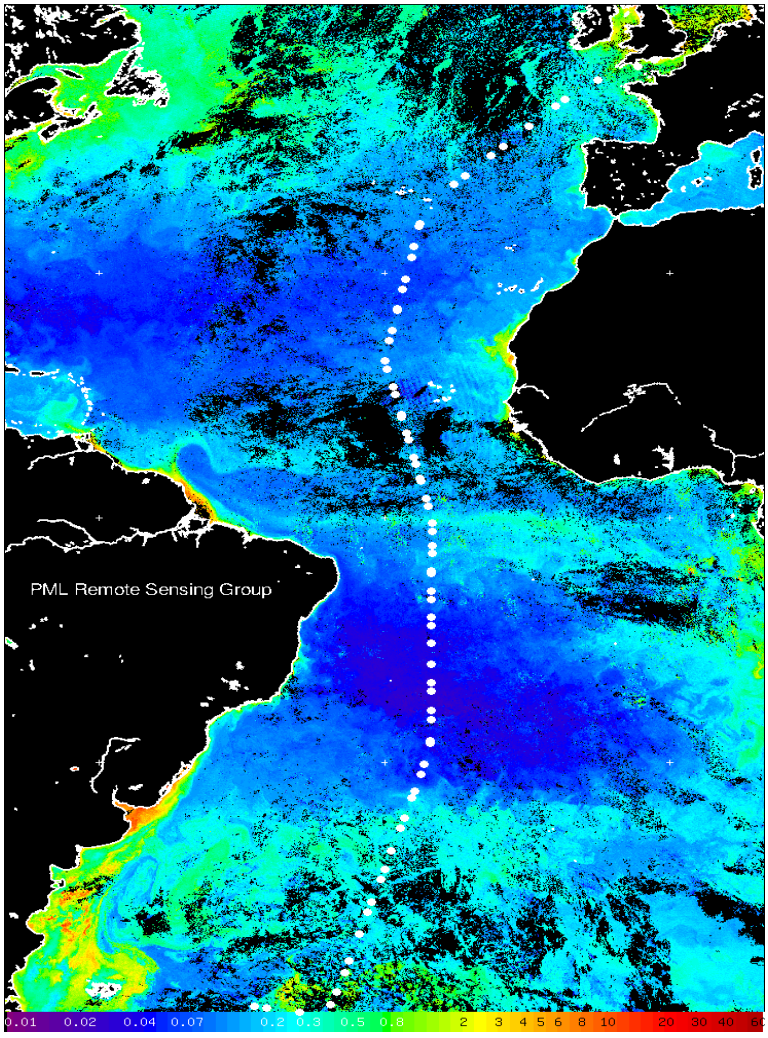
AMT 27 Cruise Report



RRS Discovery (DY084/085)

(23 September – 05 November 2017)

Principal Scientist: Andy Rees

Plymouth Marine Laboratory

PML | Plymouth Marine Laboratory

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Table of Contents

Overview

The 27th AMT cruise departed Southampton on the 23rd September 2017 and visited the Azores and South Georgia before finally arriving in the Falkland Islands on the 5th November. Onboard were teams from Plymouth Marine Laboratory, the National Oceanography Centre, University of Southampton, Naturalis – Amsterdam, University of Hawaii, Tartu Observatory-Estonia and the Royal Belgian Institute for Natural Sciences. Operations onboard included the measurement of core AMT variables in the maintenance of the now 22 year time series; Optical and atmospheric observations in support of the European Space Agency Sentinel satellites; Deployment of 29 autonomous floats for University of Washington, Euro-Argo and UK MetOffice; The genetic biodiversity and ocean acidification sensitivity of mesozooplankton; and the turnaround of the sediment trap mooring in the South Atlantic gyre. AMT's oceanography training programme continued with opportunities provided by POGO in the sponsorship of two research fellows from Sri Lanka and India, plus the first time on a research cruise for one of PMLs junior apprentices.

The whole of the scientific complement would like to extend their gratitude to Captain Jo Cox and her officers and crew who supported our activities throughout with dedication and extreme professionalism. Our thanks are also extended to the team from NMF (Dave Childs, Colin Hutton, Andrew Moore and Richie Phipps) who ensured the delivery of all scientific activities My particular thanks to Glen Tarran and Christina Devereux who assisted in ways too numerous to mention here.

Now in its 22nd year the AMT is a multidisciplinary program which undertakes biological, chemical and physical oceanographic research during an annual voyage throughout the Atlantic Ocean.

AMT objectives have evolved to enable the maintentance of a continuous set of observations, whilst addressing global issues that are raised throughout the most recent IPCC assessment and UK environmental strategy. AMT objectives are to:

(1) quantify the nature and causes of ecological and biogeochemical variability in planktonic ecosystems;
(2) quantify the effects of this variability on nutrient cycling, on biogenic export and on air-sea exchange of climate active gases;
(3) construct a multi-decadal, multidisciplinary ocean time-series which is integrated within a wider "Pole-to-pole" observatory concept;
(4) provide essential sea-truth validation for current and next generation satellite missions;
(5) provide essential data for global ecosystem model development and validation and;
(6) provide a valuable, highly sought after training arena for the next generation of UK and International oceanographers.

An exciting highlight of this AMT cruise is our continued collaboration with the European Space Agency through their funding of the AMT4SentinelFRM project. This has provided a unique opportunity to obtain high quality fiducial reference measurements for the validation of Sentinel products in a wide range of Atlantic locations.

Dr A.P. Rees

Plymouth Marine Laboratory
March 2018

Cruise Participants

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PSO

Carolyn Harris
Nutrients

Denise Cummings
Primary Production

Francesco Nencioli
Optics, Sentinel 3

Glen Tarran
Microbial communities

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Sentinel 3 calibration

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Data management

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POGO Fellow (N2O/CH4)

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Mesozooplankton

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Optics, Sentinel 3

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Microbial activity

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Lisette Mekkes
Mesozooplankton

Phyllis Lam
N Cycling

Mike Zubkov
Microbial activity

Nina Kammenay
Microbial; activity

Quinten Vanhellemont
Sentinel 3

NMF technicians Colin Hutton, Dave Childs and Andrew Moore (Richie Phipps missing)

CTD and underway sensor calibrations

Arwen Bargery
British Oceanographic Data Centre

Cruise Objectives

In total, 78 CTD casts and 1 shakedown CTD deployments along the cruise transect were used to obtain profiles of the water column from a range of sensors. All casts were conventional profiling casts with 24 x 20L OTE Niskin bottles for sampling water. CTD's were deployed pre-dawn at ~04:30am and noon ~12.30pm ship time each day, until 21st October when deployment times switched to 3:00am and 10:30am ship's time, weather permitting. Profiles were down to 500 metres depth twice a day, and every 4th day, to 1000 m, with an additional 1000 m cast after the pre-dawn. Sensors on the CTD included pressure, temperature, conductivity, oxygen, fluorescence, PAR, turbidity, transmittance and attenuance.

Methods

The Sea-Bird data collection software Seasave-Win32 recorded the raw data output from the CTD casts. Processing the raw data occurred daily, following the BODC recommended guidelines using SBE Data Processing-Win32 v7.26.7. Outlined below are the processing routines used to convert the raw CTD data into CNV files, each routine is named after each stage in brackets < >.

Conversion of the raw binary Sea-Bird files to ASCII files (CNV) containing the 24 Hz data for up and down casts <DatCnv>. Generation of bottle files for each cast containing the mean values of all the variables at the time of 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>. Identification of the surface soak for each cast using <SeaPlot>, removed manually and then 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 1 dbar downcast files for calibration and visualisation on-board <BinAverage>. Removal of the initial salinity and oxygen channels produced at the DatCnv stage, along with the conductivity, voltage and altimeter channels from the 1-dbar downcast files <Strip>.

Collation of the sensor values at bottle firing generated by the Bottle Summary routine formed the dataset for calibrating the two CTD salinity sensors and oxygen sensor against discrete bench salinometer measurements and oxygen Winkler measurements, respectively. The fluorometer sensor will be calibrated post-cruise using AC-9 data calibrated against HPLC data.

To generate a calibration, an offset between the discrete water sample measurement (salinity/oxygen) and the nominal value from the sensor at bottle firing was calculated. Outliers were identified using plots of offset against the discrete sample values and a linear regression was applied.

Where the regression was strong and significant the calibration equation was derived by rearranging the regression equation:

Offset = a * Discrete sample + b

Where offset = Discrete sample – Sensor value

To give Calibrated value = 1/(1-a) * Sensor value + 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.

Provisional Results

- Temperature

There were no independent measurements of temperature made during the cruise and the two CTD temperature sensors on the rig returned consistent data. There was no further calibration of these sensors. Fig 1. below shows the section plot of the primary temperature sensor along the cruise track.

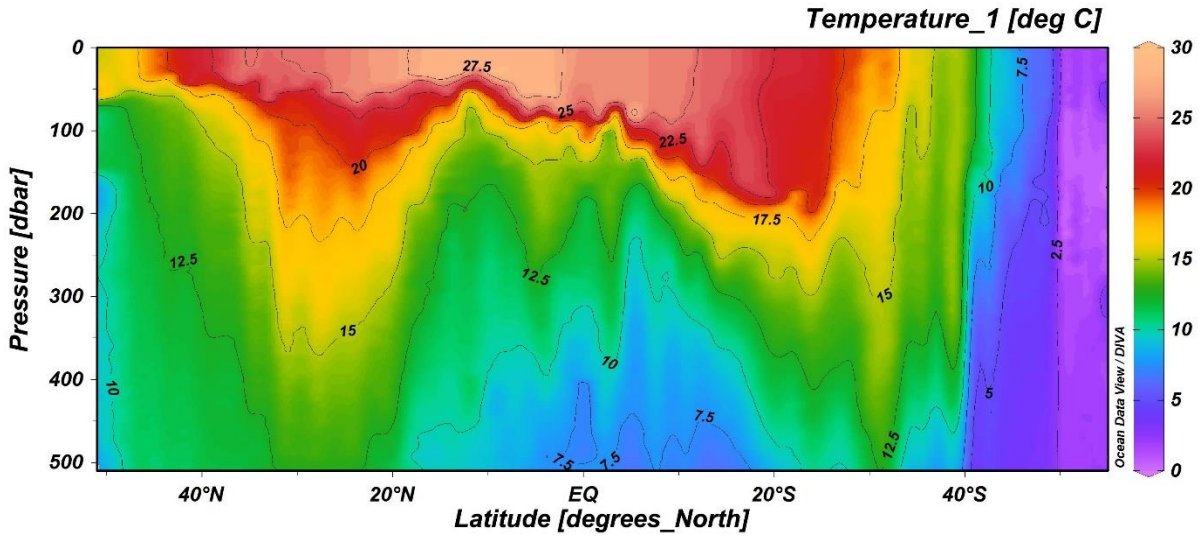

Fig. 1: Temperature section plot along the AMT27 transect by latitude (50 deg N – 54 deg S) from the primary temperature sensor, located on the CTD vane.

- Salinity

The salinity channels were calibrated against bench salinometer measurements from five samples on average collected from CTD casts every few days. Further details of these measurements can be found in the NMF-SS cruise report section.

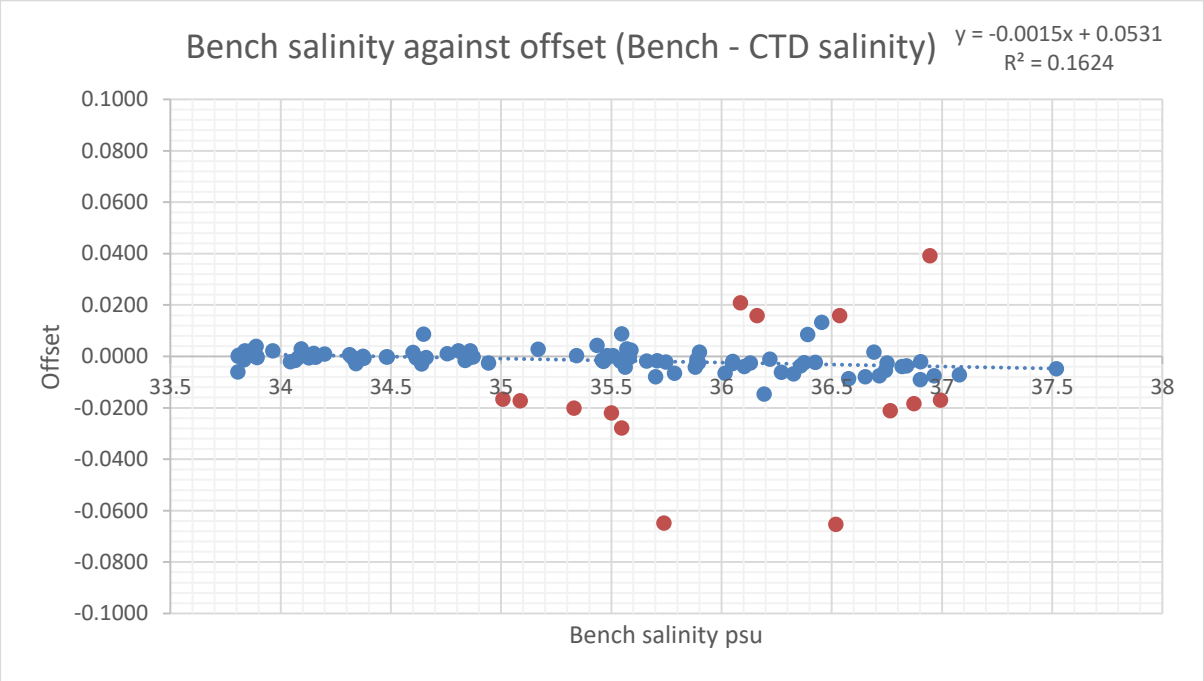

Fig. 2: Salinity offsets for the primary salinity sensor against discrete sample salinity measured with a bench salinometer.

For salinity sensor 1, there was a weak but significant relationship between bench salinity and offset ($n = 101$; $r^2 = 0.162$; $p < 0.001$). However, applying a regression did not improve the dataset nor did applying the mean offset.

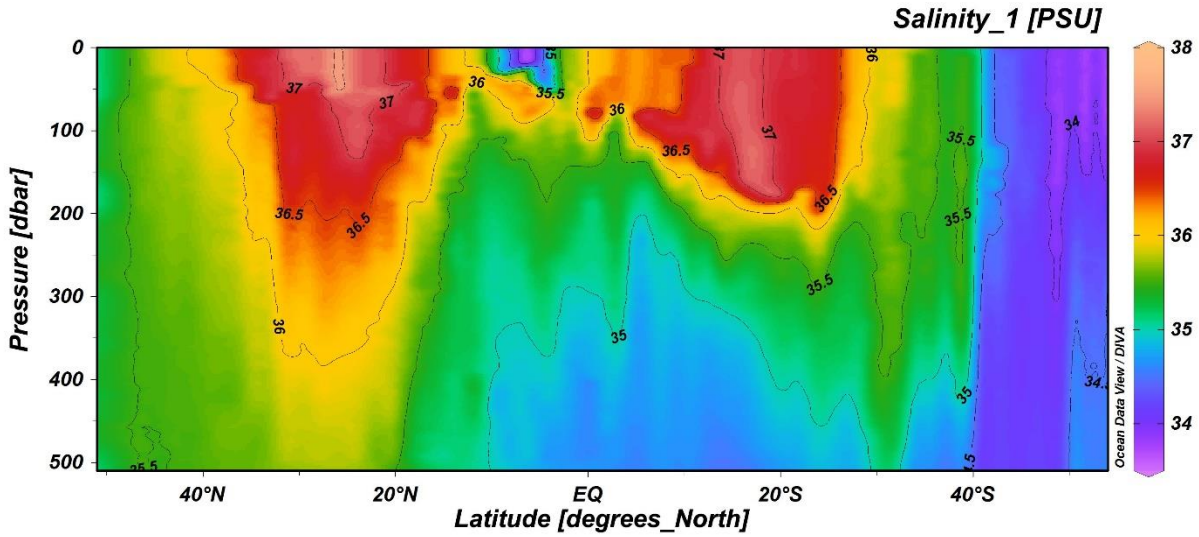

Fig. 3: Salinity section plot along the AMT27 transect by latitude (50 deg N – 54 deg S) from the primary salinity sensor.

The secondary CTD salinity sensor was calibrated against discrete salinity measurements. The regression of bench salinity against offset was not significant or strong (n = 108; r^2 = 0.00385; p >0.05) so the mean offset was applied to these data.

Calibrated secondary salinity = uncalibrated salinity - 0.00234

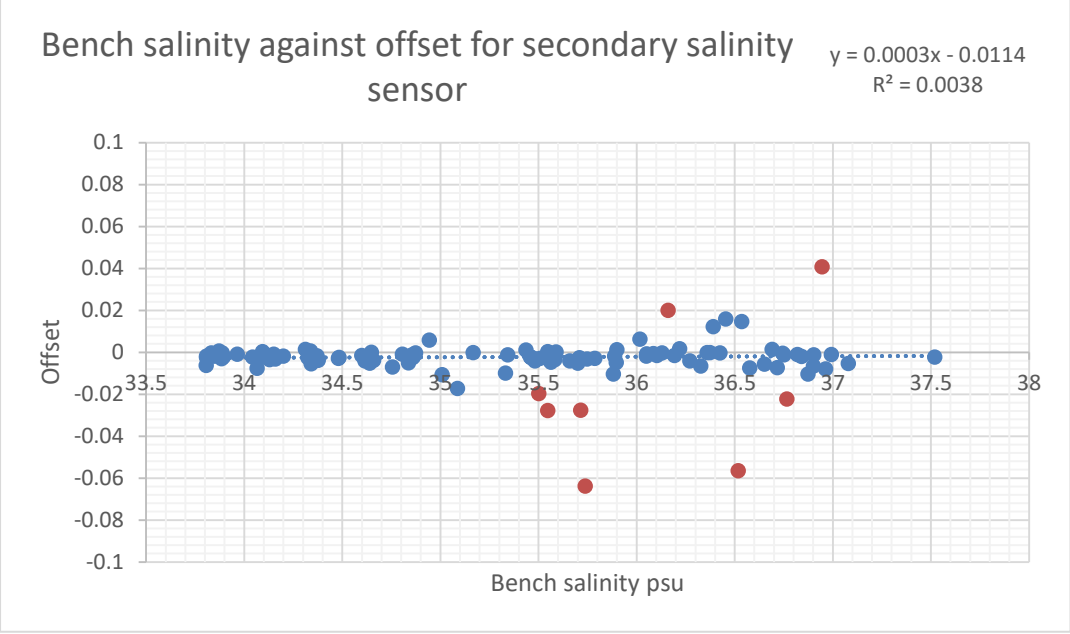

Fig. 4: Salinity offsets for the secondary salinity sensor against discrete sample salinity measured with a bench salinometer.

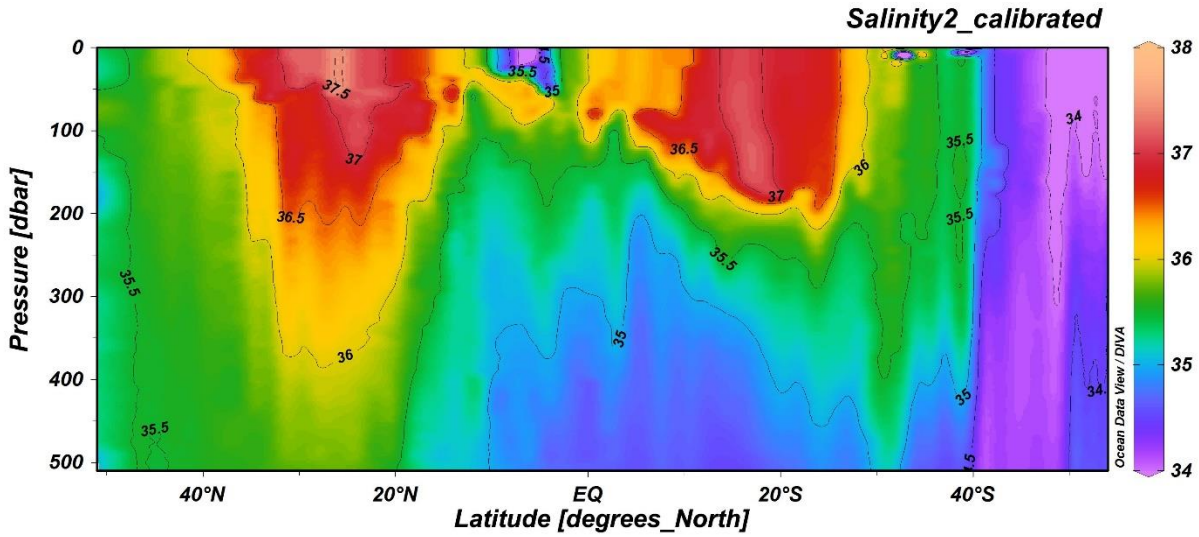

Fig. 5: Salinity section plot along the AMT27 transect by latitude (50 deg N – 54 deg S) from the secondary salinity sensor calibrated against bench salinity samples.

- Oxygen

Calibration of the SBE 43 oxygen sensor against discrete oxygen Winkler titration measurements used five depths collected from the pre-dawn and noon CTDs. More details are available in Rebecca Mays' cruise report. The CTD oxygen sensor recorded anomalous values on the shakedown cast and on CTD001, so data from these casts were not included in the calibration. The oxygen sensor operated without problem throughout the remainder of the cruise.

Several data points did not fit the pattern observed with the data from the other casts and so were excluded from the calibration data set. There was a strong, significant relationship between the offset and the discrete oxygen data, so that the trend below was applied to the CTD oxygen data.

The calibration equation:

Calibrated $O_{2\ (\text{in } \mu\text{mol/l})}$ = 1.1004 * sensor $O_{2\ (\text{in } \mu\text{mol/l})}$ – 5.9485 (n = 314; r^2 = 0.887; p < 0.001);

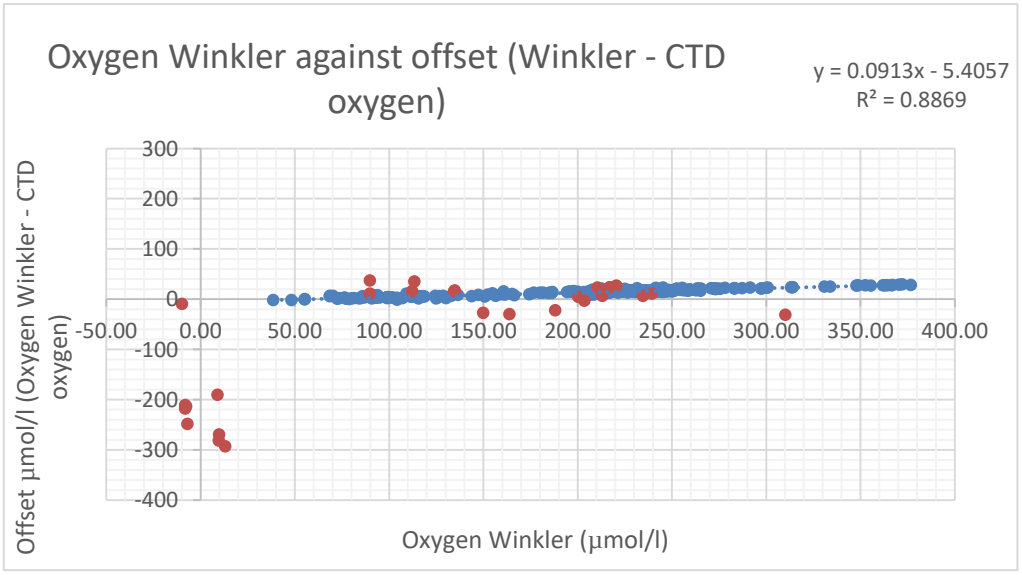

Fig. 6: Oxygen concentration offsets against Winkler titration measurements from discrete samples. Outliers removed from calibration dataset are shown.

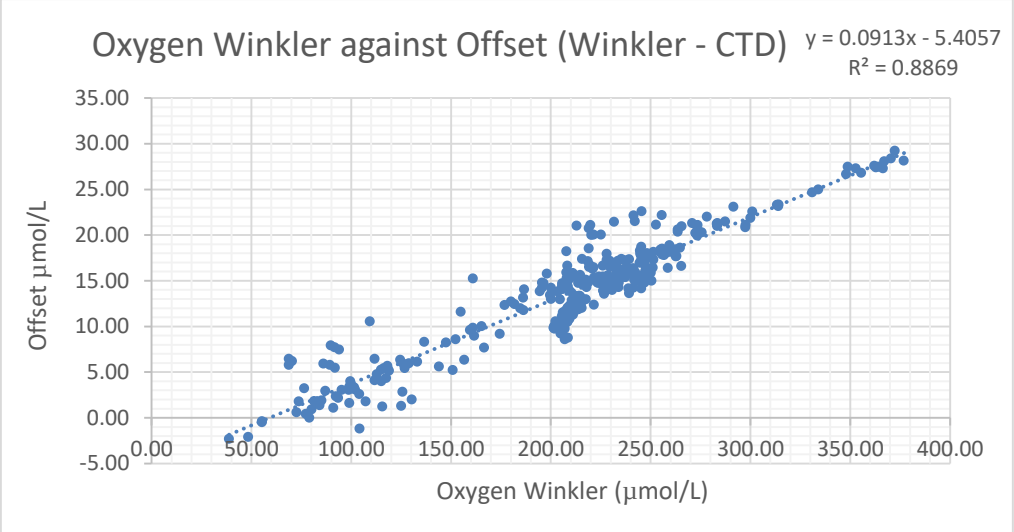

Fig. 7: Oxygen concentration offsets against Winkler titration measurements from discrete samples.

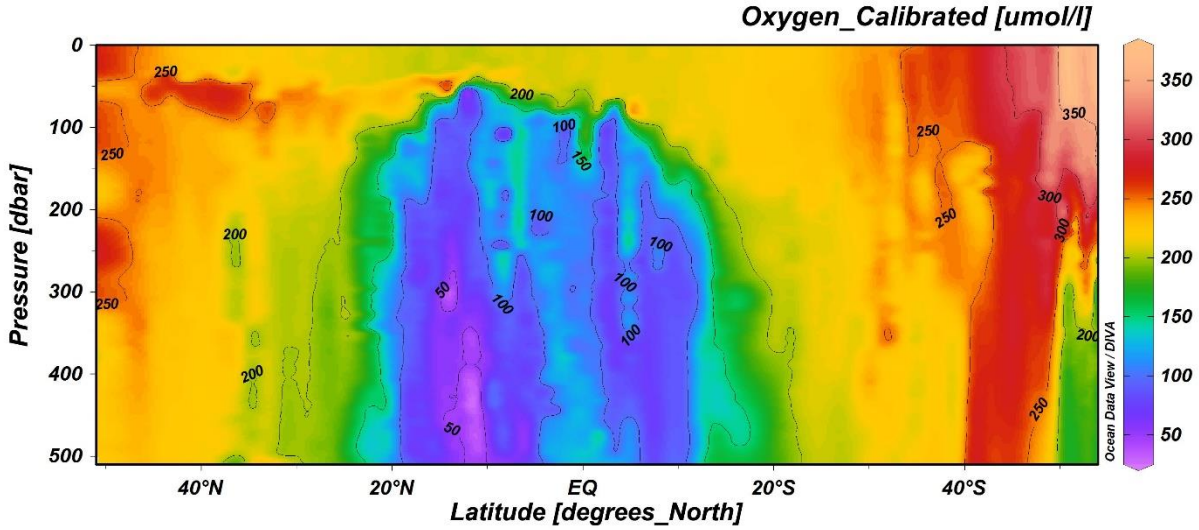

Fig. 8: Oxygen concentration section plot along the AMT27 transect by latitude (50 deg N – 54 deg S) from the SBE43 oxygen sensor calibrated against Winkler titration samples.

- Fluorometer

The CTD fluorometer operated without problem during the cruise. Calibration of the CTD fluorometer sensor against sample data will be carried out after the cruise against AC-9 and HPLC data. A section plot of the fluorescence data along the AMT27 cruise track is shown below.

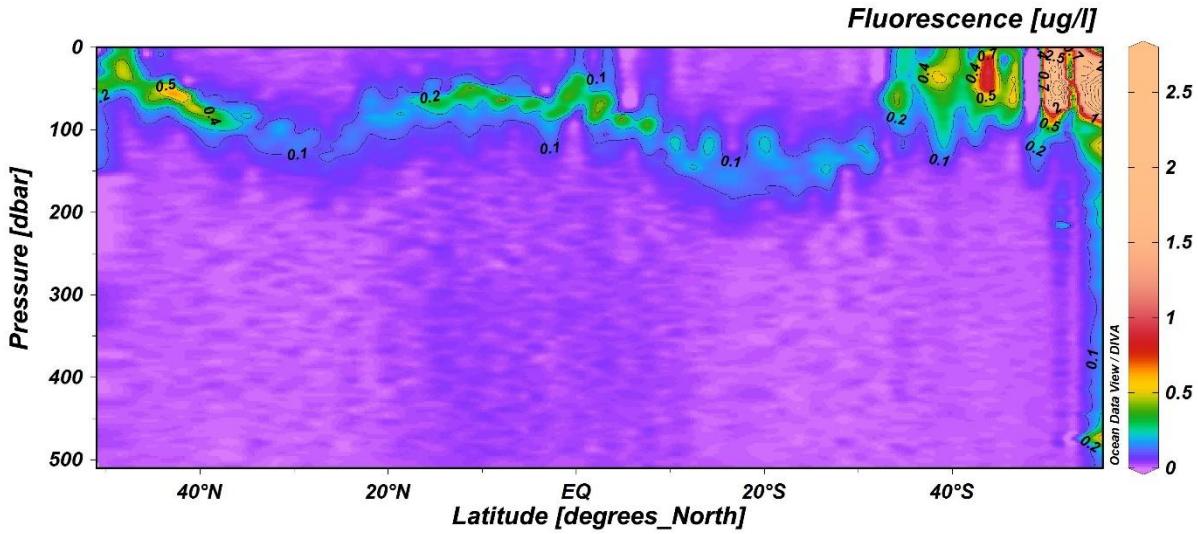

Fig. 9: Fluorometer section plot along the AMT27 transect by latitude (50 deg N – 54 deg S).

Underway sensors

The ship's underway meteorological and surface systems were run continuously throughout the cruise. The sea surface hydrography system started logging from 20/09/2017 08:45:00 (UT) prior to departure on 23/09/2017 and was switched off at arrival to the Falklands on 05/11/2017. Samples were collected to calibrate the TSG connected to the ship's non-toxic flow-through system, which draws water from approximately 5.5 m below the water line on the RRS Discovery.

- Sea Surface Temperature Hull sensor (temp_r, remote temperature)

The remote sea surface underway temperature sensor was calibrated against the mean of the primary and secondary CTD temperature sensor values from each CTD at 5.5 dbar. The isosurface temperature values at 5.5 dbar were calculated in Ocean Data View, by using the available temperature values to obtain a linearly interpolated value on the isosurface. Several values were excluded from the regression where the surface value was anomalous.

A regression analysis was performed on the offset (CTD temperature – underway temperature) against cruise day and offset against CTD temperature. Two trends were identified in the data: there was a weak, but significant regression of the offset with surface CTD sensor values ($n = 67$; $r^2 = 0.175$; $p < 0.05$) and a strong, significant relationship of offset with cruise day ($n=67$; $r^2 = 0.512$; $p < 0.05$). The regression equation for the trend with time was applied.

Calibrated underway temperature = [a + (b*day)] + underway uncalibrated
Where a = 10.2745 and b = -0.03636

The offsets with the newly adjusted values were re-calculated and regression analysis performed; there was now no relationship between offset and CTD temperature ($n = 67$; $r^2 = 0.0007$; $p > 0.05$) or offset against cruise day ($n = 67$; $r^2 =\sim 0$; $p > 0.05$), so no further calibration was necessary.

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

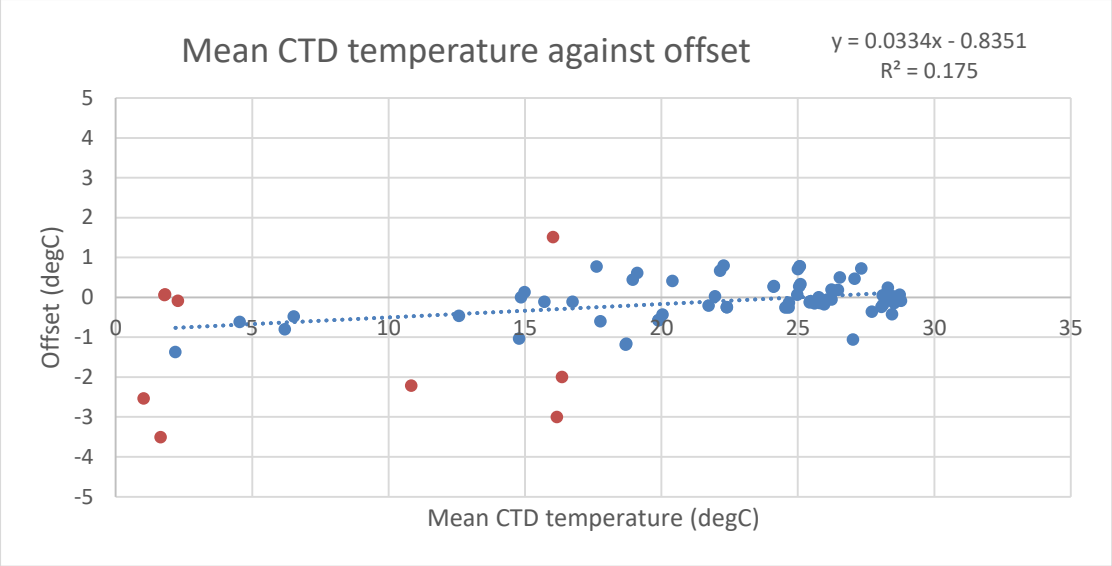

Fig. 10: Hull sensor temperature offsets against surface CTD temperature measurements.

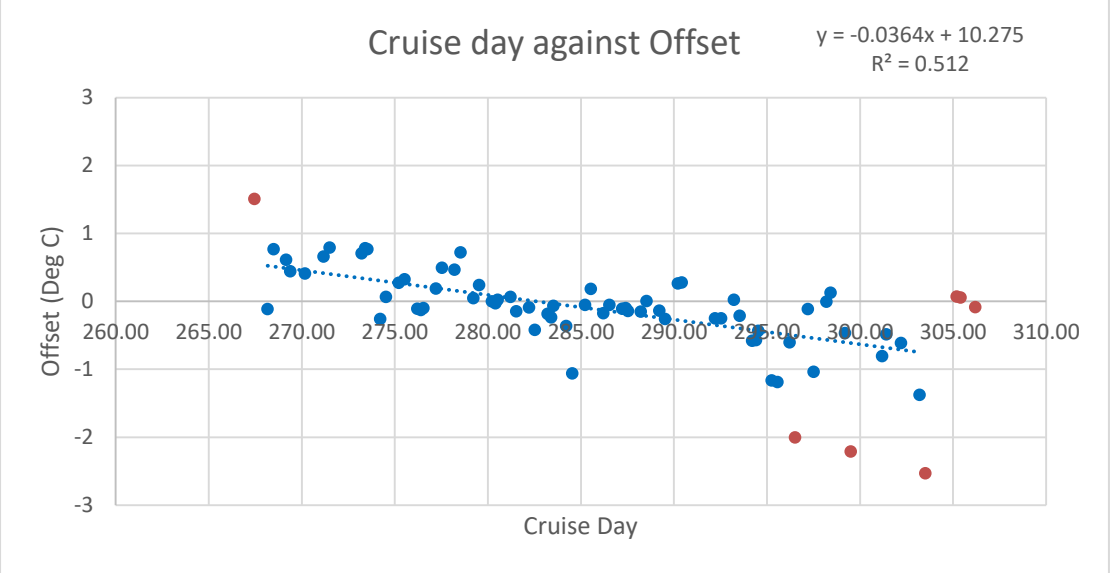

Fig. 11: Hull sensor temperature offsets against cruise day.

- 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 at approximately 8am, 12pm, 4pm and 8pm, ships time. The offset between bench salinity and underway TSG salinity sensor value was calculated. Several outliers were identified when plotting offset against bench salinity and cruise day, which were excluded from the calibration dataset. There was not a significant regression of the offset with bench salinity measurement ($n = 116$; $r^2 = 0.0018$; $p > 0.05$) and the regression between cruise day and offset was also not significant ($n = 116$; $r^2 = 0.01425$; $p > 0.05$) so the mean offset was applied to the TSG data.

Calibrated salinity = TSG salinity + 0.0076

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

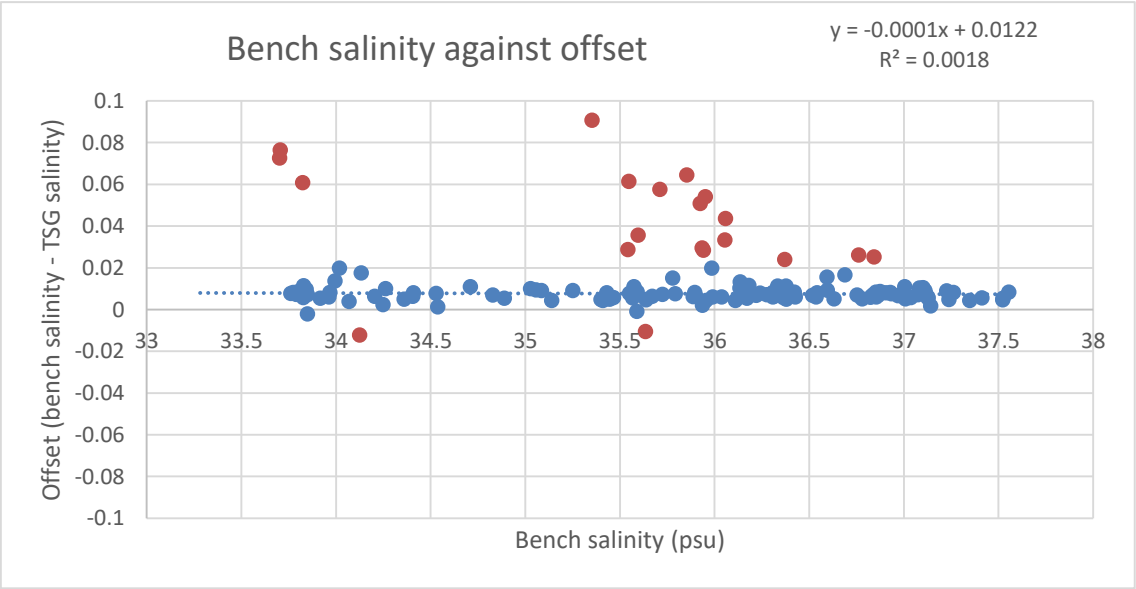

Fig. 12: Salinity offsets against bench salinometer measurements on discrete underway samples.

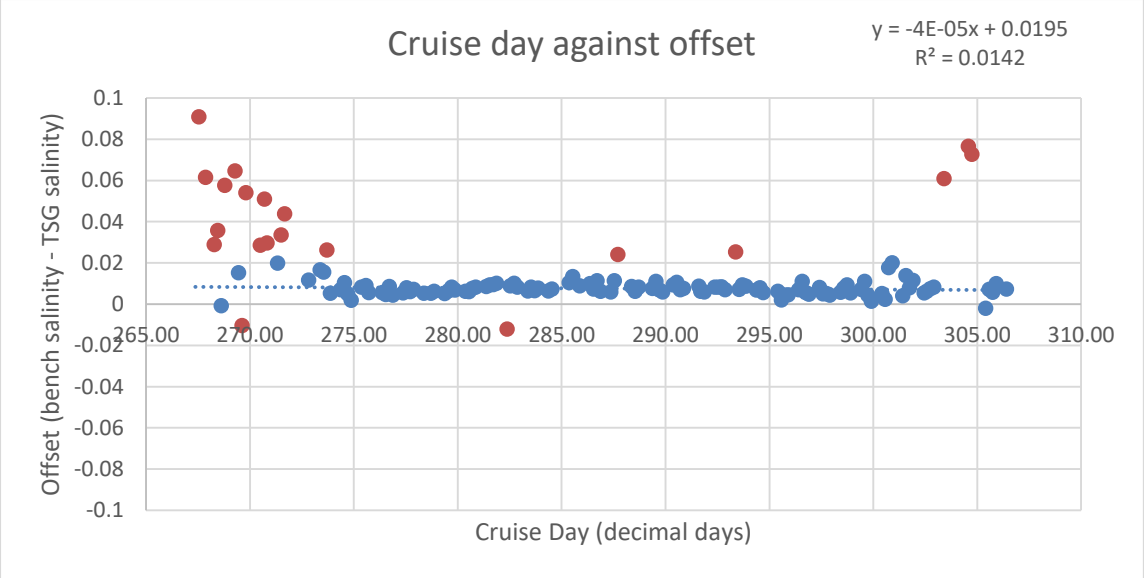

Fig. 13: Salinity offsets against cruise day

- Fluorometer

The underway fluorometer data will be calibrated against AC-9 and HPLC data generated during the cruise back at PML. The correction will be applied during BODC processing after the cruise before the data are made available online.

Sea Surface Temperature – AMT4SentinelFRM

Werenfrid Wimmer
University of Southampton

Objectives:

Collect SI traceable SSTskin measurements for the validation of SLSTR on the ESA Sentinel 3 satellite. Collect the necessary ancillary measurements for the SSTskin record to help the interpretation of the validation results. Extend the ISAR SSTskin record geographically to cover a wider range of oceanographic regimes.

Collect SSTdepth and met data from the ship underway system for comparison and the complement the SSTskin data set.

Record 6h met observations and bucket temperature measurements to verify the underway data and to provide a SI traceable reference for the SSTdepth measurements.

Automated collection of SSTskin and meteorological data:

SSTskin data was collected by ISAR (Infrared Sea surface temperature Autonomous Radiometer) mounted on the port side of the Metrological Platform (MP) at a 90 degree angle relative to the ships center line. The instruments sea viewing angle was checked on 23.09.2017 and determined with 25 deg from nadir (155 degrees in instrument coordinates). The data was logged with a data logger based in the Met Lab connected to the ships network allowing for frequent data quality checks. A flood caused by the Co2 system in the Met Lab required a power down on 19.10.2017 at 6:35 and after the ETO checked the wiring the ISAR data logger was switched back on at 11:38. The ISAR configuration was changed on 24.09.2017 to include three sky angles (15, 25, 35 degrees), changed again on 08.10.2017 to wider sky angles (05, 25, 45 degrees), than changed to a 145 degree sea view with three sky angles (25, 35, 45 degrees) on 15.10.2017 and changed on 18.10.2017 back to 155 degrees sea view with three wide sky angles (05, 25, 45 degrees), and finally changed back to the narrow sky angles (15, 25, 35 degrees) on 27.10.2017. These changes were made to help with the miss pointing characterization as described by Donlon and Nightingale, 2000 and the changes have a no impact on the use of the ISAR data for SLSTR validation.

The ISAR raingauge starting producing false positives on 29.09.2017 with eventually reversing the signal. The rain gauge was removed from the MP at the stop in the Azores and cleaned, dried and checked for problems. The rain gauge was reinstalled before leaving the Azores but no change in operation. Therefore the rain gauge signal was rewired to go to the ML before the ISAR on 30.09.2017. This allowed to manually switch the ISAR shutter while a replacement rain detector was build in a Nutella lid (NRD). The NRD uses the CASOTS Raspberry Pi together with a spare AD converter and some resistors. The NRD was installed on 01.10.2017 and used together with the ISAR rain gauge, which while still giving false positive settled down on 10.10.2017, and both RG were used until the end of the cruise.

The ancillary sensors, a Kipp and Zonen CM11, a Eppley PIR were mounted above the ISAR on the MP and a Gill Windmaster was mounted near the centre forward part of the MP in order to be free of obstruction for the Gill Windmaster, and to have a clean view of the sky for the CM11 and the PIR. The CM11 and the PIR were mounted on individual gimbals to ensure that the sensors axis is vertical even when the ship moves. The data were logged with the same logger as the ISAR data. The PIR data is processed as described in Fairall et. al. 1998.

Air temperature and Humidity data were collected with a Vaisala HMP243 sensor on the port side of the monkey island with a separate data logger which was located on the bridge..

SSTdepth (at 4m) data were collected with a Seabird SBE48 on the starboard side in he bow thruster room. A total of 198963 samples were collected at 20 second intervals.

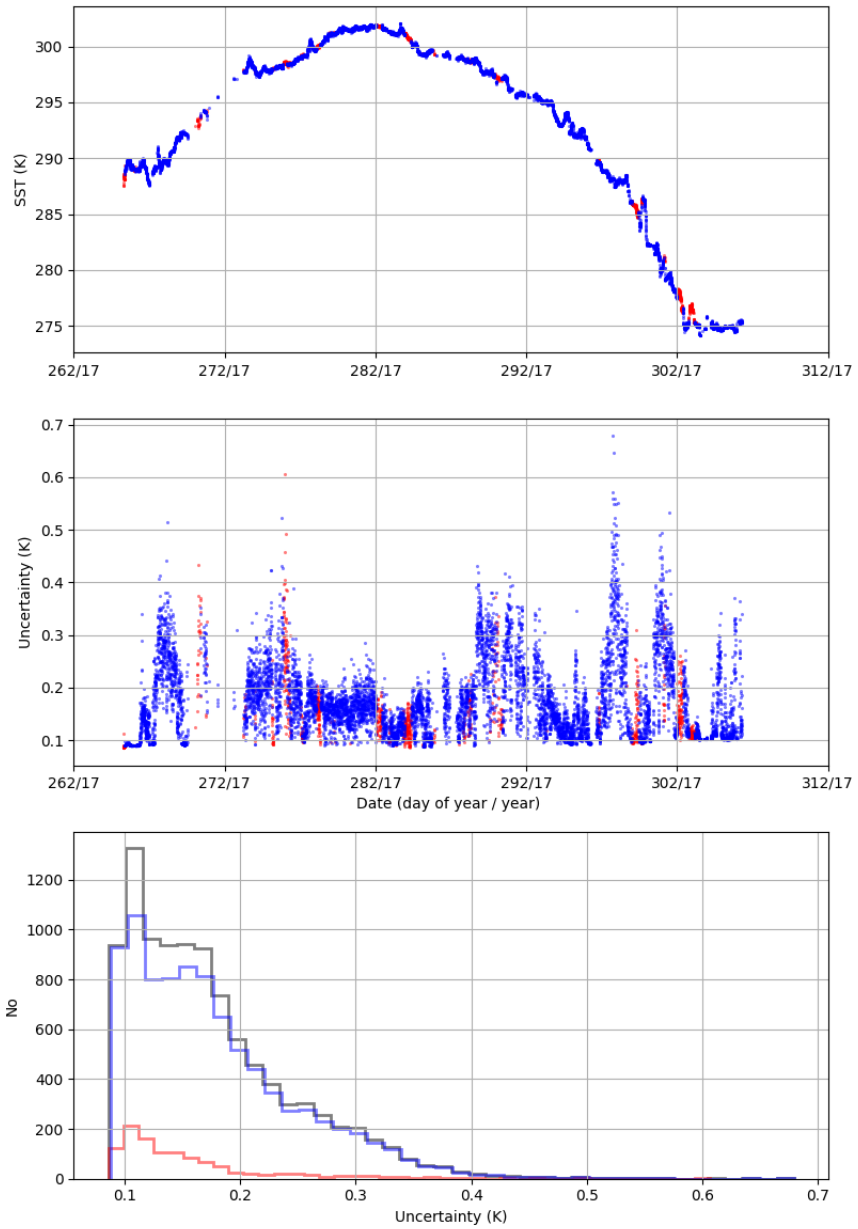

Figure 1: ISAR SST data with corresponding total uncertainty.

Sky Brightness temperature measurements

In order to characterize the miss pointing uncertainty of the ISAR instrument (Donlon and Nightingale, 2000; Wimmer and Robinson, 2016) and characterize the whole sky a Heitronics KT 15 was mounted on a three axis motor driven mount, which also recorded temperature, roll and pitch and GPS date/time and location. A sky BT characterization took approximately 30 min. Together with the KT 15 an all sky camera was mounted filming during the KT15 data acquisition in a 1 s time lapse mode. Also a number of infrared images of the sea and sky were taken with a FLIR E4/8 during each of the KT 15 data acquisitions. A total of 23 Sky brightness temperature characterizations were acquired, mainly at the noon CTD station, with one at the morning CTD station and two at the extended 1000m

second CTD station. On 14/10/2017 the zero position hall effect switch for the tilt motor failed and a software update was used to use the external switch and alignment by eye to find the horizontal tilt position. Both the KT15 mount and the all sky camera were mounted on the Met Platform on the port side above the Kipp and Zonen CM11 and Eppley PIR on top of the two scaffolding poles holding the CM11 and PIR gimbals. The Heitronics KT15 was calibrated with a CASOTS II black body before and after each measurement with a two point calibration at roughly 290 K and 303 K in the Met Laboratory.

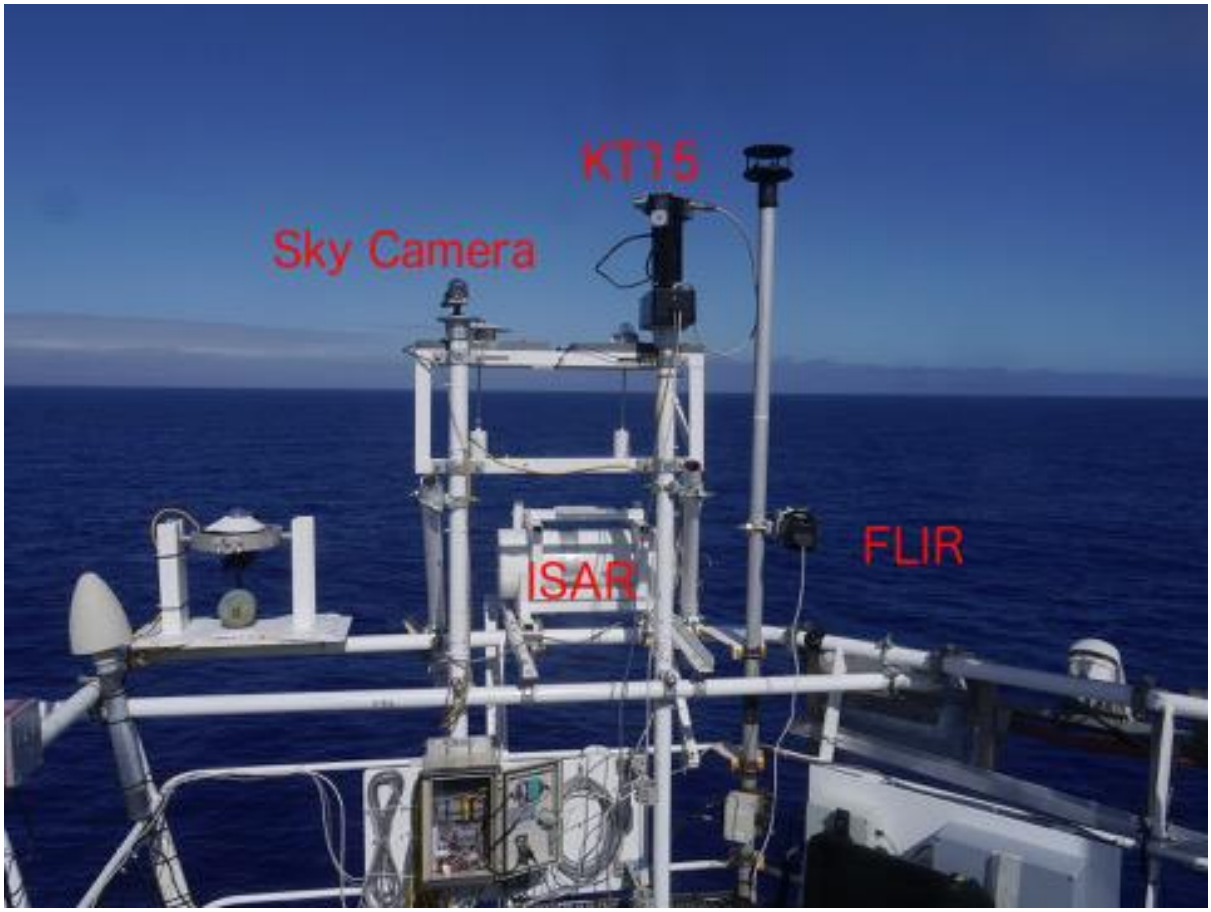

Figure 2: Sky camera and Heitronics KT15 mounted on the Met Platform.

Table 1: Sky Brightness Temperature measurements date, time and location.

No	Date	Time	Lat (+ N)	Lon (+ W)
1	25/09/2017	12:28:00	46.7	12.05
2	27/09/2017	12:43:00	42.0997	18.4787
3	28/09/2017	12:34:00	39.2131	22.4449
4	01/10/2017	13:40:00	31.4578	27.1115
5	03/10/2017	13:45:00	25.4292	28.3994
6	06/10/2017	13:43:00	15.3048	28.5095
7	07/10/2017	13:50:00	12.4932	28.0989
8	10/10/2017	13:44:00	4.4459	26.0959
9	14/10/2017	09:49:00	-6.5221	25.0113
10	14/10/2017	10:09:00	-6.5221	25.0113
11	17/10/2017	06:11:00	-15.5766	25.0299

12	17/10/2017	06:30:00	-15.5766	25.0299
13	20/10/2017	13:34:00	-25.0624	25.0184
14	20/10/2017	13:53:00	-25.0624	25.0184
15	21/10/2017	09:38:00	-27.3297	25.116
16	21/10/2017	09:57:00	-27.3297	25.116
17	21/10/2017	10:18:00	-27.3297	25.116
18	22/10/2017	14:35:00	-31.1873	26.1134
19	24/10/2017	12:54:00	-36.5959	28.2036
20	26/10/2017	13:03:00	-42.0778	30.2509
21	27/10/2017	13:04:00	-45.116	31.4425
22	29/10/2017	13:19:00	-50.213	34.1213
23	30/10/2017	13:07:00	-52.9355	35.6613

References:

Donlon, C. J. and Nightingale, T. J. (2000); Effect of Atmospheric Radiance Errors in Radiometric Sea-Surface Skin Temperature Measurements; Appl. Opt.; 39: pp. 2387–2392.

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Wimmer, W., I. Robinson, and C. Donlon, 2012: Long-term validation of AATSR SST data products using shipborne radiometry in the Bay of Biscay and English Channel. Remote Sens. Environ., 116, 17–31, doi:10.1016/j.rse.2011.03.022.

Wimmer, W., and I. Robinson, 2016: The ISAR instrument uncertainty model. J. Atmos. Oceanic Technol. doi:10.1175/JTECH-D-16-0096.1, in press.

Fairall, C. W., Persson, P. O. G., Bradley, E. F., Payne, R. E. and Anderson, S. P. (1998); A newlook at calibration and use of Eppley Precision Infrared Radiometers. PartI: theory and application; J. Atmos. Oceanic Technol.; 15: pp. 1229 – 1242.

Weather balloon – AMT4SentinelFRM

Werenfrid Wimmer and Hashan Niroshana Kokuhennadige
University of Southampton and *University of Ruhuna, Sri Lanka*

Objectives

Collect lower atmosphere profiles to aid the atmospheric radio transfer models of the Sentinel 3 satellite sensors.

Method

Weather balloons, measuring air pressure, humidity, air temperature, wind speed and direction were launched daily to collect information of the lower atmosphere composition. A total of 38 balloons were launched between 24.09 and 02.11.2017. The radiosondes used are Vaisala RS92, which were reconditioned before launch with the Vaisala GC25. A Vaisala Digicora II MW15 together with a dedicated BAS laptop was used as data receiving and storing device. The data receiving and GPS antenna were mounted on the Met Platform, the VAsiala GC 25, MW15 and the laptop were located in the Met Lab. The Balloons were inflated with He, with the He bottle rack being located in the Hangar, on the Hangar roof in a BAS provided balloon cage for until the balloon filled the cage on the middle setting. The balloons were launched from rear end of the hangar roof. Data was emailed post flight to the UK MetOffcie with the send_temp_MW15.vi .

Table 2: List of radio sonde launch dates and locations.

No	Date	Time (UTC)	Longitude	Latitude
			W pos	N pos
1	24/09/17	11:18:00	7.6232	48.9275
2	25/09/17	10:59:00	12.0500	46.7000
3	26/09/17	10:34:00	14.8300	44.8500
4	27/09/17	12:09:00	18.6300	42.2800
5	28/09/17	12:06:00	22.7317	39.3550
6	30/09/17	13:24:00	26.3367	35.0841
7	01/10/17	13:07:00	27.1660	31.8990
8	02/10/17	13:08:00	28.0700	28.2300
9	03/10/17	13:08:00	28.4743	25.8030
10	04/10/17	13:16:00	29.4775	22.2733
11	05/10/17	13:22:00	29.6800	18.7900
12	06/10/17	13:11:00	28.8543	15.5307
13	07/10/17	13:10:00	28.1638	12.8400
14	08/10/17	13:08:00	27.4508	9.9490
15	09/10/17	13:12:00	26.6885	6.8953
16	10/10/17	13:12:00	26.1642	4.7578
17	11/10/17	13:12:00	25.3568	1.4947
18	12/10/17	13:20:00	24.9958	-1.7767
19	13/10/17	13:15:00	25.0227	-4.5653
20	14/10/17	13:16:00	25.0300	-7.1178

21	15/10/17	13:12:00	25.0577	-10.4602
22	16/10/17	13:19:00	25.0702	-13.7293
23	17/10/17	13:20:00	25.0505	-15.9610
24	18/10/17	13:22:00	25.1008	-18.5447
25	19/10/17	13:22:00	25.0688	-21.7987
26	20/10/17	13:14:00	25.0302	-24.9047
27	21/10/17	13:12:00	25.2170	-27.8580
28	22/10/17	14:18:00	26.1795	-31.2945
29	23/10/17	12:42:00	27.1473	-33.8860
30	24/10/17	12:35:00	28.3375	-36.9902
31	25/10/17	12:12:00	29.2575	-39.3583
32	26/10/17	12:39:00	30.4163	-42.1295
33	27/10/17	12:45:00	31.7367	-45.1830
34	28/10/17	11:22:00	32.5682	-47.1098
35	29/10/17	12:49:00	34.1978	-50.3452
36	30/10/17	12:48:00	35.6613	-52.9355
37	01/11/17	10:36:00	38.6442	-53.5548
38	02/11/17	12:48:00	43.5943	-53.0725

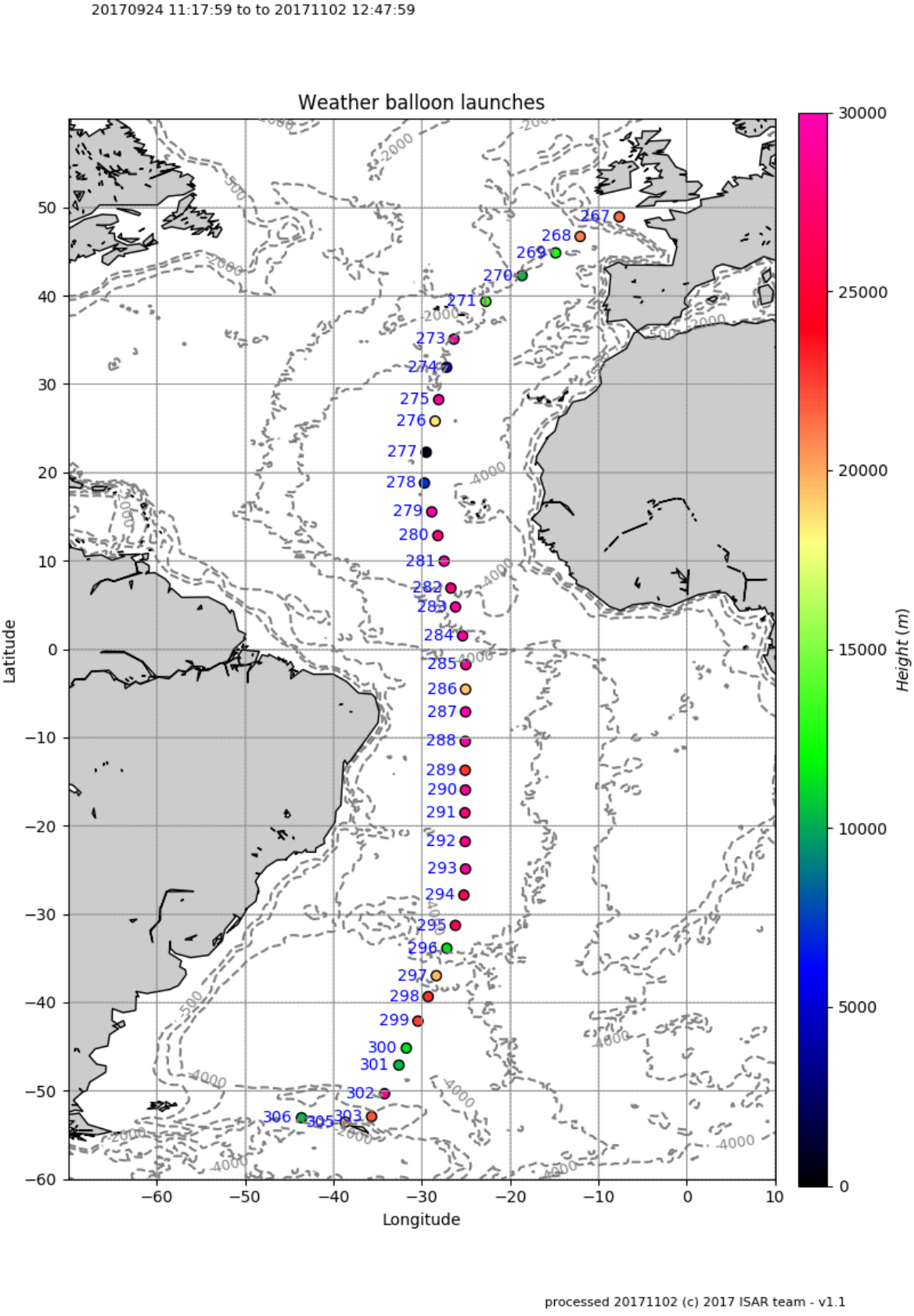

Figure 3: Plot of the Balloon launch positions with day of year labels in blue. The colour of the circle represents the height above sea level at which the balloon burst.

C-band Radar - – AMT4SentinelFRM

Werenfrid Wimmer
University of Southampton,

Objectives

Collect sea state, surface roughness and wave information for the validation of the ESA Sentinel 3 satellite radar altimeter and the synthetic aperture radar on the ESA Sentinel 1 satellite.

Methods.

The IFREMER shipborne C-band radar was mounted on the forward mast facing the port side of the ship at and angle of approximately 45 degrees horizontally. The radars look angle at the sae surface is fixed at approximately 40 degrees. The radar instrument is viewing the patch of water in front of the ISAR instrument , because, unlike on AMT26, it was not practical to align the two filed of views.. Data were recorded every 20 minutes in the Metrological Laboratory on a dedicated IFREMER data logging computer. There are two different operation modes recorded every 20 min, 3 minutes apart, one mode at 00, 20 and 40 and one mode at 03, 23 and 43. Data quality was checked during the cruise on a regular basis. Data logging seem to have crashed on 15.10.2017 and was restored by restarting and powering down the C-band radar and logging system. Together with the C-band radar 480 camera images (over approximately 5 min) were collected every 20 min to help interpret the radar data. A flood in the Met Lab on 19.10.2017 required a power down at 06.35 to check the integrity of the wiring and the CBAND radar was powered back up at 11.35.

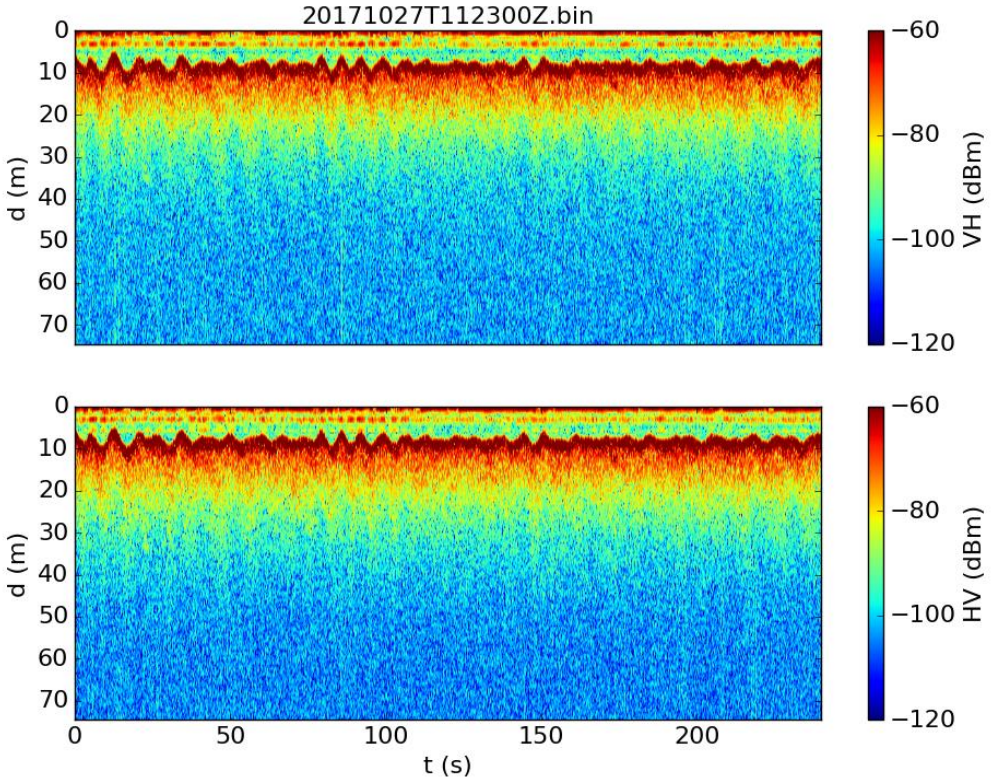

Figure 4: Example radar image from 27.10.2017 showing the vertical horizontal and horizontal vertical polarization data.

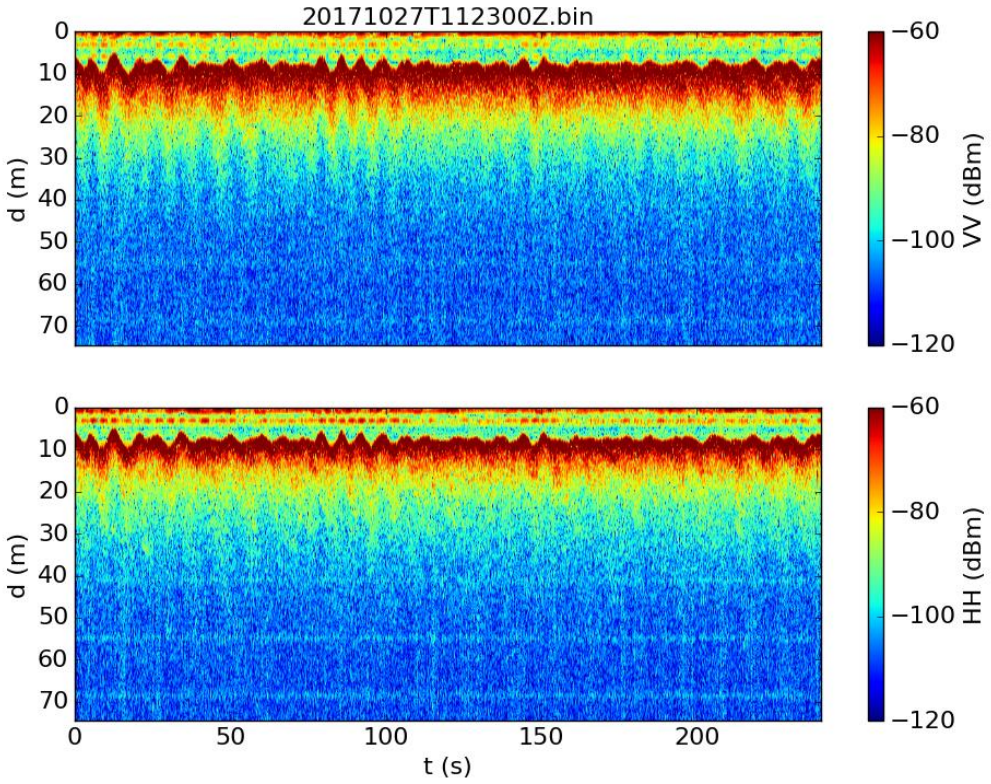

Figure 5: Example radar image from 27.10.2017 showing the vertical vertical and horizontal horizontal polarization data.

Dissolved Inorganic Nutrients

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 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 and 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) . 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), typically every unique depth was sampled from each CTD cast. These were sub-sampled into clean (acid-washed) 60ml HDPE (Nalgene) sample bottles, which were rinsed x3 with sample seawater prior to filling.

Table 1: AMT 27 - Station & CTD Sampling Summary

Stn	CTD	Lat (°N)	Long (°W)	Time	Date	Niskin bottles sampled
01	01	48°55.566	7°37.417	11:25	24/09/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
02	02	47°16.133	11°0.588	04:02	25/09/2017	1,2,3,4,5,6,7,8,10,11,12,13,14,15,16,17 18,19,20,21,22,23,24
03	03	46°41.180	12°0.011	12.03	25/09/2017	1,2,3,4,5,6,7,8,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
04	04	44°51.139	14°49.675	03:57	26/09/2017	1,2,3,4,5,6,7,8,10,11,12,13,14,15,16,17 18,19,20,21,22,23,24
04	05	44°51.139	14°.49.675	09:33	26/09/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
05	06	43°3.940	17°29.939	04:38	27/09/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18, 19,20,21,22,23,24
06	07	42°9.997	18°47.810	12:48	27/09/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
07	08	40°13.047	21°32.087	04:30	28/09/2017	1,2,3,4,5,6,7,8,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24
08	09	39°21.301	22°44.529	12:09	28/09/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
09	10	35°19.066	26°18.021	05:37	30/09/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
09	11	35°19.066	26°18.021	10:37	30/09/2017	2,3,8,13,18
10	12	5°31.037	26°20.243	13:12	30/09/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
11	13	32°53.646	26°53.389	05:43	01/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24

Stn	CTD	Lat (°N)	Long (°W)	Time	Date	Niskin bottles sampled
12	14	31°45.761	27°11.183	13:07	01/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
13	15	29°18.697	27°46.953	05:30	02/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
14	16	28°11.790	28°4.185	13:06	02/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
15	17	26°1.238	28°35.310	05:33	03/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
16	19	25°42.912	28°40.042	13:22	03/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,20,21,22,23,24
17	20	23°22.333	29°12.384	05:33	04/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17 18,20,21,22,23,24
18	21	22°15.229	29°28.982	13:06	04/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
19	22	19°50.301	29°56.061	05:34	05/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
20	23	18°47.154	29°40.940	13:01	05/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
21	24	16°33.990	29°5.130	05:33	06/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17 18,19,20,21,22,23,24
22	25	15°30.468	28°50.990	13:03	06/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
23	26	13°9.570	20°14.328	05:32	07/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24,
24	28	12°49.334	28°9.933	13:07	07/10/2017	2,3,5,7,8,9,10,11,12,13,14,15,16,17 18,19,20,21,22,23,24
25	29	10°51.901	27°37.293	05:39	08/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,20,21,22,23,24
26	30	9°55.617	27°26.634	13:03	08/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
27	31	7°44.972	26°53.910	05:28	09/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
28	32	6°52.84	26°41.161	13:02	09/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
29	33	5°2.587	26°14.779	05:30	10/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
30	35	4°44.569	26°9.638	13:08	10/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
31	36	2°29.59	25°26.71	05:28	11/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24,
32	37	1°27.635	25°21.428	13:05	11/10/2017	1,3,4,5,6,8,9,11,15,16,17,18,20,22
33	38	0°43.53	24°55.99	05:40	12/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
34	39	1°46.615	24°59.761	13:07	12/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
35	40	3°32.361	24°59.631	05:28	13/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
36	41	4°35.181	25°1.457	13:12	13/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
37	42	6°52.210	25°1.164	05:29	14/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
38	44	7°8.139	25°1.871	13:04	14/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
Stn	**CTD**	**Lat (°N)**	**Long (°W)**	**Time**	**Date**	**Niskin bottles sampled**

39	45	9°25.35	25°01.72	05:28	15/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
40	46	10°29.170	25°3.482	13:06	15/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
41	47	12°38.041	25°1.752	05:30	16/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
42	48	13°43.883	25°4.263	13:02	16/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
43	49	15°57.656	25°3.026	05.29	17/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
43	50	15°57.656	25°3.026	10:15	17/10/2017	1,3,5,9,12,13,17,21,20,5
45	51	20°44.755	25°3.854	05:28	19/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24,
46	52	21°47.980	25°4.129	13:00	19/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24,
47	53	23°59.425	24°59.921	05:35	20/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
48	54	25°6.221	25°1.885	13:03	20/10/2017	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17, 19,20,21,23,24
49	55	27°33.011	25°11.668	05:29	21/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
50	57	27°51.474	25°13.022	13:04	21/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 19,20,21,22,23,24
51	58	30°13.435	25°14.385	06:28	22/10/2017	1,2,3,4,5,7,8,9,10,11,12,13,14,15,16,17, 19,20,21,22,23,24
52	59	31°18.771	26°11.342	14:05	22/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,20,21,22,23,24
53	60	33°7.747	26°50.496	05:39	23/10/2017	1,2,3,4,5,6,7,8,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
54	61	33°53.096	27°8.872	12:35	23/10/2017	1,2,3,4,5,6,7,8,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
55	62	35°55.566	28°.0.288	04:57	24/10/2017	1,2,3,4,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
56	63	36°59.622	28°20.340	12:32	24/10/2017	1,2,3,4,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
57	64	39°21.398	29°16.119	05:10	25/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
57	65	39°21.398	29°16.119	10:31	25/10/2017	2,6,11,15,20,22,23
58	66	41°10.750	30°1.020	05:01	26/10/2017	1,2,3,4,5,6,7,8,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
59	67	42°7.743	30°25.023	12:28	26/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
60	68	44°13.144	31°20.169	05:00	27/10/2017	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
61	69	45°11.359	31°43.993	12:34	27/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
62	70	47°7.444	32°36.397	05:05	28/10/2017	1,2,3,4,5,6,7,9,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
62	71	47°7.444	32°36.397	10:22	28/10/2017	15,19,22,23
63	72	49°27.715	33°43.234	05:05	29/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
Stn	**CTD**	**Lat (°N)**	**Long (°W)**	**Time**	**Date**	**Niskin bottles sampled**
64	73	50°21.441	34°12.238	12:34	29/10/2017	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17, 18,19,20,21,22,23,24

65	74	51°56.691	35°5.631	04:58	30/10/2017	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
66	75	52°56.310	35°39.557	12:33	30/10/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24
67	76	53°33.041	38°38.411	05:09	01/11/2017	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17, 18,19,20,21,22,23,24

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Dissolved Oxygen Calibration

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Cruise Objectives

Dissolved Oxygen (O_2) in seawater is produced by photosynthesis and consumed by respiration and photochemical reactions in the surface. Equilibrium between dissolved O_2 in seawater and the atmosphere is maintained through air-sea gas exchange. O_2 was measured with a sensor mounted on the CTD hydrocast on AMT27. The objective of this work was to calibrate the sensor using discrete samples from Niskin bottles which were analysed by automated Winkler titration.

Methods

Dissolved O_2 was determined by automated Winkler titration with photometric end-point detection (Carritt and Carpenter 1966) [British Oceanographic Data Centre instrument identifier: TOOL1145]. The concentration of thiosulphate was calibrated every 3 days using a commercial 0.1N KIO_3 standard (Sigma-aldrich, FIXANAL). The pipettes used for dispensing reagents were gravimetrically calibrated prior to the cruise (Table 1). A traceable thermometer was used for measuring the fixing temperature (VWR TD 121, serial number: 92405158). Seawater samples were collected daily from the CTD hydrocast (4-5 depths per station; 352 samples in total), fixed and analysed for O_2 for the calibration of the O_2 sensor on the depth profiler (see tables below).

Table 3: Results of repeating pipette calibration (18th July 2017)

Pipette	**P1-O2**	**P2-O2**	**P3-O2**
Supplier	Eppendorf	Ritter	Eppendorf
Model	4780	ripette	4780
Nominal V=1 mL	1.000	1.000	0.997
Nominal V=1 mL	1.000	1.000	1.004
Nominal V=1 mL	0.996	0.996	1.004
Nominal V=1 mL	1.004	1.004	0.998
Nominal V=1 mL	1.003	1.003	0.999
Nominal V=1 mL	0.997	0.997	0.993
mean ± sd (*n*=6)	**1.000 ± 0.003**	**1.000 ± 0.002**	**0.999 ± 0.004**

Provisional Results

The O_2 concentration data from the titrations and corresponding O_2 sensor data are shown in Figure 1. The data show that the sensor increasingly underestimated the concentration of dissolved O_2 with increasing O_2 concentration values. The two parameters were significantly correlated (R^2=0.9905, p<0.001) and the line of best fit was described by the equation.

$$[O_2 \text{ winkler}] (\mu g\ L^{-1}) = 1.0809 \times [O_2 \text{ CTD}] (\mu g\ L^{-1}) - 2.3365$$

O_2 data from the Conductivity Temperature Depth sensor should therefore not be used without prior correction.

Figure 2 shows the absolute difference between CTD sensor and Winkler titration determined measurements of dissolved O_2. Outliers are identified as having an absolute difference higher than 100. The data will be further refined following the cruise to identify and eliminate other potential outliers.

References

Carritt, D. E., and J. H. Carpenter. 1966. Comparison and evaluation of currently employed modifications of the Winkler method for determining dissolved oxygen in seawater; a NASCO Report. J. Mar. Res. 24: 286-319.

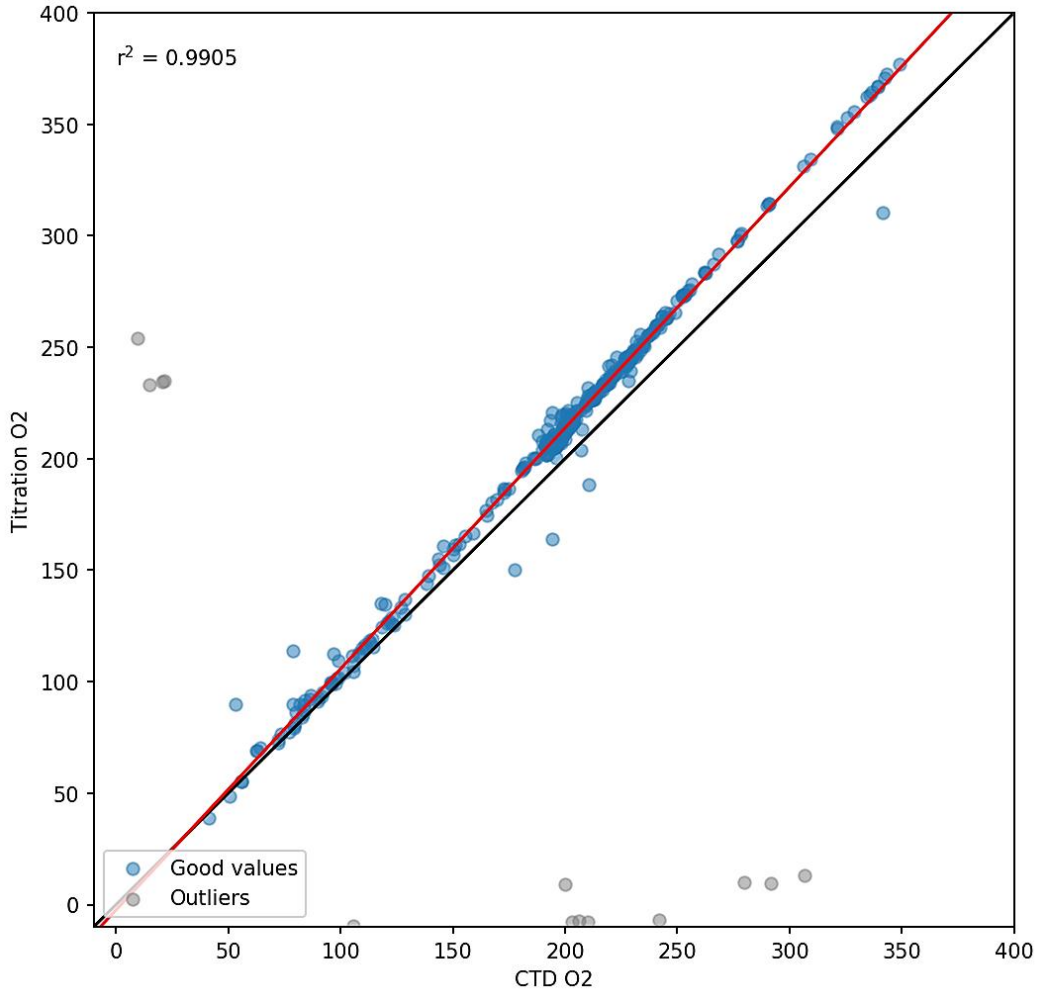

Figure 6: Calibration of O_2 sensor on the Conductivity Temperature Depth profiler during AMT 27. O_2 determined by Winkler titration against sensor data. The 1:1 line is shown in black.

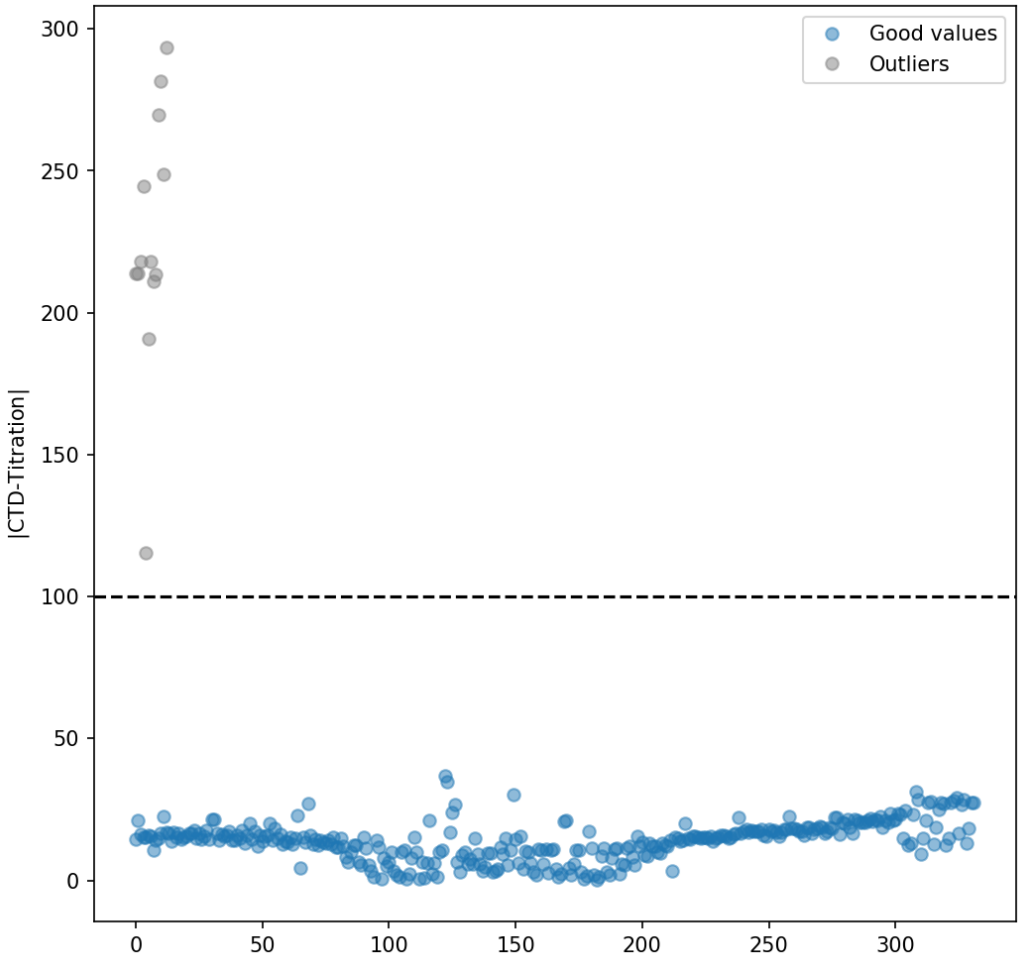

Figure 2: absolute values for the difference between CTD O_2 data and Winkler titration determined O_2.

Table 2: CTD samples collected

DATE	TIME in water (GMT)	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
24/09/17	1125	01	001	48° 55.653’	-7° 37.393’	140, 120, 80, 40, 5
25/09/17	0402	02	002	47° 16.133’	-11° 0.588’	500, 300, 100, 30, 5
25/09/17	1203	03	003	46° 41.180’	-12° 0.011’	500, 300, 75, 35, 5
26/09/17	0357	04	004	44° 51.139’	-14° 49.675’	500, 300, 125, 60, 5
26/09/17	0933	04	005	44° 51.145’	-14° 49.628’	500, 170, 50, 20, 5
27/09/17	0438	05	006	43° 3.940’	-17° 29.939’	500, 300, 125, 60, 5
27/09/17	1248	06	007	42° 9.997’	-18° 47.810’	500, 300, 150, 60, 5
28/09/17	0430	07	008	40° 13.047’	-21° 32.087’	500, 300, 150, 75, 5
28/09/17	1209	08	009	39° 21.301’	-22° 44.529’	500, 300, 150, 75, 5

30/09/17	0537	09	010	35° 19.06’	-26° 18.021’	500, 300, 150, 80, 5
30/09/17	1312	10	012	35° 5.037’	-26° 20.243’	500, 300, 150, 80, 5
01/10/17	0543	11	013	32° 53.646’	-26° 53. 389’	500, 300, 150, 120, 5
01/10/17	1307	12	014	31° 45.761’	-27° 11.183’	500, 300, 150, 90, 5
02/10/17	0530	13	015	29° 18.696’	-27° 46.952’	500, 300, 150, 70, 5
02/10/17	1306	14	016	28° 11.790’	-28° 4.185’	500, 300, 150, 60, 5
03/10/17	0533	15	017	26° 1.238’	-28° 35.310’	500, 300, 160, 100, 5
03/10/17	1322	16	019	25° 42.912’	-28° 40.042’	500, 300, 150, 80, 5
04/10/17	0533	17	020	23° 22.33’	-29° 12.38’	500, 300, 150, 85, 5
04/10/17	1306	18	021	22° 15.229’	-29° 28.982’	500, 300, 150, 50, 5
05/10/17	0534	19	022	19° 50.30’	-29° 56.06’	500, 300, 150, 60, 5
05/10/17	1301	20	023	18° 47.154’	-29° 40.940’	500, 300, 150, 50, 5
06/10/17	0533	21	024	16° 33.99’	-29° 5.13’	500, 300, 150, 40, 5
06/10/17	1303	22	025	15° 30.468’	-28° 50.990’	500, 300, 150, 50, 5
07/10/17	0532	23	026	13° 9.570’	-20° 14.328’	500, 300, 150, 35, 5
07/10/17	1307	24	028	12° 49.334’	-28° 9.983’	500, 300, 150, 40, 5
08/10/17	0539	25	029	10° 51.90’	-27° 37.29’	500, 300, 150, 30, 5
08/10/17	1303	26	030	9° 55.617’	-27° 26.634’	500, 300, 150, 40, 5
09/10/17	0528	27	031	7° 44.972’	-26° 53.910’	500, 300, 150, 35, 5
09/10/17	1302	28	032	6° 52.84’	-26° 41.161’	500, 300, 150, 30, 5
10/10/17	0530	29	033	5° 2.587’	-26° 14.779’	500, 300, 150, 25, 5
10/10/17	1308	30	035	4° 44.569’	-26° 9.638’	500, 300, 150, 30, 5
11/10/17	0528	31	036	2° 29.59’	-25° 26.71’	500, 300, 150, 25, 5
11/10/17	1305	32	037	1° 27.635’	-25° 21.428’	500, 300, 150, 30, 5
12/10/17	0540	33	038	-0° 43.53’	-24° 55.99’	500, 300, 150, 25, 5
12/10/17	1307	34	039	-1° 46.615’	-24° 59.761’	500, 300, 150, 30, 5
13/10/17	0528	35	040	-3° 32.361’	-24° 59.631’	500, 300, 150, 40, 5
13/10/17	1312	36	041	-4° 35.181’	-25° 1.457’	500, 300, 150, 50, 5

14/10/17	0529	37	042	-6° 52.210’	-25° 1.164’	500, 300, 150, 25, 5
14/10/17	1304	38	044	-7° 8.139’	-25° 1.871’	500, 300, 150, 5, 5
15/10/17	0528	39	045	-9° 25.35’	-25° 01.72’	500, 300, 150, 50, 5
15/10/17	1306	40	046	-10° 29.170’	-25° 3.482’	500, 300, 150, 40, 5
16/10/17	0530	41	047	-12° 38.014’	-25° 1.752’	500, 300, 142, 60, 5
16/10/17	1302	42	048	-13° 43.883’	-25° 4.263’	500, 300, 150, 80, 5
17/10/17	0529	43	049	-15° 57.656’	-25° 3.026’	500, 300, 160, 70, 5
19/10/17	0528	45	051	-20° 44.755’	-25° 3.854’	500, 300, 125, 55, 5
19/10/17	1300	46	052	-21° 47.980’	-25° 4.129’	500, 300, 165, 100, 5
20/10/17	0535	47	053	-23° 59.42’	-24° 59.92’	500, 300, 160, 130, 5
20/10/17	1303	48	054	-25° 6.221’	-25° 1.885’	500, 300, 133, 100, 5
21/10/17	0529	49	055	-27° 33.011’	-25° 11.608’	500, 300, 130, 110, 5
21/10/17	1304	50	057	-27° 51.474’	-25° 13.022’	500, 300, 125, 100, 5
22/10/17	0628	51	058	-30° 13.435’	-25° 45.83’	500, 300, 115, 70, 5
22/10/17	1405	52	059	-31° 18.771’	-26° 11.342’	500, 300, 130, 100, 5
23/10/17	0539	53	060	-33° 7.747’	-26° 50.496’	500, 300, 60, 35, 5
23/10/17	1235	54	061	-33° 53.096’	-27° 8.872’	500, 300, 150, 60, 5
24/10/17	0457	55	062	-35° 55.56’	-28° 0.28’	500, 300, 100, 60, 5
24/10/17	1232	56	063	-36° 59.622’	-28° 20.340’	500, 300, 150, 30, 5
25/10/17	0510	57	064	-39° 21.398’	-29° 16.119’	400, 200, 100, 40, 5
25/10/17	1031	57	065	-39° 21.40’	-29° 15.62’	400, 160, 40, 5
26/10/17	0501	58	066	-41° 10.750’	-30° 1.020’	500, 300, 150, 30, 5
26/10/17	1228	59	067	-42° 7.743’	-30° 25.023’	500, 300, 150, 45, 5
27/10/17	0500	60	068	-44° 13.144’	-31° 20.169’	500, 300, 150, 40, 5
27/10/17	1234	61	069	-45° 11.359’	-31° 43.993’	500, 300, 150, 50, 5
28/10/17	0505	62	070	-47° 7.444’	-32° 36.397’	500, 300, 125, 60, 5
28/10/17	1022	62	071	-47° 6.083’	-32° 34.379’	300, 100, 6, 5
29/10/17	0500	63	072	-49° 27.715’	-33° 43.234’	500, 300, 150, 40, 5

29/10/17	1234	64	073	-50° 21.44’	-34° 12.238’	500, 300, 150, 50, 5
30/10/17	0458	65	074	-51° 56.69’	-35° 5.03’	500, 300, 150, 60, 5
30/10/17	1233	66	075	-52° 56.310’	-35° 39.557’	500, 300, 150, 50, 5
01/11/17	0509	67	076	-53° 33.04’	-38° 38.41’	500, 300, 100, 60, 5
01/11/17	1005	67	077	-53° 33.294’	-38° 38.650’	300, 120, 40, 5
02/11/17	0504	68	078	-53° 11.088’	42° 24.390’	500, 300, 150, 40, 5

Sample collection for Total Alkalinity (TA) and Dissolved Inorganic Carbon (DIC)

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Cruise Objectives

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 (Dickson et al. 2007). Total alkalinity (TA) of seawater describes the sum of the concentrations of anions and defines the capacity of seawater to neutralise acid. Dissolved Inorganic Carbon is defined as the sum of all carbonate system species in seawater DIC= H_2CO_3+HCO_3^-, CO_3^{2-}. The objective of this work was to collect samples for the determination of TA and DIC in seawater.

Methods

The tables below list cast numbers and depths for all samples collected. Samples were collected in 125 mL borosilicate glass bottles with glass stoppers and preserved with HgCl2 until analysis at PML (25 µL of saturated HgCl2 added). The glass stoppers were greased with Apiezon-M grease. These samples will be analysed after the cruise.

Provisional Results

Samples will be analysed at the Plymouth Marine Laboratory after the cruise

References

Dickson, A. G., C. L. Sabine, and J. R. Christion. 2007. Guide to best practices for ocean CO2 measurements. PICES Special Publication 3, p. 191. PICES Special Publication 3.

Table 1: CTD samples collected

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
24/09/17	1125	01	001	48° 55.653'	-7° 37.393'	40, 5
25/09/17	0402	02	002	47° 16.133'	-11° 0.588'	500, 300, 100, 30, 5
26/09/17	0357	04	004	44° 51.139'	-14° 49.675'	500, 300, 125, 60, 5
27/09/17	0438	05	006	43° 3.940'	-17° 29.939'	500, 300, 125, 60, 5
28/09/17	0430	07	008	40° 13.047'	-21° 32.087'	500, 300, 150, 75, 5
30/09/17	0537	09	010	35° 19.06'	-26° 18.021'	500, 300, 150, 80, 5
01/10/17	0543	11	013	32° 53.646'	-26° 53. 389'	500, 300, 150, 120, 5

02/10/17	0530	13	015	29 18.696’	-27° 46.952’	500, 300, 120, 5
03/10/17	0533	15	017	26° 1.238’	-28° 35.310’	500, 300, 130, 5
04/10/17	0533	17	020	23° 22.33’	-29° 12.38’	500, 300, 150, 110, 5
05/10/17	0534	19	022	19° 50.30’	-29° 56.06’	500, 300, 150, 85, 5
06/10/17	0533	21	024	16° 33.99’	-29° 5.13’	500, 300, 150, 65, 5
07/10/17	0532	23	026	13° 9.570’	-20° 14.328’	500, 300, 150, 55, 5
08/10/17	0539	25	029	10° 51.90’	-27° 37.29’	500, 300, 150, 50, 5
09/10/17	0528	27	031	7° 44.972’	-26° 53.910’	500, 300, 150, 60, 5
10/10/17	0530	29	033	5° 2.587’	-26° 14.779’	500, 300, 150, 68, 5
11/10/17	0528	31	036	2° 29.59’	-25° 26.71’	500, 300, 150, 80, 5
12/10/17	0540	33	038	-0° 43.53’	-24° 55.99’	500, 300, 150, 60, 5
13/10/17	0528	35	040	-3° 32.361’	-24° 59.631’	500, 300, 150, 65, 5
14/10/17	0529	37	042	-6° 52.210’	-25° 1.164’	500, 300, 150, 95, 5
15/10/17	0528	39	045	-9° 25.35’	-25° 01.72’	500, 300, 113, 50, 5
16/10/17	0530	41	047	-12° 38.014’	-25° 1.752’	500, 300, 142, 60, 5
17/10/17	0529	43	049	-15° 57.656’	-25° 3.026’	500, 300, 160, 70, 5
19/10/17	0528	45	051	-20° 44.755’	-25° 3.854’	500, 300, 125, 55, 5
20/10/17	0535	47	053	-23° 59.42’	-24° 59.92’	500, 300, 160, 130, 5
21/10/17	0529	49	055	-27° 33.011’	-25° 11.608’	500, 300, 130, 110, 5
22/10/17	0628	51	058	-30° 13.435’	-25° 45.83’	500, 115, 5
23/10/17	0539	53	060	-33° 7.747’	-26° 50.496’	500, 60, 5
24/10/17	0457	55	062	-35° 55.56’	-28° 0.28’	500, 100, 5
25/10/17	0510	57	064	-39° 21.398’	-29° 16.119’	500, 40, 5
26/10/17	0501	58	066	-41° 10.750’	-30° 1.020’	500, 30, 5
27/10/17	0500	60	068	-44° 13.144’	-31° 20.169’	500, 40, 5
28/10/17	0505	62	070	-47° 7.444’	-32° 36.397	500, 60, 5

29/10/17	0500	63	072	-49° 27.715'	-33° 43.234'	500, 40, 5
30/10/17	0458	65	074	-51° 56.69'	-35° 5.03'	500, 60, 5
01/11/17	0509	67	076	-53° 33.04'	-38° 38.41'	500, 60, 5
02/11/17	0504	68	078	-53° 11.088'	42° 24.390'	500, 40, 5

Carbonate System: Total Alkalinity (A_T) and pH

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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-pCO_2* 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 pH samples collected and analysed. 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). A minimum of two samples per cast were taken at the surface and DCM. 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 24 (JR303) (stations 1-70). Final quality controlled A_T and pH_T data will be submitted to BODC within 12 months.

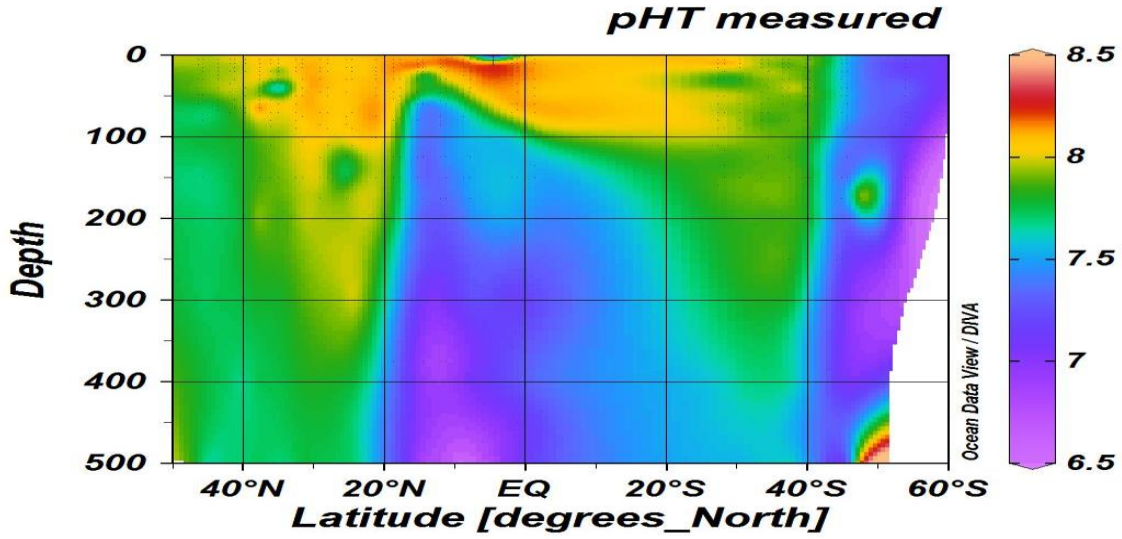

Figure 1: Preliminary pH_T data along-track for AMT 26 (JR16001). Dots show samples location.

Table 4: Samples collected from CTD hydrocast.

CTD	DATE	LAT	LONG	NISKINS	DEPTH
002	25/09/16	46.38°N	12.69°W	1,3,4,5,10,12,16,18,21,23	500,400,300,200,100,60,48,29,12,5
004	25/09/16	46.67°N	13.98°W	1,3,6,8,11,13,16,18,19,20,24	500,300,200,150,80,72,49,30,20,15,5
007	26/09/16	43.52°N	16.96°W	1,4,12,14,15,16,17,18,19,20,24	500,300,68,55,40,30,25,20,15,10,5
008	27/09/16	41.78°N	19.39°W	1,2,3,4,8,10,12,13,14,17,22,23	500,400,300,200,100,70,60,45,35,20,10,5
010	27/09/16	41.19°N	20.23°W	1,4,5,7,10,12,14,16,18,19,20,24	500,400,300,200,100,64,55,30,20,15,10,5
011	28/09/16	39.71°N	22.26°W	1,2,6,8,10,11,12,15,20,21	400,200,100,70,65,50,40,20,10,5
013	29/09/16	37.66°N	24.91°W	1,2,3,4,6,8,10,12,13,14,15,17,20,22,23	500,400,300,200,150,100,65,55,50,30,25,20,15,10,5
014	29/09/16	37.69°N	24.93°W	1,3,4,6,8,9,11,13,14,15,17,18,19,24	500,400,300,200,150,100,60,50,40,30,20,15,10,5
015	30/09/16	36.13°N	26.07°W	1,2,3,4,6,8,10,12,13,14,16,19,21,23	500,400,300,200,150,110,87,80,70,55,30,20,10,5
016	30/09/16	35.02°N	26.35°W	1,4,5,7,9,10,12,14,15,16,17,18,19,20,24	500,400,300,200,150,100,70,60,40,30,25,15,10,5
017	01/10/16	32.51°N	26.99°W	1,2,3,4,6,9,10,11,12,13,14,20,22,23	500,400,300,200,150,100,90,80,70,60,50,20,15,5
018	01/10/16	31.53°N	27.22°W	1,3,4,6,8,9,12,13,14,15,18,19,23	500,400,300,200,150,105,75,50,40,30,15,10,5
019	02/10/16	29.16°N	27.83°W	1,2,4,5,7,8,10,11,12,14,16,18,20,23	500,400,200,175,150,126,100,85,70,45,30,20,15,5
020	02/10/16	27.97°N	28.10°W	1,5,7,9,12,13,14,15,16,18,20,24	500,300,200,150,110,90,70,50,40,20,10,5
021	03/10/16	25.39°N	28.74°W	1,2,3,4,5,6,8,10,11,12,14,16,20,23	500,400,300,200,175,150,124,100,85,75,45,30,15,5
022	03/10/16	24.59°N	28.92°W	1,3,4,6,8,11,12,13,15,17,18,24	500,400,300,200,160,111,90,70,30,20,15,5

CTD	DATE	LAT	LONG	NISKINS	DEPTH
024	04/10/16	29.73°N	21.17°W	1,5,7,9,12,13,14,15,16,17,18,19,24	500,300,200,150,101,75,50,40,30,25,20,15,5
025	05/10/16	18.70°N	29.66°W	1,3,4,5,7,9,10,11,14,15,17,19,20,21,24	500,375,200,150,125,100,80,53,45,30,20,15,10,5
026	05/10/16	17.79°N	29.41°W	1,5,6,7,8,9,10,12,14,15,16,17,19,24	500,300,200,175,150,125,100,78,60,50,40,30,10,5
027	06/10/16	15.27°N	28.78°W	1,3,4,6,7,8,9,10,13,14,16,18,19,20,24	500,300,200,150,125,100,80,60,54,45,30,20,15,10,5
028	06/10/16	14.50°N	28.57°W	1,4,5,7,8,10,13,15,17,18,19,20,24	500,375,300,200,175,125,60,30,25,20,15,10,5
029	07/10/16	11.96°N	27.96°W	1,4,5,6,7,9,10,11,12,13,16,19,20,21,24	500,375,300,200,175,125,100,85,75,55,47,30,15,10,5
030	07/10/16	11.21°N	27.74°W	1,4,5,7,8,9,10,11,13,15,17,18,19,20,24	500,375,300,200,175,150,125,100,60,45,40,30,20,10,5
031	08/10/16	8.70°N	27.14°W	1,3,4,6,8,10,13,16,18,19,20,24	500,300,200,150,100,75,52,25,20,15,10,5
032	08/10/16	7.76°N	26.88°W	1,4,5,7,8,9,10,11,14,16,17,18,19,20,24	500,400,300,200,175,150,125,100,56,45,40,30,20,10,5
034	09/10/16	4.49°N	26.08 °W	1,4,5,7,9,11,13,15,17,18,19,20,24	500,400,300,200,150,100,72,60,35,20,15,10,5
035	10/10/16	1.97°N	25.48 °W	3,5,7,9,10,13,15,18,20,24	300,200,150,100,85,70,60,25,10,5
036	10/10/16	1.16°N	25.26 °W	1,3,4,5,7,9,11,13,15,16,18,19,20,24	500,450,300,200,150,100,67,60,45,35,20,15,10,5
037	11/10/16	1.42°S	25.005°W	1,4,5,6,8,9,10,13,14,15,16,17,18,21,24	500,400,300,200,150,135 100,92,70,60,50,40,30,10
039	12/10/16	4.83°S	25.02°W	1,2,3,4,5,6,7,11,12,13,14,16,18,19,24	500,400,300,200,175,150,125,83,75,60,50,25,15,10,5
040	12/10/16	5.81°S	25.03°W	1,4,5,7,8,9,10,12,14,15,16,17,18,20,24	500,400,300,200,175,150,125,93,80,60,45,35,20,10,5
041	13/10/16	5.38°S	25.04°W	1,3,4,5,6,7,8,9,12,13,14,15,17,20,24	500,400,300,200,175,150,125,105,83,75,65,50,30,10,5
042	13/10/16	9.06°S	25.04°W	2,3,4,5,7,9,10,13,15,16,17,18,19,20,24	500,450,400,300,200,150,120,105,70,50,30,20,15.10,5
043	14/10/16	11.82°S	25.06°W	1,3,5,6,7,10,12,14,15,16,17,18,19,21,24	500,400,300,200,175,148,120,90,65,50,40,30,20,10,5
044	14/10/16	11.83°S	25.05°W	17,18,20,24	30,20,10,5
045	15/10/16	14.45°S	25.07°W	1,3,4,5,6,7,10,12,13,14,15,17,19,20,24	500,400,300,200,180,160,130,105,90,80,70,50,20,15,5
046	15/10/16	15.38°S	25.08°W	1,4,5,7,8,10,12,13,15,16,17,18,20,24	500,400,300,200,185,155,145,120,80,60,40,20,10,5
047	16/10/16	18.26°S	25.12°W	1,4,5,6,7,8,11,15,16,17,20,21,24	500,400,300,250,200,180,162,95,70,20,15,10,5
048	17/10/16	20.67°S	25.01°W	2,4,5,6,7,10,11,13,14,15,16,17,20,21,24	500,300,250,200,180,152,145,120,110,95,70,55,15,10,5

CTD	DATE	LAT	LONG	NISKINS	DEPTH
049	17/10/16	21.34°S	25.01°W	1,2,3,5,7,9,11,12,14,15,16,17,18,19,24	500,400,300,200,175,149,135,120,80,60,40,20,15,10,5
050	18/10/16	23.73°S	25.02°W	1,2,3,5,10,11,13,14,15,16,17,20,21,24	500,400,300,200,135,125,105,90,80,60,55,15,10,5
051	18/10/16	24.47°S	25.02°W	1,3,4,6,7,9,11,13,14,16,17,18,19,20,24	500,400,300,250,200,150,125,120,110,80,60,40,20,10,5
052	19/10/16	27.27°S	24.45°W	1,2,3,5,7,11,13,14,15,16,17,18,20,21,24	500,400,300,200,160,110,90,80,70,60,50,30,15,10,5
053	19/10/16	28.15°S	24.30°W	1,2,3,5,8,9,11,14,15,16,17,18,19,24	500,400,300,200,150,135,117,90,70,50,30,20,10,5
054	20/10/16	30.38°S	25.31°W	1,2,3,5,7,10,13,14,15,16,17,18,20,21,24	500,400,300,200,150,117,90,80,70,60,45,30,15,10,5
056	21/10/16	33.58°S	26.78 °W	1,2,3,5,7,9,13,14,15,16,17,18,20,21,24	500,400,300,200,150,100,90,80,70,60,45,30,15,10,5
057	21/10/16	34.43°S	27.19°W	1,2,4,5,7,9,10,12,14,16,17,18,19,21	500,400,300,200,175,125,100,70,53,40,30,20,10,5
058	22/10/16	36.53°S	28.15°W	1,2,3,5,9,15,16,17,18,20,21,24	500,400,300,200,100,60,50,40,30,15,10,5
059	22/10/16	37.33°S	28.43°W	1,3,4,6,7,8,9,10,11,13,16,17,19,20,24	500,400,300,2050,200,150,125,100,80,50,40,30,15,10,5
060	23/10/16	39.70°S	28.67°W	1,2,3,4,5,7,9,11,13,16,17,18,20,21,24	500,400,300,250,200,150,100,80,60,50,40,30,15,10,5
061	23/10/16	40.40°S	28.75°W	1,2,4,7,9,10,12,14,16,17,18,24	500,400,200,150,100,90,60,50,40,30,20,5
062	25/10/16	44.91°S	31.08°W	1,2,3,4,5,6,7,9,13,16,17,18,19,21,24	500,400,30,250,175,150,100,70,50,40,30,20,10,5
063	25/10/16	45.67°S	31.49°W	1,3,4,6,7,8,9,10,13,14,15,16,18,20,24	500,400,300,200,150,125,100,90,75,60,50,40,20,10,5
064	26/10/16	47.45°S	32.49°W	1,2,3,4,5,6,7,10,11,13,15,16,18,20,24	500,400,30,250,200,175,150,85,70,60,50,40,20,10,5
065	26/10/16	48.83°S	32.87°W	1,2,3,5,7,8,9,10,11,12,15,16,18,20,24	500,400,300,200,150,125,100,85,70,60,50,40,20,10,5
066	27/10/16	49.78°S	33.78°W	1,3,4,5,6,7,11,14,15,16,17,19,21,24	500,400,300,250,200,175,110,75,60,50,40,20,10,5
067	27/10/16	50.29°S	34.09°W	1,2,3,5,6,7,8,9,10,11,14,16,18,20,24	500,400,300,200,175,150,125,100,85,75,60,40,20,10,5
069	28/10/16	52.45°S	35.38°W	1,2,3,5,6,11,12,13,14,16,18,20,24	500,400,300,200,175,105,90,75,60,40,20,10,5
070	29/10/16	55.94°S	36.30°W	1,4,6,7,8,9,10,12,15,16,17,19,20,24	200,175,150,125,100,85,75,70,50,40,30,15,10,5
071	30/10/16	54.00°S	36.84°W	1,2,4,5,6,7,8,9,11,14,15,16,18,20,24	220,200,175,150,125,100,85,75,65,60,50,40,20,10,
072	31/10/16	53.59°S	39.98°W	1,3,4,6,8,10,11,12,14,16,7,18,21,24	500,400,300,200,150,100,80,60,45,40,35,25,10,5
073	31/10/16	53.39°S	41.54°W	1,2,3,5,6,7,8,9,12,14,15,16,18,20,24	500,400,300,200,175,150,125,100,75,60,50,40,20,10,5

CTD	DATE	LAT	LONG	NISKINS	DEPTH
074	01/11/16	53.01°S	45.09°W	2,3,4,6,7,8,10,12,14, 16,17,19,21,24	500,400,300,200,175,150 ,100,60,50,40,35,20,10,5

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.

NITROUS OXIDE & METHANE

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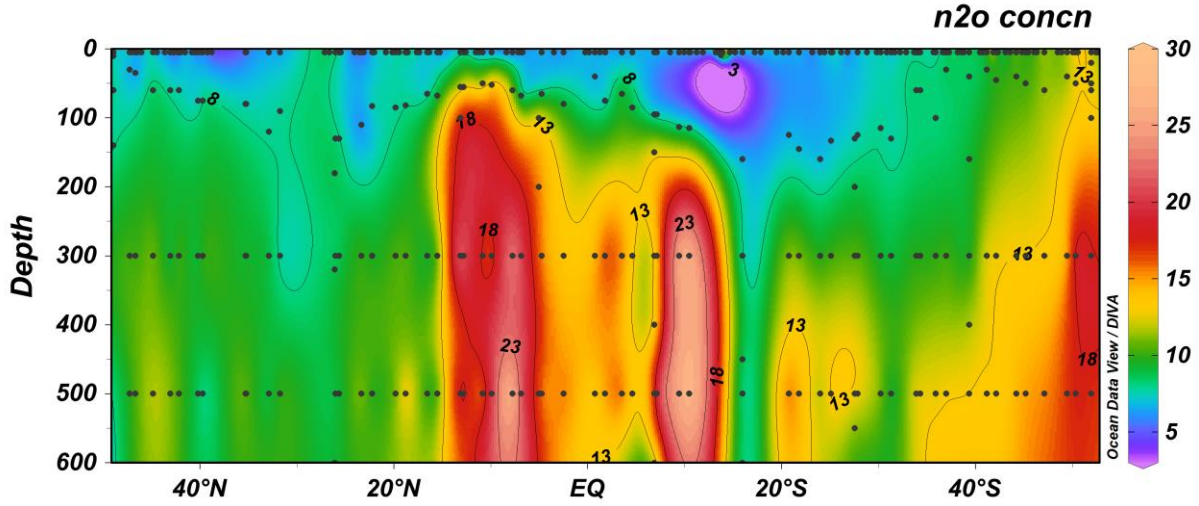
Cruise Objectives

Nitrous oxide and methane are biogenically produced trace gases and the ocean plays an important role in the global budgets of these gases each of which has production and consumption processes active in the marine environment. The latest analysis of observations from the WMO Global Atmosphere Watch (GAW) Programme shows that globally averaged surface mole fractions calculated from this in-situ network for N_2O and CH_4 have reached new highs in 2015, with N_2O at 328.0±0.1 ppb and methane at 1845±2ppb. The values constitute, respectively 121% and 256% of per-industrial (before 1750) levels (WMO, 2016)and both gases are radiatively active, contributing approximately 6% and 15% of "greenhouse effect" respectively, whilst N_2O contributes to stratospheric ozone depletion and CH_4 limits tropospheric oxidation capacity.
The oceans are generally considered to be close to equilibrium relative to the atmosphere for both gases, however oceanic source/sink distributions are largely influenced by oxygen and nutrient status and regulatory processes are complicated and are currently not well understood. Ocean areas overlying sub-oxic waters and upwelling areas dominate the ocean source and saturations of up to 300% have been reported.
Here we aim to analyse the concentrations of the two gases in the ocean in order to provide analysis of spatial variability throughout the Atlantic Ocean and to add to the database of measurements made throughout the AMT programme.

Methods

Samples were collected from CTD bottles at stations 78 stations and from the underway system at 109 stations identified below. 500ml samples were equilibrated and headspace analysis performed on board using FID-gas chromatography and ECD-gas chromatography for CH_4 and N_2O respectively.

Provisional Results



References

World Meteorological Organisation. WMO GREEN HOUSE GAS BULLETIN, No. 12, 24 October, 2016.

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

N_2O, CH_4 Sampling Date and position – AMT27

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
24/09/2017	12:00	1	001	48.928	-7.623	5, 10, 60, 40
25/09/2017	4:02	2	002	47.269	-11.010	5, 30, 300, 500
25/09/2017	12:03	3	003	46.686	-12.000	5, 35, 300, 500
26/09/2017	3:57	4	004	44.852	-14.828	5, 60, 300, 500
26/09/2017	9:33	4	005	51.002	-14.827	5, 50, 70, 170, 500, 1000
27/09/2017	4:38	5	006	43.066	-17.499	5, 60, 300, 500
27/09/2017	12:48	6	007	42.167	-19.297	5, 60, 300, 500
28/09/2017	4:30	7	008	40.217	-21.535	5, 75, 300, 500
28/09/2017	12:09	8	009	39.742	-22.430	5, 75, 300, 500
30/09/2017	5:37	9	010	35.318	-26.300	5, 80, 300, 500
30/09/2017	10:37	9	011	35.318	-26.300	100, 220, 550, 800
30/09/2017	13:12	10	012	35.251	-26.337	5, 80, 300, 500
01/10/2017	5:43	11	013	32.895	-26.889	5, 120, 300, 500
01/10/2017	13:07	12	014	31.763	-27.020	5, 90, 300, 500
02/10/2017	5:30	13	015	29.312	-27.783	5, 120, 300, 500
02/10/2017	13:06	14	016	28.197	-28.070	5, 110, 300, 500
03/10/2017	5:33	15	017	26.022	-28.589	5, 130, 300, 500
03/10/2017	10:08	15	018	26.100	-28.584	180, 320, 600, 850
03/10/2017	13:22	16	019	25.667	-28.667	5, 130, 300, 500
04/10/2017	5:33	17	020	23.367	-29.201	5, 110, 300, 500
04/10/2017	13:06	18	021	22.254	-29.483	5, 83, 300, 500
05/10/2017	5:34	19	022	19.834	-29.933	5, 85, 300, 500
05/10/2017	13:01	20	023	18.786	-29.682	5, 82, 300, 500
06/10/2017	5:33	21	024	16.552	-29.084	5, 65, 300, 500

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
06/10/2017	13:03	22	025	15.508	-29.850	5, 68, 300, 500
07/10/2017	5:32	23	026	13.160	-28.239	5, 55, 300, 500
07/10/2017	10:00	23	027	13.160	-28.239	100, 300, 500, 800
07/10/2017	13:07	24	028	12.822	-28.166	5, 55, 300, 500
08/10/2017	5:39	25	029	10.852	-27.617	5, 50, 300, 500
08/10/2017	13:03	26	030	9.927	-27.444	5, 52, 300, 500
09/10/2017	5:28	27	031	7.750	-26.899	5, 60, 300, 500
09/10/2017	13:02	28	032	6.881	-26.686	5, 60, 300, 500
10/10/2017	5:30	29	033	6.868	-26.686	5, 68, 300, 500
10/10/2017	9:59	29	034	5.044	-26.244	100, 200, 500, 800
10/10/2017	13:08	30	035	4.743	-26.161	5, 65, 300, 500
11/10/2017	5:28	31	036	2.493	-25.435	5, 80, 300, 500
12/10/2017	5:40	33	038	-0.72555	-24.918	5, 40, 300, 500
12/10/2017	13:07	34	039	-1.77692	-24.996	5, 75, 300, 500
13/10/2017	5:28	35	040	-3.53935	-24.994	5, 65, 300, 500
12/10/2017	13:12	36	041	-4.58635	-25.024	5, 85, 300, 500
14/10/2017	5:29	37	042	-6.87017	-25.019	5, 95, 300, 500
14/10/2017	10:10	37	043	-6.87023	-25.019	150, 400, 600, 800
14/10/2017	13:04	38	044	-7.13688	-25.018	5, 95, 300, 500
15/10/2017	5:28	39	045	-9.41725	-25.018	5, 113, 300, 500
15/10/2017	13:06	40	046	-10.4862	-25.058	5, 115, 300, 500
16/10/2017	5:30	41	047	-12.0169	-25.063	5, 142, 300, 500
16/10/2017	13:02	42	048	-13.7314	-25.071	5, 120, 300, 500
17/10/2017	5:29	43	049	-15.9609	-25.050	5, 160, 300, 500
17/10/2017	10:15	43	050	-15.961	-25.050	300, 450, 600, 800
19/10/2017	5:28	45	051	-20.7459	-25.064	5, 125, 300, 500
19/10/2017	13:00	46	052	-21.7997	-25.069	5, 145, 300, 500

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
20/10/2017	5:35	47	053	-23.9904	-25.985	5, 160, 300, 500
20/10/2017	13:03	48	054	-25.1037	-25.031	5, 133, 300, 500
21/10/2017	5:27	49	055	-27.5502	-25.193	5, 130, 300, 500
21/10/2017	10:12	49	056	-27.5502	-25.193	200, 550, 750, 1000
21/10/2017	13:04	50	057	-27.8579	-25.217	5, 125, 300, 500
22/10/2017	6:28	51	058	-30.2239	-25.751	5, 115, 300, 500
22/10/2017	14:05	52	059	-31.3129	-26.189	5, 130, 300, 500
23/10/2017	5:39	53	060	-34.2912	-26.842	5, 60, 300, 500
23/10/2017	12:35	54	061	-33.8849	-27.148	5, 60, 300, 500
24/10/2017	4:57	55	062	-35.9176	-28.000	5, 100, 300, 500
24/10/2017	12:32	56	063	-36.9937	-28.339	5, 30, 300, 500
25/10/2017	5:10	57	064	-39.3566	-29.269	5, 40, 300, 500
25/10/2017	10:31	57	065	-39.3507	-29.251	160, 400, 750, 1000
26/10/2017	5:01	58	066	-41.1792	-30.017	5, 30, 300, 500
26/10/2017	12:28	59	067	-42.1291	-30.417	5, 45, 300, 500
27/10/2017	5:00	60	068	-44.2191	-31.336	5, 40, 300, 500
27/10/2017	12:34	61	069	-45.1893	-31.733	5, 50, 300, 500
28/10/2017	5:05	62	070	-47.1241	-32.607	5, 60, 300, 500
28/10/2017	10:22	62	071	-7.10138	-32.573	100, 300, 500, 1000
29/10/2017	5:05	63	072	-49.4619	-33.721	5, 40, 300, 500
29/10/2017	12:34	64	073	-50.3574	-34.204	5, 50, 300, 500
30/10/2017	4:58	65	074	-51.9345	-35.083	5, 20, 300, 500
30/10/2017	12:33	66	075	-52.9386	-35.159	5, 50, 300, 500
01/11/2017	3:09	67	076	-53.5501	-38.634	5, 60, 300, 500
01/11/2017	10:05	67	077	-53.5541	-38.644	40, 120, 500, 1000
02/11/2017	5:04	68	078	-53.1848	-42.416	5, 40, 300, 500

Underway discrete samples collected from ships continuous seawater supply

DATE	TIME	STATION		DATE	TIME	STATION
25/09/2017	7:29	U01		18/10/2017	20:45	U56
25/09/2017	15:07	U02		19/10/2017	0:40	U57
25/09/2017	18:03	U03		19/10/2017	22:32	U58
26/09/2017	17:23	U04		20/10/2017	9:05	U59
26/09/2017	20:56	U05		20/10/2017	15:21	U60
26/09/2017	23:10	U06		20/10/2017	21:06	U61
27/09/2017	7:57	U07		20/10/2017	23:51	U62
27/09/2017	10:37	U08		21/10/2017	19:28	U63
27/09/2017	15:02	U09		21/10/2017	22:14	U64
27/09/2017	18:06	U10		21/10/2017	11:03	U65
27/09/2017	23:07	U11		22/10/2017	17:13	U66
28/09/2017	1:08	U12		22/10/2017	20:42	U67
28/09/2017	8:08	U13		23/10/2017	0:30	U68
28/09/2017	10:10	U14		23/10/2017	10:56	U69
28/09/2017	14:56	U15		23/10/2017	15:15	U70
28/09/2017	18:00	U16		23/10/2017	20:08	U71
03/10/2017	20:41	U17		24/10/2017	0:17	U72
03/10/2017	23:27	U18		24/10/2017	10:14	U73
03/10/2017	16:06	U19		24/10/2017	15:26	U74
04/10/2017	0:22	U20		24/10/2017	18:32	U75
04/10/2017	8:04	U21		24/10/2017	21:09	U76
04/10/2017	11:05	U22		24/10/2017	23:32	U77
04/10/2017	15:43	U23		25/10/2017	21:54	U78
04/10/2017	22:31	U24		25/10/2017	23:58	U79
05/10/2017	2:24	U25		26/10/2017	10:25	U80
05/10/2017	8:55	U26		26/10/2017	14:51	U81
05/10/2017	15:47	U27		26/10/2017	20:07	U82
05/10/2017	21:05	U28		26/10/2017	23:20	U83
05/10/2017	22:53	U29		27/10/2017	9:42	U84
06/10/2017	7:58	U30		27/10/2017	15:28	U85
06/10/2017	15:51	U31		27/10/2017	20:08	U86
07/10/2017	15:42	U32		27/10/2017	22:58	U87
07/10/2017	22:04	U33		28/10/2017	5:27	U88
08/10/2017	0:07	U34		28/10/2017	23:52	U89
09/10/2017	0:03	U35		29/10/2017	10:05	U90

09/10/2017	10:30	U36		29/10/2017	15:27	U91
09/10/2017	15:30	U37		30/10/2017	20:57	U92
10/10/2017	22:54	U38		31/10/2017	0:49	U93
11/10/2017	21:40	U39		31/10/2017	15:10	U94
12/10/2017	0:11	U40		31/10/2017	17:37	U95
12/10/2017	9:46	U41		31/10/2017	20:08	U96
12/10/2017	15:24	U42		31/10/2017	23:44	U97
13/10/2017	22:51	U43		01/11/2017	20:34	U98
14/10/2017	19:46	U44		02/11/2017	10:18	U99
14/10/2017	22:50	U45		02/11/2017	13:12	U100
15/10/2017	9:34	U46		02/11/2017	15:26	U101
15/10/2017	14:56	U47		02/11/2017	17:32	U102
15/10/2017	18:42	U48		02/11/2017	19:17	U103
15/10/2017	22:22	U49		02/11/2017	22:06	U104
16/10/2017	9:54	U50		03/11/2017	10:14	U105
16/10/2017	15:27	U51		03/11/2017	13:00	U106
17/10/2017	19:50	U52		03/11/2017	15:08	U107
17/10/2017	23:03	U53		03/11/2017	17:00	U108
17/10/2017	21:54	U54		03/11/2017	17:58	U109
18/10/2017	1:36	U55				

Measurements of optical properties

Gavin Tilstone and Francesco Nencioli
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Goal

- To determine surface and depth-resolved optical properties along the transect in support of satellite calibration/validation activities.

Methods

- Particulate optical backscattering coefficient (470, 532, 700 nm), beam-attenuation and absorption coefficients (400–750 nm) were determined quasi-continuously from the ship's underway water following methods detailed in Dall'Olmo et al. (2009). Water samples were collected every 2 days from the underway system and the CTD surface bottle for intercomparison of their optical properties. The purity of the ship Milliq System was also determined every 2 days by intercomparison of its optical properties with those of pure water standard.
- In-situ optical backscattering measurements were also collected by means of a profiling package mounting a SBE CTD and a WETLAbs AC9 to determine the particulate absorption and attenuation coefficients over the upper 250 m. The profiling package was deployed once a day simultaneously with the noon time CTD cast. On station optical deployments are given in Table 1 with two deployments per station. In Table 1, IOP is Inherent Optical Property; Bulk is for total particulate material + coloured dissolved organic matter (CDOM); Filtered is CDOM only.
- A WETLabs ECO-BB3 sensor (3 channels) was installed on the rosette frame until 17 October 2017 to collect profiles of optical backscattering from CTD casts in the upper 500 m. From 19 Ocotber 2017, the ECO-BB3 sensor was integrated into the optics profiling package.
- Above-water radiometric measurements were taken quasi-continuously using a Satlantic HyperSAS system. The HyperSAS optical remote-sensing system provided hyperspectral measurements of spectral water-leaving radiance and downwelling spectral irradiance, from which the above-water remote-sensing reflectance can be computed. The 136-channel HyperOCR radiance and irradiance sensors were mounted onboard the ship to simultaneously view the sea surface and sky.

References

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

Table 5. List of in-water optical deployments.

STATION#	DATE	TIME (GMT)	LAT (Degrees)	LONG (Degrees)	IOP*
Optics Rig 1	24/09/2017	11:04	48.94	-7.61	Bulk
Optics Rig 2	24/09/2017	11:30	48.94	-7.61	Filtered
Optics Rig 3	25/09/2017	11:11	46.69	-12.00	Bulk
Optics Rig 4	25/09/2017	11:38	46.69	-12.00	Filtered
Optics rig 5 cancelled	26/09/2017	11:12	44.85	-14.83	Bulk
Optics Rig 6	27/09/2017	12:02	42.17	-18.80	Bulk

STATION#	DATE	TIME (GMT)	LAT (Degrees)	LONG (Degrees)	IOP*
Optics Rig 7	27/09/2017	12:28	42.17	-18.80	Filtered
Optics Rig 8	28/09/2017	12:03	39.36	-22.74	Bulk
Optics Rig 9	28/09/2017	12:26	39.36	-22.74	Filtered
Optics Rig 10	30/09/2017	13:02	35.08	-26.34	Bulk
Optics Rig 11	30/09/2017	13:31	35.08	-26.34	Filtered
Optics Rig 12	01/10/2017	13:09	31.76	-27.19	Bulk
optics Rig 13	01/10/2017	13:34	31.76	-27.19	Filtered
Optics Rig 14	02/10/2017	13:32	28.20	-28.07	Bulk
Optics Rig 15	03/10/2017	13:18	25.72	-28.67	Bulk
Optics Rig 16	03/10/2017	13:47	25.72	-28.67	Filtered
Optics Rig 17	04/10/2017	13:06	22.25	-29.48	Bulk
Optics Rig 18	04/10/2017	13:33	22.25	-29.48	Filtered
Optics Rig 19	05/10/2017	13:00	18.79	-29.68	Bulk
Optics Rig 20	05/10/2017	13:26	18.79	-29.68	Filtered
Optics Rig 21	06/10/2017	13:02	15.67	-28.85	Bulk
Optics Rig 22	06/10/2017	13:28	15.67	-28.85	Filtered
Optics Rig 23	07/10/2017	13:06	12.82	-28.17	Bulk
Optics Rig 24	07/10/2017	13:31	12.82	-28.17	Filtered
Optics Rig 25	08/10/2017	13:01	9.93	-27.44	Bulk
Optics Rig 26	08/10/2017	13:31	9.93	-27.44	Filtered
Optics Rig 27	09/10/2017	13:03	6.88	-26.69	Bulk
Optics Rig 28	09/10/2017	13:52	6.88	-26.68	Filtered
Optics Rig 29	10/10/2017	13:07	4.74	-26.16	Bulk
Optics Rig 30	10/10/2017	13:36	4.74	-26.16	Filtered
Optics Rig 31	11/10/2017	13:05	1.46	-25.36	Bulk
Optics Rig 32	11/10/2017	13:33	1.46	-25.36	Filtered
Optics Rig 33	12/10/2017	13:03	-1.78	-25.00	Bulk
Optics Rig 34	12/10/2017	13:37	-1.78	-25.00	Filtered
Optics Rig 35	13/10/2017	13:06	-4.59	-25.02	Bulk
Optics Rig 36	13/10/2017	13:31	-4.59	-25.02	Filtered
Optics Rig 37	14/10/2017	13:03	-7.14	-25.03	Bulk
Optics Rig 38	14/10/2017	13:29	-7.14	-25.03	Filtered
Optics Rig 39	15/10/2017	13:03	-10.49	-25.06	Bulk
Optics Rig 40	15/10/2017	13:32	-10.49	-25.06	Filtered
Optics Rig 41	16/10/2017	13:00	-13.73	-25.07	Bulk
Optics Rig 42	16/10/2017	13:26	-13.73	-25.07	Filtered
Optics Rig 43	17/10/2017	13:05	-15.96	-25.05	Bulk
Optics Rig 44	17/10/2017	13:33	-15.96	-25.05	Filtered
Optics Rig 45	19/10/2017	13:01	-21.80	-25.07	Bulk
Optics Rig 46	19/10/2017	13:28	-21.80	-25.07	Filtered
Optics Rig 47	20/10/2017	13:02	-25.10	-25.03	Bulk
Optics Rig 48	20/10/2017	13:27	-25.10	-25.03	Filtered

STATION#	DATE	TIME (GMT)	LAT (Degrees)	LONG (Degrees)	IOP*
Optics Rig 49	21/10/2017	13:03	-27.86	-25.22	Bulk
Optics Rig 50	21/10/2017	13:34	-27.86	-25.22	Filtered
Optics Rig 51	22/10/2017	13:59	-31.31	-26.19	Bulk
Optics Rig 52	22/10/2017	14:26	-31.31	-26.19	Filtered
Optics Rig 53	23/10/2017	12:34	-33.88	-27.15	Bulk
Optics Rig 54	23/10/2017	12:56	-33.88	-27.15	Filtered
Optics Rig 55	24/10/2017	12:36	-36.99	-28.34	Bulk
Optics Rig 56	24/10/2017	13:01	-36.99	-28.34	Filtered
Optics Rig 57	26/10/2017	12:26	-42.13	-30.42	Bulk
Optics Rig 58	26/10/2017	12:51	-42.13	-30.42	Filtered
Optics Rig 59	27/10/2017	12:34	-45.19	-31.73	Bulk
Optics Rig 60	27/10/2017	12:55	-45.19	-31.73	Filtered
Optics Rig 61	28/10/2017	10:28	-47.11	-32.57	Bulk
Optics Rig 62	28/10/2017	10:52	-47.11	-32.57	Filtered
Optics Rig 63	29/10/2017	12:40	-50.36	-34.20	Bulk
Optics Rig 64	29/10/2017	13:02	-50.36	-34.20	Filtered
Optics Rig 65	30/10/2017	12:32	-52.94	-35.66	Bulk
Optics Rig 66	30/10/2017	12:54	-52.94	-35.66	Filtered
Optics Rig 67	01/11/2017	10:16	-53.55	-38.64	Bulk
Optics Rig 68	01/11/2017	10:36	-53.55	-38.64	Filtered

Table 2. List of Underway samples collected for intercomparison with corresponding CTD surface samples.

STATION#	DATE	TIME (GMT)	LAT (Degrees)	LONG (Degrees)
Optics Underway 01 CTD 07 Bottle 24	27/09/2017	13:00	42.17	-18.80
Optics Underway 02 CTD 09 Bottle 24	28/09/2017	12:49	39.36	-22.74
Optics Underway 03 CTD 12 Bottle 24	30/09/2017	13:52	35.08	-26.34
Optics Underway 04 CTD 16 Bottle 24	02/10/2017	13:42	28.20	-28.07
Optics Underway 05 CTD 21 Bottle 24	04/10/2017	13:49	22.25	-29.48
Optics Underway 06 CTD 25 Bottle 24	06/10/2017	13:41	15.51	-28.85
Optics Underway 07 CTD 30 Bottle 24	08/10/2017	13:44	9.93	-27.44
Optics Underway 08 CTD 35 Bottle 24	10/10/2017	13:54	4.74	-26.16
Optics Underway 09 CTD 39 Bottle 24	12/10/2017	13:54	-1.78	-25.00

STATION#	DATE	TIME (GMT)	LAT (Degrees)	LONG (Degrees)
Optics Underway 10 CTD 44 Bottle 24	14/10/2017	13:52	-7.14	-25.03
Optics Underway 11 CTD 48 Bottle 24	16/10/2017	13:45	-13.73	-25.07
Optics Underway 12 CTD 52 Bottle 24	19/10/2017	13:47	-21.80	-25.07
Optics Underway 13 CTD 57 Bottle 24	21/10/2017	13:52	-27.86	-25.22
Optics Underway 14 CTD 61 Bottle 24	23/10/2017	13:11	-33.88	-27.15
Optics Underway 15 CTD 65 Bottle 24	25/10/2017	11:19	-39.36	-29.26
Optics Underway 16 CTD 69 Bottle 24	27/10/2017	13:10	-45.19	-31.74
Optics Underway 17 CTD 75 Bottle 24	30/10/2017	13:11		

ABOVE WATER RADIOMETRIC MEASUREMENTS

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Cruise Objectives

Inter-comparison of above water radiometric measurements between TO's TriOS RAMSES, Royal Belgian Institute Natural Science (RBINS) TRIOS RAMSES and PML's HyperSAS SATLANTIC radiometers. In-situ radiometric measurements will be also compared against the satellite derived values of water leaving radiance.

Methods

Above-water TriOS systems (TriOS Mess- und Datentechnik GmbH, Germany) is composed of two RAMSES ARC hyperspectral radiometers measuring upwelling radiance Lu(λ) and downwelling radiance Ld(λ) in the same azimuthal plane, and one RAMSES ACC for downwelling irradiance Ed(0+,λ). The spectral range is 350-950 nm at 3 nm step and 10 nm bandwidth. The nominal FOV of radiance sensors is 7 degrees. The data stream from all three sensors are integrated by spectrometer interface controller IPS104 and logged on a PC for further processing.
Data is acquired and processed with software developed in TO. All three spectra are recorded simultaneously where the time interval between the scans can be manually set. The integration time is adjusted automatically in the range of 4ms - 4s based on the scene brightness.

The remote sensing reflectance, $\rho_w(\lambda)$, is calculated with the correction coefficient of the air-sea interface reflection. In addition NIR-similarity correction and filter for clear/cloudy sky is applied after Ruddick et al. 2006.

Provisional Results

The above-water radiometric measurements were performed along the whole AMT27 transect covering various ocean provinces. The data could be compared with the HyperSAS SATLANTIC along the whole transect and with the RBINS TRIOS RAMSES until the Azores. Also, the validation of the Sentinel-2/MSI and Sentinel-3/OLCI products could be performed.

References

Ruddick K, De Cauwer V, Park Y-J. (2006). Seaborne measurements of near infra-red water leaving reflectance: The similarity spectrum for turbid waters. Limnology and Oceanography, 51, 1167-1179.

Measurement of Fluorescence and Absorbance for characterisation of Dissolved Organic Matter (CDOM/FDOM) from CTD and underway samples, and collection of Dissolved Organic Carbon (DOC) samples

Arwen Bargery for Stuart Painter, and Andy Rees

British Oceanographic Data Centre (BODC), National Oceanography Centre Southampton (NOCS), Plymouth Marine Laboratory (PML)

Sampling Procedure

Samples were collected throughout the cruise for the separate analysis of absorbance, fluorescence and DOC from both CTD Niskin bottles and from the ships' non-toxic seawater supply. Seawater was sampled using clean, dark 250 ml polycarbonate bottles. Wearing vinyl, powdered gloves, sample bottles were rinsed with sample water before collection. Samples were collected for both immediate on-board analysis of fluorescence and absorbance and for later analysis of Dissolved Organic Carbon (DOC) back at PML.

Underway samples

Underway samples were collected at approximately 8am, 12pm, 4pm and 8pm ships time for the first two days of the cruise; for four days on the approach to South Georgia and several days on the approach to the Falkland Islands, whilst the ship was near the continental shelf. A total of 46 samples for the analysis of both DOM and DOC were collected from the non-toxic underway supply. A list of date, time and position for the underway samples can be found in the appendices.

CTD samples

Samples were collected from 68 CTD casts, from 3 depths including surface 97% light levels, mixed layer and deep chlorophyll maximum (DCM), where present. A total of 204 samples were collected from the CTD casts and analysed for FDOM/CDOM. The surface samples were also frozen for post-cruise DOC analysis. The depths, Niskin bottles and stations sampled are listed in the table below.

Sample Preparation

For each sample, a 20 ml NORM-JECT syringe was pre-rinsed with a small volume of sample water and a small volume of sample was squirted through a VWR International 25 mm syringe-end filter with 0.2 um Polyethersulfone membrane, to pre-soak the filter.

Dissolved Organic Carbon

Samples for DOC were filtered directly into 125 ml sample bottles. Samples for DOC were collected from all the surface underway samples and from one surface (5 m depth) Niskin bottle from each CTD cast (67 in total). Samples were frozen immediately after filtration in the -20 degrees Celsius freezer for later analysis.

Dissolved Organic Matter

Samples were filtered directly into a clean, pre-rinsed Starna Scientific 10 ml spectrosil cuvette for CDOM/FDOM analysis. Measurement of Absorbance was performed using an Agilent Technologies Cary 60 UV-Vis Spectrophotometer and measurement of fluorescence was performed using an Agilent Technologies Cary Eclipse Fluorescence Spectrophotometer.

A daily validation procedure was carried out on the Cary 60. Following this, the instrument was zeroed and a baseline scan performed using a sealed cell blank. The sealed cell blank was a Starna Scientific certified reference material for UV/VIS and RIR spectrophotometry (set RM-H20, s/n 25037, Cert No 101074, Calibration date 12/06/2017). A scan of a cuvette of Milli-Q followed by a scan of the sealed cell blank was run prior to running the seawater samples. All scans were performed using the Absmethod1 methods file.

Weekly validation tests were performed on the Cary Eclipse alongside a daily ramen calibration and daily scan of the sealed cell blank and cuvette of Milli-Q. All scans were performed using the NOC_method_280_650nm methods file.

Data submission

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

Table 1: List of stations and depths sampled for FDOM and DOC measurements

DATE	TIME (GMT)	STATION	CTD CAST	LAT (+ve N)	LON (+ve E)	NISKIN BOTTLES	SAMPLE DEPTHS (m)
23/09/2017	17:46:00	0	DY084_CTD000	50.0608	-3.3437	16, 20, 24	30, 20, 10
24/09/2017	11:25:00	1	DY084_CTD001	48.9268	-7.6235	9, 20, 22	60, 10, 5
25/09/2017	04:02:00	2	DY084_CTD002	47.2690	-11.0100	12, 18, 22	30, 20, 5
25/09/2017	12:03:00	3	DY084_CTD003	46.6863	-12.0002	12, 17, 22	35, 20, 5
26/09/2017	03:57:00	4	DY084_CTD004	44.8522	-14.8288	12, 18, 22	60, 20, 5
26/09/2017	09:33:00	4	DY084_CTD005	44.8524	-14.8271	21, 23, 24	50, 20, 5
27/09/2017	04:38:00	5	DY084_CTD006	43.0657	-17.4990	10, 18, 22	60, 20, 5
27/09/2017	12:48:00	6	DY084_CTD007	42.1666	-18.7968	9, 17, 22	60, 20, 5
28/09/2017	04:30:00	7	DY084_CTD008	40.2175	-21.5348	10, 18, 22	75, 20, 5
28/09/2017	12:09:00	8	DY084_CTD009	39.3550	-22.7422	8, 17, 22	75, 20, 5
30/09/2017	05:37:00	9	DY084_CTD010	35.3178	-26.3004	10, 18, 22	80, 20, 5
30/09/2017	13:12:00	10	DY084_CTD012	35.0840	-26.3374	10, 19, 23	80, 20, 5
01/10/2017	05:43:00	11	DY084_CTD013	32.8945	-25.1112	8, 19, 22	120, 20, 5
01/10/2017	13:07:00	12	DY084_CTD014	31.7627	-27.1864	10, 19, 23	90, 20, 5
02/10/2017	05:30:00	13	DY084_CTD015	29.3116	-27.7825	8, 19, 22	120, 20, 5
02/10/2017	13:06:00	14	DY084_CTD016	28.1965	-28.0698	9, 20, 23	110, 20, 5
03/10/2017	05:33:00	15	DY084_CTD017	26.0206	-28.5885	8, 19, 22	130, 20, 5
03/10/2017	13:22:00	16	DY084_CTD019	25.7152	-28.6674	9, 20, 23	130, 20, 5
04/10/2017	05:33:00	17	DY084_CTD020	23.3722	-29.2063	8, 18, 22	110, 20, 5
04/10/2017	13:06:00	18	DY084_CTD021	22.2538	-29.4830	10, 20, 23	83, 20, 5
05/10/2017	05:34:00	19	DY084_CTD022	19.8383	-29.9343	10, 20, 22	85, 20, 5
05/10/2017	13:01:00	20	DY084_CTD023	18.7859	-29.6823	10, 20, 23	82, 20, 5
06/10/2017	05:33:00	21	DY084_CTD024	16.5665	-29.0855	10, 19, 22	65, 20, 5
06/10/2017	13:03:00	22	DY084_CTD025	15.5078	-28.8498	11, 20, 23	68, 20, 5
07/10/2017	05:32:00	23	DY084_CTD026	13.1595	-28.2388	12, 19, 22	55, 20, 5
07/10/2017	13:07:00	24	DY084_CTD028	12.8222	-28.1656	13, 20, 23	53, 20, 5
08/10/2017	05:39:00	25	DY084_CTD029	10.8650	-27.6215	12, 18, 22	50, 20, 5
08/10/2017	13:03:00	26	DY084_CTD030	9.9270	-27.4439	13, 20, 23	52, 20, 5
09/10/2017	05:28:00	27	DY084_CTD031	7.7495	-26.8985	12, 19, 22	60, 20, 5
09/10/2017	13:02:00	28	DY084_CTD032	6.8807	-26.6860	12, 20, 23	60, 20, 5
10/10/2017	05:30:00	29	DY084_CTD033	5.0431	-26.2463	11, 19, 22	68, 20, 5
10/10/2017	13:08:00	30	DY084_CTD035	4.7428	-26.1606	12, 20, 23	65, 20, 5
11/10/2017	05:28:00	31	DY084_CTD036	2.4932	-25.4452	10, 19, 22	80, 20, 5
12/10/2017	05:40:00	33	DY084_CTD038	-0.7255	-24.9332	12, 19, 22	40, 20, 5
12/10/2017	13:07:00	34	DY084_CTD039	-1.7769	-24.9960	11, 20, 22	75, 20, 5
13/10/2017	05:28:00	35	DY084_CTD040	-3.5394	-24.9939	11, 19, 22	65, 20, 5
13/10/2017	13:12:00	36	DY084_CTD041	-4.5864	-25.0243	10, 20, 23	85, 20, 5

| DATE | TIME (GMT) | STATION | CTD CAST | LAT (+ve N) | LON (+ve E) | NISKIN BOTTLES | SAMPLE

							DEPTHS (m)
14/10/2017	05:29:00	37	DY084_CTD042	-6.8702	-25.0194	10, 19, 22	95, 20, 5
14/10/2017	13:04:00	38	DY084_CTD044	-7.1357	-25.0312	9, 20, 23	95, 20, 5
15/10/2017	05:28:00	39	DY084_CTD045	-9.4225	-25.0287	9, 19, 22	113, 20, 5
15/10/2017	13:06:00	40	DY084_CTD046	-10.4862	-25.0580	9, 20, 23	115, 20, 5
16/10/2017	05:30:00	41	DY084_CTD047	-12.6336	-25.0292	9, 19, 22	142, 20, 5
16/10/2017	13:02:00	42	DY084_CTD048	-13.7314	-25.0711	9, 20, 22	120, 20, 5
17/10/2017	05:29:00	43	DY084_CTD049	-15.9609	-25.0504	10, 20, 22	160, 20, 5
19/10/2017	05:28:00	45	DY084_CTD051	-20.7459	-25.0642	9, 19, 22	125, 20, 5
19/10/2017	13:00:00	46	DY084_CTD052	-21.7997	-25.0688	9, 20, 22	145, 20, 5
20/10/2017	05:35:00	47	DY084_CTD053	-23.9903	-24.9987	10, 21, 22	160, 20, 5
20/10/2017	13:03:00	48	DY084_CTD054	-25.1037	-25.0314	9, 21, 23	133, 20, 5
21/10/2017	05:29:00	49	DY084_CTD055	-27.5502	-25.1935	10, 21, 22	130, 20, 5
21/10/2017	13:04:00	50	DY084_CTD057	-27.8579	-25.2170	10, 21, 23	125, 20, 5
22/10/2017	06:28:00	51	DY084_CTD058	-30.2239	-25.7638	11, 20, 22	115, 20, 5
22/10/2017	14:05:00	52	DY084_CTD059	-31.3129	-37.3420	10, 21, 22	130, 20, 5
23/10/2017	05:39:00	53	DY084_CTD060	-33.1291	-26.8416	11, 18, 21	60, 20, 5
23/10/2017	12:35:00	54	DY084_CTD061	-33.8849	-27.1479	11, 20, 22	60, 20, 5
24/10/2017	04:57:00	55	DY084_CTD062	-35.9260	-28.0047	9, 18, 21	100, 20, 5
24/10/2017	12:32:00	56	DY084_CTD063	-36.9937	-28.3390	13, 19, 22	30, 20, 5
25/10/2017	05:10:00	57	DY084_CTD064	-39.3566	-29.2687	13, 19, 22	40, 20, 5
26/10/2017	05:01:00	58	DY084_CTD066	-41.1792	-30.0170	14, 18, 21	30, 20, 5
26/10/2017	12:28:00	59	DY084_CTD067	-42.1291	-30.4171	12, 19, 22	45, 20, 5
27/10/2017	05:00:00	60	DY084_CTD068	-44.2191	-31.3362	13, 18, 21	40, 20, 5
27/10/2017	12:34:00	61	DY084_CTD069	-45.1893	-31.7332	11, 18, 23	50, 20, 5
28/10/2017	05:05:00	62	DY084_CTD070	-47.1241	-32.6066	12, 19, 22	60, 20, 5
29/10/2017	05:05:00	63	DY084_CTD072	-49.4619	-33.7206	13, 18, 21	40, 20, 5
29/10/2017	12:34:00	64	DY084_CTD073	-50.3574	-34.2040	13, 18, 22	50, 20, 5
30/10/2017	04:58:00	65	DY084_CTD074	-51.9448	-35.0838	12, 18, 21	60, 20, 5
30/10/2017	12:33:00	66	DY084_CTD075	-52.9385	-35.6593	13, 19, 22	50, 20, 5
01/11/2017	05:09:00	67	DY084_CTD076	-53.5507	-38.6402	12, 19, 22	60, 20, 5
02/11/2017	05:04:00	68	DY084_CTD078	-53.1848	-42.4155	13, 18, 21	40, 20, 5

DY085 - SHORTCUTS IN THE OCEANIC NITROGEN CYCLE (SONiC)

Phyllis Lam[1], Jessika Fuessel[1], Andy Rees[2], Ian Brown[2], Carolyn Harris[2] and Glen Tarran[2]

[1]University of Southampton, [2]Plymouth Marine Laboratory

Cruise Objectives

The overarching goal of this project is to determine whether a shortcut exists in the remineralisation of organic nitrogen back to nitrate in the ocean's twilight zone, and its potential significance in the oceanic nitrogen budget.

Nitrogen is often a limiting nutrient to biological production, thus its availability in the surface ocean and subsequent export of organic carbon into the deep ocean are major determinants of the ocean's ability to sequester atmospheric CO_2: the Ocean's biological pump. Once exported from the surface ocean, organic matter is mostly remineralised back to CO_2 and nutrients, with >90% occurring in the ocean's twilight zone (mesopelagic) located between the sunlit surface and the deep dark ocean. The exact amounts and forms of nutrients that can be returned to surface ocean to support further phytoplankton growth, however, are governed by the depth of remineralisation within this transition zone and the mechanisms involved. Hence, accurate and quantitative understanding of nitrogen remineralisation pathways and remineralisation depths are essential to the projection of how global environmental changes may affect ocean productivity and so CO_2 sequestration. Despite such importance, actual quantification of nitrogen remineralisation fluxes in the mesopelagic is completely lacking.

This project combines a series of ^{15}N-labelling experiments, functional transcriptomics, metaproteomics and single-cell analyses to identify the microbial pathways and organisms responsible for the direct or stepwise conversion of organic nitrogen to nitrate in the oceanic twilight zone; and quantitatively assess the relative importance of each identified pathway in the mesopelagic. In order to better evaluate the global significance of the observed pathways, the above-mentioned experiments and analyses are to be conducted on samples collected from various surface nutrient regimes, thus making the AMT cruise that traverses multiple biogeochemical ocean provinces from the UK to the Falkland Islands in the Atlantic the ideal opportunity for our sampling and experimental campaign. Results from this cruise will be further evaluated with the seasonal study conducted in Bermuda Atlantic Time Series station, to assess temporal and spatial variability and significance of the observed processes.

Methods

Water Sampling

DY085 was integrated with the AMT27 cruise (DY084), with added station time every few days to allow for additional water sampling down to 1000 m and deployment of the large-volume standalone pump arrays specific for this project. We sampled 11 stations in total along the AMT27 transect, representative of different biogeochemical provinces ranging from mesotrophic temperate waters to oligotrophic subtropical north and south Atlantic gyres, subsurface hypoxic water in the tropics and the productive convergence zone and naturally iron-fertilised waters in the Scotia Sea, Southern Ocean (Table 1). At each station, four depths were chosen for ^{15}N-incubation experiments: ranging from just below the deep chlorophyll maximum where oxygen decline was the sharpest, to local oxygen minima and various features at mid-depths based on water mass distribution and oxygen profiles down to 1000 m. An array of 4 standalone pumps were first deployed at the 4 designated depths (Table 2), to collect particulate samples for metaproteomics analyses. Filter samples were then preserved in RNAlater™ (ThermoFisher) and stored at -80ºC until further processing in a shorebased laboratory.

Subsequently, water subsamples were collected with a CTD-Niskin rosette for incubation experiments, the analyses of ammonium (Holmes *et al.* 1999) and urea, and additionally for inorganic nutrients using the same protocols as for the AMT programme (please see report by Harris). A 4.5L-water sample was collected from each experimental depth and filtered onto combusted GF/F filters and dried in a drying oven (60ºC) for stable isotopic analyses particulate organic carbon and nitrogen (POC/N) back in the laboratory. At selected station, 1L of the filtrate from the POC/N filtration was

collected and then acidified to pH 2, for DOM characterization with Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICRMS). 10L water samples were also collected for functional transcriptomics by filtering onto 0.22µm-pore-size Sterivex filters, preserved in RNAlater™, and stored at -80ºC until further processing. In addition, 120ml samples were collected, fixed with paraformaldehyde (1% final concentration) for 8-12h and then filtered onto 0.2 µm-pore-sized polycarbonate membrane filters for later CARD-FISH (Catalyzed Reporter Deposition Fluorescence In situ Hybridization) analyses (Pernthaler *et al.* 2002). From the paraformaldehyde-fixed water samples, 1 ml subsample was taken from each and transferred to a cryovial for cell enumeration via flow cytometry (Tarran).

Incubation Experiments and Subsampling

For each experimental depth, 4.5L water subsamples were amended with tracer levels of ^{15}N-labeled substrates, including ammonium, nitrate, amino acids, urea, N-acetylglucosamine, dissolved organics and particulate algal matter (Table 3). The bottles were then incubated in the dark in water tanks maintained at *in situ* temperatures of the 4 respective depths. Subsampling from the 4.5L incubations was performed at 5 subsequent time intervals during the time-series incubations – ca. 0, 4, 8, 16 and 28 hours: (1) 2x15 ml subsamples were collected in sterile plastic tubes and fixed with saturated mercuric chloride for later nitrogen stable isotopic analyses in a shorebased laboratory, (2)1x15 ml in plastic tubes fixed with hypobromite/ sodium arsenite solution for later δ^{15}N-ammonium analyses, (3) 1x40ml subsample for shipboard ammonium analyses and (4) 1x30 ml subsample for shipboard nutrient analyses.

At the end of the ca. 28-hour incubations, in addition to the four subsamplings above, a 40ml subsample was fixed with paraformaldehyde (1% final conc.) for 8-12h and filtered for CARD-FISH analyses as described above. Flow cytometry subsamples were also collected from the above paraformaldehyde fixed samples, and cell enumeration was conducted onboard. The remaining water (~2.5-4L) from the 4.5L bottle was then filtered onto combusted GF/F filters for POC/N isotopic analyses as above, and at selected station, 1L filtrate was collected for DOM (FT-ICRMS) analyses. For each experimental depth, an additional 4.5L water sample was incubated in parallel and then filtered through a 0.22 µm-pore-sized Sterivex filter, treated with RNAlater™ solution and stored at -80ºC for transcriptomics analyses.

Provisional Results and Planned Analyses

As expected, ammonium concentrations remained low in most sampling depths, with values ranging from undetectable to usually under 30 nM throughout (Fig. 1). Elevated concentrations were usually associated with the sharp oxycline immediately below deep chlorophyll maxima, and higher overall values to up to almost 400 nM were detected in more productive regions, such as the temperate waters at Station 4, the convergence zone at Station 57 and the upwelling waters in the Southern Ocean at Stations 62 and 67. Occasionally, elevated concentrations of 70-80 nM could be detected in deeper mesopelagic, associated with hypoxic waters, such as at Station 43. Such elevated NH_4^+ concentrations are most likely indicative of active ammonification and remineralization processes. Net NH_4^+ loss can be observed in some incubation experiments, particularly those associated with elevated NH_4^+ at the more productive stations, and some are linked with net increases in NO_2^-/NO_3^- suggesting occurrence of nitrification.

However, in order to accurately determine how much ammonification and nitrification has occurred in the experiments, and how different forms of organic nitrogen is partitioned into ammonification, direct nitrification and assimilation, nitrogen stable isotopic analyses are necessary and have been 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. These processes were likely occurring simultaneously in the same incubations.

From shipboard counting of both high- and low- nucleic-acids-containing microbial cells (HNA and LNA cells, respectively), our incubation experiments did not seem to have significantly stimulated microbial growths within our short incubations, except for perhaps the incubations with particulate algal matter: LNA microbial cells increased in abundance by 5% to 267%, though the stimulation effects on HNA microbial populations were less pronounced or sometimes absent. To complement the above rates and biogeochemical measurements, CARD-FISH analyses would be performed to identify and enumerate active nitrifying organisms, and qualitative/ quantitative functional transcriptomics and metaproteomics 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. These results will be further evaluated in the context of the biogeochemical settings depicted by the core measurements of the AMT programme.

Acknowledgements

We would like to sincerely thank the captain and crew of the *RRS Discovery,* and the National Marine Facility support team for their tireless and conscientious support during this cruise (DY084/085), and along with the rest of the science party for making this such a pleasant and smooth expedition.

References

Holmes, R. M., Aminot, A., Kerouel, R., Hooker, B. A. and Peterson, B. J. (1999). A simple and precise method for measuring ammonium in marine and freshwater ecosystems. *Canadian Journal of Fisheries and Aquatic Sciences* **56**(10): 1801-1808.

Pernthaler, A., Pernthaler, J. and Amann, R. (2002). Fluorescence In Situ Hybridization and Catalyzed Reporter Deposition for the Identification of Marine Bacteria. *Appl. Environ. Microbiol.* **68**(6): 3094-3101.

Figure 1. Depth profiles of the preliminary ammonium concentrations measured at the 11 sampled stations for project SONiC.

Shown below are ammonium concentrations in nM (x-axis) versus depth in metres (y-axis). Also shown are ammonium measured during the pre-dawn CTD immediately prior to SONiC sampling at the same stations.

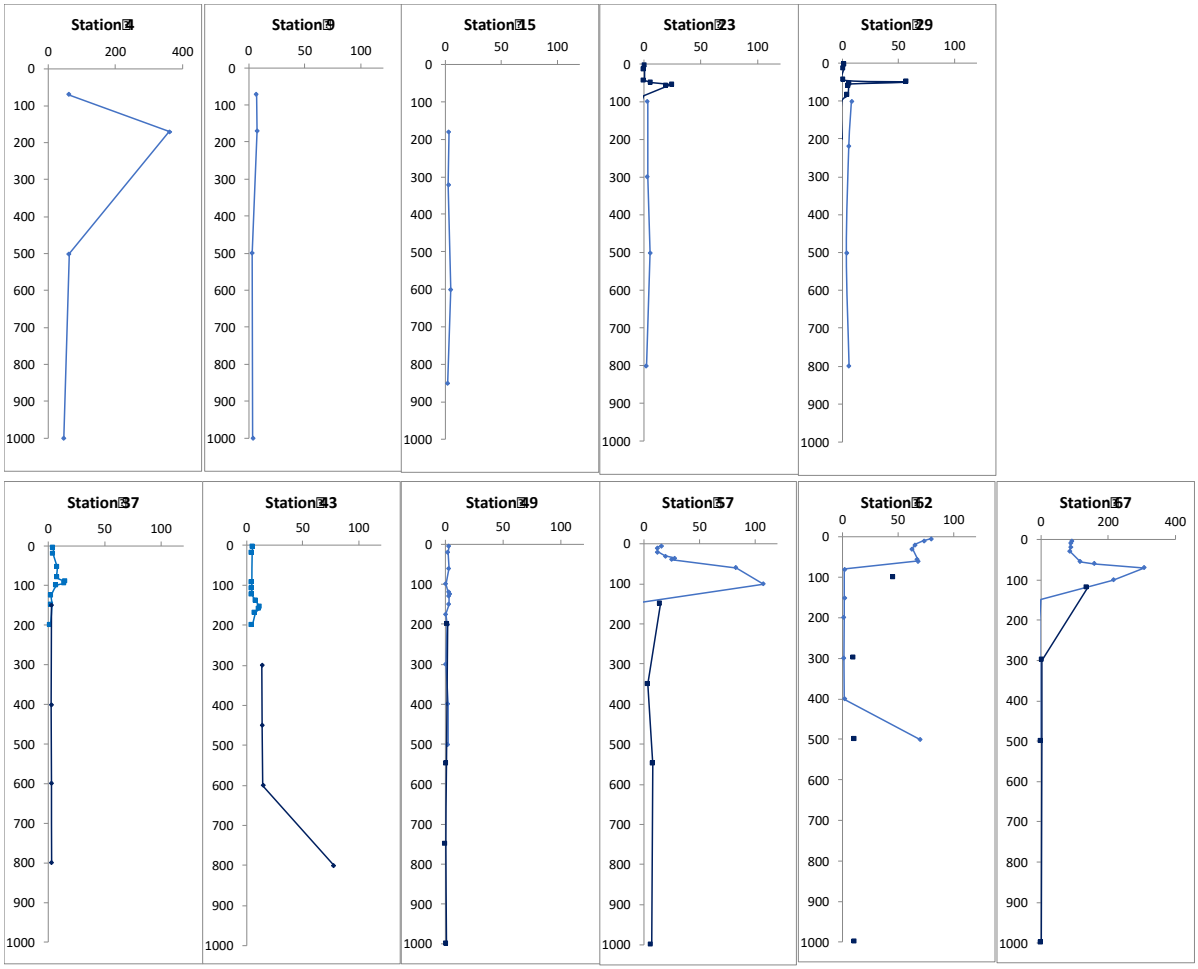

Table 1. Sampling Stations for Project SONiC (*See Table 3 for Experiment Coding).

DATE	Station No.	CTD CAST	LAT	LONG	DEPTHS SAMPLED (m)	EXPERIMENTS*
26/09/2017	4	5	44º51.145'N	14º49.628'W	70, 170, 500, 1000	CTRL, E1, E2, E3, E4, E6, E7
30/09/2017	9	11	35º19.06'N	26º18.02'W	100, 220, 550, 800	CTRL, E1, E3, E4, E5, E8, E9, E10
03/10/2017	15	18	26º 1.24'N	28º 35.30'W	180, 320, 600, 850	CTRL, E1, E2, E3, E4, E5, E6, E7
07/10/2017	23	27	13º9.573'N	28º14.338'W	100, 300, 500, 800	CTRL, E1, E3, E4, E5, E7, E10
10/10/2017	29	34	5º2.610'N	26º14.65'W	100, 220, 500, 800	CTRL, E1, E3, E4, E5, E6, E7, E8
14/10/2017	37	43	6º52.2115'S	25º1.166'W	150, 400, 600, 800	CTRL, E1, E2, E3, E4, E5, E6, E7
17/10/2017	43	50	15º57.656'S	25º3.0265'W	300, 450, 600, 800	CTRL, E1, E3, E4, E5, E7, E8, E10
21/10/2017	49	56	27º33.0114'S	25º11.6073'W	200, 550, 750, 1000	CTRL, E1, E3, E4, E5, E6, E7, E8
25/10/2017	57	65	39º21.401'S	29º15.62'W	160, 400, 750, 1000	CTRL, E1, E2, E3, E4, E5, E6, E7
28/10/2017	62	71	47º6.66'S	32º34.33'W	100, 300, 500, 1000	CTRL, E1, E3, E4, E5, E6, E7, E10
01/11/2017	67	77	52º33.2019'S	38º38.5683'W	120, 300, 500, 1000	CTRL, E1, E2, E3, E5, E7

Table 2. List of standalone pumps deployed and volume filtered at the 11 sampled stations.

Cast no.	*Date*	*Station*	*Depth (m)*	*Pump ID*	*Filtered vol (L)*
1	26/09/2017	4	70	Chloe	156
1	26/09/2017	4	170	Sandie	204.5
1	26/09/2017	4	500	Polly	189
1	26/09/2017	4	1000	Minnie	174.5
2	30/09/2017	9	100	Minnie	225.5
2	30/09/2017	9	220	Polly	237.5
2	30/09/2017	9	550	Sandie	204.5
2	30/09/2017	9	800	Chloe	156
3	03/10/2017	15	180	Chloe	244
3	03/10/2017	15	320	Sandie	235
3	03/10/2017	15	600	Polly	199.5
3	03/10/2017	15	850	Minnie	196
4	07/10/2017	23	100	Minnie	233.5
4	07/10/2017	23	300	Polly	204.5
4	07/10/2017	23	500	Sandie	194
4	07/10/2017	23	800	Chloe	149
5	10/10/2017	29	100	Minnie	243.5
5	10/10/2017	29	220	Molly	0
5	10/10/2017	29	500	Sandie	188
5	10/10/2017	29	800	Chloe	0

Cast no.	*Date*	*Station*	*Depth (m)*	*Pump ID*	*Filtered vol (L)*
6	14/10/2017	37	150	Minnie	232
6	14/10/2017	37	400	Molly	203
6	14/10/2017	37	600	Sandie	173
6	14/10/2017	37	800	Chloe	136
7	17/10/2017	43	300	Minnie	220.5
7	17/10/2017	43	450	Molly	209
7	17/10/2017	43	600	Sandie	124.5
7	17/10/2017	43	800	Chloe	0
8	21/10/2017	49	200	Minnie	243.5
8	21/10/2017	49	500	Molly	230
8	21/10/2017	49	750	Sandie	163.5
8	21/10/2017	49	1000	Chloe	0
9	25/10/2017	57	150	Minnie	218.5
9	25/10/2017	57	400	Molly	229
9	25/10/2017	57	750	Chloe	130.5
9	25/10/2017	57	1000	Sandie	93
10	28/10/2017	62	100	Minnie	170.5
10	28/10/2017	62	300	Molly	176
10	28/10/2017	62	500	Sandie	183
10	28/10/2017	62	1000	Chloe	1
11	01/11/2017	67	120	Chloe	111
11	01/11/2017	67	300	Sandie	154
11	01/11/2017	67	500	Molly	3
11	01/11/2017	67	1000	Minnie	163.5

Table 3. List ^{15}N-Experiments Conducted.

Experiment	***^{15}N-Labeled Substrates***
E1	ammonium
E2	nitrate
E3	amino acid mix
E4	urea
E5	N-acetylglucosamine (NAG)
E6	POM
E7	DOM
E8	amino acids + $^{14}NH_4^+$
E9	urea + $^{14}NH_4^+$
E10	NAG + $^{14}NH_4^+$
Control	none

Abundance and Composition of Microbial Plankton Communities by flow cytometry

Glen Tarran, *Plymouth Marine Laboratory, Plymouth* and Rebecca May, *Plymouth Marine Laboratory Lloyds Register Foundation Modern Apprentice*

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

Phytoplankton community structure and abundance by flow cytometry.
Fresh seawater samples were collected in clean 250 mL polycarbonate bottles using a Seabird CTD system containing a 24 bottle rosette of 20 L Niskin bottles from 200 m to the surface at predawn and solar noon CTD casts. Samples were stored in a refrigerator and analysed within 2 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 pico- and eukaryote phytoplankton, based on their light scattering and autofluorescence properties. Data were saved in listmode format and analysed on board.
Rebecca May analysed the fresh samples from the solar noon CTD casts. She had just completed her first year as a modern apprentice when she was asked, at very short notice (10 days before mobilisation) if she would like to participate in the cruise as another participant was unable to come. Rebecca agreed and did a fantastic job analysing the fresh samples from the solar noon CTDs, along with her other duties of measuring oxygen and collecting samples for total alkalinity (see relevant sections elsewhere in this report). The data she has acquired will be used to produce her apprentice project entitled, “The latitudinal variability of phytoplankton in the Atlantic Ocean”.
Table 1 summarises the CTD casts sampled and analysed during the cruise.

Heterotrophic bacteria community structure and abundance by flow cytometry.
Samples for bacteria enumeration were collected in clean 250 mL polycarbonate bottles using a Seabird CTD system containing a 24 bottle rosette of 20 L Niskin bottles from 200 m to the surface at predawn and solar noon CTD casts, plus samples from 500 m on the predawn casts. Samples were fixed with glutaraldehyde solution (Sigma-Aldrich, 50%, Grade 1. 0.5% final concentration, 30 mins at 4^{o}C) within half an hour of surfacing. Samples (see below) were stained for 1 h at room temperature in the dark with the DNA stain SYBR Green I (Thermo-Fisher) in order to separate particles in suspension based on DNA content and light scattering properties. This enabled bacteria to be discriminated from other particles and enumerated. Samples were generally analysed flow cytometrically within 3 hours of surfacing. Stained samples were measured using a Becton Dickinson FACSort flow cytometer. Data were saved in listmode format and analysed onboard.

***Table 1*: CTD casts sampled for phytoplankton and heterotrophic bacteria community structure & abundance.**

DATE	STN	CTD	TIME on deck (GMT)	LAT +N, -S	LONG E	DEPTHS *NISKIN BOTTLES*
24-Sep	1	1	11:55	48.93	-7.62	5 10 20 30 40 50 60 80 100 120 140 *22 20 17 15 13 11 9 7 5 3 1*
25-Sep	2	2	04:45	47.27	-11.01	5 10 15 20 25 30 35 40 75 100 150 200 500 *22 20 19 16 15 12 11 10 8 7 6 5 2*
25-Sep	3	3	12:54	46.69	-12.00	5 10 15 20 30 35 45 50 75 100 150 200 *22 20 19 18 15 12 11 9 8 7 6 5*
26-Sep	4	4	04:39	44.85	-14.83	5 10 15 20 35 55 60 70 80 100 125 150 200 500 *22 20 19 18 16 15 12 11 10 8 7 6 5 1*

DATE	STN	CTD	TIME on deck (GMT)	LAT +N, -S	LONG E	DEPTHS *NISKIN BOTTLES*
27-Sep	5	6	05:20	43.07	-17.50	5 10 15 20 30 40 45 55 60 75 100 125 150 200 500 *22 20 19 18 16 15 14 13 10 9 8 7 6 5 2*
27-Sep	6	7	13:26	42.17	-18.80	5 10 15 20 30 35 45 55 60 80 100 150 200 *22 20 19 18 15 14 13 12 9 8 7 6 5*
28-Sep	7	8	05:13	40.22	-21.53	5 10 15 20 30 45 55 70 75 100 125 150 200 500 *22 20 19 18 16 15 14 13 10 8 7 6 5 2*
28-Sep	8	9	12:58	39.36	-22.74	5 10 15 20 30 40 50 70 75 100 125 150 200 *22 20 19 18 15 14 13 12 9 8 7 6 5*
30-Sep	9	10	06:40	35.32	-26.30	5 10 15 20 35 55 60 75 80 85 110 125 150 200 500 *22 20 19 18 16 15 14 13 10 9 8 7 6 5 2*
30-Sep	10	12	13:51	35.08	-26.34	5 10 15 20 30 40 50 60 75 80 85 90 100 125 150 200 *23 21 20 19 17 16 15 14 13 10 9 8 7 6 5 4*
01-Oct	11	13	06:19	32.89	-26.89	5 10 20 30 40 50 70 90 100 115 120 135 150 200 500 *22 20 19 17 16 15 14 13 12 11 8 7 6 5 2*
01-Oct	12	14	14:03	31.76	-27.19	5 10 20 30 50 70 85 90 95 110 125 150 200 *22 21 19 17 16 15 14 10 9 8 7 6 5*
02-Oct	13	15	06:09	29.31	-27.78	5 10 20 30 40 50 70 90 100 115 120 135 150 200 500 *22 20 19 17 16 15 14 13 12 11 8 7 6 5 2*
02-Oct	14	16	13:43	28.20	-28.07	5 10 20 40 60 80 90 100 105 110 115 125 150 200 *23 21 20 18 17 16 15 14 13 9 8 7 6 5*
03-Oct	15	17	06:30	26.02	-28.59	5 15 20 30 45 55 70 100 115 125 130 140 160 200 500 *22 20 19 17 16 15 14 13 12 11 8 7 6 5 2*
03-Oct	16	19	14:01	25.72	-28.67	5 10 20 40 60 80 90 110 125 130 135 140 150 175 200 *23 21 20 18 17 16 15 14 13 9 8 7 6 5 4*
04-Oct	17	20	06:12	23.37	-29.21	5 15 20 25 45 65 85 95 105 110 125 150 200 500 *22 20 18 17 16 15 14 13 12 11 8 7 6 5 2*
04-Oct	18	21	13:49	22.25	-29.48	5 10 20 40 50 60 70 75 83 95 110 125 150 200 *23 21 20 18 17 16 15 14 10 9 8 7 6 5*
05-Oct	19	22	06:12	19.84	-29.93	5 10 20 30 35 50 60 70 80 85 95 110 125 150 200 500 *22 21 20 18 17 16 15 14 13 10 9 8 7 6 5 2*
05-Oct	20	23	13:41	18.79	-29.68	5 10 20 40 50 60 70 75 82 95 110 125 150 200 *23 21 20 18 17 16 15 14 10 9 8 7 6 5*
06-Oct	21	24	06:12	16.57	-29.09	5 15 20 25 30 40 55 60 65 85 100 125 150 200 500 *22 20 19 17 16 15 14 13 10 9 8 7 6 5 2*
06-Oct	22	25	13:44	15.51	-28.85	5 10 20 40 50 55 63 68 75 90 110 125 150 200 *23 21 20 18 17 16 15 11 10 9 8 7 6 5*
07-Oct	23	26	06:29	13.16	-28.24	5 10 15 20 35 45 20 55 60 75 85 100 125 150 200 500 *22 21 20 19 17 16 15 12 11 10 9 8 7 6 5 2*

DATE	STN	CTD	TIME on deck (GMT)	LAT +N, -S	LONG E	DEPTHS *NISKIN BOTTLES*
07-Oct	24	28	13:46	12.82	-28.17	5 10 20 40 50 53 60 70 80 90 100 125 150 200 *23 21 20 18 17 13 12 11 10 9 8 7 6 5*
08-Oct	25	29	06:15	10.87	-27.62	5 10 15 20 30 40 45 50 60 70 85 100 125 150 200 500 *22 21 20 18 17 16 15 12 11 10 9 8 7 6 5 2*
08-Oct	26	30	13:42	9.93	-27.44	5 10 20 40 47 52 60 70 80 90 100 125 150 200 23 21 20 18 17 13 12 11 10 9 8 7 6 5
09-Oct	27	31	06:06	7.75	-26.90	5 10 15 20 35 45 55 60 65 75 85 100 125 150 200 500 *22 21 20 19 17 16 15 12 11 10 9 8 7 6 5 2*
09-Oct	28	32	13:45	6.88	-26.69	5 10 20 30 45 55 60 70 80 90 100 125 150 200 *23 21 2018 17 16 12 11 10 9 8 7 6 5*
10-Oct	29	33	06:24	5.04	-26.25	5 10 15 20 25 40 55 63 68 75 85 100 125 150 200 500 *22 21 20 19 17 16 15 14 11 10 9 8 7 6 5 2*
10-Oct	30	35	13:47	4.74	-26.16	5 10 20 30 45 60 65 70 80 90 100 125 150 200 *23 21 20 17 16 15 12 11 10 9 8 7 6 5*
11-Oct	31	36	06:05	2.49	-25.61	5 10 15 20 25 40 55 65 75 80 90 100 125 150 200 500 *22 21 20 19 17 16 15 14 13 10 9 8 7 6 5 2*
11-Oct	32	37	13:44	1.46	-25.36	5 20 30 45 65 70 77 80 90 100 150 *23 20 18 17 16 15 11 10 9 8 6*
12-Oct	33	38	06:20	-0.73	-24.93	5 10 15 20 25 30 35 40 60 70 80 100 125 150 200 500 *22 21 20 19 17 16 15 12 11 10 9 8 7 6 5 2*
12-Oct	34	39	13:54	-1.78	-25.00	5 10 20 30 45 65 70 75 80 90 100 125 150 200 *23 21 20 18 17 16 15 11 10 9 8 7 6 5*
13-Oct	35	40	06:12	-3.39	-24.99	5 10 15 20 25 40 50 60 65 70 90 100 125 150 200 500 *22 21 20 19 17 16 15 14 11 10 9 8 7 6 5 2*
13-Oct	36	41	13:52	-4.59	-25.02	5 10 20 30 50 60 70 80 85 90 100 125 150 200 *23 21 20 18 17 16 15 14 10 9 8 7 6 5*
14-Oct	37	42	06:24	-6.87	-25.02	5 10 15 20 25 35 55 70 80 90 95 100 125 150 200 500 *22 21 20 19 17 16 15 14 13 12 9 8 7 6 5 2*
14-Oct	38	44	13:50	-7.14	-25.03	5 10 20 30 50 60 75 85 90 95 110 125 150 200 *23 21 20 18 17 16 15 14 13 9 8 7 6 5*
15-Oct	39	45	06:08	-9.42	-25.03	5 10 15 20 30 40 50 65 85 100 108 113 125 150 20 500 *22 21 20 19 17 16 15 14 13 12 11 8 7 6 5 2*
15-Oct	40	46	13:46	-10.49	-25.06	5 10 20 30 40 60 80 100 110 115 120 135 150 200 *23 21 20 18 17 16 15 14 13 9 8 7 6 5*
16-Oct	41	47	06:12	-12.13	-25.03	5 10 15 20 35 50 60 85 110 125 137 142 160 175 200 500 *22 21 20 19 17 16 15 14 13 12 11 8 7 6 5 2*

DATE	STN	CTD	TIME on deck (GMT)	LAT +N, -S	LONG E	DEPTHS *NISKIN BOTTLES*
17-Oct	42	48	13:45	-13.73	-25.07	5 10 20 30 40 60 80 95 115 120 130 150 175 200 *23 21 20 18 17 16 15 14 13 9 8 7 6 5*
17-Oct	43	49	06:27	-15.96	-25.05	5 20 30 70 95 110 125 140 155 160 170 185 200 500 *22 20 18 17 16 15 14 13 12 9 8 7 6 3*
19-Oct	45	51	06:09	-20.75	-25.06	5 10 15 20 30 45 55 75 100 110 120 125 140 170 200 500 *22 21 20 19 17 16 15 14 13 12 11 8 7 6 5 2*
19-Oct	46	52	13:44	-21.80	-25.07	5 10 20 40 60 80 100 120 140 145 150 165 180 200 *23 21 20 18 17 16 15 14 13 9 8 7 6 5*
20-Oct	47	53	06:17	-23.99	-25.00	5 20 40 55 65 90 110 130 140 150 160 170 185 200 500 *22 21 19 18 17 16 15 14 13 12 9 8 7 6 2*
20-Oct	48	54	13:44	-25.10	-25.03	5 20 30 60 80 100 115 125 133 150 175 200 *23 21 19 17 16 15 14 13 9 8 7 6*
21-Oct	49	55	06:25	-27.55	-25.19	5 20 30 45 60 80 100 110 120 125 130 150 175 200 500 *22 21 19 18 17 16 15 14 13 12 9 8 7 6 2*
21-Oct	50	57	13:47	-27.86	-25.22	5 20 30 60 80 100 110 120 125 140 150 175 200 *23 21 19 17 16 15 14 13 10 9 8 7 6*
22-Oct	51	58	07:05	-30.22	-25.76	5 15 20 40 50 70 90 110 115 120 130 150 200 500 *22 21 20 17 16 15 14 13 10 9 8 7 5 2*
22-Oct	52	59	14:45	-31.31	-26.19	5 20 40 60 80 100 120 130 135 140 150 175 200 *23 21 18 17 16 15 14 10 9 8 7 6 5*
23-Oct	53	60	06:18	-33.13	-26.84	5 10 15 20 25 35 45 55 60 80 125 150 175 200 500 *21 20 19 18 16 15 14 13 11 10 8 7 6 5 2*
23-Oct	54	61	13:10	-33.88	-27.15	5 10 20 30 40 50 55 60 70 100 125 150 200 *23 21 20 18 17 16 15 11 10 8 7 6 5*
24-Oct	55	62	05:36	-35.93	-28.00	5 10 15 20 25 35 45 60 75 95 100 125 150 175 500 *21 20 19 18 16 15 14 13 12 11 9 8 7 6 2*
24-Oct	56	63	13:11	-36.99	-28.34	5 10 15 20 25 30 40 50 60 80 100 125 150 *23 21 20 19 17 13 12 11 10 9 8 7 6*
25-Oct	57	64	06:11	-39.36	-29.27	5 10 15 20 25 30 35 40 50 60 80 100 125 150 200 500 *22 21 20 19 17 16 15 12 11 10 9 8 7 6 5 2*
26-Oct	58	66	05:38	-41.18	-30.02	5 10 15 20 25 30 35 40 60 80 125 150 175 200 500 *21 20 19 18 16 14 13 12 11 10 8 7 6 5 2*
26-Oct	59	67	13:10	-42.13	-30.42	5 10 15 20 30 40 45 50 60 80 100 125 150 200 23 21 20 18 17 16 12 11 10 9 8 7 6 5
27-Oct	60	68	05:34	-44.22	-31.34	5 10 15 20 30 35 40 50 60 100 125 150 175 200 500 21 20 19 18 16 15 13 12 11 9 8 7 6 5 2
27-Oct	61	69	13:10	-45.19	-31.73	5 10 15 20 30 40 50 60 80 100 125 150 200 *21 20 19 18 16 15 11 10 9 8 7 6 5*

DATE	STN	CTD	TIME on deck (GMT)	LAT +N, -S	LONG E	DEPTHS *NISKIN BOTTLES*
28-Oct	62	70	06:02	-47.12	-32.61	5 10 15 20 25 30 45 55 60 80 125 150 200 500 *22 21 20 19 17 16 15 14 11 9 7 6 5 2*
29-Oct	63	72	05:39	-49.46	-33.72	5 10 15 20 30 35 40 50 60 80 100 125 150 175 200 500 24 20 19 18 16 15 13 12 11 10 9 8 7 6 5 2
29-Oct	64	73	13:14	-50.36	-34.20	5 10 15 20 30 40 50 60 70 90 100 125 150 175 200 23 21 20 19 17 16 13 12 11 9 8 7 6 5
30-Oct	65	74	05:35	-51.94	-35.09	5 10 15 20 30 45 50 60 70 100 125 150 175 200 500 21 20 19 18 16 15 14 12 11 9 8 7 6 5 2
30-Oct	66	75	13:11	-52.94	-35.66	5 10 15 20 30 40 50 60 70 80 90 100 125 150 200 23 21 20 19 18 17 13 12 11 10 9 8 7 6 5
01-Nov	67	76	06:05	-53.55	-38.64	5 10 15 20 25 30 45 55 60 70 80 100 125 150 200 500 22 21 20 19 17 16 15 14 11 10 9 8 7 6 5 2
02-Nov	68	78	05:42	-53.18	-42.42	5 10 15 20 25 30 40 50 60 80 100 125 150 175 200 500 21 20 19 18 16 15 13 12 11 10 9 8 7 6 5 2

Additional flow cytometry.

Enumeration of bacteria in support of the SONiC project
Paraformaldehyde-fixed seawater samples (1 mL) from the SONiC incubation experiments at the beginning (T0) and end (T4) (see relevant sections elsewhere in this report) were stained for 1 h at room temperature in the dark with the DNA stain SYBR Green I (Thermo-Fisher) in order to separate particles in suspension based on DNA content and light scattering properties. This enabled bacteria to be discriminated from other particles and enumerated. Stained samples were measured using a Becton Dickinson FACSort flow cytometer. Data were saved in listmode format and will be analysed back in the laboratory. See relevant section in this report for summary of incubation experiments.

Microplankton Community Size Structure and abundance

Glen Tarran, *Plymouth Marine Laboratory, Plymouth*

Methods:

11 L seawater samples from 20 m and the deep chlorophyll maximum (DCM) were collected from solar noon CTD casts into polyethylene carboys and brought into the Main Lab. 50mm diameter plastic pipes with 20 µm mesh fitted to the end were inserted into the carboys and then siphon tubes were inserted into the filtering pipes. Seawater was then siphoned out of the carboys through the 20µm mesh, a technique known as reverse filtration, leaving a concentrated seawater sample containing plankton >20 µm of between 100-150 mL. Concentrated samples were transferred to amber glass bottles, followed by 3 mL of acid Lugols solution to preserve the plankton. Samples were then stored in the walk-in cold room at 4^{o}C. Back in the UK, samples will be analysed using a FlowCAM to provide information on taxonomic composition, size distribution and abundance.

Table 2: Details of microplankton reverse filtration samples

DATE	CTD	LAT (N+, S-)	LONG W	DEPTH SAMPLED (m)	FINAL SAMPLE VOL. mL	PRESERVED SAMPLE NAME
24-Sep	1	48.93	-7.62	20	125	A27M_0924_05
24-Sep	1	48.93	-7.62	5	150	A27M_0924_20
25-Sep	3	46.69	-12.00	20	150	A27M_0925_20
25-Sep	3	46.69	-12.00	35	134	A27M_0925_35
26-Sep	5	44.85	-14.83	20	128	A27M_0926_20
26-Sep	5	44.85	-14.83	50	133	A27M_0926_50
27-Sep	7	42.17	-18.80	20	110	A27M_0927_20
27-Sep	7	42.17	-18.80	60	100	A27M_0927_60
28-Sep	9	39.36	-22.74	20	108	A27M_0928_20
28-Sep	9	39.36	-22.74	75	150	A27M_0928_75
30-Sep	12	35.08	-26.34	20	137	A27M_0930_20
30-Sep	12	35.08	-26.34	80	134	A27M_0930_80
01-Oct	14	31.76	-27.19	20	100	A27M_1001_20
01-Oct	14	31.76	-27.19	90	144	A27M_1001_90
02-Oct	16	28.20	-28.07	20	100	A27M_1002_20
02-Oct	16	28.20	-28.07	110	130	A27M_1002_100
03-Oct	19	25.72	-28.67	20	110	A27M_1003_20
03-Oct	19	25.72	-28.67	130	120	A27M_1003_130
04-Oct	21	22.25	-29.48	20	140	A27M_1004_20
04-Oct	21	22.25	-29.48	83	110	A27M_1004_83
05-Oct	23	18.79	-29.68	20	106	A27M_1005_20
05-Oct	23	18.79	-29.68	82	124	A27M_1005_82
06-Oct	23	15.51	-28.85	20	122	A27M_1006_20
06-Oct	23	15.51	-28.85	68	136	A27M_1006_68
07-Oct	28	12.82	-28.17	20	136	A27M_1007_20
07-Oct	28	12.82	-28.17	53	126	A27M_1007_53
08-Oct	30	9.93	-27.44	20	132	A27M_1008_20
08-Oct	30	9.93	-27.44	52	128	A27M_1008_52
09-Oct	32	6.88	-26.69	20	131	A27M_1009_20
09-Oct	32	6.88	-26.69	52	147	A27M_1009_52
10-Oct	35	4.74	-26.16	20	127	A27M_1010_20
10-Oct	35	4.74	-26.16	65	132	A27M_1010_65

DATE	CTD	LAT (N+, S-)	LONG W	DEPTH SAMPLED (m)	FINAL SAMPLE VOL. mL	PRESERVED SAMPLE NAME
12-Oct	39	-1.78	-25.00	20	130	A27M_1012_20
12-Oct	39	-1.78	-25.00	75	127	A27M_1012_75
13-Oct	41	-4.59	-25.02	20	130	A27M_1013_20
13-Oct	41	-4.59	-25.02	85	124	A27M_1013_85
14-Oct	44	-7.14	-25.03	20	120	A27M_1014_20
14-Oct	44	-7.14	-25.03	95	124	A27M_1014_85
15-Oct	46	-10.49	-25.06	20	130	A27M_1015_20
15-Oct	46	-10.49	-25.06	115	126	A27M_1015_115
16-Oct	48	-13.73	-25.07	20	121	A27M_1016_20
16-Oct	48	-13.73	-25.07	120	122	A27M_1016_120
17-Oct	50	-15.96	-25.05	135	130	A27M_1017_135
19-Oct	52	-21.80	-25.07	20	125	A27M_1019_20
19-Oct	52	-21.80	-25.07	145	126	A27M_1019_145
20-Oct	54	-25.10	-25.03	20	121	A27M_1019_20
20-Oct	54	-25.10	-25.03	133	140	A27M_1019_145
21-Oct	57	-27.86	-25.22	20	134	A27M_1021_20
21-Oct	57	-27.86	-25.22	125	129	A27M_1021_125
22-Oct	59	-31.31	-26.19	20	110	A27M_1022_20
22-Oct	59	-31.31	-26.19	130	130	A27M_1022_130
23-Oct	61	-33.88	-27.15	20	126	A27M_1023_20
23-Oct	61	-33.88	-27.15	60	130	A27M_1023_60
24-Oct	63	-36.99	-28.34	30	131	A27M_1023_30
25-Oct	65	-39.36	-29.26	40	118	A27M_1025_40
26-Oct	67	-42.13	-30.42	45	112	A27M_1026_40
27-Oct	69	-45.19	-31.73	20	123	A27M_1027_20
27-Oct	69	-45.19	-31.73	50	125	A27M_1027_50
28-Oct	71	-47.10	-32.57	20	116	A27M_1028_20
28-Oct	71	-47.10	-32.57	60	116	A27M_1028_60
29-Oct	73	-50.36	-34.20	20	116	A27M_1029_20
29-Oct	73	-50.36	-34.20	20	144*	A27M_1029_20U*
30-Oct	75	-52.94	-35.66	50	130	A27M_1030_50
01-Nov	77	-38.64	2580	40	100	A27M_1101_40
01-Nov	77	-38.64	2580	40	150	A27M_1101_40U*

*Unfiltered sample. Very high biomass, probably sufficient for analysis without concentration

Mesoplankton Community Size Structure and abundance

Glen Tarran, *Plymouth Marine Laboratory, Plymouth and Hashan Niroshana Kokuhennadige, University of Ruhuna, Sri Lanka*

Methods:

Vertical net hauls were conducted each day at the pre-dawn stations for the collection of mesozooplankton samples (Table 1). A bongo (double) net frame was deployed from the Discovery's aft starboard quarter using one of the ship's cranes and a Romica general purpose winch with 8 mm steel wire. The nets used had 0.57m diameter openings and carried 2 WP-2 nets with 200 µm nylon mesh, fitted with cod ends with 200 µm mesh windows. Nets were deployed to a depth of 200 m and then hauled at a rate of 11-12 m min^{-1}, providing duplicate samples, integrated between 200m and the surface. Nets were washed with seawater whilst still outboard and then brought onboard where the cod ends containing the samples were collected into buckets. Nets were then washed down with fresh water before stowing. The duplicate samples were then combined and passed through a 200 µm sieve and the material retained on the sieve was then washed into a 100 mL plastic bottle containing 10 mL of 37% borax-buffered formaldehyde (4% final concentration) using Milli-Q water. Samples were then stored at 4^{o}C for analysis on return to the UK. Back in the UK, samples will be analysed using a combination of microscopy and FlowCAM to provide information on taxonomic composition, size distribution and abundance. At most stations, 0.2 – 0.5 mL concentrated plankton samples were collected onto pre-ashed 25 mm GF/F glass microfibre filters, placed in 35 mm diameter petri dishes and put in a drying oven at 50^{o}C. Once dried, samples were analysed for nitrogen and carbon isotopic composition by Andy Rees (see appropriate section in this cruise report for details).

Table 3: Details of bongo WP-2 net vertical deployments

DATE	Day of year	STATION	TIME on deck (GMT)	Duration (mins)	LAT +N, -S	LONG E	Preserved sample name	Stable isotope sample (mL)
26-Sep	269	4	04:12	00:19	44.85	-14.83	A27_ZV_0926_04	No sample
27-Sep	270	5	04:57	00:18	43.07	-17.50	A27_ZV_0927_05	No sample
28-Sep	271	7	04:54	00:17	40.22	-21.53	A27_ZV_0928_07	No sample
30-Sep	273	9	06:00	00:16	35.32	-26.30	A27_ZV_0930_09	No sample
01-Oct	274	11	05:55	00:18	32.89	-26.89	A27_ZV_1001_11	0.5 mL
02-Oct	275	13	05:50	00:17	29.31	-27.78	A27_ZV_1002_13	No sample
03-Oct	276	15	05:45	00:17	26.02	-28.59	A27_ZV_1003_15	0.5 mL
04-Oct	277	17	06:07	00:17	23.37	-29.21	A27_ZV_1004_17	No sample
05-Oct	278	19	05:56	00:17	19.84	-29.93	A27_ZV_1005_19	0.2 mL
06-Oct	279	21	06:01	00:17	16.57	-29.09	A27_ZV_1006_21	0.2 mL
07-Oct	280	23	05:51	00:17	13.16	-20.24	A27_ZV_1007_23	0.2 mL
08-Oct	281	25	06:01	00:17	10.87	-27.62	A27_ZV_1008_25	0.2 mL
09-Oct	282	27	05:49	00:17	7.75	-26.90	A27_ZV_1009_27	0.2 mL
10-Oct	283	29	05:52	00:17	5.04	-26.25	A27_ZV_1010_29	0.2 mL
11-Oct	284	31	05:50	00:18	2.49	-25.61	A27_ZV_1011_31	0.2 mL
12-Oct	285	33	06:08	00:17	-0.73	-24.93	A27_ZV_1012_33	0.2 mL
13-Oct	286	35	05:50	00:17	-3.39	-24.99	A27_ZV_1013_35	0.2 mL
14-Oct	287	37	05:48	00:17	-6.87	-25.02	A27_ZV_1014_37	0.2 mL
15-Oct	288	39	05:51	00:17	-9.42	-25.03	A27_ZV_1015_39	0.2 mL
16-Oct	289	41	05:52	00:17	-12.13	-25.03	A27_ZV_1016_41	0.2 mL
17-Oct	290	43	05:49	00:17	-15.96	-25.05	A27_ZV_1017_43	0.2 mL
19-Oct	292	45	05:44	00:18	-20.75	-25.06	A27_ZV_1019_45	0.2 mL
20-Oct	293	47	06:01	00:17	-23.99	-25.00	A27_ZV_1020_47	0.2 mL
21-Oct	294	49	05:52	00:17	-27.55	-25.19	A27_ZV_1021_49	0.2 mL

22-Oct	295	51	06:51	00:17	-30.22	-25.76	A27_ZV_1022_51	0.2 mL
24-Oct	297	55	05:29	00:17	-35.93	-28.00	A27_ZV_1024_55	0.2 mL
26-Oct	299	58	05:12	00:17	-41.18	-30.02	A27_ZV_1026_58	0.2 mL
30-Oct	303	65	05:26	00:17	-51.94	-35.09	A27_ZV_1030_65A	0.2 mL
30-Oct	303	65	05:26	00:17	-51.94	-35.09	A27_ZV_1030_65B	
01-Nov	305	67	05:39	00:17	-53.55	-38.64	A27_ZV_1101_67A	0.2 mL
01-Nov	305	67	05:39	00:17	-53.55	-38.64	A27_ZV_1101_67B	

Sample files ending in A or B = ½ of a single net sample, where the sample was too concentrated to fit into a single bottle.

Sample collection and filtration for N-osmolyte determination

Glen Tarran *Plymouth Marine Laboratory*

Methods:
Samples were collected, filtered and preserved for N-osmolytes, primarily glycine betaine for Ruth Airs and Rachael Beale from PML. Surface samples from solar noon CTDs were collected in a clean 1 L polycarbonate bottle, stored in a refrigerator and processed within 1.5 hours of collection. Triplicate 50 mL and 2 mL surface samples were syringe-filtered through pre-washed Whatman Nuclepore^{TM} 47 mm diameter polycarbonate filters, housed in a clear polycarbonate in-line filter housing. 5-7 mL of air in a 10 mL syringe was used to provide the pressure required to push any seawater remaining on the filter once the syringe had been emptied of sample. Filters were then placed briefly on a 200 mm diameter GF/F filter to blot them, folded using tweezers and then placed into a 2 mL cryovial. Cryovials were then placed into liquid nitrogen until all samples had been filtered, at which time the frozen filters were transferred to a -80^{o}C freezer. Samples will be transported back to the UK in a liquid nitrogen dry shipper and concentrations of N-osmolytes determined back in the laboratory.

Table 4: Details of sampling for N-osmolytes

DATE	CTD	TIME on deck (GMT)	LAT (N+, S-)	LONG W	NISKIN BOTTL No.	DEPTH SAMPLED (m)	2 mL reps filtered	50 mL reps filtered
24-Sep	1	11:55	48.93	-7.62	22	5	3	3
25-Sep	3	12:54	46.69	-12.00	22	5	3	3
26-Sep	5	10:20	44.85	-14.83	24	5	3	3
27-Sep	7	13:26	42.17	-18.80	22	5	3	3
28-Sep	9	12:58	39.36	-22.74	22	5	3	3
30-Sep	12	13:51	35.08	-26.34	23	5	3	3
01-Oct	14	14:03	31.76	-27.19	23	5	3	3
02-Oct	16	13:43	28.20	-28.07	23	5	3	3
03-Oct	19	14:01	25.72	-28.67	23	5	3	3
04-Oct	21	13:49	22.25	-29.48	23	5	3	3
05-Oct	23	13:41	18.79	-29.68	23	5	3	3
06-Oct	25	13:44	15.51	-28.85	23	5	3	3
08-Oct	30	13:42	9.93	-27.44	23	5	3	3
09-Oct	32	13:45	6.88	-26.69	23	5	3	3
10-Oct	35	13:47	4.74	-26.16	23	5	3	3
12-Oct	39	13:54	-1.78	-25.00	23	5	3	3
13-Oct	41	13:52	-4.59	-25.02	23	5	3	3
14-Oct	44	13:50	-7.14	-25.03	23	5	3	3
15-Oct	46	13:46	-10.49	-25.06	23	5	3	3
16-Oct	48	13:45	-13.73	-25.07	23	5	3	3
19-Oct	52	13:44	-21.80	-25.07	23	5	3	3
20-Oct	54	13:44	-25.10	-25.03	23	5	3	3
21-Oct	57	13:47	-27.86	-25.22	23	5	3	3
22-Oct	59	14:45	-31.31	-26.19	23	5	3	3
23-Oct	61	13:10	-33.88	-27.15	23	5	3	3
24-Oct	63	13:11	-36.99	-28.34	23	5	3	3
25-Oct	65	11:19	-39.36	-29.26	23	5	3	3
26-Oct	67	13:10	-42.13	-30.42	23	5	3	3

27-Oct	69	13:10	-45.19	-31.73	23	5	3	3
28-Oct	71	11:09	-47.10	-32.57	23	5	3	3
29-Oct	73	13:14	-50.36	-34.20	23	5	3	3
30-Oct	75	13:11	-52.94	-35.66	23	5	3	3
01-Nov	77	10:52	-53.55	-38.64	23	5	3	3

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

Gavin Tilstone and Denise Cummings

Plymouth Marine Laboratory

Objectives

- To examine the horizontal and vertical phytoplankton pigment composition along the AMT27 transect (at the surface and at the subsurface chlorophyll maximum) (NERC-NC AMT).
- The continuation of a 21-year spatially extensive and internally consistent time series of observations on the pigment structure of phytoplankton in the Atlantic Ocean (NERC-NC AMT).
- Collecting phytoplankton pigment data for the development and validation of remote-sensing algorithms and marine ecosystem models designed to predict and model the phytoplankton biomass and community structure at basin scales (AMT4SentinelFRM).
- Collecting phytoplankton pigment data for the validation of remote-sensing algorithms for estimating phytoplankton pigment concentration on the newly-launched European Space Agency (ESA) Sentinel-3 and Sentinel-2 satellites (AMT4SentinelFRM).

Equipment

- 25 mm glass fibre filters (GF/F)
- 1 and 2 litre measuring cylinders
- Millipore forceps
- Cryovials
- Cryo-pen
- Filtration rig
- Gloves
- Liquid nitrogen for flash freezing.

Methods

Seawater samples were collected from the noon CTD cast, and from the ship's 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 mixed to avoid issues with sedimentation. 2-4 L samples (depending on phytoplankton biomass, e.g. 2 L in productive waters and 4-5 L in the oligotrophic gyres) were measured using the rinsed measuring cylinders, and then decanted into rinsed polypropylene bottles with siphon tubes and inverted into a 4 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 in the -80ºC freezer. For each station, 2 samples were taken at the surface (~5m), and around the subsurface chlorophyll maximum (which varied between 23m-162m). In addition there were three CTD stations that occurred at 10:00am local time, to coincide with Sentinel-3 overpass, and water was collected at 5 and 20m. Duplicate HPLC measurements were taken at both depths for every station (except the 10:00 stations, and on occasions when a CTD bottle misfired and there was not enough water to do a duplicate). Two daily samples were also taken using the ships underway system around the time of each station (to compare with surface CTD samples and for calibrating the ACS optics instrument). Frozen samples are to be analysed using HPLC methods at Plymouth Marine Laboratory after the cruise. Table 1 shows the locations and stations of all the HPLC samples.

Table 1: Station locations of HPLC samples on AMT 27 from CTD casts.

CTD No.	DATE	START TIME (GMT)	LAT (Degrees)	LONG (Degrees)	Depth Sampled
CTD003	25/09/2017	11:49	46.69	12.00	5 & 35
CTD005	26/09/2017	09:33	44.85	14.83	5 & 50
CTD007	27/09/2017	12:12	42.17	18.80	5 & 60
CTD009	28/09/2017	12:08	39.36	22.74	5 & 75
CTD012	30/09/2017	13:11	35.08	26.34	5 & 80
CTD014	01/10/2017	13:03	31.76	27.19	5 & 90
CTD016	02/10/2017	13:05	28.20	28.07	5 & 110
CTD019	03/10/2017	13:21	25.72	28.67	5 & 130
CTD021	04/10/2017	13:05	22.25	29.48	5 & 83
CTD023	05/10/2017	12:58	18.79	29.68	5 & 82
CTD025	06/10/2017	13:02	15.67	28.85	5 & 68
CTD028	07/10/2017	13:06	12.82	28.17	5 & 63
CTD030	08/10/2017	13:00	9.93	27.44	5 & 50
CTD032	09/10/2017	13:02	6.88	26.69	5 & 60
CTD035	10/10/2017	13:07	4.74	26.16	5 & 65
CTD037	11/10/2017	13:03	1.46	25.36	5 & 77
CTD039	12/10/2017	13:06	-1.78	25.00	5 & 75
CTD041	13/10/2017	13:09	-4.59	25.02	5 & 85
CTD044	14/10/2017	13:03	-7.14	25.03	5 & 95
CTD046	15/10/2017	13:03	-10.49	25.06	5 & 115
CTD048	16/10/2017	13:00	-13.73	25.07	5 & 120
CTD050	17/10/2017	10:17	-15.96	25.05	5 & 135
CTD052	19/10/2017	13:00	-21.80	25.07	5 & 145
CTD054	20/10/2017	13:02	-25.10	25.03	5 & 133
CTD056	21/10/2017	10:12	-27.55	25.19	5 & 125
CTD057	21/10/2017	13:03	-27.86	25.22	5 & 130
CTD059	22/10/2017	14:03	-31.31	26.19	5 & 130
CTD061	23/10/2017	12:34	-33.88	27.15	5 & 60
CTD063	24/10/2017	12:32	-36.99	28.34	5 & 30
CTD065	25/10/2017	10:32	-39.36	29.26	5 & 40
CTD067	26/10/2017	12:26	-42.13	30.42	5 & 50
CTD069	27/10/2017	12:33	-45.19	31.73	5 & 50
CTD071	28/10/2017	10:21	-47.11	-32.57	5 & 60
CTD073	29/10/2017	12:34	-50.36	-34.20	5 & 50
CTD075	30/10/2017	12:32	-52.94	-35.66	5 & 50
CTD077	01/11/2017	10:05	-53.55	-38.64	5 & 40

Table 2: Station locations of HPLC samples on AMT 27 from Underway samples.

UW Sample No.	Standard Day of Yr	TIME (GMT)	LAT (Degrees)	LONG (Degrees)	Sample Depth (mts)
UW001	267	17:27	48.93	-7.62	5
UW002	268	07:06	47.05	-11.41	5
UW003	268	09:03	46.81	-11.87	5
UW004	268	11:57	46.69	-12.00	5
UW005	268	16:00	46.44	-12.44	5
UW006	268	19:23	45.84	-13.40	5
UW007	269	07:05	44.85	-15.16	5
UW008	269	11:00	44.85	-14.83	5
UW009	269	15:00	44.72	-14.97	5
UW010	269	15:00	44.20	-15.75	5
UW011	270	07:00	42.85	-17.79	5
UW012	270	10:56	42.29	-18.61	5
UW013	270	14:56	41.99	-19.05	5
UW014	270	18:52	41.44	-19.85	5
UW015	271	06:56	39.99	-21.87	5
UW016	271	10:56	39.48	-22.58	5
UW017	271	14:52	39.25	-22.86	5
UW018	271	19:00	38.67	-23.67	5
UW019	272	19:00	36.97	-25.84	5
UW020	273	15:15	34.92	-26.30	5
UW021	274	08:00	32.64	-26.96	5
UW022	274	13:07	31.76	-27.19	5
UW023	274	18:03	31.12	-27.35	5
UW024	275	09:22	28.80	-27.93	5
UW025	275	13:48	28.20	-28.07	5
UW026	275	17:05	27.75	-28.18	5
UW027	276	09:06	26.02	-28.59	5
UW028	276	13:30	25.72	-28.67	5
UW029	276	17:10	25.29	-28.77	5
UW030	276	21:07	24.61	-28.93	5
UW031	277	09:11	22.90	-29.33	5
UW032	277	13:26	22.25	-29.48	5
UW033	277	17:05	21.77	-29.59	5
UW034	277	21:03	21.09	-29.74	5
UW035	278	05:03	19.84	-29.94	5
UW036	278	09:10	19.40	-29.84	5
UW037	278	13:01	18.79	-29.68	5
UW038	278	17:07	18.32	-29.56	5

UW Sample No.	Standard Day of Yr	TIME (GMT)	LAT (Degrees)	LONG (Degrees)	Sample Depth (mts)
UW039	278	21:12	17.63	-29.39	5
UW040	278	06:40	16.17	-29.08	5
UW041	279	09:44	16.03	-28.97	5
UW042	279	13:11	15.51	-28.85	5
UW043	279	17:16	15.04	-28.72	5
UW044	279	20:01	14.57	-28.60	5
UW045	280	06:02	13.16	-28.24	5
UW046	280	13:20	12.82	-28.17	5
UW047	280	17:03	12.35	-28.05	5
UW048	280	20:01	11.86	-27.92	5
UW049	281	05:24	10.86	-27.62	5
UW050	281	09:09	10.51	-27.58	5
UW051	281	13:14	9.93	-27.44	5
UW052	281	17:09	9.47	-27.33	5
UW053	281	20:44	8.92	-27.18	5
UW054	282	04:59	7.76	-26.90	5
UW055	282	09:21	7.38	-26.81	5
UW056	282	13:19	6.88	-26.68	5
UW057	282	17:10	6.48	-26.58	5
UW058	282	20:18	6.01	-26.48	5
UW059	283	05:05	5.05	-26.25	5
UW060	283	09:07	5.04	-26.24	5
UW061	283	13:21	4.74	-26.16	5
UW062	283	17:02	4.33	-26.06	5
UW063	283	20:55	3.71	-25.91	5
UW064	284	09:07	2.04	-25.50	5
UW065	284	13:18	1.46	-25.36	5
UW066	284	18:58	0.72	-25.22	5
UW067	285	05:03	-0.72	-24.95	5
UW068	285	09:01	-1.13	-24.96	5
UW069	285	13:12	-1.78	-25.00	5
UW070	285	17:05	-1.86	-24.90	5
UW071	286	04:59	-3.54	-25.00	5
UW072	286	09:05	-3.97	-25.02	5
UW073	286	13:20	-4.59	-25.02	5
UW074	286	17:08	-5.03	-25.03	5
UW075	286	20:49	-5.65	-25.03	5
UW076	286	05:05	-6.87	-25.02	5
UW077	286	13:13	-7.14	-25.03	5
UW078	286	17:00	-7.64	-25.03	5
UW079	286	20:57	-8.21	-25.04	5

UW Sample No.	Standard Day of Yr	TIME (GMT)	LAT (Degrees)	LONG (Degrees)	Sample Depth (mts)
UW080	287	05:10	-9.42	-25.03	5
UW081	287	09:10	-9.88	-25.05	5
UW082	287	13:14	-10.49	-25.06	5
UW083	287	17:00	-10.95	-25.06	5
UW084	287	20:33	-11.56	-25.06	5
UW085	288	05:07	-12.63	-25.03	5
UW086	288	08:59	-13.08	-25.07	5
UW087	288	13:15	-13.73	-25.07	5
UW088	288	17:02	-14.20	-25.07	5
UW089	288	20:09	-14.74	-25.08	5
UW090	289	04:30	-15.96	-25.07	5
UW091	289	13:17	-15.96	-25.05	5
UW092	289	16:42	-16.34	-25.08	5
UW093	289	20:08	-16.93	-25.09	5
UW094	290	10:40	-18.55	-25.08	5
UW095	290	17:03	-18.87	-25.08	5
UW096	290	20:26	-19.44	-25.09	5
UW097	291	08:53	-21.13	-25.07	5
UW098	291	13:16	-21.80	-25.07	5
UW099	291	17:02	-22.25	-25.07	5
UW100	291	20:12	-22.77	-25.05	5
UW101	292	07:05	-24.09	-25.00	5
UW102	293	10:14	-24.64	-25.04	5
UW103	293	13:12	-25.10	-25.03	5
UW104	293	17:06	-25.58	-25.04	5
UW105	293	20:14	-26.15	-25.08	5
UW106	294	06:13	-27.55	-25.19	5
UW107	294	13:14	-27.86	-25.22	5
UW108	294	17:12	-28.39	-25.28	5
UW109	294	20:40	-29.02	-25.34	5
UW110	295	06:59	-30.22	-25.77	5
UW111	295	10:10	-30.70	-25.96	5
UW112	295	14:06	-31.31	-26.19	5
UW113	295	18:33	-31.87	-26.39	5
UW114	295	21:10	-32.30	-26.55	5
UW115	296	06:10	-33.13	-26.84	5
UW116	296	09:52	-33.54	-27.00	5
UW117	296	12:43	-33.88	-27.15	5
UW118	296	16:55	-34.42	-27.34	5
UW119	296	20:45	-35.11	-27.59	5
UW120	297	06:14	-35.96	-28.03	5

UW Sample No.	Standard Day of Yr	TIME (GMT)	LAT (Degrees)	LONG (Degrees)	Sample Depth (mts)
UW121	297	09:17	-36.50	-28.14	5
UW122	297	12:45	-36.99	-28.34	5
UW123	297	17:02	-37.54	-28.54	5
UW124	297	20:59	-38.16	-28.81	5
UW125	298	05:44	-39.36	-29.27	5
UW126	298	09:01	-39.36	-29.26	5
UW127	298	14:25	-39.43	-29.33	5
UW128	298	17:38	-39.87	-29.49	5
UW129	298	20:39	-40.29	-29.65	5
UW130	299	05:10	-41.18	-30.02	5
UW131	299	08:53	-41.62	-30.21	5
UW172	299	12:26	-42.13	-30.42	5
UW173	299	17:17	-42.70	-30.64	5
UW174	299	20:46	-43.21	-30.86	5
UW175	300	04:56	-44.22	-31.34	5
UW176	300	08:29	-44.62	-31.48	5
UW177	300	12:42	-45.19	-31.73	5
UW178	300	16:33	-45.60	-31.92	5
UW179	300	20:10	-46.08	-32.14	5
UW180	301	04:44	-47.12	-32.61	5
UW181	301	10:44	-47.11	-32.57	5
UW182	301	16:09	-47.71	-32.88	5
UW183	301	19:02	-48.17	-33.10	5
UW184	302	05:06	-49.46	-33.72	5
UW185	302	09:26	-49.97	-33.98	5
UW186	302	12:47	-50.36	-34.20	5
UW187	302	16:22	-50.68	-34.39	5
UW188	302	20:43	-51.19	-34.67	5
UW189	303	05:11	-51.94	-35.08	5
UW190	303	11:40	-52.84	-35.60	5
UW191	303	12:41	-52.94	-35.66	5
UW192	303	16:03	-53.32	-35.89	5
UW193	303	20:23	-54.03	-36.32	5
UW194	304	18:52	-53.90	-36.94	5
UW195	305	04:12	-53.53	-38.60	5
UW196	305	07:58	-53.55	-38.64	5
UW197	305	10:30	-53.55	-38.64	5
UW198	305	17:33	-53.42	-40.04	5
UW199	305	20:34	-53.35	-40.73	5
UW200	306	04:58	-53.18	-42.42	5
UW201	306	08:59	-53.14	-43.01	5

UW Sample No.	Standard Day of Yr	TIME (GMT)	LAT (Degrees)	LONG (Degrees)	Sample Depth (mts)
UW202	306	14:46	-53.03	-43.99	5
UW203	306	20:08	-52.95	-44.82	5

Acknowledgements

HPLC profiles on the noon CTD were funded by Natural Environment Research Council National Capability (NERC-NC) the Atlantic Meridional Transect (AMT).
Underway samples were funded through the European Space Agency contract: Copernicus Sentinel Atlantic Meridional Transect Fiducial Reference Measurements Campaign project (AMT4SentinelFRM; Contract No. ESRIN/RFQ/3-14457/16/I-BG).

Microbial DNA collection

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Cruise Objectives

DNA materials of seawater samples were collected for DNA archives.

Methods

10L of seawater samples were collected from surface (5m) and depths of Deep Chlorophyll Maximum using the CTD-rosette from both predawn and midday CTD casts (2 depths per station; 132 samples in total). Seawater samples were filtered through Sterivex-Gp, 0.22µm sterile vented filter units (SVGP01050) by using a ColePalmer-MasterFlex L/S Multichannel Pump (Model 7535-08) and samples were preserved with adding 1mL of RNAlater Solution (Invitrogen by Thermo fisher scientific). Afterwards, all Sterivex units were sealed with tube sealing compound and stored at -81°C in a freezer.

All samples will be archived at -80°C at PML and are available on request for future use.

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
24/09/2017	1125	1	1	48° 55.653	-7° 37.393	5, 20
25/09/2017	0402	2	2	47° 16.133	-11° 0.588	5, 30
25/09/2017	1203	3	3	46° 41.180	-12° 0.011	5, 35
26/09/2017	0357	4	4	44° 51.139	-14° 49.675	5, 60
27/09/2017	0438	5	6	43° 03.940	-17° 29.939	5, 60
27/09/2017	1248	6	7	42° 9.970	-18° 47.810	5, 60
28/09/2017	0430	7	8	40° 13.047	-21° 32.087	5, 75
28/09/2017	1209	8	9	39° 21.301	-22° 44.529	5, 75
30/09/2017	0537	9	10	35° 19.066	-26° 18.021	5, 80
30/09/2017	1312	10	12	35° 5.037	-26° 20.243	5, 80
01/10/2017	0543	11	13	32° 53.672	-26° 53.328	5, 120
01/10/2017	1307	12	14	31° 45.761	-27° 11.183	5, 90
02/10/2017	0530	13	15	29° 18.696	-27° 46.952	5, 120
02/10/2017	1306	14	16	28° 11.790	-28° 4.185	5, 110
03/10/2017	0533	15	17	26° 1.238	-28° 35.310	5, 130
03/10/2017	1322	16	19	25° 42.912	-28° 40.048	5, 130
04/10/2017	0533	17	20	23° 22.33	-29° 12.38	5, 110
04/10/2017	1306	18	21	22° 15.229	-29° 28.982	5, 83
05/10/2017	0534	19	22	19° 50.30	-29° 56.06	5, 85
05/10/2017	1301	20	23	18° 47.154	-29° 40.940	5, 82

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
06/10/2017	0533	21	24	16° 33.99	-29° 5.13	5, 65
06/10/2017	1303	22	25	15° 30.468	-28° 50.990	5, 68
07/10/2017	0532	23	26	13° 9.570	-28° 14.328	5, 55
07/10/2017	1307	24	28	12° 49.334	-28° 9.933	5, 53
08/10/2017	0539	25	29	10° 51.90	-27° 37.29	5, 50
08/10/2017	1303	26	30	9° 55.617	-27° 26.634	5, 52
09/10/2017	0528	27	31	7° 44.972	-26° 53.910	5, 60
09/10/2017	1302	28	32	6° 52.84	-26° 41.161	5, 60
10/10/2017	0530	29	33	5° 2.587	-26° 14.779	5, 68
10/10/2017	1308	30	35	4° 44.569	-26° 9.628	5, 65
11/10/2017	0528	31	36	2° 29.59	-25° 26.71	5, 80
12/10/2017	0540	33	38	-0° 43.53	-24° 55.99	5, 40
12/10/2017	1307	34	39	-1° 46.615	-24° 59.761	5, 75
13/10/2017	0528	35	40	-3° 32.361	-24° 59.631	5, 65
13/10/2017	1312	36	41	-4° 35.181	-25° 1.457	5, 85
14/10/2017	0529	37	42	-6° 52.210	-25° 1.164	5, 90
14/10/2017	1304	38	44	-7° 8.139	-25° 1.871	5, 95
15/10/2017	0528	39	45	-9° 25.35	-25° 01.72	5, 113
15/10/2017	1306	40	46	-10° 29.170	-25° 03.482	5, 115
16/10/2017	0530	41	47	-12° 38.014	-25° 1.752	5, 142
16/10/2017	1302	42	48	-13° 43.883	-25° 4.263	5, 120
17/10/2017	0529	43	49	-15° 57.656	-25° 3.026	5, 160
19/10/2017	0528	45	51	-20° 44.755	-25° 3.854	5, 125
19/10/2017	1300	46	52	-21° 47.980	-25° 4.129	5, 145
20/10/2017	0535	47	53	-23° 59.42	-24° 59.92	5, 160
20/10/2017	1303	48	54	-25° 6.221	-25° 1.885	5, 133
21/10/2017	0529	49	55	-27° 33.011	-25° 11.608	5, 130
21/10/2017	1304	50	57	-27° 51.474	-25° 13.022	5, 125
22/10/2017	0628	51	58	-30° 13.43	-25° 48.83	5, 115
22/10/2017	1405	52	59	-31° 18.771	-26° 11.342	5, 130
23/10/2017	0539	53	60	-33° 7.747	-26° 50.496	5, 60
23/10/2017	1235	54	61	-33° 53.096	-27° 8.872	5, 60
24/10/2017	0457	55	62	-35° 55.56	-28° 0.28	5, 100

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
24/10/2017	1232	56	63	-36° 59.622	-28° 20.340	5, 30
25/10/2017	0510	57	64	-39° 21.398	-29° 16.119	5, 40
26/10/2017	0501	58	66	-41° 16.750	-30° 1.020	5, 30
26/10/2017	1228	59	67	-42° 7.743	-30° 25.023	5, 45
27/10/2017	0500	60	68	-44° 13.144	-31° 20.169	5, 40
27/10/2017	1234	61	69	-45° 11.359	-31° 43.993	5, 50
28/10/2017	0505	62	70	-47° 7.444	-32° 36.397	5, 60
29/10/2017	0505	63	72	-49° 27.715	-33° 43.234	5, 40
29/10/2017	1234	64	73	-50° 21.441	-34° 12.238	5, 50
30/10/2017	0458	65	74	-51° 56.69	-35° 5.03	5, 60
30/10/2017	1233	66	75	-52° 56.310	-35° 39.557	5, 50
01/11/2017	0509	67	76	-53° 33.04	-38° 38.41	5, 60
02/11/2017	0504	68	78	-53° 11.088	-42° 24.930	5, 40

Nitrogen Fixation and Carbon Fixation Rates

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Objectives

To determine the rates of nitrogen and carbon fixation in surface waters of the Atlantic during AMT-27.

Methods

20L of surface seawater (5m) samples were collected daily from CTD-rosette in predawn (1 depth per station; 38 samples in total) and filled 2.4L of seven Nalgene bottles. Out of these seven bottles, 3 bottles were immediately filtered and the suspended particles in each bottles were collected by using gentle vacuum filtration through a 25mm pre-combusted GF/F filters to determine natural abundance of ^{15}N and ^{13}C. To other 4 bottles 2.4mL of ^{15}N-N_2 (15N2, 98%+; Cambridge Isotopic Laboratories, Inc) were injected by using a gas-tight syringe and all bottles were kept in dark bag and agitated for 30 minutes. After the agitation, caps of these bottles were removed and 12mL of seawater samples were withdrawn from each bottle using a 5mL syringe and filled 3 Exetainer tubes and before sealing the tubes, 0.1mL of $HgCl_2$ was added to each tubes (In addition to these 3 tubes, a blank sample was also prepared in another Extetainer tube with surface seawater). Afterwards, above bottles were again top up by adding 12mL of seawater to exclude air and sealed again. When performing Carbon fixation and Nitrogen fixation experiment together, 4mL of 13C solution was added to each bottles before the bottles are top up and filled with seawater to exclude air. Then out of these 4 bottles, 1 bottle was incubated for 12 hours and other 3 bottles were incubated for 24 hours in a deck incubator. At the end of each experiment, the suspended particles in each bottles were collected by using gentle vacuum filtration through a 25mm pre-combusted GF/F filters to determine ^{15}N and ^{13}C. The filters were dried at 50°C by using an oven and then wrapped in tin cups and formed into pellets. A number of samples were analysed onboard using Sercon INTEGRA 2, Stable Isotope Analyser, the remainder will be analysed at PML using SERCON 20-22. Particulate nitrogen (PN) and ^{15}N atom% were measured using continuous-flow stable isotope mass-spectrometry (Rees et al 2009).

All data will be stored at BODC

References

Rees A.P., J. A. Gilbert, B. A. Kelly-Gerreyn (2009). Nitrogen fixation in the western English Channel (NE Atlantic Ocean). Mar. Ecol. Prog. Ser. 374, 7- 12. doi:10.3354/meps07771

Location of samples collected for N and C fixation rates

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
24/09/2017	1125	1	1	48° 55.653	-7° 37.393	5
25/09/2017	0402	2	2	47° 16.133	-11° 0.588	5
25/09/2017	1203	3	3	46° 41.180	-12° 0.011	5
26/09/2017	0357	4	4	44° 51.139	-14° 49.675	5
27/09/2017	0438	5	6	43° 03.940	-17° 29.939	5
28/09/2017	0430	7	8	40° 13.047	-21° 32.087	5
30/09/2017	0537	9	10	35° 19.066	-26° 18.021	5
01/10/2017	0543	11	13	32° 53.672	-26° 53.328	5
02/10/2017	0530	13	15	29° 18.696	-27° 46.952	5

DATE	TIME	Station No.	CTD CAST	LAT (+ve N)	LONG (+ve E)	DEPTHS SAMPLED (m)
03/10/2017	0533	15	17	26° 1.238	-28° 35.310	5
04/10/2017	0533	17	20	23° 22.33	-29° 12.38	5
05/10/2017	0534	19	22	19° 50.30	-29° 56.06	5
06/10/2017	0533	21	24	16° 33.99	-29° 5.13	5
07/10/2017	0532	23	26	13° 9.570	-28° 14.328	5
08/10/2017	0539	25	29	10° 51.90	-27° 37.29	5
09/10/2017	0528	27	31	7° 44.972	-26° 53.910	5
10/10/2017	0530	29	33	5° 2.587	-26° 14.779	5
11/10/2017	0528	31	36	2° 29.59	-25° 26.71	5
12/10/2017	0540	33	38	-0° 43.53	-24° 55.99	5
13/10/2017	0528	35	40	-3° 32.361	-24° 59.631	5
14/10/2017	0529	37	42	-6° 52.210	-25° 1.164	5
15/10/2017	0528	39	45	-9° 25.35	-25° 01.72	5
16/10/2017	0530	41	47	-12° 38.014	-25° 1.752	5
17/10/2017	0529	43	49	-15° 57.656	-25° 3.026	5
19/10/2017	0528	45	51	-20° 44.755	-25° 3.854	5
20/10/2017	0535	47	53	-23° 59.42	-24° 59.92	5
21/10/2017	0529	49	55	-27° 33.011	-25° 11.608	5
22/10/2017	0628	51	58	-30° 13.43	-25° 48.83	5
23/10/2017	0539	53	60	-33° 7.747	-26° 50.496	5
24/10/2017	0457	55	62	-35° 55.56	-28° 0.28	5
25/10/2017	0510	57	64	-39° 21.398	-29° 16.119	5
26/10/2017	0501	58	66	-41° 16.750	-30° 1.020	5
27/10/2017	0500	60	68	-44° 13.144	-31° 20.169	5
28/10/2017	0505	62	70	-47° 7.444	-32° 36.397	5
29/10/2017	0505	63	72	-49° 27.715	-33° 43.234	5
30/10/2017	0458	65	74	-51° 56.69	-35° 5.03	5
01/11/2017	0509	67	76	-53° 33.04	-38° 38.41	5
02/11/2017	0504	68	78	-53° 11.088	-42° 24.930	5

Primary Production

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Objectives

During AMT27 integrated Primary production measurements were made on three size classes of phytoplankton from measurements taken from six or seven depths. These measurements aim to fulfil the following objective:
The main deliverable is to provide an unique time series (1995-2017) 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 AMT27 using methods synonymous to those used in previous AMT cruises.

Methods

Water samples were taken from pre-dawn (04:00-05:30 GMT) deployments of 24 x 20l SeaBird CTD rosette sampler on a stainless steel frame from 6 or 7 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 polycarbonate bottles which are then covered in tin foil; all bottles were pre cleaned following JGOFS protocols (IOC, 1994), to reduce trace metal contamination. Each sample was inoculated with between 185 and 555 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 (appox.12 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%) and from a chiller maintained at ±3°C of in situ temperature for the lower light level incubators (7, 3, 1, 0.1%). To terminate the incubations, suspended material were filtered sequentially through 10µm, 2µm and 0.2µm polycarbonate nucleopore filters to measure the micro, nano and pico-phytoplankton production respectively. The filters were exposed to concentrated HCl fumes for 12 h immersed in scintillation cocktail and ^{14}C disintegration time per minute (DPM) was measured on board using a Perkin Elmer, Tricarb 3180 TR/SL liquid scintillation counter, the external standard and the channel ratio methods were applied to correct for quenching.

Date	time in	CTD	Lat	Long	Depths,m
25/09/2017	04:02	2	47.26888	11.0098	5, 10, 20, 30
26/09/2017	03:57	4	44.85232	14.82792	5, 15, 35, 60, 80, 100
27/09/2017	04:38	6	43.06567	17.49898	5, 15, 30, 45, 60, 75
28/09/2017	04:30	8	40.21745	21.53478	5, 15, 30, 55, 75, 100
30/09/2017	05:37	10	35.31777	26.30035	5, 20, 35, 60, 80, 110
01/10/2017	05:43	13	32.89453	26.8888	5, 30, 50, 90, 120, 150
02/10/2017	05:30	15	29.3116	27.78253	5, 30, 50, 90, 120, 150
03/10/2017	05:33	17	26.02063	28.5885	5, 30, 45, 55, 100, 130, 160
04/10/2017	05:33	20	23.37217	29.20633	5, 25, 45, 65, 85, 110, 150
05/10/2017	05:34	22	19.83833	29.93433	5, 20, 35, 50, 60, 85, 125
06/10/2017	05:33	24	16.5665	29.0855	5, 15, 30, 40, 55, 65, 100
07/10/2017	05:32	26	13.1595	20.2388	5, 15, 35, 45, 55, 125
08/10/2017	05:39	29	10.865	27.6215	5, 15, 30, 40, 50, 100
09/10/2017	05:28	31	7.749533	26.8985	5, 15, 35, 45, 60, 85
10/10/2017	05:30	33	5.043117	26.24632	5, 15, 25, 40, 55, 68, 85

Date	time in	CTD	Lat	Long	Depths,m
12/10/2017	05:40	38	-0.72563	24.93317	5, 10, 15, 25, 30, 40, 80
13/10/2017	05:28	40	-3.53935	24.99385	5, 15, 25, 40, 50, 65, 90
14/10/2017	05:29	42	-6.87017	25.0194	5, 15, 35, 55, 70, 95, 125
15/10/2017	05:28	45	-9.4225	25.02867	5, 30, 50, 65, 85, 113, 150
16/10/2017	05:30	47	-12.6336	25.0292	5, 20, 50, 85, 110, 142, 175
17/10/2017	05:29	49	-15.9609	25.05043	5, 20, 70, 95, 125, 160, 200
19/10/2017	05:28	51	-20.7459	25.06423	5, 15, 45, 75, 100, 125, 170
20/10/2017	05:35	53	-23.9904	24.99867	5, 20, 55, 90, 110, 160, 200
21/10/2017	05:29	55	-27.5502	25.19347	5, 20, 45, 80, 100, 130, 175
22/10/2017	06:28	58	-30.2239	25.76383	5, 15, 40, 70, 90, 115, 150
23/10/2017	05:39	60	-33.1291	26.8416	5, 10, 20, 35, 45, 60, 80
24/10/2017	04:57	62	-35.926	28.00467	5, 15, 35, 60, 75, 100, 125
25/10/2017	05:20	64	-39.3566	29.26865	5, 10, 20, 30, 40, 80
26/10/2017	05:01	66	-41.1792	30.017	5, 10, 15, 25, 30, 80
27/10/2017	05:00	68	-44.2191	31.33615	5, 10, 20, 30, 40, 100
28/10/2017	05:05	70	-47.1241	32.60662	5, 15, 25, 45, 60, 80
29/10/2017	05:05	72	-49.4619	33.72057	5, 10, 15, 20, 40, 80, 125
30/10/2017	04:58	74	-51.9448	35.08383	5, 10, 20, 45, 60, 70
01/11/2017	05:09	76	-53.5507	38.64017	5, 10, 20, 45, 60, 80
02/11/2017	05:04	78	-53.1848	42.4155	5, 10, 15, 30, 40, 60

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ZOOPLANKTON DIVERSITY, ECOLOGY and EVOLUTION

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Overview & Objectives

The plankton team consisted of four members and all were collaborating on research in zooplankton diversity, ecology and evolution with three main research lines ongoing. We include information on all related projects here.

(1) Population genomics and species boundaries
A few of the primary goals of the AMT programme are to provide a means to assess biodiversity trends in relation to environmental change, improve our understanding of the structure and functioning of marine ecosystems, and understand the impact of climate change on the ocean. Our research is related to these efforts in that 1) we aim to assess biodiversity (both at specific and genetic levels) of several important components of pelagic foodwebs (copepods, amphipods, chaetognaths and planktonic gastropods), and 2) the ability of zooplankton to respond to future changes in the ocean depends on the genetic structure of populations over space and time. Planktonic gastropods were a particular taxonomic focus for our work on AMT27.

Our main research objectives on this cruise were to obtain material for studies in:

1. Population genetic structure and gene flow at basin spatial scales in key zooplankton taxa.
2. Assess temporal stability in spatial genetic patterns by repeat transect sampling on AMT.
3. Test hypotheses about mechanisms that underlie genetic breaks known to occur across the transect in a number of key zooplankton species.
4. Assess species boundaries and natural variability in two groups of planktonic gastropods: pteropods and heteropods.

(2) Shell growth and ecophysiological responses to ocean acidification (OA) in pteropods and heteropods
Shelled holoplanktonic gastropods, thecosome pteropods and atlantid heteropods, are predicted to be amongst the first organisms to be affected by anthropogenic ocean acidification. Both groups rely upon delicate aragonite shells and live in the upper ocean, where direct uptake of CO_2 from the atmosphere causes low pH and reduced aragonite saturation. Several experimental studies have shown thecosome pteropods to be negatively affected by high dissolved CO_2 concentrations (pCO_2). The atlantid heteropods have never been included in such experiments before, but a similar response to ocean acidification is anticipated.

Broadly distributed species, such as the euthecosome pteropod *Heliconoides inflatus,* inhabit several oceanographic regions, experiencing a range of water chemistry. This may indicate some level of adaptation to the local environment and a varying tolerance to change. We are investigating this varying resilience using thecosome pteropods and atlantid heteropods along a natural transect of different oceanographic regions.

Our objectives are to :

1. Investigate the calcification response of thecosome pteropod *Heliconoides inflatus* and several heteropod species to varying ocean pCO_2 along the meridional transect.
2. Investigate the calcification rates of shelled pteropod and heteropod species under ambient conditions to determine growth rates and to give insight into the life-span of these organisms.

In addition, seawater was collected to determine $\delta^{18}O$ and $\delta^{13}C_{DIC}$ isotopic composition at different depths to compare with isotopic composition of aragonite shells of planktonic gastropods collected at the same locations.

(3) Zooplankton diversity, distribution, and community structure

Marine zooplankton are the intermediate trophic levels of pelagic marine food webs, and they play an important role in global biogeochemical cycling, facilitating the movement of carbon, nitrogen and phosphorous from the surface ocean into the deep sea. With representatives from 15 animal phyla and > 7,000 species described worldwide, the taxonomic complexity of the assemblage is high. Subtropical gyres contain global maxima in species richness for this assemblage, including many hundreds of species in the epipelagic zone alone. In addition, large-scale genetic studies of zooplanktonic taxa have revealed cryptic species to be common, suggesting that our knowledge of the diversity of the assemblage is incomplete. Here we aim to re-evaluate the diversity of the assemblage across ocean biomes in the Atlantic using a metabarcoding (community amplicon sequencing) approach, with comparisons to conventional morphological identification of key taxonomic groups. We will re-examine latitudinal diversity gradients, and environmental drivers of zooplankton community diversity.

In addition, we have collected material for pilot environmental DNA (eDNA) studies to evaluate the utility of this approach to determine species richness of metazoan communities, with both vertebrate and invertebrate taxa as targets.

Our primary research objectives for this portion of the work are to:

1. Characterize species diversity and abundance of key zooplankton taxa along the transect based on traditional morphological identifications, and compare these with results from previous AMT transects, metabarcoding and eDNA analyses.
2. Characterize species diversity of the zooplankton assemblage across pelagic ecosystems in the Atlantic Ocean using a metabarcoding approach. We aim to quantify the fraction of species that are new to science, and identify taxonomic groups with high levels of undescribed diversity.
3. Examine intraspecific genetic diversity and population structure for a large number of species across the entire Atlantic basin based on a community sequencing effort (metabarcoding), using mitochondrial COI sequence datasets.
4. Complete pilot studies to evaluate diversity and species richness of all metazoans, including vertebrates and invertebrates across all 6 major pelagic biomes in the Atlantic (0-1000m) based on eDNA analyses.

Methods

Sample collection.

Macro- and mesozooplankton samples were collected with 0.71m- diameter bongo nets (200 µm), a 1m- diameter ring net (200 µm), and with an RMT1 midwater trawl (333 µm) that has a nominal mouth area of $1m^2$. A total of 73 zooplankton tows were conducted along the cruise leg (Tables 1, 2), with 33 tows conducted using the bongo, 2 samples collected with the RMT net, and 38 tows (15 stations) for experimental animals conducted using the ring net. The bongo tows were oblique tows that sampled from an average maximum depth of 342 meters (range 233 m- 422 m max depth) and the sea surface. The bongo samples will be used for quantitative estimates of animal abundance along the

cruise leg (target species only); tows were conducted with a LOTEK time-depth-recorder attached and a General Oceanics flowmeter mounted in the mouth of one net. The RMT tows also were oblique tows that sampled between 810 m maximum depth and the surface. The ring net sampled from between 52 and 121 m to the sea surface using slow, short duration (14–25 minute) oblique tows and a closed cod end to ensure the collection of undamaged gastropods for experiments. Most tows were conducted at night, in order to efficiently sample the migratory community.

Sample handling and preservation.
A quantitative 50% split of zooplankton from net 1 of the Bongo tows was preserved immediately in 100% ethyl alcohol for use in molecular and morphological studies (quantitative split, 1 x 50%), including DNA sequencing, micro-CT analysis of shells and estimates of abundance of target species. The second quantitative fraction of net 1 material was fixed in 4% buffered formaldehyde solution to evaluate species diversity of chaetognaths as well as other gelatinous groups that preserve poorly in ETOH. A quantitative split (50%) of the second Bongo net material was size-fractionated at 0.2 mm, 0.5 mm, 1 mm, 2 mm, and > 5 mm and preserved in RNALater for metabarcoding (community amplicon sequencing). The other quantitative fraction of net 2 material was sorted live immediately following collection, and animals were individually identified, and preserved in RNALater or cryopreserved (copepods, pteropods, heteropods, chaetognaths and other taxa). These animals will be used for morphological, molecular, genomic and transcriptomic analyses. In total, over 10,000 animals from > 50 target species were individually sorted and preserved. Following live sorting, the remaining plankton was preserved in 100% ethyl alcohol for further reference.

Experiments.
Twelve ocean acidification and twenty-four growth rate experiments were conducted on target species of thecosome pteropods and atlantid heteropods (Table 3). Experimental specimens were treated with calcein stain prior to all experiments to mark the start of the experiment. For ocean acidification experiments, specimens were placed in 0.2 µm filtered seawater pre-treated with either 795 ppm CO_2 in air, 180 ppm CO_2 in air, or untreated ambient water. All experiments were kept at ambient temperatures (averaged over the upper 200 m of the water column) in the dark for three days. For growth experiments, specimens were introduced into ambient filtered seawater, maintained at ambient temperature and sampled every two to three days until the number of living specimens in the experiment was exhausted. Subsequent analysis of specimens using a fluorescent microscope will allow the determination of growth rates from all experiments.

Seawater sampling from the CTD.
Seawater samples for eDNA studies were obtained from the rosette, typically at the noon CTD cast, from 500m, the DCM (variable depth), and 5m (Table 4). On deep SONIC casts, we were able to obtain samples down to 1000m, with sampling at 1000m, 500m (typically), DCM, and 5m on a total of 11 casts for the cruise. We also collected a full water column series in the south gyre, with bottles at 5000m, 2500m, 1000m, 500m, DCM, and 5m. Seawater volumes filtered were variable across depth, ranging from 6L per replicate at 5000m to 1L per replicate at 5m, with 4-6 replicates from each cast and depth. Negative controls (MilliQ, 2 replicates) were introduced at station 09. Seawater was filtered at 0.2 µm (sterile Supor filters, Pall), filters were flash frozen in liquid N, with storage in liquid N or at -80°C during the cruise. Carboys, plastics, and the workspace were treated with 10% bleach for decontamination prior to each cast (3X MilliQ wash). Carboys, tubing, and filtration rigs were stored overnight in 10% bleach (between stations) to minimize contamination from human DNA and between samples.

Seawater was collected for analyses of isotopic composition ($\delta^{18}O$ and $\delta^{13}C_{DIC}$) from a total of 15 stations and five depths per station along the transect (Table 5).

Science outreach

The zooplankton team ran an online blog about zooplankton diversity and the AMT27 cruise, hosted on the site of Naturalis Biodiversity Center (https://www.naturalis.nl/nl/over-ons/nieuws/blogs/onderzoek/ and science.naturalis.nl/katja-peijnenburg). Katja, Debbie and Lisette together contributed 8 blog posts about their work and experiences on board in Dutch and English. Blogs were also shared via Facebook and Twitter (@Naturalis_Sci). We organised a colouring competition for Dutch schoolchildren with a plankton coloring plate made by Debbie (Fig. 3). The competition is ongoing until Nov 17 (2017), see: https://www.naturalis.nl/nl/kennis/onderzoek/zelf-

ontdekken/plankton-kleurwedstrijd/ and #expeditieplankton and #naturalis. To increase awareness of atlantid heteropods and aid in their identification, Debbie hosts a new online identification portal, see: www.planktonic.org. We aim to widely use and disseminate zooplankton images made on AMT27, as we have done on prior AMT cruises (AMT24).

Table 1. List of all bongo and RMT tows conducted by the plankton team during AMT27. BON_OBL indicates bongo oblique tows (quantitative tows), and RMT tows were non-quantitative collections made down to deep mesopelagic depths (> 500m). Latitude and longitude were recorded at the start of each tow, time is local time. Numbering scheme is ZTB (Zooplankton tows, bongo) – station number – tow number. Ring net tows used to collect experimental animals are listed in Table 2.

	Station	**Latitude**	**Longitude**	**Date**	**Tow type**	**Start time**
1	ZTB_03_01	46° 41.9 N	12° 01.7 W	9/25/17	BON_OBL	11:04
2	ZTB_04_02	44° 52.2018 N	14° 50.13672 W	9/26/17	BON_OBL	3:38
3	RMT1_04_01	44° 48.08 N	14° 51.58 W	9/26/17	RMT1	12:46
4	ZTB_05_03	43° 03.855 N	17° 28.210 W	9/27/17	BON_OBL	3:34
5	ZTB_07_04	40° 14.25084 N	21° 30.74190 W	9/28/17	BON_OBL	3:34
6	ZTB_09_05	35° 18.22698 N	26° 16.85184 W	9/30/17	BON_OBL	3:35
7	ZTB_11_06	32° 52.92534 N	26° 53.94264 W	10/1/17	BON_OBL	3:40
8	ZTB_13_07	29° 18.57258 N	27° 48.09966 W	10/2/17	BON_OBL	3:34
9	ZTB_15_08	26° 0.56850 N	28° 36.11502 W	10/3/17	BON_OBL	3:34
10	ZTB_17_09	23° 21.58716 N	29° 13.333194 W	10/4/17	BON_OBL	3:49
11	ZTB_19_10	19° 49.02358 N	29° 57.21096 W	10/5/17	BON_OBL	3:38
12	ZTB_21_11	16° 33.54366 N	29° 6.24162 W	10/6/17	BON_OBL	3:48
13	ZTB_23_12	13° 8.73762 N	28° 14.81706 W	10/7/17	BON_OBL	3:35
14	ZTB_25_13	10° 50.17242 N	27° 38.36508 W	10/8/17	BON_OBL	3:30
15	ZTB_27_14	7° 46.04650 N	26° 54.41718 W	10/9/17	BON_OBL	3:30
16	ZTB_29_15	5° 3.67506 N	26° 14.99544 W	10/10/17	BON_OBL	3:34
17	ZTB_31_16	2° 30.83274 N	25° 37.38318 W	10/11/17	BON_OBL	3:30
18	ZTB_33_17	0° 42.98598 S	24° 58.00152 W	10/12/17	BON_OBL	3:47
19	RMT1_34_02	1° 47.04366 S	24° 59.23818 W	10/12/17	RMT1	13:37
20	ZTB_35_18	3° 32.37420 S	25° 0.78829 W	10/13/17	BON_OBL	3:30
21	ZTB_37_19	6° 52.21416 S	25° 2.15238 W	10/14/17	BON_OBL	3:30
22	ZTB_39_20	9° 25.36740 S	25° 2.96598 W	10/15/17	BON_OBL	3:32
23	ZTB_41_21	12° 38.05194 S	25° 2.89626 W	10/16/17	BON_OBL	3:32
24	ZTB_43_22	15° 57.68334 S	25° 4.45806 W	10/17/17	BON_OBL	3:31
25	ZTB_45_23	20° 44.896542 S	25° 4.91730 W	10/19/17	BON_OBL	3:27
26	ZTB_47_24	23° 59.90166 S	25° 1.37070 W	10/20/17	BON_OBL	3:43
27	ZTB_49_25	27° 34.62024 S	25° 11.42946 W	10/21/17	BON_OBL	3:33
28	ZTB_51_26	30° 13.44966 S	25° 46.76598 W	10/22/17	BON_OBL	3:32
29	ZTB_55_27	35° 56.59584 S	27° 58.67682 W	10/24/17	BON_OBL	2:06
30	ZTB_57_28	39° 21.425585 S	29° 16.68804 W	10/25/17	BON_OBL	10:13
31	ZTB_58_29	41° 9.57282 S	30° 0.29436 W	10/26/17	BON_OBL	1:55
32	ZTB_60_30	44° 13.69452 S	31° 19.16045 W	10/27/17	BON_OBL	2:12
33	ZTB_63_31	49° 26.62716 S	33° 42.27246 W	10/29/17	BON_OBL	2:02
34	ZTB_65_32	51° 56.48874 S	35° 4.44804 W	10/30/17	BON_OBL	2:05
35	ZTB_67_33	53° 32.81508 S	38° 36.22578 W	11/1/17	BON_OBL	2:15

Table 2. List of all ring net tows conducted to collect experimental animals for OA and growth experiments. Latitude and longitude were recorded at the start of each tow, time is local time. Numbering scheme is ZTR (Zooplankton tows, ring net) – station number – tow number. * denotes net casts where the time-depth recorder was not used. Maximum depth was calculated for these tows using the wire length and towing angle.

Station	Net code	Latitude	Longitude	Date	Start time	Duration (minutes)	Maximum depth (m)
01	ZTR01_01	48° 56.38 N	7° 36.80 W	24/09/17	11:15	24	87
11	ZTR11_02 A	32° 52.47 N	26° 54.45 W	01/10/17	02:37	25	52
	ZTR11_02 B	32° 52.61 N	26° 54.28 W	01/10/17	03:08	20	58
15	ZTR15_03 A	26° 00.22 N	28° 37.70 W	03/10/17	02:38	20	87
	ZTR15_03 B	26° 00.38 N	28° 36.44 W	03/10/17	03:02	21	90
21	ZTR21_04	16° 33.31 N	29° 06.87 W	06/10/17	03:13	21	87*
25	ZTR25_05 A	10° 48.28 N	27° 39.54 W	08/10/17	02:08	18	60
	ZTR25_05 B	10° 48.87 N	27° 39.16 W	08/10/17	02:30	20	83
	ZTR25_05 C	10° 49.34 N	27° 38.87 W	08/10/17	02:58	16	87
29	ZTR29_06 A	05° 04.66 N	26° 15.20 W	10/10/17	01:55	23	121
	ZTR29_06 B	05° 04.42 N	26° 15.14 W	10/10/17	02:21	23	115
	ZTR29_06 C	05° 04.11 N	26° 15.09 W	10/10/17	02:48	22	115
33	ZTR33_07 A	00° 41.37 S	24° 59.89 W	12/10/17	02:26	23	92*
	ZTR33_07 B	00° 42.06 S	24° 59.39 W	12/10/17	02:54	21	92*
41	ZTR41_08 A	12° 38.11 S	25° 03.97 W	16/10/17	01:59	18	79
	ZTR41_08 B	12° 38.09 S	25° 03.68 W	16/10/17	02:20	18	81
	ZTR41_08 C	12° 38.08 S	25° 03.43 W	16/10/17	02:41	18	80
43	ZTR43_09 A	15° 57.72 S	25° 05.31 W	17/10/17	02:29	18	80
	ZTR43_09 B	15° 57.70 S	25° 04.91 W	17/10/17	02:51	18	71
47	ZTR47_10 A	24° 00.36 S	25° 02.96 W	20/10/17	02:30	21	83
	ZTR47_10 B	24° 00.23 S	25° 02.44 W	20/10/17	02:55	19	87*
	ZTR47_10 C	24° 00.10 S	25° 02.00 W	20/10/17	03:16	14	83*
51	ZTR51_11 A	30° 13.56 S	25° 47.90 W	22/10/17	02:07	18	71
	ZTR51_11 B	30° 13.49 S	25° 47.68 W	22/10/17	02:29	17	62
	ZTR51_11 C	30° 13.46 S	25° 47.40 W	22/10/17	02:50	17	75

	ZTR51_11 D	30° 13.46 S	25° 47.12 W	22/10/17	03:10	14	56
55	ZTR55_12 A	35° 58.09 S	27° 56.71 W	24/10/17	00:42	22	95
	ZTR55_12 B	35° 57.68 S	27° 57.23 W	24/10/17	01:08	23	90
	ZTR55_12 C	35° 57.21 S	27° 57.85 W	24/10/17	01:35	22	91
58	ZTR58_13 A	41° 08.07 S	29° 59.37 W	26/10/17	00:38	21	99*
	ZTR58_13 B	41° 08.60 S	29° 59.67 W	26/10/17	01:02	18	99*
	ZTR58_13 C	41° 08.98 S	29° 59.92 W	26/10/17	01:22	22	99*
65	ZTR65_14 A	51° 56.10 S	35° 03.39 W	30/10/17	00:39	22	92*
	ZTR65_14 B	51° 56.24 S	35° 03.63 W	30/10/17	01:05	20	92*
	ZTR65_14 C	51° 56.30 S	35° 03.86 W	30/10/17	01:28	20	88*
67	ZTR67_15 A	53° 32.49 S	38° 53.46 W	01/11/17	00:50	24	113*
	ZTR67_15 B	53 32.58 S	38° 34.33 W	01/11/17	01:15	22	113*
	ZTR67_15 C	53° 32.68 S	38° 35.16 W	01/11/17	01:40	21	116*

Table 3. Overview of all pteropod and heteropod experiments conducted on AMT27.

Net code	Pteropods Ocean acidification	Growth rate	Heteropods Ocean acidification	Growth rate
ZTB_09_05		*Peracle sp.*		*Atlanta selvagensis* *Atlanta rosea*
ZTR_11_02	*Heliconoides inflatus*	*Limacina bulimoides* *Limacina lesueurii*	*Atlanta rosea* *Atlanta selvagensis*	
ZTR_15_03	*Heliconoides inflatus*	*Styliola subula*		*Atlanta selvagensis*
ZTR_25_05	*Heliconoides inflatus*		*Protatlanta sculpta*	
ZTR_29_06	*Heliconoides inflatus*			*Oxygyrus inflatus* *Atlanta selvagensis*
ZTR_33_07	*Heliconoides inflatus*	*Creseis virgula*		*Atlanta selvagensis*
ZTR_41_08	*Heliconoides inflatus*	*Heliconoides inflatus*	*Atlanta helicinoidea* *Atlanta fragilis*	*Atlanta inclinata*
ZTR_43_09	*Heliconoides inflatus*	*Heliconoides inflatus* *Styliola subula*		*Atlanta fragilis*
ZTR_47_10	*Heliconoides inflatus*	*Styliola subula*		
ZTR_51_11	*Heliconoides inflatus*	*Styliola subula*		*Oxygyrus inflatus*
ZTR_55_12		*Heliconoides inflatus* *Limacina helicina*		*Atlanta ariejansseni* *Atlanta fragilis*
ZTR_58_13	*Heliconoides inflatus*	*Limacina retroversa*	*Atlanta ariejansseni*	
ZTR_63_14	*Limacina retroversa*	*Limacina retroversa*		
ZTR_65_15	*Limacina retroversa*			

Table 4. List of stations, CTD casts, bottle numbers, and depths from which seawater was collected for eDNA studies (4-6 replicates per depth and station). Negative controls (2 replicates) were introduced at station 09 (MilliQ, ctrl).

Station #	CTD #	Date	GMT	Latitude	Longitude	Bottle #	Depth (m)
02	02	9/25/17	0402	47° 16.133 N	11° 0.588 W	1	500
02	02	9/25/17	0402	47° 16.133 N	11° 0.588 W	12	30
02	02	9/25/17	0402	47° 16.133 N	11° 0.588 W	21	5
04	04	9/26/17	0357	44° 51.139 N	14° 49.675 W	1	500
04	04	9/26/17	0357	44° 51.139 N	14° 49.675 W	12	60
04	04	9/26/17	0357	44° 51.139 N	14° 49.675 W	21	5
04	05	9/26/17	0933	44° 51.139 N	14° 49.675 W	5	1000
06	07	9/27/17	1248	42° 9.997 N	18° 47.810 W	1	500
06	07	9/27/17	1248	42° 9.997 N	18° 47.810 W	10	60
06	07	9/27/17	1248	42° 9.997 N	18° 47.810 W	23	5
08	09	9/28/17	1209	39° 21.301 N	22° 44.529 W	2	500
08	09	9/28/17	1209	39° 21.301 N	22° 44.529 W	23	5
08	09	9/28/17	1209	39° 21.301 N	22° 44.529 W	9&10	75
09	11	9/30/17	1037	35° 19.06 N	26° 18.02 W	1	1000
09	10	9/30/17	0537	35° 19.06 N	26° 18.02 W	1	500
09	10	9/30/17	0537	35° 19.06 N	26° 18.02 W	10	80
09	10	9/30/17	0537	35° 19.06 N	26° 18.02 W	21	5
09	10	9/30/17	0537	35° 19.06 N	26° 18.02 W	ctrl	MilliQ
12	14	10/1/17	1307	31° 45.761 N	27° 11.183 W	2	500
12	14	10/1/17	1307	31° 45.761 N	27° 11.183 W	10	90
12	14	10/1/17	1307	31° 45.761 N	27° 11.183 W	23/24	5
12	14	10/1/17	1307	31° 45.761 N	27° 11.183 W	ctrl	MilliQ
14	16	10/2/17	1306	28° 11.790 N	28° 4.185 W	2	500
14	16	10/2/17	1306	28° 11.790 N	28° 4.185 W	9	110
14	16	10/2/17	1306	28° 11.790 N	28° 4.185 W	23	5
14	16	10/2/17	1306	28° 11.790 N	28° 4.185 W	ctrl	MilliQ
15	17	10/3/17	0533	26° 1.238 N	28° 35.310 W	1	500
15	18	10/3/17	1008	26° 1.238 N	28° 35.310 W	1	1000
15	17	10/3/17	0533	26° 1.238 N	28° 35.310 W	8	130
15	17	10/3/17	0533	26° 1.238 N	28° 35.310 W	21	5
15	17	10/3/17	0533	26° 1.238 N	28° 35.310 W	ctrl	MilliQ
18	21	10/4/17	1306	22° 15.229 N	29° 28.982 W	2	500
18	21	10/4/17	1306	22° 15.229 N	29° 28.982 W	10	83
18	21	10/4/17	1306	22° 15.229 N	29° 28.982 W	23/24	5
18	21	10/4/17	1306	22° 15.229 N	29° 28.982 W	ctrl	MilliQ
20	23	10/5/17	1301	18° 47.154 N	29° 40.940 W	2	500
20	23	10/5/17	1301	18° 47.154 N	29° 40.940 W	10	82
20	23	10/5/17	1301	18° 47.154 N	29° 40.940 W	23	5
20	23	10/5/17	1301	18° 47.154 N	29° 40.940 W	ctrl	MilliQ
22	25	10/6/17	1303	15° 30.468 N	28° 50.990 W	2	500
22	25	10/6/17	1303	15° 30.468 N	28° 50.990 W	11	68
22	25	10/6/17	1303	15° 30.468 N	28° 50.990 W	23	5
22	25	10/6/17	1303	15° 30.468 N	28° 50.990 W	ctrl	MilliQ

Station #	CTD #	Date	GMT	Latitude	Longitude	Bottle #	Depth (m)
23	27	10/7/17	1000	13° 9.574 N	28° 14.340 W	1	1000
23	27	10/7/17	1000	13° 9.574 N	28° 14.340 W	7	500
23	27	10/7/17	1000	13° 9.574 N	28° 14.340 W	23	60
23	27	10/7/17	1000	13° 9.574 N	28° 14.340 W	24	5
23	27	10/7/17	1000	13° 9.574 N	28° 14.340 W	ctrl	MilliQ
26	30	10/8/17	1303	9° 55.617 N	27° 26.634 W	2	500
26	30	10/8/17	1303	9° 55.617 N	27° 26.634 W	13	52
26	30	10/8/17	1303	9° 55.617 N	27° 26.634 W	22	5
26	30	10/8/17	1303	9° 55.617 N	27° 26.634 W	ctrl	MilliQ
28	32	10/9/17	1302	6° 52.84 N	26° 41.161 W	2	500
28	32	10/9/17	1302	6° 52.84 N	26° 41.161 W	12	60
28	32	10/9/17	1302	6° 52.84 N	26° 41.161 W	22	5
28	32	10/9/17	1302	6° 52.84 N	26° 41.161 W	ctrl	MilliQ
29	34	10/10/17	0959	5° 2.611 N	26° 14.649 W	1	1000
29	34	10/10/17	0959	5° 2.611 N	26° 14.649 W	7	500
29	34	10/10/17	0959	5° 2.611 N	26° 14.649 W	23	70
29	34	10/10/17	0959	5° 2.611 N	26° 14.649 W	24	5
29	34	10/10/17	0959	5° 2.611 N	26° 14.649 W	ctrl	MilliQ
32	37	10/11/17	1305	1° 27.635 N	25° 21.428 W	2	500
32	37	10/11/17	1305	1° 27.635 N	25° 21.428 W	12	77
32	37	10/11/17	1305	1° 27.635 N	25° 21.428 W	23	5
32	37	10/11/17	1305	1° 27.635 N	25° 21.428 W	ctrl	MilliQ
34	39	10/12/17	1307	1° 49.915 S	24° 59.761 W	2	500
34	39	10/12/17	1307	1° 49.915 S	24° 59.761 W	12	75
34	39	10/12/17	1307	1° 49.915 S	24° 59.761 W	23	5
34	39	10/12/17	1307	1° 49.915 S	24° 59.761 W	ctrl	MilliQ
36	41	10/13/17	1312	4° 35.181 S	25° 1.457 W	2	500
36	41	10/13/17	1312	4° 35.181 S	25° 1.457 W	11	85
36	41	10/13/17	1312	4° 35.181 S	25° 1.457 W	23	5
36	41	10/13/17	1312	4° 35.181 S	25° 1.457 W	ctrl	MilliQ
37	43	10/14/17	1010	6° 52.213 S	25° 1.166 W	1	1000
37	43	10/14/17	1010	6° 52.213 S	25° 1.166 W	8	600
37	43	10/14/17	1010	6° 52.213 S	25° 1.166 W	23	95
37	43	10/14/17	1010	6° 52.213 S	25° 1.166 W	24	5
37	43	10/14/17	1010	6° 52.213 S	25° 1.166 W	ctrl	MilliQ
40	46	10/15/17	1306	10° 29.170 S	25° 3.482 W	2	500
40	46	10/15/17	1306	10° 29.170 S	25° 3.482 W	10	115
40	46	10/15/17	1306	10° 29.170 S	25° 3.482 W	23	5
40	46	10/15/17	1306	10° 29.170 S	25° 3.482 W	ctrl	MilliQ
42	48	10/16/17	1302	13° 43.883 S	25° 4.263 W	2	500
42	48	10/16/17	1302	13° 43.883 S	25° 4.263 W	10	120
42	48	10/16/17	1302	13° 43.883 S	25° 4.263 W	23	5
42	48	10/16/17	1302	13° 43.883 S	25° 4.263 W	ctrl	MilliQ
43	49	10/17/17	0529	15° 57.656 S	25° 3.026 W	1	1000
43	49	10/17/17	0529	15° 57.656 S	25° 3.026 W	2	500
43	49	10/17/17	0529	15° 57.656 S	25° 3.026 W	9 & 10	160
43	49	10/17/17	0529	15° 57.656 S	25° 3.026 W	21	5m

Station #	CTD #	Date	GMT	Latitude	Longitude	Bottle #	Depth (m)
43	49	10/17/17	0529	15° 57.656 S	25° 3.026 W	ctrl	MilliQ
43	50	10/17/17	1015	15° 57.656 S	25° 3.026 W	1	5000
43	50	10/17/17	1015	15° 57.656 S	25° 3.026 W	2	5000
43	50	10/17/17	1015	15° 57.656 S	25° 3.026 W	3	2500
43	50	10/17/17	1015	15° 57.656 S	25° 3.026 W	4	2500
46	52	10/19/17	1300	21° 47.980 S	25° 4.129 W	2	500
46	52	10/19/17	1300	21° 47.980 S	25° 4.129 W	10	145
46	52	10/19/17	1300	21° 47.980 S	25° 4.129 W	23	5
46	52	10/19/17	1300	21° 47.980 S	25° 4.129 W	ctrl	MilliQ
48	54	10/20/17	1303	25° 6.221 S	25° 1.885 W	2	500
48	54	10/20/17	1303	25° 6.221 S	25° 1.885 W	9 & 12	133
48	54	10/20/17	1303	25° 6.221 S	25° 1.885 W	23	5m
48	54	10/20/17	1303	25° 6.221 S	25° 1.885 W	ctrl	MilliQ
49	56	10/21/17	1012	27° 33.011 S	25° 11.607 W	1	1000
49	56	10/21/17	1012	27° 33.011 S	25° 11.607 W	12	550
49	56	10/21/17	1012	27° 33.011 S	25° 11.607 W	23	140
49	56	10/21/17	1012	27° 33.011 S	25° 11.607 W	24	5
49	56	10/21/17	1012	27° 33.011 S	25° 11.607 W	ctrl	MilliQ
52	59	10/22/17	1405	31° 18.771 S	26° 11.3442 W	2	500
52	59	10/22/17	1405	31° 18.771 S	26° 11.3442 W	11	130
52	59	10/22/17	1405	31° 18.771 S	26° 11.3442 W	23	5
52	59	10/22/17	1405	31° 18.771 S	26° 11.3442 W	ctrl	MilliQ
54	61	10/23/17	1235	33° 53.096 S	27° 8.872 W	2	500
54	61	10/23/17	1235	33° 53.096 S	27° 8.872 W	12	60
54	61	10/23/17	1235	33° 53.096 S	27° 8.872 W	23	5
54	61	10/23/17	1235	33° 53.096 S	27° 8.872 W	ctrl	MilliQ
56	63	10/24/17	1232	36° 59.622 S	28° 20.340 W	2	500
56	63	10/24/17	1232	36° 59.622 S	28° 20.340 W	14	30
56	63	10/24/17	1232	36° 59.622 S	28° 20.340 W	23	5
56	63	10/24/17	1232	36° 59.622 S	28° 20.340 W	ctrl	MilliQ
57	65	10/25/17	1031	39° 21.40 S	29° 15.62 W	1	1000
57	65	10/25/17	1031	39° 21.40 S	29° 15.62 W	10	500
57	65	10/25/17	1031	39° 21.40 S	29° 15.62 W	19	40
57	65	10/25/17	1031	39° 21.40 S	29° 15.62 W	24	5
57	65	10/25/17	1031	39° 21.40 S	29° 15.62 W	ctrl	MilliQ
59	67	10/26/17	1228	42° 7.743 S	30° 25.023 W	2	500
59	67	10/26/17	1228	42° 7.743 S	30° 25.023 W	13	45
59	67	10/26/17	1228	42° 7.743 S	30° 25.023 W	23	5
59	67	10/26/17	1228	42° 7.743 S	30° 25.023 W	ctrl	MilliQ
61	69	10/27/17	1234	45° 11.359 S	31° 43.993 W	2	500
61	69	10/27/17	1234	45° 11.359 S	31° 43.993 W	12	50
61	69	10/27/17	1234	45° 11.359 S	31° 43.993 W	21	5
61	69	10/27/17	1234	45° 11.359 S	31° 43.993 W	ctrl	MilliQ
62	71	10/28/17	1022	47° 6.083 S	32° 34.379 W	1	1000
62	71	10/28/17	1022	47° 6.083 S	32° 34.379 W	20	60
62	71	10/28/17	1022	47° 6.083 S	32° 34.379 W	24	5
62	71	10/28/17	1022	47° 6.083 S	32° 34.379 W	6	500

Station #	CTD #	Date	GMT	Latitude	Longitude	Bottle #	Depth (m)
62	71	10/28/17	1022	47° 6.083 S	32° 34.379 W	ctrl	MilliQ
64	73	10/29/17	1234	50° 21.441 S	34° 12.238 W	2	500
64	73	10/29/17	1234	50° 21.441 S	34° 12.238 W	14	50
64	73	10/29/17	1234	50° 21.441 S	34° 12.238 W	22	5
64	73	10/29/17	1234	50° 21.441 S	34° 12.238 W	ctrl	MilliQ
66	75	10/30/17	1233	52° 56.310 S	35° 39.557 W	2	500
66	75	10/30/17	1233	52° 56.310 S	35° 39.557 W	14	50
66	75	10/30/17	1233	52° 56.310 S	35° 39.557 W	23	5
66	75	10/30/17	1233	52° 56.310 S	35° 39.557 W	ctrl	MilliQ
67	77	11/1/17	1005	53° 33.294 S	38° 38.650 W	1	1000
67	77	11/1/17	1005	53° 33.294 S	38° 38.650 W	6	500
67	77	11/1/17	1005	53° 33.294 S	38° 38.650 W	19	40
67	77	11/1/17	1005	53° 33.294 S	38° 38.650 W	24	5
67	77	11/1/17	1005	53° 33.294 S	38° 38.650 W	ctrl	MilliQ

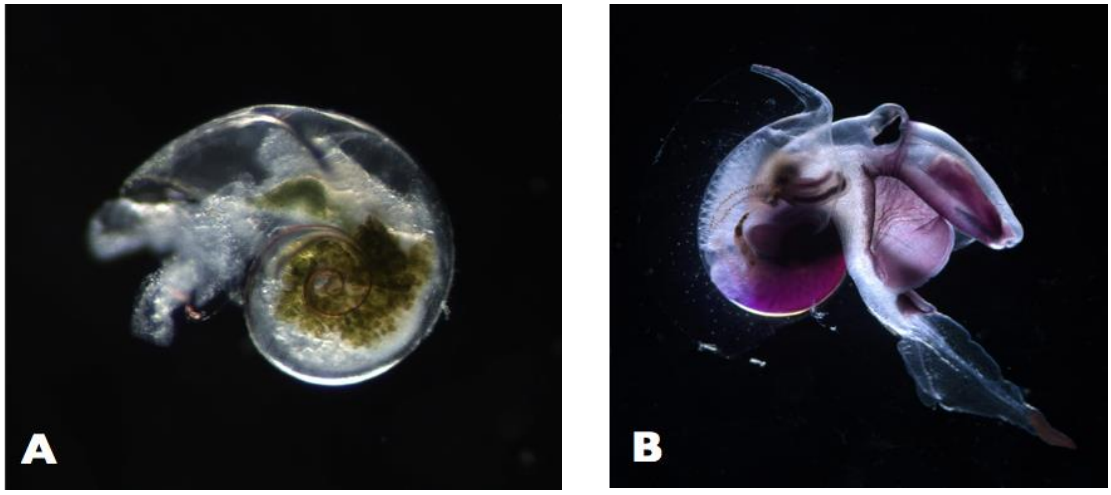
Table 5. List of stations, CTD casts, bottle numbers, and depths from which seawater was collected for isotope studies ($\delta^{18}O$ and $\delta^{13}C_{DIC}$).

Station #	CTD #	Date	Latitude	Longitude	Bottle #	Depth (m)
3	3	25/09/17	46° 41.180' N	12° 0.011' W	4	300
3	3	25/09/17	46° 41.180' N	12° 0.011' W	6	150
3	3	25/09/17	46° 41.180' N	12° 0.011' W	13	35
3	3	25/09/17	46° 41.180' N	12° 0.011' W	16	20
3	3	25/09/17	46° 41.180' N	12° 0.011' W	24	5
7	8	28/09/17	40° 13.047' N	21° 32.087' W	4	300
7	8	28/09/17	40° 13.047' N	21° 32.087' W	6	150
7	8	28/09/17	40° 13.047' N	21° 32.087' W	11	75
7	8	28/09/17	40° 13.047' N	21° 32.087' W	18	20
7	8	28/09/17	40° 13.047' N	21° 32.087' W	24	5
11	13	01/10/17	32° 53.672' N	26° 53.328' W	4	300
11	13	01/10/17	32° 53.672' N	26° 53.328' W	6	150
11	13	01/10/17	32° 53.672' N	26° 53.328' W	9	120
11	13	01/10/17	32° 53.672' N	26° 53.328' W	19	20
11	13	01/10/17	32° 53.672' N	26° 53.328' W	22	5
15	17	03/10/17	26° 1.238' N	28° 35.310' W	4	300
15	17	03/10/17	26° 1.238' N	28° 35.310' W	6	160
15	17	03/10/17	26° 1.238' N	28° 35.310' W	9	130

Station #	CTD #	Date	Latitude	Longitude	Bottle #	Depth (m)
15	17	03/10/17	26° 1.238' N	28° 35.310' W	19	20
15	17	03/10/17	26° 1.238' N	28° 35.310' W	22	5
19	22	05/10/17	19° 50.3' N	29° 56.06' W	4	300
19	22	05/10/17	19° 50.3' N	29° 56.06' W	6	150
19	22	05/10/17	19° 50.3' N	29° 56.06' W	11	85
19	22	05/10/17	19° 50.3' N	29° 56.06' W	24	5
19	22	05/10/17	19° 50.3' N	29° 56.06' W	20	20
23	26	07/10/17	13° 9.570' N	20° 14.328' W	4	300
23	26	07/10/17	13° 9.570' N	20° 14.328' W	6	150
23	26	07/10/17	13° 9.570' N	20° 14.328' W	14	55
23	26	07/10/17	13° 9.570' N	20° 14.328' W	19	20
23	26	07/10/17	13° 9.570' N	20° 14.328' W	24	5
27	31	09/10/17	7° 44.972' N	26° 53.910' W	4	300
27	31	09/10/17	7° 44.972' N	26° 53.910' W	6	150
27	31	09/10/17	7° 44.972' N	26° 53.910' W	12	60
27	31	09/10/17	7° 44.972' N	26° 53.910' W	19	20
27	31	09/10/17	7° 44.972' N	26° 53.910' W	24	5
33	38	12/10/17	0° 43.53' S	24° 55.99' W	4	300
33	38	12/10/17	0° 43.53' S	24° 55.99' W	6	150
33	38	12/10/17	0° 43.53' S	24° 55.99' W	13	40
33	38	12/10/17	0° 43.53' S	24° 55.99' W	19	20
33	38	12/10/17	0° 43.53' S	24° 55.99' W	24	5
39	45	15/10/17	9° 25.35' S	25° 01.72' W	4	300
39	45	15/10/17	9° 25.35' S	25° 01.72' W	6	150
39	45	15/10/17	9° 25.35' S	25° 01.72' W	8	113
39	45	15/10/17	9° 25.35' S	25° 01.72' W	19	20
39	45	15/10/17	9° 25.35' S	25° 01.72' W	22	5
43	49	17/10/17	15° 57.656' S	25° 03.026'W	5	300
43	49	17/10/17	15° 57.656' S	25° 03.026'W	11	160
43	49	17/10/17	15° 57.656' S	25° 03.026'W	15	110
43	49	17/10/17	15° 57.656' S	25° 03.026'W	20	20
43	49	17/10/17	15° 57.656' S	25° 03.026'W	21	5
47	53	20/10/17	23° 59.42' S	24° 59.92' W	4	300
47	53	20/10/17	23° 59.42' S	24° 59.92' W	9	160
47	53	20/10/17	23° 59.42' S	24° 59.92' W	14	130
47	53	20/10/17	23° 59.42' S	24° 59.92' W	21	20
47	53	20/10/17	23° 59.42' S	24° 59.92' W	22	5
51	58	22/10/17	30° 13.43' S	25° 45.83' W	4	300
51	58	22/10/17	30° 13.43' S	25° 45.83' W	7	150

Station #	CTD #	Date	Latitude	Longitude	Bottle #	Depth (m)
51	58	22/10/17	30° 13.43' S	25° 45.83' W	10	115
51	58	22/10/17	30° 13.43' S	25° 45.83' W	20	20
51	58	22/10/17	30° 13.43' S	25° 45.83' W	22	5
55	62	24/10/17	35° 55.56' S	28° 0.28' W	4	300
55	62	24/10/17	35° 55.56' S	28° 0.28' W	7	150
55	62	24/10/17	35° 55.56' S	28° 0.28' W	9	100
55	62	24/10/17	35° 55.56' S	28° 0.28' W	18	20
55	62	24/10/17	35° 55.56' S	28° 0.28' W	21	5
58	66	26/10/17	41° 10.750' S	30° 1.020' W	4	300
58	66	26/10/17	41° 10.750' S	30° 1.020' W	7	150
58	66	26/10/17	41° 10.750' S	30° 1.020' W	14	30
58	66	26/10/17	41° 10.750' S	30° 1.020' W	18	20
58	66	26/10/17	41° 10.750' S	30° 1.020' W	21	5
63	66	29/10/17	41° 10.750' S	30° 1.020' W	4	300
63	66	29/10/17	41° 10.750' S	30° 1.020' W	7	150
63	66	29/10/17	41° 10.750' S	30° 1.020' W	13	40
63	66	29/10/17	41° 10.750' S	30° 1.020' W	18	20
63	66	29/10/17	41° 10.750' S	30° 1.020' W	21	5

Plankton team on AMT27. Left to Right: Lisette Mekkes, Katja Peijnenburg, Debbie Wall-Palmer, Erica Goetze.



A) *Heliconoides inflatus*, a shelled pteropod from the experiments that had clearly been feeding on the algae. B) *Oxygyrus inflatus*, a shelled heteropod species that was also used in one growth experiment. Images from AMT27, made by the plankton team.

Plankton coloring plate drawn by Debbie Wall-Palmer, which was used for a competition for Dutch schoolchildren.

NMF Scientific Ship Systems

Andrew Moore (anmo@noc.ac.uk)
Scientific Ship Systems, NMF, National Oceanography Centre

Cruise overview

Cruise	Departure	Arrival	Technicians
DY084/085	23/09/17 (GBSOU)	05/11/17 (FKPSY)	Andrew Moore (anmo@noc.ac.uk)

Scientific Ship Systems (SSS) is responsible for managing the Ship's network infrastructure, data acquisition, compilation and delivery, the email system and a range of ship-fitted instruments and sensors.

Unless stated otherwise all times in this report are UTC

Scientific Computer Systems

Acquisition

Network drives were setup on the on-board file server; firstly a read-only drive of the ships instruments data and a second scratch drive for the scientific party. Both were combined at the end of the cruise and copied to disks for the PSO and BODC.

Data was logged by the Techsas 5.11 data acquisition system. The system creates NetCDF and ASCII output data files. The format of the data files is given per instrument in the "Data Description" directory:

The Ship-fitted instruments that were logged are listed in the below file (includes BODC/Level-C notes):

'DY084_BODC_ship_fitted_information_sheet_DY.docx'
Cruise Disk Location: ***'DY084/Cruise_Documentation/'***

Data was additionally logged into the legacy RVS Level-C format.
There are ASCII dumps of all the Level-C streams included on the data disk in the directory:

Cruise Disk Location: ***'DY084/Cruise_Documentation/Data_Description_Documents/'***

Cruise Disk Location: ***'DY084/Ship_Fitted_Scientific_Systems /Level-C/enterprise-pro_data/*ascii/'**

Main Acquisition Period

Techsas logging for 'DY084' commenced whilst alongside in GBSOU on 20/09/2017 (J263). Legacy 'Level-C' logging started on 21/09/2017 (J264). Following departure from GBSOU on 23/09/2017 (J266) further acoustic data collection was started.
All logging was concluded 05/11/2017 (J309) at arrival in FKPSY (Falklands).

Events/Data Losses

During the transit between South Georgia and Falklands the Fugro Seastar 9205 (Differential GPS) firmware was updated to investigate the loss of corrections to the Seapath330. This results in an acquisition data gap for the Fugro GPS between 18:14 and 18:34 on 03/11/2017 (J307).

Underway sampling acquisition gaps (from cleaning, etc.) are tabulated in the Surfmet section of this document and may also be found in the event log sheets in the Surfmet directory.

Internet provision
Satellite Communications were provided with both the Vsat and FBB systems. The Vsat had a guaranteed speed of 512kbps unlimited data (and provides 3 on board phone lines to cabins/work areas) and the FBB initially had a maximum un-guaranteed speed of 256kbps with a fair use policy that equates to 15 GB of data a month. On the 3rd Oct the FBB system was transferred to a 20GB monthly plan.
On the day/evening of the 21st October, during the GBSOU mobilisation there was a planned upgrade to the VSAT bandwidth to 1Mbps. This failed and the vessel was left without VSAT communications. The departure was postponed until 0900UTC 23/09/2017 whilst the issue was investigated. The issue was not resolved within this window and the vessel departed with only FBB communication.
The VSAT connection was restored 26/09 1630UTC – with the antenna able to operate in a less-desirable 'point-to-satellite' mode.
During the 29/09 Azores refuelling port call a satellite engineer visited the vessel and was able to restore the system to normal ('step-track') operation.
On 20/09/2017 VSAT communication became very intermittent/non-operational due to shadowing of the VSAT antenna by the vessel's main mast. This was at a position of approx. -25deg 15' lat, -25deg 01' lon. The cause was confirmed by visual inspection of the VSAT dome – which identified the antenna was pointing at the top of the mast at an elevation of 60degrees. The vessel had been on the current course for several days but due to the location of the satellite (approx. at the equator) the previous elevation of the antenna had been greater than 60degrees, meaning the mast did not block the carrier.

Email provision
Email communications were provided via the AMS system (approx. 20scientific party user, 20 marine and technician), whitelisting institute webmail pages and with individuals IMAP clients.

Instrumentation
Position and attitude
GPS and attitude measurement systems were run throughout the cruise.
The ***Applanix POSMV*** system is the vessel's primary GPS system, outputting the position of the ship's common reference point in the gravity meter room. The POSMV is available to be sent to all systems and is repeated around the vessel. The position fixes attitude and gyro data are logged to the Techsas system. True Heave is logged by the Kongsberg EM122 & EM710 systems. This was the position and attitude source that was used by the EM122 during this cruise. This was also the navigation source for the EK60, indicated by the TalkerID 'GP'.
The ***Kongsberg Seapath 300*** system is the vessel's secondary GPS system. It provides an input to the Gravity meter due to the POSMV not having vessel course available in its RMC NMEA message. Position fixes and attitude data are logged to the Techsas system.
The ***CNav 3050*** GPS system is a differential correction service. It provides the Applanix POSMV system with RTCM DGPS corrections (greater than 1m accuracy). The position fixes data are logged to the Techsas system.
The **Fugro Seastar 9205** GPS system is a differential correction service. It provides the Seapath system with RTCM DGPS corrections and is also logged to the Techsas system.

POS/ATT Instrument Events
The Fugro Seastar 9205 differential corrections to the Seapath 330 operated from prior to the cruise departure until 01:45 12/10/2017 when the DGPS input to the Seastar was no longer accepted. This was suspected to be due to the range from any of the RTCM-VBS (land-based) reference stations (>1000km). The European SBAS satellites are also out of range and so unavailable to provide GNSS corrections. However on approach to the Falklands RTCM station (<1000km) the differential correction service did not resume and further investigation is required in order to provide this additional service to the Seapath 330.

Meteorology and sea surface monitoring package
The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port and whilst alongside. Please see the separate information sheet for details of the sensors used and whether calibrations values have been applied:

'DY084_Surfmet_sensor_calibrations.docx'
Cruise Disk Location: ***'DY084/Ship_Fitted_Scientific_Systems/Surfmet/'***

Instrument calibration sheets are also included in this directory:

Underway TSG Sampling

Samples from the ships underway system were collected throughout the cruise. Scans of the underway sample logging sheets are included on the data disk. Samples were taken four times each day at approximately 0800, 1200, 1600 and 2000 (ship-time, not UTC). Salinity was also logged from the underway Seabird 45 sensor at the time the bottle sample was taken.

Fluorometer WS3S-247 is the logged instrument from the start of the cruise until 04/10/2017 13:20. This was replaced for the remainder of the cruise with WS3S-248 (commencing logging at 17:20 04/10/2017) due to a cabling issue (damaged/broken connector pin) identified during the cleaning process. The cable fault had not caused an issue with the data already logged by WS3S-247.

Other events, including cleaning and any observed issues/flow adjustments (e.g. occasions when the transmissometer was noisy) were recorded and scans of these log sheets are also included on the disk in the above 'Surfmet' directory.

Date:	Julian Day:	Time:	Event:	Notes:
04/10/2017	277	13:23	Underway stopped	Cleaning (Trans/Fluo). Broken cable pin identified. WS3S-247 removed.
04/10/2017	277	17:03	Underway started	Fluorometer WS3S-248 is fitted.
13/10/2017	286	13:02	Underway stopped	Cleaning (Trans/Fluo).
13/10/2017	286	13:19	Underway started	
24/10/2017	297	17:45	Underway stopped	Cleaning (Trans/Fluo).
24/10/2017	297	18:10	Underway started	
31/10/2017	304	18:10	Underway stopped	Cleaning (Trans/Fluo/SBE45*).
31/10/2017	304	19:10	Underway started	
01/11/2017	305	10:01	Found with 0 litres/min instrument flow	Adjusted flow to 25litres/min to restore operation (pitching seas). Data affected for several hours before issue identified.

* The SBE45 was installed and tested prior to departure on 23/09/2017 and requires cleaning approximately every month with sustained operation (Advised in Seabird Manual).

Nutrients Sensor

A nutrients sensor (Alison Schaap - NOC) was installed in the underway sampling lab prior to departure from GBSOU and was monitored to ensure there was satisfactory flow in/out of the instrument during the cruise duration. Power was removed when the underway was switched off – primarily during the Azores port call and during sensor cleaning events. This system will continue to be used on the subsequent DY086 cruise.

These events are included in the above log sheets for the underway system.

Kongsberg EA640 10 & 12 kHz Single-beam

The EA640 single-beam echo-sounder was run throughout the cruise on the K-Sync synchronisation unit (as master) with a ping interval of around 8 seconds. Both the 10 and 12kHz transducers were used. There was a period from 24/09 to 26/09 where the system would not produce bottom detections for >1000m, but this was then resolved and the system was able to detect the bottom for all required depths for the remainder of the cruise (<6000m).

The system used a constant sound velocity of 1500 ms^{-1} throughout the water column to allow it to be corrected for sound velocity in post processing if required.

Salinity (35 PSU) and Temperature (10degreeC) and Conditions (salt water) were also left at their initial constant values for the cruise duration.

Kongsberg *.raw files (100MB maximum file size) and *.xyz files are logged and depths were logged to Techsas and Level-C.

ADCP OS 75kHz & 150kHz

75kHz and 150kHz ADCPs were set up in GBSOU on 18/09/2017 with Stephanie Henson (participant of DY086) using standard NMF configuration files. The data alongside was verified by the scientists prior to departure with the requirement to keep ADCP resolution at =<4seconds during the cruise and to switch from bottom-tracking configuration as soon as the depth permits (e.g beyond approx. 800m). Below shows the events for the ADCPs, including when the bottom tracking (BT) was on and off. A ping rate of 2 and 3 seconds was maintained for most of the cruise for the 150kHz and 75kHz respectively:

Date:	Time:	Event:	Notes:
24/09/2017	23:15	Switched off BT, removed from sync	Transition over shelf
29/09/2017	05:48	Changed to bottom tracking (No sync)	Approaching Azores
29/09/2017	07:10	75/150 both switched off	Alongside
29/09/2017	15:40	75/150 both switched on – BT on (No sync)	Departing Azores
29/09/2017	16:25	Switched off BT	Deeper water (1000m)
17/10/2017	11:30	75/150 both switched off	Acoustic release test (5200m CTD)
17/10/2017	12:00	75/150 both switched on	Conclusion of release test
18/10/2017	05:35	75/150 both switched off	Mooring recovery/deployment
18/10/2017	15:15	75/150 both switched on	Conclusion of mooring activities
30/10/2017	19:07	75/150 BT switched on	Near South Georgia (<1000m)
01/11/2017	09:26	75/150 BT switched off, 75 changed to 2sec ensemble ping rate.	Depth 2500m (>1000m overnight)
05/11/2017	17:30	75/150 logging/pinging off	Conclusion of cruise (Falkland Islands)

Cruise Disk Location: ***'DY084/Ship_Fitted_Scientific_Systems/Acoustics/OS75kHz/'*** and **'../OS150kHz'**

Kongsberg EM122 multi-beam echo sounder.

The EM122 multibeam echo-sounder was run throughout the cruise triggered by the K-sync unit.
The position, attitude and velocity data was provided by the Applanix POS-MV.
Surface sound velocity was continuously provided to the system by the AML MicroX-SV sensor installed on the bottom of the drop keel.
The following figures show the system installation configuration. The values are from the ships Parker survey report, which is included on the data disk.

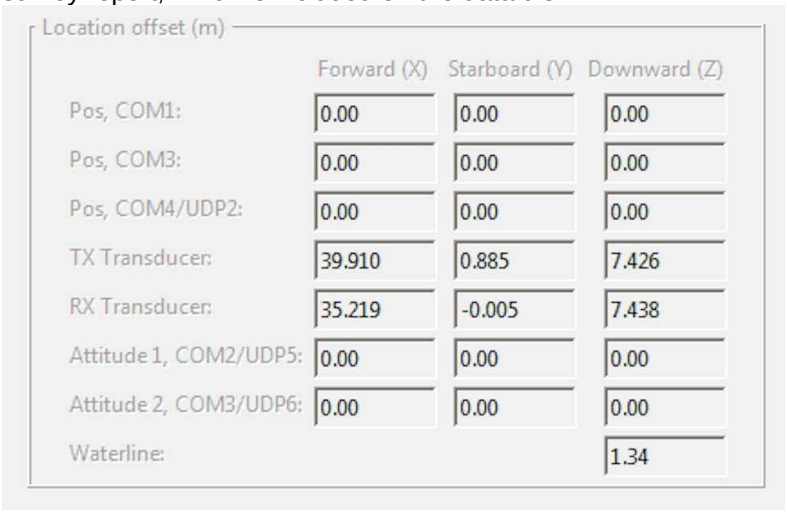


FIGURE 1 - EM120 TRANSDUCER LOCATIONS

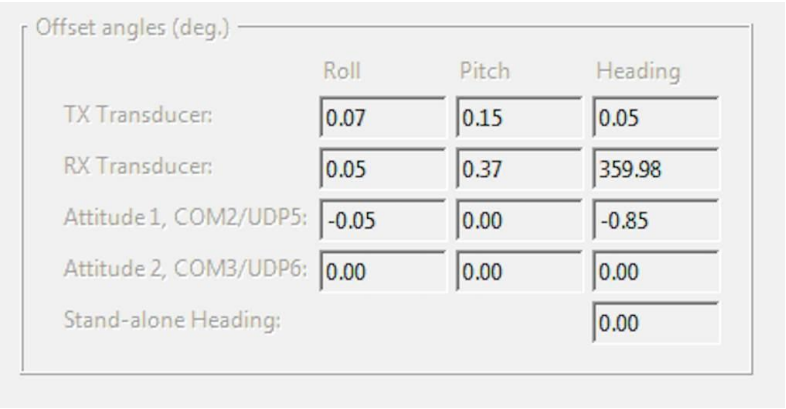
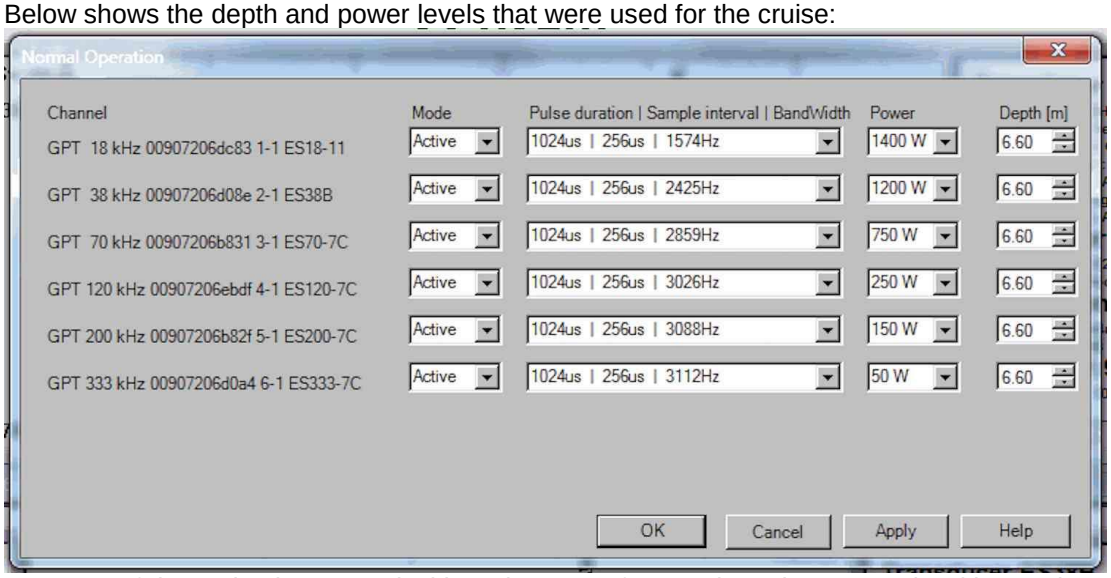


FIGURE 2 - EM120 TRANSDUCER OFFSETS

Cruise Disk Location: ***'DY084\Ship_Fitted_Scientific_Systems\Acoustics*EM122**

Kongsberg EM710 Shallow Multi-beam Echo sounder
The EM710 multibeam echo-sounder was run in the shallow water (<800m) surrounding South Georgia. Data was logged between 19:08 30/10/2017 and 09:26 01/11/2017. Pinging/logging was stopped whilst stationary.
The position, attitude and velocity data was supplied by the Applanix POS-MV.

EK60
The EK60 was run for the duration of the cruise (it will be calibrated during DY086). Prior to the cruise the transducer settings in the software were verified against the manufacturers (SIMRAD) transducer measurements sheets. The system was not calibrated.
The system is mounted on the drop keel. This remained flush (to the vessel Baseline) for the duration of the cruise, and so a depth of 6.60m was applied to the system for all transducers. This value is the depth of the transducer face relative to the water surface (**ref. 164692/D Simrad EK60 Manual**).
Below shows the depth and power levels that were used for the cruise:



For most of the cruise it operated with a ping rate of approximately 7 seconds with raw data to 500m logged. This configuration allowed the 18kHz transducer to detect the bottom in deep (>5000m) water.
At 1120UTC 28/10/2017 changes were made to the set up to demonstrate a greater ping rate – the maximum depth of any transducer was set to 1000m. This resulted in the 18kHz no longer detecting the bottom (depth still approx. 5000m), but with the sampling now at approx. 2 seconds. The raw data

that was logged was increased to 1000m with no reduction in the ping rate. This configuration was run for the remainder of the cruise.

Cruise Disk Location: ***'DY084/Ship_Fitted_Scientific_Systems/Acoustics/EK60'***

Sound velocity profiles
Sound velocity profiles were taken with the MIDAS Valeport SVP SN:41603 (2off profiles collected) and created from processing CTD cast data.

Time	Profile	Notes
20/09/2017	dy080_station1_sorted_thinned.asvp	(DY080) Pre-loaded at start of cruise.
28/09/2017 13:46	28092017_sorted_thinned.asvp (FILE2)	No improvement to SV
01/10/2017 14:30	01102017_sorted_thinned.asvp	-
01/11/2017	20171101_1234_salinity_03500.asvp	Created from CTD cast 77.

Cruise Disk Location: ***'DY084/Ship_Fitted_Scientific_Systems/Acoustics/Sound_Velocity_Profiles/'***

CTD2Met
On request from the PSO, work was completed with Tim Smyth (based onshore at PML) to integrate the 'CTD2MET' program system to automatically send low resolution CTD cast data to the Met Office in 'near-real time'. The data is automatically ingested into global ocean forecast models and feedback was received from the Met Office confirming the positive impact of the new data. Details of this activity can be found in *'DY084-Report-CTD2MET.pdf'* located in the 'Cruise Documentation' directory. Approximately 30 degraded casts were sent successfully between 16/10-02/11/2017. Permission to use this during DY086 was also obtained pending the inclusion of this item in the Data Management Programme during the Cruise Planning process for future cruises.

AirSeaII Gravity Meter
Gravity meter (S-084) was tied in at GBSOU prior to the beginning of the cruise. The instrument was operational during the cruise - running directly from the vessel's 110VAC supply available in the Gravity room.

Included Tie In Information
Lacoste & Romberg Model G land gravity meter serial number G-167 was used for the GBSOU tie-in. The meter's interval factor table is included in the 'Tie_In_Files' directory and referred to on the tie in documentation which is also included (scans and an electronic copy of the calculation).

Cruise Disk Location: ***'DY084/Ship_Fitted_Scientific_Systems/Gravity/tie_in_files'***

S-084 Configuration & Coefficient Information
Configuration information is included in sub-directories of the main Gravity_meter directory – the main meter config files are 'ASII_Hw.ini' and 'ASII_Sw.ini'. The meter coefficient (for converting from Counter Units to milligals is found in the ASII_Hw.ini file as 'Coeff1'.

For S-084 Coeff1 = 0.9967
This data is also included on the individual tie in records. GBSOU tie in information (from 21/09/2017) is included on the disk. There was no post-cruise tie in planned for the conclusion of the cruise, but the intention is to attempt a tie in at Port Stanley FI, using information kindly provided at the cruise conclusion by Rob Larter and Tom Jordan of BAS. This confirmed that access to the WRGN-orig1972 station ACIC 4721-1 in Stanley is unlikely, but local tie should be achievable by other means. Anyone interested in the post-cruise tie in should pursue later cruise reports (DY086 or DY087). The intention

is to operate the instrument until arrival in Punta Arenas (planned as 05/01/2018), when it is required for DY087 and tie in is planned at the available base station.

Gravity Data Files

Gravity data is logged by the Techsas logger in ASCII and NetCDF format (refer to Techsas section for more information) but also included on the disk is the ASCII data that is logged locally on the meter as well as ASCII from the AirSea Laptop that is installed in the gravity meter room.

The AirSeaII Meter data files (*.DAT and *.ENV) can be found in the below location. *.ENV files are environmental data files that are logged at 10-second intervals. *.DAT files are 1-second resolution and contain the gravity data. AirSeaII data format information can be found in the file ***'Air Sea II Manual v2_Oct_2010.pdf'*** located in the Manuals sub-directory of the Gravity_Meter directory.

Cruise Disk Location: ***'DY084\Ship_Fitted_Scientific_Systems\Gravity*****data'**

Wamos Wave Radar

The Wamos wave radar was run throughout the cruise but the system is currently not calibrated and appears to under-read Significant wave height (Hs) when compared to bridge observations. Summary data files (including Hs and Significant wave period, Ts) were transferred to the cruise data disk.

Cruise Disk Location: ***'DY084\Ship_Fitted_Scientific_Systems \Met*****Wamos\'**

“CTD2MET” (DY084/085)

Andrew Moore
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INTRODUCTION
This document describes the implementation of the PML/MetOffice “CTD2MET” near-real time ship-to-shore data transfer of CTD cast data. Section 6 also includes some initial Met Office feedback and example of how the data can immediately have an impact on the ocean forecasting. The data that is emailed is received by the met office **‘ocean.data@metoffice.gov.uk’** and then automatically ingested into the observational network system. The data is then used within the numerical weather prediction models to initialise the next forecast sequence. It is understood that there is about a 6-12 hour window within which data is accepted.
File transfer is minimal, at approximately 6KB for a 5000m cast.

BACKGROUND
A request was made by the PSO (Andy Rees of PML) following the commencement of DY084 (09/2017) for the Scientific Ships Systems Technician to liaise with Tim Smyth (also of PML, on shore during this period) to investigate implementing a system that sends CTD data to the shore (Met Office). The system had previously been set to run on the JCR (BAS) during JR303. This JCR system has been continuously working now since 2014.
Tim Smyth was PSO during that cruise and has been working with the Met Office for the last 5-10 years trying to implement this process on the vessels in the UK research fleet. The objective is to provide CTD data that can be ingested into operational models for use by the National Centre for Ocean Forecasting.

HISTORY AND ORIGIN
The project was originally a collaboration involving the National Centre for Ocean Forecasting (NCOF - which has now changed its name to NPOP) partners. The NPOP partnership is made up of the UK Met Office, NOC, PML and CEFAS. This started over 10 years ago, when the partnership expressed a desire to get research vessel data into the forecasting system. This was seen as especially important when the research vessels were in regions where there are very few observations (such as in the South Atlantic).

DATA MANAGEMENT CONSIDERATIONS
It is considered that the CTD data can be viewed much like an Argo float profile: in that is incredibly useful for forecasting, but that scientifically individual CTD profiles (or Argo float profiles) are not particularly useful on their own scientifically. This is especially the case when considering the degraded resolution of the sent CTD profile. Therefore, whilst this is an additional aspect of data management to be communicated during the cruise planning process, it is hoped that individual PSOs operating on the NMF fleet would not have a problem with the data being sent out, where the only recipient is the UK Met Office numerical weather prediction model, and it is being ingested with hundreds of thousands of other observations (atmosphere, ocean etc.).

DY084 STARTING POINT
A zip file was downloaded from Dropbox, containing the software (developed by Tim Smyth) and instructions from the JCR set up.
Refer to 00README (Appendix A) for the initial explanation/structure of the supplied files. The following sections explore the different elements of the software/installation.

SYSTEM COMPONENTS
MAIN CTD2MET SOFTWARE ELEMENTS
The main software components of the system are briefly explained below. The package was provided by Tim Smyth of PML and modified to work on a CTD Workstation and Linux Virtual machine both on the RRS Discovery network. Refer to Appendix A for the overview directly from the ‘00README’ file in the initial package provided. This allowed the system flow to be understood and fitted to the Discovery network/operations.

• **'met_office.tsa'** – this file (renamed from JR_met_office.tsa) is the template used on the CTD workstation (Slave station) to process the raw CTD data and output the converted file (e.g. DY084_049_met.cnv/ros) to the network 'W:' directory.
Package File Location: '…/NCOF/SeaSave/'

o Operational File Location: (Mount share: *discofs**SANDM* as W: on CTD workstation – this is done as a standard part of the CTD setup)
'W:/CTD2MET/SeaSave'
o On the JCR version SeaSave batch operations are used (run from the command line) to convert the files. However on the DY the operator runs the Seasave ! DataCnv program to produce the files above.

• **ctd2met.sh** – is a script on the VM (located in the main 'NCOF' directory) that firstly identifies if there is a new '*_met.cnv' file (from above). If so, 'ctd2met.c' is called, and then the resulting ascii file is emailed to the list of addresses within the script.

o Package File Location: '…/NCOF'
o Operational File Location: '/home/rvs/ctd2met/NCOF' (on the Linux/Centos 7 Virtual machine 'ctd2met.discovery.local')
o This file contains path information for locating Raw CTD Data within the SANDM shared network location. This directory is '/mnt/CTD2MET' and so requires the correct mounting of the network share.
o The script will also write to a logfile ('…/NCOF/log') for each instance it is run. The cron job is set to delete this logfile (ctd2met.log) at the end of each day.

• **ctd2met.c** – This c code takes a '.cnv' file that is in the format defined in Appendix A, and extracts salinity and temperature data at defined intervals for different dbar ranges (also defined in Appendix A)

o Package Location: '…/NCOF/bin'
o Operational File Location: '/home/rvs/ctd2met/NCOF/bin' (on the Linux/Centos 7 Virtual machine 'ctd2met.discovery.local').
o Un-compiled code may be found in '…/NCOF/src'
o Operational File Location*:* 'home/rvs/cdt2met/NCOF' *(on VM 'ctd2met.discovery.local')*

• **Crontab Directory** – this directory contains information for installing a crontab that will run the 'ctd2met.sh' script every hour, and delete the logfile (ctd2met.log) every day.

o Package Location: '…/NCOF/cron'
o Operational File Location: '/home/rvs/ctd2met/NCOF/cron' (on the Linux/Centos 7 Virtual machine 'ctd2met.discovery.local').
o 'crontab -l' to view the current installed crontab.
o 'crontab -e' to edit, '–r' to disable.

• **Output Directory** – this directory contains all the files that have been created on the VM from the running of the 'ctd2met.sh/c' programs

o Package Location: '…/NCOF/output'
o Operational File Location: '/home/rvs/ctd2met/NCOF/output' (on the Linux/Centos 7 Virtual machine 'ctd2met.discovery.local').
o Example of the files created (and then emailed 'Discovery_YYMMDD_HHMMSS.tem'. A 500m cast has a file size of approx. 2KB, a 5km cast has a size of approx. 6KB.

NMF-SSS VIRTUAL MACHINE
Most of the 'ctd2met' software is on the Centos 7 Virtual Machine hosted on the ships VMWare infrastructure.

The installation OS was made using the file: 'CentOS-7-x86_64-Everything-1511.iso' which was uploaded to the VMware Datastore. The VM installation had been made with settings of: 1CPU, 2048MB memory, 200GB storage.
A static DNS entry was added to the ships system for this VM:
ctd2met.discovery.local 192.168.62.57
Note: The two networked CTD workstations 'ctd1' and 'ctd2' are both on static DNS addresses of 62.58 and 62.59 respectively.

NETWORK SETTINGS
After initial power up of the VM, the Centos IPv4 'Wired' Network Settings were changed to the below:
Addresses: Manual DNS: Automatic/ON
Address: 192.168.62.57 Server: 192.168.62.1
Netmask: 255.255.255.0 Gateway: 192.168.62.1

CTD2MET INSTALLATION
The (original/JCR) zip file was placed into '/home/rvs/ctd2met' and unzipped to create the remaining file structure explained in the previous section.
'/home/rvs/ctd2met/NCOF'

NTP CLOCK
Adding the ship NTP clock to the 'ctd2met' VM and also setting it to UTC can be completed as below:
yum install ntp
timedatectl set-timezone UTC
timedatectl list-timezones (for reference: displays all available time zones)
The ntp.conf file was modified to point to the ships NTP Timeserver (for the DY this is 192.168.62.221, times.discovery.local):
nano /etc/ntp.conf
• Added *'server times.discovery.local iburst'* to line 3 of file.
• Commented out the 0-3 centos public servers lines further through the file.
systemctl enable ntpd
systemctl start ntpd (to enable and run the NTP settings)
ntpstat (returns information on the NTP Server being used, and the time period within which the clock is now set.
ntpq –p (can also be used to see the server used, and delay/offset/jitter)
date (returns date/time including timezone)

MOUNTING OF NETWORK SHARE
In order to check for any new raw CTD data files (generated using the 'met_office.psa' template in SeaSave) the ctd2met VM requires connection to the network. This can be mounted using the following command:

CTD Processing Steps – Manual Input

sudo mount –t cifs –o username=rvs //discofs/sandm /mnt
The network share 'SANDM' will then be accessible from /mnt.

SHIP NETWORK SHARES
As mentioned previously the successful operation of the ctd2met operation requires a specific share to the location of the '*_met.cnv' processed data files.
The Sensors & Moorings group use a network share 'SANDM' on the main fileserver. This can normally be mapped with '\\discofs\SANDM'. A directory was made called 'CTD2MET' in this share – this is where the '*_met.cnv' output file from Seasave should be saved to following the completion of a CTD cast and processing. This is explained in the following section.

CTD PROCESSING STEPS – MANUAL INPUT
Whilst most of the process is automated and just requires monitoring (i.e. to confirm the VM is

running, and has the SANDM share mounted), the first step following a completed cast must be manually run. This then initiates the process, so without this first step there is no 'near real time' data transfer.

SIGNIFICANCE OF NEAR-REAL TIME

The data that is emailed is received by the met office **'ocean.data@metoffice.gov.uk'** and then is automatically ingested into the observational network system. The data is then used within the numerical weather prediction models to initialise the next forecast sequence. It is understood that there is about a 6-12 hour window within which data is accepted.
The following section explains the steps required to complete the manual post-cast operation:

SEASAVE PROCESSING

Notes for Local Operations Required to Produce CTD2MET Data
==========
The network directory (W:/CTD2MET) is for all 'Near-Real Time' CTD2MET files that are created following a CTD cast.

CTD Processing Steps – Manual Input

The only local operation required is to use Seasave DataCnv to create cnv/ros files which are in the format required by the Met Office/Tim Smyth(PML). It is recommended that the slave CTD station be networked and used for this operation, as this avoids having to change any processing settings that may be being used for the cruise-specific agreed processing.
The file format is defined in the 'met_office.psa' file located in 'W:/CTD2MET/Seasave'.
It should be noted that W: is the mapping of the 'SANDM' network location on the discofs server onto the CTD Windows station. This is the mapping that is already used for copying data onto the network.
Above image shows the empty network location and the correctly configured Data Conversion, ready for
'Start Process' to be clicked.
CTD Processing Steps – Manual Input
Page 10 of 16 *NMF*
Detailed image of 'Data Conversion' of the Raw CTD data file 'DY084_038.hex' (Steps explained below)
After opening Seasave —> 'Run' —> 'Data Conversion' perform the following steps:
1) Program setup file:
Click 'Open…' and point to 'W:\CTD2MET\Seasave\met_office.psa'
2) Instrument configuration file:
Point to the current cruise xmlcon file, for example:-
W:\DY084\CTD\Data\Seasave_Setup_Files\DY084_SS.xmlcon
3) Input directory
Point to current cruise Raw Data Directory, for example: -
W:\DY084\CTD\Data\CTD Raw Data
For 'Input files'. 'Select' the most recent cast that has just been completed.
CTD Processing Steps – Manual Input
Page 11 of 16 *NMF*
ie. 'DY084_40.hex'
4) Output Directory:
Ensure the output directory is always 'W:\CTD2MET'. The program may want you to point somewhere else, but all outputted ctd2met files go here so the Virtual Machine elsewhere on the network can identify there are new files to be processed and emailed to the met office.
5) Note 'Name append' is '_met'.
6) Click 'Start Process'. Once complete you should now see two files (cnv/ros) with '_met' in their filenames, appear in the defined output directory.
7) Local process is now complete. No other user input is required as standard - The Virtual Machine 'ctd2met.discovery.local' will now collect any new files (<1hour since creation) and produce a small (approx. 2KB) file to send to the met office. This action is completed on the hour if applicable.
*Above image shows the newly created *.cnv/ros files generated from the Data Conversion processing.*

CONCLUSION

This report outlines how the existing software provided by Tim Smyth of PML was integrated to operate on the RRS Discovery during DY084/085. The main difference between this and the JCR is that it was decided not to adapt/use the Seasave batch command line processing option to create the initial *.cnv, and instead manually run the Seasave Data Converter software. Following this activity it is considered that to implement this onto the RRS James Cook should be relatively straight forward to reproduce and so is a recommended action to undertake as soon as possible.

RESULTS
The below feedback and associated images show an example of the initial use and impact that the data sent during the first week has had on the ocean forecast models.

From: "Carse, Fiona" <fiona.carse@metoffice.gov.uk>
Subject: **FW: DY084_085 - AMT27 - Met Office data**
Date: 24 October 2017 11:26:54 BST
To: "Moore, Andrew S." <anmo@noc.ac.uk>, 'Andy Rees' <APRE@pml.ac.uk>, "Tim, Smyth" <TJSM@pml.ac.uk>
Cc: "Turton, Jon" <jon.turton@metoffice.gov.uk>
Hi everyone,
Rob King has pulled out some plots and stats from our global ocean forecast model, I thought you'd like to see them.
In the profile plot, you can see there are some noticeable differences in salinity near the surface (PSAL), and
temperature in the deepest water (POTM), so your observations will definitely be giving the model a nudge in the
right direction!
Cheers,
Fiona

-----Original Message-----
From: King, Robert R
Sent: 24 October 2017 11:10
To: Carse, Fiona <fiona.carse@metoffice.gov.uk>
Subject: RE: DY084_085 - AMT27 - Met Office data
Hi Fiona,
There have been 10 temperature and salinity profiles from Discovery assimilated into global FOAM recently (obs
from 20171016T0526 - 20171023T0534, 8 profiles go down to 500m, 1 to 1000m, and 1 to 5000m). There are a
similar number of observations in the day-2 and day-1 analyses, so it looks like they are coming in good time.
I've attached a map showing the profile positions, and a plot of the obs-bkg for the deep profile.
Cheers,
Rob

APPENDIX A
'00README' document contents found in the NCOF Directory of the initial unzipped CTD2MET structure (sent by Tim Smyth):
Description of the automated CTD send to the Met Office
==========
One of the major concerns of the National Centre for Ocean Forecasting was the lack of CTD data from the UK Research Vessel Fleet. These data would prove useful for ingest into operational models, especially in regions which are data sparse. This code has been written to address this need.
Code description
==========
Version 1: Developed on D325 (11/2007) and D338 (05/2009) by TJS
Version 2: Developed on JR303 (10/2014) by TJS and interfaced with
BAS automated systems with JR, ST and JW.
src/ctd2met.c

This C code takes as input a CTD data '.cnv' file. There are a few
things
in the header that are required:
* NMEA Latitude = dd mm.mm N(S)
* NMEA Longitude = ddd mm.mm W(E)
* NMEA UTC (Time) = MMM dd yyyy hh:MM:ss
* Station:
END
The required fields for the correct operation of the code are (in
order)
name 0 = timeS: Time, Elapsed [seconds]
name 1 = depSM: Depth [salt water, m]
name 2 = prDM: Pressure, Digiquartz [db]
name 3 = t090C: Temperature [ITS-90, deg C]
name 4 = t190C: Temperature, 2 [ITS-90, deg C]
name 5 = c0S/m: Conductivity [S/m]
name 6 = c1S/m: Conductivity, 2 [S/m]
name 7 = sal00: Salinity, Practical [PSU]
name 8 = sal11: Salinity, Practical, 2 [PSU]
together with a flag (field 10).
This format is produced using the JR_met_office_cnv.psa template
file in conjuction with the DOS command file SEASAVEV7_SVP.CMD run
on the CTD logging machine. As part of the automatic processing,
the DOS script dumps the CTD cnv file (with suffix _met) onto the
unix system.
This is automatically produced every time the CTD operator issues
the DOS command SEASAVEV7_SVP.CMD.
The crontab, running as user soc on jrlc, has the shell script
ctd2met.sh called within it. The crontab commands are found in
crontab/crontab.ncof. This is run every hour and the script looks
for files that are newer than 60 minutes in the
/data/cruise/jcr/current/ctd directory. If the script finds one it
executes bin/ctd2met which formats the data and performs the
automated email send.
The code extracts the salinity and temperature data at the following
levels:
* 2 dbar intervals to 10 dbar
* 5 dbar intervals to 50 dbar
* 10 dbar intervals to 100 dbar
* 20 dbar intervals to 200 dbar
* 50 dbar intervals to 1000 dbar
* 100 dbar intervals to max depth (1500 dbar)
and prints them out together with a time stamp (decimal hours), day,
month,
year, station, latitude, longitude, station number (this is returned
as 001 if
no station ID is found).
The full header is:
Time(GMT), Day, Month, Year, Latitude, Longitude, Station Number,
Depth(db), Temperature (degC), Salinity
To compile the code type (in the NCOF directory):
gcc -o bin/ctd2met src/ctd2met.c -lm
and put the executable into the bin directory.
For more details about the formatting and other issues see the
source code.
ctd2met.sh

This is a UNIX bash shell wrapper which picks up the necessary ascii
files and
puts the data into a file ready for send off. The data are emailed

to:
ocean.data@metoffice.gov.uk
The script looks in the Data directory for data files for files
newer than 60 minutes old and if there are any (accepts multiple)
then processes them. The output is redirected to the output
directory.
crontab directory

The crontab.ncof file can be easily edited using vi or other and
then installed in the crontab using the command:
crontab crontab.ncof
The crontab can be disabled using the command
crontab -r
example_input/JR303_061met.cnv

This is an example file showing the format of data required for
input.

Tim Smyth 27/10/2014 (tjsm@pml.ac.uk) - JR303 (AMT24)

SOG Mooring Turnaround

Dave Childs
NMFSS, National Oceanography Centre

Introduction

All echo sounders were switched off or put into passive mode during acoustic interrogation of the acoustic releases to avoid any interference. In addition to this, the bridge was asked to isolate the thrusters to further reduce the risk of interference.

To communicate with the releases an Ixsea TT801 deck unit was used; this was fitted at the start of the cruse to the desk in the main lab, and connected up to the ship's fitted transducers.

A double barrel winch system was used for both mooring recovers and subsequent deployment and this consisted of a deck mounted double barrel winch, a control console, a reeling winch with either a recovery drum or the deployment drum fitted.

Recovery of the mooring took place first, with the aim of turning the mooring around as quickly as possible and going straight into re deployment.

Recovery

Recovery operation's started at first light on the morning of Wednesday the 18th of October 2017, at a position of 18°32.697' S, 25°05.875' W. Once on station and with permission from the bridge, the acoustic release was interrogated with the Arm + Diagnostic command. No reliable response from the release was received, and this remained the case after several attempts. Again, with permission from the bridge, the decision was made to send an Arm + Release command and hope the release received it and released itself from the anchor.

Unfortunately, no response was received that could be considered genuine, so a spare deck unit and an over the side transducer was used to see if a response could be received. This however failed to produce anything reliable either, so the decision was made to move the ship a few hundred meters in a different direction to see if this would help.

Despite our best efforts no reliable communication from the release was received, however a call from the bridge to say that they had a visual on the top set of buoyancy of the mooring confirmed that the release command had worked, and we could then continue with the recovery.

After both sediment traps and current meters had been recovered, 2000m of rope remained before the next set of glass, during the recovery of this it should have been possible to see the glass on the surface; however this was not the case, leading us to think that some of the lower glass had imploded. Upon completion of the mooring recovery it was found that the bottom pack of 10 glass spheres had all imploded.

All instrumentation was washed in fresh water and dried then brought into the lab for data downloading and processing. Both sediment traps had operated as expected, as had the two current meters which both had full data sets. Unfortunately, the SBE 37 microcat had stopped logging due to a low voltage warning, suspected due to the short sampling time of 30 seconds which the instrument was found to be set to.

Deployment

Once the deck had been cleared of all recovered mooring instrumentation and hardware, preparations for deployment took place. During this time the vessel relocated and got set up to allow a small run in to the intended deployment site.

On the reeling winch the deployment drum was fitted, glass buoyancy packages were lined up along the deck, instrumentation was brought from the lab and hanger onto the deck. Beacons were fitted to the Billings float and switched on, and the first section of chain and rope was connected.

Once permission from the bridge had been given, deployment commenced with the lowering of the recovery float and polyprop rope, followed by the Billings. Glass and Sediment Traps were attached at the correct breaks in the mooring line by the use of a shackle – link – shackle and then lifted up with the ships crane before being paid out from the winch.

After the last set of glass had been paid out, the release was connected to the mooring line and to the anchor, this being an 850kg clump weight. Using a quick release and the ships crane the anchor was lifted, slewed outboard and then released at 13:42 GMT at a location of 18°32.700' S, 25°04.800' W.

A series of release Arm + Arm codes were issued using the TT801 deck unit and the ships transducer to verify that the mooring was descending as expected and was continuously monitored until it was decided the anchor had landed on the seabed at 14:52 GMT.

Both mooring recovery and mooring deployment diagrams are shown below detailing instrumentation, mooring buoyancy and recovery and deployment locations and depths.

Instrument Configurations

The following shows the set-up of the upper Nortek current meter:

```
============================================================
Deployment SOG_A
Current time 18/10/2017 05:16:25
Start at 18/10/2017 05:15:54
Comment SOG 2017 TRAP A
------------------------------------------------------------
Measurement interval (s) 1800
Average interval (s) 60
Blanking distance (m) 0.50
Measurement load (%) 4
Power level HIGH
Diagnostics interval (min) 720:00
Diagnostics samples 20
Compass upd. Rate (s) 1
Coordinate System ENU
Speed of sound (m/s) MEASURED
Salinity (ppt) 35
Analog input 1 NONE
Analog input 2 NONE
Analog input power out DISABLED
Raw magnetometer out OFF
File wrapping OFF
TellTale OFF
AcousticModem OFF
Serial output OFF
Baud rate 9600
------------------------------------------------------------
Assumed duration (days) 550.0
Battery utilization (%) 89.0
Battery level (V) 13.8
Recorder size (MB) 9
Recorder free space (MB) 8.973
Memory required (MB) 2.0
Vertical vel. prec (cm/s) 1.4
Horizon. vel. prec (cm/s) 0.9
------------------------------------------------------------
Instrument ID AQD13585
Head ID A6L 8337
Firmware version 3.39
------------------------------------------------------------
Aquadopp Deep Water Version 1.40.14
Copyright (C) Nortek AS
============================================================
```

The following shows the set-up of the lower Nortek current meter:

```
============================================================
Deployment SOG_B
Current time 18/10/2017 05:20:48
Start at 18/10/2017 05:20:25
Comment SOG 2017 TRAP B
------------------------------------------------------------
Measurement interval l(s) 1800
Average interval (s) 60
Blanking distance (m) 0.50
Measurement load (%) 4
Power level HIGH
Diagnostics interval (min) 720:00
Diagnostics samples 20
Compass upd. Rate (s) 1
```

Coordinate System ENU
Speed of sound (m/s) MEASURED
Salinity (ppt) 35
Analog input 1 NONE
Analog input 2 NONE
Analog input power out DISABLED
Raw magnetometer out OFF
File wrapping OFF
TellTale OFF
AcousticModem OFF
Serial output OFF
Baud rate 9600

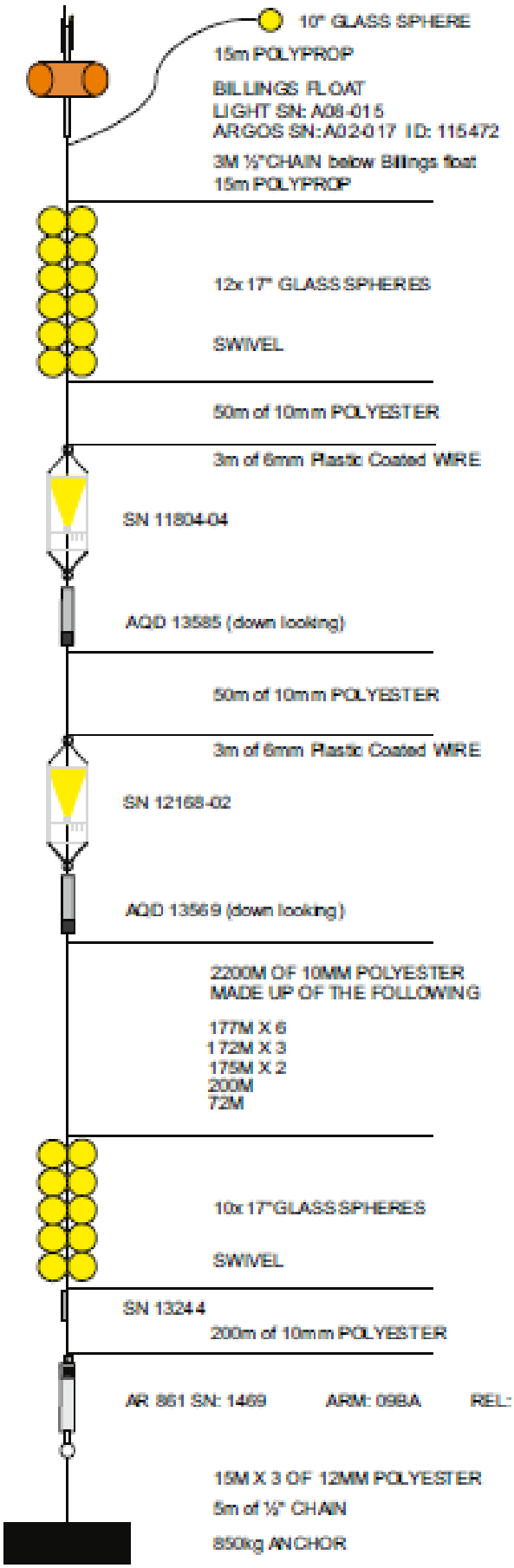
Assumed duration (days) 550.0
Battery utilization (%) 89.0
Battery level (V) 13.7
Recorder size (MB) 9
Recorder free space (MB) 8.973
Memory required (MB) 2.0
Vertical vel. prec (cm/s) 1.4
Horizon. vel. prec (cm/s) 0.9

Instrument ID AQD13569
Head ID A6L 8332
Firmware version 3.39

Aquadopp Deep Water Version 1.40.14
Copyright (C) Nortek AS
==========
The following shows the setup-up of the SBE 37 microcat:
ds
SBE37SM-RS232 v4.1 SERIAL NO. 13244 18 Oct 2017 04:52:52
vMain = 13.50, vLith = 2.81
samplenumber = 0, free = 559240
not logging, stop command
sample interval = 3600 seconds
data format = converted engineering
transmit real-time = yes
sync mode = no
pump installed = yes, minimum conductivity frequency = 2971.5
<Executed/>
startnow
<!--start logging at = 18 Oct 2017 05:53:08, sample interval = 3600 seconds-->
<Executed/>
<Executed/>
ds
SBE37SM-RS232 v4.1 SERIAL NO. 13244 18 Oct 2017 04:53:43
vMain = 13.48, vLith = 2.81
samplenumber = 0, free = 559240
logging
sample interval = 3600 seconds
data format = converted engineering
transmit real-time = yes
sync mode = no
pump installed = yes, minimum conductivity frequency = 2971.5
<Executed/>

SOG
AS DEPLOYED
2017

Release Position:
18°32.700' S
25°04.800' W



Appendix 1 – Underway Sampling Log

Sample ID	Date and Time (UT)	Lat (+ve N)	Lon (+ve E)	TSG Salinity (PSU)	Remote Temp (deg C)	Trans (%)	Chl (ug/L)	Seafloor Depth (m)	Salinity Bottle	Salinity Crate	Bench Salinity	Comments
	20/09/2017 08:45	50.89	-1.39									Underway switched on
UW_AA	24/09/2017 08:45	49.03	-7.30	35.2334	16.0808	88.3297	0.96	0.00	97	4	33.2825	Ship time GMT +1
UW_AB	24/09/2017 12:12	48.92	-7.63	35.2598	16.1323	88.0597	0.85	101.44	98	4	33.3913	
UW_AC	24/09/2017 13:00	48.87	-7.80	35.2626	16.2020	85.5727	0.62	117.82	99	4	35.3533	
UW_AD	24/09/2017 17:15	48.38	-8.79	35.3829	15.8034	86.6485	1.56	183.88				
UW_Salinity	24/09/2017 17:29	48.35	-8.84	35.3779	15.7510	85.8994	1.64	180.15	100	4	35.5245	
UW_AE	24/09/2017 21:00	47.93	-9.66	35.4859	16.6079	86.8881	1.64	516.88	101	4	35.5473	
UW_AF	25/09/2017 07:00	47.06	-11.41	35.5140	16.7629	88.3754	1.43	905.33	102	4	35.5428	
UW_AG	25/09/2017 11:00	46.69	-12.01	35.5620	17.5866	88.9177	0.41	902.97				
UW_Salinity	25/09/2017 11:03	46.69	-12.01	35.5613	17.6032	88.9503	0.41	902.86	103	4	35.5969	
UW_AH	25/09/2017 15:01	46.47	-12.39		17.8464	88.1903	1.78	902.91				
UW_Salinity	25/09/2017 15:06	46.46	-12.41	35.5911	17.8863	88.9438	0.35	902.87	104	4	35.5903	
UW_AI	25/09/2017 19:04	45.90	-13.30	35.6541	18.6497	89.5949	0.35	914.51				
UW_Salinity	25/09/2017 19:05	45.89	-13.31	35.6536	18.6456	89.5928	0.35	902.93	105	4	35.7112	
UW_Salinity	26/09/2017 07:00	44.85	-14.83	35.7880	19.1864	90.4595	0.30	732.86	106	4	35.8525	
UW_Salinity	26/09/2017 11:05	44.85	-14.83	35.7641	18.9024	90.4290	0.34	4148.01	107	4	35.7792	
UW_Salinity	26/09/2017 15:05	44.71	-14.98	35.6458	18.4264	88.9852	0.34	4833.33	108	4	35.6353	
UW_Salinity	26/09/2017 19:19	44.17	-15.79	35.8980	20.1929	90.2831	0.18	5376.09	109	4	35.952	
UW_Salinity	27/09/2017 12:00	42.17	-18.80	35.9134	20.7916	91.0584	0.17	4684.15	110	4	35.9419	
Optics Underway 01	27/09/2017 13:00	42.17	-18.80	35.8814	20.8190	90.1328	0.13	4683.49				
UW_Salinity	27/09/2017 17:02	41.71	-19.47	35.8742	21.2609	91.9077	0.13	4250.74	111	4	35.925	
UW_Salinity	27/09/2017 20:00	41.29	-20.07	35.9050	21.0735	91.3916	0.14	3003.08	112	4	35.9346	
UW_Salinity	28/09/2017 08:00	39.90	-22.01	35.9655	21.8248	92.5479	0.13	3953.23	113	4	35.9853	
UW_Salinity	28/09/2017 12:05	39.36	-22.74	36.0205	22.3002	92.4020	0.09	4134.05	114	4	36.0539	
Optics Underway 02	28/09/2017 12:49	39.36	-22.74	36.0471	22.3483	92.0492	0.09	4134.43				
UW_Salinity	28/09/2017 15:59	39.09	-23.08	36.0146	22.7328	92.2343	0.09	3933.49	115	4	36.0583	
	28/09/2017 10:00	39.61	-22.39									Underway switched at Azores

Sample ID	Date and Time (UT)	Lat (+ve N)	Lon (+ve E)	TSG Salinity (PSU)	Remote Temp (deg C)	Trans (%)	Chl (ug/L)	Seafloor Depth (m)	Salinity Bottle	Salinity Crate	Bench Salinity	Comments
	29/09/2017 20:00	36.79	-25.89									Underway switched on
UW_Salinity	29/09/2017 20:02	36.78	-25.89	36.1704	23.9861	91.6180	0.32	3509.31	116	4	36.182	
UW_Salinity	30/09/2017 09:16	35.32	-26.30	36.6726	25.0157	83.6019	0.09	4084.25	117	4	36.6892	Ship time GMT -1 (Midnight 29/09/2017)
UW_Salinity	30/09/2017 13:12	35.08	-26.34	36.5779	25.1605	89.5971	0.05	4215.45	118	4	36.5934	
Optics Underway 03	30/09/2017 13:52	35.08	-26.34	36.5923	25.1363	88.1490	0.06	4214.14				
UW_Salinity	30/09/2017 16:59	34.63	-26.46	36.7350	25.4970	91.4612	0.05	4091.07	119	4	36.7612	
UW_Salinity	30/09/2017 21:13	33.98	-26.63	37.0032	25.1086	92.0100	0.06	4623.81	120	4	37.0084	
UW_Salinity	01/10/2017 09:01	32.45	-27.01	36.8588	24.5877	86.9578	0.09	4404.06	200	20	36.8657	
UW_Salinity	01/10/2017 13:27	31.76	-27.19	37.0725	25.0348	92.6829	0.06	4740.37	201	20	37.0829	
UW_Salinity	01/10/2017 16:59	31.30	-27.31	37.2329	24.8969	90.6228	0.05	4325.11	202	20	37.2378	
UW_Salinity	01/10/2017 21:02	30.60	-27.48	37.1401	24.8602	92.2909	0.05	4682.90	203	20	37.1419	
UW_Salinity	02/10/2017 09:03	28.85	-27.91	37.2539	25.0837	93.4429	0.07	519.44	204	20	37.2621	
Optics Underway 04	02/10/2017 13:42	28.20	-28.07	37.2174	25.1498	93.9155	0.03	4799.30				
UW_Salinity	02/10/2017 13:56	28.20	-28.07	37.2175	25.1574	93.7936	0.02	4799.43	205	20	37.2264	
UW_Salinity	02/10/2017 17:16	27.72	-28.18	37.4073	25.0774	93.6259	0.05	5129.62	206	20	37.4129	
UW_Salinity	03/10/2017 09:01	26.02	-28.59	37.5194	25.4520	94.0396	0.06	5276.52	207	20	37.5249	
UW_Salinity	03/10/2017 13:04	25.72	-28.67	37.5177	25.4913	94.2008	0.03	0.00	208	20	37.5223	
UW_Salinity	03/10/2017 17:02	25.32	-28.76	37.5467	25.9381	93.5083	0.04	5382.15	209	20	37.5551	
UW_Salinity	03/10/2017 21:01	24.63	-28.92	37.3442	26.0429	92.3628	0.20	5313.52	210	20	37.3485	
UW_Salinity	04/10/2017 09:02	22.92	-29.32	37.1232	26.2095	90.6076	0.19	0.00	211	20	37.1286	
UW_Salinity	04/10/2017 12:59	22.25	-29.48	37.1060	26.6777	94.3053	0.21	5389.60	212	20	37.1139	
	04/10/2017 13:20	22.25	-29.48	37.1042	26.7088	94.1659	0.06	5389.23				Underway off due to flow change
Optics Underway 05	04/10/2017 13:49	22.25	-29.48	37.1039	26.5601	96.4177	0.00	5389.09				
	04/10/2017 17:05	21.77	-29.59	37.1209	26.9146	98.4952	0.15	5078.48				Underway on again
UW_Salinity	04/10/2017 17:06	21.77	-29.59	37.1204	26.9599	98.5497	0.15	5064.76	213	20	37.1264	
UW_Salinity	04/10/2017 21:07	21.08	-29.74	37.0678	26.9068	98.6019	0.11	4576.12	214	20	37.0749	
UW_Salinity	05/10/2017 08:59	19.43	-29.85	36.7746	27.2271	98.8110	0.13	4729.73	215	20	36.7798	
UW_Salinity	05/10/2017 17:14	18.30	-29.56	36.6269	27.6949	98.5453	0.08	4707.78	216	20	36.6321	
UW_Salinity	05/10/2017 20:59	17.67	-29.40	36.5305	28.0353	98.6193	0.08	4715.88	217	20	36.5366	
UW_Salinity	06/10/2017 08:58	16.16	-29.01	36.3736	28.1736	99.0179	0.11	4918.85	218	20	36.3786	
UW_Salinity	06/10/2017 12:59	15.51	-28.85	36.3063	28.3230	94.9477	0.12	5115.19	219	20	36.3126	
Optics Underway 06	06/10/2017 13:41	15.51	-28.85	36.3077	28.4294	98.1294	0.11	5115.54				

Sample ID	Date and Time (UT)	Lat (+ve N)	Lon (+ve E)	TSG Salinity (PSU)	Remote Temp (deg C)	Trans (%)	Chl (ug/L)	Seafloor Depth (m)	Salinity Bottle	Salinity Crate	Bench Salinity	Comments
UW_Salinity	06/10/2017 17:00	15.08	-28.73	36.2997	28.2931	98.1294	0.11	5240.46	220	20	36.3079	
UW_Salinity	06/10/2017 21:02	14.40	-28.56	36.5110	28.6145	97.9878	0.13	5271.21	221	20	36.5178	
UW_Salinity	07/10/2017 09:00	13.16	-28.24	36.0308	28.4444	98.6564	0.12	5311.38	222	20	36.0369	
UW_Salinity	07/10/2017 12:59	12.82	-28.17	35.9847	28.4947	98.3210	0.08	5439.74	223	20	35.9907	
UW_Salinity	07/10/2017 16:59	12.36	-28.05	35.7840	28.6275	98.1119	0.08	5432.25	224	21	35.7916	
UW_Salinity	07/10/2017 20:58	11.71	-27.89	35.8867	28.6076	98.2056	0.11	5307.86	225	21	35.8949	
UW_Salinity	08/10/2017 08:59	10.54	-27.59	35.5821	28.6124	98.6302	0.10	5197.49	226	21	35.5906	
UW_Salinity	08/10/2017 13:00	9.93	-27.44	35.2414	28.6248	98.7696	0.06	5224.22	227	21	35.2506	
Optics Underway 07	08/10/2017 13:44	9.93	-27.44	35.2387	28.7195	98.8654	0.06	5224.25				
UW_Salinity	08/10/2017 17:06	9.48	-27.33	35.0474	28.7859	98.4517	0.07	5307.33	228	21	35.0568	
UW_Salinity	08/10/2017 21:01	8.87	-27.17	35.0173	28.7277	98.2252	0.08	4913.89	229	21	35.0274	
UW_Salinity	09/10/2017 09:02	7.43	-26.82	34.1363	28.7549	98.3471	0.13	4736.85	230	21	34.1241	
UW_Salinity	09/10/2017 13:01	6.88	-26.69	33.7971	28.4795	97.9660	0.09	4398.25	231	21	33.8059	
UW_Salinity	09/10/2017 17:22	6.45	-26.57	34.2525	28.4177	97.9138	0.12	3935.41	232	21	34.2625	
UW_Salinity	09/10/2017 20:58	5.92	-26.46	33.9600	28.3303	97.6503	0.13	4262.63	233	21	33.9682	
UW_Salinity	10/10/2017 09:01	5.04	-26.24	34.1975	28.0782	97.9943	0.13	4501.58	234	21	34.2038	
UW_Salinity	10/10/2017 12:59	4.74	-26.16	34.4005	28.2685	98.1533	0.08	4349.71	235	21	34.4086	
Optics Underway 08	10/10/2017 13:54	4.74	-26.16	34.4055	28.3816	98.1707	0.06	4348.84				
UW_Salinity	10/10/2017 16:59	4.34	-26.06	34.3990	28.5190	97.5740	0.08	3781.82	236	21	34.4054	
UW_Salinity	10/10/2017 20:59	3.70	-25.90	34.5221	28.1664	97.8267	0.08	4137.64	237	21	34.5298	
UW_Salinity	11/10/2017 08:59	2.06	-25.50	35.6638	27.3860	98.5431	0.06	3958.58	238	21	35.6701	
UW_Salinity	11/10/2017 12:58	1.46	-25.36	35.7180	27.0427	98.2382	0.05	3840.40	239	21	35.7253	
UW_Salinity	12/10/2017 08:59	-1.12	-24.96	36.1244	26.2318	97.3432	0.42	3926.06	240	21	36.1348	
UW_Salinity	12/10/2017 12:58	-1.78	-25.00	36.1221	26.4902	97.4477	0.09	4201.18	241	21	36.1354	
Optics Underway 09	12/10/2017 13:54	-1.78	-25.00	36.1246	26.5179	96.5266	0.10	4201.33				
UW_Salinity	12/10/2017 20:58	-2.42	-25.00	36.3196	26.2803	96.7226	0.35	5411.93	242	21	36.3284	
UW_Salinity	13/10/2017 08:59	-3.95	-25.02	36.3503	25.9634	97.1385	0.35	5410.30	243	21	36.3601	
UW_Salinity	13/10/2017 13:00	-4.59	-25.02	36.2685	26.1038	97.6720	0.07	5417.46	244	21	36.2757	
UW_Salinity	13/10/2017 16:59	-5.00	-25.03	36.3219	26.3733	98.9307	0.02	5744.61	245	21	36.3331	
UW_Salinity	13/10/2017 21:05	-5.69	-25.04	36.3026	26.1376	98.8567	0.13	5124.14	246	21	36.3087	
UW_Salinity	14/10/2017 09:00	-6.87	-25.02	36.3591	25.8564	98.8916	0.04	5525.78	247	21	36.3649	
UW_Salinity	14/10/2017 13:06	-7.14	-25.03	36.3657	25.8243	98.9242	0.04	5587.17	248	22	36.3769	
Optics Underway 10	14/10/2017 13:52	-7.14	-25.03	36.3667	25.8646	98.2513	0.03	5574.29				
UW_Salinity	14/10/2017 17:00	-7.55	-25.04	36.3461	26.0040	98.9852	0.02	5731.78	249	22	36.3701	
UW_Salinity	15/10/2017 09:00	-9.85	-25.05	36.4126	25.7654	98.8720	0.03	5662.04	250	22	36.421	

Sample ID	Date and Time (UT)	Lat (+ve N)	Lon (+ve E)	TSG Salinity (PSU)	Remote Temp (deg C)	Trans (%)	Chl (ug/L)	Seafloor Depth (m)	Salinity Bottle	Salinity Crate	Bench Salinity	Comments
UW_Salinity	15/10/2017 13:00	-10.49	-25.06	36.4204	25.8040	98.7740	-0.01	5603.57	251	22	36.4265	
UW_Salinity	15/10/2017 17:02	-10.96	-25.06	36.5337	25.7324	99.0179	0.00	5661.29	252	22	36.5418	
UW_Salinity	16/10/2017 09:02	-13.09	-25.07	36.9271	24.7416	99.3467	-0.02	5546.31	253	22	36.9347	
UW_Salinity	16/10/2017 13:05	-13.73	-25.07	36.9933	24.5757	96.7509	0.00	5504.78	254	22	37.0043	
Optics Underway 11	16/10/2017 13:45	-13.73	-25.07	36.9968	24.5990	98.3384	-0.02	5504.97				
UW_Salinity	16/10/2017 17:00	-14.20	-25.07	36.9621	24.7834	99.2182	-0.01	5344.24	255	22	36.9688	
UW_Salinity	16/10/2017 21:00	-14.88	-25.08	37.0315	24.4817	99.2574	-0.02	4959.09	256	22	37.0373	
UW_Salinity	17/10/2017 09:09	-15.96	-25.05	37.1023	24.0888	99.3118	0.00	5242.25	257	22	37.1115	
UW_Salinity	17/10/2017 12:58	-15.96	-25.05	37.0908	24.2167	99.2291	-0.01	5251.42	258	22	37.1013	
UW_Salinity	17/10/2017 17:00	-16.40	-25.08	37.1115	24.0799	99.2030	-0.02	4913.17	259	22	37.1184	
UW_Salinity	17/10/2017 20:59	-17.08	-25.09	36.9920	23.1788	98.8894	0.02	5220.49	260	22	36.9996	
UW_Salinity	18/10/2017 14:48	-18.54	-25.07	36.8663	22.7619	98.9699	-0.01		261	22	36.875	
UW_Salinity	18/10/2017 16:59	-18.86	-25.08	36.8488	22.8603	98.7631	-0.01	5842.37	262	22	36.8549	
UW_Salinity	18/10/2017 21:00	-19.54	-25.09	36.8180	22.7022	98.9199	0.00	5106.53	263	22	36.8239	
UW_Salinity	19/10/2017 09:00	-21.15	-25.07	36.9199	22.4928	98.9220	0.01	5158.49	264	22	36.9281	
UW_Salinity	19/10/2017 13:03	-21.80	-25.07	36.8972	22.4865	98.8916	-0.02	5479.06	265	22	36.9053	
Optics Underway 12	19/10/2017 13:47	-21.80	-25.07	36.8989	22.5334	98.8545	-0.02	5525.85				
UW_Salinity	19/10/2017 16:59	-22.24	-25.07	36.8452	22.4402	98.7674	0.00	5393.44	266	22	36.8535	
UW_Salinity	19/10/2017 20:59	-22.91	-25.05	36.8298	22.2891	98.6172	0.00	5487.64	267	22	36.8367	
UW_Salinity	20/10/2017 09:00	-24.42	-25.03	36.8170	22.0881	98.7130	-0.01	5454.66	268	22	36.8423	
UW_Salinity	20/10/2017 13:02	-25.10	-25.03	36.7462	21.8130	98.6411	-0.02	4806.58	269	22	36.7532	
UW_Salinity	20/10/2017 16:59	-25.55	-25.04	36.5858	21.7391	98.6716	-0.03	4850.03	270	22	36.5951	
UW_Salinity	20/10/2017 21:00	-26.29	-25.09	36.3489	20.9014	98.4495	-0.02	5345.82	271	22	36.3576	
UW_Salinity	21/10/2017 09:02	-27.55	-25.19	36.2127	19.9767	98.3994	-0.01	4593.65	200	20	36.2195	
UW_Salinity	21/10/2017 13:20	-27.86	-25.22	36.2319	20.6487	98.2339	-0.03	5303.36	201	20	36.2398	
Optics Underway 13	21/10/2017 13:52	-27.86	-25.22	36.2380	20.6486	98.0814	-0.03	5303.31				
UW_Salinity	21/10/2017 16:59	-28.35	-25.28	36.1666	20.7116	98.3711	-0.03	4359.51	202	20	36.1721	
UW_Salinity	22/10/2017 10:03	-30.68	-25.95	35.8804	18.8977	98.2404	-0.03	4366.21	203	20	35.8866	Ship time GMT -2 (Midnight 21/20/2017)
UW_Salinity	22/10/2017 14:11	-31.31	-26.19	35.9345	18.9948	97.9247	-0.02	4498.83	204	20	35.9365	
UW_Salinity	22/10/2017 17:59	-31.78	-26.35	36.1063	19.4327	97.3323	-0.02	4574.68	205	20	36.1106	
UW_Salinity	22/10/2017 21:58	-32.43	-26.60	35.9498	18.7933	97.7221	0.01	4295.97	206	20	35.9542	
UW_Salinity	23/10/2017 10:01	-33.56	-27.01	35.5704	16.5284	95.6816	0.57	4261.32	207	20	35.5773	
Optics Underway 14	23/10/2017 13:11	-33.88	-27.15	35.5526	16.4091	95.1982	0.60	4635.85				
UW_Salinity	23/10/2017 13:59	-33.94	-27.17	35.5632	16.4174	95.0109	0.55	4770.85	208	20	35.5741	

Sample ID	Date and Time (UT)	Lat (+ve N)	Lon (+ve E)	TSG Salinity (PSU)	Remote Temp (deg C)	Trans (%)	Chl (ug/L)	Seafloor Depth (m)	Salinity Bottle	Salinity Crate	Bench Salinity	Comments
UW_Salinity	23/10/2017 17:59	-34.61	-27.41	35.5621	16.6904	94.9151	0.54	4268.75	209	20	35.5677	
UW_Salinity	23/10/2017 22:00	-35.31	-27.67	35.6341	16.3681	94.1594	1.00	4129.59	210	20	35.6388	
UW_Salinity	24/10/2017 09:58	-36.62	-28.18	35.4222	15.2865	94.0854	0.37	4726.62	211	20	35.4302	
UW_Salinity	24/10/2017 13:58	-37.02	-28.35	35.3959	15.0228	92.8223	0.27	4468.23	212	20	35.4008	
UW_Salinity	24/10/2017 18:10	-37.73	-28.62	35.4406	15.0624	85.6054	0.73	3951.18	213	20	35.4456	
UW_Salinity	24/10/2017 22:00	-38.33	-28.87	35.4058	14.7110	95.0632	1.60	2564.19	214	20	35.4101	
UW_Salinity	25/10/2017 10:17	-39.36	-29.26	35.4598	14.8735	96.2413	0.73	4176.04	215	20	35.4655	
Optics Underway 15	25/10/2017 11:19	-39.36	-29.26	35.4625	14.8880	95.0740	0.63	4176.13				
UW_Salinity	25/10/2017 14:09	-39.40	-29.32	35.5424	15.3493	94.7713	0.50	4237.85	216	20	35.5501	
UW_Salinity	25/10/2017 18:00	-39.92	-29.51	35.0759	14.0334	95.3985	1.09	4225.36	217	20	35.0851	
UW_Salinity	25/10/2017 21:59	-40.48	-29.73	34.8842	13.1115	96.3088	0.97	4267.76	218	20	34.8896	
UW_Salinity	26/10/2017 09:59	-41.79	-30.28	34.8212	12.0316	59.6799	0.70	4503.90	219	20	34.8282	
UW_Salinity	26/10/2017 14:12	-42.21	-30.45	34.6993	11.8787	97.0449	0.24	4415.93	220	20	34.7102	
UW_Salinity	26/10/2017 17:59	-42.80	-30.69	35.1358	13.2123	97.9813	0.24	4459.28	221	20	35.1401	
UW_Salinity	26/10/2017 21:57	-43.38	-30.94	34.5358	11.0590	96.4503	1.34	5100.82	222	20	34.5371	
UW_AJ	27/10/2017 10:04	-44.86	-31.58	34.3543	9.1197	95.4159	1.30	5276.88	223	20	34.3593	
Optics Underway 16	27/10/2017 13:10	-45.19	-31.74	34.2316	8.6888	96.1999	0.40	4510.10				
UW_AK	27/10/2017 14:00	-45.23	-31.76	34.2456	8.8831	95.9408	0.37	4827.32	248	22	34.2479	
UW_AL	27/10/2017 18:00	-45.80	-32.00	34.1152	8.2034	94.7561	0.83	4981.33	249	22	34.1328	
UW_AM	27/10/2017 22:01	-46.32	-32.26	33.9988	7.2996	95.0501	1.48	5150.33	250	22	34.0187	
UW_AN	28/10/2017 10:00	-47.11	-32.57	34.0659	6.5356	92.3519	0.96	5277.94	251	22	34.0698	
UW_AO	28/10/2017 14:00	-47.40	-32.74	33.9802	6.3954	86.0562	0.18	5403.56	252	22	33.994	
UW_AP	28/10/2017 18:00	-48.00	-33.02	33.7541	5.1364	92.1276	0.22	5433.83	253	22	33.7619	
UW_AQ	28/10/2017 22:02	-48.64	-33.31	33.8183	5.2532	96.7356	1.01	5351.18	254	22	33.8298	
UW_AR	29/10/2017 11:00	-50.19	-34.10	33.9115	1.9403	86.0475	2.52	4990.36	255	22	33.9169	
UW_AS	29/10/2017 14:00	-50.36	-34.21	33.9564	1.9254	74.5949	2.07	4897.34	256	22	33.9625	
UW_AT	29/10/2017 18:01	-50.87	-34.49	33.7969	2.3680	87.9834	3.95	4993.86	257	22	33.8043	
UW_AU	29/10/2017 22:01	-51.35	-34.75	33.7674	3.9474	96.4743	1.08	4906.93	258	22	33.7756	
UW_AV	30/10/2017 00:00	-51.62	-34.89	33.7625	3.5750	94.8955	2.35	4767.89	259	22	33.8233	
UW_AW	30/10/2017 00:00	-51.62	-34.89	33.7625	3.5750	94.8955	2.35	4767.89	260	22	34.048	
UW_AX	30/10/2017 00:00	-51.62	-34.89	33.7625	3.5750	94.8955	2.35	4767.89	261	22	33.8705	
UW_AY	30/10/2017 00:00	-51.62	-34.89	33.7625	3.5750	94.8955	2.35	4767.89	262	22	33.3469	
UW_AZ	31/10/2017 00:00	-54.29	-36.47	33.6291	1.6624	80.0305	3.22	129.82	263	22	33.7056	
UW_BA	31/10/2017 00:00	-54.29	-36.47	33.6291	1.6624	80.0305	3.22	129.82	264	22	33.7017	
UW_BB	31/10/2017 00:00	-54.29	-36.47	33.6291	1.6624	80.0305	3.22	129.82	265	22	33.7881	

Sample ID	Date and Time (UT)	Lat (+ve N)	Lon (+ve E)	TSG Salinity (PSU)	Remote Temp (deg C)	Trans (%)	Chl (ug/L)	Seafloor Depth (m)	Salinity Bottle	Salinity Crate	Bench Salinity	Comments
UW_BC	01/11/2017 10:03	-53.55	-38.64	33.8511	1.9378	89.4534	6.32	2579.98	266	22	33.849	
UW_BD	01/11/2017 14:01	-53.50	-39.24	33.8425	1.9443	91.9164	1.46		267	22	33.8496	
UW_BE	01/11/2017 18:00	-53.41	-40.14	33.8218	1.6902	89.9499	3.37	3492.36	268	22	33.8275	
UW_BF	01/11/2017 22:00	-53.32	-41.06	33.8319	1.5090	91.4373	5.00	2228.39	269	22	33.8417	
UW_BG	02/11/2017 09:59	-53.12	-43.20	33.7822	2.4403	93.3624	1.80	1805.54	270	22	33.7895	End of salinity sampling
UW_BH	02/11/2017 13:53	-53.05	-43.85	33.8179	2.2187	83.8349	0.61	1371.59				
UW_BI	02/11/2017 18:03	-52.98	-44.50	33.8253	2.6440	80.4116	0.73					
UW_BJ	02/11/2017 21:37	-52.93	-45.07	33.7675	2.4544	93.5322	0.83	2549.86				Ships time GMT -3 midnight 3/11/2017
UW_BK	03/11/2017 09:59	-52.71	-47.28	33.8924	2.6121	95.8929	0.59					
UW_BL	03/11/2017 14:01	-52.52	-48.06	34.1046	4.6763	94.3206	0.56	396.91				
UW_BM	03/11/2017 18:02	-52.44	-48.91	34.1188	5.4138	95.9495	0.23	2804.41				
UW_BN	03/11/2017 22:02	-52.48	-49.56	34.1229	5.3955	94.7997	1.63	3542.00				
UW_BO	04/11/2017 11:18	-52.11	-52.64	34.0308	4.6970	97.6394	0.05					
UW_BP	04/11/2017 14:54	-52.42	-50.03	34.1249	5.3785	96.4111	1.13	3289.36				
UW_BQ	04/11/2017 17:15	-52.42	-50.03	34.1249	5.3785	96.4111	1.13	3289.36				
UW_BR	04/11/2017 18:55	-52.42	-50.03	34.1249	5.3785	96.4111	1.13	3289.36				
UW_BS	04/11/2017 22:30	-52.42	-50.03	34.1249	5.3785	96.4111	1.13	3289.36				
UW_BT	05/11/2017 08:59	-51.87	-55.40	34.0967	5.5942	93.5780	3.83	1065.02				
UW_BU	05/11/2017 11:27	-51.87	-55.40	34.0967	5.5942	93.5780	3.83	1065.02				
	05/11/2017 12:07	-51.87	-55.40	34.0967	5.5942	93.5780	3.83	1065.02				Underway switched off

Appendix 2 – AMT27 Log of events

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
23/09/2017	12:00		50.6517	1.6250					FAOP
23/09/2017	17:55	18:16	50.0607	3.3435	50.0610	3.3427	Test	CTD	Shakedown CTD
24/09/2017	10:16	10:46	48.9397	7.6133	48.9278	7.6237	1	RING NET	Shakedown Ring Net
24/09/2017	11:04	11:29	48.9397	7.6133	48.9263	7.6233	1	OPTICS	Optics Rig 1
24/09/2017	11:18	n/a	48.9397	7.6133	n/a	n/a	1	BALLOON	Radio Sonde Balloon
24/09/2017	11:23	11:56	48.9397	7.6133	48.9250	7.6252	1	CTD	CTD001
24/09/2017	11:30	11:53	48.9397	7.6133	48.9250	7.6252	1	OPTICS	Optics Rig 2
25/09/2017	04:01	04:45	47.2688	11.0102	47.2695	11.0115	2	CTD	CTD002
25/09/2017	09:56	11:51	46.7058	12.0482	46.6917	12.0153	3	BONGO TOW	Bongo Tow 1
25/09/2017	10:59	n/a	46.6888	12.0163	n/a	n/a	3	BALLOON	Radio Sonde Balloon
25/09/2017	11:11	11:37	46.6863	12.0000	46.6863	12.0000	3	OPTICS	Optics Rig 3
25/09/2017	11:15	11:23	46.6863	12.0000	46.6863	12.0000	3	CTD	CTD dip
25/09/2017	11:36	11:40	46.6863	12.0000	46.6863	12.0000	3	CTD	CTD dip
25/09/2017	11:38	11:59	46.6863	12.0000	46.6863	12.0000	3	OPTICS	Optics Rig 4
25/09/2017	11:49	11:55	46.6863	12.0000	46.6863	12.0000	3	CTD	CTD dip
25/09/2017	12:07	12:55	46.6863	12.0000	46.6863	12.0000	3	CTD	CTD003
26/09/2017	02:33	03:25	44.8795	14.8377	44.8523	14.8318	4	BONGO TOW	Bongo Tow 2
26/09/2017	03:43	04:12	44.8520	14.8298	44.8522	14.8273	4	VERTICAL BONGO NET	Vertical Bongo Net 1
26/09/2017	03:56	04:40	44.8520	14.8285	44.8522	14.8272	4	CTD	CTD004
26/09/2017	06:02	09:06	44.8522	14.8272	44.8522	14.8272	4	SAPS	SAPS001
26/09/2017	09:32	10:22	44.8522	14.8272	44.8523	14.8272	4	CTD	CTD005
26/09/2017	10:34	n/a	44.8523	14.8272	n/a	n/a	4	BALLOON	Radio Sonde Balloon
26/09/2017	11:12	n/a	44.8523	14.8272	44.8523	14.8272	4	OPTICS	Optics rig 5 cancelled
26/09/2017	11:36	14:03	44.8523	14.8272	44.7828	14.8698	4	RMT	RMT net
27/09/2017	03:29	04:17	43.0635	17.4658	43.0668	17.4975	5	BONGO TOW	Bongo Tow 3
27/09/2017	04:34	04:58	43.0670	17.4987	43.0658	17.4992	5	VERTICAL BONGO NET	Vertical Bongo Net 2
27/09/2017	04:38	05:21	43.0668	17.4988	43.0658	17.4992	5	CTD	CTD006
27/09/2017	12:02	12:26	42.1663	18.7972	42.1662	18.7973	6	OPTICS	Optics Rig 6
27/09/2017	12:08	n/a	42.1662	18.7973	n/a	n/a	6	BALLOON	Radio Sonde Balloon
27/09/2017	12:12	13:24	42.1662	18.7973	42.1662	18.7973	6	CTD	CTD007
27/09/2017	12:28	12:52	42.1663	18.7972	42.1662	18.7973	6	OPTICS	Optics Rig 7
28/09/2017	03:35	04:20	40.2377	21.5120	40.2178	21.5342	7	BONGO TOW	Bongo Tow 4
28/09/2017	04:29	04:57	40.2172	21.5350	40.2173	21.5350	7	VERTICAL BONGO NET	Vertical Bongo Net 3
28/09/2017	04:31	05:14	40.2173	21.5350	40.2173	21.5350	7	CTD	CTD008
28/09/2017	05:29	n/a	40.2145	21.5382	n/a	n/a	7	ARGO FLOAT	Argo float

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
28/09/2017	12:03	12:25	39.3552	22.7420	39.3552	22.7420	8	OPTICS	Optics Rig 8
28/09/2017	12:06	n/a	39.3552	22.7420	n/a	n/a	8	BALLOON	Radio Sonde Balloon
28/09/2017	12:08	13:00	39.3552	22.7420	39.3552	22.7420	8	CTD	CTD009
28/09/2017	12:26	12:50	39.3552	22.7420	39.3552	22.7420	8	OPTICS	Optics Rig 9
30/09/2017	04:31	05:19	35.3025	26.2792	35.3173	26.3000	9	BONGO TOW	Bongo Tow 5
30/09/2017	05:36	06:40	35.3178	26.3005	35.3178	26.3005	9	CTD	CTD010
30/09/2017	05:36	06:06	35.3178	26.3005	35.3178	26.3005	9	VERTICAL BONGO NET	Vertical Bongo Net 4
30/09/2017	07:07	09:52	35.3178	26.3005	35.3178	26.3005	9	SAPS	SAPS002
30/09/2017	10:35	11:23	35.3178	26.3005	35.3178	26.3005	9	CTD	CTD011
30/09/2017	13:02	13:30	35.0840	26.3372	35.0840	26.3372	10	OPTICS	Optics Rig 10
30/09/2017	13:11	13:52	35.0840	26.3372	35.0840	26.3372	10	CTD	CTD012
30/09/2017	13:25	n/a	35.0840	26.3372	n/a	n/a	10	BALLOON	Radio Sonde Balloon
30/09/2017	13:31	13:55	35.0840	26.3372	35.0840	26.3378	10	OPTICS	Optics Rig 11
01/10/2017	03:35	03:57	32.8745	26.9075	32.8765	26.9052	11	RING NET	Ring Net
01/10/2017	04:01	04:22	32.8768	26.9047	32.8790	26.9022	11	RING NET	Ring Net
01/10/2017	04:34	05:21	32.8818	26.8993	32.8947	26.8887	11	BONGO TOW	Bongo Tow 6
01/10/2017	05:30	05:56	32.8947	26.8887	32.8947	26.8887	11	VERTICAL BONGO NET	Vertical Bongo Net 5
01/10/2017	05:41	06:20	32.8947	26.8887	32.8940	26.8898	11	CTD	CTD013
01/10/2017	13:03	14:06	31.7628	27.1862	31.7628	27.1862	12	CTD	CTD014
01/10/2017	13:09	n/a	31.7628	27.1862	n/a	n/a	12	BALLOON	Radio Sonde Balloon
01/10/2017	13:09	13:33	31.7628	27.1862	31.7628	27.1862	12	OPTICS	Optics Rig 12
01/10/2017	13:34	14:00	31.7628	27.1862	31.7628	27.1862	12	OPTICS	optics Rig 13
02/10/2017	04:32	05:18	29.3095	27.8027	29.3115	27.7825	13	BONGO TOW	Bongo Tow 7
02/10/2017	05:27	05:54	29.3117	27.7823	29.3117	27.7823	13	VERTICAL BONGO NET	Vertical Bongo Net 6
02/10/2017	05:29	06:10	29.3117	27.7823	29.3117	27.7823	13	CTD	CTD015
02/10/2017	13:05	13:45	28.1967	28.0700	28.1967	28.0700	14	CTD	CTD016
02/10/2017	13:08	n/a	28.1967	28.0700	n/a	n/a	14	BALLOON	Radio Sonde Balloon
02/10/2017	13:32	13:57	28.1967	28.0700	28.1967	28.0700	14	OPTICS	Optics Rig 14
02/10/2017	14:28	n/a	28.1857	28.0703	n/a	n/a	14	ARGO FLOAT	Argo float
02/10/2017	14:35	n/a	28.1813	28.0703	n/a	n/a	14	ARGO FLOAT	Argo float
03/10/2017	03:24	03:53	26.0037	28.6283	26.0060	28.6078	15	RING NET	Ring Net
03/10/2017	03:55	04:16	26.0063	28.6073	26.0083	28.6042	15	RING NET	Ring Net
03/10/2017	04:25	05:11	26.0092	28.6023	26.0203	28.5887	15	BONGO TOW	Bongo Tow 8
03/10/2017	05:23	05:48	26.0207	28.5883	26.0207	28.5883	15	VERTICAL BONGO NET	Vertical Bongo Net 7
03/10/2017	05:32	06:31	26.0207	28.5883	26.0207	28.5883	15	CTD	CTD017
03/10/2017	06:50	07:28	26.0207	28.5883	26.0207	28.5883	15	SAPS	SAPS003
03/10/2017	10:11	10:51	26.0207	28.5883	26.0207	28.5883	15	CTD	CTD018

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
03/10/2017	13:09	n/a	25.7152	28.6672	n/a	n/a	16	BALLOON	Radio Sonde Balloon
03/10/2017	13:18	13:45	25.7152	28.6662	25.7152	28.6662	16	OPTICS	Optics Rig 15
03/10/2017	13:21	14:03	25.7152	28.6662	25.7152	28.6662	16	CTD	CTD019
03/10/2017	13:47	14:09	25.7152	28.6662	25.7152	28.6662	16	OPTICS	Optics Rig 16
03/10/2017	14:16	n/a	25.7153	28.6645	n/a	n/a	16	ARGO FLOAT	Argo float
04/10/2017	04:41	05:29	23.3595	29.2227	23.3722	29.2060	17	BONGO TOW	Bongo Tow 9
04/10/2017	05:33	06:14	23.3722	29.2060	23.3722	29.2060	17	CTD	CTD020
04/10/2017	05:43	06:11	23.3722	29.2060	23.3722	29.2060	17	VERTICAL BONGO NET	Vertical Bongo Net 8
04/10/2017	13:05	13:50	22.2535	29.4820	22.2535	29.4820	18	CTD	CTD021
04/10/2017	13:06	13:32	22.2535	29.4820	22.2535	29.4820	18	OPTICS	Optics Rig 17
04/10/2017	13:17	n/a	22.2535	29.4820	n/a	n/a	18	BALLOON	Radio Sonde Balloon
04/10/2017	13:33	13:55	22.2535	29.4820	22.2535	29.4820	18	OPTICS	Optics Rig 18
05/10/2017	04:29	05:16	19.8298	29.9547	19.8382	29.9348	19	BONGO TOW	Bongo Tow 10
05/10/2017	05:32	05:58	19.8383	29.9342	19.8383	29.9342	19	VERTICAL BONGO NET	Vertical Bongo Net 9
05/10/2017	05:32	06:14	19.8383	29.9342	19.8383	29.9342	19	CTD	CTD022
05/10/2017	06:20	n/a	19.8387	29.9333	n/a	n/a	19	ARGO FLOAT	Argo float
05/10/2017	06:23	n/a	19.8393	29.9318	n/a	n/a	19	ARGO FLOAT	Argo float
05/10/2017	12:58	13:41	18.7857	29.6822	18.7857	29.6822	20	CTD	CTD023
05/10/2017	13:00	13:25	18.7857	29.6822	18.7857	29.6822	20	OPTICS	Optics Rig 19
05/10/2017	13:22	n/a	18.7857	29.6822	n/a	n/a	20	BALLOON	Radio Sonde Balloon
05/10/2017	13:26	13:52	18.7857	29.6822	18.7857	29.6822	20	OPTICS	Optics Rig 20
05/10/2017	14:01	n/a	18.7857	29.6822	n/a	n/a	20	ARGO FLOAT	Argo float
06/10/2017	03:57	04:27	16.5552	29.1145	16.5575	29.1082	21	RING NET	Ring Net
06/10/2017	04:37	05:27	16.5583	29.1058	16.5588	29.1042	21	BONGO TOW	Bongo Tow 11
06/10/2017	05:31	06:14	16.5667	29.0852	16.5667	29.0852	21	CTD	CTD024
06/10/2017	05:37	06:05	16.5667	29.0852	16.5667	29.0852	21	VERTICAL BONGO NET	Vertical Bongo Net 10
06/10/2017	13:02	13:45	15.6728	28.8497	15.6728	28.8497	22	CTD	CTD025
06/10/2017	13:02	13:27	15.6728	28.8497	15.6728	28.8497	22	OPTICS	Optics Rig 21
06/10/2017	13:11	n/a	15.6728	28.8497	n/a	n/a	22	BALLOON	Radio Sonde Balloon
06/10/2017	13:28	13:47	15.6728	28.8497	15.6728	28.8497	22	OPTICS	Optics Rig 22
07/10/2017	04:34	05:21	13.1448	28.2472	13.1595	28.2387	23	BONGO TOW	Bongo Tow 12
07/10/2017	05:27	05:53	13.1597	28.2387	13.1597	28.2388	23	VERTICAL BONGO NET	Vertical Bongo Net 11
07/10/2017	05:31	06:32	13.1597	28.2388	13.1597	28.2388	23	CTD	CTD026
07/10/2017	06:49	09:43	13.1597	28.2388	13.1597	28.2388	23	SAPS	SAPS004
07/10/2017	10:00	10:44	13.1597	28.2388	13.1597	28.2388	23	CTD	CTD027
07/10/2017	13:06	13:47	12.8218	28.1652	12.8218	28.1652	24	CTD	CTD028
07/10/2017	13:06	13:30	12.8218	28.1652	12.8218	28.1652	24	OPTICS	Optics Rig 23

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
07/10/2017	13:10	n/a	12.8218	28.1652	n/a	n/a	24	BALLOON	Radio Sonde Balloon
07/10/2017	13:31	13:55	12.8218	28.1652	12.8218	28.1652	24	OPTICS	Optics Rig 24
08/10/2017	03:08	03:28	10.8047	27.6590	10.8137	27.6532	25	RING NET	Ring Net
08/10/2017	03:31	03:51	10.8145	27.6527	10.8218	27.6482	25	RING NET	Ring Net
08/10/2017	03:54	04:15	10.8223	27.6478	10.8298	27.6433	25	RING NET	Ring Net
08/10/2017	04:29	05:15	10.8355	27.6398	10.8597	27.6248	25	BONGO TOW	bongo Tow 13
08/10/2017	05:38	06:05	10.8672	27.6202	10.8672	27.6202	25	VERTICAL BONGO NET	Vertical Bongo Net 12
08/10/2017	05:38	06:16	10.8672	27.6202	10.8672	27.6202	25	CTD	CTD029
08/10/2017	06:43	n/a	10.8732	27.6150	n/a	n/a	25	ARGO FLOAT	Argo float
08/10/2017	13:00	13:42	9.9270	27.4437	9.9270	27.4437	26	CTD	CTD030
08/10/2017	13:01	13:30	9.9270	27.4437	9.9270	27.4437	26	OPTICS	Optics Rig 25
08/10/2017	13:10	n/a	9.9270	27.4437	n/a	n/a	26	BALLOON	Radio Sonde Balloon
08/10/2017	13:31	13:55	9.9270	27.4437	9.9270	27.4437	26	OPTICS	Optics Rig 26
09/10/2017	04:24	05:14	7.7707	26.9082	7.7498	26.8987	27	BONGO TOW	Bongo Tow 14
09/10/2017	05:24	05:51	7.7493	26.8985	7.7493	26.8970	27	VERTICAL BONGO NET	Vertical Bongo Net 13
09/10/2017	05:26	06:08	7.7493	26.8985	7.7493	26.8960	27	CTD	CTD031
09/10/2017	06:38	n/a	7.7488	26.8938	n/a	n/a	27	ARGO FLOAT	Argo float
09/10/2017	13:02	13:46	6.8802	26.6857	6.8845	26.6822	28	CTD	CTD032
09/10/2017	13:03	13:30	6.8803	26.6857	6.8828	26.6817	28	OPTICS	Optics Rig 27
09/10/2017	13:12	n/a	6.8808	26.6853	n/a	n/a	28	BALLOON	Radio Sonde Balloon
09/10/2017	13:52	13:52	6.8828	26.6817	6.8852	26.6817	28	OPTICS	Optics Rig 28
09/10/2017	13:58	n/a	6.8845	26.6817	n/a	n/a	28	ARGO FLOAT	Argo float
10/10/2017	02:55	03:19	5.0777	26.2533	5.0742	26.2525	29	RING NET	Ring Net
10/10/2017	03:22	03:46	5.0737	26.2523	5.0690	26.2515	29	RING NET	Ring Net
10/10/2017	03:49	04:12	5.0685	26.2515	5.0638	26.2505	29	RING NET	Ring Net
10/10/2017	04:31	05:19	5.0618	26.2500	5.0428	26.2463	29	BONGO TOW	Bongo Tow 15
10/10/2017	05:27	05:54	5.0428	26.2463	5.0433	26.2463	29	VERTICAL BONGO NET	Vertical Bongo Net 14
10/10/2017	05:28	06:25	5.0428	26.2463	5.0433	26.2447	29	CTD	CTD033
10/10/2017	06:44	09:46	5.0433	26.2447	5.0433	26.2433	29	SAPS	SAPS005
10/10/2017	09:57	10:42	5.0433	26.2433	5.0433	26.2433	29	CTD	CTD034
10/10/2017	10:47	n/a	5.0428	26.2442	n/a	n/a	29	ARGO FLOAT	Argo float
10/10/2017	13:07	13:48	4.7430	26.1603	4.7430	26.1603	30	CTD	CTD035
10/10/2017	13:07	13:35	4.7430	26.1603	4.7430	26.1603	30	OPTICS	Optics Rig 29
10/10/2017	13:11	n/a	4.7430	26.1603	n/a	n/a	30	BALLOON	Radio Sonde Balloon
10/10/2017	13:36	14:00	4.7430	26.1603	4.7430	26.1603	30	OPTICS	Optics Rig 30
11/10/2017	04:29	05:16	2.5145	25.6235	2.4938	25.6122	31	BONGO TOW	Bongo Tow 16
11/10/2017	05:26	05:52	2.4930	25.6118	2.4930	25.6118	31	VERTICAL BONGO NET	Vertical Bongo Net 15

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
11/10/2017	05:26	06:06	2.4930	25.6118	2.4930	25.6118	31	CTD	CTD036
11/10/2017	13:03	13:45	1.4612	25.3567	1.4612	25.3567	32	CTD	CTD037
11/10/2017	13:05	13:32	1.4612	25.3567	1.4612	25.3567	32	OPTICS	Optics Rig 31
11/10/2017	13:12	n/a	1.4612	25.3567	n/a	n/a	32	BALLOON	Radio Sonde Balloon
11/10/2017	13:33	13:56	1.4612	25.3567	1.4612	25.3567	32	OPTICS	Optics Rig 32
12/10/2017	03:27	03:50	-0.6895	24.9982	-0.6895	24.9982	33	RING NET	Ring Net
12/10/2017	03:55	04:16	-0.7010	24.9898	-0.7102	24.9805	33	RING NET	Ring Net
12/10/2017	04:46	05:31	-0.7158	24.9690	-0.7248	24.9347	33	BONGO TOW	Bongo Tow 17
12/10/2017	05:40	06:21	-0.7253	24.9337	-0.7270	24.9265	33	CTD	CTD038
12/10/2017	05:44	06:15	-0.7255	24.9330	-0.7265	24.9280	33	VERTICAL BONGO NET	Vertical Bongo Net 16
12/10/2017	06:31	n/a	-0.7277	24.9235	n/a	n/a	33	ARGO FLOAT	Argo float
12/10/2017	13:03	13:26	-1.7772	24.9958	-1.7772	24.9958	34	OPTICS	Optics Rig 33
12/10/2017	13:06	13:58	-1.7772	24.9958	-1.7772	24.9958	34	CTD	CTD039
12/10/2017	13:21	n/a	-1.7772	24.9958	n/a	n/a	34	BALLOON	Radio Sonde Balloon
12/10/2017	13:37	13:52	-1.7772	24.9958	-1.7772	24.9958	34	OPTICS	Optics Rig 34
12/10/2017	14:38	17:03	-1.7830	24.9885	-1.8548	24.9002	34	RMT	RMT net
13/10/2017	04:29	05:16	-3.5395	25.0138	-3.5395	24.9938	35	BONGO TOW	Bongo Tow 18
13/10/2017	05:26	05:52	-3.5393	24.9937	-3.5385	24.9948	35	VERTICAL BONGO NET	Vertical Bongo Net 17
13/10/2017	05:27	06:13	-3.5393	24.9937	-3.5378	24.9957	35	CTD	CTD040
13/10/2017	06:20	n/a	-3.5375	24.9955	n/a	n/a	35	ARGO FLOAT	Argo float
13/10/2017	13:06	13:30	-4.5863	25.0240	-4.5863	25.0240	36	OPTICS	Optics Rig 35
13/10/2017	13:09	13:53	-4.5863	25.0240	-4.5863	25.0240	36	CTD	CTD041
13/10/2017	13:15	n/a	-4.5863	25.0240	n/a	n/a	36	BALLOON	Radio Sonde Balloon
13/10/2017	13:31	13:59	-4.5863	25.0240	-4.5863	25.0240	36	OPTICS	Optics Rig 36
13/10/2017	14:06	n/a	-4.5867	25.0233	n/a	n/a	36	ARGO FLOAT	Argo float
14/10/2017	04:27	05:14	-6.8703	25.0367	-6.8702	25.0197	37	BONGO TOW	Bongo Tow 19
14/10/2017	05:23	05:50	-6.8702	25.0192	-6.8702	25.0192	37	VERTICAL BONGO NET	Vertical Bongo Net 18
14/10/2017	05:29	06:24	-6.8702	25.0192	-6.8702	25.0192	37	CTD	CTD042
14/10/2017	06:59	09:45	-6.8702	25.0192	-6.8702	25.0192	37	SAPS	SAPS006
14/10/2017	10:19	11:04	-6.8702	25.0192	-6.8702	25.0192	37	CTD	CTD043
14/10/2017	13:03	13:52	-7.1358	25.0313	-7.1358	25.0313	38	CTD	CTD044
14/10/2017	13:03	13:28	-7.1358	25.0313	-7.1358	25.0313	38	OPTICS	Optics Rig 37
14/10/2017	13:16	n/a	-7.1358	25.0313	n/a	n/a	38	BALLOON	Radio Sonde Balloon
14/10/2017	13:29	13:55	-7.1358	25.0313	-7.1358	25.0313	38	OPTICS	Optics Rig 38
15/10/2017	04:28	05:16	-9.3895	25.0508	-9.4227	25.0288	39	BONGO TOW	Bongo Tow 20
15/10/2017	05:26	06:08	-9.4227	25.0285	-9.4227	25.0285	39	CTD	CTD045
15/10/2017	05:27	05:53	-9.4227	25.0285	-9.4227	25.0285	39	VERTICAL BONGO NET	Vertical Bongo Net 19

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
15/10/2017	06:15	n/a	-9.4227	25.0278	n/a	n/a	39	ARGO FLOAT	Argo float
15/10/2017	13:03	13:47	-10.4862	25.0578	-10.4862	25.0578	40	CTD	CTD046
15/10/2017	13:03	13:30	-10.4862	25.0578	-10.4862	25.0578	40	OPTICS	Optics Rig 39
15/10/2017	13:11	n/a	-10.4862	25.0578	n/a	n/a	40	BALLOON	Radio Sonde Balloon
15/10/2017	13:32	13:52	-10.4862	25.0578	-10.4862	25.0578	40	OPTICS	Optics Rig 40
16/10/2017	02:58	03:17	-12.6352	25.0662	-12.6348	25.0618	41	RING NET	Ring Net
16/10/2017	03:20	03:38	-12.6348	25.0613	-12.6347	25.0572	41	RING NET	Ring Net
16/10/2017	03:40	04:00	-12.6347	25.0572	-12.6343	25.0523	41	RING NET	Ring Net
16/10/2017	04:30	05:16	-12.6343	25.0495	-12.6337	25.0293	41	BONGO TOW	Bongo Tow 21
16/10/2017	05:29	05:54	-12.6337	25.0290	-12.6337	25.0290	41	VERTICAL BONGO NET	Vertical Bongo Net 20
16/10/2017	05:29	06:12	-12.6337	25.0290	-12.6337	25.0290	41	CTD	CTD047
16/10/2017	06:20	n/a	-12.6335	25.0288	n/a	n/a	41	ARGO FLOAT	Argo float
16/10/2017	13:00	13:44	-13.7310	25.0708	-13.7310	25.0708	42	CTD	CTD048
16/10/2017	13:00	13:25	-13.7310	25.0708	-13.7310	25.0708	42	OPTICS	Optics Rig 41
16/10/2017	13:19	n/a	-13.7310	25.0708	n/a	n/a	42	BALLOON	Radio Sonde Balloon
16/10/2017	13:26	13:56	-13.7310	25.0708	-13.7310	25.0708	42	OPTICS	Optics Rig 42
17/10/2017	03:28	03:48	-15.9620	25.0885	-15.9617	25.0820	43	RING NET	Ring Net
17/10/2017	03:51	04:05	-15.9617	25.0818	-15.9615	25.0777	43	RING NET	Ring Net
17/10/2017	04:31	05:16	-15.9615	25.0750	-15.9610	25.0505	43	BONGO TOW	Bongo Tow 22
17/10/2017	05:24	05:53	-15.9610	25.0021	-15.9610	25.0502	43	VERTICAL BONGO NET	Vertical Bongo Net 21
17/10/2017	05:28	06:28	-15.9610	25.0021	-15.9610	25.0502	43	CTD	CTD049
17/10/2017	06:52	09:44	-15.9610	25.0502	-15.9610	25.0502	43	SAPS	SAPS007
17/10/2017	10:17	13:37	-15.9610	25.0502	-15.9610	25.0503	43	CTD	CTD050
17/10/2017	13:05	13:32	-15.9610	25.0503	-15.9610	25.0503	43	OPTICS	Optics Rig 43
17/10/2017	13:20	n/a	-15.9610	25.0503	n/a	n/a	43	BALLOON	Radio Sonde Balloon
17/10/2017	13:33	13:55	-15.9610	25.0503	-15.9610	25.0503	43	OPTICS	Optics Rig 44
18/10/2017	06:30	10:45	-18.5435	25.1025	-18.5478	25.0762	44	MOORING	Mooring Recovery
18/10/2017	12:05	13:42	-18.5445	25.0054	-18.5448	25.0978	44	MOORING	Mooring Deployment
18/10/2017	13:23	n/a	-18.5448	25.0867	n/a	n/a	44	BALLOON	Radio Sonde Balloon
18/10/2017	14:23	n/a	-18.5448	25.0767	n/a	n/a	44	ARGO FLOAT	Argo float
18/10/2017	14:27	n/a	-18.5448	25.0753	n/a	n/a	44	ARGO FLOAT	Argo float
19/10/2017	04:25	05:10	-20.7483	25.0827	-20.7460	25.0645	45	BONGO TOW	Bongo Tow 23
19/10/2017	05:19	05:47	-20.7460	25.0640	-20.7460	25.0640	45	VERTICAL BONGO NET	Vertical Bongo Net 22
19/10/2017	05:28	06:10	-20.7460	25.0640	-20.7460	25.0640	45	CTD	CTD051
19/10/2017	06:23	n/a	-20.7477	25.0638	n/a	n/a	45	ARGO FLOAT	Argo float
19/10/2017	06:27	n/a	-20.7482	25.0632	n/a	n/a	45	ARGO FLOAT	Argo float
19/10/2017	13:00	13:45	-21.7997	25.0685	-21.7997	25.0685	46	CTD	CTD052

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
19/10/2017	13:01	13:26	-21.7997	25.0685	-21.7997	25.0685	46	OPTICS	Optics Rig 45
19/10/2017	13:23	n/a	-21.7997	25.0685	n/a	n/a	46	BALLOON	Radio Sonde Balloon
19/10/2017	13:28	13:53	-21.7997	25.0685	-21.7997	25.0685	46	OPTICS	Optics Rig 46
19/10/2017	13:59	n/a	-21.7998	25.0682	n/a	n/a	46	ARGO FLOAT	Argo float
20/10/2017	03:30	03:52	-24.0060	25.0493	-24.0042	25.0417	47	RING NET	Ring Net
20/10/2017	03:55	04:15	-24.0038	25.0407	-24.0018	25.0342	47	RING NET	Ring Net
20/10/2017	04:17	04:32	-24.0017	25.0333	-24.0000	25.0280	47	RING NET	Ring Net
20/10/2017	04:42	05:28	-23.9983	25.0233	-23.9903	24.9987	47	BONGO TOW	Bongo Tow 24
20/10/2017	05:32	06:17	-23.9902	24.9985	-23.9902	24.9985	47	CTD	CTD053
20/10/2017	05:36	06:03	-23.9902	24.9985	-23.9902	24.9985	47	VERTICAL BONGO NET	Vertical Bongo Net 23
20/10/2017	13:02	13:45	-25.1042	25.0312	-25.1042	25.0312	48	CTD	CTD054
20/10/2017	13:02	13:25	-25.1042	25.0312	-25.1042	25.0312	48	OPTICS	Optics Rig 47
20/10/2017	13:15	n/a	-25.1042	25.0312	n/a	n/a	48	BALLOON	Radio Sonde Balloon
20/10/2017	13:27	13:52	-25.1042	25.0312	-25.1042	25.0312	48	OPTICS	Optics Rig 48
21/10/2017	04:33	05:19	-27.5792	25.1905	-27.5507	25.1933	49	BONGO TOW	Bongo Tow 25
21/10/2017	05:27	05:54	-27.5500	25.1935	-27.5500	25.1935	49	VERTICAL BONGO NET	Vertical Bongo Net 24
21/10/2017	05:27	06:25	-27.5500	25.1935	-27.5500	25.1935	49	CTD	CTD055
21/10/2017	06:52	09:50	-27.5500	25.1935	-27.5500	25.1935	49	SAPS	SAPS008
21/10/2017	10:12	11:00	-27.5500	25.1935	-27.5500	25.1935	49	CTD	CTD056
21/10/2017	13:03	13:48	-27.8583	25.2167	-27.8583	25.2167	50	CTD	CTD057
21/10/2017	13:03	13:33	-27.8583	25.2167	-27.8583	25.2167	50	OPTICS	Optics Rig 49
21/10/2017	13:13	n/a	-27.8583	25.2167	n/a	n/a	50	BALLOON	Radio Sonde Balloon
21/10/2017	13:34	13:52	-27.8583	25.2167	-27.8583	25.2167	50	OPTICS	Optics Rig 50
22/10/2017	04:04	04:24	-30.2260	25.7983	-30.2250	25.7948	51	RING NET	Ring Net
22/10/2017	04:28	04:45	-30.2248	25.7947	-30.2243	25.7907	51	RING NET	Ring Net
22/10/2017	04:48	05:07	-30.2243	25.7900	-30.2243	25.7858	51	RING NET	Ring Net
22/10/2017	05:09	05:22	-30.2243	25.7853	-30.2243	25.7823	51	RING NET	Ring Net
22/10/2017	05:31	06:17	-30.2243	25.7798	-30.2238	25.7637	51	BONGO TOW	Bongo Tow 26
22/10/2017	06:24	07:06	-30.2238	25.7640	-30.2238	25.7682	51	CTD	CTD058
22/10/2017	06:25	06:52	-30.2238	25.7640	-30.2238	25.7663	51	VERTICAL BONGO NET	Vertical Bongo Net 25
22/10/2017	07:14	n/a	-30.2250	25.7675	n/a	n/a	51	ARGO FLOAT	Argo float
22/10/2017	13:59	14:25	-31.3127	26.1890	-31.3127	26.1890	52	OPTICS	Optics Rig 51
22/10/2017	14:03	14:45	-31.3127	26.1890	-31.3127	26.1890	52	CTD	CTD059
22/10/2017	14:19	n/a	-31.3127	26.1890	n/a	n/a	52	BALLOON	Radio Sonde Balloon
22/10/2017	14:26	14:45	-31.3127	26.1890	-31.3127	26.1890	52	OPTICS	Optics Rig 52
23/10/2017	05:36	06:19	-33.1290	26.8417	-33.1305	26.8402	53	CTD	CTD060
23/10/2017	12:34	12:54	-33.8848	27.1480	-33.8848	27.1480	54	OPTICS	Optics Rig 53
23/10/2017	12:34	13:11	-33.8848	27.1480	-33.8848	27.1480	54	CTD	CTD061

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
23/10/2017	12:42	n/a	-33.8848	27.1480	n/a	n/a	54	BALLOON	Radio Sonde Balloon
23/10/2017	12:56	13:11	-33.8848	27.1480	-33.8848	27.1480	54	OPTICS	Optics Rig 54
24/10/2017	02:42	03:05	-35.9682	27.9452	-35.9620	27.9528	55	RING NET	Ring Net
24/10/2017	03:08	03:32	-35.9613	27.9538	-35.9545	27.9628	55	RING NET	Ring Net
24/10/2017	03:35	03:57	-35.9535	27.9642	-35.9470	27.9727	55	RING NET	Ring Net
24/10/2017	04:05	04:51	-35.9438	27.9770	-35.9260	28.0043	55	BONGO TOW	Bongo Tow 27
24/10/2017	04:56	04:37	-35.9258	28.0047	-35.9252	28.0085	55	CTD	CTD062
24/10/2017	05:05	05:30	-35.9257	28.0052	-35.9252	28.0085	55	VERTICAL BONGO NET	Vertical Bongo Net 26
24/10/2017	05:49	n/a	-35.9238	28.0095	n/a	n/a	55	ARGO FLOAT	Argo float
24/10/2017	12:32	13:12	-36.9935	28.3392	-36.9935	28.3392	56	CTD	CTD063
24/10/2017	12:36	13:00	-36.9935	28.3392	-36.9935	28.3392	56	OPTICS	Optics Rig 55
24/10/2017	12:36	n/a	-36.9935	28.3392	n/a	n/a	56	BALLOON	Radio Sonde Balloon
24/10/2017	13:01	13:23	-36.9935	28.3392	-36.9935	28.3392	56	OPTICS	Optics Rig 56
25/10/2017	04:40	06:12	-39.3565	29.2688	-39.3563	29.2647	57	CTD	CTD064
25/10/2017	06:51	09:55	-39.3563	29.2645	-39.3567	29.2607	57	SAPS	SAPS009
25/10/2017	10:32	11:20	-39.3567	29.2607	-39.3567	29.2607	57	CTD	CTD065
25/10/2017	12:15	n/a	-39.3583	29.2600	n/a	n/a	57	BALLOON	Radio Sonde Balloon
25/10/2017	12:26	13:22	-39.4917	29.2593	-39.4895	29.2922	57	BONGO TOW	Bongo Tow 28
25/10/2017	13:39	n/a	-39.4890	29.2987	n/a	n/a	57	ARGO FLOAT	Argo float
26/10/2017	02:36	03:00	-41.1345	29.9895	-41.1425	29.9945	58	RING NET	Ring Net
26/10/2017	03:03	03:21	-41.1433	29.9945	-41.1490	29.9982	58	RING NET	Ring Net
26/10/2017	03:24	03:43	-41.1497	29.9987	-41.1583	30.0042	58	RING NET	Ring Net
26/10/2017	03:53	04:40	-41.1587	30.0043	-41.1788	30.0198	58	BONGO TOW	Bongo Tow 29
26/10/2017	04:49	05:13	-41.1788	30.0198	-41.1805	30.0173	58	VERTICAL BONGO NET	Vertical Bongo Net 27
26/10/2017	05:02	05:39	-41.1798	30.0185	-41.1823	30.0143	58	CTD	CTD066
26/10/2017	12:26	13:12	-42.1283	30.4167	-42.1283	30.4167	59	CTD	CTD067
26/10/2017	12:26	12:50	-42.1283	30.4167	-42.1283	30.4167	59	OPTICS	Optics Rig 57
26/10/2017	12:40	n/a	-42.1283	30.4167	n/a	n/a	59	BALLOON	Radio Sonde Balloon
26/10/2017	12:51	13:12	-42.1283	30.4167	-42.1283	30.4167	59	OPTICS	Optics Rig 58
27/10/2017	04:12	04:55	-44.2287	31.3185	-44.2182	31.3377	60	BONGO TOW	Bongo Tow 30
27/10/2017	04:59	05:35	-44.2180	31.3378	-44.2180	31.3378	60	CTD	CTD068
27/10/2017	05:45	n/a	-44.2173	31.3378	n/a	n/a	60	ARGO FLOAT	Argo float
27/10/2017	12:33	13:11	-45.1900	31.7333	-45.1900	31.7333	61	CTD	CTD069
27/10/2017	12:34	12:53	-45.1900	31.7333	-45.1900	31.7333	61	OPTICS	Optics Rig 59
27/10/2017	12:45	n/a	-45.1900	31.7333	n/a	n/a	61	BALLOON	Radio Sonde Balloon
27/10/2017	12:55	13:19	-45.1900	31.7333	-45.1900	31.7333	61	OPTICS	Optics Rig 60
27/10/2017	13:21	n/a	-45.1900	31.7333	n/a	n/a	61	ARGO FLOAT	Argo float
28/10/2017	05:03	06:03	-47.1242	32.6068	-47.1225	32.6013	62	CTD	CTD070

DATE	START TIME (GMT)	END TIME (GMT)	START LAT (+ve N)	START LON (+ve W)	END LAT (+ve N)	END LON (+ve W)	STATION	EQUIPMENT	ACTIVITY
28/10/2017	06:36	09:48	-47.1225	32.6010	-47.1120	32.5747	62	SAPS	SAPS010
28/10/2017	10:21	11:10	-47.1120	32.5747	-47.1120	32.5747	62	CTD	CTD071
28/10/2017	10:28	10:51	-47.1120	32.5747	-47.1120	32.5747	62	OPTICS	Optics Rig 61
28/10/2017	10:52	11:14	-47.1120	32.5747	-47.1120	32.5747	62	OPTICS	Optics Rig 62
28/10/2017	11:22	n/a	-47.1087	32.5650	n/a	n/a	62	BALLOON	Radio Sonde Balloon
29/10/2017	04:02	04:45	-49.4433	33.7040	-49.4610	33.7210	63	BONGO TOW	Bongo Tow 31
29/10/2017	05:04	05:40	-49.4623	33.7207	-49.4667	33.7173	63	CTD	CTD072
29/10/2017	12:34	13:16	-50.3575	34.2042	-50.3575	34.2042	64	CTD	CTD073
29/10/2017	12:40	13:00	-50.3575	34.2042	-50.3575	34.2042	64	OPTICS	Optics Rig 63
29/10/2017	13:02	13:25	-50.3575	34.2042	-50.3575	34.2042	64	OPTICS	Optics Rig 64
29/10/2017	13:49	n/a	-50.3575	34.2042	n/a	n/a	64	BALLOON	Radio Sonde Balloon
30/10/2017	02:38	03:01	-51.9350	35.0565	-51.9372	35.0600	65	RING NET	Ring Net
30/10/2017	03:05	03:26	-51.9373	35.0605	-51.9383	35.0640	65	RING NET	Ring Net
30/10/2017	03:29	03:49	-51.9383	35.0643	-51.9395	35.0677	65	RING NET	Ring Net
30/10/2017	04:04	04:49	-51.9410	35.0730	-51.9448	35.0857	65	BONGO TOW	Bongo Tow 32
30/10/2017	04:57	05:36	-51.9448	35.0852	-51.9438	35.0727	65	CTD	CTD074
30/10/2017	05:03	05:28	-51.9447	35.0830	-51.9442	35.0758	65	VERTICAL BONGO NET	Vertical Bongo Net 28
30/10/2017	12:32	13:14	-52.9383	35.6600	-52.9383	35.6600	66	CTD	CTD075
30/10/2017	12:32	12:52	-52.9383	35.6600	-52.9383	35.6600	66	OPTICS	Optics Rig 65
30/10/2017	12:48	n/a	-52.9383	35.6600	n/a	n/a	66	BALLOON	Radio Sonde Balloon
30/10/2017	12:54	13:18	-52.9383	35.6600	-52.9383	35.6600	66	OPTICS	Optics Rig 66
01/11/2017	02:48	03:14	-53.5415	38.8910	-53.5428	38.5710	67	RING NET	Ring Net
01/11/2017	03:16	03:38	-53.5430	38.5722	-53.5443	38.5848	67	RING NET	Ring Net
01/11/2017	03:41	04:02	-53.5447	38.5860	-53.5462	38.5973	67	RING NET	Ring Net
01/11/2017	04:10	04:58	-53.5468	38.6032	-53.5505	38.6395	67	BONGO TOW	Bongo Tow 33
01/11/2017	05:08	06:06	-53.5507	38.6405	-53.5547	38.6443	67	CTD	CTD076
01/11/2017	05:15	05:40	-53.5510	38.6415	-53.5530	38.6428	67	VERTICAL BONGO NET	Vertical Bongo Net 29
01/11/2017	06:33	09:31	-53.5548	38.6445	-53.5548	38.6445	67	SAPS	SAPS011
01/11/2017	10:05	10:54	-53.5548	38.6445	-53.5548	38.6445	67	CTD	CTD077
01/11/2017	10:17	10:35	-53.5548	38.6445	-53.5548	38.6445	67	OPTICS	Optics Rig 67
01/11/2017	10:36	10:58	-53.5548	38.6445	-53.5548	38.6445	67	OPTICS	Optics Rig 68
01/11/2017	10:37	n/a	-53.5548	38.6445	n/a	n/a	67	BALLOON	Radio Sonde Balloon
02/11/2017	05:04	05:43	-53.1848	42.4158	-53.1848	42.4158	68	CTD	CTD078
02/11/2017	12:48	n/a	-53.0617	43.6800	n/a	n/a	69	BALLOON	Radio Sonde Balloon