Cruise report:

JR288
ACCACIA Arctic Summer Cruise

RRS James Clark Ross
13 July - 16 August 2013

Principal Scientists: Lucy Carpenter & Rosie Chance

Department of Chemistry, University of York, York, YO10 5DD, UK

Email: lucy.carpenter@york.ac.uk, rosie.chance@york.ac.uk

THE UNIVERSITY of York

Table of Contents

1. Overview and objectives of cruise JR288

The cruise took place as part of the larger NERC funded consortium project called Aerosol-Cloud Coupling And Climate Interactions in the Arctic (ACCACIA). The overarching objective of the project is to reduce uncertainty in the representation of Arctic cloud and aerosol processes in climate models. Airborne measurements of aerosol and cloud properties were made concurrent with cruise JR288, using the BAS Twin Otter aircraft (MASIN) operating out of Svalbard. The campaign is the second of two to take place in the study area as part of the ACCACIA project; the first took place in March 2013 on board the ship RV Lance and the BAS MASIN and FAAM BAe146 aircraft.

Stations were occupied in open water and within the ice edge (mainly small floes). At each station, the following activities typically took place:

1. Shallow CTD cast to sample the upper water column for analysis and use in ship-board experiments
2. Deployment of sea-surface microlayer sampling boat
3. Bongo nets for copepod collection
4. VMP deployment
5. Deep CTD cast to profile the full water column

Additional sampling from the pumped underway seawater supply also took place, and extra deployments of the VMP profiler were made between selected stations. Atmospheric measurements were made continuously, or semi-continuously.

Within ACCACIA, the aims of the research cruise were to make surface based in-situ measurements of marine aerosol composition and properties, and aerosol precursor gases (DMS, VOCs, halocarbons). Trace gases were measured in air and water, and high volume aerosol samples were collected for off-line characterisation of organic composition. Ambient aerosol measurements and bubble tank experiments were conducted to characterise aerosol physical and chemical properties using a suite of instrumentation by the Manchester group. Together with black carbon/soot optical measurements and CCN measurements made as function of particle size and super-saturation, these will be used as input in cloud microphysical models to investigate their influence on aerosol-cloud feedback sensitivity whereas bubble tank results will be used to develop a primary multicomponent sea-spray aerosol flux parameterisation.

The ACCACIA teams were joined on the cruise by collaborative partners with interests highly complimentary to the ACCACIA objectives. The work conducted by these teams is summarised below:

- The sea surface microlayer (SSM) was sampled using a remote control vessel away from the ship. Measurements of the concentration and efficiency of ice nuclei within the microlayer were conducted along with other chemical and biological assays.

- Ocean microstructure was measured using a VMP 500 by Bangor University as part of the NERC funded TEA-COSI consortium project. A seasonally ice-free Arctic Ocean will be exposed to wind forcing, increasing the transfer of momentum. The oceans turbulent mixing will strengthen and dense water formation will change, altering the thermohaline circulation and affecting remote climates, including the UK. The vertical profiles of turbulent mixing collected on the cruise provide a baseline for future understanding of changes in Arctic mixing rates as well as improving understanding of the dominant processes that generate mixing across the Arctic Ocean and adjacent shelf seas.

- As part of a NERC funded project investigating 'the role of DMS in pelagic tri-trophic interactions' the team from the University of Essex and the Plymouth Marine Laboratory collected data on microzooplankton and copepods grazing rates relative to the phytoplankton community present. Throughout our grazing interaction experiments we quantified DMS production, net changes in DMSP dynamics and specific intracellular

DMSP concentrations of different subpopulations of the phytoplankton community. In total nine dilution experiments were carried out with varying phytoplankton community compositions.

- Haloperoxidase activity was measured and samples taken for related supporting parameters (i.e. size-fractionated chlorophylls and nutrient concentrations) by the team from the Environment Department at the University of York. The aim of this study was to look for the distribution of haloperoxidase activity amongst different phytoplankton groups and assess the environmental controls on activity.

- To examine the physiological status of marine phytoplankton in varying sea-ice conditions, 14C- and FRRf-based photosynthesis-irradiance experiments were conducted by Dr Heather Bouman and Alison Small (U Oxford). Fluorometric chlorophyll samples were collected and measured onboard to determine the concentration of chlorophyll biomass and to calibrate the in vivo fluorometer mounted on the CTD rosette. Samples for HPLC pigment and flow cytometry were also collected to provide information on the taxonomic structure of the natural assemblages.

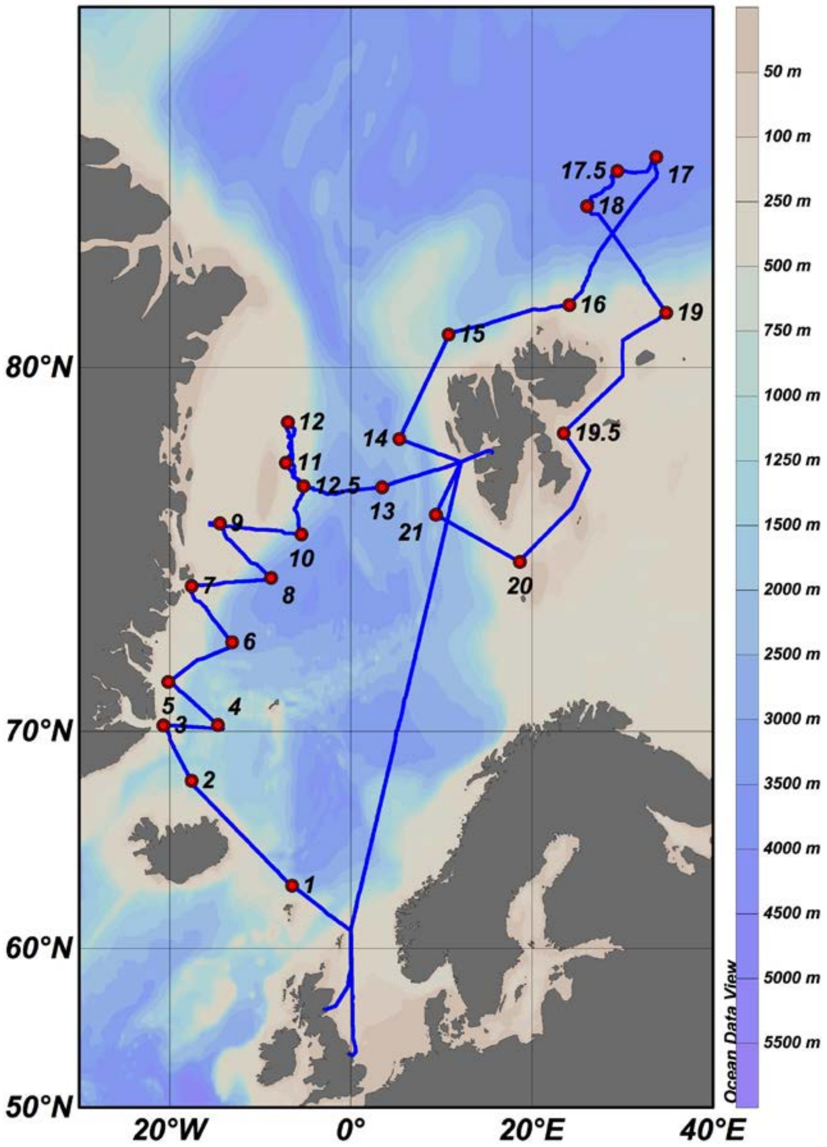

Figure 1.1. Cruise track and CTD station positions for cruise JR288

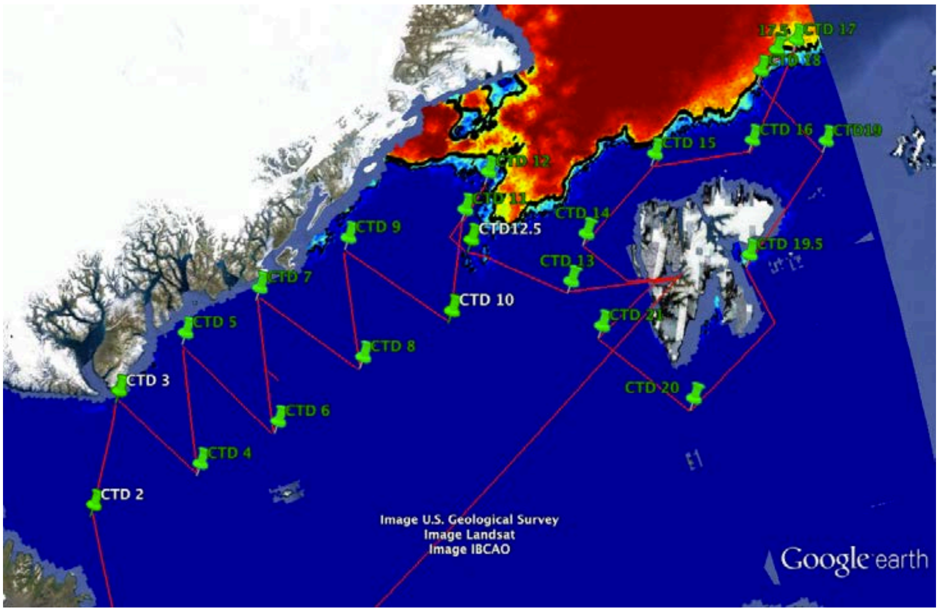

Figure 1.2. Google Earth image showing station positions and approximate cruise track, superimposed on ice edge image dated 3/8/13 (National Snow and Ice data Center).

Table 1.1. Scientific party for JR288

	Institution
Lucy Carpenter	University of York
Rosie Chance	University of York
Sina Hackenberg	University of York
Claire Hughes	University of York
Jenny Stephenson	University of York
Stephen Andrews	University of York
Jonny Taylor	University of Manchester
Juan Najera	University of Manchester
Theo Wilson	University of Leeds
Tom Whale	University of Leeds
Ben Murray	University of Leeds
Heather Bouman	University of Oxford
Alison Small	University of Oxford
John Stephens	Plymouth Marine Laboratory
Mark Breckels	University of Essex
Tom Rippeth	Bangor University
Ben Lincoln	Bangor University
Ben Powell	Bangor University
Suzanna Jackson	Bangor University
Joshua Griffiths	Bangor University
David Childs	National Marine Facility
Nick Rundle	National Marine Facility
Jeremy Robst	British Antarctic Survey
Julian Klepacki	British Antarctic Survey

2. NMFSS Sensors & Moorings Report

DAVE CHILDS, NICK RUNDLE
Sensors & Moorings Group
National Marine Facilities Sea Systems
National Oceanography Centre, Southampton

CTD System Configuration

The initial stainless sensor configuration was as follows:

- Sea-Bird 9*plus* underwater unit, SN: 09P-35716-0771
- Frequency 1 - Sea-Bird 3 Premium temperature sensor, SN: 3P-4472
- Frequency 2 - Sea-Bird 4 conductivity sensor, SN: 4C-2222
- Frequency 3 - Digiquartz temperature compensated pressure sensor, SN: 0771
- Frequency 4 - Sea-Bird 3 Premium temperature sensor, SN: 3P-2366
- Frequency 5 - Sea-Bird 4 conductivity sensor, SN: 4C-2289
- V0 – Transmissometer WetLabs C-Star, SN: CST-846DR
- V1 – Fluorimeter, Chelsea SN: 088-216
- V2 – PAR Sensor, SN: 70411
- V3 - Altimeter SN: 244738
- V4 – Oxygen Sensor, SBE 43 SN:2290

Ancillary instruments & components:

- Sea-Bird 11*plus* deck unit, SN: 11P20391-0502
- Sea-Bird 24-position Carousel, SN: 32-0636
- 24 x Ocean Test Equipment 20L water samplers.
- Primary Pump: Sea-Bird 5T, SN: 54458
- Secondary Pump: Sea-Bird 5T, SN: 51807

All sensors, deck unit's, and PC's used were from BAS, with the exception of the 20L Niskin water bottles, the slave LADCP and the secondary FRRF which belong to NMF.

The configuration file used during the cruise is given in Appendix C.

CTD Operations

Generally, CTD operations consisted of two casts per day, one shallow cast at approximately 07:15 GMT, followed by a second deeper cast at approximately 14:00 GMT.
Between casts, samples were taken by the scientific party on board, with different people sampling from different bottles as required. During this time, log sheets were completed, LADCP data was downloaded and backed up and the CTD data processed.

Due to the limited pressure rating of the secondary FRRF instrument, for casts deeper than 500m it was necessary to remove both the instrument and its external battery pack. This added in the region of 15 to 20 minutes extra work to turn around the CTD ready for the next cast, although all casts were conducted on time.

There were no issues with the mechanical CTD termination whilst on board; however on cast 42 the electronic termination failed, resulting in the CTD cast being aborted. A thorough check of the system found a slight ingress of water on the sea cable connector, this was then cleaned, dried and re-greased and then tested. All seemed fine, and the cast went ahead slightly later at approximately 11:15 GMT with no further problems.

A total of 45 CTD "casts" were completed on this cruise numbered sequentially. Cast 042 was re run as cast 043.

For each cast the ship's crew deployed the CTD package once permission was granted from the officer on watch. Deck crew assisted in getting the CTD over the bulwark and into or out of the CTD annex, whilst Dave, the Boson, drove the winch from the winch cab. For every cast, the crew was ready in advance of the deployment time, helping to ensure casts were completed as efficiently as possible.

The pressure sensor was located 30cm below the bottom and approximately 75cm below the centre of the 20L water sampling bottles.

The carousel was fitted with a complete set of 24 water samplers, numbered 1 through to 24. Not all bottles were fired during some of the casts, however where possible two bottles were fired at each depth allowing for any seal or misfire problems. Generally most bottles closed properly, most of the time. It was noted that some of the taps were stiff to operate, and checks were made to see if any needed replacing, however over time the taps became easier to operate. A few o-rings needed replacing on some of the taps as they had become brittle and broken.

Cast depths ranged from approximately 100 meters through to 3500 meters, aiming to get as close to the seabed as possible, making full use of the fitted altimeter.

All bottle firing depths were chosen by the scientific party.

Sensor Failures

During all casts all of the CTD sensors worked as expected, and no replacements we used.

Initially LADCP SN: 13329 was used for casts 1 through to 23, however during this cast it was observed that the ADCP had developed a fault. In an effort to minimise downtime the LADCP was swapped for the spare, SN: 13399

LADCP

For this cruise two LADCP's were fitted in a master and slave configuration. The master LADCP was located on the bottom of the CTD frame looking down, whilst the slave LADCP was fitted to the outside of the CTD frame, looking up. Each cast the fitted LADCP's were set up to log data via the PC using the BBTalk software application and a pre configured script file.

The following commands were used to set up the LADCP prior to each deployment:

Master:	**Slave:**
CR1	CR1
WM15	WM15
CK	CK
RN MLADCP	RN SLADCP
ED0000	ED0000
ES35	ES35
EX11111	EX11111
SM1	SM2
SA001	SA001
SI0	ST0300
SW75	TE00000100
TE00000100	TP000100
TP000100	LD111100000
LD111100000	LP1
LP1	LN015
LN015	LS800
LS800	LF0176
LF0176	LV170
LV170	LW1

LW1	EZ0111111
EZ0111111	EC1500
EC1500	EA00000
EA00000	EB00000
EB00000	CF11101
CF11101	CK
CK	CS
CS	
MLADCP	

Data Processing

CTD cast data was post-processed using SBE Data Processing (V7.20g) software. The raw data files were converted through the following steps as recommended by BODC basic on-board data processing guidelines for SBE-911 CTD (version 1.0, October 2010):

- Data Conversion (DatCnv)
- Bottle file generation (BottleSum)
- Filter
- AlignCTD
- Cell Thermal Mass (CellTM)
- Loopedit
- Derive
- Bin Average to 1m intervals (BinAve)
- Strip

3. VMP Turbulence Profiles

Ben Lincoln (ben.lincoln@bangor.ac.uk), Ben Powell, Tom Rippeth, Suzie Jackson, Josh Griffiths

Bangor University

Aims:
This research by Bangor University is part of the NERC funded TEA-COSI consortium project. The Arctic Ocean is predicted to be seasonally ice-free by the end of the century and it will change radically as a consequence. Changes in the Arctic have the potential to affect remote climates, including the UK, by changing the nature of the thermohaline circulation, offering the risk of regional cooling against a background of global warming.
The key is to quantify (for the present) and understand (for the future) the Arctic Oceans import of heat, export of freshwater and storage of both. Direct exposure of the ocean surface to wind forcing will increase the efficiency of momentum transfer so the ocean will spin up on seasonal and possibly longer timescales. The oceans turbulent mixing will strengthen and dense water formation will change. The project aims to provide a new and quantitative understanding of these processes and their impacts on a future Arctic climate.
Bangor's role within the project is to make measurements of microstructure shear for the calculation of vertical profiles of TKE dissipation. These measurements will provide a baseline for future understanding of changes in Arctic mixing rates as well as understanding the dominant processes which generate mixing across the Arctic Ocean and shelf seas. The profiles of dissipation rates may also be used to estimate vertical fluxes of nutrients, heat, and plankton using calculated profiles of eddy diffusivity, Kz.

Instrument
The Rockland Vertical Microstructure Profiler (VMP500) measures velocity shear at dissipation length scales using air-foil type probe which outputs a voltage which is proportional to the sideways forces generated by cm-mm scale eddies. These probes are mounted on the bottom of the instrument along with microstructure temperature and conductivity sensors. Temperature and conductivity were sampled by Seabird sensors on the side of the instrument.

Figure 3.1: VMP 500 setup on aft deck port side, with hydraulic line puller (left), winch (middle) and 6ft container(right) housing hydraulic powerpack and data recording laptop.

Setup
The instrument free-falls at 0.6m/s while excess cable is fed out by means of a hydraulic line puller, while the ship steams at 0.5kt away from the instrument. A dedicated hydraulic winch is used for recovery which was mounted to the deck on the port side of the aft deck (see fig 3.1),

using a 1m spaced H-plate. The line puller was strapped to the gunwale (using ratchet straps) rather than bolted to the deck since this allowed the greatest clearance of the line over the gunwale (this was changed after the line was tight against the gunwale initially). A dedicated hydraulic power-pack for powering the winch and line puller was housed in a 6ft container forward of and in line with the winch and line puller. Power for the hydraulic power-pack (3phase) and for the VMP recording equipment and power (single phase) were arranged by the ships electrician and routed through a hole in the side of the container along with the hydraulic hoses.

Deployment of the VMP was done using the port side aft deck crane to lift a specialised pulley (pulley is large diameter and can be opened on one side to remove cable) over the gunwale and approximately 2m away from the ship with sufficient height to raise the VMP over the gunwale. The VMP was then raised over the gunwale using the winch while a second person guided the VMP by hand and a third steadied the VMP using a boat hook as it was released to a vertical position. The VMP was then lowered to the water using the winch and the pulley recovered using the crane. Once the pulley was recovered the line was threaded through the line puller before the VMP was raised to the surface ready for deployment. This procedure was reversed for the recovery of the instrument.

Data

234 VMP profiles were collected during the cruise at 35 different locations. After each CTD (except CTDs 15 and 19) two full depth or 500m casts were made additionally at four different shelf stations (CTDs 11, 12, 16 and 20) a time series of VMP profile was collected from between 7 and 12 hours each. Additional stations were also added overnight along the cruise track as time allowed, these stations were all just a single cast. The first 10 of these additional stations were located on the 1000m isobath along the Greenland shelf break. These stations cross the critical latitude for propagation of the M2 internal tide in a rare Arctic region of significant tidal amplitude.

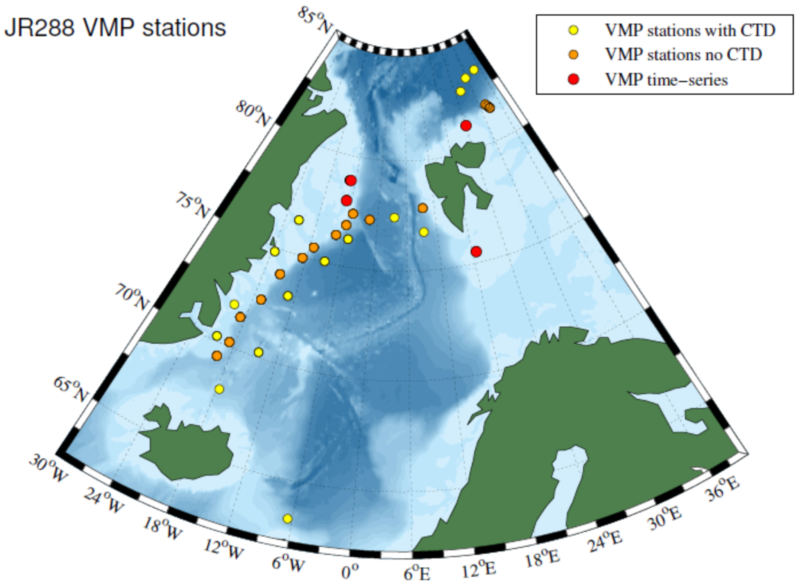

Figure 3.2. VMP stations

Later additional stations were placed across the Fram strait (along with 2 additional CTD casts to 1000m) and coming up onto the shelf break North of Svalbard at 2000m 1000m, 500m and 250m water depth.
The position of each station is plotted in figure 3.2 (the type of station is indicated in the legend). During the time series measurements as well as the ships 75kHz ADCP there were additional measurements of high vertical resolution current velocities using a 300kHz ADCP suspended over the stern from an aft deck crane. The range of these measurements was limited to ~90m and the motion of the instruments was considerable which may limit their use

Issues
The method of deployment from the aft deck while steaming at 0.5kts using the ships thrusters generated a region of turbulence with contaminated the data to a depth greater than that usually encountered ~20m. This meant that in the ice covered waters where the mixed layer was shallow estimates of dissipation at the interface are unrepresentative of actual rates.
The common problem of damage to the shear probes was encountered again which meant that on a number of casts only one shear channel was available. The shear probes used were as follows:

Casts 1-3	S1= 423	S2= 431
Casts 4 -115	S1= 423	S2= 324
Casts 116 - 142	S1= 423	S2= 315
Casts 143 - 237	S1= 316	S2= 315

4. *TRiOS* Radiometer

Joshua W. Griffiths (*UK-Fr. M.O.D. PhD Student*)
School of Ocean Sciences, Bangor University,
Menai Bridge, Anglesey. LL59 5AB.
osu868@bangor.ac.uk

PhD supervised by:
D.G. Bowers *(Bangor University)* and F. Gohin & R. Verney *(Ifremer, Brest)*

PhD Background
Visible-band satellite images show patterns in water brightness and colour, which are related to the distribution of suspended sediments in the surface layer of coastal waters (*Gohin, 2011*). The turbidity that can be seen in these images directly affects the attenuation of light in water. The large archive of satellite data that is now available can be used to produce statistical information about the spatial and temporal variation of turbidity in coastal waters and, by implication, anywhere in the world.

Precise, quantitative estimates of suspended sediment load using satellite data depend on the nature as well as the number of particles in suspension (*Bowers et al., 2005)*. Backscattering of light by suspended matter depends on the size, shape and refractive index of particles. Through flocculation, these properties are controlled by the turbulence in the water, as modelled relative to tides and wind in *Rivier et al. (2012).* If the effects of turbulence on backscattering of light by particles can be better understood, there is potential to infer turbulence parameters in the near-surface layer of the ocean from remotely sensed measurements.

Arctic Cruise Hypothesis
In a sediment-laden shelf-sea environment, turbidity is indicative of turbulent activity within the water column, with light attenuation increasing with turbidity. However, in a less turbid Arctic environment, can there still be a relationship between turbulent energy and light attenuation.

Objectives
- Measure light intensity within the visible light waveband with depth.
- Compare with CTD parameter variability.
- Compare attenuation of specific wavelengths to predicted turbulence dissipation.

Method
TRiOS radiometers measure light attenuation within the visible light waveband (300-950nm). One radiometer (*TRiOS 821B*) is first pointed up at an angle of ~30° towards the sky, remaining static throughout recordings. At the same time, a second radiometer (*TRiOS 503C*) is placed within a reversible frame. The framed radiometer can then be lowered through the water column, with spectral measurements taken at just below the surface, at 5m and at 10m. The measurements are taken firstly with the radiometer pointed towards the surface and secondly, towards the bed.

Deployment log and example data
Below is a table defining the stations in which the radiometers were deployed, including the location and device depths at which spectra were collected:

Station	Date	Latitude	Longitude	Device depths	Depth	Transmittance
15	02.08.13	80°37’N	10°44’E	0m & 10m	931m	0.44
17	04.08.13	83°19’N	33°41’E	0m, 5m & 10m	3,912m	0.51
17.5	04.08.13	83°08’N	29°28’E	0m, 5m & 10m	3,989m	0.49
18	05.08.13	82°40’N	26°06’E	0m, 5m & 10m	4,000m	0.60
19	06.08.13	80°60’N	34°51’E	0m, 5m & 10m	184m	0.34
20	08.08.13	75°32’N	18°39’E	0m, 5m & 10m	101m	0.49
21	09.08.13	76°46’N	09°22’E	0m, 5m & 10m	2,306m	0.45

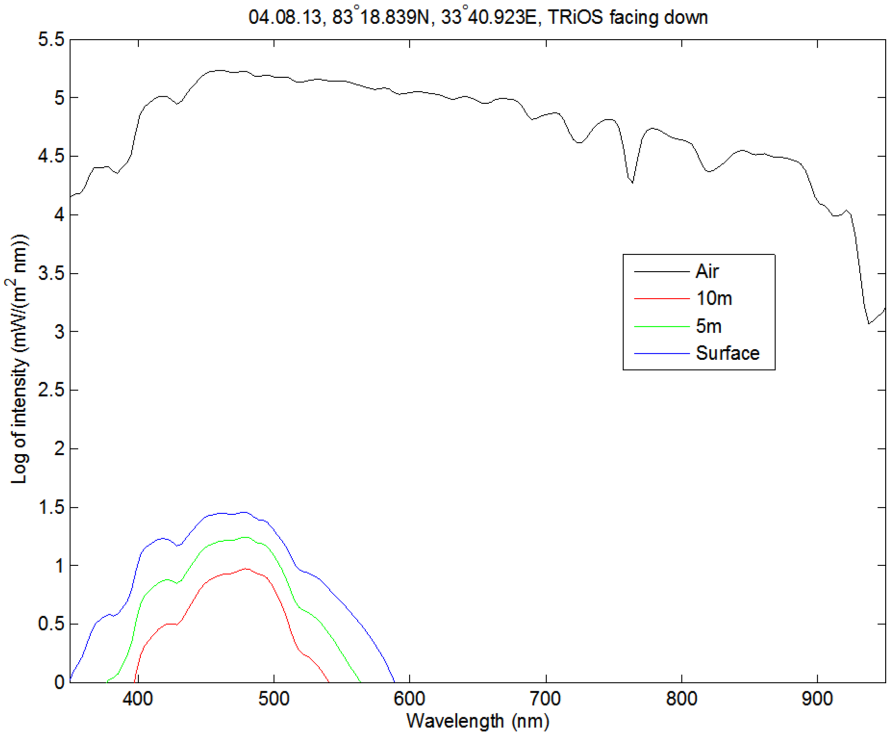

Figure 4.1. Log of intensity within the visible light waveband with the submerged TRiOS facing downwards. The devices were deployed at 10:45 GMT on the 4th August 2013, at [83°18.839'N, 33°40.923'E], station 17. The depth is 3,912m and the transmittance is 0.51. Air measurements are taken by the TRiOS 821B, with all other measurements taken by the TRiOS 503C.

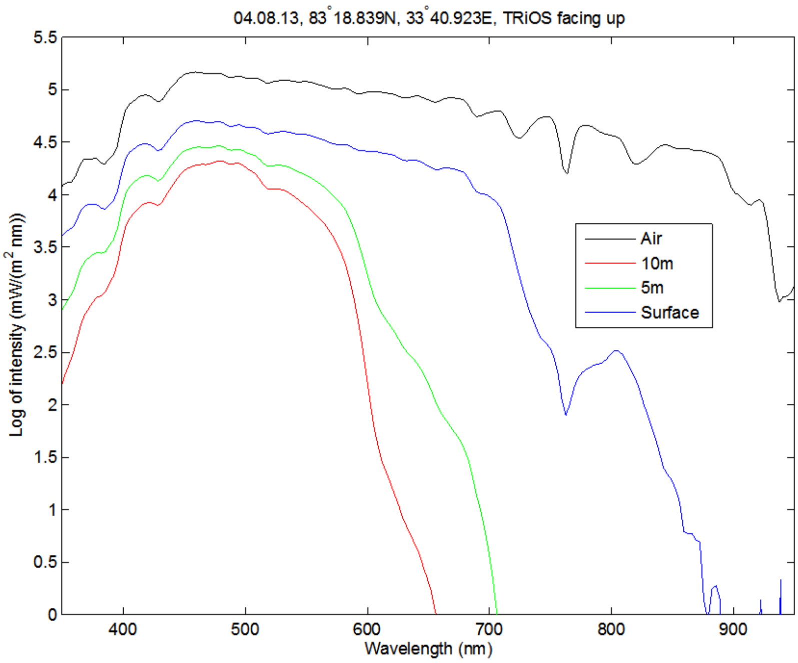

Figure 4.2. Log of intensity within the visible light waveband with the submerged TRiOS facing upwards. The devices were deployed at 10:45 GMT on the 4th August 2013, at [83°18.839'N, 33°40.923'E], station 17. The depth is 3,912m and the transmittance is 0.51. Air measurements are taken by the TRiOS 821B, with all other measurements taken by the TRiOS 503C.

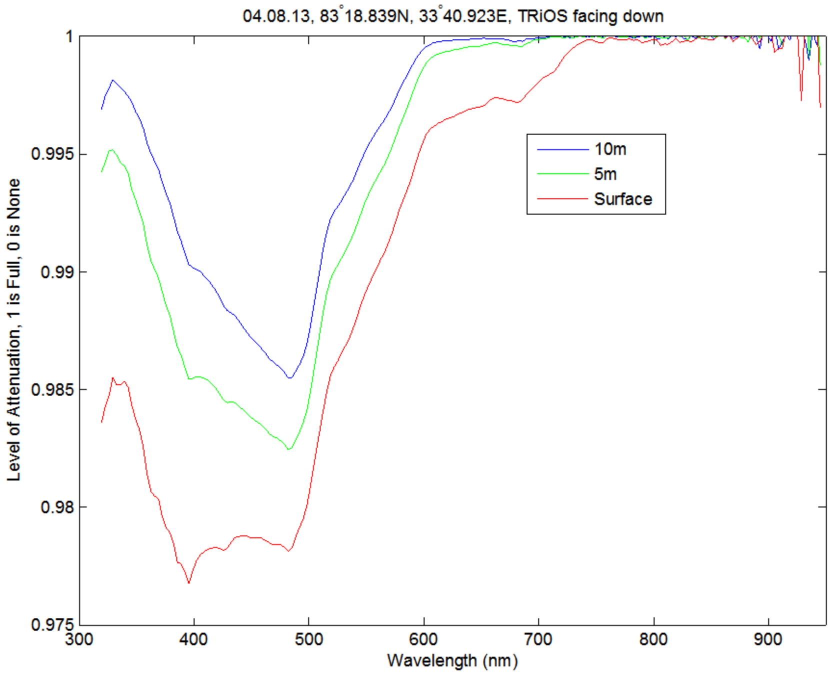

Figure 4.3. Attenuation of light within the visible light waveband with the submerged TRiOS facing downwards. The devices were deployed at 10:45 GMT on the 4th August 2013, at [83°18.839'N, 33°40.923'E], station 17. The depth is 3,912m and the transmittance is 0.51. Air measurements are taken by the TRiOS 821B, with all other measurements taken by the TRiOS 503C.

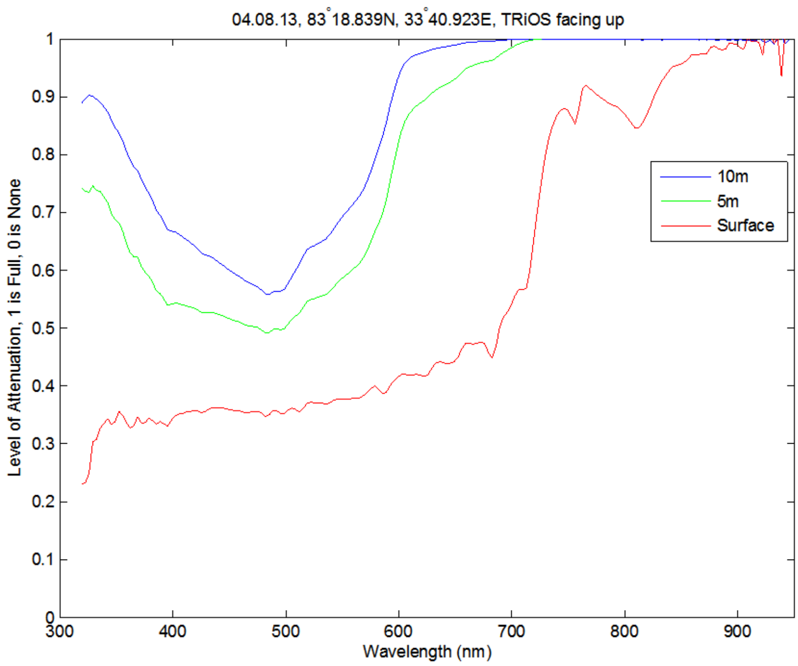

Figure 4.4. Attenuation of light within the visible light waveband with the submerged TRiOS facing upwards. The devices were deployed at 10:45 GMT on the 4th August 2013, at [83°18.839'N, 33°40.923'E], station 17. The depth is 3,912m and the transmittance is 0.51. Air measurements are taken by the TRiOS 821B, with all other measurements taken by the TRiOS 503C.

References

Bowers, D.G., Boudjelas,S., & Harker, G.E.L. (1998). *The distribution of suspended sediments in the surface water of the Irish Sea and its relationship to tidal stirring*. International Journal of Remote Sensing. **19**. 2789-2805.

Bowers, D.G., Ellis, K.M., & Jones, S.E.J. (2005). *Light scattered by particles suspended in the sea: the role of particle size and density*. Continental Shelf Research. **25**. 1071-1080.

Rivier, A., Gohin, F., Bryère, P., Petus, C., Guillou, N., & Chapalain, G. (2012). *Observed vs. predicted variability in non-algal suspended particulate matter concentration in the English Channel in relation to tides and waves*. Geo-Marine Letters. **32** (2). 139-151.

5. In-situ aerosol measurements and bubble tank experiments

Jonathan Taylor, Juan Najera
Gordon McFiggans & James Allan

Centre for Atmospheric Sciences, School of Earth, Atmospheric and Environmental Sciences, University of Manchester, UK

In order to assess the role of aerosols in changing Artic climate and cloud properties, our objectives in this research cruise were to make surface based measurements of marine aerosol composition and cloud properties, and to conduct bubble tank experiments. Such aerosols may be produced locally (by sea spray or oxidation of gas-phase species) or transported from sources elsewhere. CCN (Cloud Condensation Nucleus) measurements made as function of aerosol size and super-saturation and will be used as input in cloud microphysical models to investigate their influence on aerosol-cloud feedback sensitivity. Bubble tank results will be used to provide a primary multicomponent sea-spray aerosol flux parameterisation for direct incorporation into the global aerosol modelling.

Atmospheric aerosol *in-situ* measurements were made continuously in a sea-container lab from an aerosol inlet system mounted on a side mast using the following online instrumentation:

-High Resolution Aerodyne Time of Flight Aerosol Mass Spectrometer (HR-TOF-AMS): determination of non-refractory aerosol chemical composition

-Droplet Measurement Technologies-Cloud Condensation Nuclei Counter (DMT-CCN): determination of size-resolved aerosol cloud condensation nuclei that can form into cloud droplets. Single sized particles (range 30-110 nm) were sampled at 5 different super-saturations (SS) allowing calculation of activated fraction as a function of super-saturation and dry sizes and particle critical super-saturation.

- Condensation Particle Counter (CPC): Total aerosol number concentration

- Hygroscopic Tandem Differential Mobility Analyser (HTDMA): measurements of particle growth factors (<10% to 90% relative humidity) to assess the mixing state of aerosols, with dry particle size ranging 50-500 nm with a typical scan time of 10 minutes per dry size

-Differential Mobility Particle Sizer (DMPS): to measure ambient aerosol size distributions in the range from 3 nm to 550 nm during 15 minutes measurement period

-Particle size analyser/dust-monitor (GRIMM 1.108): to monitor aerosol number size distributions by optical particle counting. The GRIMM has a larger size cut than the DMPS and can measure coarse mode aerosol that the DMPS cannot.

-Droplet Measurement Technologies Single Particle Soot Photometer (SP2): aerosol black carbon mass and number concentrations, size distribution and mixing state

-Multi Angle Absorption Photometer (MAAP): optical measurement of equivalent aerosol black carbon concentration and aerosol light absorption properties

-Compact Cascade Impactor (CCI): integrated size resolved aerosol samples (25 samples x 6 sizes) were taken daily for off-line analysis of soluble aqueous ions (*i.e.* Na^+, Cl^-, Br^-, NH_4^+, SO_4^{2-}, Mg^{2+}, Ca^{2+}, NO_3^-, Ox^-, Mal^-)

Ambient conditions (*i.e.* wind speed and direction, barometric pressure, ambient temperature and relative humidity) were monitored using 3D apparent wind vector anemometer

(Metek Sonic) and humidity probe (Hygroclip Rotronic), which were mounted in a box at the top side mast.

Seawater samples for bubble tank generation experiments were collected daily from near-surface CTD samples. Sea-spray aerosols generated by bubble tank were measured as number-size distributions (TSI 3080 SMPS) while air flow (ALICAT), temperature and relative humidity (Rotronic) conditions were recorded. SMPS measurements in the dry size range from 15 nm to 700 nm were obtained during a 120 seconds measurement period. Complementarily aerosol instrumentation was employed to sample sea-spray aerosols to fully characterise aerosol hygroscopic properties based on the variability in the sea-spray composition resulting from different seawater samples

6. Sea surface microlayer sampling and analysis for ice nuclei

Contact: Theo Wilson, University of Leeds (t.w.wilson@leeds.ac.uk)

Introduction

Low level stratus clouds which are ubiquitous in the Arctic region are composed of a mixture of supercooled water droplets and ice particles. When ice particles grow they precipitate out. Clouds which form below 0°C can glaciate when in the presence of sufficient ice nuclei (IN). This would be expected to reduce cloud lifetime. However, Arctic stratus persist for many days despite clear signs of ice formation. This cannot currently be explained (Morrison et al., 2012). Arctic stratus clouds significantly impact the Arctic climate due to a difference of net longwave radiation of 30-40 Wm^{-2} between radiatively clear and opaque mixed phase cloud conditions. Small changes in cloud occurrence frequency may therefore strongly impact the local radiative budget with implications for sea-ice extent and climate feedbacks (Morrison et al., 2012). A limitation in our ability to quantitatively understand and model these clouds is the identity, concentration and efficiency of ice nucleating particles present in the Arctic.

Objectives

1. Collection of sea surface microlayer (SSM) using the 'Interface II' remote control microlayer sampling boat.
2. Analysis of freshly sampled sea surface microlayer to quantify the abundance and efficiency of IN using two complementary droplet based techniques.
3. Collect aerosol on filters for later analysis to look for the presence of airborne IN.

Methods

<u>**Interface II**</u>

The sea surface sampler 'Interface II' (Figure 6.1) was deployed from the ship by crane at CTD stops when the sea conditions were suitably calm. The sampler was navigated to a distance of between ~50 and 200m upwind of the stationary ship, to allow the sampling of uncontaminated SSM by means of a slowly rotating Teflon coated drum. Interface II was checked for contamination by running seawater from each location through the vessel's sampling system. This 'boat blank' water was collected, analysed and compared to virgin seawater in the same way as the actual samples to check for the presence of any artificial IN generated by the sampler.

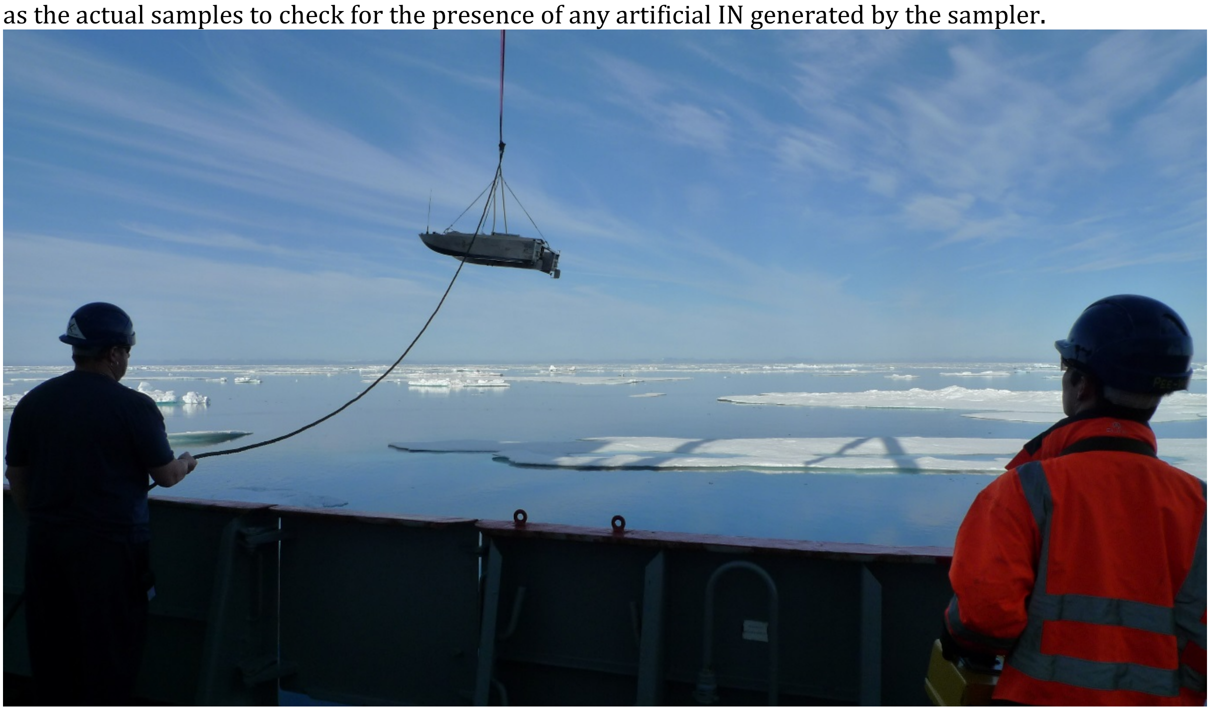

Figure 6.1. Deployment of Interface II

It was also found that during some sampling stops Interface II collected significant quantities of EPS. This was found as a variably green gungy deposit upon the sampler's scraper assembly (Figure 6.2). Samples were stored for further analysis.

Figure 6.2 EPS on scraper

Micro and nano sized droplet stages

1 μl droplets of SSM were pipetted onto a hydrophobic surface (Figure 6.3) and cooled at a rate of 1 K min^{-1} using an Asymptote EF600 cold stage until all droplets were frozen. The temperature at which individual droplets froze was recorded, allowing the construction of fraction of droplets frozen vs temperature curves to be constructed. These curves were compared to those collected for droplets of 2m CTD water sampled at the same location and also seawater boat blanks.

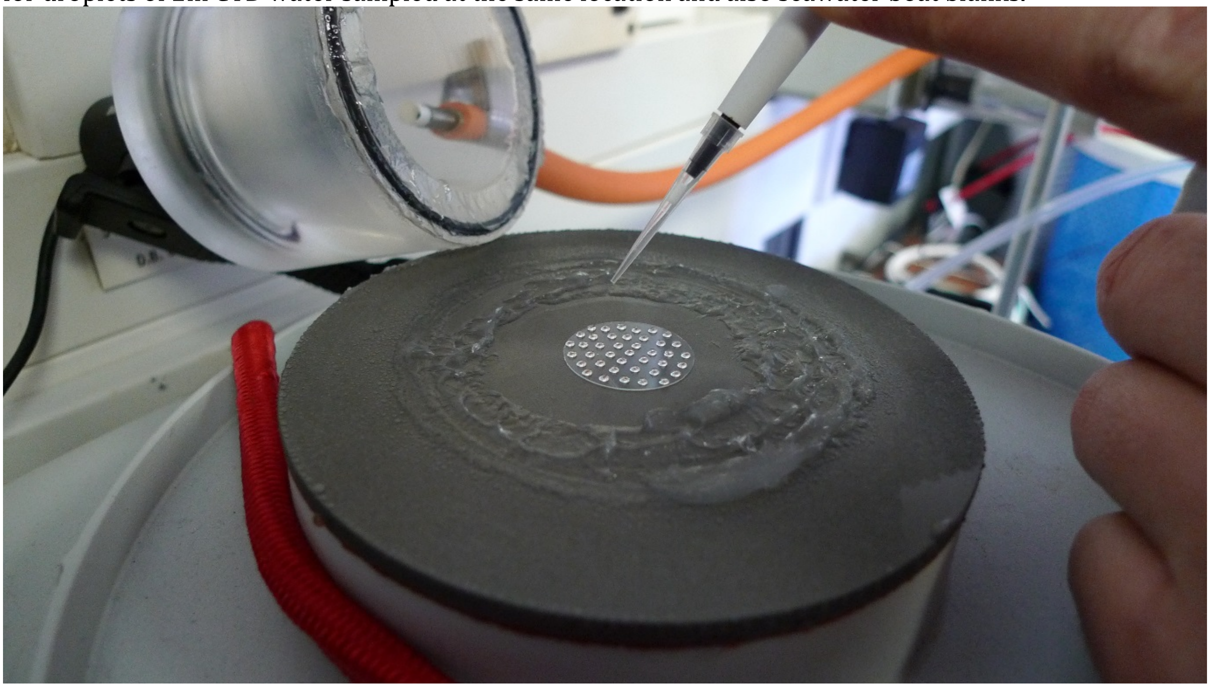

Figure 6.3 Droplet pipetting on EF600

Some experiments were also performed using smaller droplets on the 'nano' stage, though it was found that conditions on board the ship (i.e. movement) may have interfered with these experiments, making their outcome uncertain until full analysis can be completed.

Other analysis

As well as performing freezing analysis of raw SSM, samples were also filtered at a series of pore sizes and then tested to observe for changes in ice nucleating activity. Pore sizes of 10, 0.22 and 0.02 μm were tested routinely on all samples, as well as 0.4, 2 and 0.1 μm under some circumstances. SSM samples were also exposed to varying temperatures to observe any change in behaviour that might indicate the denaturing of ice active biological molecules. 10 and 100 times dilutions of SSM (with MilliQ water) were also tested as well as some experiments that used small droplets (0.2 μl) on the micro stage) in order to extend the temperature range of the freezing analysis. SSM was also distributed to other researchers on board for other analyses (Mark Breckels, Sina Hackenburg, Rosie Chance and Heather Bouman)

Sampling log

SSM

Date	CTD stop	Sampling started	Sampling ended	Samples stored				
				SSM frozen	2m CTD frozen	SSL fixed fridge	SSL raw fridge	EPS/Other
18/07	2	09:25	09:42	X				
19/07	3	09:15		x	x	X	X	
21/07	5	09:00	09:42	x		X	X	
22/07	6	09:00	09:40	x	x	X	x	
24/07	8	09:02 15:42	09:41 16:16	x	X x	X X	X X	
25/07	9	09:07	09:38	x	x	X		
26/07	10	15:24	16:21	x		X	x	
27/07	11	09:35	10:19	X	x	X	X	CTD water chlorophyll max
28/07	12	07:15	07:55	x	x	X	X	EPS
29/07	12.5	09:50	10:30	x	x	X	X	EPS
30/07	13	13:01	13:41	x	x	X		EPS
03/08	16	11:20	12:10	x	x	X	X	
04/08	17	09:03	09:45	x	x	X	X	
04/08	17.5	21:48	22:12	x	x	X	X	
05/08	18	08:53	09:41	x	x	X	X	
06/08	19	08:59	09:45	x	x	X	X	

Filters

Date	CTD stop	Sampling started	Sampling ended
16/07	1	12:53	14:53
18/07	2	11:57	14:05
19/07	3	13:42	15:48
21/07	5	11:47	13:59
22/07	6	11:42	13:39
24/07	8	08:50	10:46
26/07	10	13:54	14:56
29/07	12.5 (twin otter flypast)	11:35	13:51
30/07	13	11:09	13:15
04/08	17	09:13	11:15
06/08	19	11:44	13:43

Preliminary results

It was found that in general SSM droplets froze at significantly higher temperatures than 2m CTD water droplets (see example data from CTD stop 6, Figure 6.4). This strongly indicates the enhancement of IN concentration in the SSM compared to bulk seawater. A variation in activity was found between SSM sampled at different CTD stops, indicating variation in composition depending on location. It was also found that after heating to boiling point, the activity of SSM was reduced (See Figure 6.4), indicating that at least some of the IN present were biological. Analysis of filters and further analysis of SSM samples will take place in Leeds.

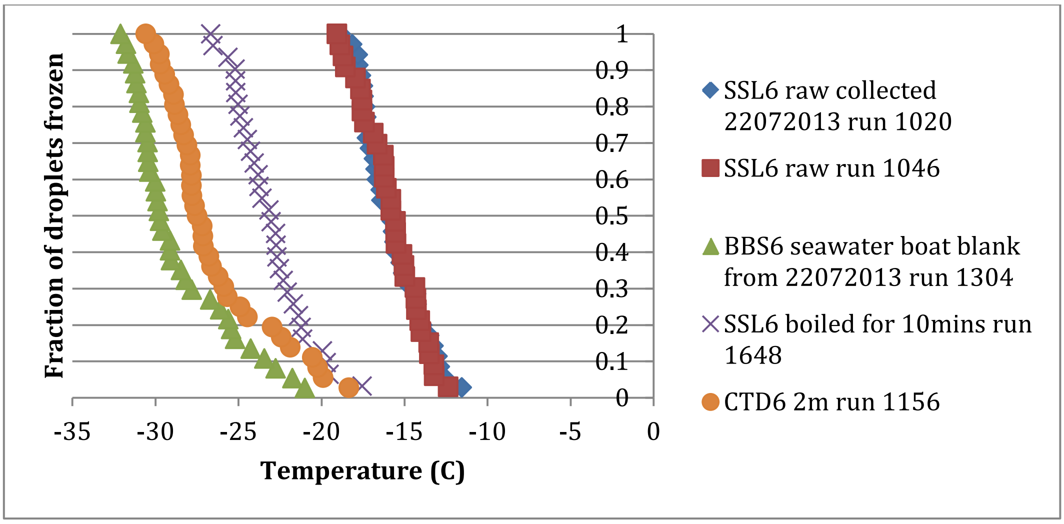

Figure 6.4. Fraction frozen data for µl size droplets of SSM (Blue diamonds and orange squares), 2m CTD water (green circles), SSM after boiling (yellow crosses) and boat blank water (grey triangles). All data from CTD stop 6.

7. Trace gas (DMS, halocarbons, terpenes and isoprene) air and water concentrations and flux calculations

Sina C. Hackenberg, Stephen J. Andrews, Lucy J. Carpenter, Rosie Chance, James Lee, Katie Read
University of York

Background

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

Dimethyl sulphide (DMS) derives from the breakdown of dimethylsulfoniopropionate (DMSP), which is produced by phytoplankton. Once vented to the atmosphere, DMS is oxidised to sulphate aerosol, and is the major source of cloud condensation nuclei (CCN) in clean marine environments such as the Arctic. Increased CCN concentrations lead to higher cloud albedo, and hence greater radiative cooling. The summertime Arctic Ocean is a strong source of DMS (Ferek 2005), and the gas is thought to be the dominant source of aerosol and Aitken mode particles during the summer. The decline in summer sea-ice coverage in the Arctic is expected to have a substantial impact on DMS fluxes, with increases of up to ~80% predicted by 2080 (Gabric et al., 2005). This is of particular importance for the radiative budget of the Arctic, as the scattering of incoming solar radiation by sulphate aerosol and brighter clouds arising from increased CCN numbers may counter the decrease in surface albedo due to reduced ice cover. Current ecosystem and biophysical models of sea-air DMS emissions are limited by the relative scarcity of data at high latitudes (Jodwallis et al., 2000; Vogt et al., 2010), and tend to underpredict Arctic DMS compared to observations.

Isoprene (C_5H_8) and monoterpenes ($C_{10}H_{16}$) are thought to form secondary organic aerosol (SOA) in the atmosphere, which can in turn act as CCN. The sources and impacts of isoprene and monoterpenes on the remote marine boundary layer is currently poorly understood, mainly due to a lack of measurements (Shaw et al. 2010, Yassaa et al. 2008, Colomb et al. 2009).

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

During JR288, DMS, halocarbons, isoprene and monoterpenes were measured in air and water samples simultaneously, in order to better constrain their sources, and how these are linked to changing ice conditions, and to improve understanding of their impacts on aerosol and clouds. Carbon monoxide (CO) and ozone (O_3) were also monitored continuously, in order to provide supporting data to help interpret trace gas measurements.

The specific aims of this study were as follows;

- Produce a set of targeted observations in regions of scarce data and under varying ice conditions to add to existing databases (e.g. NOAA/PMEL database)
- Use simultaneous measurements of air and water concentrations to infer sea-air fluxes of these compounds to the Arctic marine boundary layer.
- Use the data set to evaluate a coupled ice-ocean ecosystem DMS model (this will be done by our project partner Clara Deal) and contribute to improved estimates of pan-Arctic DMS emissions.
- Investigate links between trace gas emissions and phytoplankton community structure, using data (e.g. size fractionated chlorophyll-a, pigments, photosynthetic health) collected by other JR288 participants.

Methods

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

CO and O_3 were sampled through a separate inlet mounted on the mast attached to the Manchester container laboratory on the forecastle deck (figure 7.1). A 10 m sample line led from this inlet to the instruments in the container.

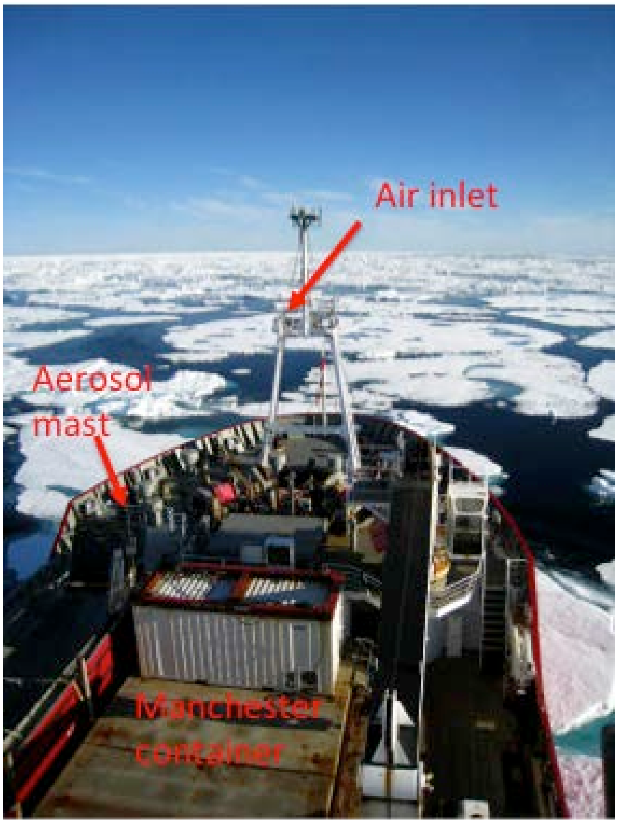

Figure 7.1. Air sampling inlets on foredeck of RRS James Clark Ross during cruise JR288

Water sampling: Underway samples were collected from the pumped non-toxic seawater supply using a semi-automated purge and trap system plumbed directly into the underway supply. The sample lines and valves were flushed with underway water and then a 20 mL sample pumped into the purge vessel (2 minute sampling time). Flow was controlled using a peristaltic pump operating at 25 rpm. These samples passed through an in-line pre-combusted GF/F filter.

Samples were also taken from the daily CTD casts at varying depths (see Table 7.1). These were sub-sampled from the Niskin bottles into amber glass stoppered bottles, via a precombusted GF/F filter (figure 7.2), in a manner designed to minimise contact between the water sample and the atmosphere (i.e. minimal headspace and bubbling). CTD samples were stored in the glass bottles at 4^{o}C and analysis took place within 8 hours of collection.

Figure 7.2. Sampling water for trace gas analysis from CTD casts

Table 7.1: Depths sampled for trace gas analysis at JR288 stations

Date	Station #	CTD #	Depth (m)
16/07/2013	1	1a	2 (x2), 5, 10, 30, 40, 60, 80
18/07/2013	2	2a	2, 5 (x2), 20, 40, 60, 80
19/07/2013	3	3a	~1, 5, 10, 20, 30 (x2), 40, 60, 80
20/07/2013	4	4a	1 (x2), 5, 10, 25, 40, 50, 70, 90
21/07/2013	5	5a	2, 5, 10 (x2), 20, 30, 60, 80
22/07/2013	6	6a	2, 5 (x2), 10, 15, 18, 23, 35, 60
	6	-	microlayer
23/07/2013	7	7a	2, 5, 10, 20 (x2), 30, 40, 80
24/07/2013	8	8a	2, 10, 15, 20, 25 (x2), 30, 50, 80
	8	8b	2500
25/07/2013	9	9a	2, 5, 20 (x2), 32, 37, 80
	9	-	microlayer
26/07/2013	10	10a	2 (x2), 5, 10, 20, 27, 35, 80
	10	-	microlayer
27/07/2013	11	11a	2, 5, 9, 12, 15 (x2), 20, 30, 60
	11	-	microlayer
	11	11b	27 (Chl-max) intercal
28/07/2013	12	-	microlayer
29/07/2013	12.5	-	microlayer
30/07/2013	13	13a	2, 5, 10, 15, 20, 30, 40, 60
01/08/2013	14	14a	5 (x2), 10, 20, 25, 35, 45, 60
02/08/2013	15	15a	2, 5, 10, 15, 35, 40, 70
03/08/2013	16	16a	2, 5 (x2), 10, 20, 30, 35, 60, 80
	16	-	microlayer
04/08/2013	17	17a	0.4, 10, 20 (x2), 29, 38, 55, 75, 90
	17	-	microlayer
04/08/2013	17.5	17.5	2, 5, 10, 15, 25, 35, 60
	17.5	-	microlayer
05/08/2013	18	18a	2, 5, 18 (x2), 30, 43, 60, 80
	18	-	microlayer
05/08/2013	18	18b	3500
06/08/2013	19	19a	2, 5, 15, 30, 38, 50, 60 (x2), 80
	19	-	microlayer
08/08/2013	20	20a	2 (x2), 5, 12, 22, 30, 40, 70, 100
09/08/2013	21	21a	2, 5 (x2), 12, 18, 24, 36, 60, 80

Table 7.2: Periods of data collection and missing data (preliminary)

Date (GMT) (start-end)	Comment
Data collection:	
13/7/13 - 12/8/13	Air trace gas data collected
13/7/13 - 12/8/13	Underway water trace gas data collected
Missing data:	
13/07-15/07/2013	CO data missing
25/07-16/08/2013	O_3 data suspect
31/07; 10/08/2013	No data collected during port calls (Longyearbyen)
Various	No underway data (non-toxic seawater pump off, refer to Appendix D for underway pump log)

Analysis: Analysis was performed on two coupled Thermal Desorption- Gas Chromatography-Mass Spectrometry systems (TD-GC-MS), one instrument was dedicated to air analysis and the other to water analysis. Both instruments were calibrated daily using pre-mixed gas standards.

For water analysis, dissolved gases extracted using an automated purge-and-trap method (Andrews et al., in preparation) similar to that described by Broadgate et al. (1997). Each 20 mL water sample was purged with 1 L of zero-grade nitrogen gas. Water analyses were alternated with air analyses, to provide carbon tetrachloride concentrations to correct for instrument sensitivity drift (see below). A bake-out program was also run between each pair of air and water samples. The duration of each sampling cycle (air-water-bake) was 65 minutes.

Atmospheric ozone levels were measured with a photometric ozone analyser and CO mixing ratios with an Ametek ta Gas Analyser. Both instruments were located in the laboratory container on the foredeck. The instruments were operated continuously, with data logged every minute. Problems with the instruments resulted in some periods of missing data (see Table 7.2).

Data processing and quality control

Measurements will be corrected for instrument drift using ambient levels of atmospheric carbon tetrachloride, and quantified using gas standard calibrations. Instrument problems resulted in some periods of poor quality data and/or irregular sampling (see Table 7.2). It is noted that instrument sensitivity also decreased significantly throughout the cruise, resulting in much higher limits of detection and quantification towards the end. Data will be filtered for contamination events arising from the ship's exhaust, using relative wind direction and speed, and possibly also black carbon measurements obtained by the University of Manchester.

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

Ozone and CO data will be quality controlled post-cruise. For CO, calibrations carried out during the cruise (using an Air Products 200ppb in air CO standard cylinder) will be applied. For Ozone a post cruise calibration (using a TEI Primary Standard) will be carried out on the instrument and applied to the data. Calibrations of CO and Ozone are traceable to WMO GAW internationally recognized standards.

References

Shaw, S. L., Gantt, B. and Meskhidze, N. (2010). Production and Emissions of Marine Isoprene and Monoterpenes: A Review, *Advances in Meteorology,* doi:10.1155/2010/408696.

Yassaa, N., Peeken, I., Zöllner, E., Bluhm, K., Arnold, S., Spracklen, D. and Williams, J. (2008). Evidence for marine production of monoterpenes. *Environmental Chemistry*, *5* (6), 391.

Colomb, A. Gros, V., Alvain, S., Sarda-Esteve, R., Bonsang, B., Moulin, C., Klüpfel, T. and Williams, J. (2009). Variation of atmospheric volatile organic compounds over the Southern Indian Ocean (30–49°S). *Environmental Chemistry*, *6* (1), 70.

Broadgate, W. J., Liss, P. S., Penkett, S. A. (1997). Seasonal emission of isoprene and other reactive hydrocarbon gases from the ocean. *Geophys. Res. Lett.* 24 (21), 2675.

Andrews, S.J., Hackenberg, S.C., Carpenter, L.J., *Manuscript in preparation*.

8. Aerosol and surface seawater sampling for organic composition measurements

Rosie Chance
rosie.chance@york.ac.uk
Department of Chemistry, University of York, YO10 5DD

Introduction and Cruise Objectives

The chemical composition of marine organic aerosol affects particle hygroscopicity and the ability of particles to act as cloud condensation- and ice-nuclei. Consequently, organic aerosol composition is expected to play a role in determining cloud microphysical and radiative properties. In the marine environment, primary organic aerosol is generated by the transfer of organic matter from the sea surface to the atmosphere during bubble bursting. Secondary organic aerosol compounds, derived from biogenic gases such as methylamines and isoprene, and long range transport of anthropogenic and terrestrial emissions may also contribute to the organic aerosol burden in the remote marine boundary layer. As yet, little is known about the molecular make-up of marine organic aerosol, or the impact that this has on aerosol properties.

Atmospheric aerosol and seawater organic matter samples were collected during cruise JR288 in order to characterise and compare the organic composition of these carbon reservoirs. The objectives of this work are to:

- Investigate the sources of marine organic aerosol in the Arctic marine boundary layer, particularly the relative contributions of primary and secondary biogenic sources to Arctic aerosol abundance, and potential links to changes in ocean biogeochemistry.

- Provide information on the organic composition of marine aerosol, in order to improve understanding and modelling of Arctic aerosol properties

Sampling protocol

Aerosol: A high volume aerosol collector (Ecotech Hi-Vol 3000) fitted with a PM2.5 size selective inlet (Ecotech) was mounted on the monkey island deck of the ship (Figure 8.1). To avoid sampling contaminated air from the ships funnel, the collector was automatically controlled such that sampling only took place when the relative wind direction was between -80 and 110 degrees (with the bow set to 0 degrees), and the relative wind speed was greater than 2 m s^{-1}. This was achieved using a 2-dimensional sonic anemometer (Gill) coupled to a data logger (Campbell Scientific CR800), which sent a trigger voltage to the aerosol collector. When on, air flow through the collector was ~68 m^3 hr^{-1}. Samples were collected onto precombusted (5 hours at 450^{o}C) Whatman QM-A quartz fibre filters deployed for periods of 24 hours each. The filters were loaded and unloaded from the sampling cassettes under a laminar flow hood; nitrile gloves were worn and the filters handled by the edges only. Exposed filters were folded in half, wrapped in clean aluminium foil, placed in sealed plastic bags and frozen at -20^{o}C for return to the UK. Unexposed filters were retained for use as filter blanks and a cassette blank, in which a filter is left in the cassette for 24 hours under clean conditions, was also taken.

Figure 8.1. Location of the aerosol collector on the monkey island deck of RRS James Clark Ross during cruise JR288.

Aerosol extracts will be analysed by Liquid Chromatography - ion trap tandem Mass Spectrometry (LC-MS) and Fourier Transform - Ion Cyclotron Resonance -Mass Spectrometry (FT-ICR-MS). This analysis will provide structural information on functional groups, and determine molecular masses to sub-ppm resolution levels for unambiguous determination of molecular formulae, respectively. Prior to analysis, aqueous extracts of the aerosol samples will undergo solid phase extraction using the method described below, for direct comparison with operationally defined seawater extracts.

Seawater dissolved organic matter: Surface seawater (10 L) was sub-sampled from Niskin bottles fired at ~2 m during the first CTD cast of each station. Sea surface microlayer samples (varying volumes, typically 1 L or less) were sub-sampled from material collected with the rotating drum sampling boat, as described in section 6. All samples were filtered under vacuum through pre-combusted (5 hours at 450^oC) Whatman GF/F filters. Dedicated, acid washed glass bottles and a polycarbonate filter holder were used; all were acid rinsed at least every few days. The filters were frozen at -80^oC for possible future analysis of marine particulate matter. An operationally defined fraction of the dissolved organic matter present in the filtrate (SPE-DOM) was isolated by solid phase extraction, using the method of Dittmar et al., 2008. The filtrate was first acidified to pH 1 - 2 using hydrochloric acid (Fisher AR grade, 32%) then applied to a solid phase extraction cartridge (Agilent Bond Elut PPL) at a flow rate of about 20 mL min^{-1} or less. Cartridges were conditioned using three volumes (~15 mL) of methanol (Fisher, HPLC grade) before use. Following application of the sample, cartridges were rinsed using 3 volumes of 0.01M hydrochloric acid (Fisher AR grade HCl in Fisher LC-MS grade water) and then allowed to dry by drawing air through. Samples were then eluted into pre-combusted glass vials using 8 mL of methanol (Fisher LC-MS grade) and stored at -20^oC for return to the UK. Procedural blanks were prepared by replacing the sample with either ~5 mL 0.01M hydrochloric acid (two blanks) or 10 L of acidified ultrapure water (one blank). The ultrapure water for the latter was taken from the ships pure water generator. Two experiments to test breakthrough from the cartridges were conducted by stacking conditioned cartridges on top of each other during the sample application stage, then eluting each separately. SPE-DOM samples will be analysed by LC-MS and FT-ICR-MS as for aerosol extracts.

POC and DOC: Selected surface seawater and microlayer samples were taken for determination of total organic carbon (TOC) and dissolved organic carbon (DOC), following established protocols (Dickson et al., 2007). TOC samples were collected into pre-combusted glass vials direct from the Niskin. To collect DOC samples an in-line filter holder was connected to the Niskin tap and samples allowed to filter under gravity into precombusted glass vials. Precombusted (5 hours at 450^oC) Whatman GF/F filters held in an acid washed polycarbonate filter holder and acid-washed silicone tubing were used. 30 mL of sample was collected in either case. Samples were immediately acidified using 30 uL of hydrochloric acid (Puriss, ~32%) and stored at 4^{o}C for return to the UK. Analysis will be by the standard method of sparging, followed by high-temperature combustion and detection of non-purgeable organic carbon as CO_2 using an infra red detector (Dickson et al., 2007).

Methylamines and glycine betaine: Surface seawater was filtered through Whatman GF/F filters under gentle vacuum and frozen at -20^{o}C for return to Charlotte Cree (PML) for determination of dissolved methylamines using gas chromatography. Thirteen sets of triplicate samples were collected. For each set of methylamine samples, a particulate sample for possible future determination of glycine betaine was also collected. 300 mL of surface seawater was passed through a precombusted GF/F filter under gravity, and the filter frozen at -80^{o}C. If time and resources allow, these samples will be analysed either at the university of York, or PML, using the method described in Airs and Archer, 2010.

Samples collected

Aerosol: 28 high volume aerosol samples were collected, including two blanks (see Table 8.1). Visual inspection of the exposed filters suggested that the air being sampled was extremely clean, and that contamination from the ships stack was successfully avoided.

Seawater dissolved organic matter: 35 SPE-DOM samples were collected, including 11 microlayer samples and five blanks, as listed in table 8.2.

Table 8.1. Aerosol samples collected during cruise JR288

NO.	TYPE	START				END			
		Date	Time (UT)	Latitude (N)	Longitude (E)	Date	Time (UT)	Latitude (N)	Longitude (E)
1	Cassette BLK	14/07/13	15:20	58.568	0.122	15/07/13	13:30	61.744	-2.189
2	Filter BLK	14/07/13	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3	Sample	15/07/13	13:53	61.774	-2.294	16/07/13	15:10	63.259	-6.529
4	Sample	16/07/13	16:22	63.291	-6.588	17/07/13	13:54	65.823	-12.358
5	Sample	17/07/13	14:17	65.870	-12.472	18/07/13	13:09	68.054	-17.612
6	Sample	18/07/13	13:45	68.054	-17.599	19/07/13	14:31	70.242	-20.575
7	Sample	19/07/13	14:49	70.242	-20.578	20/07/13	13:39	70.241	-14.706
8	Sample	20/07/13	13:57	70.241	-14.706	21/07/13	12:54	71.804	-20.169
9	Sample	21/07/13	14:03	71.787	-20.141	22/07/13	14:26	73.111	-13.241
10	Sample	22/07/13	14:44	73.111	-13.240	23/07/13	15:10	74.810	-17.580
11	Sample	23/07/13	15:10	74.810	-17.581	24/07/13	13:45	75.053	-8.806
12	Sample	24/07/13	14:05	75.053	-8.806	25/07/13	14:28	76.491	-15.523
13	Sample	25/07/13	14:47	76.490	-15.521	26/07/13	13:49	76.236	-5.490
14	Sample	26/07/13	14:02	76.235	-5.497	27/07/13	15:15	77.990	-7.179
15	Sample	27/07/13	15:28	77.989	-7.161	28/07/13	14:32	78.895	-7.361

16	Sample	28/07/13	14:48	78.893	-7.376	29/07/13	15:02	77.413	-5.398
17	Sample	29/07/13	15:16	77.414	-5.416	30/07/13	13:56	77.473	-4.042
18	Sample	30/07/13	14:21	77.499	-4.355	01/08/13	14:18	78.560	5.403
19	Sample	01/08/13	14:33	78.563	5.404	02/08/13	14:42	80.623	10.736
20	Sample	02/08/13	14:54	80.624	10.730	03/08/13	19:32	81.394	25.589
21	Sample	03/08/13	19:53	81.456	25.744	04/07/13	15:57	83.235	33.214
22	Sample	04/08/13	16:12	83.220	33.119	05/08/13	19:48	82.085	29.849
23	Sample	05/08/13	20:03	82.047	30.039	06/08/13	19:53	79.789	29.741
24	Sample	06/08/13	20:05	79.763	29.593	07/08/13	15:31	77.574	25.791
25	Sample	07/08/13	15:43	77.536	25.723	08/08/13	16:48	75.503	18.658
26	Sample	08/08/13	17:20	75.509	18.658	09/08/13	16:57	76.755	9.362
27	Sample	10/08/13	14:31	78.120	13.360	11/08/13	18:33	73.692	7.970
28	Sample	11/08/13	18:45	73.659	7.942	12/08/13	15:57	70.208	5.273

Table 8.2. Extracted organic matter samples collected during cruise JR288

SAMPLE ID	TYPE	DATE	STATION	CAST	TOC, DOC?
1	Surface sw	16/07/13	1	1a	DOC
2	Surface sw	18/07/13	2	2a	TOC, DOC
3	Surface sw	19/07/13	3	3a	TOC, DOC
BLK 1	Blank: 5 mL 0.01M HCl	19/07/13	3	n/a	
4	Surface sw	20/07/13	4	4a	TOC, DOC
5	Surface sw	21/07/13	5	5a	TOC, DOC
6	Surface sw	22/07/13	6	6a	TOC, DOC
6-ulayer	Microlayer	22/07/13	6	boat	TOC, DOC
7	Surface sw	23/07/13	7	7a	TOC, DOC
8	Surface sw	24/07/13	8	8a	TOC, DOC
8-ulayer	Microlayer + Surface sw	24/07/13	8	boat	TOC, DOC
9	Surface sw	25/07/13	9	9a	DOC only
10	Surface sw	26/07/13	10	10a	DOC only
10-ulayer	Microlayer	26/07/13	10	boat	
11	Surface sw	27/07/13	11	11a	DOC only
11-ulayer	Microlayer	27/07/13	11	boat	
BLK 2	Blank: 5 mL vol 0.01M HCl	27/07/13	11	n/a	
12-ulayer	Microlayer	28/07/13	12	boat	DOC + Niskin DOC
12.5	Surface sw	29/07/13	12.5	12.5a	DOC only
12.5-	Microlayer	29/07/13	12.5	boat	TOC, DOC

ulayer					
13	Surface sw	30/07/13	13	13a	DOC only
13-ulayer	Microlayer	30/07/13	13	boat	
15	Surface sw	02/08/13	15	15a	DOC only
15-Juan	Bubble tank sw	02/08/13	15	bubble tank	
16-ulayer	Microlayer	03/08/13	16	boat	
17	Surface sw	04/08/13	17	17a	DOC only
17-ulayer	Microlayer	04/08/13	17	boat	
18	Surface sw	05/08/13	18	18a	TOC, DOC
18-ulayer	Microlayer	05/08/13	18	boat	
18-boat BLK	Boat blk	05/08/13	18	boat	
19	Surface sw, break through test	06/08/13	19	19a	DOC only
19-ulayer	Microlayer	06/08/13	19	boat	
21	Surface sw, break through test	09/08/13	21	21a	TOC, DOC
21-boat BLK	Boat blk	09/08/13	21	boat	
BLK 3	Blank: 10 L acidified MQ	11/08/13	n/a	n/a	

Table 8.3. Methylamine samples collected during cruise JR288

SAMPLE ID	MA #	DATE	STATION	CAST
2 a,b,c	1	18/07/13	2	2b
4 a,b,c	2	20/07/13	4	4b
5 a,b,c	3	21/07/13	5	5b
7 a.b.c	4	23/07/13	7	7b
8 a,b,c	5	24/07/13	8	8b
10 a,b,c	6	26/07/13	10	10b
11 a,b,c	7	27/07/13	11	11b
13 a,b,c	8	30/07/13	13	13b
15 a,b,c	9	02/08/13	15	15b
17 a,b,c	10	04/08/13	17	17b
18 a,b,c	11	05/08/13	18	18 b
19 a,b,c	12	06/08/13	19	19a
21 a,b,c	13	09/08/13	21	21a

References

- Airs and Archer, 2010. Analysis of glycine betaine and choline in seawater particulates by liquid chromatography/electrospray ionization/mass spectrometry. Limnol. Oceanogr: Methods, 8, 499-506.
- Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. *Guide to best practices for ocean CO_2 measurements*. PICES Special Publication 3, SOP 7.
- Dittmar et al., 2008. A simple and efficient method for the solid-phase extraction of dissolved organic matter (SPE-DOM) from seawater. Limnol. Oceanogr: Methods, 6, 230-235.

9. DMSP and multi-trophic plankton interactions

Mark Breckels
University of Essex & Plymouth Marine Laboratory.
Email: mbreck@essex.ac.uk

John Stephens
Plymouth Marine Laboratory.
Email: jas@pml.ac.uk

Background:

Chemical interactions play a fundamental role in the ecology of marine foodwebs. Climatically-relevant dimethylsulfide (DMS) and its alga precursor dimethylsulfoniopropionate (DMSP) have been implicated in influencing foraging interactions in a range of marine taxa. Microzooplankton, including ciliates and heterotrophic dinoflagellates (2-200 μm), are an essential component in planktonic food webs transferring bacterioplankton and phytoplankton productivity to higher trophic levels. Currently, microzooplankton grazing selectivity on DMSP producing phytoplankton remains unresolved. Conflicting evidence demonstrates examples of both grazing preference and grazing suppression on the DMSP standing stock relative to bulk chlorophyll consumption (Breckels et al. 2010 an references therein). Here, we attempt to assess microzooplankton grazing rates on different sub populations of phytoplankton and relate grazing rates to phytoplankton intracellular DMSP concentration through a series of dilution experiments at different locations. In additional experimental treatments we aim to assess the influence of ecologically important Arctic copepod species on phytoplankton and microzooplankton. Copepod ingestion rates will be determine and assessments made regarding prey preference on phytoplankton or microzooplankton depending on the community composition. Throughout our grazing interaction experiments we will quantify DMS production and net changes in DMSP dynamics.

Specific Aims and Objectives:

1. To determine microzooplankton grazing rates on specific populations of phytoplankton.
2. To quantify copepod ingestion rates and feeding preference on phytoplankton and microzooplankton.
3. To measure relative changes in DMSP speciation during grazing interactions.
4. To quantify phytoplankton specific DMSP quotas and relate intracellular DMSP concentration to grazing rates.

Method overview:

1. Dilution experiments

Microzooplankton grazing:

Dilution experiments involve a series of treatments where whole seawater is diluted with cell-free filtered seawater at a range of dilution levels and assessing changes in phytoplankton density through time. The dilution series is based on the concept that the growth rate of phytoplankton is not influenced by the dilution level but per capita mortality is reduced as a function of lower encounter rates with microzooplankton grazers. The net growth rate of phytoplankton in each treatment is then regressed against the whole water concentration. The intercept of the regression indicates the specific phytoplankton growth rate in the absence of predation, whilst the slope gives the grazing rate.

80 L of water from the chlorophyll maximum were siphoned from the CTD through a 200 μm mesh to remove mesozooplankton. 30 L of water was gravity filtered through a 0.2 μm Pall

Acropak 500 cartridge filter. The filtrate was used to make a series of whole water concentrations; 20, 40, 70 and 100 % whole water in 10 L carboys. Each of the dilution series carboys were gently rotated and siphoned into triplicate 1250 mL polycarbonate bottles which were secured in an on-deck incubator (*t*0). The incubator was fitted with a filter screen adjusted to allow an appropriate light level for the depth the water was collected.

Phytoplankton abundance was quantified at the beginning of the experiment and after 24 hours of incubation by flow cytometry. In addition, water samples were taken for chlorophyll *a* quantification, bacteria and heterotrophic nanoflagellate abundance (all treatments except 20 % dilution) and microzooplankton quantification (100 % treatments only). Bacteria and heterotrophic nanoflagellate samples were fixed and strained with Sybr Green I DNA stain for later analysis using flow cytometry. Microzooplankton samples were preserved in Lugol's iodine solution for analysis back in the laboratory.

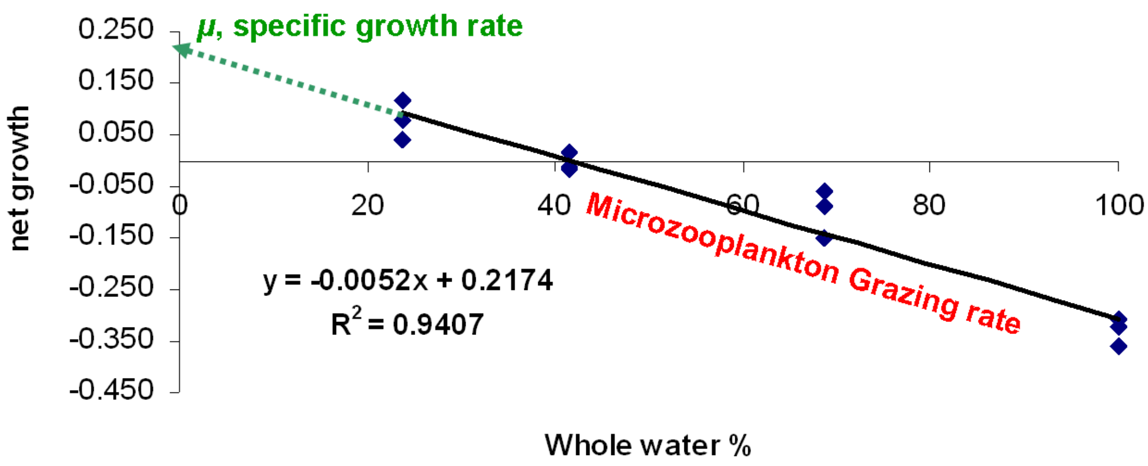

Figure 9.1: An example of a dilution series regression for picoeukaryotes from Experiment 4, the farthest north sampling station, showing the specific growth rate (intercept) of picoeukaryotes and the rate at which they are grazed by microzooplankton (slope).

Copepod grazing:

Copepods were caught using bongo nets fitted with a 50 μm mesh cod-end deployed down to 200 m the day prior to experiments. Copepods were identified under a dissecting microscope and adult females were sorted into 20 L buckets with water from the chlorophyll maximum and allowed to acclimate overnight. Copepods were added to additional 100 % whole water treatments in triplicate polycarbonate bottles as above. The stocking density of copepods was estimated based on literature values of clearance rates with a target clearance of approximately 30 % of the bottle volume (1250 mL bottle). Copepod treatments were sampled in exactly the same manner as the 100 % whole water dilution treatments. At the end of the experiment copepods were washed with Milli-Q and snap frozen before being stored at – 80 ^{o}C.

Copepod ingestions rates and feeding preference on microzooplankton and phytoplankton can be assessed by applying specific phytoplankton growth and per capita microzooplankton grazing rates derived from the dilution series following methods outlined in Nejstgaard et al. (2001).

Over the course of the cruise six different copepod species representing a range of different morphological sizes and feeding strategies were analysed (see Table 9.1).

2. Quantification of DMS species:

Analysis of DMS and DMSP was done using a Varian 3800 GC with pulsed flame photometric detector (PFPD) fitted with a manual purge-and-trap system. Prior to filling dilution experiment carboys seawater samples were collected directly from CTD bottles and stored in sealed dark vials with no headspace for *in-situ* DMS/DMSP quantification. DMS analysis was carried out within an hour of collecting water. Total DMSP (DMSPt) samples and particulate DMSP (DMSPp) samples, collected by gravity filtration onto a GF/F filter, were taken in triplicate from each treatment at the beginning of the dilution experiments and again after 24 hours. Samples were preserved using H_2SO_4, prior to analysis NaOH was used to hydrolyse DMSP. In addition to DMSPt and DMSPp, DMS concentration in each treatment was quantified at the end of the 24 hour incubation.

In total nine 24-hour dilution experiments were setup and run during the cruise (Table 9.1).

Table 9.1: Summary of dilution experiments run during JR288 cruise, indicting the depth of the chlorophyll maxima and the species of copepods used along with stocking densities. With the exception of Experiment 2 all copepods used where adult females.

Date	CTD	Expt.	Depth	Copepod species	Stocking density
16/7/2013	#1	1	2 m	**A:** *Calanus finmarchicus* (*n* = 3) **B:** *Temora longicornis* (*n* = 3)	**A:** 6 replicate^{-1} **B:** 16 replicate^{-1}
18/7/2013	#2	2	2 m	**A:** *Calanus finmarchicus* CIV (*n* = 6)	**A:** 8 replicate^{-1}
21/7/2013	#5	3	5 m	**A:** *Calanus finmarchicus* (*n* = 4) **B:** *Metridia longa* (*n* = 2)	**A:** 6 replicate^{-1} **B:** 9 replicate^{-1}
24/7/2013	#8	4	25 m	**A:** *Calanus hyperboreus* (*n* = 5) **B:** *Oithona similis* (*n* = 3)	**A:** 1 replicate^{-1} **B:** 25-30 replicate^{-1}
26/7/2013	#10	5	27 m	**A:** *Calanus glacialis* (*n* = 5) **B:** *Metridia longa* (*n* = 3)	**A:** 3 replicate^{-1} **B:** 8 replicate^{-1}
28/7/2013	#12	6	28 m	**A:** *Calanus hyperboreus* (*n* = 4) **B:** *Calanus glacialis* (*n* = 3)	**A:** 1 replicate^{-1} **B:** 3 replicate^{-1}
1/8/2013	#14	7	25 m	**A:** *Calanus finmarchicus* (*n* = 3) **B:** *Oithona similis* (*n* = 3)	**A:** 5 replicate^{-1} **B:** 30 replicate^{-1}
5/8/2013	#17.5	8	25 m	**A:** *Calanus hyperboreus* (*n* = 5) **B:** *Metridia longa* (*n* = 3)	**A:** 2 replicate^{-1} **B:** 9 replicate^{-1}
9/8/2013	#21	9	5 m	**A:** *Calanus glacialis* (*n* = 5) **B:** *Oithona similis* (*n* = 3)	**A:** 4 replicate^{-1} **B:** 30 replicate^{-1}

3. Cell sorting and intracellular DMSP characterisation

Concentrated cell solutions were harvested from the 0.2 µm Pall Acropak 500 cartridge filter used to filter 30 L of seawater from the Chlorophyll maximum for the dilution experiments. Twice during the filtration process the cartridge was inverted and allowed to drain into a small polycarbonate bottle resulting in approximately 100 mL of concentrated cell solution each time. The small polycarbonate bottles were placed in the on-deck incubator until sampling for the dilution series had been completed and we were ready to sort the cells by flow cytometry. The flow cytometer (FACSort) was set up with 0.2 µm seawater as the sheath fluid. The fluidics draw was held open and ice packs were used to keep the sheath tank and sample collection container cool. Due to the low chlorophyll concentrations encountered at most sampling stations it was necessary to employ an additional filter concentrating step, whereby the 100 mL concentrated cell solution was concentrated further via a Sterivex 0.2 µm filter unit. The secondary concentrated cell solution was then collected from the Sterivex filter giving a final volume of approximately 2.5 mL for sorting.

Concentrated samples where analysed by flow cytometry and population gates where assigned to target specific populations. The dominant phytoplankton populations were sorted individually into a cooled polycarbonate bottle. Once sufficient cells had been collected, the bottle was gentle rotated and the a sub sample was analysed for cell concentration, to determine sort efficiency and ensure sort purity. Known volumes where gravity filtered onto GF/F filter papers and preserved for subsequent DMSPp analysis. To control for background DMSP in the system calibration beads where sorted and analysed in the same manner.

References

Breckels, M.N., Roberts, E.C., Archer, S.D., Malin, G., Steinke, M. 2010. The role of dissolved infochemicals in mediating predator-prey interactions in the heterotrophic dinoflagellate *Oxyrrhis marina. Journal of Plankton Research.* **33**, 629-639.

Nejstgaard, J.C., Naustvoll, L.J., Sazhin, A. 2001. Correcting for underestimation of microzooplankton grazing in bottle incubation experiments with mesozooplankton. *Marine Ecology Progress Series.* **221**, 59-75.

10. Assessment of the photosynthetic properties of sub-arctic and arctic phytoplankton

By Heather Bouman and Alison Small
Department of Earth Sciences, University of Oxford

Rationale and Objectives

Our aim was to examine the spatial and temporal variability phytoplankton community structure and photophysiology in sub-arctic and arctic waters. Gross community structure was examined through the use of marker pigments obtained by High Performance Liquid Chromatography (HPLC) analysis of filtered samples. ^{14}C- and FRRf-based photosynthesis-irradiance (*P*-*E*) experiments were conducted to assess the rate of carbon uptake and electron transfer rates (ETR). We also collected filtered samples to determine the absorptive properties of phytoplankton to compare the light-harvesting capability of different communities (open-ocean versus ice-edge populations).

1. Fluorometric Chlorophyll-A

<u>Objectives</u>

The objective was to capture the vertical structure of chlorophyll-A concentration in the surface ocean from discrete water samples. The vertical profile of chlorophyll-A will be used to calibrate the *in vivo* profile of fluorescence measured by a Chelsea MKIII Aquatracka fluorometer mounted on the CTD rosette.

<u>Sampling Protocol</u>

Samples were collected in large (9-20L) Nalgene carboys. Each carboy was rinsed three times with sample water before being filled. From each depth triplicates of 100ml of sample water was filtered through 25mm GF/F filters. The filters were then soaked in 10ml of 90% acetone in 20ml glass vials for 24 hours at -20°C in the dark to allow the pigment to extract.

<u>Sample Collection</u>

Seawater was sampled from 6-8 depths within the photic zone (between 2m and 60m) at each station in addition to some inter-station sampling from 6m. The depths coincided with those selected for FRRF measurements, *in vivo* phytoplankton absorption, phytoplankton pigment, fluorometric and flow cytometric analysis. A detailed description of sampling stations may be found in Table 1.

<u>Sample Analysis</u>

Samples were analysed on ship using a Trilogy Fluorometer (Turner Designs). Prior to the cruise (16/4/2013) the fluorometer was pre-calibrated using spinach chlorophyll-A standard. The pigment extract was measured both before and after acidification with 2 drops of 10% hydrochloric acid according to the method described by Holm-Hansen *et al* (1965).

Figure 10.1 shows the relationship between extracted chlorophyll measured using the Trilogy fluorometer and in vivo fluorescence using the Chelsea fluorometer mounted on the CTD package.

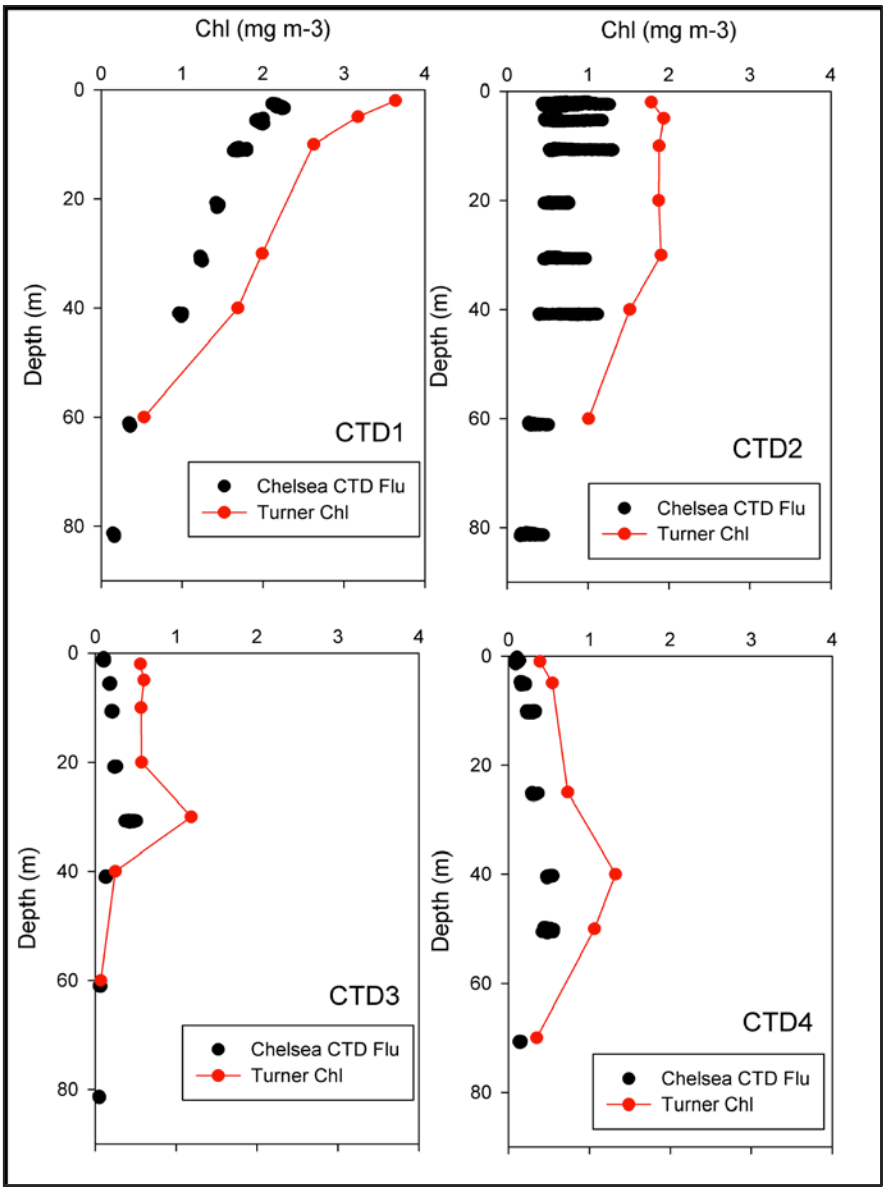

Figure 10.1: Comparison between Chelsea in vivo fluorometer mounted on CTD frame and extracted chlorophyll-A concentrations measured using a Turner Designs Trilogy fluorometer for the first four CTD stations of the ACCACIA cruise.

2. High Performance Liquid Chromatography (HLPC) Analysis of Algal Pigments

Objectives

The objective was to examine the spatial variation of marine phytoplankton groups and their optical properties. Phytoplankton pigments can be used as chemotaxonomic markers for key phytoplankton taxonomic groups that may be involved in biogeochemical cycles (for example diatoms are indicated by the diagnostic pigment fucoxanthin). In addition, these pigments also contribute to the absorptive properties of marine phytoplankton and thus can assist in analysing sources of spectral variation in the shape of phytoplankton absorption spectra.

Sampling Protocol
Between 500ml and 1000ml of seawater was subsampled from large (9-20L) Nalgene carboys and filtered through a 25mm GF/F. The filter was placed inside 2ml cryovials and flash frozen in liquid nitrogen. These were then transferred to a -80°C freezer for long term storage.

Sample collection
Seawater was sampled from 6-8 depths within the photic zone (between 2m and 60m) at each station in addition to some inter-station sampling from 6m. The depths coincided with those selected for FRRf measurements, *in vivo* phytoplankton absorption, fluorometric and flow cytometric analysis. A detailed description of sampling stations and volumes filtered may be found in Table 10.1.

Sample analysis
Samples will be transported to the University of Southampton in a dry shipper and stored at -80°C until analysed. Pigment extracts will be analysed using a reverse-phase HPLC column using Thermo-separations and Agilent instruments (Barlow *et al*., 1997).

3. Flow Cytometric Analysis of Phytoplankton Community Structure

Objectives
The objective was to measure the concentration of pico- (<2μm) and nano- (2-10μm) phytoplankton present in the upper water column.

Sampling Protocol
Seawater was subsampled from large (9-20L) Nalgene carboys which were rinsed three times with sample water from the CTD Niskin or underway system before being filled. Samples were then fixed using paraformaldehyde as soon as feasible. A 2 ml cryovial was filled via pipetting 1.875 ml of sample water and 0.125 ml of 16% paraformaldehyde (PFA) to produce a 1% PFA final concentration. The solution inside the cryovials was mixed using a vortex and let stand at room temperature in the dark for 10 minutes. The samples were than flash frozen in liquid nitrogen and subsequently transferred to a -80°C freezer for long term storage.

Sample collection
Seawater was sampled from 6-8 depths within the photic zone (between 2m and 60m) at each station in addition to some inter-station sampling from 6m. The depths coincided with those selected for FRRF measurements, *in vivo* phytoplankton absorption, fluorometric and pigment analysis. A detailed description of sampling stations may be found in Table 10.1.

Sample analysis
Samples will be analysed using a flow cytometer at the University of Essex.

4. Spectral Light Absorption by Marine Particles

Objectives
Samples were collected to examine the absorptive properties of phytoplankton cells. The absorption spectrum can be used to derive information on the absorptive efficiency of the phytoplankton assemblage. This data will aid in the interpretation of the photochemical signal obtained by the Fast Repetition Rate (FRR) Fluorometry.

Sampling Protocol
Between 500 ml and 1 litre of seawater was subsampled from large (9-20 litre) Nalgene carboys and filtered through 25 mm GF/F filters. The filters were carefully rolled into 2ml cryovials with the particle laden side facing inwards and subsequently flash frozen in liquid nitrogen. Samples were then transferred to a -80°C freezer for long term storage.

Sample collection
Seawater was sampled from 6-8 depths within the photic zone (between 2m and 60m) at each station in addition to some inter-station sampling from 6m. The depths coincided with those

selected for FRRf measurements, pigment analysis, fluorometric and flow cytometric analysis. A detailed description of sampling stations and volumes filtered may be found in Table 10.1.

Sample analysis

Frozen samples will be transported back to Oxford in a dry shipper and stored at - 80°C until analysed. Filters will be analysed using a Shimadzu UV-2550 spectrophotometer equipped with an integrating sphere over the visible range (350- 750 nm).

5. Fast Repetition Rate Fluorometry (FRRf)

Objectives

The objective was to characterise the photo-physiology of phytoplankton from discrete samples at ice-edge and open ocean locations between 61°08 and 83°19 north using Fast Repetition Rate Fluorometry (FRRf). The sampling strategy was to collect samples from multiple depths at sampling stations with some additional samples from 6m via the ship's underway system. These data will interpreted based on the availability of nutrients, light and taxonomic composition (see other relevant sections of this cruise report).

Sampling Protocol

Samples were collected in 50 ml plastic Falcon tubes which were sheathed in a 10% light level neutral density LEE filters. The tubes were rinsed three times with sample water before the final sample was collected. Samples were then left to acclimatize for 30 minutes at ambient temperature in a water bath. Low light acclimatization was chosen over dark acclimation due to the 24 hour daylight climate of the Arctic summer.

Sample Collection

At eight stations 8 samples were taken (stations 2, 7, 8, 9, 10, 11, 13, 21) throughout the photic zone from two CTD casts taken approximately six hours apart (at the majority of afore mentioned stations six depths were taken during the first CTD cast and two were taken from the second CTD cast). At eight stations 6 samples were taken (stations 1, 12, 12.5, 14, 17.5, 18, 19, 20) from a single CTD cast. At seven stations seven depths were sampled (stations 3, 4, 5, 6, 15, 16, 17) from either a single CTD cast or from two CTD casts approximately six hours apart. Depths of interest were selected based on the fluorescence profile indicated by the *in vivo* fluorometer mounted on the CTD package. Depths ranged from 2m to 60m. Samples were also taken using the ship's underway system: three samples were taken before station 1 and thirteen samples were taken after station 21. Location of sampling stations may be found in Table 1.

Sample Analysis

Analysis of all samples was completed onboard using a Chelsea FAST^{act} sample chamber, FAST^{act} base unit, and FAST$^{tracka\ 2}$ sensor. After 30 minutes of acclimatization (see Sampling Protocol section) phytoplankton were assumed to be low-light acclimated. For each sample bottle the following procedure was implemented: the sample was homogenized by inversion of the bottle and then used to rinse a glass pyrex test tube three times before filling with approximately 3ml of sample. The water jacket of the sample chamber was filled with Milli-Q pumped from a glass bottle incubated in a circulating water bath set to the ambient temperature of each station. Measurements taken using the FRRf included a single acquisition of all samples to obtain measurements of, among others, F_v/F_m (a dimensionless estimation of the maximum photochemical efficiency of photosystem II (PSII)) and σ_{PSII} (the functional absorption cross section of PSII, nm^2). For each single acquisition a blank was also obtained for correction purposes. Blanks were measured by filtering sample water through a 0.2μm pore size GF/F filter to remove phytoplankton cells, rinsing the test tube three times before filling the tube with approximately 3ml and running a single acquisition with the same LEDset and PMT values. A Rapid Light Curve (RLC) was obtained for 2-4 depths at each station. A surface (2-5m) and a Subsurface Chlorophyll Maximum (SCM) sample, where present, were selected for all stations. Additional depths were also selected to cover a range of light intensities and temperatures. The water jacket was run between single acquisitions/blanks and run constantly at a lower rate for the duration of the RLC to maintain the temperature at that of the ambient seawater. A single acquisition, blank and RLC was measured for all inter-station samples taken from the ships underway system.

Preliminary Results

Generally 'Deep' values of F_v/F_m were higher than 'Shallow' values, although this is not the case at all stations. The value of F_v/F_m in 'Shallow' samples was highest at ~63°N and generally decreased to ~74°N. Greater variation in values occurred at higher latitudes. The value of F_v/F_m in 'Deep' samples was also high at ~63°N, declined sharply at ~71°N and generally increased until ~78°N. At subsequent higher latitudes greater variation in values of F_v/F_m occurred. Note that the F_v/F_m values presented are uncorrected for blank measurements and instrument PMT gain setting (see Figure 10.2).

.

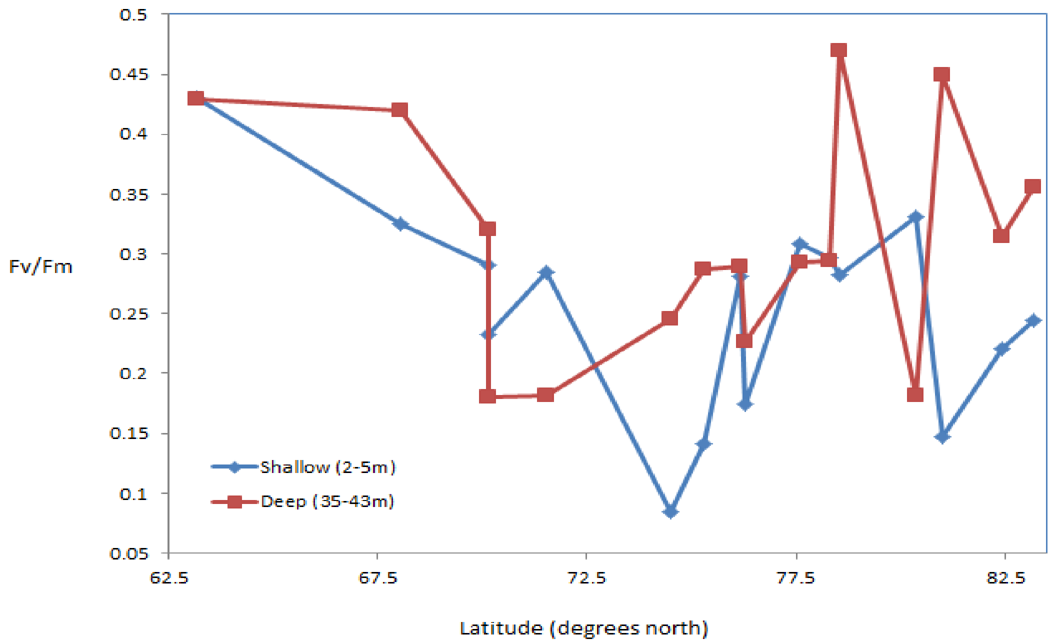

Figure 10.2: Latitudinal variability in uncorrected F_v/F_m for stations 1-20. 'Shallow' values were measured from 2-5m while 'Deep' values were measured from 35-43m

6. Photosynthesis-Irradiance (PE) Experiments

Objectives

Seawater samples were collected to determine the photosynthetic response of sub-arctic and arctic phytoplankton assemblages. These data will be used to derive information on the photosynthetic efficiency of the natural phytoplankton community, which in turn will be used to derive parameters used in remotely-sensed models of marine primary production

Sampling protocol

PI experiments were conducted in a custom-built incubator holding 15 x 60ml polycarbonate bottles. The incubator window was covered with a Lee ¼ CT blue filter to diminish the spectral dependency of the light source (2 x 35 W halogen bulbs).

Samples were maintained at *in situ* temperatures throughout the incubation period using a circulating water bath. At stations where temperatures were below 4°C, ethylene glycol was added to the water bath to prevent freezing.

Each of the 60 ml polycarbonate bottles are rinsed three times with sample water then filled to the shoulder in a low-light environment. 200 □ ^{14}C stock sodium bicarbonate solution is added to each of the 15 bottles (4 □Ci added per bottle). The bottles were placed into the incubator and diffusing filters were spaced between bottles to obtain a gradient of light levels. A single dark bottle was also placed in the incubator to measure ^{14}C incorporation in the dark. Bottles are incubated for between 1.5 and 2 hours under the light gradient at ambient temperature.

200 of Carbon stock and 4 of stock solution was pipetted into ml of scintillation cocktail was added. Counts obtained from these vials are estimates of the activity added in disintegrations per minute (DPM).

At the end of the incubation period, samples were filtered through GF/F filters at a vacuum pressure of 200 mm Hg. Filters are removed from the towers and carefully placed in a glass dessicator (in a fumehood) containing 200 ml of concentrated hydrochloric acid (HCl). The filters remain in the dessicator for 2 hours and then placed individually into plastic pony vials. 5ml of scintillation cocktail was added to each vial and was counted in the scintillation counter onboard the ship.

The light intensity inside of the incubator is measured using a Biospherical QSL2101 quantum scalar irradiance meter.

<u>Sample analysis</u>

The biomass-normalised primary production, P^B, at each light level is calculated from the formula:

$P^B = ((DPM_{light} - DPM_{dark}) \times 12000 \times ALK \times 1.05) / ((DPM_{add} \times 500) \times N \times Chl)$

Where DPM_{light} is the counts in the light bottle, DPM_{dark} is the counts in the dark bottle, ALK is the carbonate alkalinity (Meq), 12000 converts Meq to gC, 1.05 is the isot DPM_{add} is the counts from the flask inoculated with 10 ^{14}C, 500 converts counts to total counts for the DPM_{add} flask, N is the duration of the incubation in hours and Chl is the chlorophyll concentration in g l^{-1}. The units for P^B is g C l^{-1} g Chl or mg C m^{-3} h^{-1} (mg Chl)$^{-1}$

<u>Preliminary results</u>

Photosynthetic irradiance response curves showed variation in both the maximum rate of photosynthesis at saturating irradiance (assimilation number) and the initial slope of the curve (), with clear photoinhibition observed in the deeper samples (See Figure 10.3).

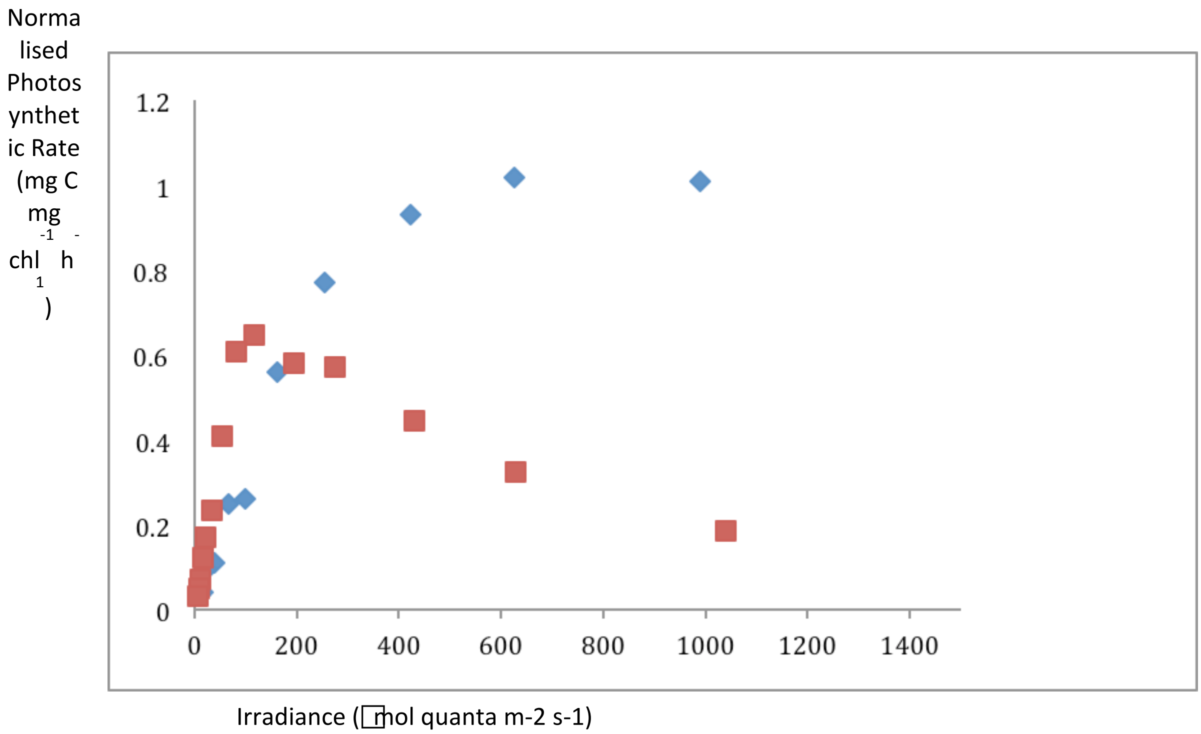

Figure 10. 3: Photosynthesis-irradiance experiments for CTD Station 4. Blue and red symbols denote the surface (1m) and deep sample (50m), respectively.

References

Barlow, R., Cummings, D. G., Gibb, S. W. (1997) Improved resolution of mono- and divinyl chlorophylls a and b and zeaxanthin and lutein in phytoplankton extracts using reverse phase C-8 HPLC. *Mar. Ecol. Prog. Ser.*, **171**: 303–307.
Holm-Hansen O., Lorenzen C. J., Holmes R. W., Strickland J. D. H. (1965) Fluorometric determination of chlorophyll. *J Cons Perm Int Explor Mer* **30**:3–15.

Table 10.1: List of samples collected during JR288 (Tchl=Turner chlorophyll, HPLC= phytoplankton accessory pigments determined using high performance liquid chromatography, ABS=spectral light absorption by phytoplankton, FCM=cell counts measured by flow cytometry, FRR=Fast Repetition Rate fluorometery. All volumes are in ml).

Date	Stn	Depth	Bottle	Long	Lat	Tchl	HPLC	ABS	FCM	FRR
15/07/13	UW1	6	N/A	000°29.62W	61°08.98N	Y	720	600	Y	Y
15/07/13	UW2	6	N/A	002°18.02W	61°46.35N	Y	1000	200	Y	Y
16/07/13	CTD1	2	22	006°29.168W	63°17.991N	Y	1000	200	Y	Y
16/07/13	CTD1	5	16	006°29.168W	63°17.991N	Y	1000	200	Y	Y
16/07/13	CTD1	10	12	006°29.168W	63°17.991N	Y	1000	200	Y	Y
16/07/13	CTD1	30	8	006°29.168W	63°17.991N	Y	1000	200	Y	Y
16/07/13	CTD1	40	5	006°29.168W	63°17.991N	Y	1000	200	Y	Y
16/07/13	CTD1	60	4	006°29.168W	63°17.991N	Y	1000	200	Y	Y
17/07/13	UW3	6	N/A	012°20.7893W	65°49.1675N	Y	500	300	Y	Y
18/07/13	CTD2	2	22	006°31.757W	63°15.517N	Y	800	300	Y	Y
18/07/13	CTD2	5	14	006°31.757W	63°15.517N	Y	800	300	Y	Y
18/07/13	CTD2	10	12	006°31.757W	63°15.517N	Y	900	300	Y	Y
18/07/13	CTD2	20	10	006°31.757W	63°15.517N	Y	900	300	Y	Y
18/07/13	CTD2	30	8	006°31.757W	63°15.517N	Y	900	300	Y	Y
18/07/13	CTD2	40	6	006°31.757W	63°15.517N	Y	1000	300	Y	Y
18/07/13	CTD2	60	4	006°31.757W	63°15.517N	Y	800	300	Y	Y
18/07/13	CTD2B	15	18	17°35.772W	68°03.206N	Y	800	300	Y	Y
18/07/13	CTD2B	25	16	17°35.772W	68°03.206N	Y	800	300	Y	Y
19/07/13	CTD3	0	22	20°41.700W	70°13.494N	Y	1000	500	Y	Y
19/07/13	CTD3	5	18	20°41.700W	70°13.494N	Y	1000	500	Y	Y
19/07/13	CTD3	10	16	20°41.700W	70°13.494N	Y	1000	500	Y	Y
19/07/13	CTD3	20	14	20°41.700W	70°13.494N	Y	1000	500	Y	Y
19/07/13	CTD3	30	8	20°41.700W	70°13.494N	Y	1000	500	Y	Y
19/07/13	CTD3	40	5	20°41.700W	70°13.494N	Y	1000	500	Y	Y
19/07/13	CTD3	60	3	20°41.700W	70°13.494N	Y	N	N	N	N
20/07/13	CTD4	1	21	14°35.291W	70°14.79N	Y	1000	500	Y	Y
20/07/13	CTD4	5	18	14°35.291W	70°14.79N	Y	1000	500	Y	Y
20/07/13	CTD4	25	14	14°35.291W	70°14.79N	Y	1000	500	Y	Y
20/07/13	CTD4	40	12	14°35.291W	70°14.79N	Y	1000	500	Y	Y
20/07/13	CTD4	50	10	14°35.291W	70°14.79N	Y	1000	500	Y	Y
20/07/13	CTD4	70	4	14°35.291W	70°14.79N	Y	1000	500	Y	Y
20/07/13	CTD4B	30	10	14°42.344W	70°14.489N	Y	1000	500	Y	Y
21/07/13	CTD5	2	22	20°18.336W	71°53.692N	Y	1250	700	Y	Y
21/07/13	CTD5	5	14	20°18.336W	71°53.692N	Y	1300	500	Y	Y
21/07/13	CTD5	10	12	20°18.336W	71°53.692N	Y	1000	500	Y	Y
21/07/13	CTD5	20	10	20°18.336W	71°53.692N	Y	1300	500	Y	Y
21/07/13	CTD5	30	8	20°18.336W	71°53.692N	Y	1000	500	Y	Y
21/07/13	CTD5	40	6	20°18.336W	71°53.692N	Y	1000	500	Y	Y

21/07/13	CTD5	60	4	20°18.336W	71°53.692N	Y	1500	400	Y	Y
22/07/13	CTD6	2	20	13°06.120W	73°06.340N	Y	1500	500	Y	Y
22/07/13	CTD6	5	19	13°06.120W	73°06.340N	Y	1500	500	Y	Y
22/07/13	CTD6	10	17	13°06.120W	73°06.340N	Y	1000	500	Y	Y
22/07/13	CTD6	15	15	13°06.120W	73°06.340N	Y	1000	500	Y	Y
22/07/13	CTD6	18	13	13°06.120W	73°06.340N	Y	1000	500	Y	Y
22/07/13	CTD6	25	6	13°06.120W	73°06.340N	Y	1000	500	Y	Y
22/07/13	CTD6	35	4	13°06.120W	73°06.340N	Y	1000	500	Y	Y
23/07/13	CTD7	5	19	17°36.137W	74°48.616N	Y	1500	1000	Y	Y
23/07/13	CTD7	10	17	17°36.137W	74°48.616N	Y	1500	1000	Y	Y
23/07/13	CTD7	20	15	17°36.137W	74°48.616N	Y	1500	500	Y	Y
23/07/13	CTD7	30	12	17°36.137W	74°48.616N	Y	1500	500	Y	Y
23/07/13	CTD7	40	6	17°36.137W	74°48.616N	Y	1500	1000	Y	Y
23/07/13	CTD7	60	4	17°36.137W	74°48.616N	Y	1500	1000	Y	Y
23/07/13	CTD7B	10	14	17°35.007W	74°48.801N	Y	1500	1000	Y	Y
23/07/13	CTD7B	40	12	17°35.007W	74°48.801N	Y	1500	1000	Y	Y
24/07/13	CTD8	2	22	08°43.511W	75°02.956N	Y	1000	500	Y	Y
24/07/13	CTD8	10	19	08°43.511W	75°02.956N	Y	1000	500	Y	Y
24/07/13	CTD8	15	17	08°43.511W	75°02.956N	Y	1000	300	Y	Y
24/07/13	CTD8	25	12	08°43.511W	75°02.956N	Y	1000	300	Y	Y
24/07/13	CTD8	30	6	08°43.511W	75°02.956N	Y	1000	500	Y	Y
24/07/13	CTD8	50	4	08°43.511W	75°02.956N	Y	1000	500	Y	Y
24/07/13	CTD8B	35	18	08°48.355W	75°03.169N	Y	1000	500	Y	Y
24/07/13	CTD8B	45	15	08°48.355W	75°03.169N	Y	1000	500	Y	Y
25/07/13	CTD9	2	22	15°31.311W	76°31.902N	Y	1500	1000	Y	Y
25/07/13	CTD9	5	19	15°31.311W	76°31.902N	Y	1500	1000	Y	Y
25/07/13	CTD9	20	17	15°31.311W	76°31.902N	Y	1500	1000	Y	Y
25/07/13	CTD9	32	15	15°31.311W	76°31.902N	Y	1500	1000	Y	Y
25/07/13	CTD9	40	6	15°31.311W	76°31.902N	Y	1500	1000	Y	Y
25/07/13	CTD9	60	4	15°31.311W	76°31.902N	Y	1500	1000	Y	Y
25/07/13	CTD9B	30	12	15°31.117W	76°29.497N	Y	1000	1000	Y	Y
25/07/13	CTD9B	40	7	15°31.117W	76°29.497N	Y	1000	1000	Y	Y
26/07/13	CTD10	5	19	5°18.642W	76°16.141N	Y	1000	500	Y	Y
26/07/13	CTD10	10	17	5°18.642W	76°16.141N	Y	1000	300	Y	Y
26/07/13	CTD10	20	15	5°18.642W	76°16.141N	Y	1000	300	Y	Y
26/07/13	CTD10	27	12	5°18.642W	76°16.141N	Y	1000	300	Y	Y
26/07/13	CTD10	35	6	5°18.642W	76°16.141N	Y	1500	500	Y	Y
26/07/13	CTD10	50	4	5°18.642W	76°16.141N	Y	1500	500	Y	Y
26/07/13	CTD10	20	15	5°29.335W	76°14.149N	Y	1000	300	Y	Y

	B									
26/07/13	CTD10 B	40	12	5°29.335W	76°14.149N	Y	1000	300	Y	Y
27/07/13	CTD11	2	22	7°04.645W	77°57.427N	Y	1500	500	Y	Y
27/07/13	CTD11	5	19	7°04.645W	77°57.427N	Y	1000	300	Y	Y
27/07/13	CTD11	9	17	7°04.645W	77°57.427N	Y	1000	200	Y	Y
27/07/13	CTD11	12	15	7°04.645W	77°57.427N	Y	1000	200	Y	Y
27/07/13	CTD11	15	12	7°04.645W	77°57.427N	Y	1000	300	Y	Y
27/07/13	CTD11	30	4	7°04.645W	77°57.427N	Y	1000	500	Y	Y
27/07/13	CTD11 B	20	17	7°10.223W	77°58.891N	Y	1000	400	Y	y
27/07/13	CTD11 B	25	16	7°10.223W	77°58.891N	Y	1000	400	y	Y
28/07/13	CTD12	2	20	7°01.993W	78°53.663N	Y	1500	500	Y	Y
28/07/13	CTD12	10	18	7°01.993W	78°53.663N	Y	1000	500	Y	Y
28/07/13	CTD12	15	16	7°01.993W	78°53.663N	Y	1000	500	Y	Y
28/07/13	CTD12	23	14	7°01.993W	78°53.663N	Y	1000	300	Y	Y
28/07/13	CTD12	28	8	7°01.993W	78°53.663N	Y	1000	300	Y	Y
28/07/13	CTD12	35	5	7°01.993W	78°53.663N	Y	1000	300	Y	Y
29/07/13	CTD12.5	5	19	5°13.61W	77°27.207N	Y	1500	500	Y	Y
29/07/13	CTD12.5	10	17	5°13.61W	77°27.207N	Y	1500	500	Y	Y
29/07/13	CTD12.5	13	15	5°13.61W	77°27.207N	Y	1000	500	Y	Y
29/07/13	CTD12.5	16	12	5°13.61W	77°27.207N	Y	1000	500	Y	Y
29/07/13	CTD12.5	25	6	5°13.61W	77°27.207N	Y	1000	500	Y	Y
29/07/13	CTD12.5	35	4	5°13.61W	77°27.207N	Y	1000	500	Y	Y
30/07/13	CTD13	2	20	17°35.043W	74°48.828N	Y	1000	300	Y	Y
30/07/13	CTD13	5	18	17°35.043W	74°48.828N	Y	1000	300	Y	Y
30/07/13	CTD13	10	16	17°35.043W	74°48.828N	Y	1000	300	Y	Y
30/07/13	CTD13	15	14	17°35.043W	74°48.828N	Y	1000	300	Y	Y
30/07/13	CTD13	20	8	17°35.043W	74°48.828N	Y	1000	300	Y	Y
30/07/13	CTD13	30	5	17°35.043W	74°48.828N	Y	1000	300	Y	Y
30/07/13	CTD13 B	5	17	3°26.422E	77°25.433N	Y	1000	300	Y	Y
30/07/13	CTD13 B	15	13	3°26.422E	77°25.433N	Y	1000	300	Y	Y
31/07/13	CTD14	2	22	5°22.634E	78°31.936N	Y	1000	300	Y	Y
31/07/13	CTD14	5	19	5°22.634E	78°31.936N	Y	1000	300	Y	Y
31/07/13	CTD14	10	17	5°22.634E	78°31.936N	Y	1000	300	Y	Y
31/07/13	CTD14	20	15	5°22.634E	78°31.936N	Y	1000	300	Y	Y
31/07/13	CTD14	25	12	5°22.634E	78°31.936N	Y	1000	300	Y	Y
31/07/13	CTD14	35	6	5°22.634E	78°31.936N	Y	1000	300	Y	Y
02/08/13	CTD15	2	22	10°47.115E	80°35.35N	Y	650	250	Y	Y
02/08/13	CTD15	5	19	10°47.115E	80°35.35N	Y	600	250	Y	Y
02/08/13	CTD15	10	17	10°47.115E	80°35.35N	Y	600	250	Y	Y
02/08/13	CTD15	15	15	10°47.115E	80°35.35N	Y	680	250	Y	Y
02/08/13	CTD15	20	12	10°47.115E	80°35.35N	Y	600	250	Y	Y

02/08/13	CTD15	35	6	10°47.115E	80°35.35N	Y	1000	400	Y	Y
02/08/13	CTD15 B	2	6	10°46.210E	80°36.760N	Y	800	300	Y	Y
03/08/13	CTD16	2	22	24°07.465E	80°08.900N	Y	1500	758 0	Y	Y
03/08/13	CTD16	10	17	24°07.465E	80°08.900N	Y	1500	750	Y	Y
03/08/13	CTD16	20	15	24°07.465E	80°08.900N	Y	1500	750	Y	Y
03/08/13	CTD16	30	12	24°07.465E	80°08.900N	Y	1500	750	Y	Y
03/08/13	CTD16	35	6	24°07.465E	80°08.900N	Y	1500	750	Y	Y
03/08/13	CTD16	60	4	23°56.620E	80°08.900N	Y	1500	750	Y	Y
03/08/13	CTD16 B	20	7	24°07.465E	81°08.050N	Y	1500	750	Y	Y
04/08/13	CTD17	2	22	33°43.967E	83°18.630N	Y	1500	750	Y	Y
04/08/13	CTD17	10	19	33°43.967E	83°18.630N	Y	1500	750	Y	Y
04/08/13	CTD17	20	17	33°43.967E	83°18.630N	Y	1500	750	Y	Y
04/08/13	CTD17	29	15	33°43.967E	83°18.630N	Y	1500	750	Y	Y
04/08/13	CTD17	38	12	33°43.967E	83°18.630N	Y	1500	750	Y	Y
04/08/13	CTD17	55	6	33°43.967E	83°18.630N	Y	1500	750	Y	Y
04/08/13	CTD17 B	20		33°44.006E	83°19.437N	Y	1500	750	Y	Y
04/08/13	CTD17. 5	2	22	33°43.231E	83°18.381N	Y	900	300	Y	Y
04/08/13	CTD17. 5	5	14	33°43.231E	83°18.381N	Y	800	300	Y	Y
04/08/13	CTD17. 5	10	12	33°43.231E	83°18.381N	Y	1000	300	Y	Y
04/08/13	CTD17. 5	15	10	33°43.231E	83°18.381N	Y	1000	500	Y	Y
04/08/13	CTD17. 5	25	8	33°43.231E	83°18.381N	Y	1000	500	Y	Y
04/08/13	CTD17. 5	35	6	33°43.231E	83°18.381N	Y	1000	500	Y	Y
05/08/13	CTD18	2		26°07.684E	82°41.5N	Y	1500	750	Y	Y
05/08/13	CTD18	5		26°07.684E	82°41.5N	Y	1500	750	Y	Y
05/08/13	CTD18	18		26°07.684E	82°41.5N	Y	1500	750	Y	Y
05/08/13	CTD18	30		26°07.684E	82°41.5N	Y	1500	750	Y	Y
05/08/13	CTD18	43		26°07.684E	82°41.5N	Y	1500	750	Y	Y
05/08/13	CTD18	60		26°07.684E	82°41.5N	Y	1500	750	Y	Y
06/08/13	CTD19	0.3	22	34°49.928E	81°00.1N	Y	1500	750	Y	Y
06/08/13	CTD19	5	19	34°49.928E	81°00.1N	Y	1500	750	Y	Y
06/08/13	CTD19	15	17	34°49.928E	81°00.1N	Y	1500	750	Y	Y
06/08/13	CTD19	30	15	34°49.928E	81°00.1N	Y	500	500	Y	Y
06/08/13	CTD19	38	12	34°49.928E	81°00.1N	Y	500	500	Y	Y
06/08/13	CTD19	50	6	34°49.928E	81°00.1N	Y	1000	500	Y	Y
07/08/13	CTD20	2	22	18°39.525E	75°30.123N	Y	1000	500	Y	Y
07/08/13	CTD20	5	19	18°39.525E	75°30.123N	Y	1000	500	Y	Y
07/08/13	CTD20	12	17	18°39.525E	75°30.123N	Y	1000	500	Y	Y
07/08/13	CTD20	22	15	18°39.525E	75°30.123N	Y	1000	500	Y	Y
07/08/13	CTD20	30	12	18°39.525E	75°30.123N	Y	1000	500	Y	Y
07/08/13	CTD20	40	6	18°39.525E	75°30.123N	Y	1000	500	Y	Y
09/08/13	CTD21	2	22	09°22.326E	76°44.786N	Y	1000	500	Y	Y
09/08/13	CTD21	5	18	09°22.326E	76°44.786N	Y	1000	500	Y	Y

09/08/13	CTD21	12	12	09°22.326E	76°44.786N	Y	1000	500	Y	Y
09/08/13	CTD21	18	10	09°22.326E	76°44.786N	Y	1000	500	Y	Y
09/08/13	CTD21	24	8	09°22.326E	76°44.786N	Y	1000	500	Y	Y
09/08/13	CTD21	36	6	09°22.326E	76°44.786N	Y	1000	500	Y	Y
09/08/13	CTD21 B	5	22	09°21.720E	76°45.329N	Y	1000	500	Y	Y
09/08/13	CTD21 B	25	20	09°21.720E	76°45.329N	Y	1000	500	Y	Y
10/08/13	UW4	6	N/A	011°49.851E	77°42.251N	Y	1000	500	Y	Y
11/08/13	UW5	6	N/A	010°47.814E	76°44.071N	Y	1000	500	Y	Y
11/08/13	UW6	6	N/A	009°38.680E	75°34.470N	Y	1000	400	Y	Y
11/08/13	UW7	6	N/A	08°55.06E	74°46.244N	Y	1000	500	Y	Y
11/08/13	UW8	6	N/A	008°02.810E	73°46.893N	Y	1000	500	Y	Y
12/08/13	UW9	6	N/A	007°14.216E	72°48.472N	Y	1000	500	Y	Y
12/08/13	UW10	6	N/A	006°21.45E	71°39.48N	Y	1000	500	Y	Y
12/08/13	UW11	6	N/A	005°45.100E	70°51.26N	Y	1000	500	Y	Y
12/08/13	UW12	6	N/A	004°59.411E	69°53.212N	Y	1000	500	Y	Y
13/08/13	UW13	6	N/A	004°26.498E	68°54.829N	Y	1000	500	Y	Y
13/08/13	UW14	6	N/A	003°42.570E	67°46.200N	Y	1000	500	Y	Y
13/08/13	UW15	6	N/A	003°13.250E	66°57.730N	Y	1000	500	Y	Y
13/08/13	UW16	6	N/A	002°38.228E	65°58.813N	Y	1000	500	Y	Y

11. Haloperoxidase activity in size-fractionated Arctic marine plankton

Claire Hughes & Jenny Stephenson

Environment Department, University of York, Heslington, York, YO10 5DD, UK

1. Abstract

The haloperoxidase enzymes, such as bromo- and iodoperoxidase, catalyse the two electron oxidation of halide ions through the breakdown of hydrogen peroxide. The haloperoxidases have been identified in a number of marine organisms but their occurrence and physiological role in marine microbes remains unknown. This study explored haloperoxidase activity, using the phenol red incubation method, in different size fractions (>20, 2-20, 0.2-2 µm) of Arctic marine plankton. Preliminary results suggest that a significant increase in bromophenol blue, indicating phenol red bromination, was observed in 14 of the 22 assays performed during the cruise. Activity was spatially variable and, consistent with previous results, was mostly highest in the >20µm fraction indicating haloperoxidase presence in large diatoms. These results will be compared to our size fractionated chlorophyll and nutrient data, water mass characteristics and other oceanographic features to explain the observed variability in haloperoxidase activity with a view to developing functional relationships for predictive model development.

2. Introduction

The haloperoxidases (chloro-, bromo- and iodoperoxidases) are a group of vanadium or haem-containing enzymes which catalyse the breakdown of hydrogen peroxide through the two electron oxidation of halide ions (Butler & Walker, 1993). This leads to the formation of reactive hypohalous acids such as HOI and HOBr which can halogenate organic substrates. In some cases this can result in the production of halocarbon gases which can mediate the sea-to-air transfer of halogens with implications for atmospheric chemistry including ozone depletion and cloud formation (von Glasow *et al*., 2004). The haloperoxidases have been found in a range of marine organisms including seaweeds (Ohsawa *et al*., 2001), cyanobacteria (Johnson *et al*., 2011) and cold water diatoms (Hill & Manley, 2009) but major questions remain regarding the occurrence of the haloperoxidases in the pelagic marine environment and the reasons for their production. As haloperoxidase formation will require significant metabolic investment it is expected that the formation of these enzymes confers a selective advantage to the organisms which produce them (Manley, 2003). Proposed roles for the haloperoxidases include oxidative stress defence through breaking down hydrogen peroxide (Kupper *et al.,* 2008), and protection against grazing/pathogens through the formation of reactive halogen species (Paul *et al*., 2010). Whilst some progress has been made in understanding the physiological role of haloperoxidase enzymes in seaweeds this is yet to be studied extensively in marine microbes. It is important that we improve our understanding of marine haloperoxidase formation so we can predict how sea-to-air halogen emissions will change in the future and improve our understanding of microbial stress defence. This is especially important in areas like the Arctic where significant climate-induced changes to the sea-ice extent and the marine ecosystem have already occurred.

The overarching aim of this study *was to determine the occurrence of the haloperoxidases in size-fractionated Arctic plankton and assess the environmental controls on activity.* This aim was addressed through the following specific objectives:

a. Establish the distribution of haloperoxidase activity in size-fractionated Arctic plankton using *in vivo* and *in vitro* assays.

b. Provide information on the physiological and ecological role of the haloperoxidases by assessing how activity varies with oceanographic features including phytoplankton community structure and physiology, nutrient status, proximity to sea-ice and water mass characteristics.

c. Make the first steps towards producing functional relationships describing haloperoxidase activity that can be used for future predictive model development.

3. Methodology

Water samples were collected from both the CTD Niskin bottles and underway seawater supply. All samples were collected in pre-rinsed carboys or polycarbonate bottles and stored in a constant temperature room in the dark prior to sample preparation. Tables 11.1 to 11.3 detail all samples and assays that were collected or performed during the cruise.

a. Size-fractionated chlorophyll a

For the size-fractionated chlorophyll *a* samples, 1L sample was first gravity filtered across a 20 µm Nylon net filter (Millipore) and the filtrate subsequently filtered across 2 and then 0.2 µm Nylon filters (Millipore) using a gentle vacuum. This process allowed the collection of the >20, 2-20 and 0.2 to 2 µm plankton size fractions. All filters were wrapped in foil, placed in cryovials and immediately stored in the -80°C freezer. Samples will be returned to the University of York on dry ice and will be stored at -80°C until extraction using 90% acetone and chlorophyll determinations using a Turner Trilogy fluorometer. All size fractionated samples were collected in triplicate.

b. Water-column nutrient concentrations

Water samples were gently filtered across a 0.7 µm GF/F filter and three 40mL aliquots of the filtrate placed in 50mL centrifuge tubes. Samples were then stored at -20°C until analysis for SiO_2, $P\text{-}PO_4^{3-}$, $N\text{-}NO^{3-}$ and $N\text{-}NH^{4+}$ at the University of York using a AA3 Seal Analytical autoanalyser.

c. In vivo haloperoxidase activity

Samples were collected from the underway and CTD Niskin bottles and filtered as described in section 3a to collect >20, 2-20 and 0.2 to 2 µm fractions of the plankton from 1L water. The filters were then placed in 20mL of 0.1M potassium phosphate buffer (pH 6.5) made up in Milli-Q water containing 35g L^{-1} NaCl and 840 µM KBr. The filters were left in the assay mixture for 2 hours in an incubation cabinet with dim lighting at 4°C. After the two hour incubation period 25 µM phenol red and 0.5 mM H_2O_2 were added to initiate the assay. Haloperoxidase activity was then monitored as the bromination of phenol red to bromophenol blue by measuring the absorbance at 592nm (to 5 decimal places) using a Perkin-Elmer UV//VIS spectrophotometer at the start of the assay and subsequently at 30, 60 and 120 minutes. All absorbance readings were corrected for turbidity by subtracting the absorbance at 750nm for each sample. Samples were removed from the assay jars using a plastic syringe and filtered across a 0.45 µm cellulose nitrate syringe filter (Sartorious) into the quartz spectrophotometer vial. All jars were swirled gently before the samples were taken. All filters were run in triplicate and controls with no filters and blank filters were run in parallel. This technique is consistent with the *in vivo* incubation assay employed by Hill and Manley (2009). A purified bromoperoxidase (Sigma, *Corallina officinalis*) was used to check the reagents at regular intervals. The rate of bromophenol blue appearance was determined by applying a least squares linear regression line to the time-series data ($R^2 > 0.6$). Data were eliminated if the relative standard deviation between triplicates for any time-point was greater than 20%.

d. In vitro haloperoxidase activity

1L water samples were collected from the CTD and underway seawater supply and filtered across 0.2 µm Nylon membrane (Millipore) for protein extraction and identification and *in vitro* haloperoxidase assays using the phenol red technique described in *Section 3c* upon return to the University of York. The techniques that will be used are described in Johnson *et al*. (2011). The filters were immediately wrapped in foil, placed in a cryovial and stored in the -80°C freezer. Samples will be returned to the University of York on dry ice and will be stored at -80°C until extraction.

Table 11.1. Locations at which samples were collected from the underway seawater supply for size-fractionated chlorophyll *a*, GF/F chlorophyll and nutrient analysis.

Sample number	Latitude	Longitude	Date	Time
1	63^0 49.77'N	07^{0}43.04'W	16-Jul	22:00
2	64^0 60.108'N	9^{0}50.68'W	17-Jul	03:00
3	65^0 07.75'N	10^{0}43.24'W	17-Jul	08:31
4	65^0 38.89'N	13^{0}37.58'W	17-Jul	14:10
5	68^0 48.93'N	18^{0}42.34'W	18-Jul	22:00
6	69^{0}62999'N	19^{0}88.01'W	19-Jul	03:00
7	70^0 11.80'N	18^{0}36.20'W	19-Jul	21:51
8	70^{0}11.922'N	15^{0}49.12'W	20-Jul	03:00
9	72^0 24.01'N	17^{0}25.92'W	21-Jul	22:08
10	72^{0}77.527'N	14^{0}70.33'W	22-Jul	03:00
11	73^0 46.87'N	15^{0}02.76'W	22-Jul	21:30
12	74^0 63.065'N	17^{0}60.29'W	23-Jul	03:30
13	75^0 32.48'N	11^{0}16.16'W	23-Jul	21:11
14	74^{0}96626'N	10^{0}9752'W	24-Jul	03:00
15	76^{0}24.76'N	11^{0}59.78'W	25-Jul	21:10
16	79^0 15.34'N	7^{0}10.17'W	01-Aug	21:54
17	80^0 07.88'N	9^{0}35.54'W	02-Aug	03:00
18	80^0 51.00'N	15^{0}58.50'W	02-Aug	21:38
19	79^{0}32.17'N	28^{0}17.44'E	06-Aug	21:45
20	79^{0}10.60'N	26^{0}15.50'E	07-Aug	01:33
21	78^{0}41.65'N	23^{0}39.10'E	07-Aug	05:00
22	77^{0}45.00'N	26^{0}10.30'E	07-Aug	15:49
23	76^{0}54.11'N	24^{0}23.10'E	07-Aug	20:49
24	76^{0}27.80'N	22^{0}31.00'E	08-Aug	00:29
25	76^{0}010'N	20^{0}39.00'E	08-Aug	04:08
26	75^{0}39.26'N	17^{0}31.28'E	08-Aug	21:46
27	75^{0}57.80'N	15^{0}17.70'E	09-Aug	01:28
28	76^{0}15.90'N	13^{0}02.55'E	09-Aug	05:08
29	77^{0}10.75'N	10^{0}17.57'E	09-Aug	23:00
30	77^{0}57.03'N	12^{0}00.91'E	10-Aug	03:26
31	78^{0}01.21'N	12^{0}10.82'W	10-Aug	19:00
32	76^{0}10.39'N	010^{0}13.41'W	11-Aug	01:05
33	75^{0}35.19'N	9^{0}39.36'W	11-Aug	08:00
34	74^{0}46.75'N	8^{0}55.44'W	11-Aug	13:00
35	73^{0}45.18'N	8^{0}01.38'W	11-Aug	19:00
36	72^{0}47.81'N	00^{0}13.62'W	12-Aug	01:00
37	71^{0}39. 98'N	06^{0}21.81'W	12-Aug	08:00
38	70^{0}51.70'N	5^{0}45.34'W	12-Aug	13:00
39	69^{0}53.39'N	4^{0}59.94'W	12-Aug	19:00
40	68^{0}54.24'N	4^{0}26.11'W	13-Aug	01:00
41	67^{0}46.69'N	03^{0}42. 85'W	13-Aug	08:00
42	66^{0}58.22'N	03^{0}13.51'W	13-Aug	13:00
43	65^{0}55.78'N	002^{0}38.21'W	13-Aug	19:00

Table 11.2. Locations and depths at which samples were taken from the CTD profiles for size fractionated chlorophyll (sf), GF/F chlorophyll and nutrients. Note size-fractionated chlorophyll a samples were only done at the surface and depth of maximum chlorophyll fluorescence

CTD number	Latitude'N	Longitude'W	Date	Depths sampled (m)
CTD 1	63^{0} 17.988'N	6^{0}29.178'W	16-Jul	2(sf), 5, 10, 30, 40, 60, 80
CTD 2	63^{0}15.517'N	6^{0}31.757'W	18-Jul	2(sf), 5, 10, 20, 30, 40, 60, 80
CTD 3	70^{0}13.499'N	20^{0} 41.687'W	19-Jul	2(sf), 5, 10, 20, 30(sf), 40, 60, 80
CTD 4	70^{0}14.077'N	14^{0}35.277'W	20-Jul	2(sf), 5, 10, 25, 40, 50(sf), 70, 90
CTD 5	71^{0}53.621'N	20^{0}18.240'W	21-Jul	2(sf), 5, 10, 20, 30, 40, 60, 80
CTD 6	73^{0}06.340'N	13^{0}06.120'W	22-Jul	2(sf), 5, 10, 15, 18(sf), 25, 35, 60
CTD 7	74^{0}48.613'N	17^{0}36.145'W	23-Jul	2(sf), 5, 10, 20, 30, 40, 60, 80
CTD 8	75^{0}02.956'N	8^{0}43.511'W	24-Jul	2(sf), 10, 15, 20, 25(sf), 30, 50, 80
CTD 9	76^{0}31.902'N	15^{0}31.311'W	25-Jul	2(sf), 5, 20, 32(sf), 37, 40, 60, 80
CTD 10	76^{0}16. 136'N	5^{0}18.650'W	26-Jul	2(sf), 5, 10, 20, 27(sf), 35, 50, 80
CTD 11	77^{0}57.429'N	7^{0}04.688'W	27-Jul	2(sf), 5, 9, 15(sf), 20, 30, 60
CTD 12	78^{0}53.663'N	7^{0}02.191'W	28-Jul	2(sf), 10, 15, 28, 35, 40, 50
CTD 12.5	77^{0}27.190'N	5^{0}13.050'W	29-Jul	2(sf), 10, 15, 23, 28(sf), 35, 40, 50
CTD 13	77^{0}26.555'N	3^{0}26. 128'W	30-Jul	2(sf), 5, 10, 15, 20(sf), 30, 40, 60
CTD 14	78^{0}31.935'N	5^{0}22. 632'W	01-Aug	2(sf), 5, 10, 20, 25, 35, 45, 60
CTD 15	80^{0}35. 038'N	10^{0} 47. 123'W	02-Aug	2(sf), 5, 10, 15, 20(sf), 35, 40, 70
CTD 16	81^{0}07.939'N	24^{0}07.148'W	03-Aug	2(sf), 5, 10, 20, 30(sf), 35, 60, 80
CTD 17	83^{0}18.630'N	33^{0}43.990'W	04-Aug	2(sf), 10, 20, 29, 38(sf), 55, 79, 90
CTD 17.5	83^{0}08.507'N	29^{0}26.480'W	04-Aug	2(sf), 10(sf)
CTD 18	82^{0}40. 940'N	26^{0}07.430'W	05-Aug	2(sf), 5, 18, 30, 43, 60, 80
CTD 19	81^{0}00.0000'N	34^{0}49.923'W	06-Aug	2(sf), 5, 15, 30, 38(sf), 50, 60, 80
CTD 20	75^{0}30.123'N	18^{0}39.533'W	08-Aug	2(sf), 5, 12, 22, 30(sf), 40, 70, 100
CTD 21	76^{0}44. 790'N	9^{0}22.327'W	09-Aug	2(sf), 5(sf), 12, 18, 24, 36, 60, 80

Table 11.3. Details of the locations/depths at which water samples were collected for the haloperoxidase incubation assays performed during the ACCACIA cruise and from which samples were also collected for protein extraction upon return to York. Where the assay was carried out on seawater collected from the CTD this was done at the depth of maximum chlorophyll fluorescence.

Date	Details	Latitude	Longitude
15 July	Bongo net concentrated sample		
16 July	CTD1, surface	63°16'N	6°24'W
18 July	CTD2, surface	67°54'N	17°30'W
19 July	CTD3, surface	70°13'N	20°41'W
20 July	CTD4, surface	70°14'N	14°37'W
21 July	CTD5, surface	71°47'N	21°08'W
22 July	CTD6, 18m (chlorophyll *a* maximum)	73° 06'N	13° 06'W
23 July	CTD7, surface	74° 49'N	17°35'W
24 July	CTD8, 25m (chlorophyll *a* maximum)	75° 03'N	8°44'W
26 July	CTD10, 27m (chlorophyll *a* maximum)	76° 16'N	5°10'W
27 July	CTD11, 18m (chlorophyll *a* maximum)	77°58'N	7°07'W
28 July	Ice algae experiment	77°58'N	7°07'W
28 July	Surface microlayer sample	78°53'N	7°00'W
30 July	CTD13, surface	77°26'N	3°26'W
1 August	CTD14, surface	78°32'N	5°23' W
2 August	CTD15, 20m (chlorophyll *a* maximum)	80°35'N	10°47'W
4 August	CTD 17, 28m (chlorophyll *a* maximum, ice edge station)	83°19'N	33°45'W
4 August	CTD17.5, surface (ice edge station)	83°09'N	29°27'W
5 August	CTD18, surface	82°40'N	26°06'W
8 August	CTD19, 30m (chlorophyll *a* maximum)	75° 30' N	18°40'W
9 August	CTD20, surface	76° 45' N	9°22'W

4. Preliminary Results

Preliminary analysis suggests that a significant increase in bromophenol blue indicating brominating activity was observed in 14 of the 22 haloperoxidase assays performed during the cruise. Activity was spatially variable and generally higher in the >20μm fraction. Figure 11.1 is an example of the results obtained from the phenol red incubation assay performed on July 24th when the highest activity was in the 2-20μm fraction. These results will be compared to the size fractionated chlorophyll, in vitro haloperoxidase assay and nutrient data alongside the water mass characteristics to try to explain the variability.

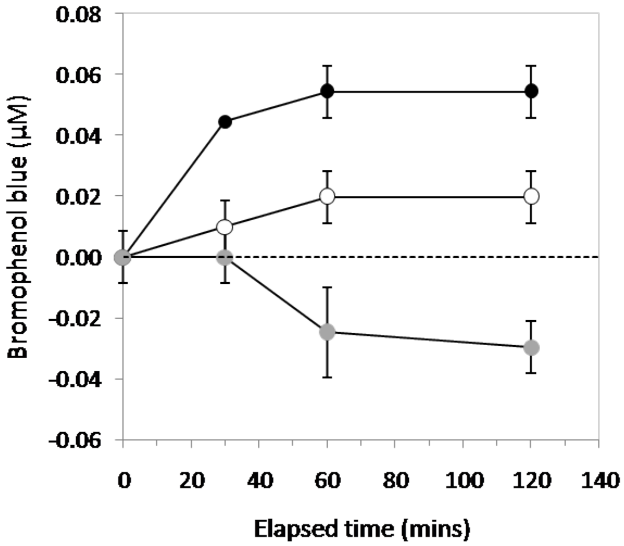

Figure 11.1. Change in the concentration of bromophenol blue (BPB) during the incubation assay performed on July 24th. The open circles show data from the > 20μm fraction, closed black dots show data obtained from 2-20 μm fraction and the grey circles show 0.2-2 μm fraction data. The error bars show the standard deviation of triplicate assays.

5. References

Butler & Walker [1993] *Chem. Rev.*, 93, 1937-1944
Hill & Manley [2009] *Limnol. Oceanogr.*, 54, 812-822
Johnson *et al*. [2011] *J. Phycol*. **47**: 792-801
Kupper *et al*. [2008] *Proc. Nat. Assoc. Sci.*, 105, 6954-6958
Manley [2002] *Biogeochemistry*, 60, 163-180
Ohsawa *et al*. [2001] *Phytochemistry*, 58, 683-692
Paul *et al*. [2006] *MEPS*, 306, 87-101
von Glasow *et al.* [2004] *Atmos. Chem. Phys*. 4, 589-608

Appendix A: Cruise Event Log

Time (UT)	Event	Lat (N)	Lon (E)	Comment
15/07/2013 14:04	Station 01	61.76792	-2.32694	Vessel set up on station in DP.
15/07/2013 14:15	Bongo 01	61.76758	-2.3303	Bongo Nets deployed
15/07/2013 14:23	Bongo 01	61.76752	-2.33083	Bongo Nets at 200m
15/07/2013 14:37	Bongo 01	61.76729	-2.33338	Bongo Nets on deck
15/07/2013 14:40	Bongo 02	61.76721	-2.33395	Bongo Nets deployed
15/07/2013 14:44	Bongo 02	61.76713	-2.33489	Bongo Nets at 100m
15/07/2013 14:51	Bongo 02	61.76692	-2.33647	Bongo Nets on deck
15/07/2013 15:55	Station 01	61.76665	-2.33888	Vessel off station and proceeding.
16/07/2013 07:00	Station 02	63.29886	-6.48092	Commenced reducing speed.
16/07/2013 07:03	Station 02	63.29976	-6.48588	Vessel set up on station in DP
16/07/2013 07:31	CTD 01a	63.29989	-6.48615	CTD1 off the deck
16/07/2013 07:33	CTD 01a	63.2999	-6.48616	CTD1 deployed
16/07/2013 07:40	CTD 01a	63.29989	-6.48616	CTD1 at 150m
16/07/2013 07:43	CTD 01a	63.29986	-6.48615	commenced hauling
16/07/2013 07:56	CTD 01a	63.29985	-6.48619	CTD1 at surface for recovery
16/07/2013 07:59	CTD 01a	63.29987	-6.48622	CTD1 recovered on deck
16/07/2013 08:36		63.29896	-6.48726	V/l moving ahead at 0.5kts
16/07/2013 08:58	VMP 01	63.29614	-6.48994	Commenced deploying VMP
16/07/2013 09:02	VMP 01	63.29562	-6.49038	VMP in the water
16/07/2013 09:17	VMP 01	63.29372	-6.49219	commenced hauling
16/07/2013 09:26	VMP 01	63.29258	-6.49327	VMP at the surface
16/07/2013 09:29	VMP 01	63.2922	-6.49362	VMP recovered
16/07/2013 14:17	CTD 01b	63.25869	-6.52924	CTD 1b - CTD off the deck
16/07/2013 14:20	CTD 01b	63.25868	-6.52924	CTD deployed - depth 1539m EA600
16/07/2013 14:48	CTD 01b	63.25867	-6.52922	CTD at depth wire 1500m
16/07/2013 15:25	CTD 01b	63.25868	-6.52921	CTD at the surface.
16/07/2013 15:25	CTD 01b	63.25868	-6.52921	CTD on deck
16/07/2013 16:05	Station 02	63.25867	-6.52923	Station completed. Deck secure. Vessel off DP and proceeding.
17/07/2013 13:02	Bongo Net 3	65.81944	-12.34636	Bongo Net deployed
17/07/2013 13:10		65.81942	-12.3464	Bongo Net at 200m
17/07/2013 13:23		65.81944	-12.34641	Bongo Net on Deck
17/07/2013 13:25	Bongo Net 4	65.81943	-12.34637	Bongo Net deployed
17/07/2013 13:30		65.81941	-12.34635	Bongo nets at 100m
17/07/2013 13:38		65.81938	-12.34636	Bongo Net on Deck
17/07/2013 13:48	Station 02	65.81942	-12.34631	DP disengaged - proceeding to next station
18/07/2013 07:06	Station 03	68.05334	-17.69579	V/l stopped in auto position DP
18/07/2013 07:19	CTD 02a	68.05336	-17.6959	CTD 2a deployed
18/07/2013 07:25	CTD 02a	68.05335	-17.69591	CTD at depth 120m
18/07/2013 07:39	CTD 02a	68.05335	-17.69595	CTD recovered
18/07/2013 08:16	Boat 01	68.05336	-17.69591	Rotating drum sampler/ boat off the deck
18/07/2013 08:19	Boat 01	68.05333	-17.69596	Boat deployed
18/07/2013 08:44	Boat 01	68.05335	-17.69586	v/l moving astern & bodily towards boat to aid recovery

18/07/2013 08:59	Boat 01	68.05308	-17.70279	Boat hooked
18/07/2013 09:00	Boat 01	68.05304	-17.70306	Boat recovered. V/l in full auto pos DP
18/07/2013 09:03		68.05308	-17.70252	V/l moving ahead at 0.5kts
18/07/2013 09:10	VMP 02	68.05322	-17.69994	VMP 02 deployed
18/07/2013 09:21	VMP 02	68.05343	-17.69595	VMP stopped free-falling
18/07/2013 09:34	VMP 02	68.05366	-17.69113	VMP at surface and re-deployed
18/07/2013 09:47	VMP 02	68.05391	-17.68637	commenced hauling
18/07/2013 09:59	VMP 02	68.05413	-17.68193	VMP at surface
18/07/2013 10:00	VMP 02	68.05416	-17.68156	VMP 02 fully recovered
18/07/2013 13:55		68.05343	-17.59625	Vessel stopped in DP for CTD 2b
18/07/2013 14:10	CTD 2b	68.05343	-17.59621	CTD 2b off the deck
18/07/2013 14:14		68.05343	-17.59621	CTD 2b deployed
18/07/2013 14:35		68.05341	-17.59616	CTD at depth
18/07/2013 15:04	CTD 02b	68.0534	-17.59623	CTD at the surface.
18/07/2013 15:05		68.05341	-17.59629	Commenced moving ahead
18/07/2013 15:06	CTD 02b	68.05339	-17.59608	CTD on deck
18/07/2013 16:05	Station 03	68.05415	-17.5754	Completed station. Deck secure. vessel off DP and proceeding
19/07/2013 00:46	VMP 03	69.40669	-19.5667	Vessel in auto DP moving ahead at 0.5 kts for deployment
19/07/2013 00:54		69.40637	-19.5632	Deploying VMP - depth of water 1056m
19/07/2013 01:07		69.40596	-19.55822	VMP at depth - commence hauling
19/07/2013 01:23		69.4054	-19.55214	VMP onboard
19/07/2013 07:01	Station 04	70.22278	-20.70072	Commenced reducing speed to bring vessel onto station.
19/07/2013 07:06	Station 04	70.22484	-20.69499	V/l stopped in auto position DP
19/07/2013 07:23	CTD 03a	70.22489	-20.69501	CTD 03a deployed
19/07/2013 07:31	CTD 03a	70.22489	-20.69502	CTD at depth 120m
19/07/2013 07:48	CTD 03a	70.22504	-20.69494	CTD 03a recovered
19/07/2013 08:12	Boat 02	70.22603	-20.69447	Boat deployed
19/07/2013 09:00	Boat 02	70.22546	-20.68855	v/l moving ahead & bodily towards boat to aid recovery
19/07/2013 09:11	Boat 02	70.22323	-20.68675	Boat recovered. V/l moving ahead at 0.5kts
19/07/2013 10:04	VMP 04	70.22807	-20.65325	VMP 04 deployed
19/07/2013 10:17	VMP 04	70.22896	-20.64868	Commenced hauling
19/07/2013 10:25	VMP 05	70.22949	-20.64583	Re-deployed VMP
19/07/2013 10:45	VMP 05	70.23084	-20.63866	VMP at surface
19/07/2013 10:48	VMP 05	70.23106	-20.63762	VMP 05 recovered
19/07/2013 13:24	Bongo Net 05	70.24123	-20.58427	Deploying Bongo Nets 05
19/07/2013 13:34		70.24125	-20.58427	Bongo Nets at 200m
19/07/2013 13:44		70.2413	-20.58429	Bongo Nets on deck
19/07/2013 13:47	Bongo Nets 06	70.24138	-20.58437	Bongo Nets Deployed 06
19/07/2013 13:53		70.24144	-20.58448	Bongo Nets at 200m
19/07/2013 14:07		70.24154	-20.58445	Bongo nets on deck
19/07/2013 14:12		70.24161	-20.58331	Vessel moving ahead at 0.5kts
19/07/2013 16:00		70.24081	-20.53941	Station completed. Vessel off DP and proceeding to next station.
19/07/2013 19:39	VMP 06	70.20177	-18.83635	Reducing speed for VMP deployment
19/07/2013 19:46		70.20056	-18.7946	V/l in auto DP moving ahead at 0.5kts
19/07/2013 19:50		70.19982	-18.78886	VMP 06 deployed

19/07/2013 20:06		70.20057	-18.78286	Commenced hauling
19/07/2013 20:21	VMP 06	70.20152	-18.77748	VMP 06 recovered
19/07/2013 20:26		70.20159	-18.77697	V/l off DP and proceeding to next station
20/07/2013 07:06		70.2346	-14.58814	Vessel set up on station in full auto pos DP.
20/07/2013 07:26	CTD 4a	70.23464	-14.58819	CTD 4a off the deck
20/07/2013 07:29		70.23464	-14.58819	CTD deployed sea depth 1143m
20/07/2013 07:34		70.23464	-14.58818	CTD at 120m
20/07/2013 07:45		70.23462	-14.58815	CTD at the surface
20/07/2013 07:50		70.23463	-14.58817	CTD on deck
20/07/2013 08:10		70.23473	-14.589	Vessel driving head to wind at 0.5kts
20/07/2013 09:30	VMP 07	70.24097	-14.61571	Commenced deployment of the VMP. Vessel moving head to wind at 0.5kts
20/07/2013 09:31	VMP 07	70.24102	-14.61609	VMP in the water. Prop and rudder de-selected. Water depth 1
20/07/2013 09:48	VMP 07	70.24171	-14.62271	VMP at depth. Commenced recovery.
20/07/2013 10:02	VMP 07 / VMP 08	70.24232	-14.62816	VMP at the surface. Redeploying.
20/07/2013 10:16	VMP 08	70.24303	-14.63359	VMP at depth. Commenced recovery.
20/07/2013 10:32	VMP 08	70.24376	-14.63971	VMP at the surface. Prop and rudder selected.
20/07/2013 10:33	VMP 08	70.24381	-14.64009	VMP on deck.
20/07/2013 13:23		70.24143	-14.70572	V/l stopped in auto position DP
20/07/2013 13:27	Bongo Nets 07	70.24143	-14.70569	Bongo nets 07 deployed
20/07/2013 13:34		70.24144	-14.70566	Bongo Nets at depth
20/07/2013 13:50	Bongo Nets 07	70.24147	-14.70572	Bongo Nets 07 recovered
20/07/2013 14:06	CTD 04B	70.24148	-14.70574	CTD off the deck.
20/07/2013 14:08	CTD 04B	70.24146	-14.70571	CTD deployed. Water depth 1120m
20/07/2013 14:30	CTD 04B	70.24149	-14.70574	CTD at depth. Wire out 1
20/07/2013 14:50	CTD 04B	70.24149	-14.70575	CTD at the surface.
20/07/2013 14:51	CTD 04B	70.24148	-14.70575	CTD on deck.
20/07/2013 15:00		70.24071	-14.70782	Completed station. Deck secure. vessel off DP and proceeding
21/07/2013 01:04	VMP 09	71.44423	-18.71325	DP engaged ready for VMP 08
21/07/2013 01:15		71.44278	-18.71669	VMP in the water
21/07/2013 01:25		71.4399	-18.72022	VMP deployed
21/07/2013 01:56		71.43024	-18.74183	VMP onboard
21/07/2013 01:57		71.43005	-18.74218	DP disengaged - proceeding to next station
21/07/2013 06:30		71.9016	-20.31574	Vessel set up on station in full auto DP.
21/07/2013 07:10	CTD 05a	71.89512	-20.30593	CTD off the deck.
21/07/2013 07:12	CTD 05a	71.89472	-20.30542	CTD deployed. Water depth 355m
21/07/2013 07:17	CTD 05a	71.89373	-20.30402	CTD at depth. Wire out 120m. Commenced recovery.
21/07/2013 07:27	CTD 05a	71.89213	-20.30211	CTD at the surface
21/07/2013 07:29	CTD 05a	71.89191	-20.30163	CTD on deck. Rotating vessel head to wind.
21/07/2013 07:38		71.88999	-20.29875	Vessel off DP. Moving ahead
21/07/2013 07:52	Boat 3	71.88484	-20.294	Boat 3 off the deck
21/07/2013 07:53		71.88463	-20.29367	Boat in water
21/07/2013 07:55		71.88441	-20.29306	Boat slipped
21/07/2013 08:49		71.87415	-20.27496	Boat hooked and clear
21/07/2013 08:51		71.8739	-20.27407	Boat on deck
21/07/2013 09:28	VMP 10	71.8613	-20.25582	VMP 10 off the deck.

21/07/2013 09:29	VMP 10	71.86107	-20.2555	VMP deployed.
21/07/2013 09:43	VMP 10	71.85703	-20.24708	VMP at depth. Commenced recovery.
21/07/2013 09:52		71.85529	-20.24146	VMP at the surface
21/07/2013 09:54		71.85506	-20.24048	VMP 10 on deck
21/07/2013 14:00	CTD 05b	71.78813	-20.14422	CTD 05b off the deck.
21/07/2013 14:02	CTD 05b	71.78767	-20.14241	CTD deployed. Water depth 312m
21/07/2013 14:10	CTD 05b	71.78634	-20.13691	CTD at depth. Wire out 200m. Commenced recovery.
21/07/2013 14:17	CTD 05b	71.78521	-20.13328	CTD at the surface.
21/07/2013 14:20	CTD 05b	71.78464	-20.13213	CTD 05b on deck.
21/07/2013 14:25	CTD 05b	71.78368	-20.13034	Deck secure. Vessel off DP and proceeding
21/07/2013 22:33	VMP 11	72.53472	-16.85918	V/l on DP at 0.5kts through the water
21/07/2013 22:36	VMP 11	72.53399	-16.85924	VMP 11 deployed
21/07/2013 22:52		72.52883	-16.85878	VMP at depth
21/07/2013 23:07		72.52466	-16.85829	VMP onboard
21/07/2013 23:12		72.5233	-16.85818	Vessel secure. vessel off DP and proceeding to next station.
22/07/2013 07:04		73.10573	-13.10204	DP engaged ready for CTD 6
22/07/2013 07:14	CTD 06a	73.10573	-13.10201	CTD 06a off the deck
22/07/2013 07:17	CTD 06a	73.10573	-13.10203	CTD deployed - depth 2581m
22/07/2013 07:21	CTD 06a	73.10573	-13.10204	CTD at depth. Wire out 120m. Commenced recovery.
22/07/2013 07:31	CTD 06a	73.10573	-13.10203	CTD at the surface.
22/07/2013 07:34	CTD 06a	73.10572	-13.10207	CTD on deck.
22/07/2013 07:55	Boat 04	73.10586	-13.10132	Boat deployed and slipped. Vessel standing off.
22/07/2013 08:49	Boat 04	73.09708	-13.0967	Moving for recovery
22/07/2013 08:54	Boat 04	73.09738	-13.0986	Boat hooked
22/07/2013 08:55	Boat 04	73.09746	-13.0986	Boat clear
22/07/2013 08:57	Boat 04	73.09731	-13.09875	Boat on deck
22/07/2013 09:35	VMP 12	73.09002	-13.10925	VMP off the deck.
22/07/2013 09:37	VMP 12	73.08971	-13.11038	VMP deployed.
22/07/2013 09:51	VMP 12	73.0885	-13.12247	VMP at depth. Commenced recovery.
22/07/2013 10:06	VMP 12/ VMP 13	73.09037	-13.1375	Vmp at the surface and re-deploying.
22/07/2013 10:25	VMP 13	73.09316	-13.1528	VMP at depth. Commenced recovery.
22/07/2013 10:37	VMP 13	73.09495	-13.16245	VMP at the surface
22/07/2013 10:39	VMP 13	73.09526	-13.16404	VMP on deck.
22/07/2013 13:27		73.11098	-13.24067	Vessel stopped in full auto DP
22/07/2013 13:31	Bongo Net 08	73.11101	-13.2406	Bongo Nets 08 off the deck
22/07/2013 13:32		73.11099	-13.24058	Bongo Net deployed
22/07/2013 13:39		73.111	-13.24053	Commenced hauling
22/07/2013 13:52		73.11102	-13.2405	Bongo Nets at the surface
22/07/2013 13:53		73.11102	-13.2405	Bongo Nets recovered
22/07/2013 13:56	Bongo Nets 09	73.11102	-13.24049	Bongo Nets 09 deployed
22/07/2013 14:02		73.11104	-13.24052	Commenced hauling
22/07/2013 14:14		73.11105	-13.24053	Bongo Nets at the surface
22/07/2013 14:17		73.11105	-13.24051	Bongo Nets recovered
22/07/2013 14:26	CTD 06b	73.11105	-13.24051	CTD 06b deployed
22/07/2013 15:14		73.11107	-13.24054	CTD at depth
22/07/2013 16:09	CTD 06b	73.11113	-13.24058	CTD 06b recovered

22/07/2013 16:29		73.11112	-13.2405	V/l off DP and proceeding
22/07/2013 21:32	VMP 14	73.91751	-15.41675	V/l on DP at 0.5kts through the water
22/07/2013 21:36		73.91755	-15.41633	VMP 14 deployed
22/07/2013 21:51		73.91824	-15.41427	Commenced hauling
22/07/2013 22:04		73.91864	-15.41219	VMP at the surface
22/07/2013 22:06	VMP 14	73.91868	-15.412	VMP 14 recovered
22/07/2013 22:09		73.91868	-15.41204	V/l off DP and proceeding
23/07/2013 04:50		74.83381	-18.0524	Vessel set up on station in full auto pos DP.
23/07/2013 06:05		74.83397	-18.04845	Vessel off DP and repositioning in ice.
23/07/2013 06:52		74.81114	-17.60371	Vessel set up on station in full auto pos DP.
23/07/2013 07:10	CTD 07a	74.81024	-17.6018	CTD off the deck.
23/07/2013 07:12	CTD 07a	74.81025	-17.60183	CTD deployed. Water depth 364m
23/07/2013 07:20	CTD 07a	74.81026	-17.60216	CTD at depth. Wire out 120m. Commenced recovery.
23/07/2013 07:29	CTD 07a	74.81027	-17.60269	CTD at the surface
23/07/2013 07:31	CTD 07a	74.81027	-17.60261	CTD on deck.
23/07/2013 09:31	VMP 15	74.80035	-17.60163	VMP off the deck
23/07/2013 09:32	VMP 15	74.80049	-17.60164	VMP deployed.
23/07/2013 09:43	VMP 15	74.80235	-17.60112	VMP at depth
23/07/2013 09:54	VMP 15	74.80415	-17.60024	VMP at surface - redeploying for VMP 16
23/07/2013 10:04	VMP 16	74.80581	-17.59944	VMP at depth - commence hauling
23/07/2013 10:14	VMP 16	74.80743	-17.59845	VMP on the surface.
23/07/2013 13:30	CTD 07b	74.81377	-17.58425	CTD 07b off the deck.
23/07/2013 13:32	CTD 07b	74.81372	-17.58416	CTD deployed. Water depth 356m
23/07/2013 13:43	CTD 07b	74.81348	-17.58369	CTD at depth. Wire out 339m. Commenced recovery.
23/07/2013 13:57	CTD 07b	74.81294	-17.58282	CTD at the surface.
23/07/2013 13:59	CTD 07b	74.81278	-17.58243	CTD 07b on deck.
23/07/2013 14:07	Bongo 10	74.81244	-17.58183	Bongo nets 10 off the deck.
23/07/2013 14:08	Bongo 10	74.81239	-17.58218	Bongo Nets deployed
23/07/2013 14:14	Bongo 10	74.81194	-17.5829	Bongo nets at depth. Wire out 200m. Commenced recovery.
23/07/2013 14:27	Bongo 10	74.81183	-17.58218	Bongo Nets at the surface
23/07/2013 14:28	Bongo 10	74.81183	-17.58216	Bongo nets on deck.
23/07/2013 14:29	Bongo 11	74.81182	-17.58216	Bongo nets 11 off the deck.
23/07/2013 14:30	Bongo 11	74.81182	-17.58217	Bongo nets deployed.
23/07/2013 14:33	Bongo 11	74.81179	-17.58223	Bongo nets at depth. Wire out 100m. Commenced recovery.
23/07/2013 14:39	Bongo 11	74.81164	-17.58234	Bongo at the surface.
23/07/2013 14:40	Bongo 11	74.8116	-17.58234	Bongo on deck.
23/07/2013 15:48		74.80763	-17.57981	V/l off DP and proceeding
24/07/2013 00:00		74.94011	-12.68494	DP engaged for VMP 17
24/07/2013 00:15	VMP 17	74.94355	-12.6749	VMP 17 - at the surface
24/07/2013 00:29	VMP 17	74.94383	-12.6635	VMP at depth - hauling
24/07/2013 00:44	VMP 17	74.94408	-12.65235	VMP at the surface
24/07/2013 00:46	VMP 17	74.9441	-12.65088	VMP on deck
24/07/2013 00:50		74.94416	-12.64793	DP disengaged heading to CTD 8
24/07/2013 05:53		75.00106	-8.99155	Vessel set up on station in full auto DP.
24/07/2013 06:00		75.00136	-8.9928	Vessel moving along 305 at 0.5kts
24/07/2013 06:30		75.00394	-9.00525	Vessel off DP and repositioning towards the North East at

				UIC's request.
24/07/2013 07:14	CTD 08a	75.04928	-8.72503	CTD off the deck.
24/07/2013 07:16	CTD 08a	75.04926	-8.72504	CTD 08a deployed. Water depth 3336m
24/07/2013 07:21	CTD 08a	75.04926	-8.725	CTD at depth. Wire out 120m. Commenced recovery.
24/07/2013 07:32	CTD 08a	75.04925	-8.725	CTD at the surface.
24/07/2013 07:34	CTD 08a	75.04924	-8.725	CTD on deck.
24/07/2013 07:52	Boat 05	75.04924	-8.72501	Boat off the deck
24/07/2013 07:53	Boat 05	75.04924	-8.72503	Boat deployed and slipped. Vessel standing off.
24/07/2013 08:40	Boat 05	75.04901	-8.7224	Vessel moving in for boat recovery.
24/07/2013 08:54	Boat 05	75.04994	-8.7235	Boat hooked.
24/07/2013 08:55	Boat 05	75.04995	-8.72349	Boat clear of the water.
24/07/2013 08:56	Boat 05	75.04994	-8.72349	Boat on deck
24/07/2013 09:31	VMP 18	75.05013	-8.74168	VMP 18 off the deck
24/07/2013 09:32	VMP 18	75.05014	-8.74219	VMP deployed.
24/07/2013 09:46	VMP 18	75.05028	-8.74974	VMP at depth. Commenced recovery.
24/07/2013 10:02	VMP 18 / VMP 19	75.05043	-8.75831	VPM at the surface and re-deployed.
24/07/2013 10:15	VMP 19	75.05053	-8.7653	VMP at depth. Commenced recovery.
24/07/2013 10:30	VMP 19	75.05068	-8.77338	VMP at the surface
24/07/2013 10:32	VMP 19	75.05069	-8.77443	VMP on deck.
24/07/2013 11:37		75.05275	-8.80567	V/L stopped in full auto position DP
24/07/2013 11:43	CTD 08b	75.05276	-8.80574	CTD 08b off the deck
24/07/2013 11:46	CTD 08b	75.05276	-8.80573	CTD 08b deployed
24/07/2013 12:43	CTD 08b	75.05275	-8.80587	CTD at depth. Wire out 3
24/07/2013 14:22	CTD 08b	75.05283	-8.80583	CTD at the surface.
24/07/2013 14:23	CTD 08b	75.05284	-8.80583	CTD on deck.
24/07/2013 14:35	Boat 06	75.0528	-8.80586	Boat 06 off the deck
24/07/2013 14:37		75.05279	-8.80584	Boat deployed and slipped. Vessel standing off.
24/07/2013 15:15		75.05051	-8.80125	Vessel moving in for boat recovery
24/07/2013 15:22		75.05154	-8.80556	Boat hooked and clear
24/07/2013 15:24		75.05169	-8.80542	Boat on deck
24/07/2013 15:57		75.04931	-8.81991	V/L off DP and proceeding to next station
24/07/2013 20:08		75.54168	-11.2663	V/l in DP
24/07/2013 20:15		75.54089	-11.26885	Ship's head re-aligned due to current (1.6kts)
24/07/2013 20:26		75.53975	-11.26863	V/l at deployment speed
24/07/2013 20:27	VMP 20	75.53975	-11.26853	VMP 20 deployed
24/07/2013 20:43		75.53976	-11.26838	VMP at depth - commence hauling
24/07/2013 20:56		75.53976	-11.26836	VMP at surface
24/07/2013 20:59	VMP 20	75.53976	-11.26832	VMP recovered
24/07/2013 21:03		75.53976	-11.26834	V/L off DP and proceeding to next station
25/07/2013 07:17		76.53149	-15.52295	Vessel set up on station in DP.
25/07/2013 07:28	CTD 09a	76.53165	-15.52232	CTD off the deck.
25/07/2013 07:30	CTD 09a	76.53164	-15.52229	CTD deployed. Water depth 210m.
25/07/2013 07:39	CTD 09a	76.53165	-15.52232	CTD at depth. Wire out 120m. Commenced recovery.
25/07/2013 07:49	CTD 09a	76.53174	-15.52185	CTD at the surface.
25/07/2013 07:51	CTD 09a	76.53181	-15.52135	CTD on deck
25/07/2013 08:00	Boat 07	76.53338	-15.51676	Boat off the deck.

25/07/2013 08:02	Boat 07	76.53347	-15.51663	Boat deployed and slipped. Vessel standing off.
25/07/2013 08:07	Bongo 12	76.53446	-15.5131	Bongo nets off the deck.
25/07/2013 08:08	Bongo 12	76.53446	-15.513	Bongo nets deployed.
25/07/2013 08:14	Bongo 12	76.53432	-15.51178	Bongo nets at depth. Commenced recovery.
25/07/2013 08:25	Bongo 12	76.53422	-15.51101	Bongo Nets at the surface
25/07/2013 08:26	Bongo 12	76.53422	-15.51094	Bongo nets at the surface
25/07/2013 08:28	Bongo 13	76.5342	-15.51085	Bongo nets deployed.
25/07/2013 08:35	Bongo 13	76.53421	-15.51081	Bongo nets at depth. Commenced recovery.
25/07/2013 08:42	Boat 07	76.53422	-15.51083	Boat driven back to ships side and hooked.
25/07/2013 08:44	Boat 07	76.53417	-15.51057	Boat lifted clear of the water.
25/07/2013 08:45	Bongo 13	76.53416	-15.51042	Bongo nets at the surface
25/07/2013 08:46	Bongo 13 / Boat 07	76.53416	-15.51042	Bongo and boat on board.
25/07/2013 09:44	VMP 21	76.52587	-15.48604	VMP deployed.
25/07/2013 09:54	VMP 21	76.52393	-15.4861	VMP at depth. Commenced recovery.
25/07/2013 09:58	VMP 21 / VMP 22	76.52314	-15.48606	Vmp at the surface and re-deploying.
25/07/2013 10:04	VMP 22	76.52198	-15.48613	VMP at depth. Commenced recovery.
25/07/2013 10:10	VMP 22 / VMP 23	76.52084	-15.48606	VMP at the surface and re-deploying.
25/07/2013 10:16	VMP 23	76.51983	-15.48605	VMP at depth. Commenced recovery.
25/07/2013 10:22	VMP 23	76.51885	-15.48604	VMP at the surface
25/07/2013 10:23	VMP 23	76.51868	-15.48606	VMP on deck.
25/07/2013 14:13	CTD 09b	76.49149	-15.51805	CTD 09b off the deck
25/07/2013 14:15	CTD 09b	76.49146	-15.51787	CTD deployed - depth 239m EA600
25/07/2013 14:22	CTD 09b	76.49137	-15.5175	CTD at depth
25/07/2013 14:30	CTD 09b	76.49131	-15.51735	CTD 09b recovered
25/07/2013 16:00		76.48296	-15.54088	V/l off DP and proceeding
26/07/2013 01:49		76.34122	-7.78848	DP engaged for VMP 24
26/07/2013 01:57	VMP 24	76.34131	-7.78832	VMP in the water
26/07/2013 01:58	VMP 24	76.31321	-7.54242	VMP deployed
26/07/2013 02:12	VMP 24	76.34146	-7.7868	VMP at depth - 500m - hauling
26/07/2013 02:25	VMP 24	76.34163	-7.78542	VMP at the surface
26/07/2013 02:27	VMP 24	76.34164	-7.78523	VMP on deck.
26/07/2013 02:28		76.34164	-7.78523	DP disengaged proceeding to CTD 10
26/07/2013 07:14		76.27023	-5.30757	DP engaged for CTD 10
26/07/2013 07:19	CTD 10a	76.26901	-5.31069	CTD 10a off the deck
26/07/2013 07:21	CTD 10a	76.269	-5.31071	CTD at the surface
26/07/2013 07:26	CTD 10a	76.26901	-5.31063	CTD at depth - wire 120m
26/07/2013 07:38	CTD 10a	76.269	-5.31068	CTD 10a at the surface
26/07/2013 07:41	CTD 10a	76.26901	-5.31068	CTD on deck
26/07/2013 07:46		76.26896	-5.31083	Vessel moving ahead at 0.5 kts
26/07/2013 09:30	VMP 25	76.25786	-5.34874	VMP off the deck.
26/07/2013 09:31	VMP 25	76.25776	-5.34907	VMP deployed. Increasing ships speed to 1kt.
26/07/2013 09:48	VMP 25	76.25422	-5.36093	VMP at depth. Commenced recovery.
26/07/2013 10:02	VMP 25 / VMP 26	76.25122	-5.37125	Vmp at the surface and re-deploying.
26/07/2013 10:16	VMP 26	76.24824	-5.38167	VMP at depth
26/07/2013 10:31	VMP 26	76.24508	-5.39295	VMP 26 on the surface

26/07/2013 10:34	VMP 26	76.24446	-5.39511	VMP on deck.
26/07/2013 12:02	CTD 10b	76.23615	-5.42815	CTD off the deck.
26/07/2013 12:04	CTD 10b	76.23615	-5.42819	CTD deployed. Water depth 2
26/07/2013 12:50	CTD 10b	76.23571	-5.44556	CTD at depth
26/07/2013 13:54	CTD 10b	76.23565	-5.49196	CTD at surface
26/07/2013 13:56	CTD 10b	76.23554	-5.49294	CTD 10b recovered
26/07/2013 14:02		76.23515	-5.49602	V/l off DP re-positioning for boat deployment
26/07/2013 14:13		76.22631	-5.53336	DP engaged
26/07/2013 14:15	Boat 08	76.22633	-5.53377	Boat 08 off the deck
26/07/2013 14:17		76.22634	-5.53388	Boat deployed and slipped. Vessel standing off
26/07/2013 15:21		76.23205	-5.56216	Vessel moving in for boat recovery
26/07/2013 15:24		76.23204	-5.56444	Boat hooked and clear
26/07/2013 15:26	Boat 08	76.23228	-5.56586	Boat 08 fully recovered
26/07/2013 15:43		76.23323	-5.5755	V/l off DP and moving at 0.5kts head to wind
26/07/2013 16:00		76.23413	-5.58372	V/l up to passage speed & proceeding to next station
26/07/2013 20:19		76.87032	-6.18797	V/l in full auto DP at 0.8kts through the water
26/07/2013 20:25	VMP 27	76.87041	-6.18819	VMP 27 deployed
26/07/2013 20:40		76.87042	-6.18843	VMP at depth - commence hauling
26/07/2013 20:53		76.86939	-6.19085	VMP at the surface
26/07/2013 20:55		76.86891	-6.1914	VMP 27 recovered
26/07/2013 21:00		76.86757	-6.19359	V/L off DP and proceeding to next station
27/07/2013 07:50		77.95628	-7.07201	Vessel set up on station in full auto pos DP.
27/07/2013 07:53	CTD 11a	77.95628	-7.07203	CTD off the deck.
27/07/2013 07:55	CTD 11a	77.9563	-7.07205	CTD deployed. Water depth 344m. Commenced moving vessel with the current.
27/07/2013 08:01	CTD 11a	77.95659	-7.0737	CTD at depth. Wire out 120m. Commenced recovery.
27/07/2013 08:11	CTD 11a	77.95718	-7.07795	CTD at the surface.
27/07/2013 08:13	CTD 11a	77.9573	-7.0788	CTD on deck.
27/07/2013 08:17		77.95754	-7.08069	Vessel off DP and repositioning close to ice edge for boat.
27/07/2013 08:27		77.95668	-7.09957	Vessel repositioned close to ice edge in JSAH.
27/07/2013 08:28	Boat 09	77.95665	-7.10006	Boat off the deck.
27/07/2013 08:30	Boat 09	77.95663	-7.10064	Boat deployed and slipped. Vessel standing off.
27/07/2013 08:36	Bongo 14	77.95749	-7.10623	Bongo nets off the deck.
27/07/2013 08:38	Bongo 14	77.95756	-7.10714	Bongo nets deployed.
27/07/2013 08:42	Bongo 14	77.95761	-7.10797	Bongo at depth. Commenced recovery.
27/07/2013 08:53	Bongo 14	77.95797	-7.11034	Bongo nets at the surface
27/07/2013 08:54	Bongo 14	77.958	-7.11052	Bongo nets on deck.
27/07/2013 08:55	Bongo 15	77.95804	-7.11078	Bongo nets off the deck.
27/07/2013 08:56	Bongo 15	77.95806	-7.11099	Bongo nets deployed.
27/07/2013 09:01	Bongo 15	77.9582	-7.11209	Bongo nets at depth. Commenced recovery.
27/07/2013 09:13	Bongo 15	77.95836	-7.11341	Bongo nets at the surface
27/07/2013 09:14	Bongo 15	77.95837	-7.11351	Bongo nets on deck.
27/07/2013 09:18	Boat 09	77.95842	-7.11394	Vessel moving in for recovery in JSAH.
27/07/2013 09:23	Boat 09	77.95827	-7.11806	Boat hooked.
27/07/2013 09:24	Boat 09	77.9583	-7.11873	Boat clear of the water.
27/07/2013 09:25	Boat 09	77.95836	-7.11927	Boat on deck.

27/07/2013 09:29	VMP 28	77.95858	-7.12058	VMP 28 off the deck.
27/07/2013 09:31	VMP 28	77.95858	-7.12056	VMP deployed.
27/07/2013 09:45	VMP 28	77.9586	-7.12046	VMP at depth - commence hauling
27/07/2013 10:02	VMP 28/9	77.95816	-7.11806	VMP at the surface redeploying
27/07/2013 10:13	VMP 29	77.95764	-7.11665	VMP at depth
27/07/2013 10:22	VMP 29/30	77.95719	-7.11559	VMP at surface and re-deployed
27/07/2013 10:33	VMP 30	77.95663	-7.11438	VMP at depth
27/07/2013 10:42	VMP 30/31	77.95615	-7.11371	VMP at the surface and re-deploying.
27/07/2013 10:52	VMP 31	77.9556	-7.11374	VMP at depth
27/07/2013 11:08	VMP 31	77.95497	-7.11475	VMP at surface
27/07/2013 11:09	VMP 31	77.95504	-7.11499	VMP 31 recovered
27/07/2013 11:11		77.95522	-7.11566	V/l off DP and repositioning
27/07/2013 11:13		77.9558	-7.11807	DP engaged ready for VMP 32
27/07/2013 11:56	VMP 32	77.97555	-7.16839	VMP 32 deployed
27/07/2013 12:05	VMP 32	77.97433	-7.16742	VMP at depth
27/07/2013 12:15	VMP 32/33	77.97339	-7.16524	VMP at surface and re-deployed
27/07/2013 12:25	VMP 33	77.97267	-7.16316	VMP at depth
27/07/2013 12:34	VMP 33/34	77.97204	-7.16137	VMP at surface and re-deployed
27/07/2013 12:44	VMP 34	77.97092	-7.16095	VMP at depth
27/07/2013 12:54	VMP 34/35	77.96953	-7.16091	Vmp at surface and re-deployed
27/07/2013 13:02	VMP 35	77.9684	-7.16068	VMP at depth
27/07/2013 13:14	VMP 35	77.96686	-7.15965	VMP 35 recovered
27/07/2013 13:28		77.98384	-7.18693	DP engaged ready for VMP 36
27/07/2013 13:31	VMP 36	77.98369	-7.18431	VMP 36 deployed
27/07/2013 13:40	VMP 36	77.9826	-7.18114	VMP at depth
27/07/2013 13:50	VMP 36	77.98161	-7.17593	VMP at the surface
27/07/2013 13:51	VMP 36	77.98153	-7.17518	VMP fully recovered
27/07/2013 14:03	CTD 11b	77.9813	-7.16983	CTD off the deck.
27/07/2013 14:05	CTD 11b	77.98129	-7.17	CTD 11b deployed
27/07/2013 14:14	CTD 11b	77.9817	-7.17068	CTD at depth 338m
27/07/2013 14:30	CTD 11b	77.98323	-7.17345	CTD 11b recovered. V/l off DP and repositioning
27/07/2013 14:43		77.99064	-7.18435	V/l on DP
27/07/2013 14:46	VMP 37	77.99065	-7.18406	VMP 37 deployed
27/07/2013 14:58	VMP 37	77.9895	-7.18114	VMP at depth
27/07/2013 15:04	VMP 37	77.98918	-7.17869	VMP at the surface
27/07/2013 15:09	VMP 38	77.98937	-7.17517	VMP 38 deployed
27/07/2013 15:20	VMP 38	77.98992	-7.16485	VMP at depth. Commenced hauling
27/07/2013 15:29	VMP 38	77.98888	-7.16138	VMP at the surface
27/07/2013 15:31	VMP 39	77.98872	-7.16127	VMP redeployed (39)
27/07/2013 15:41	VMP 39	77.98736	-7.16017	VMP at depth. Commenced hauling
27/07/2013 15:50	VMP 39/40	77.98609	-7.15978	VMP at the surface and redeployed
27/07/2013 16:01	VMP 40	77.98459	-7.15788	VMP at depth
27/07/2013 16:10	VMP 40	77.98335	-7.1579	VMP at the surface
27/07/2013 16:11	VMP 40	77.98327	-7.15789	VMP 40 recovered
27/07/2013 16:28		78.00114	-7.14061	Vessel on DP and moving ahead at 0.5kts for VMP deployment

27/07/2013 16:29	VMP 41	78.00114	-7.1406	VMP off the deck.
27/07/2013 16:30	VMP 41	78.00104	-7.14061	VMP deployed.
27/07/2013 16:41	VMP 41	77.99954	-7.1408	VMP at depth. Commenced recovery.
27/07/2013 16:50	VMP 41	77.99836	-7.1389	VMP at the surface.
27/07/2013 16:58	VMP 41	77.99736	-7.13681	VMP on deck.
27/07/2013 17:03		77.99673	-7.13542	V/l off DP and looking for sea ice sample
27/07/2013 17:38		78.01185	-7.12185	Ice sample with algae brought onboard via cage
27/07/2013 18:04		78.01292	-7.12635	V/l continuing on passage
28/07/2013 06:08	Boat 10	78.8905	-7.01979	Boat off the deck.
28/07/2013 06:10	Boat 10	78.89051	-7.01977	Boat deployed and slipped. Vessel standing off.
28/07/2013 06:55	Boat 10	78.89174	-7.02635	Vessel moving in for boat recovery.
28/07/2013 06:59	Boat 10	78.89221	-7.02844	Boat hooked.
28/07/2013 07:00	Boat 10	78.89236	-7.02885	Boat clear of the water.
28/07/2013 07:01	Boat 10	78.8925	-7.02918	Boat on deck.
28/07/2013 07:20	CTD 12a	78.89431	-7.033	CTD 12a off the deck
28/07/2013 07:25	CTD 12a	78.89452	-7.03382	CTD 12a deployed
28/07/2013 07:31	CTD 12a	78.89461	-7.03468	CTD 12a at the surface
28/07/2013 07:45	CTD 12a	78.89447	-7.03646	CTD 12a at depth wire 240m - seabed 258m
28/07/2013 07:48	CTD 12a	78.89429	-7.03681	CTD 12a on deck
28/07/2013 07:56	VMP 42	78.89243	-7.0422	VMP off the deck.
28/07/2013 07:57	VMP 42	78.89232	-7.04254	VMP deployed. Vessel moving ahead at 0.5kts.
28/07/2013 08:06	VMP 42	78.89131	-7.04626	VMP at depth. Commenced recovery.
28/07/2013 08:15	VMP 42/43	78.89063	-7.04924	Vmp at the surface and re-deploying.
28/07/2013 08:20	VMP 43	78.89023	-7.05164	VMP at depth. Commenced recovery.
28/07/2013 08:23	VMP 43/44	78.88997	-7.05345	Vmp at the surface and re-deploying.
28/07/2013 08:27	VMP 44	78.88962	-7.05606	VMP at depth. Commenced recovery.
28/07/2013 08:30	VMP 44/45	78.88931	-7.05771	VMP at the surface and re-deploying.
28/07/2013 08:34	VMP 45	78.88905	-7.05924	VMP at depth. Commenced recovery.
28/07/2013 08:37	VMP 45/46	78.88883	-7.06038	VMP at the surface and re-deploying.
28/07/2013 08:41	VMP 46	78.88847	-7.06239	VMP at depth. Commenced recovery.
28/07/2013 08:44	VMP 46/47	78.88829	-7.06425	VMP at the surface and re-deploying.
28/07/2013 08:57	VMP 47	78.88721	-7.07036	VMP at the surface. Rotating ship to improve relative wind.
28/07/2013 09:01	VMP 48	78.88707	-7.07197	VMP deployed.
28/07/2013 09:05	VMP 48	78.88708	-7.073	VMP at depth. Commenced recovery.
28/07/2013 09:08	VMP 48/49	78.88727	-7.07323	VMP at the surface and re-deploying.
28/07/2013 09:12	VMP 49	78.88709	-7.07473	VMP at depth
28/07/2013 09:16	VMP 49/50	78.88776	-7.07487	VMP at the surface and re-deploying.
28/07/2013 09:23	VMP 50	78.88904	-7.07453	VMP at depth
28/07/2013 09:33	VMP 50/51	78.88963	-7.06924	VMP at the surface and re-deploying.
28/07/2013 09:37	VMP 51	78.88955	-7.06563	VMP at depth
28/07/2013 09:52	VMP 51/52	78.88728	-7.06776	VMP at the surface and re-deploying.
28/07/2013 09:56	VMP 52	78.88659	-7.07271	VMP at depth
28/07/2013 10:00	VMP 52/53	78.88596	-7.07821	VMP at the surface and re-deploying.
28/07/2013 10:07	VMP 53	78.8853	-7.08601	VMP at depth. Commenced recovery.
28/07/2013 10:17	VMP 53/54	78.88447	-7.09825	VMP at the surface and re-deploying.
28/07/2013 10:21	VMP 54	78.88433	-7.10361	VMP at depth. Commenced recovery.

28/07/2013 10:25	VMP 54/55	78.88424	-7.10884	VMP at the surface and re-deploying.
28/07/2013 10:33	VMP 55	78.88421	-7.11984	VMP at depth. Commenced recovery.
28/07/2013 10:41	VMP 55/56	78.88433	-7.13063	VMP at the surface and re-deploying.
28/07/2013 10:46	VMP 56	78.88433	-7.13693	VMP at depth. Commenced recovery.
28/07/2013 10:49	VMP 56/57	78.88432	-7.14071	VMP at the surface and re-deploying.
28/07/2013 10:57	VMP 57	78.88422	-7.15096	VMP at depth. Commenced recovery.
28/07/2013 11:03	VMP 57/58	78.8842	-7.15828	VMP at the surface and re-deploying.
28/07/2013 11:11	VMP 58	78.88459	-7.16969	VMP at depth. Commence recovery
28/07/2013 11:14	VMP 58/59	78.88485	-7.17468	VMP at the surface and re-deploying.
28/07/2013 11:21	VMP 59	78.88555	-7.18631	VMP at depth. Commence recovery
28/07/2013 11:30	VMP 59/60	78.88598	-7.20067	VMP at the surface and re-deploying.
28/07/2013 11:36	VMP 60	78.88625	-7.20939	VMP at depth. Commence recovery
28/07/2013 11:45	VMP 60/61	78.88662	-7.22224	VMP at the surface and re-deploying.
28/07/2013 11:53	VMP 61	78.88697	-7.23346	VMP at depth. Commence recovery
28/07/2013 12:00	VMP 61/62	78.88723	-7.24165	VMP at the surface and re-deploying.
28/07/2013 12:08	VMP 62	78.88778	-7.25197	VMP at depth. Commenced recovery.
28/07/2013 12:14	VMP 62/63	78.88844	-7.25841	VMP at the surface and re-deploying.
28/07/2013 12:23	VMP 63	78.8894	-7.26717	VMP at depth. Commenced recovery.
28/07/2013 12:29	VMP 63/64	78.89019	-7.27273	VMP at the surface and re-deploying.
28/07/2013 12:37	VMP 64	78.89173	-7.28006	VMP at depth. Commenced recovery.
28/07/2013 12:45	VMP 64/65	78.89303	-7.29071	VMP at the surface and re-deploying.
28/07/2013 12:52	VMP 65	78.89356	-7.29959	VMP at depth. Commenced recovery.
28/07/2013 13:00	VMP 65/66	78.89466	-7.31005	VMP at the surface and re-deploying.
28/07/2013 13:09	VMP 66	78.89561	-7.31866	VMP at depth. Commence recovery
28/07/2013 13:13	VMP 66/67	78.89616	-7.32215	VMP at the surface and re-deploying.
28/07/2013 13:20	VMP 67	78.89725	-7.32788	VMP at depth. Commence recovery
28/07/2013 13:30	VMP 67/68	78.89925	-7.33571	VMP at the surface and re-deploying.
28/07/2013 13:38	VMP 68	78.9003	-7.34127	VMP at depth. Commence recovery
28/07/2013 13:47	VMP 68/69	78.90068	-7.33914	VMP at the surface and re-deploying.
28/07/2013 13:58	VMP 69	78.89916	-7.33425	VMP at depth. Commence recovery
28/07/2013 14:10	VMP 69/70	78.89735	-7.34191	VMP at the surface and re-deploying.
28/07/2013 14:16	VMP 70	78.89647	-7.34548	VMP at depth. Commenced recovery.
28/07/2013 14:25	VMP 70/71	78.89528	-7.35351	VMP at the surface and re-deploying.
28/07/2013 14:32	VMP 71	78.89515	-7.35988	VMP at depth. Commenced recovery.
28/07/2013 14:39	VMP 71/72	78.89496	-7.36672	VMP at the surface and re-deploying.
28/07/2013 14:45	VMP 72	78.89332	-7.37403	VMP at depth. Commenced recovery.
28/07/2013 14:53	VMP 72/73	78.89229	-7.37768	VMP at the surface and re-deploying.
28/07/2013 15:00	VMP 73	78.89132	-7.38138	VMP at depth. Commenced recovery.
28/07/2013 15:07	VMP 73/74	78.88974	-7.38662	VMP at the surface and re-deploying.
28/07/2013 15:14	VMP 74	78.88807	-7.39093	VMP at depth. Commence recovery
28/07/2013 15:21	VMP 74/75	78.88678	-7.39909	VMP at surface and re-deployed
28/07/2013 15:29	VMP 75	78.88583	-7.40785	VMP at depth
28/07/2013 15:36	VMP 75/76	78.88505	-7.41506	VMP at surface and re-deployed
28/07/2013 15:43	VMP 76	78.88387	-7.42373	VMP at depth. Commence recovery
28/07/2013 15:54	VMP 76	78.88225	-7.43261	VMP 76 at surface
28/07/2013 16:02		78.88044	-7.43682	VMP 76 fully recovered

28/07/2013 16:50	VMP 77	78.89109	-7.1447	Vessel repositioned. VMP off the deck.
28/07/2013 16:53	VMP 77	78.89078	-7.14389	VMP deployed.
28/07/2013 17:04	VMP 77	78.88974	-7.14992	VMP at depth. Commenced recovery.
28/07/2013 17:15	VMP 77/78	78.88996	-7.15913	VMP at surface and re-deployed
28/07/2013 17:23	VMP 78	78.88884	-7.163	VMP at depth
28/07/2013 17:31	VMP 78/79	78.88759	-7.16668	VMP at surface and re-deployed
28/07/2013 17:39	VMP 79	78.88676	-7.17029	VMP at depth
28/07/2013 17:45	VMP 79/80	78.88609	-7.17366	VMP at surface and re-deployed
28/07/2013 17:52	VMP 80	78.88511	-7.17815	VMP at depth
28/07/2013 17:59	VMP 80/81	78.88405	-7.1825	VMP at surface and re-deployed
28/07/2013 18:05	VMP 81	78.88323	-7.18779	VMP at depth
28/07/2013 18:13	VMP 81/82	78.88234	-7.19482	VMP at surface and re-deployed
28/07/2013 18:20	VMP 82	78.88187	-7.19868	VMP at depth
28/07/2013 18:28	VMP 82/83	78.88129	-7.20176	VMP at surface and re-deployed
28/07/2013 18:35	VMP 83	78.88085	-7.2039	VMP at depth
28/07/2013 18:41	VMP 83/84	78.88024	-7.20576	VMP at surface and re-deployed
28/07/2013 18:48	VMP 84	78.87935	-7.2084	VMP at depth
28/07/2013 18:54	VMP 84/85	78.87863	-7.21038	VMP at surface and re-deployed
28/07/2013 19:01	VMP 85	78.87772	-7.21217	VMP at depth
28/07/2013 19:08	VMP 85/86	78.8766	-7.21412	VMP at surface and re-deployed
28/07/2013 19:16	VMP 86	78.87532	-7.21706	VMP at depth
28/07/2013 19:23	VMP 86/87	78.87382	-7.21934	VMP at surface and re-deployed
28/07/2013 19:30	VMP 87	78.8719	-7.22112	VMP at depth
28/07/2013 19:39	VMP 87/88	78.86925	-7.22366	VMP at surface and re-deployed
28/07/2013 19:46	VMP 88	78.86741	-7.22402	VMP at depth
28/07/2013 19:58	VMP 88	78.86396	-7.21869	VMP 88 fully recovered
29/07/2013 05:01		77.45232	-5.21239	Vessel in heading mode DP station 12.5
29/07/2013 07:30	CTD 12.5	77.45376	-5.21757	CTD 12.5 off the deck
29/07/2013 07:33	CTD 12.5	77.45376	-5.21757	CTD 12.5 Deployed
29/07/2013 07:55	CTD 12.5	77.45374	-5.21762	CTD 12.5 at depth. Wire out 970m. Commenced recovery.
29/07/2013 08:19	CTD 12.5	77.45314	-5.21769	CTD 12.5 at the surface
29/07/2013 08:21	CTD 12.5	77.45315	-5.21767	CTD 12.5 on deck. Vessel off DP and repositioning clear of ice.
29/07/2013 08:39		77.44616	-5.13845	Vessel clear of ice and on station in DP.
29/07/2013 08:41	Boat 11	77.44615	-5.13846	Boat 11 off the deck
29/07/2013 08:43	Boat 11	77.44615	-5.13845	Boat 11 deployed and slipped.
29/07/2013 08:46	Bongo nets 11	77.44616	-5.13838	Bongo Nets 11 - deployed
29/07/2013 08:54	Bongo nets 11	77.44588	-5.1391	Nets at 200m hauling
29/07/2013 09:04	Bongo nets 11	77.4452	-5.14072	Nets on deck
29/07/2013 09:05	Bongo nets 12	77.44514	-5.14088	Bongo nets 12 - deployed
29/07/2013 09:12	Bongo nets 12	77.44459	-5.14229	Bongo nets at 200m hauling
29/07/2013 09:22	Bongo nets 12	77.44402	-5.14379	Bongo nets on deck
29/07/2013 09:35	Boat 11	77.44274	-5.14701	Boat 11 Hooked
29/07/2013 09:37	Boat 11	77.44252	-5.14752	Boat on deck. Running head to wind at 0.5kts
29/07/2013 12:04	VMP 89	77.42783	-5.22925	VMP 89 Deployed.
29/07/2013 12:20	VMP 89	77.42837	-5.24207	VMP at depth. Commenced recovery.
29/07/2013 12:34	VMP 89/90	77.43048	-5.24226	VMP at the surface and re-deploying.

29/07/2013 12:48	VMP 90	77.43206	-5.24025	VMP at depth. Commenced recovery.
29/07/2013 13:05	VMP 90	77.43331	-5.23841	VMP 90 fully recovered
29/07/2013 16:30		77.42268	-5.52655	V/l departing station
29/07/2013 22:48	CTD station 12.75	77.26394	-1.62764	Vessel in DP for CTD 12.75
29/07/2013 23:02	CTD 12.75	77.26406	-1.6278	CTD 12.75 off the deck
29/07/2013 23:05		77.26406	-1.62778	CTD 12.75 deployed
29/07/2013 23:23		77.26449	-1.62913	CTD at 1000m hauling
29/07/2013 23:40		77.26447	-1.6292	CTD 12.75 at the surface
29/07/2013 23:43	CTD 12.75	77.26448	-1.62919	CTD 12.75 on deck
29/07/2013 23:49	VMP 91	77.26463	-1.62877	VMP 91 - in the water
29/07/2013 23:50		77.2647	-1.6286	VMP 91 deployed
30/07/2013 00:04		77.26571	-1.62594	VMP 91 at depth and commenced recovery
30/07/2013 00:18		77.26672	-1.62335	VMP 91 at the surface
30/07/2013 00:20	VMP 91	77.26687	-1.62294	VMP 91 onboard
30/07/2013 00:24		77.26716	-1.62219	DP disengaged proceeding to CTD 13
30/07/2013 07:12	CTD 13a	77.44258	3.43549	CTD 13a - off the deck
30/07/2013 07:15		77.44259	3.43547	CTD 13a at 120 m hauling
30/07/2013 07:21		77.44258	3.43551	CTD 13 a deployed
30/07/2013 07:30		77.44258	3.43547	CTD 13a at the surface
30/07/2013 07:34	CTD 13a	77.44258	3.43556	CTD 13a on deck
30/07/2013 07:48	VMP 92	77.44114	3.43773	VMP 92 - in the water
30/07/2013 07:49		77.441	3.43791	VMP 92 - deployed
30/07/2013 08:03		77.43917	3.44079	VMP 92 at depth - commenced recovery
30/07/2013 08:19	VMP 92/93	77.43716	3.44397	VMP at the surface and re-deploying.
30/07/2013 08:32	VMP 93	77.43545	3.44674	VMP 93 at depth. Commenced recovery
30/07/2013 08:46	VMP 93	77.43362	3.44964	VMP 93 at the surface
30/07/2013 08:48	VMP 93	77.43336	3.45005	VMP 93 on deck.
30/07/2013 10:02	CTD 13b	77.42383	3.44013	CTD 13b off the deck.
30/07/2013 10:04	CTD 13b	77.42384	3.44017	CTD 13b deployed. Water depth 3066m.
30/07/2013 10:24	CTD 13b	77.42387	3.44039	CTD 13b at depth. Wire out 1
30/07/2013 10:44	CTD 13b	77.42387	3.44038	CTD 13b at the surface.
30/07/2013 10:46	CTD 13b	77.42387	3.44041	CTD 13b on deck.
30/07/2013 11:49	Boat 12	77.42694	3.46948	Boat 12 off the deck.
30/07/2013 11:51	Boat 12	77.42694	3.46948	Boat 12 deployed and slipped.
30/07/2013 12:53	Boat 12	77.42675	3.44221	Vessel moving in for boat recovery
30/07/2013 12:58	Boat 12	77.42563	3.44121	Boat hooked
30/07/2013 12:59	Boat 12	77.42551	3.44023	Boat clear of the water.
30/07/2013 13:01	Boat 12	77.42537	3.43906	Boat fully recovered
30/07/2013 13:03		77.42532	3.43803	V/l off DP and proceeding
30/07/2013 21:17		77.83901	9.5053	V/l on station in full auto DP
30/07/2013 21:20	CTD 13.5	77.83873	9.50526	CTD 13.5 off the deck
30/07/2013 21:22	CTD 13.5	77.83874	9.50527	CTD 13.5 deployed
30/07/2013 21:41	CTD 13.5	77.83877	9.50556	CTD at depth 986m
30/07/2013 21:58	CTD 13.5	77.83877	9.50563	CTD at the surface
30/07/2013 22:01	CTD 13.5	77.83876	9.50551	CTD 13.5 fully recovered
30/07/2013 22:08	VMP 94	77.83857	9.50635	VMP 94 deployed

30/07/2013 22:23	VMP 94	77.83754	9.51004	VMP at depth. Commence recovery
30/07/2013 22:39	VMP 94	77.83651	9.51389	VMP on the surface
30/07/2013 22:42	VMP 94	77.83632	9.51453	VMP 94 fully recovered
30/07/2013 22:44		77.83632	9.51458	V/l off DP and proceeding
01/08/2013 06:32		78.53232	5.37757	Vessel set up on station in full auto pos DP.
01/08/2013 07:12	CTD 14a	78.53226	5.37717	CTD 14a off the deck
01/08/2013 07:16		78.53225	5.37721	CTD 14a deployed
01/08/2013 07:20		78.53224	5.37716	CTD 14a at 120m
01/08/2013 07:31		78.53226	5.3772	CTD 14a at the surface
01/08/2013 07:34	CTD 14 a	78.53223	5.3771	CTD 14a on deck
01/08/2013 11:31	CTD 14b	78.54753	5.40428	CTD 14b off the deck
01/08/2013 11:33	CTD 14b	78.54751	5.40431	CTD 14b deployed
01/08/2013 12:10	CTD 14b	78.54756	5.40447	CTD 14b at depth. Wire out 2
01/08/2013 13:01	CTD 14b	78.54754	5.40456	CTD 14b at the surface
01/08/2013 13:04	CTD 14b	78.54745	5.40445	CTD on deck
01/08/2013 13:08	Bongo Net 18	78.54705	5.40381	Bongo net 18 deployed
01/08/2013 13:15	Bongo Net 18	78.54651	5.40253	Bongo at depth 200m
01/08/2013 13:26	Bongo Net 18	78.54608	5.39768	Bongo Nets at the surface
01/08/2013 13:28	Bongo Net 18	78.54609	5.39733	Bongo Nets 18 fully recovered
01/08/2013 13:34		78.54652	5.39771	Gantry lashed
01/08/2013 14:54		78.5529	5.40632	Completed station. Vessel off DP and proceeding to next site.
02/08/2013 06:58		80.5834	10.78454	DP engaged - vessel in position for CTD 15
02/08/2013 07:10	CTD 15a	80.58392	10.78527	CTD 15 a - off the deck
02/08/2013 07:13		80.58392	10.78527	CTD 15 a deployed
02/08/2013 07:19		80.58392	10.78521	CTD 15 a - wire 120m - depth 946m
02/08/2013 07:39		80.58392	10.78526	CTD 15 a at surface for recovery
02/08/2013 07:42	CTD 15a	80.58392	10.78529	CTD 15 a on deck
02/08/2013 07:46	Bongo Nets 19	80.58393	10.78522	Bongo Nets 19 - deployed
02/08/2013 07:52		80.58392	10.78522	Bongo Nets 19 - at depth - hauling
02/08/2013 08:02	Bongo Nets 19	80.58392	10.78515	Bongo Nets 19 on deck
02/08/2013 08:07	Bongo 20	80.58392	10.7852	Bongo 20 deployed
02/08/2013 08:13	Bongo 20	80.58392	10.78514	Bongo 20 at depth. Commenced recovery.
02/08/2013 08:24	Bongo 20	80.58393	10.78524	Bongo 20 at the surface
02/08/2013 08:25	Bongo 20	80.58395	10.78519	Bongo 20 on deck. Vessel moving off head to wind at 0.5kts.
02/08/2013 09:22	VMP 95	80.59262	10.78053	VMP 95 - in the water
02/08/2013 09:24	VMP 95	80.59207	10.78083	VMP 95 deployed
02/08/2013 09:38	VMP 95	80.59401	10.77993	VMP 95 - at depth and commence recovery
02/08/2013 09:53	VMP 95/96	80.59608	10.77895	VMP 95 at the surface redeploying VMP 96
02/08/2013 10:07	VMP 96	80.59802	10.77804	VMP 96 at depth. Commenced recovery.
02/08/2013 10:23	VMP 96/97	80.60022	10.77711	VMP 96 at the surface and re-deploying VMP 97.
02/08/2013 10:36	VMP 97	80.602	10.77634	VMP 97 at depth. Commenced recovery.
02/08/2013 10:50	VMP 97	80.60394	10.77538	VMP on the surafce for recovery
02/08/2013 10:52	VMP 97	80.60421	10.77527	VMP 97 on deck
02/08/2013 12:00	CTD 15b	80.61256	10.77007	CTD 15b off the deck.
02/08/2013 12:03	CTD 15b	80.61255	10.77004	CTD 15b deployed. Water depth 946m.
02/08/2013 12:22	CTD 15b	80.61255	10.76997	CTD 15b at depth. Wire out 910m. Commenced recovery.

02/08/2013 12:39	CTD15b	80.61253	10.76998	CTD at the surface. Vessel commenced moving head to wind at 0.5kts
02/08/2013 12:59	CTD 15b	80.61453	10.76285	CTD 15b ondeck.
02/08/2013 13:47		80.62027	10.74273	V/L stopped in full auto position DP
02/08/2013 13:52	Radiometer 1	80.62029	10.74263	Radiometer 1 deployed
02/08/2013 13:56	Radiometer 1	80.62029	10.74262	Radiometer 1 recovered
02/08/2013 14:00	Radiometer 2	80.62029	10.74265	Radiometer 2 deployed
02/08/2013 14:15	Radiometer 2	80.62029	10.74261	Radiometer 2 recovered
02/08/2013 16:00		80.63211	10.70637	DP disengaged - proceeding to next station
03/08/2013 05:24	VMP 98	81.13484	24.11401	VMP 98 off the deck. Vessel moving ahead at 0.5kt
03/08/2013 05:26	VMP 98	81.13484	24.11404	VMP 98 deployed.
03/08/2013 05:40	VMP 98	81.13455	24.10366	VMP at depth. Commenced recovery.
03/08/2013 05:44	VMP 98/99	81.13456	24.1017	VMP at the surface and re-deploying.
03/08/2013 05:52	VMP 99	81.13484	24.09823	VMP at depth. Commenced recovery.
03/08/2013 06:00	VMP 99/100	81.13539	24.09412	VMP at the surface and re-deploying.
03/08/2013 06:06	VMP 100	81.13563	24.09102	VMP at depth. Commenced recovery.
03/08/2013 06:16	VMP 100/101	81.13658	24.08561	VMP at the surface and re-deploying.
03/08/2013 06:22	VMP 101	81.13697	24.08228	VMP at depth. Commenced recovery.
03/08/2013 06:29	VMP 101/102	81.13731	24.07692	VMP at the surface and re-deploying.
03/08/2013 06:37	VMP 102	81.13273	24.12183	VMP 102 - at depth - commenced recovery
03/08/2013 06:44	VMP 102/103	81.13231	24.11903	VMP at surface / redeploying
03/08/2013 06:52	VMP 103	81.13818	24.05675	VMP 103 at depth. Commenced recovery
03/08/2013 06:59	VMP 103	81.13852	24.04978	VMP 103 on surface - recovering to deck
03/08/2013 07:02	VMP	81.13849	24.04748	VMP on deck - moving back to CTD 16 station
03/08/2013 07:18		81.13349	24.12451	DP engaged on station for CTD 16a
03/08/2013 07:20	CTD 16a	81.13349	24.12432	CTD 16a - off the deck
03/08/2013 07:22		81.13349	24.12434	CTD 16 a deployed
03/08/2013 07:28		81.13347	24.12428	CTD 16a at depth - wire 120m - sea depth 275m
03/08/2013 07:40		81.13249	24.12026	CTD 16a at the surface
03/08/2013 07:44	CTD 16a	81.13249	24.12026	CTD 16 a on deck
03/08/2013 07:51	VMP 104	81.13239	24.11984	VMP 104 - in the water
03/08/2013 07:53	VMP 104	81.13258	24.12033	VMP 104 deployed
03/08/2013 08:01	VMP 104	81.13328	24.11853	VMP 104 at depth. Commenced recovery.
03/08/2013 08:08	VMP 104/105	81.13357	24.1147	VMP at the surface and re-deploying.
03/08/2013 08:17	VMP 105	81.13364	24.10749	VMP at depth. Commenced recovery.
03/08/2013 08:17	VMP 105	81.13364	24.10749	VMP 105 at depth. Commenced recovery.
03/08/2013 08:23	VMP 105/106	81.13367	24.10196	VMP at the surface and re-deploying.
03/08/2013 08:32	VMP 106	81.13384	24.09462	VMP 106 at depth. Commenced recovery.
03/08/2013 08:39	VMP 106/107	81.134	24.08903	VMP at the surface and re-deploying.
03/08/2013 08:48	VMP 107	81.13386	24.08054	VMP 107 at depth. Commenced recovery.
03/08/2013 08:49	VMP 107/108	81.13381	24.07961	VMP at the surface and re-deploying.
03/08/2013 08:56	VMP 108	81.13356	24.074	VMP 108 - at depth - hauling
03/08/2013 09:03	VMP 108/9	81.13358	24.06794	VMP 108 at the surface and redeploying
03/08/2013 09:11	VMP 109	81.13309	24.06256	VMP 109 at depth and commenced recovery
03/08/2013 09:18	VMP 109/10	81.13086	24.01155	VMP at the surface - redeploying
03/08/2013 09:26	VMP 110	81.1324	24.05234	VMP at depth and commenced recovery

03/08/2013 09:33	VMP 110/111	81.13217	24.04698	VMP at the surface - redeploying
03/08/2013 09:42	VMP 111	81.13197	24.03839	VMP at depth and commenced recovery
03/08/2013 09:49	VMP 111/112	81.13173	24.03081	VMP at the surface - redeploying
03/08/2013 09:58	VMP 112	81.13135	24.0224	VMP 112 at depth. Commenced recovery.
03/08/2013 10:05	VMP 112	81.13078	24.01771	VMP 112 at the surface. Stopping the ship.
03/08/2013 10:07	VMP 112	81.13069	24.01516	VMP 112 on deck.
03/08/2013 10:09	Bongo 21	81.13059	24.01445	Vessel stopped on DP. Bongo 21 off the deck.
03/08/2013 10:10	Bongo 21 / Boat 13	81.13058	24.01438	Bongo 21 deployed. Boat 13 off the deck.
03/08/2013 10:12	Boat 13	81.1306	24.01445	Boat 13 deployed and slipped.
03/08/2013 10:16	Bongo 21	81.13082	24.01184	Bongo 21 at depth.
03/08/2013 10:27	Bongo 21	81.13087	24.0115	Bongo 21 at the surface
03/08/2013 10:28	Bongo 21	81.13087	24.01135	Bongo 21 on deck
03/08/2013 11:11	Boat 13	81.12532	23.99444	Moving in for recovery
03/08/2013 11:14	Boat 13	81.12514	23.99448	Boat 13 hooked and clear
03/08/2013 11:16	Boat 13	81.12496	23.99394	Boat 13 recovered. V/l off DP and repositioning
03/08/2013 11:39		81.13289	24.13778	V/l in position at 1-1.5kts for VMP deployment
03/08/2013 11:42	VMP 114	81.13276	24.13216	VMP 114 deployed
03/08/2013 11:51	VMP 114	81.13185	24.11704	VMP 114 at depth
03/08/2013 11:58	VMP 114/115	81.13109	24.10869	VMP at the surface and re-deploying.
03/08/2013 12:06	VMP 115	81.13018	24.09855	VMP 115 at depth. Commenced recovery.
03/08/2013 12:14	VMP 115/116	81.12921	24.08897	VMP at the surface and re-deploying.
03/08/2013 12:22	VMP 116	81.12865	24.08219	VMP 116 at depth. Commenced recovery.
03/08/2013 12:29	VMP 116/117	81.1285	24.07806	VMP at the surface and re-deploying.
03/08/2013 12:38	VMP 117	81.12898	24.06647	VMP 117 at depth. Commenced recovery
03/08/2013 12:50	VMP 117	81.12948	24.04987	VMP 117 at the surface and tangled.
03/08/2013 12:53	VMP 117	81.12959	24.04543	VMP 117 on deck
03/08/2013 13:00	VMP 118	81.12982	24.03596	VMP 118 deployed.
03/08/2013 13:09	VMP 118	81.13008	24.02188	VMP at depth. Commence recovery
03/08/2013 13:16	VMP 118/ 119	81.13009	24.01053	VMP at surface and re-deployed
03/08/2013 13:24	VMP 119	81.13001	23.99758	VMP at depth - commence hauling
03/08/2013 13:32	VMP 119/120	81.13015	23.98441	VMP at surface and re-deployed
03/08/2013 13:40	VMP 120	81.13077	23.97195	VMP at depth - commence hauling
03/08/2013 13:47	VMP 120/121	81.13157	23.96339	VMP at surface and re-deployed
03/08/2013 13:56	VMP 121	81.13283	23.95247	VMP at depth - commence hauling
03/08/2013 14:02	VMP 121	81.13404	23.94583	VMP 121 at the surface. Vessel stopping for CTD
03/08/2013 14:05		81.13432	23.94407	Vessel on station in DP for CTD
03/08/2013 14:07	CTD 16B	81.13433	23.94401	CTD 16B off the deck
03/08/2013 14:10	CTD 16B	81.13432	23.94401	CTD 16B deployed. Water depth 278m
03/08/2013 14:18	CTD 16B	81.13432	23.94401	CTD 16B at depth. Wire out 260m. Commenced recovery.
03/08/2013 14:31	CTD 16B	81.13431	23.94359	CTD 16B at the surface
03/08/2013 14:33	CTD 16B	81.1343	23.9435	CTD 16B on deck.
03/08/2013 14:39		81.1343	23.94359	Vessel off Dp and moving off for VMP deployment.
03/08/2013 14:40	VMP 122	81.13429	23.94367	VMP 122 deployed.
03/08/2013 14:48	VMP 122	81.13347	23.94577	VMP 122 at depth. Commenced recovery.
03/08/2013 14:55	VMP 122/123	81.1334	23.94648	VMP at the surface and re-deploying.

03/08/2013 15:06	VMP 123	81.1329	23.94868	VMP at depth - commence hauling
03/08/2013 15:12	VMP 123	81.13265	23.95064	VMP at the surface
03/08/2013 15:17	VMP 124	81.13229	23.95223	VMP 124 deployed
03/08/2013 15:25	VMP 124	81.13174	23.95409	VMP at depth - commence hauling
03/08/2013 15:32	VMP 124/125	81.13106	23.95698	VMP at surface and redeployed
03/08/2013 15:40	VMP 125	81.13053	23.96025	VMP at depth - commence hauling
03/08/2013 15:48	VMP 125/126	81.1296	23.96299	VMP at surface and redeployed
03/08/2013 15:54	VMP 126	81.12868	23.9656	VMP at depth - commence hauling
03/08/2013 16:00	VMP 126/127	81.12796	23.96758	Vmp at the surface and redeployed
03/08/2013 16:08	VMP 127	81.12719	23.97099	VMP 127 at depth. Commenced recovery.
03/08/2013 16:15	VMP 127/128	81.12661	23.97514	VMP at the surface and re-deploying.
03/08/2013 16:23	VMP 128	81.1261	23.98167	VMP 128 at depth. Commenced recovery.
03/08/2013 16:29	VMP 128/129	81.1259	23.98747	VMP at the surface and re-deploying.
03/08/2013 16:37	VMP 129	81.12565	23.99251	VMP 129 at depth. Commenced recovery.
03/08/2013 16:44	VMP 129/130	81.12528	23.99798	VMP at the surface and re-deploying.
03/08/2013 16:52	VMP 130	81.12497	24.0039	VMP 130 at depth. Commenced recovery.
03/08/2013 16:58	VMP 130/131	81.1249	24.00873	VMP at the surface and re-deploying.
03/08/2013 17:07	VMP 131	81.12469	24.01618	VMP at depth and commenced recovery
03/08/2013 17:15	VMP 131	81.12428	24.02447	VMP 131 fully recovered
03/08/2013 17:36		81.12462	24.05049	V/l departing station
04/08/2013 06:57		83.31056	33.73129	Vessel set up on station in DP.
04/08/2013 07:10	CTD 17a	83.31046	33.7313	CTD 17a off the deck
04/08/2013 07:12	CTD 17a	83.31047	33.73119	CTD 17a deployed
04/08/2013 07:17	CTD 17a	83.3105	33.73104	CTD 17a at depth wire 120m - seabed 3883m
04/08/2013 07:40	CTD 17a	83.31041	33.73311	CTD 17a - CTD at the surface
04/08/2013 07:43	CTD 17a	83.31036	33.73387	CTD 17a - CTD on deck
04/08/2013 07:53	Bongo Net 22	83.31025	33.73544	Bongo Nets 22 deployed
04/08/2013 07:55	Boat 14	83.3102	33.73544	Boat 14 off the deck.
04/08/2013 07:57	Boat 14	83.31014	33.73569	Boat 14 deployed and slipped.
04/08/2013 07:59	Bongo 22	83.31003	33.73653	Bongo 22 at depth. Commenced recovery.
04/08/2013 08:10	Bongo 22	83.30925	33.74245	Bongo 22 at the surface
04/08/2013 08:11	Bongo 22	83.30918	33.7427	Bongo 22 on deck
04/08/2013 08:48	Boat 14			Boat 14 - hooked
04/08/2013 08:50	Boat 14	83.30761	33.75298	Boat 14 on deck - DP disengaged to relocate for VMP
04/08/2013 09:05	VMP 132	83.31009	33.74055	VMP 132 - in the water
04/08/2013 09:06	VMP 132	83.31019	33.73955	VMP 132 deployed
04/08/2013 09:20	VMP 132	83.31113	33.72481	VMP at depth and commenced recovery
04/08/2013 09:34	VMP 132/33	83.31178	33.70472	VMP at the surface - redeploying
04/08/2013 09:42	Radiometer 3	83.31178	33.69233	Radiometer 3 deployed
04/08/2013 09:48	Radiometer 3/4	83.31183	33.68545	Radiometer at the surface - redeploying
04/08/2013 09:51	Radiometer 4	83.31186	33.68227	radiometer profiling at 10m
04/08/2013 09:53	Radiometer 4	83.31191	33.67972	Radiometer 4 recovered
04/08/2013 10:00	VMP 133	83.31219	33.6706	VMP 133 at the surface
04/08/2013 10:05	VMP 133	83.31261	33.66866	VMP on deck and proceeding at 0.5 kts
04/08/2013 11:14		83.32368	33.72974	V/l stopped in full auto DP for CTD deployment
04/08/2013 11:35	CTD 17b	83.32398	33.73286	CTD 17b off the deck

04/08/2013 11:38	CTD 17b	83.32399	33.73306	CTD 17b deployed
04/08/2013 12:46	CTD 17b	83.32226	33.71162	CTD 17b at depth. Wire out 3
04/08/2013 14:00	CTD 17b	83.32019	33.67832	CTD 17b at the surface
04/08/2013 14:03	CTD 17b	83.32024	33.67631	CTD 17b on deck
04/08/2013 14:14		83.32006	33.67025	V/l off DP and proceeding
04/08/2013 20:02		83.14121	29.45135	DP engaged on station for CTD 17.5a
04/08/2013 20:08	CTD 17.5a	83.14185	29.44558	CTD 17.5a deployed
04/08/2013 20:15	CTD 17.5a	83.1419	29.4438	CTD at depth 120m (water depth 3983m)
04/08/2013 20:30	CTD 17.5a	83.14159	29.44269	CTD at surface
04/08/2013 20:34	CTD 17.5a	83.1417	29.44261	CTD 17.5a deck
04/08/2013 20:41	Boat 15	83.14164	29.44296	Boat 15 deployed
04/08/2013 20:43	Radiometer 5	83.14153	29.44354	Radiometer 5 deployed
04/08/2013 20:48	Radiometer 5/6	83.14164	29.44263	Radiometer at the surface and redeployed
04/08/2013 20:55	Radiometer 6	83.14146	29.44562	Radiometer 6 recovered
04/08/2013 21:14	Boat 15	83.14007	29.46011	Boat hooked
04/08/2013 21:16	Boat 15	83.13998	29.46045	Boat 15 recovered
04/08/2013 21:24	VMP 134	83.13973	29.46287	VMP 134 deployed
04/08/2013 21:40	VMP 134	83.14003	29.459	VMP at depth - commence hauling
04/08/2013 21:53	VMP 134/135	83.14053	29.45373	VMP at surface and re-deployed
04/08/2013 22:23	VMP 135	83.14325	29.43648	VMP 135 fully recovered
04/08/2013 22:32	CTD 17.5b	83.14375	29.42834	CTD 17.5b off the deck
04/08/2013 22:34	CTD 17.5b	83.14356	29.42861	CTD17.5b deployed
04/08/2013 23:09	CTD 17.5b	83.14033	29.42856	CTD at depth wire 2000m - seabed 3983m
04/08/2013 23:46	CTD 17.5b	83.13716	29.4199	CTD 17.5b at the surface
04/08/2013 23:50	CTD 17.5b	83.13654	29.4212	CTD 17.5b - on deck
05/08/2013 00:01		83.13532	29.42173	DP disengaged moving off for station CTD 18
05/08/2013 06:11		82.68636	26.1316	Vessel set up on station in DP.
05/08/2013 07:11	CTD 18a	82.68317	26.12828	CTD 18a - off the deck
05/08/2013 07:13	CTD 18a	82.6831	26.12822	CTD 18a - deployed
05/08/2013 07:20	CTD 18a	82.68269	26.12605	CTD 18a at 120m wire - sea depth 4003m
05/08/2013 07:31	CTD 18a	82.68232	26.12419	CTD 18a - at the surface
05/08/2013 07:34	CTD 18a	82.68224	26.124	CTD 18a - on deck
05/08/2013 07:43	Boat 16	82.6817	26.12341	Boat 16 - hooked
05/08/2013 07:44	Boat 16	82.68161	26.12341	Boat 16 - released
05/08/2013 08:38	Boat 16	82.67556	26.10928	Vessel moving in for boat pick up.
05/08/2013 08:42	Boat 16	82.67521	26.11116	Boat 16 hooked.
05/08/2013 08:45	Boat 16	82.67492	26.11241	Boat 16 on deck. Vessel repositioning for VMP.
05/08/2013 09:01	VMP 136	82.66551	26.05787	VMP 136 - in the water
05/08/2013 09:03	VMP 136	82.66582	26.05887	VMP 136 - deployed
05/08/2013 09:10	Radiometer 7	82.66684	26.06523	Radiometer 6 deployed
05/08/2013 09:14	Radiometer 7/8	82.66751	26.06896	Radiometer at the surface and redeployed
05/08/2013 09:16	VMP 136	82.66766	26.07017	VMP at depth and hauling
05/08/2013 09:20	Radiometer 8	82.668	26.07322	radiometer on deck
05/08/2013 09:30	VMP 136/7	82.66834	26.0912	VMP at the surface - redeploying
05/08/2013 09:44	VMP 137	82.66922	26.10842	VMP 137 at depth - hauling
05/08/2013 10:00	VMP 137	82.67144	26.12652	VMP 137 at the surface.

05/08/2013 10:02	VMP 137	82.67168	26.12879	VMP 137 on deck. Vessel repositioning.
05/08/2013 10:14		82.66646	26.10315	Vessel on station in DP.
05/08/2013 10:17	CTD 18b	82.66639	26.10211	CTD 18b off the deck.
05/08/2013 10:19	CTD 18b	82.66638	26.10193	CTD 18b deployed. Water depth 4
05/08/2013 11:29	CTD 18b	82.66353	26.08738	CTD 18b at depth 3938m
05/08/2013 12:53	CTD 18b	82.66304	26.05275	CTD 18b at the surface.
05/08/2013 12:55	CTD 18b	82.66304	26.05189	CTD 18b on deck
05/08/2013 14:30		82.6595	26.0369	V/l off DP and proceeding
05/08/2013 22:33		81.68614	31.87373	DP engaged for VMP deployment
05/08/2013 22:42	VMP 138	81.68871	31.86791	VMP 138 deployed
05/08/2013 22:55	VMP 138	81.69058	31.86159	VMP at depth
05/08/2013 23:08	VMP 138	81.69213	31.85531	VMP 138 - at the surface
05/08/2013 23:11	VMP 138	81.69249	31.8539	VMP 138 - on deck
05/08/2013 23:13		81.69273	31.853	DP disengaged - moving the 1000m depth
06/08/2013 00:03		81.59332	32.25498	DP engaged at 1000m depth for VMP
06/08/2013 00:08	VMP 139			VMP 139 - off the deck
06/08/2013 00:10	VMP 139	81.59474	32.25927	VMP 139 - deployed
06/08/2013 00:23	VMP 139	81.59648	32.25596	VMP 139 - at depth - commenced recovery
06/08/2013 00:38	VMP 139	81.59835	32.24984	VMP 139 - at the surface
06/08/2013 00:40	VMP 139	81.59861	32.24902	VMP 139 - on deck
06/08/2013 00:43		81.59894	32.24843	DP disengaged - deck secure - proceeding for 500m
06/08/2013 01:36		81.48675	32.56243	DP engaged at 500m VMP site
06/08/2013 01:39		81.48697	32.56299	Vessel moving ahead on thrusters
06/08/2013 01:41	VMP 140	81.48696	32.56312	VMP 140 - in the water
06/08/2013 01:42	VMP 140	81.48701	32.563	VMP 140 - deployed
06/08/2013 01:54	VMP 140	81.48886	32.56314	VMP 140 - at depth and commenced recovery
06/08/2013 02:06	VMP 140	81.49023	32.57132	VMP 140 - at the surface
06/08/2013 02:08	VMP 140	81.49052	32.57278	VMP 140 - on deck - vessel proceeding to 250m depth
06/08/2013 02:30		81.4587	32.75148	DP engaged at 250m VMP site
06/08/2013 02:35	VMP 141	81.45914	32.75461	VMP 141 - in the water
06/08/2013 02:36	VMP 141	81.45926	32.75478	VMP 141 - deployed
06/08/2013 02:43	VMP 141	81.46021	32.75408	VMP 141 - at depth and commenced recovery
06/08/2013 02:50	VMP 141	81.46118	32.75302	VMP 141 - at the surface
06/08/2013 02:52	VMP 141	81.46146	32.75273	VMP 141 - on deck
06/08/2013 02:57		81.46238	32.75491	VMP complete - proceeding to CTD station 19
06/08/2013 06:26		81.00002	34.83206	Vesel stopped and set up on station in DP
06/08/2013 07:11	CTD 19a	81.00001	34.83213	CTD 19a - off deck
06/08/2013 07:14	CTD 19a	81.00001	34.83212	CTD 19a - deployed
06/08/2013 07:21	CTD 19a	81.00002	34.83211	CTD 19a - at depth - wire 173m - sea depth 184m
06/08/2013 07:34	CTD 19a	81.00001	34.83203	CTD 19 a at the surface
06/08/2013 07:39	CTD 19a	81.00001	34.83203	CTD 19a - on deck
06/08/2013 07:43	Bongo Nets 23	80.99999	34.83211	Bongo Nets 23 - Deployed
06/08/2013 07:47	Boat 17	81	34.83204	Boat off the deck
06/08/2013 07:50	Bongo nets 23	81.00006	34.83249	Bongo Nets at depth Hauling
06/08/2013 07:51	Boat 17	81.00006	34.83265	Boat 17 - deployed
06/08/2013 08:02	Bongo 23	81.00025	34.83425	Bongo 23 at the surface

06/08/2013 08:03	Bongo 23	81.00026	34.83427	Bongo 23 on deck
06/08/2013 08:04	Bongo 24	81.00027	34.83423	Bongo 24 off the deck
06/08/2013 08:05	Bongo 24	81.00027	34.83428	Bongo 24 deployed
06/08/2013 08:08	Bongo 24	81.00027	34.83428	Bongo 24 at depth. Commenced recovery.
06/08/2013 08:15	Bongo 24	81.00039	34.83516	Bongo 24 at the surface
06/08/2013 08:16	Bongo 24	81.0004	34.83532	Bongo 24 on deck
06/08/2013 08:43	Boat 17	81.00043	34.83566	Boat 17. Vessel moving in for boat recovery
06/08/2013 08:47	Boat 17	81.00006	34.83548	Boat 17 hooked
06/08/2013 08:50	Boat 17 / Radiometer 9	80.99997	34.83508	Boat 17 on deck. Radiometer 9 deployed.
06/08/2013 08:53	Radiometer 9	80.99997	34.8349	Radiometer 9. on deck
06/08/2013 08:54	Radipmeter 10	80.99997	34.83482	Radiometer 10 deployed.
06/08/2013 08:58	Radiometer 10	80.99997	34.83471	Radiometer 10 on deck
06/08/2013 11:00		80.99999	34.83476	V/L off DP and proceeding to next station
07/08/2013 07:11	CTD 19.5	78.66501	23.49864	CTD 19.5 - CTD 19a off the deck
07/08/2013 07:14	CTD 19.5	78.66501	23.49863	CTD 19.5 - deployed
07/08/2013 07:19	CTD 19.5	78.66502	23.49859	CTD 19.5 at depth - wire 98m - sea depth 107m
07/08/2013 07:22	CTD 19.5	78.66501	23.49864	CTD 19.5 at the surface
07/08/2013 07:25	CTD 19.5	78.66502	23.4986	CTD 19.5 on deck
07/08/2013 07:38		78.66489	23.49895	DP disengaged proceeding to CTD 20
08/08/2013 00:00		79.25003	26.6562	
08/08/2013 07:00		75.53332	18.66741	Vessel set up station in full auto pos DP.
08/08/2013 07:10	CTD 20	75.53325	18.66785	CTD 20 off the deck
08/08/2013 07:11	CTD 20	75.53325	18.66783	CTD 20 deployed
08/08/2013 07:15	CTD 20	75.53324	18.66776	Commenced recovering CTD 20 from 42m depth
08/08/2013 07:19	CTD 20	75.53323	18.66778	CTD 20 on deck. Commence moving ahead at 0.7kts
08/08/2013 07:30	VMP 142	75.53304	18.66705	VMP 140 deployed
08/08/2013 07:35	VMP 142	75.53236	18.66474	VMP at depth - commence hauling
08/08/2013 07:39	VMP 142/143	75.53177	18.66269	VMP at surface and re-deployed
08/08/2013 07:41	VMP 143	75.53147	18.66175	VMP at depth - commence hauling
08/08/2013 07:47	Radiometer 11	75.53054	18.65893	Radiometer 11 deployed
08/08/2013 07:47	VMP 143	75.53054	18.65893	VMP 143 at the surface
08/08/2013 07:51	Radiometer 11	75.52992	18.65705	Radiometer 11 recovered
08/08/2013 07:52	VMP 144	75.53038	18.65846	VMP 144 deployed
08/08/2013 07:55	Radiometer 12	75.52927	18.65529	Radiometer 12 deployed
08/08/2013 07:56	VMP 144	75.52911	18.65489	VMP at depth - commence hauling
08/08/2013 07:57	Radiometer 12	75.52895	18.65443	Radiometer 12 recovered
08/08/2013 07:57	VMP 144/145	75.52895	18.65443	VMP at surface and re-deployed
08/08/2013 08:03	VMP 145/146	75.52795	18.65203	VMP at surface and re-deployed
08/08/2013 08:09	VMP 146/147	75.52682	18.65062	VMP at surface and re-deployed
08/08/2013 08:14	VMP 147/148	75.52585	18.65036	VMP at surface and re-deployed
08/08/2013 08:21	VMP 148/149	75.52445	18.65028	VMP at surface and re-deployed
08/08/2013 08:27	VMP 149/150	75.5233	18.65024	VMP at surface and re-deployed
08/08/2013 08:34	VMP 150/151	75.52191	18.65055	VMP at surface and re-deployed
08/08/2013 08:41	VMP 151/152	75.52054	18.65095	VMP at surface and re-deployed
08/08/2013 08:46	VMP 152/153	75.5196	18.65134	VMP at surface and re-deployed

08/08/2013 08:53	VMP 153/154	75.51825	18.65183	VMP at surface and re-deployed
08/08/2013 09:00	VMP 154/155	75.51691	18.65235	VMP at surface and re-deployed
08/08/2013 09:06	VMP 155/156	75.51577	18.6528	VMP at surface and re-deployed
08/08/2013 09:13	VMP 156/157	75.51443	18.65332	VMP at surface and re-deployed
08/08/2013 09:19	VMP 157/158	75.51327	18.65381	VMP at surface and re-deployed
08/08/2013 09:26	VMP 158/159	75.51191	18.65428	VMP at surface and re-deployed
08/08/2013 09:33	VMP 159/160	75.51057	18.65489	VMP at surface and re-deployed
08/08/2013 09:39	VMP 160/161	75.50939	18.65531	VMP at surface and re-deployed
08/08/2013 09:45	VMP 161/162	75.50824	18.65588	VMP at surface and re-deployed
08/08/2013 09:52	VMP 162/163	75.5069	18.65646	VMP at surface and re-deployed
08/08/2013 09:59	VMP 163/164	75.50554	18.65704	VMP at surface and re-deployed
08/08/2013 10:05	VMP 164/165	75.50437	18.65749	VMP at surface and re-deployed
08/08/2013 10:15	VMP 165	75.50245	18.65852	VMP 165 fully recovered. V/l stopped in position
08/08/2013 10:20	CTD 20	75.50204	18.65874	CTD 20 off the deck for re-deployment
08/08/2013 10:24	CTD 20	75.50205	18.65882	CTD 20 re-deployed
08/08/2013 10:29	CTD 20	75.50204	18.65877	CTD at depth 102m
08/08/2013 10:41	CTD 20	75.50206	18.65894	CTD 20 on deck
08/08/2013 10:46	Bongo Net 25	75.50206	18.65914	Bongo Nets 25 deployed
08/08/2013 10:49	Bongo Net 25	75.50206	18.65928	Bongos at depth
08/08/2013 10:55	Bongo Net 25	75.5021	18.65774	Bongo at the surface
08/08/2013 10:58	Bongo Net 25	75.50207	18.65706	Bongos 25 on deck
08/08/2013 11:00	VMPs	75.50186	18.65723	VMP 166 in the water
08/08/2013 11:03	VMP 166	75.50145	18.65757	VMP 166 deployed
08/08/2013 11:08	VMP 166/167	75.50077	18.65811	VMP at the surface and redeployed
08/08/2013 11:16	VMP 167/168	75.4997	18.65895	VMP at the surface and redeployed
08/08/2013 11:23	VMP 168/169	75.49873	18.65941	VMP at the surface and redeployed
08/08/2013 11:30	VMP 169/170	75.49776	18.65981	VMP at the surface and redeployed
08/08/2013 11:37	VMP 170/171	75.4968	18.6603	VMP at the surface and redeployed
08/08/2013 11:43	VMP 171/172	75.49599	18.66065	VMP at the surface and redeployed
08/08/2013 11:51	VMP 172/173	75.49487	18.66112	VMP at the surface and redeployed
08/08/2013 11:57	VMP 173/174	75.49406	18.6615	VMP at the surface and redeployed
08/08/2013 12:04	VMP 174/175	75.49309	18.66194	VMP at the surface and redeployed
08/08/2013 12:10	VMP 175/176	75.49225	18.66232	VMP at the surface and redeployed
08/08/2013 12:17	VMP 176/177	75.49128	18.66273	VMP at the surface and redeployed
08/08/2013 12:23	VMP 177/178	75.49046	18.66319	VMP at the surface and redeployed
08/08/2013 12:30	VMP 178/179	75.4895	18.66368	VMP at the surface and redeployed
08/08/2013 12:36	VMP 179/180	75.48869	18.66405	VMP at the surface and redeployed
08/08/2013 12:41	VMP 181	75.488	18.66411	VMP at the surface
08/08/2013 12:43	VMP 180/181	75.48772	18.66402	VMP at the surface and redeployed
08/08/2013 12:52	VMP 181	75.52569	18.65042	VMP on deck and relocating to start point
08/08/2013 12:55		75.4857	18.66406	DP disengaged
08/08/2013 13:17		75.52878	18.65035	DP engaged at start point
08/08/2013 13:26	VMP 182	75.52763	18.65092	VMP 182 in the water
08/08/2013 13:27	VMP 182	75.52749	18.65093	VMP 182 deployed
08/08/2013 13:33	VMP 182/183	75.52667	18.65071	VMP at the surface and redeployed
08/08/2013 13:47	VMP 183/184	75.52473	18.6502	VMP at the surface and redeployed

08/08/2013 13:55	VMP 184/185	75.52363	18.6499	VMP at the surface and redeployed
08/08/2013 14:01	VMP 185/186	75.5228	18.6501	VMP at the surface and redeployed
08/08/2013 14:07	VMP 186/187	75.52198	18.65046	VMP at the surface and redeployed
08/08/2013 14:14	VMP 187/188	75.52102	18.65085	VMP at the surface and redeployed
08/08/2013 14:21	VMP 188/189	75.52006	18.65139	VMP at the surface and redeployed
08/08/2013 14:28	VMP 189/190	75.5191	18.65183	VMP at the surface and redeployed
08/08/2013 14:34	VMP 190/191	75.51827	18.6522	VMP at the surface and redeployed
08/08/2013 14:41	VMP 191/192	75.5173	18.65269	VMP at the surface and redeployed
08/08/2013 14:47	VMP 192/193	75.51647	18.65285	VMP at the surface and redeployed
08/08/2013 14:53	VMP 193/194	75.51564	18.65302	VMP at the surface and redeployed
08/08/2013 15:00	VMP 194/195	75.51456	18.65323	VMP at the surface and redeployed
08/08/2013 15:08	VMP 195/196	75.51324	18.65387	VMP at the surface and re-deploying.
08/08/2013 15:15	VMP 196/197	75.51222	18.65444	VMP at the surface and re-deploying.
08/08/2013 15:21	VMP 197/198	75.51139	18.65487	VMP at the surface and re-deploying.
08/08/2013 15:29	VMP 198/199	75.51029	18.65535	VMP at the surface and re-deploying.
08/08/2013 15:35	VMP 199/200	75.50956	18.65564	VMP at the surface and re-deploying.
08/08/2013 15:42	VMP 200/201	75.50901	18.6557	VMP at the surface and re-deploying.
08/08/2013 15:48	VMP 201/202	75.50851	18.6559	VMP at the surface and re-deploying.
08/08/2013 15:54	VMP 202/203	75.50802	18.65606	VMP at the surface and re-deploying.
08/08/2013 16:01	VMP 203/204	75.50741	18.65626	VMP at the surface and re-deploying.
08/08/2013 16:08	VMP 204/205	75.50684	18.65649	VMP at the surface and re-deploying.
08/08/2013 16:16	VMP 205/206	75.50619	18.65668	VMP at the surface and re-deploying.
08/08/2013 16:23	VMP 206/207	75.50561	18.65688	VMP at the surface and re-deploying.
08/08/2013 16:30	VMP 207/208	75.50503	18.65702	VMP at the surface and re-deploying.
08/08/2013 16:37	VMP 208/209	75.50445	18.65722	VMP at the surface and re-deploying.
08/08/2013 16:44	VMP 209/210	75.50386	18.65736	VMP at the surface and re-deploying.
08/08/2013 16:52	VMP 210/211	75.5032	18.65756	VMP at the surface and re-deploying.
08/08/2013 16:59	VMP 211/212	75.50263	18.65771	VMP at the surface and re-deploying.
08/08/2013 17:13	VMP 213/214	75.50146	18.65803	VMP at the surface and re-deploying.
08/08/2013 17:20	VMP 214/215	75.5009	18.65822	VMP at the surface and re-deploying.
08/08/2013 17:27	VMP 215/216	75.50031	18.65839	VMP at the surface and re-deploying.
08/08/2013 17:33	VMP 216/217	75.49982	18.65855	VMP at the surface and re-deploying.
08/08/2013 17:40	VMP 217/218	75.49924	18.65873	VMP at the surface and re-deploying.
08/08/2013 17:47	VMP 218/219	75.49867	18.65895	VMP at the surface and re-deploying.
08/08/2013 17:53	VMP 219/220	75.49818	18.6591	VMP at the surface and re-deploying.
08/08/2013 18:00	VMP 220/221	75.4976	18.65943	VMP at the surface and re-deploying.
08/08/2013 18:06	VMP 221/222	75.4971	18.65974	VMP at the surface and re-deploying.
08/08/2013 18:13	VMP 222/223	75.49653	18.66012	VMP at the surface and re-deploying.
08/08/2013 18:19	VMP 223/224	75.49606	18.66037	VMP at the surface and re-deploying.
08/08/2013 18:25	VMP 224/225	75.49555	18.66068	VMP at the surface and re-deploying.
08/08/2013 18:31	VMP 225/226	75.49507	18.66108	VMP at the surface and re-deploying.
08/08/2013 18:36	VMP 226/227	75.49462	18.66133	VMP at the surface and re-deploying.
08/08/2013 18:43	VMP 227	75.49365	18.66197	VMP 227 on deck
08/08/2013 18:44		75.49351	18.66205	Vessel off DP and proceeding towards next station.
09/08/2013 09:57	Station 21	76.74632	9.37211	DP engaged - vessel in position for CTD 21
09/08/2013 10:04	CTD 21a	76.74651	9.37214	CTD 21a deployed

09/08/2013 10:09	CTD 21a	76.74647	9.37214	CTD at depth 120m
09/08/2013 10:20	CTD 21a	76.74643	9.37213	CTD at the surface
09/08/2013 10:23	CTD 21a	76.74643	9.3721	CTD 21a on deck
09/08/2013 10:30	VMP 228	76.74714	9.37121	VMP 228 deployed
09/08/2013 10:37	Radiometer 13	76.74828	9.36993	Radiometer 13 deployed
09/08/2013 10:45	Radiometer 13	76.74961	9.36855	Radiometer 13 recovered
09/08/2013 10:58	VMP 228/229	76.75168	9.36624	VMP at surface and re-deployed
09/08/2013 11:10	VMP 229	76.75344	9.36421	VMP at depth
09/08/2013 11:27	VMP 229	76.75542	9.36187	VMP 229 on deck
09/08/2013 13:01	CTD 21b	76.75545	9.36205	CTD 21b off the deck
09/08/2013 13:05	CTD 21b	76.75544	9.36202	CTD 21b deployed
09/08/2013 13:45	CTD 21b	76.75544	9.36199	CTD 21b at depth - wire 2252m - sea bed depth 2306m
09/08/2013 14:39	CTD 21b	76.75545	9.36196	CTD 21b on the surface for recovery
09/08/2013 14:42	CTD 21b	76.75544	9.36201	CTD 21b on deck
09/08/2013 18:00		76.75544	9.36188	Vessel off DP and proceeding to Longyearbyen

Appendix B: Depths sampled and Niskin bottle allocations

Table B1. Depths sampled and bottle allocations for primary water sampling CTD (CTD cast a) at each station. Bottles allocated to the following groups of scientists: York trace gases and DMSPt (Y-S), York organics (Y-R), Oxford (O), York Environment (Y-E), Manchester bubble tank (M), Essex and PML (P). Leaking bottles indicated by X.

Niskin no.	CTD1		CTD2		CTD 3		CTD 4		CTD 5		CTD 6		CTD 7		CTD 8		CTD 9	
	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists
24	2	Y-S	2	Y-S	1	Y-S	1	Y-S	2	Y-S	2	Y-S	2	Y-S	2	Y-S	2	Y-S
23	2	Y-R	2	Y-R	1	Y-R	1	Y-R	2	Y-R	2	Y-R	2	Y-R	2	Y-R	2	Y-R
22	2	O	2	O	1	Y-E	1	Y-E	2	O	2	x	2	x	2	O	2	O
21	2	Y-E	2	Y-E, M	1	M	1	M	2	Y-E	2	Y-E	2	Y-E	2	Y-E	2	Y-E
20	2	P	2	P	1	O	1	O	2	P	2	M, O	2	M,O	2	M	2	M
19	2	P	2	P	5	Y-S	5	Y-S	2	P	5	O, Y-E	5	O, Y-E	10	O, Y-E	5	O, Y-E
18	2	P	2	P	5	O	5	O	2	P	5	Y-S	5	Y-S	10	Y-S	5	Y-S
17	2	P	2	P	10	Y-S, Y-E	10	Y-S	2	P	10	O, Y-E	10	O, Y-E	15	O, Y-E	20	O, Y-E
16	5	O	2	spare	10	O	10	O	2	M	10	Y-S	10	Y-S	15	Y-S	20	Y-S
15	5	Y-S, Y-E	2	spare	20	Y-S, Y-E	20	Y-S	2	O	15	O, Y-E	20	O, Y-E	20	O, Y-E	32	O
14	5	spare	5	O	20	O	20	O	5	O	15	Y-S	20	Y-S	20	Y-S	32	Y-S
13	5	spare	5	Y-S, Y-E	30	P	30	P	5	Y-S, Y-E	18	Y-S	30	Y-S	25	Y-S	32	Y-E
12	10	O	10	O	30	P	30	P	10	O	18	O	30	O	25	O	32	P
11	10	Y-S, Y-E	10	Y-S, Y-E	30	P	30	P	10	Y-S, Y-E	18	P	30	P	25	P	32	P
10	20	x	20	O	30	P	30	P	20	O	18	P	30	P	25	P	32	P
9	20	x	20	Y-S, Y-E	30	Y-S	30	Y-S	20	Y-S, Y-E	18	P	30	P	25	P	32	P
8	30	O	30	O	30	O	30	O	30	O	18	P	30	P	25	P	37	O, Y-E
7	30	Y-S, Y-E	30	Y-S, Y-E	30	Y-E	30	Y-E	30	Y-S, Y-E	18	Y-E	30	Y-E	25	Y-E	37	Y-S
6	40	x	40	O	40	Y-S, Y-E	40	Y-S	40	O	25	O, Y-E	40	O, Y-E	30	O, Y-E	40	O, Y-E
5	40	Y-S, Y-E, O	40	Y-S, Y-E	40	O	40	O	40	Y-S, Y-E	25	Y-S	40	Y-S	30	Y-S	40	Y-S
4	60	O	60	O	60	Y-S, Y-E	60	Y-S	60	O	35	O, Y-E	60	O, Y-E	50	O, Y-E	60	O, Y-E
3	60	Y-S, Y-E	60	Y-S, Y-E	60	O	60	O	60	Y-S, Y-E	35	Y-S	60	Y-S	50	Y-S	60	Y-S
2	80	O	80	O	80	Y-S, Y-E	80	Y-S	80	O	60	O, Y-E	80	O, Y-E	80	O, Y-E	80	O, Y-E
1	80	Y-S, Y-E	80	Y-S, Y-E	80	O	80	O	80	Y-S, Y-E	60	Y-S	80	Y-S	80	Y-S	80	Y-S

Table B1 continued

Niskin	CTD 10		CTD 11		CTD 12		CTD 12.5		CTD 13		CTD 14		CTD 15		CTD 16		CTD 17	
no.	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists
24	2	Y-S	2	Y-S	2	Y-S	2	Y-S	2	Y-S	2	Y-S	2	Y-S	2	Y-S	0.4	Y-S
23	2	Y-R	2	Y-R	2	Y-R	2	Y-R	2	Y-R	2	spare	2	Y-R	2	Y-R	0.4	Y-R
22	2	O	2	O	2	Y-E	2	O	2	Y-E	2	Y-E	2	O	2	O	0.4	O
21	2	Y-E	2	Y-E	2	M	2	Y-E, M	2	M	2	M	2	Y-E	2	Y-E	0.4	Y-E
20	2	M	2	M	2	O	2	x	2	O	2	O	2	M	2	M	0.4	M
19	5	O, Y-E	5	O, Y-E	10	Y-E	5	O, Y-E	5	Y-S,Y-E	5	Y-S,O,Y-E	5	O, Y-E	5	O, Y-E	10	O, Y-E
18	5	Y-S	5	Y-S	10	O	5	Y-S	5	O	5	x	5	Y-S	5	Y-S	10	Y-S
17	10	O, Y-E	9	O, Y-E	15	Y-E	10	O, Y-E	10	Y-S,Y-E	10	O, Y-E	10	O, Y-E	10	O, Y-E	20	O, Y-E
16	10	Y-S	9	Y-S	15	O	10	Y-S	10	O	10	Y-S	10	Y-S	10	Y-S	20	Y-S
15	20	O, Y-E	12	O, Y-E	23	Y-E	13	O, Y-E	20	Y-S,Y-E	20	O, Y-E	15	O, Y-E	20	O, Y-E	29	O, Y-E
14	20	Y-S	12	Y-S	23	O	13	Y-S	20	O	20	Y-S	15	Y-S	20	Y-S	29	Y-S
13	27	Y-S	15	Y-C	28	P	16	Y-S	20	P	25	P	20	x	30	Y-S	38	x
12	27	O	15	O	28	P	16	O	20	P	25	P	20	O	30	O	38	O
11	27	P	15	P	28	P	16	P	20	P	25	O	20	P	30	P	38	Y-S
10	27	P	15	P	28	P	16	P	20	P	25	Y-S	20	P	30	P	38	P
9	27	P	15	P	28	Y-S	16	P	20	Y-S	25	P	20	P	30	P	38	P
8	27	P	15	P	28	O	16	P	20	O	25	P	20	P	30	P	38	P
7	27	Y-E	15	Y-E	28	Y-E	16	Y-E	20	Y-E	25	Y-E	20	Y-S, Y-E	30	Y-E	38	Y-E
6	35	O, Y-E	20	O, Y-E	35	Y-S,Y-E	25	O, Y-E	30	Y-S,Y-E	35	O, Y-E	35	O, Y-E	35	O, Y-E	55	O, Y-E
5	35	Y-S	20	Y-S	35	O	25	Y-S	30	O	35	Y-S	35	Y-S	35	Y-S	55	Y-S
4	50	O, Y-E	30	O, Y-E	40	Y-S,Y-E	35	O, Y-E	40	Y-S,Y-E	45	O, Y-E	40	O, Y-E	60	O, Y-E	75	O, Y-E
3	50	Y-S	30	Y-S	40	O	35	Y-S	40	O	45	Y-S	40	Y-S	60	Y-S	75	Y-S
2	80	O, Y-E	60	O, Y-E	50	Y-S,Y-E	60	O, Y-E	60	Y-S,Y-E	60	O, Y-E	70	O, Y-E	80	O, Y-E	90	O, Y-E
1	80	Y-S	60	Y-S	50	O	60	Y-S	60	O	60	Y-S	70	Y-S	80	Y-S	90	Y-S

Table B1 continued

Niskin	CTD 17.5		CTD 18		CTD 19		CTD 20		CTD 21	
no.	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists	Depth (m)	Scientists
24	2	Y-S	2	Y-S	0.3	Y-S	2	Y-S	1	Y-S
23	2	Y-R	2	Y-R	0.3	Y-R	2	Y-R	1	Y-R
22	2	O	2	O	0.3	O	2	O	1	O
21	2	Y-E	2	Y-E	0.3	Y-E	2	Y-E	1	Y-E
20	2	P	2	M	0.3	M	2	M	1	M
19	2	P	5	O, Y-E	5	O, Y-E	5	O, Y-E	5	Y-S
18	2	P	5	Y-S	5	Y-S	5	Y-S	5	O
17	2	P	18	O, Y-E	15	O, Y-E	12	O, Y-E	5	P
16	2	M	18	Y-S	15	Y-S	12	Y-S	5	P
15	2	spare	30	O, Y-E	30	O, Y-E	22	O, Y-E	5	P
14	5	O, Y-E	30	Y-S	30	Y-S	22	Y-S	5	P
13	5	Y-S	43	Y-S	38	Y-S	30	Y-S	5	Y-E
12	10	O, Y-E	43	O	38	O	30	O	12	O, Y-E
11	10	Y-S	43	P	38	P	30	P	12	Y-S
10	15	O, Y-E	43	P	38	P	30	P	18	O, Y-E
9	15	Y-S	43	P	38	P	30	P	18	Y-S
8	25	O, Y-E	43	P	38	P	30	P	24	O, Y-E
7	25	Y-S	43	Y-E	38	Y-E	30	Y-E	24	Y-S
6	35	O, Y-E	60	O, Y-E	50	O, Y-E	40	O, Y-E	36	O, Y-E
5	35	Y-S	60	Y-S	50	Y-S	40	Y-S	36	Y-S
4	60	O, Y-E	80	O, Y-E	60	O, Y-E	70	O, Y-E	60	O, Y-E
3	60	Y-S	80	Y-S	60	Y-S	70	Y-S	60	Y-S
2	90	O, Y-E	80	O, Y-E	80	O, Y-E	100	O, Y-E	80	O, Y-E
1	90	Y-S	80	Y-S	80	Y-S	100	Y-S	80	Y-S

Appendix C: CTD configuration

The configuration file used during the cruise:

Configuration report for SBE 911plus/917plus CTD


```
<?xml version="1.0" encoding="UTF-8"?>
<SBE_InstrumentConfiguration SB_ConfigCTD_FileVersion="7.22.0.2" >
 <Instrument Type="8" >
  <Name>SBE 911plus/917plus CTD</Name>
  <FrequencyChannelsSuppressed>0</FrequencyChannelsSuppressed>
  <VoltageWordsSuppressed>0</VoltageWordsSuppressed>
  <ComputerInterface>0</ComputerInterface>
  <!-- 0 == SBE11plus Firmware Version >= 5.0 -->
  <!-- 1 == SBE11plus Firmware Version < 5.0 -->
  <!-- 2 == SBE 17plus SEARAM -->
  <!-- 3 == None -->
  <DeckUnitVersion>0</DeckUnitVersion>
  <ScansToAverage>1</ScansToAverage>
  <SurfaceParVoltageAdded>0</SurfaceParVoltageAdded>
  <ScanTimeAdded>0</ScanTimeAdded>
  <NmeaPositionDataAdded>1</NmeaPositionDataAdded>
  <NmeaDepthDataAdded>0</NmeaDepthDataAdded>
  <NmeaTimeAdded>0</NmeaTimeAdded>
  <NmeaDeviceConnectedToPC>1</NmeaDeviceConnectedToPC>
  <SensorArray Size="13" >
   <Sensor index="0" SensorID="55" >
    <TemperatureSensor SensorID="55" >
     <SerialNumber>03P-4472</SerialNumber>
     <CalibrationDate>30 Aug 2012</CalibrationDate>
     <UseG_J>1</UseG_J>
     <A>0.00000000e+000</A>
     <B>0.00000000e+000</B>
     <C>0.00000000e+000</C>
     <D>0.00000000e+000</D>
     <F0_Old>0.000</F0_Old>
     <G>4.41398102e-003</G>
     <H>6.42799022e-004</H>
     <I>2.19747460e-005</I>
     <J>1.88664616e-006</J>
     <F0>1000.000</F0>
     <Slope>1.00000000</Slope>
     <Offset>0.0000</Offset>
    </TemperatureSensor>
   </Sensor>
   <Sensor index="1" SensorID="3" >
    <ConductivitySensor SensorID="3" >
     <SerialNumber>04C-2222</SerialNumber>
     <CalibrationDate>24 Aug 2012</CalibrationDate>
     <UseG_J>1</UseG_J>
     <!-- Cell const and series R are applicable only for wide range sensors. -->
     <SeriesR>0.0000</SeriesR>
     <CellConst>2000.0000</CellConst>
     <ConductivityType>0</ConductivityType>
     <Coefficients equation="0" >
      <A>0.00000000e+000</A>
```

```
      <B>0.00000000e+000</B>
      <C>0.00000000e+000</C>
      <D>0.00000000e+000</D>
      <M>0.0</M>
      <CPcor>-9.57000000e-008</CPcor>
    </Coefficients>
    <Coefficients equation="1" >
      <G>-9.57287162e+000</G>
      <H>1.33670231e+000</H>
      <I>-4.60412961e-005</I>
      <J>7.67811135e-005</J>
      <CPcor>-9.57000000e-008</CPcor>
      <CTcor>3.2500e-006</CTcor>
      <!-- WBOTC not applicable unless ConductivityType = 1. -->
      <WBOTC>0.00000000e+000</WBOTC>
    </Coefficients>
    <Slope>1.00000000</Slope>
    <Offset>0.00000</Offset>
  </ConductivitySensor>
</Sensor>
<Sensor index="2" SensorID="45" >
  <PressureSensor SensorID="45" >
    <SerialNumber>0771</SerialNumber>
    <CalibrationDate>30 March 2013</CalibrationDate>
    <C1>-4.785925e+004</C1>
    <C2>-3.416160e-001</C2>
    <C3>1.442400e-002</C3>
    <D1>3.781000e-002</D1>
    <D2>0.000000e+000</D2>
    <T1>3.011158e+001</T1>
    <T2>-3.924450e-004</T2>
    <T3>4.201770e-006</T3>
    <T4>2.250320e-009</T4>
    <Slope>0.99988000</Slope>
    <Offset>-1.11540</Offset>
    <T5>0.000000e+000</T5>
    <AD590M>1.284610e-002</AD590M>
    <AD590B>-8.492760e+000</AD590B>
  </PressureSensor>
</Sensor>
<Sensor index="3" SensorID="55" >
  <TemperatureSensor SensorID="55" >
    <SerialNumber>03P-2366</SerialNumber>
    <CalibrationDate>30 Aug 2012</CalibrationDate>
    <UseG_J>1</UseG_J>
    <A>0.00000000e+000</A>
    <B>0.00000000e+000</B>
    <C>0.00000000e+000</C>
    <D>0.00000000e+000</D>
    <F0_Old>0.000</F0_Old>
    <G>4.31974772e-003</G>
    <H>6.44172106e-004</H>
    <I>2.35210024e-005</I>
    <J>2.26433319e-006</J>
    <F0>1000.000</F0>
    <Slope>1.00000000</Slope>
    <Offset>0.0000</Offset>
  </TemperatureSensor>
</Sensor>
```

```
<Sensor index="4" SensorID="3" >
 <ConductivitySensor SensorID="3" >
  <SerialNumber>04C-2289</SerialNumber>
  <CalibrationDate>21 Aug 2012</CalibrationDate>
  <UseG_J>1</UseG_J>
  <!-- Cell const and series R are applicable only for wide range sensors. -->
  <SeriesR>0.0000</SeriesR>
  <CellConst>2000.0000</CellConst>
  <ConductivityType>0</ConductivityType>
  <Coefficients equation="0" >
   <A>0.00000000e+000</A>
   <B>0.00000000e+000</B>
   <C>0.00000000e+000</C>
   <D>0.00000000e+000</D>
   <M>0.0</M>
   <CPcor>-9.57000000e-008</CPcor>
  </Coefficients>
  <Coefficients equation="1" >
   <G>-1.04066323e+001</G>
   <H>1.38729309e+000</H>
   <I>-2.46034773e-003</I>
   <J>2.40168672e-004</J>
   <CPcor>-9.57000000e-008</CPcor>
   <CTcor>3.2500e-006</CTcor>
   <!-- WBOTC not applicable unless ConductivityType = 1. -->
   <WBOTC>0.00000000e+000</WBOTC>
  </Coefficients>
  <Slope>1.00000000</Slope>
  <Offset>0.00000</Offset>
 </ConductivitySensor>
</Sensor>
<Sensor index="5" SensorID="71" >
 <WET_LabsCStar SensorID="71" >
  <SerialNumber>CST-846DR</SerialNumber>
  <CalibrationDate>13 Mar 2013</CalibrationDate>
  <M>21.4133</M>
  <B>-1.2634</B>
  <PathLength>0.250</PathLength>
 </WET_LabsCStar>
</Sensor>
<Sensor index="6" SensorID="5" >
 <FluoroChelseaAqua3Sensor SensorID="5" >
  <SerialNumber>088-216</SerialNumber>
  <CalibrationDate>19 Feb 2013</CalibrationDate>
  <VB>0.219400</VB>
  <V1>2.068800</V1>
  <Vacetone>0.228700</Vacetone>
  <ScaleFactor>1.000000</ScaleFactor>
  <Slope>1.000000</Slope>
  <Offset>0.000000</Offset>
 </FluoroChelseaAqua3Sensor>
</Sensor>
<Sensor index="7" SensorID="42" >
 <PAR_BiosphericalLicorChelseaSensor SensorID="42" >
  <SerialNumber>70441</SerialNumber>
  <CalibrationDate>16 May 2012</CalibrationDate>
  <M>1.00000000</M>
  <B>0.00000000</B>
  <CalibrationConstant>621118012400.00000000</CalibrationConstant>
```

```
    <Multiplier>1.00000000</Multiplier>
    <Offset>-0.24475179</Offset>
  </PAR_BiosphericalLicorChelseaSensor>
</Sensor>
<Sensor index="8" SensorID="0" >
  <AltimeterSensor SensorID="0" >
    <SerialNumber>244738</SerialNumber>
    <CalibrationDate>9 May 2012</CalibrationDate>
    <ScaleFactor>15.000</ScaleFactor>
    <Offset>0.000</Offset>
  </AltimeterSensor>
</Sensor>
<Sensor index="9" SensorID="38" >
  <OxygenSensor SensorID="38" >
    <SerialNumber>43-2290</SerialNumber>
    <CalibrationDate>31 March 2012</CalibrationDate>
    <Use2007Equation>1</Use2007Equation>
    <CalibrationCoefficients equation="0" >
      <!-- Coefficients for Owens-Millard equation. -->
      <Boc>0.0000</Boc>
      <Soc>0.0000e+000</Soc>
      <offset>0.0000</offset>
      <Pcor>0.00e+000</Pcor>
      <Tcor>0.0000</Tcor>
      <Tau>0.0</Tau>
    </CalibrationCoefficients>
    <CalibrationCoefficients equation="1" >
      <!-- Coefficients for Sea-Bird equation - SBE calibration in 2007 and later. -->
      <Soc>3.9790e-001</Soc>
      <offset>-0.4913</offset>
      <A>-2.0922e-003</A>
      <B> 1.0378e-004</B>
      <C>-1.6935e-006</C>
      <D0> 2.5826e+000</D0>
      <D1> 1.92634e-004</D1>
      <D2>-4.64803e-002</D2>
      <E> 3.6000e-002</E>
      <Tau20> 1.5700</Tau20>
      <H1>-3.3000e-002</H1>
      <H2> 5.0000e+003</H2>
      <H3> 1.4500e+003</H3>
    </CalibrationCoefficients>
  </OxygenSensor>
</Sensor>
<Sensor index="10" SensorID="27" >
  <NotInUse SensorID="27" >
    <SerialNumber></SerialNumber>
    <CalibrationDate></CalibrationDate>
    <OutputType>2</OutputType>
    <Free>1</Free>
  </NotInUse>
</Sensor>
<Sensor index="11" SensorID="27" >
  <NotInUse SensorID="27" >
    <SerialNumber></SerialNumber>
    <CalibrationDate></CalibrationDate>
    <OutputType>2</OutputType>
    <Free>1</Free>
  </NotInUse>
```

```
    </Sensor>
    <Sensor index="12" SensorID="27" >
     <NotInUse SensorID="27" >
      <SerialNumber></SerialNumber>
      <CalibrationDate></CalibrationDate>
      <OutputType>2</OutputType>
      <Free>1</Free>
     </NotInUse>
    </Sensor>
   </SensorArray>
  </Instrument>
</SBE_InstrumentConfiguration>
```

Appendix D: BAS AME cruise report

Cruise:JR288 Start date:13/07/2013 Finish date:17/08/2013
Name of AME engineer: Julian Klepacki
Name of principle scientist (PSO): Lucy Carpenter/Rosie Chance

LAB Instruments

Instrument	**S/N Used**	**Comments**
AutoSal	#68959	
Scintillation counter	Y	
Magnetometer STCM1	Y	
XBT		

ACOUSTIC

Instrument	**S/N Used**	**Comments**
ADCP	Y	
Hydrophone		
EM122	Y	
TOPAS		
EK60		
SSU	Y	
USBL		
10kHz IOS pinger		
Benthos 12kHz pinger S/N 1316 + bracket		
Benthos 12kHz pinger S/N 1317 + bracket		
MORS 10kHz transponder		
Benthos UDB9000		

OCEANLOGGER

Instrument	S/N Used	Comments
Barometer1(UIC)	#V145002	
Barometer1(UIC)	#V145003	
Foremast Sensors		
Air humidity & temp1	#60599556	Believe Failed Hygroclip sensor. see notes
Air humidity & temp2	#60599558	
TIR1 sensor (pyranometer)	#112993	
TIR2 sensor (pyranometer)	#112992	
PAR1 sensor	#110127	
PAR2 sensor	#110126	
Prep Lab		
Thermosalinograph SBE45	#4524698-0018	
Transmissometer C-STAR	CST-396DR	
Fluorometer	Y	see notes
Flow meter	#11950	
Uncontaminated seawater temp	Y	

CTD (all kept in cage/ sci hold when not in use)

Instrument	S/N Used	Comments
CTD PC	Y	
Deck unit 2 SBE11plus	#11P20391-0502	
Underwater unit SBE9plus	#09P35716-0771	
Temp1 sensor SBE3plus	#03P4472	
Temp2 sensor SBE3plus	#03P2366	
Cond1 sensor SBE 4C	#04C2222	see CTD notes
Cond2 sensor SBE 4C	#04C2289	
Pump1 SBE5T	#54458	
Pump 2 SBE5T	#51807	
Standards Thermometer SBE35	#3527735-0024	
Transmissometer C-	CST-846DR	

Star		
Fluorometer Aquatraka Mk3	#088-216	
Oxygen sensor SBE43	#2290	
PAR sensor	#7252	see notes
PAR sensor	#7235	added 26/07/13 to compare to #7235.
Altimeter PA200	#244740	
CTD swivel+ linkage	#196111	
Carousel + 24 Bottle Pylon	#0636	
Notes on any other part of CTD e.g. faulty cables, wire drum slip ring, bottles, swivel, frame, tubing etc		

LADCP

Instrument	**S/N Used**	**Comments**
300KHz WH Monitor	14443	configured as slave (downward)
300KHz WH Monitor		
Battery Pack	Y	
Charger	Y	
Cables	Y	changed star-cable, suspected problem, conclusion was transducer at fault.
AME Laptop (BBTalk)		

MISC

Instrument	**S/N Used**	**Comments**
NMEA Server	Y	
LabView Server	Y	See notes
DWNM		

AME UNSUPPORTED INSTRUMENTS BUT LOGGED

Instrument	**Working?**	**Comments**
EA600	Y	
Anemometer	Y	
Gyro	Y	
DopplerLog	Y	
EMLog	Y	
Seapath 320+	Y	

Additional notes and recommendations for change / future work

OceanLogger

On reinstall of the foremast sensors there was no output from any of the sensors. Further investigation had found that the main cable plug that enters the junction-box at the top of the A-frame had been pulled out? It looks like the cable had been stepped on and pulled the plug out as the bulkhead connector was also pulled out from the enclosure. Luckily no cable/connection damage had incurred. TnH1 still had no output, on further investigation I used the Nudam Utilities Terminal program to send commands to the TnH 'Hygromet' body/interface. I could communicate with the body, but it returned blank fields where the data should be in it's returned data string. This implied to me that comms etc was all good, just it's not actually getting any data from the 'Hygroclip' sensor itself indicating an failed sensor? TnH2 operated as normal. Changing out the Hygroclips needs to be done next opportunity.

PSO comments on difference between underway fluorometer measurements and ctd measurements (aquatracka + frrf). suspect 10-AU calibration. Cal should be performed with a 'blank' and 'known' concentration analyte and adjusted accordingly. To my knowledge this has not been done for some years? Also what effect does measurements taken some distance through ships pipe-work introduce, compared to fluorometer fitted to CTD? New instrument to be fitted during refit 2013.

CTD

14/07/13: 04C2255 no output, swopped out for 04C2222
26/07/13: CTD #014 reported abnormally low, output PAR ~0.1% @ 28m, too low for waters measured. Investigation: Cal coefficients entered incorrectly; factor of ten out on the cal-coefficient calculation and offset. $10E^n$ used for 10^n, $10^n = 1E^n$. After correction and archive-rerun PAR was ~3.5% at 28m. Secondary PAR installed for comparison, correlate very close, all good. An idea would be to write an application and have it on the CTD PC to just plug in the PAR, Fluoro and Trans coefficients and the correct constants produced. This way it will eliminate any finger/brain trouble with calculators etc? At present they have to be manually calculated. Maybe even produce the xmlcon file so it can be directly imported into Seasoft?

LVIEWserver

The Labview-Server PC is intended to run web-published labview applications to be available over the ships intranet, as well as locally in some instances. The PC is located at the lower section of the acoustic-cabinet in the UIC. At present it has two applications; NavMetData, which shows navigational and meteorological data and is permanently displayed on the Aft-UIC above the Microplot display. Secondly is has an application WinchChart, which monitors the CTD winch and displays information about depths and ETAs. This application is primarily for the benefit of ships deck-crew whilst on duty during CTD oprations. Enabling them to be informed of CTD status without having to hang around the water-bottle annexe or keep going to the UIC etc. *Web-*

publishing obtains an image of the vi front panel and embeds it into html code to be accessed over the network.

At present the system is not stable, with a PC/Labview error occurring after a short while of running both applications and monitoring them with a web-browser. Also since the PC has been connected to the ships network it appears to get ‘bogged-down’? Previously the PC was only connected to the data-network to access the raw data files needed for the applications. The NavMetData application displays PC time and this could be seen to update smoothly every second. It ran for months like this. Now that the PC is connected to the public network the displayed time updates itself somewhat erratically: Some periods update is normal others clock updates itself up to about every 4-6 seconds. I believe that the program is being impeded by the network connection in some capacity: Displayed time is obtained within the main loop of the program after all relevant instrument data had been read from the SCS over the network. The erratic time is indicative of ‘delays’ in obtaining raw data? The PC itself is shows only about 20% processor loading and no HD activity indicated, implying the machine itself isn’t doing much during these periods of slow performance? Also the erratic nature of sometimes updating normally and other times slowly implies it is dependent on network activity? Continuing investigations are being carried out on an opportunistic basis.

Support Engineer: Julian Klepacki Date: 11th August 2013.

Appendix E: Uncontaminated sea water pump log

Date	Time (GMT)	Pump	Filter In Use	Probe Position	EVENT	REMARKS
July						
13	15:30	2	2	MID	System ON	None
15	9:50	2	1	MID	Filter Changeover and Clean	5 % Slime
17	9:45	2	2	MID	Filter Changeover and Clean	Med Jelly fish
19	11:50	2	1	MID	Filter Changeover and Clean	1/2 doz small kryll
21	11:00	2	2	MID	Filter Changeover and Clean	Small amount of matter
22	9:45	2	1	MID	Filter Changeover and Clean	2 Kryll
22	10:40	2	1	MID	Wages sample	-
24	8:44	2	2	MID	Filter Changeover and Clean	Small amount of matter
25	4:30	2	2	MID	System Off	Sea ice - Pump damaged
25	8:54	1	1	MID	Filter Changeover and Clean/ system On	Pump changed due to leak on 2, sea ice found in filter
26	2:36	1	1	UP	System Off	Sea Ice
26	4:30	1	1	Mid	System On	Clear of Ice
26	8:42	1	2	MID	Filter Changeover and Clean	1/2 doz small kryll
26	9:00	1	2	MID	Wages sample	-
26	18:00	1	2	UP	System off	Sea Ice
27	4:50	1	2	MID	System ON	Sampling
27	6:50	1	2	UP	System OFF	ICE
27	10:30	1	1	MID	Filter Changeover and Clean/ system On	System on
27	18:00	1	1	UP	System OFF	ICE
28	5:00	1	1	MID	System ON	Clear of Ice
28	9:30	1	2	UP	System off	ICe
29	6:20	1	2	MID	System On	Sampling
29	13:50	1	1	MID	Filter Change and Clean	Filter Clean
29	14:00	1	1	MID	Wages sample	-
29	19:00	1	1	MID	System off	ICE
30	4:00	1	1	MID	System on	Sampling
31	6:30	1	1	UP	System Off	Longyerbyen
31	18:30	1	1	MID	System on	Cruise continues
Aug						
1	9:10	1	2	MID	WAGES SAMPLE	408
2	2:15	1	2	MID	System Off	Sea Ice
3	6:00	1	2	MID	System ON	Sampling
3	18:45	1	2	MID	System Off	Sea Ice
4	6:00	1	2	MID	System ON	Sampling
4	7:00	1	2	MID	System Off	Sea Ice
4	8:00	1	2	MID	System ON	Sampling
4	8:30	1	1	MID	Filter Change and Clean	Filter was clean
4	15:15	1	1	MID	System off	Sea Ice
4	21:00	1	1	MID	Sysyem On	Sampling
5	1:15	1	1	MID	System Off	Sea Ice
5	9:00	1	1	MID	System ON	Sampling
5	15:30	1	1	MID	System Off	Sea Ice
5	17:53	1	1	MID	System ON	Sampling
6	2:00	1	1	MID	System Off	Sea Ice
6	7:45	1	1	MID	System ON	Sampling
6	8:40	1	2	MID	Filter Change and Clean	Filter was clean
9	8:30	1	1	MID	Filter Change and Clean	Small Amount of matter
9	9:00	1	1	MID	WAGES SAMPLE	409

10	7:15	1	1	up	System off	Longyerbyen
10	16:30	1	1	MID	System ON	Sampling
11	9:00	1	2	MID	Filter Change and Clean	Filter was clean
12	8:50	1	1	MID	Filter Change and Clean	Filter was clean
14	22:00	1	1	MID	WAGES SAMPLE	410
15	9:00	1	2	MID	Filter Change and Clean	Filter was clean
16	10:00	1	2	MID	System Off	Dundee