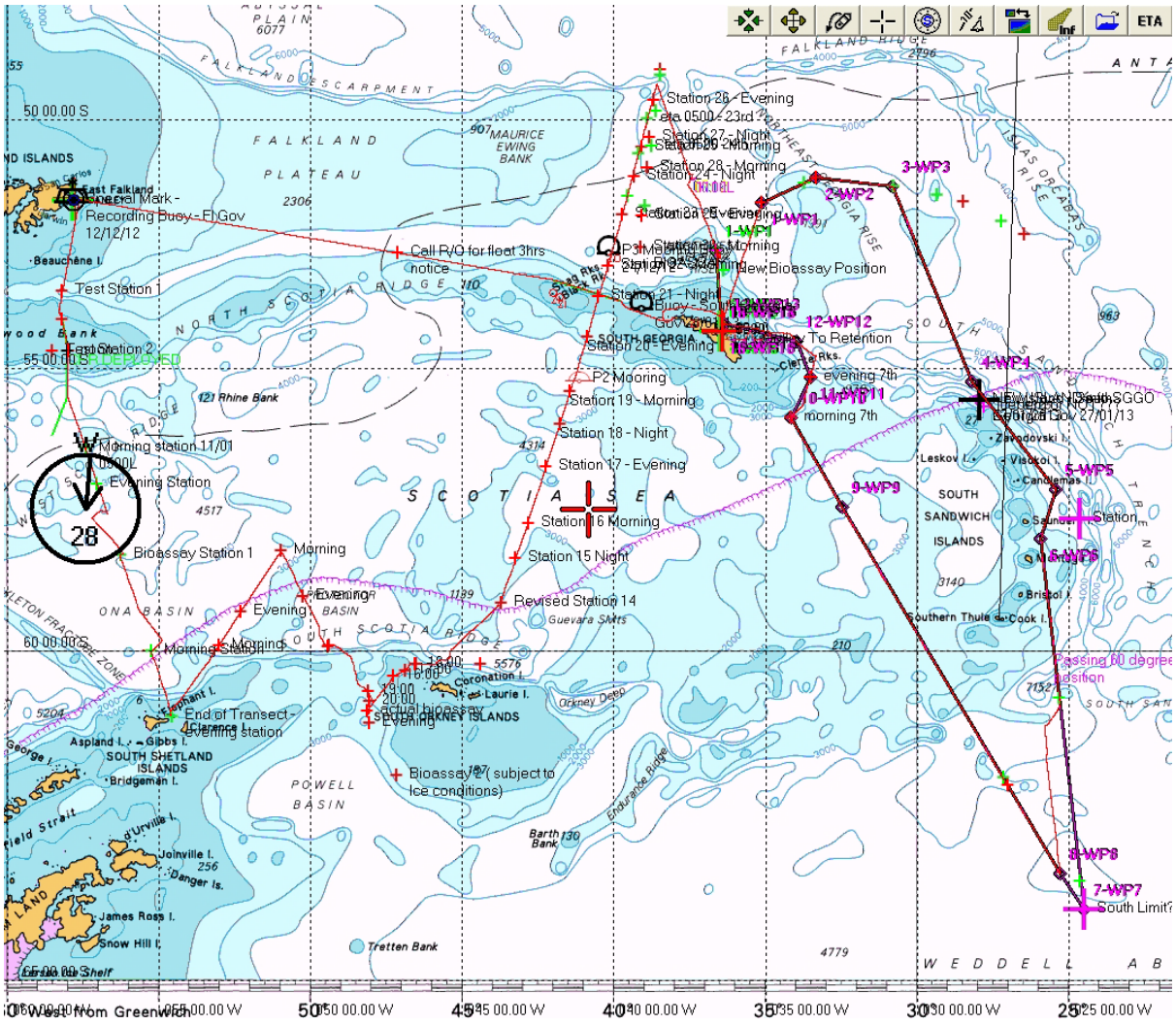
JR274 Sea Surface Ocean Acidification Consortium Cruise to the Southern Ocean

9th January to 12th February 2013



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JR274 science party, 9th Jan 2013

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Ian RAPER	Bosun's mate
George DALE	SG1A
David PHILLIPS	SG1A
Franky HERNANDEZ	SG1A
Carl BROCKWELL	SG1A
David GIBSON	SG1A
Gareth WALE	MG1
Glyn HENRY	MG1
Ashley HUNTLEY	Chief Cook
Jamie LEE	2nd Cook
Lee JONES	Sr Steward
Nick GREENWOOD	Steward
Graham (Riff) RAWORT	Steward
Carl PIPER	Steward
Hazel WOODLAND	Doctor (1st leg)
John SCHUTZER-MEISSMAN	Doctor (2nd leg)

JR274 Objectives

- To cover the regularly sampled Drake Passage (recent cruise found surface Ωaragonite from 1.25 to >2)
- To enter the exceptionally cold Weddell Sea where undersaturation is predicted to occur first in the Southern Ocean
- To transect strong gradients in ΩCaCO3 along multiple N-S transects at different longitudes, in ice edge regions and on moving into high productivity (raising pH and ΩCaCO3 but not SST) waters NW of S Georgia.
- To traverse previous BAS transects allowing repeat observations (incl. carbonate system) particularly upwelling regions where surface Ωaragonite ~ 1.

Attainment of JR274 Objectives

- To cover the regularly sampled Drake Passage (recent cruise found surface Ωaragonite from 1.25 to >2)

This was the first of the objectives to be tackled. The Drake's Passage transect was commenced on 11/1 with the first sampling station performed at 60.00°S 55.24°W. This did not include the clean sampling of water for trace metals since the sampling bottles still required a further preanalysis deployment to make them sufficiently clean. Ship's speed was reduced during passage along this transect to allow sufficient spatial resolution of sampling stations at a temporal frequency of 2 stations per day.

It was planned to set up Bioassay 1 on 12/1, but this was postponed due to high winds. Conditions abated by 13/1 and a successful set up was carried out. It was envisaged that the station would occupy a region of low productivity given its remoteness from any local source of iron. However, relatively high levels of phytoplankton biomass were encountered, suggesting that the station was positioned within a productive eddy system. Interestingly, net and bottle samples also showed evidence of volcanic ash in the water column.

A total of 5 sampling stations were ultimately carried out along the Drake's Passage transect, 3 morning station with a full suite of sampling activities (Stainless steel CTD, Bongo nets, Snow Catcher SAPS, Go Flo bottles), and 2 evening stations where activities were limited to a 300 m stainless steel CTD and a Bongo net.

The transect was completed on 14/1 at Elephant Island. There was brash-ice at the southern end of this transect.

- To transect strong gradients in ΩCaCO3 along multiple N-S transects at different longitudes, in ice edge regions and on moving into high productivity (raising pH and ΩCaCO3 but not SST) waters NW of S Georgia.

At the end of the Drake's Passage transect, we headed on a north-easterly transect. The southern regions of this transect contained some brash ice but this soon dissipated as we travelled northwards. It was intended that the location of Bioassay 2 was to be close to an ice edge. This meant that transecting speed was curtailed to ~ 6 knots during the northerly passage to avoid becoming too remote from an ice-edge on the return transect. We reached the apex of the NE transect on 16/1 at 58.28° 50.95°W, after which we headed SE. Remoteness from the ice-edge turned out not to be an issue since ice edges were already encountered by 17/1, 24 h before the intended start day of Bioassay 2. Indeed, our progress south was curtailed by pack-ice necessitating the positioning of Bioassay 2 at 60.97°S 48.13°W, which was 1° further north than originally planned.

After successfully setting up Bioassay 2, we headed northwards, to the west of the South Orkneys and then NE to join the Discovery 2010 transect. 2/10 to 5/10 pack ice was experienced during much of this passage. The Continuous Plankton Recorder (CPR) and clean-water tow-fish were not deployed during the majority of this passage.

- To traverse previous BAS transects allowing repeat observations (incl. carbonate system) particularly upwelling regions where surface Ωaragonite ~ 1.

The spatial coverage of pack-ice was further north than the seasonal average making it impossible to join the DISCOVERY2010 transect at its origin at 62.3°S 43.2°W, but 3° further north at 59.2°S 43.8°W.

Our sampling strategy was to run along this transect at between 8 to 10 knots, with a morning station comprising a full range of sampling activities, an evening station where there was a stainless steel CTD and a Bongo net deployment and a further midnight station involving only a stainless steel

CTD deployment. The location of the morning stations on 21/1 and 22/2 were such that they were in close proximity to the location of the BAS moorings P2 and P3, to the SW and NW of South Georgia. We found the DISCOVERY 2010 transect to run through 3 major biotic zones, an ice-edge influenced region to the south, an oligotrophic region midway and a region of high phytoplankton biomass towards the north. The southern part of this high biomass region was found to be dominated by *Eucampia* while, to the north, *Phaeocystis* was more common.

We followed the trajectory of the transect (heading of 17°) to well beyond the Polar Front, reaching the apex on 23/1. From there, we assessed a suitable direction south in order to place Bioassay 3 in a region where the South Georgia bloom was still in a healthy growth phase as opposed to a senescent phase (as was believed to be the case in the stations sample along the DISCOVERY2010 transect). We chose a position that was to the eastern edge of the bloom as estimated from present and historical ocean colour satellite images. This resulted in us following a heading of 160° for 2 days. During this transect, we carried out additional deployments of the Titanium CTDs to obtain water down to 1400m, principally to look at TA and DIC in deeper layers to identify any regions of upwelling (NB. the midnight stations were no longer carried out after reaching the apex of the DISCOVERY 2010 transect).

The location chosen for Bioassay 3 (52.7°S 36.6°W) actually contained lower than expected levels of phytoplankton biomass, and appeared to be in a region of reduced iron, probably from an incursion of water from the SW that had yet to be fertilised by iron from South Georgia.

Once the Bioassay setup had been completed, we steamed into King Edward Point (KEP) base for a mid cruise break.

As we left KEP on 27/1 we carried out a morning station within Cumberland Bay, a site we found to be devoid of phytoplankton but containing high abundances of *Limacina* pteropods. Our strategy was to follow the South Georgia bloom as it streamed eastwards away from South Georgia, mainly

between the SACCF and Polar Front. We followed this trajectory for a further two days before terminating our easterly course at 51.39°S 30.81°W.

- To enter the exceptionally cold Weddell Sea where undersaturation is predicted to occur first in the Southern Ocean

After performing a full depth CTD alongside standard sampling activities, we started to head south in the direction of the South Sandwich Islands on 29/1. The ship steamed at an average of 10 knots, stopping for morning and evening stations each day. We reached the northernmost South Sandwich Islands on 31/1. Our strategy for the location of Bioassay 4 was to be in a medium to high phytoplankton region, to contrast with Bioassay 3. Satellite images showed that much of the area to the east (downstream) of the islands contained relatively high biomass. We chose a region where biomass levels were below the maximum levels observed and where physiological indicators (Fv/Fm) suggested that the phytoplankton community was still in a healthy state. There was much small scale heterogeneity in species composition at the chosen site (58.09°S 25.93°W) and this was reflected in a large variance in phytoplankton levels in the 4 sequential CTD casts for bioassay water.

Once Bioassay 4 had been set up successfully, we continued to head south into the Weddell Sea. The apex of the southwards transect was reached on 3/2 at 63.47°S 25.30°W, it being the most southward point that could be reached in order to return to South Georgia in time for our scheduled rendez-vous at KEP of 8th February. A full depth CTD was carried in addition to standard sampling activities at the most southerly point.

The return northwards leg took us on a bearing of 330°, which followed a path that was upstream of the South Sandwich Islands, where phytoplankton biomass was generally low. A further 3 full depth CTDs in addition to standard sampling activities were carried out on this northward leg. Bad weather

reduced the resolution of stations towards the latter half of the northwards transect, just prior to reaching South Georgia.

We reached KEP on morning of 8th February.

The final transect travelled E to W, from the tip of South Georgia to Bird Island, which commenced on morning of 9th February. There were no sampling stations, but underway measurements were taken every 2 hours (as for the rest of the cruise) and the CPR was deployed for the duration of the transect.

The ship arrived in Port Stanley on morning of 12th February

Overview of Bioassays

The original schedule was designed around carrying out 5 x 4 day bioassays over the course of the cruise. However, this was altered to carrying out 4 bioassays of longer duration after our experience in Bioassay 1 showed that the response to treatments may be slowed by the cold ambient temperatures. Treatments were to be multifactorial in that incubations would be subjected to a combination of iron addition and pCO2 manipulation – with a rationale to show that the experimental setup was capable of resolving responses (ie. to iron addition) to place a context around the responses to pCO2 manipulation. Having shown an iron response in Bioassay 2, the treatments in the subsequent bioassays focussed on pCO2 manipulation only, although further iron addition controls were also carried out. Further deep casts were also incubated in each bioassay principally to reveal any changes to N_20 production rates (these were manipulated as for cruise JR271 – pCO2 at ambient, 500, 750 and 1000 ppm).

Bioassay	Location	Total Duration	Treatments
1 13/1/13	58.37°S 56.25°W (Mid Drake's Passage)	4 days	1)Iron + 750 ppm 2) Iron + ambient 3) No iron + ambient 4) No iron + 750 ppm + deep casts
2 18/1/13	60.97°S 48.13°W (Ice-edge SW of South Orkneys)	6 days	1)Iron + 750 ppm 2) Iron + ambient 3) No iron + ambient 4) No iron + 750 ppm + deep casts
3 25/1/13	52.69°S 36.63°W (North of South Georgia)	6 days	1)Ambient 2) 750 ppm 3) 1000 ppm 4) 2000 ppm + deep casts + additional iron controls
4 1/2/13	58.08°S 25.93°W (East of S. Sandwich Islands)	7 days	1)Ambient 2) 750 ppm 3) 1000 ppm 4) 2000 ppm + deep casts + additional iron controls

Table 1: Bioassays implemented during JR274

Summary of station deployments

The general pattern of sampling during the cruise was to carry out 2 main sampling efforts per day. During the morning (5am onwards), all major sampling devices would be deployed over a period of 4 to 7 hours. During the evening (5pm onwards), a 1 hour station would take place involving just the stainless steel CTD and a single Bongo net.

This pattern was altered during the 4 bioassay setup days, where sampling would commence at around 2am, with the consecutive deployment of 4 titanium CTDs into the surface mixed layer. Normal station sampling activities commenced after this setup had been completed (~7 am).

The general order of sampling events was relatively standard (see below). All deployments were performed from the starboard winch with the exception of the snow catcher (port aft), the CPR (aft) and the tow fish (starboard aft)

1) Bongo nets (3 consecutive nets sampled to a depth of 200 m)
2) Stainless steel CTD to 300 m
3) Snow catcher 1 (depth generally below the mixed layer, as determined by the preceding CTD cast. Deployed on the port aft using a combination of the Gilson winch and port-aft crane)
4) Go-flos to 1400 m
5) SAPS to ~60 to 80 m combined with snow catcher 2

SAPS would mainly occur every second day, with the exception of the DISCOVERY 2010 transect, where they were deployed every day. Up to 22/1, the snow catcher would be the only event to follow the Go Flos on days where the SAPS were not deployed. From 23/1 onwards, a titanium CTD deployment would be made to either 1400 m or full depth as the last activity of the morning station.

During the DISCOVERY 2010 transect, an additional stainless steel CTD deployment was made at midnight to 300 m (20-23/1).

CPR deployments were made between every station, with the exception of areas where there was too much brash ice. Also, the CPR was not deployed during evening and nighttime during the DISCOVERY 2010 transect, since the midnight station made the deployment distance too short.

The tow-fish was always deployed unless sea-iceconditions were unfavourable or repairs had to be made to the hosing.

Underway sampling from the non-toxic seawater supply continued throughout the cruise, with a resolution that varied between 1 h and 3 h.

Deployment statistics

Go Flo	**25 deployments**
Bongo nets	91 deployments
CTD	78 deployments in total SS CTD 47 deployments Ti CTD 31 deployments – 8 to 1400 m, 5 to full depth, 16 for bioassay setup, 2 for cleaning
Snow catcher	48 deployments
SAPS	14 deployments

Table 2: Deployments of different instrumentation deployed during JR274

48 h were lost to bad weather; 5 hours were lost to ship's equipment failure (spooling issues with CTD winch)

09/01/2013	Depart Stanley
10/01/2013	Travel south + tests
11/01/2013	Travel south + tests
12/01/2013	Bad Weather day
13/01/2013	Bioassay 1
14/01/2013	Bioassay 1
15/01/2013	Bioassay 1
16/01/2013	Bioassay 1
17/01/2013	Washup/turnaround
18/01/2013	Bioassay 2
19/01/2013	Bioassay 2
20/01/2013	Bioassay 2
21/01/2013	Bioassay 2
22/01/2013	Bioassay 2
23/01/2013	Bioassay 2
24/01/2013	Washup/turnaround
25/01/2013	Bioassay 3
26/01/2013	Bioassay 3 + KEP (Doctor PAX exchange)
27/01/2013	Bioassay 3 + KEP (leave early AM)
28/01/2013	Bioassay 3
29/01/2013	Bioassay 3
30/01/2013	Bioassay 3
31/01/2013	Washup/turnaround
01/02/2013	Bioassay 4
02/02/2013	Bioassay 4
03/02/2013	Bioassay 4
04/02/2013	Bioassay 4
05/02/2013	Bioassay 4
06/02/2013	Bioassay 4
07/02/2013	Bioassay 5
08/02/2013	Take down and KEP PAX uplift
09/02/2013	Bird Island PAX uplift
10/02/2013	Passage
11/02/2013	Passage
12/02/2013	Arrive Stanley
13/02/2013	DEMOB
14/02/2013	DEMOB
15/02/2013	Depart ship - 5AM

Table 3: Implemented schedule of bioassays in relation to the JR274 cruise itinerary

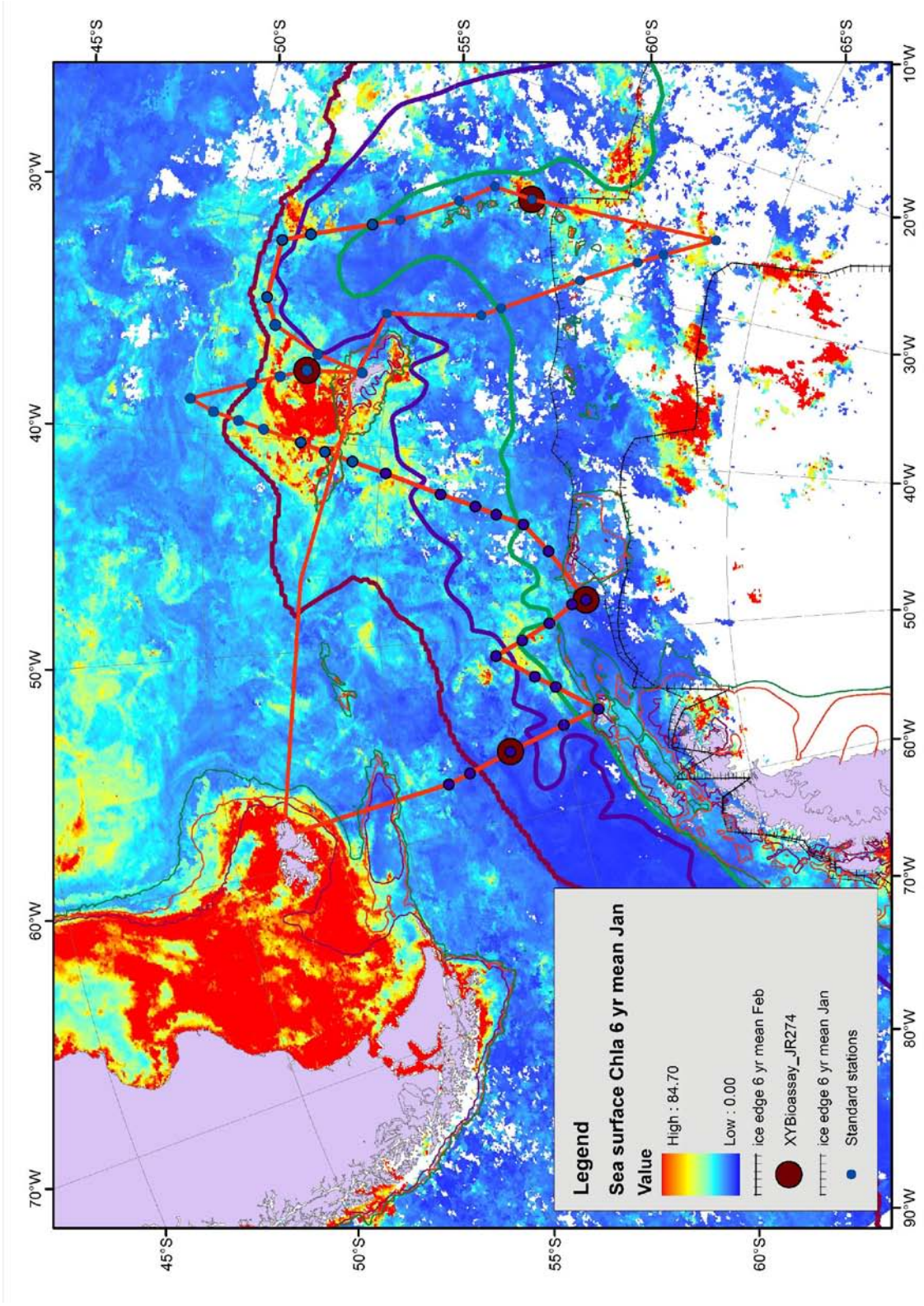


Figure 1: Cruise path of JR274 showing standard sampling station (blue) and Bioassay setup stations (blue with red surround) and with climatological sea-surface Chl-a and ice-edges for the cruise period

NMF-SS Sensors & Moorings Cruise Report

Cruise: JR274

PSO: Dr. G. Tarling

8 January – 12 February 2013

CTD system configuration

1) Two CTD systems were prepared; the first water sampling arrangement was a NOC 24-way stainless steel frame system, (s/n SBE CTD6) and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-30856-0707

Sea-Bird 3P temperature sensor, s/n 03P-5623, Frequency 0 (primary)

Sea-Bird 4C conductivity sensor, s/n 04C-4126, Frequency 1 (primary)

Digiquartz temperature compensated pressure sensor, s/n 89973, Frequency 2

Sea-Bird 3P temperature sensor, s/n 03P-5645, Frequency 3 (secondary)

Sea-Bird 4C conductivity sensor, s/n 04C-4087, Frequency 4 (secondary)

Sea-Bird 5T submersible pump, s/n 05T-4709, (primary)

Sea-Bird 5T submersible pump, s/n 05T-4488, (secondary)

Sea-Bird 32 Carousel 24 position pylon, s/n 32-46833-0636

Sea-Bird 11plus deck unit, s/n 11P-20397-0502

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

Sea-Bird 43 dissolved oxygen sensor, s/n 43-2290 (V4)

Tritech PA200 altimeter, s/n 244739 (V3)

Biospherical PAR irradiance sensor, DWIRR, s/n 70441 (V2)

WETLabs C-Star 25cm path transmissometer, s/n CST-527DR (V0)

Chelsea MKIII Aquatracka fluorometer, s/n 12-8513-003 (V1)

3) Additional instruments:

Ocean Test Equipment 20L ES-120B water samplers, s/n's 1A -12A, 15A-21A, 24A, 26A, 34A, 45A, 47A

TRDI WorkHorse 300kHz LADCP, s/n 14443 (downward-looking)

BAS WorkHorse LADCP battery pack

Chelsea FRRF MKI, s/n 05-5335-001

4) Sea-Bird 9*plus* configuration file JR274_stainless.xmlcon was used for all stainless steel frame CTD casts. The LADCP command file used for all casts was SingleLADCP_script.

5) The second water sampling arrangement was a NOC 24-way titanium frame system, (s/n SBE CTD TITA1), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-39607-0803

Sea-Bird 3P temperature sensor, s/n 03P-4381, Frequency 0 (primary)

Sea-Bird 4C conductivity sensor, s/n 04C-2165, Frequency 1 (primary)

Digiquartz temperature compensated pressure sensor, s/n 93896, Frequency 2

Sea-Bird 3P temperature sensor, s/n 03P-4593, Frequency 3 (secondary)

Sea-Bird 4C conductivity sensor, s/n 04C-3272, Frequency 4 (secondary)

Sea-Bird 5T submersible pump, s/n 05T-5247, (primary)

Sea-Bird 5T submersible pump, s/n 05T-6320, (secondary)

Sea-Bird 32 Carousel 24 position pylon, s/n 32-24680-0346

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

Sea-Bird 43 dissolved oxygen sensor, s/n 43-1624 (V0)

Chelsea MKIII Aquatracka fluorometer, s/n 88-2615-126 (V5)

Chelsea MKII 25cm path Alphatracka transmissometer, s/n 161047 (V4)

Tritech PA200 altimeter, s/n 6196.118171 (V7)

CTG 2pi PAR irradiance sensor, DWIRR, s/n PAR 03 (V2)

WETLabs light scattering sensor, s/n BBRTD-169 (V6)

7) Additional instruments:

Ocean Test Equipment 10L ES-110B trace metal-free water samplers, s/n's 1T through 24T

TRDI WorkHorse 300kHz LADCP, s/n 13400 (downward-looking)

NOC WorkHorse LADCP battery pack, s/n WH006T

8) Sea-Bird 9*plus* configuration file JR274_titanium.xmlcon was used for all titanium frame CTD casts. The LADCP command file used for all casts was SingleLADCP_script.

Other instruments

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

Guildline Autosal 8400B, s/n 65763, installed in Chemistry Laboratory as the primary instrument, Autosal set point 24C. Samples were processed according to non-WOCE cruise guidelines: The salinometer was standardized at the beginning of the first set of samples, and checked with an additional standard analysed prior to setting the RS. Once standardized the Autosal was not adjusted for the duration of sampling. Additional standards were analysed every 24 samples to monitor & record drift. These were labeled sequentially, beginning with number 999. Standard deviation set to 0.00005

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

Chelsea MKI, s/n 05-5335-001---Configured for CTD sampling, Protocol 1. The PAR sensor was replaced with the PAR sensor from s/n 182042.

3) Stand Alone Pump System---SAPS were deployed on the core wire, serial numbers as follows:

03-02, 03-04, 03-05 and 03-06---Serial numbers 03-04, 03-05 & 03-06 were deployed for 16 casts to a maximum depth of 185m. Pump delays were typically 30 minutes, with pump times set for 0.5 to 1.5 hours.

4) OTE 10L C-Free Water Samplers---Up to 12 samplers were deployed for the profiles, on a single wire, to a depth of up to 1400 metres. All serial numbers, with the exception of s/n 13, were used for the casts. They were clamped to a plastic coated 6mm diameter wire, and opened/closed with plastic coated metallic messengers.

Appendix A: Technical detail report

S/S CTD

No surface soak cast 009s & 010s, 028s, 047s, 076s because of rough weather (CTD deployed to 10m, and once pumps on, then on down to depth.)

Ti CTD

No surface soak casts 005t through 008t, 048t, 077t because of rough weather (CTD deployed to 10m, and once pumps on, then on down to depth.)

PAR sensor removed for all casts deeper than 500 metres.

Water sampler position 21 did not release on casts 040t & 042t. Upon inspection of the latch assembly it was discovered the solenoid/magnet assembly was corroded and distended, thereby inhibiting the release of the latch. Several other sampler positions were observed to have similar lesser corrosion; the SBE Carousel was replaced with s/n 32-34173-0493 after cast 045t.

Transmissometer noisy/spiking/shift on casts 037t, 039t, 045t & 048t, beginning at varying depths on downcast (~220m to 660m). Cleaned connectors, replaced two cables, checked lenses on respective casts, but problem did resolve itself until after 600m down on cast 048t.

Small shift from ~1000 to 1100m downcast during cast 075t.

Power surge during cast 072t at ~4100m on downcast: modulo error, data error, loss of pump operation, spike in all channels. All sensors subsequently resumed operation, with no obvious after effect, with the exception of dissolved oxygen. The SBE 43 sensor had a large positive value shift, and whilst the value slowly returned to appropriate levels, the sensor response suffered residual aftereffects until reaching ~300m on the upcast.

LADCP

No problems with either instrument deployed.

No log file for deployment JR274_012m.

LADCP battery on both frames charged and vented at end of cruise.

Total number of casts - 47 S/S frame, 31 Ti frame.

Casts deeper than 2000m - 0 S/S frame, 5 Ti frame.

Deepest casts -305m S/S frame, 4888m Ti frame.

Autosal

A heater lamp and the peristaltic pump required replacement at beginning of cruise.

FRRF

No data recorded for casts 022s & 023s, as battery voltage too low. Battery pack removed, connections checked: no internal moisture, no problems found, pack re-charged successfully on bench, re-installed on frame.

The PAR sensor (s/n 05-4788-05) was damaged upon CTD recovery during cast 053s (impact with overhead in CTD hanger), and was replaced with s/n 46060 for cast 056s onwards. No corresponding PAR data for cast 055s.

SAPS

Serial number 03-04 did not pump on cast 1, leaving 1 hour 30 minutes on the timer. The timer board was not fully connected for the deployment, and as a result the unit switched off. On the second cast, 03-04 only pumped for 12 minutes, and therefore was replaced for the next cast with 03-06. Filters used were two 293mm diameter filters, one 53 micron and one 1 micron. Trickle-charging both SAPS after each profile.

10L C-Free samplers

C-Free sampler s/n 05: Did not seal properly on bottom ball, deployment 1.

C-Free sampler s/n 15: Did not seal properly on top or bottom ball, deployment 1.

C-Free sampler s/n 17: Did not seal properly on bottom ball, deployment 1.

(All floating seals adjusted for appropriate tension.)

C-Free sampler s/n 15: Did not seal properly on bottom ball, deployment 2.

C-Free sampler s/n 18: Did not seal properly on bottom ball, deployment 2.

(All floating seals adjusted for appropriate tension.)

C-Free sampler s/n 15: Did not seal properly on bottom ball, deployment 3.

(Floating seal adjusted for appropriate tension.)

C-Free sampler s/n 12: Did not seal properly on bottom ball, deployment 7.

(Floating seal adjusted for appropriate tension.)

C-Free sampler s/n 14: Damaged beyond repair from impact with deck in container laboratory.

Appendix B: Configuration, protocol & command files

Stainless CTD frame:

Date: 01/12/2013

Instrument configuration file: D:\data\JR274\JR274_stainless.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0

Voltage words suppressed : 0

Computer interface : RS-232C

Deck unit : SBE11plus Firmware Version >= 5.0

Scans to average : 1

NMEA position data added : Yes

NMEA depth data added : No

NMEA time added : No

NMEA device connected to : PC

Surface PAR voltage added : No

Scan time added : No

1) Frequency 0, Temperature

Serial number : 03P-5623

Calibrated on : 13 April 2012

G : 4.33512720e-003

H : 6.27614049e-004

I : 1.98087267e-005

J : 1.51407011e-006

F0 : 1000.000

Slope : 1.00000000

Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-4126

Calibrated on : 12 April 2012

G : -9.94279356e+000

H : 1.24324961e+000

I : -2.27836797e-003

J : 2.19477346e-004

CTcor : 3.2500e-006

CPcor : -9.57000000e-008

Slope : 1.00000000

Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 89973

Calibrated on : 22 August 2012

C1 : -4.925971e+004

C2 : -2.136250e-001

C3 : 9.435710e-003

D1 : 3.900400e-002

D2 : 0.000000e+000

T1 : 2.983458e+001

T2 : -3.883229e-004

T3 : 3.262440e-006

T4 : 3.429810e-009

T5 : 0.000000e+000

Slope : 1.00010000

Offset : -1.27140

AD590M : 1.277500e-002

AD590B : -9.391460e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-5645

Calibrated on : 12 April 2012

G : 4.35334476e-003

H : 6.30144469e-004

I : 2.00303701e-005

J : 1.51938536e-006

F0 : 1000.000

Slope : 1.00000000

Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-4087

Calibrated on : 12 April 2012

G : -9.96036279e+000

H : 1.23524413e+000

I : -2.45620460e-003

J : 2.30694549e-004

CTcor : 3.2500e-006

CPcor : -9.57000000e-008

Slope : 1.00000000

Offset : 0.00000

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

Serial number : CST-527DR

Calibrated on : 6 September 2012

M : 21.7865

B : -1.2854

Path length : 0.250

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

Serial number : 12-8513-003

Calibrated on : 15 June 2012

VB : 0.207900

V1 : 2.140600

Vacetone : 0.317500

Scale factor : 1.000000

Slope : 1.000000

Offset : 0.000000

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

Serial number : 70441

Calibrated on : 16 May 2012

M : 1.00000000

B : 0.00000000

Calibration constant : 18315018320.00000000

Multiplier : 1.00000000

Offset : -0.05521952

9) A/D voltage 3, Altimeter

Serial number : 244739

Calibrated on : 9 May 2012

Scale factor : 15.000

Offset : 0.000

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

Serial number : 43-2290

Calibrated on : 31 March 2012

Equation : Sea-Bird

Soc : 3.97900e-001

Offset : -4.91300e-001

A : -2.09220e-003

B : 1.03780e-004

C : -1.69350e-006

E : 3.60000e-002

Tau20 : 1.57000e+000

D1 : 1.92634e-004

D2 : -4.64803e-002

H1 : -3.30000e-002

H2 : 5.00000e+003

H3 : 1.45000e+003

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free

Scan length : 37

Titanium CTD frame:

Date: 01/12/2013

Instrument configuration file: D:\data\JR274\JR274_titanium.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0

Voltage words suppressed : 0

Computer interface : RS-232C

Deck unit : SBE11plus Firmware Version >= 5.0

Scans to average : 1

NMEA position data added : Yes

NMEA depth data added : No

NMEA time added : No

NMEA device connected to : PC

Surface PAR voltage added : No

Scan time added : No

1) Frequency 0, Temperature

Serial number : 03P-4381

Calibrated on : 4 September 2012

G : 4.42360619e-003

H : 6.44955185e-004

I : 2.26928472e-005

J : 1.98091807e-006

F0 : 1000.000

Slope : 1.00000000

Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-2165

Calibrated on : 21 August 2012

G : -9.76498119e+000

H : 1.34284247e+000

I : -2.28914582e-003

J : 2.22101431e-004

CTcor : 3.2500e-006

CPcor : -9.57000000e-008

Slope : 1.00000000

Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 93896

Calibrated on : 12 May 2011

C1 : -8.331332e+004

C2 : -3.281962e-001

C3 : 2.216060e-002

D1 : 2.906000e-002

D2 : 0.000000e+000

T1 : 3.005232e+001

T2 : -3.843669e-004

T3 : 4.436390e-006

T4 : 0.000000e+000

T5 : 0.000000e+000

Slope : 0.99996000

Offset : -1.07670

AD590M : 1.289250e-002

AD590B : -8.106440e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-4593

Calibrated on : 1 August 2012

G : 4.35422569e-003

H : 6.44931903e-004

I : 2.20272409e-005

J : 1.81585814e-006

F0 : 1000.000

Slope : 1.00000000

Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-3272

Calibrated on : 4 September 2012

G : -9.77438225e+000

H : 1.27258249e+000

I : -1.50093790e-005

J : 6.22016902e-005

CTcor : 3.2500e-006

CPcor : -9.57000000e-008

Slope : 1.00000000

Offset : 0.00000

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

Serial number : 43-1624

Calibrated on : 3 March 2013

Equation : Sea-Bird

Soc : 5.21000e-001

Offset : -5.06400e-001

A : -3.09530e-003

B : 1.65680e-004

C : -2.10680e-006

E : 3.60000e-002

Tau20 : 1.75000e+000

D1 : 1.92634e-004

D2 : -4.64803e-002

H1 : -3.30000e-002

H2 : 5.00000e+003

H3 : 1.45000e+003

7) A/D voltage 1, Free

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

Serial number : PAR 03

Calibrated on : 14 June 2011

M : 0.43801500

B : 2.32952800

Calibration constant : 100000000000.00000000

Multiplier : 0.99990000

Offset : 0.00000000

9) A/D voltage 3, Free

10) A/D voltage 4, Transmissometer, Chelsea/Seatech

Serial number : 161047

Calibrated on : 18 March 2008

M : 23.9551

B : -0.4767

Path length : 0.250

11) A/D voltage 5, Fluorometer, Chelsea Aqua 3

Serial number : 88-2615-126

Calibrated on : 4 May 2012

VB : 0.316800

V1 : 2.173800

Vacetone : 0.370300

Scale factor : 1.000000

Slope : 1.000000

Offset : 0.000000

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

Serial number : BBRTD-169

Calibrated on : 14 April 2010

ScaleFactor : 0.003110

Dark output : 0.111200

13) A/D voltage 7, Altimeter

Serial number : 6196.118171

Calibrated on : 15 November 2006

Scale factor : 15.000

Offset : 0.000

Scan length : 37

LADCP command file:

;

$P **********

$P ******* LADCP Deployment with one ADCP. Usually looking down **********

$P **********

; Send ADCP a BREAK

$B

; Wait for command prompt (sent after each command)

$W62

;**Start**

; Display real time clock setting

```
tt?
$W62
; Set to factory defaults
CR1
$W62
; use WM15 for firmware 16.3
WM15
$W62
; Save settings as User defaults
CK
$W62
; Name data file
RN JR271
$W62
; Set transducer depth to zero
ED0000
$W62
; Set salinity to 35ppt
ES35
$W62
; Set system coordinate.
EX11111
$W62
; Set one ensemble/sec
TE00000100
$W62
; Set one second between pings
TP000100
$W62
```

; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good

LD111100000

$W62

; Set one ping per ensemble. Use WP if LADCP option is not enabled.

LP1

$W62

; Set to record 25 bins. Use WN if LADCP option is not enabled.

LN025

$W62

; Set bin size to 400 cm. Use WS if LADCP option is not enabled.

LS400

$W62

; Set blank to 176 cm (default value) Use WF if LADCP option is not enabled.

LF0176

$W62

; Set max radial (along the axis of the beam) water velocity to 176 cm/sec.

; Use WV if LADCP option is not enabled.

LV170

$W62

; Set ADCP to narrow bandwidth and extend range by 10%

LW1

$W62

; Set to use a fixed speed of the sound

EZ0111111

$W62

; Set speed of sound value. 1500 m/sec is default.

EC1500

$W62

; Heading alignment set to 0 degrees

EA00000

$W62

; Heading bias set to 0 degrees

EB00000

$W62

; Record data internally

CF11101

$W62

; Save set up

CK

$W62

; Start pinging

CS

; Delay 3 seconds

$D3

$p **

$P Please disconnect the ADCP from the computer.

$P **

; Close the log file

$l

FRRF boot protocol:

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

Fast Repetition Rate Fluorometer -  Ver 1.18
```

FPGA Version - Ver 0.1

Instrument ID - Ser 05-5335-001

Flashcard Size - 24 MB

AutoAcquire is ENABLED

Mon Jun 11 09:08:07 2012

System Battery Voltage = 14.49 V

System Current = 0.311 A

Electronics Temp = 4.15 Deg C

A: Set Date and Time

B: Boot protocol slot number - 1

C: AutoAcquire is ENABLED

D: REF Amplifier offset (counts)- 117

E: PMT Amplifier offset (counts)- 125

F: Reserved

G: Reserved

H: F0 analog output scale maximum - 1.000000

I: FM analog output scale maximum - 1.000000

J: PMT calibration threshhold is - 200 counts

K: Ref calibration threshhold is - 200 counts

L: Set PMT gain constants

M: Check PMT calibration

X: Reset to Safe values

Select option or '0' to return:

==========

Main Menu

==========

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

X. Shutdown

==========

Run Menu

==========

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

0. to Return:

*** Boot Protocol = 1 ***

6. 65535 Acquisitions
7. 16 Flash sequences per acquisition
8. 100 Saturation flashes per sequence
9. 4 Saturation flash duration (in instrument units)
A. 0 Saturation interflash delay (in instrument units)
B. DISABLED Relaxation flashes
C. 20 Relaxation flashes per sequence

D. 4 Relaxation flash duration (in instrument units)

E. 61 Relaxation interflash delay (in instrument units)

F. 30 ms Sleeptime between acquisition pairs

G. 1 PMT Gain in Normal Mode

H. DISABLED Analog Output

I. DISABLED Desktop (verbose) Mode

J. ACTIVE Light Chamber (A)

K. ACTIVE Dark Chamber (B)

L. ENABLED Logging mode to internal flashcard

M: 90 Upper Limit Autoranging Threshold value

N: 15 Lower Limit Autoranging Threshold value

J. Benson/I. Murdoch/T. Roberts

12 February 2013

Bioassay experiments set up

Sophie Richier / Mark Moore, *National Oceanography Centre Southampton*

On the present cruise, we were both coordinating the set up and logistics of the bioassay experiments designed to evaluate the short-term response to artificial carbonate system manipulation of multiple organisms and processes in the Southern ocean. In addition to changes in carbonate chemistry, iron was added to the incubation bottles in high nutrients low chlorophyll (HNLC) area along the cruise track. Conditions in the 4 main bioassays performed during the cruise are presented in Table 1.

Exp.	Condition 1	Condition 2	Condition 3	Condition 4
E01	Ambient	Fe (2 nM)	750 ppm	Fe (2 nM) + 750 ppm
E02	Ambient	Fe (2 nM)	750 ppm	Fe (2 nM) + 750 ppm
E03	Ambient	1000 ppm	750 ppm	2000 ppm
E04	Ambient	1000 ppm	750 ppm	2000 ppm

Table 1: Bioassay experiment conditions.

Bioassay experiments were set up in 4 different locations (Fig. 1). Initial environmental conditions and experiment duration at these stations are listed in Table 2.

Exp.	Lat. (S)	Long. (W)	CTD	Depth (m)	SST (°C)	Salinity	DIC (µmol.kg-1)	TA (µmol. kg-1)	Chla (µg.l^{-1})	Duration (days)
E01	58 22.00	56 15.116	5	33	1.94	33.91	2129.0	2294.8	2.37	4
			6	32.4	1.94	33.92	2131.0	2298.7	2.24	
			7	32.8	1.94	33.92	2129.0	2295.7	2.32	
E02	40 58.549	48 05.186	18	19	-1.44	33.59	2145.3	2281.5	0.61	6
			19	26.2	-1.43	33.58	2145.0	-	0.50	
			20	21.2	-1.46	33.58	2145.2	-	0.43	
E03	52 41.36	36 37.28	40	26	2.17	33.94	2155.1	2287.8	0.70	6
			41	26	2.2	33.94	2156.6	-	0.57	
			42	26	2.18	33.94	2145.3	-	0.61	
E04	58 05.13	25 55.547	62	19	0.51	33.70	2125.8	2293.00	4.61	7
			63	20	0.46	33.71	-	-	4.02	
			64	21	0.42	33.71	-	-	3.93	

Table 2: Main bioassay initial conditions.

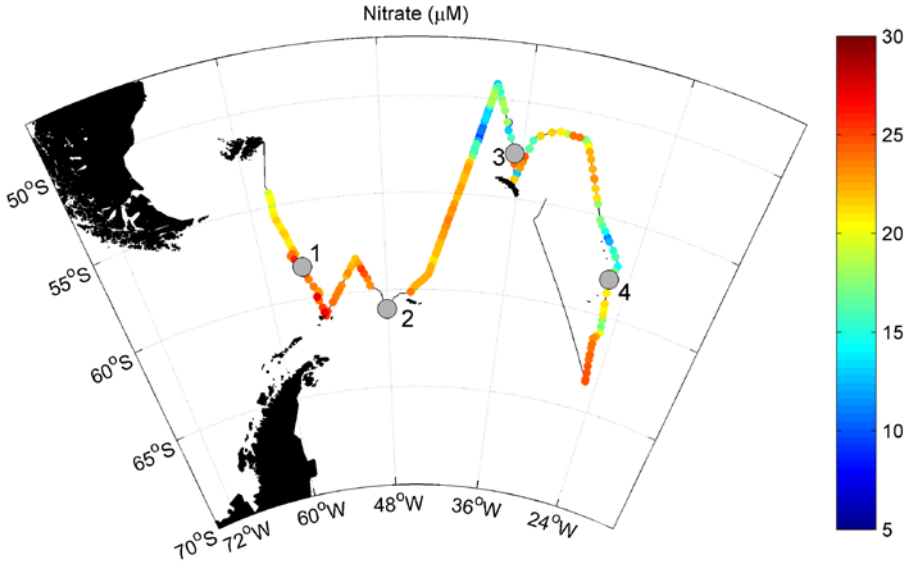


Figure 1: Map showing locations where bioassay experiments were set up. Locations of experiments (labeled 1-4) are shown superimposed on the cruise track (solid line) with surface nitrate concentrations indicated to provide some environmental context.

Methods

Surface seawater was collected from trace metal clean Niskin sampling bottles (24X10L) attached to the titanium framed CTD rosette. Four successive casts were required to provide enough water for the large number of final measurements. Once on deck the Niskin bottles were immediately transferred into a class-100 filtered air environment within a trace metal clean container to avoid contamination during the set up. Unfiltered water containing the unperturbed full site of microbial groups was dispensed into 4.5L polycarbonate incubation bottles using acid-cleaned silicon tubing and closed pending carbonate chemistry manipulation. The first 3 CTD casts were collected at the same nominal depth within the mixed layer. A further set of 1L bottles was filled off of the third CTD fired within the mixed layer. This water was subsequently amended with hand-picked copepods (~5-10 per bottle) (see zooplankton section for more details).

Water from deeper in the water column was also collected out of a fourth cast for each bioassay station in order to investigate nitrification processes (e.g. N_2O production). Depths and initial conditions for each deep bioassay are listed in Table 3.

Exp.	CTD	Depth (m)	SST (°C)	Salinity	DIC (µmol.kg-1)	TA (µmol. kg-1)
E01	008T	102	-0.11	34.03	2179.9	2299.8
E02	021T	56.4	-1.71	34.3	2180.49	2324.9
E03	043T	85	0.89	34.02	2184.81	2291
E04	065T	46	-1.2	34.1	2169.40	2288.00

Table 3: Deep bioassay set up and initial conditions

The coupled effect of added iron and high pCO_2 was tested (750 µatm + 2 nM Fe) during experiments 1 & 2, while during experiments 3 & 4 incubation bottles were individually manipulated to achieve 3 different target pCO_2 levels (750, 1000 and 2000 µatm) (see Table 1). The manipulation of the carbonate system was achieved through additions of $NaHCO_3^-$ + HCl (Borowitzka, 1981; Gattuso and Lavigne, 2009; Schulz et al., 2009) according to the initial carbonate chemistry of the seawater at the time of the water collection. Carbonate chemistry manipulation was immediately verified by total alkalinity (TA) and DIC analyses. Following manipulation of pCO_2/Fe, bottles were sealed with septum lids, parafilmed and incubated.

The incubation was performed within a purpose-built experimental laboratory container allowing precise temperature and light control. The temperature was adjusted to the *in situ* at the time of the water collection. The light was set up with a 18h/6h light/dark cycle at an irradiance of about 100 µE s-1 m-2. The experiments were run for 4 to 7 days including three collection time points: T0, T1 (2, 3 or 4 days) and T2 (4, 6 or 7 days). Each condition was run in triplicate bottles.

References

Borowitzka., 1981 Mar. Biol., 62 (1), 17-23

Gattuso, J.-P and Lavigne, H., 2009 Biogeosciences Discuss., 6, 4413-4439.

Schulk et al., 2009 Biogeosciences 6, 2145-2153.

Plankton filtration

Sophie Richier / Mark Moore / Toby Tyrrell, *University of Southampton, National Oceanography Centre, UK*

Aliquots of seawater were taken from the CTD and bioassay bottles for filtration and analyses of the following properties, which characterize biomass and/or physiology of the planktonic communities:

Total & size fractionated Chlorophyll a—

Bioassay - Aliquots of 100 mL were filtered onto 25mm Glass Fiber (GF/F) filters and onto 10µm pore size polycarbonate filters (to yield a total and >10µm size fraction, respectively and therefore by difference a <10 µm size fraction). All filters were extracted in 90% acetone for 24 h, and chlorophyll a was subsequently quantified on a Turner Designs Trilogy fluorometer. Final chlorophyll a concentrations were calibrated using dilutions of a solution of pure chlorophyll a (Sigma, UK) in 90% acetone and a solid fluorescence standard.

CTD–Aliquots of 100 mL from 6 depths were filtered onto 25mm Glass Fibre (GF/F) filters. In addition 100 mL was filtered from one depth (corresponding to the one chosen for size fractionated primary production measurements, see relevant section of cruise report) on 0.4, 2, 5, 10 and 20µm pore size polycarbonate filters. Sampled CTDs are listed in Table 4

CTD	#depths	CTD	#depths	CTD	#depths	CTD	#depths
2	6 / 1	26	6 / 1	46	6 / 1	66	6 / 1
4	6 / 1	27	6 / 1	47	6 / 1	68	6 / 1
9	6 / 1	28	6 / 1	48	6 / 1	69	6 / 1
10	6 / 1	29	6 / 1	51	6 / 1	71	6 / 1
11	6 / 1	31	6 / 1	53	6 / 1	73	6 / 1
12	6 / 1	32	6 / 1	55	6 / 1	76	6 / 1
13	6 / 1	34	6 / 1	56	6 / 1	78	6 / 1
14	6 / 1	35	6 / 1	58	6 / 1		
17	6 / 1	36	6 / 1	59	6 / 1		
24	6 / 1	44	6 / 1	61	6 / 1		

Table 4: List of CTDs sampled for chlorophyll a analysis. Numbers of depths sampled correspond to Total (GF/F) / Size fractionated.

Particulate organic carbon/nitrogen/phosphorous (POC/N/P)—

Bioassay–Aliquots of 500-750 mL of seawater from 12 bioassay bottles were filtered onto pre-ashed/washed 25 mm GF/F filters and oven dried (60ºC) for 8-12 hours; filters for POC/PON were pre-combusted at 400°C whilst those for POP were also acid soaked (and repeat milliQ rinsed). Samples were dry stored for later POC/N/P quantification at the University of Southampton. The date and volume filtered for POC/PON/POP from each bioassay are listed in Table 5.

Date	Exp.	CTD	Station	Time point	Incubation bottle	Depth (m)	VF
13.01.13	1	005T	3	0	T01	33	750
13.01.13	1	006T	3	0	T02	32.8	750
13.01.13	1	007T	3	0	T03	32.8	750
15.01.13	1	all	3	1	all	all	750
17.01.13	1	all	3	2	all	all	750
18.01.13	2	018T	12	0	T01	19	750
18.01.13	2	019T	12	0	T02	26.2	750
18.01.13	2	020T	12	0	T03	21.2	750
21.01.13	2	all	12	1	1	all	750
24.01.13	2	all	12	2	all	all	750
25.01.13	3	040T	29	0	T01	26	750
25.01.13	3	041T	29	0	T02	26	750
25.01.13	3	042T	29	0	T03	26	750
15.01.13	3	all	29	1	all	all	750
17.01.13	3	all	29	2	all	all	600
01.02.13	4	062T	40	0	T01	19	750
01.02.13	4	063T	40	0	T02	20	750
01.02.13	4	064T	40	0	T03	21	750
15.01.13	4	all	40	1	all	all	500
17.01.13	4	all	40	2	all	all	500

Table 5: Date and volume filtered for POC/PON/POP from each bioassay.

CTD–Aliquots of 400-1000 mL from 1 (evening CTD) to 3 (morning CTD) depths were filtered onto pre-ashed/cleaned 25 mm Whatman GF/F filters. The filters were treated and stored in

the same way described above.

The CTD, date and volume filtered for POC/PON/POP from each CTD are listed in Table 6.

Date	CTD	Station	Niskin bottle	Depth (m)	VF (ml)
11.01.13	2	1	22	5	1000
11.01.13	2	1	8	85	1000
11.01.13	2	1	14	35	1000
11.01.13	4	2	22	5	1000
13.01.13	9	3	8	80	1000
13.01.13	9	3	16	22	1000
13.01.13	9	3	22	5	1000
14.01.13	10	4	22	5	1000
14.01.13	10	4	16	20	1000
14.01.13	10	4	8	80	1000
14.01.13	11	5	24	5	1000
14.01.13	12	6	10	65	1000
14.01.13	12	6	18	10	1000
14.01.13	12	6	22	5	1000
15.01.13	13	7	22	5	1000
16.01.13	14	8	22	5	1000
16.01.13	14	8	16	20	1000
16.01.13	14	8	10	70	1000
16.01.13	15	9	24	5	726
17.01.13	16	10	20	5	1000
17.01.13	16	10	18	10	1000
17.01.13	16	10	12	30	1000
17.01.13	17	11	24	5	1000
18.01.13	22	12	10	55	1000
18.01.13	22	12	16	20	1000
18.01.13	22	12	22	5	1000
19.01.13	23	13	22	5	1000
19.01.13	23	13	18	15	1000
19.01.13	23	13	12	12	1000
19.01.13	24	14	24	5	1000
20.01.13	26	16	22	5	1000
20.01.13	26	16	18	15	1000
20.01.13	26	16	14	40	1000
20.01.13	27	17	24	5	1000
21.01.13	28	18	10	60	1000
21.01.13	28	18	18	20	1000
21.01.13	28	18	22	10	1000
21.01.13	29	19	24	5	1000

Table 6 (to be continued)**:** Date and volume filtered for POC/PON/POP from CTD.

Date	CTD	Station	Niskin bottle	Depth (m)	VF (ml)
22.01.13	31	22	22	5	500
22.01.13	31	22	18	10	500
22.01.13	31	22	8	75	1000
22.01.13	32	23	24	5	440
23.01.13	34	25	22	5	1000
23.01.13	34	25	18	25	1000
23.01.13	34	25	8	75	1000
23.01.13	35	26	24	5	1000
24.01.13	36	27	14	50	1000
24.01.13	36	27	18	15	750
24.01.13	36	27	22	5	750
24.01.13	38	28	24	5	1000
27.01.13	47	31	24	10	1000
28.01.13	48	32	10	75	1000
28.01.13	48	32	18	21	1000
28.01.13	48	32	22	10	1000
29.01.13	53	34	22	5	950
29.01.13	53	34	18	15	1000
29.01.13	53	34	8	75	1000
29.01.13	55	35	24	5	1000
30.01.13	56	36	22	5	1000
30.01.13	56	36	18	20	1000
30.01.13	56	36	12	50	1000
30.01.13	58	37	24	5	1000
31.01.13	59	38	11	50	400
31.01.13	59	38	16	20	400
31.01.13	59	38	22	5	400
31.01.13	61	39	24	5	1000
01.02.13	66	40	8	75	700
01.02.13	66	40	16	20	700
01.02.13	66	40	22	5	700
02.02.13	68	42	24	10	1000
03.02.13	69	43	24	5	1000
03.02.13	69	43	16	20	1000
03.02.13	69	43	8	65	1000
04.02.13	71	44	22	5	1000
04.02.13	71	44	18	15	1000
04.02.13	71	44	16	25	1000

Date	CTD	Station	Niskin bottle	Depth (m)	VF (ml)
04.02.13	71	44	8	70	1000
04.02.13	73	45	24	5	1000
05.02.13	74	46	10	50	750
05.02.13	74	46	18	10	750
05.02.13	74	46	22	5	750
06.02.13	76	48	22	10	1000
06.02.13	76	48	20	20	1000
06.02.13	76	48	10	70	1000

Table 6: Date and volume filtered for POC/PON/POP from CTD.

Cruise report JR274: Underway Sampling

Toby Tyrrell *(University of Southampton; t.tyrrell@southampton.ac.uk)* and Jeremy Young *(University College London; j.young@ucl.ac.uk)*

Underway samples were collected by: Eithne Tynan, Colin Brownlee, Mariana Ribas Ribas, Jeremy Young, Toby Tyrrell, Matthew Humphreys, Clement Georges, Richard Sanders and Jennifer Clarke.

Introduction

The underway (UW) supply (also known historically as the non-toxic supply because no anti-fouling chemicals are involved) is a pipe bringing the external seawater into the ship's science labs from an inlet in the hull at about 6m below the waterline. Samples from this source were therefore always taken from the surface mixed layer of the ocean and never from a variety of depths, unlike typical CTD stations where the sampling bottles are closed at a variety of depths. Scientists can in this way access the seawater through which the ship is passing without the ship needing to stop, i.e. while it is still underway. The seawater flowing out of the end of underway supply is identical to the seawater through which the ship is travelling, with two important exceptions: (a) very larger particles are prevented from entering the UW supply by screening using a large hole size mesh (Plate 1), (b) the water is pumped onboard using a Tangie centrifugal pump (Plate 2), with a working pressure of 4 bar and a flow rate of 7.2 cubic metres per hour.S uch pumps are relatively non-destructive. While it is possible that some organisms are affected by the pumping process, SEM microscopy from UW samples collected on cruise JR271 in June 2012 (on the same ship) found no evidence of effects on the coccolithophore assemblage.

Plate 1: Mesh that prevents larger particles from entering (and clogging up) the UW supply.

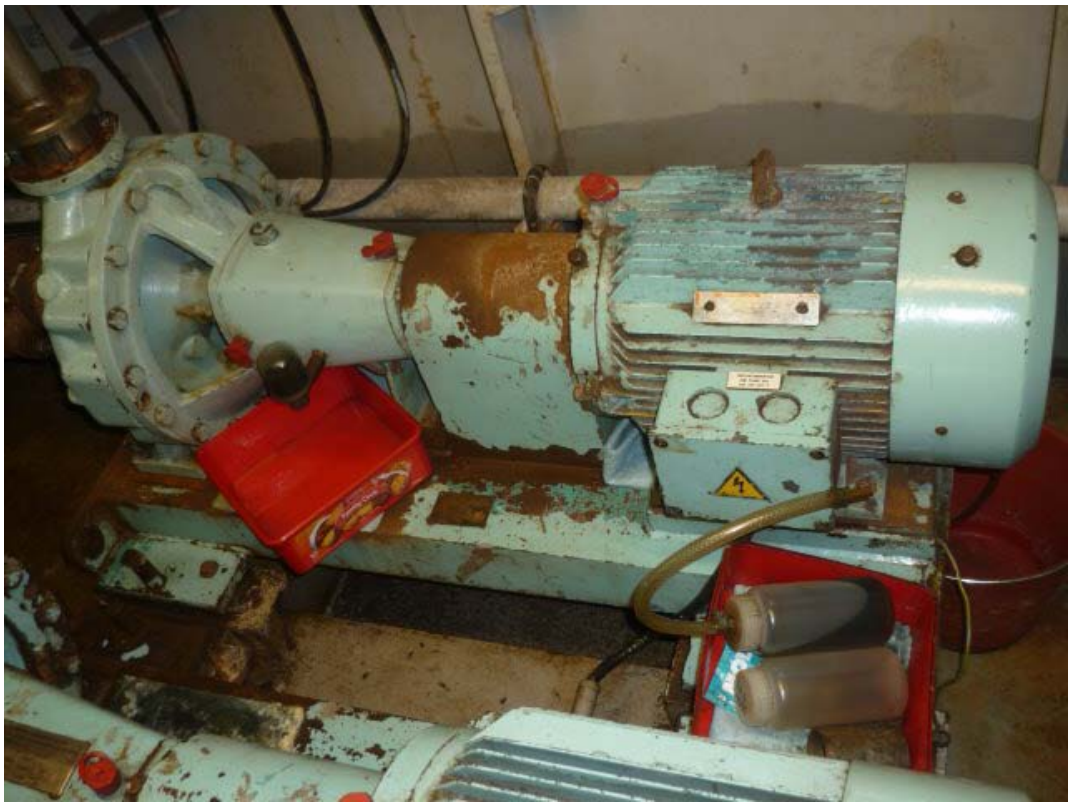


Plate 2: Tangie centrifugal pump used for the UW supply.

Objectives

A major objective of the consortium is to examine the natural variability in plankton, biogeochemical processes, climate-affecting processes and other aspects between naturally more acidic and naturally more alkaline environments. Assuming that the organisms living in such environments are evolutionarily adapted to them, then the understanding gained from this approach will help us understand impacts of OA with evolutionary adaptation factored in. We will use objective statistical techniques to analyse the degree and nature of correlations between different environmental variables (the independent or forcing variables) and various aspects that might be affected by them (the dependent or response variables).

To enhance the ability of the statistics to tease apart the different roles of different environmental factors (including carbonate chemistry) in driving place-to-place differences in biology/biogeochemistry, it is important that:

(1) data is collected from a large number of different locations.
(2) those locations differ in terms of the environmental conditions.

A wide variety of data was collected at the ~35 stainless steel CTD deployments from which water samples were collected and analysed. However, 35 points over thousands of nautical miles does not provide the degree of spatial coverage one would ideally wish for. In order to greatly increase the coverage and therefore the likely power of the statistics we also sampled from the underway supply at regular intervals in order to give a much larger dataset (nearly 300 sampling points in total, Table 1).

Although this was the main purpose of the underway sampling, the carbon isotope samples were collected with a different aim in mind: quantification of ocean uptake of anthropogenic CO_2.

Methods

Samples were collected manually from the underway supply in the prep lab (see Plate 3). The interval between sampling was two hours for most of the cruise, increased to once every hour for the long south-north transect from near the South Orkney Islands to north of South Georgia. Samples were collected throughout the day and night (24 hours a day). The underway supply was turned off when there was a lot of floating ice, and no samples could be collected at these times. Samples were not usually taken when the ship was not moving because on station.

Plate 3: Filling of sample bottle for DIC and alkalinity from the underway supply tube. Sample containers for some other parameters are lined up behind the sink.

Samples were collected for the following at each underway sampling point:

1. 250 mL for carbonate chemistry (DIC and TA)

2. 250 mL for coccolithophore enumeration via light microscopy
3. 200 mL for either PIC (calcium carbonate) concentration or BSi (biogenic silica) concentration or else coccolithophore identification and enumeration via scanning electron microscopy (the use to which they will be put will be decided later)
4. 1.6 mL for flow cytometry to count the smallest plankton
5. 20 mL for macro-nutrient concentrations (nitrate+nitrite, phosphate, silicate)

In addition, at every third sampling point samples were taken for:

6. 200 mL for salinity to calibrate continuous measurement

In addition, along some parts of the route samples were taken for:

7. 250 mL for enumeration of larger plankton (Lugols samples; along long transect only)
8. 20 mL for $\delta^{13}C$ of DIC

Occasional samples were also taken for:

9. Chlorophyll via filtration (for calibration of UW fluorometer, daytime only)

In addition the carbonate chemistry group were continuously monitoring:

10. pH
11. pCO2

Finally the shipboard oceanlogger system was continuously measuring:

12. Chlorophyll via fluorescence
13. Seawater temperature
14. Air temperature
15. Salinity
16. Transmittance
17. Above-surface irradiance
18. Barometric pressure
19. Atmospheric humidity

For all the continuously measured datasets the time collected (GMT) is recorded and can be used to extract the data corresponding to the individual underway samples. Likewise precise location can be determined from the ship's GPS logger files. A table giving all currently available data for the sample set is appended to this report.

The sensors for chlorophyll fluorescence and transmittance were not cleaned or calibrated before or during the cruise. Values should be considered as indicative rather than absolute unless (1) they were calibrated against simultaneous measurements using trusted techniques, and also (2) they were corrected for possible drift due to biofouling (as assessed by comparing, for instance, values upon leaving and returning to Port Stanley, or between the two visits to South Georgia).

Approximately 80 measurements of iron concentration (sampled from a towfish rather than from the underway supply) were taken along the route and can also be combined in future with the UW dataset. Large plankton assemblages were also sampled continuously along large fractions of the route, by the continuous plankton recorder (CPR).

The protocols for taking the various manually collected UW seawater samples were as follows:

Preparation

- Collect flow cytometry tube (pre-loaded with paraformaldehyde) from blue-handled freezer in cold room
- Put on plastic gloves (because dealing with algal poisons: HgCl & Lugol's) & rinse with underway water
- label nutrients & isotopes pots (isotopes pot on glass not lid) & flow cytometry tube
- check pipettes are set to the correct volumes (2.5ml & 50µl)

Salinity

- take upside-down bottle from crate & stopper from bag
- empty & rinse thoroughly
- fill to bottle shoulder
- record sampling time NOW (from LCD clock above the sink; MUST MATCH THE TIME EXACTLY)
- put in plastic stopper & screw lid down
- note bottle number on record sheet, + date, etc.
- replace in crate, right way up

Carbonate chemistry

- take the 250 mL glass bottle with the number for this timepoint
- Rinse bottle and lid twice
- Fill to top without bubbles, insert & remove stopper so bottle is exactly filled then…..
- Remove 2.5 mL for headspace (blue pipettor)
- Spike (add 50 µL HgCl) (grey pipettor)
- close with twist (& large black rubber band?)
- invert to mix
- put bottle, HgCl & pipettors back in box

Carbon isotopes

- take labelled 20 mL glass vial
- rinse bottle & lid THREE times
- fill gently to top without bubbles or headspace
- close & invert to mix & check for bubbles when inverted
- store in nutrients fridge in clear plastic bag

Nutrients

- rinse lid & pot three times
- fill to 1cm from top & close
- store pot in fridge in nutrient lab

Coccolithophores

- take two 250 mL brown bottles, rinse then fill to shoulder (not right to top)

- replace with other bottles

Flow cytometry

- pipette into numbered tube until 2/3 full (1.6 mL line on vial)
- close tube
- store tube in fridge in nutrient lab

Lugol's phytoplankton

- Wear plastic gloves, get bottles from under sink
- Use 250 mL dark bottle to collect sample initially (rinse first)
- Pour into glass bottles pre-loaded with Lugol's (*don't rinse those!*)
- Fill to 1cm below top (*no overflow*)
- store in box under sink

Implementation

Date	Time GMT	Time Zone	Filter (in use)	Pump	Event	Remarks	Cruise no
01/02/2013	12:00	GMT	1	2	Filter Change and Clean	Small Amount of matter	JR274
02/02/2013	11:45	GMT	2	2	Filter Change and Clean	Appeared Clean	JR274
03/02/2013	11:45	GMT	1	2	Filter Change and Clean	Small Amount of matter	JR274
04/02/2013	11:30	GMT	2	2	Filter Change and Clean	1 fish, doz krill	JR274
05/02/2013	11:55	GMT	1	2	Filter Change and Clean	Small Amount of matter	JR274
06/02/2013	11:41	GMT	2	2	Filter Change and Clean	Small Amount of matter	JR274
07/02/2013	05:08	GMT	2	2	System tripped	Bad weather	JR274
07/02/2013	06:37	GMT	2	2	System On	ON	JR274
07/02/2013	09:37	GMT	2	2	System tripped	Bad weather	JR274
07/02/2013	11:11	GMT	2	2	System ON	ON	JR274
07/02/2013	11:20	GMT	1	2	Filter Change and Clean	Small Amount of matter	JR274
09/02/2013	20:00	GMT	2	2	Filter Change and Clean	Small fish, Sea weed reed	JR274

Table 1: Deck engineer's event log for the uncontaminated (underway) seawater system, including a record of filter cleaning.

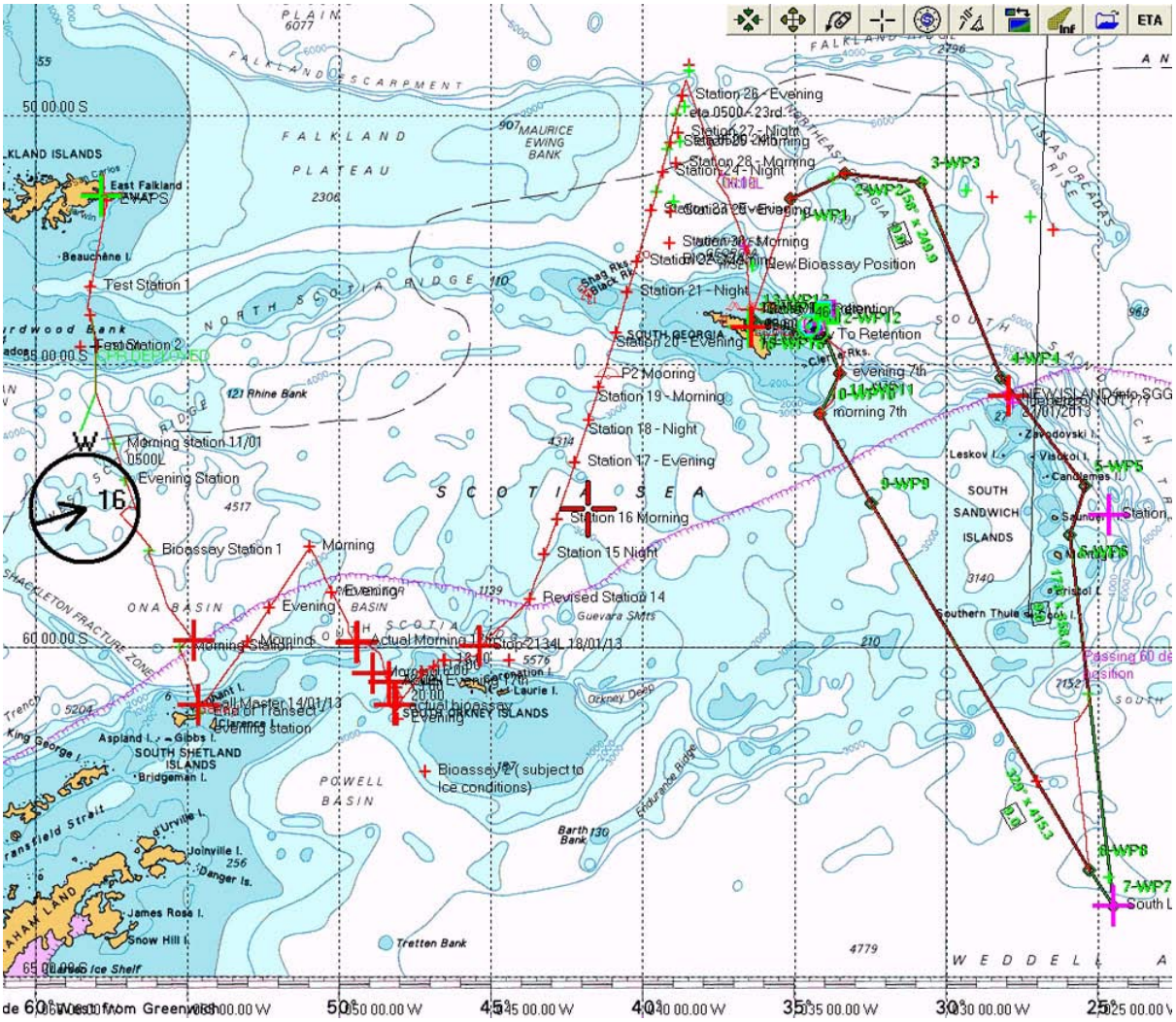


Figure 1: Map showing cruise track of JR274

Dissolved Inorganic Carbon, its Stable Isotopes, and Total Alkalinity from Underway and CTD Samples

Sampling & Analysis: Matthew Humphreys, Mariana Ribas-Ribas, Eithne Tynan, and Jennifer Clarke

Report: Matthew Humphreys

Sampling Protocols

Dissolved Inorganic Carbon and Total Alkalinity

Samples for Total Alkalinity (A_T) and Dissolved Inorganic Carbon (C_T) were collected following best practices as recommended by Dickson et al. (2007), in 250 ml Schott Duran borosilicate glass bottles with glass stoppers that provided an air-tight seal. The bottles were rinsed with sample and filled carefully with no bubbles in the bottle or sample line, and allowed to overflow. A 2.5 ml air headspace was left in each bottle and 50 µl saturated mercuric chloride solution added directly after sampling. Samples that were not analysed at sea were sealed with Apiezon L grease, and electrical tape wrapped around the bottle and stopper to hold it in place.

Stable Isotopes of Dissolved Inorganic Carbon

Samples for measurement of the stable isotopes ($\delta^{13}C$) of C_T were collected in glass vials with plastic screw-on lids that hold a septum in place over the opening to form an air-tight seal. Vials, lids and septa were cleaned with 10% hydrochloric acid and Milli-Q water before use. The bottles were rinsed with the sample 3 times before filling carefully with no bubbles in the bottle or sample line. The lids and septa were attached with no headspace or bubbles in the vial. Within a few hours of sampling, the lids were briefly removed to add 10 µL of saturated mercuric chloride solution before being re-applied. Samples were kept in the dark between sampling and addition of mercuric chloride. The lids were secured in place using electrical tape.

Analysis at sea – A_T and C_T

Measurements of A_T at sea were completed by either VINDTA 3C #038 (Marianda) or an Apollo Total Alkalinity Titrator AS-ALK2. Samples were warmed to 25°C in a water bath before analysis. Small increments of 0.1

M hydrochloric acid are added to a set volume of sample while the electromotive force is measured by a glass and reference electrode system. The amount of acid added to reach the carbonic acid equivalence point is equal to the A_T.

Measurements of C_T at sea were completed by an Apollo SciTech Dissolved Inorganic Carbon Analyzer AS-C3. At least 5 consecutive measurements were made on each sample and the average C_T value used. Each measurement used 0.75 ml of sample. All inorganic carbon in the sample is removed by addition of excess 10% phosphoric acid and purging with nitrogen gas, and the amount of carbon dioxide measured by a LI-COR LI-7000 CO_2/H_2O Analyzer, using infra-red absorption.

Regular measurements of both A_T and C_T were made from batches 119 and 120 Certified Reference Material (CRM) from A. G. Dickson (Scripps Institution of Oceanography) and used to calibrate the results for each session of analysis as follows:

$$A_T^{\text{sample, corrected}} = A_T^{\text{sample, measured}} \text{ x } (A_T^{\text{CRM, certified}} / A_T^{\text{CRM, measured}})$$

$$C_T^{\text{sample, corrected}} = C_T^{\text{sample, measured}} \text{ x } (C_T^{\text{CRM, certified}} / C_T^{\text{CRM, measured}})$$

To obtain the final results in units of µmol kg^{-1}, a correction for density (ρ) due to salinity (S) variations was then applied using salinity measured from Niskin bottle samples and an equation of the form (Zeebe and Wolf-Gladrow 2001):

$$\rho_{\text{sea water, 25°C}} = \rho_{\text{pure water, 25°C}} + AS + BS^{1.5} + CS^2$$

CTD Sample List

Cast #	A_T & C_T samples (Niskin numbers)	$\delta^{13}C$ of C_T samples (Niskin numbers)
02	1, 3, 5, 7, 11, 13, 17, 19, 21, U	
04	1, 3, 5, 7, 9, 13, 15, 19, 21	
09	1, 3, 5, 7, 11, 13, 17, 19, 21	
10	1, 3, 5, 7, 11, 14, 15, 19, 21	
11	1, 3, 5, 7, 9, 13, 15, 19, 21	
12	1, 3, 5, 7, 11, 13, 15, 17, 21, U	
13	1, 3, 5, 7, 9, 11, 15, 17, 21	
14	1, 3, 5, 7, 9, 11, 13, 15, 19, 21, U	
15	1, 3, 5, 7, 9, 13, 15, 17, 21	
16	1, 3, 5, 7, 9, 11, 15, 17, 21	
17	1, 3, 5, 7, 11, 13, 17, 19, 21	
22	1, 3, 5, 7, 9, 14, 15, 19, 21	
23	1, 3, 5, 7, 9, 11, 15, 17, 21	
24	1, 3, 5, 7, 9, 13, 15, 19, 21	
26	2, 4, 5, 7, 9, 11, 15, 17, 21, U	
27	1, 3, 5, 7, 9, 13, 15, 19, 21	
28	1, 3, 5, 7, 11, 13, 15, 17, 21	
29	1, 3, 5, 7, 9, 13, 17, 19, 21	
31	1, 3, 5, 7, 11, 13, 15, 17, 21, U	
32	1, 3, 5, 7, 9, 13, 15, 19, 21	
34	3, 5, 7, 9, 11, 15, 19, 21, U	
35	1, 3, 5, 7, 9, 11, 13, 17, 21	
36	2, 3, 5, 7, 9, 11, 15, 17, 21	
37	12, 13, 14, 17, 18, 19	12, 13, 14, 17, 18, 19
38	1, 3, 5, 7, 9, 13, 15, 17, 19, 21	

39	1, 2, 3	
44	1, 3, 5, 7, 9, 14, 15, 19, 21	
45	1, 2, 3, 5, 6, 14	
46	1, 3, 5, 7, 9, 13, 15, 17, 19	
47	1, 3, 5, 7, 9, 13, 15, 19, 21	
48	1, 2, 3, 5, 14	
49	1, 3, 5, 7, 9, 13, 15, 21	
50	1, 2, 3, 5, 6, 14	
52	1, 3, 5, 7, 9, 15, 21	
53	1, 3, 5, 7, 9, 11, 15, 17, 21	
54	1, 4, 6, 9, 10, 11, 15, 16, 19, 20, 2D, 4D, 5D, 18D	1, 4, 6, 9, 10, 11, 15, 16, 19, 20, 12, 2D, 3D, 4D, 5D, 6D, 18D
55	15, 19, 21	
56	1, 3, 5, 7, 9, 13, 15, 19, 21	
57	1, 2, 3, 4, 5, 6, 14, 18	1, 2, 3, 5, 6, 14, 18
58	1, 5, 9, 15, 19, 21	
59	1, 5, 7, 9, 13, 19, 21	1, 5, 7, 9, 13, 19, 21
60	1, 2, 3, 4, 5, 6, 14, 18	
61	1, 5, 7, 11, 13, 17, 21	
66	1, 3, 6, 7, 9, 13, 19, 21	1, 3, 6, 7, 9, 13, 19, 21
67	1, 5, D1, D2, D3, D6, D14	
68	1, 3, 5, 7, 9, 15, 21	1, 3, 5, 7, 9, 15, 21
69	1, 3, 5, 7, 11, 15, 19, 21	1, 3, 5, 7, 11, 15, 19, 21
70	5, 7, 8, 9, 11, 13, 16, 17, 20, 21, 24, 1D, 1DD, 2D, 3D, 5D, 6D, 14D, 18D	5, 7, 8, 9, 11, 13, 16, 17, 20, 21, 24, 1D, 1DD, 2D, 3D, 5D, 6D, 14D, 18D
71	1, 3, 5, 7, 9, 11, 15, 17, 21	1, 3, 5, 7, 9, 11, 15, 17, 21
72	5, 7, 8, 9, 11, 13, 16, 17, 20, 21, 22, 24, 1D, 1DD, 2D, 3D, 5D, 6D, 14D, 18D	5, 7, 8, 9, 11, 13, 16, 17, 20, 21, 22, 24, 1D, 1DD, 2D, 3D, 5D, 6D, 14D, 18D
73	1, 3, 5, 7, 9, 11, 13, 21	1, 3, 5, 7, 9, 11, 13, 21

74	1, 3, 5, 7, 9, 11, 15, 17, 21	1, 3, 5, 7, 9, 11, 15, 17, 21
75	7, 8, 9, 13, 17, 21, 22, 1D, 1DD, 2D, 3D, 5D, 6D, 14D, 18D	7, 8, 9, 13, 17, 21, 22, 1D, 1DD, 2D, 3D, 5D, 6D, 14D, 18D
76	1, 3, 5, 7, 11, 15, 17, 21	1, 3, 5, 7, 11, 15, 17, 21
77	7, 8, 11, 13, 17, 20, 21, 22, 1D, 1DD, 2D, 3D, 5D, 6D, 18D	7, 8, 11, 13, 17, 20, 21, 22, 1D, 1DD, 2D, 3D, 5D, 6D, 18D
78	1, 3, 5, 7, 9, 13, 15, 19, 21	1, 3, 5, 7, 9, 13, 15, 19, 21

Underway Samples

Additionally, samples for A_T and C_T were collected from the underway seawater system at approximately 2-hour intervals while moving between stations throughout the cruise, as described in the Underway sampling section of this report. For several stations, an underway sample was collected at the same time as the 5 metre depth rosette bottles were closed (indicated by a U on the CTD sample list), to test for any systematic offset in A_T or C_T results – no significant offset was found, as illustrated below, which is consistent with the result of a similar analysis on the previous UK Ocean Acidification Research Programme cruise JR271 in summer 2012, also on RRS James Clark Ross (see Figure).

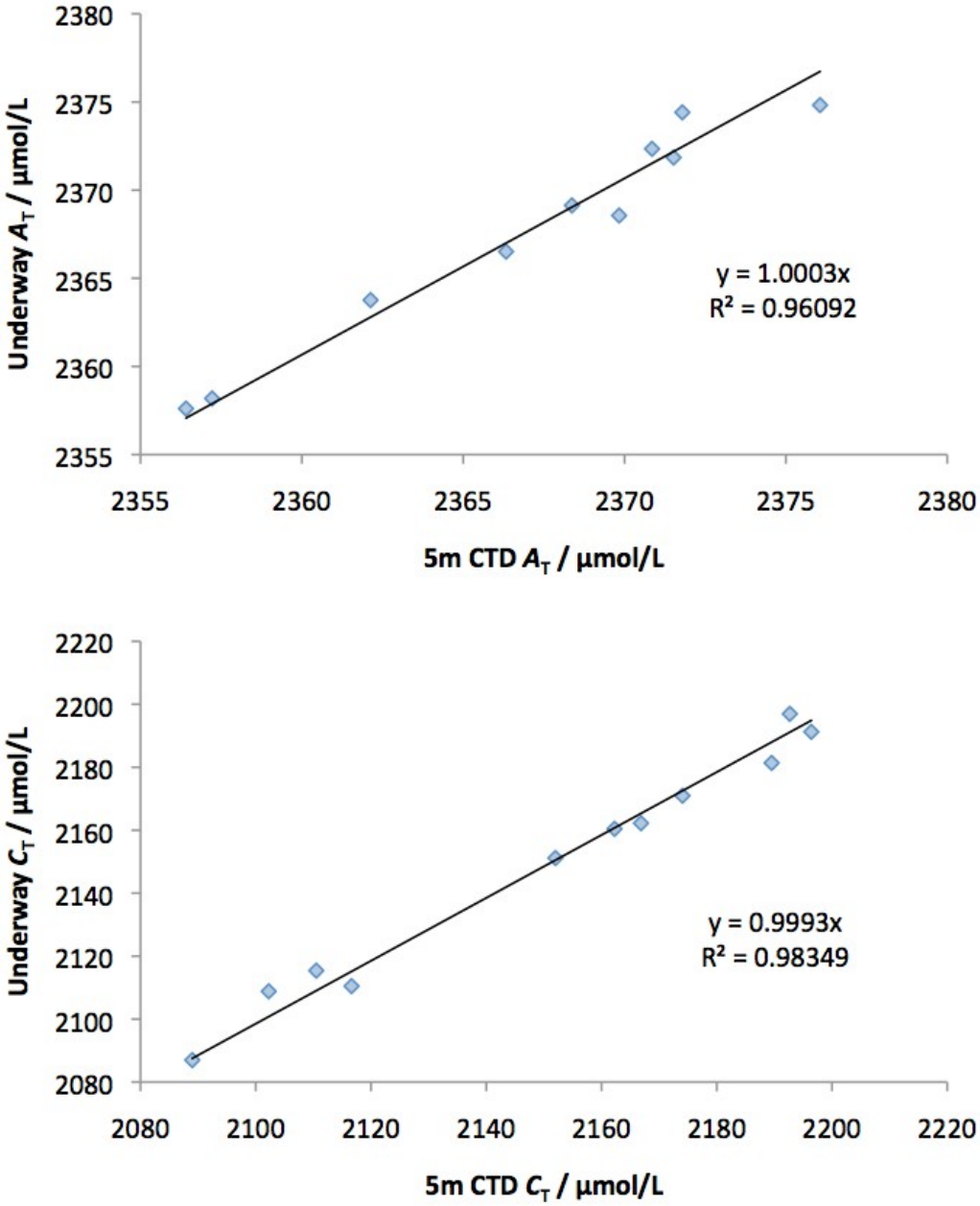


Figure. Correlation between underway and 5-metre CTD rosette A_T and C_T measurements, from cruise JR271.

References

Dickson, Andrew G., Christopher L. Sabine, and J. R. Christian. 2007. *Guide to Best Practices for Ocean CO_2 Measurements*. PICES Special Publication 3.

Zeebe, Richard E., and D. A. Wolf-Gladrow. 2001. *CO_2 in Seawater: Equilibrium, Kinetics, Isotopes*. Elsevier Oceanography Series 65.

Cruise report JR274: Sampling of Trace Metals and analysis of Dissolved Iron

Maxi Castrillejo and Eric P. Achterberg *(National Oceanography Centre of Southampton)*

1. Introduction

Iron (Fe) has been shown to be the prime limiting micronutrient in high-nutrient-low-chlorophyll waters (*Martin et al*. 1990; *de Baar et al.* 2005; *Boyd et al.* 2007). A range of other bioactive trace metals (zinc, cadmium, etc.) are also vital for biological productivity as they are often involved in enzymatic activity or become part of proteins (*Morel and Price*, 2003). Yet, little is known about the processes by which these elements are supplied to the oceans (Aeolian dust, resuspension of continental shelf sediments, upwelling, etc.) and which mechanisms govern scavenging/uptake, solubility, mineralization, or remineralization in the water column. Data are particularly scarce for the Southern Ocean. Determining the dissolved and particulate trace metal (Fe, Mn, Co, Cd, Ni, Zn, Cu, Pb, Ba) distributions within the scope of this work will therefore help fill this gap and allow inferring and quantifying the processes which are controlling primary productivity, biogeochemical processes and supply and removal of trace metals in Antarctic waters.

2. Objectives

Main objective on board is to obtain uncontaminated trace metal samples and to determine dissolved Fe concentrations that will be used to check for contamination that might occur during sampling and sample processing. Back in the laboratory at the NOCS, we aim to determine dissolved and total dissolvable distributions for the range of bioactive trace metals mentioned above and discuss the data in terms of their sources, sinks and biogeochemical cycling.

3. Methodology

3.1. Sampling: Go-Flo (vertical profiles) and FISH (surface samples)

The upper 1400 m of the water column was sampled using up to 12 GO-FLO bottles attached to a plastic coated wire. Occasionally, deeper samples were taken using a titanium rosette equipped with trace metal clean 10 L OTE (Ocean Test Equipment) sampling bottles. GO-FLO and OTE bottles were cleaned before the first sampling with ~5% HCl (Analytical grade) and acidified seawater, respectively. The sampling bottles were transferred to a trace metal clean container. Seawater was gravity filtered (using 0.2 μm Acropack filter cartridges) for the dissolved fraction. Additionally, unfiltered samples were collected for the total dissolvable fraction. Samples were stored in LDPE bottles (Nalgene, 125ml and 250ml) cleaned 1 week each in ~5% (v/v) aqueous Decon detergent, 50% (v/v) HCl and 50% (v/v) HNO_3 (Fisher Scientific, Trace Metal Analytical Grade).

Surface seawater samples were collected using an “Achterberg” tow FISH which was deployed on the side of the ship at a depth of 2-3 m. Samples were pumped using a Teflon pump and an acid cleaned hose into the clean sampling container. Filtered (0.2 μm Acropack filter) and unfiltered samples were collected every 4 h in the open ocean and more often

when approaching South Georgia Island. Some samples were also taken for lead (Pb) isotope determination (from 20 to 24/01/2013) for Imperial College.

All samples were acidified after collection using 150, 300 and 1180 μl of concentrated HCl (UpA grade) acid for 125, 250 and 1000 mL bottles respectively. Samples for inorganic nutrients (phosphate, nitrate and silicate) were taken at all station, whereas salinity was sampled only when no data were available from the stainless CTD.

3.2. Onboard analysis of Iron (III)

A total of out of 30 GO-FLO stations, as well as, samples from the fish and bioassay experiments were analyzed on board for dissolved Fe (III) using flow injection analysis (FIA) techniques. The method used is a modification of the method by *Obata et al.* (1993) and *de Jong et al.* (1998), and is based in the chemiluminescence produced by the Fe-catalysed oxidation of luminol by hydrogen peroxide.

Briefly, seawater samples were acidified to pH ~1.9 with concentrated HCl (UpA grade) 24 hours before analysis and were spiked with 0.1% hydrogen peroxide 1 hour prior to analysis to convert any Fe(II) to Fe (III). Sample was pumped for 240 seconds through a column containing Toyopearl AF-Chelate-650M chelating resin (Sigma Aldrich). A 30 seconds MQ rinse was then used to remove the residual salt in the column. Fe was eluted using 0.4 M HCl (SpA). The eluate was then mixed along a 3 m long coiled tubing which was heated to 40ºC with 0.9 M ammonia solution (SpA Romil) and 0.3M hydrogen peroxide (SpA, Romil) achieving a final pH of 9.4 ± 0.1. The solution was then passed through a photo-counter. All measurements were done in triplicate. Calibration was made adding 0.85 μM Fe spike (tipically: +20, 40, 80 and 160 μL) to 60 mL surface seawater (pH~1.9) collected during the cruise. Reference seawater (Geotraces-S) was measured to check the accuracy of the method.

All sample handling and analytical work was done under the laminar flowhood in the clean container always using clean trace metal techniques.

3.3. Multi-elemental analysis of dissolved and total dissolvable trace metals at NOCS

Multi-elemental determination of a range of trace metals (Fe, Mn, Co, Cd, Zn, Cu, Pb, Ba) will be done following the method by *Milne et al.,* (2010). The method is based in the isotope dilution technique and includes an offline pre-concentration of trace metals prior to the determination using inductively coupled plasma mass spectrometry techniques (ICP-MS) back at NOCS. Unfiltered samples will be stored for >6 months and analyzed in the same way as filtered samples.

4. Preliminary results

The main objective of running the iron FIA system onboard was to check for any contamination issues and as it can be seen in the three representative vertical profiles of dissolved iron (DFe) (Figure 1), clean sampling was achieved. Samples taken with the titanium CTD did not show sign of contamination either. Concentrations of dissolved iron were very low (<500 pM) and rarely reached concentrations above 1 nM (Figure1). Generally speaking no atmospheric inputs were observed (except at the beginning of the cruise, st 4) and dissolved iron generally increased or showed little variation with depth. No samples from South Georgia were analysed onboard in order to avoid contamination of the FIA system.

Samples will be later analyzed for dissolved and total dissolvable iron by ERIC's group with the isotope dilution technique and the ICP-MS which will provide wonderful data for iron and other bioactive trace metals.

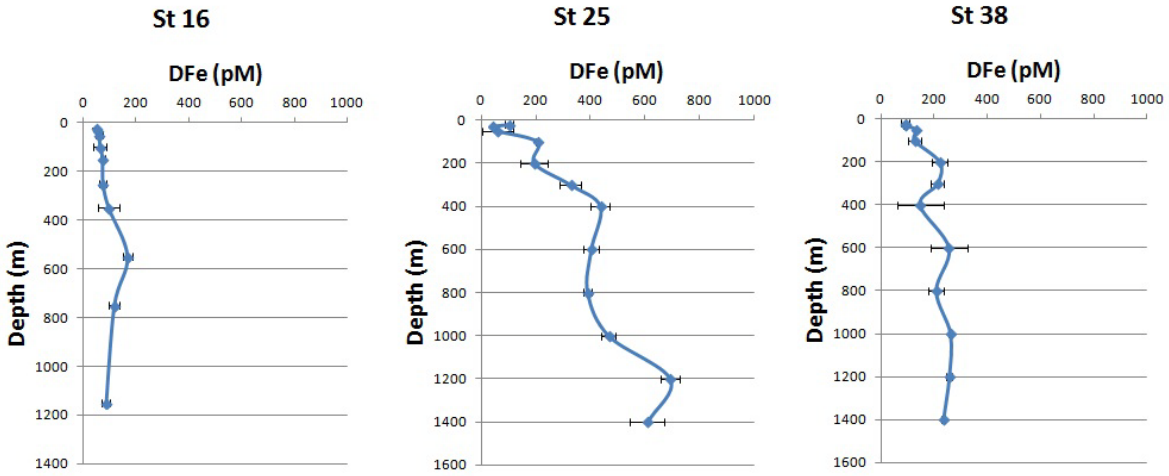


Figure 1. Vertical profiles of dissolved iron (DFe) at three representative stations (16, 25 and 38). Error calculated as 2 times the standard deviation.

References

Boyd, P.W. et al., 2007. Mesoscale iron enrichment experiments 1993-2005: Synthesis and future directions. Science, 315(5812): 612-617.

de Baar, H.J.W. et al., 2005. Synthesis of iron fertilization experiments: From the iron age in the age of enlightenment. Journal of Geophysical Research-Oceans, 110(C9).

De Jong, J.T.M et al., 1998. Dissolved iron at subnanomolar levels in the Southern Ocean as determined by ship-board analysis. Analytica Chimica Acta, 377: 113-124.

Martin, J.H., Gordon, R.M. and Fitzwater, S.E., 1990. Iron in Antarctic waters. Nature, 345(6271): 156-158.

Milne, A., Landing, W., Bizimis, M. and Morton, P., 2010. Determination of Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in seawater using high resolution magnetic sector inductively coupled mass spectrometry (HR-ICP-MS). Analytica Chimica Acta, 665(2): 200-207.

Morel, F.M.M. and Price, N.M., 2003. The biogeochemical cycles of trace metals in the oceans. Science, 300(5621): 944-947.

Obata, H. et al., 1993. Automated determination of Iron in seawater byb chelating resin concentration and chemiluminescence detection. Analytical Chemistry, vol. 65 (11): 1524-1528.

Tables

Table 1. Samples taken with towfish during cruise JR274.

SAMPLING				TYPE OF SAMPLE			
Scientist sampling	Date (dd/mm/yyyy)	Time (GMT)	Sample number	Fe/Al Onboard analysis (F)	NOCS (F)*	NOCS (UF)**	Pb Isotopes
Maxi Castrillejo	15 January 2013	14:15	1	X	X	X	
Maxi Castrillejo	15 January 2013	18:15	2	X	X	X	
Maxi Castrillejo	15 January 2013	22:40	3	X	X	X	
Maxi Castrillejo	16 January 2013	02:45	4	X	X	X	
Maxi Castrillejo	16 January 2013	12:41	5	X	X	X	
Eric Achterberg	16 January 2013	18:00	6	X	X	X	

Eric Achterberg	16 January 2013	22:35	7	X	X	X	
Maxi Castrillejo	20 January 2013	16:30	8	X	X	X	X
Eric Achterberg	20 January 2013	22:30	9	X	X	X	
Eric Achterberg	20 January 2013	02:00	10	X	X	X	X
Maxi Castrillejo	21 January 2013	03:30	11	X	X	X	X
Maxi Castrillejo	21 January 2013	14:40	12	X	X	X	X
Maxi Castrillejo	21 January 2013	18:50	13	X	X	X	X
Maxi Castrillejo	21 January 2013	22:20	14	X	X	X	X
Eithne Tynnan	21 January 2013	03:00	15	X	X	X	X
Maxi Castrillejo	22 January 2013	07:15	16	X	X	X	X
Maxi Castrillejo	22 January 2013	14:30	17	X	X	X	X
Eric Achterberg	23 January 2013	00:40	18	X	X	X	X
Maxi Castrillejo	23 January 2013	13:45	19	X	X	X	X
Maxi Castrillejo	23 January 2013	18:05	20	X	X	X	X
Maxi Castrillejo	23 January 2013	22:00	21	X	X	X	X
Eithne Tynnan	24 January 2013	02:30	22	X	X	X	X
Mark Moore	24 January 2013	07:20	23	X	X	X	X
Maxi Castrillejo	24 January 2013	15:45	24	X	X	X	
Maxi Castrillejo	24 January 2013	23:55	25	X	X	X	
Eithne Tynnan	25 January 2013	03:30	26	X	X	X	
Eric Achterberg	25 January 2013	17:45	27	X	X	X	
Maxi Castrillejo	25 January 2013	19:30	28	X	X	X	
Maxi Castrillejo	25 January 2013	20:45	29	X	X	X	
Maxi Castrillejo	25 January 2013	21:45	30	X	X	X	
Maxi Castrillejo	25 January 2013	22:45	31	X	X	X	
Maxi Castrillejo	27 January 2013	11:40	32		X	X	
Maxi Castrillejo	27 January 2013	11:45	33		X	X	
Maxi Castrillejo	27 January 2013	11:55	34		X	X	
Maxi Castrillejo	27 January 2013	12:05	35		X	X	
Maxi Castrillejo	27 January 2013	12:15	36		X	X	
Maxi Castrillejo	27 January 2013	12:35	37		X	X	
Maxi Castrillejo	27 January 2013	12:55	38		X	X	
Maxi Castrillejo	27 January 2013	13:30	39		X	X	
Maxi Castrillejo	27 January 2013	14:30	40		X	X	
Maxi Castrillejo	27 January 2013	23:00	41		X	X	
Maxi Castrillejo	28 January 2013	03:05	42		X	X	
Maxi Castrillejo	28 January 2013	15:45	43		X	X	
Maxi Castrillejo	28 January 2013	19:30	44		X	X	
Maxi Castrillejo	29 January 2013	00:05	45		X	X	
Maxi Castrillejo	29 January 2013	04:50	46		X	X	
Eric Achterberg	29 January 2013	19:45	47		X	X	
Maxi Castrillejo	29 January 2013	22:45	48		X	X	
Mariana Ribas	30 January 2013	02:45	49		X	X	
Maxi Castrillejo	30 January 2013	15:50	50		X	X	
Maxi Castrillejo	30 January 2013	23:15	51		X	X	

Mariana Ribas	31 January 2013	02:53	52		X	X	
Maxi Castrillejo	31 January 2013	14:45	53		X	X	
Mark Moore	31 January 2013	19:10	54		X	X	
Maxi Castrillejo	31 January 2013	23:05	55		X	X	
Mariana Ribas	01 February 2013	03:47	56		X	X	
Eric Achterberg	01 February 2013	12:15	57		X	X	
Maxi Castrillejo	01 February 2013	22:30	58		X	X	
Mariana Ribas	02 February 2013	03:05	59		X	X	
Maxi Castrillejo	02 February 2013	17:45	60		X	X	
Eric Achterberg	02 February 2013	23:59	61		X	X	
Mariana Ribas	03 February 2013	03:06	62		X	X	
Maxi Castrillejo	03 February 2013	07:32	63		X	X	
Mark Moore	03 February 2013	22:48	64		X	X	
Maxi Castrillejo	04 February 2013	18:35	65		X	X	
Eric Achterberg	04 February 2013	23:40	66		X	X	
Mariana Ribas	05 February 2013	03:05	67		X	X	
Mark Moore	05 February 2013	07:45	68		X	X	
Eric Achterberg	05 February 2013	16:00	69		X	X	
Maxi Castrillejo	05 February 2013	22:00	70		X	X	
Mariana Ribas	06 February 2013	03:10	71		X	X	
Eric Achterberg	06 February 2013	16:20	72		X	X	
Maxi Castrillejo	06 February 2013	18:07	73		X	X	
Maxi Castrillejo	06 February 2013	23:35	74		X	X	
Eric Achterberg	09 February 2013	14:55	75		X	X	
Maxi Castrillejo	09 February 2013	18:20	76		X	X	
Maxi Castrillejo	09 February 2013	22:30	77		X	X	
Eric Achterberg	10 February 2013	01:39	79		X	X	
Maxi Castrillejo	10 February 2013	05:35	80		X	X	
Maxi Castrillejo	10 February 2013	10:10	81		X	X	
Eric Achterberg	10 February 2013	15:05	82		X	X	
Eric Achterberg	10 February 2013	18:40	83		X	X	
Maxi Castrillejo	10 February 2013	19:20	84		X	X	
Maxi Castrillejo	10 February 2013	23:30	85		X	X	
Maxi Castrillejo	11 February 2013	03:30	86		X	X	
Maxi Castrillejo	11 February 2013	09:30	87		X	X	
Eric Achterberg	11 February 2013	14:50	88		X	X	
Eric Achterberg	11 February 2013	18:15	89		X	X	
Eric Achterberg	11 February 2013	20:20	90		X	X	
Eric Achterberg	11 February 2013	22:45	91		X	X	
Maxi Castrillejo	12 February 2013	00:25	92		X	X	
Maxi Castrillejo	12 February 2013	02:00	93		X	X	
Mariana R. and Maxi C.	12 February 2013	03:00	94		X	X	

*(F): filtered
**(UF): Unfiltered

Table 2. Samples taken with GO-FLO bottles (and clean Ti CTD for trace metals).

Station	Type	yyyy-mm-ddThh:mm:ss	Latitude [degrees_north]	Longitude [degrees_east]	Bot. Depth [m]	Max. sampled depth [m]
test 1	Go-Flo	2013/01/11 11:50	-56.46457	-57.42051	3701	160
3	Go-Flo	2013/01/13 13:00	-58.3667	-56.25205	3920	600
4	Go-Flo	2013/01/14 10:06	-60.00292	-55.22971	3545	600
6	Go-Flo	2013/01/15 10:08	-59.90964	-53.02372	3422	600
8	Go-Flo	2013/01/16 10:19	-58.29466	-50.96991	3972	600
10	Go-Flo	2013/01/17 10:13	-59.89531	-49.39129	3582	1200
12	Go-Flo	2013/01/18 12:03	-60.96994	-48.13067	2694	1400
13	Go-Flo	2013/01/19 09:58	-59.94083	-45.27963	4835	1400
16	Go-Flo	2013/01/20 09:55	-57.82114	-42.83161	2879	1350
19	Go-Flo	2013/01/21 08:53	-55.20466	-41.32035	3324	1400
22	Go-Flo	2013/01/22 09:48	-52.71257	-40.05704	3785	1400
25	Go-Flo	2013/01/23 09:58	-50.14834	-38.95713	4731	1400
27	Go-Flo	2013/01/24 09:52	-51.15392	-37.48338	1840	1400
29	Go-Flo	2013/01/25 12:24	-52.69303	-36.62551	2436	1400
30	Go-Flo	2013/01/27 09:54	-54.27857	-36.43799	253	200
32	Go-Flo	2013/01/28 09:48	-51.61609	-34.71588	4777	1400
34	Go-Flo	29/01/2013 time?	-51.39285	-30.80584	3926	1400
34	Ti CTD 54	2013/01/29 11:58	-51.39285	-30.80584	3926	2000
36	Go-Flo	2013/01/30 09:44	-53.82523	-29.18881	4645	1400
38	Go-Flo	2013/01/31 09:47	-56.08997	-27.02803	1974	1400
40	Go-Flo	2013/02/01 11:31	-58.08931	-25.92921	2894	1400
43	Go-Flo	2013/02/03 09:43	-63.46579	-25.29853	4937	1400
43	Ti CTD 70	2013/02/03 14:02	-63.46659	-25.29452	4942	4888
44	Go-Flo + Ti CTD	2013/02/04 09:48	-62.13826	-27.0257	4199	1400
44	Ti CTD 72	2013/02/04 11:59	-62.13825	-27.02291	4193	4290
46	Go-Flo	2013/02/05 09:47	-59.99653	-29.66034	2602	1200
46	Ti CTD 75	2013/02/05 13:46	-59.9974	-29.65944	2559	2550
48	Go-Flo	2013/02/06 09:05	-57.92679	-32.05345	2903	1400
48	Ti CTD 77	2013/02/06 13:36	-57.92901	-32.05401	2870	2860
50	Go-Flo	07/02/2013				1400

Cruise Report for Nutrients

Dr R Sanders, *NOC*

Nitrate+Nitrite, Phosphate and Silicate were analysed on a Skalar San Plus autoanalyser following Sanders and Jickells (2000), Total Organic Nutrients in Drake Passage, Deep Sea Research 47(6) 997-1014. The system functioned well throughout the cruise with the exception of one occasion when the instrument stopped logging and the spare computer swapped in. Incompatabilities in the software setup between the instrument and the new computer (which were subsequently resolved) meant that the silicate data from one run on 19th January containing samples from station 13, a zooplankton bioassay and underway samples 61-66 was of reduced quality and has not been reported. All stainless CTDs were sampled, generally from the odd numbered niskin bottles, together with all goflos and all titanium CTD casts except the bioassay setup ones. Overall approximately 1750 samples were analysed in total comprising 500 from Stainless steel CTD deployments, 600 from the various bioassay experiments, 250 from the Go-Flo deployments, 250 from the underway sampling and 150 from the Titanium CTD. Generally all samples from each day were analysed in a single long run although occasionally two runs were undertaken. Standards were made up from weighed dried salts in duplicate at the start of the cruise and a single set of standards was used throughout the cruise. Drift and baseline checks were run within each run and the software used to automatically correct for drift in either the baseline or in sensitivity. CRMs from Ocean Scientific International were run at the beginning and end of the cruise and a deep water sample was used as an internal quality control system. A nitrite sample was measured on each run to detect the efficiency of the cadmium column.

The performance of the autoanalyser was monitored continuously throughout the cruise using a series of metrics. The baseline values remained fairly constant throughout the cruise (Figure) , except for large changes in N and Si on 17 and 13 Jan respectively. These are linked to the replacement of the computer on 17th Jan and to a replacement bulb being fitted on 13 Jan. There was a long term decline in phosphate baseline, probably linked to the reagent ageing over the cruise.

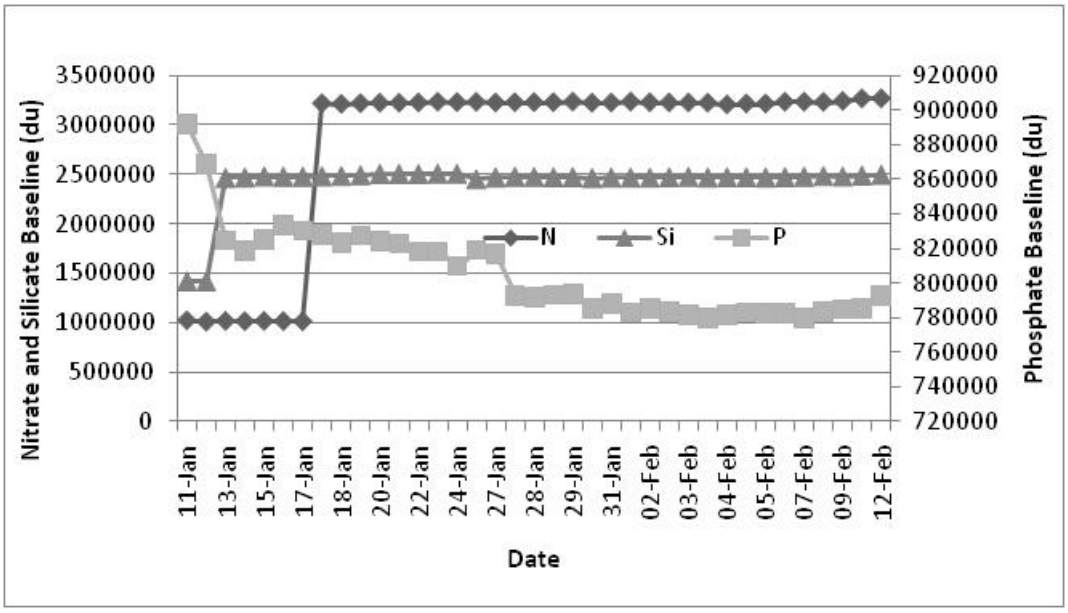
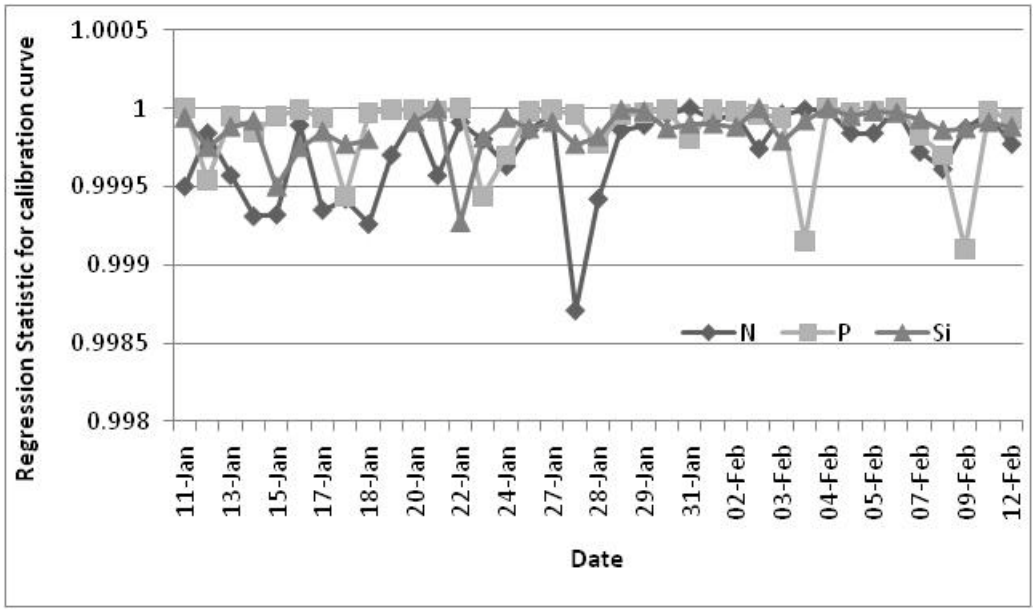


Figure – Time series of baseline values

The regression statistics for the calibration curves were, with the exception of one occasion for nitrate on 28th January, always over 0.999 (Figure). Generally the regression statistics improved over the course of the cruise.



Figure, Time series of calibration curve regression coefficients

The gradient of the calibration curve, or gain, in digital units per micromole is an index of sensitivity. Generally there were low levels of variability with changes in N and Si values being linked to the preparation of new reagents (Figure). One high value correlated with the poor correlation coefficient warrants further investigation.

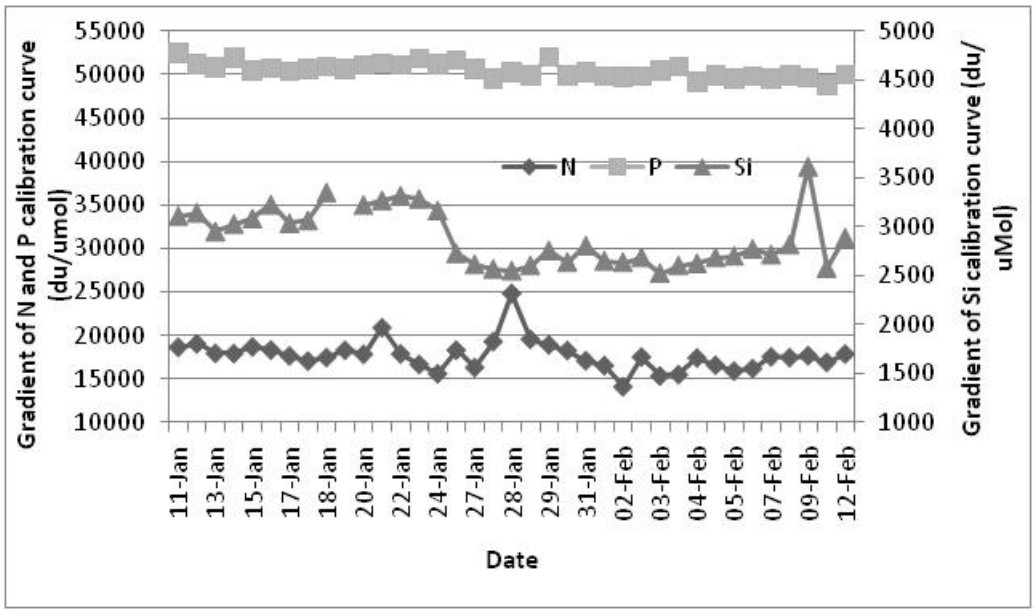
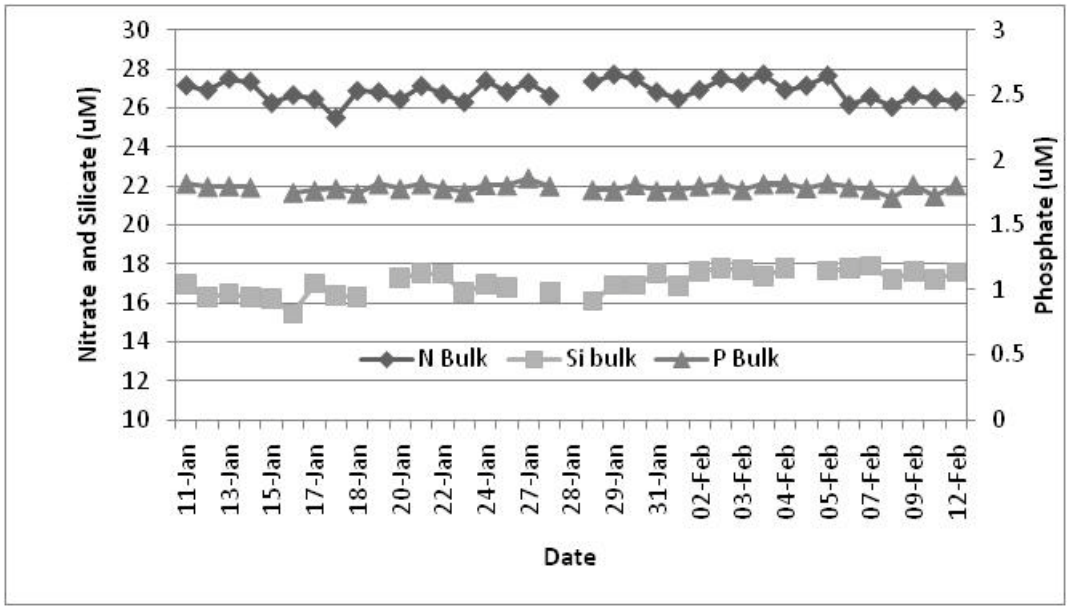


Figure Time series of instrument sensitivity

A bulk water sample was analysed on every run. This serves as an independent check on the analyses and allows for the calculation of an estimate of internal consistency and to monitor any potential degradation in the standards. There was rather little change in time in the bulk deep water sample implying both that it is suitable as in internal reference and that there was no long term degradation of the standards.



Figure, Time series of bulk nutrient concentrations

The mean concentrations of nutrients measured in this sample are shown in Table together with the Nitrate/ Phosphate ratio and the absolute and relative standard deviations of these observations.

	N	P	Si	N/P
Mean	26.9	1.79	17.0	15.07
Standard Deviation	0.5	0.03	0.8	0.25
r.s.d.	1.9	1.6	4.5	1.63

Table, mean concentrations of nutrients observed in the bulk nutrient sample

The standard deviations of the bulk nutrient observations suggest that the level of internal consistency in the data is 2% for N, 1.6% for P and the N/P ratio and 4.5% for silicate with the rather high value for silicate being driven by analyses undertaken on 3 days (16 and 27 Jan and 5 Feb), without which the level of internal consistency improves to 3%. Future work in Southampton will focus on examining the data to improve this level of internal consistency.

<u>Current status of dataset.</u>

A full preliminary dataset has been submitted to the Ships network for usage in calculations. I anticipate a fully quality controlled and calibrated dataset being available in the next 2 months.

Dissolved oxygen cruise report

Dr R Sanders, *NOC*

Dissolved oxygen was analysed on odd bottles from all CTD casts and on samples from titanium CTD casts. The whole bottle winkler method was used with amperometric end point detection. A single batch of thiosulphate was used throughout the cruise. This was calibrated via titration against reference iodate from Ocean Scientific International. Between the period of 21 and 27 January (Stations 20-30) thiosulphate titration volumes became very unstable and increased by up to 10%, the problem was eventually traced to the electrode becoming coated with organic debris. Removal of this improved the precision of the measurements considerably and resulted in the initial average standard titre volumes being resumed. All oxygen concentrations have been calculated using the mean titre value from the periods between 10-21 January and 26 January – 8 February but only data from the period when the thiosulphate was stable have been archived to the network.

The CTD oxygen sensor on the stainless rosette appears to have been operating well (Figures 1-3) and similarly on both sides of the period when the data is of suspect quality, suggesting that a producing a full high quality oxygen data set for the middle part of the cruise should be feasible.

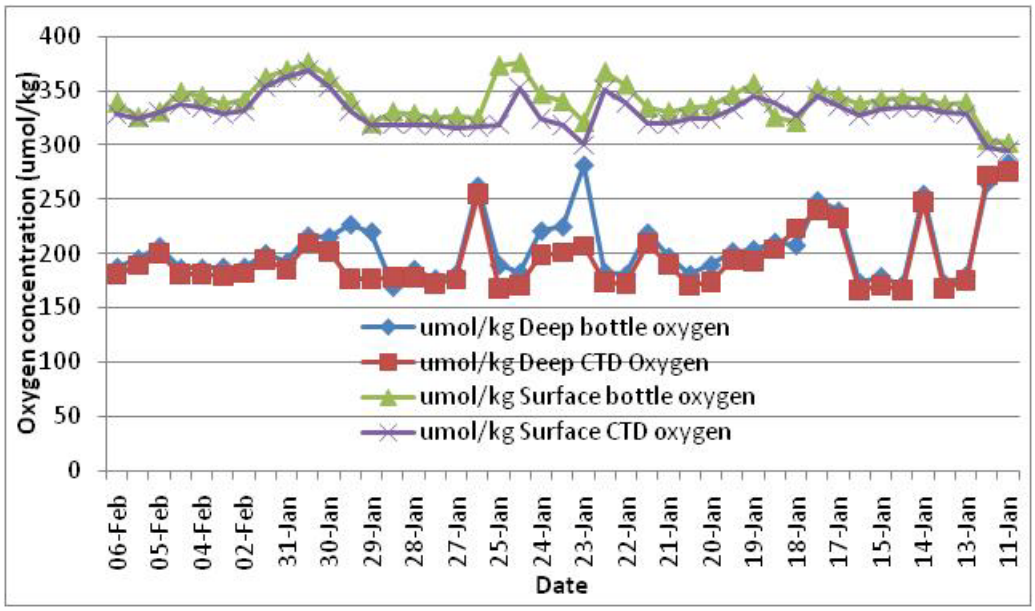


Figure 1. Comparison of oxygen concentrations from surface and 300m bottles on the Stainless Steel Rosette. The period during the middle part of the cruise when the oxygen data is of reduced quality is clearly visible.

Figure 2. Regression between surface oxygen concentrations from the stainless steel sensor and from bottle samples, excluding stations in the central part of the cruise when the data is of reduced quality.

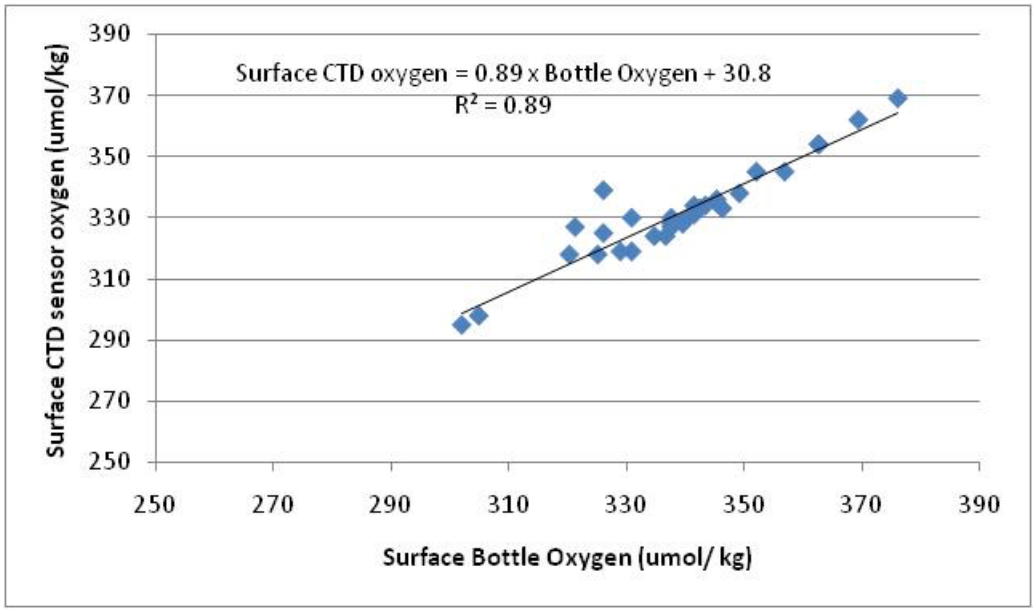
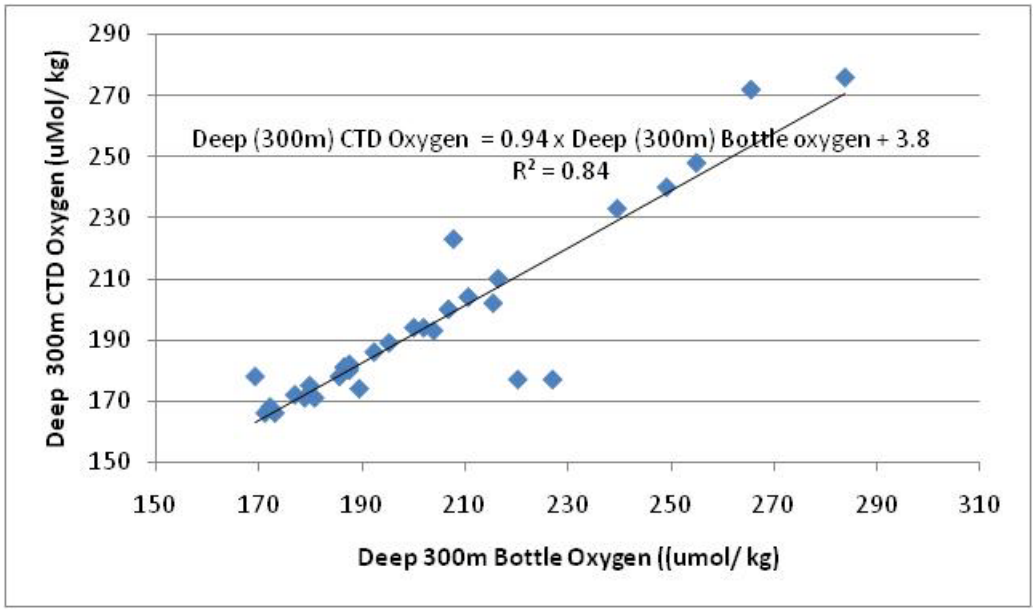
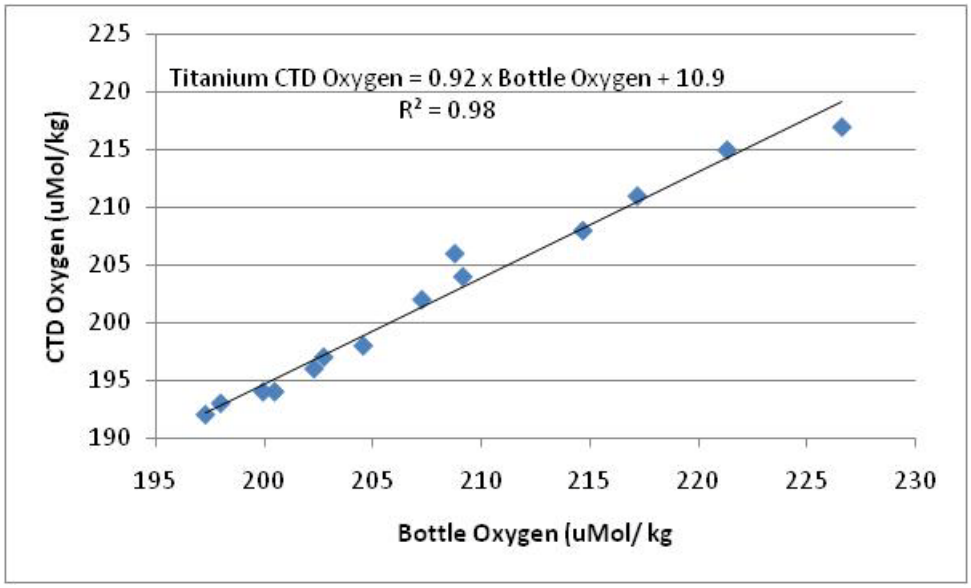


Figure 3. Regression between 300m oxygen concentrations from the stainless steel sensor and from bottle samples, excluding stations in the central part of the cruise when the data is of reduced quality.



Oxygen samples were also drawn from the titanium rosette on all casts except those which were used to take bioassay samples. Most of these, (including all the very deep casts) took place after the point at which thiosulphate stability was restored. We have not managed a full calibration of the titanium sensor however a comparison from the final station suggests that the sensor is working well (Figure 4)

Figure 4, comparison of bottle and CTD oxygen from the final titanium cast (Cast 77, Station 48)


Titanium CTD Oxygen = 0.92 x Bottle Oxygen + 10.9
R² = 0.98
CTD Oxygen (uMol/kg)
Bottle Oxygen (uMol/ kg
225
220
215
210
205
200
195
190
195
200
205
210
215
220
225
230

Carbonate Chemistry from on-board experiments

Eithne Tynan, Mariana Ribas-Ribas and Matthew P. Humphreys

(Ocean and Earth Science, National Oceanography Centre, Southampton)

Objectives:

The objectives on this cruise were to provide carbonate chemistry measurements from the bioassays in order to determine the initial conditions and to monitor the carbonate chemistry throughout the experiments. Dissolved Inorganic Carbon (DIC) and Total Alkalinity (TA) samples were collected from the bioassay CTDs before any experiment bottles were filled. The samples were analysed immediately in order to determine the initial conditions and to calculate the amount of bicarbonate and hydrochloric acid solutions to add for each treatment. DIC and TA were also measured in each treatment just after spiking in order to check the initial targets.

Sampling protocol:

The sampling procedure used for the initial Dissolved Inorganic Carbon and Total Alkalinity measurements followed Dickson et al. (2007). For the initial conditions, one surface sample from each of the CTDs, plus one deep sample from the deeper cast were collected in 250 ml Schott Duran borosilicate glass bottles with glass stopper. Samples were taken straight after the Niskin bottle was opened. A piece of silicone tubing was used for the sampling and care was taken to prevent any air bubbles being trapped in the sample. The bottle was air-tight sealed with a glass stopper and the samples were analysed immediately (within 1 hour of sampling).

The T0 samples were collected directly after carbonate chemistry manipulation. They were immediately poisoned with a saturated solution of mercuric chloride (10 µl) and analysed the same day.

T1 and T2 samples were collected in 40 ml EPA vials and were immediately poisoned with a saturated solution of mercuric chloride (10 µl) and analysed within two days.

Samples collected:

Samples for initial DIC and TA were collected from each bioassay cast and samples for DIC and TA monitoring were collected from all experiment time-point bottles.

Sample analysis:

The instrument used for the determination of DIC was the Apollo AS-C3 (Apollo SciTech, USA; Figure 1). The system uses a LI-COR (7000) CO_2 infrared analyser as a detector, a mass-flow-controller to precisely control the carrier gas (N_2) flow, and a digital pump for transferring accurate amounts of

reagent and sample. Phosphoric acid (10%) was used to convert all the CO_2 species. The sample volume was set to 0.75 ml for the whole cruise. The system generally achieved a precision of 0.1% or better. Certified Reference Materials (batch 109) from A.G. Dickson (Scripps Institution of Oceanography) were used as standards to calibrate the system at the beginning of each day of analysis.

The instrument used for the determination of TA was the Apollo AS-ALK2 (Apollo SciTech, USA; Figure 1). The system is equipped with a combination pH electrode (8102BNUWP, Thermo Scientific, USA) and temperature probe for temperature control (Star ATC probe, Thermo Scientific, USA) connected to a pH meter (Orion 3 Star benchtop pH meter, Thermo Scientific, USA). Each seawater sample was titrated with hydrochloric acid 0.1 M using an open-cell titration (Dickson et al. 2007). All TA samples were analyzed at 25 ºC (±0.1 ºC) with temperature regulation using a water-bath (GD120, Grant, UK). The acid is added in small increments and the electromotive force monitored for every step until the carbonic acid equivalence point is reached (protonation of carbonate and bicarbonate ions). The system conducts an automated Gran titration. Certified Reference Materials (batch 109) from A.G. Dickson (Scripps Institution of Oceanography) were used as standards to standardize the acid at the beginning of each day of analysis.

All DIC and TA samples were analysed on board. No major problem was encountered with the analysis.

References:

Dickson, A.G., Sabine, C.L., Christian, J.R. (Eds.) 2007. Guide to best practices for ocean CO_2 measurements. PICES Special Publication 3, IOCCP report No. 8, 191 pp.

Figure 1. Apollo AS-C3 (left) and AS-ALK2 (right) used for the determination of Dissolved Inorganic Carbon and Total Alkalinity.

JR274 Cruise Report: pH measurements

Jennifer Clarke *(School of Ocean and Earth Science, NOCS)*

Introduction

The carbonate system is a key component of the chemical perspective of oceanography as it plays an important role in the oceans' capacity to take up atmospheric CO_2. Dissolved inorganic carbon (DIC) is present in seawater in three forms ($CO_{2\ (aq)}$, HCO_3^- and CO_3^{2-}) which are in equilibrium on timescale longer than a few minutes. In oceanography, the carbonate system can be determined by four parameters: DIC, pCO_2, alkalinity and pH (Millero 1995; Zeebe and Wolf-Gladrow 2005; Millero 2007).

This project aims to measure seawater pH. This cruise was an opportunity for me to test my pH sensor based on an immobilised indicator in a membrane, and analysis based on time-domain dual-luminophore referencing (Liebsch et al. 2001; Schroeder et al. 2005; Stahl et al. 2006). I also was testing the spectrophotometric sensors developed by Victoire Rerolle at NOCS ((Rérolle et al. 2012)), as used on the JR271 cruise to the arctic earlier this year. In the last leg of the cruise the immobilised pH indicator was switched for an untested pCO_2 indicator based on similar technology (Liebsch et al. 2000; Neurauter et al. 2000).

Objectives

To test developmental pH sensors from NOC: one discrete system based on spectrophotometric measurement of meta-cresol purple, two continuous systems with one based on spectrophotometric measurement of thymol blue and one based on an immobilized indicator in a membrane.

Method

pH sensor- pH is measured by adding a colored indicator to the seawater sample and measuring the color of the mix. The indicators used are 2 mM thymol blue for the underway system and 2 mM meta-cresol purple for the discrete samples. The pH sensors have been developed at the NOCS (Sensor group). The immobilized indicator was purchased from PreSens and attached to a fibre optic cable using silicone rubber glue.

Underway measurements- The automated spectrophotometric pH system was running continuously on the non-toxic water supply from the 15/01/2013 to the 8/02/2013. The immobilized pH indicator system was running continuously from 9/01/2013 to 2/02/2013. From the 2/02/2013 the immobilized pH indicator was replaced by the immobilized pCO_2

indicator which ran continuously until 12/02/2013. Measurements were only interrupted for system performance checking, maintenance and when the non-toxic water supplied was stopped. The spectrophotometric sensor further filtered the seawater using a 0.45 ul Millipore filter, where the immobilized indicator used water straight from the underway.

Discrete sample measurements- The discrete pH sensor however had electronic and sealant problems discovered early on in mobilization/first leg of the cruise and remained unused.

The performance of the system is evaluated by running certified reference material (Tris buffer) provided by the Scripps Institute of Oceanography. The consistency of the data will be checked thanks to continuous pCO_2 measurements (see Carbonate chemistry cruise report), DIC/Alkalinity sampled on the underway supply every two hours (see Carbonate chemistry cruise report) and trends in other parameters such as chlorophyll, temperature, salinity and nutrients. Further analysis and temperature/salinity corrections will be performed at the NOCS.

References

Liebsch, G., I. Klimant, et al. (2000). "Luminescence lifetime imaging of oxygen, ph and carbon dioxide distribution using optical sensors." Applied Spectroscopy **54**(4): 548-559.

Liebsch, G., I. Klimant, et al. (2001). "Fluorescent Imaging of pH with Optical Sensors Using Time Domain Dual Lifetime Referencing." Analytical Chemistry **73**(17): 4354-4363.

Millero, F. J. (1995). "Thermodynamics of the carbon dioxide system in the oceans." Geochimica et Cosmochimica Acta **59**(4): 661-677.

Millero, F. J. (2007). "The Marine Inorganic Carbon Cycle." Chemical Reviews **107**(2): 308-341.

Neurauter, G., I. Klimant, et al. (2000). "Fiber-optic microsensor for high resolution pCO_2 sensing in marine environment." Fresenius Journal of Analytical Chemistry **366**: 481-487.

Rérolle, V. M. C., C. F. A. Floquet, et al. (2012). "Seawater-pH measurements for ocean-acidification observations." TrAC Trends in Analytical Chemistry **40**: 146-157.

Schroeder, C. R., B. M. Weidgans, et al. (2005). "pH Fluorosensors for use in marine systems." Analyst **130**(6): 907-916.

Stahl, H., A. Glud, et al. (2006). "Time-resolved pH imaging in marine sediments with a luminescent planar optode." Limnology and Oceanography: Methods **4**: 336-345.

Zeebe, R. E. and D. A. Wolf-Gladrow (2005). CO_2 in Seawater: Equilibrium, Kinetics, Isotopes. Oxford, Elsevier.

In situ Observations of Partial Pressure of Carbon Dioxide on Ocean Acidification JR274

Mariana Ribas Ribas, Dorothee C.E. Bakker and Gareth Lee, School of Ocean and Earth *Science, University of Southampton, NOCS and School of Environmental Sciences, University of East Anglia, Norwich, UK*

Partial pressure of CO_2 in surface water and marine air

Continuous measurements of the partial pressure of CO_2 (pCO_2) in surface water and marine air were made throughout the cruise by infrared detection on a LI-COR 7000. The ship's seawater supply provided water for underway sampling from 5 m depth at the bow to the main lab. Temperature and salinity of the intake water were determined by the ship's sensors.

Seawater flowed through an equilibrator. Part of the water went to waste via a bypass. The equilibrator was operated at a flow rate of 0.8 to 1.8 L min^{-1}.

Marine air was pumped through tubing from the monkey island. Two Pt-100 probes accurately determined the water temperature in the equilibrator. A long vent kept the headspace of the equilibrator close to atmospheric pressure. The CO_2 content and the moisture content of the headspace were determined by an infrared LI-COR 7000 analyser. The analysis of the CO_2 content in the headspace was interrupted at regular intervals for that of the CO_2 content in marine air and in four CO_2 standards. Samples from the equilibrator headspace and marine air were partly dried to 10°C below the ambient temperature in an electric cool box. The standards bought from BOC of 0, 250, 350 and 450 µmol CO_2 mol^{-1} in a nitrogen and oxygen mixture had been calibrated against certified NOAA standards prior to the cruise and will be recalibrated after the cruise at UEA. The analyses were carried out for a flow speed of 100 ml min^{-1} through the LI-COR at a slight overpressure. A final analysis for each parameter was made at atmospheric pressure with no flow. The flow and overpressure did not have a discernable effect on the CO_2 and moisture measurements, once the pressure had been corrected for.

The correction by Takahashi et al. (1993) will be used to correct for warming of the seawater between the ship's water intake and the equilibrator. Our own GPS stop working on 23/01/2012. I adjust the PC clock with the boat clock and take a careful note. We will then synchronized the ship GPS with our dataset. The pCO_2 data await data quality control. The Mass Flow control and temperature readings were lost for one day (1 to 2 February). This means that it is kind of impossible to Quality Control these pCO_2 data.

The data look reasonable for the first days of the cruise (the only we analysed) with a dummy correction for warming in the absence of SST for the moment.

Ammonium measurements in water column and zooplankton experiments on cruise JR274

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Introduction

My contribution towards the research activities on the cruise consisted of undertaking ship-board measurements of ammonium in water column samples at all stations and in zooplankton experiments.

Materials and methods

Samples for water column measurements of ammonium were taken from the 20 L OTE bottles deployed on the stainless steel CTD rosette frame. Samples were taken on a daily basis, and all CTD stations sampled with the stainless frame were covered. Samples for ammonium were collected in polypropylene vials and reagent added, with subsequent fluorimetric analysis 24 h later. The method by Kerouel, Aminot (1997) was followed, allowing nanomolar ammonium concentrations to be determined. Typically 8-10 depths were covered for a CTD cast.

Ammonium measurements were also undertaken in the zooplankton respiration and zooplankton pCO_2 perturbation experiments. For this purpose, 10 ml of sample was poured from the incubation bottles into a polypropylene vial and reagent was added. The same protocol as for the water column samples was followed.

Results

Ammonium measurements at sea were successful. The concentrations were typically lower in the surface mixed layer (typically 200-400 nM) with enhanced concentrations (typically between 400-900 nM, but as high as 2 to 3 μM) at depth below the mixed layer as a result of bacterially mediated organic matter remineralisation. At the deeper stations, the ammonium concentrations decreased to < 10 nM at depths below ca. 150 m.

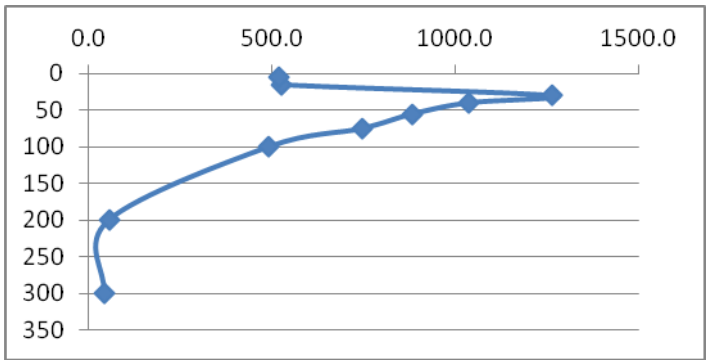

Figure 1 shows an example of a depth profile for station 13, with depth in meters on y axis and ammonium concentrations in nM on x axis.

Acknowledgements

We want to thank the captain, officers and crew of the RRS *James Clark Ross* for support during the cruise.

Literature.

Kerouel, R., Aminot, A. (1997). *Marine Chemistry* 57: 265-275.

Dissolved Organic Carbon (DOC) and Transparent Exopolymer Particles (TEP)

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1. Introduction

Oceanic dissolved organic carbon (DOC) is one of the major carbon reservoirs on Earth and plays an important role in the carbon cycle. The export of organic carbon can be accelerated by transparent exopolymer particles (TEP). TEP are carbon-rich and polymeric gel particles derived from dissolved or colloidal polysaccharides, produced as a result of algal cellular carbon overflow (Passow, 2002).

Mesocosm and ship-board studies have found increased dissolved inorganic carbon consumption and organic carbon production at high CO_2 levels (Egge, Thingstad, Larsen, & Engel, 2009; Feng et al., 2009), but some studies have not (Tortell, Payne, & Gueguen, 2008). Nutrient limitation has been shown to enhance organic carbon production at high CO_2 (Egge et al., 2009). TEP production may also increase in response to nutrient limitation and extracellular organic matter production at elevated pCO2 levels. Engel *et al.* (2004) have found increased TEP production at high CO_2 levels, but no significant changes in DOC production.

2. Objectives

The objectives of the study are: 1. to investigate the vertical distributions of DOC and TEP in surface waters across natural carbonate chemistry gradients; 2. to study the effects of pCO_2 perturbations on DOC and TEP production in incubation experiments with natural phytoplankton communities.

3. Methodology

- *DOC sampling and analysis*

Seawater samples were taken from CTD casts and pCO_2 perturbation bioassay experiments. Sampling details are shown in the tables at the end of this report. Water taken from shallower than 300 m from CTD niskin bottles was filtered using pre-combusted (450 °C, > 5 h) GF/F filters to remove the particulate carbon and most organisms in the seawater. All samples from bioassay experiments were filtered. Samples were collected into pre-combusted glass vials and acidified to pH < 2 by adding 40 µL 50% HCl immediately after

collection. The vials were then closed with acid-cleaned PTFE lined polypropylene caps and stored in fridge (4 °C) for post-cruise analysis on return to the UK.

DOC samples will be analysed using the high temperature combustion technique. The principle of this technique is to combust the dissolved organic carbon compounds in the samples into CO_2 and measure the amount of generated CO_2. Filtered and acidified seawater samples are to be sparged with oxygen to remove dissolved inorganic carbon from the water and then injected into a combustion column. The non-purgeable organic carbon in the sample is combusted at 680 °C and converted to CO_2, which can be detected by a non-dispersive infrared detector (NDIR). A Shimadzu TOC-TDN instrument (TOC V_{CPN}) will be used for DOC analysis.

- *TEP sampling and analysis*

Seawater was taken from CTD casts and bioassay experiments. Sampling details are shown in the tables at the end of this report. TEP were collected by filtering the seawater through 0.4 µm pore-size polycarbonate filters (25 mm in diameter) at constant 200 mBar vacuum. Three replicates were filtered for each sample. The particles retained on the filters were stained with 500 µL of 0.02% aqueous Alcian Blue in 0.06% acetic acid (pH = 2.5). The dye was pre-filtered with 0.2 µm pore-size polycarbonate filters before use. After being stained, filters were rinsed once with Milli-Q water and put into 15 mL polypropylene centrifuge tubes. Filters were then stored in freezer at - 20 °C for post-cruise analysis on return to the UK.

TEP will be analysed using a colorimetric technique. The particles can be detected by staining with Alcian Blue, a cationic copper phthalocyanine dye that combines with carboxyl (-COO-) and half-ester sulphate (-OSO3-) reactive groups of acidic polysaccharides (Passow & Alldredge 1995). The amount of Alcian Blue adsorbed onto the filter is directly related to the weight of the polysaccharide retained on the filter (Passow & Alldredge 1995). The filters will be soaked in 6 mL of 80% sulphuric acid for 2 h to dissolve the adsorbed Alcian Blue. The absorbance of the solution at 787 nm (absorption maximum) will be measured using Hitachi U-1800 spectrophotometer.

4. References

Egge, J., Thingstad, T., Larsen, A., & Engel, A. (2009). Primary production during nutrient-induced blooms at elevated CO2 concentrations. *Biogeosciences*, *6*, 877–885. doi:10.5194/bg-6-877-2009

Engel, A., Delille, B., Jacquet, S., Riebesell, U., Rochelle-Newall, E., Terbrüggen, A., & Zondervan, I. (2004). Transparent exopolymer particles and dissolved organic carbon

production by Emiliania huxleyi exposed to different CO2 concentrations: a mesocosm experiment. *Aquatic Microbial Ecology*, *34*, 93–104. doi:10.3354/ame034093

Feng, Y., Hare, C., Leblanc, K., Rose, J., Zhang, Y., DiTullio, G., Lee, P., et al. (2009). Effects of increased pCO2 and temperature on the North Atlantic spring bloom. I. The phytoplankton community and biogeochemical response. *Marine Ecology Progress Series*, *388*, 13–25. doi:10.3354/meps08133

Passow, U. (2002). Transparent exopolymer particles (TEP) in aquatic environments. *Progress In Oceanography*, *55*(3-4), 287–333. doi:10.1016/S0079-6611(02)00138-6

Passow, U., & Alldredge, A. (1995). A dye-binding assay for the spectrophotometric measurement of transparent exopolymer particles (TEP). *Limnology and Oceanography*, *40*(7), 1326–1335. Retrieved from http://www.jstor.org/stable/2838691

Tortell, P., Payne, C., & Gueguen, C. (2008). Inorganic carbon uptake by Southern Ocean phytoplankton. *Limnology and Oceanography*, *53*(4), 1266–1278. Retrieved from http://www.jstor.org/stable/10.2307/40058250

5. Sampling details

Table 1. Details of sampling from CTDs

Date	Station	CTD	Type	Niskin	Depth [m]	DOC	TEP
2013/01/11	1	2	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	85	√	√
				11	50	√	
				13	35	√	√
				17	20	√	
				19	10	√	√
				21	5	√	√
2013/01/11	2	4	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	60	√	√
				9	45	√	√
				13	30	√	
				15	20	√	√
				19	10	√	
				21	5	√	√
2013/01/13	3	9	SS CTD	1	300	√	
				3	200	√	
				5	120	√	
				7	80	√	√
				11	60	√	
				13	40	√	√
				17	25	√	√
				19	10	√	
				21	5	√	√
2013/01/14	4	10	SS CTD	1	300	√	
				3	200	√	
				5	120	√	
				7	80	√	
				9	65	√	√
				14	35	√	
				15	20	√	√
				19	10	√	√
				21	5	√	√

2013/01/14	5	11	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	50	√	√
				13	35	√	
				15	25	√	√
				19	15	√	
				21	5	√	√
2013/01/15	6	12	SS CTD	1	300	√	
				3	180	√	
				5	120	√	
				7	65	√	√
				11	50	√	
				13	35	√	√
				15	20	√	
				17	10	√	√
				21	5	√	√
2013/01/15	7	13	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	60	√	
				11	45	√	√
				15	30	√	
				17	15	√	√
				21	5	√	√
2013/01/16	8	14	SS CTD	1	300	√	
				3	200	√	
				5	130	√	
				7	90	√	
				9	70	√	√
				11	50	√	
				13	35	√	√
				15	20	√	√
				19	10	√	
				21	5	√	√
2013/01/16	9	15	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	65	√	
				9	50	√	√
				13	35	√	√
				15	25	√	
				17	15	√	√

				21	5	√	√
2013/01/17	10	16	SS CTD	1	300	√	
				3	130	√	
				5	80	√	
				7	60	√	√
				9	40	√	
				11	30	√	√
				15	20	√	
				17	10	√	√
				21	5	√	√
2013/01/17	11	17	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	45	√	√
				13	35	√	
				15	25	√	√
				19	15	√	
				21	5	√	√
2013/01/18	12	22	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	55	√	√
				14	35	√	
				15	20	√	√
				19	10	√	
				21	5	√	√
2013/01/19	13	23	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	55	√	
				11	40	√	√
				15	30	√	
				17	15	√	√
				21	5	√	√
2013/01/19	14	24	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	50	√	√
				13	35	√	
				15	25	√	√
				19	15	√	

				21	5	√	√
2013/01/20	16	26	SS CTD	2	300	√	
				4	210	√	
				5	140	√	
				7	90	√	
				9	65	√	√
				11	40	√	√
				15	30	√	
				17	15	√	√
				21	5	√	√
2013/01/20	17	27	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	50	√	√
				13	35	√	
				15	25	√	√
				19	15	√	
				21	5	√	√
2013/01/21	19	28	SS CTD	1	300	√	
				3	200	√	
				5	120	√	
				7	80	√	
				11	60	√	√
				13	50	√	
				15	35	√	√
				17	20	√	√
				21	10	√	√
2013/01/21	20	29	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	60	√	√
				13	45	√	
				17	30	√	√
				19	15	√	
				21	5	√	√
2013/01/22	22	31	SS CTD	1	300	√	
				3	150	√	
				5	100	√	
				7	75	√	√
				11	50	√	
				13	35	√	√
				15	25	√	
				17	10	√	√

				21	5	√	√
2013/01/22	23	32	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	45	√	√
				13	35	√	
				15	25	√	√
				19	15	√	
				21	5	√	√
2013/01/23	25	34	SS CTD	3	200	√	
				5	110	√	
				7	75	√	√
				9	50	√	
				11	40	√	√
				15	25	√	√
				19	10	√	
				21	5	√	√
2013/01/23	26	35	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	85	√	
				9	75	√	√
				11	50	√	
				13	40	√	√
				17	20	√	√
				21	5	√	√
2013/01/24	27	36	SS CTD	2	300	√	
				3	200	√	
				5	150	√	
				7	100	√	
				9	75	√	
				11	50	√	√
				15	30	√	√
				17	15	√	√
				21	5	√	√
2013/01/24	28	38	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	
				9	50	√	√
				13	40	√	
				15	30	√	√
				17	20	√	
				19	10	√	√

				21	5	√	√
2013/01/24	28	39	Ti CTD	1	800	√	
				5	700	√	
				2	600	√	
				14	500	√	
				3	400	√	
2013/01/25	29	44	SS CTD	1	300	√	
				3	200	√	
				5	115	√	
				7	80	√	
				9	60	√	√
				14	40	√	
				15	25	√	√
				19	10	√	√
				21	5	√	√
2013/01/25	29	45	Ti CTD	2	1400	√	
				5	1200	√	
				6	1000	√	
				3	800	√	
				1	600	√	
				14	400	√	
2013/01/27	30	46	SS CTD	1	240	√	
				3	200	√	
				5	150	√	
				7	100	√	
				9	75	√	√
				13	50	√	√
				15	30	√	
				17	15	√	√
				19	surface	√	√
2013/01/27	31	47	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	50	√	√
				13	35	√	
				15	25	√	√
				19	18	√	
				21	10	√	√
2013/01/27	31	48	Ti CTD	2	1400	√	
				5	1200	√	
				6	1000	√	
				3	800	√	
				1	600	√	
				14	400	√	

2013/01/28	32	49	SS CTD	1	300	√	
				3	200	√	
				5	150	√	
				7	100	√	
				9	75	√	√
				11	60	√	
				13	50	√	√
				15	35	√	
				17	20	√	√
				21	10	√	√
2013/01/28	32	50	Ti CTD	1		√	
				2		√	
				3		√	
				5		√	
				6		√	
				14		√	
2013/01/28	33	52	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	45	√	√
				13	35	√	
				15	25	√	√
				19	15	√	
				21	5	√	√
2013/01/29	34	53	SS CTD	1	300	√	
				3	200	√	
				5	110	√	
				7	75	√	√
				9	60	√	
				11	45	√	√
				15	30	√	
				17	15	√	√
				21	5	√	√
2013/01/29	35	55	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	50	√	√
				13	40	√	
				15	25	√	√
				19	15	√	
				21	5	√	√
2013/01/30	36	56	SS CTD	1	300	√	
				3	200	√	

				5	130	√	
				7	80	√	
				9	50	√	√
				13	30	√	
				15	20	√	√
				19	10	√	√
				21	5	√	√
2013/01/30	36	57	Ti CTD	2	1400	√	
				14	1200	√	
				1	1000	√	
				6	800	√	
				5	700	√	
				4	600	√	
				18	500	√	
				3	400	√	
2013/01/30	37	58	SS CTD	1	300	√	
				3	200	√	
				5	110	√	
				7	75	√	√
				9	50	√	√
				13	35	√	
				15	25	√	√
				19	15	√	
				21	5	√	√
2013/01/31	38	59	SS CTD	1	300	√	
				3	200	√	
				5	130	√	
				7	65	√	√
				9	50	√	√
				13	30	√	
				15	20	√	√
				19	10	√	
				21	5	√	√
2013/01/31	38	60	Ti CTD	2	1400	√	
				14	1200	√	
				1	1000	√	
				6	800	√	
				5	700	√	
				4	600	√	
				18	500	√	
				3	400	√	
2013/01/31	39	61	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	65	√	√

				9	55	√	
				11	45	√	
				13	30	√	√
				17	15	√	√
				21	5	√	√
2013/02/01	40	66	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	50	√	√
				13	30	√	
				15	20	√	√
				19	10	√	
				21	5	√	√
2013/02/01	40	67	Ti CTD	2D	1400	√	
				1	1200	√	
				14D	1000	√	
				6D	800	√	
				18	700	√	
				3D	600	√	
				5	500	√	
				1D	400	√	
2013/02/02	42	68	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	50	√	√
				14	40	√	
				15	30	√	
				17	20	√	√
				21	10	√	√
2013/02/03	43	69	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	65	√	√
				11	45	√	
				13	30	√	√
				15	20	√	√
				19	10	√	
				21	5	√	√
2013/02/03	43	70	Ti CTD	18D	1800	√	
				8	4888	√	
				9	4788	√	
				13	4500	√	
				24	4200	√	

				16	3900	√	
				11	3600	√	
				5	3200	√	
				20	2800	√	
				21	2400	√	
				7	2000	√	
				17	1600	√	
				6D	1400	√	
				3D	1200	√	
				5D	1050	√	
				1DD	900	√	
				2D	750	√	
				1D	600	√	
				14D	450	√	
2013/02/04	44	71	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	70	√	√
				9	50	√	
				11	40	√	√
				15	25	√	
				17	15	√	√
				21	5	√	√
2013/02/04	44	72	Ti CTD	11	4000	√	
				5	3700	√	
				20	3400	√	
				21	3100	√	
				8	2800	√	
				7	2500	√	
				17	2200	√	
				13	1900	√	
				9	1650	√	
				22	1400	√	
				14D	1200	√	
				2D	1000	√	
				18D	900	√	
				1D	800	√	
				6D	700	√	
				1DD	600	√	
				5D	500	√	
				3D	400	√	
				24	4290	√	
				16	4190	√	
2013/02/04	45	73	SS CTD	1	300	√	
				3	200	√	

				5	100	√	
				7	70	√	√
				9	55	√	
				11	40	√	
				13	25	√	√
				17	15	√	√
				21	5	√	√
2013/02/05	46	74	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	70	√	√
				9	50	√	
				13	30	√	√
				15	20	√	
				17	10	√	√
				21	5	√	√
2013/02/05	46	75	Ti CTD	8	2450	√	
				21	2200	√	
				9	2000	√	
				13	1800	√	
				7	1600	√	
				17	1400	√	
				14D	1200	√	
				2D	1000	√	
				1D	900	√	
				18D	800	√	
				6D	700	√	
				1DD	600	√	
				5D	500	√	
				3D	400	√	
				22	2550	√	
2013/02/06	48	76	SS CTD	2	300	√	
				3	200	√	
				5	100	√	
				7	85	√	
				9	75	√	√
				11	55	√	√
				15	35	√	
				17	20	√	√
				21	10	√	√
2013/02/06	48	77	Ti CTD	20	2760	√	
				13	2600	√	
				21	2200	√	
				7	2000	√	
				8	1800	√	

				22	1600	√	
				17	1400	√	
				2D	1000	√	
				1D	900	√	
				18D	800	√	
				6D	700	√	
				1DD	600	√	
				5D	500	√	
				3D	400	√	
				11	2860	√	
2013/02/06	49	78	SS CTD	1	300	√	
				3	200	√	
				5	100	√	
				7	75	√	√
				9	50	√	√
				13	40	√	
				15	30	√	√
				19	20	√	
				21	10	√	√

Table 2. Details of sampling from the bioassay experiments

Experiment	Date	Incubation Time [h]	Bottle no.	DOC	TEP
1	13/01/2013	0	T01	√	√
			T02	√	√
			T03	√	√
	14/01/2013	24	ZJR274E01Z01	√	√
			ZJR274E01Z04	√	√
			ZJR274E01Z06	√	√
			ZJR274E01Z10	√	√
	15/01/2013	48	1	√	√
			2	√	√
			3	√	√
			19	√	√
			20	√	√
			21	√	√
			37	√	√
			38	√	√
			39	√	√
			55	√	√
			56	√	√
			57	√	√
	17/01/2013	96	10	√	√

			11	√	√
			12	√	√
			28	√	√
			29	√	√
			30	√	√
			46	√	√
			47	√	√
			48	√	√
			64	√	√
			65	√	√
			66	√	√
			ZJR274E01Z14	√	√
			ZJR274E01Z17	√	√
			ZJR274E01Z19	√	√
			ZJR274E01Z23	√	√
Experiment	Date	Incubation Time [h]	Bottle no.	DOC	TEP
2	18/01/2013	0	T01	√	√
			T02	√	√
			T03	√	√
	19/01/2013	24	ZJR274E02Z01	√	√
			ZJR274E02Z04	√	√
			ZJR274E02Z06	√	√
			ZJR274E02Z10	√	√
	21/01/2013	72	1	√	√
			2	√	√
			3	√	√
			19	√	√
			20	√	√
			21	√	√
			37	√	√
			38	√	√
			39	√	√
			55	√	√
			56	√	√
			57	√	√
	22/01/2013	96	ZJR274E02Z14	√	√
			ZJR274E02Z17	√	√
			ZJR274E02Z19	√	√
			ZJR274E02Z23	√	√
	24/01/2013	144	10	√	√
			11	√	√
			12	√	√
			28	√	√
			29	√	√
			30	√	√
			46	√	√

			47	√	√
			48	√	√
			64	√	√
			65	√	√
			66	√	√
Experiment	Date	Incubation Time [h]	Bottle no.	DOC	TEP
3	25/01/2013	0	T01	NA	NA
			T02	√	√
			T03	√	√
	26/01/2013	24	ZJR274E03Z01	√	√
			ZJR274E03Z04	√	√
			ZJR274E03Z06	√	√
			ZJR274E03Z10	√	√
	28/01/2013	72	1	√	√
			2	√	√
			3	√	√
			19	√	√
			20	√	√
			21	√	√
			37	√	√
			38	√	√
			39	√	√
			55	√	√
			56	√	√
			57	√	√
	29/01/2013	96	ZJR274E03Z14	√	√
			ZJR274E03Z17	√	√
			ZJR274E03Z19	√	√
			ZJR274E03Z23	√	√
	31/01/2013	144	10	√	√
			11	√	√
			12	√	√
			28	√	√
			29	√	√
			30	√	√
			46	√	√
			47	√	√
			48	√	√
			64	√	√
			65	√	√
			66	√	√
Experiment	Date	Incubation Time [h]	Bottle no.	DOC	TEP
4	01/02/2013	0	T01	√	√
			T02	√	√
			T03	√	√

	02/02/2013	24	ZJR274E04Z01	√	√
			ZJR274E04Z04	√	√
			ZJR274E04Z06	√	√
			ZJR274E04Z10	√	√
	05/02/2013	96	1	√	√
			2	√	√
			3	√	√
			19	√	√
			20	√	√
			21	√	√
			37	√	√
			38	√	√
			39	√	√
			55	√	√
			56	√	√
			57	√	√
			ZJR274E03Z14	√	√
			ZJR274E03Z17	√	√
			ZJR274E03Z19	√	√
			ZJR274E03Z23	√	√
	08/02/2013	168	10	√	√
			11	√	√
			12	√	√
			28	√	√
			29	√	√
			30	√	√
			46	√	√
			47	√	√
			48	√	√
			64	√	√
			65	√	√
			66	√	√

References

Takahashi, T., J. Olafsson, J.G. Goddard, D.W. Chipman, S.C. Sutherland (1993) Seasonal variation of CO_2 and nutrients in the high-latitude surface oceans: a comparative study. Global Biogeochemical Cycles 7, 843-878.

Assessing the effects of ocean acidification on dimethyl sulfide (DMS), dimethyl sulfoniopropionate (DMSP) and associated processes in the Southern Ocean.

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Introduction

Oceanic emission of the trace gas dimethyl sulfide (DMS) is the major source of reduced sulfur into the marine boundary layer, influencing atmospheric chemistry (von Glasow et al. 2004) and contributing to the radiative properties of oceanic clouds (Ayers et al 1991, Charlson et al. 1987, Korhonen et al 2008). DMS is an enzymatic breakdown product of dimethylsulfoniopropionate (DMSP) synthesised by phytoplankton. Both DMS and DMSP also contribute significant proportions of the carbon and sulphur flux through microbial foodwebs (Simo et al. 2004) and may play important roles as infochemicals, influencing predator prey interactions (Wolfe et al. 1997). In consequence alterations in atmospheric pCO_2 concentrations that lead to increased sea surface temperature, changes in upper-ocean stratification and decreasing ocean pH are likely to influence the extent of DMS and DMSP production, with potential impacts on climate, ocean biogeochemistry and microbial food web structure and function.

A number of previous studies have recorded responses in net DMS and DMSP production in relation to varied pCO_2, including high-latitude mesocosm experiments (Archer et al., 2013, Hopkins et al., 2010, Wingenter et al., 2007) and ship-board incubation experiments (Lee et al., 2009). However, there remains limited understanding of the mechanisms behind the observed pH-related changes in DMS and DMSP concentrations. Our overarching objective was to improve our understanding of the processes that may alter net DMS production and hence, its emission to the atmosphere, in the face of changing ocean pH in the Southern Ocean.

Objectives and Aims

1. To determine the spatial variability in water column DMS and DMSP concentrations in relation to varied pCO_2, pH and microbial community composition.

2. To quantify DMSP production rates in relation to varied pCO_2 exposure in bioassay experiments and relate this to phytoplankton community composition.

3. To quantify the biological loss rates of DMS in relation to varied pCO_2 exposure in bioassay experiments and thereby determine the rates of gross production of DMS.

Methods

1. DMS and DMSP concentrations: CTD profiles

Seawater samples for DMS and DMSP were directly taken from Niskin bottles, and collected in 250 ml amber glass-stoppered bottles. The bottle was rinsed three times before being filled gently from the bottom through the Tygon tubing, and then allowed to over-flow 2 – 3 times. Once full, the glass stopper was securely placed on the bottle, ensuring the presence of no headspace. Samples were kept in a coolbox and analysed within 2 hours. For analysis, 20ml of seawater was gently drawn from the amber bottle into a glass syringe through ¼" nylon tubing. The samples were gently filtered through a stainless steel Millipore filtration unit containing 25mm GF/F filter, directly into a 10ml glass syringe. The addition of air/bubbles was kept to a minimum at all times. 5ml of filtered seawater was injected into a glass purge tower. The sample was purged with He gas for 5 minutes at 60 ml/min, and the sample stream was dried by passing through a stainless steel counterflow nafion drier, at a flow rate of ~180 ml/min. The sample was trapped in a 1/16" PTFE loop held in liquid nitrogen. Once purging was complete, the sample loop was rapidly submerged in boiling water, injecting the sample into a Varian 3800 GC with pulsed flame photometric detector (PFPD). The oven was held at 60°C until DMS eluted at ~3.3 minutes, and for the remainder of the 5 minute runtime run the oven ramped to 250°C.DMS calibrations were performed using alkaline cold-hydrolysis (10M NaOH) of DMSP diluted 3 times in MilliQ, to give working standards in the range 0.03 – 3.3 ng S ml^{-1}. Four to five point calibrations were performed every 2 days throughout the cruise.

Samples for total DMSP were taken from the same amber bottles used for DMS analysis. Once the DMS sample had been removed, the bottle was gently rotated 3 times, and 7ml of seawater was removed using a pipette, and transferred into an 8ml glass vial. Samples were immediately hydrolysed with 1ml 10M NaOH, and analysed after 4 – 6 hours. Where sample storage was required, samples were fixed by addition of 35µl of 50% H_2SO_4, and hydrolysed 4 – 6 hours before analysis. Table 1 lists the CTD casts and depths from which samples for DMS and DMSPt were taken.

Table 1. CTD sample log: DMS and DMSP (total)

Cast	Date & Time (GMT)	Nominal depths & Niskin:							No. samples
CTD002	11/1/2013 10:15	5m	10m	20m	35m	50m	85m		6
		21	19	17	13	11	7		
CTD004	11/1/2013 :20:15	5m	10m	20m	30m	45m	60m	100m	7
		21	19	17	13	9	7	5	
CTD009	13/1/2013 12:00	5m	10m	25m	40m	60m	80m		6
		21	19	17	13	11	9		

CTD010	14/1/2013 09:30	5m	10m	20m	35m	65m	80m		6
		21	19	17	14	9	7		
CTD011	14/1/2013 20:15	5m	15m	25m	35m	50m	75m		6
		21	19	15	13	9	7		
CTD013	15/1/2013 20:15	5m	15m	30m	45m	60m	75m	100m	7
		21	17	15	11	9	7	5	
CTD014	16/1/2013 09:30	5m	10m	20m	35m	50m	70m		6
		21	19	15	13	11	9		
CTD015	16/1/2013 20:15	5m	15m	25m	35m	50m	65m		6
		21	17	15	13	9	7		
CTD016	17/1/2013 09:30	5m	10m	20m	30m	40m	60m	80m	7
		21	17	15	11	9	7	5	
CTD017	17/1/2013 20:15	5m	15m	25m	35m	45m	75m		6
		21	19	15	13	9	7		
CTD022	18/1/2013 11:00	5m	10m	20m	30m	55m	75m		6
		21	19	15	14	9	7		
CTD023	19/1/2013 09:00	5m	15m	30m	40m	55m	75m		6
		21	17	15	11	9	7		
CTD024	19/1/2013 20:00	5m	15m	25m	35m	50m	75m		6
		21	19	15	13	9	7		
CTD026	20/1/2013 09:00	5m	15m	30m	40m	65m	90m		6
		21	17	15	11	9	7		
CTD027	20/1/2013 20:00	5m	15m	25m	35m	50m	75m		6
		21	19	15	13	9	7		
CTD028	21/1/2013 11:00	10m	20m	35m	50m	60m	80m		6
		21	19	15	13	11	7		
CTD029	21/1/2013 20:00	5m	15m	30m	45m	60m	75m		6
		21	19	17	13	9	7		

CTD031	22/1/2013 09:00	5m	10m	25m	35m	50m	75m		6
		21	17	15	13	11	7		
CTD032	22/1/2013 20:00	5m	15m	25m	35m	45m	75m		6
		21	19	15	13	9	7		
CTD034	23/1/2013 09:00	5m	10m	25m	40m	50m	75m		6
		21	19	15	11	9	7		
CTD035	23/1/2013 20:00	5m	20m	40m	50m	75m	85m		6
		21	17	13	11	9	7		
CTD038	24/1/2013 20:00	5m	10m	20m	30m	40m	50m	75m	7
		21	19	17	15	13	9	7	
CTD044	25/1/2013 11:30	5m	10m	25m	40m	60m	80m		6
		21	19	15	14	9	7		
CTD047	27/1/2013 20:00	10m	18m	25m	35m	50m	75m		6
		21	19	15	13	9	7		
CTD048	28/1/2013 09:00	10m	20m	35m	50m	60m	75m		6
		21	17	15	13	11	9		
CTD052	28/1/2013 20:30	5m	15m	25m	35m	45m	75m		6
		21	19	15	13	9	7		
CTD053	29/1/2013 09:00	5m	15m	30m	45m	60m	75m		6
		21	17	15	11	9	7		
CTD055	29/1/2013 20:00	5m	15m	25m	40m	50m	75m		6
		21	19	15	13	9	7		
CTD056	30/1/2013 09:00	5m	10m	20m	30m	50m	80m		6
		21	19	15	13	9	7		
CTD058	30/1/2013 20:00	5m	15m	25m	35m	50m	75m		6
		21	19	15	13	9	7		
CTD059	31/1/2013 09:00	5m	10m	20m	30m	50m	65m		6
		21	19	15	13	9	7		

CTD061	31/1/2013 20:00	5m	15m	30m	45m	55m	65m		6
		21	17	13	11	9	7		
CTD066	1/2/2013 11:00	5m	10m	20m	30m	50m	75m		6
		21	19	15	13	9	7		
CTD068	2/2/2013 20:00	10m	20m	30m	40m	50m	75m		6
		21	17	15	14	9	7		
CTD069	3/2/2013 09:00	5m	10m	20m	30m	45m	65m	100m	7
		21	19	15	13	11	7	5	
CTD071	4/2/2013 09:00	5m	10m	20m	30m	45m	70m	100m	7
		21	17	15	11	9	7	5	
CTD073	4/2/2013 20:00	5m	15m	25m	40m	55m	70m		6
		21	17	13	11	9	7		
CTD074	5/2/2013 09:00	5m	10m	20m	30m	50m	70m		6
		21	17	15	13	9	7		
CTD076	6/2/2013 12:30	10m	20m	35m	55m	70m	85m		6
		21	17	15	11	9	7		
CTD078	6/2/2013 20:00	10m	20m	30m	40m	50m	75m		6
		21	19	15	13	9	7		

2. Experimental incubations

a. DMS and DMSP standing stocks

Samples for standing stocks of DMS and DMSP (total and particulate) were taken from bioassay bottles at T0, T1 and T2 of each bioassay experiment (see Tables 2 and 3below for specific bioassay bottle numbers and specific timepoints). For T0, samples were taken directly from the Niskin bottles on the CTD cast used to collect the bioassay water. Samples were collected as described in Section 1 above. At T1 and T2, samples were siphoned directly from the bioassay incubation bottles using 6mm silicone tubing into 100ml clear glass-stoppered bottles. The bottles were first rinsed then, allowed to fill to the top, ensuring

the presence of no bubbles or headspace. Samples for DMS and total DMSP (DMSPt) were analysed as described above for CTD samples. For particulate DMSP (DMSPp), a 7ml sub-sample was gravity filtered through 25mm GF/F, and the filter was placed in an 8ml glass vial containing 7ml of MilliQ and 1ml of 10M NaOH. DMS samples were analysed within 2 hours of collection, and DMSPt and DMSPp samples were analysed within 12 hours.

b. DMSP synthesis rates

Specific synthesis rates of DMSP were determined using a stable isotope-based approach, involving tracing the incorporation of ^{13}C into DMSP by proton transfer reaction-mass spectrometry (PTR-MS) (Stefels et al 2010). DMSP production was determined in sub-incubations of the main bioassay experiments at T0, T1 and T2 hours, as detailed in the Tables 2 and 3 below. Three 500 ml polycarbonate bottles were filled directly from each bioassay bottle, and spiked with tracer concentrations of ^{13}C-H_2CO_3. Samples were taken at T0, then at two further time points over a 9 – 10 hour period. 250ml was gravity filtered through 47mm GF/F, the filter gently folded and placed in a 20ml serum vial with 10ml of Milli-Q and one NaOH pellet, and the vial was crimp-sealed. Samples were stored at -20°C until analysis by PTR-MS at Plymouth Marine Laboratory.

c. DMS loss and production rates

DMS loss rates were determined by the addition of tracer-level ^{13}C-DMS to dark sub-incubations of seawater. Incubations were performed at T0, T1 and T2 of the four bioassay experiments (see Tables 2 and 3 for details of treatments), during which concentrations of both ^{13}C-DMS and ^{12}C-DMS were monitored to determine rates of consumption, net production and gross production of DMS. 500ml of seawater was siphoned from the bioassay bottle into a 1L Tedlar bag. Once filling was complete, all bubbles/headspace were removed from the bag. Each Tedlar bag was spiked with the working solution of ^{13}C-DMS to give concentrations of 0.3 – 0.7 nM. After spiking, the Tedlar bags were left for one hour to allow complete homogenisation of the tracer. The Tedlar bags were incubated in the dark, in the bioassay incubation container. 10ml samples were withdrawn using a glass syringe at T0, and at 3 further time-points over a 12 hour period. The samples were gently filtered through a stainless steel Millipore filtration unit containing 25mm GF/F filter, directly into a 5ml glass syringe. The addition of air/bubbles was kept to a minimum at all times. 5ml of filtered seawater was injected into a glass purge tower. The sample was purged with He gas for 7 minutes at 90 ml/min, and the sample stream was dried by passing through a PTFE counterflow nafion drier, at a flow rate of ~180 ml/min. The sample was trapped in a 1/16" PTFE loop held in liquid nitrogen. Once purging was complete, the sample loop was rapidly submerged in boiling water, injecting the sample into an Agilent 5973N gas chromatograph with mass spectral detector, using a 60m DB-VRX capillary column. The oven was held at 60°C for 8 minutes, and for the remainder of the 10 minute runtime the oven ramped to 220°C. DMS and ^{13}C-DMS eluted at ~5.3 minutes. In order to monitor system sensitivity and drift, 250µl of a 5 ppmv deuterated DMS (d6) gas standard was injected upstream of each sample. DMS-d6 eluted at ~5.2 minutes. Tables 2 and 3 list the bioassay experiments, CO_2 and/or Fe treatments and bioassay bottle numbers from which dark DMS loss and gross production rates were determined.

Table 2. Bioassays E01 and E02: CO_2 and Fe treatments, and bioassay bottle numbers from which DMS and DMSP parameters were determined. E01 T1 = 48h, T2 = 96h. E02 T1 = 72h, T2 = 144h.

	Ambient *Bottle #*			***Fe*** *Bottle #*			***750 µatm*** *Bottle #*			***750µatm+Fe*** *Bottle #*		
T1	*1*	*2*	*3*	*19*	*20*	*21*	*37*	*38*	*39*	*55*	*56*	*57*
T2	*10*	*11*	*12*	*28*	*29*	*30*	*46*	*47*	*48*	*64*	*65*	*66*
Standing stocks DMS & DMSP (total)	√	√	√	√	√	√	√	√	√	√	√	√
DMSP synthesis	√	√	√	√	√	√	√	√	√	√	√	√
DMS consumption and production	√	√		√	√		√	√		√	√	

Table 3. Bioassays E03 and E04: CO_2 treatments and bioassay bottle numbers from which DMS and DMSP parameters were determined. E03 T1 = 72h, T2 = 144h. E04 T1 = 96h, T2 = 168h.

	Ambient *Bottle #*			***1000 µatm*** *Bottle #*			***750 µatm*** *Bottle #*			***2000 µatm*** *Bottle #*		
T1	*1*	*2*	*3*	*19*	*20*	*21*	*37*	*38*	*39*	*55*	*56*	*57*

T2	*10*	*11*	*12*	*28*	*29*	*30*	*46*	*47*	*48*	*64*	*65*	*66*
Standing stocks *DMS & DMSP (total)*	√	√	√	√	√	√	√	√	√	√	√	√
DMSP synthesis	√	√	√	√	√	√	√	√	√	√	√	√
DMS consumption and production	√	√	√				√	√	√			

Preliminary results

1. CTD profiles

DMS and DMSPt concentrations were obtained for the CTD casts listed in Table 1. Surface DMS ranged from 0.6 nM (CTD078) – 15.7 nM (CTD038). Surface DMSPt ranged from 6.9 nM (CTD069) – 418.1 nM (CTD032). In general, elevated DMS and DMSPt were associated with the presence of blooms of *Phaeocystis antarctica*, a species known to be a prolific producer of DMSP.

2. Experimental Incubations

a. Standing stocks of DMS and DMSP

DMS and DMSP (total and particulate) concentrations (nM) were quantified for all bioassay experiments at T0, T1 and T2. As example, the results for bioassay E03 are shown in Figure 1. No clear effect of treatment was observed in DMS standing stocks. DMSP was consistently lower at 2000 µatm. The full dataset data from all bioassay experiments will undergo further quality control and statistical analysis upon return to PML.

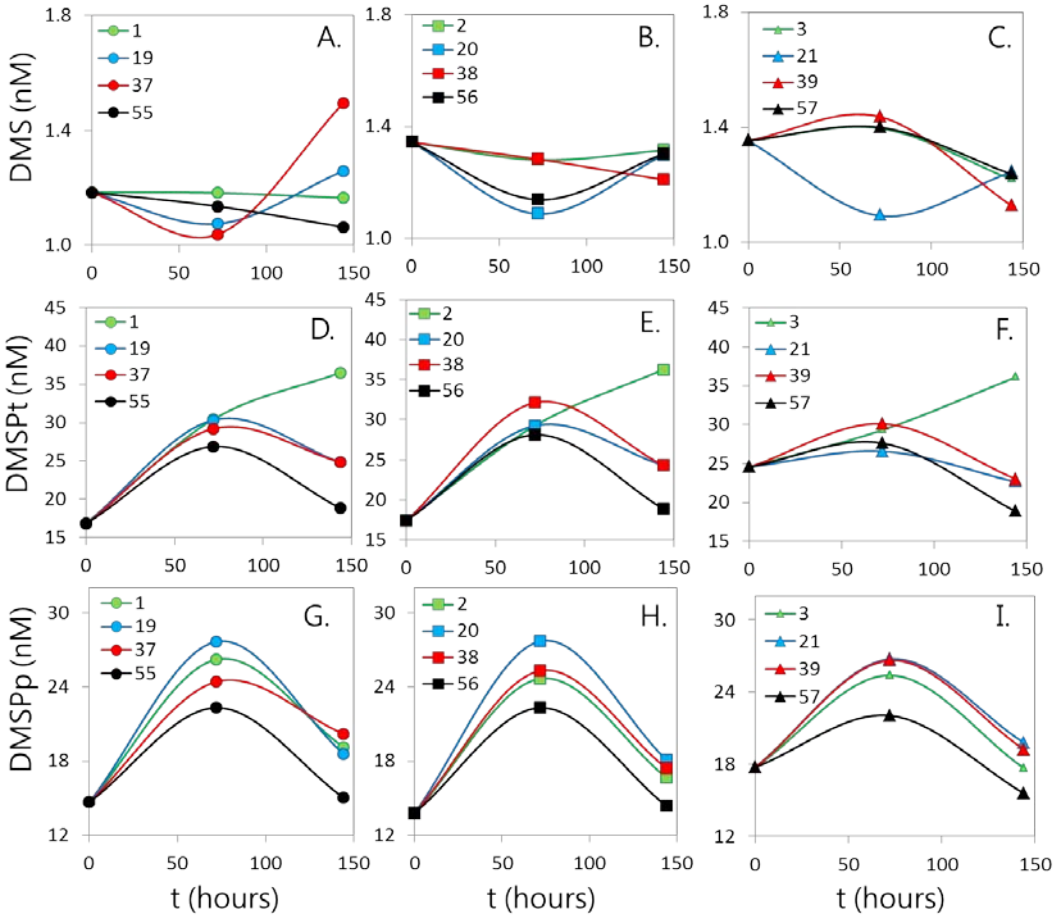

Figure 1. Standing stocks (nM) of DMS (A-C), DMSPt (total) (D-F) and DMSPp (particulate) (G –I) from bioassay E03. Green = ambient, blue = 1000 µatm, red = 750 µatm, black = 2000 µatm. Legends show bioassay bottle number.

b. DMSP synthesis rates

Incubations for calculation of DMSP synthesis rates were made at T0, T1 and T2 of each bioassay experiment. The samples will be analysed upon return to PML, so no data is available at this stage.

c. DMS consumption and production rates

Rates of DMS consumption, and gross DMS production (nM d^{-1}) have been made for all bioassay experiments at T0, T1 and T2. The data will undergo quality control and finalisation upon return to PML.

References

Archer SD, et al., 2010, Aquatic Microbial Ecology 10.3354/ame01464

Archer SD et al., 2013, Biogeosciences

Ayers, G.P., et al., 1991, Nature, 1991. 349 (6308), 404-406.

Charlson, R.J., et al.,1987. 326 (6114), 655-661.

Hopkins F.E. et al., 2010, Proceedings of the National Academy of Sciences USA, 107: 760-765.

Korhonen, H., et al., 2008, Journal of Geophysical Research- Atmospheres,113, (D15).

Stefels, J., et al., 2009, Limnology and Oceanography-Methods, 7, 595-611.

von Glasow, R., et al., 2004, Atmospheric Chemistry and Physics, 4, 2481-2497.

N-cycling rate measurements during ocean acidification bioassay experiments

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Introduction

Within the structure of the UK Ocean Acidification (OA) surface ocean cruise programme, nitrogen cycling experiments have been conducted to better understand the potential effects of decreasing pH on components of the nitrogen cycle in polar waters where the cooler temperatures are expected to have a more pronounced effect on marine ecosystems. Previous OA-related studies, within a range of matrices including oil, sludge, sediment and seawater have found rates of NH_4^+ oxidation have dropped under increasingly acidic conditions ($NH_4^+ \leftrightarrow NH_3$). However, methods have varied greatly, some using additions of ammonium far in excess of ambient. The studies with in the UK OA surface ocean programme may represent the first investigations of N-regeneration within the euphotic zone using trace additions of ^{15}N-labelled inorganic nitrogen compounds.

Objectives

Measure rates of N-cycling during ocean acidification bioassay experiments.

Methods

Experiments were conducted at all time-points for the four bioassay experiments conducted during the cruise (details given elsewhere in the cruise report). For each bioassay, 2 depths were studied: a depth within the surface mixed layer (the depth studied by the majority of scientists) and a deeper sample, approx. 5-10 m below the base of the mixed layer (just studied for nitrogen cycling components). For all depths and time-points, experiments were conducted to study ammonium regeneration and ammonium oxidation (nitrification) rates. For the surface mixed layer, triplicate 1L samples were collected for all four CO_2 treatments.

These were spiked with ^{15}N- labelled ammonium (NH_4^+) for regeneration experiments and ^{15}N-labelled nitrite (NO_2^-) for oxidation experiments at approx. 10% ambient using nutrient data provided by Richard Sanders. Samples were then split: triplicate 500 mL polycarbonate bottles were filled and incubated under simulated light conditions in a 20 foot ISO refrigerated container at ambient seawater temperature for 24 h. The remaining water was pooled, filtered through GF/F filters and subsamples had reagents added to develop dyes to quantify the individual nitrogen cycling processes. Once the dyes had developed the samples were run through C18 solid phase extraction columns which retained the dye under low vacuum. The resulting dye-containing columns were dried under high vacuum, capped with Parafilm^{TM} and stored at -20^{o}C. For the deeper samples there was no replication and samples were incubated with the container in the dark.

On return to the UK the samples will be analysed in a GC-MS to quantify the ^{15}N products and calculate regeneration and oxidation rates. In addition, it will also be possible to provide estimations of ammonium, nitrite and nitrate concentrations, with detection limits in the region of 1 nmol-N.L^{-1}.

Nitrous Oxide

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Nitrous oxide is a biogenically produced trace gases whose atmospheric concentrations is increasing at a rate in the order of 0.7 ppbv y^{-1}. N2O is radiatively active, contributing approximately 6% of the "greenhouse effect" , whilst also contributing to stratospheric ozone depletion and.

The oceans are generally considered to be close to equilibrium relative to the atmosphere for both gases, however oceanic source/sink distributions are largely influenced by oxygen and nutrient status and regulatory processes are complicated

and are currently not well understood. Little is know of the impacts of ocean acidification.

Aim:- *To examine spatial variability in Nitrous oxide along the cruise tract and in the bioassay CO2 Deep manipulations*

Methods

Samples were collected from CTD at stations identified below. 1 litre samples were equilibrated with compressed air and headspace analysis performed on board using ECD-gas chromatography for N_2O. Atmospheric concentrations were determined by the same methods using a pumped supply from the ships monkey island. Sample from the bioassays were sampled in the same way. Samples were collected from an additional deep bioassay collected from water around 1% SPAR or 10 meters below the mixed layer. The deep bioassay was manipulated and incubated in the same manner as the surface bioassay and time pointe were measured every 12 hours for the 4 day bioassay and every 24 hrs for the longer duration bioassays. Details of the deep bioassays can be found in table 3 of bioassay experiments set up report of Sophie Richier and Mark Moore samples were collected at the start, middle and end point of each bioassay.

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CTD cast #	*Date*	*Depth (m)*	*Parameters*
02	11 January 2013	300,100,50,35,20,5	N2O
03	11 January 2013	2	N2O
17	17 January 2013	2	N2O
31	22 January 2013	5,100	N2O
44	25 January 2013	5,25,60,80,115,300	N2O

Effects of ocean acidification on microbial dynamics in the Antarctic

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1. Introduction

Aim: To assess the effects of ocean acidification on microbial group-specific metabolic activities and predation. To link community composition and function by phylogenetic affiliation of these groups using molecular methods.

Objectives:

- To estimate concentrations of dominant bacterioplankton and smallest protists in the water column
- To assess the effects of acidification on bacterioplankton and smallest protists concentrations within the collaborative bioassays
- To complete an index of the microzooplankton (dinoflagellates and ciliates) diversity in the Southern ocean with the collaborative KEOPS 2 cruise.

2. Methods

2.1 Flow cytometry Sampling

Fresh seawater samples were collected in clean falcon tubes from a Seabird CTD system containing a 24 bottles rosette of 20 L Niskin bottles from CTD casts (Table 1. summarises the CTD casts sampled and analysed during the cruise). CTD samples were fixed with paraformaldehyde and stained with the DNA stain SYBR Green I (Sigma) in order to separate particles in suspension based on DNA content and light scattering properties. Each stained sample was run twice through a Becton Dickinson FACSort flow cytometer; first to analyse sub-micron particles and then to analyse particles greater than 1 micron in diameter. Data were saved and will be analysed ashore. Concentrations per ml of Heterotrophic bacteria and Protists will be calculated.

Underway samples were drawn every two hours from the ship's non-toxic seawater supply (Tecan Miniprep 60, Tecan, Reading, UK). Samples were fixed instantly with paraformaldehyde, frozen in liquid nitrogen after half an hour at room temperature and stored at -80°C.

Table 1: CTD casts sampled and analysed during the cruise

DATE	CTD	Station number	DEPTHS SAMPLED (m)
11-janv	2	1	ALL
11-janv	4	2	ALL
13-janv	9	3	ALL
14-janv	10	4	ALL
14-janv	11	5	ALL
15-janv	12	6	ALL
15_janv	13	7	ALL
16-janv	14	8	ALL
16-janv	15	9	ALL
17-janv	16	10	ALL
17-janv	17	11	ALL
18-janv	22	12	ALL
19-janv	23	13	ALL
19-janv	24	14	ALL
20-janv	26	16	ALL
20-janv	27	17	ALL
21-janv	28	19	ALL
21-janv	29	20	ALL
22-janv	31	22	ALL
22-janv	32	23	ALL
23-janv	34	25	ALL
23-janv	35	26	ALL
24-janv	36	27	ALL
24-janv	38	28	ALL
25-janv	44	29	ALL
27-janv	46	30	ALL
27-janv	47	31	ALL
28-janv	49	32	ALL
28-janv	51	33	ALL
29-janv	53	34	ALL
29-janv	55	35	ALL
30-janv	56	36	ALL
30-janv	58	37	ALL
31-janv	59	38	ALL
31-janv	61	39	ALL
1-feb	66	40	ALL
2-feb	68	42	ALL
3-feb	69	43	ALL
4-feb	71	44	ALL
4-feb	73	45	ALL
5-feb	74	46	ALL

6-feb	76	48	ALL
6-feb	78	49	ALL

Bioassay samples were drawn at different time points (see Table 2). Samples were fixed in paraformaldehyde and snap frozen in the liquid nitrogen after half an hour at room temperature and analysed during the cruise.

Table 2: Bioassay samples collected and analysed during the cruise

Date	Exp.	CTD	Station	Time point	Incubation bottle
13.01.13	1	005T	3	0	T01
13.01.13	1	006T	3	0	T02
13.01.13	1	007T	3	0	T03
15.01.13	1	all	3	1	all
17.01.13	1	all	3	2	all
18.01.13	2	018T	12	0	T01
18.01.13	2	019T	12	0	T02
18.01.13	2	020T	12	0	T03
21.01.13	2	all	12	1	all
24.01.13	2	all	12	2	All
25.01.13	3	040T	29	0	T01
25.01.13	3	041T	29	0	T02
25.01.13	3	042T	29	0	T03
15.01.13	3	all	29	1	all
17.01.13	3	all	29	2	all
01.02.13	4	062T	40	0	T01
01.02.13	4	063T	40	0	T02
01.02.13	4	064T	40	0	T03
15.01.13	4	all	40	1	all
17.01.13	4	all	40	2	all

2.2 Microzooplankton sampling

Fresh seawater samples were collected in clean bottles from a Seabird CTD system containing a 24 bottles rosette of 20 L Niskin bottles from CTD casts (Table 3. summarises the CTD casts sampled). CTD samples were fixed in Lugol and stored at 4°C. Samples will be counted and analysed ashore.

Table 3: Lugols samples

Stations	Depth (m)
1	35
2	Max fluo
3	60
4	Max fluo
5	25
6	10
7	15
8	35
9	50
10	20
11	45
13	15
14	25
16	15
17	25
18	35
22	25
23	25
25	40
26	25
27	10
29	60
30	25
31	50
32	50
33	45
34	15
36	20
37	25
38	20
40	20
43	65

4. References

Hill PG, Mary I, Purdie DA & Zubkov MV (2011) Similarity in microbial amino acid uptake in surface waters of the North and South Atlantic (sub-)tropical gyres. *Progress in Oceanography* **91**: 437-446.

Mary I, Tarran GA, Warwick PE, Terry MJ, Scanlan DJ, Burkill PH & Zubkov MV (2008) Light enhanced amino acid uptake by dominant bacterioplankton groups in surface waters of the Atlantic Ocean. *FEMS Microbiology Ecology* **63**: 36-45.

Wright RT & Hobbie JE (1966) Use of glucose and acetate by bacteria and algae in aquatic ecosystems. *Ecology* **47**: 447-464.

Zubkov MV, Tarran GA, Mary I & Fuchs BM (2008) Differential microbial uptake of dissolved amino acids and amino sugars in surface waters of the Atlantic Ocean. *Journal of Plankton Research* **30**: 211-220.

Phytoplankton sampling for DNA, RNA, flow cytometry, and strain isolation. Cruise number JR274, RRS James Clark Ross.

Colin Brownlee *(MBA, Plymouth, UK)*

Introduction

The genetic and physiological variability of phytoplankton populations undepins their ability to adapt to short and long term changes in environmental parameters. We are particularly interested in the adaptive capacity of coccolithophore populations with a focus on the cosmopolitan species *Emiliania huxelyi*. The data and samples obtained on this cruise will complement that from the previous two OARP cruises as well as a US-led Southern Ocean Great Calcite Belt Cruise undertaken in Feb-March 2012. Together they will form an extensive resource for ongoing and future population, genetic and physiological studies.

Cruise objectives

1. Assess the genetic variability of key phytoplankton species across spatial gradients of carbonate chemistry parameters.
2. Establish a resource of phytoplankton DNA and RNA for future analyses of species composition and gene expression
3. Continue studies of *Emiliania huxleyi* genetic variability within and between geographically separate populations
4. Determine changes phytoplankton abundance and strain type in bioassay experiments with a focus on *E. huxleyi*.
5. Establish uniclonal cultures for physiological experiments in the laboratory.

Sampling

Water was collected in pre-washed Nalgene bottles (HCl 1.5%, and rinsed 3X with MilliQ water.

(1) *CTD casts* – Water samples (2L) were collected from one or light depths from a total of 17 predawn or early evening CTD casts (*Table 1*). Samples were confined to either upper mixed layer depths or deep chlorophyll maximum where this was present. From each CTD sample 3 replicates were sampled for DNA and RNA, one sample for culture and 1 for flow cytometry. For detailed description of DNA, RNA flow cytometry and culture samples see “CTD and Bioassay Log” spreadsheet.

(2) *(2) Bioassays experiments* – 3 replicate bottles were (800 ml) were collected from each bioassay treatment and time point for all 4 bioassays. Each replicate was sampled for DNA, RNA, flow cytometry and cell culture.

Table 1 CTD casts sampled.CM = Chlorophyll maximum; UML = Upper mixed layer

DATE	TIME (LOCAL)	TIME (GMT)	Station	CTD cast	Bottle	Depth
11/01/2013	07:30	10:30	1	2	12	CM50
					22	UML 20
14/01/2013	09:30	12:30	1	9	12	CM50
16/01/2013	07:00	10:00	8	14	15	UML 20
19/01/2013	07:00	10:00	13	23	16	UML 20
20/01/2013	06:30	09:30	19	26	12	CM50
22/01/2013	06:30	09:30	22	31	14	CM50
23/01/2013	06:30	09:30	23	32	14	CM50
23/01/2103	17:30	20:30	26	35	18	UML 20
24/01/2012	17:30	20:30	28	38	20	UML 20
27/01/2013	06:30	09:30	30	46	14	CM50
27/01/2013	17:30	20:30	31	47	12	CM50
29/01/2013	05:30	08:30	34	53	18	UML 20
29/01/2013	17:30	20:30	35	55	18	UML 20
30/01/2013	05:30	08:30	36	56	18	UML 20
31/01/2013	05:30	08:30	39	61	18	UML 20
04/02/2013	06:23	09:23	44	71	12	CM40
06/02/2013	09:49	12:49	46	76	18	UML 20

Methodology

Filtration – Aliquots (3 x 330 ml from CTD bottes; 1 x (250 or 330) ml from bioassay bottles were filtered through 0.45 µm polycarbonate filters using a vacuum pump and a filter rig (previously washed with acid solution, HCl 1.5%, and rinsed three times with MilliQ water).

DNA extraction and RNA collection – For RNA, filters were folded into 2ml Cryovials and immediately covered with 2ml RNA Later. These were left overnight at 4°C and subsequently put in the freezer at -20°C. They will be analysed post-cruise.

For DNA, filters were folded into 2 ml Eppendorf vials and stored at -80C for post-cruise analysis cruise.

Flow cytometry - 2 ml of sample was pipette into an Eppendorf containing 20 ml of gluteraldehyde. Tubes were stored at -20C for subsequent analysis

Cell culture. – 20 ml of seawater sample were added to 50 ml culture flasks containing 30 ml of F/2 medium. Cultures were kept in a cooled incubator (2C; 16/8 h light dark cycle).

Microsocopy – Samples from CTD casts and bioassay experiments were routinely observed and photographed using a Nikon Diaphot inverted microscope. Samples were filtered and concentrated cell suspensions were obtained from above filters (10 ml) during filtration.

Preliminary results

A catalogue of representative images has been deposited in the "Plankton" folder. Full image archive is also available in that folder. See "Brownlee CTD and bioassay log" to select images from particular locations and experiments.

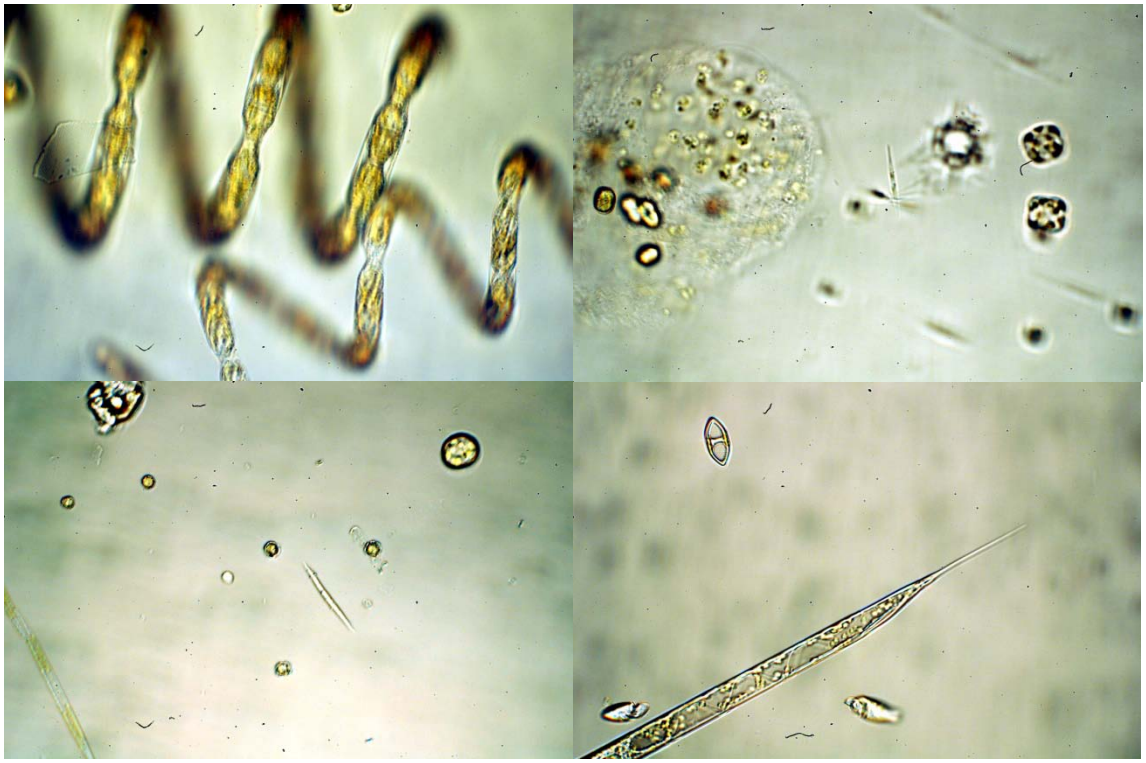


Figure 1. Representative images of phytoplankton from bioassay and CDT samples. A full key and list is available in the Plankton/representative images folder.

Fluorescence and Phytoplankton Photophysiology

Laura Bretherton, Mark Moore

Background

Ocean acidification is a result of an increase in the rate at which CO_2 dissolves into seawater (Raven *et al.* 2005). Many marine biological processes utilise DIC, with photosynthesis by marine phytoplankton being of particular importance. In the modern ocean, CO_2 is not at high enough concentrations to saturate the primary carboxylating enzyme used in the carbon fixation process, RubisCO (Riebesell 2004), so ocean acidification has the potential to stimulate primary production in marine environments. This has not always shown to be the case, though, as some taxa have evolved means of concentrating carbon (Giordano *et al.* 2005) to ensure maximal rates of photosynthesis (Rost *et al.* 2003). These differences in response to increased carbon availability could mean that ocean acidification will cause community shifts, further complicated by the fact that different pre-adapted communities of phytoplankton will exist along natural environmental gradients and possibly each respond differently to CO_2.

Chlorophyll fluorescence offers a non-invasive method of assessing photosynthesis and carbon assimilation *in vivo* (Baker 2008), and can be used to monitor several photophysiological parameters. It is therefore a useful tool for measuring any changes in photosynthesis, or potential stress signals, in response to ocean acidification.

Aims and Objectives

The aims of the work carried on cruise JR274 were to find out:

a) how various photophysiological parameters of phytoplankton change depending on local environmental factors, and;
b) if the physiologies of natural phytoplankton assemblages are affected by manipulation of the carbonate system.

These aims were achieved by taking samples from CTD casts at different stations along the cruise track, as well as from four bioassay experiments, and analysing them using a Fast Repetition Rate Fluorometer (FRRF).

Approach and Methodology

General FRRF Protocol

All samples were incubated in the dark for 15-20 minutes in a water bath kept at the *in situ* temperature. After incubation, a 2mL sub-sample was pipetted into the FRRF for single turnover acquisitions to obtain general photophysiological parameters. In addition, a rapid light curve (RLC) was also carried out on some samples to further assess photophysiology.

PAR values used in the RLC ranged between 0-1400 μmol photons m^{-2} s^{-1}. In order to run blanks, 10mL of each sample was filtered using 0.2μm syringe filter, and gently gravity filtered to minimise the amount of cells lysing and contaminating the filtrate with chlorophyll.

Photophysiology of Natural Phytoplankton Communities

A 50mL sample was taken from CTD casts where possible for analysis using the FRRF. Samples were collected in black plastic bottles from the depth of the chlorophyll maximum. Both single acquisitions and RLCs were measured on the environmental samples.

Photophysiology of Phytoplankton in Manipulated Seawater

Samples for FRRF analysis were taken from every bioassay bottle (36 at each time point) in blacked out vials. In addition to the single turnover acquisitions, RLCs were run on one replicate per CO_2 treatment (Group C only).

Sampling Log

Table 1 – Stations and depths sampled for FRRF measurements over the course of cruise JR274 (excludes CTD casts used for bioassay T0 samples).

Date	Station	CTD No.	Niskin	Depth (m)
11/01/2013	1	2	14	35
	2	4	10	45
14/01/2013	4	10	14	35
15/01/2013	7	13	20	15
17/01/2013	10	16	14	30
	11	17		
20/01/2013	16	23	12	40
	17	27	16	25
22/01/2013	22	31	14	35
	23	32	16	25
23/01/2013	25	34		
27/01/2013	30	46	14	30
29/01/2013	34	53	18	15
30/01/2013	38	59		
03/02/2013	43	69		
04/02/2013	44	71		
05/02/2013	46	74	12	30
06/02/2013	48	76	18	20

Table 2 – Bottles sampled for FRRF measurements from every bioassay experiment.

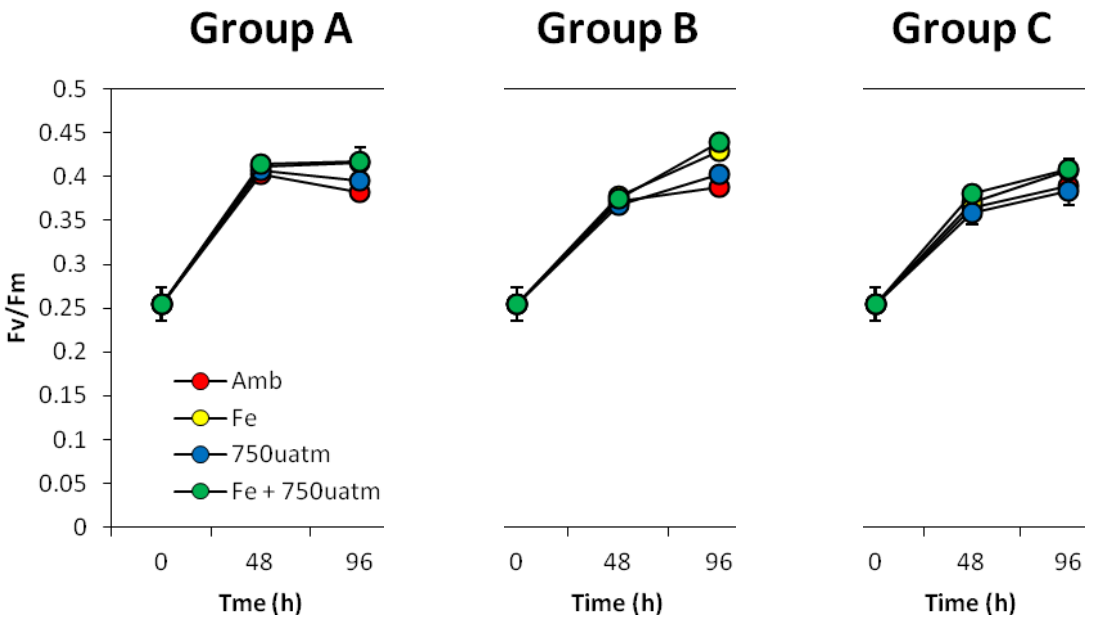
	Bioassay T1	**Bioassay T2**
Group A	1	10
	2	11
	3	12
	19	28
	20	29
	21	30
	37	46
	38	47
	39	48
	55	64
	56	65
	57	66
Group B	4	13
	5	14
	6	15
	22	31
	23	32
	24	33
	40	49
	41	50
	42	51
	58	67
	59	68
	60	69

Group C	7	16
	8	17
	9	18
	25	34
	26	35
	27	36
	43	52
	44	53
	45	54
	61	70
	62	71
	63	72
Extra bottles	-	83
	-	84
	-	85
	-	86
	-	87
	-	88

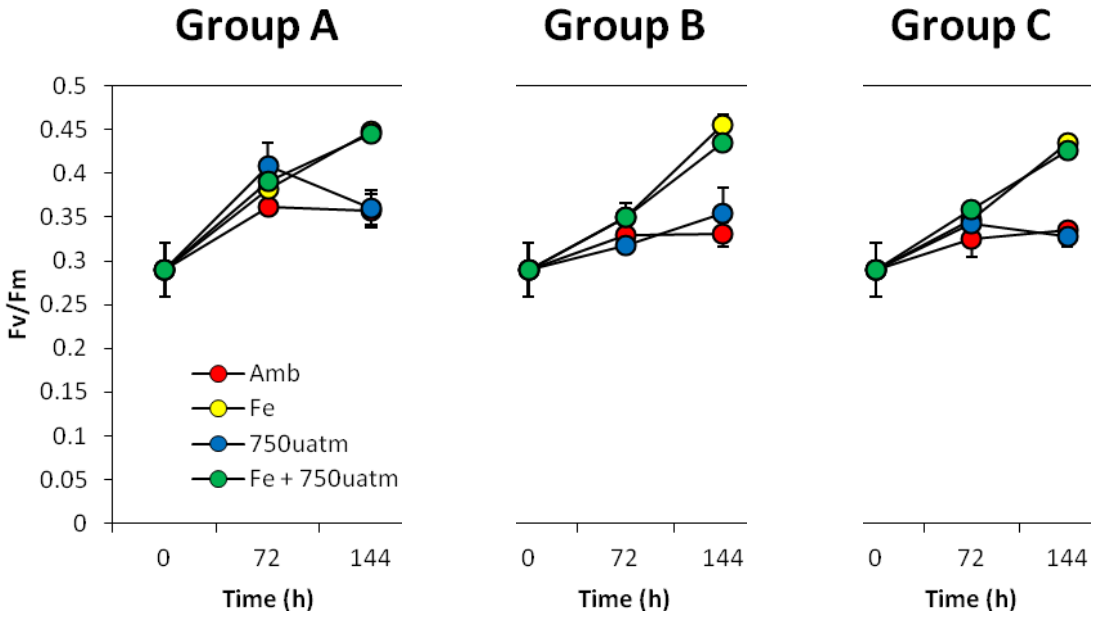
Preliminary Results

F_v/F_m values (an indicator of photosynthetic efficiency) are plotted over time for all bioassays, and demonstrate different responses between starting communities (Fig. 1). All data will be analysed fully after the cruise. The RLC data will be analysed by fitting the Jassby and Platt (1976) model to the curves to obtain more information on the photophysiology.

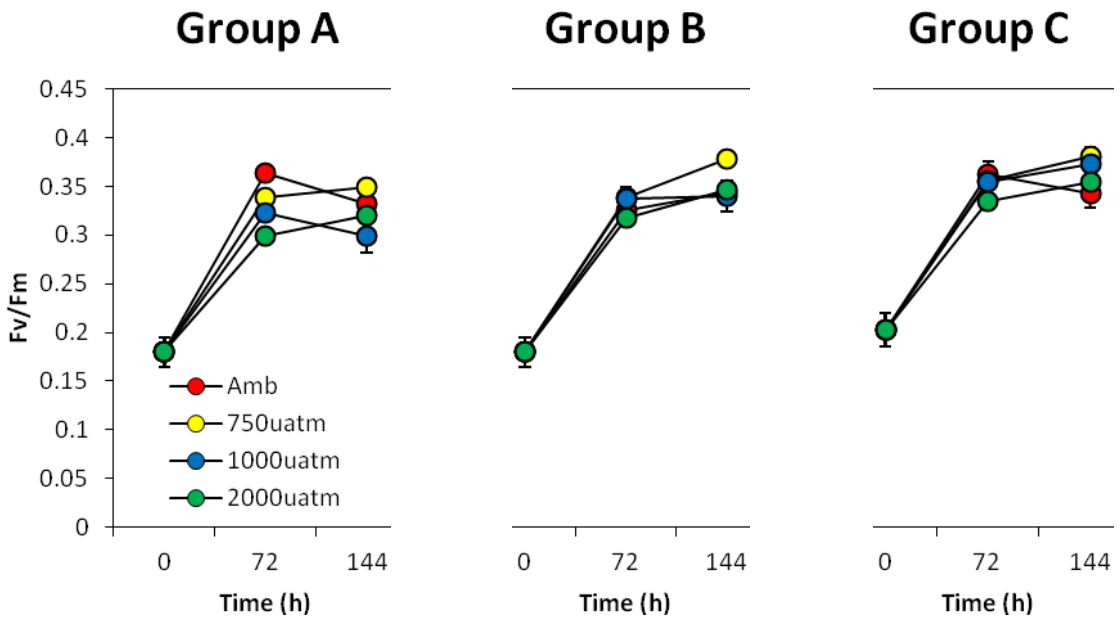
Bioassay 1



Bioassay 2



Bioassay 3



Bioassay 4

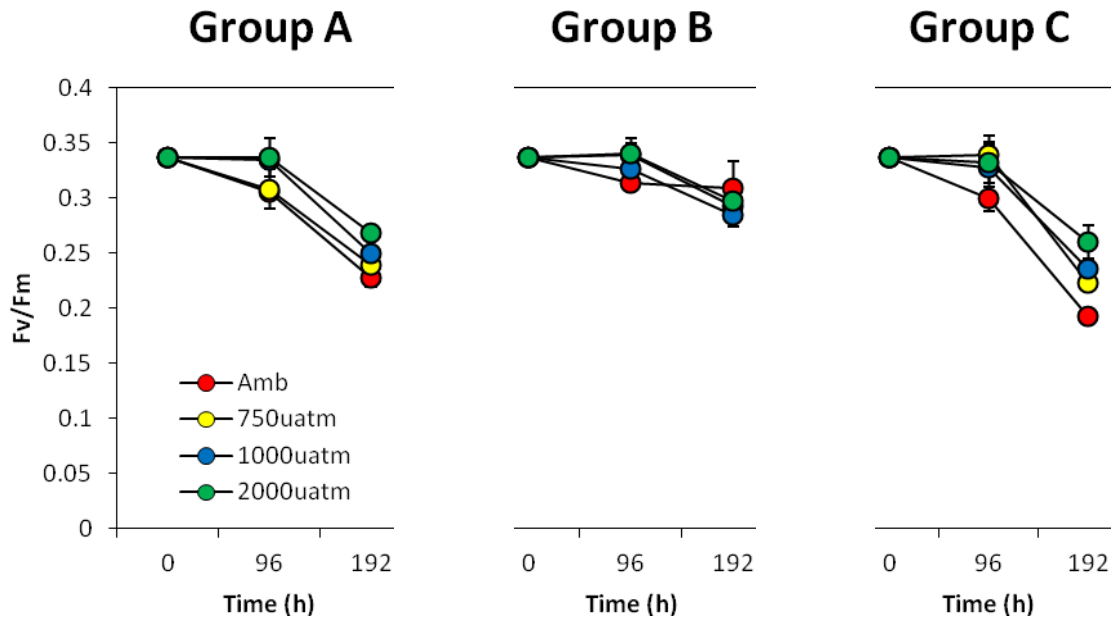


Fig. 1 – The changes in F_v/F_m values over time for JR274 shipboard bioassays. Error bars are +/- 1 S.E., *n*=3.

References

Baker, N. R. (2008). Chlorophyll fluorescence: A probe of photosynthesis *in vivo*. *Annu. Rev. Plant Biol.* **59**: 89-113.

Giordano, M., Beardall, J. and Raven, J. A. (2005). CO_2 concentrating mechanisms in algae: Mechanisms, environmental modulation, and evolution. *Annu. Rev. Plant Biol.* **56**: 99-131.

Jassby, A. D. and Platt, T. (1976). Mathematical formulation of the relationship between photosynthesis and light for phytoplankton. *Limnol. Oceanogr.* **21**(4): 540-547.

Raven, J. A., Caldeira, K., Elderfield, H., Hoegh-Guldberg, O., Liss, P., Riebesell, U., Shepherd, J., Turley, C. and Watson, A. (2005). *Ocean acidification due to increasing atmospheric carbon dioxide*, U. The Royal Society.

Riebesell, U. (2004). Effects of CO_2 enrichment on marine phytoplankton. *Journal of Oceanography* **60**(4): 719-1448.

Rost, B., Riebesell, U., Burkhardt, S. and Sultemeyer, D. (2003). Carbon acquisition of bloom-forming marine phytoplankton. *Limnol. Oceanogr.* **48**(1): 55-67.

Primary production (total and >10 µm) and Calcite Production

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Introduction

Coccolithophores are the most abundant calcifying phytoplankton in the ocean, constituting up to 20% of phytoplankton biomass (Poulton et al. 2007; Poulton et al. 2010) and responsible for around half of oceanic carbonate production (Broecker and Clark 2009). Through the production and export of their calcium carbonate extracellular plates (coccoliths), coccolithophores are a significant component of the global carbon cycle. The response of calcifying plankton to ocean acidification could have considerable ramifications; their response is currently unclear with conflicting responses from culture studies (Iglesias-Rodriguez et al. 2008; Langer et al. 2009). The goal of this work is to assess the dynamics of the coccolithophore community both in terms of its rates of calcification and primary production and its contribution to the total phytoplankton community. Furthermore cellular rates of calcification will be derived from the community structure and compared with environmental conditions.

Sampling

(1) Predawn CTD casts – Measurements were made on water samples collected from middle of the mixed layer (~55% of surface irradiance) during 24 early morning (0600-0800) CTD casts. Water samples were incubated in an on-deck incubator on the aft deck, with surface light level replicated using misty blue light filters and in situ temperatures were replicated by continuously flushing the incubators with sea-surface water.

(2) OA Bioassays – Measurements were made for the Tzero, and two further time points for all four (JR274 E01-E04) of the bioassays. All samples were incubated in the OA container on the aft deck.

Methodology

(1) Primary Production (total) and Calcite Production – Daily (dawn-to-dawn, 24-hrs) rates of primary production (PP) and calcite production (CP) were determined at 22 CTD stations following the methodology of Balch et al. (2000). Water samples (70-ml, 3 light, 1 formalin-killed) were collected from surface waters, spiked with 30-40 µCi of 14C-labelled sodium bicarbonate and incubated on deck. Incubations were terminated by filtration through 25-mm 0.4-µm Nucleopore polycarbonate filters, with extensive rinsing with fresh filtered seawater to remove any labeled ^{14}C-DIC. Filters were then placed in glass vials with gas-tight septum and a bucket containing a Whatman GFA filter soaked with 200-µl phenylethylamine (PEA) attached to the lid. Phosphoric acid (1-ml, 1%) was injected through the septum into the bottom of the vial to convert any labeled ^{14}C-PIC to ^{14}C-CO_2 which was then caught in the PEA soaked filter. After 20-24 hrs, GFA filters were removed and placed in fresh vials and 8-10-ml of Ultima-Gold liquid scintillation cocktail was added to both vials: one containing the polycarbonate filter (non-acid labile production, organic or primary production) and one containing the GFA filter (acid-labile production, inorganic production or calcite production). Activity in both filters was then determined on a Tri-Carb 2100 low level liquid scintillation counter and counts converted to uptake rates using standard methodology.

(2) >10 μm Primary production - Daily rates of size-fractionated primary production (>10 μm) were also measured from the 22 production CTD casts. Triplicate water samples were collected from each light depth (70-ml), spiked with 6-7 μCi ^{14}C-labelled sodium bicarbonate and incubated on deck. Incubations were terminated after 24 hours with filtering through 25-mm 10-μm Nucleopore polycarbonate filters, with extensive rinsing with fresh filtered seawater to remove any labeled ^{14}C-DIC. Ultima-Gold liquid scintillation cocktail (8-10-ml) was then added and activity on the filters was determined on a Tri-Carb 2100 low level liquid scintillation counter and counts converted to uptake rates using standard methodology.

(3) Additional Size Fraction Primary production – Additional size-fractions (>2 μm, >5 μm, >20 μm) were also measured for Primary production following the >10 μm methodology (see (2)). However, the 2 and 5 μm fractions were measured in duplicate, with only one measurement of the 20 μm fraction. The 20 μm fraction was spiked with 12-14 μCi ^{14}C-labelled sodium bicarbonate.

(4) Dissolved production (DOC) – Production of DOC was measured following Lopez-Sandoval et al. (2011) all bioassays at both time points and from the daily measurements of primary production. 2.5 ml aliquots were removed from the sample bottles at the end of the incubation period, gently filtered through 0.2 μm syringe tip filters into 20-ml glass scintillation vials and the processed as in the Micro-Diffusion Technique (see (1)) with the addition of 50 μl of 50% Hydrochloric acid.

References

Balch, W.M., Drapeau, D.T., Fritz, J.J., 2000, Monsoonal forcing of calcification in the Arabian Sea, Deep-Sea Research II, 47, 1301-1337.

Broecker, W., and Clark, E. 2009. Ratio of coccolith $CaCO_3$ to foraminifera $CaCO_3$ in late Holocene deep sea sediments. Palaeoceanography, 24: PA3205

Iglesias-Rodriguez, M.D., and others. 2008. Phytoplankton calcification in a high CO_2 world. Science. Science 329: 336.

Langer, G., Nehrke, G., Probert, I., Ly, J. and Ziveri, P. 2009. Strain-specific repsonses of *Emiliania huxleyi* to changing seawater carbonate chemistry. Biogeosciences, 6: 2637-2646

Lopez-Sandoval, D.C., Fernandez, A., Maranon, E., 2011, Dissolved and particulate primary production along a longitudinal gradient in the Mediterranean Sea, Biogeosciences, 8, 815-825.

Poulton, A. J., Adey, T. R., Balch, W. M. and Holligan. P. M., 2007. Relating coccolithophore calcification rates to phytoplankton community dynamics: Regional differences and implications for carbon export. Deep-Sea Res. II 54: 538–557.

Poulton, A. J., Charalampopoulou, A., Young, J. R., Tarran, G. A., Lucas, M. I. and Quartly, G. D., 2010. Coccolithophore dynamics in non-bloom conditions during late summer in the central Iceland Basin (July–August 2007). Limnol. Oceanogr. 55: 1601–1613

Table 1. List of CTDs sampled for Primary Production (total and >10 μm, PP),Calcite Production (CP) and production of Dissolved Organic Carbon (pDOC).

Date	CTD number	Depth (m)	Date	CTD number	Depth (m)
13 Jan	C009	25	24 Jan	C036	15
14 Jan	C010	20	25 Jan	C044	25
15 Jan	C012	10	28 Jan	C049	20
16 Jan	C014	20	29 Jan	C053	15
17 Jan	C016	10	30 Jan	C056	20
18 Jan	C022	20	31 Jan	C059	20
19 Jan	C023	15	1 Feb	C066	20
20 Jan	C026	15	3 Feb	C069	20
21 Jan	C028	20	4 Feb	C071	15
22 Jan	C031	10	5 Feb	C074	10
23 Jan	C034	25	6 Feb	C076	20

Phytoplankton community composition

Chris Daniels and Glaucia Fragoso, *NOC Southampton, UK*

Light microscopy – Water samples were preserved with 2-3% acidic Lugol's solution from 1-2 depths (mixed layer, chlorophyll maximum where present) from 24 CTD casts and from each treatment bottle from the 5 bioassay experiments. In the case of CTD sampling, 100-ml samples were collected and preserved, while 250-ml samples were collected from the bioassays. Phytoplankton community composition will be assessed using light microscopy (following Poulton et al. 2007) for diatoms, dinoflagellates, and planktonic ciliates.

References

Poulton, A.J., Moore, C.M., Seeyave, S., Lucas, M.I., Fielding, S., Ward, P., 2007, Phytoplankton community composition around the Crozet Plateau, with emphasis on diatoms and *Phaeocystis*, Deep-Sea Research II 54, 2085-2105.

Coccolithophore assemblage composition and morphology

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Introduction

Coccolithophores are the most abundant and widespread marine pelagic calcifiers and a significant component of the marine phytoplankton. Consequently they have attracted much attention in ocean acidification research but with highly variable results being reported. The objective of the current research is to test if consistent responses of coccolithophores to carbonate chemistry conditions can be detected by compiling extensive datasets of coccolith composition and morphology data from environmental and bioassay samples. The Southern Ocean is a prime area to test this since it has been suggested that the southern limit of occurrence of coccolithophores is controlled by carbonate chemistry.

Sampling

(1) Bioassays – Samples were collected from the initial, intermediate and final time points for all four of the bioassays. From each bioassay three replicate samples were taken from each of the four CO_2 conditions, i.e. 12 samples per time point and 27 samples total per bioassay. In total 135 bioassay samples were taken.

(2) CTD casts – Samples were collected from all regular CTD casts (additional casts were made for trace element chemistry and were not sampled), usually from 6 water depths. The number of water depths and the depths selected varied depending on the nature of the water profile but typically samples were taken from each of the surface mixed layer, thermocline and sub-thermocline water. In total 205 samples were taken.

(3) *Underway samples* – Throughout the cruise, except while within the ice, samples were collected as part of the underway sampling collection set. Typically samples were collected at two hourly intervals from the non-toxic seawater supply system, with slightly longer sampling interval at times during the evening. Comparative data available for this sample set will include carbonate chemistry, nutrient analysis, flow cytometry, and from the shipboard sensors temperature, salinity, fluorescence, length transmittance and weather data. In total 270 samples were taken.

(4) *PIC and BSi samples.* In parallel samples were taken for Particulate Inorganic Carbon (PIC) and Biogenic Silica (BSi). Samples were taken from each of the bioassays and from a single water depths from each standard CTD casts and the bioassay samples. Samples were collected by vacuum filtration onto

25mm polycarbonate filter membranes of between 150 and 400ml sea water. The membranes were then transferred into plastic tubes and oven dried.

Methodology

(1) Coccolithophore assemblage samples – for each of the CTD, underway and bioassay samples 100 to 200ml of water was filtered, onto 25mm diameter 0.8µm mesh filter membranes, by vacuum filtration, without prefiltration. Samples were rinsed with ammonia-buffered milli-Q water immediately after filtration. Two filters were taken per sample, one on polycarbonate filters (Whatman nuclepore) for scanning electron microscopy and a second on cellulose nitrate filters (Whatman ref 7188-002) for light microscopy. The filters were then transferred to plastic petrislides, secured with a small piece of sticky tape and oven dried at 40°C for 2 to 4 hours. For the CTD cast and bioassay samples, the water was filtered immediately after collection. For the underway samples water was stored after collection and processed in batches once or twice a day.

Light microscopy preparations were made later the same day from the cellulose nitrate filters. For this a portion of filter was mounted on a glass microscope slide using a low viscosity UV-setting adhesive (Norland Optical Adhesive 74). For the CTD cast and bioassay samples, the water was filtered immediately after collection. For the underway samples water was stored after collection and processed in batches once or twice a day.

(2) Reconnaissance sampling for bioassays. Prior to commencement of bioassays 3 and 4 reconnaissance study of the phytoplankton population was undertaken by JRY and Colin Brownlee, at half hour intervals for 3-4 hours. To allow study of the coccolithophores as soon as possible after sample collection the standard preparation protocol was adjusted in various ways – a smaller water volume was filtered (100ml); strong vacuum was used; a microwave oven way used for sample drying; slides were examine without curing the optical adhesive. In this way it was possible to examine assemblages <10minutes after collection.

(3) Assemblage counts. The coccolithophore assemblage was analysed by light microscopy using a Leitz Ortholux polarizing microscope at x1000 magnification. Counts were made of coccolithophores present per filter area and converted to specimens per litre. Approximately 1/4 of the underway samples and 1/3 of the CTD samples were analysed during the cruise.

(4) Planned post-cruise work. (a) Directly post-cruise LM counts will be completed for all samples collected. (b) In parallel SEM imaging of selected samples will be undertaken using the automated SEM of NOC Southampton (organised with Toby Tyrrell and Richard Pearce). The sampling for this will include one replicate from each bioassay. These SEM image sets will be used for morphometric analysis of *Emiliania huxleyi* and loose coccolith counts. They will also be used, by Alex Poulton, to assist phytoplankton counts and can be made be available to other project members. (c) LM-based image analysis will be used to carry out morphometrics, including mass estimation, of an extended set of samples.

Preliminary Results and Prognosis

Enough light microscopy has been carried out on-ship to give an overview of the coccolithophore assemblages encountered. All samples with coccolithophores were dominated by *Emiliania huxleyi*, and in most samples it was the only coccolithophore observed. *Gephyrocapsa muellerae* was present in samples on the Falkland Shelf, and it is likely that with extended analysis a few other species will be encountered but clearly coccolithophore calcification in the Southern Ocean is essentially due to E. huxleyi as has been previously documented (e.g. Verbeek 1989, Findlay & Giraudeau 2001, Charalampopoulou 2011). This is in marked contrast to the Arctic where diverse communities are encountered with *Coccolithus, Algirosphaera, Syracosphaera* and *Calciopappus* all occurring at high abundances and dominating some samples, and where *Coccolithus* is the dominant calcifier.

E. huxleyi itself is not present throughout the cruise but only in the more northerly samples – out of the 280 underway samples examined *Emiliania huxleyi* was present in 134 samples with a highly predictable pattern of being present in the more northerly samples. The transition between waters with and without *E. huxleyi* was crossed six times during the cruise and sampled at high resolution through the underway sampling.

The prime objectives of research on the sample set collected will be to determine (1) if the presence/absence of *E. huxleyi* is correlated with carbonate chemistry; (2) if populations near the margin of the occurrence of *E. huxleyi* show evidence of inhibition of calcification; (3) if the contrast between the assemblages in the Arctic and Antarctic can be related to carbonate chemistry.

Charalampopoulou, A., 2011, Coccolithophores in high latitude and polar regions: Relationships between community composition, calcification and environmental factors PhD: Southampton University, 300 p.

Findlay, C. S., and Giraudeau, J., 2001, Extant calcareous nannoplankton in the Australian sector of the Southern Ocean (austral summers 1994 and 1995): Marine Micropaleontology, v. 40, no. 4, p. 417-439.

Verbeek, J. W., 1989, Recent calcareous nannoplankton in the southernmost Atlantic: Polarforschung, v. 59, no. 45-60.

Cruise report JR274: Zooplankton

Geraint Tarling, Vicky Peck, Pete Ward and Natalie Ensor *(British Antarctic Survey)*

Introduction
Zooplankton work is incorporated in a number of workpackages within the surface consortium OA programme, namely WP2 and WP7 - bioassay experiments encompassing foodweb effects; WP4 – plankton community structure and WP6 – biocalcification. In so doing, it encompasses both experimental and observational work. The starting point for most zooplankton activities was the sampling of a motion compensated Bongo net (100 and 200 μm mesh, Plate 1), deployed between 0 and 200 m depth. The net was deployed each morning (from 08:15 GMT), three times in succession, with one set of samples being immediately preserved (ethanol and formalin) and the two other sets used for hand picking copepods, pteropods and foraminifera for bioassays, rate measurements, body condition analyses, shell chemistry and size-normalised weights. An evening Bongo deployment was also carried out at about 20:30 GMT. The subsequent sections describe how the various treatments of these samples contributed to respective workpackages. Note that WP4 also describes the deployment of the Continuous Plankton Recorder, which was the other means by which mesozooplankton was collected.

Plate 1: Retrieval of the motion-compensated Bongo net

WP2 and WP 7: BIOASSAY EXPERIMENTS

Objectives
To perform bioassay experiments designed to evaluate the response to artificial carbonate system manipulation of multiple organisms and processes. In particular with regards zooplankton, incubations are to be carried out to study foodweb effects at different pCO2 levels using modified natural sea-water. DIC, TA, DOC and TEP measurements will be made on aliquots taken at the start and end of incubations. Bacterio-plankton and protist counts will be carried out through flow cytometry on freshly fixed samples. Microplankton enumeration and identification will be performed on Lugols-preserved samples and/or FlowCam microscopy. Measurements of nutrient and ammonia levels will also be made.

Methods
1L Duran bottles were filled with untreated natural seawater modified with varying aliquots of 1.00 M HCl and 0.95 M $NaHCO_3$ (see Annex Acid_Base additions for zooplankton bioassays) to achieve pCO2 levels 750 and 1000 uatm. All treatments were carried out in triplicate (i.e. 3 individual 1 L Duran bottles per pCO2 level), including triplicate ambient conditions. There were two separate sets of bottles, one for a 24 h incubation, the other for a 96 h incubation.

Hand-picked copepods were introduced to the bottles, with the species of copepod and the number of specimens per bottle varying between bioassays depending on the prevailing natural copepod community. Some bottles were left without copepods to act as controls. The bottles were topped up to the rim and the lids sealed with parafilm before being placed on plankton wheels within a controlled temperature container maintained at ambient surface water temperature. Diffused light fields were maintained next to the wheels to simulate the light regime at 5 m depth.

Inspections of the copepods were made before stopping an incubation (Plate 3) and the number of dead specimens noted. The bottles were then sampled for microplankton composition and abundance, TA and DIC, TEP and DOC, bacterial abundance, bacterial production, nutrient levels (silicate, nitrate, phosphate), ammonia and oxygen concentrations (Annex – Zooplankton_bioassay). It was not possible to make all measurements on all bottles because of the volumes required for each analytical method. However, each measurement was made on at least one seeded and one control bottle at each pCO2 level. Bacterial abundance, bacterial production and microplankton samples were only made on the 24 h incubation, to avoid exponential growth and overgrazing effects respectively. Subsequent to sampling, the copepods were extracted and all live specimens snap frozen in liquid nitrogen for future analysis of gut fluorescence and enzyme activity.

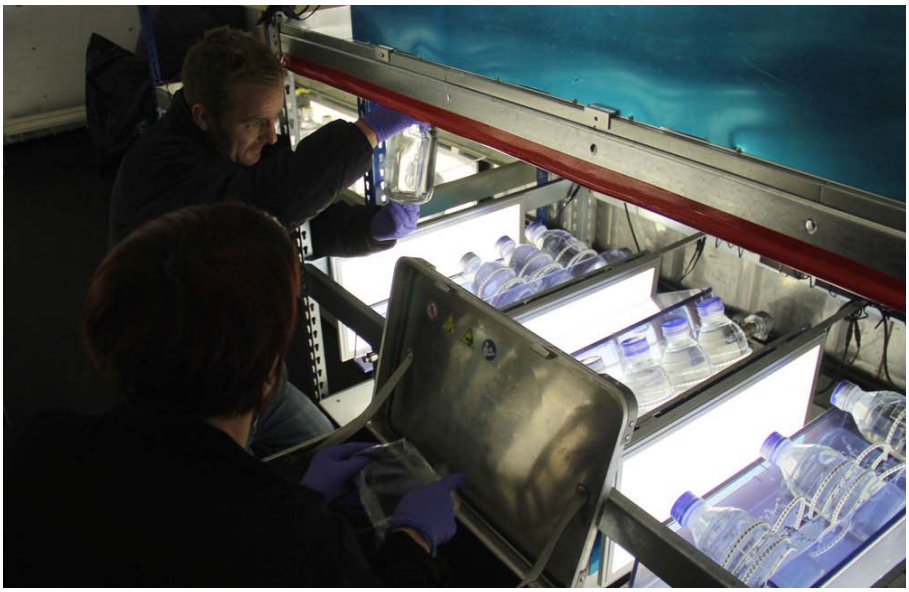

Plate 2: Inspection of incubation bottles during takedown of a zooplankton bioassay

Implementation
Bioassay 1: Set up on 13/1/2013 24 h at 58.36676S, 56.25187W
Copepod species/stage: *Calanoides acutus* CV – 10 per bottle.
pCO2 conditions: ambient, 750 and 1000 uatm

Bioassay 2: Set up on 18/1/2013 at 60.97399S, 48.13571W
Copepod species/stage: *Calanoides acutus* CV and female – 10 per bottle
pCO2 conditions: ambient, 750, 1000 uatm

Bioassay 3: Set up on 25/1/2013 at 52.68939S, 36.62285W

Copepod species/stage: *Calanoides acutus* CV – 10 per bottle
pCO2 conditions: ambient, 750 and 1000 uatm

Bioassay 4: Set up on 1/2/2013 at 58.08565S, 25.92564W
Copepod species/stage: *Calanoides acutus* CV and female– 10 per bottle
pCO2 conditions: ambient, 750 and 1000 uatm

Additional incubations for respiration and excretion rates

Incubations of copepods in ~300 ml BOD bottles were carried out to determine respiration and ammonia excretion rates of both copepods and pteropods. Bottles were filled with 0.22 um filtered water and modified with varying aliquots of 1.00 M HCl and 0.95 M $NaHCO_3$ (see Annex Acid_Base additions for zooplankton bioassays) to achieve pCO2 levels 750 and 1000 uatm. The species/stage of incubated copepods varied in line with those in the parallel bioassay experiments. 10 copepod were placed in each bottle and incubated for 48 h. Between 1 and 3 further bottles were not seeded with copepods at each pCO2 level to act as controls. A further non-seeded bottle at each manipulated pCO2 level was also setup for TA and DIC analysis to verify the pCO2 level achieved by the acid/base manipulation.

At the end of the incubation, bottles were inspected for mortalities before adding Winkler chemicals I and II and the temperature and time noted. A Winkler titration was subsequently carried out after a further 24 h at room temperature.

A total of 1 x 48 h incubations of krill larvae, 1 x 48 h incubation of *Calanus simillimus* and 11x 48 h incubations of *Calanoides acutus* were carried out at pCO2 levels of ambient, 750 and 1000 uatm (Table 1).

Experiment	Species	Date	Bongo/Station	Lat	Long
R1	Krill larvae	17/1/13	10	-59.90447	-49.40827
R2	*Calanoides acutus*	20/1/13	16	-57.82158	-42.83066
R3	*C. acutus*	21/1/13	19	-55.20284	-41.32260
R4	*C. acutus*	22/1/13	22	-52.71083	-40.05788
R5	*Calanus simillimus*	23/1/13	25	-50.13603	-38.95733
R6	*C. acutus*	24/1/13	27	-51.15362	-37.50513
R7	*C. acutus*	27/1/13	30	-54.27842	-36.43765
R8	*C. acutus*	28/1/13	32	-51.61659	-34.71691
R9	*C. acutus*	29/1/13	34	-51.38896	-30.81196
R10	*C. acutus*	30/1/13	36	-53.82668	-29.18689
R11	*C. acutus*	3/2/13	42	-61.67224	-25.75237
R12	*C. acutus*	5/2/13	46	-59.99497	-29.66156
R13	*C. acutus*	6/2/13	48	-57.92734	-32.05341

Table 1. Summery of animal collection for respiration experiments

WP 4: PLANKTON COMMUNITY STRUCTURE

Objectives: The rate at which a biologically-mediated process proceeds, when expressed as a rate per unit volume of seawater, is the product of the abundance per unit volume of the relevant organism(s) and the per-organism physiological rates. The identification and enumeration of plankton communities is therefore a necessary parameter to place measurement of processes within a biogeochemical context. Collection of specimens for this purpose was mainly achieved through the deployment of vertical net hauls (motion compensated Bongo net, 100µm and 200µm mesh) and the Continuous Plankton Recorder (CPR) tows (>10 nm long at 0- 10 m depth, 270 µm mesh).

Methods: The Bongo net was deployed between 0 and 200 m each day at approximately 08:00 (GMT). The deployments were made in immediate succession. Generally, the samples from the first deployment were preserved and the subsequent two were used to pick out live specimens for incubation, snap-freezing or for CHN analysis. An evening deployment of the Bongo was made around 20:30 (GMT) – this was preserved although some pteropod, *Themisto* and foraminifera specimens may have been removed from the 100μm sample and noted on the sample label. With respect to preservation, the 100 μm samples was preserved in Ethanol and the 200 μm in Steedman's (a formalin based) solution.

The CPR was deployed continuously during transects between stations, with the exception of ice-covered regions during the period 10th January-12th February. Ship's speed between stations was approximately 10 knots. The CPR was recovered just prior to the morning station (generally around 05:00) and serviced in readiness for redeployment once station activities had been completed. A daytime tow ensued until the evening station when again it was recovered and then redeployed to tow overnight. Deployments were curtailed between 16/1/2013 and 20/1/2013 due to working in ice.

Servicing the CPR involved extracting the internal mechanism, making a note of patch number, drawing a red line in marker pen at this point, winding on the gauze for ~2 patches, marking the new position with a green marker pen. Formalin was added to the spool well and the mechanism was reinserted (Plate 3). An inspection was made of the seaworthiness of the CPR body (front opening, propeller blades, fenders etc.) upon each retrieval.

Plate 3: Recovery of CPR and winding-on of the internal mechanism

Implementation

92 Bongo net deployments were made between 11th Jan and 7th Feb 2013.Of these, 47 were preserved in Formalin/Ethanol (Table 1) and the remainder were used for picking live animals before being discarded.

Start Date/Time of deployment(s)	Latitude	Longitude	Water Depth (m)	Sea Surface Temp	Salinity	Max Depth

11/1/13 – 08:27	-56.46667	-57.42649	3742.52	5.35	34.0124	0-200m
11/1/13 – 20:51	-57.11789	-57.42154	4178.28	5.21	33.9513	0-200m
13/1/13 – 10:49	-58.36674	-56.25188	3922.93	1.69	33.7674	0-200m
14/1/13 – 08:14	-60.00022	-55.23775	3545.14	0.54	33.7728	0-200m
14/1/13 – 20:52	-61.03972	-54.60652	469.79	-0.66	33.5997	0-200m
15/1/13 – 08:11	-59.90941	-53.03938	3428.37	0.79	33.6555	0-200m
15/1/13 – 20:51	-59.34897	-52.32404	3554.24	0.80	33.6661	0-200m
16/1/13 – 08:29	-58.28845	-50.96875	3953.62	1.46	33.6008	0-200m
16/1/13 – 20:41	-59.07668	-50.24093	3656.87	-0.44	33.6198	0-200m
17/1/13 – 08:04	-59.90448	-49.41032	3591.10	12.34	32.6005	0-200m
17/1/13 – 20:37	-60.56883	-48.35963	2033.66	-1.33	33.4543	0-200m
18/1/13 – 09:54	-60.97419	-48.13781	2697.22	13.85	33.1865	0-200m
19/1/13 – 08:04	-59.94942	-45.30535	4890.61	-0.76	33.1893	0-200m
19/1/13 – 20:34	-59.20801	-43.75757	3520.54	0.80	33.4525	0-200m
20/1/13 - 07:59	-57.82130	-42.83151	2878.36	1.4	33.8134	0-200m
20/1/13 – 20:38	-56.80879	-42.25410	4057.84	2.27	33.7338	0-200m
21/1/13 – 08:05	-55.20054	-41.32610	3333.10	8.49	32.3627	0-200m
22/1/13 – 08:00	-52.71007	-40.05827	3787.82	3.11	33.7720	0-200m
22/1/13 – 20:33	-51.99970	-39.73537	3744.89	3.8	33.7250	0-200m
23/1/13 – 08:01	-50.13283	-38.95772	4727.67	5.15	33.7698	0-200m
23/1/13 – 20:31	-49.45321	-38.46794	1745.01	4.16	33.6926	0-200m
24/1/13 – 08:02	-51.15360	-37.51285	1842.90	4.7	33.7107	0-200m
24/1/13 – 20:29	-51.95156	-37.05733	unknown	4.16	33.8122	0-200m
25/1/13 – 10:24	-52.68939	-36.62285	2444.36	2.36	33.8981	0-200m
27/1/13 – 07:59	-54.27840	-36.43762	253.95	2.38	32.4317	0-200m
27/1/13 – 20:34	-52.94004	-35.80348	3579.37	2.81	33.9323	0-200m
28/1/13 – 08:00	-51.61692	-34.71769	4777.04	3.23	33.8290	0-200m
28/1/13 – 20:28	-51.25902	-33.51398	2168.79	2.87	33.9387	0-200m
29/1/13 – 07:58	-51.38883	-30.81240	3929.08	3.94	33.8395	0-200m
29/1/13 – 20:37	-52.16251	-30.28004	2807.83	3.37	33.9090	0-200m
30/1/13 – 07:58	-53.82737	-29.18620	4650.91	1.3	33.8716	0-200m
30/1/13 – 20:29	-54.57431	-28.67160	5802.77	2.1	33.9856	0-200m
31/1/13 – 08:00	-56.09017	-27.02821	1973.32	0.76	33.6281	0-200m
31/1/13 – 20:29	-56.96536	-25.79522	3431.48	0.42	33.5670	0-200m
1/2/13 – 09:43	-58.08565	-25.92564	2901.73	0.14	33.6502	0-200m
2/2/13 – 20:26	-61.67224	-25.75241	4540.55	0.11	33.4896	0-200m
3/2/13 – 07:57	-63.46412	-25.29755	4936.06	0.06	33.7861	0-200m
4/2/13 – 08:01	-62.13467	-27.02752	4138.06	-0.11	33.5665	0-200m
4/2/13 – 20:25	-61.47097	-27.86412	3704.58	0.07	33.5880	0-200m
5/2/13 – 07:57	-59.99403	-29.66227	2586.65	0.25	33.4872	0-200m
6/2/13 – 10:46	-57.92690	-32.05340	2903.35	1.27	33.7670	0-200m
6/2/13 – 20:27	-57.41325	-32.61575	3897.83	1.23	33.6773	0-200m

Table 2: Bongo net deployments: 100 um sample preserved in Ethanol (70% up to 14/6;100% 15/6 onwards) and the 200um sample in Steedmans (formalin based) solution

The CPR was deployed continuously between 10/1 and 16/1 and then between 20/1 and 7/2. Final tows from South Georgia towards Stanley were undertaken between 9/2 and 11/2. A total of 8 different internal mechanisms were used, including the respooling of mechanisms 157/0 and 157/1 with new mesh for a second deployment.

Across all deployments, a total of 548 patches were sampled, equating to 2738 nautical miles. Full details of the numbers of patches sampled each day and the wind-on increments are listed in Annex CPR1: Short leg CPR tow forms. Lats and longs at the start and end of each CPR deployment are given in Annex CPR2: CPR log sheets

	Date	Mechanism	CPR body	Total number of patches (bottom of tunnel)
1	10/1/13 to 16/1/13	157/0	157	68.7
2	20/1/13 to 25/1/13	157/1	157	90
3	25/1/13 to 29/1/13	157/2	157	78.3
4	29/1/13 to 2/2/13	167/0	167	80.4
5	2/2/13 to 7/2/13	167/1	167	84.7
6	7/2/13 to 7/2/13	167/2	167	11.2
7	9/2/13 to 10/2/13	157/0	157	57.2
8	10/2/13 to 12/2/13	157/1	157	77.1
			Total	**547.6**
			Nautical miles	*2738*

Table 3: Deployment of CPR mechanisms during JR274

WP 6: IMPACT OF OCEAN ACIDIFICATION ON BIOCALCIFICATION

Objectives: To carry out extensive observations on the effect of natural gradients in pH and ΩCaCO3 on calcifying organisms, in parallel with bioassay experiments to test the following hypotheses:
$H1_1$: Size-normalised weight of foraminiferal species will decrease in tandem with ΩCaCO3*.*
$H1_2$: Pteropod shells will show evidence of dissolution and/or inhibited calcification in lowest ΩCaCO3 *waters.*
Planktonic foraminifera and pteropods to be collected from the plankton net and underway sampling of the uncontaminated was supply. Cleaned specimens will be imaged in standard orientations, measured and weighed to produce size-weight spectra for each of the main species. In addition, live specimens of *L. helicina (*and *L. retroversa* when available) will be handpicked for incubation experiments at the same range of pCO2 conditions. Both field and incubated pteropod specimens will be examined in detail by a combination of light and scanning electron microscopy (to identify external dissolution).

Methods:
Bongo netting: Both foramanifera and pteropod specimens were extracted from Bongo deployments (see above). All foraminifera and a representative sample of pteropod specimens were rinsed in ammonia buffered Milli-Q before being placed on specimen slides to air dry.

Incubations: Live pteropods for bioassays were obtained from the Bongo nets (see above). Once a representative sample of pteropods had been picked to provide a reference, half of the number of picked specimens were placed in pH-buffered milli-Q to cause mortality, the remainder were kept alive. Two sets of pCO2 manipulated bottles were prepared, one for dead specimens only, the other only for live specimens. The manipulations created pCO2 levels of 550, 750 and 1000 uatm as well as ambient. A 2000 uatm level replaced 550 uatm in P10. Once the pteropods had been introduced, the bottles were sealed and incubated either for 8, 14 or 21 days. The pteropods were placed in 1L Duran bottles or 290 ml glass BOD bottles containing unfiltered seawater. Bottles were kept in the dark in the cold store at ~0.5 C. During the incubation bottles were checked every two days to check that specimens were still alive and each bottle gently inverted to re-suspend particulate matter. Manipulations were made through addition of aliquots of 1M HCl and NaHCO3 determined through reference to the ambient TA and DIC conditions. At the termination of the incubation, any mortalities in the live specimen incubations was noted before specimens were decanted and pipetted out of the water. Light microscope pictures were taken before rinsing in buffered Milli-Q water and drying out in specimen slides.
Two foraminifera incubations of *Neogloboquadrina pachyderma* sinistral were carried out. Determining whether specimens were alive at the end of the incubation proved difficult and time consuming, however, time-lapse images taken on an inverted microscope demonstrated cytoplasm steaming at the end of the 6 day incubations in several specimens.

Implementation:

In total, 10 incubations on *L. helicina* were carried out.

Incubation #	Pteropod collection date	Incubation vessel	End date	Duration (days)
P1A	20/01/2013	BOD	28/01/2013	8
P1B	20/01/2013	BOD	10/02/2013	21
P2	21/01/2013	BOD	11/02/2013	21
P3	22/01/2013	BOD	05/02/2013	14
P4	23/01/2013	Duran	13/02/2013	21
P5	24/01/2013	Duran	07/02/2013	14
P6	25/01/2013	Duran	02/02/2013	8
P7	27/01/2013	BOD	10/02/2013	14
P8	28/01/2013	BOD	11/02/2013	14
P9	29/01/2013	Duran	12/02/2013	14
P10	06/02/2013	BOD	14/02/2013	8

Table 4: Pteropod bioassays

Recommendations

Calcein staining is recommended for future incubations of both foraminifera and pteropods to confirm active calcification during the incubation and to assess the amount of calcification at the

various CO2 treatments. A fluorescence microscope would be required to observe the incorporation of calcein within the shells.

L. helicina were abundant in Cumberland Bay. The assemblage collected on 27/2/13 included veligers of <300μm and juveniles with a range of diameters including numerous specimens >500 μm, the largest specimens collected during this cruise. The occurrence of this diverse population so close to the research station at King Edward Point provides an ideal opportunity to study this species in further detail, including life cycle and population observations and stage-specific incubations. Incubating specimens ashore will allow a broader range of treatments to be applied, including temperature and pCO2 permutations and longer incubations. In addition, calcein staining can be used to quantify linear extension of the shell and 'repair' calcification during the incubations and additional responses such as respiration rates would be better assessed in a shore-based laboratory.

Marine Snow catcher cruise report – JR274

Emma Cavan

Introduction

In the surface ocean phytoplankton convert inorganic carbon to organic forms, which are then transferred to the deep (Steinberg *et al*., 2008). Generally organic carbon sinks as marine snow aggregates or zooplankton fecal pellets out of the mixed layer (Dumont *et al*., 2011). Marine snow aggregates are considered to be >0.5mm in diameter composed of different species of detrital phytoplankton (Allredge, 1988). Only 1% of surface produced carbon reaches the seafloor, the rest is remineralised in the upper ocean by bacteria and zooplankton (Dumont *et al*., 2011). There are considered to be 3 different pools of carbon export; suspended, slow-sinking and fast-sinking. It is important to understand the magnitude, composition, rate and biological origin of organic carbon the pools so future predictions can be made with regard to the effect of climate variability on the extent of export.

Objectives and aims

The objective for this cruise was to use the marine snow catchers (MSCs) to measure the export of organic carbon from the mixed layer. The magnitude of fluxes is relative simple to measure but the composition of particles is harder to quantify, often done from microscope observations. However, on this cruise I have collected seawater to be analyzed using organic geochemical analysis to identify the compounds, mostly lipids and proteins, the particles are formed of. This should aid in identifying the origin of the exported particles.

The main aims of the cruise were to:

1) Measure export of particulate organic carbon (POC), Particulate inorganic carbon (PIC), Biogenic Silica (BSi)
2) Identify composition of suspended and slow-sinking fluxes using organic geochemical analysis
3) Use two snow catchers to observe how particles change in depth from 10m below the mixed layer depth (MLD) and 100m below the MLD.
4) Calculate rate of fast-sinking material from sinking experiments

Method

Marine snow catchers are large water bottles (100l) which are closed at a certain depth and left to settle, typically for 2 hours, on deck to allow the distinction of the three carbon pools (suspended and slow- and fast sinking). The MSCs were each deployed once a day during the morning stations at 10 and 100m below the mixed layer depth (MLD). This was determined from the CTD depth profile. The MSC only remains at depth long enough for the messenger to reach the release and seal the plungers. Once on deck a 2 litre sample was taken from the bottom tap (time=0) and then the MSC was left to stand for 2 hours. This sample represents the average POC content in a homogenous water column. It will be used to calculate the rate of slow-sinking material. A 4 litre sample is taken again from the bottom tap (t=2), representing the suspended pool of flux and the rest was drained. The base containing 7 litres was then taken to the fridge, and aggregates or fecal

pellets picked out and from this a sample of 4 litres of water was collected. All water collected was filtered for POC, PIC, BSi and for organic geochemical analysis and also all water collected at t=2 was sampled for chlorophyll and at some stations preserved in lugols.

Particles from the base were photographed using an Olympus SZX16 microscope and a Canon T2-EOS 60D camera and those that were visible by eye were sunk in a measuring cylinder to measure sinking velocity.

Sampling stations

In total 49 deployments were made at 23 stations and 44 were successful. Unsuccessful deployments were due to water leaking between the top and the base or the messenger not firing.

Table 1. Sampling stations, depth deployed to and time landed back on depth

Date	Station	MSC	Depth (m)	Time out (local)
11/1/13	1	A	75	1130
13/1/13	3	A	75	1200
14/1/13	4	A	75	8045
		B	175	1025
15/1/13	6	A	50	0845
		B	150	0915
16/1/13	8	A	50	0630
		B	150	0900
17/1/13	10	A	25	0700
		B	125	0915
18/1/13	12	A	75	0850
		B	175	1100
19/1/13	13	A	50	0645
		B	150	0930

20/1/13	16	A B	50 150	0630 0900
21/1/13	19	A B	50 150	0830 1045
22/1/13	22	A B	75 175	0645 0915
23/1/13	25	A B	75 175	0650 0915
24/1/13	27	A B	50 150	0645 0915
25/1/13	29	A B	50 150	0915 1115
27/1/13	30	A B	5 25	0645 0745
28/1/13	32	A B	50 150	0645 0900
29/1/13	34	A B	50 150	0645 0850
30/1/13	36	A B	50 150	0640 0900
31/1/13	38	A B	50 150	0645 0900
1/2/13	40	A B	50 150	0830 1045
3/2/13	43	A B	50 150	0640 0910
4/2/13	44	A B	50 150	0645 0900
5/2/13	46	A	25	0645

		B	125	0900

Preliminary results

Fast sinking particles from the base of the MSC were picked out and photographed were put into one of three categories; fecal pellets, marine snow aggregates or miscellaneous, which generally also just meant ‘other’. Figure 1 shows examples of each classification.

Figure 1. Examples of particles collected from the base of MSC classified as fast-sinking; (top left) marine snow aggregate, 2x magnification (top right) possibly a sponge larvae advected from the south sandwich islands, classified as miscellaneous, 3.2x magnification (bottom left) miscelleneaous, 1.6x magnification (bottom right) fecal pellets, 4x magnification

The only data I was able to collect on ship was the sinking speed of these large particles. Figure 2 shows the mean sinking velocities calculated for the marine snow aggregates, fecal pellets and miscellaneous particles.

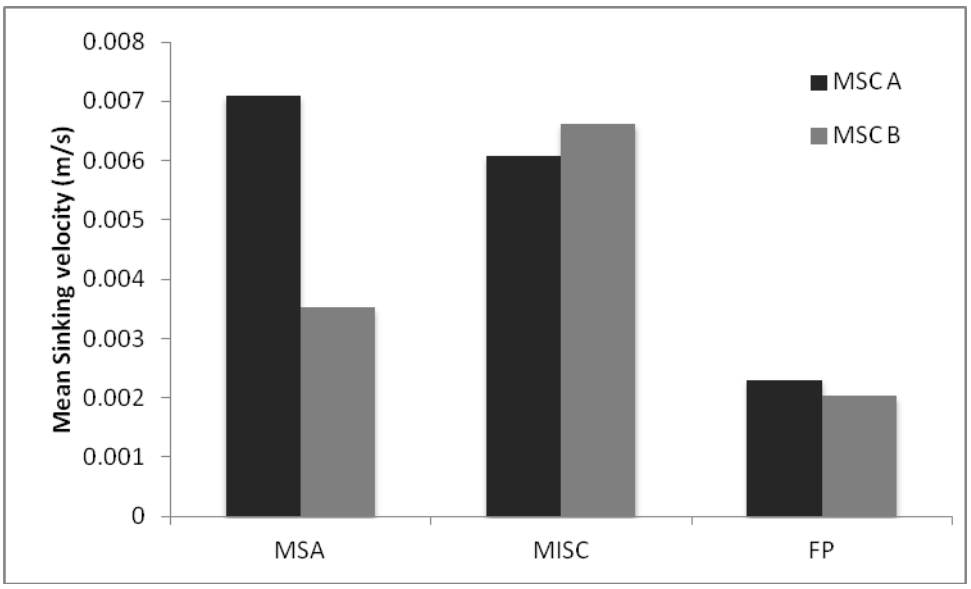

Figure 2. Mean sinking velocities of the fast-sinking material from both deployments, A & B, for all three types of particles collected, MSA = marine snow aggregates (n=25) , MISC = miscellaneous (n=17), FP = fecal pellets (124).

A large difference is observed in the sinking speeds of the MSAs between the two different depths sampled, but not for the miscellaneous or fecal pellets. However, the number of particles tested for sinking velocity for the MSAs and miscellaneous group is low (see legend) therefore decreasing the potential validity of the results. However the 'n' value for the fecal pellets was high so I feel this is sufficient to say there is likely to be no statistical difference between sinking speeds of fecal pellets at depth (statistical test yet to be completed). This result is what one may expect as aggregates are formed of different particles, which attach to each other at different times and the decrease at depth could be due to remineralisation or disaggregation. This could decrease their density and therefore sinking speeds. Whereas the fecal pellets are formed of compacted processed particles therefore potentially less subjected to disaggregation. These results represent the fast-sinking organic carbon pool only.

Figure 3 shows the total number of the various particles found. Not all particles were visible by the eye for sinking experiments and some were often lost in the process of picking, photographing and then attempting to sink.

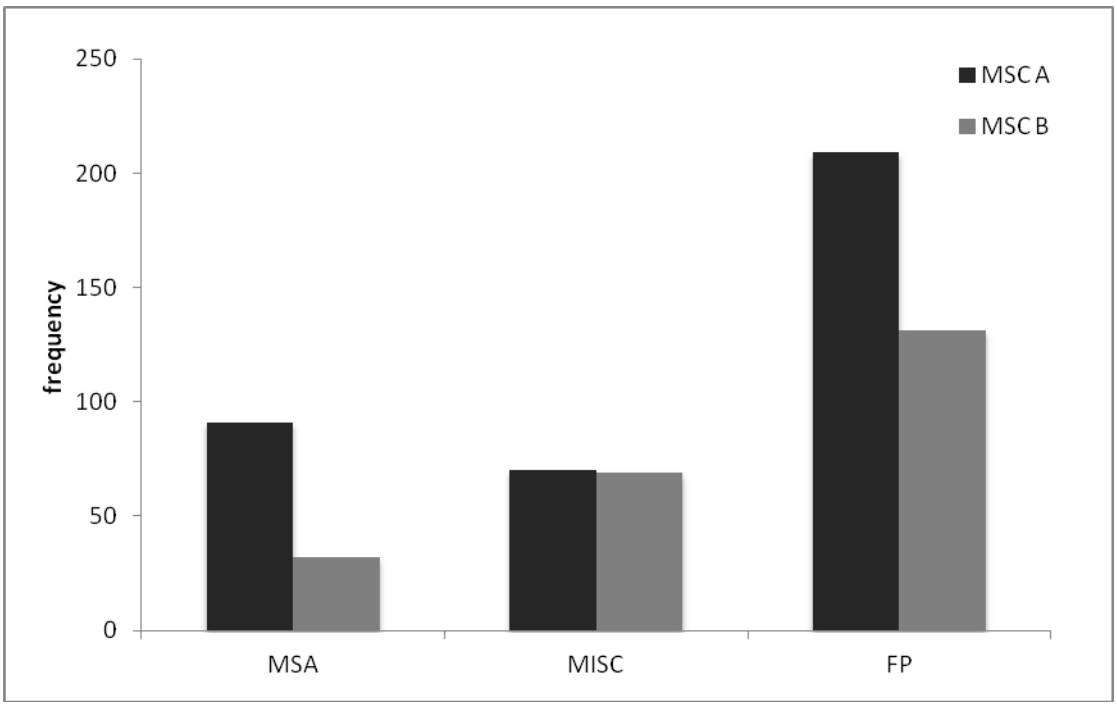

Figure 3. Total number of each type of particle found during the cruise. , MSA = marine snow aggregates, MISC – miscellaneous, FP = fecal pellets.

Both the MSAs and FPs decrease in abundance at depth, possibly due to scavenging and remineralisation. So the number of MSAs and their sinking speeds decrease 100m below the MLD, yet for FPs the sinking speed does not change yet the abundance does.

These results are extremely primitive and on return to NOCS I will analyse the filters collected for POC, PIC, BSi and biomarker compounds for the other pools (suspended and slow-sinking). This will allow me to find the sinking speed of the slow-sinking pool and the extent of export below the MLD. POC of the fast-sinking pool will be calculated from the photographs using method outlined by Alldredge (1998). These results will be compared with the vast range of datasets collected on this cruise including surface biological community structure and the varying biogeochemical conditions along the cruise track.

References

Alldredge, A. The carbon, nitrogen and mass content of marine snow as a fraction of aggregate size. *Deep Sea Research*, Part 1. **45** (4-5), 529-541. (1998)

Dumont, I., Schoemann, V., Jacquet, S. H. M., Masson, F. & Becquevort, S. Bacterial abundance and production in epipelagic and mesopelagic waters in the Subantarctic and Polar Front zones south of Tasmania. *Deep Sea Research Part II: Topical Studies in Oceanography* **58**, 2212-2221, doi:10.1016/j.dsr2.2011.05.024 (2011).

Steinberg, D. K. *et al.* Bacterial vs. zooplankton control of sinking particle flux in the ocean's twilight zone. *Limnology and Oceanography* **53**, 1327-1338 (2008).

Cruise Report ^{234}Th and SAPS JCR 274 Antarctic cruise on board the RSS James Clark Ross 9th January – 12th February 2013

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^{234}Th derived carbon and biomineral fluxes

Scientific motivation

The Radioactive short-lived Thorium-234 (^{234}Th, t1/2=24,1d) has been used as a tracer of several transport processes and particle cycling in aquatic systems by different techniques (Van der Loeff et al 2006). It can be used to estimate how much POC is exported into the deep ocean (Buesseler et al 1992). ^{234}Th is the daughter isotope of naturally occurring 238-Uranium (^{238}U, t1/2=4,47.10^9y) which conservative in the seawater and proportional to salinity in well oxygenated environment (Ku et al 1977). Unlike ^{238}U, ^{234}Th is particle reactive in the water column. As particles with ^{234}Th sink through the water column, a radioactive disequilibrium is formed between ^{238}U and ^{234}Th, which can be used to quantify the rate of carbon and biominerals export from the surface ocean. This is possible with the ratios of POC, PIC or BSI to particulate ^{234}Th activity (Tsunogai & Minagawa 1976) obtained from large volume samples (e.g. *in situ* pumps: SAPS). ^{234}Th POC, PIC and opal downward fluxes will be calculated to assess the strength of downward export of particulate matter and interactions between POC and biomineral fluxes (Le Moigne et al 2012, Le Moigne et al 2013b) along contrasted environments in the southern ocean as described in (Le Moigne et al 2013a).

Sampling methodology and sampling treatment on board

Samples for thorium analysis were collected from a stainless steel CTD rosette at various stations (see figure 1 and table 1). 4L water samples were collected at ten horizons from surface to to 500m depth where a significant export of particles are expected and thereby a disequilibrium between ^{234}Th and ^{238}U. ^{238}U concentration is derived from salinity measurement and thus is not directly measured from seawater samples. Total ^{234}Th is obtained by adding $KMnO_6$ (potassium permanganate), $MnCl_2$ (manganese dichloride) and concentrated ammonia (NH_3) to the 4L. Thorium is precipitated with MnO_2 within 8 hours after a spike a ^{230}Th was added as a yield monitor as described in Pike *et al* (2006). The formed precipitate is filtered onto 25mm precombusted QMA filters. Filters were then wrapped in mylar foil and counted in a Riso beta counter as described in (Le Moigne et al 2013b). Corrections are made for ^{234}Th decay and ^{234}Th in growth from ^{238}U decay

since sampling. To calibrate ^{234}Th counting efficiency, mid water (2000m) samples were used, away from the surface ocean, coastal areas and seafloor nephleloid layers, where the secular equilibrium between ^{234}Th and ^{238}U is expected. The ratios of POC, PIC or BSI to particulate ^{234}Th activity will be obtained from particles from several depths sampled using SAPS as described in (Le Moigne et al 2013b).

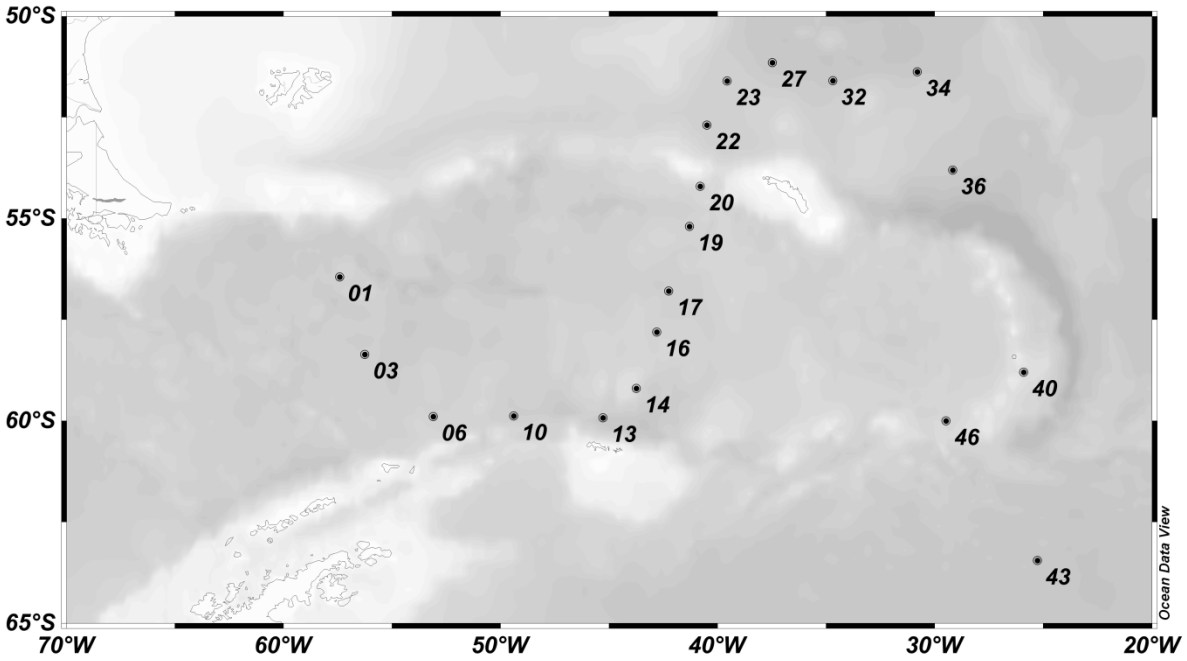


Figure 2: JR 274 station positions.

Table 1: Station ID, CTD num, date, depth range and position.

Station	CTDs num	Date	Number of sample	Depth range (in m)	Lat	Long
01	02	11-Jan	9	5-300	56° 27	57° 25
03	09	13-Jan	9	5-300	58° 22	56° 15
06	12	15-Jan	9	5-300	59° 54	53° 01
10	16	17-Jan	9	5-300	59° 53	49° 24
13	23	19-Jan	8	5-300	59° 56	45° 17
14	24	19-Jan	8	5-300	59° 12	43° 45
16	26	20-jan	8	5-300	57° 49	42° 49

17	27	20-jan	8	5-300	56° 48	42° 15
19	28	21-Jan	8	5-300	55° 12	41° 18
20	29	21-Jan	8	5-300	54° 13	40° 48
22	31	22-Jan	8	5-300	52° 42	40° 03
23	35	22-Jan	8	5-300	51° 37	39° 34
27	36	24-Jan	8	5-300	51° 09	37° 29
32	47	28-Jan	8	5-300	51° 36	34° 42
34	54	29-Jan	3	2000	51° 23	30° 48
36	56	30-Jan	8	5-300	53° 49	29° 11
40	66	1-Feb	8	5-300	58° 05	25° 55
43	69	3-Feb	8	5-300	63° 27	25° 17
46	76	5-Feb	8	5-300	60° 00	29° 39
		7-Feb	8	5-300		

Further work and scientific outcomes

These results of ^{234}Th will be corrected with two “background counting” in three and six month. The ^{238}U results will be calculated from calibrated salinity measurements. The recovery will be calculated by ^{230}Th measured with an ICPMS at NOCS. Once corrected, the ^{234}Th results will be integrated in order to obtain the ^{234}Th fluxes (dpm m^{-2} d^{-1}) to further extrapolate POC, calcite and opal export (g m^{-2} d^{-1}) with POC/^{234}Th, PIC/^{234}Th and Bsi/^{234}Th ratio obtained from high volume collection of particulate matter (SAPS).

SAPS deployment

Two standing alone pumping system (SAPS) were devoted for Th derived carbon and biomineral fluxes as summarised in table 2. SAPS pumping time was set as 60-90min. After recovery, particles were rinsed off the mesh on Th devoted SAPS and splitted in four portion for further Th, POC, PIC and Bsi analisys back in homelab.

Table 2: SAPS depths, filter types and splits.

station number	Th SAPS depths	Type of mesh	Splits
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	85	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
1	185	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	75	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
3	175	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	50	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
6	150	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	25	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
10	125	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	40	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	Mesh frozen
13	40	1µm NITEX	Mesh frozen
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	40	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	Mesh frozen
16	40	1µm NITEX	Mesh frozen
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
19	60	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi

		53µm NITEX	Mesh frozen
	60	1µm NITEX	Mesh frozen
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	75	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	Mesh frozen
22	75	1µm NITEX	Mesh frozen
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	50	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
27	150	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	60	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
32	160	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	50	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
36	150	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	50	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
40	150	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	50	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
43	150	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	30	1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
46	130	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi

1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi

References

Buesseler KO, Bacon MP, Cochran JK, Livingston HD. 1992. Carbon and nitrogen export during the JGOFS North Atlantic Bloom Experiment estimated from ^{234}Th:^{238}U disequilibria. *Deep-Sea Research I* 39: 1115-37

Ku TL, Knauss KG, Mathieu GG. 1977. Uranium in open ocean: concentration and isotopic composition. *Deep-Sea Research* 24: 1005-17

Le Moigne FAC, Boye M, Masson A, Corvaisier R, Grosstefan E, et al. 2013a. Description of the biogeochemical features of the subtropical southeastern Atlantic and the Southern Ocean south off South Africa during the austral summer of the International Polar Year. *Biogeosciences* 10: 1-15

Le Moigne FAC, Sanders RJ, Villa-Alfageme M, Martin AP, Pabortsava K, et al. 2012. On the proportion of ballast versus non-ballast associated carbon export in the surface ocean. *Geophys. Res. Lett.* 39: L15610

Le Moigne FAC, Villa-Alfageme M, Sanders RJ, Marsay CM, Henson S, Garcia-Tenorio R. 2013b. Export of organic carbon and biominerals derived from ^{234}Th and ^{210}Po at the Porcupine Abyssal Plain. *Deep Sea Research Part I* 72: 88-101

Tsunogai S, Minagawa M. 1976. Th-234, Pb-210 AND Po-210 in surface and deep waters of Pacific as tracers of particulate materials. *Transactions-American Geophysical Union* 57: 255-55

Van der Loeff MR, Sarin MM, Baskaran M, Benitez-Nelson C, Buesseler KO, et al. 2006. A review of present techniques and methodological advances in analyzing Th-234 in aquatic systems. *Marine Chemistry* 100: 190-212

PUBLIC OUTREACH – THE ANTARCTIC OA CRUISE BLOG

Jeremy Young ,Toby Tyrrell and Athena Drakou

Background

Public outreach and knowledge transfer are an increasingly important component of modern science. This is especially so in the current project since its fundamental objective is to provide an assessment of the degree of threat posed by ocean acidification. So, providing a good-quality cruise blog was seen as an important component of the work. On the first UK Ocean Acidification cruise, D366 on the NW European Shelf, a blog was produced which documented in some detail the range of science being undertaken (http://noc.ac.uk/news/rrs-discovery-cruise-366), this blog has also been reproduced as a separate publication. On the second cruise, JR271 to the Arctic, a more informal blog (http://www.arcticoacruise.org) was produced intended for an audience of young scientists, undergraduate science students, and the general public. The Arctic Cruise model was followed here but we also noted that items on the natural history of the environments had been particularly popular and had increased the readership of he blog. We decided to develop this aspect with more posting of short items on the wildlife and scenery and nice images in between the items on our science.

Target audience and objectives

While editing the blog and guiding contributors we had three main objectives and target audiences in mind.

1. To produce documentation of our research accessible to the general public in order to raise public understanding of ocean acidification and oceanographic research.

2. To document our activities and progress for the particular audience of family, friends and colleagues of the participants, whilst at the same time informing them of our science. In our experience this is the largest immediate audience for the blog and also one which with some encouragement and promotion can be very large.

3. Providing a web-accessible record of the nature of oceanographic research. We suspect that blogs such as this will increasingly be used by for instance school students interested in potential careers in science or researching how science works.

This mix of audiences means that we needed a mix of documentation of the scientific work and some more immediately accessible content such as interesting images and personal perspectives.

People involved/process

Cruise participants – we decided to follow the model adopted on Cruise JR271and ask all members of the cruise science party to contribute to the blog. To ensure this happened we used the device of producing a schedule for the cruise and asking each science participant to commit to writing a blog on one specific day. This proved an effective way to get widespread participation. The response to this was good and included technical staff as well as researchers.

Participants were left free to choose their own topic, with a general brief to write for a non-technical audience and a guide length of about a page (i.e. 200-400 words). Having a wide participation gave a diverse range of approaches and served to introduce the full range of cruise participants –from first year PhD students to senior academics. This also meant that the blog was a communal effort and that all participants gained some experience of writing for a popular audience.

Blog editors - Jeremy Young took on the role of blog editor, compiling content on a daily basis and sending it to Athena for posting to the web. This included obtaining content from other participants, writing short items as needed to ensure coverage of events and continuity of coverage; light editing of submitted written content; undertaking some photography for the blog; editing of photographs for posting on the blog. Typically this involved 1-2 hours work per day.

Toby Tyrrell and Jeremy Young wrote additional blog posts as needed to ensure continuous daily coverage of the blog, especially during the first few days.

The internet connection was severely limited throughout the cruise hence it was important to conserve bandwidth. To achieve this, photographs were reformatted in Photoshop; they were resized to 1000 pixel width, and saved as medium to high resolution JPEG images using the "Save for Web" process - this process removes embedded thumbnails and metadata giving final file sizes of ca 100kb. Videos were compressed using Quicktime Player to save in MPEG-4-(.m4v) format which enabled video clips to be compressed to a few Mb (10Mb was the largest file size which could be sent).

Content manager – in Southampton Athena Drakou reformatted the content and posted it on a daily basis to the main blog website – www.antarcticoacruise.org. In addition AD copied content and kept updated a Facebook page ("Arctic Ocean Acidification Cruise") and twitter stream @arcticoacruise, while she also maintained a Flickr photo account where the best photos of the cruise were posted.

She also developed and updated regularly a Google map showing JRC route. All this involved about 1 1/2 - 2 hrs work per day, excluding the design and maintenance of the website.

JCR IT support- on the JCR the IT support expert Johnnie Edmonston set up a mirror of the blog on the ship's intranet in order to make it available to the cruise participants and ship personnel. This was. however, only partially successful owing to the use on the blog of some modern technologies which conflicted with the mirroring process.

Outcome

Blog posts were made daily throughout the cruise with additional wildlife updates on some days. A total of about **40** posts were made (from 8th Jan to 12th Feb) and over **200** images posted. Content covered included the range of science being undertaken, logistic aspects of cruise organisation, progress of the cruise in terms of science and places visited, wildlife encountered, and aspects of the social life on the ship. Probably the most popular posts were those featuring the ice, penguins, birds, and whales.

On ship access to the blog was limited since the internet connection did not allow WWW use, and the local mirror did not work well. Consequently the prime access to the blog was via the server copies of the unformatted posts. These were still widely used but the blog did not really have a high impact on-ship. Conversely we did have much good feedback from family and friends who were using the blog to follow our activities.

Statistics

Areas for improvement – web access

Whilst we felt the blog was a successful public outreach activity we were very aware that the potential in this area was constrained by the very limited internet access available on the ship at the current time. This had three specific effects. First, we were limited in the amount of content that could be uploaded from the ship for the blog – in particular use of movie clips was constrained. Second, the blog was not readable from the ship, as a consequence there was less communal ownership of the project than we would have liked and the blog was less publicised among contacts of the ship party. Third, ship participants could not use social media such as Facebook and Twitter to provide publicity for the blog and extend the outreach from the cruise.

Annex 1: Event Log

Time	Evt No.	Start time	Bottom time	End time	Station	Latitude	Longitude	Depth (m)	Activity	Operator	Comment
12/02/2013 09:50	299	09:50				-51.661	-57.62875	63.03	CPR recovery	Pete	157/1 (2nd)
10/02/2013 19:31	299	19:28				-52.7946	-46.66522	2774.11	CPR deployment	Pete	157/1 (2nd)
10/02/2013 19:22	298	19:22				-52.7977	-46.6458	2727.71	CPR recovery	Pete	157/0 (2nd)
09/02/2013 14:34	298	14:34				-54.0543	-38.10164	103.87	CPR deployment	Pete	157/0 (2nd)
09/02/2013 14:31	297	14:31				-54.0509	-38.09574	100.7	Tow fish deployed	Eric	
07/02/2013 16:41	296	16:41	17:28	18:02	50	-54.7368	-33.36481	3500	Go-Flo	Eric	Go Flo 25
07/02/2013 16:27	295	16:27			50	-54.7369	-33.36277	3554.26	CPR recovery	Pete	167/2
07/02/2013 11:24	295	11:24				-55.6915	-33.77266	3302.16	CPR deployment	Pete	167/1
07/02/2013 10:27	295	10:27				-55.6915	-33.77266	3302.16	CPR recovery	Pete	167/2
06/02/2013 20:52	294	20:52			49	-57.4127	-32.61686	3901.45	CPR deployment	Pete	167/2
06/02/2013 20:28	293	20:28	20:34	20:43	49	-57.4132	-32.6158	3901.36	Bongo	Pete	Bongo 91 (200 m cable out)
06/02/2013 19:57	292	19:57	20:07	20:22	49	-57.4132	-32.61576	3898.16	SS CTD	Jeremy	CTD No 78 (SS CTD 47 300 m cable out)
06/02/2013 19:47	291	19:47			49	-57.415	-32.61279	3898.73	CPR recovery	Pete	167/1
06/02/2013	291	15:34			48	-57.4127	-32.61686	3901.45	CPR	Geraint	167/1

15:34									deployment		
06/02/2013 13:36	290	13:36	14:27	15:26	48	-57.929	-32.05401	2869.57	Ti CTD	Matt/Eric	CTD No 77 (Ti CTD 31 2860 m cable out)
06/02/2013 12:50	289	12:50	12:57	13:12	48	-57.929	-32.05382	2869.11	SS CTD	Chris	CTD No 76 (SS CTD 46 300 m cable out)
06/02/2013 11:20	288	11:20	11:26	11:36	48	-57.9282	-32.05365	2881.46	Bongo	Geraint	Bongo 90 (200 m cable out)
06/02/2013 11:03	287	11:03	11:10	11:19	48	-57.9273	-32.05357	2896.26	Bongo	Geraint	Bongo 89 (200 m cable out)
06/02/2013 10:46	286	10:46	10:53	11:02	48	-57.9269	-32.05353	2903.35	Bongo	Geraint	Bongo 88 (200 m cable out)
06/02/2013 09:05	285	09:05	09:42	10:40	48	-57.9268	-32.05345	2902.86	Go-Flo	Eric	Go Flo 24
06/02/2013 07:49	284	07:49			48	-57.9279	-32.0496	2903.58	CPR recovery	Geraint	167/1
05/02/2013 15:36	284	15:36			46	-59.9966	-29.66164	2586.64	CPR deployment	Geraint	167/1
05/02/2013 13:46	283	13:46	14:32	15:29	46	-59.9974	-29.65944	2559	Ti CTD	Matt/Eric	CTD No 75 (Ti CTD 30 2550 m cable out)
05/02/2013 11:55	282	11:55		12:05	46	-59.9967	-29.66019	2568.14	Snow-Catcher	Emma/Richard	Snow catcher 48
05/02/2013 11:30	281	11:30	11:39	13:36	46	-59.9966	-29.66037	2586.8	SAPS	Fred	SAPS 14 (140 m cable out)
05/02/2013	280	09:47	10:29	11:21	46	-59.9965	-29.66034	2602.08	Go-Flo	Eric	Go Flo 23

09:47											
05/02/2013 09:42	279	09:42		09:47	46	-59.9965	-29.66041	2580.49	Snow-Catcher	Emma/Richard	Snow catcher 47
05/02/2013 09:31	278	09:31		09:37	46	-59.9966	-29.66037	2568.01	Snow-Catcher	Emma/Richard	Snow catcher 46 (deployment failed)
05/02/2013 08:58	277	08:58	09:07	09:23	46	-59.9966	-29.66046	2567.95	SS CTD	Chris	CTD No 74 (SS CTD 45 300 m cable out)
05/02/2013 08:33	276	08:33	08:40	08:49	46	-59.9958	-29.66092	2577.48	Bongo	Geraint	Bongo 87 (200 m cable out)
05/02/2013 08:16	275	08:16	08:23	08:32	46	-59.9949	-29.66155	2598.9	Bongo	Geraint	Bongo 86 (200 m cable out)
05/02/2013 07:57	274	07:57	08:05	08:14	46	-59.9939	-29.66228	2586.65	Bongo	Geraint	Bongo 85 (200 m cable out)
05/02/2013 07:48	273	07:48			46	-59.9954	-29.66025	2586.52	CPR recovery	Geraint	167/1
04/02/2013 20:49	273	20:49			45	-61.4721	-27.86589	3720.18	CPR deployment	Pete	167/1
04/02/2013 20:25	272	20:25	20:32	20:41	45	-61.4709	-27.86421	3704.58	Bongo	Pete	Bongo 84 (200 m cable out)
04/02/2013 19:54	271	19:54	20:03	20:20	45	-61.4709	-27.86421	3735.58	SS CTD	Jeremy	CTD No 73 (SS-CTD 44 300 m cable out)
04/02/2013 19:46	270	19:46			45	-61.4741	-27.85952	3554.46	CPR recovery	Geraint	167/1
04/02/2013	270	15:07			44	-62.1349	-27.02783	3975.37	CPR	Geraint	167/1

15:07									deployment		
04/02/2013 11:59	269	11:59	13:21	14:59	44	-62.1383	-27.02291	4192.95	Ti CTD	Matt/Eric	CTD 72 (Ti CTD 29 4290 m cable out)
04/02/2013 11:32	268	11:32		11:45	44	-62.1383	-27.02578	4233.31	Snow-Catcher	Emma/Richard	Snow catcher 45
04/02/2013 09:48	267	09:48	10:30	11:24	44	-62.1383	-27.0257	4199.34	Go-Flo	Eric	Go Flo 22
04/02/2013 09:34	266	09:34		09:41	44	-62.1384	-27.02569	4509.71	Snow-Catcher	Emma/Richard	Snow catcher 44
04/02/2013 08:59	265	08:59	09:09	09:26	44	-62.1384	-27.02567	4147.03	SS CTD	Chris	CTD No 71 (SS CTD 43 300 m cable out)
04/02/2013 08:35	264	08:35	08:42	08:51	44	-62.1372	-27.02623	4239.45	Bongo	Geraint	Bongo 83 (200 m cable out)
04/02/2013 08:19	263	08:19	08:25	08:34	44	-62.1358	-27.0267	4159.75	Bongo	Geraint	Bongo 82 (200 m cable out)
04/02/2013 08:01	262	08:01	08:08	08:16	44	-62.1346	-27.02765	4138.06	Bongo	Geraint	Bongo 81 (200 m cable out)
04/02/2013 07:52	261	07:52			44	-62.1351	-27.0253	4181.45	CPR recovery	Geraint	167/1
03/02/2013 21:56	261	21:53			43	-63.4653	-25.30447	4931.04	CPR deployment	Geraint	167/1
03/02/2013 18:20	260	18:20	20:04	21:47	43	-62.1349	-27.02783	3975.37	Ti CTD	Deck	Deployed with no bottles for respooling purposes)
03/02/2013 14:02	259	14:02	15:29	16:22	43	-63.4666	-25.29452	4942.37	Ti CTD	Matt/Eric	CTD No. 70 (Ti CTD 28

											4888 m cable out)
03/02/2013 12:00	258	12:00		12:12	43	-63.4658	-25.29838	4942.74	Snow-Catcher	Emma/Richard	Snow catcher 43
03/02/2013 11:45	257	11:45	11:55	13:53	43	-63.4658	-25.29851	4936.46	SAPS	Fred	SAPS 13 (160 m cable out)
03/02/2013 09:43	256	09:43	10:47	11:37	43	-63.4658	-25.29853	4936.84	Go-Flo	Eric	Go Flo 21
03/02/2013 09:31	255	09:31		09:38	43	-63.4658	-25.29843	4937.03	Snow-Catcher	Emma/Richard	Snow catcher 42
03/02/2013 08:56	254	08:56	09:05	09:22	43	-63.4658	-25.29852	4936.72	SS CTD	Chris	CTD No 69 (SS CTD 42 300 m cable out)
03/02/2013 08:30	253	08:30	08:38	08:47	43	-63.4649	-25.29814	4936.37	Bongo	Geraint	Bongo 80 (200 m cable out)
03/02/2013 08:14	252	08:14	08:21	08:29	43	-63.464	-25.29769	4936.05	Bongo	Geraint	Bongo 79 (200 m cable out)
03/02/2013 07:56	251	07:56	08:03	08:12	43	-63.464	-25.29769	4936.93	Bongo	Geraint	Bongo 78 (200 m cable out)
03/02/2013 07:48	250	07:48			43	-63.4592	-25.2949	4936.56	CPR recovery	Geraint	167/1
02/02/2013 20:56	250	20:56			42	-61.672	-25.76184	4509.72	CPR deployment	Pete	167/1
02/02/2013 20:26	249	20:26	20:35	20:38	42	-61.6722	-25.75259	4540.55	Bongo	Pete	Bongo 77 (200 m cable out)
02/02/2013 19:55	248	19:55	20:04	20:20	42	-63.4666	-25.29452	4942.37	SS CTD	Jeremy	CTD No. 68 (SS CTD 41 300 m cable

											out)
02/02/2013 12:04	247	12:04				-62.1351	-27.0253	4181.45	CPR recovery	Geraint	167/0 recovered due to bad weather
01/02/2013 15:43	247	15:43			40 (Bioassay 4)	-58.0891	-25.92402	2899.97	CPR deployment	Geraint	167/0
01/02/2013 14:38	246	14:38	15:03	15:34	40 (Bioassay 4)	-58.0899	-25.92779	2893.64	Ti CTD	Geraint	CTD No 67 (Ti CTD 27 1400 m cable out)
01/02/2013 13:24	245	13:24		13:36	40 (Bioassay 4)	-58.0894	-25.92906	2895.49	Snow-Catcher	Emma/Richard	Snow catcher 41
01/02/2013 13:14	244	13:14	13:22	14:22	40 (Bioassay 4)	-58.0893	-25.92913	2894.21	SAPS	Fred	SAPS 12 (160 m cable out)
01/02/2013 11:31	243	11:31	12:11	13:05	40 (Bioassay 4)	-58.0893	-25.92921	2893.83	Go-Flo	Eric	Go Flo 20
01/02/2013 11:22	242	11:22		11:26	40 (Bioassay 4)	-58.0885	-25.93015	2896.1	Snow-Catcher	Emma/Richard	Snow catcher 40
01/02/2013 10:45	241	10:45	10:55	11:10	40 (Bioassay 4)	-58.0879	-25.93085	2895.94	SS CTD	Chris	CTD No. 66 (SS CTD 40 300 m cable out)
01/02/2013 10:18	240	10:19	10:25	10:34	40 (Bioassay 4)	-58.087	-25.92901	2899.38	Bongo	Geraint	Bongo 76 (200 m cable out)
01/02/2013 10:01	239	10:01	10:07	10:16	40 (Bioassay 4)	-58.0861	-25.92704	2899.89	Bongo	Geraint	Bongo 75 (200 m cable out)

01/02/2013 09:43	238	09:43	09:44	09:59	40 (Bioassay 4)	-58.0856	-25.92565	2901.73	Bongo	Geraint	Bongo 74 (200 m cable out)
01/02/2013 08:04	237	08:04	09:23	09:37	40 (Bioassay 4)	-58.087	-25.92901	2899.38	Ti CTD	Mark	CTD No 65 (Ti CTD 26 100 m cable out)
01/02/2013 07:47	236	07:47	07:51	08:02	40 (Bioassay 4)	-58.0856	-25.92582	2905.99	Ti CTD	Mark	CTD No 64 (Ti CTD 25 100 m cable out)
01/02/2013 06:39	235	06:39	06:42	06:56	40 (Bioassay 4)	-58.0857	-25.92578	2903.13	Ti CTD	Mark	CTD No 63 (Ti CTD 24 100 m cable out)
01/02/2013 05:20	234	05:20	05:25	05:40	40 (Bioassay 4)	-58.0857	-25.92582	2902.54	Ti CTD	Mark	CTD No 62 (Ti CTD 23 100 m cable out)
31/01/2013 20:29	233	20:29	20:36	20:45	39	-56.9653	-25.79539	3431.48	Bongo	Pete	Bongo 73 (200 m cable out)
31/01/2013 19:57	232	19:57	20:07	20:23	39	-56.9653	-25.79537	3437.47	SS CTD	Jeremy	CTD No 61 (SS CTD 39 300 m cable out)
31/01/2013 19:48	231	19:48			39	-56.9602	-25.79933	3403.71	CPR recovery	Pete	167/0
31/01/2013 13:10	231	13:10			38	-56.0941	-27.0284	1504.95	CPR deployment	Geraint	167/0
31/01/2013 12:01	230	12:01	12:28	12:58	38	-56.0893	-27.0249	1990.56	Ti CTD	Geraint	CTD No 60 (Ti CTD 22 1400 m cable out)
31/01/2013	229	11:36		11:48	38	-56.0901	-27.02763	1976.56	Snow-	Emma/Richard	Snow

11:36									Catcher		catcher 39
31/01/2013 09:58	226	08:58	09:09	09:26	38	-56.09	-27.02802	1974.48	SS CTD	Chris	CTD No. 59 (SS CTD 38 300 m cable out)
31/01/2013 09:47	228	09:47	10:31	10:53	38	-56.09	-27.02803	1973.64	Go-Flo	Eric	Go Flo 19
31/01/2013 09:35	227	09:37		09:41	38	-56.0901	-27.02827	1972.43	Snow-Catcher	Emma/Richard	Snow catcher 38
31/01/2013 08:34	225	08:34	08:41	08:50	38	-56.0901	-27.02824	1972.84	Bongo	Geraint	Bongo 72 (200 m cable out)
31/01/2013 08:17	224	08:17	08:24	08:33	38	-56.0901	-27.02824	1972.84	Bongo	Geraint	Bongo 71 (200 m cable out)
31/01/2013 07:59	223	07:59	08:07	08:16	38	-56.0901	-27.02822	1972.54	Bongo	Geraint	Bongo 70 (200 m cable out)
31/01/2013 07:49	222	07:49			38	-56.0854	-27.02957	1988.78	CPR recovery	Geraint	167/0
30/01/2013 20:56	222	20:56			37	-54.57	-28.67191	5799.73	CPR deployment	Pete	167/0
30/01/2013 20:29	221	20:29	20:36	20:45	37	-54.5742	-28.6716	5802.77	Bongo	Pete	Bongo 69 (200 m cable out)
30/01/2013 19:57	220	19:57	20:06	20:23	37	-54.5743	-28.67163	5803.04	SS CTD	Jeremy	CTD No. 58 (SS CTD 37 300 m cable out)
30/01/2013 19:47	219	19:47			37	-54.5693	-28.67171	5793.77	CPR recovery	Pete	167/0
30/01/2013 14:55	219	14:55			36	-53.8265	-29.18784	4647.8	CPR deployment	Geraint	167/0
30/01/2013	218	13:51	14:17	14:48	36	-53.825	-29.18898	4645.09	Ti CTD	Geraint	CTD No. 57

13:51											(Ti CTD 21 1400 m cable out)
30/01/2013 11:44	217	11:44		11:57	36	-53.8252	-29.18882	4647.78	Snow-Catcher	Emma/Richard	Snow catcher 37
30/01/2013 11:32	216	11:32	11:42	13:43	36	-53.8252	-29.18881	4645.01	SAPS	Fred	SAPS 11 (165 m cable out)
30/01/2013 09:44	215	09:44	10:28	11:25	36	-53.8252	-29.18881	4645.09	Go-Flo	Eric	Go Flo 18
30/01/2013 09:32	214	09:32		09:39	36	-53.8251	-29.18845	4645.18	Snow-Catcher	Emma/Richard	Snow catcher 36
30/01/2013 08:56	213	08:56	09:06	09:24	36	-53.8251	-29.18846	4644.71	SS CTD	Chris	CTD No. 56 (SS CTD 36 300 m cable out)
30/01/2013 08:32	212	08:32	08:39	08:47	36	-53.8259	-29.18767	4647.58	Bongo	Geraint	Bongo 68 (200 m cable out)
30/01/2013 08:14	211	08:14	08:22	08:31	36	-53.8268	-29.18687	4651.09	Bongo	Geraint	Bongo 67 (200 m cable out)
30/01/2013 07:58	210	07:58	08:05	08:13	36	-53.8275	-29.18624	4650.91	Bongo	Geraint	Bongo 66 (200 m cable out)
30/01/2013 07:49	209	07:49			36	-53.8241	-29.18564	4645	CPR recovery	Geraint	167/0
29/01/2013 21:01	209	21:01			35	-52.1643	-30.27767	2810.93	CPR deployment	Geraint	167/0
29/01/2013 20:36	208	20:36	20:43	20:52	35	-52.1626	-30.28002	2807.86	Bongo	Pete	Bongo 65 (200 m cable out)
29/01/2013 20:04	207	20:04	20:13	20:30	35	-52.1626	-30.27999	2807.87	SS CTD	Jeremy	CTD No. 55 (SS CTD 35

											300 m cable out)
29/01/2013 19:47	206	19:47			35	-52.1593	-30.28116	2807.52	CPR recovery	Pete	157/2
29/01/2013 14:43	206	14:43			34	-51.3932	-30.81233	3922.94	CPR deployment	Geraint	157/2
29/01/2013 11:58	205	11:58	13:06	14:30	34	-51.3929	-30.80584	3925.9	Ti CTD	Geraint	CTD No. 54 (Ti CTD 20 1400 m cable out)
29/01/2013 11:31	204	11:31		11:44	34	-51.3937	-30.80888	3925.61	Snow-Catcher	Emma/Richard	Snow catcher 35
29/01/2013 09:49	203	09:49	10:30	11:26	34	-51.3895	-30.81014	3932.05	Snow-Catcher	Eric	Go Flo 17
29/01/2013 09:37	202	09:37		09:43	34	-51.3894	-30.81058	3926.22	Snow-Catcher	Emma/Richard	Snow catcher 34
29/01/2013 08:58	201	08:58	09:08	09:25	34	-51.3894	-30.8106	3925.99	SS CTD	Chris	CTD No. 53 (SS CTD 34 300 m cable out)
29/01/2013 08:32	200	08:32	08:39	08:48	34	-51.3891	-30.81128	3925.72	Bongo	Geraint	Bongo 64 (200 m cable out)
29/01/2013 08:15	199	08:15	08:22	08:31	34	-51.3889	-30.81191	3928.97	Bongo	Geraint	Bongo 63 (200 m cable out)
29/01/2013 07:57	198	07:57	08:04	08:13	34	-51.3888	-30.81236	3926.04	Bongo	Geraint	Bongo 62 (200 m cable out)
29/01/2013 07:49	197	07:49			34	-51.3886	-30.81898	3926.08	CPR recovery	Geraint	157/2
28/01/2013 21:28	197	21:18			33	-51.2511	-33.51405	2144.34	CPR deployment	Pete	157/2
28/01/2013	196	20:49	20:58	21:13	33	-51.2592	-33.51341	2168.81	SS CTD	Jeremy	CTD No. 52

20:49											(SS CTD 33 300 m cable out) - repeat CTD
28/01/2013 20:27	195	20:27	20:34	20:43	33	-51.259	-33.51412	2168.52	Bongo	Pete	Bongo 61 (200 m cable out)
28/01/2013 19:56	194	19:56	20:06	20:22	33	-51.2592	-33.51341	2168.81	SS CTD	Jeremy	CTD No. 51 (SS CTD 32 300 m cable out) - water not collected since screw caps not sealed
28/01/2013 19:48	193	19:48			33	-51.2605	-33.51049	0	CPR recovery	Pete	157/2
28/01/2013 14:53	193	14:53			32	-51.6023	-34.69904	4294.22	CPR deployment	Geraint	157/2
28/01/2013 13:48	192	13:48	14:13	14:42	32	-51.6074	-34.70032	4792.74	Ti CTD	Geraint	CTD No. 50 (Ti CTD 19 1400 m cable out)
28/01/2013 11:46	191	11:46		11:59	32	-51.6137	-34.71209	4779.86	Snow-Catcher	Emma/Richard	Snow catcher 33
28/01/2013 11:29	190	11:29	11:39	13:38	32	-51.6142	-34.7132	4776.72	SAPS	Fred	SAPS 10 (170 m cable out)
28/01/2013 09:48	189	09:48	10:29	11:21	32	-51.6161	-34.71588	4776.61	Go-Flo	Eric	Go Flo 16
28/01/2013 09:34	188	09:34		09:42	32	-51.6161	-34.71587	4773.55	Snow-Catcher	Emma/Richard	Snow catcher 32
28/01/2013 09:00	187	09:00	09:10	09:32	32	-51.6161	-34.71588	4773.97	SS CTD	Chris	CTD No. 49 (SS CTD 31

											300 m cable out)
28/01/2013 08:34	186	08:34	08:42	08:51	32	-51.6164	-34.71649	4777.39	Bongo	Geraint	Bongo 60 (200 m cable out)
28/01/2013 08:17	185	08:17	08:24	08:33	32	-51.6166	-34.71708	4773.95	Bongo	Geraint	Bongo 59 (200 m cable out)
28/01/2013 07:59	184	07:59	08:07	08:15	32	-51.617	-34.7178	4774.01	Bongo	Geraint	Bongo 58 (200 m cable out)
28/01/2013 07:52	183	07:52			32	-51.6162	-34.71729	4780.41	CPR recovery	Geraint	157/2
27/01/2013 22:04	183	22:04			31	-52.939	-35.80366	3574.44	CPR deployment	Pete	157/2
27/01/2013 21:01	182	21:01	21:29	21:58	31	-52.939	-35.80361	3575.3	Ti CTD	Matt	CTD No. 48 (Ti CTD 18 1400 m cable out)
27/01/2013 20:33	181	20:33	20:41	20:49	31	-52.9401	-35.80364	3579.37	Bongo	Pete	Bongo 57 (200 m cable out)
27/01/2013 19:59	180	19:59	20:10	20:28	31	-52.94	-35.80365	3584.58	SS CTD	Jeremy	CTD No. 47 (SS CTD 30 300 m cable out)
27/01/2013 19:50	179	19:17			31	-52.9421	-35.80012	3578.83	CPR recovery	Geraint	157/2
27/01/2013 11:33	179	11:33			30	-54.2544	-36.44507	261.15	CPR deployment	Geraint	157/2
27/01/2013 11:28	178	11:28			30	-54.2606	-36.445	261.87	Tow fish deployed	Eric	
27/01/2013 10:38	177	10:38		10:43	30	-54.2785	-36.43801	253.97	Snow-Catcher	Emma/Richard	Snow catcher 31

27/01/2013 09:54	176	09:54	10:10	10:24	30	-54.2786	-36.43799	253.25	Go-Flo	Eric	Go Flo 15
27/01/2013 09:35	175	09:35		09:41	30	-54.2786	-36.43806	253.66	Snow-Catcher	Emma/Richard	Snow catcher 30
27/01/2013 08:59	174	08:59	09:09	09:26	30	-54.2786	-36.43797	253.1	SS CTD	Chris	CTD No. 46 (SS CTD 29 240 m cable out)
27/01/2013 08:33	173	08:33	08:40	08:49	30	-54.2786	-36.43791	253.34	Bongo	Geraint	Bongo 56 (200 m cable out)
27/01/2013 08:16	172	08:16	08:23	08:32	30	-54.2784	-36.43756	253.73	Bongo	Geraint	Bongo 55 (200 m cable out)
27/01/2013 07:59	171	07:59	08:06	08:15	30	-54.2784	-36.43755	253.95	Bongo	Geraint	Bongo 54 (200 m cable out)
25/01/2013 22:55	170	22:55				-53.8594	-36.47556	281.45	CPR recovery	Geraint	157/2
25/01/2013 15:50	170	15:50			29 (Bioassay 3)	-52.6925	-36.62644	2434.43	CPR deployment	Pete	157/2
25/01/2013 15:25	169	15:25	15:32	15:41	29 (Bioassay 3)	-52.6932	-36.62611	2434.23	Bongo	Geraint	Bongo 53 (200 m cable out)
25/01/2013 14:22	168	14:22	14:50	15:20	29 (Bioassay 3)	-52.6933	-36.62613	2434.31	Ti CTD	Geraint	CTD No. 45 (Ti CTD 17 1400 m cable out)
25/01/2013 14:16	167	14:16		14:30	29 (Bioassay 3)	-52.6933	-36.62611	2434.03	Snow-Catcher	Emma/Richard	Snow catcher 29
25/01/2013 12:24	166	12:14	13:14	14:07	29 (Bioassay	-52.693	-36.62551	2436.1	Go-Flo	Eric	Go Flo 14

					3)						
25/01/2013 12:05	165	12:05		12:13	29 (Bioassay 3)	-52.6927	-36.62563	2436.98	Snow-Catcher	Emma/Richard	Snow catcher 28
25/01/2013 11:31	164	11:31	11:39	11:56	29 (Bioassay 3)	-52.6927	-36.6257	2436.42	SS CTD	Chris	CTD No.44 (SS CTD 28 300 m cable out)
25/01/2013 11:01	163	11:01	11:08	11:18	29 (Bioassay 3)	-52.6919	-36.62501	2438.22	Bongo	Geraint	Bongo 52 (200 m cable out)
25/01/2013 10:43	162	10:43	10:51	11:00	29 (Bioassay 3)	-52.6907	-36.62416	2440.84	Bongo	Geraint	Bongo 51 (200 m cable out)
25/01/2013 10:24	161	10:24	10:32	10:42	29 (Bioassay 3)	-52.6893	-36.62291	2444.36	Bongo	Geraint	Bongo 50 (200 m cable out)
25/01/2013 09:57	160	09:57	10:01	10:18	29 (Bioassay 3)	-52.6894	-36.62298	2444.37	Ti CTD	Mark	CTD No. 43 (Ti CTD 16 100 m cable out)
25/01/2013 08:13	159	08:13	08:19	08:35	29 (Bioassay 3)	-52.6893	-36.62303	2445.19	Ti CTD	Mark	CTD No. 42 (Ti CTD 15 100 m cable out)
25/01/2013 06:48	158	06:48	06:53	07:10	29 (Bioassay 3)	-52.6893	-36.62309	2444.72	Ti CTD	Mark	CTD No. 41 (Ti CTD 14 100 m cable out)
25/01/2013 05:26	157	05:26	05:32	05:44	29 (Bioassay 3)	-52.6894	-36.62316	2444.75	Ti CTD	Mark	CTD No. 40 (Ti CTD 13 100 m cable out)
25/01/2013 04:51	156	04:51			29 (Bioassay	-52.6808	-36.58239	2528.35	CPR recovery	Geraint	157/1

					3)						
24/01/2013 21:42	155	21:42			28	-51.9521	-37.05787	835.69	CPR deployment	Pete	157/1
24/01/2013 21:00	154	21:00	21:17	21:36	28	-51.9521	-37.05743	838.05	Ti CTD	Geraint	CTD No. 39 (Ti CTD 12 800 m cable out)
24/01/2013 20:29	153	20:29	20:36	20:45	28	-51.9515	-37.05741	838.75	Bongo	Pete	Bongo 49 (200 m cable out)
24/01/2013 19:56	152	19:56	20:06	20:23	28	-51.9516	-37.0574	835.17	SS CTD	Jeremy	CTD No. 38 (SS CTD 27 300 m cable out)
24/01/2013 19:48	151	19:48			28	-51.945	-37.05984	814.1	CPR recovery	Geraint	157/1
24/01/2013 14:18	151	14:18			27	-51.1436	-37.40155	1828.25	CPR deployment	Geraint	157/1
24/01/2013 13:13	150	13:13	13:40	14:09	27	-52.6894	-36.62316	2444.75	Ti CTD	Geraint	CTD No. 37 (Ti CTD 11 1400 m cable out)
24/01/2013 11:53	149	11:53		12:06	27	-51.1537	-37.44427	1834.36	Snow-Catcher	Emma/Richard	Snow catcher 27
24/01/2013 11:35	148	11:35	11:46	12:49	27	-51.1541	-37.44877	1834.16	SAPS	Fred	SAPS 09 160 m cable out
24/01/2013 09:52	147	09:52	10:31	11:26	27	-51.1539	-37.48338	1840.21	Go-Flo	Eric	Go Flo 13
24/01/2013 09:31	146	09:31		09:40	27	-51.154	-37.48528	1840.28	Snow-Catcher	Emma/Richard	Snow catcher 26
24/01/2013 09:00	145	09:00	09:11	09:29	27	-51.1539	-37.48999	1846.52	SS CTD	Chris	CTD No. 36 (SS CTD 26 300 m cable out)

24/01/2013 08:37	144	08:37	08:44	08:53	27	-51.1538	-37.49752	1843.15	Bongo	Geraint	Bongo 48 200 m cable out
24/01/2013 08:21	143	08:21	08:27	08:35	27	-51.1536	-37.50528	1843.35	Bongo	Geraint	Bongo 47 200 m cable out
24/01/2013 08:02	142	08:02	08:10	08:19	27	-51.1536	-37.51301	1842.9	Bongo	Geraint	Bongo 46 200 m cable out
24/01/2013 07:54	141	07:54			27	-51.1472	-37.5161	1846.52	CPR recovery	Geraint	157/1
23/01/2013 20:55	141	20:55			26	-49.4518	-38.46697	1744.84	CPR deployment	Geraint	157/1
23/01/2013 20:31	140	20:31	20:39	20:47	26	-49.4532	-38.46797	1744.46	Bongo	Pete	Bongo 45 200 m cable out
23/01/2013 19:58	139	19:58	20:08	20:25	26	-49.4531	-38.46797	1744.81	SS CTD	Jeremy	CTD No. 35 (SS CTD 25 300 m cable out)
23/01/2013 19:52	138	19:51			26	-49.4543	-38.46636	1747.85	CPR recovery	Geraint	157/1
23/01/2013 12:23	138	12:23			25	-50.1725	-38.9545	4728.07	CPR deployment	Geraint	157/1
23/01/2013 11:57	137	11:57		12:12	25	-50.1675	-38.95708	4724.89	Snow-Catcher	Emma/Richard	Snow catcher 25
23/01/2013 09:58	136	09:58	10:46	11:44	25	-50.1483	-38.95713	4730.81	Go-Flo	Eric	Go Flo 12
23/01/2013 09:38	135	09:38		09:49	25	-50.1469	-38.95718	4727.53	Snow-Catcher	Emma/Richard	Snow catcher 24
23/01/2013 09:02	134	09:02	09:13	09:33	25	-50.1441	-38.95718	4730.71	SS CTD	Chris	CTD No. 34 (SS CTD 24 300 m cable out)

23/01/2013 08:36	133	08:36	08:43	08:51	25	-50.1402	-38.95724	4724.47	Bongo	Geraint	Bongo 44 200 m cable out
23/01/2013 08:19	132	08:19	08:26	08:34	25	-50.136	-38.95725	4727.71	Bongo	Geraint	Bongo 43 200 m cable out
23/01/2013 08:00	131	08:00	08:08	08:17	25	-50.136	-38.95725	4727.71	Bongo	Geraint	Bongo 42 200 m cable out
23/01/2013 02:34	130	02:34	02:42	02:48	24	-50.8821	-39.26671	4205.76	SS CTD	Toby	CTD N0. 33 (SS CTD 23 300 m cable out)
22/01/2013 20:34	129	20:34	20:41	20:50	23	-51.6192	-39.57366	3747.92	Bongo	Pete	Bongo 41 200 m cable out
22/01/2013 20:00	128	20:00	20:10	20:28	23	-51.6192	-39.57362	3753.9	SS CTD	Jeremy	CTD No. 32 (SS CTD 22 300 m cable out)
22/01/2013 19:52	127	19:52			23	-51.6188	-39.57183	3759.78	CPR recovery	Geraint	157/1
22/01/2013 13:04	127	13:04			22	-52.716	-40.05678	3787.55	CPR deployment	Geraint	157/1
22/01/2013 11:58	126	11:58		12:13	22	-52.7158	-40.05464	3787.61	Snow-Catcher	Emma/Richard	Snow catcher 23
22/01/2013 11:45	125	11:45	11:53	12:52	22	-52.7155	-40.05496	3787.81	SAPS	Fred	SAPS 08 85 m cable out
22/01/2013 09:48	124	09:48	10:43	11:36	22	-52.7126	-40.05704	3784.72	Go-Flo	Eric	Go Flo 11
22/01/2013 09:33	123	09:33		09:43	22	-52.7126	-40.05705	3787.97	Snow-Catcher	Emma/Richard	Snow catcher 22
22/01/2013 09:01	122	09:01	09:11	09:31	22	-52.7125	-40.05703	3784.51	SS CTD	Chris	CTD No. 31 (SS CTD 21

											300 m cable out)
22/01/2013 08:36	121	08:36	08:44	08:52	22	-52.7117	-40.05751	3790.86	Bongo	Geraint	Bongo 40 200 m cable out
22/01/2013 08:18	120	08:18	08:25	08:35	22	-52.7108	-40.05802	3793.58	Bongo	Geraint	Bongo 39 200 m cable out
22/01/2013 07:59	119	07:59	08:07	08:15	22	-52.7125	-40.05703	3784.51	Bongo	Geraint	Bongo 38 200 m cable out
22/01/2013 02:47	118	02:47	02:56	03:06	21	-53.4268	-40.42895	2257.77	SS CTD	Toby	CTD No. 30 (SS CTD 20 300 m cable out)
21/01/2013 20:36	116	20:36	20:44	20:53	20	-54.2313	-40.81124	2101.05	Bongo	Pete	Bongo 37 200 m cable out
21/01/2013 20:02	115	20:02	20:12	20:30	20	-54.2313	-40.81069	2107.51	SS CTD	Geraint	CTD No. 29 (SS CTD 19 300 m cable out)
21/01/2013 19:51	114	19:51			20	-54.2304	-40.79565		CPR recovery	Geraint	157/1
21/01/2013 13:48	114	13:48			19	-55.212	-41.30096	3311.76	CPR deployment	Geraint	157/1
21/01/2013 13:30	113	13:30		13:42	19	-55.2128	-41.30149	3314.49	Snow-Catcher	Emma/Richard	Snow catcher 21
21/01/2013 11:44	112	11:44	11:51	13:22	19	-55.2127	-41.30826	3317.65	SAPS	Fred	SAPS 07 (70 m cable out)
21/01/2013 11:32	111	11:32		11.37	19	-55.213	-41.30882	3317.66	Snow-Catcher	Emma/Richard	Snow catcher 20
21/01/2013 10:56	110	10:56	11:07	11:24	19	-55.2127	-41.31037	3317.66	SS CTD	Chris	CTD No. 28 (SS CTD 18

											300 m cable out)
21/01/2013 08:53	109	08:53	09:38	10:28	19	-55.2047	-41.32035	3323.88	Go-Flo	Eric	Go Flo 10
21/01/2013 08:23	108	08:23	08:30	08:40	19	-55.2027	-41.32288	3332.83	Bongo	Geraint	Bongo 36 200 m cable out
21/01/2013 08:04	107	08:04	08:13	08:22	19	-55.2006	-41.32624	3336.04	Bongo	Geraint	Bongo 35 200 m cable out
21/01/2013 02:40		02:40			18	-56.0063	-41.7761	3658.96			Station 18 aborted due to large swell
20/01/2013 20:37	106	20:37	20:45	20:54	17	-53.4268	-40.42895	2257.77	Bongo	Pete	Bongo 34 200 m cable out
20/01/2013 20:02	105	20:02	20:12	20:31	17	-56.8087	-42.25444	4058.02	SS CTD	Jeremy	CTD No. 27 (SS CTD 17 300 m cable out)
20/01/2013 19:53	104	19:53			17	-56.8142	-42.2514	4085.81	CPR recovery	Geraint	157/1
20/01/2013 13:26	104	13:36			16	-57.8203	-42.83054	2878.39	CPR deployment	Geraint	157/1
20/01/2013 11:49	103	11:49		12:02	16	-57.8211	-42.83135	2878.46	Snow-Catcher	Emma/Richard	Snow catcher 19
20/01/2013 11:38	102	11:38	11:44	13:15	16	-57.8212	-42.8317	2881.41	SAPS	Fred	SAPS 06 50 m cable out
20/01/2013 09:55	101	09:55	10:36	11:29	16	-57.8211	-42.83161	2878.68	Go-Flo	Eric	Go Flo 09
20/01/2013 09:33	100	09:33		09:41	16	-57.8211	-42.83168	2878.69	Snow-Catcher	Emma/Richard	Snow catcher 18
20/01/2013	99	09:02	09:12	09:31	16	-57.8213	-42.83111	2878.71	SS CTD	Chris	CTD No. 26

09:02											(SS CTD 16 300 m Cable out)
20/01/2013 08:35	98	08:35	08:43	08:52	16	-57.8216	-42.8308	2878.47	Bongo	Geraint	Bongo 33 200 m cable out
20/01/2013 08:17	97	08:17	08:25	08:34	16	-57.8215	-42.83077	2881.4	Bongo	Geraint	Bongo 32 200 m cable out
20/01/2013 07:50	96	07:58	08:07	08:16	16	-57.8215	-42.8316	2878.66	Bongo	Geraint	Bongo 31 200 m cable out
20/01/2013 02:22	95	02:22	02:32	02:37	15	-58.4249	-43.24598	3065.72	SS CTD	Toby	CTD No. 25 (SS CTD 15 300 m cable out)
19/01/2013 20:33	94	20:33	20:42	20:52	14	-59.2081	-43.75782	3520.51	Bongo	Pete	Bongo 30
19/01/2013 20:03	93	20:03	20:12	20:28	14	-59.2104	-43.75769	3529.81	SS CTD	Jeremy	CTD No. 24 (SS CTD 14 300 m cable out)
19/01/2013 12:04	93	12:04		12:17	13	-59.9338	-45.26329	4694.01	Snow-Catcher	Emma/Richard	Snow catcher 17
19/01/2013 11:51	92	11:51	11:56	14:02	13	-59.9342	-45.26333	4703.27	SAPS	Fred	SAPS 05 50 m cable out
19/01/2013 09:58	91	09:58	10:49	11:42	13	-59.9408	-45.27963	4835.34	Go-Flo	Eric	Go Flo 08
19/01/2013 09:37	90	09:37		09:49	13	-59.9428	-45.284	4909.09	Snow-Catcher	Emma/Richard	Snow catcher 16
19/01/2013 09:03	89	09:03	09:15	09:35	13	-59.9459	-45.29096	4945.93	SS CTD	Chris	CTD No. 23 (SS CTD 13 300 m cable out)

19/01/2013 08:38	88	08:38	08:46	08:55	13	-59.9477	-45.2969	4942.87	Bongo	Geraint	Bongo 29 200 m cable out
19/01/2013 08:21	87	08:21	08:28	08:37	13	-59.9485	-45.30127	4908.99	Bongo	Geraint	Bongo 28 200 m cable out
19/01/2013 08:03	86	08:03	08:10	08:20	13	-59.9495	-45.30575	4890.61	Bongo	Geraint	Bongo 27 200 m cable out
18/01/2013 13:48	85	13:48		14:02	12 (Bioassay 2)	-60.9692	-48.12808	2694.15	Snow-Catcher	Emma/Richard	Snow catcher 15
18/01/2013 12:03	83	12:03	12:50	13:42	12 (Bioassay 2)	-60.9699	-48.13067	2694.15	Go-Flo	Eric	Go Flo 07
18/01/2013 11:48	83	11:48		11:55	12 (Bioassay 2)	-60.9701	-48.13034	2694.18	Snow-Catcher	Emma/Richard	Snow catcher 14
18/01/2013 11:04	82	11:04	11:15	11:35	12 (Bioassay 2)	-60.9715	-48.13172	2694.14	SS CTD	Chris	CTD No. 22 (SS CTD 12 300 m cable out)
18/01/2013 10:31	81	10:31	10:40	10:49	12 (Bioassay 2)	-60.9733	-48.13415	2697.21	Bongo	Geraint	Bongo 26 200 m cable out
18/01/2013 10:12	80	10:12	10:20	10:30	12 (Bioassay 2)	-60.9741	-48.13598	2697.19	Bongo	Geraint	Bongo 25 200 m cable out
18/01/2013 09:53	79	09:53	10:01	10:10	12 (Bioassay 2)	-60.9742	-48.13806	2697.25	Bongo	Geraint	Bongo 24 200 m cable out
18/01/2013 09:23	78	09:23	09:28	09:42	12 (Bioassay 2)	-60.9738	-48.13854	2697.2	Ti CTD	Mark	CTD No. 21 (Ti CTD 10 300 m? cable out)

18/01/2013 07:49	77	07:49	07:55	08:08	12 (Bioassay 2)	-60.9625	-48.12895	2687.99	Ti CTD	Mark	CTD No. 20 (Ti CTD 09 100 m cable out)
18/01/2013 06:42	76	06:42		06:58	12 (Bioassay 2)	-60.9654	-48.11142	2681.84	Ti CTD	Mark	CTD No. 19 (Ti CTD 08 100 Cable out)
18/01/2013 05:26	75	05:26	05:31	05:47	12 (Bioassay 2)	-60.9756	-48.08661	2672.65	Ti CTD	Mark	CTD No. 18 (Ti CTD 07 100 m cable out)
17/01/2013 20:36	74	20:36	20:45	20:55	11	-60.5689	-48.35972	2033.7	Bongo	Pete	Bongo 23 200 m cable out
17/01/2013 20:07	73	20:07	20:17	20:31	11	-60.5689	-48.35974	2033.71	SS CTD	Jeremy	CTD No. 17 (SS CTD 11 300 m cable out)
17/01/2013 12:06	73	12:06		12:16	10	-59.8911	-49.37054	0	Snow-Catcher	Emma/Richard	Snow catcher 13
17/01/2013 11:53	72	11:53	12:02	14:02	10	-59.8921	-49.37142	3680.27	SAPS	Fred	SAPS 04 135 m cable out
17/01/2013 10:13	71	10:13	10:51	11:40	10	-59.8953	-49.39129	3581.96	Go-Flo	Eric	Go Flo 06
17/01/2013 09:54	70	09:54		10:01	10	-59.8963	-49.39626	3505.1	Snow-Catcher	Emma/Richard	Snow catcher 12
17/01/2013 09:17	69	09:17	09:25	09:44	10	-59.897	-49.40004	3643.38	SS CTD	Chris	CTD No. 16 (SS CTD 10 300 m cable out)
17/01/2013 08:44	68	08:44		09:01	10	-59.9044	-49.40535	3603.5	Bongo	Geraint	Bongo 22 200 cable out

17/01/2013 08:25	67	08:25	08:32	08:43	10	-59.9045	-49.40846	3830.78	Bongo	Geraint	Bongo 21 200 m cable out
17/01/2013 08:03	66	08:03	08:11	08:22	10	-59.9044	-49.41049	3591.17	Bongo	Geraint	Bongo 20 200 m cable out
16/01/2013 22:48	51	22:48				-59.3214	-49.99487	3882.89	Tow fish recovery	Eric	
16/01/2013 20:40	65	20:40	20:48	21:00	9	-59.0766	-50.24111	3658.79	Bongo	Pete	Bongo 19 200 m cable out
16/01/2013 20:07	64	20:07	20:17	20:33	9	-59.0766	-50.24104	3658.78	SS CTD	Jeremy	CTD No. 15 (SS CTD 09 300 m cable out)
16/01/2013 19:53	63	19:53			9	-59.0671	-50.24097	3686.43	CPR recovery	Geraint	157/0
16/01/2013 12:03	63	12:03			8	-58.2946	-50.97493	3975.21	CPR deployment	Geraint	157/0
16/01/2013 10:34	62	11:33		11:49	8	-58.2948	-50.97007	3972.2	Snow-Catcher	Emma/Richard	Snow catcher 11
16/01/2013 10:19	61	10:19	10:44	11:19	8	-58.2947	-50.96991	3972	Go-Flo	Eric	Go Flo 05
16/01/2013 09:42	60	09:42	09:52	10:10	8	-58.2947	-50.96993	3969.03	SS CTD	Chris	CTD No. 14 (SS CTD 08 300 m cable out)
16/01/2013 09:10	59	09:10	09:19	09:29	8	-58.2925	-50.96993	3962.85	Bongo	Geraint	Bongo 18 200 m cable out
16/01/2013 08:50	58	08:50	08:57	09:09	8	-58.2903	-50.96985	3956.67	Bongo	Geraint	Bongo 17 200 m cable out
16/01/2013	57	08:28	08:37	08:48	8	-58.2884	-50.96884	3953.5	Bongo	Geraint	Bongo 16

08:28											200 m cable out
16/01/2013 08:14	56	08:14		08:21	8	-58.2884	-50.96892	3953.6	Snow-Catcher	Emma/Richard	Snow catcher 10
16/01/2013 07:58	55	07:58			8	-58.2893	-50.95088	3950.74	CPR recovery	Geraint	157/0
15/01/2013 21:18	55	21:18			7	-59.3472	-52.32056	3554.58	CPR deployment	Geraint	157/0
15/01/2013 20:50	54	20:50	20:59	21:10	7	-59.3489	-52.32432	3554.26	Bongo	Pete	Bongo 15 200 m cable out
15/01/2013 20:07	53	20:07	20:17	20:37	7	-59.3489	-52.32418	3554.33	SS CTD	Jeremy	CTD No. 13 (SS CTD 07 300 m cable out)
15/01/2013 19:51	52	19:51			7	-59.3495	-52.29697	3548.27	CPR recovery	Geraint	157/0
15/01/2013 13:17	52	13:17			6	-59.9083	-53.01807	3425.1	CPR deployment	Geraint	157/0
15/01/2013 13:12	51	13:12			6	-59.9078	-53.0149	3422.18	Tow fish deployed	Eric	
15/01/2013 11:55	50	11:55		12:11	6	-59.9087	-53.01444	3422.27	Snow-Catcher	Emma/Richard	Snow catcher 09
15/01/2013 11:39	49	11:39		11:45	6	-59.9091	-53.01449	3425.23	Snow-Catcher	Emma/Richard	Snow catcher 08
15/01/2013 11:23	48	11:23	11:32	13:03	6	-59.9097	-53.01584	3422.14	SAPS	Fred	SAPS 03 160 cable out
15/01/2013 10:08	47	10:08	10:39	11:12	6	-59.9096	-53.02372	3422.25	Go-Flo	Eric	Go-Flo 04
15/01/2013 09:28	46	09:28	09:38	09:58	6	-59.9096	-53.02372	3425.27	SS CTD	Chris	CTD No. 12 (SS CTD 06 300 m cable out)
15/01/2013	45	08:56	09:05	09:16	6	-59.9096	-53.02926	3428.36	Bongo	Geraint	Bongo 14

08:56											200 m cable out
15/01/2013 08:35	44	08:35	08:43	08:55	6	-59.9095	-53.03488	3425.22	Bongo	Geraint	Bongo 13 200 m cable out
15/01/2013 08:10	43	08:10	08:22	08:33	6	-59.9094	-53.0396	3422.32	Bongo	Geraint	Bongo 12 200 m cable out
15/01/2013 07:58	42	07:58			6	-59.9095	-53.02091	3422.19	CPR recovery	Geraint	157/0
14/01/2013 21:25	42	21:25			5	-61.0408	-54.60193	452.72	CPR deployment	Geraint	157/0
14/01/2013 20:51	41	20:51	21:03	21:16	5	-59.9094	-53.0396	3422.32	Bongo	Pete	Bongo 11 200 m cable out
14/01/2013 20:12	40	20:12	20:23	20:45	5	-59.3489	-52.32418	3554.33	SS CTD	Jeremy	CTD No. 11 (SS CTD 05 300 m cable out)
14/01/2013 17:24	38	17:24				-60.5719	-54.8893	3271.48	Tow fish recovery	Eric	Tow fish recovery due to ice
14/01/2013 17:19	39	17:19				-60.5683	-54.89115	3274.53	CPR recovery	Geraint	157/0 Recovery due to ice
14/01/2013 13:38	39	13:38			4	-59.9998	-55.23558	3545.23	CPR deployment	Geraint	157/0
14/01/2013 13:29	38	13:29			4	-60.0002	-55.23173	3545.02	Tow fish deployed	Eric	
14/01/2013 13:06	37	13:06		13:21	4	-60.0008	-55.23134	3545.06	Snow-Catcher	Emma/Richard	Snow catcher 07
14/01/2013 11:45	36	11:45		12:02	4	-60.0022	-55.23023	3545.15	Snow-Catcher	Emma/Richard	Snow catcher 06
14/01/2013	35	11:25		11:35	4	-60.0028	-55.22978	3541.97	Snow-	Emma/Richard	Snow

11:25									Catcher		catcher 05
14/01/2013 10:06	34	10:06	10:38	11:12	4	-60.0029	-55.22971	3544.81	Go-Flo	Eric	Go-Flo 03
14/01/2013 09:27	33	09:27	09:37	09:54	4	-60.0029	-55.22979	3541.97	SS CTD	Chris	CTD No. 10 (SS CTD 04 300 m cable out)
14/01/2013 08:56	32	08:56	09:06	09:16	4	-60.0021	-55.23292	3542.01	Bongo	Geraint	Bongo 10 200 m cable out
14/01/2013 08:34	31	08:34	08:43	08:55	4	-60.0014	-55.23729	3545.26	Bongo	Geraint	Bongo 09 200 m cable out
14/01/2013 08:14	30	08:14	08:23	08:33	4	-60.0002	-55.23797	3545.14	Bongo	Geraint	Bongo 08 200 m cable out
14/01/2013 08:00	29	08:00		08:03	4	-59.9962	-55.22544	3545.07	CPR recovery	Geraint	157/0
13/01/2013 16:32	29	16:32			3 (Bioassay 1)	-58.3612	-56.25655	3907.82	CPR deployment	Geraint	157/0
13/01/2013 15:34	28	15:34		15:49	3 (Bioassay 1)	-58.3623	-56.25406	3913.9	Snow-Catcher	Emma/Richard	Snow catcher 04
13/01/2013 15:12	27	15:12	15:20	15:30	3 (Bioassay 1)	-58.3637	-56.25344	3916.72	Snow-Catcher	Emma/Richard	Snow catcher 03 175 m cable out misfired
13/01/2013 14:53	26	14:53	14:56	16:13	3 (Bioassay 1)	-58.3637	-56.25344	3916.72	Snow-Catcher	Emma/Richard	Snow catcher 02 75 m cable out
13/01/2013 14:33	25	14:33	14:43	16:05	3 (Bioassay	-58.3668	-56.25205	3919.87	SAPS	Fred	SAPS 02 185 m cable out

					1)						
13/01/2013 13:00	24	13:00	13:52	14:23	3 (Bioassay 1)	-58.3667	-56.25205	3920.45	Go-Flo	Eric	Go-Flo 02
13/01/2013 12:08	23	12:08	12:17	12:35	3 (Bioassay 1)	-58.3667	-56.25203	3922.85	SS CTD	Chris	CTD No. 9 (SS CTD 03 300 m cable out)
13/01/2013 11:35	22	11:35	11:44	11:55	3 (Bioassay 1)	-58.3667	-56.25205	3923.28	Bongo	Geraint	Bongo 07 200 m cable out
13/01/2013 11:15	21	11:15	11:25	11:34	3 (Bioassay 1)	-58.3667	-56.2521	3922.9	Bongo	Geraint	Bongo 06 200 m cable out
13/01/2013 10:48	20	10:48	10:59	11:13	3 (Bioassay 1)	-58.3667	-56.25206	3923.05	Bongo	Geraint	Bongo 05 200 m cable out
13/01/2013 10:12	19	10:12	10:22	10:38	3 (Bioassay 1)	-58.3668	-56.25207	3923.39	Ti CTD	Mark	CTD No. 8 (Ti CTD 06 300 m cable out)
13/01/2013 08:23	18	08:23	08:29	08:42	3 (Bioassay 1)	-58.3668	-56.25207	3923.39	Ti CTD	Mark	CTD No. 7 (Ti CTD 05 100 m cable out)
13/01/2013 07:27		07:27		07:31		-58.3667	-56.25205	3923.09	Tow fish recovery	Eric	
13/01/2013 07:05	17	07:05	07:10	07:23	3 (Bioasay 1)	-58.3668	-56.25203	3923.13	Ti CTD	Mark	CTD No. 6 (Ti CTD 04 100 m cable out)
13/01/2013 05:39	16	05:39	05:46	06:00	3 (Bioassay 1)	-60.0029	-55.22979	3541.97	Ti CTD	Chris	CTD No. 5 (Ti CTD 03 100 m cable out)

12/01/2013 00:58	15	00:58				-57.6438	-56.71462	3557.36	CPR recovery	Geraint	157/0 CPR recovered early due to high winds
11/01/2013 21:21	15	21:21		21:28	2	-57.1179	-57.05091	4170.34	CPR deployment	Geraint	157/0
11/01/2013 20:50	14	20:50	20:58	21:11	2	-57.118	-57.05144	4175.56	Bongo	Pete	Bongo 04 200 m cable out
11/01/2013 20:12	13	20:12	20:23	20:41	2	-57.1179	-57.05145	4177.8	SS CTD	Jeremy	CTD No. 4 (SS CTD 02 300 m cable out)
11/01/2013 20:00	12	20:00		20:02	2	-57.1118	-57.04811	0	CPR recovery	Geraint	157/0
11/01/2013 15:56	12	15:56			1	-56.4642	-57.42227	3701.43	CPR deployment	Geraint	157/0
11/01/2013 13:50	11	13:50		14:28	1	-56.4646	-57.42051	3701.21	Snow-Catcher	Emma/Richard	Snow catcher 01 75 m cable
11/01/2013 13:24	10	13:24	13:41	15:39	1	-56.4646	-57.42055	3701.06	SAPS	Fred	SAPS 01 195 m cable out pump 1 at 90 m pump 2 at 10 m
11/01/2013 11:50	9	11:50	12:43	13:04	1	-56.4646	-57.42051	3701.21	Go-Flo	Eric	Go-Flo 01
11/01/2013 11:06	8	11:06	11:12	11:25	1	-56.4665	-57.4262	3736.5	Ti CTD	Mark	CTD No. 3 (Ti CTD 02 80 m cable)
11/01/2013 09:50	7	09:50	10:04	10:27	1	-56.4662	-57.41651	3691.63	SS CTD	Chris	CTD No. 2 (SS CTD 01 300 m cable out)

11/01/2013 09:18	6	09:18	09:25	09:38	1	-56.4664	-57.4216	3710.96	Bongo	Geraint	Bongo 03 200 m cable out
11/01/2013 08:56	5	08:56	09:03	09:17	1	-56.4664	-57.4216	3710.96	Bongo	Geraint	Bongo 02 200 m cable out
11/01/2013 08:12	4	08:12	08:34	08:50	1	-60.0014	-55.23729	3545.26	Bongo	Geraint	Bongo 01 200 m cable out
11/01/2013 08:03	3	08:03				-56.4741	-57.42313	3922.8	CPR recovery	Geraint	157/0
10/01/2013 14:56	3	14:36				-51.6917	-57.82397	0	CPR deployment	Geraint	157/0
10/01/2013 14:00	2	14:00	14:25	14:36		-54.6671	-57.99904	164.65	Ti CTD	Mark	CTD No. 1 (Ti CTD 01 - Flushing of CTD for cleaning) - 150 m cable out
09/01/2013 20:15	1	20:15				-53.8135	-58.27587	775.62	Tow fish deployed	Eric	

Annex 2

JR274 Cruise Narrative

Note: all times in local (GMT -3 h)

Precruise

The science party arrived in Prot Stanley 3 waves, the first arriving on 3rd January, followed by a small number on 5th and the remainder on 7th. Mobilisation involved the setting up of 11 containers of equipment, 6 containers being cargo, 5 containers being laboratory spaces secured on the aft deck. The mobilisation was assisted by Jez Evans, NMF Head of Mobilisation, who returned to UK on completion.

The scheduled date for departure was 8th January. However, this was delyaed to 9th Jan to allow sufficient time to complete CTD cable terminations before departure.

A emergency drill briefing was received by the science party on morning of 8th followed by a lifeboat drill.

Weds 9th January

Scheduled departure was 13:00 - at the point of a suitable tide. There was a minor delay to leaving FIPASS because of propeller motor failure. The ship then achored just off Port Stanley to carry out a test deployment of the port side lifeboat. The ship set sail at 15:10.

Clean water tow fish was set up around 16:00 although there was some minor delays in its deployment.

A general science meeting was held at 16:00 outlining the cruise plan and recommended laboratory practises.

Overnight – en route to Test station (54° 40'S, 58° 32'W) – Burdwood Bank

Thurs 10th January **(midday: wind 20 knots, sea state 2, 7oC air, 6oC sea surface, ice 0)**

Arrived at Test station at 11:00 – deployed the titanium CTD and filled rosette bottles for cleaning.

CPR deployed at 12:00 (Body 157)

Bioassay meeting held at 15:00 to talk through protocols.

Overnight – en route to station 1 (56° 28'S 57° 26'W)

Friday 11th January **(midday: wind 18 knots, sea state 4, 8oC air, 5oC sea surface, ice 0)**

Arrived at station 1 at 05:00. CPR recovered

Bongo nets deployed for first time – wire snagged in sheef overhead and severed 2 strands of the steel wire – deployments continued successfully.

Stainless steel CTD deployed to 300 m. Titanium CTD sampled to 80 m principally to wash bottles. GO FLO bottles also deployed for same purpose. SAPS were deployed successfully to max depth of 195 m. Snow catcher was deployed simultaneously from port aft to 75 m – several attempts were made before settling on adding a ~70 kg weight to stabilise the instrument during deployment. CPR deployed on leaving station at 13:00.

Travelled along transect at 10 knots for 4 hours. Did not reach intended coordinate for Station 2 but stopped at 17:00 and proceeded with station 2 deployments at that location (57.11800° S, 57.05137° W). Stainless steel CTD deployed to 300 m, followed by Bongo net deployment. CPR deployed on leaving station at 18:30.

Wind freshening to 30 knots at 20:00 – aft deck and containers only accessible on request to bridge. En route to station 3 (58° 22'S, 56° 15'W) to carry out Bioassay 1.

21:30 – wind gusting to 50 knots – science suspended until further notice (CPR taken out of water)

Saturday 12th January **(midday: wind 30 knots, sea state 7, 2.1°C air, 2.6°C sea surface, ice 0)**

Hove to until 16:30. CPR recovered.

Then headed south via several tacks to station 3 in preparation for station 3 – Bioassay station 1. Clean water tow fish was damaged during storm and was not functioning during passage to station 3.

Arrived at Station 3 (Bioassay 1) station location at 20:30 – held station until following morning

Sunday 13th January **(midday: wind 18 knots, sea state 6, 1.7°C air, 1.7°C sea surface, ice 0)**

Commenced Bioassay 1 activities at 02:00 with 4 Titanium CTD deployments. The majority of bottles were fired at 30 m with the exception of the 4th deployment where the bottles were fired below the mixed layer.

Bongo deployments followed at 07:50, then stainless steel CTD (to 300 m), Go-flo bottles (8 secured onto wire in total), SAPS and snow catches simultaneously (the former to 185 m, the latter to 75 m and then 175 m in two separate deployments). Station activities were completed by 13:30 when the CPR was deployed on leaving the station.

The overall impression of conditions was that there was a relatively high biomass of phytoplankton in the water column, with salps and copepods as the main grazers. Pteropods were few but some foramanifera were present and incubated under a range of pCO2 conditions.

The swell is relatively high, causing significant rolling on passage to station 4.

Monday 14th January **(midday: wind 17 knots, sea state 4, 0.5°C air, 0.6°C sea surface, ice 0)**

CPR recovered then commenced with Station 4 at 60° 00'S 55° 14'W. Bongo nets, SS CTD, Go-flos, and snow catcher. The water was less productive compared to station 3, and very few copepods in

water column. Second snow catcher deployment resulted in a a crane malfunction and a blow to the instrument against the side of the ship. A third deployment was carried out although it was found the blow had caused a minor leak to the instrument. Left station at 10:46 to head for Station 5. Clean water tow fish had been repaired and was deployed during this leg alongside CPR.

Brash ice encountered around 14:15. Clean water tow fish and CPR recovered around 14:30. Continued on to station 5.

Station 5 was positioned in an ice-free region at a water depth of 500. A suitable site was reached at 17:00. The station was easily in sight of Elephant Island. Clear weather provided splendid views of the island as well as of the neighbouring Clarence Island. Sea state much calmer.

SS CTD and Bongo nets performed before leaving to head NE to Station 6. CPR but not the tow fish were deployed on leaving (tow fish left out because of the threat of brash ice).

Tuesday 15th January **(midday: wind 9 knots, sea state 3, 0.2°C air, 0.6°C sea surface, ice 0)**

Arrived at Station 6 at 05:00. Retrieved CPR and then proceeded with regular station activities – Bongo net, stainless steel CTD, Go Flos, SAPS and snow catcher simultaneously. All activities went well and the station was completed by 10:20.

Travelled to station 7 at a steady speed and arrived at 17:00 to carry out a stainless steel CTD and Bongo net.

Today was the 48 h take down day of Bioassay 1. This proceeded slowly but successfully and was mainly completed by lunch having started around 03:00.

Weather moderate to calm, making work on board relatively comfortable.

Dartcom and Polarview images showing ice covering much of South Orkney shelf region but decision yet to be made on most suitable location for Bioassay 2, which aims to be next to an ice-edge.

Wednesday 16th January **(midday: wind 14 knots, sea state 3, 1.7°C air, 1.5°C sea surface, ice 0)**

Station 8 - Recovered CPR. Started with deployment of snow catcher at 05:00 followed by Bongo, stainless steel CTD, Go flos and snow catcher again. Completed station by 09:20, deploying CPR on departure.

Small bergy bits en route to station 9.

CPR recovered at Station 9 (17:00) the stainless steel CTD and 1 x Bongos deployed. CPR not redeployed on leaving station because of impending brash ice. Clean water two fish extracted at 20:00.

Brash ice encountered around 21:30. Non-toxic seawater supply turned off. Made progress until around 23:00 and then held station until following morning

Thursday 17th January **(midday: wind 14 knots, sea state 2, -1.3°C air, 1.5°C sea surface [-0.75 – CTD], ice 4/10)**

Station 10 was sited at 59° 54.27'S 49° 24.62'W at the position held from last night. CPR not in water. Bongo, stainless steel CTD, snow catcher x 1, Go-flos, SAPS and snowcatcher x 1.

Intention to sail east after this station to get out of brash ice and find some clear water to head further south.

Reached station 11 after heading ESE until 5pm at 60.56882°S 48.35966°W

Carried out stainless steel CTD and then a Bongo net.

Now head due south until night fall, ice depending, where we will hold position in readiness for Bioassay 2.

Friday 18th January **(midday: wind 6 knots, sea state 2, -2.3°C air, sea surface [-1 – CTD], ice 5/10)**

Progress to the intended position for Bioassay 2 (station 12) stopped late last night when it became clear that the location was covered in pack-ice. The location chosen for the station was 61°0.37'S 48°21.58'W. This was open enough for us to carry out regular sampling activities without too many worries about brash ice. Bioassay station activities started around 02:30 with 4 Titanium CTDs which went well. Bongo nets were being deployed by 06:53, and thankfully contained enough copepods to populate a bioassay (pteropods are still too few to do likewise with them). Subsequent station activities proceeded as planned – stainless steel CTD, Snow catchers, Go-flos and a further snow catcher. The station was completed by 11:02.

The vessel headed in a north-easterly direction although progress was hindered by ice causing diversions and some crashing through. Progress towards station 13 was halted around 22:30, around 30 nm short of intended location as a result of a substantial ice-barrier along the intended course.

Saturday 19th January **(midday: wind 6 knots, sea state 1, -2.3°C air, -0.6 sea surface, ice 2/10)**

Position station 13, at 59° 56.51'S 45° 16.88'W was west of intended location due to ice. Ice was similar to yesterday, with open pools surrounded by more solid pack.

Sampling commenced at 05:00 with Bongo nets, followed by stainless steel CTD, snowcatcher, Go-Flo bottles, SAPS and snowcatcher. Station activities ended at 11:02.

Journey to station 14 took a north-easterly route to try to get onto the DISCOVERY2010 transect, given that this was not possible with respect to station 13. Open pack and much wildlife made for an scenic journey.

Intended location for station transect for station 14 was reached by 17:00

A CTD was performed at midnight also to increase sampling resolution along the transect (St 15). No water was collected, only sensor reading taken down to 300 m.

Sunday 20th January **(midday: wind 23 knots, sea state 4, 2.4°C air, 1.4°C sea surface, ice 0/10)**

Continuing to head NNE on transect to Polar Front. Station 16 was arrived at by 05:00, with usual station activities. It is to be noted that SAPS will be deployed every day during this transect.

Ice has now largely gone so CPR and towfish were redeployed after leaving morning station at ~10:30.

Stations are spaced apart so that a speed of between 8 and 10 knots is required to arrive at the next station position, provided that there are no delays in station activities.

Station 17 was started at 17:00 without any hitches.

CPR was not redeployed on leaving station 17 since the distance between the two nighttime legs is insufficient for adequate operation of the device. It will be deployed between the morning and evening stations only during this transect.

Monday 21st January **(midday: wind 21 knots, sea state 4, 2.5°C air, 2.7°C sea surface, ice 0/10)**

Midnight CTD did not take place with winds gusting to 35 knots. This was noted as station 18 cancelled in records.

There was also some interruptions with the non-toxic water supply overnight – believed to be a tripping problem – the deck engineer – Craig, was called out at 2 am and then at 5:30 am. No further issues were noted after that.

Conditions were still difficult this morning for Station 19 and there was a little delay in the start of activities as we considered the state of the swell. The Bongo deployments eventually went OK although some swell did wash down the side deck. GO-Flos were deployed next, which was a departure from the scheduled programme, since they were easier to deploy in a high swell. The stainless steel deployed was finally believed safe deploy after the Go Flos although it took some skill from the winch operator (Commodore Bosun Dave Peck) to deploy it. Recovery was a bit more

problematic, and some breakers opened some of the bottles, potentially contaminating the samples. Scientists were made aware of this issue. Following deployments went OK – Snow catcher, SAPS and then Snow catcher once the SAPS had been recovered. The CPR was deployed on leaving the station.

Station 20 in the evening was carried out without any issues.

SS CTD was giving some tell tale signs of cable termination problems. The cable is presently being reterminated – a load test will be performed at 23:00 in advance of midnight station 21.

Tuesday 22nd January **(midday: wind 18 knots, sea state 3, 3.6°C air, 3.1°C sea surface, ice 0/10)**

Midnight CTD went without a hitch subsequent to load test.

Station 22: Morning activities were as scheduled, with weather and sea state relatively mild.

Sea surface looked oily black and Bongo net returned with large amount of phytoplanton in the buckets – probably *Corethron*. Stainless steel CTD, Go Flos, SAPS and snow catchers deployments all went OK. Left station around 10am.

Steamed at 10 knots to station 23. We are now some hours ahead of schedule, given there have been no hitches to deployments or any slowing of speed due to weather. Therefore, a more ambitous northerly end to the transect has been set, 45 nm further north than originally planned at ~48° 30'S.

16:00 a talk was given by Toby, Jeremy and myself to crew and scientists about the general aims of JR274 and some of the main activities on board. The talk was much appreciated by the crew and even the scientists who attended found it interesting.

Evening station carried out without any issues.

Wednesday 23rd January **(midday: wind 17 knots, sea state 3, 5.7°C air, 4.7°C sea surface, ice 0/10)**

Midnight CTD went OK (station 24). Morning station (station 25) operations started with Bongo net, followed by SS CTD, Snow catcher, Go Flo and a further snow catcher before deploying the CPR on leaving the station at 10:20.

Executive group meeting took place at 14:00. It was decided to place Bioassay 3 towards the SE of the South Georgia bloom in the hope that this location would contain iron replete but low phytoplankton biomass conditions, with the potential of growth. Conditions sampled during the present transect show very high and possibly senescent phytoplankton communities (Eucampia to the south, Phaeocystis towards the north) that would not be ideal for a bioassay setup. These

communities are well downstream of the shelf region where the fertilisation takes place. Our plan is to get close to this area of initial fertilisation.

As a result of discussions, it was decided to turn the ship round from its northerly course at 15:20. The direction south was then towards the proposed Bioassay station location at 53° 8.8'S 36° 36.94'W, which we plan to reach on 25th at 02:00.

Station 26 was arrived at along this new southward trajectory at 17:00 at the position 49°13.29'S 38° 35.45'W. CPR was recovered, followed by CTD and Bongo net. CPR was redeployed on leaving station and will be towed overnight until reaching Station 27 at 05:00 tomorrow.

Thursday 24th January **(midday: wind 3 knots, sea state 1, 3.1°C air, 4.5°C sea surface, ice 0/10)**

Large iceberg was immediately SW of the location of station 27 but did not interfere with operations. Station proceeded as planned, with 3 Bongo nets, SS CTD, Snow catcher, Go-Flos to 1400 m, SAPS and snow catcher. Added a further CTD to the end of the sequence to examine properties of deeper water , particularly TA and DIC given that this region (particularly SE of the present location) was shown to experience upwelling that brought undersaturated waters closer to the surface. The Ti CTD was used since the SS CTD has a FRRF that is rated only to 500 m. The total water column depth was ~1800 m. The profile was made to 1400 m, with bottles fired at 1400, 1200, 1000, 800, 600 and 400 m. Other measurements were made on these bottles in addition to TA and DIC were oxygen, and TEP, possibly nutrients. Left station around 11:15

Station 28 operations were as planned – SS CTD and Bongo plus a further Ti CTD – the bathymetry was shallower than expected – 830 m – uncharted seamount. Profile made to 800 m with bottles fired at 800, 700, 600, 500, 400 m.

Now proceeding towards station 29 – Bioassay station. General plan is to keep sampling every 30 mins from 20:00 onwards to detect a non-Phaeocystis region with relatively low fluorescence. Such a position will be marked and returned to for 02:00 tomorrow for the start of the Bioassay station.

Friday 25th January **(midday: wind 14 knots, sea state 2, 3.1°C air, 2.4°C sea surface, ice 0/10)**

Phytoplankton observations made the previous night showed that there was a mixed assemblage of coccolithophores, diatoms and dinoflagellates from 20:00 onwards. Underway fluorescence measurements estimated Chl-a to be between 1.0 and 1.5 ug/l. The fluorescence appeared to be dropping towards midnight. Furthermore, sections of satellite images not obscured by cloud showed that sea surface Chl-a was generally decreasing to the south of the transect. We therefore decided to made Bioassay 3 at the position passed at 23:30 at 52.69337°S, 36.62614°W.

Because the CPR was in, the ship made a large loop to time its arrival back at the above position at 02:00, having maintained a speed at or above 6 knots during the interim.

Operations started at 02:00 with 4 x Ti CTD. Bongo nets started at 07:15, followed by SS CTD, Snow catcher, Go-Flos and a further snow catcher. The Ti CTD was the deployed to obtain a profile down

to 1400 m with water being sampled every 200 m for TA and DIC. There was also a further Bongo net because the numbers of animals in the previous nets was low and 210 healthy copepods were required to set up the bioassay experiment. The CPR was deployed on leaving station.

The afternoon was spent heading towards South Georgia. Expected time of arrival in Cumberland Bay tomorrow is 07:00.

Saturday 26th January **(midday: wind 1 knots, sea state 1, 0.5°C air, ?°C sea surface, ice 1/10)**

Went alongside KEP at 08:00 during a heavy snow fall. Pat Lurcock , KEP Harbour master gave a talk on access to areas around KEP. Most science staff had gone ashore by 09:00.

Shore leave ended by 16:30. Ship left quayside by 18:00

Spent night in Cumberland Bay

Sunday 27th January **(midday: wind 1 knots, sea state 1, 3.0°C air, 3.0°C sea surface, ice 0/10)**

Did morning station in main channel in Cumberland Bay (water depth 240 m).

Main activities carried out as normal – Bongo x 3, SS CTD, snow catcher, Go Flo and then another snow catcher.

Zooplankton abundant in nets including larval and juvenile pteropods. No sizeable phytoplankton in water despite Chl-a maximum at 30 m.

Headed NE until evening station. Swell increasing although winds relatively light – swell probably resulting from a previous storm while we were in South Georgia

Evening station went as planned – SS CTD, Bongo and Ti CTD to 14:00.

Are now heading in NE direction until morning station

Monday 28th January **(midday: wind 7.6 knots, sea state 4, 3.4°C air, 3.6°C sea surface, ice 0/10)**

Morning activities for station 32 were carried out as planned. Bongo nets, followed by SS CTD, Snow catcher, Go Flos, SAPS with simultaneous snow catcher and Ti CTD to 1400 m. Completed station by 12:00.

Moved ENE to station 33, which was the most northerly point in our present trajectory. First SS CTD was contaminated because bleed screws were not sealed. Therefore a second deployment was made after the Bongo net.

Continuing to head east to station 34, which will be the last station before we start to head south to the South Sandwich Islands.

Tuesday 29th January **(midday: wind 22.3 knots, sea state 4, 3.3°C air, 3.2°C sea surface, ice 0/10)**

Station 34 – wind picking up while deploying the Bongo nets but deployments were completed successfully. Other deployments went as planned – SS CTD, Snow catcher, Go Flos, Snow catcher, full depth Ti CTD. The Ti CTD was deployed with 16 bottles, 8 of which were trace metal clean. Water was extracted in the clean container from these bottles. Antarctic Bottom Water was not found at the deeper depths – max depth was ~4000 m

Moved southwards after station 34 heading towards a position just east of the South Sandwich Islands, which will be reached on the morning of 1st in time for Bioassay 4.

An executive meeting considered our route to this position and features to aim for. It was agreed that we should try to get to a spot with high phytoplankton biomass since such a feature has yet to be sampled in the 3 previous bioassays. There is evidence of a bloom roughly midway along the South Sandwich archipelago to the downstream (east) side.

There was also talk of a new volcanic island of which there have been reports just north of Zavodoski Island. A deviation to take us past this position will only involve an extra 5 nm of steaming. We should go past this position at 2amon 31st Jan. We will monitor the pCO2 sensor through the night for any indication of volcanically induced CO2 seepage.

Station 35 in the evening proceeded at planned – SS CTD followed by Bongo. The CPR body was changed to body 167 containing mechanism 167/0.

Wednesday 30th January **(midday: wind 13.4 knots, sea state 3, 1.4°C air, 1.4°C sea surface, ice 0/10)**

Station 36 - activities were carried out as planned – Bongo, SS CTD, Snow catcher, Go Flos, SAPS, snow catcher and Ti CTD to 1400 m (with 8 bottles). CPR deployed on leaving station.

Weather sunny making a pleasant passage to station 37 very pleasant.

Activities at station 37 took place as planned.

Now setting a course to steam close to the position of a possible new island. However, recent contact with the hydrographic office suggests that the possibility that one exists is quite remote.

We will be due to sail past the position at 01:30. If there is any sighting, we will reverse course and make a station at the nearby site for tomorrow morning. Else, we will continue to steam on this same SSE trajectory until 05:00.

Thursday 31st January **(midday: wind 19.1 knots, sea state 5, 1.6°C air, 0.7°C sea surface, ice 0/10)**

An object was spotted on radar SE of the indicated place of the potential island but uncertain whether this was an iceberg or land. The ship continued on its trajectory until 05:00 for station 38

Station 38 - Wind freshening but station activities took place as planned – Bongo, CTD, snow catcher, Go Flos, snow catcher and Ti CTD.

Continued on a SE course until reaching St 39 for evening station, which wnt ahead as planned.

Now surveying phtoplankton community every 30 minutes to determine composition, biomass and health to find a suitable location for Bioassay 4. Presently in a large Phaeocystis bloom which would not be suitable so hoping to find better conditions as we head SE and then SW to come in closer to the S Sandwich Islands and, hopefully, into a region where the bloom is initiated.

Friday 1st February **(midday: wind 21.5 knots, sea state 5, 0.3°C air, 0.2°C sea surface, ice 0/10)**

The monitoring of phytoplankton conditions along the transect leading up to the Bioassay station did not reveal an ideal site. Chl-a levels remained relatively high (uncalibrated fluorescence of between 6 and 7), variable amounts of Phaeocystis and Fv/Fm scores of between 3.0 and 3.5. By 01:30, conditions had not changed and so the station was sited at that spot.

Wind was around 25 knots and swell was picking up but it was deemed to be adequate for sampling.

Sampling operations started at 02:00 at Station 40 (Bioassay 4), with the deployment of the first of 4 Ti CTDs. This operation was completed by around 07:00 after which followed standard station sampling activities – Bongos, SS CTD, Snow catcher, Go Flos, SAPS, Snow catcher and Ti CTD. The station was completed by around 13:00.

Weather was continuing to freshen as we continued along transit to our next station scheduled for 05:00 tomorrow.

Saturday 2nd February **(midday: wind 24.0 knots, sea state 7, 0.36°C air, -0.03°C sea surface, ice 0/10)**

Wind around 35 to 40 knots over a sustained period during the night – swell quite high. Decision made at 04:30 to cancel the station and proceed along our SSE course to the next station. (Crew cabins flooded during the night, crew door not closed during period of high swell).

Access to outside containers restricted during passage. Decision made to go hove to at 09:00 to allow container operations to take place and also to retrieve the CPR.

Weather calmed considerably during the latter morning and swell declined sufficiently to allow the ship to resume passage at aroun 14:00 (work was allowed to continue in containers). CPR was not deployed in water during this period of passage.

Station 42 arrived at 17:00 and activities carried out as originally planned (SS CTD followed by Bongo). CPR deployed on leaving station.

Pub quiz that evening hosted by Jeremy and Vicky.

Sunday 3rd February **(midday: wind 23.3 knots, sea state 5, -0.24°C air, -0.07°C sea surface, ice 0/10)**

St 43 – Wind remained relatively calm overnight with moderate swell in morning. Station activities carried out as planned – Bongos, SS CTD, Snow catcher, Go Flos, SAP, Snowcatcher, Full depth Ti CTD.

Around 13:30, a winding-on problem developed during the full depth CTD with 3600 m of cable out. The Ti CTD was recovered and the Niskin bottles recovered into clean container (if clean) or sampled directly from the frame (if not clean). However, the spool was misaligned and the Ti CTD minus bottles was redeployed to full depth so that the winding on could be redone taking care with the alignment in the process. The whole process lasted until around 18:50. Accordingly, the evening station was cancelled.

CPR deployed on leaving station. Now heading north on a trajectory back to South Georgia.

Monday 4th February **(midday: wind 19.7 knots, sea state 4, -0.46°C air, -0.19°C sea surface, ice 0/10)**

St 44 – Weather moderate. Station activities were carried out as planned – Bongos,SS CTD, Snow catcher, Go Flos, Snow catcher, full depth Ti CTD. The CTD went down to around 4000 m. Station was completed by 12:00.

Steaming to evening station pleasant with sightings of breaching whales.

Evening station carried out as planned.

Weather increasingly calm – takedown planned for 3am tomorrow.

Tuesday 5th February **(midday: wind 19.7 knots, sea state 5, 1.50°C air, 0.24°C sea surface, ice 0/10)**

St 46 – Weather starting to freshen. Station operations carried out as planned – Bongos, SS CTD, Snow catcher, Go Flos, SAPS, Snow catcher and Ti CTD. The Ti CTD was deployed to full depth (not as originally planned to 1400 m) – Eric wishes to make the entire length of this transect full depth (i.e. tomorrow and Thursday), to compliment the CTDs carried out to the extreme south and north of the previous transect.

Weather continued to freshen during the afternoon and is now gusting to 40 knots. Swell has also picked up to sea state 7 to 8. Evening station was therefore cancelled. CPR was left out as we continue to steam north at 10 knots.

Wednesday 6th February **(midday: wind 22.2 knots, sea state 6, 2.35°C air, 1.38°C sea surface, ice 0/10)**

St 48 – swell rough to very rough at 04:30 this morning . An assessment was made once arriving on station where it was decided to postpone operations until 06:00 to see if conditions improved. The wind moderated to 20 to 25 knots over that period and there was some decrease in the swell along with some adaptation by JCR to conditions. Operations started with Go Flos at 06:00. This was followed by Bongos at 07:30. On completion, the swell was still too high to carry out CTD operations so a further hour was waited. At 09:45, SS CTD was deployed (with extra men to effect a safe exit from the garage). This was followed by a full depth Ti CTD at ~10:45. The Ti CTD returned on deck at ~12:15. Snow catcher operations were cancelled. CPR was deployed in leaving station at ~12:20.

Passage to next station was rough with swell still not abating despite decreasing wind stress.

Evening station carried out as planned – SS CTD followed by Bongo

Swell still crossed on passage to tomorrow's station just to south and east of South Georgia

Thursday 7th February **(midday: wind 37.9 knots, sea state 7, 3.00°C air, 2.33°C sea surface, ice 0/10)**

Winds increasing swell high this morning.

Decided to proceed north until 08:00 and reassess

Weather still too rough for deployments so continued to head north until 13:00, when hopefully swell is dampened by lee of South Georgia

Wind abated to around 20 knots and swell had calmed somewhat by 13:00. Captain said conditions were workable.

Deployed Go Flo at 13:00 location (St 50).

Conditions deteriorated during deployment. Abandoned further deployments and left station after retrieving Go Flos. Head WNW further in to South Georgia

Reassessed condtions at 17:30. Wind abated to an extent but swell still high.

Decided to cancel evening station and head in to South Georgia, hopefully to reach calmer waters in time for the final take down starting at 03:00.

Friday 8th February **(midday: wind 4.2 knots, sea state 4, 5.51°C air, 5.08°C sea surface, ice 0/10)**

Moved into Cumberland at 8am having spent the evening outside the Bay on DP. Anchored just off the base. PAX were shipped out using KEP jet pilot boats. Natalie Ensor went into the base on the first pilot boat return trip in order to uses microbalance. Several other trips were made to exchange PAX and some cargo. Final trip occurred around 10:30, on which Ensor returned to the vessel. Total of 10 PAX were uplifted in total.

Moved out to Cumberland Bay and stopped for emergency drills and lifeboat drills. Drills completed by 11:30 am.

On passage to Bird Island by 12:00. CPR and tow fish were not deployed.

Saturday 9th February **(midday: wind 16.4 knots, sea state 5, 3.74°C air, 2.48°C sea surface, ice 0/10)**

Arrived just outside Bird Island during the night and held on DP for the remainder of the night. Moved to an anchorage just outside Bird Island and deployed two ribs. Doctor taken into base to inspect a FID who had suffered a seal bite. Returned just after 11 with 1 PAX (Forcada) and moved off by 11:30.

CPR and tow fish deployed on leaving Bird Island, around 11:45.

Sunday 10th February **(midday: wind 28.0 knots, sea state 3, 4.39°C air, 4.1°C sea surface, ice 0/10)**

Steaming to Port Stanley. – CPR and towfish deployed - underway sampling continuing.

Monday 11th February **(midday: wind 17.7 knots, sea state 3, 7.13°C air, 6.33°C sea surface, ice 0/10)**

On passage – CPR and towfish deployed – underway sampling continuing

Tuesday 12th February

CPR and towfish taken out at 07:00. Arrived at FIPASS 08:00. Demobilisation activities commenced. Changed berth twice during day.

Wednesday 13th February

Demobilisation completed at 15:00

British Antarctic Survey Post-Cruise Assessment Form
MS.AV

Principal Scientists and Charterers should complete this form. This will enable NERC to monitor the performance of its research ship and technician/equipment support operations. ***Completed forms should be sent (or via email) to Chris Hindley – BAS. (copies will be forwarded to Dr Mike Webb for NERC funded cruises)***

Ship: RRS James Clark Ross	*Cruise no. JR274*	*Dates: 3rd Jan – 15th Feb 2013*

PS name: Geraint Tarling	Institution & position: BAS, Head of Ocean Ecosystems	Email: gant@bas.ac.uk

Work type: Biological Oceanography	Area of operation: Scotia Sea and Weddell Sea
Master: J Burgan	Tech Liaison Off. Chris Hindley

Please tick boxes A to E and add comments if required.(A = Excellent; B = Good; C = Average; D = Poor; E = Unacceptable)

	A	B	C	D	E	Comments
Pre-cruise planning		x				
Mobilisation support		x				Transport of chemicals was difficult (see comments below) but all other mobilisation matters were dealt with efficiently
Onboard marine support	x					The JCR officers and crew were highly professional in supporting the science objectives
Onboard technical support	x					
Ship/technical/scientific staff interface	x					
Demobilisation support	x					
Suitability of "pool" equipment		x				One laboratory container (trace metal analysis) had issues with heating and a faulty door. Trace metal clean sampling was compromised by the lack of a trace metal clean winch system. This resulted in

						substituting the Ti CTD with Go Flos, which is a much more laborious method of sampling.
Facilities in laboratories		x				
Fixed scientific facilities		x				The only major difficulty encountered was the slowness of internet access. This interfered with science operations in that reports could not be consulted in appropriate time frames. Furthermore, this also hindered access to satellite information that was crucial to day to day decision making. Although certain mitigation measures were taken, the situation was often inadequate for a modern day research vessel.
Safety instruction		x				
Onboard safety practices		x				
Onboard hotel facilities		x				
Onboard catering service	x					
Cleanliness of ship	x					
Other – Please specify						

Are there any Safety Points which were raised during the cruise/charter still "open". **No**

If so detail (on separate page if necessary).

Do you wish to be informed of "actions and closure" after leaving the ship. **N/A**

Please provide the following information on attached sheets.

1. Were the science objectives of this cruise met? Please explain, especially if the objectives were not met
2. The number of lost days and the reason for lost days
3. Are there any changes that you recommend to improve results and/or safety before the ship is used again for this or similar projects?
4. Please make suggestions for improving the pre-cruise planning and co-ordination, logistics, shore support or living conditions on the ship

5. Please make any comments regarding the ship's operation, equipment, ship's personnel, technicians, shore support or science party

1. Were the science objectives of this cruise met? Please explain, especially if the objectives were not met

The objectives of the cruise were as follows:

- To cover the regularly sampled Drake Passage (recent cruise found surface Ωaragonite from 1.25 to >2)
- To enter the exceptionally cold Weddell Sea where undersaturation is predicted to occur first in the Southern Ocean
- To transect strong gradients in ΩCaCO3 along multiple N-S transects at different longitudes, in ice edge regions and on moving into high productivity (raising pH and ΩCaCO3 but not SST) waters NW of S Georgia.
- To traverse previous BAS transects allowing repeat observations (incl. carbonate system) particularly upwelling regions where surface Ωaragonite ~ 1.

Each of these objectives were met in that the ship was able to place us in these environments and traversed transects at optimum speeds.

The ships equipment was functional throughout the science operation

2. The number of lost days and the reason for lost days

48 h were lost to bad weather; 5 hours were lost to ship's equipment failure (spooling issues with CTD winch)

3. Are there any changes that you recommend to improve results and/or safety before the ship is used again for this or similar projects?

Safety procedures and standards were made clear at the start of the cruise and were inspected during science operations. Failures to comply with the standards were brought to the attention of the PSO who acted to rectify these matters

4. Please make suggestions for improving the pre-cruise planning and co-ordination, logistics, shore support or living conditions on the ship

The major difficulty with the science operation was in the transport of chemicals to the ship. As PSO, it was extremely time consuming trying to ensure that chemicals were adequately packed and had the appropriate Bills of Lading. I would suggest that, in the future, any UK institute wishing to consign chemicals on a BAS ship have a liaison officer who has undergone an induction course on how to carry this out to comply with BAS standards. Quite often, I was caught in the middle of BAS logistics, who were at the point of refusing to transport chemicals because of non-compliance, and the respective institute, who were insistent that the chemicals were packed to acceptable international standards. It is not for the PSO to adjudicate on such matters, particularly if they are not experts on chemical transport themselves. This will become an ever greater issue as standards of transport becomes ever more stringent.

5. Please make any comments regarding the ship's operation, equipment, ship's personnel, technicians, shore support or science party

The support from National Marine Facilities was excellent and I would like to congratulate Jez Evans and his team for smooth mobilisation and demobilisation operations. We suffered no major equipment failures during the cruise. The BAS technical staff did a remarkable job at reviving analytical instruments within our laboratories that failed, probably as a result of their transport down through the tropics prior to the cruise. The container laboratories functioned as required, although one container (trace metal analysis) did suffer from heating issues and had a faulty door. Trace metal clean sampling was compromised by the lack of a trace metal clean winch system. This resulted in substituting the Ti CTD with Go Flos, which is a much more laborious method of sampling.

CRUISE SUMMARY REPORT

FOR COLLATING CENTRE USE

Centre: BODC Ref. No.:

Is data exchange restricted ☐ Yes ☐ In part ☐ No

SHIP enter the full name and international radio call sign of the ship from which the data were collected, and indicate the type of ship, for example, research ship; ship of opportunity, naval survey vessel; etc.

Name: RRS James Clark Ross **Call Sign: ZDLP**

Type of ship: Research Ship

CRUISE NO. / NAME JR274 (UK Ocean Acidification Sea Surface Consortium Southern Ocean Cruise)

enter the unique number, name or acronym assigned to the cruise (or cruise leg, if appropriate).

CRUISE PERIOD start 9 /1/2013 to 12 /2 /2013 end
(set sail) day/ month/ year day/ month/ year (return to port)

PORT OF DEPARTURE (enter name and country) **Stanley, Falkland Islands**

PORT OF RETURN (enter name and country) **Stanley, Falkland Islands**

RESPONSIBLE LABORATORY enter name and address of the laboratory responsible for coordinating the scientific planning of the cruise

Name: British Antarctic Survey

Address: High Cross, Madingley Road, Cambridge, CB3 0ET

Country: UK

CHIEF SCIENTIST(S) enter name and laboratory of the person(s) in charge of the scientific work (chief of mission) during the cruise.

Dr Geraint Tarling, British Antarctic Survey, High Cross, Madingley Rd, Cambridge, CB3 0ET, UK

OBJECTIVES AND BRIEF NARRATIVE OF CRUISE enter sufficient information about the purpose and nature of the cruise so

as to provide the context in which the report data were collected.

JR274 was conducted within the Scotia Sea and Weddell Sea in the Atlantic Sector of the Southern Ocean. The transects were run as follows 1) Falkland Islands to Elephant Island (following the NOC Drake's Passage transect) 2) Elephant Island to South Orkneys (in three transects heading NE and SE) 3) South Orkneys to NW South Georgia (following the DISCOVERY 2010 transect and beyond the Polar Front) 4) South Georgia to South Sandwich Islands (initially heading E and then SE) 5) South Sandwich Islands to Weddell Sea 6) Weddell Sea to South Georgia 7) South Georgia to Falkland Islands.

A total of 48 sampling stations were undertaken, while samples were also taken between every 2 and 4 hours en route from the underway non toxic pumped sea water supply. The sampling stations were mainly to sample the carbonate chemistry system and the accompanying biotic communities (microplankton, phytoplankton and zooplankton). Carbon and carbonate chemistry was also measured as well as trace metals and trace gasses. The majority of measurements were limited to the upper 300 m of the water column although there were 5 full depth CTD deployments during Legs 5 and 6.

The sampling was carried out as part of the UK Ocean Acidification Sea Surface Consortium with a remit to investigate the influence pH and carbonate chemistry on pelagic communities and upper ocean chemical processes.

PROJECT (IF APPLICABLE) if the cruise is designated as part of a larger scale cooperative project (or expedition), then enter the name of the project, and of organisation responsible for co-ordinating the project.

Project name: UK Ocean Acidification Sea Surface Consortium

Coordinating body: National Oceanography Centre, Waterfront Campus, Southampton, SO14 3ZH, UK

PRINCIPAL INVESTIGATORS: Enter the name and address of the Principal Investigators responsible for the data collected on the cruise and who may be contacted for further information about the data. (The letter assigned below against each Principal Investigator is used on pages 2 and 3, under the column heading 'PI', to identify the data sets for which he/she is responsible)

A. Phytoplankton – Alex Poulton, NOCS

B. Carbon and Carbonate chemistry – Eric Achterberg, NOCS

C. Zooplankton – Geraint Tarling, BAS

D. Trace gases – Andy Rees, PML

E. Chemical oceanography – Richard Sanders, NOC

F. Calcifying plankton – Jeremy Young, University College, London

G. Trace metals – Eric Achterberg, NOCS

H. Microplankton – Mike Zubkov, NOC

I. Phytoplankton bioassays – Mark Moore, NOCS

J.Supporting oceanography – Toby Tyrrell, NOC

MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS

This section should be used for reporting moorings, bottom mounted gear and drifting systems (both surface and deep) deployed and/or recovered during the cruise. Separate entries should be made for each location (only deployment positions need be given for drifting systems). This section may also be used to report data collected at fixed locations which are returned to routinely in order to construct 'long time series'.

PI	APPROXIMATE POSITION						DATA TYPE	DESCRIPTION
	LATITUDE			LONGITUDE				
See top of page.	deg	min	N/S	deg	min	E/W	enter code(s) from list on last page.	Identify, as appropriate, the nature of the instrumentation the parameters (to be) measured, the number of instruments and their depths, whether deployed and/or recovered, dates of deployments and/or recovery, and any identifiers given to the site.

								Please continue on separate sheet if necessary

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN

Except for the data already described on page 2 under 'Moorings, Bottom Mounted Gear and Drifting Systems', this section should include a summary of all data collected on the cruise, whether they be measurements (e.g. temperature, salinity values) or samples (e.g. cores, net hauls).

Separate entries should be made for each distinct and coherent set of measurements or samples. Different modes of data collection (e.g. vertical profiles as opposed to underway measurements) should be clearly distinguished, as should measurements/sampling techniques that imply distinctly different accuracy's or spatial/temporal resolutions. Thus, for example, separate entries would be created for i) BT drops, ii) water bottle stations, iii) CTD casts, iv) towed CTD, v) towed undulating CTD profiler, vi) surface water intake measurements, etc.

Each data set entry should start on a new line – it's description may extend over several lines if necessary.

NO, UNITS : for each data set, enter the estimated amount of data collected expressed in terms of the number of 'stations'; miles' of track; 'days' of recording; 'cores' taken; net 'hauls'; balloon 'ascents'; or whatever unit is most appropriate to the data. The amount should be entered under 'NO' and the counting unit should be identified in plain text under 'UNITS'.

PI see page 2	NO see above	UNITS see above	DATA TYPE Enter code(s) from list on last page	DESCRIPTION Identify, as appropriate, the nature of the data and of the instrumentation/sampling gear and list the parameters measured. Include any supplementary information that may be appropriate, e. g. vertical or horizontal profiles, depth horizons, continuous recording or discrete samples, etc. For samples taken for later analysis on shore, an indication should be given of the type of analysis planned, i.e. the purpose for which the samples were taken.
A	47	Deployments	B01, B02, B08	CTD (plus underway – ship's non-toxic pumped sea water supply sampled intermittently)
B	47	Deployments	B06 H09, H27, H28, H74	CTD (plus underway – ship's non-toxic pumped sea water supply sampled intermittently)
C	91	Deployments	B09, B20, B21	Bongo net – vertically hauled
D	47	Deployments	H33	CTD (plus underway – ship's non-toxic pumped sea water supply sampled intermittently)
E	47	Deployments	H21-H26, H76, B71	CTD (plus underway – ship's non-toxic pumped sea water supply sampled intermittently)
F	47	Deployments	B08	CTD (plus underway – ship's non-toxic pumped sea water supply sampled intermittently)
G	30	Deployments	H30	Go-Flo bottles (clean water) Titanium CTD (clean water) Clean-water tow fish
H	47	Deploy	B08,	CTD (plus underway – ship's non-toxic pumped sea water supply sampled

		ments	B09	intermittently)
I	16	Deploy ments	B01, B02	Titanium CTD (clean water) Clean incubation bottles for on-board bioassays
J	78	Deploy ments	H10, H71	CTD, Oceanlogger system (total transected distance ~5000 nm)

				Please continue on separate sheet if necessary

TRACK CHART: You are strongly encouraged to submit, with the completed report, an annotated track chart illustrating the route followed and the points where measurements were taken.	**Insert a tick(✓) in this box if a track chart is supplied**	√

GENERAL OCEAN AREA(S): Enter the names of the oceans and/or seas in which data were collected during the cruise – please use commonly recognised names (see, for example, International Hydrographic Bureau Special Publication No. 23, 'Limits of Oceans and Seas').

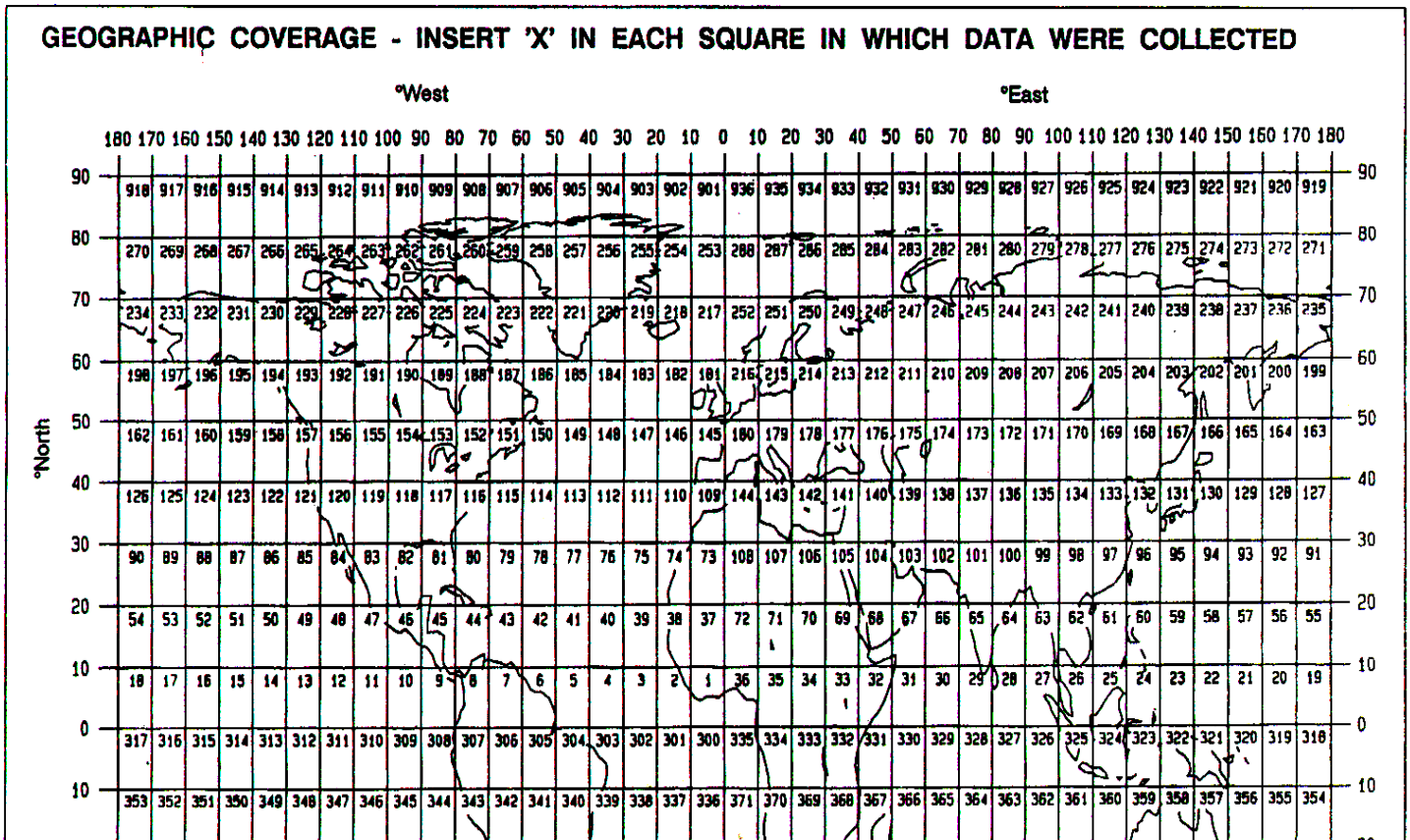
Scotia Sea and Weddell Sea (Atlantic sector of Southern Ocean)

SPECIFIC AREAS: If the cruise activities were concentrated in a specific area(s) of an ocean or sea, then enter a description of the area(s). Such descriptions may include references to local geographic areas, to sea floor features, or to geographic coordinates.

Please insert here the number of each square in which data were collected from the below given chart

485, 521,484,520,483,519,482, 518

see above



PARAMETER CODES

METEOROLOGY

M01	Upper air observations
M02	Incident radiation
M05	Occasional standard measurements
M06	Routine standard measurements
M71	Atmospheric chemistry
M90	Other meteorological measurements

PHYSICAL OCEANOGRAPHY

H71	Surface measurements underway (T,S)
H13	Bathythermograph
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T,S)
H72	Thermistor chain
H16	Transparency (eg transmissometer)
H17	Optics (eg underwater light levels)
H73	Geochemical tracers (eg freons)
D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys
D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements

CHEMICAL OCEANOGRAPHY

H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total - P
H24	Nitrate
H25	Nitrite
H75	Total - N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

MARINE CONTAMINANTS/POLLUTION

P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements

MARINE BIOLOGY/FISHERIES

B01	Primary productivity
B02	Phytoplankton pigments (eg chlorophyll, fluorescence)
B71	Particulate organic matter (inc POC, PON)
B06	Dissolved organic matter (inc DOC)
B72	Biochemical measurements (eg lipids, amino acids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs & larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements

MARINE GEOLOGY/GEOPHYSICS

G01	Dredge
G02	Grab
G03	Core - rock
G04	Core - soft bottom
G08	Bottom photography
G71	In-situ seafloor measurement/sampling
G72	Geophysical measurements made at depth
G73	Single-beam echosounding
G74	Multi-beam echosounding
G24	Long/short range side scan sonar
G75	Single channel seismic reflection
G76	Multichannel seismic reflection
G26	Seismic refraction
G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements