IBIS (Irminger Basin Iron Study)

Cruise Reports

RRS *Discovery 350* (26th April to 9th May 2010)

Principal Scientist: Mark Moore (University of Southampton, National Oceanography Centre Southampton)

and

RRS *Discovery 354* (4th July to 11th August 2010)

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Preface

The data presented in this Cruise Report are provisional and should not be used or reproduced without permission. In some cases they are fully calibrated and in other cases not. Further details can be obtained from the originators (see Scientific Reports). In due course the full data set will be lodged with the British Oceanographic Data Centre.

Acknowledgements

We thank the Master, the officers and the crew of the RRS *Discovery* for their constant support and assistance, and for providing a safe and efficient platform which allowed us to meet the scientific objectives of D350 and D354.

Excellent support was provided by the NMFSS staff members on board.

NERC is acknowledged for funding of the cruise.

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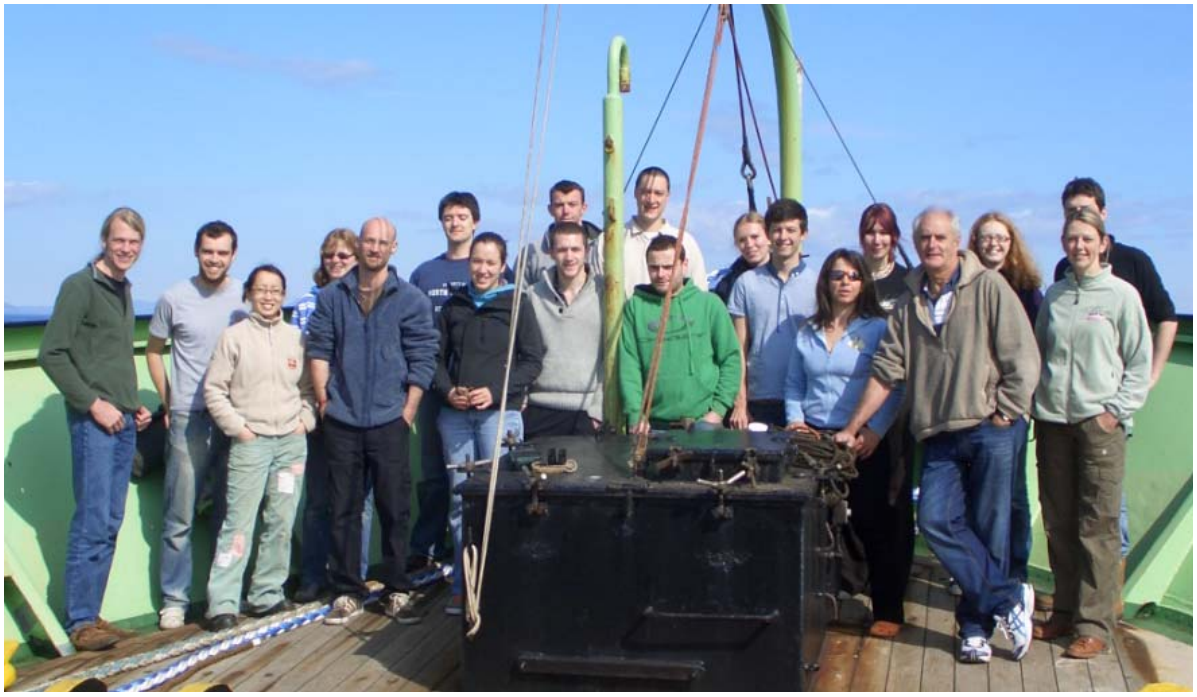

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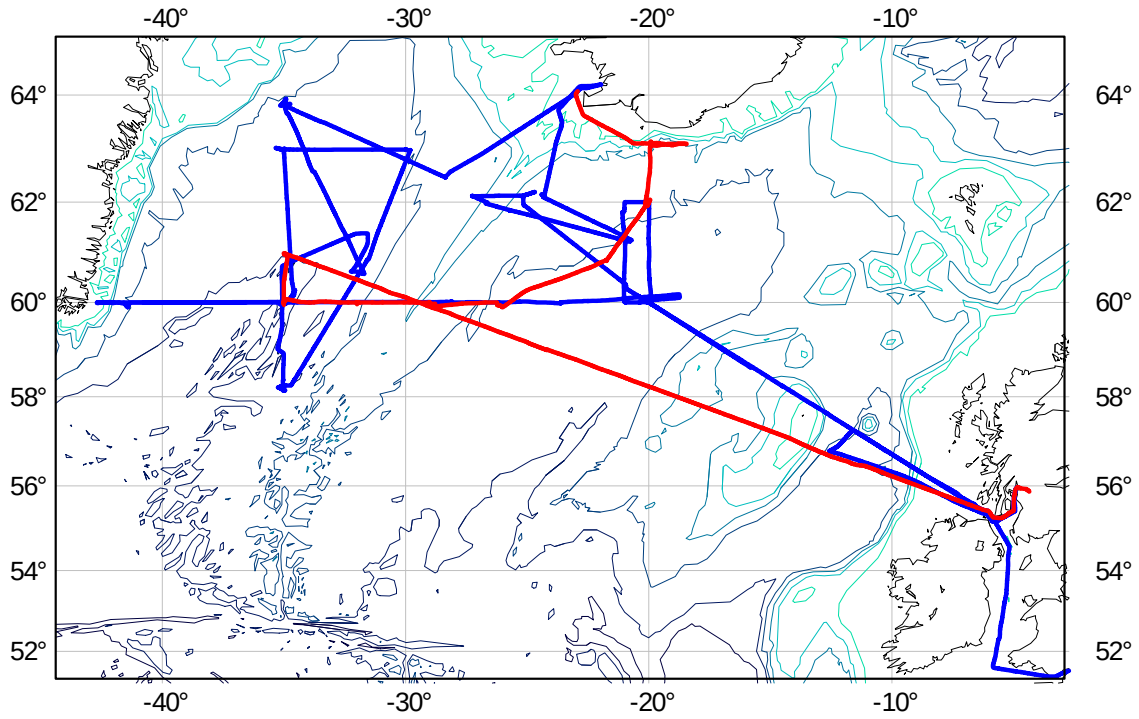

Fig. 1: Cruise tracks of D350 (red) and D354 (blue); contour lines show 200, 500, 1000, 2000, 3000 and 4000 m bottom depth

Iron Biogeochemistry in the High Latitude North Atlantic Ocean

1. Introduction and motivation for the project

Iron and marine primary productivity-An estimated 40% of photosynthesis on earth occurs in the marine environment and the turnover time for marine plant biomass is nearly three orders of magnitude faster than that of terrestrial biomass (1). Hence, nutrients that regulate primary production in the ocean have a significant effect on the global carbon cycle and consequently play a key role in regulating climate. In many oceanic regions, primary productivity, species composition, and the trophic structure of planktonic communities is controlled by light and macro-nutrients i.e. N, P, Si (2-4). However there is now overwhelming evidence that the availability of the nano-nutrient Fe, plays a critical role in regulating phytoplankton primary productivity and microbial diversity in the major High Nutrient Low Chlorophyll (HNLC) regions of the subarctic and equatorial Pacific (5,6) and Southern Ocean (7). These regions account for 40% of the world's oceans and are replete with macro-nutrients but have low productivity as a result of a limited supply of Fe, intensified by the low solubility of Fe under oxidising conditions (8). The important role of Fe for microbial organisms is linked to its obligatory requirement in enzymes involved in photosynthesis, respiration, nitrate reduction and nitrogen fixation (9-11).

Iron and nutrient supply to the surface ocean-Fe and nutrients are supplied to the surface ocean via the atmospheric transport of dust and its deposition, as well as by the upwelling, entrainment, or mixing of deeper waters relatively rich in nutrients and metals (12,13). These sources supply new (not acquired via recycling) nutrients and metals to the euphotic zone. Rivers

and continental margin sediments are a significant source of nutrients and trace metals to coastal waters (14,15), however uptake by coastal phytoplankton and sedimentation of the fluvial inputs render these compounds typically inaccessible to oceanic phytoplankton. In the oceanic euphotic zone, nutrients and metals are also recycled from living matter to sustain regenerated biological production. Whilst the relative importance of atmospheric versus deep ocean sources of nutrients and trace metals to the euphotic zone will vary both spatially and temporally.

Iron distribution in the N Atlantic –Little dissolved Fe data is available for the N Atlantic; in particular deep ocean Fe profiles and speciation data are lacking, hampering accurate Fe model simulations. Dissolved Fe displays a nutrient-type profile in the N Atlantic (15,17,18) with upper water column dissolved Fe concentrations of 0.07-0.1 nmol kg-1 (17) increasing to 0.6-0.8 nM below 900 m. The surface water concentrations are controlled by microbial uptake processes, vertical mixing and particle scavenging, whereas subsurface concentrations are controlled by the interplay between microbial Fe regeneration of sinking organic detritus and particle scavenging. Decreasing surface water dissolved Fe concentrations with increasing latitude have been reported for the N Atlantic by (18), as a consequence decreasing atmospheric Fe inputs (16). The atmospheric supply of total Fe to the high latitude N Atlantic region is estimated as 103 µM Fe m-2 y-1 (north of 60^{o}N) by (16), which is only 30% higher than for the HNLC Southern Ocean.

Productivity in the High Latitude N Atlantic- The high latitude N Atlantic is a major component of the oceanic biological carbon cycle. Intense spring blooms follow winter overturning and consequently the region is responsible for major fluxes of particulate organic carbon to the deep ocean (20). Regions of the high latitude N Atlantic are sites of deep-water formation (North Atlantic Deep Water; 21,22). Such areas have particular importance for atmospheric CO2 sequestration, as any residual nitrate entrained into the formation of deep water represents a lowering of the efficiency of the biological pump (23). Furthermore, increased nutrient utilisation in the high latitude surface oceans, as a result of enhanced Fe supply through increased dust inputs, has been invoked as a cause of the lower atmospheric pCO2 during glacial times (e.g. 24). Residual nitrate concentrations of 3-5 µM have been observed in boreal summer in the high latitude N Atlantic region. This situation corresponds to HNLC regions such as the Southern Ocean. In the Irminger Basin (58-66^{o}N, 24-44^{o}W) we observed residual nitrate stocks during late summer (Holeton et al. unpublished) with relatively low export (60 gC m-2 y-1) (29,20), indicating that new production failed to exhaust nitrate stocks. Utilisation of this residual nitrate could equate to a potential doubling of new production

Iron limitation in the N Atlantic- Fe supply to the N Atlantic has been postulated to be sufficient to meet microbial demands due to enhanced dust deposition (*13*). In contrast to this paradigm, recent work by our group (*25,31*) and others (*26*,*27*) has provided clear indications of Fe limitation in the N Atlantic. Community productivity was shown to be Fe limited in the central N Atlantic at 42°N, 42°W during the early stages of a spring bloom (*25,31*) and increased significantly in the NE Atlantic (39-45°N, 17-21°W) upon a combined addition of +Fe+NPSi above that of +NPSi alone (*26*). Addition of Fe during the spring bloom at the BATS site (32°N, 64°W) has also been demonstrated to result in enhanced chlorophyll synthesis (*27*). Furthermore, very low dissolved Fe concentrations (0.02-0.19 nM) within the deep chlorophyll maximum in this region during summer have been suggested to result in Fe limitation (*19*).

Most recently we undertook Iceland Basin which provided further evidence for Fe limitation of phytoplankton in the high latitude N Atlantic *(31)*. Low photochemical quantum efficiencies (F_v/F_m) of phytoplankton were observed in summer in the central Irminger Basin (*29*), despite residual nitrate stocks consistent with earlier observations in the Iceland Basin, also with shallow mixed layers and elevated nitrate concentrations, suggesting potential Fe control (*28*). In contrast higher photochemical quantum efficiencies are observed in high latitude N Atlantic shelf regions (*28,29*), similar to observations in the Southern Ocean (*30*) and consistent with significant benthic Fe sources.

2. Objectives

Our overall objective is to study the Fe biogeochemistry in the high latitude N Atlantic, assess whether community productivity in parts of the high latitude N Atlantic is Fe limited following the annual spring bloom and determine the factors which lead to this situation.

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Narrative cruise overview D350

The *RRS Discovery* departed on cruise D350 from King George V dock, Govan, UK, at 1215 h on Monday 26th April 2010 and docked in Reykjavik, Iceland, after 14 days at sea at 1745 h on Sunday 9th May. Prior to the cruise, the eruption of an Icelandic volcano (*Eyjafjallajokull*) created a number of logistical problems, the most serious of which being a member of the scientific compliment getting stranded in the US and hence was ultimately unable to make it to the ship on time. Another member of the compliment also had a gruelling 5 day journey from South Africa. The continuing eruption also generated uncertainty with respect to the final port call. However, given our area of scientific interest, the potential impact of a large amount of volcanic ash to the upper ocean in our study region, presented considerable scientific opportunities throughout the cruise. Despite the logistical difficulties, the cruise both left on time and ultimately was highly successful.

During the cruise all scientific work was recorded on GMT and ship time was altered from BST (GMT+1hr) to GMT on 28th April. The cruise track during D350 is shown in figure 1. A total of 9 stations were occupied from 29th April – 8th May 2010, with one shakedown station and 8 principal scientific sampling stations. After an initial long passage including the shakedown station and regularly underway sampling for nutrients, chlorophyll and trace metals, intensive over the side scientific work commenced on 1st May, with one major station being occupied daily from 1st May – 8th May inclusive. Once commenced at 1200 h on 28th April underway sampling was maintained while off station at hourly intervals for all parameters other than metals, the latter being collected at 2 hourly intervals. Dates, times and locations of stations together with detailed information of scientific activities on station are provided in the CTD report and the narrative cruise diary (Appendix A). Dates, times and positions of underway samples are also provided in appendix A.

In general, stations were commenced at night (typically between 2300 h and 0300 h) and consisted of a number of CTD casts, using both a stainless steel and a titanium rosette frame, zooplankton net hauls, and Stand Alone Pump Systems (SAPS) deployments. The order of events on station and exact timings of deployments were adjusted depending on scientific staff work schedules and in order to keep zooplankton net hauls during the hours of darkness where possible. None of the planned stations were aborted for any reason.

A trace metal clean tow fish was also deployed throughout the cruise starting at 0715 h on 28th April with samples being collected every 2 hours whilst off station through to 16:00 on 8th May. Water from the epoxy coated fish was pumped directly into a clean chemistry container using a Teflon pump system through acid washed PVC tubing. The system performed well, with only one partial recovery required to straighten and strengthen a kink in the hose during station on 5th May. A wide variety of samples were collected from both the underway supplies and during CTD stations (see scientific reports and appendix A). Although some parameters were measured at sea, the majority of samples will be returned to shore laboratories for analysis.

Experimental work was also performed on the cruise to measure the biological response to both artificial manipulation of the availability of the micronutrient iron and grazing pressure (p. 42 and 77/ 83, respectively). Measurements of the uptake rate of various substrates was further performed using a variety of tracer techniques (p. 29, 36 and 58).

The towed undulating sensor system Seasoar was also deployed twice on the cruise. Considerably work was required to get Seasoar ready for first deployment on 4th May. This deployment was only partially successful due to problems with the CTD system. The second deployment overnight on 7th May was fully successful with all new instruments appearing to produce data including the new laser optical plankton counter (LOPC). An APEX float was also deployed during the cruise at the end of occupation of the second major station.

Following departure from Govan, the Discovery navigated the Clyde, Irish Sea and then set course for our first waypoint/station in the central Irminger Basin. Underway sampling was performed during passage once we had entered international waters. A shakedown station was also performed while on passage. During the passage leg, preliminary data indicated that nutrient (nitrate and silicate) levels were high with an increasing trend from east to west. Simultaneously, chlorophyll concentrations decreased to a low point at our furthest point north west (Figure 1). The general pattern suggested a transect through waters encountering progressively earlier stages of the spring bloom.

Following occupation of this first full station in the Irminger Basin, we then proceeded south for a day, where a further station was occupied and an APEX float released, before transecting back east across the Reykjanes Ridge into the Iceland Basin. Once into the Irminger heading north east and finally north to occupy some stations south of Iceland near to the region under influence of the Eyjafallajokull volcano. During the whole CTD/Station transect, there was again some indication of increasing chlorophyll concurrent with decreasing macronutrients. Overall the underway sampling and data collected on the station transect should prove more than adequate for satisfying our scientific objectives as stated in our original proposal.

Moreover, following occupation of our final station, ~50 miles south of the *Eyjafallajokull* volcano, the *RRS Discovery* steamed in under the ash plume. This opportunity to collect a data set on atmospheric ash composition concurrently with the chemical and biological response within the upper ocean is highly unprecedented and will hopefully provide unique new information on the importance of volcanic ash inputs for upper ocean biogeochemistry. Although unplanned (and indeed completely unpredictable), this aspect of the cruise predictably promoted the greatest media response, with our press release being picked up and the cruise featured on the BBC website.

One minor accident occurred during the cruise when a scientist knocked thier knee while passing through a doorway. Such accidents are largely unpreventable. An additional near miss report was filled following the a heavy piece of scientific equipment coming loose in a moderately rough sea.

A more detailed description of event and activities is provided within the narrative diary in Appendix A2.

Scientific Reports D350

^{234}Th derived carbon and biomineral fluxes (Fred Le Moigne)

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Scientific motivation

The Radioactive short-lived Thorium-234 (^{234}Th, t1/2=24,1d) (Bath *et al*., 1969) has been used as a tracer of several transport processes and particle cycling in aquatic systems by different techniques (Rutgers 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; Cochran and Masqué, 2003; Rutgers van der Loeff, 2001). ^{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; Chen et al.,1986). 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 et 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 during the D350.

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 Buesseler *et al* (1999). 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 (1000m) 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.

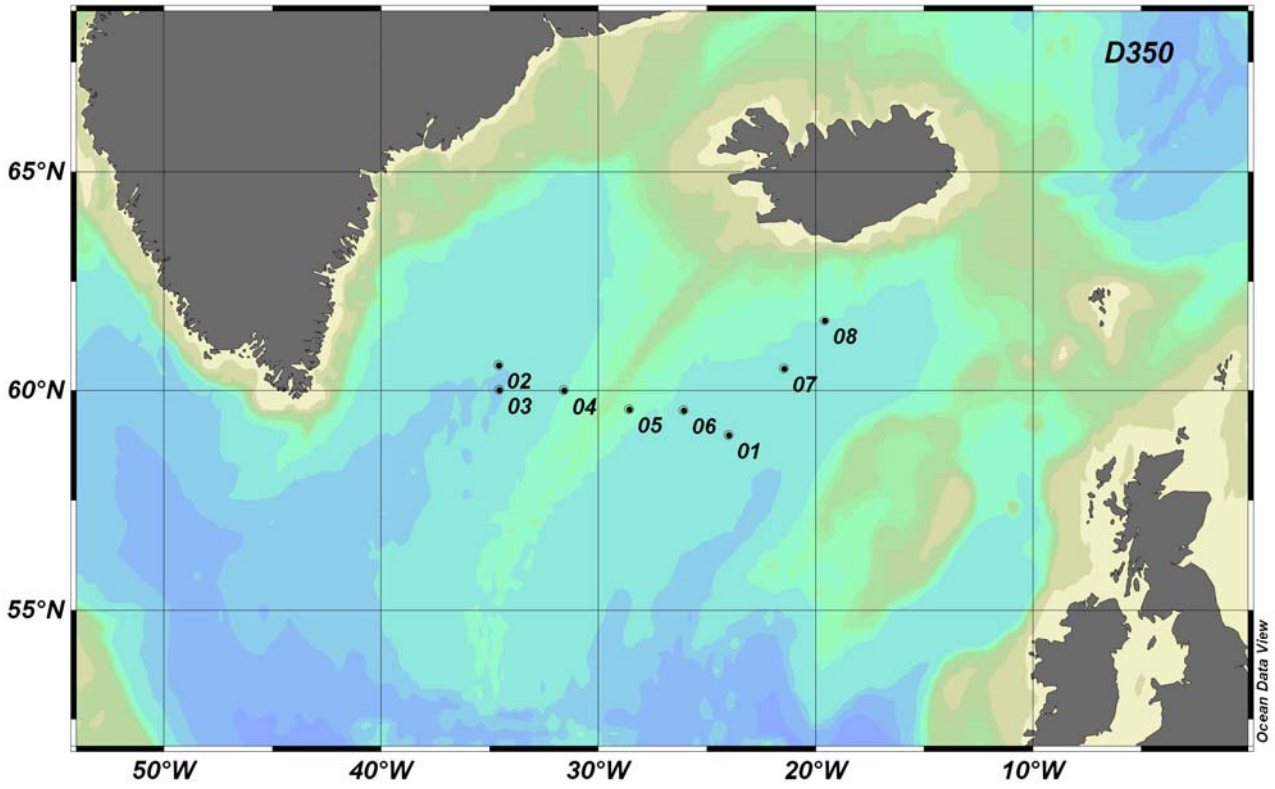

Figure 1: D350 station positions.

Table 1: Station ID with sampling date, depth range and volume sampled.

Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 A	intercal BV	29 Aprl	14H35	5	50	10
D350 B	intercal BV	29 Aprl	14H35	6	50	10
D350 C	intercal BV	29 Aprl	14H35	7	50	10
D350 D	intercal BV	29 Aprl	14H35	8	50	10
D350 E	intercal BV	29 Aprl	14H35	9	50	10
D350 F	intercal BV	29 Aprl	14H35	10	50	10
D350 G	intercal BV	29 Aprl	14H35	11	50	10
D350 H	intercal BV	29 Aprl	14H35	12	50	10
D350 I	intercal BV	29 Aprl	14H35	13	50	10
D350 J	intercal BV	29 Aprl	14H35	14	50	10
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 1	intercal SV	29 Aprl	14H35	6	50	4
D350 2	intercal SV	29 Aprl	14H35	7	50	4

D350 3	intercal SV	29 Aprl	14H35	8	50	4
D350 4	intercal SV	29 Aprl	14H35	9	50	4
D350 5	intercal SV	29 Aprl	14H35	10	50	4
D350 6	intercal SV	29 Aprl	14H35	11	50	4
D350 7	intercal SV	29 Aprl	14H35	12	50	4
D350 8	intercal SV	29 Aprl	14H35	13	50	4
D350 9	intercal SV	29 Aprl	14H35	14	50	4
D350 10	intercal SV	29 Aprl	14H35	15	50	4
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 AAA	intercal BV2	29 Aprl	14H35	5	50	10
D350 BBB	intercal BV2	29 Aprl	14H35	6	50	10
D350 CCC	intercal BV2	29 Aprl	14H35	7	50	10
D350 DDD	intercal BV2	29 Aprl	14H35	8	50	10
D350 EEE	intercal BV2	29 Aprl	14H35	9	50	10
D350 FFF	intercal BV2	29 Aprl	14H35	10	50	10
D350 GGG	intercal BV2	29 Aprl	14H35	11	50	10
D350 HHH	intercal BV2	29 Aprl	14H35	12	50	10
D350 III	intercal BV2	29 Aprl	14H35	13	50	10
D350 JJJ	intercal BV2	29 Aprl	14H35	14	50	10
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 1	002	1 May	5H35	1	500	4
D350 2	002	1 May	5H35	2	200	4
D350 3	002	1 May	5H35	3	150	4
D350 4	002	1 May	5H35	4	100	4
D350 5	002	1 May	5H35	10	80	4
D350 6	002	1 May	5H35	12	60	4
D350 7	002	1 May	5H35	13	53	4
D350 8	002	1 May	5H35	15	35	4
D350 9	002	1 May	5H35	17	20	4
D350 10	002	1 May	5H35	19	10	4
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 1	003	2 May	9H00	1	500	4
D350 2	003	2 May	9H00	2	200	4
D350 3	003	2 May	9H00	3	150	4
D350 4	003	2 May	9H00	4	100	4
D350 5	003	2 May	9H00	5	80	4
D350 6	003	2 May	9H00	7	60	4
D350 7	003	2 May	9H00	13	53	4
D350 8	003	2 May	9H00	15	35	4
D350 9	003	2 May	9H00	17	20	4
D350 10	003	2 May	9H00	19	10	4
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 1	004	3 May	8H00	1	500	4
D350 2	004	3 May	8H00	2	200	4
D350 3	004	3 May	8H00	3	150	4
D350 4	004	3 May	8H00	4	100	4
D350 5	004	3 May	8H00	5	80	4
D350 6	004	3 May	8H00	7	60	4
D350 7	004	3 May	8H00	13	53	4
D350 8	004	3 May	8H00	15	35	4

D350 9	004	3 May	8H00	18	20	4
D350 10	004	3 May	8H00	19	10	4
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 1	005	4 May	7H30	1	500	4
D350 2	005	4 May	7H30	2	200	4
D350 3	005	4 May	7H30	3	150	4
D350 4	005	4 May	7H30	4	100	4
D350 5	005	4 May	7H30	5	80	4
D350 6	005	4 May	7H30	7	60	4
D350 7	005	4 May	7H30	9	53	4
D350 8	005	4 May	7H30	17	35	4
D350 9	005	4 May	7H30	18	20	4
D350 10	005	4 May	7H30	19	10	4
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 1	006	5 May	7H00	18	505	4
D350 3	006	5 May	7H00	8	355	4
D350 4	006	5 May	7H00	10	215	4
D350 5	006	5 May	7H00	14	155	4
D350 6	006	5 May	7H00	16	105	4
D350 7	006	5 May	7H00	18	74	4
D350 8	006	5 May	7H00	19	50	4
D350 9	006	5 May	7H00	22	24	4
D350 10	006	5 May	7H00	24	11	4
D350 eq1	006	5 May	7H00	6	1000	4
D350 eq2	006	5 May	7H00	6	1000	4
D350 eq3	006	5 May	7H00	6	1000	4
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	Volume
D350 1	007	6 May	8H00	1	500	4
D350 2	007	6 May	8H00	2	200	4
D350 3	007	6 May	8H00	3	150	4
D350 4	007	6 May	8H00	4	100	4
D350 5	007	6 May	8H00	6	80	4
D350 6	007	6 May	8H00	7	60	4
D350 7	007	6 May	8H00	9	53	4
D350 8	007	6 May	8H00	16	35	4
D350 9	007	6 May	8H00	18	20	4
D350 10	007	6 May	8H00	24	10	4
Sample	Station	Date	Time of sampling (GMT)	Niskin	Depth	
D350 1	008	7 May	7H30	1	500	4
D350 2	008	7 May	7H30	2	200	4
D350 3	008	7 May	7H30	4	150	4
D350 4	008	7 May	7H30	6	100	4
D350 5	008	7 May	7H30	8	80	4
D350 6	008	7 May	7H30	10	60	4
D350 7	008	7 May	7H30	16	53	4
D350 8	008	7 May	7H30	18	35	4
D350 9	008	7 May	7H30	23	20	4
D350 10	008	7 May	7H30	24	10	4

Further work and scientific outcomes

These results of ^{234}Th will be corrected with two "background counting" in three and six months. 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 (Chris Marsay and Fred Le Moigne)

Standing alone pumping system (SAPS) were deployed at every station during the D350. Four SAPS were deployed per cast. Two were devoted for Th derived carbon and biomineral fluxes (Fred Le Moigne) and two for trace metal work (Chris Marsay) as summarised in table 2. SAPS pumping time was set as 90min allowed a filtration volume from 500 to 2000l. 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. Trace metal SAPS filters and meshes were frozen and stored for multiple trace metal analysis by ICPMS (an acetic acid leach and a concentrated acid digest will be used to calculate labile and total trace metals).

station number	Th SAPS depths	Type of mesh	Splits
2	50	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	150	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
3	50	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	150	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
4	60	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	160	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
5	50	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	150	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
6	50	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	150	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
7	50	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	150	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
8	50	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi

		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
	150	53µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi
		1µm NITEX	1/4Th, 1/4POC, 1/4 PIC, 1/4 Bsi

station number	Trace metal SAPS depths	Type of mesh	Splits
2	50	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
3	50	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
	150	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
4	60	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
	160	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
5	50	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
	150	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
6	50	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
	150	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
7	50	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
	150	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
8	50	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
	150	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
9	15	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
	100	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements
	150	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	ICPMS multiple elements

Risk assessment issues

Due to an incident related to the position of the lead set used for for Beta counter on the ship, the risk assesment for Th work at sea has been updated. Henceforth, the set of lead will be position on the deck, underneath a bench, tying down gears used will have to be checked and secured by an NMF personel.

Trace metal distribution in the water column during D350

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Introduction

It is well established that iron availability is of great importance in regulating primary productivity in the High Nutrient Low Chlorophyll (HNLC) regions of the Southern Ocean and Northwest Pacific. However there is also evidence that phytoplankton primary production in other regions, including the high latitude North Atlantic, can periodically be subject to iron limitation. In the latter case, such conditions are most likely to be observed in summer following the spring bloom, and are thought to result from Fe:nutrient supply ratios being below those needed for optimal phytoplankton growth, and exacerbated by enhanced Fe:nutrient export ratios.

The main sources of iron to the euphotic zone of the open ocean are from atmospheric inputs and from upwelling and mixing of deeper ocean water. Whereas much of the North Atlantic receives relatively large amounts of atmospheric dust each year through inputs of Saharan dust, leading to surface water dissolved iron concentrations of up to 2nM, the atmospheric supply of iron to the high latitude (higher than 60^{o}) North Atlantic is estimated to be only 30% higher than that to the Southern Ocean, a major HNLC region.

The relative rates at which iron and macronutrients (N, P, Si) are recycled from sinking particulate material will also have an effect on whether or not iron limitation occurs. A recent study in an area with HNLC characteristics found an increasing Fe:C ratio in particulate material with depth, suggesting a preferential regeneration of carbon over iron in sinking particulate material, which would amplify any effect of low Fe:nutrient supply ratios.

The deficiency of dissolved iron appears to limit the growth of phytoplankton over several large areas of the open ocean with high nitrate and low chlorophyll (HNLC) contents (Martin and Fitzwater 1988, Martin and Gordon 1988, Martin *et al.* 1989, 1990, 1991). Based on thermodynamic calculations of speciation measurements, it is predicted that > 99% of Fe in seawater is complexed by organic ligands of unknown origin (Gledhill and Van den Berg 1994, Van den Berg 1995, Rue and Bruland 1995, Wu and Luther 1995, Rue and Bruland 1997). Laboratory and field experiments have provided evidence suggesting that some components of the natural organic Fe-binding ligand pool in seawater consist of siderophores (Haygood *et al.* 1993, Rue and Bruland 1995, Wilhelm *et al.* 1998, Hudson 1998, Hutchins *et al.* 1999).

Under iron-limiting growth conditions (< 10^{-5} mol dm^{-3}), most microorganisms use a high-affinity iron acquisition system involving the production of iron(III)-specific extracellular chelators (siderophores) for iron uptake at low concentrations. The iron-siderophore complex is actively taken up by the cell. Once inside the cell, iron is released from the complex and utilized in cellular metabolism (Neilands 1973). Siderophores (from the Greek: “iron carriers”) are low-molecular-weight organic compounds (500 - 1500 Da). The biosynthesis of siderophores is regulated by iron concentration in solution, and the stability constants for iron siderophore complex formation are of the order of 10^{30} or higher (Neilands 1995). Hence, it can be concluded that siderophores are produced by several species of

bacteria, fungi, blue-green algae, and eukaryotic organisms.Another trace metal, aluminium, does not have the same biological impact as iron. Like iron, it is a major component element of continental crust, yet only nanomolar concentrations of the dissolved metal are found in surface ocean waters. It has been shown that dissolved aluminium concentrations in open ocean surface waters can be used to estimate atmospheric dust fluxes to these areas, and thus it can serve as a tracer of atmospheric inputs of iron and other biolimiting (Zn, Co, Cu) trace elements. Comparison of Fe:Al ratios in atmospheric dust and dissolved in seawater can therefore provide information about the degree to which iron is utilised.

Furthermore, relative concentrations of aluminium to other metals (V, Pb) in aerosol samples can give information about whether the source of atmospheric inputs is crustal (e.g. dust blown from deserts and other arid regions) or industrial (burning of fossil fuels).

Methods

Sampling – Water column samples were collected at selected CTD stations along the transect using the titanium-frame CTD, which was fitted with trace metal clean 10L OTE (Ocean Technology Equipment) sampling bottles with external springs, modified for trace metal work. At these stations samples were collected at up to 14 depths. The trace metal clean OTE sample bottles were then transferred to a clean van on the back deck for sample processing. In addition, underway samples were collected along the transect using a towfish deployed off the port side of the ship. Near-surface seawater (~2 metre depth) was pumped into the clean van using a teflon diaphragm pump connected to clean oilfree compressed air compressor and samples collected every one to two hours while the ship was in transit.

Sample processing – From the titanium frame rosette bottles, both unfiltered and filtered samples were collected (for total dissolvable trace metals and dissolved trace metals respectively) in 125mL Nalgene LDPE bottles. At selected stations 250 ml of filtered water was sampled from the OTE bottles and frozen immediately for Fe ligand titrations back home at NOCS. Unfiltered samples were collected directly from the rosette bottles. Filtered samples were collected through a Sartobran 300 MF 0.2μm filter cartridge under slight positive pressure (oxygen-free N_2). Filtered (as above) and unfiltered underway samples were also collected in 125mL Nalgene LDPE bottles, using a Sartobran 300MF 0.2μm filter cartridge. All water samples were acidified to pH~2 nitric acid (Romil UpA) within twelve hours of collection. Unfiltered samples will be left for >6 months before analysis.

From all the TiCTD casts samples for phosphate, nitrate, salinity measurements were taken.

Analysis – All filtered water samples were analysed on board for dissolved Al and dissolved Fe via flow injection analysis techniques using lumogallion-Al fluorescence (FIA-FL) (Resing and Measures, 1994, Obata et al., 2000) and luminol-Fe(III) chemiluminescence (FIA-CL) (Obata and al., 1996), respectively. Replicate samples will be analysed for a range of trace metals, e.g. Fe, Mn, Co, Cd, Zn, Cu, Pb, by inductively coupled plasma mass spectrometry (ICP-MS) back at NOCS. Also at NOCS the Fe ligand titrations will be done electrochemically via competitive ligand exchange cathodic stripping voltammetry (CLE-CSV) (Croot and Johansson, 2000).

Results

Eight profiles were sampled (Fig. 1, 3 and Tab. 1) from the Ti-frame CTD and 73 underway samples (U1-U73, Fig. 2) from the tow-fish. The samples were analysed on board for DAl and DFe. Further trace metal analysis will be done back home at NOCS (Southampton). Preliminary analysis (Fig. 2) showed concentrations of 0.2-0.3 nM DFe in surface waters of the Iceland Basin, about 0.1 nM for the Irminger Basin, increasing towards Iceland and extremely high (well above 3 nM DFe) directly under the ash plume (underway samples U72, U73).

Preliminary analysis of the TiCTD depth profiles (Fig.3) showed generally increasing DFe concentrations with depth. The concentration at 20 m is gradually increasing from 0.1 nM at T003 to 0.4 nM at T011. Profile T008 shows a strong signal from the sediments. A pronounced DFe spike at 280 m is present in profile T005.

DAl concentrations will be calculated once back at the NOCS, where the necessary Matlab tool is available, although at first sight it can be said that DAl concentrations show increase with depth (up to around 2 nM) at the studied CTD stations. The underway samples have generally shown low DAl concentrations (below 0.25 nM). The samples taken under the volcanic dust plume are not yet analyzed.

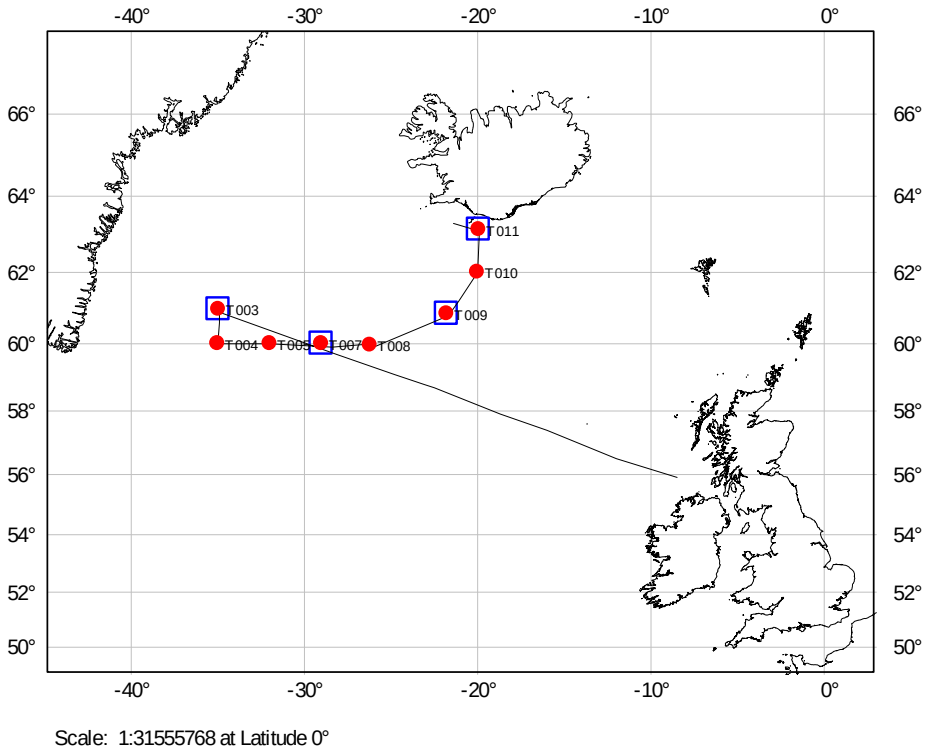

Figure 1: D350 cruise track, TiCTD casts shown in red, samples for ligand titration taken at the blue squares

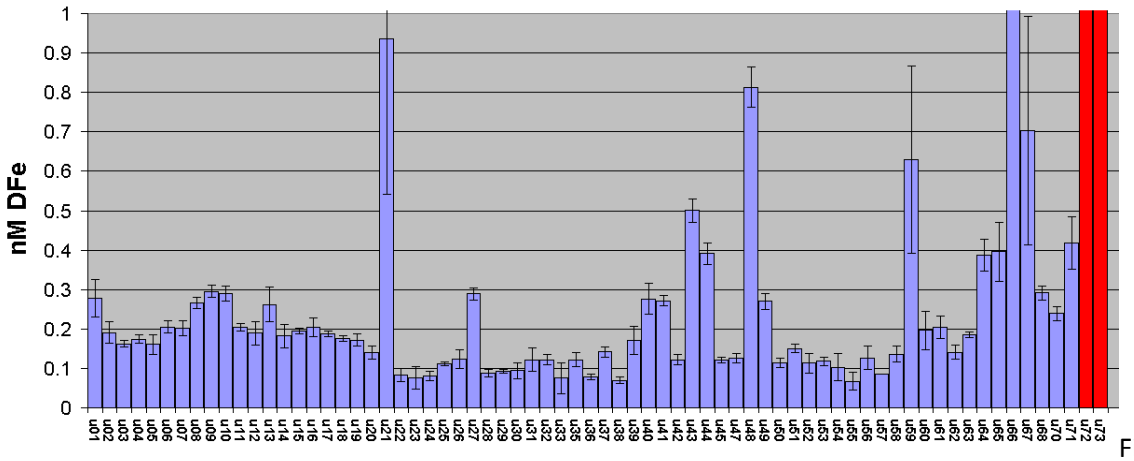

Figure 2: DFe concentrations in the underway tow fish samples (every 2h), U72 and 73 were directly affected by the ash plume (red bars)

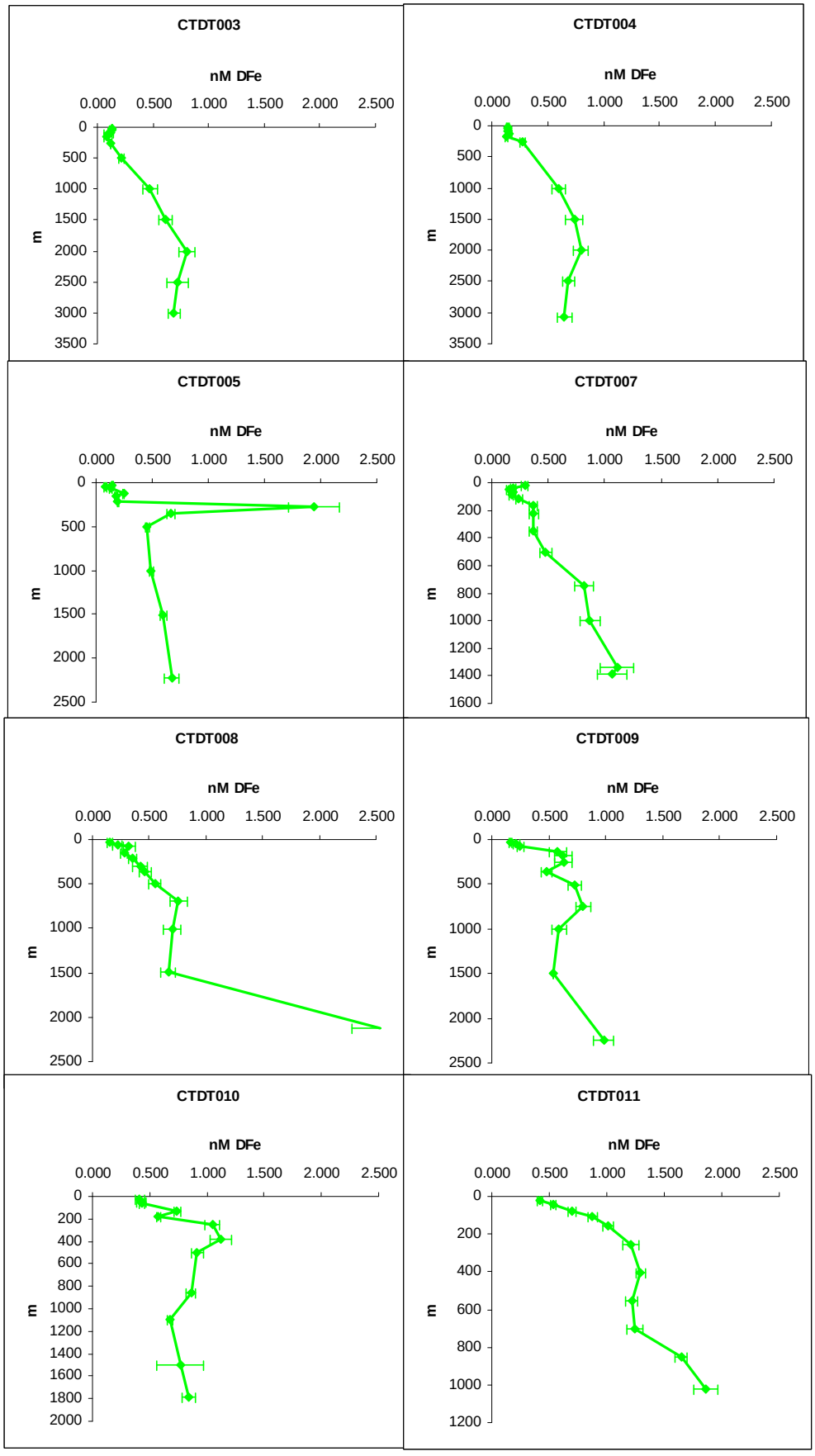

Figure 3: DFe depth profiles from TiCTD

Table 1: List of stations which were sampled for dissolved/total iron and aluminium

Date	Cast	Lat (North)	Lon (West)	Depths (m)
1/5/10	T003	60°58.300	34°56.950	20, 35, 80, 100, 150, 250, 500, 1000, 1500, 2000, 2500, 3006
2/5/10	T004	60°00.184	35°00.327	20, 35, 85, 125, 175, 250, 400, 500, 1000, 1500, 2000, 2500, 3075
3/5/10	T005	60°00.172	31°58.824	25, 45, 66, 116, 155, 215, 280, 355, 503, 1004, 1504, 2223
4/5/10	T007	59°59.889	28°59.757	23, 38, 53, 67, 84, 113, 163, 223, 353, 502, 751, 1003, 1341, 1391
5/5/10	T008	59°56.640	26°11.807	25, 55, 74, 105, 155, 215, 295, 355, 504, 700, 1002, 1495, 2128
6/5/10	T009	60°51.386	21°45.914	26, 45, 70, 130, 180, 255, 355, 505, 755, 1000, 1500, 2250
7/5/10	T010	61°59.506	20°00.411	20, 45, 65, 135, 180, 255, 380, 505, 855, 1100, 1500, 1785
8/5/10	T011	63°08.157	19°54.621	20, 45, 80, 105, 155, 255, 405, 555, 705, 850, 1020

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^{55}Fe uptake

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1. Introduction

The high latitude North Atlantic is a very dynamic area with dense cold water sinking (Watson et al. 1999) and large spring blooms (Sanders et al. 2005). The area also supports a large commercial fishing industry. Very few studies of iron have been conducted in the high latitude North Atlantic (Martin et al. 1993; Measures et al. 2008; Nielsdottir et al. 2009). During the JGOFS North Atlantic Bloom Experiment Martin et al (1991) came to the conclusion that the area was not iron limited despite increased growth and CO_2 uptake after iron addition. However, studies conducted after the NABE observed high macronutrients in the Irminger Basin (Henson et al. 2006) and a similar situation was observed in the Iceland Basin (Nielsdottir et al. 2009). During the BIB project it was proven that the postbloom in situ phytoplankton community is iron limited in the Iceland Basin (Nielsdottir et al. 2009). Whether the post-bloom iron limitation scenario is also applicable to the Irminger Basin is unclear. The pre-bloom concentration of iron and whether spring phytoplankton communities exhibit iron limitation in the North Atlantic are key questions which require further attention. The present work attempts to address these questions by measuring iron uptake using a radioactive tracer (^{55}Fe) technique. Previous studies of *in-situ* iron uptake rates are scarce; two have been conducted in the Pacific (Maldonado and Price 1999; Tortell et al. 1996) and one in the Indian sector of the Southern Ocean (Zubkov et al 2007). The main finding of these previous studies is that bacteria dominate iron uptake rates in post-bloom scenarios. The aim of the present study is to measure iron uptake rates by spring bloom communities in the Irminger Basin. Novel ^{55}Fe uptake experiments were conducted with carrier-free ^{55}Fe and no ligand additions.

2. Methods

Water was collected from the titanium CTD at 20 m. 700 mL aliquots were incubated in triplicate. A carrier free ^{55}Fe iron spike (Zubkov et al. 2007) was added at pM concentrations. Incubations were kept at surface temperature and two 4W white light sources were used to maintain light throughout the incubations.100-200 mL were filtered through 5 □m and 0.2 □m polycarbonate filters filters (Whatman) in sequence at hourly intervals. Cells were washed with either a Ti-buffer (Hudson and Morel 1989) for intracellular uptake or seawater for total adsorbed iron.

Filters were added to 20 mL counting tubes and scintillation cocktail (Goldstar) was added. Samples were counted on the onboard liquid scintillation counter (Perkin Elmer). Samples were also counted back at NOC, S with the low level counter.

In total 9 experiments were conducted.

3. Experimental Summary

The objectives and outcome of the experiments carried out on D350 are briefly described below. All experiments included intracellular and total uptake measurements.

[Exp. 1] 5 day uptake experiment, unsuccessful due to problems with filtering and insufficient tracer addition.

[Exp. 2] 5 day uptake experiment, successful.

[Exp. 3] 1-6 hour uptake experiment, unsuccessful due to insufficient tracer addition

[Exp. 4] 22 hour uptake experiment to verify quantity of tracer addition

[Exp. 5] 2-22 hour uptake experiment, successful

[Exp. 6] 4 day uptake experiment, successful

[Exp. 7] 1-22 hour uptake experiment, successful

[Exp. 8] 1-22 hour uptake experiment, successful

[Exp. 9] 1-24 hour uptake experiment, successful

4. Results and Preliminary Synthesis

<u>24 Hour Uptake Experiments</u>

(i) Intracellular iron uptake

In total four time-course uptake experiments (5, 7, 8, 9) were successfully conducted during the cruise. The time kinetics indicated that for both the >5µm and 0.2-5µm size fractions uptake was linear during the first 10-12 hours of incubation (Figure 1). Considering these kinetic constraints the quantification of uptake rates was limited to those time points falling within the linear section of the uptake curve. Generally this involved omitting a single time point (22 hours) from each incubation experiment. The % uptake rate was calculated according to equation 1:

$$R(t) = [(V_{inc} / V_{sam}) * CPM_{sam}] / CPM_{add} \quad \text{Eq 1.}$$

V_{inc} is the total volume of the incubation, V_{sam} is the volume of sub-sample filtered for a given measurement, CPM_{sam} is the sample count and CPM_{add} is the activity of the tracer addition which was determined empirically for each experiment.

The term V_{inc}/V_{sam} provides a normalisation to account for the fact that different sub-sample volumes were used for individual time points. Percent uptake rates were calculated by multiplying

the decimal fraction R(t) by 100. For each experiment, size-fraction data were pooled from different time-points and replicate incubations.

All data was normalised by expressing %uptake rate per hour, allowing statistically robust averages and errors to be compared between experiments. The %uptake rate / hr for each experiment are presented in Figure 2. Uptake rates in the >5 µm fraction were consistently larger than those observed in the <5-0.2µm fraction

The uptake rates measured in the >5µm fraction can be reliably approximated to eukaryotic cells (> 5µm). Although the uptake rates in the <5-0.2 µm fraction are probably mediated primarily by heterotrophic prokaryotes (e.g. Zubkov et al. 2007), important contributions from smaller eukaryotes and photosynthetic prokaryotes cannot be ruled out. The uptake rates in the <5-0.2 µm fraction should therefore be treated as an upper estimate by heterotrophic prokaryotic populations. Taking these considerations into account our data strongly contrast with previous studies which indicate iron uptake is dominated by bacteria (Maldonado and Price 1999; Tortell et al. 1996; Zubkov et al. 2007). These previous studies have addressed iron uptake in post-bloom and/or HNLC scenarios. The present study is among the first to examine the phytoplankton/bacterial competition for iron under bloom conditions and documents for the first time the dominance of iron uptake by eukaryotic populations.

The %uptake rate in the >5µm fraction was strongly correlated with chlorophyll measurements (Figure 3a), suggesting total phytoplankton biomass rather than community structure to be the key factor. The %uptake in the <5-0.2µm size fraction was also correlated with chlorophyll (Figure 3b) although it was a weaker function than the 5 µm size fraction. If we consider Chl a as a proxy for phytoplankton DOC exudation, this suggests that C-limitation of bacterial metabolism during the spring bloom period may limit their iron uptake capacity. In the summer-cruise which follows we will perform similar measurements in post-bloom conditions. Under this scenario we expect to see that iron uptake rates will be dominated by the <5-0.2 µm fraction in line with previous studies.

(ii) Total uptake (including extracellular absorption)

Three of the four 24 hour uptake experiments (7, 8, 9) were examined for total iron uptake (Figure 3). For all three experiments the total uptake was at least 1 order of magnitude greater than intracellular uptake for both the >5 and <5-0.2 µm size fractions. The time kinetics displayed only slight positive trends for both size fractions, showing a significant majority of the total uptake had occurred within the first hour of incubation (Figure 3). The results indicate that >90% of the iron associated with eukaryotic (5µm) and small eukaryotic/heterotrophic prokaryotic cells is adsorbed to extracellular surfaces. Although difficult to verify, the time kinetics suggest that these adsorptive processes occur predominantly through passive rather than active mechanisms. The results show that biological particles scavange a significant amount of dissolved iron from seawater. Over the time course (<10 hours) of our experiments there is no detectable decrease in total uptake suggesting a rapid equilibrium (<1 hr) exists between extracellular dissolved iron concentrations and available biological surface area. Interestingly two out of the three total uptake experiments (7 and 8) displayed larger extracellular adsorption in the 5 µm fraction.

4-5 Day Uptake Experiments

The 4-5 day uptake experiments were conducted to examine the intracellular storage. Preliminary results showed that the difference between the two size fractions diminished with time and that around day 3 the intracellular uptake reached a plateau (Figure 5).

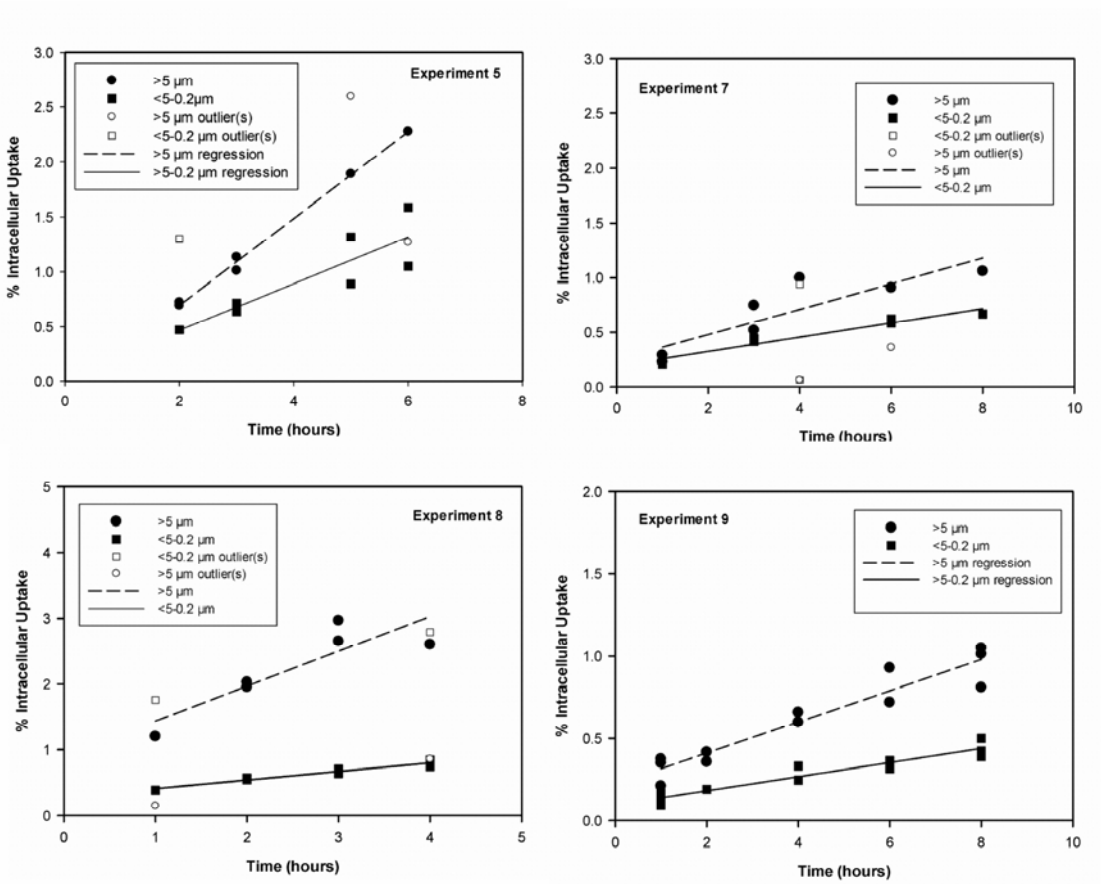

Figure 1 Time-series experiments of ^{55}Fe intracellular uptake. Data is expressed as the percent uptake of the total amount of tracer added to the incubations. Open symbols are outliers excluded from statistical analysis.

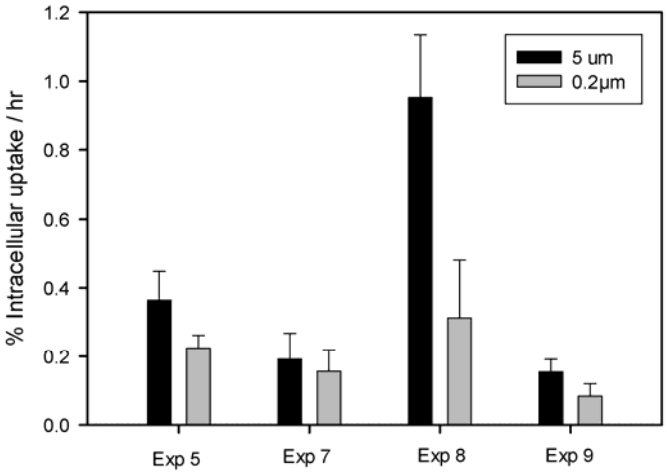

Figure 2 Comparison of intracellular uptake rates

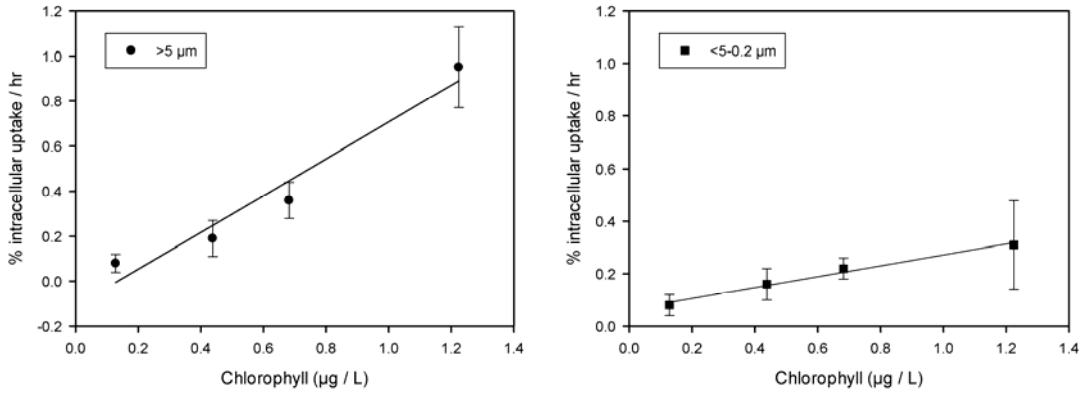

Figure 3 Correlation between total chlorophyll and intracellular uptake rates of different size fractions.

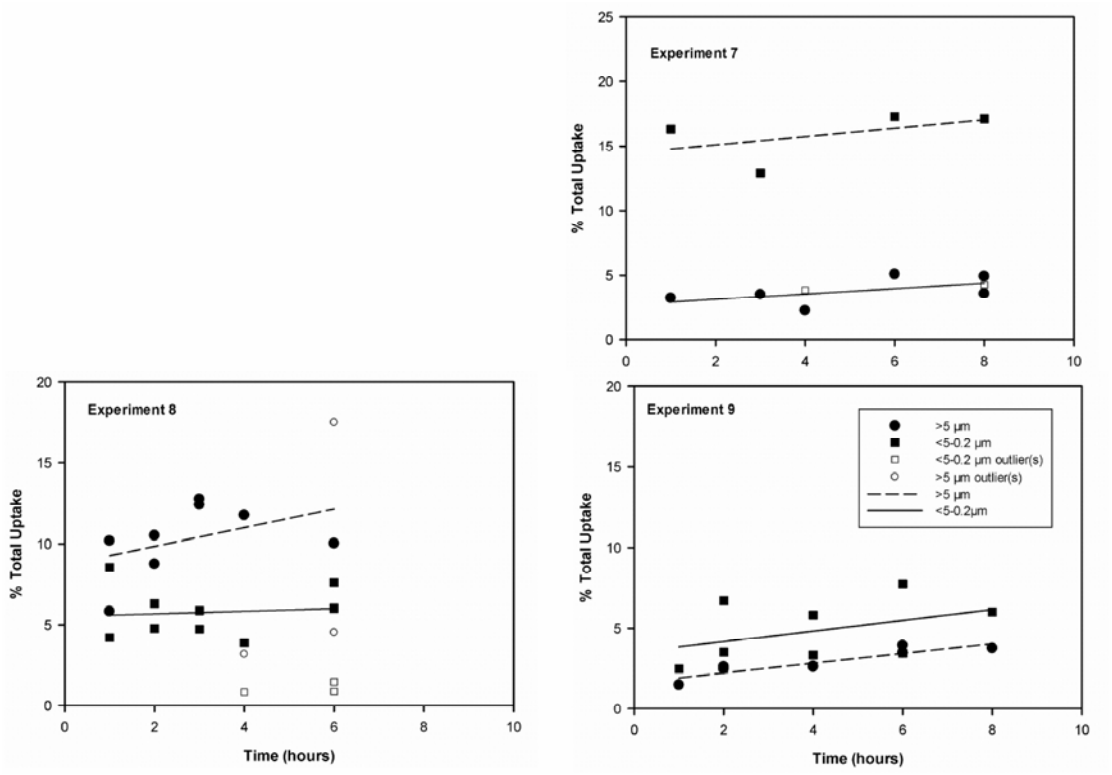

Figure 4 Time-series experiments of ^{55}Fe total uptake. Data is expressed as the percent uptake of the total amount of tracer added to the incubations. Open symbols are outliers excluded from statistical analysis.

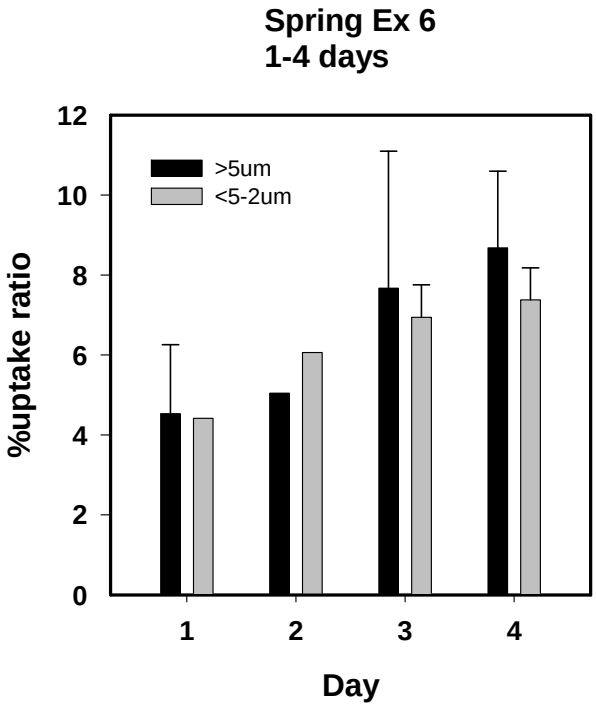

Figure 5 4 day time series experiment of intracellular uptake of ^{55}Fe.

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Primary production, calcification and nitrate uptake rates by phytoplankton.

Mike Lucas, University of Cape Town, South Africa (mikelucasuct@gmail.com)

I. 24 hour +Fe / -Fe and ρNO_3 incubations with Tommy Ryan-Keogh

For these experiments, water was collected from the towed fish, and in the trace metal clean container, decanted into 6 x 1.2L polycarbonate bottles. All six were spiked with 100µl trace metal cleaned $^{15}N\text{-}NO_3$ (1 µmol N/100µl stock). This assumes an enrichment of ~10% of ambient NO_3 assuming an *in situ* concentration of ~10 µmol l^{-1}. Of the six, three had DFe additions of 2nM, while the remaining 3 received no DFe additions. At time zero (To), initial parameters of chl-a, nutrients, FRRf and flow cytometry were measured. At T24, NO_3, FRRf and ρNO_3 were taken.

Date	JD	Exp ID	NO_3	FRRf	ρNO_3
3 May		MIL 1	✓	✓	✓
5 May		MIL 2	✓	✓	✓
6 May		MIL 3	✓	✓	✓
7 May		MIL 4	✓	✓	✓
8 May		MIL 5	✓	✓	✓

Bottles: 3 replicates +Fe (bottles 1-3); 3 replicates –Fe (bottles 4-6).
Spikes: 100µl $15N\text{-}NO_3$

II. Under the Ash Cloud sampling and ρNO_3 (8 May 2010)

Taking advantage of our passage beneath the ash cloud on 8 May, measurements of NO3, FRRf, size-fractionated chl-a, SEM and ρNO_3 were measured at short time intervals. ρNO_3 incubations using the surface NT supply (1.2L) were inoculated with 100µl $^{15}N\text{-}NO_3$ (1 µmol N/100µl stock) and incubated for 24 hours.

Sample	GMT	NO_3	FRRf	Tot chl	>5 chl	SEM (v)	ρNO_3 (v)
MIL 1	15:54	✓	0.54	✓	✓	500	8555
MIL 2	16:00	✓	0.55	✓	✓	500	890
MIL 3	16:11	✓	0.52	✓	✓	500	940
MIL 4	16:25	✓	0.54	✓	✓	500	935
MIL 5	16:42	✓	0.54	✓	✓	500	830
MIL 6	17:06	✓	0.50	✓	✓	500	820
MIL 7	19:12	✓	0.41	✓	✓	500	570

Bottles: 1 x surface incubation only. **Spikes:** 100µl $15N\text{-}NO_3$ + 200µl 13C

III. 15N + 13C Incubations for PP, Calcification and ρNO_3

Seawater samples for these experiments were collected from the shallow pre-dawn stainless cast (CTDs). Typically eight x 1.2l samples were taken from 5 light level determined depths (4 from 55%, 1 from each 33%, 14%, 4.5%, and 1%). These samples were then spiked with ~104 µmol C l^{-1} ^{13}C-stock (200µl) to provide a DIC concentration of ~5%; assuming an ambient DIC concentration of ~2.0836 mmol C l^{-1}. In addition, a spike of 15N-NO3 (1 µmol N/100µl stock) of ^{15}N (100µl) was added to the bottles (~10% of ambient NO_3 assuming an *in situ* concentration of ~10 µmol l^{-1}). Bottles were incubated for 24 hours in incubators at light levels corresponding to the collection depth. The samples were then filtered onto 25mm diameter pre-ashed GF/F filters and frozen at -20°C. Of the 4 surface bottles filtered, 2 filters will be acid fumed to remove PIC and 2 will not be fumed. The difference in 13C fixation between the two sets of surface bottles ought to represent calcification. The remaining bottles at lower light depths are not to be fumed, so that profiles of primary production can be established.

Date	**JD**	**Stn No**	**Exp ID**	**NO_3**	**Chl-a**	**$\rho NO_3 + \rho^{13}C$**
29-Apr		UW 17	Surface	✓	✓	✓
30-Apr		UW 39	Surface	✓	✓	✓
1 May		Stn 2	CTDs 3	✓	✓	✓
2 May		Stn 3	CTDs 5	✓	✓	✓
3 May		Stn 4	CTDs 6	✓	✓	✓
4 May		Stn 4	CTDs 8	✓	✓	✓
5 May		Stn 6	CTDs 11	✓	✓	✓
6 May		Stn 7	CTDs 13	✓	✓	✓
7 May		Stn 8	CTDs 15	✓	✓	✓
8 May		Stn 9	CTDs 17	✓	✓	✓

Bottles: CTD's - 4 x replicate surface incubations + 4 single bottles at different light depths below – see D350 report by Martine Couapel.
Spikes: 100µl 15N-NO_3 + 200µl 13C

Mike Lucas

10 August 2010

Phytoplankton community structure, physiology, and molecular profiles.

Thomas Ryan-Keogh, Tom Bibby, and Mark Moore (University of Southampton, National Oceanography Centre, UK)

A series of experiments and samples were taken during D350 to characterise the community structure of phytoplankton, the physiology of the phytoplankton and the molecular composition of the phytoplankton community. As well as sampling the whole in situ community a series of on deck manipulation experiments were conducted in which iron (Fe) as added to determine the response of the phytoplankton to this potentially limiting nutrient.

Flowcytometry (FCM), Photosynthetic physiology (FRRf) and Molecular Analysis were all performed in parallel on samples collected for vertical profiles (CTD casts), Underway analysis and bioassay incubation experiments.

The following is a summary of the methods of collection and analysis, the locations and times of sampling and preliminary results.

Phytoplankton physiology (Fast Repetition Rate Fluorometry (FRRf)

FRRf is a well developed technique for assessing the physiology of phytoplankton communities in ocean systems. The instrument measured a suite of parameters pertaining to the photosynthetic physiology of the entire community, Including the photosynthetic energy transfer efficiency (Fv/Fm) which is a proxy of potential productivity of the system and an indictor of nutrient limitation. The FRRf technique measures in real time, in situ and at high sensitivity.

(1) Underway Fast Repetition Rate fluorometry (FRRf). Thomas Ryan-Keogh, Mark Moore

A Chelsea Scientific instruments FAST*track*^{TM} Fast Repetition Rate fluorometer (FRRf) (Kolber et al. 1998) was connected to the ships non-toxic supply within the bottle annex in order to assess and monitor the physiological state of Photosystem II (PSII) within the surface phytoplankton population of the study area. Saturation of variable chlorophyll fluorescence was performed using manfactures instructions using the below settings. –

6. Acq = 0
7. Flash seq/Acq = 16
8. Sat flash/seq = 100
9. Sat flash duration = 4
A. Sat interflash delay = 0
B. Relax flash – Enabled
C. Relax flash/seq = 20
D. Relax flash/seq = 4
E. Relax flash int. = 61
F. Sleeptime – 30000
G. Gain – autoranging – 1
H. Analyse out – disabled
I. Verbose – enabled

The data were stored internally on the instrument and were downloaded between 24 hours and 48 hours intervals throughout D350. The Instrument optics were cleaned whilst the download operation was being carried out and before the protocol was set to run again, blank measurements were performed to calibrate the results.

A total of 9 files were collected (Table 1). Data were then analysed using custom software in a Matlab™ environment. The number of sequences averaged the files to record results every 15 minutes.

Much of the signal was dominated by marked diel variability in the parameters that can be measured by an FRRf deployed in this mode (F_v'/F_m' and σ_{PSII}'), the data also indicated the presence of a dawn maxima signal before quenching began.

	UW1	UW2	UW3	UW4	UW5	UW6	UW7	UW8	UW9
Start Time (GMT)	11:00:00 28/04/10	08:37:00 29/04/10	08:45:00 30/04/10	13:34:00 01/05/10	15:02:00 02/05/10	17:01:30 03/05/10	15:32:00 04/05/10	16:08:00 05/05/10	15:40:00 07/05/10
Special Notes		Cleaned + blank run	Cleaned	Cleaned	Cleanedd	Cleaned + blank run	Cleaned *Forgot to plug back into system, flow restored at 18:45:00	Cleaned	*System left running while ship sampled under volcanic ash cloud

Table 2 Underway FRRf files collected during D350.

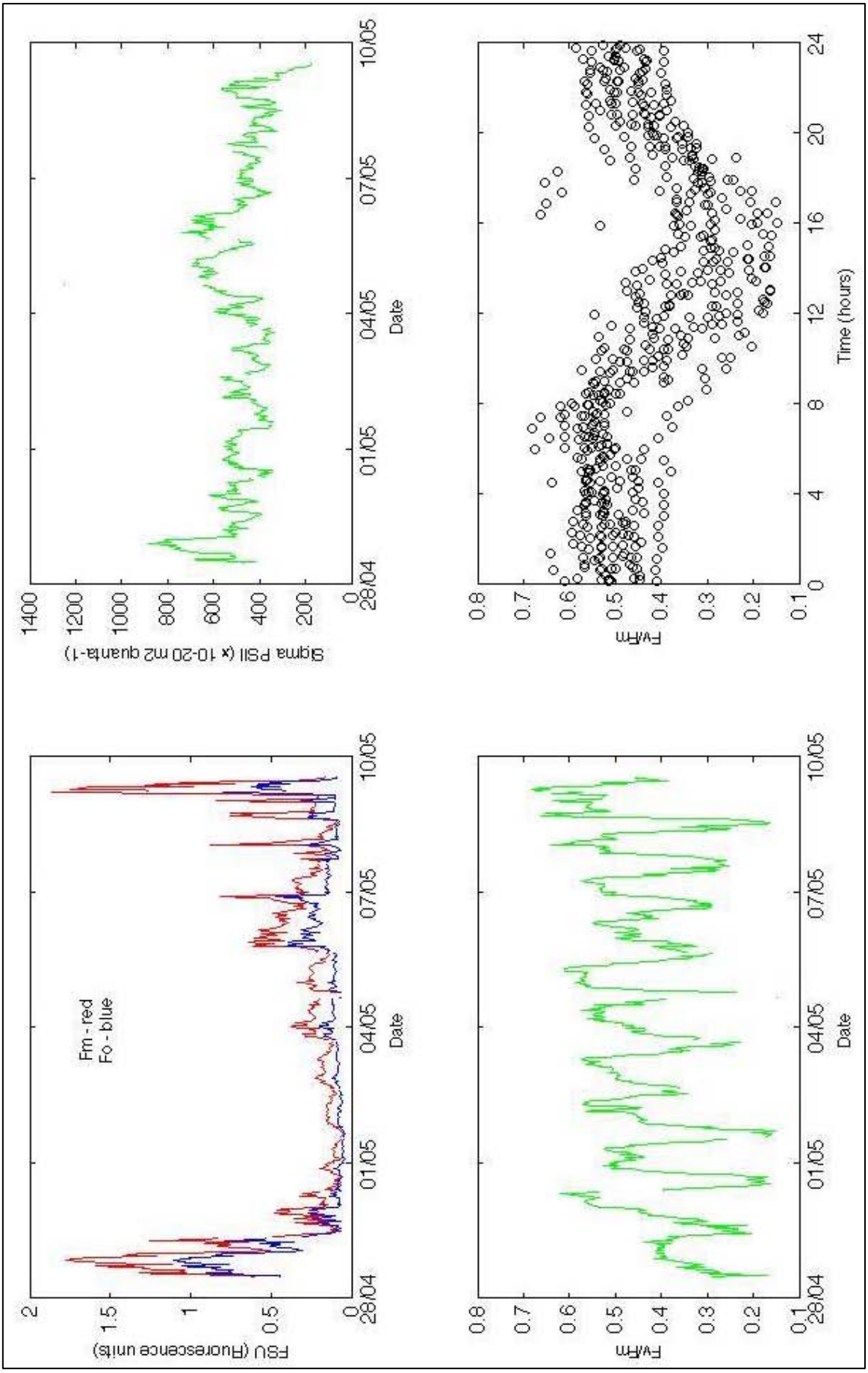


Figure 2 Preliminary data from the Underway FRRf.

(2) Vertical profiles FRRF

In order to assess the profile of phytoplankton physiology discrete samples were collected from the pre-dawn CTD casts during D350. Six depths in the euphotic zone were sampled in parallel with nutrient and flow-cytometry measurements. 500ml samples were collected in dark bottles and stored at sea-surface temperatures for @30 min prior to analyses. Each sample was run three times through both A Chelsea Scientific instruments FAST*track*™ Fast Repetition Rate fluorometer (FRRf) and the updated FAST*track*™ II. Each sample was run in parallel with a blank measurement (0.2um filtered samples were used as blank measurements).

Phytoplankton species community

Flow cytometry samples were collected to analyse the community composition of the photosynthetic species <5um throughout the cruise. Samples were collected from (a) surface waters every 24 hours (0400 GMT) and (b) six-depths throughout the euphotic zone in parallel with FRRF, Nutrient and HPLC measurements. 1.8ml samples are collected which are fixed using 1% PFA. Fixing takes place in the dark at 4 deg C for > 2 hours. Samples are then snap frozen in liquid nitrogen and stored at minus 80 deg C for shipping and analysis at NOCS using the flow-cytometry facility.

Molecular analysis of phytoplankton communities.

In order to quantify the abundance of key photosynthetic proteins (PSII, PSI and RUBISCO) in the community samples were collected on GFF filters and snap frozen in liquid nitrogen prior to storage at minus 80 degC and shipping/analysis in the molecular facilities in NOCS. From each pre-dawn CTD a total of 4x4L were filtered onto four separate 25 mm GFF filters for each of the surface (~5m,) and DCM samples. Filtration time was kept less then 1 hour.

Table 2 – Summary of discrete samples from CTD profiles

Cruise	Date	JDAY	Station	CTD	Lat (N)	Long (W)	Depth	Niskin	FRRF	FCM	Protein
D350	01-May-05	121	2	2	69 58	34 59	100	5	1	1	1
D350	01-May-05	121	2	2	69 58	34 59	80	11	2	2	
D350	01-May-05	121	2	2	69 58	34 59	53	14	3	3	
D350	01-May-05	121	2	2	69 58	34 59	35	16	4	4	
D350	01-May-05	121	2	2	69 58	34 59	20	18	5	5	
D350	01-May-05	121	2	2	69 58	34 59	10	20	6	6	2
D350	02-May-10	122	3	5	60 01.397	034 57.614	85	6	1	1	
D350	02-May-10	122	3	5	60 01.397	034 57.614	50	8	2	2	1
D350	02-May-10	122	3	5	60 01.397	034 57.614	53	14	3	3	
D350	02-May-10	122	3	5	60 01.397	034 57.614	30	16	4	4	
D350	02-May-10	122	3	5	60 01.397	034 57.614	10	18	5	5	
D350	02-May-10	122	3	5	60 01.397	034 57.614	5	20	6	6	2

D350	03-May-10	123	4	7	60 00.172	31 58.824	80	5	1	1	
D350	03-May-10	123	4	7	60 00.172	31 58.824	60	7	2	2	1
D350	03-May-10	123	4	7	60 00.172	31 58.824	53	13	3	3	
D350	03-May-10	123	4	7	60 00.172	31 58.824	35	16	4	4	
D350	03-May-10	123	4	7	60 00.172	31 58.824	30	18	5	5	
D350	03-May-10	123	4	7	60 00.172	31 58.824	7	19	6	6	2
D350	04-May-10	124	5	8	59 59.4123	28 59.7338	80	6	1	1	
D350	04-May-10	124	5	8	59 59.4123	28 59.7338	60	8	2	2	
D350	04-May-10	124	5	8	59 59.4123	28 59.7338	53	12	3	3	1
D350	04-May-10	124	5	8	59 59.4123	28 59.7338	35	16	4	4	
D350	04-May-10	124	5	8	59 59.4123	28 59.7338	20	18	5	5	
D350	04-May-10	124	5	8	59 59.4123	28 59.7338	7	23	6	6	2
D350	05-May-10	125	6	10	59 56.009	026 07.081	80	5	1	1	
D350	05-May-10	125	6	10	59 56.009	026 07.081	60	7	2	2	
D350	05-May-10	125	6	10	59 56.009	026 07.081	40	9	3	3	
D350	05-May-10	125	6	10	59 56.009	026 07.081	30	16	4	4	1
D350	05-May-10	125	6	10	59 56.009	026 07.081	20	17	5	5	
D350	05-May-10	125	6	10	59 56.009	026 07.081	7	19	6	6	2
D350	06-May-10	126	7	13	60 50.779	021 45.065	80	6	1	1	
D350	06-May-10	126	7	13	60 50.779	021 45.065	60	8	2	2	
D350	06-May-10	126	7	13	60 50.779	021 45.065	40	10	3	3	
D350	06-May-10	126	7	13	60 50.779	021 45.065	30	12	4	4	1
D350	06-May-10	126	7	13	60 50.779	021 45.065	20	18	5	5	
D350	06-May-10	126	7	13	60 50.779	021 45.065	5	22	6	6	2
D350	07-May-10	127	8	15	61 59.948	019 59.959	120	3	1	1	
D350	07-May-10	127	8	15	61 59.948	019 59.959	90	6	2	2	
D350	07-May-10	127	8	15	61 59.948	019 59.959	60	7	3	3	
D350	07-May-10	127	8	15	61 59.948	019 59.959	40	9	4	4	1
D350	07-May-10	127	8	15	61 59.948	019 59.959	30	15	5	5	
D350	07-May-10	127	8	15	61 59.948	019 59.959	5	19	6	6	2

Nutrient addition bioassay experiments.

Nutrient addition bioassay experiments were performed using a highly replicated design to investigate the effect of iron availability on phytoplankton physiology, growth and nutrient drawdown over different timescales. Two different experimental designs were run simultaneously: 24 hr incubations and 5-day incubations. The short-term bioassays were primarial run to analyse the rapid changes in physiology upon iron addition while the long-term bioassays were to assess changes in community physiology and structure, as well as additional parameters such as nutrient drawdown.

As with all work involving the manipulation of iron availability, strict controls were put into place to avoid the contamination of incubation containers and sampled water. Incubations for the 24 hr bioassays were performed in 1 L polycarbonate bottles and the incubations for the 5-day bioassays were performed in 4.5 L polycarbonate bottles. All incubations were passed through a rigorous cleaning process involving a Decon wash and soaking in 50% HCl for 1 week, followed by rinsing then storage with acidified Milli-Q prior to sailing.

The original intention was to collect water for the 24 hr bioassays from the Fe fish and to collect water for the 5-day bioassays from the Titanium CTD, however due to constraints upon water budgets on the Titanium CTD and to make results directly comparable between both bioassays, all incubation water was collected using the Fe fish. In order to ensure there was no contamination of water, the tow-fish was only used when the ship was sailing at a minimum of 5 knots either towards the station or doing a track around the station. Due to the possibility of sampling between different communities, initial samples were taken before the bottles were filled, when all bottles were half filled and finally when all the bottles had been filled to capacity. The average time between the primary initial and final initial sample for the 24 hr bioassays was 10 minutes while on the 5-day bioassays it reached 30-40 minutes. This longer sampling time lead to variability within the initial samples and possible problems when interpreting the responses of iron manipulation. On leg D354 water budgets may have to be adjusted to allow for water to be used for the 5-day bioassays to try and correct some of this variability.

The experimental design of the 24 hr bioassays involved the incubation of 6 bottles, 2 sets of 3 bottles, one for iron addition at a concentration of 2.0 nM and one for controls. A mistake during the set up of the first bioassay lead to the addition of iron at a concentration of only 0.2 nM, however a response was still measured. The experimental design was reconfigured to allow for iron additions at 2 different concentrations (2.0 nM and 0.2 nM), increasing the total bottle number to 9. After the 6th bioassay it was noticed that there was very little difference between the controls and the iron addition bottles, due to a possible contamination. To confirm whether this was a true, a second set of controls was run for the 7th bioassay, the results then showed a difference between both sets of controls and the iron additions. For the final bioassay the second set of controls was not run. Samples were taken for chlorophyll, flow Cytometry and FRRf; measured on both a Chelsea FAST*track*^{TM} FRRf and a FAST*act*^{TM} FRRf laboratory system.

The experimental design of the 5-day bioassays involved the incubation of 16 bottles, 2 sets of 8 bottles, one set for iron addition at a concentration of 0.2 nM and one set for controls. 3 bottles from each set were broken down after 24 hrs to collect samples for protein analysis. Two bottles from each sets were sub-sampled at time points of 24 hrs, 72 hrs and at the end. The remaining three replicates from each set were not sampled until the end time-point to check whether sub-sampling had led to contamination of the time-series measurements. Such a strategy also provides more robust statistics and a large volume of water for an additional suite of final measurements.

Sampling of the time-series was routinely performed for chlorophyll, flow Cytometry, macronutrient concentrations (N, P and Si) and PSII characteristics. Additional sampling of the time-series bottles was performed at 24 hrs to collect samples for Heme concentrations. The final sampling of the bottles consisted of further protein samples, Heme samples, Lugols

iodine for phytoplankton counts and HPLC samples. In order to assess contamination, samples were also collected for analysis of total dissolvable iron (TDFe) at the end of experiments.

	Expt 1	Expt 2	Expt 3	Expt 4	Expt 5	Expt 6	Expt 7	Expt 8
Sampling location								
Sampling method	Fe fish	Fe fish	Fe fish	Fe fish	Fe fish	Fe fish	Fe fish	Fe fish
Bottle set	1	1	1	1	1	1	1	1
Start Point	29/04/10 04:28:00 GMT	30/04/10 04:42:00 GMT	02/05/10 02:47:00 GMT	03/05/10 02:11:00 GMT	05/05/10 02:07:00 GMT	06/05/10 02:11:00 GMT	07/05/10 05:31:00 GMT	08/05/10 04:36:00 GMT
End Point	30/04/10 04:00:00 GMT	01/05/10 00:30:00 GMT	03/05/10 01:00:00 GMT	04/05/10 02:00:00 GMT	06/05/10 01:00:00 GMT	07/05/10 04:30:00 GMT	08/05/10 03:30:00 GMT	09/05/10 05:30:00 GMT
Initial Chlorophyll ($\mu g.L^{-1}$)	1.8520	0.9696	0.6110	0.8641				

Table 3 Sampling methods, locations, times and initial chlorophyll concentrations for 24 hour bioassay experiments.

A total of 8 experiments were performed lasting 24 hours during D350. A complete list of experiments along with sampling locations and initial conditions is provided in Table 2.

	Expt 1	Expt 2
Sampling location		
Sampling method	Fe fish	Fe fish
Bottle set	1	2
Start Point	01/05/10 02:00:00 GMT	04/05/10 03:00:00 GMT
End Point	06/05/10 03:30:00 GMT	09/05/10 05:30:00 GMT
Initial Chlorophyll ($\mu g.L^{-1}$)	0.4396	1.2074

Table 4 Sampling methods, locations, times and initial chlorophyll concentrations for 5 day bioassay experiments.

A total of 2 experiments were performed lasting 5-days during D350. A complete list of experiments along with sampling locations and initial conditions is provided in Table 3.

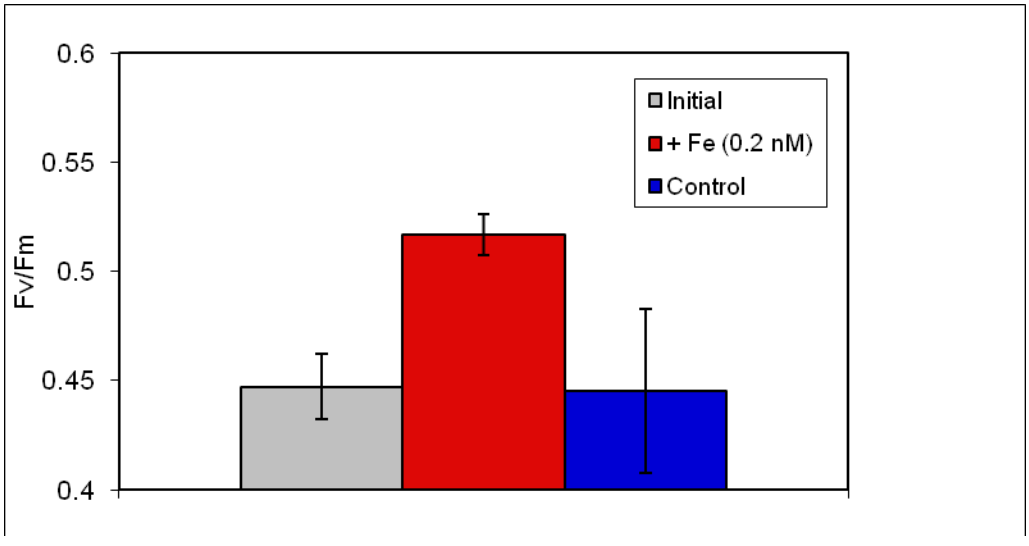


Figure 3 24 Hr Bioassay Experiment No. 1 FRRf results.
FRRf results.

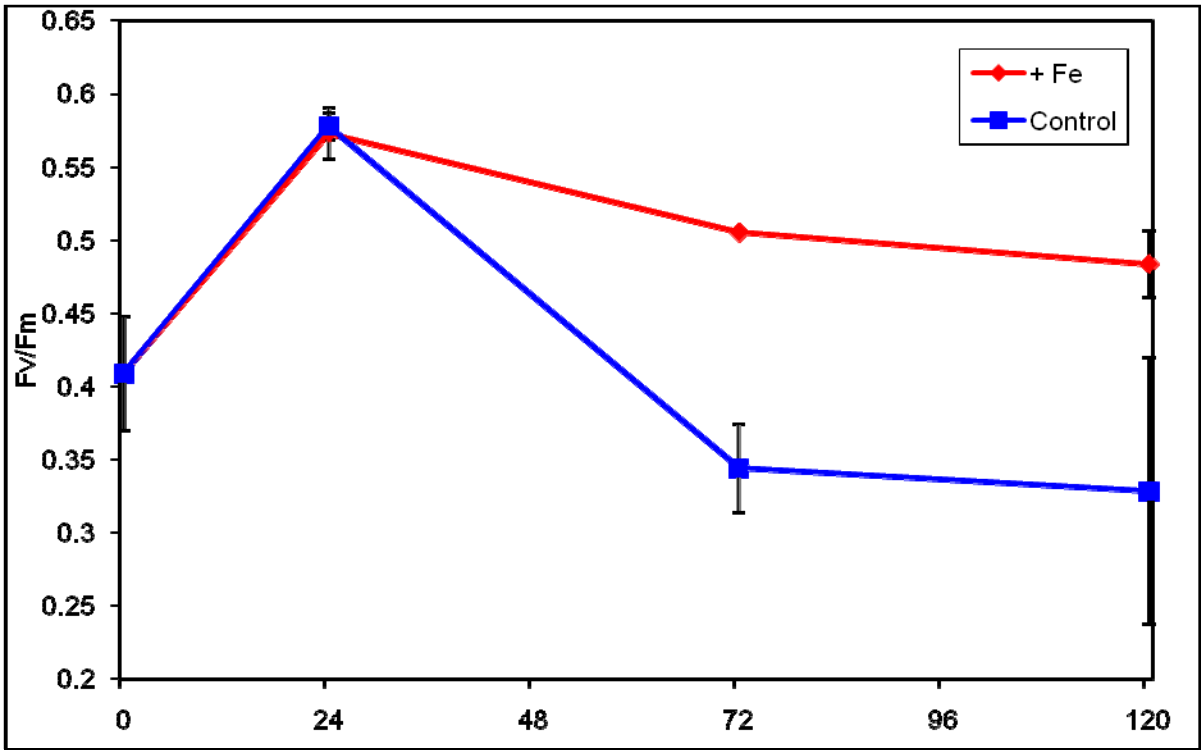


Figure 4 5-day Bioassay Experiment No. 1 FRRf Results.

Dissolved Oxygen Analysis

Mark Stinchcombe, (University of Southampton, National Oceanography Centre, UK) (mcs102@noc.soton.ac.uk), *Debbie Hembury, University of Southampton, UK*(d.hembury@noc.soton.ac.uk)

Cruise objectives:

The objectives of the dissolved oxygen analysis were to provide a calibration data set for the oxygen sensor mounted on the frame of the CTD for cruise D350 to the Irminger Basin in the North Atlantic. For this, a Winkler titration with amperometric end point detection was performed on a number of water samples drawn from the Niskin bottles mounted on the CTD frame.

Methods:

Dissolved oxygen samples were only taken from the deep stainless steel CTD casts and they were the first samples to be drawn from the Niskin bottles. Due to the relative small number of oxygen samples that would be taken it was decided that twenty four samples would be drawn from each cast sampled. These were split across all depths. Some casts had twelve Niskin bottles sampled but duplicated and some had all twenty four Niskin bottles sampled once. On these casts, depths were often doubled up so there were still at least two samples from each depth. On one station we duplicated every bottle on the rosette giving us a total of 48 samples from the one cast. The samples were drawn through short pieces of silicon tubing into clear, pre-calibrated, wide-necked glass bottles. The temperature of the water sample at the time of sampling was measured using an electronic thermometer probe. The temperature would be used to calculate any temperature dependant changes in the sample bottle volumes. Each of the samples was fixed immediately using 1ml of manganese chloride and 1ml of alkaline iodide. The samples were shaken thoroughly and left to settle for approximately thirty minutes before being shaken again. The samples were then left for at least an hour before analysis but all were analysed within twelve hours.

The samples were analysed in the chemistry laboratory following the procedure outlined in Holley and Hydes (1995). The samples were acidified using 1ml of sulphuric acid immediately before titration and stirred using a magnetic stirrer. The Winkler whole bottle titration method with amperometric endpoint detection with equipment supplied by Metrohm UK Ltd was used to determine the oxygen concentration.

At the start of the cruise, on 30th April 2010, the normality of the sodium thiosulphate titrant was checked using a potassium iodate standard. This was only done the once on this cruise as it was so short. Sodium thiosulphate standardisation was carried out by adding the reagents in reverse order with a long stir in between and then 10ml of a 0.01N

potassium iodate solution. The sample was then titrated and the volume of sodium thiosulphate required was noted. This was repeated six times until five measurements agreed to within 0.002ml of each other. The average of the best five titrations was used to calculate the amount of sodium thiosulphate. This standardisation was then used in the calculation of the final dissolved oxygen calculation. The volumes of sodium thiosulphate required in this standardisation process can be seen in Table 1.

Reading	**1**	**2**	**3**	**4**	**5**	**6**
Volume	1.0135ml	1.0120ml	1.0120ml	1.0170ml	1.0140ml	1.0125ml
Volumes used in average	1.0135ml	1.0120ml	1.0120ml		1.0140ml	1.0125ml
Average	**1.0128ml**					

Table 1: Sodium thiosulphate standardisation was performed at the start of the cruise. Six measurements were carried out until five were within 0.002ml of each other. These were then averaged and this average was used in the calculation of the final oxygen concentration.

A blank was also carried out at the start of the cruise, on the 30th April 2010, to account for the oxygen in the reagents. The reagents were added in reverse order, as for the sodium thiosulphate standardisation, and then 1ml of the potassium iodate standard was added. This was titrated and the volume of sodium thiosulphate required was noted. 1ml was again added to the same sample and it was titrated again. This was repeated. The average of the second two volumes of sodium thiosulphate was subtracted from the first volume. This whole process was repeated four times in total until three blanks agreed within 0.002ml of each other. The average blank was taken of the best three values and used in the calculation of the final dissolved oxygen calculation. The volumes of sodium thiosulphate required in this blanking process can be seen in Table 2.

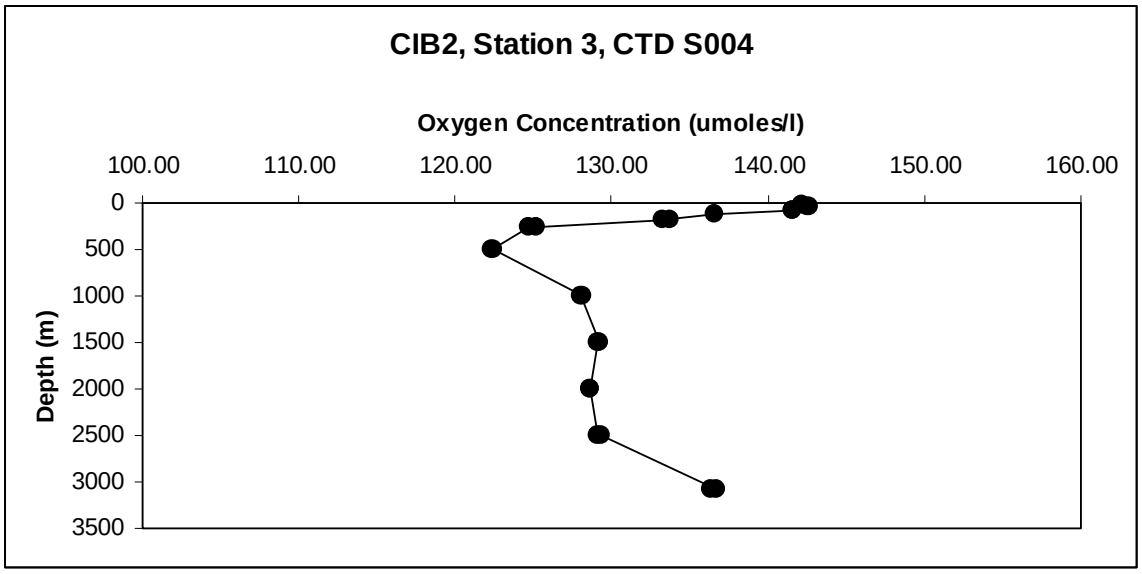
Reading	**A**	**B**	**C**	**A – (Average of B and C)**	**Average of 2, 3 & 4**
1	0.1020ml	0.1015ml	0.1010ml	0.0007ml	0.0033ml
2	0.1035ml	0.1000ml	0.1010ml	0.0030ml	
3	0.1050ml	0.1005ml	0.1010ml	0.0042ml	
4	0.1035ml	0.1005ml	0.1010ml	0.0027ml	

Table 2: A blank determination was performed at the start of the cruise. Four measurements were carried out until three were within 0.002ml of each other. These were then averaged and this average was used in the calculation of the final oxygen concentration.

Preliminary Data

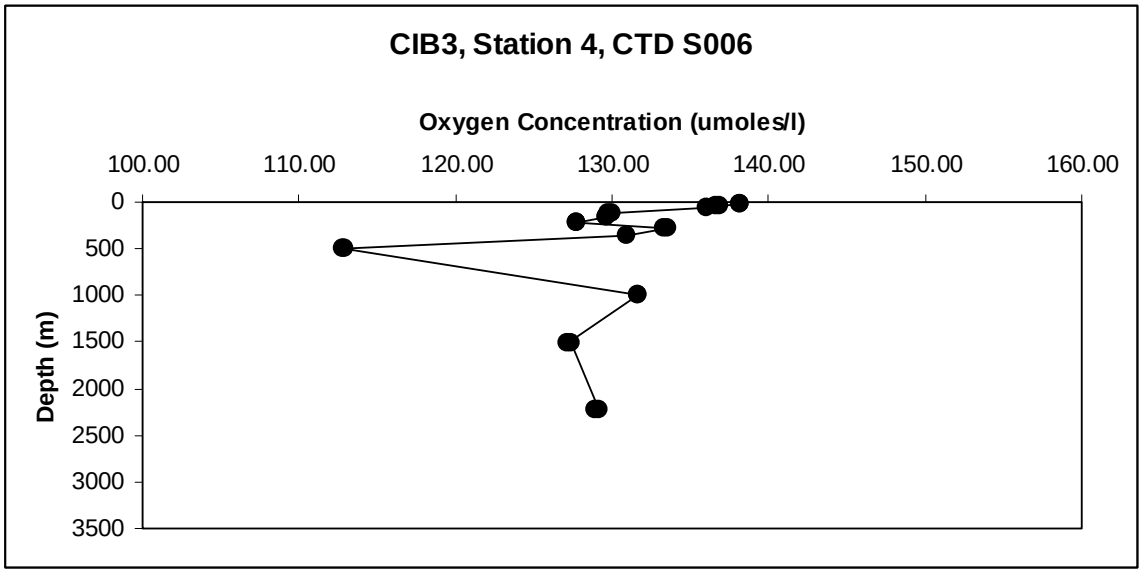
The data was collected and analysed on board. Some final quality controlling of the data set will be undertaken back at the NOC but preliminary profiles can be shown. Figures 1, 2 and 3 show the profiles of oxygen concentration from the deep stainless CTD casts.

a)

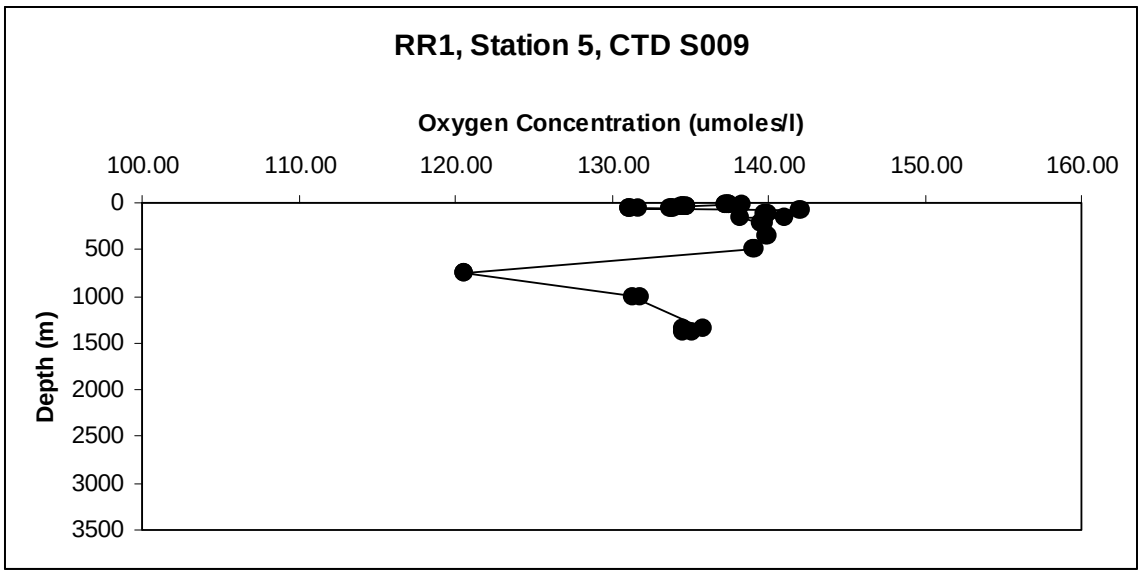


b)

Figure 1: Oxygen profiles from a) Station 2, CTD S003 and b) Station 3, CTD S004. The y axis will remain the same on all these plots to get an idea of scale.

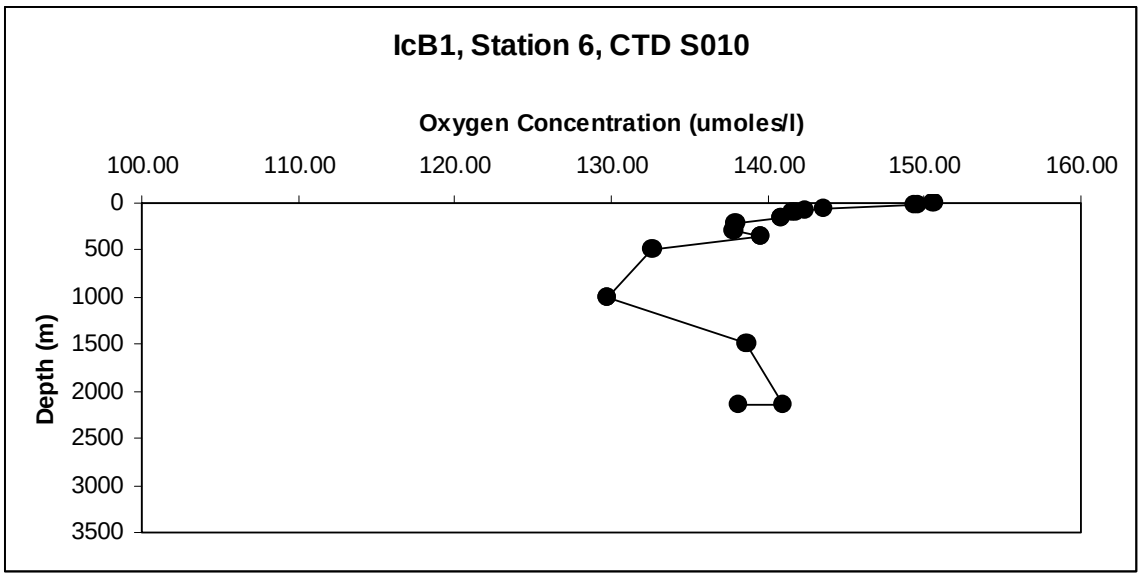


a)

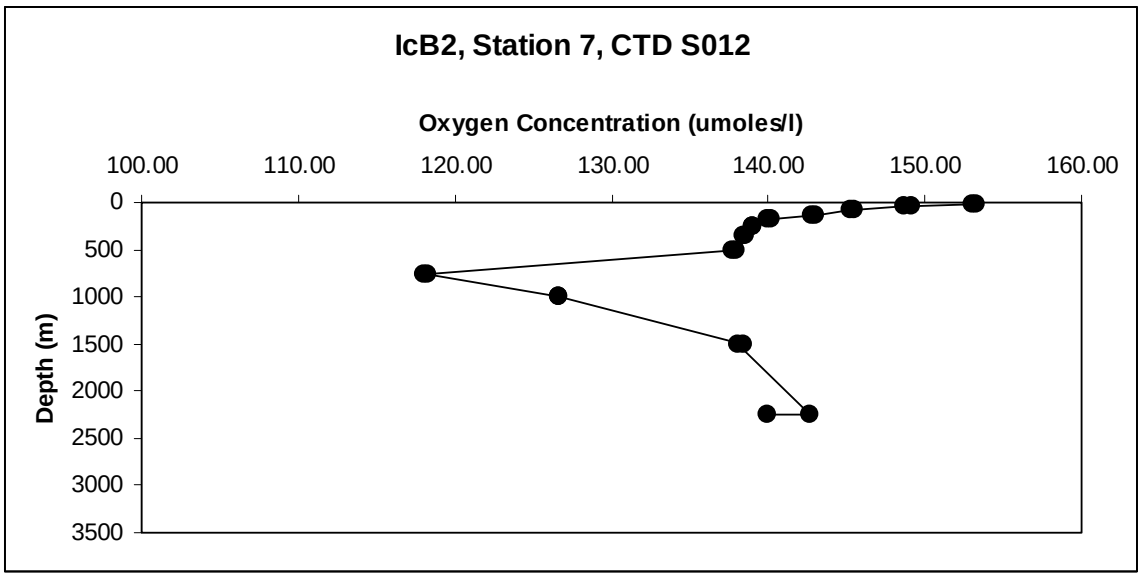


b)

Figure 2: Oxygen profiles from a) Station 4, CTD S006 and b) Station 5, CTD S009. The y axis will remain the same on all these plots to get an idea of scale.



a)



b)

Figure 3: Oxygen profiles from a) Station 6, CTD S010 and b) Station 7, CTD S012. The y axis will remain the same on all these plots to get an idea of scale.

Duplicate sample analysis

During D350 we took a large number of duplicate samples. We could use these to calculate the precision of our results. The duplicate values were separated and the difference between the values was calculated (Figure 4). Using the average difference between duplicates it was calculated that the precision of the data was good within ±0.4umoles/l.

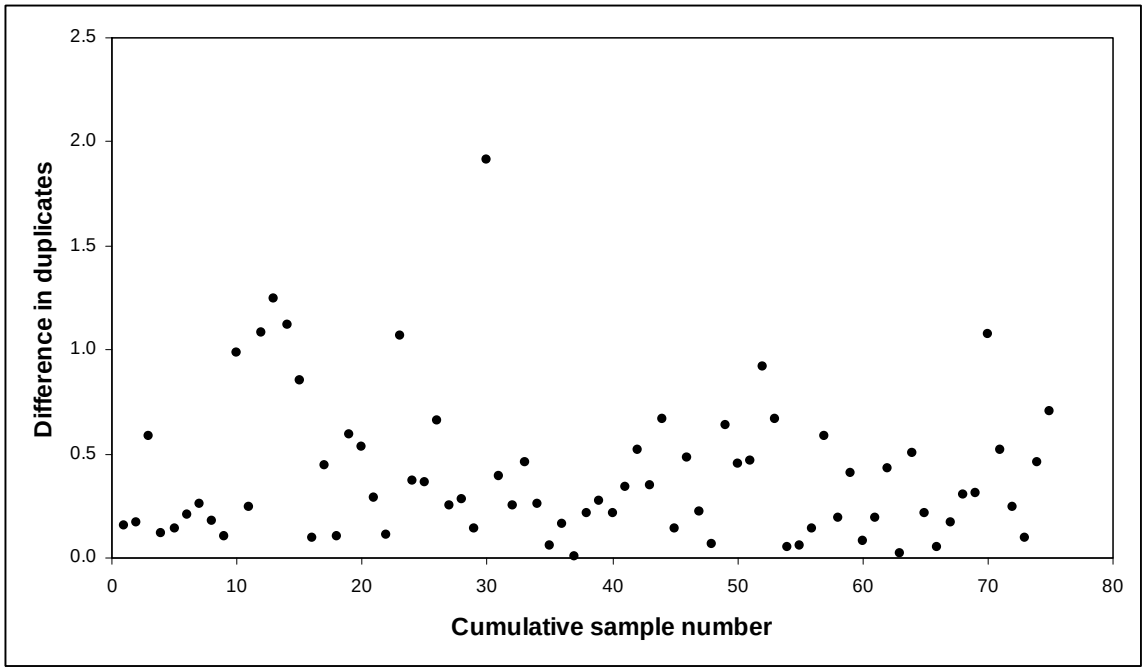


Figure 4: This plot shows the difference between duplicates for each set of duplicate samples taken on the cruise. The average difference was 0.4 therefore we can consider the dissolved oxygen data for D350 to have a precision of ±0.4umoles/l.

Oxygen sensor calibration

The oxygen data will be used to calibrate the oxygen sensor on the CTD. The preliminary data was collated onto a spreadsheet and passed over to Stuart Painter who ran a regression of sensor data vs bottle data (Figure 5). The regression showed a very good fit with r^2 of 0.9965. The equation of this line will be used to correct the oxygen data from the CTD sensor. A first attempt at this has been done. Figure 6 shows the residual values before and after the regression has been applied. The residual value is the difference between the oxygen concentration from the Winkler titrations and the sensor on the CTD. If we now compare what this does to a single profile (Figure 7) we can see that the sensor data now looks very good compared to the bottle data from the Winkler titrations.

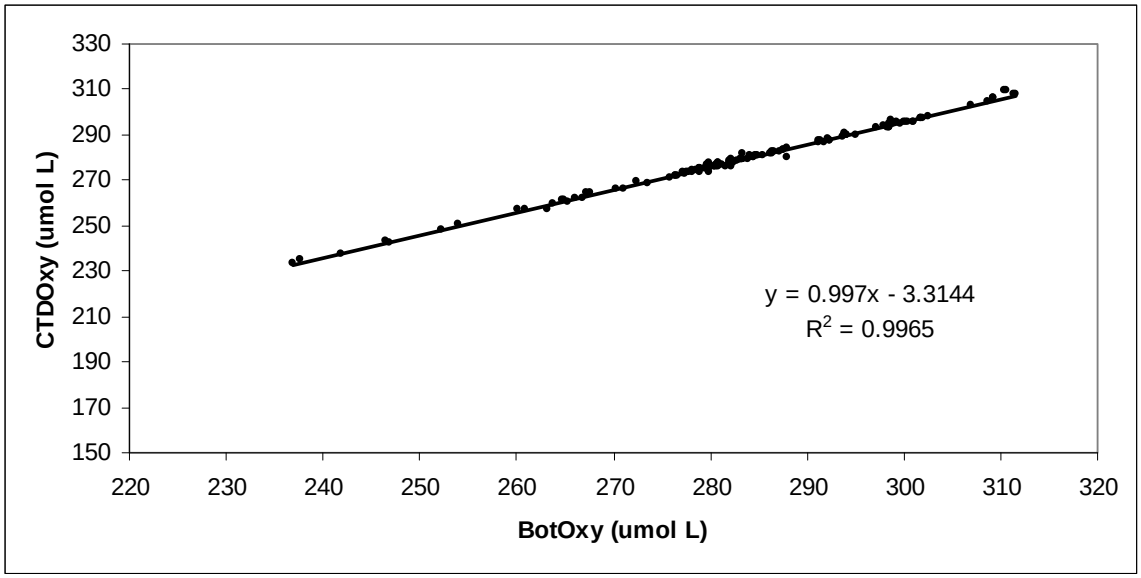


Figure 5: Bottle oxygen vs sensor oxygen concentrations. The fit is very good with an r^2 of 0.9965. This plot was from the preliminary bottle oxygen data and also included all the outliers so this fit could be improved once quality controlling of the data is complete.

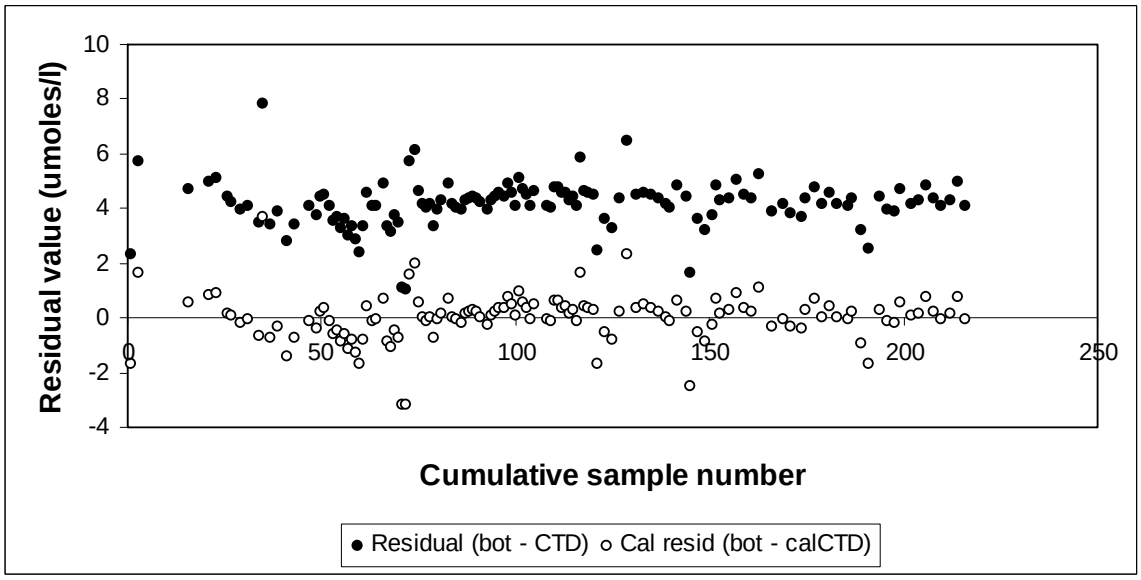


Figure 6: Residuals before and after the regression was applied. Before the regression has been applied there is a residual value of approximately 4umoles/l but this is reduced to almost 0 once the regression has been applied.

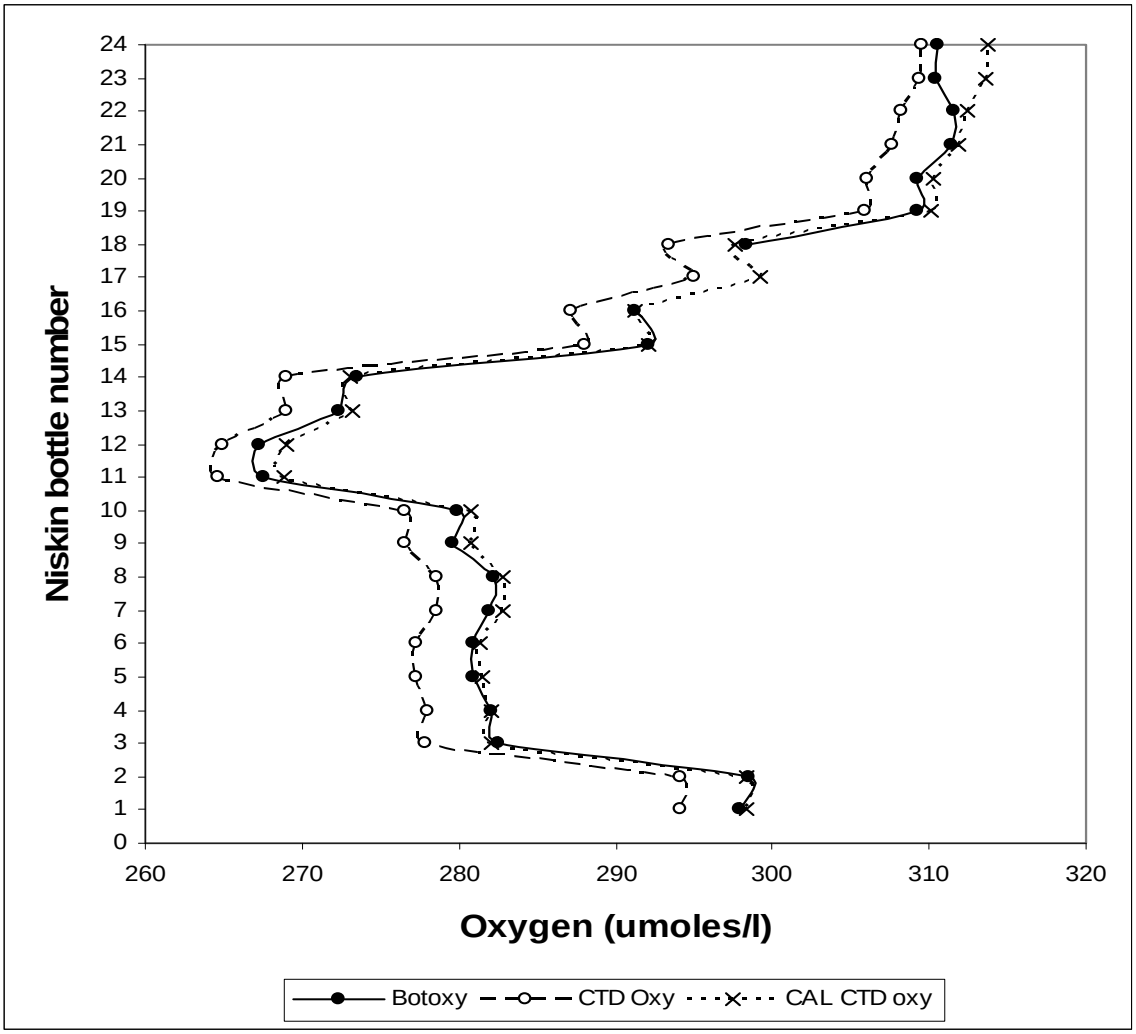


Figure 7: This profile from Station 4, Cast S006, shows the difference between the sensor oxygen value (CTD Oxy) and the bottle oxygen derived from the Winkler titrations (Botoxy). Overlaid on this is the recalculation of the sensor oxygen (CAL CTD oxy) made using the regression from figure 5. The sensor and bottle oxygen profiles now show a very good fit.

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Inorganic nutrient analysis

Mark Stinchcombe, (University of Southampton, National Oceanography Centre, UK) (mcs102@noc.soton.ac.uk), Debbie Hembury(University of Southampton, UK) (d.hembury@noc.soton.ac.uk)

Cruise Objectives:

Our objective on cruise D350 to the Irminger Basin in the North Atlantic was to measure the concentrations of the inorganic nutrients: TON, silicate and phosphate using segmented flow analysis. Unfortunately, due to issues discussed later, water samples were only analysed for TON and silicate and samples were frozen for phosphate analysis back at the NOC.

Method:

Analysis for micro-molar concentrations of nitrate and nitrite (hereinafter Total Oxidised Nitrogen or TON), and silicate was undertaken on a Skalar San+ segmented flow autoanalyser following methods described by Kirkwood (1996). Samples were drawn from Niskin bottles on the CTD into 25ml sterilin coulter counter vials and kept refrigerated at approximately 4^{o}C until analysis, which commenced within twelve hours. Overall 13(?) runs were undertaken with 1000(?) samples being analysed in total. This brakes down as 500(?) CTD samples, 150(?) underway samples and 350(?) samples from on board experiments and were being analysed for other cruise participants. An artificial seawater matrix (ASW) of 40g/litre sodium chloride was used as the intersample wash and standard matrix. The nutrient free status of this solution was checked by running Ocean Scientific International (OSI) low nutrient seawater (LNS) on every run. A single set of mixed standards were made up by diluting 5mM solutions made from weighed dried salts in 1litre of ASW into plastic 1litre volumetric flasks that had been cleaned by soaking in MQ water. The concentration of the standards was tested on every run by analysing diluted OSI certified standards, one low concentration sample (1.1µM for TON and silicate) and one high concentration sample (32.0µM for TON and silicate). Data processing was undertaken using Skalar proprietary software and was done within 24 hours of the run being finished. The wash time and sample time were 90 seconds; the lines were washed daily with 10% Decon.

Performance of the Analyser:

Where do we begin! In the last 12 to 18 months a few issues have been raised which finally culminated in big problems for the nutrient analysis on D350. Firstly there was a problem with getting the most recent software (FlowAccess v2.0.20) to communicate properly with the autoanalyser interface when installed on a few of the new laptops we have bought recently. Three laptops were bought for the nutrient chemistry group so they could

work away from the office but also to act as a back up to run the autoanalyser if the computer running it failed on a cruise. As a few of the older laptops have become obsolete, we needed to use one of these laptops first on a series of cruises last year, JC30, JC31 and JC32. It became apparent that although the software would install ok, there was no communication between the laptop and the autoanalyser.

Just before D350 was a 24^{o}N cruise (D346), and the issue with the laptops arose again when the two analysers were set up. They could not both be used due to this problem. After D346 I investigated this problem further. I installed an older version of the software (FlowAccess v1.3.11) but this did not work. I contacted Skalar and also Toshiba about this issue and it was found to be that the software can't cope with machines that have a dual/multi core processor. Nothing we tried would get it to work on the Toshiba laptops.

Because of this I trawled through our collection of machines and managed to find two. One was a laptop with a broken screen which has been known to crash at times so was a good spare machine but could not be replied upon as the main computer. The other was a desktop. The older version of the software was loaded onto both machines and seemed to work. On the ship at the start of D350 the desktop was used as our main computer and all seemed well. This was until a proper analysis run was tried. It appeared that we could not change any of the method settings. A solution was found though. Remembering an old trick from previous problems we were able to set up the methods as we wanted them on the broken screen laptop and then copy the relevant set up file onto a USB stick and move it onto the desktop. This didn't work to start with but when we borrowed a laptop from Sebastian Steigenberger we got it to work. Now we were ready to run inorganic nutrient samples on a borrowed laptop with software we had to copy across from another machine.

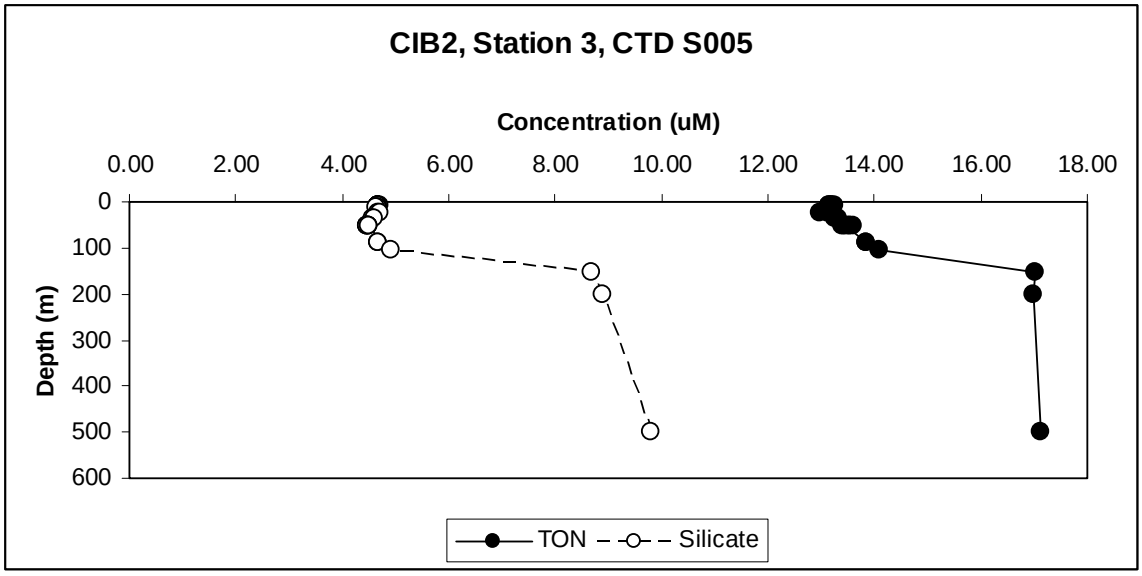
When an actual analysis was done it appeared as though there was a lot of noise on the TON baseline. We made up the standards as normal and got a standard run underway but the noise levels were huge. After a large amount of cleaning and a new cadmium column the noise levels hadn't dropped. The next step was to change the reagents but there was still no change. The system was left with just MQ water running through it but still the noise remained so it seemed the problem lay elsewhere. The flow cell was switched to the spare slot on detector one but still no change. Finally I swapped the flow cell with one from detector two, i.e. running the TON flow cell through detector two and the phosphate flow cell through detector one. There was now no noise on the TON line but a lot of noise on the phosphate line. The problem was found, detector one was faulty. There was no spare on board so the solution was to run TON and silicate samples on board and freeze samples to be analysed for phosphate back at the NOC. We were finally ready to run samples for real, after five days of problems.

After this the TON and silicate lines behaved very well and we got some very good data from them. There was no drifting on either line and the noise levels were extremely small. The software also behaved itself and even allowed us to change the methods again when we changed the standard range halfway through the cruise. It crashed once but a restart of the laptop fixed that. Peak shapes were also very smooth and the standards didn't degrade as checked by the OSI standards. The LNS showed a little TON contamination in the ASW but this was accounted for with a blanking run. This contamination was in the salt itself as each fresh batch of ASW made up had the same result against the LNS.

Preliminary Data

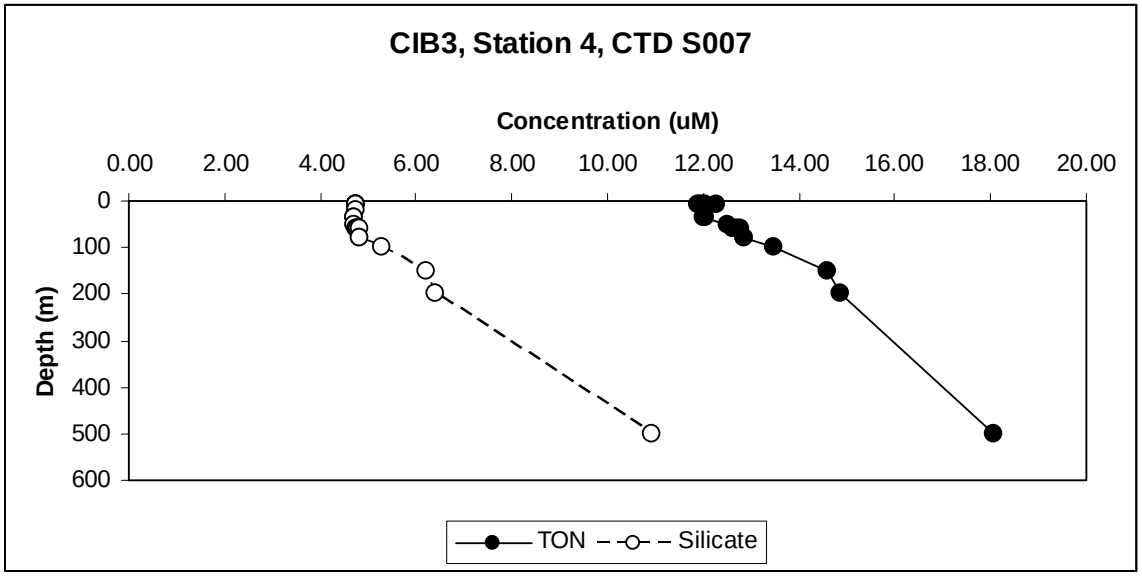
Data was being processed during the cruise and the final quality checking of this data will take place back at the NOC over the coming months. There is only preliminary data to show here. The quality control process though is not expected to significantly change these numbers. Below are a number of profiles from the shallow stainless steel CTD casts.

a)

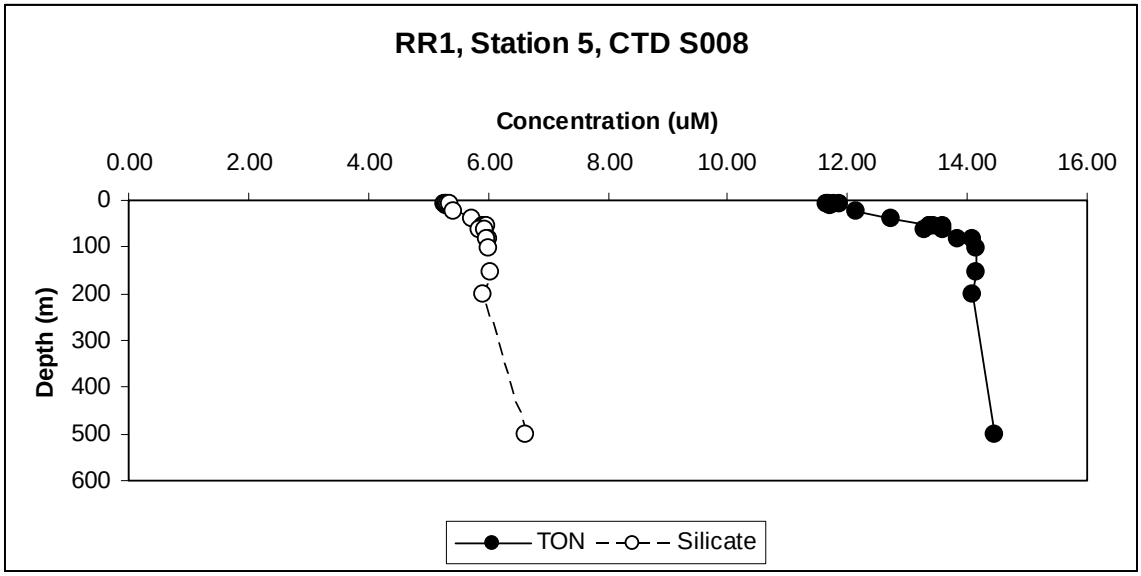


b)

Figure 1: TON and silicate profiles from the first two shallow stainless steel CTD casts. a) shows the profile from CTD S002 and a pronounced intrusion of a possible different water mass or a mixing event can be seen at 100m. b) shows the profile from CTD S005 with the nutracline at 125m.



a)



b)

Figure 2: TON and silicate profiles from the third and fourth shallow stainless steel CTD casts. a) shows the profile from CTD S007 with the nutricline at 100m. b) shows the profile from CTD S008 with a relatively well mixed water column.

Isotopic silica sampling

Mark Stinchcombe (mcs102@noc.soton.ac.uk), Alex Poulton (aljp@noc.soton.ac.uk) (University of Southampton, National Oceanography Centre, UK), Mike Lucas (michael.lucas@uct.za.ac) University of Cape Town, South Africa

Cruise Objectives:

Our objective on cruise D350 to the Irminger Basin in the North Atlantic was to take samples for ^{29}Si analysis. These samples would be analysed using a mass spectrometry protocol that is still in development and so were taken for method development. This work included samples of particulate isotopic silica, dissolved isotopic silica, ^{29}Si uptake rate experiments and ^{29}Si kinetic experiments.

Method:

There were four different types of sample taken for the ^{29}Si work. All of the methods will be described here. No analysis of samples was done on board as these have to be run on a mass spectrometer. They will be sent off to Ben Reynolds (Eidgenössische Technische Hochschule, Switserland) for analysis.

Particulate isotopic silica (PISi):

Six depths were generally sampled for PISi, all in the top 150m and all off the shallow stainless steel CTD cast (Table 1). Water was drawn into a large, 10litre, carboy through silicon tubing where it was homogenised before being sampled for numerous biological parameters. For PISi, between 750ml and 2,000ml were filtered under low vacuum onto a 0.8µm polycarbonate filter. The filter was then stored, sample up, on a petrislide and then frozen at -20^{o}C.

Dissolved isotopic silica (DISi):

Water for DISi was drawn from the same homogenised carboy as the PISi samples and from the same six depths (Table 1). Water was poured into a 60ml syringe. The sample was then passed through a pre-activated (with 1ml 100% ethanol) 0.2µm PTFE membrane filter. The 50ml of filtrate was then collected in a centrifuge tube. The tube was sealed with parafilm and placed in the fridge at 4^{o}C.

^{29}Si uptake experiments:

Uptake experiments were performed 5 times during the cruise and all used water taken from the shallow stainless steel CTD casts (Table 1). The water was taken from five depths that roughly represented certain light levels. These were 55%, 33%, 14%, 4.5% and 1% of surface photosynthetically active radiation (PAR). The water samples were drawn from the same homogenised carboys as described above and put into rinsed 1,000ml Nalgenes. These held 1,200ml of sample when filled to the neck.

Once filled, the water samples were inoculated with a ^{29}Si spike solution. The spike was 1ml of approximately 900 times the specific activity and was made up in an artificial seawater solution. After the spiking the bottles were gently inverted to mix them.

The Nalgene bottles were then incubated for 24 hours in on-deck incubators which had been covered in filters so that the light inside was approximately equivalent to the light level the water was taken from. The following day the whole water sample was filtered onto a 0.8µm polycarbonate filter under light vacuum. The filter was then placed, sample side up, onto a petrislide and stored at -20^{o}C.

Date	Station	Cast	Number of DISi	Number of PISi	Number of ^{29}Si
01.05.2010		S002	5	6	5
03.05.2010		S007	5	6	5
04.05.2010		S008	4	5	5
04.05.2010		S009	2	N/A	N/A
05.05.2010		S011	6	6	5
06.05.2010		S013	6	5	5
07.05.2010		S015	6	6	4
08.05.2010			6	6	5

^{29}Si kinetic experiments:

Kinetic experiments were performed three times over the cruise and were only done when uptake experiments weren't taking place. The water for the kinetic experiments was always drawn from the underway non-toxic supply but this did coincide with the main sampling stations (Table 2). Water was drawn into a large, 10litre carboy and homogenised. Seven Nalgene bottles were then filled up to the neck, 1,200ml. One of these bottles was left as an ambient control. The remaining six were then inoculated with a ^{29}Si spike (approximately 300 times the specific activity) which had been diluted in an artificial seawater matrix. The water samples were inoculated with different amounts of the spike solution. The six additions were 1µmole, 5µmoles, 10µmoles, 15µmoles, 20µmoles and 25 µmoles. This was worked out as 1ml of spike solution for every µmole required, i.e. 1ml for 1 µmole, 5ml for 5µmoles, etc.

The Nalgene bottles were then incubated for 24 hours in an on-deck incubators which had been covered in filters so that the light inside was approximately equivalent to the light level the water was taken from, in this case 55%. The following day the whole water sample was filtered onto a 0.8µm polycarbonate filter under light vacuum. The filter was then placed, sample side up, onto a petrislide and stored at -20^{o}C.

Kinetic	Date	Station	Nearest CTD in	UW sample for kinetic
1		003	S005	06:27 GMT
2	04.05.2010	005	S008	06:32 GMT
3		007	S013	08:00 GMT

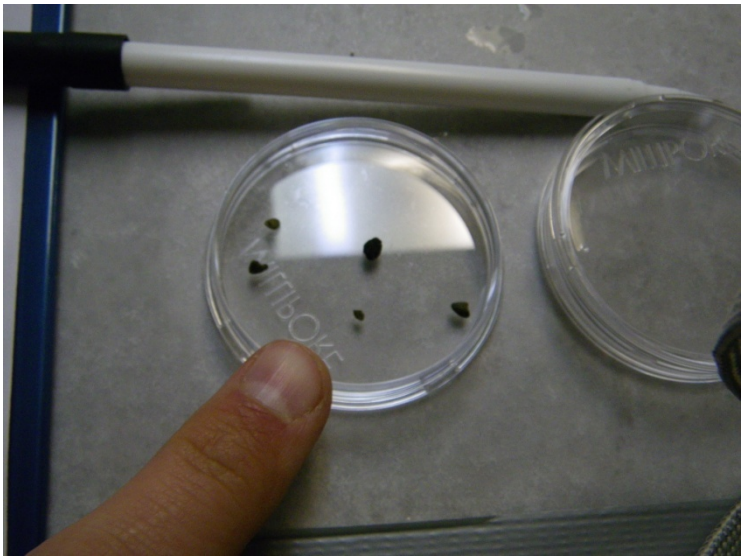
Table 2: The dates, stations and approximate stainless steel casts where the water for the ^{29}Si kinetic experiments was drawn from. The water for these samples was taken from the underway non-toxic supply.

D350 Sampling the volcanic plume from Eyjafjallajökull

Michael Cassidy and Debbie Henbury (University of Southampton, UK)

Samples were taken throughout D350 for Pb isotope analysis. Whilst underway, two 1 Litre seawater samples (one 0.2µm polycarbonate filtered, one unfiltered) were taken from the towed fish water supply in the clean lab to analyse for Pb isotopes. This was conducted to assess the volcanic input into the ocean. Pb isotopes serve as a good determinant for the presence of fresh volcanic ash from Eyjafjallajökull, due to the distinctive $^{207/208}$Pb ratio of Icelandic lavas. This will help to distinguish between dust sources of older ages or sources or from different origins. The seawater samples will be used in conjunction with trace element concentrations from samples taken at the same time during the cruise, to give an insight to the amount of volcanic ash which has entered the ocean.

Samples were taken on the underway towed fish sampler at 12 hour intervals in transit to the first station once the ship left Irish waters. Samples were taken from each of the CTD Ti cast at the shallowest depth (10-20 m) at these stations IM1, IM2, IM3, RR1 IcB1, IcB2,. A 5 depth profile was carried out at IcB3 at 1800, 255, 65, 45 and 20 m depths and a 3 depth profile was sampled at RR5 just 40 km from the eruption plume from 1200, 255 and 10 metres. In total there were 23 samples sites (46 1 litre samples).



Other observations

-Sub-rounded juvenile Scoria lapilli ~6 mm in size were found in the planktonic nets at station RR5, these were found floating in the water and therefore were highly vesicular. Samples as big as 2 cm diameter were found in the nets also, a sign of significant fallout of tephra from a large range of grain-sizes at this location in the past few weeks. A sample of this will be taken back to Southampton and polished to assess the degree of vesiculation and look at mineral phases and compositions.

- On the aerosol samples there was prominent discolouration of the filters, with specks of fine ash (<50 µm) on the filters when closer to the eruption plume (~80 km), which was not present when the ship was more distal to the eruption plume.

- Tephra fall-out of the volcanic

plume occurred when in transit under the plume, a piece of paper and synthetic paint brush were used collected 6 30 ml pots of the darkly coloured ash from the life boat deck for analysis back in Southampton for major and trace element concentrations, Pb isotopes, leaching and settling experiments and SEM and grain size analysis.

Coccolithophore Biogeography

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Background

Coccolithophores are a prominent component of the open ocean phytoplankton. They typically dominate the eukaryotic phytoplankton within the oceanic gyres, but occur throughout the world ocean. In addition to their role as primary producers they are the most important single contributors to pelagic carbonate sedimentation. Consequently they are of great interest to geologists and biogeochemists as well as marine biologists and have been the subject of extensive multidisciplinary research (e.g. Thierstein & Young 2004, de Vargas et al. 2007). This combined with their relatively well-established taxonomy (Young et al. 2003) makes them an ideal group for monitoring the response of phytoplankton to global change. A good knowledge of their ecology, biogeography, and biodiversity will help understanding spatial and temporal population change. The D350 cruise aboard the MNF RV Discovery is a great opportunity to collect samples from high latitude North Atlantic that will complete the extended set of samples collected across the Atlantic Ocean (AMT18 cruise). Furthermore, the chemical analyses undertaken during this cruise will provide a suite of environmental data valuable to interpret assemblage data and to understand population dynamic.

Objectives

1. To carry out high resolution analysis of nannofossil assemblages from D350, including detailed sampling through the water column, to refine understanding of coccolithophore biogeography in the high latitude of the North Atlantic.

2. Collect medium resolution set of samples using the COD-FISH protocol to allow DNA probe studies of distribution of specific taxonomic groups, and when specific or generic level probes are available to identify life cycle phases. This technique should allow estimating the proportion of naked *Emiliania huxleyi* in the high latitude of the North Atlantic.

3. To collect a set of environmental DNA samples from high latitude North Atlantic for clone library study of haptophyte diversity.

Sampling

1 - Sampling for coccolithophore assemblage analysis

Filter samples for coccolithophore assemblage analysis were collected from the shallow pre-dawn stainless cast (CTD S). Typically samples of ca 5l were taken from Non-Toxic water (NT) and 8 depths. This usually included six light level determined depths (55%, 33%, 14%, 4.5%, 1%), 100 and 200m. In the following hours, 2.5l were filtered onto 47mm cellulose nitrate 1µm for light microscope (LM) analysis and 2.5l were filtered onto 47mm polycarbonate 1µm for scanning electron microscope (SEM) analysis using a low vacuum pressure. Filters were oven dried at 30°C for 24 hours and were archived at room temperature in millipore petrislides for subsequent study.

Summary: In total 78 filters for LM and 79 filters for SEM investigation were taken.

2 - Sampling for COD-FISH analysis

COD-FISH is a modification of Fluorescence In-Situ Hybridisation (FISH) method using non-acidic buffers (Frada et al. 2006). It allows cross-polarised light identification of coccolithophores (based on morphology of the calcite coccolith) to be combined with fluorescent labelling of cells by DNA probes. Study of these filters will be conducted in collaboration with the research team of Colomban de Vargas (Station Biologique de Roscoff) who has developed a range of probes for different coccolithophore groups.

COD-FISH samples were usually collected at 3 depths from the shallow pre-dawn stainless cast (CTD S). Typically samples of ca 2l were taken into a 2l light-tied bottle then fixed with 2ml of PFA 10%, and incubated in the at -4°C for at least 1hr. The preparation was then gently mixed and filtered through a 47 mm 0.22 mm Anodisc membrane filter using a low vacuum pressure. At the end of the filtration, the filter was rinsed in a series of increasing purity ethanol baths. The filter was dried at room temperature, then stored in a petrislide dish, and frozen at -20°C.

Summary: In total 25 filters were taken for CODFISH analysis.

3 - Environmental DNA samples

Molecular genetic studies of microplankton have traditionally been limited to species available in culture, which for oceanic groups such as coccolithophores is a very limited sampling of total diversity. Increasingly the alternative approach of analysing DNA diversity from bulk samples is being used to circumvent this bottleneck. I have been collaborating with the research team of Colomban de Vargas (Station Biologique de Roscoff) in application of this methodology to study of coccolithophore diversity through parallel study of morphological and molecular diversity of selected samples (Hui et al. *submitted*).

Bulk DNA samples were usually collected from the shallow pre-dawn stainless cast (CTD S). Typically samples of 8l to 15l were taken from NT and two light level determined depths 33% and 4.5%. Seawater was pre-filtered through a 53 mm mesh during recovery from Niskin bottles or from NT water supply, into a 15l plastic carboy. A sterile vented filter unit SterivexTM-GV 0.22mm was then connected with silicone tubing to a peristaltic pump, and the other side of the tube was plunge into the carboy. When all the sampled water was filtered the filter unit was kept connected to the pump for 30min to dry out. Subsequently, 2 ml of buffer solution was injected into the filter unit with a micropipette. Finally the filter unit was sealed with parafilm, stored in a finger of a plastic glove, and frozen at -20°C. For the last 3 stations, some DNA samples were also filtered on GF/F filters using a low vacuum pressure, and frozen at -20°C.

Summary: In total 34 bulk-DNA samples were filtered for molecular genetic studies.

^{13}C and ^{15}N 24 hours incubation experiment

Seawater samples for this experiment were collected from the shallow pre-dawn stainless cast (CTD S). Typically eight 1.2l samples were taken from six light level determined depths (4 from 55%, 1 from each 33%, 14%, 4.5%, and 1%). These samples were then spiked with 1 µmol of ^{13}C (200ml) and 1 µmol of ^{15}N (100ml) and incubated for 24 hours in the incubator with a light level corresponding to the collection depth. The samples were then filtered on 25mm diameter pre-ashed GF/F filter and frozen at -20°C.

Summary: In total 78 samples corresponding to 9 stations

Grazing experiments

On the behave of Alex Poutron (NOC) and in collaboration with Michele Hale (dilution experiments on microzooplakton) and Sari Giering (dilution experiments on macrozooplakton) some sub-samples (250 to 350 ml) at various T times of their experiments were filtered on 25 mm diameter cellulose nitrate filter for LM counts. T0 was commun for both experiments and was only mearsured on Sarah experiments. Michelle did two 48hours experiments and Sarah did three 24hours.

Summary: In total 45 and 27 samples were filtered for LM counts bulk-DNA samples were filtered for molecular genetic studies.

Summarised sampling table

DATE	LATITUDE	LONGITUDE	STATION	CAST	DEPTH	LM	SEM	DNA	CF	^{13}C
29-Apr	58° 32' 70"	21° 40' 51"	Uw 17	NT	5.5			2		4
29-Apr	59° 00' 24"	24° 11' 80"	Uw 26	NT	5.5	1	2	1		
29-Apr	59° 00' 24"	24° 11' 80"	St 1	CTD	10	2	2	1	1	
					35	2	2	1	1	
					50	2	2	1	1	
30-Apr	59° 41' 43"	27° 47' 57"	Uw 39	NT	5.5	1	1	1	1	4
1-May	60° 58' 78"	31° 59' 27"	St 2	NT	5.5	1	1	1	1	
1-May	60° 58' 78"	31° 59' 27"	St 2	CTD	10	1	1	1	1	4
					20	1	1			1
					35	1	1			1
					53	1	1			1
					80	1	1			1
					100	1	1	1	1	
2-May	60° 01' 40"	34° 57' 61"	St 3	NT	5.5	1	1	1		
2-May	60° 01' 40"	34° 57' 61"	St 3	CTD	5	1	1			
					10	1	1	1		4
					20	1	1			1
					35	1	1			1
					50	1	1	1		1
					85	1	1			1
					100	1	1			
					150	1	1			
3-May	60° 00' 17"	31° 58' 82"	St 4	NT	5.5	1	1	1		
3-May	60° 00' 17"	31° 58' 82"	St 4	CTD	7	1	1	1	1	4
					20	1	1			1
					35	1	1	1	1	1
					53	1	1			1
					60	1	1	1	1	
					80	1	1			1
					100	1	1			
					150	1	1			
4-May	59° 59' 41"	28° 59' 73"	St 4	NT	5.5	1	1	1		
4-May	59° 59' 41"	28° 59' 73"	St 4	CTD	7	1	1		1	4
					20	1	1		1	1
					35	1	1			1
					53	1	1	1	1	1
					60	1	1			
					80	1	1			1
					100	1	1			
					150	1	1			
5-May	59° 56' 65"	26° 12' 67"	St 6	NT	5.5	1	1	1		
5-May	59° 56' 65"	26° 12' 67"	St 6	CTD	7	1	1		1	4
					20	1	1	1	1	1
					30	1	1			1
					40	1	1	1	1	1
					60	1	1			1
					80	1	1			
					100	1	1			
					150	1	1			
6-May	60° 50' 78"	21° 45'	St 7	NT	5.5	1	1	1		
6-May	60° 50' 78"	21° 45' 06"	St 7	CTD	5	1	1			4
					20	1	1	1	1	1
					30	1	1		1	1
					40	1	1	1	1	1

					60	1	1			1
					80	1	1	1		
					100	1	1			
					150	1	1			
7-May	61° 59' 95"	21° 45'	St 8	NT	5.5	1	1	1		
7-May	61° 59' 95"	21° 45' 06"	St 8	CTD	5	1	1	1	1	4
					20	1	1			1
					30	1	1			1
					40	1	1	1	1	1
					60	1	1			1
					80	1	1			
					100	1	1			
					150	1	1			
8-May	63° 07' 83"	19° 54'	St 9	NT	5.5	1	1	1		
8-May	63° 07' 83"	19° 54'	St 9	CTD	5	1	1		1	4
					15	1	1	1	1	1
					25	1	1	1	1	1
					40	1	1			1
					50	1	1	1	1	1
					80	1	1			
					100	1	1			
					150	1	1			

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DIC and alkalinity

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-68 250 ml seawater samples of were taken for DIC (Dissolved Inorganic carbon) and alkalinity measurements on behalf of Victoire Rerolle. Samples were taken from the deep Stainless steel CTD cast. 6 profiles were taken, sampling seawater from 9 to 12 depths at stations CIB1, CIB2, CIB3, IcB1, IcB2 and RR1. 6 underway samples were taken in between sites. The analysis will provide an insight into the carbonate system in the ocean, the analysis of the samples will analysed in Southampton.

The distribution of siderophores in the High latitude North Atlantic

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Introduction

Iron has been shown to play a critical role in ocean productivity and community structure. Iron limitation of the phytoplankton community in the high latitude North Atlantic (Iceland Basin) reduces the efficiency of ocean carbon dioxide uptake in that region, thereby affecting the efficiency of the biological pump (Nielsdottir et al., 2009). The chemical form of iron in seawater is a very important factor as this will govern the amount of iron which is immediately available for use by marine phytoplankton and bacteria. Little is known about the chemical form of iron other than that it is largely bound by organic compounds. These organic compounds are thought to originate from phytoplankton or bacteria. We will search for siderophores, metal chelates produced by bacteria as part of a highly specific iron uptake mechanism (Mawji et al., 2008a). The research will contribute to our knowledge of iron chemistry in seawater and the way in which marine organisms acquire iron in order to grow.

Objectives

- To investigate the distribution of siderophores in the dissolved and particulate phase in the Irminger and Icelandic Basins.
- To identify novel siderophores produced by marine bacteria from the HLNA in nutrient enriched incubated high latitude North Atlantic Seawater

Method

Table 1. Position and depths of siderophore samples

Label	Date	long	lat	time	UW/CTD	Depth
UW	29/04/2010			4.00	UW	3
CIB1	01/05/2010	60 56.66	34 52.31	14.33	CTD	25
CIB1	01/05/2010	61 56.66	35 52.31	15.33	CTD	85
CIB2	02/05/2010	60 02.37	34 57.47	12.07	CTD	27
CIB2	02/05/2010	60 02.37	34 57.47	12.07	CTD	93
CIB3	03/05/2010	59 59.54	37 55.98	14.03	CTD	27
CIB3	03/05/2010	59 59.54	37 55.98	14.03	CTD	68
RR1	04/05/2010	59 58.508	29 10.032	15.30	CTD	24
IbB1	05/05/2010	59 54.45	26 02.34	13.45	CTD	30
IcB2	06/05/2010	60 50.603	21 44.537	14.26	CTD	30
IcB3	07/05/2010	61 57.41	20 01.97	12.51	CTD	20
RR5	08/05/2010	63 05.27	19 52.54	11.18	CTD	23

Extraction and preconcentration of dissolved and particulate siderophores: Seawater (20 L) was collected from the trace metal clean tow fish or from the titanium CTD and filtered through 3 and 0.2 μm polycarbonate membrane filters. Filters were frozen at -80 °C for later analysis of particulate siderophores after extraction into ethanol Dissolved siderophores were concentrated onto polystyrene divinyl benzene polymeric resin (ISOLUTE ENV+ solid phase extraction cartridge) and were frozen at -20 °C. Siderophores will be quantified by high performance liquid chromatography – inductively coupled plasma – mass spectrometry (HPLC-ICP-MS) and identified HPLC - electrospray ionization – mass spectrometry (ESI-MS)(Mawji et al., 2008a).

Incubation method: Incubations were carried out using sea waters collected from the Iceland Basin (sampled from trace metal clean towfish, 29/04/10) and from the Irminger basin (sampled from the titanium CTD station CIB3, depth 27 m) according to the methods of (Gledhill et al., 2004). Seawater was enriched with glucose (100 μM), ammonia (200 μM) and phosphate (20 μM) and incubated for 5 days in the controlled temperature laboratory at 12 °C. Iron was added at three concentrations (no addition, 9 nM Fe and 90 nM Fe) with the aim of identifying optimal siderophore producing conditions. Un-enriched seawater served as a control. Bacterial growth was monitored daily by absorbance at 600 nm. Samples were collected daily for enumeration of bacteria (flow cytometry). Incubations were sampled for siderophores on Day 3 and 5 of the experiments. Incubated seawaters were filtered through 3 and 0.2 μm polycarbonate membrane filters and the filters frozen at -80°C. Dissolved siderophores were pre - concentrated onto polymeric resin and frozen as above. Sub samples were taken for analysis of bacterial community structure (capillary electrophoresis – single strand conformation polymorphism, CE-SSCP). Siderophores in the incubations will be quantified by high performance liquid chromatography – inductively coupled plasma – mass spectrometry (HPLC-ICP-MS) and identified and characterized by HPLC - electrospray ionization – mass spectrometry (ESI-MS) (Mawji et al., 2008a; Mawji et al., 2008b)

Table 2. Positions from which seawater was sampled for incubations

	Station	Date	Long	lat	time	UW/CTD	Depth
Incubation	UW1	29/04/2010			4.00	UW	3
Incubation	CIB3	03/05/2010	59 59.54	37 55.98	14.03	CTD	27

Results

Dissolved and particulate siderophore concentrations in seawater samples and incubated seawaters will be determined at NOCS. Flow cytometry will be carried out at NOCS. CE-SSCP will be undertaken by I. Salter at Banyuls, France. Final absorbance readings suggest that the bacterial biomass was greatest in the treatment containing 9 nM added iron (Fig. 1).

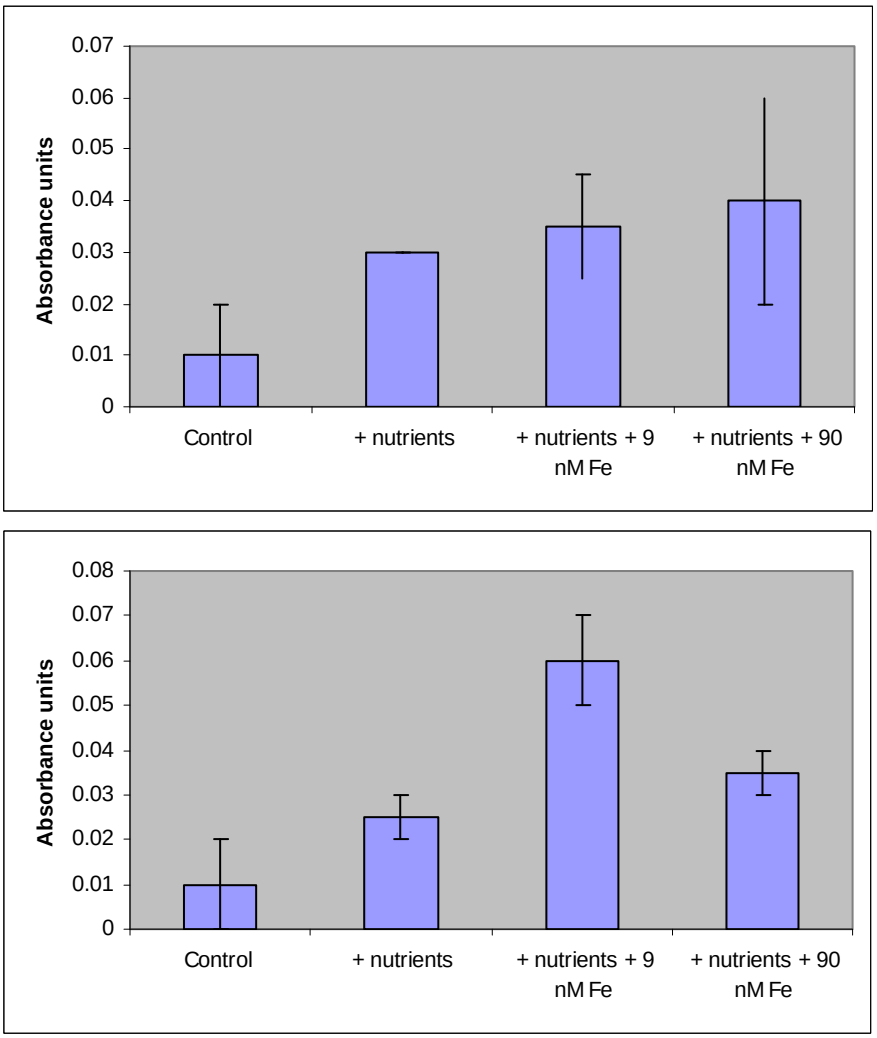

Fig 1. Absorbance (600 nm) of incubated seawater enriched with nutrients (100 μM glucose, 200 μM N, 20 μM P) and Fe. Top: incubation 1, bottom: incubation 2.

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The distribution of heme b in the High latitude North Atlantic

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Introduction

The High Latitude North Atlantic is a region known to have very low total dissolved iron concentrations and has been hypothesized to be seasonally iron limited (Nielsdottir et al., 2009). In such areas, iron deficiency limits processes such as photosynthesis, respiration and N_2 fixation (Saito et al., 2005). Many of the essential proteins used for these processes, such as cytochromes, catalses and oxidases, are hemoproteins. Hemes form the prosthetic groups of hemoproteins. This study will investigate the occurrence of heme b, the most ubiquitous heme, in particulate material in the High Latitude north Atlantic (Gledhill, 2007).

Objectives

- To investigate the distribution of hemes in the particulate phase in the Irminger and Icelandic Basins.

Method

Extraction of heme: Seawater was collected every 2 hrs from the trace metal clean underway sampling system and from the stainless steel CTD when on station. Two liters were filtered onto glass fiber filters (25mm). Filters were frozen at -70°C for later analysis. Filters for POC/PON analysis were also collected on precombusted GF/F filters (25mm) from the trace metal clean underway seawater sampling system and frozen at -20°C. Samples were also obtained from the iron bioassays undertaken by Ryan-Keogh et al.. Heme will be analyzed by high performance liquid chromatography (Gledhill, 2007).

Table 2: Heme samples

label	Date	time	Long	Lat	UW/CTD	Depth (m)
UW1	28/04/2010	1235	57 37.8	16 57.4	UW	3
UW2	28/04/2010	1950	58 02.4	19 03.26	UW	3
UW3	28/04/2010	2350			UW	3
UW4	29/04/2010	0406	58 34.4	21 51.1	UW	3
UW5	29/04/2010	0555	58 39.27	22 16.1	UW	3
UW6	29/04/2010	0745	58 46.09	22 49.57	UW	3
UW7	29/04/2010	0955	58 52.09	23 23.14	UW	3
UW8	29/04/2010	1200	59 00.34	24 11.6	UW	3
UW9	29/04/2010	1753			UW	3
UW10	29/04/2010	1955			UW	3
UW11	29/04/2010	2155			UW	3
UW12	29/04/2010	2355			UW	3
UW13	30/04/2010	0200			UW	3
UW14	30/04/2010	0408	59 41.44	27 49.1	UW	3
UW15	30/04/2010	0555	59 48.11	28 21.1	UW	3
UW16	30/04/2010	0802	59 54.54	29 01.32	UW	3
UW17	30/04/2010	0952	60 01.12	29 34.15	UW	3
UW18	30/04/2010	1200			UW	3
UW19	30/04/2010	1400			UW	3
UW20	30/04/2010	1600			UW	3
UW21	30/04/2010	1800			UW	3
UW22	30/04/2010	2000			UW	3
UW23	30/04/2010	2200			UW	3
UW24	01/05/2010	0000			UW	3
UW25	01/05/2010	0245	60 59.56	35 00.3	UW	3
CTD S002	01/05/2010	0540	60 58.91	34 59.38	CTD	10
CTD S002	01/05/2010	0540	61 58.91	35 59.38	CTD	20
CTD S002	01/05/2010	0540	62 58.91	36 59.38	CTD	35
CTD S002	01/05/2010	0540	63 58.91	37 59.38	CTD	53
CTD S002	01/05/2010	0540	64 58.91	38 59.38	CTD	80
CTD S002	01/05/2010	0540	65 58.91	39 59.38	CTD	100
UW26	02/05/2010	1800			UW	3
UW27	02/05/2010	2000			UW	3
UW28	02/05/2010	2200			UW	3
BB1 -Fe	02/05/2010				Bioassay	
BB1 -Fe	02/05/2010				Bioassay	
BB1 +Fe	02/05/2010				Bioassay	
BB1 +Fe	02/05/2010				Bioassay	
CTD S005	02/05/2010	0853	60 03.09	34 57.06	CTD	8
CTD S005	02/05/2010	0853	61 03.09	35 57.06	CTD	14
CTD S005	02/05/2010	0853	62 03.09	36 57.06	CTD	23
CTD S005	02/05/2010	0853	63 03.09	37 57.06	CTD	37
CTD S005	02/05/2010	0853	64 03.09	38 57.06	CTD	52
CTD S005	02/05/2010	0853	65 03.09	39 57.06	CTD	87
UW29	02/05/2010	1400			UW	3
UW30	02/05/2010	1600			UW	3
UW31	02/05/2010	1800			UW	3
UW32	02/05/2010	2000			UW	3
UW33	02/05/2010	2200			UW	3
UW33NT	02/05/2010	2200			UW	3
UW34	03/05/2010	0000			UW	3
CTD S007	03/05/2010	0747	60 00.14	31 58.53	CTD	11
CTD S007	03/05/2010	0747	61 00.14	32 58.53	CTD	25
CTD S007	03/05/2010	0747	62 00.14	33 58.53	CTD	39

CTD S007	03/05/2010	0747	63 00.14	34 58.53	CTD	58
CTD S007	03/05/2010	0747	64 00.14	35 58.53	CTD	65
CTD S007	03/05/2010	0747	65 00.14	36 58.53	CTD	85
UW35	03/05/2010	1815			UW	3
UW36	03/05/2010	2000			UW	3
UW37	03/05/2010	2200			UW	3
UW38	04/05/2010	0000			UW	3
UW39	04/05/2010	0200			UW	3
CTD S008	04/05/2010	0729	59 59.425	28 59.78	CTD	10
CTD S008	04/05/2010	0729	59 59.425	28 59.78	CTD	22
CTD S008	04/05/2010	0729	59 59.425	28 59.78	CTD	38
CTD S008	04/05/2010	0729	59 59.425	28 59.78	CTD	55
CTD S008	04/05/2010	0729	59 59.425	28 59.78	CTD	63
CTD S008	04/05/2010	0729	59 59.425	28 59.78	CTD	83
CTD S009	04/05/2010	1010	59 59.889	28 59.76	CTD	38
CTD S009	04/05/2010	1010	59 59.889	28 59.76	CTD	23
UW40	04/05/2010	1600			UW	3
UW41	04/05/2010	1800			UW	3
UW42	04/05/2010	2000			UW	3
UW43	04/05/2010	2200			UW	3
UW44	04/05/2010	2358			UW	3
BB2 -Fe	05/05/2010	0200			Bioassay	
BB2 -Fe	05/05/2010	0200			Bioassay	
BB2 +Fe	05/05/2010	0200			Bioassay	
BB2 +Fe	05/05/2010	0200			Bioassay	
CTD S011	05/05/2010	0822	59 56.099	26 07.481	CTD	7
CTD S011	05/05/2010	0822	59 56.099	26 07.481	CTD	20
CTD S011	05/05/2010	0822	59 56.099	26 07.481	CTD	30
CTD S011	05/05/2010	0822	59 56.099	26 07.481	CTD	40
CTD S011	05/05/2010	0822	59 56.099	26 07.481	CTD	60
CTD S011	05/05/2010	0822	59 56.099	26 07.481	CTD	80
UW45	05/05/2010	1600			UW	3
UW46	05/05/2010	1800			UW	3
UW47	05/05/2010	2000			UW	3
UW48	05/05/2010	2200			UW	3
UW49	06/05/2010	0000			UW	3
UW50	06/05/2010	0200			UW	3
CTD S013	06/05/2010	0813	60 50.779	21 45.065	CTD	7
CTS S013	06/05/2010	0813	60 50.779	21 45.065	CTD	22
CTD S013	06/05/2010	0813	60 50.779	21 45.065	CTD	32
CTS S013	06/05/2010	0813	60 50.779	21 45.065	CTD	42
CTD S013	06/05/2010	0813	60 50.779	21 45.065	CTD	62
CTS S013	06/05/2010	0813	60 50.779	21 45.065	CTD	83
UW51	06/05/2010	1800			UW	3
UW52	06/05/2010	2000			UW	3
UW53	06/05/2010	2200			UW	3
UW54	07/05/2010	0000			UW	3
CTD S015	07/05/2010	0738	61 59.95	19 59.96	CTD	8
CTD S015	07/05/2010	0738	61 59.95	19 59.96	CTD	32
CTD S015	07/05/2010	0738	61 59.95	19 59.96	CTD	43
CTD S015	07/05/2010	0738	61 59.95	19 59.96	CTD	63
CTD S015	07/05/2010	0738	61 59.95	19 59.96	CTD	92
CTD S015	07/05/2010	0738	61 59.95	19 59.96	CTD	123
UW55	07/05/2010	1800			UW	3
UW56	07/05/2010	2000			UW	3
UW57	07/05/2010	2200			UW	3
UW58	08/05/2010	0500			UW	3

CTD S017	08/05/2010	0529	63 06.490	19 53.510	CTD	5
CTD S017	08/05/2010	0529	63 06.490	19 53.510	CTD	15
CTD S017	08/05/2010	0529	63 06.490	19 53.510	CTD	25
CTD S017	08/05/2010	0529	63 06.490	19 53.510	CTD	40
CTD S017	08/05/2010	0529	63 06.490	19 53.510	CTD	50
CTD S017	08/05/2010	0529	63 06.490	19 53.510	CTD	80
UW59	08/05/2010	1230			UW	3
UW60	08/05/2010	1315			UW	3
UW61	08/05/2010	1415			UW	3
UW62	08/05/2010	1515			UW	3
BB2 –Fe	09/05/2010	0600			UW	
BB2 +Fe	09/05/2010	0600			UW	

Results

No results are available at present

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Mesozooplankton grazing estimations

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Mesozooplankton plays an important role in the ecosystem as they function as link between primary producers and higher trophic levels. During spring in the North Atlantic, copepods like *Calanus* spp and *Metridia* spp dominate the mesozooplankton community. Adult *Calanus* overwinter in depth >1000 m and migrate into surface waters at the onset of the spring bloom, where they reproduce and feed off the phytoplankton. Grazing by copepods can significantly reduce the phytoplankton stock. When assessing what controls the phytoplankton in the Irminger Basin, it is therefore vital to accurately estimate grazing pressure by mesozooplankton.

There are different methods on how to estimate grazing rates. On this cruise, I used the following two:

1) Grazing experiments
2) Gut fluorescence measurements

1. Grazing experiments

Food removal experiments are used to calculate grazing rates. Animals of interest are incubated in bottles with prey items for a set length of time. The final concentration of prey items in the incubation bottles is compared to that in control bottles without added grazers. The aim of these grazing experiments is to resemble natural conditions as closely as possible. It is a direct method, which has been in use since the early 1950s (Gauld 1951). So far it is the only method that enables quantification of feeding on non-phytoplanktonic prey. Its results however may be limited by 'bottles effects', which include stress during capture and handling of zooplankton, unnaturally high densities of grazers in incubation bottles, and changes in growth behaviour of prey items (Roman & Rublee 1980).

As mesozooplankton preys selectively, it may remove significant amounts of microzooplankton. Consequentially, the grazing pressure on microzooplankton prey items decreases. This shift in grazing pressure makes the comparison of incubation bottles and control bottles difficult, leading occasionally to negative grazing rate estimations. To overcome this problem, I support my grazing experiments with a series of dilution experiments (Landry & Hassett 1982).

1.2 Material and Methods

1.2.1 Seawater

Seawater for the incubations is sampled from the Chlorophyll *a* maximum depths with a titanium CTD directly before the animal's collection. The CTD Niskin bottles are brought into a trace-metal clean container. In the clean container, the water is filtered through a 200 μm mesh to remove smaller zooplankton and eggs, and collected in a 100 L polycarbonate carboy. The incubation water is carefully filled into 15 acid-cleaned polycarbonate bottles (2 L) little by little and randomly to provide homogeneity. Three of the bottles serve as initials; the remaining twelve are used as incubation bottles.

1.2.2 Animals

Experimental animals are collected with a 200 μm WP2 net at night-time form a depth of approximately 60 m. Nets are hauled at approximately 10 m min^{-1}. Nets are not rinsed with water prior to unscrewing the cod-ends, as animals that are stuck to the net will most likely be very stressed and potentially damaged. The cod-end is wrapped into a clean plastic-bag, carefully unscrewed and immediately brought into the controlled temperature laboratory (CT lab). A plastic bucket (20 L) and eight plastic pots (20 mL) with lid have been acid-washed, filled with filtered water from the titanium CTD, double bagged and transported into the CT lab. There, the outer bag is removed and the bucket and pots are placed in the laminar flow hood. Under the laminar flow hood, the cod-end is carefully emptied into the water bucket to reduce zooplankton density. Using a microscope, acid cleaned mesh dishes and coated tweezers, 10-20 animals (size-dependent) of the most dominant copepod species are picked and transferred into the plastic pots. The pots are placed on a wooden tray, double bagged and carefully brought into the trace-metal clean container.

The animals in the plastic pots are carefully poured into the incubation bottles and 200 μm iron-spike is added to selected incubation bottles (Table 1). Bottles are filled up with filtered seawater until the surface is convex. A square of cling foil is carefully slid over the convex and the bottle top is screwed on. No air bubble must be present in the incubation bottle, as it may cause turbulence and damage microzooplankton. All bottles are placed onto a temperature-controlled plankton wheel at *in situ* temperature (sea surface temperature) and kept at ambient photoperiodic light.

After use, the net is washed thoroughly with hot freshwater and hung to dry.

Table 1 Treatments in the twelve incubation bottles

		water treatment	
		no	+ iron
copepods	no	1	7
	no	2	8
	no	3	9
	yes	4	10
	yes	5	11
	yes	6	12

After 24 h, the animals are filtered out of the incubation water, counted and their health status examined. Healthy animals are transferred into glass vials containing 6 mL acetone for gut fluorescence analysis. The following water samples are taken from each of the three initial bottles and the twelve incubation bottles:

Chlorophyll *a* (250 mL), cellulose nitrate (250 mL), flow cytometry (2 mL), FRRf (50 mL), Lugol's iodine (250 mL), nutrients (100 mL) and POC/PON (1000 mL).

2. Gut fluorescence analysis

Grazing experiments give very detailed information about grazing behaviour but are very time and labour intensive. A quick but less accurate estimate of mesozooplankton grazing rates can be obtained by gut fluorescence analysis (GFA). Chlorophyll *a* and pheaopigment content in the guts of mesozooplankton can be quantified using gut fluorescence measurements: Ingested phytoplanktonic chlorophyll is extracted in an organic solvent and its fluorescence measured using a fluorometer. Ingestion rates can now be calculated using gut fluorescence and turnover rate of the animal's gut content (Mackas & Bohrer 1976). Limitations of GFA include, among others, rapid pigment destruction when the sample is exposed to light, pigment destruction by the animal's digestive system, and the experimental restriction to herbivorous animals. Moreover, accurate knowledge about copepod gut clearance rates is vital when calculation ingestion rates based on gut fluorescence (Peterson et al. 1990). Thus, additional experiments are necessary.

2.1 Material and methods

2.1.1 Gut fluorescence

Animals are collected using a 200 µm WP2 net with non-filtering cod-end from a depth of approximately 60 m. Nets are hauled at approximately 10 m min^{-1} to minimize gut

evacuation during ascend. As animals that are stuck to the net will most likely be stressed and potentially damaged, nets are not rinsed with water prior to unscrewing the cod-end. The content of the cod-end is filtered through a small piece of mesh. The mesh is carefully double folded, wrapped in aluminium foil, put into a plastic bag containing the label and frozen immediately in liquid nitrogen. Samples are stored at -20 °C.

Two fluorometers are set up for the Welshmeyer technique (fluorometer A) and for the acidification technique (fluorometer B). Blank, solid blank (high and low) for the two fluorometers are read before and after processing the samples.

The samples is taken out of the freezer and immediately processed. Frozen animals are rinsed from the net onto a Petri dish using non-toxic seawater. Animals are kept defrosted for as short as possible at any time. Under a light microscope at dim light, 10-20 individuals of the dominant copepod species are picked, transferred into 6 mL acetone (90 %) and stored at -20 °C for 24 h. Following extraction, the sample is mixed thoroughly and decanted into a fluorometer glass tube. Readings are taken using fluorometer A and B. The sample is filled into a second glass tube and 150 µL of 10 % HCl (1.2 M) is added. After 90 sec a second reading is taken with fluorometer B. Chl *a* and phaeopigment concentration is calculated following JGOFS Protocol.

2.1.2 Gut clearance rates

The animals are collected as described for the gut fluorescence analysis. A bucket (20 L) is filled with GF/F filtered, food particle-free seawater. After unscrewing the cod-end, the content is carefully filtered through a 100 µm mesh dish, which is immersed in water. The animals in the water above the mesh dish are immediately transferred into the bucket with filtered water. The bucket is placed in the CT lab and kept in darkness. 10-20 animals are removed every 5-30 min, put into 6 mL acetone (90 %) and processed as described for the gut fluorescence analysis.

3. Abundance estimates

The two methods, grazing experiment and GFA, give a grazing rate for the chosen individuals, only. To extrapolate the data for the study area and compare it to other regions, it is vital to know overall mesozooplankton community structure, abundance and possible patchiness in the study area.

3.1 Material and Methods

Prior to sampling with the WP2 net, a Bongo net (95 μm and 200 μm) with filtering cod-ends is deployed. A flowmeter is fitted and readings are taken before and after deployment. Nets are hauled from a depth of approximately 100 m at about 20 m min^{-1}. Nets are not rinsed prior to unscrewing the cod-ends (standard procedure according to MS Aberdeen). Cod-ends are carefully rinsed into round 500 mL Nalgene bottles with seawater. 50 mL formaldehyde (40 %) is added and the bottle is filled to the top with seawater to make up a 4% formaldehyde solution. Samples are labelled and stored in a dark, dry place. Analysis (ID, counting and size measurements) is done on shore.

4. Samples

19 nets were deployed at nine different stations (Table 2). Three grazing experiments were carried out (D1, D2 & G3), from which two were carried out together with a series of dilution experiments (D1 & D2). Four gut clearance experiments were undertaken (GC1-4) and samples for gut fluorescence analysis were taken from seven different stations. For the grazing experiments, 48 samples were taken for each Chlorophyll a, cellulose nitrate, flow cytometry, FRRf, Lugol's iodine, nutrients and POC/PON. Chorophyll a, FRRf and Nutrient samples (silica & nitrates) were analysed on board. Lugol's samples were stored in darkness and the remaining samples were stored at -20 °C or -80 °C until further analysis on shore. A total of 96 GFA samples were taken and analysed on board.

Table 2 Net deployments

Date	Station		Net	Time	Position		Type	Depth	Exp.
29/04	01	*	01	14:25	59.00.44 N	24.11.49 W	Bongo	100	
01/05	02	CIB1	02	03:53	60.59.31 N	35.00.00 W	Bongo	100	
01/05	02	CIB1	03	04:07	60.59.20 N	34.59.83 W	WP2	60	D1
02/05	03	CIB2	04	01:45	60.00.24 N	33.00.24 W	Bongo	100	
02/05	03	CIB2	05	01:58	60.00.24 N	33.00.24 W	WP2	60	GC1
03/05	04	CIB3	06	05:43	60.00.1 N	31.59.1 W	Bongo	100	
03/05	04	CIB3	07	06:02	60.00.2 N	31.59.1 W	WP2	60	GC2
04/05	05	RR1	08	05:13	59.59.7 N	28.59.9 W	Bongo	100	
04/05	05	RR1	09	05:30	59.59.7 N	28.59.9 W	WP2	60	
04/05	05	RR1	10	06:10	59.59.4 N	28.59.8 W	WP2	100	
05/05	06	IcB1	11	03:10	59.56.61 N	26.13.17 W	Bongo	100	
05/05	06	IcB1	12	03:25	59.56.65 N	26.12.67 W	WP2	60	D2
06/05	07	IcB2	13	03:31	60.51.41 N	21.46.14 W	Bongo	100	
06/05	07	IcB2	14	03:43	60.51.41 N	21.46.14 W	WP2	60	GC3
07/05	07	IcB2	15	11:25	60.50.6 N	21.44.6 W	Bongo	100	
07/05	08	IcB3	16	04:18	61.58.7 N	20.01.0 W	Bongo	100	
07/05	08	IcB3	17	04:36	61.58.6 N	20.01.2 W	WP2	60	G3
08/05	09	RR5	18	03:46	63.08.2 N	19.55.2 W	Bongo	100	
08/05	09	RR5	19	04:04	63.08.1 N	19.54.9 W	WP2	60	GC4

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The role of microzooplankton grazing in the sub-Arctic North Atlantic

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Background

The microbial biomass observed in the oceans is a direct result of the balance between nutrient availability (bottom up) and grazing pressure (top down). It is important to distinguish and quantify both directions of control to understand the forcing effects of, in this case, hypothesised seasonal Fe limitation in the Irminger Basin.

Microzooplankton consume a substantial fraction of phytoplankton and bacterioplankton production, remineralising nutrients and providing a major trophic link to larger protozoan and metazoan consumers (1,2). As well as their ability to exert top down forcing on primary productivity there is also emerging evidence that this grazing is a significant source of bioavaliable trace metals such as Fe (3,4,5,6).

Our work will compliment the research being done by providing a top down perspective on primary productivity control. We also hope to quantify the first rates of biogenic particulate trace metal growth and loss. These studies will further our understanding and parameterization of the grazing pressure shaping microbial trophic levels and how carbon and trace metals are cycled within them.

Objectives

Determine the gross growth and grazing rates of bacteria and phytoplankton.

Determine the rate of growth and loss of size fractionated biogenic particulate trace metals.

Undertake on-board Fe enrichment bioassay experiments to determine grazer responses to stimulated phytoplankton growth

Determine carbon ingestion rates of microzooplankton.

Determine whether microzooplankton selectively graze trace-metal rich bacteria and phytoplankton, relative to total prey.

Methods

All work was carried out in a trace metal clean environment using trace metal clean equipment.

Microzooplankton grazing assay

Microzooplankton bacterivory and herbivory was determined using a modified dilution assay (7, 8). Seawater was collected from a titanium OTE CTD, filtered through a 202 µm Nitex mesh to remove larger grazers, and diluted with particle-free filtrate prepared by gravity filtration though a 0.2 µm Millipore cartridge filters to the following target dilutions (< 202 µm: < 0.2 µm filtered water): 1.0, 0.9, 0.75, 0.5, 0.35, 0.2 and 0.1. 7 out of the 14 containers were spiked with 600-800 µl of 20 nM $FeCl_3$ depending on volume. All samples were incubated in 10 L flexible LDPE cubitainers, in on-deck incubators at ambient temperatures (± 0.5°C) and ~50% of incident irradiance, for 48 h. Abundances of bacteria as well as pico- and nanophytoplankton, will be determined by flow cytometry (9, 10) and Acridine Orange Direct Counts (AODC; 11). Bacterial cell volume will be determined by image analysis of Acridine Orange (AO) stained cells using an Image-Pro Plus image analysis system (12). Nutrient (nitrate, silicate and phosphate), Chl *a* and Fast Repetition Rate fluorometry samples were collected and analysed on board (see Stinchcombe, Lucas & Ryan respectively). Subsamples for light microscopy identification were also collected in Lugols along with cellulose nitrate filters for coccolithophores.

The apparent growth rate of each group at each of the seven dilutions will be computed from the time-dependent changes in abundance or concentration. Rates of grazing mortality will be determined from the linear regression of apparent growth rate against dilution, with the intercept of the line providing an estimate of growth rate and the negative slope of the line providing an estimate of grazing mortality (8).

Our experiments were done in conjunction with mesozooplankton grazing experiments conducted by Giering

Biogenic particulate trace metals

2 L subsamples were taken in trace metal clean LDPE bottles at the start and end points of the grazing assay. These were sequentially filtered through 10 µm, 1 µm and 0.2 µm polycarbonate filters and frozen prior to analysis on land. Dissolved samples were also taken, spiked with 250 µl of trace metal clean concentrated HCl & stored at room temperature. A two stage leach (13) of the filters will determine labile and refractory phase trace metals and the apparent growth and loss rates of each size fraction will be estimated using the method

described above. Experiment T1 was collect from the tow-fish underway and used to collect process blanks and samples for method development on shore.

Study Sites

Grazing assays

Date	Location	Station	CTD #	Experiment	Depth	Time (GMT)
29/4/10	60^0 06'.19"N 30^0 00'.29"W	*n/a*	*n/a*	T1	2m	11:00
1/5/10	60^0 59'.666"N $35^0$00'.425"W	002	CTDT002	D1	20m	03:25
4/5/10	59^0 58'.007"N 28^0 59'.900"W	005	CTDT006	D2	20m	04:55

Samples Collected from assays

	Chl	AO	Nuts	FCM	FRRf	Lugols	CN	POC/PON	TM
CTD	y	y	y	y	y	y	y	y	y
RSW	y	y	y	y	y	y	y	y	y
SW		y	y	y				y	y
control	y	y	y	y					y
	y	y	y	y					y
	y	y	y	y					y
+Fe	y	y	y	y					y
	y	y	y	y					y
	y	y	y	y					y
	y	y	y	y					y
control	y	y	y	y					y
L	y	y	y	y					y
2	y	y	y	y					y
	y	y	y	y					y
+Fe	y	y	y	y					y

TO

15	y	y	y	y				y
1	y	y	y	y	y	y	y	y
2	y	y	y	y	y	y	y	y
3	y	y	y	y	y	y	y	y
4	y	y	y	y	y	y	y	y
5	y	y	y	y	y	y	y	y
6	y	y	y	y	y	y	y	y
7	y	y	y	y	y	y	y	y
9	y	y	y	y	y	y	y	y
10	y	y	y	y	y	y	y	y
11	y	y	y	y	y	y	y	y
12	y	y	y	y	y	y	y	y
13	y	y	y	y	y	y	y	y
14	y	y	y	y	y	y	y	y
15	y	y	y	y	y	y	y	y

Tf

Key:
Chl. = Chl.a
AO = Acridine Orange
Nuts = Nutrients (phosphate, silicate, nitrate)
FCM = Flow Cytometry
FRRf = Fast Repetition Rate fluorometry
Lugols = Lugols iodine
CN = Cellulose Nitrate filters for Coccoliths
POC/PON = Particulate Organic Carbon/Nitrogen
TM = Trace Metals, particulate and dissolved

RSW = 202µm filtered seawater
FSW = 0.2µm filtered seawater
To = start time
Tf = end time

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Computing and Instrumentation Reports D350

NMF-SS Sensors & Moorings Cruise Report

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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 CTD4 (1415)), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-31240-0720

Sea-Bird 3P temperature sensor, s/n 03P-4151, Frequency 0 (primary)

Sea-Bird 4C conductivity sensor, s/n 04C-2841, Frequency 1 (primary)

Digiquartz temperature compensated pressure sensor, s/n 90573, Frequency 2

Sea-Bird 3P temperature sensor, s/n 03P-4872, Frequency 3 (secondary, vane mounted)

Sea-Bird 4C conductivity sensor, s/n 04C-3258, Frequency 4 (secondary, vane mounted)

Sea-Bird 5T submersible pump, s/n 05T-4510, (primary)

Sea-Bird 5T submersible pump, s/n 05T-3086, (secondary, vane mounted)

Sea-Bird 32 Carousel 24 position pylon, s/n 32-37898-0518

Sea-Bird 11plus deck unit, s/n 11P-24680-0587

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

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

Tritech PA200 altimeter, s/n 6196.118171 (V2)

Chelsea MKIII Aquatracka fluorometer, s/n 88-2050-095 (V3)

Chelsea MKII 10cm path Alphatracka transmissometer, s/n 161049 (V6)

3) Additional instruments:

Ocean Test Equipment 20L ES-120B water samplers, s/n's 27 through 33, 36-41, 43, 44, 46, 48-59

Sonardyne HF Deep Marker beacon, s/n 213797-001

NOC 10 kHz acoustic bottom finding pinger, s/n B9

TRDI WorkHorse 300kHz LADCP, s/n 13329 (downward-looking)

NOC WorkHorse LADCP battery pack, s/n WH007

4) Sea-Bird 9*plus* configuration file D350_st_NMEA.con was used for the first three CTD casts, with D350_st_no_NMEA.con used for the back-up, simultaneous logging desktop computer. The CTG transmissometer failed prior to the second cast, and was replaced after the third cast with s/n 161050. The new configuration files were D350_st_NMEA_ trans.con and D350_st_no_NMEA_trans respectively. The LADCP command file used for all casts was WHMD350.txt.

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-24680-0637

Sea-Bird 3P temperature sensor, s/n 03P-2729, Frequency 0 (primary)

Sea-Bird 4C conductivity sensor, s/n 04C-2858, Frequency 1 (primary)

Digiquartz temperature compensated pressure sensor, s/n 79501, Frequency 2

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

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

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

Sea-Bird 5T submersible pump, s/n 05T-5301, (secondary, vane mounted)

Sea-Bird 32 Carousel 24 position pylon, s/n 32-34173-0493

Sea-Bird 11plus deck unit, s/n 11P-19817-0495

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

Sea-Bird 43 dissolved oxygen sensor, s/n 43-0621 (V0)

Chelsea MKIII Aquatracka fluorometer, s/n 088244 (V2)

Benthos PSA-916T altimeter, s/n 47597 (V3)

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

Chelsea MKII 25cm path Alphatracka transmissometer, s/n 161048 (V7)

7) Additional instruments:

Ocean Test Equipment 10L ES-110B trace metal-free water samplers, s/n's 1 through 24

Sonardyne HF Deep Marker beacon, s/n 234002-002

TRDI WorkHorse 300kHz LADCP, s/n 10607 (downward-looking)

NOC WorkHorse LADCP battery pack, s/n WH008T

8) Sea-Bird 9*plus* configuration file D350_ti_NMEA.con was used for the CTD casts, with D350_ti_no_NMEA.con used for the back-up, simultaneous logging desktop computer. The LADCP command file used for all casts was WHMD350.txt.

Other instruments

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

Guildline Autosal 8400B, s/n 68958, installed in Stable Laboratory as the primary instrument, Autosal set point 21C.

2) Fast Repetition Rate Fluorometer---Two FRRF systems were installed as follows:

Chelsea MKI, s/n 182039---Configured for underway sampling, located in Water Bottle Annexe. After initial set-up and operation, the instrument was observed to have noisy background signal, and to be saturated as well. It was replaced with s/n 05-4845-001.

Chelsea MKI, s/n 04-4364-003---Configured for discrete sampling, located in Deck Laboratory.

3) Stand Alone Pump System---Four SAPS were deployed up to depth of 200 metres on plastic coated steel wire, serial numbers as follows:

03-03 through 03-05, and 03-07---All functioned as expected; there were continuing problems with plastic impellor housing threaded nipples breaking when flow meters were attached. Various types of glues and adhesives were used in attempting to repair the housings, without success. All three spare housings were installed.

Navigation, Ship's Attitude and Position

Stuart Painter, Stephanie Henson **(University of Southampton, National Oceanography Centre, UK)**

The ship's best determined position was calculated from multiple navigation sources within the NMF process 'bestnav'. The primary data source is the ship's GPS Trimble 4000 system, which has been shown on previous cruises to provide positions accurate to ~1.0 m. Data were transferred daily from the NMF 'bestnav' file to the pstar absolute navigation file 'abnv3501' for use in pstar processing. GPS_4000 data ('gps_4000' datastream) were also transferred and processed daily.

The ship's gyro instrument is the most reliable direction indicator on the ship and provides essential information for correcting the ADCP velocities to Earth co-ordinates. The gyro data stream 'gyro' was processed as described below and a correction subsequently applied to individual ADCP profiles which is more accurate than correcting averaged ensembles. However, the gyro suffers from drift when the ship manoeuvres and therefore needs correcting with the ship's attitude (ashtech). Gyro data were transferred daily.

The Pstar execs used for processing navigation datastreams were:

navexec0: transferred the '*bestnav*' data stream to Pstar format. Ship's velocities were calculated from position and distance run calculated after appending to the master abnv3501 file.

gps4exec0: transferred the '*gps_4000*' data stream to Pstar format. Data with pdop (position dilution of position) outside the range 0-7 were removed. Gaps were interpolated before the file was appended to the master file gp435001 and distance run calculated. A 30 second average file gp435001.30sec was also created.

gyroexec0: transferred data from the '*gyro*' stream to Pstar format. Headings outside the range 0-360° were deleted and the file appended to the master gyr35001 file.

Ship's heading and attitude

The ship's attitude was measured every second by the 3D GPS Ashtech navigation system. Four antenna, two on the boat deck, two on the bridge top, measured the phase difference between incoming satellite signals from which the ship's heading, pitch and roll were determined. Ashtech data were read from the datastream '*gps_ash'* into Pstar and used to calibrate the gyro heading information as follows.

ashexec0: transferred data from the '*gps_ash*' data stream to Pstar binary file ash350nn, where nn is a daily processing number.

ashexec1: merged ashtech and gyro heading data and calculated the ashtech – gyro heading difference (a-ghdg). All values were set between -180 – 180°

ashexec2: edited the data outside the following ranges

heading 0 - 360

pitch -5 - 5

roll -7 - 7

attitude flag -0.5 - 0.5

measurement RMS error 0.00001 - 0.01

baseline RMS error 0.00001, 0.1

ashtech – gyro heading -7, 7

Heading differences greater than 1.0° from a 5 point running median were removed. Data were then averaged to 2 minute intervals and further edited to remove data cycles where

pitch -2 - 2

mrms, 0 - 0.004

a-ghdg, -10 - 10

Results were merged with the gyro file and ship's velocity calculated.

During the cruise a number of short gaps occurred in the Ashtech datastream. Those greater than 60 seconds are listed below.

Known problems

During D350 there were problems with the GPS_4000 system, which resulted in data drop outs and a loss of navigation. The GPS_4000 unit was restarted on two occasions during the cruise but due to recurrent problems processing ADCP data it is possible that some additional cleaning of the navigation data may be required.

General Acoustic Doppler Current Profiler Operation

Stuart Painter, Stephanie Henson(University of Southampton, National Oceanography Centre, UK)

RRS Discovery is equipped with two hull mounted Ocean Survey broadband ADCPs. The 150 kHz ADCP is mounted in the hull 1.75 m to port of the keel, 33 m aft of the bow at the waterline and at an approximate depth of 5.3 m. The 75 kHz ADCP is also mounted in the hull, but in a second well 4.15 m forward and 2.5 m to starboard of the 150 kHz well.

Recent changes to the network COM ports on *RRS Discovery* occurred during the 2010 refit and the following is now applicable for both ADCPs.

COM PORT	Baud Rate	Data Stream
COM1	9600	ADCP
COM2	4800	NMEA1 ($GPGGA – Position)
COM3	9600	NMEA2 ($GPPAT – Ashtech)

Known problems

Problems were encountered during the processing of both ADCP data sets which indicate the presence of duplicate times and or time reversals in the data. This will require further investigation upon return to NOC, as time was limited during the cruise to fully investigate this problem. It is likely that some reprocessing will be required.

150 kHz vessel mounted Acoustic Doppler Current Profiler

The 150 kHz vessel mounted acoustic doppler profiler was configured to sample with 96 bins of 4 m size with a blank beyond transmit of 4 m. Gyro heading and GPS Ashtech, location and time were automatically fed into the software which was configured to use the Gyro heading as its reference. Two configuration files were set up, one for water tracking, the other for bottom tracking in shallow water (<400 m). Two minute and ten minute averages were recorded using the software package VmDAS (v1.46) which was installed on the acquisition PC.

Sequentially numbered files were created whenever data logging was stopped and restarted (usually once a day). All data was transferred to the Unix directory /data32/D350/os150/raw for further processing as detailed below.

s150exec0: transferred data from the RDI binary format to Pstar. The data were split into two files; "gridded" depth dependent data were placed into "adp" files while "non-gridded" depth independent data were placed into "bot" files. Velocities were scaled to cm/s and amplitude by 0.42 to db. Nominal edits were made on all the velocity data to remove both bad data and to change the VmDAS defined absent data value to the Pstar absent value. The depth of the first bin was determined as follows:

Depth of 1st bin = transducer depth (5 m) + blank distance (4 m) + half bin size (2 m) = 11 m.

Output files: adp350###.raw & bot350###.raw

s150exec1: data edited according to status flags (flag of beam 1 used to indicate bad data). Velocity data replaced with absent data if variable "*2+bmbad*" was greater than 25% (% of pings where >1 beam was bad therefore no velocity computed). Time of ensemble moved to the end of the ensemble period (120 secs added with pcalib).

Output files: adp350### & bot350###

s150exec2: merged the ADCP data (both bottom track and water track files if present) with the ashtech minus gyro variable (a-ghdg) created by ashexec2. The ADCP velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables that occurs with this exec.

Output files: adp350###.true & bot350###.true

s150exec3: applied the misalignment angle, ø, and scaling factor, A, to both ADCP files. The ADCP data were edited to delete all velocities where the percent good variable was 25% or less. Again, variables were renamed and re-ordered to preserve the original raw data.

Output files: adp350###.cal & bot350###.cal

s150exec4: merged the ADCP data (both water track and bottom track files) with the absolute navigation file (abnv3501) created by *navexec0*. Ship's velocity was calculated from the 2 minute positions and applied to the ADCP velocities. The end product was the absolute velocity of the water.

Output files: adp350###.abs & bot350###.abs

Calibration for misalignment angle and scaling factor

Calibration of the OS150 was conducted during the run out from Glasgow towards the continental shelf edge. The calculated calibration coefficients were:

ϕ (misalignment angle) = 1.596°

A (scaling factor) = 1.00102°.

File No.	Data filename (Short Term Average)	Bottom Track	Comments
1	D350001_000000.STA	Yes	Bad time base
2	D350002_000000.STA	Yes	
3	D350os150001_000000.STA	No	Bad time base
4	D350os150002_000000.STA	No	
5	D350os150003_000000.STA	No	

6	D350os150004_000000.STA	No	Bad time base
7	D350os150005_000000.STA	No	Short file – no data
8	D350os150006_000000.STA	No	Bad time base
9	D350os150007_000000.STA	No	
10	D350os150008_000000.STA	No	
11	D350os150009_000000.STA	No	Bad time base
12	D350os150010_000000.STA	No	
13	D350os150011_000000.STA	No	
14	D350os150012_000000.STA	No	
15	D350os150013_000000.STA	No	
16	D350os150014_000000.STA	No	
17	D350os150015_000000.STA	No	
18	D350os150016_000000.STA	No	
19	D350os150017_000000.STA	No	
20	D350os150018_000000.STA	No	

Summary table of OS150 kHz VM-ADCP datafiles

OS150 – Config File (D350_BT_on.ini)

[Version Info]
VmDasVersion=Version 1.46
Option Table Version=1
[Expert only options]
SaveOnlyChangedOptions=TRUE
TurnedOffBeam=0
PashrImuFlagUseNormalInterpretation=TRUE
[ADCP Port Setup]
AdcpComPortName=COM1
AdcpComBaudRate=9600
AdcpComParity=NOPARITY
AdcpComStopBits=1
AdcpComDataBits=8
ADCPSoftBreak=FALSE
TimeoutNoRespCmd=1000
TimeoutHaveCharCmd=100
TimeoutNoRespSlowCmd=10000
TimeoutHaveCharSlowCmd=10000
TimeoutNoRespBreak=3000
TimeoutHaveCharBreak=2000
TimeoutNoEns=0
[NMEA Port Setup]
NmeaNavComEnable=TRUE
NmeaNavComPortName=COM2
NmeaNavComBaudRate=4800
NmeaNavComParity=NOPARITY
NmeaNavComStopBits=1
NmeaNavComDataBits=8
NmeaRPHComEnable=TRUE
NmeaRPHComPortName=COM3
NmeaRPHComBaudRate=9600
NmeaRPHComParity=NOPARITY
NmeaRPHComStopBits=1
NmeaRPHComDataBits=8
Nmea3ComEnable=FALSE
Nmea3ComPortName=None

Nmea3ComBaudRate=4800
Nmea3ComParity=NOPARITY
Nmea3ComStopBits=1
Nmea3ComDataBits=8
Nmea Nav Ethernet Enable=FALSE
Nmea Nav IP Addy=0.0.0.0
Nmea Nav Ethernet Port=5678
Nmea Nav Ethernet Connection Type TCP-UDP=1
Nmea Nav Ethernet Service Type Server-Client=1
Nmea Nav Ethernet Broadcast flag=FALSE
Nmea RPH Ethernet Enable=FALSE
Nmea RPH IP Addy=0.0.0.0
Nmea RPH Ethernet Port=5679
Nmea RPH Ethernet Connection Type TCP-UDP=1
Nmea RPH Ethernet Service Type Server-Client=1
Nmea RPH Ethernet Broadcast flag=FALSE
Nmea3 Ethernet Enable=FALSE
Nmea3 IP Addy=0.0.0.0
Nmea3 Ethernet Port=5680
Nmea3 Ethernet Connection Type TCP-UDP=1
Nmea3 Ethernet Service Type Server-Client=1
Nmea3 Ethernet Broadcast flag=FALSE
[NMEA Comm window]
NoDataTimeout(ms)=5000
AutoOpen=TRUE
NumNmeaDisplayedOnErrRecovery=10
[Serial Port for Binary Ensemble Data Output]
BinaryEnsembleOutputComEnable=FALSE
BinaryEnsembleOutputComPortName=None
BinaryEnsembleOutputComBaudRate=9600
BinaryEnsembleOutputComParity=NOPARITY
BinaryEnsembleOutputComStopBits=1
BinaryEnsembleOutputComDataBits=8
BinaryEnsembleOutputDataType(0:none;1:enr;2:enx;3:sta;4:lta)=0
BinaryEnsembleOutputRefVelType(0:none;1:Bottom;2:Mean)=0
BinaryEnsembleOutputStartBin=1
BinaryEnsembleOutputEndBin=4
BinaryEnsembleOutputMeanStartBin=1
BinaryEnsembleOutputMeanEndBin=4
BinaryEnsembleOutputLeader(0:no;1:yes)=FALSE
BinaryEnsembleOutputBottomTrack(0:no;1:yes)=FALSE
BinaryEnsembleOutputNavigation(0:no;1:yes)=TRUE
BinaryEnsembleOutputVelocity(0:no;1:yes)=TRUE
BinaryEnsembleOutputIntensity(0:no;1:yes)=TRUE
BinaryEnsembleOutputCorrelation(0:no;1:yes)=TRUE
BinaryEnsembleOutputPercentGood(0:no;1:yes)=TRUE
BinaryEnsembleOutputStatus(0:no;1:yes)=TRUE
BinaryEnsembleOutputNetEnable=FALSE
BinaryEnsembleOutputIPPortNumber=5433
=0.0.0.0
BinaryEnsembleOutputConType=1
BinaryEnsembleOutputSvcType=1
BinaryEnsembleOutputBcast=FALSE
[Serial Port for ASCII Ensemble Data Output]

AsciiEnsembleOutputComEnable=FALSE
AsciiEnsembleOutputComPortName=None
AsciiEnsembleOutputComBaudRate=9600
AsciiEnsembleOutputComParity=NOPARITY
AsciiEnsembleOutputComStopBits=1
AsciiEnsembleOutputComDataBits=8
AsciiEnsembleOutputDataType(0:none;1:enr;2:enx;3:sta;4:lta)=0
AsciiEnsembleOutputRefVelType(0:none;1:Bottom;2:Mean)=0
AsciiEnsembleOutputStartBin=1
AsciiEnsembleOutputEndBin=4
AsciiEnsembleOutputStoreToDisk(0:no;1:yes)=FALSE
AsciiEnsembleOutMeanStartBin=1
AsciiEnsembleOutputMeanEndBin=4
AsciiEnsembleOutputLeader(0:no;1:yes)=TRUE
AsciiEnsembleOutputBottomTrack(0:no;1:yes)=TRUE
AsciiEnsembleOutputNavigation(0:no;1:yes)=TRUE
AsciiEnsembleOutputVelocity(0:no;1:yes)=TRUE
AsciiEnsembleOutputIntensity(0:no;1:yes)=TRUE
AsciiEnsembleOutputCorrelation(0:no,1:yes)=TRUE
AsciiEnsembleOutputPercentGood(0:no;1:yes)=TRUE
AsciiEnsembleOutputStatus(0:no;1:yes)=TRUE
BinaryEnsembleOutput Ascii NetEnable=FALSE
BinaryEnsembleOutput Ascii IPPortNumber=5433
BinaryEnsOutAscii IP=0.0.0.0
BinaryEnsembleOutput Ascii ConType=1
BinaryEnsembleOutputAscii SvcType=1
BinaryEnsembleOutputAscii Bcast=FALSE
[Serial Port for Speed Log Output]
SpeedLogComEnable=FALSE
Speed Log ComPortName=None
Speed Log ComBaudRate=9600
Speed Log ComParity=NOPARITY
Speed Log ComStopBits=1
Speed Log ComDataBits=8
SpeedLogDataSource=STA
SpeedLogWLSource=WP
SpeedLogWLStartBin=3
SpeedLogWLEndBin=5
BinarySpeedLog NetEnable=FALSE
BinarySpeedLog IPPortNumber=5434
BinarySpeedLog Ip Addy=0.0.0.0
BinarySpeedLog ConType=1
BinarySpeedLog SvcType=1
BinarySpeedLog Bcast=FALSE
[Fake Data Options]
AdcpSimInAirEnable=FALSE
AdcpFakeDataEnable=FALSE
AdcpFakeDataFilename=SimAdcp.enr
FakeDataTimeBetweenEnsembles=2
NMEAFakeDataEnable=FALSE
NMEAFakeDataFilename=SimNav.nmr
[File Name Components]
EnableDualRecordDir=TRUE
FileRecordPath=C:\RDI\Data\D350\

FileRecordBackupPath=Z:\d350\os150\raw\
DeploymentName=D350
DeploymentNumber=1
MaximumFileSize=100
[Bottom Track Data Screening Options]
BTAmpScreenEnable=FALSE
BTCorScreenEnable=FALSE
BTErrScreenEnable=FALSE
BTVertScreenEnable=FALSE
BTFishScreenEnable=FALSE
BTPctGoodScreenEnable=FALSE
BTAmplitudeThreshold=30
BTCorrelationThreshold=220
BTErrorVelThreshold=1000
BTVerticalVelThreshold=1000
BTFishThreshold=50
BTPctGoodThreshold=50
[Water Track Data Screening Options]
WTAmpScreenEnable=FALSE
WTCorScreenEnable=FALSE
WTErrScreenEnable=FALSE
WTVertScreenEnable=FALSE
WTFishScreenEnable=FALSE
WTPctGoodScreenEnable=FALSE
WTAmplitudeThreshold=30
WTCorrelationThreshold=180
WTErrorVelThreshold=1000
WTVerticalVelThreshold=1000
WTFishThreshold=50
WTPctGoodThreshold=50
[Profile Data Screening Options]
PRAmpScreenEnable=FALSE
PRCorScreenEnable=FALSE
PRErrScreenEnable=FALSE
PRVertScreenEnable=FALSE
PRFishScreenEnable=FALSE
PRPctGoodScreenEnable=FALSE
PRMarkBadBelowBottom=FALSE
PRAmplitudeThreshold=30
PRCorrelationThreshold=180
PRErrorVelThreshold=1000
PRVerticalVelThreshold=1000
PRFishThreshold=50
PRPctGoodThreshold=50
[2nd Band Profile Data Screening Options]
PRAmpScreenEnable=FALSE
PRCorScreenEnable=FALSE
PRErrScreenEnable=FALSE
PRVertScreenEnable=FALSE
PRFishScreenEnable=FALSE
PRPctGoodScreenEnable=FALSE
PRAmplitudeThreshold=30
PRCorrelationThreshold=180
PRErrorVelThreshold=1000

PRVerticalVelThreshold=1000
PRFishThreshold=50
PRPctGoodThreshold=50
[Transformation Options]
XformToEarth=TRUE
Allow3Beam=TRUE
BinMap=TRUE
BeamAngleSrc(0:auto,1:man)=0
ManualBeamAngle=30
HeadingSource(0:adcp,1:navHDT,2:navHDG,3:navPRDID,4:manual)=1
NMEAPortForHeadingSource=1
ManualHeading=0
TiltSource(0:adcp,1:nav,2:man)=2
NMEAPortForTiltSource=-1
ManualPitch=0
ManualRoll=0
SensorConfigSrc(0:PRfixed,1:Pfixed,2:auto)=2
ConcavitySource(0:convex,1:concave,2:auto)=2
UpDownSource(0:dn,1:up,2:auto)=2
EnableHeadingCorrections=FALSE
SinCorrectionAmplitudeCoefficient=0
SinCorrectionPhaseCoefficient=0
MagneticOffsetEV=0
BackupMagneticOffsetEV=0
AlignmentOffsetEA=0
EnableVelocityScaling=FALSE
VelocityScaleFactorForBTVelocities(unitless)=1
VelocityScaleFactorForProfileAndWTVelocities(unitless)=1
EnableTiltAlignmentErrorCorrection=TRUE
TiltAlignmentHeadingCorr(deg)=0
EAOptionSource=TRUE
TiltAlignmentPitchCorr(deg)=0
TiltAlignmentRollCorr(deg)=0
[2nd Band Transformation Options]
EnableVelocityScaling=FALSE
VelocityScaleFactorForProfileVelocities(unitless)=1
[Backup HPR NMEA Source Options]
EnableBackupHeadingSource=FALSE
BackupHeadingSource(0:adcp,1:navHDT,2:navHDG,3:navPRDID,4:manual,5:PASHR,6:PASHR,
ATT,7:PASHR,AT2)=3
NMEAPortForBackupHeadingSource=2
BackupManualHeading=0
EnableBackupTiltSource=FALSE
BackupTiltSource(0:adcp,1:nav,2:man,3:PASHR,4:PASHR,ATT,5:PASHR,AT2)=0
NMEAPortForBackupTiltSource=-1
BackupManualPitch=0
BackupManualRoll=0
[Ship Pos Vel NMEA Source Options]
EnableGGASource=TRUE
NmeaPortForGGASource=1
EnableGGABackupSource=FALSE
NmeaPortForGGABackupSource=-1
EnableVTGSource=FALSE
NmeaPortForVTGSource=1

EnableTVGBackupSource=FALSE
NmeaPortForVTGBackupSource=-1
[Averaging Options]
AvgMethod(0:time,1:dist)=0
FirstAvgTime=120
SecondAvgTime=600
FirstAvgDistance=500
SecondAvgDistance=5000
EnableRefLayerAvg=FALSE
RefLayerStartBin=3
RefLayerEndBin=10
[Reference Velocity Options]
RefVelSelect(0:none,1:BT,2:WT,3:LYR,4:NDP,5:NAP,6:NSPD)=1
VelRefLayerStartBin=3
VelRefLayerEndBin=5
RefVelUnitVel(0:mm/s,1:m/s,2:knots,3:ft/s)=1
RefVelUnitDepth(0:m,1:cm,2:ft)=0
[User Exit Options]
UserWinAdcpEnable=FALSE
UserWinAdcpPath=C:\Program Files\RD Instruments\WinAdcp\WinAdcp.exe
UserWinAdcpUpdateInterval(sec)=10
UserWinAdcpFileType(0:enr,1:enx,2:sta,3:lta)=3
UserAdcpScreening=FALSE
UserNavScreening=FALSE
UserTransform=FALSE
[Shiptrack Options]
ShipTrack1Source(0:Nav;1:BT;2:WT;3:Layer)=0
ShipTrack2Source(0:Nav;1:BT;2:WT;3:Layer)=1
ShipTrack1RedStickEnable=TRUE
ShipTrack1GreenStickEnable=FALSE
ShipTrack1BlueStickEnable=FALSE
ShipTrack2RedStickEnable=TRUE
ShipTrack2GreenStickEnable=FALSE
ShipTrack2BlueStickEnable=FALSE
ShipTrack1RedBin=1
ShipTrack1GreenBin=2
ShipTrack1BlueBin=3
ShipTrack2RedBin=1
ShipTrack2GreenBin=2
ShipTrack2BlueBin=3
ShipTrack1DisplaySelect(0:Lat/Lon;1:Distance)=0
ShipTrack2DisplaySelect(0:Lat/Lon;1:Distance)=0
ShipTrack1WaterLayerStartBin=3
ShipTrack1WaterLayerEndBin=5
ShipTrack2WaterLayerStartBin=3
ShipTrack2WaterLayerEndBin=5
ShipTrackDistanceUnit=0
[Narrow Band Shiptrack Options]
RadioBtnSelForShipPosition1DataType=0
RadioBtnSelForShipPosition2DataType=0
ShipTrack1RedStickEnable=TRUE
ShipTrack1GreenStickEnable=FALSE
ShipTrack1BlueStickEnable=FALSE
ShipTrack2RedStickEnable=TRUE

ShipTrack2GreenStickEnable=FALSE
ShipTrack2BlueStickEnable=FALSE
ShipTrack1RedBin=1
ShipTrack1GreenBin=2
ShipTrack1BlueBin=3
ShipTrack2RedBin=1
ShipTrack2GreenBin=2
ShipTrack2BlueBin=3
[ADCP Setup Options]
SetProfileParameters=TRUE
NumberOfBins=96
BinSize(meters)=4
BlankDistance(meters)=4
TransducerDepth(meters)=5.3
SetBTEnable(0:SendBPCmd,1:Don'tSendBPCmd)=TRUE
ADCPSetupMethod(0:Options,1:CommandFile)=0
BtmTrkEnable(0:SendBP0,1:SendBP1)=1
MaxRange(meters)=400
SetHdgSensorType=TRUE
HdgSensorType(0:internal,1:external)=1
SetTiltSensorType=TRUE
TiltSensorType(0:internal,1:external)=1
SetProcessingMode=TRUE
BandwidthType(0:Wide,1:Narrow)=0
ADCPTimeBetweenEnsemblesSel=0
ADCPTimeBetweenEnsembles=0

75 kHz vessel mounted Acoustic Doppler Current Profiler

During D350 the OS75 was configured to sample over 100 bins of 8 m depth with both 2 minute and 10 minute averages. The acquisition PC was running RDI software VmDAS v1.46. Gyro heading and GPS Ashtech, location and time were automatically fed into the software which was configured to use the Gyro heading. For the majority of the cruise the instrument was operated in water tracking mode with the exception of cruise start and cruise end when the bottom was shallow enough (<800m) to provide calibration of the instrument.

Sequentially numbered files were created whenever data logging was stopped and restarted (usually once a day). All data were manually transferred to the Unix directory /data32/D350/os75/raw for further processing as it was noted that file sizes tended to differ when the data was automatically written to the Unix directory by VmDAS.

s75exec0: This exec reads data from RDI binary files into pstar equivalents. Water track velocities are written into 'sur…' files, bottom track velocities into 'bot…' files. Velocities scaled to cm/s and amplitude by 0.45 to dB. The time variable was corrected to GPS time by combining the PC clock time and the PC-GPS offset. The depth of each bin was determined from the user supplied information and calculated as:

Depth of 1st bin = transducer depth (5 m) + blank distance (8 m) + half bin size (4 m) = 17 m.

Output files: sur350##.raw and sbt350##.raw

s75exec1: data edited according to status flags beam 1 data. Velocity replaced with absent data if variable 2+bmbad was greater than 25% (this being a measure of the number of times more than 1 beam was bad).

Output files: sur350## and sbt350##

s75exec2: Merges the ADCP data with the ashtech a-ghdg created by ashexec2. The ADCP velocities are converted to speed and direction so that the heading correction could be applied and then returned to east and north components.

Output files: sur350##.true and sbt350##.true

s75exec3: Applies the misalignment angle (ϕ) and scaling factor (A) to both files (if both are present). Variables are renamed and reordered to preserve original data files.

Output files: sur350##.cal and sbt350##.cal

s75exec4: merges the ADCP data with the bestnav navigation file (abnv3501) created by *navexec0*. Ship's velocity was calculated from spot positions taken from the abnv3501 file and applied to the ADCP velocities. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 5 minute ensemble by subtracting 150 seconds and new positions were taken from abnv3501.

Output files: sur350##.abs and sbt350##.abs

Calibration for misalignment angle and scaling factor

Calibration of the OS75 was conducted during the run out from Glasgow towards the continental shelf edge. The calculated calibration coefficients were:

ϕ (misalignment angle) = 2.8208^{o}

A (scaling factor) = 1.0018^{o}.

File No.	Data filename (Short Term Average)	Bottom Track	Comments
1	D350001_000000.STA	Yes	Problem with time base
2	D350002_000000.STA	Yes	
3	D350003_000000.STA	No	Problem with time base
4	D350004_000000.STA	No	
5	D350005_000000.STA	No	
6	D350006_000000.STA	No	Problem with time base
7	D350007_000000.STA	No	Problem with time base
8	D350008_000000.STA	No	
9	D350009_000000.STA	No	
10	D350010_000000.STA	No	Problem with time base
11	D350011_000000.STA	No	
12	D350012_000000.STA	No	
13	D350013_000000.STA	No	

14	D350014_000000.STA	No
15	D350015_000000.STA	No
16	D350016_000000.STA	No
17	D350017_000000.STA	No
18	D350018_000000.STA	No

Summary table of OS75 kHz VM-ADCP datafiles

OS75 – Config File (D350_BT_on.ini)

[Version Info]
VmDasVersion=Version 1.46
Option Table Version=1
[Expert only options]
SaveOnlyChangedOptions=TRUE
TurnedOffBeam=0
PashrImuFlagUseNormalInterpretation=TRUE
[ADCP Port Setup]
AdcpComPortName=COM1
AdcpComBaudRate=9600
AdcpComParity=NOPARITY
AdcpComStopBits=1
AdcpComDataBits=8
ADCPSoftBreak=FALSE
TimeoutNoRespCmd=1000
TimeoutHaveCharCmd=100
TimeoutNoRespSlowCmd=10000
TimeoutHaveCharSlowCmd=10000
TimeoutNoRespBreak=3000
TimeoutHaveCharBreak=2000
TimeoutNoEns=0
[NMEA Port Setup]
NmeaNavComEnable=TRUE
NmeaNavComPortName=COM2
NmeaNavComBaudRate=4800
NmeaNavComParity=NOPARITY
NmeaNavComStopBits=1
NmeaNavComDataBits=8
NmeaRPHComEnable=TRUE
NmeaRPHComPortName=COM3
NmeaRPHComBaudRate=9600
NmeaRPHComParity=NOPARITY
NmeaRPHComStopBits=1
NmeaRPHComDataBits=8
Nmea3ComEnable=FALSE
Nmea3ComPortName=None
Nmea3ComBaudRate=4800
Nmea3ComParity=NOPARITY
Nmea3ComStopBits=1
Nmea3ComDataBits=8
Nmea Nav Ethernet Enable=FALSE
Nmea Nav IP Addy=0.0.0.0
Nmea Nav Ethernet Port=5678
Nmea Nav Ethernet Connection Type TCP-UDP=1
Nmea Nav Ethernet Service Type Server-Client=1

Nmea Nav Ethernet Broadcast flag=FALSE
Nmea RPH Ethernet Enable=FALSE
Nmea RPH IP Addy=0.0.0.0
Nmea RPH Ethernet Port=5679
Nmea RPH Ethernet Connection Type TCP-UDP=1
Nmea RPH Ethernet Service Type Server-Client=1
Nmea RPH Ethernet Broadcast flag=FALSE
Nmea3 Ethernet Enable=FALSE
Nmea3 IP Addy=0.0.0.0
Nmea3 Ethernet Port=5680
Nmea3 Ethernet Connection Type TCP-UDP=1
Nmea3 Ethernet Service Type Server-Client=1
Nmea3 Ethernet Broadcast flag=FALSE
[NMEA Comm window]
NoDataTimeout(ms)=5000
AutoOpen=TRUE
NumNmeaDisplayedOnErrRecovery=10
[Serial Port for Binary Ensemble Data Output]
BinaryEnsembleOutputComEnable=FALSE
BinaryEnsembleOutputComPortName=None
BinaryEnsembleOutputComBaudRate=9600
BinaryEnsembleOutputComParity=NOPARITY
BinaryEnsembleOutputComStopBits=1
BinaryEnsembleOutputComDataBits=8
BinaryEnsembleOutputDataType(0:none;1:enr;2:enx;3:sta;4:lta)=0
BinaryEnsembleOutputRefVelType(0:none;1:Bottom;2:Mean)=0
BinaryEnsembleOutputStartBin=1
BinaryEnsembleOutputEndBin=4
BinaryEnsembleOutputMeanStartBin=1
BinaryEnsembleOutputMeanEndBin=4
BinaryEnsembleOutputLeader(0:no;1:yes)=FALSE
BinaryEnsembleOutputBottomTrack(0:no;1:yes)=FALSE
BinaryEnsembleOutputNavigation(0:no;1:yes)=TRUE
BinaryEnsembleOutputVelocity(0:no;1:yes)=TRUE
BinaryEnsembleOutputIntensity(0:no;1:yes)=TRUE
BinaryEnsembleOutputCorrelation(0:no;1:yes)=TRUE
BinaryEnsembleOutputPercentGood(0:no;1:yes)=TRUE
BinaryEnsembleOutputStatus(0:no;1:yes)=TRUE
BinaryEnsembleOutputNetEnable=FALSE
BinaryEnsembleOutputIPPortNumber=5433
=0.0.0.0
BinaryEnsembleOutputConType=1
BinaryEnsembleOutputSvcType=1
BinaryEnsembleOutputBcast=FALSE
[Serial Port for ASCII Ensemble Data Output]
AsciiEnsembleOutputComEnable=FALSE
AsciiEnsembleOutputComPortName=None
AsciiEnsembleOutputComBaudRate=9600
AsciiEnsembleOutputComParity=NOPARITY
AsciiEnsembleOutputComStopBits=1
AsciiEnsembleOutputComDataBits=8
AsciiEnsembleOutputDataType(0:none;1:enr;2:enx;3:sta;4:lta)=0
AsciiEnsembleOutputRefVelType(0:none;1:Bottom;2:Mean)=0
AsciiEnsembleOutputStartBin=1

AsciiEnsembleOutputEndBin=4
AsciiEnsembleOutputStoreToDisk(0:no;1:yes)=FALSE
AsciiEnsembleOutMeanStartBin=1
AsciiEnsembleOutputMeanEndBin=4
AsciiEnsembleOutputLeader(0:no;1:yes)=TRUE
AsciiEnsembleOutputBottomTrack(0:no;1:yes)=TRUE
AsciiEnsembleOutputNavigation(0:no;1:yes)=TRUE
AsciiEnsembleOutputVelocity(0:no;1:yes)=TRUE
AsciiEnsembleOutputIntensity(0:no;1:yes)=TRUE
AsciiEnsembleOutputCorrelation(0:no,1:yes)=TRUE
AsciiEnsembleOutputPercentGood(0:no;1:yes)=TRUE
AsciiEnsembleOutputStatus(0:no;1:yes)=TRUE
BinaryEnsembleOutput Ascii NetEnable=FALSE
BinaryEnsembleOutput Ascii IPPortNumber=5433
BinaryEnsOutAscii IP=0.0.0.0
BinaryEnsembleOutput Ascii ConType=1
BinaryEnsembleOutputAscii SvcType=1
BinaryEnsembleOutputAscii Bcast=FALSE
[Serial Port for Speed Log Output]
SpeedLogComEnable=FALSE
Speed Log ComPortName=None
Speed Log ComBaudRate=9600
Speed Log ComParity=NOPARITY
Speed Log ComStopBits=1
Speed Log ComDataBits=8
SpeedLogDataSource=STA
SpeedLogWLSource=WP
SpeedLogWLStartBin=3
SpeedLogWLEndBin=5
BinarySpeedLog NetEnable=FALSE
BinarySpeedLog IPPortNumber=5434
BinarySpeedLog Ip Addy=0.0.0.0
BinarySpeedLog ConType=1
BinarySpeedLog SvcType=1
BinarySpeedLog Bcast=FALSE
[Fake Data Options]
AdcpSimInAirEnable=FALSE
AdcpFakeDataEnable=FALSE
AdcpFakeDataFilename=SimAdcp.enr
FakeDataTimeBetweenEnsembles=2
NMEAFakeDataEnable=FALSE
NMEAFakeDataFilename=SimNav.nmr
[File Name Components]
EnableDualRecordDir=TRUE
FileRecordPath=C:\RDI\ADCP\D350_OS75\
FileRecordBackupPath=Z:\d350\os75\raw\
DeploymentName=D350
DeploymentNumber=1
MaximumFileSize=100
[Bottom Track Data Screening Options]
BTAmpScreenEnable=FALSE
BTCorScreenEnable=FALSE
BTErrScreenEnable=FALSE
BTVertScreenEnable=FALSE

BTFishScreenEnable=FALSE
BTPctGoodScreenEnable=FALSE
BTAmplitudeThreshold=30
BTCorrelationThreshold=220
BTErrorVelThreshold=1000
BTVerticalVelThreshold=1000
BTFishThreshold=50
BTPctGoodThreshold=50
[Water Track Data Screening Options]
WTAmpScreenEnable=FALSE
WTCorScreenEnable=FALSE
WTErrScreenEnable=FALSE
WTVertScreenEnable=FALSE
WTFishScreenEnable=FALSE
WTPctGoodScreenEnable=FALSE
WTAmplitudeThreshold=30
WTCorrelationThreshold=180
WTErrorVelThreshold=1000
WTVerticalVelThreshold=1000
WTFishThreshold=50
WTPctGoodThreshold=50
[Profile Data Screening Options]
PRAmpScreenEnable=FALSE
PRCorScreenEnable=FALSE
PRErrScreenEnable=FALSE
PRVertScreenEnable=FALSE
PRFishScreenEnable=FALSE
PRPctGoodScreenEnable=FALSE
PRMarkBadBelowBottom=FALSE
PRAmplitudeThreshold=30
PRCorrelationThreshold=180
PRErrorVelThreshold=1000
PRVerticalVelThreshold=1000
PRFishThreshold=50
PRPctGoodThreshold=50
[2nd Band Profile Data Screening Options]
PRAmpScreenEnable=FALSE
PRCorScreenEnable=FALSE
PRErrScreenEnable=FALSE
PRVertScreenEnable=FALSE
PRFishScreenEnable=FALSE
PRPctGoodScreenEnable=FALSE
PRAmplitudeThreshold=30
PRCorrelationThreshold=180
PRErrorVelThreshold=1000
PRVerticalVelThreshold=1000
PRFishThreshold=50
PRPctGoodThreshold=50
[Transformation Options]
XformToEarth=TRUE
Allow3Beam=TRUE
BinMap=TRUE
BeamAngleSrc(0:auto,1:man)=0
ManualBeamAngle=30

HeadingSource(0:adcp,1:navHDT,2:navHDG,3:navPRDID,4:manual)=1
NMEAPortForHeadingSource=1
ManualHeading=0
TiltSource(0:adcp,1:nav,2:man)=2
NMEAPortForTiltSource=-1
ManualPitch=0
ManualRoll=0
SensorConfigSrc(0:PRfixed,1:Pfixed,2:auto)=2
ConcavitySource(0:convex,1:concave,2:auto)=2
UpDownSource(0:dn,1:up,2:auto)=2
EnableHeadingCorrections=FALSE
SinCorrectionAmplitudeCoefficient=0
SinCorrectionPhaseCoefficient=0
MagneticOffsetEV=0
BackupMagneticOffsetEV=0
AlignmentOffsetEA=0
EnableVelocityScaling=FALSE
VelocityScaleFactorForBTVelocities(unitless)=1
VelocityScaleFactorForProfileAndWTVelocities(unitless)=1
EnableTiltAlignmentErrorCorrection=TRUE
TiltAlignmentHeadingCorr(deg)=0
EAOptionSource=TRUE
TiltAlignmentPitchCorr(deg)=0
TiltAlignmentRollCorr(deg)=0
[2nd Band Transformation Options]
EnableVelocityScaling=FALSE
VelocityScaleFactorForProfileVelocities(unitless)=1
[Backup HPR NMEA Source Options]
EnableBackupHeadingSource=FALSE
BackupHeadingSource(0:adcp,1:navHDT,2:navHDG,3:navPRDID,4:manual,5:PASHR,6:PASHR,
ATT,7:PASHR,AT2)=3
NMEAPortForBackupHeadingSource=2
BackupManualHeading=0
EnableBackupTiltSource=FALSE
BackupTiltSource(0:adcp,1:nav,2:man,3:PASHR,4:PASHR,ATT,5:PASHR,AT2)=0
NMEAPortForBackupTiltSource=-1
BackupManualPitch=0
BackupManualRoll=0
[Ship Pos Vel NMEA Source Options]
EnableGGASource=TRUE
NmeaPortForGGASource=1
EnableGGABackupSource=FALSE
NmeaPortForGGABackupSource=-1
EnableVTGSource=FALSE
NmeaPortForVTGSource=1
EnableTVGBackupSource=FALSE
NmeaPortForVTGBackupSource=-1
[Averaging Options]
AvgMethod(0:time,1:dist)=0
FirstAvgTime=120
SecondAvgTime=600
FirstAvgDistance=500
SecondAvgDistance=5000
EnableRefLayerAvg=FALSE

RefLayerStartBin=3
RefLayerEndBin=10
[Reference Velocity Options]
RefVelSelect(0:none,1:BT,2:WT,3:LYR,4:NDP,5:NAP,6:NSPD)=1
VelRefLayerStartBin=3
VelRefLayerEndBin=5
RefVelUnitVel(0:mm/s,1:m/s,2:knots,3:ft/s)=1
RefVelUnitDepth(0:m,1:cm,2:ft)=0
[User Exit Options]
UserWinAdcpEnable=FALSE
UserWinAdcpPath=C:\Program Files\RD Instruments\WinAdcp\WinAdcp.exe
UserWinAdcpUpdateInterval(sec)=10
UserWinAdcpFileType(0:enr,1:enx,2:sta,3:lta)=3
UserAdcpScreening=FALSE
UserNavScreening=FALSE
UserTransform=FALSE
[Shiptrack Options]
ShipTrack1Source(0:Nav;1:BT;2:WT;3:Layer)=0
ShipTrack2Source(0:Nav;1:BT;2:WT;3:Layer)=1
ShipTrack1RedStickEnable=TRUE
ShipTrack1GreenStickEnable=FALSE
ShipTrack1BlueStickEnable=FALSE
ShipTrack2RedStickEnable=TRUE
ShipTrack2GreenStickEnable=FALSE
ShipTrack2BlueStickEnable=FALSE
ShipTrack1RedBin=1
ShipTrack1GreenBin=2
ShipTrack1BlueBin=3
ShipTrack2RedBin=1
ShipTrack2GreenBin=2
ShipTrack2BlueBin=3
ShipTrack1DisplaySelect(0:Lat/Lon;1:Distance)=0
ShipTrack2DisplaySelect(0:Lat/Lon;1:Distance)=0
ShipTrack1WaterLayerStartBin=3
ShipTrack1WaterLayerEndBin=5
ShipTrack2WaterLayerStartBin=3
ShipTrack2WaterLayerEndBin=5
ShipTrackDistanceUnit=0
[Narrow Band Shiptrack Options]
RadioBtnSelForShipPosition1DataType=0
RadioBtnSelForShipPosition2DataType=0
ShipTrack1RedStickEnable=TRUE
ShipTrack1GreenStickEnable=FALSE
ShipTrack1BlueStickEnable=FALSE
ShipTrack2RedStickEnable=TRUE
ShipTrack2GreenStickEnable=FALSE
ShipTrack2BlueStickEnable=FALSE
ShipTrack1RedBin=1
ShipTrack1GreenBin=2
ShipTrack1BlueBin=3
ShipTrack2RedBin=1
ShipTrack2GreenBin=2
ShipTrack2BlueBin=3
[ADCP Setup Options]

SetProfileParameters=TRUE
NumberOfBins=100
BinSize(meters)=8
BlankDistance(meters)=8
TransducerDepth(meters)=5.3
SetBTEnable(0:SendBPCmd,1:Don'tSendBPCmd)=TRUE
ADCPSetupMethod(0:Options,1:CommandFile)=0
BtmTrkEnable(0:SendBP0,1:SendBP1)=1
MaxRange(meters)=800
SetHdgSensorType=TRUE
HdgSensorType(0:internal,1:external)=1
SetTiltSensorType=TRUE
TiltSensorType(0:internal,1:external)=1
SetProcessingMode=TRUE
BandwidthType(0:Wide,1:Narrow)=0
ADCPTimeBetweenEnsemblesSel=0
ADCPTimeBetweenEnsembles=0

SeaSoar CTD Data

- Stuart Painter, Stephanie Henson, (University of Southampton, National Oceanography Centre, UK)

Dougal Mountifield (Nationa Marine Facilities, National Oceanography Centre, UK)

SeaSoar was deployed twice during D350. Significant technical problems were experienced with the winch system (non-functioning load cell) and with the instrumentation payload (Minipack CTD) which delayed deployment of SeaSoar until quite late in the cruise. See the technical report section for a fuller description of the problems encountered and of the solutions found. During the first deployment a critical failure of the Minipack CTD after 5 hours terminated data collection. This failure was traced back to a dead battery located on one of the Minipack circuit boards (specifically the RAM battery backup). This was replaced with a battery scavenged from the original non-functioning Minipack unit that was removed from SeaSoar early in the cruise. The following is a brief account of how SeaSoar was instrumented and what data files were collected. Limited data processing was attempted on board.

Tow	Start Date & Time	Stop Date & Time	Notes
1	04/05/2010 16:26	05/05/2010 02:50	Profiling terminated at 22:00 due to failure of Minipack CTD system. SeaSoar was towed until recovery at 02:50
2	07/05/2010 16:00	08/05/2010 00:30	This tow occurred with minimal problems, the SeaSoar controller crashed once necessitating an emergency surface at 00:00.

Summary of SeaSoar tows.

Instrumentation

The SeaSoar system is currently equipped with a Chelsea Technologies Group (CTG) Minipack CTDF (Conductivity, Temperature, Depth and Fluorescence) instrument. SeaSoar was also equipped with the SUV-6 UV nitrate Sensor, a PML PAR sensor, a Brooke Ocean laser optical plankton counter (LOPC), a CTG Fast Repetition Rate Fluorimeter (FRRF), one Aanderaa Optode oxygen sensor, four Turner Designs filtered fluorometers and a CTG *Glowtracka* bioluminescence sensor.

During SeaSoar deployments data were recovered, in real time, from the PENGUIN data handling system on SeaSoar by ftp to create identical data files on the EMPEROR topside Linux PC in the main lab. Data were logged in four files, one containing the minipack CTDF measurements and associated additional analogue channels, and three other files for the FRRF, LOPC and SUV-6 nitrate sensor data.

Since its last deployment in 2007 Seasoar has undergone some enhancements including the fitting of the LOPC and changes to the way in which data is retrieved from the vehicle whilst in use. Both the FRRf and LOPC instruments can now be accessed in real time using the respective manufacturer's software running on topside laptops through the application of a LINUX software programme called *soccat*. This allows a direct link to be established between the laptops and the instruments giving the user direct control over the instrument, allowing changes to the settings to be made whilst SeaSoar is deployed and for data to be processed in real time. This procedure worked extremely well for both the FRRf and LOPC however the LOPC software was prone to crashing, requiring the software to be restarted on a regular basis. No data was lost during the software crashes as the data is stored locally in a memory buffer on SeaSoar until communication is re-established. Consideration will need to be given on how best to process and integrate the LOPC data.

All of the variables output by the MiniPack CTDF were calibrated using pre-set calibrations stored in the instrument firmware. The sensors are sampled in the MiniPack at 16 Hz, but the data are 1Hz averaged prior to the output data stream from the MiniPack. The variables output from the Minipack were:

Conductivity ($mScm^{-1}$)

Temperature (°C)

Pressure (dbar)

ΔT ($°Cs^{-1}$), temperature change over the one second averaging period.

Chlorophyll-*a* ($mg\ m^{-3}$)

Each of these were output at one second intervals and a time/date stamp was added by the DAPS handling software on PENGUIN. The time rate of change of temperature, ΔT ($°Cs^{-1}$), is the difference between the first and the last sample in the one second average of temperature. In addition to the MiniPack fluorimeter, SeaSoar was fitted with four Turner Designs CYCLOPS-7 submersible fluorometers, which were connected to the MiniPack analogue instrument channels, as were the Aanderaa Optode oxygen, PML PAR, and CTG *GlowTracka* bioluminescence sensors.

Turner Designs chlorophyll-a sensor, serial no. 2100432

Turner Designs Phycocyanin sensor, serial no. 2100433
Turner Designs Phycoerythrin sensor, serial no. 2100594
Turner Designs CDOM "U" sensor, serial no. 2100595
Anderaa Data Instruments Oxygen Optode 3830, serial no. 891
PML PAR sensor, serial no. 0064-3097
Chelsea TG Glowtracka Bioluminescence sensor – s/n's 07-6244-001 & 002

Processing steps

Due to the limited collection of data and uncertainty regarding the nature of the instrumentation failure, only the initial data processing step was undertaken for the Minipack data.

pgexec0: Read the raw DAPS (minipack) data into Pstar format and added information to the Pstar header. In addition time in seconds was calculated from the jday variable used by DAPS. Note that it was necessary to use the -square command line option for the pexec program pxtime. Unless this option was specified pxtime rounded the time to the nearest second occasionally giving rise to two records having the same time.

Minipack data file structure(Channel)	Data stream
1	Jday
2	Day
3	Month
4	Year
5	Hour
6	Minute
7	Seconds
8	Conductivity
9	Temperature
10	Pressure
11	Fluorescence
12	Battery Voltage
13	Battery Current
14	-
15	-
16	-
17	-
18	-
19	Chromophoric Dissolved Organic Matter (CDOM)
20	Phycocyanin
21	Phycoerythrin
22	Chlorophyll-a fluorescence (Turner)
23	-
24	Aanderaa Optode oxygen
25	Aanderaa Optode temperature
26	- (But usually used for Seabird SBE43
27	CTG Glowtracka Bioluminescence sensor
28	PAR
29	-
30	-
31	-

Summary of the Minipack data format

Instrument	Date files	Instrument	Date files
SUV6	SUV6256.000	Minipack	Minipack250.000
	SUV6345.000		Minipack346.000
	SUV6391.000		Minipack392.000
	SUV6305.000		
		LOPC	LOPC_2010-05-04_154046.dat
FRRf	File001.fnp		LOPC_2010-05-04_173217.dat
	File002.fnp		LOPC_2010-05-04_184747.dat
	File003.fnp		LOPC_2010-05-04_193715.dat
	File004.fnp		LOPC_2010-05-04_200630.dat
	File005.fnp		LOPC_2010-05-04_212129.dat
	File006.fnp		LOPC_2010-05-04_212237.dat
			LOPC_2010-05-04_220903.dat
			LOPC_2010-05-04_220920.dat
			LOPC_2010-05-04_222624.dat
			LOPC_2010-05-04_222647.dat
			LOPC_2010-05-04_230642.dat
			LOPC_2010-05-04_231506.dat
			LOPC_2010-05-04_233305.dat
			LOPC_2010-05-04_234815.dat
			LOPC_2010-05-05_002650.dat
			LOPC_2010-05-05_003858.dat

List of data file produced during Tow 1

Instrument	Date files	Instrument	Date files
SUV6	SUV6254.000	Minipack	Minipack255.000
	SUV6300.000		Minipack301.000
	SUV6325.000		Minipack324.000
	SUV6348.000		Minipack349.000
	SUV6373.000		Minipack372.000
	SUV6397.000		Minipack396.000
	SUV6421.000		Minipack420.000
	SUV6445.000		Minipack444.000
FRRf	File001.fnp	LOPC	LOPC_2010-05-07_160423.dat
	File002.fnp		LOPC_2010-05-07_175043.dat
	File003.fnp		LOPC_2010-05-07_191413.dat
	File004.fnp		LOPC_2010-05-07_200926.dat
	File005.fnp		LOPC_2010-05-07_212442.dat
	File006.fnp		LOPC_2010-05-07_222212.dat
	File007.fnp		LOPC_2010-05-07_225940.dat
	File008.fnp		LOPC_2010-05-07_232706.dat
			LOPC_2010-05-07_002316.dat

List of data file produced during Tow 2

CTD CRUISE REPORT D350

CTD DATA AQUISITION AND PROCESSING

Stuart Painter, Stephanie Henson (University of Southampton, National Oceanography Centre, UK)*, Jeff Benson, Jon Short, Dougal Mountifield (National Marine Facilities, National Oceanografy VCentre, Southampton, UK)*

Station List

CTD stn.	Cruise Identifier	Date (ddmmyy)	jday	time	Lat (N)	Lon (W)	Cast types
1	Ctd_S_001	29.04.2010	119	13.10	59 00.44	24 11.81	StS
2	Ctd_T_001	29.04.2010	119	15.15	59 00.24	24 11.81	TiT
3	Ctd_T_002	01.05.2010	121	03.04	60 59.67	35 00.35	TiT
4	Ctd_S_002	01.05.2010	121	04.45	60 58.91	34 59.39	StS
5	Ctd_S_003	01.05.2010	121	06.52	60 58.30	34 56.95	StS
6	Ctd_T_003	01.05.2010	121	13.27	60 56.66	34 52.31	TiT
7	Ctd_S_004	01.05.2010	121	22.33	60 00.18	35 00.33	StS
8	Ctd_S_005	02.05.2010	122	07.57	60 01.40	34 57.61	StS
9	Ctd_T_004	02.05.2010	122	09.35	60 02.37	34 57.47	TiT
10	Ctd_S_006	03.05.2010	123	03.12	59 59.98	31 59.60	StS
11	Ctd_S_007	03.05.2010	123	06.47	60 00.17	31 58.82	StS
12	Ctd_T_005	03.05.2010	123	12.00	59 59.54	37 55.98	TiT
13	Ctd_T_006	04.05.2010	124	04.30	59 59.78	29 00.42	TiT
14	Ctd_S_008	04.05.2010	124	06.32	59 59.43	28 59.78	StS
15	Ctd_S_009	04.05.2010	124	08.36	59 59.89	28 59.76	StS
16	Ctd_T_007	04.05.2010	124	13.51	59 58.51	29 01.02	TiT
17	Ctd_S_010	05.05.2010	125	04.00	59 56.64	26 10.84	StS
18	Ctd_S_011	05.05.2010	125	07.15	59 56.1	26 07.48	StS
19	Ctd_T_008	05.05.2010	125	11.37	59 54.45	26 02.34	TiT
20	Ctd_S_012	06.05.2010	126	04.02	60 51.39	21 45.91	StS
21	Ctd_S_013	06.05.2010	126	07.18	60 50.78	21 45.07	StS
22	Ctd_T_009	06.05.2010	126	00.00	60 50.60	21 44.54	TiT
23	Ctd_S_014	07.05.2010	127	02.06	61 59.51	20 00.41	StS
24	Ctd_S_015	07.05.2010	127	06.40	61 59.95	19 59.96	StS
25	Ctd_T_010	07.05.2010	127	10.40	61 57.41	20 01.97	TiT
26	Ctd_S_016	08.05.2010	128	02.05	63 08.16	19 54.62	StS
27	Ctd_S_017	08.05.2010	128	05.29	63 07.83	19 54.98	StS
28	Ctd_T_011	08.05.2010	128	09.38	63 05.27	19 52.54	TiT

Data Processing

Data Processing using the SeaBird Software on the data-logging PC

Following each cast the logging was stopped and the data saved to the deck unit PC. The logging software outputs four files per CTD cast in the form CTDSnnn or CTDTnnn with the following extensions: .dat (raw data file), .con (data configuration file), .btl (record of bottle firing locations), and .hdr (a header file). The identifiers T and S were used to denote the titanium or stainless steel CTD rosette and nnn the cast number.

These files were manually backed up onto the UNIX network, via ftp to the file location /data32/d350/ctd/StS/raw or /data32/d350/ctd/TiT/raw. The raw data files were then processed using SeaBird's own CTD data processing software, SBEDataProcessing-Win32: v.7.2a. SeaBird CTD processing routines were used as follows.

DatCnv: The Data Conversion routine, DatCnv, read in the the raw CTD data file (e.g. CTDSnnn.dat). This contained the raw CTD data in engineering units output by the SeaBird hardware on the CTD rosette. DatCnv requires a configuration file that defines the calibrated CTD data output so that it is in the correct form to be read into the Pstar format on the UNIX system. The output file (CTDSnnn.cnv) format was set to binary and to include both up and down casts. A second output file (CTDSnnn.ros) contained bottle firing information, taking the output data at the instant of bottle firing.

AlignCTD: This program read in CTDSnnn.cnv and was set to shift the oxygen sensor relative to the pressure data by 5 seconds compensating for lags in the sensor response time. The output was written over the input file.

WildEdit: A de-spiking routine, the input and output files again were CTDSnnn.cnv. The data was scanned twice calculating the standard deviation of a set number of scans, setting values that are outside a set number of standard deviations (sd) of the mean to bad data values. On this cruise, the scan range was set to 500, with 2 sd's on the first pass and 10 sd's on the second.

CellTM: The effect of thermal 'inertia' on the conductivity cells was removed using the routine CellTM. It should be noted that this routine must only be run after Wildedit or any other editing of bad data values. This routine uses the temperature variable to adjust the conductivity values and if spikes exist in the former they are amplified in the latter. The algorithm used was:

$$dt = t_i - t_{i-7}$$
$$ctm_i = -b * ctm_{i-7} + a * \partial c \partial t * dt$$
$$c_{cor,i} = c_{meas,i} + ctm_i$$
$$a = \frac{2\alpha}{7\Delta * \beta + 2}$$
$$b = 1 - 2a/\alpha$$
$$\partial c \partial t = 0.8 * (1 + 0.006 * (t_i - 20))$$

where α, the thermal anomaly amplitude was set at 0.03 and β, the thermal anomaly time constant was set at 1/7 (the SeaBird recommended values for SBE911+ pumped system). Δ is the sample interval (1/24 second), dt is the temperature (t) difference taken at a lag of 7 sample intervals. $c_{cor,i}$ is the corrected conductivity at the current data cycle (i), $c_{meas,i}$ the raw value as logged and ctm_i is the correction required at the current data cycle, $\partial c \partial t$ is a correction factor that is a slowly varying function of temperature deviation from 20 °C.

Translate: Finally, the CTDSnnn.cnv file was converted from binary into ASCII format so that it could be easily read into Pstar format. The header information was checked at this stage to ensure that all of the processes had been performed on each station.

The .cnv and .ros files were then copied via ftp to /data32/d350/ctd/StS/SBEprocessed or to /data32/d350/ctd/TiT/SBEprocessed so that data processing could be continued using PEXEC routines.

Data Processing on the UNIX system

The following Pstar scripts were used to process the data. Two versions of all the scripts were created, one for the stainless steel frame and one for the titanium frame CTD (denoted by *s* or *t* in the script name).

ctds0 and ctdt0: These scripts read in the SeaBird processed ascii file (.cnv) and converted it into Pstar format, also setting the required header information. The latitude and longitude of the ship when the CTD was at the bottom were typed in manually and added to the header. The output file contained the data averaged to 24hz. The output file was ctd350nnn.24hz or ctd350nnnT.24hz

ctds1 and ctdt1: These scripts operated on the .24hz file and used the PEXEC program *pmdian* to remove residual spikes from all of the variables. The data were then averaged into a 1hz file using *pavrge*. Absent data values in the pressure data were interpolated across using *pintrp*. Salinity, potential temperature, sigma0 and sigma2 (referenced to 2000 db) were calculated using *peos83* and finally a 10 second averaged file was also created. The output files were ctd350nnn.1hz and ctd350nnn.10s or ctd350nnnT.1hz and ctd350nnnT.10s.

ctds2 and ctdt2: These scripts carried out a head and tail crop of the .1hz file to select the appropriate data cycles for just the up and down casts of the CTD. Before running ctd2, the .1hz files were examined in *mlist* to determine the data cycles for i) the shallowest depth of the CTD rosette after the initial soaking at 10m, ii) the greatest depth, and iii) the last good point before the CTD is removed from the water. These values were then manually entered at the correct screen prompts in ctd2. The data were then cut out with *pcopya* and the file ctd350nnn.ctu or ctd350nnnT.ctu created. Finally, the data were averaged into two db pressure bins creating the files ctd350nnn.2db or ctd350nnnT.2db.

fir and firt0:: These scripts converted the .ros file into Pstar format. It then took the relevant data cycles from the .10s averaged file (secondary output from ctd1) and pasted it into a new file fir350nnn containing the mean values of all variables at the bottle firing locations.

samfir and samfirt: These scripts created the file, sam350nnn, containing selected variables from fir350nnn or fir350nnnT so that the results from the bottle sampling analysis could be added.

Once salinity bottle data had been processed, and txt files created for each CTD cast, then the following scripts were run.

Sal and salt0: Read in the sample bottle txt files, that had been saved as tab delimited text only files, and converted some PC unique characters into UNIX friendly characters. Then sal0 created Pstar format files with *pascin* and output file sal350nnn.bot

Passal and passalt: Pastes bottle file (sal350nnn.bot) values into sam350nnn files.

The final conductivity calibration was not attempted at sea and will be applied to the CTD data upon return to NO

Salinity Bottle Samples

- Stephanie Henson, Stuart Painter (University of Southampton, National Oceanography Centre, UK)

Salinity samples were drawn from the Niskin bottles mounted on the CTD rosette from the deepest depth, and several depths below ~ 150 m. Samples were taken from both the stainless steel and titanium frame CTDs (where titanium samples where taken in the clean lab by the trace metal scientists). Samples were taken using 200 mL glass sample bottles that were rinsed three times in the sample water, filled to the shoulder and sealed with a disposable plastic insert and the bottle's own screw cap. Samples were also taken from the ThermoSalinoGraph (TSG) every hour whilst steaming to calibrate the continual TSG measurements.

The salinometer for on-board salinity determination was sited in the gravimetric lab (maintained at 21 ºC); a Guildline model 8400B Autosal salinometer serial no. 68958 fitted with a peristaltic pump. Once a crate of sample bottles had been filled they were moved into the gravimetric lab to stand for 24 hours prior to analysis. Standardisation was performed using IAPSO Standard Seawater batch P151 before the analysis of each crate.

NMFSS's Autosal software was used throughout. The software and the Autosal worked well and the stability of measurements, determined by monitoring the standard deviation of salinity measurements, was good.

Some initial problems with suspected operator error meant that salinity readings from the 1st crate of TSG samples and 1st crate of CTD samples were suspect. Once this had been resolved, good quality salinity readings were obtained. Occasional poor sampling, *i.e.* salt in the bottle caps, bottles being overfilled etc. was experienced, but overall standards were high.

Following salinometer processing, the data was copied from the un-networked salinometer PC to a thumb drive, and then onto the network. For underway samples, a spreadsheet of bottle numbers and sample times obtained from the raw log sheets were matched with corresponding bottle salinities. For CTD samples, a spreadsheet of bottle salinities and the corresponding Niskin bottle from which they were taken (derived from the raw CTD log sheets) was created for each CTD cast. Data from the files were then incorporated into the sam files using the Pstar scripts *sal0* and *passal*.

Thermosalinograph and Surfmet Data

Instruments

Underway surface meteorology and thermosalinograph measurements were recorded by the RVS Surfmet system. Further details of the instrumentation used are given in the computing and instrumentation section of this cruise report. Large jumps and spikes were observed to occur regularly in the TSG record. Some discontinuities were due to bubbles,

some due to cleaning of the system and some to changes in flow rate. The TSG record will require careful calibration, probably with different corrections for separate sections of the record.

The parameters measured were:

Non-toxic supply
- *Intake water temperature (temp_r)*
- *TSG housing water temperature (temp_h)*
- *Conductivity*
- *Fluorescence (Chl-a)*
- *Turbidity (transmissometer)*

Meteorology
- *Sea level pressure*
- *Air temperature/humidity*
- *Photosynthetically available radiation (PAR) - port/starboard sensors*
- *Total Incident Radiation (TIR) - port/starboard sensors*
- *Wind speed and direction*

Processing

Processing of the underway data was performed daily using the Pstar routines detailed below.

surfmet0: This script was used to read in and convert the data from RVS format to Pstar format using datapup.

Output file: smt350**.raw

surfmet1: This sets absent Surfmet data values to -999. Instrument calibrations are applied by the Surfmet system to the data already so only minimal adjustments are needed in this step. Wind direction is corrected.

Output file: smt350**

surfmet2: The master navigation file (abnv3501) and master Ashtech files (ashmaster) are merged with smt350** at this point to allow accurate heading data to be incorporated into the underway dataset. This step creates the file smt321**.hdg

Output file: smt350**.hdg

A full post-cruise calibration will be conducted upon return to NOC.

Cruise D354

Narrative cruise overview D354

The *RRS Discovery* departed on cruise D354 from Avonmouth, UK, at 0900 h on Sunday 4th July 2010 and docked in Birkenhead, UK, after 37 days at sea at 1400 h on Wednesday 11th August. Cruise 354 was the second cruise of our High Latitude North Atlantic Fe limitation project. Whilst D350 investigated the pre and early bloom conditions in the Iceland and Irminger Basins, D354 investigated further developed conditions of phytoplankton growth and nutrient status in the summer period. Furthermore, prior to and during the D350 cruise, the eruption of an Icelandic volcano (*Eyjafjallajokull*) resulted in the delivery of significant amounts of volcanic ash (including Fe) into the surface ocean of our study region. This provided an excellent opportunity to investigate the effects of ash inputs on iron distributions and ocean productivity.

During the cruise all scientific work was recorded on GMT and ship time was altered from BST (GMT+1hr) to GMT on 5th July. The cruise track during D354 is shown in figure 1, covering a distance of 4678 nautical miles. A total of 33 stations were occupied from 10th July – 5th August 2010, with one shakedown station and 32 principal scientific sampling stations. At 5 stations we stayed on station for at least 24 h to conduct diurnal microbial studies (stations 2, 8, 16, 20/21 and 22). After an initial long passage including the shakedown station and regularly underway sampling for nutrients, chlorophyll and trace metals, intensive over the side scientific work commenced on 11th July, with one major station being occupied daily from 11st July – 7th August inclusive. Once commenced at 0400 h on 7th July underway sampling was maintained while off station at hourly intervals for all parameters other than metals, the latter being collected at 2 hourly intervals. Dates, times and locations of stations together with detailed information of scientific activities on station are provided in the CTD report and the narrative cruise diary (Appendix A). Dates, times and positions of underway samples are also provided in appendix A.

In general, stations were commenced at night (typically at 0200-0300 h) and consisted of sampling from the tow fish for bioassay experiments, a number of CTD casts, using both a stainless steel and a titanium rosette frame, zooplankton net hauls, vertical profiler deployments and Stand Alone Pump Systems (SAPS) deployments. The order of events on station and exact timings of deployments were adjusted depending on scientific staff work schedules and in order to keep bioassay tow fish sampling, zooplankton net hauls and biological stainless steel CTD casts during the hours of darkness where possible. None of the planned stations were aborted for any reason.

A trace metal clean tow fish was also deployed throughout the cruise starting at 1500 h on 9th July with samples being collected every 2 hours whilst off station from 0800 h on 10th July through to 9th August. Water from the epoxy coated fish was pumped directly into a clean chemistry container using a Teflon pump system through acid washed PVC tubing. The system performed well, with a couple of recoveries to undertake repairs to the hose. A wide variety of samples were collected from both the underway supplies and during CTD stations (see scientific reports and appendix A). Although some parameters were measured at sea, the majority of samples will be returned to shore laboratories for analysis.

We have undertaken 4 Pelagra (neutral buoyant sediment traps) deployments for collection of sinking particulate material. Three Pelagra systems were deployed simultaneously at different depths. Following deployment of up to ca. 70-80 h, the units surfaced and were recovered. They recovery procedure was relatively smooth, facilitated by Iridium positioning communication. Particulate matter from the Pelagra deployments will be analysed at NOCS.

Experimental work was also performed on the cruise to measure the biological response to both artificial manipulation of the availability of the micronutrient iron and grazing pressure. Measurements of the uptake rate of various substrates was further performed using a variety of tracer techniques.

Ship departed at 0900 h July 4 from Avonmouth. Rough seas were encountered in the Bristol Channel and St Georges Channel. Majority of science party was affected by seasickness. Weather in Irish Sea improved on July 5. We sailed out of the Northern Channel towards the shelf edge and had planned a first CTD station (shake down) in 1500 m water at 1400 h July 6. This was delayed due to deteriorating weather conditions. The weather conditions were such that in the evening the ship was positioned into the wind and we endured force 9-10 winds. The worst wind conditions occurred at ca. 0400 h July 7, and we incurred damage to scientific equipment and containers on the aft deck and starboard side. Two of the Pelagras were damaged and not useable during the cruise. The other units were repaired and functional. Seasickness of one of the scientists was not improving. Medical advice was sought, and following this we decided to return to port in the UK in the Clyde. Two of the scientists disembarked in Glasgow. The seasick scientist has fully recovered.

On Friday July 9 we sailed to the shelf edge and commenced sampling. The cruise re-visited stations occupied during the D350 cruise, in addition to a range of other stations. The D354 cruise visited the Iceland Basin, where low post bloom chlorophyll a and nitrate concentrations were encountered. The Irminger Basin showed residual nitrate concentrations and with pronounced spatial variations in chlorophyll. The Greenland shelf was also visited with the occupation of a number of shallow stations on the shelf. The phytoplankton bloom strength and timing in our study region in 2010 was potentially influenced by the iron supplied through volcanic ash deposition and the strongly negative phase of the North Atlantic Oscillation.

A second unplanned port call was made in Reykjavik on August 2 to disembark a scientist for compassionate reasons.

No incidents occurred on the cruise.

The cruise attracted attention from the media because of our investigations into the chemical and biological consequences on the Iceland and Irminger Basins of the volcanic ash deposition. We were featured on a BBC website and also several interviews were conducted by telephone.

A more detailed description of event and activities is provided within the narrative diary provided in Appendix B.

Scientific Reports D354

^{210}Po derived carbon flux

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1. Scientific motivation

^{210}Pb (T1/2 = 22.3 yr) and its daughter ^{210}Po (T1/2 = 138.4 d) are natural particle reactive radioisotopes that can be used as tracers of particle cycling in the upper ocean (Cochran and Masque, 2003). Both radioisotopes have a strong affinity for particles, but whereas ^{210}Pb is only adsorbed on particle surfaces, ^{210}Po is also bioaccumulated, being incorporated into the cytoplasm of some species of phytoplankton (Fisher et al., 1983) and bacteria (Cherrier et al., 1995; La Rock et al., 1996); its partitioning is similar to that of protein and sulphur within the cell (Fisher et al., 1983; Stewart and Fisher, 2003a, b; Stewart et al., 2005). These differences result in ^{210}Po being more efficiently removed from surface waters than ^{210}Pb via sinking particles. Hence, disequilibrium between the two radionuclides occurs when biological activity is high and downward ^{210}Po fluxes can be calculated.

During D354, ^{210}Po downward fluxes will be calculated to assess the strength of downward export of particulate matter. POC/^{210}Po ratios measured in sinking particles (from SAPS and PELAGRA, *See SAPS and PELAGRA report*) will be used to obtain into POC, PIC and opal fluxes from ^{210}Po fluxes.

Those results will be complementary with the export fluxes that will be obtained from the disequilibrium between ^{234}Th and ^{238}U (*See ^{234}Th report*). ^{210}Po fluxes obtained from to ^{210}Pb and ^{210}Po disequilibrium differ from the ^{234}Th fluxes from ^{234}Th-^{238}U disequilibrium in several ways: First, ^{234}Th is attached to the surface of the particles, on the contrary ^{210}Po is also assimilated by the organic matter. Thus it is expected that ^{210}Po-^{210}Pb disequilibrium allow us to better estimate POC fluxes whereas ^{234}Th will be used to estimate particle scavenging. Study timescales are different, going from several days (^{234}Th) to several months (^{210}Po) due to the different half lives of ^{234}Th (24d) and ^{210}Po (138.4d). Finally, due to ^{210}Po longer half-life and its highest affinity with carbon, ^{210}Po-^{210}Pb disequilibrium occurs from 0 to 500-600m, allowing us to quantify carbon fluxes in deeper depths (down to 400m) than using ^{234}Th method (~150 m).

2. Sampling summary

Samples for ^{210}Po and ^{210}Pb analysis were collected from a stainless steel CTD rosette at several stations (see Table 1). 5L water samples were collected from 10 to 13 depths between 5-1000m. The sampling distribution was focused between 0 and 500 m, where the most significant disequilibrium between ^{210}Po and ^{210}Pb is expected.

Seawater profiles of 10-13 depths (10-1000 m) for the ^{210}Pb-^{210}Po work were collected from 15 stations. A total of 173 samples were collected, including 3 blanks and 4 replicate samples to ensure reproducibility.

TABLE 3: Station ID, coordenates, sampling date and depths sampled

STATION #	DEPTHS (m)	Sampling date	LAT (N)	LON (W)
02	10 20 30 40 50 60 80 100 150 300 400 800 800	11/07/2010 16:50	60.00.0	19.59.0
04	10 20 30 40 50 60 80 100 150 400 600 800 1000	13/07/2010 13:30	61.47.5	21.04.9
06	10 20 30 40 50 80 100 150 300 600	15/07/2010 13:40	59.59.005	23.37.2
08	10 20 30 40 50 60 100 150 300 600	17/07/2010 18:52	60.00.2	34.59.5
010	10 20 30 40	19/07/2010 12:27	59.54.5	41.25.1

	50 60 100 150 300 500			
015	10 20 30 40 50 60 100 150 400 600	21/07/2010 00:32	59.59.6	34.59.4
016	10 20 30 40 50 80 100 150 400 600 1500	22/07/2010 15:43	62.60.0	34.60.0
018	10 20 30 40 50 60 80 100 150 400 500 500	24/07/2010 12:39	62.59.5	29.49.8
020	10 20 30 40 50 80 100 150 400 600 1004 1503 2001 2510	26/07/2010 18:17	58.13.2	35.07.4
22	10 20 30 40	30/07/2010 14:13	63.49.4	35.05.5

	50 60 100 150 200 300 400 600 1000			
24	20 30 40 50 75 100 200 300 400 700	01/08/2010 7:33	62.28.4	28.21.7
27	10 20 30 40 50 60 100 150 300 500 1000	03/08/2010 15:00	62.05.8	24.20.2
28	10 20 30 40 50 60 100 150 400 500	04/08/2010 13:15	61º13.6	20º47.1
31	10 20 30 40 50 75 100 150 250 500	05/08/2010 15:41	61.58.6	26.42.0
33	10 20 20 40 50 60 80	07/08/2010 13:24	60.18.2	20.58.8

100 150 400 600 20			

3. Pretreatment on board

Samples were immediately acidified, spiked with radioactive ^{209}Po, stable Pb^{2+}, as yield tracers, and Fe^{3+} carrier added. After 6 h of equilibration, the pH was adjusted to 8.5 with NH_4OH, and $Fe(OH)_3$ allowed to form and settle. The supernatant was carefully removed via siphoning and the precipitate transferred to 250-mL bottles and stored for its later treatment. The radiochemical analysis of these samples will be done at Universidad de Sevilla.

4. Further work

Once in the laboratory, in order to isolate ^{210}Po and ^{210}Pb and take it to an appropriate form for its proper measurement, radiochemical purification of polonium must be conducted. Afterwards, polonium will be plated onto silver discs and measured.

For ^{210}Pb determination, the plating solution will be stored for at least 6 months to allow for ^{210}Po ingrowth and to permit determination of ^{210}Pb by re-plating of the ^{210}Po.

Pb yields will be determined through measurement of stable Pb by ICP-OES. ^{210}Po yields will be determined using radioactive ^{209}Po as internal tracer.

^{210}Po and ^{210}Pb will be analysed at the Universidad de Sevilla through alpha spectrometry using Canberra PIPS detectors. Decay corrections would be done to ^{210}Pb and ^{210}Po results before obtaining activity concentration in water.

5. Scientific outcomes

^{210}Po fluxes will be calculated from the disequilibrium between ^{210}Pb and ^{210}Po activities in each depth and integrating to depths 50, 150 and 400m.

SAPS pumps were deployed for every ^{210}Po-^{210}Pb water depth profile (see SAPS report). ^{210}Po and ^{210}Pb, together with POC, PIC and BSi in particles, will be measured in the particles collected from in-situ pumps.

The ratio $^{210}Po/POC$, $^{210}Po/PIC$, $^{210}Po/BSi$ in sinking particles, can be then calculated and ^{210}Po export fluxes will be converted into POC, opal and calcite fluxes.

^{210}Po and ^{210}Pb will be also measured in PELAGRA samples to obtain complementary $^{210}Po/POC$ data.

Those results will be complemented with the information obtained from ^{234}Th derived fluxes (*see ^{234}Th report*) and fluxes obtained from PELAGRA traps for a global assessment of the strength of downward export of particulate matter.

Finally, ^{210}Po and ^{210}Pb concentration in depth profiles will be compared to lead concentration and other trace metal concentrations for a better understanding of the ^{210}Po geochemistry in relation to sinking particles.

Potential control of phytoplankton stocks by mesozooplankton

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1. Scientific motivation

Whilst control of phytoplankton growth in high-nutrient low-chlorophyll (HNLC) regions like the Irminger Basin is often attributed to limitations in iron supply (e.g. Martin & Fitzwater 1988, Martin & Gordon 1988, Martin et al. 1989), low chlorophyll levels can also be explained with high grazing pressure by micro- and mesozooplankton (e.g. Cullen et al. 1992, Frost & Franzen 1992, Tsuda et al. 2007). Thus, in the latter case, iron levels are relatively low yet sufficient to support phytoplankton growth. Moreover, zooplankton has been shown to play a central role for iron recycling (Tovar-Sanchez et al. 2007). The potential of mesozooplankton to support phytoplankton growth by releasing bioactive elements such as iron and ammonia may therefore play an important role in HNLC areas. When assessing what controls phytoplankton stocks in the Irminger Basin, it is therefore vital to accurately quantify mesozooplankton grazing rates and recycling potentials. Therefore, on D354, extensive grazing experiments have been carried out to address the potential of mesozooplankton to control phytoplankton biomass.

On D354, grazing rates were estimated based on bottle incubations with and without added iron (Gauld 1951) and supported by dilution experiments (Landry & Hassett 1982). To account for any community changes due to contamination with iron during the experimental set up, bottle incubations were set up with and without added iron under iron-clean conditions. In addition, samples were taken for gut fluorescence analysis, and gut clearance rates were experimentally estimated (Mackas & Bohrer 1976). The potential release thus recycling potential of macronutrients and iron by mesozooplankton was measured using gut clearance methods. To extrapolate grazing rates for the complete study area and to assess spatial variability, mesozooplankton biomass and composition, a Bongo net was deployed at every station.

2. Materials & Methods

Grazing experiments

Seawater for the incubations is sampled either from the Chlorophyll *a* maximum depths with a titanium CTD or via the trace-metal clean tow-fish directly before the animal's collection. When using the CTD, CTD Niskin bottles are brought into a trace-metal clean container, where the water is filtered through a 200 μm mesh to remove smaller zooplankton and eggs, and collected in a 100 L polycarbonate carboy. The incubation water is carefully filled into 15 acid-cleaned polycarbonate bottles (2 L) little by little and randomly to provide homogeneity. Three of the bottles serve as initials; the remaining twelve are used as incubation bottles.

Experimental animals are collected with a 200 μm WP2 net at night-time form a depth of approximately 60 m. Nets are hauled at approximately 10 m min^{-1}. Nets are not rinsed with water prior to unscrewing the cod-ends, as animals that are stuck to the net will most likely be stressed and potentially damaged. The cod-end is wrapped into a clean plastic-bag, carefully unscrewed and immediately brought into the controlled temperature laboratory (CT lab). A plastic bucket (20 L) and eight plastic pots (20 mL) with lid have been acid-washed, filled with filtered water from the titanium CTD, double bagged and transported into the CT lab. There, the outer bag is removed and the bucket and pots are placed in the laminar flow hood. Under the laminar flow hood, the cod-end is carefully emptied into the

water bucket to reduce zooplankton density. Using a microscope, acid cleaned mesh dishes and coated tweezers, 10-20 animals (size-dependent) of the most dominant copepod species are picked and transferred into the plastic pots. The pots are placed on a wooden tray, double bagged and carefully brought into the trace-metal clean container.

The animals in the plastic pots are carefully poured into the incubation bottles and 200 μm iron-spike is added to selected incubation bottles (Table 1). Bottles are filled up with filtered seawater until the surface is convex. A square of cling foil is carefully slid over the convex and the bottle top is screwed on. No air bubble must be present in the incubation bottle, as it may cause turbulence and damage microzooplankton. All bottles are placed onto a temperature-controlled plankton wheel at *in situ* temperature (sea surface temperature) and kept at ambient photoperiodic light.

After use, the net is washed thoroughly with hot freshwater and hung to dry.

Table 1 Treatments in the twelve incubation bottles

		water treatment	
		no	+ iron
copepods	no	G1	G7
	no	G2	G8
	no	G3	G9
	yes	G4	G10
	yes	G5	G11
	yes	G6	G12

After 24 h, the animals are filtered out of the incubation water, counted and their health status examined. Healthy animals are transferred into glass vials containing 6 mL acetone for gut fluorescence analysis. The following water samples are taken from each of the three initial bottles and the twelve incubation bottles:

Chlorophyll *a* (250 mL), cellulose nitrate (200 mL), flow cytometry (2 mL), FRRf (50 mL), Lugol's iodine (150 mL), nutrients (50 mL) and POC/PON (800 mL).

Gut fluorescence analysis

Animals are collected using a 200 μm WP2 net with non-filtering cod-end from a depth of approximately 30 m. Nets are hauled at approximately 10 m min^{-1} to minimize gut evacuation during ascend. As animals that are stuck to the net will most likely be stressed and potentially damaged, nets are not rinsed with water prior to unscrewing the cod-end. The content of the cod-end is filtered through a small piece of mesh. The mesh is carefully double folded, wrapped in aluminium foil, put into a plastic bag containing the label and frozen immediately in liquid nitrogen. Samples are stored at -20 °C.

A fluorometer is set up for the Welshmeyer technique, and blank, solid blank (high and low) are read before and after processing the samples. The frozen samples is taken out of the freezer and immediately processed. Frozen animals are rinsed from the net onto a Petri dish using non-toxic seawater. Animals are kept defrosted for as short as possible at any time. Under a light microscope at dim light, 10-20 individuals of the dominant copepod species are picked, transferred into a known volume of acetone (90 %) and stored at -20 °C for 24 h. Following extraction, the sample is mixed thoroughly and decanted into a fluorometer glass tube. The fluorescence measurement is read and Chl *a* concentration is calculated following JGOFS Protocol.

Gut clearance rates

The animals are collected as described for the gut fluorescence analysis. A bucket (20 L) is filled with GF/F filtered, food particle-free seawater. After unscrewing the cod-end, the content is carefully filtered through a 100 μm mesh dish, which is immersed in water. The animals in the water above the mesh dish are immediately transferred into the bucket with filtered water. The bucket is placed in the CT lab and kept in darkness. 10-20 animals are removed every 5-30 min, put into 6 mL acetone (90 %) and processed as described for the gut fluorescence analysis.

Mesozooplankton release experiments

All work was carried out under iron-clean conditions in a laminar flow hood. The collected animals (20 m depths) are carefully poured from the cod-end into a big mesh-dish (100μm) submerged in iron-clean sea water. The mesh-dish is immediately taken out of the bucket and the animals are transfered into 10 L of iron-clean, 0.2 μm filtered sea water. Samples for nutrients, ammonium, dissolved iron, dissolvable iron and particulate carbon are taken using a peristaltic pump. Samples are taken in defined time intervals (5-60 min) for up to 5 hours. After incubation, animals are preserved in 4% sea-water buffered formaldehyde for later enumeration and identification.

Abundance estimates

A Bongo net (95 μm and 200 μm) with filtering cod-ends is deployed at every station. A flowmeter is fitted and readings are taken before and after deployment. Nets are hauled from a depth of approximately 100 m at about 10 m min^{-1}. Nets are rinsed prior to unscrewing the cod-ends. Cod-ends are carefully rinsed into round 250 mL Nalgene bottles with seawater. 25 mL formaldehyde (40 %) is added and the bottle is filled to the top with seawater to make up a 4% formaldehyde solution. Samples are labelled and stored in a dark, dry place. Analysis (ID, counting and size measurements) is done on shore.

3. Sample summary

44 nets were deployed at 22 different stations (Table 2). Ten grazing experiments were carried out, from which four were carried out together with a series of dilution experiments. Seven gut clearance experiments were undertaken and samples for gut fluorescence analysis were taken from 15 different stations. Six mesozooplankton release experiments were conducted at six different stations. For the grazing experiments, 150 samples were taken for each Chlorophyll a, cellulose nitrate, flow cytometry, FRRf, Lugol's iodine, nutrients and POC/PON. Chorophyll a, FRRf and Nutrient samples (silica & nitrates) were analysed on board. Lugol's samples were stored in darkness and the remaining samples were stored at -20 °C or -80 °C until further analysis on shore. A total of 145 GFA samples were taken and analysed on board. For the release experiments, following samples were taken: 112 samples for nutrients, 115 samples for ammonia, 26 samples for dissolved iron, 31 samples for dissolvable iron, 66 samples for dissolved organic carbon, and 19 samples for dissolvable organic carbon.

Table 2 Net deployments. Experiment code: G – Grazing experiment, D – Grazing experiment with dilution series, GC – Gut clearance experiment

Date	Julian Day	Station	Nets	Time on board	Position		Type	Depth (m)	Exp.
11/07	192	02	1/2	19:00	60°10.0 N	19°58.4 W	Bongo/WP2	100/60	*
12/07	193	03	3/4	4:10	60°00.3 N	19.58.7 W	Bongo/WP2	100/60	D4
13/07	194	04	5/6	3:25	61°49.8 N	21°00.4 W	Bongo/WP2	100/60	GC5
14/07	195	05	7/8	3:20	60°00.23 N	19°59.72 W	Bongo/WP2	100/60	G5
15/07	196	06	9/10	3:40	59°59.96 N	23°37.58 W	Bongo/WP2	100/60	GC6
16/07	197	07	11/12	3:40	60°00.54 N	28°08.51 W	Bongo/WP2	100/60	G6
17/07	198	08	13/14	5:30	59°59.96 N	35°00.28 W	Bongo/WP2	100/60	GC7
18/07	199	09	15/16	3:30	59°59.98 N	35°00.05 W	Bongo/WP2	100/60	GC8
19/07	200	10	17/18	3:30	59°59.73 N	41°21.80 W	Bongo/WP2	100/60	D7
22/07	203	16	19/20	5:25	62°59.97 N	35°00.14 W	Bongo/WP2	100/60	G8
23/07	204	17	21/22	3:30	63°00.50 N	34°59.65 W	Bongo/WP2	100/60	GC9
24/07	205	18	23/24	3:40	63°00.08 N	29°59.26 W	Bongo/WP2	100/60	G9
25/07	206	19	25/26	3:30	60°53.4 N	31°30.6 W	Bongo/WP2	100/30	GC10
26/07	207	20	27	3:20	58°14.75 N	34°45.94 W	Bongo	100	*
27/07	208	21	29/30	3:40	58°08.25 N	34°57.44 W	Bongo/WP2	100/40	G10
30/07	211	22	31/32	3:30	63°49.22 N	35°00.99 W	Bongo/WP2	100/20	G11
31/07	212	23	34/35	3:30	63°49.9 N	35°00.4 W	Bongo/WP2	100/30	G12
1/08	213	24	36/37	3:40	62°28.4 N	28°21.2 W	Bongo/WP2	100/30	R3
3/08	215	27	38/39	5:20	62°08.1 N	24°19.1 W	Bongo/WP2	100/30	R4
4/08	216	28	40/41	4:10	61°15.57 N	20°42.27 W	Bongo/WP2	100/30	R5
5/08	217	29	42/43	5:25	61°50.4 N	25°40.2 W	Bongo/WP2	100/30	G13
7/08	219	33	44/45	3:40	60°21.6 N	20°56.7 W	Bongo/WP2	100/30	R6

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The important of siderophores to the iron speciation in the high latitude North Atlantic Ocean

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Introduction

Iron has been shown to play a critical role in ocean productivity and community structure. A recent study in the high latitude (>55 ^{0}N) North Atlantic Ocean found very low dissolved iron (dFe) concentrations in surface waters with an average of 0.093 nM (*n* =43) nM and suggested the formation of seasonal high-nutrient, low chlorophyll (HNLC) conditions (Nielsdottir et al., 2009). It is known that more than 99% of the dFe in seawater is complexed by dissolved organic Fe(III)-binding ligands (Gledhill and van den Berg, 1994), which enhances the otherwise very low (0.1 nM) inorganic Fe solubility (Wu et al., 2001). However, the nature and origin of these organic ligand complexes remains largely unknown. But, they are known to have a range of stability constants between log K of 19 and 23 (Rue & Bruland, 1997) which are similar to those of siderophores (metal chelates) which have been produced and purified from culture (Macrellis et al., 2001). Siderophores are part of a highly specific bacterial iron uptake mechanisms. This study will investigate the presence and nature of marine siderophores and other Fe binding ligands, and contribute to our knowledge of iron speciation in seawater and the way in which marine microbial organisms acquire iron in order to grow under ultra low iron conditions.

The aims of this research are to investigate the speciation of dissolved Fe in the sub-polar North Atlantic Ocean, to investigate the distribution of siderophores in the dissolved and particulate phase and to identify novel siderophores produced by marine bacteria in nutrient enriched seawater incubations.

Methods

***Iron binding ligands*:** Depth profiles of seawater samples for NOCS based Fe ligand determinations were collected at stations along the *RRS Discovery* cruise 354 track. The

profiles sample were collected with a trace metal clean titanium CTD frame fitted with 10 L trace metal clean Teflon coated OTE (Ocean Technology Equipment) bottles. Samples were filtered under pressure using 0.2 μm pore size cartridge filters (Sartobran P-300, Sartorius). All 250 mL low density polyethylene bottles (Nalgene) were cleaned prior to the cruise according to a standard protocol (Achterberg et al., 2001). Samples were immediately frozen at -20°C (not acidified) for subsequent land based analysis. The iron (III) binding ligands and their conditional stability constants will be determined at NOCS by using competitive ligand exchange-adsorptive cathodic stripping voltammetry (CLE-ACSV) with TAC (thiazolylazo-p-cresol) as competing ligand (Croot and Johansson, 2000).

***Dissolved and particulate siderophores*:** Seawater (2 x 20 L) was collected by using the titanium CTD at two different depths; the depth with enhanced chlorophyll and the depth below the enhanced chlorophyll. Samples were filtered through 3.0 and 0.2 μm cellulose nitrate membrane filters for collection of the particulate siderophores. Filters were frozen at -20 °C for later analysis and dissolved siderophores were concentrated onto polystyrene divinyl benzene polymeric resin (ISOLUTE ENV+ solid phase extraction cartridge) and were frozen at -20 °C. Siderophores will be quantified and identified using previous developing method by Mawji et al. (2008).

***Incubation experiment*:** Incubations were carried out using sea waters collected from the Iceland Basin, Mid Atlantic Ridge region, Irminger Basin and Greenland slope region. Seawater (2 L) was enriched with nutrients as follows: (A) 2 x 2 L; glucose (100 μM), (B) 2 x 2 L; glucose (100 μM), phosphate (20 μM), ammonia (200 μM) and (C) 2 x 2 L; glucose (100 μM), phosphate (20 μM), nitrate (200 μM)**.** Seawater was incubated for 5 days in the controlled temperature laboratory at 12 °C. Un-enriched seawater was used as a blank (2 x 2 L). Bacterial growth in each sample was monitored daily by using a spectrophotometer at 600 nm wavelength. Samples were collected daily for identification of bacteria by flow cytometry (at NOCS). Incubation seawaters were sampled for particulate and dissolve siderophores after the incubation period. Siderophores in the incubations will be identified and characterized as mentioned above.

Results

Five seawater incubation experiments were conducted during the *RRS Discovery* cruise 354 (11 July – 6 Aug. 2010) and they were from the Iceland Basin (St.3), Mid Atlantic Ridge (St. 6), Irminger Basin (St. 9 and 20) and Greenland slope (St. 11) (Fig. 1).

Our absorbance measurement for the bacterial biomass in the nutrient added seawater samples after the incubation period is shown in Fig. 1. The result showed that the absorbance in the incubation seawater samples which were enriched with glucose, phosphate and ammonium (B) were higher than nitrate (C) treatment in most of our incubations. It indicated that the different nitrogen source will affect the bacterial growth and subsequent production of siderophores in our incubation seawater. However we need to confirm this finding by flow cytometry analysis at NOCS.

In addition, all our nutrient treatment seawater samples (A, B, C) showed enhanced bacterial biomass in the samples from the Iceland Basin (St.3) and Mid Atlantic Ridge (St. 6),

compared to the seawater from the Irminger Basin (St. 9) and Greendland slope (St.11). Moreover, the incubation seawater samples from south of Irminger Basin (St. 20) showed higher bacteria biomass in all nutrient treatment samples, compared to the middle part of the basin (St. 9).

Table 1. Location of the samples which were collected along the *RRS Discovery* cruises 354 tracks July/ August 2010.

Location	Date	St.	Long.	Lat	Iron ligand	Dissolved /Particulate Siderophores	Incubation experiment
Iceland Basin	11-Jul	St. 2	60 ^{0} 00	19 ^{0} 58	√	√	
	12-Jul	St. 3	60 ^{0} 02	19 ^{0} 55	√		√
	13-Jul	St. 4	61 ^{0} 48	21 ^{0} 05	√		
	14-Jul	St. 5	60 ^{0} 02	19 ^{0} 55	√	√	
Mid Atlantic Ridge	15-Jul	St. 6	60 ^{0} 02	23 ^{0} 37	√		√
	16-Jul	St. 7	60 ^{0} 02	29 ^{0} 00	√	√	
Irminger Basin	18-Jul	St. 9	60 ^{0} 02	35 ^{0} 00	√		√
Greenland slope	19-Jul	St. 10	59 ^{0} 56	41 ^{0} 24	√		
		St. 11	59 ^{0} 59	41 ^{0} 35	√	√	√
		St. 12	59 ^{0} 59	41 ^{0} 59	√		
		St. 13	60 ^{0} 02	42 ^{0} 12	√		
	20-Jul	St. 14	59 ^{0} 59	42 ^{0} 39	√		
Irminger Basin	21-Jul	St. 15	63 ^{0} 00	34 ^{0} 59			
	22-Jul	St. 16	63 ^{0} 00	34 ^{0} 58	√	√	
	23-Jul	St. 17	62 ^{0} 59	29 ^{0} 54	√		
	24-Jul	St. 18	60 ^{0} 51	31 ^{0} 34	√	√	
	26-Jul	St. 20	58 ^{0} 13	35 ^{0} 02	√	√	√
	30-Jul	St. 22	63 ^{0} 49	35 ^{0} 04		√	
	31-Jul	St. 23	63 ^{0} 30	33 ^{0} 23		√	
Mid Atlantic Ridge	01-Aug	St. 24	62 ^{0} 28	28 ^{0} 19	√		
Iceland Shelf	02-Aug	St. 25	63 ^{0} 25	23 ^{0} 35	√	√	
		St. 26	63 ^{0} 09	23 ^{0} 47	√		
Mid Atlantic Ridge	03-Aug	St. 27	61 ^{0} 47	24 ^{0} 27	√	√	
Iceland Basin	04-Aug	St. 28	61 ^{0} 14	20 ^{0} 45		√	
	06-Aug	St. 34	61 ^{0} 45	24 ^{0} 00		√	

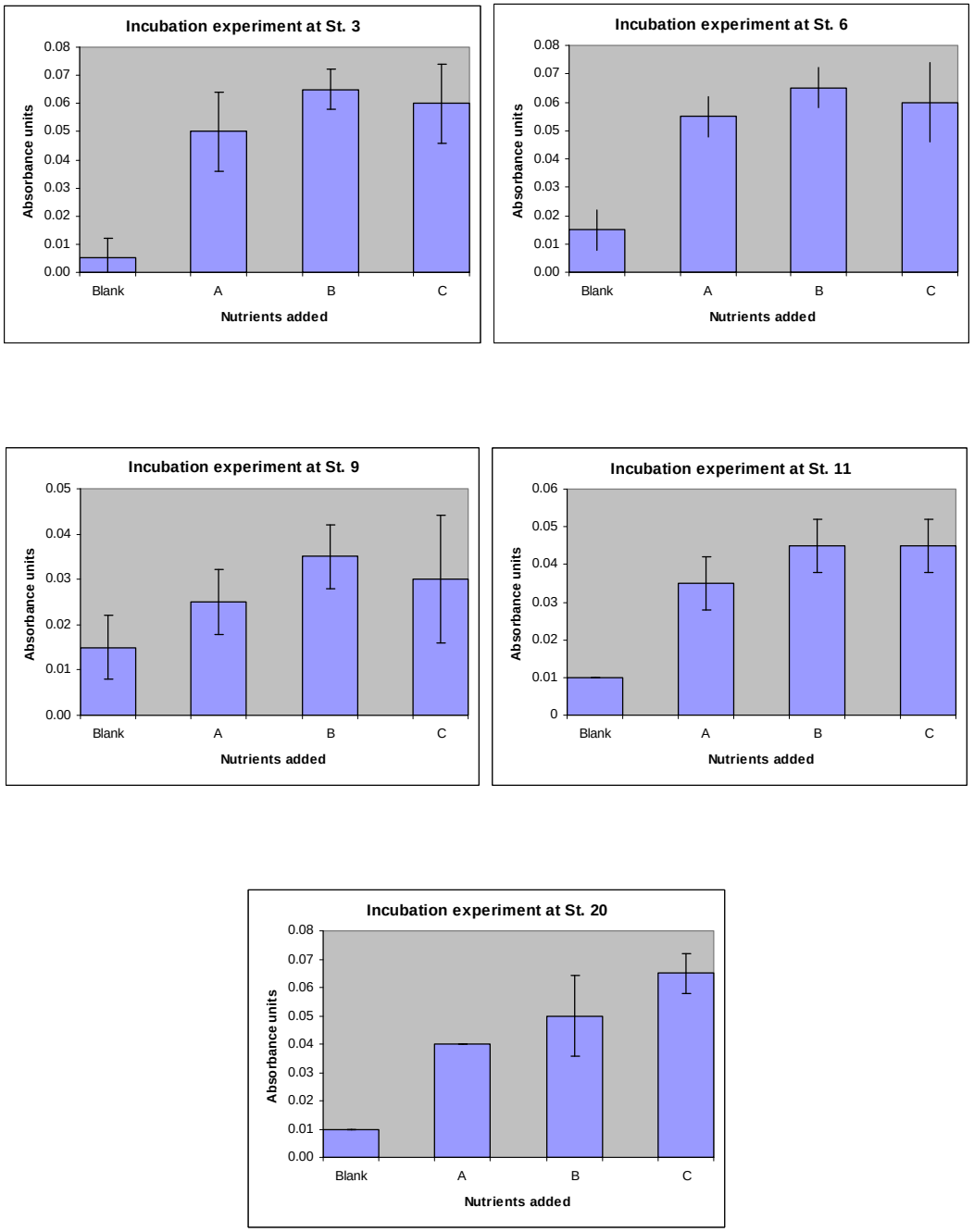

Fig 1. Absorbance (600 nm) of incubated seawater which were enriched with nutrients; **A**, 100 μM glucose; **B**, glucose (100 μM), phosphate (20 μM), ammonia (200 μM) and **C**, glucose (100 μM), phosphate (20 μM), nitrate (200 μM). The absorbance readings suggest that the bacterial biomass was greatest in the treatment containing **B** nutrient added.

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Low-volume aerosol sampling

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Rationale and objectives

The atmospheric transport of dust from terrestrial sources and its deposition represent a major supply of numerous trace metals and nutrients to the surface ocean (Jickells and Spokes, 2001). This is a particularly important input pathway to the open ocean. There remains considerable uncertainty regarding the relative importance of the atmospheric input of soluble iron versus deep ocean inputs through upwelling/entrainment of water rich in recycled iron.

Models suggest a relatively low aerosol input to the high latitude North Atlantic (Duce and Tindale, 1991), though there have been relatively few direct measurements in the region. The main aim of aerosol sampling during research cruise D354 is to provide data of atmospheric inputs of iron and other trace metals and nutrients at the time of the transect. However, any data obtained would provide a useful addition to the total number of measurements made in the region.

Methods

Sample collection methodology is similar to that used by Buck *et al.* (2006). A low volume (flow rate of 20 – 30 L/min) aerosol sampler designed to take four filters at a time was installed above the ships bridge and programmed to operate only under favourable wind conditions – when the wind was blowing from within 90^{o} either side of the front of the ship at a relative speed of at least 2m/s. For each deployment, the sampler was fitted with two or three 47mm polypropylene 0.4μm filters and one or two polycarbonate filters (also 47mm, 0.4μm).

After deployment, filters were transferred to a -20^{o}C freezer for storage until they can be analysed. One filter will be used for total acid digestion and subsequently analysed for multiple elements by ICP-MS. Another will be leached with ultra-pure water to determine the "instantaneously soluble" fraction of iron and other trace metals, nutrients and major anions in the aerosol material. Seawater leaches will also be carried out on some filters, and there are plans for scanning electron microscopy (SEM) analysis to look at the mineralogy of any dust collected.

Samples collected

Visual inspection of the used filters suggests that aerosol loadings were generally very low throughout the cruise.

As much as possible, the sampler was turned off during periods of rain, and the filter holders covered to prevent raindrops being blown up onto the filters. However, the prevalence of foggy conditions during some sampling periods also caused problems with water droplets on the aerosol collectors, which may have affected the integrity of these samples. There were also problems with the data logger of the low-volume sampler. Although the pumps worked as expected, turning on/off as the wind conditions changed, the system would occasionally stop logging data (date, time and flow rates). On these occasions, flow rates and the pump operation time were estimated using the Surfmet wind speed/direction data and flow rates prior to and after the gap in data.

A total of eleven filter sets were deployed on the low volume system for periods of 24 – 72 hours (see table 1). It was often left on while on station due to it having its own controls for turning on and off depending on the wind speed and direction. Near the end of the cruise, one polypropylene filter from each sample was leached with 100ml each of ultrapure water and the leachates and leached filters stored at -20^{o}C.

Table 1 – Low volume sample deployment times

Sample	Installation time (GMT)	Removal time (GMT)
Lo-vol 1	19:52 09/07/10	15:30 12/07/10
Lo-vol 2	16:22 12/07/10	09:10 15/07/10
Lo-vol 3	11:04 15/07/10	11:00 18/07/10
Lo-vol 4	12:20 18/07/10	19:50 20/07/10
Lo-vol 5	20:22	09:20

	20/07/10	23/07/10
Lo-vol 6	12:46	14:05
	24/07/10	26/07/10
Lo-vol 7	13:12	16:25
	27/07/10	30/07/10
Lo-vol 8	21:36	08:05
	31/07/10	02/08/10
Lo-vol 9	22:01	14:00
	02/08/10	04/08/10
Lo-vol 10	15:05	21:00
	04/08/10	06/08/10
Lo-vol 11	22:27	13:40
	06/08/10	08/08/10

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SAPS deployment (Chris Marsay, María Villa, Fred Le Moigne)

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During the D354, 17th deployments for Standing alone pumping system (SAPS) were performed. Five SAPS were deployed per cast. Generally two were devoted for ^{234}Th and ^{210}Po derived carbon and biomineral fluxes (Fred Le Moigne and Maria Villa) and three for trace metal work (Chris Marsay) as summarised in Tables 1 and 2. SAPS pumping time was set as 90min allowed a filtration volume from 500 to 2000l. After recovery, particles were rinsed off the mesh on ^{234}Th-^{210}Po devoted SAPS and splitted in five portion for further ^{210}Po-^{210}Pb, ^{234}Th, POC, PIC and Bsi analisys back in homelab. ^{210}Po and ^{210}Pb will be analysed at University de Sevilla. Trace metal SAPS filters and meshes were frozen and stored for multiple trace metal analysis by ICPMS (an acetic acid leach and a concentrated acid digest will be used to measure labile and total trace metals).

TABLE 1: ^{234}Th and ^{210}Po-^{210}Pb SAPS

station number	^{234}Th and ^{210}Po SAPS depths (m)	Type of mesh	Splits
02	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
04	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
06	40	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	140	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
08	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
10	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi

	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
15	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
16	40	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	140	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
18	40	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	140	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
20-1st depl.	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
20-2nd depl.	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	300	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	400	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
22	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	200	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	300	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi

	400	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
24	40	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	140	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
27	40	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	140	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
28	40	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	140	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	400	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
31	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
33-1st deploy	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
33-2nd deploy	50	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	150	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
	400	1µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi
		53µm NITEX	1/4 Po-Pb,1/4Th, 1/4POC, 1/8 PIC, 1/8 BSi

TABLE 2: Trace metal SAPS

station	Trace metal SAPS	Type of mesh	Splits
02	20	53µm NITEX	ICPMS multiple elements
		1µm Nuclepore	
	50	53µm NITEX	
		1µm Nuclepore	
	150	53µm NITEX	
		1µm Nuclepore	
04	20	53µm NITEX	
		1µm Nuclepore	
	50	53µm NITEX	
		1µm Nuclepore	
	150	53µm NITEX	
		1µm Nuclepore	
06	20	53µm NITEX	
		1µm Nuclepore	
	40	53µm NITEX	
		1µm Nuclepore	
	140	53µm NITEX	
		1µm Nuclepore	
08	20	53µm NITEX	
		1µm Nuclepore	
	50	53µm NITEX	
		1µm Nuclepore	
	150	53µm NITEX	
		1µm Nuclepore	
10	20	53µm NITEX	
		1µm Nuclepore	
	50	53µm NITEX	
		1µm Nuclepore	
	150	53µm NITEX	
		1µm Nuclepore	
15	20	53µm NITEX	
		1µm Nuclepore	
	50	53µm NITEX	
		1µm Nuclepore	
	150	53µm NITEX	
		1µm Nuclepore	
16	20	53µm NITEX	
		1µm Nuclepore	
	40	53µm NITEX	
		1µm Nuclepore	
	140	53µm NITEX	
		1µm Nuclepore	
18	20	53µm NITEX	
		1µm Nuclepore	
	40	53µm NITEX	
		1µm Nuclepore	
	140	53µm NITEX	
		1µm Nuclepore	
20-1st depl.	20	53µm NITEX	
		1µm Nuclepore	
	150	53µm NITEX	
		1µm Nuclepore	

	50	53µm NITEX
		1µm Nuclepore
	150	53µm NITEX
		1µm Nuclepore
20-2nd depl.	150	53µm NITEX
		1µm Nuclepore
	300	53µm NITEX
		1µm Nuclepore
	400	53µm NITEX
		1µm Nuclepore
22	20	53µm NITEX
		1µm Nuclepore
	50	53µm NITEX
		1µm Nuclepore
	150	53µm NITEX
		1µm Nuclepore
	300	53µm NITEX
		1µm Nuclepore
	400	53µm NITEX
		1µm Nuclepore
24	20	53µm NITEX
		1µm Nuclepore
	40	53µm NITEX
		1µm Nuclepore
	140	53µm NITEX
		1µm Nuclepore
27	20	53µm NITEX
		1µm Nuclepore
	40	53µm NITEX
		1µm Nuclepore
	140	53µm NITEX
		1µm Nuclepore
28	40	53µm NITEX
		1µm Nuclepore
	140	53µm NITEX
		1µm Nuclepore
31	20	53µm NITEX
		1µm Nuclepore
	50	53µm NITEX
		1µm Nuclepore
	150	53µm NITEX
		1µm Nuclepore
33-1st depl.	20	53µm NITEX
		1µm Nuclepore
	50	53µm NITEX
		1µm Nuclepore
	150	53µm NITEX
		1µm Nuclepore
	400	53µm NITEX
		1µm Nuclepore

^{234}Th derived carbon and biomineral fluxes

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Scientific motivation

The Radioactive short-lived Thorium-234 (^{234}Th, t1/2=24,1d) (Bath *et al*., 1969) has been used as a tracer of several transport processes and particle cycling in aquatic systems by different techniques (Rutgers 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; Cochran and Masqué, 2003; Rutgers van der Loeff, 2001). ^{234}Th is the daughter isotope of naturally occurring 238-Uranium (^{238}U, t1/2=4,47.10^{9}y) which conservative in the seawater and proportional to salinity in well oxygenated environment (Ku et al.,1977; Chen et al.,1986). 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 et 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 during the D354.

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 Buesseler *et al* (1999). 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 (1000m) 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.

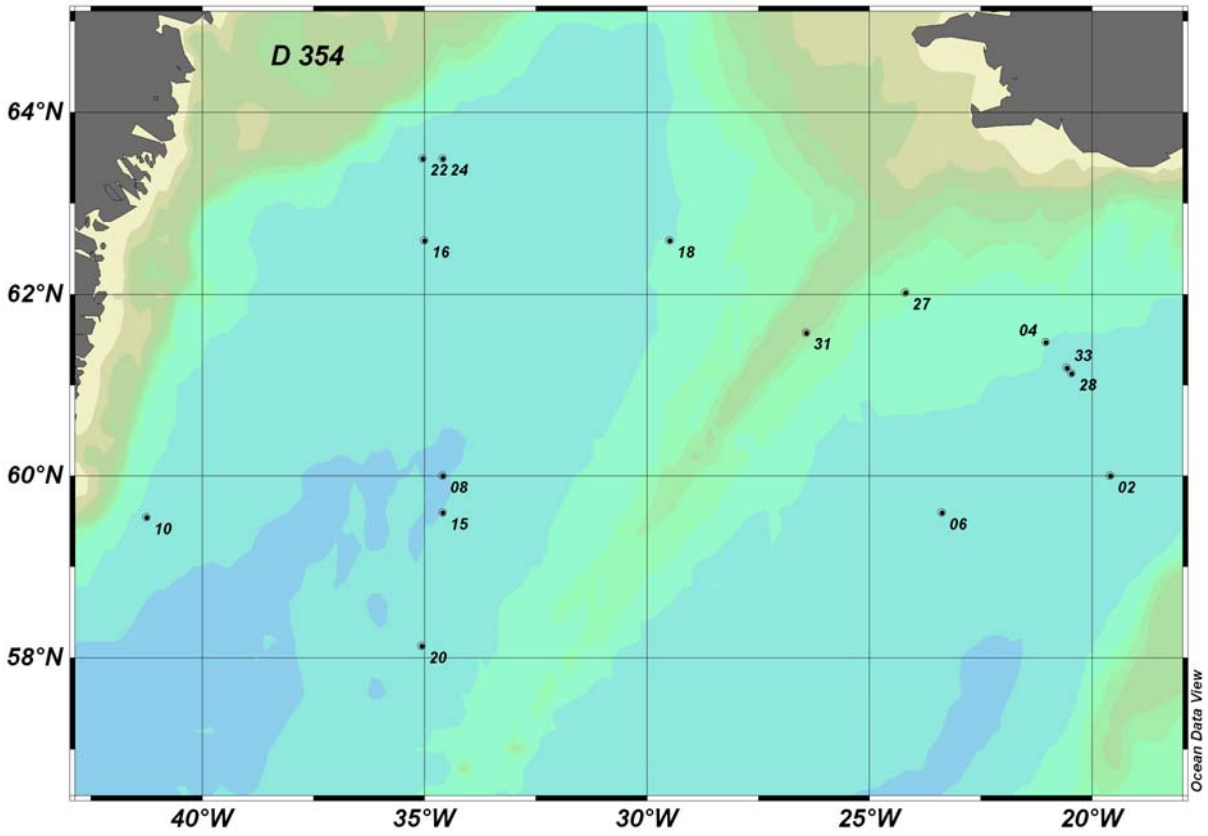

Figure 5: D354 station positions.

Table 4: Station ID with sampling date, depth range and volume sampled.

Sample	Station	CTD num	Date	Niskin	Depth	position
D354	02	02	11/07	3	400	60.00N 19.59W
D354				5	150	
D354				6	100	
D354				7	80	
D354				8	60	
D354				9	50	
D354				11	40	
D354				14	30	
D354				16	20	
D354				19	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	04	05	13/07	5	400	61.47N 21.04W
D354				7	150	
D354				9	100	
D354				11	80	
D354				13	60	

D354				15	50	
D354				17	40	
D354				19	30	
D354				21	20	
D354				23	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	06	008	15/07	4	300	59.59N 23.37W
D354				6	150	
D354				8	100	
D354				12	80	
D354				14	60	
D354				16	50	
D354				18	40	
D354				20	30	
D354				22	20	
D354				24	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	08	10	17/07	3	300	60.00N 34.59W
D354				6	150	
D354				7	100	
D354				9	80	
D354				11	60	
D354				13	50	
D354				16	40	
D354				17	30	
D354				21	20	
D354				23	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	10	13	19/07	4	400	59.54N 41.25W
D354				6	150	
D354				8	100	
D354				10	80	
D354				12	60	
D354				14	50	
D354				18	40	
D354				20	30	
D354				21	20	
D354				23	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	15	15	21/07	15	600	59.59N 34.59W
D354				16	400	
D354				17	150	
D354				18	100	
D354				19	60	
D354				20	50	
D354				21	40	
D354				22	30	
D354				23	20	
D354				24	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	16	18	22/07	16	400	62.59N 35.00W
D354				17	150	

D354				18	100	
D354				19	80	
D354				20	50	
D354				21	40	
D354				22	30	
D354				23	20	
D354				24	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	18	21	24/07	4	400	62.59N 29.49W
D354				6	150	
D354				8	100	
D354				10	80	
D354				12	60	
D354				14	50	
D354				15	40	
D354				18	30	
D354				20	20	
D354				22	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	20	24	26/07	4	400	58.13N 35.07W
D354				8	150	
D354				10	100	
D354				12	80	
D354				14	60	
D354				16	50	
D354				18	40	
D354				20	30	
D354				22	20	
D354				24	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	22	27	30/07	5	400	63.49N 35.05W
D354				10	150	
D354				12	100	
D354				13	80	
D354				14	60	
D354				16	50	
D354				18	40	
D354				20	30	
D354				22	20	
D354				24	10	
D354				3	1000	
D354				3	1000	
D354				3	1000	
D354				3	1000	
D354				1	1000	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	24	Ti 22	1/08	13	20	63.49N 34.59W
D354				12	30	
D354				11	40	
D354				10	50	
D354				9	75	
D354				8	100	
D354				7	200	

D354				6	300	
D354				5	400	
D354				4	500	

Sample	Station	CTD num	Date	Niskin	Depth	position
D354	27	32	3/08	3	400	62.06N 24.20W
D354				8	150	
D354				10	100	
D354				12	80	
D354				14	60	
D354				16	50	
D354				18	40	
D354				20	30	
D354				22	20	
D354				24	10	

Sample	Station	CTD num	Date	Niskin	Depth	position
D354	28	34	4/08	3	400	61.13N 20.46W
D354				8	150	
D354				10	100	
D354				12	80	
D354				14	60	
D354				16	50	
D354				18	40	
D354				20	30	
D354				22	20	
D354				24	10	

Sample	Station	CTD num	Date	Niskin	Depth	position
D354	31	36	5/08	2	500	61.58N 26.42W
D354				6	150	
D354				8	100	
D354				11	60	
D354				10	75	
D354				12	50	
D354				14	40	
D354				16	30	
D354				20	20	
D354				22	10	
Sample	Station	CTD num	Date	Niskin	Depth	position
D354	33	38	7/08	4	400	61.19N 20.57W
D354				6	150	
D354				8	100	
D354				10	80	
D354				12	60	
D354				14	50	
D354				16	40	
D354				18	30	
D354				21	20	
D354				22	10	

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).

The role of microzooplankton grazing in the sub-Arctic Atlantic

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Background

The microbial biomass observed in the oceans is a direct result of the balance between nutrient availability (bottom up) and grazing pressure (top down). It is important to distinguish and quantify both directions of control to understand the forcing effects of, in this case, hypothesised seasonal Fe limitation.

Microzooplankton consume a substantial fraction of phytoplankton and bacterioplankton production, remineralising nutrients and providing a major trophic link to larger protozoan and metazoan consumers (1,2). As well as their ability to exert top down forcing on primary productivity there is also emerging evidence that this grazing is a significant source of bioavaliable trace metals such as Fe (3,4,5,6).

Our work will compliment the research being done by providing a top down perspective on primary productivity control. We also hope to quantify the first rates of biogenic particulate trace metal growth and loss. These studies will further our understanding and parameterization of the grazing pressure shaping microbial trophic levels and how carbon and trace metals are cycled within them.

Objectives

1. Determine the gross growth and grazing rates of bacteria and phytoplankton.
2. Determine the rate of growth and loss of size fractionated biogenic particulate trace metals.
3. Undertake on-board Fe enrichment bioassay experiments to determine grazer responses to stimulated phytoplankton growth
4. Determine carbon ingestion rates of microzooplankton.
5. Determine whether microzooplankton selectively graze trace-metal rich bacteria and phytoplankton, relative to total prey.

Methods

All work was carried out in a trace metal clean environment using trace metal clean equipment.

Microzooplankton grazing assay

Microzooplankton bacterivory and herbivory was determined using a modified dilution assay (7, 8). Seawater was collected from a titanium OTE CTD, filtered through a 202 µm Nitex mesh to remove larger grazers, and diluted with particle-free filtrate prepared by gravity filtration though a 0.2 µm Sartobran cartridge filters to the following target dilutions (< 202 µm: < 0.2 µm filtered water): 1.0, 0.9, 0.75, 0.5, 0.35, 0.2 and 0.1. 7 out of the 14 containers were spiked with 600 µl of 20 nM $FeCl_3$. All samples were incubated in 10 L flexible LDPE cubitainers, in on-deck incubators at ambient temperatures (± 0.5°C) and ~50% of incident irradiance, for 48 h. Abundances of bacteria as well as pico- and nanophytoplankton, will be determined by flow cytometry (9, 10) and Acridine Orange Direct Counts (AODC; 11). Bacterial cell volume will be determined by image analysis of Acridine Orange (AO) stained cells using an Image-Pro Plus image analysis system (12). Nutrient (nitrate, silicate and phosphate), Chl *a* and Fast Repetition Rate fluorometry samples were collected and analysed on board. Subsamples for light microscopy identification were also collected in Lugols along with cellulose nitrate filters for coccolithophores.

The apparent growth rate of each group at each of the seven dilutions will be computed from the time-dependent changes in abundance or concentration. Rates of grazing mortality will be determined from the linear regression of apparent growth rate against dilution, with the intercept of the line providing an estimate of growth rate and the negative slope of the line providing an estimate of grazing mortality (8).

Our experiments were done in conjunction with mesozooplankton grazing experiments conducted by Giering

Biogenic particulate trace metals

2 L subsamples were taken at the start and end points of the grazing assay. These were sequentially filtered through 10 µm, 1 µm and 0.2 µm polycarbonate filters and frozen prior to analysis on land. Dissolved samples were taken, spiked with 250 µl of trace metal clean 11.65 M HCl & stored at room temperature. Trace element analysis will be performed on land via inductively coupled mass spectrometry. Samples for Fe speciation were collected from one set of incubations and immediately frozen (-20^0c) prior to electrochemical analysis on land.

A two stage leach (13) of the filters will determine labile and refractory phase trace metals and the apparent growth and loss rates of each size fraction will be estimated using the method described above.

Date	Location	Station	CTD #	Experiment	Depth	Time (GMT)
11/7/10	60^0 00.01'N	002	CTDT003	DA	30m	23:50
19/7/10	59^0 56.23'N	010	CTDT010	DB	20m	08:17
31/7/10	63^0 49.92'N	023	CTDT022	DC	20m	07:04
5/8/10	61^0 50.78'N	029	CTDT028	DD	23m	09:09

Study Sites

Grazing assays

Samples collected from assays

		From	Sample								
			Chl.a	Nutrients	FCM	AO	pTM	dTM	Spec.	Lugols	Cocco.
		Niskin Bottle	Y	Y	Y	Y	Y	Y	Y	y	
		<202µm filtrate	Y	Y	y	y	y	y	y	y	y
		<0.2µm filtrate		Y	Y	Y	Y	Y	Y		
Start time	Control	Incubation bottle 1	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 2	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 3	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 4	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 5	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 6	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 7	Y	Y	Y	Y	Y	Y	Y		
	Fe Enrichment	Incubation bottle 8	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 9	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 10	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 11	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 12	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 13	Y	Y	Y	Y	Y	Y	Y		
		Incubation bottle 14	Y	Y	Y	Y	Y	Y	Y		
End time	Control	Incubation bottle 1	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 2	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 3	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 4	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 5	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 6	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 7	Y	Y	Y	Y	Y	Y	Y		Y
	Fe enrichment	Incubation bottle 8	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 9	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 10	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 11	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 12	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 13	Y	Y	Y	Y	Y	Y	Y		Y
		Incubation bottle 14	Y	y	Y	Y	Y	Y	Y		Y

Key:
AO = Acridine Orange Chl.a = Chlorophyll a
Cocco. = coccoliths dTM = dissolved Trace Metals
FCM = Flow cytometry Frrf = Fast Repetition Rate fluorometry
Lugols = Lugols iodine Nutrients = phosphate, silicate, nitrate
pTM = Particulate Trace Metals
spec. = Fe speciation

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Key metabolic proteins in marine microbial communities: the role of iron availability

Anna Macey, Mark Moore, Tom Bibby (University of Southampton, National Oceanography Centre, UK)

Introduction

The diversity of marine microbial communities is poorly understood, however, microbial processes catalyse biochemical cycles on global scales. Despite this diversity the protein catalysts that perform the chemistry of these reactions are highly conserved. Iron (Fe) is a fundamental requirement for high rates of production due to the abundance of Fe-containing protein catalysts in the photosynthetic apparatus of photosynthetic cells (Shi et al. 2007). Thus Fe availability has the potential to limit the abundance of these proteins and set a limit on metabolic activity and hence primary production within the ocean. Primary production in the ocean is usually quantified through basic methods in oceanography (e.g. chlorophyll content, photosynthetic efficiency (Fv/Fm), satellite pictures). Using this novel quantitative technique we will investigate the photosynthetic process at a molecular level in order to better understand the role of Fe availability on photosynthetic activity. Samples were collected for metabolic protein analysis in Fe-replete and Fe-deplete regions of the North Atlantic and within nutrient amendment bioassay experiments.

Methods

Sampling for proteins

Water samples were collected from the stainless CTD (Table 1), the ships non-toxic supply (Table 2) and from nutrient addition experiments (see Nutrient addition experiments, Thomas Ryan-Keogh, Anna Macey and Mark Moore). From the CTD, samples were collected from the surface (5m) and the base of the mixed layer. Samples were collected in polyethylene carboys and volumes ranging from 1.2L to 2.1L (depending on biomass in seawater) were filtered in triplicate for 1-2 hours through GF/F filters (0.7 µm, 25mm, Whatman). The filters were then snap-frozen in liquid nitrogen and stored at -80^{o}C. Filters will be used for protein extractions on return to the NOCS to target key photosynthetic proteins including components of PSII and PSI.

Auxiliary samples were also taken from the non-toxic supply at the same time as sampling for underway proteins. The following were taken: flow cytometry, chlorophyll *a*, macronutrients, lugols preserved seawater for phytoplankton counts and FRRf.

Table 1. CTD station numbers, locations and samples

Station	Date	Depth
CTDS002	11/7/10	5 20
CTDS003	12/7/10	5 20
CTDS004	13/7/10	5 20
CTDS006	14/7/10	5 20
CTDS007	15/7/10	5 15
CTDS009	16/7/10	5 20
CTDS011	18/7/10	5 20
CTDS012	19/7/10	5 15
CTDS017	22/7./10	5 20
CTDS019	23/7/10	5 20
CTDS020	24/7/10	5 20
CTDS022	25/7/10	5 20
CTDS023	26/7/10	5
CTDS025	27/7/10	5 30
CTDS026	30/7/10	5 15
CTDS028	31/7/10	5 15
CTDS029	1/8/10	5 14
CTDS031	3/8/10	10 25
CTDS033	4/8/10	5

		20
CTDS035	5/8/10	5 20
CTDS037	7/8/10	5 20

Table 2. Underway sampling times and samples taken

UW No.	Date	Time	Depth (m)	Protein	Chl *a*	Nutrients	FRRf	Lugols	FCM	Cellulose Nitrate filters
UW1	10/7/10	18:00	Surface	*	*	*	*			
UW2	11/7/10	16:00	Surface	*	*	*	*	*	*	*
UW3	11/7/10	20:00	Surface	*	*	*	*	*	*	*
UW4	12/7/10	00:00	Surface	*	*	*	*	*	*	*
UW5	12/7/10	04:00	Surface	*	*	*	*	*	*	*
UW6	12/7/10	10:54	Surface	*	*	*	*	*	*	*
UW7	17/7/10	08:00	Surface	*	*	*	*	*	*	*
UW8	17/7/10	12:12	Surface	*	*	*	*	*	*	*
UW9	17/7/10	16:02	Surface	*	*	*	*	*	*	*
UW10	17/7/10	20:03	Surface	*	*	*	*	*	*	*
UW11	18/7/10	00:00	Surface	*	*	*	*	*	*	*
UW12	18/7/10	08:00	Surface	*	*	*	*	*	*	*
UW13	22/7/10	11:58	Surface	*	*	*	*	*	*	*
UW14	22/7/10	16:00	Surface	*	*	*	*	*	*	*
UW15	22/7/10	20:00	Surface	*	*	*	*	*	*	*
UW16	23/7/10	00:00	Surface	*	*	*	*	*	*	*
UW17	23/7/1	08:00	Surface	*	*	*	*	*	*	*
UW18	26/7/10	06:04	Surface	*	*	*	*	*	*	*
UW19	26/7/10	18:02	Surface	*	*	*	*	*	*	*
UW20	27/7/10	00:00	Surface	*	*	*	*	*	*	*

References

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Underway Fast Repetition Rate fluorometry (FRRf).

Thomas Ryan-Keogh, Mark Moore (University of Southampton, National Oceanography Centre, UK)

A Chelsea Scientific instruments FAST*track*™ Fast Repetition Rate fluorometer (FRRf) (Kolber et al. 1998) was connected to the ships non-toxic supply within the bottle annex in order to assess and monitor the physiological state of Photosystem II (PSII) within the surface phytoplankton population of the study area.

The FRRf had the following settings when performing measurements:

6. Acq = 0
7. Flash seq/Acq = 16
8. Sat flash/seq = 100
9. Sat flash duration = 4
A. Sat interflash delay = 0
B. Relax flash – Enabled
C. Relax flash/seq = 20
D. Relax flash/seq = 4
E. Relax flash int. = 61
F. Sleeptime – 30000
G. Gain – autoranging – 1
H. Analyse out – disabled
I. Verbose – enabled

The data were stored internally on the instrument and were downloaded between 24 hours and 48 hours intervals throughout D354. The Instrument optics were cleaned whilst the download operation was being carried out and before the protocol was set to run again, blank measurements were performed to calibrate the results.

A total of 22 files were collected (Table 1). Data were then analysed using custom software in a Matlab™ environment. The number of sequences averaged within the recorded files resulted in an average every 15 minutes.

Much of the signal was dominated by marked diel variability in the parameters that can be measured by an FRRf deployed in this mode (F_v'/F_m' and σ_{PSII}'), the data also indicated the presence of a dawn maxima signal before quenching began.

	UW1	UW2	UW3	UW4	UW5	UW6	UW7	UW8	UW9
Start Time (GMT)	06/07/10 03:00	09/07/10 13:05	11/07/10 14:20	12/07/10 16:40	13/07/10 13:09	14/07/10 18:37	16/07/10 18:04	17/07/10 16:25	18/07/10 17:29
	UW10	UW11	UW12	UW13	UW14	UW15	UW16	UW17	UW18
Start Time (GMT)	20/07/10 18:56	22/07/10 18:18	23/07/10 18:46	25/07/10 19:43	26/07/10 20:36	27/07/10 20:34	28/07/10 19:08	30/07/10 19:17	31/07/10 21:46
	UW19	UW20	UW21	UW22					
Start Time (GMT)	02/08/10 11:03	03/08/10 19:14	04/08/10 18:27	05/08/10 22:09					

Table 5 Underway FRRf files collected during D354.

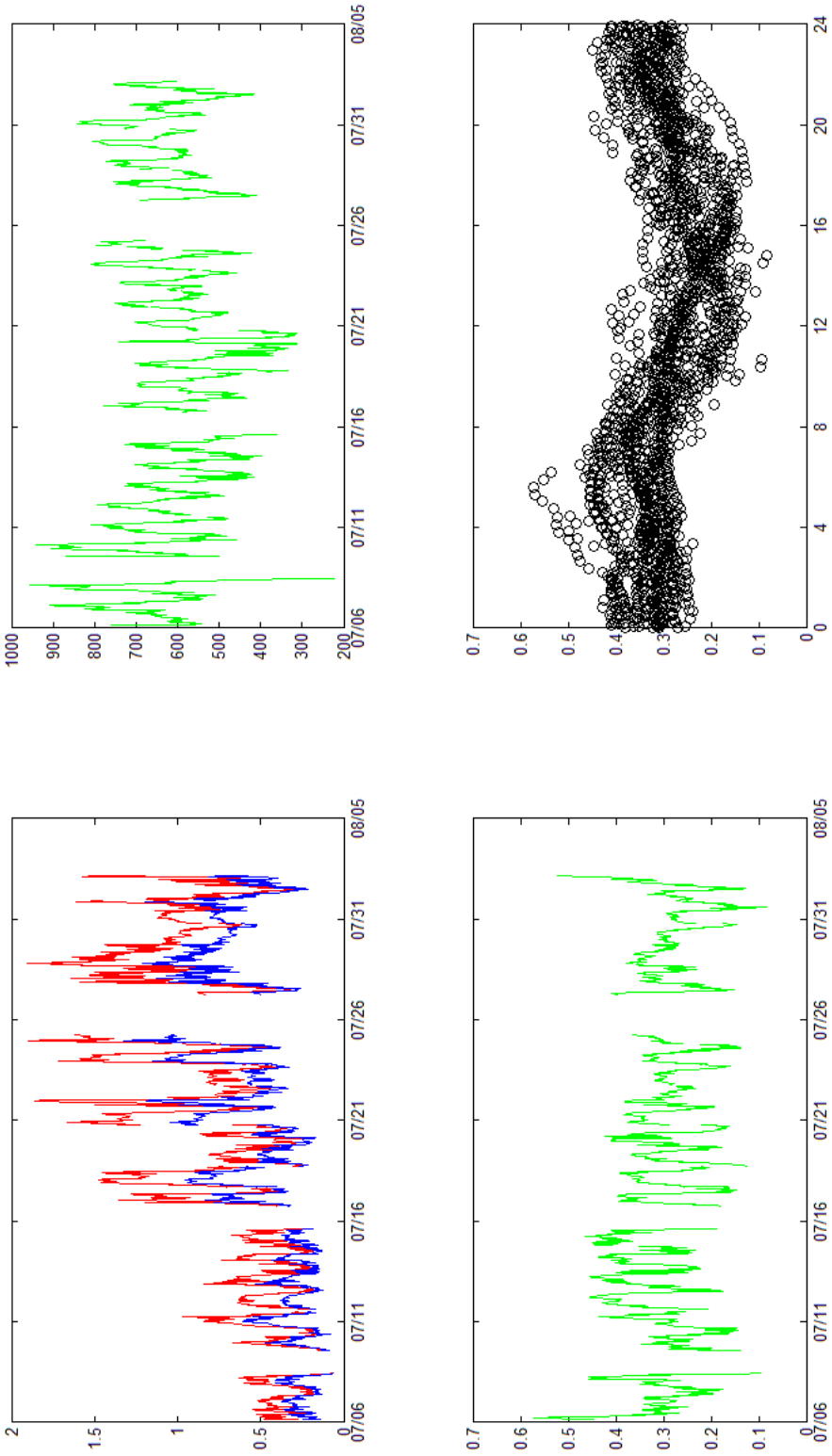

Figure 6. Preliminary data from underway FRRf collected onboard D354.

Primary production, calcification and nitrate uptake rates by phytoplankton.

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I. 24 hour +Fe / -Fe and ρNO_3 incubations with Tommy Ryan-Keogh

For these experiments, water was collected from the towed fish, and in the trace metal clean container, decanted into 6 x 1.2L polycarbonate bottles. All six were spiked with 100µl trace metal cleaned $^{15}N\text{-}NO_3$ (1 µmol N/100µl stock). This assumes an enrichment of ~10% of ambient NO_3 assuming an *in situ* concentration of ~10 µmol l^{-1}. Of the six, three had DFe additions of 2nM, while the remaining 3 received no DFe additions. At time zero (To), initial parameters of chl-a, nutrients, FRRf and flow cytometry were measured. At T24, NO_3, chl-a, FRRf and ρNO_3 were taken.

Date	JD (To)	Exp ID	Chl-a	NO_3	FRRf	ρNO_3
10/11 July	191	MIL 1	✓	✓	✓	✓
11/12 July	192	MIL 2	✓	✓	✓	✓
12/13 July	193	MIL 3	✓	✓	✓	✓
13/14 July	194	MIL 4	✓	✓	✓	✓
15/16 July	196	MIL 5	✓	✓	✓	✓
16/17 July	197	MIL 6	✓	✓	✓	✓
18/19 July	199	MIL 7	✓	✓	✓	✓
19/20 July	200	MIL 8	✓	✓	✓	✓
22/23 July	203	MIL 9	✓	✓	✓	✓
24/25 July	205	MIL 10	✓	✓	✓	✓
25/26 July	206	MIL 11	✓	✓	✓	✓
26/27 July	207	MIL 12	✓	✓	✓	✓
30/31 July	210	MIL 13	✓	✓	✓	✓
1/2 August	213	MIL 14	✓	✓	✓	✓
3/4 August	215	MIL 15	✓	✓	✓	✓
5/6 August	217	MIL 16	✓	✓	✓	✓
6/7 August	218	MIL 17	✓	✓	✓	✓

Bottles: 3 replicates +Fe (bottles 1-3); 3 replicates –Fe (bottles 4-6).

Spikes: 100µl 15N-NO_3

II. Bio-Assay Experiments (Moore, Anna Macey & Tommy Ryan-Keogh)

On three occasions, 15N-NO3 spike was used to provide a nitrate source for the bio-assay experiments where the ambient nitrate pool was very low. This provided an opportunistic opportunity to measure ρNO_3 at the end point of the experiments in 3 bio-assay bottles that were supplemented with DFe and in 3 bio-assay bottles that were not**.** For these experiments, 4.2 L of sample water from the fish was spiked with 1.0ml trace metal clean $^{15}N\text{-}NO_3$ (1 µmol N/100µl stock).

Bio-Assay	JD	Exp ID	Chl-a			ρNO_3
16 July	JD 197	IE 5.2 T48	✓			✓
27 July	JD 208	IE 5.5 T72	✓			✓
7 August	JD 219	IE 5.7 T72	✓			✓

III. 15N + 13C Incubations for PP, Calcification and ρNO_3

Seawater samples for these experiments were collected from the shallow pre-dawn stainless cast (CTDs). On each occasion, 6 x 1.2l samples were taken from the surface bottle of the stainless CTD cast for that day. These samples were then spiked with ~104 µmol C l^{-1} ^{13}C-stock (200µl) to provide a DIC concentration of ~5%; assuming an ambient DIC concentration of ~2.0836 mmol C l^{-1}. In addition, a spike of 15N-NO3 (1 µmol N/100µl stock) of ^{15}N (50µl) was added to the bottles (~10% of ambient NO_3 assuming a summer *in situ* concentration of ~5 µmol l^{-1}). Bottles were incubated for 24 hours in incubators at light levels corresponding to the collection depth. The samples were then filtered onto 25mm diameter pre-ashed GF/F filters and dried on board for later Mass Spec analyses at the University of Cape Town. Of the six bottles filtered, 3 filters will be acid fumed to remove PIC and 3 will not be fumed. The difference in 13C fixation between the two sets of 3 bottles ought to represent calcification.

Date	JD	Stn No	CTDs / Exp ID	NO_3	Chl-a	$\rho NO_3 + \rho^{13}C$
12 July	193	003	003 / MIL 1	✓	✓	✓
13 July	194	004	004 / MIL 2	✓	✓	✓
14 July	195	005	006 / MIL 3	✓	✓	✓
15 July	196	006	007 / MIL 4	✓	✓	✓
16 July	197	007	009 / MIL 5	✓	✓	✓
18 July	199	009	011 / MIL 6	✓	✓	✓
19 July	200	010	012 / MIL 7	✓	✓	✓
22 July	203	016	017 / MIL 8	✓	✓	✓
23 July	204	017	019 / MIL 9	✓	✓	✓
24 July	205	018	020 / MIL 10	✓	✓	✓
25 July	206	019	022 / MIL 11	✓	✓	✓
27 July	208	021	025 / MIL 12	✓	✓	✓
30 July	211	022	027 / MIL 13	✓	✓	✓
31 July	212	023	028 / MIL 14	✓	✓	✓
1 August	213	024	029 / MIL 15	✓	✓	✓
3 August	215	027	031 / MIL 16	✓	✓	✓
4 August	216	028	033 / MIL 17	✓	✓	✓
5 August	217	029	035 / MIL 18	✓	✓	✓

Bottles: CTD's - 6 x replicate surface incubations (3 to be fumed for calcification estimate by difference from the 3 un-fumed filters.)

Spikes: 50µl 15N-NO_3 + 200µl 13C

Mike Lucas

10 August 2010

Chlorophyll-a, HPLC, POC, PIC, BSi and Microscopy sampling from the CTD and non-toxic UW seawater supplies.

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Mike Lucas, University of Cape Town, South Africa (mikelucasuct@gmail.com)

CTD Sampling

For each stainless steel CTD cast (CTDs), water from typically the top 6 depths of the euphotic layer (surface to approx 50m) was drawn into 20L black carboys to filter for pigments (chl-a, HPLC), particulate organic and inorganic carbon (POC/N, PIC), particle absorbance (PABs) and biogenic silica (BSi). Additionally, phytoplankton community structure was determined by microscopy from preserved (Lugols) and filtered (SEM, light microscopy) samples. The isotopic signature of particulate and dissolved Si (Part Si, Sol Si) was also recorded for many stations. Separately, nutrient and oxygen samples were taken from each CTD bottle at all depths.

Underway non-toxic sampling

At typically 2-hour intervals, but sometimes at hourly or 4 hourly intervals depending on the resolution required, samples were taken from the non-toxic supply in the wet lab for nutrient, chl-a, salinity and SEM samples.

Filtering and preservation of samples

1.) Top six depths: water was filtered for size-fractionated chl-a (total, >5µm), POC/N, BSi and PIC.

Chlorophyll-a

For chl-a, 250ml seawater (SW) was filtered onto Whatman GF/F filters that were then placed in 8ml 90% acetone for ~24hrs in a dark 4°C CT room for pigment extraction. For the >5µm fraction, phytoplankton were retained from a 250ml filtered sample on Millipore 5µm membrane filters and pigment was extracted as before. After extraction, chl-a was measured on a Turner fluorometer (Welschmeyer technique) using solid Turner standards.

Particulate Organic Carbon and Nitrogen (POC/N)

For POC/N, between 1000 and 2000mls SW was filtered onto pre-ashed Whatman GF/F filters. These were then placed in Eppendorf tubes and dried overnight in an oven at 30°C for storage prior to analyses back at NOC.

Biogenic Silica (BSi)

For BSi, between 250 and 500 mls SW was filtered onto Whatman 0.8µm polycarbonate filters. After filtration, the filters were placed into plastic 20ml scintillation vials to dry at room temperature prior to later digestion and analyses back at NOC.

Particulate Inorganic Carbon (PIC)

This fraction is dominated by calcite, and provides a measure of coccolithophore abundance. Between 250-500 mls SW was filtered onto Whatman 0.8µm polycarbonate filters that were then rinsed in buffered ammonium soln to remove salts. The filters were placed in 60ml centrifuge tubes to dry at room temperature prior to later digestion and analyses back at NOC.

2.) At two depths: (surface and the deep chl-a maximum), samples were taken for HPLC pigments, particle absorbance (PABs) and for preserved phytoplankton samples (Lugols, SEM, light microscopy). In addition, the isotopic signature of particulate and dissolved Si (Part Si, Sol Si) was also recorded for many stations.

HPLC

Between 1000 and 2000 mls SW was filtered onto Whatman GF/F filters for later extraction of pigments by HPLC. After filtration, HPLC filters were placed into nunc™ CryoTube™ vials and stored at -80°C prior to later analyses back at NOC.

Particle Absorbance (PABs)

For PABs, between 1000 and 2000 mls SW was filtered onto Whatman GF/F filters for later absorbance measurements. The filters were placed flat into Millipore Petri Slides, wrapped in tin foil, and stored in the -80°C freezer.

Scanning Electron Microscopy (SEM)

For SEM samples, between 250 and 500 mls was filtered onto Whatman 0.8µm polycarbonate filters. These were rinsed in buffered ammonium soln to remove salts. The filters were placed in Millipore Petri slides and dried overnight at 30°C before being stored at room temperature.

Light Microscopy

For light microscopy samples, between 250 and 500 mls was filtered onto Whatman 0.8µm cellulose nitrate filters. The filters were placed in Millipore Petri slides and dried overnight at 30°C before being stored at room temperature.

Isotopic Particulate Si (Part Si)

At some stations, between 250 and 500 mls was filtered onto Whatman 0.8µm polycarbonate filters, placed in Millipore Petri slides, and then frozen at -20°C.

Isotopic Soluble Si (Sol Si)

At some stations, 60 mls was filtered by syringe through Millex 0.2µm disposable filters and the filtrate retained in 60 ml centrifuge tubes for later analyses.

Preserved phytoplankton (Lugols)

To brown 150ml medicine bottles containing 3 mls Lugols solution, 125mls SW was added to preserve phytoplankton for later enumeration and identification.

Nutrient addition bioassay experiments.

Thomas Ryan-Keogh, Anna Macey, Mark Moore (University of Southampton, National Oceanography Centre, UK)

Nutrient addition bioassay experiments were performed using a highly replicated design to investigate the effect of nutrient (iron (Fe) and Nitrate) availability on phytoplankton physiology, growth and nutrient drawdown and the photosynthetic molecular composition of the microbial communities, over different timescales. Three different experimental designs were run simultaneously: 24 hr incubations, 2/3-day and 5-day incubations; with the short-term bioassays primary function to analyse the rapid changes in physiology upon Fe addition while the long-term bioassays were to assess changes in community physiology, structure and photosynthetic molecular composition in response to Fe, nitrate and additions of volcanic ash collected on board ship during a prior cruise (D350).

Strict controls were required to avoid the contamination of incubation containers and sampled water. Incubations for the 24 hr bioassays were performed in 1 L polycarbonate bottles and the incubations for the 2/3 and 5-day bioassays were performed in 4.5 L polycarbonate bottles. All bottles used in incubations were passed through a rigorous cleaning process involving a Decon wash and soaking in 50% HCl for 1 week, followed by rinsing then storage with acidified Milli-Q prior to sailing. Bottle filling and all manipulation steps including spiking and sub-sampling were performed within the dedicated Class-100 air filtered clean container.

Incubation water was collected using the trace metal clean tow fish. In order to ensure there was no contamination of water, the tow-fish was only used when the ship was sailing at a minimum of 5 knots either towards the station or doing a track around the station. Due to the possibility of sampling between different communities, initial samples were taken before the bottles were filled, when all bottles were half filled and when all the bottles were filled. The average time between the primary initial and final initial sample for the 24 hr bioassays was 10 minutes while on the 2/3 and 5-day bioassays it reached 30-40 minutes. This longer sampling time lead to variability within the initial samples and possible problems when interpreting the responses of Fe manipulation. Following filling, bottles were sealed with parafilm, then double bagged before being incubated on deck at sea surface temperature.

The experimental design of the 24 hr bioassays involved the incubation of 9 bottles, in 3 sets of 3 bottles; one set for iron addition at a concentration of 2.0 nM, one set for iron addition at a concentration of 0.2 nM and one for controls. Samples were taken for chlorophyll, flow Cytometry, nutrients and FRRf; measured on both a Chelsea FAST*track*^{TM} FRRf and a FAST*act*^{TM} FRRf laboratory system. A complete list of sampling locations and initial chlorophyll is provided in table 2.

Table 2. *Sampling locations, sampling methods, start and end times and initial conditions for the 24 hour experiments.*

	Expt 1	Expt 2	Expt 3	Expt 4	Expt 5	Expt 6	Expt 7	Expt 8
Sampling location	57.0285 -10.9011	58.7899 -16.2012	59.9938 -19.9051	61.8953 -21.001	60.0043 -23.4962	60.0013 -27.661	60.0172 -34.9955	59.9999 -41.2236
Sampling method	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish
Bottle set	1	1	1	1	1	1	1	1
Start Point	191	192	193	194	196	197	199	200
End Point	192	193	194	195	197	198	200	201
Initial Chlorophyll ($\mu g.L^{-1}$)	0.576	1.332	0.697	1.340	1.528	2.684	2.524	0.701
	Expt 9	Expt 10	Expt 11	Expt 12	Expt 13	Expt 14	Expt 15	Expt 16
Sampling location	62.8321 -34.9808	63.0001 -30.0825	60.9293 -31.4793	58.264 -34.6861	58.1497 -35.0065	60.8921 -34.4115	63.8436 -34.9941	62.5305 -28.6218
Sampling method	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish
Bottle set	1	1	1	1	1	1	1	1
Start Point	203	205	206	207	208	209	211	213
End Point	204	206	207	208	209	210	212	214
Initial Chlorophyll ($\mu g.L^{-1}$)	1.940	2.495	3.100	2.059	1.844	1.773	1.136	1.442
	Expt 17	Expt 18	Expt 19					
Sampling location	62.4533 -24.1379	61.7443 -24.8494	62.1162 -26.9766					
Sampling method	Trace clean fish	Trace clean fish	Trace clean fish					
Bottle set	1	1	1					
Start Point	215	217	218					
End Point	216	218	219					
Initial Chlorophyll ($\mu g.L^{-1}$)	1.589	1.645	1.632					

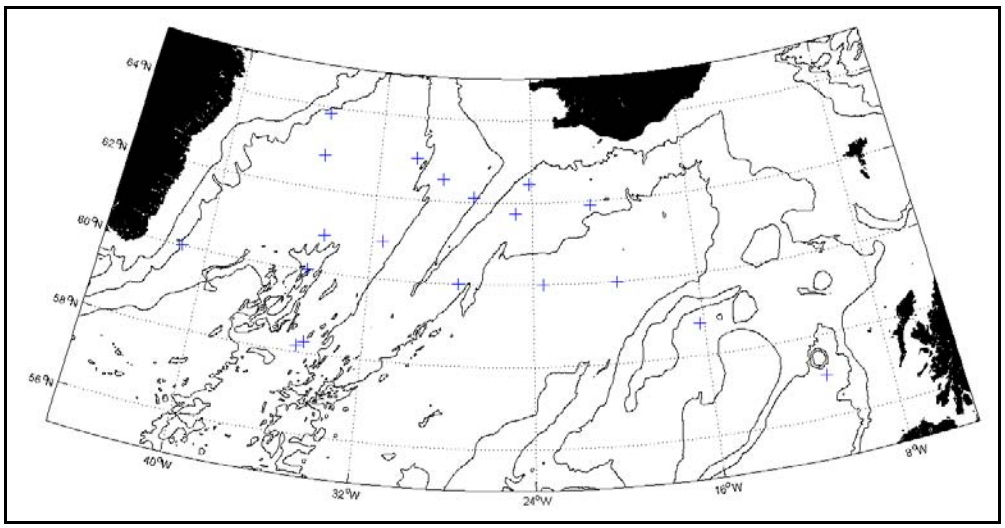


Figure 2. Location map of 24 hour incubation experiments performed onboard D354.

The experimental design of the 2/3-day bioassays involved the incubation of 18 bottles in 4 sets of replicates. One set was for the control (6 bottles), one for Fe addition (2nM) (6 bottles), one for nitrate addition (2 µM) (3 bottles) and one for Fe (2nM) and nitrate (2µM) addition (3 bottes). Each bottle was sub-sampled at 24 hr and 48 hr and for the later 2 experiments at 72 hr. The 3 additional bottles in the control and Fe treatments were sampled at 24 hr and 48 hr to sample for proteins (see separate report section by Macey). Measurements taken at sampling points included chlorophyll *a*, macronutrients, FRRf, proteins, lugols preserved samples for phytoplankton counts and flow cytometry. A total of 4 experiments lasting 2-3 days were carried out during D354. A complete list of 3-day experiments along with sampling locations and initial conditions is provided in Table 3.

Table 3. *Sampling locations, sampling methods, start and end times and initial conditions for the 2-3 day experiments. *data unavailable until return to NOCS.*

	IE5.1	IE5.2	IE5.5	IE5.7
Sampling Location	58.7899 -16.2012	59.9999 -20.4745	58.155 -35.0315	61.3675 -21.1584
Sampling Method	Trace clean fish	Trace clean fish	Trace clean fish	Trace clean fish
Start Date	12-7-10	14-7-10	27-7-10	4-8-10
End Date	14-7-10	16-7-10	30-7-10	7-8-10
Initial chlorophyll *a* (µg l^{-1})	0.697 ± 0.584	1.627 ± 0.367	1.750 ± 0.068	0.993 ± 0.047
Initial nitrate (µM)	0.71 ± 0.48	0.29 ± 0.24	4.27 ±0.04	*

The experimental design of the 5-day bioassays involved the incubation of 21 bottles in 3 sets of 8 replicates. One set was for the control, one for Fe addition (2nM) and one for the

addition of ash from the Iceland Eyjafjallajökull volcano eruption in May 2010. 3 bottles from each set were sub-sampled at 24 hr and broken down at 72 hr to collect samples for protein analysis. Two bottles from each set were sub-sampled at time points of 24 hrs, 72 hrs and at the end. The remaining three replicates from each set were not sampled until the end time-point to check whether sub-sampling had led to contamination of the time-series measurements. Such a strategy also provides more robust statistics and a large volume of water for an additional suite of final measurements. Measurements taken at sampling points included chlorophyll *a*, macronutrients, FRRf, proteins, lugols preserved samples for phytoplankton counts and flow cytometry. A total of 3 experiments lasting 5 days each were carried out during D354. A complete list of 5-day experiments along with sampling locations and initial conditions is provided in Table 4.

A location map showing 2/3 and 5 day experiments can be seen in Fig. 3.

Table 4. *Sampling locations, sampling methods, start and end times and initial conditions for the 5 day experiments.*

	IE5.3	IE5.4	IE5.6
Sampling Location	60.0016	63.0273	63.8401
	-34.3769	-35.2885	-34.7382
Sampling Method	Trace clean fish	Trace clean fish	Trace clean fish
Start Date	17-7-10	23-7-10	31-7-10
End Date	22-7-10	28-7-10	5-8-10
Initial chlorophyll *a* ($\mu g\ l^{-1}$)	2.323 ± 0.201	1.175 ± 0.025	1.499 ± 0.008

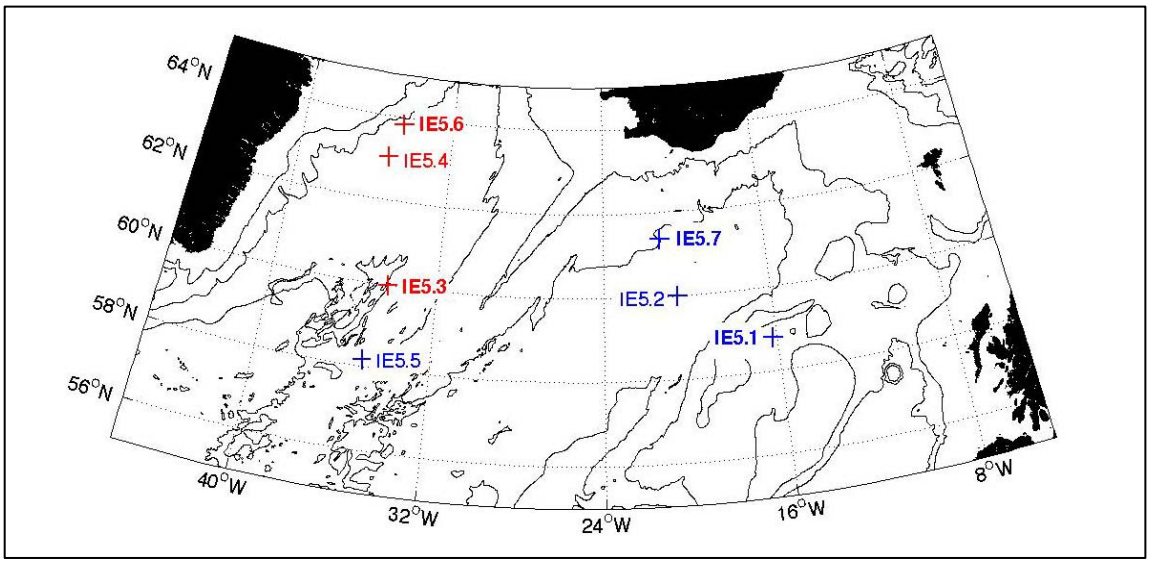


Figure 3. *Locations of 2/3 day (blue crosses) and 5 day (red crosses) incubation experiments.*

CTD Sampling for Flow Cytometry, FRRf and Rapid Light Curves – *Thomas Ryan-Keogh, Mark Moore*

From the biological CTDs the following samples were collected and measured; flow cytometry, FRRf and rapid light curves. The flow cytometry samples were preserved in PFA to a final concentration of 0.1%; they were allowed to fix overnight at 4°C before they were stored at -80°C. The PFA stock was prepared using filtered seawater and was made up to a concentration of 10%.

A total of 126 flow cytometry samples were collected from the biological CTDs, with a total of 126 FRRf measurements. From each biological CTD a rapid light curve was performed on seawater collected at the surface and from the base of the mixed layer; a total of 40 rapid light curves.

Table 5. Samples and measurements taken from CTDs including depths samples collected.

CTD	Depth	Flow Cytometry	FRRf	Rapid Light
2	5	•	•	
	10	•	•	
	20	•	•	
	30	•	•	
	40	•	•	
	50	•	•	
3	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	57	•	•	
4	5	•	•	•
	10	•	•	
	15	•	•	
	20	•	•	•
	35	•	•	
	50	•	•	
6	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
7	5	•	•	•
	8	•	•	
	15	•	•	•
	20	•	•	
	30	•	•	
	40	•	•	
9	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	

11	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
12	5	•	•	•
	10	•	•	
	15	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
17	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
19	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
20	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
22	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
23	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
25	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
26	5	•	•	•
	10	•	•	
	15	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
28	5	•	•	•
	10	•	•	
	15	•	•	•

	30	•	•	
	40	•	•	
	50	•	•	
29	5	•	•	•
	14	•	•	•
	20	•	•	
	30	•	•	
	40	•	•	
	50	•	•	
31	10	•	•	•
	20	•	•	
	25	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
33	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
35	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	
37	5	•	•	•
	10	•	•	
	20	•	•	•
	30	•	•	
	40	•	•	
	50	•	•	

Dissolved iron and aluminium distribution in the Iceland and Iminger Basin during D354

Sebastian Steigenberger,Jessica Klar, Eric Achterberg (University of Southampton, National Oceanography Centre, UK)

Introduction

It is well established that iron availability is of great importance in regulating primary productivity in the High Nutrient Low Chlorophyll (HNLC) regions of the Southern Ocean and Northwest Pacific. However there is also evidence that phytoplankton primary production in other regions, including the high latitude North Atlantic, can periodically be subject to iron limitation. In the latter case, such conditions are most likely to be observed in summer following the spring bloom, and are thought to result from Fe:nutrient supply ratios being below those needed for optimal phytoplankton growth, and exacerbated by enhanced Fe:nutrient export ratios

The main sources of iron to the euphotic zone of the open ocean are from atmospheric inputs and from upwelling and mixing of deeper ocean water. Whereas much of the North Atlantic receives relatively large amounts of atmospheric dust each year through inputs of Saharan dust, leading to surface water dissolved iron concentrations of up to 2nM, the atmospheric supply of iron to the high latitude (higher than 60^{o}) North Atlantic is estimated to be only 30% higher than that to the Southern Ocean, a major HNLC region.

The relative rates at which iron and macronutrients (N, P, Si) are recycled from sinking particulate material will also have an effect on whether or not iron limitation occurs. A recent study in an area with HNLC characteristics found an increasing Fe:C ratio in particulate material with depth, suggesting a preferential regeneration of carbon over iron in sinking particulate material, which would amplify any effect of low Fe:nutrient supply ratios.

The deficiency of dissolved iron appears to limit the growth of phytoplankton over several large areas of the open ocean with high nitrate and low chlorophyll (HNLC) contents (Martin and Fitzwater 1988, Martin and Gordon 1988, Martin *et al.* 1989, 1990, 1991). Based on thermodynamic calculations of speciation measurements, it is predicted that > 99% of Fe in seawater is complexed by organic ligands of unknown origin (Gledhill and Van den Berg 1994, Van den Berg 1995, Rue and Bruland 1995, Wu and Luther 1995, Rue and Bruland 1997). Laboratory and field experiments have provided evidence suggesting that some components of the natural organic Fe-binding ligand pool in seawater consist of siderophores (Haygood *et al.* 1993, Rue and Bruland 1995, Wilhelm *et al.* 1998, Hudson 1998, Hutchins *et al.* 1999).

Under iron-limiting growth conditions (< 10^{-5} mol dm^{-3}), most microorganisms use a high-affinity iron acquisition system involving the production of iron(III)-specific extracellular chelators (siderophores) for iron uptake at low concentrations. The iron-siderophore complex is actively taken up by the cell. Once inside the cell, iron is released from the complex and utilized in cellular metabolism (Neilands 1973). Siderophores (from the Greek: “iron carriers”) are low-molecular-weight organic compounds (500 - 1500 Da). The biosynthesis of siderophores is regulated by iron concentration in solution, and the stability constants for iron siderophore complex formation are of the order of 10^{30} or higher

(Neilands 1995). Hence, it can be concluded that siderophores are produced by several species of bacteria, fungi, blue-green algae, and eukaryotic organisms.

Another trace metal, aluminium, does not have the same biological impact as iron. Like iron, it is a major component element of continental crust, yet only nanomolar concentrations of the dissolved metal are found in surface ocean waters. It has been shown that dissolved aluminium concentrations in open ocean surface waters can be used to estimate atmospheric dust fluxes to these areas, and thus it can serve as a tracer of atmospheric inputs of iron and other biolimiting (Zn, Co, Cu) trace elements. Comparison of Fe:Al ratios in atmospheric dust and dissolved in seawater can therefore provide information about the degree to which iron is utilised

Furthermore, relative concentrations of aluminium to other metals (V, Pb) in aerosol samples can give information about whether the source of atmospheric inputs is crustal (e.g. dust blown from deserts and other arid regions) or industrial (burning of fossil fuels).

Methods

Sampling – Water column samples were collected at selected CTD stations along the transect using the titanium-frame CTD, which was fitted with trace metal clean 10L OTE (Ocean Technology Equipment) sampling bottles with external springs, modified for trace metal work. At these stations samples were collected at up to 14 depths. The trace metal clean OTE sample bottles were then transferred to a clean van on the back deck for sample processing. In addition, underway samples were collected along the transect using a towfish deployed off the port side of the ship. Near-surface seawater (~2 metre depth) was pumped into the clean van using a teflon diaphragm pump connected to clean oilfree compressed air compressor and samples collected every four hours while the ship was in transit.

Sample processing – From the titanium frame rosette bottles, both unfiltered and filtered samples were collected (for total dissolvable trace metals and dissolved trace metals respectively) in 125mL Nalgene LDPE bottles. Unfiltered samples were collected directly from the OTE bottles. Filtered samples were collected through a Sartobran 300 MF 0.2μm filter cartridge under slight positive pressure (oxygen-free N_2). All water samples were acidified to pH~2 using nitric acid (Romil UpA) within twelve hours of collection. Unfiltered samples will be left for >6 months before analysis.

From all the TiCTD casts samples for nutrients and salinity measurements were taken.

Analysis – All filtered water samples were analysed on board for dissolved Fe via flow injection analysis techniques using luminol-Fe(III) chemiluminescence (FIA-CL) (Obata and al., 1996) as well as for dissolved Al using the flow injection analysis technique developed by Resing and Measures (1994), where Al is detected by the fluorescence of a formed chelate by reaction with lumigallion. Replicate samples will be analysed for a range of trace metals, e.g. Fe, Mn, Co, Cd, Zn, Cu, Pb, by inductively coupled plasma mass spectrometry (ICP-MS) back at NOCS.

Results

Dissolved iron – 30 profiles were sampled (Fig. 1, 3 and Tab. 1) from the Ti-frame CTD and 106 underway samples (U1-U102, Fig. 2) from the tow-fish. The samples were analysed on board for DFe. Further trace metal analysis will be done back home at NOCS (Southampton). Preliminary analysis (Fig. 2) showed concentrations of 0.074-0.529 nM DFe, with an average of 0.180 nM in surface waters of the Iceland Basin, and <0.020-0.390 nM, with an average of 0.110nM for the Irminger Basin (high coastal values excluded for the calculation of the average concentration in both basins).

Preliminary analysis of the TiCTD depth profiles showed generally increasing DFe concentrations in the upper 500 m and quite constant maximum values of about 1 nM below 1000 m (Fig.3, T004 and T009). Coastal profiles (Fig.3, T014 and T024) show a rapid increase to about 1 nM DFe already in the upper 100 m and even higher concentrations towards the sediment (almost 3 nM). Over the Icelandic ridge the profiles reach the maximum DFe concentrations at intermediate depths of 400-500 m. T002 and T006, both at the same position in the central Iceland Basin, show a strong unusual DFe signal (up to 1.2 nM at 40 m) just below the mixed layer which was persistent for at least 3days. If remineralisation or a different water mass, maybe in combination with the volcanic ash input earlier in the summer, caused this can only be speculated and needs detailed analysis of the data.

Dissolved aluminium - 30 profiles were sampled (Fig. 1, 5 and Tab. 1) from the Ti-frame CTD and 103 underway samples (U1-U102, Fig. 2) from the tow-fish. The samples were analysed on board for dAl. Preliminary analysis (Fig. 4) showed concentrations of <0.20 – 5.7 nM dAl, with an average of 1.37 nM in surface waters of the Iceland Basin, and <0.20-4.33 nM, with an average of 0.60 nM for the Irminger Basin.

Preliminary analysis of the TiCTD depth profiles in the two basins showed generally increasing dAl towards depth and values of about 10 to 15 nM below 1000 m (Fig.3, T007 and T009). In contrast to the Greenland shelf, which shows dAl of only up to 6 nM at depth (Fig.3, T014), on the Icelandic shelf (Fig.3, T024) there is a rapid increase of dAl (up to 24 nM) towards the sediments. Over the Reykjanes Ridge (Fig. 3, T029 and T030) the dAl reaches maximum values of 20 nM at depth.

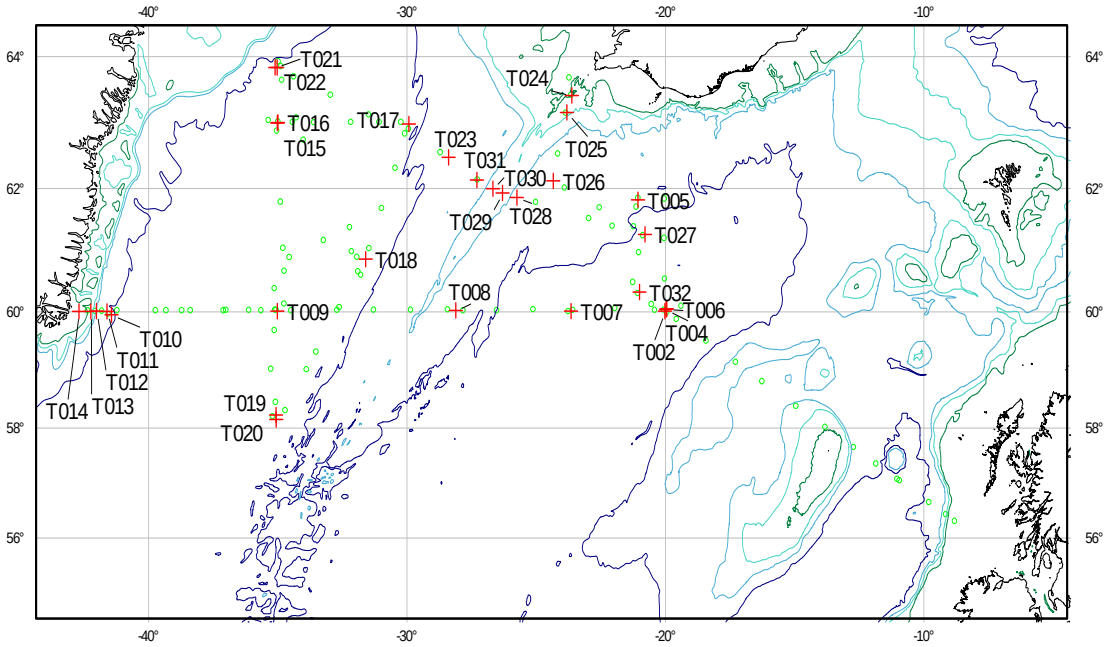


Figure 1: D354 TiCTD casts shown in red, underway samples shown in green

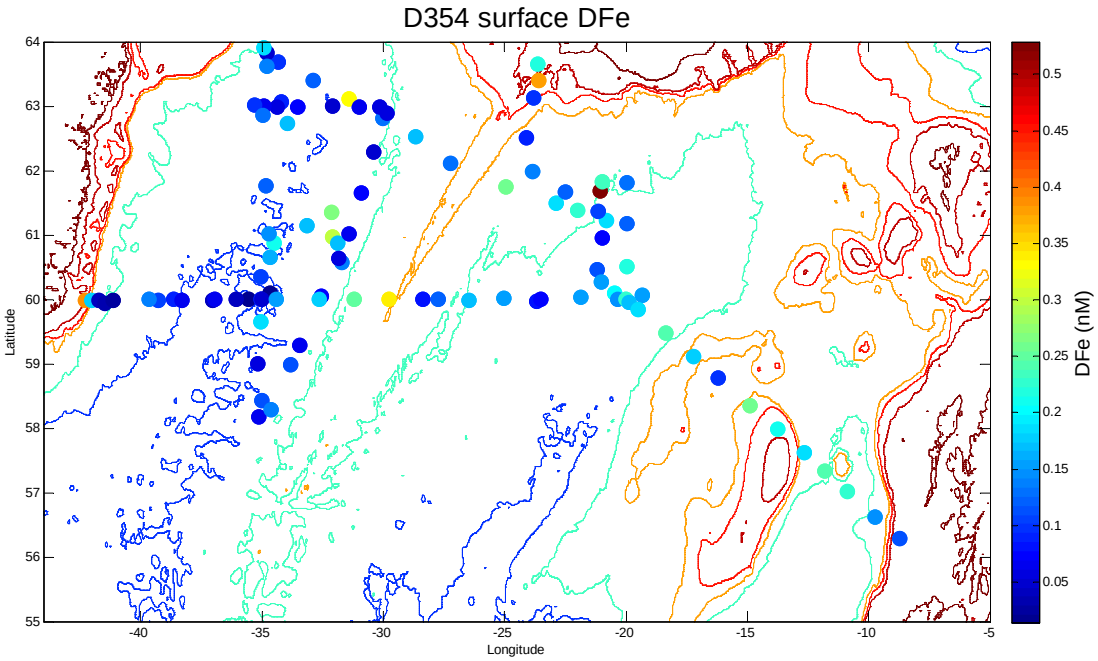
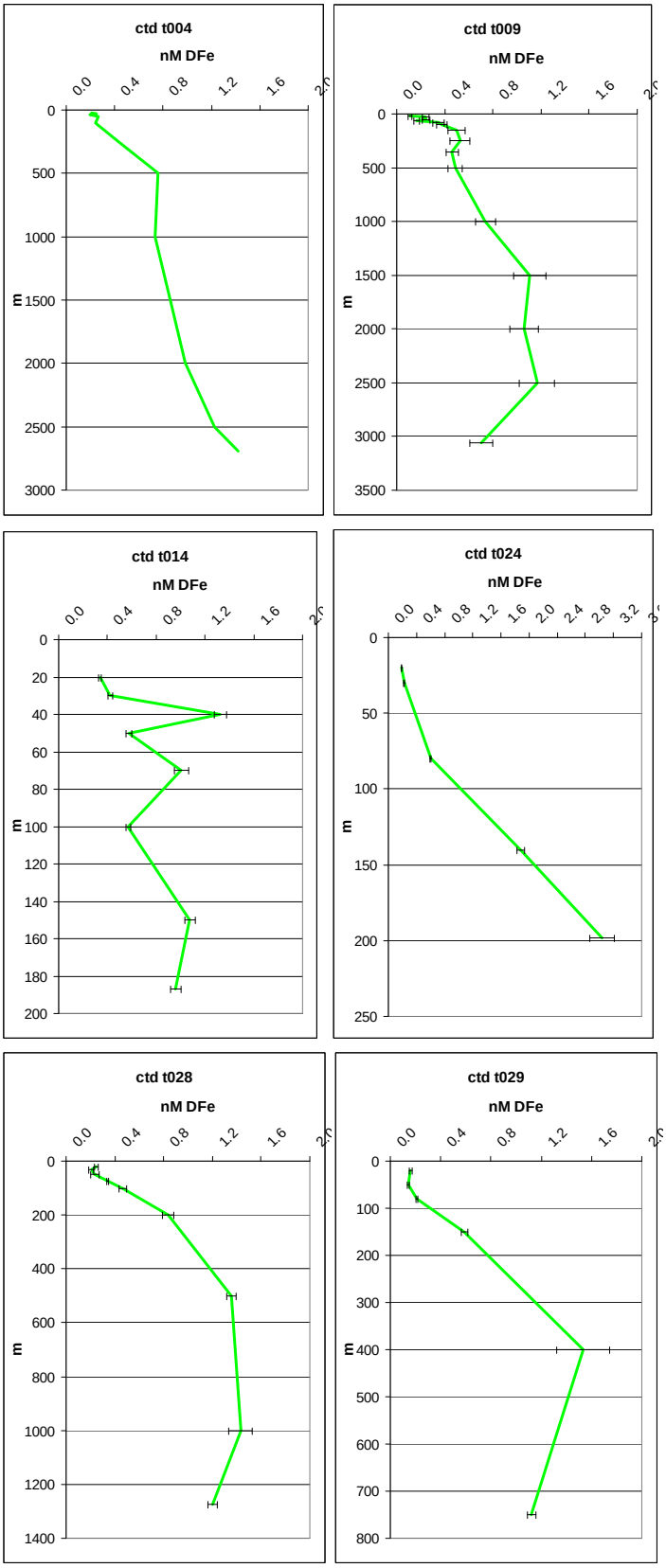


Figure 2: DFe concentrations in the underway tow fish samples (every 4h)


ctd t004
nM DFe
0.0 0.4 0.8 1.2 1.6
0 500 1000 1500 2000 2500 3000
m
ctd t009
nM DFe
0.0 0.4 0.8 1.2 1.6
0 500 1000 1500 2000 2500 3000 3500
m
ctd t014
nM DFe
0.0 0.4 0.8 1.2 1.6
0 20 40 60 80 100 120 140 160 180 200
m
ctd t024
nM DFe
0.0 0.4 0.8 1.2 1.6 2.0 2.4 2.8 3.2
0 50 100 150 200 250
m
ctd t028
nM DFe
0.0 0.4 0.8 1.2 1.6
0 200 400 600 800 1000 1200 1400
m
ctd t029
nM DFe
0.0 0.4 0.8 1.2 1.6
0 100 200 300 400 500 600 700 800
m

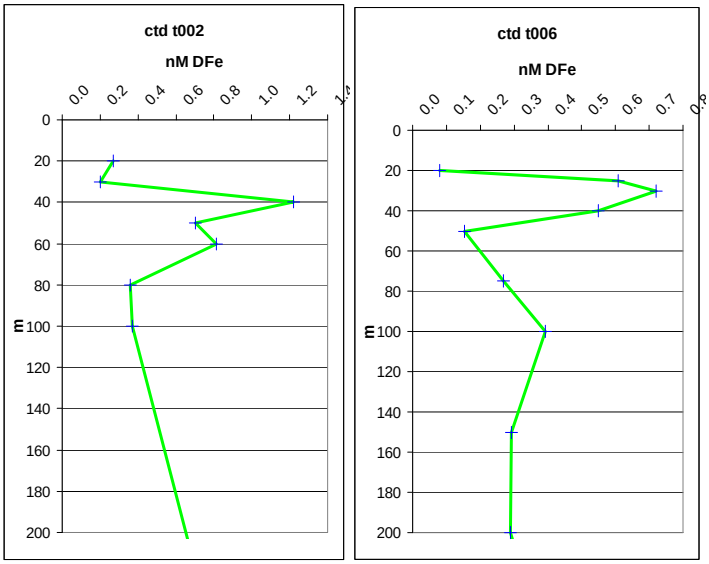


Figure 3: DFe depth profiles from the TiCTD, showing deep oceanic (T009 and T004), coastal (T014 and T024) and the DFe distribution over the Icelandic ridge (T028 and T029). T002 and T006 show a strong DFe signal just below the mixed layer.

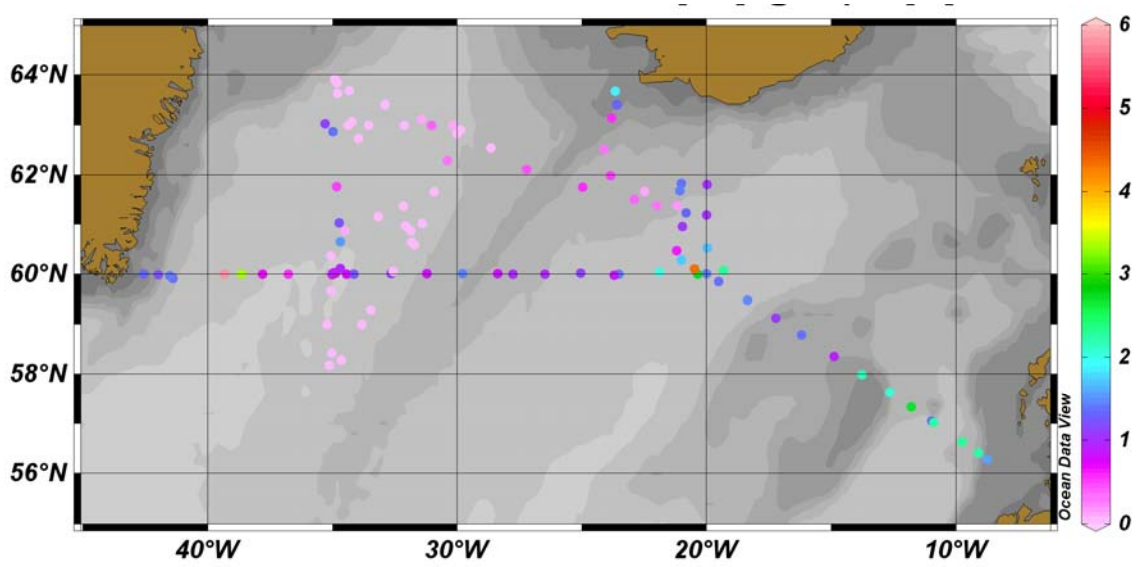


Figure 4: dAl (nM) concentrations in the underway tow fish samples (every 4h)

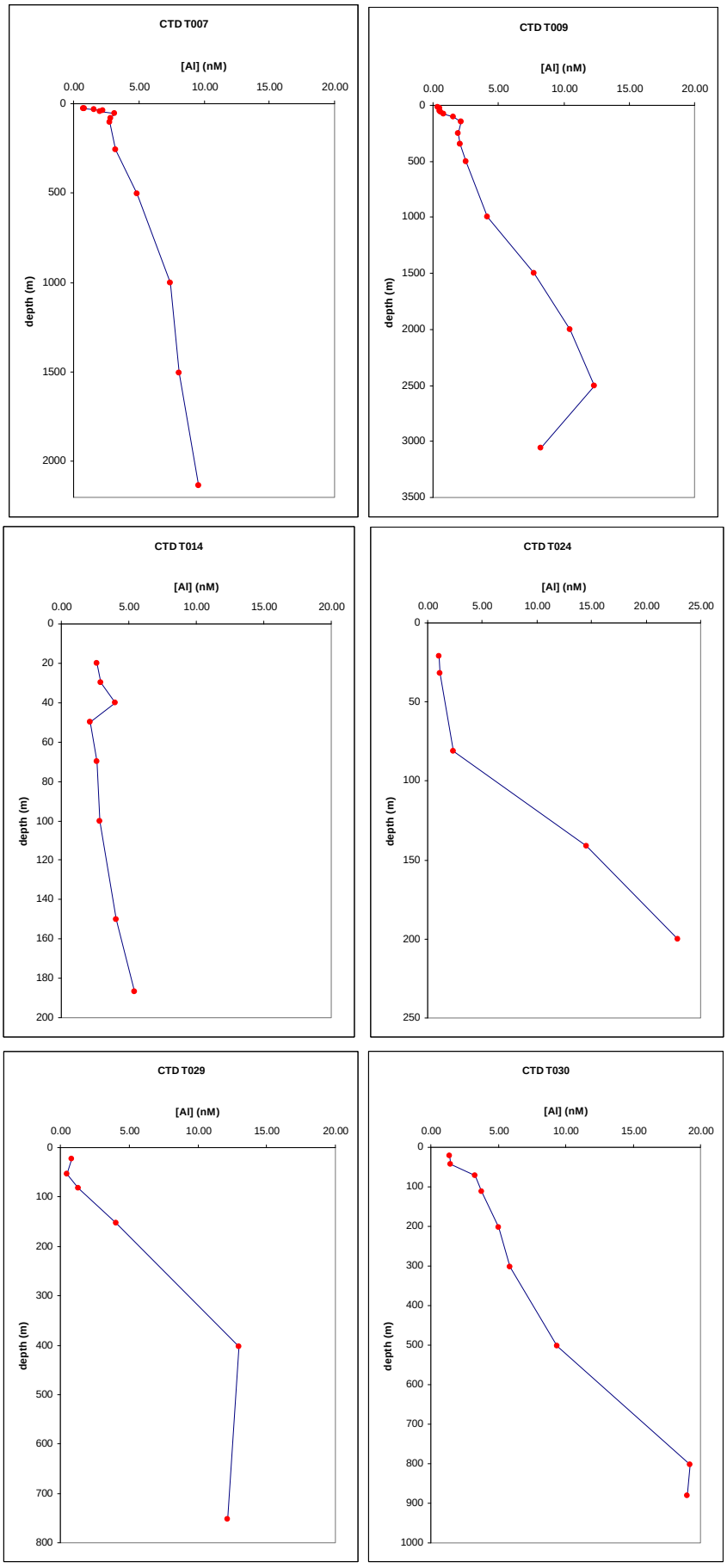


Figure 5: dAl depth profiles from the TiCTD, showing deep oceanic (T007 and T009), coastal (T014 and T024) and the dAl distribution over the Reykjanes Ridge (T029 and T030).

Table 1: List of stations which were sampled for dissolved/dissolvable iron

Date	Cast	Lat (North)	Lon (West)	Depths (m)
11/7/10	T002	60°00.09	19°59.90	20, 30, 40, 50, 60, 80, 100, 150, 300, 400, 600, 800
12/7/10	T004	60°01.71	19°56.78	20, 30, 40, 50, 100, 250, 500, 1000, 1500, 2000, 2500, 2695
13/7/10	T005	61°48.68	21°02.38	20, 25, 30, 35, 40, 50, 75, 100, 250, 500, 750, 1000, 1500, 1835
14/7/10	T006	60°02.22	19°55.24	20, 25, 30, 40, 50, 75, 100, 150, 200, 350, 600, 800
15/7/10	T007	60°00.07	23°37.70	20, 25, 30, 35, 40, 50, 75, 100, 250, 500, 1000, 1500, 2140
16/7/10	T008	60°00.90	28°05.24	20, 30, 40, 50, 75, 90, 100, 150, 250, 500, 750, 1000, 1535
18/7/10	T009	60°00.08	34°59.73	20, 30, 50, 60, 80, 100, 150, 250, 350, 500, 1000, 1500, 2000, 2500
19/7/10	T010	59°56.48	41°24.32	20, 30, 40, 50, 60, 100, 150, 290, 500, 800, 1200, 1600, 1895
19/7/10	T011	59°59.88	41°35.18	20, 30, 40, 60, 80, 150, 250, 400, 600, 900, 1250, 1600, 1835
19/7/10	T012	59°59.92	41°59.60	20, 50, 30, 100, 200, 300, 500, 900
19/7/10	T013	59°59.83	42°12.77	20, 30, 40, 75, 100, 200, 300, 340
20/7/10	T014	59°59.79	42°39.92	20, 30, 40, 50, 70, 100, 150, 187
22/7/10	T015	63°00.01	34°59.70	20, 30, 40, 50, 70, 100, 250, 500, 900, 1400, 2000, 2500, 2655
23/7/10	T016	63°00.49	34°58.16	20, 30, 40, 50, 70, 100, 150, 270, 400, 600, 800
24/7/10	T017	62°59.08	29°54.13	20, 30, 40, 50, 60, 80, 100, 320, 500, 1000, 1380, 1800, 1935
25/7/10	T018	60°51.49	31°34.68	20, 30, 40, 50, 60, 80, 100, 150, 200, 280, 400, 600, 800

26/7/10	T019	58°13.18	35°02.48	20, 25, 30, 35, 40, 50, 80, 100, 300, 500, 1000, 1500, 2000, 2445
27/7/10	T020	58°08.32	35°02.12	20, 25, 30, 35, 40, 50, 60, 80, 150, 250, 400, 600, 800
30/7/10	T021	63°49.69	35°04.86	20, 25, 30, 35, 40, 50, 60, 80, 100, 150, 250, 500, 1100, 1500, 2165
31/7/10	T022	63°49.89	35°00.01	20, 30, 40, 50, 75, 100, 150, 275, 400, 600, 800
1/8/10	T023	62°28.43	28°21.86	20, 30, 40, 50, 75, 100, 200, 300, 400, 500, 700, 1200, 1650
2/8/10	T024	63°24.78	23°35.95	20, 30, 80, 140, 198
2/8/10	T025	63°09.67	23°47.43	20, 30, 40, 60, 80, 100, 150, 250, 408
3/8/10	T026	62°06.56	24°18.56	20, 25, 30, 40, 50, 75, 100, 150, 250, 560, 1000, 1363
4/8/10	T027	61°15.48	20°45.84	20, 30, 40, 50, 75, 100, 150, 250, 500, 830, 1300, 1930, 2210
5/8/10	T028	61°50.83	25°43.31	20, 30, 50, 75, 100, 200, 500, 1000, 1275
5/8/10	T029	61°55.15	26°16.63	20, 50, 80, 150, 400, 750
5/8/10	T030	61°59.01	26°38.89	20, 40, 70, 110, 200, 300, 500, 800, 880
5/8/10	T031	62°07.22	27°15.93	20, 50, 100, 200, 400, 700, 900, 1100, 1330
7/8/10	T032	60°19.07	20°58.58	20, 30, 40, 50, 75, 150, 250, 400, 600, 800

Table 2: List of dissolved/dissolvable iron underway samples

Sample	underway	date	Time	Lat (N)	Lon (W)
1	U1	06/07/2010	10:00	56.4095	-9.0987
2	U2	06/07/2010	18:20	57.0572	-10.9858
3	U3	09/07/2010	18:00	56.289	-8.7514
4	U4	09/07/2010	22:00	56.6346	-9.7507
5	U5	10/07/2010	2:30	57.0285	-10.9011
6	U6	10/07/2010	6:02	57.3351	-11.8051
7	U7	10/07/2010	10:02	57.632	-12.6629
8	U8	10/07/2010	14:04	57.9928	-13.7703
9	U9	10/07/2010	21:58	58.3631	-14.9038

10	U10	11/07/2010	2:30	58.7915	-16.2059
11	U11	11/07/2010	6:02	59.1225	-17.2321
12	U12	11/07/2010	10:00	59.4876	-18.3747
13	U13	11/07/2010	14:00	59.8502	-19.522
14	U13a	11/07/2010	15:21	59.9658	-19.89
15	U14	12/07/2010	2:59	60.0081	-20.0104
16	U15	12/07/2010	13:57	60.5226	-19.9768
17	U16	12/07/2010	18:00	61.187	-19.9984
18	U17	12/07/2010	21:58	61.8128	-19.9879
19	U18	13/07/2010	3:45	61.827	-21.0092
20	U19	13/07/2010	14:15	61.6875	-21.0728
21	U20	13/07/2010	18:15	60.954	-20.9769
22	U21	13/07/2010	21:59	60.2842	-21.0235
23	U22	14/07/2010	1:40	60.0025	-20.364
24	U23	14/07/2010	10:00	60.0712	-19.3433
25	U24	14/07/2010	18:02	60.1033	-20.4922
26	U25	14/07/2010	21:57	60.0402	-21.8984
27	U26	15/07/2010	2:30	60.0032	-23.5321
28	U27	15/07/2010	14:07	59.9827	-23.7116
29	U28	15/07/2010	18:05	60.0174	-25.0674
30	U29	15/07/2010	22:02	59.999	-26.4783
31	U30	16/07/2010	1:45	60.0001	-27.7733
32	U31	16/07/2010	10:09	60.0113	-28.3723
33	U32	16/07/2010	14:01	60.0106	-29.8003
34	U33	16/07/2010	18:00	60.0095	-31.2333
35	U34	16/07/2010	21:59	60.0058	-32.6578
36	U35	17/07/2010	3:00	60.0015	-34.4359
37	U36	18/07/2010	2:12	60.0103	-35.0059
38	U36a	18/07/2010	8:34	60.009	-35.0584
39	U37	18/07/2010	11:29	60.0058	-36.0673
40	U38	18/07/2010	14:02	60.0031	-36.948
41	U39	18/07/2010	18:01	59.9998	-38.3277
42	U40	18/07/2010	21:56	60.0002	-39.6784
43	U41	19/07/2010	2:14	59.9997	-41.1677
44	U42	19/07/2010	13:33	59.9432	-41.5
45	U43	19/07/2010	16:30	59.9926	-41.7516
46	U44	19/07/2010	18:59	59.9868	-42.02
47	U45	19/07/2010	20:59	59.9946	-42.2931
48	U46	20/07/2010	12:04	59.9999	-39.2773
49	U47	20/07/2010	13:45	60.0002	-38.6659
50	U48	20/07/2010	18:13	60	-37.0517
51	U49	20/07/2010	22:09	60.0002	-35.5911
52	U50	21/07/2010	10:21	60.1111	-34.7039
53	U51	21/07/2010	16:07	60.6534	-34.696
54	U52	21/07/2010	18:03	61.0281	-34.7443
55	U53	21/07/2010	22:05	61.7649	-34.839
56	U54	22/07/2010	4:00	62.8685	-34.9857
57	U55	23/07/2010	1:30	63.0289	-35.3055
58	U55a	23/07/2010	8:10	63.0059	-34.9396
59	U56	23/07/2010	10:17	62.9979	-34.3785
60	U57	23/07/2010	13:55	62.9951	-33.5516
61	U58	23/07/2010	18:07	63.0001	-32.126
62	U59	23/07/2010	22:04	62.9999	-31.0236
63	U60	24/07/2010	2:32	63	-30.1772
64	U61	24/07/2010	14:09	62.8995	-29.8831
65	U62	24/07/2010	18:07	62.2951	-30.401
66	U63	24/07/2010	22:07	61.6614	-30.9331

67	U64	25/07/2010	2:40	61.0211	-31.4157
68	U65	25/07/2010	10:25	60.643	-31.8435
69	U66	25/07/2010	14:00	60.0512	-32.5698
70	U67	25/07/2010	19:13	59.2988	-33.4745
71	U68	25/07/2010	21:59	58.9968	-33.8324
72	U69	26/07/2010	2:30	58.2866	-34.6603
73	U70	27/07/2010	2:55	58.18	-35.1423
74	U71	27/07/2010	10:02	58.4302	-35.0355
75	U72	27/07/2010	14:00	59.0061	-35.2111
76	U73a	27/07/2010	18:10	59.6647	-35.0773
77	U73	27/07/2010	22:05	60.364	-35.0805
78	U74	28/07/2010	2:19	60.8732	-34.5006
79	U75	28/07/2010	6:07	61.152	-33.174
80	U76	28/07/2010	9:58	61.3618	-32.1656
81	U77	28/07/2010	14:09	60.8771	-31.8844
82	U78	28/07/2010	19:36	60.5847	-31.7322
83	U79	28/07/2010	22:06	60.9686	-32.0868
84	U80	29/07/2010	10:05	62.7307	-33.9543
85	U81	29/07/2010	13:58	63.0691	-34.2373
86	U82	29/07/2010	18:08	63.6302	-34.7925
87	U83	30/07/2010	2:45	63.9082	-34.9352
88	U84	31/07/2010	1:40	63.839	-34.8251
89	U85	31/07/2010	10:02	63.6834	-34.3374
90	U86	31/07/2010	14:02	63.4116	-32.9038
91	U87	31/07/2010	18:11	63.1124	-31.4344
92	U88	31/07/2010	22:00	62.8239	-30.0329
93	U89	01/08/2010	2:25	62.5396	-28.6651
94	U90	02/08/2010	15:14	63.6657	-23.6748
95	U91	02/08/2010	19:55	63.4091	-23.6027
96	U92	02/08/2010	22:14	63.1389	-23.8101
97	U93	03/08/2010	2:40	62.5151	-24.1077
98	U94	03/08/2010	18:06	61.9854	-23.8485
99	U95	03/08/2010	22:01	61.6757	-22.4971
100	U96	04/08/2010	2:15	61.3726	-21.1787
101	U97	04/08/2010	14:12	61.2293	-20.82
102	U98	04/08/2010	18:15	61.3823	-21.9983
103	U99	04/08/2010	21:56	61.5006	-22.9113
104	U100	05/08/2010	3:10	61.7581	-24.9677
105	U101	06/08/2010	2:49	62.1126	-27.2271
106	U102	07/08/2010	2:30	60.469	-21.2086

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Radio-tracer ^{55}Fe uptake experiments

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Community uptake of ^{55}Fe

To measure the turnover and uptake rates of the ambient DFe pool, we have measured the biological incorporation of ^{55}Fe by the entire *in situ* plankton community, representing both autotrophic uptake by phytoplankton and heterotrophic uptake my microheterotrophs, including bacteria. In these experiments we have not conclusively separated autotrophic and heterotrophic uptake, despite experiments run in the dark and in the light. Size-fractionated experiments we conducted measured ^{55}Fe uptake in the total (>0.2µm) and in the >5µm fractions, but this too does not entirely discriminate between autotrophic and heterotrophic uptake.

Basic Protocol

The basic protocol was to measure 55Fe uptake in small volume (125ml) incubations run over a time series; typically with 3 time points at ~+2 hours, +6 hours and +12 hours. At approx 3-4 am GMT, a water sample was collected from the trace metal clean towed fish. Sample water was dispensed into 6 x 125ml polycarbonate bottles to which a trace spike of ~99000 DPM of ^{55}Fe was added, enriching the sample bottles by around 3 pM, significantly less than ~10% of the ambient DFe pool. At each time step, the activity in each sample bottle was measured and approx 40 mls of sample were filtered onto 25mm 0.2µm polycarbonate filters. Incubations were run under controlled conditions of (ambient) temperature and a constant light level of 98 µmol photons m^{-2} s^{-1} in a temperature controlled incubator unit illuminated by white light LED's. To differentiate between uptake into cells relative to apparent uptake due to adhesion of ^{55}Fe onto external cell surfaces, the filters and cells were rinsed at the end of the sample filtration with a buffered Ti-EDTA-citrate solution which scavenges adhered ^{55}Fe. Filter samples placed in 5ml Ultima Gold were then counted on a scintillation counter on board.

In subsets of experiments, samples were placed in a black bag to measure dark vs light uptake. For size-fractionated experiments (SF), serial filtration through >5µm and onto 0.2µm membrane filters held in Swinnex filter holders in series allowed size-fractionated as

well as total uptake to be measured. Further experiments examined ^{55}Fe uptake in response to different ambient concentrations of added "cold" DFe, ranging from ambient to +200 and +2000 pmol additions.

In total, twelve experiments were run:

Date	Exp	Experimental Type
22 July	01	Simple 3hr test uptake experiment, 3 bottles.
23 July	02	6 bottles, 3 time points, light & dark
25 July	03	6 bottles, 3 time points, light & dark
27 July	04	6 bottles, 4 time points, different cold DFe additions
30 July	05	6 bottles, 3 time points, different cold DFe additions
31 July	06	6 bottles, 3 time points; SF: 3 x total & 3 x >5µm onto 0.2µm
01 Aug	07	6 bottles, 3 time points; SF: 3 x total & 3 x >5µm onto 0.2µm
03 Aug	08	6 bottles, 3 time points; SF: 3 x total & 3 x >5µm onto 0.2µm plus different different cold DFe additions
04 Aug	09	6 bottles, 3 time points; SF: 3 x total & 3 x >5µm onto 0.2µm plus different different cold DFe additions
05 Aug	10	6 bottles, 3 time points; SF: 3 x total & 3 x >5µm onto 0.2µm plus different different cold DFe additions
06 Aug	11	6 bottles, 3 time points; SF: 3 x total & 3 x >5µm onto 0.2µm plus different different cold DFe additions
07 Aug	12	6 bottles, 3 time points; SF kill control with glutaraldehyde

Mike Lucas
10 August 2010

Ammonium, dissolved organic carbon and nitrogen (DOC-DON) and hemes in the sub-polar North Atlantic Ocean

Eric P. Achterberg, University of Southampton, School of Ocean and Earth Science, National Oceanography Centre, Southampton, UK. Email: eric@noc.soton.ac.uk

Introduction

My contribution towards the research activities on the cruise consisted of undertaking ship-board measurements of ammonium. Furthermore, samples were collected and preserved for DOC-DON and heme analyses to be undertaken upon return to the laboratory at NOCS. Heme are to be undertaken by Dr Martha Gledhill.

Materials and methods

Samples for ammonium, DOC-DON and hemes 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 were covered. Samples for ammonium were collected 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 12 depths were covered for a CTD cast.

Samples for DOC-DON analyses were filtered directly from the OTE bottle using pre-ashed GFF filters and stainless steel filtration unit. The filtrate was acidified to pH 2 and sealed in glass ampoules for subsequent analysis using high temperature catalytic combustion (Shimadzu TOC5000-Antek) at NOCS (Badr et al., 2003). Typically 12 depths were covered for a CTD cast.

Samples for heme (Fe containing compounds) were filtered onto GFF filters (2 litres of water filtered) and the filters stored at -80ºC for subsequent HPLC analyses at NOCS (Gledhill, 2007). Six depths were covered for a CTD cast.

Results

The results for the majority of the analyses will become available upon return to the UK.

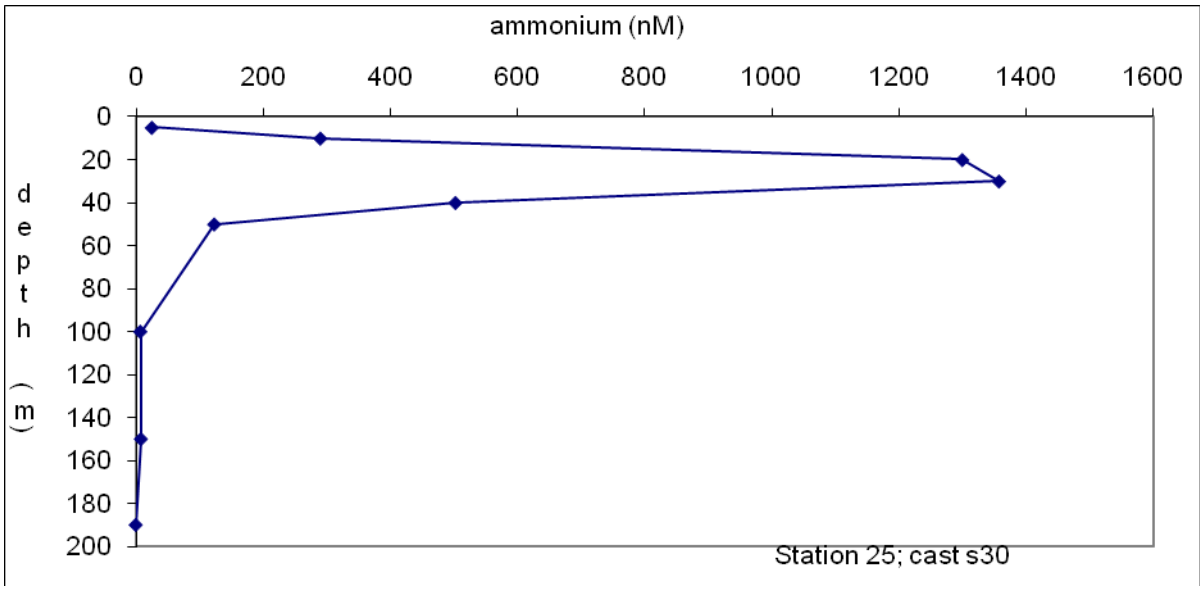

Figure 1: Ammonium depth profile at station 25, cast S30.

Ammonium measurements at sea were successful. The concentrations were typically lower in the surface mixed layer (typically 20-400 nM) with enhanced concentrations (typically between 400-900 nM, but as high as 2.4 µM) at depth immediately below the mixed layer as a result of bacterial breakdown of phytoplankton. Below 100 m, the ammonium concentrations decreased to < 10 nM.

Figure 1 shows an example of a depth profile for station 25, cast s 30.

Table 1. Station list with Stainless Steel Rosette CTD casts sampled for DOC-TDN and Hemes.

Stn No.	CTD No.	Cruise Identifier	Date (ddmmyy)	jday	time	Lat (N)	Lon (W)	Cast types
1	1	CTD001S	10.07.10	191	17:17	58 14.53	14 32.17	StS
2	3	CTD002S	11.07.10	192	16:12	60 00.18	19 59.59	StS
3	6	CTD003S	12.07.10	193	05.34	60 00.98	19 57.11	StS
4	8	CTD004S	13.07.10	194	04.39	61 49.11	21 00.94	StS
4	10	CTD005S	13.07.10	194	12.48	61 47.43	21 04.84	StS
5	11	CTD006S	14.07.10	195	04.08	60 00.35	19 59.06	StS
6	13	CTD007S	15.07.10	196	04.53	59 59.22	23 37.52	StS
6	15	CTD008S	15.07.10	196	13.04	59 59.00	23 37.25	StS
7	16	CTD009S	16.07.10	197	04.39	60 00.67	28 08.35	StS
8	18	CTD010S	17.07.10	198	18.52	60 00.25	34 59.46	StS
9	19	CTD011S	18.07.10	199	04.18	60 00.05	34 59.99	StS
10	21	CTD012S	19.07.10	200	04.42	59 58.57	41 21.36	StS
14	27	CTD014S	19.07.10	200	23.04	59 59.82	42 40.42	StS
15	29	CTD015S	21.07.10	202	00:32	59 59.53	34 59.31	StS
15	30	CTD016S	21.07.10	202	07.39	59 58.04	34 56.74	StS
16	31	CTD017S	22.07.10	203	06.43	62 59.62	35 00.02	StS
16	33	CTD018S	22.07.10	203	15.43	62 59.98	34 59.89	StS
17	34	CTD019S	23.07.10	204	04.21	63 00.10	34 59.89	StS
18	36	CTD020S	24.07.10	205	04.44	62 59.92	29 58.73	StS
18	38	CTD021S	24.07.10	205	12.39	62 59.48	29 49.12	StS
19	39	CTD022S	25.07.10	206	04.25	60 52.40	31 31.99	StS

20	41	CTD023S	26.07.10	207	09.45	58 14.69	34 58.15	StS
20	43	CTD024S	26.07.10	207	18.17	58 13.11	35 07.36	StS
21	44	CTD025S	27.07.10	208	04.38	58 08.14	34 58.80	StS
22	46	CTD026S	30.07.10	211	05.17	63 49.37	35 02.23	StS
22	48	CTD027S	30.07.10	211	14.13	63 49.88	35 00.70	StS
23	49	CTD028S	31.07.10	212	04.17	63 49.32	35 05.42	StS
24	51	CTD029S	01.08.10	213	04.33	62 28.85	28 21.34	StS
25	53	CTD030S	02.08.10	214	16.55	63 25.96	23 35.66	StS
27	56	CTD031S	03.08.10	215	06.44	62 08.44	24 20.95	StS
27	58	CTD032S	03.08.10	215	15.55	62 05.84	24 20.17	StS
28	59	CTD033S	04.08.10	216	05.15	61 15.40	20 42.91	StS
28	61	CTD034S	04.08.10	216	13.15	61 13.58	20 47.12	StS
29	62	CTD035S	05.08.10	217	06.16	61 50.36	25 40.36	StS
31	65	CTD036S	05.08.10	217	15.41	61 58.61	26 41.98	StS
33	68	CTD037S	07.08.10	219	04.19	60 20.98	20 56.27	StS
33	70	CTD038S	07.08.10	219	13.24	60 18.19	20 58.67	StS

Acknowledgements

We want to thank the captain Richardson, officers and crew of the RRS Discovery for support during the cruise. The researchers all did a great job and made this cruise a great success.

Literature.

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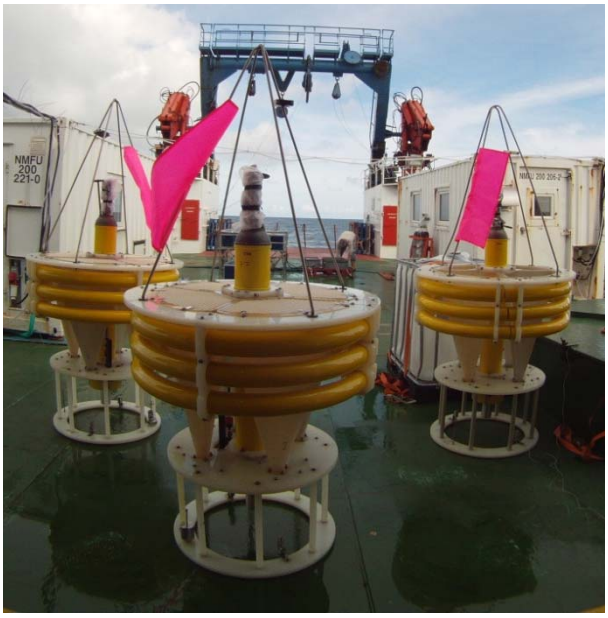
Gledhill, Martha (2007) The determination of heme b in marine phyto- and bacterioplankton. *Marine Chemistry*, 103, (3-4), 393-403. (doi:10.1016/j.marchem.2006.10.008)

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

PELAGRA –Neutrally Buoyant Sediment Traps (1)

S.J. Ward (National Marine Facilities, National Oceanography Centre, Southampton, UK)



The Pelagra sediment traps have recently had modifications to upgrades which were added before the trails cruise JR221.

The original upgrades consisted of:

- Addition of GPS positioning
- Addition of Iridium satellite telemetry
- Firmware modification to enable acquisition of a sigma-theta value once the programmed park depth has been obtained.
- Firmware modification to enable automatic activation of 'recovery mode' should the trap surface before the scheduled end-of-mission time.

Due to issues with some of the upgrades modifications to the Apex floats were needed before D354.

The modifications to the upgrades before D354 consisted of:

- Fixing issues with the firmware that enables the acquisition of a sigma-theta value once the programmed park depth has been obtained.
- Extending the telemetry retry interval during the mission prelude
- Fixing the issue of the Apex floats doing a CTD profile which prevented them staying at their designated park depth
- Automatically adding the Recovery Mode mission.cfg file via the Iridium sever at NOCS instead of doing it manually on the ship.

All of these modifications to the upgrades have been successful and the only issue that remains is why two of the Apex Floats P4 and P7 are coming to the surface five hours early? This could be down to issues with the Apex floats them selves or due to damage caused by bad weather in the first week of the cruise?

P5 and P2 unfortunately could not be used due to damaged caused by bad weather in the first week of D354, so it is unknown whether the modifications that have been implemented have been successful? I would suggest from the information gathered during the post deployment tests that they work sufficiently, but until they have had a proper mission this can not be confirmed.

Brief Pelagra Damage Report

(Due to bad weather in the first week of D354)

P6: Working appropriately.

P7: Minor issues with sampling pots, surfacing 5 hours early and has one funnel damaged.

P4: Minor issues with sampling pots, surfacing 5 hours early, one funnel damaged, titanium frame arm sheared at weld and bottom Pillars lost and replaced with P2 to allow P4 to be operational.

P5: Float untested after weather damage, 3 Funnels damaged, top ring snapped and bottom pillars lost.

P2: Float untested after weather damage, 3 funnels damaged, 1 set of buoyancy hoops off due to helicoils being ripped out. Bottom pillars removed and placed on P4.

Deployment 1, Station 2, 12/07/2010

P4 Deployment 1, 60° 00 N, 19° 59.8 W. 00:34 am

Target depth: 80m

Sink time: 15 minutes

Down time: 54 hours

Stabilization: 24 hours

Sampling: 30 hours

50g was subtracted from the ballast as suggested from the data gathered from JR221.

P6 Deployment 1, 60° 00 N, 19° 59.7 W. 01:03 am

Target depth: 150m

Sink time: 27 minutes

Down time: 54 hours

Stabilization: 24 hours

Sampling: 30 hours

50g was subtracted from the ballast as suggested from the data gathered from JR221.

P7 Deployment 1

Did not deploy due to issue with motor and sample pots.

Recovery 1, Departed Station 5, 14/7/2010

P4 Recovery 1, 60° 06.4 N, 18° 43.2 W. 12:05 pm

Collected 4 samples, 1 intentional blank.

P4 came to the surface 5 hours early unexpectedly which did corrupt the quality of the Samples.

P4 hit its programmed depth of 80m.

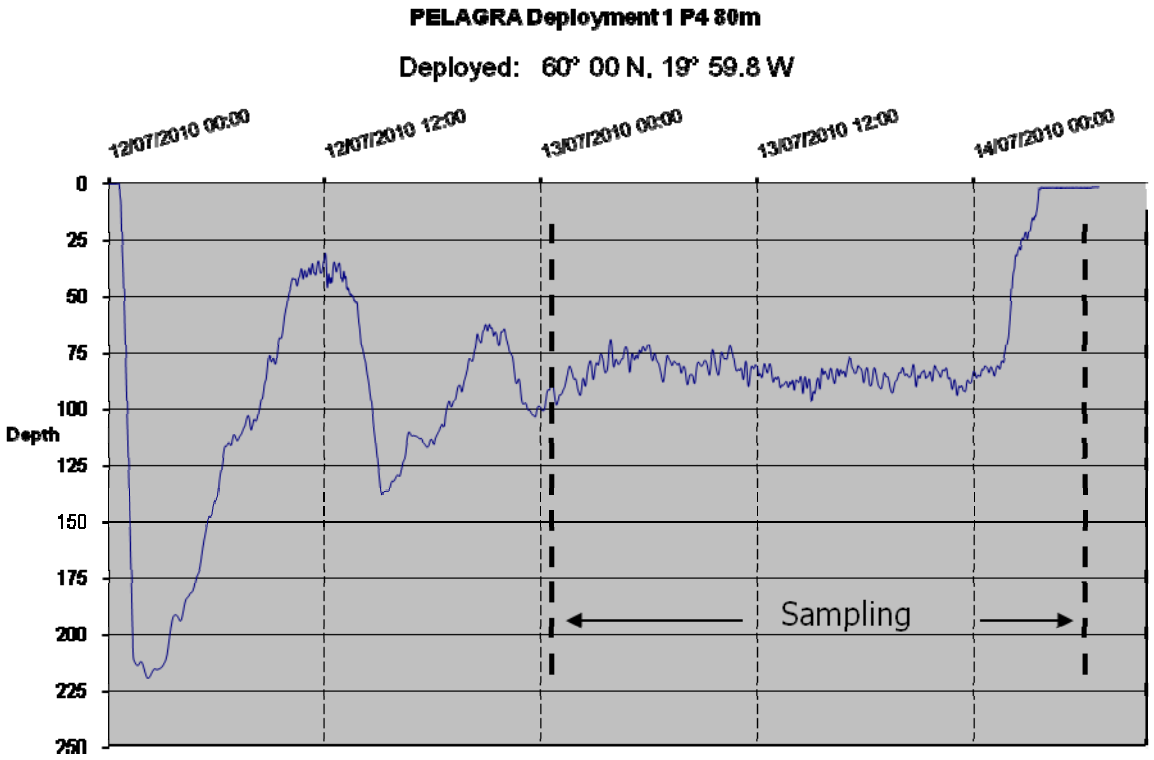
P4 Apex float average piston position when at depth = 163>164.

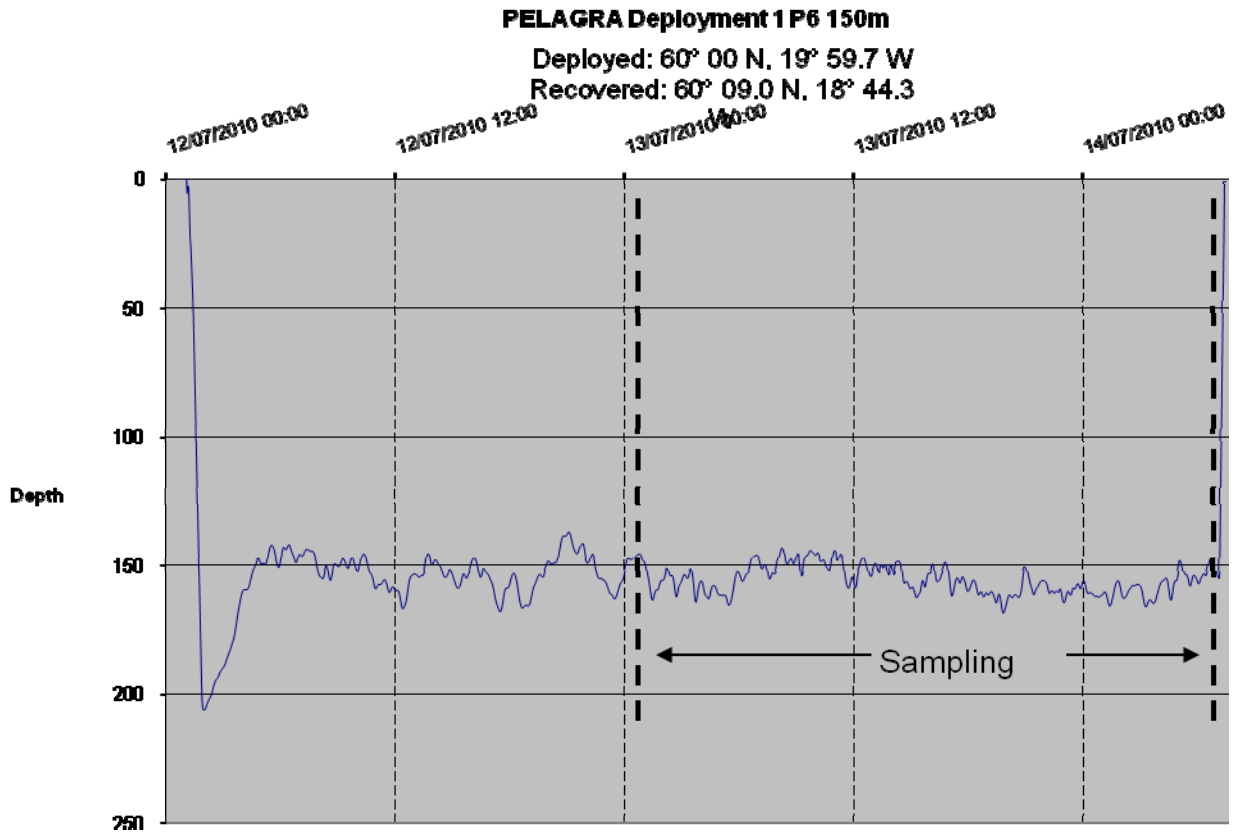
P6 Recovery 1, 60° 09.0 N, 18° 44.3 W. 12:43 pm

Collected 4 samples, 1 intentional blank.

P6 hit its programmed depth of 150m and surfaced when expected.

P6 Apex float average piston position when at depth = 131>132.





Deployment 2, Station 8, 18/07/2010

P4 Deployment 2, 60° 03.0 N, 034° 58.5 W. 01:05 am

Target depth: 80m

Sink time: 29 minutes

Down time: 78 hours

Stabilization: 24 hours

Sampling: 48 hours

Sampling pots were set to close 6 hours early to allow for unexpected surfacing issue. This time no ballast adjustment was made due to human error.

P6 Deployment 2, 60° 03.18 N, 034° 58.0 W. 01:37 am

Target depth: 150m

Sink time: 27 minutes

Down time: 78 hours

Stabilization: 24 hours

Sampling: 54 hours

No ballast adjustment made due to human error.

P7 deployment 3, 60° 02.8 N, 034° 58.7 W. 00:36 am

Target depth: 400m

Sink time: 222 minutes

Down time: 78 hours

Stabilization: 24 hours

Sampling: 54 hours

No ballast adjustment made due to human error.

Recovery 2, Departed station 14, 21/07/2010

P4 Recovery 2, 60° 14.9 N, 034° 34.8 W. 11:38 am

Collected 4 samples, 1 intentional blank.

P4 still came up 5 hours early, but because of the shortened sampling period the sample cups shut before P4 ascended.

Suspected issue with sample pots opening as very little material was collected. There was still more material collected than the blank which suggested that the pots did open partially.

P4 did hit its programmed depth of 80m.

P4 Apex float piston position average when at depth = 200>201

The piston position suggested that P4 does need the -50g ballast adjustment.

P6 Recovery 2, 60° 08.7 N, 034° 35.2 W. 13:00 pm

Collected 4 samples, 1 intentional blank.

P6 hit its programmed depth of 150m and surfaced when expected.

P6 Apex float average piston position when at depth = 164>165

The piston position suggested that P4 does need the -50g ballast adjustment.

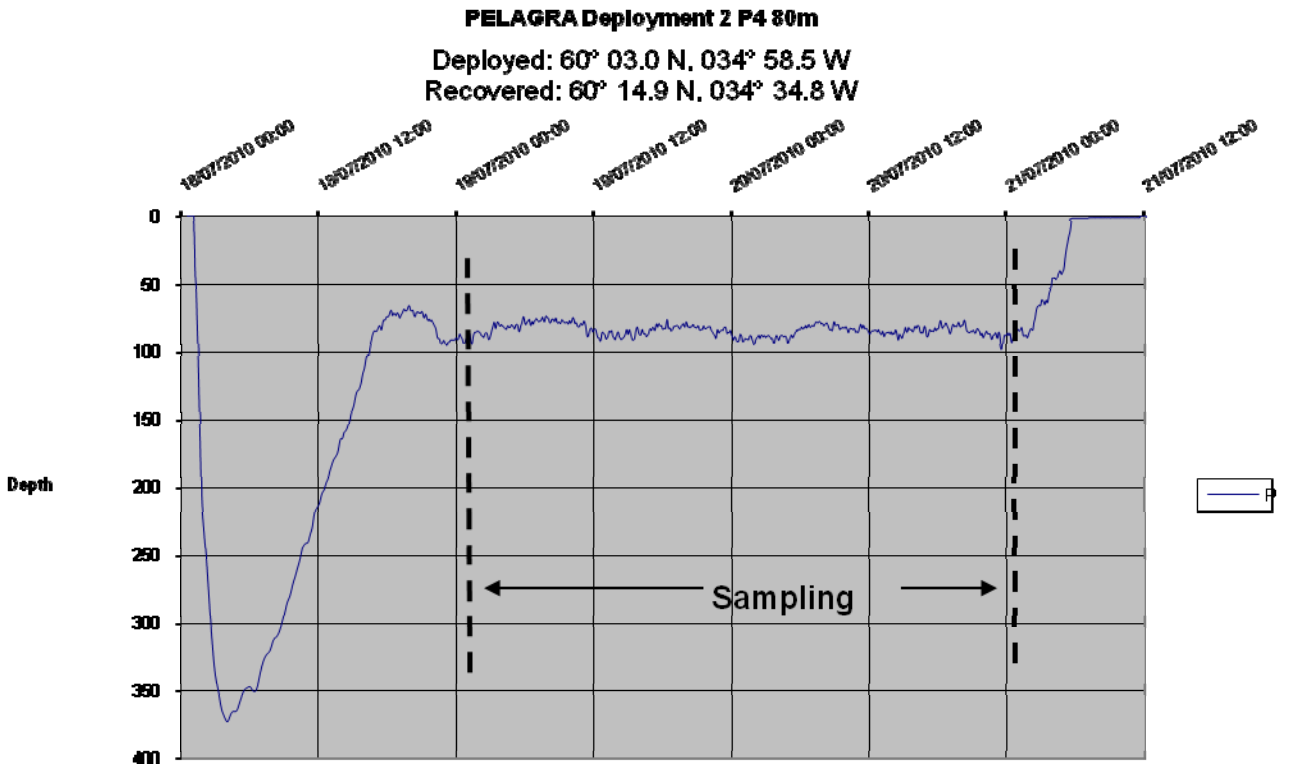
P7 Recovery 2, 60° 04.2 N, 034° 45.8 W. 09:43 am

P7 was recovered with its sample pots open.

P7 hit its programmed depth but surfaced 5 hours early like P4.

P7 Apex float average piston position when at depth = 135>136

The piston position suggested that P7 does didn’t need the -50g ballast adjustment.


PELAGRA Deployment 2 P4 80m
Deployed: 60° 03.0 N, 034° 58.5 W
Recovered: 60° 14.9 N, 034° 34.8 W
18/07/2010 00:00
18/07/2010 12:00
19/07/2010 00:00
19/07/2010 12:00
20/07/2010 00:00
20/07/2010 12:00
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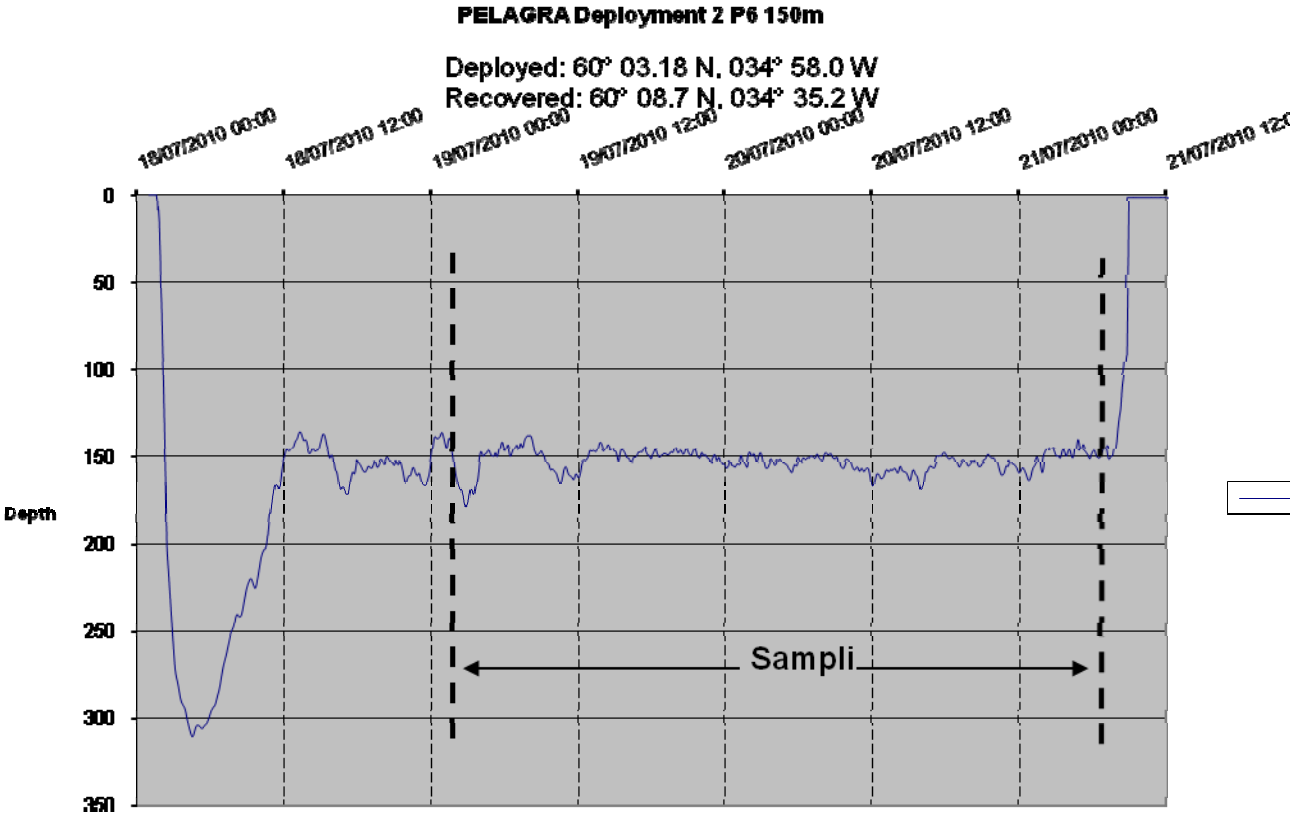
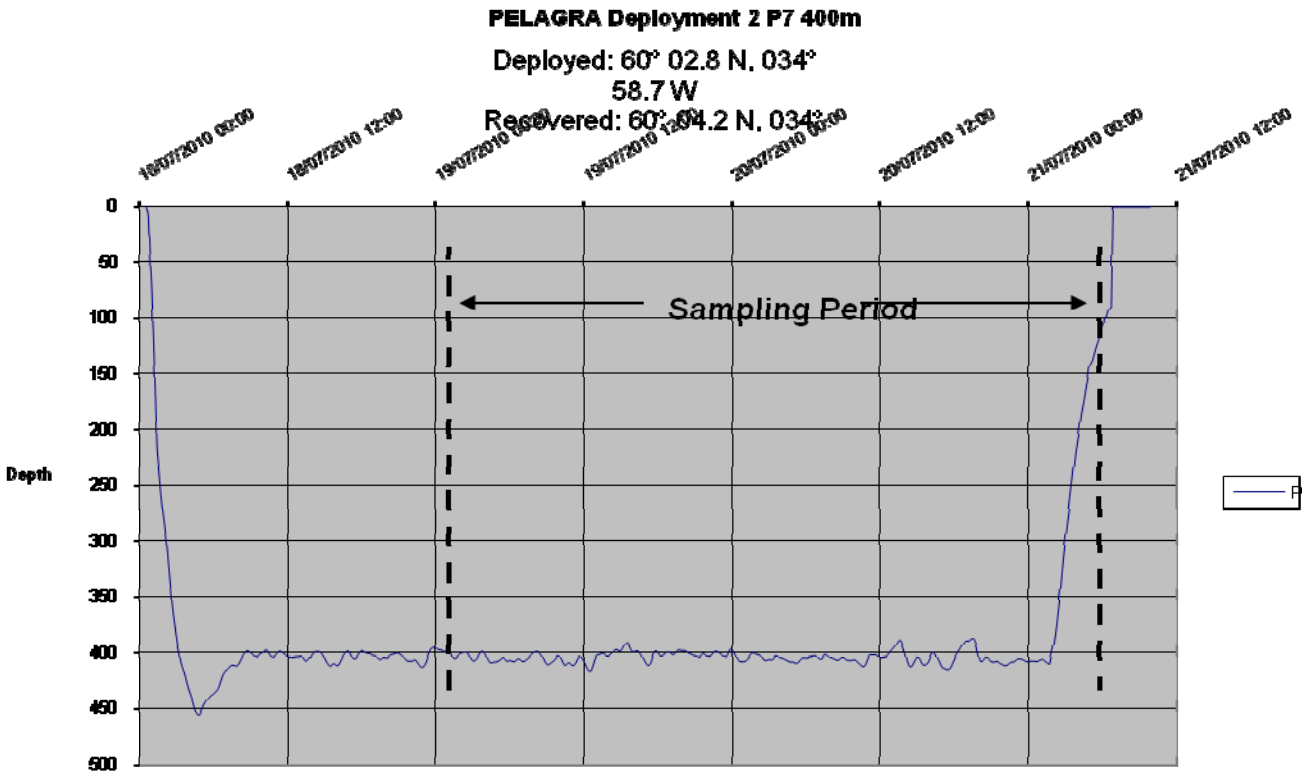
21/07/2010 12:00
Depth
0
50
100
150
200
250
300
350
400
Sampling


PELAGRA Deployment 2 P6 150m
Deployed: 60° 03.18 N, 034° 58.0 W
Recovered: 60° 08.7 N, 034° 35.2 W
18/07/2010 00:00
18/07/2010 12:00
19/07/2010 00:00
19/07/2010 12:00
20/07/2010 00:00
20/07/2010 12:00
21/07/2010 00:00
Depth
0
50
100
150
200
250
300
350
Sampli



Sampling pots stayed open and float came up 5 hours early.

Deployment 3, Station 19, 25/07/2010

P4 Deployment 3, 60° 50.6 N, 31° 35.8 W. 08:04 am

Target depth: 80m

Sink time: 29 minutes

Down time: 74 hours

Stabilization: 24 hours

Sampling: 44 hours

Sampling pots were set to close 6 hours early to allow for unexpected surfacing issue. This time the -50g ballast adjustment was applied due to the piston position from the last deployment.

P6 Deployment 3, 60° 50.3 N, 31° 35.9 W. 08:36 am

Target depth: 150m

Sink time: 27 minutes

Down time: 74 hours

Stabilization: 24 hours

Sampling: 50 hours

This time the -50g ballast adjustment was applied due to the piston position from the last deployment.

P7 Deployment 3, 60° 50.9 N, 31° 35.7 W. 07:39 am

Target depth: 400m

Sink time: 222 minutes

Down time: 74 hours

Stabilization: 24 hours

Sampling: 44 hours

Sampling pots were set to close 6 hours early to allow for unexpected surfacing issue. This time the -50g ballast adjustment was again not applied due to the piston position from the last deployment.

Recovery 3, Departed station 21, 28/07/2010

P4 Recovery 3, 60° 37.9 N, 32° 14.4 W. 15:59 pm

Collected 4 samples, 1 intentional blank.

P4 still came up 5 hours early, but because of the shortened sampling period the sample cups shut before P4 ascended.

Issue with sample pots was resolved.

P4 did hit its programmed depth of 80m.

P6 Recovery 3, 60° 35.2 N, 31° 45.6 W. 18:28 pm

Collected 4 samples, 1 intentional blank.

P6 hit its programmed depth of 150m and surfaced when expected.

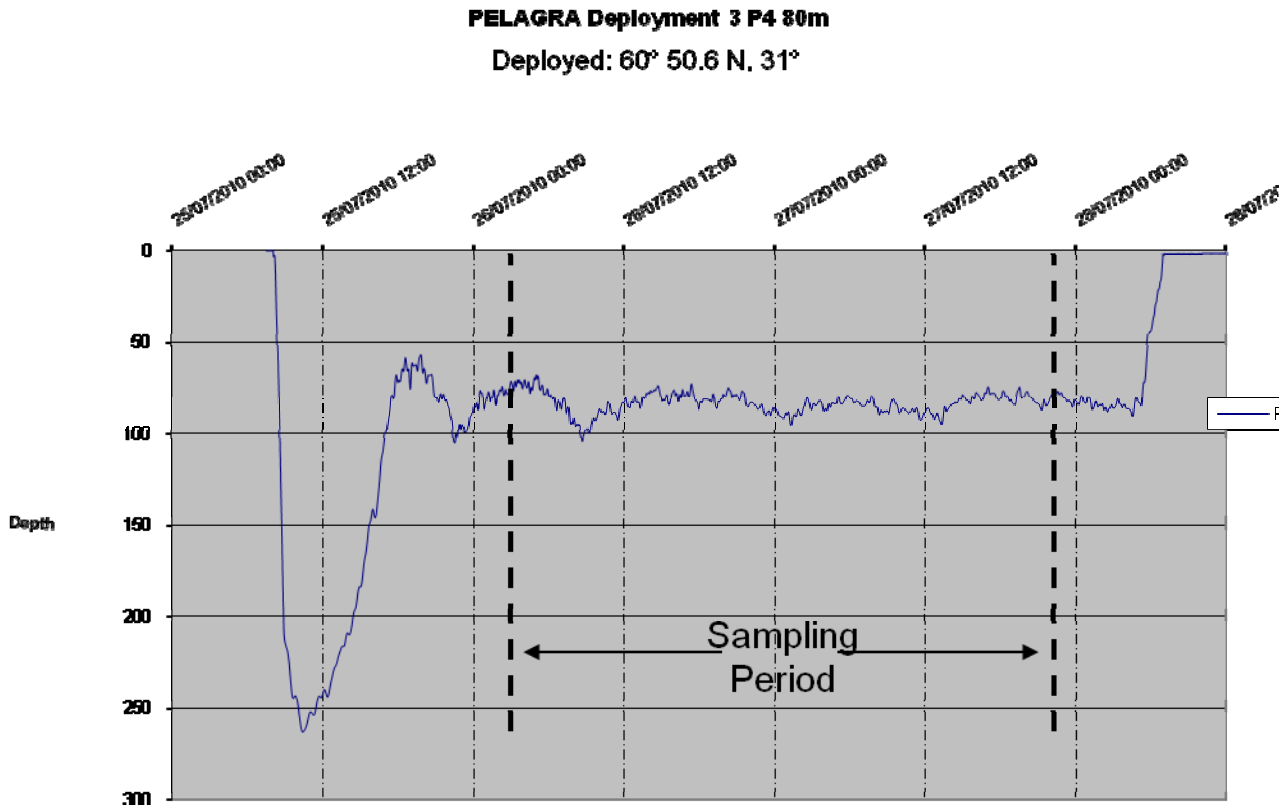
P7 Recovery 3, 60° 37.2 N, 31° 56.4 W. 17:21 pm

Collected 4 samples, 1 intentional blank.

P7 still came up 5 hours early, but because of the shortened sampling period the sample cups shut before P7 ascended.

Issue with sample pots was resolved.

P7 hit its programmed depth of 400m.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Deployed: 60° 50.6 N, 31°
25/07/2010 00:00
25/07/2010 12:00
26/07/2010 00:00
26/07/2010 12:00
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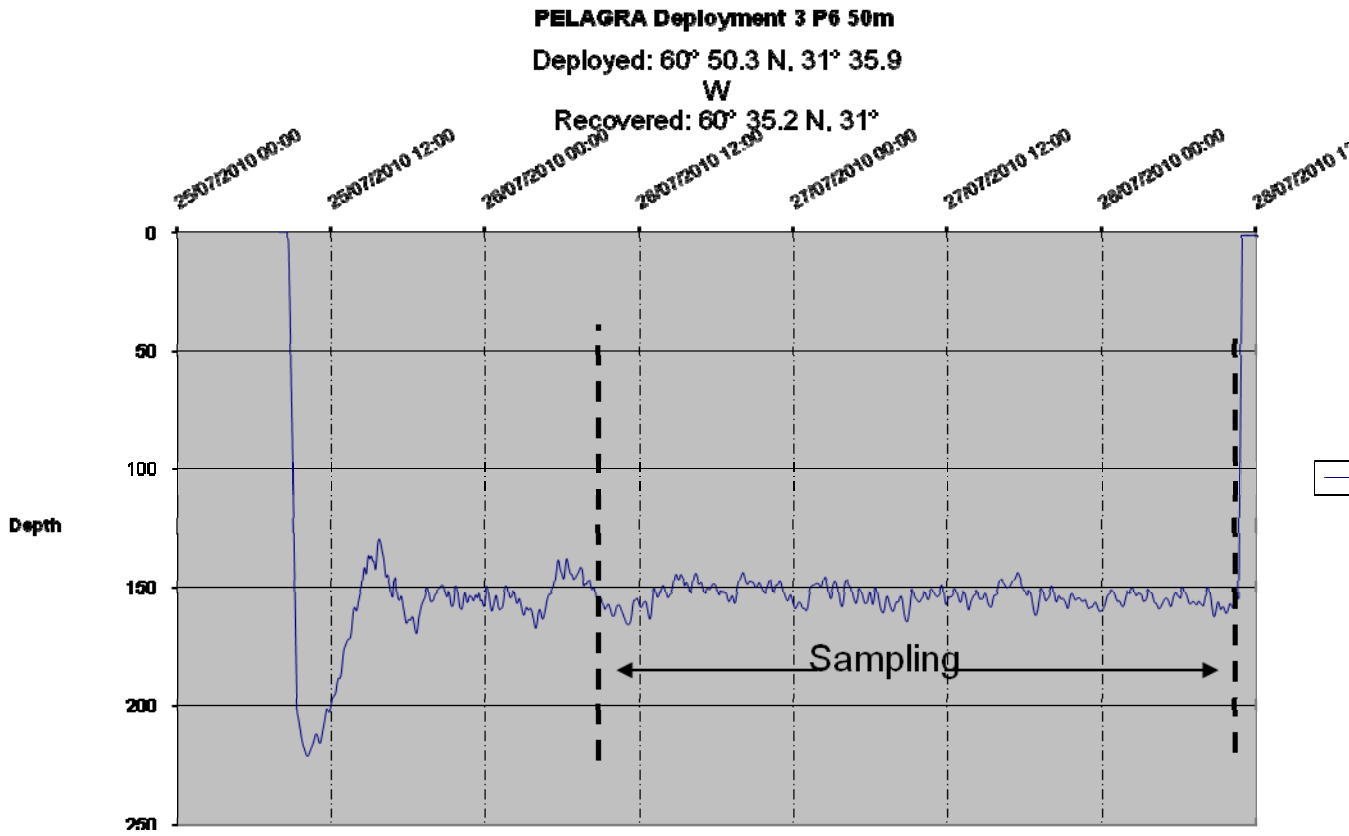
28/07/2010 00:00
Depth
0
50
100
150
200
250
300
Sampling
Period


PELAGRA Deployment 3 P6 50m
Deployed: 60° 50.3 N, 31° 35.9 W
Recovered: 60° 35.2 N, 31°
25/07/2010 00:00
25/07/2010 12:00
26/07/2010 00:00
26/07/2010 12:00
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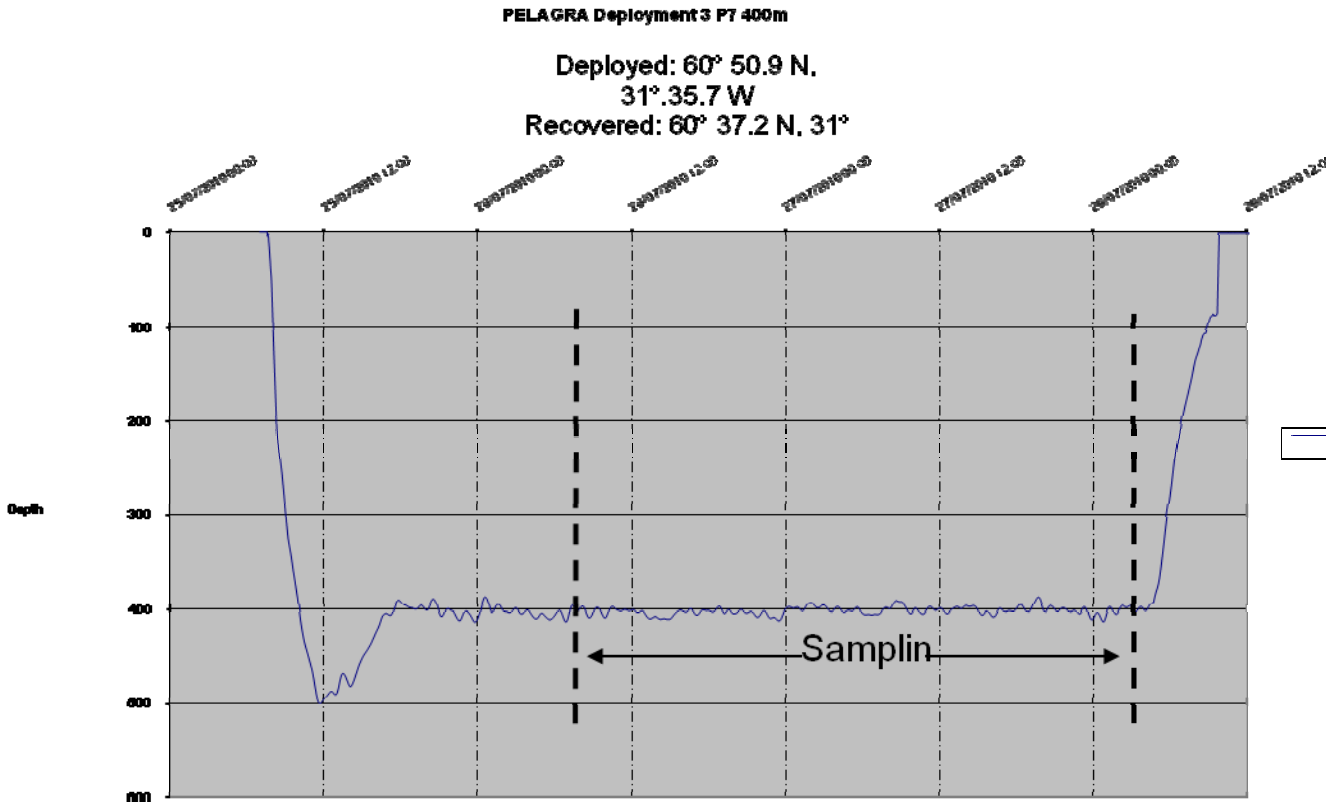
Depth
0
50
100
150
200
250
Sampling



Deployment 4, Station 27, 3/08/2010

P4 Deployment 4, 62° 08.7 N, 24° 23.4 W. 08:35 am

Target depth: 80m

Sink time: 29 minutes

Down time: 70 hours

Stabilization: 24 hours

Sampling: 40 hours

Sampling pots were set to close 6 hours early to allow for unexpected surfacing issue. -50g ballast adjustment was applied.

P6 Deployment 4, 62° 08.7 N, 24° 24.2 W. 09:10 am

Target depth: 150m

Sink time: 27 minutes

Down time: 70 hours

Stabilization: 24 hours

Sampling: 46 hours

-50g ballast adjustment was applied.

P7 Deployment 4, 62° 08.7 N, 24° 24.2 W. 08:04 am

Target depth: 400m

Sink time: 222 minutes

Down time: 70 hours

Stabilization: 24 hours

Sampling: 40 hours

Sampling pots were set to close 6 hours early to allow for unexpected surfacing issue. No ballast adjustment.

Recovery 4, Departed station 32, 6/08/2010

P4 Recovery 4, 62° 07.3 N, 25° 09.3 W. 10:54 am

Collected 4 samples, 1 intentional blank.

P4 still came up 5 hours early, but because of the shortened sampling period the sample cups shut before P4 ascended.

P6 Recovery 4, 61° 56.35 N, 25° 07.5 W. 12:20 pm

Collected 4 samples.

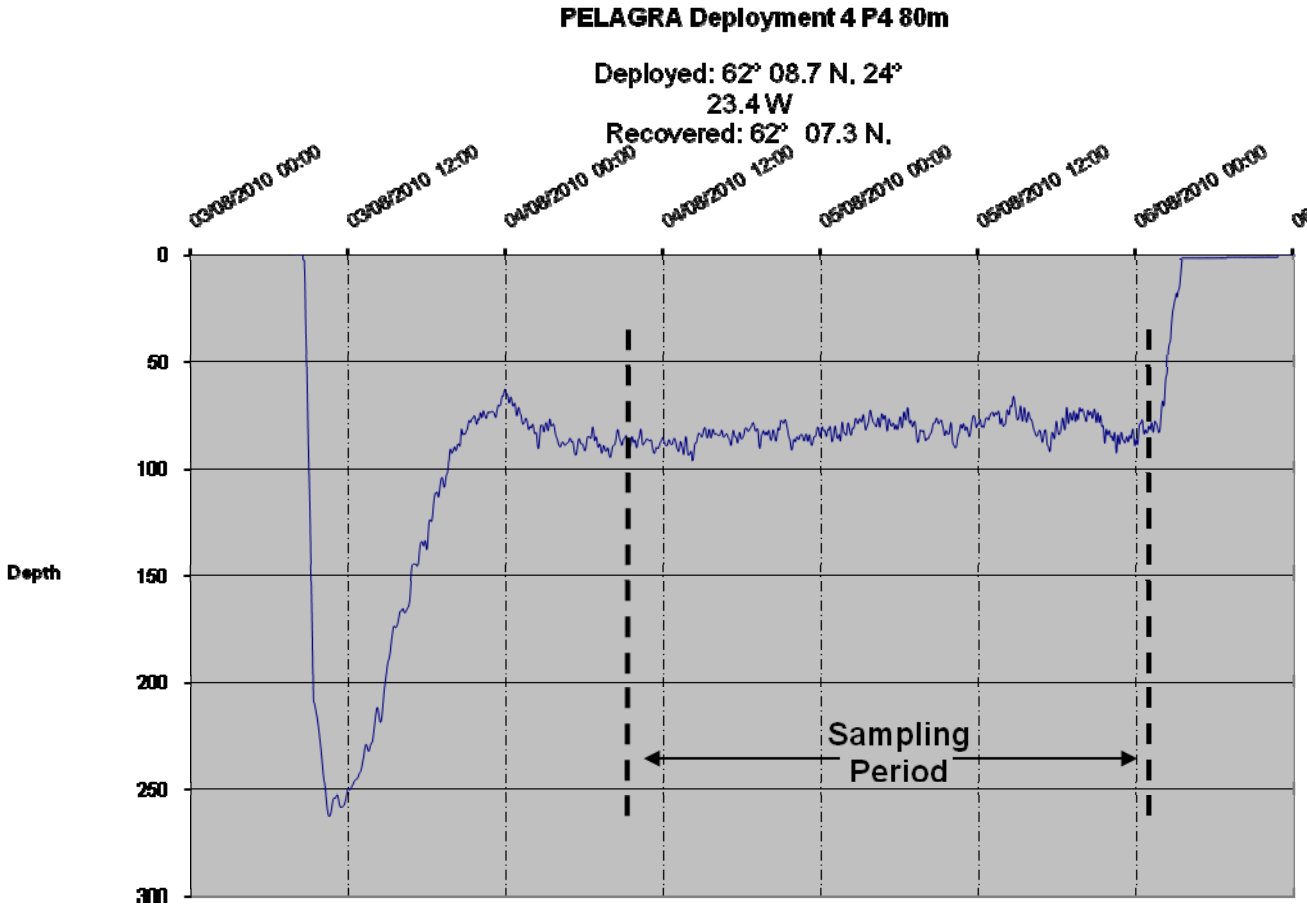
P6 hit its programmed depth of 150m and surfaced when expected.

P7 Recovery 4, 62° 11.8 N, 24° 42.0 W. 09:17 am

Collected 4 samples, 1 intentional blank.

P7 still came up 5 hours early, but because of the shortened sampling period the sample cups shut before P7 ascended.

P7 hit its programmed depth of 400m.


PELAGRA Deployment 4 P4 80m
Deployed: 62° 08.7 N. 24° 23.4 W
Recovered: 62° 07.3 N.
03/08/2010 00:00
03/08/2010 12:00
04/08/2010 00:00
04/08/2010 12:00
05/08/2010 00:00
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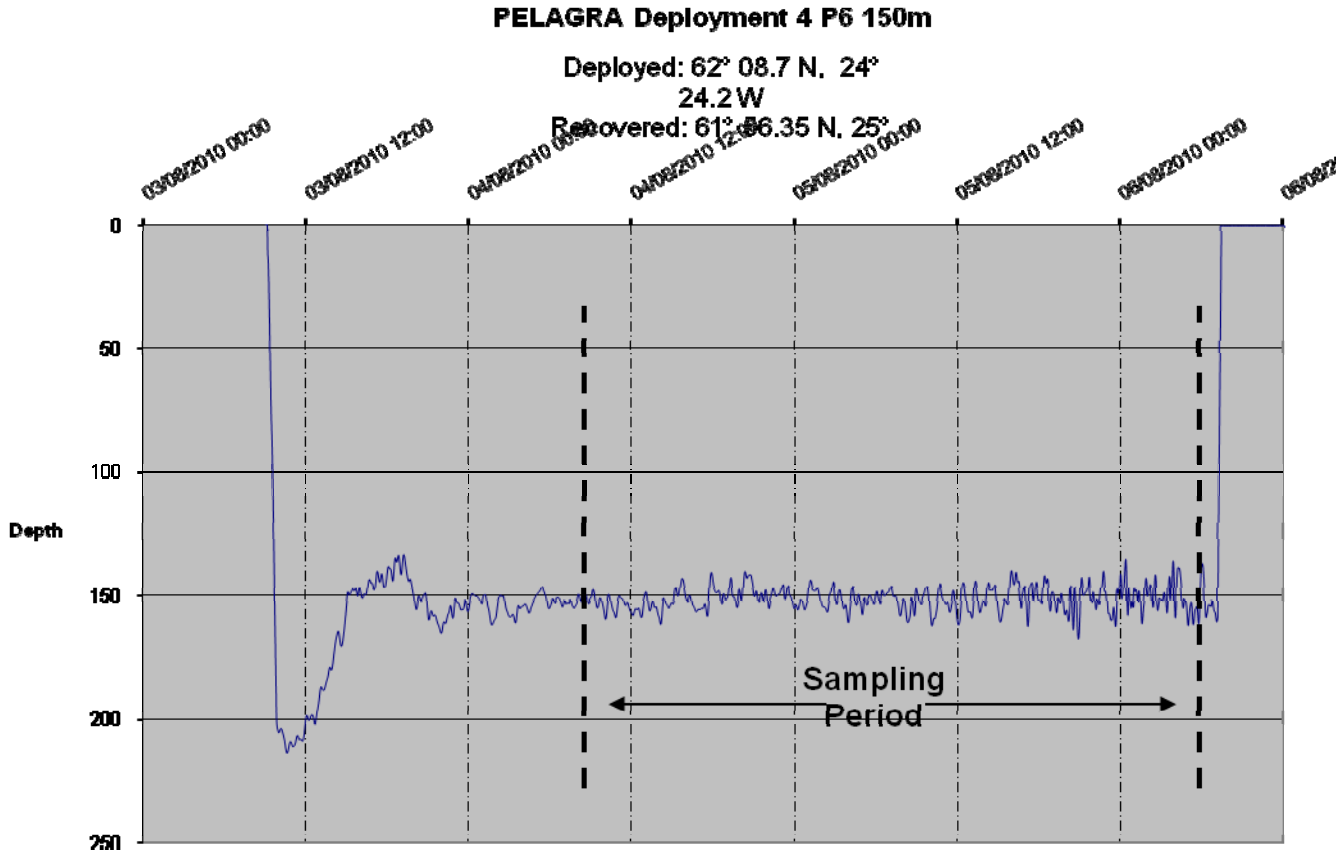
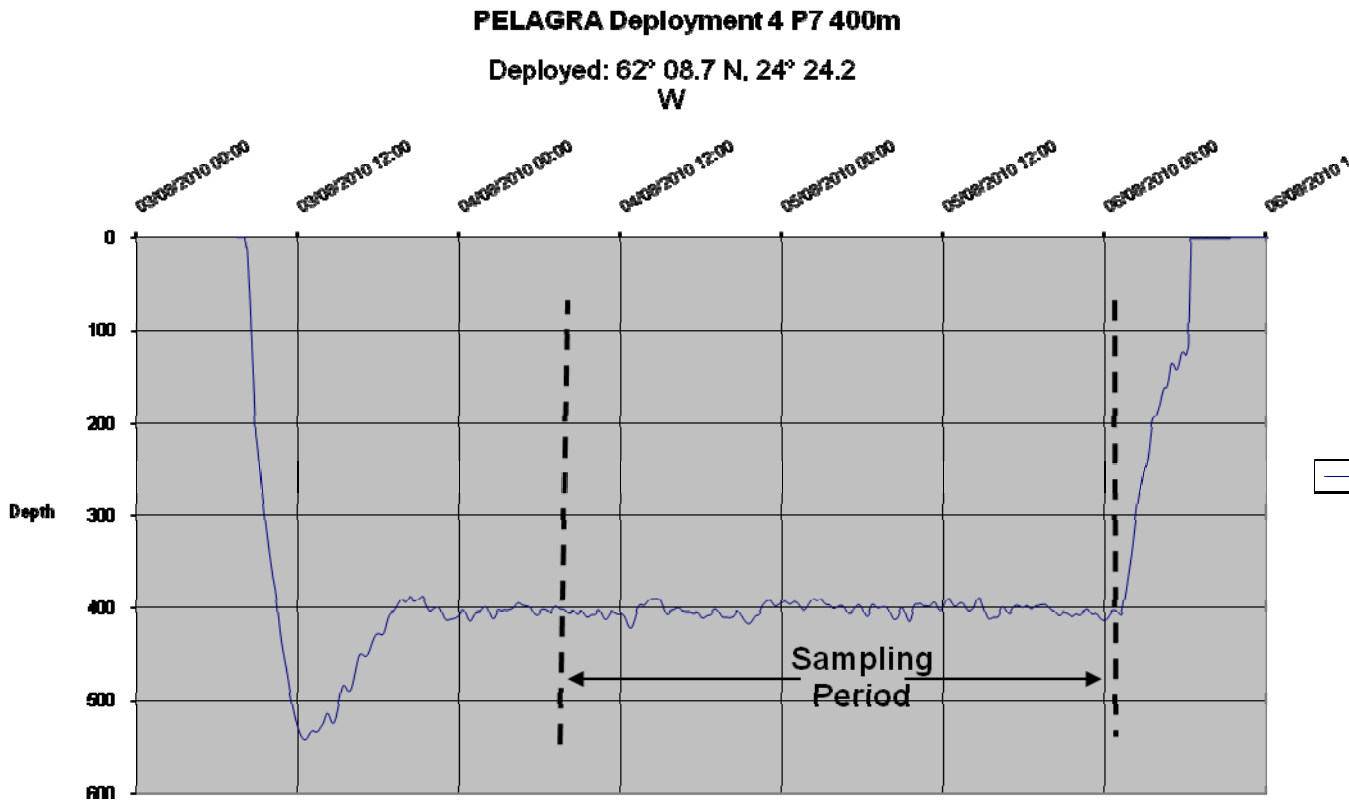
Depth
0
50
100
150
200
250
300
Sampling Period


PELAGRA Deployment 4 P6 150m
Deployed: 62° 08.7 N. 24° 24.2 W
Recovered: 61° 56.35 N. 25°
03/08/2010 00:00
03/08/2010 12:00
04/08/2010 00:00
04/08/2010 12:00
05/08/2010 00:00
05/08/2010 12:00
06/08/2010 00:00
Depth
0
50
100
150
200
250
Sampling Period



Acknowledgments

I would like to thank:

Eric Achterberg for being so patient and understanding due to unexpected problems which occurred during D354.

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Chris Marsay for doing an excellent job in supporting the Pellagras scientifically.

With out this invaluable help, knowledge and experience, the Pelagras wouldn't have been able to of achieved the level of success which they have during D354. Especially in the testing circumstances which occurred…

PELAGRA – neutrally buoyant sediment traps (2)

Chris Marsay (University of Southampton, National Oceanography Centre, UK)

One of the main aims of cruise D341 was to measure the downward flux of carbon and other elements, with PELAGRA providing one of the tools for achieving this aim. It was hoped that from each deployment, measurements could be made of particulate organic and inorganic carbon in sinking material collected at each of the target depths, along with biogenic silica and trace metal concentrations.

Brine preparation and other considerations

Due to the desire for trace metal information from the sinking particulate material, precautions needed to be taken to minimise contamination of the sample pots both before and after deployment.

To minimise the in situ concentrations of metals within the sample pots, the preparation of the poisoned brine involved partially freezing filtered seawater from 400m depth (collected in water >1000m deep) for several hours, then collecting the high salinity liquid fraction as the ice began to melt. The aim was to create a brine in the range of 40 – 45 salinity units. One litre of formaldehyde (VWR) was added to each 19L batch of brine to give a 5% solution.

Other precautions taken to reduce contamination included attaching and removing the sample pots immediately prior to and after deployment and otherwise keeping them capped when not in the trace metal van; all sample processing was carried out in the trace metal van, which has a filtered air supply.

As PELAGRA was not designed for trace metal work there is a slight potential for sample contamination, although modifications made to the design and setup were carried out to reduce this risk. Nevertheless, it was decided to run some process blanks to check for trace metal contamination of the sample pots. For the blanks, one cup filled with the same poisoned brine was programmed to remain closed for the duration of the deployment. Blanks were run on all PELAGRA deployments except the fourth deployment of P6 (see technical report).

Sample treatment for core measurements

For each PELAGRA trap, three of the four sample cups were combined to provide particulate material for the core measurements. The three sample pots were emptied into a 4L bottle through a filter funnel topped with 350um mesh. After rinsing any remaining material out of the pot with poisoned brine (set aside before deployment), visible swimmers were then picked off the surface of the mesh and placed in a labelled glass vial. The mesh was then given a further rinse with poisoned brine.

The 4L bottle was then capped with a modified cap, consisting of a length of tubing with a stopcock inline, and inverted. The other end of the tubing was connected to a motorised

splitter, loaded with eight 500mL bottles, and with the splitter rotating and the 4L bottle contents kept mobile by gentle agitation, the stopcock was opened to drain the sample. In theory this would give eight splits of equal volume and composition. In practice, it was found that the sample volume typically varied by 10-20%, so split volumes were recorded. For some of the traps, a number of these splits were recombined and then split again, providing more splits so that replicate samples for some of the core parameters could be obtained.

The resulting eight splits were designated for the following analyses:

1. Trace metals – 2 step leach; filtered onboard
2. ^{234}Th measurements – sample passed on to Fred Le Moigne
3. Pb/Po measurements – sample passed on to Maria Villa
4. Taxonomy – sample passed on to Alex Poulton
5. POC – filtered onboard
6. BSi –filtered onboard
7. PIC –filtered onboard
8. spare or used for chlorophyll/pigment analysis

Picture 1: Example of PELAGRA pot contents

Notes on filtering

Trace metal splits were filtered through 47mm polycarbonate 1μm Nucleopore membranes under a laminar flow hood in the starboard trace metal van, and rinsed with pH-adjusted Milli-Q water. For all except the first deployment, further filtration through 0.2μm Nucleopore membranes was also carried out. Filtrates were kept for analysis of trace metals in the dissolved phase.

POC splits were filtered through ashed Whatman GFF filters (nominal pore size 0.7μm).

PIC and BSi splits were both filtered through 25mm polycarbonate 0.8μm Nucleopore membranes. PIC sample filters were rinsed with pH-adjusted Milli-Q water.

All filters were pre-weighed, with the aim of measuring mass of material collected prior to further sample processing. Following filtration, all filters were transferred to the -20°C freezer until they can be analysed back on land.

Blanks

For each of the three batches of poisoned brine used, replicate volumes were filtered through the appropriate filters to provide "brine blanks".

The PELAGRA pots dedicated as process blanks (one on each trap) were subject to the same treatment as sample pots and duplicate splits filtered for POC, PIC, BSi and trace metal analysis.

Coccolithophore dynamics in the Irminger Basin

Dr. Alex Poulton, NOCS, U.K.

Background

Sub-polar waters are an important biome for coccolithophores, with late summer in the Iceland Basin being characterised by relatively high coccolithophore abundances and calcification rates. By comparison, relatively little is known of coccolithophore dynamics in the Irminger Basin, or of the seasonal changes in coccolithophore community composition in the subpolar North Atlantic. Objective (1) of this work was to examine the spatio-temporal distribution of coccolithophores (abundance, distribution, calcification rate, growth rate) in the Iceland and Irminger Basin over the summer of 2010 (Note: samples were also collected during earlier cruises: April, Irminger Basin (D350); and May Extended Ellett line (D351).

Previous work in the Iceland Basin (60oN, 20oW) has observed a response by coccolithophores to iron addition (Nielsdottir et al., 2009), although iron is not generally regarded as one of the factors controlling coccolithophore calcification or growth rates (Zondervan, 2007). Parallel to the experimental observations of Nielsdottir et al. (2009), Poulton et al. (2010) found that coccolithophore abundance and calcification rates did not correlate with any of the factors currently associated with coccolithophore blooms (irradiance, mixed layer depth, nitrate, phosphate) and concluded that iron may be an important factor in regulating cellular calcification and (gross) growth rates. Objective (2) of this work was to examine the observations of Nielsdottir et al. (2009) by measuring the response of coccolithophore calcification to iron and nutrient manipulation in on-deck bioassays.

Two main methods of measuring coccolithophore calcification have been employed in the literature: the 'difference' technique, where calcification is estimated as the difference between total particulate production (TPP) and primary production (PP) (e.g., Fernandez et al. 1993); and the 'Micro-diffusion Technique' (e.g., Balch et al. 2000), which measures the acid-labile (inorganic) and non-labile (organic) particulate carbon pools. No comparison has

yet been made in field conditions of the relative performance of the two techniques. Objective (3) of this work was to examine calcification rates determined from the "difference" and "Micro-Diffusion Technique". The results will inform future field studies of coccolithophore dynamics, including the response of this planktonic group to ocean acidification.

Objectives

(i) Examine the spatio-temporal distribution of coccolithophore dynamics (abundance, diversity, calcification rate) in the Iceland and Irminger Basins;

(ii) Examine the response of coccolithophores to iron and nutrient addition;

(iii) Compare the two main methods currently used for measuring calcification rates.

Methods

Coccolithophore abundance and diversity

Two kinds of water samples (200-300 ml) were collected for the analysis of coccolithophore abundance and diversity: (1) samples filtered onto cellulose nitrate (25 mm dia., 0.8 mm pore size) filters for analysis via light microscopy; and (2) samples filtered onto polycarbonate (25 mm dia., 0.8 mm pore size, rinsed with pH-adjusted MilliQ) filters for analysis via Scanning Electron Microscopy. Filters were oven dried at 30-40^{o}C for ~6-12 hrs and stored in petrislides. Samples were collected underway (2-4 hourly; total 146) from the non-toxic sea water supply, from two depths during CTD sampling (surface and base of mixed layer; total 93), and from the various bioassay and grazing experiments performed onboard (nutrient bioassays, dilution experiments, mesozooplankton grazing; total 383). Water samples were also collected via the PELAGRA deployments ($^{1}/_{8}$ splits) and will be analysed via both light and scanning electron microscopy.

Molecular diversity

Water samples were also collected for the analysis of the proportion of coccolithophores in the naked haploid and calcifying diploid life-cycle phases through the COD-FISH technique (Frada et al. 2006). COD-FISH allows cross-polarised light identification of coccolithophores to be combined with fluorescent labelling of cells by DNA probes. Analysis of these filters will be carried out by Dr. Martine Couapel (Natural History Museum / Station Biologique de Roscoff). COD-FISH samples (0.5-1.5 L) were collected from the surface and base of the mixed layer. In parallel, water samples were also filtered for the analysis of environmental DNA (1-3 L, 1 μm polycarbonate filter) and viral/bacterial DNA (1 L, Sterivex filter units, 0.22 μm). Environmental DNA samples will be analysed by Dr. Couapel, while viral DNA samples were collected for Dr. Ian Salter.

Calcification rates (daily)

Two methods were used to measure calcification rates on a daily basis: (a) the Micro-Diffusion Technique; and (b) the 'difference' method.

<u>(a) Micro-Diffusion Technique (MDT)</u>

Daily rates (dawn-to-dawn, 24-hrs) of primary production (PP) and calcification (CF) were determined at 19 CTD stations following the of Balch et al.(2000). Water samples (150-ml, 3 light, 1 formalin-killed) were collected from the surface CTD Niskin bottle (~55% incident irradiance), spiked with 30-60 μCi of ^{14}C-labelled sodium bicarbonate and incubated on deck. On deck incubators were chilled with sea surface water and light depths were replicated through the use of misty blue light filters. Incubations were terminated by filtration through 25-mm 0.2-μm polycarbonate filter, 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 in 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 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 calcification). Activity in both filters was then determined on a liquid scintillation counter and counts converted to uptake rates using standard methodology.

(b) Calcification by difference

In parallel to MDT measurements of calcification rates (and primary production), measurements were also made of total particulate production (TPP) and primary production (PP). Water samples (150 ml, 3 or 6 or 7) were collected, spiked with 12.5 uCi ^{14}C-labelled sodium bicarbonate and incubated on deck. Incubations were terminated after 24 hours with filtering through 25-mm 0.2-μm polycarbonate filter, with extensive rinsing with fresh filtered seawater to remove any labeled ^{14}C-DIC. Filters for the measurement of TPP were placed directly into scintillation cocktail, whereas filters for the measurement of PP were either acid-fumed (HCl, 2-3 hrs) or had 1 ml of 1% phosphoric acid added (20-24 hrs) in an identical manner to the MDT. Five experiments were made where TPP and PP were measured from separate bottles (3 each), and 14 experiments were made where TPP and PP were measured from the same bottle (sample split before filtering). Five measurements were also made of TPP and PP from Formalin-killed samples.

[Note: Primary production in the >5 mm size fraction was also measured during the cruise. Triplicate water samples were collected, spiked with 12.5 uCi ^{14}C-labelled sodium bicarbonate and incubated on deck. Incubations were terminated after 24 hours with filtering through 25-mm 5.0-μm polycarbonate filter, with extensive rinsing with fresh filtered seawater to remove any labeled ^{14}C-DIC. Filters were then either acid-fumed (HCl, 2-3 hrs) or had 1 ml of 1% phosphoric acid added (20-24 hrs) in an identical manner to the MDT.]

Bioassays

The response of calcification rates, total primary production and >5 μm primary production were measured in three nutrient bioassays. Incubations were carried out in 1.2 L polycarbonate bottles, spiked with 100 uCi ^{14}C-labelled sodium bicarbonate and incubated on deck. Incubations were terminated after 24 hours, with the sample split into six 200 ml replicates: from three, calcification and primary production were measured following the

MDT; from the other three, >5 μm primary production was measured as detailed in the last section.

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Table 1. List of CTDs sampled for calcification, total primary production and >5 μm primary production. Samples for coccolithophore abundance and diversity were also collected from these stations.

Station no.	*Date*
S003	12/07/2010
S004	13/07/2010
S006	14/07/2010
S007	15/07/2010
S009	16/07/2010
S011	18/07/2010
S012	19/07/2010
S017	22/07/2010
S019	23/07/2010
S020	24/07/2010
S022	25/07/2010
S025	27/07/2010
S026	30/07/2010
S028	31/07/2010
S029	01/08/2010
S031	03/08/2010
S033	04/08/2010
S035	05/08/2010

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Dissolved Inorganic Carbon (DIC), Total Alkalinity (TA), and pH measurements

Victoire Rerolle (University of Southampton, National Oceanography Centre, UK)

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_{2aq}, 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.

This project aims to determine the carbonate chemistry through DIC and alkalinity. This cruise was also an opportunity to test the first prototype of the spectrophotometric pH sensor I am developing for my PhD.

Method

Sampling – Profiles of DIC/TA were sampled from the Stainless Steel and Titanium CTDs (see Table 1 for list of the stations and depths sampled). Underway DIC/TA samples were also taken from the non-toxic seawater supply (intake at ~5m depth) (see Table 2).

DIC/alkalinity sampling: 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 sample was stored in a borosilicate glass bottle (250 mL), which was rinsed twice with the sample in order to remove traces of a previous sample. The tubing was inserted at the bottom of the bottle which was then filled and water was left to overflow by one bottle volume. The glass stopper was inserted in the bottle in order to remove the stopper volume and a head space of 1% (2.5mL) was allowed for water expansion. The sample was then poisoned with a saturated solution of mercuric chloride (7g/100mL) in a 0.02% volume ratio (50µL) in order to prevent any biological activity in the stored sample. The bottle was air-tight sealed with a glass stopper and shaken to mix the mercuric chloride homogeneously.

Water for DIC/alkalinity measurements was stored in a cool and dark place for analysis back at NOCS.

pH sensor test- pH is measured by adding a colored indicator to the seawater sample and measuring the color of the mix. The indicator used is Thymol Blue. The cruise was an opportunity to test the mixing efficiency of the custom made flow cell and the measurement protocol. Tests and further development have been done during first three weeks of the cruise. The system has then been automated and pH of underway seawater has been measured every 5-6 min from the 27/07/2010 to the 07/08/2010. The consistency of the data will be checked thanks to DIC and Alkalinity underway sampled in parallel and trends in other parameters such as chlorophyll, temperature, salinity and nutrients. **The data will not be used for any biogeochemical study as additional work needs to be done on the sensor before getting reliable measurements.**

Table 1: **List of the stations and depths sampled for DIC/TA**

CTD	mon/day/yr	Lat (°N)	Lon (°E)	Depth [m]
S003	07/12/2010	60.0137	-19.569	2710
				2000
				2500
				1000
				250
				40
				30
				20
				10
				5
S004	07/13/2010	61.4888	-21.0157	1835
				1000
				750
				500
				75
				100
				50
				20
				15
				10
				5
S007	07/15/2010	59.5911	-23.3736	1500
				75
				250
				100
				40
				30
				20
				15
				8
				5
S009	07/16/2010	60.0062	-28.0828	1465
				1000
				500
				250
				100
				50
				40
				30
				20
				10
				5
T009	07/18/2010	60.0053	-34.5842	3060
				2500
				2000
				1500
				1000
				500
				250
				100
				60
				50
				30
				20
S012	07/19/2010	59.5794	-41.2146	1945
				1500
				1000
				500
				250
				100
				50
				40
				30
				15
				10
				5
T011	07/19/2010	59.5929	-41.3523	1833
				1600
				1251
				903
				603
				403
				254
				154
				84
				45
				35
				25
S014	07/19/2010	59.5983	-42.4039	190
				150
				100
				50
				30
				20
				10
				5
S015	07/21/2010	59.5983	-42.4039	1500
				1500
T015	07/22/2010	62.5987	-34.5856	2655
				2500
				2000
				1400
S018	07/22/2010	62.5987	-34.5856	1498
				603
				404
				153
				84
				54
				33
				23
				13

CTD	mon/day/yr	Lat (°N)	Lon (°E)	Depth [m]
S020	07/24/2010	62.599	-29.5714	2005
				1800
				1500
				1000
				500
				100
				50
				40
				30
				20
				10
				5
S022	07/25/2010	60.5136	-31.351	800
				600
				400
				100
				50
				20
				10
				5
S023	07/26/2010	58.1444	-34.5847	2510
				2000
				1500
				1000
				500
				250
				100
				50
				30
				25
				10
				5
S026	07/30/2010	63.4936	-35.0222	2100
				1500
				1000
				500
				250
				100
				50
				40
				30
				15
				10
				5
S029	08/01/2010	62.2866	-28.2132	1665
				1000
				500
				250
				150
				100
				50
				40
				30
				20
				14
				5
S030	08/02/2010	63.2599	-23.3563	190
				150
				100
				50
				30
				20
				10
				5
S031	08/02/2010	62.8437	-24.2096	1360
				1000
				500
				250
				150
				100
				50
				40
				30
				25
				20
				10
S033	08/04/2010	65.1524	-20.4328	2210
				1500
				1000
				500
				250
				100
				50
				40
				30
				20
				10
				5
S035	08/05/2010	61.5041	-25.4085	1305
				500
				250
				100
				50
				30
				20
				10
				5

Sample	mon/day/yr	Time	Lat (°N)	Lon (°E)	Depth [m]
UW1	07/12/2010	15:00	60.42128	-19.5962	surface
UW2	07/12/2010	19:00	61.2052	-20.0034	surface
UW3	07/12/2010	23:00	61.59196	-19.5963	surface
UW4	07/13/2010	16:00	61.2195	-21.0055	surface
UW5	07/13/2010	19:00	60.4897	20.5937	surface
UW6	07/13/2010	22:00	60.1695	-21.014	surface
UW7	07/14/2010	00:00	59.5996	-20.5099	surface
UW8	07/14/2010	10:00	60.4031	-19.1958	surface
UW9	07/14/2010	14:55	60.0818	-19.2384	surface
UW10	07/14/2010	00:00	60.04	-21.1205	surface
UW11	07/14/2010	23:00	60.0185	-22.1654	surface
UW12	07/15/2010	16:00	59.5988	-24.211	surface
UW13	07/15/2010	20:00	60.0017	-25.4545	surface
UW14	07/15/2010	23:00	60.0002	-26.4918	surface
UW15	07/16/2010	11:00	60.0049	-28.4155	surface
UW16	07/16/2010	14:00	60.0062	-29.4744	surface
UW17	07/16/2010	17:00	60.006	-30.521	surface
UW18	07/16/2010	20:00	60.0044	-31.5662	surface
UW19	07/16/2010	23:00	60.0028	-33.0219	surface
UW20	07/17/2010	03:00	60.0009	-34.2643	surface
UW21	07/18/2010	08:00	60.0053	-34.5842	surface
UW22	07/18/04	11:00	60.0038	-35.5297	surface
UW23	07/18/2010	15:00	60.0013	-37.1693	surface
UW24	07/18/2010	17:00	59.5999	-37.5844	surface
UW25	07/18/2010	20:00	59.5999	-39.0029	surface
UW26	07/18/2010	23:00	60	-40.0309	surface
UW27	07/19/2010	15:00	59.5929	-41.3523	surface
UW29	07/19/2010	20:00	59.9985	-42.2112	surface
UW30	07/21/2010	14:00	60.307	-34.6224	surface
UW31	07/21/2010	15:00	60.4673	-34.6748	surface
UW32	07/21/2010	15:58	60.6499	-34.6955	surface
UW33	07/21/2010	20:00	61.2406	-34.4753	surface
UW34	07/22/2010	16:00	62.5987	-34.5856	surface
UW35	07/23/2010	13:02	62.9951	-33.5512	surface
UW36	07/23/2010	16:02	62.9988	-32.7041	surface
UW37	07/23/2010	22:00	62.0999	-31.0124	surface
UW38	07/24/2010	15:00	62.4492	-31.0079	surface
UW39	07/25/2010	09:00	60.7897	-31.6619	surface
UW40	07/25/2010	10:00	60.6416	-31.8452	surface
UW41	07/25/2010	11:03	60.4937	-32.0283	surface
UW42	07/25/2010	13:00	60.1985	-32.3904	surface
UW43	07/25/2010	14:00	60.0487	-32.5727	surface
UW44	07/25/2010	16:00	59.7529	-32.9311	surface
UW45	07/25/2010	17:00	59.6016	-33.113	surface
UW46	07/25/2010	20:00	59.1462	-33.6554	surface
UW47	07/27/2010	12:00	58.7457	-35.0116	surface
UW48	07/27/2011	18:00	59.2951	-35.0469	surface
UW49	07/27/2012	21:00	60.1915	-35.0757	surface
UW50	07/28/2010	01:00	60.4811	-24.4875	surface
UW51	07/28/2011	09:00	61.2165	-32.102	surface
UW52	07/28/2012	15:00	60.4421	-32.0315	surface
UW53	07/28/2013	20:00	60.395	-31.4584	surface
UW54	07/29/2010	00:00	61.1701	-32.2288	surface
UW55	07/29/2010	10:00	62.4417	-33.5752	surface
UW56	07/29/2010	13:00	63.0395	-34.1407	surface
UW57	07/29/2010	16:00	63.2444	-34.3315	surface
UW58	07/29/2010	19:00	63.4384	-34.5562	surface
UW59	07/31/2010	13:07	63.4756	-33.2196	surface
UW60	07/31/2010	17:10	63.174	-31.7359	surface
UW61	07/31/2010	20:00	62.9633	-30.7086	surface
UW62	07/31/2010	23:00	62.7529	-29.6899	surface
UW63	08/01/2010	02:00	62.5389	-28.6618	surface
UW64	08/01/2010	13:00	62.4116	-27.4553	surface
UW651	08/01/2010	16:04	62.9813	-26.6551	surface
UW652	08/01/2010	19:00	63.2577	-25.7097	surface
UW66	08/01/2010	22:00	63.5011	-24.8682	surface
UW67	08/02/2010	13:00	63.899	-23.3846	surface
UW67	08/02/2010	13:00	63.899	-23.3846	surface
UW69	08/03/2010	18:05	61.9788	-23.82	surface
UW70	08/03/2010	20:02	61.6719	-22.4809	surface
UW71	08/03/2010	23:01	61.6	-22.1676	surface
UW72	08/04/2010	16:02	61.3064	-21.4172	surface
UW73	08/04/2010	18:10	61.3889	-22.0512	surface
UW74	08/04/2010	20:00	61.4599	-22.5997	surface
UW75	08/04/2010	22:02	61.5417	-23.2345	surface
UW76	08/05/2010	00:03	61.6301	-23.9194	surface
UW77	08/05/2010	16:29	61.9807	-26.6963	surface
UW78	08/06/2010	00:01	62.1213	-27.2606	surface
UW79	08/06/2010	15:58	61.562	-24.0954	surface
UW80	08/06/2010	18:00	61.3459	-23.517	surface
UW80	08/06/2010	18:00	61.3459	-23.517	surface
UW81	08/06/2010	20:01	61.1319	-22.9479	surface

Table 2: List and position of the non-toxic underway samples

Dissolved Oxygen Analysis

Mark Stinchcombe, (University of Southampton, National Oceanography Centre, UK) (mcs102@noc.soton.ac.uk)

Cruise objectives:

The objectives of the dissolved oxygen analysis were to provide a calibration data set for the oxygen sensor mounted on the frame of the CTD for cruise D354 to the Irminger Basin in the North Atlantic. For this, a Winkler titration with amperometric end point detection was performed on a number of water samples drawn from the Niskin bottles mounted on the CTD frame.

Methods:

Water for the determination of the dissolved oxygen concentration was only taken from the deep stainless steel CTD casts and they were the first samples to be drawn from the Niskin bottles. Due to the relative small number of dissolved oxygen samples that would be analysed it was decided that twenty four samples, twelve depths in duplicate, would be sufficient for the calibration. The water was drawn through short pieces of silicon tubing into clear, pre-calibrated, wide-necked glass bottles. The temperature of the water at the time of sampling was measured using an electronic thermometer probe. The temperature would be used to calculate any temperature dependant changes in the bottle volumes. Each of the samples was fixed immediately using 1ml of manganese chloride and 1ml of alkaline iodide, shaken thoroughly and left to settle for approximately thirty minutes. After this time they shaken again and then left for at least an hour before analysis but all were analysed within twelve hours.

It should be noted that there were no dissolved oxygen samples analysed after station 23, CTDS028. This was due to there being no-one on board to perform the analysis. It was felt, however, that there were enough samples from all the previous stations to enable a good calibration of the sensor so this was not deemed to be a problem.

The samples were analysed in the chemistry laboratory following the procedure outlined in Holley and Hydes (1995). The samples were acidified using 1ml of sulphuric acid immediately before titration and stirred using a magnetic stirrer. The Winkler whole bottle titration method with amperometric endpoint detection with equipment supplied by Metrohm UK Ltd was used to determine the oxygen concentration.

During the first couple of days on the ship the, on 4th July 2010, the sodium thiosulphate was made up with 25g/l. The normality of the sodium thiosulphate titrant was checked using a

potassium iodate standard on the 10th July. The sodium thiosulphate needs at least one day to stabilise but we prefer to leave it for more than two days if possible. This was repeated four times through out the cruise. Sodium thiosulphate standardisation was carried out by adding the reagents in reverse order with a long stir in between and then 10ml of a 0.01N potassium iodate solution. The sample titrated and the volume of sodium thiosulphate required was recorded. This was repeated nine or ten times until at least five measurements agreed to within 0.003ml of each other. The average of these titrations was used to calculate the volume of sodium thiosulphate which was then used in the calculation of the final dissolved oxygen calculation. The volumes of sodium thiosulphate required in this standardisation process can be seen in Table 1.

Date	1	2	3	4	5	6	Average
10th July	1.0275	1.0275	1.0270	1.0270	1.0265	1.0265	**1.0270**
16th July	1.0260	1.0290	1.0280	1.0265	1.0290		**1.0272**
23rd July	1.0265	1.0290	1.0280	1.0285	1.0280	1.0280	**1.0280**
31st July	1.0240	1.0230	1.0230	1.0245	1.0220	1.0230	**1.0230**

Table 1: Standardisation of the sodium thiosulphate was performed four times on the cruise. This table shows the final volumes with the averages that were used during the calculation of dissolved oxygen. All values are millilitres.

A blank measurement was also carried out on the 10th July to account for the oxygen in the reagents. The reagents were added in reverse order, as for the sodium thiosulphate standardisation, and then 1ml of the potassium iodate standard was added. This was titrated and the volume of sodium thiosulphate required was recorded. 1ml of potassium iodate was again added to the same sample and it was titrated again. This was repeated a third time. The average of the second two volumes of sodium thiosulphate was subtracted from the first. This process was repeated at least five times until three or more blanks agreed within 0.001ml of each other. The average blank value used in the calculation of the final dissolved oxygen calculation. The volumes of sodium thiosulphate required in this blanking process can be seen in Table 2.

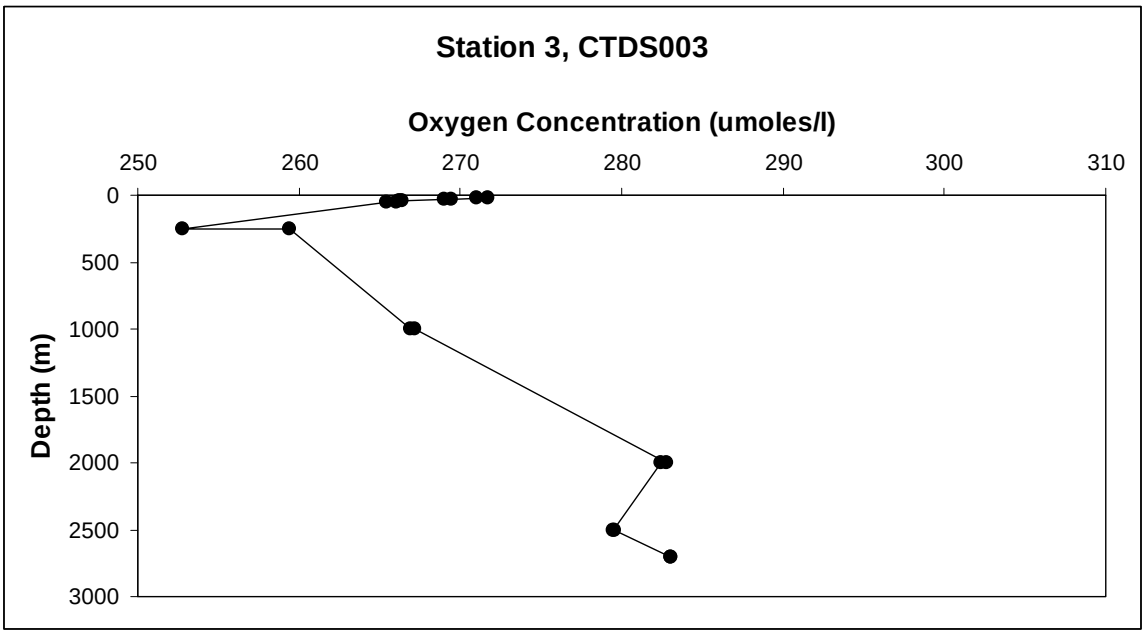
Date	Volume of sodium thiosulphate			A – ((B + C) / 2)	Average Blank
	A	B	C		
10th July	0.1025	0.1020	0.1015	**0.0007**	**0.0007**
	0.1025	0.1015	0.1020	**0.0007**	
	0.1025	0.1015	0.1020	**0.0007**	
16th July	0.1045	0.1015	0.1005	**0.0035**	**0.0032**
	0.1050	0.1005	0.1030	**0.0032**	
	0.1050	0.1005	0.1020	**0.0037**	
	0.1045	0.1015	0.1015	**0.0030**	
	0.1045	0.1015	0.1020	**0.0027**	
23rd July	0.1040	0.1020	0.1010	**0.0025**	**0.0025**
	0.1040	0.1015	0.1015	**0.0025**	
	0.1040	0.1020	0.1010	**0.0025**	
31st July	0.1040	0.1010	0.1010	**0.0030**	**0.0032**
	0.1040	0.1005	0.1005	**0.0035**	
	0.1045	0.1005	0.1015	**0.0035**	

	0.1035	0.1010	0.1005	**0.0027**	

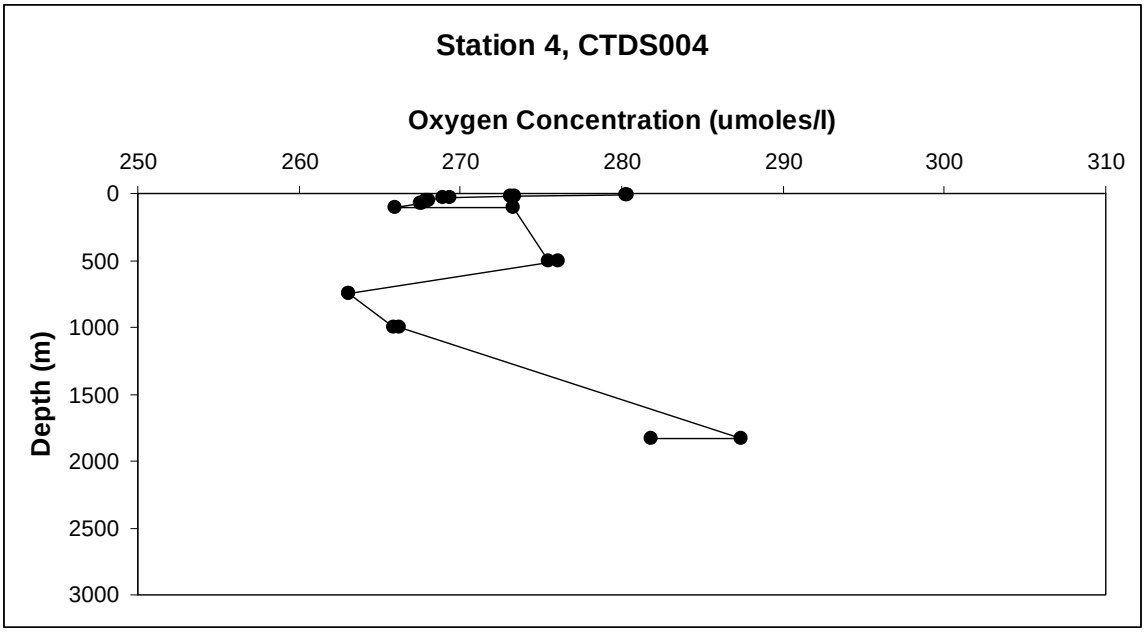
Table 2: A blank measurement was performed four times on the cruise. This table shows the final volumes with the averages that were used during the calculation of dissolved oxygen. All values are millilitres.

Preliminary Data

The data was collected and analysed on board. Final quality controlling of the data set was undertaken back at the NOC. Figures 1, 2 and 3 show the profiles of oxygen concentration from some of the deep stainless CTD casts.

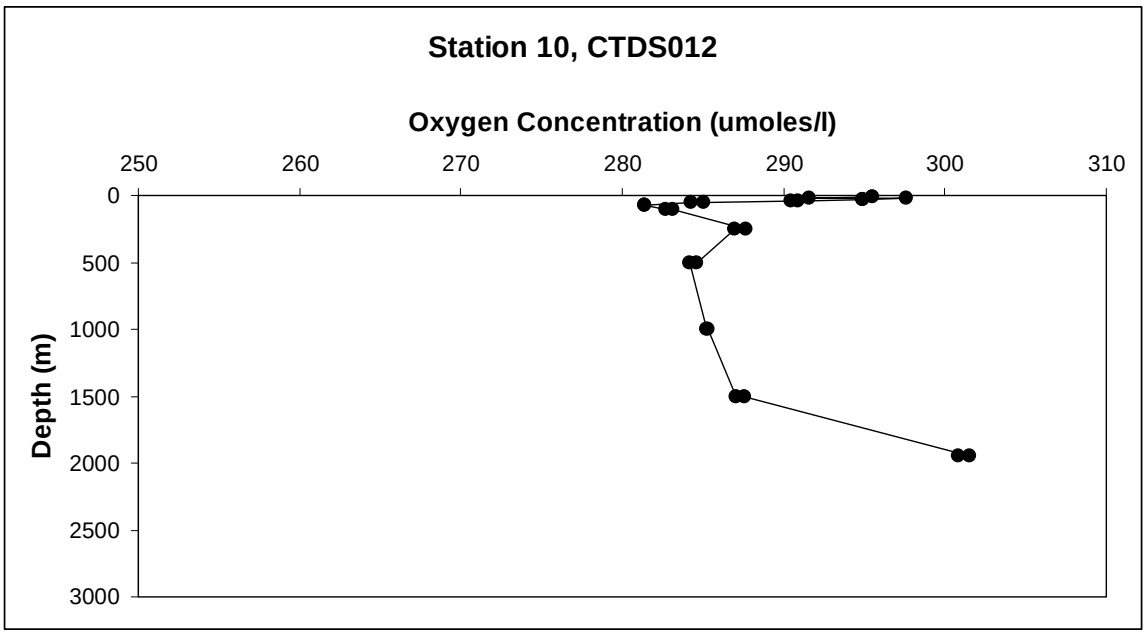


a.

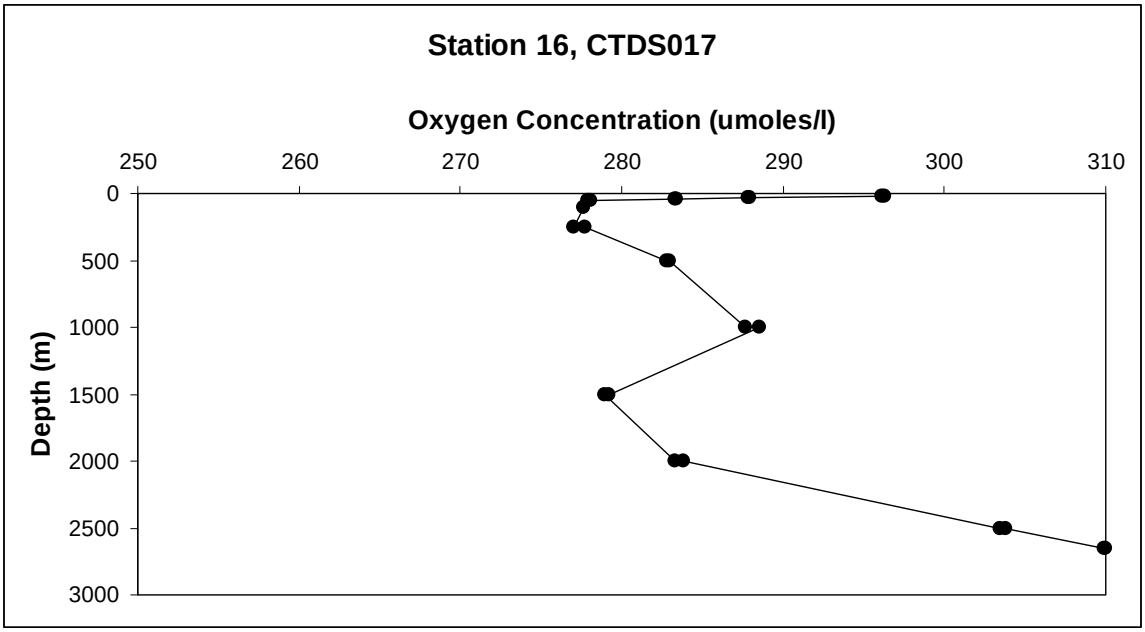


b.

Figure 1: Two oxygen profiles from the early part of the cruise. Profile a is station 3, CTDS003 and is at 60 00.98N, 19 57.11W and profile b is station 4, CTDS004 and is at 61 49.11N, 21 00.94W. These are both in the Iceland Basin.

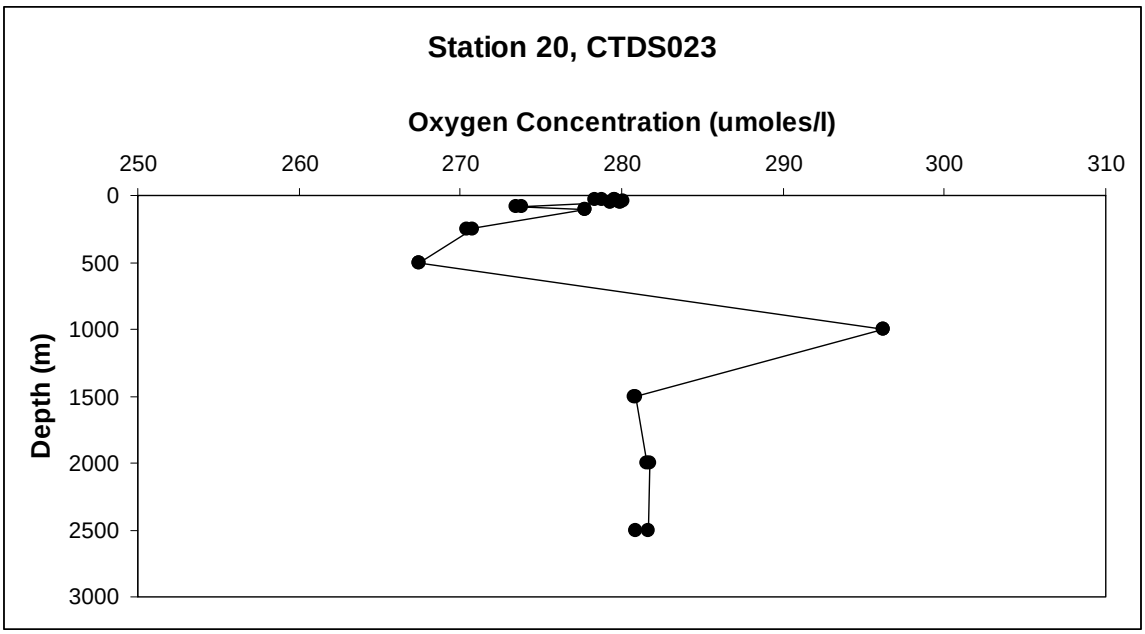


a.

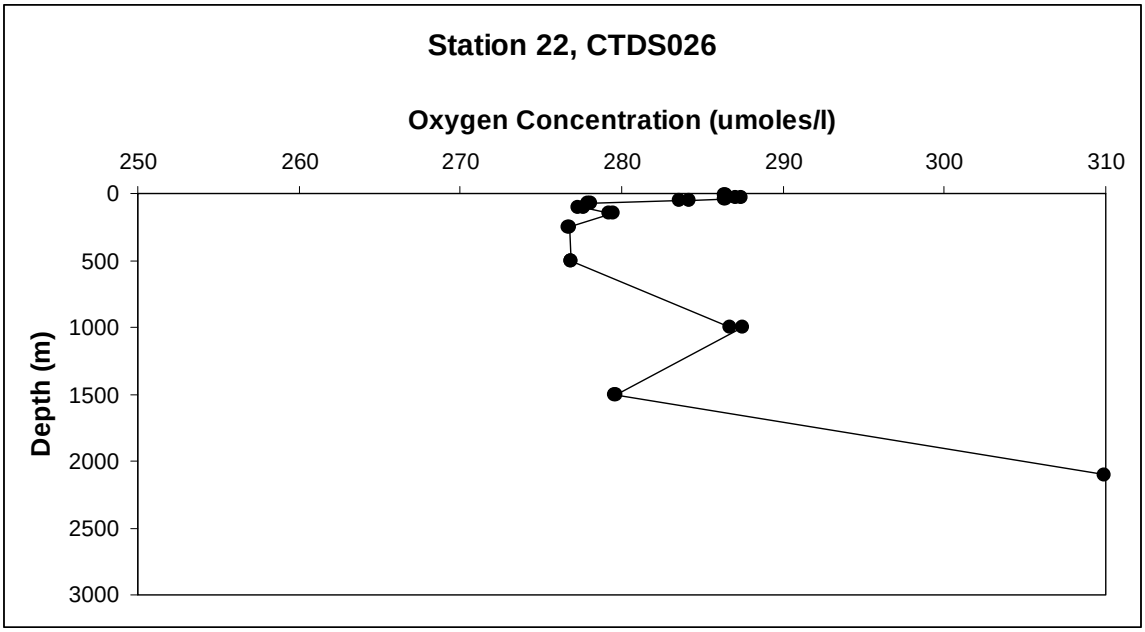


b.

Figure 2: Two oxygen profiles from the middle of the cruise. Profile a is station 10, CTDS012 and is at 59 58.57N, 41 21.36W and profile b is station 16, CTDS017 and is at 62 59.62N, 35 00.02W. These are both in the Irminger Basin, CTDS012 is at the west edge near the Greenland Shelf.



a.



b.

Figure 3: Two oxygen profiles from toward the end of the cruise. Profile a is station 20, CTDS023 and is at 58 14.69N, 34 58.15W and profile b is station 12, CTDS026 and is at 63 49.37N, 35 02.23W. These are both in the Irminger Basin and mark the most southerly (CTDS023) and northerly (CTDS026) of our stations in this basin

Oxygen sensor calibration

The oxygen data has been used by Stuart Painter to calibrate the oxygen sensor on the CTD. The bottle data was plotted against sensor data (Figure 4).

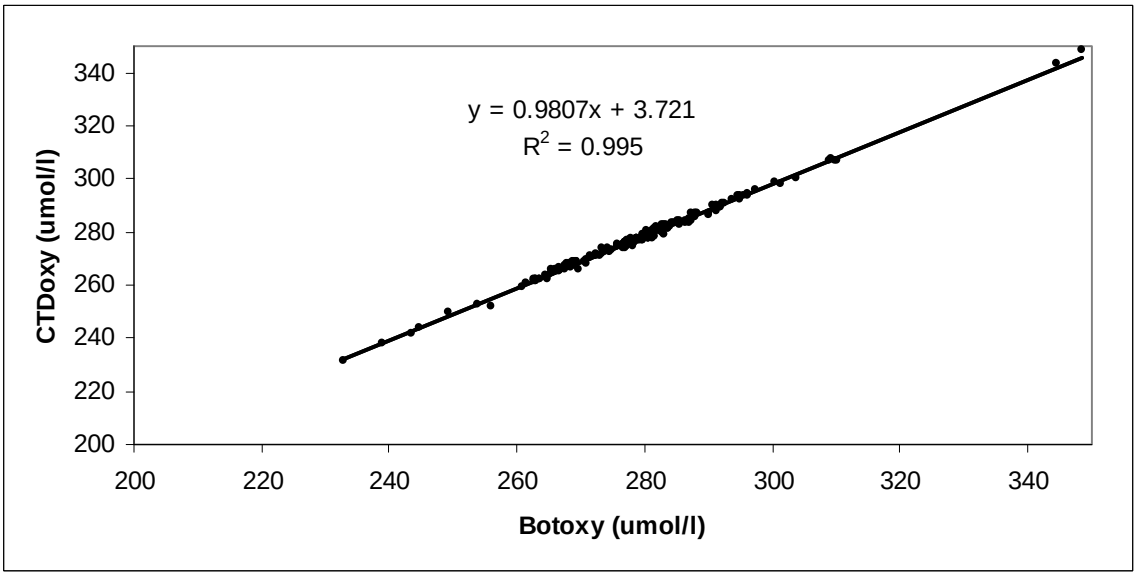


Figure 4: Bottle oxygen vs. sensor oxygen concentrations. The fit is very good with an r^2 of 0.995.

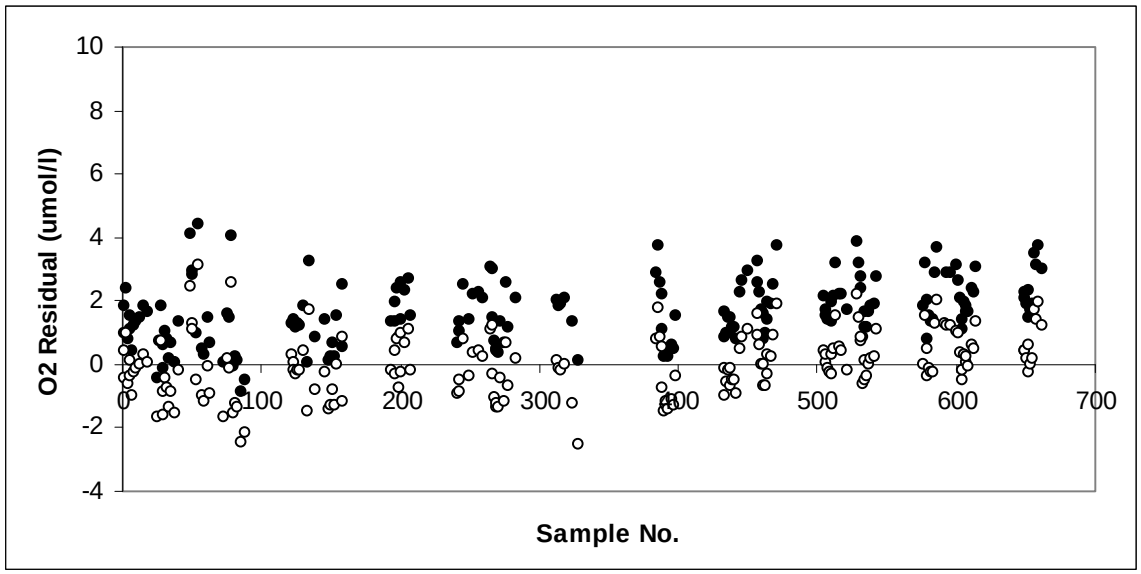


Figure 5: Residuals before and after the regression was applied. Closed circles are before the regression was applied. The mean residual for this group is approximately 2umoles/l. After the regression (open circles) the mean residual is approximately 0.

The regression showed a very good fit with r^2 of 0.995. Figure 5 shows the residual values before and after the regression has been applied. The residual value is the difference between the oxygen concentration from the Winkler titrations and the sensor on the CTD. Figure 6 shows how this affects a single profile. It shows the trace of the sensor before and after the regression has been applied and compares it to the actual bottle oxygen data. Although the shift from the uncalibrated profile to the calibrated profile is not as obvious as during D350, it is important to remember that the average uncalibrated residual for D350 was approximately 4umoles/l where as for D354 it's only 2umoles/l.

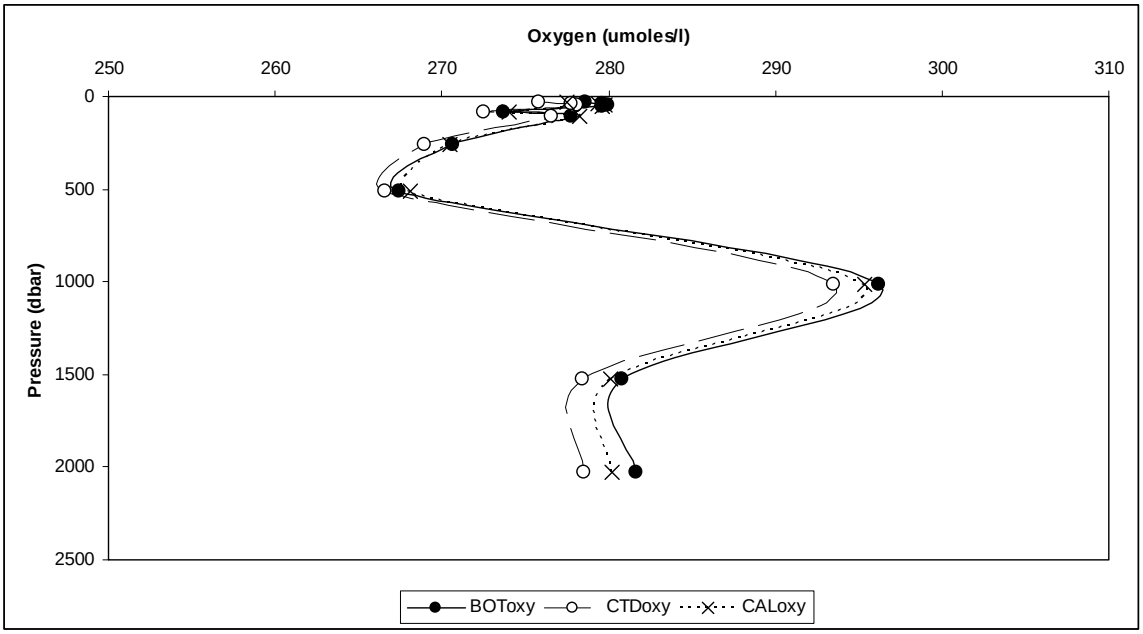


Figure 6: This profile from Station 20, CTDS023, shows the difference between the sensor oxygen value (CTDoxy) and the bottle oxygen derived from the Winkler titrations (BOToxy). Overlaid on this is the recalculation of the sensor oxygen (CALoxy) made using the regression from figure 5.

Inorganic nutrient analysis

Mark Stinchcombe, (University of Southampton, National Oceanography Centre, UK)

(mcs102@noc.soton.ac.uk)

Cruise Objectives:

Our objective on cruise D354 to the Irminger Basin in the North Atlantic was to measure the concentrations of the inorganic nutrients: TON, silicate and phosphate using segmented flow analysis. The majority of these samples were analysed onboard but all samples after Station 24, CTDS029 were frozen for analysis back at the NOC.

Method:

Analysis for micro-molar concentrations of nitrate and nitrite (hereinafter Total Oxidised Nitrogen or TON), phosphate and silicate were undertaken on a Skalar San+ segmented flow autoanalyser following methods described by Kirkwood (1996). Samples were drawn from Niskin bottles on the CTD into 25ml Sterilin coulter counter vials and kept refrigerated at approximately 4^{o}C until analysis, which commenced within 12 hours. Overall 31 runs with a total of 1853 samples were analysed on the ship and 11 runs with a total of 599 samples were analysed at the NOC. In all there were 846 CTD samples, 426 underway samples and 1180 experimental samples. An artificial

seawater matrix (ASW) of 40g/litre sodium chloride was used as the inter-sample wash and standard matrix. The nutrient free status of this solution was checked by running Ocean Scientific International (OSI) low nutrient seawater (LNS) on every run.

A single set of mixed standards were made up by diluting 5mM solutions made from weighed dried salts in 1litre of ASW into plastic 1litre volumetric flasks that had been cleaned by soaking in MilliQ water (MQ). The concentration of the standards were tested on every run by analysing diluted OSI certified standards, one high concentration sample (29.25µM for TON, 19.50µM for silicate and 1.95µM) and one low concentration sample (0.98µM for TON and silicate and 0.1µM for phosphate). These OSI standards were only used during the analysis on the ship and not at the NOC. Data processing was undertaken using Skalar proprietary software and was performed within 24 hours of the run being finished. The wash time and sample time were 90 seconds; the lines were washed daily with 10% Decon and MQ.

Performance of the Analyser:

During the precursor cruise (D350) there was a failure of one of the spectrophotometers on the analyser. This meant only two channels could be analysed. So samples were frozen and measured for phosphate back at the NOC. By the start of D354 we had replaced the spectrophotometer and so were back up to running all three channels. Another problem which occurred on D350 was that the software would freeze and have to be re-installed. This problem was also seen during D354 but it was quickly dealt with and no samples were lost. The reason for this is still unknown and Skalar are unsure as to why it happens either.

Early in the cruise we had some fairly rough seas. The ship was moving quite a bit and this affected the analyser. The light source is a filament bulb and during times of ship motion the filament can move creating very noisy baselines. The noise is reduced when the ships motion is minimal but unfortunately there is not much that can be done to stop this other than replacing the light sources with LEDs but this is expensive and so is unlikely to happen in the near future.

In the first few runs there appeared to be a problem with the phosphate line. Before and after each sample there was an area of noise in the baseline. The source of this was traced back to the inter-sample air bubble. Due to the large volume of sample that the phosphate line requires, this line pulls in the majority of this inter-sample bubble. Although the bubble itself does not go through the flow cell, the large bubble influences the amount of reagents that are in the segment in front and behind it. It's this digression from the usual sample to reagent ratio that creates the noisy baseline at these points. To combat this I placed a debubbler on the phosphate line in front of the pump decks.

The final issues concerned the TON channel. Firstly the calibration was not linear, even over a relatively small range. However, during a check back at the NOC when both our analysers were running, it was found that the curved calibration gave just as good results as the linear calibration as long as all samples were within the range of the standards. Finally there was a slight cross over issue from one sample to the next. This occurred because the sample is debubbled before it passes through the cadmium column. Not much can be down about this. The effect was minimised by never running two samples of largely differing concentrations next to each other, i.e. high concentration deep water samples before low concentration surface water samples.

All stations up to and including Station 23 were analysed on board the ship. After station 23 all samples were frozen and analysed back at the NOC. The samples analysed at the NOC were run on the other instrument as this seemed to have less cross over and a linear calibration, but as mentioned before, when tests were carried out to compare the two, no difference could be seen in the data.

Data

Once the data had been analysed it was passed onto BODC. I have included here a few plots of data including the underway data for TON, silicate and phosphate as well as a couple of profiles, one from the Iceland Basin and one from the Irminger Basin.

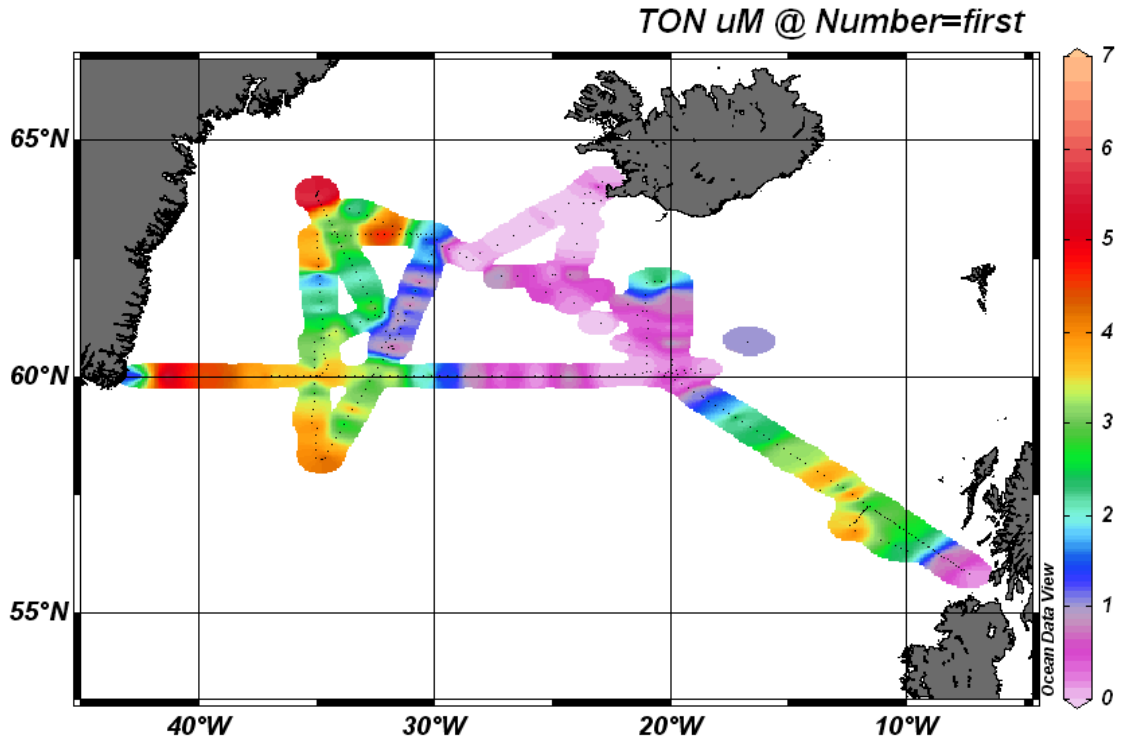


Figure 1: A surface plot of TON concentration (µM) from the underway data using Ocean Data View 4. There is a striking gradient in TON concentrations from east to west. This coincides with the Reykjanes Ridges (not shown). In the Iceland Basin to the east of the ridge there are much lower concentrations of TON than in the Irminger basin to the west.

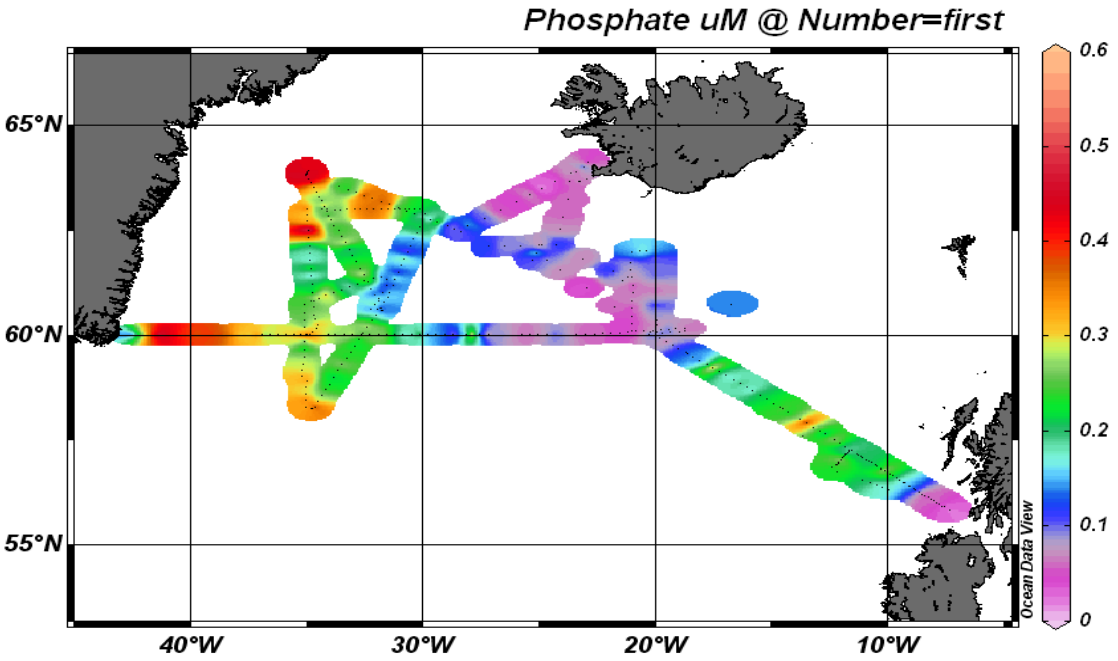


Figure 2: This surface plot shows phosphate concentrations (µM) along the cruise track from the underway data using Ocean Data View 4. The same spatial pattern can be seen as for TON. It can clearly be seen that in the east of the study area (the Iceland Basin) there is very little phosphate but to the west (the Irminger Basin) the phosphate levels are much higher.

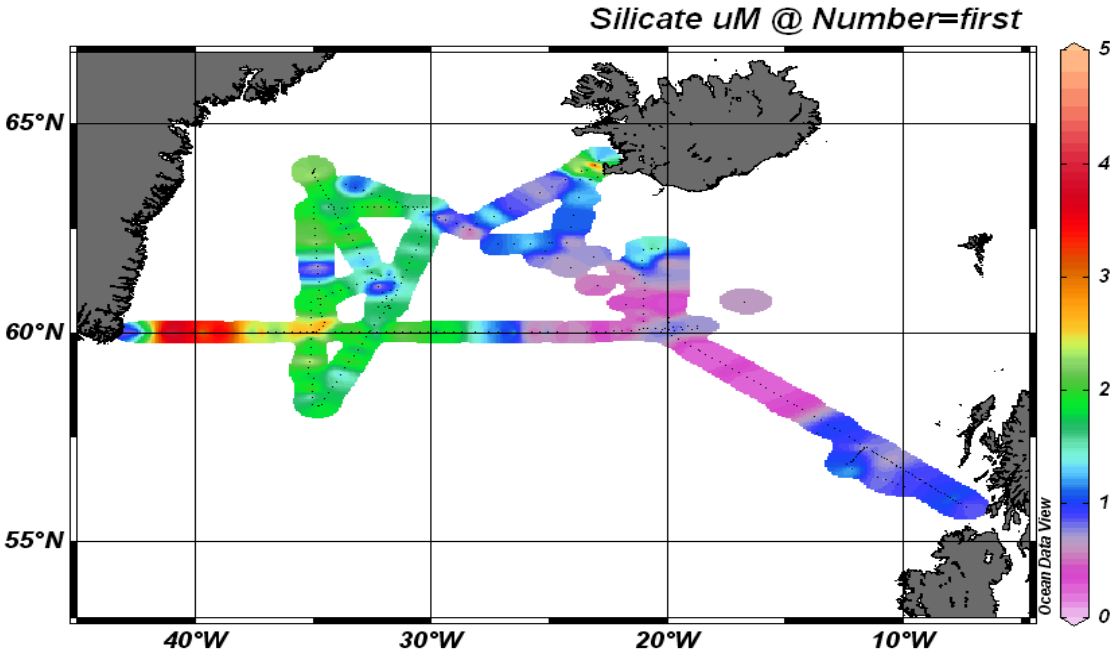
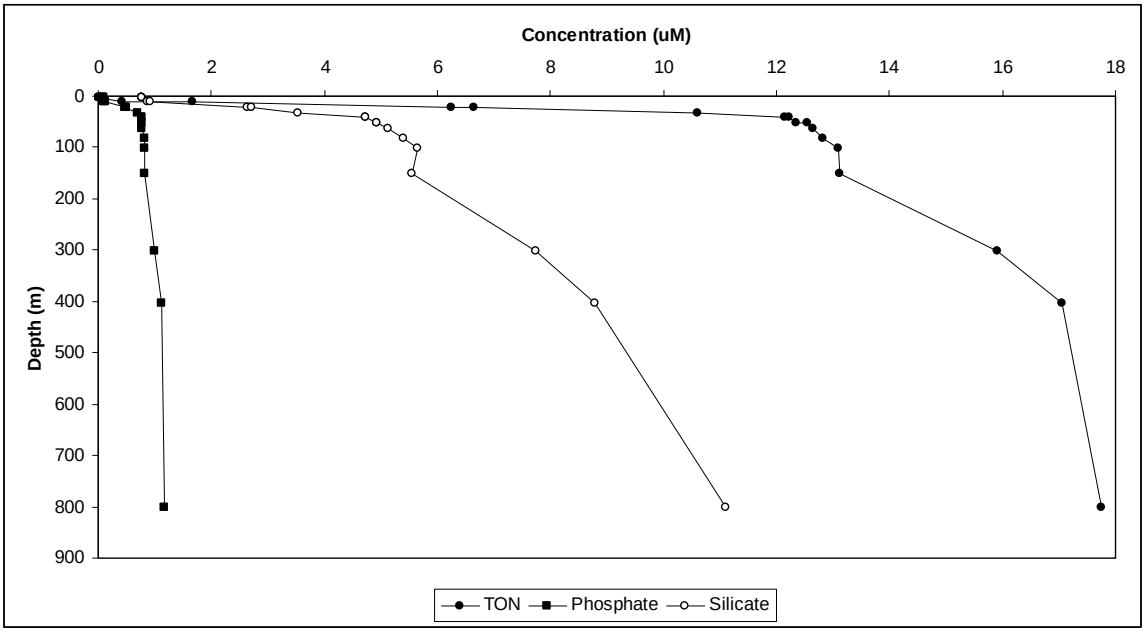
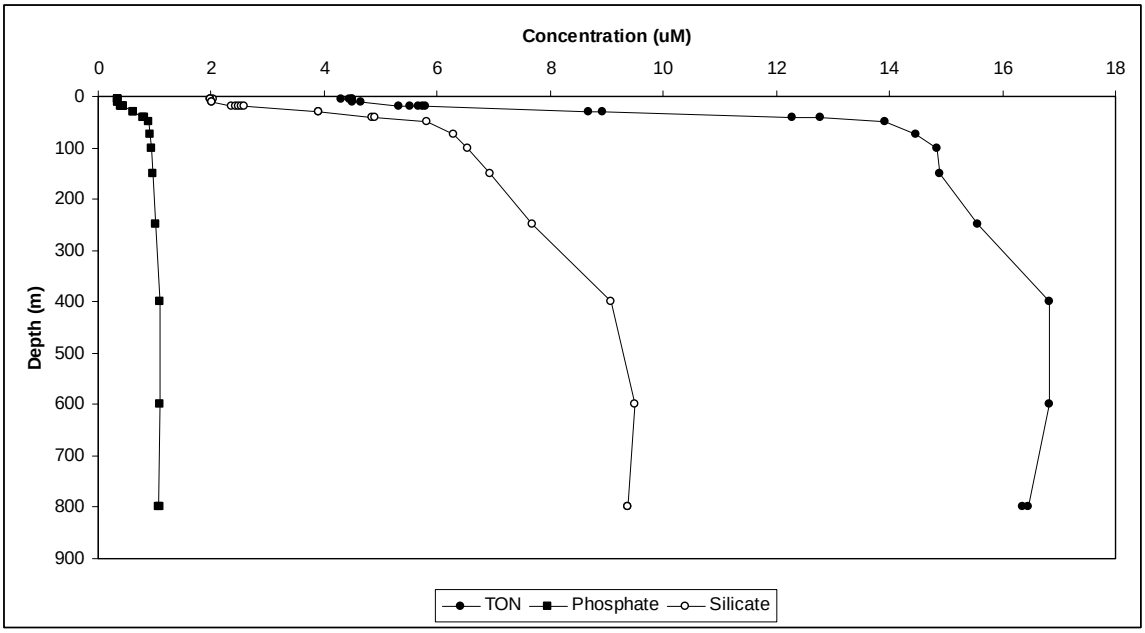


Figure 3: This surface plot using Ocean Data View 4 and the underway data shows silicate concentrations (µM). The Iceland Basin to the east again shows much lower concentrations than the Irminger Basin to the west.



A.



B.

Figure 4: Plot A is station 2, CTDS002 and is in the Iceland Basin. Plot B is station 17, CTDS019 and is from the Irminger Basin. Although deep water concentrations in both are similar, it is at the surface where there is a striking difference. In the Iceland Basin concentrations have been drawn down to <0.1 µM for TON and phosphate and below 1 µM for silicate compared to values of >4 µM for TON,

>0.3 µM for phosphate and ~2 µM for silicate. Even at 200m the concentrations are lower in the Iceland Basin. Only at approximately 400m do the concentrations reach a similar level in both basins.

Computing and Instrumentation Report D354

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RVS LEVEL C System

Level C - The level C system is a Sun Solaris 10 UNIX Workstation discovery1 also known as ABCGATE. The RVS software suite is available on this machine. This suite of software allows the processing, editing and viewing of all data within the RVS data files. This system also has monitors that allow us to ensure that the level C is receiving data from the level B.

Ifremer Techsas System

The Ifremer data logging system is the system that will inevitably replace the existing Level A + B system while for the most part the Level C will remain as the main system for outputting, viewing and editing the acquired data.

The Techsas software is installed on an industrial based system with a high level of redundancy. The operating system is Red Hat Enterprise Linux Edition Release 3. The system itself logs data on to a RAID 0 disk mirror and is also backed up from the Level C using a 200GB / 400GB LTO 2 Tape Drive. The Techsas interface displays the status of all incoming data streams and provides alerts if the incoming data is lost. The ability exists to broadcast live data across the network via NMEA.

The storage method used for data storage is NetCDF (binary) and also pseudo-NMEA (ASCII). At present there are some issues on some data streams with file consistency between the local and network data sets for the ASCII files. NetCDF is used as the preferred data type as it does not suffer from this issue.

The Techsas data logging system was used to log the following instruments:

1) Trimble GPS 4000 DS Surveyor (converted to RVS format as gps_4000)
2) Chernikeef EM speed log (converted to RVS format as log_chf)
3) Ships Gyrocompass (converted to RVS format as gyro)
4) Simrad EA500 Precision Echo Sounder (ea500)
5) NMFD Surface-water and Meteorology (surfmet) instrument suite
6) ASHTECH ADU-2 Altitude Detection Unit (gps_ash)
7) NMFD Winch Cable Logging And Monitoring CLAM (winch)
8) Fugro Seastar 9200 G2 XP Differential (gps_g2)
9) Seabird SBE45 MicroTSG (seabird)

Fugro Seastar DGPS Receiver

The Fugro Seastar G2 is a Glonass and GPS receiver that is used to provide 10CM accuracy and also receives differential from the Fugro differential system. This signal is then buffered out to multiple systems including the Trimble 4000 DS. The Seastar was purchased as an upgrade to the old Seastar and G12 combination. The system is designed to cope wit the future expected solar activity that is expected to disable part of the existing GPS network. The system is also capable of receiving corrections via Internet if necessary.

NetCDF files for this system s9200G2s-FUGRO.gps

RVS Stream gps_g2

Forms part of the bestnav stream

Trimble 4000 DS Surveyor

The Trimble 4000DS is a single antenna survey-quality advanced GPS receiver with a main-masthead antenna. It uses differential corrections from the Fugro Seastar unit to produce high quality differential GPS (DGPS) fixes. It is the prime source of scientific navigation data aboard RRS Discovery and is used as the data source for Navigation on the ships display system (SSDS). This antenna is directly on top of the mast and suffers from negligible interference from other items on the mast. It is also almost directly at the centre point of the ship making it an ideal navigation system.

The Techsas NetCDF File ends with the following extensions :

Position-4000.gps

Satelliteinfo-4000.hps

RVS Stream gps_4000

Forms part of the bestnav stream

Ashtec ADU-2

This is a four antenna GPS system that can produce attitude data from the relative positions of each antenna and is used to correct the VMADCP for ship motion. Two antennae are on the Bridge Top and two on the boat deck.

The Ashtec system worked reliably throughout the cruise with some gaps that are quite usual with this system due to the amount of calculations necessary. No Large data gaps are present. The ADU-2 forms part of the bestnav system which is an assembly of multiple GPS signals including the gyronmea and emlog stream in order to calculate the best possible position, speed heading pitch and roll of the ship. The Ashtech is not as reliable as the Fugro Seastar G2 and the 4000DS mainly due to its low position on the ship it is hard for this system to maintain locks on satellites when the ship is maneuvering and the bridge and main mast come into its direct line of sight with the satellites.

The Techsas NetCDF File ends with the following extensions :

ADUPOS-PAPOS.gps

gppat-GPPAT.att

RVS Stream gps_ash

Forms part of the bestnav stream

Gyronmea

The Gyronmea is a file that receives its data from the Ships gyro compass located on the bridge. There are two such Gyros on the bridge and we are able to use either one of them as a source of heading. The selected Gyro is logged by the TECHSAS system and is used as part of the bestnav calculation.

The NetCDF File for Techsas ends with gyro-GYRO.gyr

RVS data stream gyro

RDI Ocean Surveyor 75KHz Vessel Mounted ADCP (VMADCP)

The RDI Ocean Surveyor was setup by the science party at the start of the cruise with a bottom track and water track file that is included with the dataset. The configuration was changed when we left the shelf and went to deeper water. The Ocean surveyors are fed with data from the ships GPS, Gyro and ADU systems in order so that the system can calculate true speeds and direction of the currents below the ship.

100 Bins

8 Meter Bin Size

8 meter Blank

5.3 Meter Transducer Depth

Hi Resolution (short Range)

Ping as fast as possible.

RDI 150KHz Vessel Mounted ADCP (VMADCP)

The RDI Ocean Surveyor was setup by the science party at the start of the cruise with a bottom track and water track file that is included with the dataset. The configuration was changed when we left the shelf and went to deeper water. The Ocean surveyors are fed with data from the ships GPS, Gyro and ADU systems in order so that the system can calculate true speeds and direction of the currents below the ship.

100 Bins

4 Meter Bin Size

4 meter Blank

5.3 Meter Transducer Depth

Hi Resolution (short Range)

Ping as fast as possible.

Chernikeef EM log

The Chernikeef EM log is a 2-axis electromagnetic water speed log. It measures both longitudinal (forward-aft) and transverse (port – starboard) ships water sped.

The EM log was not calibrated prior to the cruise and was reading at 0.0 knots when alongside. The Chernikeef was accurate at the lower speeds but then an offset was obvious when the speed was increased at 10.6 Knots over ground the speed of the Chernikeef was at 8 Knots.

The system was logged by the TECHSAS logging system.

DYLog-LOGCHF-DYLog

RVS Stream chernikeef

Simrad EA500 Precision Echo Sounder (PES)

The PES system was used throughout the cruise, with a variation between use of the Fish and use of the hull transducer. The PES was deployed on the fish as soon as we stopped to deploy the first CTD. The fish is more accurate than the hull transducer as it is capable of being deployed deeper and is also decoupled from the noise of the ship.

The PES outputs its data to a stream called ea500 on the Level C System.

Surfmet System

This is the NMFD surface water and meteorology instrument suite. The surface water component consists of a flow through system with a pumped pickup at approx 5m depth. TSG flow is approx 25

litres per minute whilst fluorometer and transmissometer flow is approx 3 l/min. Flow to instruments is degassed using a debubbler with 40 l/min inflow and 10/l min waste flow.

The meteorology component consists of a suite of sensors mounted on the foremast at a height of approx 10m above the waterline. Parameters measured are wind speed and direction, air temperature, humidity and atmospheric pressure. There is also a pair of optical sensors mounted on gimbals on each side of the ship. These measure total irradiance (TIR) and photo-synthetically active radiation (PAR).

The Non Toxic system was enabled as soon as we were far enough away from land.

Surfmet Non Toxic On around 091760000

Surfmet Non Toxic Off (End of Cruise) 09184123500

The SBE45 unit was changed prior to sailing as another unit had just been returned from Calibration at Seabird and was available for the cruise while the existing unit was out of calibration.

The Transmissometer and Fluorometer were also changed prior to sailing for this reason.

Techsas NetCDF Files for Surfmet

Surf-SURFMET.SURFMETv2

MET-SURFMET.SURFMETv2

Light-SURFMET.SURFMETv2

SBE45-SBE45.TSG

Surfmet rvs stream is the raw data captured from the TECHSAS System

Surftmp is the rvs stream containing the same variables as surfmet however it has been despiked.

The temp_h temp_m and cond data in the surfmet file is a direct copy of the seabird data however it can be delayed in time. For that reason, always use the data from the seabird instead of the surfmet for protsg and salinity calibrations.

These files contain

Temp_h (Housing Temperature from the SBE45 in the wetlab)

Temp_m (Marine Temperature from the Hull intake)

Cond (Conductivity from the SBE45 in the wet lab)

Trans (Raw Voltage from Transmissometer)

Fluo (Raw Voltage from Fluorometer)

Speed (Wind Speed from Gill Windsonic Anemometer)

Direct (Wind Direction from Gill Windsonic Anemometer)

Airtemp (Air Temperature from Vaisala HMP45A)

Humid (Air Temperature from Vaisala HMP45A)

Pressure (Air Pressure from Vaisala PTB100)

PPAR (Photosynthetic Active Radiation from SKE510 PAR Sensor on PORT Gimbal)

SPAR (Photosynthetic Active Radiation from SKE510 PAR Sensor on STBD Gimbal)

PTIR (Total Incidental Radiation from CM6B TIR Sensor on PORT Gimbal)

STIR (Total Incidental Radiation from CM6B TIR Sensor on STBD Gimbal)

Seabird is the raw log of the SBE45 and SBE38 through the SBE45 Junction Box.

Temp_h (Housing Temperature of SBE45 TSG)

Temp_m (Remote or Marine Temperature from Inlet pipe)

Cond (Conductivity in SBE45 TSG)

Salin (Calculated Salinity from Instrument)

Sndspeed (Calculated Sound Velocity from Instrument)

Surfmet : The Sensor List

Met Platform Sensors

Wind Speed and Direction

Manufacturer : Gill

Model : Windsonic (Option 3)

Ultrasonic Output Rate	1, 2, 4Hz
Wind Speed	Range 0-60 m/s
Wind Direction Range	0-359 no dead band
Operating Temp Range	-35 ºC to +70 ºC
Moisture Protection	IP65
External Construction	Luran
Digital O/P Options	RS232 / 422 / 485 / SDI-12
NMEA O/P	Yes
Analogue Outputs	2 (optional)
Calibration	Generic

Total Incidental Radiation

Manufacturer : Kipp and Zonen

Model Number : CM6B

Spectral range	305...2800 nm (50%points)
Sensitivity	9...15 µV/Wm-2
Impedance	70...100 Ohm
Response time	1/e 5 s, 99 % 55 s
Non-linearity	<1.5 % (<1000 W/m 2)
Tilt error	<1.5 % at 1000 W/m 2
Operating temperature	-40...+90 _C
Temperature dependence of sensitivity	_2 %
	(-10...+40_C)
Maximum irradiance	2000 W/m2
Directional error	< _20 W/m2 at 1000 W/m2
Weight	0.85 kg
Cable length	10 m

Temperature and Humidity

Manufacturer : Vaisala

Model Number : HMP45A

Relative humidity measurement

HMP45A	
Measurement range	0.8 ... 100 % RH
Accuracy at +20 °C (+68 °F)	± 2 % RH (0 ... 90 % RH)
	± 3 % RH (90 ... 100 % RH)
Sensor	Vaisala HUMICAP® 180

Temperature measurement

HMP45A	
Measurement range	-39.2 ... +60 °C (-38.6 ... +140 °F)
Accuracy +20 °C (+68 °F)	± 0.2 °C (± 0.36 °F)
Sensor	Pt 1000 IEC 751

Operating environment

Temperature	
operation	-40 ... +60 °C (-40 ... +140 °F)
storage	-40 ... +80 °C (-40 ... +176 °F)

Inputs and outputs

Operating Voltage	7 ... 35 VDC
Power consumption	< 4 mA
Output load	> 10 kohm (to ground)
Output scale	-40 ... +60 °C (-40 ... +140 °F) equals to 0...1V
Output signal	resistive 4-wire connection

Photosynthetic Active Radiation

Manufacturer : Skye Instruments

Model Number : SKE 510

Spectral Range	400-700nm
Sensitivity Current	3.5µA/100Wm^2
Sensitivity Voltage	1mV/100Wm^2
Working Range	0 – 5000Wm^2
Linear Error	<0.2%
Absolute Calibration Error	typ <3% max 5%
Cosine Error	3%
Azimuth Error	<1%
Temperature coefficient	+/-0.1%/ºC
Longterm Stability	+/-2%
Response Time	10ns
Internal Resistance	300Ohms
Temperature Range	-35ºC … +70ºC
Humidity Range	0 – 100% RH

Barometric Pressure

Barometric pressure measurement

Pressure range	800 ... 1100 hPa
Accuracy at +20 °C (+68 °F)	±0.3 hPa
Sensor	Vaisala BAROCAP®

Operating environment

Temperature range	-5 ... +45 °C (+23 ... +113 °F)
Humidity range	<80 % RH

Inputs and outputs

Operating voltage	9 ... 16 VDC
Power consumption:	
operation mode	2 mA (typical)
shutdown mode	150 µA (typical)
Output voltage	0 … 2.5 VDC

Sea Surface Instruments

Fluorometer

Manufacturer : WetLabs

Model Number : WetStar

Temperature Range	0-30 C
Depth Rating	600m
Response time	0.17s
Input Voltage	7-15vdc
Current Draw	< 40 mA
Output	0-5VDC

Transmissometer

Manufacturer : WetLabs

Model Number : CStar

Pathlength	25cm
Wavelength	660nm
Bandwidth	~ 20nm
Rated Depth	600m
Temperature	0-30ºC
Power Input	7-15VDC
Current Draw	< 40mA
Data Output	0-5Volts
Time Constant	0.167 sec
Temperature Error	0.02 percent F.S./deg C

Seabird Micro TSG SBE45

Measurement Range

Conductivity: 0-7 S/m (0-70 mS/cm)

*Temperature *:* -5 to 35 °C

Initial Accuracy

Conductivity: 0.0003 S/m (0.003 mS/cm)

*Temperature *:* 0.002 °C

Salinity: 0.005 PSU, typical

Typical Stability *(per month)*

Conductivity: 0.0003 S/m (0.003 mS/cm)

*Temperature *:* 0.0002 °C

Salinity: 0.003 PSU, typical

Resolution

Conductivity: 0.00001 S/m (0.0001 mS/cm)

*Temperature *:* 0.0001 °C

Salinity: 0.0002 PSU, typical

Calibration Range

Conductivity: 0-6 S/m (60 mS/cm); physical

calibration 2.6-6 S/m (26-60 mS/cm),

plus zero conductivity (air)

*Temperature *:* +1 to +32 °C

Time Resolution	1 second
Clock Stability	13 seconds/month
Input Power	8-30 VDC
Acquisition Current	34 mA at 8 VDC; 30 mA at 12-30 VDC
Quiescent Current	10 microamps
Acquisition Rate	1 Hz maximum
Operating Pressure	34.5 decibars (50 psi) maximum
Flow Rate	10 to 30 ml/sec (0.16 to 0.48 gal/min)
Materials	PVC housing
Weight	4.6 kg (10.2 lbs)

Seabird SBE 38 Digital Oceanographic Thermometer

Measurement Range	-5 to +35 °C
Initial Accuracy	± 0.001 °C (1 mK)
Typical Stability	0.001 °C (1 mK) in 6 months, certified
Resolution	0.00025 °C (0.25 mK)
Calibration	-1 to +32 °C
Response Time	500 milliseconds
Self-Heating Error	less than 200 µK

RMS Noise

(at temperature

equivalent of 8.5 °C)

NAvg	**Noise (°C)**
1	0.000673
2	0.000408
4	0.000191
8	0.000133
16	0.000081
32	0.000052

Note:

NAvg = number of A/D cycles per sample.

Interval between samples (seconds)

= (0.133 * **NAvg**) + 0.339

RS-232 (standard):

	8 – 15 VDC at 10 milliamps average
External Power	*RS-485 half-duplex (optional):*
	8 – 15 VDC at 6 milliamps average
Materials	Titanium pressure case rated
	at 10,500 meters (34,400 feet)
Weight	In water: 0.5 kg (1.2 lbs)
	In air: 0.9 kg (2.0 lbs)

Processed Data files

Relmov – Relmov is the relative motion file for this cruise. This is generated using the ships gyro and ships Chernikeef Log data to extract a movement in a given direction. This is then used by bestnav when and where necessary to calculate fixes if GPS fixes were not available.

Bestnav – Bestnav uses all 3 GPS Systems logged, gps_4000, gps_g2, gps_ash and creates a best suite stream by providing an as complete account of the ships track as possible. This is done by reading all 3 GPS streams with gps_4000 being primary, gps_g2 as secondary and gps_ash as tertiary. The system looks for gaps of a certain length in the primary and when it finds those gaps it requests that the next gps down fill in the gaps. If no GPS data is available it asks RELMOV to fill in until data is available again. Then the system calculates back over itself to ensure that the extrapolated positions are correct using the GPS data available around the gap.

Bestdrf – Bestdrf is a product of bestnav. When run bestnav uses the relmov data which contains a predicted vn and ve based upon direction and speed through the water. The Bestdrf file is the accurate drift velocity of what actually occurred based on the GPS changes between each record.

Protsg - Protsg is the Processed Thermosalinograph data. The raw data is taken from the seabird stream or seatemp stream if cleaned and then ran through a salinity calculation. The data varies slightly from the raw seabird salin variable as they use a slightly different algorithm for the calculation of salinity.

Pro_wind – This program is designed to remove the relative variables from the wind data logged by surfmet. By removing any fixed offsets in the system and removing the affect of ship motion pro_wind is a true representation of ships wind data.

Intdep – Intdep is a Interpolated data set that extrapolates data where none was logged based on a 2min band pass filter. Intdep is then passed to which takes Carters tables into account.

Prodep – Prodep is an automated process that access the bestnav position fix data and then uses a pre programmed Carters table of corrections and corrects the echo sounder data for that given time.

Network Services

Networking worked well throughout the cruise despite a few hiccups with one of the wireless access points on the Forecastle Deck

Data Storage

Two USB external hard drives are being use as a RAID 0 mirror hosted by Discovery3 at the /data32 export. The mirror uses the modern meta device commands available in Solaris 10. This increases storage robustness by providing another layer of redundancy at the online storage level. The maintenance and administration of the disk set is minimal and the performance more than adequate.

All cruise data except for the /rvs path were stored on this storage area. Access was given to scientists to some of the folders via Samba shares.

All CTD, ADCP and LADCP data was backed up to these drives on acquisition.

PSTAR was used directly on data32 directory.

Level C data was logged to the discovery1 internal disk, Techsas backs its data to here under /rvs/pro_data/TECHSAS and also stores it on its own internal raided drive array.

Data Backups

Backups of the Level C data were done twice daily as a tar file to DLT tape and LTO tape. Alternating between the standard backup below and a full /rvs backup. The following paths were included in the tar file:

/rvs/raw_data

/rvs/pro_data

/rvs/def7/control

/rvs/users

In addition to the redundancy provided by the RAID 0 pair, daily backups of the /data32 directory were done by a tar of the file system to the LTO 2 tape. The whole disk was backed up not just current cruise data.

The LTO2 system was backed up on a daily basis in a rolling 2 tape system.

Data Archiving

The Data archive will be provided on 4 x 320GB USB Hard Drive.

1 x HDD to BODC, disk to be returned once data extracted.

2 x HDD to PSO

1 x HDD to NOCS held by NMFSS for 6 Months

Appendix 1 Surfmet Sensor Information

Ship	RRS Discovery
Cruise	D354
Technician	Chris Barnard
Date	10/08/10

Manufacturer	Sensor	Serial no	Comments	Calibration Expires
Seabird	SBE45	229	TSG	29/03/11
Seabird	SBE38	475	Remote Temperature	14/03/11
Wetlabs	fluorometer	117		24/05/11
Seatech	transmissometer	CST-112R		24/05/11
Vaisala	Barometer PTB100A	S3610008		15/04/11
Vaisala	Temp/humidity HMP45A	B4950010		05/04/11
SKYE	PAR SKE510	28557	PORT	11/02/11
SKYE	PAR SKE510	28556	STBD	11/02/11
Kipp and Zonen	TIR CMB6	047462	PORT	09/07/11
Kipp and Zonen	TIR CMB6	962301	STBD	19/02/11
Sensors without cal				
Seabird	P/N 90402 SBE45 JB	63	Junction Box	
Gill	Windsonic Option 3	071123		

Manufacturer	Sensor	Serial no	Comments	Calibration Expires
Seabird	SBE45	NO SPARE		
Seabird	SBE38	476,490	Remote Temperature	14/03/11, 17/11/10
Wetlabs	fluorometer	WS3S-246		24/05/11
Wetlabs	transmissometer	CST-113R		24/05/11
Vaisala	Barometer PTB100A	S3440012		
Vaisala	Temp/humidity HMP45A	NO SPARE		
SKYE	PAR SKE510	NO SPARE		
SKYE	PAR SKE510	NO SPARE		
Kipp and Zonen	TIR CMB6	NO SPARE		
Kipp and Zonen	TIR CMB6	NO SPARE		
Sensors without cal				
Seabird	P/N 90402 SBE45 JB	65	Junction Box	
Gill	Windsonic Option 3	071121		

Navigation, Ship's Attitude and Position –

Nick Rogan (University of Liverpool, UK) , Stuart Painter and Stephanie Henson (University of Southampton, National Oceanography Centre, UK)

The ship's best determined position was calculated from multiple navigation sources within the NMF process 'bestnav'. The primary data source is the ship's GPS Trimble 4000 system, which has been shown on previous cruises to provide positions accurate to ~1.0 m. Data were transferred daily from the NMF 'bestnav' file to the pstar absolute navigation file 'abnv3541' for use in pstar processing. GPS_4000 data ('gps_4000' datastream) were also transferred and processed daily.

The ship's gyro instrument is the most reliable direction indicator on the ship and provides essential information for correcting the ADCP velocities to Earth co-ordinates. The gyro data stream 'gyro' was processed as described below and a correction subsequently applied to individual ADCP profiles which is more accurate than correcting averaged ensembles. However, the gyro suffers from drift when the ship manoeuvres and therefore needs correcting with the ship's attitude (ashtech). Gyro data were transferred daily.

The Pstar execs used for processing navigation datastreams were:

navexec0: transferred the '*bestnav*' data stream to Pstar format. Ship's velocities were calculated from position and distance run calculated after appending to the master abnv3541 file.

gps4exec0: transferred the '*gps_4000*' data stream to Pstar format. Data with pdop (position dilution of position) outside the range 0-7 were removed. Gaps were interpolated before the file was appended to the master file gp435401 and distance run calculated. A 30 second average file gp435401.30sec was also created.

gyroexec0: transferred data from the '*gyro*' stream to Pstar format. Headings outside the range 0-360° were deleted and the file appended to the master gyr35401 file.

Ship's heading and attitude

The ship's attitude was measured every second by the 3D GPS Ashtech navigation system. Four antenna, two on the boat deck, two on the bridge top, measured the phase difference between incoming satellite signals from which the ship's heading, pitch and roll were determined. Ashtech data were read from the datastream '*gps_ash*' into Pstar and used to calibrate the gyro heading information as follows.

ashexec0: transferred data from the '*gps_ash*' data stream to Pstar binary file ash354nn, where nn is a daily processing number.

ashexec1: merged ashtech and gyro heading data and calculated the ashtech – gyro heading difference (a-ghdg). All values were set between -180 – 180°

ashexec2: edited the data outside the following ranges

heading 0 - 360

pitch -5 - 5

roll -7 - 7

attitude flag -0.5 - 0.5

measurement RMS error 0.00001 - 0.01

baseline RMS error 0.00001, 0.1

ashtech – gyro heading -7, 7

Heading differences greater than 1.0° from a 5 point running median were removed. Data were then averaged to 2 minute intervals and further edited to remove data cycles where

pitch -2 - 2

mrms, 0 - 0.004

a-ghdg, -10 - 10

Results were merged with the gyro file and ship's velocity calculated.

Following the executables there is a manual editing step to despike the data. The data in ***ash354##.ave*** are plotted using ***ash.pdf*** as the plot description file. The obvious spikes are removed and the file saved.

General Acoustic Doppler Current Profiler Operation

Nick Rogan (University of Liverpool, UK), Stephanie Henson and Stuart Painter (University of Southampton, National Oceanography Centre, UK)

RRS Discovery is equipped with two hull mounted Ocean Survey broadband ADCPs. The 150 kHz ADCP is mounted in the hull 1.75 m to port of the keel, 33 m aft of the bow at the waterline and at an approximate depth of 5.3 m. The 75 kHz ADCP is also mounted in the hull, but in a second well 4.15 m forward and 2.5 m to starboard of the 150 kHz well.

Below is a table detailing the network COM ports for the ADCP and navigation data streams on RRS Discovery can be found below.

COM PORT	Baud Rate	Data Stream
COM1	9600	ADCP
COM2	4800	NMEA1 ($GPGGA – Position) ($HEHDT – Gyro)
COM3	9600	NMEA2 ($GPPAT – Ashtech)

Known problems

A problem developed when the ADCP PCs refused to backup the data files from the local drive onto the ship's network. Chris Barnard tackled the issue and felt it best to reboot the system. Following this reboot, at 2000 hrs JDay 204, both the 75 and 150 KHz ADCP failed to recommence data acquisition. This issue came to light during processing the following morning and, as a consequence, data from JDay 204 2000hrs - JDay205 0800hrs are missing. The error message occurred sporadically on both machines following this first instance. It often related to days when the ship's network was undergoing extreme traffic and having problems of its own. For subsequent events however, Chris Barnard was able to resolve the issue without rebooting. The data acquisition during these later episodes was not affected; the only issue was the lack of a backup copy of the files during the periods for which communication with the ship's network were not possible. In addition to the above issues the problem with time reversals in the processed data was also spotted, though this did not immediately affect the processing of the data. It is likely that, as a result, some further processing will be required upon return to NOC.

150 kHz vessel mounted Acoustic Doppler Current Profiler

The 150 kHz vessel mounted acoustic doppler profiler was configured to sample with 96 bins of 4 m size with a blank beyond transmit of 4 m. Gyro heading and GPS Ashtech, location and time were automatically fed into the software which was configured to use the Gyro heading as its reference. Two configuration files were set up, one for water tracking, the other for bottom tracking in shallow water (<400 m). Two minute and ten minute averages were recorded using the software package VmDAS (v1.46) which was installed on the acquisition PC.

Sequentially numbered files were created whenever data logging was stopped and restarted (usually once a day). All data was transferred to the Unix directory /data32/d354/os150/raw for further processing as detailed below.

s150exec0: transferred data from the RDI binary format to Pstar. The data were split into two files; "gridded" depth dependent data were placed into "adp" files while "non-gridded" depth independent data were placed into "bot" files. Velocities were scaled to cm/s and amplitude by 0.42 to db. Nominal edits were made on all the velocity data to remove both bad data and to change the VmDAS defined absent data value to the Pstar absent value. The depth of the first bin was determined as follows:

Depth of 1st bin = transducer depth (5 m) + blank distance (4 m) + half bin size (2 m) = 11 m.

Output files: adp354###.raw & bot354###.raw

s150exec1: data edited according to status flags (flag of beam 1 used to indicate bad data). Velocity data replaced with absent data if variable "2+bmbad" was greater than 25% (% of pings where >1 beam was bad therefore no velocity computed). Time of ensemble moved to the end of the ensemble period (120 secs added with pcalib).

Output files: adp354### & bot354###

s150exec2: merged the ADCP data (both bottom track and water track files if present) with the ashtech minus gyro variable (a-ghdg) created by ashexec2. The ADCP velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables that occurs with this exec.

Output files: adp354###.true & bot354###.true

s150exec3: applied the misalignment angle, ø, and scaling factor, A, to both ADCP files. The ADCP data were edited to delete all velocities where the percent good variable was 25% or less. Again, variables were renamed and re-ordered to preserve the original raw data.

Output files: adp354###.cal & bot354###.cal

s150exec4: merged the ADCP data (both water track and bottom track files) with the absolute navigation file (abnv3541) created by navexec0. Ship's velocity was calculated from the 2 minute positions and applied to the ADCP velocities. The end product was the absolute velocity of the water.

Output files: adp354###.abs & bot354###.abs

Calibration for misalignment angle and scaling factor

Calibration of the OS150 was conducted during the run out from Avonmouth towards the continental shelf edge. The calculated calibration coefficients were:

ϕ (misalignment angle) = 1.5373^{o}

A (scaling factor) = 1.0007^{o}.

Summary table of OS150 kHz VM-ADCP datafiles

File No.	Data filename (Short Term Average)	Bottom	Comments
1	D354os150001_000000.STA	No	Not processed
2	D354os150002_000000.STA	Yes	
3	D354os150003_000000.STA	Yes	
4	D354os150004_000000.STA	Yes	
5	D354os150005_000000.STA	Yes	
6	D354os150006_000000.STA	No	
7	D354os150007_000000.STA	No	
8	D354os150008_000000.STA	No	

9	D354os150009_000000.STA	No	
10	D354os150010_000000.STA	No	
11	D354os150011_000000.STA	No	
12	D354os150012_000000.STA	No	
13	D354os150013_000000.STA	No	
14	D354os150014_000000.STA	No	
15	D354os150015_000000.STA	No	
16	D354os150016_000000.STA	No	
17	D354os150017_000000.STA	No	
18	D354os150018_000000.STA	No	
19	D354os150019_000000.STA	No	
20	D354os150020_000000.STA	No	
21	D354os150021_000000.STA	No	
22	D354os150022_000000.STA	No	
23	D354os150023_000000.STA	No	
24	D354os150024_000000.STA	No	
25	D354os150025_000000.STA	No	
26	D354os150026_000000.STA	No	
27	D354os150027_000000.STA	No	
28	D354os150028_000000.STA	No	
29	D354os150029_000000.STA	No	
30	D354os150030_000000.STA	No	
31	D354os150031_000000.STA	No	
32	D354os150032_000000.STA	No	
33	D354os150033_000000.STA	No	
34	D354os150034_000000.STA	No	
35	D354os150035_000000.STA	No	
36	D354os150036_000000.STA	No	
37	D354os150037_000000.STA	No	
38	D354os150038_000000.STA	No	
39	D354os150039_000000.STA	No	
40	D354os150040_000000.STA	No	
41	D354os150041_000000.STA	No	

OS150 – Config File (D354_BT_ON.ini)
[Version Info]
VmDasVersion=Version 1.46
Option Table Version=1
[Expert only options]
SaveOnlyChangedOptions=TRUE
TurnedOffBeam=0
PashrImuFlagUseNormalInterpretation=TRUE
[ADCP Port Setup]
AdcpComPortName=COM1
AdcpComBaudRate=9600
AdcpComParity=NOPARITY
AdcpComStopBits=1
AdcpComDataBits=8
ADCPSoftBreak=FALSE
TimeoutNoRespCmd=1000
TimeoutHaveCharCmd=100
TimeoutNoRespSlowCmd=10000

TimeoutHaveCharSlowCmd=10000
TimeoutNoRespBreak=3000
TimeoutHaveCharBreak=2000
TimeoutNoEns=0
[NMEA Port Setup]
NmeaNavComEnable=TRUE
NmeaNavComPortName=COM2
NmeaNavComBaudRate=4800
NmeaNavComParity=NOPARITY
NmeaNavComStopBits=1
NmeaNavComDataBits=8
NmeaRPHComEnable=TRUE
NmeaRPHComPortName=COM3
NmeaRPHComBaudRate=9600
NmeaRPHComParity=NOPARITY
NmeaRPHComStopBits=1
NmeaRPHComDataBits=8
Nmea3ComEnable=FALSE
Nmea3ComPortName=None
Nmea3ComBaudRate=4800
Nmea3ComParity=NOPARITY
Nmea3ComStopBits=1
Nmea3ComDataBits=8
Nmea Nav Ethernet Enable=FALSE
Nmea Nav IP Addy=0.0.0.0
Nmea Nav Ethernet Port=5678
Nmea Nav Ethernet Connection Type TCP-UDP=1
Nmea Nav Ethernet Service Type Server-Client=1
Nmea Nav Ethernet Broadcast flag=FALSE
Nmea RPH Ethernet Enable=FALSE
Nmea RPH IP Addy=0.0.0.0
Nmea RPH Ethernet Port=5679
Nmea RPH Ethernet Connection Type TCP-UDP=1
Nmea RPH Ethernet Service Type Server-Client=1
Nmea RPH Ethernet Broadcast flag=FALSE
Nmea3 Ethernet Enable=FALSE
Nmea3 IP Addy=0.0.0.0
Nmea3 Ethernet Port=5680
Nmea3 Ethernet Connection Type TCP-UDP=1
Nmea3 Ethernet Service Type Server-Client=1
Nmea3 Ethernet Broadcast flag=FALSE
[NMEA Comm window]
NoDataTimeout(ms)=5000
AutoOpen=TRUE
NumNmeaDisplayedOnErrRecovery=10
[Serial Port for Binary Ensemble Data Output]
BinaryEnsembleOutputComEnable=FALSE
BinaryEnsembleOutputComPortName=None
BinaryEnsembleOutputComBaudRate=9600
BinaryEnsembleOutputComParity=NOPARITY
BinaryEnsembleOutputComStopBits=1

BinaryEnsembleOutputComDataBits=8
BinaryEnsembleOutputDataType(0:none;1:enr;2:enx;3:sta;4:lta)=0
BinaryEnsembleOutputRefVelType(0:none;1:Bottom;2:Mean)=0
BinaryEnsembleOutputStartBin=1
BinaryEnsembleOutputEndBin=4
BinaryEnsembleOutputMeanStartBin=1
BinaryEnsembleOutputMeanEndBin=4
BinaryEnsembleOutputLeader(0:no;1:yes)=FALSE
BinaryEnsembleOutputBottomTrack(0:no;1:yes)=FALSE
BinaryEnsembleOutputNavigation(0:no;1:yes)=TRUE
BinaryEnsembleOutputVelocity(0:no;1:yes)=TRUE
BinaryEnsembleOutputIntensity(0:no;1:yes)=TRUE
BinaryEnsembleOutputCorrelation(0:no;1:yes)=TRUE
BinaryEnsembleOutputPercentGood(0:no;1:yes)=TRUE
BinaryEnsembleOutputStatus(0:no;1:yes)=TRUE
BinaryEnsembleOutputNetEnable=FALSE
BinaryEnsembleOutputIPPortNumber=5433
=0.0.0.0
BinaryEnsembleOutputConType=1
BinaryEnsembleOutputSvcType=1
BinaryEnsembleOutputBcast=FALSE
[Serial Port for ASCII Ensemble Data Output]
AsciiEnsembleOutputComEnable=FALSE
AsciiEnsembleOutputComPortName=None
AsciiEnsembleOutputComBaudRate=9600
AsciiEnsembleOutputComParity=NOPARITY
AsciiEnsembleOutputComStopBits=1
AsciiEnsembleOutputComDataBits=8
AsciiEnsembleOutputDataType(0:none;1:enr;2:enx;3:sta;4:lta)=0
AsciiEnsembleOutputRefVelType(0:none;1:Bottom;2:Mean)=0
AsciiEnsembleOutputStartBin=1
AsciiEnsembleOutputEndBin=4
AsciiEnsembleOutputStoreToDisk(0:no;1:yes)=FALSE
AsciiEnsembleOutMeanStartBin=1
AsciiEnsembleOutputMeanEndBin=4
AsciiEnsembleOutputLeader(0:no;1:yes)=TRUE
AsciiEnsembleOutputBottomTrack(0:no;1:yes)=TRUE
AsciiEnsembleOutputNavigation(0:no;1:yes)=TRUE
AsciiEnsembleOutputVelocity(0:no;1:yes)=TRUE
AsciiEnsembleOutputIntensity(0:no;1:yes)=TRUE
AsciiEnsembleOutputCorrelation(0:no,1:yes)=TRUE
AsciiEnsembleOutputPercentGood(0:no;1:yes)=TRUE
AsciiEnsembleOutputStatus(0:no;1:yes)=TRUE
BinaryEnsembleOutput Ascii NetEnable=FALSE
BinaryEnsembleOutput Ascii IPPortNumber=5433
BinaryEnsOutAscii IP=0.0.0.0
BinaryEnsembleOutput Ascii ConType=1
BinaryEnsembleOutputAscii SvcType=1
BinaryEnsembleOutputAscii Bcast=FALSE
[Serial Port for Speed Log Output]
SpeedLogComEnable=FALSE

Speed Log ComPortName=None
Speed Log ComBaudRate=9600
Speed Log ComParity=NOPARITY
Speed Log ComStopBits=1
Speed Log ComDataBits=8
SpeedLogDataSource=STA
SpeedLogWLSource=WP
SpeedLogWLStartBin=3
SpeedLogWLEndBin=5
BinarySpeedLog NetEnable=FALSE
BinarySpeedLog IPPortNumber=5434
BinarySpeedLog Ip Addy=0.0.0.0
BinarySpeedLog ConType=1
BinarySpeedLog SvcType=1
BinarySpeedLog Bcast=FALSE
[Fake Data Options]
AdcpSimInAirEnable=FALSE
AdcpFakeDataEnable=FALSE
AdcpFakeDataFilename=SimAdcp.enr
FakeDataTimeBetweenEnsembles=2
NMEAFakeDataEnable=FALSE
NMEAFakeDataFilename=SimNav.nmr
[File Name Components]
EnableDualRecordDir=FALSE
FileRecordPath=C:\RDI\Data\D354\
FileRecordBackupPath=Z:\d350\os150\raw\
DeploymentName=D354os150
DeploymentNumber=1
MaximumFileSize=100
[Bottom Track Data Screening Options]
BTAmpScreenEnable=FALSE
BTCorScreenEnable=FALSE
BTErrScreenEnable=FALSE
BTVertScreenEnable=FALSE
BTFishScreenEnable=FALSE
BTPctGoodScreenEnable=FALSE
BTAmplitudeThreshold=30
BTCorrelationThreshold=220
BTErrorVelThreshold=1000
BTVerticalVelThreshold=1000
BTFishThreshold=50
BTPctGoodThreshold=50
[Water Track Data Screening Options]
WTAmpScreenEnable=FALSE
WTCorScreenEnable=FALSE
WTErrScreenEnable=FALSE
WTVertScreenEnable=FALSE
WTFishScreenEnable=FALSE
WTPctGoodScreenEnable=FALSE
WTAmplitudeThreshold=30
WTCorrelationThreshold=180

WTErrorVelThreshold=1000
WTVerticalVelThreshold=1000
WTFishThreshold=50
WTPctGoodThreshold=50
[Profile Data Screening Options]
PRAmpScreenEnable=FALSE
PRCorScreenEnable=FALSE
PRErrScreenEnable=FALSE
PRVertScreenEnable=FALSE
PRFishScreenEnable=FALSE
PRPctGoodScreenEnable=FALSE
PRMarkBadBelowBottom=FALSE
PRAmplitudeThreshold=30
PRCorrelationThreshold=180
PRErrorVelThreshold=1000
PRVerticalVelThreshold=1000
PRFishThreshold=50
PRPctGoodThreshold=50
[2nd Band Profile Data Screening Options]
PRAmpScreenEnable=FALSE
PRCorScreenEnable=FALSE
PRErrScreenEnable=FALSE
PRVertScreenEnable=FALSE
PRFishScreenEnable=FALSE
PRPctGoodScreenEnable=FALSE
PRAmplitudeThreshold=30
PRCorrelationThreshold=180
PRErrorVelThreshold=1000
PRVerticalVelThreshold=1000
PRFishThreshold=50
PRPctGoodThreshold=50
[Transformation Options]
XformToEarth=TRUE
Allow3Beam=TRUE
BinMap=TRUE
BeamAngleSrc(0:auto,1:man)=0
ManualBeamAngle=30
HeadingSource(0:adcp,1:navHDT,2:navHDG,3:navPRDID,4:manual)=1
NMEAPortForHeadingSource=1
ManualHeading=0
TiltSource(0:adcp,1:nav,2:man)=2
NMEAPortForTiltSource=-1
ManualPitch=0
ManualRoll=0
SensorConfigSrc(0:PRfixed,1:Pfixed,2:auto)=2
ConcavitySource(0:convex,1:concave,2:auto)=2
UpDownSource(0:dn,1:up,2:auto)=2
EnableHeadingCorrections=FALSE
SinCorrectionAmplitudeCoefficient=0
SinCorrectionPhaseCoefficient=0
MagneticOffsetEV=0

BackupMagneticOffsetEV=0
AlignmentOffsetEA=0
EnableVelocityScaling=FALSE
VelocityScaleFactorForBTVelocities(unitless)=1
VelocityScaleFactorForProfileAndWTVelocities(unitless)=1
EnableTiltAlignmentErrorCorrection=TRUE
TiltAlignmentHeadingCorr(deg)=0
EAOptionSource=TRUE
TiltAlignmentPitchCorr(deg)=0
TiltAlignmentRollCorr(deg)=0
[2nd Band Transformation Options]
EnableVelocityScaling=FALSE
VelocityScaleFactorForProfileVelocities(unitless)=1
[Backup HPR NMEA Source Options]
EnableBackupHeadingSource=FALSE
BackupHeadingSource(0:adcp,1:navHDT,2:navHDG,3:navPRDID,4:manual,5:PASHR,6:PASHR,ATT,7:P
ASHR,AT2)=3
NMEAPortForBackupHeadingSource=2
BackupManualHeading=0
EnableBackupTiltSource=FALSE
BackupTiltSource(0:adcp,1:nav,2:man,3:PASHR,4:PASHR,ATT,5:PASHR,AT2)=0
NMEAPortForBackupTiltSource=-1
BackupManualPitch=0
BackupManualRoll=0
[Ship Pos Vel NMEA Source Options]
EnableGGASource=TRUE
NmeaPortForGGASource=1
EnableGGABackupSource=FALSE
NmeaPortForGGABackupSource=-1
EnableVTGSource=FALSE
NmeaPortForVTGSource=1
EnableTVGBackupSource=FALSE
NmeaPortForVTGBackupSource=-1
[Averaging Options]
AvgMethod(0:time,1:dist)=0
FirstAvgTime=120
SecondAvgTime=600
FirstAvgDistance=500
SecondAvgDistance=5000
EnableRefLayerAvg=FALSE
RefLayerStartBin=3
RefLayerEndBin=10
[Reference Velocity Options]
RefVelSelect(0:none,1:BT,2:WT,3:LYR,4:NDP,5:NAP,6:NSPD)=1
VelRefLayerStartBin=3
VelRefLayerEndBin=5
RefVelUnitVel(0:mm/s,1:m/s,2:knots,3:ft/s)=1
RefVelUnitDepth(0:m,1:cm,2:ft)=0
[User Exit Options]
UserWinAdcpEnable=FALSE
UserWinAdcpPath=C:\Program Files\RD Instruments\WinAdcp\WinAdcp.exe

UserWinAdcpUpdateInterval(sec)=10
UserWinAdcpFileType(0:enr,1:enx,2:sta,3:lta)=3
UserAdcpScreening=FALSE
UserNavScreening=FALSE
UserTransform=FALSE
[Shiptrack Options]
ShipTrack1Source(0:Nav;1:BT;2:WT;3:Layer)=0
ShipTrack2Source(0:Nav;1:BT;2:WT;3:Layer)=1
ShipTrack1RedStickEnable=TRUE
ShipTrack1GreenStickEnable=FALSE
ShipTrack1BlueStickEnable=FALSE
ShipTrack2RedStickEnable=TRUE
ShipTrack2GreenStickEnable=FALSE
ShipTrack2BlueStickEnable=FALSE
ShipTrack1RedBin=1
ShipTrack1GreenBin=2
ShipTrack1BlueBin=3
ShipTrack2RedBin=1
ShipTrack2GreenBin=2
ShipTrack2BlueBin=3
ShipTrack1DisplaySelect(0:Lat/Lon;1:Distance)=0
ShipTrack2DisplaySelect(0:Lat/Lon;1:Distance)=0
ShipTrack1WaterLayerStartBin=3
ShipTrack1WaterLayerEndBin=5
ShipTrack2WaterLayerStartBin=3
ShipTrack2WaterLayerEndBin=5
ShipTrackDistanceUnit=0
[Narrow Band Shiptrack Options]
RadioBtnSelForShipPosition1DataType=0
RadioBtnSelForShipPosition2DataType=0
ShipTrack1RedStickEnable=TRUE
ShipTrack1GreenStickEnable=FALSE
ShipTrack1BlueStickEnable=FALSE
ShipTrack2RedStickEnable=TRUE
ShipTrack2GreenStickEnable=FALSE
ShipTrack2BlueStickEnable=FALSE
ShipTrack1RedBin=1
ShipTrack1GreenBin=2
ShipTrack1BlueBin=3
ShipTrack2RedBin=1
ShipTrack2GreenBin=2
ShipTrack2BlueBin=3
[ADCP Setup Options]
SetProfileParameters=TRUE
NumberOfBins=96
BinSize(meters)=4
BlankDistance(meters)=4
TransducerDepth(meters)=5.3
SetBTEnable(0:SendBPCmd,1:Don'tSendBPCmd)=TRUE
ADCPSetupMethod(0:Options,1:CommandFile)=0
BtmTrkEnable(0:SendBP0,1:SendBP1)=1

MaxRange(meters)=400
SetHdgSensorType=FALSE
HdgSensorType(0:internal,1:external)=1
SetTiltSensorType=FALSE
TiltSensorType(0:internal,1:external)=1
SetProcessingMode=TRUE
BandwidthType(0:Wide,1:Narrow)=1
ADCPTimeBetweenEnsemblesSel=0
ADCPTimeBetweenEnsembles=0

75 kHz vessel mounted Acoustic Doppler Current Profiler

During D354 the OS75 was configured to sample over 100 bins of 8 m depth with both 2 minute and 10 minute averages. The acquisition PC was running RDI software VmDAS v1.46. Gyro heading and GPS Ashtech, location and time were automatically fed into the software which was configured to use the Gyro heading. For the majority of the cruise the instrument was operated in water tracking mode with the exception of cruise start and cruise end when the bottom was shallow enough (<800m) to provide calibration of the instrument.

Sequentially numbered files were created whenever data logging was stopped and restarted (usually once a day). All data were manually transferred to the Unix directory /data32/d354/os75/raw for further processing as it was noted that file sizes tended to differ when the data was automatically written to the Unix directory by VmDAS.

s75exec0: This exec reads data from RDI binary files into pstar equivalents. Water track velocities are written into 'sur…' files, bottom track velocities into 'bot…' files. Velocities scaled to cm/s and amplitude by 0.45 to dB. The time variable was corrected to GPS time by combining the PC clock time and the PC-GPS offset. The depth of each bin was determined from the user supplied information and calculated as:

Depth of 1st bin = transducer depth (5 m) + blank distance (8 m) + half bin size (4 m) = 17 m.

Output files: sur354##.raw and sbt354##.raw

s75exec1: data edited according to status flags beam 1 data. Velocity replaced with absent data if variable 2+bmbad was greater than 25% (this being a measure of the number of times more than 1 beam was bad).

Output files: sur354## and sbt354##

s75exec2: Merges the ADCP data with the ashtech a-ghdg created by ashexec2. The ADCP velocities are converted to speed and direction so that the heading correction could be applied and then returned to east and north components.

Output files: sur354##.true and sbt354##.true

s75exec3: Applies the misalignment angle (ϕ) and scaling factor (A) to both files (if both are present). Variables are renamed and reordered to preserve original data files.

Output files: sur354##.cal and sbt354##.cal

s75exec4: merges the ADCP data with the bestnav navigation file (abnv3541) created by navexec0. Ship's velocity was calculated from spot positions taken from the abnv3541 file and applied to the ADCP velocities. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 5 minute ensemble by subtracting 150 seconds and new positions were taken from abnv3541.

Output files: sur354##.abs and sbt354##.abs

Calibration for misalignment angle and scaling factor

Calibration of the OS75 was conducted during the run out from Avonmouth towards the continental shelf edge. The calculated calibration coefficients were:

ϕ (misalignment angle) = 2.7919^{o}

A (scaling factor) = 1.0015^{o}.

Summary table of OS75 kHz VM-ADCP datafiles

File No.	Data filename (Short Term Average)	Bottom	Comments
1	D354_OS75001_000000.STA	No	Not processed
2	D354_OS75002_000000.STA	Yes	
3	D354_OS75003_000000.STA	Yes	
4	D354_OS75004_000000.STA	Yes	
5	D354_OS75005_000000.STA	No	
6	D354_OS75006_000000.STA	No	
7	D354_OS75007_000000.STA	No	
8	D354_OS75008_000000.STA	No	
9	D354_OS75009_000000.STA	No	
10	D354_OS75010_000000.STA	No	
11	D354_OS75011_000000.STA	No	
12	D354_OS75012_000000.STA	No	
13	D354_OS75013_000000.STA	No	
14	D354_OS75014_000000.STA	No	
15	D354_OS75015_000000.STA	No	
16	D354_OS75016_000000.STA	No	
17	D354_OS75017_000000.STA	No	
18	D354_OS75018_000000.STA	No	
19	D354_OS75019_000000.STA	No	
20	D354_OS75020_000000.STA	No	
21	D354_OS75021_000000.STA	No	
22	D354_OS75022_000000.STA	No	
23	D354_OS75023_000000.STA	No	
24	D354_OS75024_000000.STA	No	
25	D354_OS75025_000000.STA	No	
26	D354_OS75026_000000.STA	No	
27	D354_OS75027_000000.STA	No	
28	D354_OS75028_000000.STA	No	

29	D354_OS75029_000000.STA	No	
30	D354_OS75030_000000.STA	No	
31	D354_OS75031_000000.STA	No	
32	D354_OS75032_000000.STA	No	
33	D354_OS75033_000000.STA	No	
34	D354_OS75034_000000.STA	No	
35	D354_OS75035_000000.STA	No	
36	D354_OS75036_000000.STA	No	
37	D354_OS75037_000000.STA	No	
38	D354os150038_000000.STA	No	
39	D354os150039_000000.STA	No	
40	D354os150040_000000.STA	No	

OS75 – Config File (D354_BT_ON.ini)
[Version Info]
VmDasVersion=Version 1.46
Option Table Version=1
[Expert only options]
SaveOnlyChangedOptions=TRUE
TurnedOffBeam=0
PashrImuFlagUseNormalInterpretation=TRUE
[ADCP Port Setup]
AdcpComPortName=COM1
AdcpComBaudRate=9600
AdcpComParity=NOPARITY
AdcpComStopBits=1
AdcpComDataBits=8
ADCPSoftBreak=FALSE
TimeoutNoRespCmd=1000
TimeoutHaveCharCmd=100
TimeoutNoRespSlowCmd=10000
TimeoutHaveCharSlowCmd=10000
TimeoutNoRespBreak=3000
TimeoutHaveCharBreak=2000
TimeoutNoEns=0
[NMEA Port Setup]
NmeaNavComEnable=TRUE
NmeaNavComPortName=COM2
NmeaNavComBaudRate=4800
NmeaNavComParity=NOPARITY
NmeaNavComStopBits=1
NmeaNavComDataBits=8
NmeaRPHComEnable=TRUE
NmeaRPHComPortName=COM3
NmeaRPHComBaudRate=9600
NmeaRPHComParity=NOPARITY
NmeaRPHComStopBits=1
NmeaRPHComDataBits=8
Nmea3ComEnable=FALSE
Nmea3ComPortName=None
Nmea3ComBaudRate=4800

Nmea3ComParity=NOPARITY
Nmea3ComStopBits=1
Nmea3ComDataBits=8
Nmea Nav Ethernet Enable=FALSE
Nmea Nav IP Addy=0.0.0.0
Nmea Nav Ethernet Port=5678
Nmea Nav Ethernet Connection Type TCP-UDP=1
Nmea Nav Ethernet Service Type Server-Client=1
Nmea Nav Ethernet Broadcast flag=FALSE
Nmea RPH Ethernet Enable=FALSE
Nmea RPH IP Addy=0.0.0.0
Nmea RPH Ethernet Port=5679
Nmea RPH Ethernet Connection Type TCP-UDP=1
Nmea RPH Ethernet Service Type Server-Client=1
Nmea RPH Ethernet Broadcast flag=FALSE
Nmea3 Ethernet Enable=FALSE
Nmea3 IP Addy=0.0.0.0
Nmea3 Ethernet Port=5680
Nmea3 Ethernet Connection Type TCP-UDP=1
Nmea3 Ethernet Service Type Server-Client=1
Nmea3 Ethernet Broadcast flag=FALSE
[NMEA Comm window]
NoDataTimeout(ms)=5000
AutoOpen=TRUE
NumNmeaDisplayedOnErrRecovery=10
[Serial Port for Binary Ensemble Data Output]
BinaryEnsembleOutputComEnable=FALSE
BinaryEnsembleOutputComPortName=None
BinaryEnsembleOutputComBaudRate=9600
BinaryEnsembleOutputComParity=NOPARITY
BinaryEnsembleOutputComStopBits=1
BinaryEnsembleOutputComDataBits=8
BinaryEnsembleOutputDataType(0:none;1:enr;2:enx;3:sta;4:lta)=0
BinaryEnsembleOutputRefVelType(0:none;1:Bottom;2:Mean)=0
BinaryEnsembleOutputStartBin=1
BinaryEnsembleOutputEndBin=4
BinaryEnsembleOutputMeanStartBin=1
BinaryEnsembleOutputMeanEndBin=4
BinaryEnsembleOutputLeader(0:no;1:yes)=FALSE
BinaryEnsembleOutputBottomTrack(0:no;1:yes)=FALSE
BinaryEnsembleOutputNavigation(0:no;1:yes)=TRUE
BinaryEnsembleOutputVelocity(0:no;1:yes)=TRUE
BinaryEnsembleOutputIntensity(0:no;1:yes)=TRUE
BinaryEnsembleOutputCorrelation(0:no;1:yes)=TRUE
BinaryEnsembleOutputPercentGood(0:no;1:yes)=TRUE
BinaryEnsembleOutputStatus(0:no;1:yes)=TRUE
BinaryEnsembleOutputNetEnable=FALSE
BinaryEnsembleOutputIPPortNumber=5433
=0.0.0.0
BinaryEnsembleOutputConType=1
BinaryEnsembleOutputSvcType=1

BinaryEnsembleOutputBcast=FALSE
[Serial Port for ASCII Ensemble Data Output]
AsciiEnsembleOutputComEnable=FALSE
AsciiEnsembleOutputComPortName=None
AsciiEnsembleOutputComBaudRate=9600
AsciiEnsembleOutputComParity=NOPARITY
AsciiEnsembleOutputComStopBits=1
AsciiEnsembleOutputComDataBits=8
AsciiEnsembleOutputDataType(0:none;1:enr;2:enx;3:sta;4:lta)=0
AsciiEnsembleOutputRefVelType(0:none;1:Bottom;2:Mean)=0
AsciiEnsembleOutputStartBin=1
AsciiEnsembleOutputEndBin=4
AsciiEnsembleOutputStoreToDisk(0:no;1:yes)=FALSE
AsciiEnsembleOutMeanStartBin=1
AsciiEnsembleOutputMeanEndBin=4
AsciiEnsembleOutputLeader(0:no;1:yes)=TRUE
AsciiEnsembleOutputBottomTrack(0:no;1:yes)=TRUE
AsciiEnsembleOutputNavigation(0:no;1:yes)=TRUE
AsciiEnsembleOutputVelocity(0:no;1:yes)=TRUE
AsciiEnsembleOutputIntensity(0:no;1:yes)=TRUE
AsciiEnsembleOutputCorrelation(0:no,1:yes)=TRUE
AsciiEnsembleOutputPercentGood(0:no;1:yes)=TRUE
AsciiEnsembleOutputStatus(0:no;1:yes)=TRUE
BinaryEnsembleOutput Ascii NetEnable=FALSE
BinaryEnsembleOutput Ascii IPPortNumber=5433
BinaryEnsOutAscii IP=0.0.0.0
BinaryEnsembleOutput Ascii ConType=1
BinaryEnsembleOutputAscii SvcType=1
BinaryEnsembleOutputAscii Bcast=FALSE
[Serial Port for Speed Log Output]
SpeedLogComEnable=FALSE
Speed Log ComPortName=None
Speed Log ComBaudRate=9600
Speed Log ComParity=NOPARITY
Speed Log ComStopBits=1
Speed Log ComDataBits=8
SpeedLogDataSource=STA
SpeedLogWLSource=WP
SpeedLogWLStartBin=3
SpeedLogWLEndBin=5
BinarySpeedLog NetEnable=FALSE
BinarySpeedLog IPPortNumber=5434
BinarySpeedLog Ip Addy=0.0.0.0
BinarySpeedLog ConType=1
BinarySpeedLog SvcType=1
BinarySpeedLog Bcast=FALSE
[Fake Data Options]
AdcpSimInAirEnable=FALSE
AdcpFakeDataEnable=FALSE
AdcpFakeDataFilename=SimAdcp.enr
FakeDataTimeBetweenEnsembles=2

NMEAFakeDataEnable=FALSE
NMEAFakeDataFilename=SimNav.nmr
[File Name Components]
EnableDualRecordDir=FALSE
FileRecordPath=C:\RDI\ADCP\D354_OS75\
FileRecordBackupPath=Z:\d350\os75\raw\
DeploymentName=D354_OS75
DeploymentNumber=1
MaximumFileSize=100
[Bottom Track Data Screening Options]
BTAmpScreenEnable=FALSE
BTCorScreenEnable=FALSE
BTErrScreenEnable=FALSE
BTVertScreenEnable=FALSE
BTFishScreenEnable=FALSE
BTPctGoodScreenEnable=FALSE
BTAmplitudeThreshold=30
BTCorrelationThreshold=220
BTErrorVelThreshold=1000
BTVerticalVelThreshold=1000
BTFishThreshold=50
BTPctGoodThreshold=50
[Water Track Data Screening Options]
WTAmpScreenEnable=FALSE
WTCorScreenEnable=FALSE
WTErrScreenEnable=FALSE
WTVertScreenEnable=FALSE
WTFishScreenEnable=FALSE
WTPctGoodScreenEnable=FALSE
WTAmplitudeThreshold=30
WTCorrelationThreshold=180
WTErrorVelThreshold=1000
WTVerticalVelThreshold=1000
WTFishThreshold=50
WTPctGoodThreshold=50
[Profile Data Screening Options]
PRAmpScreenEnable=FALSE
PRCorScreenEnable=FALSE
PRErrScreenEnable=FALSE
PRVertScreenEnable=FALSE
PRFishScreenEnable=FALSE
PRPctGoodScreenEnable=FALSE
PRMarkBadBelowBottom=FALSE
PRAmplitudeThreshold=30
PRCorrelationThreshold=180
PRErrorVelThreshold=1000
PRVerticalVelThreshold=1000
PRFishThreshold=50
PRPctGoodThreshold=50
[2nd Band Profile Data Screening Options]
PRAmpScreenEnable=FALSE

PRCorScreenEnable=FALSE
PRErrScreenEnable=FALSE
PRVertScreenEnable=FALSE
PRFishScreenEnable=FALSE
PRPctGoodScreenEnable=FALSE
PRAmplitudeThreshold=30
PRCorrelationThreshold=180
PRErrorVelThreshold=1000
PRVerticalVelThreshold=1000
PRFishThreshold=50
PRPctGoodThreshold=50
[Transformation Options]
XformToEarth=TRUE
Allow3Beam=TRUE
BinMap=TRUE
BeamAngleSrc(0:auto,1:man)=0
ManualBeamAngle=30
HeadingSource(0:adcp,1:navHDT,2:navHDG,3:navPRDID,4:manual)=1
NMEAPortForHeadingSource=1
ManualHeading=0
TiltSource(0:adcp,1:nav,2:man)=2
NMEAPortForTiltSource=-1
ManualPitch=0
ManualRoll=0
SensorConfigSrc(0:PRfixed,1:Pfixed,2:auto)=2
ConcavitySource(0:convex,1:concave,2:auto)=2
UpDownSource(0:dn,1:up,2:auto)=2
EnableHeadingCorrections=FALSE
SinCorrectionAmplitudeCoefficient=0
SinCorrectionPhaseCoefficient=0
MagneticOffsetEV=0
BackupMagneticOffsetEV=0
AlignmentOffsetEA=0
EnableVelocityScaling=FALSE
VelocityScaleFactorForBTVelocities(unitless)=1
VelocityScaleFactorForProfileAndWTVelocities(unitless)=1
EnableTiltAlignmentErrorCorrection=TRUE
TiltAlignmentHeadingCorr(deg)=0
EAOptionSource=TRUE
TiltAlignmentPitchCorr(deg)=0
TiltAlignmentRollCorr(deg)=0
[2nd Band Transformation Options]
EnableVelocityScaling=FALSE
VelocityScaleFactorForProfileVelocities(unitless)=1
[Backup HPR NMEA Source Options]
EnableBackupHeadingSource=FALSE
BackupHeadingSource(0:adcp,1:navHDT,2:navHDG,3:navPRDID,4:manual,5:PASHR,6:PASHR,ATT,7:PASHR,AT2)=3
NMEAPortForBackupHeadingSource=2
BackupManualHeading=0
EnableBackupTiltSource=FALSE

BackupTiltSource(0:adcp,1:nav,2:man,3:PASHR,4:PASHR,ATT,5:PASHR,AT2)=0
NMEAPortForBackupTiltSource=-1
BackupManualPitch=0
BackupManualRoll=0
[Ship Pos Vel NMEA Source Options]
EnableGGASource=TRUE
NmeaPortForGGASource=1
EnableGGABackupSource=FALSE
NmeaPortForGGABackupSource=-1
EnableVTGSource=FALSE
NmeaPortForVTGSource=1
EnableTVGBackupSource=FALSE
NmeaPortForVTGBackupSource=-1
[Averaging Options]
AvgMethod(0:time,1:dist)=0
FirstAvgTime=120
SecondAvgTime=600
FirstAvgDistance=500
SecondAvgDistance=5000
EnableRefLayerAvg=FALSE
RefLayerStartBin=3
RefLayerEndBin=10
[Reference Velocity Options]
RefVelSelect(0:none,1:BT,2:WT,3:LYR,4:NDP,5:NAP,6:NSPD)=1
VelRefLayerStartBin=3
VelRefLayerEndBin=5
RefVelUnitVel(0:mm/s,1:m/s,2:knots,3:ft/s)=1
RefVelUnitDepth(0:m,1:cm,2:ft)=0
[User Exit Options]
UserWinAdcpEnable=FALSE
UserWinAdcpPath=C:\Program Files\RD Instruments\WinAdcp\WinAdcp.exe
UserWinAdcpUpdateInterval(sec)=10
UserWinAdcpFileType(0:enr,1:enx,2:sta,3:lta)=3
UserAdcpScreening=FALSE
UserNavScreening=FALSE
UserTransform=FALSE
[Shiptrack Options]
ShipTrack1Source(0:Nav;1:BT;2:WT;3:Layer)=0
ShipTrack2Source(0:Nav;1:BT;2:WT;3:Layer)=1
ShipTrack1RedStickEnable=TRUE
ShipTrack1GreenStickEnable=FALSE
ShipTrack1BlueStickEnable=FALSE
ShipTrack2RedStickEnable=TRUE
ShipTrack2GreenStickEnable=FALSE
ShipTrack2BlueStickEnable=FALSE
ShipTrack1RedBin=1
ShipTrack1GreenBin=2
ShipTrack1BlueBin=3
ShipTrack2RedBin=1
ShipTrack2GreenBin=2
ShipTrack2BlueBin=3

ShipTrack1DisplaySelect(0:Lat/Lon;1:Distance)=0
ShipTrack2DisplaySelect(0:Lat/Lon;1:Distance)=0
ShipTrack1WaterLayerStartBin=3
ShipTrack1WaterLayerEndBin=5
ShipTrack2WaterLayerStartBin=3
ShipTrack2WaterLayerEndBin=5
ShipTrackDistanceUnit=0
[Narrow Band Shiptrack Options]
RadioBtnSelForShipPosition1DataType=0
RadioBtnSelForShipPosition2DataType=0
ShipTrack1RedStickEnable=TRUE
ShipTrack1GreenStickEnable=FALSE
ShipTrack1BlueStickEnable=FALSE
ShipTrack2RedStickEnable=TRUE
ShipTrack2GreenStickEnable=FALSE
ShipTrack2BlueStickEnable=FALSE
ShipTrack1RedBin=1
ShipTrack1GreenBin=2
ShipTrack1BlueBin=3
ShipTrack2RedBin=1
ShipTrack2GreenBin=2
ShipTrack2BlueBin=3
[ADCP Setup Options]
SetProfileParameters=TRUE
NumberOfBins=100
BinSize(meters)=8
BlankDistance(meters)=8
TransducerDepth(meters)=5.3
SetBTEnable(0:SendBPCmd,1:Don'tSendBPCmd)=TRUE
ADCPSetupMethod(0:Options,1:CommandFile)=0
BtmTrkEnable(0:SendBP0,1:SendBP1)=1
MaxRange(meters)=800
SetHdgSensorType=FALSE
HdgSensorType(0:internal,1:external)=1
SetTiltSensorType=FALSE
TiltSensorType(0:internal,1:external)=1
SetProcessingMode=TRUE
BandwidthType(0:Wide,1:Narrow)=1
ADCPTimeBetweenEnsemblesSel=0
ADCPTimeBetweenEnsembles=0

Vertical turbulence profiler

Stephanie Henson, Stuart Painter (University of Southampton, National Oceanography Centre, UK), Nick Rogan (University of Liverpool, UK)

The turbulence profiler was deployed at 23 stations during D354, usually between the dawn stainless CTD cast and the titanium CTD cast. At most of these stations, 10 profiles were completed. Profiles were done to depths of 200 m, 150 m or 120 m. During the cruise, we chose shallower maximum depths a) to save time, and b) as it became clear there was little change in profiles below the mixed layer, which was of the order 20-40 m deep.

Turbulence profiler stations:

Turbulence station number	Cruise station number	Date	Position	Number of profiles	Depth	Comments
1	4	13/07/2010	61 48.7N	5	200 m	Sinking speed test
2	5	14/07/2010	60 00.7N	10	200 m	Shear sensor 1
3	6	15/07/2010	59 59.2N	10	150 m	Shear sensor 1
4	7	16/07/2010	60 00.7N	10	150 m	Shear 1 replaced,
5	8	17/07/2010	60 00.4N	10	150 m	Both shear sensors
6	10	19/07/2010	59 57.6N	10	150 m	
7	14	19/07/2010	59 59.5N	10	150 m	The night of the X4
8	16	22/07/2010	62 59.5N	10	150 m	
9	17	23/07/2010	63 00.2N	10	150 m	
10	18	24/07/2010	62 59.8N	10	150 m	
11	19	25/07/2010	60 52.2N	8	120 m	Short on time
12	20	26/07/2010	58 14.1N	10	120 m	
13	22	30/07/2010	63 49.0N	10	120 m	
14	23	31/07/2010	63 49.8N	10	120 m	
15	24	01/08/2010	62 29.3N	10	120 m	
16	25	02/08/2010	63 25.7N	4	120 m	Power failure,
17	27	03/08/2010	62 06.8N	10	120 m	
18	28	04/08/2010	61 15.3N	10	120 m	
19	29	05/08/2010	61 50.4N	10	120 m	Intermittent
20	30	05/08/2010	61 54.4N	10	120 m	Lost comms with
21	31	05/08/2010	61 58.9N	10	120 m	
22	32	06/08/2010	62 07.4N	10	120 m	
23	33	07/08/2010	60 19.4N	10	120 m	

Maintenance of the profiler:

Deploying, operating and recovering the profiler was straightforward, when it was working. A common (but minor) issue was that the cable didn't wind evenly onto the drum (when raising the profiler) or would get tangled when lowering the profiler. The only way to avoid this was by keeping a close eye on the cable during deployments (and not get distracted by the wildlife). Additionally, a litany of more serious faults plagued the instrument throughout the cruise.

Some of these issues were a direct result of the entire winch, motor and deck box getting immersed during the force 10 storm we encountered in the first days of the cruise. The base plate was severely bent, but easily banged back into shape. The motor, deck box and winch were dismantled, dried out and loose wiring fixed. The brake was also readjusted as it was dragging. During the storm the connector on the deck data cable was ripped off and was replaced with the connector from the extension cable.

During station 3, shear sensor 1 began reading all zeros. The sensor was replaced after the station, tested on deck and found to be working. However, at the next station the sensor again began reading zeros part way through the first profile. A poorly soldered board inside the profiler was found to be the problem and after re-working it, both shear sensors operated well during the rest of the cruise.

Intermittent issues with the power supply to the winch over the course of several days were traced to multiple problems. Badly insulated wiring in the deck box resulted in intermittent short circuits, causing complete power failure. The sheathing on the power cable between the deck box and the motor was found to be frayed, exposing bare wires. Boxes stowed on the aft deck were found to be crushing the wires. And finally, the data cable connected to the winch was also found to be poorly insulated resulting in data loss. Several of these problems with the profiler were found to be due to water (rain or waves) getting in to the 'watertight' connectors.

Notes on what to do before processing data for the first time:

Check the serial number of the shear probes installed on the profiler. Look at the latest version of the convert+shear.msb batch script (at time of writing, 15/07/10, latest version is convert+shear D354.msb). Check modul07 and modul08 to make sure the serial numbers of the shear sensors in the script matches those installed on the profiler. If the serial numbers are different (or if one of the shear sensors breaks and you have to replace it), look up the sensitivity on the relevant shear probe calibration sheet in the yellow manual folder. Enter this value in the 'sensitivity' column of the spreadsheet MSSproCalib.xls. Coefficients A0 and A1 will be calculated. These need to be entered in the convert+shear.msb script in modul07 and modul08 as 'value07_05' and 'value08_05' (and remember to save the script with a different filename).

You should also update the header information in the SDA software to note the serial numbers of shear sensors 1 and 2.

Shear sensors used during D354:

Stations 1-3

SHE1: 6091

SHE2: 6090

Shear sensor 6091 failed during station 3 (reading all zeros). Replaced 15/07/2010.

Stations 4-23

SHE1: 6086

SHE2: 6090

On-deck testing suggested new shear sensor 1 (6086) was working fine, however during the first deployment with the new sensor (at station 4), shear 1 was reading all zeros again. After re-soldering the affected parts, shear sensor 1 (6086) worked well (from station 5 onwards).

Data processing during D354:

The basic processing steps used on D354 were as follows:

Run *convert+shear D354.mbs* on tubulence laptop **input: raw/dipX_X.mrd; output: convert+shear/csdipX_X.tob**
Copy files to Unix (/data32/turbulence)
Run *AF_cleanTob.awk* on Unix station **input: convert+shear/csdipX_X.tob; output cut_files/dipX_Xcut.tob**
Copy back to turbulence laptop
Check spectrum (optional) **using cut_file and Panchev-Kesich spectrum**
Run *epsilon+thorpe-new.msb* on turbulence laptop **input: cut_files/dipX_Xcut.tob; output: eps_thorpe/etdipX_X.tob**
Run *eddy.msb* on turbulence laptop **input: eps_thorpe/etdipX_X.tob; output: diffuse/dfdipX_X.tob**
Check profiles (optional) **Use *epsilonADR01.dgi* config to view etdipX_X.tob data** **Use *eddyADR01.dgi* config to view dfdipX_X.tob data**
Copy all data to Unix (/data32/turbulence)

Processing the data was *very* slow. As the MSSpro software seems to be installable on any Windows PC, we suggest a different (newer, faster) laptop is used next time. The laptop frequently ran out of virtual memory during processing, and also ran out of hard drive disk space causing the software to crash with mysterious messages. As all the data was backed up to the network after processing, files were deleted from the hard drive on a rolling basis.

The original processing notes we used (from D321) recommended using the in-built *cutgraf* function in MSSpro to trim the files. However, we found that the laptop couldn't handle loading the files and/or interactively editing them. Instead we used an awk script, *AF_cleanTob.awk*, supplied by Alex Forryan. This entailed the additional tedious step of transferring the data from the turbulence laptop, to the Unix system, running the awk script, and then copying the resulting files back to the turbulence laptop again for the remaining processing steps. A more powerful laptop may also get around this problem and allow interactive editing of the data.

For stations 1-3, script convert+shear D354_1.mbs was used (shear sensors 6091 and 6090). For stations 4 and onwards, script convert+shear D354_2.mbs was used (shear sensors 6086 and 6090). Additionally, for stations 3 and 4 (when shear sensor 1 was faulty and reading zero), alternative scripts for calculating the epsilon+Thorpe and eddy diffusivity parameters were required. These scripts used only the data from shear sensor 2. Default scripts are epsilon+thorpe-new.msb and eddy.msb; alternative scripts for stations 3 and 4 are epsilon+thorpe-D354_she2.msb and eddy-D354_she2.msb.

CTD CRUISE REPORT D354

CTD DATA AQUISITION AND PROCESSING

Stuart Painter, , Stephanie Henson (University of Southampton, National Oceanography Centre, UK), Nick Rogan (University of Liverpool, UK), Jeff Benson, Chris Barnard, Dougal Mountifield (National Marine Facilities, National Oceanography Centre, Southampton, UK)

SummaryIn total 70 CTD casts were performed during D354 consisting of 38 stainless and 32 titanium framed casts. No major problems were experienced with instrumentation on either frame but indications of an 0.02 offset in the secondary conductivity sensor on the stainless frame were verified by the subsequent bottle salinity analyses. Initial calibrations for conductivity and oxygen were obtained during the cruise.

Station List

Stn No.	CTD No.	Cruise Identifier	Date (ddmmyy)	jday	time	Lat (N)	Lon (W)	Cast types
1	1	CTD001S	10.07.10	191	17:17	58 14.53	14 32.17	StS
1	2	CTD001T	10.07.10	191	18:35	58 14.24	14 31.16	TiT
2	3	CTD002S	11.07.10	192	16:12	60 00.18	19 59.59	StS
2	4	CTD002T	11.07.10	192	17:35	60 00.67	19 58.69	TiT
2	5	CTD003T	11.07.10	192	23.50	60 00.02	19 59.84	TiT
3	6	CTD003S	12.07.10	193	05.34	60 00.98	19 57.11	StS
3	7	CTD004T	12.07.10	193	08.36	60 02.05	19 56.29	TiT
4	8	CTD004S	13.07.10	194	04.39	61 49.11	21 00.94	StS
4	9	CTD005T	13.07.10	194	06.54	61 48.59	21 03.11	TiT
4	10	CTD005S	13.07.10	194	12.48	61 47.43	21 04.84	StS
5	11	CTD006S	14.07.10	195	04.08	60 00.35	19 59.06	StS
5	12	CTD006T	14.07.10	195	07.39	60 02.36	19 54.96	TiT
6	13	CTD007S	15.07.10	196	04.53	59 59.22	23 37.52	StS
6	14	CTD007T	15.07.10	196	08.52	60 00.11	23 37.87	TiT
6	15	CTD008S	15.07.10	196	13.04	59 59.00	23 37.25	StS
7	16	CTD009S	16.07.10	197	04.39	60 00.67	28 08.35	StS
7	17	CTD008T	16.07.10	197	08.01	60 00.76	28 04.84	TiT
8	18	CTD010S	17.07.10	198	18.52	60 00.25	34 59.46	StS
9	19	CTD011S	18.07.10	199	04.18	60 00.05	34 59.99	StS
9	20	CTD009T	18.07.10	199	06.32	60 00.35	34 58.93	TiT
10	21	CTD012S	19.07.10	200	04.42	59 58.57	41 21.36	StS
10	22	CTD010T	19.07.10	200	08.17	59 56.23	41 27.74	TiT
10	23	CTD013S	19.07.10	200	12.27	59 54.46	41 25.10	StS
11	24	CTD011T	19.07.10	200	14.47	59 59.43	41 35.19	TiT
12	25	CTD012T	19.07.10	200	18.03	59 59.67	41 59.60	TiT
13	26	CTD013T	19.07.10	200	20.08	59 59.82	42 12.78	TiT
14	27	CTD014S	19.07.10	200	23.04	59 59.82	42 40.42	StS
14	28	CTD014T	20.07.10	201	01.23	59 59.63	42 40.07	TiT
15	29	CTD015S	21.07.10	202	00:32	59 59.53	34 59.31	StS

15	30	CTD016S	21.07.10	202	07.39	59 58.04	34 56.74	StS
16	31	CTD017S	22.07.10	203	06.43	62 59.62	35 00.02	StS
16	32	CTD015T	22.07.10	203	10.54	62 59.95	34 59.20	TiT
16	33	CTD018S	22.07.10	203	15.43	62 59.98	34 59.89	StS
17	34	CTD019S	23.07.10	204	04.21	63 00.10	34 59.89	StS
17	35	CTD016T	23.07.10	204	07.01	63 00.48	34 58.15	TiT
18	36	CTD020S	24.07.10	205	04.44	62 59.92	29 58.73	StS
18	37	CTD017T	24.07.10	205	08.15	62 58.99	29 53.47	TiT
18	38	CTD021S	24.07.10	205	12.39	62 59.48	29 49.12	StS
19	39	CTD022S	25.07.10	206	04.25	60 52.40	31 31.99	StS
19	40	CTD018T	25.07.10	206	06.28	60 51.38	31 35.05	TiT
20	41	CTD023S	26.07.10	207	09.45	58 14.69	34 58.15	StS
20	42	CTD019T	26.07.10	207	13.43	58 13.13	35 02.92	TiT
20	43	CTD024S	26.07.10	207	18.17	58 13.11	35 07.36	StS
21	44	CTD025S	27.07.10	208	04.38	58 08.14	34 58.80	StS
21	45	CTD020T	27.07.10	208	07.12	58 08.39	35 02.28	TiT
22	46	CTD026S	30.07.10	211	05.17	63 49.37	35 02.23	StS
22	47	CTD021T	30.07.10	211	10.39	63 49.46	35 05.51	TiT
22	48	CTD027S	30.07.10	211	14.13	63 49.88	35 00.70	StS
23	49	CTD028S	31.07.10	212	04.17	63 49.32	35 05.42	StS
23	50	CTD022T	31.07.10	212	07.04	63 49.92	35 00.34	TiT
24	51	CTD029S	01.08.10	213	04.33	62 28.85	28 21.34	StS
24	52	CTD023T	01.08.10	213	07.33	62 28.45	28 21.67	TiT
25	53	CTD030S	02.08.10	214	16.55	63 25.96	23 35.66	StS
25	54	CTD024T	02.08.10	214	18.39	63 24.73	23 35.99	TiT
26	55	CTD025T	02.08.10	214	21.08	63 09.67	23 47.57	TiT
27	56	CTD031S	03.08.10	215	06.44	62 08.44	24 20.95	StS
27	57	CTD026T	03.08.10	215	10.36	62 06.70	24 18.29	TiT
27	58	CTD032S	03.08.10	215	15.55	62 05.84	24 20.17	StS
28	59	CTD033S	04.08.10	216	05.15	61 15.40	20 42.91	StS
28	60	CTD027T	04.08.10	216	08.47	61 15.19	20 45.82	TiT
28	61	CTD034S	04.08.10	216	13.15	61 13.58	20 47.12	StS
29	62	CTD035S	05.08.10	217	06.16	61 50.36	25 40.36	StS
29	63	CTD028T	05.08.10	217	09.09	61 50.78	25 43.36	TiT
30	64	CTD029T	05.08.10	217	13.13	61 55.18	26 16.84	TiT
31	65	CTD036S	05.08.10	217	15.41	61 58.61	26 41.98	StS
31	66	CTD030T	05.08.10	217	18.11	61 59.05	26 38.68	TiT
32	67	CTD031T	05.08.10	217	23.51	62 07.27	27 15.70	TiT
33	68	CTD037S	07.08.10	219	04.19	60 20.98	20 56.27	StS
33	69	CTD032T	07.08.10	219	09.33	60 18.94	20 58.77	TiT
33	70	CTD038S	07.08.10	219	13.24	60 18.19	20 58.67	StS

N.B Grey shaded regions denote cruise stations.

Data Processing

Data Processing using the SeaBird Software on the data-logging PC

Following each cast the logging was stopped and the data saved to the deck unit PC. The logging software outputs four files per CTD cast in the form CTDSnnn or CTDTnnn with the following extensions: .dat (raw data file), .con (data configuration file), .btl (record of bottle firing locations), and .hdr (a header file). The identifiers T and S were used to

denote the titanium or stainless steel CTD rosette and nnn the cast number.These files were manually backed up onto the UNIX network, via ftp to the file location /data32/d354/ctd/StS/raw or /data32/d354/ctd/TiT/raw. The raw data files were then processed using SeaBird's own CTD data processing software, SBEDataProcessing-Win32: v.7.2a. SeaBird CTD processing routines were used as follows. ***DatCnv***: The Data Conversion routine, DatCnv, read in the the raw CTD data file (e.g. D354CTDnnnS.dat). This contained the raw CTD data in engineering units output by the SeaBird hardware on the CTD rosette. DatCnv requires a configuration file that defines the calibrated CTD data output so that it is in the correct form to be read into the Pstar format on the UNIX system. The output file (D354CTDnnnS.cnv) format was set to binary and to include both up and down casts. A second output file (CTDSnnn.ros) contained bottle firing information, taking the output data at the instant of bottle firing. ***AlignCTD***: This program read in D354CTDnnnS.cnv and was set to shift the oxygen sensor relative to the pressure data by 5 seconds compensating for lags in the sensor response time. The output was written over the input file.***WildEdit***: A de-spiking routine, the input and output files again were D354CTDnnnS.cnv. The data was scanned twice calculating the standard deviation of a set number of scans, setting values that are outside a set number of standard deviations (sd) of the mean to bad data values. On this cruise, the scan range was set to 500, with 2 sd's on the first pass and 10 sd's on the second.

CellTM: The effect of thermal 'inertia' on the conductivity cells was removed using the routine CellTM. It should be noted that this routine must only be run after Wildedit or any other editing of bad data values. This routine uses the temperature variable to adjust the conductivity values and if spikes exist in the former they are amplified in the latter. The algorithm used was:

$$dt = t_i - t_{i-7}$$
$$ctm_i = -b * ctm_{i-7} + a * \partial c \partial t * dt$$
$$c_{cor,i} = c_{meas,i} + ctm_i$$
$$a = \frac{2\alpha}{7\Delta * \beta + 2}$$
$$b = 1 - 2a/\alpha$$
$$\partial c \partial t = 0.8 * (1 + 0.006 * (t_i - 20))$$

where α, the thermal anomaly amplitude was set at 0.03 and β, the thermal anomaly time constant was set at 1/7 (the SeaBird recommended values for SBE911+ pumped system). Δ is the sample interval (1/24 second), dt is the temperature (t) difference taken at a lag of 7 sample intervals. $c_{cor,i}$ is the corrected conductivity at the current data cycle (i), $c_{meas,i}$ the raw value as logged and ctm_i is the correction required at the current data cycle, $\partial c \partial t$ is a correction factor that is a slowly varying function of temperature deviation from 20 °C.

Translate: Finally, the D354CTDnnnS.cnv file was converted from binary into ASCII format so that it could be easily read into Pstar format. The header information was checked at this stage to ensure that all of the processes had been performed on each station.

The .cnv and .ros files were then copied to /data32/d354/ctd/StS/SBEprocessed or to /data32/d354/ctd/TiT/SBEprocessed so that data processing could be continued using PEXEC routines.

Data Processing on the UNIX system

The following Pstar scripts were used to process the data. Two versions of all the scripts were created, one for the stainless steel frame and one for the titanium frame CTD (denoted by *s* or *t* in the script name).

ctds0 and ctdt0: These scripts read in the SeaBird processed ascii file (.cnv) and converted it into Pstar format, also setting the required header information. The latitude and longitude of the ship when the CTD was at the bottom were typed in manually and added to the header. The output file contained the data averaged to 24hz. The output file was ctd354nnnS.24hz or ctd354nnnT.24hz

ctds1 and ctdt1: These scripts operated on the .24hz file and used the PEXEC program *pmdian* to remove residual spikes from all of the variables. The data were then averaged into a 1hz file using *pavrge*. Absent data values in the pressure data were interpolated across using *pintrp*. Salinity, potential temperature, sigma0 and sigma2 (referenced to 2000 db) were calculated using *peos83* and finally a 10 second averaged file was also created. The output files were ctd354nnnS.1hz and ctd354nnnS.10s or ctd354nnnT.1hz and ctd354nnnT.10s.

ctds2 and ctdt2: These scripts carried out a head and tail crop of the .1hz file to select the appropriate data cycles for just the up and down casts of the CTD. Before running ctd2, the .1hz files were examined in *mlist* to determine the data cycles for i) the shallowest depth of the CTD rosette after the initial soaking at 10m, ii) the greatest depth, and iii) the last good point before the CTD is removed from the water. These values were then manually entered at the correct screen prompts in ctd2. The data were then cut out with *pcopya* and the file ctd354nnnS.ctu or ctd354nnnT.ctu created. Finally, the data were averaged into two db pressure bins creating the files ctd354nnnS.2db or ctd354nnnT.2db. At this stage all CTD files were then merged with navigation to obtain accurate position fixes replacing the manually entered values under ctds0 and ctdt0

fir and firt0:: These scripts converted the .ros file into Pstar format. It then took the relevant data cycles from the .10s averaged file (secondary output from ctd1) and pasted it into a new file fir354nnnS or fir354nnnT containing the mean values of all measured variables at the bottle firing locations.

samfir and samfirt: These scripts created the file, sam354nnn, containing selected variables from fir354nnnS or fir354nnnT which were pasted into a WOCE style master template. The sam file forms the basis for recording the bottle sample data (nutrients, salinity, oxygen)

alongside CTD variables and is used in the calibration of the conductivity and oxygen sensors.

Sample Bottle Data

Once salinity, nutrient and oxygen bottle data were available txt files were created for each parameter and for each CTD cast using Excel (saved as tab delimited txt files). The following scripts were run on the .txt files thus created.

Sal and salt0: Read in the salinity sample bottle txt files and convert some unique PC file characters into UNIX friendly characters. Then *sal0* and *salt0* create Pstar formatted files with *pascin* and produce the output files sal354nnnS.bot and sal354nnnT.bot

Passal and passalt: Pastes salinity bottle file data (e.g. sal354nnn.bot) into sam354nnn files.

Nut0 and nut0T: Read in the nutrient sample bottle txt files and convert some unique PC file characters into UNIX friendly characters. Then *nut0* and *nut0T* create Pstar formatted files with *pascin* and produce the output files nut354nnnS.bot and nut354nnnT.bot

Pasnut and pasnutT**:** Pastes nutrient bottle file data (e.g. nut354nnn.bot) into sam354nnn files.

Oxy0: Read in the oxygen sample bottle txt files and convert some unique PC file characters into UNIX friendly characters. Then *oxy0* creates a Pstar formatted file with *pascin* and produces the output file oxy354nnnS.bot.

No oxygen data were collected from the titanium framed CTD during D354.

Pasoxy**:** Pastes oxygen bottle file data (e.g. oxy354nnn.bot) into sam354nnn files.

Calibration

Calibrations for conductivity and oxygen were obtained during the cruise for the stainless framed CTD, and for conductivity on the titanium framed CTD (oxygen will be cross calibrated against the stainless CTD data upon return to NOC). As not all data were available until quite late in the cruise the following remain as preliminary indicators of the calibration coefficients. Final calibrations will be confirmed after return to NOC when all data will be available for this purpose.

peos83: Bottle salinities from salinometry samples were converted to conductivities using both primary and secondary temperatures using the equation of state (UNESCO 1983). This information was used to determine the calibration coefficients A and B, which are used to correct the measured conductivities as described below,

$$conductivity = A * (primary\ conductivity)$$

$$conductivity = B * (secondary\ conductivity)$$

where

$$A = \frac{\sum Cond_{bot} Cond_{ctd}}{\sum (Cond_{ctd})^2} = \frac{\overline{Cond_{bot} Cond_{ctd}}}{\overline{(Cond_{ctd})^2}}$$

and

$$B = \frac{\sum Cond2_{bot} Cond2_{ctd}}{\sum (Cond2_{ctd})^2} = \frac{\overline{Cond2_{bot} Cond2_{ctd}}}{\overline{(Cond2_{ctd})^2}}$$

$cond2$ and $cond2_{bot}$ are the sample bottle conductivities determined with the primary and secondary temperature variables respectively.

Ctdcondcals and ctdcondcalt: These scripts were used to calibrate the .ctu and .2db files for both Stainless Steel and Titanium CTD casts. It also re-calculates salinity, potential temperature and sigma0/sigma2. For the stainless steel CTD A and B were set to 1.00012407 and 1.00061972 respectively.

For the titanium framed CTD A and B were set to 1.00027784 and 1.00023613

Mean residual conductivity differences for the stainless steel CTD were 0.0000 with a standard deviation of 0.0020 and 0.0024 for primary and secondary conductivity sensors. A slight drift in the residuals with time is evident in the calibrated data but is within the accuracy stated by Seabird for the conductivity instruments (± 0.003).

Mean residual conductivity differences for the titanium CTD were 0.0000 with a standard deviation of 0.0011 and 0.0012 for primary and secondary conductivity sensors respectively.

Oxygen Calibration

The Stainless Steel CTD frame was equipped with a SBE43 Dissolved Oxygen sensor which was calibrated against discrete oxygen samples measured via Winkler titration. The appropriate calibration is a linear calibration between the instrument measurement (x) and the Winkler titration measurement (y) with zero offset. The calibration equation thus obtained was y = 1.006048x. The mean residual (Winkler Oxygen – SBE43 Oxygen) after calibration was -0.005±0.98 μmol L^{-1}.

Calibration of the oxygen sensor on the Titanium frame was not attempted during the cruise and will be investigated after return to NOC.

Salinity Bottle Samples

- Stuart Painter, Stephanie Henson (University of Southampton, National Oceanography Centre, UK), Nick Rogan (University of Liverpool, UK)

Salinity samples were drawn from the Niskin bottles mounted on the CTD rosette from the deepest depth, and several depths below ~ 150 m. Samples were taken from both the stainless steel (n = 138) and titanium (n = 115) frame CTDs (where titanium samples where taken in the clean lab by the

trace metal group). Samples were taken using 200 mL glass sample bottles that were rinsed three times in the sample water, filled to the shoulder and sealed with a disposable plastic insert and the bottle's own screw cap. Samples (n = 456) were also taken from the ThermoSalinoGraph (TSG) every hour whilst steaming to calibrate the continual TSG measurements.

The salinometer for on-board salinity determination was sited in the gravimetric lab (maintained at 21 ºC); a Guildline model 8400B Autosal salinometer serial no. 68958 fitted with a peristaltic pump. Once a crate of sample bottles had been filled they were moved into the gravimetric lab to stand for 24 hours prior to analysis. Standardisation was performed using IAPSO Standard Seawater batch P151 (OSIL Ltd.) before the analysis of each crate.

NMFSS's Autosal software was used throughout. The software and the Autosal worked well and the stability of measurements, determined by monitoring the standard deviation of salinity measurements, was good.

Following salinometer processing, the data was copied from the un-networked salinometer PC to a USB thumb drive, and then onto the network. For underway samples, a spreadsheet of bottle numbers and sample times obtained from the raw log sheets were matched with corresponding bottle salinities. These data were then merged with the TSG data to allow calibration of the TSG data. For CTD samples, a spreadsheet of bottle salinities and the corresponding Niskin bottle from which they were taken (derived from the raw CTD log sheets) was created for each CTD cast. Data from the files were then incorporated into the CTD sam files using the Pstar scripts *sal0* or *salt0* and *passal* or *passalt*.

For the purposes of calibration all bottle salinities derived from salinometry analysis were converted to conductivity values using the UNESCO 1983 Equation of State and the appropriate temperature measurements (CTD or TSG).

Thermosalinograph and Surfmet Data

Stephanie Henson, Stuart Painter (University of Southampton, National Oceanography Centre, UK), Nick Rogan (university of Liverpool, UK)

Instruments

Underway surface meteorology and thermosalinograph measurements were recorded by the RVS Surfmet system. Further details of the instrumentation used are given in the computing and instrumentation section of this cruise report. The parameters measured were:

Non-toxic supply
- *Intake water temperature (temp_r)*
- *TSG housing water temperature (temp_h)*
- *Conductivity*
- *Fluorescence (Chl-a)*
- *Turbidity (transmissometer)*

Meteorology
- *Sea level pressure*

Air temperature/humidity
Photosynthetically available radiation (PAR) - port/starboard sensors
Total Incident Radiation (TIR) - port/starboard sensors
Wind speed and direction

Processing

Processing of the underway data was performed daily using the Pstar routines detailed below.

surfmet0: This script was used to read in and convert the data from RVS format to Pstar format using datapup.

Output file: smt354**.raw

surfmet1: This sets absent Surfmet data values to -999. Instrument calibrations are applied by the Surfmet system to the data already so only minimal adjustments are needed in this step. Wind direction is corrected.

Output file: smt354**

surfmet2: The master navigation file (abnv3541) and master Ashtech files (ashmaster) are merged with smt354** at this point to allow accurate heading data to be incorporated into the underway dataset. This step creates the file smt354**.hdg

Output file: smt354**.hdg

A full post-cruise calibration will be conducted upon return to NOC.

Appendices

Appendix A: Cruise D350

1. Station times, positions and casts D350

Table A1: Station times, positions and casts D350

Stn no.	CTD cast no.	CTD Identifier	Date (ddmmyy)	jday	time	Lat (N)	Lon (W)	CTD cast type	other deployments
1	1	Ctd_S_001	29.04.2010	119	02:24	59 00.44	24 11.81	StS	Net 001
	2	Ctd_T_001			03:36	59 00.24	24 11.81	TiT	
2	3	Ctd_T_002	01.05.2010	121	00:57	60 59.67	35 00.35	TiT	Net 002, 003, SAPS 001
	4	Ctd_S_002			10:48	60 58.91	34 59.39	StS	
	5	Ctd_S_003			12:28	60 58.30	34 56.95	StS	
	6	Ctd_T_003			06:28	60 56.66	34 52.31	TiT	
3	7	Ctd_S_004	02.05.2010	122	07:55	60 00.18	35 00.33	StS	Net 004, 005, SAPS 002, APEX
	8	Ctd_S_005			13:40	60 01.40	34 57.61	StS	
	9	Ctd_T_004			08:24	60 02.37	34 57.47	TiT	
4	10	Ctd_S_006	03.05.2010	123	02:52	59 59.98	31 59.60	StS	Net 006, 007, SAPS 003
	11	Ctd_S_007			11:16	60 00.17	31 58.82	StS	
	12	Ctd_T_005			00:00	59 59.54	37 55.98	TiT	
5	13	Ctd_T_006	04.05.2010	124	07:12	59 59.78	29 00.42	TiT	Net 008, 009, 010, SAPS 004, Seasoar 001 (transit to stn 6)
	14	Ctd_S_008			07:40	59 59.43	28 59.78	StS	
	15	Ctd_S_009			08:38	59 59.89	28 59.76	StS	
	16	Ctd_T_007			12:14	59 58.51	29 01.02	TiT	
6	17	Ctd_S_010	05.05.2010	125	00:00	59 56.64	26 10.84	StS	Net 011, 012, SAPS 005
	18	Ctd_S_011			03:36	59 56.1	26 07.48	StS	
	19	Ctd_T_008			08:52	59 54.45	26 02.34	TiT	
7	20	Ctd_S_012	06.05.2010	126	00:28	60 51.39	21 45.91	StS	Net 013, 014, 015, SAPS 006
	21	Ctd_S_013			04:19	60 50.78	21 45.07	StS	
	22	Ctd_T_009			00:00	60 50.60	21 44.54	TiT	
8	23	Ctd_S_014	07.05.2010	127	01:26	61 59.51	20 00.41	StS	Net 016, 017, SAPS 007, Seasoar 002 (transit to stn 9)
	24	Ctd_S_015			09:36	61 59.95	19 59.96	StS	
	25	Ctd_T_010			09:36	61 57.41	20 01.97	TiT	
9	26	Ctd_S_016	08.05.2010	128	01:12	63 08.16	19 54.62	StS	Net 018, 019, SAPS 008
	27	Ctd_S_017			06:57	63 07.83	19 54.98	StS	
	28	Ctd_T_011			09:07	63 05.27	19 52.54	TiT	

2. Narrative cruise diary/event timetable D350

All times GMT

Date

Time

Event

23rd - 25th April 2010

Transport of scientists to ship and cruise mobilisation. A number of people had difficult (or ultimately non-existent! Sorry Cynthia!) journeys to the ship. Many of scientific party travelled by coach and Mike Lucas took 5 days to get to the ship from Cape Town.

26th April 2010

0930 Safety briefing and signing on.

1215 Departed King George V Dock. Everything appears to be coming together, labs now look as if they will survive first few hours at sea! Forecast is for a bit of weather on the way out, but hopefully nothing too bad.

1836 Passed Aaron, rounding Mull of Kintyre

27th April 2010

0000 55 25.0 N, 6 02.0 W

0640 55 59.1 N 8 50.6 W, Steaming on route Irminger Basin, doing 10.5 kts. Overcast, currently force 4, forecast 5-7 increasing 8, S-SE.

0730 Muster and boat drill. All mustered and then went to boat stations. We all then got into boats, which is never pleasant at the best of times. *I think a few people may have enjoyed it even less than most! Anyway, all learnt of safety procedures and equipment available within boats.*

~1300 Beta counter came loose from fixings on bench, thankfully stayed on bench, but counter now relocated to floor. Near miss report filled and Risk Assessment to be re-assessed.

1930 Wind and sea state beginning to drop after getting up during the day. Somewhat uncomfortable passage so far, but hopefully improving. Original plan to deploy trace metal clean sampling fish at midnight when passed into international waters abandoned due to sea state. Situation to be re-assessed at 8am.

28th April 2010

0000 56 47.3 N, 13 01.2 W

0614 Wind and sea state continuing to drop. Overcast currently force 3-4. Forecast good. 57 18.9N, 15 21.4W, currently doing 10.5 kts. Continuing to steam towards station CIB, ETA currently 1957 on 30th, estimated ~2200 30th allowing for trace metal fish deployment and shakedown station tomorrow.

0715 Stopped for deployment of PES fish (10 kHz) and trace metal clean fish. Both deployed successfully, resume passage 0840.

1200 Commenced science watches, sampling commenced from underway systems including towed trace metal clean fish. *Science underway at last!*

29th April 2010

0000 58 12.7 N, 19 56.6 W

0400 Underway sampling continues. First 24hr Fe addition experiment set up.

0709 58 43.07 N 22 34.00 W. Still making good progress, currently 9.6 kts. Forecast good. *Internet still down.*

1100 *Discovered that fans on clean containers have been inserted to pump air in wrong direction. Fans are plumbed in to pump air out of container, so air is being sucked in through all doors/holes etc and not being filtered. Notified Jon Short and he and Richie are investigating stripping fan out and flipping around. Mark S. also having some problems with nutrient analyser.*

1240 Hove to on **Station 001**, 59 00 N, 24 11.3 W for shakedown casts.

1308 **CTD S 001** deployed to 500m, recovered 1407

1421 **Net 001** deployed to 100m, recovered 1437

1511 **CTD T 001** deployed to 500m, recovered 1610

Successful test deployments of both CTD systems and bongo nets. Samples collected for Th234 calibration as well as samples for Martine, chlorophylls, nutrients and oxygen samples. Continued on route for Irminger Basin 1610. ETA now ~0400 Saturday 1st May.

1600 Science meeting to discuss plans for next few days and overall plans for cruise, decision made that we would likely visit close to Iceland in order to attempt to find water influenced by ash plume. Discussions of experimental setup for first station.

2001 *Autoanalyser now running but only on 2 channels (nitrate and silicate) due to failed detector on third channel. Jon and Ritchie completed turning fans around in clean container.*

30th April 2010

0000 59 27.8 N, 26 32.9 W

0400 First 24hr bioassay experiment broken down. Appears to show a clear response to iron. Underway sampling proceeding OK. Second 24hr bioassay experiment set up.

0830 Meeting in plot. Informed heads of departments of plans for next 24-48hrs. Finalised plan for station after meeting and posted POA for rest of 30th and 1st May. Agreed to give science meeting in bar.

1630 Started running chlorophylls using Welshmeyer technique. Think that calibration/drift problem is solvable.

1800 Underway sampling continued smoothly throughout the day.

1830 *Gave science talk in bar, hopefully entertaining.*

1st May 2010

0000 60 51.8 N, 34 13.7 W

0130 Ship slowed to 6 kts to allow time for underway sampling of fish water to set up larger scale bioassay experiment. Bioassay experiment 2 broken down, again appears to be clear Fe response. Large scale bioassay 1 setup. Micro and mesozooplankton grazing experiments set up from experimental CTD.

0300 Hove to on **Station 002**. 60 59.54N, 35 00.35W.

Sea state calm, light winds, forecast good. Looking to be a nice day for first real science station!

0304 **CTD T 002** Experimental CTD deployed to 100m on deck 0324

0335 **Nets 002** (Bongo) Deployed to 100m, on deck 0344

0400 **Nets 003** Deployed to 100m, on deck 0407

0442 **CTD S 002** Deployed to 500m, on deck 0540

0650 **CTD S 003** Deployed to bottom (~3000m), on deck 0928

1004 **SAPS 001** Deployed to 150m, on deck 1232

1327 **CTD T 003** Deployed to bottom (~3000m), on deck 1608

End station 002, set course for CIB2 (60N, 35W)

Drifted around 10km south east during station. It was apparent from CTD profiles and TSG data that there was considerable spatial variability within the region. Stratification weak and complicated vertical profiles, apparently low surface biomass, lots of large grazers.

1705 Steaming towards CIB2, ETA 2200. Conditions calm.

Unsure when or where we picked up our passenger (sparrow hawk or similar (note added later, actually a Merlin, stays with us all the way to Iceland)), but it still appears to be going strong. Was sighted eating the remains of a small bird it had caught a few days ago

2nd May 2010

0000 60 00.2 N, 35 00.2 W

2231 Hove to on **Station 003** (CIB2 60 N, 35 W).

2231 **CTD S 004** Deployed to bottom (3070m), on deck 0120

0132 **Nets 004** Deployed to 100m, on deck 0149

0151 **Nets 005** Deployed to 100m, on deck 0200

0200 Steaming off station to collect water from trace metal clean fish for short term bioassay experiment 3, then return to site (CIB2) at 0340

0430 **SAPS 002** Deployed to 150m, on deck 0708

0758 **CTD S 005** Deployed to 500m, on deck 0850

0932 **CTD T 004** Deployed to bottom (2950m), on deck 1207

1215 Deployed **APEX float** 60 03.9 N, 34 56.5 W

End station 003. Set course for location CIB3 (60N, 32W), steaming at 6.5 kts in order to arrive at 0300

First time point of large bioassay experiment taken. End of first mesozooplankton grazing experiment.

Think we are really getting into the swing of things now. Although a couple of flooded pumps on that last one! Dougal seems to think that Seasoar might be ready for deployment at end of next station after fixing a number of problems with minipack CTD. Beginning to think a bit more about collected data. It looks like station CIB was in pre-bloom waters and looking at underway chlorophyll data to date I think we have a potentially nice transect in from already stratified bloom waters through to largely mixed pre-bloom waters. Hopefully we can pick up a similar reverse pattern as we transect east over the ridge and then up towards Iceland.

3rd May 2010

0000 60 00.0 N, 32 10.1 W

0100 Hove to at CIB3 (60 N 32 W) awaiting station

0200 Steaming off station at 5 kts to collect samples from trace metal clean fish to start short term bioassay 4. Break down of short term bioassay experiment 3. *Looks to be some response again.*

0300 Hove to on **Station 004** (CIB3, 60N 32W)

0310 **CTD S 006** Deployed to bottom (2200m), on deck 0518

0543 **Net 006** Deployed to 100m, on deck 0600

0602 **Net 007** Deployed to 100m, on deck 0611

0646 **CTD S 007** Deployed to 500m, on deck 0745

0856 **SAPS 003** Deployed to 200m, on deck 1127

1155 **CTD T 005** Deployed to 2200m, on deck 1404

End station 004, repositioning back to CIB3 for Seasoar deployment and commencement of tow to RR1 (60N, 29W).

Breakdown of microzooplankton dilution experiment.

~1500 Minky whale sighted close to ship, breached a couple of times while swimming close to bow.

1600 Problems with Seasoar continue, failure of load cell on winch. Investigation underway to establish whether spare amplifier available on ship.

1630 Decision made to continue steaming to next station (RR1) at 8 kts to allow for outside possibility of Seasoar deployment. Also to make sure of timing for arrival ~0400

Continue re-evaluating positions for stations, currently heading east along 60N.

4th May 2010

0000 60 00.0N 30 03.3W

0400 Hove to on location RR1 for station 005. Steamed off at 5 kts for extra 30 minutes to finish collecting samples from trace metal clean fish for setup of larger bioassay 2.

0430 Hove to on **Station 005** (RR1, 60N, -29 W)

0430 **CTD T 006** (experimental CTD) Deployed to 100m, on deck 0453

0505 **Net 008** (Bongo) Deployed to 100m, on deck 0518

0521 **Net 009** (WP2) Deployed to 100m, on deck 0534

Few adult copepods in net so Sari requested extra net.

0600 **Net 010** (WP2) Deployed to 100m, on deck 0617

0630 **CTD S 008** Deployed to 500m, on deck 0729

0834 **CTD S 009** Deployed to bottom (1375m), on deck 1010

1043 **SAPS 004** Deployed to 200m, on deck 1300

1349 **CTD T 007** Deployed to bottom (1380m), on deck 1530

End Station 005

Setup of second micro and mesozooplankton grazing experiments. Setup of second longer term bioassay experiment. Sampling time-point at 72 hr from first bioassay experiment. Breakdown of shorterm bioassay 4.

1530 Commenced transit off station towards IcB1 (60N, -26W)

1612 Hove to for Seasoar deployment

1621 Seasoar outboard

1706 Commence **Seasoar 001**, continue along line to IcB1

Seasoar finally in water! Some initial problems with comms when switching from override control on box to software, but appears to be solvable and now undulating well (1924), struggling to reach shallower than 30 m. All instruments appear to be working including new LOPC and Fastracka mk II.

On request from Sari will pull Seasoar early to do net as early as possible (and still well in darkness). Some communication with base including JFR to discuss plans for changeover, still planning on Reykjavik port call.

1930 *Sun is finally out!*

5th May 2010

0000 59 59.7N 26 47.1W

0237 Seasoar recovery. CTD (minipack) on Seasoar stopped working approximately 2030 hrs on night of 4th. Towed through rest of night at surface.

Dougal sounds optimistic that minipack would be reparable. Tow certainly allowed successful test of new LOPC and FRRf II. Sounds promising for a further tow in 2 days time.

0240 Hove to on **Station 006** (IcB1, 59 56.7 N, 26 12.7 W)

0258 **Net 011** (Bongo) Deployed to 100m, on deck 0312

0314 **Net 012** (WP2) Deployed to 100m, on deck 0325

0350 **CTD S 010** Deployed to bottom (2135m), on deck 0604

0714 **CTD S 011** Deployed to 500m, on deck 0821

0847 **SAPS 005** Deployed to 200m, on deck 1056

1134 **CTD T 008** Deployed to bottom (2190m), on deck 1345

End station 006, steaming to IcB2 (61 N, 22 W)

First time point of second large bioassay experiment sampled. Sari decided not to take option of second net scheduled between 2 stainless steel casts.

Trace metal clean fish pulled in while on station (1250 – 1314) as was pumping slowly over last couple of nights. Kink found in hose just above fish. Reinforced with some extra thick tubing and redeployed.

1500 Meeting in main lab to request cruise report contributions and talk about port call, as well as run through plans for last 4 days of cruise.

Now beginning to head north towards Iceland and hopeful encounter with ash plume!

1729 Speed steady at >11 kts due to following sea and current. In order to arrive on station at 0300 and not to have made too much northward progress decided to redirect line to heading aimed at 61 N, 21 W. Intention to stop along line to be on station at 0300.

1900 Still making good progress >11 kts, ship rolling a bit with following sea, but beautiful evening.

6th May 2010

0000 60 39.6 N 22 42.3 W

0300 Hove to on **Station 007** (IcB2, 60 51.4 N 21 46.2 W)

0317 **Net 013** Deployed to 100m, on deck 0331

0332 **Net 014** Deployed to 100m, on deck 0343

0400 **CTD S 012** Deployed to bottom (2250m), on deck 0612

0716 **CTD S 013** Deployed to 500m, on deck 0812

0858 **SAPS 006** Deployed to 200m, on deck 1117

1125 **Net 015** Deployed to 100m, on deck 1145

1200 **CTD T 009** Deployed to bottom (2260m), on deck 1425

End station 007, steaming off to station 008 (IcB3, 62 N, 20 W) at 8kts for planned arrival 0100

Break down of large bioassay experiment 1, some indication of development of iron response later in experiment. Setup of short term bioassay. Breakdown of second microzooplankton grazing experiment.

Informed that no chance of Seasoar deployment tonight, and looking unlikely for rest of trip.

Election day! All seems a bit far away from here. Downloaded some good recent satellite images of volcano, hopeful we may see some evidence of it (at least visually!) when approaching Iceland on Saturday.

1730 *Steaming along pleasantly at 8 kts, calm sea, have had amazing weather so far, and hopeful will continue through to weekend.*

7th May 2010

0000 61 55.8 N 20 06.9 W

0050 Hove to on **Station 008** (IcB3, 61 59.8 N 20 00.2 W)

0205 **CTS S 014** Deployed to bottom (1790m), on deck 0404

0418 **Net 016** Deployed to 100m, on deck 0435

0436 **Net 017** Deployed to 100m, on deck 0448

0448 Steamed off station for 90 minutes to collect samples from underway trace metal clean fish for setup of short term bioassay experiment.

0635 Hove to back on station

0635 **CTD S 015** Deployed to 500m, on deck 0738

0802 **SAPS 007** Deployed to 200m, on deck 1006

1040 **CTD T 010** Deployed to bottom (1785m), on deck 1255

End station 008, remain hove to until 1600

Time point at 72 hrs for long term bioassay 2. Short term bioassay set up and broken down.

1615 Seasoar deployed for **Seasoar tow 002** transect to station 009 (RR5, 63 08 N, 19 55 W)

2020 Steaming with Seasoar north, wind NNE and fresher than last few days, but clear skies. Haze on horizon in all directions. *Indication of ash in atmosphere? Arrangements now set for port call, going into Reykjavik for pilot 0900 Monday.*

~2200 Clearly dust in atmosphere earlier and main dust plume just coming into view! Still 50 miles off and plume very visible. Also great sunset complete with whales!

7th May 2010

0000 63 02.2 N, 19 56.9 W

0030 Commence Seasoar recovery.

0058 Seasoar inboard, end tow 002

0130 Hove to on **Station 009** (RR5, 63 08 N, 19 55 W)

0130 **CTD S 016** Deployed to bottom (1020m), on deck 0337

0346 **Net 018** Deployed to 100m, on deck 0400

0400 No plume visible due to fog/low cloud

0404 **Net 019** Deployed to 100m, on deck 0412

0414 Commence steam off station to collect water of trace clean metal fish for short term bioassay experiment.

0524 Hove to on station again, ready for deployment of:

0524 **CTD S 017** Deployed to 500m, on deck 0626

0704 **SAPS 008** Deployed to 200m, on deck 0915

0745 Clearing sky, plume becomes visible and then good view of volcano

0937 **CTD T 011** Deployed to bottom (1100m), on deck 1117

1117 Steam off station to east towards location beneath ash plume as indicated by satellite imagery (MODIS image 7th May 2010).

Short term bioassays set up and broken down.

Small pieces of pumice collected in nets!

1310 Some fantastic views of volcano and ash plume. Plume extends to horizon, appears dark gray at base close to volcano, lightening to white as becomes more diffuse out over the sea.

1430 Angle to ash plume closing, visibility dropping. Master measured angle to top of individual ash plumes directly over volcano, from measured angle and position, estimated that plume is at a height of around 7000m. Ash fall clear on ship.

1500 Clearly getting more into plume. Can see blue sky on both sides of plume, but little visibility directly overhead.

1700 Large ashfall on ship. Decks covered with coarse grained ash. Large volumes of material could be easily collected off deck. Filters on aerosol samplers changed as

rapidly as possible. Decision made to turn back west and steam out of ash plume after collection of underway trace clean sample directly underneath plume at 1600.

1831 Heave into wind on western extremity of plume for aerosol sampling.

2230 Moving off station ahead of increased ashfall again.

9th May 2010

0000 63 07.3 N, 19 39.5 W

0048 Hove to for aerosol sampling.

0200 Set off for Reykjavik

Some preliminary evidence of interesting data collected during transect under dust plume. Higher chlorophyll, although other potential causes for this will need investigating, given potentially complex hydrographic regime in region. Dissolved iron concentrations very high under region of densest ash fall.

1745 Alongside Reykjavik. Packing and cruise report writing continue.

3. Underway samples, date, time and position and the parameters sampled for D350

Table A2: Samples labelled U1-U73 are underway samples for trace metal (TM) analysis, samples 1-144 are for nutrients (TON, P, Si), chlorophyll and salinity measurements.

underway	date	Time	Jday	Lat (N)	Lon (W)	sampled for:
1	28/04/2010	12:00	118	57.633	-16.9661	TON,P,Si,Chl,S
U 1	28/04/2010	12 : 0 5	118	57.638024	-16.991432	TM
2	28/04/2010	13:02	118	57.6951	-17.2855	TON,P,Si,Chl,S
3	28/04/2010	14:00	118	57.7522	-17.5745	TON,P,Si,Chl,S
U 2	28/04/2010	14 : 0 9	118	57.760479	-17.619022	TM
4	28/04/2010	15:02	118	57.8117	-17.8805	TON,P,Si,Chl,S
U 3	28/04/2010	16 : 0 5	118	57.872723	-18.194814	TM
5	28/04/2010	16:01	118	57.8687	-18.1746	TON,P,Si,Chl,S
6	28/04/2010	17:02	118	57.9277	-18.4763	TON,P,Si,Chl,S
U 4	28/04/2010	18 : 0 0	118	57.98333	-18.763979	TM
7	28/04/2010	18:04	118	57.9871	-18.7839	TON,P,Si,Chl,S
8	28/04/2010	18:59	118	58.0401	-19.0543	TON,P,Si,Chl,S
9	28/04/2010	20:00	118	58.0985	-19.3569	TON,P,Si,Chl,S
U 5	28/04/2010	20 : 0 0	118	58.098455	-19.356948	TM
10	28/04/2010	20:59	118	58.1552	-19.6507	TON,P,Si,Chl,S
11	28/04/2010	21:59	118	58.2118	-19.9399	TON,P,Si,Chl,S
U 6	28/04/2010	22 : 0 0	118	58.212606	-19.944613	TM
12	28/04/2010	23:00	118	58.2654	-20.2287	TON,P,Si,Chl,S
U 7	28/04/2010	23 : 58	118	58.317327	-20.507157	TM

13	29/04/2010	00:00	119	58.3191	-20.5168	TON,P,Si,Chl,S
14	29/04/2010	01:00	119	58.3771	-20.8056	TON,P,Si,Chl,S
U 8	29/04/2010	1 : 59	119	58.435941	-21.088841	TM
15	29/04/2010	02:00	119	58.437	-21.0937	TON,P,Si,Chl,S
16	29/04/2010	03:00	119	58.4921	-21.3856	TON,P,Si,Chl,S
17	29/04/2010	03:58	119	58.5441	-21.6689	TON,P,Si,Chl,S
U 9	29/04/2010	4 : 0 9	119	58.55372	-21.721012	TM
U 10	29/04/2010	5 : 59	119	58.651962	-22.241756	TM
18	29/04/2010	05:01	119	58.5979	-21.9706	TON,P,Si,Chl,S
19	29/04/2010	06:00	119	58.6529	-22.2464	TON,P,Si,Chl,S
20	29/04/2010	07:00	119	58.7087	-22.5199	TON,P,Si,Chl,S
U 11	29/04/2010	7 : 58	119	58.76305	-22.797025	TM
21	29/04/2010	08:03	119	58.7678	-22.8213	TON,P,Si,Chl,S
22	29/04/2010	09:00	119	58.8202	-23.0998	TON,P,Si,Chl,S
U 12	29/04/2010	9 : 57	119	58.868661	-23.383112	TM
23	29/04/2010	09:58	119	58.8696	-23.3881	TON,P,Si,Chl,S
24	29/04/2010	10:58	119	58.9261	-23.6931	TON,P,Si,Chl,S
U 13	29/04/2010	11 : 59	119	58.983086	-24.01254	TM
25	29/04/2010	11:59	119	58.9831	-24.0125	TON,P,Si,Chl,S
26	29/04/2010	12:56	119	59.0084	-24.1907	TON,P,Si,Chl,S
27	29/04/2010	14:00	119	59.004	-24.1968	TON,P,Si,Chl,S
U 14	29/04/2010	17 : 54	119	59.103654	-24.704739	TM
28	29/04/2010	17:02	119	59.0506	-24.4344	TON,P,Si,Chl,S
29	29/04/2010	18:00	119	59.1098	-24.7359	TON,P,Si,Chl,S
30	29/04/2010	18:58	119	59.1759	-25.0221	TON,P,Si,Chl,S
31	29/04/2010	19:59	119	59.2318	-25.3258	TON,P,Si,Chl,S
U 15	29/04/2010	20 : 0 4	119	59.236319	-25.3508	TM
32	29/04/2010	21:00	119	59.2915	-25.632	TON,P,Si,Chl,S
U 16	29/04/2010	22 : 0 0	119	59.347091	-25.938483	TM
33	29/04/2010	22:00	119	59.3471	-25.9385	TON,P,Si,Chl,S
34	29/04/2010	23:00	119	59.4017	-26.2435	TON,P,Si,Chl,S
35	30/04/2010	00:00	120	59.4639	-26.5484	TON,P,Si,Chl,S
U 17	30/04/2010	0 : 0 0	120	59.463865	-26.548368	TM
36	30/04/2010	01:00	120	59.5211	-26.8518	TON,P,Si,Chl,S
37	30/04/2010	02:00	120	59.578	-27.1587	TON,P,Si,Chl,S
U 18	30/04/2010	2 : 0 5	120	59.582955	-27.184009	TM
38	30/04/2010	02:59	120	59.6317	-27.4546	TON,P,Si,Chl,S
U 19	30/04/2010	4 : 0 9	120	59.691414	-27.797069	TM
39	30/04/2010	04:01	120	59.6842	-27.7589	TON,P,Si,Chl,S
U 20	30/04/2010	5 : 58	120	59.799159	-28.327227	TM
40	30/04/2010	05:01	120	59.7435	-28.0496	TON,P,Si,Chl,S
41	30/04/2010	05:59	120	59.8	-28.3322	TON,P,Si,Chl,S
42	30/04/2010	07:00	120	59.8508	-28.641	TON,P,Si,Chl,S
43	30/04/2010	08:00	120	59.9023	-28.96	TON,P,Si,Chl,S
U 21	30/04/2010	8 : 0 7	120	59.909528	-28.996951	TM
44	30/04/2010	08:58	120	59.9642	-29.2498	TON,P,Si,Chl,S
U 22	30/04/2010	9 : 56	120	60.016748	-29.550845	TM
45	30/04/2010	10:00	120	60.0204	-29.5716	TON,P,Si,Chl,S

U 23	30/04/2010	11 : 58	120	60.133527	-30.189878	TM
46	30/04/2010	11:01	120	60.0808	-29.8826	TON,P,Si,Chl,S
47	30/04/2010	11:58	120	60.1335	-30.1899	TON,P,Si,Chl,S
48	30/04/2010	13:01	120	60.1822	-30.536	TON,P,Si,Chl,S
U 24	30/04/2010	14 : 0 1	120	60.24876	-30.85914	TM
49	30/04/2010	14:16	120	60.2671	-30.9368	TON,P,Si,Chl,S
U 25	30/04/2010	15 : 58	120	60.374405	-31.522462	TM
50	30/04/2010	15:29	120	60.3462	-31.3556	TON,P,Si,Chl,S
51	30/04/2010	16:03	120	60.3794	-31.5497	TON,P,Si,Chl,S
U 26	30/04/2010	17 : 58	120	60.491245	-32.155188	TM
52	30/04/2010	17:05	120	60.4449	-31.879	TON,P,Si,Chl,S
53	30/04/2010	18:04	120	60.4965	-32.1871	TON,P,Si,Chl,S
54	30/04/2010	19:02	120	60.5529	-32.5017	TON,P,Si,Chl,S
U 27	30/04/2010	20 : 0 0	120	60.614342	-32.835139	TM
55	30/04/2010	20:02	120	60.6163	-32.8469	TON,P,Si,Chl,S
56	30/04/2010	21:03	120	60.6823	-33.202	TON,P,Si,Chl,S
57	30/04/2010	22:00	120	60.7362	-33.5407	TON,P,Si,Chl,S
U 28	30/04/2010	22 : 0 4	120	60.740306	-33.564015	TM
58	30/04/2010	23:00	120	60.8008	-33.8863	TON,P,Si,Chl,S
59	01/05/2010	00:00	121	60.8643	-34.2304	TON,P,Si,Chl,S
U 29	01/05/2010	0 : 0 2	121	60.866477	-34.241965	TM
60	01/05/2010	01:04	121	60.9284	-34.605	TON,P,Si,Chl,S
61	01/05/2010	02:00	121	60.9705	-34.8535	TON,P,Si,Chl,S
U 30	01/05/2010	17 : 53	121	60.668127	-34.928393	TM
62	01/05/2010	17:18	121	60.7641	-34.8988	TON,P,Si,Chl,S
63	01/05/2010	17:59	121	60.6519	-34.9335	TON,P,Si,Chl,S
64	01/05/2010	19:02	121	60.4867	-34.9847	TON,P,Si,Chl,S
65	01/05/2010	19:57	121	60.3466	-35.0022	TON,P,Si,Chl,S
U 31	01/05/2010	20 : 0 3	121	60.331733	-35.003814	TM
66	01/05/2010	20:58	121	60.2006	-35.0065	TON,P,Si,Chl,S
67	01/05/2010	21:58	121	60.0558	-35.0119	TON,P,Si,Chl,S
U 32	01/05/2010	22 : 0 5	121	60.038561	-35.013006	TM
U 33	02/05/2010	2 : 54	122	59.963854	-35.001717	TM
68	02/05/2010	13:18	122	60.0521	-34.7484	TON,P,Si,Chl,S
69	02/05/2010	13:59	122	60.038	-34.6043	TON,P,Si,Chl,S
U 35	02/05/2010	14 : 0 2	122	60.037	-34.593637	TM
U 36	02/05/2010	15 : 59	122	60.003901	-34.164729	TM
70	02/05/2010	15:01	122	60.0137	-34.3775	TON,P,Si,Chl,S
71	02/05/2010	16:01	122	60.0037	-34.1574	TON,P,Si,Chl,S
72	02/05/2010	17:03	122	59.998	-33.9221	TON,P,Si,Chl,S
73	02/05/2010	18:00	122	60.0065	-33.6885	TON,P,Si,Chl,S
U 37	02/05/2010	18 : 0 2	122	60.007	-33.680013	TM
74	02/05/2010	18:57	122	60.017	-33.4448	TON,P,Si,Chl,S
75	02/05/2010	20:00	122	60.0142	-33.177	TON,P,Si,Chl,S
U 38	02/05/2010	20 : 0 7	122	60.013385	-33.1485	TM
76	02/05/2010	21:00	122	60.0073	-32.9287	TON,P,Si,Chl,S
U 39	02/05/2010	22 : 30	122	59.999755	-32.538064	TM
77	02/05/2010	22:01	122	59.9999	-32.6651	TON,P,Si,Chl,S

78	02/05/2010	23:02	122	60.0012	-32.4038	TON,P,Si,Chl,S
79	03/05/2010	00:00	123	60.0007	-32.1687	TON,P,Si,Chl,S
U 40	03/05/2010	0 : 0 4	123	60.000901	-32.152678	TM
80	03/05/2010	01:00	123	60.0021	-32.0013	TON,P,Si,Chl,S
81	03/05/2010	17:04	123	60.0013	-31.8614	TON,P,Si,Chl,S
U 41	03/05/2010	18 : 20	123	60.000607	-31.52056	TM
82	03/05/2010	18:01	123	59.9993	-31.6046	TON,P,Si,Chl,S
U 42	03/05/2010	19 : 57	123	59.996812	-31.099121	TM
83	03/05/2010	19:11	123	59.9987	-31.3004	TON,P,Si,Chl,S
84	03/05/2010	20:01	123	59.9973	-31.0811	TON,P,Si,Chl,S
85	03/05/2010	20:59	123	60.0009	-30.8225	TON,P,Si,Chl,S
86	03/05/2010	22:00	123	60.0007	-30.5598	TON,P,Si,Chl,S
U 43	03/05/2010	22 : 0 3	123	60.000573	-30.547449	TM
87	03/05/2010	23:00	123	60.0004	-30.3073	TON,P,Si,Chl,S
U 44	04/05/2010	0 : 0 0	124	60.001015	-30.057295	TM
88	04/05/2010	00:02	124	60.001	-30.0491	TON,P,Si,Chl,S
89	04/05/2010	01:00	124	59.9981	-29.7831	TON,P,Si,Chl,S
90	04/05/2010	01:59	124	59.9972	-29.4931	TON,P,Si,Chl,S
U 45	04/05/2010	2 : 0 0	124	59.997209	-29.488194	TM
91	04/05/2010	03:00	124	59.9945	-29.2005	TON,P,Si,Chl,S
U 46	04/05/2010	4 : 0 2	124	59.983521	-29.001413	TM
U 47	04/05/2010	16 : 0 9	124	59.974197	-28.806584	TM
92	04/05/2010	16:05	124	59.9733	-28.8303	TON,P,Si,Chl,S
93	04/05/2010	16:58	124	59.9207	-28.7512	TON,P,Si,Chl,S
U 48	04/05/2010	18 : 0 8	124	59.936463	-28.42724	TM
94	04/05/2010	18:08	124	59.9365	-28.4272	TON,P,Si,Chl,S
95	04/05/2010	19:04	124	59.9514	-28.1508	TON,P,Si,Chl,S
U 49	04/05/2010	20 : 0 1	124	59.964731	-27.870651	TM
96	04/05/2010	20:04	124	59.9656	-27.8561	TON,P,Si,Chl,S
97	04/05/2010	21:01	124	59.9787	-27.5798	TON,P,Si,Chl,S
U 50	04/05/2010	22 : 0 2	124	59.98235	-27.307713	TM
98	04/05/2010	22:03	124	59.9824	-27.3034	TON,P,Si,Chl,S
99	04/05/2010	23:00	124	59.9858	-27.0516	TON,P,Si,Chl,S
U 51	05/05/2010	0 : 0 0	125	59.996774	-26.78725	TM
100	05/05/2010	00:01	125	59.9967	-26.7825	TON,P,Si,Chl,S
101	05/05/2010	00:59	125	60.0015	-26.5133	TON,P,Si,Chl,S
U 52	05/05/2010	1 : 59	125	59.992704	-26.240208	TM
102	05/05/2010	02:06	125	59.9795	-26.2342	TON,P,Si,Chl,S
U 55	05/05/2010	8 : 0 2	125	59.933029	-26.108298	TM
103	05/05/2010	14:05	125	59.9188	-25.9461	TON,P,Si,Chl,S
104	05/05/2010	14:54	125	60.0098	-25.6986	TON,P,Si,Chl,S
105	05/05/2010	15:55	125	60.1221	-25.3955	TON,P,Si,Chl,S
U 53	05/05/2010	16 : 0 1	125	60.133018	-25.364483	TM
106	05/05/2010	16:45	125	60.2095	-25.1416	TON,P,Si,Chl,S
U 54	05/05/2010	17 : 52	125	60.297505	-24.754055	TM
107	05/05/2010	18:04	125	60.309	-24.6826	TON,P,Si,Chl,S
108	05/05/2010	18:59	125	60.3612	-24.3663	TON,P,Si,Chl,S
109	05/05/2010	20:00	125	60.4175	-24.0247	TON,P,Si,Chl,S

110	05/05/2010	21:01	125	60.4738	-23.6875	TON,P,Si,Chl,S
U 56	05/05/2010	22 : 0 1	125	60.532156	-23.362388	TM
111	05/05/2010	22:03	125	60.5342	-23.3513	TON,P,Si,Chl,S
112	05/05/2010	23:02	125	60.5973	-23.0267	TON,P,Si,Chl,S
113	06/05/2010	00:00	126	60.6594	-22.7106	TON,P,Si,Chl,S
U 57	06/05/2010	0 : 15	126	60.673665	-22.628505	TM
114	06/05/2010	01:00	126	60.7162	-22.3833	TON,P,Si,Chl,S
U 58	06/05/2010	1 : 59	126	60.790699	-22.060676	TM
115	06/05/2010	01:59	126	60.7907	-22.0607	TON,P,Si,Chl,S
116	06/05/2010	15:56	126	61.002	-21.5201	TON,P,Si,Chl,S
117	06/05/2010	17:01	126	61.1328	-21.3377	TON,P,Si,Chl,S
118	06/05/2010	18:00	126	61.2389	-21.1656	TON,P,Si,Chl,S
U 59	06/05/2010	18 : 0 2	126	61.242591	-21.159535	TM
119	06/05/2010	18:50	126	61.332	-21.0123	TON,P,Si,Chl,S
U 60	06/05/2010	20 : 0 8	126	61.486973	-20.798932	TM
120	06/05/2010	20:01	126	61.473	-20.8184	TON,P,Si,Chl,S
121	06/05/2010	21:00	126	61.5867	-20.6408	TON,P,Si,Chl,S
U 61	06/05/2010	22 : 0 4	126	61.709417	-20.443155	TM
122	06/05/2010	22:02	126	61.7055	-20.449	TON,P,Si,Chl,S
123	06/05/2010	22:59	126	61.8179	-20.2894	TON,P,Si,Chl,S
124	07/05/2010	00:00	127	61.9313	-20.117	TON,P,Si,Chl,S
U 62	07/05/2010	0 : 0 0	127	61.931317	-20.116966	TM
U 63	07/05/2010	5 : 47	127	62.04586	-19.950406	TM
125	07/05/2010	16:20	127	61.9213	-20.1205	TON,P,Si,Chl,S
126	07/05/2010	16:54	127	61.9732	-20.1426	TON,P,Si,Chl,S
127	07/05/2010	17:59	127	62.1282	-20.087	TON,P,Si,Chl,S
U 64	07/05/2010	18 : 10	127	62.155737	-20.076004	TM
128	07/05/2010	18:58	127	62.2824	-20.0319	TON,P,Si,Chl,S
129	07/05/2010	19:58	127	62.4373	-20.0029	TON,P,Si,Chl,S
U 65	07/05/2010	20 : 0 2	127	62.447518	-20.000628	TM
130	07/05/2010	20:58	127	62.5867	-19.953	TON,P,Si,Chl,S
131	07/05/2010	21:59	127	62.7406	-19.9369	TON,P,Si,Chl,S
U 66	07/05/2010	22 : 0 7	127	62.761166	-19.935443	TM
132	07/05/2010	23:04	127	62.8975	-19.9501	TON,P,Si,Chl,S
133	08/05/2010	00:00	128	63.0349	-19.9473	TON,P,Si,Chl,S
U 67	08/05/2010	0 : 0 4	128	63.04505	-19.945852	TM
134	08/05/2010	01:05	128	63.1505	-19.9197	TON,P,Si,Chl,S
U 68	08/05/2010	4 : 49	128	63.093375	-19.939211	TM
135	08/05/2010	11:56	128	63.0759	-19.7114	TON,P,Si,Chl,S
U 69	08/05/2010	12 : 10	128	63.078518	-19.643662	TM
136	08/05/2010	13:00	128	63.0931	-19.4121	TON,P,Si,Chl,S
U 70	08/05/2010	13 : 0 3	128	63.094118	-19.398685	TM
137	08/05/2010	13:58	128	63.1073	-19.1295	TON,P,Si,Chl,S
U 71	08/05/2010	14 : 0 5	128	63.107696	-19.09369	TM
138	08/05/2010	14:58	128	63.1081	-18.8255	TON,P,Si,Chl,S
U 72	08/05/2010	15 : 0 2	128	63.108638	-18.805758	TM
U 73	08/05/2010	15 : 59	128	63.109397	-18.512359	TM
139	08/05/2010	15:47	128	63.11	-18.5735	TON,P,Si,Chl,S

140	08/05/2010	16:00	128	63.1093	-18.5072	TON,P,Si,Chl,S
141	08/05/2010	16:28	128	63.1039	-18.5011	TON,P,Si,Chl,S
142	08/05/2010	17:01	128	63.108	-18.6394	TON,P,Si,Chl,S
143	08/05/2010	17:56	128	63.1006	-18.8667	TON,P,Si,Chl,S
144	08/05/2010	18:59	128	63.0886	-18.9808	TON,P,Si,Chl,S

Appendix B: Cruise D354

1. Station times, positions and casts D354

Table B1: Station times, positions and casts D354.

Stn no.	CTD cast no.	CTD Identifier	Date (ddmmyy)	jday	time	Lat (N)	Lon (W)	CTD cast type	other deployments
1	1	CTD001S	10.07.10	191	17:45	58 14.53	14 32.17	StS	
	2	CTD001T			18:18	58 14.24	14 31.16	TiT	
2	3	CTD002S	11.07.10	192	15:33	60 00.18	19 59.59	StS	Nets, profiler, SAPS 001
	4	CTD002T			17:15	60 00.67	19 58.69	TiT	
	5	CTD003T			23:43	60 00.02	19 59.84	TiT	
3	6	CTD003S	12.07.10	193	04:35	60 00.98	19 57.11	StS	Pelagras (in), nets
	7	CTD004T			07:42	60 02.05	19 56.29	TiT	
4	8	CTD004S	13.07.10	194	03:57	61 49.11	21 00.94	StS	Nets, profiler, SAPS 002
	9	CTD005T			06:14	61 48.59	21 03.11	TiT	
	10	CTD005S			12:00	61 47.43	21 04.84	StS	
5	11	CTD006S	14.07.10	195	03:45	60 00.35	19 59.06	StS	Nets, Profiler, Pelagras (out)
	12	CTD006T			07:22	60 02.36	19 54.96	TiT	
6	13	CTD007S	15.07.10	196	04:08	59 59.22	23 37.52	StS	Nets, profiler, SAPS 003
	14	CTD007T			08:08	60 00.11	23 37.87	TiT	
	15	CTD008S			12:39	59 59.00	23 37.25	StS	
7	16	CTD009S	16.07.10	197	04:00	60 00.67	28 08.35	StS	Nets, profiler
	17	CTD008T			07:26	60 00.76	28 04.84	TiT	
8	18	CTD010S	17.07.10	198	18:30	60 00.25	34 59.46	StS	Nets, profiler, SAPS 004
9	19	CTD011S	18.07.10	199	04:05	60 00.05	34 59.99	StS	Pelagras (in), nets
	20	CTD009T			05:28	60 00.35	34 58.93	TiT	
10	21	CTD012S	19.07.10	200	04:01	59 58.57	41 21.36	StS	Nets, profiler, SAPS 005
	22	CTD010T			07:33	59 56.23	41 27.74	TiT	
	23	CTD013S			12:14	59 54.46	41 25.10	StS	
11	24	CTD011T	19.07.10	200	14:10	59 59.43	41 35.19	TiT	
12	25	CTD012T	19.07.10	200	17:39	59 59.67	41 59.60	TiT	
13	26	CTD013T	19.07.10	200	19:54	59 59.82	42 12.78	TiT	

14	27	CTD014S	19.07.10	200	22:53	59 59.82	42 40.42	StS	Profiler
	28	CTD014T	20.07.10	201	00:30	59 59.63	42 40.07	TiT	
15	29	CTD015S	21.07.10	202	00:00	59 59.53	34 59.31	StS	SAPS 006, Pelagras (out)
	30	CTD016S			07:02	59 58.04	34 56.74	StS	
16	31	CTD017S	22.07.10	203	05:50	62 59.62	35 00.02	StS	Nets, profiler, SAPS 007
	32	CTD015T			10:02	62 59.95	34 59.20	TiT	
	33	CTD018S			15:08	62 59.98	34 59.89	StS	
17	34	CTD019S	23.07.10	204	03:55	63 00.10	34 59.89	StS	Nets, profiler
	35	CTD016T			06:41	63 00.48	34 58.15	TiT	
18	36	CTD020S	24.07.10	205	03:57	62 59.92	29 58.73	StS	Nets, profiler, SAPS 008
	37	CTD017T			07:34	62 58.99	29 53.47	TiT	
	38	CTD021S			12:23	62 59.48	29 49.12	StS	
19	39	CTD022S	25.07.10	206	04:02	60 52.40	31 31.99	StS	Nets, profiler, Pelagras (in)
	40	CTD018T			06:09	60 51.38	31 35.05	TiT	
20	41	CTD023S	26.07.10	207	08:52	58 14.69	34 58.15	StS	Nets, profiler, SAPS 009, 010
	42	CTD019T			12:51	58 13.13	35 02.92	TiT	
	43	CTD024S			18:02	58 13.11	35 07.36	StS	
21	44	CTD025S	27.07.10	208	04:10	58 08.14	34 58.80	StS	Nets, profiler, Pelagras (out, 28/7/10)
	45	CTD020T			06:52	58 08.39	35 02.28	TiT	
22	46	CTD026S	30.07.10	211	04:30	63 49.37	35 02.23	StS	Nets, profiler, SAPS 011, 012
	47	CTD021T			09:32	63 49.46	35 05.51	TiT	
	48	CTD027S			13:46	63 49.88	35 00.70	StS	
23	49	CTD028S	31.07.10	212	03:53	63 49.32	35 05.42	StS	Nets, profiler
	50	CTD022T			06:44	63 49.92	35 00.34	TiT	
24	51	CTD029S	01.08.10	213	03:57	62 28.85	28 21.34	StS	Nets, profiler, SAPS 013
	52	CTD023T			06:58	62 28.45	28 21.67	TiT	
25	53	CTD030S	02.08.10	214	16:44	63 25.96	23 35.66	StS	Profiler
	54	CTD024T			18:30	63 24.73	23 35.99	TiT	
26	55	CTD025T	02.08.10	214	20:51	63 09.67	23 47.57	TiT	
27	56	CTD031S	03.08.10	215	06:06	62 08.44	24 20.95	StS	Nets, profiler, SAPS 014, Pelagras (in)
	57	CTD026T			09:55	62 06.70	24 18.29	TiT	
	58	CTD032S			15:36	62 05.84	24 20.17	StS	
28	59	CTD033S	04.08.10	216	04:25	61 15.40	20 42.91	StS	Nets, profiler, SAPS 015
	60	CTD027T			07:42	61 15.19	20 45.82	TiT	
	61	CTD034S			12:57	61 13.58	20 47.12	StS	
29	62	CTD035S	05.08.10	217	05:44	61 50.36	25 40.36	StS	Nets, profiler
	63	CTD028T			08:35	61 50.78	25 43.36	TiT	
30	64	CTD029T	05.08.10	217	12:54	61 55.18	26 16.84	TiT	Profiler
31	65	CTD036S	05.08.10	217	15:15	61 58.61	26 41.98	StS	Profiler, SAPS 016
	66	CTD030T			17:41	61 59.05	26 38.68	TiT	

32	67	CTD031T	05.08.10	217	23:21	62 07.27	27 15.70	TiT	Profiler (6/8/10), Pelagras (out, 6/8/10)
33	68	CTD037S	07.08.10	219	03:57	60 20.98	20 56.27	StS	Nets, profiler, SAPS 017, 018
	69	CTD032T			09:14	60 18.94	20 58.77	TiT	
	70	CTD038S			13:09	60 18.19	20 58.67	StS	

2. Cruise Timetable of Events D354

RRS Discovery, cruise narrative D354 **July 1 - August 11 2010**

Thursday 1-7-2010

Arrival at vessel in morning by majority of science party. Off-loading of containers commenced. Installation of instruments in ship's laboratories and container laboratories commenced. PSO arrived at vessel at 1800 h.

Friday 2-7-2010

Science party continued installing equipment.

Saturday 3-7-2010

Further installation of labs. All going smooth.

Science party stayed on ship at night.

Sunday 4-7-2010

Ship departed at 0900 h. Rough seas in Bristol Channel and St Georges Channel. Majority of science party affected by seasickness.

Monday 5-7-2010

Weather in Irish Sea improved and majority of science party feeling well. Ship is making good progress.

Tuesday 6-7-2010

Further travel in the Irish Sea, and out of the Northern Channel towards the shelf edge. We had planned a first CTD station (shake down) in 1500 m water at 1400 h. This was delayed due to deteriorating weather conditions. The weather conditions were such that in the evening the ship was positioned into the wind and we endured force 9-10 winds.

Wednesday 7-7-2010

Worst wind conditions occurred at ca. 0400 h, and we incurred damage to scientific equipment and containers on the aft deck and starboard side. Main Engine Power was lost for 5 min before breakfast. Power was regained swiftly.

In the afternoon it became apparent that Maria Nielsdottir was not improving. Medical advice was sought, and following this we decided to return to port in the UK. This decision was made following consultation between the Master, second officer and myself.

The vessel was turned around in the afternoon and we set sail for the Clyde.

In improved weather conditions in the afternoon, an inspection was undertaken of the damage on the decks, and equipment was fastened and where appropriate taken inside.

It appeared that 2 out of 5 Pelagras required shore repairs and were not in working order. In addition, repairs had to be conducted on 5 of the trace metal clean OTE bottles. A number of bioassay containers had been damaged. We have however sufficient spares to continue the planned work. Damage to the aft deck lab containers was assessed and repaired. Damage to the electronics and motor of the deployment unit of the vertical profiler was assessed and repairs commenced.

Thursday 8-7-2010

With improving weather conditions we sailed into the Irish Sea. We arrived in the Clyde and conducted a boat to boat transfer for Ian Salter and Maria Nielsdottir at 2300 h GMT. Following this we returned to the N Atlantic to conduct our scientific mission.

Friday 09-7-2010

We steamed to the shelf edge and commenced underway sampling.

1200 h Commence underway sampling.

1500 h Trace metal fish launched.

Weather smooth.

Saturday 10-7-2010

Station 1 (shake down) 58º14.314' N, 14º31.369'W; water depth 576 m.

0200 h Bioassay water collection from fish starts (whilst steaming)

Shake-down station in 1500 m deep waters was planned for 0900 h. However, problems with the winch cable (had come off sheave during storm) meant that next opportunity for CTD was late afternoon.

1745 h Stainless CTD (400 m) with PAR CTD S01

1818 h Ti CTD (400 m) Ti01

Continue to sail to Iceland Basin station

Sunday 11-7-2010

0200 h Bioassay water collection from fish starts (whilst steaming)

Station 2 Iceland Basin 60ºN 20ºW; water depth 2729 m

24 h station for biological work

Times are tentative, depending in arrival time at station

1553 h Stainless CTD (800 m) CTD S02

1715 h Ti CTD (800 m) Ti02

1854 h Zooplankton nets

1900 h Vertical profiler

This operation was cancelled as the profiler did not yet function.

2019 h SAPS in water SAPS1

2336 h SAPS on deck

2343 h Ti CTD (shallow for zooplankton) Ti03

Monday 12-7-2010

0030 h Pelagras 1 out for 54 h

0100 h Pelagras 2 out for 54 h

0130 h Pelagras 3 out for 54 h.

This operation was cancelled as the third Pelagra did not function.

0130 h Bioassay water collection from fish (whilst steaming)

Station 3 Iceland Basin 60ºN 20ºW; water depth 2730 m

0330 h Zooplankton nets

0435 h Stainless CTD (full depth) CTD S03

0742 h Ti CTD (full depth) Ti04

1002 h Vertical Profiler

This operation was cancelled after a few attempts as the profiler did not yet function. No communication with deck unit.

1055 h Trace metal fish deployed.

1100 h Depart for survey of Iceland Basin

It was noticed that the power to the port side container was very unstable with strong voltage fluctuations. Upon careful inspection, it appeared that the container had been supplied with dirty power (220 V). This was rectified immediately by supplying clean power and problems with the electronic equipment stopped.

Tuesday 13-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

Station 4 Iceland Basin 61º49'N 21 º00'W; water depth 1864 m

0300 h Zooplankton nets

0357 h Stainless CTD (full depth) CTD S04

0614 h Ti CTD (full depth) Ti05

0814 h Vertical Profiler

0938 h SAPS 2

1200 h Stainless CTD for Th/Po/Pb CTD S05

0130 h Depart for 60ºN 20ºW

All operations went smooth today. The vertical profiler worked well.

Wednesday 14-7-2010

0000 h Bioassay water collection from fish (whilst steaming)

Station 5 Iceland Basin 60ºN 20ºW; water depth 2729 m

0250 h Zooplankton nets

0345 h Stainless CTD (800 m depth). Cast s006

0523 h Vertical Profiler

0722 h Ti CTD (800 m depth). Cast t006

0820 h Retrieve Pelagras

Pelagras were 3 h steaming (ca. 30 nm) to the northeast. The units were retrieved successfully. They were 2.5 nm apart.

1300 h Depart for Mid Atlantic Ridge

The retrieval of the Pelagra units went very smoothly. The seas were light, and the units were retrieved within an hour. However, only1 Pelagra had material in it (150 m unit).

Thursday 15-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

Station 6 Towards Mid Atlantic Ridge 60ºN 23º38'W; water depth 2175 m

0254 h Zooplankton nets

0408 h Stainless CTD (full depth). Cast s007

0617 h Vertical Profiler

0808 h Ti CTD (full depth); Cast t007

1008 h SAPS 3

1239 h Stainless CTD S08

Operations smooth, no hold ups. Winch systems operating well.

Friday 16-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

Station 7 Mid Atlantic Ridge 60ºN 28º8.47W; water depth 1484 m

0255 h Zooplankton nets

0400 h Stainless CTD (full depth) CTD S09

0542 h Vertical Profiler

0726 h Ti CTD (full depth) Ti 08

0905 h Departure

Operations smooth, no hold ups. Winch systems operating well.

Saturday 17-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

Station 8 Irminger Basin 60ºN 35ºW; water depth 3115 m

Start of 24 h station

0452 h Zooplankton nets

The net deployments were challenging due to strong winds and currents. Nevertheless, the operations were successful. Whilst getting ready for the stainless CTD, a large wave came onto the starboard deck Operations were halted until the seastate had improved. This was not until 1800 h.

We lost 12 h due to bad weather conditions. No CTD work possible.

1830 h Stainless CTD (600 m) CTD S010

1947 h Vertical Profiler

2150 h SAPS 4

Sunday 18-7-2010

0036 h Pelagras in for 79.5 h.

0200 h Bioassay water collection from fish (whilst steaming)

Station 9 Irminger Basin 60ºN 35ºW ; water depth 3136 m

0258 h Zooplankton nets

0405 h Stainless CTD (150 m) CTD S011

0528 h Ti CTD (full depth)

0810 h Depart for Greenland shelf

Monday 19-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

Station 10 Greenland slope ca. 59º54.6'N 41º25.1'W; water depth 1926 m

0258 h Zooplankton nets

0401 h Stainless CTD (full depth) CTD S012

0603 h Vertical Profiler

0733 h Ti CTD (full depth) Ti10

0930 h SAPS 5

1214 h Stainless CTD for Th/Po/Pb (500 m) CTD S013

Station 11 Greenland slope ca. 60º00' N 41º35.159'W; water depth 1862 m

1410 h Ti CTD (full depth) Ti 11

Station 12 Greenland slope ca. 60º 00' N 42º00 W; water depth 1071 m

1739 h Ti CTD (full depth) Ti 12

Station 13 Greenland shelf 60º00' N 42º12.45' W; water depth 371 m

1954 h Ti CTD (full depth) Ti 13

The weather conditions on the way to the Greenland shelf deteriorated, with visibility becoming poor and the possibility of sea ice in the East Greenland Current. Speed of the vessel was reduced to 3-5 knots.

Station 14 Greenland shelf 60º00' N 42º40' W; water depth 192 m

2253 h Stainless CTD (full depth) CTD S014

2351 h Vertical Profiler

Tuesday 20-7-2010

Station 14 Greenland shelf ca. 60º 00'N 42º40'W; water depth 192 m

0030 h Ti CTD (full depth) Ti 14

The station close in to the Greenland coast was cancelled due to adverse weather conditions.

0200 h Depart to retrieve Pelagras

Wednesday 21-7-2010

Station 15 Irminger Basin 60ºN 35ºW ; water depth 3089 m

0000 h Stainless CTD S015 for Th/Po/Pb and filling of nutrient tank (1500 m). Operation successful, with 250 L tank filled with 0.2µm filtered and UVC sterilised water.

0155 h SAPS 6

0702 h Stainless CTD S016 (1500 m) for filling of DIC-alkalinity tank. Operation successful, with 250 L tank filled with 0.2µm filtered and UVC sterilised water. 50 ml of saturated $HgCl_2$ added to tank.

The CTD deployment was used to test hydraulic extending arm on the CTD Rosette frame. The arm moves outwards below 10 m. The arm has CTD sensor on it. The reason for using an arm is to reduce data spikes. Spikes are typically caused by turbulence in the CTD frame where the sensors are traditionally placed. The arm moves the sensors away from the frame and may hence reduce turbulence. This was indeed the case, the operation was successful. CTD winching had to proceed slower compared with standard set-up.

0943 h 60ºN 35ºW Retrieval of Pelagras.

Retrieval operations successful. However, only 150 m Pelagra had functioned properly and had material in it.

Thursday 22-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

24 h station

Station 16 Irminger Basin 63ºN 35ºW; water depth 2678 m

0453 h Zooplankton nets

0550 h Stainless CTD s017 (full depth)

0811 h Vertical Profiler

1002 h Ti CTD 015 (full depth)

1232 h SAPS7

1508 h Stainless CTD 018 for Th/Po/Pb and DIC-Alkalinity (1500 m). This operation was succesful with 250 L tank filled with 0.2µm filtered and UVC sterilised water. 50 ml of saturated $HgCl_2$ added to tank.

Friday 23-7-2010

0000 h Bioassay water collection from fish (whilst steaming)

Station 17 Irminger Basin 63ºN 35ºW; water depth 2675 m

0253 h Zooplankton nets

0355 h Stainless CTD 019 (800 m)

0518 h Vertical Profiler

0641 h Ti CTD 016 (800 m)

Saturday 24-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

Station 18 Irminger Basin 63ºN 30ºW; water depth 2041 m

0254 h Zooplankton nets

0357 h Stainless CTD 020 (full depth)

0603 h Vertical Profiler

0734 h Ti CTD 017 (full depth)

0942 h SAPS 8

1223 h Stainless CTD 021 for Th/Po/Pb (500 m)

1245 h Depart

Sunday 25-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

Station 19 Irminger Basin ca. 60º52.62' N 31º32'W; water depth 2226 m

0256 h Zooplankton nets

0402 h Stainless CTD 022 (800 m)

0515 h Vertical Profiler

0609 h Ti CTD 018 (800 m)

0734 h Pelagras in for 74 h. Deployment operation successful with 3 Pelagra deployed.

Monday 26-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

24 h station

Station 20 Irminger Basin 58º13.2N 35º02'W; water depth 2508 m

0257 h Zooplankton nets

0314 h operations suspended due to poor weather conditions

0852 h Stainless CTD 023 (full depth)

1108 h Vertical Profiler

1251 h Ti CTD 019 (full depth)

1531 h SAPS 9

1802 h Stainless CTD 024 for Th/Po/Pb (600 m)

2240 h SAPS 10

Tuesday 27-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

24 h station

Station 21 Irminger Basin 58º8.2'N 35ºW; water depth 2579 m

0314 h Zooplankton nets

0410 h Stainless CTD 025 (800 m)

0550 h Vertical Profiler

0652 h Ti CTD 020 (800 m)

Return north to retrieve Pelagras (after midday Wednesday)

Wednesday 28-7-2010

1540 h Pelagra recovery completed

Thursday 29-7-2010

Planned station and bioassay work cancelled due to bad weather. We steamed on to 63º50'N 35ºW. Wind force 8-9 during day. Arrive at planned 63º50'N 35ºW at 2000 h. Wait there until station 22.

Friday 30-7-2010

0200 h Bioassay water collection from fish (whilst steaming)

24 h station

Station 22 Irminger Basin 63º50'N 35º1.9'W ; water depth 2124 m

0304 h Zooplankton nets

0430 h Stainless CTD 026 (full depth)

0642 h SAPS 11

0932 h Ti CTD 021 (full depth)

1204 h Vertical Profiler

1346 h Stainless CTD 027 for Th/Po/Pb (1000 m)

1902 h SAPS 12

Saturday 31-7-2010

0000 h Bioassay water collection from fish (whilst steaming)

Station 23 Irminger Basin 63º50'N 35º1.2'W; water depth 2110 m

0255 h Zooplankton nets

0353 h Stainless CTD 028 (800 m)

0522 h Vertical Profiler

0644 h Ti CTD 022 (800 m)

Sunday August 1

0200 h Bioassay water collection from fish (whilst steaming)

Station 24 Mid Atlantic Ridge 62º28'N 28º21.3'W; water depth 1681 m

0300 h Zooplankton nets

0357 h Stainless CTD 029 (full depth)

0540 h Vertical Profiler

0658 h Ti CTD 023 (full depth)

0846 h SAPS 13

1058 h Depart for Reykjavik to disembark scientist for compassionate reason; steam for 20 h. Plan of sampling re-organised and station dropped due to time constraints.

Monday August 2

0800 h Agent launch met off Reykjavik and scientist was disembarked. We set course for station 25

Station 25 Iceland Shelf 63º26' N 23º35.51'W; water depth 203 m

1644 h Stainless CTD 030 (full depth)

1733 h Vertical Profiler

1830 h Ti CTD 024 (full depth)

1857 h Steam for 2 h

Station 26 Iceland Shelf 63º09.8'N 23º47.50'W; water depth 413 m

2051 h Ti CTD 025 (full depth)

2100 h Steam for ca. 8 h

Successful day on shelf, with two good CTD stations. Vertical profiler worked again after some minor repairs.

Tuesday August 3

0100 h Bioassay water collection from fish (whilst steaming)

Station 27 Mid Atlantic Ridge 62º8.3'N 24º20.5'W; water depth 1376 m

0456 h Zooplankton nets

0606 h Stainless CTD 031 (full depth)

0804 h Pelagra out for 72 h

0955 h Ti CTD 026 (full depth)

1140 h Vertical Profiler

1259 h SAPS 14

1536 h Stainless CTD 032 (500 m)

1600 h Steam for 11 h

Successful day with all operations going as planned.

Wednesday August 4

0000 h Bioassay water collection from fish (whilst steaming

Station 28 Iceland Basin 61º15'N 20º42'W; water depth 2229 m

0330 h Zooplankton nets

0425 h Stainless CTD 033 (full depth)

0634 h Vertical Profiler

0752 h Ti CTD 027 (full depth)

1006 h SAPS 15

1257 h Stainless CTD 034 (600 m) Th/Po

1350 h Steam for 15 h

Successful day with all operations going as planned.

Thursday August 5

0200 h Bioassay water collection from fish (whilst steaming)

Station 29 Mid Atlantic Ridge 61º50.4'N 25º40'W; water depth 1316 m

0505 h Zooplankton nets

0544 h Stainless CTD 035 (full depth)

0710 h Vertical Profiler

0835 h Ti CTD 028 (full depth)

0952 h Steam for 1.5 h

Steam to station 29 was slower as expected due to weather conditions. This resulted in a 2 h later start as planned. We were unable to make up the time during the day, resulting in a very long science day for quite a number of the scientific team. Nevertheless, all went well and all operations were conducted.

Station 30 Mid Atlantic Ridge 61º55.1'N 26º16.6'W; water depth 780 m

1115 h Vertical Profiler

1254 h Ti CTD 029 (full depth)

1354 h Steam for 1.5 h

Station 31 Mid Atlantic Ridge 61º58.4'N 26º42.45'W; water depth 1007 m

1515 h Stainless CTD 036 (full depth) (incl. Po)

1636 h Vertical Profiler

1741 h Ti CTD 030 (full depth)

1901 h SAPS 16

2116 h Steam for 2 h

Station 32 Mid Atlantic Ridge 62º07.23'N 27º16'W; water depth 1356 m

2321 h Ti CTD 031 (full depth)

Friday August 6

0050 h Vertical Profiler

0207 h Steam for 8 h

Pelagras have come up, and had not moved much from deployment site.

First Pelagra was retrieved at 0917 h with last unit at 1220 h.

Steam for 15 h

Saturday August 7

Station 33 Iceland Basin 60.21.3ºN 20º56.4'W; water depth 2661 m

0200 h Bioassay water collection from fish (whilst steaming)

0300 h Zooplankton nets

0357 h Stainless CTD 037 (800 m)

0515 h SAPS 17

0748 h Vertical Profiler

0914 h Ti CTD 032 (800 m)

1028 h SAPS 18

1309 h Stainless CTD 038 (600 m) Th/Po

1400 h Transit to Birkenhead whilst towing trace metal clean fish

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Wednesday August 11

Arrive Birkenhead at 1400 h BST

Vittoria Dock

3. Underway samples, date, time and position and the parameters sampled for D354

Table B2: Samples labelled U1-U102 are underway samples for trace metal (TM) analysis, samples 1-466 are for nutrients (TON, P, Si), chlorophyll and salinity measurements.

underway	date	Time	Jday	Lat (N)	Lon (W)	sampled for:
1	07/07/2010	04:01	187	55.913	-7.6743	TON,P,Si,Chl,S
2	07/07/2010	5 :0 1	187	55.9939	-7.9052	TON,P,Si,Chl,S
3	07/07/2010	6 :0 2	187	56.0805	-8.1531	TON,P,Si,Chl,S
4	07/07/2010	7 :0 1	187	56.1633	-8.3902	TON,P,Si,Chl,S
5	07/07/2010	8 :0 0	187	56.2449	-8.6244	TON,P,Si,Chl,S
6	07/07/2010	9 :0 3	187	56.3319	-8.8753	TON,P,Si,Chl,S
7	07/07/2010	9 : 57	187	56.4054	-9.0866	TON,P,Si,Chl,S
U1	07/07/2010	10:00	187	56.4095	-9.0987	TM
8	07/07/2010	10 : 56	187	56.4909	-9.3347	TON,P,Si,Chl,S
9	07/07/2010	11 : 58	187	56.5816	-9.5966	TON,P,Si,Chl,S
10	07/07/2010	13 : 0	187	56.6749	-9.8681	TON,P,Si,Chl,S
11	07/07/2010	13 : 59	187	56.7666	-10.1349	TON,P,Si,Chl,S
12	07/07/2010	15 :0 0	187	56.8077	-10.2853	TON,P,Si,Chl,S
13	07/07/2010	16 :0 0	187	56.8652	-10.443	TON,P,Si,Chl,S
14	07/07/2010	17 :0 0	187	56.9524	-10.6779	TON,P,Si,Chl,S
15	07/07/2010	17 : 58	187	57.0293	-10.9041	TON,P,Si,Chl,S
U2	07/07/2010	18:20	187	57.0572	-10.9858	TM
16	07/07/2010	19 :0 0	187	57.1049	-11.1254	TON,P,Si,Chl,S
17	07/07/2010	20 :0 2	187	57.177	-11.3389	TON,P,Si,Chl,S
18	07/07/2010	21 :0 2	187	57.2405	-11.528	TON,P,Si,Chl,S
19	07/07/2010	22 :0 0	187	57.2404	-11.6374	TON,P,Si,Chl,S
20	07/07/2010	23 :0 1	187	57.2246	-11.6863	TON,P,Si,Chl,S
21	08/07/2010	0 :0 2	188	57.1986	-11.7383	TON,P,Si,Chl,S
22	08/07/2010	1 :0 0	188	57.1765	-11.7751	TON,P,Si,Chl,S
23	08/07/2010	2 :0 2	188	57.153	-11.8189	TON,P,Si,Chl,S
24	08/07/2010	3 :0 1	188	57.1253	-11.8554	TON,P,Si,Chl,S
25	08/07/2010	4 :0 3	188	57.1073	-11.8847	TON,P,Si,Chl,S
26	08/07/2010	5 :0 0	188	57.0654	-11.9513	TON,P,Si,Chl,S
27	08/07/2010	6 :0 0	188	57.0181	-12.0296	TON,P,Si,Chl,S
28	08/07/2010	6 : 59	188	56.973	-12.1035	TON,P,Si,Chl,S
29	08/07/2010	8 :0 0	188	56.9505	-12.141	TON,P,Si,Chl,S
30	08/07/2010	9 :0 0	188	56.9197	-12.1951	TON,P,Si,Chl,S
31	08/07/2010	10 :0 0	188	56.8955	-12.2544	TON,P,Si,Chl,S
32	08/07/2010	12 :0 0	188	56.8464	-12.4001	TON,P,Si,Chl,S
33	08/07/2010	16 :0 2	188	56.7319	-12.1843	TON,P,Si,Chl,S
34	08/07/2010	19 : 58	188	56.5315	-11.1013	TON,P,Si,Chl,S
35	08/07/2010	21 : 10	188	56.4704	-10.7694	TON,P,Si,Chl,S
36	08/07/2010	22 :0 8	188	56.4124	-10.4849	TON,P,Si,Chl,S
37	08/07/2010	23 :0 3	188	56.3626	-10.2229	TON,P,Si,Chl,S
38	09/07/2010	0 :0 3	189	56.309	-9.937	TON,P,Si,Chl,S
39	10/07/2010	12 :0 4	190	55.8225	-7.3123	TON,P,Si,Chl,S

40	10/07/2010	13 :0 0	190	55.9039	-7.5562	TON,P,Si,Chl,S
41	10/07/2010	13 : 59	190	55.9686	-7.7607	TON,P,Si,Chl,S
42	10/07/2010	15 :0 0	190	56.0485	-8.0139	TON,P,Si,Chl,S
43	10/07/2010	16 :0 0	190	56.1261	-8.2608	TON,P,Si,Chl,S
44	10/07/2010	16 : 59	190	56.2036	-8.5059	TON,P,Si,Chl,S
U3	10/07/2010	18:00	190	56.289	-8.7514	TM
45	10/07/2010	18 :0 8	190	56.3004	-8.7843	TON,P,Si,Chl,S
46	10/07/2010	19 :0 8	190	56.3872	-9.0343	TON,P,Si,Chl,S
47	10/07/2010	20 :0 7	190	56.4697	-9.2729	TON,P,Si,Chl,S
48	10/07/2010	20 : 56	190	56.5396	-9.4755	TON,P,Si,Chl,S
U4	10/07/2010	22:00	190	56.6346	-9.7507	TM
49	10/07/2010	22 :0 6	190	56.6436	-9.7769	TON,P,Si,Chl,S
50	10/07/2010	22 : 58	190	56.721	-10.0019	TON,P,Si,Chl,S
51	11/07/2010	0 :0 0	191	56.8108	-10.2642	TON,P,Si,Chl,S
52	11/07/2010	1 :0 2	191	56.8981	-10.5193	TON,P,Si,Chl,S
53	11/07/2010	2 :0 4	191	56.9903	-10.789	TON,P,Si,Chl,S
U5	11/07/2010	2:30	191	57.0285	-10.9011	TM
54	11/07/2010	3 :0 9	191	57.0847	-11.0663	TON,P,Si,Chl,S
55	11/07/2010	3 : 52	191	57.1474	-11.2513	TON,P,Si,Chl,S
56	11/07/2010	5 :0 2	191	57.2499	-11.5539	TON,P,Si,Chl,S
U6	11/07/2010	6:02	191	57.3351	-11.8051	TM
57	11/07/2010	6 :0 8	191	57.3434	-11.8299	TON,P,Si,Chl,S
58	11/07/2010	7 :0 4	191	57.4237	-12.0682	TON,P,Si,Chl,S
59	11/07/2010	7 : 59	191	57.5048	-12.3095	TON,P,Si,Chl,S
U7	11/07/2010	10:02	191	57.632	-12.6629	TM
60	11/07/2010	10 :0 4	191	57.635	-12.6717	TON,P,Si,Chl,S
61	11/07/2010	11 :0 2	191	57.7196	-12.9323	TON,P,Si,Chl,S
62	11/07/2010	12 :0 0	191	57.8054	-13.1962	TON,P,Si,Chl,S
63	11/07/2010	13 :0 2	191	57.899	-13.4841	TON,P,Si,Chl,S
U8	11/07/2010	14:04	191	57.9928	-13.7703	TM
64	11/07/2010	14 :0 4	191	57.9928	-13.7703	TON,P,Si,Chl,S
65	11/07/2010	16 :0 0	191	58.1689	-14.3025	TON,P,Si,Chl,S
66	11/07/2010	17 :0 2	191	58.2439	-14.5375	TON,P,Si,Chl,S
67	11/07/2010	18 :0 0	191	58.2399	-14.5273	TON,P,Si,Chl,S
68	11/07/2010	21 :0 0	191	58.2736	-14.6377	TON,P,Si,Chl,S
U9	11/07/2010	21:58	191	58.3631	-14.9038	TM
69	11/07/2010	22 :0 0	191	58.3663	-14.9132	TON,P,Si,Chl,S
70	11/07/2010	23 :0 0	191	58.4626	-15.2011	TON,P,Si,Chl,S
71	11/07/2010	23 : 59	191	58.5575	-15.4864	TON,P,Si,Chl,S
72	12/07/2010	1 :0 8	192	58.6656	-15.8185	TON,P,Si,Chl,S
73	12/07/2010	2 :0 2	192	58.7484	-16.073	TON,P,Si,Chl,S
U10	12/07/2010	2:30	192	58.7915	-16.2059	TM
74	12/07/2010	3 :0 2	192	58.8407	-16.3576	TON,P,Si,Chl,S
75	12/07/2010	3 : 57	192	58.9253	-16.6194	TON,P,Si,Chl,S
76	12/07/2010	5 :0 7	192	59.0341	-16.9567	TON,P,Si,Chl,S
77	12/07/2010	6 :0 0	192	59.1194	-17.2223	TON,P,Si,Chl,S
U11	12/07/2010	6:02	192	59.1225	-17.2321	TM
78	12/07/2010	7 :0 4	192	59.2181	-17.5298	TON,P,Si,Chl,S

79	12/07/2010	7 : 54	192	59.2946	-17.7691	TON,P,Si,Chl,S
80	12/07/2010	8 : 59	192	59.3933	-18.0783	TON,P,Si,Chl,S
U12	12/07/2010	10:00	192	59.4876	-18.3747	TM
81	12/07/2010	10 :0 0	192	59.4876	-18.3747	TON,P,Si,Chl,S
82	12/07/2010	11 :0 0	192	59.5791	-18.6634	TON,P,Si,Chl,S
83	12/07/2010	12 :0 8	192	59.6853	-18.9964	TON,P,Si,Chl,S
84	12/07/2010	13 :0 0	192	59.7626	-19.2411	TON,P,Si,Chl,S
85	12/07/2010	13 : 59	192	59.8489	-19.5173	TON,P,Si,Chl,S
U13	12/07/2010	14:00	192	59.8502	-19.522	TM
86	12/07/2010	15 :0 0	192	59.9351	-19.7931	TON,P,Si,Chl,S
U13a	12/07/2010	15:21	192	59.9658	-19.89	TM
U14	13/07/2010	2:59	193	60.0081	-20.0104	TM
87	13/07/2010	11 :0 4	193	60.0546	-19.9063	TON,P,Si,Chl,S
88	13/07/2010	12 :0 8	193	60.2346	-19.9239	TON,P,Si,Chl,S
89	13/07/2010	12 : 53	193	60.3544	-19.9511	TON,P,Si,Chl,S
U15	13/07/2010	13:57	193	60.5226	-19.9768	TM
90	13/07/2010	13 : 59	193	60.5279	-19.9773	TON,P,Si,Chl,S
91	13/07/2010	15 :0 0	193	60.694	-19.9929	TON,P,Si,Chl,S
92	13/07/2010	15 : 59	193	60.8574	-19.99	TON,P,Si,Chl,S
93	13/07/2010	17 :0 5	193	61.0375	-19.981	TON,P,Si,Chl,S
U16	13/07/2010	18:00	193	61.187	-19.9984	TM
94	13/07/2010	18 :0 0	193	61.187	-19.9984	TON,P,Si,Chl,S
95	13/07/2010	19 :0 5	193	61.356	-20.0052	TON,P,Si,Chl,S
96	13/07/2010	20 :0 4	193	61.5056	-19.9957	TON,P,Si,Chl,S
97	13/07/2010	21 :0 3	193	61.6605	-19.9876	TON,P,Si,Chl,S
U17	13/07/2010	21:58	193	61.8128	-19.9879	TM
98	13/07/2010	22 :0 0	193	61.8184	-19.9881	TON,P,Si,Chl,S
99	13/07/2010	22 : 57	193	61.9758	-19.9853	TON,P,Si,Chl,S
100	14/07/2010	0 :0 5	194	62.0024	-20.3623	TON,P,Si,Chl,S
101	14/07/2010	1 :0 3	194	61.9989	-20.7062	TON,P,Si,Chl,S
102	14/07/2010	2 :0 0	194	61.9779	-20.9984	TON,P,Si,Chl,S
U18	14/07/2010	3:45	194	61.827	-21.0092	TM
103	14/07/2010	14 :0 4	194	61.7212	-21.0756	TON,P,Si,Chl,S
U19	14/07/2010	14:15	194	61.6875	-21.0728	TM
104	14/07/2010	14 : 56	194	61.5622	-21.0508	TON,P,Si,Chl,S
105	14/07/2010	15 : 58	194	61.374	-21.0107	TON,P,Si,Chl,S
106	14/07/2010	16 : 58	194	61.1939	-20.9764	TON,P,Si,Chl,S
107	14/07/2010	17 : 55	194	61.0165	-20.9757	TON,P,Si,Chl,S
U20	14/07/2010	18:15	194	60.954	-20.9769	TM
108	14/07/2010	18 : 56	194	60.8267	-20.9883	TON,P,Si,Chl,S
109	14/07/2010	19 : 56	194	60.6481	-21.0038	TON,P,Si,Chl,S
110	14/07/2010	20 : 59	194	60.463	-21.0168	TON,P,Si,Chl,S
111	14/07/2010	21 : 57	194	60.2902	-21.0239	TON,P,Si,Chl,S
U21	14/07/2010	21:59	194	60.2842	-21.0235	TM
112	14/07/2010	23 :0 1	194	60.097	-21.0094	TON,P,Si,Chl,S
113	15/07/2010	0 :0 3	195	59.9993	-20.8422	TON,P,Si,Chl,S
114	15/07/2010	1 :0 3	195	59.9995	-20.5497	TON,P,Si,Chl,S
U22	15/07/2010	1:40	195	60.0025	-20.364	TM

115	15/07/2010	2 :0 1	195	60.0059	-20.2576	TON,P,Si,Chl,S
116	15/07/2010	9 :0 0	195	60.0539	-19.7128	TON,P,Si,Chl,S
U23	15/07/2010	10:00	195	60.0712	-19.3433	TM
117	15/07/2010	10 :0 0	195	60.0712	-19.3433	TON,P,Si,Chl,S
118	15/07/2010	11 :0 0	195	60.0828	-18.9682	TON,P,Si,Chl,S
119	15/07/2010	12 :0 0	195	60.1076	-18.7212	TON,P,Si,Chl,S
120	15/07/2010	13 :0 0	195	60.1634	-18.7452	TON,P,Si,Chl,S
121	15/07/2010	14 :0 2	195	60.1504	-19.1108	TON,P,Si,Chl,S
122	15/07/2010	15 :0 0	195	60.1355	-19.4186	TON,P,Si,Chl,S
123	15/07/2010	16 :0 0	195	60.121	-19.7671	TON,P,Si,Chl,S
124	15/07/2010	16 : 57	195	60.1128	-20.1024	TON,P,Si,Chl,S
125	15/07/2010	17 : 59	195	60.1039	-20.474	TON,P,Si,Chl,S
U24	15/07/2010	18:02	195	60.1033	-20.4922	TM
126	15/07/2010	18 : 58	195	60.0887	-20.8286	TON,P,Si,Chl,S
127	15/07/2010	20 :0 0	195	60.0666	-21.2021	TON,P,Si,Chl,S
128	15/07/2010	20 : 57	195	60.0514	-21.5452	TON,P,Si,Chl,S
U25	15/07/2010	21:57	195	60.0402	-21.8984	TM
129	15/07/2010	21 : 57	195	60.0402	-21.8984	TON,P,Si,Chl,S
130	15/07/2010	22 : 55	195	60.0313	-22.2416	TON,P,Si,Chl,S
131	15/07/2010	23 : 58	195	60.0266	-22.6207	TON,P,Si,Chl,S
132	16/07/2010	1 :0 6	196	60.0195	-23.0295	TON,P,Si,Chl,S
133	16/07/2010	2 :0 6	196	60.0086	-23.3881	TON,P,Si,Chl,S
U26	16/07/2010	2:30	196	60.0032	-23.5321	TM
134	16/07/2010	3 :0 2	196	60.0002	-23.6246	TON,P,Si,Chl,S
135	16/07/2010	13 : 56	196	59.9813	-23.652	TON,P,Si,Chl,S
U27	16/07/2010	14:07	196	59.9827	-23.7116	TM
136	16/07/2010	15 :0 0	196	59.9928	-24.0074	TON,P,Si,Chl,S
137	16/07/2010	16 :0 1	196	59.9981	-24.3511	TON,P,Si,Chl,S
138	16/07/2010	16 : 58	196	60.0039	-24.6759	TON,P,Si,Chl,S
139	16/07/2010	18 :0 0	196	60.0176	-25.0383	TON,P,Si,Chl,S
U28	16/07/2010	18:05	196	60.0174	-25.0674	TM
140	16/07/2010	19 :0 4	196	60.0127	-25.4135	TON,P,Si,Chl,S
141	16/07/2010	19 : 56	196	60.0036	-25.7219	TON,P,Si,Chl,S
142	16/07/2010	20 : 57	196	59.9995	-26.091	TON,P,Si,Chl,S
143	16/07/2010	22 :0 0	196	59.9991	-26.4662	TON,P,Si,Chl,S
U29	16/07/2010	22:02	196	59.999	-26.4783	TM
144	16/07/2010	23 :0 0	196	60.0005	-26.8232	TON,P,Si,Chl,S
145	17/07/2010	0 :0 0	197	60.0047	-27.1749	TON,P,Si,Chl,S
146	17/07/2010	1 :0 6	197	60.0023	-27.5543	TON,P,Si,Chl,S
U30	17/07/2010	1:45	197	60.0001	-27.7733	TM
147	17/07/2010	2 :0 1	197	60	-27.8639	TON,P,Si,Chl,S
148	17/07/2010	3 :0 4	197	60.0079	-28.1412	TON,P,Si,Chl,S
U31	17/07/2010	10:09	197	60.0113	-28.3723	TM
149	17/07/2010	11 :0 0	197	60.0083	-28.6918	TON,P,Si,Chl,S
150	17/07/2010	12 :0 0	197	60.0074	-29.0682	TON,P,Si,Chl,S
151	17/07/2010	13 :0 0	197	60.0059	-29.4279	TON,P,Si,Chl,S
U32	17/07/2010	14:01	197	60.0106	-29.8003	TM
152	17/07/2010	14 :0 2	197	60.0108	-29.8064	TON,P,Si,Chl,S

153	17/07/2010	14 : 59	197	60.0118	-30.1465	TON,P,Si,Chl,S
154	17/07/2010	15 : 57	197	60.0112	-30.4893	TON,P,Si,Chl,S
155	17/07/2010	16 : 59	197	60.01	-30.8643	TON,P,Si,Chl,S
156	17/07/2010	17 : 56	197	60.0095	-31.2096	TON,P,Si,Chl,S
U33	17/07/2010	18:00	197	60.0095	-31.2333	TM
157	17/07/2010	18 : 59	197	60.0085	-31.5827	TON,P,Si,Chl,S
158	17/07/2010	19 : 57	197	60.0075	-31.9245	TON,P,Si,Chl,S
159	17/07/2010	20 : 57	197	60.0067	-32.2775	TON,P,Si,Chl,S
160	17/07/2010	21 : 58	197	60.0059	-32.6517	TON,P,Si,Chl,S
U34	17/07/2010	21:59	197	60.0058	-32.6578	TM
161	17/07/2010	22 : 59	197	60.0048	-33.022	TON,P,Si,Chl,S
162	17/07/2010	23 : 59	197	60.0039	-33.3751	TON,P,Si,Chl,S
163	18/07/2010	1 :0 5	198	60.003	-33.7667	TON,P,Si,Chl,S
164	18/07/2010	1 : 57	198	60.0023	-34.0676	TON,P,Si,Chl,S
U35	18/07/2010	3:00	198	60.0015	-34.4359	TM
165	18/07/2010	3 :0 5	198	60.0013	-34.4654	TON,P,Si,Chl,S
166	18/07/2010	4 :0 6	198	60.0005	-34.8228	TON,P,Si,Chl,S
U36	19/07/2010	2:12	199	60.0103	-35.0059	TM
167	19/07/2010	8 : 17	199	60.0104	-34.9729	TON,P,Si,Chl,S
U36a	19/07/2010	8:34	199	60.009	-35.0584	TM
168	19/07/2010	9 :0 8	199	60.0083	-35.2517	TON,P,Si,Chl,S
169	19/07/2010	10 :0 0	199	60.0074	-35.5494	TON,P,Si,Chl,S
170	19/07/2010	11 :0 0	199	60.0063	-35.8979	TON,P,Si,Chl,S
U37	19/07/2010	11:29	199	60.0058	-36.0673	TM
171	19/07/2010	12 :0 0	199	60.0052	-36.2484	TON,P,Si,Chl,S
172	19/07/2010	13 :0 0	199	60.0041	-36.5925	TON,P,Si,Chl,S
173	19/07/2010	14 :0 0	199	60.0032	-36.9366	TON,P,Si,Chl,S
U38	19/07/2010	14:02	199	60.0031	-36.948	TM
174	19/07/2010	14 : 52	199	60.0024	-37.2341	TON,P,Si,Chl,S
175	19/07/2010	15 : 58	199	60.0012	-37.618	TON,P,Si,Chl,S
176	19/07/2010	16 : 55	199	60.0001	-37.9465	TON,P,Si,Chl,S
177	19/07/2010	17 : 55	199	59.9999	-38.2933	TON,P,Si,Chl,S
U39	19/07/2010	18:01	199	59.9998	-38.3277	TM
178	19/07/2010	19 :0 5	199	60	-38.6911	TON,P,Si,Chl,S
179	19/07/2010	20 :0 0	199	60	-39.0088	TON,P,Si,Chl,S
180	19/07/2010	20 : 59	199	60	-39.3524	TON,P,Si,Chl,S
U40	19/07/2010	21:56	199	60.0002	-39.6784	TM
181	19/07/2010	22 :0 0	199	60.0001	-39.7013	TON,P,Si,Chl,S
182	19/07/2010	22 : 58	199	60.0001	-40.0343	TON,P,Si,Chl,S
183	20/07/2010	0 :0 1	200	60	-40.4	TON,P,Si,Chl,S
184	20/07/2010	0 : 57	200	59.9999	-40.7279	TON,P,Si,Chl,S
185	20/07/2010	2 :0 6	200	59.9995	-41.1227	TON,P,Si,Chl,S
U41	20/07/2010	2:14	200	59.9997	-41.1677	TM
186	20/07/2010	3 : 10	200	59.9938	-41.3619	TON,P,Si,Chl,S
U42	20/07/2010	13:33	200	59.9432	-41.5	TM
U43	20/07/2010	16:30	200	59.9926	-41.7516	TM
187	20/07/2010	16 : 59	200	59.999	-41.9059	TON,P,Si,Chl,S
U44	20/07/2010	18:59	200	59.9868	-42.02	TM

U45	20/07/2010	20:59	200	59.9946	-42.2931	TM
188	21/07/2010	3 :0 8	201	59.9973	-42.476	TON,P,Si,Chl,S
189	21/07/2010	4 : 28	201	60.0002	-42.013	TON,P,Si,Chl,S
190	21/07/2010	5 : 11	201	60.0003	-41.7553	TON,P,Si,Chl,S
191	21/07/2010	6 : 12	201	59.9997	-41.3981	TON,P,Si,Chl,S
192	21/07/2010	7 : 13	201	60.0005	-41.0317	TON,P,Si,Chl,S
193	21/07/2010	8 :0 2	201	60.0002	-40.7396	TON,P,Si,Chl,S
194	21/07/2010	9 :0 0	201	60.0001	-40.3922	TON,P,Si,Chl,S
195	21/07/2010	10 :0 0	201	59.9999	-40.0308	TON,P,Si,Chl,S
196	21/07/2010	11 :0 0	201	60	-39.6681	TON,P,Si,Chl,S
197	21/07/2010	12 :0 1	201	59.9999	-39.2955	TON,P,Si,Chl,S
U46	21/07/2010	12:04	201	59.9999	-39.2773	TM
198	21/07/2010	13 :0 0	201	60.0002	-38.9355	TON,P,Si,Chl,S
U47	21/07/2010	13:45	201	60.0002	-38.6659	TM
199	21/07/2010	14 :0 0	201	60.0002	-38.5766	TON,P,Si,Chl,S
200	21/07/2010	15 : 35	201	60	-38.0117	TON,P,Si,Chl,S
201	21/07/2010	16 :0 1	201	59.9998	-37.8574	TON,P,Si,Chl,S
202	21/07/2010	17 :0 1	201	60.0001	-37.4963	TON,P,Si,Chl,S
203	21/07/2010	17 : 57	201	60.0001	-37.1517	TON,P,Si,Chl,S
U48	21/07/2010	18:13	201	60	-37.0517	TM
204	21/07/2010	19 : 14	201	60.0001	-36.6739	TON,P,Si,Chl,S
205	21/07/2010	19 : 57	201	60.0001	-36.4073	TON,P,Si,Chl,S
206	21/07/2010	20 : 55	201	60.0001	-36.0445	TON,P,Si,Chl,S
207	21/07/2010	21 : 58	201	60.0002	-35.6583	TON,P,Si,Chl,S
U49	21/07/2010	22:09	201	60.0002	-35.5911	TM
208	21/07/2010	22 : 54	201	60	-35.3161	TON,P,Si,Chl,S
209	22/07/2010	0 :0 0	202	59.9983	-34.998	TON,P,Si,Chl,S
210	22/07/2010	1 : 22	202	59.9863	-34.9836	TON,P,Si,Chl,S
211	22/07/2010	9 : 11	202	60.009	-34.8619	TON,P,Si,Chl,S
212	22/07/2010	10 :0 0	202	60.0744	-34.7509	TON,P,Si,Chl,S
U50	22/07/2010	10:21	202	60.1111	-34.7039	TM
213	22/07/2010	12 :0 0	202	60.2481	-34.5526	TON,P,Si,Chl,S
214	22/07/2010	12 : 53	202	60.1452	-34.5914	TON,P,Si,Chl,S
215	22/07/2010	14 : 28	202	60.3883	-34.6529	TON,P,Si,Chl,S
216	22/07/2010	15 :0 2	202	60.4705	-34.6751	TON,P,Si,Chl,S
217	22/07/2010	16 :0 3	202	60.6623	-34.6973	TON,P,Si,Chl,S
U51	22/07/2010	16 : 0 7	202	60.6534	-34.696	TM
218	22/07/2010	16 : 54	202	60.8198	-34.7183	TON,P,Si,Chl,S
219	22/07/2010	18 :0 0	202	61.028	-34.7443	TON,P,Si,Chl,S
U52	22/07/2010	18 : 0 3	202	61.0281	-34.7443	TM
220	22/07/2010	18 : 58	202	61.2118	-34.7677	TON,P,Si,Chl,S
221	22/07/2010	19 : 58	202	61.3969	-34.7917	TON,P,Si,Chl,S
222	22/07/2010	20 : 59	202	61.5796	-34.8149	TON,P,Si,Chl,S
223	22/07/2010	22 :0 0	202	61.7646	-34.839	TON,P,Si,Chl,S
U53	22/07/2010	22 : 0 5	202	61.7649	-34.839	TM
224	22/07/2010	23 :0 0	202	61.9488	-34.8581	TON,P,Si,Chl,S
225	22/07/2010	23 : 57	202	62.1239	-34.8892	TON,P,Si,Chl,S
226	23/07/2010	0 : 58	203	62.3105	-34.911	TON,P,Si,Chl,S

227	23/07/2010	1 : 57	203	62.4899	-34.9347	TON,P,Si,Chl,S
228	23/07/2010	3 :0 7	203	62.706	-34.964	TON,P,Si,Chl,S
U54	23/07/2010	4 : 0 0	203	62.8685	-34.9857	TM
229	23/07/2010	4 :0 0	203	62.8685	-34.9857	TON,P,Si,Chl,S
230	23/07/2010	5 :0 4	203	63	-35.0027	TON,P,Si,Chl,S
U55	24/07/2010	1 : 30	204	63.0289	-35.3055	TM
U55a	24/07/2010	8 : 0 1	204	63.0059	-34.9396	TM
231	24/07/2010	10 :0 0	204	62.9978	-34.3797	TON,P,Si,Chl,S
U56	24/07/2010	10 : 17	204	62.9979	-34.3785	TM
232	24/07/2010	11 :0 0	204	62.9979	-34.1136	TON,P,Si,Chl,S
233	24/07/2010	12 :0 8	204	62.9939	-33.8035	TON,P,Si,Chl,S
234	24/07/2010	12 : 59	204	62.995	-33.5608	TON,P,Si,Chl,S
U57	24/07/2010	13 : 55	204	62.9951	-33.5516	TM
235	24/07/2010	14 :0 2	204	62.9965	-33.2602	TON,P,Si,Chl,S
236	24/07/2010	15 : 10	204	62.9977	-32.9431	TON,P,Si,Chl,S
237	24/07/2010	16 :0 0	204	62.9988	-32.7088	TON,P,Si,Chl,S
238	24/07/2010	17 :0 1	204	62.9998	-32.4163	TON,P,Si,Chl,S
239	24/07/2010	17 : 56	204	63.0002	-32.1469	TON,P,Si,Chl,S
U58	24/07/2010	18 : 0 7	204	63.0001	-32.126	TM
240	24/07/2010	19 :0 7	204	63	-31.7825	TON,P,Si,Chl,S
241	24/07/2010	19 : 58	204	63	-31.5153	TON,P,Si,Chl,S
242	24/07/2010	21 :0 0	204	63.0001	-31.2464	TON,P,Si,Chl,S
243	24/07/2010	22 :0 0	204	62.9999	-31.0239	TON,P,Si,Chl,S
U59	24/07/2010	22 : 0 4	204	62.9999	-31.0236	TM
244	24/07/2010	23 :0 0	204	63.0001	-30.7994	TON,P,Si,Chl,S
245	25/07/2010	0 :0 0	205	62.9999	-30.6067	TON,P,Si,Chl,S
246	25/07/2010	1 :0 2	205	63.0001	-30.3919	TON,P,Si,Chl,S
247	25/07/2010	2 :0 5	205	63	-30.16	TON,P,Si,Chl,S
U60	25/07/2010	2 : 32	205	63	-30.1772	TM
248	25/07/2010	3 :0 0	205	63.0005	-29.999	TON,P,Si,Chl,S
249	25/07/2010	14 :0 4	205	62.89	-29.8914	TON,P,Si,Chl,S
U61	25/07/2010	14 : 0 9	205	62.8995	-29.8831	TM
250	25/07/2010	15 :0 2	205	62.7445	-30.0166	TON,P,Si,Chl,S
251	25/07/2010	16 :0 8	205	62.5784	-30.1592	TON,P,Si,Chl,S
252	25/07/2010	16 : 59	205	62.4504	-30.269	TON,P,Si,Chl,S
253	25/07/2010	18 :0 0	205	62.2954	-30.4007	TON,P,Si,Chl,S
U62	25/07/2010	18 : 0 7	205	62.2951	-30.401	TM
254	25/07/2010	18 : 58	205	62.1448	-30.5283	TON,P,Si,Chl,S
255	25/07/2010	20 :0 0	205	61.9792	-30.6674	TON,P,Si,Chl,S
256	25/07/2010	21 :0 0	205	61.819	-30.8018	TON,P,Si,Chl,S
257	25/07/2010	22 :0 5	205	61.6488	-30.9434	TON,P,Si,Chl,S
U63	25/07/2010	22 : 0 7	205	61.6614	-30.9331	TM
258	25/07/2010	23 :0 3	205	61.4993	-31.0678	TON,P,Si,Chl,S
259	26/07/2010	0 :0 1	206	61.3503	-31.1862	TON,P,Si,Chl,S
260	26/07/2010	0 : 58	206	61.1961	-31.2946	TON,P,Si,Chl,S
261	26/07/2010	2 :0 4	206	61.0115	-31.4224	TON,P,Si,Chl,S
U64	26/07/2010	2 : 40	206	61.0211	-31.4157	TM
262	26/07/2010	3 :0 3	206	60.8866	-31.5137	TON,P,Si,Chl,S

263	26/07/2010	9 :0 1	206	60.7897	-31.662	TON,P,Si,Chl,S
264	26/07/2010	10 :0 7	206	60.6271	-31.8633	TON,P,Si,Chl,S
U65	26/07/2010	10 : 25	206	60.643	-31.8435	TM
265	26/07/2010	11 :0 2	206	60.4913	-32.0313	TON,P,Si,Chl,S
266	26/07/2010	11 : 56	206	60.3595	-32.1937	TON,P,Si,Chl,S
267	26/07/2010	13 :0 6	206	60.1862	-32.4057	TON,P,Si,Chl,S
U66	26/07/2010	14 : 0 0	206	60.0512	-32.5698	TM
268	26/07/2010	14 :0 1	206	60.0487	-32.5728	TON,P,Si,Chl,S
269	26/07/2010	15 :0 5	206	59.8912	-32.7642	TON,P,Si,Chl,S
270	26/07/2010	16 :0 3	206	59.7479	-32.9371	TON,P,Si,Chl,S
271	26/07/2010	17 :0 0	206	59.6042	-33.11	TON,P,Si,Chl,S
272	26/07/2010	17 : 58	206	59.456	-33.2873	TON,P,Si,Chl,S
273	26/07/2010	18 : 59	206	59.3018	-33.4708	TON,P,Si,Chl,S
U67	26/07/2010	19 : 13	206	59.2988	-33.4745	TM
274	26/07/2010	19 : 59	206	59.1511	-33.6497	TON,P,Si,Chl,S
275	26/07/2010	21 :0 5	206	58.9867	-33.8443	TON,P,Si,Chl,S
U68	26/07/2010	21 : 59	206	58.9968	-33.8324	TM
276	26/07/2010	22 :0 5	206	58.8371	-34.0199	TON,P,Si,Chl,S
277	26/07/2010	23 :0 4	206	58.6929	-34.1884	TON,P,Si,Chl,S
278	27/07/2010	0 :0 1	207	58.5568	-34.3471	TON,P,Si,Chl,S
279	27/07/2010	1 :0 1	207	58.4172	-34.5093	TON,P,Si,Chl,S
280	27/07/2010	2 :0 3	207	58.2823	-34.6654	TON,P,Si,Chl,S
U69	27/07/2010	2 : 30	207	58.2866	-34.6603	TM
281	27/07/2010	2 : 59	207	58.2461	-34.7647	TON,P,Si,Chl,S
282	27/07/2010	4 : 34	207	58.2441	-34.8145	TON,P,Si,Chl,S
U70	28/07/2010	2 : 55	208	58.18	-35.1423	TM
283	28/07/2010	9 :0 3	208	58.279	-35.0372	TON,P,Si,Chl,S
U71	28/07/2010	10 : 0 2	208	58.4302	-35.0355	TM
284	28/07/2010	10 :0 5	208	58.4431	-35.0359	TON,P,Si,Chl,S
285	28/07/2010	11 :0 5	208	58.5994	-35.0304	TON,P,Si,Chl,S
286	28/07/2010	12 :0 1	208	58.7457	-35.0116	TON,P,Si,Chl,S
287	28/07/2010	13 :0 4	208	58.912	-35.008	TON,P,Si,Chl,S
U72	28/07/2010	14 : 0 0	208	59.0061	-35.2111	TM
288	28/07/2010	14 :0 3	208	59.0108	-35.2243	TON,P,Si,Chl,S
289	28/07/2010	15 :0 1	208	59.1573	-35.2043	TON,P,Si,Chl,S
290	28/07/2010	15 : 56	208	59.311	-35.1389	TON,P,Si,Chl,S
291	28/07/2010	16 : 56	208	59.4805	-35.0798	TON,P,Si,Chl,S
292	28/07/2010	17 : 58	208	59.6586	-35.077	TON,P,Si,Chl,S
U73a	28/07/2010	18 : 10	208	59.6647	-35.0773	TM
293	28/07/2010	19 :0 1	208	59.8396	-35.0749	TON,P,Si,Chl,S
294	28/07/2010	20 :0 3	208	60.0203	-35.0631	TON,P,Si,Chl,S
295	28/07/2010	21 :0 0	208	60.1886	-35.0755	TON,P,Si,Chl,S
296	28/07/2010	21 : 59	208	60.3609	-35.0803	TON,P,Si,Chl,S
U73	28/07/2010	22 : 0 5	208	60.364	-35.0805	TM
297	28/07/2010	23 :0 3	208	60.5425	-35.0918	TON,P,Si,Chl,S
298	29/07/2010	0 :0 5	209	60.7215	-35.077	TON,P,Si,Chl,S
299	29/07/2010	1 :0 2	209	60.8034	-34.8072	TON,P,Si,Chl,S
300	29/07/2010	2 :0 2	209	60.8751	-34.4917	TON,P,Si,Chl,S

U74	29/07/2010	2 : 19	209	60.8732	-34.5006	TM
301	29/07/2010	3 :0 7	209	60.9495	-34.1394	TON,P,Si,Chl,S
302	29/07/2010	4 :0 6	209	61.0188	-33.8104	TON,P,Si,Chl,S
303	29/07/2010	4 : 58	209	61.0794	-33.5199	TON,P,Si,Chl,S
304	29/07/2010	6 :0 4	209	61.1566	-33.1524	TON,P,Si,Chl,S
U75	29/07/2010	6 : 0 7	209	61.152	-33.174	TM
305	29/07/2010	7 :0 3	209	61.2249	-32.8238	TON,P,Si,Chl,S
306	29/07/2010	8 :0 0	209	61.2919	-32.5032	TON,P,Si,Chl,S
307	29/07/2010	9 :0 5	209	61.3665	-32.1433	TON,P,Si,Chl,S
U76	29/07/2010	9 : 58	209	61.3618	-32.1656	TM
308	29/07/2010	10 :0 3	209	61.3898	-31.8096	TON,P,Si,Chl,S
309	29/07/2010	11 :0 3	209	61.3402	-31.5444	TON,P,Si,Chl,S
310	29/07/2010	12 :0 0	209	61.1811	-31.5711	TON,P,Si,Chl,S
311	29/07/2010	12 : 59	209	61.0304	-31.7156	TON,P,Si,Chl,S
312	29/07/2010	14 :0 0	209	60.8774	-31.884	TON,P,Si,Chl,S
U77	29/07/2010	14 : 0 9	209	60.8771	-31.8844	TM
313	29/07/2010	15 :0 1	209	60.7294	-32.0623	TON,P,Si,Chl,S
314	29/07/2010	16 :0 5	209	60.629	-32.2445	TON,P,Si,Chl,S
315	29/07/2010	16 : 58	209	60.6262	-31.9947	TON,P,Si,Chl,S
316	29/07/2010	17 : 57	209	60.5998	-31.817	TON,P,Si,Chl,S
317	29/07/2010	19 :0 0	209	60.5848	-31.7333	TON,P,Si,Chl,S
U78	29/07/2010	19 : 36	209	60.5847	-31.7322	TM
318	29/07/2010	19 : 59	209	60.658	-31.7633	TON,P,Si,Chl,S
319	29/07/2010	21 :0 1	209	60.8138	-31.9307	TON,P,Si,Chl,S
320	29/07/2010	21 : 57	209	60.9602	-32.079	TON,P,Si,Chl,S
U79	29/07/2010	22 : 0 6	209	60.9686	-32.0868	TM
321	29/07/2010	22 : 58	209	61.1222	-32.2268	TON,P,Si,Chl,S
322	29/07/2010	23 : 56	209	61.2731	-32.371	TON,P,Si,Chl,S
323	30/07/2010	1 :0 3	210	61.4411	-32.55	TON,P,Si,Chl,S
324	30/07/2010	2 :0 4	210	61.5938	-32.7165	TON,P,Si,Chl,S
325	30/07/2010	3 : 15	210	61.77	-32.8911	TON,P,Si,Chl,S
326	30/07/2010	4 :0 5	210	61.8929	-33.0193	TON,P,Si,Chl,S
327	30/07/2010	5 :0 1	210	62.0349	-33.1617	TON,P,Si,Chl,S
328	30/07/2010	6 : 11	210	62.2111	-33.3415	TON,P,Si,Chl,S
329	30/07/2010	7 :0 8	210	62.3531	-33.4936	TON,P,Si,Chl,S
330	30/07/2010	8 :0 2	210	62.4829	-33.6377	TON,P,Si,Chl,S
331	30/07/2010	9 :0 2	210	62.6055	-33.8362	TON,P,Si,Chl,S
U80	30/07/2010	10 : 0 5	210	62.7307	-33.9543	TM
332	30/07/2010	10 : 15	210	62.759	-33.9767	TON,P,Si,Chl,S
333	30/07/2010	11 :0 4	210	62.8517	-34.0464	TON,P,Si,Chl,S
334	30/07/2010	12 :0 1	210	62.9567	-34.1331	TON,P,Si,Chl,S
335	30/07/2010	13 :0 1	210	63.0692	-34.2373	TON,P,Si,Chl,S
U81	30/07/2010	13 : 58	210	63.0691	-34.2373	TM
336	30/07/2010	14 :0 8	210	63.1971	-34.3517	TON,P,Si,Chl,S
337	30/07/2010	15 :0 3	210	63.2995	-34.4439	TON,P,Si,Chl,S
338	30/07/2010	16 :0 1	210	63.4094	-34.5546	TON,P,Si,Chl,S
339	30/07/2010	17 :0 1	210	63.5202	-34.6719	TON,P,Si,Chl,S
340	30/07/2010	18 :0 0	210	63.6299	-34.7922	TON,P,Si,Chl,S

U82	30/07/2010	18 : 0 8	210	63.6302	-34.7925	TM
341	30/07/2010	18 : 59	210	63.7244	-34.9223	TON,P,Si,Chl,S
342	30/07/2010	20 :0 0	210	63.8314	-34.9987	TON,P,Si,Chl,S
343	30/07/2010	21 :0 2	210	63.8338	-35.0208	TON,P,Si,Chl,S
344	30/07/2010	22 :0 4	210	63.8377	-35.0395	TON,P,Si,Chl,S
345	30/07/2010	23 : 10	210	63.8667	-35.0075	TON,P,Si,Chl,S
346	31/07/2010	0 :0 1	211	63.8955	-34.9664	TON,P,Si,Chl,S
347	31/07/2010	1 :0 2	211	63.9139	-34.9391	TON,P,Si,Chl,S
348	31/07/2010	2 : 40	211	63.8483	-34.9897	TON,P,Si,Chl,S
U83	31/07/2010	2 : 45	211	63.9082	-34.9352	TM
349	31/07/2010	3 : 16	211	63.8198	-35.0177	TON,P,Si,Chl,S
350	01/08/2010	0 : 21	212	63.8391	-34.9583	TON,P,Si,Chl,S
U84	01/08/2010	1 : 40	212	63.839	-34.8251	TM
351	01/08/2010	8 :0 5	212	63.8255	-34.984	TON,P,Si,Chl,S
352	01/08/2010	9 :0 0	212	63.7566	-34.6847	TON,P,Si,Chl,S
353	01/08/2010	10 :0 1	212	63.6823	-34.3317	TON,P,Si,Chl,S
U85	01/08/2010	10 : 0 2	212	63.6834	-34.3374	TM
354	01/08/2010	11 :0 0	212	63.6149	-33.9841	TON,P,Si,Chl,S
355	01/08/2010	11 : 59	212	63.5452	-33.6314	TON,P,Si,Chl,S
356	01/08/2010	13 :0 2	212	63.4815	-33.2492	TON,P,Si,Chl,S
U86	01/08/2010	14 : 0 2	212	63.4116	-32.9038	TM
357	01/08/2010	14 :0 4	212	63.4068	-32.88	TON,P,Si,Chl,S
358	01/08/2010	15 :0 5	212	63.3323	-32.5126	TON,P,Si,Chl,S
359	01/08/2010	15 : 59	212	63.2654	-32.1838	TON,P,Si,Chl,S
360	01/08/2010	17 :0 0	212	63.188	-31.804	TON,P,Si,Chl,S
361	01/08/2010	17 : 57	212	63.1163	-31.4536	TON,P,Si,Chl,S
U87	01/08/2010	18 : 11	212	63.1124	-31.4344	TM
362	01/08/2010	19 :0 1	212	63.0374	-31.0699	TON,P,Si,Chl,S
363	01/08/2010	20 :0 2	212	62.962	-30.7027	TON,P,Si,Chl,S
364	01/08/2010	21 :0 2	212	62.8915	-30.3599	TON,P,Si,Chl,S
U88	01/08/2010	22 : 0 0	212	62.8239	-30.0329	TM
365	01/08/2010	22 :0 6	212	62.817	-29.9987	TON,P,Si,Chl,S
366	01/08/2010	23 :0 0	212	62.7541	-29.6956	TON,P,Si,Chl,S
367	01/08/2010	23 : 58	212	62.6855	-29.3654	TON,P,Si,Chl,S
368	02/08/2010	1 :0 4	213	62.6065	-28.9859	TON,P,Si,Chl,S
369	02/08/2010	2 :0 3	213	62.5365	-28.6505	TON,P,Si,Chl,S
U89	02/08/2010	2 : 25	213	62.5396	-28.6651	TM
370	02/08/2010	3 :0 3	213	62.4712	-28.3527	TON,P,Si,Chl,S
371	02/08/2010	12 :0 4	213	62.5983	-28.0933	TON,P,Si,Chl,S
372	02/08/2010	13 :0 2	213	62.6897	-27.7466	TON,P,Si,Chl,S
373	02/08/2010	14 : 13	213	62.8002	-27.3209	TON,P,Si,Chl,S
374	02/08/2010	15 :0 1	213	62.8744	-27.0344	TON,P,Si,Chl,S
375	02/08/2010	16 :0 6	213	62.983	-26.6491	TON,P,Si,Chl,S
376	02/08/2010	17 :0 2	213	63.0788	-26.3247	TON,P,Si,Chl,S
377	02/08/2010	18 :0 0	213	63.1743	-25.9949	TON,P,Si,Chl,S
378	02/08/2010	18 : 59	213	63.2549	-25.7193	TON,P,Si,Chl,S
379	02/08/2010	20 :0 2	213	63.3412	-25.4213	TON,P,Si,Chl,S
380	02/08/2010	21 :0 0	213	63.4183	-25.1537	TON,P,Si,Chl,S

381	02/08/2010	22 :0 0	213	63.4997	-24.8729	TON,P,Si,Chl,S
382	02/08/2010	23 :0 1	213	63.5856	-24.5741	TON,P,Si,Chl,S
383	02/08/2010	23 : 59	213	63.6675	-24.2862	TON,P,Si,Chl,S
384	03/08/2010	1 :0 3	214	63.7574	-23.9753	TON,P,Si,Chl,S
385	03/08/2010	2 :0 8	214	63.8511	-23.6443	TON,P,Si,Chl,S
386	03/08/2010	3 :0 2	214	63.9291	-23.3691	TON,P,Si,Chl,S
387	03/08/2010	4 :0 4	214	64.0086	-23.0878	TON,P,Si,Chl,S
388	03/08/2010	5 :0 1	214	64.0953	-22.8665	TON,P,Si,Chl,S
389	03/08/2010	11 :0 2	214	64.1265	-22.9115	TON,P,Si,Chl,S
390	03/08/2010	12 :0 2	214	64.0083	-23.1595	TON,P,Si,Chl,S
391	03/08/2010	13 :0 2	214	63.8971	-23.3885	TON,P,Si,Chl,S
392	03/08/2010	14 :0 1	214	63.7918	-23.6006	TON,P,Si,Chl,S
393	03/08/2010	15 :0 6	214	63.6522	-23.6653	TON,P,Si,Chl,S
U90	03/08/2010	15 : 14	214	63.6657	-23.6748	TM
394	03/08/2010	16 :0 5	214	63.5091	-23.5653	TON,P,Si,Chl,S
U91	03/08/2010	19 : 55	214	63.4091	-23.6027	TM
395	03/08/2010	20 :0 9	214	63.2402	-23.7344	TON,P,Si,Chl,S
396	03/08/2010	22 :0 0	214	63.1394	-23.8097	TON,P,Si,Chl,S
U92	03/08/2010	22 : 14	214	63.1389	-23.8101	TM
397	03/08/2010	23 :0 0	214	62.9854	-23.8793	TON,P,Si,Chl,S
398	04/08/2010	0 :0 3	215	62.8196	-23.9602	TON,P,Si,Chl,S
399	04/08/2010	1 :0 0	215	62.67	-24.0317	TON,P,Si,Chl,S
400	04/08/2010	2 :0 0	215	62.5168	-24.1071	TON,P,Si,Chl,S
U93	04/08/2010	2 : 40	215	62.5151	-24.1077	TM
401	04/08/2010	3 :0 2	215	62.3606	-24.1819	TON,P,Si,Chl,S
402	04/08/2010	4 : 27	215	62.1477	-24.2841	TON,P,Si,Chl,S
403	04/08/2010	4 : 54	215	62.1357	-24.3116	TON,P,Si,Chl,S
404	04/08/2010	16 : 56	215	62.0717	-24.2269	TON,P,Si,Chl,S
405	04/08/2010	17 : 57	215	61.9895	-23.8667	TON,P,Si,Chl,S
U94	04/08/2010	18 : 0 6	215	61.9854	-23.8485	TM
406	04/08/2010	19 :0 5	215	61.8998	-23.4729	TON,P,Si,Chl,S
407	04/08/2010	20 :0 0	215	61.8276	-23.1589	TON,P,Si,Chl,S
408	04/08/2010	20 : 59	215	61.7528	-22.8311	TON,P,Si,Chl,S
409	04/08/2010	22 :0 0	215	61.6757	-22.4972	TON,P,Si,Chl,S
U95	04/08/2010	22 : 0 1	215	61.6757	-22.4971	TM
410	04/08/2010	23 :0 0	215	61.6012	-22.173	TON,P,Si,Chl,S
411	05/08/2010	0 :0 0	216	61.5268	-21.8419	TON,P,Si,Chl,S
412	05/08/2010	1 :0 0	216	61.4516	-21.5086	TON,P,Si,Chl,S
413	05/08/2010	2 :0 0	216	61.3729	-21.18	TON,P,Si,Chl,S
U96	05/08/2010	2 : 15	216	61.3726	-21.1787	TM
414	05/08/2010	2 : 59	216	61.2931	-20.8582	TON,P,Si,Chl,S
415	05/08/2010	14 :0 0	216	61.2291	-20.8191	TON,P,Si,Chl,S
U97	05/08/2010	14 : 12	216	61.2293	-20.82	TM
416	05/08/2010	15 :0 1	216	61.2683	-21.1174	TON,P,Si,Chl,S
417	05/08/2010	16 :0 0	216	61.3047	-21.4029	TON,P,Si,Chl,S
418	05/08/2010	16 : 57	216	61.3415	-21.6841	TON,P,Si,Chl,S
419	05/08/2010	17 : 57	216	61.3802	-21.9816	TON,P,Si,Chl,S
U98	05/08/2010	18 : 15	216	61.3823	-21.9983	TM

420	05/08/2010	18 : 58	216	61.4194	-22.2837	TON,P,Si,Chl,S
421	05/08/2010	20 :0 2	216	61.4606	-22.605	TON,P,Si,Chl,S
422	05/08/2010	21 :0 2	216	61.5013	-22.917	TON,P,Si,Chl,S
U99	05/08/2010	21 : 56	216	61.5006	-22.9113	TM
423	05/08/2010	22 :0 1	216	61.5417	-23.2345	TON,P,Si,Chl,S
424	05/08/2010	23 :0 3	216	61.5866	-23.5794	TON,P,Si,Chl,S
425	05/08/2010	23 : 59	216	61.6272	-23.8961	TON,P,Si,Chl,S
426	06/08/2010	0 : 59	217	61.6726	-24.2497	TON,P,Si,Chl,S
427	06/08/2010	2 : 10	217	61.7234	-24.6705	TON,P,Si,Chl,S
U100	06/08/2010	3 : 10	217	61.7581	-24.9677	TM
428	06/08/2010	3 : 50	217	61.7927	-25.2611	TON,P,Si,Chl,S
429	06/08/2010	5 :0 3	217	61.8402	-25.6684	TON,P,Si,Chl,S
430	06/08/2010	23 :0 4	217	62.1114	-27.2151	TON,P,Si,Chl,S
431	07/08/2010	2 : 20	218	62.1128	-27.1693	TON,P,Si,Chl,S
U101	07/08/2010	2 : 49	218	62.1126	-27.2271	TM
432	07/08/2010	3 :0 1	218	62.1172	-26.9064	TON,P,Si,Chl,S
433	07/08/2010	4 :0 2	218	62.1197	-26.5198	TON,P,Si,Chl,S
434	07/08/2010	5 :0 3	218	62.1224	-26.1408	TON,P,Si,Chl,S
435	07/08/2010	5 : 59	218	62.123	-25.7873	TON,P,Si,Chl,S
436	07/08/2010	6 : 57	218	62.1244	-25.4215	TON,P,Si,Chl,S
437	07/08/2010	8 :0 8	218	62.1484	-25.0018	TON,P,Si,Chl,S
438	07/08/2010	9 :0 0	218	62.1927	-24.7109	TON,P,Si,Chl,S
439	07/08/2010	10 :0 0	218	62.1616	-24.9111	TON,P,Si,Chl,S
440	07/08/2010	11 :0 0	218	62.1121	-25.1576	TON,P,Si,Chl,S
441	07/08/2010	12 :0 0	218	61.9462	-25.1459	TON,P,Si,Chl,S
442	07/08/2010	13 :0 0	218	61.8806	-24.9566	TON,P,Si,Chl,S
443	07/08/2010	14 :0 1	218	61.7719	-24.6616	TON,P,Si,Chl,S
444	07/08/2010	14 : 57	218	61.6725	-24.3938	TON,P,Si,Chl,S
445	07/08/2010	15 : 55	218	61.5692	-24.1147	TON,P,Si,Chl,S
446	07/08/2010	17 :0 0	218	61.4534	-23.8047	TON,P,Si,Chl,S
447	07/08/2010	18 :0 0	218	61.3476	-23.5216	TON,P,Si,Chl,S
448	07/08/2010	19 :0 0	218	61.2411	-23.2378	TON,P,Si,Chl,S
449	07/08/2010	20 :0 4	218	61.1266	-22.9335	TON,P,Si,Chl,S
450	07/08/2010	20 : 56	218	61.0315	-22.682	TON,P,Si,Chl,S
451	07/08/2010	21 : 58	218	60.9173	-22.3811	TON,P,Si,Chl,S
452	07/08/2010	23 :0 0	218	60.8038	-22.0826	TON,P,Si,Chl,S
453	08/08/2010	0 :0 3	219	60.6881	-21.7796	TON,P,Si,Chl,S
454	08/08/2010	1 :0 0	219	60.5824	-21.5037	TON,P,Si,Chl,S
455	08/08/2010	2 :0 8	219	60.4551	-21.1724	TON,P,Si,Chl,S
U102	08/08/2010	2 : 30	219	60.469	-21.2086	TM
456	08/08/2010	3 :0 3	219	60.3642	-20.9488	TON,P,Si,Chl,S
457	08/08/2010	15 :0 2	219	60.2232	-20.7331	TON,P,Si,Chl,S
458	08/08/2010	16 :0 5	219	60.1418	-20.4651	TON,P,Si,Chl,S
459	08/08/2010	16 : 59	219	60.0745	-20.244	TON,P,Si,Chl,S
460	08/08/2010	17 : 59	219	60.0034	-20.0117	TON,P,Si,Chl,S
461	08/08/2010	19 :0 0	219	59.9306	-19.7831	TON,P,Si,Chl,S
462	08/08/2010	20 :0 5	219	59.8553	-19.5482	TON,P,Si,Chl,S
463	08/08/2010	21 :0 0	219	59.7869	-19.3358	TON,P,Si,Chl,S

464	08/08/2010	21 : 58	219	59.712	-19.1031	TON,P,Si,Chl,S
465	08/08/2010	23 :0 0	219	59.6313	-18.8542	TON,P,Si,Chl,S
466	09/08/2010	0 :0 0	220	59.5501	-18.6038	TON,P,Si,Chl,S