**National Oceanography Centre**

# Cruise Report No. 06

# RRS *Discovery* Cruise 365

11 MAY-02 JUN 2011

The Extended Ellett Line 2011

*Principal Scientist*
J F Read

2011

National Oceanography Centre, Southampton
University of Southampton Waterfront Campus
European Way
Southampton
Hants SO14 3ZH
UK

Tel: +44 (0)23 8059 60643220
Email: jfr@noc.ac.uk

# DOCUMENT DATA SHEET

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*ABSTRACT*


The Extended Ellett Line is a full-depth hydrographic section between Iceland, 60°N 20°W, Rockall and Scotland. The original Ellett Line across the Rockall Trough was first occupied in 1975 when measurements were attempted four times a year. In 1996 the line was extended to Iceland and since then has been occupied approximately annually. The data form a 35 year time series of the oceanic conditions west of the British Isles.

The section monitors the characteristics of the warm water inflow into the Nordic Seas and thence to the Arctic, and observes part of the returning cold water outflow with measurements of the Iceland-Scotland Overflow and the overflow of the Wyville-Thomson Ridge into the Rockall Trough.

The 2011 occupation, *RRS Discovery* cruise 365, was curtailed by both technical problems and bad weather. 45 of the 48 CTD stations were worked between the Iceland and Scotland shelf edges. Line G, part of the SAMS observation network of the Scottish continental shelf was partially completed, with 4 stations at the western end not worked. Samples were taken for CFC and SF6 analysis, DIC and alkalinity, inorganic nutrients, aluminium, POC, bacterial abundance and biomass, and for phytoplankton community structure. Plans to repeat stations, to collect validation data for the SAMS glider and to investigate eddies in the Rockall Trough had to be abandoned.



*KEYWORDS*

cruise 365 2011, CTD observations, *Discovery*, Ellett Line, Iceland Basin, North Atlantic, Rockall Trough



*ISSUING ORGANISATION* **National Oceanography Centre, Southampton**
**University of Southampton Waterfront Campus**
**European Way**
**Southampton SO14 3ZH UK**
Tel: +44(0)23 80596116 Email: nol@noc.soton.ac.uk

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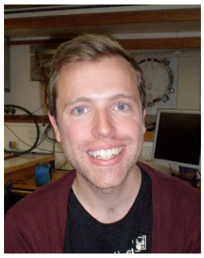
Jane Read


John Allen


Denise Smythe-Wright


Dmitry Aleynik


Mike Nelson

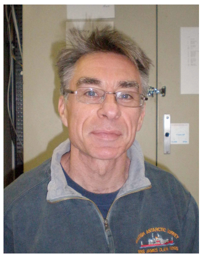

Estelle Dumont


Aaron Daniel

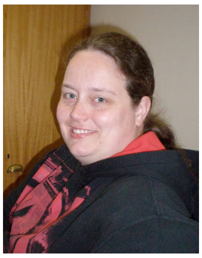

Oonagh Daly


Shaun Scally


Diane Purcell


Tim Brand

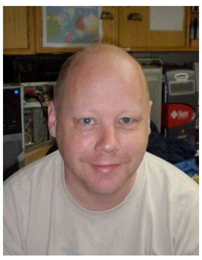

Mario Eposito

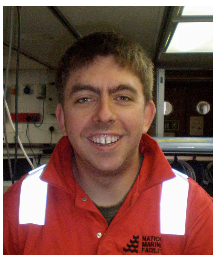

Tamara Green


Harriet Cole


Marta Skiba

## NMFSS Technicians


Paul Duncan


Chris Barnard


Paul Provost


Steve Whittle

SCIENTIFIC PERSONNEL

| | |
|---|---|
| READ, Jane (Principal Scientist) | NOCS-OBE |
| ALLEN, John | NOCS-OBE |
| COLE, Harriet | NOCS-OBE (PhD) |
| DANIEL, Aaron | NOCS-OBE |
| EPOSITO, Mario | NOCS-OBE (MSc) |
| PURCELL, Diane | NOCS-OBE |
| SKIBA. Marta | NOCS-OBE (PhD) |
| SMYTHE-WRIGHT, Denise | NOCS-OBE |
| DALY. Oonagh | Portsmouth University (undergrad) |
| NELSON, Mike | BODC |
| SCALLY, Shaun | UEA |
| ALEYNIK, Dmitry | SAMS |
| BRAND, Tim | SAMS |
| DUMONT, Estelle | SAMS |
| GREEN, Tamara | SAMS (undergrad) |
| BARNARD, Chris | NOCS-NMFD |
| DUNCAN, Paul | NOCS-NMFD |
| PROVOST, Paul | NOCS-NMFD |
| WHITTLE, Steven | NOC S-NMFD |

**SHIP'S PERSONNEL**

| | |
|---|---|
| GATTI, Antonio | Master |
| NEWTON, Peter | Chief Officer |
| MCLEOD, Iain | Second Officer |
| COUTTS, Gemma | Third Officer |
| MCLAUGHLIN, Edward | Chief Engineer |
| HAGAN, John | Second Engineer |
| HARNETT, John | Third Engineer |
| WILSON, Kevin | Third Engineer |
| DOYLE, Kevin | ETO |
| WILLIAMS, Emlyn | ERPO |
| COOK, Stuart | CPO (deck) |
| HARRISON, Martin | CPO (scientific) |
| DUNCAN, Steve | PO (deck) |
| MOORE, Mark | Seaman |
| CANTLIE, Ian | Seaman |
| FARLEY, Paul | Seaman |
| MILLS, Ian | Seaman |
| HARTSHORNE, David | PCO |
| LYNCH, Peter | Chef |
| SUTTON, Lloyd | Assistant Chef |
| MINGAY, Graham | Steward |

**NOCS** - National Oceanography Centre, Southampton
OBE – Ocean Biogeochemistry and Ecosystems
NMFD – NERC Marine Facilities Division
BODC – British Oceanographic Data Centre
SAMS – Scottish Association for Marine Science
UEA – University of East Anglia

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**RRS *DISCOVERY* 365, 11 MAY – 2 JUNE 2011.**

**The Extended Ellett Line 2011**

# 1. INTRODUCTION

The Extended Ellett Line is a full depth hydrographic section between Scotland, Rockall, 60°N 20°W and Iceland. The Anton Dohrn section across the Rockall Trough (which became the 'Ellett Line') has been occupied up to four times a year since 1975. In 1996 the section was extended to Iceland, and sampling reduced to an annual occupation. The data provide a time series of the oceanographic conditions west of the British Isles, which can impact on UK climate and weather (Ellett, 1993).

Of about 70 attempted occupations only 70% have been successful, an indication of the severe weather that can be encountered in the area. This fact is best not forgotten, even in late spring.

Observations began at about the time of the 1970's Great Salinity Anomaly (Dickson et al, 1988), thus the mean temperature and salinity of the upper 800 m during the first few years were relatively fresh and cool. Since then there has been a steady increase in both temperature and salinity, except for a dip in the 1990's due to the circulation of another salinity anomaly (Reverdin et al, 1997). The change in water properties results from a change in the circulation of the subpolar gyre, with more water coming from the south rather than the North Atlantic Current (Hatun et al, 2005). The most likely cause appears to be changes in the wind stress curl (Hakkinen et al, 2011). The North Atlantic Current follows the line of zero wind stress curl, hence strengthening or weakening of the wind stress curl will affect the advection of water in the current. The increase in temperature and salinity appeared to stabilise after about 2004, and there has even been a small decrease in temperature since 2006. It is not yet clear whether the decrease is significant and continued measurements are needed into the future to understand the extent of natural variability and possible climate related changes.

The deep water of the Rockall Trough, Labrador Sea Water, which was constant in temperature and salinity during the first few years of observations, underwent a decrease in the late 1980's and 1990's. Since then there has been little change, apart from year to year variability. This is believed to reflect the changes that have taken place in the source regions (the Labrador Sea) where renewed convection in the early 1990's led to a marked cooling and freshening of the water mass (Yashayaev, 2007) but has since ceased or been more limited in extent.

The Extended Ellett Line provides a platform for additional research into the area. In the past the line has supported the investigation of the role of iron at high latitudes (Nielsdottir et al, 2008) and speciation of phytoplankton (Kirkham et al, 2011). This year, in addition to core measurements, sampling took place for CFC and SF6 analysis (University of East Anglia), particulate organic carbon and aluminium (both Scottish Association for Marine Science), bacterial biomass and abundance (University of Portsmouth), dissolved inorganic carbon and alkalinity (NOCS) and for phytoplankton community structure (NOCS).

Additional work was planned with four days of sea-time funded by the Oceans 2025 programme under theme 2. It was hoped that there would be time to repeat selected stations to quantify the short-term variability in quasi-synoptic oceanic hydrographic sections. Following last years survey of the Anton Dohrn seamount, further investigations were planned to link eddies observed in the Rockall Trough with the topographic effects of the seamount and Rockall Bank.

The SAMS glider was deployed before the cruise began and it was planned to work CTD profiles in the vicinity of the glider to provide validation data for the glider.

Cruise Objectives

1. To occupy the Extended Ellett Line hydrographic section and add to the 35-year time series of temperature and salinity and tracer properties of the water column (Oceans 2025 Theme 10 SO4).

2. To recover, service and redeploy the SAMS ADCP mooring on the Wyville Thomson Ridge.

3. To collect CTD profiles in the vicinity of the SAMS glider to provide validation data.

4. To repeat stations to quantify the short-term variability in a trans-ocean section.

5. To further investigate the links between the Anton Dohrn seamount and the Rockall Bank and deep eddies in the Rockall Trough, building on last years SeaSoar survey.

*Student Research*

1. To investigate concentrations of DIC/TA

2. To investigate bacterial biomass and abundance

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**Summary**

The cruise was curtailed by both equipment problems and bad weather.

Sailing delayed by 2.5 days for the CTD gantry luffing arm to be repaired (this included time for the vessel-mounted ADCP to be installed),

3 days in dock for the CTD sheave to be repaired (this included time to replace a broken salinometer),

Passage time totaled 4.25 days (Southampton to Govan, Govan to Sound of Mull, Barra Head to Liverpool),

Bad weather totaled 5.75 days, including steaming from Barra Head to Iceland.

This left approximately 6.5 days work, 32% of the 22-day allocated cruise time.

It was particularly unfortunate that the delays at the beginning of the cruise meant that we missed a period of excellent weather and when we finally reached the open ocean, were hit by storms lasting 4 days.

The line was completed, apart from 3 shallow stations, in a record 6.5 days. When work took place, it was very efficient. Fortunately the mooring deployment was transferred to the R/V Scotia. All other science (objectives 3, 4 and 5) was abandoned.

## 2. NARRATIVE

### Cruise Narrative

*Thursday 5 May* (times in BST). Discovery has been alongside the quay at NOCS for two weeks after refit. Now the starboard A frame, used for the CTD, has failed. It can't be fixed until next Thursday, with load testing on Friday, so sailing is delayed by 2 days. At the same time, we are still waiting for a vessel-mounted ADCP. After much chasing by Paul Duncan, RDI say they can return the 150 kHz transducer over the weekend, but no chance of getting back the 75 kHz transducer. Circulate to all scientific participants delaying their arrival at the ship.

*Monday 9 May.* There is no sign of the 150 kHz ADCP. More phone calls. NOCS based equipment is loaded and the phyto-pigment group start setting up, beginning with the installation and programming of an FRRF by Protool.

*Tuesday 10 May.* SAMS equipment arrives and is loaded. Apparently the 150kHz ADCP is 'in the air' and on its way to us.

*Wednesday 11 May.* The autoanalyser is set up in the chemistry lab and titration unit in the deck lab. Apparently the ADCP transducer is in the country at Stansted airport, but no sign of it getting any further. The UEA van arrives full of crates of bottles, which are loaded onboard.

*Thursday 12 May (day 132).* Most participants arrive. Still no sign of the ADCP, it is being held by customs who have apparently decided that Discovery is a pleasure craft (if only they knew!). The divers, who arrived after lunch, are sent away after arranging to return tomorrow morning. Scaffolding is removed from the repaired crane, but there is no progress on the A frame gantry. It seems the company repairing it have decided they can't do any welding today. Departure is now delayed until

Friday evening. The ADCP is on the road at last, ETA at NOC sometime in the evening.

*Friday 13 May (day 133).* The ship is turned in the dock at 7am, to enable weight testing to take place over the port side and over water. The ADCP unit arrived last night and is checked out in the NOCS workshop. A fitting on the top of the stem is missing and a replacement is made by Richie Phipps. The divers are on hand to install the unit in the hull, with the usual difficulty. The crane is load tested first and seems to be fine. The rams for the A frame gantry are lifted on board early, but progress is very slow. Safety briefing and signing on proceeded smoothly at 9am. A biology and chemistry sample discussion takes place after 10am. The ADCP is installed by midday and checks out, the system is configured and waiting to go. Work is complete on the A frame gantry by 1600 with load testing underway and a pilot ordered for 1930. Discovery departs at exactly 1930 BST, just a few people to wave goodbye, including the Director on his personal balcony. The ADCP is started up about 2030, all other ship equipment is already logging.

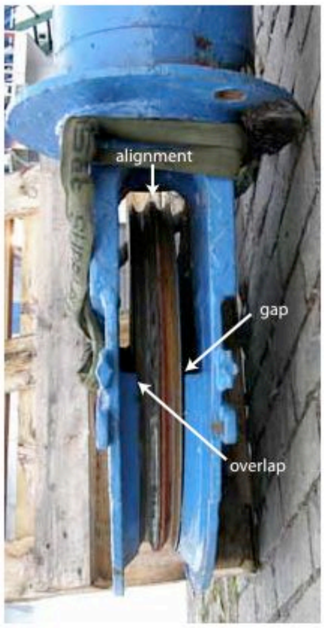
*Saturday 14 May (day 134).* Discovery makes excellent speed through the English Channel. Emergency muster drill takes place at 1030. NMF techs make up the termination on the CTD. The liquid nitrogen generator finishes purging and is fired up. Lands End is turned about midday (actually, it takes several hours to go all the way round it). Our direction is now north and the internet connection has failed because the dome is in the shadow of the radar mast on the monkey island. After a calm night and morning, there is a bit more of a sea, which reduces several people to their bunks. Sunny but breezy. CTD wire load tested on deck. Apparently the load cell has disappeared.

*Sunday 15 May (day 135).* Continuing steadily northwards across the Irish Sea. Weather grey and miserable but sea no worse than yesterday and people seem to be adjusting to the ships motion. Watches, sampling procedures discussed (again). Briefing at 1300 from the Master. Wire test in 193 m of water started about 1500. During the test we have internet connection again (heading about 270°). John has obtained a good calibration for the ADCP, and good results for the navigation streams.

Then it all goes pear-shaped, the engineers discover that the sheave at the head of the gantry is not aligned correctly and a gap is opening up between the pulley and the side plates every turn. It would be possible for the cable to drop into that gap. The Master was happy to continue with the planned test CTD to give a further opportunity for evaluation. This took place at 1800 in 130m of water. All bottles were fired at 3 depths to give plenty of water for sampling practice. However, the Master and engineers decided that the risk of the cable snatching off the block was too great and that we needed to dock to repair the sheave. As we are currently in the North Channel, the logical destination is Fairlie, however the agent quickly established that Fairlie was already in use, which means trekking up the Clyde to Glasgow.

*Monday 16 May (day 136).* Steaming through the Firth of Clyde in the early morning, grey and wet. Pilot on board at 1000, and alongside in King George V dock, Govan by midday. All then went quiet for a long time. Late afternoon it was clear we would be in overnight as the engineering company could not look at the sheave before tomorrow. Scientists and crew were given permission to go ashore.

*Tuesday 17 May (day 137).* MarMac engineer arrived at 0700, the offending sheave removed and taken away by lorry to the workshops. Scientists variously worked, walked out or slept. About 1630 the Master extended shore leave to midday Wednesday, as MarMac said they should have the sheave ready for return tomorrow morning and had arranged for a load test at 1200. If all went well we could leave immediately afterwards (depending on a pilot). Apparently the job was botched during refit, as one set of bearings was nylon and the other metal.




*Wednesday 18 May (day 138).* The sheave was returned by MarMac and refitted before midday. Load testing took place about 1300, and was completed soon after 1400 (testing to 5.25t). The pilot was booked for 1600. At 1530 a problem was reported with the two salinometers. The 8400B, set up at the beginning of the cruise, was giving ridiculous readings, similar to those experienced before and the reason it had been returned to OSIL for repair, replacement of the thermistor board and servicing. The 8400A had been set up, but it too was giving unreliable readings and the pumps were playing up. It is possible that the 8400A can be serviced and made useable, but it seems unwise to set out with one broken and one suspect salinometer. Enquiries were made and a spare 8400B, that should have been on board but that hadn't been returned by OSIL in time, was located at NOCS and arrangements made to have it driven to Glasgow overnight.

The pilot was cancelled and re-booked for 0800 Thursday. The only consolation is that the James Cook has spent the day sheltering behind the Isle Of Lewis because of gale force winds. If we had set out, it is unlikely we would have been able to work. It is still possible that we will miss a working window, but we seem to have missed all the good weather, with the forecast for the next week looking pretty bad. Another 12 hours in port seems unlikely to make much difference.

*Thursday 19 May (day 139).* The driver from NOC arrived about 0130. At 0700 two 8400B salinometers were craned on board, and the broken 8400B taken off for return to NOC. A box of spares arrived as well. The car, the NOC Renault Laguna, wouldn't start and had been giving serious problems the last 10 miles of the drive to Glasgow. The AA van arrived as the crew raised the gangway. Pilot on board at 0800. The ship backed out of the dock, turning at the entrance to the river. With the tide low and rising, the current was against us all the way down river. The weather was mainly clear but windy, with heavy rain showers passing over. The pilot disembarked at 1100 and the ship continued down the Firth of Clyde. After lunch it was discovered that the surfmet wind speed and direction were not recording. The PAR and TIR sensors seemed to be giving sensible reading. Chris went up the foremast and discovered that the power cable had fallen out. Once replaced and secured the instruments were fine.

Meanwhile, John started a salinometer session and discovered that the 8400A still had pump problems. One of the new, 8400B salinometers was set up and giving stable readings. The pump in the 8400A was replaced. ETA at the first station, 1G, about

0100-0200 tomorrow morning, so watches have to start at midnight. The ship will change to GMT before the station.

*Friday 20 May (day 140)* (times in GMT until further notice). PES fish deployed as coming onto the first station 1G at 0245. Station 1G, ctd001 completed successfully. Half hour steaming between stations, so reached the position of 2G before sampling complete. Stations 2, 3, 4, 5, 6, 7G all completed successfully. Increasingly variable moisture signals from the upward looking ADCP gave cause for concern, so at the end of 8G the instrument was replaced with a spare. During the process a pin broke off the deck cable. A bit off the secondary (fin) temperature probe was damaged and replaced. The changes meant some delay to the start of 9G. 9G and 10G (ctd010) completed but wind speed increasing. Increased seas caused zero to excess tensions on the CTD cable so at 1530, the end of 10G, the Master decided we should take shelter behind nearby Barra Head. Wind speed about 30 knots. Disappointing because it is a bright sunny day, just very windy.

*Saturday 21 May (day 141).* Tried returning to Line G at station 11G, but winds at >30 knots and conditions unworkable. No point in staying so steamed back behind Barra. After reviewing the various weather forecasts, and hearing from the James Cook at the northern end of The Minch, it was agreed that we attempt to get to the northern end of the extension, steaming through The Minch and heading northwest to Iceland. Set off before lunch and by late afternoon were in much calmer conditions. Rounded the Butt of Lewis during the evening and headed out into the North Atlantic. Late evening the news arrived of a volcanic eruption in Iceland, Grimsvotn, under the Vatnajokull ice cap. It is north of the line, but unlikely to affect us. Still, there is a sense of déjà vu after last year (*Discovery* 351).

*Sunday 22 May (day 142).* Crossed a weather front about 8am, with an immediate increase in wind speeds that persisted all day (order 30 knots). Continuing to steam northwest across the North Atlantic. While the conditions encountered are not good, they are even worse where we came from. The FRRF and two PAR sensors removed from the CTD frame. Winds greatly moderated during the evening, down to F3. Still rolling because of the swell.

*Monday 23 May (day 143).* Continuing northwest towards Iceland. Winds increased again, about F7. About midday, a huge fog/cloud bank appeared ahead. As we sailed into it, about 1230, there was a sulphurous smell about the ship, the 'fog' was a dirty yellowish brown colour that reduced the daylight to gloom. Evidently we had sailed into the ash plume from Grimsvotn, the volcano that erupted on Saturday underneath the Vatnajokull ice cap in Southeast Iceland. The fall out was nothing like that encountered last year on di350, but there was soon a fine grey dust covering the ship. The engineers installed additional filters on the engine intake, and the Master had some paper facemasks put out for anyone going on deck. About 1700 wind speed increased to F9. Discovery passed out of the ash cloud about 1845 into relatively clear air. Wind speed then decreased to a more workable F5. Station IB20s (ctd011) reached about 2145. All went smoothly with the CTD inboard at midnight. While hove to (about 2215) the PAR and TIR sensors on the foremast were washed clean of ash.

*Ash from Grimsvotn. Left: ship's superstructure through the ash cloud, John Allen, right: new white paint covered in ash, Oonagh Daly.*

*Tuesday 24 May (day 144).* Winds increased again and the ship could only manage 6 knots northward to the next station. On arrival at IB21s conditions were deemed unworkable and the ship hove to. About 0700 the ship was re-positioned on station, but with winds still F8-9 it was still not possible to work. Eventually the winds moderated sufficiently for work to restart about dinner time (still F6-7). IB21s (ctd012) started at 1800. IB22s (ctd013) completed at 2130 and IB23s (ctd014) completed 2300. The Vestmanjaer Islands were directly ahead of the ship, but Iceland remained under cloud and there was no sign of Grimsvotn.

*Wednesday 25 May (day 145).* Now steaming south, winds still F6 from the north. Stations IB19s (ctd015), IB18s (ctd016), IB17 (ctd017), IB16a (ctd018), IB16 (ctd019) and IB15 (ctd020) completed successfully. Winds decreased to about F4. Some confusion over sampling as we try to establish a routine.

*Thursday 26 May (day 146).* Stations IB14 – IB11a (ctds 021-026) completed successfully. Three argo floats deployed (after ctds 021, 023 and 025). Weather deteriorated during the day, with winds reaching F6, but it remained workable.

*Friday 27 May (day 147).* Continuing with stations IB11 – IB9 (ctds 027-029). The fourth and final argo float was deployed after ctd 027. Once past 60°N 20°W the course brought us beam on to a southwesterly swell. Watchkeepers on deck sampling the CTD were dowsed several times with water shipped over the side, and it became necessary to remain hove-to while sampling took place. By the time we reached IB8, about 1500, conditions were deemed too bad to risk putting the CTD over side. The ship remained hove to once more.

*Waiting for the weather. Left: Oonagh Daly, right: Mike Nelson*

*Saturday 28 May (day 148).* Winds reached F10 overnight, with swell of up to 8 - 9 m peak to trough. Ship movement wasn't too bad because the swell was unidirectional, great long lines of rollers coming in from the west. Atmospheric pressure levelled off early morning and the wind began to ease, however, it took much longer for the sea state to reduce. Better conditions by 1500 found us about 30 miles west of station IB8 meaning a 3-hour steam back. The swell gradually eased and stations IB8 and IB7 (ctds 030-031) were completed. IB6 was omitted because of the shortage of time.

*Sunday 29 May (day 149).* Stations IB5, IB4a, IB4, IB3, IB2, A and B (ctds 032 - 038) were completed successfully in improving weather. IB1 was omitted because of shortage of time. James Cook is experiencing 40 knot winds but she is on the southern end of Rockall Bank. With a bit of luck, the bad weather has passed south of us.

*Rockall once more, Jane Read*

*Monday 30 May (day 150).* A really nice day at last, stations C to L (ctds 039 - 048) were completed with no problems.

*Tuesday 31 May (day 151).* The day started with lovely weather and it looked as if we might actually complete the section and have enough time to finish Line G, but the weather deteriorated in the afternoon with winds reaching F9 by early evening. Stations M, N, O, P, Q and R (ctds 049 - 054) were successfully completed. Station S (ctd055) was worked in marginal conditions. The ship then hove to at station T to see if the weather would moderate enough to allow us to work the final station of the Ellett line. It didn't. At midnight scientific work ended and the ship set out for Liverpool.

*Wednesday 1 June (day 152).* After a rough night, beam on to the swell, scientists started packing equipment while processing of the final data continued. An RPC was held in the bar during the evening. The ship reverted to BST over night.

*Thursday 2 June* (times now BST). At the entrance to the Mersey and pilot on board at 0630. Vessel hove to off Gladstone Lock at 0810. Alongside at berth S7-S8 in Seaforth Dock soon after 0900. Demob started. Scientists started leaving the vessel mid-morning.

*Jane Read*

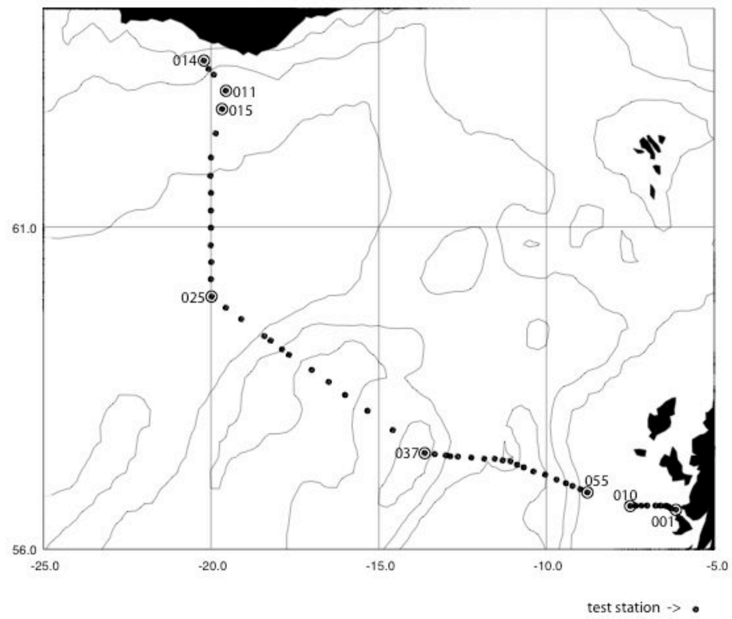



*Figure 1.* CTD station positions during RRS Discovery cruise 365 (bathymetry contoured at 200, 1000, 2000, 3000 m).

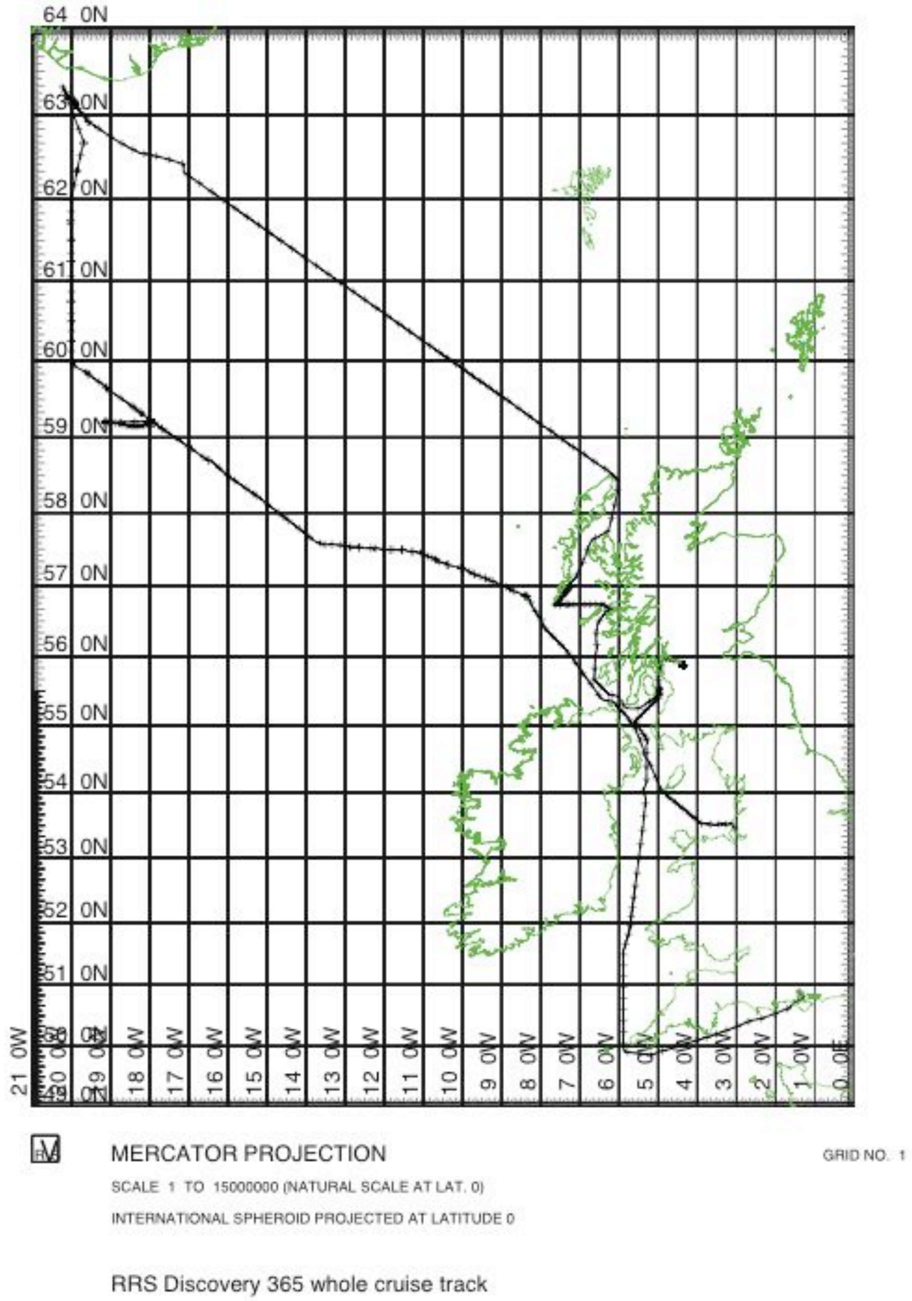
Table 1. CTD station listing (next two pages).

deg – degrees; mins – minutes; hgt off – height off bottom (m); CFC – chlorofluorocarbons and sulphur hexafluoride; O2 – dissolved oxygen; DIC – dissolved inorganic carbon and total alkalinity; al – dissolved aluminium; POC – particulate organic carbon; nut – nutrients; bac – bacteria; sal – salinity; pig – phytoplankton community structure.

| station | no | jday | date | deg N | mins | deg W | mins | time start | down | end | depth m | wire out | hgt off |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| test | | 135 | 15v11 | 55 | 0.38 | 5 | 33.22 | 17:09 | 17:19 | 17:36 | 135 | 125 | 10 |
| 1G | 1 | 140 | 20v11 | 56 | 39.97 | 6 | 8.57 | 01:57 | 02:06 | 02:20 | 181 | 10 | 171 |
| 2G | 2 | | | 56 | 41.27 | 6 | 16.95 | 03:17 | 03:23 | 03:33 | 34.5 | 5.5 | 29 |
| 3G | 3 | | | 56 | 43.21 | 6 | 21.94 | 04:04 | 04:09 | 04:18 | 48 | 7 | 41 |
| 4G | 4 | | | 56 | 43.99 | 6 | 26.86 | 04:56 | 05:02 | 05:17 | 76 | 67 | 9 |
| 5G | 5 | | | 56 | 44.10 | 6 | 35.73 | 06:00 | 06:06 | 06:21 | 72.5 | 67 | 5.5 |
| 6G | 6 | | | 56 | 44.07 | 6 | 44.77 | 07:10 | 07:15 | 07:25 | 37 | 34 | 3 |
| 7G | 7 | | | 56 | 44.07 | 6 | 59.75 | 08:45 | 08:56 | 09:20 | 135 | 127 | 8 |
| 8G | 8 | | | 56 | 44.02 | 7 | 10.04 | 10:12 | 10:20 | 10:31 | 170 | 164 | 6 |
| 9G | 9 | | | 56 | 44.11 | 7 | 20.00 | 12:22 | 12:30 | 12:50 | 152 | 140 | 12 |
| 10G | 10 | | | 56 | 43.75 | 7 | 30.14 | 14:12 | 14:26 | 14:52 | 217 | 196 | 21 |
| IB20s | 11 | 143 | 23v11 | 62 | 55.06 | 19 | 33.51 | 22:16 | 22:53 | 23:50 | 1409 | 1386 | 23 |
| IB21s | 12 | 144 | 24v11 | 63 | 8.22 | 19 | 54.91 | 18:14 | 18:40 | 19:28 | 1033 | 1020 | 13 |
| IB22s | 13 | | | 63 | 12.66 | 20 | 4.63 | 20:30 | 20:57 | 21:29 | 702 | 693 | 9 |
| IB23s | 14 | | | 63 | 19.32 | 20 | 13.09 | 22:34 | 22:42 | 23:00 | 124 | 113 | 11 |
| IB19s | 15 | 145 | 25v11 | 62 | 40.13 | 19 | 40.47 | 03:10 | 03:57 | 05:04 | 1689 | 1664 | 25 |
| IB18s | 16 | | | 62 | 19.99 | 19 | 51.39 | 07:15 | 07:52 | 08:58 | 1811 | 1801 | 10 |
| IB17 | 17 | | | 61 | 59.92 | 19 | 59.96 | 11:08 | 11:53 | 13:03 | 1792 | 1781 | 11 |
| IB16a | 18 | | | 61 | 44.66 | 20 | 0.86 | 14:51 | 15:28 | 16:39 | 1800 | 1790 | 10 |
| IB16 | 19 | | | 61 | 30.02 | 19 | 59.94 | 18:15 | 19:00 | 20:11 | 2225 | 2205 | 20 |
| IB15 | 20 | | | 61 | 14.93 | 20 | 0.03 | 21:43 | 22:35 | 23:52 | 2382 | 2361 | 21 |
| IB14 | 21 | 146 | 26v11 | 61 | 0.22 | 20 | 0.16 | 01:35 | 02:30 | 03:52 | 2407 | 2382 | 25 |
| IB13a | 22 | | | 60 | 44.95 | 20 | 0.32 | 05:53 | 06:40 | 08:00 | 2373 | 2348 | 25 |
| IB13 | 23 | | | 60 | 30.11 | 19 | 59.53 | 09:42 | 10:38 | 11:58 | 2520 | 2510 | 10 |
| IB12 | 24 | | | 60 | 15.17 | 19 | 59.89 | 13:55 | 14:47 | 16:01 | 2639 | 2628 | 11 |
| 60 20 | 25 | | | 59 | 59.57 | 19 | 58.94 | 17:56 | 18:56 | 20:14 | 2727 | 2713 | 14 |
| IB11a | 26 | 147 | 27v11 | 59 | 49.90 | 19 | 33.59 | 22:30 | 23:29 | 00:56 | 2702 | 2691 | 11 |
| IB11 | 27 | | | 59 | 39.60 | 19 | 6.01 | 02:48 | 03:42 | 05:21 | 2679 | 2654 | 25 |
| IB10 | 28 | | | 59 | 24.08 | 18 | 24.71 | 08:21 | 09:28 | 10:43 | 2409 | 2384 | 25 |
| IB9 | 29 | | | 59 | 19.99 | 18 | 13.59 | 11:54 | 12:36 | 13:35 | 1840 | 1830 | 10 |
| IB8 | 30 | 148 | 28v11 | 59 | 12.02 | 17 | 53.16 | 19:14 | 20:18 | 21:08 | 1530 | 1514 | 16 |
| IB7 | 31 | | | 59 | 6.95 | 17 | 40.33 | 22:15 | 22:42 | 23:24 | 995 | 980 | 15 |
| IB5 | 32 | 149 | 29v11 | 58 | 52.99 | 17 | 0.17 | 02:06 | 02:36 | 03:35 | 1155 | 1140 | 15 |
| IB4a | 33 | | | 58 | 42.05 | 16 | 29.31 | 05:38 | 06:04 | 06:57 | 1190 | 1175 | 15 |
| IB4 | 34 | | | 58 | 29.92 | 15 | 59.97 | 08:54 | 09:35 | 10:21 | 1184 | 1184 | 0 |
| IB3 | 35 | | | 58 | 15.11 | 15 | 19.81 | 12:48 | 13:07 | 13:42 | 655 | 645 | 10 |
| IB2 | 36 | | | 57 | 56.86 | 14 | 34.97 | 16:36 | 16:55 | 17:27 | 443 | 435 | 8 |
| A | 37 | | | 57 | 34.92 | 13 | 37.95 | 21:10 | 21:17 | 21:28 | 107 | 101 | 6 |
| B | 38 | | | 57 | 33.95 | 13 | 20.09 | 22:43 | 22:53 | 23:09 | 175 | 170 | 5 |
| C | 39 | 150 | 30v11 | 57 | 32.93 | 12 | 59.97 | 00:34 | 00:46 | 01:07 | 292 | 283 | 9 |
| D | 40 | | | 57 | 32.06 | 12 | 52.15 | 01:50 | 02:14 | 03:02 | 1087 | 1063 | 24 |
| E | 41 | | | 57 | 31.70 | 12 | 38.44 | 04:06 | 04:44 | 05:58 | 1640 | 1622 | 18 |
| F | 42 | | | 57 | 30.64 | 12 | 14.37 | 07:27 | 08:11 | 09:20 | 1808 | 1790 | 18 |
| G | 43 | | | 57 | 29.52 | 11 | 50.97 | 10:35 | 11:32 | 12:34 | 1788 | 1778 | 10 |
| H | 44 | | | 57 | 29.61 | 11 | 32.73 | 13:53 | 14:43 | 15:48 | 2007 | 1998 | 9 |
| I | 45 | | | 57 | 28.09 | 11 | 18.73 | 16:51 | 17:13 | 17:43 | 745 | 735 | 10 |
| J | 46 | | | 57 | 27.03 | 11 | 4.63 | 18:39 | 19:00 | 19:28 | 587 | 580 | 7 |
| K | 47 | | | 57 | 23.84 | 10 | 52.35 | 20:29 | 20:56 | 21:30 | 777 | 770 | 7 |
| L | 48 | | | 57 | 21.44 | 10 | 40.59 | 20:34 | 23:24 | 00:30 | 2100 | 2094 | 6 |
| M | 49 | 151 | 31v11 | 57 | 17.26 | 10 | 23.16 | 01:46 | 02:35 | 03:50 | 2225 | 2204 | 21 |
| N | 50 | | | 57 | 14.43 | 10 | 2.52 | 05:07 | 05:52 | 07:07 | 2106 | 2084 | 22 |
| O | 51 | | | 57 | 9.34 | 9 | 42.19 | 08:36 | 09:26 | 10:25 | 1930 | 1912 | 18 |
| P | 52 | | | 57 | 6.02 | 9 | 25.12 | 11:38 | 12:24 | 13:22 | 1420 | 1410 | 10 |
| Q | 53 | | | 57 | 3.14 | 9 | 13.01 | 14:20 | 14:32 | 14:55 | 305 | 298 | 7 |
| R | 54 | | | 57 | 0.11 | 8 | 59.41 | 16:03 | 16:13 | 16:30 | 133 | 123 | 10 |
| S | 55 | | | 56 | 57.03 | 8 | 46.84 | 17:48 | 17:55 | 18:07 | 125 | 113 | 12 |

| station | date | | lat N | lon W | time start | CFC | O2 | DIC | al | POC | nut | bac | sal | pig |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| test | 15v11 | CT365tst | 55.006399 | -5.553634 | 17:09 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 9 | 3 |
| 1G | 20v11 | CT365001 | 56.66615 | -6.142792 | 01:57 | 0 | 5 | 5 | 0 | 0 | 5 | 0 | 2 | 5 |
| 2G | | CT365002 | 56.687862 | -6.28242 | 03:17 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 |
| 3G | | CT365003 | 56.720138 | -6.365618 | 04:04 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 2 | 3 |
| 4G | | CT365004 | 56.73313 | -6.447613 | 04:56 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 1 |
| 5G | | CT365005 | 56.734974 | -6.595423 | 06:00 | 0 | 2 | 5 | 0 | 0 | 4 | 0 | 3 | 5 |
| 6G | | CT365006 | 56.73451 | -6.746095 | 07:10 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| 7G | | CT365007 | 56.734479 | -6.995899 | 08:45 | 5 | 1 | 6 | 0 | 4 | 6 | 0 | 3 | 6 |
| 8G | | CT365008 | 56.733599 | -7.167277 | 10:12 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 |
| 9G | | CT365009 | 56.735225 | -7.333251 | 12:22 | 0 | 0 | 8 | 0 | 0 | 0 | 3 | 2 | 8 |
| 10G | | CT365010 | 56.729089 | -7.502293 | 14:12 | 5 | 2 | 8 | 0 | 5 | 8 | 0 | 3 | 8 |
| IB20s | 23v11 | CT365011 | 62.91762 | -19.558465 | 22:16 | 7 | 3 | 10 | 10 | 5 | 11 | 0 | 4 | 10 |
| IB21s | 24v11 | CT365012 | 63.137075 | -19.915166 | 18:14 | 7 | 2 | 9 | 0 | 5 | 11 | 3 | 6 | 9 |
| IB22s | | CT365013 | 63.210918 | -20.077172 | 20:30 | 4 | 0 | 8 | 5 | 5 | 8 | 3 | 4 | 8 |
| IB23s | | CT365014 | 63.322063 | -20.218178 | 22:34 | 0 | 0 | 7 | 0 | 5 | 7 | 3 | 2 | 7 |
| IB19s | 25v11 | CT365015 | 62.668892 | -19.674446 | 03:10 | 12 | 0 | 12 | 0 | 0 | 12 | 0 | 6 | 11 |
| IB18s | | CT365016 | 62.333209 | -19.85658 | 07:15 | 12 | 3 | 9 | 10 | 5 | 12 | 0 | 6 | 9 |
| IB17 | | CT365017 | 61.99869 | -19.999412 | 11:08 | 11 | 2 | 11 | 0 | 5 | 12 | 0 | 6 | 11 |
| IB16a | | CT365018 | 61.744328 | -20.014393 | 14:51 | 9 | 0 | 12 | 9 | 5 | 12 | 3 | 6 | 9 |
| IB16 | | CT365019 | 61.500377 | -19.999028 | 18:15 | 11 | 3 | 13 | 0 | 5 | 12 | 0 | 6 | 9 |
| IB15 | | CT365020 | 61.248803 | -20.000433 | 21:43 | 10 | 0 | 13 | 10 | 0 | 12 | 0 | 6 | 9 |
| IB14 | 26v11 | CT365021 | 61.003638 | -20.002631 | 01:35 | 11 | 0 | 12 | 0 | 0 | 11 | 0 | 6 | 9 |
| IB13a | | CT365022 | 60.749231 | -20.005262 | 05:53 | 12 | 0 | 15 | 0 | 5 | 15 | 0 | 6 | 11 |
| IB13 | | CT365023 | 60.501847 | -19.992187 | 09:42 | 9 | 0 | 13 | 10 | 5 | 12 | 0 | 8 | 11 |
| IB12 | | CT365024 | 60.252779 | -19.998239 | 13:55 | 9 | 3 | 14 | 9 | 5 | 13 | 3 | 6 | 10 |
| 60 20 | | CT365025 | 59.992751 | -19.982404 | 17:56 | 11 | 0 | 11 | 0 | 0 | 13 | 0 | 6 | 10 |
| IB11a | 27v11 | CT365026 | 59.831636 | -19.559781 | 22:30 | 12 | 0 | 12 | 0 | 0 | 14 | 3 | 10 | 10 |
| IB11 | | CT365027 | 59.659986 | -19.100103 | 02:48 | 11 | 0 | 11 | 0 | 0 | 13 | 0 | 6 | 10 |
| IB10 | | CT365028 | 59.401282 | -18.411901 | 08:21 | 12 | 0 | 12 | 10 | 6 | 14 | 0 | 6 | 10 |
| IB9 | | CT365029 | 59.333165 | -18.226427 | 11:54 | 10 | 2 | 14 | 0 | 5 | 13 | 3 | 6 | 10 |
| IB8 | 28v11 | CT365030 | 59.200274 | -17.886033 | 19:14 | 10 | 0 | 10 | 10 | 5 | 12 | 0 | 4 | 8 |
| IB7 | | CT365031 | 59.115911 | -17.672176 | 22:15 | 0 | 4 | 11 | 0 | 5 | 12 | 3 | 3 | 9 |
| IB5 | 29v11 | CT365032 | 58.883121 | -17.002879 | 02:06 | 9 | 0 | 12 | 0 | 0 | 10 | 0 | 4 | 9 |
| IB4a | | CT365033 | 58.70089 | -16.488425 | 05:38 | 8 | 0 | 12 | 0 | 0 | 11 | 0 | 5 | 9 |
| IB4 | | CT365034 | 58.498689 | -15.999499 | 08:54 | 9 | 4 | 11 | 0 | 5 | 11 | 0 | 3 | 0 |
| IB3 | | CT365035 | 58.251796 | -15.330126 | 12:48 | 7 | 0 | 8 | 4 | 5 | 11 | 3 | 3 | 9 |
| IB2 | | CT365036 | 57.947739 | -14.582833 | 16:36 | 0 | 0 | 8 | 4 | 5 | 9 | 0 | 3 | 7 |
| A | | CT365037 | 57.582002 | -13.632421 | 21:10 | 0 | 2 | 5 | 1 | 3 | 5 | 3 | 1 | 5 |
| B | | CT365038 | 57.565829 | -13.334764 | 22:43 | 4 | 2 | 5 | 1 | 4 | 5 | 0 | 1 | 5 |
| C | 30v11 | CT365039 | 57.54883 | -12.999522 | 00:34 | 0 | 0 | 5 | 0 | 0 | 5 | 0 | 1 | 5 |
| D | | CT365040 | 57.534318 | -12.869118 | 01:50 | 6 | 0 | 6 | 0 | 0 | 9 | 0 | 4 | 8 |
| E | | CT365041 | 57.528391 | -12.640589 | 04:06 | 9 | 0 | 7 | 0 | 0 | 10 | 0 | 6 | 9 |
| F | | CT365042 | 57.510642 | -12.23954 | 07:27 | 10 | 0 | 7 | 0 | 0 | 9 | 0 | 5 | 10 |
| G | | CT365043 | 57.491934 | -11.849572 | 10:35 | 10 | 3 | 7 | 10 | 5 | 13 | 0 | 4 | 9 |
| H | | CT365044 | 57.493429 | -11.545557 | 13:53 | 10 | 3 | 9 | 10 | 5 | 13 | 0 | 5 | 10 |
| I | | CT365045 | 57.468089 | -11.312093 | 16:51 | 5 | 0 | 5 | 4 | 5 | 9 | 3 | 4 | 8 |
| J | | CT365046 | 57.450562 | -11.077225 | 18:39 | 0 | 0 | 5 | 4 | 5 | 7 | 3 | 3 | 5 |
| K | | CT365047 | 57.397252 | -10.872439 | 20:29 | 6 | 0 | 7 | 7 | 5 | 10 | 3 | 3 | 6 |
| L | | CT365048 | 57.357351 | -10.676513 | 20:34 | 11 | 3 | 9 | 10 | 0 | 12 | 0 | 4 | 7 |
| M | 31v11 | CT365049 | 57.287706 | -10.385933 | 01:46 | 12 | 0 | 10 | 0 | 0 | 12 | 0 | 4 | 8 |
| N | | CT365050 | 57.240438 | -10.042073 | 05:07 | 10 | 0 | 11 | 0 | 0 | 11 | 0 | 6 | 8 |
| O | | CT365051 | 57.155605 | -9.703133 | 08:36 | 10 | 0 | 7 | 10 | 5 | 13 | 0 | 3 | 8 |
| P | | CT365052 | 57.1003 | -9.418726 | 11:38 | 7 | 0 | 9 | 9 | 5 | 11 | 0 | 4 | 9 |
| Q | | CT365053 | 57.052389 | -9.216818 | 14:20 | 0 | 0 | 8 | 4 | 5 | 8 | 3 | 2 | 6 |
| R | | CT365054 | 57.001885 | -8.990157 | 16:03 | 0 | 0 | 6 | 2 | 5 | 6 | 3 | 3 | 6 |
| S | | CT365055 | 56.9505 | -8.780667 | 17:48 | 4 | 0 | 3 | 0 | 4 | 4 | 0 | 3 | 3 |
| Total samples drawn | | | | | | 352 | 53 | 460 | 163 | 156 | 501 | 48 | 236 | 411 |

*Figure 2. RRS Discovery* cruise 365 track.



## Master's Summary

| Start Date | Time | End Date | Time | | Indicator | d h:mm | hours |
|---|---|---|---|---|---|---|---|
| 9/05/2011 | 8:00 | 11/05/2011 | 9:00 | Mobilisation | Dem/Mob | 2 01:00 | 49.00 |
| 11/05/2011 | 09:00 | 13/05/2011 | 19:13 | Awaiting repair to stbd gantry | DTShip | 2 10:13 | 58.22 |
| 13/05/2011 | 19:13 | 13/05/2011 | 20:58 | Pilotage leaving Southampton | RWP | 0 01:45 | 1.75 |
| 15/05/2011 | 15:10 | 15/05/2011 | 16:36 | Test deployment of CTD wire using weight | Stat | 0 01:26 | 1.43 |
| 15/05/2011 | 16:36 | 15/05/2011 | 18:09 | Passage while preparing CTD for test deployment | RWP | 0 01:33 | 1.55 |
| 15/05/2011 | 18:09 | 15/05/2011 | 18:40 | CTD test deployment. Problem noticed with head sheave on CTD boom | Stat | 0 00:31 | 0.52 |
| 15/05/2011 | 18:40 | 16/05/2011 | 09:53 | Proceed to Clyde for repairs to sheave | DTShip | 0 15:13 | 15.22 |
| 16/05/2011 | 09:53 | 16/05/2011 | 12:23 | Pilotage to Govan KGV | DTShip | 0 02:30 | 2.50 |
| 16/05/2011 | 12:23 | 18/05/2011 | 16:00 | Repairs made to sheave and tested - all ok. Salinometer reported not working prior to sailing. New one to be delivered | DTShip | 2 03:37 | 51.62 |
| 18/05/2011 | 16:00 | 19/05/2011 | 08:02 | Waiting for new Salinometer to arrive | DTTech | 0 16:02 | 16.03 |
| 19/05/2011 | 08:02 | 19/05/2011 | 10:57 | Pilotage departing Govan | DTShip | 0 02:55 | 2.92 |
| 19/05/2011 | 10:57 | 19/05/2011 | 16:44 | Returning to science passage to Sound of Mull station | DTShip | 0 05:47 | 5.78 |
| 19/05/2011 | 16:44 | 20/05/2011 | 01:44 | Passage to first station 1G. Ships clocks retarded 1 hr to GMT | RWP | 0 09:00 | 9.00 |
| 20/05/2011 | 01:44 | 20/05/2011 | 02:24 | CTD at 1G | Stat | 0 00:40 | 0.67 |
| 20/05/2011 | 02:24 | 20/05/2011 | 03:07 | Reposition to next stn | RWP | 0 00:43 | 0.72 |
| 20/05/2011 | 03:07 | 20/05/2011 | 03:35 | CTD at 2G | Stat | 0 00:28 | 0.47 |
| 20/05/2011 | 03:35 | 20/05/2011 | 04:00 | Reposition to next stn | RWP | 0 00:25 | 0.42 |
| 20/05/2011 | 04:00 | 20/05/2011 | 04:20 | CTD at 3G | Stat | 0 00:20 | 0.33 |
| 20/05/2011 | 04:20 | 20/05/2011 | 04:51 | Reposition to next stn | RWP | 0 00:31 | 0.52 |
| 20/05/2011 | 04:51 | 20/05/2011 | 05:17 | CTD at 4G | Stat | 0 00:26 | 0.43 |
| 20/05/2011 | 05:17 | 20/05/2011 | 05:57 | Reposition to next stn | RWP | 0 00:40 | 0.67 |
| 20/05/2011 | 05:57 | 20/05/2011 | 06:22 | CTD at 5G | Stat | 0 00:25 | 0.42 |
| 20/05/2011 | 06:22 | 20/05/2011 | 07:05 | Reposition to next stn | RWP | 0 00:43 | 0.72 |
| 20/05/2011 | 07:05 | 20/05/2011 | 07:25 | CTD at 6G | Stat | 0 00:20 | 0.33 |
| 20/05/2011 | 07:25 | 20/05/2011 | 08:42 | Reposition to next stn | RWP | 0 01:17 | 1.28 |
| 20/05/2011 | 08:42 | 20/05/2011 | 09:19 | CTD at 7G | Stat | 0 00:37 | 0.62 |
| 20/05/2011 | 09:19 | 20/05/2011 | 10:09 | Reposition to next stn | RWP | 0 00:50 | 0.83 |
| 20/05/2011 | 10:09 | 20/05/2011 | 10:30 | CTD at 8G | Stat | 0 00:21 | 0.35 |
| 20/05/2011 | 10:30 | 20/05/2011 | 11:43 | Reposition to next stn | RWP | 0 01:13 | 1.22 |
| 20/05/2011 | 11:43 | 20/05/2011 | 12:21 | Preparing CTD - change of cable | RWP | 0 00:38 | 0.63 |
| 20/05/2011 | 12:21 | 20/05/2011 | 12:55 | CTD at 9G | Stat | 0 00:34 | 0.57 |
| 20/05/2011 | 12:55 | 20/05/2011 | 13:50 | Reposition to next stn | RWP | 0 00:55 | 0.92 |
| 20/05/2011 | 13:50 | 20/05/2011 | 14:54 | CTD at 10G | Stat | 0 01:04 | 1.07 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20/05/2011 | 14:54 | 20/05/2011 | 15:35 | Move to 11G Barra Head stn. Assessing weather, science ops stopped due to weather | RWP | 0 00:41 | 0.68 |
| 20/05/2011 | 15:35 | 21/05/2011 | 03:00 | Sheltering in the Lee of Isle of Barra | DTWx | 0 11:25 | 11.42 |
| 21/05/2011 | 03:00 | 21/05/2011 | 07:37 | Proceed to Barra Head to assess weather conditions | DTWx | 0 04:37 | 4.62 |
| 21/05/2011 | 07:37 | 21/05/2011 | 07:55 | Assessing weather conditions at Barra Head | DTWx | 0 00:18 | 0.30 |
| 21/05/2011 | 07:55 | 21/05/2011 | 11:50 | Sheltering in the Lee of Isle of Barra | DTWx | 0 03:55 | 3.92 |
| 21/05/2011 | 11:50 | 23/05/2011 | 21:57 | Passage to Iceland through the Minches. Weather forecast for Rockall indicates better to relocate to Northern end of Ellett Line first | DTWx | 0 10:07 | 58.12 |
| 23/05/2011 | 21:57 | 23/05/2011 | 23:53 | CTD at IB20 | Stat | 0 01:56 | 1.93 |
| 23/05/2011 | 23:53 | 24/05/2011 | 02:53 | Reposition to next stn | RWP | 0 03:00 | 3.00 |
| 24/05/2011 | 02:53 | 24/05/2011 | 18:06 | Waiting on weather. F8&9 throughout the day | DTWx | 0 15:13 | 15.22 |
| 24/05/2011 | 18:06 | 24/05/2011 | 19:30 | CTD at IB21S | Stat | 0 01:24 | 1.40 |
| 24/05/2011 | 19:30 | 24/05/2011 | 20:26 | Reposition to next stn | RWP | 0 00:56 | 0.93 |
| 24/05/2011 | 20:26 | 24/05/2011 | 21:33 | CTD at IB22S | Stat | 0 01:07 | 1.12 |
| 24/05/2011 | 21:33 | 24/05/2011 | 22:32 | Reposition to next stn | RWP | 0 00:59 | 0.98 |
| 24/05/2011 | 22:32 | 24/05/2011 | 23:05 | CTD at IB23S | Stat | 0 00:33 | 0.55 |
| 24/05/2011 | 23:05 | 25/05/2011 | 03:05 | Reposition to next stn | RWP | 0 04:00 | 4.00 |
| 25/05/2011 | 03:05 | 25/05/2011 | 05:02 | CTD at IB19S | Stat | 0 01:57 | 1.95 |
| 25/05/2011 | 05:02 | 25/05/2011 | 07:11 | Reposition to next stn | RWP | 0 02:09 | 2.15 |
| 25/05/2011 | 07:11 | 25/05/2011 | 08:58 | CTD at IB18S | Stat | 0 01:47 | 1.78 |
| 25/05/2011 | 08:58 | 25/05/2011 | 11:01 | Reposition to next stn | RWP | 0 02:03 | 2.05 |
| 25/05/2011 | 11:01 | 25/05/2011 | 13:05 | CTD at IB17 | Stat | 0 02:04 | 2.07 |
| 25/05/2011 | 13:05 | 25/05/2011 | 14:43 | Reposition to next stn | RWP | 0 01:38 | 1.63 |
| 25/05/2011 | 14:43 | 25/05/2011 | 16:37 | CTD at IB16a | Stat | 0 01:54 | 1.90 |
| 25/05/2011 | 16:37 | 25/05/2011 | 18:11 | Reposition to next stn | RWP | 0 01:34 | 1.57 |
| 25/05/2011 | 18:11 | 25/05/2011 | 20:04 | CTD at IB16 | Stat | 0 01:53 | 1.88 |
| 25/05/2011 | 20:04 | 25/05/2011 | 21:37 | Reposition to next stn | RWP | 0 01:33 | 1.55 |
| 25/05/2011 | 21:37 | 25/05/2011 | 23:55 | CTD at IB15 | Stat | 0 02:18 | 2.30 |
| 25/05/2011 | 23:55 | 26/05/2011 | 01:30 | Reposition to next stn | RWP | 0 01:35 | 1.58 |
| 26/05/2011 | 01:30 | 26/05/2011 | 03:54 | CTD at IB14 | Stat | 0 02:24 | 2.40 |
| 26/05/2011 | 03:54 | 26/05/2011 | 05:44 | 0415 ARGO float deployed. Reposition to next stn. | RWP | 0 01:50 | 1.83 |
| 26/05/2011 | 05:44 | 26/05/2011 | 08:01 | CTD at IB13a | Stat | 0 02:17 | 2.28 |
| 26/05/2011 | 08:01 | 26/05/2011 | 09:38 | Reposition to next stn | RWP | 0 01:37 | 1.62 |
| 26/05/2011 | 09:38 | 26/05/2011 | 12:00 | CTD at IB13 | Stat | 0 02:22 | 2.37 |
| 26/05/2011 | 12:00 | 26/05/2011 | 13:51 | 1216 ARGO float deployed. Reposition to next stn | RWP | 0 01:51 | 1.85 |
| 26/05/2011 | 13:51 | 26/05/2011 | 16:02 | CTD at IB12 | Stat | 0 02:11 | 2.18 |
| 26/05/2011 | 16:02 | 26/05/2011 | 17:55 | Reposition to next stn | RWP | 0 01:53 | 1.88 |
| 26/05/2011 | 17:56 | 26/05/2011 | 20:15 | CTD at 6020 | Stat | 0 02:19 | 2.32 |
| 26/05/2011 | 20:15 | 26/05/2011 | 22:23 | 2122 ARGO float deployed. Reposition to next stn | RWP | 0 02:08 | 2.13 |
| 26/05/2011 | 22:23 | 27/05/2011 | 01:00 | CTD at IB11a | Stat | 0 02:37 | 2.62 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27/05/2011 | 01:00 | 27/05/2011 | 02:48 | Reposition to next stn | RWP | 0 01:48 | 1.80 |
| 27/05/2011 | 02:48 | 27/05/2011 | 05:23 | CTD at IB11 | Stat | 0 02:35 | 2.58 |
| 27/05/2011 | 05:23 | 27/05/2011 | 08:17 | 0539 ARGO float deployed. Reposition to next stn | RWP | 0 02:54 | 2.90 |
| 27/05/2011 | 08:17 | 27/05/2011 | 10:44 | CTD at IB10 | Stat | 0 02:27 | 2.45 |
| 27/05/2011 | 10:44 | 27/05/2011 | 11:32 | Reposition to next stn | RWP | 0 00:48 | 0.80 |
| 27/05/2011 | 11:32 | 27/05/2011 | 13:40 | CTD at IB9 | Stat | 0 02:08 | 2.13 |
| 27/05/2011 | 13:40 | 27/05/2011 | 15:34 | At IB8. Weather increasing. 30kts wind increasing. Rough seas. Science suspended | RWP | 0 01:54 | 1.90 |
| 27/05/2011 | 15:34 | 28/05/2011 | 19:34 | Waiting on weather. F8&9 occ'l 10 throughout the night/day. | DTWx | 1 04:00 | 28.00 |
| 28/05/2011 | 19:34 | 28/05/2011 | 21:11 | CTD at IB8 | Stat | 0 01:37 | 1.62 |
| 28/05/2011 | 21:11 | 28/05/2011 | 22:12 | Reposition to next stn | RWP | 0 01:01 | 1.02 |
| 28/05/2011 | 22:12 | 28/05/2011 | 23:26 | CTD at IB7 | Stat | 1 0 01:14 | 1.23 |
| 28/05/2011 | 23:26 | 29/05/2011 | 02:04 | Reposition to next stn | RWP | 0 02:38 | 2.63 |
| 29/05/2011 | 02:04 | 29/05/2011 | 03:35 | CTD at IB5. No IB6 | Stat | 0 01:31 | 1.52 |
| 29/05/2011 | 03:35 | 29/05/2011 | 05:32 | Reposition to next stn | RWP | 0 01:57 | 1.95 |
| 29/05/2011 | 05:32 | 29/05/2011 | 06:58 | CTD at IB4a | Stat | 0 01:26 | 1.43 |
| 29/05/2011 | 06:58 | 29/05/2011 | 08:58 | Reposition to next stn | RWP | 0 02:00 | 2.00 |
| 29/05/2011 | 08:58 | 29/05/2011 | 10:17 | CTD at IB4 | Stat | 0 01:19 | 1.32 |
| 29/05/2011 | 10:17 | 29/05/2011 | 12:47 | Reposition to next stn | RWP | 0 02:30 | 2.50 |
| 29/05/2011 | 12:47 | 29/05/2011 | 13:40 | CTD at IB3 | Stat | 0 00:53 | 0.88 |
| 29/05/2011 | 13:40 | 29/05/2011 | 16:31 | Reposition to next stn | RWP | 0 02:51 | 2.85 |
| 29/05/2011 | 16:31 | 29/05/2011 | 17:24 | CTD at IB2 | Stat | 0 00:53 | 0.88 |
| 29/05/2011 | 17:24 | 29/05/2011 | 21:01 | Reposition to next stn | RWP | 0 03:37 | 3.62 |
| 29/05/2011 | 21:01 | 29/05/2011 | 21:30 | CTD at A. No IB1 | Stat | 0 00:29 | 0.48 |
| 29/05/2011 | 21:30 | 29/05/2011 | 22:38 | Reposition to next stn | RWP | 0 01:08 | 1.13 |
| 29/05/2011 | 22:38 | 29/05/2011 | 23:13 | CTD at B | Stat | 0 00:35 | 0.58 |
| 29/05/2011 | 23:13 | 30/05/2011 | 00:30 | Reposition to next stn | RWP | 0 01:17 | 1.28 |
| 30/05/2011 | 00:30 | 30/05/2011 | 01:07 | CTD at C | Stat | 0 00:37 | 0.62 |
| 30/05/2011 | 01:07 | 30/05/2011 | 01:45 | Reposition to next stn | RWP | 0 00:38 | 0.63 |
| 30/05/2011 | 01:45 | 30/05/2011 | 03:00 | CTD at D | Stat | 0 01:15 | 1.25 |
| 30/05/2011 | 03:00 | 30/05/2011 | 04:05 | Reposition to next stn | RWP | 0 01:05 | 1.08 |
| 30/05/2011 | 04:05 | 30/05/2011 | 05:57 | CTD at E | Stat | 0 01:52 | 1.87 |
| 30/05/2011 | 05:57 | 30/05/2011 | 07:25 | Reposition to next stn | RWP | 0 01:28 | 1.47 |
| 30/05/2011 | 07:25 | 30/05/2011 | 09:15 | CTD at F | Stat | 0 01:50 | 1.83 |
| 30/05/2011 | 09:15 | 30/05/2011 | 10:32 | Reposition to next stn | RWP | 0 01:17 | 1.28 |
| 30/05/2011 | 10:32 | 30/05/2011 | 12:45 | CTD at G | Stat | 0 02:13 | 2.22 |
| 30/05/2011 | 12:45 | 30/05/2011 | 13:51 | Reposition to next stn | RWP | 0 01:06 | 1.10 |
| 30/05/2011 | 13:51 | 30/05/2011 | 16:00 | CTD at H | Stat | 0 02:09 | 2.15 |
| 30/05/2011 | 16:00 | 30/05/2011 | 16:48 | Reposition to next stn | RWP | 0 00:48 | 0.80 |
| 30/05/2011 | 16:48 | 30/05/2011 | 17:43 | CTD at I | Stat | 0 00:55 | 0.92 |
| 30/05/2011 | 17:43 | 30/05/2011 | 18:35 | Reposition to next stn | RWP | 0 00:52 | 0.87 |
| 30/05/2011 | 18:35 | 30/05/2011 | 19:29 | CTD at J | Stat | 0 00:54 | 0.90 |
| 30/05/2011 | 19:29 | 30/05/2011 | 20:27 | Reposition to next stn | RWP | 0 00:58 | 0.97 |
| 30/05/2011 | 20:27 | 30/05/2011 | 21:34 | CTD at K | Stat | 0 01:07 | 1.12 |
| 30/05/2011 | 21:34 | 30/05/2011 | 22:29 | Reposition to next stn | RWP | 0 00:55 | 0.92 |
| 30/05/2011 | 22:29 | 31/05/2011 | 00:40 | CTD at L | Stat | 0 02:11 | 2.18 |
| 31/05/2011 | 00:40 | 31/05/2011 | 01:44 | Reposition to next stn | RWP | 0 01:04 | 1.07 |
| 31/05/2011 | 01:44 | 31/05/2011 | 03:57 | CTD at M | Stat | 0 02:13 | 2.22 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 31/05/2011 | 03:57 | 31/05/2011 | 05:05 | Reposition to next stn | RWP | 0 01:08 | 1.13 |
| 31/05/2011 | 05:05 | 31/05/2011 | 07:07 | CTD at N | Stat | 0 02:02 | 2.03 |
| 31/05/2011 | 07:07 | 31/05/2011 | 08:32 | Reposition to next stn | RWP | 0 01:25 | 1.42 |
| 31/05/2011 | 08:32 | 31/05/2011 | 10:27 | CTD at O | Stat | 0 01:55 | 1.92 |
| 31/05/2011 | 10:27 | 31/05/2011 | 11:33 | Reposition to next stn | RWP | 0 01:06 | 1.10 |
| 31/05/2011 | 11:33 | 31/05/2011 | 13:23 | CTD at P | Stat | 0 01:50 | 1.83 |
| 31/05/2011 | 13:23 | 31/05/2011 | 14:18 | Reposition to next stn | RWP | 0 00:55 | 0.92 |
| 31/05/2011 | 14:18 | 31/05/2011 | 15:00 | CTD at Q | Stat | 0 00:42 | 0.70 |
| 31/05/2011 | 15:00 | 31/05/2011 | 15:56 | Reposition to next stn | RWP | 0 00:56 | 0.93 |
| 31/05/2011 | 15:56 | 31/05/2011 | 16:31 | CTD at R | Stat | 0 00:35 | 0.58 |
| 31/05/2011 | 16:31 | 31/05/2011 | 17:39 | Reposition to next stn | RWP | 0 01:08 | 1.13 |
| 31/05/2011 | 17:39 | 31/05/2011 | 18:09 | CTD at S | Stat | 0 00:30 | 0.50 |
| 31/05/2011 | 18:09 | 01/06/2011 | 00:01 | Waiting on weather. Wind 30-35kts and rough seas. End of Science 00:01 for passage back to Liverpool. | DTWx | 0 05:52 | 5.87 |
| 01/06/2011 | 00:01 | 02/06/2011 | 06:45 | Passage to Liverpool pilot | Pass | 1 06:44 | 30.73 |
| 02/06/2011 | 06:45 | 02/06/2011 | 09:12 | Pilotage in through Gladstone Lock to SeaForth Docks | Pass | 0 02:27 | 2.45 |
| 02/06/2011 | 09:12 | 02/06/2011 | 17:00 | Demobilisation D365 | Dem/Mob | 0 07:48 | 7.80 |

*Table 2*. Aggregated Hours for each Activity

| Indicator | Hours |
|---|---|
| **Dem/Mob** | 56.80 |
| **Pass** | 33.18 |
| **Stat** | 80.20 |
| **RWP** | 92.87 |
| **DTWx** | 127.45 |
| **DTShip** | 136.25 |
| **DTTech** | 16.03 |
| **DTOther** | 0.00 |
| | 542.78 |
| days | 22.62 |

*Table 3*. Indicator Legend

| **Code** | **Explanation** |
|---|---|
| Dem/Mob | All demob/mobilising activities |
| Pass | Pilotage and non-science passage. |
| Stat | All stationary work such as CTD |
| RWP | Repositioning, waiting and preparation |
| DTWx | Downtime for weather |
| DTShip | Downtime ship systems |
| DTTech | Downtime scientific systems |
| DTOther | Downtime other (medical, rendering assistance, etc) |

*A. Gatti*

## 3. TECHNICAL SUPPORT

**Sensors and Moorings** - *Chris Barnard, Paul Provost, Steve Whittle*

CTD system configuration

1) One CTD system was 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-46253-0869
Sea-Bird 3P temperature sensor, s/n 03P-2919, Frequency 0 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-2571, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 100898, Frequency 2

Sea-Bird 3P temperature sensor, s/n 03P-4151, Frequency 3 (secondary, vane mounted)
Sea-Bird 4C conductivity sensor, s/n 04C-3054, Frequency 4 (secondary, vane mounted)
Sea-Bird 5T submersible pump, s/n 05T-2279, (primary)
Sea-Bird 5T submersible pump, s/n 05T-3002, (secondary, vane mounted)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-37898-0518
Sea-Bird 11plus deck unit, s/n 11P-34173-0676

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

Sea-Bird 43 dissolved oxygen sensor, s/n 43-1882 (V0)
Tritech PA200 altimeter, s/n 6196.118171 (V2)
Chelsea MKIII Aquatracka fluorometer, s/n 88-2050-095 (V3)
Chelsea 2-pi PAR irradiance sensor, UWIRR, s/n PAR 07 (V4)
Chelsea 2-pi PAR irradiance sensor, DWIRR, s/n PAR 06 (V5)
Chelsea MKII 25cm path Alphatracka transmissometer, s/n 07-6075-001 (V6)
WETLabs light scattering sensor, red LED, 650nm, s/n BBRTD-169 (V7)

3) Additional instruments:

Ocean Test Equipment 10L water samplers, s/n's 1-24
Sonardyne HF Deep Marker beacon, s/n 245116-001
NOC 10 kHz acoustic bottom finding pinger, s/n B6
TRDI WorkHorse 300kHz LADCP, s/n 15288 (downward-looking)
TRDI WorkHorse 300kHz LADCP, s/n 13329 (upward-looking)
NOC WorkHorse LADCP battery pack, s/n WH001
Chelsea Fastracka FRRF, s/n 05-4845-001

4 Sea-Bird 9*plus* configuration file D365_st_NMEA.xmlcon was used for all CTD casts, with D365_st_noNMEA.xmlcon used for the back-up, simultaneous logging desktop computer. Both PAR sensors and the FRRF were removed for any cast deeper than 500 meters. The LADCP command file used for all casts was WHMD365.txt and WHSD365.txt.

<u>Other instruments</u>

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

Guildline Autosal 8400B, s/n 68426, installed in Constant Temperature Laboratory as the primary instrument, Autosal set point 21C. This instrument was found to be faulty during standardization. The results observed were similar to the symptoms of thermistor failure as occurred to this unit on JC053. The unit was repaired following JC053 and this was its first use following that repair. The unit was removed from service and returned to NOC for service.

Guildline Autosal 8400A, S/N 56747, was then installed as above in the CT Laboratory at set point of 21C. This unit has not been used in some time and as a result the Air pumps that form part of the cell filling process were stalling due to belt slippage. There appears to be oil on the outside of the piston. The pump was replaced with a spare sent from NOC but the unit was removed from service and 2 more units sent from NOC.

Guildline Autosal 8400B, S/N 60898 was installed in the CT Lab at a set point of 21C. The system appeared to have a faulty lamp however this was then found to be a simple connection issue.

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

Chelsea MKI, s/n 05-4845-001---Configured for profiling, mounted on Stainless Frame for all Casts less than 500m.

<u>Technical details</u>

*<u>CTD</u>*

Cast CTD365001 Bottle 9 failed to close. The bottle fire was initiated however the latch on the carousel was stuck. The latch was manually freed however on subsequent casts the latch failed to release each time. The carousel was removed from the frame and it was found that the epoxy that covers the magnet at bottle 9 had been dislodged and therefore the mechanism was no longer free to move. This was rectified following cast 10.

Issues with Bottles 5, 9, 13, 18 failing to fire on occasion. Position 9 Resin appears to be moving out of position which blocks the latch being pulled by the magnet. 5, 13,18 are about 50% fire rate. 5 and 18 found to have loose screws. Latch assembly broken down into 24 latches and cleaned. Screws tightened as required. Unit inverted and latches released to ensure good release. Carousel Reassembled. Deck Tested ok. All bottles fired successfully on following cast (032)

Cast 34 Bottle 3 failed to fire. Removed Carousel latch mechanism again and checked screws. All fine. All bottles fired successfully on next 8 casts.

Cast CTD365007 – Prior to the cast it was noticed that the T Duct on the Primary (Frame Mounted) Temperature probe was loose. This is normally screwed into the therm guard that protects the temperature probe. This was removed and replaced. The screws holding this in place appeared to have been snapped. The therm guard also appears to be out of shape as if it had been struck. This was replaced prior to the cast using spares on board.

Total number of casts 55

Deepest casts m S/S frame : 2800

*<u>FRRF</u>*

No issues reported

*<u>LADCP's</u>*

Post Cast 008 there were communications issues with the Upward Looking Slave S/n 13329. On reseating the connector the message ALARM BREAK was seen on the terminal. We believed that water had contaminated the pressure housing or possibly condensation. The unit is still in working order but was replaced with S/N 10607 as it was uncommunicative.

In attempting to communicate with the slave unit the cable was cleaned and it was during this that the Pin 7 (-VE) broke away. The Star Cable on the CTD was replaced. Communication problems still ensued and it was found that the Deck cable for the slave was also having intermittent issues. The Deck cable was replaced and ops continued.

Both cables were later repaired with spares available on board.

Following 3 days of transit to Iceland the ADCP's were deployed on cast 011 when it was noticed that the battery level was very low despite having been charged following the previous cast.

It was noted that one ADCP was waking up when sent the CZ (Power down) command. The ADCP would wakeup with BREAK WAKEUP B which placed it in RS422 mode instead of RS232 mode and occasionally it would wakeup in BREAK WAKEUP AB, an AB wakeup could indicate that the ADCP's communications switch was hovering between the two positions and so ADCP 15288 was removed from the master position and replaced by 13329.

ADCP 15288 was inspected internally where it was found that a bag of silica had burst and had been spread across the circuit boards. The communication switch was firmly set in the RS232 position. The silica was removed and replaced and the electronics cleaned. On deck tests did not show the wake up issue reoccurring?

**Computing & Instrumentation Report** - *Paul Duncan*

<u>TECHSAS & Level C</u>

All data (other than ADCP and SBWR) were logged on TECHSAS (as NetCDF files) and also on the Level C (which receives UDP broadcasts from TECHSAS) as Level C streams. The Level C data areas were exported via NFS to the scientists Sun Workstation in the main lab, so that they could be read into the Pstar system.

The instrumentation logged was:

| | |
|---|---|
| Fugro Seastar 9200G2 | primary navigation system |
| Trimble 4000DL | secondary navigation system |
| Ashtech ADU5 | attitude GPS |
| Simrad EA-500 | 10KHz echo sounder |
| Surfmet | sea surface and meteorological sensors |
| Seabird 45 & 38 | sea surface temperature and TSG |
| Winch | CLAM winch monitoring system |

<u>Navigation Systems</u>

This was the first time that some of the scientists had sailed with the new Fugro Seastar system and the ADU5. John Allen did some testing and was pleased with the performance of both systems, and noted that the ADU5 crashed far less than the earlier ADU2 system which had been in use on Discovery previously (it is still on board as the spare attitude GPS receiver).

The one downside is that the accuracy of positions from the Trimble receiver seems to have suffered recently. We believe this is because the original Trimble antenna has failed, and an antenna originally used by the old Ashtech GG24 GPS/GLONASS system is currently in use in its place. We are unwilling (especially in the current financial climate) to spend money on a replacement antenna for the Trimble system since it is exceedingly obsolete, and Trimble no longer supply spares for the main receiver unit. This receiver should be regarded as a "last ditch" positioning solution. John Allen's tests revealed that the ADU5's position accuracy was significantly better than the accuracy of the Trimble receiver.

Surfmet

*Table 2*. Surfmet sensor information

| Manufacturer | Sensor | Serial no | Comments | Calibration Expires |
|---|---|---|---|---|
| Seabird | SBE45 | 0230 | TSG | 16/07/11 |
| Seabird | SBE38 | 0490 | Remote Temperature | 04/10/11 |
| Wetlabs | fluorometer | WS3S-248 | | 15/12/11 |
| Seatech | transmissometer | CST-1131R | | 24/03/12 |
| Vaisala | Barometer PTB100A | S3440012 | | 21/03/12 |
| Vaisala | Temp/humidity HMP45A | E1055002 | | 30/09/11 |
| SKYE | PAR SKE510 | 28563 | PORT | 12/06/11 |
| SKYE | PAR SKE510 | 28558 | STBD | 12/06/11 |
| Kipp and Zonen | TIR CM6B | 944133 & 962301 | PORT – Sensors changed during Glasgow port call on | 26/04/13 (both) |
| Kipp and Zonen | TIR CM6B | 962276 | STBD | 17/09/12 |
| Sensors without cal | | | | |
| Seabird | P/N 90402 SBE45 JB | unknown | Junction Box | |
| Gill | Windsonic Option 3 | Inv# 250004845 | | |

SPARES

| Manufacturer | Sensor | Serial no | Comments | Calibration Expires |
|---|---|---|---|---|
| Seabird | SBE45 | 0229 | | 13/04/12 |
| Seabird | SBE38 | 0476 | Remote Temperature | 13/04/12 |
| Wetlabs | fluorometer | WS3S-247 | | 20/04/12 |
| Wetlabs | transmissometer | CST-112R | | |
| Vaisala | Barometer PTB100A | Z470021 | | 15/09/11 |
| Vaisala | Temp/humidity HMP45A | B4950011 | | 10/04/12 |
| SKYE | PAR SKE510 | 28559 | | unknown |
| SKYE | PAR SKE510 | | | |
| Kipp and Zonen | TIR CMB6 | | | |
| Sensors without cal | | | | |
| Gill | Windsonic Option 3 | 071121 | | |
| Seabird | P/N 90402 SBE45 JB | | Junction Box | |
| | | | | |
| | | | | |
| Gill | Windsonic Option 3 | | | |
| | | | | |

The Surfmet system suffered from a few problems during this cruise, mostly with the light sensors. The system had a major upgrade during the refit, and this was completed just prior to the cruise.
During the port call in Govan one of the CM6B TIR sensors was replaced with the spare. Later in the cruise investigations would reveal that the problems had been caused by a fault in the cable from the sensor to the masthead junction box.

The ship steamed through a cloud of Icelandic volcanic ash. This caused attenuation of the light sensor data, necessitating several trips up the foremast to clean them off. I'm not sure if other sensors were affected as well. There was at least one suggestion that the Gill Windsonic was not reading correctly.

The final problem was a loose connection to one of the masthead Udam modules, which caused loss of most of the met data. Chris Barnard went up the mast to sort this out.

There were the usual problems with bubbles causing bad transmissometer data. This can be sorted out by briefly increasing the water flow beyond the normal 1.8L/min.

Vessel-mounted ADCP

Since the refit the ship had not had an ADCP head installed, but thanks to the ship sailing late, the 150KHz ADCP was returned by TRDI after being repaired and was immediately fitted to the ship.

There were problems with the lift bag, which is beginning to show its age. It has been patched numerous times, and uses a type of valve incompatible with modern diving systems. The divers suggest that a new lift bag should be purchased before the refitting of the 75KHz head.

Once installed and running at sea, the system appeared to give good data.

Shipborne Wave Recorder

This was run at the request of the scientists, although I am not sure if the data were actually read into pstar and used.

## 4. SCIENTIFIC INVESTIGATIONS

**CTD Data Acquisition and Processing** – *Estelle Dumont, Harriet Cole, John Allen, Mike Nelson*

As far as possible, the processing route for CTD data followed that used on RRS *Discovery* 298 in August/September 2005.

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 output four files per CTD cast in the form D365nnn with the following extensions: .hex (raw data file), .xmlcon (data configuration file), .bl (contained record of bottle firing locations), and .hdr (a header file).

These files were manually backed up onto the UNIX network, via ftp to the file location /D365/ctd/raw/CTD1. The raw data files were then processed using SeaBird's own CTD data processing software, SBEDataProcessing-Win32: v.7.21a. SeaBird CTD processing routines were run using a batch command file, and were used as follows:

**DatCnv**: The Data Conversion routine, DatCnv, read in the raw CTD data file (CTD365nnn.hex). 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 (ctd365nnn.cnv) format was set to binary and to include both up and down casts. The variables included were: elapsed time, pressure, primary and secondary temperature, primary and secondary conductivity, conductivity difference, temperature difference, beam attenuation, beam transmission, fluorescence, oxygen sensor voltage, oxygen saturation, oxygen concentration, primary and secondary salinity, salinity difference, density (sigma-theta), turbidity, altimeter, upward-looking PAR/Irradiance, downward-looking PAR/Irradiance, scan number and flag. A second output file (ctd365nnn.ros) contained bottle firing information, taking the output data at the instant of bottle firing.

**AlignCTD**: This program read in ctd365nnn.cnv and was set to shift the oxygen sensor relative to the pressure data compensating for lags in the sensor response time. An alignment of + 4 seconds has been applied to the casts over the Scottish shelf (casts number 001 to 010). For the rest of the casts, the oxygen data was shifted by + 5 seconds. The output was written to the file ctd365nnn_2.cnv (a bug in the SBEDataProcessing software made it impossible to batch-process without renaming the output file).

**WildEdit**: This is a de-spiking routine, using the input file ctd365nnn_2.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. The output was written to the file ctd365nnn_3.cnv.

**CellTM:** The effect of thermal 'inertia' on the conductivity cells was removed using the routine Celltm on the file ctd365nnn_3.cnv. 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 $\alpha$, the thermal anomaly amplitude was set at 0.03 and $\beta$, the thermal anomaly time constant was set at 1/7 (the SeaBird recommended values for SBE911+ pumped system). $\Delta$ 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. The output was written to the file ctd365nnn_4.cnv.

**Translate**: Finally, the ctd365nnn_4.cnv file was converted from binary into ASCII format and saved as the original filename ctd365nnn.cnv, 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 /D365/ctd/SBEprocessed so that data processing could be continued using PEXEC routines.

*Data Processing on the UNIX system*

The following c-shell UNIX scripts were used to process the data.

**ctd0**: This script 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 ctd365nnn.24hz.

**ctd1**: This script 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 ctd365nnn.1hz and ctd365nnn.10s respectively.

**ctd2**: This script carried out a head and tail crop of the .1hz file to select the relevant 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 files ctd365nnn.ctu created. Finally, the data were averaged into two decibar pressure bins creating the files ctd365nnn.2db.

**ctd3**: The script ctd3 was used to produce the user's preferred raw plots of the data in the .ctu files.

**fir0**: This script 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 fir365nnn containing the mean values of all variables at the bottle firing locations.

**samfir**: This script created the file, sam365nnn containing selected variables from fir365nnn so that the results from the bottle sampling analysis could be added.

**ctd4**: This script checked the true position and water depth from the master navigation and master bathymetry files. This allowed the user to correct the information in all CTD and sample files.

Once salinity bottle data had been processed and excel files created for each ctd cast then the following scripts.

**sal0**: Read in the sample bottle excel 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*: output file sal365nnn.bot.

**passal**: Pasted bottle file (sal365nnn.bot) values into sam365nnn files.

**peos83**: This program was used to calculate the conductivity for bottle salinities using both primary and secondary temperatures.

**oxy0**: Read in the oxygen sample bottle excel files, that had been saved as tab delimited text only files, and converted some PC unique characters into UNIX friendly characters. Then oxy0 created pstar format files with *pascin*: output file oxy365nnn.bot.

**pasoxy**: Pasted bottle file (oxy365nnn.bot) values into sam365nnn files.

The oxygen bottle samples were pasted into the sample (sam365nnn) files and plots were made of the residual differences and of oxygen bottle sample vs. CTD oxygen. So far, no calibration has been attempted.

*Conductivity Calibration*

SeaBird claim that the correct in-situ calibration for their conductivity sensors is a linear function of conductivity with no offset. Plots of conductivity difference against conductivity added support to this and therefore *parith* and *allav* were used to calculate the mean square of the conductivity values and the mean product of the bottle and CTD conductivity values; to solve thus,

$$conductivity = A * (primary\ conductivity)$$
$$conductivity = B * (secondary\ conductivity)$$

where

$$A = \frac{\sum Cond_{bot} Cond_{ctd}}{\sum (Cond_{ctd})^2} = \frac{\overline{Cond_{bot} Cond_{ctd}}}{\overline{(Cond_{ctd})^2}}$$

and

$$B = \frac{\sum Cond2_{bot} Cond2_{ctd}}{\sum (Cond2_{ctd})^2} = \frac{\overline{Cond2_{bot} Cond2_{ctd}}}{\overline{(Cond2_{ctd})^2}}$$

and $cond2_{bot}$ is the sample bottle conductivity determined with the secondary temperature variable.

The original, pre-calibration residual conductivity differences were both 0.0003 with standard deviations of 0.0008 and 0.0007 for primary and secondary conductivity sensors respectively. These are small enough to fall within the limits of the instrumental accuracy for the SeaBird 911 but the calibration was carried out anyway as an instructional exercise. The residual conductivity differences were passed through *datpik* to remove data points that fell outside of 1 standard deviation. This step was done twice before calculating A and B above. The ctd casts were then calibrated using ctdcondcal.

**ctdcondcal**: This script was used to calibrate the .ctu and .2db files and re-calculate salinity, potential temperature and sigma0/sigma2. A and B were set to 1.0000070967 and 0.9999925401 respectively.

The final residual conductivity differences were both 0.0000 with a standard deviation of 0.0008 and 0.0007 for both primary and secondary conductivity sensors respectively.

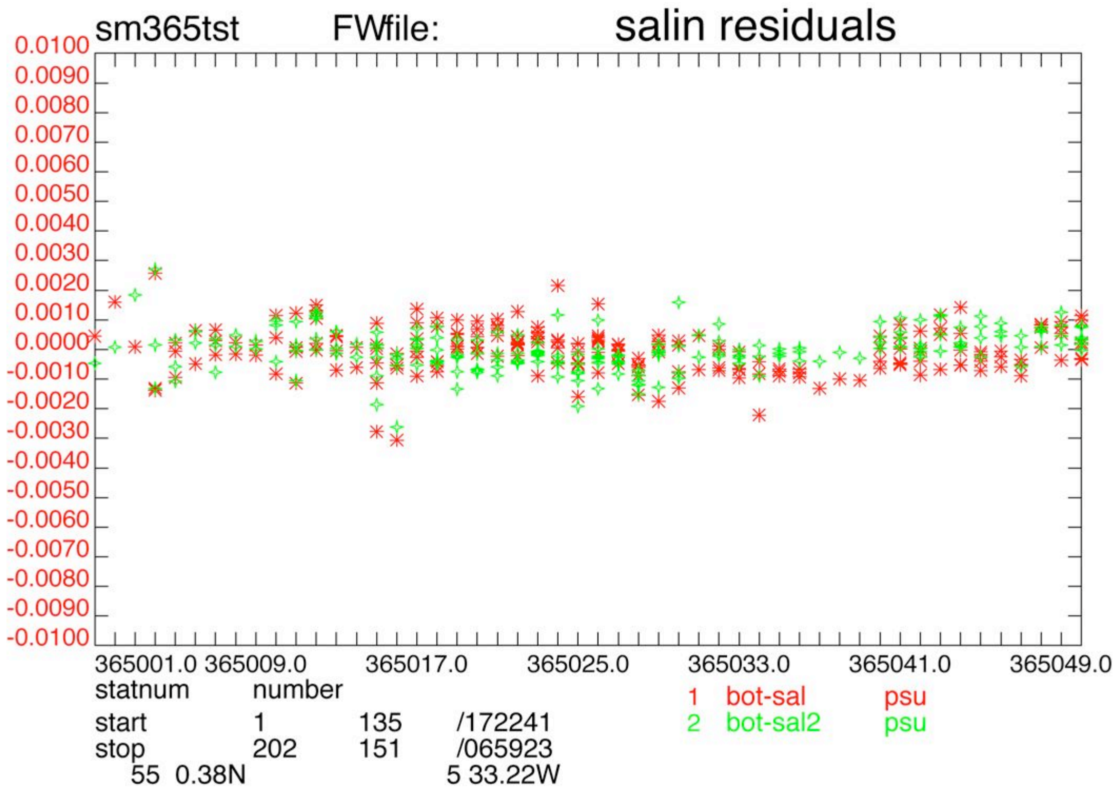



*Figure 3.* Bottle-CTD salinity residuals after calibration

**Lowered ADCP** – *Jane Read*

Two TRDI WorkHorse 300 kHz acoustic Doppler current profilers were mounted on the CTD frame. One was positioned to look downwards (Master), while the second looked upwards (slave). At the beginning of the cruise S/N 15288 was positioned looking downwards and S/N 13329 was positioned looking upwards. For cast 009, S/N 13329 was removed and replaced with S/N 10607 for reasons explained in the technical report. For cast 012 the S/N 15288 was replaced with S/N 13329. Hence the upward looking instrument became the downward looking instrument.

Data were processed using MatLab Visbeck v10 software with additional data handling programmed by 'Alderson Associates'. The Visbeck software incorporates ship's position, CTD pressure and time and vessel mounted ADCP currents to obtain the best solution for water column currents. Vessel mounted ADCP data were not used during the processing at sea. CTD data were merged with the 'abnv3651' (bestnav) file for position, then converted from pstar 2db files to MatLab format. Time, position and pressure were separated into different .mat files for the Visbeck software.

The Visbeck software cannot handle profiles that are too shallow, because there is insufficient data for the algorithm. Ctd casts 001-010, Line G worked on the shelf, were not processed. A number of processes failed for no obvious reason (casts 022, 025, 026, 027, 032, 038, 040, 041, 042, 043, 044). Further analysis of the data will be made at NOC.

**Vessel Mounted ADCP (VM-ADCP) and Navigation Data** – *John Allen, Dmitry Aleynik*

Introduction

The RRS *Discovery* is usually equipped with two hull mounted Ocean Survey broadband ADCPs. An RDI broad band 150 kHz (Ocean Surveyor) phased array style VM-ADCP is mounted in the hull 1.75 m to port of the keel, 33 m aft of the bow at the waterline, at an approximate depth of 5.3 m. A 75 kHz ADCP is also mounted in the hull, in a second well 4.15 m forward and 2.5 m to starboard of the 150 kHz well. During refit in Amsterdam just prior to this cruise, D365, it was discovered that the 75 kHz VM-ADCP had significant damage to the transducer phase, possibly caused by barnacle fouling. As watertight integrity of the transducer face was almost certainly threatened, the unit was sent back to RDI in California for repair. For a while it looked highly likely that RRS *Discovery* would be without a VM-ADCP at all as the 150 kHz unit was still awaiting delivery from RDI, California following a requirement to re-mould that transducer head earlier in the year. Luckily the 150 kHz VM-ADCP arrived 48 hours before our delayed departure date from Southampton and was fitted by divers on the morning of departure at the NOCS quayside. Not having a spare transducer on shelf for eventualities like this is a major oversight on the part of NERC and it's marine equipment pool. The cost of a spare is equivalent to 2-3 days of the total cost to the tax payer of running one of our ocean research vessels, and the damage to the scientific objectives of physics and multidisciplinary research programmes caused by not having spare units is enormous in comparison. Spare VM-ADCPs do not degrade in storage and therefore there is no increased running cost in having spares. Due to the delay in the cruise departure for other engineering difficulties, we were now able to determine ocean currents over the top 300-350 m of the water column, however, our ability to measure ocean currents between 350 m and 700 m during D365 had gone.

This section describes the operation and data processing paths for the VM-ADCP. The navigation data processing is described first since it is key to the accuracy of the ADCP current data. All integrated underway data were logged using the Ifremer TechSAS data logging system. As on D351, the Extended Ellett line 2010, the 'live' RVS data format streams have overcome the problem discussed in previous reports of insufficient significant figure resolution in position data using *nclistit*. These live streams do not convert the netcdf format to RVS data format, instead, they log TechSAS broadcast messages independently.

Method

*Navigation*

The ship's primary position instrument was a new Fugro SeaStar 9200G2 system. The previous Trimble 4000 had become obsolete and its positional accuracy had deteriorated significantly, indeed the routine positional accuracy check whilst tied up alongside the NOC, Southampton, was found to be ± 4-6 m S.D., as though it was no longer interpreting the differential inputs. The positional accuracy for the SeaStar 9200 system, on the other hand, was an astonishing ± 0.03 m S.D. fully supporting its advertised 10 cm accuracy. For this cruise, our back up system would be the new Ashtech ADU5 3-D GPS system, replacing the previous ADU2 system, and the positional accuracy of which was in parallel determined to be ± 0.3-0.5 m S.D.

Both the SeaStar 9200 and the Ashtech ADU5 systems have sufficient precision to enable the calculation of ship's velocities to much better than 1 cm $s^{-1}$ over 2 minute ensemble periods and therefore below the instrumental limits (~ 1 cm $s^{-1}$) of the RDI VM-ADCP systems. Using the Fugro SeaStar 9200G2 system as its primary navigation source, the NMFSS Bestnav combined (10 second) cleaned navigation process was operational and working well on D365.

Navigation and gyro data were transferred daily from the RVS format file streams to pstar navigation files, e.g. abnv36501, gpC36501 and gyr36501.

Scripts:

**navexec0**: transferred data from the RVS *bestnav* stream to pstar, calculated the ships velocity, appended onto the absolute (master) navigation file and calculated the distance run from the start of the master file. Output: abnv3651

**gyroexec0**: transferred data from the RVS *gyro* stream to pstar. A nominal edit was made for directions between 0-360° before the file was appended to a master file.

**gpCexec0**: transferred data from the RVS *gps_g2* stream to pstar, edited out pdop (position dilution of precision) greater than 7 and appended the new 24 hour file to a master file. The master file was averaged to create an additional 30 second file and distance run was calculated and added to both.

<u>*Heading*</u>

The ships attitude was determined every second with the ultra short baseline 3D GPS Ashtech ADU5 navigation system. The Ashtech data were used to calibrate the gyro heading information as follows:

**ashexec0**: transferred data from the RVS format stream *gps_ash* to pstar.

**ashexec1**: merged the ashtech data from ashexec0 with the gyro data from gyroexec0 and calculated the difference in headings (hdg and gyroHdg); ashtech-gyro (a-ghdg).

**ashexec2**: edited the data from ashexec1 using the following criteria:

| | |
|---|---|
| heading | 0 < hdg < 360 (degrees) |
| pitch | -5 < pitch < 5 (degrees) |
| roll | -7 < roll < 7 (degrees) |
| attitude flag | -0.5 < attf < 0.5 |
| measurement RMS error | 0.00001 < mrms < 0.01 |
| baseline RMS error | 0.00001 < brms < 0.1 |
| ashtech-gyro heading | -7 < a-ghdg < 7 (degrees) |

The heading difference (a-ghdg) was then filtered with a running mean based on 5 data cycles and a maximum difference between median and data of 1 degree. The data were then averaged to 2 minutes and further edited for

-2 < pitch <2
0 < mrms < 0.004

The 2 minute averages were merged with the gyro data files to obtain spot gyro values. The ships velocity was calculated from position and time, and converted to speed and direction. The resulting a-ghdg should be a smoothly varying trace that can be merged with ADCP data to correct the gyro heading. Diagnostic plots were produced to check this. During ship manoeuvres, bad weather or around data gaps, there were spikes, which were edited out manually (plxyed, **Fig.x.1**).

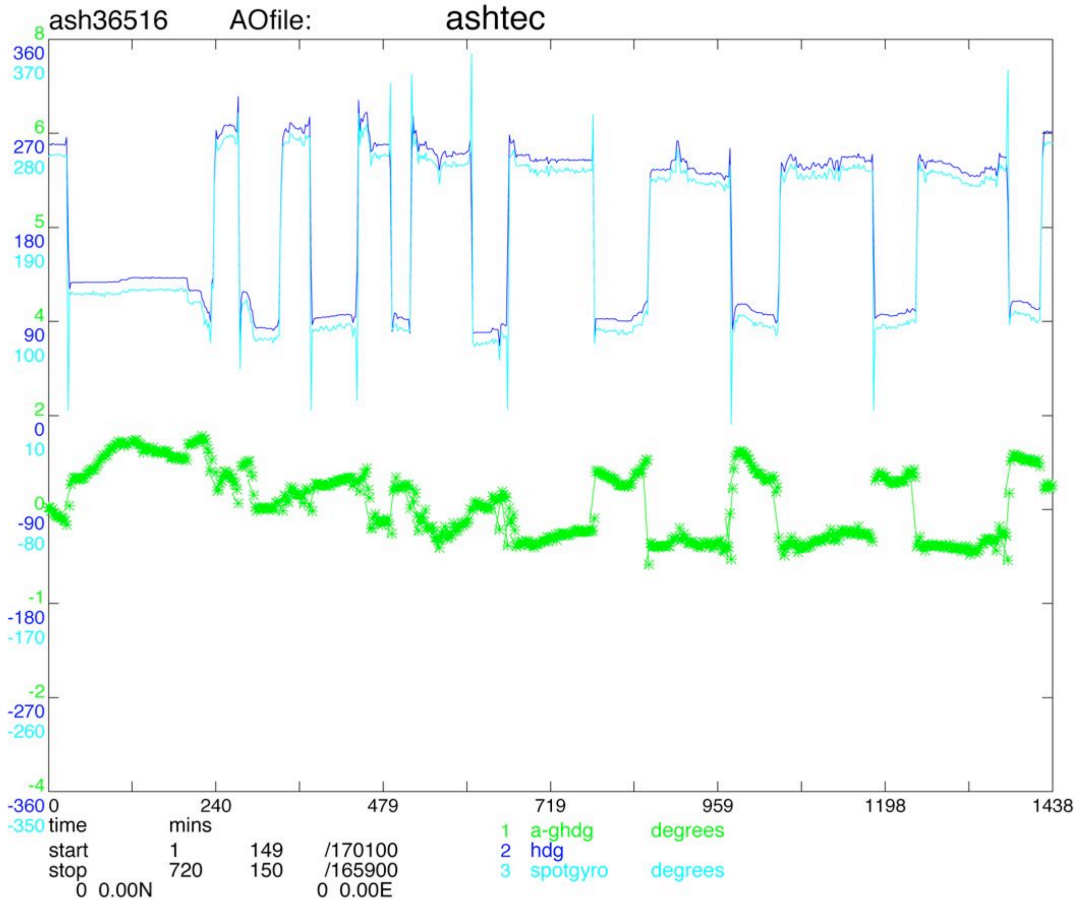



*Figure 4*. Example of the onscreen output of daily navigation hdg data generated by gyro (light blue line), ashtech ADU5 (dark blue line) and the difference between them (green line).

Ashtech ADU5 3D GPS coverage was excellent. Gaps of any duration in the data stream are listed below.

time gap : 11 134 19:05:11 to 11 134 19:05:57 (46 s)
time gap : 11 135 11:38:10 to 11 135 11:38:46 (36 s)
time gap : 11 135 11:39:03 to 11 135 11:39:31 (28 s)
time gap : 11 135 11:39:31 to 11 135 11:39:35 (4 s)
time gap : 11 136 16:53:29 to 11 136 16:53:57 (28 s)
time gap : 11 141 11:21:03 to 11 141 11:21:08 (5 s)
time gap : 11 141 11:22:38 to 11 141 11:22:42 (4 s)
time gap : 11 142 07:31:11 to 11 142 07:31:13 (2 s)
time gap : 11 142 07:34:17 to 11 142 07:34:19 (2 s)
time gap : 11 143 07:33:02 to 11 143 07:33:04 (2 s)

VM-ADCP data

This section describes the operation and data processing paths for the VM-ADCP, and closely follows that used on RRS *Discovery* 351 but with a different selection of vertical bin length and number of bins.

*150 kHz VM-ADCP data processing*

The RDI Ocean Surveyor 150 kHz Phased Array VM-ADCP was configured to sample over 120 second intervals with 50 bins of 8 m length and a blank beyond transmit of distance of 4 m. The instrument is a broad-band phased array ADCP with 153.6 kHz frequency and a 30° beam angle.

The deck unit had firmware upgrades to VMDAS 23.17 following the March 2008 refit. The controlling PC ran RDI software VmDAS v1.46.

Recent changes to the network COM ports on *RRS Discovery* occurred during the 2010 refit and the following is now applicable for both ADCPs when in operation (Table 2).

*Table 3*: Changes of COM ports during *RRS Discovery* 2010 refit

| COM PORT | Baud Rate | Data Stream |
|---|---|---|
| COM1 | 9600 | ADCP |
| COM2 | 4800 | NMEA1 ($GPGGA – Position)<br>($HEHDT – Gyro) |
| COM3 | 9600 | NMEA2 ($GPPAT – Ashtech) |

Gyro heading, and GPS Ashtech heading, location and time were fed as NMEA messages into the serial ports of the controlling PC and VmDAS was configured to use the Gyro heading for co-ordinate transformation. VmDAS logs the PC clock time, stamps the data (start of each ensemble) with that time, and records the offset of the PC clock from GPS time. This offset was applied to the data in the PSTAR processing path, see below, before merging with navigation.

The 2 minute averaged data were written to the PC hard disk in files with a .STA extension, eg D365os150001_000000.STA, D365os150002_000000.STA, etc. Sequentially numbered files were created whenever data logging was stopped and re-started. The software was set to close the file once it reached 100 MB in size, though on D365 files were closed and data collection restarted daily such that the files never became that large. All files were transferred to the unix directory /D365/os150/raw setup on the ship's new Dell file server. This transfer included the plethora of much larger ping by ping data files, these can be useful in the event of major failure of the ship's data handling systems as they record all the basic navigation and ships heading/attitude data supplied by NMEA message.

The VM-ADCP was configured to run in 'Narrowband' range over resolution mode. Bottom tracking was used when over the UK continental shelf on the way out; files 001-007. At the time of writing it is expected that bottom tracking will be used as we return across the UK continental shelf to port.

The VM-ADCP processing path followed an identical route to that developed in 2001 for the 75 kHz ADCP (RRS *Discovery* cruise 253). In the following script descriptions, "##" indicates the daily file number.

**s150exec0:** data read into pstar format from RDI binary file (psurvey2). Water track velocities were written into "adp" files, bottom track into "bot" files if in bottom track mode. Velocities were 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. An offset depth for the depth bins was provided in the user supplied information, 9 m for the 150 kHz instruments, this equated to the sum of the water depth of the transducer in the ship's hull (~5 m in RRS *Discovery*) and the blank beyond transmit distance used in the instrument setup (see earlier). Output Files: (adp365##.raw, bot365##.raw).

**s150exec1**: data edited according to status flags (flag of 1 indicated bad data). Velocity data replaced with absent data if variable "2+bmbad" was greater than 25% (% of pings where >1 beam bad therefore no velocity computed). Time of ensemble moved to the end of the ensemble period (120 secs added with pcalib). Output files: (adp365##, bot365##).

**s150exec2**: this merged the adcp data (both water track and bottom track files, where they existed) with the ashtech 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. Output files: (adp365##.true, bot365##.true).

**s150exec3**: applied the misalignment angle, ø, and scaling factor, A, discussed below, to both files. Variables were renamed and re-ordered to preserve the original raw data. Output Files: (adp365##.cal, bot365##.cal).

**s150exec4**: merged the adcp data (both files) with the bestnav (10 sec) NMFSS combined navigation imported to pstar through navexec0 (abnv3651). Ship's velocity was calculated from spot positions taken from the abnv3651 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 2 minute ensemble by subtracting 60 seconds and new positions were taken from abnv3651. Output Files: (adp365##.abs, bot365##.abs).

*150 kHz VM-ADCP calibration*

A calibration of the 150 kHz VM-ADCP was achieved using bottom tracking data available from our departure from Southampton, westwards down the channel and then northwards into the Irish Sea (file 001). No further calibration was deemed necessary from inspection of the processed data during the cruise. Using long, straight, steady speed sections of standard two minute ensemble profiles over reasonably constant bottom depth the following calibrations for mis-alignment angle, $\phi$, and necessary amplification (tilt), A, were derived by comparing GPS derived component vectors of the vessel speed and direction with processed VM-ADCP bottom track determined component vectors of the vessel speed and direction:

| | | | | | |
|---|---|---|---|---|---|
| ***150 kHz:*** | ø | mean | -0.6383 | s.d. | ±0.1131 |
| | A | mean | 1.0067 | s.d. | ±0.0018 |

No comparisons could be made with previous cruises as the instrument had been refitted in Port just before departure as discussed earlier.

Results and Discussion

Initial data inspection included absolute velocity vectors at 21 m and 205 m. Water track files were appended daily, averaged in a 4 km regular grid, and plotted along the ship track. Visual comparison of these plots allowed rough assessment of the data consistency. The vectors at 21 m clearly showed the ~5 knot tidal currents responsible for *Discovery*'s 16 knot passage northwards through the North Channel (Figure 5). In the deeper waters of the Iceland Basin, the currents at 205 m were, as expected, dominated by eddy like rotational scales of perhaps 30-100 km (Figure 6).

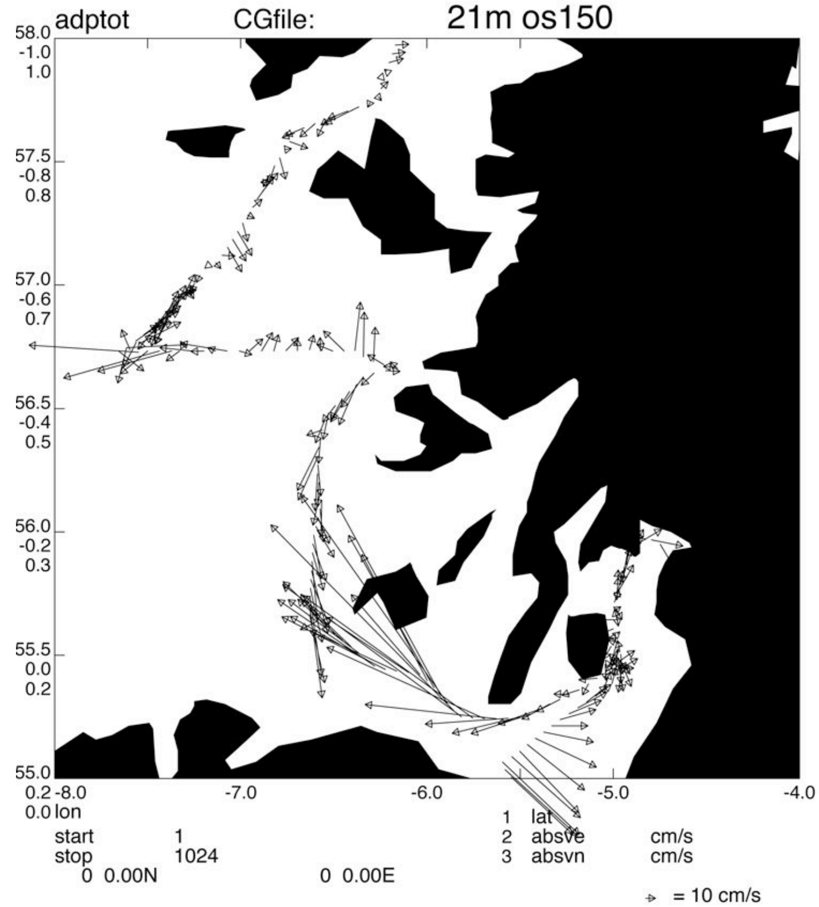



*Figure 5*. Absolute velocity vectors for 4 km averages at 21 m bindepth.

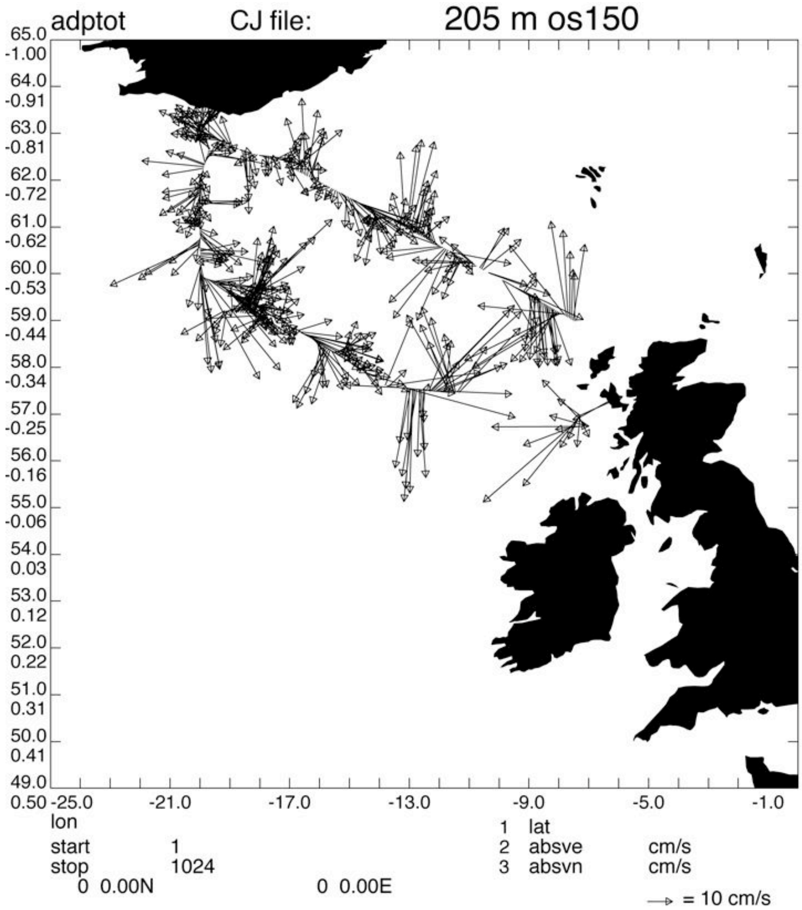



*Figure 6*. Absolute velocity vectors for 4 km averages at 205 m bindepth.

Matlab data processing

The same initial data set was used to perform velocity mapping to the reference frame of the vessel but using MatLab processing instead of pstar. Position and attitude information was provided via an Ashtech ADU5 multi-receiver GPS attitude sensor (in N2R files), as well as ship's heading information from the vessel's Gyro, though streamed to and saved by the OS150 logging PC (in N1R files). A suite of MATLAB routines used by Dr. M. Inall on RRS *Discovery D312* and RV *Poseidon PO328* were used to perform data screening and transformation to absolute velocities in Earth coordinates. The routines have been recently adjusted by Dr D. Aleynik to the current on-board version of RDI software (VmDAS v1.46) and to the recent navigational data output. A summary of the configuration, processing steps and recent updates in scripts is given below.

*OS150 VMADCP configuration*

- No. bins = 50
- Bin size = 8 m
- Blank after transmit = 8 m
- Transducer depth = 5.3 m
- Bottom track (when on) maximum depth 1100 m
- Time between pings = as fast as possible (typically 5s)
- Low-resolution long-range processing mode

*MATLAB Processing Steps*

1. RDI binary file with extension ENX (single-ping ADCP ship referenced data from VMDAS) and extension N2R (ascii NMEA output from ADU5 saved by VMDAS) read into MATLAB environment. The N2R file consists of ADCP single ping time stamps ($PADCP string) and ADU5 pitch, roll and heading information ($PASHR,ATT string.) The latter NMEA string was created from the raw ADU5 string since file 002 (14 May 2011) and was not available in for first file (13 May 2011, where gyro substitution was used).
2. Ensembles with no ADCP data removed
3. Ensembles with bad or missing ADU5 GPS heading data identified and adjusted GYRO heading substituted
4. Attitude information time-merged with single ping data
5. Heading data used to rotate single ping ADCP velocities from vessel centreline reference to True North reference
6. Transducer mis-alignment error corrected (derived from the mis-alignment determination)
7. Ship velocity derived from ADU5 positional information
8. Further data screening performed:
    - Max heading change between pings (10 degrees per ping)
    - Max ship velocity change between pings (>2 $ms^{-1}$ ping $rate^{-1}$)
    - Error velocity greater than twice stdev of error velocities of single ping profile
9. All data averaged into 600-second super-ensembles (user selectable)
10. Determine absolute water velocities from either bottom track derived ship velocity or ADU5 GPS derived ship velocity. ADU5 derived velocity was favoured during D365

All 10 steps are performed within the same routine as used for misalignment determination (by 'one click' at *OS150_D365_test_DA.m*).

*Transducer misalignment and amplitude correction determination:*

The misalignment angle of the transducer relative to the vessel (α) and the velocity amplitude correction factor (A) were determined as follows. A reference layer velocity between 50 and 300 m is calculated from the super-ensembles (u and v), and the ship velocity calculated for the corresponding super ensembles (su and sv). First differences are taken (du, dv, dsu, and dsv) between all possible pairs of super ensembles, then differences selected for when the ship speed exceeded 3 $ms^{-1}$ over the ground between ensembles not more than n·5000 m or n·3600 s apart in space or time (n=1÷24). Then the following function was minimised for α and A using the Matlab function FMINSEARCH.m (a multidimensional minimization method).

$$f(A,\alpha) = (Adu\cos\alpha - Adv\sin\alpha + dsu)^2 + (Adu\sin\alpha + Adv\cos\alpha + dsv)^2$$

An initial guess at A and α is made in order to perform the minimisation on the super-ensembles outlined above. The whole processing procedure is then repeated for the newly determined values for A and α to give the final absolute velocities. Values estimated by this method are in the Table 3.

| | | D365os150003_000000.ENX Ashtech: N2R | |
|---|---|---|---|
| | | A | α |
| 1h | mean | 1.266201 | 0.6943 |
| | std | 0.077257 | 0.6605 |

*Table 4.* Calibration data obtained with Matlab.

The difference with the values obtained with pexec routines (above) is quite small for angle (α) and slightly higher for Amplitude (A). Post cruise manual editing left the option for improving.

The instruments (ADCP and Ashtech ADU5) both functioned well during the cruise. Few GPS data drop-outs occurred, and typically for no more than a few seconds at a time. Due to the rough weather and consequent frequent presence of air bubbles under the hull and across the transducer face, water profiles were often quite poor (less than 50% percent good at depth as shallow as 180 m). An example figure of processed data is shown in Fig. 7.

Raw data files in RDI format and processed data files in MATLAB format will be logged with BODC after the cruise, the approximate total quantity of data will be 4GB. Raw RDI data are divided into 18 series (series D365os150001_0000 to D365os150018_0000). Within each series files are subdivided into files of maximum 100MB in size. Series number is incremented each time VMDAS is stopped and restarted; the number of sub-files per series is therefore variable.

*Table 5.* Content of processed Matlab data files.

| File name | Structured array name | Contents |
|---|---|---|
| D365os15000N_00000d.mat | d | Single ping ADCP data |
| D365os15000N_00000d_ATT.mat | att | Heading data at each ADCP ping |
| D365os15000N_00000_ATT.mat | att | Heading data for super ensembles |
| D365os15000N_00000N_M_hc.mat | b, c | Super ensembles |

All processed output files are in MATLAB proprietary *.mat binary files, where N denotes the series number (N = 1 to18 for D365):

*<u>D365 adjustments in the matlab scripts:</u>*

*OS150_D365_test_DA.m* is used to estimate misalignment error detection, there were added two calls to external scripts with an option to select heading information source files by the extensions .N1R or .N2R:

d1=*include_att_discovery_DA*(d1,'N1R') or

d2=*include_att_discovery_DA*(d2,'N2R').

*Include_att_discovery_DA.m* has calls to other scripts, where the reading of data are performed:

*read_nmea_att_discovery_DAN1R(d); %use gyro data*

*read_nmea_att_discovery_DAN2R(d); %use ashtech ADU5*

The last two scripts select the heading, pitch and roll data, adjacent to the nearest time to the $PADCP data records as described in the *VmDas* User's Guide [Teledyne RDI, 95A-6015-00, 2007]. Scripts have been adjusted to the latest VmDAS v1.46 data files, based on the first 3 files, produced in the beginning of cruise.

1st script read $**HEHDT** lines from N1R files, where the data are from the ships Gyro system. This line format is described in section 8.3 (p. 62), *VmDas* User's Guide, 2007.

2nd script use $**PASHR,ATT** from N2R files - Global Positioning System Attitude Data from ADU5, saved by VmDAS. This line format is described in section 8.2.6 (p. 60) *VmDas* User's Guide, 2007.

<u>Generic Processing Procedure:</u>

1. Create a directory structure similar to that shown below
2. Place all the MATLAB functions supplied from the directory "OS75functions" into the directory of the same name on your PC.
3. Place the file named "OS150_D365.m" in the directory named "m".
4. Place raw VMDAS files with extensions ENX and N1R or N2R into a directory of your choice. The extract below reads data from the "reprocessed" directory, but also has a DVD data disk mounted as the D drive option commented out.
5. Edit (and rename) the file "R1_OS150_D365_test_DA.m" so the PATH and RAWPATH variables exactly match the full path of these directories on your PC – remember to end with a forward slash "\" character. Lines 24 and 26.
6. Edit the addpath command to the full path location of the *OS75functions* directory. Line 22.
7. Edit the VMDAS filename for your cruise. Line 4.
8. Choose which series (one or more) number(s) for your cruise you wish to process (the sub-series files will be automatically loaded). More than one series at a time can be chosen (e.g. "files=[2 3 4 5 6]" is allowed). Line 19.
9. Choose how long the temporal average for the "super ensembles" should be (set to 600s for D365). Line 20.
10. If Bottom Track is on and you want to use it rather than GPS derived ship velocity, then edit the function named "ship_velocity_mei.m" at Line 43. There are comments in this function.


Results and Discussion

The results of VMADCP measurements have been visually inspected using vector maps and vertical plots for each recorded file and the summary plots for each separated transects. The preliminarily analysis revealed that it worked satisfactorily, and that the data required some attention to remove several unrealistic spikes at the deeper layer below 300 m depth and in regions with shallow water. VM-ADCP data were divided into four transects reflecting straight lines (Fig. 7), the metadata are summarised in the inventory Table 5.

| Tran -sect | Dates & start | Time end | ctd365 ### | Ellet Line # | VM-ADCP D365Os 150### | Area |
|---|---|---|---|---|---|---|
| I | 2011/05/20 01:51 | 2011/05/20 15:18 | 001 – 010 | 01G – 10G | 005 - 006 | Shelf from Isle of Mull to Isle of Barra westward along 56° 45'N from 6°30'W to 7°45'W |
| II | 2011/05/21 20:31 | 2011/05/24 07:42 | - | - | 007 – 010 | On the way from Isle of Lewis toward Iceland 58° 30' N, 6° 00'W to 63° 20° 00'W |
| III | 2011/05/24 07:43 | 2011/05/26 17:45 | 012 – 023 | IB23 – IB11 | 011 – 013 | From Iceland Shelf 63°19' N to 60° 00' N southward along ~ 19°59'W |
| IV | 2011/05/26 17:46 | 2011/05/31 15:49 | 024 – 035 | IB11a – A | 014 – 017 | From Iceland Basin toward Rockall Bank and Scottish Shelf from 60° 00' N, 20°00' W to 56° 45' N, 8° 00' W. |

*Table 6.* VM ADCP os150 kHz transects inventory.

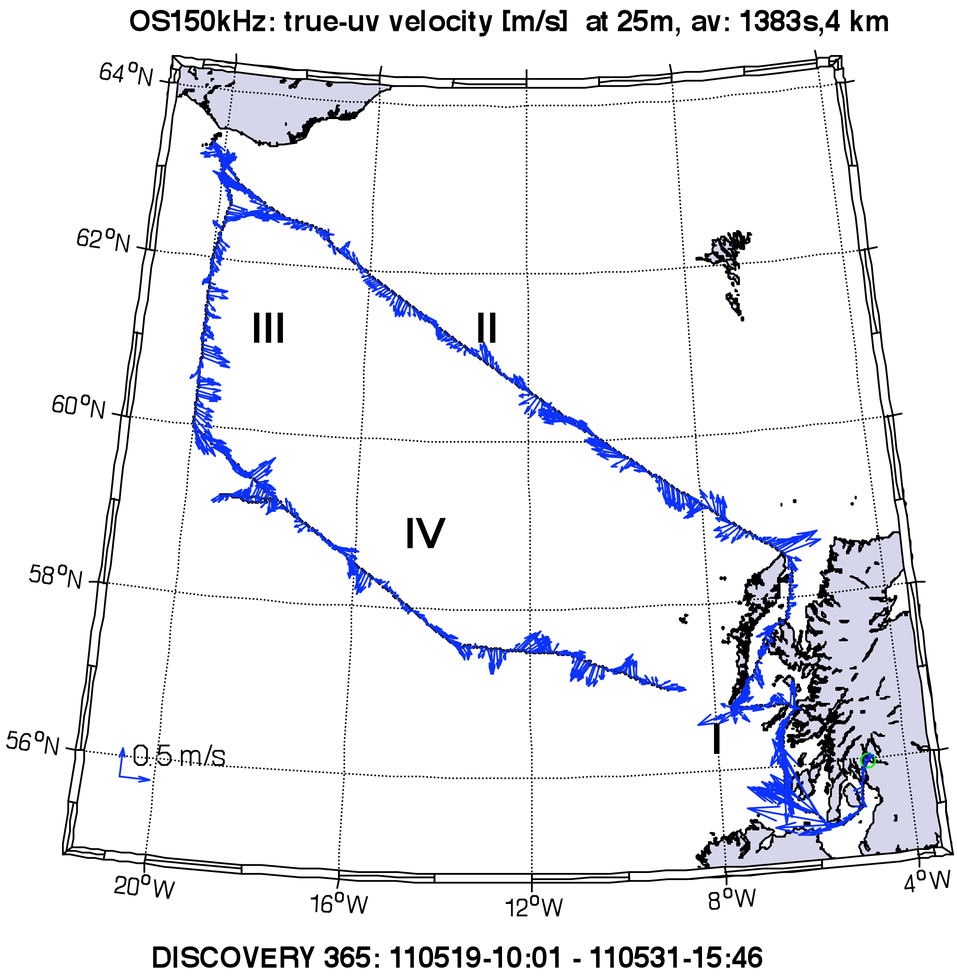



*Figure 7.* Absolute velocity vectors at 25 m, 4 km averages for all transects I – IV.

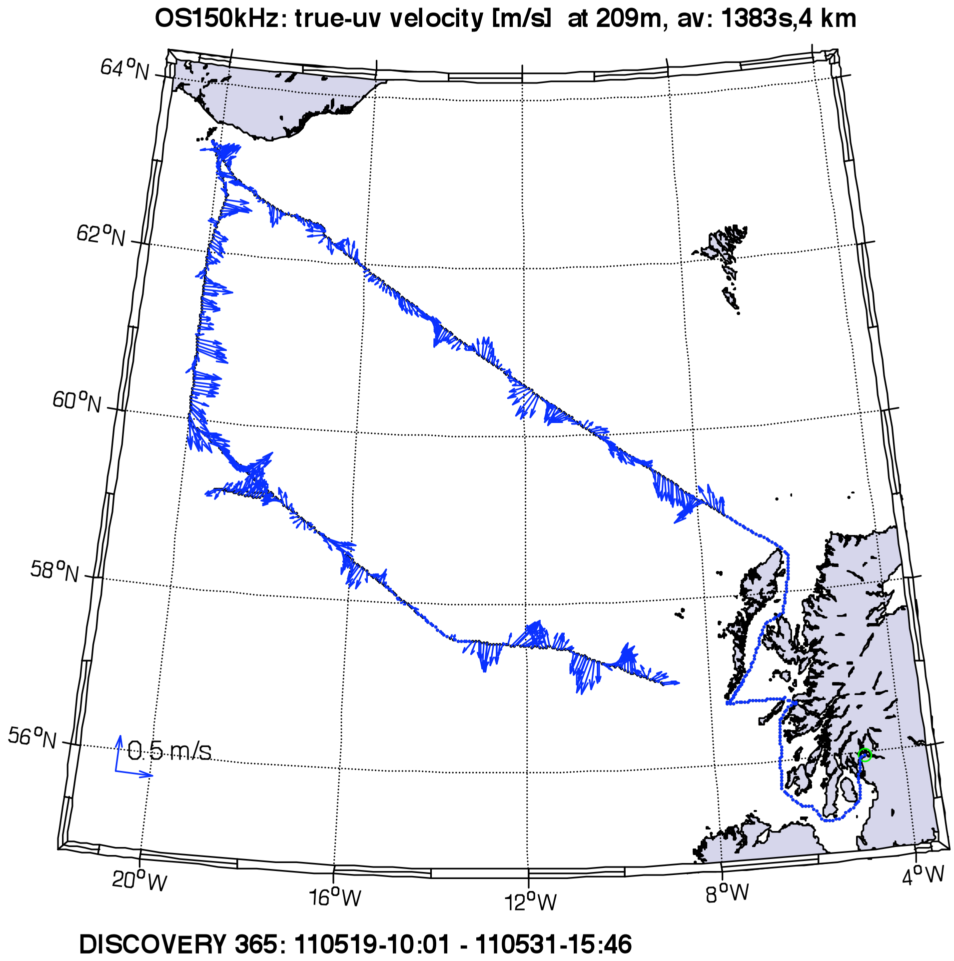



*Figure 8.* Absolute velocity vectors at 209 m, 4 km averages for all transects I – IV.

To reveal the main hydrodynamic features observed with VM-ADCP measurements the following maths was applied to the initial data, stored by manufacturer's (RDI) VMDAS program (v1.46) in 2 minute average ensemble (.STA) files. Firstly heading misalignment correction (Table 4) was added to the initial data converted into direction and absolute velocity, and the result was converted back into corrected $u$ and $v$ values. Then vertical mean velocity was calculated to obtain components $U_{bt}$, $V_{bt}$ , which can be interpreted as '*barotropic*' if measurements occupy the whole water depth from surface to the sea-bed:

$$U_{bt} = \int_{Z_1}^{Z_N} udz \ ; \qquad V_{bt} = \int_{Z_1}^{Z_N} vdz \qquad (1)$$

These results were subtracted at each depth from the full velocity profile to calculate '*baroclinic*' components $U_{bc}$ and $V_{bc}$ :

$$U_{bc} = u - U_{bt} \ ; \qquad V_{bc} = v - V_{bt} \qquad (2)$$

In order to obtain the transport across the transect line(s) the results of operation (2) could be decomposed into the *normal* and *tangential* transect values $U_{bcr}$ and $V_{bcr}$ respectively, using simple polar coordinate transformation, with angle θ defined as the angle between axis X (East) and direction from position of the first velocity profiles to position of the second one for each pair along the transect:

$$U_{bcr} = U_{bc} \cdot cos\ (\theta) - V_{bc} \cdot sin\ (\theta)\ ;$$

$$V_{bcr} = U_{bc} \cdot sin(\theta) + V_{bc} \cdot cos\ (\theta) \qquad (3)$$

To illustrate the approach consider Transect **I**, where we had an option to activate the bottom track mode for ADCP. On a full velocity (v,u) transect strong tidal currents were observed - northward on the eastern side, and south-westward on the western one (Fig. 9a) .

Decomposition of the velocity field into barotropic and baroclinic components revealed the presence of the different streams shown on Fig. 9b. In the upper layer (17 – 70 m) in the western (deeper) part of Transect I there was mostly westward flow with a weak northward component, while in the central part (40– 65 km) of the Transect a weak southward current at depth 17 - 65 m has been revealed. Below a depth of 65 m the currents reversed in direction, which is consistent with the first (baroclinic) vertical mode.

A more complicated story was observed on the longer northern Transect **II** between Isle of Lewis and southern Iceland. There, several (5) pairs of strong narrow jets with opposite directions (Fig. 10a) were detected in the full velocity field. Subtraction of vertical mean velocity from total velocity profiles revealed the presence of two wider (150-200 km) streams with dominant westward- north-westward direction in the upper 100-120 m and speed 0.8 and 0.7 m $s^{-1}$ in subsurface layers (Fig. 10b). Weaker (0.2 m $s^{-1}$) counter flow in the layers extending from 120 m to detectable range 300 – 350 m were found in the eastern part of transect (Fig. 10b, lower panel). This current with its core at depth 150 – 200 m was located ~250 km from the start of the transect: between Rosemary Bank and Bill Bailey Bank in the northern part of the Rockall Trough. Note that there were very strong winds during the time of measurement, associated with an atmospheric depression that dominated the south of the area at the time.

Currents on Transect **III** along 20°W meridian from 63°30N toward 60°N were mainly eastward, ENE in the northern part of transect and ESE in the southern part south of 62°N. Westward current was observed in the shallow northernmost part of transect, close to the Iceland shelf. Decomposition of velocity with ($U_{bc}$=u-$U_{bt}$) revealed a gradual change in direction of currents in the upper layers (17-100 m) from -0.10 in the northern part of transect III to +0.08 m·$s^{-1}$ in its southern part (Fig. 11), and opposite change in the sign and values in layers below 100 m.

The main feature revealed on Transect **IV** is that in the Rockall Trough the circulation generally was stronger than in the Iceland Basin, while in both areas it was dominated by narrow jets (30 – 70 km wide) with alternating direction of flow. This indicates the presence of several intensive eddies. There is a suggestion about the amplifying effect of complex topography (Anton Dohrn and other seamounts) on the eddies in the area to the east and northeast of Rockall Bank. One such eddy trapped the SAMS glider 1-2 weeks before the Discovery-D365 expedition arrived, and the glider was moved essentially northward. Strong generally northward currents over the continental slope were also observed at Transect II and IV, (Fig. 10a and 12a). Preliminary results demonstrate that the velocity field is dominated by barotropic current. Nevertheless the presence of noticeable vertical shear in horizontal velocities was determined in the upper 300 m of water column, which is considered to be evidence of significant contribution of baroclinicity (and stratification) in the resulting current field in the study area of the North East Atlantic.

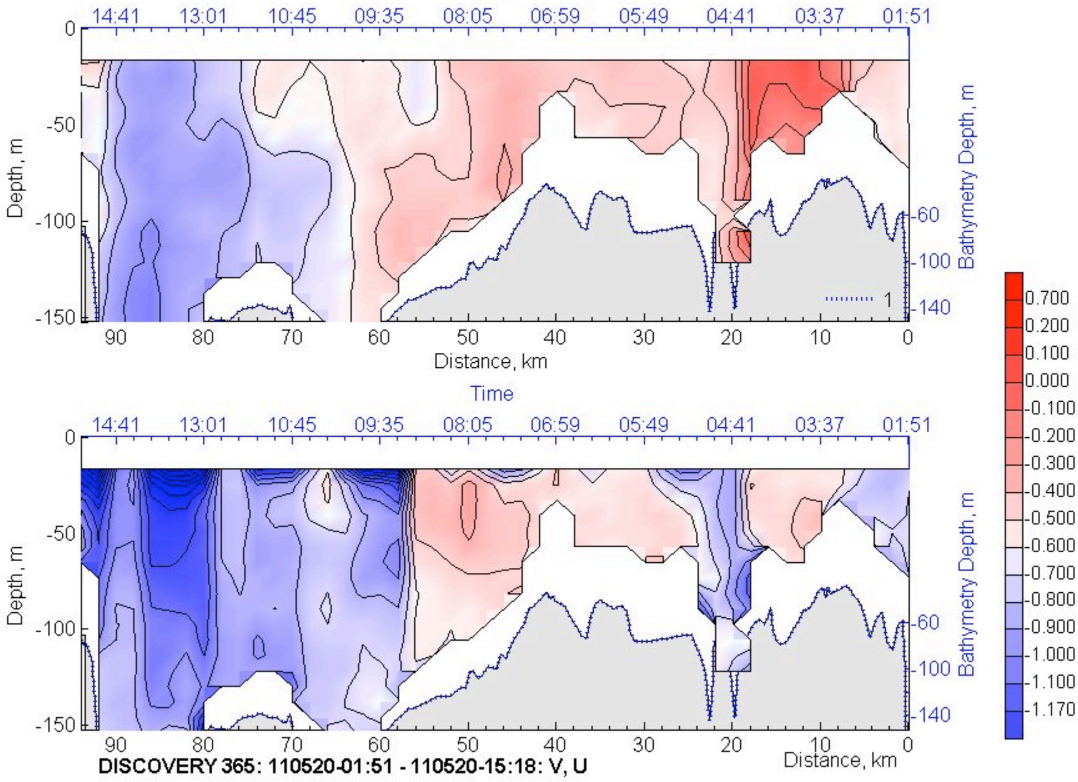



*Figure 9a.* Total Meridional (v) and zonal (u) velocity across transect I, gridded (8 m × 2 km).

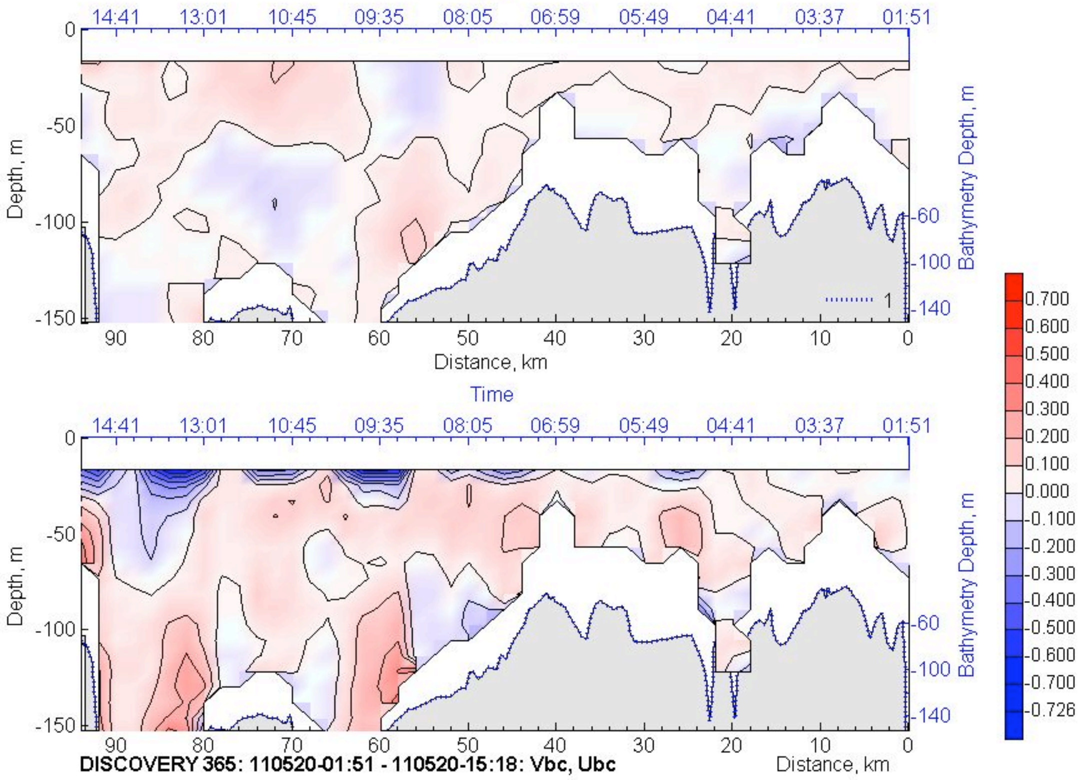



*Figure 9b.* Baroclinic ($V_{bc}$=$v$-$V_{bt}$) velocity across transect I, gridded on a mesh 8 m × 2 km.

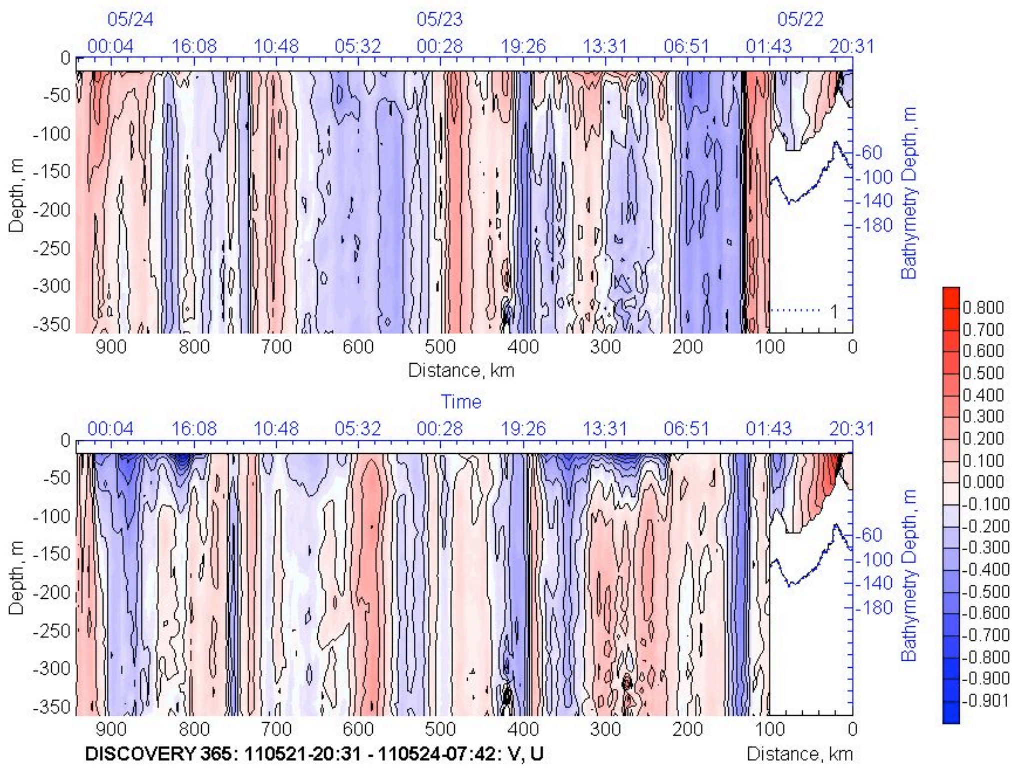



*Figure 10a.* Total Meridional (v) and zonal (u) velocity, transect II (8 m × 4 km).

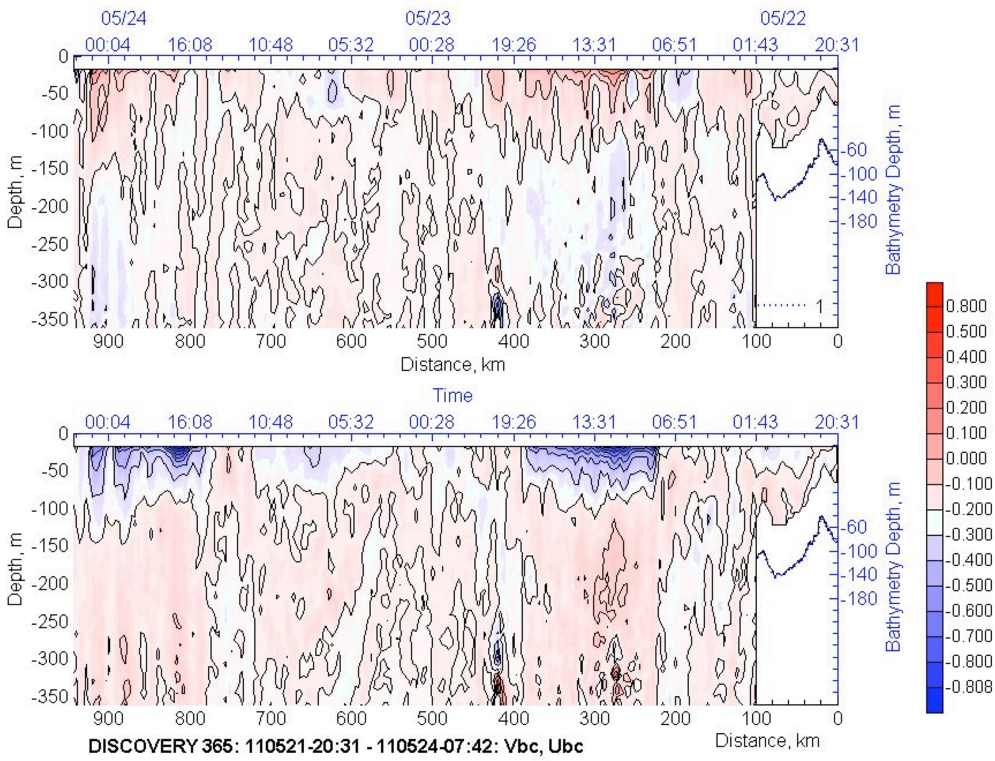



*Figure 10b.* Meridional ($V_{bc}$=$v$-$V_{bt}$) and zonal ($U_{bc}$=$u$-$U_{bt}$) velocity, transect II (8 m × 4 km).

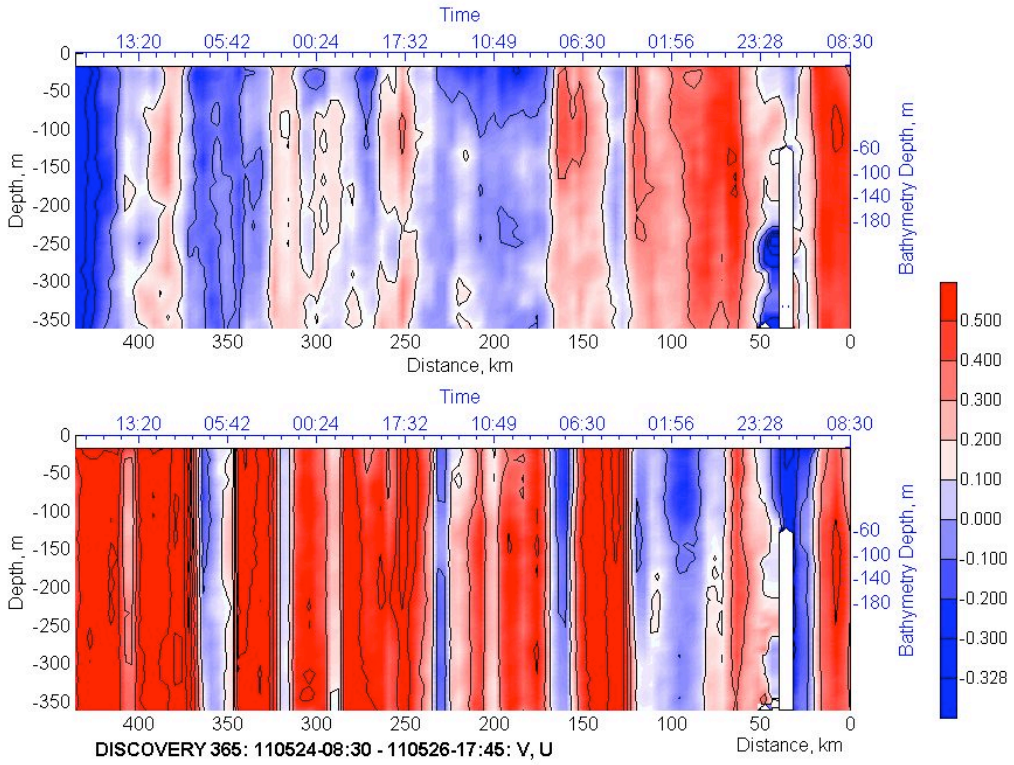



*Figure 11a.* Total Meridional (v) and zonal (u) velocity, transect II (8 m × 4 km).

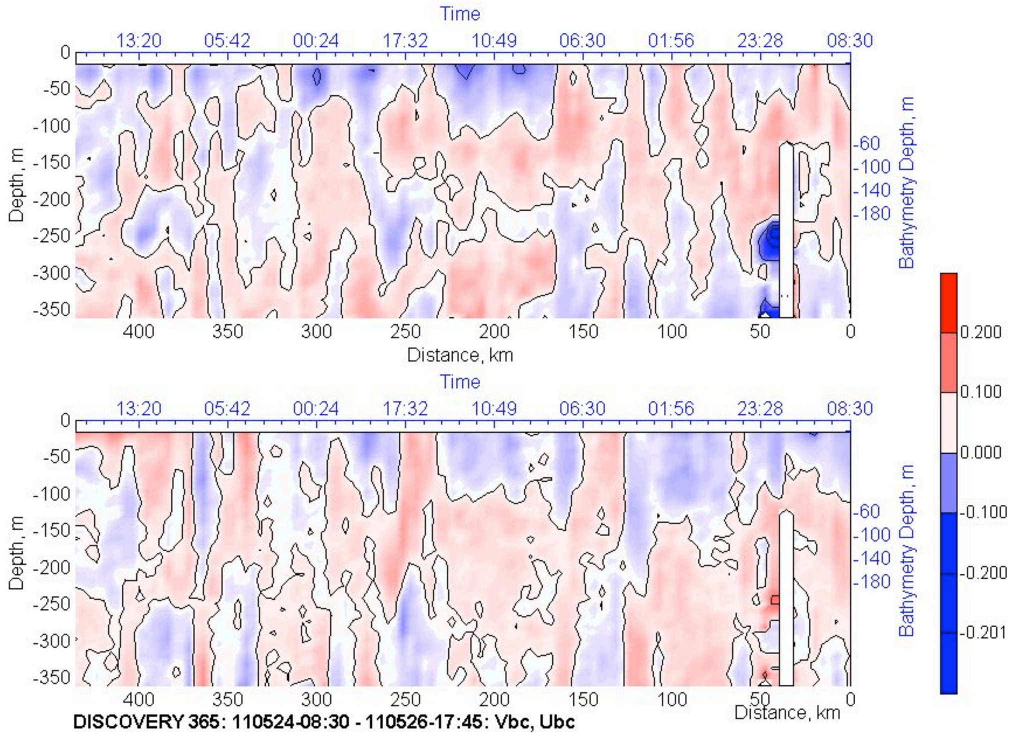



*Figure 11b.* Meridional ($V_{bc}=v-V_{bt}$) and zonal ($U_{bc}=u-U_{bt}$) velocity, transect III (8 m × 4 km).

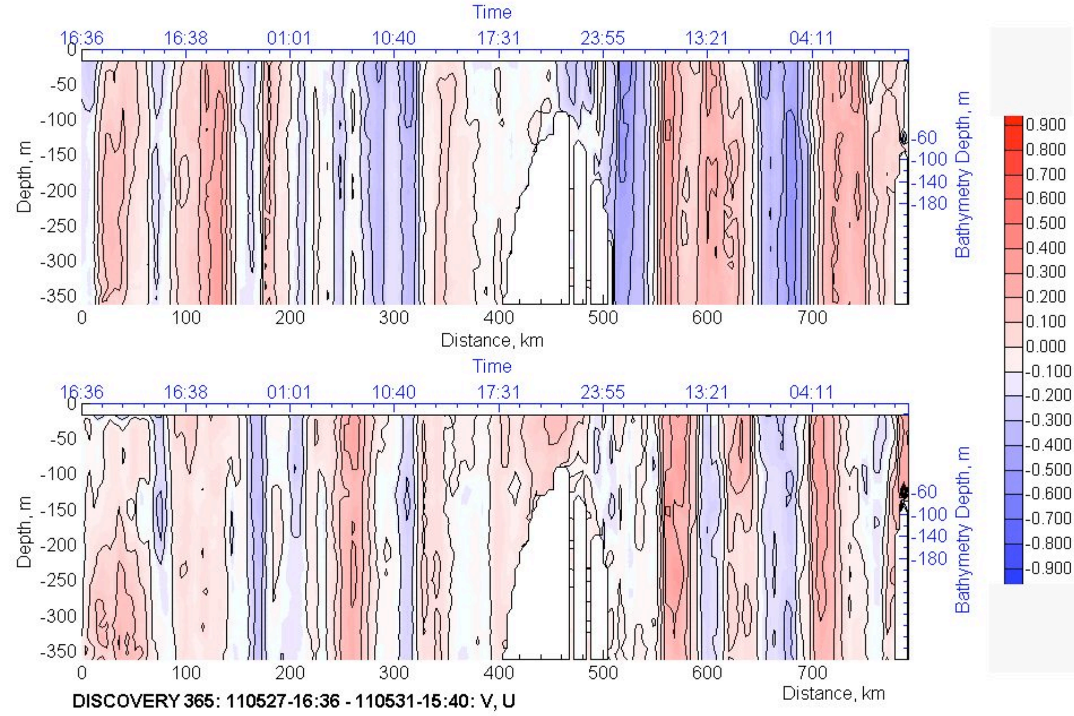



*Figure 12a.* Total Meridional (v) and zonal (u) velocity, transect IV (8 m × 4 km).

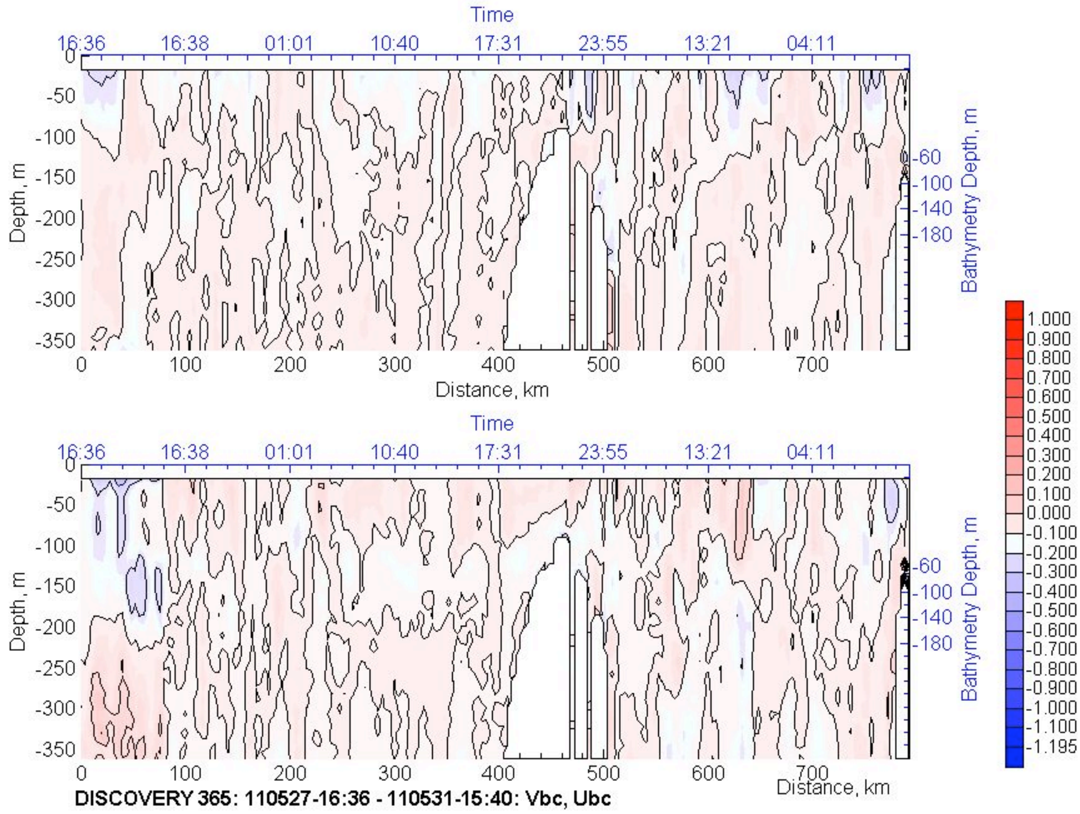



*Figure 12b.* Meridional ($V_{bc}$=$v$-$V_{bt}$) and zonal ($U_{bc}$=$u$-$U_{bt}$) velocity, transect V (8 m × 4 km).

**Thermosalinograph and Surfmet Data** – *Mike Nelson, John Allen, Estelle Dumont*

Instruments

Underway surface meteorology and thermosalinograph measurements were recorded by the RVS Surfmet system throughout *Discovery* cruise 365. Sensors are listed in Table 2. Parameters measured were:

*Non-toxic supply*

*Intake water temperature (temp_m)*
*TSG housing water temperature (temp_h)*
*conductivity*
*Fluorescence (Chla)*
*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 undertaken daily which entailed running several PSTAR routines as detailed below.

**surfmet0**: This script was used to convert the data from RVS format to PSTAR format using datapup. Resultant file was smt365**.raw

**surfmet1***:* This ensured absent Surfmet data values were set to -999. The script also calculated TSG salinity using housing temperature, conductivity and a pressure value set to zero. The Surfmet system applies the laboratory temperature sensor calibrations, before the data reach the RVS surfmet stream that was read in with *smtexec0*. Other calibrations are applied within the TechSAS system.

**surfmet2:** The master Ashtech file and navigation file were merged with smt365** at this point. This allowed accurate heading data to be incorporated into the underway dataset for correction of wind direction. The data were also averaged to 2 minute values. This step creates the file smt365**.hdg

**surfmet3:** This routine computed vessel speed and subtracted it from relative winds to obtain true wind speed and direction. Resultant file was smt365**.met

**papend** was used to concatenate each daily file to produce a file containing surfmet data for the entire cruise, smt365tot

The met sensors functioned correctly with the following exceptions; on Jday 137, while docked in Govan, the ptir sensor malfunctioned and was replaced. On Jday 139, it was noticed that the met data stream had stopped at around 14:00. The system was restarted at around 16:00. The TSG sensors were cleaned between 19:50-20:37 on Jday 147.

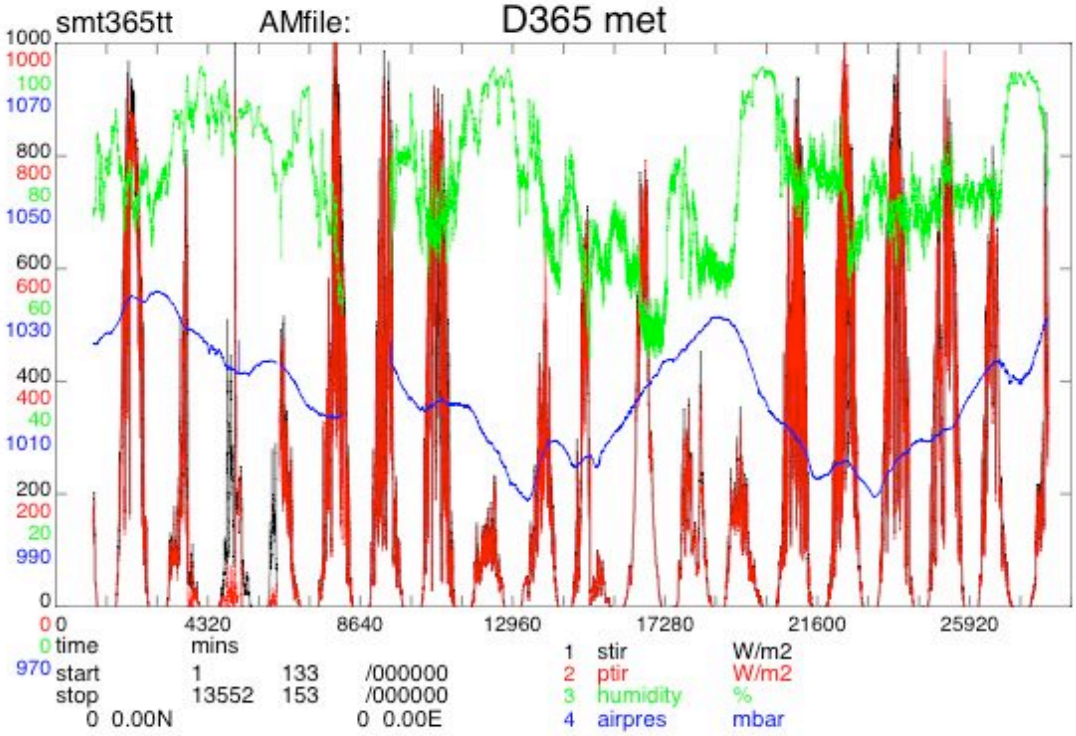
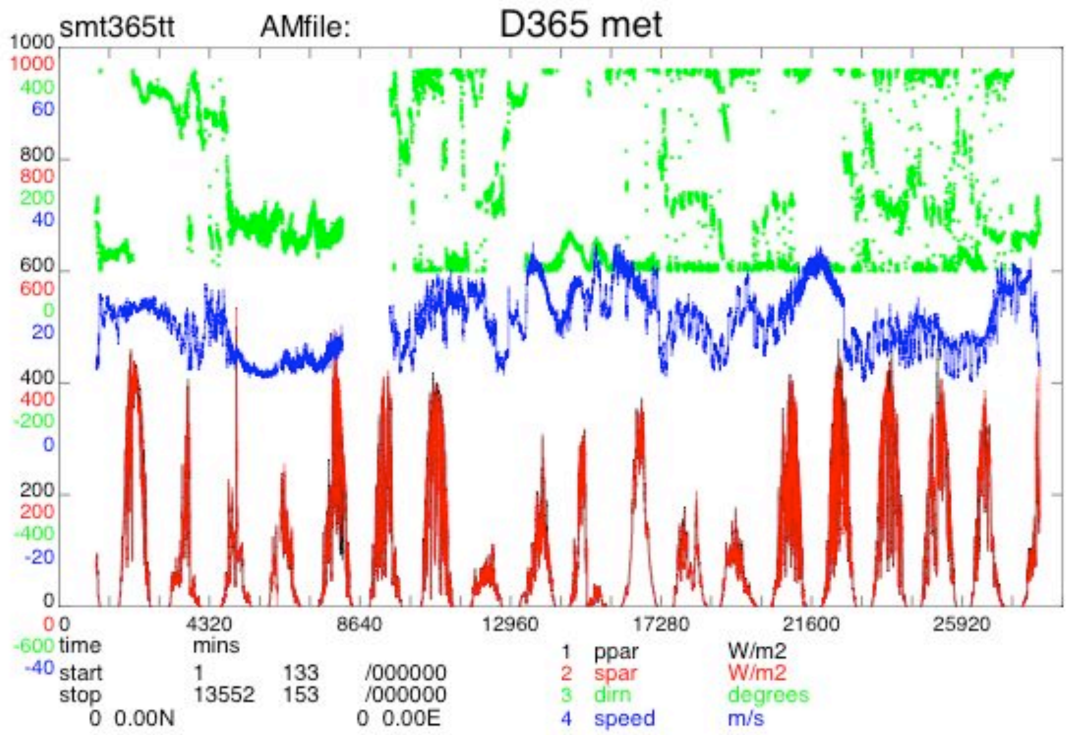



*Figure 13.* Meteorological conditions during *RRS Discovery* cruise 365 (stir, ptir – starboard, port total irradiance, airpres – atmospheric air pressure).

*Figure 14.* Wind speed and direction during *RRS Discovery* cruise 365 (ppar, spar – port, starboard photosynthetically active radiation, speed, dirn – wind speed and direction).



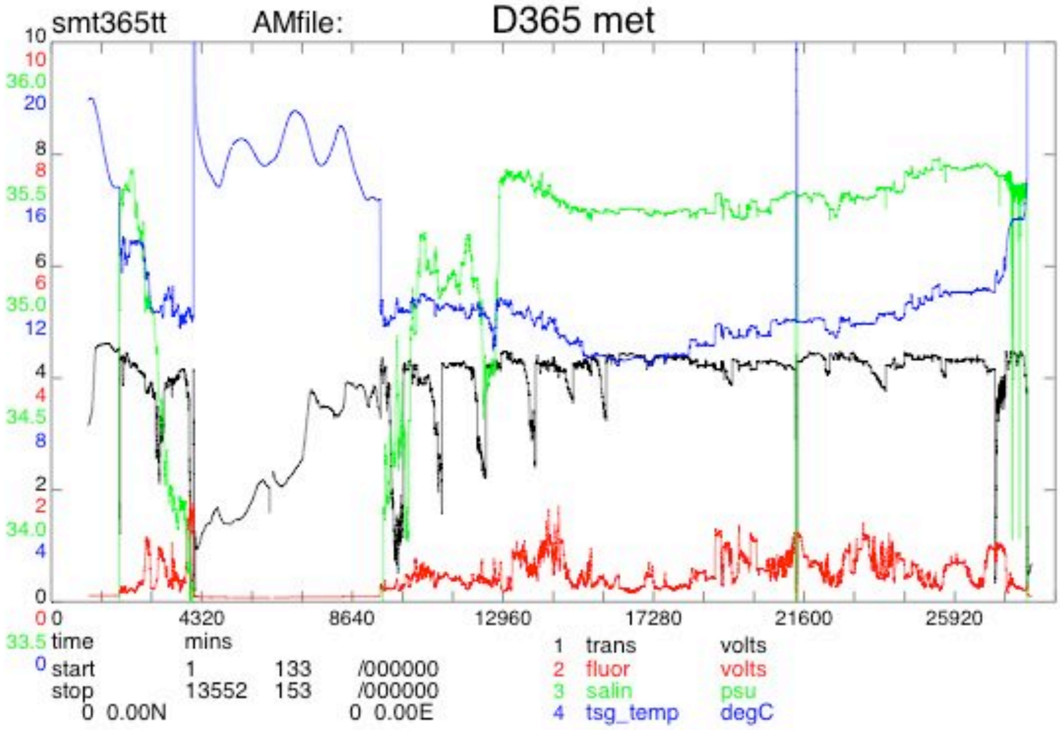



*Figure 15.* Surface water conditions as measured by the thermosalinograph during *RRS Discovery* cruise 365 (trans – transmittance, fluor – fluorescence, salin – salinity, tsg_temp – sea surface temperature).

Temperature calibration

A full inspection of TSG temperature against surface CTD values will be carried out later.

Salinity calibration

Salinity samples were taken from the underway source routinely between CTDs. A master Excel file of sample times and corresponding bottle salinities, as described in the Salinity Bottle Analysis section, was read into PSTAR. The new file was then merged, using *pmerge*, with the existing smt365nn files to directly compare underway salinity (salin) and bottle salinity (botsal) with a view to applying a calibration to the underway salinity data.

During analysis of the final crate of salinity samples taken from the underway source, the salinometer appeared to be reading 0.001 salinity units high compared to the IAPSO standard. This value was subtracted from the bottle salinity readings of these samples.

The initial comparisons between the TSG salinities and those of the bottle samples appeared to be good. Two rounds of statistical analysis showed that the TSG salinities were high compared to the bottle salinities by a mean offset of 0.006 with a standard deviation of ± 0.002. This value was subtracted from the salinity values using *pcalib*.

**Echosounder Data** – *Mike Nelson, John Allen, Paul Duncan*

RRS *Discovery* is equipped with a SIMRAD EA500 Echosounder system. Acoustic bathymetry measurements were made for the majority of the cruise using a 10 kHz transducer in the Precision Echosounder (PES) 'fish' suspended over the port side of the ship. The PES provides a quieter environment for determining water depth in deep water and poor sea states than the alternative hull mounted transducer. The output from the echosounder was displayed on two SIMRAD VDU's located in the main lab. The speed of sound in the water was set to 1500 m/s.

The raw data was logged by TechSAS and provided as an RVS format *ea500* datastream containing values of uncorrected depth and time. In addition, the *ea500* data-stream was processed on the NMFSS workstations. A correction was made, taking into account the variability of sound speed in water, 'Carter' tables, and errors in the data-stream were visually identified and removed. A new off-line data-stream named *prodep* was created, and appended to every 24 hours, containing uncorrected depth, corrected depth and measurement time.

During the cruise, these data-streams were then processed as follows every 24 hours using a series of UNIX shell scripts utilising PEXEC routines.

**simexec0:** This script took the raw data from the two data streams creating files of raw data (*sim365nn*) and corrected data (*sim365nn.cal*).

**simexec1:** This script edited out depths less than 10 m in both the raw and corrected depth files in order to remove anomalous zero values.

Every 24 hours, corrected files (*sim365nn.cal*) were *papend* 'ed to a master bathymetry file *dep3651*, and a 5 minute averaged file was also created, using *pavrge* (*dep3651.5min*), from which header depths were obtained in the routine CTD processing.

**Salinity Bottle Analysis** – *John Allen, Estelle Dumont, Mike Nelson, Harriet Cole, Dmitry Aleynik*

Salinity samples were drawn from the Niskin bottles mounted on the CTD rosette from a selection of depths spanning the salinity range and wherever a weak salinity stratification was observed. 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) between CTDs to calibrate the continual TSG measurements.

The salinometer for on-board salinity determination was sited in the stable lab; a model 8400B Autosal salinometer fitted with a peristaltic pump. Once a crate of sample bottles had been filled they were moved into the constant temperature lab to stand for 12-24 hours prior to analysis. Standardisation was performed using IAPSO Standard Seawater batch P152 before the analysis of each crate.

The salinometer acted erratically during testing whilst the ship was docked for repairs at Govan. Investigation suggested that the problems were due to an electronics board failure. A replacement salinometer (s/n 60839) was brought up from the hold, however this also proved to be faulty due to sporadic stalling of both of the air pumps. NOC Southampton was contacted and a replacement salinometer was delivered the following day. This unit functioned correctly for the duration of the cruise.

On Jday 148, the software recorded an erroneously high offset of 0.99981. Salinity values were subsequently recalculated using a spreadsheet from a cruise several years ago which contained the UNESCO algorithm for calculating salinity from conductivity ratio. This error did not occur during the rest of the cruise.

In total, 231 samples were analysed. However, the last 15 samples (corresponding to the last five casts, i.e. casts 51 to 55) were not recorded due to a bug in the Autosal software. These data were lost, making the total number of samples available for calibration 216.

Following salinometer processing, the data were copied from the un-networked salinometer PC to a USB stick. From here the data were transferred onto the network and imported into excel via a Mac laptop. For underway samples, a spreadsheet of bottle numbers and sample times obtained from the raw log sheets were matched with corresponding bottle salinities. Each time a new file was created it was appended onto the master excel file. 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.

**Dissolved Oxygen** – *Tim Brand, Tamara Green, Oonagh Daly*

Water column dissolved oxygen was determined from selected CTD samples collected throughout the cruise to determine the calibration of the CTD '*Sea Bird'* oxygen probe.

Triplicate oxygen samples were collected from up to 4 selected depths on 19 CTD casts taken throughout the cruise. One hundred and fifty samples were collected and analysed in total

The Winkler chemistry methodology of Carrit and Carpenter (1966) was used to fix and titrate the sample. A *Copenhagen Radiometer* auto-titrator was used for the titrations and the end point was determined spectrophotometrically.

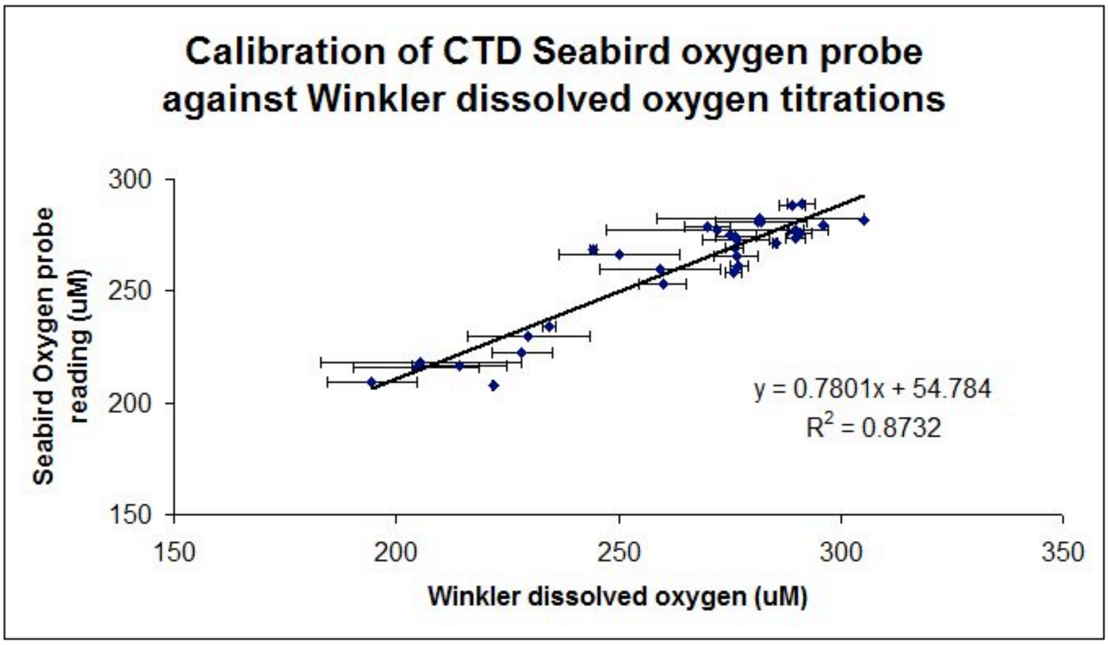



*Figure 16.* Comparison of CTD Seabird oxygen probe against Winkler dissolved oxygen titrations.

References

Carrit, D.E., Carpenter, J.H., 1966. Recommended procedure for Winkler analyses of seawater for dissolved oxygen. Journal of Marine Research, 24, 313-318.

**Dissolved Inorganic Nutrients** – *Tim Brand*

Introduction

The basic water column dissolved nutrients, ammonia, phosphate, silicate (reactive silica) and total oxidized nitrogen (nitrite + nitrate) were analyzed from CTD casts along the extended Ellett line and, for a 48 hour period, from the ships non-toxic sea water supply. CTD depths for the samples were chosen to correspond with those of the chlorophyll and algal cell count studies (Smythe-Wright, this report) down to 200m and at depths below this corresponding with CFC gas studies (Scally, this report). Additional other depths were sometimes chosen to coincide with changes in water mass identified by the TS and dissolved oxygen characteristics from the CTD casts. A full list of CTD and non-toxic supply samples taken is available in Table 1 and Appendix II.

In total 512 nutrient samples were measured in triplicate from 50 CTD stations along the extended Ellett line and adjoining shelf G station transects, together with 24 non-toxic supply samples (1608 individual analyses in total).

Method

Samples were collected in 125ml acid cleaned polythene bottles directly from the CTD spigots without the use of a tube. Samples were always analyzed within 24 hours of collection and stored in a fridge prior to analysis. Measurement was conducted using a Lachat *QuikChem 8500* flow injection autoanalyser using the manufacturers recommended methods: Ammonia, 31-107-06-1-B; Orthophosphate, 31-115-01-1-G; Silicate, 31-114-27-1-A and Nitrate/Nitrite, 31-107-04-1-A.

Samples were measured in triplicate to identify instrument precision. Standards were prepared in deionised water and the samples and standards were run in a carrier stream of deionised water. Five standard concentrations and a blank were run in all cases. New standards were prepared every 48hrs. Three standard concentration ranges were prepared for the non-toxic supply samples and CTD transect samples depending upon expected sample nutrient concentration, *vis*

| | Ammonia (µM) | Phosphate (µM) | Silicate (µM) | Total Oxid. N (µM) |
|---|---|---|---|---|
| Non-toxic | 0.0 – 2.5 | 0.0 – 2.5 | 0.0 – 2.5 | 0.0 – 2.5 |
| G transect | 0.0 – 2.5 | 0.0 – 2.5 | 0.0 – 15.0 | 0.0 – 15.0 |
| Ellett Line | 0.0 – 2.5 | 0.0 – 2.5 | 0.0 – 20.0 | 0.0 – 30.0 |
| Iceland Basin | 0.0 – 2.5 | 0.0 – 2.5 | 0.0 – 20.0 | 0.0 – 25.0 |

*Table 7.* Nutrient standard concentrations.

Salt correction of the result was performed by running three Low Nutrient Sea Water samples (OSIL, http://www.osil.co.uk, Batch LNS 17, Salinity 35) at the beginning of each sample batch run and the mean result was subtracted from sample results.

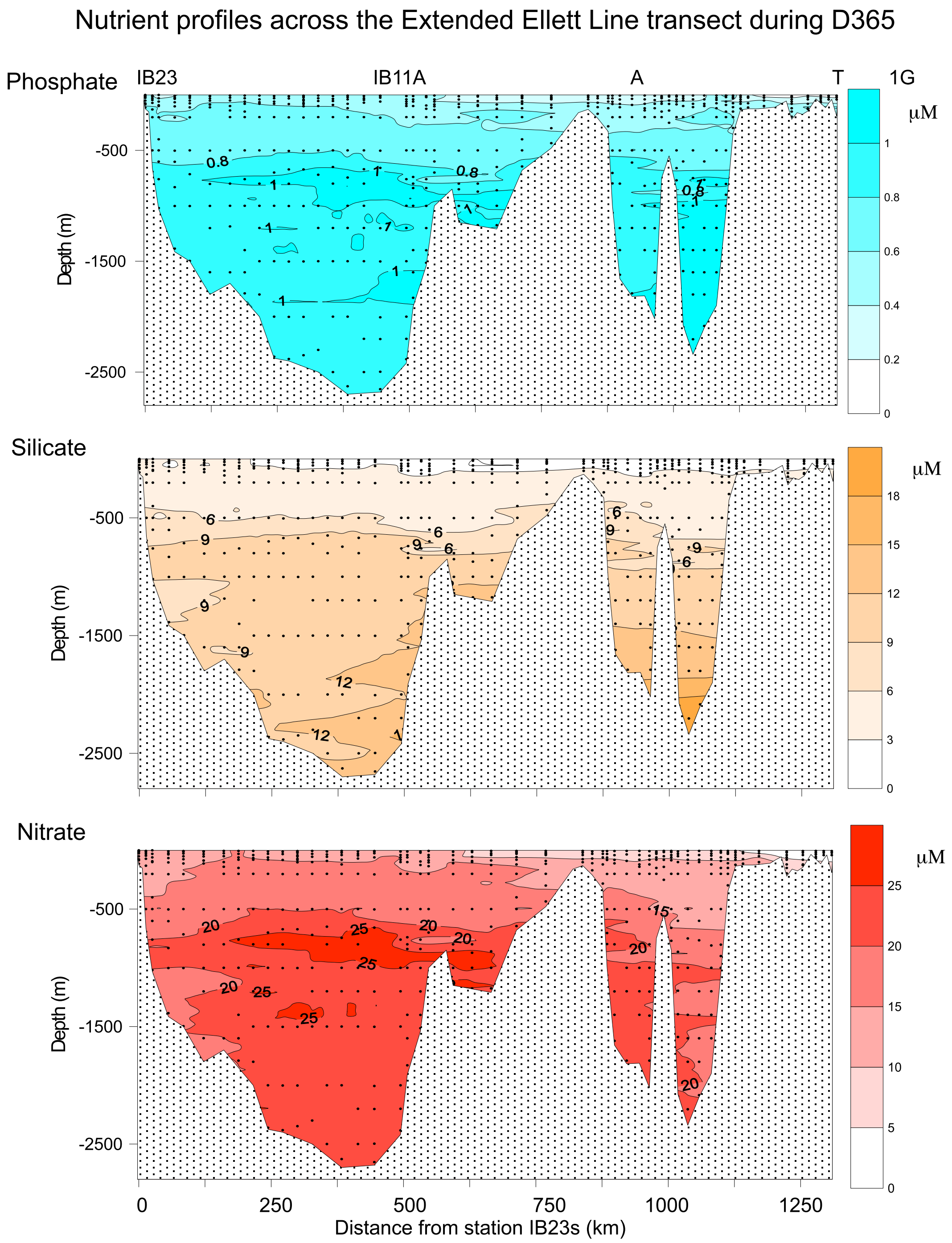
A standard reference solution prepared from nutrient standard solutions supplied by OSIL containing 1µM$NH_4$, 1µM$PO_4$, 10µM$SiO_2$ and 10µM$NO_3$ was run at the start and end of each sample batch to determine analytical accuracy and to adjust for calibration drift during the course of a sample batch analysis.

## Data quality

Lachat instrument *precision*, determined from analysing each sample in triplicate, routinely yielded a coefficient of variation (SD/mean x 100%) of less than 2% for nutrient concentrations greater than 10µM and generally less than 5% for concentrations less than 10µM. Analysis *accuracy* determined from analysis of the standard reference solution was consistently equal to or better than 95%

## Results

*Figure 17.*



**Particulate Organic Carbon** – *Tim Brand, Tamara Green, Oonagh Daly*

Introduction

To determine the transfer of organic carbon from the chlorophyll maxima to mid water depths along the extended Ellett line transect (500m water depth) water samples were collected from the CTD and filtered. A selection of depths were chosen corresponding to those of the chlorophyll and algal cell count studies (Smythe-Wright, this report) down to 500m.

Method

Samples were collected from the CTD in 2 litre polythene bottles and between 0.5 and 1 litre of each sample were filtered through pre-combusted (500C, 3hrs) 13mm diameter Gelman A/D glass fibre filters. The filtration rig used is an in-house design that uses 13mm filter holders and vacuum filtration. Normally 0.5 l of sample was filtered if from the chlorophyll maxima and 1 l was filtered for samples taken below this depth. A maximum of five depths were sampled from 36 casts along the transect. Samples, once collected and filtered, were stored in plastic 30mm diameter petri dishes in the -20C freezer. Analysis will take place at SAMS using a Costech Elemental Analyser. Prior to analysis the samples will undergo 24hrs of hydrochloric acid fuming to removing inorganic carbon (calcium carbonate).

**Dissolved Aluminium** – *Tim Brand*

Introduction

Work by Clare Johnson (SAMS PhD 2005- ) on using dissolved aluminium to determine water mass identity in the North Atlantic had proved inconclusive due to insufficient samples and some technical difficulties with the analytical process. It was proposed that D365 could prove to be an opportunistic sampling campaign to retest whether dissolved aluminium determined by the classic technique of Lumogallion fluorescence (Hydes, 1976) could be used to determine water mass identity in the North Atlantic.

Method

Samples were collected from the CTD in acid washed (5% nitric acid), 100ml polythene (LDPE) bottles and frozen immediately on collection (-20°C). Samples were collected from the CTD spigot without the use of a tube. Up to 10 samples were collected from 25 CTD yielding 180 samples in total. Samples will be analysed at SAMS using the Hydes (1976) technique and a turner bench top fluorimeter.

References

Hydes, D.J., Liss, P.S., 1976. Fluorimetric method for the determination of low concentrations of dissolved aluminium in natural waters. Analyst, 101, 922-931, DOI:10.1039/AN9760100922

Sample summary

| | Nutrients | Dissolved oxygen | POC/PON | Dissolved Aluminum |
|---|---|---|---|---|
| CTD casts | 50 | 19 | 36 | 25 |
| CTD individual samples | 512 | 150 | 172 | 180 |
| Non toxic supply samples | 24 | -- | -- | -- |

*Table 8.* Summary of discrete samples

**Empirical relationships between bacterial abundance/biomass and chlorophyll a concentrations along the Extended Ellett Line** – *Oonagh Daly*

Background

The efficiency of the microbial loop is determined by the density of marine bacteria in the microbial loop (Taylor and Joint, 1990). Dissolved organic carbon (DOC) is returned to higher trophic levels via incorporation into bacterial biomass, and coupled with the classic food chain formed by phytoplankton-zooplankton-nekton (Azam et al, 1983). The concept of the microbial loop proposes that the role of marine bacteria is to participate in the marine ecosystem carbon and nutrient cycles in the marine environment. It is recognized that abundance and biomass of bacteria in the ocean are positively correlated with regions of high primary productivity (Pomeroy and Johannes, 1968; Sieburth et al., 1978; Haas and Webb, 1979; Hollibaugh et al., 1980),

The general aim of research cruise D365 was to investigate and determine the biomass and abundance of bacteria at various depths along the Extended Ellett line and depict its relationship alongside chlorophyll concentrations.

Objectives

1. Determine the abundance of bacteria with depth across the Extended Ellett line.
2. Determine the change in biomass of bacteria with depth across the Extended Ellett line.

Method

40ml of sample is collected and added to a falcon tube, the sample is fixed with Glutaraldehyde using a standard 1ml pipette. Once fixed, samples are placed in a fridge.

Using vacuum filtering apparatus, the sample is added and stopped when the sample has filtered down to 5ml. Using a fixed pipette, 200µm of AO/MQ solution added and the sample left for 2 minutes.

When filtered, the filter is placed on to a glass slide and a drop of immersion oil is added before placing a cover slide on top.

Once finished, the glass slides are placed in a -20°C freezer.

Bacterial abundance is determined by Acridine Orange Direct Counts (AODC ; Hobbie et al, 1977). Bacterial cell volume is determined via image analysis of Acridine Orange stained cells using an Image-Pro Plus image analysis system (Loferer-Kroβbacher et al, 1998). The individual cells are counted in fields of view of known area and the concentration of bacteria in the original sample is calculated in terms of the number of bacteria cells/ kg of seawater.

Bacterial abundance (cells/liter) = $(C_f \times R)/F_s$

Where:
$C_f$ = mean number of cells/field
$R$ = (active area of filter)/(area of field counted)'
$F_s$ = volume of water filtered (liter)

*Table 9.* Study sites: Bacterial abundance and biomass

| Date | Station | Depths (m) | Bottle number |
|---|---|---|---|
| 20/05/2011 | 7G | 5,40,127 | 16,11,2 |

| | | | |
|---|---|---|---|
| 20/05/2011 | 9G | 5,10,140 | 17,15,2 |
| 23/05/2011 | IB20 | 7.5,25,1000 | 23,21,4 |
| 24/05/2011 | IB21 | 5,30,1000 | 23,21,3 |
| 24/05/2011 | IB22 | 5,30,700 | 22,16,3 |
| 24/05/2011 | IB23 | 5,25,113 | 14,10,2 |
| 25/05/2011 | IB16a | 5,30,1000 | 24,21,7 |
| 26/05/2011 | IB12 | 5,20,1000 | 24,21,8 |
| 26/05/2011 | IB11a | 10,30,1000 | 23,20,18 |
| 27/05/2011 | IB9 | 10,28,1000 | 23,21,7 |
| 28/05/2011 | IB7 | 10,75,980 | 22,17,2 |
| 29/05/2011 | IB3 | 5,30,645 | 24,18,3 |
| 29/05/2011 | A | 5,30,101 | 15,9,3 |
| 30/05/2011 | J | 5,30,735 | 24,16,2 |
| 30/05/2011 | K | 5,15,577 | 20,17,2 |
| 30/05/2011 | L | 5,15,770 | 20,17,1 |
| 30/05/2011 | Q | 5,30,298 | 18,14,2 |
| 30/05/2011 | R | 5,30,123 | 13,9,1 |

## Chlorophyll *a* Analysis

*Objectives*

1. Determine Chlorophyll a concentrations with depth across the Extended Ellett Line.

*Method*

500ml of sample is collected; all bottles are rinsed with sample water prior to collection.

500ml is measured using a volumetric cylinder and then filtered through a filtration unit using a 25mm GF/F filter immediately to avoid photo-degradation.

Once sample has filtered, the filter is placed onto foil and folded in half, before placing in a -20°C freezer.

Note is taken of the station, date, time and bottle used.

After removal from the freezer, the pigments are extracted by placing the filters in 5.0ml 100% acetone. The samples are covered with Para film to reduce evaporation, and allowed to extract for 4 hours in the dark at -20°C.

Following extraction, samples are vortexed; filters are pressed to the bottom of the tube with a stainless steel spatula and spun down in a centrifuge for 5 minutes to remove cellular debris (Holm-Hansen et al, 1965).

Chlorophyll $a = (A_{max-} A_{750nm})/(E \times L) \times (1000mg)/(1\ gram)$

Where:
$A_{max}$ = absorption maximum (664nm)
$A_{750nm}$ = absorbance at 750 nm to correct for light scattering
E = extinction coefficient for chl *a* in 90% acetone *at* 664nm (87.67 L g-1 cm-1)
*L* = cuvette path length (cm)

*Table 10.* Study sites: Chlorophyll a

| **Date** | **Station** | **Depths (m)** | **Bottle number** |
|---|---|---|---|
| 25/05/2011 | IB16a | 5,30,1000 | 24,21,7 |
| 26/05/2011 | IB12 | 5,20,1000 | 24,21,8 |
| 26/05/2011 | IB11a | 10,30,1000 | 23,20,18 |
| 27/05/2011 | IB9 | 10,28,1000 | 23,21,7 |
| 28/05/2011 | IB7 | 10,75,980 | 22,17,2 |
| 29/05/2011 | IB3 | 5,30,645 | 24,18,3 |
| 29/05/2011 | A | 5,30,101 | 15,9,3 |
| 30/05/2011 | J | 5,30,735 | 24,16,2 |
| 30/05/2011 | K | 5,15,577 | 20,17,2 |
| 30/05/2011 | L | 5,15,770 | 20,17,1 |
| 30/05/2011 | Q | 5,30,298 | 18,14,2 |
| 30/05/2011 | R | 5,30,123 | 13,9,1 |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**CFC Sampling** – *Shaun Scally*

Aims and objectives

Many of the complex interactions between the cycles of carbon, nutrients and iron, ocean circulation and global climate are not well understood. Dramatic changes of global temperature, the atmospheric carbon dioxide (CO2) content and ocean circulation between glacial and interglacial periods demonstrate the presence of such interactions.

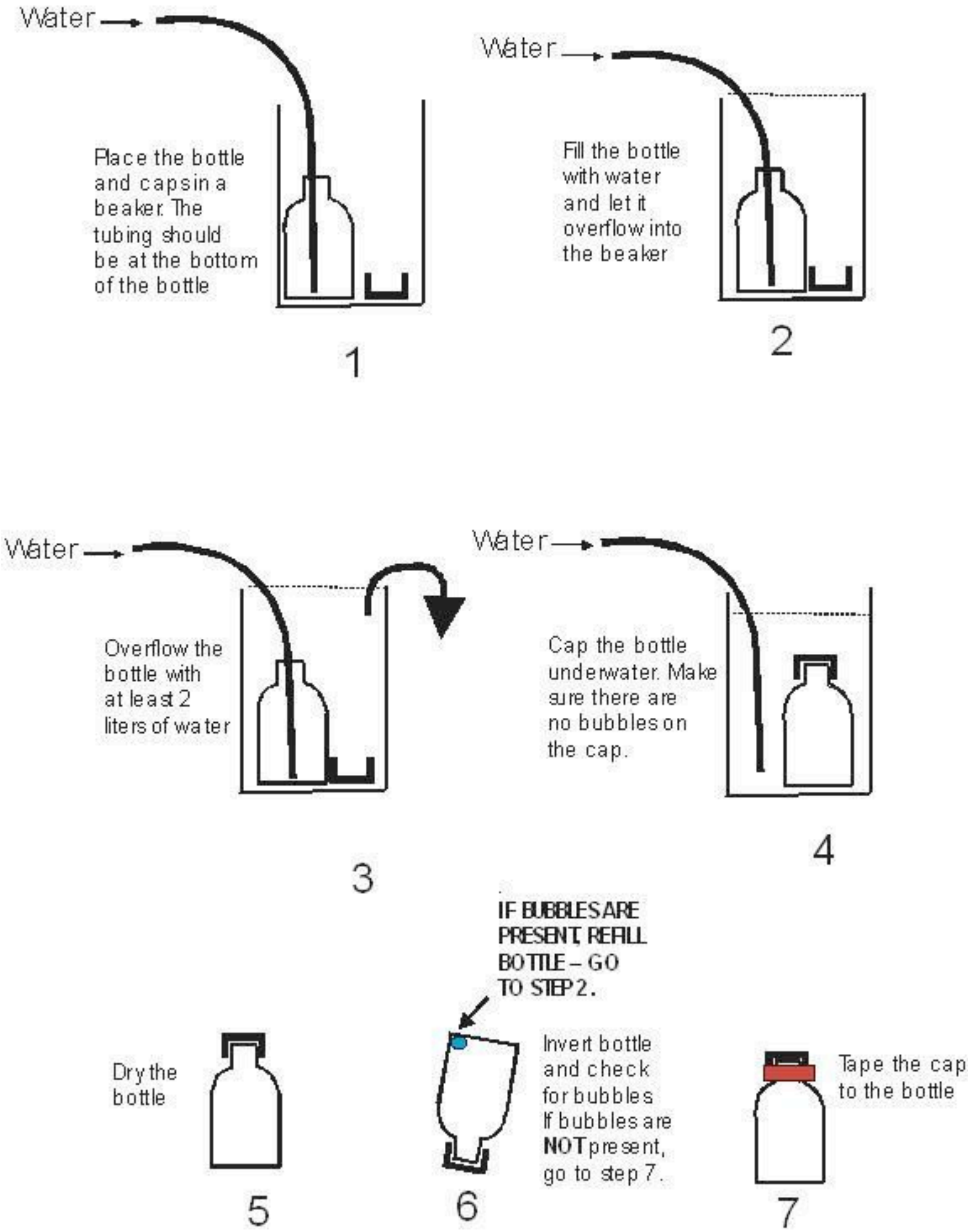
*Transient tracers* (e.g. chlorofluorocarbons, CFCs, and sulfur hexafluoride, SF6) are used as 'tracers' of ocean circulation, ocean mixing and water mass formation. Tracers are also used to quantify the oceanic uptake of 'anthropogenic' carbon. The oceanographic research carried out by UEA scientists has the aim to quantify storage and transport of natural and anthropogenic carbon in these basins and is part of the SOFI Oceans 2025 and ANDREX programmes. For D365, the aim is to continue this work by sampling deep-water stations along the Ellett Line and Extended Ellett Line. Samples taken are listed in Appendix II and will be stored and analysed at UEA at a later date.

CFC Sampling procedure

The bottles and caps are thoroughly rinsed with seawater from the Niskin bottle first, using Tygon tubing connected to the bottom nozzle of the Niskin. The bottles are filled **underwater in a beaker and capped underwater**. The filling procedure is carried out in a 3-litre glass or plastic beaker. There is also a solid plastic block in the beaker, which holds the bottle in place and also ensures that the total amount of water used is around 2 litres.

The procedure is shown below:

1. Once the Niskin is open and the bottle has been rinsed, place the bottle in the beaker and then insert the end of the Tygon tubing all the way into the **bottom** of the bottle.
2. Fill the bottle as shown with seawater until it overflows.
3. Continue to overflow the bottle until the beaker overflows. Allow at least 2 liters of water to flow through the bottle and out of the beaker.
4. Select a cap and tap it under water to dislodge air bubbles. Remove the Tygon tube from the bottle and **tightly cap the bottle underwater** without allowing the water in the bottle to come in contact with air. Flushing the bottle with more water is far better than with less water.
5. Remove the capped bottle from the beaker, dry the bottle and **RE-tighten** the cap. The tighter the cap the better.
6. Invert the bottle, tap it and check it for air bubbles. If there are bubbles, repeat the procedure from step 2 above. If it is necessary to refill the bottle, you must use a **new** cap.
7. If there are no bubbles present, tape the cap **securely** to the bottle with **electrical tape**. Wrap the tape in a clockwise direction looking down from the bottle top. Two rounds of electrical tape are needed.
8. Store bottles upside down until shipment. A bubble will form in most samples. This is normal.




**Dissolved Inorganic Carbon/Alkalinity** - *Mario Eposito, Marta Skiba*

<u>Introduction</u>

The increasing level of carbon dioxide in the atmosphere is altering the carbonate system equilibrium in the ocean. The dissolution of $CO_2$ in seawater produces a series of chemical reactions that contribute to increase dissolved inorganic carbon (DIC) concentrations and to decrease the pH of the ocean, leading to possible negative consequences for marine ecosystems both for taxa and habitat. DIC and alkalinity of the ocean are in strict relationship with physical and biological processes occurring in the ocean. As water mass properties characterise and determine the rates of exchange of carbon and its storing capacity, measurements of carbonate system parameters and observations of eventual changes over different years are the key for understanding how the ocean is responding to the anthropogenic impact.

Method

*Sampling.* In total, 491 samples over 51 stations (Table 11) were collected from Niskin bottles on the stainless steel CTD. Samples were taken from various depths with specific focus on the chlorophyll maxima, oxygen minima, and water masses with differing environmental parameters.

*Sampling procedure.* Sampling bottles were rinsed 3 times by half filling with seawater and shaking vigorously. A plastic tube from the sampling tap to the base of the bottle was used to carefully fill the bottles. While filling, the bottle was rotated to ensure no bubbles accumulated inside. To avoid the persistence of any minute bubbles, the bottle was allowed to overflow. In the wet lab, 2.5 ml of seawater was pipetted out and 50 µl of mercuric chloride was alliquoted to preserve the sample. Silicone grease was smeared around the stopper and carefully placed into the bottle, PVC tape was then wrapped around to seal the sample. Bottles were labelled and stored in the cold store ready for analysis back at NOCS.

*Underway sampling.* Due to poor weather hindering our progress, it was decided to take an alternative course north in search of shelter and thus begin the first station closer to Iceland. This meant we had three days in which to take a non-toxic supply sample every two to three hours, which enhanced our surface sample set. 33 samples (Table 12) were taken in total, using the same preservation method as that for CTD casts.

*Table 11.* List of DIC/Alkalinity samples

| Station | Date | Time | Latitude (°N) | Longitude (°W) | Total depths sampled |
|---|---|---|---|---|---|
| 1G | 20/05/2011 | 02:11 | 56 39.98 | 06 08.59 | 5 |
| 3G | 20/05/2011 | 04:04 | 56 43.15 | 6 21.89 | 3 |
| 5G | 20/05/2011 | 06:07 | 56 44.06 | 6 35.74 | 5 |
| 7G | 20/05/2011 | 08:59 | 56 44.07 | 6 59.76 | 6 |
| 9G | 20/05/2011 | 12:40 | 56 44.12 | 7 20.01 | 8 |
| 10G | 20/05/2011 | 14:30 | 56 43.79 | 7 30.16 | 8 |
| IB20 | 23/05/2011 | 00:10 | 62 55.11 | 19 33.60 | 10 |
| IB21 | 24/05/2011 | 19:45 | 63 08.06 | 19 55.04 | 9 |
| IB22 | 24/05/2011 | 21:45 | 63 12.65 | 20 64.54 | 8 |
| IB23 | 24/05/2011 | 23:25 | 63 15.91 | 20 10.03 | 7 |
| IB19 | 25/05/2011 | 03:11 | 62 40.11 | 19 40.10 | 12 |
| IB18 | 25/05/2011 | 10:20 | 62 20.03 | 19 51.66 | 9 |
| IB17 | 25/05/2011 | 13:20 | 61 59.85 | 20 00.25 | 11 |
| IB16a | 25/05/2011 | 15:40 | 61 44.65 | 20 00.88 | 12 |
| IB16 | 25/05/2011 | 19:00 | 61 30.01 | 19 59.93 | 12 |
| IB15 | 25/05/2011 | 22:00 | 61 14.92 | 20 00.83 | 13 |
| IB14 | 26/05/2011 | 02:30 | 61 00.21 | 20 00.16 | 13 |
| IB13a | 26/05/2011 | 08:30 | 60 45.00 | 20 00.58 | 15 |
| IB13 | 26/05/2011 | 12:15 | 60 30.12 | 19 59.86 | 14 |
| IB12 | 26/05/2011 | 15:00 | 60 15.18 | 19 59.90 | 14 |
| 60N20W | 26/05/2011 | 18:00 | 59 59.61 | 19 59.96 | 12 |

| | | | | | |
|---|---|---|---|---|---|
| IB11a | 26/05/2011 | 23:30 | 59 49.92 | 19 33.66 | 12 |
| IB11 | 27/05/2011 | 03:40 | 59 39.95 | 19 06.43 | 12 |
| IB10 | 27/05/2011 | 11:45 | 59 23.99 | 18 24.36 | 12 |
| IB9 | 27/05/2011 | 14:00 | 59 19.94 | 18 13.46 | 14 |
| IB8 | 28/05/2011 | 20:00 | 59 11.97 | 17 13.00 | 10 |
| IB7 | 28/05/2011 | 22:30 | 59 06.96 | 17 40.46 | 11 |
| IB5 | 29/05/2011 | 02:30 | 58 52.98 | 17 00.18 | 12 |
| IB4a | 29/05/2011 | 06:00 | 58 42.05 | 16 29.29 | 12 |
| IB4 | 29/05/2011 | 11:45 | 58 26.36 | 15 50.31 | 11 |
| IB3 | 29/05/2011 | 13:00 | 58 15.14 | 15 19.75 | 8 |
| IB2 | 29/05/2011 | 16:30 | 57 56.90 | 14 34.87 | 8 |
| A Rockall | 29/05/2011 | 21:00 | 57 34.92 | 13 37.93 | 5 |
| B | 29/05/2011 | 23:00 | 57 33.94 | 13 20.08 | 5 |
| C | 30/05/2011 | 00:45 | 57 32.91 | 12 59.97 | 5 |
| D | 30/05/2011 | 02:15 | 57 32.07 | 12 52.14 | 6 |
| E | 30/05/2011 | 04:45 | 57 31.82 | 12 38.39 | 7 |
| F | 30/05/2011 | 08:10 | 57 30.75 | 12 13.58 | 7 |
| G | 30/05/2011 | 12:00 | 57 29.50 | 11 50.97 | 7 |
| H | 30/05/2011 | 14:00 | 57 29.33 | 11 32.31 | 9 |
| I | 30/05/2011 | 17:00 | 57 28.07 | 11 18.74 | 5 |
| J | 30/05/2011 | 18:30 | 57 26.96 | 11 04.82 | 5 |
| K | 30/05/2011 | 21:00 | 57 23.75 | 10 52.40 | 7 |
| L | 30/05/2011 | 23:30 | 57 21.17 | 10 40.76 | 9 |
| M | 31/05/2011 | 02:30 | 57 17.29 | 10 23.15 | 10 |
| N | 31/05/2011 | 05:40 | 57 14.40 | 10 02.52 | 11 |
| O | 31/05/2011 | 11:00 | 57 09.47 | 9 42.17 | 7 |
| P | 31/05/2011 | 13:30 | 57 06.02 | 9 25.31 | 9 |
| Q | 31/05/2011 | 15:00 | 57 03.31 | 9 12.85 | 8 |
| R | 31/05/2011 | 16:00 | 57 00.07 | 8 59.13 | 6 |
| S | 31/05/2011 | 17:55 | 56 57.63 | 8 46.84 | 3 |

Table 12. List of DIC/alkalinity underway samples

| **Date** | **Time** | **Latitude (°N)** | **Longitude (°W)** |
|---|---|---|---|
| 20/05/2011 | 03:33 | 56 41.27 | 6 16.95 |
| 20/05/2011 | 05:02 | 56 43.99 | 6 26.86 |
| 20/05/2011 | 07:21 | 56 44 | 6 44.77 |
| 20/05/2011 | 10:30 | 56 44.01 | 7 10.25 |
| 21/05/2011 | 13:06 | 57 10.05 | 7 03.49 |
| 21/05/2011 | 16:00 | 57 39.50 | 6 35.04 |
| 21/05/2011 | 19:00 | 58 7.29 | 6 63.25 |
| 21/05/2011 | 22:00 | 58 35.66 | 6 22.16 |
| 21/05/2011 | 00:00 | 58 47.24 | 6 54.71 |
| 22/05/2011 | 03:30 | 59 08.61 | 7 54.16 |
| 22/05/2011 | 07:10 | 59 30.74 | 8 54.81 |
| 22/05/2011 | 08:00 | 59 35.60 | 9 08.36 |
| 22/05/2011 | 10:00 | 59 44.60 | 9 33.75 |
| 22/05/2011 | 12:00 | 59 52.94 | 9 57.19 |

| | | | |
|---|---|---|---|
| 22/05/2011 | 14:00 | 60 01.55 | 10 21.54 |
| 22/05/2011 | 16:00 | 60 11.41 | 10 49.59 |
| 22/05/2011 | 18:00 | 60 22.69 | 11 21.88 |
| 22/05/2011 | 20:00 | 60 34.28 | 11 55.14 |
| 22/05/2011 | 22:00 | 60 46.57 | 12 30.77 |
| 23/05/2011 | 00:00 | 60 59.10 | 13 07.31 |
| 23/05/2011 | 02:00 | 61 12.09 | 13 45.40 |
| 23/05/2011 | 04:00 | 61 24.51 | 14 22.02 |
| 23/05/2011 | 06:00 | 61 35.85 | 14 55.77 |
| 23/05/2011 | 08:00 | 61 47.74 | 15 31.34 |
| 23/05/2011 | 10:00 | 61 59.82 | 16 07.63 |
| 23/05/2011 | 12:00 | 62 11.59 | 16 43.26 |
| 23/05/2011 | 14:00 | 62 25.37 | 17 08.99 |
| 23/05/2011 | 16:00 | 62 30.92 | 17 50.48 |
| 23/05/2011 | 18:00 | 62 38.85 | 18 26.25 |
| 23/05/2011 | 20:00 | 62 45.12 | 19 00.92 |
| 23/05/2011 | 22:00 | 62 54.96 | 19 33.08 |
| 23/05/2011 | 23:35 | 62 55.11 | 19 33.60 |
| 24/05/2011 | 01:34 | 62 02.58 | 19 46.16 |

**Phytoplankton community structure** – *Denise Smythe-Wright, Diane Purcell, Aaron Daniel*

Objective

The purpose of this work was to collect samples for the identification and enumeration of phytoplankton using a combination of analytical methods viz plant pigment analysis, light and scanning electronic microscopy (SEM) and flow cytometry. There were four primary objectives to the work:

- to interpret the resulting data set alongside the dissolved inorganic carbon data collected simultaneously, to study the relationship between phytoplankton and carbon chemistry in the ocean.
- to study the relationship between individual plant pigments and phytoplankton groups to be able to better classify phytoplankton (possibly even to species level) using pigment ratios.
- to study the movement of pigments and their degradation products throughout the water column and to assess their potential as a food source to the benthos.
- to collect pigment data for the calibration and validation of a new tool for primary productivity measurements being developed under EU project PROTOOL (see FRRF section )

Methodology

Samples were collected from all 55 CTD stations along the extended Ellett Line (Appendix III, Table 1) and also from the ships sea water supply at 31 locations, primarily along the passage leg from Scotland to Iceland (Appendix III, Table 2); the latter was not initially planned but opportunistic due to the bad weather.

Water samples were collected directly from the 10L Niskin bottles or from the non-toxic supply into plastic 10L containers. Each sample was then divided for

- *Plant pigment analysis:* 2-6 L of water (dependent on the depth - >200 m requiring 4-6 L) being filtered through 25 mm GFF filters. The filters were placed in cryovials and flash frozen with liquid nitrogen before being transferred to a -80°C freezer.
- *Light microscopy identification and enumeration:* 100 ml transferred to two amber glass bottles one containing 0.4 ml of lugols iodine solution and the other 2 ml of 20% paraformaldehyde solution as preservative. The bottles were stored in the walk in fridge at 8°C.
- *Flow cytometry identification and enumeration of cyanobacteria:* 1.8 ml pipetted into a cryovial containing 0.2 ml of 20% paraformaldehyde solution as a preservative.
- *Coccolithophore enumeration by SEM:* between 200 -500 ml (sufficient to give colouration) filtered through 25mm 0.8µm membrane filters, which were placed in petri dishes and allowed to air dry before storage.

Problems

No major problems were encountered, although it was pointed out to us on 24 May that the non-toxic supply connections we had used in the wet laboratory were taking water indirectly via a tank rather than directly from the ship's hull. On investigation it appeared that up to then all the geochemistry had been collected from the same supply and the only major effect was the absolute positioning at the time of sampling; this was likely to be ~ one nautical miles earlier and from a mixture over this distance. It would be helpful if taps throughout the ship were labelled accordingly to avoid such a mistake in future.

**Fast Repetition Rate Fluorometer (FRRF) measurements** - *Denise Smythe-Wright, Aaron Daniel and Diane Purcell*

Objective

The purpose of this study was to use two Chelsea *fast tracka* FRRF instruments to better understand the photosynthetic activity of the phytoplankton and hence estimate primary productivity over the entire cruise track. There were two aspects to the work.

1. To make continuous measurements from the ships underway sea water system under variable light conditions. This work, together with the high quality pigment data simultaneously collected, forms part of the EU project PROTOOL (www.protool-project.eu/project/the-project). PROTOOL stands for PROductivity TOOLs and is a 3 year project to develop and adapt technology to measure primary production of phytoplankton with automated optical techniques, so that they can be placed on ships of opportunity (SOOP, ferries, container ships). The data collected from this research cruise will be used in the development, calibration and validation of the new instrument.
2. To obtain profiles of FRRF data throughout the water column by collecting bottle samples from CTD's and running them using an NMFD bench-top FRRF.

Methodology

The two FRRF systems were set up horizontally alongside each other in the wet laboratory:

*Continuous Flow Through*

NMFD FRRF instrument (serial number: 182042) was fitted with a continuous flow through cuvette supplied by Jacco Kromkamp, NIOO (Netherlands Institute of Ecology, Centre for Estuarine and Marine Ecology) and set with a flow rate of approx 38 sec/L. An LED light panel (also provided by NIOO), which continually cycled through a full rapid light curve in 300 seconds, was placed at a distance of approximately 10 cm in front of the cuvette. The sampling protocol of the FRRF was set to an acquisition sequence of 100 saturation flashes, 20 relaxation flashes per sequence and 3000 m/sec sleep time between acquisitions. The flash duration was of 0.65 µ sec (4 instrument units), and was run in AutoRanging mode (PMT gain=16). Such a sampling protocol provided FRRF fluorescence under varying light intensities in open oceanic waters. The instrument was connected to an HP laptop computer and accessed using hyperterminal. The FRRF's analogue output and logging to internal flashcard modes were disabled and the data were recorded by capturing the text files on the computer. Two text files each containing approximately 5600 sequences were saved every day at midday and midnight.

For a correct determination of the quantum efficiency (*fv/fm*) it was necessary to correct the background fluorescence by running blanks. This was achieved by collecting 2L of water from three locations with different environmental characteristics (Iceland Basin, Rockall-Hatton Bank, and Scotland Shelf) and filtering them through 0.2µm polycarbonate filters. 30 sequences were run in Normal Range mode using all PMT gains (0, 1, 4, 16, 64, 256) with both light and dark chambers enabled in order to attain minimum and maximum fluorescence.

In addition, the clock that controls the light panel was known to be off by a fraction of a second and so to match the light levels with the FRRF measurements, it was necessary to note down to the exact second (using windows desktop clock) when the LED panel went from the highest light level to no light. This was done three to four times a day, and will help ensure the precise light conditions for every fluorescence measurement.

*Discrete measurements*

NMFD instrument (serial number: 055335001), fitted for discrete dark chamber measurements, was placed alongside the continuous flow through instrument. At each CTD station the dark chamber was filled with water from up to 10 depth levels and after an interval of 10 minutes, to ensure that the phytoplankton had adjusted to the dark, measurements were made for 50 acquisitions. All data were recorded in the same way as the flow through (capturing text) on a Toshiba laptop computer. Details of these measurements are included in Appendix III, Table 1.

Problems

There were no major problems.

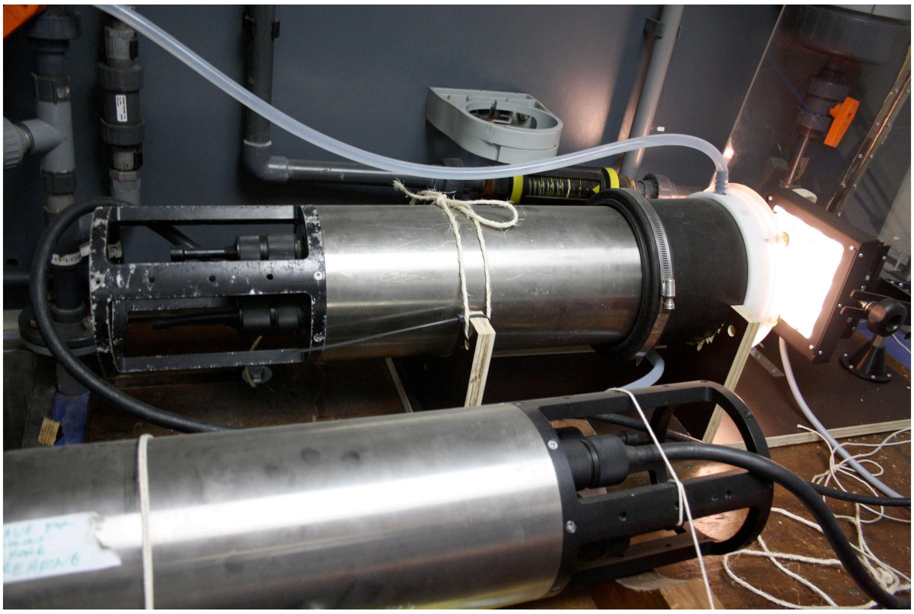
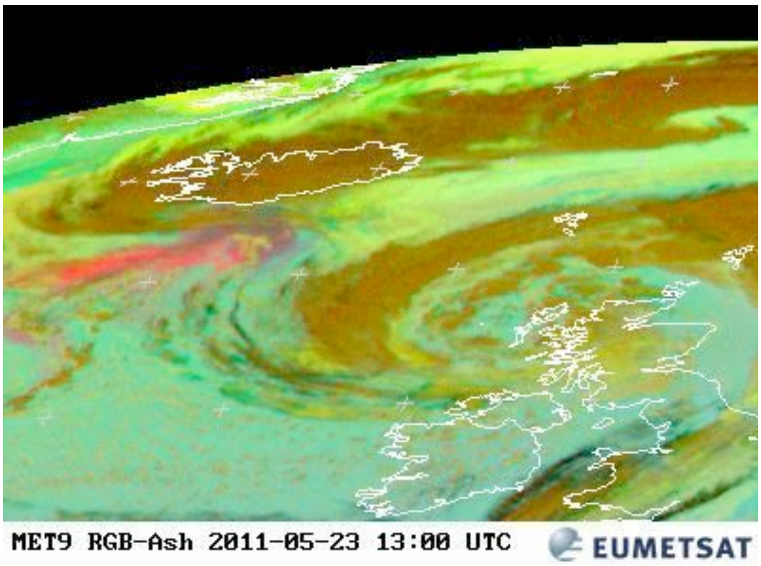


*Figure 18.* FRRF's in the water bottle annex during *RRS Discovery* cruise 365.

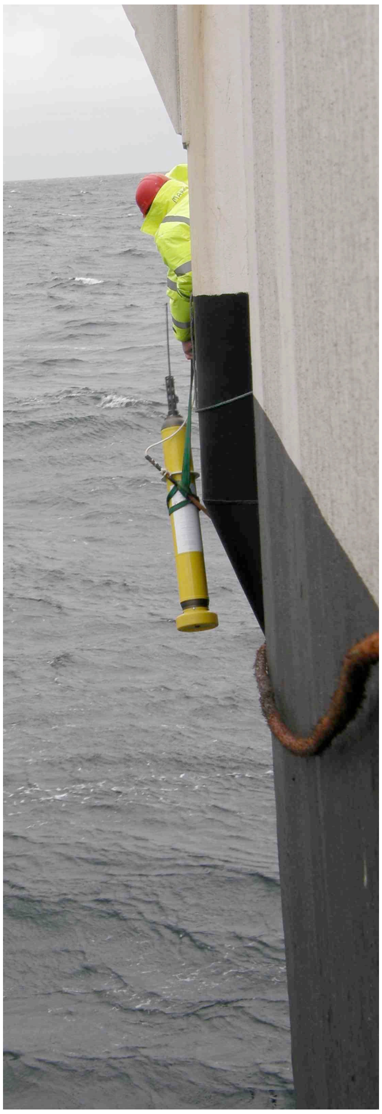
**Sampling ash from the Grimsvotn volcanic eruption 21/05/2011** - *Dmitry Aleynik*

Samples of ash have been collected on board *RRS Discovery* during D365 cruise. The yellowish cloud covered the ships surfaces on the way from the Isle of Lewis towards Iceland at midday of 23 May 2011 at coordinates 62° 25.0'N 17° 07.5'W. After a few days all dust had been washed away except for some spots on the ships masts and the roof of the bridge from where the samples were collected on 26 May 2011 at 09:46 at 60°37.02'N 019°59.82'W (soon after Station IB13a, CTD365022).

Samples will be subjected to Laser Ablation ICP-MS analysis for ash particles (if they are big enough) in the wet lab of the Natural History Museum, London, UK. Many thanks to Tim Brand for advice and the help of Paul Duncan and the ships crew (Paul).




**Argo Float Deployments** – *Jane Read*



Four Argo floats were provided by the UK Meteorological Office for deployment in the Iceland Basin. These were successfully released as follows:

S/N 5540 deployed 0415 26/5/2011 at 60° 59.41' N 020° 00.68' W after station IB14.

S/N 5541 deployed 1205 26/5/11 at 60° 29.35' N 019° 59.299' W after station IB13.

S/N 5537 deployed 2006 26/5/11 at 59° 58.5' N 019° 57.8' W following station 6020

S/N 5353 deployed 0530 27/5/11 at 59° 37.71' N 019° 07.01' W after station IB11.

All floats switched on normally and were lowered over the stern on a strop. No problems were encountered.

*Figure 19.* Argo float deployment over the stern of *RRS Discovery* (right).

**Data Management** – *Mike Nelson*

During the cruise, CTD bottle firing and sampling log sheets were maintained by the watchkeepers. The log sheets were initially identical to those used on D351. However, it soon became apparent that they would require some modification to help coordinate the order that samples were taken from the Niskin bottles. This was essential in preserving the integrity of the CFC, DIC and dissolved oxygen samples. The sheets were updated to include the measurement type and sample sequence, allowing scientists to easily check if the bottle they required was free to take water from or if they needed to wait for other samples to be taken first. This enhancement seemed to ease the sample coordination procedure noticeably. Log sheets of samples taken from the ship's non-toxic supply were maintained by those groups that took them. At the end of the cruise, these log sheets were combined to produce an overall record of all non-toxic samples taken (Appendix V).

In addition, an event log recorded additional activities that took place, such as Argo float deployments and ad-hoc volcanic ash sampling. Supplementary information, including the underway sensors being cleaned, was also included in this log to provide an overall picture of events taking place that may affect data quality. This log would also have proved useful should the UK, Irish or Icelandic authorities have requested detailed information about the activities carried out in their waters (Appendix IV).

All logs were digitized and made available by placing on the shared network drive.

## ACKNOWLEDGEMENTS

The cruise suffered an exceptional amount of downtime, both from equipment problems and bad weather. My thanks to the Master, officers and crew for doing all they could to help, and to the scientists for their understanding. Funding was provided through the NERC Oceans 2025 core strategic science programme.

*Jane Read*

**APPENDIX I: CTD and LADCP configurations**

CTD Configuration
Date: 05/23/2011

Instrument configuration file: C:\Program Files\Sea-Bird\SeasaveV7\D365\raw_data\CTDTEST.xmlcon

Configuration report for SBE 911plus/917plus CTD
----------------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : No
Scan time added : Yes

1) Frequency 0, Temperature
Serial number : 03P-2919
Calibrated on : 07-Apr-2011
G : 4.31698973e-003
H : 6.44474855e-004
I : 2.28345651e-005
J : 2.13820706e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity
Serial number : 04C-2571
Calibrated on : 22-Feb-2011
G : -1.02886039e+001
H : 1.59706391e+000
I : -3.05733193e-004
J : 1.25567101e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC
Serial number : 100898
Calibrated on : 31-07-2009
C1 : -4.405863e+004
C2 : -6.206030e-002
C3 : 1.337540e-002
D1 : 3.669100e-002
D2 : 0.000000e+000
T1 : 2.990734e+001
T2 : -3.493620e-004
T3 : 4.061200e-006
T4 : 3.043880e-009
T5 : 0.000000e+000
Slope : 0.99994000
Offset : -1.08250
AD590M : 1.288520e-002
AD590B : -8.271930e+000

4) Frequency 3, Temperature, 2
Serial number : 03P-4151
Calibrated on : 07-Apr-2011
G : 4.39927067e-003
H : 6.69948622e-004
I : 2.51685282e-005
J : 2.05251681e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2
Serial number : 04C-3054
Calibrated on : 31-Mar-2011
G : -1.02006288e+001
H : 1.40412747e+000
I : -5.73045235e-004
J : 1.08104091e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43
Serial number : 43-1882
Calibrated on : 10-Jul-2010
Equation : Sea-Bird
Soc : 4.96700e-001
Offset : -5.00600e-001
A : -3.52060e-003
B : 1.57910e-004
C : -2.41260e-006
E : 3.60000e-002
Tau20 : 1.82000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Altimeter
Serial number : 6196.118171
Calibrated on : 14-Nov-06
Scale factor : 15.000
Offset : 0.000

9) A/D voltage 3, Fluorometer, Chelsea Aqua 3
Serial number : 88-2050-095
Calibrated on : 21-Apr-2011
VB : 0.395200
V1 : 2.073700
Vacetone : 0.433000
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor
Serial number : 07

Calibrated on : 01-Oct-2010
M : 0.45485300
B : 1.72176700
Calibration constant : 100000000000.00000000
Multiplier : 0.99960000
Offset : 0.00000000

11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2
Serial number : 06
Calibrated on : 01-Oct-2010
M : 0.45145500
B : 1.69229900
Calibration constant : 1000000000000.00000000
Multiplier : 0.99980000
Offset : 0.00000000

12) A/D voltage 6, Turbidity Meter, WET Labs, ECO-BB
Serial number : BBRTD-169
Calibrated on : 14-Apr-2009
ScaleFactor : 0.003110
DarkVoltage : 0.111200

13) A/D voltage 7, Transmissometer, Chelsea/Seatech/WET Lab CStar
Serial number : 07-6075-001
Calibrated on : 05-Oct-2010
M : 23.8692
B : -0.2578
Path length : 0.025

Scan length : 41

LADCP Master Configuration

PS0
CR1
CF11101
EA00000
EB00000
ED00000
ES35
EX11111
EZ0011101
WM15
LW1
LD111100000
LF0500
LN016
LP00001
LS1000
LV250
SM1
SA001
SW05000
TE00:00:01.00
TP00:00.00
CK
CS

LADCP Slave Configuration

PS0
CR1
CF11101
EA00000
EB00000
ED00000

ES35
EX11111
EZ0011101
WM15
LW1
LD111100000
LF0500
LN016
LP00001

LS1000
LV250
SM2
SA001
ST0
TE00:00:01.00
TP00:00.00
CK
CS

## APPENDIX II: CFC Samples

| | Niskin | Depth | Bottle |
|---|---|---|---|
| **Date:** 20/05/2011 | 1 | 67 | 001 |
| **Station:** 4G | 3 | 40 | 002 |
| | 5 | 20 | 003 |
| | 7 | 5 | 004 |
| **Date:** 20/05/2011 | 2 | 127 | 005 |
| **Station:** 7G | 5 | 120 | 006 |
| | 8 | 80 | 007 |
| | 11 | 40 | 008 |
| | 17 | 5 | 009 |
| **Date:** 20/05/2011 | 1 | 200 | 010 |
| **Station:** 10G | 6 | 150 | 011 |
| | 7 | 120 | 012 |
| | 11 | 80 | 013 |
| | 24 | 10 | 014 |
| **Date:** 23/05/2011 | 2 | 1385 | 015, 016 |
| **Station:** IB20 | 4 | 1000 | 017 |
| | 5 | 830 | 018 |
| | 8 | 600 | 019 |
| | 9 | 500 | 020 |
| | 12 | 200 | 021 |
| | 22 | 5 | 022 |
| **Date:** 24/05/2011 | 1 | 1020 | 023,024 |
| **Station:** IB21 | 4 | 900 | 025 |
| | 6 | 760 | 026 |
| | 7 | 600 | 027 |
| | 8 | 500 | 028 |
| | 10 | 400 | 029 |
| | 24 | 5 | 030 |
| **Date:** 24/05/2011 | 2 | 700 | 031,032 |
| **Station:** IB22 | 4 | 500 | 033 |
| | 8 | 200 | 034 |
| | 20 | 5 | 035 |
| **Date:** 25/05/2011 | 1 | 1708 | 036,037 |
| **Station:** IB19 | 3 | 1500 | 038 |
| | 5 | 1200 | 039 |
| | 7 | 1000 | 040 |
| | 8 | 715 | 041 |
| | 10 | 500 | 042 |
| | 11 | 200 | 043 |
| | 13 | 110 | 044 |
| | 15 | 75 | 045 |
| | 17 | 50 | 046 |
| | 19 | 25 | 047 |
| | 21 | 10 | 048 |
| | 23 | 5 | 049 |
| **Date:** 25/05/2011 | 2 | 1800 | 050,051 |
| **Station:** IB18 | 3 | 1600 | 052 |

| | Niskin | Depth | Bottle |
|---|---|---|---|
| | 4 | 1400 | 053 |
| | 6 | 1200 | 054 |
| | 7 | 1000 | 055 |
| | 8 | 800 | 056 |
| | 10 | 500 | 057 |
| | 13 | 110 | 058 |
| | 16 | 85 | 059 |
| | 18 | 50 | 060 |
| | 20 | 30 | 061 |
| | 23 | 5 | 062 |
| **Date:** 25/05/2011 | 1 | 1782 | 063,064 |
| **Station:** IB17 | 2 | 1600 | 065 |
| | 3 | 1400 | 066 |
| | 4 | 1200 | 067 |
| | 5 | 1000 | 068 |
| | 6 | 800 | 069 |
| | 8 | 500 | 070 |
| | 10 | 200 | 071 |
| | 12 | 120 | 072 |
| | 14 | 100 | 073 |
| | 20 | 5 | 074 |
| **Date:** 25/05/2011 | 2 | 1790 | 075,076 |
| **Station:** IB16A | 3 | 1600 | 077 |
| | 4 | 1400 | 078 |
| | 5 | 1200 | 079 |
| | 6 | 1000 | 080 |
| | 8 | 760 | 081 |
| | 10 | 500 | 082 |
| | 12 | 200 | 083 |
| | 14 | 150 | 084 |
| | 24 | 5 | 085 |
| **Date:** 25/05/2011 | 2 | 2205 | 086,087 |
| **Station:** IB16 | 3 | 2000 | 088 |
| | 4 | 1800 | 089 |
| | 6 | 1500 | 090 |
| | 7 | 1200 | 091 |
| | 8 | 1000 | 092 |
| | 10 | 800 | 093 |
| | 12 | 500 | 094 |
| | 14 | 200 | 095 |
| | 16 | 80 | 096 |
| | 24 | 5 | 097 |
| **Date:** 25/05/2011 | 2 | 2358 | 098,099 |
| **Station:** IB15 | 3 | 2200 | 100 |
| | 4 | 2000 | 101 |
| | 5 | 1800 | 102 |
| | 6 | 1500 | 103 |

| | Niskin | Depth | Bottle |
|---|---|---|---|
| | 7 | 1200 | 104 |
| | 8 | 1000 | 105 |
| | 10 | 800 | 106 |
| | 14 | 500 | 107 |
| | 16 | 200 | 108 |
| | 24 | 10 | 109 |
| **Date:** 26/05/2011 | 2 | 2400 | 110,111 |
| **Station:** IB14 | 3 | 2200 | 112 |
| | 4 | 2000 | 113 |
| | 6 | 1800 | 114 |
| | 7 | 1500 | 115 |
| | 9 | 1200 | 116 |
| | 10 | 1000 | 117 |
| | 11 | 800 | 118 |
| | 14 | 500 | 119 |
| | 15 | 200 | 120 |
| | 24 | 5 | 121 |
| **Date:** 26/05/2011 | 2 | 2400 | 122,123 |
| **Station:** IB13A | 3 | 2200 | 124 |
| | 4 | 2000 | 125 |
| | 5 | 1800 | 126 |
| | 6 | 1500 | 127 |
| | 7 | 1200 | 128 |
| | 8 | 1000 | 129 |
| | 9 | 800 | 130 |
| | 12 | 500 | 131 |
| | 14 | 200 | 132 |
| | 18 | 50 | 133 |
| | 24 | 5 | 134 |
| **Date:** 26/05/2011 | 1 | 2510 | 135,136 |
| **Station:** IB13 | 2 | 2300 | 137 |
| | 3 | 2000 | 138 |
| | 4 | 1800 | 139 |
| | 5 | 1500 | 140 |
| | 7 | 1200 | 141 |
| | 8 | 1000 | 142 |
| | 9 | 800 | 143 |
| | 12 | 500 | 144 |
| | 14 | 200 | 145 |
| | 19 | 55 | 146 |
| | 24 | 5 | 147 |
| **Date:** 26/05/2011 | 2 | 2628 | 148,149 |
| **Station:** IB12 | 3 | 2300 | 150 |
| | 4 | 2000 | 151 |
| | 5 | 1800 | 152 |
| | 6 | 1500 | 153 |
| | 7 | 1200 | 154 |
| | 8 | 1000 | 155 |

| | Niskin | Depth | Bottle |
|---|---|---|---|
| | 9 | 745 | 156 |
| | 11 | 500 | 157 |
| | 13 | 200 | 158 |
| | 15 | 120 | 159 |
| | 23 | 5 | 160 |
| **Date:** 26/05/2011 | 2 | 2713 | 161,162 |
| **Station:** 60N20W | 3 | 2500 | 163 |
| | 4 | 2200 | 164 |
| | 6 | 2000 | 165 |
| | 7 | 1500 | 166 |
| | 8 | 1200 | 167 |
| | 9 | 1000 | 168 |
| | 10 | 800 | 169 |
| | 12 | 650 | 170 |
| | 14 | 500 | 171 |
| | 16 | 200 | 172 |
| | 20 | 55 | 173 |
| | 24 | 10 | 174 |
| **Date:** 26/05/2011 | 1 | 2691 | 175,176 |
| **Station:** IB11a | 3 | 2500 | 177 |
| | 4 | 2200 | 178 |
| | 5 | 2000 | 179 |
| | 6 | 1500 | 180 |
| | 7 | 1200 | 181 |
| | 8 | 1000 | 182 |
| | 10 | 800 | 183 |
| | 12 | 500 | 184 |
| | 14 | 200 | 185 |
| | 18 | 45 | 186 |
| | 24 | 10 | 187 |
| **Date:** 27/05/2011 | 1 | 2670 | 188 |
| **Station:** IB11 | 3 | 2500 | 189,190 |
| | 4 | 2200 | 191 |
| | 6 | 2000 | 192 |
| | 7 | 1500 | 193 |
| | 8 | 1200 | 194 |
| | 9 | 1000 | 195 |
| | 10 | 800 | 196 |
| | 13 | 500 | 197 |
| | 15 | 200 | 198 |
| | 19 | 45 | 199 |
| | 23 | 5 | 200 |
| **Date:** 27/05/2011 | 1 | 2382 | 201 |
| **Station:** IB10 | 3 | 2200 | 202 |
| | 4 | 2000 | 203 |
| | 6 | 1800 | 204 |
| | 7 | 1500 | 205 |
| | 8 | 1200 | 206 |

| | Niskin | Depth | Bottle |
|---|---|---|---|
| | 10 | 1000 | 207 |
| | 12 | 760 | 208 |
| | 13 | 500 | 209 |
| | 14 | 200 | 210 |
| | 19 | 50 | 211 |
| | 23 | 5 | 212 |
| **Date:** 27/05/2011 | 2 | 1830 | 213,214 |
| **Station:** IB9 | 3 | 1600 | 215 |
| | 4 | 1400 | 216 |
| | 6 | 1200 | 217 |
| | 7 | 1000 | 218 |
| | 10 | 800 | 219 |
| | 12 | 500 | 220 |
| | 13 | 200 | 221 |
| | 18 | 50 | 222 |
| | 23 | 5 | 223 |
| **Date:** 28/05/2011 | 2 | 1514 | 224,225 |
| **Station:** IB8 | 3 | 1400 | 226 |
| | 4 | 1200 | 227 |
| | 6 | 1000 | 228 |
| | 8 | 840 | 229 |
| | 10 | 760 | 230 |
| | 11 | 500 | 231 |
| | 12 | 200 | 232 |
| | 19 | 62 | 233 |
| | 24 | 10 | 234 |
| **Date:** 29/05/2011 | 2 | 1150 | 235,236 |
| **Station:** IB5 | 3 | 1000 | 237 |
| | 7 | 800 | 238 |
| | 8 | 500 | 239 |
| | 10 | 300 | 240 |
| | 13 | 150 | 241 |
| | 15 | 100 | 242 |
| | 19 | 50 | 243 |
| | 24 | 5 | 244 |
| **Date:** 29/05/2011 | 2 | 1175 | 245,246 |
| **Station:** IB4a | 3 | 1000 | 247 |
| | 7 | 800 | 248 |
| | 10 | 500 | 249 |
| | 11 | 300 | 250 |
| | 18 | 55 | 251 |
| | 24 | 5 | 252 |
| **Date:** 29/05/2011 | 1 | 1175 | 253,254 |
| **Station:** IB4 | 4 | 1000 | 255 |
| | 5 | 860 | 256 |
| | 9 | 500 | 257 |
| | 11 | 300 | 258 |
| | 14 | 125 | 259 |

| | Niskin | Depth | Bottle |
|---|---|---|---|
| | 17 | 86 | 260 |
| | 23 | 5 | 261 |
| **Date:** 29/05/2011 | 2 | 645 | 262 |
| **Station:** IB3 | 4 | 500 | 263 |
| | 6 | 400 | 264 |
| | 8 | 200 | 265 |
| | 12 | 120 | 266 |
| | 16 | 57 | 267 |
| | 24 | 5 | 268 |
| **Date:** 29/05/2011 | 2 | 170 | 269 |
| **Station:** B | 5 | 110 | 270 |
| | 9 | 70 | 271 |
| | 15 | 10 | 272 |
| **Date:** 30/05/2011 | 1 | 1063 | 273 |
| **Station:** D | 3 | 800 | 274 |
| | 9 | 500 | 275 |
| | 11 | 200 | 276 |
| | 19 | 50 | 277 |
| | 24 | 5 | 278 |
| **Date:** 30/05/2011 | 2 | 1622 | 279,280 |
| **Station:** E | 3 | 1400 | 281 |
| | 4 | 1200 | 282 |
| | 6 | 1000 | 283 |
| | 7 | 800 | 284 |
| | 9 | 500 | 285 |
| | 11 | 200 | 286 |
| | 17 | 50 | 287 |
| | 23 | 5 | 288 |
| **Date:** 30/05/2011 | 1 | 1810 | 289,290 |
| **Station:** F | 3 | 1600 | 291 |
| | 4 | 1350 | 292 |
| | 5 | 1200 | 293 |
| | 7 | 1000 | 294 |
| | 8 | 800 | 295 |
| | 10 | 500 | 296 |
| | 12 | 200 | 297 |
| | 20 | 35 | 298 |
| | 23 | 5 | 299 |
| **Date:** 30/05/2011 | 1 | 1778 | 300,301 |
| **Station:** G | 3 | 1600 | 302 |
| | 5 | 1400 | 303 |
| | 7 | 1200 | 304 |
| | 9 | 1000 | 305 |
| | 11 | 820 | 306 |
| | 13 | 500 | 307 |
| | 16 | 200 | 308 |
| | 21 | 60 | 309 |
| | 24 | 5 | 310 |

| | Niskin | Depth | Bottle |
|---|---|---|---|
| **Date:** 30/05/2011 | 1 | 1998 | 311,312 |
| **Station:** H | 3 | 1880 | 313 |
| | 5 | 1600 | 314 |
| | 6 | 1400 | 315 |
| | 7 | 1200 | 316 |
| | 9 | 1000 | 317 |
| | 10 | 800 | 318 |
| | 12 | 500 | 319 |
| | 13 | 200 | 320 |
| | 18 | 56 | 321 |
| | 24 | 5 | 322 |
| **Date:** 30/05/2011 | 2 | 735 | 323,324 |
| **Station:** I | 4 | 500 | 325 |
| | 6 | 200 | 326 |
| | 9 | 100 | 327 |
| | 14 | 60 | 328 |
| | 24 | 5 | 329 |
| **Date:** 30/05/2011 | 1 | 770 | 330,331 |
| **Station:** K | 5 | 500 | 332 |
| | 7 | 200 | 333 |
| | 11 | 100 | 334 |
| | 14 | 60 | 335 |
| | 20 | 5 | 336 |
| **Date:** 30/05/2011 | 1 | 2100 | 337,338 |
| **Station:** L | 3 | 1800 | 339 |
| | 4 | 1600 | 340 |
| | 5 | 1400 | 341 |
| | 7 | 1200 | 342 |
| | 8 | 1000 | 343 |
| | 10 | 866 | 344 |
| | 12 | 600 | 345 |
| | 14 | 200 | 346 |
| | 17 | 50 | 347 |
| | 23 | 5 | 348 |
| **Date:** 31/05/2011 | 1 | 2204 | 349,350 |
| **Station:** M | 3 | 2000 | 351 |
| | 4 | 1800 | 352 |
| | 5 | 1600 | 353 |
| | 7 | 1400 | 354 |

| | Niskin | Depth | Bottle |
|---|---|---|---|
| | 8 | 1200 | 355 |
| | 9 | 1000 | 356 |
| | 11 | 800 | 357 |
| | 13 | 500 | 358 |
| | 15 | 200 | 359 |
| | 19 | 60 | 360 |
| | 23 | 5 | 361 |
| **Date:** 31/05/2011 | 2 | 2084 | 362,363 |
| **Station:** N | 3 | 1800 | 364 |
| | 4 | 1600 | 365 |
| | 6 | 1400 | 366 |
| | 7 | 1200 | 367 |
| | 8 | 1000 | 368 |
| | 14 | 500 | 369 |
| | 16 | 100 | 370 |
| | 18 | 60 | 371 |
| | 24 | 5 | 372 |
| **Date:** 31/05/2011 | 1 | 1912 | 373,374 |
| **Station:** O | 3 | 1600 | 375 |
| | 5 | 1400 | 376 |
| | 6 | 1200 | 377 |
| | 8 | 1000 | 378 |
| | 9 | 810 | 379 |
| | 11 | 500 | 380 |
| | 14 | 200 | 381 |
| | 18 | 60 | 382 |
| | 23 | 5 | 383 |
| **Date:** 31/05/2011 | 1 | 1410 | 384,385 |
| **Station:** P | 3 | 1200 | 386 |
| | 5 | 1000 | 387 |
| | 7 | 800 | 388 |
| | 9 | 500 | 389 |
| | 11 | 200 | 390 |
| | 17 | 60 | 391 |
| | 23 | 5 | 392 |
| **Date:** 31/05/2011 | 2 | 113 | 393 |
| **Station:** S | 4 | 75 | 394 |
| | 6 | 25 | 395 |
| | 8 | 15 | 396 |

**APPENDIX III: Phytoplankton community structure**

**Table 1**

| | | | | | | | SAMPLES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CTD CAST | DATE | CTD OUT TIME (GMT) | LONGITUDE | LATITUDE | NUMBER OF DEPTHS SAMPLED | HPLC | SEM | LIGHT MICROSCOPE | FLOW CYTOMETRY | FRRF | TOTAL SAMPLES COLLECTED |
| 1G | 1 | 20/05/2011 | 02:11 | 06°08.59 | 56°39.99 | 5 | 5 | 5 | 5 | 5 | 0 | 20 |
| 2G | 2 | 20/05/2011 | 03:33 | 06°19.92 | 56°41.22 | 1 | 1 | 1 | 1 | 1 | 0 | 4 |
| 3G | 3 | 20/05/2011 | 04:04 | 06°21.89 | 56°43.15 | 3 | 3 | 3 | 3 | 3 | 0 | 12 |
| 4G | 4 | 20/05/2011 | 04:56 | 06°28.86 | 56°43.96 | 1 | 1 | 1 | 1 | 1 | 0 | 4 |
| 5G | 5 | 20/05/2011 | 06:00 | 06°35.74 | 56°44.06 | 5 | 5 | 5 | 5 | 5 | 0 | 20 |
| 6G | 6 | 20/05/2011 | 07:10 | 06°44.78 | 56°44.03 | 1 | 1 | 1 | 1 | 1 | 0 | 4 |
| 7G | 7 | 20/05/2011 | 08:45 | 06°59.85 | 56°44.02 | 6 | 6 | 4 | 6 | 6 | 0 | 22 |
| 8G | 8 | 20/05/2011 | 10:12 | 07°10.03 | 56°44.01 | 1 | 1 | 1 | 1 | 1 | 0 | 4 |
| 9G | 9 | 20/05/2011 | 13:00 | 07°20.02 | 56°44.13 | 8 | 8 | 5 | 6 | 6 | 0 | 25 |
| 10G | 10 | 20/05/2011 | 14:12 | 07°30.00 | 56°43.88 | 8 | 8 | 4 | 5 | 8 | 0 | 25 |
| IB20S | 11 | 23/05/2011 | 22:55 | 19°33.08 | 62°54.92 | 10 | 10 | 4 | 5 | 10 | 10 | 39 |
| IB21S | 12 | 24/05/2011 | 18:46 | 19°54.90 | 63°08.22 | 9 | 9 | 3 | 5 | 9 | 9 | 35 |
| IB22S | 13 | 24/05/2011 | 20:35 | 20°04.55 | 63°12.67 | 9 | 9 | 4 | 5 | 9 | 5 | 32 |
| IB23S | 14 | 24/05/2011 | 22:40 | 20°13.10 | 63°19.32 | 7 | 7 | 3 | 7 | 7 | 7 | 31 |
| IB19S | 15 | 25/05/2011 | 03:11 | 19°40.10 | 62°40.12 | 11 | 11 | 4 | 6 | 11 | 6 | 38 |
| IB18 | 16 | 25/05/2011 | 07:30 | 19°50.86 | 62°19.85 | 9 | 9 | 5 | 5 | 5 | 5 | 29 |
| IB17 | 17 | 25/05/2011 | 11:30 | 19°59.90 | 61°59.90 | 10 | 10 | 6 | 6 | 6 | 6 | 34 |
| 1B16A | 18 | 25/05/2011 | 16:00 | 20°01.12 | 61°44.56 | 9 | 9 | 4 | 5 | 5 | 5 | 28 |
| 1B16 | 19 | 25/05/2011 | 18:58 | 19°59.89 | 61°29.90 | 9 | 9 | 6 | 6 | 6 | 6 | 33 |
| IB15 | 20 | 25/05/2011 | 22:15 | 19°59.95 | 61°14.96 | 9 | 9 | 6 | 6 | 7 | 6 | 34 |

| STATION | CTD CAST | DATE | CTD OUT TIME (GMT) | LONGITUDE | LATITUDE | NUMBER OF DEPTHS SAMPLED | SAMPLES | | | | | TOTAL SAMPLES COLLECTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | HPLC | SEM | LIGHT MICROSCOPE | FLOW CYTOMETRY | FRRF | |
| IB14 | 21 | 26/05/2011 | 02:06 | 20°00.05 | 61°00.20 | 8 | 8 | 5 | 5 | 6 | 5 | 29 |
| IB13A | 22 | 26/05/2011 | 06:04 | 19°59.94 | 60°45.00 | 11 | 11 | 8 | 8 | 9 | 8 | 44 |
| 1B13 | 23 | 26/05/2011 | 10:38 | 19°59.10 | 60°30.10 | 11 | 11 | 7 | 7 | 8 | 8 | 41 |
| 1B12 | 24 | 26/05/2011 | 15:00 | 19°59.90 | 60°15.18 | 9 | 9 | 4 | 6 | 6 | 6 | 31 |
| 60N20W | 25 | 26/05/2011 | 19:00 | 19.58.90 | 59°59.62 | 9 | 9 | 4 | 6 | 6 | 6 | 31 |
| IB11A | 26 | 26/05/2011 | 23:15 | 19°33.68 | 59°49.93 | 9 | 9 | 4 | 6 | 6 | 6 | 31 |
| IB11 | 27 | 27/05/2011 | 03:03 | 19°06.44 | 59°39.95 | 10 | 10 | 4 | 7 | 8 | 7 | 36 |
| IB10 | 28 | 27/05/2011 | 08:21 | 18°24.99 | 59°24.07 | 10 | 10 | 5 | 5 | 7 | 7 | 34 |
| IB9 | 29 | 27/05/2011 | 12:30 | 18°13.59 | 59°19.99 | 10 | 10 | 5 | 6 | 7 | 7 | 35 |
| IB8 | 30 | 28/05/2011 | 20:25 | 17°53.00 | 59°11.97 | 8 | 8 | 3 | 4 | 5 | 5 | 25 |
| IB7 | 31 | 28/05/2011 | 22:45 | 17°40.04 | 59°06.96 | 9 | 9 | 4 | 6 | 6 | 6 | 31 |
| IB5 | 32 | 29/05/2011 | 02:06 | 17°00.01 | 58°53.01 | 9 | 9 | 4 | 6 | 6 | 6 | 31 |
| IB4A | 33 | 29/05/2011 | 06:25 | 16°28.96 | 58°42.12 | 7 | 7 | 4 | 4 | 4 | 4 | 23 |
| IB4 | 34 | 29/05/2011 | 09:30 | 15°59.93 | 58°29.93 | 9 | 9 | 5 | 5 | 9 | 5 | 33 |
| IB3 | 35 | 29/05/2011 | 13:00 | 15°19.92 | 58°14.90 | 9 | 9 | 5 | 5 | 7 | 6 | 32 |
| IB2 | 36 | 29/05/2011 | 17:00 | 14°34.99 | 57°56.88 | 7 | 7 | 4 | 5 | 5 | 5 | 26 |
| A ROCKALL | 37 | 29/05/2011 | 21:20 | 13°37.9 | 57°34.92 | 5 | 5 | 3 | 4 | 4 | 4 | 20 |
| B | 38 | 29/05/2011 | 22:55 | 13°20.07 | 57°33.95 | 5 | 5 | 3 | 4 | 4 | 4 | 20 |
| C | 39 | 29/05/2011 | 00:34 | 13°00.04 | 57°32.99 | 5 | 5 | 3 | 4 | 4 | 4 | 20 |
| D | 40 | 30/05/2011 | 02:10 | 12°52.15 | 57°32.07 | 8 | 8 | 4 | 6 | 6 | 6 | 30 |
| E | 41 | 30/05/2011 | 04:30 | 12°38.39 | 57°31.82 | 9 | 9 | 5 | 6 | 7 | 7 | 34 |
| F | 42 | 30/05/2011 | 07:30 | 12°14.87 | 57°30.51 | 10 | 10 | 5 | 6 | 9 | 10 | 40 |

| | | | | | | | SAMPLES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CTD CAST | DATE | CTD OUT TIME (GMT) | LONGITUDE | LATITUDE | NUMBER OF DEPTHS SAMPLED | HPLC | SEM | LIGHT MICROSCOPE | FLOW CYTOMETRY | FRRF | TOTAL SAMPLES COLLECTED |
| G | 43 | 30/05/2011 | 12:05 | 11°57.06 | 57°29.5 | 9 | 9 | 5 | 5 | 9 | 9 | 37 |
| H | 44 | 30/05/2011 | 14:00 | 11°32.20 | 57°29.10 | 10 | 10 | 6 | 6 | 7 | 7 | 36 |
| I | 45 | 30/05/2011 | 17:20 | 11°18.74 | 57°28.07 | 8 | 8 | 4 | 5 | 6 | 6 | 29 |
| J | 46 | 30/05/2011 | 19:00 | 11°04.67 | 57°26.90 | 5 | 5 | 3 | 3 | 4 | 4 | 19 |
| K | 47 | 30/05/2011 | 21:00 | 10°52.29 | 57°23.86 | 6 | 6 | 3 | 4 | 6 | 5 | 24 |
| L | 48 | 30/05/2011 | 23:30 | 10°40.56 | 57°21.47 | 7 | 7 | 4 | 5 | 6 | 6 | 28 |
| M | 49 | 31/05/2011 | 02:09 | 10°23.18 | 57°17.58 | 8 | 8 | 4 | 6 | 7 | 7 | 32 |
| N | 50 | 31/05/2011 | 05:35 | 10°02.61 | 57°14.23 | 8 | 8 | 4 | 6 | 7 | 7 | 32 |
| O | 51 | 31/05/2011 | 11:00 | 09°42.18 | 57°09.16 | 8 | 8 | 4 | 5 | 6 | 6 | 29 |
| P | 52 | 31/05/2011 | 13:30 | 09°25.10 | 57°05.99 | 9 | 9 | 4 | 4 | 9 | 7 | 33 |
| Q | 53 | 31/05/2011 | 15:00 | 09°12.85 | 57°03.71 | 6 | 6 | 4 | 4 | 5 | 5 | 24 |
| R | 54 | 31/05/2011 | 16:13 | 08°59.60 | 57°00.02 | 5 | 5 | 3 | 4 | 5 | 5 | 22 |
| S | 55 | 31/05/2011 | 17:55 | 08°46.81 | 56°57.63 | 3 | 3 | 2 | 2 | 3 | 3 | 13 |
| | | | | | | | | | | | | |
| | | | | | | total | 410 | 223 | 270 | 331 | 274 | |
| | | | | | | | | | | grand | total | 1508 |

## APPENDIX III: Phytoplankton community structure

**Table 2**

| STATION | DATE | TIME (GMT) | LON | LAT |
|---|---|---|---|---|
| NON TOX 1 | 20/05/2011 | 02:55 | 06.16.49 | 56.40.997 |
| NON TOX 2 | 20/05/2011 | 04:48 | 06.26.488 | 56.43.947 |
| NON TOX 3 | 20/05/2011 | 06:57 | 06.43.731 | 56.44.020 |
| NON TOX 4 | 21/05/2011 | 09:10 | 07.24.8 | 56.52.2 |
| NON TOX 5 | 21/05/2011 | 13:00 | 07.04.5 | 57.08.9 |
| NON TOX 6 | 21/05/2011 | 16:00 | 06.35.78 | 57.39.38 |
| NON TOX 7 | 21/05/2011 | 19:00 | 06.06.48 | 58.07.06 |
| NON TOX 8 | 21/05/2011 | 22:00 | 06.21.92 | 58.35.61 |
| NON TOX 9 | 22/05/2011 | 00:00 | 06.54.07 | 58.47.01 |
| NON TOX 10 | 22/05/2011 | 02:00 | 07.27.9 | 58.59.17 |
| NON TOX 11 | 22/05/2011 | 04:00 | 08.02.35 | 59.11.39 |
| NON TOX 12 | 22/05/2011 | 06:00 | 08.35.00 | 59.23.60 |
| NON TOX 13 | 22/05/2011 | 08:00 | 09.07.1 | 59.35.2 |
| NON TOX 14 | 22/05/2011 | 10:00 | 09.32.7 | 59.44.3 |
| NON TOX 15 | 22/05/2011 | 12:00 | 09.57.4 | 59.53.1 |
| NON TOX 16 | 22/05/2011 | 14:00 | 10.22.7 | 60.02.10 |
| NON TOX 17 | 22/05/2011 | 16:00 | 10.49.7 | 60.11.5 |
| NON TOX 18 | 22/05/2011 | 18:00 | 11.21.39 | 60.22.55 |
| NON TOX 19 | 22/05/2011 | 20:00 | 11.54.87 | 60.34.21 |
| NON TOX 20 | 22/05/2011 | 22:00 | 12.30.25 | 60.46.44 |
| NON TOX 21 | 23/05/2011 | 00:00 | 13.07.44 | 60.59.14 |
| NON TOX 22 | 23/05/2011 | 02:00 | 13.44.57 | 61.11.82 |
| NON TOX 23 | 23/05/2011 | 04:00 | 14.21.42 | 61.24.32 |
| NON TOX 24 | 23/05/2011 | 06:00 | 14.55.66 | 61.35.81 |
| NON TOX 25 | 23/05/2011 | 08:00 | 15.30.4 | 61.47.5 |
| NON TOX 26 | 23/05/2011 | 10:00 | 16.06.0 | 61.59.3 |
| NON TOX 27 | 23/05/2011 | 12:00 | 16.43.5 | 62.11.7 |
| NON TOX 28 | 23/05/2011 | 14:00 | 17.04.7 | 62.25.5 |
| NON TOX 29 | 23/05/2011 | 16:00 | 17.54.4 | 62.30.9 |
| NON TOX 30 | 23/05/2011 | 18:00 | 18.25.78 | 62.35.75 |
| NON TOX 31 | 23/05/2011 | 20:00 | 19.00.98 | 62.45.16 |

## APPENDIX IV: Cruise D365 Event Log

### Cruise D365 Event Log

| Event No. | JDay | Date | Station | Latitude | Longitude | Depth (m) | Time IN (GMT) | Time BOTTOM (GMT) | Time OUT (GMT) | Activity | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 001 | 135 | 15/5/11 | TEST | 55°00.00'N | 006°33.00'W | 135 | 17:09 | 17:19 | 17:36 | CTD | TEST DIP |
| 002 | 140 | 20/5/11 | 1G | 56°39.97'N | 006°08.39'W | 198 | 01:35 | - | 01:50 | PES Deployment | |
| 003 | 140 | 20/5/11 | 1G | 56°39.97'N | 006°08.57'W | 181 | 01:57 | 02:06 | 02:20 | CTD001 | |
| 004 | 140 | 20/5/11 | 2G | 56°41.27'N | 006°16.95'W | 34.5 | 03:17 | 03:23 | 03:33 | CTD002 | |
| 005 | 140 | 20/5/11 | 3G | 56°43.21'N | 006°21.93'W | 41 | 04:04 | 04:09 | 04:18 | CTD003 | |
| 006 | 140 | 20/5/11 | 4G | 56°43.99'N | 006°26.86'W | 67 | 04:56 | 05:02 | 05:17 | CTD004 | |
| 007 | 140 | 20/5/11 | 5G | 56°44.10'N | 006°35.72'W | 67 | 06:00 | 06:06 | 06:21 | CTD005 | |
| 008 | 140 | 20/5/11 | 6G | 56°44.07'N | 006°44.77'W | 34 | 07:10 | 07:15 | 07:25 | CTD006 | |
| 009 | 140 | 20/5/11 | 7G | 56°44.02'N | 006°59.85'W | 135 | 08:42 | 08:55 | 09:18 | CTD007 | |
| 010 | 140 | 20/5/11 | 8G | 56°44.01'N | 007°10.03'W | 120 | 10:12 | 10:20 | 10:31 | CTD008 | |
| 011 | 140 | 20/5/11 | 9G | 56°44.11'N | 007°19.99'W | 152 | 12:22 | 12:30 | 12:50 | CTD009 | PAR & irradiance sensors washed |
| 012 | 140 | 20/5/11 | 10G | 56°43.74'N | 007°30.13'W | 217 | 14:12 | 14:26 | 14:52 | CTD010 | |
| 013 | 143 | 23/5/11 | IB20 | 62°54.46'N | 019°33.13'W | 1409 | 22:16 | 22:53 | 23:50 | CTD011 | |
| 014 | 144 | 24/5/11 | IB21 | 63°08.22'N | 019°54.91'W | 1033 | 18:14 | 18:40 | 19:28 | CTD012 | |
| 015 | 144 | 24/5/11 | IB22 | 63°12.65'N | 020°04.54'W | 702 | 20:30 | 20:57 | 21:29 | CTD013 | |
| 016 | 144 | 24/5/11 | IB23 | 63°19.31'N | 020°13.09'W | 124 | 22:34 | 22:42 | 23:00 | CTD014 | |
| 017 | 145 | 25/5/11 | IB19 | 62°40.12'N | 019°40.44'W | 1689 | 03:10 | 03:57 | 05:04 | CTD015 | |
| 018 | 145 | 25/5/11 | IB18 | 62°19.32'N | 019°50.89'W | 1811 | 07:15 | 07:52 | 08:58 | CTD016 | |
| 019 | 145 | 25/5/11 | IB17 | 61°59.91'N | 019°59.96'W | 1781 | 11:02 | 11:53 | 13:03 | CTD017 | |
| 020 | 145 | 25/5/11 | IB16a | 61°44.65'N | 020°00.86'W | 1800 | 14:51 | 15:28 | 16:39 | CTD018 | |
| 021 | 145 | 25/5/11 | IB16 | 61°29.95'N | 019°59.34'W | 2225 | 18:15 | 19:00 | 20:11 | CTD019 | |
| 022 | 145 | 25/5/11 | IB15 | 61°14.93'N | 020°00.00'W | 2382 | 21:43 | 22:35 | 23:52 | CTD020 | |
| 023 | 146 | 26/5/11 | IB14 | 61°00.21'N | 020°00.16'W | 2407 | 01:35 | 02:30 | 03:52 | CTD021 | |
| 024 | 146 | 26/5/11 | IB14 | 60°59.41'N | 020°00.68'W | 2406 | 04:15 | - | - | Argo float deployment | s/n 5540 |
| 025 | 146 | 26/5/11 | IB13a | 60°45.04'N | 019°59.94'W | 2373 | 05:53 | 06:40 | 08:00 | CTD022 | Ash samples collected from bridge roof (+20m) |
| 026 | 146 | 26/5/11 | IB13 | 60°30.10'N | 019°59.10'W | 2520 | 09:42 | 10:38 | 11:58 | CTD023 | |
| 027 | 146 | 26/5/11 | IB13 | 60°29.35'N | 019°59.30'W | 2538 | 12:15 | - | - | Argo float deployment | s/n 5541 |
| 028 | 146 | 26/5/11 | IB12 | 60°15.16'N | 019°59.90'W | 2639 | 13:55 | 14:47 | 16:01 | CTD024 | |
| 029 | 146 | 26/5/11 | 60N20W (IB12a) | 59°59.98'N | 019°59.81'W | 2727 | 17:56 | 18:56 | 20:14 | CTD025 | |

| Event No. | JDay | Date | Station | Latitude | Longitude | Depth (m) | Time IN (GMT) | Time BOTTOM (GMT) | Time OUT (GMT) | Activity | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 030 | 146 | 26/5/11 | 60N20W (IB12a) | 59°58.50'N | 019°57.80'W | 2715 | 21:22 | - | - | Argo float deployment | s/n 5537 |
| 031 | 146 | 26/5/11 | IB11a | 59°49.90'N | 019°33.58'W | 2702 | 22:30 | 23:39 | 00:56 | CTD026 | |
| 032 | 147 | 27/5/11 | IB11 | 59°39.58'N | 019°05.99'W | 2679 | 02:48 | 03:42 | 05:21 | CTD027 | |
| 033 | 147 | 27/5/11 | IB11 | 59°38.71'N | 019°07.01'W | 2680 | 05:30 | - | - | Argo float deployment | s/n 5353 |
| 034 | 147 | 27/5/11 | IB10 | 59°24.07'N | 018°24.74'W | 2408 | 08:21 | 09:28 | 10:43 | CTD028 | |
| 035 | 147 | 27/5/11 | IB09 | 59°19.99'N | 018°13.59'W | 1840 | 11:54 | 12:36 | 13:35 | CTD029 | TSG sensors cleaned 19:50-20:37 on Jday 147 |
| 036 | 148 | 28/5/11 | IB08 | 59°17.97'N | 017°53.00'W | 1530 | 19:40 | 20:18 | 21:08 | CTD030 | |
| 037 | 148 | 28/5/11 | IB07 | 59°06.95'N | 017°40.32'W | 995 | 22:15 | 22:42 | 23:24 | CTD031 | |
| 038 | 149 | 29/5/11 | IB05 | 58°52.98'N | 017°00.18'W | 1155 | 02:06 | 02:36 | 03:35 | CTD032 | |
| 039 | 149 | 29/5/11 | IB4a | 58°42.05'N | 016°29.29'W | 1190 | 05:38 | 06:04 | 06:57 | CTD033 | |
| 040 | 149 | 29/5/11 | IB4 | 58°29.93'N | 015°59.93'W | 1184 | 08:59 | 09:35 | 10:21 | CTD034 | |
| 041 | 149 | 29/5/11 | IB3 | 58°15.13'N | 015°19.75'W | 655 | 12:48 | 13:07 | 13:42 | CTD035 | |
| 042 | 149 | 29/5/11 | IB2 | 57°56.89'N | 014°34.93'W | 443 | 16:36 | 16:55 | 17:27 | CTD036 | |
| 043 | 149 | 29/5/11 | A | 57°34.92'N | 013°37.93'W | 107 | 21:10 | 21:17 | 21:28 | CTD037 | |
| 044 | 149 | 29/5/11 | B | 57°33.95'N | 013°20.06'W | 176 | 22:43 | 22:53 | 23:09 | CTD038 | |
| 045 | 150 | 30/5/11 | C | 57°32.91'N | 012°59.97'W | 292 | 00:34 | 00:46 | 01:07 | CTD039 | |
| 046 | 150 | 30/5/11 | D | 57°32.06'N | 012°52.16'W | 1087 | 01:50 | 02:14 | 03:02 | CTD040 | |
| 047 | 150 | 30/5/11 | E | 57°31.71'N | 012°38.44'W | 1640 | 04:06 | 04:44 | 05:58 | CTD041 | |
| 048 | 150 | 30/5/11 | F | 57°30.51'N | 012°14.87'W | 1808 | 07:27 | 08:11 | 09:20 | CTD042 | |
| 049 | 150 | 30/5/11 | G | 57°29.51'N | 011°50.98'W | 1788 | 10:35 | 11:32 | 12:34 | CTD043 | |
| 050 | 150 | 30/5/11 | H | 57°29.602'N | 011°32.727'W | 2007 | 13:53 | 14:43 | 15:48 | CTD044 | |
| 051 | 150 | 30/5/11 | I | 57°28.08'N | 011°18.72'W | 745 | 16:51 | 17:13 | 17:43 | CTD045 | |
| 052 | 150 | 30/5/11 | J | 57°27.02'N | 011°04.67'W | 587 | 18:39 | 19:00 | 19:28 | CTD046 | |
| 053 | 150 | 30/5/11 | K | 57°23.97'N | 010°52.22'W | 777 | 20:29 | 20:56 | 21:30 | CTD047 | |
| 054 | 150 | 30/5/11 | L | 57°21.45'N | 010°40.58'W | 2100 | 22:34 | 23:24 | 00:33 | CTD048 | |
| 055 | 151 | 31/5/11 | M | 57°17.29'N | 010°23.15'W | 2225 | 01:46 | 02:35 | 03:50 | CTD049 | |
| 056 | 151 | 31/5/11 | N | 57°14.40'N | 010°02.52'W | 2106 | 05:07 | 05:52 | 07:07 | CTD050 | |
| 057 | 151 | 31/5/11 | O | 57°09.16'N | 009°12.21'W | 1930 | 08:36 | 09:26 | 10:25 | CTD051 | |
| 058 | 151 | 31/5/11 | P | 57°06.02'N | 009°25.10'W | 1420 | 14:08 | 14:20 | 14:41 | CTD052 | |
| 059 | 151 | 31/5/11 | Q | 57°03.15'N | 009°12.99'W | 305 | 14:20 | 14:32 | 14:55 | CTD053 | |
| 060 | 151 | 31/5/11 | R | 57°00.13'N | 008°59.38'W | 133 | 16:03 | 16:13 | 16:30 | CTD054 | |
| 061 | 151 | 31/5/11 | S | 56°57.03'N | 008°46.84'W | 125 | 17:48 | 17:55 | 18:07 | CTD055 | Master requested minimal sampling due to adverse weather |
| 062 | 152 | 01/6/11 | - | °.'N | °.'W | 120 | - | - | 14:30 | PES Recovered | |

**APPENDIX V: Cruise D365 Underway Log**

## DIC

| Date | Time | Lat | Lon | Comments |
|---|---|---|---|---|
| 20/05/2011 | 03:33 | 56 41.27 | 6 16.95 | Surface bot. sample from CTD002 |
| 20/05/2011 | 05:02 | 56 43.99 | 6 26.86 | Surface bot. sample from CTD004 |
| 20/05/2011 | 07:21 | 56 44 | 6 44.77 | Surface bot. sample from CTD006 |
| 20/05/2011 | 10:30 | 56 44.01 | 7 10.25 | Surface bot. sample from CTD008 |
| 21/05/2011 | 13:06 | 57 10.05 | 7 03.49 | |
| 21/05/2011 | 16:00 | 57 39.50 | 6 35.04 | |
| 21/05/2011 | 19:00 | 58 7.29 | 6 63.25 | |
| 21/05/2011 | 22:00 | 58 35.66 | 6 22.16 | |
| 21/05/2011 | 00:00 | 58 47.24 | 6 54.71 | |
| 22/05/2011 | 03:30 | 59 08.61 | 7 54.16 | |
| 22/05/2011 | 07:10 | 59 30.74 | 8 54.81 | |
| 22/05/2011 | 08:00 | 59 35.60 | 9 08.36 | |
| 22/05/2011 | 10:00 | 59 44.60 | 9 33.75 | |
| 22/05/2011 | 12:00 | 59 52.94 | 9 57.19 | |
| 22/05/2011 | 14:00 | 60 01.55 | 10 21.54 | |
| 22/05/2011 | 16:00 | 60 11.41 | 10 49.59 | |
| 22/05/2011 | 18:00 | 60 22.69 | 11 21.88 | |
| 22/05/2011 | 20:00 | 60 34.28 | 11 55.14 | |
| 22/05/2011 | 22:00 | 60 46.57 | 12 30.77 | |
| 23/05/2011 | 00:00 | 60 59.10 | 13 07.31 | |
| 23/05/2011 | 02:00 | 61 12.09 | 13 45.40 | |
| 23/05/2011 | 04:00 | 61 24.51 | 14 22.02 | |
| 23/05/2011 | 06:00 | 61 35.85 | 14 55.77 | |
| 23/05/2011 | 08:00 | 61 47.74 | 15 31.34 | |
| 23/05/2011 | 10:00 | 61 59.82 | 6 07.63 | |
| 23/05/2011 | 12:00 | 62 11.59 | 16 43.26 | |
| 23/05/2011 | 14:00 | 62 25.37 | 17 08.99 | |
| 23/05/2011 | 16:00 | 62 30.92 | 17 50.48 | |
| 23/05/2011 | 18:00 | 62 38.85 | 18 26.25 | |

## Pigments & Taxonomy/Nutrients

| Date | Time | Lat | Lon | Comments |
|---|---|---|---|---|
| 20/05/2011 | 02:55 | 56.40.997 | 06.16.49 | No nutrients |
| 20/05/2011 | 04:48 | 56.43.947 | 06.26.488 | No nutrients |
| 20/05/2011 | 06:57 | 56.44.020 | 06.43.731 | No nutrients |
| 21/05/2011 | 09:10 | 56.52.2 | 07.24.8 | No nutrients |
| 21/05/2011 | 13:00 | 57.08.9 | 07.04.5 | No nutrients |
| 21/05/2011 | 16:00 | 57.39.38 | 06.35.78 | No nutrients |
| 21/05/2011 | 19:00 | 58.07.06 | 06.06.48 | No nutrients |
| 21/05/2011 | 22:00 | 58.35.61 | 06.21.92 | |
| 22/05/2011 | 00:00 | 58.47.01 | 06.54.07 | |
| 22/05/2011 | 02:00 | 58.59.17 | 07.27.9 | |
| 22/05/2011 | 04:00 | 59.11.39 | 08.02.35 | |
| 22/05/2011 | 06:00 | 59.23.60 | 08.35.00 | |
| 22/05/2011 | 08:00 | 59.35.2 | 09.07.1 | |
| 22/05/2011 | 10:00 | 59.44.3 | 09.32.7 | |
| 22/05/2011 | 12:00 | 59.53.1 | 09.57.4 | |
| 22/05/2011 | 14:00 | 60.02.10 | 10.22.7 | |
| 22/05/2011 | 16:00 | 60.11.5 | 10.49.7 | |
| 22/05/2011 | 18:00 | 60.22.55 | 11.21.39 | |
| 22/05/2011 | 20:00 | 60.34.21 | 11.54.87 | |
| 22/05/2011 | 22:00 | 60.46.44 | 12.30.25 | |
| 23/05/2011 | 00:00 | 60.59.14 | 13.07.44 | |
| 23/05/2011 | 02:00 | 61.11.82 | 13.44.57 | |
| 23/05/2011 | 04:00 | 61.24.32 | 14.21.42 | |
| 23/05/2011 | 06:00 | 61.35.81 | 14.55.66 | |
| 23/05/2011 | 08:00 | 61.47.5 | 15.30.4 | |
| 23/05/2011 | 10:00 | 61.59.3 | 16.06.0 | |
| 23/05/2011 | 12:00 | 62.11.7 | 16.43.5 | |
| 23/05/2011 | 14:00 | 62.25.5 | 17.04.7 | |
| 23/05/2011 | 16:00 | 62.30.9 | 17.54.4 | |

## DIC

| Date | Time | Lat | Lon | Comments |
|---|---|---|---|---|
| 23/05/2011 | 20:00 | 62 45.12 | 19 00.92 | |
| 23/05/2011 | 22:00 | 62 54.96 | 19 33.08 | |
| 23/05/2011 | 23:35 | 62 55.11 | 19 33.60 | |
| 24/05/2011 | 01:34 | 62 02.58 | 19 46.16 | |

## Pigments & Taxonomy/Nutrients

| Date | Time | Lat | Lon | Comments |
|---|---|---|---|---|
| 23/05/2011 | 18:00 | 62.35.75 | 18.25.78 | |
| 23/05/2011 | 20:00 | 62.45.16 | 19.00.98 | |

N.B. Samples for DIC and pigments were taken from separate non-tox outlets. The lat/lons occasionally do not match as the timings were only accurate to the nearest minute.

## Salinity

| Day | Time | Sample bottle no. |
|---|---|---|
| 140 | 00 : 56 : 20 | 901/1 |
| 140 | 04 : 36 : 45 | 901/2 |
| 140 | 10 : 05 : 00 | 901/3 |
| 140 | 13 : 09 : 05 | 901/4 |
| 140 | 16 : 32 : 42 | 901/5 |
| 140 | 20 : 39 : 00 | 901/6 |
| 141 | 00 : 40 : 40 | 901/7 |
| 141 | 04 : 30 : 36 | 901/8 |
| 141 | 10 : 55 : 00 | 901/9 |
| 141 | 12 : 35 : 09 | 901/10 |
| 141 | 16 : 27 : 56 | 901/11 |
| 141 | 22 : 15 : 00 | 901/12 |
| 142 | 00 : 48 : 38 | 901/13 |
| 142 | 04 : 44 : 10 | 901/14 |
| 142 | 10 : 15 : 00 | 901/15 |
| 142 | 12 : 39 : 59 | 901/16 |
| 142 | 16 : 34 : 31 | 901/17 |
| 142 | 22 : 10 : 00 | 901/18 |
| 143 | 00 : 28 : 59 | 901/19 |
| 143 | 04 : 22 : 48 | 901/20 |

| Day | Time | Sample bottle no. |
|---|---|---|
| 143 | 09 : 00 : 00 | 901/21 |
| 143 | 12 : 36 : 28 | 901/22 |
| 143 | 16 : 33 : 47 | 901/23 |
| 143 | 22 : 10 : 00 | 901/24 |
| 144 | 00 : 38 : 23 | Green/97 |
| 144 | 04 : 40 : 01 | Green/98 |
| 144 | 09 : 17 : 01 | Green/99 |
| 144 | 12 : 22 : 09 | Green/100 |
| 144 | 16 : 28 : 54 | Green/101 |
| 144 | 22 : 05 : 01 | Green/102 |
| 145 | 00 : 34 : 20 | Green/103 |
| 145 | 05 : 32 : 27 | Green/104 |
| 145 | 21 : 38 : 10 | Green/105 |
| 145 | 12 : 31 : 27 | Green/106 |
| 145 | 17 : 20 : 22 | Green/107 |
| 145 | 20 : 52 : 10 | Green/108 |
| 146 | 00 : 41 : 52 | Green/109 |
| 146 | 04 : 26 : 05 | Green/110 |
| 146 | 10 : 57 : 30 | Green/111 |
| 146 | 12 : 38 : 33 | Green/112 |

| Day | Time | Sample bottle no. |
|---|---|---|
| 146 | 17 : 20 : 13 | Green/113 |
| 146 | 20 : 48 : 30 | Green/114 |
| 147 | 00 : 29 : 11 | Green/115 |
| 147 | 06 : 13 : 53 | Green/116 |
| 147 | 09 : 42 : 50 | Green/117 |
| 147 | 12 : 47 : 28 | Green/118 |
| 147 | 16 : 53 : 45 | Green/119 |
| 147 | 20 : 46 : 50 | Green/120 |
| 148 | 00 : 52 : 13 | Green/121 |
| 148 | 04 : 39 : 22 | Green/122 |
| 148 | 09 : 17 : 30 | Green/123 |
| 148 | 12 : 30 : 37 | Green/124 |
| 148 | 17 : 01 : 17 | Green/125 |
| 148 | 21 : 32 : 55 | Green/126 |
| 149 | 00 : 53 : 22 | Green/127 |
| 149 | 04 : 48 : 08 | Green/128 |
| 149 | 11 : 11 : 50 | Green/129 |
| 149 | 12 : 35 : 28 | Green/130 |
| 149 | 18 : 53 : 02 | Green/131 |
| 149 | 21 : 40 : 30 | Green/132 |

| Day | Time | Sample bottle no. |
|---|---|---|
| 150 | 01 : 22 : 34 | Green/133 |
| 150 | 04 : 16 : 06 | Green/134 |
| 150 | 09 : 12 : 00 | Green/135 |
| 150 | 12 : 26 : 53 | Green/136 |
| 150 | 16 : 29 : 32 | Green/137 |
| 150 | 21 : 42 : 38 | Green/138 |
| 151 | 00 : 26 : 07 | Green/139 |
| 151 | 04 : 27 : 54 | Green/140 |
| 151 | 10 : 48 : 52 | Green/141 |
| 151 | 14 : 08 : 26 | Green/142 |
| 151 | 19 : 06 : 59 | Green/143 |