National Oceanography Centre, Southampton

Cruise Report No. 50

RRS *Discovery* Cruise 351

10-28 MAY 2010

The Extended Ellett Line 2010

Principal Scientist

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2010

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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 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 2010 occupation, *RRS Discovery* Cruise 351, was completed successfully with 48 CTD stations worked between the Iceland and Scotland shelf edges. Additionally, Line G, part of the SAMS observation network of the Scottish continental shelf was completed. Samples were taken for inorganic nutrients, iron and trace metals, bioluminescence and microscope analysis. Incubation experiments were performed to investigate the role of microzooplankton grazing and the speciation of iron, and to investigate the presence of dinoflagellate bioluminescence.

In addition to the planned programme, sampling took place to investigate the extent of the fall out from the ash plume emitted by the Iceland volcano, Ejyafjallajokull, and its impact on the biogeochemistry and productivity of the upper ocean.

A trial tow of SeaSoar and a short survey of the upper ocean over the Anton Dohrn seamount were successfully completed.

KEYWORDS

cruise 351 2010, CTD observations, *Discovery*, Ellett Line, Iceland Basin, North Atlantic, Rockall Trough, SeaSoar observations

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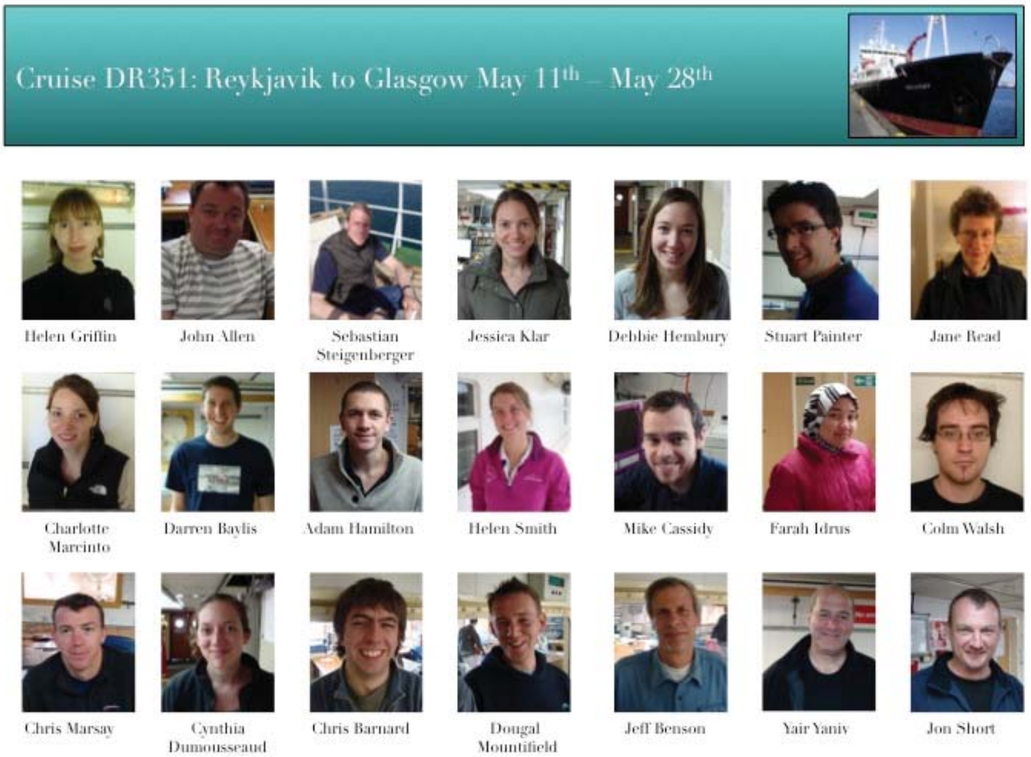
NOCS - National Oceanography Centre, Southampton
OBE – Ocean Biogeochemistry and Ecosystems
GG – Geology and Geophysics
NMFD – NERC Marine Facilities Division

The Scientific Crew



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1. INTRODUCTION

The Extended Ellett Line is a full depth hydrographic section that runs from the Scottish continental shelf across the Rockall Trough to Rockall, and to 60°N 20°W and Iceland.

The original 'Anton Dohrn' section (which became the 'Ellett Line'), from the shelf edge to Rockall, was first worked in 1975. Originally the section was worked at least 4 times a year whenever possible. However, as part of the World Ocean Circulation Experiment of the 1990's, the line was extended to Iceland in 1996, and from then the section was occupied roughly annually. This (2010) is the 35th anniversary of the line, and the 69th attempted occupation. Of the total attempts to occupy the line only 50 have been successful (Alcock & Richards), an indication of the severe weather that can be encountered in the area.

The data are used to calculate a time series of the characteristics of the upper ocean, and of the deep water. Over the duration of the time series, there has been a continual increase in both temperature and salinity of the top 800 m, although it should be noted that prior to 1975, temperature and salinity were also higher, and that the line began at a relatively cool, fresh period in the history of the region (Dooley et al, 1984; Holliday et al, 2009). The increase in temperature and salinity has been shown to result from a change in the circulation of the subpolar gyre (Hakkinen & Rhines, 2004; Hatun et al, 2005). The gyre has contracted and the inflow of warm water in the North Atlantic Current has reduced, allowing warm saline water from the inter-gyre region (Bay of Biscay area) to spread northwards.

The advection of warmer water can be traced through the Nordic Seas and into the Arctic (Holliday et al, 2008), where it has had a significant effect in contributing to the reduction of ice cover and general warming of the region. Changes to the west of the British Isles also impact on UK climate and weather (Ellett, 1993). Thus, it is important to continue to observe the area, both to document the changes that are occurring and to understand the dynamics and processes behind any change.

In contrast, the time series of deep, Labrador Sea Water, showed a noticeable decrease in temperature and salinity in the late 1980's and early 1990's. Prior to this the characteristics were roughly constant and since the 1990's there has been very little change, apart from year to year variability. This is believed to reflect the changes that have taken place in the source region (the Labrador Sea) where renewed convection in the early 1990's led to a marked change (cooling and freshening) in the properties of Labrador Sea Water (Yashayaev et al, 2007).

The Extended Ellett Line is also a platform for further research into the area. Recent work suggests that the high latitude North Atlantic might be seasonally iron limited for primary production. Measurements for iron and other trace metals were made on the 2009 Extended Ellett Line post-bloom. With the earlier timing of the 2010 occupation it was hoped that pre- to mid-bloom conditions might be encountered and sampled.

Following problems in 2009 and prior to the final NOCS Oceans 2025 Theme 2 experiment in the subtropical gyre in 2011, it was agreed to test the current configuration of SeaSoar. A tow across the Rockall Trough was proposed, to be followed by a survey of the Anton Dohrn seamount, depending on how much time was available at the end of the cruise and how well the equipment performed.

The Extended Ellett Line cruise provides an ideal platform for student training and research. Experiments for two PhD projects were carried out during the cruise, and samples were drawn for analysis at NOCS for another three student projects.

Following the eruption of the Eyjafjallajokull volcano on 20 March 2010 and the development of a large plume of ash over the North Atlantic on 14 April 2010, a last minute addition to the cruise was made, to sample the upper ocean for lead isotopes, to investigate the extent and impact of volcanic ash fall out on the chemistry of the sea water.

Cruise Objectives

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

2. To investigate the iron and trace metal distribution and variability in the Northeast Atlantic (NERC consortium grant)

3. To investigate the physical processes operating at the Anton Dohrn seamount and identify whether there are mechanisms promoting productivity through the enhancement of nutrient concentrations (Oceans 2025 Theme 2 WP2.5)

4. To investigate the presence of volcanic ash in the upper water column south of Iceland and investigate the impact on the chemistry of seawater, following the eruption of the Eyjafjallajokull volcano.

Student Research

1. To conduct experiments to determine the horizontal, vertical and diurnal distribution of bioluminescence in dinoflagellates.

2. To investigate the role of microzooplankton grazing on carbon ingestion and iron speciation

3. To draw samples for aluminium analysis, manganese analysis, dissolved organic carbon and alkalinity, for 3 separate student research projects.

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2. NARRATIVE

Cruise Narrative

Monday 10 May. Sailing at 1200 delayed. The party travelling from the UK (including PS) that was supposed to fly to Reykjavik on Sunday afternoon was diverted via Glasgow and Akureyri, arriving in Reykjavik at 0930 on Monday morning, about 12 hours late and without their luggage. The agent was tasked with locating the luggage while the scientists tried to work out whether or not we could sail without.

Tuesday 11 May. The missing luggage was finally recovered by the agent and delivered to the ship about 1400. One bag was still missing, and Yair Yaniv was taken shopping by the agent. Discovery moved to bunkers at 1600 to take on about 100 tonnes of fuel then set sail at 1900. A safety briefing for newcomers was held at 1630. A science meeting to discuss sampling was held at 1815. The weather forecast was for south westerlies overnight, F7 (30 knots). Steaming overnight to first station close by Vestmanjaer Islands

Wednesday 12 May. F7 overnight as we steamed around the southwest coast of Iceland, but westerlies so following winds, and on shelf there is little sea. However, there was one bad case of sea-sickness overnight and during the morning. Muster 0830 for fire and boat drill. Master’s daily briefing at 0855. On station 001 (IB23s) at 0900. The Vestmanjaer islands were clear to the west, although rather gloomy. The ash plume from the Eyjafjallajokull eruption was obscured.

Stainless steel CTD to 130 m went well, lots of samples taken for oxygen practise, salinities, nutrients, chlorophyll and SEM. PES and clean fish deployed before moving off station. Autoanalyser only running two channels following a failure on the previous cruise. Samples being frozen for phosphate analysis back at NOC.

Offers to continue east to explore the ash plume were not taken up, it seems that sufficient work was done on this during the last cruise. The objective now is to see how much effect the ash has had on a transect away from the volcano, along 20°W.

Second station (IB22s) about 1100 for titanium cast. On completion it was found that the cable needed re-terminating. Stayed hove-to initially, then moved to the next station while work underway. Load test fine. Started the third station (IB21s) with the stainless steel CTD about 1730. The ash plume was now clear to see to the east. Underway again about 1900, swell from the west so speed reduced to less than 9 knots. Cast 004 (IB20s) underway about 21:00, slow going because heavy drag on the package and full lowering rate not attained until over 900 m deep. This is going to make CTD casts take much longer than planned. CTD finished at about 23:15. At only 1400 m deep the CTD should have taken about 1.5 hours, but it actually took 2.25 hours. By the end of the first day of science we were about 5 hours behind schedule, mainly because of the re-termination.

Charlotte & Helen's first bioluminescence experiment failed with the glowtracka coming apart and needing gluing back together.

Figure 1. The ash plume from Eyjafjallajokull volcano, Iceland.

Thursday 13 May. F7, 30 knot winds, continuing, leaving us in a cross swell and having to make doglegs to prevent excessive rolling. Progress is very slow. Station 005 (IB19s) completed about 0330, station 006 (IB18s) was completed at 0900. There were a few uncomfortable rolls as we left station, then it took 4 hours to steam the 20 nm to the next station at 62°N. The vessel first headed southeast then southwest back to the line. Station 007 (IB17) was worked with the titanium CTD and completed by 1515, then followed by a 3 instrument SAPs deployment until 1845. The first drifter was deployed for the French Met Office immediately afterwards, at 1849 (SN 300034012548820). Reached next station in better time, arriving at 1900 and completing CTD 008 (IB16a) by 2300. There were some large tensions during deployment and recovery. Air pressure is rising and the wind has reduced slightly, but we remained hove-to while sampling.

The autoanalyser is not working properly, however, the glowtracka is now fine. Adam decided to set up a bioassay experiment

Friday 14 May. Although the wind dropped to about 20 knots late yesterday, it was up to 40 knots again over night. It is very cold as well, with air temperatures about 6°C. Station 009 (IB16) completed early morning and station 010 (IB15) underway at 0730. However, just after reaching the bottom the instruments started spiking very badly. On recovery, testing found a short circuit in the wire so a complete re-termination was required. The ship proceeded to the next station and hove-to to wait. The termination was completed and load tested late afternoon. However, by this time the bridge had decided that conditions were marginal and rather than risk equipment and personnel, further work over the side was delayed until conditions had improved. It was then discovered that the manufacturers had reversed the wiring in the "tail" used for the ctd termination, so re-termination had to be done again, but since we were hove-to, no time was lost to this.

At least the autoanalyser seemed to be working better although there were still problems with the software. The ship remained hove-to overnight.

Saturday 15 May. Conditions had eased enough by 5am to attempt a CTD station, but the wire came off a sheave and operations were suspended until the wire was secured. Eventually the stainless steel CTD was deployed at about 7am, but the pumps failed to turn on. After various checks the CTD was recovered and the titanium CTD rig deployed instead at 0900. Station 011 (IB14) was completed successfully at 1110 and followed by the deployment of an apex argo float (SN 3865) and a surface drifter (SN 300034012543300). Both were reported to the relevant authorities. The ship then continued to the next CTD station. No solution was found to the inoperable pumps on the stainless CTD so work continued with the titanium rig but with standard (non trace-metal) sampling using 12 bottles. At least the autoanalyser is now working and the backlog of samples cleared. The milliQ in the deck lab remains a problem. Fortunately there is a low volume back up in the trace metal container.

By afternoon the sea had eased considerably and CTD stations 012 (IB13a) and 013 (IB13) were completed without problems using the titanium rig. Six “ultra clean” bottles were replaced with “clean” bottles on station 014 (IB12a) to provide additional water for bioluminescence experiments. Note by this time we are about 36 hours behind schedule, about 12 hours from re-termination and equipment failures, the rest from weather problems.

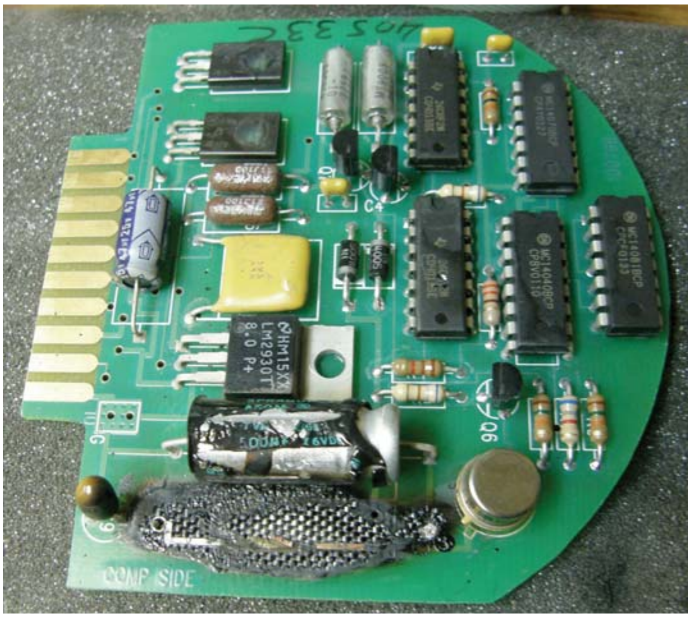


Figure 2. Damaged CTD board.

Sunday 16 May. Station 015 (IB12) was worked at 60°N 20°W with the titanium rig and sampled for trace metal analysis. Deployment of two SAPs instruments was delayed until the sampling of the titanium rig for standard measurements was completed. Immediately on recovery of the SAPS and as moving off station, the second APEX float was deployed (SN 3866) at 0830 followed by the third Met Office drifting buoy (SN 300034012347680) at 0838.

The problem with the stainless CTD was traced to an overheated capacitor on the pump switch electronic board that had melted the track and soldering. By station 016 (IB11a) the stainless CTD had been re-assembled and was ready for deployment. All went well until 700 m when the pumps stopped working again. The CTD was recovered and the titanium rig deployed instead. Station 016 was completed at 1450. At 1615, just before reaching station 017 the ship hove-to suddenly for emergency work in the engine room (tacho belt). Aargh!! Every time I go to the lab, there is another problem …

Figure 3. Met drifter.

Work began again soon after 2030, with the titanium CTD at IB11, station 017. Because this station was so delayed, it fell into the time period when Charlotte and Helen need to sample for bioluminescence. They require 5 bottles from the top 75m. This meant that there were only 7 bottles available for the rest of the 2700 m water column. The station was successfully completed about 2340 and followed by deployment of the third Apex float (SN 3863) at 2358.

We are now about 43 hours behind schedule, about 15 hours from equipment failures, 24 hours from bad weather, and 4 hours to fix the engine problem.

Monday 17 May. The stainless steel CTD was successfully deployed at station 018 (IB10), the problem seems to have been resolved as one of the lanyards was hitting the pump connectors when the bottle was fired. Bottle 9 must no longer be fired. Fingers crossed that all is now okay. Station 018 (IB10) was completed at 05:15 and followed by the fourth Apex float release (SN 2704). Station 019 was completed at 08:40. The weather is now calm, with a good forecast for the next few days. The engine room will need another half hour at some stage to work on the main propulsion.

Stations 020, 021 and 022 were completed with nothing worse than a few loose screws in the stainless steel rosette and some bottles not firing. Large volumes of water were drawn from 021 for Adam to set up a bioassay incubation and from 022 for Charlotte and Helen to set up a bioluminescence incubation experiment. The fourth and last Met Office drifter (SN 300034012547840) was chucked over the side at 1725, between stations 021 and 022. Station 023 (IB5) was worked with the titanium CTD frame for trace metal sampling and completed about 2200. We are now

46 hours behind schedule, 16 hours for equipment failures, 24 hours for bad weather, 6 hours for the engines.

Figure 4. Argo float deployment.

Tuesday 18 May. Rain and winds up to 20 knots during the day, but they eased by the evening. Successfully completed stations 024 – 028 (ib4a – ib1) during the day. Finally reached Rockall just after dinner and worked the first station, A of the Ellett Line just before 2000 (station 029). Rockall outcrop was clear a couple of miles off on a bright, clear evening. Arranged to reduce some of the sampling as the stations are so closely spaced across the Rockall Trough. Completed stations 030 - 031 (B and C).

Figure 5. Rockall.

Wednesday 19 May. A huge improvement in the weather, which is now sunny, mild and calm. Station 032 (D) completed at 0200. At station 033 (E), an extra dip was made to 400 m for Chris Marsay to collect large volumes of water to make brine. SAPs followed, then a full depth titanium cast (station 034), which was completed by 0848. During the day, stations 035 – 037 (F – I) were completed with no problems. Apex floats were deployed after station 036 (G) (SN 3862) and station 037 (H) (SN 3861).

Thursday 20 May. Completed the last titanium station 039 (K) at 0225. A gloomy day with fog that never lifted. Completed stations 040 – 047 (J – S) during the day. At station M a pod of over a dozen pilot whales spent some time alongside the ship. They appeared to be feeding, and together with the number of gannets in the area, suggested that the water here was locally productive. At station N, contact was made with the Royal Navy over a 'no go' area centred at station P and extending as far as N. Permission was given to continue along the line.

Friday 21 May. Another foggy and gloomy day, but calm. Completed the Ellett Line in the early morning at station 048 (T). Continued along line G, working stations 049 – 062 (14G – 1G) across the shelf into the Sound of Mull. The ship was surrounded by dolphins at station 056 (7G). In the afternoon some of the fog lifted and the weather brightened, although the remaining banks of fog and mist partly obscured the islands. The line was completed at 1950 and the ship turned to head back to sea. Initially plunged into fog, this cleared once away from land. Heading back to Q, on the continental slope, to deploy SeaSoar and run back to Anton Dohrn Seamount, eta 0700 tomorrow.

Saturday 22 May. Reached station Q about 0645 and continued steaming along the line while SeaSoar was set up. SeaSoar deployed about 0700 and all was well except for the conductivity sensor, which wasn't working. SeaSoar was recovered at 0820. While the Chelsea minipack was replaced, the engineers were able to stop the engines to complete the work on the tachyometer that broke earlier in the cruise. Conditions were calm and foggy but bright, with a gentle swell.

The engine work was completed first but SeaSoar was ready for redeployment soon after, over the stern about 0900 and undulating by 0930. By 1000 everything had settled into a routine. SeaSoar was towed throughout the day. The centre of the SeaSoar grid, station J, was passed at 1600, and the grid started on the 300° leg. The southwest turn was made at 2230.

Sunday 23 May. The weather remained calm, grey and misty for most of the day, but clearing in the evening. The SeaSoar tow continued throughout the day. Pilot whales were seen briefly at about 1130. The sea surface was very calm at about 1230 and long slicks of green algae and foam were seen on the surface, along with the patchy surface slicks that indicate internal waves and Langmuir circulations. The northeast turn was made at 0530, the north turn was made about 0900, the south turn at about 1545 and the southeast turn at 1845.

Examination of the SeaSoar minipack data showed rather noisy conductivity and a large offset in salinity. Also, CDOM was saturated, so providing no signal. Therefore the SeaSoar was recovered at the end of the 30nm grid, at point J at 2230 and fully inboard at 2300.

Monday 24 May. While replacing the minipack and adjusting the CDOM sensor, the ship was repositioned to pass through J and pick up the 330° leg of the 20nm survey.

SeaSoar was ready to redeploy at 0045 and in the water at 0100. The second SeaSoar survey started from J at 0130. The 120° turns took about 20 minutes to complete and took place at approximately 0340 (NW), 0550 (W), 1015 (E), 1250 (NE), 1715 (SW) and 1930 (SE). The weather was sunny for much of the day, calm but with a fresher wind than previous days and no fog. The grid was completed at 2200 and SeaSoar recovered at about 2230. The ship then steamed to the yoyo position along the 30° track in approximately 800 m of water. The CTD yoyo began at 0030.

Tuesday 25 May. The CTD yoyo began with a cast for water collection (063). Samples were drawn for dissolved oxygen, nutrients, salinity and chlorophyll when the CTD was brought inboard at about 0115. The CTD yoyo restarted at 0150, with the CTD lowered to 800m and hauled to the surface for approximately 6 hours, (064-072). At the end of 072 at 0730, the package was brought inboard for sampling. The yoyo restarted at 0815 and casts 073-081 continued until 1415 (later than intended) when brought in for sampling. The yoyo restarted at 1500 and casts 082-087 worked until 1916 for sampling. The final 6 hours of the yoyo started at 1950 with cast 088 and continued until cast 095 ending at 0130. However, on profile 93 the primary conductivity sensor suddenly shifted low by about 0.3 at the bottom of the cast. It remained low for the rest of the yoyo, and was thought to be cracked.

The weather was cold with air temperatures of about 7°C, but it remained calm and sunny. The clean sampling fish was brought inboard during the morning. Large numbers of pilot whales were seen during the afternoon.

Wednesday 26 May. The CTD yoyo was completed at 0130 after a total of 33 profiles. The primary conductivity sensor was replaced before any further work could be done. The ship turned onto a 30° course, along the SeaSoar line, to work 4 CTDs down the slope of the seamount. The idea was to work stations at the 1000, 1500 and 2000 m contours, and at the deepest point of the surrounding moat (about 2200m). However, picking the correct depths proved difficult, especially at 1500 m, because of the steepness of the slope. Because of the time taken, the deepest station, in the moat, was abandoned, in order to ensure that there was time to work two stations in a counter-rotating eddy to the north. The weather remained bright and cold throughout the day but with increasing winds.

There was some disagreement about when scientific work should stop, with a full day and a half wanted for demobilisation by technicians. Station 096 in 1000 m of water was completed at 0400, station 097 in 1500m of water was completed at 0730. CTD station (098) at bottom of seamount slope completed at 1030. Full steam to the northern station, hopefully in an anticlockwise eddy to contrast with the cyclonic eddies on the Ellett Line, with CTD 099 completed by 1615. Station 100 was completed by 1900. The F6-8 winds forecast for late in the day did not materialise, but wind speeds reached 20 knots. The winds were from the north, so once the northern station was worked, they were behind the ship, helping her on her way south.

Thursday 27 May. On our final station just before midnight. Station 101 completed at 0145. PES fish brought in and depth logging stopped. Ship set course for the Clyde. Steamed steadily throughout the day. Off Ireland mid afternoon and into the North Channel. By 10pm steaming slowly though the islands. RPC in the bar for all hands during the evening.

Friday 28 May. Pilot on board at 0700. Bright sunny morning. River Clyde negotiated with no problems. Into King George V Dock, Govan at 9:30 and alongside before 10am. De-mob started. Scientists started leaving the ship after midday.

Jane Read

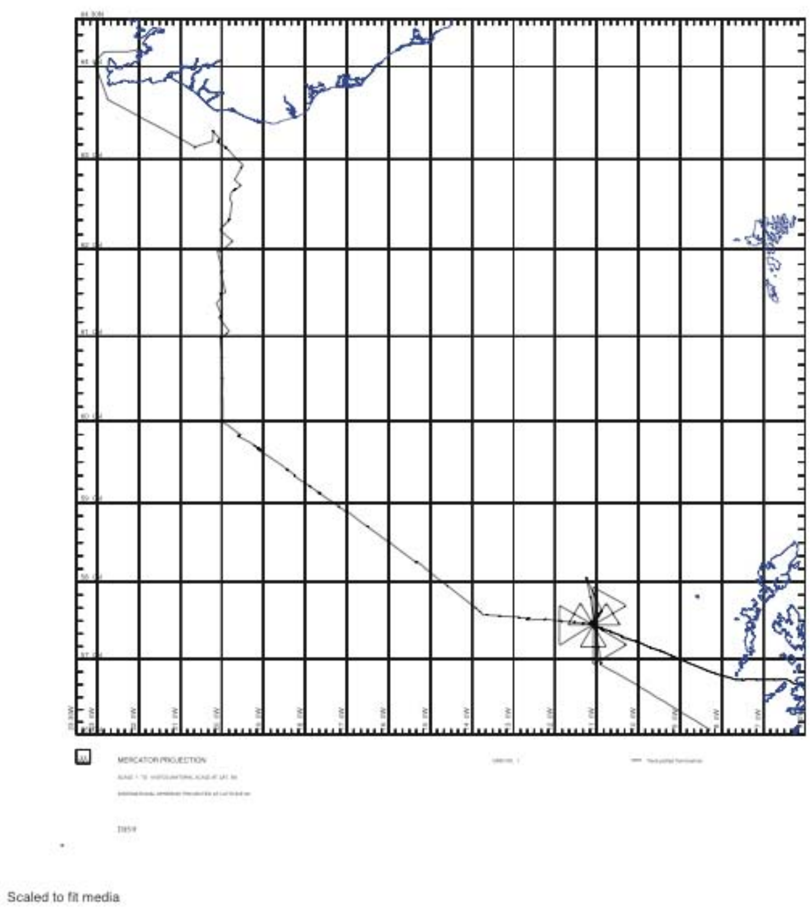
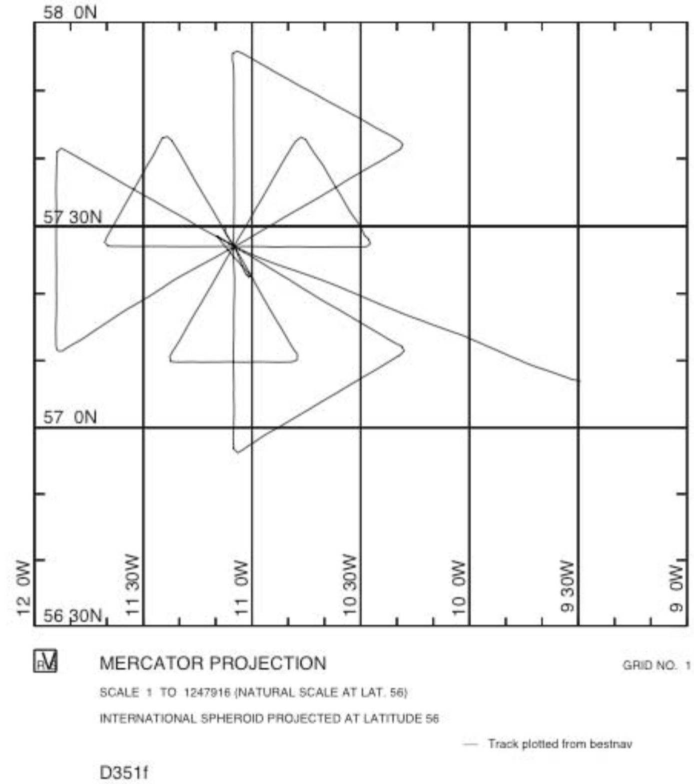


Figure 6. RRS Discovery cruise 351 track plot

Figure 7. RRS Discovery cruise 351 SeaSoar survey track.



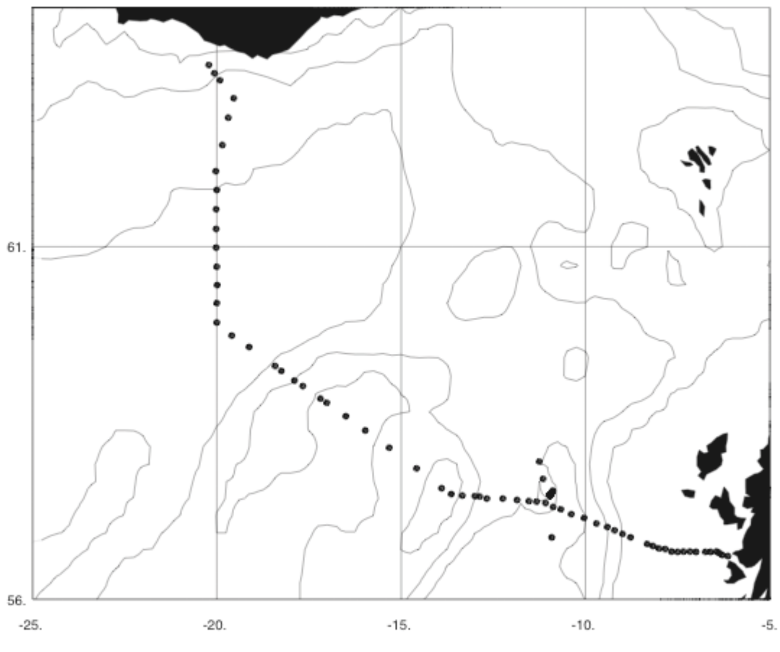


Figure 8. CTD station positions during *RRS Discovery* cruise 351 (bathymetry contoured at 200, 1000, 2000, 3000m).

Table 1. RRS Discovery cruise 351 CTD station listing.

Station no	name	jday	date	start time	down time	end time	lat °N	lon °W	depth m	hght off bottom
Extended Ellett Line										
001	ib23s	132	12v10	0926	0935	0948	63 19.02	-20 12.94	130	10
002T	ib22s	132	12v10	1059	1120	1200	63 12.88	-20 3.82	676	10
003	ib21s	132	12v10	1728	1804	1853	63 7.85	-19 54.73	1049	10
004	ib20s	132	12v10	2117	2207	2312	62 54.61	-19 32.17	1415	10
005	ib19s	133	13v10	0139	0219	0320	62 40.23	-19 41.35	1686	11
006	ib18s	133	13v10	0710	0755	0901	62 19.67	-19 50.76	1815	8
007T	ib17	133	13v10	1321	1423	1530	61 59.56	-20 1.54	1821	10
008	ib16a	133	13v10	2058	2153	2305	61 45.22	-19 59.77	1796	10
009	ib16	134	14v10	0205	0256	0410	61 29.99	-20 0.95	2224	10
010	ib15	134	14v10	0725	0820	0938	61 14.74	-20 0.94	2386	10
011T	ib14	134	14v10	0853	0951	1110	60 59.97	-20 0.97	2415	9
012T	ib13a	135	15v10	1305	1404	1530	60 45.01	-20 0.11	2382	11
013T	ib13	135	15v10	1711	1823	1959	60 30.17	-19 59.65	2537	7
014T	ib12a	135	15v10	2211	2323	0056	60 15.65	-19 59.90	2652	17
015T	ib12	136	16v10	0300	0358	0525	60 0.04	-20 0.08	2730	8
016T	ib11a	136	16v10	1200	1314	1450	59 49.27	-19 35.74	2718	7
017T	ib11	136	16v10	2050	2154	2336	59 39.71	-19 7.55	2680	10
018	ib10	137	17v10	0248	0353	0513	59 24.20	-18 25.16	2417	10
019	ib9	137	17v10	0640	0728	0837	59 20.03	-18 15.13	1695	10
020	ib8	137	17v10	1035	1121	1225	59 12.08	-17 53.32	1539	10
021	ib7	137	17v10	1415	1442	1600	59 7.20	-17 39.89	981	-
022	ib6	137	17v10	1806	1832	1930	58 56.87	-17 11.48	895	-
023T	ib5	137	17v10	2043	2115	2223	58 53.32	-17 1.03	1145	10
024	ib4a	138	18v10	0035	0110	0204	58 41.90	-16 29.89	1192	10
025	ib4	138	18v10	0425	0502	0555	58 29.95	-15 58.68	1195	10
026	ib3	138	18v10	0840	0908	1000	58 15.26	-15 19.49	656	10
027	ib2	138	18v10	1316	1337	1426	57 57.09	-14 35.02	439	8
028	ib1	138	18v10	1720	1729	1748	57 39.98	-13 54.07	144	10
Ellett Line										
029	A	138	18v10	1927	1933	1956	57 34.85	-13 38.26	110	14
030	B	138	18v10	2108	2119	2149	57 33.84	-13 20.27	178	10
031	C	138	18v10	2303	2316	2348	57 33.08	-13 0.04	292	11
032	D	139	19v10	0032	0108	0202	57 32.95	-12 52.21	1022	12
033	E	139	19v10	0307	0324	0343			1646	to 400m
033T	E	139	19v10	0700	0740	0848	57 30.94	-12 40.35	1602	9
034	F	139	19v10	1020	1109	1231	57 31.12	-12 14.35	1804	8
035	G	139	19v10	1404	1442	1552	57 29.85	-11 51.02	1791	6
036	H	139	19v10	1722	1811	1929	57 28.80	-11 31.85	2030	7
037	I	139	19v10	2038	2103	2155	57 28.28	-11 19.55	750	15
038	J	139	19v10	2300	2322	2359	57 27.11	-11 5.08	586	10
039T	K	140	20v10	0110	0136	0225	57 23.63	-10 52.65	775	9
040	L	140	20v10	0355	0447	0557	57 21.64	-10 40.19	2118	9
041	M	140	20v10	0725	0815	0930	57 17.23	-10 22.88	2223	5
042	N	140	20v10	1050	1138	1255	57 14.02	-10 2.24	2109	6
043	O	140	20v10	1422	1505	1618	57 8.95	-9 41.97	1929	10
044	P	140	20v10	1730	1807	1909	57 5.93	-9 24.34	1364	8
045	Q	140	20v10	2009	2019	2055	57 3.04	-9 12.65	290	13
046	R	140	20v10	2155	2203	2224	56 59.89	-8 59.77	130	10
047	S	140	20v10	2322	2330	2350	56 56.95	-8 46.81	123	10
048	T	141	21v10	0128	0137	0159	56 50.86	-8 19.72	130	10

Station no	name	jday	date	start time	down time	end time	lat °N	lon °W	depth m	hght off bottom
Line G – Scottish Shelf										
049	14G	141	21v10	0249	0259	0316	56 49.05	-8 10.16	124	10
050	13G	141	21v10	0422	0431	0448	56 47.03	-8 0.16	117	10
051	12G	141	21v10	0559	0606	0617	56 46.24	-7 50.24	70	7
052	11G	141	21v10	0722	0728	0740	56 44.02	-7 40.18	58	8
053	10G	141	21v10	0832	0846	0913	56 43.75	-7 29.96	219	7
054	9G	141	21v10	1015	1023	1042	56 44.13	-7 20.13	154	7
055	8G	141	21v10	1130	1136	1200	56 44.08	-7 9.98	173	10
056	7G	141	21v10	1249	1300	1318	56 43.82	-7 0.03	134	10
057	6G	141	21v10	1424	1426	1440	56 43.87	-6 44.89	38	-
058	5G	141	21v10	1518	1523	1538	56 43.96	-6 36.01	73	6
059	4G	141	21v10	1625	1629	1639	56 43.99	-6 26.86	75	5
060	3G	141	21v10	1726	1730	1740	56 42.92	-6 21.95	73	10
061	2G	141	21v10	1823	1828	1835	56 41.06	-6 17.24	22	4
062	1G	141	21v10	1927	1934	1950	56 40.10	-6 8.15	115	10
Anton Dohrn yoyo										
063		144	24v10	2357	0023	0106	57 31.12	-12 14.35	801	11
064		145	25v10	0147	0211	0228	61 14.74	-20 0.94	801	11
065				0230	0249	0304	57 33.95	-10 57.52		8
066				0306	0326	0341	57 33.99	-10 57.40		8
067				0343	0400	0416	57 34.00	-10 57.426		10
068				0418	0435	0452	57 33.97	-10 57.40		6
069				0453	0511	0528	57 33.98	-10 57.36		7
070				0531	0548	0605	57 34.02	-10 57.45		9
071				0606	0624	0640	57 33.99	-10 57.43		8
072				0644	0700	0735	57 34.01	-10 57.49	803	10
073				0815	0838	0859	57 34.00	-10 57.41	803	10
074				0902	0920	0938	57 34.01	-10 57.37		7
075				0940	1000	1016	57 34.00	-10 57.38		10
076				1017	1036	1054	57 34.01	-10 57.41		8
077				1056	1116	1132	57 33.99	-10 57.40		9
078				1133	1151	1207	57 34.00	-10 57.39		8
079				1209	1230	1245	57 34.01	-10 57.44		12
080				1247	1304	1319	57 34.03	-10 57.41		9
081				1320	1339	1415	57 34.03	-10 57.41	805	8
082				1506	1527	1543	57 34.01	-10 57.37	806	9
083				1544	1605	1623	57 34.04	-10 57.35		10
084				1623	1640	1657	57 34.01	-10 57.35		10
085				1659	1715	1730	57 33.98	-10 57.39		10
086				1732	1749	1806	57 34.00	-10 57.38		11
087				1808	1827	1916	57 33.99	-10 57.41	804	9
088				1950	2011	2028	57 34.01	-10 57.37	804	6
089				2033	2052	2108	57 34.01	-10 57.38		10
090				2110	2128	2145	57 34.00	-10 57.41		8
091				2148	2207	2224	57 34.01	-10 57.40		13
092				2226	2245	2303	57 33.97	-10 57.42		10
093				2305	2323	2341	57 34.00	-10 57.41		13
094				2344	0001	0018	57 33.97	-10 57.41		11
095		146	26v10	0022	0045	0129	57 33.97	-10 57.41	803	10
Anton Dohrn seamount										
096		146	26v10	0237	0313	0357	57 35.71	-10 55.54	1038	13
097		146	26v10	0545	0626	0725	57 36.20	-10 54.74	1515	100
098		146	26v10	0839	0922	1030	57 38.02	-10 52.96	2014	7
099		146	26v10	1330	1415	1517	58 3.26	-11 15.22	1960	5
100		146	26v10	1701	1744	1850	57 48.31	-11 9.07	2023	8.6
101		147	27v10	2343	0034	0145	56 56.66	-10 54.59	2379	10

Master's Summary

Start Date	Time	End Date	Time	Comment All times GMT	Indicator	dd hh:mm	Hours
9/05/2010	17:42	11/05/2010	19:00	Alongside Reykjavik. Personnel transfers.	Port	2 01:18	49.30
11/05/2010	19:00	12/05/2010	09:20	Passage to D351 station 1.	Pass	0 14:20	14.33
12/05/2010	09:20	12/05/2010	09:25	Prepare for CTD ops.	RWP	0 00:05	0.08
12/05/2010	09:25	12/05/2010	09:48	CTD op 1	CTD	0 00:23	0.38
12/05/2010	09:48	12/05/2010	10:56	Transit to stn 2	RWP	0 01:08	1.13
12/05/2010	10:56	12/05/2010	12:00	CTD op 2	CTD	0 01:04	1.07
12/05/2010	12:00	12/05/2010	17:26	CTD wire retermination/transit to stn 3.	DTEquip	0 05:26	5.43
12/05/2010	17:26	12/05/2010	18:49	CTD op 3	CTD	0 01:23	1.38
12/05/2010	18:49	12/05/2010	21:16	Transit to stn 4	RWP	0 02:27	2.45
12/05/2010	21:16	12/05/2010	23:12	CTD op 4	CTD	0 01:56	1.93
12/05/2010	23:12	13/05/2010	01:40	Transit to stn 5	RWP	0 02:28	2.47
13/05/2010	01:40	13/05/2010	03:20	CTD op 5	CTD	0 01:40	1.67
13/05/2010	03:20	13/05/2010	06:40	Sampling and transit to stn 6	RWP	0 03:20	3.33
13/05/2010	06:40	13/05/2010	07:08	Preparing CTD	RWP	0 00:28	0.47
13/05/2010	07:08	13/05/2010	09:02	CTD op 6.	CTD	0 01:54	1.9
13/05/2010	09:02	13/05/2010	12:55	Transit to stn 7.	RWP	0 03:53	3.88
13/05/2010	12:55	13/05/2010	13:20	Preparing CTD	RWP	0 00:25	0.42
13/05/2010	13:20	13/05/2010	15:30	CTD op 7	CTD	0 02:10	2.17
13/05/2010	15:30	13/05/2010	16:26	Prepare SAPS	RWP	0 00:56	0.93
13/05/2010	16:26	13/05/2010	18:40	SAPS op 1	SAPS	0 02:14	2.23
13/05/2010	18:40	13/05/2010	18:48	Met drifter deployed	Buoy	0 00:08	0.13
13/05/2010	18:48	13/05/2010	20:40	Transit to stn 8	RWP	0 01:52	1.87
13/05/2010	20:40	13/05/2010	20:57	Prepare CTD	RWP	0 00:17	0.28
13/05/2010	20:57	13/05/2010	23:03	CTD op 8.	CTD	0 02:06	2.1
13/05/2010	23:03	14/05/2010	02:02	Sampling and transit to stn 9	RWP	0 02:59	2.98
14/05/2010	02:02	14/05/2010	04:07	CTD op 9	CTD	0 02:05	2.08
14/05/2010	04:07	14/05/2010	07:24	Transit to stn 10 in deteriorating weather.	RWP	0 03:17	3.28
14/05/2010	07:24	14/05/2010	09:40	CTD op 10	CTD	0 02:16	2.27
14/05/2010	09:40	14/05/2010	12:32	Transit to stn 11	RWP	0 02:52	2.87
14/05/2010	12:32	14/05/2010	16:10	CTD wire retermination	DTEquip	0 03:38	3.63
14/05/2010	16:10	15/05/2010	05:42	WOW	DTWx	0 13:32	13.53
15/05/2010	05:42	15/05/2010	07:42	CTD wire realigned in winch room (off comp sheave)	DTSip	0 02:00	2
15/05/2010	07:42	15/05/2010	08:05	CTD op 11	CTD	0 00:23	0.38
15/05/2010	08:05	15/05/2010	08:53	Stainless steel CTD inoperative. Decision taken to revert to Titanium CTD.	DTEquip	0 00:48	0.8
15/05/2010	08:53	15/05/2010	11:11	CTD op 11	CTD	0 02:18	2.3
15/05/2010	11:11	15/05/2010	11:21	Met drifter deployed, APEX float deployed	Buoy	0 00:10	0.17
15/05/2010	11:21	15/05/2010	13:05	Transit to stn 12	RWP	0 01:44	1.73
15/05/2010	13:05	15/05/2010	15:30	CTD op 12	CTD	0 02:25	2.42
15/05/2010	15:30	15/05/2010	17:09	Transit to stn 13	RWP	0 01:39	1.65
15/05/2010	17:09	15/05/2010	19:55	CTD op 13	CTD	0 02:46	2.77
15/05/2010	19:55	15/05/2010	21:40	Transit to stn 14	RWP	0 01:45	1.75
15/05/2010	21:40	15/05/2010	22:12	Prepare for CTD ops.	RWP	0 00:32	0.53
15/05/2010	22:12	15/05/2010	00:56	CTD op 14	CTD	0 02:44	2.73
16/05/2010	00:56	16/05/2010	03:00	Transit to stn 15	RWP	0 02:04	2.07

16/05/2010	03:00	16/05/2010	05:24	CTD op 15	CTD	0 02:24	2.4
16/05/2010	05:24	16/05/2010	06:10	Prepare for SAPS op	RWP	0 00:46	0.77
16/05/2010	06:10	16/05/2010	08:23	SAPS op 2	SAPS	0 02:13	2.22
16/05/2010	08:23	16/05/2010	08:36	Met drifter deployed, APEX float deployed	Buoy	0 00:13	0.22
16/05/2010	08:36	16/05/2010	10:24	Transit to stn 16	RWP	0 01:48	1.8
16/05/2010	10:24	16/05/2010	11:21	CTD op 16	CTD	0 00:57	0.95
16/05/2010	11:21	16/05/2010	12:00	Op 16 aborted. CTD failure. Recover and revert to Titanium CTD	DTEquip	0 00:39	0.65
16/05/2010	12:00	16/05/2010	14:48	CTD op 16	CTD	0 02:48	2.8
16/05/2010	14:48	16/05/2010	16:07	Transit to stn 17.	RWP	0 01:19	1.32
16/05/2010	16:07	16/05/2010	20:35	Main motor tacho belt failure . DY NM 08-10	DTShip	0 04:28	4.47
16/05/2010	20:35	16/05/2010	23:33	CTD op 17	RWP	0 02:58	2.97
16/05/2010	23:33	16/05/2010	23:59	APEX float deployed	Buoy	0 00:26	0.43
16/05/2010	23:59	17/05/2010	02:50	Transit to stn 18	RWP	0 02:51	2.85
17/05/2010	02:50	17/05/2010	05:12	CTD op 18	CTD	0 02:22	2.37
17/05/2010	05:12	17/05/2010	05:19	APEX float deployed	Buoy	0 00:07	0.12
17/05/2010	05:19	17/05/2010	06:40	Transit to stn 19	RWP	0 01:21	1.35
17/05/2010	06:40	17/05/2010	08:35	CTD op 19	CTD	0 01:55	1.92
17/05/2010	08:35	17/05/2010	10:35	Transit to stn 20	RWP	0 02:00	2
17/05/2010	10:35	17/05/2010	12:26	CTD op 20	CTD	0 01:51	1.85
17/05/2010	12:26	17/05/2010	14:16	Transit to stn 21	RWP	0 01:50	1.83
17/05/2010	14:16	17/05/2010	16:00	CTD op 21	CTD	0 01:44	1.73
17/05/2010	16:00	17/05/2010	18:03	Transit to stn 22, Met drifter buoy deployed en-route	RWP	0 02:03	2.05
17/05/2010	18:03	17/05/2010	19:36	CTD op 22	CTD	0 01:33	1.55
17/05/2010	19:36	17/05/2010	20:42	Transit to stn 23	RWP	0 01:06	1.1
17/05/2010	20:42	17/05/2010	22:21	CTD op 23	CTD	0 01:39	1.65
17/05/2010	22:21	18/05/2010	00:36	Transit to stn 24	RWP	0 02:15	2.25
18/05/2010	00:36	18/05/2010	02:05	CTD op 24	CTD	0 01:29	1.48
18/05/2010	02:05	18/05/2010	04:24	Transit to stn 25	RWP	0 02:19	2.32
18/05/2010	04:24	18/05/2010	05:54	CTD op 25	CTD	0 01:30	1.5
18/05/2010	05:54	18/05/2010	08:41	Transit to stn 26	RWP	0 02:47	2.78
18/05/2010	08:41	18/05/2010	09:58	CTD op 26	CTD	0 01:17	1.28
18/05/2010	09:58	18/05/2010	13:12	Transit to stn 27	RWP	0 03:14	3.23
18/05/2010	13:12	18/05/2010	14:24	CTD op 27	CTD	0 01:12	1.2
18/05/2010	14:24	18/05/2010	17:18	Transit to stn 28	RWP	0 02:54	2.9
18/05/2010	17:18	18/05/2010	17:47	CTD op 28	CTD	0 00:29	0.48
18/05/2010	17:47	18/05/2010	19:24	Transit to stn 29	RWP	0 01:37	1.62
18/05/2010	19:24	18/05/2010	19:53	CTD op 29	CTD	0 00:29	0.48
18/05/2010	19:53	18/05/2010	21:07	Transit to stn 30	RWP	0 01:14	1.23
18/05/2010	21:07	18/05/2010	21:45	CTD op 30	CTD	0 00:38	0.63
18/05/2010	21:45	18/05/2010	23:02	Transit to stn 31	RWP	0 01:17	1.28
18/05/2010	23:02	18/05/2010	23:45	CTD op 31	CTD	0 00:43	0.72
18/05/2010	23:45	19/05/2010	00:32	Transit stn 32	RWP	0 00:47	0.78
19/05/2010	00:32	19/05/2010	02:02	CTD op 32	CTD	0 01:30	1.5
19/05/2010	02:02	19/05/2010	03:08	Transit to stn 33	RWP	0 01:06	1.1
19/05/2010	03:08	19/05/2010	03:45	CTD op 33	CTD	0 00:37	0.62
19/05/2010	03:45	19/05/2010	03:57	Prepare for SAPS op	RWP	0 00:12	0.2
19/05/2010	03:57	19/05/2010	06:12	SAPS op 3	SAPS	0 02:15	2.25
19/05/2010	06:12	19/05/2010	06:59	Transit to stn 34	RWP	0 00:47	0.78
19/05/2010	06:59	19/05/2010	08:47	CTD op 34	CTD	0 01:48	1.8

19/05/2010	08:47	19/05/2010	10:20	Transit to stn 35	RWP	0 01:33	1.55
19/05/2010	10:20	19/05/2010	12:31	CTD op 35	CTD	0 02:11	2.18
19/05/2010	12:31	19/05/2010	14:02	Transit to stn 36	RWP	0 01:31	1.52
19/05/2010	14:02	19/05/2010	15:50	CTD op 36	CTD	0 01:48	1.8
19/05/2010	15:50	19/05/2010	16:00	APEX float deployed	Buoy	0 00:10	0.17
19/05/2010	16:00	19/05/2010	17:17	Transit to stn 37	RWP	0 01:17	1.28
19/05/2010	17:17	19/05/2010	19:28	CTD op 37	CTD	0 02:11	2.18
19/05/2010	19:28	19/05/2010	19:32	APEX float deployed	Buoy	0 00:04	0.07
19/05/2010	19:32	19/05/2010	20:37	Transit to stn 38	RWP	0 01:05	1.08
19/05/2010	20:37	19/05/2010	21:53	CTD op 38	CTD	0 01:16	1.27
19/05/2010	21:53	19/05/2010	23:00	Transit to stn 39	RWP	0 01:07	1.12
19/05/2010	23:00	20/05/2010	00:00	CTD op 39	CTD	0 01:00	1
20/05/2010	00:00	20/05/2010	01:13	Transit to stn 40	RWP	0 01:13	1.22
20/05/2010	01:13	20/05/2010	02:27	CTD op 40	CTD	0 01:14	1.23
20/05/2010	02:27	20/05/2010	03:18	Transit to stn 41	RWP	0 00:51	0.85
20/05/2010	03:18	20/05/2010	03:50	Prepare for CTD ops.	RWP	0 00:32	0.53
20/05/2010	03:50	20/05/2010	05:58	CTD op 41	CTD	0 02:08	2.13
20/05/2010	05:58	20/05/2010	06:00	APEX float deployed	Buoy	0 00:02	0.03
20/05/2010	06:00	20/05/2010	07:24	Transit to stn 42	RWP	0 01:24	1.4
20/05/2010	07:24	20/05/2010	09:28	CTD op 42	CTD	0 02:04	2.07
20/05/2010	09:28	20/05/2010	09:36	APEX float deployed	Buoy	0 00:08	0.13
20/05/2010	09:36	20/05/2010	10:50	Transit to stn 43	RWP	0 01:14	1.23
20/05/2010	10:50	20/05/2010	13:00	CTD op 43	CTD	0 02:10	2.17
20/05/2010	13:00	20/05/2010	14:15	Transit to stn 44	RWP	0 01:15	1.25
20/05/2010	14:15	20/05/2010	16:18	CTD op 44	CTD	0 02:03	2.05
20/05/2010	16:18	20/05/2010	17:28	Transit to stn 45	RWP	0 01:10	1.17
20/05/2010	17:28	20/05/2010	19:12	CTD op 45	CTD	0 01:44	1.73
20/05/2010	19:12	20/05/2010	20:08	Transit to stn 46	RWP	0 00:56	0.93
20/05/2010	20:08	20/05/2010	20:53	CTD op 46	CTD	0 00:45	0.75
20/05/2010	20:53	20/05/2010	21:54	Transit to stn 47	RWP	0 01:01	1.02
20/05/2010	21:54	20/05/2010	22:20	CTD op 47	CTD	0 00:26	0.43
20/05/2010	22:20	20/05/2010	23:20	Transit to op 48	RWP	0 01:00	1
20/05/2010	23:20	20/05/2010	23:49	CTD op 48	CTD	0 00:29	0.48
20/05/2010	23:49	21/05/2010	01:30	Transit to stn 49	RWP	0 01:41	1.68
21/05/2010	01:30	21/05/2010	02:00	CTD op 49	CTD	0 00:30	0.5
21/05/2010	02:00	21/05/2010	02:45	Transit to stn 50	RWP	0 00:45	0.75
21/05/2010	02:45	21/05/2010	03:16	CTD op 50	CTD	0 00:31	0.52
21/05/2010	03:16	21/05/2010	04:22	Transit to stn 51	RWP	0 01:06	1.1
21/05/2010	04:22	21/05/2010	04:48	CTD op 51	CTD	0 00:26	0.43
21/05/2010	04:48	21/05/2010	05:57	Transit to stn 52	RWP	0 01:09	1.15
21/05/2010	05:57	21/05/2010	06:14	CTD op 52	CTD	0 00:17	0.28
21/05/2010	06:14	21/05/2010	07:20	Transit to stn 53	RWP	0 01:06	1.1
21/05/2010	07:20	21/05/2010	07:34	CTD op 53	CTD	0 00:14	0.23
21/05/2010	07:34	21/05/2010	08:31	Transit to stn 54	RWP	0 00:57	0.95
21/05/2010	08:31	21/05/2010	09:31	CTD op 54	CTD	0 01:00	1
21/05/2010	09:31	21/05/2010	10:16	Transit to stn 55	RWP	0 00:45	0.75
21/05/2010	10:16	21/05/2010	10:42	CTD op 55	CTD	0 00:26	0.43
21/05/2010	10:42	21/05/2010	11:27	Transit to stn 56	RWP	0 00:45	0.75
21/05/2010	11:27	21/05/2010	12:00	CTD op 56	CTD	0 00:33	0.55
21/05/2010	12:00	21/05/2010	12:51	Transit to stn 57	RWP	0 00:51	0.85
21/05/2010	12:51	21/05/2010	13:20	CTD op 57	CTD	0 00:29	0.48
21/05/2010	13:20	21/05/2010	14:22	Transit to stn 58	RWP	0 01:02	1.03
21/05/2010	14:22	21/05/2010	14:36	CTD op 58	CTD	0 00:14	0.23

21/05/2010	14:36	21/05/2010	15:15	Transit to stn 59	RWP	0 00:39	0.65
21/05/2010	15:15	21/05/2010	15:39	CTD op 59	CTD	0 00:24	0.4
21/05/2010	15:39	21/05/2010	16:22	Transit to stn 60	RWP	0 00:43	0.72
21/05/2010	16:22	21/05/2010	16:40	CTD op 60	CTD	0 00:18	0.3
21/05/2010	16:40	21/05/2010	17:22	Transit to stn 61	RWP	0 00:42	0.7
21/05/2010	17:22	21/05/2010	17:42	CTD op 61	CTD	0 00:20	0.33
21/05/2010	17:42	21/05/2010	18:21	Transit to stn 62	RWP	0 00:39	0.65
21/05/2010	18:21	21/05/2010	18:33	CTD op 62	CTD	0 00:12	0.2
21/05/2010	18:33	21/05/2010	19:24	Transit to stn 63	RWP	0 00:51	0.85
21/05/2010	19:24	21/05/2010	19:48	CTD op 63	CTD	0 00:24	0.4
21/05/2010	19:48	22/05/2010	06:56	Transit to SeaSoar deployment posn.	RWP	0 11:08	11.13
21/05/2010	06:56	22/05/2010	08:16	SeaSoar survey op 1	SS	0 01:20	1.33
22/05/2010	08:16	22/05/2010	09:27	SeaSoar recovered to correct sensor problem	DTEquip	0 01:11	1.18
22/05/2010	09:27	22/05/2010	22:54	SeaSoar survey toward and around Anton Dohrn Seamount completed	SS	1 13:27	37.45
23/05/2010	22:54	24/05/2010	00:11	SeaSoar on deck. Sensor change and transit to start posn for survey 2	RWP	0 01:17	1.28
24/05/2010	00:11	24/05/2010	22:26	SeaSoar survey op 2	SS	0 22:15	22.25
24/05/2010	22:26	24/05/2010	23:24	Transit to stn 64	RWP	0 00:58	0.97
24/05/2010	23:24	24/05/2010	23:56	Prepare for CTD ops.	RWP	0 00:32	0.53
24/05/2010	23:56	25/05/2010	01:05	CTD op 64	CTD	0 01:09	1.15
25/05/2010	01:05	25/05/2010	01:44	Sampling. V/L remains on stn 64	RWP	0 00:39	0.65
25/05/2010	01:44	25/05/2010	01:30	Single site (Yo-Yo) CTD op 65. Recovery for sampling at 6 hr intervals.	CTD	0 23:46	23.77
26/05/2010	01:30	26/05/2010	02:35	Transit to 1000m contour to N of Seamount	RWP	0 01:05	1.08
26/05/2010	02:35	26/05/2010	03:57	CTD op '1000m'	CTD	0 01:22	1.37
26/05/2010	03:57	26/05/2010	05:44	Transit to 1500m contour to N of Seamount.	RWP	0 01:47	1.78
26/05/2010	05:44	26/05/2010	07:24	CTD op '1500m'	CTD	0 01:40	1.67
26/05/2010	07:24	26/05/2010	08:38	Transit to 2000m contour to N of Seamount	RWP	0 01:14	1.23
26/05/2010	08:38	26/05/2010	10:30	CTD op '2000m'	CTD	0 01:52	1.87
26/05/2010	10:30	26/05/2010	13:28	Transit to stn Seamount 1.	RWP	0 02:58	2.97
26/05/2010	13:28	26/05/2010	15:15	CTD op Seamount 1	CTD	0 01:47	1.78
26/05/2010	15:15	26/05/2010	16:59	Transit to stn Seamount 2	RWP	0 01:44	1.73
26/05/2010	16:59	26/05/2010	18:51	CTD op Seamount 2	CTD	0 01:52	1.87
26/05/2010	18:51	26/05/2010	23:41	Transit to stn Seamount 3	RWP	0 04:50	4.83
26/05/2010	23:41	27/05/2010	01:48	CTD op Seamount 3	CTD	0 02:07	2.12
27/05/2010	01:48	28/05/2010	06:00	Passage to Clyde Pilot	Pass	1 04:12	28.2
28/05/2010	06:00	28/05/2010	08:30	All fast alongside KG V berth 1.	Pass	0 02:30	2.5

Table 2. Aggregated Hours for each Activity

Indicator	Hours
Mob	0.00
Port	49.30
Pass	45.03
CTD	119.83
SS	61.03
SAPS	6.70
RWP	131.73
DTWx	13.53
DTShip	4.47
DTEquip	11.70
Buoy	1.47
	443.33
days	18.47

Table 3. Indicator Legend

Mob	Mobilising
Port	Bunkering etc
Pass	Pilotage & Passage
CTD	CTD
SS	SeaSoar
SAPS	SAPS
Buoy	Deployment of Buoys/Floats
RWP	Reposition/Waiting/Preparation/ Sampling recovered CTD
DTWx	Downtime weather
DTShip	Downtime ship systems
DTEquip	Downtime scientific systems
DTOther	Downtime Other (Medical etc)

W. Richardson

3. TECHNICAL SUPPORT

Sensors and moorings – *Jeff Benson, Dougal Mountifield, Jon Short*

CTD System Configuration

1) Two CTD systems were prepared; the first water sampling arrangement was a NOC 24-way stainless steel frame system, (s/n SBE CTD4 (1415)), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-31240-0720
Sea-Bird 3P temperature sensor, s/n 03P-4151, Frequency 0 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-2841, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 90573, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P-4872, Frequency 3 (secondary, vane mounted)
Sea-Bird 4C conductivity sensor, s/n 04C-3258, Frequency 4 (secondary, vane mounted)
Sea-Bird 5T submersible pump, s/n 05T-4510, (primary)
Sea-Bird 5T submersible pump, s/n 05T-3086, (secondary, vane mounted)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-37898-0518
Sea-Bird 11plus deck unit, s/n 11P-24680-0587

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

Sea-Bird 43 dissolved oxygen sensor, s/n 43-1624 (V0)
Tritech PA200 altimeter, s/n 6196.118171 (V2)
Chelsea MKIII Aquatracka fluorometer, s/n 88-2050-095 (V3)
Chelsea MKII 10cm path Alphatracka transmissometer, s/n 161050 (V6)

3) Additional instruments:

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

Sonardyne HF Deep Marker beacon, s/n 213797-001
NOC 10 kHz acoustic bottom finding pinger, s/n B9
TRDI WorkHorse 300kHz LADCP, s/n 13329 (downward-looking)
NOC WorkHorse LADCP battery pack, s/n WH007

4) Sea-Bird 9*plus* configuration file D351_st_NMEA_trans.con was used for all CTD casts through CTD095s; D351_st_NMEA_trans_cond.con was used from cast CTD096s onwards. D351_st_no_NMEA_trans.con used for the back-up, simultaneous logging desktop computer for all CTD casts through CTD095s; D351_st_no_NMEA_trans_cond.con was used from cast CTD096s onwards. The LADCP command file used for all casts was WHMD351.txt, excepting the 24 hour "yo-yo" CTD time series, which used WHMD351_2sec.txt.

5) Cast problems, failures, etc.

CTDS004: Two files written for LADCP data: CTDS004m.000 and CTDS004m.001, as first memory card in LADCP was filled. Automatic switch to second memory card.

CTD010s: Modulo error, spike at depth. Cast failed at 1500m on up cast. Pumps not switched on. New data file written; CTD010as. Upon recovery EM cable meggered and indicated short-circuit; wire re-terminated. Deploy for next cast, pumps still not working. Continued with titanium frame whilst investigating pump issue.

CTD018s: Determined pump problem to be water sampler position 9 bottom end cap was striking pump cable connector and causing short-circuit to develop. Replaced pump 'Y' cable. No position 9 sample to be taken for remainder of casts.

CTD021s: Observed three loose screws on latches of SBE32; re-tightened. Several following casts had water sampler positions not 'fired'. Loosened screws to relieve pressure on latch; still periodic errors with SBE32 positions not 'fired' on other subsequent casts.

CTD031s: LADCP "Star" cable not unplugged whilst shifting CTD frame on railway track, consequent strong pull on cable. Episodic charging problems for remainder of casts. Changed to other leg of Star cable but charging issues remained. No problems with maintaining battery pack full-charge, as used deck lead from power supply in lab to battery when could not rely on Star cable for charging.

CTD034s: RS-232 communications lost at 1555m on up cast. Sea cable fuse failed upon re-start, no modem to SBE32. Replaced fuse. Re-started and new file written: CTD034s_1, no further problems.

CTD093s: At bottom of cast primary conductivity reading shifted -0.03mS/cm (suspect cracked cell). Replaced with s/n 04C-3272 for cast CTD096s onwards.

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

Sea-Bird 9plus underwater unit, s/n 09P-24680-0637
Sea-Bird 3P temperature sensor, s/n 03P-2729, Frequency 0 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-2858, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 79501, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P-4593, Frequency 3 (secondary, vane mounted)

Sea-Bird 4C conductivity sensor, s/n 04C-3272, Frequency 4 (secondary, vane mounted)
Sea-Bird 5T submersible pump, s/n 05T-5247, (primary)
Sea-Bird 5T submersible pump, s/n 05T-5301, (secondary, vane mounted)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-34173-0493
Sea-Bird 11plus deck unit, s/n 11P-19817-0495

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

Sea-Bird 43 dissolved oxygen sensor, s/n 43-0621 (V0)
Chelsea MKIII Aquatracka fluorometer, s/n 088244 (V2)
Benthos PSA-916T altimeter, s/n 47597 (V3)
WETLabs light scattering sensor, s/n BBRTD-169 (V6)
Chelsea MKII 25cm path Alphatracka transmissometer, s/n 161048 (V7)

8) Additional instruments:

Ocean Test Equipment 10L ES-110B trace metal-free water samplers, s/n's 1 through 24
Sonardyne HF Deep Marker beacon, s/n 234002-002
TRDI WorkHorse 300kHz LADCP, s/n 10607 (downward-looking)
NOC WorkHorse LADCP battery pack, s/n WH008T

9) Sea-Bird 9*plus* configuration file D351_ti_NMEA.con was used for the CTD casts, with D351_ti_no_NMEA.con used for the back-up, simultaneous logging desktop computer. The LADCP command file used for all casts was WHMD351.txt.

Other instruments

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

Guildline Autosal 8400B, s/n 68958, installed in Stable Laboratory as the primary instrument, Autosal set point 21C to 24C. It was noted during changes to suppression values the readings would sometimes shift significantly lower for 2x conductivity ratio.

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

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

SeaSoar Operations

Summary

The SeaSoar system that was deployed during the cruise was configured as on D321 (2007) but no SBE 43 Dissolved Oxygen sensor was available and with the replacement of the Focal OPC with the a new ODIM Laser Optical Plankton Counter (LOPC). After repeated trimming of the wing angle, the fish was eventually towed at 8.5 - 9 knts on 740m of faired cable and undulated between near surface (<10m) and 420-430m.

Developments to the Seasoar system prior to D350 include the replacement of the inappropriate VDSL2 modems (trialed unsuccessfully during D341 mobilisation) with g.SHDSL.bis units, and a new topside interface box. The notable new capability is logging of the CTG Fastracka-II and the new ODIM LOPC using the Linux socat tool as a serial over ethernet multiplexer. This brings the PENGUIN serial ports seamlessly up to the topside where the instruments are logged using manufacturers software running on laptops. This allows the rapid integration of new instruments at a time when data formats are becoming increasingly complex and also allows complete control of the instrument at the topside.

The LOPC produced a very interesting data set, but this will require difficult processing using time indexing to convert to depth bins. The future addition of an external pressure sensor (or perhaps CTD) interfaced with the LOPC external instrument port is proposed for the future.

Emperor, PENGUIN and the LOPC and FRRF-II laptops were NTP time synchronised to the ship's NTP GPS clock. Emperor and PENGUIN used ntpd with the iburst option preceeded by an ntpdate step sync at boot. The LOPC and FRRF-II laptops were synchronised using the Meinberg port of the unix NTP suite for Windows, again using iburst.

A total of five Seasoar tows (three on D351) were undertaken during which approximately 60 hrs time in the water was accumulated. Total tow length was approximately 670 nm.

Considerable problems were experienced with the CTG Minipacks. A total of 5 units were available during the cruise and by the end there was only one serviceable unit producing good quality data. These issues will be discussed with the manufacturer post-cruise.

From a technical perspective, overall a very useful, though challenging, series of Seasoar tows that have proved many of the changes that have been implemented since D321 and also exposed other issues that have not been experienced before. These problems highlight the importance of trials cruises for a system that gets infrequent use and is continuously being developed.

SeaSoar System

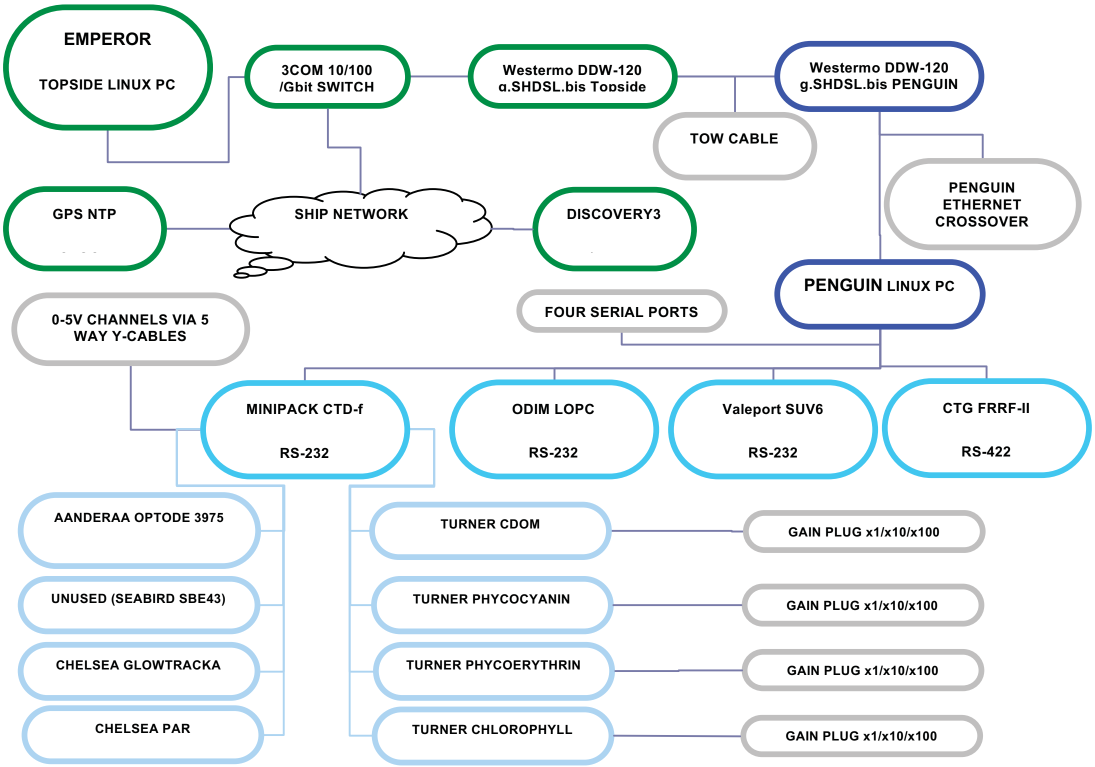


Figure 9. SeaSoar system

Figure 10. SeaSoar deployment

System Developments Prior to D350/1

PENGUIN

CPU Cards/RAM/Hard disks

New TP500 PC/104 CPU cards were fitted to replace TP400 units with failed serial ports. RAM has been doubled again to 512Mb and larger 16Gb 2.5” IDE flash disks have been fitted. The new CPU cards have created two problems. Firstly the BIOS battery backup does not work. DSP design has been consulted and their recommended test schedule suggests a problem with their power management of the ethernet port. We are still awaiting a solution from DSP design. The second problem is that they have remapped the PCI bus and this causes a resource conflict with the, as yet unused, general IO PC/104 card. Hence this has been removed. The requirement to eventually sample the Glowtracka bioluminescence sensor at 1kHz may require a wholesale redesign of PENGUIN.

Spare PENGUIN (PENGUIN2)

The second unit has now been completely built with new end-cap wiring, new chassis metal work and new PSU and interface PCBs built. This unit was cloned from PENGUIN 1 and bench tested ok. This is the first time that a working spare PENGUIN unit has been available.

g.SHDSL.bis Modems

Following the unsuccessful trial of the VDSL2 modems during D341 mob, the tow cable characteristics are now well understood and a more appropriate modem technology has been selected. The new Westermo DDW-120 modems are DIN rail mounting units using the g.SHDSL.bis standard. This allows a reliable link at approximately 2300kbit/s @ 15db SNR (NFS 270kbytes/s) concurrently in both directions, ie. it is a symmetrical DSL technology. The units feature an audio jack USB connection that allows monitoring of the link with the manufacturers supplied software tool. They establish a link within 1 minute and consume about 250mA at 15VDC.

These modems use the POTS band from 300 to 3400Hz and bandwidth continues to about 700kHz at the reliable connection speed obtained on the Seasoar tow-cable. The tow cable capacitive load is about 50nF from core to core and 150nF from core to armour. It is primarily the capacitance between core and armour that limits the bandwidth of the cable. The modems were configured with PENGUIN as CPE and the topside unit as CO. They were set to auto negotiate speed, to prevent loss of comms with a deteriorating tow cable.

A line was added to rc.local to do ntpdate prior to starting the ntp daemon due to no battery backup of clock. This will force the clock to synchronise by step change. PENGUIN may occasionally take longer to boot (a few minutes) due to filesystem checking caused by clock going back to default. The ‘watchscr’ modem reset code was removed as this is not required with new modems.

Emperor

A new CPU and Hard disk (Fedora 10) were fitted and configured with one each available as a spare. NFS was configured for async in server exports, and hard mount tcp on client with rsize and wsize of 1024 (to minimize latency). NFS transfers were tested ok for tolerance of temporary loss of ethernet connection, dsl connection, modem power, and nfs server restart.

SeaSoar Tow-fish Configuration Including Spares

Sensors as deployed bracketed in bold

Hydraulic units – s/n’s RVS01, **[RVS03]**, RVS04 & RVS05
PENGUIN Submersible Linux Computer – s/n's **[PENGUIN1]** & PENGUIN2
Chelsea TG Minipack CTD-f - s/n **[210011]** & **[210012]** & **[210035]** & 210039 & 04-4330-003
Chelsea TG Fastracka-II FRRF-II s/n **[07-6139-001]** & 07-6480-002
Chelsea TG Glowtracka Bioluminescence sensor – s/n’s 07-6244-001 & **[07-6244-002]**
Maurer Instruments Ltd Flow Meter Model SR150 – s/n **[2885]**
Chelsea TG Hemispherical PAR sensor 0046-3097 – s/n 46/2835/08 & **[46/2835/09]**
Turner Cyclops mini fluorimeter – Chlorophyll “C” – s/n **[2100432]**
Turner Cyclops mini fluorimeter – Phycocyanin “P” – s/n **[2100433]**
Turner Cyclops mini fluorimeter – Phycoerythrin “E” – s/n **[2100594]**
Turner Cyclops mini fluorimeter – CDOM “U” – s/n **[2100595]**
Chelsea TG Unilux Nephelometer 2125-021-PL-D s/n 005 & 006 (UNUSED)
Aanderaa Optode 3975 Dissolved Oxygen – s/n **[891]**
NOC/Valeport SUV-6 UV Nutrient Sensor – no serial number marked
ODIM LOPC Optical Plankton Counter (660m pressure case) – s/n 10690 & **[10693]**

SeaSoar PENGUIN Instrument Configuration

The following instruments were logged using the four serial ports in PENGUIN:

/dev/ttyS0 - Chelsea TG Minipack CTD-f (9600 baud)
/dev/ttyS1 – NOC/Valeport SUV-6 UV Nutrient Sensor (19,200 baud)
/dev/ttyS2 – ODIM LOPC Optical Plankton Counter (115,200 baud)
/dev/ttyS3 - Chelsea TG Fastracka-II FRRF-II (115,200 baud)

All the remaining instruments were logged using the auxiliary 0-5VDC inputs of the Chelsea Minipack CTD-f as follows:

Table 4. Y-Cable A

Cable #	**Minipack Channel**	**Instrument**
1	10	UNUSED
1	11	UNUSED
2	12	Cyclops CDOM
3	13	Cyclops Phycocyanin
4	14	Cyclops Phycoerythrin
5	15	Cyclops Chlorophyll

Table 5. Y-Cable B

Cable #	**Minipack Channel**	**Instrument**
1	17	Optode Oxygen Conc
1	18	Optode Oxygen Temperature
2	19	UNUSED
3	20	Chelsea Glowtracka
4	21	Chelsea PAR
5	22	UNUSED

SeaSoar Deployment Notes

The topside PSU voltage was set at 80 V to yield approximately the PENGUIN PSU clamping voltage of 59 V at the fish end. The resistance of the power conductor loop in the tow cable was approximately 25 Ω. Total power supply current was found to be 0.75A with the wire on the winch and 0.85 A with 740m of wire streamed.

There were various and numerous issues during the cruise:

- Failure of the Protech primary load-cell transmitter output during mobilization prior to D350. The secondary output to the control box panel meter was redirected to lab. Subsequently this output also failed. A Vishay Nobel AST 3P intelligent strain gauge transmitter from CTD winch system was loaned from the ETO, and installed as a temporary replacement for the Protech unit. This was powered by an old LADCP 110VAC/24VDC PSU and calibrated by loading the winch drum with a chain block to deck. A new Vishay AST 3P ordered for D351 via NOC. This was fitted during the early part of D351. Proper installation of the AST 3P and its DIN-rail mount PSU is required after removal of the old Protech unit post-cruise.
- LOPC s/n 10690 was fitted to the Seasoar vehicle during mobilisation. Communication was established with it, and the frame counter incremented, but no MEP data were produced using test beads. The unit was removed and bench tested with manufacturers deck unit but the same problem remained. Notably the Lvolt and Lmon values are considerably different from the spare unit and examples in the manual. These values refer to the laser drive circuit. The unit was replaced with s/n 10693 which experienced no problems for the whole of the cruise. The issue with 10690 may be a configuration issue and requires further investigation post-cruise.
- Minipack s/n 210035 failed during mobilisation. Spare unit s/n 210012 fitted as replacement. On closer inspection it was found that both minipacks were configured for 0-2.5VDC external inputs, not 0-5VDC as stated by CTG in July 2007. The PSU board was initially suspected. PSU board from 04-4330-003 fitted as test, but the problem remained. Suspect XTAL failure on logger board due to age and/or transport shock. The logger PCB was removed and replaced with the logger PCB from s/n 210039 including its battery. The replacement logger PCB was reprogrammed with the identity and calibration for 210035 sensors. The logger PCB was converted from 0-2.5VDC to 0-5VDC external inputs by fitting 1206 and 0805 package SMD 100k resistors in positions R12-R19. The external inputs were calibrated using a bench PSU and a non-traceable DVM and the coefficients programmed into the logger PCB. The resistors on 210035's original logger PCB that were removed to convert 210012 to 0-5VDC during D350 were replaced during the Reykjavik port-call. This PCB was also converted to 0-5VDC. Deployed for tow 2 of D351 but has 0.2PSU offset and noisy conductivity data. This requires assessment by CTG post-cruise.
- Minipack s/n 210012 was converted to 0-5VDC inputs by fitting R12-R19 (8 places) on the logger PCB with 100k 1206 SMD resistors to divide down the outputs from the two analogue multiplexers 50%. These resistors were removed from various locations on the logger board of the non-functioning unit s/n 210035. The instrument was then calibrated to engineering units using the CTG minipack software with the inputs driven by a bench PSU and measured with a non-

traceable DVM. A stock of 0805 and 1206 SMD resistors was ordered for the D350/1 port-call in Iceland along with more appropriate soldering tools for SMD rework. This unit ceased logging midway through D350 tow 1. This was investigated whilst the tow continued without minipack data. Subsequent to the minipack failure the Seasoar fish was towed without undulation as no pressure data was available for fish control. The other instruments were stopped intermittently to allow testing and diagnosis of the minipack problem, but some data were acquired. The problem was traced to a failed Lithium battery module for the battery backed RAM/RTC following consultation with the manufacturer. It is suspected that the RAM battery backup failure caused a power supervisor IC RAM reset, loss of identity and calibration and halting of data output. The battery was measured at 2.79V. The battery module from failed unit s/n 210035 was tested at 2.98V and fitted in s/n 210012 as a replacement. 1 calibrated spare Minipack (210011) was requested for the D350/1 port call in Iceland along with two further units for spare parts. The conductivity cell failed as soon as Seasoar was immersed during tow 1 of D351 with the conductivity saturating at full-scale (~70mS/cm). Requires new RAM backup battery and investigation of conductivity sensor problem post-cruise.

- Minipack s/n 210011 – Bench tested upon receipt and found to loose its RTC and calibration settings. Battery replaced with good one from ex-Ferrybox unit. The problem remained. The battery contacts on the RAM IC were found to be worn. The contacts were flowed with solder, but the problem remained, suspect RAM IC on logger PCB. The logger PCB was removed and replaced with the logger PCB from s/n 04-4330-003 including the battery from 04-4330-003. The replacement logger PCB was reprogrammed with the identity, and calibrations for 210011 sensors. The logger PCB was converted from 0-2.5VDC to 0-5VDC external inputs by fitting 1206 and 0805 package SMD 100k resistors in positions R12-R19. The external inputs were calibrated using a bench PSU and a non-traceable DVM and the coefficients programmed into the logger PCB. Successfully deployed during tow 3 of D351 with good conductivity data. This is currently the only functioning trialled Minipack that produces sufficiently good data quality.
- s/n 210039 (ex-Ferrybox unserviceable) Logger PCB removed for use in 210011. This unit requires assessment and service by CTG post-cruise.
- s/n 04-4330-003 (ex-Ferrybox unserviceable) Logger PCB removed for use in 210035. This unit requires assessment and service by CTG post-cruise.
- Previous problems with the CTG Fasttracka-II PMT overload shutdown and logging seem to have been resolved by firmware updates from CTG. However the Fastpro software does not log in realtime, requiring the user to frequently save files manually. Also when the software buffer reached 10081 samples, it goes into a FIFO mode overwriting older data in a moving window. This was not caused by a lack of RAM (there was over 1.5Gb of unused real RAM when this occurred). It seems that the software has a fixed size buffer and this requires the user to cycle files approximately every 3hrs. These issues should be resolved by CTG as a matter of urgency to prevent possible data loss.
- All externally logged instruments are powered from the +15VDC DC-DC converter in PENGUIN via the Minipack. The Westermo modem is also powered from the +15VDC supply. When the Minipack is first powered up using the i2C mp_on command, this causes a dip on the +15VDC rail, which causes PENGUIN

to reboot. This issue is another motivation for a complete redesign of PENGUIN internals using off-the-shelf components.

- The LOPC software crashed periodically. Sometimes it crashes frequently, and at other times it runs well for hours. This is either a bug with the software or a problem with socat mangling particular characters. The LOPC uses a proprietary binary compressed data format, in the socat documentation it states that socat passes (nearly) all characters unprocessed in raw mode. Further testing is required with socat and also liaison with ODIM to resolve the problem is proposed. It is suspected that the LOPC software is at fault.
- There was no apparent signal from the Glowtracka bioluminescence sensor. As has already been identified this requires sampling at approximately 1kHz due to the flash characteristic of the organisms. A complete redesign of the PENGUIN system will probably be necessary to achieve this capability

- *Table 6.* Minipack configurations and calibrations as deployed

D350 Tow 1, D350 Tow 2, D351 Tow 1	**D351 Tow 2**	**D351 Tow 3**
Minipack logger V0.2	Minipack logger V0.2	Minipack logger V0.2
1:210-0012	1:210-0035	1:210-0011
02/05/2010,02:12:33	11/05/2010,14:04:40	10/05/2010,15:38:01
19/03/2004,17:36:00	19/03/2004,17:36:00	19/03/2004,17:36:00
19/03/2004,17:37:00	19/03/2004,17:37:00	19/03/2003,17:37:00
00:00:01,00:00:01	00:00:01,00:00:01	00:00:01,00:00:01
-6.624255E-11,+1.111136E-03,-9.504244E-01	-7.883401E-11,+1.117247E-03,-9.756547E-01	-4.088424E-11,+1.105736E-03,-1.170684E+00
+5.084257E-11,+6.010486E-04,-2.822126E+00	+5.132801E-11,+6.014755E-04,-2.779083E+00	+4.079812E-11,+6.024551E-04,-2.516179E+00
-1.793258E-09,+9.455666E-03,-1.027665E+01	-1.442156E-09,+9.420346E-03,-9.440930E+00	-1.483997E-09,+9.465378E-03,-1.029030E+01
+0.000000E+00,+3.030000E-03,-5.295820E+00	+0.000000E+00,+2.912000E-03,-5.541900E+00	+0.000000E+00,+3.183000E-03,-5.693800E+00
+2.512157E-04,+6.997072E-02	+2.512157E-04,+6.997072E-02	+2.512157E-04,+6.997072E-02
+1.464345E-02,-3.468707E+00	+1.464345E-02,-3.468707E+00	+1.464345E-02,-3.468707E+00
+9.999999E-06,+0.000000E+00	+9.999999E-06,+0.000000E+00	+9.999999E-06,+0.000000E+00
+9.999997E-06,+0.000000E+00	+9.999999E-06,+0.000000E+00	+9.999999E-06,+0.000000E+00
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
+7.735311E-05,-1.758030E-05	+7.764082E-05,-7.598852E-04	+7.735312E-05,-1.758030E-05
00:05	00:05	00:05
00000	OFF	OFF
00001	OFF	OFF

SeaSoar Tow Log

Table 7. D351 Tow 1 (wing angle +/-15 deg) Minipack 210012 with RAM backup battery from 210035:

Time	**Comments**
22/5/2010 Jday 142 06:56	57 deg 03.5'N 009 deg 15.0'W All ready for deployment
22/5/2010 Jday 142 07:02	Seasoar in water
22/5/2010 Jday 142 07:18	All wire streamed and coming up to survey speed.
22/5/2010 Jday 142 07:57	57 deg 05.9'N 009 deg 24.8'W Waypoint P
22/5/2010 Jday 142 08:03	Decision to recover Seasoar due to failed conductivity sensor on Minipack 2100012
22/5/2010 Jday 142 08:16	57 deg 06.6'N 009 deg 27.4'W Seasoar clear of water
22/5/2010 Jday 142 08:18	All secure and powered down. 1hr 14 mins in water over approx 10nm

Table 8. D351 Tow 2 (wing angle +/-15 deg) Minipack 210012 replaced with 210035. 3 off 30nm sided radial triangles around Waypoint 'J' = 270nm

Time	**Comments**
22/5/2010 Jday 142 09:27	57 deg 06.9'N 009 deg 29.6'W All ready for deployment
22/5/2010 Jday 142 10:07	57 deg 08.1'N 009 deg 36.5'W All wire streamed vsl at survey speed (9knts) Continuing run-in to survey
22/5/2010 Jday 142 15:54	~57 deg 27'N 011 deg 06'W 1st Survey starts 300T Waypoint 'J'
22/5/2010 Jday 142 19:02	~57 deg 42'N 011 deg 54'W Commence turn to port to 180T
22/5/2010 Jday 142 19:14	Steady on 180T
22/5/2010 Jday 142 22:31	~57 deg 12'N 011deg 54'W Commence turn to port to 060T
22/5/2010 Jday 142 22:48	Steady on 060T to pass back through Waypoint 'J'
23/5/2010 Jday 143 05:22	~57 deg 42'N 010 deg 18'W Commence turn to port to 300T
23/5/2010 Jday 143 05:34	Steady on 300T
23/5/2010 Jday 143 08:45	~57 deg 57'N 011 deg 06'W Commence turn to port to 180T
23/5/2010 Jday 143 08:57	Steady on 180T to pass back through

	Waypoint 'J'
23/5/2010 Jday 143 15:30	~56 deg 57'N 011 deg 06'W Commence turn to port to 060T
23/5/2010 Jday 143 15:46	Steady on 060T
23/5/2010 Jday 143 18:45	57 deg 12'N 010 deg 18'W Commence turn to port to 300T
23/5/2010 Jday 143 18:59	Steady on 300T final leg of 1st survey
23/5/2010 Jday 143 22:35	Passed Waypoint 'J' reducing vsl speed for recovery after completion of 1st survey
23/5/2010 Jday 143 22:40	Commence hauling Seasoar
23/5/2010 Jday 143 22:51	Seasoar clear of water
23/5/2010 Jday 143 22:54	Seasoar on deck and secure, powering down. Approx 37 hrs in water over 330nm including 60nm run-in

Table 9. D351 Tow 3 (wing angle +/- 15 deg) Minipack 210035 replaced with 210011. Turner Cyclops CDOM gain reduced from x100 to x10. 3 off 20nm sided radial triangles around Waypoint 'J' = 180nm:

Time	**Comments**
24/5/2010 Jday 144 00:11	57 deg 22.6'N 011 deg 00.6'W Vsl in position for run-in to 2nd survey
24/5/2010 Jday 144 00:41	All powered up and ready for deployment
24/5/2010 Jday 144 00:48	Seasoar off deck
24/5/2010 Jday 144 00:50	Seasoar in water
24/5/2010 Jday 144 00:56	Fish towing well, vessel speed increasing, commence paying out
24/5/2010 Jday 144 01:04	All wire streamed, vsl speed increasing to survey speed
24/5/2010 Jday 144 01:15	Vessel at 9knts survey speed, Seasoar on 1st dive on run-in to Waypoint 'J'
24/5/2010 Jday 144 01:33	57 deg 22.6'N 011 deg 05.2'W Past Waypoint 'J', commencing 2nd survey 330T
24/5/2010 Jday 144 03:33	~57 deg 45'N 011 deg 24'W Commence turn to port to 210T
24/5/2010 Jday 144 03:45	Steady on 210T
24/5/2010 Jday 144 05:42	~57 deg 27'N 011 deg 45'W Commence turn to port to 090T
24/5/2010 Jday 144 05:54	Steady on 090T to pass back through Waypoint 'J'.
24/5/2010 Jday 144 10:09	~57 deg 27'N 010 deg 27'W Commence turn to port to 330T
24/5/2010 Jday 144 10:21	Steady on 330T
24/5/2010 Jday 144 12:40	~57 deg 45'N 010 deg 45'W Commence turn to port to 210T

24/5/2010 Jday 144 13:00	Steady on 210T to pass back through Waypoint 'J'.
24/5/2010 Jday 144 17:09	~57 deg 09'N 011 deg 24'W Commence turn to port to 090T
24/5/2010 Jday 144 17:22	Steady on 090T
24/5/2010 Jday 144 19:23	~57 deg 09'N 010 deg 45'W Commence turn to port to 330T
24/5/2010 Jday 144 19:35	Steady on 330T for final leg of 2nd survey.
24/5/2010 Jday 144 22:07	Past Waypoint 'J' reducing vessel speed for recovery after completion of 2nd survey
24/5/2010 Jday 144 22:10	Commence hauling Seasoar
24/5/2010 Jday 144 22:24	Seasoar clear of water
24/5/2010 Jday 144 22:26	Seasoar on deck.
24/5/2010 Jday 144 22:32	Seasoar all secure and powering down. Approx 21.5 hrs in water over 190nm including 10nm run-in

Table 10. Seasoar Tow Summary

Tow	Deployment + Recovery Time (power-up to power-down) /hrs	Time in Water / hrs	Estimated Distance through water /nm	Comments
tow 1	0.72	1.25	10	Wing angle +15/-15 degrees. Minipack 210012 conductivity cell failed at full scale as soon as fish entered the water.
tow 2	1	37	330	Wing angle +15/-15 degrees, fish undulating between near surface (0-10m) and 420-430m. Minipack 210035 fitted and found to have noisy conductivity data with a 0.2PSU offset. Turner Cyclops CDOM fluorimeter saturating.
tow 3	1	21.5	190	Wing angle +15/-15 degrees, fish undulating between near surface (0-10m) and 420-430m. Minipack 210011 fitted and found to have good conductivity data. Turner Cyclops CDOM fluorimeter gain set to x10, now near full scale at peaks but no longer clipping.
total	**2.72 hrs**	**59.75 hrs**	**530nm**	

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Vessel-mounted ADCP's

The ADCP's were run for the entirety of D350 and D351.

Software (Genie Timeline) has been installed to automatically backup the data areas of the machine to a Freenas Computer. This runs on the machine all the time performing hourly synchronisation of the data in the folders.

The System was run on D350 with Time Synchronisation to the NTP Clock however on D351 it was decided to allow the clock to drift naturally as the way that Windows update's the time is with immediate effect which creates jumps in time with the data. By tracking the time offset the scientists can apply a linear correction across the cruise to account for any time changes that happen with the data.

Seamet (Dartcom Replacement System) on trial

The Seamet system is on trial from SEA for D350, D351 and D352. The system utilises an omnidirectional antenna to acquire images from the NOAA 15, 17, 18 and 19 satellites. The system is based on a Windows 7 computer with the antenna's connected through sound boards on the Computer.

1 Antenna receives the HRPT images and the other antenna receives the Weather Fax images as can be obtained by the bridge.

We have made a few changes to the configuration during D350 and D351 in order to try and yield better results. The images do suffer from time to time from bad reception at the higher and lower elevations of the satellite but generally the data in the middle looks of good quality.

The HRPT images are sent to a piece of software called WXTOIMG. This software requires little user interaction. The software is capable of receiving the image, processing it and storing it to disk and to website automatically. The most annoying part of the software that I have found is that considering all the complex processing it does, a lot of the time it is not able to put the map overlay in the correct position. Obviously this is a minor thing but it does mean that the auto processing conveniently done by the software has to be redone. Some images are sometimes totally garbled which can be associated with the heading of the vessel a lot of the time.

I have no doubt that with a move up the mast to a more unobscured area that the system would perform better.

TECHSAS System

The Techsas system performed well during the whole cruise with 2 minor issues arising.

1) ADUPOS Module Crash : This module crashed a few times during the early stages of the cruise. This was due to the ADU-2 sending an empty NMEA message, which the software expected to parse. $PASHR,POS,,,,,,,,,*2 would come in every now and then. This module having run successfully over the last year without this issue is a sign of a problem in the ADU2. This happened to the previous ADU-2 prior to its demise during D336T. The situation needs to be monitored with the unit and the issue highlighted that the ADU-2 could possibly be at a point where it could fail and we have no spares or replacements.

2) SBE45 Crash. The SBE45 module crashed twice during the cruise. At the first instance the opportunity to turn on some Debugging code installed in the module was taken. At the second failure, thanks to the debugging code the reason for the crash could be seen easily. The message is formed as follows :
t1=ttt.tt, c1=cc.ccccc, s=ss.sssss, sv=ss.sssss, t2=tt.ttttt
However on this occasion the '=' symbol following the sv was missing which caused techsas to fail to interpret the message. This is the first time I have seen this happen and is possibly a bug in the SBE45 JB or the SBE45 itself. Seabird have been contacted and a temporary piece of code installed in the techsas module to work around the issue. So far this has not been noted on the James Cook.

The TECHSAS System was run in parallel with a new system. This system is one of the upgraded TECHSAS units, which will replace the old hardware completely at the end of this cruise.

The new hardware was used to create a module for the new Fugro Seastar 9200 G2, which despite being installed outside the PSO Office (which is not the best view) it still performed well.

The Portable system was put on a subnet mask that meant it could not hear the other techsas box and vice versa. The systems both ran well concurrently for most of the cruise (with the exception of development time). Both systems used the clock successfully by us utilising the separate network port on the back of the upgraded NTP.

Techsas hardware replaced :

Raid Unit ACS-7500 – ACS-75170
Single Board Computer removed
PCA-6184 2.8Ghz P4 with 512MB Ram upgraded to :
PCA-6010 2.8Ghz Dual Core Core 2 Duo with 4GB Ram.
Raid Hard drives changed from Seagate 120GB Barracuda 7 to Seagate 320Gb Barracuda 11.
DVD Drives swapped to Sata drives Sony Optiarc DVD-RAM.
Raid Hard Drive Serial port installed and software and Serial ports in use on Old Surfmet PC. Hard Drive monitoring cable from PC.

Level C

The Level C was cleared down from the previous cruise and ran well from the beginning to end. Discovery4 was also brought up as a secondary level C in order to practice level C commands without the possibility of affecting the Level C that the scientists were using to provide PSTAR with data.

PSTAR setup copied to Enterprise in order to improve processing speed.

Surfmet System

Meteorological instruments installed/swapped prior to D350.

Barometric Pressure Sensor S3440012 for S3610008
Temperature/Humidity Sensor B4950011 for B4950000
Light sensors cleaned. Prior to D350 and D351.

Seastar transmissometer installed in place of missing sensor. Existing cable disconnected at junction box.

Pipework changes D350:

Existing pipework removed from bottom (outlet) end of the vortex debubbler. A new valve and flow gauge were fitted, a T-piece splitting the flow between the drain, where another new valve was fitted, and the instruments. A 0-2L/min flow gauge installed to measure the flow for the instruments. (It will be obvious when you look at the changes rather than for me to explain without the help of a diagram).

Problems observed were issues to do with the flow through the Seabird TSG. No matter what we did, after a while the readings would start to drift, get noisy and become unsatisfactory. The order of instruments at this stage were Inlet -> Transmissometer -> Fluorometer -> TSG -> Outlet. Towards the end of the cruise we made a decision to change around the order (on recommendation of Jeff Benson) so that the TSG was first. The current order of instruments is Inlet -> TSG -> Fluorometer -> Transmissometer -> Outlet. Now the transmissometer gets all the bubble build up, but the TSG is a lot more stable.

Suggested changes time and science permitting.

Pipework split 4 ways after the debubbler.
1 -> valve -> Fluormeter -> flow meter -> out
2 -> valve -> Transmissometer -> flow meter -> out
3 -> valve -> TSG -> flow meter -> out
4 -> valve -> out

Also to install all instruments vertically (TSG can stay in the same orientation/position)

At the very start of D351 the transmissometer issues were noticed. The solution that we came to was to close the sampling pipe between the TSG and the Fluorometer. This stopped air from being dragged inside but also meant that the scientists could no longer sample. The main outlet was disconnected from the pipe work and allowed to drain directly into the sink giving the scientists a good water flow for sampling and limiting the bubble build up. The transmissometer and all other instruments have worked really well except when the flow changes significantly (ie someone turns on incubators or turns them off again).

I think the suggestion to turn the instruments vertically is a good one as well as the idea of a 4 ways split. A suitable tank at the top of the surfmet system that is higher than the sensors and after them would be a good solution for the bubbles. It would give the bubbles somewhere to gather rather than them gathering in the transmissometer which is the highest instrument. We could then use a bleed valve similar to that of a radiator to remove the air from the tank periodically.

I believe the way forward should be as follows.

Pipework split 4 ways after the debubbler.
1 -> valve -> flow meter -> Fluormeter -> Header Tank -> Out
2 -> valve -> flow meter -> Transmissometer -> Header Tank -> Out
3 -> valve -> flow meter -> TSG -> Header Tank -> Out
4 -> valve -> out

The system was not cleaned during the cruise only prior to sailing. The PS asked that the instruments be left so that the data could then be looked at and any offsets from fouling removed in post processing.

The Surfmet PC suffered a slight Windows issue (typical Microsoft). This required us to reboot the PC. At this point we loaded the SURFMET shortcut. This software did not appear to be the correct version of SURFMET as it was missing several buttons off the screen.

After several attempts to find the correct version (6 on the screen) we saw a folder on the desktop and found in there, 2 further versions. Loading the newest one we found the version that looked as we expected. Except it did not get any data. We eventually found that the system was polling the Serial ports but for some reason was not displaying the data. We eventually realised that one of the other surfmet versions was blocking the ports (despite them not running). So we rebooted again and started the correct version and data logged again.

The whole issue lost us data between 10 142 141029 and 10 142 144745

Manufacturer	Sensor	Serial no	Comments	Calibration Expires
Seabird	SBE45	232	TSG	15/06/10
Seabird	SBE38	475	Remote Temperature	14/03/11
Wetlabs	fluorometer	246		22/06/10
Seatech	transmissometer	T1011D	Temporary due to lack of instruments	No Record
Vaisala	Barometer PTB100A	S3610008		15/04/11
Vaisala	Temp/humidity HMP45A	B4950010		05/04/11
SKYE	PAR SKE510	28557	PORT	11/02/11
SKYE	PAR SKE510	28556	STBD	11/02/11
Kipp and Zonen	TIR CMB6	994133	PORT	23/06/10
Kipp and Zonen	TIR CMB6	962301	STBD	19/02/11
Sensors without cal				
Seabird	P/N 90402 SBE45 JB		Junction Box	
Gill	Windsonic Option 3	071123		

SPARES

Manufacturer	Sensor	Serial no	Comments	
Seabird	SBE45	0229	TSG	29/03/11
Seabird	SBE38	476 490	Remote Temperature	14/03/11, 17/11/10
Wetlabs	fluorometer		No Spares all at Wetlabs	
Seatech	transmissometer		No Spares all at wetlabs	
Vaisala	Barometer PTB100A	S3440012		31/03/10
Vaisala	Temp/humidity HMP45A	B4950011		21/06/10
SKYE	PAR SKE510	28559		02/06/10
SKYE	PAR SKE510			
Kipp and Zonen	TIR CMB6	994132		23/06/10
Kipp and Zonen	TIR CMB6	047462		05/07/11
Sensors without cal				
Seabird	P/N 90402 SBE45 JB	063	Junction Box	
Gill	Windsonic Option 3	071121		

TSG Samples were taken by the scientists through out the cruise. There have been issues with the stability of the Salinometer and the samples have not yet been processed and may not be available before the end of the cruise.

Table 11. Surfmet Sensor Information

Ship	RRS Discovery
Cruise	D351
Technician	Chris Barnard
Date	22/05/10

Port TIR Light Sensor will be changed post cruise and returned to NOCS.
994133 and 994132 (TIRS) returned for cal.
28559(PAR) Returned for Cal.
S3440012 (Pressure Sensor) Returned for cal.

Chernikeef Log Calibration

The speeds were 75RPM, 125RPM, & 160RPM

All previous tables were cleared

Current tables:

V	S	A
75	302	261
75	619	526
125	783	671
125	928	806
160	1036	948
160	1174	1049

The calibration document was completed and filed in the manual (located in the comms room).

Echosounder & PES Fish

After much messing about and fault diagnosis we found that the only part that was faulty was the fish cable (between the winch drum and the fish). All three ground cores (10, 11, and 12) were in some way failing insulation test (to core 2), but 11 was the best of the three. 10, and 12 were isolated at both ends of the cable with all transducer grounds using core 11:

Winch JB	Fish Cable	Transducer Housing
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5

6	6	6
7	7	7
8	8	8
9	9	9
10	11	10
11	11	11
12	11	12

The PES was deployed and worked very well all trip.

	Megger 1kV Insulation (MΩ)	Capacitance (Thandar) (nF)	Capacitance #2 (nF)
1	4.5	18.4	22
2	0.9	19.4	6.0
3	3.3	19.0	23
4	6.2	18.8	22
5	15.7	17.8	22
6	3.7	17.9	22
7	3.3	18.2	22
8	6.0	18.7	22
9	5.8	18.5	22

A new PES Cable and strut were brought out to repair the spare in case the issue's above became worse. However it was not known at this point that there is considerable mechanical wear to the spare PES Fish, Strut pivot pin. There are also signs of wear on the fish pivot point itself indicating that it has been installed incorrectly previously. It is now to be returned along with new cable to be made mechanically sound in the workshop and hopefully rebuilt to a complete unit prior to D354.

Millipore System #07

At the start of the cruise the Milli-Q was exhibiting problems in dispensing on the Qpod's auto quantity dispenser. This QPod was changed to another Qpod that was in the spares box. Unfortunately this did not fix the issue and then it was found that we could no longer dispense at all. The original QPod was reinstalled but unfortunately the unit still cannot dispense.

The units were stripped down and checked. The solenoids inside the Milli-Q Advantage can be heard to open and close and water can be seen recirculating with air in the line. The air is not able to come out as we are not able to dispense. Water can be seen going all the way to the solenoid valve however it appears that the solenoid does not actuate. Several communications with Millipore have not yielded many replies and no results. It appears that whichever board or circuit that provides the solenoid with voltage to actuate it is not functioning. As we have tried both QPod's we have no alternative but to revert to the manufacturer for information on where the problem lies, as they do not provide the drawings for this unit.

Some issue's with the UV Lamp and the Total Oxidizable Carbon were evident at various points through fault finding but they do appear to be working and the water that we are extracting from the unit appears to be of the expected quality.

It's just harder than getting blood from a stone at the moment.

Fugro Seastar 3000L and Fugro Seastar 9200G2

The Fugro 3000L has been at the end of its life for many years and now has come the time to replace the unit. A new unit the 9200G2 has been purchased which has an accuracy of 10CM. It is a dual GPS and Glonass System using Corrections on both services to gain its accuracy.

The Fugro was tested and a module for TECHSAS developed with the unit on the Forecastle Deck. The unit has now been moved to the mast following issues with the 3000L L1 Service.

The unit will now be moved to the main mast at the highest point of the ship where it will have a very clear view of the sky.

The G12 will be decommissioned as it forms part of the Fugro 3000L although there is no reason why the G12 could not be reused as a GPS unit if that was required.

4. SCIENTIFIC INVESTIGATIONS

CTD Data Acquisition and Processing - *Stuart Painter, Jeff Benson, Jon Short, Dougal Mountifield*

In total 101 CTD profiles were conducted during D351 using a combination of Stainless Steel and Titanium framed rosette systems. Summaries of the instrumentation on each frame are provided below. 62 CTD casts were conducted to obtain the 2010 Ellett Line hydrographic section. A further 39 CTD profiles were conducted after completion of the Ellett Line section as part of a 24 hour station occupation above the Anton Dorn seamount during which time the CTD was repeatedly 'yo-yoed' from the surface to a depth of ~800m and as part of a short survey away from the seamount itself.

In general the conductivity sensors on both frames performed without problem until late in the cruise, but it was noted that, as expected, various offsets existed between the two CTD systems and between the primary and secondary conductivity cells on individual frames. These offsets should be correctable following calibration against salinometry bottle samples. During the 4th 'yo-yo' CTD station (casts 351088-351094) the primary conductivity cell (s/n 4C-2841) on the stainless steel CTD developed an offset of ~0.03 mS/cm in conductivity (~0.33 in salinity) during cast 351093. The primary conductivity cell was replaced after cast 351095, thus casts 351093-351095 require correcting for this offset. Casts 351096 onwards require a new calibration to correct the primary conductivity cell and whilst salinity samples were collected for this purpose, they had not been run at the time of writing.

Of far greater concern is the calibration of the oxygen sensors on both frames, which will not be as easy as recent cruise history would lead one to expect. The SBE-43 dissolved oxygen sensor on the titanium frame (s/n 43-0621) exhibited a pronounced pressure hysteresis but the effect appears well defined. Efforts to obtain a calibration for this sensor based upon downcast oxygen measurements, as opposed to upcast bottle firing depth measurements, are ongoing and may overcome this problem.

It is believed that the dissolved oxygen sensor on the stainless steel frame performed well but a change in the reagents used in the Winkler titrations appeared to produce pronounced steps in the calibration data. These will require further consideration before a calibration can be obtained (see section on dissolved oxygen measurements).

Table 12. Stainless steel frame instrumentation

Sensor/System Type	Serial No.	Service / Cal	Cruise Notes
SBE 9+ CTD Underwater Unit	09P-31240-0720	Serviced 23 October 2008	Main unit on 24 way frame
Digiquartz Pressure	90573	20 Oct 2008	Fitted to 9+ 0720 Main CTD Pressure Sensor
SBE 3P Temperature	3P-4151	27 Feb 2010	Primary Temperature Sensor (9+ mounted)
SBE 3P Temperature	3P-4872	31 Mar 2010	Secondary Temperature Sensor (vane mounted)
SBE 4C Conductivity	4C-2841	10 Mar 2010	Primary Conductivity Sensor (9+ mounted)
SBE 4C Conductivity	4C-3258	31 Mar 2010	Secondary Conductivity Sensor (vane mounted)
SBE 43 Dissolved Oxygen	43-1624	9 April 2010	Primary DO Sensor
SBE 5T Pump	5T-4510		Primary Pump Main CTD
SBE 5T Pump	5T-3086		Secondary Pump Vane Mounted
SBE 32 24-way Carousel	32-37898-0518	Serviced 26 Oct 2009	Main Carousel on 24-way CTD
Sonardyne HF Marker Beacon (4000m rated)	213797-01		Fitted to Main CTD Frame
NMF 10kHz Pinger	B9		Fitted to main CTD frame
CTG MKIII Aquatracka Fluorimeter	88-2050-095	19 Jan 2009	Fitted to main CTD frame
CTG MKII Alphatracka Transmissometer (10cm path)	161049	24 Sep 2005	Fitted to main stainless steel CTD frame (failed after cast CTDS002)
CTG MKII Alphatracka Transmissometer (10cm path)	161050	7 Nov 2005	Fitted to main stainless steel CTD frame (from cast CTDS004)
Tritech PA200 Altimeter	6196.118171		Fitted to main CTD frame
TRDI WHM300kHz LADCP	13329	Serviced 21 Sep 2009	Downward-looking
CTG 2pi-PAR light	PAR06	26 Oct 2007	DWIRR
CTG 2pi-PAR light	PAR07	11 Oct 2007	UWIRR

NOCS/TRDI WHM300kHz LADCP battery pack	WH007		Fitted to main CTD frame
OTE 20L Custom Water Samplers	27-33, 36-41, 43, 44, 46, 48-59		Fitted to main CTD frame, plus one spare
24-way stainless steel CTD frame	SBE CTD4 (1415)		Lower adapter plate does not align well with upper plate: pins not centred (cumulative effect of offset error in manufacture)

Table 13. Titanium frame instrumentation

Sensor/System Type	Serial No	Service / Cal	Cruise Notes
SBE 9+ CTD Underwater Unit	09P-24680-0637	Serviced 22 September 2008	Main unit on 24 way frame
Digiquartz Pressure	79501	22 Sep 2008	Fitted to 9+ 0637 Main CTD Pressure Sensor
SBE 3P Temperature	3P-2729	10 Feb 2010	Primary Temperature Sensor (9+ mounted)
SBE 3P Temperature	3P-4593	13 Feb 2010	Secondary Temperature Sensor (vane mounted)
SBE 4C Conductivity	4C-2858	3 Mar 2010	Primary Conductivity Sensor (9+ mounted)
SBE 4C Conductivity	4C-3272	25 Feb 2010	Secondary Conductivity Sensor (vane mounted)
SBE 43 Dissolved Oxygen	43-0621	20 Mar 2010	Primary DO Sensor
SBE 5T Pump	5T-5247		Primary Pump Main CTD
SBE 5T Pump	5T-5301		Secondary Pump Vane Mounted
SBE 32 24-way Carousel	32-34173-0493	Serviced 16 April 2008	Main Carousel on 24-way CTD
Sonardyne HF Marker Beacon (4000m rated)	234002-002		Fitted to Main CTD Frame
CTG MKIII Aquatracka Fluorimeter	088244	11 Feb 2010	Fitted to main CTD frame
CTG MKII Alphatracka Transmissometer (25cm path)	161048	28 May 2008	Fitted to main CTD frame
Benthos PSA-916T Altimeter	47597		Fitted to main CTD frame
TRDI WHM300kHz LADCP	10607	Serviced 26 Mar 2008	Downward-looking
CTG 2pi-PAR light	PAR02	28 Jan 2010	DWIRR

NOCS/TRDI WHM300kHz LADCP battery pack	WH008T		Fitted to main CTD frame
OTE 10L Trace Metal-Free Water Samplers	1-29		Fitted to main CTD frame, plus 5 spares
WETLabs BBRTD Light Scatter Sensor	BBRTD-169	14 April 2010	Fitted to main CTD frame
24-way titanium CTD frame	SBE CTD TITA1		

Table 14. Station listing: Extended Ellett Line hydrographic section

CTD stn.	Cruise Identifier	Date (ddmmyy)	jday	time	Lat (N)	Lon (W)	Cast types
1	CTDS001[a] (CTD001s)	12.05.2010	132	09.26	63 19.02	20 12.94	StS
2	CTDT001 (CTD002t)	12.05.2010	132	10.59	63 12.90	20 03.81	TiT
3	CTDS002 (CTD003s)	12.05.2010	132	17.28	63 07.85	19 54.73	StS
4	CTDS003 (CTD004s)	12.05.2010	132	21.17	62 54.61	19 32.17	StS
5	CTDS004 (CTD005s)	13.05.2010	133	01.39	62 40.23	19 41.35	StS
6	CTDS005 (CTD006s)	13.05.2010	133	07.10	62 19.67	19 50.76	StS
7	CTDT002 (CTD007t)	13.05.2010	133	13.21	61 59.56	20 01.52	TiT
8	CTD008s	13.05.2010	133	21.53	61 45.22	19 59.77	StS
9	CTD009s	14.05.2010	134	02.56	61 29.99	20 00.97	StS
10	CTD010s[b] CTD010as[c]	14.05.2010	134	08.20	61 14.74	20 00.94	StS
11	CTD011t	15.05.2010	135	09.51	60 59.97	20 00.97	TiT
12	CTD012t	15.05.2010	135	14.04	60 45.01	20 00.12	TiT
13	CTD013t	15.05.2010	135	18.23	60 30.16	19 59.63	TiT
14	CTD014t	15.05.2010	135	23.23	60 15.64	19 59.93	TiT
15	CTD015t	16.05.2010	136	03.58	60 00.04	20 00.08	TiT
16	CTD016t	16.05.2010	136	13.14	59 49.27	19 35.76	TiT
17	CTD017t	16.05.2010	136	21.54	59 39.70	19 07.54	TiT
18	CTD018s	17.05.2010	137	03.43	59 24.20	18 25.16	StS
19	CTD019s	17.05.2010	137	07.28	59 20.03	18 15.12	StS
20	CTD020s	17.05.2010	137	11.21	59 12.31	17 53.31	StS
21	CTD021s	17.05.2010	137	14.42	59 07.19	17 39.89	StS
22	CTD022s	17.05.2010	137	18.32	58 56.88	17 11.50	StS
23	CTD023t	17.05.2010	137	21.15	58 53.3	17 01.05	TiT
24	CTD024s	18.05.2010	138	01.10	58 41.9	16 29.88	StS
25	CTD025s	18.05.2010	138	05.02	58 29.95	15 58.67	StS
26	CTD026s	18.05.2010	138	09.08	58 15.26	15 19.50	StS

27	CTD027s	18.05.2010	138	13.37	57 57.11	14 35.00	StS
28	CTD028s	18.05.2010	138	17.29	57 39.98	13 54.07	StS
29	CTD029s	18.05.2010	138	19.33	57 34.85	13 38.26	StS
30	CTD030s	18.05.2010	138	21.19	57 33.84	13 20.25	StS
31	CTD031s	18.05.2010	138	23.16	57 33.07	13 00.00	StS
32	CTD032s	19.05.2010	139	01.00	57 32.96	12 52.21	StS
33	CTD033t	19.05.2010	139	07.40	57 30.94	12 40.35	TiT
34	CTD034s[b] CTD034s_1[c]	19.05.2010	139	11.09	57 31.12	12 14.35	StS
35	CTD035s	19.05.2010	139	14.42	57 29.85	11 51.02	StS
36	CTD036s	19.05.2010	139	18.11	57 28.80	11 31.86	StS
37	CTD037s	19.05.2010	139	21.03	57 28.28	11 19.54	StS
38	CTD038s	19.05.2010	139	23.22	57 27.11	11 05.08	StS
39	CTD039t	20.05.2010	140	01.36	57 23.63	10 52.65	TiT
40	CTD040s	20.05.2010	140	04.47	57 21.64	10 40.19	StS
41	CTD041s	20.05.2010	140	08.15	57 17.22	10 22.89	StS
42	CTD042s	20.05.2010	140	11.38	57 14.01	10 02.25	StS
43	CTD043s	20.05.2010	140	15.05	57 08.97	09 41.94	StS
44	CTD044s	20.05.2010	140	18.07	57 05.93	09 24.36	StS
45	CTD045s	20.05.2010	140	20.19	57 03.04	09 12.65	StS
46	CTD046s	20.05.2010	140	22.03	56 59.89	08 59.77	StS
47	CTD047s	20.05.2010	140	23.30	56 56.96	08 46.82	StS
48	CTD048s	21.05.2010	141	01.37	56 50.86	08 19.72	StS
49	CTD049s	21.05.2010	141	02.59	56 49.04	08 10.15	StS
50	CTD050s	21.05.2010	141	04.31	56 47.03	08 00.16	StS
51	CTD051s	21.05.2010	141	06.06	56 46.24	07 50.24	StS
52	CTD052s	21.05.2010	141	07.28	56 44.02	07 40.18	StS
53	CTD053s	21.05.2010	141	08.46	56 43.75	07 29.96	StS
54	CTD054s	21.05.2010	141	10.23	56 44.13	07 20.13	StS
55	CTD055s	21.05.2010	141	11.36	56 44.09	07 09.99	StS
56	CTD056s	21.05.2010	141	13.00	56 43.82	07 00.03	StS
57	CTD057s	21.05.2010	141	14.26	56 43.87	06 44.89	StS
58	CTD058s	21.05.2010	141	15.23	56 43.96	06 36.00	StS
59	CTD059s	21.05.2010	141	16.29	56 43.99	06 26.86	StS
60	CTD060s	21.05.2010	141	17.30	56 42.93	06 21.96	StS
61	CTD061s	21.05.2010	141	18.28	56 41.06	06 17.4	StS
62	CTD062s	21.05.2010	141	19.34	56 40.09	06 08.14	StS

[a] CTD station nomenclature was changed after the first 7 stations to simplify record keeping. In this table the original station nomenclature is listed to provide a permanent record of station identifiers.

[b] These casts failed during the upcast and subsequent files were started to record the remainder of the data.

[c] These partial files were renamed during processing to ctd351999s and ctd 351899s. These numbers were also applied to the SeaBird processing output (i.e. CTD999s.ros, CTD999s.cnv)

Table 15. Station listing: Anton Dohrn Seamount

CTD stn.	Cruise Identifier	Date (ddmmyy)	Jday	time	Lat (N)	Lon (W)	Cast types
	Yoyo						
63	CTD063s	25.05.2010	145	00.23	57 33.95	10 57.47	StS
64	CTD064s[a]	25.05.2010	145	02.11	57 33.93	10 57.47	StS
65	CTD065s	25.05.2010	145	02.11	57 33.93	10 57.47	StS
66	CTD066s	25.05.2010	145	02.11	57 33.93	10 57.47	StS
67	CTD067s	25.05.2010	145	02.11	57 33.93	10 57.47	StS
68	CTD068s	25.05.2010	145	02.11	57 33.93	10 57.47	StS
69	CTD069s	25.05.2010	145	02.11	57 33.93	10 57.47	StS
70	CTD070s	25.05.2010	145	02.11	57 33.93	10 57.47	StS
71	CTD071s	25.05.2010	145	02.11	57 33.93	10 57.47	StS
72	CTD072s	25.05.2010	145	07.00	57 34.00	10 57.49	StS
73	CTD073s[a]	25.05.2010	145	08.38	57 33.99	10 57.41	StS
74	CTD074s	25.05.2010	145	08.38	57 33.99	10 57.41	StS
75	CTD075s	25.05.2010	145	08.38	57 33.99	10 57.41	StS
76	CTD076s	25.05.2010	145	08.38	57 33.99	10 57.41	StS
77	CTD077s	25.05.2010	145	08.38	57 33.99	10 57.41	StS
78	CTD078s	25.05.2010	145	08.38	57 33.99	10 57.41	StS
79	CTD079s	25.05.2010	145	08.38	57 33.99	10 57.41	StS
80	CTD080s	25.05.2010	145	08.38	57 33.99	10 57.41	StS
81	CTD081s	25.05.2010	145	13.39	57 34.02	10 57.41	StS
82	CTD082s[a]	25.05.2010	145	15.27	57 34.02	10 57.37	StS
83	CTD083s	25.05.2010	145	15.27	57 34.02	10 57.37	StS
84	CTD084s	25.05.2010	145	15.27	57 34.02	10 57.37	StS
85	CTD085s	25.05.2010	145	15.27	57 34.02	10 57.37	StS
86	CTD086s	25.05.2010	145	15.27	57 34.02	10 57.37	StS
87	CTD087s	25.05.2010	145	18.27	57 33.99	10 57.42	StS
88	CTD088s[a]	25.05.2010	145	20.11	57 34.01	10 57.37	StS
89	CTD089s	25.05.2010	145	20.11	57 34.01	10 57.37	StS
90	CTD090s	25.05.2010	145	20.11	57 34.01	10 57.37	StS
91	CTD091s	25.05.2010	145	20.11	57 34.01	10 57.37	StS
92	CTD092s	25.05.2010	145	20.11	57 34.01	10 57.37	StS
93	CTD093s	25.05.2010	145	20.11	57 34.01	10 57.37	StS
94	CTD094s	25.05.2010	145	20.11	57 34.01	10 57.37	StS
95	CTD095s	26.05.2010	146	00.45	57 33.97	10 57.41	StS
96	CTD096s	26.05.2010	146	03.13	57 35.71	10 55.54	StS
97	CTD097s	26.05.2010	146	06.26	57 36.21	10 54.74	StS
98	CTD098s	26.05.2010	146	09.22	57 38.02	10 52.95	StS
99	CTD099s	26.05.2010	146	14.15	58 03.28	11 15.20	StS
100	CTD100s	26.05.2010	146	17.44	57 48.31	11 09.07	StS
101	CTD101s	27.05.2010	147	00.34	56 56.66	10 56.59	StS

[a] Nominal position for ‘yo-yo’ CTD casts

Data Processing

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

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

These files were manually backed up onto the UNIX network, via ftp to the file location /data32/d351/ctd/StS/raw or /data32/d351/ctd/TiT/raw. The raw data files were then processed using SeaBird's own CTD data processing software, SBEDataProcessing-Win32: v.7.2a. SeaBird CTD processing routines were used as follows.

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

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

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

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

$$dt = t_i - t_{i-7}$$

$$ctm_i = -b * ctm_{i-7} + a * \partial c \partial t * dt$$

$$c_{cor,i} = c_{meas,i} + ctm_i$$

$$a = \frac{2\alpha}{7\Delta * \beta + 2}$$

$$b = 1 - {2a}/{\alpha}$$

$$\partial c \partial t = 0.8 * (1 + 0.006 * (t_i - 20))$$

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

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

The .cnv and .ros files were then copied via ftp to /data32/d351/ctd/StS/SBEprocessed or to /data32/d351/ctd/TiT/SBEprocessed so that data processing could be continued using PEXEC routines.

Data Processing on the UNIX system

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

ctds0 and ctdt0: These scripts read in the SeaBird processed ascii file (.cnv) and converted it into Pstar format, also setting the required header information. The latitude and longitude of the ship when the CTD was at the bottom were typed in manually and added to the header. The output file contained the data averaged to 24hz. The output file was ctd351nnn.24hz.

ctds1 and ctdt1: These scripts operated on the .24hz file and used the PEXEC program *pmdian* to remove residual spikes from all of the variables. The data were then averaged into a 1hz file using *pavrge*. Absent data values in the pressure data were interpolated 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 ctd351nnn.1hz and ctd351nnn.10s.

ctds2 and ctdt2: These scripts carried out a head and tail crop of the .1hz file to select the appropriate data cycles for just the up and down casts of the CTD. Before running ctd2, the .1hz files were examined in *mlist* to determine the data cycles for i) the shallowest depth of the CTD rosette after the initial soaking at 10m, ii) the greatest depth, and iii) the last good point before the CTD is removed from the water. These values were then manually entered at the correct screen prompts in ctd2. The data were then cut out with *pcopya* and the file ctd351nnn.ctu created. The position of the ship when the CTD was at the bottom of the cast were identified by merging with abnv3511 and added to the head of all files from the CTD cast. Finally, the data were averaged into two db pressure bins creating the file ctd351nnn.2db.

firs0 and firt0: These scripts converted the .ros file into Pstar format. It then took the relevant data cycles from the .10s averaged file (secondary output from ctd1) and pasted it into a new file fir351nnn containing the mean values of all variables at the bottle firing locations.

samfir and samfirt: These scripts created the file, sam351nnn, containing selected variables from fir351nnn so that the results from the bottle sampling analysis could be added.

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

sal0 and salt0: Read in the sample bottle txt files, that had been saved as tab delimited text only files, and converted some PC unique characters into UNIX friendly characters. Then sal0 created PSTAR format files with *pascin* and output file sal351nnn.bot

passal and passalt: Pastes bottle file (sal351nnn.bot) values into sam351nnn files.

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

oxy0 and oxyt0: Read in the sample bottle txt files, that had been saved as tab delimited text only files, and converted some PC unique characters into UNIX friendly characters. Create PSTAR format files with *pascin* and output file oxy351nnn.bot

pasoxy and pasoxyt: Pastes bottle file (oxy351nnn.bot) values into sam351nnn files.

peos83: Bottle salinities were converted to conductivities using both primary and secondary temperatures using the equation of state 1983. This information was used to determine the calibration coefficients A and B, which are used to correct the measured conductivities as described below,

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

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

where

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

and

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

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

ctdcondcal: This script was used to calibrate the .ctu and .2db files for both Stainless Steel and Titanium CTD casts. It also re-calculates salinity, potential temperature and sigma0/sigma2. For the stainless steel CTD A and B were set to 1.00013479 and 1.00028104 respectively.

For the titanium framed CTD A and B were set to 1.00017129 and 1.00003340

Mean residual conductivity differences for the stainless steel CTD were 0.0000 with a standard deviation of 0.00128 and 0.00137 for primary and secondary conductivity sensors. A slight drift (~0.004) in the residuals with time is evident in the calibrated data but is within the accuracy stated by Seabird for the conductivity instruments.

Mean residual conductivity differences for the titanium CTD were 0.0000 with a standard deviation of 0.0008 for primary and secondary conductivity sensors. A slight drift in the residuals with time is evident in the calibrated data but is within the accuracy stated by Seabird for the conductivity instruments.

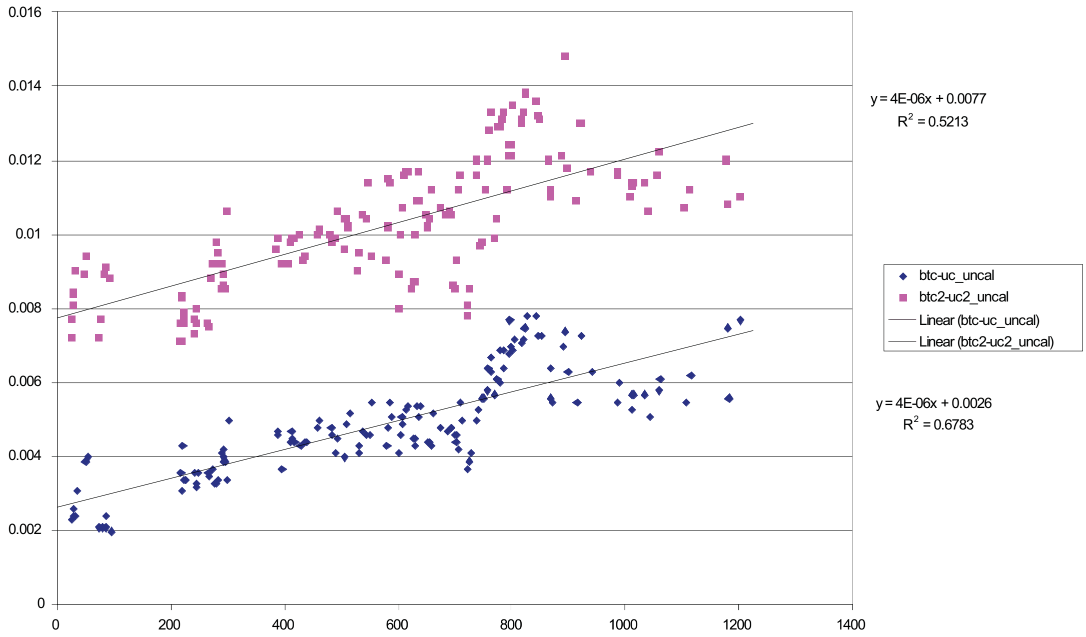


Figure 11. Bottle-CTD salinity residuals for the stainless steel CTD.

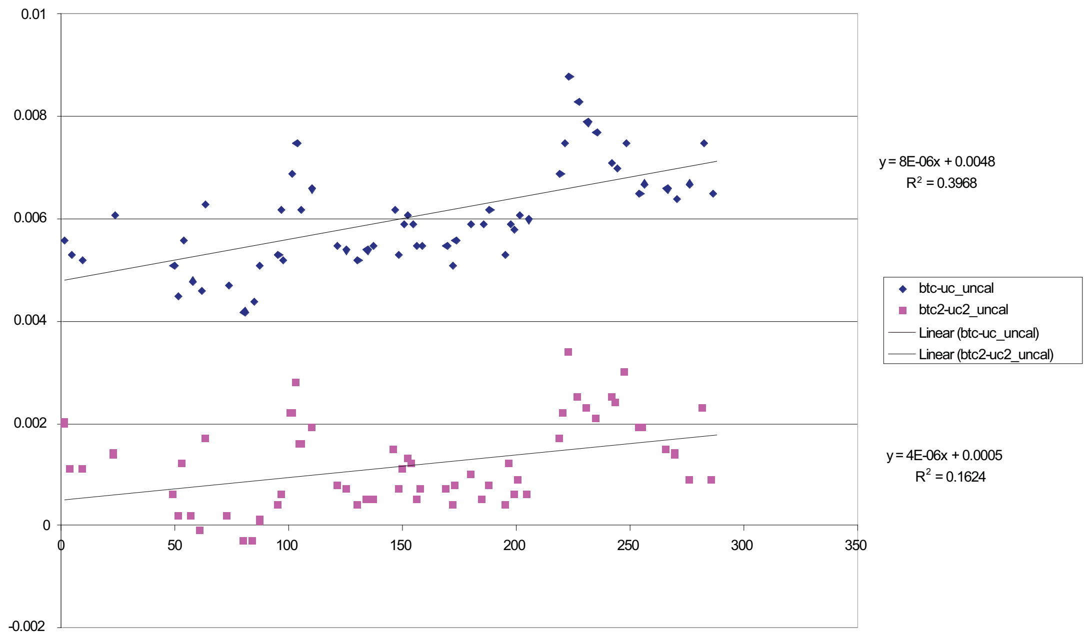


Figure 12. Bottle-CTD salinity residuals for the titanium CTD.

Lowered ADCP Data – *Jane Read*

Two TRDI WorkHorse 300 kHz lowered acoustic Doppler current profilers (LADCP were mounted on the two CTD frames. Serial number 13329 was mounted on the stainless steel frame. The titanium cased LADCP, s/n 10607, was mounted on the titanium frame. Both instruments were positioned to look downwards. Both instruments worked well throughout the cruise, without any evidence of problems.

Data were processed using MatLab Visbeck v10 software, with additional data handling programmed by Stephen Alderson on *RRS Discovery* cruise 321. The Visbeck software incorporates ship's position, CTD pressure and vessel mounted ADCP currents to obtain the best solution for water column currents. However, vessel mounted ADCP were not ready during the cruise so the processing was run without. CTD data were merged with the 'abnv3511' (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.

All CTD profiles along the Extended Ellett Line were processed, but not the last few stations at the Anton Dohrn seamount, or the 24 hour CTD yoyo. Processing of stations 010, 025, 051, 052, 055, and 057 all crashed. Stations 051, 052, 055 and 057 were all in shallow water, where there were insufficient data for the processing to work. It is not clear why stations 010 and 025 failed to process as inspection of the LADCP data with the RDI software winADCP identified nothing wrong.

Comparison of the LADCP u velocities with the cross-track geostrophic velocity on the 20°W section showed a good correspondence. It also indicated that there was no level of no motion in the Iceland Basin and that the currents were dominated by eddies. Comparison of the LADCP currents with those measured by the two VM-ADCPs along the section also showed good agreement, increasing confidence in both sets of measurements.

SeaSoar CTD Data – *Charlotte Marcinko, John Allen*

Overview

Having finished the traditional extended Ellett line, two SeaSoar surveys of the Anton Dohrn seamount were planned for the weekend of the 22nd-24th May. The deployment of SeaSoar began with the MiniPack (S/N 210012) CTD unit from the immediately preceding D350 cruise. However, the conductivity sensor failed immediately the vehicle entered the water, giving a full scale reading in seawater and an instrumental zero reading in air, but nothing else. The SeaSoar vehicle was recovered, a much easier task with the new winch scrolling gear, and MiniPack 210035 was fitted and deployed for the first survey. This unit worked well, except for conductivity, which was unusually noisy. As this was something of a SeaSoar trial for a forthcoming cruise in 2011, much to our concern we recovered a perfectly working system at the end of the first survey and replaced the MiniPack CTD with unit S/N 210011 before beginning the second survey. Thankfully this second unit appeared to produce better results than 210035 and our gamble paid off. This separation of the two surveys also gave us a chance to reduce the sensitivity of the CDOM sensor from 100x to 10x, as it had been noted that the sensor voltage had been saturating during the first survey. More information regarding the sensors and the flying of the SeaSoar vehicle are provided in the technical section of this report. However, we note here, that following problems on the preceding D350 cruise, all the MiniPack CTDs had been necessarily taken apart and fully repaired/serviced by Dougal Mountifield on board.

Table 16. SeaSoar runs during D351

station	start	stop	duration	distance run km			notes
				start	end	total	
	22/5/10 06:30	22/5/10 08:30	~ 2h	-	-	-	1
JS1	22/5/10 09:04:44	23/5/10 22:55:59	37h 51m 15s	2009.4	2616.8	607.4	2
JS2	24/5/10 00:28:34	24/5/10 22:33:26	22h 4m 52s	2632.6	2971.6	339.0	3
			Total	**Dist**		**946.4**	

1. Aborted attempt to start the first survey over the Anton Dohrn sea-mount, JS1. The conductivity sensor on MiniPack 210012 failed in the water immediately with a full-scale value of ~ 57 mmho cm^{-1}

2. Restart the first survey over the Anton Dohrn sea-mount, JS1, with MiniPack 210035

3. Second high resolution survey over the central region of Anton Dohrn sea-mount, JS2, with MiniPack 210011

Data

The 'C21' SeaSoar system (Allen *et al.,* 2002), used for the first time on D253 (May/June 2001), carries a Chelsea Technologies Group (CTG) Minipack CTDF (Conductivity, Temperature, Depth and Fluorescence) instrument which is considerably more compact than CTD instruments traditionally carried by the SeaSoar vehicle. Thus there is a substantial payload space available in the SeaSoar for a multidisciplinary suite of additional instruments. Prior to RRS *Discovery* cruise D351, the SeaSoar vehicle had been prepared to carry the (NOC/Valeport) SUV-6 UV Nutrient Sensor, a PAR sensor, a Brooke Ocean laser optical plankton counter (LOPC), a second generation CTG Fast Repetition Rate Fluorimeter (FRRFII), two oxygen sensors, four further fluorimetric pigment sensors and a bioluminescence sensor.

During SeaSoar deployments data were recovered, in real time, from the PENGUIN data handling system on SeaSoar. In the case of the MiniPack and SUV-6 instruments the files were buffered for transfer in PENGUIN and the master data files were recorded on the EMPEROR Linux PC in the main lab. For the LOPC and the FRRFII, the recently developed freely available software ‘socat’ was used to provide a virtual RS232 link bridging the instruments to their parent software on two dedicated PC laptops in the main lab: all the EMPEROR and PENGUIN data handling is discussed in detail in the technical support section. Thus data were logged in four types of file, two DAPS files containing the CTDF measurements and its associated additional analogue channels and SUV-6 UV Nutrient Sensor data, and the proprietary PC files for the FRRFII and the LOPC. The FRRFII, LOPC and SUV-6 UV Nutrient Sensor data were not dealt with during the cruise and will not be mentioned further in this report.

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

Conductivity ($mScm^{-1}$)
Temperature (°C)
Pressure (dbar)
DT ($°Cs^{-1}$), temperature change over the one second averaging period.
Chlorophyll (mgm^{-3})

Each of these were output at one second intervals and a time/date stamp was added by the DAPS handling software on PENGUIN. The time rate of change of temperature, DT ($°Cs^{-1}$), is the difference between the first and the last sample in the one second average of temperature. Firmware calibration coefficients for the two CTDs were as follows:

Minipack serial no. 210035, calibration date 11/05/10,

$$press = (-1.442156x10^{-9}xbits^2) + (9.420346x10^{-3}xbits) - 9.44093$$

$$temp = 5.132801x10^{-11}xbits^2 + 6.014755x10^{-4}xbits - 2.779083$$

$$cond = (-7.883401x10^{-11}xbits^2) + (1.117247x10^{-3}xbits) - 0.9756547$$

$$chlconc = (0.002192xbits) - 5.5419$$

Minipack serial no. 210011, calibration date 07/07/09,

$$press = (-1.483997x10^{-9}xbits^2) + (9.465378x10^{-3}xbits) - 10.2903$$

$$temp = 4.079812x10^{-11}xbits^2 + 6.024551x10^{-4}xbits - 2.516179$$

$$cond = (-4.088424x10^{-11}xbits^2) + (1.105736x10^{-3}xbits) - 1.170684$$

$$chlconc = (0.003183xbits) - 5.6938$$

In addition to the MiniPack fluorimeter, the SeaSoar package was fitted with four Turner Designs CYCLOPS-7 Submersible Fluorimetric instruments, PN2100-000 with sensors as detailed below:

Turner Designs chlorophyll sensor, serial no. 2100432

Turner Designs Phycocyanin sensor, serial no. 2100433

Turner Designs Phycoerythrin sensor, serial no. 2100594

Turner Designs CDOM "U" sensor, serial no. 2100595

These were connected to the MiniPack analogue instrument channels, as should have been two oxygen sensors, a PAR sensor and a CTG GlowTracker bioluminescence sensor. Sadly it was considered that there were too few SBE-43 oxygen sensors in the NMEP pool to 'risk' putting one on SeaSoar this time, despite, firstly there being an unused sensor on the titanium CTD frame for the latter half of the cruise, secondly the successful deployment of an SBE-43 on SeaSoar during twice the length of deployment of SeaSoar during D321, and thirdly, that the only other NMEP funded instrument on the SeaSoar was a light sensor. This matter was wholly unsatisfactory and will be taken up in the future.

Anderaa Data Instruments Oxygen Optode 3830, serial no. 891 (calibration date 21st June 2007)

PML PAR sensor, serial no. 0064-3097 (calibration date 5th July 2007)

Chelsea TG Glowtracka Bioluminescence sensor – s/n's 07-6244-001 & 002

No attempt was made to calibrate the additional analogue sensors during the cruise.

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

Table 17. Summary of the Minipack data file format.

Processing steps

The following processing route was used as required (approximately every 8 hours) during SeaSoar tows. In order to transfer data, the DAPS data file on EMPEROR was stopped and a new one started. On cruises prior to D321 this was the point at which PC clock drifts were checked and corrected, however here, as on D321, both PENGUIN and EMPEROR had been set up to reference their Linux time to a UTC time server on the shipboard SUN UNIX system; as had the PC laptops handling the FRRFII and LOPC data. The latest closed DAPS data files were copied from the EMPEROR PC to the shipboard SUN UNIX system over the ship's ethernet.

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

pgexec1: With the Minipack set to output variables in physical units it is not necessary to use the pexec program *ctdcal*, and so this script (*pgexec1*) was written to replace *ssexec1* by D. Smeed during D253. The main steps are

a) *pcalc* to apply temperature lag correction

b) *pintrp* to interpolate pressure across gaps in the data. Typically less than 0.3% of the data had to be interpolated

c) *peos83* to calculate salinity and density.

pedita was then used to remove the worst surface salinity spiking and fluorometer spikes. Further editing for spikes, and salinity offsets due to high vehicle dive rates was carried out by inspection with the interactive PSTAR editors *plpred* and *plxyed*.

Subsequently, files were appended to produce a single file for each survey; these were then merged with navigation data to obtain a distance run variable and finally interpolated to a 6 km by 8 dbar regular grid using *pgrids*.

Temperature correction

It is necessary to make a correction for the small delay in the response of the CTD temperature sensor for two reasons. Firstly, to obtain a more accurate determination of temperature for points in space and time, but more importantly, to obtain the correct temperature corresponding to conductivity measurements, so that an accurate calculation of salinity can be made.

A lag in temperature is apparent in the data in two ways. There is a difference between up and down profiles of temperature (and hence salinity) because the time rate of change of temperature has opposite signs on the up and down casts. The second manifestation is the "spiking" of salinity as the sensors traverse maxima in the gradients of temperature and salinity. The rate of ascent and descent of SeaSoar is greater (up to 2-4 ms^{-1} at the beginning of descent and ascent) than that of a lowered CTD package, thus the effects of the temperature lag are more pronounced. The following correction was applied to the temperature during *pgexec1* before evaluating the salinity

$$T_{corr} = T_{raw} + \tau.\Delta T$$

where ΔT is the temperature change over the one second averaging period as discussed earlier and τ is a time constant determined by trial and inspection.

The best value of τ was chosen so as to minimise the difference between up and down casts and noise in the salinity profile. The best value for survey 1 (S1) using minipack 210035 was found to be $\tau = 0.25$ second. This was significantly reduced when using minipack 210011 during the second survey (S2) to a value of $\tau = 0$ second. This latter value is possible because the CTG electronics inside the MiniPack are supposed to adjust for the temperature inertia of the thermometer, however, this is the first time John Allen has ever seen this happen! These values were used to provide the cleanest profiles and the best fit between up and down profiles for the respective surveys.

SeaSoar minipack calibration

We had two tools for the calibration of the Minipack CTD data, the underway thermosalinograph (TSG) connected to the ship's non-toxic supply and the well-constrained T/S profiles from the traditional vertical CTD (SeaBird) stations.

It has not been feasible to provide any preliminary calibration of the TSG salinity data whilst on-board due to the apparent poor quality of this data (see Thermosalinograph and Surfmet section). Thus, no preliminary comparison between TSG and the SeaSoar data was possible. A detailed comparison between SeaSoar near surface salinity values and surface bottle samples will be carried out at NOCS on return.

The suggested preliminary SeaSoar calibrations detailed below were from inspection on-board with the uncalibrated CTD T/S profiles. They have not been applied to the data at this stage. A final master file of fully calibrated SeaSoar data will be created back at NOCS in the near future.

Temperature

A full comparison with TSG surface temperatures will be made back at NOCS in the near future.

Salinity

Following the final calibration of the SeaSoar temperature data back at NOCS, the salinity values will be recalculated from the conductivity and corrected temperature. An initial indication of the salinity calibration that would be needed was attempted through a comparison of T/S plots of each of the two SeaSoar surveys against a similar plot of data from the vertical CTD casts within approximately the same region. SeaSoar T/S profiles suggested varying water masses were present throughout the two surveys. However, it was possible to match profiles from the vertical CTD casts to those observed from SeaSoar. Salinity values in S1 were found to be ~ 0.105 ± 0.01 high compared to the uncalibrated CTD data. Whilst, S2 salinities are estimated to be ~ 0.11 ± 0.005 low compared to the uncalibrated CTD data. Time did not allow further investigation into this and is, again, pending examination back at NOCS.

Summary

Despite a full calibration not being possible whilst on-board D351, the SeaSoar data proved useful and interesting in the analysis of the physical conditions and biophysical interactions in the survey area.

Allen, J., Dunning, J., Cornell, V., Moore, C.M., Crisp, N., 2002. Operational Oceanography using the 'new' SeaSoar ocean undulator. Sea Technology 43, 35-40.

Vessel Mounted ADCP (VM-ADCP) and Navigation Data - *Charlotte Marcinko, John Allen, Stuart Painter*

Introduction

The RRS *Discovery* is 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.

This section describes the operation and data processing paths for both ADCPs. 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 that has been gradually implemented on RRS *Discovery* for approximately 3 years. The extensive NMFSS scripts to read the netcdf format TechSAS file streams and create RVS data streams have been developed alongside the implementation of the system and most errors and wrinkles have been worked out. The 'live' RVS data format streams have overcome the problem discussed in some recent reports of insufficient significant figure resolution in position data using *nclistit*. Apparently these 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 the GPS Trimble 4000 system. The positional accuracy for the GPS 4000 system was determined previously on D340 from the data recovered whilst tied up alongside in Reykjavik. Standard deviation for positional accuracy was found to be ~ 2.13 m in latitude and 1.53 m in longitude, but some of this maybe due to heave in the mooring lines.

The GPS 4000 system has sufficient precision to enable the calculation of ship's velocities to better than 1 cms^{-1}, and therefore below the instrumental limits (~ 1 cms^{-1}) of the RDI ADCP systems. Using the GPS 4000 system as its primary navigation source, the NMFSS Bestnav combined (10 second) clean navigation process was operational and working well on D351.

Navigation and gyro data were transferred daily from the RVS format file streams to pstar navigation files, e.g. abnv3511, gps35101 and gyr35101.

Scripts:

navexec0: transferred data from the RVS *bestnav* file 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: abnv3511

gyroexec0: transferred data from the RVS gyronmea file to PSTAR, a nominal edit was made for directions between 0-360° before the file was appended to the master file, gyr35101.

gps4exec0: transferred data from the RVS gps_4000 file 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, gps35101, gps35101.30sec.

Heading

The ships attitude was determined every second with the ultra short baseline 3D GPS Ashtech ADU2 navigation system. The Ashtech data were used to calibrate the gyro heading information as follows:

Scripts:

ashexec0: transferred data from the RVS format file 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. 13).

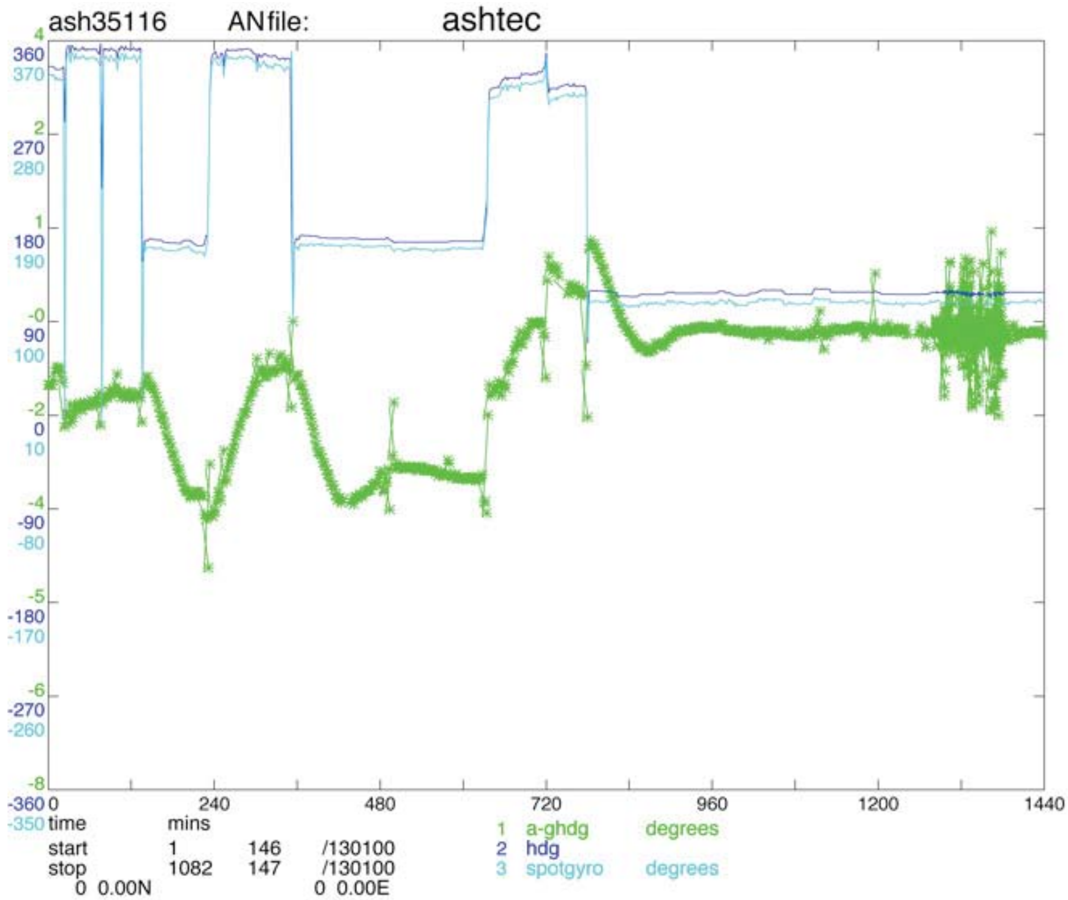


Figure 13. Example of the onscreen output of daily navigation hdg data generated by gyro (blue line) and ashtech (green line)

Ashtech 3D GPS coverage was generally good. Gaps over 1 minute in the data stream are listed below.

time gap : 10 131 13:49:26 to 10 131 13:52:14 (2.8 mins)
time gap : 10 132 12:27:55 to 10 132 12:29:02 (67 s)
time gap : 10 133 04:01:44 to 10 133 04:02:52 (68 s)
time gap : 10 133 14:38:55 to 10 133 14:39:58 (63 s)
time gap : 10 134 02:10:54 to 10 134 02:13:16 (2.4 mins)
time gap : 10 134 03:37:51 to 10 134 03:38:55 (64 s)
time gap : 10 135 02:06:43 to 10 135 02:07:50 (67 s)
time gap : 10 135 14:09:50 to 10 135 14:10:53 (63 s)
time gap : 10 136 01:58:24 to 10 136 02:00:42 (2.3 mins)
time gap : 10 136 03:37:30 to 10 136 03:38:37 (67 s)
time gap : 10 137 03:45:32 to 10 137 03:47:06 (94 s)
time gap : 10 137 12:49:30 to 10 137 12:50:35 (65 s)
time gap : 10 137 12:55:49 to 10 137 12:56:54 (65 s)
time gap : 10 137 13:20:23 to 10 137 13:25:18 (4.9 mins)
time gap : 10 142 03:02:45 to 10 142 03:03:46 (61 s)
time gap : 10 142 03:04:58 to 10 142 03:06:01 (63 s)
time gap : 10 144 09:15:23 to 10 144 09:37:23 (22.0 mins)
time gap : 10 146 01:35:35 to 10 146 08:00:53 (6.4 hrs)
time gap : 10 147 01:19:05 to 10 147 01:20:08 (63 s)

VM-ADCP Data

This section describes the operation and data processing paths for both ADCPs, and closely follows that used on RRS *Discovery 340*.

75 kHz and 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 96 bins of 4m depth and a blank beyond transmit of distance of 4m. The instrument is a broad-band phased array ADCP with 153.6 kHz frequency and a 30° beam angle.

The RDI Ocean Surveyor 75 kHz Phased Array VM-ADCP was configured to sample over 120 second intervals with 100 bins of 8m depth and a blank beyond transmit of distance of 8m. The instrument is a broad-band phased array ADCP with 76.8 kHz frequency and a 30° beam angle.

Both deck units had firmware upgrades to VMDAS 23.17 after the March 2008 refit. Both PCs 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 (Table 18).

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

Table 18. Changes of COM ports during RRS Discovery 2010 refit

Gyro heading, and GPS Ashtech heading, location and time were fed as NMEA messages into the serial ports of both PCs 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 processing path before merging with navigation.

The 2 minute averaged data were written to the PC hard disk in files with a .STA extension, e.g. D351os150001_000000.STA, D351os150002_000000.STA etc. for the 150kHz data and D351os75001_000000.STA, D351os75002_000000.STA etc. for the 75 kHz data. Sequentially numbered files were created whenever data logging was stopped and re-started. The software was set to close the file once it reached 100MB in size, though on D351 files were closed and data collection restarted daily such that the files never became that large. All files were transferred to the unix directories /data32/d351/os150/raw and /data32/d351/os75/raw as appropriate. 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.

Both instruments were configured to run in 'Narrowband' range over resolution mode. Bottom tracking was used leaving Reykjavik, over the Icelandic shelf; file 001 for both instruments. Bottom tracking mode was also used over the UK continental shelf during the completion of the Ellet line CTD casts in this region prior to the seasoar survey; file 012. 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.

Scripts:

s75exec0 and s150exec0: data read into PSTAR format from RDI binary file (psurvey2). Water track velocities written into "sur" (75kHz) or "adp" (150kHz) files, bottom track into "sbt" (75kHz) or "bot" (150kHz) 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 (13 m for the 75kHz and 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: 75kHz (sur351##.raw, sbt351##.raw), 150 kHz (adp351##.raw, bot351##.raw).

s75exec1 and 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: 75kHz (sur351##, sbt351##), 150 kHz (adp351##, bot351##).

s75exec2 and s150exec2: this merged the adcp data (both files) 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: 75kHz (sur351##.true, sbt351##.true), 150 kHz (adp351##.true, bot351##.true).

s75exec3 and s150exec3: applied the misalignment angle, ø, and scaling factor, A, to both files. Variables were renamed and re-ordered to preserve the original raw data. Output Files: 75kHz (sur351##.cal, sbt351##.cal), 150 kHz (adp351##.cal, bot351##.cal).

s75exec4 and s150exec4: merged the adcp data (both files) with the bestnav (10 sec) NMFSS combined navigation imported to pstar through navexec0 (abnv3511). Ship's velocity was calculated from spot positions taken from the abnv3511 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 abnv3511. Output Files: 75kHz (sur351##.abs, sbt351##.abs), 150 kHz (adp351##.abs, bot351##.abs).

75 kHz and 150 kHz VM-ADCP calibration

A calibration of both VM-ADCPs was achieved using bottom tracking data available from our departure from Reykjavik across the Icelandic continental shelf. 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, ϕ, 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:

		ϕ	A
150 kHz:			
	mean	1.552749952	1.000666704
	s.d	0.580535294	0.006883268
75 kHz:		ϕ	A
	mean	2.845586341	1.002266493
	s.d.	0.575752298	0.009364685

Calibrations were very similar to those obtained on D350.

<u>Results and Discussion</u>

Initial data inspection included absolute velocity vectors at selected depths, **105 m** (75 kHz), and **31 m** (150 kHz) were averaged to a 4 km regular grid and plotted along the ship track. Visual comparison of these plots allowed rough assessment of the data consistency. The two VM-ADCP units agreed well all trip indicating that we had a good calibration for each, an example of this agreement is shown in the current vectors at ~ 100 m (os150) and ~ 400 m (os75) over the Anton Dohrn seamount from the first SeaSoar survey, Fig.3.

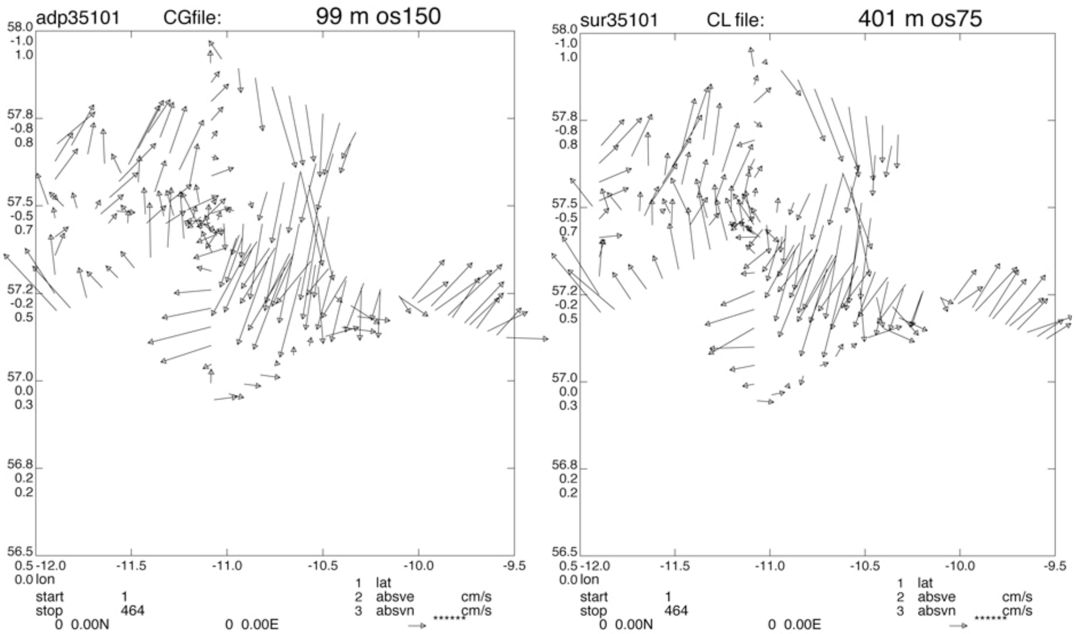


Figure 14. Absolute velocity vectors for 6 km averages

Thermosalinograph and Surfmet Data – *John Allen*

<u>Instruments</u>

Underway surface meteorology and thermosalinograph measurements were recorded by the RVS Surfmet system throughout *RRS Discovery* cruise 351. The details of the instruments used are given in the earlier computing and instrumentation section, however, the 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

<u>Data Processing</u>

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 smt351**.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. Laboratory calibration of meteorological variables was applied also at this point. The Surfmet system applies the laboratory temperature sensor calibrations, as given in the earlier technical section, before the data reaches the RVS surfmet stream that we read in with *smtexec0*.

surfmet2: The master Ashtech file and navigation file were merged with smt351** at this point. This allowed accurate heading data to be incorporated into the underway dataset. The data were also averaged to 2 minute values. This step creates the file smt351**.hdg

surfmet3: This routine computed vessel speed and subtracted it from relative winds to obtain true wind speed and direction. Resultant file was smt351**.met

<u>Temperature calibration</u>

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

<u>Salinity calibration</u>

Salinity samples were taken from the underway source routinely between CTDs and once every hour during SeaSoar surveys. A master Excel file of sample times and corresponding bottle salinities, as described in the Salinity Bottle Samples section, was read into PSTAR. The new file was then merged, using *pmerge*, with the existing smt351nn files to directly compare underway salinity (salin) and bottle salinity (botsal) with a view to applying a calibration to the underway salinity data. The initial comparisons are not good, which was a surprise, for many cruises over recent years RRS Discovery's TSG has provided good TSG data that can be calibrated to around the 0.01 salinity unit level. However, on D351 the computed TSG salinity appeared to vary between 0.2 and 0.3 away from bottle values. Initially it was thought that this may have incorporated a long term drift, but later samples from the end of the SeaSoar deployments would suggest that this may simply be a large scatter in the data. Strangely the salinity data do not look particularly noisy, suggesting that there is just a significant wander in the absolute calibration. This was a short cruise with a somewhat reduced physics crew, more time will be spent post-cruise to look at the TSG values.

(PS. Post-cruise an error was found in the surfmet1 script such that the inlet (manifold) temperature was used to calculate salinity instead of the housing temperature. Initial assessment suggests that using the correct temperature might significantly improve the salinity calibration).

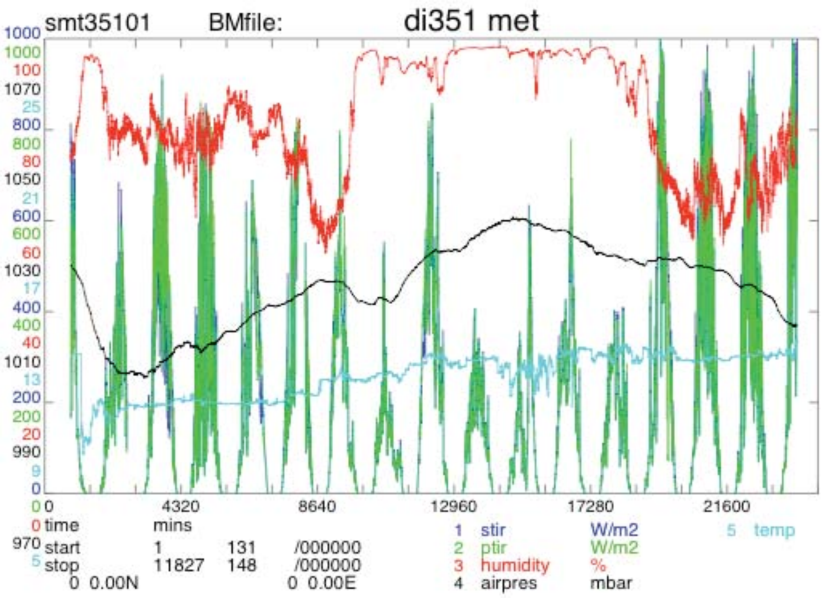
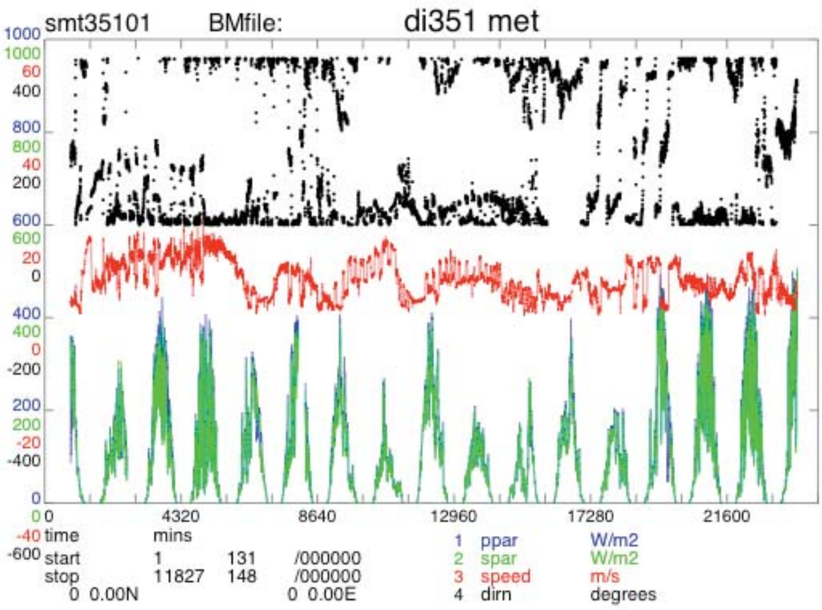


Figure 15. Meteorological conditions during *RRS Discovery* cruise 351 (stir, ptir – starboard, port total irradiance, airpres – atmospheric air pressure).

Figure 16. Wind speed and direction during *RRS Discovery* cruise 351 (ppar, spar – port, starboard photosynthetically active radiation, speed, dirn – wind speed and direction).



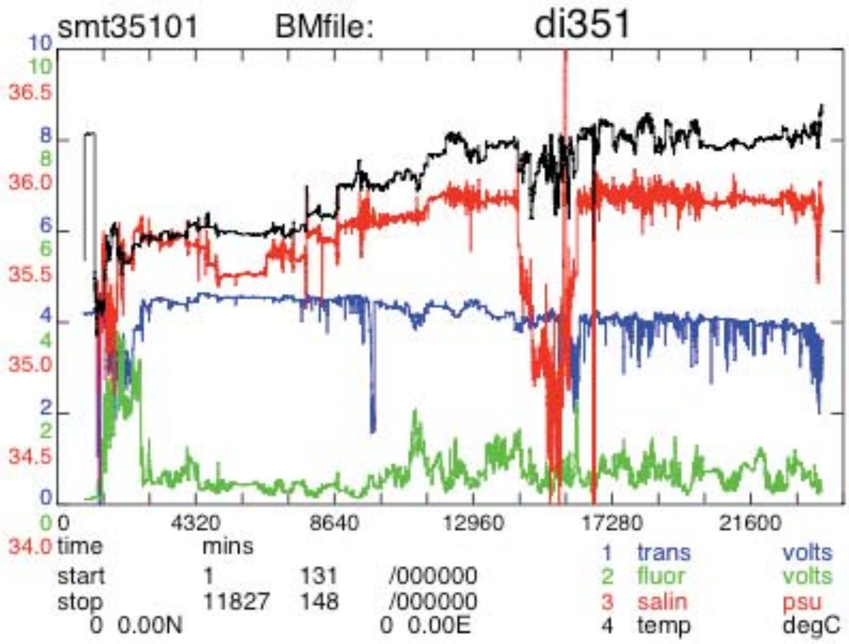


Figure 17. Surface water conditions as measured by the thermosalinograph during *RRS Discovery* cruise 351 (trans – transmittance, fluor – fluorescence, salin – salinity, temp – temperature).

Salinity Bottle Samples – *John Allen, Charlotte Marcinko, Stuart Painter, Helen Griffin, Helen Smith, Jeff Benson*

Salinity samples were drawn from the Niskin bottles mounted on the CTD rosette from a selection of depths spanning the salinity range and wherever 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 and every hour during SeaSoar surveys to calibrate the continual TSG measurements.

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

The salinometer acted rather erratically for much of the cruise. In general it was difficult to standardise, the first reading or two were often erroneous, eventually we learned to ignore such readings and restart the software once the instrument had stabilised. In addition the operation of the range knob did not seamlessly transition between the bottom of one range and the top of another or vice versa, with a significant fraction of a second required to get stability, as a result, any sample near the range boundary at ~ 35.0 could not be determined with the autosal/NMEP software. Our subsequent conclusions were that the salinometer sample data may only have been good to the 0.001 salinity units level. Occasional poor sampling, *i.e.*

salt in the bottle caps, bottles being overfilled etc. was experienced, but overall standards were high for a multidisciplinary cruise.

The results from the salinometer processing 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. After merging with the CTD data, the salinity samples were used to calibrate the CTD sensors (see CTD Data Acquisition section).

Dissolved Oxygen Analysis - *Cynthia Dumousseaud, Debbie Hembury, Helen Smith*

Cruise objectives

The objective of the dissolved oxygen analysis was to provide a calibration data set for the oxygen sensor mounted on the frame of the CTD for cruise D351, the Extended Ellet line, to the Iceland Basin in the North Atlantic. For this, a Winkler titration with amperometric end point detection was performed on a number of water samples drawn from the Niskin bottles mounted on the CTD frame.

Methods

Dissolved oxygen samples were taken from both the Stainless Steel and the Titanium CTD. Oxygen samples were the first samples to be drawn from the Niskin bottles. The samples were drawn through short pieces of silicon tubing into clear, pre-calibrated, wide-necked glass bottles. The temperature of the water sample at the time of sampling was measured using an electronic thermometer probe. The temperature would be used to calculate any temperature dependant changes in the sample bottle volumes. Each of the samples was fixed immediately using 1ml of manganese chloride and 1ml of alkaline iodide. The samples were shaken thoroughly and left to settle for approximately thirty minutes before being shaken again. The samples were then left for at least an hour before analysis but all were analysed within twelve hours.

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

At the start of the cruise, 12th May 2010, the normality of the sodium thiosulphate titrant was checked using a potassium iodate standard. Sodium thiosulphate standardisation was carried out by adding the reagents in reverse order with a long stir in between and then 10ml of a 0.01N potassium iodate solution. The sample was then titrated and the volume of sodium thiosulphate required was noted. This was repeated six times until five measurements agreed to within 0.004ml of each other. The average of the best five titrations was used to calculate the amount of sodium thiosulphate. This standardisation was then used in the calculation of the final dissolved oxygen calculation. Due to the large number of oxygen samples, the manganese chloride, alkaline iodide reagents and sulphuric acid were replaced several times during the cruise (before station 018, before station 051, and before station 072. The thiosulphate solution was also replaced during the cruise just before station 036. The volumes of sodium thiosulphate required in this standardisation process can be seen in Table 1.

Reading	1	2	3	4	5	**Average**
Volumes used in average (001-035), ml	1.0220	1.0205	1.0200	1.0195	1.0215	**1.0207**
Volumes used in average (036-end), ml	1.0000	1.0040	1.0015	1.0050	1.0025	**1.0026**

Table 19. Sodium thiosulphate standardisation was performed at the start of the cruise, and again before station 036. Six measurements were carried out until 5 were within 0.005ml of each other. These were then averaged and this average was used in the calculation of the final oxygen concentration.

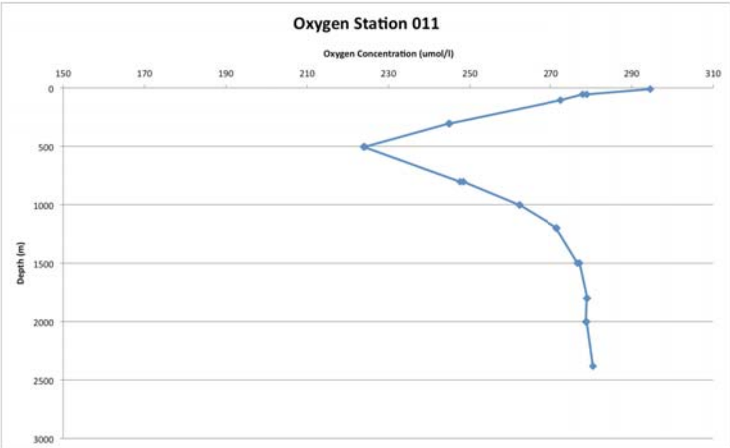
Blank date	Reading	A	B	C	**A – (Avg of B and C)**	**Avg of 1st, 2nd and 3rd readings**
12/05/10	1st	0.1065	0.1020	0.1025	0.0042	0.0032
	2nd	0.1040	0.1015	0.1010	0.0028	
	3rd	0.1035	0.1010	0.1010	0.0025	
17/05/10	1st	0.1015	0.0990	0.0820	0.0110	0.0052
	2nd	0.1030	0.1010	0.1000	0.0025	
	3rd	0.0985	0.0935	0.0995	0.0020	
19/05/10	1st	0.1025	0.1000	0.1000	0.0025	0.0029
	2nd	0.1030	0.1000	0.1000	0.0030	
	3rd	0.1030	0.0995	0.1000	0.0032	
21/05/10	1st	0.0955	0.0990	0.0985	-0.0033	0.0010
	2nd	0.1015	0.0990	0.0995	0.0023	
	3rd	0.1030	0.0990	0.0990	0.0040	

Table 20. A blank determination was performed at the start of the cruise and each time the reagents were replaced. Six measurements were carried out until 5 were within 0.002ml of each other. These were then averaged and this average was used in the calculation of the final oxygen concentration.

A blank was also carried out at the start of the cruise, on the 12th May 2010, and each time the reagents were replaced, to account for the oxygen in the reagents. The reagents were added in reverse order, as for the sodium thiosulphate standardisation, and then 1ml of the potassium iodate standard was added. This was titrated and the volume of sodium thiosulphate required was noted. 1ml was again added to the same sample and it was titrated again. This was repeated. The average of the second two volumes of sodium thiosulphate was subtracted from the first volume. This whole process was repeated four times in total until three blanks agreed within 0.002ml of each other. The average blank was taken of the best three values and used in the calculation of the final dissolved oxygen calculation. The volumes of sodium thiosulphate required in this blanking process can be seen in Table 2.

Preliminary Data

The data were collected and analysed on board. Some final quality controlling of the data set will be undertaken back at the NOC but preliminary profiles and calibration data can be shown. Figure 18 shows the profiles of oxygen concentration from the two of the deeper CTD casts.



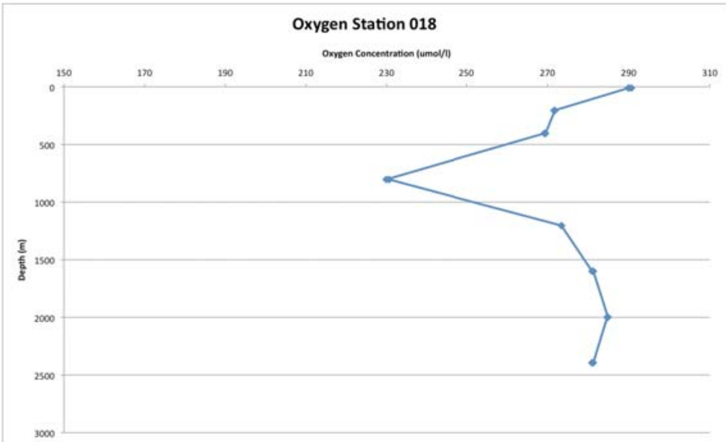


Figure 18. Oxygen profiles from CTD casts. Top: Titanium CTD cast at station 011 and bottom: stainless steel cast at station 018.

Oxygen sensor calibration

The oxygen data will be used to calibrate the oxygen sensor on the CTD. The preliminary data were collated and passed to Stuart Painter, who ran a regression of sensor data vs bottle data (Figure 19). This regression revealed some irregularities in the data set, which are detailed below.

During D351, two batches of thiosulphate and four batches of the other reagents (manganese chloride, alkaline iodide and sulphuric acid) were used. Details of reagent changes are as follows.

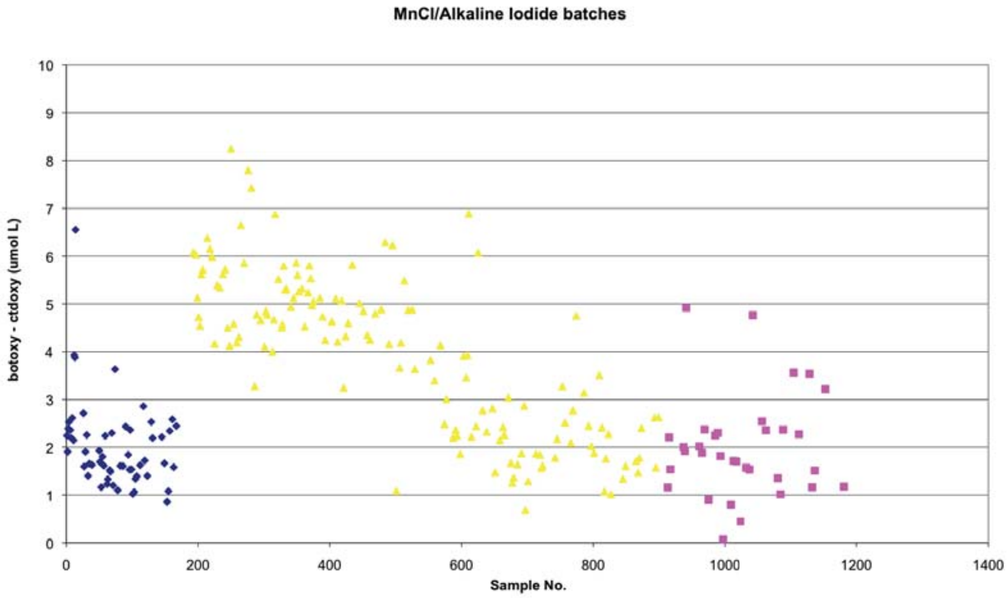


Figure 19. Difference between bottle oxygen and CTD oxygen data. Blue data are the first set of standardisation/blank determination. The blue diamonds denote the 1st set of reagents. At sample 200, manganese chloride, alkaline iodide and sulphuric acid were changed. At sample ~600 the sodium thiosulphate was changed. At sampled ~920 the manganese chloride and sulphuric acid were changed.

Between station 017 and 018 (sample number ~200), on the 17/05/10, the manganese chloride, alkaline iodide and sulphuric acid were changed and standardisation and blank determinations were conducted. Between stations 035 and 036 (sample number ~600), on the 19/05/10, the sodium thiosulphate was changed and both standardisation and blank determinations were performed. Between stations 050 and 051 (sample number ~920), on the 21/05/10, the manganese chloride and sulphuric acid were changed, and a standardisation and blank determination were conducted, but only the blank values were changed for calculations. Finally, after station 072, on the 25/05/10, the alkaline iodide was changed and a blank determination was conducted and changed for calculations.

Upon examination of the results, there is an offset in the correlation between the sensor and the bottle oxygen data after station 017 (Figure 2). The sodium thiosulphate was not changed at this point, however the other reagents were and therefore a new thiosulphate standard volume has been applied to the data. The sodium thiosulphate standard titre volume drops from 1.0207 to 1.0026 after station 017. This is perhaps surprising, considering that the sodium thiosulphate was not changed at this point. Applying this new value to oxygen concentration calculations, the sensor to bottle calibration offset increases by an average of approximately +3 µmol/L. If the sodium thiosulphate titre volume is not changed between station 017 and 018, bottle oxygen-CTD oxygen values are closer to (in fact slightly lower than) the preceding values (stations 001-017).

Further analysis and processing will be undertaken at NOC, Southampton.

Holley, S.E., Hydes, D.J., 1995. Procedures for the determination of dissolved oxygen in seawater. James Rennell Centre for Ocean Circulation, Internal Document No 20, 38pp (unpublished manuscript).

Inorganic Nutrient Analysis - *Cynthia Dumousseaud, Debbie Hembury, Helen Smith*

Cruise Objectives

Our objective on the Extended Ellett Line cruise (D351) in the North Atlantic was to measure the concentrations of the inorganic nutrients: nitrate, nitrite, silicate and phosphate using segmented flow analysis. Unfortunately, due to issues discussed later, water samples were only analysed for nitrate, nitrite and silicate. Additional samples were frozen for phosphate analysis back at the NOC.

Method

Analysis for micro-molar concentrations of nitrate and nitrite (hereinafter Total Oxidised Nitrogen or TON), and silicate was undertaken on a Skalar San+ segmented flow autoanalyser following methods described by Kirkwood (1996). Samples were drawn from Niskin bottles on the CTD into 25ml sterilin coulter counter vials and kept refrigerated at approximately 4°C until analysis, which commenced within twelve hours. Overall 21 runs were undertaken with approximately 900 samples analysed in total, 680 from CTD samples. 170 underway samples (TSG, DIC and tow fish) and 50 samples from on board experiments were analysed.

An artificial seawater matrix (ASW) of 40g/litre sodium chloride was used as the intersample wash and standard matrix. The nutrient free status of this solution was checked by running Ocean Scientific International (OSI) low nutrient seawater (LNS) on every run. A single set of mixed standards were made up by diluting 5 mM solutions made from weighed dried salts in 1 litre of ASW into plastic 1 litre volumetric flasks that had been cleaned by soaking in MQ water. The concentration of the standards was tested on every run by analysing diluted OSI certified standards, one low concentration sample (1.1µM for TON and silicate) and one high concentration sample (32.0µM for TON and silicate). Data processing was undertaken using Skalar proprietary software and was done within 24 hours of the run being finished. The wash time and sample time were 90 seconds; the lines were washed daily with 10% Decon (> 10 minutes) then MQ water (> 15 minutes).

Part way through the cruise the Milli-Q system failed to dispense water via the pump. The first batch collected manually was run through the autoanalyser to check if the production of Milli-Q was unaffected. The Milli-Q baselines for both silicate and nitrate displayed no additional noise than before the dispensing failure. Therefore the Milli-Q continued to be used for the rest of the cruise.

Performance of the Analyser

On the previous cruise (D350), a problem was found on detector one and samples for phosphate analysis were frozen for analysis back at NOC, while TON and silicate samples were analysed on board. A spare detector was brought for D351 but arrived too late to be installed on the system. As on D350 the samples for phosphate analysis were frozen for analysis back at NOC.

The software was reinstalled twice after the counter failed to start during analysis. If there was a communication issue between the computer and integrator, both were switched off for ~ 30 minutes. The integrator was then switched on at least 30 minutes before the computer. Occasionally the computer would crash during an analytical run, which required a complete re-run of the samples if the data had not been automatically saved.

The nitrate baseline was observed to drift upwards during some runs. The autoanalyser was cleaned thoroughly with 10% Decon (>30 mins), dilute NaOH (~10 mins) and finally Milli-Q (>30 mins) following the run. This appeared to reduce the drift in the nitrate baseline for the next few runs. This problem occurred more frequently towards the end of the cruise. The tubing in the pump was replaced for the nitrate line but the baseline still showed drift.

A new nitrite standard was made up at the beginning of the cruise to the specified concentration. However, the peak height did not correspond to the nitrate standard of similar concentration. Several nitrite standards were run, none of which were suitable for calculation of cadmium column efficiency. From run 11 onwards the correct concentration for nitrite was obtained.

A high noise level in both lines was observed during run 15. The artificial seawater used for the wash was replaced and noise levels returned to normal.

<u>Preliminary Data</u>

Data were processed during the cruise and the final quality checking of these data will take place back at the NOC over the coming months. There is only preliminary data to show here. The quality control process though is not expected to significantly change these numbers. Below are the depth distributions of TON and silicate from all the Ellett Line CTD casts (Figures 20 and 21).

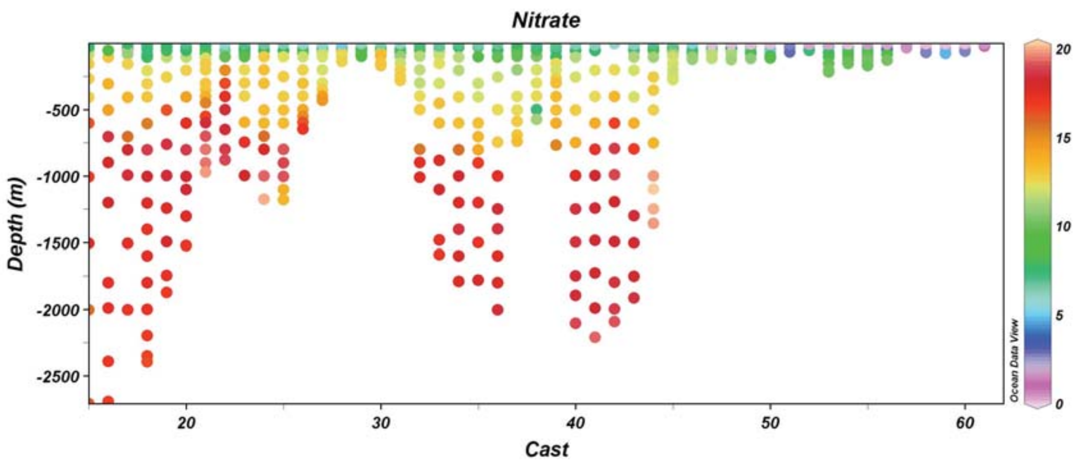


Figure 20. TON depth distributions (µmol l^{-1}) for stations 001 to 062.

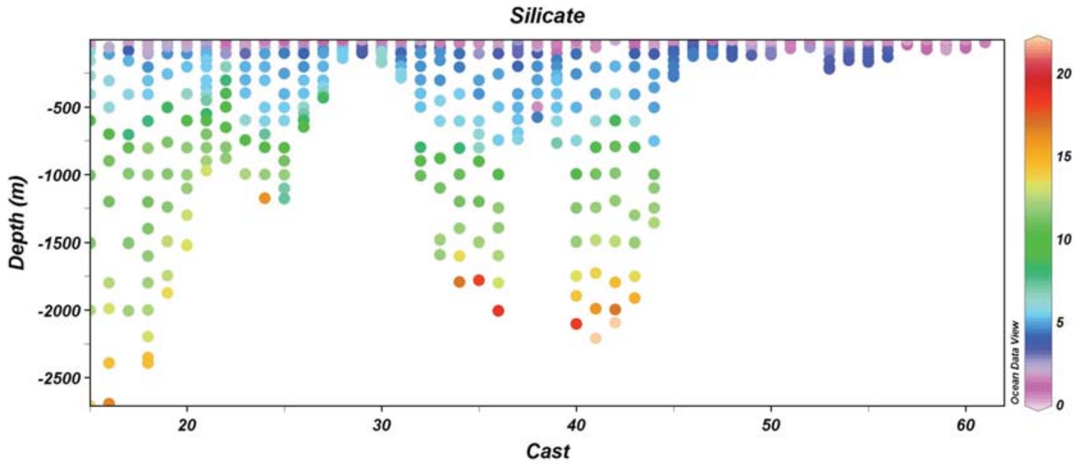


Figure 21. Silicate depth distributions (µmol l^{-1}) for stations 001 to 062.

Kirkwood, D.S., 1996. Nutrients: Practical notes on their determination in seawater. In: *ICES Techniques in Marine Environmental Sciences Report 17*, International Council for the Exploration of the Seas, Copenhagen, p.25.

Chlorophyll-a Sampling – *Colm Walsh*

Figure 22. Filtration apparatus.

Two or three samples of water for Chlorophyll analysis were collected from depths of between 100 and 5 metres by the CTD at every station. Samples were collected in brown bottles in order to avoid photo-degradation of the sample. Samples were also collected from the underway trace metal sampler and from 48hr microzooplankton grazing bioassay incubations (see microzooplankton grazing section) from time to time. Then 250ml of each sample was measured using a volumetric cylinder and placed into the vacuum filter and filtered through a 25mm GF/F filter paper. Following filtration the filter papers were placed in a numbered vial and 8ml of 90% acetone was added. The samples were then placed in the fridge overnight between 18 and 24 hours in order to allow time for the acetone to separate the chlorophyll from the filter paper, the fridge was also dark to avoid photo-degradation. Note was taken in the log of sampling time, time placed in the fridge, vial number, volume filtered and volume of acetone added.

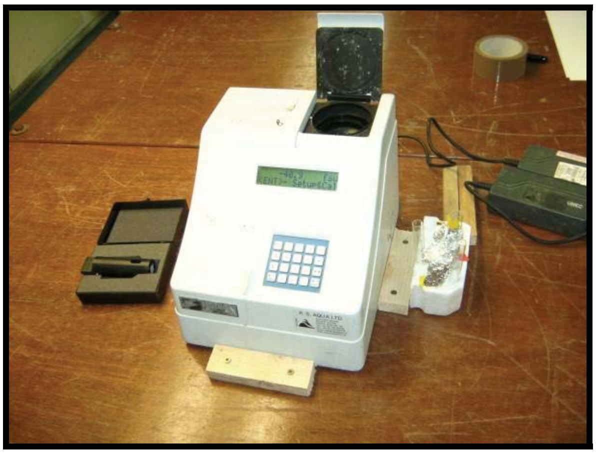


Figure 23. Turner Designs Fluorometer TD-700.

After approximately 24hrs, samples were taken from the fridge for processing using a fluorometer (Turner Designs TD–700). Note was taken in the log of the base reading from the machine before processing. A test tube was filled with 8ml acetone and placed in the fluorometer in order to provide a blank reading, then a solid-read standard was placed in the machine and a high and low reading was taken. After these were all noted in the log the samples were processed. The contents of each vial were placed into a test tube and placed in the fluorometer and the reading taken and noted in the log. After a group of samples were processed, note was again taken of the base reading, the blank acetone reading and the high and low readings of the Solid-Red standard. This was done in order to record the drift in the readings before and after sampling. At some stations chlorophyll readings were over-range therefore samples had to be diluted x4. Towards the end of the cruise we ran out of acetone so the remaining samples were frozen for future analysis.

Vertical and Horizontal Distributions of Dinoflagellate Bioluminescence –
Charlotte Marcinko, Stuart Painter, Helen Griffin

<u>Background and Objectives</u>

The objectives of the D351 study were to (1) undertake nightly profiles of bioluminescence in the upper water column; (2) carry out incubation experiments to identify whether night-time bioluminescence varied with daytime light exposure; (3) characterise the taxonomic composition of bioluminescent dinoflagellates samples used in the incubation experiment(s).

Nightly profiles were designed to examine the horizontal and vertical distribution of bioluminescent dinoflagellates in the water column. Surface and subsurface measurements taken as part of these profiles can be combined with environmental parameters gained from the corresponding CTD casts to investigate relationships between bioluminescence and other physical/chemical/biological variables. Incubation experiments were designed to investigate what affect different levels of daytime light exposure may have upon night time bioluminescence.

<u>Instrument description</u>

Measurements of stimulated bioluminescence were taken using a GLOWtracka bathyphotometer manufactured by the Chelsea Technologies Group, which has been modified for bench top use. This instrument is designed to provide measurements of stimulated bioluminescence, at a frequency of 1 kHz, from a constant flow of water. The voltage potential recorded can then be converted into units of photons cm^{-2} sec^{-1} using a set calibration equation provided by the manufacturers. Specifically this apparatus was setup in such a way as to maximise the recording of light emission from any bioluminescent dinoflagellate species that may have been present in a water sample. All data from the instrument were recorded using Agilent VEE release 8.5 software and stored in a comma-separated numbers (.csv) format. Data were stored using a standard file naming convention as follows 'stationzzzctdxxx_ddm_yyyyyyy_tttttttt.csv' where 'zzz' was the station number and 'xxx' the ctd cast, followed by 'dd' which represented the depth of the sample. 'yyyyyyy' and 'tttttttt' are the date and time stamp added automatically when the sample is run.

Profile Sampling Strategy

Samples for stimulated bioluminescence measurements were taken from evening CTD casts between Julian day 132 and 141 (Table 18). Two litres of water were collected in blacked out carboys from five depths (5m, 25m, 40m, 55m and 75m) for each cast sampled. Samples were measured for bioluminescence using the GlowTracka bathyphotometer, described above, between the hours of 23:00 and 03:00 GMT. The only exception to this was at station 4 where instrument failure prevented samples being run in this time window. If samples were collected prior to 23:00 GMT they were stored in the blacked out carboys at a constant temperature of 10˚ C, representative of surface water temperatures. Samples for microscopy were preserved in a 2 % lugols solution from station 37.

Table 21. Overview of sampling information for bioluminescent measurements

Station no.	CDT Cast	Julian Day	Depth (m)	CTD On Deck Time (GMT)	Sample run Time (GMT)	Bottle Number
4	4	132	5	23:12:00	14:40:00	24
4	4	132	25	23:12:00	17:26:00	22
4	4	132	40	23:12:00	17:41:00	20
4	4	132	55	23:12:00	17:51:00	18
4	4	132	75	23:12:00	18:02:00	16
8	8	133	5	23:05:00	23:54:00	24
8	8	133	25	23:05:00	00:05:00	20
8	8	133	40	23:05:00	00:15:00	18
8	8	133	55	23:05:00	00:26:00	16
8	8	133	75	23:05:00	00:35:00	14
14	14	135	5	00:56:00	01:57:00	12
14	14	135	25	00:56:00	02:08:00	11
14	14	135	40	00:56:00	02:18:00	10
14	14	135	55	00:56:00	02:26:00	9
14	14	135	75	00:56:00	02:37:00	8
17	17	136	5	23:36:00	00:20:00	1
17	17	136	25	23:36:00	00:29:00	2
17	17	136	40	23:36:00	00:37:00	3
17	17	136	55	23:36:00	00:46:00	4

17	17	136	75	23:36:00	00:54:00	5
23	23	137	5	22:23:00	23:12:00	1
23	23	137	25	22:23:00	23:20:00	2
23	23	137	40	22:23:00	23:28:00	3
23	23	137	55	22:23:00	23:37:00	4
23	23	137	75	22:23:00	23:45:00	5
29	29	138	5	19:56:00	23:06:00	21
29	29	138	25	19:56:00	23:50:00	17
29	29	138	40	19:56:00	23:58:00	15
29	29	138	55	19:56:00	00:06:00	12
29	29	138	75	19:56:00	00:51:00	7
37	37	139	5	21:55:00	23:34:00	24
37	37	139	25	21:55:00	23:42:00	22
37	37	139	40	21:55:00	23:49:00	20
37	37	139	55	21:55:00	23:57:00	18
37	37	139	75	21:55:00	00:05:00	16
45	45	140	5	20:55:00	23:13:00	24
45	45	140	25	20:55:00	23:20:00	18
45	45	140	40	20:55:00	23:29:00	17
45	45	140	55	20:55:00	23:36:00	15
45	45	140	75	20:55:00	23:44:00	13
62	62	141	5	19:50:00	23:47:00	22
62	62	141	25	19:50:00	23:54:00	18
62	62	141	40	19:50:00	00:02:00	14
62	62	141	55	19:50:00	00:10:00	11
62	62	141	75	19:50:00	00:48:00	5

Incubation Experiments

Incubation experiments were carried out at stations 22 (Table 19) and 45 (Table 20). Experiment methodology was as follows. Sixty four litres of surface water from 7 m depth were collected and evenly distributed into eight polycarbonate bottles of eight litre volume. Bottles were then split into groups of two and each group placed into one of four simulated in situ incubators. Incubators were covered with optical filters in order to restrict light to ~ 55, 33, 7 and 1% of the ambient light level (Table 21). Samples were incubated from collection time through to the following evening. Two litre sub-samples were then run from each light level hourly between 21:00 GMT to 03:00 GMT, ensuring the maximum bioluminescence peak was captured. Samples for microscopy were preserved in a 2 % lugols solution at the beginning and end of each incubation experiment.

Table 22. Overview of sampling information for incubation experiment 1

Station number	Cast Number	Day of Year (Cast)	CTD Deck Time (GMT)	Day of Year (Sample run)	Sample run Time (GMT)	Light Intensity (%)	Bottle Numbers
22	22	137	19:32	138	21:42:00	1	21 – 24
22	22	137	19:32	138	22:44:00	1	21 – 24
22	22	137	19:32	138	23:41:00	1	21 – 24

22	22	137	19:32	139	00:41:00	1	21 – 24
22	22	137	19:32	139	01:42:00	1	21 – 24
22	22	137	19:32	139	02:41:00	1	21 – 24
22	22	137	19:32	139	03:44:00	1	21 – 24
22	22	137	19:32	138	21:33:00	7	21 – 24
22	22	137	19:32	138	22:34:00	7	21 – 24
22	22	137	19:32	138	23:33:00	7	21 – 24
22	22	137	19:32	139	00:33:00	7	21 – 24
22	22	137	19:32	139	01:34:00	7	21 – 24
22	22	137	19:32	139	02:33:00	7	21 – 24
22	22	137	19:32	139	03:36:00	7	21 – 24
22	22	137	19:32	138	21:25:00	33	21 – 24
22	22	137	19:32	138	22:25:00	33	21 – 24
22	22	137	19:32	138	23:24:00	33	21 – 24
22	22	137	19:32	139	00:25:00	33	21 – 24
22	22	137	19:32	139	01:25:00	33	21 – 24
22	22	137	19:32	139	02:25:00	33	21 – 24
22	22	137	19:32	139	03:27:00	33	21 – 24
22	22	137	19:32	138	21:15:00	55	21 – 24
22	22	137	19:32	138	22:16:00	55	21 – 24
22	22	137	19:32	138	23:16:00	55	21 – 24
22	22	137	19:32	139	00:16:00	55	21 – 24
22	22	137	19:32	139	01:17:00	55	21 – 24
22	22	137	19:32	139	02:17:00	55	21 – 24
22	22	137	19:32	139	03:18:00	55	21 – 24

Table 23. Overview of sampling information for incubation experiment 2

Station number	Cast Number	Day of Year (Cast)	CTD Deck Time (GMT)	Day of Year (Sample run)	Sample run Time (GMT)	Light Intensity (%)	Bottle Numbers
45	45	141	20:55	142	21:38:00	1	21 – 24
45	45	141	20:55	142	22:38:00	1	21 – 24
45	45	141	20:55	142	23:38:00	1	21 – 24
45	45	141	20:55	143	00:39:00	1	21 – 24
45	45	141	20:55	143	01:38:00	1	21 – 24
45	45	141	20:55	143	02:36:00	1	21 – 24
45	45	141	20:55	143	03:41:00	1	21 – 24
45	45	141	20:55	142	21:29:00	7	21 – 24
45	45	141	20:55	142	22:30:00	7	21 – 24
45	45	141	20:55	142	23:29:00	7	21 – 24
45	45	141	20:55	143	00:32:00	7	21 – 24
45	45	141	20:55	143	01:30:00	7	21 – 24
45	45	141	20:55	143	02:28:00	7	21 – 24
45	45	141	20:55	143	03:33:00	7	21 – 24
45	45	141	20:55	142	21:21:00	33	21 – 24
45	45	141	20:55	142	22:22:00	33	21 – 24
45	45	141	20:55	142	23:21:00	33	21 – 24

45	45	141	20:55	143	00:25:00	33	21 – 24
45	45	141	20:55	143	01:23:00	33	21 – 24
45	45	141	20:55	143	02:21:00	33	21 – 24
45	45	141	20:55	143	03:25:00	33	21 – 24
45	45	141	20:55	142	21:13:00	55	21 – 24
45	45	141	20:55	142	22:14:00	55	21 – 24
45	45	141	20:55	142	23:13:00	55	21 – 24
45	45	141	20:55	143	00:17:00	55	21 – 24
45	45	141	20:55	143	01:15:00	55	21 – 24
45	45	141	20:55	143	02:13:00	55	21 – 24
45	45	141	20:55	143	03:17:00	55	21 – 24

Table 24: Light filter covers for Incubation experiments at stations 22 and 45.

	Layers of Light Filter		
Approximate Light Level (%)	Misty Blue	Neutral Grey	Lagoon Blue
1	3	2	0
7	2	1	0
33	0	0	2
55	1	0	0

Bioluminescence Data Processing

Processing and analysis of all these data will be carried out in the near future at the National Oceanography Centre, Southampton, UK, using custom based scripts written in MatLab.

Cellulose Nitrate (CN) Filters for Coccolithophore Counts – *Stuart Painter, Helen Griffin (PI: Alex Poulton)*

Samples were collected for the determination of coccolithophore cell numbers, species identification and determination of coccolithophore cell calcite by scanning electron microscopy.

Surface and when possible sub-surface water was collected from the CTD in blacked out carboys. Samples were taken when time permitted, with a minimum of one a day. One litre per sample was filtered through a 0.45-mm cellulose nitrate filter, oven dried at 30°C for ~24 hrs and stored in petri-slides; n = 71. When productivity was exceptionally high, the sample size was reduced to 0.5 litres.

Table 25. Overview of stations, Niskin bottles and sample depths for scanning electron microscopy

Date	Time CTD on deck (GMT)	Sample no.	Station no.	Ellet Line station no.	Niskin	Depth (m)	sample volume (litres)
05/12/10	9:45	1	CTDS001	IB22S	20	13	1
05/12/10	18:45	2	CTDS002	IB21S	23	13	1
05/13/10	4:00	3	CTDS004	IB19S	23	8	1
05/13/10	9:01	4	CTDS006	IB18S	24	11	1

05/13/10	9:01	5	CTDS006	IB18S	22	56	1
05/14/10	4:10	6	CTD009S	IB16	23	13	1
05/14/10	4:10	7	CTD009S	IB16	21	37	1
05/14/10	9:38	8	CTD010S	IB15	24	5	1
05/14/10	9:38	9	CTD010S	IB15	22	56	1
05/15/10	11:10	10	CTD011T	IB14	24	11	1
05/15/10	11:10	11	CTD011T	IB14	23	56	1
05/15/10	15:31	12	CTD012T	IB13A	18	30	1
05/15/10	15:31	13	CTD012T	IB13A	24	9	1
05/15/10	20:53	14	CTD013T	IB13	24	6	1
05/15/10	20:53	15	CTD013T	IB13	23	36	1
05/16/10	1:20	16	CTD014T	IB12A	12	5	1
05/16/10	1:20	17	CTD014T	IB12A	10	40	1
05/16/10	5:45	18	CTD015T	IB12	1	27	1
05/16/10	5:45	19	CTD015T	IB12	2	47	1
05/16/10	15:43	20	CTD016T	IB11A	23	56	1
05/17/10	5:15	21	CTD018S	IB10	21	46	1
05/17/10	5:15	22	CTD018S	IB10	24	5	1
05/17/10	8:37	23	CTD019S	IB09	24	9	1
05/17/10	8:37	24	CTD019S	IB09	22	29	1
05/17/10	8:37	25	CTD019S	IB09	24	9	1
05/17/10	8:37	26	CTD019S	IB09	22	29	1
05/17/10	16:00	27	CTD021S	IB7	24	7	1
05/17/10	16:00	28	CTD021S	IB7	19	52	1
05/17/10	19:45	29	CTD022S	IB6	18	50	1
05/17/10	23:05	30	CTD023T	IB5	1	7	1
05/17/10	23:05	31	CTD023T	IB5	3	42	1
05/18/10	6:00	32	CTD025S	IB3	22	54	1
05/18/10	6:00	33	CTD025S	IB3	24	7	1
05/18/10	9:55	34	CTD026S	IB7	23	27	1
05/18/10	9:55	35	CTD026S	IB7	22	9	1
05/18/10	9:55	36	CTD027S	IB2	22	27	1
05/18/10	18:15	37	CTD027S	IB2	23	7	1
05/18/10	18:15	38	CTD028S	IB1	12	50	1
05/18/10	18:15	39	CTD028S	IB1	20	5	1
05/18/10	20:00	40	CTD029S	A	22	5	1
05/18/10	20:00	41	CTD029S	A	16	40	1
05/19/10	13:00	42	CTD034S	F	24	8	1
05/19/10	13:00	43	CTD034S	F	22	55	1
05/19/10	13:00	44	CTD034S	F	24	8	1
05/19/10	13:00	45	CTD034S	F	22	58	1
05/19/10	16:11	46	CTD035S	G	21	28	1
05/19/10	16:11	47	CTD035S	G	24	9	1
05/19/10	19:30	48	CTD036S	H	24	6	1
05/19/10	19:30	49	CTD036S	H	22	54	1
05/19/10	22:00	50	CTD037S	I	24	5	1
05/19/10	22:00	51	CTD037S	I	22	25	1
05/20/10	6:00	52	CTD040S	L	22	56	1
05/20/10	6:00	53	CTD040S	L	23	10	1
05/20/10	9:30	54	CTD041S	M	24	12	1
05/20/10	9:30	55	CTD041S	M	22	56	1
05/20/10	16:30	56	CTD043S	O	20	54	1
05/20/10	16:30	57	CTD043S	O	24	9	1
05/20/10	19:10	58	CTD044S	P	20	56	1
05/20/10	19:10	59	CTD044S	P	24	6	1
05/20/10	20:19	60	CTD045S	Q	20	5	1
05/20/10	20:19	61	CTD045S	Q	16	40	1
05/21/10	4:55	62	CTD050S	13G	22	3	0.5

05/21/10	4:55	63	CTD050S	13G	14	48	0.5
05/21/10	6:20	64	CTD051S	12G	22	9	0.5
05/21/10	7:45	65	CTD052S	11G	22	8	0.5
05/21/10	9:22	66	CTD053S	10G	23	7	0.5
05/21/10	09:13	67	CTD053S	10G	20	26	0.5
05/21/10	16:45	68	CTD059S	4G	22	3	0.5
05/21/10	17:45	69	CTD069S	3G	22	3	0.5
05/21/10	18:40	70	CTD061S	2G	15	3	0.5
05/21/10	19:50	71	CTD062S	1G	22	7	0.5

Trace metal distribution in the water column - *Sebastian Steigenberger, Jessica Klar (PI: Eric Achterberg)*

Introduction

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

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

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

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

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

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

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

Methods

Sampling – Water column samples were collected at selected CTD stations along the transect using the titanium-frame CTD, which was fitted with trace metal clean 10L OTE (Ocean Technology Equipment) sampling bottles with external springs, modified for trace metal work. At these stations samples were collected at up to 12 depths. The trace metal clean OTE sample bottles were then transferred to a clean van on the back deck for sample processing. In addition, underway samples were collected along the transect using a towfish deployed off the port side of the ship. Near-surface seawater (~2 metre depth) was pumped into the clean van using a teflon diaphragm pump connected to clean oilfree compressed air compressor and samples collected every one to two hours while the ship was in transit. On the seamount Anton Dohrn (57.45ºN, 11.08ºW) SeaSoar survey underway samples were taken every three hours.

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

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

<u>Results</u>

Seven profiles were sampled (Fig. 24 and Table 23) from the Ti-frame CTD and 68 underway samples (U74-U140, Fig. 24 and Table 24) from the tow-fish. The data analysis for DAl and DFe, as well as further trace metal analysis will be done back home at NOCS (Southampton).

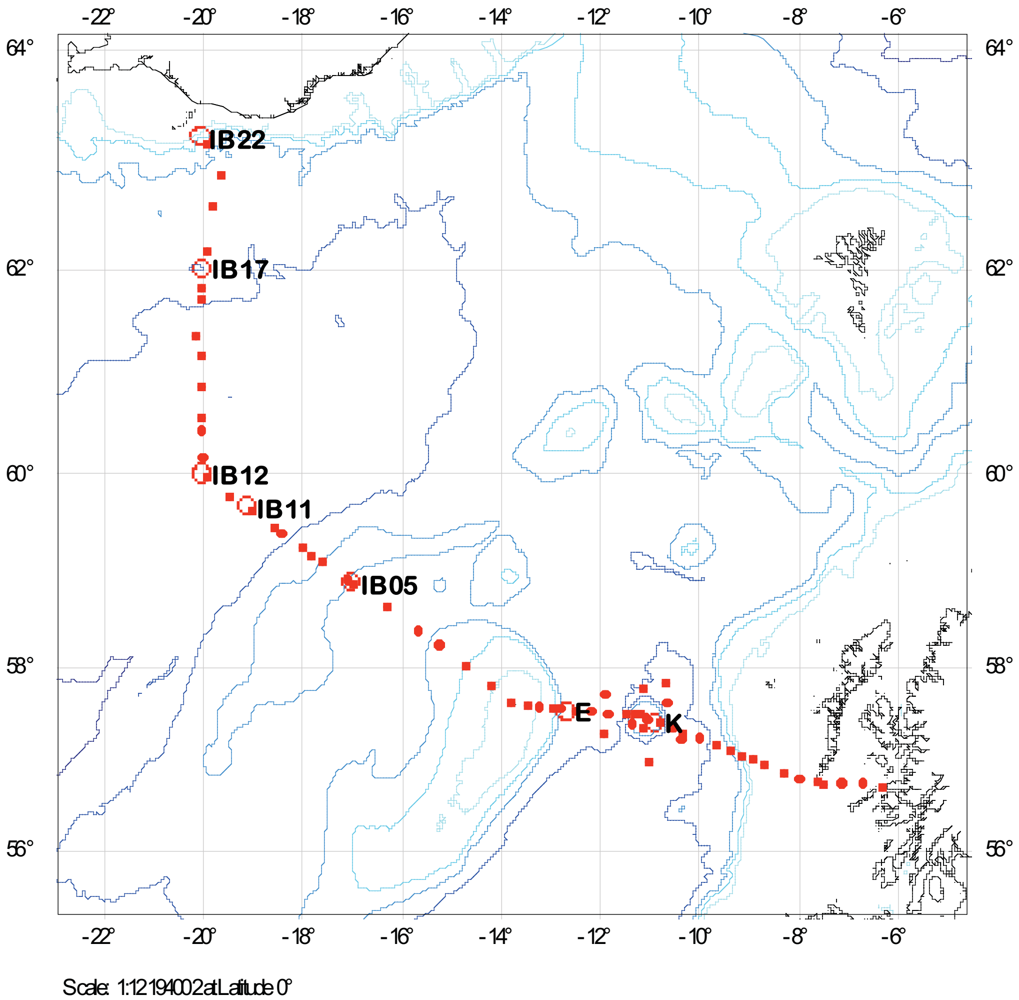


Figure 24. D351 cruise track, TiCTD casts shown as open circles, and the underway samples as filled circles.

Table 26. List of stations that were sampled for dissolved/total iron and aluminium

Date	Cast	Latitude (N)	Longitude (W)	Depths (m)
12/05/10	T001 (IB 22)	63°13.23	20°03.76	20, 30, 40, 100, 200, 350, 500, 650
13/05/10	T002 (IB 17)	61°59.86	20°00.63	20, 35, 55, 85, 150, 300, 500, 700, 890, 1100, 1400, 1800
16/05/10	015T (IB 12)	60°00.03	19°59.95	20, 40, 60, 80, 150, 260, 400, 600, 1000, 1500, 2000, 2700
16/05/10	017T (IB 11)	59°40.03	19°07.11	20, 40, 55, 75, 150, 400, 700, 800, 1000, 1500, 2000, 2665
17/05/10	023T (IB 5)	58°53.09	17°01.23	20, 40, 55, 75, 100, 200, 300, 400, 600, 750, 1000, 1135
19/05/10	033T (E)	57°31.23	12°40.09	20, 40, 60, 90, 150, 300, 450, 600, 880, 1100, 1980, 1588
20/05/10	039T (K)	57°23.80	10°52.22	20, 30, 50, 100, 150, 200, 260, 300, 400, 500, 600, 770

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Table 27. Underway sampling times and positions for total/dissolved iron and aluminium, nitrates, phosphates and chlorophyll

Underway Sample	Date	hour (GMT)	latitude (N)	longitude (W)
074	12/05/2010	15:44	63.1444	-19.9319
075	12/05/2010	17:09	63.1346	-19.9141
076	12/05/2010	23:33	62.8701	-19.5821
077	13/05/2010	04:59	62.5763	-19.8032
078	13/05/2010	09:56	62.3002	-19.8924
079	13/05/2010	11:09	62.1636	-19.9111
080	13/05/2010	20:06	61.8138	-20.0174
081	14/05/2010	00:01	61.7175	-20.0129
082	14/05/2010	06:08	61.3580	-20.1055
083	14/05/2010	10:43	61.1778	-20.0025
084	15/05/2010	12:15	60.8591	-20.0158
085	15/05/2010	16:39	60.5581	-19.9923
086	15/05/2010	20:25	60.4373	-19.9893
087	16/05/2010	01:44	60.1545	-19.9843
088	16/05/2010	09:07	59.9615	-19.9075
089	16/05/2010	15:23	59.7736	-19.4590
090	17/05/2010	00:25	59.6189	-19.0366
091	17/05/2010	02:05	59.4518	-18.5394
092	17/05/2010	05:39	59.3980	-18.4016
093	17/05/2010	09:46	59.2403	-17.9965
094	17/05/2010	13:34	59.1655	-17.7856
095	17/05/2010	16:29	59.0906	-17.5827
096	17/05/2010	20:14	58.9069	-17.0739
097	17/05/2010	22:43	58.8729	-16.9430
098	18/05/2010	02:54	58.6234	-16.3027
099	18/05/2010	07:14	58.3764	-15.6580
100	18/05/2010	10:28	58.2191	-15.2133
101	18/05/2010	12:31	58.0017	-14.7116
102	18/05/2010	15:59	57.7894	-14.1980
103	18/05/2010	18:35	57.6061	-13.7768
104	18/05/2010	20:37	57.5709	-13.4492
105	18/05/2010	22:11	57.5604	-13.2441
106	19/05/2010	00:04	57.5536	-12.9503
107	19/05/2010	02:23	57.5393	-12.7915
108	19/05/2010	09:28	57.5167	-12.4813
109	19/05/2010	12:47	57.5201	-12.1699
110	19/05/2010	16:11	57.4946	-11.8305
111	19/05/2010	19:54	57.4788	-11.4615
112	19/05/2010	22:10	57.4730	-11.2839
113	20/05/2010	00:13	57.4411	-11.0453
114	20/05/2010	02:55	57.3781	-10.7581
115	20/05/2010	06:37	57.3303	-10.5231
116	20/05/2010	09:46	57.2681	-10.3177
117	20/05/2010	13:13	57.2273	-9.9804
118	20/05/2010	16:37	57.1389	-9.6380
119	20/05/2010	19:26	57.0845	-9.3484
120	20/05/2010	21:10	57.0348	-9.1446
121	20/05/2010	22:40	56.9837	-8.9286
122	21/05/2010	00:06	56.9314	-8.7060
123	21/05/2010	02:19	56.8345	-8.2665
124	21/05/2010	05:07	56.7798	-7.9665
125	21/05/2010	07:56	56.7330	-7.6173
126	21/05/2010	09:29	56.7246	-7.4671
127	21/05/2010	12:13	56.7314	-7.1280
128	21/05/2010	14:52	56.7309	-6.6914
129	21/05/2010	20:17	56.6808	-6.2595
130	22/05/2010	16:07	57.4668	-11.1349
131	22/05/2010	19:00	57.6855	-11.8534
132	22/05/2010	22:00	57.2715	-11.8997
133	23/05/2010	00:59	57.3710	-11.3451
134	23/05/2010	04:02	57.5896	-10.6329
135	23/05/2010	06:56	57.8061	-10.6478
136	23/05/2010	10:04	57.7578	-11.0830
137	23/05/2010	12:55	57.3376	-11.0804
138	23/05/2010	15:55	56.9548	-11.0132
139	23/05/2010	19:02	57.2049	-10.3212
140	23/05/2010	22:03	57.4246	-11.0006

Dissolved Manganese Sampling - *Farah Idrus*

Introduction

Manganese is a key element in photosynthesis (Sunda *et al.,* 1983; Peers and Price, 2004), and also involved through redox processes (Sunda and Huntsman, 1988) in cycles of many elements in oceanic waters. It is also a good tracer of atmospheric and terrestrial inputs. In addition, the recent volcanic eruption in Iceland could supply a massive atmospheric input of manganese from the volcanic ash plume. Manganese can be dissolved from volcanic ash dust and thus may be a useful indicator of volcanic dust inputs to the surface ocean. The general aim of this cruise was to improve the knowledge of the clean sampling of manganese and other trace metals onboard ship.

Method

Sampling – Low Density Poly Ethylene (LDPE) bottles (Nalgene, Fisher Scientific UK) were used for the storage of the seawater samples for Mn analysis, which have been thoroughly acid-washed. Water column samples were collected at four selected CTD stations along the transect using the titanium-frame CTD, which was fitted with trace metal clean 10L OTE (Ocean Technology Equipment) sampling bottles with external springs, modified for trace metal work. At these stations LDPE sample bottles were used to collect seawater samples at up to twelve depths, depending on water depth at each station. The trace metal sample bottles were then transferred to a clean van on the back deck for sample processing. The underway surface sampling was conducted every one to two hours during transit between stations along transect. However, only six samples of underway samples were collected during this cruise for manganese analysis. This was done with a towfish deployed off the port side of the ship. Water was pumped into the clean van with a diaphragm pump connected to the ship's compressed air.

Sample processing – Filtered samples were collected (for dissolved manganese) in 1L Nalgene LDPE bottles from the titanium frame rosette bottles. Filtered samples were collected through a Sartobran 300 MF 0.2mm filter cartridge under slight positive pressure (oxygen-free N_2). Underway samples were also collected in 1L Nalgene LDPE bottles, using a Sartobran 300MF 0.2mm filter cartridge. All water samples were acidified to pH~2 with 1mL Hydrochloric acid per 1L seawater sample (Romil UpA) within 24 hours of collection. These were carried out on a laminar flow clean bench to minimise the risk of contamination.

Data analysis – Samples from underway and vertical profiles are to be analysed using a flow injection system that was set up in the laboratory at the NOCS. The method is based on a flow injection analysis (FIA) chemiluminescene technique (Doi *et al.*, 2004) where manganese catalyses the peroxide oxidation of luminol in the presence of hydroxide salt as an activator. However, the method as used here has some important modifications, including using a commercially available complexing resin, Toyopearl AF Chelate-650M to preconcentrate the manganese, and using the nitrilotriacetic acid (NTA) to remove interfering iron ions in the carrier solution.

Results

Four profiles were sampled (see Figure 25 and Table 25) from the Ti-frame CTD and 6 underway samples (Figure 25 and Table 26) from the tow-fish. The samples will be analysed in the lab at NOCS (Southampton).

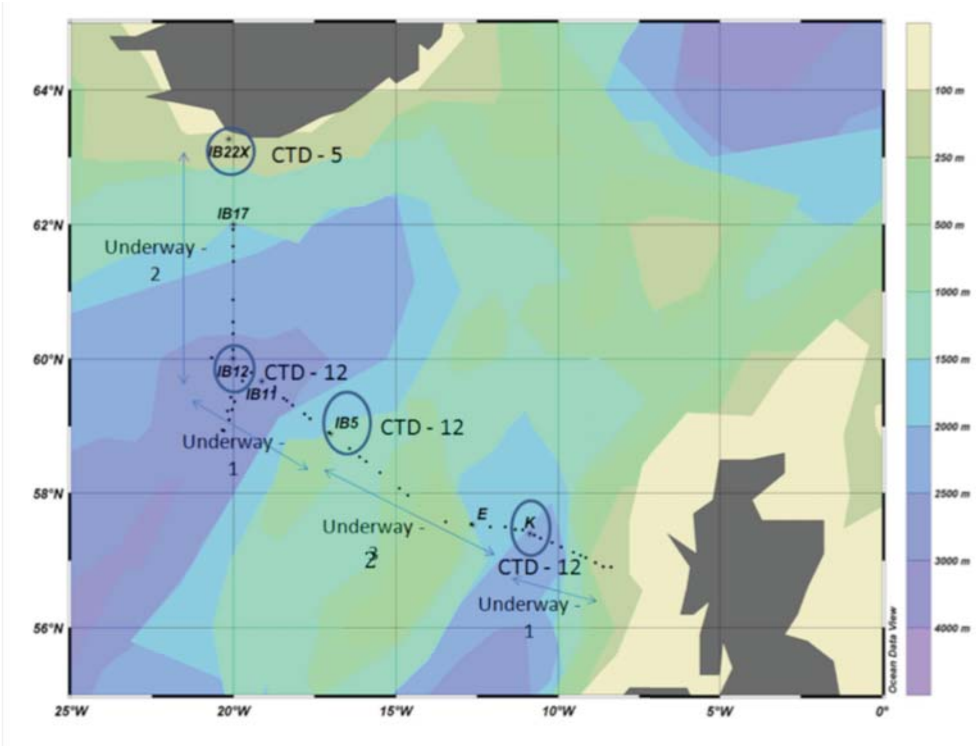

Figure 25. Cruise track with positions of Ti-frame CTDs and underway samples. Blue circles are the sampling stations for CTDs and numbers indicate the samples taken at each station.

Table 28. List of stations sampled for vertical profiles of dissolved manganese

Date	Time in water (GMT)	Station	Latitude (North)	Longitude (West)	Depths (m)
12/05/10	10:59	IB22X	63°13.132	20°03.760	22, 32, 42, 102, 201, 351, 500, 653
16/05/10	03:00	IB12	60°00.280	19°59.873	27, 47, 62, 88, 158, 268, 406, 606, 1007, 1507, 2004, 2709
17/05/10	20:13	IB5	58°53.174	17°01.214	22, 42, 57, 77, 103, 202, 300, 397, 597, 746, 998, 1135
20/05/10	01:10	K	57°23.799	10°52.223	22, 32, 53, 103, 152, 202, 262, 302, 402, 501

Table 29. List of stations sampled for underway dissolved manganese

Date	Time (GMT)	Station	Latitude (North)	Longitude (West)
12/05/10	17:24	U75	63°13.132	20°03.760
15/05/10	12:43	U84	60°59.965	20°00.524
17/05/10	09:45	U93	59°20.028	18°14.412
18/05/10	07:19	U99	59°30.055	15°58.911
18/05/10	22:34	U105	57°33.840	13°20.250
21/05/10	20:11	U129	56°40.085	06°08.130

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Sampling the Volcanic Plume from Eyjafjallajökull: Lead Isotope Analysis -
Michael Cassidy, Deborah Hembury

Samples were taken throughout D351 for Pb isotope analysis. Whilst underway, two 1 Litre seawater samples (one 0.2µm polycarbonate filtered, one unfiltered) were taken from the towed fish water supply in the clean lab to analyse for Pb isotopes. This was conducted to assess the volcanic input into the ocean. Pb isotopes serve as a good determinant for the presence of fresh volcanic ash from Eyjafjallajökull, due to the distinctive $^{207/208}$Pb ratio of Icelandic lavas. This will help to distinguish between dust sources of older ages or sources or from different origins. The seawater samples will be used in conjunction with trace element concentrations from samples taken at the same time during the cruise, to give an insight to the distribution of volcanic ash in the ocean.

A higher concentration of samples were taken on the underway towed fish sampler stations on the 20 West track, almost between every station, becoming less frequent as we got further away from the volcano. Two 3-depth profiles were taken with the Titanium CTD cast at stations IB21 and IB17 at 653, 102 & 22 m and 1400, 88 & 22 m respectively. In total there were 20 samples sites (40 1 litre samples).

Table 30. Lead isotope samples

Date	Station	Desired time of sample	Time of sample	Sample number	Sample type	Lat °N Long °W
12/05/2010	IB21	Ti CTD 001 profile deep	niskin14- 653 m	Pb25U	Unfiltered	63.2189 -20.0627
12/05/2010	IB22	Ti CTD station deep	niskin 14	Pb25F	Filtered	63.2189 -20.0627
12/05/2010	IB23	Ti CTD station mix layer ~100 m	niskin 10- 102 m	Pb26U	Unfiltered	63.2189 -20.0627
12/05/2010	IB24	Ti CTD station mix layer ~100 m	niskin 10	Pb26F	Filtered	63.2189 -20.0627
12/05/2010	IB25	Ti CTD station surface	niskin 7 - 22 m	Pb27U	Unfiltered	63.2189 -20.0627
12/05/2010	IB26	Ti CTD station surface	niskin 7	Pb27F	Filtered	63.2189 -20.0627
12/05/2010	IB21S- IB20	u74	15:49	Pb24U	Unfiltered	63.1383 -19.9099
12/05/2010	IB20S- IB19	u75	17:14	Pb28U	Unfiltered	63.1346 -19.9141
12/05/2010	IB20S- IB19		17:07	Pb28F	Filtered	63.1343 -19.9134
12/05/2010	IB19S- IB18	u76	23:47	Pb29U	Unfiltered	62.8406 -19.6182
12/05/2010	IB19S- IB18		23:47	Pb29F	Filtered	62.8406 -19.6182
13/05/2010	IB18S- IB17	u78	10:05	Pb30U	Unfiltered	62.2850 -19.9267
13/05/2010	IB18S- IB17		10:14	Pb30F	Filtered	62.2695 -19.9597
13/05/2010	IB17	Ti 002 profile	niskin 7 - 22 m	Pb31U	Unfiltered	61.9976 -20.0105
13/05/2010	IB17	Ti 002 deep	niskin 7	Pb31F	Filtered	61.9976 -20.0105
13/05/2010	IB17	Ti 002 deep	niskin 10 - 88 m	Pb32U	Unfiltered	61.9976 -20.0105
13/05/2010	IB17	Ti 002 deep	niskin 10	Pb32F	Filtered	61.9976 -20.0105
13/05/2010	IB17	Ti 002 deep	niskin 17 - 1400 m	Pb33U	Unfiltered	61.9976 -20.0105
13/05/2010	IB17	Ti 002 deep	niskin 17	Pb33F	Filtered	61.9976 -20.0105
13/05/2010	IB17S- IB16a	u80	20:16	Pb34U	Unfiltered	61.7869 -20.0051
13/05/2010	IB17S- IB16a		20:14	Pb34F	Filtered	61.7924 -20.0076
14/05/2010	IB16a- IB16	u81	00:12	Pb35U	Unfiltered	61.6873 -19.9995
14/05/2010	IB16a- IB16		00:16	Pb35F	Filtered	61.6762 -19.9950
14/05/2010	IB16- IB15	u82	06:13	Pb36U	Unfiltered	61.3461 -20.0946
14/05/2010	IB16- IB15		06:15	Pb36F	Filtered	61.3413 -20.0902
14/05/2010	IB15- IB14	u83	11:06	Pb37U	Unfiltered	61.1243 -19.9205
14/05/2010	IB15- IB14		11:04	Pb37F	Filtered	61.1292 -19.9274
15/05/2010	IB14-	u84	12:25	Pb38U	Unfiltered	60.8301

	IB13					-20.0091
15/05/2010	IB14- IB13		12:34	Pb38F	Filtered	60.8046 -20.0052
15/05/2010	IB13- 1B12	u86	20:36	Pb39U	Unfiltered	60.4055 -19.9908
15/05/2010	IB13- 1B12		20:33	Pb39F	Filtered	60.4139 -19.9901
17/05/2010		U90	00:41	Pb40U	Unfiltered	59.5921 -18.9537
17/05/2010			00:39	Pb40F	Filtered	59.5954 -18.9642
17/05/2010		U94	13:45	Pb41U	Unfiltered	59.1458 -17.7339
17/05/2010			13:44	Pb41F	Filtered	59.1476 -17.7386
18/05/2010		u100	10:42	Pb42U	Unfiltered	58.1941 -15.1573
18/05/2010			10:40	Pb42F	Filtered	58.1979 -15.1653
18/05/2010		u104	20:31	Pb43U	Unfiltered	57.5720 -13.4803
18/05/2010			20:35	Pb43F	Filtered	57.5713 -13.4596
19/05/2010		u109	12:58	Pb44U	Unfiltered	57.5139 -12.1109
19/05/2010			13:02	Pb44F	Filtered	57.5116 -12.0892

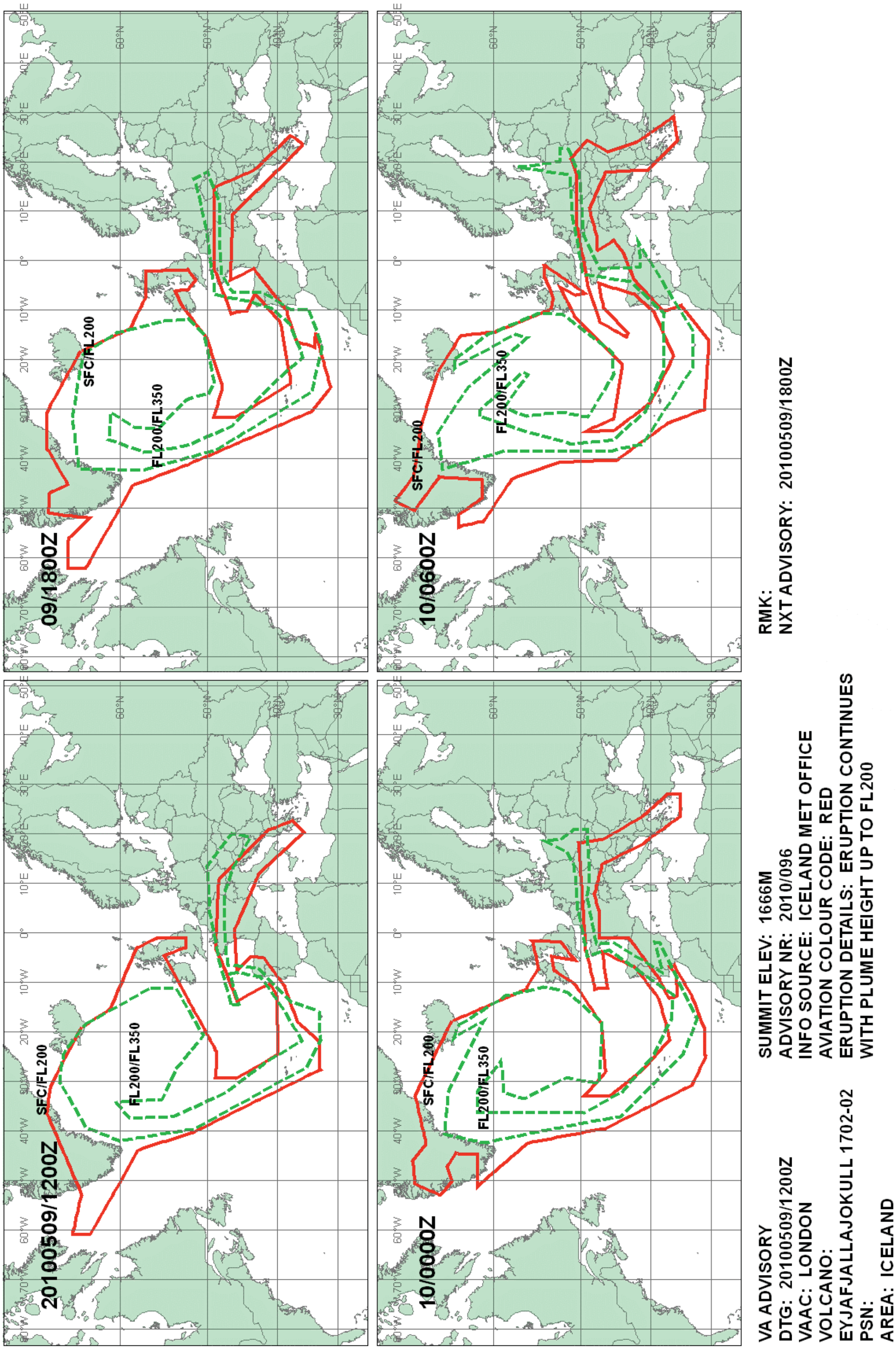

Figure 26. Spread of the ash plume from Eyjafjallajökull eruption

Dissolved Inorganic Carbon and Alkalinity - *Michael Cassidy (PI: Victoire Rerolle)*

79 250 ml seawater samples were taken for DIC (Dissolved Inorganic carbon) and alkalinity measurements on behalf of Victoire Rerolle. Samples were taken from both Stainless steel and Titanium CTD casts. 10 CTD profiles were taken, sampling seawater from various depths at stations IB22, IB17, IB11a, IB11, IB15, E, H, J and Q (Table 28). 18 underway samples were taken in between sites, including 2 duplicates for assessing the reproducibility. The analysis will provide an insight into the carbonate system in the ocean. The samples will be analysed back in Southampton.

Table 31. DIC and alkalinity samples

Cast Station name or Under way number	**Bottle no**	**Time**	**Day**	**Depth**	**Lat**	**Long (degrees, mins, secs)**	**Comments**
Cruise D351							
IB22 CTD Ti	13A	12:00	132	202	631312	200376	
	13B			102			
	13C			42			
	13D			35			
	13E			7			
underway	14	19:13	132	surface	630624	195048	Corresponds DIC 1 nutrient sample
underway	15	23:41	132	surface	625826	193739	DIC 2
underway	16	10:05	133	surface	621659	195550	DIC 3
IB17 CTD Ti	17A	15:30	133	1800			
	17B			1100			
	17C			700			
	17D			500			
	17E			300			
	17F			153			
	17G			57			
	17H			22			
underway	18	20:25	133	surface	61453075	195940	DIC 4
underway	19	11:42	134	surface	610289	195152	DIC 5
underway	20	16:55	135	surface	603052	1959402	DIC6
IB11a CTD 016 Ti	21A	16:06	136	2906	5949247	1935035	
	21B			2392			
	21C			1991			
	21D			900			
	21E			703			
	21F			505			
	21G			107			
	21H			56			no surface CTD DNF
IB11 CTD 017	22A	23:36	136	2005	593951	190841	
	22B			994			
	22C			802			
	22D			407			
	22E			157			

	22F			83			
	22G			62			
	22H			32			
	22I			14			
underway	23	09:24	137	surface	591631	180600	DIC 7
underway	24	20:10	137	surface	585466	1705007	DIC 8
IB5 023 Ti	25A	22:33	137	998	58531	1713	
	25B			597			
	25C			300			
	25D			103			
	25E			57			
	25F			27			
	25G			7			
underway	26	08:31	138	surface	581554	152036	DIC 9
underway	27	19:09	138	surface	573478	134005	DIC 10
underway	28	22:20	138	Surface	573354	1310614	DIC 11
underway	29	22:21	138	surface	573354	1310614	DIC 12 duplicate of 28
E CTD T 033	30A	08:46	139	1590	5730944	1240349	
	30B			1402			
	30C			882			
	30D			603			
	30E			303			
	30F			153			
	30G			23			
underway	31	16:35	139	surface	572944	114155	DIC 13
H CTD 036S	32A		139	2005	5728954	1132021	
	32B			1598			
	32C			1248			
	32D			999			
	32E			747			
	32F			501			
	32G			255			
	32H			104			
	32I			54			
	32J			6			
J CTD S 038	33A	23:58	139	575	5727129	1105079	
	33B			400			
	33C			200			
	33D			5			
underway	34	13:16	140	surface	5713248	95751	DIC 14
Q CTD S 045	35A	21:00	140	295	57303	91288	
	35B			200			
	35C			100			
	35D			25			
underway	36	22:58	140	surface	565766	85093	DIC 15
underway	37	00:19	141	surface	565489	83759	DIC 16
underway	38	09:39	141	surface	5643017	72577	DIC 17
underway	39	09:39	141	surface	5643017	72577	DIC 18- duplicate of 38
CRUISE D351- 79 SAMPLES TAKEN							

The Role of Microzooplankton Grazing in the North Atlantic and Iron Speciation of the Extended Ellett Line - *Adam Hamilton*

<u>Background</u>

The microbial biomass observed in the oceans is a direct result of the balance between nutrient availability (bottom up) and grazing pressure (top down). Microzooplankton consume a substantial fraction of phytoplankton and bacterioplankton production, remineralising nutrients and providing a major trophic link to larger protozoan and metazoan consumers (Irigoien et al, 2005; Vaqué et al, 2008). As well as their ability to exert top down forcing on primary productivity there is also emerging evidence that this grazing plays a prominent role in the cycling of trace metals such as Fe (Barbeau et a;. 1996; Brussaard et al, 2008; Dalbec et al, 2009; Vogel et al, 2009).

Tephra from the recent eruption of Eyjafjallajokull in Iceland may be a significant source of Fe on deposition in the North Atlantic. Reductions in pH and subsequent changes in Fe speciation have been observed elsewhere from volcanic ash in contact with seawater (Duggen et al, 2010). Also, emerging evidence shows that ocean acidification can affect iron speciation and may provide a negative climate feedback mechanism (Breitbarth et al, 2010).

Our work will compliment the research being done (including that of D350) by providing a top down perspective on primary productivity control and quantifying Fe speciation in the North Atlantic.

<u>Objectives</u>

1. Determine the gross growth and grazing rates of bacteria and phytoplankton.
2. Determine carbon ingestion rates of microzooplankton.
3. Determine Fe speciation profiles

<u>Methods</u>

<u>Microzooplankton grazing assay</u>

Microzooplankton bacterivory and herbivory were determined using a modified dilution assay (Landry & Hassett, 1982; Rivkin et al, 1999). Seawater was collected from a stainless steel CTD, or the TowFish whilst underway. Water was filtered through a 202 µm Nitex mesh to remove larger grazers, and diluted with particle-free filtrate prepared by gravity filtration though a 0.2 µm Gelman cartridge filter to the following target dilutions (202 µm: 0.2 µm filtered water): 1.0, 0.9, 0.75, 0.5, 0.35, 0.2 and 0.1. All samples were incubated in 2 L polycarbonate containers, in on-deck incubators at ambient temperatures (± 0.5°C) and ~50% of incident irradiance, for 48 h. Abundances of bacteria as well as pico- and nanophytoplankton, will be determined by flow cytometry (Marie et al, 1999; Li & Dickie, 2001) and Acridine Orange Direct Counts (AODC; Hobbie et al, 1977). Bacterial cell volume will be determined by image analysis of Acridine Orange (AO) stained cells using an Image-Pro Plus image analysis system (Loferer-Kroßbacher et al, 1998). Nutrient (nitrate, silicate and phosphate) and Chl *a* samples were collected and analysed on board. Subsamples for light microscopy identification were also collected in Lugols Iodine.

The apparent growth rate of each prey group will be computed from the time-dependent changes in abundance or concentration within the seven different dilutions. Rates of grazing mortality will be determined from the linear regression of apparent growth rate against dilution, with the intercept of the line providing an estimate of growth rate and the negative slope of the line providing an estimate of grazing mortality (Rivkin et al, 1999).

Table 32. Study sites: Grazing Assays

Date	Location		Station	Event	Niskin	Collection Depth	Time on Deck
	N	W		#	#	m	GMT
13/5/10	61° 45.08'	19° 59.56'	IB16A	351-012	21, 22	25	23:05
17/5/10	59° 07.234'	17° 39.901'	uway	n/a	TowFish	2	14:00
17/5/10	59° 07.103'	17° 40.002'	IB7	351-033	21	22	15:58

Fe Speciation

Two 250mL samples of 0.2 µm filtered seawater were collected under trace metal conditions from a titanium CTD. One bottle from each pair was spiked with 250 µl of ultra pure HCl while the other was immediately frozen (-20°C). Speciation will be determined using EchoChimie electrochemical equipment.

Table 33. Study sites: Iron Speciation

Date	Location		Station	Event	Niskin	Collection Depth	Time on Deck
	N	W		#	#	m	GMT
13/5/10	61° 59.856'	20° 00.632'	IB17	351-007	7	220	15:30
					8	35	
					9	55	
					10	85	
					11	150	
					12	300	
					13	500	
					14	700	
					15	890	
					16	1100	
					17	1400	
					18	1800	
16/5/10	60° 00.028'	19° 59.873'	IB12	351-021	7	27	05:25
					8	47	
					9	62	
					10	88	
					11	158	
					12	268	
					13	406	
					14	606	
					15	1007	
					16	1507	
					17	2004	
					18	2709	
16/5/10	58° 39.935'	19° 07.212'	IB11	351-027	7	27	23:36
					8	48	
					9	62	
					10	83	
					11	157	
					12	407	
					13	705	
					14	802	
					15	994	
					16	1506	
					17	2005	

					18	2666	
17/5/10	58° 53.1’	17° 01.3’	IB5	351-036	7 8 9 10 11 12 13 14 15 16 17 18	22 42 57 77 103 202 300 397 597 746 998 1135	22:23
19/5/10	57° 30.944’	12° 40.349’	E	351-049	7 8 9 10 11 12 13 14 15 16 17 18	23 43 63 93 153 303 453 604 882 1102 1482 1590	08:48
21/5/10	57° 23.799’	10° 52.223’	K	351-057	7 8 9 10 11 12 13 14 15 16 17 18	22 32 53 103 152 202 262 302 402 501 601 767	02:25

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Aerosol Sampling - *Chris Marsay (PI: Eric Achterberg)*

Rationale and objectives

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

Models suggest a relatively low aerosol input to the high latitude North Atlantic (Duce and Tindale, 1991), though there have been relatively few direct measurements in the region. The main aim of aerosol sampling during research cruise D351 is to provide data of atmospheric inputs of iron and other trace metals and nutrients at the time of the transect. However, any data obtained would provide a useful addition to the total number of measurements made in the region.

Methods

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

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

Samples collected

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

As much as possible, the sampler was turned off during periods of rain, and the filter holders covered to prevent raindrops being blown up onto the filters. However, the prevalence of foggy conditions during some sampling periods also caused problems with water droplets on the aerosol collectors, which may have affected the integrity of these samples.

A total of six filter sets were deployed on the low volume system for up to 48 hours (see *Table 1)*. It was often left on while on station due to it having its own controls for turning on and off depending on the wind speed and direction. One batch of polypropylene filters was leached with 100ml each of ultrapure water during the cruise and the leachates and leached filters stored at -20°C.

Table 34. Low volume aerosol sample deployment times

Sample	Installation time (GMT)	Removal time (GMT)	Approximate total pump hours
Lo-vol 1	11:12 12/05/10	03:07 14/05/10	39
Lo-vol 2	10:35 15/04/10	05:54 17/05/10	28
Lo-vol 3	07:03 17/05/10	10:00 19/05/10	Discarded
Lo-vol 3	15:22 19/05/10	06:10 21/05/10	15
Lo-vol 4	19:30 21/05/10	15:00 23/05/10	26
Lo-vol 5	19:27 23/05/10	08:45 25/05/10	21
Lo-vol 6	09:34 25/05/10	11:15 26/05/10	23.3

Buck, C. S., W. M. Landing, J. A. Resing and G. T. Lebon (2006). Aerosol Iron and Aluminum Solubility in the Northwest Pacific Ocean: Results from the 2002 Ioc Cruise. *Geochemistry Geophysics Geosystems* **7**.

Duce, R. A. and N. W. Tindale (1991). Atmospheric Transport of Iron and Its Deposition in the Ocean. *Limnology and Oceanography* **36**(8): 1715-1726.

Jickells, T. D. and L. J. Spokes (2001). Atmospheric Iron Inputs to the Oceans. *In:* The Biogeochemistry of Iron in Seawater. D. R. Turner and K. A. Hunter. Chichester, John Wiley & Sons**:** 85 - 122.

SAPS Deployments - *Chris Marsay (PI: Eric Achterberg)*

Rationale and objectives

The relative rates of remineralisation of nutrient and trace elements from sinking particulate material can have important implications for the limitation of primary production. Recent studies have demonstrated a lower flux attenuation of particulate iron with depth than those for carbon or the macronutrients (N, P, Si), observed through an increase in the Fe/C ratio of particulate material with depth (Frew et al., 2006; Lamborg et al., 2008). This preferential remineralisation of carbon and macronutrients over iron would serve to amplify the effects of low iron:nutrient supply ratios through new inputs in high nutrient low chlorophyll (HNLC) regions.

The use of *in situ* pumps such as the Stand Alone Pump System (SAPS) allows large volumes (100s – 2000+ litres) of seawater to be filtered at specified depths to collect particulate material. The objective on this cruise was to collect size-fractionated particulate material to analyse for biologically important trace metals (notably iron) and also aluminium, which can be used as a tracer for lithogenic material, allowing for the comparison of elemental composition of particles with depth.

Method

Each SAPS unit was loaded with a 53mm Nitex prefilter and a 1mm Sterlitech polycarbonate filter to allow size-fractionated collection of particulate material. All filter loading and removal was carried out in the trace metal van under clean conditions.

SAPS deployments were made at three separate stations from the starboard A-frame, using a plastic coated wire (Table 32). On each occasion, two or three SAPS units were deployed at the same time and programmed to pump for ninety minutes. Each deployment was carried out following a CTD station so that the mixed layer depth could be calculated. One SAPS unit would be deployed at a depth approximately ten metres below the base of the mixed layer, and the second a further one hundred metres deeper. For the first deployment, a third SAPS unit was deployed within the mixed layer. The volume of seawater filtered during sampling ranged from 415 – 1412 litres.

Within one hour of recovery, filters were removed from the filter housing, folded and transferred to labelled Ziploc bags. Samples were then transferred to the -20^{o}C freezer until further processing and analysis on land.

Table 35. SAPS deployment stations during D351.

Date	Time (deployment)	Station	Latitude (N)	Longitude (W)	Deployment depths (m)
13/05/10	16:27	IB17	61^{o}59.8	20^{o}03.1	25, 70, 170
16/05/10	06:10	IB12	59^{o}59.8	20^{o}01.1	60, 160
19/05/10	03:57	E	57^{o}31.8	12^{o}38.6	60, 160

Frew, R. D., D. A. Hutchins, S. Nodder, S. Sanudo-Wilhelmy, A. Tovar-Sanchez, K. Leblanc, C. E. Hare and P. W. Boyd (2006). Particulate Iron Dynamics During Fecycle in Subantarctic Waters Southeast of New Zealand. *Global Biogeochemical Cycles* **20**(1).

Lamborg, C. H., K. O. Buesseler, J. Valdes, C. H. Bertrand, R. Bidigare, S. Manganini, S. Pike, D. Steinberg, T. Trull and S. Wilson (2008). The Flux of Bio- and Lithogenic Material Associated with Sinking Particles in the Mesopelagic "Twilight Zone" of the Northwest and North Central Pacific Ocean. *Deep-Sea Research Part II-Topical Studies in Oceanography* **55**(14-15): 1540-1563.

Meteorological Drifter Deployments – *Jane Read, Jon Short, Bill Richardson*

Meteo-France requested that 4 drifters be released as part of their observation system. The four instruments were successfully deployed, all working perfectly. Measurements are transmitted via Iridium SBD and forwarded to the Global Telecommunication System of WMO by Meteo-France. The data are assimilated by numerical weather prediction models in many countries, contributing to improved weather forecasts.

Buoy id: 300034012548820
Deployed at: 61° 59.6' N 20° 05.9' W, 18:48 GMT 13 May 2010
Conditions: sea height 4 metres, wind speed 35 knots, ship speed 2 knots
Wind ahead, waves on starboard fore-quarter,
Buoy dropped by hand from the starboard stern-quarter
The apparent status after deployment was okay.

Buoy id: 300034012543300
Deployed at 60° 59.828'N 20° 2.441'W, 11:20 GMT 15 May 2010
Conditions: sea height 2 metres, wind speed 8 knots, ship speed 2 knots
Wind and waves both ahead
Buoy dropped by hand from the starboard stern quarter, 5m above sea level
The apparent status after deployment was okay.

Buoy id: 300034012347680
Deployed at 59° 59.987'N 20° 2.29'W, 0838 GMT 16 May 2010
Conditions: sea height 1.5 metres, wind speed 20 knots, ship speed 2 knots
Wind on the port fore-quarter, waves ahead
Buoy dropped by hand from the starboard stern quarter, 5m above sea level
The apparent status after deployment was okay.

Buoy id: 300034012547840
Deployed at 58° 59.90'N 17° 19.24'W, 1725 GMT 17 May 2010
Conditions: sea height 1 metre, wind speed 16 knots, ship speed 10 knots
Wind on the port fore-quarter, waves ahead
Buoy dropped by hand from the stern, 5m above sea level
The apparent status after deployment was okay.

Argo Float Deployments - *Jane Read, Jon Short*

Eleven Argo floats were delivered to the ship in Reykjavik, however, there was some confusion over what the floats were, and that several were labeled for the Indian Ocean. It was decided not to deploy the floats in cardboard tubes or boxes labeled for the Somali Basin/Arabian Sea leaving eight available for immediate use. Unfortunately, after deployment, it was discovered that two of those used (2704 & 2705) were also intended for the Somali Basin. There should be three floats still available for deployment on the Extended Ellett Line and these should be released on next years cruise (2011). Deployment of the floats was reported to BODC and the data will be available from the BODC and Argo websites.

Table 36. Argo Float Deployments

Float S/N	Station identifier	Time	Date	Latitude N	Longitude W	BODC No.	WMO No.
3865	(011 ib14)	1120	15/5/2010	60° 59.828'	20° 2.441'	81210	6900613
3866	(015 ib12)	0830	16/5/2010	59° 59.987’	20° 2.29’	81211	6900614
3863	(017 ib11)	2358	16/5/2010	59° 39.330'	19° 8.297'	81208	6900615
2704	(018 ib10)	0519	17/5/2010	59° 24.5’	18° 25.6’	63373	6900616
3862	(035 G)	1600	19/5/2010	57° 29.83’	11° 51.74’	81207	6900618
3861	(036 H)	1933	19/5/2010	57° 29.34’	11° 31.51’	81206	6900617
2705	(040 L)	0606	20/5/2010	57° 20.86’	10° 40.03’	63374	6900619
2635	(041 M)	0935	20/5/2010	57° 16.49’	10° 21.9’	63351	6900620

BODC Data Management - *Darren Bayliss*

Throughout the cruise, sampling and metadata were checked and discrepancies queried to ensure all samples were recorded centrally. An Event Log, which detailed the deployment of each instrument such as the CTD, Argo floats and SAPS deployments, was maintained. In addition, CTD bottle firing logs, the underway logs during the SeaSoar deployments and the chlorophyll fluorometry log were maintained. These logs were digitized and made centrally available by placing on the shared drive. The logs are reproduced in the Appendix.

ACKNOWLEDGEMENTS

After a slow start, the cruise achieved all the objectives, and this is thanks to the work of all. Especial thanks go to the agent, for collecting the shattered travellers after their epic trek to Reykjavik and for recovering all but one piece of luggage. Many thanks also to the Master, officers and crew for their support while the scientists got going and for their professionalism and expertise throughout the cruise. I would like to express my appreciation to the Royal Navy for allowing science to continue in their no-go zone, even if the fog had stopped their play. Finally, thanks to all those in NMF-SS who helped navigate the tortuous and unfathomable deeps of administration involved in organising a research cruise. Funding was provided primarily through the NERC Oceans 2025 core strategic science programme.

Jane Read

APPENDIX I

Cruise D351 Event Log

Event No.	Date	Station	Latitude (N)	Longitude (E)	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
351_001	12/05/2010	001	63 19.105	-20 12.907	129	09:26	09:35	09:48	SS CTD	IB23S
351_002	12/05/2010	002	63 13.132	-20 03.760	657	10:59	11:20	12:00	Ti CTD	IB22S
351_003	12/05/2010	003	63 08.009	-19 54.802	1044	17:28	18:04	18:53	SS CTD	IB21S
351_004	12/05/2010	004	62 54.83	-19 31.95	1410	21:17	22:07	23:12	SS CTD	IB20S
351_005	13/05/2010	005	62 40.23	-19 41.06	1685	01:39	02:19	03:20	SS CTD	IB19S
351_006	13/05/2010	006	62 19.970	-19 50.478	1808	07:10	07:55	09:01	SS CTD	IB18S
351_007	13/05/2010	007	61 59.856	-20 00.632	1815	13:21	14:23	15:30	Ti CTD	IB17
351_008	13/05/2010	007	61 59.8	-20 03.1	1840	16:27	-	18:30	SAPS	IB17
351_009	13/05/2010	007	61 59.8	-20 03.1	1840	16:33	-	18:35	SAPS	IB17
351_010	13/05/2010	007	61 59.8	-20 03.1	1840	16:36	-	18:40	SAPS	IB17
351_011	13/05/2010	007	61 59.6	-20 05.9	1804	18:49	-	-	Drifter	IB17. On behalf of Iceland Met Office. ID: 300034012548820
351_012	13/05/2010	008	61 45.08	-19 59.56	1803	20:58	21:53	23:05	SS CTD	IB16A
351_013	14/05/2010	009	61 29.97	-19 59.96	2226	02:05	02:59	04:10	SS CTD	IB16
351_014	14/05/2010	010	61 15.058	-20 00.265	2411	07:25	08:20	09:38	SSCTD	IB15. CTDs suspended due to weather
351_015	15/05/2010	011	60 59.965	-20 00.524	2428	08:43	09:51	11.10	Ti CTD	IB14. SS CTD out of order
351_016	15/05/2010	011	60 59.828	-20 02.441	-	11:10	-	-	Apex float	IB14. SN - 3855
351_017	15/05/2010	011	60 59.828	-20 02.441	-	11:20	-	-	Drifter	IB14. On behalf of Iceland Met Office. ID: 300034012543300

Event No.	Date	Station	Latitude (N)	Longitude (E)	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
351_018	15/05/2010	012	60 44.986	-20 00.100	2374	13:05	14:04	15:30	Ti CTD	IB13A
351_019	15/05/2010	013	60 30.11	-19 59.847	2555	17:11	18:23	19:59	Ti CTD	IB13. Bottle tap 23 is lose
351_020	15/05/2010	014	60 15.18	-19 59.7	2655	22:11	23:23	00:56	Ti CTD	IB12A
351_021	16/05/2010	015	60 00.028	-19 59.873	2733	03:00	03:58	05:25	Ti CTD	IB12
351_022	16/05/2010	015	59 59.8	-20 01.1	2733	06:10	-	08:25	SAP	IB12
351_023	16/05/2010	015	59 59.8	-20 01.1	2733	06:14	-	08:21	SAP	IB12
351_024	16/05/2010	015	59 59.99	-20 2.29	-	08:30	-	-	Apex float	IB12. SN – 3866
351_025	16/0/2010	015	59 59.99	-20 2.29	-	08:36	-	-	Drifter	IB12. ID 300034012347680
351_026	16/05/2010	016	59 49.247	-19 35.035	2717	12:00	13:14	14:50	Ti CTD	IB11A
351_027	16/05/2010	017	59 39.99	-19 07.19	2680	20:53	21:54	23:36	Ti CTD	IB11
351_028	16/05/2010	017	59 39.33	-19 8.30	-	23:58	-	-	Apex float	IB11. SN - 3863
351_029	17/05/2010	018	59 24.05	-18 25.13	2411	02:48	03:43		SS CTD	IB10
351_030	17/05/2010	018	59 24.5	-18 25.6	2444	05:19	-	-	Apex float	IB10. SN - 2704.
351_031	17/05/2010	019	59 20.028	-18 14.412	1884	06:40	07:28	08:37	SS CTD	IB9
351_032	17/05/2010	020	59 11.986	-17 53.010	1539	10:35	11:21	12:25	SS CTD	IB8
351_033	17/05/2010	021	59 7.103	-17 40.002	981	14:15	14:42	16:00	SS CTD	IB7
351_034	17/05/2010	022	59 59.90	-17 19.24	-	17:25	-	-	Drifter	IB6. ID: 300034012547840
351_035	17/05/2010	022	58 57.016	-17 11.222	895	18:06	18:32	19:32	SS CTD	IB6
351_036	17/05/2010	023	58 53.1	-17 1.3	1148	20:43	21:15	22:23	Ti CTD	IB5
351_037	18/05/2010	024	58 41.89	-16 29.93	1192	00:35	01;10	02:04	SS CTD	IB4A

Event No.	Date	Station	Latitude (N)	Longitude (E)	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
351_038	18/05/2010	025	59 30.055	-15 58.911	1193	04:25	05:02	05:55	SS CTD	IB34
351_039	18/05/2010	026	58 15.258	-15 19.497	698	08:40	09:08	10:00	SS CTD	IB3
351_040	18/05/2010	027	57 57.11	-14 35.12	435	13:16	13:37	14:26	SS CTD	IB2
351_041	18/05/2010	028	57 39.99	-13 54.10	144	17:20	17:29	17:48	SS CTD	IB1
351_042	18/05/2010	029	57 34.87	-13 36.25	110	19:27	19:33	19:56	SS CTD	A
351_043	18/05/2010	030	57 33.84	-13 20.25	178	21:08	21:19	21:49	SS CTD	B
351_044	18/05/2010	031	57 33.10	-13 0.0	292	23:03	23:16	23:48	SS CTD	C
351_045	19/05/2010	032	57 32.9	-12 52.35	1033	00:32	01:08	02:02	SS CTD	D
351_046	19/05/2010	033	57 31.892	-12 38.091	1639	03:07	03:24	03:43	Ti CTD	E. Water for SAPS. Named as 033_TC
351_047	19/05/2010	033	57 31.8	-12 38.6	-	03:57	-	06:09	SAP	E
351_048	19/05/2010	033	57 31.6	-12 38.6	-	04:01	-	06:05	SAP	E
351_049	19/05/2010	033	57 31.168	-12 40.173	1604	07:00	07:40	08:48	Ti CTD	E
351_050	19/05/2010	034	57 31.030	-12 15.00	1801	10:20	11:09	12:31	SS CTD	F
351_051	19/05/2010	035	57 29.847	-11 51.057	1800	14:04	14:42	15:52	SS CTD	G
351_052	19/05/2010	035	57 29.83	-11 51.74	-	16:00	-	-	Apex float	G. SN - 3862
351_053	19/05/2010	036	57 28.954	-11 32.021	2020	17:22	18:11	19:29	SS CTD	H
351_054	19/05/2010	036	57 29.34	-11 31.51	-	19:33	-	-	Apex float	H. SN - 3861
351_055	19/05/2010	037	57 28.08	-11 19.25	747	20:38	21:03	21:55	SS CTD	I
351_056	19/05/2010	038	57 27.129	-11 5.079	585	23:00	23:22	23:59	SS CTD	J
351_057	20/05/2010	039	57 23.799	-10 52.223	783	01:10	01:36	02:25	Ti CTD	K

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
351_058	20/05/2010	040	57 21.985	-10 40.189	2088	03:55	04:47	05:57	SS CTD	L
351_059	20/05/2010	040	57 20.86	-10 40.03	-	06:06	-	-	Apex float	L. SN 2705
351_060	20/05/2010	041	57 17.776	-10 23.093	2223	07:25	08:15	09:30	SS CTD	M
351_061	20/05/2010	041	57 16.49	-10 21.9	-	09:35	-	-	Apex float	M. SN – 2635
351_062	20/05/2010	042	57 14.025	-10 03.630	2113	10:50	11:38	12:55	SS CTD	N
351_063	20/05/2010	043	57 08.967	-9 42.009	1938	14:22	15:05	16:18	SS CTD	O
351_064	20/05/2010	044	57 05.98	-9 24.94	1412	17:30	18:07	19:09	SS CTD	P
351_065	20/05/2010	045	57 03.023	-9 12.440	287	20:09	20:19	20:55	SS CTD	Q
351_066	20/05/2010	046	56 59.90	-8 59.90	129	21:55	22:03	22:24	SS CTD	R
351_067	20/05/2010	047	56 57.03	-8 46.91	124	23:22	23:03	23:50	SS CTD	S
351_068	21/05/2010	048	56 50.86	-8 19.81	150	01:28	01:37	01:59	SS CTD	T
351_069	21/05/2010	049	56 49.03	-8 10.15	122	02:49	02:59	03:16	SS CTD	14G
351_070	21/05/2010	050	56 47.028	-8 00.145	117	04:22	04:31	04:48	SS CTD	13G
351_071	21/05/2010	051	56 44.050	-7 50.183	70	05:29	06:06	06:17	SS CTD	12G
351_072	21/05/2010	052	56 44.000	-7 40.210	57	07:22	07:28	07:40	SS CTD	11G
351_073	21/05/2010	053	56 43.876	-7 30.017	219	08:32	08:46	-9:13	SS CTD	10G
351_074	21/05/2010	054	56 44.135	-7 20.121	154	10:15	10:23	10:42	SS CTD	9G
351_075	21/05/2010	055	56 44.08	-7 10.11	174	11:30	11:36	12:00	SS CTD	8G
351_076	21/05/2010	056	56 43.86	-6 59.99	134	12:49	13:00	13:18	SS CTD	7G

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
351_077	21/05/2010	057	56 43.89	-6 44.91	42	14:24	14:26	14:40	SS CTD	6G
351_078	21/05/2010	058	56 44.00	-6 36.05	70	15:18	15:23	15:38	SS CTD	5G
351_079	21/05/2010	059	56 43.99	-6 26.922	80	16:25	16:29	16:39	SS CTD	4G
351_080	21/05/2010	060	56 42.972	-6 21.996	62	17:26	17:30	17:40	SS CTD	3G
351_081	21/05/2010	061	56 41.045	-6 17.215	25	18:23	18:28	18:35	SS CTD	2G
351_82	21/05/2010	062	56 40.085	-6 8.130	146	19:27	19:34	19:50	SS CTD	1G
351_083	22/05/2010	-	57 03.21	-9 14.051	423	07:05	-	08:05	Seasoar	Recovered due to faulty cond sensor
351_084	22/05/2010	-	57 03.21	-9 14.051	-	09:20	-	23/05/2010 22:54	Seasoar	Recovered to change Minipak
351_085	24/05/2010	-	57 27.11	-11.5	-	00:41	-	22:32	Seasoar	
351_086	24/05/2010	-	57 33.04	-10 57.471	802	23:52	00:23	01:06	SS CTD	24 hr yo-yo ctd. 1st recovery (ctd_063)
351_086	25/05/2010	-	57 33.970	-10 57.453	802	06:44	07:00	07:35	SS CTD	24 hr yo-yo ctd 2nd recovery (ctd_072)
351_086	25/05/2010	-	57 34.016	-10 57.406	805	13:17	13:39	14:15	SS CTD	24 hr yo-yo ctd 3rd recovery (ctd_081)
351_086	25/05/2010	-	57 34.004	-10 57.378	800	18:08	18:27	19:16	SS CTD	24 hr yo-yo ctd 4th recovery (ctd_087)
351_086	26/05/2010	-	57 33.98	-10 57.43	802	00:22	00:45	01:29	SS CTD	24 hr yo-yo ctd 5th recovery (ctd_095)
351_087	26/05/2010	096	57 35.616	-10 55.659	971	02:37	03:13	03:57	SS CTD	1000m cast. Cond sensor changed
351_088	26/05/2010	097	57 36.179	-10 54.921	1464	05:45	06:26	07:25	SS CTD	1500m cast
351_089	26/05/2010	098	57 38.041	-10 52.932	2014	08:39	09:22	10:30	SS CTD	2000m cast
351_090	26/05/2010	099	58 03.062	-11 15.042	1960	13:30	14:15	15:17	SS CTD	
351_091	26/05/2010	100	57 48.116	-11 8.977	2016	17:01	17:44	18:30	SS CTD	
351_092	26/05/2010	101	56 56.937	-10 54.086	2379	23:43	00:34	01:49	SS CTD	

APPENDIX II

Cruise D351 SeaSoar Underway Log

Salinity

Date/Time	Sample Number
22/5/10 07:39	44
22/5/10 08:30	45
22/5/10 09:31	46
22/5/10 10:33	47
22/5/10 11:32	48
22/5/10 12:34	901/1
22/5/10 13:28	901/2
22/5/10 14:30	901/3
22/5/10 15:32	901/4
22/5/10 16:37	901/5
22/5/10 17:30	901/6
22/5/10 18:31	901/7
22/5/10 19:30	901/8
22/5/10 20:43	901/9
22/5/10 21:34	901/10
22/5/10 22:35	901/11
22/5/10 23:27	901/12
23/5/10 00:30	901/13
23/5/10 01:28	901/14
23/5/10 02:26	901/15
23/5/10 03:26	901/16

Chlorophyll

Date/Time	Sample Number	Vial
22/5/10 07:39	uw28	56
22/5/10 08:33	uw29	35
22/5/10 09:33	uw30	57
22/5/10 10:31	uw31	58
22/5/10 11:29	uw32	34
22/5/10 12:35	uw33	59
22/5/10 13:35	uw34	60
22/5/10 14:28	uw35	61
22/5/10 15:35	uw36	62
22/5/10 16:37	uw37	63
22/5/10 17:32	uw38	64
22/5/10 18:32	uw39	65
22/5/10 19:32	uw40	67
22/5/10 20:44	uw41	55
22/5/10 21:33	uw42	41
22/5/10 22:30	uw43	28
22/5/10 23:27	uw44	27
23/5/10 00:29	uw44a	69
23/5/10 01:26	uw45	26
23/5/10 02:24	uw46	15
23/5/10 03:25	uw47	72

Nutrients

Date/Time	Sample Number
22/5/10 07:39	TSG01
22/5/10 08:38	TSG02
22/5/10 09:35	TSG03
22/5/10 10:35	TSG04
22/5/10 11:37	TSG05
22/5/10 12:37	TSG06
22/5/10 13:31	TSG07
22/5/10 14:31	TSG08
22/5/10 15:35	TSG09
22/5/10 16:38	TSG10
22/5/10 17:31	TSG11
22/5/10 18:32	TSG12
22/5/10 19:31	TSG13
22/5/10 20:45	TSG14
22/5/10 21:34	TSG15
22/5/10 22:31	TSG16
22/5/10 23:29	TSG17
23/5/10 00:29	TSG18
23/5/10 01:30	TSG19
23/5/10 02:24	TSG20
23/5/10 03:25	TSG21

Trace Chl

Date/Time	Brown bottle no.	Sample Number	Vial
22/5/10 16:05	6	uw130	
22/5/10 19:07	4	uw131	66
22/5/10 22:07	13	uw132	68
23/5/10 01:09	5	uw133	70
23/5/10 04:01		uw134	73
23/5/10 06:55		uw135	78
23/5/10 09:58	4	uw136	
23/5/10 13:02	6	uw137	82
23/5/10 15:55		uw138	86
23/5/10 19:07	4	uw139	90
23/5/10 22:09	6	uw140	94

Salinity	
Date/Time	Sample Number
23/5/10 04:30	901/17
23/5/10 05:30	901/18
23/5/10 06:29	901/19
23/5/10 07:28	901/20
23/5/10 08:33	901/24
23/5/10 09:31	901/21
23/5/10 10:32	901/22
23/5/10 11:33	901/23
23/5/10 12:26	903/49
23/5/10 13:26	903/50
23/5/10 14:26	903/51
23/5/10 15:33	903/52
23/5/10 16:35	903/53
23/5/10 17:36	903/54
23/5/10 18:30	903/55
23/5/10 19:30	903/56
23/5/10 20:33	903/64
23/5/10 21:30	903/63
23/5/10 22:31	903/62
23/5/10 23:29	903/61
23/5/10 00:27	903/60
24/5/10 01:30	903/59
24/5/10 02:31	903/58
24/5/10 03:35	903/57
24/5/10 04:29	903/65
24/5/10 05:29	903/66

Chlorophyll		
Date/Time	Sample Number	Vial
23/5/10 04:31	uw48	74
23/5/10 05:31	uw49	75
23/5/10 06:27	uw50	76
23/5/10 07:26	uw51	77
23/5/10 08:30	uw52	58
23/5/10 09:29	uw53	57
23/5/10 10:28	uw54	56
23/5/10 11:30	uw55	54
23/5/10 12:26	uw56	79
23/5/10 13:20	uw57	83
23/5/10 14:26	uw58	84
23/5/10 15:35	uw59	85
23/5/10 16:37	uw60	87
23/5/10 17:38	uw61	88
23/5/10 18:32	uw62	89
23/5/10 19:32	uw63	91
23/5/10 20:29	uw64	92
23/5/10 21:29	uw65	93
23/5/10 22:29	uw66	95
23/5/10 23:28	uw67	96
24/5/10 00:27	uw68	97
24/5/10 01:28	uw69	98
24/5/10 02:30	uw70	99
24/5/10 03:32	uw71	100
24/5/10 04:31	uw72	1
24/5/10 05:30	uw73	2

Nutrients	
Date/Time	Sample Number
23/5/10 04:31	TSG22
23/5/10 05:29	TSG23
23/5/10 06:28	TSG24
23/5/10 07:27	TSG25
23/5/10 08:35	TSG26
23/5/10 09:33	TSG27
23/5/10 10:33	TSG28
23/5/10 11:34	TSG29
23/5/10 12:26	TSG30
23/5/10 13:24	TSG31
23/5/10 14:27	TSG32
23/5/10 15:33	TSG33
23/5/10 16:36	TSG34
23/5/10 17:37	TSG35
23/5/10 18:31	TSG36
23/5/10 19:31	TSG37
23/5/10 20:33	TSG38
23/5/10 21:30	TSG39
23/5/10 22:30	TSG40
23/5/10 23:30	TSG41
24/5/10 00:27	TSG42
24/5/10 01:32	TSG43
24/5/10 02:32	TSG44
24/5/10 03:34	TSG45
24/5/10 04:30	TSG46
24/5/10 05:30	TSG47

Trace Chl			
Date/Time	Brown bottle no.	Sample Number	Vial

Salinity			Chlorophyll				Nutrients			Trace Chl			
Date/Time	Sample Number		Date/Time	Sample Number	Vial		Date/Time	Sample Number		Date/Time	Brown bottle no.	Sample Number	Vial
24/5/10 06:27	903/67		24/5/10 06:25	uw74	3		24/5/10 06:27	TSG48					
24/5/10 07:29	903/68		24/5/10 07:27	uw75	4		24/5/10 07:28	TSG49					
24/5/10 08:26	903/69		24/5/10 08:34	uw76	5		24/5/10 08:31	TSG50					
24/5/10 09:29	903/70		24/5/10 09:26	uw77	6		24/5/10 09:31	TSG51					
24/5/10 10:22	903/71		24/5/10 10:19	uw78	7		24/5/10 10:24	TSG52					
24/5/10 11:29	903/72		24/5/10 11:27	uw79	8		24/5/10 11:30	TSG53					
24/5/10 12:34	25		24/5/10 12:31	uw80	9		24/5/10 12:34	TSG54					
24/5/10 13:36	26		24/5/10 13:37	uw81	10		24/5/10 13:37	TSG55					
24/5/10 14:40	27		24/5/10 14:42	uw82	11		24/5/10 14:41	TSG56					
24/5/10 15:30	28		24/5/10 15:26	uw83	12		24/5/10 15:26	TSG57					
24/5/10 16:30	29		24/5/10 16:28	uw84	13		24/5/10 16:30	TSG58					
24/5/10 17:30	30		24/5/10 17:32	uw85	14		24/5/10 17:31	TSG59					
24/5/10 18:29	31		24/5/10 18:31	uw86	15		24/5/10 18:30	TSG60					
24/5/10 19:31	32		24/5/10 19:33	uw87	16		24/5/10 19:32	TSG61					
24/5/10 20:33	40		24/5/10 20:30	uw88	17		24/5/10 20:34	TSG62					
24/5/10 21:35	39		24/5/10 21:32	uw89	18		24/5/10 21:33	TSG63					
24/5/10 23:30	38		24/5/10 23:29	uw90	19		24/5/10 23:31	TSG64					