National Oceanography Centre, Southampton

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RRS *Discovery* Cruise 321

24 JUL – 23 AUG 2007

Biophysical interactions in the Iceland Basin 2007

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ABSTRACT

D321 was the first of three National Oceanography Centre 'process study' research cruises to be run by the Ocean Biogeochemistry and Ecosystems research group under the NERC Oceans 2025 research programme. The scientific work began by carrying out some of the extended Ellett Line stations on the way out to our study region; which centred around the historical JGOFS Ocean Weather Station India site (~ 59° N, ~ 19° W) and the northward turn of the extended Ellett line at 20° W. The Iceland Basin, like much of the N. Atlantic subpolar gyre, is characterised by a 'bloom and bust' seasonal cycle. Spring stratification triggers a major diatom dominated bloom event. This bloom is short lived, limited by silicate (orthosilicic acid) exhaustion (Brown *et al*., 2003). Two community succession pathways commonly follow the demise of the diatom bloom; typically through dinoflagellate and/or coccolithophore production. The spring bloom is dominated by eddy scale (several 10's of km) patchiness, driven by the upward and downward pumping effect of eddies on the newly forming spring stratification. However these eddy structures have another, more important, impact on phytoplankton production (Allen *et al*., 2005). In the release of potential energy, eddies effect a real three dimensional exchange of water across the thermocline bringing new dissolved nutrients from deeper waters up into the photic zone and transporting biogenic particles into the deep ocean. Thin ribbon like structures around the edges of eddies are clearly seen in ocean colour satellite images. The four repeated surveys carried out during D321 observed the evolution of an 'eddy dipole' in a background ocean full of eddies and other turbulent motions. Daily, near real-time, satellite images and in-situ vessel mounted acoustic current profiling were used to determine the movement of the eddy centres and the dipole central jet. Targeted nets and water collection within the various components of the eddy dipole enabled the assessment of its biological impacts.

KEYWORDS

cruise 321 207, current profiles, diatoms, *Discovery*, Iceland Basin, National Oceanography Centre Southampton, ocean eddies, phytoplankton, primary production, remote sensing

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Contents

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NOC - National Oceanography Centre

OBE – Ocean Biogeochemistry and Ecosystems

OOC – Ocean Observing and Climate

OMF – Ocean Modelling and Forecasting

NMFSS – NERC Marine Facilities Sea Systems

PML – Plymouth Marine Laboratory

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MOORE, Mark	SG.1A
STEPHENS, Lee	S/Man.1A
DOWNIE, Eric	SG.1A
SANGSTER, Matthew	Motorman.1A
LYNCH, Peter	Head Chef
ISBY, Wilmot	Chef
ORSBORN, Jeffrey	STWD

LIST OF FIGURES *Page*

LIST OF TABLES *Page*

ABSTRACT

D321 was the first of three National Oceanography Centre 'process study' research cruises to be run by the Ocean Biogeochemistry and Ecosystems research group under the NERC Oceans 2025 research programme. The scientific work began by carrying out some of the extended Ellett Line stations on the way out to our study region; which centred around the historical JGOFS Ocean Weather Station India site (~ 59° N, ~ 19° W) and the northward turn of the extended Ellett line at 20° W. The Iceland Basin, like much of the N. Atlantic subpolar gyre, is characterised by a 'bloom and bust' seasonal cycle. Spring stratification triggers a major diatom dominated bloom event. This bloom is short lived, limited by silicate (orthosilicic acid) exhaustion (Brown *et al.*, 2003). Two community succession pathways commonly follow the demise of the diatom bloom; typically through dinoflagellate and/or coccolithophore production. The spring bloom is dominated by eddy scale (several 10's of km) patchiness, driven by the upward and downward pumping effect of eddies on the newly forming spring stratification. However these eddy structures have another, more important, impact on phytoplankton production (Allen *et al.*, 2005). In the release of potential energy, eddies effect a real three dimensional exchange of water across the thermocline bringing new dissolved nutrients from deeper waters up into the photic zone and transporting biogenic particles into the deep ocean. Thin ribbon like structures around the edges of eddies are clearly seen in ocean colour satellite images. The four repeated surveys carried out during D321 observed the evolution of an 'eddy dipole' in a background ocean full of eddies and other turbulent motions. Daily, near real-time, satellite images and in-situ vessel mounted acoustic current profiling were used to determine the movement of the eddy centres and the dipole central jet. Targeted nets and water collection within the various components of the eddy dipole enabled the assessment of its biological impacts.

1. INTRODUCTION

On the 25th July 2007, RRS *Discovery* slipped from King George V dock, Govan, just after 10:00 am, to begin the first Oceans 2025 research cruise. Oceans 2025 is the new £120 million research programme, funded by the Natural Environment Research Council, to deliver key strategic scientific goals. Comprising ten themes, it has been designed by, and implemented through, the UK's seven leading marine centres, including the NOCS, to enhance the research capabilities and facilities available for marine science. Although primarily focussed on themes 2 and 5, this research cruise, *Discovery* cruise 321 (D321) "Biophysical Interactions in the Iceland Basin", was designed to provide observations of direct relevance to themes 1, 2, 5, 9 and 10 of Oceans 2025. The scientific work began by carrying out some of the extended Ellett Line stations on the way out to our study region; which centred around the historical JGOFS Ocean Weather Station India site (~ 59° N, ~ 19° W) and the northward turn of the extended Ellett line at 20° W (**Figure 1**).

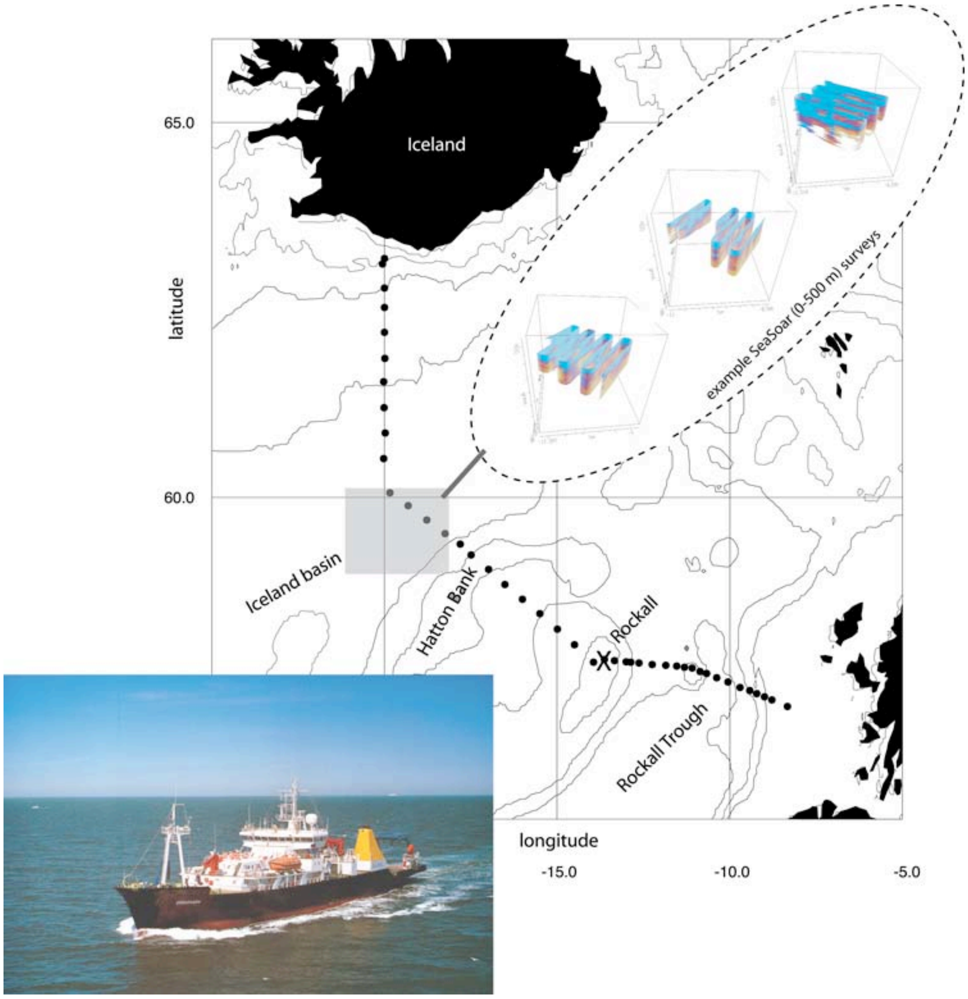


Figure 1: Simplified chart showing the extended Ellett line repeat hydrography stations (black dots) and a grey box indicating the approximate cruise study region; inset are three previous examples of the type of high resolution multidisciplinary survey to be repeated at the study region, and a picture of the RRS *Discovery*.

D321 was the first of three National Oceanography Centre process study research cruises to be run by the Ocean Biogeochemistry and Ecosystems research group under Oceans 2025. These will comprise a series of locally intensive process studies around spatially and/or temporally extensive time series observations, supplemented by remote sensing and modelling. In addition to D321 at OWS India, we will conduct intensive process cruises at the Porcupine Abyssal plain site in 2009 and a North Atlantic Subtropical Gyre site in 2011; making repeated physical, biological, chemical and sediment measurements at high spatial resolution to quantify key variables and their short term variability. Focussing these high resolution experiments in regions of large scale historical studies (theme 10), collaborating with our leading edge modellers (theme 9) and under the 'gaze' of our UK earth observation scientists (theme 1), we will begin to quantify the impact of the highly turbulent ocean on biological production and the natural sequestration of carbon dioxide at the ocean basin scale.

The Iceland Basin, like much of the N. Atlantic subpolar gyre, is characterised by a 'bloom and bust' seasonal cycle. Deep winter mixing sets the spring surface nutrient concentrations. Spring stratification triggers a major bloom event, dominated by rapidly growing diatom populations. However, this bloom is short lived, limited by silicate (orthosilicic acid) exhaustion (Brown *et al.*, 2003). Two community succession pathways commonly follow the demise of the diatom bloom. One of these, the path to flagellate and dinoflagellate communities, sets the ecosystem on a principally recycled production loop. The alternative pathway, to coccolithophores (Holligan *et al.*, 1993), allows carbon export ballasted by calcium carbonate to occur. The 'decision' making ecosystem cues that determine the community succession are not understood, but are critical to predicting how phytoplankton community composition will change with climatic drivers.

The spring bloom is not uniform in latitudinal bands as one might expect. Instead it is dominated by eddy scale (several 10's of km) patchiness. The formation and propagation of eddies produces an upward and downward pumping effect on the newly forming spring stratification and it is this which produces the patchiness in the spring bloom. However these eddy structures have another, more important, impact on phytoplankton production (Allen, 2005). In the release of potential energy, eddies effect a real three dimensional exchange of water across the thermocline bringing lighter (generally warmer) water up and over denser water; this energy release mechanism is known as baroclinic instability. Thus they bring new dissolved nutrients from deeper waters up into the photic zone and they transport biogenic particles into the deep ocean. Thin ribbon like structures around the edges of eddies are clearly seen in ocean colour satellite images, where the spring bloom is maintained or re-ignited by the periodic supply of deep water nutrients. Recently we have shown how this mechanism may double the new productivity from seasonal overturning within a period of just 20-25 days (Allen *et al*., 2005).

The extended Ellett line (EEL) monitors the N. E. Atlantic current extension through the Iceland Basin, the recirculation of the eastern subpolar gyre and the Iceland Scotland overflow. The EEL has been occupied almost annually since 1988 and has thus revealed upper ocean mode water variability of order 1-1.5 °C and 0.15 salinity over 5-10 year periods (Holliday, 2003). Surveys in 1996 and 2001 (Vivaldi'96 and FISHES respectively) demonstrated that the North Atlantic current (NAC) can follow different paths through the North Iceland Basin with effects on water mass structure and stratification (Pollard *et al*., 2004). The region is one of deep mixed layers (Read, 2001) and intense mesoscale activity; large eddies may significantly affect the path of the NAC (Read and Pollard, 2001). Observations made on the 2004 Ellett Line occupation, in the region of 60 °N, 20 °W, showed shallow (50m) mixed layers, abundant surface nutrients (5 µmol L^{-1} nitrate), low chl-*a* (0.32-0.53 mg m^{-3}) and low values of F_v/F_m (0.3 - 0.4) consistent with a phytoplankton community in poor physiological state. These environmental conditions are comparable to those in classical HNLC regions (Subarctic Pacific, Equatorial Pacific and the Southern Ocean). Martin *et al*., (1993) measured low Fe levels (0.07 nmol L^{-1}) in this region and speculated that the region may be iron limited under some circumstances. The World Ocean Atlas also shows non-zero values of nitrate in much of the subpolar N Atlantic during mid-late summer, indicating that the area may be extensive.

2. NARRATIVE

PSO's Diary

<u>25th July (Day 206)</u>

RRS *Discovery* slipped from King George V dock, Govan, just after 10:00 am. In all we had been delayed by ~ 26 hours. The last three hours of this had been waiting for Dr. Sinhue Torres-Valdez to fly up from Southampton with a spare Metrohm Titrino dosimeter for the DIC Vindta instrument. The dosimeter had stopped working at 17:00 hours the previous evening. We were all most grateful to Sinhue and presented him with a couple of RRS *Discovery* T-shirts !

The weather forecast looked good for the old OWS India region, but we were to expect a little lumpiness *en-route*. Although a remnant swell had knocked the edge off our speed, we were well past Islay by late evening.

<u>26th July (Day 207)</u>

A reasonably comfortable night followed by a beautiful sunny morning: the remnant swell was still there but otherwise a calm sea. How it had been so different so many years ago still amazes me (RRS *Discovery* cruise 245). Sadly we would not expect to make Rockall by evening light, but our first station, IB6 (part of the extended Ellett line) would be expected at 09:00 GMT tomorrow.

By late afternoon a strong N. Westerly wind accompanied by frequent squalls had blown up. By 19:30 the ship's speed had been reduced to ~ 8.5 knots: sadly our new ETA at IB6 was now 15:00 GMT tomorrow. The trace metal tow fish was deployed on the aft port side davit at 18:30.

<u>27th July (Day 208)</u>

As the wind died down overnight *Discovery*'s speed picked up. Despite a somewhat rocking and rolling night we clawed back some time and by 08:00 our ETA for IB6 had been brought forward to 13:00. The longer term weather forecast was still good.

Discovery was hove to at IB6 by 13:17 and the stainless steel CTD was in the water at 13:24 (**16195A**). The suffix letter refers to the type of instrument platform deployed, according to the following table:

Stainless Steel CTD	A	
Titanium productivity CTD	B	(only dawn stations)
Titanium incubation experiment CTD	C	(one dawn station per survey)
SAPS	D	(only dawn stations)
Vertical plankton nets	E	(only dawn stations
Turbulence profiler deployments	F	(only dawn stations)
Argo float deployment	G	
Pelagra deployments	H	
SeaSoar tows	I	

The trace metal fish was recovered at 14:06 with a crushed water pipe where the pipe leaves the fish. The CTD was inboard by 14:43 at which time we began a 'shake-down' of the turbulence profiler. Gently underway at 0.5 knots, the turbulence profiler was deployed three times (**16195F**) to check that its buoyancy had been adjusted correctly and its fall velocity was between 0.5 and 1.0 ms^{-1}. The test deployments were a success and the turbulence profiler was recovered on deck by 15:12. Following redeployment of the repaired trace metal fish, *Discovery* came up to speed and headed for IB7.

We arrived on station IB7 and the CTD was deployed (**16196A**) at 17:44; recovery was completed by 19:08. The temperature, salinity and particularly oxygen profiles indicated that in recent years deep winter mixing had reached around 650-700 m. This would suggest that our process CTDs would need to achieve a depth of around 800 m.

The CTD was deployed at IB8 (**16197A**) by 20:45, after being delayed on station by a winch compensator error for ~ 30 minutes. The CTD was recovered and inboard by 22:51.

28th July (Day 209)

CTD deployed at IB9 (**16198A**) at 00:52, recovered and inboard by 02:28.

CTD deployed at IB10 (**16199A**) at 03:56, recovered and inboard by 05:56.

Discovery heaved to in position 59° 38.7' N, 18° 46.4' W for mooring STNE at 08:08. Overnight there had been some minor problems with data spikes which had been traced to suggest a main CTD cable problem. Inspection showed that a region of damaged cable did exist and therefore, whilst communications with the mooring were being established, a re-termination procedure began.

Mooring STNE signalled release at 08:30 and began rising at 40-50 m per minute. The buoyancy was spotted on the surface by the captain at 09:09 (*Discovery* stn. **16200**). Grappled at 09:26, the mooring was successfully recovered by 09:52. It was immediately clear that the sediment trap had collected a significant amount of exported material, with at least one sample pot nearly half full.

Discovery was hove to on station C1C5, where the second two alphanumeric characters provide a coordinate (**Figure 2**) of the process study survey region, at 10:34. With the CTD termination at an early stage it was decided that we would carry out turbulence profiling here. With a good weather forecast we expected significant surface re-stratification over the weekend and therefore it would be useful to obtain both before and after profiles of turbulence in the region. Repeated turbulence profiles (**16201F**) were completed by 11:34 and *Discovery* headed north for the north-east corner of the survey region C1A5.

Re-termination of the CTD cable was a lengthy procedure, not helped by what seems like an overly complex load testing procedure and the winch compensator triggering a shut down several times during load testing. Just to be consistent the compensator then triggered a shut down a further time whilst trying to deploy the CTD. The CTD was finally deployed at C1A5 (**16202A**) at 16:15. Station C1A5 was completed by 17:20.

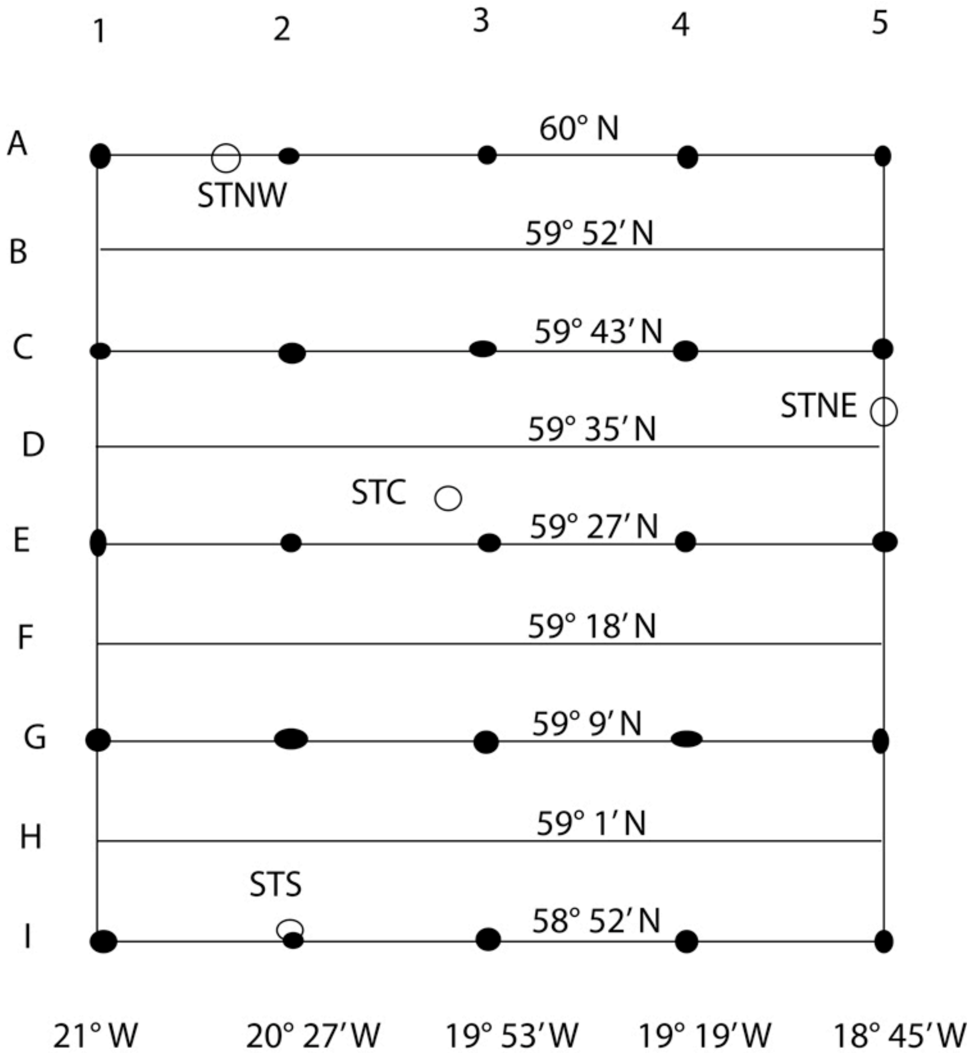


Figure 2: Cartoon diagram of the process study survey region for surveys C1 and S1 showing the four sediment trap mooring locations.

The CTD was deployed at C1A4 (**16203A**) at 19:21, recovered and inboard by 20:26.

The first productivity station began at C1A3 which was also to become a substitute for extended Ellett line station IB12. The order of the various instrument deployments was set by a dawn timing for the trace metal titanium frame CTD cast, from which incubation samples would be drawn, and a darkness requirement for the vertical plankton net hauls, to avoid diel migration. Arriving on station at ~ 22:35, the stainless steel CTD was deployed first at ~ 22:40 (**16204A**), to go to full depth as part of the extended Ellett line and also to test two acoustic releases. The CTD was back on deck at 01:32. Some time had been lost whilst the CTD was near the bottom; as this would be one of the rare deep casts the opportunity was used to re-adjust the scrolling gear and thus spool the wire on the winch drum rather better than had been the case. This would save considerable time in the long run.

29th July (Day 210)

Two plankton net hauls were completed (**16204E**) by 02:29 whilst the dawn timing constrained titanium CTD cast was being prepared. The titanium CTD was deployed at 02:56, but having reached its intended maximum depth of 800 m none of the bottles would fire. The CTD was recovered, the software reset and successfully tested on deck by 03:45. The CTD was then redeployed at 03:51 (**16204B**). After successful bottle firing on the upcast the CTD was recovered at 04:45. Stand alone pumps (SAPS) were deployed (**16204D**) on the coring wire at 05:32. Having given them enough time to complete their timed pumping sequence, the SAPS were recovered at 08:20. The turbulence profiler was deployed at 08:33, and after 14 profiles (**16204F**) it was recovered at 10:04 to complete the productivity station.

The stainless steel CTD was deployed at C1A2 (**16205A**) at 12:28, recovered and inboard by 13:27.

The STNW (sediment trap north-west) mooring (**16206**) was released at 15:09 and sighted at 15:58 by the CPO(S). After a successful recovery *Discovery* set course for C1A1 at 16:45. The catch in the trap bottles was noticeably different to that found at STNE – mesoscale heterogeneity in export flux perhaps ? – or too early to call !

The stainless steel CTD was deployed at C1A1 (**16207A**) at 17:35, recovered and inboard by 18:40.

The stainless steel CTD was deployed at C1C1 (**16208A**) at 20:45, recovered and inboard by 21:52.

Half a mile before C1C2, two Pelagra drifting sediment traps were launched (**16209H**) for short test deployments, both traps had been successfully deployed by 23:57.

30th July (Day 211)

After launching the Pelagra traps, now also visible at night by their flashing red or white lights, *Discovery* re-positioned half a mile along track to begin our second productivity station at C1C2.

Vertical net hauls began at 00:16 (**16209E**), strong surface currents required significant ship control to keep the kevlar line vertical as it spooled off the aft Rozler (Wrexroth replacements) winch. Three nets were completed by 01:00 hrs. In just 45 minutes *Discovery* had drifted over 0.8 nm, and therefore I authorised some element of repositioning between instrument deployments on this station. The titanium CTD was deployed (**16209B**) at 01:16 and recovered by 02:07. This was followed by the stainless steel CTD (**16209A**) at 02:19. Following recovery of the CTD, SAPS were deployed at 04:27 (**16209D**). By 08:16 the SAPS had been recovered and we proceeded to carry out a combination of turbulence profiling (**16209F**) and Pelagra recovery. After one turbulence profile the Pelagras had been spotted. Further turbulence profiles were suspended.

One Pelagra was recovered and on board by 10:00. The other, we later found out, had not released its ballast weight and was lying low in the water. We had seen this problem before (RRS *Discovery* cruises 285, 286 and 306 in particular). After two unsuccessful attempts to find and recover, the Pelagra would sink as soon as it got close to the ship, *Discovery*'s RIB was launched at 12:47 crewed by CPO(S) Steve Smith, 2nd Officer Malcolm Graves and 3rd Officer Tanveer Azhar. A messenger line was attached to the Pelagra and this line was passed to *Discovery* deck on close approach (**Figure 3)**. The Pelagra and the RIB were recovered by 13:10.

Turbulence profiling (**16209F**) was continued following recovery of the RIB, however, problems with the portable profiler winch drew an early close to this and *Discovery* set course for station C1C3 at ~ 14:15. Driving rain and increasing winds were not pleasant but weather forecasts suggested only force seven/eight for a short time as a depression moved eastwards just to the north of us.

Figure 3: Recovering a rogue Pelagra drifting sediment trap.

The CTD was deployed at C1C3 (**16210A**) at 16:20, recovered and inboard by 17:18. Sadly, deteriorated weather conditions required that *Discovery* remained hove-to whilst sampling the CTD rosette. With sampling completed, *Discovery* set course toward C1C4 at 17:44.

Discovery hove-to on station C1C4 (**16211A**) at 19:38. With 23 knot winds, a rough sea state but only a moderate swell, the station was considered workable. However the CTD was not deployed until 20:48, and only after the Master provided written instruction that deployments must be made according to the vast wealth of experience of the crew, engineers and technicians on board, and not through strong advice from those ashore. In this case, recent instructions would have made force five/six seas marginal and we could expect 50% or less workable time on this (summer) cruise in this part of the N. Atlantic. The CTD was recovered and secured by 21:55.

Hove-to at 23:45 on station C1C5, we began our third productivity station.

<u>31st July (Day 212)</u>

A titanium CTD cast to collect water for experimental incubations was carried out first (**16212C**); the CTD was deployed at 00:02 and recovered from a depth of ~ 10 m at 00:09. Vertical plankton net hauls began (**16212E**) at 00:15 and were completed after the third net at 00:59. The stainless steel CTD (**16212A**) was deployed to 800 m at 01:07 and recovered by 02:17. Sampling of the first titanium CTD was complex and time consuming, thus it was not until 03:02 that the normal productivity titanium CTD was lowered into the water (**16212B**). The CTD was recovered and on deck by 03:53. SAPS were deployed (**16212D**) at 04:40 and recovered after their programmed pumping sequence at 07:12. Turbulence profiling began at 07:15 (**16212F**) and was completed at 08:30 with the re-deployment of the trace metal fish. In the roughish sea conditions it was not easy to determine how much slack cable was in the water following the descending profiler, which made deployments somewhat difficult.

On station C1E5 at 10:10. The CTD was deployed (**16213A**) at 10:17, secured in-board and sampling completed by 11:42. At this station we realised that going for a mooring in the afternoon with these rough conditions would be inadvisable, so the planned survey station sequence was rapidly re-configured to head for STC (sediment trap central) the following morning.

On station C1G5 and CTD deployed at 14:14 (**16214A**). Bright weather, but wind speed and sea state marginal. The CTD was recovered and on deck by 15:06.

The CTD was deployed at C1I5 (**16215A**) at 18:07, recovered and in-board by 19:03.

Steaming into the sea westwards towards C1I4 would be a long haul. However, at 22:50 *Discovery* heaved-to at C1I4; the CTD **(16216A)** was in the water at 23:01, back on deck and sampling completed by 00:36.

1st August (Day 213)

The CTD was deployed at C1G4 (**16217A**) at 03:25, recovered and sampling completed by 05:20.

The CTD was deployed at C1E4 (**16218A**) at 08:07, recovered and sampling completed by 09:23.

The position of the central sediment trap (STC) mooring was reached just after 13:00 (59° 29.82’ N, 19° 59.15’ W). Having completed its acoustic tests, the mooring was released (**16219**) at 13:21. The SC-ADCP sphere and the recovery line pellet float reached the surface quickly and were sighted just 40 m off the port bow. Once the main buoyancy reached the surface some 20 or more minutes later, *Discovery*, having initially backed off, made an approach down wind and the recovery line was grappled at 13:59. All ~ 2500 m of the mooring had been recovered by 16:15. The sediment trap had clearly been a great success like those at STNE and STNW, and again showed a significant difference in sediment volume caught and timing.

Station C1E3 was carried out without re-locating at position 59° 29' N, 20° W. The CTD was deployed at 16:45 (**16220A**), recovered and sampled by ~18:00. Before leaving station, a Pelagra floating sediment trap (**16220H**) was launched for a 4+ day deployment. Two ARGO floats, one Apex and one Martek Provor, were launched gently of the stern at 18:55 (**16220G1**) and 19:08 (**16220G2**).

The weather forecast for Friday, Saturday and Sunday was now well confirmed and showed that we were to be hit by extra-tropical cyclone 'Chantal'. The objective now was to finish the mooring recovery and as much of the CTD survey, C1, as possible over the next 24 hour weather window before expecting to heave-to in greater than Beaufort force 10 gales.

The CTD was deployed at C1G3 (**16221A**) at 21:28, recovered and steaming for C1I3 by 22:24.

<u>2nd August (Day 214)</u>

C1I3 would become our fourth productivity station. This began with a water collecting titanium CTD cast at 00:25 (**16222C**), recovered at 00:38. Vertical net hauls followed at 00:57 (**16222E**) and finished after just 2 nets at 01:18. The stainless steel CTD (**16222A**) was deployed by 01:35, recovered by 02:28. The productivity incubation titanium CTD cast (**16222B**) began at 03:09 and was recovered by 04:03. The SAPS deployment followed at 04:35 and the pumps were recovered after their pumping sequence (**16222D**) at 07:05. Just over an hour of turbulence profiling (**16222F**) began at 07:17 and ended at 08:39, whereupon RRS *Discovery* headed for mooring location STS, nominally 58° 51.96'N, 20° 24.17'W.

What a calm before the storm, not quite a flat sea but only a whisper of wind. Communication from the RRS *James Cook*, some ~ 600 nm to the SSE of us, reported 30 knot winds as 'Chantal's' warm sector began to strike - this would be us in perhaps little more than 12-24 hours !

Discovery was hove-to on STS at 10:41. Although the acoustic release provided good ranging signals, we had considerable difficulty receiving diagnostic information and we were unable to receive confirmation of a release command. Through the combined use of both NavOceano TT301 and 801 deck transducer signal generators (The TT301 would successfully send commands, but only the TT801 could understand the replies !), the mooring was finally released and rising at 50 metres per minute by 12:15. Sighted on the bridge by 12:50, grappled at 13:34, the mooring was fully recovered by 13:58 (**16223**). A 'clean sweep' (what a great name for a party thought the Captain !), four out of four moorings and successfully recorded sediment trap records of seasonal and spatial variability in deep particle export had now been secured.

C1I2 would be carried out at our location at the end of mooring recovery, 50° 52.2' N, 20° 24.64' W. A report arrived at this moment from RRS *James Cook* experiencing storm force 11; our barograph was dropping fast but conditions still moderate for now. The CTD was deployed (**16224A**) at 14:21, recovered at 15:12.

The southerly wind began to strengthen significantly en-route to station C1G2. The CTD was deployed at C1G2 (**16225A**) at 17:33, recovered and sampled by 19:00. At which point, science ceased for an uncertain period; 30 knot winds, an increasingly rough sea and a dramatically falling barograph heralded the inevitable arrival of 'Chantal' (**Figure 4**).

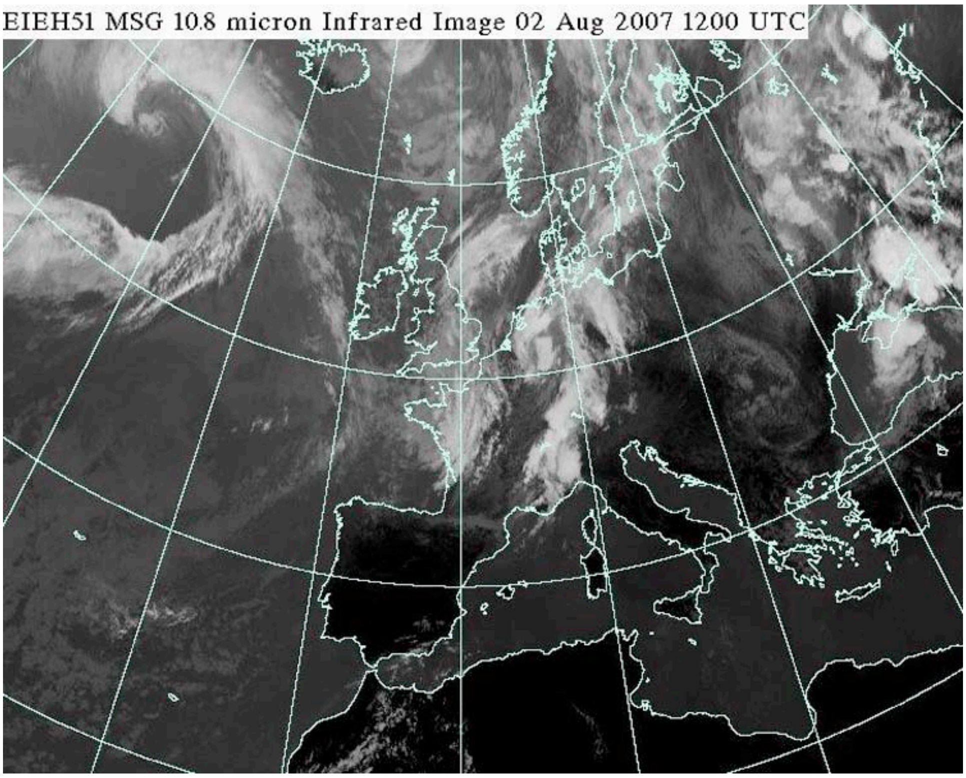


Figure 4: Extra-tropical cyclone 'Chantal' is clearly visible in the top left hand corner of this infra-red satellite image

By 22:00, the barograph had levelled and the winds dropped, had we called too early ?, probably not, this was after all typical of the spiral like structure associated with a sub-tropical storm. However, this might give us a little time to get to the most south-western corner of our survey area, I1, where we could expect conditions to improve soonest following the passage of the storm.

3rd August (Day 215)

By 06:00 *Discovery* was hove-to at 58° 52' N, 20° 58.9' W. At 09:15, wind speed was a steady 35-40 knots, barograph still falling through 985 mbar; mean significant wave height ~5.5 m, peak values around 7.5 m.

At 12:56, *Discovery* remained hove-to at 58° 50.6' N, 21° 16.6' W. Wind speed had risen to 40-45 knots, barograph still falling through 982 mbar, the wave height had risen to a mean significant value of 7.75 m and a peak of ~ 9.5 m.

Just before dinner, 17:37, there was no change in wind speed, the barograph was still falling, but, through 976 mbar and thus this should soon level out !, mean significant wave height still around 6 m with peak values of ~9 m.

At 21:50 the barograph was levelling towards 969 mbar, the wind speed had dropped to 35-40 knots, we seemed to be close to the centre of the storm which according to forecasts was due to pass right over our survey area.

4th August (Day 216)

At 08:55, *Discovery* remained hove-to at 58° 32.26' N, 22° 28.5' N – 50 miles to the south-west of I1. The barograph was now rising sharply through 986 mbar, but the wind speed was still a modest 30-35 knots.

At 09:37, *Discovery* turned onto a course of ~ 075° T to attempt to relocate to position I1 (the south west corner of our survey region). I have never seen *Discovery* so stable, and nearly beam on to one of the swell directions.

Discovery was hove-to at 15:12 at C1I1 assessing weather conditions. The barograph had risen to 993 mbar and so far, rather than experiencing strong northerly winds on the back wall of the storm, 'Chantal' appeared to have filled around us and merged with a low pressure north of Iceland, we've been lucky.

At C1I1 we would make our fifth productivity station. The stainless steel CTD was deployed (**16226A**) at 21:00 with two acoustic releases attached. The CTD was taken to full depth, at which point the acoustic releases were tested, unfortunately one of these failed to release. The CTD was back on deck and being sampled by 23:50.

5th August (Day 217)

SAPS (**16226D**) were deployed by 00:16 and recovered after their pumping sequence at 02:52. The titanium CTD was deployed at 03:19 (**16226B**) and recovered by 04:30, at which point vertical net hauls began (**16226E**). The plankton net was deployed three times and recovered at 05:16. Turbulence profiling (**16226F**) was carried out between 05:35 and 07:05.

At 08:22, SeaSoar deployment began (**16227I**). By 09:13, deployment, instrument checks and the necessary stopping off of both the SeaSoar and deck winches had been completed. At 09:58 *Discovery* came up to speed 8-9 knots on the first survey leg S1I. The SeaSoar vehicle was not easy to tune for a good flight profile and only a maximum depth of 370-390 m could be achieved. The flight profile showed a similar uncontrolled rapid dive and climb, but a struggle to achieve either depth or the surface, as it had done on the MADEX cruise (RRS *Discovery* 288) in February 2005. The common and most likely source of the problem lay in the use of the 6000 m pressure rated OPC. This is very heavy and relatively much heavier in water than the original 600 m rated OPC instruments, because the electronics cases were much smaller in diameter and consequently vastly less buoyant, and is thought likely to make the SeaSoar vehicle fly rather tail down. Sadly the deep OPC is the only serviceable OPC currently in the NMEP.

At ~14:30 the FRRF-II instrument on the SeaSoar stopped working due to a firmware fault/feature (this is effectively a Chelsea Technologies Group prototype, even though it is currently marketed), which rather foolishly locks up logging and user control of the instrument if the photomultiplier tube gets light saturated (pointed at the open sky for instance, as might reasonably be the case at the beginning of a CTD cast !). At ~16:00 the SeaSoar was brought to the surface and the whole system power-cycled. Following this we were then unable to get the SeaSoar vehicle to return to flight control. During the afternoon it had been noticed that the maximum depth achieved had reduced from 390 m to ~ 350 m and that the down profile had become very gentle. However, we had not considered such an early hydraulic failure. Just after dinner, at ~18:30, SeaSoar was in recovery. Once on deck it was clearly apparent that a gentle turning of the wings by hand could force the hydraulic ram in and out, indicating that hydraulic power pack failure had been the cause of flight control failure. Replacement of the hydraulic power unit would take some time. Thus we would carry out leg H with CTDs, however we would maintain the S1 prefix for this survey as we fully expected to deploy SeaSoar within 12-24 hours.

The stainless steel CTD was deployed at S1H5 (**16228A**) at 21:03, recovered at 22:10.

6th August (Day 218)

The CTD was deployed at S1H4 (**16229A**) at 00:35, recovered and sampled by 02:06.

The CTD was deployed at S1H3 (**16230A**) by 04:13, recovered and sampled by 05:47.

The CTD was deployed at S1H2 (**16231A**) at 08:04, secured and sampled by 09:35.

The CTD was deployed at S1H1 (**16232A**) at 11:44. Following recovery at 12:40, a series of turbulence profiles were recorded (**16232F**) until 14:02.

Discovery then set a northerly course towards S1G1. The decision had been made to make a further line of CTDs rather than immediately redeploy SeaSoar. There were two reasons for this, firstly there was some debate about whether to deploy with the FRRF-II or whether to re-engineer the payload to return to the use of the FRRF-I and secondly, the PELAGRA drifting sediment trap was alive and well, waiting to be picked up between G4 and G5. In the end it was decided to keep the FRRF-II on SeaSoar, but to fit it with the dark chamber from the laboratory instrument to overcome the photomultiplier saturation problem.

The afternoon had been sunny and warm, about time too !. By 15:09, the CTD was deployed (**16233A**) at S1G1, recovered and secured by 16:03.

The CTD was deployed at S1G2 (**16234A**) at 18:07, recovered and secured by 19:10.

The CTD was deployed at S1G3 (**16235A**) at 21:24, recovered and secured by 22:28; together with 16236B this would later become our sixth productivity station (as defined by the making of uptake rate measurements).

7th August (Day 219)

The titanium CTD was deployed at S1G4 (**16236B**) at 00:31, recovered and secured by 01:29.

Discovery then set course eastwards towards the last reported position of PELAGRA, 59° 9.06’ N, 19° 3.42’ W. We expected from its previous reported positions that we should sight PELAGRA before reaching the last reported position, this was not to be the case. By 02:52 we were vigorously searching for PELAGRA both visually and by Gonio receiver. At 03:56 we had visually located the flashing red light on PELAGRA. However, it was still a little too dark to consider an immediate recovery. Station S1G5 was therefore moved to our new PELAGRA position (59° 10.57'N 18° 53.17' W).

The titanium CTD was deployed at 04:17 (**16237B**), recovered and secured by 05:12.

The PELAGRA recovery was straightforward in the calm sea and this too was on board and secured before 06:00

SeaSoar was re-deployed near F5 and *Discovery* had come up to a survey speed of 8-9 knots by 10:15, to continue survey S1 (**16227**). Whilst on deck, an extra 5 degrees of mechanical down-wing bias had been added through adjusting the length of the control rods, this made a lot of difference with a more controlled flight and a maximum depth of 440-450 m.

Point S1F1 was turned through at ~ 16:40.

Point S1E1 was turned through at ~ 17:35 to begin leg E of the survey. The weather was calm, although cloudy, at least it feels more like summer.

8th August (Day 220)

Discovery turned through S1E5 at ~ 00:40 and then S1D5 at ~ 01:30 to begin leg D. Around 03:00, *Discovery* was slowed to 5 knots for a short period to allow SeaSoar to sink and correct its flight attitude after flipping upside-down at the surface. A glitch in the flight control software just before this had brought the vehicle to the surface too quickly and this is believed to have triggered the resulting inversion of SeaSoar.

Point S1D1 was reached at 09:05, followed by S1C1 at 10:10 after which *Discovery* began leg C of the survey. At around this time, the FRRF-II stopped logging and required the power cycling of the whole SeaSoar vehicle. The recovery from this power cycle left the communication through the modems rather fragile, but a second full power cycle including the top modem solved this.

At approximately 13:38, the PENGUIN data acquisition linux system on SeaSoar crashed and could not be reliably re-booted. At 14:33 we began SeaSoar recovery at 59° 42.36' N, 19° 42.65' W. SeaSoar was safely recovered at 14:58. Mega-Ohm testing of the sea cable showed that re-termination would be required. In addition, the voltage clamp circuit inside PENGUIN had failed and a new transistor would need fitting. We would carry on survey S1 with CTDs. The VM-ADCP data showed that the currents mirrored a satellite ocean colour described eddy dipole structure that had migrated from the north-west into our survey area (**Figure 5**). It was imperative that we understood the northern boundary of this area.

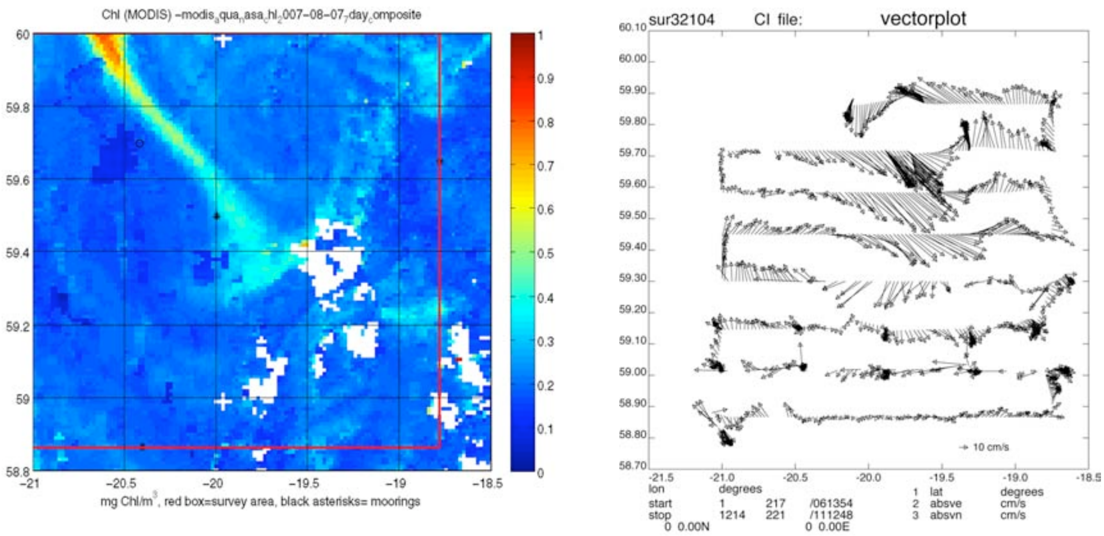


Figure 5: Left, an ocean colour composite showing the productive jet and eddy dipole sampled during survey S1. Right, the 75 kHz VM-ADCP current vectors at ~ 30 m depth.

The titanium CTD was deployed at S1C3 (**16238B**) at 17:32, following a problem with the sea cable connection to the CTD frame. The CTD was recovered and secured by 18:30.

The stainless steel CTD was deployed at S1C4 (**16239A**) at 20:20, recovered and secured by 21:40.

<u>9th August (Day 221)</u>

The CTD was deployed at S1C5 (**16240A**) at 23:44, recovered and secured by 00:37. The weather was now rather unpleasant, driving rain, but little wind and a steady barograph were its saving graces.

At S1B5 (~ 02:08) the CTD work had to be aborted due to a broken armour strand in the CTD cable at the tear drop mechanical link with the CTD frame. The decision was made to continue the survey underway at reduced speed to achieve the best possible quality VM-ADCP water current profiles.

In an attempt to look at the effect of high shear in an eddy dipole central jet, two turbulence profiler stations were made during the late morning. The first of these

(**16241F**) was carried out at ~ 59° 52’ N, 19° 37’ W between 06:05 and 07:30. The second (**16242F**) was carried out at ~ 59° 52’ N, 20° 7’ W between 09:37 and 10:55. By this time, the CTD cable had been re-terminated and load-tested successfully.

The stainless steel CTD was deployed at S1B2 (**16243A**) at ~ 12:20, recovered and secured by 13:14.

The CTD was deployed at S1B1 (**16244A**) at ~ 15:17, recovered and secured by 16:10.

Discovery was hove to at S1A1 by 17:22. The CTD was deployed (**16245A**) at 17:33, and recovered by 18:30.

Discovery heaved to and came head to wind for mooring STNW at 19:26. The mooring was released at 20:13 (**16246**) at 59° 59.89’ N, 20° 51.52’ W. After acoustically monitoring the descent of the release and checking that it remained at its maximum depth, *Discovery* set course for S1A2 which would become our 7th productivity station.

A PELAGRA drifting sediment trap was deployed at S1A2 (**16247H**) at 22:06, for a six hour ballasting test deployment. The Stainless steel CTD was deployed (**16247A**) at 22:25, recovered and secured by 23:30.

<u>10th August (Day 222)</u>

The titanium CTD was deployed for water collection (**16247C**) at 00:47, recovered and secured by 00:57. Three vertical plankton net hauls began (**16247E**) at 01:06 and were completed by 01:46. The titanium CTD was deployed for productivity incubation at 02:17 (**16247B**), recovered and secured by 03:08. SAPS were deployed (**16247D**) at 03:26, recovered after their pumping sequence at 06:40. At 06:50, one turbulence profile was made (**16247F**) but further profiles were suspended after we had received gonio direction finder signals from PELAGRA indicating that heaving-to, head to wind, was in fact taking us away from PELAGRA. Two ARGO floats were deployed whilst looking for PELAGRA; the first, (**16247G1**) at 08:11 and the second, (**16247G2**) at 08:13. Having approached PELAGRA to a distance where strong signals (gonio strength 7) were obtained, we were still unable to sight it. Therefore we re-started turbulence profiling between 08:31 (**16247F**) and 09:43. Returning to PELAGRA hunting, it took another hour to sight the drifting trap; although gonio signals had been strong, only inaccurate error codes were being received, which had made it difficult to distinguish from other signals. PELAGRA was recovered (**16247H**) and secured by 10:50, *Discovery* set course for S1A3.

The stainless steel CTD was deployed at S1A3 (**16248A**) by 12:53, recovered and secured by 13:49.

The CTD was deployed at S1A2 (**16249A**) by 16:00. At ~ 400 m on the upcast the CTD deck unit began to alarm and promptly blew a fuse. The CTD was recovered by 16:51. After investigation, it was found that the recent re-termination had flooded and there had been water ingress up to and probably past the mechanical termination: a full re-termination was required. This heralded the official end of the 'SeaSoar' survey, S1.

Following inspection of the data-sets the previous evening, it was clear that the eddy scale physics were driven by gradients between water masses which included winter mode waters that extended to over 800 m, some clear similarity with the PRIME and ACSOE studies. SeaSoar could never achieve sufficient depth to provide a sensible lower bound for the data-set. Thus a third and final survey had been designed for CTD survey 2 (C2), which would cover the same survey area with 49 CTDs to a depth of 1000 m (**Figure 6**). However, for now we would head towards STNE to replace the sediment trap mooring we had recovered earlier in the cruise; transiting the ~ 28 nm to STNE, laying the mooring and transiting back to C2A7 would be expected to allow time for the re-termination of the CTD cable.

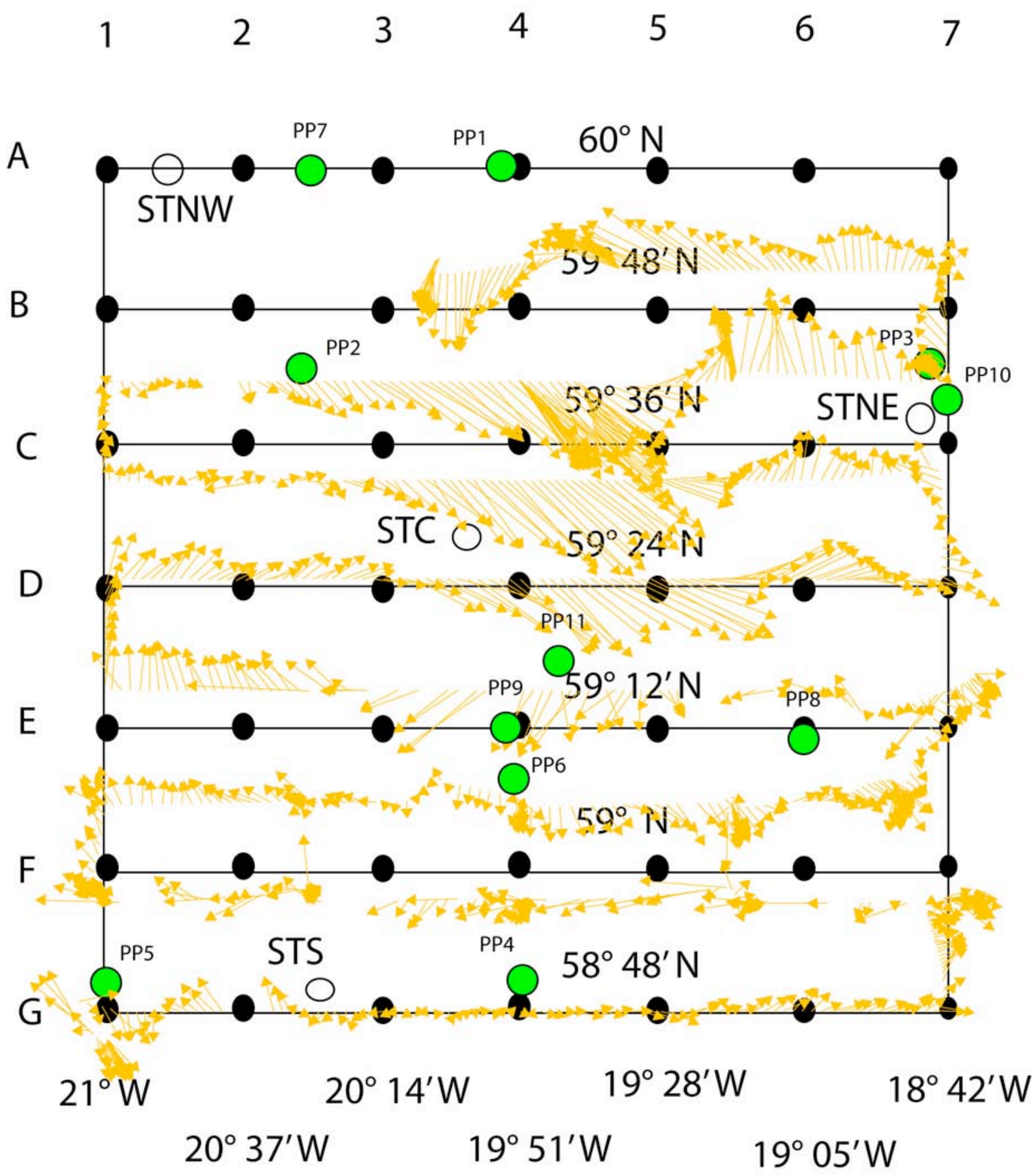


Figure 6: Cartoon diagram of the process study survey region for survey C2 showing the four sediment trap mooring locations, the primary productivity stations during the cruise, and the current vectors (30 m depth) from survey S1.

Discovery was hove-to on STNE (Disco. Stn. **16250**) at 20:30. The sediment trap mooring was released at 21:05 (59° 39.62' N, 18° 50.36' W) and its settling on the sea bed was confirmed by 21:27. *Discovery* set a return course for the first station of CTD survey C2, C2A7.

11th August (Day 223)

The stainless steel CTD was deployed at C2A7 (**16251A**) by 00:06, recovered and secured by 01:05.

The CTD was deployed at C2B7 (**16252A**) by 02:51, recovered and secured by 04:00.

The CTD was deployed at C2C7 (**16253A**) by 05:36, recovered and secured by 06:42.

The CTD was deployed at C2D7 (**16254A**) at 08:07, sampling began at 09:26, *Discovery* set course for C2E7 at 10:00. The weather was choppy , force 5-6, but according to forecasts this was as bad as it would get for several days.

The CTD was deployed at C2E7 (**16255A**) by 11:38, recovered and secured by 12:38.

The CTD was deployed at C2F7 (**16256A**) at 14:13, recovered and secured by 15:30.

The CTD was deployed at C2G7 (**16257A**) by 16:50, recovered and secured by 18:00.

The CTD was deployed at C2G6 (**16258A**) at 19:37, recovered and secured by 20:55.

The CTD was deployed at C2F6 (**16259A**) at 22:25, recovered and secured by 23:43, *Discovery* continued north towards C2E6 to begin our eighth productivity station.

<u>12th August (Day 224)</u>

A vertical plankton net was deployed first at C2E6 (**16260E**) at 01:22. Three nets were completed by 01:59, and the stainless steel CTD was deployed (**16260A**) at 02:16. Following recovery of the stainless steel CTD at 03:13, the titanium CTD was deployed (**16260B**) by 03:40. Communication problems with the CTD forced us to stop the deployment at 965 m and begin hauling. After several deck unit resets and a complete re-boot of the deck control PC, communications were restored as the CTD passed ~565 m; bottle stops and bottle firings were therefore restored above this depth. The CTD was recovered and secured by 04:35, it was clear that bottles had fired as requested. The most likely and preferable initial cause of the communications problem was a poorly mated sea-cable connector; this has to be disconnected from one CTD frame and connected to the other two or more times during productivity stations. SAPS were deployed (**16260D**) at 05:00, recovered after completion of their pumping sequence at 07:30. Finally, turbulence probe profiling was carried out between 07:40 and 09:00 (**16260F**).

The stainless steel CTD was deployed at C2D6 (**16261A**) at 10:58, recovered and secured by 12:16.

The CTD was deployed at C2C6 (**16262A**) at 13:51. This station was very close to extended Ellett Line station IB11. Thus the CTD was taken to full depth, 2665 m, where a fourth mooring was successfully tested. On recovery, 8 bottles were fired at 2000 m for a ^{234}Th export control measurements. The CTD was recovered and secured by 16:00.

Discovery reached C2B6 (**16263A**) at 17:30, however sampling of the previous cast continued until ~ 17:40. The CTD was deployed at 17:50, recovered and secured by 18:55.

The CTD was deployed at C2A6 (**16264A**) at 20:16, recovered and secured by 21:45.

The CTD was deployed at C2A5 (**16265A**) at 23:07.

13th August (Day 225)

The CTD was recovered and secured by 00:35, *Discovery* set course south for C2B5.

The CTD was deployed at C2B5 (**16266A**) at 02:06, recovered and secured by 03:01.

The CTD was deployed at C2C5 (**16267A**) at 04:40, recovered and secured by 05:50.

The CTD was deployed at C2D5 (**16268A**) at 07:05, recovered and secured by 08:21. Overnight and through the early morning, intermittent communication problems with the CTD continued; on at least one occasion this required manual bottle firing and a further re-boot of the deck control PC.

Early calibration of the thermosalinograph (TSG) to underway bottle samples, indicated a well behaved TSG with an offset of about 0.1 and by inspection a standard deviation of 0.02-0.03 would be found. However, both bottle samples and TSG show a freshening of the surface water around 0.08-0.1 during the time we had been in the region. Interestingly, the poor weather during the early period of the cruise, now some 9 days ago, had little effect on mixed layer depth, it was perceived that this resulted from very little difference between sea surface temperatures and sea level air temperatures and thus there had been negligible buoyancy forcing. However, several more recent CTD profiles had indicated that there was a stable stratification in salinity in the 'mixed' layer. On a more anecdotal level, until perhaps only the last two days, there had been significant rainfall associated with both the poor weather at the start of the cruise and the frequent weak warm fronts that had passed through during the current calm weather – but could this level of rainfall really account for such a significant freshening of the surface ocean here ? the 'back of an envelope' calculation would imply a requirement of 8 or more cm of rainfall, however, the nature of the freshening makes it difficult to see from where else the fresher water input could have come.

The CTD was deployed at C2E5 (**16269A**) at 09:52. Following recovery of the CTD at 11:08, the turbulence profiler was deployed between 11:10 and 12:22 (**16269F**). According to the VM-ADCP data, it looked as though the tightest part of the current jet, between the cyclonic/anticyclonic eddy pair, had advected/developed towards this station position.

The CTD was deployed at C2F5 (**16270A**) at 14:00, recovered and secured by 15:01.

The CTD was deployed at C2G5 (**16271A**) at 16:40, recovered and secured by 17:43.

The CTD was deployed at C2G4 (**16272A**) at 19:17, recovered and secured by 20:38.

Discovery was on station C2F4 at 22:05, the CTD was deployed (**16273A**) at 22:25, recovered and secured by 23:45. *Discovery* headed north for our ninth productivity station at C2E4.

14th August (Day 226)

Discovery was on station C2E4 by 01:15. Force 6 winds and a moderately worsening forecast drove us to assess carefully whether to make a short (~ 3 hour) PELAGRA test deployment. PELAGRA (P4) was deployed by 01:30 (**16274H**). The titanium CTD was deployed to 10 m on an incubation water collection exercise (**16274C**) at 01:42, recovered and secured by 01:51. The vertical plankton net was deployed at 02:01, however only one net haul was made after the strengthening winds made it difficult to handle (**16274E**). The stainless steel CTD was deployed (**16274A**) at 02:35, recovered and secured by 03:34. At 04:00, science operations were suspended due to worsening weather, 20-30 knot winds and a moderate to rough sea: we began to search for PELAGRA. *Discovery* heaved-to at ~ 59° 13.08' N, 19° 52.35' W at ~ 05:50 with PELAGRA in sight, near dead-ahead. By 07:10, wind speeds were 25-30 knots but the mean significant wave height remained less than 2.5 m with peaks not exceeding ~ 3.5 m. At 09:40, the hunt for PELAGRA began again in earnest, wind speed had now dropped off somewhat. PELAGRA was grappled at 09:57, on board and secure by 10:08. Bearing in mind the time lost to bad weather, at this point station C2E4 was considered complete.

The stainless steel CTD was deployed at C2D4 (**16275A**) at 12:20, recovered and secured by 13:18. *Discovery* now set a WNW course for a 'tow-in' position on the central sediment trap mooring (STC), this mooring has an upward looking SC-ADCP just over 500 m below the surface, ideally.

Discovery was hove-to at 14:40, 2 nm down wind of STC. At 14:42 the deployment of STC began. The anchor weight was released at 16:25 (59° 30.32' N, 20° 00.78' W) and the mooring was confirmed on the bottom, staying on the bottom, by 16:55.

Discovery was hove-to on C2C4 at 18:20, however a crossed swell and wind direction delayed deployment of the CTD. The CTD (**16277A**) was deployed at 19:00, recovered and secured by 20:10.

The CTD was deployed at C2B4 (**16278A**) at 22:12, recovered, secured, and sampled on station by 23:40.

<u>15th August (Day 227)</u>

Discovery was hove-to on station C2A4 at 02:02, science was postponed due to marginal conditions. AutoFlux, corrected, wind speeds were around 25 knots, the bridge anemometer however indicated 30 + knot, force 7 winds. Mean significant wave height reached ~3.5 m. By 07:20, wind speed was 20-25 knots, but sadly we were still not working due to occasional packets of swell waves coming in from the north-east. A beautiful day, sunny and bright, what more could we ask for ? a calmer sea perhaps.

With no other options, we set course for C2A3 at ~ 09:45, wind speed steady at around 25 knots and a mean significant wave height of ~ 2.75 m. The plan now was to assess each station along leg 3, work it if possible, continue south along leg 3 if not, and eventually end up at the southern end of the survey region ready to deploy the southern sediment trap mooring (STS).

By ~ 10:50 *Discovery* had heaved-to at C2A3, 25-30 knot winds were maintained, sea still moderate to rough. On the bridge, the decision was made that it was too rough to work. The weather forecast suggested that winds would back westerly force 4 by late evening/nightfall. *Discovery* set course south along 20° 14'W at 10:52.

By 14:25, the AutoFlux corrected wind speed remained at ~ 25 knots, with a mean wave height between 2.5 and 3.0 m.

At 18:00, *Discovery* heaved-to near the location for the southern sediment trap mooring (STS). At 18:50, the mooring deployment began (**16279**). The anchor weight was released at 19:25 (58° 52.14' N, 20° 22.05' W), confirmed on the bottom and staying on the bottom at 19:45. Weather conditions were rather marginal and we would wait for further forecasts before calling on over-the-side wire deployments. In the mean-time we would circuit the STS site within a radius of 2-3 nm (**16279J**), and at a speed of 3-4 knots, taking water from the trace metal fish, increasing underway sampling and further filtering work to look at the proteomics of phytoplankton growth dynamics (~ 12 hours of filtering for one ~ 25 ml sample !).

16th August (Day 228)

At 00:15 wind speed was still 25-30 knots and considered unworkable, this was not in the MetWorks forecasts; mean significant wave height was still ~ 2.75 m although a peak of ~ 4 m was recorded.

At 07:16 *Discovery* was near C2F2, wind speed was 15-20 knots, and preparations had begun for making a CTD cast, but a final decision awaited. The Stainless steel CTD (**16280A**) was deployed at 07:33, recovered and secured by 09:00. Two Argo floats were then deployed here, at 09:10 (**16280G1**) and at 09:18 (**16280G2**). Sampling of the CTD was completed at 09:24.

The CTD was deployed (**16281A**) at C2E2 at 10:53, recovered and secured by 12:19.

The titanium CTD was deployed (**16282B**) at C2D2 at 14:12, recovered and secured by 15:17.

The stainless steel CTD was deployed (**16283A**) at C2C2 at 16:51, recovered and secured by 18:06. We commenced turbulence profiling at 18:10 (**16283F**) and finished at 19:18. This concluded, albeit incompletely, CTD survey 2.

At 19:41, SeaSoar was deployed (**16284**) for an overnight tow eastwards along line C, 59° 36’ N, to pick up the northern, cyclonic, eddy of our dipole pair.

17th August (Day 229)

At ~ 03:30, SeaSoar and VM-ADCP data were downloaded and processed to look for a signal of the cyclonic eddy. This time coincided with our position near the eastern boundary of our survey region. The datasets clearly showed a strong signal of the cyclonic eddy at around 18° 45’ W but indicated that we would need to continue onward another ~ 30 nm in order to ensure we had completely crossed the eddy.

At ~ 06:41, *Discovery* towed SeaSoar through 17° 45’ W and began an ~ 15 minute turn onto a course of ~ 241° T to head towards 59° 10’ N, 19° 12’ W; this position was, by inspection of all the information available, where we expected to find the core of the southern, anticyclonic, component of the eddy dipole.

At ~ 12:45, we were passing through our determined waypoint, 59° 10’ N, 19° 12’ W. A new satellite image showed that the anticyclonic eddy had remained almost stationary since the last survey. Thus, at 13:12 we altered course to 270° T in order to pass closer to the eddy centre.

At 15:00 hours the recovery of SeaSoar began, and the vehicle was safely recovered and secured by 15:52. Having located the two eddies, *Discovery* now steamed to a position within the northern, cyclonic, eddy to begin our 10th productivity station, (59° 40’ N, 18° 45’ W) S2CYC. We did not make the return transit to S2CYC with SeaSoar because, SeaSoar tows now needed to be dedicated to overnight sections particularly looking out for dinoflagellate bioluminescence which we hoped to detect with the bathyphotometer fitted inside SeaSoar. We did not have time to consider further re-terminations, and top priority was an overnight section through the southern anticyclonic mode water eddy the following evening.

The SAPS were deployed at S2CYC (**16285D1**) at 21:01, recovered after completion of their pumping sequence at 23:32. PELAGRA P2 was launched for a short test deployment (**16285H**) at 23:43. Sadly this was again to be unsuccessful, re-surfacing just over a couple of hours later.

<u>18th August (Day 230)</u>

The plankton net was deployed at 00:02 (**16285E**) and recovered after three net hauls at 00:43. The titanium CTD was deployed (**16285B**) at 01:17, recovered and secured by 02:21. At 03:14 PELAGRA was sighted astern. The stainless steel CTD was deployed at 03:30 (**16285A**), recovered and secured by 04:35. A second SAPS deployment began at 04:53 (**16285D2**) to collect coccolithophore and other cells for proteomic studies. The SAPS were recovered after their pumping sequence at 07:37. Turbulence profiler deployments began at 07:56 (**16285F**) and were completed by 09:12; hunting the PELAGRA began. PELAGRA was grappled at 10:35, secured on deck by 10:45.

Discovery set course for position 60° 04’ N, 18° 10’ W, to continue SeaSoar survey S2 with a line approximately south-west across and between the two eddies.

SeaSoar was deployed (**16284I** – continued) at the north-east end of the line at 14:08, flying and up to speed by 14:39. At ~ 22:00 hrs, *Discovery* passed through 59° 12’ N, 19° 25’ W where we expected the centre of the southern, anti-cyclonic, mode water eddy. The weather had deteriorated, there was nothing terrible in the forecasts, but wind speeds had reached ~ 15 knots and it was raining quite hard.

At 23:03 we began turning to the north-west, a new satellite image and both VM-ADCP and SeaSoar data processed up to 22:00 indicated that the core of the anticyclonic eddy had in fact remained near C2E4 where we had sampled it last (**16274**). *Discovery* was steady on a course of ~ 320° T at 23:10.

19th August (Day 231)

We began recovery of SeaSoar at 01:47 at 59° 21.7'N, 20° 07.2' W. At 02:03 the SeaSoar winch cut out and for the next ~ 2 hours the winch was effectively out of service. The emergency direct electric motor drive was also cutting out with an over current circuit-breaker. Eventually the main hydraulic power system was reinstated following a detailed fault tracing exercise and much invaluable help from both the Duty Engineer and the ETO, many thanks. The problem was an open circuit trip switch designed to detect if the emergency electric drive gearbox clutch was engaged. At 04:47, SeaSoar was finally back on board and secured.

Although compromised by the time of day, dawn was breaking, we steamed as quickly as possible to station S2ANT which had been relocated close to C2E4 at 59° 15' N, 19° 51' W, close to the inferred centre of the anti-cyclonic eddy.

Hove-to on S2ANT for our 11th productivity station at 06:45, the titanium CTD (**16286B**) was launched, recovered and secured by 08:09. SAPS were deployed at 08:35 (**16286D**), recovered after completion of their pumping sequence at ~ 11:22. The stainless steel CTD was deployed to full depth (**16286A**) at 11:42, it reached ~ 2740 m at the bottom by 12:38 and was recovered on deck at 13:50. An ARGO float (**16286G**) was launched at 13:54, after which turbulence profiling (**16286F**) began at 14:00. Turbulence profiler casts were finished by 15:15 and *Discovery* set course for a station on the south-west periphery of the anti-cyclonic eddy.

The CTD was deployed at station S2ANTSW (59° 07' N, 20° 15' W) at 17:06 (**16287A**), reached the bottom (2775 m) at 18:10, recovered and secured by 19:37.

SeaSoar re-deployment (**16284**-continued) began at 20:13 with the full 760 m of faired cable payed out by 20:56. The plan was to tow SeaSoar along 59° 07'N eastwards skirting the southern periphery of the anti-cyclonic eddy, then turn north along 19° 15’ W to pass between the two eddies, and finally turn east again along 59° 40’ N to determine the new position of the northern, cyclonic, eddy before recovery around breakfast time.

<u>20th August (Day 232)</u>

Discovery turned north along 19° 15’ W at ~ 01:35.

Discovery turned east along 59° 40’ N at ~ 05:25.

SeaSoar was recovered and secured by 08:45, recovery had begun at 59° 41.15’ N, 18° 22.64’ W. *Discovery* then set a south westerly course to begin a series of turbulence profiling stations between the two eddies.

The vertical plankton net was deployed at S2T1, 59° 30’ N, 19° 02’W (**16288E**) at 11:42; recovered after two net hauls at 12:05. Turbulence profiling (**16288F**) began at 12:12 and finished at 13:25. As we began to move off station a T7 XBT was launched (**16288X**) at 13:28. Shortly after recording the XBT, the PC controlling and recording XBT launches promptly fell over and could not be restarted.

By station S2T2 (**59° 26’ N, 19° 16’ W**) there was still no sign of life from the XBT controller PC, despite swapping hard disks and even PCs in addition to the usual software installations. The vertical plankton net was deployed (**16289E**) at 14:48 and recovered after two net hauls at 15:13. Turbulence profiling began (**16289F**) at 15:19 and was completed after 10 profiles at 16:30. By this time, Chris Barnard, had done a sterling job breathing life back into the old XBT PC and thus at 16:30 an XBT (**16289X**) was launched as we left station.

At 16:50 (**59° 23.49’ N, 19° 19.04’ W**) an XBT was launched (**16290X).**

At 17:10 (**59° 22.39’ N, 19° 23.80’ W**) an XBT was launched (**16291X).**

The vertical plankton net was deployed (**16292E**) at S2T3 (**59° 22’ N, 19° 27’ W**) at 17:25, recovered after two net hauls by 17:52. Turbulence profiling began (**16292F**) at 18:00 and was completed at 19:05. At 19:10 an XBT (**16292X**) was launched as we left station.

At 19:30 (**59° 19.85’ N, 19° 27.85’ W**) an XBT was launched (**16293X).**

At 20:00 (**59° 18.17’ N, 19° 35.61’ W**) an XBT was launched (**16294X).**

The turbulence profiler was deployed (**16295F**) at S2T4 (**59° 18’ N, 19° 40’ W**) at 20:23. Turbulence profiling was completed by 21:34. The vertical plankton net was deployed at 21:36 (**16295E**), recovered after two net hauls at 22:00. An XBT was launched (**16295X**) on station at 22:08, wire stretch on the way down led to the deployment of a second XBT (**16295X2**) some 5 or so minutes later. The stainless steel CTD was deployed at 22:32 (**16295A**) but at ~ 750 m depth, all communication with the CTD ceased. The CTD was recovered by 23:18.

<u>21st August (Day 233)</u>

By 00:00 it was clear that the termination was in fact not at fault, indeed everything pointed to an electrical failure somewhere in the SeaBird CTD unit on the frame. This had been determined in part by swapping the termination to the titanium frame. The titanium CTD was deployed (**16295B**) at ~ 00:20, reached the bottom at 2745 m by 01:22, recovered and secured by 02:15.

The titanium CTD was deployed at S2T2 (positions – see previous day) at ~ 04:00 (**16296B**), recovered and secured by 06:00.

Discovery was hove-to on station S2CYCSW (59°34’N, 18° 48’ W) at 07:56. A PELAGRA drifting sediment trap was launched (**16297H1**) on a test deployment at 08:01. A second PELAGRA was launched (**16297H2**) at 08:06. The titanium CTD was deployed (**16297B**) at 08:16, reached the bottom (2700 m) by 09:15. We had an enormous pod of pilot whales surrounding the ship and their behaviour I had not seen previously outside an aquarium. Their antics included raising their heads vertically out of the water turning slowly around as if to look at what was happening at the surface, tails extended vertically out of the water, and swimming backwards with up to half the length of their body out of the water – incredible ! The CTD was recovered at 10:07. The first PELAGRA was recovered at 10:40, but not before the pilot whales had thoroughly investigated it ! The second PELAGRA was recovered by 11:03.

Discovery was hove-to on station S2CYCNE (59° 42’ N, 18° 34’ W) at 12:14. A PELAGRA was launched (**16298H**) at 12:17. The titanium CTD was deployed (**16298B**) at 12:32, reached the bottom (2670 m) at 13:24, recovered and secure by 14:17. The pilot whales remained, as fascinated with us as we were with them. This was sheer indulgence on a sunny afternoon, but for us, them or both ? PELAGRA was hooked by 15:56, on board and secured by 16:00.

Discovery set a course of 344°T heading for a final SeaSoar section in ~ 20 hours time off the Icelandic shelf, this was to provide a high productivity ‘control’ for the various biogeochemical instruments on SeaSoar.

By mid-evening 25-30 knot winds were whipping up a good sea; no workable conditions for the immediate future. Although little would stop a good RPC, the old *Discovery* bar stool trick was in evidence later in the evening.

22nd August (Day 234)

By 08:30, 30-40 knot winds and a rough sea began to sap hopes of a SeaSoar deployment. Autoflux recorded steady 25 knot mean wind speeds, and the shipboard wave recorder had displayed mean wave heights of over 3 m for some time, with peaks around 5 m.

By 11:00, the wind and sea state had dropped remarkably, much more than we could have anticipated. At 13:56 the PES fish was deployed as a lookout for any uncharted seamounts, this provides a much better bathymetry signal than the hull mounted transducer but had not been used until now to avoid any possible spurious source of turbulence for the turbulence profiles. At 14:25 SeaSoar was deployed and by 14:57 the final SeaSoar tow had begun (**16299I**) at a position ~ 62° 52.9’ N, 20° 38’ W. At 18:00 hrs, SeaSoar recovery began at ~ 62° 55’ N, 21° 37’ W. SeaSoar was recovered and secure by 18:35. The vertical plankton net was deployed at 18:45 at 62° 53.82’ N, 21° 38.61’ W (**16300E**). After two hauls to 100 m the plankton net was recovered at 19:06. The catch appeared very similar to many of those in our earlier survey area ~ 200 nm to the south, surprising as the waters here appeared to be an order of magnitude more productive from an autotrophic perspective.

The trace metal fish and PES fish were recovered and *Discovery* set course for Reykjavik.

Master's Diary (Summary)

Date	Time (UT)	Event
20/07/07	0800	Author of following report joins vessel in GOVAN, Glasgow
		Mobilisation for Cruises 321A and 321B commences
21/07/07	0650	Commence loading BUNKERS
	1600	Bunkers loaded for the day
23/07/07	0630	Commence loading BUNKERS
	1700	Bunkers loaded for the day
24/07/07	0730	Commence loading BUNKERS
		Sailing delayed to 0600 UT 25/07/07
	0850	All bunkers loaded (286 T)
	0900	Mobilisation complete

Securing and setting up throughout the day. An inoperable metrome dosometer is causing concern throughout the day.

	1900	Sailing further delayed to 0900 UT 25/7/07 to wait for replacement metrome dosometer.
25/07/07	0820-30	Final Pre sailing checks to all critical equipment and propulsion
	0837	Pilot on board
	0913	All gone and clear of berth
		pilotage down Clyde
	1117	Pilot disembarks off Kemplock Point.
		Navigating down the Firth of Clyde.
	1200	FULL AWAY on passage Toward Pt bore219˚ T x 2.27M
		Course 191˚ T
	1331	a/c to 180˚ T 55 39.4 N 005 00.3 W
	1444	a/c to 200˚ T 55 27.0 N 005 00.0 W
	1506	a/c to 242˚ T 55 24.0 N 005 02.0 W
	1515-34	Emergency and Lifeboat muster for all personnel
	1700	a/c to 271˚ T 55 15.0 N 005 30.6 W
	1815	a/c to 324˚ T 55 15.4 N 005 51.0 W off Mull of Kyntyre

	1931	a/c to 283˚ T 55 25.0 N 006 07.0 W
	2005	a/c to 301˚ T 55 26.5 N 006 18.0 W
26/07/07	0000	Position Latitude 55 50.1 N Longitude 007 28.1 W
	1200	Position Latitude 56 56.8 N Longitude 010 50.4 W
	1830	Trace metal fish outboard 57 32.3 N 012 39.2 W
27/07/07	0000	Position Latitude 57 55.8 N Longitude 013 54.6 W
	1200	Position Latitude 58 51.2 N Longitude 016 52.0 W
	1318	Hove to on Station
	1324-1443	**Stn 16195 A –CTD cast to 880 m 58 57.0N 017 11.2W**
	1406	Trace metal fish recovered
	1452-1512	**Stn 16195 F** - Turbulence Probe deployed for testing purposes
	1529	Trace Metal Fish deployed 58 57.3 N 017 11.9 W
	1602	Set Course 304˚ T for next station 58 59.0 N 017 17.0 W
	1735	Hove to on Station 16196 (IB7)
	1744-1908	**Stn 16196 A – CTD cast to 990 m 59 07.2N 017 40.4W (IB7)**
	2013	Hove to on Station 16197 (IB8) – awaiting winch problems
	2045-2251	**Stn 16197 A – CTD cast to 1530 m 59 12.2N 017 53.5W (IB8)**
28/07/07	0040	Hove to on Station 16198 (IB9)
	0052-0228	**Stn 16198 A – CTD cast to 1830 m 59 20.1N 018 13.4W (IB9)**
	0340	Hove to on Station 16199 (IB10)
	0356-0556	**Stn 16199 A – CTD cast to 2395 m 59 24.1N 018 25.0W (IB10)**
	0808	Hove to on **Mooring Station STNE Stn 16200** for its recovery
		Also making initial preparations to re-terminate CTD cable.
	0834	Mooring STNE released 59 38.3 N 018 46.5 W
	0952	Mooring Inboard and secure
	1034	Hove to on Station 16210 (C1C5) speed 0.5 knots
	1038	**Stn 16201 F –**Turbulence Probe cast outboard **59 42.9N 018 45.1W**
	1134	Turbulence Probe inboard **59 43.9N 018 45.4W** set co to next station

1300 Still awaiting completion of CTD termination and testing reducing speed

1400-1600 Hove to on station 16202. Termination and testing waiting time

(Down Time)

1600-1717 **Stn 16202 A – CTD cast to 400 m 59 59.9N 018 45.9W (C1A5)**

1600-15 **Delay** in cast due to compensator on winch

1912 Hove to on Station 16203 (C1A4)

1921-2026 **Stn 16203 A – CTD cast to 800 m 60 00.1N 019 19.0W (C1A4)**

2030 Set Course for Productivity Station 16204 (C1A3)

2233 Hove to on **Productivity** Station 16204 (C1A3)

2241-0132 **Stn 16204 A – CTD cast to 2668 m 59 59.5N 019 52.2W (C1A3)**

29/07/07 0202-0229 **Stn 16204 E – Plankton nets cast 59 59.5N 019 52.4W (C1A3)**

0256-0445 **Stn 16204 B – Titanium CTD cast to 800 m 59 59.3N 019 51.9W**

0532 Coring cable outboard

0550-0811 **Stn 16204 D – SAPS cast outboard 59 58.9N 019 50.4W**

0820 Coring cable inboard

0833 **Stn 16204 F –**Turbulence Probe cast outboard **59 57.1N 019 49.6W**

1004 Turbulence Probe inboard **59 56.2N 019 51.2W**

1014 TMS deployed - set co to next station

1200 Position Latitude 60 00.0 N Longitude 020 22.4 W

1221 Hove to on Station 16205 (C1A2)

1228-1327 **Stn 16205 A – CTD cast to 800 m 59 59.6N 020 27.1W (C1A2)**

1340 Set Course 275˚ T for next station

1454 Hove to on **Mooring Station STNW Stn 16206** for its recovery

1509 Mooring STNW released 60 00.0 N 020 48.7 W

1635 Mooring Inboard and secure 59 59.3 N 020 48.7 W

1645 Set Course 280˚ T for next station

1731 Hove to on Station 16207 (C1A1)

1735-1840 **Stn 16207 A – CTD cast to 800 m 59 59.6N 020 59.9W (C1A1)**

1840 Set Course 180˚ T for next station

2040 Hove to on Station 16208 (C1C1)

2045-2152 **Stn 16208 A – CTD cast to 795 m 59 43.1N 020 59.7W (C1C1)**

2155 Set Course 090˚ T for next station

2240 Hove to on **Productivity** Station 16209 (C1C2)

2342 **Stn 16209 H –**PELAGRA I cast outboard **59 42.8N 020 27.8W**

2357 **Stn 16209 H –**PELAGRA II cast outboard **59 42.8N 020 27.8W**

30/7/07 0016-0100 **Stn 16209 E – Plankton nets cast 59 42.4N 020 26.4W (C1C2)**

0116-0207 **Stn 16209 B – Titanium CTD cast to 800 m 59 42.7N 020 26.7W**

0219-0314 **Stn 16209 A – CTD cast to 800 m 59 41.3N 020 24.3W (C1C2)**

0420 Coring cable outboard

0427-0810 **Stn 16209 D – SAPS cast outboard to 2205 m 59 41.7N 020 25.2W**

0816 Coring cable inboard

0830 **Stn 16209 F –**Turbulence Probe cast outboard **59 39.0N 020 22.6W**

0845 Turbulence Probe inboard **59 38.6N 020 22.5W**

1000 PELAGRA I recovered on board **59 39.1N 020 21.8W**

1000-1215 3 unsuccessful attepts to recover an intermittently surfaced PELAGRA II – Decision made to launch workboat

1240-1320 Workboat in use away from ship **59 37.7N 020 19.3W**

1310 PELAGRA II recovered on board **59 37.8N 020 19.3W**

1320 Workboat safely on board and secure

1336 **Stn 16209 F –**Turbulence Probe cast outboard **59 37.6N 020 19.0W**

1348 Turbulence Probe inboard **59 37.2N 020 18.6W**

1418 TMS deployed - set co 059˚ T to next station

1606 Hove to on Station 16210 (C1C3)

1620-1718 **Stn 16210 A – CTD cast to 800 m 59 43.0N 019 52.5W (C1C3)**

1718 CTD Inboard - Sampling

1744 Set Course 090˚ T for next station

1938 Hove to on Station 16211 (C1C4)

1938-2048 **CABLE HAULER Policy making so as to get station work done**

2048-2149 **Stn 16211 A – CTD cast to 800 m 59 42.6N 019 17.7W (C1C4)**

2149 CTD Inboard - Sampling

2155 Set Course 090˚ T for next station

2300 Hove to on **Productivity** Station 16212 (C1C5)

31/7/07 0002-0009 **Stn 16212 C – Titanium incubation experiment CTD cast to 10 m 59 43.0N 018 44.7W (C1C5)**

0024-0059 **Stn 16212 E – Plankton nets cast 59 42.8N 018 44.8W (C1C5)**

0122-0217 **Stn 16212 A – CTD cast to 800 m 59 42.7N 018 45.1W (C1C5)**

0302-53 **Stn 16212 B – Titanium CTD cast to 800 m 59 41.8N 018 45.1W**

0500-0712 **Stn 16212 D – SAPS cast outboard 59 40.8N 018 46.4W**

0715 **Stn 16212 F –**Turbulence Probe cast outboard **59 40.6N 018 46.5W**

0820 Turbulence Probe inboard **59 40.6N 018 48.5W**

0830 TMS deployed - set co to next station

1010 Hove to on Station 16213 (C1E5)

1017-1112 **Stn 16213 A – CTD cast to 800 m 59 27.2N 018 44.5W (C1E5)**

1112 CTD Inboard - Sampling

1142 Set Course 180˚ T for next station

1402 Hove to on Station 16214 (C1G5)

1414-1506 **Stn 16214 A – CTD cast to 800 m 59 08.7N 018 44.9W (C1G5)**

1506 CTD Inboard - Sampling

1531 Set Course 180˚ T for next station

1754 Hove to on Station 16215 (C1I5)

1807-1903 **Stn 16215 A – CTD cast to 800 m 58 51.2N 018 44.5W (C1I5)**

1903 CTD Inboard - Sampling

1907 Set Course 270˚ T for next station

2250 Hove to on Station 16216 (C1I4)

2301-0006 **Stn 16216 A – CTD cast to 800 m 58 52.1N 019 18.5W (C1I4)**

01/08/07 0006 CTD Inboard - Sampling

0036 Set Course 360˚ T for next station

0300 Hove to on Station 16217 (C1G4)

0325-0419 **Stn 16217 A – CTD cast to 800 m 59 09.0N 019 19.0W (C1G4)**

0419 CTD Inboard - Sampling

0520 Set Course 360˚ T for next station

0755 Hove to on Station 16218 (C1E4)

0807-58 **Stn 16218 A – CTD cast to 800 m 59 27.1N 019 18.9W (C1E4)**

0858 CTD Inboard - Sampling

0823 Set Course 277˚ T for next station (Mooring STC)

1309 Hove to on **Mooring Station STC Stn 16219** for its recovery

1321 Mooring STC released 59 29.8 N 019 59.1 W

1400-1615 Grappled mooring and recovering

1615 Mooring Inboard and secure 59 29.2 N 020 00.0 W

1645-1740 **Stn 16220 A – CTD cast to 800 m 59 28.9N 020 00.1W (C1E3)**

1740 CTD Inboard – Sampling and awaiting PELAGRA and ARGOS

1800-30 Meal break

1845 **Stn 16220 H –**PELAGRA cast outboard **59 27.5N 020 00.0W**

1855 **Stn 16220 G1 –** ARGOS I cast outboard **59 27.5N 020 00.0W**

1900 **Stn 16220 G2 –** ARGOS II cast outboard **59 27.4N 020 00.1W**

Set Course 170˚ T for next station

2118 Hove to on Station 16221 (C1G3)

2128-2221 **Stn 16221 A – CTD cast to 800 m 59 08.9N 018 53.5W (C1G3)**

2224 Set Course 000˚ T for next station (C1I3)

02/08/07 0025 Hove to on **Productivity** Station 16222 (C1I3)

0032-38 **Stn 16222 C – Titanium incubation experiment CTD cast to 12 m 58 52.0N 019 53.0W (C1I3)**

0057-0118 **Stn 16222 E – Plankton nets cast 58 52.0N 019 53.1W (C1I3)**

0135-0228 **Stn 16222 A – CTD cast to 802 m 58 51.8N 019 53.0W (C1I3)**

0309-0403 **Stn 16222 B – Titanium CTD cast to 800 m 58 51.6N 019 52.4W**

0435-0705 **Stn 16222 D – SAPS cast outboard 58 51.3N 019 51.8W**

0717 **Stn 16222 F –**Turbulence Probe cast outboard **58 49.9N 019 50.9W**

0839 Turbulence Probe inboard **58 48.4N 019 50.7W**

0840 TMS deployed - Set Course for next station (Mooring STS)

1041 Hove to on **Mooring Station STS Stn 16223** for its recovery

1040-1200 Talking but not releasing - yet

1215 Mooring STS released 58 52.2 N 020 23.7 W

1334-58 Grappled mooring and recovering

1358 Mooring Inboard and secure 58 52.0 N 020 24.7 W

1421-1512 **Stn 16224 A – CTD cast to 800 m 58 52.3N 020 24.6W (C1I2)**

1533 Set Course 355˚ T for next station (C1G2)

1715 Hove to on Station 16225 (C1G2)

1733-1825 **Stn 16225 A – CTD cast to 800 m 59 09.4N 020 26.8W (C1G2)**

1900 Science temporarily closes due to oncoming bad weather

03/08/07 0000 Position Latitude 59 00.8 N Longitude 020 25.9 W

1200 Position Latitude 58 50.6 N Longitude 021 16.6 W

04/08/07 0000 Position Latitude 58 40.9 N Longitude 021 41.7 W

0835 Set Course 068˚ T to relocate to C1I1 58 32.6 N 022 31.0 W

1200 Position Latitude 58 38.8 N Longitude 021 51.8 W

1512 Hove to – assessing weather 58 51.7 N 020 59.6 W

Further amelioration needed before starting science

2030 Hove to on **Productivity** Station 16226 (C1I1)

2100-2350 **Stn 16226 A – CTD cast to 2800 m 58 51.2N 020 59.9W (C1I1)**

Also attached are 4 x releases for testing

2350 CTD Inboard

05/08/07 0016 Coring cable outboard – veering

0033-0252 **Stn 16226 D – SAPS cast outboard 58 50.4N 021 01.0W**

0319-0430 **Stn 16226 B – Titanium CTD cast to 800 m 58 50.0N 021 00.4W**

	0450-0525 (C1I1)	**Stn 16226 E – Plankton nets cast 58 49.7N 021 00.1W**
	0535-0705	**Stn 16226 F –**Turbulence Probe cast outboard **58 49.5N 021 00.0W**
	0717	TMS deployed – Preparing to deploy Sea Soar
	0826	**Stn 16227 I –**SEA SOAR fish cast outboard **58 49.4N 021 00.0W**
		Commenced streaming at 2-3 knots
	0958	SEA SOAR fully deployed Survey begins Course 068˚ T @ 9 knots
		58 52.0 N 020 56.7 W (LINE S1)
	1200	Position Latitude 58 52.0 N Longitude 020 22.0 W
	1700	SEA SOAR Problems – 58 52.0 N 018 51.6 W not diving
	1746-1935	recovery of SEA SOAR
	1935	SEA SOAR inboard 59 00.0 N 018 47.4 W
	2011	Hove to on Station 16228 (S1H5)
	2033	TMS Fish deployed
	2103-2205 (S1H5)	**Stn 16228 A – CTD cast to 800 m 59 01.1N 018 43.2W**
	2205	CTD Inboard - Set Course 270˚ T for next station (S1H4)
06/08/07	0035	Hove to on Station 16229 (S1H4)
	0038-0133 (S1H4)	**Stn 16229 A – CTD cast to 800 m 59 00.9N 019 18.6W**
	0133	CTD Inboard – sampling
	0206	Set Course 270˚ T for next station (S1H3)
	0404	Hove to on Station 16230 (S1H3)
	0415-0511 (S1H3)	**Stn 16230 A – CTD cast to 800 m 59 00.9N 019 52.9W**
	0511	CTD Inboard – sampling
	0547	Set Course 270˚ T for next station (S1H2)
	0745	Hove to on Station 16231 (S1H2)
	0804-0906 (S1H2)	**Stn 16231 A – CTD cast to 800 m 59 01.3N 020 26.6W**
	0906	CTD Inboard – sampling
	0935	Set Course 270˚ T for next station (S1H1)
	1136	Hove to on Station 16232 (S1H1)
	1144-1240 (S1H1)	**Stn 16232 A – CTD cast to 800 m 59 01.1N 021 00.2W**
	1240	CTD Inboard – sampling

	1245	**Stn 16232 F –**Turbulence Probe cast outboard **59 01.1N 021 00.6W**
	1402	Turbulence Probe inboard **59 02.0N 021 02.1W**
	1404	TMS deployed - Set Course for next station (S1G1)
	1505	Hove to on Station 16233 (S1G1)
	1509-1603	**Stn 16233 A – CTD cast to 800 m 59 08.7N 021 00.5W (S1G1)**
	1603	CTD Inboard – Set Course 090˚ T for next station (S1G2)
	1805	Hove to on Station 16234 (S1G2)
	1807-1910	**Stn 16234 A – CTD cast to 800 m 59 09.0N 020 27.3W (S1G2)**
	1910	CTD Inboard – Set Course 090˚ T for next station (S1G3)
	2117	Hove to on Station 16235 (S1G3)
	2124-2226	**Stn 16235 A – CTD cast to 800 m 59 08.8N 019 53.0W (S1G3)**
	2226	CTD Inboard – Set Course 090˚ T for next station (S1G4)
07/08/07	0031	Hove to on Station 16236 (S1G4)
	0040-0129	**Stn 16236 B – Titanium CTD to 800m 59 08.6N 019 18.9W (S1G4)**
	0129	CTD Inboard – Searching for the PELAGRA
	0356	PELAGRA sighted
	0410	Hove to on Station 16237 (S1G5) close to PELAGRA
	0417-0512	**Stn 16237 B – Titanium CTD to 800m 59 10.2N 018 53.9W (S1G5)**
	0512	CTD Inboard – sampling – manoeuvring toward PELAGRA
	0547	PELAGRA recovered and secured.
	0610	Set Course 023˚ T for station F5
	0828	**Stn 16227 I –**SEA SOAR fish cast outboard **59 19.0N 018 39.6W**
		Commenced streaming at 2-3 knots
	0913	SEA SOAR fully deployed Survey begins Course 270˚ T @ 9 knots
		59 17.3 N 018 47.6 W (SURVEY S1 continued) Line F
	1200	Position Latitude 59 18.0 N Longitude 019 34.8 W
	1634-42	Altered course 10˚ / Min to 360˚ T 59 18.0 N 020 58.6 W
	1728-40	Altered course 10˚ / Min to 090˚ T 59 27.0 N 020 57.1 W LEG E
08/08/07	0032-52	Altered course 10˚ / Min to 360˚ T 59 27.0N 018 46.0 W

0123-40 Altered course 10˚ / Min to 270˚ T 59 36.0 N 018 48.6 W

LEG D

0905 Altered course 10˚ / Min to 360˚ T 59 34.9 N 020 59.3 W

1010 Altered course 10˚ / Min to 090˚ T 59 42.7 N 020 59.6 W

LEG C

1338 **Sea Soar data Failure**

1433-56 Recovering Sea Soar

1456 Sea Soar recovered 59 41.2 N 019 42.2 W

1609 Set Course 306˚ T for next station (S1C3)

1700 Hove to on Station 16238 (S1C3)

1702-1830 **Stn 16238 B – Titanium CTD to 800m 59 42.4N 019 52.2W (S1C3)**

1830 CTD Inboard – Set Course 087˚ T for next station (S1C4)

2020 Hove to on Station 16239 (S1C4)

2030-2140 **Stn 16239 A – CTD veered to 800m 59 43.2N 019 18.7W (S1C4)**

2140 CTD Inboard – Set Course 090˚ T for next station (S1C5)

2330 Hove to on Station 16240 (S1C5)

2344-0037 **Stn 16240 A – CTD veered to 801m 59 43.2N 018 45.4W (S1C5)**

09/08/07 0037 CTD Inboard – Set Course 000˚ T for next station (S1B5)

0206 Hove to on Station 16241 (S1B5) 59 52.0 N 018 44.9 W

0208 Broken strand discovered on CTD Cable – DOWNTIME
Station 16241 temporarily aborted.

0218 Commenced ADCP survey 59 52.1 N 018 44.9 W

0249 Set Course 265˚ T for next station (16241) 59 52.0 N 018 49.7 W

0555 Hove to on Station 16241 59 52.1 N 019 37.1 W

0605 **Stn 16241 F –**Turbulence Probe cast outboard **59 52.3N 019 37.3W**

0730 Turbulence Probe inboard **59 53.6N 019 38.5W** Set Co 264˚ T

0937 **Stn 16242 F –**Turbulence Probe cast outboard **59 51.0N 020 07.1W**

1055 Turbulence Probe inboard **59 52.9N 020 06.2W**
Set Co 264˚ T for next station (S1B2)

1220 Hove to on Station 16243 (S1B2)

1222-1314 **Stn 16243 A – CTD cast to 800 m 59 51.8N 020 27.3W (S1B2)**

1314 CTD Inboard – Set Course 270˚ T for next station (S1B1)

1513 Hove to on Station 16244 (S1B1)

1517-1610 **Stn 16244 A – CTD cast to 800 m 59 51.9N 021 00.2W (S1B1)**

1610 CTD Inboard – Set Course 360˚ T for next station (S1A1)

1722 Hove to on Station 16245 (S1A1)

1733-1830 **Stn 16245 A – CTD cast to 800 m 60 00.2N 021 00.8W (S1A1)**

1830 CTD Inboard – Set Course 090˚ T for Mooring dep;oyment STNW

1926 Hove to on Mooring (sediment trap) site STNW

1933-2013 Deploying SEDIMENT TRAP **Stn 16246 STNW**

2013 **SEDIMENT TRAP DEPLOYED 59 59.89N 020 51.52W (STNW)**

2018-30 'Watching it down'

2033 Set Co 090 for next station (C1A2)

2159 Hove to on **Productivity** Station 16247 (C1A2)

2206 **Stn 16247 H –**PELAGRA cast outboard **59 59.9N 020 27.2W**

2225-2330 **Stn 16247 A – CTD cast to 800 m 59 59.9N 020 27.7W (C1A2)**

10/08/07 0047-57**Stn 16247 C – Titanium incubation experiment CTD cast to 10 m 59 59.8N 020 28.3W (C1A2)**

` 0106-46 **Stn 16247 E – Plankton nets cast 59 59.7N 020 28.4W (C1A2)**

0217-0308 **Stn 16247 B – Titanium CTD cast to 800 m 59 59.4N 020 28.6W**

0326 SAPS cable and anchor deployed

0337-0640 **Stn 16247 D – SAPS cast outboard 59 58.3N 020 29.7W**

0640-1030 Searching for PELAGRA

0811 **Stn 16247 G3 –** ARGOS III cast outboard **59 56.3N 020 27.4W**

0813 **Stn 16247 G4 –** ARGOS IV cast outboard **59 56.2N 020 27.4W**

0831 **Stn 16247 F –**Turbulence Probe cast outboard **59 55.8N 020 26.2W**

0943 Turbulence Probe inboard **59 56.0N 020 28.4W**

1030-46 Manoeuvring toward PELAGRA

1046 PELAGRA recovered and secured 59 53.8 N 020 23.8 W

		Set Course 069˚ T for next station (S1A3)
	1250	Hove to on Station 16248 (S1A3)
	1253-1345	**Stn 16248 A – CTD cast to 800 m 60 00.0N 019 53.1W (S1A3)**
	1345	CTD Inboard – Set Course 090˚ T for next station (S1A4)
	1559	Hove to on Station 16249 (S1A4)
	1600-51	**Stn 16249 A – CTD cast to 800 m 60 00.1N 019 19.1W (S1A4)**
	1615-1700	Emergency Drill and Lifeboat Muster
	1639	At 400 metres – CTD hauled up because of termination problems
	1651	CTD Inboard – investigating Termination problem.
	1712	Set Course 090˚ T for next station (S1A5)
	1800	Change of Plan – set course 152˚ T for Mooring site STNE
	2030	Hove to on Mooring (sediment trap) site STNE
	2033-2105	Deploying SEDIMENT TRAP **Stn 16250 STNE**
	2105	**SEDIMENT TRAP DEPLOYED 59 39.81N 018 48.57W (STNE)**
	2112-27	'Watching it down'
	2130	Set Co for next station (C2A7)
	2350	Hove to on Station 16251 (C2A7)
11/08/07	0006-0105	**Stn 16251 A – CTD cast to 1000 m 60 00.1N 018 41.7W (C2A7)**
	0105	CTD Inboard – Set Course 180˚ T for next station (C2B7)
	0247	Hove to on Station 16252 (C2B7)
	0251-0351	**Stn 16252 A – CTD cast to 1000 m 59 48.0N 018 42.0W (C2B7)**
	0351	CTD Inboard – Set Course 180˚ T for next station (C2C7)
	0526	Hove to on Station 16253 (C2C7)
	0536-0642	**Stn 16253 A – CTD cast to 1000 m 59 36.3N 018 42.1W (C2C7)**
	0642	CTD Inboard – Set Course 180˚ T for next station (C2D7)
	0807	Hove to on Station 16254 (C2D7)
	0817-0926	**Stn 16254 A – CTD cast to 1000 m 59 24.0N 018 40.9W (C2D7)**
	0926-1000	CTD inboard - Sampling
	1000	Set Course 180˚ T for next station (C2E7)
	1130	Hove to on Station 16255 (C2E7)

1138-1238 **Stn 16255 A – CTD cast to 1000 m 59 11.8N 018 41.9W (C2E7)**

1238-1300 CTD inboard - Sampling

1300 Set Course 180˚ T for next station (C2F7)

1413 Hove to on Station 16256 (C2F7)

1416-1513 **Stn 16256 A – CTD cast to 1000 m 59 00.1N 018 41.7W (C2F7)**

1513-30 CTD inboard - Sampling

1530 Set Course 180˚ T for next station (C2G7)

1645 Hove to on Station 16257 (C2G7)

1650-1800 **Stn 16257 A – CTD cast to 990 m 58 47.9N 018 41.5W (C2G7)**

1800 CTD inboard - Set Course 270˚ T for next station (C2G6)

1935 Hove to on Station 16258 (C2G6)

1937-2055 **Stn 16258 A – CTD cast to 1000 m 58 48.2N 019 05.5W (C2G6)**

2055 CTD inboard - Set Course 360˚ T for next station (C2F6)

2225 Hove to on Station 16259 (C2F6)

2232-2343 **Stn 16259 A – CTD cast to 1000 m 58 59.9N 019 05.6W (C2F6)**

2343 CTD inboard - Set Course 360˚ T for next station (C2E6)

12/08/07 0121 Hove to on **Productivity** Station 16260 (C2E6)

0122-0159 **Stn 16260 E – Plankton nets cast 59 11.9N 019 05.4W (C2E6)**

0216-0313 **Stn 16260 A – CTD cast to 1000 m 59 11.6N 019 06.3W (C2E6)**

0338-0435 **Stn 16260 B – Titanium CTD cast to 965 m 59 11.6N 019 06.8W**

0500-0730 **Stn 16260 D – SAPS cast outboard 59 11.5N 019 07.9W**

0740-0900 **Stn 16260 F –**Turbulence Probe cast outboard **59 10.2N 019 08.0W**

0900 Turbulence Probe inboard **59 08.7N 019 06.5W**

TMS fish outboard – Set Course 360˚ T for next station (C2D6)

1053 Hove to on Station 16261 (C2D6)

1058-1212 **Stn 16261 A – CTD cast to 1000 m 59 23.6N 019 04.2W (C2D6)**

1212 CTD inboard - Set Course 360˚ T for next station (C2C6)

1346 Hove to on Station 16262 (C2C6)

1351-1600 **Stn 16262 A – CTD cast to 2665 m 59 36.2N 019 04.4W (C2C6)**

1600 CTD inboard

1609 Set Course 360˚ T for next station (C2B6)

1730 Hove to on Station 16263 (C2B6) Still sampling bottles

1750-1855 **Stn 16263 A – CTD cast to 1000 m 59 48.3N 019 05.8W (C2B6)**

1855 CTD inboard - Set Course 003˚ T for next station (C2A6)

2016 Hove to on Station 16264 (C2A6)

2025-2145 **Stn 16264 A – CTD cast to 1000 m 60 00.2N 019 04.7W (C2A6)**

2145 CTD inboard - Set Course 270˚ T for next station (C2A5)

2307 Hove to on Station 16265 (C2A5)

2316-0035 **Stn 16265 A – CTD cast to 1000 m 60 00.0N 019 27.9W (C2A5)**

13/08/07 0035 CTD inboard

0040 Set Course 180˚ T for next station (C2B5)

0205 Hove to on Station 16266 (C2B5)

0206-0301 **Stn 16266 A – CTD cast to 1000 m 59 47.9N 019 28.7W (C2B5)**

0301 CTD inboard

0319 Set Course 180˚ T for next station (C2C5)

0430 Hove to on Station 16267 (C2C5)

0440-0542 **Stn 16267 A – CTD cast to 1000 m 59 35.7N 019 27.1W (C2C5)**

0542 CTD inboard

0552 Set Course 180˚ T for next station (C2D5)

0705 Hove to on Station 16268 (C2D5)

0706-0821 **Stn 16268 A – CTD cast to 1000 m 59 23.9N 019 27.3W (C2D5)**

0821 CTD inboard- Set Course 180˚ T for next station (C2E5)

0940 Hove to on Station 16269 (C2E5)

0952-1108 **Stn 16269 A – CTD cast to 1000 m 59 11.7N 019 27.8W (C2E5)**

1108 CTD inboard- Set Course 180˚ T for next station (C2E5)

1110-1222 **Stn 16269 F –**Turbulence Probe cast outboard **59 11.6N 019 27.5W**

1222 Turbulence Probe inboard **59 12.3N 019 25.9W**

TMS fish outboard – Set Course 186˚ T for next station (C2F5)

1356 Hove to on Station 16270 (C2F5)

1400-1501 **Stn 16270 A – CTD cast to 1000 m 59 00.2N 019 28.5W (C2F5)**

1501 CTD inboard- Set Course 183˚ T for next station (C2G5)

1639 Hove to on Station 16271 (C2G5)

1640-1743 **Stn 16271 A – CTD cast to 1000 m 58 48.3N 019 27.7W (C2G5)**

1743 CTD inboard- Set Course 270˚ T for next station (C2G4)

1915 Hove to on Station 16272 (C2G4)

1917-2038 **Stn 16272 A – CTD cast to 1000 m 58 48.3N 019 51.3W (C2G4)**

2038 CTD inboard- Set Course 000˚ T for next station (C2F4)

2205 Hove to on Station 16273 (C2F4)

2225-2341 **Stn 16273 A – CTD cast to 1000 m 59 00.0N 019 53.3W (C2F4)**

2341 CTD inboard- Set Course 000˚ T for next station (C2E4)

14/08/07 0120 Hove to on **Productivity** Station 16274 (C2E4)

0132 **Stn 16274 H –** PELAGRA cast outboard **59 12.00N 019 51.7W**

0142-51 **Stn 16274 C – Titanium incubation experiment CTD cast to 10 m 59 12.1N 019 52.3W (C2E4)**

0201-11 **Stn 16274 E – Plankton net cast 59 12.3N 019 53.0W (C2E4)**

(one cast only dur to weather deterioration)

0235-0334 **Stn 16274 A – CTD cast to 1000 m 59 12.7N 019 53.8W (C2E4)**

0400 Science temporarily closes due to worsening bad weather

0900 Manoeuvring toward PELAGRA

0940-1000 PELAGRA recovered and secured 59 14.2 N 019 50.9 W

Set Course 000˚ T for next station (C2D4)

1154 Hove to on Station 16275 (C2D4)

1154-1218 Awaiting CTD readiness

1220-1318 **Stn 16275 A – CTD cast to 1000 m 59 23.6N 019 49.4W (C2D4)**

1318 CTD inboard- Sampling

1357 Set Course 284˚ T for next station (Mooring STC)

1440 Hove to on Mooring (sediment trap) site STC

1442-1625 Deploying SEDIMENT TRAP **Stn 16276 STC**

1625 **SEDIMENT TRAP DEPLOYED 59 30.32N 020 00.78W (STC)**

1630-55 'Watching it down'

1655 Set Course 041˚ T for next station (C2C4)

1810 Hove to on Station 16277 (C2C4) 59 35.6 N 019 50.8 W

1810-1900 Science temporarily delayed due to heavy cross swell

1900-2000 **Stn 16277 A – CTD cast to 1000 m 59 35.4N 019 50.2W (C2C4)**

2010 CTD secured Set Course 360˚ T for next station (C2B4)

2200 Hove to on Station 16278 (C2B4)

2212-2340 **Stn 16278 A – CTD cast to 1000 m 59 47.6N 019 51.1W (C2B4)**

2340 CTD secured - sampling

2357 Set Course 360˚ T for next station (C2A4)

15/08/07 0100 Hove to on Station 16279 (C2A4)

0100-0200 Assessing sea conditions

0218 Science temporarily closes due to sea conditions

0218-0930 Hove to

0930-1800 Set course to the South of the area visiting stations on the way – all too rough for CTD workings

1800 Hove to on Mooring (sediment trap) site STS

1850-1925 Deploying SEDIMENT TRAP **Stn 16279 STS**

1925 **SEDIMENT TRAP DEPLOYED 58 52.13N 020 22.03W (STS)**

1930-45 'Watching it down'

2015-2150 **Stn 16279 J TMS Survey in vicinity of above mooring**

2200-0730 Vessel remains hove to in inclement weather and rough seas

16/08/07 0733-0900 **Stn 16280 A – CTD cast to 1000 m 59 00.8N 020 34.0W (C2F2)**

0900 CTD inboard – preparing for ARGO Float deployment

0910 **Stn 16280 G1 –** ARGOS I cast outboard **59 01.2N 020 34.8W**

0918 **Stn 16280 G2 –** ARGOS II cast outboard **59 01.3N 020 32.0W**

Set Course 270˚ T for next station

1053 Hove to on Station 16281 (C2E2)

1100-1217 **Stn 16281 A – CTD cast to 1000 m 59 12.0N 020 37.3W (C2E2)**

1217 CTD secured Set Course 360˚ T for next station (C2D2)

1409 Hove to on Station 16282 **(C2D2)**

1412-1515 **Stn 16282 B – Titanium CTD cast to 1000 m 59 24.1N 020 36.6W**

1517 CTD secured Set Course 360˚ T for next station (C2C2)

1649 Hove to on Station 16283 (C2C2)

1651-1806 **Stn 16283 A – CTD cast to 1000 m 59 35.9N 020 37.2W (C2C2)**

1806 CTD inboard

1810 **Stn 16283 F –**Turbulence Probe cast outboard **59 35.6N 020 37.8W**

1918 Turbulence Probe inboard **59 35.7N 020 39.4W**

1941 **Stn 16284 I –**SEA SOAR fish cast outboard **59 35.8N 020 40.2W**

Commenced streaming at 2-3 knots

2058 **SEA SOAR fully deployed** Survey begins Course 090˚ T @ 8-9 knots

59 36.0 N 020 38.0 W (SURVEY S2)

engaged in **Stn 16284 I –**SEA SOAR

17/08/07 0000 Position Latitude 59 36.0 N Longitude 020 47.9 W

0640-55 Altered course 10˚ / Min to 241˚ T 59 36.0 N 017 43.0 W

1200 Position Latitude 59 13.4 N Longitude 018 59.6 W

1312 Altered course 10˚ / Min to 270˚ T 59 08.1 N 019 18.8 W

1500 Sea Soar ordered to surface 59 07.9 N 019 51.4 W

1514-52 Recovering Sea Soar

1552 Sea Soar recovered 59 11.1 N 019 54.4 W

1600 Set Course 051˚ T for next station

2040 Hove to on **Productivity** Station 16285 (S2CYC)

2101 Coring wire outboard

2119-2332 **Stn 16285 D1 – SAPS cast outboard 59 40.0N 018 44.7W**

2348 **Stn 16285 H –** PELAGRA cast outboard **59 40.2N 018 44.0W**

18/08/07 0002-43 **Stn 16285 E – Plankton nets cast 59 39.9N 018 44.6W (S2CYC)**

0117-0219 **Stn 16285 B – Titanium CTD cast to 1000 m 59 39.7N 018 44.5W**

0219-0330 DOWN TIME – sampling and monitoring PELAGRA

0330-0435 **Stn 16285 A – CTD cast to 1000 m 59 40.3N 018 43.3W (S2CYC)**

0453-0737 **Stn 16285 D2 – SAPS cast outboard 59 40.9N 018 42.7W**

0756-0912 **Stn 16285 F –**Turbulence Probe cast outboard **59 41.3N 018 41.8W**

0912 Turbulence Probe inboard **59 42.2N 018 43.5W**

0912 Manoeuvring toward PELAGRA

1025-40 PELAGRA recovered and secured 59 39.2 N 018 37.8 W

1040 Set Course 029˚T for next stn - Sea Soar survey (16284–continued)

1408 **Stn 16284 I (2) –**SEA SOAR fish cast outboard **60 04.1N 018 08.8W**

Commenced streaming at 2-3 knots

1439 **SEA SOAR fully deployed** Survey begins Course 216˚ T @ 8-9 knots

60 02.5 N 018 12.7 W (SURVEY S2 continued)

2300-10 Altered course 10˚ / Min to 321˚ T 59 05.2 N 019 35.6 W

19/08/07 0000 Position Latitude 59 11.6 N Longitude 019 46.1 W

0123 Sea Soar ordered to surface 59 21.7 N 020 02.6 W

0147 Commenced recovering Sea Soar

0203 Sea Soar Winch electrical failure – all stopped hauling

0410 Sea soar winch repaired – re-commence hauling

0447 Sea Soar recovered 59 18.9 N 020 16.8 W

0507 Set Course 106˚ T for next station (C2E5)

0642 Hove to on **Productivity** Station 16286 (C2E5)

0645-0809 **Stn 16286 B – Titanium CTD cast to 1000 m 59 14.3N 019 46.0W**

0835-1122 **Stn 16286 D – SAPS cast outboard 59 14.7N 019 46.7W**

1142-1350 **Stn 16286 A – CTD cast to 2740 m 59 17.0N 019 47.6W (C2E5)**

1345 **Stn 16286 G –** ARGOS cast outboard **59 17.6N 019 47.6W**

1400-1508 **Stn 16286 F –**Turbulence Probe cast outboard **59 17.7N 019 47.8W**

1508 Turbulence Probe inboard **59 17.8N 018 50.6W**

TMS fish outboard – Set Course 229˚ T for next station (S2ANTSW)

1700 Hove to on Station 16287 (S2ANTSW)

1706-1937 **Stn 16287 A – CTD cast to 2775 m 59 07.0N 020 15.2W (S2ANTSW)**

1937 CTD inboard- Preparing sea Soar

2013 **Stn 16284 II –**SEA SOAR fish cast outboard **59 08.0N 020 14.6W**

Commenced streaming at 2-3 knots

2156 **SEA SOAR fully deployed** Survey begins Course 090˚ T @ 8-9 knots

59 07.0 N 020 13.7 W (SURVEY S2 - cont)

engaged in **Stn 16284 II –**SEA SOAR

20/08/07 0000 Position Latitude 59 07.0 N Longitude 019 38.9 W

0120-32 Altered course 10˚ / Min to 360˚ T 59 07.0 N 019 16.4 W

0515-25 Altered course 10˚ / Min to 090˚ T 59 39.2 N 019 15.0 W

0800 Sea Soar ordered to surface 59 40.0 N 018 24.4 W

0815-45 Recovering Sea Soar

0845 Sea Soar recovered 59 42.6 N 018 22.9 W

0847 Set Course 236˚ T for next station (S2T1)

1141 Hove to on **Productivity** Station 16288 (S2T1)

1142-1205 **Stn 16288 E – Plankton nets cast 59 29.8N 019 01.6W (S2T1)**

1212-1325 **Stn 16288 F –**Turbulence Probe cast outboard **59 29.7N 019 01.3W**

1325 Turbulence Probe inboard **59 29.3N 019 01.3W** TMS fish outboard

1328 **Stn 16288 X – XBT launched 59 29.3N 019 01.3W (S2T1)**

1340 Set Course 246˚ T for next station (S2T2)

1445 Hove to on Station (S2T2)

1448-1513 **Stn 16289 E – Plankton nets cast 59 25.7N 019 15.4W (S2T2)**

1519-1630 **Stn 16289 F –**Turbulence Probe cast outboard **59 25.6N 019 15.0W**

1630 Turbulence Probe inboard **59 24.5N 019 15.2W** TMS fish outboard

1630 **Stn 16289 X – XBT launched 59 24.5N 019 15.2W (S2T2)**

Set Course 248˚ T for next station (S2T3)

1650 **Stn 16290 X – XBT launched 59 23.5N 019 19.0W**

1710 **Stn 16291 X – XBT launched 59 22.4N 019 23.4W**

1725 Hove to on Station (S2T3)

1731-52 **Stn 16292 E – Plankton nets cast 59 21.7N 019 26.3W (S2T3)**

1800-1905 **Stn 16292 F –**Turbulence Probe cast outboard **59 21.7N 019 26.0W**

1905 Turbulence Probe inboard **59 21.0N 019 23.9W** TMS Fish outboard

1910 **Stn 16292 X – XBT launched 59 20.9N 019 23.7W (S2T3)**

Set Course 248˚ T for next station (S2T4)

1930 **Stn 16293 X – XBT launched 59 19.8N 019 27.8W**

2000 **Stn 16294 X – XBT launched 59 18.2N 019 35.6W**

2020 Hove to on Station (S2T3)

2023-2134 **Stn 16295 F –**Turbulence Probe cast outboard **59 18.0N 019 39.8W**

2134 Turbulence Probe inboard **59 17.1N 019 40.0W** TMS Fish outboard

2138-2200 **Stn 16295 E – Plankton nets cast 59 17.0N 019 39.8W (S2T4)**

2208 **Stn 16295 X – XBT launched 59 17.1N 019 38.5W**

2232-2318 **Stn 16295 A – CTD cast – ABORTED – No Signal**

21/08/07 0020-0213 **Stn 16295 B – Titanium CTD cast to 2745 m 59 17.4N 019 39.0W**

0215 Set Course 057˚ T for next station (S2T2)

0400 Hove to on Station (S2T2)

0412-0600 **Stn 16296 B – Titanium CTD cast to 2750 m 59 25.5N 019 14.6W**

0600 Set Course 056˚ T for next station (S2CYCSW)

0756 Hove to on Station (S2CYCSW)

0801 **Stn 16297 H1 –** PELAGRA 1 cast outboard **59 33.9N 018 47.8W**

0806 **Stn 16297 H2 –** PELAGRA 2 cast outboard **59 33.8N 018 47.5W**

0816-1007 **Stn 16297 B – Titanium CTD cast to 2700 m 59 33.3N 018 45.8W**

1007 Manoeuvring toward PELAGRA 1

1036-40 PELAGRA 1 recovered and secured 59 34.0 N 018 43.9 W

1059-1103 PELAGRA 2 recovered and secured 59 33.5 N 018 43.0 W

1040 Set Course 022˚T for next station (S2CYCNE)

1214 Hove to on Station (S2CYCNE)

1217 **Stn 16298 H –** PELAGRA cast outboard **59 42.0N 018 33.8W**

	1232-1414	**Stn 16298 B – Titanium CTD cast to 2670 m 59 42.2N 018 33.0W**
	1417	Manoeuvring toward PELAGRA
	1444-1556	PELAGRA recovered and secured 59 43.6 N 018 32.3 W
	1600	Set Course 344˚T for Sea Soar Survey in Icelandic waters
22/08/07	0000	Position Latitude 61 02.9 N Longitude 019 19.5 W
	0142-0200	A/C to 010˚T to alleviate rolling in high seas 61 24.0 N 019 30.0 W
	0745	a/c to 260˚ T 62 23.0 N 019 06.0 W
	0900	a/c to 305˚ T 62 23.9 N 019 20.7 W
	1337	a/c to 272˚ T 62 53.3 N 020 25.9 W
	1356	Hove to on Station (16299) PES Fish outboard
	1425	**Stn 16299 I –** SEASOAR fish cast outboard **63 53.2N 020 33.7W**
		Commenced streaming at 2-3 knots
	1444	**SEA SOAR fully deployed** Survey begins Course 273˚ T @ 8-9 knots
		62 53.0 N 020 37.3 W
	1800	Sea Soar ordered to surface 62 55.0 N 021 36.3 W
	1815-35	Recovering Sea Soar
	0835	Sea Soar recovered 62 53.8 N 021 38.8 W
	1845-1906	**Stn 16300 E – Plankton nets cast 62 53.8N 021 38.6W**
	1848	TMS Fish inboard
	1850	PES Fish inboard
	1906	**SCIENCE ENDS** Set Course 329˚ T for passage to Reykjavik
		62 53.8 N 021 38.4 W
23/08/07	0800 (prov)	ETA Reykjavik

3. TECHNICAL SUPPORT

Deck Operations and NMEP Laboratory Equipment – *Emma Northrop*

Liquid Nitrogen Generator

At the beginning of the cruise this was working well, but developed icing up of the Level sensor. As a result the Dewar was decanted into an external Dewar and the unit allowed to thaw. During the thaw process a leak through the service valve knob meant a loss of a significant amount of the Helium refrigerant in the refrigerant circuit which cools the Dewar. The leak was fixed, the refrigerant circuit recharged with Helium, and the generator restarted. After 18 days of production, and 70 Litres drawn, a chattering noise was noted. This was believed to be the solenoid valve in the compressor refrigerant circuit and would be replaced at the end of the cruise, when parts could be flown out to meet the ship.

Trace Metal Sampling Fish (Achterberg design)

The fish was deployed from the 2 Tonne Danfoss winch with a 10 mm stainless tow wire and a Schatt Davit located at the Port Quarter just forward of the pedestal crane. The hose was supplied by the user, although due to kinking of the hose the section between the fish and deck was replaced with a clear PVC braided type.

At each deployment of the Turbulence Profiler, the trace metal fish was brought to the surface to reduce any turbulence generated by the fish.

Laboratory Containers

Three portable Laboratory containers were used during this cruise; one for Clean Chemistry, one for Radionuclide work and one for Radionuclide and Flow Cytometry. Aside from some minor plumbing leaks the only other problem noted was rocking of the container which was located in the mid aft fo'c's'le slot.

Millipore Units

Two Elix10/Advantage Q Millipore systems were used on this cruise. They were located in the Deck Laboratory and the Clean Chemistry Laboratory Container. No problems were reported with their performance.

Fume Hoods

Fume Hoods were located in the Chemistry Laboratory and the Radionuclide Laboratory Container. Filters supplied were selected to suit the chemical lists provided. No problems were reported with their performance.

Laminar Flow Cabinets

Two Laminar Flow Cabinets were onboard, one in the Deck Laboratory and one in the Clean Chemistry Laboratory Container. No problems were reported with their performance.

Liquid Scintillation Counter

A Perkin Elmer Tricarb 3100TR was located in the Deck Laboratory. Following previous experience it was positioned athwart-ships and performed reliably.

Icemaker

A Scotsman AF80 icemaker was located in the Hangar and performed reliably.

-80 °C Chest Freezers

Two -80 °C Chest Freezers were located in the Hold. Apart from one occasion where the electrical supply plug for one of them became dislodged they maintained temperature reliably.

Starboard Deployments

Nets with a weight below the cod end were deployed outboard of the starboard pendulum roller on kevlar rope from the forward rotzler winch.

SAPs were deployed on the Core Warp with standard routing over the starboard gantry and a chain clump.

CTDs were deployed on the Standard CTD wire with standard routing over the starboard gantry.

CTD Operations – *Dave Teare*

Two CTD systems were used during the cruise. A ‘standard’ stainless steel unit for physics and general sampling plus a titanium unit for trace metal and productivity sampling. Both units were fitted with Seabird CTDs and associated equipment.

CTD configurations

The stainless CTD package comprised of the following instruments:

- A Seabird 911+ CTD with dual pumped temperature and conductivity sensors, for which the secondary sensor pair were vane mounted to reduce salinity spiking.
- A Seabird SBE 43 oxygen sensor fitted in the primary duct.
- A Seabird carousel type SBE 32.
- Two RDI 300Khz workhorse ADCPs, one upward looking (slave) and one downward looking (master).
- Chelsea instruments Alphatracka (transmissometer) and Aquatracka (fluorometer).
- A PML 2π PAR down welling light sensor.
- A Benthos altimeter type 915T.
- Twenty four, 20 litre OTE Water bottles.

A Satlantic 'ISUS' nitrate sensor was often also fitted for evaluation purposes. The PAR and nitrate sensors were removed for casts greater than 1000m due to their pressure case limitations.

The titanium CTD comprised of the following:

- A Seabird 911+ CTD with dual pumped temperature and conductivity sensors, both pairs were mounted on the CTD.
- A Seabird SBE 43 oxygen sensor in line with the primary sensor duct.
- A SBE 32 carousel.
- Chelsea Alphatracka and Aquatracka.
- PML 2π PAR light sensors, one for down welling and one for up welling light.
- A Tritech P200 altimeter.
- And twenty four, 10 litre OTE trace metal water bottles.

Equipment performance.

Generally both systems performed reasonably well. There were however a larger number of modulo errors than normal. These were traced to faulty cables, a poor termination and to the eventual failure of the 'stainless system' CTD near the end of the cruise. The 20 litre water bottles had a failure rate of around one bottle per cast. There were no sensor changes required on either system.

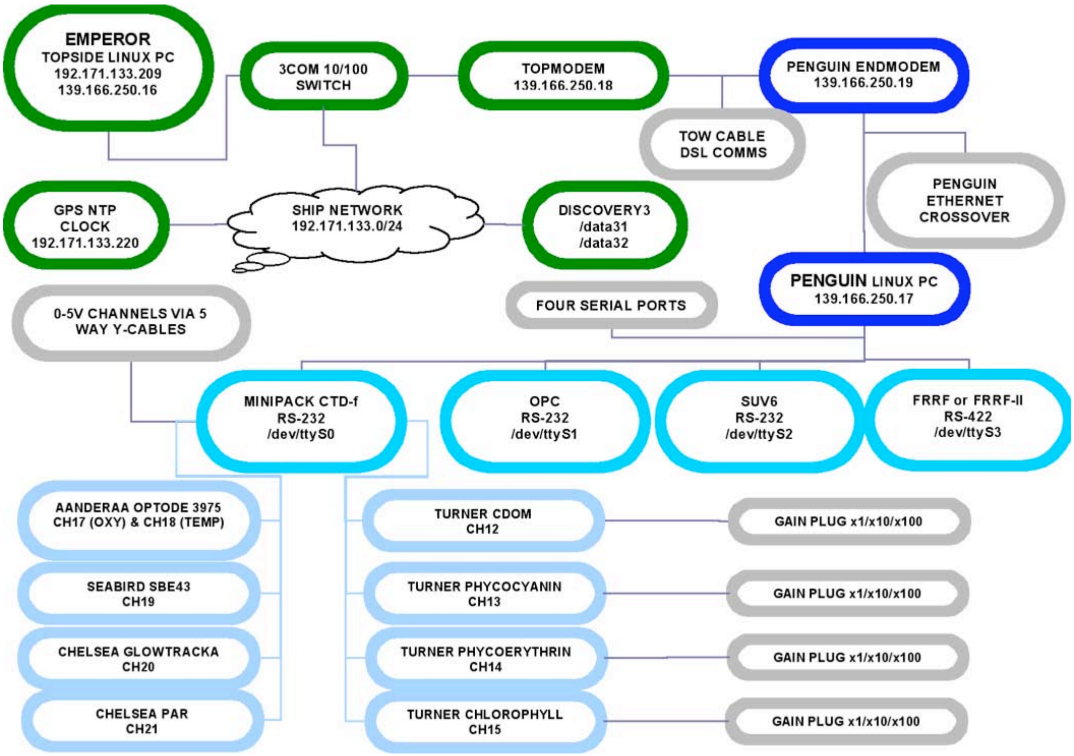
SeaSoar Operations – *Dougal Mountifield*

Summary

The SeaSoar system that was deployed during the cruise has benefited from numerous improvements to improve reliability and time-stamping accuracy. A new suite of instruments was deployed on the tow-fish to further develop its use for biological measurements. These included various fluorimeters, two dissolved oxygen sensors, a solid state nitrate sensor and a bioluminescence sensor. The new Chelsea Fastracka-II FRRF was also trialled on the vehicle. The new instruments were deployed in addition to the normal payload of a fast repetition rate fluorimeter, the minipack CTD-f and the Focal OPC. The fish was towed at 9 knots on up to 760m of faired cable and obtained depths of around 450m.

Six SeaSoar tows were undertaken during which nearly four days time in the water was accumulated. Total tow length was approximately 750 nm. The final deployment was a short shallow tow in high productivity water as a control for the new instrumentation. After early teething problems with a failed hydraulic unit and an unreliable PSU board in PENGUIN, the system was repeatedly deployed with no further problems.

SeaSoar System Details



System Developments Prior to D321

PENGUIN

End-caps

New pressure case top end-caps have been manufactured to incorporate smaller and more serviceable bulkhead connectors from the Impulse LPMIL series. This yields more space between PENGUIN and the FRRF bay and most importantly allows easier mating and removal of the connectors and hence less force on the sealing o-rings. A new suite of cables for the standard instrument payload was also procured to mate with the new bulkhead connectors. One major advantage of the new connectors is that the sea-cable tail now passes around the mechanical termination loops very easily. The mechanical termination used to take 2-3 people a couple of hours, it now takes 1 person half an hour.

Solid State Hard-disk

Following problems in the past with failed magnetic hard disks due to shock loading of the vehicle a new solid state disk has been incorporated. The M-Systems FFD 2.5" UATA flash disk is the same mechanical and electrical form factor as a standard hard disk. It is not only considerably more tolerant of shock loads in use but is faster both reading and writing than a conventional disk. Because of its high cost (£700) only 4GB of storage is available. However this is ample storage for even a long dedicated SeaSoar cruise, even if the new NFS mount technique developed during CD173, and used on this cruise was not used. The FFD has sustained read & write speeds of > 40 Mbytes/s, an access time of < 0.04 µs, an endurance of 5 million erase/write cycles and most importantly it can withstand operating vibration of 16.3G and operating shock of 1,500G. PENGUIN now boots within 30 seconds and halts within 15 seconds.

BIOS Battery Backup

Since the re-engineering of the PENGUIN PSU and IO boards by SEAMAP, the battery backup for the BIOS on the PC-104 CPU card had not functioned. This meant that PENGUIN lost its real-time clock settings after each power cycle and required the user to set the time at the start of each run with limited accuracy. The BIOS battery backup problem has now been traced to a faulty SEAMAP IO board which has been replaced and PENGUIN now retains its clock between power cycles.

RAM Upgrade

To mitigate against software memory leaks and to provide more resource for future software development, the RAM in PENGUIN has been doubled from 128 Mbytes to 256 Mbytes.

Internal Cabling

All internal cables within PENGUIN have been replaced to prevent cable failure due to age, vibration induced weakening, or connector wear.

Upgrade to Slackware 10.4

An adaptor board has been procured that allows a CD/DVD drive to be attached directly to PENGUIN for software installation. Hence the need to remove disks and install using an external laptop is now obsolete. The use of Slackware 10.4 means that there is no longer a requirement to build custom kernels. The I2C drivers for instrument power control are now built in to the kernel as standard. These two developments have significantly reduced the time required to create a working PENGUIN operating system from scratch. Various other contemporary flavours of Linux were evaluated and tested but Slackware still offers the best solution in terms of simplicity and efficiency.

DAPS Library Rebuild

The DAPS libraries were rebuilt with additional baud rate speed switches included to allow use of speeds greater than 19,200 baud. Speeds of up to 115,200 are now available. This enabled the use of the Fastracka-II at full serial speed.

New DAPS modules

Two DAPS acquisition modules (suv6 & frrf_ii) were written during the early part of the cruise to log the SUV6 and the FRRF-II summary data via the PENGUIN serial ports. Due to the lack of documentation available for DAPS this software development was very time consuming.

<u>Emperor</u>

NFS Data Transfer

In the past the Emperor process on the top-side Linux box has periodically transferred PENGUIN data up the tow-cable using ftp approximately every 30 seconds. This was changed during CD173 to mitigate for a failing hard disk. The new method involves mounting an exported directory from Emperor on Penguin using NFS. This method also seems to make better use of the DSL tow-cable link by trickling data up the wire rather than sending it in bursts. The NFS method was used during D321 with no problems. Before acquisition was started the system was tested to ensure it was mounted and possible to write to.

NTP Time Synchronisation

As a further improvement to time accuracy Emperor was configured to use NTP to synchronise its system clock to the GPS NTP time server on *Discovery*. The specified accuracy of this protocol is +/- 128 ms, but in practice it is normally of the order of +/- 50 ms. As well as being a client to the GPS time server, Emperor was configured to be an NTP server for PENGUIN. Thus PENGUIN is now synchronised to a GPS clock to within a few tens of ms. The NTP synchronisation process was configured to occur automatically upon boot-up. The ntpd daemons on both Emperor and PENGUIN were run all the time and use of drift files to apply local clock corrections between server polls was incorporated. Thus the user simply had to check the clock synchronisation before starting instrument acquisition processes using ntpstat.

New Ethernet Switch

A new 10/100 Ethernet switch was installed in the Emperor rack to prevent loss of communication with the tow fish that were experienced when transferring data to the ship’s network using the old 10 Mbit Ethernet hub.

<u>SeaSoar Tow-fish</u>

Fish Bodies

Prior to the cruise considerable work had to be undertaken to consolidate the four NMEP damaged and incomplete vehicles to build two deployable fish (**Figure 7**). This included fabrication of a new set of aluminium tail planes and mounting plates to replace parts lost on CD173. The fifth ex-DERA fish, which is currently incompatible with NMEP instrument brackets and hydraulic units, also had to be cannibalised. New wing tips were fitted on the main vehicle using industrial window sealant as a filler, and this proved to be a robust material for the application.

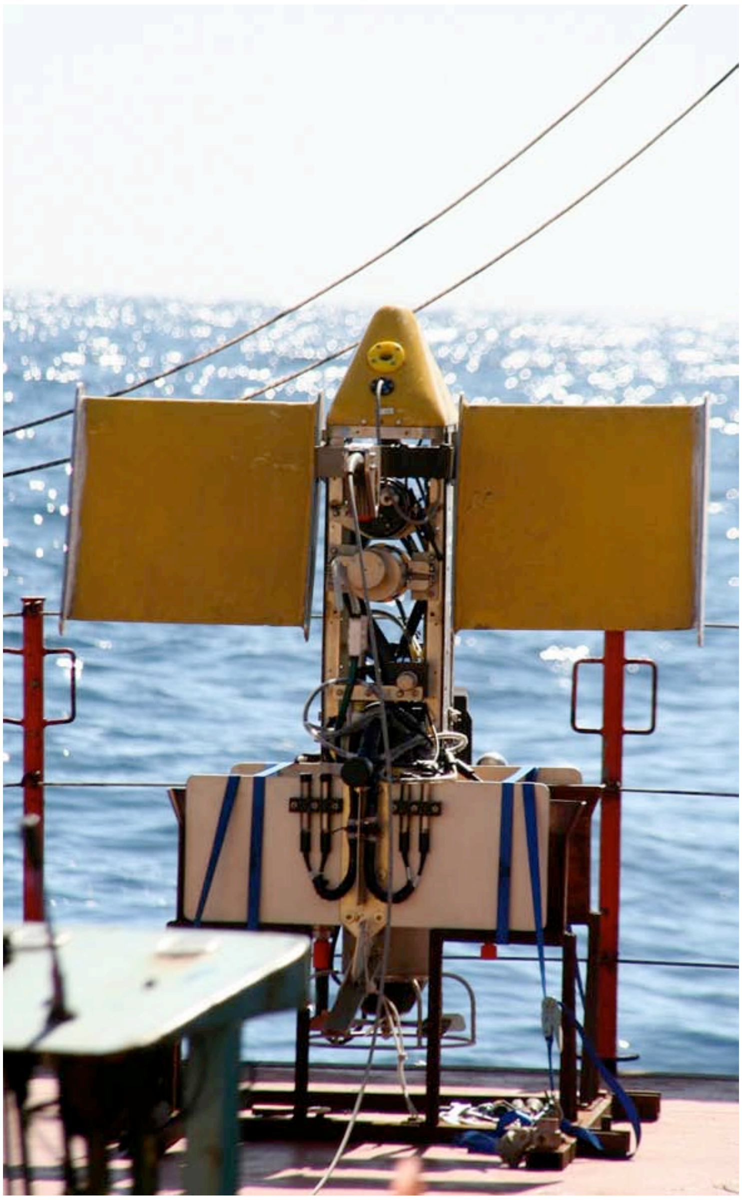


Figure 7: The SeaSoar vehicle on its vertical launch and recovery stand, the top and bottom payload bay covers are removed and the instrument layout can be seen.

A damaged nose section was repaired onboard using a GRP repair kit acquired via the ships' agent during mobilisation.

A previously unused larger diameter titanium hydraulic impellor was fitted to the main tow vehicle in an attempt to generate higher wing forces for a given tow-fish speed, and assist in attaining greater dive depths.

Instrument Mounting

The Maurer Instruments SR150 flowmeter for use with the Glowtracka was fitted in the top half of the SeaSoar nose section below the tow-cable fairlead. This was later removed to allow fitment of the mk.1 FRRF, but the outer mounting plate for the SR150 was used in conjunction with a pipe fitting that was fabricated onboard.

Fabrication of the brackets detailed below was started at the NOC prior to the cruise, but due to the unavailability of instruments, and limited space within the tow-body this had to be continued during mobilisation, and during the first week of the cruise:

- Clamps for mounting Turner Cyclops instruments on the top tail plane and fitting of ‘P’ clips to secure the cables on the tail fin. The cable cut-away in the top SeaSoar cover for the PAR cable had to be enlarged to accommodate the additional Cyclops cables.
- An SUV6 clamp for vertical mounting within vehicle behind minipack, the optical head protruding above top of minipack through new hole cut in SeaSoar top cover. The instrument was located such that the bulkhead connectors meshed around FRRF/FRRF-II bulkhead connectors.
- FRRF-II clamps for horizontal mounting in existing FRRF bay.
- A Glowtracka clamp modified from minipack clamp but shallower in height. This was mounted upside down in top bay just forward of hydraulic unit with flow head upwards. A further cut-out was made in the clamp to clear the bulkhead connector.
- Aanderaa Optode & SBE43 Oxygen sensor clamps. These were mounted in the top bay between Glowtracka and SUV6. This clamp required further modification to integrate it with the hose run for the Glowtracka. The SBE43 sensor was mounted in horizontal plane and in a forward-aft orientation. An inlet funnel for the Seabird sensor was fabricated and located forward of minipack on top cover of SeaSoar with hose through the minipack cut-away to SBE43 inlet. The SBE43 exhaust hose was routed past the hydraulic unit and through a tail drain hole. The

Aanderaa Optode sensor was mounted in the vertical plane with sensor head passing through new hole cut in top cover.

Instrument Interfacing

New cables were designed and procured prior to the cruise for incorporating the new instrumentation. These included cables for the FRRF-II and SUV6 into PENGUIN and a new system for breaking out the minipack auxiliary inputs. These consist of one to five way Y-mould cables that break out 6 minipack channels. Two Y-cables can be used together to access 12 minipack 0-5VDC analogue inputs. These were used for interfacing the Oxygen, PAR, Bioluminescence, and Cyclops fluorimeters. The Turner Cyclops instruments have pin programmable gains and these were broken out with additional Y-cables to allow instrument gain to be changed simply by fitting a different blanking plug. Gains of x1, x10 and x100 are available.

All cables were wrapped in spiral wrap and insulating tape to protect them from chaffing and provide additional mechanical stiffness. Additional use of friction tape was made on cables where ‘P’ clips were located. Unused cables on the one to five way Y-cables were fitted with blanking plugs.

Instrumentation Servicing

During the mobilisation the SUV-6 had to be dismantled to fit locking rings on its bulkhead connectors to prevent the cable and blanking plug from becoming detached due to towing drag. Upon inspection, one of the pressure case ‘o’ rings was split and no spares had been sent with the unit. Spare 100mm ID x 3.5mm wall ‘o’rings were procured through the ship’s agent and although not a perfect fit did not compromise the integrity of the seal. As a precaution the new ‘o’ ring was fitted in the internal groove of the double piston seal. 99mm ID x 3.5mm wall ‘o’ rings would be more appropriate. An additional DC-DC converter was fitted within the SUV-6 prior to the cruise to allow it to be powered directly from the tow-cable (~60V). Unfortunately no documentation was available to assist with the support and characterisation of the SUV6.

The OPC was found to be missing a blanking plug from the unused bulkhead connector. The pressure case was opened to electrically isolate the connector from the internal electronics and the instrument was then deployed with no blanking plug fitted to this connector.

Ex-IOS SeaSoar Winch Refurbishment

The ex-IOS horizontal winch was completely overhauled prior to the cruise. This included re-plating of scroll gear bearers and fabrication of a new sheave. Various problems were encountered with the winch. The winch power pack failed during recovery of tow 4 and a 2.5 hour delay was incurred before the vehicle was safely recovered on deck. The problem was traced to a faulty limit switch on the emergency recovery system clutch and was bypassed for the remainder of the cruise.

No problems were encountered with the integral 0-5V strain gauge on the brake assembly.

A new tow-cable and fairing was wound onto the winch prior to the cruise and very few problems were experienced with it. The 7 conductor 8mm tow-cable was terminated using the red and one clear conductor for power, the black conductor and armour for power return, and one clear conductor each for the positive and negative of the DSL comms and the hydraulic control loops.

SeaSoar Tow-fish Configuration

Hydraulic units – s/n's RVS03, 04 & 05

PENGUIN

Chelsea TG Minipack CTD-f - s/n 210035

Chelsea TG Fastracka-II FRRF (tows 1&2) – s/n 07-6139-001

Chelsea TG Fastracka FRRF (tows 3-6) – s/n 182043

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

Maurer Instruments Ltd Flow Meter Model SR150 – s/n 2885

Chelsea TG Hemispherical PAR sensor – s/n 0046-3097 (046059)

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

Seabird Electronics SBE43 Dissolved Oxygen (unpumped) – s/n 1196

Aanderaa Optode 3975 Dissolved Oxygen – s/n 891

NOC/Valeport SUV-6 UV Nutrient Sensor

Focal OPC Optical Plankton Counter (4000m SS pressure case) – s/n TOW048

SeaSoar Tow-fish Instrument Configuration

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

- /dev/ttyS0 - Chelsea TG Minipack CTD-f
- /dev/ttyS1 – NOC/Valeport SUV-6 UV Nutrient Sensor
- /dev/ttyS2 – Focal OPC Optical Plankton Counter
- /dev/ttyS3 - Chelsea TG Fastracka or Fastracka-II FRRF

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

<u>Y-Cable A</u>

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

Y-Cable B

Cable #	Minipack Channel	Instrument
1	17	Optode Oxygen Conc
1	18	Optode Oxygen Temperature
2	19	SBE43 Oxygen Conc
3	20	Chelsea Glowtracka
4	21	Chelsea PAR
5	22	UNUSED

SeaSoar Deployment Notes

The topside PSU voltage was set at 85 V to yield approximately a couple of volts higher than 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 0.85 A with the FRRF-II and 0.97 A with the FRRF.

The following problems occurred during the cruise:

- Hydraulic failure during tow 1. Hydraulic unit RVS4 replaced by RVS3.
- Suspect PENGUIN PSU board. Replaced along with CPU card and internal Ethernet cable.
- Destroyed PENGUIN PSU clamping transistors. Occurred twice. Replaced with spares.
- When exposed to sunlight the Fastracka-II shuts down its PMT and the current acquisition can never complete. Subsequently deployed with dark chamber.
- When logging internally to its flashcard the Fastracka-II will not allow the user to close or download a file when the card becomes full.
- The Glowtracka 0-5V analogue output was wired incorrectly by manufacturer. This caused PENGUIN to reboot due to power surge when the I2C mp_on

command was first used and also meant no data was recorded from the Glowtracka for the first two tows. Both Glowtrackas were subsequently rewired internally to conform to the manufacturers product manual. The Glowtracka was evaluated on the bench and does not have a bandpass filter as implied by the manual. It also produces a 4V f.s.d. contrary to the manual.

SeaSoar Tow Log

Tow #	Time in Water	Time on Deck	Time & Distance	Comments
1	2007 217 08:29	2007 217 19:40	11.2 hrs 84nm	FRRF-II with cage, no internal logging. All Cyclops @ x10 gain. Glowtracka s/n 01 with flowmeter. Wing angle set to +/- 15 deg. Tow terminated due to hydraulic Failure
2	2007 219 08:30	2007 220 15:00	30.5 hrs 272nm	FRRF-II with dark chamber and internal logging. Cyclops Chlorophyll @ x10 gain, all others @ x100 gain. Glowtracka s/n 01 with flowmeter. Wing angle set to +12/-18 deg. Tow terminated due to PENGUIN failure.
3	2007 228 19:47	2007 229 15:52	20.1 hrs 177nm	New PENGUIN CPU and PSU boards. Replaced failed PENGUIN PSU clamp transistor. New Internal PENGUIN Ethernet crossover cable. New Emperor NIC. FRRF-I, with PAR still logged by Minipack. Glowtracka s/n 02 rewired, with flow meter removed. Wing angle as Tow 2. All Cyclops @ x100 gain. Planned recovery with system still working.
4	2007 230 14:07	2007 231 05:00	14.9 hrs 103nm	Same configuration as Tow 3. Planned recovery with system still working. Winch failure during recovery incurred a 2.5 hr delay in recovery.
5	2007 231 20:10	2007 232 08:46	12.5 hrs 101nm	Same configuration as Tow 3. Planned recovery with system still working.

6	2007 234 14:25	2007 234 18:41	4.3 hrs 31nm	Same configuration as Tow 3 but lower FRRF gain. 500m of tow-cable at 8 knots diving to 250m. High productivity shelf break tow. Planned recovery with system still working.

All tows were on 760m faired cable at 9 knots apart from tow 6.

Total time in water: 93 hrs or 3.9 days

Total tow distance: 768 nm

Average tow speed including deployment and recovery time: 8.3 knts

Computing and Instrumentation - *Chris Barnard*

RVS LEVEL ABC System

The LEVEL ABC system is a system comprised of multiple components that can be adjusted and altered to suit the needs of the cruise in progress. The system is due to be retired due to its age and the difficulty in acquiring spares. The ABC system is created of 3 tiers:

- Level A - The Level A's role in the system is to acquire the data from an instrument, parse the data stream into the necessary format to be recorded by the level B and also place a timestamp on each piece of data. The instruments are connected to the Level A's via RS-232 and are also connected to the level B in the same way. This allows simple interrogation of messages when attempting to track a problem with the system.

- Level B - The level B is sent all data from the Level A's and allows you to view all the data as it is coming in. The Level B allows the backup of the data to magnetic disks which are backed up on the Level C in compressed Zip format. The Level B transmits the data to the Level C and the data is parsed directly into the RVS data files that we use now. All data, errors, comments can be viewed for each individual instrument.

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

The Level A's acquire their timestamp from a Radio code GPS Clock that is distributed via the RVS Master / Slave Clock System.

The ABC system still remains the main data logging format for the ship, this is being run in parallel with the new Ifremer Techsas Sensor Acquisition System. This system is currently being proven and a database of drivers being built to enable us to interface with the instruments on board. This system will then become the primary system for data logging.

For RRS *Discovery* cruise D321 the Level A system was used to log:

1) Ashtech ADU-2 multi antenna GPS with attitude (gps_ash)
2) Ashtec GPS G12 integral to the FUGRO Seastar DGPS receiver (gps_g12)
3) NMFD Surface-water and Meteorology instrument suite (surfmet)
4) NMFD Winch Cable Logging And Monitoring CLAM (winch)
5) Chernikeef Log – Ship's speed through water (log_chf)

The RVS level ABC system suffered no major issues during the cruise with the exception of the failure of the ea500d1 level A that was to be used for the cruise. This level A has been functioning well and I believe that its failure is due to the loss of power prior to sailing. The Echo Sounder was logged with TECHSAS however at present it only logs the raw depth value and not the full field listing that the Level A currently logs.

Ifremer Techsas System

The Ifremer data logging system is the system that will inevitably replace the existing Level A + B system while for the most part the Level C will remain as the main system for outputting, viewing, editing and processing the acquired data.

The Techsas software is installed on an industrial based system with a high level of redundancy. The operating system is Red Hat Enterprise Linux Edition Release 3. The system itself logs data on to a RAID 0 disk mirror and also logs to the backup logger. The Techsas interface displays the status of all incoming data streams and provides alerts if the incoming data is lost. The ability exists to broadcast live data across the network via NMEA.

The storage method used for data storage is NetCDF (binary) and also pseudo-NMEA (ASCII). At present there are some issues on some data streams with file consistency between the local and network data sets for the ASCII files. NetCDF is used as the preferred data type as it does not suffer from this issue.

The Techsas data logging system was used to log the following instruments:

1) Trimble GPS 4000 DS Surveyor (converted to RVS format as gps_4000)
2) Chernikeef EM speed log (converted to RVS format as log_chf)
3) Ships Gyrocompass (converted to RVS format as gyronmea)
4) Simrad EA500 Precision Echo Sounder
5) NMFD Surface-water and Meteorology (SURFMET) instrument suite
6) ASHTECH ADU-2 Altitude Detection Unit
7) NMFSS Cable Logging and Monitoring (Still in testing)

This system is still being trial run by platform systems as the replacement to the aging RVS system, no major issues occurred during this cruise and no substantial data losses occurred. During the port call the most recent version of the software was successfully installed and the memory leaks which caused the system to crash or need resetting every 2 days in order to avoid crashing did not occur. The new version of the software also works correctly with the nclistit application from the RVS System allowing error free conversion between the NetCDF and Level C file system.

Techsas NetCDF to RVS Data Conversion

An in house application was used to handle the conversion of NetCDF files to the RVS format. This was then parsed back to the data file and was processed as normal. These 2 new applications being ncvars and nclistit.

These new binaries require two environment variables in order to function:

$NCBASE – the base for the NetCDF binaries system, set to /rvs/def9

$NCRAWBASE – the base for the raw data files, set to /rvs/pro_data/TECHSAS/D321/NetCDF

The existing $PATH variable must also include the path to the NC binaries, the path /rvs/def9/bin was appended to the $PATH variable.

All Techsas data file names are in the format of YYYYMMDD-HHMMSS-name-type.category with the data/timestamp being the time the file was created by Techsas.

The files were processed in the following way for this cruise:

nclistit 20070813-000001-gyro-GYRO.gyr - | titsil Gyronmea -

This output gyro data from TECHSAS, in the listit output format, is then read in by the titsil application.

Data Processing

Daily data transfer of GPS_4000, GYRONMEA, and EA500 took place in order to process the relmov files for bestnav and to allow bestnav to complete. This was then made available for the processing of ADCP and SeaSoar data. Processing was conducted by the science party using Matlab hosted on discovery2ng and also PSTAR on discovery2ng and discovery5.

Fugro Seastar DGPS Receiver

The Fugro Seastar is the source of custom differential corrections based on its position fixed by its internal Ashtec G12 GPS module. It outputs corrections via RS-232 using the standard RTCM message. The message is distributed to the Trimble 4000 DS GPS receiver where it is used to compute its own DGPS positions.

The Fugro Seastar functioned correctly throughout the cruise. There have been issues with this system previously not detecting the correct satellites due to location. The device was upgraded prior to the sailing of the previous cruise due to an update from FUGRO to the message they send. The system worked correctly throughout the cruise despite passing the shut off date of the old system showing that the update was successful.

Trimble 4000 DS Surveyor

The Trimble 4000DS is a single antenna survey-quality advanced GPS receiver with a main-masthead antenna. It uses differential corrections from the Fugro Seastar unit to produce high quality differential GPS (DGPS) fixes. It is the prime source of scientific navigation data aboard RRS *Discovery* and is used as the data source for

Navigation on the ships display system (SSDS). This system was logged by the TECHSAS System only.

Ashtec ADU-2

This is a four antenna GPS system that can produce attitude data from the relative positions of each antenna and is used to correct the VMADCP for ship motion. Two antennae are on the Bridge Top and two on the boat deck.

The Ashtec system worked reliably throughout the cruise with some gaps that are quite usual with this system due to the amount of calculations necessary and the roll of the ship causing bad satellite communication. No large data gaps are present. The ADU-2 forms part of the bestnav system which is an assembly of multiple GPS signals including the gyronmea and em-log stream in order to calculate the best possible position, speed, heading, pitch and roll of the ship.

Gyronmea

The Gyronmea is a file that receives its data from the ship's gyro compass. There are two such Gyros and we are able to use either one of them as a source of heading. The selected Gyro is logged by the TECHSAS system and is used as part of the bestnav calculation.

Dartcom satellite imaging system.

The dartcom system is able to receive signals from satellites that take images of cloud coverage, these images can be used to see the type of atmospheric and weather conditions nearby. The Dartcom system did not work for the entirety of the cruise. This system had worked reliably since April following a network hub replacement. The issue at the moment appears to be following the power cut that occurred in Govan. The system is able to calculate positions of satellites, however, the acquisition of images is not successful due to a now faulty Receiver Module as no signal is being received by the Dartcom rack. Spares from the Ex- Charles Darwin system are currently en-route to repair the faulty unit.

RDI Ocean Surveyor 75KHz Vessel Mounted ADCP (VMADCP)

The RDI Ocean Surveyor system was monitored throughout the cruise by the science party and by myself with the configuration and data processing being conducted by the science party using the *bestnav* data and the PSTAR applications.

The ADCP 75Khz computer was allowed to time drift in order to allow processing to correct any time loss at the end of the cruise. Time corrections under windows XP do not record drift logs and so time jumps are experienced when syncing to the NTP clock.

RDI 150KHz Vessel Mounted ADCP (VMADCP)

The 150Khz Vessel Mounted ADCP is an ageing system that has been on board the ship for a number of years and is due for replacement in the near future. The system was configured by the scientific party and monitored throughout the cruise. There were issues with configuration files that caused no data to be logged by the 150Khz ADCP. The reason for this to my knowledge is currently unknown however the issue was resolved after some investigation. The clock on this system was allowed to drift and so the raw data will have to have corrections applied. This was conducted on board throughout the cruise by the science party using the PSTAR system.

Chernikeef EM log

The Chernikeef EM log is a 2-axis electromagnetic water speed log. It measures both longitudinal (forward-aft) and transverse (port-starboard) ships speed through the water. The EM log was not calibrated prior to the cruise and was reading -1.0 knots astern when alongside. The system was logged by the TECHSAS logging system and also the RVS Level A system.

Simrad EA500 Precision Echo Sounder (PES)

The PES System was used throughout the cruise, however, it was used on the ship's hull transducer only. Several gaps exist during mooring recoveries and deployments due to having to stop the PES from pinging as it was causing interference with the acoustic releases. The system, while on the hull is easily 'distracted' from the correct depth of the water by the pinger that is mounted on the Stainless CTD Frame. Generally this only occurred when the CTD was close to the vessel.

Surfmet System

This is the NMFD surface water and meteorology instrument suite. The non-toxic surface water component consists of a flow through system with a pumped pickup at approx 5m depth. Thermosalinograph (TSG) flow is approx 25 litres per minute whilst fluorometer and transmissometer flow is approx 3 L min^{-1}. Flow to instruments is degassed using a debubbler with 40 L min^{-1} inflow and 10 L min^{-1} waste flow.

The meteorology component consists of a suite of sensors mounted on the foremast at a height of approx 10 m above the waterline. Parameters measured are wind speed and direction, air temperature, humidity and atmospheric pressure. There is also a pair of optical sensors mounted on gimbals on each side of the ship. These measure total irradiance (TIR) and photo-synthetically active radiation (PAR).

The non toxic system was enabled as soon as we were far enough away from land. The Surfmet system began receiving the non toxic supply around time stamp 072061537 (yyjdayhhmm). The system then ran continuously until 072342155.

The transmissometer and fluorometer were cleaned at the end of the previous cruise and also each week during the cruise. The TSG tank and also the flow meters were also cleaned, during which time the system was turned off. The system was then flushed with fresh water which remained in the system until the non-toxic supply was made available once more.

Salinity samples were taken on an average basis of 1 per 4 hours during normal operations and then 1 per hour during SeaSoar deployments. These samples were taken by the science party and salinometer measurements performed as and when crates were filled.

The transmissometer began delivering strange readings during the cruise and the science party were made aware of that fact. Due to the way in which Surfmet is setup it would have involved shutting the system down in order to rewire the cabling to the transmissometer. This was not an option during the cruise and so the science party requested that the transmissometer be left running until the end of the cruise. The transmissometer was tested on the bench and still appears to be working. A cable error seems to have developed and will be repaired during the Reykjavik port call.

Meteorological Instrumentation

Measurement	Wind Speed	Spec : Range 0.4-75 ms^{-1}, output: 0-75 ms^{-1} = 0-750 Hz, Accuracy: +/-0.17 ms^{-1}
Manufacturer	Vaisala	
Model Nº	WAA151	

Measurement	Wind Direction	Spec : Range: 0-360º, output: 6 bit parallel grey code
Manufacturer	Vaisala	
Model Nº	WAV151	

Measurement	PAR	Spec : Range 350-700 nm output depends on sensor, (see cal sheet), Accuracy: +/-5%. Port and starboard sensors.
Manufacturer	Skye Inst. Ltd	
Model Nº	SKE 510 1204 28561 SKE 510 1204 28562	

Measurement	TIR	Spec : spectral Range 335-2200 nm (95%) irradiance 0-1440 Wm^2, Sensitivity 9-15 $\mu vW^{-1}m^2$. Port and starboard sensors.
Manufacturer	Kipp & Zonen	
Model Nº	CM 6B (serial nos. 973135 and 973134	

Measurement	Temp & Humidity	Spec : Temp, -20 - +60ºC, accuracy at 20⁰C, +/-0.4⁰C Humidity, 0-100% RH Accuracy, +/-4%
Manufacturer	Vaisala	
Model Nº	HMP45 (serial no. V1850014)	

Measurement	Barometric Pressure	Spec : Range 800-1060 mbar, Accuracy at 20^{o}C : +/-0.3 mbar
Manufacturer	Vaisala	
Model N^o	PTB100A (serial no. Z4740021)	

Surface Sampling

Measurement	Housing Temperature	Spec Range: -2 - +32^{o}C, accuracy: +/- 0.003^{o}C, res:0.0001^{o}C Stability: +/-0.0005 ^{o}C
Manufacturer	FSI	
Model N^o	OTM	

Measurement	Remote Temperature	Spec Range:-2 - +32^{o}C, accuracy: +/- 0.003^{o}C, res:0.0001^{o}C Stability: +/-0.0005 ^{o}C
Manufacturer	FSI	
Model N^o	OTM	

Measurement	Conductivty	Spec :
Manufacturer	FSI	
Model N^o	OCM	

Measurement	Turbidity	Spec : Range 0-100% or 90-100%, Output: 0-5 vdc Or -5 - +5 vdc Accuracy: 0.1%
Manufacturer	Wetlabs	
Model N^o	20cm	

Measurement	Fluorescence	Spec : Output ∞ emitted light at 685 nm Output: 0-+5 vdc
Manufacturer	Wetlabs	
Model Nº	WETStar	

CASIX PCO2 System

This system is an autonomous pCO_2 system developed by PML and Dartcom. I am not entirely sure of the full details of this, therefore if further information is required I advise that you contact Nick Hardman-Mountford at PML for information. The system was run at the same time as the Surfmet system. Several errors of Low Gas Standard readings were recorded via email to Nick (nhmo@pml.ac.uk) and also several issues with marine air flow.

Network Services

The networking on board was used heavily during the cruise for the use of Xterm across the network to the Solaris boxes in the computer room and also the use of the matlab license manager. The data32 storage area was also heavily in use during the cruise and the network suffered no errors due to this. The networking on the Boat Deck suffered a shut down due to the disconnection of cables in rough weather.

Wireless Networking had no issues with the exception of a reboot of an access point on the fo'c'stle deck

E-mail system

The email system worked reliably throughout the cruise except during times when the ship was headed on a direction due East when the Main Mast would block the satellites that were to the south of us from being 'seen'.

Data Storage

Two USB external hard drives are being use as a RAID 0 mirror hosted by discovery3 at the /data32 export. The mirror uses the modern meta device commands available in Solaris 10. This increases storage robustness by providing another layer of redundancy at the online storage level. The maintenance and administration of the disk set is minimal and the performance more than adequate.

All cruise data except for the /rvs path were stored on this storage area. Access was given to scientists to some of the folders via Samba sharing.

Level C data was logged to the discovery1 internal disk, TECHSAS, following the upgrade in Govan was changed slightly in the method of transferring data. The TECHSAS systems now have cross mounted areas that they are able to access on the opposite box. This was due to the fact that previously, with the level C having no power backup, data logging on Techsas had stopped as discovery1 went down. By backing up to the opposite logger this allowed data logging of any instruments that would still be powered up to continue logging for approximately 30 mins. This storage solution also means that the data is written to 2 mirrored disk sets and so 4 full copies are available in the case of a massive crash of the systems. The RVS system then was allowed read only access to this area for NC system data processing.

Data Backups

Daily backups of the Level C data were made as a tar file to DLT tape. The following paths were included in the tar file:

/rvs/raw_data
/rvs/pro_data
/rvs/def7/control
/rvs/users

In addition to the redundancy provided by the RAID 0 pair, daily backups of the /data32 directory were made by a level tar of the file system to the LTO 2 tape. The whole disk was backed up, rather than just current cruise data.

The LTO2 and DLT system were backed up on a daily basis in a rolling 5 tape sequence.

Mooring Operations – *Paul Provost*

Mooring recoveries

Four moorings that had been deployed during D312 were due for recovery and redeployment during D321. Three were identical, the recoverable part consisting of buoyancy, a McLane Parflux sediment trap, an Aanderaa RCM8 and an Ixsea acoustic release. The fourth mooring was similar except for the addition of a RD Instruments Workhorse Long Ranger 75kHz ADCP in a syntactic floatation buoy and an extra buoyancy package above the commonly shared mooring package.

Recovery of the moorings are detailed below:

STNE (recovered 28/07/07)

Contact made at 08:30 – 2654m range

08:33:20	2654m (released)
08:33:50	2624m
08:34:30	2594m
08:35:00	2571m
08:38:30	2410m
08:39:00	2383m
08:39:30	2359m

Average rise rate: 47m min^{-1}

Transducer inboard	@ 08:40
Surface visual	@ 09:09
Recovered on deck	@ 10:00

RCM8 – 12302

Switched off:	11:20
DSU no.:	14308
Word bits:	43662
File name:	12302_1.dsu
Battery volts:	7.32v

AR661 RT061– s/n 321 (Mode A – 8KHz)

Battery volts: 3x 8.46; 1x 9.42

Sediment trap ML11804-01

Downloaded: 29/07/07

File: ML11804_01.txt

STNW (recovered 29/07/07)

Contact made at 15:03:00 – 2613m range

15:08:00 2615m (released)

15:09:00 2568m

15:10:00 2519m

15:11:00 2471m

15:12:00 2424m

Average rise rate: 48m min^{-1}

Transducer inboard @ 15:12

Surface visual @ 15:53

Recovered on deck @ 16:50

RCM8 – 11216

Switched off: 17:17

DSU no.: 14304

Word bits: 43848

File name: 11216_1.dsu

Battery volts: 7.24v

AR661 RT061– s/n 440 (Mode B – 12KHz)

Battery volts: 3x 8.48; 1x 9.51

Sediment trap ML11804-05

Downloaded: 29/07/07

File: ML11804_05.txt

STC (recovered 01/08/07)

Contact made at 13:15 – 2579m range

13:25:45 2577m (released)

13:26:45 2479m

13:27:30 2408m

13:28:00	2361m

Average rise rate: 94m min^{-1}

Transducer inboard	@ 13:28
Surface visual	@ 13:29 (ADCP floatation visible, deeper packages still rising)
Recovered on deck	@ 16:40

RCM8 – 9682

Switched off:	20:58
DSU no.:	14402
Word bits:	44322
File name:	9682_1.dsu
Battery volts:	7.25v

AR661 RT061– s/n 325 (Mode B)

Battery volts: 3x 8.82; 1x 9.62

Sediment trap ML11804-02

Downloaded:	01/08/07
File:	ML11804_02.txt

RDI 75KHz Long Ranger ADCP – s/n

Downloaded:	01/08/07, 20:57
File:	D312C000.000

STS (recovered 02/08/07)

Contact made at 11:05 – 2862m range

11:06 – 11:51 erroneous readings and data from deck units, TT300 and TT801

Ranges 2863m, 2867m, 2810m

11:52:00	2844m (released)
11:53:00	2812m
12:04:30	2330m
12:06:00	2253m
12:07	2212m
12:10	2084m
12:12	2002m

12:13 1968m

12:14 1937m

Average rise rate: 42m min^{-1}

Transducer inboard @ 12:15

Surface visual @ 12:50

Recovered on deck @ 13:58

RCM8 – 3259

Switched off: 16:01

DSU no.: 14409

Word bits: 44442

File name: 3259_1.dsu

Battery volts: 7.25v

RT661 – s/n 183 (Mode B)

Sediment trap ML11262-08

Downloaded: 02/08/07

File: ML11262-08.txt

The release (serial no. 183) gave erroneous messages to both deck units, and it was unclear the exact status of the instrument. All acoustic signals from the ship were isolated as much as possible but ‘noise’ was still present and interfered with the return signal from the release. In the end TT300 was used to send the release signal, but TT801 tracked the released package. Due to the difficulty in communicating with acoustic release serial no. 183, the decision was made not to service and redeploy this instrument.

<u>*Recovered sediment trap operation files*</u>

Mooring STS - ML11262-08

```
McLane Research Laboratories, USA
          ParFlux 21-Cup Sediment Trap
            with Compass and Tilt
        Version: pst-21c4.c   S/N: ML11262-08

        Éííííííííííííííííííííííííííííííííí»
        º          Main Menu          º
        Èííííííííííííííííííííííííííííííííí¼
           Thu Aug  2 16:47:56 2007

        <1> Set Time            <5> Create Schedule
        <2> Diagnostics         <6> Deploy System
        <3> Fill Containers     <7> Offload Data
        <4> Sleep               <8> Contacting McLane

          Selection  ? 7

        Éííííííííííííííííííííííííííííííííí»
        º   Offload/Display Data File    º
        Èííííííííííííííííííííííííííííííííí¼
           Thu Aug  2 16:48:01 2007
```

<1> Display all data
<2> Display event summary
<3> Display tilt data
<4> Display backup EEPROM
<M> Main Menu

Selection ? 1

To copy the instrument data file to a disk file, initiate your communication program's file logging command now and then press any key to start the transfer. The instrument data file will remain resident and is not erased by this offload procedure.

Software version: pst-21c4.c
Compiled: Jan 15 2003 18:20:44
Electronics S/N: ML11262-08

Data recording start time = 10/15/2006 15:11:50
Data recording stop time = 08/02/2007 16:47:02

HEADER
______

Iceland Basin 4 ML11262_08 Deployment 45

SCHEDULE
____

Event 01 of 22 @ 11/22/2006 12:00:00
Event 02 of 22 @ 12/06/2006 12:00:00
Event 03 of 22 @ 12/20/2006 12:00:00
Event 04 of 22 @ 01/03/2007 12:00:00
Event 05 of 22 @ 01/17/2007 12:00:00
Event 06 of 22 @ 01/31/2007 12:00:00
Event 07 of 22 @ 02/14/2007 12:00:00
Event 08 of 22 @ 02/28/2007 12:00:00
Event 09 of 22 @ 03/14/2007 12:00:00
Event 10 of 22 @ 03/28/2007 12:00:00
Event 11 of 22 @ 04/11/2007 12:00:00
Event 12 of 22 @ 04/25/2007 12:00:00
Event 13 of 22 @ 05/09/2007 12:00:00
Event 14 of 22 @ 05/23/2007 12:00:00
Event 15 of 22 @ 06/06/2007 12:00:00
Event 16 of 22 @ 06/20/2007 12:00:00
Event 17 of 22 @ 07/04/2007 12:00:00
Event 18 of 22 @ 07/18/2007 12:00:00
Event 19 of 22 @ 08/01/2007 12:00:00
Event 20 of 22 @ 08/15/2007 12:00:00
Event 21 of 22 @ 08/29/2007 12:00:00
Event 22 of 22 @ 09/12/2007 12:00:00

DEPLOYMENT DATA
____

Event 01

Scheduled start time: 11/22/2006 12:00:00
Event start time: 11/22/2006 12:00:00
Event stop time: 11/22/2006 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	19.5	3øC	0ø	0ø
Stop:	Y	19.1	4øC	0ø	0ø

Event 02

Scheduled start time: 12/06/2006 12:00:00
Event start time: 12/06/2006 12:00:00
Event stop time: 12/06/2006 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	19.2	3øC	0ø	0ø
Stop:	Y	18.9	4øC	0ø	0ø

Event 03

Scheduled start time: 12/20/2006 12:00:00
Event start time: 12/20/2006 12:00:00
Event stop time: 12/20/2006 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	19.1	3øC	0ø	0ø
Stop:	Y	18.6	4øC	0ø	0ø

Event 04

Scheduled start time: 01/03/2007 12:00:00
Event start time: 01/03/2007 12:00:00
Event stop time: 01/03/2007 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	19.1	3øC	0ø	0ø
Stop:	Y	18.4	4øC	0ø	0ø

Event 05

Scheduled start time: 01/17/2007 12:00:00
Event start time: 01/17/2007 12:00:00
Event stop time: 01/17/2007 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	18.8	3øC	0ø	0ø
Stop:	Y	18.4	4øC	0ø	0ø

Event 06

Scheduled start time: 01/31/2007 12:00:00
Event start time: 01/31/2007 12:00:00
Event stop time: 01/31/2007 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	18.7	3øC	0ø	0ø
Stop:	Y	18.3	4øC	0ø	0ø

Event 07

Scheduled start time: 02/14/2007 12:00:00
Event start time: 02/14/2007 12:00:00
Event stop time: 02/14/2007 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	18.6	3øC	0ø	0ø
Stop:	Y	17.9	4øC	0ø	0ø

Event 08

Scheduled start time: 02/28/2007 12:00:00
Event start time: 02/28/2007 12:00:00
Event stop time: 02/28/2007 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	18.6	3øC	0ø	0ø
Stop:	Y	17.8	4øC	0ø	0ø

Event 09

Scheduled start time: 03/14/2007 12:00:00
Event start time: 03/14/2007 12:00:00
Event stop time: 03/14/2007 12:00:29

	Aligned	Battery	Temperature	Tilt	Heading
Start:	Y	18.3	3øC	0ø	0ø
Stop:	Y	17.8	4øC	0ø	0ø

Event 10

Scheduled start time: 03/28/2007 12:00:00
Event start time: 03/28/2007 12:00:00
Event stop time: 03/28/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   18.1   3øC   0ø   0ø
Stop: Y   17.6   3øC   0ø   0ø

Event 11

Scheduled start time: 04/11/2007 12:00:00
Event start time: 04/11/2007 12:00:00
Event stop time: 04/11/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   18.1   3øC   0ø   0ø
Stop: Y   17.5   4øC   0ø   0ø

Event 12

Scheduled start time: 04/25/2007 12:00:00
Event start time: 04/25/2007 12:00:00
Event stop time: 04/25/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   18.1   3øC   0ø   0ø
Stop: Y   17.3   4øC   0ø   0ø

Event 13

Scheduled start time: 05/09/2007 12:00:00
Event start time: 05/09/2007 12:00:00
Event stop time: 05/09/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   17.8   3øC   0ø   0ø
Stop: Y   17.3   4øC   0ø   0ø

Event 14

Scheduled start time: 05/23/2007 12:00:00
Event start time: 05/23/2007 12:00:00
Event stop time: 05/23/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   17.8   3øC   0ø   0ø
Stop: Y   17.2   4øC   0ø   0ø

Event 15

Scheduled start time: 06/06/2007 12:00:00
Event start time: 06/06/2007 12:00:00
Event stop time: 06/06/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   17.8   3øC   0ø   0ø
Stop: Y   17.0   4øC   0ø   0ø

Event 16

Scheduled start time: 06/20/2007 12:00:00
Event start time: 06/20/2007 12:00:00
Event stop time: 06/20/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   17.5   3øC   0ø   0ø
Stop: Y   16.9   3øC   0ø   0ø

Event 17

Scheduled start time: 07/04/2007 12:00:00
Event start time: 07/04/2007 12:00:00
Event stop time: 07/04/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   17.4   3øC   0ø   0ø
Stop: Y   16.9   4øC   0ø   0ø

Event 18

Scheduled start time: 07/18/2007 12:00:00
Event start time: 07/18/2007 12:00:00
Event stop time: 07/18/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   17.4   3øC   0ø   0ø
Stop: Y   16.7   4øC   0ø   0ø

Event 19

Scheduled start time: 08/01/2007 12:00:00
Event start time: 08/01/2007 12:00:00
Event stop time: 08/01/2007 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y   17.4   3øC   0ø   0ø
Stop: Y   16.7   4øC   0ø   0ø

Schedule was not completed.

End of instrument data file.

Mooring STNE - ML11804-01

McLane Research Laboratories, USA
ParFlux 21-Cup Sediment Trap
Version: pst-21_1.c   S/N: ML11804-01

Éííííííííííííííííííííííííííííííííí»
º   Main Menu   º
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Sat Jul 28 13:57:57 2007

<1> Set Time   <5> Create Schedule
<2> Diagnostics   <6> Deploy System
<3> Fill Containers   <7> Offload Data
<4> Sleep   <8> Contacting McLane

Selection ? 7

Éííííííííííííííííííííííííííííííííí»
º   Offload/Display Data File   º
Èííííííííííííííííííííííííííííííííí¼

Sat Jul 28 13:58:01 2007

<1> Display data file
<2> Display backup EEPROM
<M> Main Menu

Selection ? 1

To copy the instrument data file to a disk file, initiate your communication program's file logging command now and
then press any key to start the transfer. The instrument data file will remain resident and is not erased by this offload procedure.

Software version: pst-21_1.c
Compiled: Sep 26 2002 11:10:14
Electronics S/N: ML11804-01

Data recording start time = 10/15/2006 15:07:06
Data recording stop time = 07/28/2007 13:52:00

HEADER
______

ML11804_01_D312 Iceland Basin Sed Trap 3 Mooring 44
STNE

SCHEDULE
____

Event 01 of 22 @ 11/22/2006 12:00:00
Event 02 of 22 @ 12/06/2006 12:00:00
Event 03 of 22 @ 12/20/2006 12:00:00
Event 04 of 22 @ 01/03/2007 12:00:00
Event 05 of 22 @ 01/17/2007 12:00:00
Event 06 of 22 @ 01/31/2007 12:00:00
Event 07 of 22 @ 02/14/2007 12:00:00
Event 08 of 22 @ 02/28/2007 12:00:00
Event 09 of 22 @ 03/14/2007 12:00:00
Event 10 of 22 @ 03/28/2007 12:00:00
Event 11 of 22 @ 04/11/2007 12:00:00
Event 12 of 22 @ 04/25/2007 12:00:00
Event 13 of 22 @ 05/09/2007 12:00:00
Event 14 of 22 @ 05/23/2007 12:00:00
Event 15 of 22 @ 06/06/2007 12:00:00
Event 16 of 22 @ 06/20/2007 12:00:00
Event 17 of 22 @ 07/04/2007 12:00:00
Event 18 of 22 @ 07/18/2007 12:00:00
Event 19 of 22 @ 08/01/2007 12:00:00
Event 20 of 22 @ 08/15/2007 12:00:00
Event 21 of 22 @ 08/29/2007 12:00:00
Event 22 of 22 @ 09/12/2007 12:00:00

DEPLOYMENT DATA
____

Event 01

Scheduled start time: 11/22/2006 12:00:00
Event start time: 11/22/2006 12:00:00
Event stop time: 11/22/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	20.6	3 øC
Stop:	Y	20.2	3 øC

Event 02

Scheduled start time: 12/06/2006 12:00:00
Event start time: 12/06/2006 12:00:00
Event stop time: 12/06/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	20.4	3 øC
Stop:	Y	19.9	3 øC

Event 03

Scheduled start time: 12/20/2006 12:00:00
Event start time: 12/20/2006 12:00:00
Event stop time: 12/20/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	20.1	3 øC
Stop:	Y	19.7	3 øC

Event 04

Scheduled start time: 01/03/2007 12:00:00
Event start time: 01/03/2007 12:00:00
Event stop time: 01/03/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	20.0	3 øC
Stop:	Y	19.5	3 øC

Event 05

Scheduled start time: 01/17/2007 12:00:00
Event start time: 01/17/2007 12:00:00
Event stop time: 01/17/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.8	3 øC
Stop:	Y	19.4	3 øC

Event 06

Scheduled start time: 01/31/2007 12:00:00
Event start time: 01/31/2007 12:00:00
Event stop time: 01/31/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.6	3 øC
Stop:	Y	19.2	3 øC

Event 07

Scheduled start time: 02/14/2007 12:00:00
Event start time: 02/14/2007 12:00:00
Event stop time: 02/14/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.5	3 øC
Stop:	Y	19.1	3 øC

Event 08

Scheduled start time: 02/28/2007 12:00:00
Event start time: 02/28/2007 12:00:00
Event stop time: 02/28/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.4	3 øC
Stop:	Y	18.9	3 øC

Event 09

Scheduled start time: 03/14/2007 12:00:00
Event start time: 03/14/2007 12:00:00
Event stop time: 03/14/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.4	3 øC
Stop:	Y	18.8	3 øC

Event 10

Scheduled start time: 03/28/2007 12:00:00
Event start time: 03/28/2007 12:00:00
Event stop time: 03/28/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.3	3 øC
Stop:	Y	18.8	3 øC

Event 11

Scheduled start time: 04/11/2007 12:00:00
Event start time: 04/11/2007 12:00:00
Event stop time: 04/11/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.2	3 øC
Stop:	Y	18.6	3 øC

Event 12

Scheduled start time: 04/25/2007 12:00:00
Event start time: 04/25/2007 12:00:00
Event stop time: 04/25/2007 12:00:25

Aligned   Battery   Temperature
Start: Y   19.1   3 øC
Stop: Y   18.5   3 øC

Event 13

Scheduled start time: 05/09/2007 12:00:00
Event start time: 05/09/2007 12:00:00
Event stop time: 05/09/2007 12:00:25

Aligned   Battery   Temperature
Start: Y   19.0   3 øC
Stop: Y   18.5   3 øC

Event 14

Scheduled start time: 05/23/2007 12:00:00
Event start time: 05/23/2007 12:00:00
Event stop time: 05/23/2007 12:00:25

Aligned   Battery   Temperature
Start: Y   19.0   3 øC
Stop: Y   18.4   3 øC

Event 15

Scheduled start time: 06/06/2007 12:00:00
Event start time: 06/06/2007 12:00:00
Event stop time: 06/06/2007 12:00:25

Aligned   Battery   Temperature
Start: Y   18.9   3 øC
Stop: Y   18.3   4 øC

Event 16

Scheduled start time: 06/20/2007 12:00:00
Event start time: 06/20/2007 12:00:00
Event stop time: 06/20/2007 12:00:25

Aligned   Battery   Temperature
Start: Y   18.8   3 øC
Stop: Y   18.2   3 øC

Event 17

Scheduled start time: 07/04/2007 12:00:00
Event start time: 07/04/2007 12:00:00
Event stop time: 07/04/2007 12:00:25

Aligned   Battery   Temperature
Start: Y   18.7   3 øC
Stop: Y   18.2   3 øC

Event 18

Scheduled start time: 07/18/2007 12:00:00
Event start time: 07/18/2007 12:00:00
Event stop time: 07/18/2007 12:00:25

Aligned   Battery   Temperature
Start: Y   18.7   3 øC
Stop: Y   18.1   3 øC

Schedule was not completed.

System recovered early.

End of instrument data file.

Mooring STC - ML11804-02

McLane Research Laboratories, USA
ParFlux 21-Cup Sediment Trap
Version: pst-21_1.c   S/N: ML11804-02

Éííííííííííííííííííííííííííííííííí»
º   Main Menu   º
Èííííííííííííííííííííííííííííííííí¼
Wed Aug 1 21:52:56 2007

<1> Set Time   <5> Create Schedule
<2> Diagnostics   <6> Deploy System
<3> Fill Containers   <7> Offload Data
<4> Sleep   <8> Contacting McLane

Selection ? 7

Éííííííííííííííííííííííííííííííííí»
º   Offload/Display Data File   º
Èííííííííííííííííííííííííííííííííí¼
Wed Aug 1 21:53:02 2007

<1> Display data file
<2> Display backup EEPROM
<M> Main Menu

Selection ? 1

To copy the instrument data file to a disk file, initiate your communication program's file logging command now and then press any key to start the transfer. The instrument data file will remain resident and is not erased by this offload procedure.

Software version: pst-21_1.c
Compiled: Sep 26 2002 11:10:14
Electronics S/N: ML11804-02

Data recording start time = 10/14/2006 21:30:48
Data recording stop time = 08/01/2007 21:52:27

HEADER
______

Deployment 43 IB2 ML11804_02_D312_Final

SCHEDULE
____

Event 01 of 22 @ 11/22/2006 12:00:00
Event 02 of 22 @ 12/06/2006 12:00:00
Event 03 of 22 @ 12/20/2006 12:00:00
Event 04 of 22 @ 01/03/2007 12:00:00
Event 05 of 22 @ 01/17/2007 12:00:00
Event 06 of 22 @ 01/31/2007 12:00:00
Event 07 of 22 @ 02/14/2007 12:00:00
Event 08 of 22 @ 02/28/2007 12:00:00
Event 09 of 22 @ 03/14/2007 12:00:00
Event 10 of 22 @ 03/28/2007 12:00:00
Event 11 of 22 @ 04/11/2007 12:00:00
Event 12 of 22 @ 04/25/2007 12:00:00
Event 13 of 22 @ 05/09/2007 12:00:00
Event 14 of 22 @ 05/23/2007 12:00:00

Event 15 of 22 @ 06/06/2007 12:00:00
Event 16 of 22 @ 06/20/2007 12:00:00
Event 17 of 22 @ 07/04/2007 12:00:00
Event 18 of 22 @ 07/18/2007 12:00:00
Event 19 of 22 @ 08/01/2007 12:00:00
Event 20 of 22 @ 08/15/2007 12:00:00
Event 21 of 22 @ 08/29/2007 12:00:00
Event 22 of 22 @ 09/12/2007 12:00:00

DEPLOYMENT DATA
____

Event 01

Scheduled start time: 11/22/2006 12:00:00
Event start time: 11/22/2006 12:00:00
Event stop time: 11/22/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	20.1	3 øC
Stop:	Y	19.6	4 øC

Event 02

Scheduled start time: 12/06/2006 12:00:00
Event start time: 12/06/2006 12:00:00
Event stop time: 12/06/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.8	3 øC
Stop:	Y	19.4	4 øC

Event 03

Scheduled start time: 12/20/2006 12:00:00
Event start time: 12/20/2006 12:00:00
Event stop time: 12/20/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.6	3 øC
Stop:	Y	19.2	4 øC

Event 04

Scheduled start time: 01/03/2007 12:00:00
Event start time: 01/03/2007 12:00:00
Event stop time: 01/03/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.5	3 øC
Stop:	Y	18.9	4 øC

Event 05

Scheduled start time: 01/17/2007 12:00:00
Event start time: 01/17/2007 12:00:00
Event stop time: 01/17/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.3	3 øC
Stop:	Y	18.7	4 øC

Event 06

Scheduled start time: 01/31/2007 12:00:00
Event start time: 01/31/2007 12:00:00
Event stop time: 01/31/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.1	3 øC
Stop:	Y	18.6	4 øC

Event 07

Scheduled start time: 02/14/2007 12:00:00
Event start time: 02/14/2007 12:00:00
Event stop time: 02/14/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.0	3 øC
Stop:	Y	18.5	4 øC

Event 08

Scheduled start time: 02/28/2007 12:00:00
Event start time: 02/28/2007 12:00:00
Event stop time: 02/28/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.9	3 øC
Stop:	Y	18.4	4 øC

Event 09

Scheduled start time: 03/14/2007 12:00:00
Event start time: 03/14/2007 12:00:00
Event stop time: 03/14/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.9	3 øC
Stop:	Y	18.3	4 øC

Event 10

Scheduled start time: 03/28/2007 12:00:00
Event start time: 03/28/2007 12:00:00
Event stop time: 03/28/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.8	3 øC
Stop:	Y	18.2	4 øC

Event 11

Scheduled start time: 04/11/2007 12:00:00
Event start time: 04/11/2007 12:00:00
Event stop time: 04/11/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.7	3 øC
Stop:	Y	18.1	4 øC

Event 12

Scheduled start time: 04/25/2007 12:00:00
Event start time: 04/25/2007 12:00:00
Event stop time: 04/25/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.6	4 øC
Stop:	Y	18.0	4 øC

Event 13

Scheduled start time: 05/09/2007 12:00:00
Event start time: 05/09/2007 12:00:00
Event stop time: 05/09/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.5	3 øC
Stop:	Y	17.9	4 øC

Event 14

Scheduled start time: 05/23/2007 12:00:00
Event start time: 05/23/2007 12:00:00
Event stop time: 05/23/2007 12:00:25

	Aligned	Battery	Temperature

Start: Y 18.4 4 øC
Stop: Y 17.8 4 øC

Event 15

Scheduled start time: 06/06/2007 12:00:00
Event start time: 06/06/2007 12:00:00
Event stop time: 06/06/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.3	3 øC
Stop:	Y	17.7	4 øC

Event 16

Scheduled start time: 06/20/2007 12:00:00
Event start time: 06/20/2007 12:00:00
Event stop time: 06/20/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.2	3 øC
Stop:	Y	17.6	4 øC

Event 17

Scheduled start time: 07/04/2007 12:00:00
Event start time: 07/04/2007 12:00:00
Event stop time: 07/04/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.2	3 øC
Stop:	Y	17.5	4 øC

Event 18

Scheduled start time: 07/18/2007 12:00:00
Event start time: 07/18/2007 12:00:00
Event stop time: 07/18/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.1	3 øC
Stop:	Y	17.4	4 øC

Event 19

Scheduled start time: 08/01/2007 12:00:00
Event start time: 08/01/2007 12:00:00
Event stop time: 08/01/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.0	3 øC
Stop:	Y	17.4	4 øC

Schedule was not completed.

System recovered early.

End of instrument data file.

Mooring STNW - ML11804-05

McLane Research Laboratories, USA
ParFlux 21-Cup Sediment Trap
Version: pst-21_1.c S/N: ML11804-05

ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
º Main Menu º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
Mon Jul 30 15:52:48 2007

<1> Set Time <5> Create Schedule
<2> Diagnostics <6> Deploy System
<3> Fill Containers <7> Offload Data
<4> Sleep <8> Contacting McLane

Selection ? 2

Press any key to pause/continue display, <X> to exit

07/30/2007 15:52:54 18.6 Vb 16 øC aligned
07/30/2007 15:52:55 18.5 Vb 16 øC aligned
07/30/2007 15:52:56 18.5 Vb 16 øC aligned
07/30/2007 15:52:57 18.5 Vb 16 øC aligned
07/30/2007 15:52:58 18.4 Vb 16 øC aligned
07/30/2007 15:52:59 18.4 Vb 16 øC aligned
07/30/2007 15:53:00 18.4 Vb 16 øC aligned
07/30/2007 15:53:01 18.3 Vb 16 øC aligned
07/30/2007 15:53:02 18.3 Vb 16 øC aligned
07/30/2007 15:53:03 18.3 Vb 16 øC aligned
07/30/2007 15:53:04 18.3 Vb 16 øC aligned
07/30/2007 15:53:05 18.3 Vb 16 øC aligned
07/30/2007 15:53:09 18.2 Vb 16 øC aligned
07/30/2007 15:53:10 18.2 Vb 16 øC aligned
07/30/2007 15:53:11 18.2 Vb 16 øC aligned

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McLane Research Laboratories, USA
ParFlux 21-Cup Sediment Trap
Version: pst-21_1.c S/N: ML11804-05

ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
º Main Menu º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
Mon Jul 30 15:53:11 2007

<1> Set Time <5> Create Schedule
<2> Diagnostics <6> Deploy System
<3> Fill Containers <7> Offload Data
<4> Sleep <8> Contacting McLane

Selection ? 7

ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
º Offload/Display Data File º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
Mon Jul 30 15:53:18 2007

<1> Display data file
<2> Display backup EEPROM
<M> Main Menu

Selection ? 1

To copy the instrument data file to a disk file, initiate your communication program's file logging command now and
then press any key to start the transfer. The instrument data file will remain resident and is not erased by this offload procedure.

Software version: pst-21_1.c
Compiled: Sep 26 2002 11:10:14
Electronics S/N: ML11804-05

Data recording start time = 10/14/2006 21:21:35
Data recording stop time = 07/30/2007 15:51:42

HEADER

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Deployment 42 Iceland Basin NE D312
ML11804_05

SCHEDULE
____

Event 01 of 22 @ 11/22/2006 12:00:00
Event 02 of 22 @ 12/06/2006 12:00:00
Event 03 of 22 @ 12/20/2006 12:00:00
Event 04 of 22 @ 01/03/2007 12:00:00
Event 05 of 22 @ 01/17/2007 12:00:00
Event 06 of 22 @ 01/31/2007 12:00:00
Event 07 of 22 @ 02/14/2007 12:00:00
Event 08 of 22 @ 02/28/2007 12:00:00
Event 09 of 22 @ 03/14/2007 12:00:00
Event 10 of 22 @ 03/28/2007 12:00:00
Event 11 of 22 @ 04/11/2007 12:00:00
Event 12 of 22 @ 04/25/2007 12:00:00
Event 13 of 22 @ 05/09/2007 12:00:00
Event 14 of 22 @ 05/23/2007 12:00:00
Event 15 of 22 @ 06/06/2007 12:00:00
Event 16 of 22 @ 06/20/2007 12:00:00
Event 17 of 22 @ 07/04/2007 12:00:00
Event 18 of 22 @ 07/18/2007 12:00:00
Event 19 of 22 @ 08/01/2007 12:00:00
Event 20 of 22 @ 08/15/2007 12:00:00
Event 21 of 22 @ 08/29/2007 12:00:00
Event 22 of 22 @ 09/12/2007 12:00:00

DEPLOYMENT DATA
____

Event 01

Scheduled start time: 11/22/2006 12:00:00
Event start time: 11/22/2006 12:00:00
Event stop time: 11/22/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	20.3	3 øC
Stop:	Y	19.9	3 øC

Event 02

Scheduled start time: 12/06/2006 12:00:00
Event start time: 12/06/2006 12:00:00
Event stop time: 12/06/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	20.1	3 øC
Stop:	Y	19.6	3 øC

Event 03

Scheduled start time: 12/20/2006 12:00:00
Event start time: 12/20/2006 12:00:00
Event stop time: 12/20/2006 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.8	3 øC
Stop:	Y	19.4	3 øC

Event 04

Scheduled start time: 01/03/2007 12:00:00
Event start time: 01/03/2007 12:00:00
Event stop time: 01/03/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.7	3 øC
Stop:	Y	19.2	3 øC

Event 05

Scheduled start time: 01/17/2007 12:00:00
Event start time: 01/17/2007 12:00:00
Event stop time: 01/17/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.5	3 øC
Stop:	Y	19.0	3 øC

Event 06

Scheduled start time: 01/31/2007 12:00:00
Event start time: 01/31/2007 12:00:00
Event stop time: 01/31/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.4	3 øC
Stop:	Y	18.9	4 øC

Event 07

Scheduled start time: 02/14/2007 12:00:00
Event start time: 02/14/2007 12:00:00
Event stop time: 02/14/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.3	3 øC
Stop:	Y	18.7	3 øC

Event 08

Scheduled start time: 02/28/2007 12:00:00
Event start time: 02/28/2007 12:00:00
Event stop time: 02/28/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.2	3 øC
Stop:	Y	18.6	3 øC

Event 09

Scheduled start time: 03/14/2007 12:00:00
Event start time: 03/14/2007 12:00:00
Event stop time: 03/14/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.1	3 øC
Stop:	Y	18.5	3 øC

Event 10

Scheduled start time: 03/28/2007 12:00:00
Event start time: 03/28/2007 12:00:00
Event stop time: 03/28/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	19.0	3 øC
Stop:	Y	18.4	3 øC

Event 11

Scheduled start time: 04/11/2007 12:00:00
Event start time: 04/11/2007 12:00:00
Event stop time: 04/11/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.9	3 øC
Stop:	Y	18.3	3 øC

Event 12

Scheduled start time: 04/25/2007 12:00:00
Event start time: 04/25/2007 12:00:00
Event stop time: 04/25/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.8	3 øC
Stop:	Y	18.2	3 øC

Event 13

Scheduled start time: 05/09/2007 12:00:00
Event start time: 05/09/2007 12:00:00
Event stop time: 05/09/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.7	3 øC
Stop:	Y	18.1	3 øC

Event 14

Scheduled start time: 05/23/2007 12:00:00
Event start time: 05/23/2007 12:00:00
Event stop time: 05/23/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.7	3 øC
Stop:	Y	18.1	3 øC

Event 15

Scheduled start time: 06/06/2007 12:00:00
Event start time: 06/06/2007 12:00:00
Event stop time: 06/06/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.6	3 øC
Stop:	Y	18.0	3 øC

Event 16

Scheduled start time: 06/20/2007 12:00:00
Event start time: 06/20/2007 12:00:00
Event stop time: 06/20/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.5	3 øC
Stop:	Y	17.9	4 øC

Event 17

Scheduled start time: 07/04/2007 12:00:00
Event start time: 07/04/2007 12:00:00
Event stop time: 07/04/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.4	3 øC
Stop:	Y	17.8	3 øC

Event 18

Scheduled start time: 07/18/2007 12:00:00
Event start time: 07/18/2007 12:00:00
Event stop time: 07/18/2007 12:00:25

	Aligned	Battery	Temperature
Start:	Y	18.3	3 øC
Stop:	Y	17.7	4 øC

Schedule was not completed.

System recovered early.

End of instrument data file.

Instrument service and set-up details

All four Aanderaa RCM8 instruments were inspected, serviced and prepared for redeployment. Two of the recovered McLane Parflux Mk7-21 sediment traps were cleaned, inspected, serviced and prepared for redeployment along with two McLane Parflux Mk7-13 sediment traps that had been prepared for deployment at NOCS. Three of the acoustic releases were inspected, serviced and prepared for redeployment. All four acoustic releases that were deployed during D321 were subjected to a full working pressure and operation (release) test prior to mooring deployment. The RD Instruments Workhorse Long Ranger 75kHz ADCP was replaced with an identical instrument that had batteries replaced and had been compass calibrated at NOCS. The syntactic floatation buoy was reused. All 17” glass spheres used as buoyancy were removed from their protective plastic hard hats and visually inspected for damage. Of the 34 spheres recovered, one had physical damage and 4 showed signs of leakage, and were therefore exchanged with inspected replacements. All of the mooring hardware, including ropes, shackles, swivel, links, sediment trap bridles, and chains were replaced with new items for deployment. The only exception to this was the 24 mm gold-strand rope used on the ADCP floatation buoy that was inspected but was not a structural part of the mooring and was therefore left intact and spliced.

RCM 8

s/n	Battery old	Battery new	DSU no.	DSU time set	Erased	DSU check	Installed	Started
11216	7.24v 29/07/07	7.34v 29/07/07	14304	04/08/07	04/08/07	04/08/07	04/08/07	21:00 04/08/07
12302	7.32v 28/07/07	7.35v 28/07/07	14308	04/08/07	04/08/07	04/08/07	04/08/07	21:00 04/08/07
9682	7.25v 01/08/07	7.36v 01/08/07	14402	04/08/07	04/08/07	04/08/07	04/08/07	21:00 04/08/07
3259	7.25v 02/08/07	7.36v 02/08/07	14409	04/08/07	04/08/07	04/08/07	04/08/07	21:00 04/08/07

The RCM8s were set to record every hour (sampling interval no.8) with the low temperature range (no.1). All instruments were checked between 08:16 and 08:32 on 09/08/07 and all DSUs read 684 words. All Batteries – LITHIUM.

RCM8 calibrations

S/n: 3259	**S/n: 9682**
Temperature A= -1.44322E+00 B= 1.11112E-02 C= -1.90056E-07 D= 1.87308E-10	Temperature A= -1.48436E+00 B= 1.10635E-02 C= -4.39304E-07 D= 4.91637E-10

S/n: 11216	**S/n: 12302**
Temperature A= -2.90273E+00 B= 7.63721E-03 C= -7.52022E-08 D= 2.36896E-11 Conductivity A= 2.49182E+01 B= 4.92583E-03	Temperature A= -2.86450E+00 B= 7.49652E-03 C= 1.28782E-07 D= -7.69418E-11 Conductivity A= 2.58338E+01 B= 5.14251E-03

Acoustic releases

s/n	Battery old	Battery new	Wire test	Test depth	Notes
325	3x8.82v; 1x9.62v	3x9.67v; 1x9.61v	04/08/07	2750m	All OK
440	3x8.48v; 1x9.51v	3x9.67v; 1x9.63v	12/08/07	2650m	All OK
321	3x8.46v; 1x9.42v	3x9.67v; 1x9.63	29/07/07	2700m	All OK
305	Serviced	At NOC	29/07/07	2700m	All OK

All batteries - ALKALINE

Sediment traps

The recovered and redeployed McLane Parflux Mk7-21 sediment traps (serial numbers ML11804-05 and ML11804-02) had main and back-up batteries replaced with new installed voltages of 22.7v (main) and 9.6v (back-up). The McLane Parflux Mk7-13 sediment traps (serial numbers 532 and 543) had main and back-up battery voltages of 22.6v (main – soldered battery packs) and 9.6v (back-up). All batteries – ALKALINE.

For all instruments, the carousels were rotated, had the bottles attached, filled and set to deployment positions on old batteries. The fresh batteries were installed in the instruments once all mechanical alignment was completed but prior to the deployment programme being set-up.

Due to the fact that 2 sediment traps had 21 bottles and 2 had 13 bottles, the sampling regime for the 2 types of trap were set-up differently and are detailed separately in this report.

ADCP

The RD Instruments Workhorse Long Ranger 75kHz ADCP (serial no. 1767) had batteries installed and a compass calibration performed at NOCS. The instrument was programmed to start recording at 21:00 on 09/08/07. The basic parameters of the instrument are listed below. All batteries – ALKALINE.

Frequency:	76.8 kHz
Bin size:	16m
No. of bins:	35
Pings/ensemble:	25
1st bin depth:	24.49m
Time/ping:	02:24
Ensemble size:	848 bytes

<u>ADCP set-up file</u>

[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 16.12

RD Instruments (c) 1996-2000

```
All Rights reserved.
>TS070809160439
>CZ

Powering Down

>>>>>> Function starting 08/09/07 16:04:50 >>>>>>

[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 16.12
RD Instruments (c) 1996-2000
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>DEPLOY?
Deployment Commands:
RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name

WD = 111 100 000 --------- Data Out (Vel,Cor,Amp; PG,St,P0; P1,P2,P3)
WF = 0704 ---------------- Blank After Transmit (cm)
WN = 040 ----------------- Number of depth cells (1-128)
WP = 00010 --------------- Pings per Ensemble (0-16384)
WS = 1600 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

TE = 00:30:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 03:00.00 ------------ Time per Ping (min:sec.sec/100)
TS = 07/08/09,16:04:51 --- Time Set (yr/mon/day,hour:min:sec)

EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00000 -------------- Heading Bias (1/100 deg)
ED = 06000 --------------- Transducer Depth (0 - 65535 dm)
ES = 36 ------------------ Salinity (0-40 pp thousand)
EX = 11111 --------------- Coord Transform (Xform: Type,Tilts,3 Bm,Map)
EZ = 1111111 ------------- Sensor Source (C,D,H,P,R,S,T)
```

CF = 11101 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)

CK ---------------------- Keep Parameters as USER Defaults

CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)

CS ---------------------- Start Deployment

>SYSTEM?

System Control, Data Recovery and Testing Commands:

AC ---------------------- Output Active Fluxgate & Tilt Calibration data

AF ---------------------- Field calibrate to remove hard/soft iron error

AR ---------------------- Restore factory fluxgate calibration data

AX ---------------------- Examine compass performance

AZ ---------------------- Zero pressure reading

CB = 811 ----------------- Serial Port Control (Baud; Par; Stop)

CP # --------------------- Polled Mode (0 = NORMAL, 1 = POLLED)

CZ --------------------- Power Down Instrument

FC ---------------------- Clear Fault Log

FD ---------------------- Display Fault Log

OL ---------------------- Display Features List

PA ---------------------- Pre-Deployment Tests

PC1 --------------------- Beam Continuity

PC2 --------------------- Sensor Data

PS0 --------------------- System Configuration

PS3 --------------------- Transformation Matrices

RR ---------------------- Recorder Directory

RF ---------------------- Recorder Space used/free (bytes)

RY ---------------------- Upload Recorder Files to Host

>TS?

TS = 07/08/09,16:04:57 --- Time Set (yr/mon/day,hour:min:sec)

>PS0

Instrument S/N: 1767

Frequency: 76800 HZ
Configuration: 4 BEAM, JANUS
Match Layer: 10
Beam Angle: 20 DEGREES
Beam Pattern: CONVEX
Orientation: UP
Sensor(s):   HEADING   TILT 1   TILT 2   DEPTH   TEMPERATURE PRESSURE
Pressure Sens Coefficients: (c3,c2,c1,offset) 0.00,-0.00,0.60,-100.69

Temp Sens Offset: -0.34 degrees C

CPU Firmware: 16.12 [0]
Boot Code Ver: Required: 1.13   Actual: 1.13
DEMOD #1 Ver: ad48, Type: 1f
DEMOD #2 Ver: ad48, Type: 1f
PWRTIMG Ver: 85d3, Type: 6

Board Serial Number Data:
01 00 00 02 F9 5C 48 09 TUN727-1005-06X
21 00 00 02 48 9B F5 09 DSP727-2001-06F
AA 00 00 02 80 7E 4D 09 HPA727-3009-0XB
56 00 00 02 F8 ED DD 09 REC727-1004-06A
13 00 00 00 25 7F 43 09 HPI727-3007-0XC
25 00 00 02 00 39 EB 09 CPU727-2000-00H
>PA

PRE-DEPLOYMENT TESTS

CPU TESTS:
RTC......................................PASS
RAM......................................PASS
ROM......................................PASS
RECORDER TESTS:
PC Card #0...............................DETECTED
Card Detect............................PASS

Communication..........................PASS
DOS Structure..........................PASS
Sector Test (short)....................PASS
PC Card #1...............................NOT DETECTED
DSP TESTS:
Timing RAM...............................PASS
Demod RAM...............................PASS
Demod REG...............................PASS
FIFOs...................................PASS
SYSTEM TESTS:
XILINX Interrupts... IRQ3 IRQ3 IRQ3 ...PASS
Receive Loop-Back........................PASS
Wide Bandwidth........................***FAIL***
Narrow Bandwidth......................***FAIL***
RSSI Filter..............................PASS
Transmit..............................***FAIL***
SENSOR TESTS:
H/W Operation.........................***FAIL***
>PC2

Press any key to quit sensor display ...

Heading	Pitch	Roll	Up/Down	Attitude Temp	Ambient Temp	PRESSURE
225.53ø	17.42ø	17.84ø	Up	17.69øC	18.28øC	9.0 kPa

>RS
RS = 017,411 ------------- REC SPACE USED (MB), FREE (MB)

>PC1

BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected beam's face. If a beam does not PASS the test, send any character to the ADCP to automatically select the next beam.

Collecting Statistical Data...
24 27 28 31

Rub Beam 1 = PASS

Rub Beam 2 = PASS

Rub Beam 3 = PASS

Rub Beam 4 = PASS

>CZ

Powering Down

>>>>>> Function starting 08/09/07 16:07:36 >>>>>>

[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 16.12

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>AZ

Pressure Offset Updated in NVRAM.

>CZ

Powering Down

>>>>>> Function starting 08/09/07 16:07:48 >>>>>>

[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 16.12

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>RE ErAsE erasing...

Recorder erased.

>CZ

Powering Down

>>>>>> Function starting 08/09/07 16:08:26 >>>>>>

```
[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 16.12
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>RR
Recorder Directory:
Volume serial number for device #0 is 0b50-13f1

  No files found.

  Bytes used on device #0 = 0
Total capacity   =  448249856 bytes
Total bytes used =         0 bytes in 0 files
Total bytes free =  448249856 bytes

>
[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 16.12
RD Instruments (c) 1996-2000
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>CR1
[Parameters set to FACTORY defaults]
>CQ255
>CF11101
>EA0
>EB0
>ED0
>ES35
>EX11111
>EZ1111111
>WA50
>WB1
>WD111100000
>WF704
```

>WN37

>WP25

>WS1600

>WV175

>TE01:00:00.00

>TP02:24.00

>TF07/08/09 21:00:00

>CK

[Parameters saved as USER defaults]

>The command CS is not allowed in this command file. It has been ignored.

>The following commands are generated by this program:

>CF?

CF = 11101 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)

>CF11101

>RN D_321

>cs

Mooring deployments

STNW

Date	=	9th August 2007 (221)
Deployment start/release	=	19:26/20:13
Discovery #	=	16246
Position	=	59°59.89'N
		20°51.52'W
Water depth	=	
Mooring length	=	461m
Depth to top of mooring	=	

Yellow pellet (17" Benthos)

15m x 24mm 3 strand polypropylene rope

Buoyancy package on 6m ½" galvanized chain (3x 17" Benthos (upper - yellow); 3x 17" Nautilus (lower - orange))

25m x 12mm double braid polyester rope

3x 1m wire coated bridles

Sediment trap: McLane Parflux Mk7-21 (serial no. ML11804-05)

3x 1m 3/8” galvanized chain bridles

15m x 12mm double braid polyester rope

Current meter: RCM8 (serial no. 11216)

100m x 10mm double braid polyester rope

95m x 10mm double braid polyester rope

Acoustic release: Ixsea AR861 B2S (serial no. 325)

95m x 10mm double braid polyester rope

95m x 10mm double braid polyester rope

10m ½” galvanized chain

Anchor: 600kg

Deployed 20:13

20:18 – 918m	20:27 – 2254m
20:20 – 1131m	20:29 – 2577m
20:21 – 1296m	20:30 – 2602m
20:22 – 1455m	20:31 – 2603m
20:23 – 1616m	20:32 – 2604m
20:25 – 1946m	

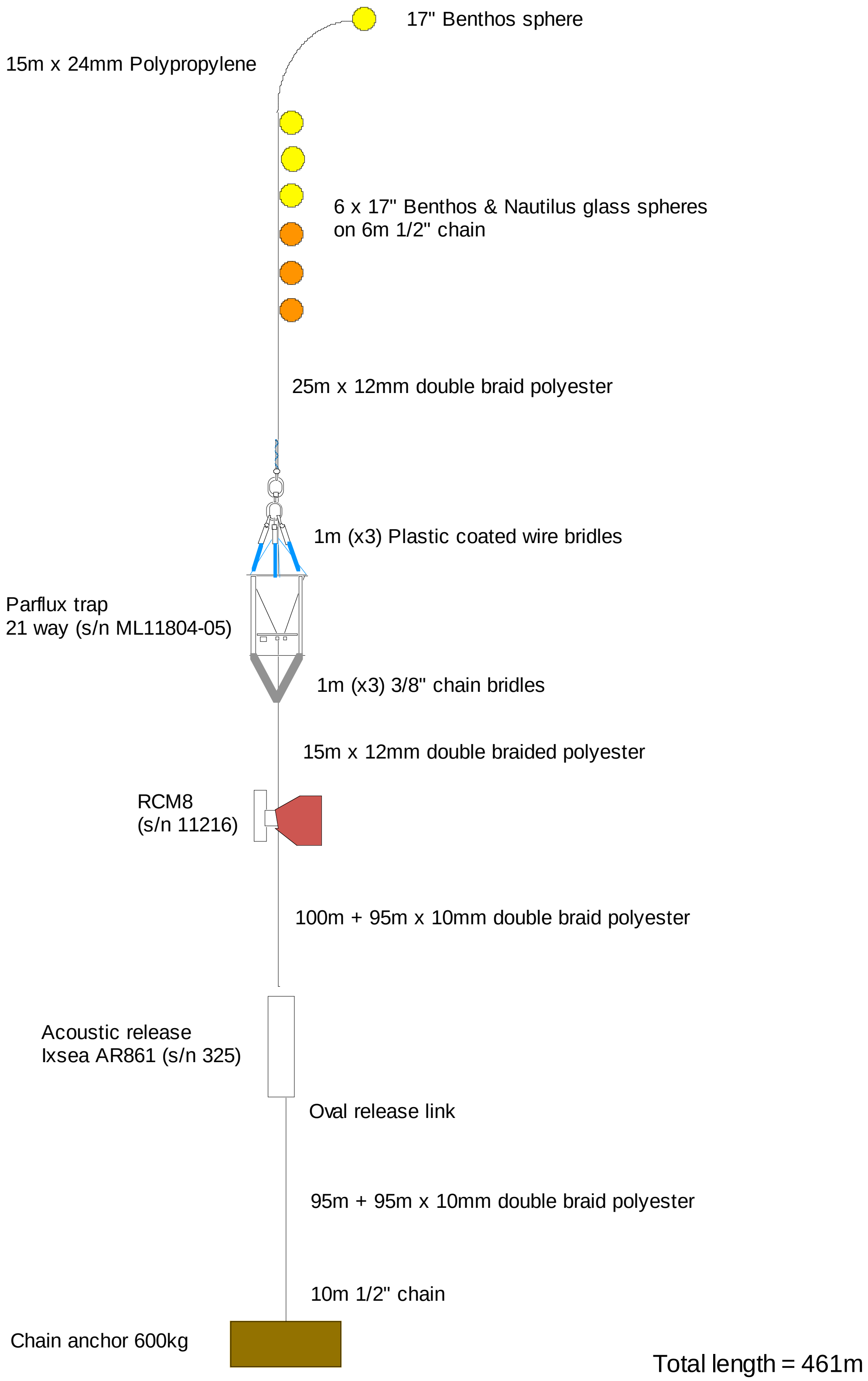
AR861 B2S s/n **325**.

CAF = 12kHz

ARM/RANGING	14D5
RELEASE	ARM + 1455
RELEASE WITH PING	ARM + 1456
PING ON	ARM + 1447
PING OFF	ARM + 1448
DIAGNOSTIC	ARM + 1449

RECEIVER MODE B=12KHZ A=8KHZ (OLD)

Mooring STNW



STNE

Date	=	10th August 2007 (222)
Deployment start/release	=	20:30/21:05
Discovery #	=	16250
Position	=	59°39.62'N
		18°50.36'W
Water depth	=	
Mooring length	=	461m
Depth to top of mooring	=	

Yellow pellet (17" Benthos)

15m x 24mm 3 strand polypropylene rope

Buoyancy package on 6m ½" galvanized chain (6x 17" Benthos)

25m x 12mm double braid polyester rope

3x 1m wire coated bridles

Sediment trap: McLane Parflux Mk7-21 (serial no. ML11804-02)

3x 1m 3/8" galvanized chain bridles

15m x 12mm double braid polyester rope

Current meter: RCM8 (serial no. 12302)

100m x 10mm double braid polyester rope

95m x 10mm double braid polyester rope

Acoustic release: Ixsea RT661 B2S (serial no. 321)

95m x 10mm double braid polyester rope

95m x 10mm double braid polyester rope

10m ½" galvanized chain

Anchor: 600kg

Deployed 21:04

21:19:30 – 2256m

21:20 – 2402m

2124 – 2528m

2125 – 2521m

2126 – 2524m

2127 – 2529m

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MORS SYSTEMS
Operational Sheet

CRUISE **D321** DATE **August 2007**

TYPE **RT 661 B2S**
FUNCTION **RELEASE TRANSPONDER RT661 - B**
SERIAL No. **321**
Delivery **FEB 96**

Int Frequency **Reply Frequen cy**
FR1 = 9.0khz **FT1 = 13.0khz**
FR2 = 13.0khz **FT2 = 09.0khz**
FR3 =10.5khz
FR4 =14.5khz **FT4 = 10.0khz**
FT0,FT5,FT6,FT7,FT8,FT9,FT10,FT11,FT15 = 08.0khz

Function / Code	**TT301**	**Reply**	**Specifications**
WINDOW	C446	FT0	Wait time sec Active sec
ON FR1-FR2	C447	FT0	
OFF FR1-FR2-PINGER	C448	FT0	
RELEASE 1 (W)	C485	FT0-FT5	
RELEASE 2 (W)	C486	FT0-FT6	
DIAGNOSTIC(W)	C487	FT0-FT7	Measure delay sec Vert offset sec
PYROTECHNIC(W)	C491	FT0-FT11	Wait time s Pulse s
PINGER (W)	C470	FT0-FT4	Pulse width Ms Recur sec

Power Config uration 3 banks of 6 ALKALINE D
1 bank of 1 Alkaline PP3
Power partition Standby - power motor

Diagnostic Measure t(FT7) - t(FT0) - 3s (13 s in horizontal position)
Cells voltage (V) Diagnostic measure x 4.1
Batteries fitted :29/07/07
Wire test :2700m 29/07/07
Functions check :Diagnostics and Release
Deployed Mooring : STNE Discovery # 16 250 Date: 10/08/07

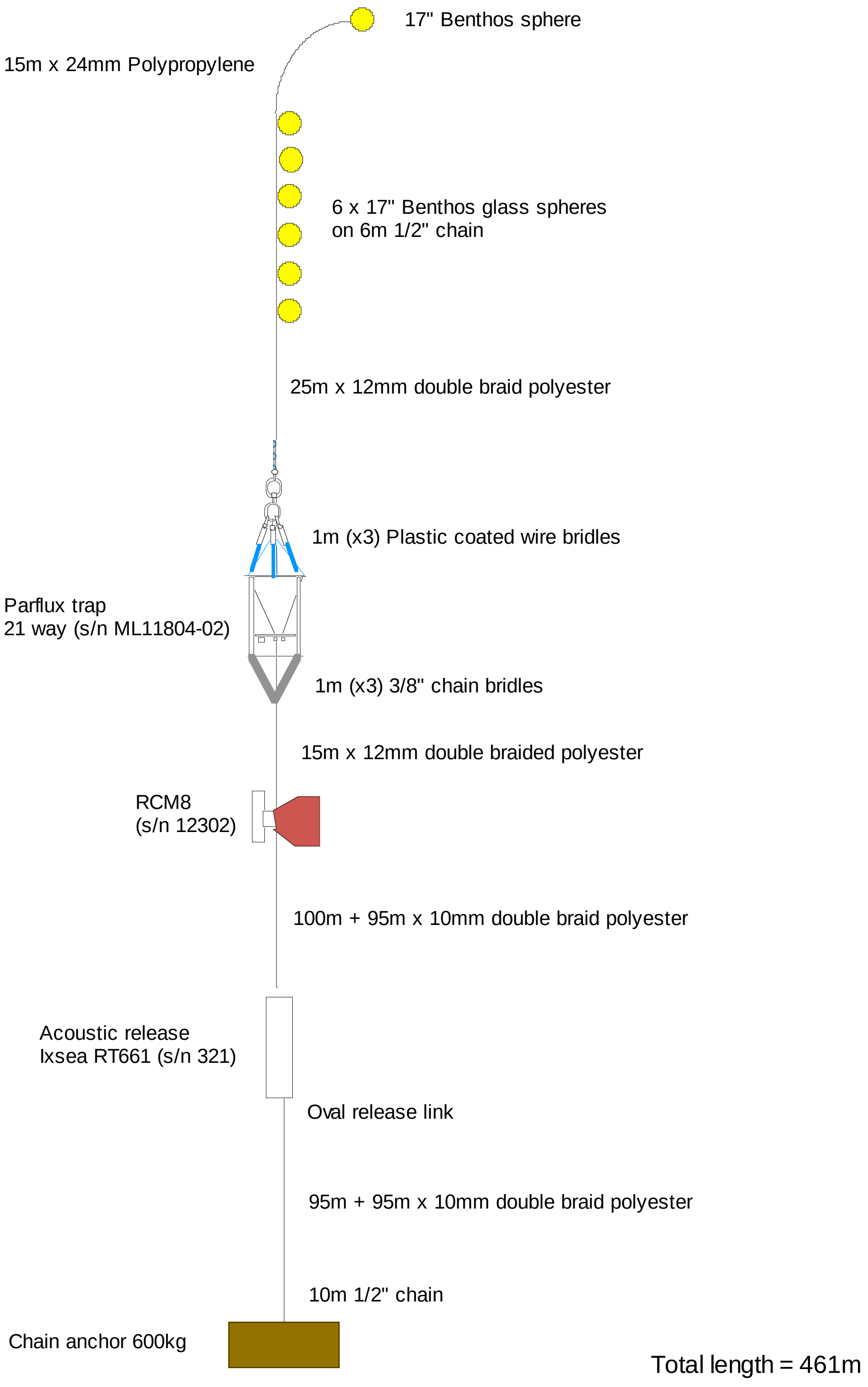
Recovery limit : Date :

Recovered : Date :

COMMENTS ON CONDITION

ACTIONS REQUIRED AT LABORATORY

Mooring STNE



STC

Date	=	14th August 2007 (226)
Deployment start/release	=	14:45/16:25
Discovery #	=	16276
Position	=	59°30.32'N
		20°00.78'W
Water depth	=	
Mooring length	=	2234m
Depth to top of mooring	=	

Yellow pellet (17" Benthos)

10m x 24mm 3 strand polypropylene goldstrand rope

Floatation Technologies 45" syntactic sphere

RD Instruments Workhorse Long Ranger 75kHz ADCP (serial no. 1767)

Novatech Seimac RF-700A1 VHF beacon (serial no. U11-016; CH72; Freq. 156.625MHz; cycle 2 on, 4 off)

Novatech Seimac ST400A xenon beacon (serial no. S01-188; double burst flash, auto daylight off)

5m x 5/8" galvanized chain

Titanium swivel (SWL 2T)

50m x 10mm double braid polyester rope

200m x 10mm double braid polyester rope

250m x 10mm double braid polyester rope

250m x 10mm double braid polyester rope

Buoyancy package on 6m ½" galvanized chain (6x 17" Benthos)

500m x 10mm double braid polyester rope

500m x 10mm double braid polyester rope

Buoyancy package on 6m ½" galvanized chain (6x 17" Benthos)

25m x 12mm double braid polyester rope

3x 1m wire coated bridles

Sediment trap: McLane Parflux Mk7-13 (serial no. 543)

3x 1m 3/8" galvanized chain bridles

15m x 12mm double braid polyester rope

Current meter: RCM8 (serial no. 9682)

200m x 10mm double braid polyester rope

Acoustic release: Ixsea RT661 (serial no. 440)

200m x 10mm double braid polyester rope

10m ½” galvanized chain

Anchor: 700kg

Deployed 16:25

16:33 – 1076m	16:43 – 2188m
16:34 – 1213m	16:45 – 2369m
16:35 – 1321m	16:47 – 2526m
16:37 – 1558m	16:48 – 2527m
16:39 – 1794m	16:49 – 2527m
16:41 – 2001m	16:50 – 2527m

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MORS SYSTEMS
Operational Sheet

CRUISE **D321** DATE **August 2007**

TYPE **RT 661 B2S -DDL**
FUNCTION **RELEASE TRANSPONDER RT661 - B**
SERIAL No. **440**
Delivery **FEB 2001**

Int Frequency	**Reply Fr equency**
FR1 = 9.0khz	**FT1 = 10.0khz**
FR2 = 10.0khz	**FT2 = 9.0khz**
FR3 =14.5khz	
FR4 = 15.5khz	**FT4 =10.0khz**

FT0,FT5,FT6,FT7,FT8,FT9,FT10,FT11,FT15 = 12.0khz

Function / Code	**TT301**	**Reply**	**Specifications**
WINDOW	EC77	FT0	Wait time sec Active sec
ON FR1-FR2	EC78	FT0	
OFF FR1-FR2-PINGER	EC79	FT0	
RELEASE 1 (W)	EC85	FT0-FT5	
RELEASE 2 (W)	EC86	FT0-FT6	
DIAGNOSTIC(W)	EC87	FT0-FT7	Measure delay sec Vert offset sec
PYROTECHNIC(W)	EC91	FT0-FT11	Wait time s Pu lse s
PINGER (W)	EC94	FT0-FT4	Pulse width Ms Recur sec

Power Configuration 3 banks of 6 ALKALINE D
1 bank of 1 Alkaline PP3
Power partition Standby - power motor

Diagnostic Measure t(FT7) - t(FT0) - 3s (13 s in horizontal position)
Cells voltage (V) Diagnostic measure x 4.1
Batteries fitted : 12/08/07

Wire test :2650 m 12/08/07
Functions check : Diagnostics and Release
Deployed Mooring : STC Discovery # 16 276 Date : 14/08/07

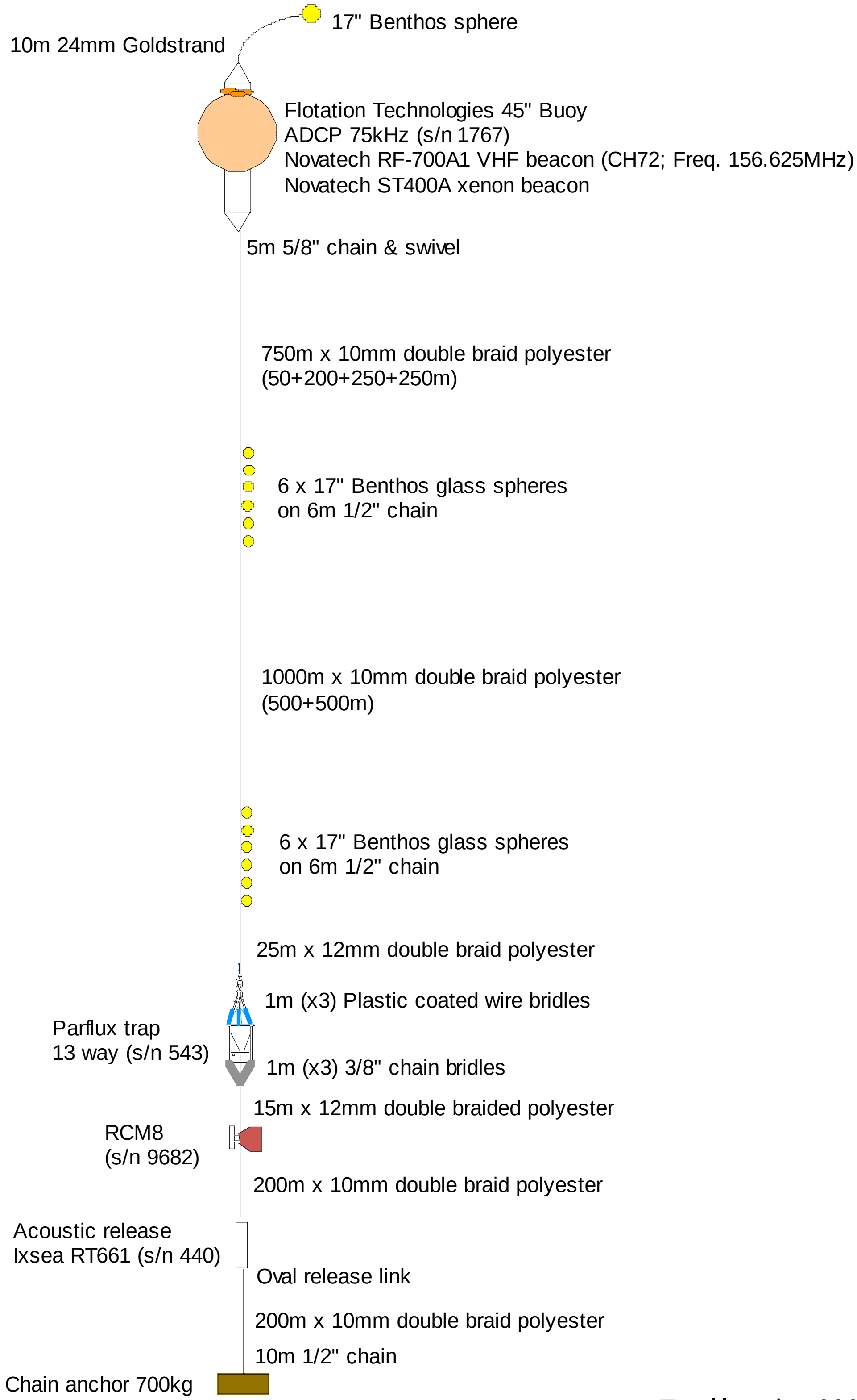
Recovery limit : Date :

Recovered : Date :

COMMENTS ON CONDITI ON

ACTIONS REQUIRED AT LABORATORY

Mooring STC



Total length = 2234m

STS

Date	=	15th August 2007 (227)
Deployment start/release	=	18:50/19:25
Discovery #	=	16279
Position	=	58°52.14'N
		20°22.05'W
Water depth	=	
Mooring length	=	466m
Depth to top of mooring	=	

Yellow pellet (17" Benthos)

15m x 24mm 3 strand polypropylene rope

Buoyancy package on 6m ½" galvanized chain (6x 17" Benthos)

25m x 12mm double braid polyester rope

3x 1m wire coated bridles

Sediment trap: McLane Parflux Mk7-13 (serial no. 532)

3x 1m 3/8" galvanized chain bridles

15m x 12mm double braid polyester rope

Current meter: RCM8 (serial no. 3259)

100m x 10mm double braid polyester rope

100m x 10mm double braid polyester rope

Acoustic release: Ixsea AR861 B2S (serial no. 245)

95m x 10mm double braid polyester rope

95m x 10mm double braid polyester rope

10m ½" galvanized chain

Anchor: 600kg

19:25 – deployed

19:32 – 1232m	19:40 – 2533m
19:33 – 1359m	19:41 – 2671m
19:34 – 1529m	19:42 – 2674m
19:35 – 1700m	19:43 – 2674m
19:36 – 1863m	19:44 – 2674m
19:38 – 2193m	

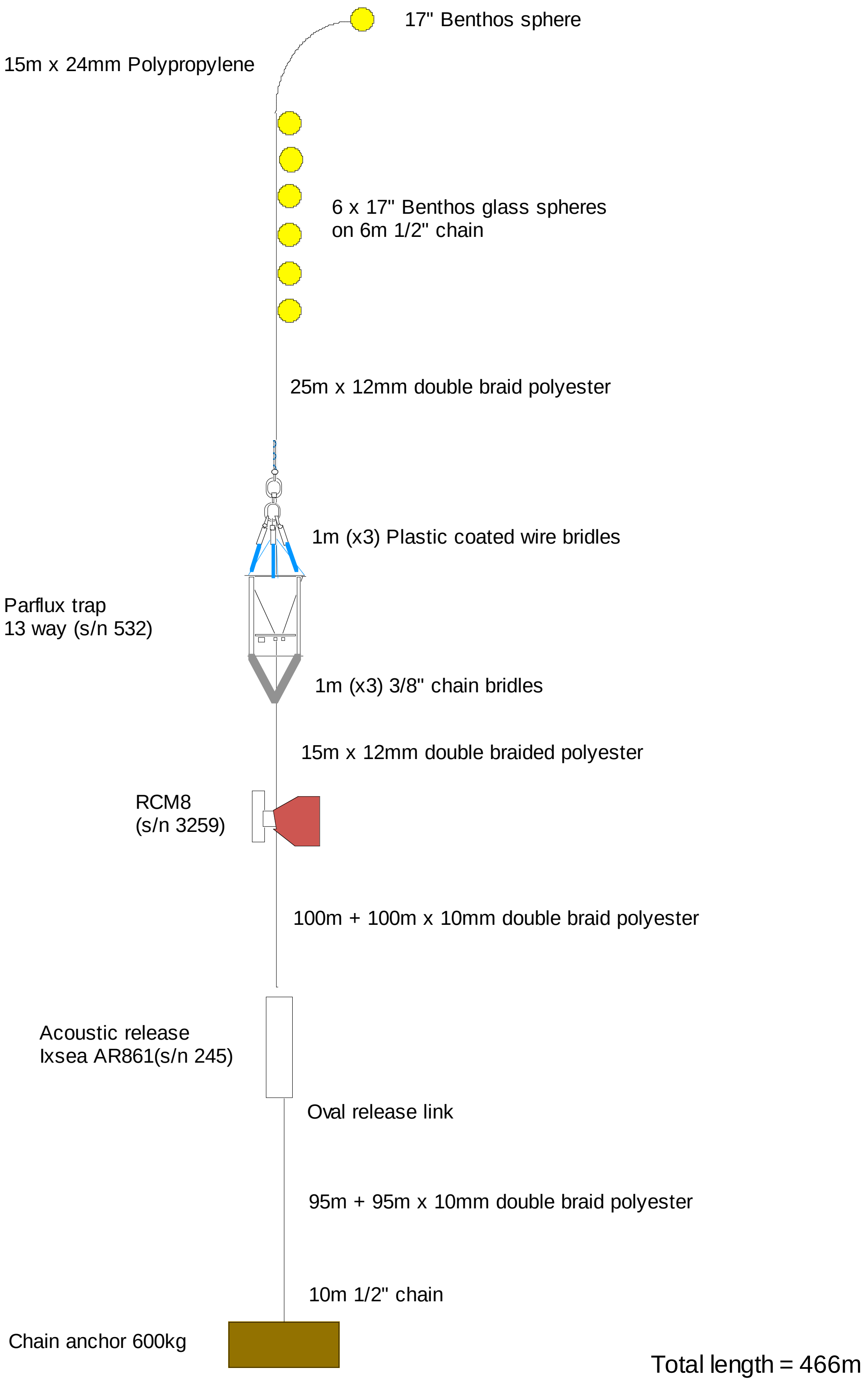
AR861 B2S s/n **245**.

CAF	=	12kHz
PINGER	=	12kHz

ARM/RANGING	14A2
RELEASE	ARM + 1455
RELEASE WITH PING	ARM + 1456
PING ON	ARM + 1447
PING OFF	ARM + 1448
DIAGNOSTIC	ARM + 1449

RECEIVER MODE B=12KHZ

Mooring STS


17" Benthos sphere
15m x 24mm Polypropylene
6 x 17" Benthos glass spheres
on 6m 1/2" chain
25m x 12mm double braid polyester
1m (x3) Plastic coated wire bridles
Parflux trap
13 way (s/n 532)
1m (x3) 3/8" chain bridles
15m x 12mm double braided polyester
RCM8
(s/n 3259)
100m + 100m x 10mm double braid polyester
Acoustic release
Ixsea AR861(s/n 245)
Oval release link
95m + 95m x 10mm double braid polyester
10m 1/2" chain
Chain anchor 600kg
Total length = 466m

4. SCIENTIFIC INVESTIGATIONS

Navigation, Ship's Attitude and Position – *Stuart Painter and Steven Alderson*

Meaningful water velocities from the vessel-mounted acoustic Doppler current profiler (VM-ADCP) can only be obtained when the ADCP data are corrected for the ship's direction, speed and attitude; in effect removing the ship's motion from the ADCP's initial estimate of water column movement. Several processing steps are performed which combine the required navigational information prior to ADCP data processing. Position, gyro-heading and ship's attitude information were transferred from the National Marine Facilities (NMF) Tech-SAS and Level C data streams to PSTAR files daily and processed as described below.

Ship's position and navigation data

The ship's best determined position was calculated by the NMF process 'bestnav'. The main data source was the ships GPS Trimble 4000 system, which provides the most accurate position, determined on previous cruises to be ~1.0 m. Data were transferred daily from the NMF 'bestnav' file to the PSTAR absolute navigation file 'abnv3211' for use in PSTAR processing. GPS_4000 data ('gps_4000' data stream) were also transferred and processed daily.

The ship's gyro instrument is the most reliable direction indicator on the ship and provides essential information for correcting the ADCP velocities to earth co-ordinates. The gyro data stream 'gyronmea' is processed as described below and a correction subsequently applied to individual ADCP profiles which is more accurate than correcting averaged ensembles. However, the gyro suffers from drift when the ship manoeuvres and therefore needs correcting with the ships attitude. Gyro data were transferred daily using the script gyroexec0.

The PSTAR execs used for processing navigation datastreams were:

navexec0: transferred the NMF 'bestnav' data stream to PSTAR format. Ship's velocities were calculated from position and distance run calculated after appending to the master abnv3211 file.

gps4exec0: transferred the NMF Tech-SAS ‘gps_4000’ data stream to PSTAR format. Data with pdop (position dilution of position) outside the range 0-7 were removed. Further edits were made to remove outliers and gaps interpolated before the file was appended to the master file gp432101 and distance run calculated. A 30 second average file gp432101.30sec was also created.

gyroexec0: transferred data from the NMF level C ‘gyronmea’ stream to PSTAR format. Headings outside the range 0-360° were deleted and the file appended to the master gyr32101 file.

Ships heading and attitude

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

ashexec0: transferred data from the NMF Tech-SAS ‘gps_ash’ data stream to PSTAR binary file ash321nn, where nn was a daily processing stamp.

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

ashexec2: edited the data outside the following ranges:

heading 0 - 360
pitch -5 - 5
roll -7 - 7
attitude flag -0.5 - 0.5
measurement RMS error 0.00001 - 0.01
baseline RMS error 0.00001, 0.1
ashtech – gyro heading -7, 7

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

mrms, 0 - 0.004

a-ghdg, -10 - 10

Results were merged with the gyro file and ships velocities calculated

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

time gap : 07 208 06:02:59 to 07 208 06:04:00 (61 s)

time gap : 07 209 09:18:41 to 07 209 09:19:48 (67 s)

time gap : 07 209 22:01:12 to 07 209 22:02:13 (61 s)

time gap : 07 211 00:56:41 to 07 211 00:58:13 (92 s)

time gap : 07 211 00:58:23 to 07 211 00:59:55 (92 s)

time gap : 07 212 05:03:14 to 07 212 05:04:15 (61 s)

time gap : 07 212 08:30:19 to 07 212 08:31:41 (62 s)

time gap : 07 212 08:55:03 to 07 212 08:56:34 (91 s)

time gap : 07 214 20:29:42 to 07 214 20:32:23 (161 s)

time gap : 07 215 07:57:50 to 07 215 07:59:02 (72 s)

time gap : 07 215 08:23:59 to 07 215 10:15:51 (1.86 h)

time gap : 07 215 18:04:12 to 07 215 18:05:15 (63 s)

time gap : 07 216 21:22:11 to 07 216 21:23:14 (63 s)

time gap : 07 217 01:02:08 to 07 217 01:03:12 (64 s)

time gap : 07 217 17:48:49 to 07 217 17:50:19 (100 s)

time gap : 07 217 20:32:46 to 07 217 20:33:48 (62 s)

time gap : 07 217 20:52:43 to 07 218 00:00:13 (3.29 h)

time gap : 07 219 13:43:35 to 07 219 13:44:39 (64 h)

time gap : 07 221 20:51:39 to 07 221 20:52:42 (63 s)

time gap : 07 222 16:10:27 to 07 222 16:11:31 (64 s)

time gap : 07 223 07:43:35 to 07 223 07:44:40 (65 s)

time gap : 07 223 08:07:29 to 07 223 08:08:31 (62 s)

time gap : 07 224 07:57:10 to 07 224 09:22:48 (1.4 h)

time gap : 07 225 20:13:04 to 07 225 20:14:15 (71 s)

time gap : 07 225 23:12:03 to 07 225 23:13:08 (65 s)

time gap : 07 227 04:48:56 to 07 227 04:49:58 (62 s)

time gap : 07 231 20:09:01 to 07 231 20:10:16 (75 s)

150 kHz Vessel Mounted Acoustic Doppler Current Profiler (VM-ADCP) –

Stuart Painter, Steven Alderson and Rosalind Pidcock

<u>*Summary*</u>

Prior to this cruise operational problems with the 150 kHz VM-ADCP had been reported. A technical investigation revealed that one of the four transducer heads was no longer functioning resulting in considerable data drop out during use, not only on the dead head but also on the remaining three transducers. In an effort to rectify this problem a spare transducer head from the decommissioned RRS *Charles Darwin* was recently fitted to RRS *Discovery* by diver whilst RRS *Discovery* was in port on the Clyde. This appeared to correct the problem of the dead transducer head as the VM-ADCP began to operate normally again when powered up. However, the replacement of the ADCP appears to have altered the misalignment angle of the ADCP relative to the ship. During cruise D306 the misalignment angle was reported as ~45°, during this cruise we obtained a misalignment angle of 14.4°. Sadly, despite a promising start the operation of this instrument during the cruise was fraught with problems. After an initially successful calibration of the ADCP over the continental shelf on route to the survey site, which allowed calculation of the misalignment angle, the instrument began to report Beam 3 errors on JDay 209 and by JDay 210 had ceased working, barely 5 days into a 31 Day cruise. Attempted remedies included restarting the instrument, bleeding the valve above the ADCP transducer head and changing from 4 to 3 beam solutions. Further investigation by Steven Alderson and Chris Barnard indicated that by changing the .config file to a previous cruise setup the instrument began to work again although data was only obtained to depths of 250m. Reverting to the .config file for Cruise D321 the instrument continued to work and was left running with a 3 beam bottom track solution in operation. This restart happened on JDay 212 and despite some concerns over the quality of the data and several beam error messages the instrument continued to work until cruise end.

It is our understanding that this instrument is due for replacement during *Discovery's* next dry dock refit, planned for February 2008. This needs to be followed up with some urgency.

Vessel mounted 150 kHz acoustic doppler current profiler data processing

The 150 kHz vessel mounted acoustic doppler profiler (VM-ADCP) was operated and logged throughout the cruise albeit with some concern over the quality of the data given the operational problems noted above. The transducer unit is installed in the hull 1.75 m to port of the keel, 33 m aft of the bow at the waterline and at an approximate depth of 5 m. Data were logged using IBM Data Acquisition Software (DAS) version 2.48 with profiler software 17.10. The instrument was configured to sample over 120 second intervals with 96 bins of 4 m depth, using pulse length 4 m and blank beyond transmit of 4 m. Two configuration files were set up, one for water tracking only, the other for bottom tracking in shallow water.

On setting sail from Glasgow (JDay 205) time was initially spent showing the new ADCP initiate how to operate and work with the instrument providing time to experiment with settings and analyse results. Thus the ADCP logged in bottom track mode from JDay 206/11:52 until 207/08:40. This is period during which the calibration was made. A small mistake in using 120 bins in the .config file was later identified during the processing of the data. At the shelf edge on day 207/09:00 the instrument was switched to water tracking mode with the correct number of depth bins (96).

Raw data were recorded on an AP PC and like all PC’s the clock lost time steadily throughout the cruise at approximately 50 seconds per day (a very poor internal clock indeed). This was corrected during the data processing.

Spot gyro heading data are fed into the 150 kHz ADCP transducer deck unit where they are incorporated into the individual ping profiles to correct the velocities to earth co-ordinates before being reduced to 2 minute ensembles. The averaged ADCP data are logged continually by a NMF level C computer. From there data were transferred usually once a day to the PSTAR processing system. Standard processing was used, thus; the clock error was corrected, the gyro heading was corrected using the Ashtech heading information, the velocities were calibrated for instrument misalignment angle and scaling and finally corrected for ships velocity and converted to absolute velocities using the ships position from the absolute navigation files. The following scripts were used:

adpexec0: transferred data from the NMF level C "adcp" data stream to PSTAR. The data were split into two files; "gridded" depth dependant data were placed into "adp" files while "non-gridded" depth independent data were placed into "bot" files. Velocities were scaled to cm/s and amplitude by 0.42 to db. Nominal edits were made on all the velocity data to remove both bad data and to change the DAS defined absent data value to the PSTAR value. The depth of each bin was determined from the user supplied information.

adpexec1: created a file of time corrections that was merged, linearly interpolated and added to time in (both) the adcp files. This corrected the clock drift problems caused by the PC logging of the ADCP data.

adpexec2: merged the adcp data (both files) with the ashtech-gyro correction (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.

adpexec3: applied the misalignment angle, ø, and scaling factor, A, to both adcp files. The adcp data were edited to delete all velocities where the percent good variable was 25% or less. Again, variables were renamed and re-ordered to preserve the original raw data.

adpexec4: merged the adcp data (both files) with the absolute navigation file created by *navexec0*. Ship's velocity was calculated from the 2 minute positions and applied to the adcp velocities. The end product was the absolute velocity of the water.

Calibration for misalignment angle and scaling factor

The run out from Glasgow to the shelf edge provided ideal conditions for calibration of the instrument using bottom track data. The values of ϕ (misalignment angle) = 14.4° and A (scaling factor) = 0.9683 were derived. The result of this is surprising as the misalignment angle is considerably different to previous cruises and may relate to the diver replacement of the dead transducer head.

75 kHz "Ocean Surveyor" VM-ADCP – *Stuart Painter and Steven Alderson*

The vessel mounted RDI Ocean Surveyor 75 kHz ADCP was configured to sample over 60 bins of 16m depth at 300 second intervals. The PC was running RDI software VmDAS v1.43.19. Gyro heading and GPS Ashtech, location and time are automatically fed into the software which was configured to use the Gyro heading. The software logs the PC clock time, stamps the data (start of each ensemble) with that time, and records the offset of the PC time from GPS time. This offset is automatically applied to the ADCP data in the processing path before merging with the navigation data. For the majority of the cruise the instrument was operated in water tracking mode with the exception of cruise start and cruise end when the bottom was shallow enough (<1000m) to provide calibration of the instrument.

Calibration of the instrument during bottom track mode was established during the run out from Glasgow over the continental shelf. Values of ϕ **–** (misalignment angle) = -59.4636° and A (scaling factor) = 1.0019 were obtained. The magnitude of the misalignment angle reported here differs from previous cruises and results from the offset angle being set to 0° in the software (previous cruises sometimes set the offset angle to 60° in the software and thus obtain a far smaller value for ϕ).

Unlike previous cruises which used a 2 minute average we opted for a 5 minute average and data were written to the PC hard disk with a .STA extension. Sequentially numbered files were created whenever data logging was stopped and restarted and although the software was set to close files when they reached 100 Mb in size, data logging was stopped once every 24hrs to allow transfer of the data to the Unix directory /data32/d321/os75. Previously this has been by ftp transfer but this has now been simplified via the inclusion of a direct network link from the ADCP PC to the Unix directory. Once transferred processing of the data could be performed as outlined below.

surexec0: data read into PSTAR format from RDI binary file. Water track velocities written into 'sur…' files, bottom track velocities into 'bot…' files. Velocities scaled to cm s^{-1} and amplitude by 0.45 to dB. The time variable was corrected to GPS time by combining the PC clock time and the PC-GPS offset. The depth of each bin was determined from the user supplied information. Output files sur321##.raw and bot321##.raw.

surexec1: data edited according to status flags. Velocity replaced with absent data if variable 2+bmbad was greater than 25% (this being a measure of the number of times more than 1 beam was bad).

surexec2: Merges the adcp data with the ashtech a-ghdg created by *ashexec2*. The adcp velocities are converted to speed and direction so that the heading correction could be applied and then returned to east and north components. Output files sur321##.true and sbt321##.true.

surexec3: Applies the misalignment angle (ϕ) and scaling factor (A) to both files (if both are present). Variables are renamed and reordered to preserve original data files. Output files sur321##.cal and sbt321##.cal.

surexec4: merges the adcp data with the GPS4000 navigation file (gp432101) created by *gps4exec0*. Ship's velocity was calculated from spot positions taken from the gps432101 file and applied to the adcp velocities. The end product is the absolute velocity of the water (**Figure 8**). The time base of the adcp profiles was then shifted to the centre of the 5 minute ensemble by subtracting 150 seconds and new positions were taken from gp432101. Output files sur321##.abs and sbt321##.abs.

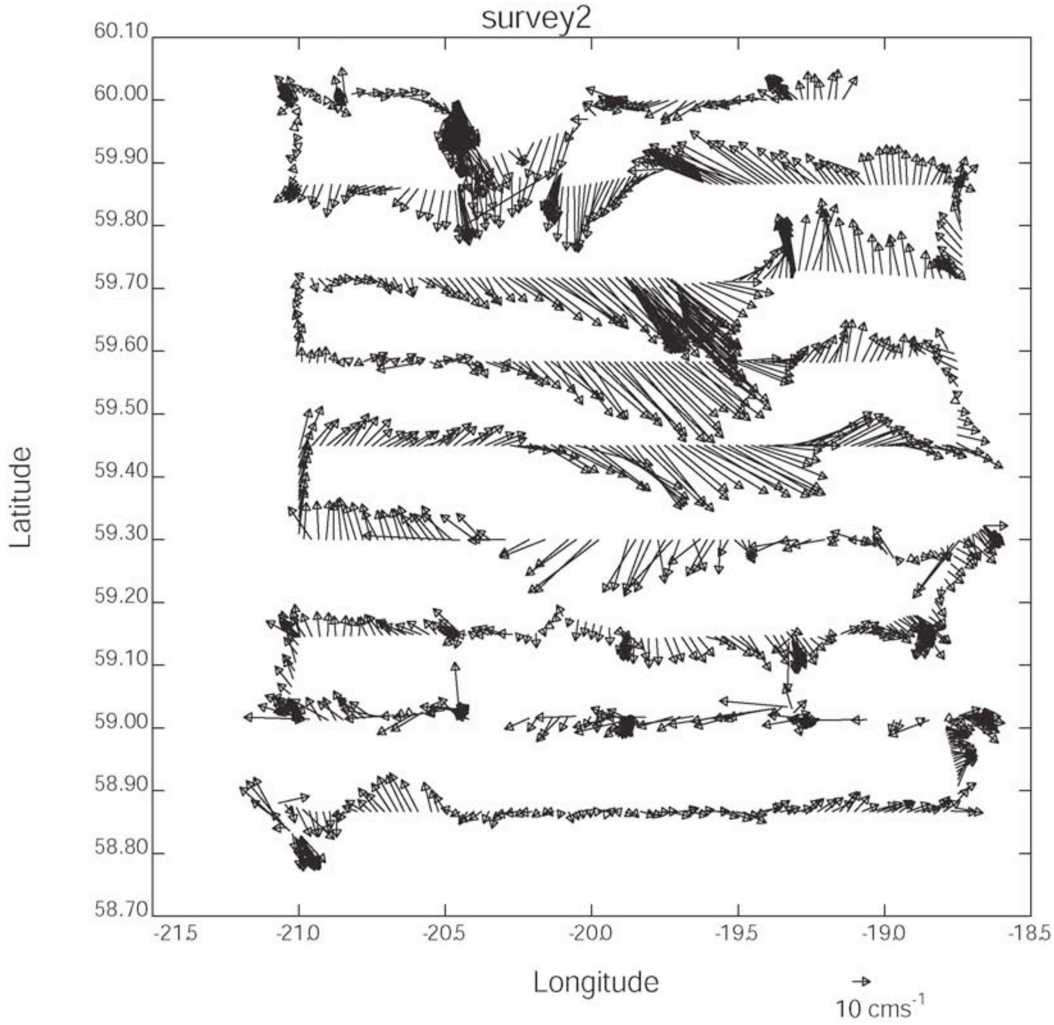


Figure 8: Water currents at 30m depth as seen by the *Ocean Surveyor* 75 kHz VM-ADCP. This dataset from the second spatial survey clearly reveals an eddy dipole consisting of a cyclonic eddy at 59.80° N, 19.75° W and an anticyclonic eddy at 59.40° N, 20.25° W with a region of high current shear between them.

Lowered CTD Sampling, Processing and Calibration – *Adrian Martin*

Introduction

In total 84 CTD profiles were completed on cruise D321 (excluding several dips to 10m to collect water for experiments). Of these, 6 were completed as part of the extended Ellett Line, 22 as part of CTD survey 1 (C1), 19 as part of SeaSoar survey (S1), 31 as part of CTD survey 2 (C2) and 7 as part of SeaSoar survey 2 (S2). Depths of the profiles varied from 10m ('experimental' CTDs whose CTD data was not processed) to full depth - close to 2800m. The first CTD and SeaSoar surveys went to a depth of 800m. The second CTD and SeaSoar surveys went to a depth of 1000m to better resolve deeper structure (motivated by the ‘lens’ anti-cyclonic eddy found to be in the survey area) though this was achieved most comprehensively with a number of full depth CTDs as part of S2.

Sampling

Samples were taken from all CTDs in the following order; oxygen, DIC, everything else. All CTDs other than the Ellett Line and full depth ones were sampled at the following fixed depths: 5 (55%), 10 (33%), 20 (14%), 27 (7%), 32 (4.5%), 47 (1%), 75, 125, 200, 400, 600, 800m for the first CTD and ‘SeaSoar’ survey with an additional bottle at 1000m for the second, deeper, CTD and SeaSoar surveys. Near-surface depths were based on percentages of surface irradiance taken from initial casts (in brackets).

Processing

The processing of SeaBird CTD data closely followed that of D306. That in turn was a modified version of the protocol adopted on RV *Poseidon* P314 and D258, Marine Productivity I. Details can be found below.

Note that 6-digit CTD station numbers were used throughout the cruise – DDDDDN, where DDDDD is the *Discovery* number and N is a code letter denoting the type of CTD: a=steel ctd, b= titanium CTD. In addition, each CTD forming part of the mesoscale surveys was given a separate code denoting location in the survey – CqYX, where C denotes CTD survey, q denotes the survey number, Y ranges from A (northern-most) through C, E and G to I (southern-most) and X ranges from 1 (western-most) to 7 (eastern-most). All processed CTD files are named according to CTD station number and the code representing the type of CTD e.g. cta16210 for a steel CTD at station 16210. Note that because of problems with SeaSoar a number of CTDs were taken at the standard depths during the first SeaSoar survey. For these casts the location is denoted as S1YX. **Table 1** shows the pairings of CTD station and survey grid/Ellett line numbers.

CTD stn.	Survey/Ellett Line no.	Date	jday	time	Lat (N)	Lon (W)	Cast types
16195	IB6	27.07.2007	209	13.48	58 56.94	17 11.16	a
16196	IB7	27.07.2007	209	18.13	59 07.31	17 40.45	a
16197	IB8	27.07.2007	209	21.25	59 12.21	17 53.32	a
16198	IB9	27.07.2007	209	01.31	59 20.13	18 13.42	a
16199	IB10	28.07.2007	209	04.49	59 24.11	18 25.01	a
16202	C1A5	28.07.2007	209	16.36	59 59.85	18 45.82	a
16203	C1A4	28.07.2007	209	19.43	60 00.10	19 19.03	a
16204	C1A3/IB12	28.07.2007	209	23.38	59 59.78	19 52.58	a,b
16205	C1A2	28.07.2007	210	12.46	59 59.64	20 27.17	a
16207	C1A1	29.07.2007	210	17.55	59 59.64	20 59.92	a
16208	C1C1	29.07.2007	210	21.08	59 53.01	20 59.58	a
16209	C1C2	29.07.2007	211	02.37	59 41.90	20 25.15	a,b
16210	C1C3	30.07.2007	211	16.41	59 43.04	19 52.45	a
16211	C1C4	30.07.2007	211	21.08	59 42.61	19 17.92	a
16212	C1C5	30.07.2007	212	01.40	59 42.66	18 45.09	a,b
16213	C1E5	31.07.2007	212	10.35	59 27.19	18 43.37	a
16214	C1G5	31.07.2007	212	14.33	59 08.75	18 44.92	a
16215	C1I5	31.07.2007	212	18.28	58 51.77	18 44.36	a
16216	C1I4	31.07.2007	212	23.30	58 52.15	19 18.28	a
16217	C1G4	31.07.2007	213	03.43	59 09.03	19 19.01	a
16218	C1E4	01.08.2007	213	08.26	59 27.18	19 19.01	a

16220	C1E3	01.08.2007	213	17.07	59 28.90	20 00.14	corrupted
16221	C1G3	01.08.2007	213	21.50	58 08.95	19 53.37	a
16222	C1I3	01.08.2007	214	01.53	58 51.80	19 52.95	a,b
16224	C1I2	02.08.2007	214	14.38	58 52.36	20 24.56	a
16225	C1G2	02.08.2007	214	17.51	59 09.57	20 26.49	a
16226	C1I1	02.08.2007	217	03.36	58 51.01	21 00.74	a,b
16228	S1H5	05.08.2007	217	21.24	58 01.10	18 43.29	a
16229	S1H4	05.08.2007	218	00.58	59 00.95	19 18.63	a
16230	S1H3	06.08.2007	218	04.33	59 00.95	19 52.93	a
16231	S1H2	06.08.2007	218	08.24	59 01.47	20 26.78	a
16232	S1H1	06.08.2007	218	12.04	59 01.12	21 00.38	a
16233	S1G1	06.08.2007	218	15.29	59 08.81	21 00.32	a
16234	S1G2	06.08.2007	218	18.34	59 09.00	20 27.27	a
16235	S1G3	06.08.2007	218	21.25	59 08.90	19 52.96	a
16236	S1G4	06.08.2007	219	00.59	59 08.61	19 18.91	b
16237	S1G5	07.08.2007	219	04.35	59 10.34	18 53.00	b
16238	S1C3	07.08.2007	220	17.51	59 42.39	19 52.24	b
16239	S1C4	08.08.2007	220	20.31	59 43.05	19 18.85	a
16240	S1C5	08.08.2007	221	00.05	59 43.21	18 45.48	a
16243	S1B2	09.08.2007	221	12.40	59 51.77	20 27.30	a
16244	S1B1	09.08.2007	221	15.36	59 51.94	21 00.30	a
16245	S1A1	09.08.2007	221	17.51	60 00.22	21 00.77	a
16247	S1A2	09.08.2007	221	22.49	59 59.93	20 27.20	a,b

16248	S1A3	09.08.2007	222	13.11	59 59.97	19 53.06	a
16249	S1A4	10.08.2007	222	16.24	60 00.10	19 19.08	a
16251	C2A7	10.08.2007	223	00.27	60 00.13	18 41.67	a
16252	C2B7	11.08.2007	223	03.13	59 48.00	18 42.01	a
16253	C2C7	11.08.2007	223	06.00	59 36.31	18 42.10	a
16254	C2D7	11.08.2007	223	08.40	59 24.03	18 41.30	a
16255	C2E7	11.08.2007	223	12.00	59 11.93	18 42.31	a
16256	C2F7	11.08.2007	223	14.37	59 00.14	18 41.65	a
16257	C2G7	11.08.2007	223	17.17	58 47.99	18 41.50	a
16258	C2G6	11.08.2007	223	20.06	58 48.04	19 05.73	a
16259	C2F6	11.08.2007	223	22.55	58 59.90	19 05.30	a
16260	C2E6	11.08.2007	224	02.37	59 11.71	19 05.96	a,b
16261	C2D6	12.08.2007	224	11.23	59 23.66	19 04.20	a
16262	C2C6	12.08.2007	224	14.43	59 39.14	19 04.98	a
16263	C2B6	12.08.2007	224	18.14	59 48.37	19 05.93	a
16264	C2A6	12.08.2007	224	20.45	60 00.10	19 04.80	a
16265	C2A5	12.08.2007	225	23.17	60 00.01	19 27.98	a
16266	C2B5	12.08.2007	226	02.27	59 47.83	19 28.98	a
16267	C2C5	13.08.2007	226	05.04	59 35.44	19 26.70	a
16268	C2D5	13.08.2007	226	07.10	59 23.92	19 27.81	a
16269	C2E5	13.08.2007	226	09.54	59 11.99	19 28.00	a
16270	C2F5	13.08.2007	226	14.21	59 00.14	19 28.61	a
16271	C2G5	13.08.2007	226	17.04	58 48.25	19 27.66	a

16272	C2G4	13.08.2007	226	19.41	58 48.31	19 51.29	a
16273	C2F4	13.08.2007	226	22.47	58 59.95	19 51.92	a
16274	C2E4	14.08.2007	226	02.59	59 12.59	19 53.84	a
16275	C2D4	14.08.2007	226	12.42	59 23.82	19 50.07	a
16277	C2C4	14.08.2007	226	19.19	59 35.38	19 50.21	a
16278	C2B4	14.08.2007	226	22.12	59 47.83	19 51.07	a
16280	C2F2	16.08.2007	228	08.00	59 00.81	20 34.04	a
16281	C2E2	16.08.2007	228	11.40	59 11.98	20 37.29	a
16282	C2D2	16.08.2007	228	14.36	59 24.15	20 36.47	a
16283	C2C2	16.08.2007	228	17.22	59 35.88	20 37.24	a
16285	S2CYC	18.08.2007	230	01.39	59 39.74	18 44.40	a,b
16286	S2ANT	19.08.2007	231	07:12	59 14.28	19 45.98	a,b
16287	S2ANTSW	19.08.2007	231	18:07	59 07.03	20 15.17	a
16295	S2T4	20.08.2007	232	22.30	59 17.09	19 39.56	a,b
16296	S2T2	21.08.2007	233	05:06	59 25.49	19 14.66	b
16297	S2CYCNE	21.08.2007	233	09:12	59 33.32	18 45.80	b
16298	S2CYCNE	21.08.2007	233	13:23	59 42.20	18 33.00	b

Table 1: CTD stations

SeaBird Software Processing (SBEDataProcessing-Win32)

The calibrations applied to the raw data, by the SeaBird logging software prior to being stored in the files described below, can be found in the .CON file for each cast. All processing was carried out in \\Discovery2ng\d321\ctd\ctd\D321StS\Data and \\Discovery2ng\d321\ctd\ctd\D321TiT\Data for the steel and titanium CTDs respectively. Full pathnames should be used throughout though from now on \ctd\raw and \ctd are used here as shorthand for convenience.

The following steps were run on the binary 24Hz data. The input files were DDDDDN.dat, DDDDDN.BL, DDDDDN.CON and DDDDDN.HDR where DDDDD is the *Discovery* number. All input files were kept in \raw with processed data being stored in \ctd. A batchfile (D321Batch.txt) was created in both …\D321StS\Data\raw and \D321TiT\Data\raw for steel and titanium CTDs respectively to process each raw file:

Datcnv /i%1\%2.DAT /c%1\%2.CON /p%1\DatCnv.psu /o%1

Wildedit /i%1\%2.CNV /p%1\WildEdit.psu /o%1

Filter /i%1\%2.cnv /p%1\Filter.psu /o%1

Alignctd /i%1\%2.CNV /p%1\AlignCTD.psu /o%1

Celltm /i%1\%2.CNV /p%1\CellTM.psu /o%1

Bottlesum /i%1\%2.ROS /c%1\%2.CON /p%1\BottleSum.psu /o%1

Trans /i%1\%2.CNV /p%1\Trans.psu /o%1

BinAvg /i%1\%2.cnv /p%1\BinAvg.psu /o%1

AsciiOut /i%1\%2.1Hz.cnv /p%1\Ascii_Out.psu /o%1

e.g to process raw file 176001.dat, execute

sbebatch \\Discovery2ng\d306\D306\ctd\raw\D306Batch.txt
\\Discovery2ng\d306\D306\ctd\raw 176001

The steps carried out by the batch file were set up in the following manner (batch files for steel and titanium CTDs are identical except where indicated):

<u>Data conversion</u>

This generates .cnv and .ros file

File setup

Program setup file DatCnv.psu was created in \raw

Instrument config file: set to whatever you like – it is immaterial as it is overridden by batch file

Config. file: matched to input file.

Input dir: \raw

Input file: as instrument configuration file

Output dir: \raw

Name append: left blank (will automatically append .cnv)

Output file: left blank

Data setup

Process scans to end of file: yes

Scans to skip over: 0

Ouput format: ascii

Convert data from: upcast and downcast

Create file types: both bottle and data

Source of scan range data: .BL file

Scan range offset: 0sec

Scan range duration:

5sec for standard casts (chosen after discussion with Dave Teare on D306 – CTD exceedingly unlikely to move on again within 5sec of bottle firing)

Merge separate header file: No

Select output variables:

Note: temp2 and cond2 are the preferred sensors on the vane. The others (temp and cond) have a considerable lag (~5-10dbar) due to entrainment by the CTD frame. The names are swapped by ctd0 such that temp2 in the binary data becomes temp in the PSTAR version and vice versa (ditto for cond).

pressure (digiquartz) – dbar

temp 2 (ITS-90) – deg C

cond 2– mS/cm

temp (ITS-90) – deg C

cond – mS/cm

altimeter – m

oxygen (SBE43) – µmol/kg

temp difference, 2-1 (ITS-90) – deg C

cond difference, 2-1 – mS/cm

pot. temp (ITS-90) – deg C

fluor (Chelsea Aqua 3 Chl Con) – μg/l

Steel: user poly (ISUS), **Titanium**: Beam attenuation

Beam transmission (Chelsea/Seatech/Wetlab)

time elapsed - seconds

jday

latitude – deg

longitude – deg

PAR (downwelling) – W/m^2

PAR (upwelling) – W/m^2

<u>WildEdit</u>

Details as in P314 report

File setup

Program setup file WildEdit.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

standard deviations for pass 1: 1

standard deviations for pass 2: 2

scans per block: 10

keep data within this distance of mean: 0

Exclude scans marked bad: yes

Select WildEdit variables:

select all

<u>Filter</u>

Details as suggested in P314 report

File setup

Program setup file Filter.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

Low pass filter A: 0.03

Low pass filter B: 0.15

A should be applied to conductivity (1,2 and 1-2)

B should be applied to pressure

AlignCTD

Details as suggested in P314 report. A little more explanation might be helpful though on the subject of the oxygen advance. SeaBird recommend that the oxygen signal is advanced to give the best match between up and down casts. An advancement of 7sec would be satisfactory for this. However, it can be argued that because entrainment by the rising CTD leads to a lagged response it is further necessary to take this lag into account to accurately match oxygen from sensor to oxygen bottle samples. As the primary temperature sensor is on the vane whilst the secondary one is by the oxygen sensor the offset between the two on up casts can be used to estimate the lag. This necessitates some degree of subjective judgement in comparing 'up' profiles of the two temperature sensors with different advance times applied to the temperature recorded by the sensor next to the oxygen sensor. A lag time of 3 or 4 seconds seemed to give the best agreement. A total advance of 10 secs was therefore used. Talking to the PSO afterwards it transpires that this is also a value used by Raymond Pollard previously.

File setup

Program setup file AlignCTD.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

Enter advance values

oxygen advanced 10sec, all others unaffected

CellTM

Details as suggested in P314 report

File setup

Program setup file CellTM.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

α=0.03

1/β=7

both applied to both temperature sensors

BottleSum (has been renamed from RosSum since P314)

Generates a .btl file

Details as suggested in P314 report (JTA)

File setup

Program setup file BottleSum.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Config. filename doesn't matter as over-ridden by batch file

Match to input file: yes

Data setup

Output min and max for averages variables: yes

All variables EXCEPT TIME to be averaged (also exclude scan count if it appears)

Derived variables to average:

none

Translate

Details as suggested in P314 report

Note the output file (.cnv) has an extra variable to that chosen in Data Conversion. It is a flag of some type though haven't tracked down what yet. In ctd0 it is just referred to as "flag"

File setup

Program setup file Trans.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

Bin->ascii

BinAvg

Generates .1Hz.cnv file

Details as suggested in P314 report (JTA)

File setup

Program setup file BinAvg.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Name append: .1Hz

Data setup

Bin type: time (seconds)

Bin size: 1 sec

Include no. scans per bin: no

Exclude scans marked bad: yes

Scans to skip over: 0

Cast to process: up and down

<u>AsciiOut</u>

Generates .1hz.asc file

File setup

Program setup file ASCII_Out.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

Output header: yes

Lines/page: 60

Output data: yes

Exclude bad scans: yes

Columns labelled at top of file

Column separator: space

Julian days format: Julian days

Replace bad flag: -999.0

PSTAR Processing

Note that execs are slightly modified versions of those used on D306 which are in turn slightly tweaked versions of those from *Poseidon* 314. They appear to differ considerably from those used on other *Discovery* cruises (with the exception of D309) so care should be exercised to ensure the correct exec version is used for any subsequent reanalysis. Separate execs are needed for steel and titanium CTDs because

a. only the steel CTD had the ISUS nitrate sensor attached
b. the data are contained in different directories

ctd0S and ctd0T: Translate the 24Hz SeaBird ctnDDDDD.cnv file into PSTAR format. Require the latitude and longitude of the bottom of the cast. These are entered manually from details on the CTD log-sheet but can be automatically checked and corrected later on. Output ctNDDDDD.24hz

ctd1S and ctd1T: After checking output of ctd0 with plxyed (using ctd24Hz.pdf) for spikes that may need to be removed before proceeding, *ctd1S/T* averages 24Hz data into 1Hz and derives salinity, potential temperature and density. Output ctNDDDDD.1hz (and ctNDDDDD.10s)

ctd2S and ctd2T: Require the user to first find the first in-water, deepest and last in-water datacycle using plxyed (with ctd1Hz.pdf) prior to use. These execs then extract data corresponding to full up and down casts (ctNDDDDD.ctu) and purely the downcast (ctNDDDDD.2db) averaged into 2db bins.

sam0S and sam0T: Create a file, fir/fiNDDDDD, containing CTD data corresponding to the firing times of the bottles. It does so using the relevant .btl file in raw/. The resulting PSTAR file has both mean and standard deviation for all variables.

sam1S and sam1T: Create a sample file, saNDDDDD, containing both CTD data at bottle firing depths but also with space for variables for which samples were taken e.g. oxygen, nutrients, chlorophyll. The list of sampled variables is contained in sam.names. Note is also made at this stage of the number of bottles fired on each cast to ensure the ascii sample file (see Salinometry section of report) has only this number of rows.

The following steps were only applied to the steel CTDs as it was felt most sensible to calibrate the steel CTD using bottle salinity samples first and then to calibrate the titanium CTD against the steel one. Unfortunately there was not time on the cruise to perform the second step of calibrating the titanium CTD.

passam: Inserts the sample salinity values into the corresponding PSTAR saNDDDDD file.

makeresid: Subtracts CTD 'salinities' (calculated using standard SeaBird calibrated conductivities) from bottle salinities, putting results in a new PSTAR file reNDDDDD.

Comments on CTD casts

The data from cast 16620 was corrupted. One of the technicians opened the original binary file with Notepad, unwittingly inserting a variety of special characters in the process. When the file was saved on exit the original was corrupted. Despite the best efforts of Steve Alderson the file has proved impossible to restore.

Salinity calibration and sensor issues

The following discusses a preliminary calibration as at the time of writing there were still outstanding salinity samples to process. Data up to and including samples from 16282 were used. Prior to looking for trends and offsets the differences between bottle and CTD estimated salinity were twice screened to exclude data-points outside 2 standard deviations of the mean. This was felt necessary due to a temperamental salinometer.

There is an indication of a small offset prior to cast 16224 (jday 214, 2/8/07) with a slightly higher offset thereafter (see **Figure 9**, top panel) for the difference between bottle salinities and the salinity estimated using the sensors on the vane. For the sensors on the main body there is also evidence of change in offset during the cruise (see **Figure 9**, second panel). However, there is a similar trend in the difference between the two CTD estimated salinities (**Figure 9**, third panel) suggesting that the problem lies with the CTD sensors rather than with the salinometer. The cruise was therefore split into two parts for the purposes of calibration: pre and post 16224. For the first period a regression of botsal=0.1761+0.9951*CTDsal (R^2=0.9996) was used to correct whilst that for the second period was botsal=0.1447+0.9961*CTDsal (R^2=0.9992). With these corrections the difference between bottle and CTD salinity has a mean of 1.4×10^{-15} and a standard deviation of 0.0033 (**Figure 9**, bottom panel).

On the final SeaSoar survey, in the middle of a sequence of deep CTDs, the steel CTD went out of order (16295a was the last steel cast and has only 750m of data before data connection was lost, and frankly the first 750dbar look dodgy too). It was replaced with the titanium CTD for the rest of the deep stations. However, the primary T sensor on this malfunctioned from 16295b onwards. Therefore it will be necessary to use the secondary T and C sensors' data to calculate derived variables. As this requires a rewriting of the execs this has not yet been done.

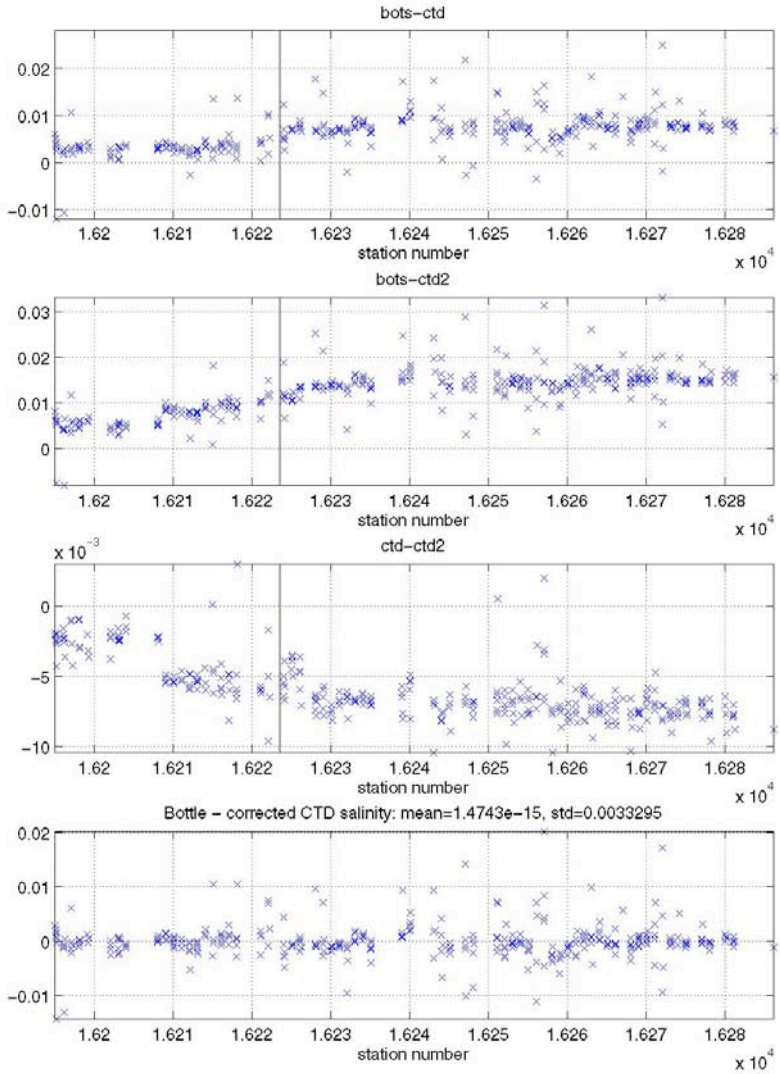


Figure 9: Salinity comparisons for the stainless steel framed CTD package. The difference between bottle sample salinity and salinity derived from the primary CTD (top panel), the difference between bottle sample salinity and salinity derived from the secondary CTD (second panel), the difference between the salinities derived from the two CTDs (third panel), and the residual between bottle sample salinity and the calibrated salinity derived from the primary CTD (bottom panel).

Lowered ADCP (LADCP) Data Processing - *Steven Alderson*

Data from the Lowered Acoustic Doppler Current Meter was processed with the IFM-GEOMAR/LDEO Matlab LADCP-Processing system, version 10 beta. This is a new version of the LDEO software with a new interface, but with the same underlying processing code and theory as previous versions.

A strict directory structure is imposed on the user, with a matlab script called create_cruise.m supplied to create it. This creates a set of directories corresponding to a particular cruise: in this case d321. Inside directory d321 there are two scripts called cruise_params.m and cast_params.m which need to be modified appropriately. When processing is started, all parameters are set to default values; the cruise specific parameters are reset; and finally cast specific parameters (eg if there is no bottom track data on one cast). This is accomplished using these two m-files. To find the parameter values that can be changed and their meanings, the user needs to examine script default_params.m in the m/ladcp sub-directory at the same level as the cruise directory (*i.e.* d321).

On this cruise, following the method used on cruise D309, cast_params.m was modified to get relevant information from a file called stations.dat via a second m-file called shipshape.m which simply parsed the stations file. The latter contains a header line followed by a line of data for each station containing in this order:

station number
start year (yyyy)
start month
start day
start hour
start minute
start second
stop year (yyyy)
stop month
stop day
stop hour
stop minute
stop seconds

depth of package at start (usually zero)

maximum depth of package

depth of package at end (usually zero)

start latitude as a real number (negative for southern hemisphere)

start longitude as a real number (negative for western hemisphere)

stop latitude

stop longitude

flags string

full pathname of PSTAR navigation file covering cast

full pathname of PSTAR ctd file

full pathname of ship ADCP PSTAR file if used

The flags string is new for D321, and contains three characters, each of which can be either 'y' or 'n'. The three characters correspond to whether or not the processing should make use of navigation data, CTD data and shipboard ADCP data respectively. The names of these three files, used in the processing, then follows on the same line. The full navigation file becomes large over the course of the cruise, so a section is extracted covering the time period of each cast; similarly CTD and shipboard ADCP data files are specified.

Inside directory d321 there is a sub-directory called 'm' containing five sample interface m-files: prepladcp.m, prepsadcp.m, prepnav.m, prepctdtime.m and prepctdprof.m. As their names suggest these are intended to prepare each source of data by reading any user supplied data sources and converting them into the correct form. They need to be edited to interface to the users own data. In practice, these m-files were held in another directory and symbolic links created in the working m directory. This was intended to avoid any accidental use of create_cruise.m which may have overwritten the edited versions.

To provide an interface directly to PSTAR files a set of matlab utilities written on D309 were used to read directly from these binary format files. These are pstar.m and indata.m and a number of ancillary files.

Since modifications have been made to some scripts from those used on D312, the edited versions of m-files used on this cruise are listed below in LADCP Appendix.

In addition prepsadcp.m has been used on this cruise when it had not been tested on D312.

A lot of warning messages are issued by matlab during processing, because in calculating a vertical velocity from the CTD pressure and comparing it to the LADCP data there may be no data in one of the resulting fields. This problem, though annoying, seems to cause no problems in the results and was ignored.

The following steps were performed for each cast:

a) edit relevant information into stations.dat file

b) run script ladpos (which requires the last three digits of the *Discovery* station number) to copy out a section of navigation data between the start and end times of the cast found in stations.dat, to the correct directory.

c) in the OS75 directory run script ladadp (which requires a two digit Surveyor file number), to create a file called "sga.abs" and then append to it once it exists; this file contains absolute velocity, depth and time variables.

d) run script ladstn (which requires the three digit station number and the type of shipboard ADCP, in this case 75), to copy out the relevant section of ADCP data to the correct directory.

e) run ladctd (which requires the three digit station number) to copy (with some simple editing) the CTD data into the correct directory.

f) start matlab ("matlab -nodesktop -nosplash") and run mfiles clear_prep(nnn) and process_cast(nnn), where nnn is the three digit station number.

g) repeat f) with different flags set in stations.dat.

For the early part of the cruise, CTD data was not yet ready, so processing was performed without it. This practice was continued throughout the cruise for the purposes of comparison.

Stations were mainly only to a depth above 1000m. This means that no bottom tracking data is available for most stations. Consequently the averaged on station data from the shipboard OS75 ADCP (SADCP) was included in the processing.

For each station three solutions were obtained: one with no CTD and no SADCP data; one with CTD but no SADCP data; and a final solution with both CTD and SADCP data included. For most stations there was good agreement between all three solutions. **Figure 10** shows a typical set of profiles from station 16235. The shear in all profiles is the same. The rms differences between the profiles are comparable to the estimate of error made by the inverse method for the barotropic part of the calculation. There are a few stations however where this is not true. The worst case is that of station 16204 which is a full depth cast which exhibits a 5 cm/s offset between the SADCP profile and those calculated with no SADCP data (see **Figure 11**). No explanation has been found for this offset.

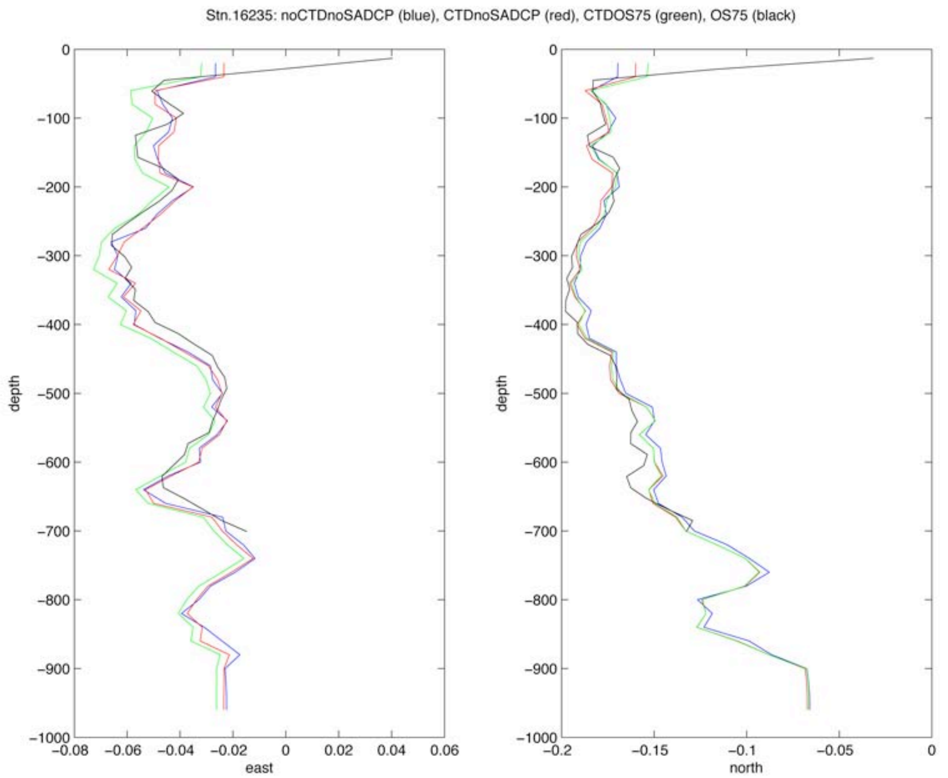


Figure 10: Comparison of absolute velocity solutions (east component - left panel, north component right panel) for station 16235. The solution with no CTD or SADCP data is shown in blue; with CTD but no SADCP data in red; with both CTD and SADCP data in green; and the averaged SADCP data in black.

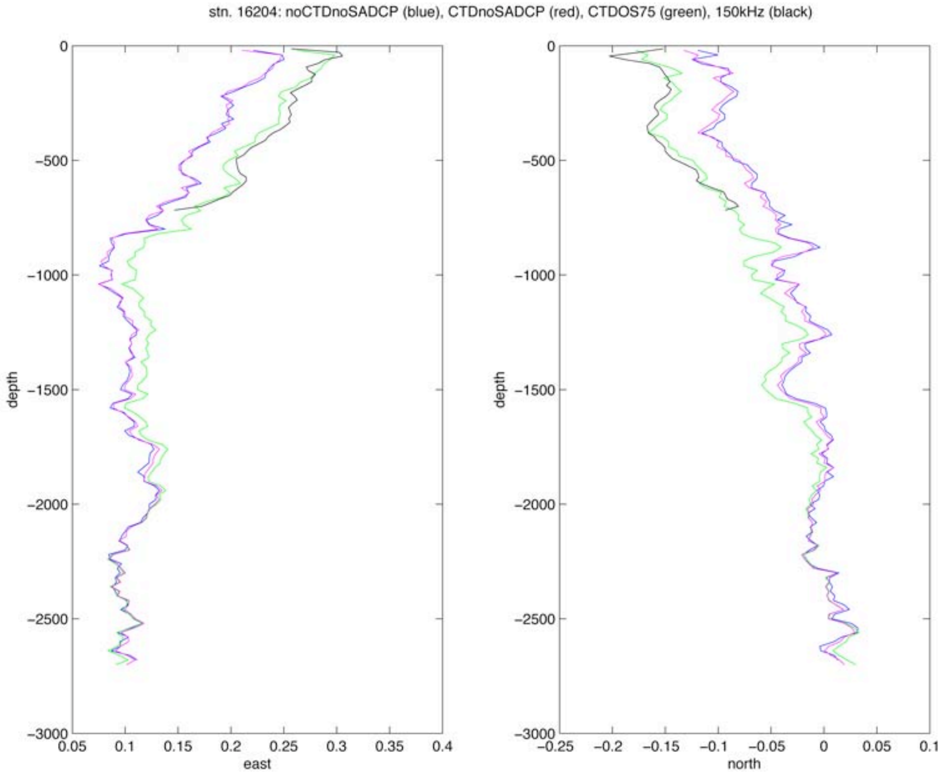


Figure 11: Comparison of absolute velocity solutions (east component - left panel, north component right panel) for station 16204. The solution with no CTD or SADCP data is shown in blue; with CTD but no SADCP data in red; with both CTD and SADCP data in green; and the averaged SADCP data in black.

<u>*LADCP Appendix*</u>

prepnav.m

```
function prepnav(stn,values)
% function prepnav(stn,values)
%
% prepare navigational data for LADCP
% we an array 'data' containing the 2 columns
% latitude in decimal degrees    longitude in decimal degrees
% and the vector 'timnav' containing the time of the navigational
% data in Julian days
%
% THIS FILE IS CRUISE SPECIFIC
%
% to create a file for your own cruise, modify this file
%
```

```
% The navigational data should be at a resolution of 1 per second.
% Lower resolution will lead to worse processing results.

% G.Krahmann, IFM-GEOMAR, Aug 2005

% if you do no have navigational data to be used in the
% LADCP processing, uncomment the next line

% disp('YOU FIRST NEED TO EDIT THE FILE cruise_id/m/prepnav.m !')
% return

% first copy navigational data to the raw NAV data directory
% data/raw_nav

% this edit SGA D312 August 2007

% load this data and convert to standard format
%
% extract the lat and lon columns
% into 'data' and the time vector into 'timctd'
%
% make sure that the time is stored in Julian days

flags = shipshape(stn,'flags');
if flags(1) == 'n'
  disp('no NAV input');
  return;
end
navname = shipshape(stn,'navigation');
if length(navname) == 4 & navname == 'none'
  disp('no NAV file');
  return;
end

disp(['navname: ',navname]);
pd = pstar(navname);

timnav = squeeze(indata(pd,'time'))';
lon = indata(pd,'lon');
lat = indata(pd,'lat');
```

```
data = [squeeze(lat);squeeze(lon)]';       % note transpose to get
shape

fclose(pd.fid);

% To reduce the amount of data we crop the navigational data to
% the same time as the CTD-TIME data. In our example case that
% was an unnecessary exercise since they are the same data, but if
% you have independent navigational data (e.g. daily navigational
files)
% this will reduce file size.

fprintf(2,'%10.2f %10.2f\n',values.start_cut,values.end_cut);
good = find(timnav>=values.start_cut & timnav<=values.end_cut);
timnav = timnav(good);
data = data(good,:);

% store data in the standard location
if str2num(version('-release'))>=14
  eval(['save data/nav/nav',int2str0(stn,3),' timnav data -v6'])
else
  eval(['save data/nav/nav',int2str0(stn,3),' timnav data'])
end
```

prepctdprof.m

```
function [values] = prepctdprof(stn,values)
% function [values] = prepctdprof(stn,values)
%
% prepare CTD profile for LADCP
% we need an array 'data' containing the 3 columns
% pressure in dbar    in situ temperature in degrees C    salinity in
psu
%
% THIS FILE IS CRUISE SPECIFIC
%
% to create a file for your own cruise, modify this file
%
% the data should typically be a profile in 1dbar or 1m steps
% (a lower resolution of down to 10dbar or 10m might be sufficient)
% it will be used to calculate depth dependent sound speed
corrections
```

```
%
% If such data is not available, a sound speed profile will be
% derived from the ADCP's temperature sensor, the integrated
% vertical velocity and a constant salinity.

% G.Krahmann, IFM-GEOMAR, Aug 2005

% if you do no have CTD profile data to be used in the
% LADCP processing, uncomment the next line

% disp('YOU FIRST NEED TO EDIT THE FILE cruise_id/m/prepctdprof.m !')
% return

% this edit SGA D312 August 2007

% load the data and convert to standard format
%
% in this example
% we extract the PTS columns and get position and time data from the
header
%
% pressure in dbar

flags = shipshape(stn,'flags');
if flags(2) == 'n'
  disp('no CTD input')
  return
end
ctdname = shipshape(stn,'ctd');
if length(ctdname) == 4 & ctdname == 'none'
  disp('no CTD file')
  return;
end

disp(['ctdname: ',ctdname]);
pd = pstar(ctdname);

pres = indata(pd,'press');
temp = indata(pd,'temp');
salt = indata(pd,'salin');
ctdprof = [squeeze(pres);squeeze(temp);squeeze(salt)]';
```

```
% extract position and time
tctd = squeeze(indata(pd,'time'));

fclose(pd.fid);

values.ctd_time = 0.5*(tctd(1)+tctd(end));
fprintf(2,'%10.2f\n',values.ctd_time);

% the pressure data in the example had some spikes which
% could be removed by the following
% If your data quality is already good, you won't need the
% following lines
good = find(ctdprof(:,3)>1);
ctdprof = ctdprof(good,:);

% store data at the standard location
if str2num(version('-release'))>=14
  eval(['save data/ctdprof/ctdprof',int2str0(stn,3),' ctdprof -v6'])
else
  eval(['save data/ctdprof/ctdprof',int2str0(stn,3),' ctdprof'])
end

% save filename
file = ['data/ctdprof/ctdprof',int2str0(stn,3)];
```

prepctdtime.m

```
function prepctdtime(stn)
% function prepctdtime(stn)
%
% prepare CTD data against time for LADCP
%
% we need a vector 'timctd' with the time of the CTD in Julian days
% and an array 'data' with the 3 columns
% pressure in dbar    in situ temperature in degrees C    salinity in
psu
%
% THIS FILE IS CRUISE SPECIFIC
%
% to create a file for your own cruise, modify this file
%
```

```
% the data should typically be the data recorded during a CTD
% cast in about 1 second steps
% it will be used to calculate the depth of the LADCP system

% G.Krahmann, IFM-GEOMAR, Aug 2005

% if you do no have CTD time data to be used in the
% LADCP processing, uncomment the next line

% disp('YOU FIRST NEED TO EDIT THE FILE cruise_id/m/prepctdtime.m !')
% return

% this edit SGA D312 August 2007

%
% load this data and convert to standard format
% we need the data:
%
% time in decimal julian days ( January 1, 2000 = 2451545 )
% pressure in dbar
% in situ temperature in degrees C
% salinity in psu
%
% time is stored as acolumn vector in 'timctd'
% the other variables as columns PTS in the array 'data'
%
%
% in this example
% we skip the header of the file and extract the PTS columns
% into 'data' and the time vector into 'timctd'
%
% you might have to convert depth to pressure in dbar
% and/or conductivity to salinity
%
% and you will have to make sure that the time is stored in Julian
days
%
% in this example we add the julian day January 0 of the year of the
% cast to the time stored in the file
% THIS IS APPROPRIATE FOR SEABIRD CNV FILES that contain the
% variable 'time in julian days'
```

```
%
flags = shipshape(stn,'flags');
if flags(2) == 'n'
  disp('no CTD input')
  return;
end
ctdname = shipshape(stn,'ctd');
if length(ctdname) == 4 & ctdname == 'none'
  disp('no CTD file')
  return;
end

disp(['ctdname: ',ctdname]);
pd = pstar(ctdname);

pres = indata(pd,'press');
temp = indata(pd,'temp');
salt = indata(pd,'salin');
data = [squeeze(pres);squeeze(temp);squeeze(salt)]';

timctd = squeeze(indata(pd,'time'))';

fclose(pd.fid);
%
% the pressure data on one of our cruises had some spikes which
% could be removed by the following
% If your data quality is already good, you won't need the
% following lines. If it is bad you will need do create your
% own despiking.
%
good = find(data(:,3)>1);
data = data(good,:);
timctd = timctd(good);
%
% In our example the CTD cast recording began a bit before the
% actual down movement of the CTD. We want only the real
% down and uptrace of the cast. A good part of this will be
% done again in the main processing, but sometimes those
% routines failed and it was simple enough to do here.
%
% The extraction of this part is sometimes tricky. You might
```

```
% have to 'invent' your own methods to make sure that only the
% cast is extracted.
%
% Here we cut start and end of profiles to near sea surface.
% This is done by taking the maximum pressure
% finding the two values closest to half of this pressure
% on the up and the down casts and go towards the
% surface on up and down casts until one reaches either 2dbar or
% the last value
%
% uncomment the following only, if you experience problems with the
% determination of beginning and end of cast
%
%[pmax,indmax] = nmax(data(:,1));
%[dummy,mid1] = min( abs(pmax/2-data(1:indmax,1)) );
%[dummy,mid2] = min( abs(pmax/2-data(indmax+1:end,1)) );
%mid2 = mid2+indmax-1;
%inds = max( find( data(1:mid1,1)< 2 ) );
%if isempty(inds)
%  inds = 1;
%end
%inde = min( find( data(mid2:end,1)< 2 ) ) + mid2-1;
%if isempty(inde)
%  inde = size(data,1);
%end
%data = data(inds:inde,:);
%timctd = timctd(inds:inde);
%
% The following might not be necessary. But we needed it
% in some cases.
% Interpolate to a regular time stepping.
%
% uncomment the following only, if you experience problems with the
% CTD interpolation in the merging part of the processing
%
%min_t = min(timctd);
%max_t = max(timctd);
%delta_t = median(diff(timctd));
%data = interp1q(timctd,data,[min_t:delta_t:max_t]');
%timctd = [min_t:delta_t:max_t]';
```

```
%disp(sprintf('    interpolated  to  %d  CTD  scans;  delta_t  =  %.2f
seconds',...
%      length(timctd),median(diff(timctd))*24*3600));
%
% store data in the standard location
%
if str2num(version('-release'))>=14
  eval(['save  data/ctdtime/ctdtime',int2str0(stn,3),'  timctd  data  -
v6'])
else
  eval(['save data/ctdtime/ctdtime',int2str0(stn,3),' timctd data'])
end
```

prepsadcp.m

```
function [] = prepsadcp(stn,values)
% function [] = prepsadcp(stn,values)
%
% prepare Ship-ADCP data for LADCP processing
%
% we need the vectors 'tim_sadcp' , 'lon_sadcp' , 'lat_sadcp'
% and 'z_sadcp'
% and the arrays 'u_sadcp' and 'v_sadcp'
%
% THIS FILE IS CRUISE SPECIFIC
%
% to create a file for your own cruise, modify this file
%
% the data should be the result of shipboard or later
% SADCP processing

% G.Krahmann, IFM-GEOMAR, Aug 2005

% if you do no have SADCP data to be used in the
% LADCP processing, uncomment the next line

% disp('YOU FIRST NEED TO EDIT THE FILE cruise_id/m/prepsadcp.m !')
% return

% this edit SGA D312 August 2007

% load data and convert to standard format
```

```
%
% in this example we load the velocity and position/time files
% (the processing of the SADCP was also done in matlab which
% made the loading of files easy)
% and extract the necessary information
%
% again make sure that the time is in Julian days
% In the example the cruise was in 2004 and the processing
% stored only the day of the year not the actual year !!!

flags = shipshape(stn,'flags');
if flags(3) == 'n'
  disp('no SADCP input');
  return;
end
adpname = shipshape(stn,'adcp');
if length(adpname) == 4 & adpname == 'none'
  disp('no SADCP file');
  return;
end

disp(['adpname: ',adpname]);
pd = pstar(adpname);

tim_sadcp = indata(pd,'time');
lon_sadcp = indata(pd,'lon');
lat_sadcp = indata(pd,'lat');
z_sadcp = indata(pd,'bindepth');
u_sadcp = indata(pd,'absve');
v_sadcp = indata(pd,'absvn');

tim_sadcp = squeeze(tim_sadcp(1,:));
lon_sadcp = squeeze(lon_sadcp(1,:));
lat_sadcp = squeeze(lat_sadcp(1,:));
z_sadcp = squeeze(z_sadcp(:,1));

fclose(pd.fid);

% restrict the data to the time of the cast

good = find(tim_sadcp>=values.start_cut & tim_sadcp<=values.end_cut);
```

```
tim_sadcp = tim_sadcp(good);
lat_sadcp = lat_sadcp(good);
lon_sadcp = lon_sadcp(good);

% velocities in m/s
u_sadcp = 0.01 * u_sadcp(:,good);
v_sadcp = 0.01 * v_sadcp(:,good);

% store the data
if str2num(version('-release'))>=14
  eval(['save data/sadcp/sadcp',int2str0(stn,3),...
      ' tim_sadcp lon_sadcp lat_sadcp u_sadcp v_sadcp z_sadcp -v6'])
else
  eval(['save data/sadcp/sadcp',int2str0(stn,3),...
      ' tim_sadcp lon_sadcp lat_sadcp u_sadcp v_sadcp z_sadcp'])
end
```

SeaSoar CTD Data - *Roz Pidcock*

Table of SeaSoar runs during D321

station	*start*	*stop*	*duration*	*distance run km*			*notes*
				start	*end*	*total*	
d16227	5/8/07 08:30:50	5/8/07 16:27:11	7h 56m 21s	2203.8	2331.3	127.5	Beginning of first survey leg (leg I) FRRF #1 ceased communication SeaSoar recovered due to hydraulic failure
d16227	7/8/07 08:05:26	8/8/07 13:36:28	29h 31m 2s	3112.6	3109.1	479.0	Resume survey at beginning of 4th leg (leg F). Recovered half way through leg 7 (leg C) due to Penguin fallover
d16284	16/8/07 19:38:14	17/8/07 15:54:12	20h 15m 58s	4628.8	4959.7	330.9	Tow 1 Targetted overnight tow from position C2

							toward northern cyclonic eddy then southern anticyclonic eddy This time with FRRF #2 Winch failure during recovery
d16284	18/8/07 14:08:08	19/8/07 02:03:15	11h 55m 7s	5438.6	5623.8	185.2	Tow 2 Targetted overnight tow from centre of cyclonic eddy back through anti- cyclonic eddy
d16284	19/8/07 20:13:08	20/8/07 08:45:16	12h 32m 8s	5717.2	5910	192.8	Tow 3 East-North-East Dogleg
d16299	22/8/07 14:25:06	22/8/07 18:00:04	3h 34 58s	6527.1	6580.4	53.3	S3 over continental shelf
			Total	**Dist**		**1368.7**	

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. A substantial payload space is available in the SeaSoar for a multidisciplinary suite of additional instruments. Prior to RRS *Discovery* cruise D321, the SeaSoar vehicle had been prepared to carry the (NOC/Valeport) SUV-6 UV Nutrient Sensor, a PAR sensor, a Focal Technologies optical plankton counter (OPC), a CTG Fast Repetition Rate Fluorimeter (FRRF), 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 by ftp to create identical data files on the EMPEROR Linux PC in the main lab: this is discussed in detail in the technical support section. Thus data were logged in three files, one containing the CTDF measurements and its associated additional analogue channels, and three other files for the FRRF, OPC and SUV-6 UV Nutrient Sensor data. The FRRF, OPC and SUV-6 UV Nutrient Sensor data are dealt with elsewhere 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 1Hz averaged prior to the output data stream from the MiniPack. The variables output were:

Conductivity ($mScm^{-1}$)
Temperature (°C)
Pressure (dbar)
ΔT (°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, ΔT (°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 06/07/07,

$$press = (-1.437383x10^{-9}xbits^2) + (9.418578x10^{-3}xbits) - 9.4556$$
$$temp = 5.329251x10^{-11}xbits^2 + 6.012504x10^{-4}xbits - 2.784764$$
$$cond = (-8.306143x10^{-11}xbits^2) + (1.116676x10^{-3}xbits) - 0.9803308$$
$$chlconc = (0.002025xbits) - 3.90077$$

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 were two oxygen sensors, a PAR sensor and a CTG GlowTracker bioluminescence sensor:

Anderaa Data Instruments Oxygen Optode 3830, serial no. 891 (calibration date 21st June 2007)
Seabird Electronics SBE43 Dissolved Oxygen (unpumped) – s/n 1196
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 on-board.

Processing steps

The following processing route was followed as required (approximately every 12 hours) during SeaSoar tows. In order to transfer data, the DAPS data file on EMPEROR was stopped and a new one started. On previous cruises this was the point at which PC clock drifts were checked and corrected but for D321, software had been setup on both PENGUIN and EMPEROR to reference their Linux time to a UTC time server on the shipboard SUN UNIX system. 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 rare 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 merged to produce a single file for each survey and a master file containing all data from all tows; these were then merged with navigation data to obtain a distance run variable and finally interpolated to a 7 km by 8 dbar regular grid using *pgrids*.

<u>*Temperature correction*</u>

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. Thus, 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. Initially the best value was found to be $\tau = 0.15$ second, but this had noticeably drifted by the start of the second survey (S2) (stn. 16284) to a value of $\tau = 0.11$ second. This value was used for the remainder of D321 to provide the cleanest profiles and the best fit between up and down profiles.

D321 SeaSoar minipack calibrations

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.

A preliminary calibration of the TSG temperature and salinity data was made whilst on-board to enable a comparison with the SeaSoar data in order to assess its performance. Back at NOCS a full TSG calibration was carried out (see later Thermosalinograph and Surfmet section). The SeaSoar calibrations detailed below were calculated on-board using the preliminary TSG calibration. They should, therefore be considered preliminary themselves and have not been applied to the data. A final master file of fully calibrated SeaSoar data will be created back at NOCS in the near future.

Temperature

Against the corrected TSG temp_m, each of the SeaSoar sections showed the minipack to be fairly consistently measuring high by ~0.023°C, with the exception of the third section which experienced a period of very spiky TSG temperature data for approximately 5 hours towards the end of the tow. Given that the reason for this blip was the TSG, it was decided that the standard calibration value required for the SeaSoar temperature data was -0.023°C:

$$temp = temp - 0.023$$

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 TS plots of each of the four SeaSoar sections against a similar plot from the CTD data. This proved difficult and inconclusive due to the very complicated and varied water in the region. A more intensive inspection of the individual plots for each section against only the CTD data from the same part of the survey area will enable identification of principal water masses and characteristic features of each sub-section. A useful starting point will be inspection of water masses from within both the cyclonic and anti-cyclonic eddies observed in the data.

Comparison with the (preliminary) calibrated thermosalinograph data was made by selecting SeaSoar Minipack data on a depth range of 4-5 metres using *datpik*. The comparison was made separately for each SeaSoar tow. The second SeaSoar tow was further sub-divided into two sections for calibration where the mean value of tsg-SeaSoar salinity appeared to change significantly. 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 D321, the SeaSoar data proved useful and interesting in the analysis of the physical conditions and biophysical interactions in the survey area. One of the most striking observations made was that the cyclonic and anti-cyclonic eddies initially appeared very similar in the contoured temperature and density sections. This was because the characteristic weak stratification and eventual depression of isopycnals in the anti-cyclonic eddy existed below the maximum depth attainable by the SeaSoar vehicle. This became clear on inspection of the CTD profiles from within the eddy. which revealed the presence of winter mode waters extending to over 800m within the anticyclonic eddy.

Salinity Bottle Samples **-** *Roz Pidcock*

Additional operators – John Allen, Steven Alderson, Meric Srokosz, Adrian Martin, Stuart Painter

Salinity samples were drawn from the Niskin bottles mounted on the CTD rosette from the deepest depth, the surface and several depths in between where a weak salinity stratification was observed. A duplicate sample was taken from the deepest Niskin bottle on most stations. Samples were taken using 200 mL glass sample bottles that were rinsed three times in the sample water, filled to the shoulder and sealed with a disposable plastic insert and the bottle's own screw cap. Samples were also taken from the ThermoSalinoGraph (TSG) every 4 hours during CTD surveys and every hour during SeaSoar surveys to calibrate the continual TSG measurements.

The salinometer for on-board salinity determination was sited in the constant temperature lab; a model 8400B Autosal salinometer serial no. 60839 fitted with a peristaltic pump. Once a crate of sample bottles had been filled they were moved into the constant temperature lab to stand for 24 hours prior to analysis. Standardisation was performed using IAPSO Standard Seawater batch P314 before the analysis of each crate.

The salinometer remained fairly stable all cruise. However, towards the end of the cruise it was noticed that the salinometer was acting a little more erratically. This was not attributed to any particular technical problem, but an increased tendency for trapped air bubbles within the conductivity cells probably indicated that the cells would benefit from a good soaking in Deacon solution after the cruise. 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.

Following salinometer processing, the data was copied from the un-networked salinometer PC to a zip disk. From here the data was transferred onto the network and imported into excel via a Mac laptop and portable zip disk reader. 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.

Thermosalinograph and Surfmet Data – *Roz Pidcock*

Instruments

Underway surface meteorology and thermosalinograph measurements were recorded by the RVS Surfmet system throughout *Discovery* cruise 321. 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

Seal level pressure

Air temperature/humidity

Photosynthetically available radiation (PAR) - port/starboard sensors

Total Incident Radiation (TIR) - port/starboard sensors

Wind speed and direction

Processing

Processing of the underway data was undertaken daily which entailed running several PSTAR routines as detailed below.

smtexec0: This script was used to convert the data from RVS format to PSTAR format using datapup. Resultant file was smt321**.raw

smtexec1a: 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. It was believed on board, but not confirmed, that the Surfmet system does apply the laboratory temperature sensor calibrations, as below, before the data reaches the RVS surfmet stream that we read in with *smtexec0*.

$$temp_h(housing) = -7.48453013x10^{-3} + 1.00060764(temp_{rawh})$$
$$-6.00362039x10^{-5}(temp_{rawh})^2 + 1.11000097x10^{-6}(temp_{rawh})^3$$

$$temp_m(remote) = 2.30711152x10^{-3} + 1.00108689(temp_{rawm})$$
$$-9.54037439x10^{-5}(temp_{rawm})^2 + 2.00706518x10^{-6}(temp_{rawm})^3$$

Bestnav positions (every 30 seconds) were then merged into the file smt321**.raw and this was subsequently averaged into a 2 minute file smt321**.av.

smtexec1b: The master Ashtech file was merged with smt321**.av at this point. This allowed accurate heading data to be incorporated into the underway dataset. This step creates the file smt321**.hdg

smtexec2: This routine computed vessel speed and subtracted it from relative winds to obtain true wind speed and direction. Resultant file was smt321**.met

The .met files were appended to each other to create a single large data file called smt321.int for D321.

Following an initial examination of the offsets in terms of TSG temperature and salinity on-board D321, a full post-cruise calibration was carried out back at NOCS with the full smt321.int data file as detailed below.

Temperature calibration

CTD temperature data from between 4-5 metres water depth during both up and down casts was extracted using the *datpik* routine. This was then merged on time with the smt321.int file in order to directly compare underway remote temperature (tsg_temp) and CTD temperature (ctd_temp). A scatter plot of the difference between these two values (tsg-ctdT) showed no temperature drift. A group of extreme outliers occurred in a small section around the middle of the cruise, which heavily influenced the mean value for tsg-ctdT. The data was transferred into Excel and all data outside of 1 standard deviation (SD) (0.049ºC) of this mean were removed. This produced a new mean value of 0.00857ºC. This agreed closely with the initial estimate of 0.0083ºC obtained from the scatter plot. Therefore, the following calibration value was applied to temp_m in the smt321.int file:

$$temp\_m = temp\_m - 0.0085.$$

Salinity calibration

Salinity samples were taken from the underway source routinely once per watch (4 hours) and once every hour during SeaSoar surveys. The master Excel file of sample times and corresponding bottle salinities, as described in the previous Salinity Bottle Samples section, was read into PSTAR and renamed d321uw. The new file was then merged, using *pmerge*, with the existing smt321.int file to directly compare underway salinity (tsg_sal) and bottle salinity (botsal) with a view to applying a calibration to the underway salinity data. The variable tsg-botS was created and the data transported into excel for examination. Several clearly anomalous values (>1) were removed from the start of the file. All data outside of 1SD (0.042) from the mean were also removed. This produced a new mean value of tsg-botsal of 0.118. This agreed closely with the initial estimate of 0.117 obtained from the scatter plot. Tsg_sal was also compared with salinity measurements from the CTD taken between 4-5m (tsg-ctdS) to confirm the existing offset. The data was merged and examined as with previous data. All data lay within 1SD of the mean and data removal was not required. The mean value for tsg-ctdS was calculated as 0.126. Again, this matches closely the estimate from the scatter plot and from comparison with the bottle salinities. It was, therefore, decided that the following calibration should be applied:

$$salin = salin - 0.12$$

The calibrations for temp_m and salinity were applied to the original smt321.int file to create a master TSG file, smt321.master.

Laboratory calibrations

The most recent laboratory calibration of other sensors on the Surfmet package are given in the table below:

Instrument	*Serial No.*	*Calibration*	*Comments*
Barometric Pressure	Z4740021	(y=A+Bx) A = 0.0464399 B = 0.999388	27/04/2007
PAR	SKE 510 1204 28561	7.015 µA per 100 Wm^{-2}	16/04/2007

		1.020 mV per 100 Wm^{-2}	
PAR	SKE 510 1204 28562	7.467 µA per 100 Wm^{-2} 1.020 mV per 100 Wm^{-2}	10/04/2007
Air Temp. / Humidity	U1850014	(y=A+Bx) temp/humidity A = 0.02 / A = 0.15 B = 1.0228 / B = 1.0189	12/02/2003
TIR (Pyranometer)	CM6B 973135	11.66 µV per Wm^{-2}	03/04/2007
TIR (Pyranometer)	CM6B 973134	10.84 µV per Wm^{-2}	03/04/2007

Turbulence Measurements - *Adrian Martin, Meric Srokosz, Stuart Painter*

As the MSS turbulence profiler is a new piece of equipment for the NMF equipment pool this report will be rather more detailed than it would be otherwise. In this spirit we attach at the end of this section some general notes on use of the probe and follow this with a detailed protocol for deployment of the equipment and then processing of the collected data, developed from the experience on this cruise.

Summary of turbulence stations on D321

From experience of analysing turbulence probe data from the D306 cruise to the PAP site it was decided that at least 10 profiles per station would be conducted wherever possible on D321. This is because the above analysis revealed the turbulent diffusivities to be log-normally distributed (if not worse) with the causative mixing being intermittent. Therefore, 10 is viewed as the smallest practical number of profiles to calculate profiles of mean turbulent diffusivity.

The majority of the turbulence stations were conducted as the last component of primary productivity stations. However, there were a number of additional stations. Taking advantage of a time when both SeaSoar and CTD were out of action, 16241F and 16242F were carried out on the basis of ADCP data from the previous occupation of this transect line. It was hoped that they would provide measurements at the periphery and in the centre of the high strain region between the two eddies respectively. Later analysis of the corresponding ADCP data showed that unfortunately we were upstream of the high strain region. Stations 16228F, 16289F, 16292F and 16295F (S2T1-4 respectively) formed a transect between the two eddies (with corresponding zooplankton nets and XBTs) in the hope of measuring turbulent diffusivities in a high shear region. As the corresponding ADCP data had not been worked up at the time of writing it is currently unknown whether this was successful. Failure is more likely to be due to the tendency of the eddies to move apart towards the end of the survey than misconstruing where the eddies were as we were commuting between them daily by this point.

In addition to hopefully providing an excellent dataset the cruise was also useful in training personnel in use of the new equipment. The laptop end of operations is literally a push one button affair and so of no problem. Spooling out of the cable as the probe descends requires a little more knowledge. Adrian Martin, Meric Srokosz and Stuart Painter all successfully carried out this operation. In addition John Allen, Dave Teare, Dougal Mountifield and Emma Northrop all observed deployment and are fully aware of the only two issues: cable should be fed out sufficiently quickly to ensure that at least two loops are always visible in the top few metres of water; the cable has a tendency to catch occasionally, possibly because of salt crystals forming on it, so it is necessary to keep one hand between spooling out cable (but not touching the cable as there is an outside chance this can induce vibrations that would be recorded as turbulence) and the drum to quickly catch and throw off any loops that catch so that it is not necessary to stop the winch and hence affect the freefall sinking of the probe. The latter may be rectified by fastening of a metal pin where the hand would otherwise be held. This should be looked into prior to the next use of the probe.

Summary of turbulence measurements made on D321

Stat. no.	Date	Jday	Pos'n.	PC time Start cast GMT	Ship time Start cast GMT	Profile number	Sea state	Wind speed (m/s)	Wave height (m)	Air temp (oC)	Comments
16195F	27.07.2007	208	58 57N 17 11W	1501	-	velcal01-velcal02	-	8	-	12.5	Trial casts to check sinking velocity
16201F	28.07.2007	209	59 42N 18 45W	1044-1131	1039-1125	D321C001-D321C010	3	5	2	12	

			59 43N 18 45W								
16204F	29.07.2007	210	59 57N 19 49W - 59 56N 19 51W	0841-1002	0835-0956	D321C011-D321C024	4-5	7	1	13	Possibly in filament region.
16209F	30.07.2007	211	59 39N 20 23W - 59 39N 20 22W	0834-0850	0828-0841	-	5	-	-	-	Sink velocity tuning test - didn't sink!
16209F	30.07.2007	211	59 37N 20 19W	1343	1347	D321C026	6	-	-	-	Test dip for velocity calibration
16212F	31.07.2007	212	59 40N 18 46W - 59 40N 18 48W	0729-0813	0724-0807	D321C027-D321C030	6	-	-	-	More velocity calibration dips – curtailed due to rough sea state
16222F	02.08.2007	214	58 50N 19 51W - 58 49N 19 51W	0726-0834	0720-0828	D321C031-D321C040	2-3	5	2	12.75	
16226F	05.08.2007	217	58 50N 21 00W - 58 49N 20 59W	0544-0701	0538-0655	D321C041-D321C051	3-4	8	2.7	13	First deployment after storm on 3.08.07.
16232F	06.08.2007	218	59 01N 21 00W - 59 02N 21 02W	1258-1400	1252-1354	D321C052-D321C061	1	-	-	-	Deployment prior to SeaSoar redeployment
16241F	09.08.2007	221	59 52N 19 37W - 59 53N 19 38W	0613-0717	0607-0711	D321C062-D321C072	1	5	2	13	Adjacent to strain region?
16242F	09.08.2007	221	59 52N 20 07W - 59 53N 20 06W	0942-1054	0936-1048	D321C073-D321C084	2	5	2	13	In strain region?
16247F	10.08.2007	222	59 58N 20 30W	0659	0652	D321C085	2	-	-	-	Measurements suspended for

											Pelagra hunting
			59 56N 20 26W	0840-0941	0834-0935	D321C086-D321C095	2	4	1.5	13.5	New set of measurements
16260F	12.08.2007	224	59 10N 19 8W	0750-0854	0743-0847	D321C096-D321C105	2	2	1.5	12.5	
16269F	13.08.2007	225	59 12N 19 28W	1119-1218	1113-1212	D321C106-D321C115	4	7	1.5	12	
16283F	16.08.2007	228	59 36N 20 38W	1820-1917	1813-1911	D321C116-D321C125	2-3	5.5	2.1	12.1	
16285F	18.07.2007	229	59 41N 18 42W	0803-0909	0757-0902	D321C126-D321C136	4	4.3	2.7	12.3	In centre of cyclonic eddy
16286F	19.08.2007	231	59 17N 19 47W	1407-1506	1400-1459	D321C137-D321C146	4	8	1.5	13.5	In centre of anticyclonic eddy
16288F	20.08.2007	232	59 30N 19 02W	1222-1324	1215-1318	D321C147-D321C156	3	4	1.5	13.2	S2T1
16289F	20.08.2007	232	59 26N 19 16W	1527-1627	1520-1620	D321C157-D321C166	3	5	1.4	13.5	S2T2
16292F	20.08.2007	232	59 22N 19 26W	1820-1908	1803-1901	D321C167-D321C176	1	3	1.8	13.5	S2T3
16295F	20.08.2007	232	59 18N 19 40W	2032-2132	2025-2125	D321C177-D321C186	3	5	1.5	13	S2T4

Table 2: Turbulence profiler deployments

Profiler description

During the *Discovery* cruise D321, the microstructure profiler MSS90L, serial number 35 was used for microstructure measurements. The profiler is produced by Sea and Sun Technology GmbH in co-operation with ISW Wassermesstechnik.

The MSS profiler is an instrument for simultaneous microstructure and precision measurements of physical parameters in marine and limnic waters. It is designed for vertical profiling within the upper 300 m. The data are transferred via electrical cable to an on-board unit which pipes the data to a laptop PC.

The main housing of the MSS90L profiler comprises a cylindrical titanium tube of length 1250 mm and diameter 90 mm. The housing is pressure tight to 5MPa (500 m). Weights and buoyancy rings can be added to the top and bottom of the robe respectively. This allows the user to tune the sinking velocity by altering the buoyancy.

The MSS profiler was equipped with 2 velocity microstructure shear sensors (for turbulence measurements: SHE1 and SHE2), a microstructure temperature sensor (NTC), standard CTD sensors for precision measurements (PRESS, TEMP, COND), a turbidity (light scattering) sensor, a vibration control sensor (ACC), a two component tilt sensor (TILTX, TILTY) and surface detection sensor (SD) to indicate the water surface hit at rising measurements (see table below). The sampling rate for all sensors is 1024 samples per second, the resolution 16 bit. All sensors are mounted at the measuring head of the profiler (sensor end). The microstructure sensors are placed at the tip of a slim shaft, about 150 mm in front of the CTD sensors.

The general behaviour of the MSS profiler is described in detail by Prandke, Holtsch and Stips (2000).

Background to microstructure shear measurement

For measurements of velocity microstructure (turbulence), the MSS profiler is equipped with two shear probes PNS01. This type of shear probe comprises an axially symmetric airfoil separated by a cantilever from a piezoelectric beam. The piezoelectric bending element is isolated from the water by a Teflon tube. This gives the sensor excellent long-term stability. The length and diameter of the airfoil are 4mm and 3mm respectively. The spatial resolution of the PNS shear probe is approx 8mm. The general behaviour of an airfoil sensor has been described in detail by Osborn and Crawford (1980). The mean velocity due to the profiling speed of the probe is aligned with the axis of revolution. While the probe is not sensitive to axial forces, the cross-stream (transverse) components of turbulent velocity produce a lifting force at the airfoil. The piezoelectric beam senses the lift force. The output of the piezoelectric element is a voltage proportional to the instantaneous cross-stream component of the velocity field.

Deployment and operation of the microstructure measuring system

For vertical sinking measurements, the profiler was balanced with a negative buoyancy which gave it a sinking velocity of 0.56-0.58 ms^{-1}. This took a little fine tuning, as can be seen from the log of deployments. As a rule of thumb, for the density profiles typical of the NE Atlantic one of the steel rings adds around 0.13 ms^{-1} to the sinking speed. Adding one of the foam rings reduces the sinking velocity by a much larger amount possibly up to 0.5 ms^{-1}, but certainly sufficient to stop it sinking at all when both a steel ring was removed and a foam ring added.

The MSS was operated via a winch SWM1000, mounted on the port stern quarter of the vessel. In addition to the fastening provided by the construction of the mounting plate the plate was further secured to the bulwark with a steel bolt which ran through bulwark and plate and with a pair of G clamps. This is strongly recommended.

During the MSS measurements, the ship was moving with speed approx. 0.5-1.0 knots with respect to the water against the wind. Disturbing effects caused by cable tension (vibrations) and the ship's movement were minimized by maintaining slack in the cable – as a rule of thumb two "loops" should always be visible just below the sea surface.

In order to take into account the intermittent nature of marine turbulence, repeated MSS measurements were carried out in bursts of typically 10 profiles per station. The measurement interval was approx. 7 min for a profile to 140 dbar. The profiler fell to a depth of typically 140 dbar even though the winch was stopped when the pressure reached 100 dbar. 100 dbar was chosen as the target depth as the mixed layer was found from CTD profiles to be consistently at 40-50 m and it was wished to characterize the turbulent mixing to a sufficient depth below this. The excess 40 dbar in depth was due to the amount of slack in the cable As the profiler is rated to 300 m it was felt that the extra depth was preferable to the possibility of having insufficient slack in the cable and thereby affecting the measurements through vibrations on the cable.

Data collection and archiving

The raw data from the MSS profiler are transmitted via RS485 data link to the on board interface unit of the measuring system. Details relating to each station were noted in an XL file. For data acquisition, on-line display and storage of data the software package SDA 180 (Sea & Sun Technology GmbH) was used. The icon on the laptop desktop has label SSsda_183. The rawdata/ directory in which the raw data from each profile are stored, can be found in C:sst_sda/. The raw data are stored in the MRD (microstructure raw data) binary format.

Calibration and sensor tests

Calibration of the shear sensors was performed by ISW Wassermesstechnik using a special shear probe calibration system. The probe rotates about its axis of symmetry at 1Hz under an angle of attack in a water jet of constant velocity. At different angles of attack the rms voltage output of the probe is measured. The probe sensitivity is the slope of the regression (best fit of a cubic approximation) of the sensor output versus the angle of attack.

The calibration of the CTD sensors had been carried out by Sea & Sun Technology GmbH using standard calibration equipment and procedures for CTD probes.

The vibration control sensor and the tilt sensors were calibrated by ISW Wassermesstechnik using special calibration equipment for both sensors.

Sensor damage and replacement

After deployment on 29.7.07 at station 16204F it was noticed that the shear signal for probe 1 looked just like noise with a very low signal and erratic spikes. Shear for probe 2 was smoother and bore a relation to water column structure. Shear probe 1 was therefore replaced. Physically this is quite simple if a little fiddly with full instructions in the manual. However, it is important to also update the batch program "convert+shear NOC" to use the "sensitivity" for the new probe. The sensitivity affects two key parameters, a0 and a1, which must be recalculated using the new sensitivity (top right corner of data sheet for new probe). Details can be found in the manual.

General notes on deployment

a. The velocity microstructure sensors are incredibly delicate. One was broken on D321 without really knowing how – it may simply have been inexperience in handling and cleaning the probe. Pay careful attention to the manual on how to clean the probes before trying (definitely do not spray a hose across the tips) and ensure that the covers are on whenever the probe is not in operation. It may also be advisable to remove the shear sensors prior to transporting the probe and to carry them separately on the person as a precaution. See later for details regarding replacement of the broken sensor.

b. Operation of the profiler requires a minimum of 2 people: the first operates the winch, the second monitors the profiler's progress on the laptop. Both people are necessary for deployment and recovery of the probe over the side of the vessel – one to control the winch and the other to carefully lower/lift the probe over the side.
c. It is wise to leave the handset connected to the control box for the duration of the cruise. Otherwise there is considerable chance of getting moisture and salt crystals in the connection socket even if treated with care. This can cause the connections to short circuit leading to odd behaviour of the winch – the most alarming being an unstoppable outward spooling of the cable. As a precaution it is best to cover the handset (still connected) with a plastic bag when not in use and to place it in a position where it will not be knocked or dislodged by the ship's movement. More generally the system should be set up at the start of the cruise and the only cables that should be disconnected on a daily basis are the power cable to the ship power supply and the interface box to the laptop. This minimizes the risk of getting sea water into sockets.
d. The winch brake switch was installed to provide for situations where the cable becomes jammed. This could be due to it catching on the seafloor (strongly recommended not to send it that close) or if the probe collides with the winch on recovery due to it being reeled in too fast. For normal use the switch should be set to 'off'. If the cable catches the switch should be set to 'on'. It should then be possible to move the drum by hand to free the cable. Note that if the probe does get reeled in too fast and collides with the drum there would appear to be a cut out – the winch will not function again for a good couple of hours.
e. On *Discovery* a good location for securing the winch is on the rear port bulwark. The starboard is not as good a location as if moorings need to be recovered the winch will need to be removed each time this takes place. Furthermore, on the port bulwark there is a hole by which the mounting plate can be further secured to the ship using a steel bolt. It was further secured by use of two G clamps.

Protocol for turbulence dips:

<u>Preparation:</u>

1. Check all securing bolts and nuts on the winch and mounting plate.
2. Take turbulence probe stand out to deck and position by winch
3. Take turbulence probe out on deck and place on stand
4. Connect power to winch
5. Ensure winch brake is set to "off" – it's not like it sounds (see above notes)
6. Let out a little slack in cable from drum
7. Connect probe to cable: data cable and bracket
8. Turn on interface. **DO NOT DO THIS BEFORE CONNECTING THE PROBE TO THE CABLE.**
9. Wait a few seconds for current reading to stabilize (should be 25-60 mA)

10. Boot up laptop
11. Connect laptop to interface
12. Start SSsda software by double clicking icon. A header should appear.
13. Decide maximum depth with second operative
14. Get 2 walkie-talkies: one for winch operator, one for laptop operator

Deployment:

1. Remove securing rope from winch
2. Ask bridge to get ship speed to 0.5-1 knot with respect to the water (and to raise any deployed fish to near surface to avoid turbulent "contamination")
3. Ask bridge for station number, wind speed and sea state. Note details
4. Fill in header details: don't bother with "press" but do note wind speed and sea state in comments
5. Click red cross in top right hand corner of header
6. Click 'no' to request for this to be template header when prompted
7. Check that stream of data appears on screen
8. Remove covers from sensors
9. Ask bridge for permission to deploy probe
10. Gently lower probe so that just below water surface
11. For laptop operator: click start ONCE (square should now go red and display 'STOP' rather than 'START')
12. For laptop operator: Tell winch operator to start descent
13. For winch operator: begin descent (typically at half of dial for a sinking velocity of 0.6m/s) such that always two coils visible in water near surface. **Cable must be allowed to drop straight down from drum rather than go over 'arm'.**
14. For laptop operator: when pressure reading reaches maximum agreed depth, stop data acquisition by clicking ONCE on the obvious 'STOP' box
15. For laptop operator: Request winch operator to stop descent and to begin ascent
16. For laptop operator: add max pressure to header ('no' to template again)
17. For laptop operator: save file with required filename to C:/sst_sda/Rawdata
18. For winch operator: put cable over 'arm'
19. For winch operator: begin ascending probe, stop when near surface
20. Back to 12 and repeat as necessary

Recovery:

1. Ask bridge for permission to recover probe
2. Gently raise probe back on deck and place on to stand
3. Tell bridge probe on board
4. **TURN OFF INTERFACE**
5. Disconnect probe: bracket and cable
6. Put cover socket on termination and secure in safe location
7. Cover handset with plastic bag and place in safe location still attached
8. Disconnect power to winch
9. Secure winch with rope
10. Wash probe, sensors and their covers. **SEE THE MANUAL FOR THE CORRECT AND SAFE WAY TO WASH THE VELOCITY MICROSTRUCTURE SENSORS.**

11. Put probe on stand in hangar or lab to dry
12. Make a note of air temperature and significant wave height from Met Data
13. Back up data to CD
14. Back up data to UNIX

Basic guide to processing necessary to obtain turbulent diffusivity

It is important to set up different directories for the different stages of processing as there is the potential to overwrite files. Note also that the software has to sit directly under C: to use the current batch files. For D306 the following directories were used:

C: \sst_sda\Rawdata – for storage of raw files as they are generated

C: \datpro\cutfiles – raw files copied here for depth trimming

C: \datpro\ascii – for files now converted to ascii with shear calculated

C: \datpro\dissThorpe – for files once dissipation rate and Thorpe scale calculated

C: \datpro\eddy_diff – for files once turbulent diffusivity calculated

Checking sinking velocity:

At the start of the cruise the sinking velocity of the probe should be checked. This should be between 0.5 and 0.7 ms^{-1} to give best signal to noise ratio. Only one cast is required to check the sinking velocity. Rather than go through the lengthy processing steps below there is a quicker route…

1. Copy file to C: \datpro\cutfiles and trim it as in 3. below.
2. Click Run button in top menu bar, then Batch job.
3. Choose Velocity option
4. Configure batch job as in 4.e -f. below but you may want to set up a new directory e.g. C: \datpro\velocity for doing this test
5. Click start
6. Use Datgraf (see 7 below) and the configuration file Velocity to check the vertical velocity profile

Processing steps:

1. Copy files to process from C: \sst_sda\Rawdata to \datpro\cutfiles

2. Start msspro by double-clicking on icon

3. Trimming profiles-

   a. Click Utilities Button once, then click once on the Cutgraf option and a new window should appear.

b. Click on Input files and select required files from \cutfiles. Note that this program will overwrite these files once edited which is why they must be copied here from C: \sst_sda\Rawdata
c. The filenames should appear in the right margin. Double-click on the first file.
d. Move cursor to top of hashed rectangle in lower half of plot such that double-headed arrow appears. Hold down left button and drag the top of the blue hashed rectangle downwards until just above the point at which the pressure starts to decrease again. Press F9 to cut the profile such that data within the remains of the blue hashed rectangle is deleted. The program automatically moves on to the next file. Note: it may be the over-sensitive touch pad but this can be a bit fiddly as if you click even slightly away from the top of the rectangle you instead zoom in (to an area within a red hashed rectangle which will appear). Right click to zoom out again.
e. Repeat until the end of the file list is reached – then click 'OK' when it tells you this point is reached.

4. Converting files to ascii and calculating shear-

a. In datpro click once on File, then click once on Select input files for file list
b. In window that appears, navigate to C: \datpro\cutfiles, set type to .mrd and choose required files.
c. Click once on Run in top menu bar
d. Select Batch job and choose Convert+shear NOC from the options that appear. If they don't appear, navigate to C: \datpro\batch
e. A configure batch job window should appear. Set the output directory to C: \datpro\ascii. A window of possible files will appear, but click any single letter into the filename box and hit OK.
f. Set the output filename prefix in the same window. Note i. that the filenames are restricted to 8 characters and ii. that this step will overwrite the relevant leading letters of your initial filename e.g. if the rawfile is called abcdefgh and you choose prefix D321A then the output file will be called D321Afgh. It is therefore important that you choose the structure of your filename and your prefixes carefully to avoid over-writing files. For D321 the prefix D321A was used for this stage leaving the last 3 characters for the sequential profile number.
g. Click Start job. For 10 profiles of roughly 100m this batch job will take of order 3 hours to run, possibly longer.

5. Calculating turbulent dissipation rates and Thorpe scale

a. If you have just done the preceding stage you will first need to clear the input file list. Click on the Input file list button. Select all the files visible. Click once on the File button on the top bar. Click on Reject selected input files.
b. Now load files for this stage of processing. Click on the File button in the top menu bar, then on Select input files.
c. Navigate to C: \datpro\ascii and select required files
d. Click once on Run button in top menu bar, then on the Batch job option that appears.
e. Choose epsilon+Thorpe – new from options (see 4.e)

f. In Configure batch job window that appears set output directory to C: \dissThorpe, once again typing a random single letter into the output filename before hitting OK.
g. In the same window set the output file prefix e.g. D321D
h. Click Start. This stage will take a couple of hours roughly for 10 profiles to 100m.

6. Calculate turbulent diffusivities

a. Clear previous input files as in 5.a.
b. Now load files for this stage of processing. Click on the File button in the top menu bar, then on Select input files.
c. Navigate to C: \datpro\dissThorpe and select required files
d. Click once on Run in top menu bar then on Batch job option that should appear
e. Choose Eddy option (see 4.e.)
f. In Configure batch job window that appears set output directory to eddy_diff once again typing any single letter in as the output filename.
g. In the same window set the output prefix e.g. D321E
h. Click start job. This stage will take only a few minutes for 10 profiles to 100m.

7. Examining data i.e. dissipation rates

a. Click once on Utilities button on top menu bar.
b. Click on Datgraf option – a new window should appear.
c. Click on Configure button in Datgraf, then on the Load configuration option.
d. Choose epsilon D321
e. Set work path to C: \datpro\dissThorpe
f. Click on the file of interest in the right margin and the data should appear in the adjacent plots. The plot ranges (and parameters plotted) can be adjusted by clicking Configure, then Options, then the Data parameters tab.
g. Eps1 and eps2 are the dissipation rates as estimated from the two velocity microstructure probes. They should be pretty similar. If one is systematically much lower than the other or even just systematically different in structure and amplitude it may be an indication that one of the sensors is broken. In this case you need to work out which of the two you trust most. Looking at previous profiles should help in this regard.

Profiling Floats – *Stuart Painter, Rosalind Pidcock*

Cruise D321 was provided with 8 profiling floats by Brian King (NOCS) to deploy within the Iceland Basin. Four of the floats were of the APEX variety, a familiar type deployed successfully on several previous cruises. The other four floats were of a new design provided by the alternative French manufacturer. These PROVOR floats were an unknown and as we were supplied with floats numbered 01–05 (03 remaining in Brian King’s office) there was not a pool of acquired knowledge from which we could seek guidance in the event of problems. To minimise complications and potential data loss we deployed 1 APEX float and 1 PROVOR float together, a dual deployment, on three occasions during the cruise. These dual deployments took place within the confines of the survey area (**Figure 12**) putting 6 floats close to Hatton Bank (PROVOR floats 01, 04, 05; APEX floats 2631, 2634, 2633). The last two floats were to be deployed separately, one PROVOR float (02) was released within the centre of an anticyclonic eddy identified within our survey area but the final APEX float (2635) was not released due to initialisation problems. Positions and times of release are listed in **Table 3**.

Release Details						Calibration CTD
Float No.	Type	Latitude (N)	Longitude (W)	Jday	Time (GMT)	*Discovery* Station No. (survey number)
2631	Apex	59° 27.4	20° 00.16	213	18:56	16220 (C1E3)
01	Provor	59° 27.4	20° 00.16	213	18:58	16220 (C1E3)
2634	Apex	59° 55	20° 25	222	08:16	16247 (S1A2)
05	Provor	59° 55	20° 25	222	08:14	16247 (S1A2)
2633	Apex	59° 01	20° 35	228	09:15	16280 (C2F2)
04	Provor	59° 01	20° 35	228	09:15	16280 (C2F2)
2635	Apex	-	-	-	-	-
02	Provor	59° 17.7	19° 48.5	231	13:40	16286 (S2ANT)

Table 3: Release locations and times of the 8 profiling floats. In all cases a CTD station was completed nearby which may be useful for calibration/reference purposes. Listed in the table are the *Discovery* Station number and a cruise survey station number.

As there are few profiling floats in the Iceland Basin to date these floats are likely to prove very useful over the coming months, particularly with regards to questions concerning the general anticlockwise circulation of the Iceland Basin.

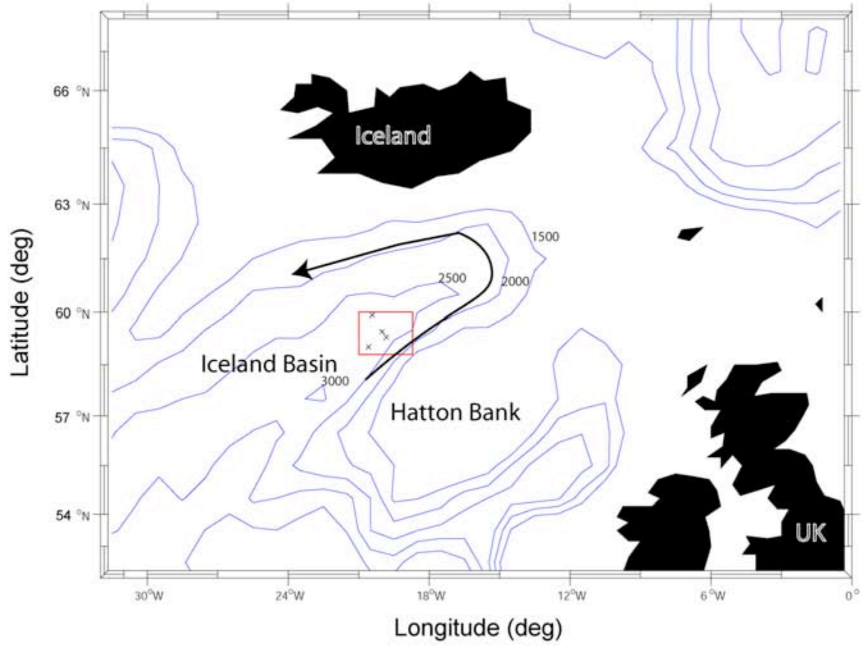


Figure 12: Argo float deployment locations (black stars) and cruise survey area (red box). The general circulation within the Iceland Basin and the expected path of the floats is indicated by the black arrow with depth contours at 500m intervals from 3000m to 1500m for reference.

Optical Plankton Counter (OPC - SeaSoar) data processing - *Meric Srokosz*

The OPC data from Penguin was transferred at (nominal) twelve hour intervals onto the shipboard Unix system and placed into /data32/d321/seasoar/penguin. They were copied to /data32/d321/opc for processing. The files were processed using scripts that ran *pexec* programmes (as described below). The file naming convention follows that used for SeaSoar processing, with file names beginning op321*nnn*, where 321 is the cruise number and *nnn* is the file number, starting with 001 and incrementing. Note that these are chosen to correspond to the SeaSoar processing file identifiers sa321*nnn* and gr321*nnn*.

The files from Penguin have random numbers assigned to them, so determining the correspondence between the different data streams (OPC, SUV6, Minipack) is somewhat problematic unless a careful track is kept of the numbers (though all the files contain time information which can be used to match them). The OPC processed file numbers also have suffixes appropriate to the stage of processing (**Table 4**), with the end result being in files op321*nnn*.all (see processing description below).

SeaSoar survey no.	Raw OPC file no.	Processed file no.
1	opc497.000	op321001
1	opc367.000	op321002
1	opc2289.00	op321003
1	opc356.000	op321004
1	opc683.cat (concatenated file containing opc683.000 opc409.000 opc336.000 opc421.000 opc596.000 necessary due to SeaSoar problems)	op321005
2	opc349.000*	op321006 op321007
2	opc535.000*	op321008 op321009
2	opc522.000	op321010

*OPC file split to match SeaSoar gridded files gr321*nnn*

Table 4: Raw and processed OPC data file numbers.

OPC data processing steps

The OPC data were processed using the following sequence of scripts :

Script 1: opc1s

- Uses *grep* to extract lines with particle data in them from the raw OPC file.
- Runs *pascin* to convert the resultant ASCII data to PSTAR format
- Uses *pcopya* to add an extra jday variable and then runs *ptime* to convert that to a time variable in seconds. Note that on the Unix system *ptime* is the name of a system programme so the script uses the full path for *ptime* [n.b. alternatively use *pxtime*].
- Runs *pmerge* to merge OPC data with the corresponding SeaSoar 1second file sa321*nnn*_dist to get pressure and distrun. Files at this stage are named op321*nnn*.mrg. N.b. for this to work the OPC file time range must lie within that of the corresponding SeaSoar file, otherwise the merge will not work. The script tells you the ranges for the two files and if that of the OPC file does not

lie within that of the SeaSoar then exit. The OPC file op321*nnn* needs to be trimmed using *pcopya*. Then re-run the final part of opc1s with option 3 (i.e. to do this type: *opc1s 3*).

Script 2: opc2s

- Runs *gropc4* to grid OPC data into 7km x 8m bins and the size classes in the table below. The bin size is chosen to match that used for the processing of the SeaSoar Minipack data (so that the gridded files can more easily be merged later with the SeaSoar gr321*nnn* files).
- Merges gridded file with the navigation data to get latitude and longitude. Files at this stage are named op321*nnn*nav.spd

Note that *gropc4* handles particle class size boundaries using digital size values (DS) and these have to be supplied as bin widths – the programme assumes that the lowest bin starts with DS = 1. Here the bin width values 5, 17, 63, 230, 874, 1651 are used to generate the 6 equivalent spherical diameter (ESD) size classes given in **Table 5**. The size class boundaries are therefore at DS = 1, 6, 23, 86, 316, 1190 and 2841. Other size class distributions can be chosen if required by changing the bin widths. For more information see Focal Technologies (1999).

OPC size classes (µm)	
actual (ESD)	**nominal**
99.0676 - 247.4949	100 - 250
247.4949 - 497.8647	250 - 500
497.8647 - 1000.5470	500 - 1000
1000.5470 - 1999.3565	1000 - 2000
1999.3565 - 3999.5676	2000 - 4000
3999.5676 - 8000.4155	4000 - 8000

Table 5: OPC size classes selected for D321

Script 3: opcsplit

- Uses *pcopyg* to take output file from *gropc4* (i.e. op321*nnn*.spd) and create four files (op321*nnn*.250, op321*nnn*.500, op321*nnn*.1000, op321*nnn*.2000).

These contain the biovolume (in mm^3/m^3) and counts (no. of particles/m^3) in the size classes 250-500µm, 500-1000µm, 1000-2000µm and 2000-4000µm. In the process the variables are all given unique names using *pheadr*.

Script 4: opcjoin

- Uses *pjoin* (with option -loop) to concatenate the output files from the script opcsplit. The output file is op321*nnn*.all.

Essentially the processing is a variant of that on the MadEx cruise (D288; see Quartly, 2006). The two quantities calculated are biovolume in mm^3/m^3 and abundance in no. of particles/m^3. These are calculated for 4 standard nominal size classes 250-500 µm, 500-1000 µm, 1000-2000 µm and 2000-4000 µm. Here *gropc4* was set up to calculate data in 6 size classes (see above) but, because of the characteristics of the OPC, data in classes outside the range 250-400 0µm are not considered reliable, so those data are discarded. [N.b. they can be retrieved from the file produced at the end of the processing by the script opc2s – op321*nnn*nav.spd. Furthermore, the input to *gropc4* can be modified to produce data for different choices of size classes.] The biovolume is calculated from the equivalent spherical diameter (ESD) measurement of each zooplankton the OPC measures. To account for the non-sphericity of the zooplankton (Mustard and Anderson, 2005) a 0.61 multiplicative calibration factor is applied to the volume. As this is a linear calibration the biovolume calculated may easily be re-scaled, as required.

<u>*Initial data inspection*</u>

Assuming that the OPC is measuring mesozooplankton, during the first SeaSoar survey the mesozooplankton biovolume (mm^3/m^3) and abundance (no. of zooplankton/m^3) in the mixed layer were higher overall than during the second SeaSoar survey, consistent with the net hauls for zooplankton (down to 100m). The zooplankton distributions for both surveys were patchy, with zooplankton patchiness being related to phytoplankton patchiness (as seen in the SeaSoar fluorescence), though not in a simple manner. There was no evidence in the OPC data during the cruise of vertical migration (though evidence of this was found in the ADCP data – see ADCP backscatter section of this report). For both surveys biovolume peaked at ~140, 400, 500 and 1000 mm^3/m^3 and abundance peaked at ~6400, 2700, 500 and 150 no. of zooplankton/m^3 in the near surface for the size classes 250-500, 500-1000, 1000-2000 and 2000-4000 µm, respectively. However, for the second survey the high values were only found in a few small isolated patches and generally the biovolume and abundance were lower than for the first survey. Another characteristic difference between the surveys is that during the first survey the OPC measured a significant number of particles and biovolume amounts in the water column below the mixed layer in the two smaller size classes – 250-500 and 500-1000 μm. These were seen in plots of the data (not shown) as vertical streaks down to 400 m; uncorrelated with PAR, so not a signature of diel vertical migration. These vertical structures seem to be associated with high values of biovolume in the 2000-4000 μm size class in the mixed layer. It seems unlikely that these high values below the mixed layer are due to small zooplankton (as there are no phytoplankton at depth) and it is hypothesized that they may be small particles exported from the mixed layer. The vertical structure of the export flux can have a power law dependence, so this idea was tested by taking data from leg I of the first SeaSoar survey (below the mixed layer 50-40 0m), averaging the 250-500 and 500-1000 μm biovolume data along-track and then fitting a power law to the resulting measurements (see **Figure 13**). The fit to $depth^P$ has exponents P = -0.6047, -0.4011 and -0.4844 for the 250-500 and 500-1000 μm size classes and total biovolume, respectively. Fitting over the depth range 100-400 m gave similar results (P = -0.6965, -0.4458 and -0.5475). The fit is more convincing for the smaller size class particles (250-500 μm). Since the OPC does not identify what type of particle it is measuring, it is not possible to say whether these data actually represent the export flux of small particles from the mixed layer, but the results are suggestive of this (it is not clear what an alternative explanation might be).

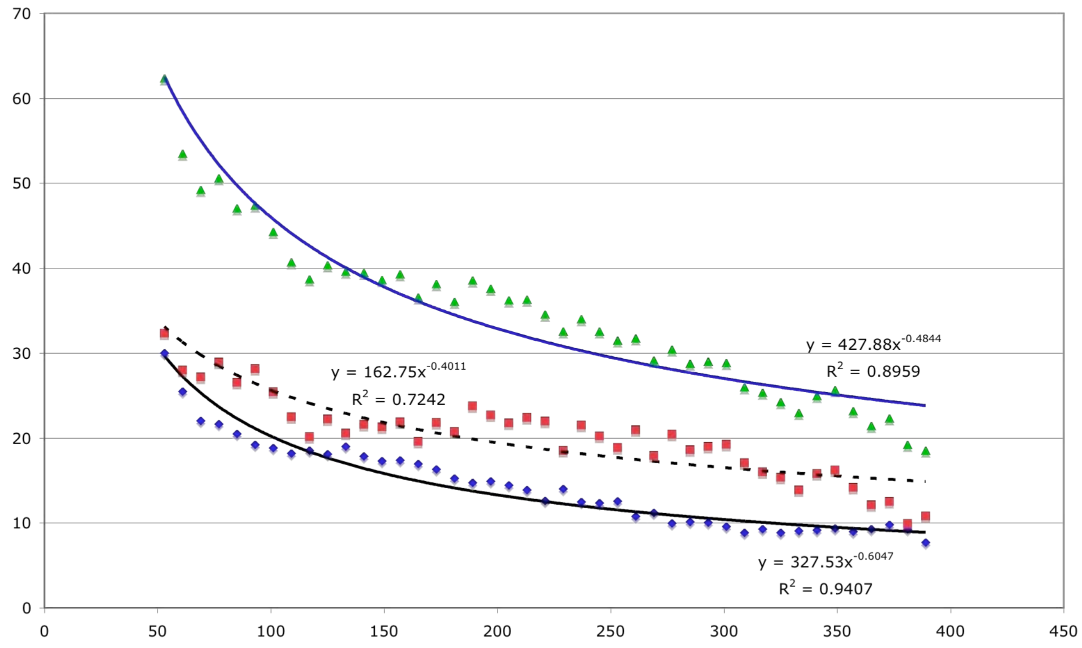


Figure 13: Plot of biovolume (mm^3/m^3) in two size classes (250-500, 500-1000µm; blue diamonds, red squares) and their sum (green triangles) as a function of depth over 50-400m, that is, below the mixed layer. Fitted lines are power law relationships. The data are from leg I of the 1st SeaSoar survey averaged along-track over the whole leg.

ADCP Backscatter - *Meric Srokosz*

Backscatter from both the RDI 150kHz ADCP and Ocean Surveyor 75kHz ADCP were examined during the cruise to determine whether diel vertical migration was occurring for the larger zooplankton; those of O(1-2cm) in size; that is, zooplankton larger than those that can be measured by the OPC. As there was no means of calibrating the 75kHz data to obtain absolute backscatter, the raw data from the four beams was examined (n.b. that is the variables *intense1* to *intense4* in the PSTAR data files). Clear signals of diel vertical migration were seen in the data (an example is shown in **Figure 14**; clear signal of migration to ~450 m). These signals were consistent among the four beams, though the values of the measured backscatter did differ from beam to beam.

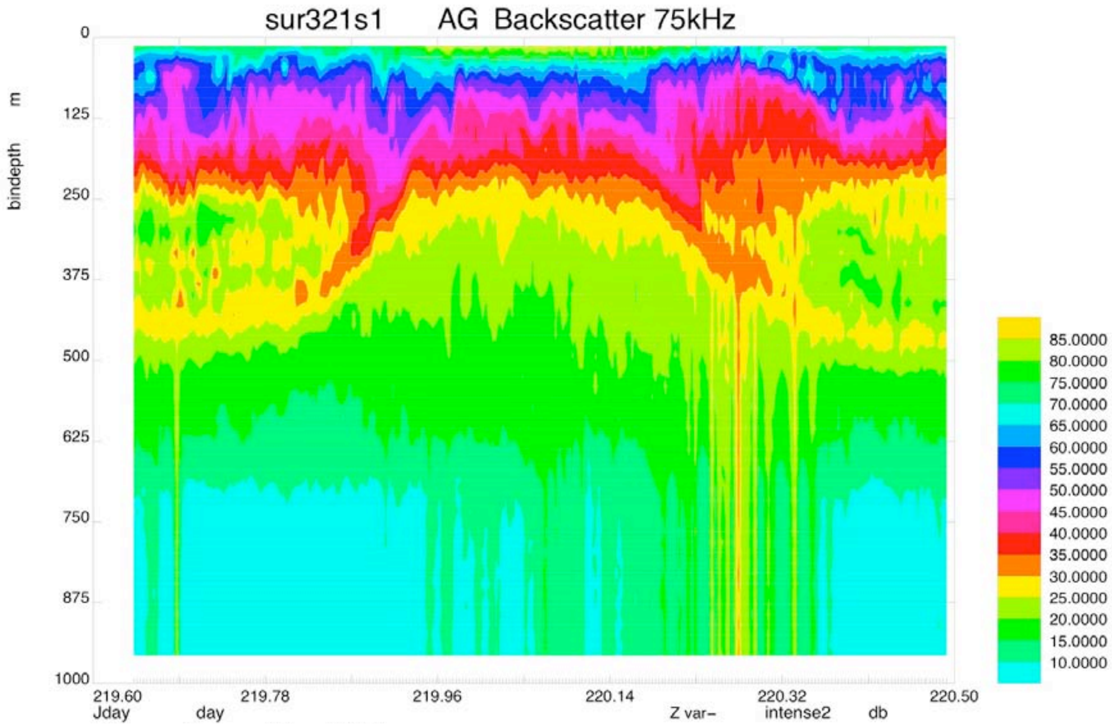


Figure 14: 75kHz ADCP backscatter (dB) from beam 2 during the first SeaSoar survey (data from the other three beams is similar), as a function of depth and Jday.

In principle, the 150kHz ADCP backscatter data (variable *ampl* in the PSTAR data files) can be calibrated to absolute backscatter using the *pexec* programme *amplcal* (or variants thereof). An attempt was made to calibrate the 150kHz data using old information on the RDI instrument, but the results did not show much difference from the raw backscatter values (n.b. the current instrument on RRS *Discovery* is the one that was previously fitted to RRS *Charles Darwin*). Therefore, the raw 150kHz backscatter data were used to look for diel vertical migration. Diel vertical migration was seen in the data, but the signature in the backscatter was less pronounced than that found in the 75kHz data (compare **Figure 15** with **Figure 14** – note that the 150kHz ADCP does not penetrate the water column as far as the 75kHz ADCP).

The fact that the backscatter signals observed are due to diel vertical migration is confirmed by the PAR (light) data from SeaSoar corresponding to the 75kHz and 150kHz data (compare **Figure 16** to **Figures 14** and **15**). These observations of diel vertical migration are consistent with the samples collected in the vertical net hauls at night, which showed significant numbers of larger zooplankton present in the water column. Examination of the SeaSoar OPC data did not reveal any obvious signal of diel vertical migration, which suggests that the smaller (<2 mm) zooplankton remain inn the surface layer during the day. Note that the characteristics of the OPC and the ADCPs mean that little can be said about zooplankton in the size range 2 mm-1 cm.

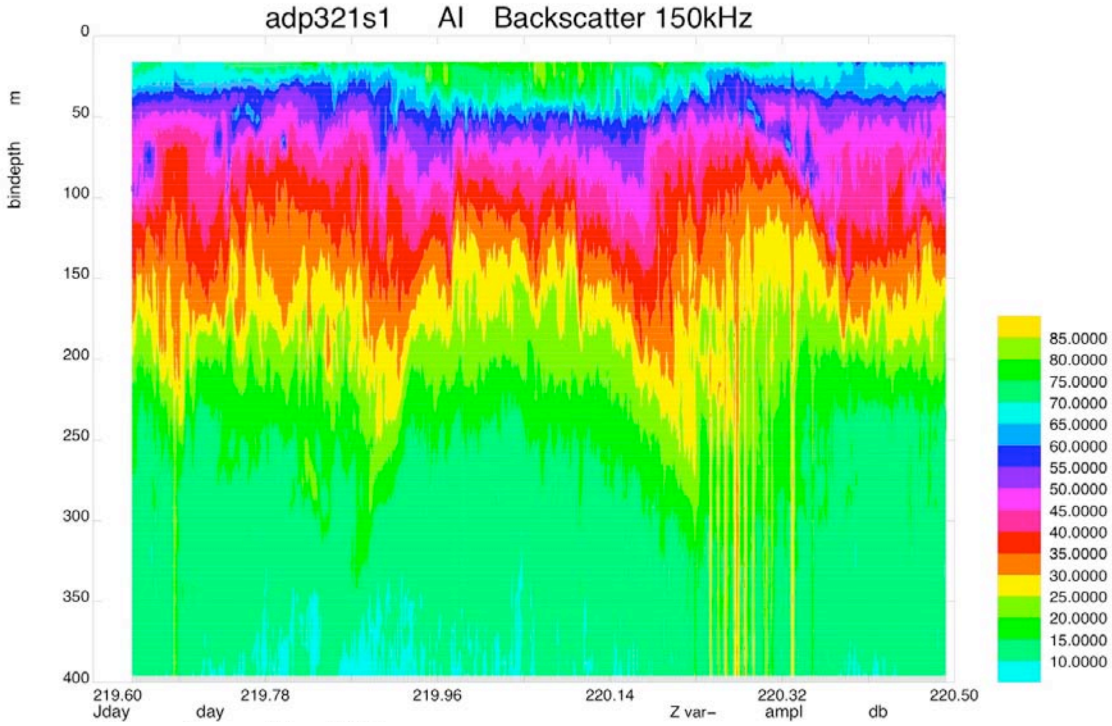


Figure 15: 150kHz ADCP backscatter (dB), as a function of depth and Jday, corresponding to **Figure 14** (note different depth scale).

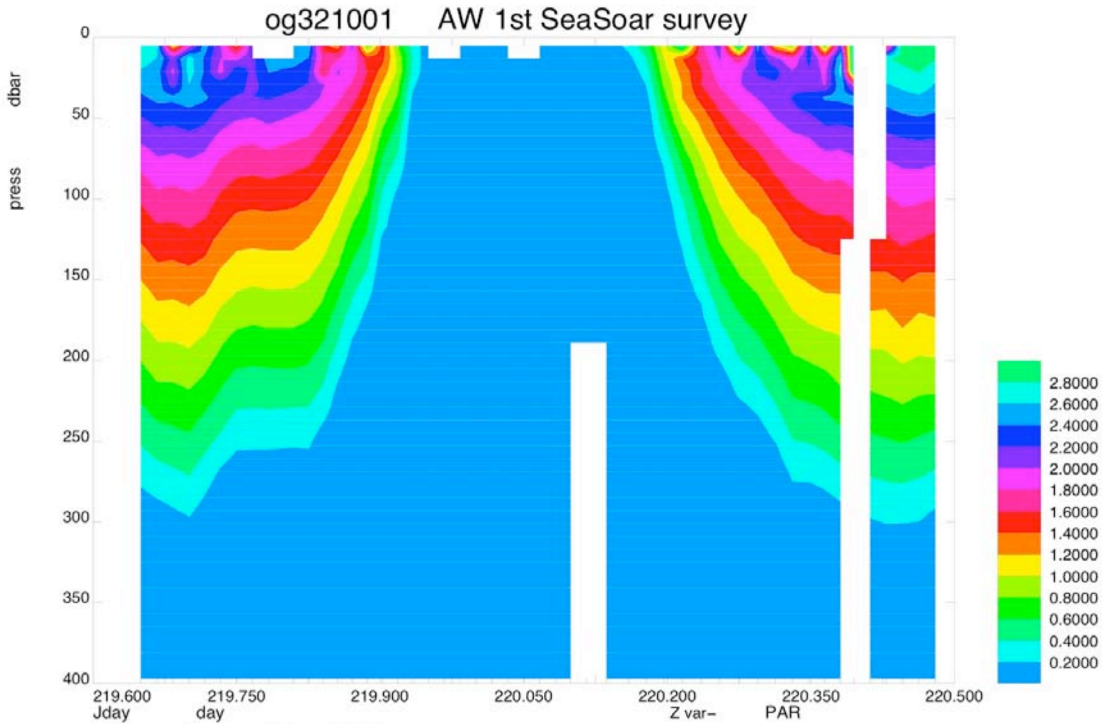


Figure 16: PAR data (uncalibrated) from SeaSoar, as a function of depth and Jday, corresponding to the period of 75kHz and 150kHz backscatter data in **Figures 14** and **15** (above).

Dissolved Oxygen Concentration – *Mark Stinchcombe, Richard Sanders*

Cruise objectives

The objective of the dissolved oxygen analysis was to provide a calibration for the oxygen sensor mounted on the frame of the CTD for cruise D321 to the Icelandic Basin in the North Atlantic. For this, a Winkler titration was done from a number of water samples from the niskins bottles mounted on the CTD frame.

Methods

Dissolved oxygen samples were only taken from the CTD casts and they were the first samples to be drawn from the niskin bottles. Six to ten oxygen samples were taken from the niskin bottles that had fired. The depths sampled were decided by the trace from the oxygen sensor on the CTD, which provided near to real time results. Samples for calibration of the sensor are best taken where there are no gradients in the concentration of oxygen, so where the trace appears flat. The samples were drawn through short pieces of silicon tubing into clear, pre-calibrated, wide-necked and short-necked glass bottles. The temperature of the sample water at the time of sampling was measured using an electronic thermometer probe. The temperature would be used to calculate any temperature dependant changes in the sample bottle volumes. Unfortunately, the thermometers broke on station 16233 (S1G1). After this no temperatures could be recorded. We'll hopefully be able to read the temperature off from the bottle files recorded by the Seabird software. Each of these samples was fixed immediately using 1 ml of manganese chloride and alkaline iodide. The samples were shaken thoroughly and then left to settle for approximately 30minutes before being shaken again. The samples were then left for a few hours before analysis.

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 colourimetric endpoint detection with equipment supplied by SIS, was used to determine the oxygen concentration.

The normality of the sodium thiosulphate titrant was checked using a potassium iodate standard. This was done four times throughout the cruise. Thiosulphate standardisation was carried out by adding 5 ml iodate solution after the other reagents had been added to a water sample in reverse order. The sample was then titrated and the volume of sodium thiosulphate required was noted. This was repeated 5 times and the average amount of sodium thiosulphate required was calculated. This standardisation was then used in the calculation of the final dissolved oxygen calculation. The change in sodium thiosulphate required to titrate 5ml of potassium iodate can be seen in **Figure 17**.

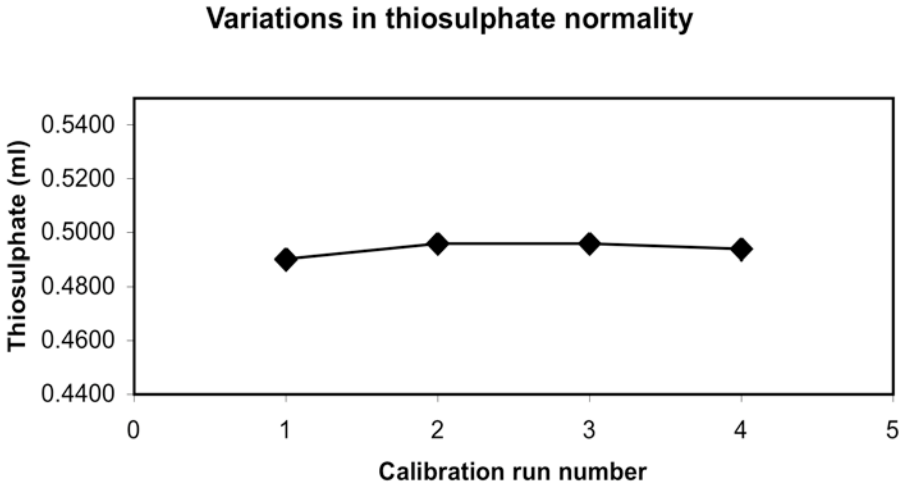


Figure 17: The volume of sodium thiosulphate required to titrate 5 ml of potassium iodate. There was little drift over the course of the cruise, implying that degradation of the sodium thiosulphate was kept to a minimum.

A blank was also carried out to account for the oxygen in the reagents. The reagents were added in reverse order, as for the sodium thiosulphate standardisation, and then 1 ml of the potassium iodate standard was added. This was titrated and the volume of sodium thiosulphate required was noted. 1 ml was again added to the same sample and it was titrated again. This was again repeated. The average of the second two volumes of sodium thiosulphate was subtracted from the first volume. This whole process was repeated three times in total and the average blank was taken and used in the calculation of the final dissolved oxygen calculation.

Unfortunately, due to time constraints and the number of casts and depths sampled, we weren't able to fully work up the data on the ship. This will be done back at NOCS.

Inorganic Nutrient Analysis – *Mark Stinchcombe, Richard Sanders*

Cruise Objectives

Our objective for cruise D321 to the Icelandic Basin, was to measure the in-situ concentrations of the inorganic nutrients, nitrate, silicate and phosphate, using segmented flow analysis.

Method

Analysis for micro-molar concentrations of nitrate and nitrite (hereinafter nitrate), phosphate and silicate was undertaken on a scalar sanplus autoanalyser following methods described by Kirkwood (1996) with the exception that the pump rates through the phosphate line are increased by a factor of 1.5, which improves reproducibility and peak shape. Samples were drawn from niskin bottles on the CTD into 25 ml sterilin coulter counter vials and kept refrigerated at approximately 4°C until analysis, which commenced within 24 hours. Stations were run in batches of 1 to 5 with most runs containing 2 or 3 stations. Overall 37 runs were undertaken with 2146 samples being analysed in total. This broke down as 1502 CTD samples, 260 underway samples and 384 samples analysed for other cruise participants. An artificial seawater matrix (ASW) of 40g/L 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) nutrient free seawater on every run. A single set of mixed standards were made up by diluting 5 mmol L^{-1} 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. Data processing was undertaken using Skalar proprietary software and was done within 72 hours of the run being finished. The wash time and sample time were 90 seconds; the lines were washed daily with 0.5 mol L^{-1} sodium hydroxide and 10% Decon. Time series of baseline, instrument sensitivity, calibration curve correlation coefficient, nitrate reduction efficiency and duplicate difference was complied to check the performance of the autoanalyser over the course of the cruise.

Performance of the Analyser

On the whole the analyser performed very well. The noise level of all three chemistries appeared lower than it has been on a few previous cruises. The problems with the catastrophic failure of the phosphate baseline appear to have been solved. This problem seems to be a result of not being cleaned thoroughly. On previous cruises, the baseline of the phosphate chemistry would suddenly and dramatically jump and would take time to return to normal, making the samples that were being run at the time, unreadable and so they would have to be repeated. The problem would normally right itself after a good shake of the flowcell, which would indicate that it was something stuck in the flowcell. On this trip we would wash the lines thoroughly with 0.2 mol L^{-1} sodium hydroxide and 10% decon, sometimes up to a litre of each over the course of a few hours, to make sure the lines are clean. Catastrophic failure of the phosphate baseline was seen a couple of times during this cruise, but only after the analyser had been run for upwards of 12 hours without cleaning due to heavy sample load. The problem was solved by quickly shaking the flowcell, re-running any ruined samples, and cleaning the lines after the end of the run.

The main problem that was experienced over the whole of the cruise was a decrease in the signal from the nitrate line. This resulted in a lower intensity signal being received and so the peak heights were all much lower than would be expected. For example, on D285 and D286, we ran a 30 μmol L^{-1} nitrate standard, which gave a reading of approximately 3,000 digital units. During D321 we ran a 30 μmol L^{-1} nitrate standard that gave a reading of between 800 to 1,200 digital units. Despite changes in reagents, software and hardware, the problem could not be solved. The noise level of the baseline was sometimes higher than expected as a result, but generally the noise level was as reduced as the peak heights. As all samples had a relatively high nitrate value (even above 1.5 μmol L^{-1} for the surface samples) the problem of trying to pick out peak heights that were of a similar level to the noise was not encountered.

The general performance of the analyser was monitored via the following parameters: Sensitivity, baseline value, regression coefficient of the calibration curve, nitrate reduction efficiency and the error in duplicate samples. Time series of these parameters are shown in **Figures 18** through **21**.

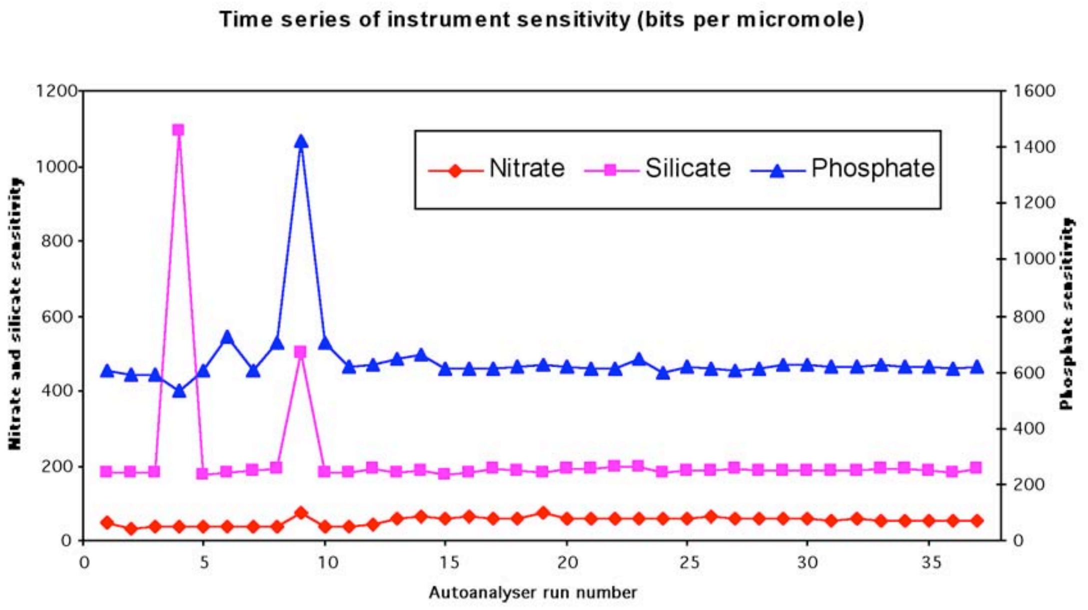


Figure 18: The sensitivity of the analyser in bits per micromole.

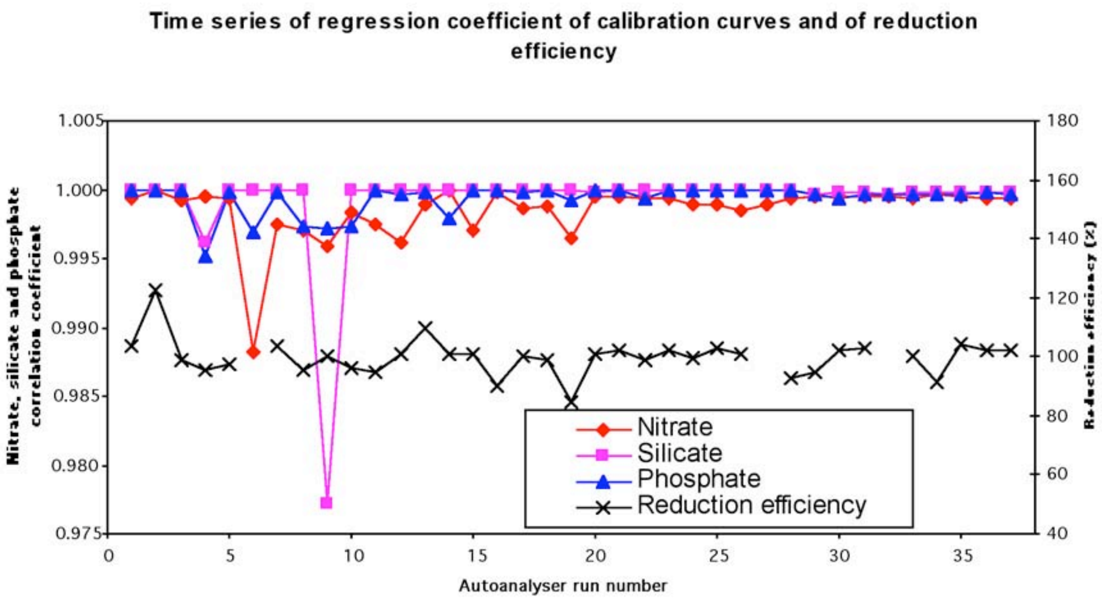


Figure 19: The regression coefficients of the calibration curves for all three chemistries and the efficiency of the cadmium column in the nitrate line.

The sensitivity of the analyser stayed relatively constant throughout the cruise (**Figure 18**). There was only one run that showed a different sensitivity in all three chemistries, run nine, and only one other run where any significant change was observed. This was on the silicate line on the 4th run. This run was repeated as the baseline values were also significantly different (**Figure 20**).

The regression coefficients of the calibration curves for all three chemistries were all higher than 0.975 (**Figure 19**). Only two fell outside 0.995 whilst more than 50% of them were above 0.999. Nitrate consistently had below 0.999, which was, in part, due to the intensity problem in the nitrate line. The reduction efficiency of the cadmium column never got below 85%, though all bar 5 runs were above 95% (**Figure 19**). This gives us good confidence in the reduction of nitrate through the cadmium column.

The time series of the baseline values shows that there was a large jump in the baseline values for nitrate and silicate after run 11 (**Figure 20**). This coincided with a new artificial seawater solution being made up after a contaminated batch had been noticed before (though not used for many runs). There was also a large shift in the baselines on run 4, the same run as the shift in sensitivity for silicate. As mentioned before, this run was repeated.

The time series in percentage error between duplicates (**Figure 21**) was calculated by comparing the values of the first two drift samples analysed on each run for each chemistry. All bar seven runs came in below a 3% error margin. The silicate chemistry was always below 3%, whilst nitrate had three runs that were above 3% (the highest being 14%) and phosphate had four runs above 3% (the highest being about 9.5%).

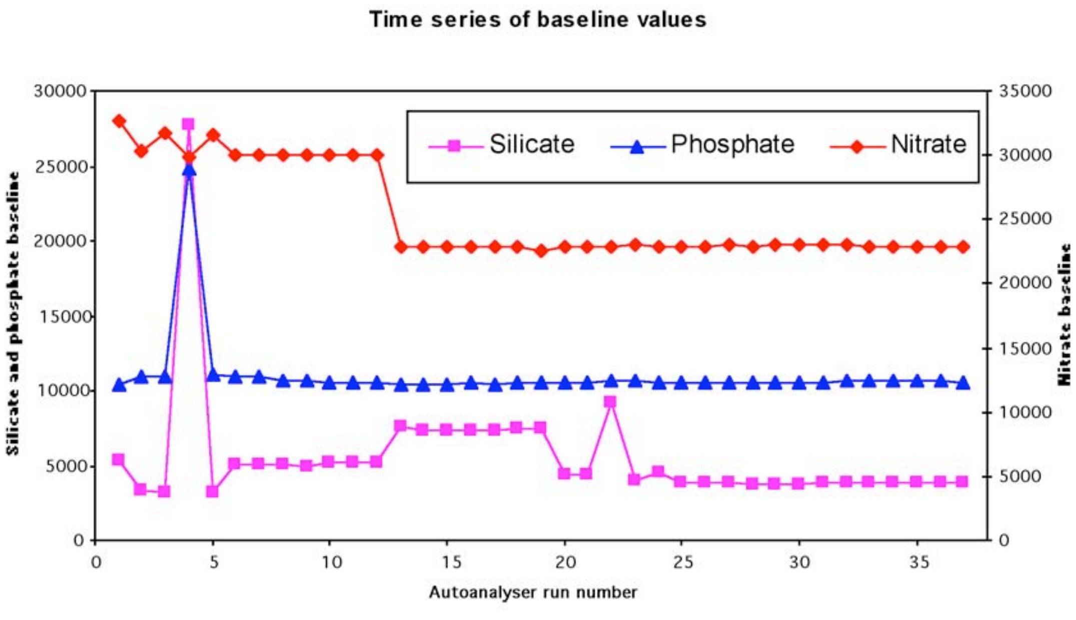


Figure 20: The baseline values for all three chemistries.

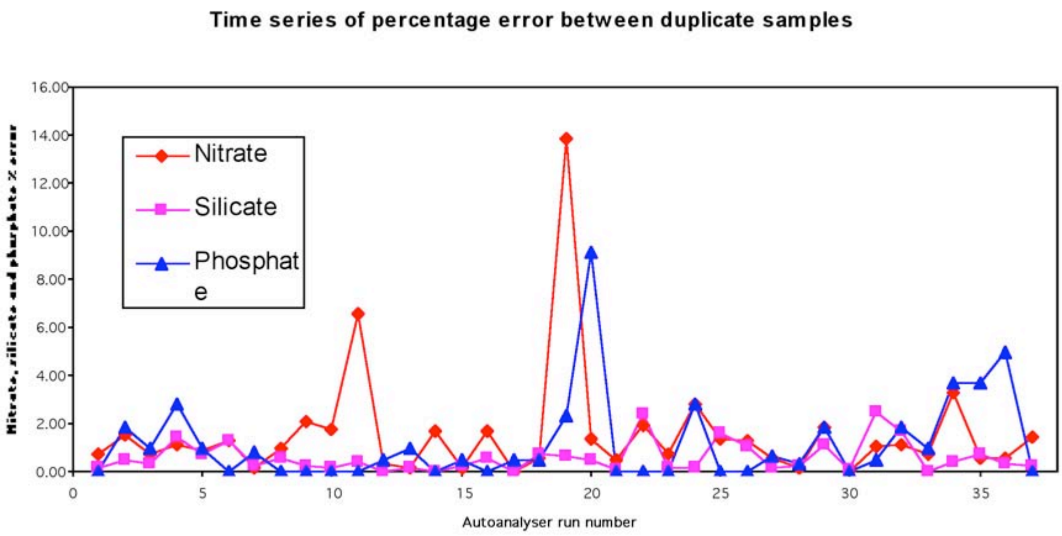


Figure 21: The time series of % error for each chemistry calculated from duplicate drift samples.

Iron Biogeochemistry in the Iceland Basin - *Maria Nielsdóttir, Eric Achterberg, Mark Moore*

<u>Introduction</u>

Iron is an essential element for all living organisms and is of major importance for aquatic photosynthetic organisms. Due to the insolubility of Fe(III) the concentration of iron in oxygenated seawater is extremely low (<0.5 nmol L^{-1} in the open ocean). Iron is supplied to the surface ocean via atmospheric transport of dust and its deposition, as well as by upwelling, entrainment, or mixing of deeper waters relatively rich in nutrients and metals.

<u>Sample method</u>

Underway:

Samples were taken from a metal tow-fish that was towed at the stern on port side of the ship. Tubing went from the fish into the container where it was pumped through with a Teflon diaphragm pump.

Underway samples were filtered online through a 0.2 μm Sartorius Sartobran filter. All underway samples were acidified to a pH~1.8 with ultra pure HCl from Fisher.

Profiles:

Profiles were carried out with the Titanium frame CTD. 12 bottles were designated "iron-clean" and were washed twice with 10% HCl, before first ctd and after a couple of days usage. The bottles were carried to and from the Ti-frame to the clean container where they were sampled. Pressure filtration with nitrogen free oxygen was used for dissolved iron (0.4 μm and 0.2 μm). Unfiltered samples were also taken at various stations.

Samples were taken from 9-10 horizons. All samples were acidified to a pH~1.8 with ultra pure HCl from Fisher.

Analysis of iron

Dissolved iron was measured using the flow-injection chemiluminescence method by Obata (1993) and modified by de Jong (1998). Samples were buffered with ammonium acetate to a pH=4 and pre-concentrated on a resin column during analysis. Each sample took 20 min to analyse. Determination of the dissolved iron concentration was calculated with standard addition and area integration. Each sample was run in triplicate.

Results

13 profiles were sampled (see table 1) and 54 underway samples from the tow-fish. The samples were analysed onboard with flow injection chemiluminescence.

Dissolved iron surface concentrations ranged from 0.02 to 0.3 nmol L^{-1}. The profiles had a nutrient like shape (**Figure 22**).

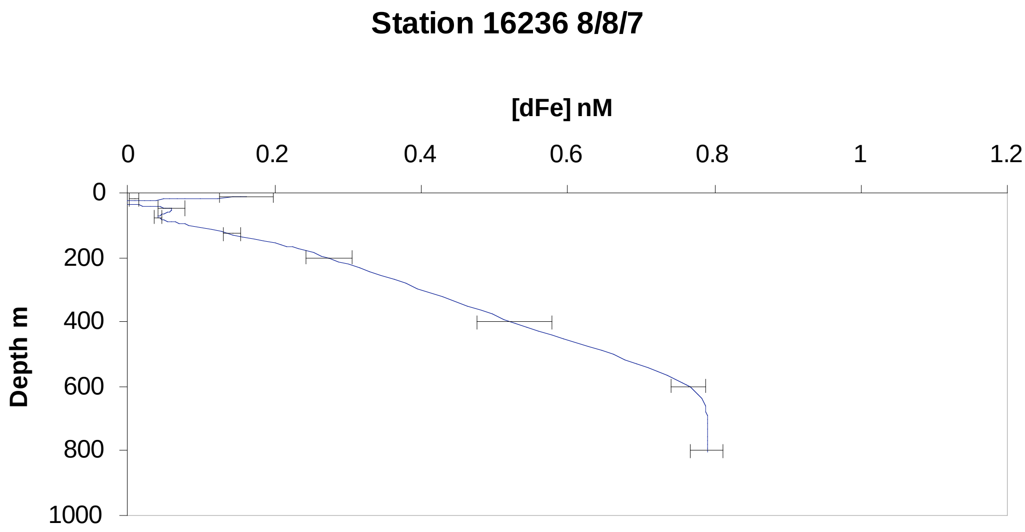


Figure 22: Depth profile of dissolved iron concentration for *Discovery* stn. 16236.

Date	Station	on deck	latitude	longitude	
29.07.07	16204	05:57	59 59.25N	19 51.91W	PP
30.07.07	16209	02:09	59 42.63N	20 26.70W	PP
31.07.07	16212	03:53	59 41.86N	18 45.05W	PP
02.08.07	16222	04:05	58 51.57N	19 52.43W	PP
05.08.07	16226	04:30	58 49.82	21 00.23w	PP
07.08.07	16237	05:15	59 9.90N	18 52.73W	BIOASSAY
08.08.07	16236	18:32	59 42.03N	19 51.38W	NON-PP
10.08.07	16247	03:09	59 59.25	20 28.49W	PP
12.08.07	16260	04:38	59 11.61N	19 7.01W	PP
16.08.07	16282	15:16	59 24.25N	20 36.13W	PP
16.08.07	16282	15:16	59 24.25N	20 36.13W	NON-PP
18.08.07	16285	02:21	59 39.80	18 43.98W	PP
19.08.07	16286	08:08	59 14.44	18 46.20W	PP

Table 6: List of stations at which dissolved iron concentration profiles were determined: primary productivity stations marked (PP).

Equipment

The clean container: The UKORS clean container was used as the trace metal laboratory. All worked fine and was in excellent condition.

Active Chlorophyll Fluorescence Measurements (FRR and FIRe fluorometery) - *Mark Moore*

Introduction

Active chlorophyll *a* fluorescence is a non-invasive method of probing phytoplankton photophysiology by providing information on the functioning of photosystem II within the photosynthetic apparatus (Kolber *et al.,* 1998; Suggett *et al.,* 2005). Changes in biophysical parameters measured by active fluorescence techniques can then be used to infer the factors influencing phytoplankton growth in situ, including nutrient and light availability/stress (e.g. Greene *et al.,* 1994). During D321a a number of active chlorophyll fluorometers were employed in a variety of modes including continuous underway measurements, in situ measurements and analysis of discrete samples from CTDs and bioassay experiments. Two of the instruments, the FAST*tracka*™ I and II using the Fast Repetition Rate (FRR) technique, were manufactured by Chelsea Technologies Group (CTG) (UK). A third instrument, using the so-called Fluorescence Induction and Relaxation (FIRe) technique, was manufactured by SATLANTIC (Canada). Initial comparisons between trends in photophysiological parameters measured by the 3 instruments were reasonable (**Figure 23**). However, further analysis is clearly desirable in order to resolve discrepancies in absolute values and reduce the variability. For example potential artifacts in the retrieval of parameters from fluorescence induction curves are well known and studied for the FAST*tracka*™ I (Laney, 2003; Suggett *et al.,* 2005) and similar work will also likely be required for the FAST*tracka*™ II and FIRe instruments. Detailed analysis of calibration and blank data collected during D321 should enable more satisfactory comparisons to be performed. The FAST*tracka*™ I performed according to previous experience (Moore *et al.,* 2005; 2006). FIRe measurements on natural populations were also comparable with previous experience with dilute suspensions of laboratory cultures (Suggett and Moore, unpublished data). As far as the author is aware D321a represented the first use of the FAST*tracka*™ II instrument on natural oceanic phytoplankton populations. The instrument appeared to perform well in terms of measurement capability, being at least as sensitive as the other two instruments (**Figure 23a**) and was considerably more versatile than the earlier FAST*tracka*™ I (**Figure 23b**). However, much further development is required, particularly in terms of firmware, which completely compromised the effective use of this instrument on SeaSoar (see below).

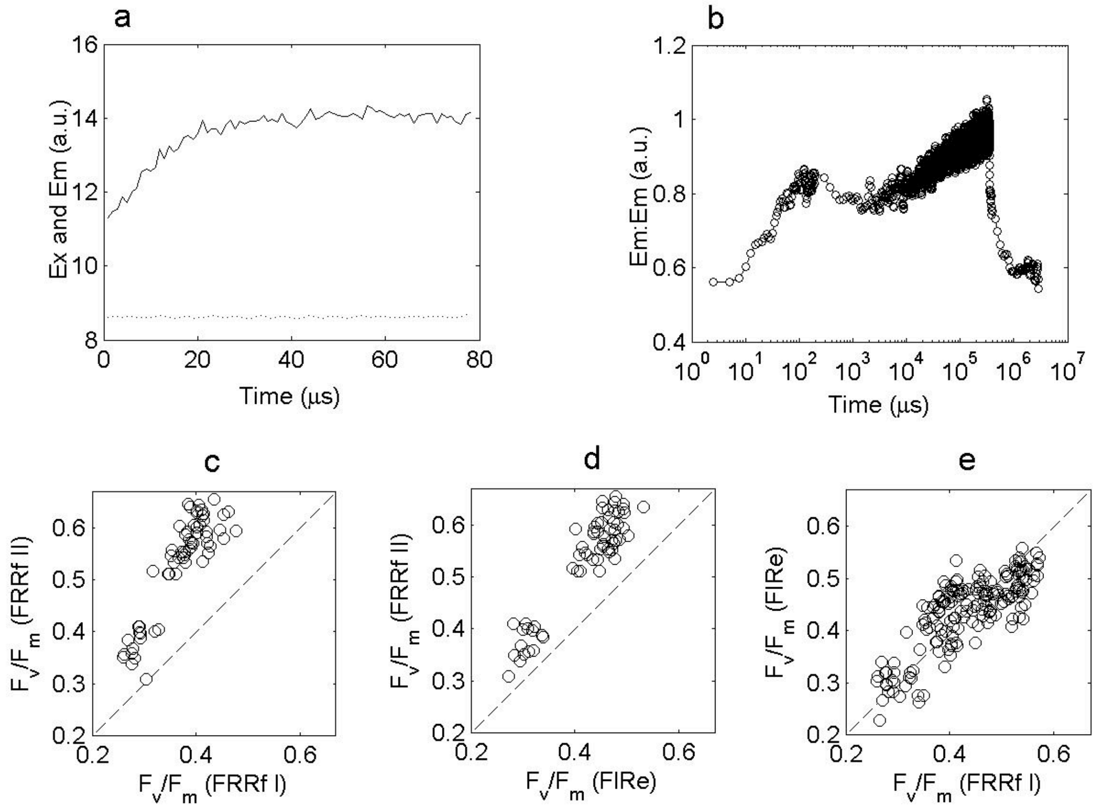


Figure 23: Examples of active fluorescence data. (a) Example excitation (dotted line) and emission (solid line) measured over 200 μs of a single turnover (ST) measurement of the primary stable PSII acceptor (Q_a) using FAST*tracka*™ II FRRf (b) ST turnover (1-200 μs) followed immediately by a multiple turnover (200 μs – 500 ms) which fully reduces the PQ pool between PSII and PSI as well as Q_a and relaxation phase (500 ms – 3 s) (see Kolber *et al.*, 1998). (c-d) example comparisons of F_v/F_m measured on discrete samples using different instruments/techniques.

<u>*Underway measurements on ships non-toxic supply*</u>

A CTG FAST*tracka*™ I FRRf was connected to the ships non-toxic supply within the bottle annex in order to monitor the physiological state of photosystem II (PSII) within the surface phytoplankton population throughout the study area. Saturation of variable chlorophyll fluorescence was performed using 100 flashlets of 1.1 μs duration with a 2.3 μs repetition rate. Subsequent relaxation of fluorescence was monitored using flashlets provided at 98.8 μs spacing, giving a total relaxation protocol length of around 2 ms.

The data were stored internally on the instrument and downloaded at between 1 and 3 day intervals throughout D321a (**Table 7**). Instrument optics were cleaned whilst the download operation was being carried out. Fouling of the optical surfaces during 2-3 day sample collection periods resulted in daily download and cleaning being employed from file 8 onwards. A total of 21 files were collected. Data were then analysed using custom software in a Matlab™ environment. Surface patterns were dominated by complicated diel signals in the parameters which can be measured by an FRRf deployed in this mode (F_v'/F_m' and σ_{PSII}'). In particular, in addition to the typical depression of F_v'/F_m' during daytime, a marked increase in F_v'/F_m' was also observed following dawn on most mornings (**Figure 24**).

	Start date	**Start time**	**End date**	**End time**	**Gain**
UW1	27/07	1227	28/07	1157	4
UW2	28/08	1228	30/07	1554	4
UW3	30/07	1642	31/07	1513	4
UW4	31/07	1352	02/08	1434	4
UW5	02/08	1449	04/08	1429	4
UW6	04/08	1445	07/08	1459	4
UW7	07/08	1522	09/08	1202	4
UW8	09/08	1221	10/08	0630	4
UW9	10/08	0638	10/08	1727	1
UW10	10/08	1743	11/08	1705	4
UW11	11/08	1714	12/08	1636	4

UW12	12/08	1637	13/08	1420	4
UW13	13/08	1435	14/08	1715	4
UW14	14/08	1724	15/08	1642	4
UW15	15/08	1647	16/08	1920	4
UW16	16/08	1943	17/08	1613	4
UW17	17/08	1621	18/08	1559	4
UW18	18/08	1607	19/08	0707*	4
UW19	19/08	1658	20/08	1715	4
UW20	20/08	1721	21/08	1448	4
UW21	21/08	1455	22/08	~2100**	4

Table 7: Underway sampling files, dates and times. * indicates instrument stopped logging, suspect keyboard was accidentally knocked while terminal window was open. ** file still being collected at time of writing

Measurements on SeaSoar

The initial intention was to employ a CTG FAST*tracka*™ II FRRf on SeaSoar, logging data in real time using the PENGUIN control and data acquisition system. However, the current version of the firmware installed on this instrument did not allow for continuous output of the full data from each flashlet (as could be recorded internally), nor is there currently any capacity to average fluorescence sequences internally. Consequently, in order to obtain data at sufficient temporal resolution on SeaSoar, large files were generated very rapidly (0.5 Gb on flashdisk within ~12 hours). This would have proved prohibitive in terms of download time, which was currently only achievable in ASCII format. Additionally, once the flashcard was filled, the instrument failed to respond to commands. Finally, when used without a ‘dark chamber’, the instrument would often become non-responsive and display an ‘Ambient light PMT error’. This not only occurred on deck, but also whilst the instrument was being towed.

Consequently, following a largely unsuccessful deployment on survey S1, a CTG FAST*tracka*™ I FRRf was flown on the SeaSoar instrument package for survey S2. Data collection from this instrument was also handled using the PENGUIN control and data acquisition system as performed on previous cruises, D253 (FISHES), JR98 and D285 (CROZEX). Instrument setup was identical to that used during D253 and D285. Saturation of variable chlorophyll fluorescence was performed using 100 flashlets of 1.1 μs duration with a 2.3 μs repetition rate. The instrument gain setting was fixed at a value of 4.

Processing of the data was performed in Matlab™ using custom codes written during D253 (FISHES). Data were then merged with the depth record from the minipack. Initial quality checks indicated no significant problems with the deployment strategy other than those inherent to the FAST*tracka*™ I FRRf instrument and well documented elsewhere (Laney, 2003; Suggett *et al.*, 2005). As expected, diel variability in parameters recorded using the underway measurements were also observed in SeaSoar data, potentially complicating analysis in terms of spatial variability in photophysiology (**Figure 24**).

Discrete measurements of samples from CTDs and bioassays

Discrete samples from a limited number of CTD casts and all the Fe addition bioassays were run through all three active fluorometers. Samples were collected from bottles fired at 5, 10, 20, 27, 32, 47 and 75m for CTDs from stations 16222, 16226, 16243, 16244, 16247, 16253, 16254, 16256, 16257, 16260, 16261, 16262, 16268, 16270, 16273 and 16285 in order to further investigate observed diel patterns (**Figure 24**).

Samples collected from bioassays and CTDs were allowed to relax in the dark for >30 minutes prior to being measured. Data from all three instruments were analysed using custom codes within Matlab™.

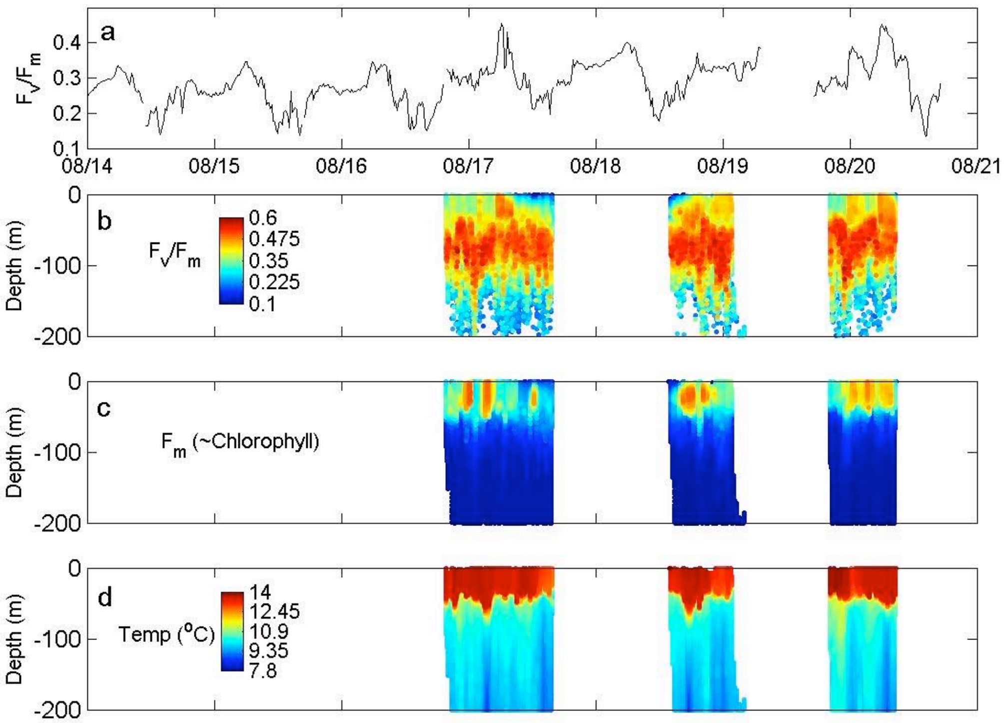


Figure 24: Examples of diel patterns and SeaSoar data. (a) Subset of data collected using FAST*tracka*™ I FRRf on underway system for period from 14-21 August 2007 (b-c) in situ data collected using FAST*tracka*™ I on SeaSoar undulator during Survey S2. (b) Fv/Fm, (c) Fm which will be roughly proportional to in situ chlorophyll concentration, (d) raw potential temperature from minipack.

Nutrient Addition Bioassay Experiments - *Mark Moore, Maria Nielsdotir, Eric Achterberg, Mike Lucas*

Nutrient addition bioassay experiments were performed to investigate the inter-dependence of iron (Fe) and light availability on phytoplankton physiology, growth and nutrient drawdown. Experiments were similar in design to those performed during D285 (CROZEX).

Strict controls were required to avoid contamination of incubation containers and sampled water. Incubations were performed in acid washed 4.5 L polycarbonate bottles. Bottle filling and all manipulation steps including spiking and sub-sampling were performed within the dedicated Class-100 clean air filtered container. Samples were either collected from the 12 bottles reserved for trace metal clean work on the Ti

CTD rig (E01-E03) or from the trace metal clean sampling fish (E04). Following filling, bottles were sealed with Parafilm, then double bagged before being incubated on deck at 33 or 4.5% of the above water irradiance and at sea surface temperature. Despite the precautions taken it was suspected that the first experiment (E01) was contaminated, with initial measured Fe concentrations of 0.5-1.1 nmol L^{-1} being considerably higher than in situ values.

A total of four experiments lasting 5-6 days each were carried out during D321a. A complete list of experiments along with sampling locations and initial conditions is provided in **Table 8**.

The experimental design involved the incubation of 12 bottles in 4 sets of 3 replicates, one each for high light (control and +Fe) and low light (control and +Fe), although for experiment 2 the low light treatments were replaced with a silicate treatment. Bottles were sub-sampled every 2 days.

Sampling was routinely performed for chlorophyll, macronutrients (N, P and Si) and PSII characteristics as measured by active chlorophyll fluorescence (see above). Additional sampling at the end time point consisted of POC/PON, HPLC and preservation of samples in lugols iodine for phytoplankton counts. In order to assess contamination and drawdown, samples were also collected for Fe analysis at the end of the experiments.

Despite potential contamination problems, preliminary results appeared satisfactory. Relatively few experiments on the combined effects of Fe and light availability have been performed in the field, and none in the current study region. Preliminary results from experiment 3 are presented below (**Figure 25**) for illustration.

	E01	E02	E03	E04
Sampling station	**16212**	**16237**	**16274**	**16279**
Sampling method	Ti CTD	Ti CTD	Ti CTD	Trace clean fish
Start date	31st July	7th August	14th August	15th August
End date	6th August	13th August	20th August	21st August
Initial chlorophyll concentration	0.25 ± 0.01	0.24 ± 0.01	0.39 ± 0.02	0.37 ± 0.002
Initial Nitrate concentration	1.29 ± 0.03	3.27 ± 0.02	5.0 ± 0.02	2.88 ± 0.03
Initial Silicate concentration	0.09 ± 0.01	0.33 ± 0.01	0.70 ± 0.01	0.35 ± 0.01
Comments	Likely contaminated	Silicate addition used rather than low light level, potentially contaminated.		

Table 8: Sampling methods, locations, dates and initial conditions for bioassay experiments.

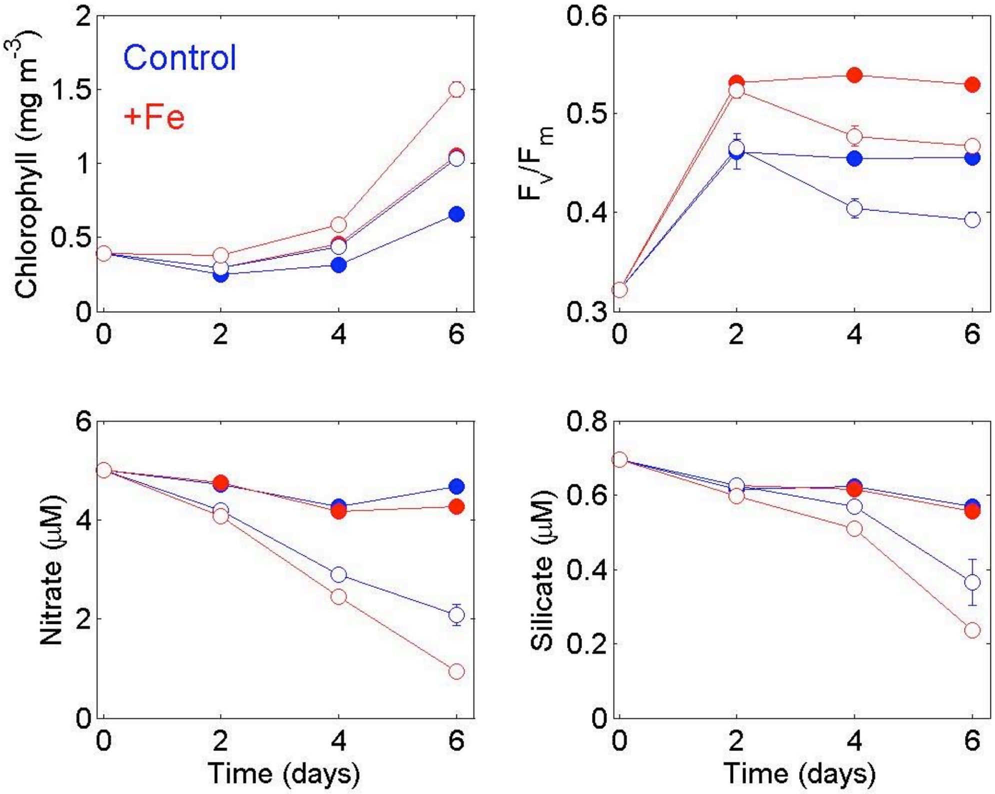


Figure 25: Preliminary results from experiment E03. Open symbols indicate samples incubated at high light (33% above water irradiance), Closed symbols indicate samples incubated at low light (4.5% above water irradiance). Error bars indicate ± 1 s.d. for triplicate bottles and are frequently less than symbol size.

HPLC / Microscopy Samples - *Young-Nam Kim*

Preserved samples of phytoplankton (~700 samples) were collected from various light depths (3-7 depths) from all CTD stations. Samples were preserved with 1-2% acidified Lugols solution and 20% buffered formalin solution and stored in 150 ml brown, tightly stopped bottles until further analysis with light microscopy in the laboratory. Sampling stations and depths shown in **Table 9**.

CTD#	Station	5m	10(15)m	20m	27(25)m	32(30)m	40m	47(50)m	75m
16195	IB6	O	O			O	O	O	O
16196	IB7	O	O			O	O	O	O
16197	IB8	O			O			O	
16198	IB9	O	O		O				O
16199	IB10	O	O		O				O
16202	C1A5	O		O		O		O	O
16203	C1A4	O		O		O			O
16204	C1A3	O	O	O	O	O		O	O
16205	C1A2	O			O			O	O
16207	C1A1	O			O			O	O
16208	C1C1	O		O		O			O
16209	C1C2	O	O	O	O	O		O	
16210	C1C3	O		O				O	O
16211	C1C4		O	O				O	O
16212	C1C5	O	O	O	O	O		O	
16213	C1E5		O	O				O	O
16214	C1G5		O	O				O	O
16215	C1I5	O		O				O	O
16216	C1I4		O	O				O	O
16217	C1G4		O	O				O	O
16218	C1E4		O	O				O	O
16220	C1E3	O		O				O	O
16221	C1G3	O		O				O	O
16222	C1I3		O	O		O		O	O
16224	C1I2	O		O				O	O
16225	C1G2	O		O				O	O
16226	C1I1	O	O	O	O	O		O	O
16228	S1H5	O				O		O	O
16229	S1H4	O				O		O	O
16230	S1H3	O				O		O	O
16231	S1H2	O				O		O	
16232	S1H1	O				O		O	
16233	S1G1	O				O		O	
16234	S1G2	O				O		O	
16235	S1G3	O				O		O	
16236	S1G4	O				O		O	
16237	S1G5	O				O		O	
16238	S1C3	O		O		O		O	O

16239	S1C4	O				O		O	O
16240	S1C5	O		O		O		O	
16243	S1B2	O		O		O		O	
16244	S1B1	O		O		O		O	
16245	S1A1	O		O		O		O	
16247	S1A2	O	O		O	O		O	O
16248	S1A3	O				O			O
16251	C2A7	O				O			O
16252	C2B7	O		O				O	O
16253	C2C7	O		O				O	O
16254	C2D7	O		O				O	O
16255	C2E7	O				O		O	O
16256	C2F7	O		O				O	O
16257	C2G7	O				O		O	O
16258	C2G6	O				O		O	O
16259	C2F6	O		O				O	O
16260	C2E6	O	O	O	O	O		O	
16261	C2D6	O		O				O	O
16262	C2C6	O		O				O	O
16263	C2B6	O		O				O	O
16264	C2A6	O		O				O	O
16265	C2A5	O		O				O	O
16266	C2B5	O		O				O	O
16267	C2C5	O		O				O	O
16268	C2D5	O		O				O	O
16269	C2E5	O		O				O	O
16270	C2F5	O		O				O	O
16271	C2G5	O		O				O	O
16272	C2G4	O		O				O	O
16273	C2F4	O		O				O	O
16274	C2E4		O	O				O	O
16275	C2D4	O		O				O	O
16277	C2C4	O		O				O	O
16278	C2B4	O		O				O	O
16280	C2F2	O		O				O	O
16281	C2E2	O		O		O			O
16282	C2D2		O	O				O	O
16283	C2C2	O		O				O	O
16285	S2CYC		O	O		O		O	O

16286	S2ANT		O	O		O		O	O
16287	S2ANTSW		O	O		O		O	O
16295	S2T4		O		O				O
16296	S2T3				O				O
16297	S2CYCSW		O		O				O
16298	S2CYCNE		O		O				O

Table 9: Stations and depths for microscopy sampling.

(Underway samples are not presented in the table.)

Water samples for HPLC (High Performance Liquid Chromatography) analysis were collected from 5-12 different depths (5 m – up to 1000 m) from all CTD stations (~750 samples). Various volumes of waters (1000 – 6000 mL) were filtered onto GF/F filters (pore-size 0.7 μm) and frozen immediately with liquid nitrogen. The filters were then stored in the freezer at -80 °C. HPLC analysis of the pigments will be carried out back in the laboratory. Sampling stations and depths shown in **Table 10**.

CTD #	**Station**	**5**	**10 (15)**	**20**	**27 (25)**	**32 (30)**	**40**	**47 (50)**	**75**	**125**	**200**	**300**	**400**	**500**	**600**	**800**
16195	IB6	O	O			O	O	O	O	O	O	O	O	O	O	
16196	IB7	O	O			O	O	O	O							
16197	IB8	O	O		O			O	O	O						
16198	IB9	O	O		O				O	O	O					
16199	IB10	O	O		O				O	O	O					
16202	C1A5	O	O	O	O	O		O	O		O		O		O	
16203	C1A4	O	O	O	O	O		O	O	O						
16204	C1A3	O	O	O	O	O		O	O							
16205	C1A2	O	O	O	O	O		O	O		O	O	O		O	O
16207	C1A1	O	O	O	O	O		O	O	O	O		O		O	
16208	C1C1	O		O		O			O	O	O					
16209	C1C2	O	O	O	O	O		O	O							
16210	C1C3	O		O		O		O	O	O	O		O		O	O
16211	C1C4		O	O		O		O	O	O						
16212	C1C5	O	O	O	O	O		O	O	O						
16213	C1E5		O	O		O		O	O	O	O		O		O	O
16214	C1G5		O	O		O		O	O	O	O		O		O	O
16215	C1I5	O		O		O		O	O	O	O					

16216	C1I4		O	O				O	O							
16217	C1G4		O	O				O	O							
16218	C1E4		O	O				O	O							
16220	C1E3	O		O		O		O	O	O	O		O			
16221	C1G3	O		O		O		O	O	O						
16222	C1I3		O	O		O		O	O	O						
16224	C1I2	O		O		O		O	O	O	O		O			
16225	C1G2	O		O		O		O	O	O						
16226	C1I1	O	O	O	O	O		O	O	1	O				O	O
16228	S1H5	O		O	O	O		O	O	O	O					
16229	S1H4	O		O		O		O	O	O						
16230	S1H3	O		O		O		O	O	O						
16231	S1H2	O		O		O		O	O	O						
16232	S1H1	O		O		O		O	O	O						
16233	S1G1	O		O		O		O	O	O						
16234	S1G2	O		O		O		O	O		O					
16235	S1G3	O		O		O		O	O		O					
16236	S1G4	O		O		O		O	O	O						
16237	S1G5	O		O		O		O	O	O						
16238	S1C3	O		O		O		O	O	O	O					
16239	S1C4	O	O			O		O	O		O					
16240	S1C5	O		O		O		O	O	O						
16243	S1B2	O		O		O		O	O	O						
16244	S1B1	O		O		O		O	O		O		O			O
16245	S1A1	O		O		O		O	O	O	O		O			O
16247	S1A2	O	O		O	O		O	O	O						
16248	S1A3	O		O		O		O	O	O	O		O		O	O
16251	C2A7	O		O		O		O	O	O						
16252	C2B7	O		O		O		O	O	O						
16253	C2C7	O		O		O		O	O	O						
16254	C2D7	O		O		O		O	O	O	O		O		O	O
16255	C2E7	O		O	O	O		O	O	O	O		O		O	O
16256	C2F7	O		O		O		O	O	O						
16257	C2G7	O		O		O		O	O	O	O		O		O	O
16258	C2G6	O		O		O		O	O	O						
16259	C2F6	O		O		O		O	O	O						
16260	C2E6	O	O	O	O	O		O	O	O	O					
16261	C2D6	O		O		O		O	O	O	O		O		O	O
16262	C2C6	O		O		O		O	O	O	O					

16263	C2B6	O		O		O		O	O	O	O		O		O	O
16264	C2A6	O		O				O	O							
16265	C2A5	O		O				O	O							
16266	C2B5	O		O				O	O							
16267	C2C5	O		O				O	O							
16268	C2D5	O		O		O		O	O	O	O					
16269	C2E5	O		O		O		O	O	O	O		O		O	O
16270	C2F5	O		O		O		O	O	O						
16271	C2G5	O		O		O		O	O	O	O		O		O	O
16272	C2G4	O		O		O		O	O	O	O					
16273	C2F4	O		O		O		O	O	O						
16274	C2E4		O	O		O		O	O	O						
16275	C2D4	O		O		O		O	O	O	O		O		O	O
16277	C2C4	O		O		O		O	O	O	O		O		O	O
16278	C2B4	O		O				O	O	O						
16280	C2F2	O		O		O		O	O	O	O		O		O	O
16281	C2E2	O		O		O		O	O	O	O					
16282	C2D2		O	O		O		O	O	O	O		O		O	O
16283	C2C2	O		O		O		O	O	O	O					
16285	S2CYC		O	O		O		O	O	O	O		O		O	O
16286	S2ANT		O	O		O		O	O	O	O		O		O	O
16287	S2ANT SW	O	O	O	O	O		O	O	O	O					
16295	S2T4		O		O				O	O						
16296	S2T3				O				O	O						
16297	S2CYC SW		O		O				O	O						
16298	S2CYC NE		O		O				O	O						

(Duplicate samples and underway samples were not present in the table.)

Table 10: Stations and depths for HPLC sampling.

Phytoplankton New and Regenerated Production - *Mike Lucas, Mark Moore, Anastasia Charalampopoulou*

Long-term objectives

1. To measure phytoplankton new and regenerated production using ^{15}N-NO_3, ^{15}N-NH_4 and ^{13}C tracers.

2. To compare nitrate uptake with the upward diffusive flux of nitrate determined from turbulence measurements.

3. To assess phytoplankton new production in response to ambient light and Fe gradients.

4. To assess Redfield C:N fixation rates from dual-labelling (^{13}C, ^{15}N) experiments

General approach and methods

Uptake measurements were made within the survey region on 13 separate days from 30 July to 21 August. Two types of productivity measurements were made:

1. *In situ* profile measurements of dual labelled (^{13}C + ^{15}N) light and dark nitrate uptake and C fixation from 6 light depths (55, 33, 14, 7, 4.5 and 1%). At each of these depths, ammonium uptake and regeneration was also measured (**Table 11**).

2. Experimental measurements of dual labelled nitrate uptake and C fixation were made on the *Moore & Achterberg* nutrient limitation experiments (EO2, EO3 and EO4) (**Table 12**)

New production, nitrate and ammonium uptake and carbon fixation.

Dual-labelled (^{15}N-NO_3, ^{13}C-bicarbonate) light and dark nitrate (+^{13}C) and ammonium uptake (^{15}N-NH_4) incubations were conducted at the 6 light depths in 2.0 L polycarbonate bottles for ~ 10 hours. Light and dark bottles were inoculated with both ^{15}N (0.1 µmol $K^{15}NO_3$ / 100 µl) and ^{13}C spikes (4.2507 g sodium bicarbonate / 100 ml Milli Q water) to achieve ^{15}N-NO_3 and ^{13}C enrichments of ~10 and 4% respectively. Ammonium uptake bottles were spiked with 0.1 µmol $^{15}NH_4Cl$ / 100 µl to also achieve an enrichment of ~10%. After incubation, samples were filtered onto ashed GF/F filters; stored frozen (at -20°C) prior to measuring ^{15}N and ^{13}C enrichment on a mass spectrometer at NOC. The mapped positions of all the productivity stations are shown in **Figure 6**.

Ammonium was measured using the orthophthaldialdehyde (OPA) fluoresence protocol (discussed elsewhere). Nitrate measurements were determined on-board using standard colorimetric techniques on a Skalar San plus autoanalyser (discussed elsewhere).

Ammonium regeneration

Isotopic dilution NH_4^+ regeneration experiments were conducted to correct for $^{14}NH_4^+$ re-cycling in the $^{15}NH_4^+$ incubation bottles. Immediately after spiking the 2L NH_4^+ uptake bottles, exactly 1L was recovered from each and promptly filtered through a 25mm (ashed) Whatman GF/F filter to collect 900 ml filtrate for transfer into 6 x 1.0L glass Schotte bottles. Exactly 200 µl NH_4Cl solution (10 µmol / ml) was added to each of these bottles as a "carrier" prior to freezing the samples at –20°C. This sample provided the time zero NH_4^+ regeneration concentration (R0). The GF/F filter from this sample was stored at -80°C and retained for later HPLC analyses. At the end of the 12 hr incubation period, a further 900 ml filtrate was recovered from the NH_4^+ uptake filtration to measure ^{15}N isotopic dilution (Rt). Carrier (200 µl) was added and the Rt sample was frozen as before. The aqueous NH_4^+ was recovered onto GF/F filters by diffusion and the isotopic composition (and dilution) was measured by mass spectrometry as before.

***Discovery* station no.**	**Latitude**	**Longitude**	**Date**
16209B	59º 42.12	20º 25.65	30 July
16212B	59º 42.66	18º 45.09	31 July
16222B	58º 51.80	19º 52.95	2 August
16226B	58º 51.40	21º 00.64	4 August
16235A	59º 08.90	19º 52.96	6 Aug., Filament
16247B	59º 59.93	20º 27.20	10 Aug., Filament
16260B	59º 11.71	19º 05.96	12 August
16285B	59º 40.26	18º 43.56	18 Aug., N Eddy
16286B	59º 16.40	19º 47.60	19 Aug., S. Eddy

Table 11: *In situ* ^{15}N Productivity Stations**.**

Exp. No	Date
EO2	13 August
EO4	15 August (time zero)
EO3	20 August
EO4	21 August (end exp)
Dual label test	21 August

Table 12: Experimental ^{15}N experiments

Coccolithophores (Scanning Electron Microscope), Particulate Inorganic Carbon (PIC), Particulate Organic Carbon (POC), Biogenic Silica (BSi) and Chlorophyll-a - *Anastasia Charalampopoulou Mike Lucas*

The main hypotheses to test on D321 regarding coccolithophores and the carbonate system were as follows:

Hypothesis 1: Coccolithophores are more successful in high saturation state conditions.

Test 1: Spatial comparison of carbonate chemistry and coccolithophores abundance.

Hypothesis 2: Bulk in-situ calcification rate is positively correlated with calcite saturation state.

Test 2: Spatial comparison of carbonate chemistry (saturation state) and calcification rate.

Hypothesis 3: CaCO3 export flux and rain ratio are reduced in low saturation state conditions.

Test 3: Spatial comparison of carbonate chemistry and calcification rate, CaCO3 export flux and rain ratio.

Hypothesis 4: Coccolithophores dominate bulk in-situ calcification in this part of the ocean.

Test 4: Spatial and vertical comparison of calcification rate and coccolithophore abundances.

Hypothesis 5: Coccosphere size is positively correlated with [CO_2(aq)].

Test 5: Spatial comparison of [CO_2(aq)] and coccosphere size.

Hypothesis 6: The frequency of malformed coccoliths is negatively correlated with [CO_3^{2-}].

Test 6: Spatial comparison of [CO_3^{2-}] and coccolithophores.

Hypothesis 7: Absolute calcification rates and calcification: silicification ratios decline with depth.

Test 7: Vertical comparison of calcification and silicification rates with depth.

In order to test these hypotheses, we sampled for coccolithophores, PIC, POC and BSi and matched our sampling with sampling for DIC, alkalinity measurements and for calcification rates described elsewhere in this report.

Samples were taken from the stainless steel framed CTD on every primary productivity cast and additional sampling from the underway non-toxic supply ensured greater resolution in areas of interest such as eddies, coccolithophore blooms or when there was no CTD cast due to bad weather conditions.

In total, samples were taken from 11 primary productivity CTD stations (**Figure 6**), one Ellett Line station (IB6) and three other CTD stations, one of which was within the area of a coccolithophore bloom (16217A), another within a filament that ran between the northern cyclonic eddy and the southern anticyclonic eddy that developed in the survey area (16243A) (**Table 13**). One more CTD station (16266A) was also sampled only from the surface water bottle. There were 75 samples collected from the underway supply and details of positions and times can be found in **Table 13**. Note here that between sampling events AC#63 to AC#83 no samples were collected for POC and BSi due to time constraints.

SEM

Samples for coccolithophore analysis under the Electron Microscope were taken from the 8 top depths (5-125 m) and at 400 m. Exactly 1L of seawater was filtered on 1.2 μm Isopore membrane filters under low vacuum. The filters were rinsed with analytical grade ammonium solution (pH ~ 9.7) to prevent the formation of salt crystals that makes analysis under the SEM difficult and were dried at ~30ºC, placed in sealed Petri dishes, wrapped in tin foil and kept in a cool and dry place until SEM analysis.

PIC

Samples for PIC were taken from the 8 top depths (5-125 m) and at 400 m. Exactly 500 mL of seawater was filtered on 0.2 μm polycarbonate filters. The filters were rinsed with analytical grade ammonium solution (pH ~ 9.7) in order to dissolve salt that would otherwise contaminate the sample, placed in centrifuge tubes and kept at 4ºC until analysis at NOC.

POC

Samples for POC were taken from 12 depths up to 800m. Between 1.5 and 2 L of seawater was filtered on pre-ashed GF/F filters. The filters were placed in Petri dishes, wrapped in tin foil and kept at -20ºC until analysis at NOC.

BSi

Samples for BSi were taken from the 8 top depths (5-125 m) and at 400 m. Between 500 mL and 1 L of seawater was filtered onto 1.0 μm polycarbonate membrane filters. The filters were placed in plastic vials and kept at -20ºC until analysis at NOC.

***Discovery* station no.**	**Latitude**	**Longitude**	**SEM**	**PIC**	**POC**	**BSi**	**Comments**
16195A	58º 57.00	17º 11.05	✓	✓	✓		Ellet Line station (IB6), 6 light depths
16204A	59º 59.96	19º 52.72	✓	✓	✓	✓	PP station SEM, PIC, BSi (11 depths) POC (6

							depths)
16209A	59º 42.12	20º 25.65	✓	✓	✓	✓	PP station
16212A	59º 42.66	18º 45.09	✓	✓	✓	✓	PP station
16217A	59º 09.03	19º 19.01	✓	✓			Coccos bloom, no POC and BSi samples
16222A	58º 51.80	19º 52.95	✓	✓	✓	✓	PP station, no POC at 800m
16226A	58º 51.40	21º 00.64	✓	✓	✓	✓	PP station, no POC at 800m
16235A	59º 08.90	19º 52.96	✓	✓	✓	✓	PP station, POC (11 depths)
16243A	59º 51.92	20º 27.14	✓	✓			In filament, no POC and BSi samples
16247A	59º 59.93	20º 27.20	✓	✓	✓	✓	PP station
16260A	59º 11.71	19º 05.96	✓	✓	✓	✓	PP station
16266A	59º 47.96	19º 28.23	✓	✓	✓	✓	Only 5m sampled
16274A	59º 12.57	19º 53.59	✓	✓	✓	✓	PP station, 5m sample taken from underway supply
16280A	59º 00.85	20º 33.82	✓	✓	✓	✓	
16285A	59º 40.26	18º 43.56	✓	✓	✓	✓	PP station
16286A	59º 16.40	19º 47.60	✓	✓	✓	✓	PP station, no sample at 27m

Table 13: CTD stations, positions and samples taken. At all stations SEM, PIC and BSi samples were taken from the 8 top depths and from 400m and POC samples were taken from 12 depths up to 800m, unless otherwise indicated.

Chlorophyll-a and HPLC

Chlorophyll-a samples were taken from the top 8 depths of all stainless steel CTD casts and from the top 7 depths of all titanium CTD casts. Also, 253 samples were collected from the underway supply. Exactly 200 mL of seawater were filtered on GF/F filters and chlorophyll-a was extracted in 10 mL 90% acetone for about 24 hours at 4 ºC. Measurements were made on a Turner fluorometer following the Welschmeyer protocol calibrated against a spectrophotometrically determined calibration curve of commercial grade (SIGMA) chl-a using the SCOR / UNESCO tri-chromatic equations. HPLC samples from the underway supply (sampling events 209-253) were made on 1-2 L water samples filtered on GF/F filters and kept in cryogenic vials at -80ºC.

Primary Production and Calcification - *Alex Poulton*

Daily rates (dawn to dawn, 24-hrs) of primary production and calcification were determined at 11 CTD stations and during 3 variable-pCO_2 experiments (see later section; and **Table 14**) following the methodology of Paasche and Brutak 1994 (as modified by Balch *et al.*, 2000). Water samples (150 mL, 3 incubated, 1 formalin-killed) were collected from 6 light depths (55, 33, 14, 7, 5, 1% incident light), spiked with 80-100 µCi of ^{14}C-labelled sodium bicarbonate, and incubated on deck. On deck incubators were chilled with sea surface water and light depths were replicated through the use of a mixture of misty blue and grey light filters. Incubations were terminated by filtration through 25 mm 0.2 µm polycarbonate filter, with extensive rinsing with fresh filtered seawater to remove any labeled ^{14}C-DIC. Filters were then placed in glass vials with gas-tight septum and a bucket containing a GFA filter soaked in phenylethylamine (PEA) attached to the lid. Phosphoric acid (1 mL, 1%) was injected through the septum into the bottom of the vial to convert any labeled ^{14}C-PIC to ^{14}C-CO_2 which was then caught in the PEA soaked filter. After 20-24-hrs, GFA filters were removed and placed in a fresh vial and liquid scintillation cocktail was added to both vials: one containing the polycarbonate filter (non-acid labile production, organic or primary production) and one containing the GFA filter (acid-labile production, inorganic production or calcification). Activity in both filters was then determined on a liquid scintillation counter and counts converted to uptake rates using standard methodology. Each measurement of calcification was matched with a sample for the determination of coccolithophore cell numbers and species identification by light microscopy (500 mL filtered through a 0.4 µm cellulose nitrate filter, oven dried at 30 °C for 6-8 hrs and stored in petri-dishes until analysis; ~ 90 samples).

Station no.	***Date***	***ID***	***Position***	***ρPOC/ρPIC***	***ρBSi***
(a) CTD stations and underway samples					
uw 1*	27/07	surface (uw)	58.09°N, 14.37°W	X	
uw 10*	28/07	surface (uw)	59.36°N, 18.29°W	X	
16204a	29/07	PP1	59.59°N, 19.52°W	X	X
16209b	30/07	PP2	59.41°N, 20.25°W	X	X
16212b	31/07	PP3	59.42°N, 18.45°W	X	X
16222b	02/08	PP4	58.51°N, 19.52°W	X	X
16226b	05/08	PP5	58.51°N, 21.00°W	X	X
16236b	07/08	PP6	59.08°N, 19.18°W	X	
uw 131*	08/08	surface (uw)	59.34°N, 19.19°W	X	
uw 151*	09/08	surface (uw)	59.52°N, 19.10°W	X	
16247b	10/08	PP7	59.59°N, 20.28°W	X	X
16260b	12/08	PP8	59.12°N, 19.06°W	X	X
16266a*	13/08	surface	59.47°N, 19.28°W	X	
16274a	14/08	cancelled PP9	59.12°N, 19.51°W	X	X
16285b	18/08	PP10	59.49°N, 18.43°W	X	X

16286b	19/08	PP11	59.14°N, 19.45°W	X	X
(b) pCO$_2$ experiments					
16222c	02/08	DIR 1 T0	58.51°N, 19.52°W	X	X
-	05/08	DIR 1 T72-96	-	X	X
16247c	10/08	DIR 2 T0	59.59°N, 20.28°W	X	X
-	13/08	DIR T72-96	-	X	X
16274c	14/08	DIR 3 T0	59.12°N, 19.51°W	X	X
-	17/08	DIR 3 T72-96	-	X	X

Table 14: Details of primary production (ρPOC), calcification (ρPIC) and silicification (ρBSi) sampling stations. Note: * indicates samples taken from surface waters only (5 m ctd bottle or from non-toxic underway).

Silicate Assimilation - *Mark Stinchcombe, Alex Poulton*

Daily rates (dawn to dawn, 24 hrs) of silicate uptake (silicification) were made at 10 stations and during 3 variable-pCO$_2$ experiments (see later section; **Table 14 previous section above**) following the methodology of Brzezinski & Philips (1997) and Brown *et al.,* (2003). Water samples (3 times 150 mL) were collected from 6 light depths (55, 33, 14, 7, 5, 1% incident light) through the water column, spiked with ~0.03 µCi of a high specific activity (2.06 µCi mL^{-1}) ^{32}Si-labelled silicic acid and incubated on deck alongside samples for primary production. Incubations were terminated by filtering onto 1 µm polycarbonate filters, with thorough rinsing of the filters to remove labeled silicic acid. The filters were then digested with 2.5 mL 0.2 mol L^{-1} sodium hydroxide at 85 °C for 1-hour, and the pH adjusted by addition of 2.5 mL 0.2 mol L^{-1} hydrochloric acid after cooling. Liquid scintillation cocktail was then added to the mixture before the samples were stored for analysis back at NOCS. Samples will be analyzed using a liquid scintillation counter with a dual window 60-min counting protocol (Brown *et al.,* 2003). Counting efficiency in the assigned windows will be calibrated using ^{32}Si and its daughter product, ^{32}P (Brzezinski & Philips 1997; Brown *et al.,* 2003). Spike activity was determined by diluting an aliquot of the ^{32}Si stock in 10 mL of 0.2 mol L^{-1} sodium hydroxide, removal of triplicate 2.5 mL subsamples, addition of 2.5 mL 0.2 mol L^{-1} hydrochloric acid and liquid scintillation cocktail.

Nitrification - *Stuart Painter, Alex Poulton*

On three occasions during the cruise (**Table 15**) we took the opportunity to perform an experimental procedure intended to measure the autotrophic carbon assimilation related to the process of nitrification. The technique used was that described by Rees *et al*., (2006) and based upon previous work by Dore and Karl (1996). This technique measures the dark uptake of ^{14}C with and without the presence of Allylthiourea (ATU), a nitrification inhibitor (added to 125 ml dark bottles at a concentration equivalent to 80 µmol L^{-1}). Specifically, ATU inhibits the oxidation of NH_4^+ to NO_2^- and the difference in dark carbon assimilation between the control and inhibited bottle provides a measure of the metabolic cost associated with this oxidative step. Thereafter a partial nitrification rate can be calculated on the basis of a molar conversion ratio converting the difference in carbon assimilation to a nitrogen equivalent. This last step is inherently variable, the C:N conversion ratio being influenced by processes which are themselves largely variable and thus this technique for measuring nitrification has been questioned. Nevertheless the initial stages of this technique provide an accurate measure of the carbon cost of nitrification and this was the primary motivation behind the application of this technique.

Initial results show that ATU does inhibit the dark uptake of ^{14}C, as suggested from previous studies, but it has also highlighted numerous questions concerning the validity of the technique, particularly with regards to what components of the plankton community are influenced by ATU. Whilst the initial results are encouraging and indicate an important additional sink for inorganic carbon in the surface ocean much more needs to be done to fully categorise the inhibitory effects of ATU before then tackling the thorny issue of the C:N conversion ratio, which from literature estimates varies by a factor of 5.

Jday	*Discovery* Station (cruise station)	Latitude (°N)	Longitude (°W)	Sampled Depths (m)	Comments
222	16247 (S1A2)	59 59.94	20 27.2	10, 20, 47, 75, 125	
226	16274 (C2E4)	59 12.57	19 53.59	10, 20, 32, 47, 75, 125	High surface fluorescence levels
230	16285 (S2CYC)	59 40.26	18 43.56	5, 20, 32, 47, 75, 125	Cyclonic eddy

Table 15: Stations at which nitrification was measured.

Ammonia, DOC, TDN, Amino Acids, Hemes, and Dissolved Aluminium - *Eric Achterberg*

During RRS *Discovery* cruise D321 shipboard water column ammonium and dissolved aluminium measurements were made, and samples were collected for dissolved organic carbon (DOC), total dissolved nitrogen (TDN), amino acids and hemes for subsequent analyses in the laboratory at NOC.

Samples for the non-metal variables were collected from the 20 litre Niskin OTE bottles mounted on the CTD rosette. Samples for DOC and TDN analyses were filtered using an in-line stainless steel filtration unit and ashed GF/F filters. The samples for DOC and TDN were acidified and stored in sealed glass ampoules. Samples for amino acids were filtered using 0.2 µm cellulose acetate filters (Supatop, Anachem) and stored frozen in microcentrifuge vials (1 vial per sample).

Samples for dissolved aluminium were collected from the OTE bottles on the Titanium CTD frame and filtered in the trace metal clean container (using 0.4 and 0.2 µm filters). These samples were stored acidified prior to analysis. The analyses were conducted using a flow-injection system, with fluorescence detection of the lumigallion-aluminium complex. The analyses were successful, and 13 profiles were analysed, with another 50 underway samples (collected from the towed fish). The alumium concentrations ranged from 1-3 nmol L^{-1} in the surface waters to 10-14 nmol L^{-1} at depth (up to 1000 m).

A total of 13 water column profiles (productivity casts) were analysed for ammonium on the cruise with typically 8 samples for each profile. The ammonium measurements were conducted using the OPA fluorescence method. A volume of 2 mL mixed OPA-borate reagent was added to 25 mL of sample, and this was allowed to react for 24 h. Samples were subsequently analysed on a Turner Design fluorimeter (TD700) equipped with filters for ammonium measurements. The ammonium measurements have been successful, with 100-400 nanomolar concentrations throughout the water column. Distinct maxima were observed at the chlorophyll maximum (up to > 1 µmol L^{-1}) in most casts (**Figure 26**).

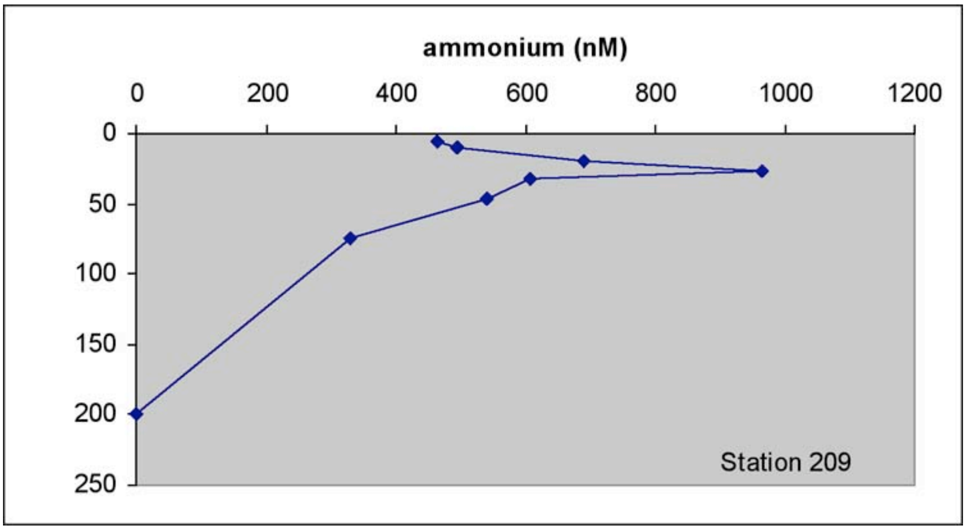


Figure 26: Ammonium profile for station 16209 (30/07/07)

For DOC, TDN, hemes (to be analysed by Dr Martha Gledhill at NOC) and amino acids samples (collected for a further PhD project at NOC) have been collected for 13 water column profiles (typically 8 samples for each profile; generally productivity casts). Sample analyses will be conducted over the coming months in Southampton.

Stations analysed for dissolved aluminium:

Discovery Stations 16204, 16209, 16212, 16226, 16243, 16247, 16262, 16282, 16286, 16285.

Stations analysed for ammonium and sampled for DOC-TDN, hemes, amino acids:

Discovery Stations 16204, 16209, 16212, 16222, 16226, 16243, 16247, 16260, 16262, 16274, 16281, 16285, 16286.

Dissolved Inorganic Carbon (DIC), Total Alkalinity (TA) and pH Determinations - *Cynthia Dumousseaud*

Sampling

The sampling procedure used for the determination of Dissolved Inorganic Carbon and Total Alkalinity was according to DOE (1994). Samples were taken as soon as possible after the Niskin bottle was opened (following oxygen samples) to prevent any gas exchange of the sample with the head space of the bottle. A piece of silicone tubing was used for the sampling and care was taken to prevent any air bubbles being trapped in the sample. The sample was stored in a borosilicate glass bottle (250 mL), which was rinced once with the sample in order to remove trace of the previous sample. The tubing was inserted at the bottom of the bottle which was then filled and water was let to overflow by at least half a bottle volume. The glass stopper was inserted in the bottle in order to remove the stopper volume and a head space of 1% (2.5 mL) was allowed for water expansion. The sample was then poisoned with a saturated solution of mercuric chloride (7 g/100 mL) in a 0.02% volume ratio (50 µL) in order to prevent any biological activity in the stored sample. The bottle was air-tight sealed with a glass stopper and shaken to mix the mercuric chloride homogeneously. Samples were stored in a cool and dark place until analysis. DIC samples were generally analysed within less than 2 days after sampling and water for alkalinity measurements was stored for analysis back at NOC.

During the cruise, underway samples were taken from the non-toxic seawater supply (intake at ~5 m depth) along with nutrients, chlorophyll and SEM samples in order to obtain a good surface coverage of the survey region (**Table 16**). The position and time of each sampling point were carefully recorded and will be matched with the pH and pCO_2 data (courtesy of PML) in order to characterize the carbonate system. A potentiometric pH system was installed on the non-toxic sea water supply and was run continuously during the cruise. The measurements were set to a rate of 1 minute intervals.

Event	Day	Time	Latitude	Longitude	Event	Day	Time	Latitude	Longitude
UW1	27/07/07	03:05	59°09	14°38	AC47	05/08/07	20:00	59°00.79	18°45.99
UW10	28/07/07	03:05	59°21	18°17	AC48	05/08/07	23:44	59°00.82	19°08.35
AC11	28/07/07	08:00	59°38.10	18°45.60	AC49	06/08/07	04:05	59°00.41	19°52.84
AC12	28/07/07	12:04	59°48.20	18°45.30	AC50	06/08/07	07:56	59°01.11	20°26.88
AC13	28/07/07	16:01	59°59.80	18°45.10	AC51	06/08/07	12:00	59°01.14	21°00.18
AC14	28/07/07	20:00	60°00.10	19°18.90	AC52	06/08/07	16:12	59°08.70	21°00.55
AC15	29/07/07	00:01	59°59.60	19°52.50	AC53	06/08/07	19:48	59°08.93	20°18.98
AC16	29/07/07	11:55	60°00.14	20°20.64	AC54	07/08/07	08:08	59°19.21	18°39.40
AC17	29/07/07	15:58	59°59.92	20°48.84	AC55	07/08/07	12:25	59°17.98	19°42.31
AC18	29/07/07	20:05	59°46.10	21°00.01	AC56	07/08/07	16:02	59°18.00	20°50.07
AC19	30/07/07	00:03	59°42.61	20°28.01	AC57	07/08/07	20:01	59°26.99	20°12.57
AC20	30/07/07	12:07	59°38.11	20°19.44	AC58	07/08/07	23:50	59°26.95	18°58.81
AC21	30/07/07	16:00	59°43.09	19°53.16	AC59	08/08/07	03:59	59°34.98	19°29.28
AC22	30/07/07	20:03	59°42.77	19°18.27	AC60	08/08/07	07:53	59°34.99	20°32.58
AC23	30/07/07	23:51	59°42.98	18°44.78	AC61	08/08/07	12:00	59°43.01	20°26.69
AC24	31/07/07	12:00	59°25.28	18°42.94	AC62	08/08/07	16:01	59°38.84	19°41.84
AC25	31/07/07	16:03	59°05.59	18°46.57	AC63	08/08/07	18:46	59°42.00	19°48.74
AC26	31/07/07	20:00	58°51.97	18°50.31	AC64	08/08/07	20:04	59°43.03	19°21.91
AC27	01/08/07	00:09	58°52.27	19°17.78	AC65	08/08/07	21:05	59°43.34	19°18.67
AC28	01/08/07	07:59	59°27.06	19°18.69	AC66	08/08/07	21:54	59°43.77	19°16.04
AC29	01/08/07	11:57	59°28.86	19°47.99	AC67	08/08/07	23:00	59°43.17	18°54.46
AC30	01/08/07	16:18	59°29.21	20°00.08	AC68	08/08/07	23:55	59°43	18°45

AC31	01/08/07	20:03	59°20.84	19°56.98	AC69	09/08/07	00:51	59°43.25	18°44.83
AC32	01/08/07	23:59	58°54.95	19°53.43	AC70	09/08/07	01:52	59°51.73	18°44.87
AC33	02/08/07	12:00	58°52.37	20°24.19	AC71	09/08/07	02:58	59°51.96	18°51.42
AC34	02/08/07	16:01	58°57.12	20°24.85	AC72	09/08/07	04:07	59°52.00	19°09.16
AC35	02/08/07	21:00	59°06.61	20°15.27	AC73	09/08/07	05:03	59°52.03	19°24.14
AC36	03/08/07	05:00	59°53	20°53	AC74	09/08/07	06:01	59°52.15	19°37.15
AC37	03/08/07	09:03	58°50.58	21°08.14	AC75	09/08/07	06:58	59°53.16	19°38.08
AC38	03/08/07	15:04	58°51.29	21°26.32	AC76	09/08/07	07:58	59°53.35	19°45.38
AC39	03/08/07	20:58	58°45.89	21°36.73	AC77	09/08/07	09:20	59°51.70	20°05.77
AC40	04/08/07	05:00	58°31.85	22°04.22	AC78	09/08/07	10:09	59°52.40	20°06.97
AC41	04/08/07	09:02	58°32.30	22°29.25	AC79	09/08/07	11:23	59°52.76	20°12.44
AC42	04/08/07	15:27	58°51.73	20°59.77	AC80	09/08/07	12:04	59°51.95	20°26.60
AC43	04/08/07	19:42	58°51.32	21°00.07	AC81	09/08/07	14:14	59°51.83	20°44.50
AC44	05/08/07	09:09	58°51.78	21°05.19	AC82	09/08/07	15:02	59°51.80	21°00.08
AC45	05/08/07	12:23	58°52.01	20°15.03	AC83	09/08/07	18:23	60°00.50	21°01.15
AC46	05/08/07	16:04	58°52.01	19°09.04	AC84	12/08/07	12:27	59°24.26	19°03.74

Table 16: List and position of the underway DIC/TA samples

Profiles of DIC and TA were sampled from at least each productivity station on the stainless steel CTD (see **Table 17** for list and position of the stations). Samples were taken at the following 9 depths for each of the stations sampled : 400, 125, 75, 47, 32, 27, 20, 10 and 5 metres, except for station 16204A (500, 250, 75, 47, 32, 27, 20, 10, 5) and station 16260 for which the sample at 400 m was replaced by one at 600 m. Two deep casts (16262 and 16286) were sampled at the following depths: 2500, 2000, 1400, 600, 125, 75, 32, 20 m for station 16262A, and 2500, 2000, 1500, 1000, 400, 125, 75, 47, 32, 20, 10, 5 m for station 16286A.

Cast	Time	Julian Day	Day	Lat	Long
16204A	01:06	210	29/07/2007	59°59.96	19°52.72
16209A	02:49	211	30/07/2007	59°42.12	20°25.65
16212A	01:51	212	31/07/2007	59°42.66	18°45.09
16217A	04:03	213	01/08/2007	59°09.03	19°19.01
16222A	02:05	214	02/08/2007	58°51.80	19°52.95
16226A	02:05	216	02/08/2007	58°51.40	21°00.60
16231A	08:00	218	06/08/2007	59°07.47	20°26.78
16235A	21:45	218	06/08/2007	59°08.90	19°52.96
16243A	12:50	221	09/08/2007	59°51.37	20°27.32
16247A	22:49	221	09/08/2007	59°59.93	20°27.2
16260A	02:37	224	12/08/2007	59°11.71	19°05.96
16262A	14:48	224	12/08/2007	59°39.14	19°04.98
16274A	03:13	226	14/08/2007	59°12.57	19°53.59
16280A	08:00	228	16/08/2007	59°00.85	20°34.04
16285A	04:08	230	18/08/2007	59°40.26	18°43.56
16286A	12:44	231	19/08/2007	59°17.02	19°47.55

Table 17: List of the stations sampled for DIC and TA

DIC measurements

All the DIC samples were analysed using a coulometric titration. The instrument used for this purpose was the VINDTA 3C (**Figure 27**) from Marianda (Kiel, Germany) connected with a coulometer (UIC). Repeated measurements on the same batch of seawater ($n \geq 3$) were run every day of analysis, prior to the sample analysis, in order to assess the precision of the method. The standard deviation of the sub-samples analysed ranged between 0.04% and 0.09%, with a mean value of 0.07% for the whole cruise (less than 2 µmol kg^{-1}), which is well within the expected value of less than 0.1% (Bates *et al.*, 1996 ; Johnson *et al.*, 1998). Certified Reference Materials (CRMs) from A.G. Dickson (Scripps Institution of Oceanography) were used as standards to calibrate the system at the beginning of each day of analysis. A correction factor was applied to all measured values according to Millero *et al.*, (1998) in order to normalize the measured values :

$$DIC(corr.) = DIC(meas.) \times \left(CRM_{cert} / CRM_{meas.}\right);$$

where CRM_{cert} is the certified value for the specific batch of CRMs used.

The sample is acidified with phosphoric acid 10% which results in the conversion of total dissolved inorganic carbon ($[CO_2*] + [HCO_3^-] + [CO_3^{2-}]$; where $[CO_2*] = [CO_2] + [H_2CO_3]$) to CO_2 gas. The CO_2 generated is carried into the coulometric cell using an inert gas (N_2) and titrated coulometrically.

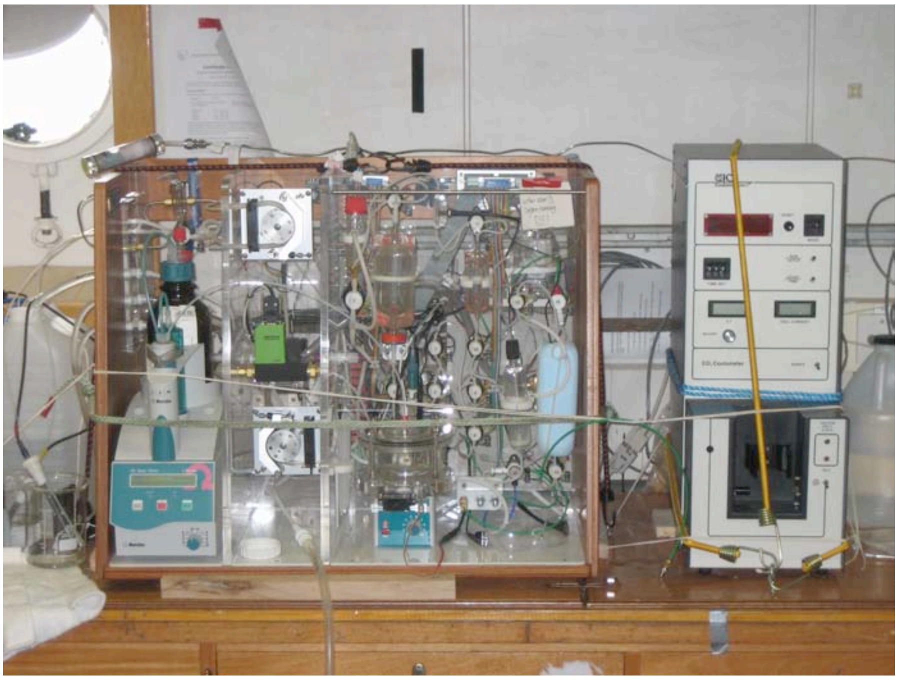


Figure 27: The VINDTA 3C instrument and the UIC coulometer

The coulometric cell is composed of two half cells : anode and cathode. The cathode cell contains mono-ethanolamine, a colorimetric pH indicator (Thymol blue) and a platinum electrode, whereas the anode cell is composed of a silver electrode and contains an anode solution saturated with potassium iodide crystals. The CO_2 purged causes the indicator to fade and the percentage of transmission (%T) to increase, and the titration current is automatically activated. The final titration point is determined spectrophotometrically when the final transmittance of the solution is kept at a constant value (29%T).

Figure 28 shows the DIC profile obtained for station 16204A. The values obtained are well in agreement with values reported in this area (Sarmiento and Gruber, 2004).

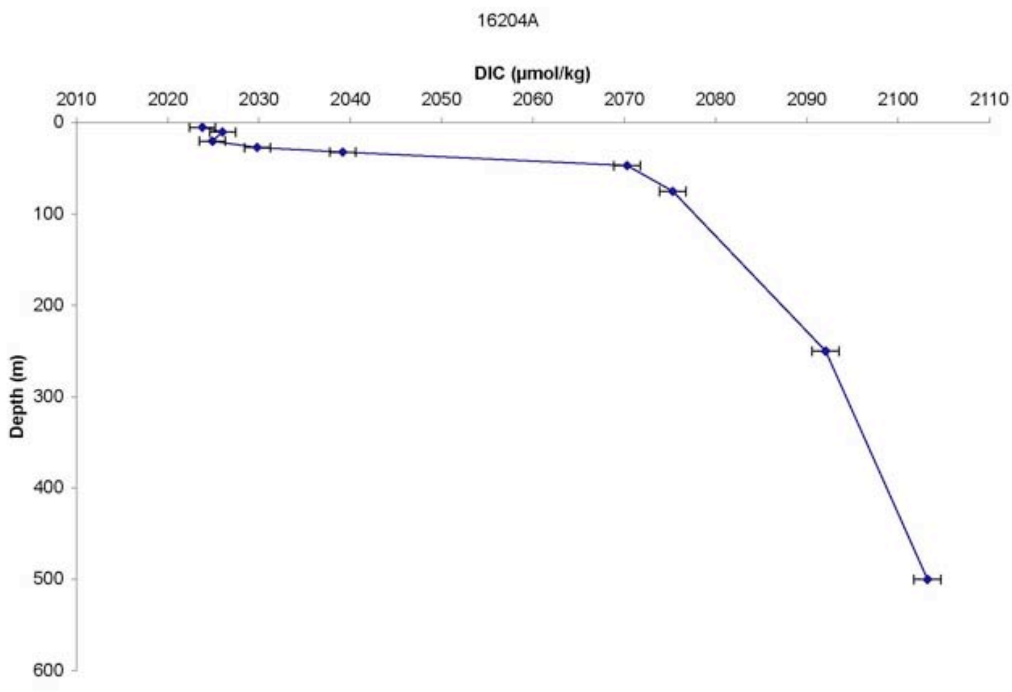


Figure 28: Profile of DIC (µmol kg^{-1}) at station 16204A

Total Alkalinity determination

The TA measurements at sea failed because of software and communication problem between the computer and the titration unit. After determination of DIC concentration, samples were well sealed and kept for TA analysis back to NOCS.

For the determination of TA, the sample of seawater is titrated with hydrochloric acid 0.1 mol L^{-1}. The acid solution is added in small increments until the carbonic acid equivalence point is reached (protonation of carbonate and bicarbonate ions). The total volume added allows the calculation of total alkalinity to be undertaken. A glass electrode/reference electrode system monitors the titration (measurement of the electromotive force).

pH measurement

The potentiometric method for the determination of pH in seawater consists of the measurement of the electromotive force (emf) of a cell composed of a silver/silver chloride electrode and a glass pH electrode. The instrument used for the determination of pH was the portable pH monitor from Ruthern Instrument. This system consists of a highly reproducible free-diffusion liquid junction which has been shown to reduce the usual liquid junction potential error encountered with the electrode systems (Whitfield *et al.*, 1985; Covington *et al.*, 1988). A capillary liquid junction is formed between the reference reservoir (containing the silver/silver chloride electrode) and the pH cell (containing the pH electrode and the sample to be analysed). The bridge solution (2.5 mol L^{-1} KCl in deionised water) allows the ionic contact between the hydrogen and reference electrode and is introduced below the sample via a solenoid pump.

To avoid errors with electrode drift, calibration of the system was undertaken every 8 to 12 hours with Tris buffer made up in artificial sea water according to Millero (1986). The buffer was kept in a fridge between each calibration and was brought approximately to the sea water temperature (within 5 °C) in order to maximize the accuracy. The temperature of the pH cell was recorded using a Platinum Resistance Thermometer (0.1 °C precision). The accuracy of the method was established from the comparison between pH obtained from calibration and calculated pH and estimated as 0.02 pH units. The overall precision of the method is of 0.01 pH unit. The pH scale used in the pH calculation of the system is the free hydrogen ion concentration scale : pH_F, which uses the concentration of free proton to define the hydrogen ion activity (Bates 1975).

The preliminary results of the potentiometric pH were compared with the Fluorescence data (**Figure 29**) and the pCO_2 data (not shown), suggesting high resolution data.

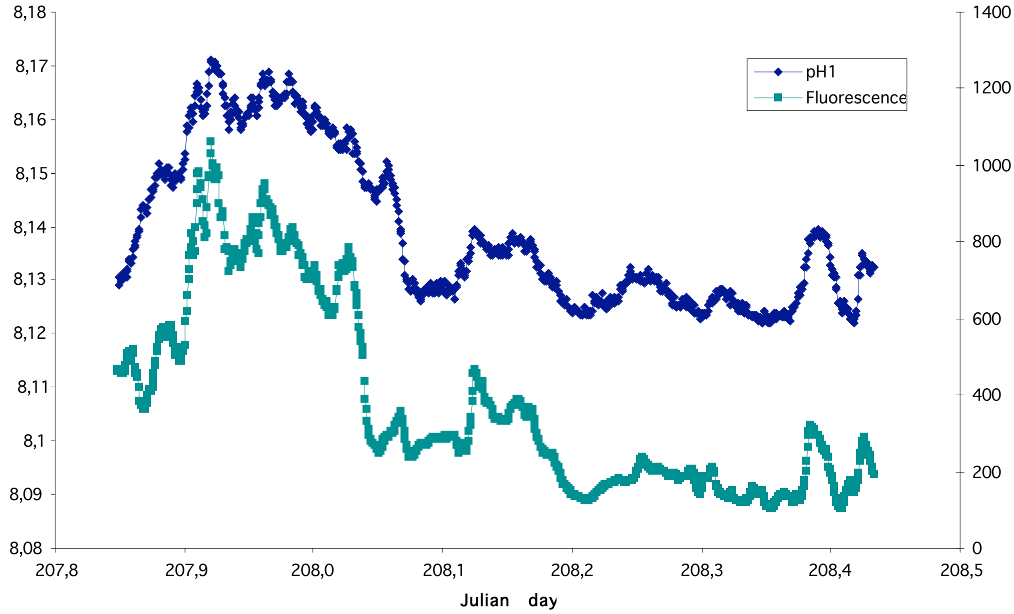


Figure 29: Trend of in situ potentiometric pH and Fluorescence

Thorium-234 Measurements - *Paul Morris*

The aim of this work was to measure total (dissolved + particulate) thorium-234 as a proxy measurement for particle export.

Introduction

Naturally occurring radioactive thorium-234 (^{234}Th, half-life of 24.1 days) can be used to trace particle export through the water column. This proxy measurement relies on the differing properties of ^{234}Th and its parent nuclide uranium-238 (^{238}U). ^{238}U is conservative in seawater and proportional to salinity (Ku *et al.*, 1977; Chen *et al.*, 1986), whereas ^{234}Th is particle reactive and readily adheres to particles. As particles sink through the water column a radioactive disequilibrium is formed between ^{238}U and ^{234}Th which can be used to quantify the rate of particle export from the surface ocean when combined with data on the elemental ratio between particulate ^{234}Th activity and the element of interest, such as carbon (Tsunogai and Minagawa, 1976).

Samples to measure the elemental ratios between ^{234}Th and carbon, nitrogen, biogenic silica and calcite were taken to measure the export of carbon, nitrogen, biogenic silica and calcite respectively.

Total ^{234}Th analysis

The method used to measure total ^{234}Th was the same at that described by Morris *et al.*, (2007), which was previously based on the methods described by Rutgers van der Loeff and Moore (1999). In brief, 10 L of seawater was precipitated with manganese dioxide and left for 8 hours to scavenge all the thorium. The precipitate was then filtered out onto 142 mm diameter (0.8 µm pore size), polycarbonate, Isopore filters. Filters were left to air dry and then folded with repeatable geometry, wrapped in mylar film, and counted onboard ship on a low-level beta GM multicounter system (Model Risø GM-25-5A) for ^{234}Th activity. Samples were counted as soon as possible after sampling, typically 3-5 days. Samples need to be repeatedly counted during the decay of ^{234}Th thus tracking the decay of the isotope over its natural life time (> 6 ^{234}Th half lives). Therefore counting would be continued on leg 2 of D321 by Sandy Thomalla and then at NOC once the samples and counter arrive back there.

Calibration and extraction efficiency

To calibrate the total ^{234}Th technique mid-water (2000 m) samples were used based on the recommendations of Rutgers van der Loeff *et al.*, (2006). These samples were collected well away from the surface ocean, the continental shelf and seafloor nepheloid layers. At this depth the rates of processes other than radioactive production and decay of ^{234}Th are negligible and ^{234}Th is assumed to be in secular equilibrium with ^{238}U. Therefore it is assumed that ^{238}U activity equals the total ^{234}Th activity. Deep water was collected at stations 16262A, 16286A and 16287A.

Manganese dioxide is typically very efficient at scavenging ^{234}Th. However, to examine the extraction efficiency and check the technique is working properly, a double precipitation is performed on one profile. This entails collecting the filtrate from the first precipitation and repeating the precipitation on the filtrate. This precipitation is then left for 8 hours and filtered in the same manner. On first inspection of the raw counts it appears that the method is operating at approximately 100% efficiency.

Stations sampled

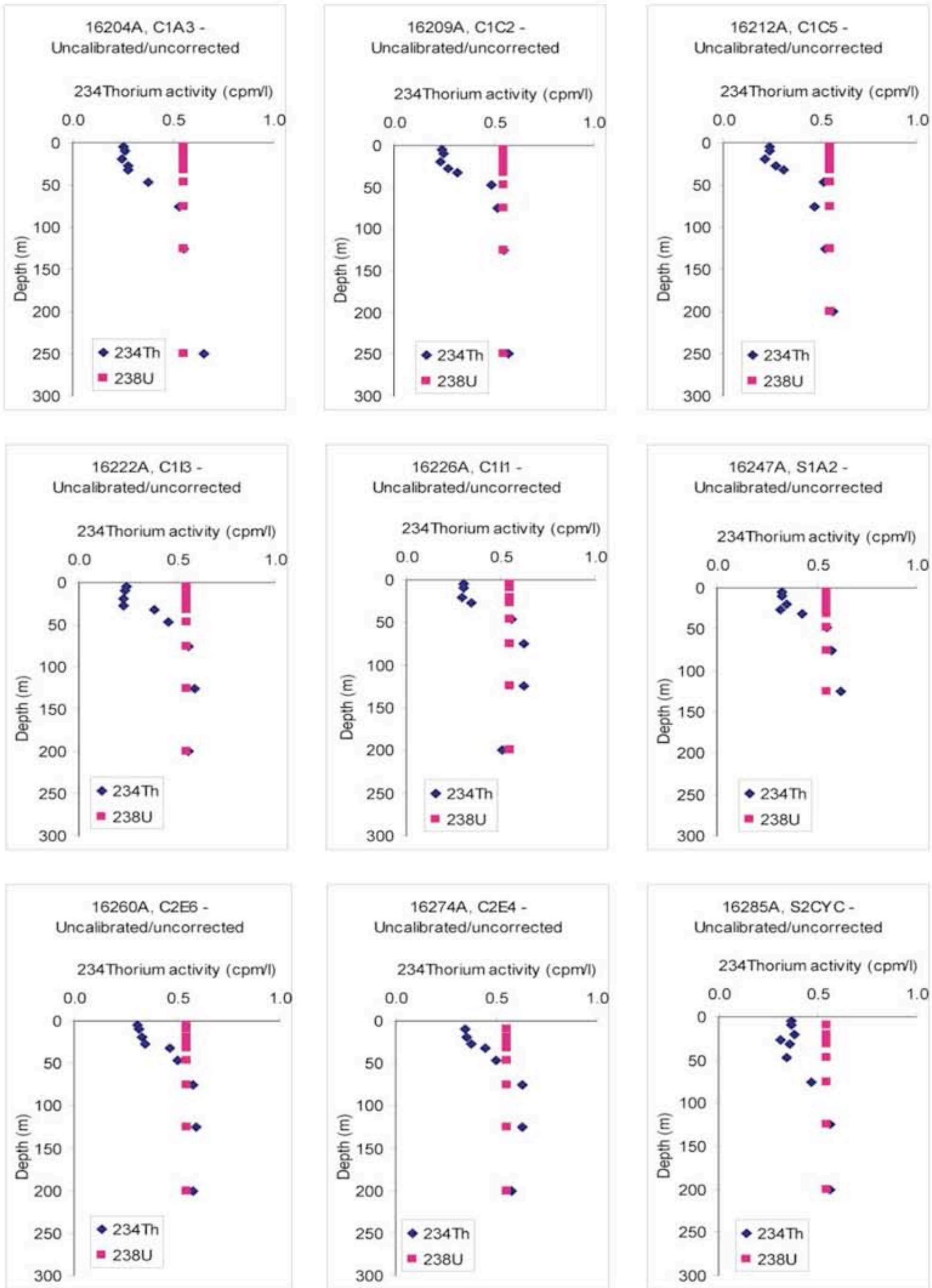
All major primary productivity stations were sampled, for a complete list see **Table 18**. All samples were taken off the stainless steel productivity cast, denoted the ‘A’ cast for identification during the cruise (**Figure 30**). Total volume of water filtered: 1050 litre.

Discovery station	Survey/grid position	Sample details
16204A	C1A3	9 depths, 5-250 m
16209A	C1C2	9 depths, 5-250 m
16212A	C1C5	9 depths, 5-200 m
16222A	C1I3	10 depths, 5-400 m
16226A	C1I1	9 depths, 5-400 m
16247A	S1A2	10 depths, 5-600 m
16260A	C2E6	10 depths, 5-600 m
16262A	C2C6	5 calibration samples, 2000 m
16274A	C2E4	9 depths, 5-400 m. No SAPS
16285A	S2CYC	10 depths, 5-400 m
16286A	S2ANT	8 depths, 10-400 m. 1 calibration sample, 2000 m
16287A	S2ANTSW	1 calibration sample, 2000 m

Table 18: The *Discovery* station, survey/grid position and sample details for all the total ^{234}Th samples collected.

Problems

On several occasions the sample volume had to be reduced to 5 litre or the sample dropped completely due to insufficient water available from the CTD cast.



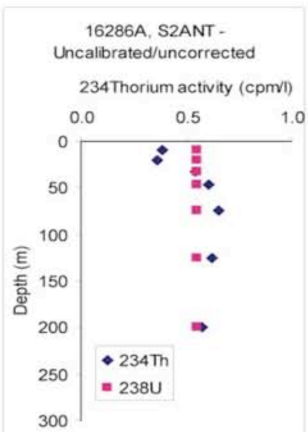


Figure 30: Raw counts for total ^{234}Th profiles. Caution has to be exercised on the following: the raw counts have not been calibrated or corrected and the ^{238}U line has been estimated and may not be in exactly the correct place. These figures should only be used for relative comparisons between stations.

Stand Alone Pump System – SAPS

SAPS are a self contained pumping unit which are used to filter large volumes of water in situ. These were used to filter large volumes of water and collect particles for determination of elemental ratios between ^{234}Th and carbon, nitrogen, biogenic silica and calcite. A 293 mm filter housing capable of mounting two filters in series was used to sequentially filter through nitex screen of 53 µm and 1 µm pore size, the recommended procedure by Buesseler *et al.,* (2006). The SAPS were deployed at 60 m and 100 m whenever a ^{234}Th profile was collected. For a complete list of stations sampled see **Table 19**.

In addition to SAPS for ^{234}Th, SAPS were also deployed for the iron group in parallel with the ^{234}Th SAPS, however only the >53 µm size fraction was filtered. This was for the measurement of ratios between iron and carbon, and iron and nitrogen. On two occasions two SAPS were deployed at greater depths for HPLC, and on one occasion two shallow SAPS were deployed for genetics.

Processing of the ^{234}Th SAPS samples

The ^{234}Th SAPS samples were processed as follows: The nitex screen was removed from the filter housing and the particles rinsed off using thorium free seawater. The resuspended particles were then split using a Folsom splitter for analysis of ^{234}Th, POC/N, biogenic silica and calcite. The ^{234}Th split was filtered on to 142 mm diameter (0.8 µm pore size), polycarbonate, Isopore filters. The POC/N split was filtered onto 25 mm, pre-weighed, pre-combusted GFF filters and stored at -20°C. The biogenic silica and calcite splits were filtered on to 25 mm, 0.2 µm polycarbonate filters and stored at -20°C. The ^{234}Th splits were counted in the same manner as the total ^{234}Th samples and the other splits are to be returned to NOC for processing.

Problems

One of the SAPS pumps started to cut out early and did not pump for the full 1.5 hours. Eventually, the pump was replaced with the spare but the spare proved to be even less reliable so the original pump had to be put back in. A second SAPS also started to cut out early but the pumping time lost did not warrant any action.

Deployment details										
Cast	**Station**	**Grid Position**	**S/N**	**Depth**	**Analysis**	**Start vol (l)**	**End vol (l)**	**Vol filtered (l)**	GMT	
									Time on	**Time off**
1	16204D	C1A3	03-04	60	Thorium	35243.5	37198.3	1954.8	05:45	07:45
1	16204D	C1A3	03-06	100	Thorium	92867.9	94758.4	1890.5	05:45	07:45
1	16204D	C1A3	03-03	60	Iron	74757.5	76721.4	1963.9	05:50	07:50
1	16204D	C1A3	03-02	100	Iron	85103.3	87442.4	2339.1	05:50	07:50
2	16209D	C1C2	03-04	60	Thorium	37198.3	38985.3	1787.0	04:55	07:25
2	16209D	C1C2	03-06	100	Thorium	94758.4	96729.7	1971.3	04:55	07:25
2	16209D	C1C2	03-03	1000	HPLC	76721.4	78149.6	1428.2	04:45	07:15
2	16209D	C1C2	03-02	2000	HPLC	87442.4	89016.3	1573.9	04:35	07:05
3	16212D	C1C5	03-04	60	Thorium	38985.3	41280.5	2295.2	04:45	06:45
3	16212D	C1C5	03-06	100	Thorium	96729.7	98637.3	1907.6	04:45	06:45
3	16212D	C1C5	03-03	60	Iron	78149.6	80214.2	2064.6	04:45	06:45
3	16212D	C1C5	03-02	100	Iron	89016.3	91387.3	2371.0	04:45	06:45
4	16222D	C1I3	03-04	60	Thorium	41280.5	43595.3	2314.8	04:40	06:40
4	16222D	C1I3	03-06	100	Thorium	98637.3	100519.9	1882.6	04:40	06:40
4	16222D	C1I3	03-03	60	Iron	80214.2	82302.9	2088.7	04:40	06:40
4	16222D	C1I3	03-02	100	Iron	91387.3	93752.7	2365.4	04:40	06:40
5	16226D	C1I1	03-04	60	Thorium	43595.3	45711.5	2116.2	00:30	02:30
5	16226D	C1I1	03-06	100	Thorium	100519.9	102419.3	1899.4	00:30	02:30
5	16226D	C1I1	03-03	60	Iron	82302.9	84389.6	2086.7	00:30	02:30
5	16226D	C1I1	03-02	100	Iron	93752.7	96130.7	2378.0	00:30	02:30
6	16247D	S1A2	03-04	60	Thorium	45711.5	47937.3	2225.8	03:28	05:58
6	16247D	S1A2	03-06	100	Thorium	102419.3	104131.2	1711.9	03:28	05:58
6	16247D	S1A2	03-03	500	HPLC	84389.6	85752.1	1362.5	03:28	05:58
6	16247D	S1A2	03-02	1000	HPLC	96130.7	97726.7	1596.0	03:28	05:58
7	16260D	C2E6	03-04	60	Thorium	47937.3	50218.6	2281.3	05:10	07:10
7	16260D	C2E6	03-06	100	Thorium	104131.2	105703.7	1572.5	05:10	07:10
7	16260D	C2E6	03-03	60	Iron	85752.1	87766.9	2014.8	05:10	07:10
7	16260D	C2E6	03-02	100	Iron	97726.7	99714.4	1987.7	05:10	07:10
8	16285D	S2CYC	03-04	60	Thorium	50218.6	52496.7	2278.1	21:05	23:05
8	16285D	S2CYC	03-02	100	Thorium	99714.4	101919.1	2204.7	21:05	23:05
8	16285D	S2CYC	03-03	60	Iron	87766.9	89545.1	1778.2	21:05	23:05
8	16285D	S2CYC	02-004	100	Iron	105703.7	106652.2	948.5	21:05	23:05
9	16285D	S2CYC	03-04	10	Proteomics	52496.6	53631.9	1135.3	05:11	07:11
9	16285D	S2CYC	03-02	27	Proteomics	101919.3	103112.2	1192.9	05:11	07:11
9	16285D	S2CYC	03-06	27	Iron	106651.9	108290.3	1638.4	05:11	07:11

9	16285D	S2CYC	03-03	60	Iron	89545.1	91534.5	1989.4	05:11	07:11
10	16286D	S2ANT	03-04	60	Thorium	53632.1	55825.4	2193.3	08:48	10:48
10	16286D	S2ANT	03-02	100	Thorium	103112.3	105353.9	2241.6	08:48	10:48
10	16286D	S2ANT	03-03	60	Iron	91534.7	93490.5	1955.8	08:48	10:48
10	16286D	S2ANT	03-06	100	Iron	108300.3	109990.4	1690.1	08:48	10:48

Table 19: Summary of all the SAPS deployments. Station numbers were denoted the ‘D’ cast for identification during the cruise. Total volume of water filtered for thorium only: 36729 litre.

Deploying PELAGRA Drifting Sediment Traps - *Richard Sanders, Patrick Martin*

A total of nine PELAGRA deployments were made during the cruise (**Table 20**). The original aim of these was to compare the flux of particulate matter out of the euphotic zone as measured by PELAGRA to the amount of flux inferred from ^{234}Th disequilibria, as well as to try to simultaneously measure particle fluxes in the ‘twilight zone’, at 500 m depth.

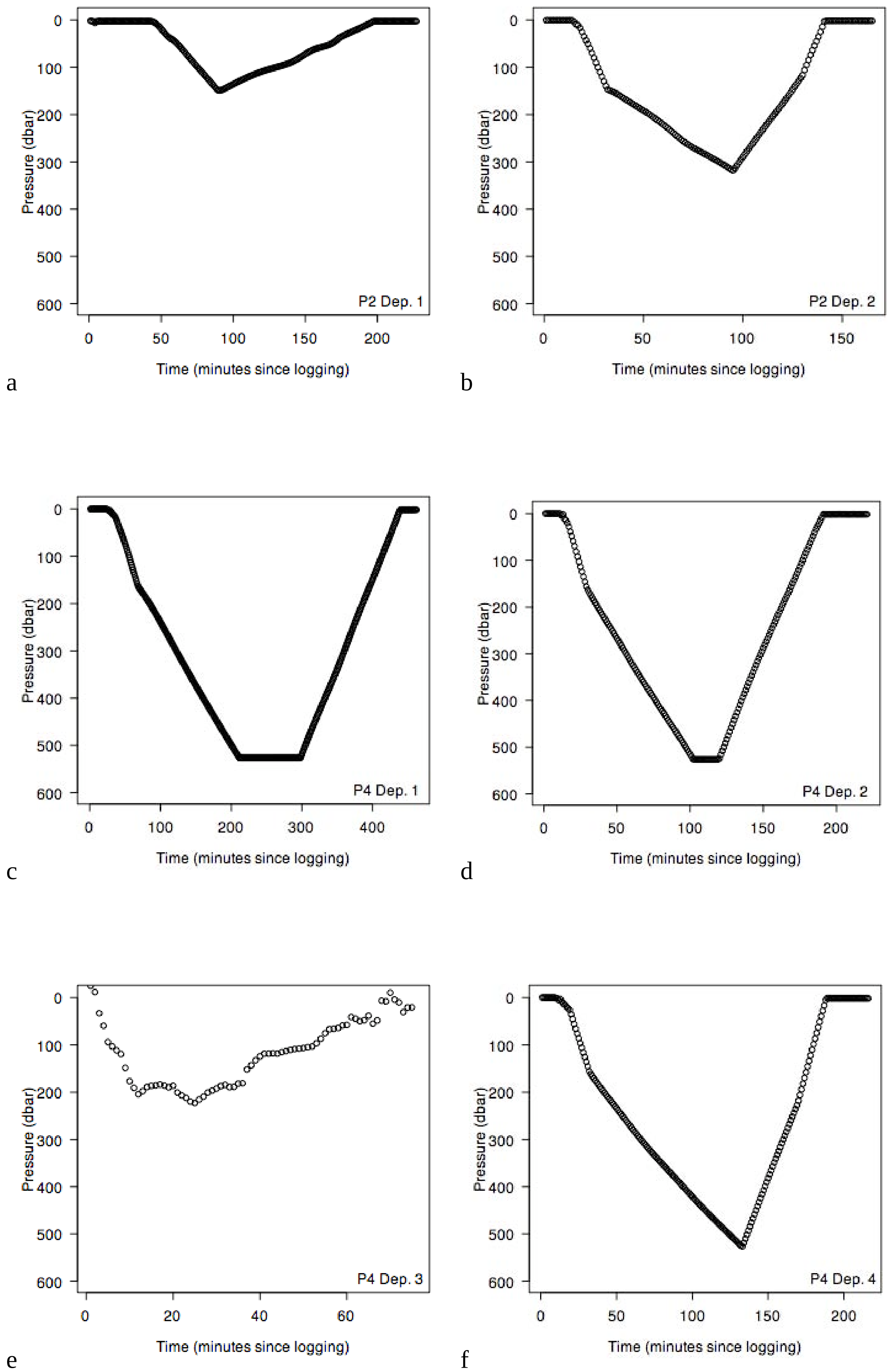
Unfortunately, we experienced serious problems with ballasting the traps, as the ballasting spreadsheets proved to be inaccurate. Despite attempting to calculate the correct amount of ballast on the basis of trap density and the density of seawater at depth, none of the traps deployed stayed neutrally buoyant at any depth for a satisfactory length of time. **Figures 31a-h** show the deployment profiles of each trap during each deployment. Although it appears as though trap P4 was neutrally buoyant at 500 m during its first deployment, it soon dropped its emergency 500 m weight to then ascend rapidly (and earlier than planned). This pattern repeated itself at each deployment of both P2 and P4: the trap would descend, drop either or both its 100 m and 500 m weights, and ascend earlier than planned. The only exception was the final (sixth) deployment of P4, during which the trap descended more slowly after dropping its 100 m weight and did not reach 500 m before the planned ascent began with the release of the main drop weight. However, even this trap failed to achieve neutral buoyancy at any depth. Thus, we did not obtain useful samples of sinking particles from PELAGRA during this cruise.

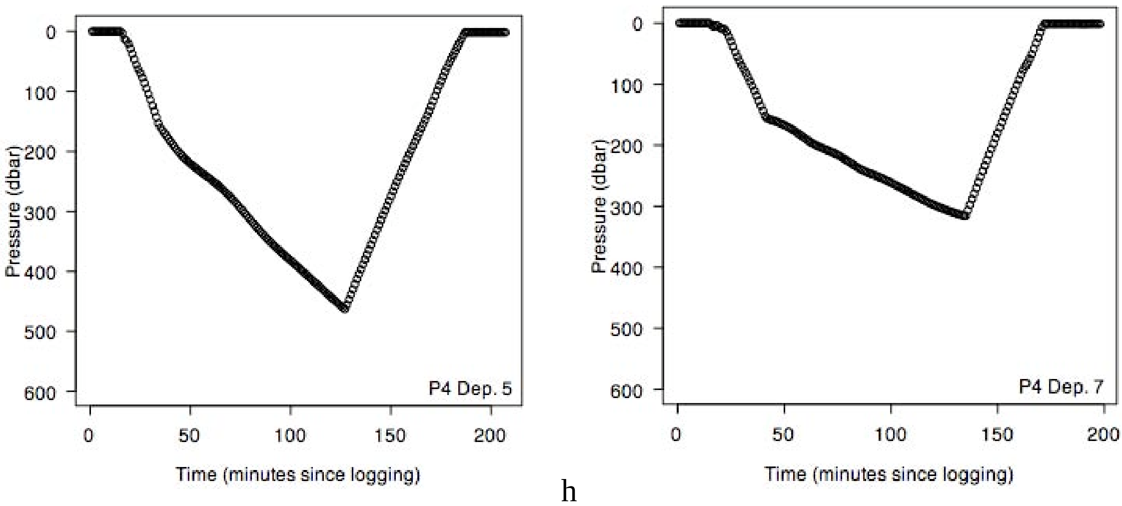
That no more than eight deployments were carried out, and largely using P4, is due to time constraints as well as the fact that the timer of P2 was suspected to be faulty.

After the first deployment of P2, the trap had not correctly fired its burnwire, and hence not dropped its main weight. Subsequent load testing showed that the battery was almost empty; it was unclear whether this was due merely to having used an empty battery, or whether there was a short circuit in the timer that drained the battery before it was due to drop its main weight.

Trap number	**Deployment number**	**Date**	**Notes**
P2	1	30/07/07	
P2	2	21/08/07	Suspect timer or battery
P4	1	30/07/07	Too heavy, dropped 500 m weight
P4	2	01/08/07	Too heavy, dropped 500 m weight
P4	3	10/08/07	Too light
P4	4	14/08/07	Too heavy, dropped 500 m weight
P4	5	17/08/07	Too heavy, dropped 500 m weight
P4	6	21/08/07	100 m drop weight fell off on deployment, trap did not sink
P4	7	21/08/07	Slow descent, possibly OK

Table 20: Summary of PELAGRA deployments carried out on D321 with notes on ballasting.


P2 Dep. 1
P2 Dep. 2
P4 Dep. 1
P4 Dep. 2
P4 Dep. 3
P4 Dep. 4
Pressure (dbar)
Time (minutes since logging)
a
b
c
d
e
f



g h

Figure 31: Depth profiles of each PELAGRA deployment carried out on D321. Profiles are sorted in descending order according to trap (P2 and P4) and deployment number. Note that the profile of the third deployment of P4 (Fig. 1e) was calculated from temperature data recorded by the trap's temperature probe, and using a depth-temperature regression calculated from CTD data as depth = -241.213*temperature + 2594.086 (r^2 = 0.978, temperatures from above the seasonal thermocline were excluded to calculate the regression).

Moored Sediment Trap Data - *Richard Sanders, Patrick Martin*

An array of four 21 bottle McClane sediment traps 400 m above the bottom was deployed in the Iceland Basin on cruise D312 in October 2006. The array was triangular with one trap in the centre and underlay the area studied on D321 (**Figures 2 and 6**). The length scale separating each trap was ~ 70 km and the central trap was equipped with an upward looking ADCP at approx 350 m beneath the sea surface. Each trap had a current meter beneath it recording current speed, direction and in some cases temperature and salinity. The purpose of the array was to capture sinking material from the study region with the four traps being separated by typical dimensions of the eddies which occur in the region and which have sufficiently high velocities associated with them that individual sediment traps may under-collect at times. The philosophy was that, the separation of the traps should ensure that at least one of them would be collecting efficiently at any time, this would then allow a composite of flux to be made from the good points. In the event that two or more traps were collecting efficiently some estimate of mesoscale variability in deep flux might be made.

All four traps deployed on D321 were recovered successfully. All had functioned according to the pre-programmed schedule (Allen *et al.*, 2007) and had collected plausible looking time series of material with the fall out from the spring bloom clearly identifiable (**Figure 32**). A second minor peak in flux was evident in each trap. Further analysis at NOCS will include picking the samples for swimmers, analyses of particulate organic carbon, opal, calcite and lithogenic material and enumeration of recognisable algal cells. Comparisons with satellite ocean colour derived chlorophyll, calcite and IR sea-surface temperature will be made and also with upper ocean nutrient inventories.

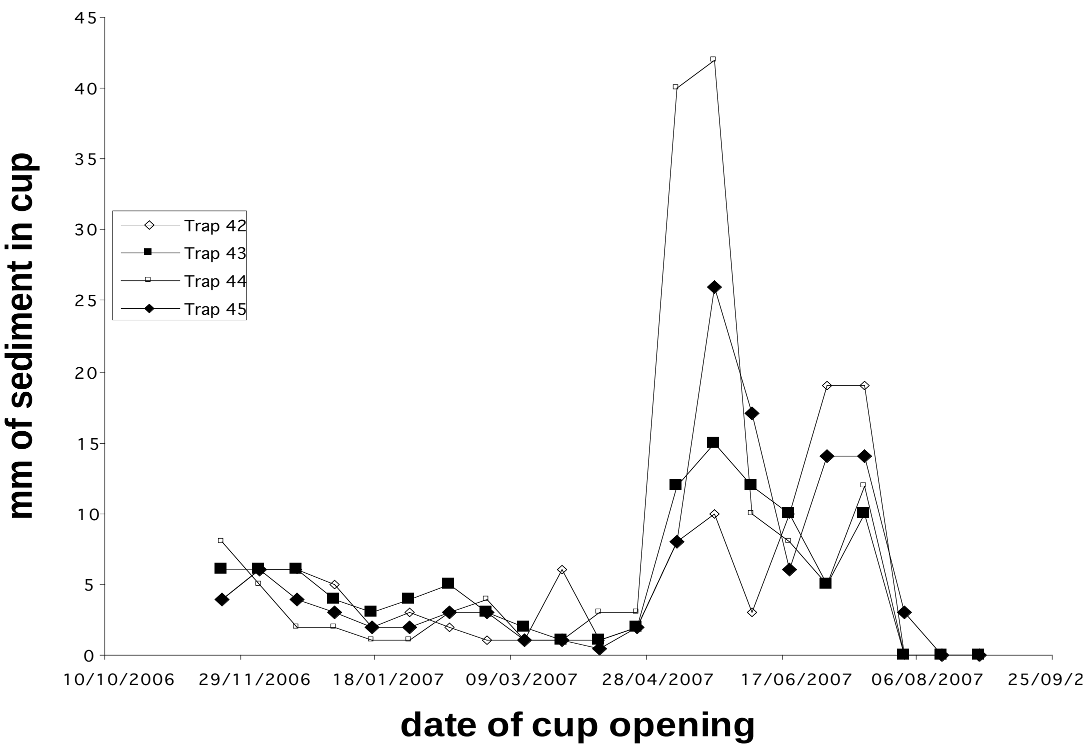


Figure 32: Time series of material fluxes at each site. All cups were open for two weeks.

The current meter data (**Figure 33**) indicated that each trap had been collecting efficiently, for a good proportion of the time deployed, if a threshold value of 15 cms^{-1} is considered to separate good and bad samples.

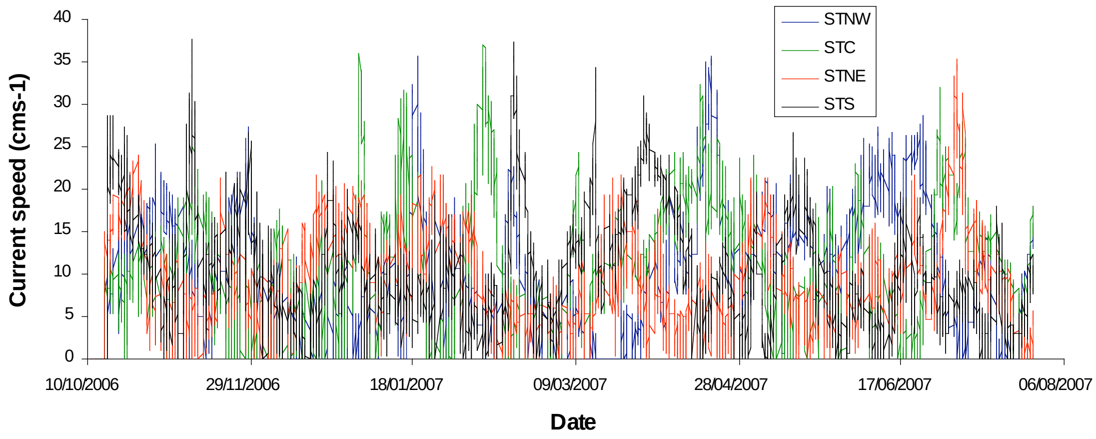


Figure 33: Time series of current velocities at each trap site.

Logsheets for each trap recovered were filled in, see below:-

Deployment No:xxxxll

Cruise deployed: D312
Date: 15/10/06
BY: sanders
Start & end times: 8.02.00, 8.28
Trap A= 2381
Trap B= 21 bottle ml11804-05

Site: INDIA STNW
Station #: 16137
Sounding: 2781

Position: 60 N, 20.49.51W
Cruise recovered: D321
Date: 29/07/2007
BY: sanders and martin
Start & end times:

Current Meters: rcm8 11216
Acoustic release: rt661 440

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
L-A-1	22/11/06	11/22/06	325.5	326.5	332.5	14		8.0
L-A-2	06/12/06	12/06/06	339.5	340.5	346.5	14		8.0
L-A-3	20/12/06	12/20/06	353.5	354.5	178	14		8.0
L-A-4	03/01/07	01/03/07	2.5	3.5	9.5	14		8.0
L-A-5	17/01/07	01/17/07	16.5	17.5	23.5	14		8.0
L-A-6	31/01/07	01/31/07	30.5	31.5	37.5	14		8.0
L-A-7	14/02/07	02/14/07	44.5	45.5	51.5	14		8.5
L-A-8	28/02/07	02/28/07	58.5	59.5	65.5	14		8.0
L-A-9	14/03/07	03/14/07	72.5	73.5	79.5	14		8.5
L-A-10	28/03/07	03/28/07	86.5	87.5	93.5	14		8.0
L-A-11	11/04/07	04/11/07	100.5	101.5	107.5	14		8.5
L-A-12	25/04/07	04/25/07	114.5	115.5	121.5	14		8.0
L-A-13	09/05/07	05/09/07	128.5	129.5	135.5	14		8.0
L-A-14	23/05/07	05/23/07	142.5	143.5	149.5	14		8.0
L-A-15	06/06/07	06/06/07	156.5	157.5	163.5	14		8.5
L-A-16	20/06/07	06/20/07	170.5	171.5	177.5	14		8.5
L-A-17	04/07/07	07/04/07	184.5	185.5	191.5	14		8.0
L-A-18	18/07/07	07/18/07	198.5	199.5	205.5	14	Under funnel at r	8.0
L-A-19	01/08/07	08/01/07	212.5	213.5	219.5	14		8.0
L-A-20	15/08/07	08/15/07	226.5	227.5	233.5	14		
L-A-21	29/08/07	08/29/07	240.5	241.5	247.5	14		
Final move to open l	12/09/07	09/12/07	254.5	255.5				

Deployment No:xxxxIII

Cruise deployed: D312
Date: 15/10/06
BY: sanders
Start & end times:15:20, 16:50
Trap A= 2350
Trap B= 21 bottle ml11804-02

Site: INDIA STC
Station #: 16138
Sounding: 2765

Position: 59 29.913 N 19 59.76 W
Cruise recovered: D321
Date:
BY: sanders and martin
Start & end times:

Current Meters: rcm8 9682
Acoustic release: ar861b2s 325

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
L-A-1	22/11/06	11/22/06	325.5	326.5	332.5	14		7.5
L-A-2	06/12/06	12/06/06	339.5	340.5	346.5	14		8.0
L-A-3	20/12/06	12/20/06	353.5	354.5	178	14		8.0
L-A-4	03/01/07	01/03/07	2.5	3.5	9.5	14		7.0
L-A-5	17/01/07	01/17/07	16.5	17.5	23.5	14		7.5
L-A-6	31/01/07	01/31/07	30.5	31.5	37.5	14		7.0
L-A-7	14/02/07	02/14/07	44.5	45.5	51.5	14		8.5
L-A-8	28/02/07	02/28/07	58.5	59.5	65.5	14		8.0
L-A-9	14/03/07	03/14/07	72.5	73.5	79.5	14		8.0
L-A-10	28/03/07	03/28/07	86.5	87.5	93.5	14		7.5
L-A-11	11/04/07	04/11/07	100.5	101.5	107.5	14		7.0
L-A-12	25/04/07	04/25/07	114.5	115.5	121.5	14		7.0
L-A-13	09/05/07	05/09/07	128.5	129.5	135.5	14		7.5
L-A-14	23/05/07	05/23/07	142.5	143.5	149.5	14		7.5
L-A-15	06/06/07	06/06/07	156.5	157.5	163.5	14		8.0
L-A-16	20/06/07	06/20/07	170.5	171.5	177.5	14		7.0
L-A-17	04/07/07	07/04/07	184.5	185.5	191.5	14		7.5
L-A-18	18/07/07	07/18/07	198.5	199.5	205.5	14		8.0
L-A-19	01/08/07	08/01/07	212.5	213.5	219.5	14	Under funnel at r	8.0
L-A-20	15/08/07	08/15/07	226.5	227.5	233.5	14		
L-A-21	29/08/07	08/29/07	240.5	241.5	247.5	14		
Final move to open I	12/09/07	09/12/07	254.5	255.5				

Deployment No:xxxxiv

Cruise deployed: D312
Date: 15/10/06
BY: sanders
Start & end times: 20.44 21.02
Trap A= 2317
Trap B= 21 bottle ml11804-01

Site: INDIA STNE
Station #: 16137
Sounding: 2781

Position: 59 38.972 18 48.838
Cruise recovered: D321
Date: 28/07/2007
BY: sanders and martin
Start & end times:

Current Meters: rcm8 12302
Acoustic release: rt551 321

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
L-A-1	22/11/06	11/22/06	325.5	326.5	332.5	14		8.0
L-A-2	06/12/06	12/06/06	339.5	340.5	346.5	14		7.5
L-A-3	20/12/06	12/20/06	353.5	354.5	178	14		7.0
L-A-4	03/01/07	01/03/07	2.5	3.5	9.5	14		7.5
L-A-5	17/01/07	01/17/07	16.5	17.5	23.5	14		7.0
L-A-6	31/01/07	01/31/07	30.5	31.5	37.5	14		8.0
L-A-7	14/02/07	02/14/07	44.5	45.5	51.5	14	amphipod	8.0
L-A-8	28/02/07	02/28/07	58.5	59.5	65.5	14		8.5
L-A-9	14/03/07	03/14/07	72.5	73.5	79.5	14		7.5
L-A-10	28/03/07	03/28/07	86.5	87.5	93.5	14		8.0
L-A-11	11/04/07	04/11/07	100.5	101.5	107.5	14		8.5
L-A-12	25/04/07	04/25/07	114.5	115.5	121.5	14		7.5
L-A-13	09/05/07	05/09/07	128.5	129.5	135.5	14	v large catch	7.0
L-A-14	23/05/07	05/23/07	142.5	143.5	149.5	14	v large catch	7.5
L-A-15	06/06/07	06/06/07	156.5	157.5	163.5	14	large catch	8.0
L-A-16	20/06/07	06/20/07	170.5	171.5	177.5	14		7.5
L-A-17	04/07/07	07/04/07	184.5	185.5	191.5	14		8.0
L-A-18	18/07/07	07/18/07	198.5	199.5	205.5	14	under funnell	8.0
L-A-19	01/08/07	08/01/07	212.5	213.5	219.5	14		8.0
L-A-20	15/08/07	08/15/07	226.5	227.5	233.5	14		
L-A-21	29/08/07	08/29/07	240.5	241.5	247.5	14		
Final move to open h	12/09/07	09/12/07	254.5	255.5				

Deployment No:xxxxv

Site: INDIA STS
Position: 58 51.968 20 24.169
Cruise deployed: D312
Station #: 16137
Cruise recovered: D321
Date: 16/10/06
Sounding: 2781
Date:
BY: sanders
BY: sanders and martin
Start & end times: 6:18 6:44
Start & end times:
Trap A= 2441
Trap B= 21 bottle ml11262-08
Current Meters: rcm8 3344
Acoustic release: rt661 183

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
L-A-1	22/11/06	11/22/06	325.5	326.5	332.5	14		8.0
L-A-2	06/12/06	12/06/06	339.5	340.5	346.5	14		8.5
L-A-3	20/12/06	12/20/06	353.5	354.5	178	14		8.0
L-A-4	03/01/07	01/03/07	2.5	3.5	9.5	14		8.5
L-A-5	17/01/07	01/17/07	16.5	17.5	23.5	14		8.5
L-A-6	31/01/07	01/31/07	30.5	31.5	37.5	14		8.5
L-A-7	14/02/07	02/14/07	44.5	45.5	51.5	14		8.5
L-A-8	28/02/07	02/28/07	58.5	59.5	65.5	14		8.5
L-A-9	14/03/07	03/14/07	72.5	73.5	79.5	14		8.5
L-A-10	28/03/07	03/28/07	86.5	87.5	93.5	14		8.5
L-A-11	11/04/07	04/11/07	100.5	101.5	107.5	14		8.5
L-A-12	25/04/07	04/25/07	114.5	115.5	121.5	14		8.5
L-A-13	09/05/07	05/09/07	128.5	129.5	135.5	14		8.5
L-A-14	23/05/07	05/23/07	142.5	143.5	149.5	14		8.5
L-A-15	06/06/07	06/06/07	156.5	157.5	163.5	14		8.5
L-A-16	20/06/07	06/20/07	170.5	171.5	177.5	14		8.5
L-A-17	04/07/07	07/04/07	184.5	185.5	191.5	14		8.5
L-A-18	18/07/07	07/18/07	198.5	199.5	205.5	14		8.5
L-A-19	01/08/07	08/01/07	212.5	213.5	219.5	14	under funnel	8.0
L-A-20	15/08/07	08/15/07	226.5	227.5	233.5	14		8.5
L-A-21	29/08/07	08/29/07	240.5	241.5	247.5	14		
Final move to open h	12/09/07	09/12/07	254.5	255.5				

Two of the four traps were re-deployed, the other two were replaced with two thirteen bottle traps. The intention is to recover them on the extended Ellett line cruise in spring 2008. All were filled with hyperdense 2% formalin made using deep water with a sample being archived for potential future analysis. All were programmed on board with schedules listed below. Copies of the hyperterminal dialogue with each trap were archived, unfortunately one was overwritten and one was garbled such that it is unreadable. This occurred on two occasions, on the first occasion when the trap was logged into the previously created programme was running, thus when it occurred the second time it was decided to accept the trap as having been programmed despite the garbled dialogue.

Deployment No:XLVII

Site: INDIA
Position:
Cruise deployed:
Station #:
Cruise recovered:
Date:
Sounding:
Date:
BY:
BY:
Start & end times:
Start & end times:
Trap A=
Trap B=
Current Meters:
Acoustic release:

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
XLVII-A-1	26/08/07	08/26/07	224	225	231	14		
XLVII-A-2	09/09/07	09/09/07	238	239	245	14		
XLVII-A-3	23/09/07	09/23/07	252	253	259	14		
XLVII-A-4	07/10/07	10/07/07	266	267	280	28		
XLVII-A-5	04/11/07	11/04/07	294	295	315	42		
XLVII-A-6	16/12/07	12/16/07	336	337	174.5	42		
XLVII-A-7	27/01/08	01/27/08	13	14	27	28		
XLVII-A-8	24/02/08	02/24/08	41	42	48	14		
XLVII-A-9	09/03/08	03/09/08	55	56	62	14		
XLVII-A-10	23/03/08	03/23/08	69	70	76	14		
XLVII-A-11	06/04/08	04/06/08	83	84	90	14		
XLVII-A-12	20/04/08	04/20/08	97	98	104	14		
XLVII-A-13	04/05/08	05/04/08	111	112	118	14		
Final move to open l	18/05/08	05/18/08	125	126				

Deployment No:XLVIII

Site: INDIA
Position:
Cruise deployed:
Station #:
Cruise recovered:
Date:
Sounding:
Date:
BY:
BY:
Start & end times:
Start & end times:
Trap A=
Trap B=
Current Meters:
Acoustic release:

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
XLVIII-A-1	26/08/07	08/26/07	224	225	231	14		
XLVIII-A-2	09/09/07	09/09/07	238	239	245	14		
XLVIII-A-3	23/09/07	09/23/07	252	253	259	14		
XLVIII-A-4	07/10/07	10/07/07	266	267	280	28		
XLVIII-A-5	04/11/07	11/04/07	294	295	315	42		
XLVIII-A-6	16/12/07	12/16/07	336	337	174.5	42		
XLVIII-A-7	27/01/08	01/27/08	13	14	27	28		
XLVIII-A-8	24/02/08	02/24/08	41	42	48	14		
XLVIII-A-9	09/03/08	03/09/08	55	56	62	14		
XLVIII-A-10	23/03/08	03/23/08	69	70	76	14		
XLVIII-A-11	06/04/08	04/06/08	83	84	90	14		
XLVIII-A-12	20/04/08	04/20/08	97	98	104	14		
XLVIII-A-13	04/05/08	05/04/08	111	112	118	14		
Final move to open l	18/05/08	05/18/08	125	126				

Deployment No:XLIX

Site: INDIA
Position:
Cruise deployed: D321
Station #:
Cruise recovered:
Date: 09/08/07
Sounding:
Date:
BY: Martin + Sanders
BY:
Start & end times: 26/08/2007
Start & end times:
Trap A=
Trap B=
Current Meters:
Acoustic release:

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
XLIX-A-1	26/08/07	08/26/07	224	225	231	14		
XLIX-A-2	09/09/07	09/09/07	238	239	245	14		
XLIX-A-3	23/09/07	09/23/07	252	253	259	14		
XLIX-A-4	07/10/07	10/07/07	266	267	273	14		
XLIX-A-5	21/10/07	10/21/07	280	281	287	14		
XLIX-A-6	04/11/07	11/04/07	294	295	301	14		
XLIX-A-7	18/11/07	11/18/07	308	309	315	14		
XLIX-A-8	02/12/07	12/02/07	322	323	329	14		
XLIX-A-9	16/12/07	12/16/07	336	337	343	14		
XLIX-A-10	30/12/07	12/30/07	350	351	357	14		
XLIX-A-11	13/01/08	01/13/08	364	365	6	14		
XLIX-A-12	27/01/08	01/27/08	13	14	20	14		
XLIX-A-13	10/02/08	02/10/08	27	28	34	14		
XLIX-A-14	24/02/08	02/24/08	41	42	48	14		
XLIX-A-15	09/03/08	03/09/08	55	56	62	14		
XLIX-A-16	23/03/08	03/23/08	69	70	76	14		
XLIX-A-17	06/04/08	04/06/08	83	84	90	14		
XLIX-A-18	20/04/08	04/20/08	97	98	104	14		
XLIX-A-19	04/05/08	05/04/08	111	112	118	14		
XLIX-A-20	18/05/08	05/18/08	125	126	132	14		
XLIX-A-21	01/06/08	06/01/08	139	140	146	14		
Final move to open l	15/06/08	06/15/08	153	154				

Deployment No:L

Cruise deployed: D321
Date: 09/08/07
BY: Martin + Sanders
Start & end times: 26/08/2007
Trap A=
Trap B=

Site: INDIA
Station #:
Sounding:

Position:
Cruise recovered:
Date:
BY:
Start & end times:

Current Meters:
Acoustic release:

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
L-A-1	26/08/07	08/26/07	224	225	231	14		
L-A-2	09/09/07	09/09/07	238	239	245	14		
L-A-3	23/09/07	09/23/07	252	253	259	14		
L-A-4	07/10/07	10/07/07	266	267	273	14		
L-A-5	21/10/07	10/21/07	280	281	287	14		
L-A-6	04/11/07	11/04/07	294	295	301	14		
L-A-7	18/11/07	11/18/07	308	309	315	14		
L-A-8	02/12/07	12/02/07	322	323	329	14		
L-A-9	16/12/07	12/16/07	336	337	343	14		
L-A-10	30/12/07	12/30/07	350	351	357	14		
L-A-11	13/01/08	01/13/08	364	365	6	14		
L-A-12	27/01/08	01/27/08	13	14	20	14		
L-A-13	10/02/08	02/10/08	27	28	34	14		
L-A-14	24/02/08	02/24/08	41	42	48	14		
L-A-15	09/03/08	03/09/08	55	56	62	14		
L-A-16	23/03/08	03/23/08	69	70	76	14		
L-A-17	06/04/08	04/06/08	83	84	90	14		
L-A-18	20/04/08	04/20/08	97	98	104	14		
L-A-19	04/05/08	05/04/08	111	112	118	14		
L-A-20	18/05/08	05/18/08	125	126	132	14		
L-A-21	01/06/08	06/01/08	139	140	146	14		
Final move to open l	15/06/08	06/15/08	153	154				

Mesozooplankton Community Structure and Abundance – *Patrick Martin*

The mesozooplankton community was sampled at eight of the primary productivity stations with the aim of recording its taxonomic composition and determining the relative abundance of taxa. Between two and three samples were taken at each station, with vertical net hauls to 100 m depth, using a plankton net of 200 µm mesh size deployed from the A-frame used for CTD deployments. In order to account for diel vertical migration of the zooplankton, samples were taken at night. The station numbers at which zooplankton was sampled are listed in **Table 21**, together with their positions, time and date of sampling, the number of net hauls taken, and the dominant taxa found. The latter were identified upon cursory inspection of the samples on board; due to the difficulty of microscopy at sea a more systematic analysis was not attempted. The dominance of thaliaceans at the first stations caused these samples to have a high settled volume; samples at later stations had a far lower volume due to the preponderance of copepods and amphipods in place of thaliaceans. Overall, the zooplankton community appeared to be relatively diverse, with several species each of thaliaceans, calanoid copepods, hyperiid amphipods and pteropods found at most stations along with polychaetes, siphonophores, mysid or euphausiid decapods and occasional fish larvae.

Each sample was split into two subsamples using a Folsom sample splitter. One of these was preserved in 4% buffered formalin for subsequent taxonomic analysis, while the remaining subsample was filtered onto a 53 µm mesh and frozen at -75°C to allow for chemical analyses such as aragonite *versus* calcite content.

Station	**Date**	**Sampling Time (GMT)**	**Number of hauls**	**Dominant taxa**
16204	28/07/07	02:00	2	Thaliaceans, calanoids
16209	30/07/07	00:00	3	Thaliaceans, calanoids
16212	31/07/07	00:30	3	Thaliaceans, calanoids
16222	02/08/07	01:00	2	Thaliaceans, calanoids
16226	05/08/07	05:00	3	Calanoids, fewer thaliaceans than above
16247	09/08/07	01:00	2	As for station 16247
16260	12/08/07	01:00	3	Calanoids
16285	18/08/07	00:15	3	Calanoids, hyperiids
*16288	20/08/07	11:30	2	Calanoids, hyperiids
*16289	20/08/07	13:45	2	Calanoids, hyperiids
*16292	20/08/07	17:30	2	Calanoids
*16295	20/08/07	21:30	2	Calanoids, hyperiids

Table 21: The stations at which zooplankton were sampled.

In addition to those taken during productivity stations, two daytime zooplankton samples were taken at each of four stations located on a transect across the dipole eddy structure that was discovered during the cruise. These stations are marked with an asterisk in **Table 21.** The zooplankton community was very low in diversity at these stations and did not appear to change much along the transect: although a small number of thaliaceans was found at station 16288, and three pteropods (*Clio* sp.) were caught in the final net haul at station 16295.

Although it may be tempting to try to derive quantitative data on zooplankton biomass from these samples, the sampling methodology employed on this cruise is too crude for this to be reliably possible. Vertical net hauls can deliver biased estimates due to the occurrence of plankton swarms (towed nets that yield a sigmoidal trajectory are hence to be preferred), and without a mounted flow meter it is not possible to know the exact quantity of water filtered. These samples are therefore to be viewed as semi-quantitative. Furthermore, the net's original cod-end broke at the end of sampling at station 16247; all samples from station 16260 onwards were taken with a new cod-end that had a mesh size of only 50 µm.

Microbial Community Abundance, Structure and Dynamics - *Mike Zubkov, Glen Tarran*

The aim of this work was to study abundance, community composition and metabolic activities of dominant microbial groups within planktonic communities and to assess rates of protist bacterivory in the temperate North Atlantic Ocean.

Objectives

1) To determine the vertical and spatial distribution, abundance and community structure of nano- and picoplankton in the euphotic zone by flow cytometry, from CTD casts during CTD surveys.

2) To collect concentrated seawater samples for analysis of plankton community composition in the euphotic zone using molecular approaches, including fluorescence *in situ* hybridisation.

3) To estimate the turnover of dissolved organic nutrients using methionine and leucine tracers, to assess microbial competition for these compounds.

4) To estimate rates of bacterivory by dominant flagellates.

5) Underway sampling from the uncontaminated seawater supply to assess microbial spatial variability at 4 km scale during Seasoar surveys.

Methods

Plankton community structure and abundance by flow cytometry.

During CTD surveys, water samples were collected from the 6 light depths (1, 4.5, 7, 14, 33 and 55% of surface light) and either one or two depths below the euphotic zone. Samples from CTDs coinciding with bacterivory experiments were analysed immediately by flow cytometry to determine microbial abundance and composition. Samples from all other CTD stations were preserved and frozen at -80 °C for post-cruise analysis. For immediate analyses, fresh seawater samples were collected in clean 250 mL polycarbonate bottles from a Seabird CTD system containing either 24 x 20 L Niskin bottles or 24 x 10 L bottles for iron analysis. Samples were stored in a refrigerator and analysed within 1-2 hours of collection. Fresh samples were measured using a Becton Dickinson FACSort instrument, which characterised and enumerated *Synechococcus* spp. (cyanobacteria), picoeukaryotes, cryptophytes, coccolithophores and other nanophytoplankton based on their light scattering and autofluorescence properties. Microorganisms were also preserved with paraformaldehyde (1% final concentration) and then stained with SYBR Green I nucleic acid stain. The samples were then left in the dark at room temperature for at least 1 hour before enumeration of bacterioplankton, heterotrophic and phototrophic flagellates by flow cytometry. Samples for post-cruise analysis were collected in 50 mL polypropylene centrifuge tubes and stored in a refrigerator for up to 4 h before fixing with paraformaldehyde (1% final concentration). Samples were then left to fix in a refrigerator for a minimum of 1 hour before being frozen and stored in a -80 °C freezer. **Table 22** summarises the CTD casts sampled and analysed during the cruise.

Date	**Time on deck (GMT)**	**Station**	***Discovery* Stn. no.**	**Lat**	**Long**	**Depths sampled**
28-Jul-07	17:22	C1A5	16202A	60.00	18.76	5 10 20 27 32 47 75
28-Jul-07	19:43	C1A4	16203A	60.00	19.32	5 10 20 27 32 47 75 125
28-Jul-07	01:34	C1A3	16204A	60.00	19.88	5 10 20 27 32 47 75 125

29-Jul-07	13:24	C1A2	16205A	60.00	20.45	5 10 20 27 32 47 75
29-Jul-07	18:45	C1A1	16207A	60.00	21.00	5 10 20 27 32 47 75 125
29-Jul-07	21:50	C1C1	16208A	59.88	20.99	5 10 20 27 32 47 75 125
30-Jul-07	02:09	C1C2	16209B	59.71	20.45	5 10 20 27 32 47 75 125
30-Jul-07	17:25	C1C3	16210A	59.72	19.88	5 10 20 27 32 47 75 125
30-Jul-07	21:47	C1C4	16211A	59.71	19.30	10 20 27 32 47 75 125 200
31-Jul-07	03:53	C1C5	16212B	59.70	18.75	5 10 20 27 32 47 75
31-Jul-07	11:10	C1E5	16312A	59.45	18.75	5 10 20 27 32 47 75 125
31-Jul-07	15:07	C1G5	16214A	59.15	18.75	10 20 27 32 47 75 125 200
31-Jul-07	19:06	C1I5	16215A	58.87	18.75	10 20 27 32 47 75 125 200
31-Jul-07	00:07	C1I4	16216A	58.87	19.31	5 10 20 27 32 47 75 125
1-Aug-07	04:22	C1G4	16217A	59.15	19.32	5 10 20 27 32 47 75
1-Aug-07	17:41	C1E3	16220A	59.48	20.00	5 10 20 27 32 47 75 125
1-Aug-07	22:20	C1G3	16221A	58.15	19.89	5 10 20 27 32 47 75 125
2-Aug-07	04:05	C1I3	16222B	58.86	19.88	5 10 20 27 32 47 75
2-Aug-07	15:11	C1I2	16224A	58.87	20.41	5 10 20 27 32 47 75 125
2-Aug-07	18:25	C1G2	16225A	59.16	20.45	5 10 20 27 32 47 75 200
5-Aug-07	04:30	C1I1	16226B	58.84	22.01	5 10 20 27 32 47 75
5-Aug-07	22:08	S1H5	16228A	58.02	18.73	5 10 20 27 32 47 75 125
6-Aug-07	01:33	S1H4	16229A	59.02	19.32	5 10 20 27 32 47 75 125
6-Aug-07	05:13	S1H3	16230A	59.02	19.88	5 10 20 27 32 47 75
6-Aug-07	09:05	S1H2	16231A	59.02	20.45	5 10 20 27 32 47 75
6-Aug-07	12:40	S1H1	16232A	59.02	21.00	5 10 20 27 32 47 75 125

6-Aug-07	15:29	S1G1	16233A	59.15	21.00	5 10 20 27 32 47 75 125
6-Aug-07	19:12	S1G2	16234A	59.15	20.45	5 10 20 27 32 47 75 200
6-Aug-07	22:25	S1G3	16235A	59.15	19.88	5 10 20 27 32 47 75 125
7-Aug-07	01:30	S1G4	16236B	59.15	19.32	5 10 20 27 32 47 75
8-Aug-07	18:32	S1C3	16238B	59.71	19.88	5 10 20 27 32 47 75 125
8-Aug-07	20:52	SIC4	16239A	59.72	19.31	5 10 20 27 32 47 75 200
8-Aug-07	00:40	S1C5	16240A	59.72	18.75	5 10 20 27 32 47 75 125
9-Aug-07	13:17	S1B2	16243A	59.87	20.45	5 10 20 27 32 47 75 125
9-Aug-07	16:10	S1B1	16244A	59.87	21.00	5 10 20 27 32 47 75 200
9-Aug-07	18:33	S1A1	16245A	60.00	21.01	5 10 20 27 32 47 75 125
9-Aug-07	23:30	S1A2	16247A	60.00	20.45	5 10 20 27 32 47 75
10-Aug-07	03:09	S1A2	16247B	59.99	20.48	5 10 20 27 32 47 75
10-Aug-07	13:46	S1A3	16248A	60.00	19.88	5 10 20 27 32 47 75
11-Aug-07	01:07	C2A7	16251A	60.00	18.70	5 10 20 27 32 47 75 125
11-Aug-07	03:52	C2B7	16252A	59.80	18.70	5 10 20 27 32 47 75
11-Aug-07	06:44	C2C7	16253A	59.60	18.70	5 10 20 27 32 47 75 125
11-Aug-07	12:40	C2E7	16255A	59.20	18.70	5 10 20 27 32 47 75 125
11-Aug-07	17:58	C2G7	16257A	58.80	18.70	5 10 20 27 32 47 75 125
12-Aug-07	04:38	C2E6	16260A	59.19	19.11	10 20 27 32 47 75
12-Aug-07	00:37	C2A5	16265A	60.00	19.47	5 10 20 27 32 47 75 125
13-Aug-07	03:05	C2B5	16266A	59.80	19.47	5 10 20 27 32 47 75
13-Aug-07	05:47	C2C5	16267A	59.60	19.46	5 10 20 27 32 47 75 125
13-Aug-07	17:45	C2G5	16271A	59.80	19.46	5 10 20 27 32 47 75 125

16-Aug-07	08:43	C2F2	16280A	59.01	20.56	5 10 20 27 32 47 75
18-Aug-07	02:20	S2CYC	16285B	59.66	18.75	5 10 20 27 32 47 75
19-Aug-07	08:07	S2ANT	16286B	59.24	19.76	5 10 20 27 32 47 75

Table 22: CTD casts sampled for phytoplankton and bacterial commumity structure and abundance.

Microbial Amino acid Uptake and Bacterivory Experiments.

Table 23 summarises station information for grazing and uptake experiments as well as sample collection and concentration for post-cruise molecular determination of microbial community composition.

Grazing expt no.	Date	Station	Depth sampled (m)	*Discovery* Stn. no.	CTD type	Lat	Long
1	30 Jul 07	C1C2	5	16209B	Productivity	59.71	20.45
2	31 Jul 07	C1C5	5	16212B	Productivity	59.70	18.75
3	1 Aug 07	C1G4	5	16217A	Standard	59.15	19.32
4	2 Aug 07	C1I3	5	16222B	Productivity	58.86	19.88
5	5 Aug 07	C1I1	5	16226B	Productivity	58.84	22.01
6	7 Aug 07	S1G4	47	16236B	Standard	59.15	19.32
7	9 Aug 07	S1A2	5	16247B	Productivity	60.00	20.45
8	11 Aug 07	C2B7	47	16252A	Standard	59.80	18.70
9	12 Aug 07	C2E6	47	16260B	Productivity	59.19	19.11
10	13 Aug 07	C2B5	5	16266A	Standard	59.80	19.47
11	16 Aug 07	C2F2	47	16280A	Standard	59.01	20.56
12	18 Aug 07	S2CYC	5	16285B	Productivity	59.66	18.75
13	19 Aug 07	S2ANT	5	16286B	Standard	59.24	19.76

Table 23: CTD casts sampled for sample concentration for molecular analysis and bacterivory experiments.

Bioassays of ambient bioavailable concentrations, microbial uptake rates of amino acids and bacterivory rates by pico- and nano-planktonic flagellates were conducted on board by incubating samples with isotopically labelled precursor molecules: ^{35}S-methionine and ^{3}H-leucine.

Objective 5 was unable to be fulfilled owing to a combination of problems with SeaSoar and science down-time due to bad weather.

Preliminary observations

The heterotrophic bacteria community in the survey area was reasonably constant in terms of the flow cytograms of light scatter vs green fluorescence from stained DNA. Abundance in the mixed layer varied from approx. 0.5 to 2.4 million cells mL^{-1}. *Synechococcus* sp. cyanobacteria were more variable, abundance ranging from 3,000 to almost 80,000 cells mL^{-1}. Picophytoplankton (<2 µm) were the most abundant eukaryotes, with concentrations varying by almost an order of magnitude from 2,500 to 21,000 cells mL^{-1}. Small coccolithophores (<10 µm), probably *Emiliania huxleyi* also varied by an order of magnitude, abundance ranging from approx. 100-1000 cells mL^{-1}. The most abundant station for small coccolithophores, *Synechococcus* sp., picoeukaryote phytoplankton, as well as heterotrophic bacteria was S1A2 on 10 August. The other two groups discriminated using flow cytometry were cryptophytes and 'other' nanophytoplankton. Cryptophytes were below reliable detection limits throughout most of the survey area, only a few stations had measurable cryptophytes and they were all smaller than 5 µm. The 'other' nanophytoplanton ranged from approx 500 – 2100 cells mL^{-1} and were generally most abundant in the upper 30 m.

Scintillation counts were done on board the ship and a five fold range of rates of microbial activity was observed. Boiassayed concentrations of methionine and leucine in surface waters ranged between 0.06-0.35 nmol L^{-1} and 0.13-0.55 nmol L^{-1}, respectively. Estimated fast turnover of methionine and leucine molecules by bacterioplankton ranged between 1.7-6.5 hours and 1.2-5.0 hours, respectively. Detailed analysis of the collected tracer samples will be carried out after the cruise on low background scintillation counters back at the NOCS, because of the sensitivity limitations of the scintillation counter on board the ship. When completed, the data set will allow estimation of the rates of bacterioplankton metabolic activity, production and mortality due to grazing, as well as linking between bacterial function, composition and hydrological structure of the water column.

Physiological Acclimation of Phytoplankton Populations to High CO_2 - *M. Debora Iglesias-Rodriguez, Alex Poulton, Maria Salta*

Recent concern about the consequences of rising CO_2 partial pressure, as a result of human-induced climate change, has prompted oceanographers to investigate the fate of phytoplankton functional groups in a high CO_2 world. The limited observations in the lab and in the field suggest that marine ecosystems are sensitive to CO_2 increase. Laboratory and field studies revealed that the growth of diatoms is enhanced under high CO_2 conditions (Tortell *et al.,* 2000). In the case of coccolithophores, the extent of $CaCO_3$ dissolution is expected to increase as a function of the decrease in the pH and the saturation state of calcite (Riebesell *et al.,* 2000, Zondervan *et al.,* 2001, Rost and Riebesell, 2004). However, experiments on coccolithophores have, at least, in part, manipulated the carbonate system by the addition of acid or base to the growth medium (Nimer and Merrett, 1993, Buitenhuis *et al.,* 1999, Riebesell *et al*., 2000, Zondervan *et al*., 2001, Zondervan *et al*., 2002). One problem with this approach is that it alters the total alkalinity, which is not the case when fossil fuel-derived CO_2 dissolves in the ocean. While previous studies focused largely on laboratory-maintained species, the work we conducted here tests the effect of CO_2 partial pressure on open ocean North Atlantic phytoplankton population physiology, with a special focus on coccolithophores. Specifically, we report on the effect of high CO_2 partial pressures on phytoplankton physiology in bloom, and non-bloom conditions under nutrient-replete and nutrient-limiting conditions.

Methods

Incubation experiments

We conducted replicate experiments by bubbling subsurface seawater with air containing different partial pressures of CO_2 (BOC Special Products), to give 385, 750, and 1200 p.p.m.v. CO_2 in the seawater. One control for each treatment consisted of GF/F-filtered seawater, and was used to monitor pH changes (**Figure 34**). Replicates of 16 L of seawater (plus one filtered seawater control) were incubated in 20 L Nalgene flasks fitted with Dreschel heads. The CO_2 concentration became stable typically 48 h after the beginning of bubbling. The subsequent growth of phytoplankton raised the pH in the medium. Experiments were conducted in non-bloom and bloom phytoplankton populations. Nutrients were not added to the incubations. Cell density, pH, DIC, alkalinity, nutrients, calcification rates, organic carbon production rates, and silicification rates were measured at the start of the experiment and after 96 hours (see **Tables 24, 25,** and **26**). Additionally, sampling for RNA, DNA, fast repetition rate fluorometry (FRRF) measurements, Coulter counter and scanning electron microscopy were conducted for further laboratory analysis at the National Oceanography Centre (NOC), Southampton. Cell density values estimated by flow cytometry, FRRF measurements, calcification rates, nutrient concentrations and chlorophyll analyses are described elsewhere in this report.

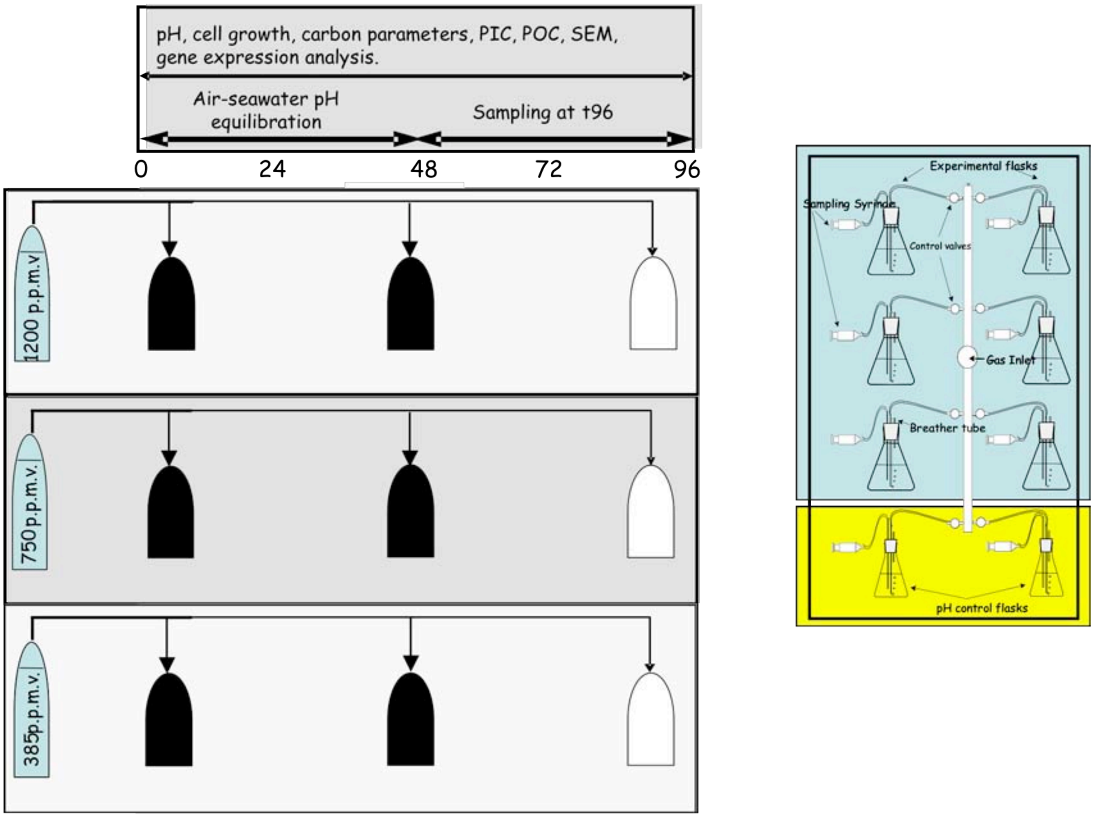


Figure 34: Diagram of CO_2-enrichment experiments on deck. The black bottles represent replicates and the white bottles represent controls of filtered seawater.

Particulate inorganic carbon analysis

Aliquots of cultures were filtered through 0.22 µm and stored for further analysis with a Perkin Elmer Optima 4300 DV inductively coupled plasma-optical emission spectrometer (ICP-OES) at the NOC.

Particulate organic carbon and particulate organic nitrogen analysis

Samples for particulate organic carbon and particulate organic nitrogen analysis were prepared by filtering 500 mL aliquots onto pre-combusted 25 mm MF300 (Fisher Scientific, UK) filters and storing at -20°C for further analysis using a Thermo Finnigan flash EA1112 elemental analyzer.

Carbonate chemistry analyses

Replicate sample aliquots (300 mL) were collected for further analysis using a VINDTA (Versatile INstrument for the Determination of Titration Alkalinity).

Scanning electron microscopy

Sample aliquots of 100 mL were vacuum filtered onto 0.4 µm polycarbonate membranes and rinsed three times with alkaline seawater (using NaOH to obtain pH= 9). Filter membranes were then dried at 37 °C for further analysis using a JEOL JSM-840A scanning electron microscope.

Coulter Counter Analysis

Samples were preserved by addition of 1 volume of 10% formaldehyde (stored at -80 °C after freshly prepared from paraformaldehyde), 0.5% glutaraldehyde, 100 mM sodium borate pH 8.7 to 9 volumes of sample. These samples will be analysed using a Beckman Coulter Multisizer III, fitted with a 20 µm aperture.

Flow cytometry analysis

Samples were preserved as described above for Coulter counter analysis and flash-frozen in liquid nitrogen for further analysis. Chlorophyll-containing cells and detached coccoliths will be identified based on forward scatter, side scatter, and chlorophyll fluorescence (measured at 692 nm with 40 nm bandpass) in NOC.

Results

The tables below are a synthesis of preliminary physico-chemical and phytoplankton physiology data of bloom and non-bloom coccolithophore population incubated at 385, 750 and 1200 p.p.m.v. CO_2. Coccos = coccolithophores; N, Si and P represent nitrate, silicate and phosphate concentrations in µmol L^{-1}. C:P represents the PIC:POC ratio from mmol C/m^3 day.

	Coccos/ml	pH	N	Si	P	POC (mmol C/cell d)	PIC (μmol C/cell d)	C:P
T0	380	7.973	2.00		0.19	0.002	0.052	0.03
385	979	7.971	0.07	0.11	0.09			
750	962	7.814	0.14	0.11	0.04	0.004	0.253	0.07
1200	748	7.763	0.08	0.08	0.11	0.005	0.250	0.04

Table 24: Synthesis of physico-chemical and physiological data of a non-bloom coccolithophore population under silicate limitation.

	Coccos/ml	pH	N	Si	P	POC (mmol C/cell d)	PIC (μmol C/cell d)	C:P
T0	1031	8.032	2.55	0.20	0.17	1.813	0.251	0.14
385	2463	7.818	0.17	0.33	0.05	1.120	0.284	0.25
750	1863	7.836	0.14	0.33	0.05	1.427	0.309	0.22
1200	1048	7.777	0.16	0.35	0.06	2.604	0.486	0.19

Table 25: Synthesis of physico-chemical and physiological data of a coccolithophore bloom population under silicate limitation.

	Coccos/ml	pH	N	Si	P	POC (mmol C/cell d)	PIC (μmol C/cell d)	C:P
T0	643	7.99	5.04	0.67	0.32	1.648	0.338	0.21
385	392	8.07	2.66	0.35	0.15	4.260	0.955	0.22
750	575	7.96	2.28	0.20	0.12	3.513	0.573	0.16
1200	487	7.72	2.31	0.23	0.14	4.045	0.616	0.15

Table 26: Synthesis of physico-chemical and physiological data of a coccolithophore non-bloom population.

Spatial and Temporal Distribution of Dinoflagellate Bioluminescence in the North Atlantic - *Maria Salta, M. Debora Iglesias Rodriguez*

Although accounting for less than 1% of the global photosynthetic biomass, phytoplankton is responsible for at least 45% of the annual net primary production (Field *et al*., 1998). Among these organisms, dinoflagellates are considered central contributors to primary production in both coastal (Morin, 1983) and open ocean (Kelly & Tett, 1978) and represent an important eukaryotic phytoplankton functional group. Bioluminescent dinoflagellates are a common occurrence in coastal environments yet their abundance and distribution in the open ocean remains an open question. The objectives of this study are to (1) test whether bioluminescent dinoflagellates are present in the Iceland Basin; (2) assess their vertical zonation in the water column; (3) characterize the taxonomic composition of bioluminescent dinoflagellates; (4) assess whether a circadian clock controls the activity of bioluminescence; and (5) to calibrate the bathyphotometery signal with *in-situ* data on luciferase presence and activity. To meet these objectives we used a combination of molecular, optical, and physiological approaches.

<u>*1. Bioluminescence Surveys*</u>

CTD

Water samples were collected from CTD casts from four different depths, 5-10m, 32m, 75m, and 125m; samples were processed for DNA and RNA extraction. Additionally, samples were collected for single cell PCR to assess the diversity of luciferase in the water column and for taxonomy.

Sampling at different depths will provide information about the vertical distribution of the luciferace gene. The CTD stations sampled are listed in **Table 27**.

Station	Cast	Jday	Date	Time	Lat	Lon
16204	C1A3	209	29/07/07	01:34	59 59.60N	19 52.44W
16209	C1C2	211	30/07/07	03:16	59 41 24N	20 24.30W
16222	C1I3	214	02/08/07	02:30	58 52.72N	19 52 84W

16226	C1I1	217	04-05/08/07	23:47	58 50.62N	21 00.87W
16260	C2E6	224	12/08/07	03:15	59 11.59N	19 60.37W
16263	C2B6	224	12/08/07	18:56	59 48.54N	19 06.27W
16274	C2E4	226	14/08/07	02:59	59 12.59N	19 53.84W
16283	C2C3	228	16/08/07	17:22	59 35.88N	20 37.24W
16286	S2ANT	231	19/08/07	13:52	59 17.64N	17 57.58W

Table 27: CTD stations sampled for bioluminescence.

SeaSoar (SS)

For RRS *Discovery* cruise D321, the towed CTD vehicle, SeaSoar, had been modified to carry a CTG bathyphotometer (GlowTracker). During SeaSoar surveys underway samples were taken from the ship's non-toxic supply to identify the presence or otherwise of dinoflagellate luciferase specific primers (Baker *et al.*, 2007), to detect the presence of bioluminescent dinoflagellates in the water column. Additionally, samples were collected for HPLC analysis of phytoplankton functional group-specific pigments, and for taxonomic identification of phytoplankton.

Samples were pre-filtered using a 255 μm mesh. At least two replicate samples were collected for DNA in order to assess the presence of luciferase. Samples were also collected for RNA in order to quantify the activity, if luciferase genes were present, and for single cell PCR. Sampling over diel cycles will provide information on the circadian rhythm of bioluminescence that is understood to be controlled by the light:dark cycle (Knaust *et al.*, 1998). **Table 28** provides the geographical positions of the underway samples collected.

Date	Time (GMT)	Lat (dec. °)	Lon (dec. °)
07/08/2007	04:01:00	59.179697	18.893621
07/08/2007	16:06:00	59.300066	20.835089
07/08/2007	20:05:00	59.449965	20.195038
08/08/2007	00:00:00	59.44938	18.933562

08/08/2007	04:06:00	59.583064	19.517014
08/08/2007	08:18:00	59.583082	20.663979
08/08/2007	12:00:00	59.716817	20.451034
08/08/2007	16:10:00	59.657531	19.722699
08/08/2007	20:52:00	59.720061	19.312272
09/08/2007	05:21:00	59.866339	19.476006
09/08/2007	10:00:00	59.871172	20.117732
09/08/2007	16:00:00	59.865301	21.007184
16/08/2007	22:09:50	59.600179	20.358939
16/08/2007	23:09:50	59.599655	20.054861
17/08/2007	14:00:00	59.599095	19.726675
17/08/2007	01:02:07	59.599792	19.47985
17/08/2007	02:07:00	59.600147	19.146117
17/08/2007	03:06:29	59.600081	18.837476
17/08/2007	04:30:00	59.600029	18.411676
17/08/2007	05:11:00	59.599733	18.198714
17/08/2007	05:59:38	59.60025	17.943835
17/08/2007	06:55:47	59.57817	17.715887
17/08/2007	07:56:17	59.505793	17.975605
17/08/2007	09:07:52	59.422423	18.277776
17/08/2007	10:07:47	59.353018	18.523977
17/08/2007	11:10:32	59.281594	18.785788
17/08/2007	12:06:57	59.214609	19.026944
17/08/2007	13:05:43	59.14246	19.286373
17/08/2007	14:15:10	59.130344	19.62353
18/08/2007	14:26:55	60.058585	18.18865
18/08/2007	15:11:40	59.983431	18.294148
18/08/2007	16:12:05	59.866434	18.458235
18/08/2007	17:07:20	59.760966	18.610283

18/08/2007	18:12:30	59.637862	18.789809
18/08/2007	19:07:40	59.532508	18.94108
18/08/2007	20:05:15	59.419718	19.101604
18/08/2007	21:06:50	59.305691	19.266596
18/08/2007	22:06:14	59.192436	19.427937
18/08/2007	23:11:15	59.098163	19.624462
19/08/2007	00:09:00	59.21267	19.809035
19/08/2007	01:28:00	59.368169	20.059114
19/08/2007	20:25:50	59.141517	20.268539
19/08/2007	21:35:00	59.137158	20.318804
19/08/2007	22:50:00	59.115948	19.975351
19/08/2007	23:40:00	59.11653	19.73953
20/08/2007	00:30:10	59.115853	19.507154
20/08/2007	01:23:00	59.118322	19.263266
20/08/2007	02:40:00	59.290098	19.250581
20/08/2007	03:34:00	59.41418	19.249949
20/08/2007	04:34:00	59.554819	19.249979
20/08/2007	05:27:00	59.665169	19.204009

Table 28: Underway sampling positions for bioluminescence.

2. Processing Water Samples

Water samples were filtered for RNA, DNA, single cell PCR and taxonomy (flow cytometry and formalin) according to the protocol given in **Table 29**.

Parameter	***Volume (L) x replicates***	***Pre-filtration (µm) / Filtration (µm)***
RNA	2L x 3	255/ 0.45
DNA	2L x 1	255/ 0.45

Single Cell PCR	1L x 1	255/ 10
Taxonomy-Formalin	0.45 x 3	255
Flow Cytometry	0.09 x 3	255

Table 29: Bioluminescence related variables sampled.

RNA extractions

Water samples for RNA were pre-filtered with a 255 μm mesh and filtered using 0.45 μm filters which were added RNAlater and kept in the fridge at 4 °C for 8-10 hours. The samples were further stored at -80 °C after 10 hours. The samples will be analysed at NOCS.

DNA

Water samples for DNA were pre-filtered with a 255 μm using 0.45 μm filters and stored at -80 °C. DNA will be extracted at NOC and signals will be analysed for luciferase gene.

Single Cell PCR

Water samples were pre-filtered with a 255 μm mesh and filtered using 10 μm filters. The filter was then placed in a Petri-dish and cells were washed off the filter with 2ml 90% ethanol. Samples were stored in 2ml Ependorff tubes and stored at -80 °C. The samples will be analysed at NOCS for taxonomy and PCR of single cell to conduct analysis of luciferase diversity.

Taxonomy-Formalin

Samples of 255 μm pre-filtered sea water were stored in 50ml tubes. In specific, 45ml of sample plus 3ml of formalin were stored at -4 °C. The samples will be analysed at NOCS.

Flow cytometry analysis

Samples were preserved by addition of 1 volume of 10% formaldehyde (stored at -80 °C after freshly prepared from paraformaldehyde), 0.5% glutaraldehyde, 100 mM sodium borate pH 8.7 to 9 volumes of sample and flash-frozen in liquid nitrogen for further analysis. Chlorophyll-containing cells will be identified based on forward scatter, side scatter, and chlorophyll fluorescence (measured at 692 nm with 40 nm bandpass) in NOCS.

We thank Dr. Mike Lucas for his help with filtering-related equipment.

Phytoplankton Metaproteomics - *Bethan Jones and M. Débora Iglesias-Rodriguez*

Introduction

Marine microbes play key roles within oceanic ecosystems and are ubiquitous in marine environments. Despite this, our knowledge of the structure and activities of these communities is limited because most of these microbial species cannot be cultivated in the laboratory. This means that their physiology and function are difficult to study with traditional oceanographic approaches.

In recent years, a variety of metagenomic sequencing projects have offered a glimpse into the life-styles and metabolic capabilities of uncultured organisms occupying various environmental niches (*e.g.* Venter *et al.*, 2004; Rusch *et al.*, 2007). By mass sequencing of DNA from the oceans, it has been possible to predict the genetic levels of diversity that can be present and to hypothesise the range of proteins that may be present within microbial systems (Yooseph *et al.*, 2007).

Whilst information provided by these projects is extremely useful, it is essential to understand which of these genes are expressed under conditions of interest in order to characterise ocean processes in a functionally meaningful way. The rapidly emerging field of metaproteomics presents the opportunity to assess levels of protein diversity present within oceanic environments. By identification of the entire protein complement present within a defined size fraction, an insight can be gained into the key functional processes taking place within a microbial community at a given location.

During this cruise, we aimed to develop a protocol for extracting the metaproteome from the eukaryotic phytoplankton population between 0.45 µm and 45 µm in size. Further work will be carried out on the sampled fractions at the National Oceanography Centre, Southampton and at the Centre for Proteomic Research, University of Southampton. To our knowledge, this is the first time that a metaproteomic sampling of the eukaryotic microbial size range has been carried out within an oceanic environment.

Method

Samples were collected coincidental with primary productivity CTD stations (where the largest ancillary data were collected) when the vessel was quasi-stationary for a period of time greater than six hours (**Figure 35**). Between 60 to 120 L (**Table 30**) of seawater from a 5 m depth were continuously taken from the non-toxic underway system in 5 L increments and were prefiltered with a 45 µm nitex mesh. The sample was filtered on ice through a Sartocon tangential flow filtration system (Sartorius, UK) fitted with a 0.45 µm Sartocon slice cassette filter and was concentrated to a final volume of 1.2 L. This fraction was very gently vacuum-filtered through 1.0 µm Cyclopore membrane filters in 75 mL stages (Whatman, UK). The fraction larger than 1.0 µm was washed off the filter using calcium free artificial seawater and 10 ml of glycerol were added. The sample was snap-frozen in liquid nitrogen to be stored at -80 ºC until further analysis.

This method has the serious limitation that the metaproteome under study could change over the course of a few minutes or even seconds. As this method is time consuming and requires continuous sampling over a period of several hours, it cannot capture shifts at this resolution. Recognising this limitation, the use of a stand alone pump system (SAPS) was trialled at station S2CYC (*Discovery* stn. 16285). Operation of the SAPS system was carried out with assistance from Paul Morris. Prior to use, the equipment was triple washed with Milli-Q water, all surfaces coming into contact with filters were rinsed with methanol and again triple washed with Milli-Q. A 53 µm nitex prefilter was fitted to the system and samples were collected on a 1 µm nitex mesh. Two SAPS were deployed to sample from two depths, one being the chlorophyll maximum. Following SAPS deployment, SAPS were disassembled and the 1 µm mesh was rinsed with calcium free seawater to remove the 1 µm - 53 µm size fraction, which was then retained. Samples were then stored in a manner identical to those processed using tangential flow filtration.

Triplicate samples for DNA and RNA analyses were also taken during the period seawater was taken for proteomic analysis. 2 L of seawater from the non-toxic underway system was vacuum-filtered through 0.45 µm cellulose nitrate or 1 µm

Cyclopore membrane filters. Filters were placed in 2 mL Eppendorf tubes, snap frozen in liquid nitrogen and stored at -80 ºC. Additionally, triplicate samples were taken for flow cytometric analysis; in brief, 1ml of formaldehyde and glutaraldehyde fixative solution was added to 9 mL of the seawater sample, gently shaken, snap frozen in liquid nitrogen and stored at -80 ºC. Finally, 45 mL of seawater was taken from the underway for taxonomic analysis, 3 ml of formalin were added and samples were stored at 4 ºC.

Day	**JDay**	**Station**	***Discovery* Stn.**	**Primary productivity Stn**	**Depth**	**Method**	**Volume (litre)**
29/7/07	210	C1A3	16204	1	5 m	TFF	120
30/7/07	211	C1C2	16209	2	5 m	TFF	110
31/7/07	212	C1C5	16212	3	5 m	TFF	80
2/8/07	214	C1I3	16222	4	5 m	TFF	90
04-05/08/07	216/217	C1I1	16226	5	5 m	TFF	100
7/8/07	219	No station			5 m	TFF	80
10/8/07	222	C1A2	16247	7	5 m	TFF	80
12/8/07	224	C2E6	16260	8	5 m	TFF	80
14/8/07	226	C2E4	16274	9	5 m	TFF	70
15-16/08/07	227/228	No station			5 m	TFF	65
17-18/08/07	229/230	S2CYC	16285	10	5 m	TFF	60
18/8/07	230	S2CYC	16285	10	10 m	SAPS	1135.3
18/8/07	230	S2CYC	16285	10	27 m	SAPS	1192.9

Table 30: Date and volumes of samples taken (TFF = tangential flow filtration).

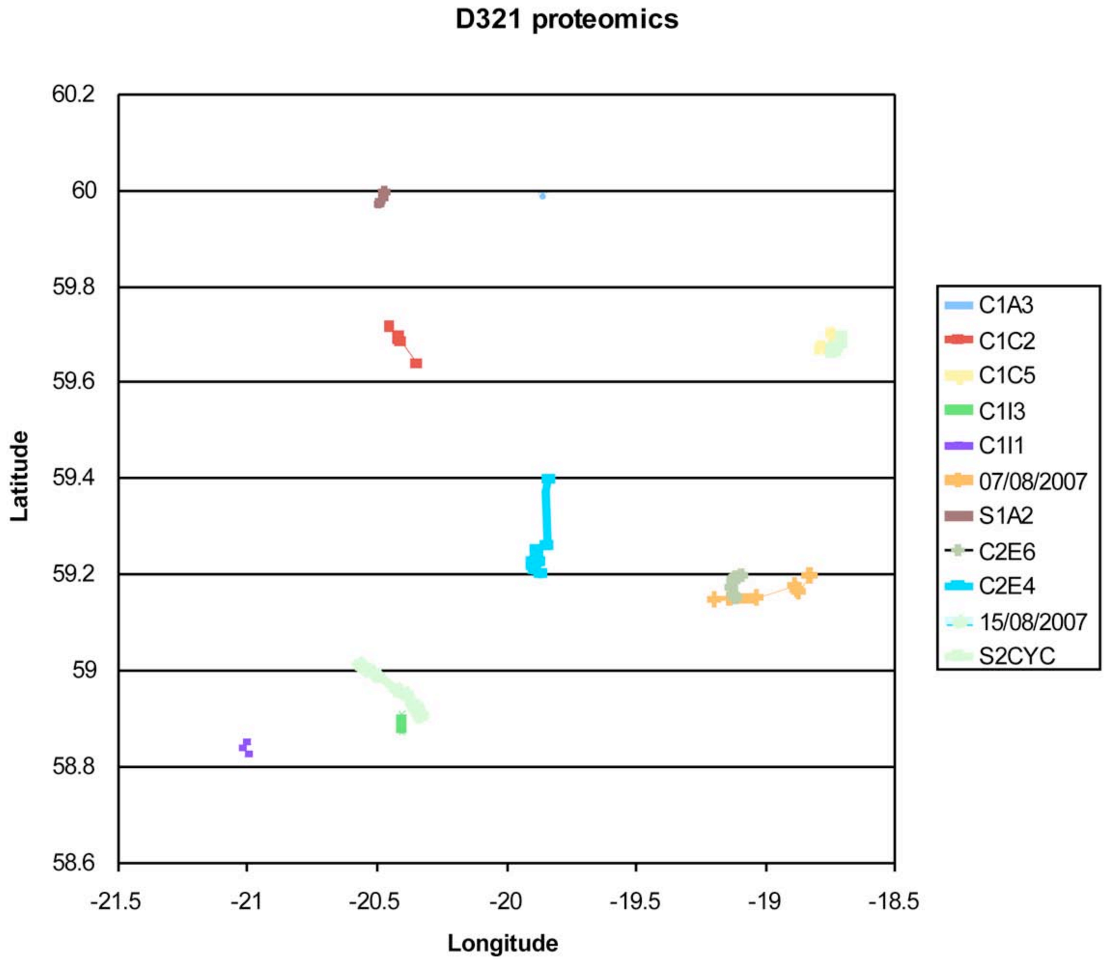


Figure 35: Sampling locations for metaproteomic analysis. Individual points indicate sampling events within each station. Note that the ship did not stay in one position for some samples, therefore absolute homogeneity may be lost in these instances.

Atmospheric Aerosols - *Eric Achterberg*

Aerosol collection was undertaken on D321 using a high volume aerosol collector from UEA. The aerosol collector was positioned on the bridge top (monkey island). Samples were obtained from the collector on a daily basis; a collection time of 24 h was used.

Visual inspection of the filters indicated very little dust on the filters. In case there were obvious signs of particles (typically black), this was most likely contamination from the ship's exhaust stack due to the course taken by the vessel during the period of sample collection.

A total of 20 samples were obtained, and stored frozen. These have been sent to UEA (Dr. Alex Baker/Prof. Tim Jickells). Analysis data for Fe, Al, Si, N and P is expected in the next few months.

5. DISCUSSION

The four repeated surveys carried out during D321 observed the development and travel of an individual ‘eddy dipole’ in a background ocean full of ‘eddies’ and other turbulent motions. ‘Eddies’ are the ocean’s equivalent of atmospheric storms, three dimensional highly energetic motions found everywhere in the open ocean, and often formed in counter spinning pairs (‘dipoles’). In the ocean, however, the ‘storm’ scale is around 10-100 km, unlike the 100-1000 km scale found in the atmosphere. Early in the cruise, sea surface temperature and ocean colour satellite images clearly showed the appearance of an eddy dipole structure within our survey site (**Figure 36**). Further, daily, near real-time satellite images and in-situ vessel mounted acoustic current profiling were used to determine the movement of the eddy centres and the central jet as the system developed and propagated eastward through our survey area.

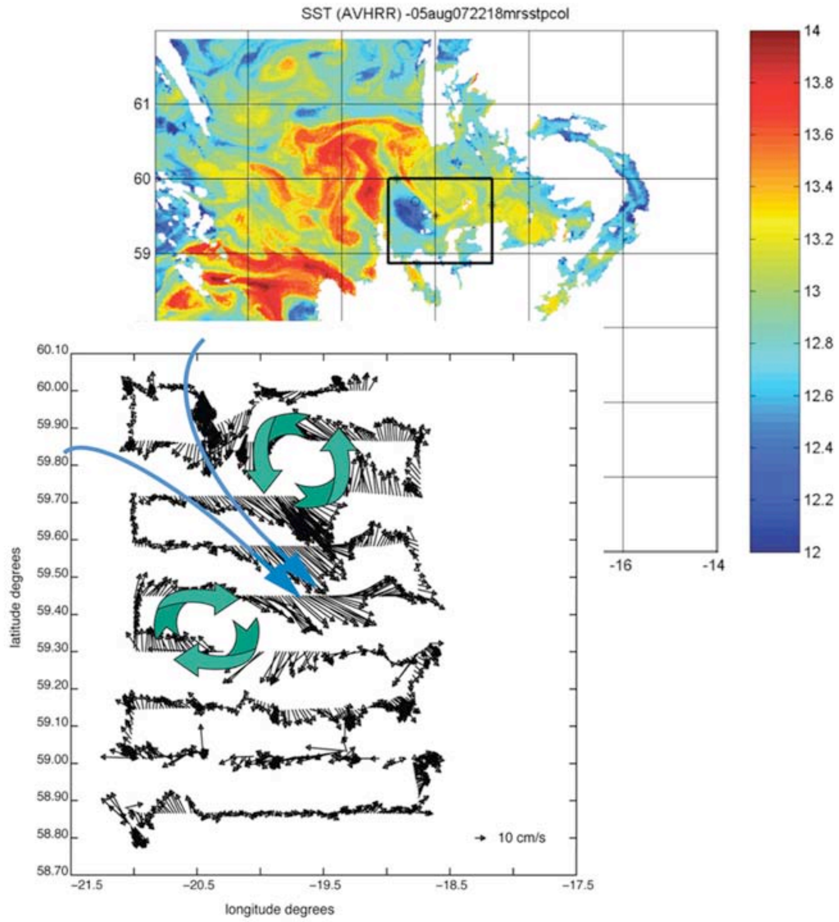


Figure 36: Here the counter-rotating eddies of the dipole are clearly seen in the ocean currents (bottom) and in their cold and warm surface signatures in the sea-surface temperature satellite image (note the blue and bright yellow patches within the black rectangle - top).

Targeted nets and water collection within each component of the eddy dipole enabled the assessment of their biological impacts. There were significant differences in phytoplankton and zooplankton communities between the eddies and within the central jet, although quantitatively much of this data is still to be worked up. Forecast modelling back at the NOC successfully represented most of the spatial patterns in terms of the domination of the physical regime by the development of an eddy dipole from mid-July until the end of August. Adjusted biological parameters began to show similar patterns to observations, particularly in a grazing pressure relationship between larger zooplankton and ammonium concentration in the mixed layer. The research is still at an early stage - considerable analysis and synthesis of the observations is planned for the forthcoming months, during which time we expect to understand these and other relationships through, for example, examination of the observations made of the microbial loop.

Acknowledgements

For a ‘summer cruise’ the weather conditions during D321 were somewhat disappointing; please excuse the classic British understatement !. The North Atlantic storm track remained further south than typical for this time of year resulting in a poor summer for our region of the N. Atlantic and indeed the British Isles. Upon arrival in Reykjavik, we were informed by the local taxi drivers that Iceland had experienced one of its best summers on record; clearly a well appreciated consolation !. Nevertheless, D321 achieved most of its objectives through the dedication of the Master, officers, crew, engineers and scientists involved.

In particular, many thanks to all the officers and crew, involved in recovering the rogue Pelagra on the 30th of July, no matter whether you played a major or minor role, what I saw was excellence in team work and it is much appreciated.

We thank the NERC for its continued commitment to long-term core science support. This was the first research cruise of the new OCEANS 2025 strategic funding programme.

Following the interminable period of nearly five months that it took for the various tiers of management structure to take the success of OCEANS 2025 and produce a vaguely workable structure in which a research cruise could be manned and organised, little time was available for the novel instrumentation of platforms like SeaSoar required for this cruise. The real hero here was Dougal Mountifield, who prepared and engineered a totally new instrument payload package for SeaSoar in just three months. This three month period had to include the ordering of instruments, the design and ordering of cabling purely from manufacturers descriptions (several instruments only arrived at the time of mobilisation of the ship), and the engineering required to fit the payload in the vehicle. The success of this endeavor is a testament to Dougal’s hard work and commitment, many thanks.

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