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RRS *Discovery* Cruise 312
11 – 31 OCT 2006

The extended Ellett Line 2006

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ABSTRACT

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Since 1996 NOCS and SAMS have been occupying an extended version of the Ellett Line that runs all the way to Iceland. The Extended Ellett line is important oceanographically because it completes the measurements of the warm saline water flowing into the Nordic Seas from the eastern North Atlantic. It also monitors around half of the returning deep and cold current, the overflow water (the rest returns to the Atlantic via the Denmark Strait to the west of Iceland).

There is little added cost, either in time or financially, in making a number of biogeochemical measurements using water samples from the hydrographers' CTD stations. Thus, recently, the scientific interests in the Extended Ellett line have become more multidisciplinary; the 2006 occupation was no exception. Samples were filtered for POC, HPLC studies and trace aluminium concentration determination, in addition some extra time was found for a number of zooplankton net hauls.

KEYWORDS

acronym, ATLNENROC, ATLNN, cruise 312 2006, CTD observations, *Discovery*, Ellett Line, Iceland Basin, Rockall Trough, sediment traps, Wyville Thomson Ridge

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ABSTRACT

UK oceanographers have been making repeated measurements on a short section across the Rockall Trough, since 1975. The section consists of a series of stations from the Scottish continental shelf to Rockall. The time series was established by David Ellett and was thus called the "Ellett Line". The Ellett line is one of a relatively small number of high quality physical time series in the North Atlantic Ocean and is important for monitoring oceanic climate variability.

Since 1996 NOCS and SAMS have been occupying an extended version of the Ellett Line that runs all the way to Iceland. The Extended Ellett line is important oceanographically because it completes the measurements of the warm saline water flowing into the Nordic Seas from the eastern North Atlantic. It also monitors around half of the returning deep and cold current, the overflow water (the rest returns to the Atlantic via the Denmark Strait to the west of Iceland).

There is little added cost, either in time or financially, in making a number of biogeochemical measurements using water samples from the hydrographers' CTD stations. Thus, recently, the scientific interests in the Extended Ellett line have become more multidisciplinary; the 2006 occupation was no exception. Samples were filtered for POC, HPLC studies and trace aluminium concentration determination, in addition some extra time was found for a number of zooplankton net hauls.

1. INTRODUCTION

The Ellett Line has revealed interannual to decadal scale variability in properties, including a significant rise in temperature since 1995 (Ellett et al. 1986, Holliday et al. 2000, Holliday, 2003). This warming likely results from a greater inflow of warm salty waters rather than changes in atmospheric fluxes. The extension to Iceland increases the value of the original section by monitoring the N. E. Atlantic current extension, the recirculation of the eastern subpolar gyre and the Iceland Scotland overflow. The Extended Ellett Line 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). Data from recent extended Ellett Line occupations show that the upper layers (upper ~ 800 m) of the Rockall Trough are the warmest and saltiest of the time series so far. The Rockall Trough has a strong seasonal cycle in the upper layers (broadly speaking cold and salty in the winter, warm and fresher in the summer) and this cycle has to be eliminated on a cruise-by-cruise basis in order to highlight the changes over longer timescales.

In the deeper waters the Labrador Sea Water (LSW) in 2005 showed an increase in salinity over the previous year (little change in temperature). The source region of LSW, the Labrador Basin, showed dramatic freshening and cooling in the 1990s when unusually deep winter convection took place (0.05 psu and 0.5 °C at 1800m), followed by a similar increase from 1998 onwards. The changes seen in the Rockall Trough may reflect those large changes in the Labrador Sea, but alternatively, may simply reflect local differences in mixing between LSW and other more saline water masses.

An extensive suite of bio-geochemical observations can be made on hydrographic cruises at the cost of minimal extra on-station time. We observed intense silicification, the production of a mineral phase which is likely linked to export, in this region in spring 2001 (Brown et al., 2003) and calcifying plankton also bloom extensively (Holligan et al. 1991, 1993) in the region. Waniek et al. (2005) showed opposing gradients in opal fluxes in the N. E. Atlantic; the implications of this for shallow particle export are unclear. On this occupation of the extended Ellett Line additional water samples were taken for a total of 12 upper ocean (~ 350 m) profiles of particulate organic carbon (POC) content, chlorophyll concentration and HPLC pigment determination. Deep ocean water samples from 19 CTD stations were filtered for trace aluminium concentration particularly focussed where deep-water outflows were expected.

In addition to the extended Ellett Line, extra time was allocated on this cruise to three other tasks required by different complementary science programmes. Firstly, four sediment trap and current meter moorings were deployed some 70 km apart in a triangular array centred near 59 °N, 19 °W. These are intended to provide a particulate export dataset, pertaining to, and to be turned around during the first cruise of Theme 2 of the OCEANS2025 NERC core strategic programme. Secondly, a limited number of vertical zooplankton net hauls were made on selected stations to support a historical record of zooplankton observations maintained by scientists at the SAMS. Thirdly, a study of turbulence over a tidal cycle had been planned with the use of a new free-fall turbulence probe acquired by the SAMS.

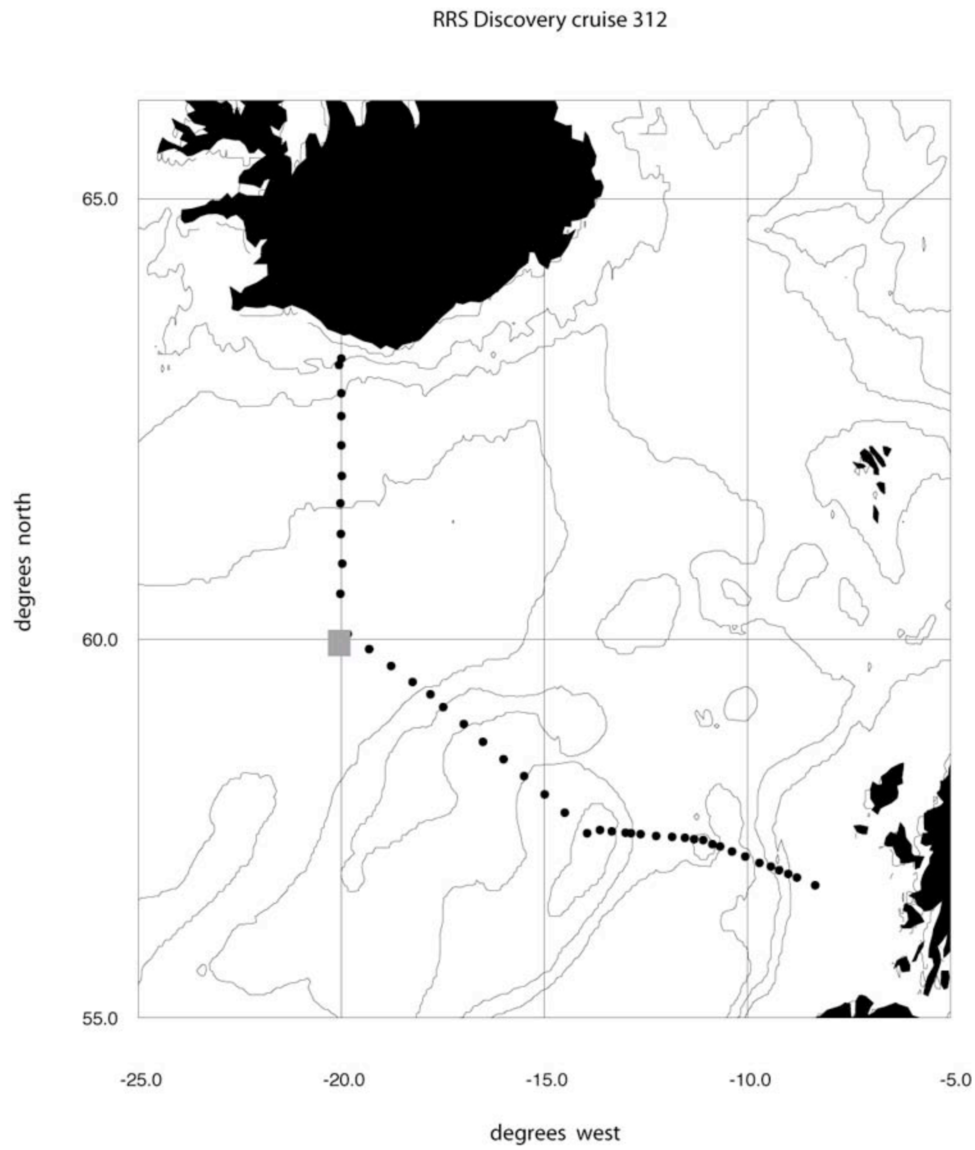


Figure 1: Schematic cruise track for Ellett.

2. NARRATIVE

PSO's Diary

<u>11th Oct (Day 284)</u>

Discovery slipped from Reykjavik harbour at 09:20; towed out stern first by tug due to increasingly poor weather and increasing wind speeds. At 10:30 a meeting was held in the plot for all senior scientists, at which the responsibilities for all the main jobs were shared out and a number of decisions were made regarding the processing routes that would be used. With a forecast of continued force 6/7 winds all day, the safety muster and call to boat stations was held at 13:00 whilst still in the lee of the Reykjanes Peninsular. A general science meeting for all the ships company both available and ‘feeling up to it’ was held at 16:15. Weather forecasts indicated marginal conditions for the next couple of days – but apparently there is an Icelandic saying along the lines of ‘…leave in a storm for a fine weather trip...’ so we held tightly onto this small comfort!

12th Oct (Day 285)

Overnight *Discovery* had held a course towards station IB21S rather than IB23S as this provided a much more comfortable heading. By first light the wind had dropped and the sea state was clearly lighter. We were on station IB21S at 08:30 and the PES (Precision Echo Sounder) fish was deployed at a depth of 8 m. The initial deployment of the CTD was aborted when the primary temperature sensor suffered severe data spiking. A wet connector plug was discovered and the connector lead was replaced. At the same time the primary conductivity and temperature sensors were moved onto the vane. The CTD was redeployed for IB21S (stn. **16126**) at 10:45. Sadly, on reaching the bottom of the cast, it was found that we had no bottle firing control and the CTD was recovered without any water bottle samples. The CTD was inboard at 11:44 and the ship set course NW for station IB22S.

Whilst steaming further cable problems were diagnosed and the cable between the CTD and the bottle firing pylon was replaced. We arrived at IB22S at 13:12 but by this time the wind was gusting strongly at 40 knots plus and so science was stopped and the vessel was hove to. With conditions marginally workable later in the day, IB22S (stn. **16127**) began at 18:40 and was completed successfully by 19:48. Conditions were not such as to allow sampling on deck whilst steaming and therefore the steam to IB23S, our most northerly station and closest to the Vestmannaeyjar, did not begin until 20:30.

During IB22S the oxygen data became very spiky and once again this was traced to a wet connector. The lead was replaced as we came onto station IB23S and the CTD was in the water (stn. **16128**) by 21:47. IB23S was completed at 22:15 and we began the 30 n. mile steam back south to IB20S, slowly at first to allow for safe sampling of the CTD.

13th Oct (Day 286)

A lovely start to the day, still blustery, but clear, sunny, and a sea state of 4/5. Station IB20S (stn. **16129**) had begun at 02:39 and was completed by 04:33. Station IB19S (stn. **16130**) had begun at 06:43 and was completed after breakfast at 08:18. We were not losing any time overall on station, but a heavy swell and difficult positioning on station were accounting for significant loses between stations.

Station IB18S (stn. **16131**), was completed, on board and secure by 13:09. Station IB17 (stn. **16132**) began at ~16:15 but nearly 45 minutes were lost trying to position the ship. It was a reminder of how difficult even moderate seas can be. Head to wind the ship rolled terribly because wind and swell were at right angles, however head to swell left the ship drifting at speeds around 1 knot. Nevertheless the station was successfully completed by 18:02.

Station IB16 (stn. **16133**) began at 21:16, by now however, the weather had seriously deteriorated and a severe showery squall of high winds nearly stopped the show. Acoustic releases were tested here, one successfully, one not so successfully – c'est la vie, we will have to try for a better day tomorrow. IB16 was completed at 00:08 on the 14th and *Discovery* headed south for IB15.

<u>14th Oct (Day 287)</u>

Whilst writing my daily plan of action at ~ 00:30 a rapidly intensifying roaring of the wind past the windows of the PSO's office made me realise that further writing would be fairly futile; plans would change soon. By 01:15 *Discovery* was hove to in wind speeds of 55-60 knots. This small depression had been forecast, but it was rather more severe in reality.

During the early morning, *Discovery* continued to edge further south towards IB15 as conditions began to moderate. By 07:45 we had reached IB15 and we waited for conditions to improve sufficiently to work. The CTD was deployed (**16134**) at 09:25 and mooring releases were tested successfully. Station IB15 was completed by ~12:00.

IB14 (stn. **16135**) was completed successfully by 16:57. The final two acoustic releases were also successfully tested here.

Just after lunch a new weather forecast indicated force 9 northeast winds by late afternoon Monday (16th). This forced a change of plan in order to endeavour to start and complete the sediment trap mooring array (four moorings in an triangular pattern of side ~ 120 km, but with a central mooring providing a 70 km separation scale) by noon on Monday. As a result, IB12 and IB11 would be removed from the station list at least for now; however, full depth CTDs at the mooring locations would provide closure of the 60 °N, 20 °W corner of the extended Ellett line even if the line looked a little awkward geographically.

IB13 (stn. **16136**) was successfully completed by 23:29 and *Discovery* set off in a south-south-west direction towards the first sediment trap mooring location STNW (sediment trap NW).

15th Oct (Day 288)

A full depth CTD was completed at mooring station STNW (**16137**#1) by 06:58. The hash number referring to the platform being deployed, these would be as follows: #1 CTD, #2 vertical net hauls, #3 series of rapid turbulence profiler deployments, #4 mooring deployment, and #5 to be assigned to a SAMS experimental 'modified' argo float if deployed. At 08:02 the mooring anchor for the STNW sediment trap mooring (**16137**#4) was released (60° 00.063' N, 020° 49.572' W) and the descent of the acoustic release was monitored until the anchor had clearly reached the bottom. By 08:30, *Discovery* had set course for the central mooring location ~ 70 km away in a roughly south-southeast direction.

An upward looking 75 kHz SC-ADCP, unique to mooring STC (sediment trap central), was setup and started pinging at 11:59. A new weather forecast indicated that the force 9 gales originally forecast for Monday afternoon may well increase to force 10 but that the strongest winds may develop to the east by Tuesday/Wednesday. Therefore the order of the last two moorings would be changed to attempt to steam with the wind/sea where possible: we would then plan to remain west and attempt to complete the extended Ellett line eastwards following behind the path of the weather. The CTD station on station STC began at 12:30 (stn. **16138**#1) and the mooring deployment was completed at ~17:10 (stn. **16138**#4) at position 59° 29.913' N, 019° 59.757'W.

Figure 2: Deployment of the SC-ADCP (left and bottom) and sediment trap (right) at STC.

A long cloudbank indicated that the cold front at the head of the impending weather system was closing on our position possibly more rapidly than expected. As mooring station STNE (sediment trap NE) was very close to the Ellett line we decided that we would cancel the CTD deployment here and try to pick it up on our return to the line when behind the weather system. *Discovery* arrived on station STNE at ~ 20:45 and the sediment trap mooring had been fully deployed and landed by ~21:25 (**16139**#4) at position 59° 38.972’ N, 18° 46.838’ W.

Discovery set course south south-west for the fourth, final and southern most sediment trap mooring deployment, STS (sediment trap south): winds were freshening, still south south-westerly but veering slowly and still expected strong and north-easterly by Monday afternoon.

16th Oct (Day 289)

By 05:10 *Discovery* was on station STS and, with a freshening wind that had veered northerly as forecast through the night, we decided to deploy the sediment trap mooring first and carry out the full depth CTD if conditions were still workable later. The mooring was fully deployed (**16140**#4 – at 58° 51.96' N, 020° 24.17' W) by 07:12 and *Discovery* repositioned 1 n. mile down wind to deploy the CTD. The CTD at STS was completed (**16140**#1) at 10:15 and *Discovery* set a northerly course for IB12 which had previously been skipped in our hurry to undertake the mooring deployments before the weather conditions deteriorated too far.

A continued increasing of sea state under constant wind speeds of 25-30 knots resulted in *Discovery* taking a more northerly course to IB12, overshooting, and then making a south southeasterly course with the swell into the IB12 station position. We were hove to on station IB12 and the CTD was deployed (**16141**) by 20:30. Station IB12 was completed by 23:00. Conditions were very marginal but a similar careful choice of steaming direction would hopefully allow us to get further along the Ellett line to at least IB11 whilst conditions remained workable.

17th Oct (Day 290)

Despite a heavy swell, the 4-8 watch began station IB11 (**16142**) at 04:52 and the CTD was back inboard and secured by 07:18. Sadly, the forecast force 9/10 winds hit us at 08:35 and 50 knot winds forced *Discovery* to heave to. From the forecasts this looks set in for a few days. As always these storm conditions are both spectacular and humbling when viewed from the bridge windows.

Just after lunch, new detailed forecasts confirmed a long duration for these conditions but they also indicated much closer isobar spacing and potentially more severe conditions for the end of the week. We would wait until the next forecast on Wednesday before making a final decision to run southwest in a small lull that we are expecting on Wednesday night.

18th Oct (Day 291)

The wind began to drop somewhat over night and during the morning, but 40 knot winds were still sufficient to maintain and even continue to build the swell. During our period hove to, we had slowly steamed NE against the swell; by 10:20 we were around 60° 11' N, 17° 55' W. With the latest forecasts still indicating force 9/10 winds from the NE for as far as they could forecast, i.e. 4/5 days, it was time to try and get round the weather rather than just sit it out. *Discovery* turned to run as south of SW as possible at 12:30, with the swell as far on her port quarter as possible. The forecasts all showed that Rockall might be suffering somewhat lighter weather in 2-3 days time and that conditions might be workable if we could just get there. A course of ~210° T was comfortable for now.

19th Oct (Day 292)

Wind speed had dropped a little over night but during the morning it increased slowly to a steady 40 knots again by lunchtime. However, over night the wind direction had backed more northerly and a slightly more southerly course of 205° T had been held during the morning. At 12:30, *Discovery* was around 56° 29’ N, 22° 20’ W. At this point we decided to try turning round and heading NNE towards the Rockall Plateau. *Discovery* was able to hold a course of 065-070° T at 4-5 knots initially with moderate comfort. Later in the afternoon the sea had eased sufficiently to allow speeds of between 6 and 8 knots, but it would still be a long haul to Rockall. Still heading towards IB4 at midnight, but we continue to try for a more easterly course.

20th Oct (Day 293)

By late morning the sea had dropped significantly, and 25-30 knot winds opposed the swell. *Discovery* was now maintaining ~ 10 knots on a course of ~ 055° T with an ETA at station IB4 of ~ 19:00.

At 16:15 an emergency muster drill was followed by a quiz for all the scientists. We had at last now clearly made it over to the SE side of the front that had been causing us so much trouble, and although we had probably now lost stations IB10 through IB5, we had high hopes of sampling much of the Ellett line from Rockall east. Interestingly we were in a quasi-stationary low pressure region: its stationary appearance driven by the blocking highs over Greenland and northern Europe creating a kind of *cul-de-sac* in which this low pressure system had become corralled. A long cloudbank marked the front under which we would still have been suffering gale or even severe gale force winds.

Before reaching IB4 the wind speed began to rise sharply as we approached the front, itself spreading in a southerly direction, from the south side. *Discovery* hove to and this became station IB4a, an alternative position in the centre of the Hatton-Rockall Basin, approximately 10 n. miles WSW of the original IB4. The CTD at IB4a (**16143**) was in the water at 18:47 and the station was completed with the CTD secured by 20:15.

Sadly the transect to IB3 would be tortuous, a heavy swell still requiring that we travel a long way south before turning NNE into the sea to reach the station.

21st Oct (Day 294)

Discovery finally reached IB3 at 04:30. Significantly deteriorating weather, 30+ knot winds force seven seas and occasional packets of large swell waves, made this station a close call. But at 05:07 the CTD was deployed (**16144**). IB3 was completed with the CTD secured on deck by 06:00.

The lunchtime MetWorks forecasts were not good, our weather window had closed and the next significant window would be Tuesday, it is now Saturday! Small comfort was taken from their expression "…. amazed anyone can do any work in those conditions up there just now but I guess you guys are used to that by now.".

We were on station IB2 at 14:54, once again in extremely marginal conditions with 25-40 knot winds and force 7 seas. The CTD (**16145**) was deployed at 15:17 and it was back on deck and secured by 16:05.

Discovery was hove to on IB1 at 23:30, whilst the marginal conditions were assessed.

22nd Oct (Day 295)

Once again IB1 would be in marginal conditions, force 7 seas and occasional gale force gusting winds. It is useful to note here that everyone is working very hard to get work done. In a generally fine weather cruise we would have made the simpler decision to heave to and wait more often. The CTD was deployed (**16146**) at 12:46, but not before a trip out on the winch slack wire compensator had required the CTD to be lashed down just above the deck frame. Station IB1 was completed at 01:11. The Rockall station, A, would not be carried out during darkness and therefore, with time pressing, station A would be dropped for now. We will try to make station B by first light and carry out the net hauls intended for station A at station B instead.

The CTD at station B (**16147**) began at 07:28 and was completed by 08:18. The vertical net hauls were cancelled due to the continued marginal seas. These vertical hoop nets have a relatively light compressor weight and in these conditions the net could easily be drawn under the ship during deployment or recovery.

The CTD at station C (**16148**) began at 11:48 and was completed and secured by 12:40.

The CTD at station D (**16149**) began at 14:50 and was completed and secured by 16:03.

The CTD at station D1 (**16150**) began at 17:43 and was completed and secured by 19:24.

The CTD at station E (**16151**) began at 21:12 and was completed and secured by 23:07.

Although the weather conditions had not deteriorated as forecast today, there had been little let up from the force 7/8 winds except for a brief period of 25 knot winds during the afternoon. Working along the Ellett line was still difficult and slow.

23rd Oct (Day 296)

Discovery was hove to at E1 by 00:45 and the CTD was in the water (**16152**) at 01:03. The CTD recovery was difficult as a result of increased sea-state and strong 35+ knot winds. After three attempts to land the CTD in the deck frame the CTD was finally secured at 02:46. With significant water now washing on deck from occasional swell waves, conditions had passed from marginal to unworkable, at least in darkness. *Discovery* set a course for station F where we would heave to until first light and then the conditions would be re-assessed.

Discovery was hove to on station F at 07:24. It was immediately clear that weather and sea-state had significantly deteriorated over night with strong winds and a mounting swell; we remained hove to. The forecasts at mid-day indicated that conditions should improve later, we wait eagerly.

24th Oct (Day 297)

After a day of unremitting 35+ knot winds until late evening, a somewhat calmer first light was most welcome. *Discovery* had relocated to station F by 08:30 and the CTD (**16153**#1) was deployed at 08:53. With the CTD recovered and secured by 10:47, the bongo net was deployed at 10:53 and three net hauls were made (**16153**#2) to complete the station at 11:25. There was considerable excitement at the first zooplankton samples collected, but before anyone could take a look the biologists had them in the formalin – call me a physicist, but a couple of minutes observation first please!!

Then bad news, our third officer had not been very well for a couple of days. What had appeared like signs of a good recovery yesterday had not been maintained today sadly. We steamed east to await a helicopter Med-Evac organised by Stornoway Coastguard. Our casualty was winched up off the aft deck at 13:45 into a hovering Sea-King helicopter. *Discovery* headed back to station G; in fact the Med-Evac had cost us little time as we had ended up just 6 n. miles NNE of G.

Figure 3: Stornoway Coastguard arrives

The CTD at station G (**16154**) began at 14:47 and was completed and secured by 16:37. *Discovery* still had to make a dog-leg course between stations due to the size of the swell coming from a northeasterly direction. Contrary to the forecast the wind speed had increased again during the afternoon, blowing 25-30 knots steadily by early evening.

The CTD at station H (**16155**#1) began at 19:15 and was completed and secured by 21:16. Bongo nets followed (**16155**#2) at 21:30 and the standard three net hauls were completed at 22:03.

<u>25th Oct (Day 298)</u>

The CTD at station I (**16156** – western Anton Dohrn station) began at 00:06 and was completed and secured by 01:10.

Discovery was hove to on station J at 04:08. The CTD was delayed due to problems with the winch compensator, but was deployed (**16157**#1 – Anton Dohrn) by 04:35. The CTD was back on board and secured at 05:32 and vertical plankton net hauls (**16157**#2) began at 05:49. The station was completed after three net hauls at 06:23.

The CTD at station K (**16158**) began at 07:50 and was completed and secured by 08:45.

Discovery was hove to on station L at 10:18. The CTD was deployed (**16159**#1) at 10:31. The CTD was back on board and secured at 12:23 and vertical plankton net hauls (**16159**#2) began at 12:35. The station was completed after three net hauls at 13:01. A gale force warning from the routine meteorological service was not supported by the MetWorks forecasts – we await our fate.

The CTD at station M (**16160**#1) began at 15:40 and was completed and secured by 17:25. Vertical net hauls (**16160**#2) followed the CTD at 17:41 and the station was completed at 17:53.

Sea state and wind had dropped significantly during the day and a direct steaming course could now be made between stations. The CTD at station N (**16161**) began at 19:34 and was completed and secured by 21:35.

Discovery had now been joined by an entire flight of migrating redwings, presumably nearing the end of their journey south. Sadly I don't think our presence was doing much for their survival, but they are most curious of us.

Figure 4: Migrating redwings took an extraordinary interest in us.

The CTD at station O (**16162**) began at 23:10 and was completed and secured by 00:45 on Thursday morning.

26th Oct (Day 299)

The CTD at station P (**16163**) was deployed at 02:45, recovered and secured by 04:07.

The CTD at station Q (**16164**#1) was deployed at 05:10, recovered and secured by 05:51. The plankton net was deployed at 06:03 (**16164**#2), only one net haul is now being carried out routinely and the station was finished at 06:18.

The CTD at station R (**16165**#1) was deployed at 07:30, recovered and secured by 07:51. The plankton net was deployed at 08:00 (**16165**#2) and the station was finished at 08:06.

The CTD at station S (**16166**) was deployed at 09:25, recovered and secured by 09:47.

The CTD at station 15G (**16167**) was deployed at 11:02, recovered and secured by 11:20.

The CTD at station T (**16168**) was deployed at 12:42, recovered and secured by 13:00.

The CTD at station 14G (**16169**) was deployed at 14:40, recovered and secured by 14:58.

Discovery then proceeded to the Barra Head turbulence profiler transect. This was designed to be a 13 hour repeated series of transits along 56° 40’ N backwards and forwards from 007° 34.2’ W to 007° 37.2’ W. The transits began (**16170**) at 19:18. Once the buoyancy of the turbulence profiler had been assessed as correct the profiling began in earnest. In each descent, the profiler was sent to the bottom with sufficient slack wire in the water to ensure the profiler was free falling. The profiler was then hauled back in on its own winch. Each profile cycle took around 10 minutes. Sadly, at 20:25, after only a few profiles the turbulence profiler became held fast on the bottom in 170 m of water. Despite stopping the ship and then trying to pay out slack wire and backtrack, the cable parted near the seabed at ~20:30.

A CTD (**16171**) was deployed at 56° 40.2’ N, 007° 34.6’ W to set the limited turbulence data that was gathered in a hydrographic context. The CTD was deployed at 21:26 and recovered by 22:00. Now *Discovery* set a course for 9G to complete more of the Ellett line westwards to where we left off earlier in the day. We still plan to head towards the Wyville Thomson ridge tomorrow morning to turn around a SAMS mooring there.

The CTD at station 9G (**16172**#1) was deployed at 23:07, recovered and secured by 23:30. The plankton net was deployed at 23:45 (**16172**#2) and the station was finished at 00:00 Friday.

27th Oct (Day 300)

The CTD at station 10G (**16173**) was deployed at 01:05, recovered and secured by 01:34.

The CTD at station 11G (**16174**#1) was deployed at 02:30, recovered and secured by 02:42. The plankton net was deployed at 02:53 (**16174**#2) and the station was finished at 03:00.

The CTD at station 12G (**16175**) was deployed at 03:53, recovered and secured by 04:04.

The CTD at station 13G (**16176**#1) was deployed at 05:03, recovered and secured by 05:27. The plankton net was deployed at 05:39 (**16176**#2) and the station was finished at 06:04.

Discovery then set course northwards for the Wyville Thomson ridge. We made a series of small course changes just before lunch to make a close pass on the St. Kilda islands at around 11:45. Unfortunately, visibility was poor, winds were fresh (~ 30 knots) and it was drizzling heavily, not exactly fine sightseeing conditions but we could at least make out the outlines of some of the big cliffs through the gloom.

28th Oct (Day 301)

A new ‘W’ CTD section across the ‘Ellett’ gully had been planned during the steam north. This ~ 9 mile long section of 11 CTDs, from north to south, would look at the volume of Færœ Shetland overflow water crossing the Wyville Thomson Ridge to the south via a small east-west gully on the southern slope of the ridge. The section passed through the SAMS upward looking ADCP mooring and was similar to a section carried out last year on RRS *Charles Darwin* cruise 176.

The CTD at station W1 (**16177**) was deployed at 04:22, recovered and secured by 04:55.

The CTD at station W2 (**16178**) was deployed at 05:54, recovered and secured by 06:28.

The CTD at station W3 (**16179**) was deployed at 07:39, recovered and secured by 08:27.

The CTD at station W5 (**16180**) was deployed at 09:31, recovered and secured by 10:17.

Discovery was hove to at 10:47, 60° 15.7’ N, 008° 54.5’ W, to release the SAMS bottom mounted SC-ADCP mooring (**16181**). This was released, hooked and safely recovered by 11:25. Over the next four hours the data were downloaded and the instrument was prepared for re-deployment.

The CTD at station W4 (**16182**) was deployed at 12:33, recovered and secured by 13:18.

The CTD at station W6 (**16183**) was deployed at 14:02. The mooring release had been serviced and attached to the CTD frame, the release mechanism was tested and confirmed as released at 14:41 when the CTD was at ~1150 m. The CTD was recovered and secured by 15:27.

A position of 60° 15’ N, 008° 55’ W, was then aimed for to re-deploy the SAMS ADCP mooring, i.e. more or less a direct replacement. The mooring was deployed (**16184**) at 60° 15.003’ N, 008° 54.990’ W by 16:05 and acoustic confirmation that it had reached the bottom and was staying there was made by 16:20.

The CTD at station W8 (**16185**) was deployed at 16:51, recovered and secured by 18:15.

The CTD at station W9 (**16186**) was deployed at 19:27, recovered and secured by 20:42.

Stations W7 (60° 14.76’ N, 008° 55.02’ W), W10 (60° 13.02’ N, 008° 55.02’ W) and W11 (60° 11.40’ N, 008° 54.84’ W) were dropped in order to allow time to head south and complete the shelf section of the Ellett line. The signal of the overflow water was not considered strong enough at this point in time to justify continuing further science here as an alternative to completing the Ellett line, and 30-35 knot northwesterly winds had kicked in as forecast this evening. The latest in a long line of depressions to hit us, at least we had just had the nicest and calmest day of the cruise although a strong swell had made things difficult on station at times. *Discovery* set a southerly course for station 8G some ~240 n. miles away.

29th Oct (Day 302)

At 10:00 we held a de-brief meeting. In total, including time lost making sea-state determined courses between stations; over 6 of the 20 days had been lost to weather. Nevertheless 80-85 % of the scientific objectives had been achieved and this level of success in the face of adversity is a testament to the hard work and determination of all on board, particularly some exemplary winch driving and close co-operation between the deck officers and the winch drivers.

By 11:00 we were approaching the St. Kilda island group again. Under clearer skies we had a much nicer view of the islands this time. Village bay looked distinctly deserted as we bore away and left the islands behind us.

The CTD at station 8G (**16187**) was deployed at 20:54, recovered, secured and sampled by 21:45.

The CTD at station 7G (**16188**) was deployed at 22:29, recovered, secured and sampled by 23:00.

The weather had been deteriorating significantly all evening, 30-40 knot south southwesterly winds heralded the leading edge of yet another depression.

30th Oct (Day 303)

The CTD at station 6G (**16189**) was deployed at 00:22, recovered, secured and sampled by 00:33.

The CTD at station 5G (**16190**) was deployed at 01:37, recovered, secured and sampled by 01:48.

The CTD at station 4G (**16191**) was deployed at 02:45, recovered, secured and sampled by 03:03.

The CTD at station 3G (**16192**) was deployed at 03:54, recovered and secured by 04:12.

The CTD at station 2G (**16193**) was deployed at 05:02, recovered and secured by 05:17.

The CTD at station 1G (**16194**) was deployed at 06:35, recovered, secured and sampled by 07:00.

Discovery set course for the Sound of Mull. With continued gales, *Discovery* entered the Sound of Islay early in the afternoon.

31st Oct (Day 304)

Arrival in Govan, demobilisation all day.

J. Allen

Master's Diary (Summary)

Times in text are UTC

2006-10-10

0900 Scientific party commence joining v/l
Mobilisation continues
1500 Sign-on & Safety Briefing for Sci/Tech contingent

2006-10-11

0830 Critical instrument tests – all satisfactory
0850 PoB Ragnasson

0906	ERSB	
0908	Singling up	
0910	Tug ‘Magni’ fast, port aft	
0917	All gone & clear fore & aft	
0928	Clearing harbour stern first under tow	
0936	Let go Tug	
0940	Pilot away; v/l turning to port off harbour entrance	
1000	FAOP; Akurey 182 degs x 0.79nm	
1200	64 07.4N 22 48.9W	Wind E’ly 30 knots
1305	63 58.2N 22 55.6W	Complement mustered @ emergency & boat stations
1425	Reykjanes 043 degs x 2.2nm; v/l hove-to for foc’sle vent closing	
1430	Reduction in rpm continued due rough head seas & heavy swell	
1600	Staoarborg 018 degs x 5.4nm Wind SE 32 knots	
2000	63 34.7N 22 12.4W	Wind SExE 28 knots
2400	63 23.5N 21 31.7W	Wind SExE 25 knots

2006-10-12

0400	63 12.5N 20 51.0W	Surtsey Is 028 degs x 7.9nm; A/c 097 degs; Wind SExE 32 knots
0830	63 08.2N 19 55.2W	Hove-to on stn ‘IB21S’; comm of science; Wind ESE 28 knots
0851		PES deployed
0915		CTD deployed; Stn 16126#1
0930		CTD recovered due temp probe failure
1042	63 08.2N 19 54.8W	CTD re-deployed; Stn 16126#1
1109	63 08.3N 19 54.9W	@ bottom, 1026m
1144		CTD recovered; (bottles inop)
1155		In transit to next stn; Wind E’ly 35 knots
1312	63 13.0N 20 04.7W	Hove-to @ stn ‘IB22S’; WoW; Wind gusting > 40 knots
1600		Wind E’ly 31 knots
1830		Resumption of science
1841	63 13.1N 20 03.7W	CTD deployed; Stn 16127#1
1948		CTD recovered; Wind E’ly 20 knots
2030	63 14.3N 20 02.1W	Sampling complete; In transit to next stn.

2128			Hove-to @ stn 'IB23S'
2146	63 19.1N	20 13.0W	CTD deployed; Stn 16128#1
2215			CTD recovered; in transit to next stn
2400			Wind SxE 23 knots

2006-10-13

0239	62 54.9N	19 32.5W	Hove-to @ stn 'IB20S'
0258			CTD deployed; Stn 16129#1
0340	62 54.9N	19 32.5W	@ bottom, 1400m; Wind S'ly 25 knots
0433	62 54.9N	19 31.7W	CTD recovered; in transit to next stn 'IB19S'
0643	62 40.1N	19 40.9W	Hove-to & CTD deployed; Stn 16130#1
0719	62 40.3N	19 41.1W	@ bottom, 1660m
0800			Wind S'ly 20 knots
0818	62 40.4N	19 41.4W	CTD recovered; v/l slow-steaming towards next stn 'IB18S'
1128	62 20.0N	19 49.8W	Hove-to & CTD deployed; Stn 16131#1
1208			@ bottom, 1790m; Wind SxE 18 knots
1309			CTD recovered; v/l slow-steaming towards next stn
1540	62 00.1N	20 00.5W	V/l hove-to 'IB17'; assessing best heading in prevailing conditions
1600			Wind SExS 20 knots
1615	62 00.1N	20 00.9W	CTD deployed; Stn 16132#1
1701	62 00.1N	20 01.4W	@ bottom, 1800m
1802	62 00.3N	20 01.7W	CTD recovered; v/l in transit to next stn
2000			Wind ExS 20 knots
2126	61 30.1N	20 00.0W	Hove-to 'IB16' & CTD deployed; Stn 16133#1
2250	61 30.6N	19 59.0W	@ bottom, 2180m
2400			Wind SxE 28 knots

2006-10-14

0006			CTD recovered; v/l in transit to next station
0110	61 26.3N	19 57.1W	Wind gusting to 55 knots; v/l hove-to for sample completion
0234	61 26.3N	20 01.9W	Sampling complete; deck secure; co & spd as per conditions

0400		Wind WSW 45 knots
0745	61 14.9N 20 00.0W	On stn – assessing conditions
0800		Wind SW 25 knots
0900		Preparing to resume CTD ops ‘IB15’
0925	61 15.0N 20 00.0W	CTD deployed; Stn 16134#1
1021	61 15.1N 19 59.6W	@ bottom, 2359m
1155	61 15.2N 19 59.7W	CTD recovered; v/l in transit to next stn; Wind S’ly 25 knots
1436	61 00.0N 20.00.0W	CTD deployed ‘IB14’; Stn 16135#1
1534		@ bottom, 2375m
1600		Wind SSW 23 knots
1657	61 00.5N 19 58.9W	CTD recovered; v/l in transit to next stn
2000		Wind S’ly 23 knots
2058	60 30.0N 20 00.0W	Hove-to ‘IB13’ & CTD deployed; Stn 16136#1
2329	60 29.9N 19 59.1W	CTD recovered; v/l in transit to next stn
2400		Wind SxW 25 knots

2006-10-15

0400		Wind WSW 20 knots
0437	60 00.1N 20 50.0W	Hove-to ‘STNW’ & CTD deployed; Stn 16137#1
0537	60 00.3N 20 50.1W	@ bottom, 2755m
0656	60 00.7N 20 50.6W	CTD recovered; v/l repositioning for ST mooring deployment
0730	60 00.2N 20 49.0W	Comm streaming mooring (STNW)
0802	60 00.063N 20 49.572W	Mooring anchor wt released; Stn 16137#4; Wind WSW 15 knots
0830		Mooring confirmed @ bottom; v/l in transit to next stn
1200		Wind SW 20 knots
1230	59 29.9N 20.00.0W	Hove-to ‘STC’ & CTD deployed; Stn 16138#1
1327		@ bottom, 2775m
1450		CTD recovered; v/l repositioning
1522	59 30.5N 19 58.6W	Comm streaming mooring (STC)
1547		First buoyancy o’side @ 800m line out
1600		Wind SW 20 knots
1616		Second buoyancy o’side @ 1800m line out

1650 59 29.913N 19 59.757W Mooring anchor wt released; Stn 16138#4 (2775m water depth)

1710 Mooring confirmed @ bottom; v/l in transit to next stn

2000 Wind SW 23 knots

2045 59 39.2N 19 46.2W Hove-to & comm streaming mooring (STNE)

2102 59 38.972N 18 46 838W Mooring anchor wt released; Stn 16139#4

2128 Mooring confirmed @ bottom; v/l in transit to next stn

2400 59 22.6N 19 19.0W Wind SW 25 knots

2006-10-16

0400 Wind W'ly 30 knots

0510 58 52.0N 20 24.0W Hove-to on stn 'STS'; preparation of mooring

0618 58 51.6N 20 23.2W Commence streaming mooring

0644 58 51.968N 20 24.169W Mooring anchor wt released; Stn 16140#4

0712 Mooring confirmed @ bottom; v/l repositioning for CTD stn

0734 58 52.3N 20 26.3W CTD deployed; Stn 16140#1

0800 Wind WNW 28 knots

0836 58 52.3N 20 27.6W @ bottom, 2822m

1015 CTD recovered & secure; v/l in transit towards 'IB12' CTD stn

1200 Wind NWxN 25 knots

1600 59 37.4N 20 24.8W Wind NxE 32 knots

2000 Wind NNE 33 knots

2030 59 59.9N 19 59.7W Hove-to 'IB12' & CTD deployed; Stn 16141#1

2124 59 59.7N 19 59.0W @ bottom, 2705m

2300 59 59.6N 19 58.6W CTD recovered; v/l in transit towards 'IB11'

2400 Wind NNE 30 knots

2006-10-17

0200 59 43.5N 19 36.9W V/l in zig-zag transit towards next stn

0305 59 36.8N 19 25.7W A/c to 070 (G) towards next stn

0400 Wind NE 31 knots

0452 59 39.6N 19 06.5W Hove-to 'IB11' & CTD deployed; Stn 16142#1

0549	59 39.3N	19 06.2W	@ bottom, 2640m
0718	59 39.1N	19 06.1W	CTD recovered; v/l comm zig-zag transit towards next stn
0800			Wind NE 28 knots
0836	59 28.2N	19 10.6W	Wind NE 50 knots; v/l round & hove-to, WoW
1200	59 34.2N	19 00.2W	Wind NExE 45 knots; hove-to, head to sea, WoW
1600	59 41.1N	18 48.0W	Wind NExE 38 knots
2000	59 47.4N	18 37.0W	Wind NExE 35 knots
2400	59 58.0N	18 28.9W	Wind NExE 40 knots; hove-to, head to sea, WoW

2006-10-18

0400	59 59.9N	18 17.4W	Wind ENE 40 knots
0800	60 07.0N	18 04.3W	Wind NExE 38 knots
1200	60 13.7N	17 47.5W	Wind ENE 38 knots
1230	60 14.5N	17 45.3W	A/c to run downwind; hdng 215 degs G
1600	59 43.2N	18 27.6W	Wind ENE 30 knots
2000	59 03.7N	19 08.4W	Wind NExE 35 knots
2400	58 25.3N	20 06.3W	Wind NExE 35 knots; hdng 215 (G) @ 11 knots

2006-10-19

0400	57 48.7N	20 56.1W	Wind NExE 35 knots
0800	57 09.7N	21 41.5W	Wind NE 45 knots
1200	56 31.5N	22 16.1W	Wind NE 40 knots; hdng 215 (G) @ 11 knots
1230	56 28.6N	22 19.6W	V/l a/c, head to weather; making good ENE track @ 5 knots
1600	56 30.9N	21 46.1W	Wind NE 48 knots
2000	56 40.5N	21 32.2W	Wind NExN 25 knots
2400	56 55.4N	20 16.5W	Wind NNE 38 knots; making good ENE track @ 8 knots

2006-10-20

0400	57 11.6N	19 20.8W	Wind Var 8 knots
0800	57 36.2N	18 33.9W	Wind S'ly 25 knots
1200	58 00.4N	17 39.8W	Wind SE 23 knots; making good NExE track @ 10 knots

1600	58 19.1N	16 50.9W	Wind ENE 22 knots
1615			Emergency exercises: l'boat video/'table-top'/safety quiz
1830	58 30.2N	16 18.2W	Heaving-to 10nm west of 'IB4' for CTD
1847	58 30.3N	16 17.9W	CTD deployed; Stn 16143#1
1921	58 30.6N	16 17.8W	@ bottom, 1200m
2000			Wind E'ly 15 knots
2015	58 30.9N	16 17.9W	CTD recovered; v/l turning to 180 (G) for z-z co to next stn
2348	57 58.4N	16 16.1W	A/c to 060 (G) towards 'IB3'; Wind ExN 30 knots

2006-10-21

0400			Wind ExN 38 knots
0430	58 15.1N	15 20.1W	Hove-to on stn; assessing conditions
0507	58 15.5N	15 20.2W	CTD deployed; Stn 16144#1
0559	58 16.2N	15 20.4W	CTD recovered; v/l turning to S'ly track for z-z co to next stn
0915	57 45.3N	15 26.6W	A/c to 068 (G) towards 'IB2'
1200	57 51.7N	15 00.9W	Wind ExN 38 knots
1517	57 57.0N	14 34.9W	Hove-to & CTD deployed; Stn 16145#1
1534			@ bottom, 430m; Wind NExE 38 knots
1604	57 56.8N	14 34.9W	CTD recovered; v/l turning to S'ly track for z-z co to next stn
1844	57 32.1N	14 50.8W	A/c to 075 (G) towards 'IB1'
2000			Wind NExE 33 knots
2330	57 40.0N	13 54.0W	Hove-to @ IB1 assessing conditions
2400			Wind NE 35 knots

2006-10-22

0048	57 39.9N	13 54.4W	CTD deployed; Stn 16146#1
0055			@ bottom, 135m
0109	57 39.8N	13 54.6W	CTD recovered
0125			V/l turned to 206 (G), comm z-z track to next stn
0250	57 26.1N	14 06.4W	A/c to 070 (G) towards Stn 'B'
0400			Wind ENE 30 knots
0728	57 34.0N	13 19.9W	Hove-to on stn

0745			CTD deployed; Stn 16147#1; Wind NE 33 knots
0818	57 34.3N	13 19.6W	CTD recovered; v/l comm z-z track, 067 (G), towards next stn
1043	57 38.6N	12 54.8W	A/c to 215 (G) towards Stn 'C'
1148			Hove-to on stn
1206	57 33.0N	12 59.7W	CTD deployed; Stn 16148#1; Wind NE 30 knots
1218			@ bottom, 280m
1240	57 32.8N	12 59.6W	CTD recovered; v/l comm z-z track, 065 (G), towards next stn
1430			Hove-to on stn 'D'
1450	57 32.4N	12 52.1W	CTD deployed; Stn 16149#1
1521			@ bottom, 1060m
1603	57 32.5N	12 52.4W	CTD recovered; v/l on z-z track to next stn; Wind NExE 25 knots
1743	57 32.3N	12 45.7W	Hove-to 'D1' & CTD deployed; Stn 16150#1
1822			@ bottom, 1440m
1924	57 32.2N	12 45.6W	CTD recovered; v/l on z-z track towards next stn
2000			Wind NE 33 knots
2056			Hove-to on stn 'E'
2112	57 31.8N	12 37.4W	CTD deployed; Stn 16151#1
2153			@ bottom, 1640m wire out
2305	57 31.9N	12 37.4W	CTD recovered; v/l comm z-z track towards next stn
2400			Wind NE 40 knots

2006-10-23

0045	57 31.5N	12 32.0W	Hove-to on stn 'E1'
0103	57 31.6N	12 31.8W	CTD deployed; Stn 16152#1
0143	57 31.7N	12 31.8W	@ bottom, 1730m
0246			CTD recovered; v/l comm z-z track towards next stn
0400			Wind NE 35 knots
0615	57 37.6N	12 04.1W	A/c towards station
0724	57 30.5N	12 15.2W	Hove-to on stn 'F'; Wind gusting 45 knots; V/l WoW
0800			
1200	57 37.0N	12 07.3W	Wind NE 35 knots
1600	57 43.7N	11 52.0W	Wind NE 33 knots

2000	57 48.3N	11 42.0W	Wind NE 33 knots
2400			Wind NE 35 knots

2006-10-24

0400	57 56.7N	11 22.9W	Wind NE 30 knots
0430	57 57.6N	11 20.7W	A/c to 225 (G) towards work site
0800			Wind NE 30 knots
0830	57 30.5N	12 15.1W	Hove-to on stn 'F'; resume science
0836	57 30.5N	12 15.0W	CTD deployed; Stn 16153#1
0935	57 30.8N	12 15.2W	@ bottom, 1790m
1047	57 31.6N	12 15.7W	CTD recovered
1053			Commence bongo net deployments; Stn 16153#2
1125	57 31.9N	12 16.3W	Comp. bongo net deployments; v/l in z-z transit for site 'G'
1200			Steering 080 (G) for 1330hrs Helo r'vous; Wind ENE 30 knots
1312	57 33.0N	11 52.0W	VHF exchange with Rescue Helicopter 'MU'
1334			'MU' on station of port qtr; v/l head to wind (060 G) @ 4.5 knots
1339			Winchman on deck via Hi-Line
1341			Bags winched up to 'MU'
1345			Casualty & Winchman winched off deck
1346			'MU' clear of v/l, bound for Stornoway
1350	57 34.5N	11 45.4W	Aft deck secure; v/l round & hdg for stn 'G'
1447	57 29.4N	11 50.8W	Hove-to & CTD deployed; Stn 16154#1
1527			@ bottom, 1775m
1600			Wind ENE 23 knots
1637	57 29.4N	11 51.1W	CTD recovered; v/l comm z-z transit towards next stn
1915	57 29.0N	11 31.9W	Hove-to 'H' & CTD deployed; Stn 16155#1
2000			@ bottom, 2000m; Wind NE 30 knots
2116	57 30.1N	11 31.5W	CTD recovered
2130			Bongo net deployed; Stn 16155#2
2203			Bongo net sampling complete
2225	57 30.9N	11 28.5W	V/l on z-z transit towards Stn 'I'
2353	57 28.0N	11 19.2W	Hove-to on stn; Wind NE 35 knots

2006-10-25

0006			CTD deployed; Stn 16156#1
0033			@ bottom, 745m
0110			CTD recovered; v/l comm z-z transit towards next stn
0400			Wind NExE 28 knots
0408	57 26.9N	11 05.2W	Hove-to on stn 'J'; CTD winch compensator problems
0435	57 27.0N	11 05.2W	CTD deployed; Stn 16157#1
0457			@ bottom, 565m
0532	57 27.3N	11 05.4W	CTD recovered
0549	57 27.4N	11 05.6W	Bongo net deployed; Stn 16157#2
0623	57 27.9N	11 06.0W	Bongo net sampling complete; comm z-z transit to next stn
0750	57 24.0N	10 52.0W	Hove-to 'K' & CTD deployed; Stn 16158#1
0811			@ bottom, 770m; Wind NE 30 knots
0845	57 24.4N	10 52.1W	CTD recovered; comm z-z transit towards next stn
1018			Hove-to on stn 'L'
1027	57 22.0N	10 40.0W	CTD deployed; Stn 16159#1
1114	57 22.1N	10 40.0W	@ bottom, 2095m wire out
1200			Wind ExN 30 knots
1223	57 22.1N	10 39.8W	CTD recovered
1235			Bongo net deployed; Stn 16159#2
1301			Bongo net sampling complete
1320			Crane secure; comm z-z transit towards next stn
1540	57 17.8N	10 23.1W est	Hove-to 'M' & CTD deployed; Stn 16160#1
1626	57 18.2N	10 22.7W	@ bottom, 2200m; Wind ExN 20 knots
1725	57 18.6N	10 22.3W	CTD recovered
1741			Bongo net deployed; 16160#2
1753			Bongo net recovered; v/l in transit to next stn
1934	57 14.0N	10 03.0W	Hove-to 'N' & CTD deployed; Stn 16161#1
2000			Wind E'ly 15 knots
2023	57 14.0N	10 02.9W	@ bottom, 2090m wire out
2135	57 14.2N	10 02.5W	CTD recovered; v/l in transit to next stn 'O'
2310	57 09.0N	09 41.9W	Hove-to & CTD deployed; Stn 16162#1

2352	57 08.9N	09 42.1W	@ bottom, 1914m wire out
2400			Wind ESE 8 knots

2006-10-26

0045			CTD recovered; v/l in transit to next stn
0245	57 05.9N	09 25.3W	Hove-to 'P' & CTD deployed; Stn 16163#1
0320			@ bottom, 1420m
0407	57 05.9N	09 25.7W	CTD recovered; v/l in transit to stn 'Q'; Wind NxW 20 knots
0510	57 03.0N	09 13.0W	Hove-to & CTD deployed; Stn 16164#1
0551	57 03.2N	09 13.5W	CTD recovered
0603			Bongo net deployed; 16164#2
0618			Bongo net recovered; v/l in transit to stn 'R'
0730	57 00.0N	09 00.0W	Hove-to & CTD deployed; Stn 16165#1
0751	56 59.9N	09 00.0W	CTD recovered
0800			Bongo net deployed; 16165#2; Wind NNW 15 knots
0816			Bongo net recovered; v/l in transit to stn 'S'
0925	56 57.0N	08 47.0W	Hove-to & CTD deployed; Stn 16166#1
0935			@ bottom, 118m
0947	56 57.1N	08 47.0W	CTD recovered; v/l in transit to stn '15G'
1102	56 53.0N	08 30.2W	Hove-to & CTD deployed; Stn 16167#1
1120	56 52.9N	08 30.3W	CTD recovered; v/l in transit to stn 'T'
1200	56 48.8N	08 22.1W	Wind NxW 25 knots
1245	56 50.4N	08 20.4W	Hove-to & CTD deployed; Stn 16168#1
1300			CTD recovered; v/l in transit to stn '14G'
1440	56 48.7N	08.09.9W	Hove-to & CTD deployed; Stn 16169#1
1458			CTD recovered; v/l in z-z transit towards Turb Profiler site
1600	56 43.9N	08 05.1W	Strng 160 (G); Wind N'ly 33 knots
1710	56 33.1N	07 56.6W	A/c 055 (G)
1845	56 39.9N	07 37.7W	Assessing conditions @ Profiler site
1918	56 39.9N	07 37.2W	SoL (E-going); adjusting buoyancy; Stn 16170
1929	56 39.9N	07 36.8W	Profiler streamed; comm cont. vert. profiling; v/l 1.2 kn thro' water
2000			Wind N'ly 25 knots;

2025 56 40.05N 07 34.80W Request to heave-to; instrument snagged on seabed

2030 56 40.07N 07 34.80W Instrument lost; reeling in slack cable

2040 All cable recovered

2050 V/l repositioning for CTD @ position of loss

2126 56 40.2N 07 34.6W Hove-to & CTD deployed; Stn 16171#1

2138 56 40.2N 07 34.5W @ bottom, 215m

2157 56 40.3N 07 34.6W CTD recovered; v/l in transit to stn '9G'

2307 56 44.1N 07 19.9W Hove-to & CTD deployed; Stn 16172#1

2330 56 44.1N 07 19.9W CTD recovered

2345 Bongo net deployed

2400 Bongo net recovd; v/l in transit to stn '10G'; Wind NNE 10 knots

2006-10-27

0105 56 43.9N 07 30.2W Hove-to & CTD deployed; Stn 16173#1

0134 CTD recovered; v/l in transit to stn '11G'

0230 56 44.2N 07 40.2W Hove-to & CTD deployed; Stn 16174#1

0242 CTD recovered

0253 Bongo net deployed; 16174#2

0300 Bongo net recovered; v/l in transit to stn '12G'

0353 56 45.5N 07 50.0W Hove-to & CTD deployed; Stn 16175#1

0400 Wind Var & Lt

0404 56 45.7N 07 50.0W CTD recovered; v/l in transit to stn '13G'

0503 56 47.0N 07 59.9W Hove-to & CTD deployed; Stn 16176#1

0527 56 47.3N 07 59.7W CTD recovered

0539 Bongo net deployed; Stn 16176#2

0549 Bongo net recovered

0604 56 47.4N 07 58.9W Deck secure; v/l sets co for Wyville Thomson Ridge

0800 Wind SxW 15 knots

0806 57 09.8N 08 06.4W Adj co to 344 (G)

1136 57 48.3N 08 27.5W A/c to 270 (T) for passage past St. Kilda

1153 Levanish Is 170 (G) x 0.94 A/c to 322 (T)

1208 Mina Stac Is 181 (G) x 1.0 A/c to 357 (T); Wind SWxS 30 knots

1600 58 25.8N 08 31.6W Wind SxW 25 knots
1615 Security briefing for ship's staff
2000 59 00.0N 08 39.0W Wind SW 23 knots
2400 59 46.5N 08 49.4W Wind SW 25 knots

2006-10-28

0345 60 20.6N 08 59.1W Hove-to @ Stn 'W1'; assessing conditions
0400 Wind SWxW 38 knots
0422 60 20.6N 08 59.5W CTD deployed; Stn 16177#1
0455 60 20.5N 08 59.5W CTD recovered; v/l repositioning
0544 60 18.7N 08 56.9W CTD deployed 'W2'; Stn 16178#1
0628 60 18.7N 08 57.0W CTD recovered; v/l repositioning
0739 60 17.8N 08 55.9W CTD deployed 'W3'; Stn 16179#1
0800 Wind SWxW 28 knots
0827 60 17.9N 08 55.9W CTD recovered; v/l repositioning to 'W5'
0931 60 16.0N 08 55.1W CTD deployed; Stn 16180#1
1017 60 15.9N 08 55.0W CTD recovered; v/l repositioning to interrogate & release mooring
1040 Mooring location verified; Stn 16181
1047 60 15.7N 08 54.5W V/l hove-to & mooring released
1057 Mooring @ surface
1112 60 15.1N 08 54.6W ADCP hooked alongside
1125 Recovery via hangar top crane completed
1200 60 16.5N 09 01.9W V/l repositioning for 'W4' stn; Wind SWxW 15 knots
1236 60 16.9N 08 55.4W Hove-to & CTD deployed; Stn 16182#1
1318 CTD recovered; v/l repositioning to stn 'W6'
1405 60 15.3N 08 55.1W Hove-to & CTD deployed; Stn 16183#1
1434 @ bottom, 1160m
1527 CTD recovered; v/l repositioning for mooring re-deployment
1558 60 15.0N 08 54.9W ADCP flotation buoy streamed; Wind SWxW 15 knots
1603 60 15.003N 08 54.990W Mooring clump weight released; Stn 16184
1651 60 14.2N 08 54.9W Hove-to 'W8' & CTD deployed; Stn 16185#1
1726 60 14.2N 08 55.0W @ bottom, 1200m

1815	60 14.1N	08 55.0W	CTD recovered; v/l repositioning for final WTR stn
1927	60 13.6N	08 55.0W	Hove-to & CTD deployed; Stn 16186#1
1957			@ bottom, 859m; Wind NWxW 25 knots
2017	60 13.6N	08 55.0W	CTD recovered
2042	60 14.0N	08 55.7W	Sampling comp & deck secure; v/l in transit towards Barra Hd
2400	59 28.1N	08 57.7W	Wind NWxN 35 knots

2006-10-29

0400	58 59.0N	08 46.1W	Wind NWxN 15 knots
0800			Wind W'ly 15 knots
1000	58 00.4N	08 28.0W	Boreray Is 188 (G) x 7.8nm
1046-1153			Co var to MO passing St Kilda group of islands
1200			Wind WSW 12 knots
1600	57 05.4N	08 04.7W	Wind SxE 15 knots
1730	56 52.2N	07 59.9W	A/c 128 (G)
1845	56 44.8N	07 44.2W	A/c 092 (G); v/l rounding Barra Head
2000			Wind SSE 35 knots
2054	56 44.1N	07 09.9W	Hove-to '8G' & CTD deployed; Stn 16187#1
2120	56 44.2N	07 09.6W	CTD recovered; hove-to sampling then v/l in transit to stn '7G'
2229	56 44.1N	07 00.0W	Hove-to '7G' & CTD deployed; Stn 16188#1
2247	56 44.2N	07 59.5W	CTD recovered; hove-to sampling then v/l in transit to stn '6G'
2355	56 44.0N	06 44.9W	V/l hove-to on stn; Wind SxE 40 knots

2006-10-30

0022			CTD deployed; Stn 16189#1
0033			CTD recovered; hove-to sampling then v/l in transit to stn '5G'
0137	56 43.9N	06 36.1W	Hove-to & CTD deployed; Stn 16190#1
0148			CTD recovered; hove-to sampling then v/l in transit to stn '4G'
0250	56 43.9N	06 27.0W	Hove-to & CTD deployed; Stn 16191#1
0303			CTD recovered; hove-to sampling then v/l in transit to stn '3G'
0354	56 42.6N	06 22.0W	Hove-to & CTD deployed; Stn 16192#1
0400			Wind SW 30 knots

0412 CTD recovered; hove-to sampling then v/l in transit to stn '2G'

0502 56 41.0N 06 16.9W Hove-to & CTD deployed; Stn 16193#1

0517 CTD recovered; hove-to sampling then v/l in transit to stn '1G'

0545 est Stbd anchor cleared

0635 56 40.0N 06 08.0W Hove-to & CTD deployed; Stn 16194#1

0658 CTD recovered

0700 56 40.0N 06 08.1W D312 science comp; v/l transitting Snd. of Mull on passage Govan

0800 Wind SWxS 30 knots

0932 Clearing Sound of Mull

1200 Wind WSW 25 knots

1248 Entering Sound of Islay

1352 Clearing Sound of Islay

1516 Rubha nan bcn 283 (G) x 6.0nm; A/c to 234 degs

1600 55 29.2N 06 15.3W Wind SWxW 30 knots

1615 PES recovered

1745 Altacarry Hd 206 (G) x 3.5nm; A/c to 144 degs

2000 Wind WSW 25 knots

2012 Sanda Is 334 (G) x 3.84nm; A/c 051 degs; reduce to 85 rpm

2205 Ailsa Craig 132 (G) x 4.0nm

2400 Wind SW 30 knots

_2006-10-31_

0200 Holy Is 280 (G) x 7.0nm

0233 ETA reported to Clydeport Estuary Control

0400 Wind NW 50 knots

0430 Anchors cleared approaching Cumbrae channel

0532 Mounstuart buoy abeam to port

0630 All critical instruments tested & satis.

0642 ERSB approaching Kempock Pilot stn

0711 Pilot o/b I. Jamieson

0801 Garrison bcn abeam to stbd; Wind WNW 25 knots

0841 Tug 'Battler' in attendance

0900	V/l swinging into dock basin
0917	Spring ashore for'd
0919	'Battler' pushing port qtr
0922	Alongside & making fast
0923	Tug away
0930	All fast 4&2 F&A; RFWE; Pilot away

P. Sarjeant

3. TECHNICAL SUPPORT

Deck Operations – *Alan Sherring*

Sediment Trap / Current Meter Mooring Deployments

Moorings were deployed using a double barrel capstan winch with 90 degree diverter sheave and reeling winch in conjunction with the ship fitted, aft Effer cranes. Mooring lines were passed under a deck mounted counting sheave located in front of the double barrel winch and up through a wide throated sheave block hung from the port crane.

Buoyancy spheres, current meters and acoustic releases were manually handled and connected in, after stopping off the mooring line to a deck-mounted eyebolt. Sediment traps and clump weights were deployed from the starboard crane using a release hook.

ADCP Mooring Turn Around (Wyville Thomson Ridge)

The mooring was recovered by attaching a snap hook onto the buoy frame with a pole from the starboard side. The mooring was then hoisted onto the starboard deck using the ships forward crane. Re-deployment was carried out from the aft deck using both of the aft cranes and quick release hooks, the starboard one for the buoy and port for clump weight.

Zooplankton Net Deployments

Nets were deployed to 100 metres depth using a hydraulic deck winch mounted on the starboard deck in conjunction with the amidships crane fitted with a 2Te snatch block. A Kevlar rope marked off with tape at 25 metre intervals was used. The winch was connected to an 11 gpm deck hydraulic supply giving a rope speed of approx 25 m/min.

The deployment of nets could only be carried out in relatively calm conditions due to concerns with the rope leading aft and becoming entangled with the propeller / rudder.

CTD Deployments

CTDs were deployed using the ship fitted winch (standard CTD cable) and the starboard gantry. The CTD "railway track" was used to allow the CTD to be moved forward after deployment to give some degree of shelter during sampling activities.

UKORS Instrumentation – *Terry Edwards*

CTD Instrumentation

A total of 70 CTD profiles were carried out. The stainless steel frame configuration was as follows:

• Sea-Bird 9/11 *plus* CTD System

• 24 by 10L Ocean Test Equipment External Spring Water Samplers

• Sea-Bird 43 Oxygen Sensor

• Chelsea MKIII Aquatracka Fluorometer

• Chelsea MKII Alphatracka 25cm path Transmissometer

• OED LADCP Pressure Case Battery Pack

• RD Instruments Workhorse 300 KHz Lowered ADCP (downward-looking master configuration)

• RD Instruments Workhorse 300 KHz Lowered ADCP (upward-looking slave configuration)

• Benthos Altimeter

The pressure sensor was located 30cm from the bottom of the water samplers, and 119cm from the top of the water samplers.

CTD Instrument Configuration

The Sea-Bird CTD configuration can be found in the relevant con files on the D312 SeaBird data disk, but for example, calibration details as follows:-

Date: 10/12/2006

ASCII file: C:\D312\ctd\data\16126.con

Configuration report for SBE 911/917 plus CTD

Frequency channels suppressed: 0

Voltage words suppressed: 0

Computer interface: RS-232C

Scans to average: 1

Surface PAR voltage added: No

NMEA position data added: Yes

Scan time added: No

1) Frequency 0, Temperature

Serial number: 03P-2728

Calibrated on: 15 Mar 06

G: 4.36015616e-003

H: 6.44627842e-004

I: 2.34904246e-005

J: 2.24154778e-006

F0: 1000.000

Slope: 1.00000000

Offset: 0.0000

2) Frequency 1, Conductivity

Serial number: 04C-2851

Calibrated on: 9 JUN 06

G: -9.96127762e+000

H: 1.35418827e+000

I: 7.83385464e-004

J: 1.65005990e-005

CTcor: 3.2500e-006

CPcor: -9.57000000e-008

Slope: 1.00000000

Offset: 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number: 94756

Calibrated on: 15 Apr 2004

C1: -4.722750e+004

C2: -1.465524e-001

C3: 1.449080e-002

D1: 3.863800e-002

D2: 0.000000e+000

T1: 3.011286e+001

T2: -2.710648e-004

T3: 4.095660e-006

T4: 2.377730e-009

T5: 0.000000e+000

Slope: 1.00000000

Offset: 0.00000

AD590M: 1.285020e-002

AD590B: -8.056957e+000

4) Frequency 3, Temperature, 2

Serial number: 03P-4490

Calibrated on: 11 Jun 06

G: 4.40570480e-003

H: 6.48469763e-004

I: 2.29513343e-005

J: 2.00503804e-006

F0: 1000.000

Slope: 1.00000000

Offset: 0.0000

5) Frequency 4, Conductivity, 2

Serial number: 04C-2450

Calibrated on: 15 Jun 06

G: -1.05486233e+001

H: 1.67929419e+000

I: -1.02258454e-003

J: 1.86389112e-004

CTcor: 3.2500e-006

CPcor: -9.57000000e-008

Slope: 1.00000000

Offset: 0.00000

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

Serial number: 0612

Calibrated on: 24 Nov 05

Soc: 3.5720e-001

Boc: 0.0000

Offset: -0.5035

Tcor: 0.0011

Pcor: 1.35e-004

Tau: 0.0

7) A/D voltage 1, Free

8) A/D voltage 2, Altimeter

Serial number: 1037
Calibrated on:
Scale factor: 15.000
Offset: 0.000

9) A/D voltage 3, Fluorometer, Chelsea Aqua 3

Serial number: 088108
Calibrated on: 17 Nov 2004
VB: 0.287100
V1: 1.978300
Vacetone: 0.331500
Scale factor: 1.000000
Slope: 1.000000
Offset: 0.000000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, User Polynomial

Serial number: 169
Calibrated on: 7 Jul 05
Sensor name: BBRTD
A0: -0.00025440
A1: 0.00318000
A2: 0.00000000
A3: 0.00000000

13) A/D voltage 7, Transmissometer, Chelsea/Seatech/Wetlab CStar

Serial number: 04-4223-001
Calibrated on: 8 Dec 04
M: 20.2870
B: -1.0144
Path length: 0.250

CTD Frame Deployment Notes

One frame was used throughout the cruise. The following notes are taken from the technician diary and are organised by time. Individual casts that had no outstanding events or sensor changes are not logged here.

12 Oct 2006

CTD cast 001 (16126) aborted at 80m, primary temp spiking to full scale. Leaking BH connector on CTD. Cleaned it up, and at same time put primary sensors on vane.

Re did the cast same numbers, data good, but bottles would not fire, no feedback. Leaky BH connector on CTD(JT7), cleaned and cable replaced.

13 Oct 2006

Removed BBRTD sn169. Had been very noisy. CG had noted that the black end portion had rotated when removing the cap. Noted on removal that the rubber on the pins was damaged also, with slight corrosion on 1 pin.

Still noise on V6 . Checked cabling etc.

Cast 16132, comms problem on master ladcp. Removed cable from unit to reset comms, worked ok, but also reset clock.

Exchanged altimeter. Removed #1040, fitted #1037. Worked ok, locked fully at 50m. Still using echosounder for approach. #1040 appears to have something loose inside.

Cast 16133 fitted releases 325 and 440 for wire test. Also fitted full 24 bottles. 325 diagnostics ok, then fired ok. 440, ranged ok, but could not get diagnostics or release to work. Suspect TE finger trouble with TT801.

Post cast, still getting rogue voltage on V6, slight leak at BOB end of aux3 cable. Removed and blanked both ends, put trans onto v4. Removed uwirr cable, as found corrosion on that. Also corrosion on bob trans BH connector, cleaned all BOB connectors, and changed trans cable.

18th Oct 2006

Stripped alt. 1040, slight leak some corrosion on board. Outer O-ring damaged, but also found BH connector not tight. Cleaned and reassembled, but still didn't work.

21st Oct 2006

Oxy sensor BH leaked. Changed BH connector, now ok, continuous checking for leaky connectors.

26th Oct 2006

Altimeter inconsistent. Found damaged cable, broken in moulding so swapped that out.

Slave LADCP has failed to start on 3 casts, resulting in no data, winadcp showing all zeros for start and end times. Have added a 10 minute delay (ST600) in case it is lack of a synch pulse from the master.

Casts with no data, 16138, 16165 and 16169

27th Oct 2006

Removed and cleaned / checked Latch Mechanism from Rosette. Bottle 15 has been sporadically not firing. No obvious reason, and unable to recreate the problem on deck.

Sediment trap mooring operations – *Terry Edwards, Richard Sanders, Paul Provost, Colin Griffiths*

<u>*Mooring deployment 1.*</u>

STNW Discovery # 16137 15th Oct 06 08:02 2781m

60º 00.063’ N 20º 49.512’ W

RCM8 #11216

Sed trap 21 bottle # ML11804-05

Acoustic release RT661, #440

Timing	0730	Buoyancy in water
	0735	Sed trap in water
	0736	RCM in water
	0739	100m cable join
	0752	Release in water
	0802	Anchor in water

Tracked using SAMS TT301, single element PES fish.

Ship position 60º 00.0141’N, 20º 49.7065’W

1401m@0814

1837m@0817

2200m@0820

Bottom 0828. Confirmed static.

Mooring Deployment 2

STC Discovery # 16138 15th Oct 06 1650 2775m (2765 corrected)

59º 29.913' N 19º 59.757' W

RCM8 #9682

Sed trap 21 bottle # ML11804-02

Acoustic release AR861B2s # 325

RDI 75Khz long ranger #

From Bottom, 1000kg chain clump, 2 x 100m, Release, 200m 10mm polyester, RCM8, 15m 12mm polyester, sed trap, 25m 12mm polyester, 7m chain with 6 spheres, 506+528 10mm polyester, 7m chain with 6 spheres, 887 m 10mm polyester, made up of 520 + 153 + 152 + 45 + 20, 5m chain, 2m 5/8 chain, ADCP in 45" flotech buoy. Total length 2402m. During deployment, the line lengths were calculated incorrectly, a 200m section was not taken into account. Therefore the ADCP is actually at 363m below surface.

Timing

1520 Pellet in water

1523 ADCP in water

1549 Upper buoyancy

1618 lower buoyancy

1628 Sed trap

1631 RCM8

1650 Anchor

Release tracked using SAMS TT301 through fish single element. Descent 140m/min, slowing to 120. Confirmed on seabed static at 1710, range 2585m

Mooring Deployment 3

STNE Discovery # 16139 15th Oct 2006 2102GMT 2732m

59º 38.972N 18º 46.838W

RCM8 # 12302

Release RT661 # 321

Sediment trap # ML11804-01

Timing

2044 Pellet in water

2045 Buoyancy

2046 Sed trap

2047 RCM8

2053 Release

2101 Anchor gone

500kg 2 x railway wheel anchor.

Tracked using SAMS TT301 through PES fish single element. Descent 130m/min, ranged on bottom at 2127GMT, 2532m.

Mooring Deployment 4

STS Discovery # 16140 16th Oct 2006 0644 2856m

58º 51.968"N 20º 24.169"W

RCM8 # 3344

Release RT661 # 183

Sd trap ML11262-08

Timing

0618	Pellet and buoyancy
0620	Sed trap
0621	RCM8
0629	Release
0643	Anchor

Tracked using SAMS TT301 through PES fish single element. Descent 130m/min. Confirmed on bottom and static at 0711, range 2664m

Maclane Sediment Traps

Sediment traps were set up as indicated below. They were pressure washed prior to sailing and the tops covered with Clingfilm until deployment. Richard sanders carried out the bottle filling and programming. All units had new batteries fitted, both motor batteries and 9v backup. Rotations for bottle filling and alignment were carried out using the spare controller pack. Log files are listed in order of deployment.

ML11804-05

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

ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
º   Main Menu   º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
Sat Oct 14 21:20:33 2006

<1> Set Time   <5> Create Schedule

<2> Diagnostics <6> Deploy System
<3> Fill Containers <7> Offload Data
<4> Sleep <8> Contacting McLane

Selection ? 6

Is the rotator aligned to the
open hole (Yes/No) [N] ? y

Clock reads 10/14/2006 21:21:07
Change time & date (Yes/No) [N] ? n

Existing deployment data file will be
erased. Continue (Yes/No) [N] ? y

Enter new deployment schedule (Yes/No) [N] ? n

Schedule Verification

Event 1 of 22 = 11/22/2006 12:00:00
Event 2 of 22 = 12/06/2006 12:00:00
Event 3 of 22 = 12/20/2006 12:00:00
Event 4 of 22 = 01/03/2007 12:00:00
Event 5 of 22 = 01/17/2007 12:00:00
Event 6 of 22 = 01/31/2007 12:00:00
Event 7 of 22 = 02/14/2007 12:00:00
Event 8 of 22 = 02/28/2007 12:00:00
Event 9 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
Press any key to continue.
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

Modify an event (Yes/No) [N] ? n
Current Header reads:

Deployment 42 Iceland Basin NE D312
ML11804_05

```
Do you want a different header (Yes/No) [N] ? n

System status:


 10/14/2006 21:21:32   21.6 Vb    15 øC  aligned


Caution:  Deployment will overwrite the
          EEPROM data backup cache.

Proceed with the deployment (Yes/No) [N] ? y

 >>> Remove communication cable and <<<
      >>> attach dummy plug. <<<
>>> Sediment trap is ready to deploy. <<<



<10/14/2006 21:21:35> Waiting for Event 01 of 22 @ 11/22/2006 12:00:00

<10/14/2006 21:21:36> Sleeping . . .
```

ML11804-02

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

         ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
         º            Main Menu            º
         ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
             Sat Oct 14 21:30:15 2006

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

          Selection  ? 6

Is the rotator aligned to the
open hole (Yes/No) [N] ? y

Clock reads 10/14/2006 21:30:29
Change time & date (Yes/No) [N] ? n

Existing deployment dat
erased.  Continue (Yes/No) [N] ? y
```

```
Enter new deployment schedule (Yes/No) [N] ? n

Schedule Verification

Event   1 of  22 = 11/22/2006 12:00:00
Event   2 of  22 = 12/06/2006 12:00:00
Event   3 of  22 = 12/20/2006 12:00:00
Event   4 of  22 = 01/03/2007 12:00:00
Event   5 of  22 = 01/17/2007 12:00:00
Event   6 of  22 = 01/31/2007 12:00:00
Event   7 of  22 = 02/14/2007 12:00:00
Event   8 of  22 = 02/28/2007 12:00:00
Event   9 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
Press any key to continue.
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

Modify an event  (Yes/No) [N] ? n
Current Header reads:

Deployment 43 IB2 ML11804_02_D312_Final

Do you want a different header (Yes/No) [N] ? n

System status:

 10/14/2006 21:30:45   21.5 Vb    15 øC  aligned

Caution:  Deployment will overwrite the
          EEPROM data backup cache.

Proceed with the deployment (Yes/No) [N] ? y

 >>> Remove communication cable and <<<
       >>> attach dummy plug. <<<
>>> Sediment trap is ready to deploy. <<<

<10/14/2006 21:30:48> Waiting for Event 01 of 22 @ 11/22/2006 12:00:00
```

```
<10/14/2006 21:30:50> Sleeping . . .
```

ML11804-01

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

       ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
       º          Main Menu          º
       ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
          Sun Oct 15 14:32:50 2006

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

        Selection  ? 1

 Clock reads 10/15/2006 14:34:19
 Change time & date (Yes/No)

 Enter date as MM DD YY HH MM SS
 Enter year 2001 as 1, 01, 101, or 2001

 Enter correct time [10/15/2006 14:34:33] ? 10/15/2006 15:04:00

 Clock reads 10/15/2006 15:04:00
 Change time & date (Yes/No) [N] ? n

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

       ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
       º          Main Menu          º
       ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
          Sun Oct 15 15:04:07 2006

      <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
```

```
 10/15/2006 15:04:17   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:18   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:19   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:20   22.3 Vb    17
 10/15/2006 15:04:21   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:22   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:23   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:24   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:25   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:26   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:27   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:28   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:29   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:30   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:31   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:32   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:33   22.3 Vb    17 øC  aligned
 10/15/2006 15:04:34   22.3 Vb    17 øC  aligned

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

        ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
        º           Main Menu           º
        ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
            Sun Oct 15 15:04:34 2006

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

         Selection  ? 5

 Existing deployment data file will be
 erased.  Continue (Yes/No) [N] ? y

 Enter new deployment schedule (Yes/No) [N] ? y

 Enter the number of events to program  (0 to 22) ? 22

        ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
        º         Schedule Menu         º
        ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼

         <1> Enter each event time
         <2> Enter start date & interval
         <3> Enter start date & end date
         <M> Main Menu
```

Selection ? 2

Enter START date and time [10/15/2006 15:05:06] ? 11/22/2006 12:00:00

Enter interval

Days (0 to 365) ? 14
Hours (0 to 23) ? 0
Minutes (0 to 59) ? 0

Schedule Verification

Event 1 of 22 = 11/22/2006 12:00:00
Event 2 of 22 = 12/06/2006 12:00:00
Event 3 of 22 = 12/20/2006 12:00:00
Event 4 of 22 = 01/03/2007 12:00:00
Event 5 of 22 = 01/17/2007 12:00:00
Event 6 of 22 = 01/31/2007 12:00:00
Event 7 of 22 = 02/14/2007 12:00:00
Event 8 of 22 = 02/28/2007 12:00:00
Event 9 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 12:00:0
Event 15 of 22 = 06/06/2007 12:00:00º Main Menu
Event 16 of 22 = 06/20/2007 12:00:00

Press any key to continue.12:00
Event 17 of 22 = 07/04/2007 12:00:00

McLane Research Labor
Event 18 of 22 = 07/18/2007 12:00:00
Event 19 of 22 = 08/01/2007 12:00:00 ParFlux 21-Cup Sediment Trap
Event 20 of 22 = 08/15/2007 12:00:00 Sel
Version:
Event 21 of 22 = 08/29/2007 12:00:00

Is
Event 22 of 22 = 09/12/2007 12:00:00

ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ

Modify an event (Yes/No) [N] ? n
º
Event 16 of
ÈÍÍ

McLane Research Laboratories, USA
Enter
ParFlux 21-Cup Sedime
Existing deployment data file will be
10/14/2006 20:21:39   22.0 Vb   15
erased. Continue (Yes/No) [N] ? y

Enter new deployment schedule (Yes/No) [N] ? Schedule Verification
Event   1 of 22 = 11/22/2006 12:00:008>

Event   2 of 22 = 12/06/2006 12:00:00

Event   3 of 22 = 12/20/2006 12:00:00
ParFlux 21-Cup Sed
Event   4 of 22 = 01/03/2007 12:00:00

Sys
Version: p
Event   5 of 22 = 01/17/2007 12:00:00

ÉÍÍÍ
Event   6 of 22 = 01/31/2007 12:00:00yment will overwrite the
Event   7 of 22 = 02/14/2007 12:00:00

Event   8 of 22 = 0
Event 21 of 22 = 08/29/2007 12:00:00   Selection ? 1
Event 22 of 22 = 09/12/2007 12:00:00
Event 10 of 22 = 03/28/2007

Modify an event (Yes/No) [N] ? n
Ch
Event 11 of 2
Current Header reads:

Mooring IRM-3, deploy sept 19th 2005 on CAMP/LOCO/CIS04/25/2007 12:00:00________
RV Pelagia cruise 64PE240, position 59 20.08 N 38 50.98 We Research
met de groeten aan Gert-Jan en Lukas.:00

Do you want a different header (Yes/No) [N] ? y
Event 19 of 22 = 08
Enter new header (three lines, 80 characters/line)

<1> Set Time   <5>

> ML11804_01_D312 Iceland Basin Sed Trap 3 Mooring 44
<2

Do you want a different header (Yes/No) [N] ? n

System status:

10/15/2006 15:07:01   22.3 Vb   17 øC aligned
Caution: Deployment will overwrite the
EEPROM data backup cache.

Proceed with the deployment (Yes/No) [N] ? y

>>> Remove communication cable and <<<
>>> attach dummy plug. <<<
>>> Sediment trap is ready to deploy. <<<
<10/15/2006 15:07:06> Waiting for Event 01 of 22 @ 11/22/2006 12:00:00

<10/15/2006 15:07:07> Sleeping . . .

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
Sun Oct 15 15:09:44 2006

<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

10/15/2006 15:10:26   21.5 Vb   15øC   0øT   0øH aligned
10/15/2006 15:10:30   21.5 Vb   15øC   0øT   0øH aligned
10/15/2006 15:10:33   21.4 Vb   15øC   0øT   0øH aligned
10/15/2006 15:10:36   21.4 Vb   15øC   0øT   0øH aligned
10/15/2006 15:10:39   21.4 Vb   15øC   0øT   0øH aligned
10/15/2006 15:10:42   21.4 Vb   15øC   0øT   0øH aligned
10/15/2006 15:10:45   21.4 Vb   15øC   0øT   0øH aligned
10/15/2006 15:10:48   21.4 Vb   15øC   0øT   0øH aligned

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
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
    Sun Oct 15 15:10:52 2006

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

  Selection  ? 6

Is the rotator aligned to the
open hole (Yes/No) [N] ? y

Clock reads 10/15/2006 15:11:07
Change time & date (Yes/No) [N] ? n

Existing deployment data file will be
erased.  Continue (Yes/No) [N] ? y

Enter new deployment schedule (Yes/No) [N] ? n

Schedule Verification

Event   1 of  22 = 11/22/2006 12:00:00
Event   2 of  22 = 12/06/2006 12:00:00
Event   3 of  22 = 12/20/2006
Event   4 of  22 = 01/03/2007 12:00:00
Event   5 of  22 = 01/17/2007 12:00:00
Event   6 of  22 = 01/31/2007 12:00:00
Event   7 of  22 = 02/14/2007 12:00:00
Event   8 of  22 = 02/28/2007 12:00:00
Event   9 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 12:00:0
Press any key to continue.cable and <<<
Event  17 of  22 = 07/04/2007 12:00:00ttach dummy plug. <<<
Event  18 of  22 = 07/18/2007 12:00:00eady to deploy. <<<
Event  19 of  22 = 08/01/2007 12:00:001:08:22> Waiting for Event 01 of 22 @ 1
Event  20 of  22 = 08/15/2007 12:00:00
Event  21 of  22 = 08/29/2007 12:00:00ing . . .
Event  22 of  22 = 09/12/2007 12:00:00

<10/1
```

Modify an event (Yes/No) [N] ? ned by operator.
Current Header reads:

Enter tilt sample interval [minutes] (43 to 1440) ? 1440

System status:

10/15/2006 15:11:40   21.5 Vb   15øC   0øT   0øH aligned

Caution: Deployment will overwrite the
EEPROM data backup cache.

Proceed with the deployment (Yes/No) [N] ? y

>>> Remove communication cable and <<<
>>> attach dummy plug. <<<
>>> Sediment trap is ready to deploy. <<<

<10/15/2006 15:11:50> Waiting for Event 01 of 22 @ 11/22/2006 12:00:00

<10/15/2006 15:11:51> Sleeping . . .

Acoustic Releases.

All the releases were wire tested on the CTD prior to deployment.

Build sheets below, except for # AR861 325, settings as below.

Wire test 2200m, diagnostics and release checked.

12KHz CAF

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)

Ocean Engineering Division
UKORS

MORS SYSTEMS
Operational Sheet

CRUISE **D312** DATE **23 Oct 06**

TYPE **RT 661 B1S**
FUNCTION **RELEASE TRANSPONDER RT661 - B**
SERIAL No. **183**
Delivery **JULY 2001**

Int Frequency	**Reply Frequency**
FR1 = 9.0khz	**FT1 = 8.5khz**
FR2 = 8.5khz	**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	EC2A	FT0	Wait time sec Active sec
ON FR1 -FR2	EC2B	FT0	
OFF FR1 -FR2 -PINGER	EC2C	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 Pulse s
PINGER (W)	EC94	FT0 -FT4	Pulse width Ms Recur sec
2 SEC PINGER			

Power Configuration 3 banks of 6 Lithium D installed for
1 bank of 1 Alkaline PP3 installed for
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 : YES - ALKALINE - 30TH JULY 06

Wire test :Tested to 2200m
Functions check : Diagnostics and release
Deployed Mooring : STS Discovery # 16140 Date : 16 oct

Recovery limit : Date :

Recovered : Date :

COMMENTS ON CONDITION
Good condition, no problems

ACTIONS REQUIRED AT LABORATORY

Natural Environment Research Council — Southampton Oceanography Centre

Ocean Engineering Division
UKORS

MORS SYSTEMS
Operational Sheet

CRUISE **D312** DATE **23 Oct 2006**

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 Configuration 3 banks of 6 ALKALINE D installed for D312
1 bank of 1 Alkaline PP3 installed for D312
Power partition Standby - power motor

Diagnostic Measure t(FT7) - t(FT0) - 3s (13 s in hori zontal position)
Cells voltage (V) Diagnostic measure x 4.1
Batteries fitted : YES 29TH JULY 2006

Wire test :2200m
Functions check : Diagnostics and Release
Deployed Mooring : STNE Discovery # 16139 Date : 16 Oct 06

Recovery limit : Date :

Recovered : Date :

COMMENTS ON CONDITION

ACTIONS REQUIRED AT LABORATORY

Ocean Engineering Division
UKORS

MORS SYSTEMS
Operational Sheet

CRUISE **D312** DATE **23 Oct 06**

TYPE **RT 661 B2S -DDL**
FUNCTION **RELEASE TRANSPONDER RT661 - B**
SERIAL No. **440**
Delivery **FEB 2001**

Int Frequency	**Reply Freq uency**
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 Puls e s
PINGER (W)	EC94	FT0 -FT4	Pulse width Ms Recur sec

Power Configuration 3 banks of 6 ALKALINE D installed for D312
1 bank of 1 Alkaline PP3 installed for D312
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 : YES - 29TH JULY 2006

Wire test :2200m
Functions check : Diagnostics and Release
Deployed Mooring : STNW Discovery # 16137 Date : 16 Oct 06

Recovery limit : Date :

Recovered : Date :

COMMENTS ON CONDITION

ACTIONS REQUIRED AT LABORATORY

Wyville Thomson Ridge mooring turn-around - *Paul Provost, Terry Edwards, Toby Sherwin, Mark Inall, Colin Griffiths*

The LR-ADCP mooring was successfully serviced on the 29th October 2006. Recovery went very smoothly in calm conditions with a moderate swell. The mooring was released at 1047Z, diagnostic 5092, ascent speed was ~100m/min and the mooring was spotted on the surface at 1056Z. The mooring was recovered on the starboard side. The mooring had been deployed in the Ellett Gully, the first deployment was from CD176 in October 2005 and subsequently serviced from RV Scotia in May 2006. The mooring components were all in good condition. The LR-ADCP was removed from the S/S sphere, the instrument was still pinging and the data was downloaded. First look at the data indicated a good data set for the duration of the deployment over a range of ~500m. The batteries (4 packs) were changed and the instrument set for deployment. The batteries were also changed in the acoustic release, the release was wire tested on the CTD prior to deployment, diagnostic 5309. The mooring was deployed over the stern using both gantry cranes and a BOSS slip hook for the S/S sphere and then the 1000Kg anchor. The deployment took 4 minutes, (**S**peedy **A**pplied **M**ooring **S**ervices **L**td); the anchor was released at 1601Z. The acoustic release was tracked during the descent. The anchor landed on the bottom at ~1608Z. The descent speed was ~240m/min.

All instruments were provided from the NMEP with mooring hardware from the S&M division, UKORS, NOCS, Southampton. Ancillary data from the LR_ADCP included temperature, pressure, pitch, roll and heading.

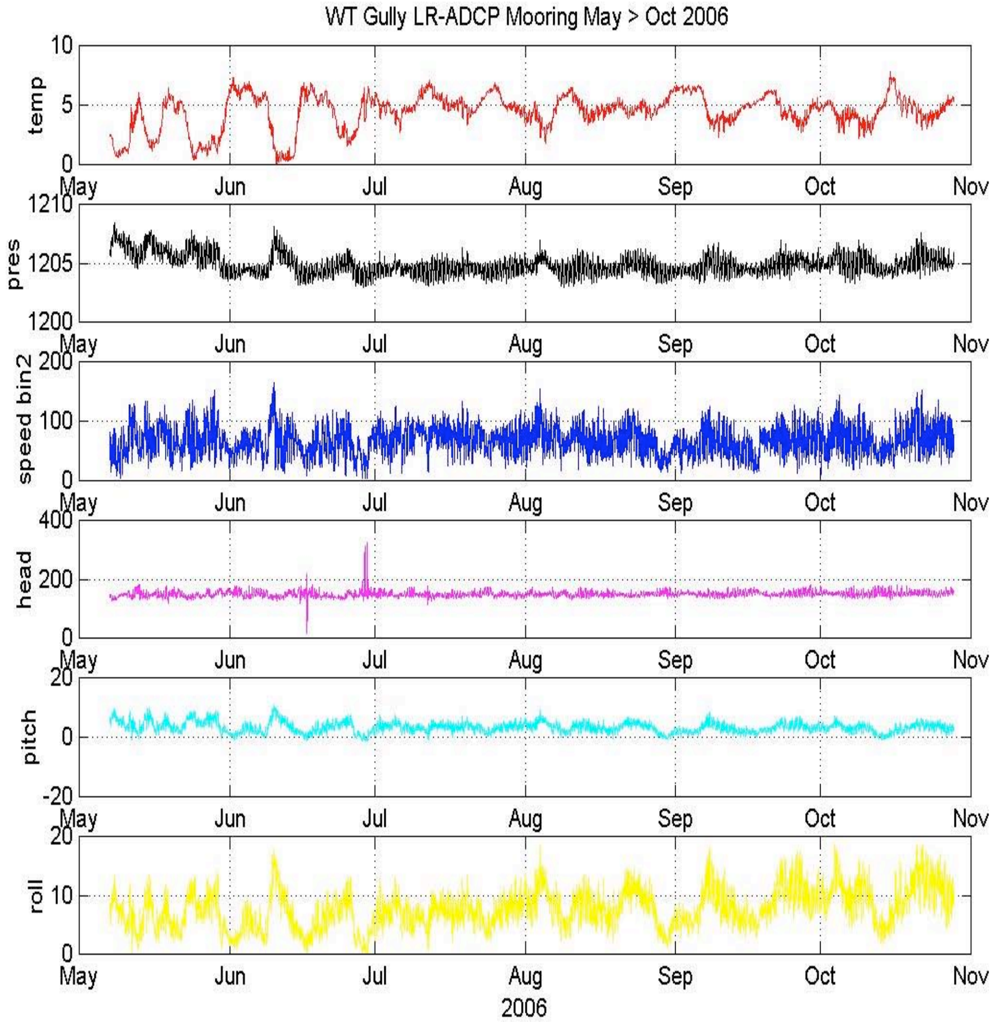


Figure 5: Wyville Thomson gully LR-ADCP mooring, May to October 2006.

The highest currents measured were during the early part of the deployment in the early summer. These currents coincided with near zero temperatures. The highest speed measured was ~191cm/s (269ºM) from bin 11, ~127m above the seabed at 1047Z 10/6/2006.

The mooring performed very well in this high current regime. The maximum tilt measured by the LR-ADCP was ~20º from the vertical.

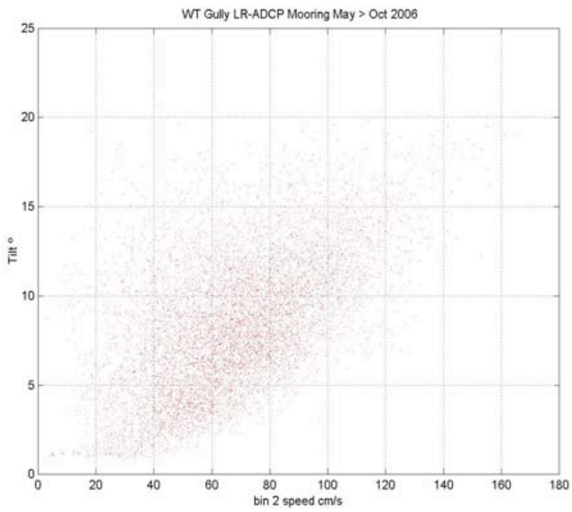


Figure 6: Wyville Thomson gully LR-ADCP mooring, May to October 2006, tilt readings.

The flow was predominantly westward in the lower bins as can be clearly seen from the scatter plots. The top row is from bin 1 to bin 8, 2d row bin 9 to bin 16 etc…

The scale of each axis is -200cm/s to 200cm/s E-W & N-S, the bin length was 8m with a blanking distance of ~7m. The data return from the upper 6 bins is very patchy, bins 59 to 64.

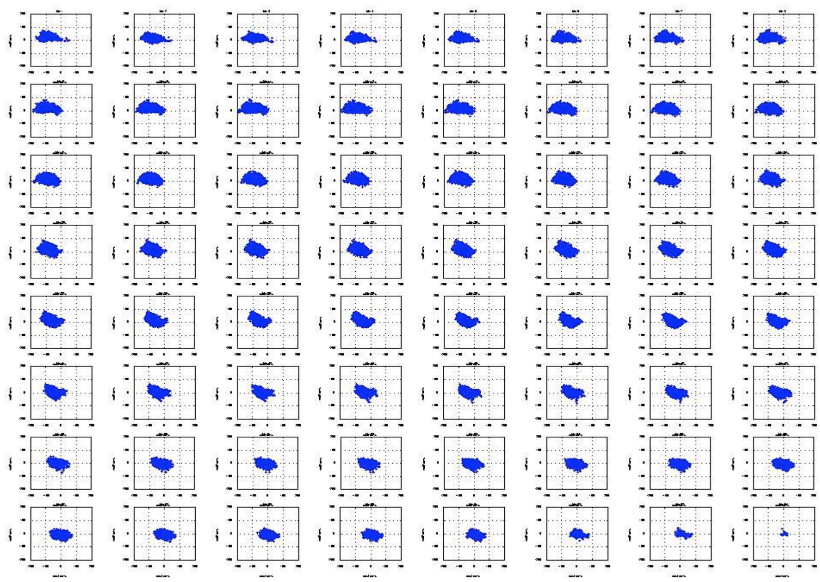


Figure 7: Wyville Thomson gully LR-ADCP mooring, May to October 2006, direction of flow.

Table 1: Wyville Thomson gully LR-ADCP mooring and instrument set-up details.

Mooring deployment details	Instrument set-up for ADCP
Position: 60º 15.00’ N 008º 54.99’ W Depth: 1218m Date: 29th Oct 2006 Time: 16:01 GMT	High power, long range mode Time of First Ping: 29th October 2006 15:00 GMT Ensemble interval: 30 mins Number of depth cells: 64 Pings per Ensemble: 23 Depth Cell Size: 8 m Blank After Transmit: 7.04 cm Frequency: 76.8 kHz Expected battery life (4 packs) : 180 days

Figure 8: Mooring components being moved into place prior to deployment of the mooring over the stern.

Table 2: Mooring set-up, equipment and chain lengths.

Item	Details	Height above seabed
Rope (30mm 3-strand polyprop)	7.5m, soft eye splice, Taped to frame	
5/8" oval link shackle		

RDI ADCP	RD Instruments Workhorse, Serial No. 1644	17m
49” syntactic sphere	Floatation Technologies	16m
2 shackles		
Titanium swivel (SWL 3T)		
shackle		
5/8” oval link		
shackle		
5/8” long link chain	Galvanised, 10m	
shackle		
Acoustic release	Oceano RT661 B2S, Serial No. 234	6m
20mm oval link		
shackle		
½” long link chain	Yellow, 5m	
shackle		
Anchor clump	1000kg	0m

Figure 9: Final preparation of the sub-surface syntactic sphere housing the LR-ADCP.

Figure 10: Big Splash, then 6 minutes later some poor echinoderm is toast!

Ship Fitted Systems – *Gareth Knight*

The ships on board data logging system recorded.

Trimble DS4000 GPS navigation data

Ashtech ADU5 attitude and navigation data

Ashtech G12 GPS navigation data

These were all corrected with a differential GPS output from the Fugro SeaStar service. The em log, ships gyrocompass and winch data were also recorded, in addition to the surfmet package of metrology and surface sampling instruments.

Vessel Mounted RDI 150khz and 75khz ADCPs were recorded as stand alone logging instruments and data transferred to the networked work area. Data from the ships wave recorder was also handled in this way.

Scientific computing and data storage took place on networked systems with a data storage area served to all users. The on board systems were used for Pstar data processing with Matlab and Uniras licensed packages having been setup prior to the cruise.

Printing from the normally reliable networked colour laser printer failed roughly half was through the cruise. The fault was diagnosed as requiring a manufacturer repair. The fallback of using a networked monochrome laser printer and colour inkjet printer proved adequate, however a spare colour laser printer would be an advantage in the future, it was noted that the current printer has a total print usage in excess of seventy five thousand pages.

All instrumentation performed well with no data logging issues being apparent during the cruise. We suffered one interruption to the Ashtech ADU5 logging from 06:295:00:39:24 to 06:295:09:41:48, the system was eventually restarted and the problem did not reoccur again.

4. SCIENTIFIC INVESTIGATIONS

Lowered CTD Data - *Colin Griffiths, Jane Read*

<u>*CTD Sensors*</u>

The CTD used through cruise D312 was a SeaBird 9/11+ with 24-way rosette and additional oxygen, fluorometer, transmissometer, BBRTD, and altimeter sensors.

SBE9/11+ CTD system with 24 10l OTE Bottles

SBE9+ Underwater Unit 09P37898-0782

SBE11+ Deck Unit 11P-19817-0495

SBE32 24way Rosette 32-0344

SBE Pressure: 94756 Calibrated on: 15 Apr 2004

Primary T & C Sensors (On Vane)

SBE3 Temperature: 03P-2728 Calibrated on 15/03/06

SBE4 Conductivity: 04C-2851 Calibrated on 09/06/06

SBE5 Pump: 053962 (3K)

Secondary T & C Sensors

SBE3 Temperature: 03P-4490 Calibrated on 11/06/06

SBE4 Conductivity: 04C-2450 Calibrated on 15/06/06

SBE5 Pump: 054164 (3K)

Additional Sensors

SBE 43 Oxygen: 0612 Calibrated on 24/11/05

Chelsea Aqua 3 Fluorometer: 088108 Calibrated on 17/11/04

Transmissometer: 04-4223-001 Calibrated on 08/12/04

WetLabs BBRTD: 169 Calibrated on 07/07/05

Altimeter: 1037

Data processing

CTD data processing followed standard paths used on previous hydrographic cruises. After each cast data were saved to the deck unit PC and transferred over the network to the unix data disk at /data32/d312/ctd. The logging software output four files per CTD cast named by Discovery station number with the following extensions: .dat (raw data file), .con (data configuration file), .BL (contained record of bottle firing locations), and .HDR (a header file).

The SBE Seasave Win32 V 5.35 software was used to perform initial processing and was followed by Pstar processing to clean and reduce the data to 2db. SeaBird CTD processing routines were used as follows.

DatCnv: converted raw CTD data in the .dat file from engineering units using the calibration information provided in the configuration file (.con). Files output consisted of binary .cnv files containing the 24hz down and up casts and .ros files containing values at the time each Niskin bottle was fired.

AlignCTD: used to shift the dissolved oxygen sensor output relative to the pressure data by 5 seconds to compensate for lags in the sensor response time. The routine overwrites the oxygen variable in the .cnv file.

WildEdit: de-spikes data by calculating the standard deviation of a set number of scans. Two passes through the data were made, both taking the mean of 500 scans. Values outside two standard deviations from the mean on the first pass and ten standard deviations from the mean on the second pass were flagged as bad. Output was written to the .cnv file.

CellTM: removes the effect of thermal 'inertia' on the conductivity cells using the algorithm:

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

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

Translate: converts the binary .cnv files into ASCII format .cnv files for conversion to Pstar binary format.

Pstar processes were incorporated into 3 scripts: ctd0, 1 and 2. These can be summarised as follows:

ctd0: transferred data from the .cnv ASCII file to Pstar binary format in file ctdnnnnn.24hz, where nnnnn is the 5 digit Discovery station number. The position at the bottom of the cast, obtained by the user from the rvs data stream 'bestnav', was entered into the header, together with other relevant information taken from the header of the .cnv file.

ctd1: converted cond & cond2 from S/m to mS/cm, smoothed press, temp, cond, temp2, cond2 with a running 5 point median deleting values greater than 5, 0.1, 0.1, 0.1, 0.1 respectively from the median. Results were output to the .24hz file and averaged to 1 second intervals in the file ctdnnnnnn.1hz

Processing continued using the .1hz file with interpolation on pressure and calculation of salinity, potential temperature and density. Data were further averaged to 10 second intervals in the file ctdnnnnn.10s

ctd2: truncated the start and end of the .1hz cast to the .ctu file using data cycles provided by the user after manual inspection of the .1hz file, the down cast was also extracted and averaged to 2db in the .2db file.

Data were then plotted manually for visual inspection of profile quality. On this cruise the data were clean and no further editing was necessary.

Files were created to compare CTD and bottle sample values for calibration of the CTD sensors and analysis of geochemical data using two scripts as follows.

fir0: imported the .ros file to Pstar file firnnnnn and merged relevant data from the .10s CTD file for each bottle fired. Data were also transferred from the RVS level C 'winch' data stream to Pstar file winnnnnn. Note that no winch data were available for the first six casts.

sam0: combined data from the fir file with bottle sample data in new file samnnnnn

No samples were available for the first cast, 16126, because the rosette failed to fire. Otherwise sample values for salinity, dissolved oxygen and the nutrients nitrate+nitrite, phosphate and silicate were provided in various formats. Excel files were exported in .csv format: 'strings' was used to replace dos with unix characters in .txt files. Unique identifying sample numbers were generated for nutrient data (last three digits of the station number and a two digit Niskin bottle number). Data were then read into Pstar format using pascin. The sample number was used as a control variable to enter the sample values into the sam file using the program ppaste. The resulting sam files were then used to calibrate the CTD conductivity and dissolved oxygen sensors.

A total of 65 stations were worked, 17 on the Ellett Line extension, 21 on the Ellett Line, 15 on Line 'G', 3 at sediment trap sites, 1 after the turbulence experiment and 8 across the Ellett Gully in the Wyville Thomson Ridge (Table 3).

Table 3: RRS *Discovery* cruise 312 CTD Station List.

Stn. No.	Name/ comment	jday	date	Start time hhmm	Bot. time hhmm	End time hhmm	Lat. ° N ‘ N	Lon. ° W ‘ W	Water depth (m)	Max. wire out (m)	Min. dist. off bot.	Max. press	Add. notes
16126	IB21s	285	12/10	1044	1114	1144	63 8.28	19 54.76	1036	-	5	1042	
16127	IB22s	285	12/10	1840	1905	1946	63 13.21	20 3.69	-	626	8	638	
16128	IB23s	285	12/10	2148	2158	2114	63 19.17	20 13.10	128	114	-	117	
16129	IB20s	286	13/10	0257	0338	0429	62 54.94	19 32.24	1419	1400	-	1423	A
16130	IB19s	286	13/10	0642	0718	0811	62 40.28	19 41.13	1696	1663	15	1687	
16131	IB18s	286	13/10	1127	1206	1307	62 20.04	19 50.27	1808	1790	-	1813	A
16132	IB17	286	13/10	1618	1702	1759	62 0.11	20 1.38	1820	1790	8	1831	
16133	IB16	286	13/10	2125	2214	0008	61 30.40	19 59.44	2225	2195	-	2231	A, P
16134	IB15	287	14/10	0925	1021	1151	61 15.10	19 59.65	2386	2364	-	2401	P
16135	IB14	287	14/10	1435	1531	1652	61 0.23	19 59.40	2914	2390	13	2426	P

16136	IB13	287	14/10	2058	2152	2329	60 30.06	19 59.72	2539	2511	-	2553	
16137	STNW	288	15/10	0440	0535	0658	60 0.29	20 50.12	2780	2756	-	2803	P
16138	STC	288	15/10	1230	1325	1453	59 29.80	19 59.58	2775	2749	-	2796	A, P
	STNE	No CTD carried out											
16140	STS	289	16/10	0734	0835	1014	58 52.27	20 27.54	2844	2826	-	2874	P
16141	IB12	289	16/10	2029	2124	2300	59 59.72	19 59.06	2733	2705	10	2754	P
16142	IB11	290	17/10	0452	0547	0712	59 39.25	19 6.21	2685	2640	25	2689	

3 days hove to in storms

16143	IB4	293	20/10	1848	1921	2010	58 30.56	16 17.80	1216	1200	20	1219	A, P
16144	IB3	294	21/10	0507	0524	0554	58 15.77	15 20.28	674	660	17	664	P
16145	IB2	294	21/10	1516	1539	1601	57 56.91	14 34.91	444	430	15	438	A
16146	IB1	295	22/10	0047	0055	0111	57 39.86	13 54.47	148	135	11	141	
16147	B	295	22/10	0746	0758	0817	57 34.17	13 19.84	163	163	11	170	
16148	C	295	22/10	1207	1218	1240	57 32.90	12 59.60	303	280	20	287	A
16149	D	295	22/10	1450	1521	1605	57 32.41	12 52.18	1061	1060	13	1077	A
16150	D1	295	22/10	1743	1819	1918	57	12	1454	1440	8	1459	A

							32.30	45.60					
16151	E	295	22/10	2113	2151	2308	57 31.82	12 37.40	1657	1640	15	1664	A
16152	E1	296	23/10	0102	0141	0247	57 31.72	12 31.83	1740	1730	12	1745	A

Another day hove to in storms

16153	F	297	24/10	0853	0934	1046	57 30.75	12 15.16	1807	1790	10	1811	A, P, Z
16154	G	297	24/10	1447	1525	1634	57 29.26	11 50.76	1795	1775	12	1802	A
16155	H	297	24/10	1914	2002	2115	57 29.43	11 31.59	2022	2010	10	2035	A, P, Z
16156	I	298	25/10	0006	0032	0111	57 27.92	11 19.53	760	745	13	754	A
16157	J	298	25/10	0433	0456	0525	57 27.08	11 5.33	585	565	16	575	Z
16158	K	298	25/10	0751	0809	0846	57 24.15	10 52.13	784	770	-	780	
16159	L	298	25/10	1030	1112	1219	57 22.10	10 40.04	2096	2095	-	2128	P, Z
16160	M	298	25/10	1537	1625	1720	57 18.20	10 22.74	2212	2200	10	2231	Z
16161	N	298	25/10	1936	2022	2131	57 14.00	10 2.90	2107	2090	10	2124	P
16162	O	298	25/10	2311	2350	0044	57 8.92	9 42.06	1933	1914	10	1944	
16163	P	299	26/10	0246	0318	0406	57 5.91	9 25.21	1437	1420	10	1437	
16164	Q	299	26/10	0509	0526	0548	57	9	325	310	10	315	Z

							3.06	13.18					
16165	R	299	26/10	0732	0739	0747	56 59.92	8 60.00	135	130	4	134	Z
16166	S	299	26/10	0926	0934	0945	56 56.99	8 47.00	128	118	10	124	
16167	15G	299	26/10	1102	1110	1121	56 52.97	8 30.28	130	120	-	123	
16168	T	299	26/10	1243	1250	1259	56 50.39	8 20.45	134	120	14	123	
16169	14G	299	26/10	1442	1447	1455	56 48.83	8 9.94	127	110	15	114	

turbulence experiment

16171		299	26/10	2125	2137	2200	56 40.22	7 34.55	222	215	10	219	
16172	9G	299	26/10	2307	2315	2330	56 44.11	7 19.88	160	148	10	152	A, Z
16173	10G	300	27/10	0104	0118	0135	56 43.85	7 30.38	225	210	15	214	
16174	11G	300	27/10	0231	0236	0239	56 44.34	7 40.35	61	45	13	50	Z
16175	12G	300	27/10	0354	0359	0403	56 45.62	7 50.06	55	45	10	48	
16176	13G	300	27/10	0505	0513	0523	56 47.15	7 59.81	121	110	8	114	Z

16177	W1	301	28/10	0421	0438	0451	60 20.56	8 59.53	501	487	7	495	
16178	W2	301	28/10	0543	0604	0623	60	8	616	600	-	611	

							18.69	56.92					
16179	W3	301	28/10	0747	0805	0827	60 17.88	8 55.92	763	763	8	778	
16180	W5	301	28/10	0931	0954	1018	60 15.95	8 55.10	900	890	8	902	

mooring recovery

16182	W4	301	28/10	1236	1257	1319	60 17.04	8 55.45	822	815	9	826	
16183	W6	301	28/10	1405	1433	1528	60 15.30	8 54.94	1162	1160	10	1157	A

mooring deployment

16185	W8	301	28/10	1652	1724	1812	60 14.19	8 54.97	1112	1164	15	1181	A
16186	W9	301	28/10	1929	1956	2019	60 13.63	8 55.02	859	859	3	870	

16187	8G	302	29/10	2054	2105	2121	56 44.10	7 9.80	175	164	11	170	
16188	7G	302	29/10	2230	2236	2250	56 44.13	6 59.80	140	130	8	135	
16189	6G	303	30/10	0023	0026	0032	56 43.92	6 44.81	49	35	12	39	
16190	5G	303	30/10	0138	0142	0149	56 43.90	6 36.15	76	65	10	69	
16191	4G	303	30/10	0251	0257	0305	56 43.96	6 27.03	92	80	10	83	
16192	3G	303	30/10	0354	0400	0404	56 42.60	6 22.06	76	65	10	68	

16193	2G	303	30/10	0503	0509	0513	56 41.00	6 16.90	38	35	2	39	
16194	1G	303	30/10	0634	0644	0654	56 39.99	6 8.10	195	180	11	185	

Notes: A = aluminium samples, P = POC and chl a samples, Z = zooplankton net. All CTDs were sampled for salinity, dissolved oxygen and macro-nutrients no2+3, po4, sio2. IB = Iceland Basin, G = shelf line G, W = Wyville Thomson Ridge.

CTD conductivity sensor calibration

Salinity samples were used to calculate conductivity for each bottle value. Differences between bottle and CTD conductivity were plotted by station (Figure 11). There was a significant offset between the two CTD sensors, and only the primary sensor (on the fin) was calibrated. Figure 11 also shows offsets with time, with residuals varying from about -0.003 to +0.002. The sequence of stations was therefore divided into segments and, excluding outliers, the mean conductivity ratio (bottle/CTD) calculated for each segment. The resulting ratios (Table 4) were used to correct the CTD data. Following calibration the new bottle-CTD conductivity and salinity residuals were calculated and plotted against station (Figure 12) and pressure (Figure 13). Salinities are believed to be good to better than 0.002.

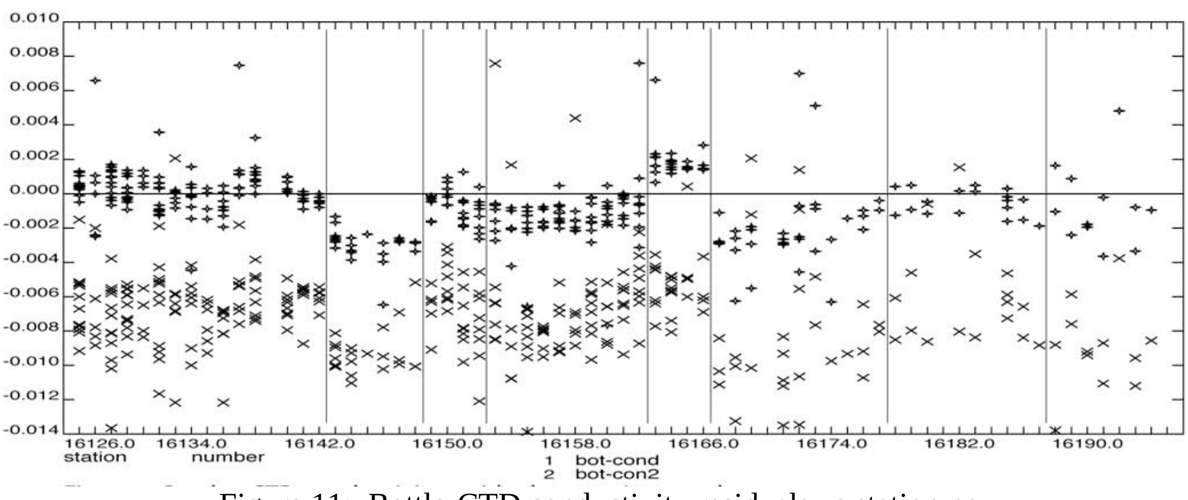


Figure 11: Bottle-CTD conductivity residuals vs station no.

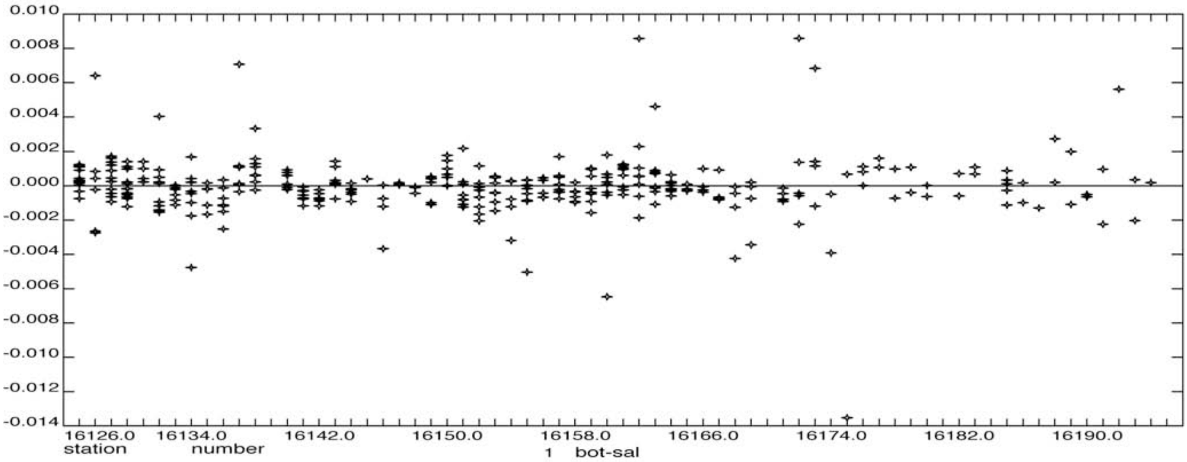


Figure 12: Bottle-CTD salinity residuals vs station no.

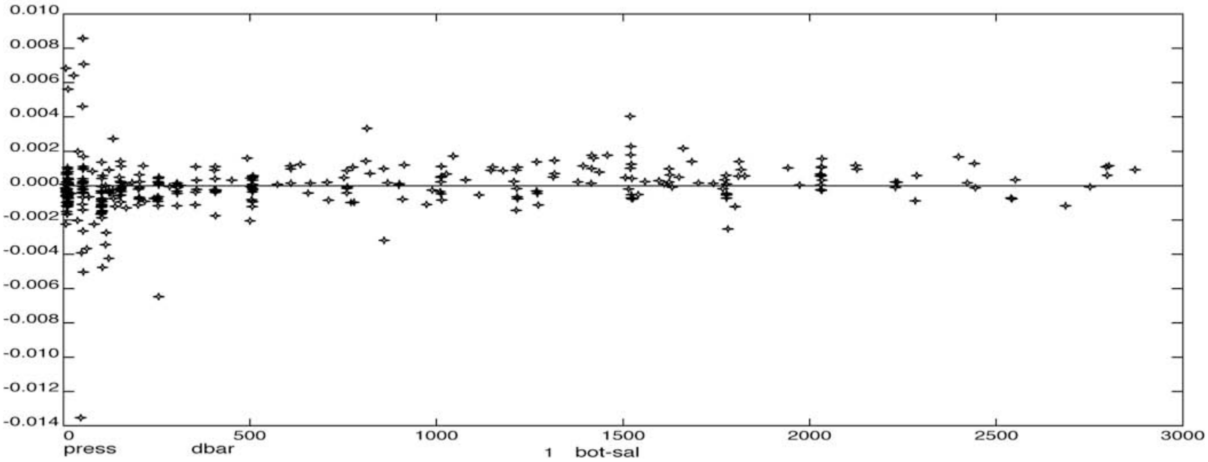


Figure 13: Bottle-CTD salinity residuals vs pressure.

Table 4: Conductivity ratio.

Station	conductivity ratio	standard deviation
16126 - 16142	1.00000570	2.222e-5
16143 - 16148	0.99992771	1.396e-5
16149 - 16152	0.99998226	2.681e-5
16153 - 16162	0.99996807	1.968e-5
16163 - 16166	1.00004310	1.286e-5
16167 - 16177	0.99994824	2.186e-5
16178 - 16187	0.99998627	2.007e-5
16188 - 16194	0.99996986	3.895e-5

Dissolved oxygen

Differences between oxygen bottle samples and CTD sensor data were plotted against station (Figure 14). This showed a significant offset between the two and a noticeable drift with time. Unfortunately only two samples per cast were collected on the last 24 casts making it difficult to distinguish between scatter and drift. A simple straight line fit between bottle and CTD oxygen was estimated ignoring outliers and bias to shallow stations:

new oxygen = CTD oxygen * 0.63 + 51.6

The resulting residuals were plotted against station (Figure 15) and a series of offsets estimated to make a final correction (Table 5). Final residuals were plotted against station (Figure 16) and pressure (Figure 17)

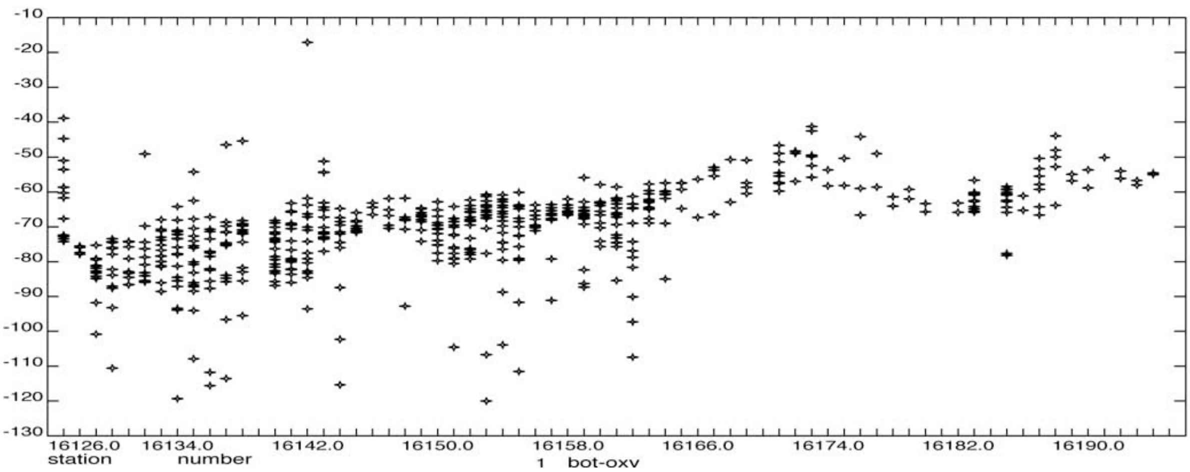


Figure 14: Bottle-CTD oxygen residuals vs station no.

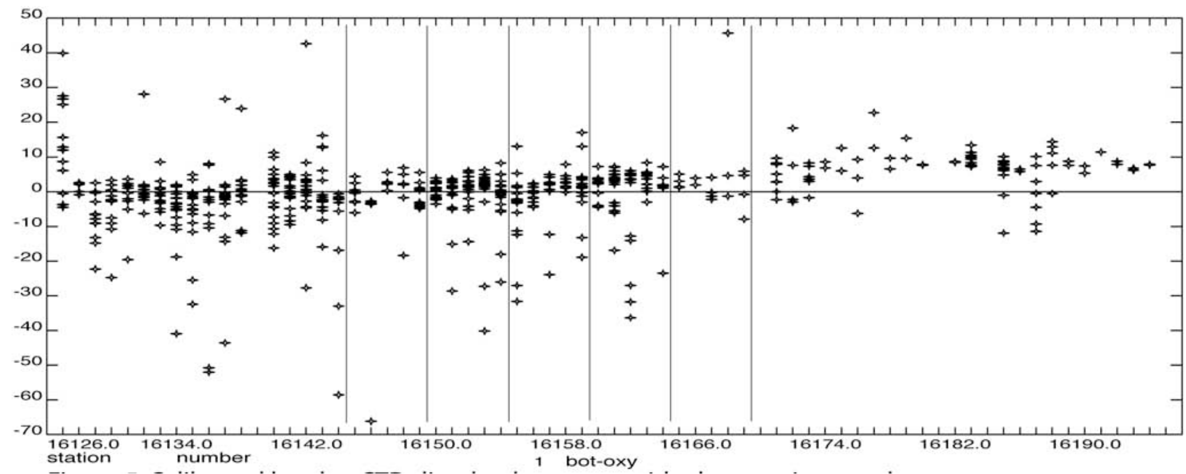


Figure 15: New bottle-CTD oxygen residuals vs station no.

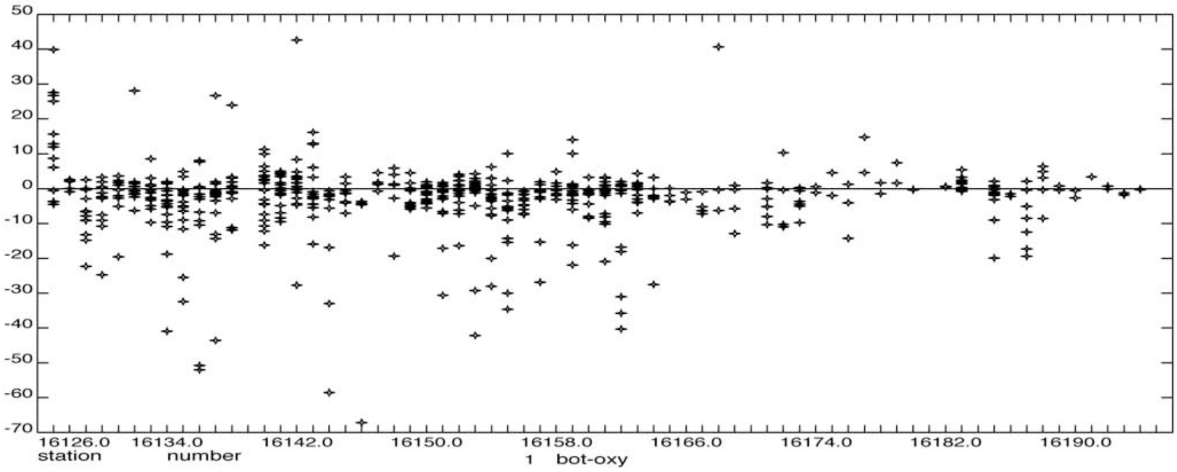


Figure 16: Final bottle-CTD oxygen residuals vs station no.

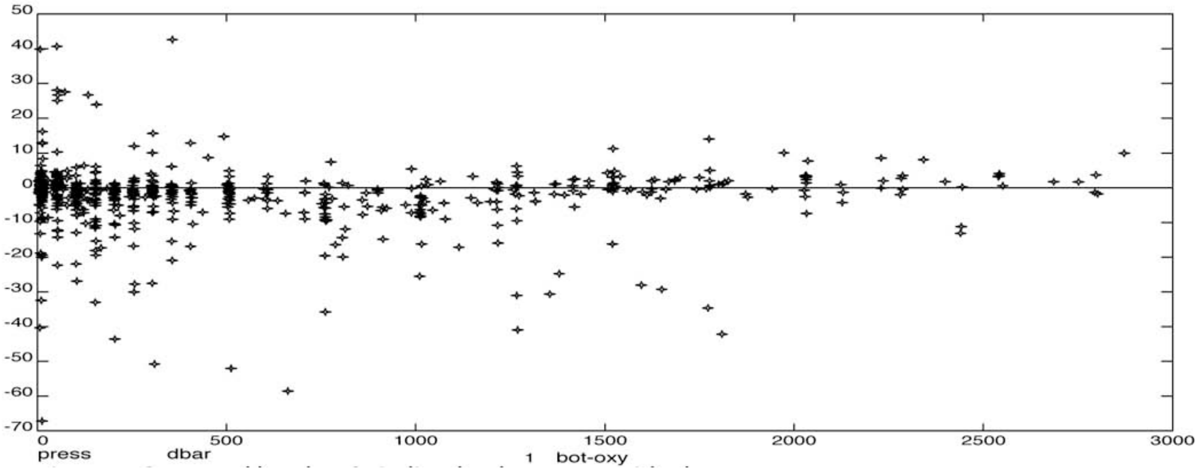


Figure 17: Final bottle-CTD oxygen residuals vs pressure.

Table 5: Oxygen correction.

Station	
	correction
16126 - 16144	0.
16145 - 16149	1.
16150 - 16154	2.
16155 - 16159	3.
16160 - 16164	4.
16165 - 16169	5.
16171 - 16194	8.

Salinity Bottle Samples - *Mark Barham and Phil Wallhead*

Salinity samples were drawn from Niskin bottles mounted on the CTD rosette at depths determined by the PSO or Watch Leader. The Niskin bottles were typically fired away from salinity gradients in an attempt to gain a stable measurement. The sampling process involved rinsing then filling the 200 ml sample bottles with their respective sample water, drying the inside of the bottle neck and plastic insert, then sealing the sample with both the insert and bottle screw top.

A Guildline Autosal salinometer (model 8400B, serial no. 60839) was installed in the controlled temperature laboratory maintained at 21°C. The manual quotes a successful operating temperature range between 4°C below and 2°C above the bath temperature, the preferred temperature being in the middle of this range. A thermometer attached to the side of the salinometer was used to measure temperature within the constant temperature (CT) lab, which varied between 21.5°C and 22°C. Salinity samples were stored in the CT lab. and left for at least 24 hours prior to analysis. The salinometer was stable and generally behaved well for the duration of the cruise.

OSIL's Autosal software, Softsal, was used throughout. The software worked well and the stability achieved, determined by monitoring the standard deviation of salinity measurements, was good. With only a few exceptions, the bottle samples were determined to a precision greater than 0.001. There are a couple of points worth noting about using this software however; firstly the software encourages the operator to re-trim the salinometer after each standardisation to standard seawater. This is almost certainly because the measured salinity standard is not recorded in the output file (the second point to note), so no post measurement offset can be made. OSIL's latest software appears to overcome this limitation and furthermore is designed to be directly compatible with spreadsheet packages like Excel. Standardisation of Autosal was performed using IAPSO Standard Seawater (batch no. P145, K_{15} value 0.99981) and was done, as mentioned above, prior to the analysis of each crate. Standard seawater samples were also analysed at the end of every crate as a quality check. A minor problem in the form of a computer fault occurred while analysing sample 670 from station 16163. The computer was re-booted which appeared to rectify the problem. The sample was re-analysed and the crate completed under a different file name. On a couple of occasions the computer also shutdown by itself, a reason for which was not found. Analysis was automatically saved and the operators were able to start from last analysed sample.

Salinity values were transferred from the PC running Autosal in the CT lab. to a laptop where the salinity results were copied into an Excel spreadsheet. There is a slight drift in the data as well as a dip that occurs between stations 16143 and 16148 (Figure 11, in the previous section). This dip cannot be explained by operator error nor does it occur within a single crate suggesting the problem may lie in the CTD sensor calibration.

Underway data - *Jane Read*

The surfmet package worked uninterrupted throughout the cruise logging water temperature, conductivity, fluorescence, transmittance, air pressure, temperature and humidity, Photosynthetically active radiation (par) incoming irradiance (tir), wind speed and direction. Data were transferred from the RVS level C ‘surfmet’ data stream to Pstar and processed using a set of four scripts:

smtexec0: transferred data from the RVS level C ‘surfmet’ data stream to Pstar. Fluorescence and transmittance were scaled and data output to the file smt31201.raw

smtexec1a: edited data on time and pressure spikes, calibrated pressure, ppar, spar, ptir, humidity, air temperature and transmittance with the manufacturers coefficients. Spikes of 0.1, 0.1, 0.05, 0.005, 0.005, and 1 from a 5 point running median were deleted from temp_h, temp_m, cond, fluor, trans and airtemp respectively. GPS4000 position information was added and the data averaged to 2 minutes in file smt31201.av

smtexec1b: used the a-ghdg information to correct the wind direction for gyro error in file smt31201.hdg

smtexec2: corrected the wind speed and direction for vessel heading to obtain true wind speed and direction in the file smt31201.met.

Raw depth information logged by the precision echosounder (10 kHz) system was obtained from the RVS level C ‘ea500d1’ data stream using the script simexec0 and output to the Pstar file sim31201. Corrected depths were obtained from the RVS level C ‘pro_dep’ stream and output to the file sim31201.cal.

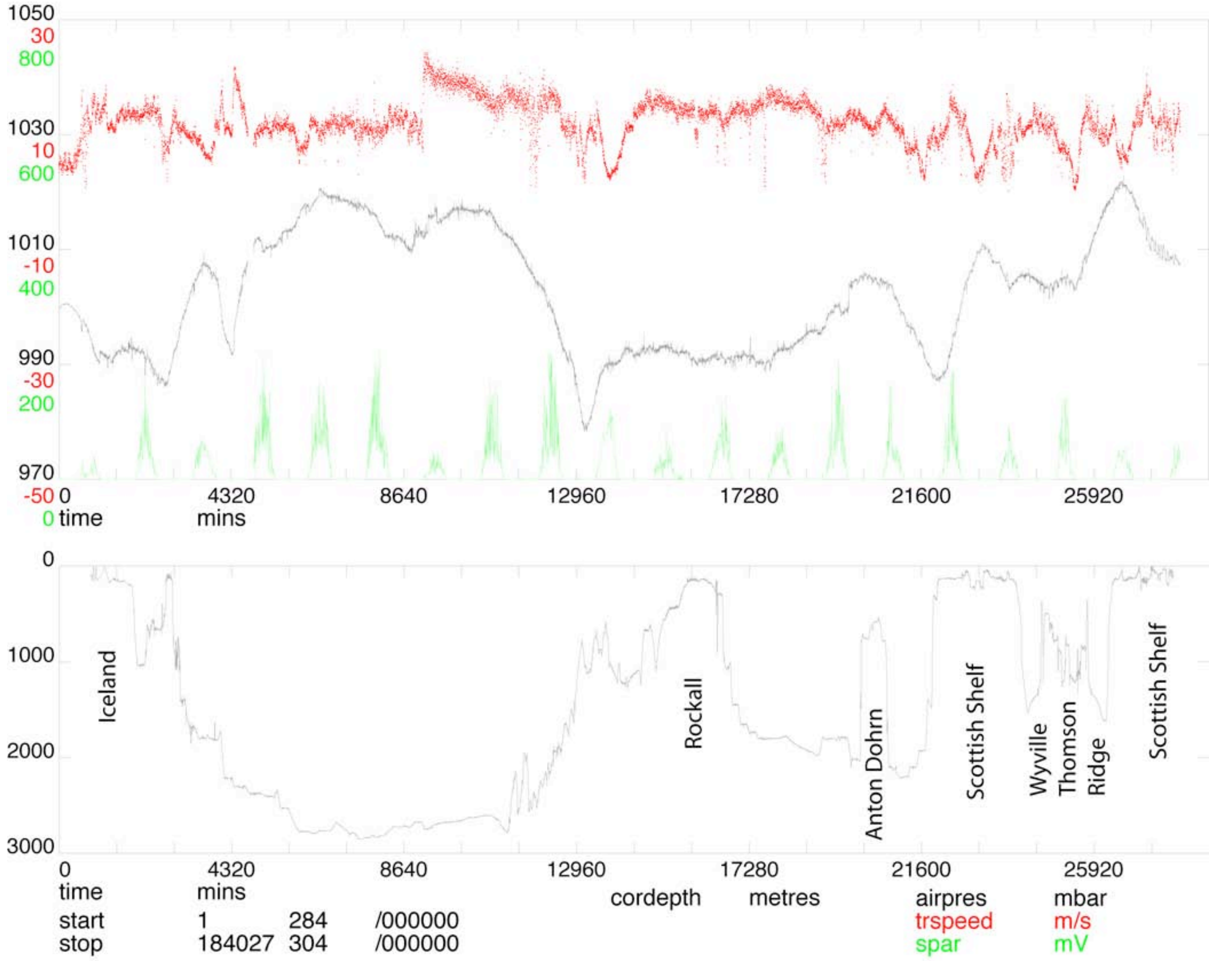


Figure 18: From top to bottom, wind speed (m/s), air pressure (mbar), PAR (raw mV) and echosounder depth (m) for the duration of the cruise.

150 KHz Vessel Mounted ADCP (VM-ADCP), ship's attitude and position information – *Jane Read and Phil Wallhead*

To obtain meaningful water velocities from the vessel-mounted acoustic Doppler current profiler, the ADCP data need to be corrected for the ship's direction, speed and attitude. A number of parallel processes are run to combine the required information. Position, gyro-heading and attitude information were transferred from the RVS level C data streams to Pstar files daily and processed as described below.

<u>Ship's position and navigation data</u>

The ship's best determined position was calculated by the RVS 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 for the GPS4000 system compared to ~ 2.0 m for the G12 system.

Data were transferred daily from the RVS level C ‘bestnav’ file to the Pstar absolute navigation file ‘abnv3121’ for use in Pstar processing. Gps_4000 data were also transferred daily. The Pstar execs used were:

navexec0: transferred the RVS level C ‘bestnav’ data stream to Pstar format. Ship’s velocities were calculated from position and distance run calculated after appending to the master abnv3121 file.

gp4exec0: transferred the RVS level C ‘gps_4000) data stream to Pstar format. Data with pdop outside the range 0-7 was removed. Further edits were made to remove outliers and gaps interpolated before the file was appended to the master file gp431201 and distance run calculated. A 30 second average file gp431201.30sec was created.

Ships heading and attitude

Spot gyro heading data were fed into the 150 kHz ADCP transducer deck unit where they were incorporated into the individual ping profiles to correct the velocities to earth co-ordinates before being reduced to 2 minute ensembles. The gyro instrument is the most reliable direction indicator on the ship and applying the correction to individual profiles 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. Ashtech data are not used directly for correcting the ship’s heading because the data stream is unreliable and suffers gaps and drop outs. Rather, they are used to correct the gyro heading.

Gyro data were transferred daily using the script gyroexec0.

gyroexec0: transferred data from the RVS level C ‘gyronmea’ stream to Pstar format. Headings outside the range 0-360° were deleted and the file appended to the master gyr31201 file.

The ship’s attitude was measured every second by the 3D GPS Ashtech ADU2 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. Configuration settings from previous calibrations (April 2001) were used throughout the cruise. These were:

Adjusted relative antenna positions (m), which require no pitch or roll offset angle.

	X(R)	Y(F)	Z(U)
1-2 vector	0.000	6.492	0.167
1-3 vector	-10.162	0.135	-4.337
1-4 vector	-10.113	6.431	-4.193

Ashtech data were read from the RVS level C binary stream ‘gps_ash’ into Pstar and used to calibrate the gyro heading information as follows.

ashexec0: transferred data from the RVS level C ‘gps_ash’ data stream to Pstar binary file ash312nn, where nn is incremented daily.

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 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

ashexec3: appended the daily file to a master file ash312smt.ave for use in meteorological data processing.

During the cruise a number of short gaps (minutes) occurred, however, there was one long gap on 22 October (day295) when ashtech data were unavailable for a 9 hour period. Occasional spikes exist in the data. These have not been deleted and may give rise to spurious currents.

Vessel mounted 150 kHz acoustic Doppler current profiler

The 150 kHz vessel mounted acoustic Doppler profiler (VM-ADCP) was operated and logged throughout the cruise. The transducer unit, serial number 34 with frequency 153 kHz was 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 depending on the trim of the ship. 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 2^2 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 Reykjavik the ADCP logged in bottom track mode. At the shelf edge on day 286/02:18 this was switched to water tracking mode. On the Scottish continental shelf bottom tracking was switched back on, day 299/17:30. Water tracking mode was resumed for passage to the Wyville Thomson Ridge and returned to bottom tracking on day 301/05:00.

Data were recorded on an AP PC and like all PC's the clock lost time steadily throughout the cruise at approximately 4 seconds per day. This was corrected during the data processing.

The ADCP data were logged continually by the RVS level C. From there they were transferred 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 misalignment angle and scaling and finally corrected for ships velocity and converted to absolute velocities using the ships position from the absolute navigation files. Scripts used were:

adpexec0: transferred data from the RVS level C "adcp" data stream to Pstar. The data were split into two; "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 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 weather at the beginning of the cruise was poor, so no particular attempt was made to calibrate the ADCP misalignment angle and scaling factor. The long passage across the Icelandic continental shelf was examined for periods of steady steaming. However, speed varied significantly and no sensible numbers could be obtained. In the end the mean was taken of two previous calibrations obtained on cruises D306 and D309, giving a misalignment angle of 0.6610 and scaling factor of 1.000.

The weather during the cruise was fairly bad so the data were generally poor quality with characteristic large velocities in the direction of travel, believed to be caused by air bubbles beneath the hull. However some data appeared good, and the outstanding feature of the cruise was the presence of a large anticyclonic eddy in the Iceland basin in the location of the four sediment trap moorings. (Figure 19).

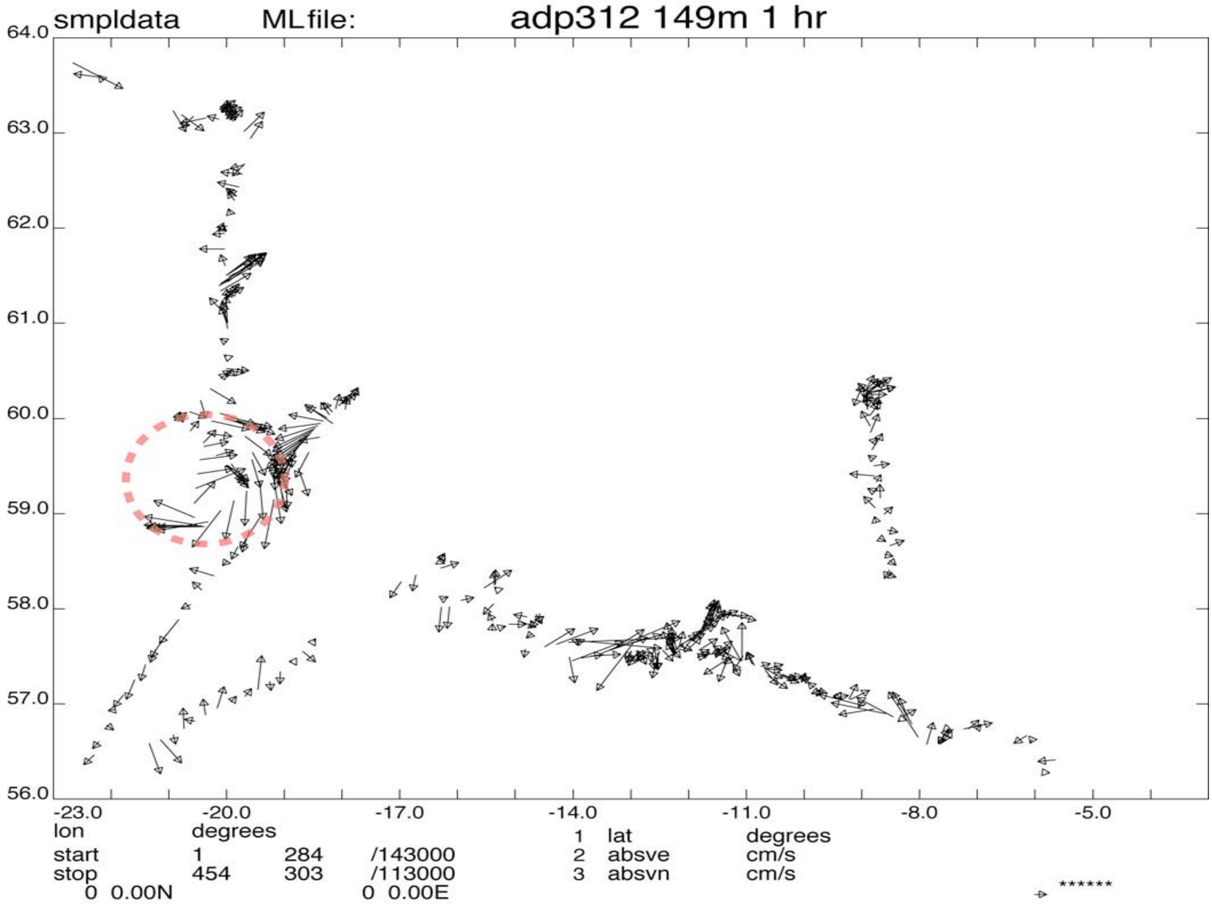


Figure 19: 150 KHz VM-ADCP vectors at a depth of ~149 m. The feint red dotted circle highlights a clear anticyclonic eddy signature in the region of the sediment trap mooring deployments.

Note that the depth of the mid-point of each bin is determined by the formula:

Distance from the surface to the centre of the first bin = [blank beyond transmit] + [depth cell] + ([transmit pulse length] – [depth cell]) / 2 + [transducer depth]

For [blank beyond transmit] = 4 m

[depth cell] = 4 m

[transmit pulse length] = 4 m

[transducer depth] = 5 m

giving a mid-bin depth range of 13-393 m.

75 kHz Vessel Mounted ADCP (VM-ADCP) data processing - *Mark Inall*

OS75 configuration

RRS *Discovery* is fitted with an RD Instruments 75kHz Ocean Surveyor ADCP (Transducer SN 2011). Positional and attitude information is provided via an Ashtech ADU5 multi-receiver GPS attitude sensor. Ship's heading information from the vessel's Gyro, though streamed to and saved by the OS75 logging PC, was not used in the processing steps described here. The RDI proprietary software VMDAS (V1.42) was used to configure the ADCP and perform velocity mapping to the reference frame of the vessel. Bottom tracking was not enabled. A suite of MATLAB routines were used to perform data screening and transformation to absolute velocities in Earth coordinates: A summary of configuration and the processing steps is given below.

OS75 VMADCP Configuration

- No bins = 60
- Bin size = 16 m
- Blank after transmit = 8 m
- Transducer depth = 5.3 m
- Bottom track (when on) maximum depth 1100m
- Time between pings = as fast as possible (typically 5s)
- Low-resolution long-range processing mode

MATLAB Processing Steps

1. RDI binary file with extension ENX (single-ping ADCP ship referenced data from VMDAS) and extension N2R (ASCII NMEA output from ADU5 saved by VMDAS)

read into MATLAB environment. NB: The N2R file consists of ADCP single ping time stamps ($PADCP string) and ADU5 pitch, roll and heading information ($PRDID string). The latter NMEA string is created from the raw ADU5 string ($PASHR,ATT) by a splitter box on board RSS *Discovery*. The reason for this is that early versions of VMDAS were unable to directly interpret the $PASHR,ATT NMEA string.)

2. Ensembles with no ADCP data removed
3. Ensembles with bad or missing ADU5 GPS heading data identified and adjusted GYRO heading substituted
4. Attitude information time-merged with single ping data
5. Heading data used to rotate single ping ADCP velocities from vessel centreline reference to True North reference
6. Transducer misalignment error corrected for (derived from the misalignment determination – see text below)
7. Ship velocity derived from ADU5 positional information
8. Further data screening performed:
    - Max heading change between pings (10 degrees per ping)
    - Max ship velocity change between pings (>2ms^{-1}pingrate^{-1})
    - Error velocity greater than twice Stdev of error velocities of single ping profile
9. All data averaged into 600-second super-ensembles (user selectable)
10. Determine absolute water velocities from either bottom track derived ship velocity or ADU5 GPS derived ship velocity. ADU5 derived velocity was favoured during D312

Transducer misalignment and amplitude correction determination:

The misalignment angle of the transducer relative to the vessel (α) and the velocity amplitude correction factor where determined as follows. A reference layer velocity between 100 and 300m is calculated from the super-ensembles (u and v), and the ship velocity calculated for the corresponding super ensembles (su and sv). First differences are taken (du, dv, dsu, and dsv) between all possible pair of super ensembles, then differences selected for when the ship speed exceeded 3 ms^{-1} over the ground between ensembles not more than 5000m or 3600s apart in space or time. Then the following function was minimised for α and A using the Matlab function FMINSEARCH.m (a multidimensional minimization method).

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

An initial guess at A and 〈 is made in order to perform the minimisation on the super-ensembles outlined above. The whole processing procedure is then repeated for the newly determined values for A and 〈 to give the final absolute velocities. Values estimated by this method: A=1.00100, 〈=59.3393.

The instruments (ADCP and Ashtech ADU5) both functioned well during the cruise. With the exception of one period of several hours when the ADU5 crashed (00:40 – 09:46 on 22 October 2006), few GPS data dropouts occurred, and typically for no more than a few seconds at a time. Due to the rough weather and consequent frequent presence of air bubbles under the hull and across the transducer face, water profiles where often quite poor (less than 50% percent good at depth as shallow as 180m). An example figure of processed data is shown in Figure 20.

Raw data files in RDI format and processed data files in MATLAB format will be logged with BODC after the cruise, the approximate total quantity of data will be 3GB. Raw RDI data are divided into 22 series (series OSD312_0001 to OSD312_022). Within each series files are subdivided into files of maximum 10MB in size. Series number is incremented each time VMDAS is stopped and restarted; the number of sub-files per series is therefore variable.

Output file formats:

All processed output files are in MATLAB proprietary *.mat binary files, where N denotes the series number (N = 1 to 22 for D312):

Table 6: Contents of processed Matlab data files.

File name	Structured array name	Contents
OSD31200N_00000Nd.mat	d	Single ping ADCP data
OSD31200N_00000Nd_ATT.mat	att	Heading data at each ADCP ping
OSD31200N_00000N_ATT.mat	att	Heading data for super ensembles
OSD31200N_00000N_M_hc.mat	b, c	Super ensembles

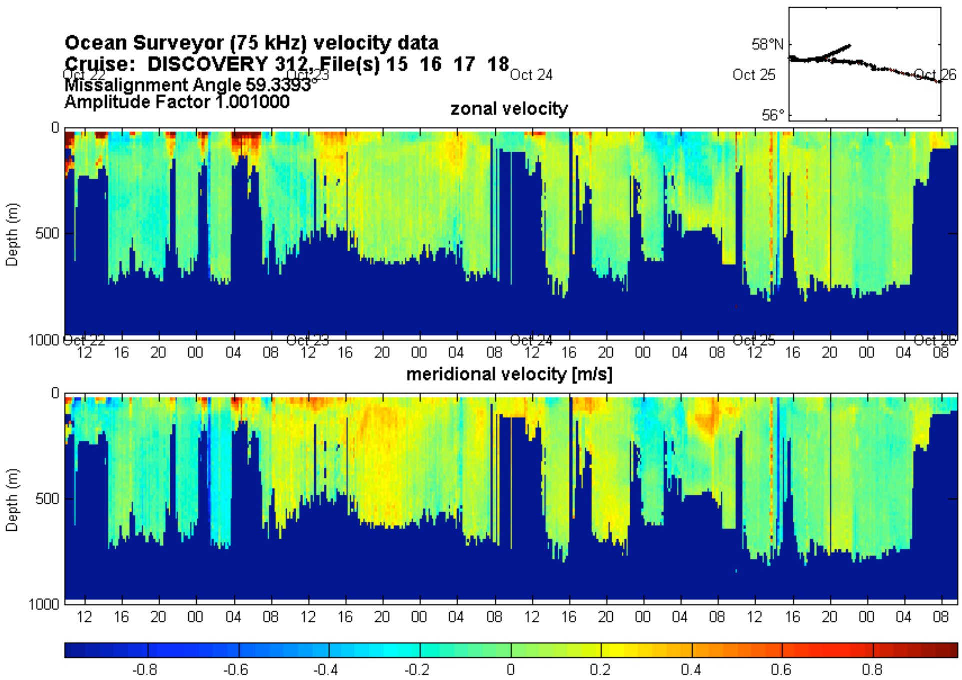
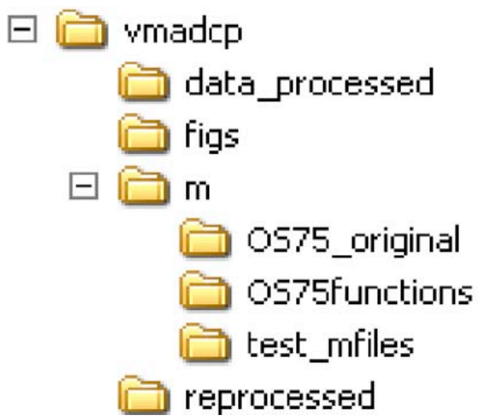


Figure 20: Processed OS75 VMADCP data covering approximately the CTD transect from Rockall to the UK shelf.

Generic Processing Procedure

1. Create a directory structure similar to that shown below



2. Place all the MATLAB functions supplied from the directory “OS75functions” into the directory of the same name on your PC.
3. Place the file named “OS75_D312.m” in the directory named “m”.
4. Place raw VMDAS files with extensions ENX and N2R into a directory of your choice. The extract below reads data from the “reprocessed” directory, but also has a DVD data disk mounted as the D drive option commented out.
5. Edit (and rename) the file “OS75_D312.m” so the PATH and RAWPATH variables exactly match the full path of these directories on your PC – remember to end with a forward slash “\” character. Lines 24 and 26.
6. Edit the addpath command to the full path location of the OS75functions directory. Line 22.
7. Edit the VMDAS filename for your cruise. Line 4.
8. Chose which series (one or more) number(s) for your cruise you wish to processes (the sub-series files will be automatically loaded). More than one series at a time can be chosen (e.g. “files=[2 3 4 5 6]” is allowed). Line 19.
9. Chose how long the temporal average for the “super ensembles” should be (set to 600s for D312). Line 20.
10. If Bottom Track is on and you want to use it rather than GPS derived ship velocity, then edit the function named “ship_velocity_mei.m” at Line 43. There are comments in this function.

Lowered ADCP (LADCP) - *Toby Sherwin, Emily Venables, Terry Edwards,*

Two 300 kHz, RDI 'Workhorse', Lowered Acoustic Doppler Current Profilers (LADCP) were deployed on the CTD frame throughout the cruise. In general the instruments functioned well, although there were some timing anomalies and occasionally only one of the Master or Slave actually worked. The warning message 'Beam 3 weak' was reported for some profiles and needs further investigation. More information on the performance and set up of the LADCPs is provided in the UKORS instrumentation section of this report earlier.

The LADCP data were processed in Matlab using the 'Visbeck' v7 data processing suite as a 'black box', i.e. without fully understanding how it works and without tuning any parameters. Ship's navigation and the CTD pressure sensor have both been used to improve the accuracy of the derived profiles. The majority of the profiles had been satisfactorily processed by the end of the cruise.

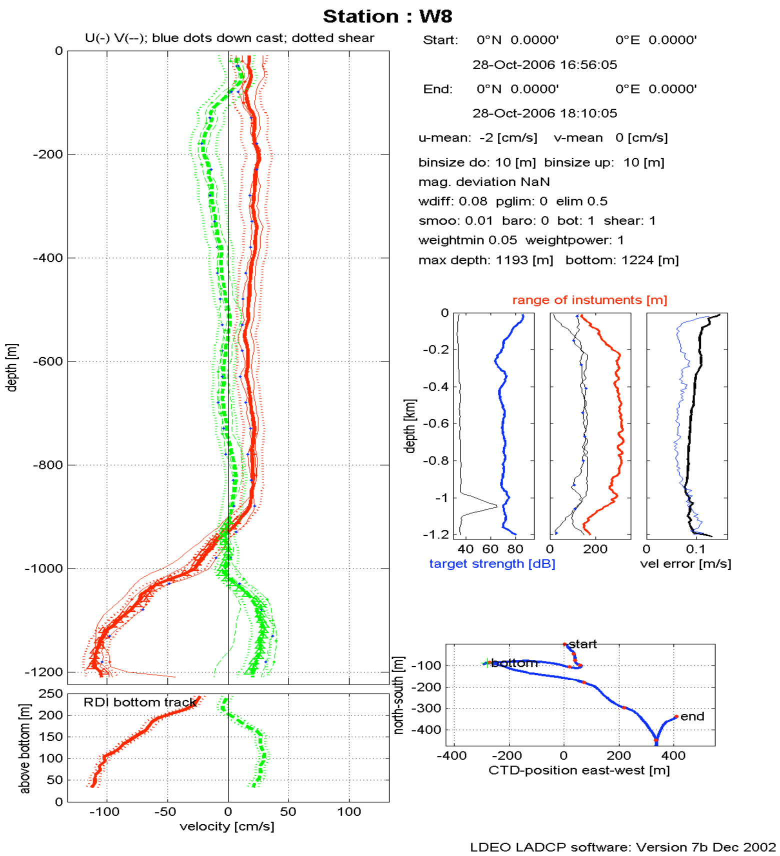


Figure 21 (previous page): LADCP profile 16185 from the centre of the Ellett gully showing a strong westward current exceeding 1 m s^{-1} in the bottom 200 m, and relatively small error bars throughout the water column.

The overflow in the Wyville Thomson Ridge is a good test of the functionality of the LADCP data, as was demonstrated in CD176. The profile in Figure 21 shows a very realistic and typical velocity profile in the Ellett gully, which without being taken as conclusive evidence of good performance, is a strong indication that the instruments were working satisfactorily.

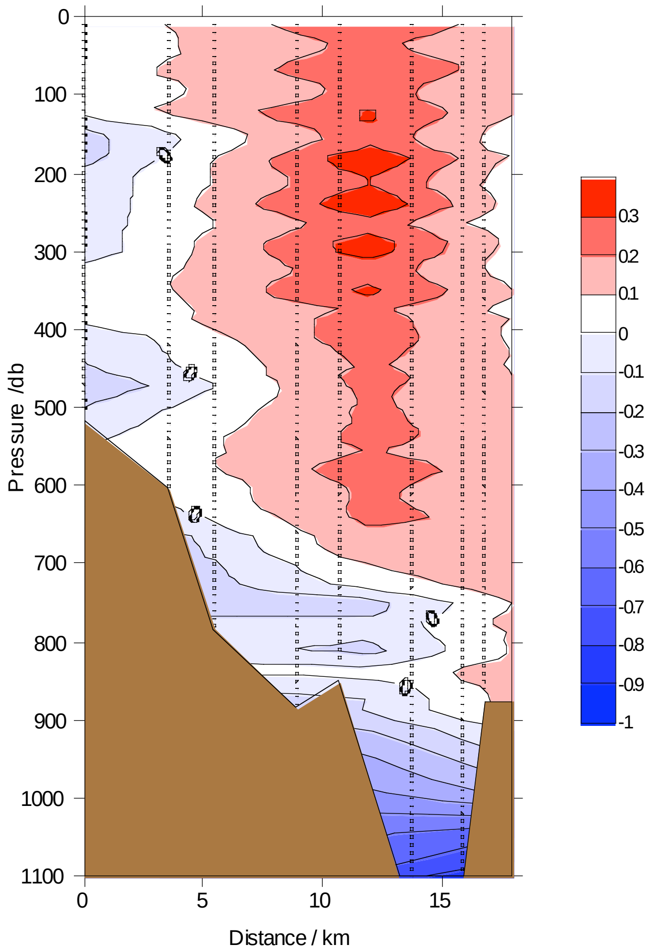


Figure 22: Eastward velocity section across the Ellett gully. Fast currents in excess of 0.8 m s^{-1} are observed near the seabed. The warm inflow can be seen in the upper layers. The Färoe Bank is on the left and the Ymir Ridge is on the right.

An LADCP section across the gully (Figure 22) shows that a strong overflow was underway during the cruise (even if this was not reflected in the bottom currents). From earlier work (Sherwin and Turrell, 2006) it is suggested that this apparent anomaly may be because the flow had only just started. The apparent vertical oscillation in velocity indicates that a further vertical low pass filtering is required. The section will be compared with geostrophic velocities derived from the CTD data.

Inorganic Nutrient Data; Nitrate, Nitrite, Silicate, Phosphate - *Richard Sanders, Ian Rae, Margaret Marks, Stuart Painter*

Inorganic nutrients were measured on every bottle from every CTD cast following Sanders and Jickells (2000) using a Skalar San Plus autoanalyser equipped with an all glass phosphate line purchased in 2002 and the integrator that was bought with this. All data was processed in flow access version 1.04.4. In total 634 niskin bottle and 25 underway samples were analysed. Samples were drawn directly from niskin bottles into 25ml sterilin polystyrene coulter counter vials, refrigerated in the dark at 4°C and analysed within 24 hours. Overall seventeen runs were carried out, detailed below in Table 7 with comments regarding significant events. Quite clearly the instrument did not perform well on this trip despite the usual precautions being taken (washing the lines with 10% Decon (N, Si) or Sodium Hydroxide (P), changing the tubes). Despite the various problems encountered all samples were analysed satisfactorily with the exception of phosphate from station 152.

Table 7: List of runs undertaken, dates performed and significant events.

Name	Date	Comments
Stations 127-130	13/10/06	New standards and reagents, bulb for P and Si changed
Stations 131-133	14/10/06	
Stations 134-137	15/10/06	New Standards
Stations 138-140	16/10/06	Nitrate drift very bad
Stations 138-140 repeat	16/10/06	Change bulb and redo nitrates from previous station
Stations 141-142	17/10/06	
Stations 143-144	21/10/06	New Standards, All tubes changed

Stations 145-147	22/10/06	New nitrate reagents
Stations 148-152	23/10/06	P peaks on 152 poor
Stations 152-157	25/10/06	New standards, New Si ascorbic and Oxalic reagents
Stations 158-165	26/10/06	Nitrate baseline large drift after station 160, New bulb Si and P, New Si molybdate reagent
Stations 160-169	26/10/06	New nitrate bulb, large shift in nitrate baseline after standards, new standards placed in run Phosphate stations 165-169 poor
Stations 166-176	27/10/06	Disintegration of nitrate baseline for stations 166-168, solved by shaking flow cell. Phosphate 173-176 poor
Stations 173-183	28/10/06	New Standards
Stations 185-186	28/10/06	Nitrate baseline disintegrated
Stations 185-186 repeat	29/10/06	New nitrate reagents, new standard 3
Stations 187-194	30/10/06	

There are three areas of concern when evaluating data quality. These are i) the reproducibility of measurements on a single day (precision), ii) the absolute accuracy of the measurements and iii) the internal consistency of the dataset. To evaluate these three factors we routinely monitor the performance of the analyser by constructing time series of 1) instrument baseline, 2) correlation coefficient of the calibration curve, 3) the slope of the calibration curve, 4) the concentration of a large volume water sample, 5) the duplicate analyses, 6) the concentration of a nitrite standard used to monitor the performance of the cadmium column and 7) the analysis of Ocean Scientific international nutrient standards. The following section of the report discusses each of these quality control indices. The report then concludes with a preliminary statement regarding reproducibility, accuracy and internal consistency.

Baselines

Figure 23 Shows time series of instrument baseline correlation coefficients for the instrument. Large discontinuities in N and Si baselines are associated with changes in bulbs as detailed earlier. However the cause of the shift is not solely related to the act of changing the bulb for nitrate as it occurred midway through a run. Between these events the baselines were essentially stable.

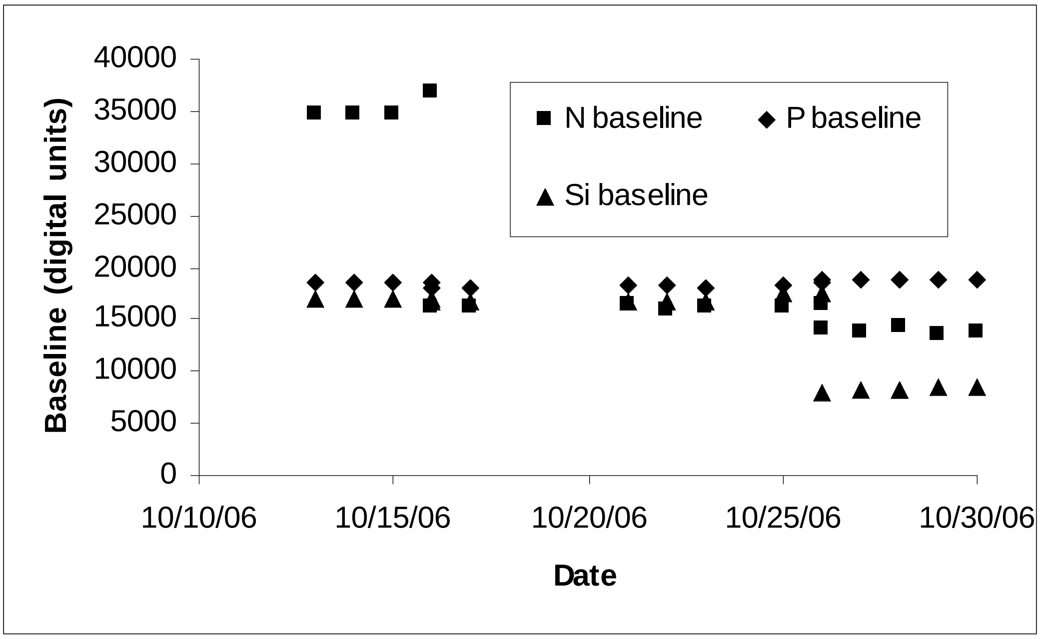


Figure 23: Time series of instrument baselines.

Sensitivity

Figure 24 shows time series of the instrument sensitivity in digital units per micromole. The slope of the phosphate calibration curve changed abruptly in response to the change in bulb detailed earlier however the silicate slope showed no such abrupt change, instead increasing quasi linearly over the course of the cruise. None of the three baselines showed any sensitivity to changes in reagents.

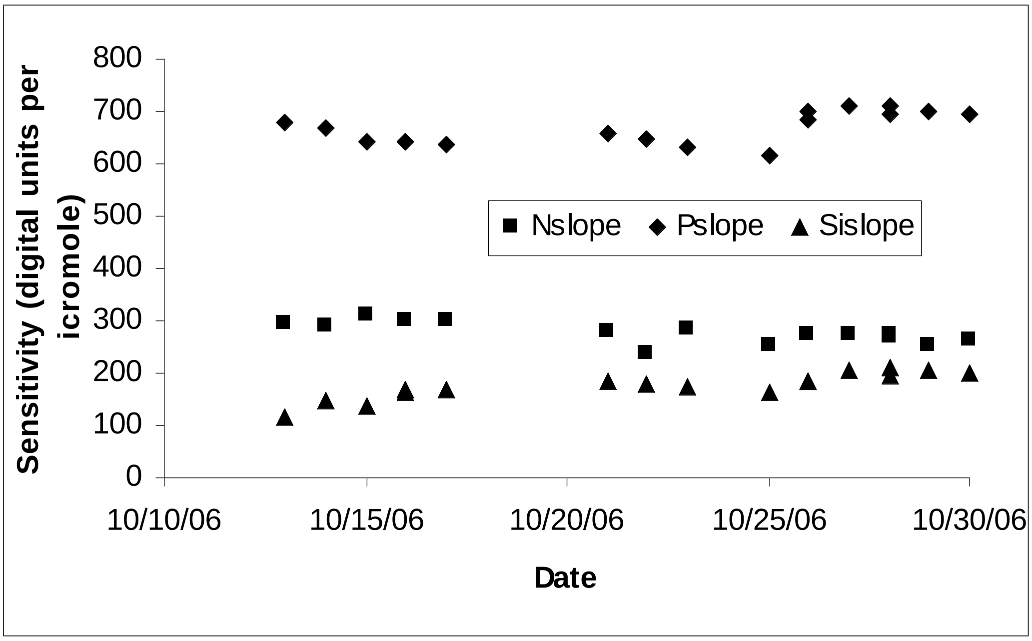


Figure 24: Instrument sensitivities.

Calibration curves

Figure 25 provides a time series of regression coefficients for the calibration curve. Occasional low values are apparent but generally the instrument behaved in a linear fashion.

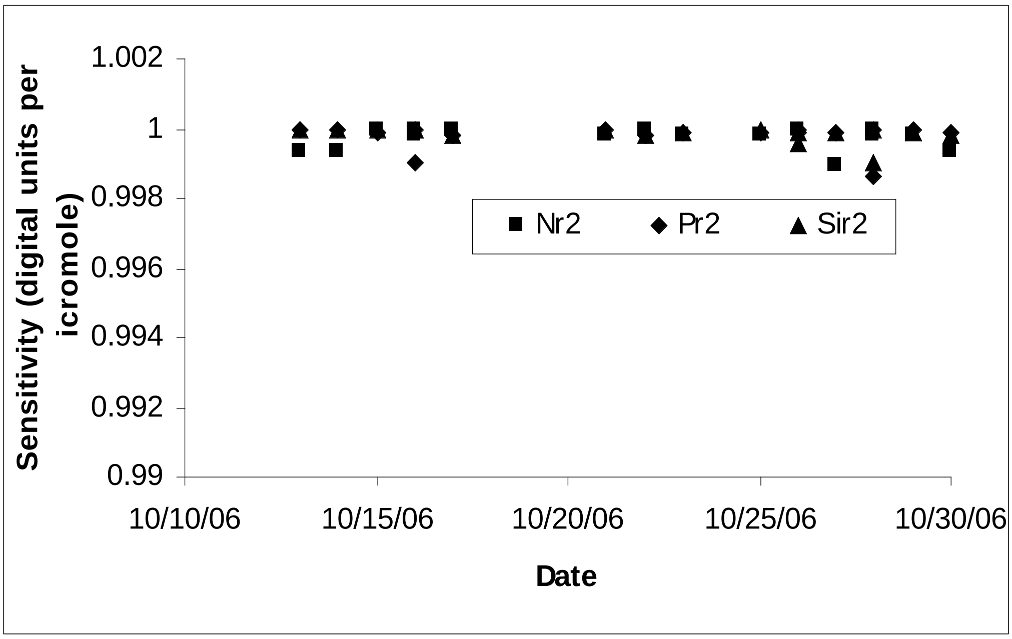


Figure 25: Time series of calibration curves.

Bulk sample

Figure 26 provides a time series of bulk nutrient concentration. Some of the phosphate data from the bulk sample have been discarded due to the problems encountered with the analyzer or due to difficulties encountered in sampling the bulk standard. All three nutrients show a decline in concentration with time as usually found in bulk samples taken on previous cruises. The phosphate concentration changed radically over a very short period of time from about 1 micromolar to 0.76 micromolar. To evaluate the internal consistency of the dataset we fit a linear regression to the entire nitrate and silicate datasets and in two parts to the phosphate dataset. We then use these regressions to calculate modelled values for each day and then calculate residuals for each point. The size of the residual, when compared to the mean value, is an estimate of the internal consistency. These values were 2.39%, 2.83% and 1.15% for N, P and Si.

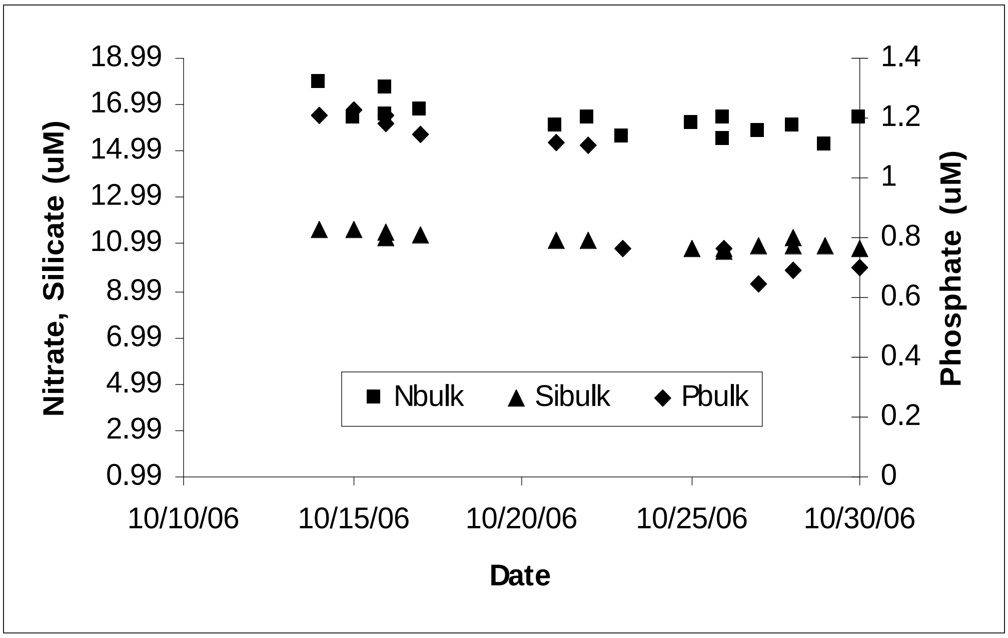


Figure 26: Time series of bulk nutrient concentrations.

Duplicates

Some 100 samples were run in duplicate over the course of the cruise. The mean percentage difference between duplicate pairs was 0.7% for nitrate, 1.2 % for phosphate and 0.6% for silicate. These values are satisfactory.

Cadmium column efficiency

The efficiency of the cadmium column was highly variable with a mean value of 106 +/- 5%. Column efficiency was not correlated with the residual of the nitrate bulk concentration from the interpolated bulk nitrate concentration or with the slope of the nitrate calibration curve. However it declined over time implying that it may have contributed in some way to the variability in N/P ratio seen.

Standards

Analysis of ocean scientific international solutions with nominal concentrations of N 10 uM, P 1 uM and Si 10 uM produced the following results. N 9.97 +/- 0.03, P 0.99 +/- 0.04, Si, 10.2 +/- 0.07. On the basis of these determinations the Nitrate and Phosphate data is considered to be accurate to within the limits of the instrument whereas the silicate data is considered to be approximately 2% too low. No correction was applied for this.

Conclusions

The dataset obtained is internally consistent to within about 2%, precise to about 0.7% and accurate within these analytical uncertainties. The instrument was extremely problematic. The cause of the problems was never traced however with hindsight an obvious factor that was not evaluated was the integrator.

Dissolved Oxygen Concentration - *Stuart Painter, Ian Rae, Richard Sanders*

Dissolved oxygen concentrations were determined using the Winkler whole bottle titration method with the aim of providing 1) accurate measurements of in-situ dissolved oxygen concentrations, 2) a calibration tool for the oxygen sensor deployed on the CTD and 3) and an extension to the time series of oxygen measurements obtained from previous Ellett Line cruises.

All seawater samples were drawn through short pieces of silicone tubing from the Niskin bottles into clear, pre-calibrated borosilicate glass bottles (approx 100 ml in volume). The temperature of each sample was measured with a handheld digital thermometer prior to the addition of 1 ml manganous chloride and 1 ml of alkaline iodide (reagents made following Dickson 1994). Glass stoppers were then inserted taking care to avoid bubbles and/or headspaces in each bottle and the bottle was shaken vigorously for 30 seconds. All Niskin bottles were sampled from every CTD cast (table 1). Samples were taken back to the chemistry lab and left for at least 1 hour before analysis. If time permitted, bottles were left for 1-2 hours before being given a second shaking and then left allowing the precipitate to settle.

Analysis of all samples used the Winkler whole bottle titration method with spectrophotometric end-point and started with the addition of 1 ml of dilute sulphuric acid (280 ml concentrated H_2SO_4 made up to 1 L with Milli-Q water) to each sample bottle. A small magnetic bar was added to each bottle to facilitate the dissolution of the precipitate, which was aided by placing each bottle onto a magnetic stirring plate. Each bottle was then titrated with sodium thiosulphate until clear. The titration volume (ml) was recorded and used with the initial fixing temperature in the calculations of Dickson (1994) to calculate the dissolved oxygen concentration.

One batch of sodium thiosulphate was made up during the cruise (25g L^{-1}) and was tested daily for stability. This was achieved by titrating the sodium thiosulphate against 5 ml of certified potassium iodate standard. The daily mean (n = 5) volume of thiosulphate required to titrate the iodate standard was then used in the calculation of dissolved oxygen concentration for all samples collected on that day. Thiosulphate stability during the cruise is shown in figure 27.

At each station a number of replicates were taken. Replicate reproducibility improved during the cruise with experience and the cruise mean percentage difference between replicate samples was 1 ± 1%.

Table 8: Stations sampled and problems encountered.

Station Number	Number of Depths Sampled	Depth Range (m)	Notes	Failed Titrations (Niskin Number)
16127	13	0 - 626	1st station, multiple replicates, multiple samplers	

16128	6	0 -114		
16129	12	0 -1400		
16130	12	0 -1663		
16131	12	0 – 1790	2 failed titrations	8, 9
16132	12	0 -1790		
16133	20	0 -2195	Bottle 15 did not fire, 2 failed titrations	4, 14
16134	19	0 -2364		
16135	18	0 – 2390	3 failed titrations	1, 5 (rep), 18 (rep)
16136	20	0 – 2511	7 failed titrations	5, 14, 15, 16, 17, 18, 19
16137	16	0 – 2756		
16138	16	0 – 2749	2 failed titrations	4, 9
16140	20	0 – 2826	1 failed titration	8
16141	19	0 -2705		
16142	18	0 – 2640		
16143	15	0 – 1200		
16144	12	0 – 660		
16145	11	0 – 430	1 failed titration	5
16146	4	0 – 135		
16147	5	0 – 163		

16148	6	0 – 280		
16149	12	0 – 1060		
16150	16	0 – 1440	Bottle 15 did not fire	
16151	17	0 - 1640		
16152	18	0 – 1730		
16153	20	0 – 1790	Bottle 15 did not fire correctly. 2 dubious titrations	2, 3
16154	20	0 - 1755	1 failed titration	4
16155	20	0 - 2010	3 failed titrations	1, 5, 9
16156	12	0 - 745		
16157	10	0 – 565		
16158	10	0 – 770		
16159	19	0 – 2095	1 failed titration	6
16160	12	0 – 2200		
16161	18	0 – 2090	Bottle 15 did not fire	
16162	16	0 – 1914		
16163	13	0 – 1420		
16164	8	0 – 310		
16165	4	0 – 130		
16166	4	0 - 118	3 failed titrations	1, 3, 2 (rep)

16167	4	0 - 120		
16168	4	0 - 120	Bottle 3 had headspace	
16169	4	0 - 110		
16171	8	0 - 215	2 failed titrations	4, 5 (rep)
16172	5	0 – 148	1 failed titration	3
16173	6	0 – 210		
16174	2	0 - 45		
16175	2	0 – 45		
16176	3	0 - 110		
16177	2	0 - 487		
16178	2	0 – 600		
16179	2	0 - 673		
16180	2	0 - 890	1 failed titration	2 (rep)
16182	2	0 - 815		
16183	14	0 – 1160	2 failed titrations	10, 12
16185	14	0 - 1164	1 failed titration	1
16186	2	0 - 859		
16187	2	0 – 164		
16188	2	0 – 130		
16189	2	0 – 35		

16190	2	0 -65		
16191	2	0 – 80		
16192	2	0 - 65		
16193	2	0 – 35		
16194	2	0 – 180		
65	631		Total	34

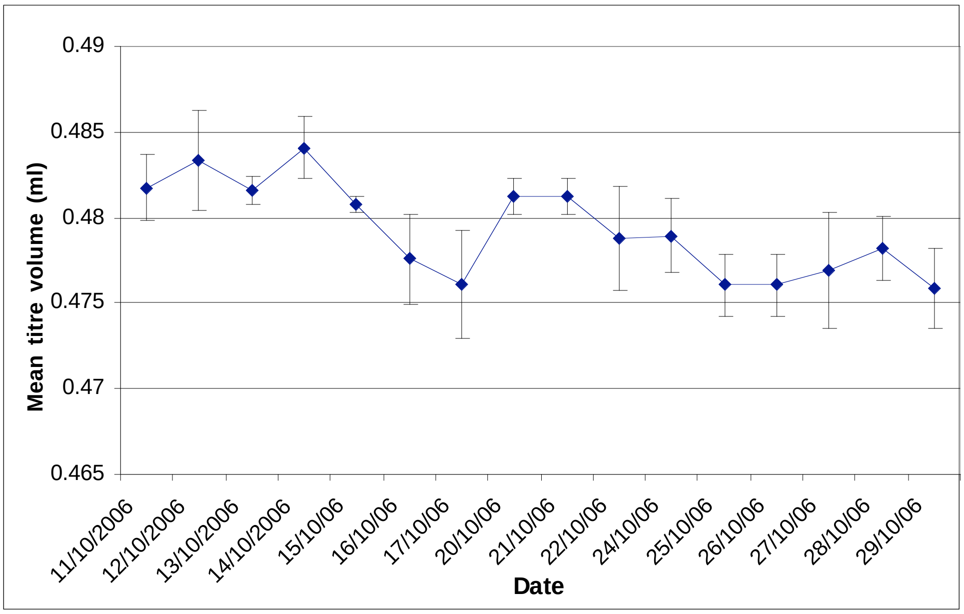


Figure 27: Sodium thiosulphate stability tests. Mean titration volumes are shown (n = 5) with error bars representing ±1 standard deviation of the mean.

Problems

Several problems occurred during the cruise, including poorly closed Niskin bottles and failed titrations. Niskin bottles failing to close properly happened four times (bottle 15 in all cases) and as a precaution a duplicate Niskin bottle was fired at the same depth from station 16151 onwards if bottle 15 was to be used. Titration failures accounted for a loss of ~5% of all samples (excluding replicates) and were a persistent problem during the early stages of the cruise. These failures seemed to be systematic with two primary causes, one was attributed to the roll of the ship in high seas and the second was the placement of the sample bottles within the spectrophotometer beam. The first cause could not be anticipated, and neither could it be definitively identified but may actually have resulted from minor movements of the sample bottle in a manner similar to problem two. Although by no means a definitive statement solving the second problem seems to have eliminated the first problem as well.

The second problem of poor placement was resolved by ensuring that all sample bottles were located as far forward as possible on the magnetic stirrer plate. This positioned the sample bottles in direct alignment with the photometer beam and would suggest that the photometer is slightly skewed with respect to the stirrer plate. Taking such precautions reduced, but did not eliminate further titration failures.

A third minor problem was also encountered with bottles that had a frosted labelling section on them as this would obscure the spectrophotometer beam and produced poor titration values. This was resolved by simply ensuring that the frosted section was pointing towards the back of the stirrer plate and at 90° to the photometer beam. In future such bottles should be avoided.

Results

The results were processed during the cruise and will be available from BODC in due course. Dissolved oxygen concentrations along transects ranged from 215 – 300 μmol O_2 L^{-1} and were higher at depth than in surface waters (Figure 28). N.B. Figure 28 also shows outlier data which will be removed from the final submitted dataset). Vertical profiles reveal, as expected, the presence of an oxygen minimum at ~800m depth (Figure 29). Surface dissolved oxygen concentrations were variable depending upon the sampling location. Concentrations below 800m were more uniform but a distinct separation in the data can be observed when stations from west of Rockall are compared to stations east of Rockall, particularly in the depth range 800 – 1400m.

Preliminary contoured sections of the dataset, with outliers removed (contoured in Pstar) are shown in Figure 29 (Iceland Basin) and Figure 30 (Rockall Trough).

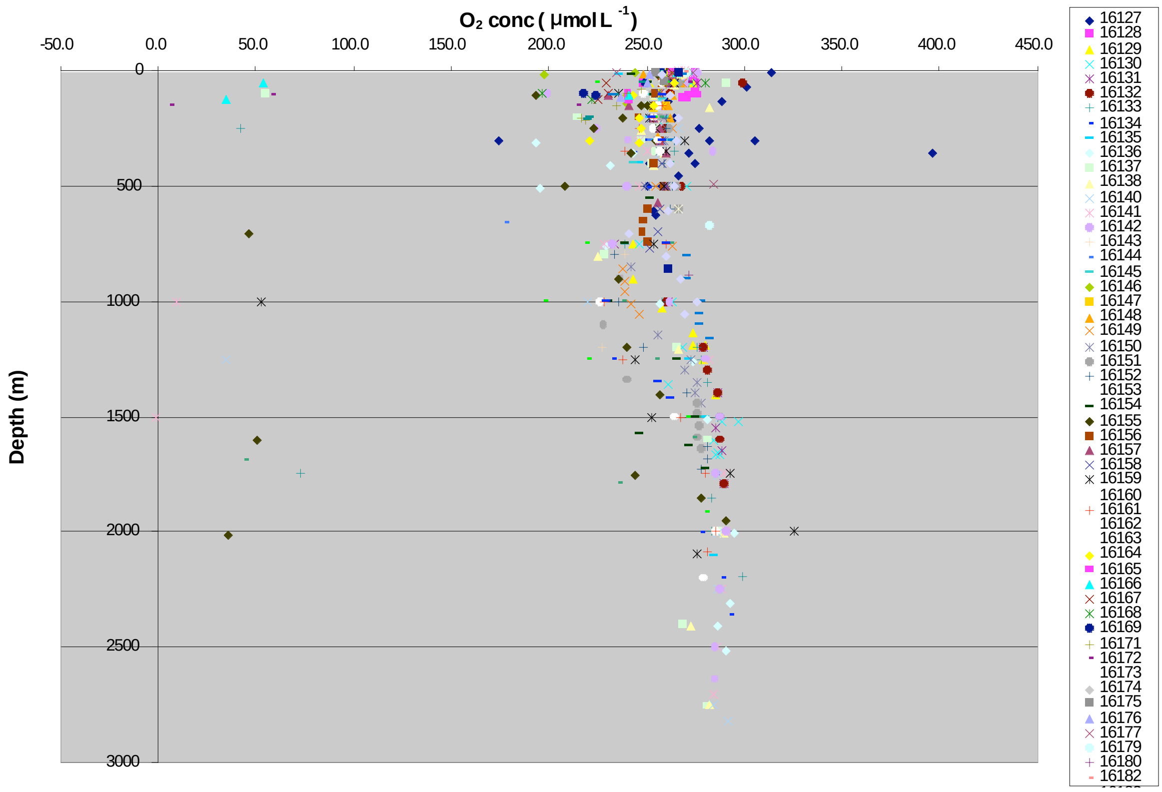


Figure 28: Vertical profiles from all sampled stations. N.B. this figure includes all results including outlier values that will be removed from the final dataset. Data shown is from stations 16127 to 16186.

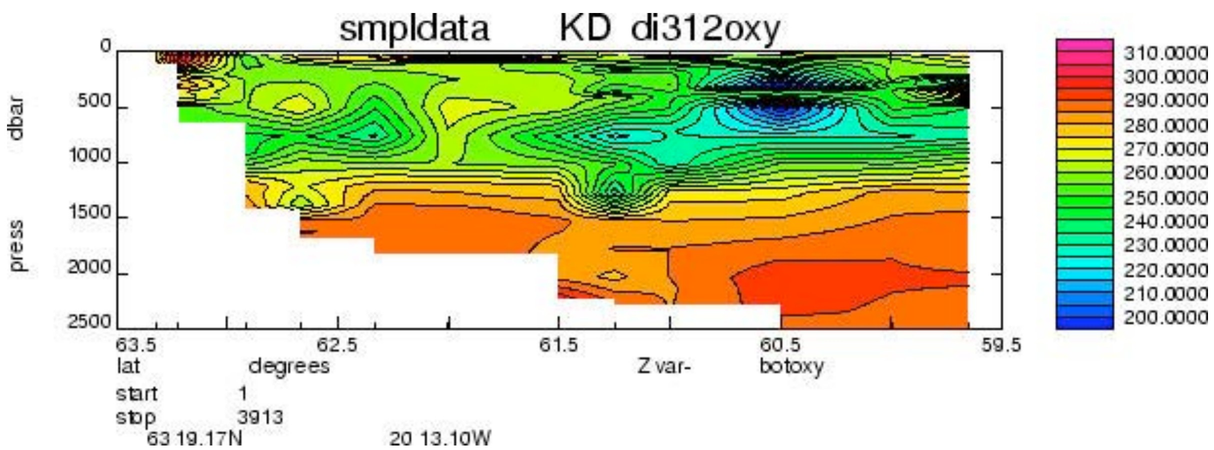


Figure 29: Preliminary contoured section of dissolved oxygen concentrations for the Iceland Basin (data contoured in Pstar).

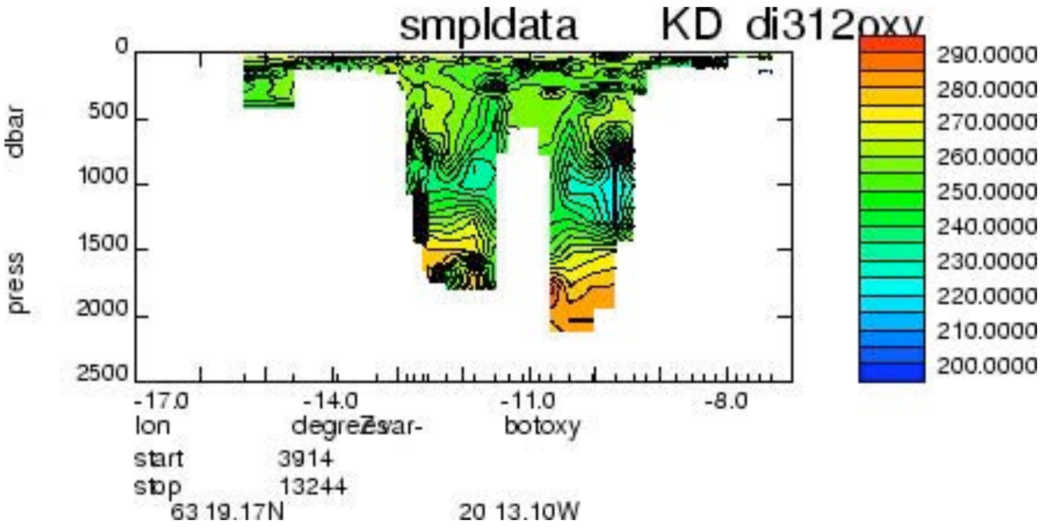


Figure 30: Preliminary contoured section of dissolved oxygen concentrations around Rockall.

Particulate Organic Carbon (POC), chlorophyll and HPLC sampling – *Katie Evans, Maria Pöllüpüü, Richard Sanders*

Samples were taken from 12 stations during the cruise for POC, chlorophyll and HPLC analyses, with the aim of relating the depth penetration of POC to the upper ocean biological community. Stations were selected through consideration of water depth, and topographic influence. Deep-water stations, with minimal influence from bottom topography were favoured. Time constraints also played a role, as the need to re-use each bottle to take the samples, meant that adequate time to complete filtering between POC stations was necessary; consequently it was rarely feasible to take samples from two consecutive stations.

Typically the depth of samples ranged from 5m to 350m, with 3 litres of water taken at eight depths for POC analyses, and 5 litres taken from surface (5-10m) for HPLC analyses. In addition chlorophyll samples were taken at each depth from 5 – 350m. Replicates were also taken for both POC and chlorophyll, although a limited supply of filters meant this was not possible for all twelve stations.

POC analyses:

Water samples from CTD bottles (3 litres) were taken from each depth, and filtered onto MF filters, 25mm, (pre-combusted at 400°C). They were then stored at -80°C, to be analysed at NOCS.

Pigments: chlorophyll

For each POC and underway station, chlorophyll samples were obtained by filtering 250 ml of sea water onto Whatman 25 mm GF/F filters to yield total chlorophyll. Filters were then placed in the -80°C freezer for analyses at NOCS.

Pigments: HPLC

For each of the POC stations HPLC samples were taken from the surface (5-10m), by filtering 5 litres of seawater onto 25mm Whatman GF/F filters that were then frozen at -80 °C for later HPLC analyses at NOCS.

Underway Chlorophyll samples:

Table 9: The underway Chlorophyll samples.

Time (secs past 01/01/06 0000)	Sample No	JDAY
24694170	1	286
24733080	2	287
24778920	3	287
24832500	4	288
24839640	5	288
24863880	6	288
24876900	7	288
24883500	8	289
24892800	9	289
24898080	10	289
24926100	11	289
24934260	12	289
24940980	13	289
24949920	14	289
24976260	15	290
25050000	16	290

25094880	17	291
25126620	18	291
25182000	19	292
25244640	20	293
25332600	21	294
25378800	22	294
25398900	23	294
25427700	24	295

POC / Chlorophyll stations:

Table 10: Discovery Station: 16133, Station: IB16.

Niskin Bottle	**fpress dbar**	**Samples taken**
20	7.5	HPLC / chl
19	7.4	POC / chl
18	52.2	POC / chl
17	104.7	POC /chl
16	152.5	POC / chl
15	204.5	POC / chl
14	254.5	POC /chl
13	306.5	POC /chl
12	354.4	POC /chl

Table 11: Discovery Station: 16134, Station: IB15.

Niskin Bottle	**fpress dbar**	**Samples taken**
19	9.3	HPLC / chl
18	9	POC / chl
17	54	POC / chl

16	103.8	POC / chl
15	156.4	POC / chl
14	205.6	POC / chl
13	258.1	POC / chl
12	306.4	POC / chl
11	356	POC / chl

Table 12: Discovery Station: 16135, Station: IB14.

Niskin Bottle	fpress dbar	Samples taken
18	10.2	HPLC / POC /chl
17	52.1	POC / chl
16	104.4	POC / chl
15	153.1	POC / chl
14	202.1	POC / chl
13	254.5	POC / chl
12	306.1	POC / chl
11	406.2	POC / chl

Table 13: Discovery Station: 16137, Station: STNW.

Niskin Bottle	fpress dbar	Samples taken
16	4.6	HPLC
15	4.3	POC / chl
14	55.4	POC / chl
13	104.5	POC / chl
12	154.6	POC / chl
11	206	POC / chl
10	257	POC / chl
9	307.4	POC / chl

8	358.3	POC / chl

Table 14: Discovery Station: 16140, Station: STNC.

Niskin Bottle	**fpress dbar**	**Samples taken**
20	8.1	HPLC
19	8.6	POC / chl
18	53.6	POC / chl
17	105.2	POC / chl
16	155.2	POC / chl
15	205.7	POC / chl
14	255.5	POC / chl
13	307	POC / chl
12	357	POC / chl

Table 15: Discovery Station: 16141, Station: IB12.

Niskin Bottle	**fpress dbar**	**Samples taken**
16	3.9	HPLC
15	4.8	POC / chl
14	53	POC / chl
13	105.3	POC / chl
12	154.8	POC / chl
11	205.1	POC / chl
10	251.5	POC / chl
9	302.6	POC / chl
8	354.6	POC / chl

Table 16: Discovery Station: 16143, Station: IB4.

Niskin Bottle	**fpress dbar**	**Samples taken**
15	13.4	HPLC
14	13.3	POC / chl
12	55.8	POC / chl
11	104.5	POC / chl
10	154.2	POC / chl
9	205	POC / chl
8	255.2	POC / chl
7	307.5	POC / chl
6	359	POC / chl

Table 17: Discovery Station: 16144, Station: IB3.

Niskin Bottle	**fpress dbar**	**Samples taken**
12	12.2	HPLC
11	12.6	POC / chl
10	51.7	POC / chl
9	104.5	POC / chl
8	152.3	POC / chl
7	203.8	POC / chl
6	252.9	POC / chl
5	306	POC / chl
4	354.5	POC / chl

Table 18: Discovery Station: 16153, Station: F.

Niskin Bottle	fpress dbar	Samples taken
20	7.9	HPLC
19	7.4	POC / chl
18	54.5	POC / chl
17	104.6	POC / chl
16	154.5	POC / chl
14	205.4	POC / chl
13	256.7	POC / chl
12	305	POC / chl
11	406	POC / chl

Table 19: Discovery Station: 16155, Station: H.

Niskin Bottle	fpress dbar	Samples taken
20	12.4	HPLC
19	12.8	POC / chl
18	53	POC / chl
17	103.9	POC / chl
16	154.3	POC / chl
14	204.7	POC / chl
13	255.1	POC / chl
12	305	POC / chl
11	357.2	POC / chl

Table 20: Discovery Station: 16159, Station: L.

Niskin Bottle	fpress dbar	Samples taken
19	6.4	HPLC
18	6.4	POC / chl
17	51.7	POC / chl
14	102.5	POC / chl
13	152.3	POC / chl
12	203	POC / chl
11	253.1	POC / chl
10	304.5	POC / chl
9	355.8	POC / chl

Table 21: Discovery Station: 16161, Station: N.

Niskin Bottle	fpress dbar	Samples taken
18	8.1	HPLC
17	8.3	POC / chl
16	52.8	POC / chl
14	103.6	POC / chl
13	154	POC / chl
12	205.6	POC / chl
11	255.5	POC / chl

Trace Aluminium sampling - *Toby Sherwin, Emily Venables*

Samples were taken from the Rosette sampler at 19 CTD stations, which were located on the Ellett Line (15), on the southern side of the Wyville Thomson Ridge (3, including 1 precision sample) along with a sedimentary trap mooring (1 precision sample). A procedural blank was taken from Sta 1G at the end of the cruise. Typically 10 Niskin bottles were sampled per CTD station, following the strategy discussed before the cruise, and from each bottle one filtered and one unfiltered sample was taken. Towards the end of the cruise, when it became apparent that there was going to be a surplus of sample bottles, the number of Niskin bottles sampled per cast was increased to 14. The sampling strategy aimed to provide a fairly even distribution of aluminium samples over the water column along the deep water of the Ellett line. At the edge of the Rockall and Iceland shelves samples were concentrated near the bottom. On the Wyville Thomson Ridge gully the emphasis was on sampling the bottom waters that were crossing the ridge, in an attempt to identify the source waters to the north of the Rockall Trough.

The sampling procedure followed the protocol prepared by Clare Johnson before the cruise and all samples had either Emily Venables or Toby Sherwin leading the sample taking.

After trial and error the filling protocol was adapted to make it as efficient as possible whilst also conforming to Clare's requirements. One person held the syringe and tube and stayed at the frame, whilst the other ferried bottles back and forth from under cover to the Niskin bottles. The procedure worked along these lines: The syringe holder attached the tube to the tap of a Niskin bottle and flushed the syringe twice, whilst the bottle carrier took the sample bottles from the last Niskin to the under cover store and returned with new ones and a new filter. The bottle carrier handed the filter to the syringe holder who then filled the syringe a third time whilst the bottle holder opened the unfiltered sample bottle. Then whilst the bottle carrier collected the unfiltered sample, the syringe holder stood to one side and flushed the filter with the water in the syringe. Then while the bottle carrier opened the unfiltered bottle, the syringe holder refilled the syringe and reattached the filter ready to deliver the filtered sample. The bottle carrier then flushed the sample bottle, which was subsequently filled with the filtered sampled.

To further speed up the sampling procedure a 'scribe' was employed to write down the numbers of the sample bottles which, sometimes randomly and sometimes in order, were selected from a 20 bottle bag. These numbers can be found on the aluminium sampling sheets.

At nearly all stations, the filter was placed in a bag with the filtered sample, whilst the unfiltered sample was placed in a bag on its own. Both filtered and unfiltered bottles were then placed together in a large aluminium bag marked with the cruise identification (D132), station name and CTD number and stored in a chest freezer.

A few further points should be noted. i) although the talcum free plastic 'gloves' were slippery and it was often quite difficult to open the sample bottle bags with them. ii) whilst the plastic tube fitted the Niskin tap, it was too large for the syringe. Using a blower drier to warm it we had to reshape the nozzle end of the tube to fit the syringe intake; iii) unlike on CD176 the crew did not always pay close attention to the no smoking request. The door to the 'coffee shop' rest room was situated close to the CTD access area and, whilst there is no real reason to believe that samples have been compromised, it is necessary to report this situation. iv) no incineration was undertaken during sampling.

These data will be analysed by Clare Johnson, a PhD student at SAMS.

Table 22: Stations at which Aluminium sampling occurred.

Discovery no.	**Station name**	**No of Niskin bottles sample**
16129	IB20S	10
16131	IB18S	10
16133	IB16	10
16138	STC	1 (Precision protocol)
16143	IB4A	10
16145	IB2	9
16148	C	6
16149	D	10

16150	D1	10
16151	E	10
16152	E1	10
16153	F	10
16154	G	14
16155	H	14
16156	I	10
16172	9G	5*
16183	W6	14
16185	W8	14
16186	W9	1 (Precision protocol)
16194	1G	Procedural blank

*Double samples from each bottle

Figure 31: The CTD frame in its sampling position in relation to i) the door to the coffee shop (to the left of the white steps) and ii) the entrance to the ship (beneath the green steps) where bottles were stored during sampling.

Shear Microstructure profiler measurements - *Mark Inall*

Unfortunately after only 6 casts the MSS90 microstructure profiler was lost. Here follows the Captain's Incident and Investigation report pertaining to the loss.

RRS *DISCOVERY* INCIDENT & INVESTIGATION REPORT

INCIDENT Report No: 053

Type: Loss of SAMS Turbulence Probe	**Date:** 26/10/06	**Time:** 2025 (UT)
Geographical Position: 56 40.05N 007 34.80W	**Geographical Location:** 7nm SSE of Barra Head	
Location on Ship: Small winch mounted on bulwarks, stbd aft.		
Weather: Wind NNE 15 knots. Slt sea; low swell.	**Course:** 060 (G), 095 CMG	**Speed:** 1.2 knots (thro' water; approx 1.0 knot over ground)
Activity: Tide cycle measurements of turbulence through water column.		
Nature of Incident: Profiler fouled on seabed @ extremity of freefall. V/l could not be stopped over ground in sufficient time, or cable veered sufficiently quickly, to prevent parting of cable at seabed. All cable - bar possibly last few metres - recovered.		

Investigation:

A standard procedure - undertaken many times by SAMS scientists with this type of instrument at many different shelf-break locations - was taking place.

The procedure involved allowing the instrument to free-fall via just sufficient slack cable until a levelling-off of pressure indicated that the instrument was at the seabed. (It is standard practice to allow the instrument to land on the seabed). Heaving then started immediately.

On this occasion, after hauling for about 10 seconds, the cable tension indicated fouling. A call from the Deck to the Bridge requested the vessel to heave-to, and the cable was veered.

Unfortunately the subsequent v/l manoeuvres allied with an inability to allow the cable to free-run caused increased tension on - and ultimately parting of - the cable.

Scratch marks on the cable were consistent with a cut caused possibly by coral. Proper procedures were being followed both on deck and on the Bridge. Communications were good and operating conditions were normal. Best efforts were made to rectify the problem once it occurred.
Conclusion & Recommendations: A meeting between M. Inall (SAMS), T. Edwards (OED TLO) – both operating the equipment on the aft deck at the time of the incident – and P. Sarjeant (Master) – conning the vessel – concluded the following: Ideally a pre-survey of bottom topography and improved knowledge of bottom type should be available prior to profiling on a new location. A winch system that facilitated 'free-wheel' pay out of up to 400m of cable in the event of seabed fouling would be beneficial.

Completed By: Peter Sarjeant - Master	

Mesozooplankton net sampling – *Maria Pöllupüü, Timo Arula, Toby Sherwin*

Sample collection

The plankton net was attached to the deck winch and lowered to a max depth of 100 m and retrieved at a speed of about 0.5 to 1m per second. When the net was back on deck, the net was rinsed down using the ships hose so that animals attached to the net mesh were washed into the cod end, the mesh windows of the cod end were also rinsed down. The contents were drained into the bucket. The sample was concentrated by pouring it through a sieve and then washed into a sample bottle.

Sample preservation

Depending of the sample volume the appropriate size (250 or 500 ml) sample containers were used. Formaldehyde (40%) was poured into the sample to create a final concentration in the sample of about 5% formalin. For example, for a sample volume of about 100 ml about 5 ml of formaldehyde was added.

A waterproof sample label was put in the sample container with the following details: sample station, date, time, sample depth, cruise no, collector name + container was labelled outside with the sample station.

Table 23: Zooplankton sampling stations on the Ellett Line October 2006.

Sample	Station	Date	Time	Sample depth (m)	Latitude	Longitude	Bottom depth (m)	Collector
ZOO 001	16153 (F)	24/10	10.46	100	57 30.99 N	12 14.963 W	1804	M. Põllupüü
ZOO 002	16155 (H)	24/10	21.25	100	57 30.114 N	11 31.519 W	2025	M. Põllupüü
ZOO 003	16157 (J)	25/10	05.35	100	57 27.220 N	11 05.404 W	582	T. Arula
ZOO 004	16159 (L)	25/10	12.29	100	57 22.0816 N	10 39.6299 W	2138	T. Arula
ZOO 005	16160 (M)	25/10	17.30	100	57 18.563 N	10 22.415 W	2207	M. Põllupüü
ZOO 006	16164 (Q)	26/10	06.10	100	57 03.236 N	09 13.729 W	355	T. Arula
ZOO 007	16165 (R)	26/10	08.00	100	56 59.899 N	09 00.321 W	137	M. Põllupüü

ZOO 008	16172 (9G)	26/10	23.45	100	56 44.112 N	07 19.888 W	160	M. Põllupüü
ZOO 009	16174 (11G)	27/10	02.45	50	56 44.3552 N	07 40.4176 W	61	M. Põllupüü
ZOO 010	16176 (13G)	27/10	05.30	100	56 47.223 N	07 59. 710 W	118	M. Põllupüü

Nets were not deployed at stations A, C, D and E due to rough weather conditions.

Wyville Thomson Ridge bathymetry - *Toby Sherwin*

The bathymetric data collected during the brief survey of the Ellett gully have been used in conjunction with data collected during Scotia cruise SC0804 to produce a new bathymetry for the gully. These data have been added to previous data collected by Dave Ellett, during CD176 and during previous Scotia cruises. In addition all data from the Scotia cruises have undergone additional de-spiking. All data were pooled into squares of 0.005° latitude and 0.01° longitude (i.e. about 500 m square) before being gridded with a Krigging technique and plotted with Surfer. A full data check is required before this chart can be considered definitive.

The new bathymetry removes a small ridge across the gully that appeared in the previous version at about 8.93° W. A secondary gully that was previously present on the northern side of the gully at 8.75° W has also disappeared.

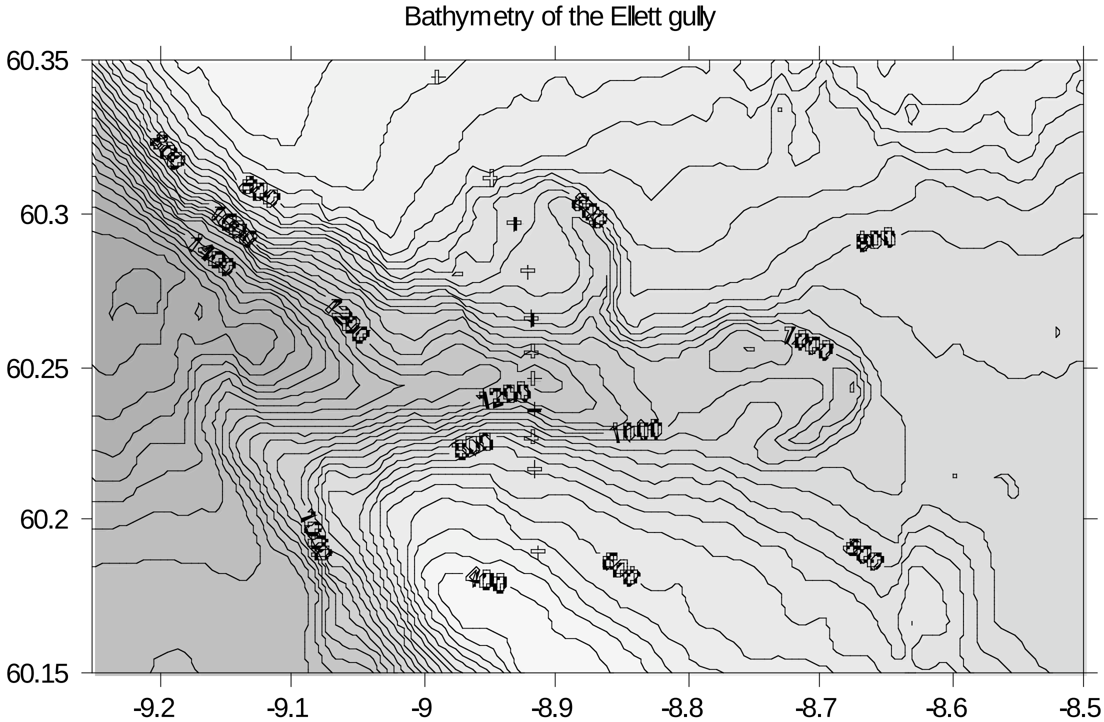


Figure 32: A draft version of the revised bathymetry of the Ellett gully, also showing CTD stations on the W line ('+', not all of which were sampled). The moored SC-ADCP was deployed along this line at the deepest part of the gully.

Artist's report – *Margaret Marks*

I am one of 20 artists from **Artel**; a professional contemporary art group based in Chichester, who are involved in an art/science collaboration with **NOCS**, the National Oceanography Centre, Southampton. The ensuing outcome of art from this association, will be an exhibition entitled The Oceanography Project at the Bargate Monument Gallery and the medieval city vaults in Southampton, in June 2007. As part of the collaboration I have been able to join this cruise both as an artist and also to be part of a watch assisting the scientists in their data collection.

I work in digital media and in textiles, often the techniques and imagery of one informing the other. I like to produce patterns, repeating movements, text and sound to express my ideas. My area of artistic research has usually been in the study of facial expression and the thoughts that that may exist behind them.

My aim was to visually study the scientists and crew in their activities during the cruise and to get an insight into their work. To this end I have collected several hours of video and about 500 photographs.

Figure 33: Visual studies of scientists at work.

I also provided mobile phones for each watch to photograph images of their interest over a 12 hour period. I have collected scientists' rough notes, weather charts, ship's plans, chart readings, acronyms, nomenclature, statistics and 'plans of action' with the intention of amalgamating these into film or into textiles. The final films will be produced after extensive editing, image manipulation, drawing into the film and additional animation.

An opportunist project, completed on board, was the production of 19 sketches of each scientist onto polystyrene cups. These were sent to 2000 metres on a CTD thus pressurising them to miniatures.

Figure 34: Pressurised Scientists on the Ellett Line.

Thorpe scale analysis of CTD data – *Toby Sherwin*

<u>*Background*</u>

Thorpe scale analysis is a technique that allows measurements of fine scale temperature or density structure to be converted into estimates of vertical diffusion in the ocean. Although the method was originally developed for measurements made in freshwater lakes, it has been adapted to the ocean in particular using tethered free falling floats (Inall, pers. comm.) and sub-surface drifters.   Other investigations have demonstrated that under certain conditions realistic vertical diffusion coefficients can be derived from a conventional fast sampling CTD (see e.g. Stansfield *et al.*, 2001 and Sherwin and Turrell, 2005). During D312 we have undertaken a further investigation with a CTD combined with a full rosette of 24 water bottles.

Figure 35: Detail of the CTD frame and rosette sampler system. The primary CTD sensors are attached to the bottom of the vane on the right. The secondary sensors are strapped to the top of the right hand horizontal cylinder beneath the bottles.

Methodology

On D312 observations were made with two Seabird 911*plus* CTDs, which sample at 24 Hz and use a pumped system on the conductivity sensor to derive very accurate measurements of conductivity. Two CTDs were used, the primary one was located on a stabilising fin on the outside of the frame, whilst a secondary one was placed near the bottom on the inside of the frame (see Figure 35).

In the present exercise we have tackled three things that complicate the problem of performing a Thorpe scale analysis on data from a conventional CTD rosette system carried by a ship at sea. These problems are over and above those that might be expected with measurements made from a stable platform in a freshwater lake. The principle problems at sea are:

1. Ship motion, in particular rolling in heavy seas when the winch mechanism does not compensate the movement and the CTD is periodically dragged back upwards during its descent phase.
2. A non-monotonic relationship between temperature and salinity, due to mixing of water masses, coupled to
3. A salinity signal that is significantly less stable than temperature

Rolling

The CTD on *Discovery* is deployed a little aft of amidships on the starboard side from a hydrographic winch that projects about 2 m from the hull, and is normally lowered at about 1 m s^{-1}. Since *Discovery* itself is about 14 m wide this means that the hydrographic wire is positioned about 9 m from the centre of motion rolling. (*Discovery* is sufficiently long (90.25 m) and the wire sufficiently close to midships that pitching is not a significant problem.) Thus typical roll of 5° results in a potential vertical movement of the wire of about 0.8 m. During much of D312 the swell was often large, with on many occasions a range of about 5 m and period of 8 to 10 s. Under these conditions, the pressure record indicates that the motion of the ship was directly transferred to the CTD frame. The problem might have been reduced had the heave compensation mechanism on the winch been working during the cruise.

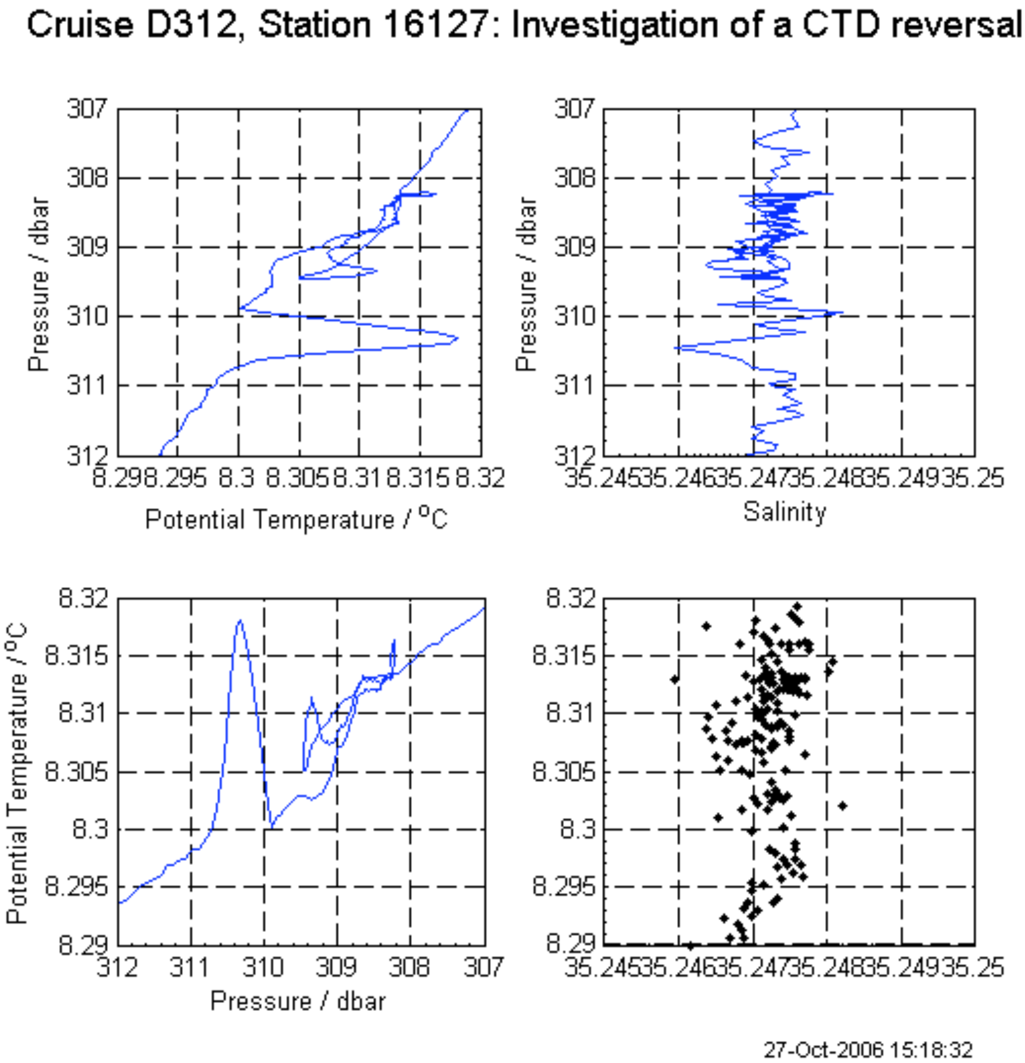


Figure 36: Detailed presentation of primary sensor data at 24 Hz during a roll.

The effect of ship movement was to cause the CTD to periodically oscillate and often reverse its descent, rising through the water column by up to 2 m. The precise motion of the frame varied from one roll to another, but a good example is shown in Fig. 2, taken from Sta. 16127. The pressure sensor initially descended to 309.5 dbar, but then rose back to 308.2 dbar before continuing its descent. During the first phase of the roll the primary thermistor (located on a vane attached to the side of the frame) detected a potential temperature of about 8.274 °C at 309.5 dbar, but on its second pass this water appeared to have cooled by about 3 millidegrees. A little later, at 310.3 dbar, the thermistor passed through a patch of warm water, about 0.5 m thick, with a maximum temperature of 8.287 °C. The sensors were finally clear of the mixing region at 311 m. At the same time the conductivity sensor observed a similar effect, and a TS plot showed that the temperature and salinity compensated each other.

The secondary sensors located inside the frame were also disrupted. During a normal descent these sensors measured very similar temperatures to the primary ones. However, the initial reversal resulted in a larger temperature rise (0.03 °C), and the secondary pulse (observed at 311 m) whilst less severe (a rise of 0.015 °C) lasted longer so that the sensors were not fully clear of the mixing zone until about 313 m.

An interpretation of these effects is summarised in Figure 37. Normally when the CTD descends undisturbed water beneath it flows through the frame and past both sensors in a satisfactory manner (Figure 37a). However, if its descent is suddenly reversed then as it rises the motion draws in undisturbed water from beneath the frame and ejects water that was previously trapped inside it (Figure 37b). As a result when the CTD starts to descend again (Figure 37c) it passes through the ejected warm water that now lies in a pool beneath it.

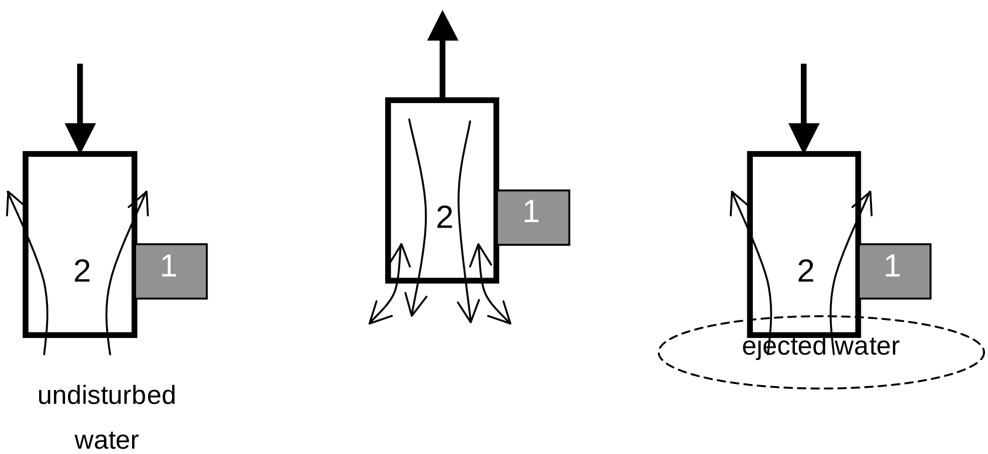


Figure 37: Schematic representation of the effects of ship rolling on the performance of a CTD frame. 1 and 2 are the primary and secondary sensors. LH panel: normal operation of descent – water sweeps up past the sensors. Middle panel: temporary upward movement of frame – water trapped in frame is ejected from the base. RH panel. Return to descent – sensors now pass through ejected water.

Rolls have been detected and eliminated using the Seabird post-processing suite LOOPEDIT, which flags bad data, combined with some additional analysis. The Seabird manual does not explain precisely how LOOPEDIT works but tests suggest that it is more sophisticated than simply eliminating all velocities below the user set minimum speed (20 cm s^{-1}). However, it does not eliminate the unwanted secondary effects of a roll on the high frequency density profile. To do this it has been necessary to ignore all measurements made from the start of a reversal until the CTD had travelled 2 m below the previous maximum depth. However, as no two rolls were the same and to minimise the loss of data, observations were accepted from 2.5 s after the roll has ended even if the frame has not descended the necessary 2 m.

Salinity related problems

Ideally Thorpe length scales should be based on potential density, ρ_θ, and in theory this should not be difficult since the Seabird CTD makes very accurate measurements. However, previous tests and analysis of another Seabird system has demonstrated that the conductivity signal has a significant noise level that can only be eliminated to the level that we require by averaging over large periods of time (see appendix and Sherwin and Lichtman, 2004). By contrast the temperature signal was very stable. This means that a straightforward conversion of temperature, conductivity and pressure to the stable accuracy required here is not possible, even after low pass filtering to 1 second intervals. On the Wyville Thomson Ridge this problem was easily overcome because potential temperature, θ, is mapped monotonically onto salinity, *S*, and so could be treated as a tracer (Sherwin and Turrell, 2005). In the Iceland Basin this is not always the case.

A single routine has been written to overcome these two problems. The method is simply to divide the profile into typically 9 m bins, and apply a least squares linear fit, such that for each bin, *i*,

$$S_i = a_i + b_i\theta_\iota. \qquad (1)$$

Then at each data point the original salinity, S_i, is replaced with a new one, s_i mapped from the observed θ_ι using (1). Using s_i should thus result in a less noisy potential density profile than using S_i. In order to reduce any mismatches at the join between two bins a low pass filter was subsequently applied to each of the two series of linear coefficients, a_i and b_i.

Potential density can then be calculated as $\rho_\theta = f(p, s, \theta)$, where p is pressure, instead of the more noisy $\rho_\theta = f(p, S, \theta)$.

Results

Estimates of the spatial distribution of the vertical diffusion coefficient, K_Z, have been made during the cruise. Preliminary results suggest that the method may have some merit to it with indications of larger mixing rates near the Icelandic shelf edge than in the basin itself. The results are being compared with Richardson number estimates and the turbulence probe data.

Appendix

Thorpe scale calculations

Temperature profiles in lakes, when resolved to fine scales, reveal dynamic instabilities that Thorpe (1977) showed could be indicative of vertical mixing. Subsequent workers (e.g. Dillon, 1982, Crawford, 1986, Stansfield *et al*., 2001) have confirmed that in the ocean such instabilities can be related to turbulent dissipation, and hence used to estimate vertical diffusion coefficients, K_Z.

The derived density and pressure data were averaged over 0.1 dbar segments, and then re-ordered in the water column so that density increased monotonically with depth to give a dynamically stable profile. The distances that each segment moved up or down, d, were then used to compute the Thorpe scale from $L_T = \sqrt{\langle d^2 \rangle}$, where the angle brackets indicate an averaging process. On D312 case d^2 was smoothed with a filter width of about 30 m. The diffusion coefficient was then found from a semi-empirical formula (see Dillon, 1982)

$$K_Z = 0.128 L_T^2 N \qquad \text{(A.1)}$$

where $N^2 = -\dfrac{g}{\rho}\dfrac{d\rho}{dz}$ is the local buoyancy frequency derived from the reordered profile.

A detailed investigation has previously been made of the performance of the Seabird 911*plus*, both under laboratory conditions and at sea, the latter by taking data from the bottom of a cast in the Färoe-Shetland Channel where the state variables were almost uniform. The temperature sensor appeared to perform to the manufacturer's specification (resolution of

0.0002 ºC), but in any case was averaged over 0.1 dbar. There was a small amount of high frequency electrical and vibration noise in the pressure signal, which had a standard deviation of 0.046 dbar in the laboratory and 0.01 dbar at sea. However, this noise is insignificant - using worst-case values of L_T = 0.046, and $N = 1\times10^{-5}$, (A.1) gives $K_Z = 2.9\times10^{-9}$ m^2 s^{-1}, which is several orders smaller than values quoted here. The salinity signal had a significant oscillation at 4.3 Hz with an amplitude that varied between 0.01 units in the laboratory and 0.001 units at sea. Values of N^2 were smoothed using a Hamming filter with a 5 to 50 m half width (depending on the water depth) to remove any small density inversions that still remained.

Acknowledgements

The weather experienced during this autumnal cruise was not particularly memorable for its extremes, however it was remarkable for its consistency and that its consistent state was ‘marginal’ regarding any deck work. I think the Scots word ‘dreich’ sums up the conditions rather well! Nonetheless, D312 achieved 80-85 % of its objectives and this is testament to the exemplary teamwork achieved by the Master, officers, crew, engineers and scientists involved in the cruise. Their enthusiasm, patience and professionalism enabled me to remain focussed on the job in hand - many thanks.

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