Cruise Report, RRS James Cook JC054 (DIMES UK2)

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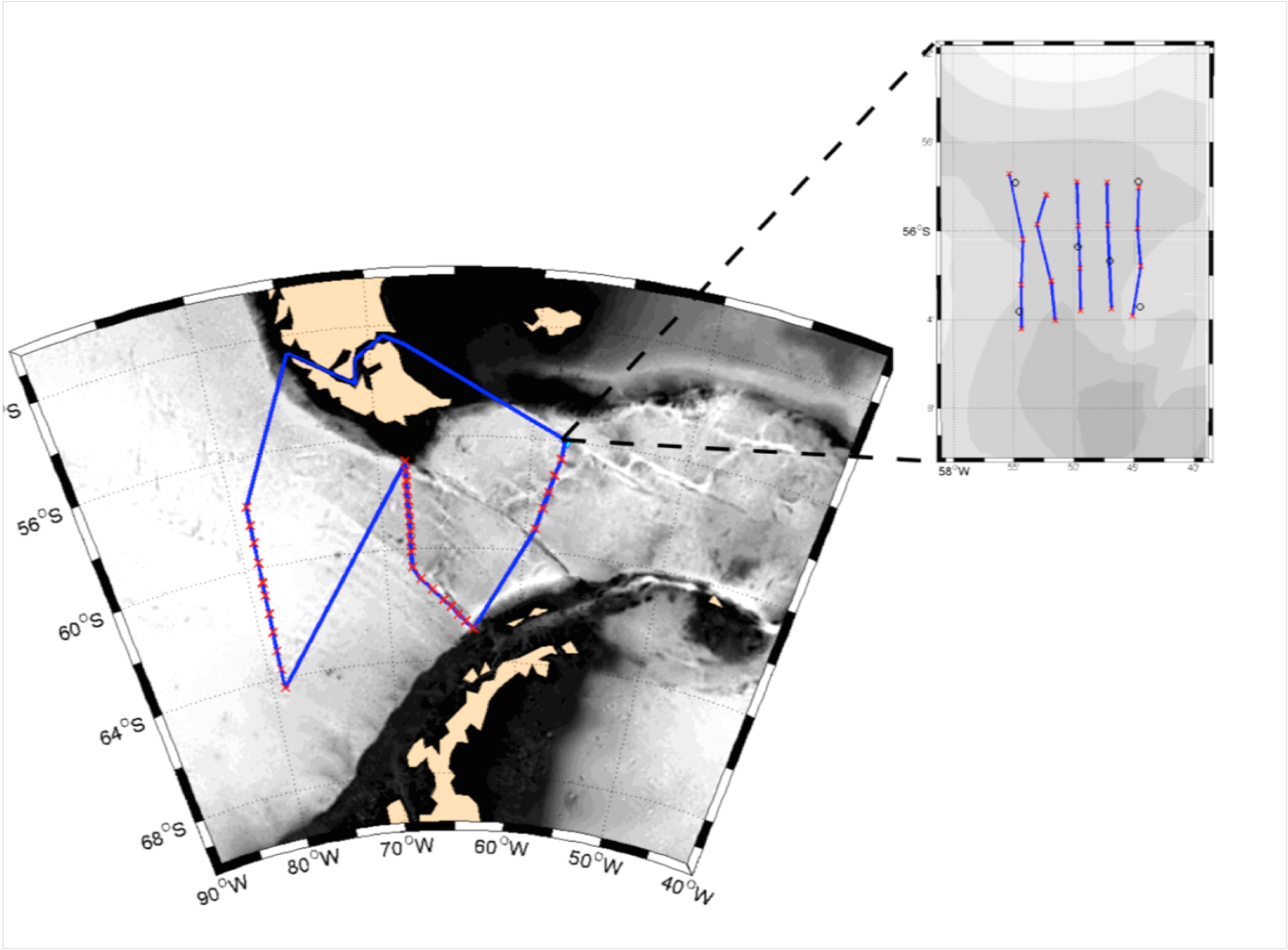
30 November 2010 to 8 January 2011



Frontispiece: Cruise track of RRS James Cook in the Southeast Pacific, Drake Passage and western Scotia Sea during cruise JC054. Cruise was conducted clockwise to and from Punta Arenas, Chile.

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1.1. Scientific Personnel

Meredith, Michael Paul (British Antarctic Survey; Principal Scientist)

Bogdanoff, Alec (Florida State University)

Boland, Emma Joan (British Antarctic Survey and Cambridge University)

Brearley, James Alex (National Oceanography Centre, Southampton)

Brousseau, Andrew White (University of East Anglia)

Burris, James Edward (National Marine Facilities, Southampton)

Cunningham, Nathan John (British Antarctic Survey)

Decoteau, Kenneth Lee (Woods Hole Oceanographic Institution)

Edwards, Terry (National Marine Facilities, Southampton)

Keogh, Robert (National Marine Facilities, Southampton)

Kilbourne, Byron Lee (Applied Physics Laboratory, University of Washington)

Ledwell, James Robert (Woods Hole Oceanographic Institution)

Liang, Xinfeng (Lamont Doherty Earth Observatory)

Mackay, Neill (University of East Anglia)

Messias, Marie-José (University of East Anglia)

Naveira Garabato, Alberto Carlos (National Oceanography Centre, Southampton)

O'Donnell, Christopher (University of East Anglia)

Provost, Paul Graham (National Marine Facilities, Southampton; STO)

Rolley, Leighton (National Marine Facilities, Southampton)

Sallée, Jean-Baptiste (British Antarctic Survey)

Sheen, Katy Louise (National Oceanography Centre, Southampton)

Smeed, David (National Oceanography Centre, Southampton)

Thurnherr, Andreas (Lamont Doherty Earth Observatory)

Waterman, Stephanie (National Oceanography Centre, Southampton)

Watson, Andrew James (University of East Anglia)

White, Stephanie Anne (Florida State University)

Woodward, Stephen Colin (University of East Anglia)

1.2. Ship Personnel

Gatti, Antonio (Master)

Gauld, Philip Douglas (Chief Officer)

Mitchell, John Woodruff (Second Officer)

McClintock, Liam (Third Officer)

Lucas, Robert (Chief Engineer)

Hagan, John Andrew (Second Engineer)

Maclean, Innes (Third Engineer)

Silajdzic, Edin (Third Engineer)

Hawksworth, David (ETO)

Gregory, Joanna (Doctor)

Stevens, Anthony (PCO)

Minnock, Michael (CPOS)

Pook, Glenn Alan (CPOD)

Maclean, Andrew (POD)

Crabb, Gary (SG1A)

Price, David Anthony (SG1A)

Jennings, Aidan (SG1A)

Smith, Peter (SG1A)

Hillier, Leslie James (ERPO)

Keighley, Christopher (H/Chef)

Whalen, Amy Kerry (Chef)

Mingay, Graham (Steward)

Patterson, Thomas (A/Steward)

1.3. Overview and Rationale for JC054

RRS James Cook cruise JC054 was the second UK cruise undertaken as part of the DIMES (Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean) programme, a major UK/US field programme aimed at measuring mixing along and across the tilting isopyncals of the Antarctic Circumpolar Current. The rationale for DIMES derives from the role of the ocean's overturning circulation as a critical regulator of the Earth's climate. Climate models are highly sensitive to the representation of mixing in the Southern Ocean, where this overturning circulation is closed, but the lack of extensive *in situ* observations of Southern Ocean mixing has made difficult the quantification of this mixing and the elucidation of the processes responsible. DIMES will obtain measurements that will quantify both along-isopycnal eddy-driven mixing and cross-isopycnal interior mixing. Full information on DIMES is available at http://dimes.ucsd.edu/

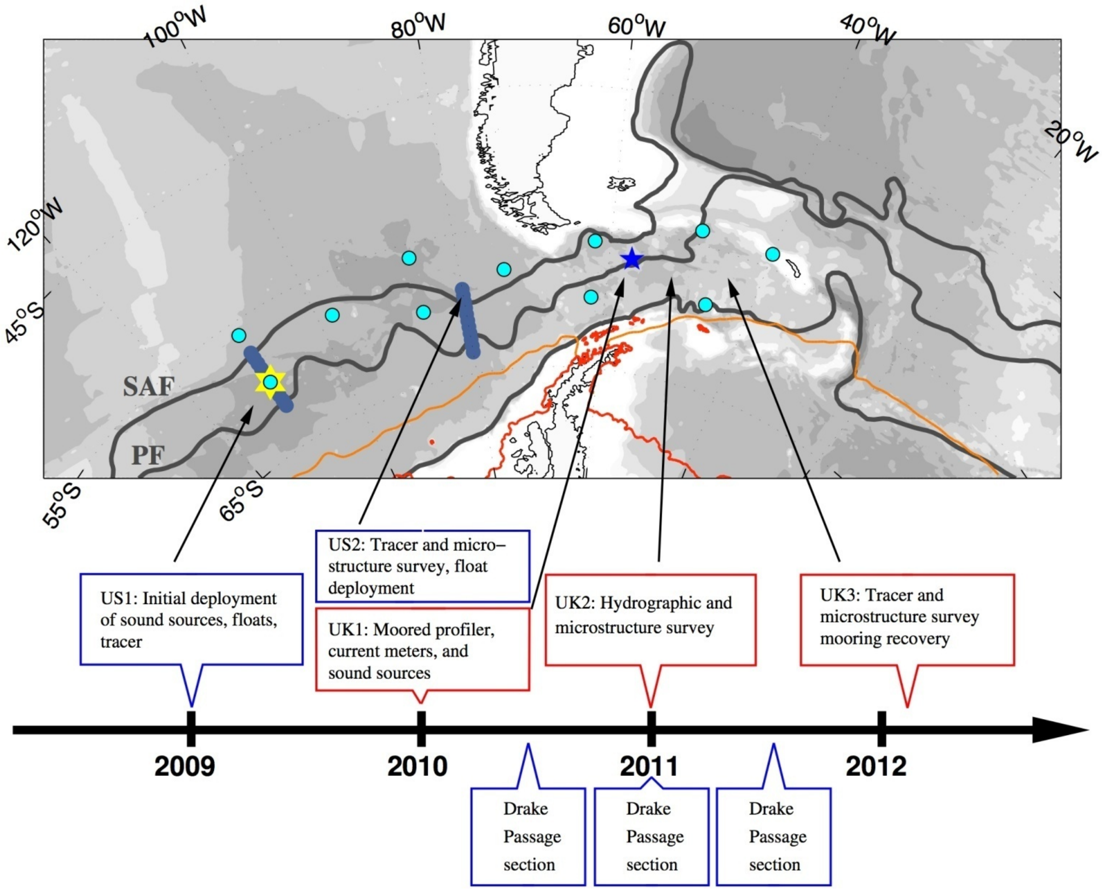


Figure 1.1. DIMES fieldwork timeline, and location of UK2 (JC054) therein.

A range of observational techniques is being used as part of DIMES. These include the purposeful release of a passive tracer (CF_3SF_5) in the southeast Pacific, with subsequent tracer mapping cruises to track and quantify the spreading of the tracer in four-dimensional space as it transits through Drake Passage and the Scotia Sea. Deployments of isopycnal-following floats and surface drifters are being made, and measurements of ocean microstructure and finestructure taken, the results of which will inform on stirring, dispersion and mixing. A mooring cluster in Drake Passage has been deployed, with the purpose of investigating the interaction of mesoscale eddies with internal waves. A range of other techniques is also being used, including analysis of conventional CTD and profiling float data, inverse analyses, theoretical and model studies, and analysis of satellite altimeter data.

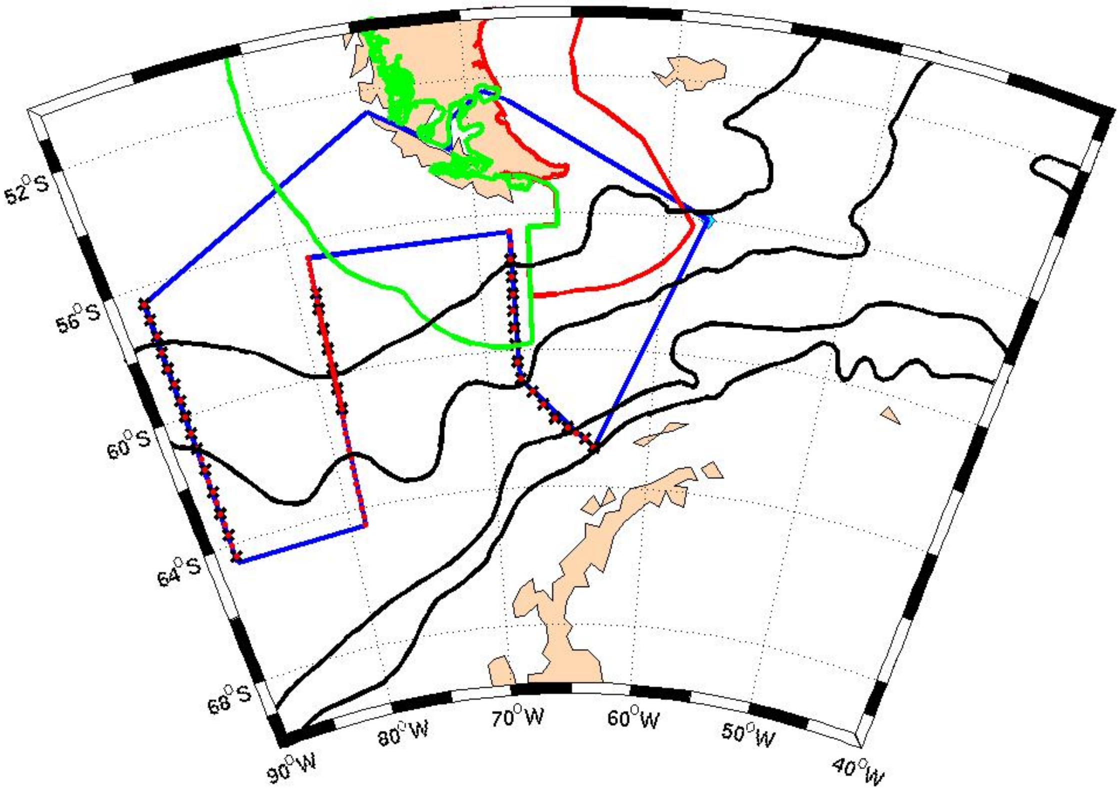


Figure 1.2. Intended cruise track for JC054 (DIMES UK2).

The specific purposes of cruise JC054 (DIMES UK2) were (a) to recover and redeploy the DIMES mooring cluster in Drake Passage, (b) to conduct a closely-spaced grid of hydrographic/tracer/microstructure measurements at the mooring cluster location, (c) to collect sections of hydrographic/tracer/microstructure data across Drake Passage and two other meridional lines in the southeast Pacific, and (d) to deploy a range of floats and drifters in strategic locations within the DIMES field area. The cruise track was evolved taking into consideration the territorial waters in which we were allowed to work, the need to map the DIMES tracer adequately in space, and the need to generate hydrographic data from which the DIMES inverse analyses could be conducted. Figure 1.2 shows the cruise track as planned at the time of sailing. The actual cruise track completed was to deviate from this quite significantly (see Frontispiece, page 1).

1.4. PSO Narrative

25 November 2010

James Cook arrived in Punta Arenas and anchored offshore, there being no space at the jetty for her to moor alongside. Boat transfers were used to disembark science party from JC053 and exchange some officers and crew. The advanced party for JC054 have to wait and watch, currently unable to board.

27 November 2010

James Cook came alongside in Punta yesterday evening, around 1800. Demobilisation of JC053 slowed by a few technical challenges with e.g. hatch covers; this, and the delay in coming alongside, meant a slower start to mobilisation of JC054 than envisaged, but hopefully not critical. The WHOI container was put onto the ship in the evening, and four of us were around to begin unloading (Meredith, Ledwell, White, Wienders), with help from NMF and crew. An empty container was put aboard for storage of floats and driters during cruise. Ledwell now able to start constructing his tracer chemistry gear.

28 November 2010

Mobilisation continues. The UEA tracer container was placed on aft deck; some issues with powering it, but a suitable cable eventually found. Small issue with a missing NOC VMP laptop, but a work-around was found (a BAS MacBook is being adapted for purpose).

29 November 2011

Issue with an electrical part for one of the ship's engines is requiring a new unit to be shipped from the UK. This will hopefully arrive 1 December (Wednesday), so sailing will be delayed until at least then. Ship can function on just three generators (indeed normally runs on just two), but for the Southern Ocean the full capability is needed in reserve, it seems. Not a great start.

30 November 2010 (Prof. Andrew Watson FRS's birthday)

Sailing to bunker was postponed due to high winds. The PSO gave a presentation in the afternoon about the scientific background for the work we are going to do, and some more details on the specifics of who is doing what. Wind dropped and we sailed around 1700 and headed along the coast to bunker. Moored overnight at bunker terminal.

1 December 2010.

A frustrating day spent at the bunker terminal, waiting for the replacement generator part to arrive, and for the strong winds to abate. All this waiting around means that mobilisation is nearly done, and everyone's gear is almost ready, but we are now eating into science days. Byron Kilbourne's floats do not seem likely to make it to the ship in time, even with the delays – a disappointment for him, and us.

2 December 2010

Another frustrating day spend at the bunker terminal in Punta – we are all questioning how long this is this going to last. Float tests on the VMPs conducted in the afternoon, both successfully. Word from NERC is that no extension to the cruise will be possible, despite the very delayed sailing – deeply disappointing. Ship moved back to the jetty at Punta in the evening, to take on water and await the arrival of the seemingly-mythical replacement part.

3 December 2010

So, the generator part arrived, at long long last, but doesn't seem to have cured the problem. Deeply disappointing, again. There is talk of an engineer needing to fly from the UK to work on the problem, which would add further delays to starting the science. NERC seem adamant that extending the tail end of the cruise is not possible, so there is much discussion of which elements of the programme should be retained and which can be sacrificed – but until we have sailed properly and we know exactly how much time has been lost, there is very little replanning that can be done. Very frustrating for all onboard.

4 December 2010

Ship sailed at 0600 this morning. The generator problem is still not solved, but the engineers want to conduct some tests that cannot be performed while alongside. We are all keeping our fingers crossed for a positive outcome; if it goes well, we will continue on to the science area. Windy and choppy, but the ship motion seems almost a relief having been in port so long.

5 December 2010

Tests seemed to go okay, the engineers proclaimed themselves to be "as happy as they can be". We didn't dare ask for more clarification; the upshot seemed to be that we can carry on toward the science area and begin the cruise in earnest. Day spent steaming at up to 14 knots, to try and recover some of the lost time. Planned VMP tests were not conducted in the afternoon, since there is a chance of reaching the site of the first mooring close to first light tomorrow, and we need to maximise the probability of getting three moorings lifted in the day. Muster and boat drill in the morning, which kept people suitably entertained for an hour.

6 December 2010

Reached site of the first mooring close to daybreak, so no chance for a test CTD before moorings operations commenced. Took a couple of attempts and some searching, but mooring NE was lifted, all intact bar a flooded RCM and some destroyed buoyancy. Unfortunately though, upon examining the data, it seemed that the loss of the buoyancy meant that the mooring crumpled to the seabed around 50 days after deployment – a disappointment. Moved on to mooring SE, which was successfully recovered with a couple of damaged current meters. Weather at moment is murky but calm, but forecast is for some lumpiness overnight and into tomorrow – so pressure is on to make the most of the benign conditions while we can. Moved on to mooring M, and after some debate concerning the fog, it was released and spotted at the surface relatively easily, and was duly recovered.

7 December 2010

Work was halted overnight due to the conditions, but they abated relatively quickly, and a full-depth CTD was conducted at site G1.1 before daylight (no VMP). Mooring SW was then lifted, but seems to have suffered the same problem as mooring NE – destroyed buoyancy, with the instruments falling to the seabed. It seemed to happen at around the same time, within a few days, raising the likelihood that it was due to an extreme knock-down event. Mooring C was lifted, and despite being on a straight line between SW and NE, it seems to have survived intact – a relief.

8 December 2010

VMP tests conducted overnight. The test of the WHOI one was not successful, with weights being dropped early and other problems occurring. The sea state precluded testing the NOCS VMP straight after, so a repeat of CTD G1.1 was conducted, with the rationale that a tantalizing hint of tracer may have been found on the first occupation, but was only in one bottle so its presence could not be confirmed. Moved on to G1.2 after 1.1, and deployed VMP and CTD. All worked, but there was a problem with a couple of bottles not closing properly. Jim has tried changing the length of the lanyards; will see what impact this has. Could move them to different positions on the rosette if remain problematic. Moved to G1.3. VMP deployment delayed by weights releasing themselves on deck, but once fixed both VMP and CTD were deployed.

9 December 2010

Much interest with the growing realization that DIMES tracer is detectable at the stations on our grid, albeit at very low concentrations. This was not fully expected, although it had certainly been hoped for, and there has been a lot of discussion concerning whether extra stations can be inserted between the grid and the southern end of Drake Passage, in order to map the tracer across the SAF and PF in this region. No decision yet, because timings remain very tight after the delay due to the engine problems. Tourist highlight of the day was the James Cook being passed by the James Clark Ross early this afternoon. She had been conducting part of the annual SR1b hydrographic line, and was steaming north to Stanley. Working around the grid with VMPs and CTDs continued. The CTD at site G2.3 was aborted early, since the VMP had begun ascending prematurely and we did not want to risk losing it at the surface while waiting for the CTD to finish. The CTD was recommenced after the VMP had been recovered.

10 December 2010

A very frustrating and depressing day. Problems with the generators and electrics in the early hours have demonstrated that the issues present before we sailed are still live. The decision was taken to return to Punta Arenas, and have an engineer fly down to investigate. It is not clear how much time we will lose, but is likely to be order of a week minimum. Much communication between ourselves and NERC concerning how to handle this and try to meet the science goals of DIMES.

14 December 2010

Past few days have been somewhat trying for all involved. James Cook returned to Punta Arenas, and the scientific party did what work could be done en route, including running the samples that had been accumulated and looking through the moorings data that had been recovered. Some entertainment was possible yesterday, specifically a visit to the Pali Aike National Park, which was certainly impressive and also perhaps the windiest place that many of us had ever experienced. The news as of now is that the fault has still not been traced completely, but that things appear more stable after some of the changes that have been made. We may sail tomorrow.

16 December 2010

Didn't sail on the 15th, but finally did on the 16th. The hoped-for sailing on the 15th almost happened, but immediately after leaving the jetty at Punta Arenas, the instruction came through from the UK to bunker with maximum fuel. This was perceived as a good thing, indicating perhaps use of all generators for the rest of the cruise, or even possibly an extension. It did, however, necessitate an overnight stay followed by moving to the bunker terminal on the morning of the 16th. After bunkering, a quick trip back to PA was required to deposit three SAPs that had been sent to the Cook by mistake – they should have been destined for JCR. After this, we sailed in earnest and headed back toward the moorings site. The good news of the day was that NERC and BAS have arranged for us to have some time on James Clark Ross in March/April, so as to enable us to conduct the science that we no longer have time to do on JC054. Current plan is to complete as much of the cruise as possible prior to the planned end date of Jan 8th, and leave one section in the SE Pacific to be done from JCR. This news came as a relief to all involved, since it means that (barring any more problems) a decent mapping of the tracer can still be achieved this season.

17 December 2010

A calm, sunny day, and with four generators going the ship was at times making 16 knots toward the moorings sites. People readjusting their sleep patterns so as to resume watchkeeping when we reach the science area. In the afternoon, a muster was called, followed by familiarization with life rafts and a safety training video. Not especially cheerful, but these things never are.

18 December 2010

We reached the mooring grid around lunchtime, and recovered the SAMS mooring first before deploying mooring C. There was thought of deploying mooring NW also, but nightfall was approaching and the fear was that, if difficulties were encountered, it could end up being deployed in the dark. Consequently we moved to position G5.4, at the southeastern corner of the grid, and commenced VMP/CTD/tracer stations. The intention is to redeploy the moorings and complete as much of the grid as possible before the evening of December 22nd, and then head south and west toward Drake Passage but conducting some extra tracer stations along the way.

20 December 2010

Moorings NW, M and SW successfully deployed yesterday, thanks to sterling efforts from the NMF team, followed by the remaining two moorings (SE and NE) today. Quite a relief to get them all done, especially for the NMF group who can now spread out among the watches and not have to focus their efforts quite so intensively during daylight. VMP/CTD/tracer stations around the rest of the grid were resumed, with the decision made to skip G4.3 to try and save some time, and also to avoid potential problems with the mooring we have deployed at that location. We were joined by a whale at site G4.1, which was variously identified as a humpback or a sei. There were also claims of a great white shark at the same site, possibly of slightly more dubious authenticity. More details of the JCR "rescue" cruise for DIMES UK2 came through today – it appears we will be sailing on April 8th, or slightly before, again from Punta Arenas. Demob port will be Stanley; not as desirable as Rothera, but will still be a welcome change from PA, of which we have all seen far too much lately.

22 December 2010

Work around the grid continued over the past couple of days, with mercifully not much by way of interruption from the weather. Aside from G4.3, all the planned stations were occupied, and pretty much to time. Once done, some time was spent triangulating the positions of the moorings, followed by some drifter and float deployments as part of the AARDVARK programme. This marked the end of the time spent at the grid, which seems now to stretch back almost into eternity. We headed off in a south and west direction to conduct the shallow extra CTD/tracer stations, and onwards toward the southern end of our Drake Passage section. Much speculation concerning when/if we might see icebergs.

23 December 2010

Work on the S0 line commenced, with shallow CTDs (down to the level of the tracer rather than the seabed) in a line south and west from the grid. No VMPs were conducted at these stations. The tracer data from these proved fascinating, in that concentrations were markedly higher than on the grid, and remained high across the Polar Front. This prompted a responsive addition of a CTD at the end of the S0 line, to establish whether the tracer concentration had diminished south of the PF. This was conduced overnight on the morning of the 24th.

24 December 2010

Aside from the overnight CTD/tracer station, the day was spent steaming toward the start of the S1 line (Drake Passage). The decision was made to conduct this line south-to-north, to hopefully avoid the bad weather brewing at the north side of Drake Passage. This gave people chance to catch up on data processing and running backlogs of samples. Some also entered into the Christmas spirit by constructing model Santas, elves and reindeer. Very festive.

26 December 2010

Christmas Day was spent working, sadly, but the lack of time left on the cruise meant this was unavoidable. The plan now is to celebrate in earnest during the long steam to the west – the 29th or 30th – when people will have more time to enjoy themselves, and the night shift workers can hopefully adjust their clocks a little so as to be able to join in. Stations were conducted along the southern part of our Drake Passage line, but so far no sightings of icebergs. During Boxing Day, stations continued, and it became increasingly clear that we were going to be extremely pushed for time if we were going to complete everything planned. Accordingly, we began dropping some stations, and have begun discussions concerning moving the westernmost line planned onto the middle line, in order to save a couple of days' steaming time. Not ideal, but almost all cruises involve making compromise choices at some point, and given the generator problems we had at the start it was inevitable that we would have to also.

28 December 2010

Progress made northward along our Drake Passage section over the past couple of days. It has seemed frustratingly slow at times, but we are getting there. On the afternoon of the 27th, work was halted temporarily because of a large swell; eventually this subsided and a VMP was deployed, followed by a shallow (tracer depth) CTD. On the evening of the 28th, the VMP took much searching for once at the surface, which lost us a little more time, but not a critical amount. The decision was taken to conduct our western transect along the original planned position of the middle transect, to save steaming time – this appears our only realistic option of getting a decent set of measurements upstream of Drake Passage on this cruise.

29 December 2010

Bright and sunny but with a large swell, which hampered our progress northward between stations, and led to some debate about whether the CTD was safe to deploy at times. In the afternoon, a VMP surfaced and was spotted but was then lost in the waves while the CTD was being brought up and recovered. This then took some extensive searching before eventually being sighted – a nuisance given that we are behind time already.

30 December 2010

More stations done, but the large swell has meant progress has been rather slower again. And more problems with VMP recovery – again it was the WHOI instrument that took significant searching for, though part of the delay was well-used with the deployment of four EM-APEX floats. The thought is now to use the NOC VMP preferentially since it has a slower fall rate and hence should surface closer in time to the CTD.

31 December 2010

Christmas Day was finally celebrated onboard the James Cook, albeit on New Year's Eve. The Drake Passage line was finished yesterday evening, and we are now steaming south and west toward the start of our 79W section, which provided enough downtime for enough people to make a celebration possible. The galley team did us proud, with an excellent Christmas lunch, preceded by champagne, and with the pub quiz in the evening. The traditional ringing of the ship's bell happened at midnight, with Jim having the honour of ringing out the old year, and Tom the new. A very welcome day of rest and recreation, for most of the scientists at least.

1 January 2011

New Year's Day 2011 was spent steaming further south and west into the Pacific, to the start of our 79W section. With no scheduled science, it enabled people to catch up on the backlog of work that had accumulated, and to catch breath before the final week of the cruise. In the evening, we had a science meeting in the conference room, giving us chance to take stock of what we had achieved, and for each of the individual groups on board to present their data and preliminary thoughts about what they might mean.

2 January 2011

Work recommenced soon after midnight. The VMP was deployed, as was the CTD - but the latter was not successful: a problem with the winch meant it had to be recovered when only around 800m down. Bottles were closed on the way up, and showed small but measureable concentrations of tracer. We moved onto the next station on the line (S2.2) to conduct a shallower (2500m) station. The decision was made not to try for a deep CTD station here despite the failure at S2.1, since the VMP from 2.1 should provide near full-depth hydrographic data and hopefully meet the requirements for the inverse analyses. Problems with bottle firings on S2.2 meant that tracer data were compromised. To cap a miserable day, winch problems (an oil leak) led to a delay in S2.3. We replanned section S2 to now cover 13 stations instead of the originally-intended 15, since time is against us.

3 January 2011

Beautifully sunny and mercifully calm, with work continuing northward along line S2.

5 January 2011

Work continued northward along the S2 line, but the predicted weather closed in, and strong winds and a building sea prevented deployment of any gear at site S2.12. The decision was made to keep steaming northward, since it was not clear that the ship would be able to hold position against the conditions we were encountering on dynamic positioning alone. The intention was to assess our position when the sea had calmed sufficiently to enable work to resume, and decide then whether to move back along the line or continue from where we found ourselves. Unfortunately, we never reached the point of making this decision since the seas continued to grow, with winds reaching a maximum of 60 knots and wave heights of up to 45 feet being encountered. This effectively spelt the end of the measurements along line S2, and at 2am overnight the decision to head back to Punta Arenas was taken. A shame to end not with a bang but with a whimper, but so it goes.

6 January 2011

Conditions abated during the day, and the sea became progressively more benign. By mid-afternoon, it was suitable for deploying gear again, and although we are now a long way from our planned sections, we decided to conduct a joint dip of the NOC and WHOI VMPs, for intercomparison purposes – this should prove useful in deriving a homogeneous dataset from this cruise, and across DIMES as a whole. Continuing toward Punta Arenas.

7 January 2011

Cruise now being wound up; much packing and dismantling of gear. The ship entered the western entrance of Magellan Strait shortly after first light, and progressed along as the day continued. Fine weather brought lots of people onto the forecastle deck, and they were rewarded with some excellent sightings of whales, dolphins and penguins. Container stuffing continued, with gear for transfer to JCR being backfilled into a container on the aft deck.

1.5. Acknowledgements

JC054 was a challenging and at times deeply frustrating cruise for all concerned, and the technical problems encountered meant that less was achieved than we had hoped for. Nonetheless, a large quantity of high-quality data was still obtained, and will enable the work of DIMES to be significantly progressed. I am very grateful to all on board who enabled this to be achieved. I am particularly grateful to Captain Gatti for remaining calm and sympathetic to the science throughout. As PSO, I also express my sincere thanks to the scientific party, who remained positive and supportive during testing times, and to the NMF team for working tirelessly in support of the science.

2.1. Navigation

Chris O'Donnell and David Smeed

A number of different navigation systems were in use on the *RRS James Cook* during JC054. The data from these were recorded on the Techsas data logging system. All data are recorded approximately once per second.

Techsas Datastream	**Mstar nav directory**	**Comments**
position-Applanix_GPS_JC1.gps	posmvpos	Primary navigation. Used by VMADCP
position-DPS-116_JC1.gps	dps116	Ship's primary GPS
position-Seapath200_JC1.gps	seapos	Started on day 343
cnav-CNAV.GPS	cnav	Correction needed for format error
shipattitude-Aplanix_TSS_JC1.att	posmvtss	Applanix attitude data
shipattitude-Seapath200AT_JC1.att	attsea	Seapath attitude data
GPPAT-GPPAT_JC1.GPPAT	ash	Ashtec GPS position and attitude
gyro-SGYRO_JC1.gyr	gyros	Ship's gyro
gyro-GYRO1_JC1.gyr	gyropmv	Gyro – heading data from Applanix
EMLog-log_chf_JC1.EMLog	log_chf	EM log
VDVHW-log_skip_JC1.Log	log_skip	EM Log

Table 2.1. Techsas streams for navigation data and the corresponding 'mstar' directory to which the data were downloaded.

There are 5 different GPS systems. CNAV uses Satellite Based Augmentation Systems and provides DGPS corrections for the other systems. The Seapath and Applanix systems are "inertially aided" systems and also produce attitude data. The Applanix POS MV is the primary system used for science. The Applanix position and attitude data is fed into the VM ADCP data and the position is also recorded in the CTD data. The DPS116 is the primary system used for the ship's navigation.

Data were retrieved daily from the Techsas using the mstar script 'mday_00'. This creates a raw mstar file for each data stream with name <var>_<cruise>_d<day>_raw.nc. Most data streams were appended into a single file for the cruise with name <var>_<cruise>_01.nc. However, some streams were processed as follows:-

1) The CNAV data were written to the Techsas as integer degrees with minutes following the decimal point. These were corrected to be decimal degrees, the same format used for all other streams.

2) Ashtec and gyro data were merged to enable correction of the gyro heading. There was a large gap in the Ashtec data on days 368 and 369.

3) A 'bestnav' file was created, using 30 second averages of the Applanix position data as its core input.

2.2 Surface Meteorological Sampling System (Surfmet)

Chris O'Donnell and David Smeed

The surface meteorological conditions were measured throughout the cruise using the Surfmet package. A brief discussion of the performance of the meteorological sensors is given in this section.

2.2.1 Instrumentation

The *RRS James Cook* is instrumented with a variety of meteorological sensors to measure air temperature and humidity, atmospheric pressure, short wave radiation, and wind speed and direction. These are logged as part of the Surfmet system. The meteorological instruments were mounted on the ship's foremast in order to obtain the best exposure. The heights of the instruments above the foremast platform were: Gill WindSonic anemometer, 2.3 m; Vaisala air temperature and humidity 1.85 m and the irradiance sensors 1.38 m. Section describes the setup, configuration and troubleshooting of the instruments in detail.

2.2.2 Routine Processing

Files were transferred from the onboard logging system (Techsas) to the UNIX system on a daily basis, using the script mday_00_get_all.m. The raw Surfmet data files have names of the form met_jc054_d***_raw.nc, where *** represents the day number.

True wind speed and direction were calculated using the script mtruew_01 as follows. Bestnav navigation data were merged onto the timings of the Surfmet data. To avoid problems associated with averaging wind direction over time, the relative wind speed, ship's heading and course made good were converted to eastward (u) and northward (v) components, using the script muvsd.m. The true wind direction was calculated and the data were averaged into 1-minute bins and saved in the file met_JC054_trueav.nc

2.3. Single-beam Bathymetry

The Simrad EA600 single beam echo-sounder data was processed on a daily basis using an interactive editor to remove spikes. There are sometimes gaps in the data for any of several reasons: the instrument was often turned off during VMP casts, sometimes the correct range was not set, or the data were very noisy due to the speed and movement of the ship.

2.4. Underway Temperature and Salinity

Chris O'Donnell and David Smeed

Near-surface oceanographic parameters were measured by sensors located in the non-toxic supply. The sea surface temperature (SST) was measured at a depth of 5.5m below the sea surface. This section describes the calibration of the underway temperature and salinity measurements.

Variable	Instrument	Serial number	Sensor position	Accuracy
Thermosalinograph - housing temperature	SBE45 MicroTSG	0233	Water sampling room	
Thermosalinograph - conductivity	SBE45 Micro TSG	0233	Water sampling room	
Sea surface temperature	SBE38 Digital Thermometer	0476	Near intake	
Fluorescence	Wetlabs Fluorometer	WS3S-246	Water sampling room	± 0.66mV
Transmittance	Seatech Transmissometer	CST-1132PR	Water sampling room	

Table 2.2: Underway SST, SSS, fluorescence and transmittance instrument details.

2.4.1 Calibration of Underway Sea Surface Temperature

The SST measurements were compared to the surface temperature measurements from the sensors on the CTD frame. The depth of the intake for he TSG system is ~5.5m hence CTD measurements were selected between 4db and 8db for comparison. Figure 2.1 shows that the remote temperature sensor overestimates the CTD measurements by

0.023°C (s.d. 0.014). The offset was near constant over the temperature range encountered during the cruise.

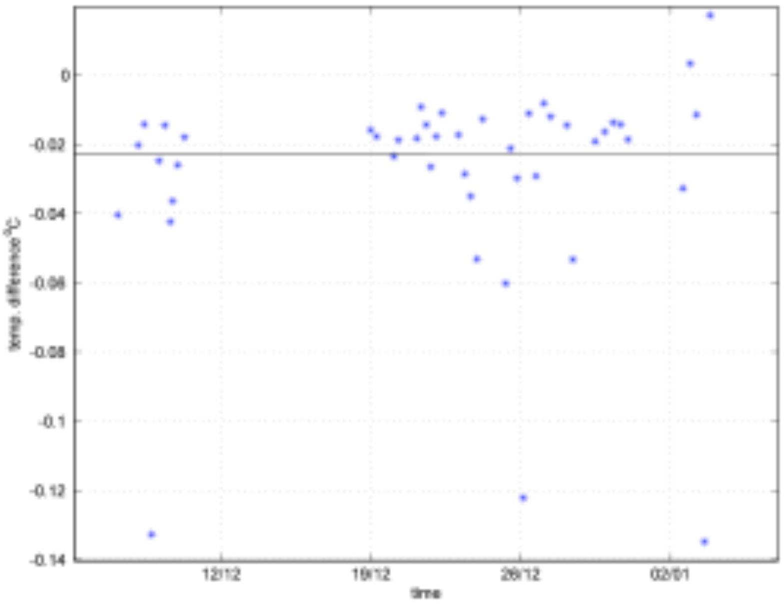


Figure 2.1. Difference between CTD temperature and TSG temperature for the duration of cruise JC054. The interruption of the cruise due to engine problems explains the absence of data near the middle section.

2.4.2 Calibration of Underway Salinity Data

Two approaches were taken for the calibration of the underway salinity data. The salinities measured by the SBE45 were compared with; 1) salinity samples collected from the non-toxic water supply outflow, and 2) the surface salinities measured from near-surface CTD.

The bottle salinity values and times of the measurements were imported into a file in mstar format for comparison with the TSG. Salinity data from the CTDs was also compared with the TSG, with the CTD data selected as per the criteria outlined in 2.4.1.

On average the TSG salinities were greater than both the bottle salinities and the CTD salinities (Figure 2.2). There appears to be a slight drift with the TSG salinity tending to increase relative to both the CTD and bottle samples during the cruise. On average (after removal of outliers) the TSG was 0.006 PSU saltier than the bottles samples with a standard deviation of 0.004. The mean difference relative to the CTD data was 0.008 with a standard deviation of 0.002.

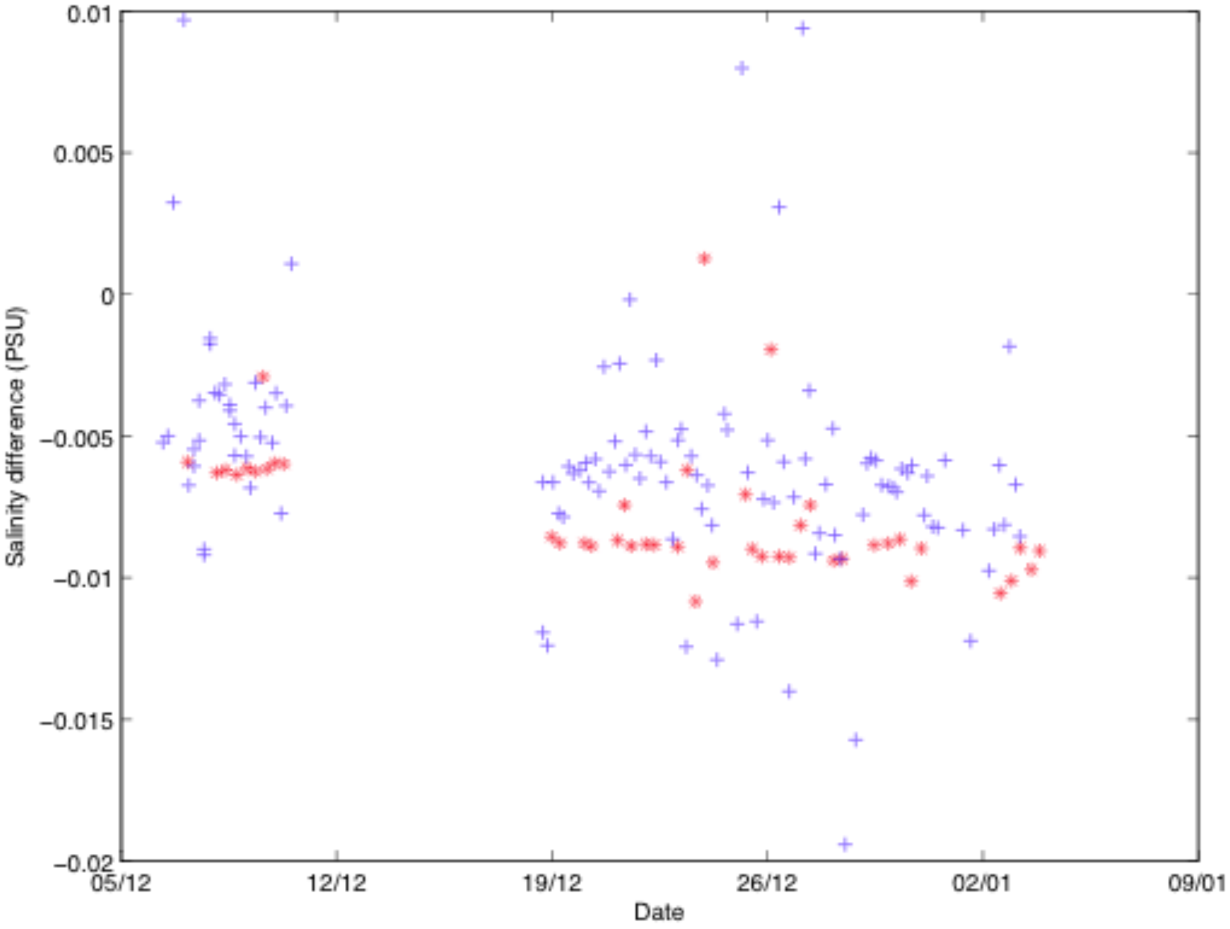


Figure 2.2 Difference between the TSG salinity and the bottle samples (blue crosses) and CTD salinities (red stars). The interruption of the cruise due to engine problems explains the absence of data near the middle section.

2.5. Multibeam Bathymetry

Nathan Cunningham, Leighton Rolley and Peter Keen

2.5.1 EM120 Operation

The acquisition system functioned satisfactorily throughout. A full report on its operation is given in Section 7. The EM120 was used opportunistically throughout the cruise. This means that the bathymetry data produced were collected not at optimal conditions. The Science System Technician Report outlines the compromises made.

2.5.2 Depth Processing using MB-SYSTEM

Swath bathymetry data for the entire cruise were cleaned and processed using MB-System v5.1.3 MB is primarily a Unix command line package used to process a wide variety of bathymetry data formats. One main advantage of the program is that different bathymetry sources can be processed and gridded together. It is closely integrated with GMT (Generic Mapping Tools), with most of the plotting and grid commands outputting GMT scripts that can be run ‘as is’ or modified if needed. After MB has been set up (setup mb at the Unix command line), an overview of the program can be found by typing man mb_system. It is advisable to setup GMT at the same time.

Setting up the laptop:-

The laptop used VMWare Player v3.1.3 to run Centos 2.6.18. The data paths for the James Cook backed up central work drive were setup up by modifying fstab to access /etc/drobo. Now fstab contains the following:

```
  LABEL=/                    /                   ext3    defaults        1 1

  tmpfs                      /dev/shm            tmpfs   defaults        0 0

  devpts                     /dev/pts            devpts  gid=5,mode=620  0 0

  sysfs                      /sys                sysfs   defaults        0 0

  proc                       /proc               proc    defaults        0 0

  /dev/cdrom/                /media/cdrom        auto    ro,noauto,user,exec   0 0

  192.168.62.11:/data/JC54   /home/pdc/techsas   nfs     defaults      0 0

  //drobo-fs/public          /home/pdc/drobo     cifs    username=pstar,password=pstar
0 0

  LABEL=SWAP-sda2            swap                swap    defaults        0 0
```

The drobo mount was added to /home/pdc/drobo as the mountpoint.

Symbolic links added /home/pdc that point to the em120 and MB directories on the drobo.

```
  ln -s drobo/JC054/Acoustic/EM120/mb_processed_data/ mb

  ln -s /home/pdc/drobo/JC054/Acoustic/EM120/JC054/JamesCook em120
```

The following steps were used to process the raw data into gridded output.

Copying the data:-

EM120 data corresponds to MB format 56. The MB manual suggests that this format does not contain the necessary space to flag/unflag bad data and advices that all such data be copied into MB format 57. This was accomplished using the following assuming that you are in the raw data directory (see fstab and symbolic links above):

```
 cd /home/pdc/em120/2010/12/06

 foreach f (*.all)

       mbcopy -F56/57 -I$f -O/home/pdc/mb/mb57/$f.mb57

 end
```

The 9999.all.mb57 was removed from /home/pdc/mb/mb57

A list of all the .mb57 in the /home/pdc/mb/mb57 directory was made using:

```
 ls *.mb57 > datalist.mb-1
```

Creating auxiliary files:-

Auxiliary files are created to make other processes such as cleaning and gridding quicker to complete. In this and other processes files are created with the same root name but with different suffixes. Three types of files are created;

- .inf files contain basic header information for each file (lat/lon limits, min/max depth etc),
- .fbt contain bathymetry data in a form more easily processed by MB
- .fnv contain navigation data in a similar format.

All three are created using the following command within the directory containing the .mb57 data:

```
mbdatalist -Idatalist.mb-1 -Z -O
```

Cleaning the data:-

Data can be cleaned automatically or manually. The command mbclean has various options to run through the raw data and remove bad pings. The following was used to clean the data:

```
mbclean –Iraw_datalist.mb-1 –F-1

      -A100 (absolute deviation away from a median depth –100m here)

      -B500/5000 (simple high/low filter – only accept 500m – 5000m here)

      -C1 (maximum ping to ping slope angle – tan-1 1 = 45°)

      -G0.9/1.1 (proportional deviation from median depth)

      -M1 (flags the ping rather than zeroing it)

      -X5 (flags last 5 pings at either end of the swath ping)
```

There are many other options found in the mbclean man pages. Data collected on JC054 were cleaned using the above options but there was a tendency to remove too many pings that were considered good when inspected manually. The main culprits seemed to be the –A and –C options. Indeed, even with the slope option set to –C4 (>75°), there were still a large number of pings flagged for excessive slopes. Further testing of the mbclean command was undertaken to find a variety of options that will provide a light cleaning to both almost clean and very noisy data alike. Since the JC054 data were collected under variety of conditions, some times the swath is good and other times it is poor. Manual data cleaning was explored to preserve as much depth information as possible.

This was performed using a graphical editor within MB called by the command mbedit. This contains an intuitive interface where the user can flag bad data on a line by line basis. Generally the data collected on JR054 needed major cleaning, mostly of the outer beams and in some cases when the mbclean had flagged them outside the acceptable range

Both ways of cleaning the data create two additional files, a .esf file which holds the flagging information and a .par file which contains a whole variety of edits including cleaning and navigation fixes.

Fixing navigational errors:-

This was not a problem for the James Cook EM120 system as the GPS collected is very reliable. Additional editing such as applying sound velocity profiles (see next section for SVPs used) post data collection and editing sidescan data can be performed within MB but were not used during this cruise.

Quick Plot:-

Create a quick plot to look at the data and swath coverage.

```
mbm_plot -F-1 -I datalist.mb-1 -N
```

This creates datalist.mb-1.cmd.

```
./datalist.mb-1.cmd
```

To generate a postscript file. open this with kghostview

```
kghostview datalist.mb-1.ps
```

Copy this file to another name if you want to keep it.

Quick contour plot:-

Make plot to look primarily for contours that are jagged and irregular to signify data that requires editing.

```
mbm_plot -F-1 -I datalist.mb-1 -C -G1

./datalist.mb-1.cmd

kghostview datalist.mb-1.ps
```

Processing the data:-

The command mbprocess takes information from the .par file and processes the .mb57 data to produce a final output file. If the input file is called data.all.mb57, the processed file becomes data.allp.mb57. mbprocess also creates additional auxillary files (.inf, .fnv, .fbt). The command takes the form of:

```
mbprocess -Ifilelist.mb-1 -f-1
```

A text file containing the names of all the processed data can then be created (proc_datalist on this cruise). If at some point the user decides to go back and re-clean the data or edit the navigation for a single file, mbprocess can be run with the same command and it will process only the newly edited files.

Gridding the data:-
The command mbgrid with its associated options produces a user defined grid as well as a GMT script that can be run straight away or modified to take advantage of the range of mapping options available within GMT. However, the majority of GMT's functions are already embedded within the mbgrid command so it was generally unnecessary to alter the script produced. The command and some of the more common options are:

```
   mbgrid -Iproc_datalist -O 'filename'

        -R-80/-55/-65/-55 (bounding co-ords, min long/max long/min lat/max lat)

        -E500/500/meters (grid resolution; 500m in this case)

        -F1 (type of filter used; 1=gaussian weighting, 2=median weighting)

        -C5/1 (weight sonar footprint used to fill two gaps up to two times clip size

        -M (outputs separate grids of standard deviation and data density)

        -N (outputs null values as NaN. Useful for GMT and Matlab)

        -W2 (width of the gaussian weighting function: twice the grid spacing in this

        -A2 (bathymetry added as topography upwards)

        -G4 ARCGIS ASCII grid

        -T0.35 Sets tension used in thin plate spline.

        -P2 Sets averaging of input data

        -V Set process to verbose
```

The following was used to produce the output grid:

```
  mbgrid -Ifilelist.mb-1 -Oupto27dec -R-70/-55/-63/-55 -E500/500/meters -F1 -C3 -M -N -W2 -
Ktopo_all.grd
```

Running the command produces an output.grd and an output.grd.cmd. Running the latter GMT script produces output.grd.ps, which can be viewed in xv or ghostview. More advanced maps can be generated from the .grd files using the MB macro mbm_grdplot. Another macro, mbm_plot is also useful for producing initial plots of swath data and for constructing cruise tracks. See their respective man pages for more details of the options available.

2.5.3 Depth Processing of the Mooring Grid using the CARIS HIPS and SIPS Software

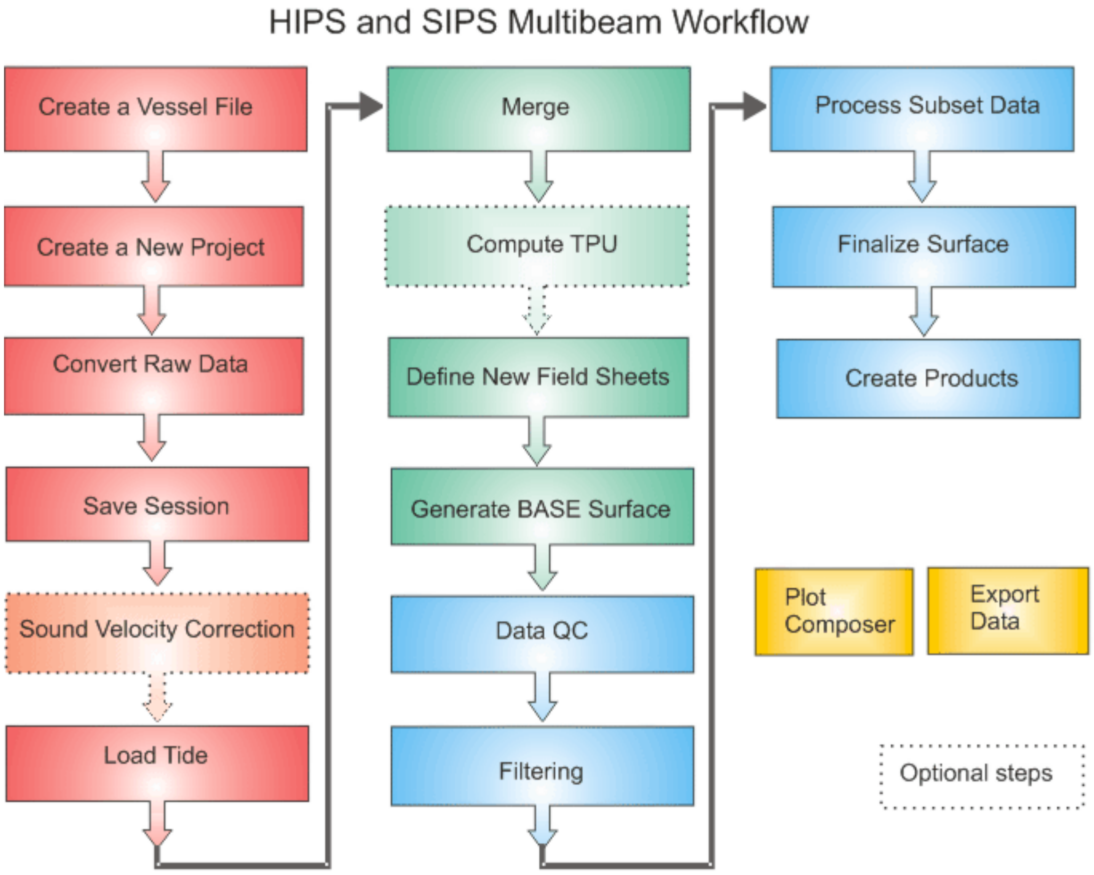
The development of HIPS and SIPS as a modern and powerful bathymetric and side scan sonar processing system was made possible through the cooperation of several organizations:

- The Canadian Hydrographic Service (CHS)

- The Ocean Mapping Group of the University of New Brunswick

- The National Oceanic and Atmospheric Administration (NOAA)

Figure 2.3 below shows the work flow followed for processing the mooring grid multibeam data. This work was a priority output of the opportunistic swath for JC054.



2.3. Figure 1. SIP and HIPS Workflow

The workflow was followed using the Caris_cheat_sheet.doc prepared by Leighton Rolley and the CARIS HIPS & SIPS 7.0 Users Guide.pdf to import the data for the mooring grid, clean it and create a finalised surface. Peter Keen manually cleaned all the nav files to produce a set of straight transects. The BASE Surface was cleaned following the Data QC guide notes from the user guide. Figure 2.4 shows the base surface layer, and Figures 2.5 and 2.6 show the cleaned mooring bathymetry in regular coordinates and also draped on Google Earth.

Mooring ground XYZ ASCII Output

The final product produced was an ASCII CSV file called Mooring_Groung_JC054.csv. The file was produced using the CARIS HIPS SIPS export wizard called BASE Surface to ASCII. It contains the latitude, longitude, depth (m) and an uncertainty value associated with the depth. The output was set to 1:10,000 with a resolution of 50m. The uncertainty value is derived from the standard processing outlines in the userguide. It shows the likely accuracy of each data point in metres. It was important to include this in the csv file as the swath was collected inconsistently due to the nature of opportunistic swathing. A readme file is provided with the XYZ that outlines how the uncertainty was derived.

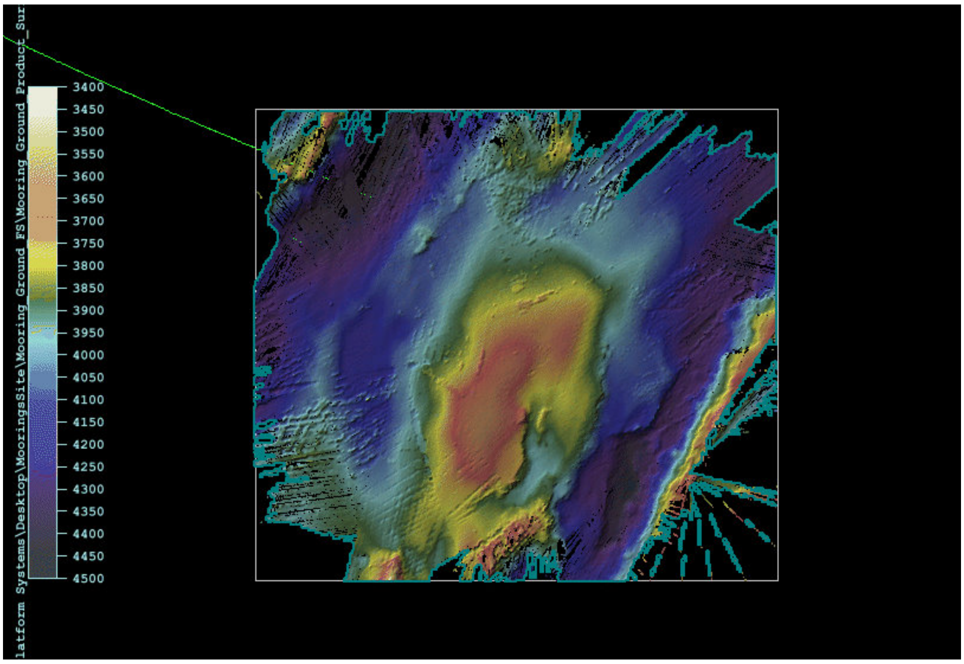


Figure 2.4. Output of the BASE Surface Layer

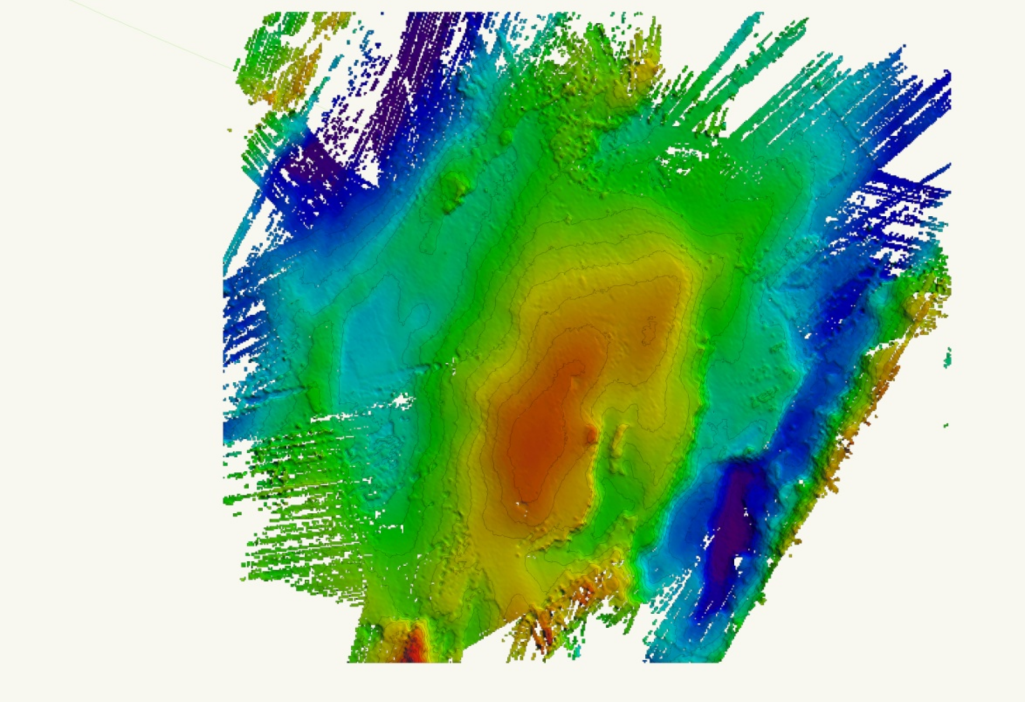


Figure 2.5. Output of the Product Surface (Cleaned)

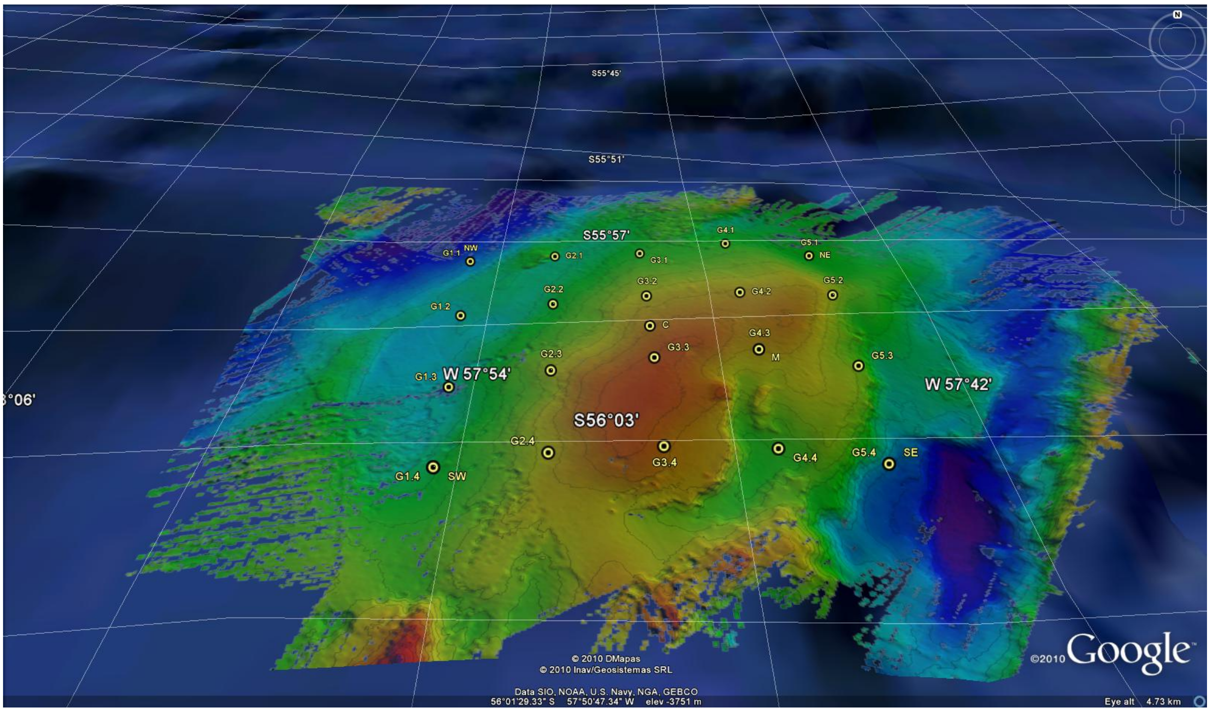


Figure 2.6 Output of the Product Surface draped on Google Earth

2.6 Vessel Mounted ADCP Instruments

Xinfeng Liang and Alex Brearley

2.6.1 Introduction

The two vessel-mounted Acoustic Doppler Current Profilers (ADCPs) onboard RRS James Cook were used throughout the cruise to estimate the horizontal velocity field. These instruments, installed on the port drop keel of the ship, are 75 kHz and 150 kHz Ocean Surveyor (OS) instruments supplied by Teledyne RD Instruments, Poway, California. The instruments can be operated with the keel either retracted or lowered (hereafter known as 'keel up' and 'keel down' respectively). The keel up position allows greater ship speed, as the vessel is limited to 10 knots with the keel down, but also exposes the instrument to more bubbles, which significantly reduces its profiling range. By contrast, in the keel down position, the influences of bubbles can be diminished but the ship speed has to be sacrificed. Due to the limitation of the cruise time, we chose to run the instruments with the keel up throughout the cruise.

The different frequencies of the two instruments affect both their depth range and resolution. The 150 kHz allows smaller depth bins and consequently higher vertical resolution, but the signal is more rapidly attenuated and typically only penetrates to ~500 m. The 75 kHz lacks such good vertical resolution but penetrates to ~1000 m.

2.6.2 Real Time Data Acquisition

The data from the two instruments were acquired using the RD Instruments VmDas software package version 1.42. This software is installed on two PCs in the main laboratory, which control the 75 kHz and 150 kHz Ocean Surveyor instruments respectively. The software allows data acquisition in a number of configurable formats and performs preliminary screening and transformation of the data from beam to Earth coordinates.

In order to collect data in VmDas:

1. Open VmDas from the Start Menu and click on "Collect Data" in the File Menu.
2. Under Options, click "Edit Data Options" and then set the configurable parameters. Under the ADCP setup tab, specify the relevant control file in Table 2.3. It is important each time the ADCP is restarted to increase the number in the recording tab by 1; otherwise VmDas may overwrite previously written files.
3. Recording commences by clicking the blue record button in the top left of the screen.
4. Collection stops by pressing the blue stop recording button in the top left of the screen. Data collection was supposed to stop and restart with a new ensemble number every 1-3 days during the cruise, as leaving it on the same file for more than three days allows the files to become too large and post-processing in CODAS becomes slow. However, due to the interference with the acoustic equipment on the microstructure profilers (VMP), both ADCPs were stopped and restarted frequently. There are thus too many files that last only several hours, especially in the first half of the cruise.

2.6.2.1 Files Produced by VmDas

The files we produced have names of the form OS<inst>_JC054<nnn>_<filenumber>. <ext>, where <inst> is the instrument name (75 or 150), <nnn> is the file sequence number, <filenumber> is the number of the file in the sequence and <ext> is the extension. We set a new <filenumber> to occur every time a file size of 10Mb was reached.

The list of files produced is given below:

- .ENR files are the binary raw data files.
- .ENS files are binary ADCP data after being screened for RSSI and correlation and with navigation data included.
- .ENX files are ADCP single ping data and navigation data after having been bin-mapped, transformed to Earth coordinates and screened for error velocity and false targets.
- .STA files are binary files of short-term average ADCP data (120s, user-specified in VmDas).
- .LTA files are binary files of long-term average ADCP data (600s, user-specified in VmDas).
- .N1R files are ASCII text files of raw NMEA navigation data from the NMEA1 stream.
- .N2R files are ASCII text files of raw NMEA navigation data from the NMEA2 stream.
- .NMS files are binary files of navigation data after screening.
- .VMO files are ASCII text files specifying the option settings used for the data collection.
- .LOG files are ASCII text files logging all output and error messages.

These files were stored in the C:\ADCP\Data\JC054 directory.

2.6.2.2 Real Time Data Monitoring

The ‘R’, ‘S’ and ‘L’ tabs on the VmDas menu bar allow you to swap between graphical output from the .ENR, .STA and .LTA files. When in ‘R’ mode, the default upper left hand display in VmDas is the raw velocity parallel to each beam, but this can be difficult to interpret as it is shown in beam coordinates. A more useful plot can be made in either the ‘S’ or the ‘L’ mode, displaying the current at a specified depth level as a stick plot in Earth coordinates. To produce these plots, ensure ‘Ship Track 1’ and/or ‘Ship Track 2’ is ticked in the Chart menu. The bins used in the stick plot are specified within “Options”, “Edit Display Options”. We used the NAV as the ship’s position source throughout.

The data can also be inspected in real-time using the WinADCP software, which loads the .ENX, .STA or .LTA files and displays the output as contour plots. The Monitor Option should be switched on with a suitable time interval (120s), meaning the contour plot is regularly updated. Plots of u and v were routinely examined throughout the cruise to check the data stream and to inform the bridge of ADCP measurements as required on station.

Several other things were also regularly checked whilst the ADCPs were recording:

- We made sure the ensemble number in the real time display of VmDas was increasing and that the size of the files in the C:\ADCP\Data\JC054 directory was increasing.
- We checked the deviation of the PC clock from the ship's clock. This synchronisation occurs through setting the ship's clock as the time server of the PC. Since the temporal interval of the automatic update is too large, we sometimes needed to do the synchronisation manually.
- We ensured that records of the files created were kept up-to-date.
- The .LOG file records any problems such as timeouts and navigation problems and was occasionally inspected.

2.6.2.3 Alignment

As outlined in the JC053 cruise report, it is known that the OS75 instrument is roughly 9° out of alignment, in spite of the installation report stating that both ADCPs are perfectly aligned with the ship's axis. We once again used the EA00900 command setting in the control file to enable real time monitoring of the currents and for internal VmDas processing. However, in the first 32 files we found that even the EA00900 command had been applied in the control file, the log files showed that it would be automatically set back to EA00000. We finally figured out that it is due to the setting of the Tilt Correction in the transform tab of the Data Option in VmDas. By unchecking the Tilt Correction, this problem was solved.

Control file name	Time between ensembles (s)	Bin Depth	Time between bottom and water pings (s)	Coarse transducer misalignment	Max bottom search depth (m)
OS75NB_BTon_JC054_up.txt	3	16 m	1.5	9°	1200
OS75NB_BToff_JC054_up.txt	3	16 m	1.5	9°	1200
OS75NB_BTon_JC054_up_zero.txt	3	16 m	1.5	0°	1200
OS75NB_BToff_JC054_up_zero.txt	3	16 m	1.5	0°	1200
OS150NB_BTon_JC054_up.txt	2	8 m	1	0°	800
OS150NB_BToff_JC054_up.txt	2	8 m	1	0°	800
OS150NB_BTon_JC054_up_corrected.txt	2	8 m	1	0°	800
OS150NB_BToff_JC054_up_corrected.txt	2	8 m	1	0°	800

Table 2.3: Configurations of individual control files used on JC054. Bottom and water tracked files are denoted in the filename by 'BTon' and 'BToff' respectively.

2.6.2.4 General Settings

During JC054, we ran both instruments in narrowband single-ping mode. Where depth permitted, we ran both instruments in bottom track mode to obtain the most accurate phase and amplitude calibrations. Typically, the instruments were switched between bottom tracking and water tracking close to 1000 m. The filenames and configurations used are shown in Table 2.3.

Bin numbers for OS75 and OS150 are 55 and 60, respectively. The bin size for the OS75 is 16 m and for the OS150 is 8 m. A blanking distance of 8 m was used for the OS75 and 6 m for the OS150, in order to avoid ringing from the transmit pulse. During JC054, OS75 and OS150 had been run with a 2s and 3s 'time between ensembles', respectively. While in water track mode, the 'time between BT and WT pings' for OS75 and OS150 are 1.5s and 1s, respectively.

2.6.2.5 Sound Speed Considerations

According to the ADCP Principles of Operation Primer, supplied by Teledyne with the instrument, the measurement of x and y velocities is independent of sound speed for a phased array instrument. Each of the Ocean Surveyor ADCPs on RRS James Cook is of the phased array type, comprising a single ceramic assembly that produces 4 acoustic beams simultaneously from the same aperture. Each element in the array is driven with the same signal except for a phase shift, which is constant for a given frequency and element spacing. If the speed of sound changes, the angle of the beam will consequently change. Fortunately, this beam angle change occurs in the same ratio as the Doppler shift equation, meaning that a change in the Doppler frequency shift of a particle moving parallel to the face is compensated entirely by the corresponding beam angle shift, rendering the horizontal velocity component independent of sound speed (although the vertical component is more sensitive than in a conventional transducer). As a result of these findings, accuracy of the sound speed measurements did not require further consideration.

2.6.3 Post-Processing

The final processing of the data was done using the CODAS (Common Ocean Data Access System) suite of software provided by the University of Hawaii. This suite of Unix and Matlab programs allows manual inspection and removal of bad profiles and provides best estimates of the required rotation of the data, either from water profiling or bottom tracking.

2.6.3.1 Transferring the Data

CODAS was run on the nosea1 terminal, so the files had to be transferred from the ADCP PCs to this Linux box. This was done by firstly making new directory named /noc/users/pstar/jc054/data/vmadcp/jc054_os75/rawdata<nnn> or /noc/users/pstar/jc054/data/vmadcp/jc054_os150/rawdata<nnn>, where <nnn> is the file sequence number and then copying all the files with the same sequence number from DROBO to the new directory.

2.6.3.2 Setting Up the Directories and Using quick_adcp

Once loaded into the directory of /noc/users/pstar/jc054/data/vmadcp/jc054_os75/ or /noc/users/pstar/jc054/data/vmadcp/jc054_os150/, the following steps were followed:

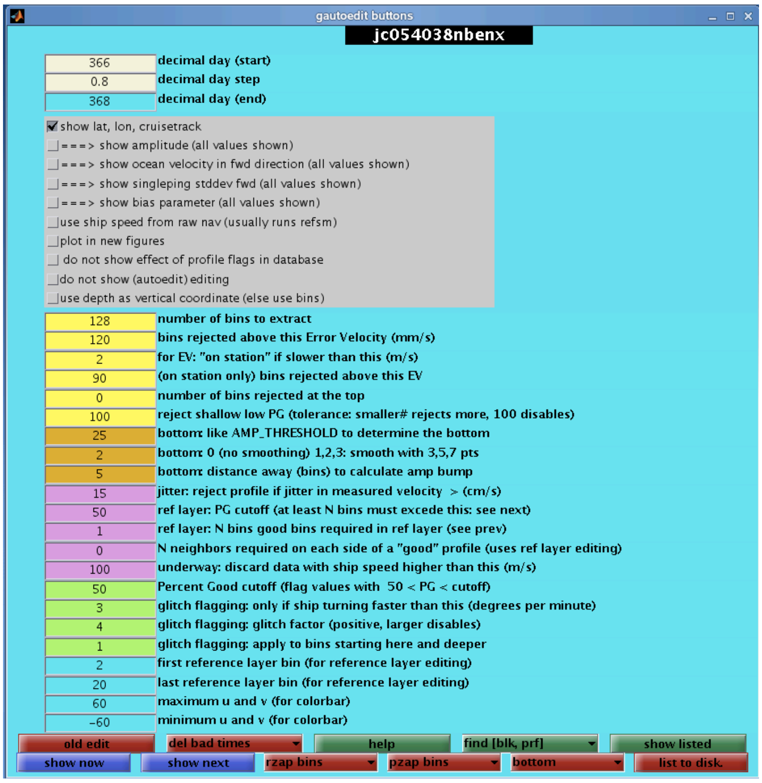
1. The command adcptree.py jc054<nnn>nbenx --datatype enx was typed at the command window. This command sets up a directory tree for the codas dataset and an extensive collection of configuration files, text files and m files.
2. The directory was then changed to new directory jc054<nnn>nbenx using the cd command, and the control files q_py.cnt, q_pyedit.cnt and q_pyrot.cnt were copied into that directory.
3. We then used the command: 'quick_adcp.py --cntfile q_py.cnt', which loads the data into the directory tree, performs routine editing and processing and makes estimates of both water track and (if available) bottom track calibrations. The raw ping files are also averaged into 5-minutes periods. The calibration values are stored in the adcpcal.out and btcaluv.out files found in the cal/watertrk and cal/botmtrk directory and are appended each time quick_adcp.py is run.

2.6.3.3 Gautoedit

The gautoedit package within CODAS allows the user to review closely the data collected by VmDas and flag any data that is deemed to be bad. These flags can then be passed forward and, using the q_pyedit.cnt control file, the data removed. Typically, the data were reviewed as follows:

1. Matlab was opened in the jc054<nnn>nbenx directory (for the portion of data we wished to process). In the command window, typing 'codaspaths', 'cd edit', 'gautoedit'

This started up an editing gui, shown in Figure 2.7. The editing was done from here.



366	decimal day (start)
0.8	decimal day step
368	decimal day (end)

☑ show lat, lon, cruisetrack
☐ ===> show amplitude (all values shown)
☐ ===> show ocean velocity in fwd direction (all values shown)
☐ ===> show singleping stddev fwd (all values shown)
☐ ===> show bias parameter (all values shown)
☐ use ship speed from raw nav (usually runs refsm)
☐ plot in new figures
☐ do not show effect of profile flags in database
☐ do not show (autoedit) editing
☐ use depth as vertical coordinate (else use bins)

128	number of bins to extract
120	bins rejected above this Error Velocity (mm/s)
2	for EV: "on station" if slower than this (m/s)
90	(on station only) bins rejected above this EV
0	number of bins rejected at the top
100	reject shallow low PG (tolerance: smaller# rejects more, 100 disables)
25	bottom: like AMP_THRESHOLD to determine the bottom
2	bottom: 0 (no smoothing) 1,2,3: smooth with 3,5,7 pts
5	bottom: distance away (bins) to calculate amp bump
15	jitter: reject profile if jitter in measured velocity > (cm/s)
50	ref layer: PG cutoff (at least N bins must excede this: see next)
1	ref layer: N bins good bins required in ref layer (see prev)
0	N neighbors required on each side of a "good" profile (uses ref layer editing)
100	underway: discard data with ship speed higher than this (m/s)
50	Percent Good cutoff (flag values with 50 < PG < cutoff)
3	glitch flagging: only if ship turning faster than this (degrees per minute)
4	glitch flagging: glitch factor (positive, larger disables)
1	glitch flagging: apply to bins starting here and deeper
2	first reference layer bin (for reference layer editing)
20	last reference layer bin (for reference layer editing)
60	maximum u and v (for colorbar)
-60	minimum u and v (for colorbar)

Figure 2.7: The gautoedit editing window within the CODAS suite of programs in Matlab.

2. To get an initial feel for the data, the start time of the ENX file was entered in the decimal day (start) box and the length of the data set (in days) was entered in the decimal day step box. Upon pressing Show Now, two plots are displayed. One contains four subplots: the first displays the absolute east-west velocity component, the second shows the absolute north-south component, the third shows the percentage good parameter and the fourth shows the ship speed (in m/s) and an editing parameter called jitter. The second figure contains subplots of ship's track and mean absolute velocity vectors at the reference layer. By default, this reference layer is set at bin 2 using the First Reference Layer Bin command. An error command will appear if there are no data in the selected time range. This initial review of the data allows the user to confirm the direction of steaming, identify the position of on-station and off-station parts of the file and spot any areas with low percentage good. It is also useful to identify the maximum and minimum values of u and v to allow a suitable colour bar to be used when examining the data more closely (by default -60 to +60 is used). To change this, use the maximum u and v and minimum u and v boxes.

3. To inspect the data more closely and to start applying edits, the data must be inspected in shorter time sections. Typically, we worked from the start of the data in 0.4 days portions as this allowed us to see the individual 5-minutes bins. Once the edits were finished on one portion, the List to Disk option was selected to save the flags before using Show Next to advance onto the next 0.4 days section. Routine editing for each section included:

    - Looking for bad profiles (i.e. those in which the u and/or v had a systematic offset over all depth levels). These were flagged using the del bad times command.

    - Looking for bad levels. This is common at the bottom of profiles where the amplitude return is small and the profiles commonly have a low percentage good. These bad 'tails' are removed most easily using the rzap bins command, which allows the user to flag all data within a defined rectangular box.

- Looking at the jitter parameter in the bottom subplot. A high level of jitter either indicates noise in the navigation and/or rapidly changing velocities. Generally, the default jitter threshold (set in the Jitter: reject profile if jitter in measured velocity) of 15 cm/s seemed to be a reasonable value for flagging potentially bad profiles and did not need to be changed.

4. More specialised editing was required for some parts of the dataset where we suspected velocity biases were present. In particular, the presence of either enhanced scattering layers in the profiles or bubbles directly beneath the ship are known to bias the underway velocities in the affected layers in the direction of steaming. These biases are discussed at more length in Section 2.6.4, but the typical steps taken to remove them were:

    - Inspecting the echo amplitude plot, which shows the magnitude of the return at each depth. Enhanced scattering layers can be distinguished clearly in this plot.

    - Inspecting the bias parameter plot. This shows the vertical gradient in the demeaned amplitude, multiplied by the ship velocity. The demeaning removes the mean amplitude at the particular depth level, so the plot is really the vertical derivative of the amplitude anomaly multiplied by velocity. In an enhanced scattering layer (e.g. due to zooplankton) the bias parameter tends to have positive (red) values towards the top of the layer (as the anomaly increases with depth) and negative values below (as the anomaly decreases), though the sizes of these anomalies need not be symmetric. On station the parameter, by definition, has a value of zero. Positive values in the top two or three bins often indicate bubbling. The bias parameter thus indicates the potential for velocity bias, but does not show bias in itself.

    - Inspecting the along-track velocities on steaming sections. Regions of potential bias highlighted with the bias parameter were then examined for underway bias in the velocity. If bias in the direction of travel whilst the ship was steaming could be found, the bad bins were flagged using rzap bins. In the presence of anomalous scattering, it was common to find a layer of positive velocity bias above a layer of negative bias. In these cases, both layers were removed.

Although it is possible to edit data using other thresholds (e.g. percentage good and number of neighbours), this was not found to be necessary during JC054. Further details of gautoedit capabilities can be found at:
http://currents.soest.hawaii.edu/docs/adcp_doc/edit_doc/index.html

5. Once satisfied with the changes made, the List to Disk option is selected which creates and updates a*.asc files in the jc054<nnn>nbenx/edit directory.

2.6.3.4 Applying the Edits

Once the a*.asc files have been created, the edits are applied using the following command at the Unix terminal prompt from within the jc054<nnn>nbenx directory:

- quick_adcp.py --cntfile q_pyedit.cnt

The q_pyedit.cnt file has to have the correct instname command line (OS75 or OS150).

2.6.3.5 Calibration

In order to obtain accurate horizontal velocities, it is vital to correct for heading errors. These can either occur as a result of transducer misalignment with respect to the hull, or from errors in navigation. Fortunately, the navigation is fed directly into VmDas from the Applanix POSMV, which incorporates a GPS heading source that is not sensitive to many of the heading errors that occur when gyrocompasses are used in isolation.

The best calibration estimates are obtained when the velocity data are referenced to the bottom. However, bottom track calibration estimates are only obtainable when the water depth is within 1.5 times the depth of the ADCP profiling range. We were able to obtain two separate periods of bottom tracking when *RRS James Cook* left Punta Arenas. We examined both bottom track and water track calibrations for consistency on each section before deciding on best amplitude and phase corrections for each instrument.

The quick adcp.py script estimates amplitude and phase corrections for each set of data. The values for these are presented in Appendix I. By default, the water track estimates have an ensemble length of 7, meaning that seven individual five-minute ensembles bracket each turn or acceleration. The bottom track estimates have a default step size of 1, meaning that the individual ensembles are used to evaluate the calibration. Step sizes of 2 and 3 are also permissible, meaning that adjacent profiles of length 2 or 3 are averaged to obtain the amplitude and phase. By changing the control file timslip.tmp using the emacs editor and the Matlab file calladcpcal_tmp.m, the length of water track ensembles can be changed for each section. As it was found in past cruises that varying the choice of ensemble length did not substantially change the values of amplitude and phase obtained, we chose to study the water track estimates based on ensemble length 7 and the bottom track estimates based on ensemble length 1.

OS75: The individual bottom track calibrations for file sequence numbers 002, 003 and 021 were compared with the water track calibrations from file sequence 038, 039, 040, 041 and 042. The single best estimate water track calibration was based on a mean value of the three individual estimates from the above stations. The best estimate for bottom track was based on a mean value of the three individual estimates from 002, 003 and 021, weighted by the number of ensembles used. All results are given in Table 2.4. The values from the water track and the bottom track are not very consistent as previous cruises. Considering the high quality and the larger number of the bottom track data, we chose to use the value obtained from the bottom track.

Calibration Method	Number of ensembles	Amplitude		Phase (deg)	
		Median	Mean	Median	Mean
Water track	24	1.0112	1.0103	0.0775	0.0251
Bottom track	382	**1.0047**	1.0045	**0.0831**	0.1018

Table 2.4: Best estimates of OS75 calibration for water tracking and bottom tracking. The bold figures are the final calibration applied.

OS150: The individual bottom track calibrations for file sequence numbers 001 and 017 were compared with water track calibrations from file sequences 031,033 and 035. Using the same methodology as for the OS75, the results are given in Table 2.5. Similar to the OS75, the results from water track and bottom track are not very consistent. Considering the high quality and the larger number of the bottom track data, we chose to use the value obtained from the bottom track.

Calibration Method	Number of ensembles	Amplitude		Phase (deg)	
		Median	Mean	Median	Mean
Water track	29	1.0113	1.01358	-0.4152	0.0589
Bottom track	361	**1.0032**	1.0043	**-0.2852**	-0.2717

Table 2.5: Best estimates of OS150 calibration for water tracking and bottom tracking. The bold figures are the final calibration applied.

2.6.3.6. Applying the Rotation

The final calibrations discussed above were applied to each file sequence using:

- quick_adcp.py –cntfile q_pyrot.cnt

in the jc054<nnn>nbenx directory in the Unix terminal window. This rotates the data by the phase and amplitude specified by the user in the control file q_pyrot.cnt. A recalculated calibration (after taking the first calibration into account) is printed to the *.out file(s). The data were then double checked in gautoedit to ensure that any vertical striping associated with on/off station differences had been removed by application of the calibration.

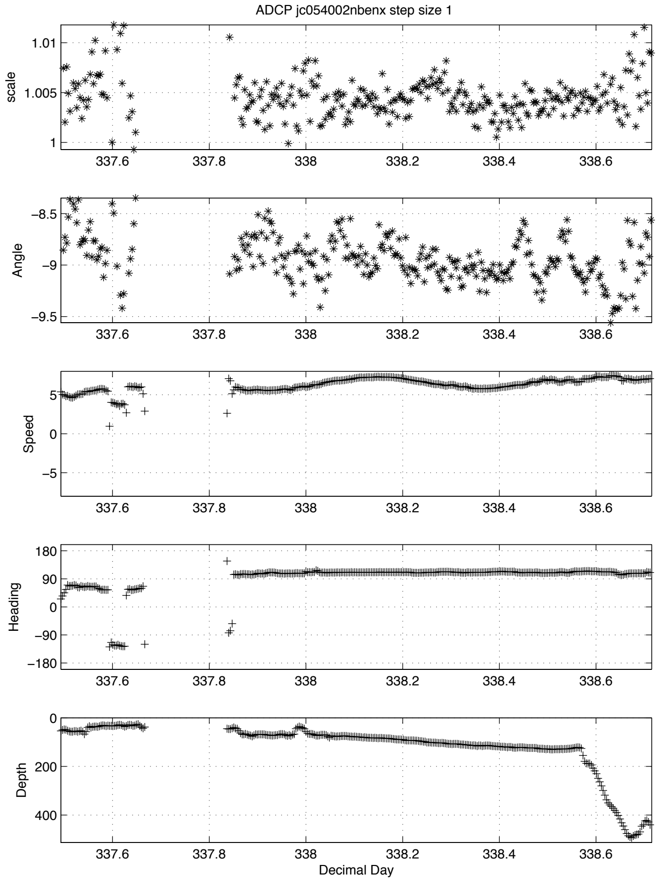


Figure 2.8: Amplitude scale and phase calibrations for OS75 instrument for the period of bottom tracking when the cruise started. Speed and heading (from nav) are given in the lower panels.

2.6.3.7. Creating the Output Files

Once the editing and rotation was complete, the final velocities were collated into mstar files (*.nc) using the following commands in the jc054<nnn>nbenx directory of a Matlab command window:

- m_setup
- m_addpath
- mcod_01
- mcod_02

The first two commands set up the mstar suite of programs and the relevant paths. The other two commands (derivatives of mcod_01 and mcod_02 respectively) load in the final data for the file sequence and save it as two mstar files. The first command produces a file of the form os75_jc054<nnn>nnx.nc that includes the variables:

- time - (in seconds since [2010 1 1 0 0 0])
- lon - (0 to 360)

- lat - (-90 to 90)
- depth - (of bin)
- uabs - (absolute u velocity in cm/s)
- vabs - (absolute v velocity in cm/s)
- uship - (u velocity of ship over ground)
- vship - (v velocity of ship over ground)
- decday - (decimal day of year)

The second file is of the form os75_jc054<nnn>nnx_spd.nc and includes, in addition to the above variables:

- speed - (scalar water speed in cm/s)
- shipspd - (scalar ship speed over ground in cm/s).

The individual os75_jc054<nnn>nnx.nc and os150_jc054<nnn>nnx.nc files can be appended together into a single output file for the cruise using the mapend command. This command relies on an input file containing the paths of all the individual files to be merged. However, since on this cruise the two instruments were not always turned on and off together, we did not merge these files.

2.6.4 Data Quality Issues

Whilst carrying out gautoedit editing, several quality control issues were identified and discussed as follows.

2.6.4.1 Bubble Contamination and Bias

Two potential issues arise from the presence of bubbles immediately below the transducer face. The first is that bubbles can prevent penetration of the transmit pulse and lead to truncated or bad quality profiles. The second is the problem of bubble bias. It is known that the high amplitude return from bubbles can cause anomalous velocities in the direction of ship steaming. It is commonly identified by a relatively low percentage good in the top few bins, and a red surface stripe in the along-track bias parameter (Figure 2.9). It typically does not affect lower bins of the profile, which remain good.

Bubble contamination was not a frequent problem for data on stations. But when streaming, strong velocities in the surface associated with anomalously high returns were observed and the top few bins were discarded as a result. In addition, the bubble prevention of transmit pulse is also very clear, especially when the ship was streaming (Figure 2.10). The reason for that could be the retracted keel position.

2.6.4.2 Anomalous Scattering Bias

Another possible problem is the presence of anomalous scattering layers leading to along-track velocity bias. The presence of layers of scatterers such as zooplankton in the water can cause severe bias in the direction of travel whilst the ship is steaming. This has been observed as horizontal stripes in the velocity field which disappear when the vessel is on station. If the layers are very strong, a layer of negative bias will also appear immediately below the scattering layer. Although this has been observed in many other cruises, visual examination shows no clear features like layers of scatterers on this cruise.

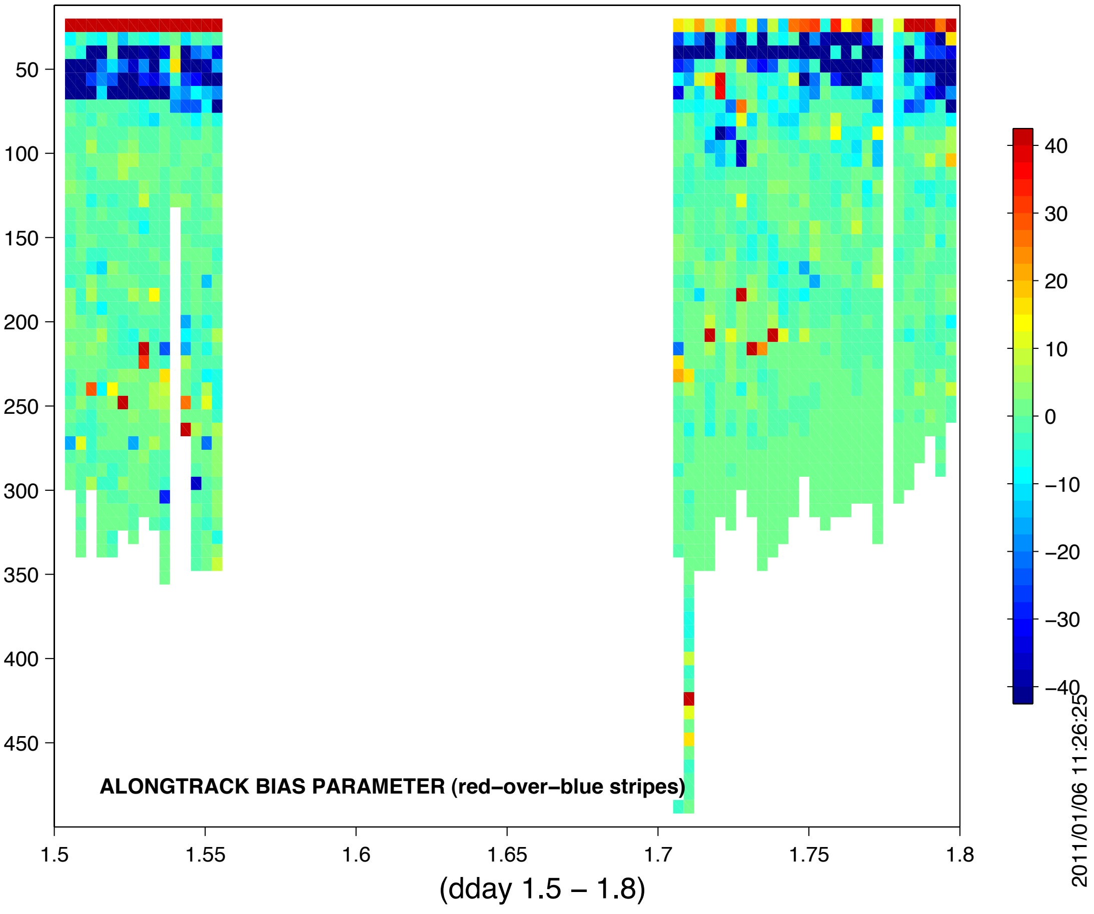


Figure 2.9: Bias parameter for OS150 on decimal day 1 (2011). Note the strong red-over-blue stripes during the steaming periods at the surface. They are most likely the result of bubbles below the ship.

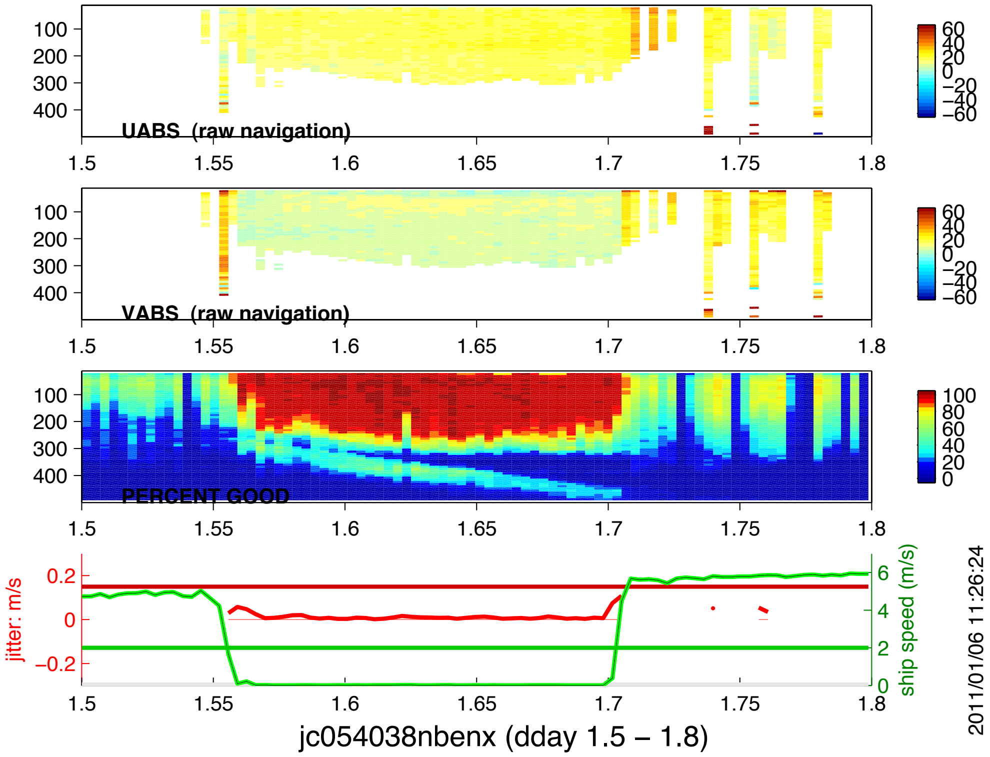


Figure 2.10: Anomalous region of low percentage good during steaming for the same period. This could be caused by the rolling of the ship and the bubbles below the ship.

2.6.5 Preliminary Results

2.6.5.1 Section 1: Drake Passage

The mean on-station velocities at 103 m are shown in Figure 2.11. The results suggest that the westward flow at the Drake Passage is very narrow and strong at the depth of 103 m. The core of the eastward flow at the depth of 100 m is at the latitude of 59°S and the flow can speed up to about 1 m/s. Also, the flow is weaker in the south of the Drake Passage than the north.

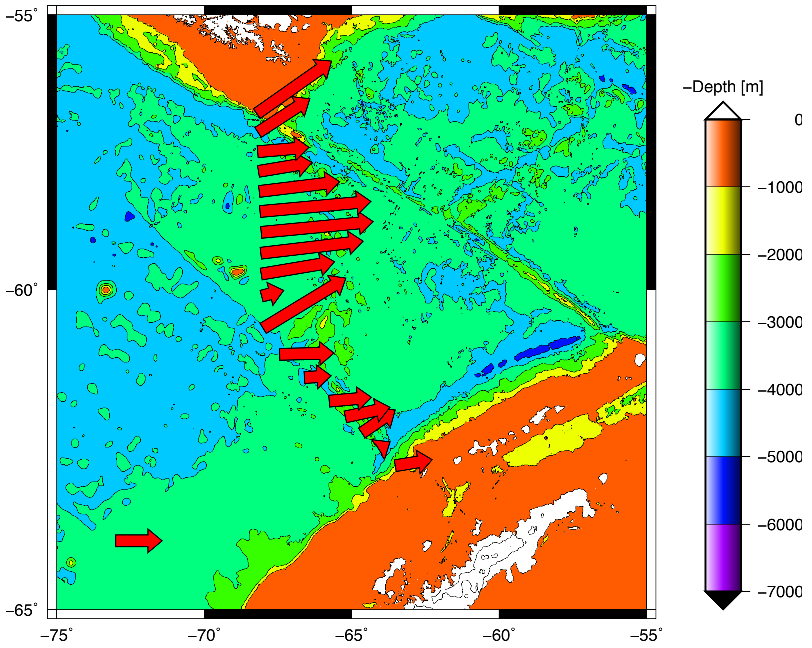


Figure 2.11: Mean on-station VMADCP velocities from the OS75 at 103 m the section S1. The lower left arrow shows the velocity of 20cm/s.

2.6.5.2 Section 2: 79°W

The 103 m velocities for the section along 79°W are shown in Figure 2.12. The currents here are much weaker than in the Drake Passage, although the currents are still mainly flowing eastward. There are three strong signals in the middle of the sections, and their directions are opposite. More careful examination is needed in future to determine whether those signals are real.

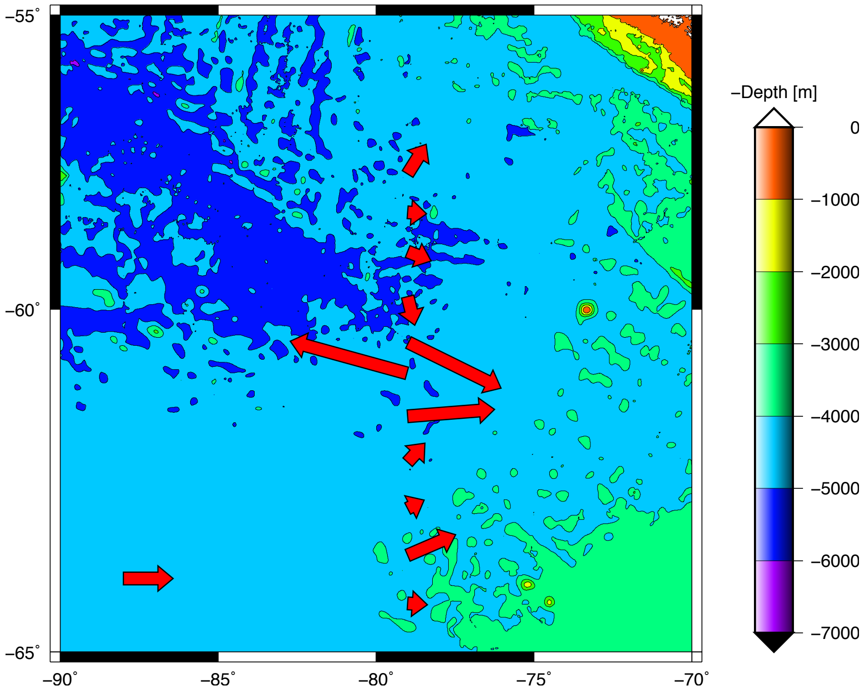


Figure 2.12: Mean on-station VMADCP velocities from OS75 at 103 m for the 79°W section. The lower left arrow shows the velocity of 20 cm/s.

2.6.6 Problems

During the whole cruise, we encountered several problems with the instruments, especially the OS75. They are listed as follows:

2.6.6.1 Transducer Misalignment

As outlined in the previous cruise reports, it is known that the OS75 instrument is roughly 9° out of alignment, in spite of the installation report stating that both ADCPs are perfectly aligned with the ship's axis. We therefore used the EA00900 command setting in the control file to enable real time monitoring of the currents and for internal VmDas processing. However, in the first 18 files we found that even the EA00900 command had been applied in the control file, the calibration results still suggested roughly a 9° out of alignment. We firstly thought that could be due to the old misalignment problem had been solved before the cruise and our setting of EA00900 was not correct. Then we replaced the EA00900 in the control file with EA00000. Unfortunately, when we got about another 10 files, the calibrations still suggested a misalignment of 9°. After examining the log files, we found that no matter what command we used, the VmDas would automatically set the command back to EA00000. We then tested different possible reasons and finally figured out that this problem was due to the setting of the Tilt Correction in the transform tab of the Data Option in VmDas. By unchecking the Tilt Correction, this problem was solved and all the following files were collected with the command of EA00900. In addition, with this problem in mind, all the first 32 files are processed with the phase list in Table 2.4 plus an extra 9°.

2.6.6.2 Control Files

For the instrument of OS150, the first 9 files were collected with the control files OS150NB_BToff_JC054_up.txt and OS150NB_BTon_JC054_up.txt. Then we found that in both files the value of the transducer depth was set to be 6.9 m rather than the correct value 6.0 m. After that, two new control files (OS150NB_BToff_JC054_up_corrected.txt, OS150NB_BToff_JC054_up_corrected.txt) were generated and used to collect data. Also, as mentioned in section 2.6.6.1 we also changed the control files for OS75 to solve the "misalignment" problem.

2.6.6.3 Wrong Setting on the OS75

At the beginning of the cruise, several files (sequence numbers: 008-015) obtained from OS75 cannot go through the processing of quick_adcp.py. After communicating with Dr. Brian King, it turned out the problem was due to the incorrectly setting of the ping mode. For ordinary operation the instrument should be set as NB (narrow band) rather than BB (broad band). When trying to find the operator who were responsible for those files, we found no information on the log sheet. That reminded us of the importance of proper operation, therefore we required specific people on each shift to operate the instrument.

2.6.6.4 Interference Issues

During JC054, interference with the acoustic instrument on the microstructure profiler (VMPs) occurred very frequently, especially in the first half of cruise. Due to this interference, both ADCPs were turned off when the microstructure team wanted to locate the VMP. This led to a large number of files with small sizes. To perform the calibration with water-track data only relatively large ADCP files are useable, thus this interference resulted in some potential difficulties to the post-processing. For example, the reason that it took a long time to figure out the misalignment of the OS75 was mainly due to the lack of calibration points. This aside, no obvious evidence of interference with other instruments was seen in the amplitude returns during the cruise, despite the use of other acoustic instruments.

2.6.6.5 IO problem on the OS150

During the second half cruise, we had several large files from OS150 which lasted more than 1 day. For two of them, when we tried to start a new file with everything correctly set, error messages such as “IO Error” occurred. After rebooting the PC, the problem was solved automatically. In addition, the same error occurred when the ship suffered the engineering problem in the first half of cruise.

3.1 Salinometry

Emma Boland

3.1.1. Introduction

Discrete salinity samples were taken throughout the cruise for two purposes, namely the calibration of CTD salinity profiles and the calibration of underway TSG data. These were then analysed using a salinometer on board. The following outlines the method of sampling and sample processing.

3.1.2. Sampling Method

All samples were taken using 200 ml glass sample bottles with plastic lids, supplied by OSIL[1], in cases of 24 bottles. Each bottle was labelled with a unique number, and in a uniquely numbered case. Log sheets were used to note the case number and bottle number of each sample taken. Bottles were filled in order to leave minimal air for evaporation to occur whilst leaving enough air to allow for adequate mixing of the sample before sampling, in order to counteract any stratification that may have developed. The bottle necks and lids were dried thoroughly before plastic caps, also supplied by OSIL, were placed inside the bottle necks immediately after sampling in order to seal the air within the bottles to counteract evaporation.

3.1.2.1. CTD sampling

The CTD package includes a rosette of 24 Niskins, closed at various depths during deployment in order to capture samples of water at those depths. For each CTD cast, the Niskins to sample for salinity were chosen so as to provide the best coverage of the salinity profile measured by the conductivity probe on the CTD. In practice, this normally meant sampling from the deepest Niskins, the shallowest Niskins, and some in the middle. With the depths of closure of Niskins determined primarily by the need to resolve vertically the DIMES tracer, the distribution of bottles was not optimal for salinity, however the approach adopted here seems adequate.

When sampling, the sample bottles were first rinsed a minimum of three times using the water from the Niskin to be sampled. This was to minimise contamination of the sample from anything on the inside surface of the bottle. The bottle was then filled as described above, capped and replaced in the relevant case.

3.1.2.2. TSG sampling

See section 2.4 for a brief description of underway TSG measurements. Underway instrumentation aboard the ship constantly measured the salinity of the seawater passing through the ship from the immediate surroundings. In order to calibrate these measurements, samples of this water were taken roughly every 4 hours as part of the watchkeepers’ duties. The tap supplying the underway water was turned on for roughly 10 seconds to ensure a fresh sample. Then the sample bottle was filled and emptied 3 times to ensure minimum contamination, before being filled as described above, capped and placed in the relevant case.

3.1.3. Sample Processing

Once a case of sample bottles was full, it was transferred to the salinometer laboratory, kept at 22.5 degrees Celsius, where it remained a minimum of 24 hours before being analysed. This is because salinity (the desired variable) is derived from measured conductivity, which is a function of temperature. Salinity measurements were taken using a Guildline[2] AutoSal salinometer, model 8400b, s/n 65764, provided by OSIL.

At the beginning of the cruise, the machine was standardised using a bottle of IAPSO Standard Seawater, batch P151, conductivity ratio $K_{15} = 0.99997$, provided by OSIL. The standardisation dial was set to 16.7, where it was left for the remainder of the cruise.

The salinometer was connected to a desktop PC which recorded the salinometry using National Instruments[3] LabVIEW 8.5 software provided by OSIL. At the beginning of each sampling run, the standardisation was checked using a bottle of IAPSO Standard Seawater, batch P151, conductivity ratio $K_{15} = 0.99997$. The software then corrected the subsequent measurements by the discrepancy measured.

The salinometric analysis was carried out as per the manufacturer's recommendations. The sample bottle to be measured was first inverted at least three times to remove any stratification. Before any measurements were taken, the measurement cell was filled using the peristaltic pump and flushed three times with the relevant sample in order to avoid any contamination from previous samples. The analyst ensured that no bubbles were present in the cell before measuring the sample. The software averaged the measurement over a period of 10 seconds before recording it. The cell was flushed, filled and then measured a further two times in order to have a total of three measurements for each sample. The software calculated the standard deviation of the three measurements, and prompted the analyst to resample if this was larger than the set tolerance of 0.00005 in conductivity ratio.

This was repeated for each sample in the relevant crate. Once all samples in the crate had been analysed, another bottle of IAPSO Standard Seawater was analysed in the same way as a sample, in order to ascertain whether the salinometer precision had remained the same throughout the analysis of that crate.

Throughout sampling, a physical log sheet of the sample readings was kept in case of data loss and to encourage the analyst to check for any obvious errors in the readings. This log also recorded the actual temperature in the lab at the time of sampling.

The software produced a .xls document containing the measurement details for each log. This was then updated manually with the relevant sampling data - CTD cast number and Niskin number for CTD samples, Julian day and time for TSG samples. This was then placed on the shared drive for use by the relevant scientists for calibrations.

The accuracy of the results gained is improved by time averaging and the three separate measurements for each sample. The standardisation check at the beginning and end of the crate gave an idea of how consistent the salinometer precision had been, which should be taken into account in error analysis. The temperature of the water bath in the salinometer was kept at 24 degrees Celsius throughout the cruise. The temperature of the lab was monitored roughly every 4 hours throughout the cruise, and was fairly constant, although slight diurnal variations and the effect of the analyst being in the lab during the sampling process could not be avoided completely. This is not expected to affect the results as the water bath in the salinometer ensures consistency of analysis.

A total of 11 duplicate samples were taken over the course of the cruise, from both CTD and TSG samples. The average standard deviation between two duplicate samples was 0.0006 on the practical salinity scale. The maximum standard deviation between two duplicate values was 0.002 on the practical salinity scale.

3.1.4. References

1. OSIL
   Culkin House
   C7/C8 Endeavour Business Park
   Penner Road, Havant
   Hampshire PO9 1QN

2. Guildline Instruments Ltd.
   P.O. Box 99, 21 Gilroy St.
   Smith Falls, Ontario,
   K7A 4S9

3. National Instruments Corporation Ltd.
   Measurement House, Newbury Business Park
   London Road
   Newbury, Berkshire RG14 2PS

3.2. Measurements and distribution of the tracer CF_3SF_5 – University of East Anglia

Marie-José Messias, Andrew Brousseau, Neill Mackay, Andrew Watson and Steve Woodward

3.2.1. Sample collection and analysis

The DIMES-released tracer, trifluoromethyl sulphur pentafluoride (CF_3SF_5), and a series of three transient tracers (sulphur hexafluoride (SF_6) trifluoro chloromethane (CFC-13) and dichlorodifluoromethane (CFC-12) were measured on board by a purge-and-trap gas chromatographic method. The instrumentation was built and developed at the University of East Anglia following the Lamont Doherty Earth Observatory (LDEO) design [Smethie et al., 2000]. The system was set up in a container that was installed on the after deck of *RRS James Cook*. A total of 1350 samples including ~10% of duplicates were measured.

3.2.1.1. Sample collection

Water samples were collected from 10 litre bottles as soon as the CTD sampling rosette was on board. The Niskin nitrile 'O' rings were first washed in isopropanol and baked in a vacuum oven for 24 hours to remove susceptible contamination before installation in individual Niskin bottles. The trigger system of the bottles was external. Water samples were collected in 2 litre ground-glass stoppered bottles that were filled from the bottom using Tygon tubing and overflowed 1 time to expel all water exposed to the air. Immediately after sampling, the glass bottles were immersed in a cool box of cold deep seawater in the sampling hangar until the analysis. Ice packs were added as necessary to maintain a temperature below 5°C and prevent degassing.

3.2.1.2. Analysis technique

Sample analysis was performed as soon as possible within six hours of the sampling. Samples were introduced to the system by applying nitrogen (N_2) pressure to the top of the sample bottles, forcing the water to flow through and fill a 1135 cm^3 calibrated volume. The measured volumes of seawater were then transferred to a purge and trap system, entering the sparge tower under vacuum. The water was sparged with a N_2 flow at 250ml/mn for 3 minutes and trapped at -100°C on a Unibeads 3S trap (two inches of 1/8inch tubing) immersed in the headspace of liquid nitrogen. The purge and trap system was interfaced to an Agilent 6890N gas chromatograph with electron capture detector (MicroECD at 320°C). The traps were heated to 110° C and injected into the gas chromatographs. The CF_3SF_5 and SF_6, CFC-13, CFC-12 separation was achieved using a 1m Porasil B packed pre-column and a 1.5m carbograph AC main column. A six inches molecular sieve post column was used to remove N_2O. Examples of the resulting chromatograms are displayed in Figure 3.1. The three columns were kept in the oven at 75°C. The carrier gas, N_2, was cleaned by a series of purifying traps (VICI nitrogen purifier and oxygen trap). The running time per sample is ~13 minutes.

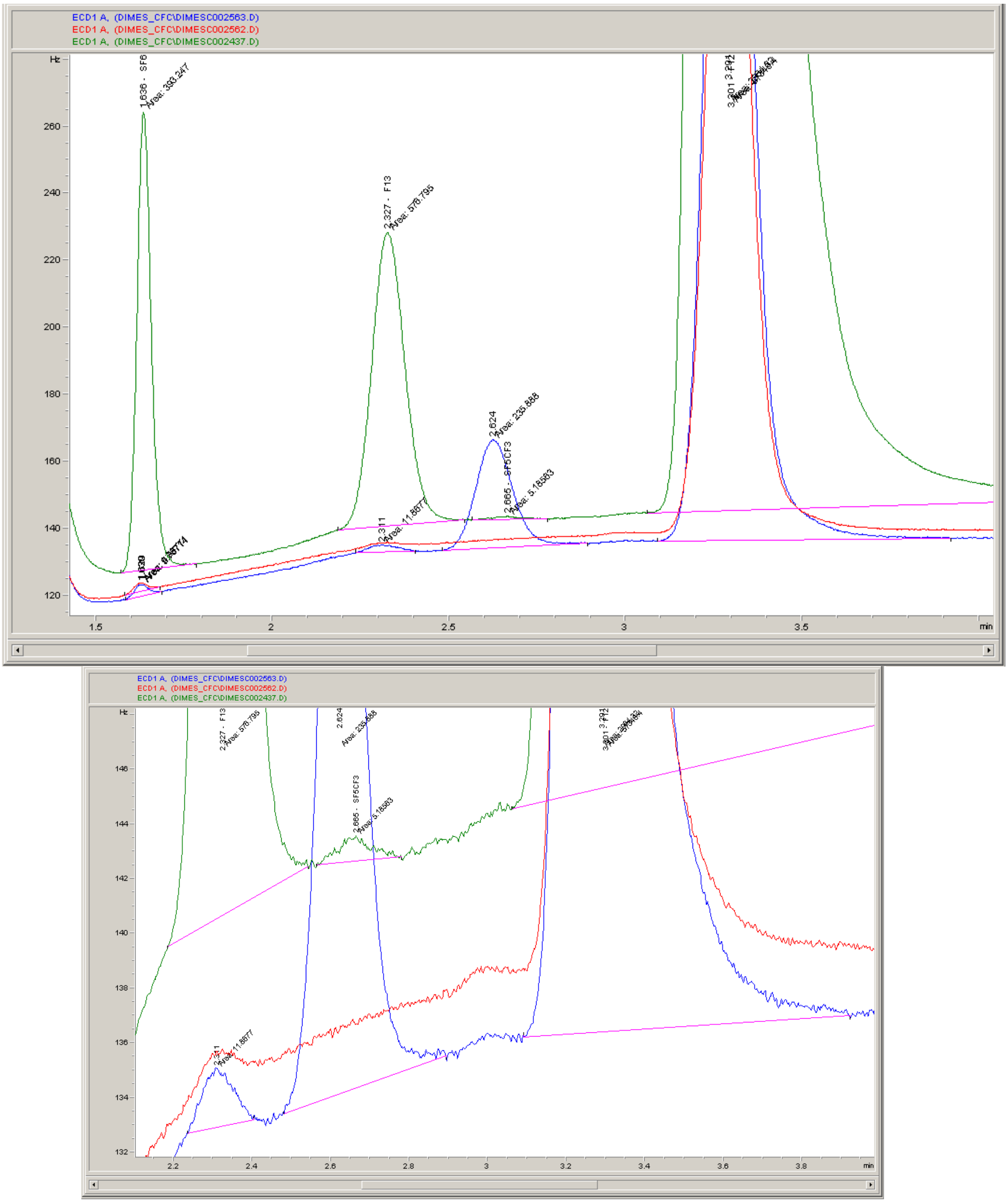


Figure 3.1: Examples of chromatograms, (a) near-surface chromatogram (green), showing SF_6, F13, background CF_3SF_5 (very small peak) and F12 (left to right). Blue is a chromatogram at the target density, and red is a deep sample that is tracer free.

3.2.1.3. Calibration

The CF_3SF_5 and SF_6, CFC-13, CFC-12 concentrations in air and water were calculated using an external gaseous standard. The working standard was supplied by NOAA (Brad Hall, March 2010). It corresponds to clean dry air enriched in CF_3SF_5 inside a 29L Aculife-treated aluminum cylinders. The standard was intercalibrated for the tracer CF_3SF_5 with Ledwell 5B tank during the cruise with our instrument, which has been calibrated by Busenberg (pers comm.). The tracer was found to give a very nearly linear response over a large range (Figure 3.2), and linear calibration was used for all the levels that we encountered The routine calibration curves were made by multiple injections of 9 different volumes (0.1, 0.25, 0.3, 0.5, 1, 2, 3, 5, 8 ml) of standard that span the range of tracers measured in the water for CF_3SF_5 and SF_6). Multiple injections of large loops of standard, up to 136 ml, were made to calibrate CFC-12 and CFC-13 in surface waters as the large volume of seawater required for the tracer was inappropriate for surface seawater measurements of CFC-12 and CFC-13. Routine calibration curves were made when time permitted, around once a day. The changes in the sensitivity of the system were tracked by measuring a fixed volume of standard gas every ~ 2 hours (Figure 3.3) and used to adjust the calibration curves respectively. The calibration precision was better than 1% for the tracer CF_3SF_5 and SF_6 and for CFC-13, CFC-12 at the target density range. For surface values of CFC-12 and CFC-13 the calibration precision was estimated to be only 5 %.

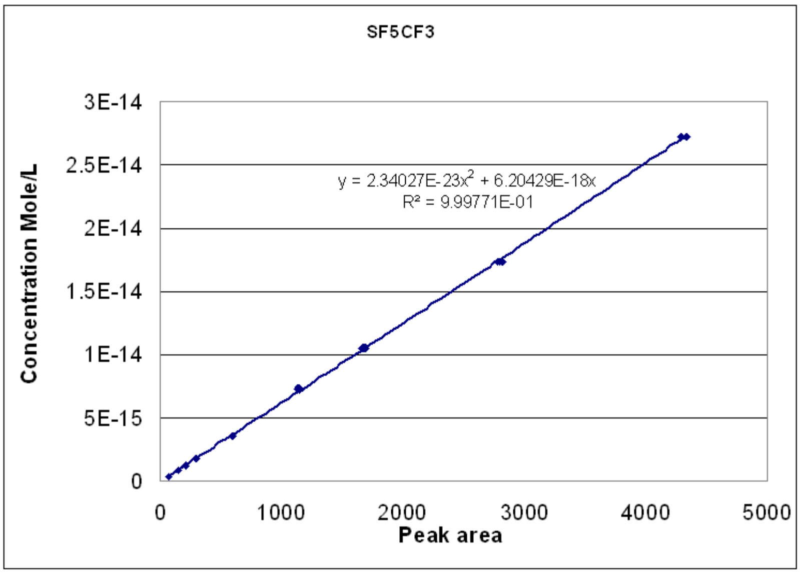


Figure 3.2: calibration curve for CF_3SF_5 tracer

	Mixing ratio ppt	Std Dev	Calibration
SF6	14.0	0.05	Scale NOAA 2006
CFC-12	513.9	1.3	Scale NOAA 2001
CFC-13	2	---	Estimated from literature for air, Busenberg, 2008
CF_3SF_5	63.9	0.1	Intercalibration with Ledwell 5B tank 7/01/2011

Table 3.1: Concentrations of the working standard NOAA tank # ALL-072115

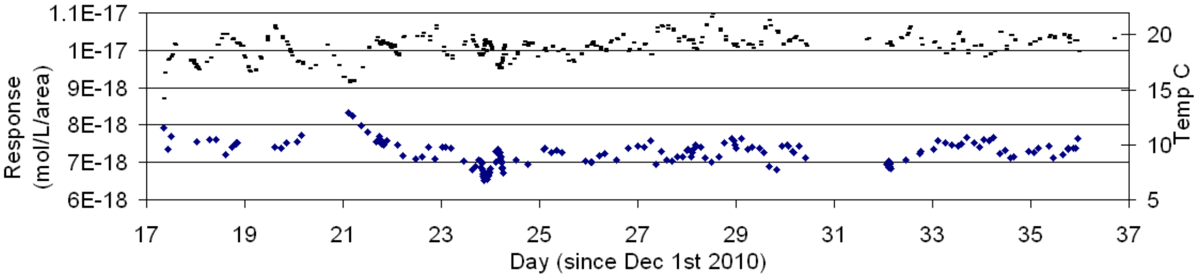


Figure 3.3: Instrument response for CF_3SF_5 and temperature in the container.

3.2.1.3. Detection limit, precision and accuracy

An unusually large volume of water (1135 ml) was analysed in order to increase the detection limit of the tracer in water as less tracer was released than originally planned. The detection limit for CF_3SF_5 was 0.003 fmol/l.

The precision (or reproducibility) for the water samples measurements can be determined from replicate samples drawn on the same Niskin. In total, 100 duplicate samples were drawn randomly from the rosette along the cruise when time permitted. The average standard deviation for Niskin duplicates was 0.005 fmol/L for SF_6, 0.02fmol/L for CFC-13 , 0.005 fmol/L (or 1% if greater) for CF_3SF_5, and 0.07pmol/L for CFC-12

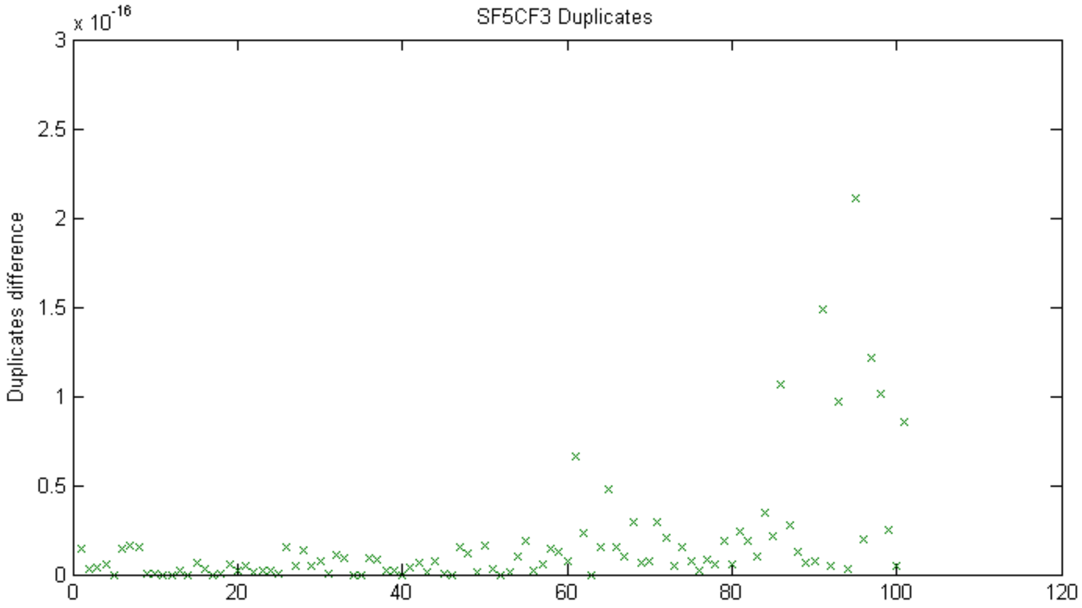


Figure 3.4: differences between duplicates of CF_3SF_5

For the tracer, no blank correction was applied as no trace of CF_3SF_5 was detected in the samples from depth. The other compound blanks need be assessed in more detail and will be accounted for in the final data. Sparging efficiency was determined by successive resparge of a single sample until complete no further compound could be detected (Table 3.2).

The accuracy of the results was checked by comparing measured surface concentrations with expected concentration inferred from known atmospheric concentrations and the solubility equation (Table 3.2). The distributions of the CFCs and SF_6 seen here are consistent with previous studies, showing high surface values and the signal of Antarctic Bottom Water in the bottom waters. We also measured CF_3SF_5 in marine air, and found a value of 0.19 +/-0.1ppt,

Tracer	Sparge efficiency
SF_6	90.2 %
CFC-13	91.7 %
CF_3SF_5	96.1 %
CFC-12	88 %

Table 3.2. Sparge efficiencies estimated for the tracers under investigation during JC054.

3.2.2. Narrative and Results

The tracer, 76 kg of trifluoromethyl sulphur pentafluoride (CF_3SF_5), was released from R/V Roger Revelle on the 27.906 kg m^{-3} neutral density surface (in UCDW near 1500-m depth) west of the Drake Passage in the Antarctic Circumpolar Current near 58S, 107W, in early February 2009 (Ledwell et al 2011). The tracer patch was surveyed one year later during the US2 cruise, in January-February 2010, from R/V Thomas G. Thompson West of Drake Passage. On the present cruise we conducted a large scale survey of the tracer 22 months after the release extending from 58W east to 79W in the region of Drake Passage. Although, the planned comprehensive survey of the tracer patch could not be fully conducted due to time shortage, the tracer program was very successful. Fifty five vertical profiles spaced at ~ 1/3 of a degree latitude along 3 meridian sections (60W, 67W and 79W) showed measurable tracer concentration at all the surveyed locations except one (which did was on the continental slope of Antarctica where the depth was only 400m, so no UCDW was present). In particular, the cruise tracer data set provides valuable information for a study of diapycnal mixing across Drake Passage and gives a snapshot of the horizontal distribution of the tracer ~2 years after its release in the region. The proposed fine scale resolution survey was postponed to April 2011.

3.2.2.1. Horizontal Distributions

Column integrals of tracer concentration, in picomoles/m^2 are presented in Figure 3.5. Although the large horizontal resolution of 1/3 of a degree cannot resolve the streakiness of the patch, the overall spreading of the patch appears fairly homogeneous. As expected, we found higher values in the section west of Drake Passage compared with the eastern section. A rough contouring by eye of the integrals gives an approximate budget for the surveyed area of 2.5 kg of CF_3SF_5.

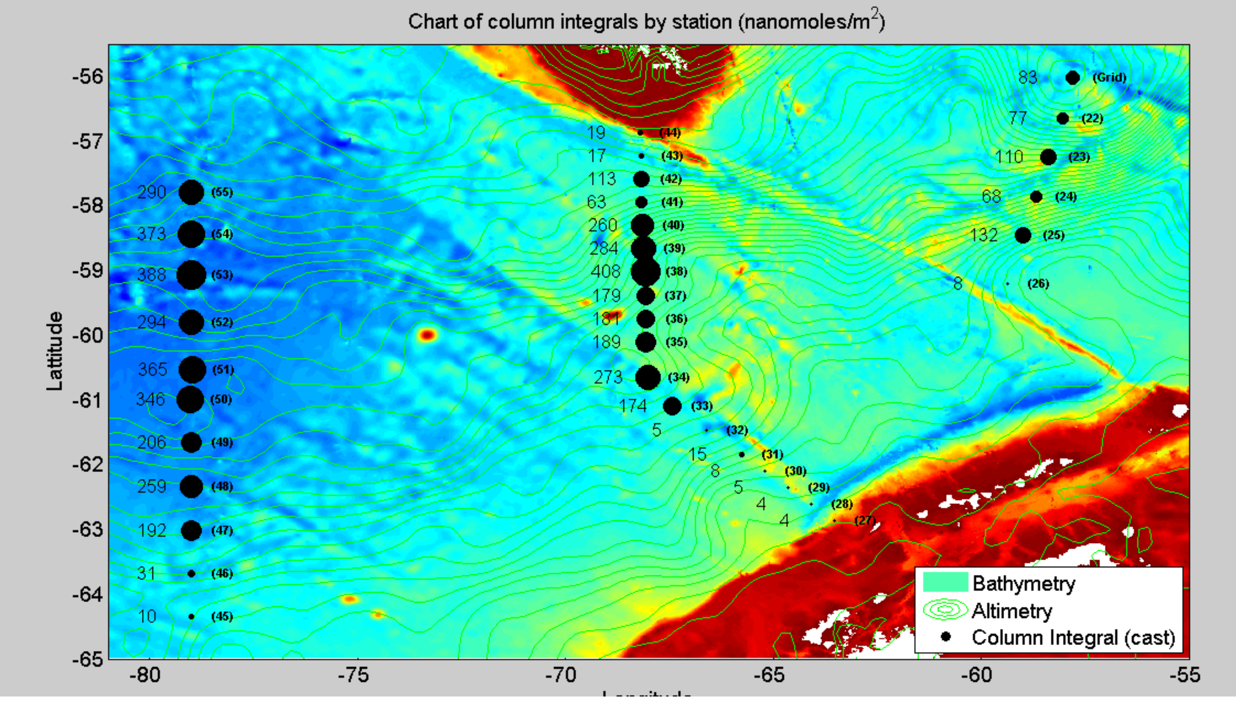


Figure 3.5: Column integrals, presented as size of the dots with values in picomoles m^{-2} in light type, for the three sections.

3.2.2.2. East of Drake Passage: 60W, the mooring grid and section 0.

We found significant concentrations of tracer at the mooring grid (stations 2 to 21) with peak maximum concentration ranging from 0.02 to 0.3 fmol/l. The tracer profiles at the first seven stations are very low in concentration and appeared noisy: they present sharp small multi peaks. These are signatures of isopycnal mixing of small quantities of tracer (~ 0.03 fmol/l) with tracer free eddy filaments. From station 8, the concentrations are larger and tracer profiles were smoother with peak widths that Imply a large diapycnal mixing rate when comparing density corrected depth/tracer profiles with the US2 tracer profiles centred around 95 W (see vertical spreading section). Interestingly, the concentrations of tracers measured at the grid show an increase with time, suggesting that we may have caught in the mooring area the arrival of a 'bulge of tracer' and/or a leading edge of the tracer patch. Assuming that the 'main' tracer path follows the altimetry-derived streamlines, one can trace back a northern long circuitous route for the tracer to the grid area from the west of Drake Passage. The relatively high concentrations of tracer found in the grid were an incentive to add a southward section (section 0, station 22 to 26) crossing the ACC from the grid to the SACCF. We believe this documents the early stage of the tracer invasion east of Drake Passage. However, it is not possible to say when the tracer arrived there. With a spatial resolution of 1/3 of a degree, section 0 shows a fairly homogeneous distribution of the tracer with column integrals ranging from 68 to 132 pmol/m^2 north of the SACCF. Those correspond to maximum peak concentrations ranging from 0.5 to 0.7 fmol/l (maximum found at station 25).

3.2.2.3. West of Drake Passage: sections 1 (68W) and 2 (79W).

The column integrals along section 1 west of Drake Passage (station 27 to 43) were significantly higher than in the eastern section reaching up to ~400 pmol/m^2 (peak maximum=3.3 fmol/l). Three major features appeared on the tracer horizontal distribution which seem linked to the structure of ACC, which is constricted at this longitude. South of the Polar Front (station 28 to32), tracer concentrations were low with column integrals ranging from 2 to 5 picomoles/m^2. The stations 33 to 37 followed the Polar Front and present column integrals between 160 and 185 of pmol/m^2. Finally the highest concentrations reaching 400 picolmole/m^2 were found within the Subantarctic Front (SAF). The tracer along section 2 (stations 43 to 55) shows a relatively homogeneous distribution ranging from ~190 to ~380 pmol/m^2, except for the two southernmost stations which have low concentrations.

Overall, the tracer had reached the east side of Drake Passage earlier than expected from extrapolation of the US2 results, but show lower concentration in the west.

3.2.2.4. Vertical dispersion

Vertical profiles of the tracer were well defined with a good resolution by spacing Niskin bottles between 20-30 meters around the target density. The depth of the tracer maximum shoaled from 2000 m in the northern part of the SAF to 1100m in the Polar Front and 400m in the Southern Boundary however the tracer was found close to the target density at all locations. Detailed examination shows the maximum of the peak slightly above the target density.

Within the ACC, all the profiles presented a near-Gaussian shape when averaged as a function of neutral density, and then transformed to depth using the mean depth/density relationship for the entire cruise. The mean profiles for the three sections are shown in Figure 3.6. The mean standard deviations for the 3 section were respectively 84 m (section 0), 62m (section 1) and 55 m (section 2). If we take the time of transit between the each of section 2 and 1, and section 1 and 0, rough estimates of the diapycnal diffusivity required to produce this evolution are 2.1 x 10^{-4} m^2 s^{-1} averaged over 3 months between sections 0 and 1, and 0.5 x 10^{-4} m^2 s^{-1} between sections 1 and 2. The inferred high diapycnal mixing rate integrated all mixing processes affecting the tracer as it passed the rough bathymetry of Drake Passage.

Interestingly, the mean widths of the profiles appeared higher for lower tracer concentrations. This contrasts with the low diapycnal diffusivity of (1.3 ± 0.2) x 10^{-5} m^2 s^{-1} estimated in the eastern Pacific ACC measured during US2 cruise (Ledwell et al., 2011).

The tracer profile at station 24 shows an intrusion near the target density of colder and richer-CFC water originating from water ~200 m higher up in the water column, possibly the result of isopycnal interleaving and cross-frontal processes. It is interesting to see that the mean width for this double peak at station 24 is one of the largest (115m). Note that this profile was not used in mean profile of section 1 in Figure 3.6.

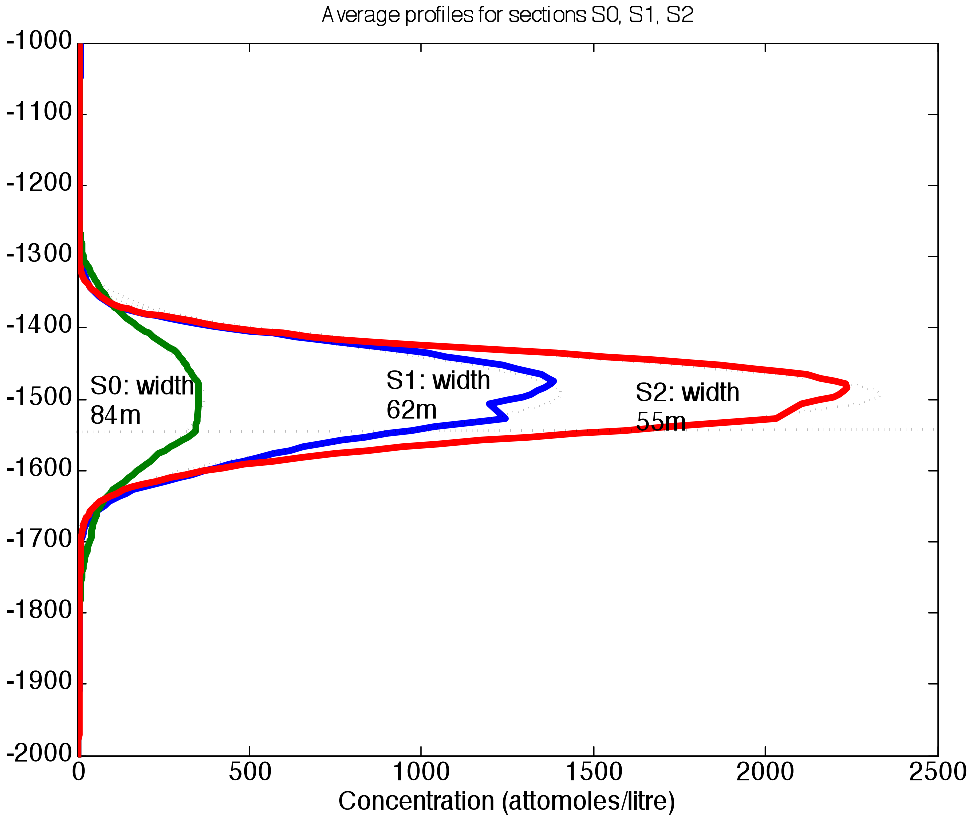


Figure 3.6: Mean tracer profiles for the three sections, plotted against neutral density and converted to depth using the cruise-mean density-vs-depth profile to convert between the two variables. Gaussians of the form $C_0 exp\{0.5[(z\text{-}zmax)/\sigma]^2\}$ were fitted to the profiles, and the values for σ are shown as the widths. The dotted line shows the depth of the γ_n=27.095 density level, on which the tracer was released.

3.2.2.5. Acknowledgements

We would like to acknowledge the help of all the ship-side staff, the NMF technicians and the scientific party aboard cruise JC054: Special thanks to Jim Ledwell who was part of the night watch for the tracer team.

3.3. WHOI Tracer Analysis System

Jim Ledwell

3.3.1. Introduction

The WHOI gas chromatograph system for analyzing the tracer, CF_3SF_5, was brought on the cruise as a backup for the UEA system. It was not used for real samples, but it was brought up to running condition, characterised, and duplicate samples were run from two casts. Basic information on the system is given here for reference and for preparation for future cruises where both the UEA and Woods Hole systems may be used. There are no data to be reported from this system beyond what is in this written section.

3.3.2. Samples

Samples were taken in 1-L glass bottles with screw caps in which a solid urethane rounded cone was inserted to displace water when the cap is put on. It had been found on a previous cruise that both the urethane cones and the interior surfaces of 4-lliter PVC Niskin bottles had a capacity to adsorb the tracer. The combined effect of adsorption onto the walls of the Niskin and loss to the gas phase in the Niskin during sampling was about 1% in tests. The effect in 10-L bottles with external springs will be smaller because of the smaller surface to volume ratio, perhaps as small as 0.5%. The loss of tracer to the urethane stopper in the glass bottle was found to be about 0.5%.

3.3.3. System and Procedure

Gas Chromatograph

Shimadzu GC8A

Detector Temperature: 330C

Detector Current: 2.0 nA

Noise level: approximately 0.08 mv peak to peak

Response to 0.922 ml of 106.0 ppt CF3SF5: approx. 45 mv-s

Peak width (rms of Gaussian fit to a sample or standard): 6.0 s.

Minimum Detectable CF3SF5: approx. 0.03 fM (for the 680-ml sparge tower)

Blank: < 0.03 fM (1 fM = 10^{-15} moles/L)

Cold Trap

Approximately 0.1 ml of Unibeads 2S 60/80 (Grace)

Isopropyl Alcohol bath at -70 C

Heated to 80 C for release

In carrier line for 1 minute during the GC injection

After that minute it is in line with the sparge gas at 80C for 1.5 min for cleaning before cooling again (making sure especially N2O is out).

Sparge Tower

Volume = 680 ml

Sparge time = 4.0 min

Flow rate =~ 110 ml/min

Pressure =~ 10 psig

Efficiency =~ 0.98

Columns

All columns were in the GC oven at 70C, in the following order:

25-cm Mol Sieve 5A 80/100 mesh in 1/8” OD SS tubing

120-cm Res-Sil B 60/80 mesh, Max Temp 150C (ResTek)

180-cm 1% AT-1000 on 60/80 Carbograph-1 (Grace)

Flow rate = 26 ml/min

Inlet pressure = 30.5 psig

Note: 10” mol sieve 5A column downstream of ECD to pressurize the cell to about 2.5 psig

The Mol Sieve column comes first and is backflushed after 1 minute. Its purpose is to block nitrous oxide. The other two columns are in series on the same valve and are backflushed after 4 minutes. The baseline did seem to deteriorate while running a full cast. The Mol Sieve column should have its own heater so that it can run cooler than the main columns and can be baked hotter than the main columns.

Table 3.3. Retention times (approximate):

CFC13	2.7 min
CF3SF5	3.33 min
CFC12	leading edge starts just before 4 min

Calibration

Calibration was done by comparing peak areas with that of a 106.0 parts per trillion standard of CF3SF5 in nitrogen (Standard 5a). The absolute calibration of this standard was determined by comparing it with Standard 5b, which had been calibrated to have 100.6 ppt by E. Busenberg at USGS. All concentrations run with the Woods Hole system during this cruise were low enough that a straight line passing through zero and the area for Standard 5a, 0.922 ml loop, was used for calibration. Pressure and temperature were recorded during standard runs and used to determine the quantity of standard in the loop.

Table 3.4. Sample Processing Times

Action	**Time (min)**	**Notes**
Sample Introduction	1.0	Could be 0.7 min
Sparge	4.0	Could be 3 min
Trap heating	0.85	
Sample drain	0.70	Could be 0.5 min
Trap in Carrier line	1.0	
Trap cleaning, hot	1.5	
Trap cooling	1.0	
Vacuum on Tower	2.5	
Main column forward	4.0	
Main column backflush	4.9	
Mol Sieve column forward	1.0	
Mol Sieve backflush	7.9	

Data acquisition

Integrator: Shimadzu CR5A, short term data storage only; integration only for larger peaks, baseline estimated automatically at slope sensitivity of 2500.

A/D Converter for data files: DATAQ 710, long term data storage; integration for all peaks, baseline estimated manually.

Chart Recorder: 1 mv full scale, paper record; charts saved.

Chromatograms

A chromatogram for a water sample with 0.28 fM tracer concentration is shown in Figure 3.7.

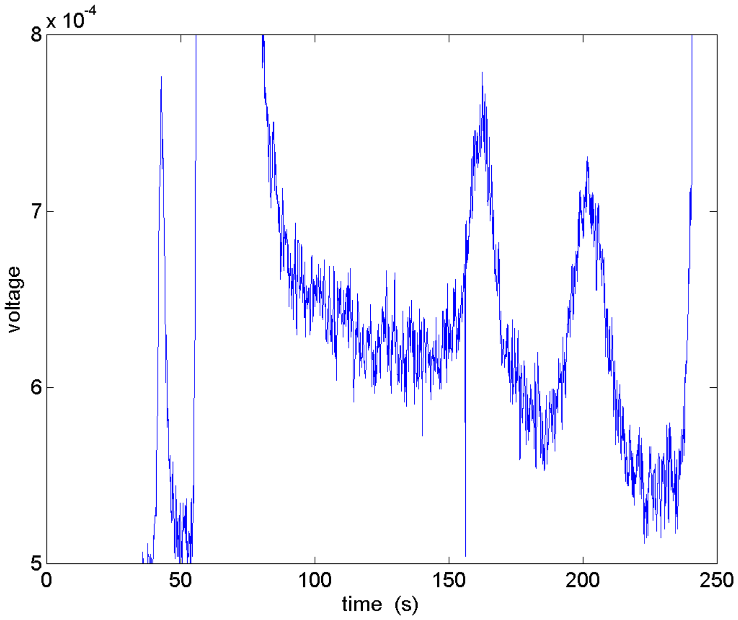


Figure 3.7. Chromatogram for the sample from Cast 22, Niskin 13. Peaks at approximately 160 s, 200 s, and 240 s are CFC-13, CF_3SF_5, and CFC-12, respectively. The concentration of CF_3SF_5 was 0.28 fM = 0.28 x 10^{-15} mol/litre for this sample.

Minimum Detectable Level

The smallest concentration detectable is set by the noise level. An example of a barely detected peak is shown in Figure 3.8.

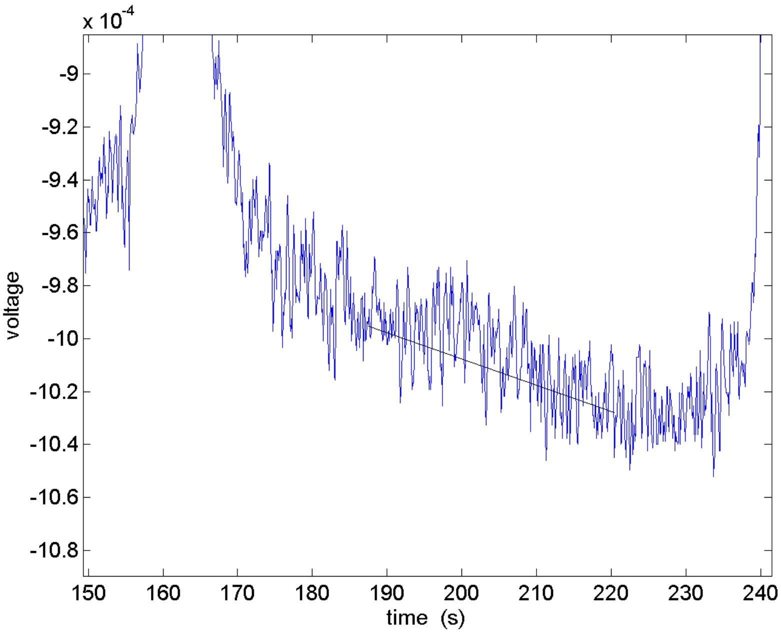


Figure 3.8. Detail of a GC record around a low tracer peak with a line-segment drawn manually to estimate the location of the baseline, i.e. the line about which the signal would oscillate if there were no tracer. The sample is from Cast 22, Niskin 1. The tails of a CF3SF5 standard would reach from 185 s to 221 s. The area above the line segment is 215 microvolt-seconds, giving a concentration of 0.028 fM.

Evaluation of peak areas

Tracer concentrations were analyzed by drawing a straight line segment as a baseline manually under the tracer peak and integrating the difference between the GC signal and this line segment. There is uncertainty in how to draw the baseline, and this uncertainty propagates to the concentration, especially for samples with very little tracer. An example of a low concentration sample (~0.03 fM) is shown in Figure 3.8. A more robust peak is shown in Figure 3.9, which is a detail of the CF3SF5 peak from the chromatogram shown in Figure 3.7.

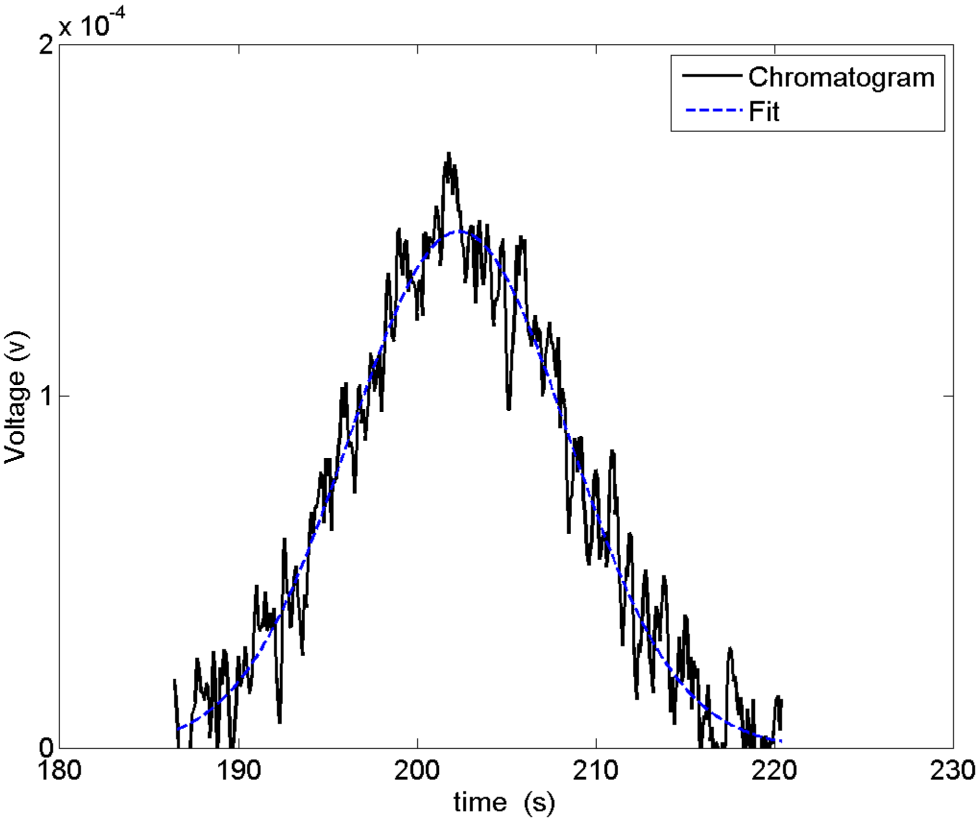


Figure 3.9. Chromatogram and Gaussian fit for sample from Cast 22, Niskin 13. This is a detail from Figure 3.7, with the time scale expanded and an estimate of the baseline subtracted. The area is 2.241 mv-s, and the corresponding concentration is 0.281 fM, one of the higher concentrations for the early part of JC054. The Gaussian curve has the same area as that estimated for the peak and is included merely for comparison.

3.3.4. Comparison with the UEA GC

Samples were taken into 1-L bottles after the 2-L samples had been taken on Cast 15 and Cast 22 to compare the two analysis systems. The 1-L samples would have been more compromised by gas exchange so that very low concentrations would be elevated by invasion from the air, while concentrations above equilibrium with the atmosphere would be diminished by evasion. The results of the comparison of the WHOI GC analysis of samples from Station 15 with the UEA GC (in fM) are given in the following table:

Table 3.5. Comparison of Woods Hole analysis with UEA analysis, Cast 15 (fM).

Niskin	UEA	WHOI	Difference
1	.04	.03	-0.01
2	.00	.01	+0.01
4	.19	.18	-0.01
5	.17	.16	-0.01
6	.22	.24	+0.02
7	.24	.26	+0.02
9	.21	.22	+0.01
10	.02	.05	+0.03
11	.23	.25	+0.02
12	.18	.21	+0.03
13	nan	.24	UEA sample not run

The whoi mean was 0.008 fM higher than the UEA mean.
The rms difference between the two analyses was 0.015 fM for Cast 15.

The whole profile was run with the Woods Hole system for Cast 22 (Figure 3.10). In this case the Woods Hole mean was 0.012 fM higher than UEA and the rms difference was 0.017 fM. These differences are most likely due to systematic differences in how the baseline is manually estimated in the two systems. The Woods Hole system is less sensitive than the UEA system because the volume of water is about half as great and because the signal to noise level is perhaps twice as low, even for the same quantity of tracer injected, due to a longer retention time, and thus broader peak, and possibly inherently noisier baseline for the Woods Hole system (this needs to be checked). Therefore the small differences found in absolute concentrations are not surprising. It would be effective to run alternate casts with the two different systems in a future cruise, with perhaps more attention given to determining the blank for both systems that may arise from the method of choosing the baseline (see below).

The signal to noise ratio is much better for the UEA system than for the WHOI system, as can be seen by comparing Figure 3.11 with Figure 3.10, both of which are chromatograms, with the baseline subtracted, for samples from Niskin 13, Cast 22. The ratio of the signal to peak-to-peak noise appears to be about 20 in the case of the UEA GC while it appears to be about 5 for the WHOI GC, so about 4 times better by that measure. Half of this difference may be attributed to the sparging of nearly twice as much water in the UEA system. The rest may be attributed to the narrower, taller peak for the UEA system. The standard deviation of a Gaussian fit to the UEA peak is 3.1 s compared with 6.0 s for the WHOI peak.

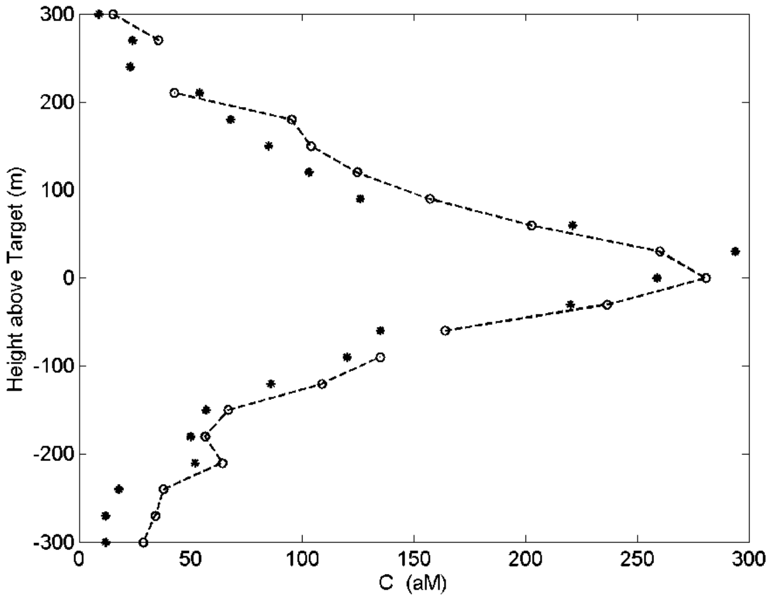


Figure 3.10. Comparison of concentrations from the same Niskin bottles (but different sample bottles) analysed by the Woods Hole system (open circles and dashed line) and the UEA system (asterisks), Cast 22. Concentrations are in attamoles/litre, i.e., 10^{-18} moles/litre.

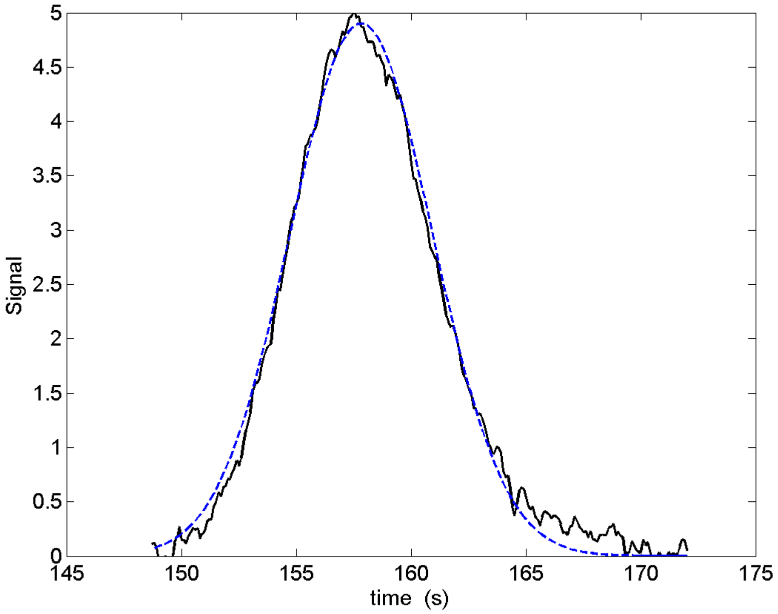


Figure 3.11. Chromatogram for Niskin 13, Cast 22, from the UEA analysis system. The standard deviation of the Gaussian (dashed line) fit to the peak is 3.1 s versus 6.0 s for the WHOI peak, and the noise level is 4 times smaller compared with the peak height for the UEA peak.

Blank

Figure 3.10 suggests that there is a blank in the Woods Hole system, possibly as great as 30 aM, or 0.03 fM. This estimate is based on the level of the tails of the profile and also on the elevation of the Woods Hole analysis above the UEA analysis. The blank most likely comes from negative curvature in the baseline that is present in the absence of any tracer during the time when the tracer elutes. That is, the "peak" in Figure 3.8, for example, may actually be a blank. Not enough blank samples have been run to confirm this surmise, however.

Further evidence of such a blank in the WHOI system can be seen by comparing the chromatogram for Niskin 1, Cast 22, from the UEA system (Figure 3.12), with Figure 3.7 from the WHOI system. For the UEA system a peak is not easy to perceive, and in fact the operators of the UEA system declared there to be no peak at all for this sample, and they were probably correct. If one insists on integrating a peak for this chromatogram, if only to estimate the value of the blank for the UEA system one finds a concentration about one third as great as for the WHOI peak, or about 0.01 fM (Figure 3.13). This result suggests that the WHOI blank is at least 0.02 fM.

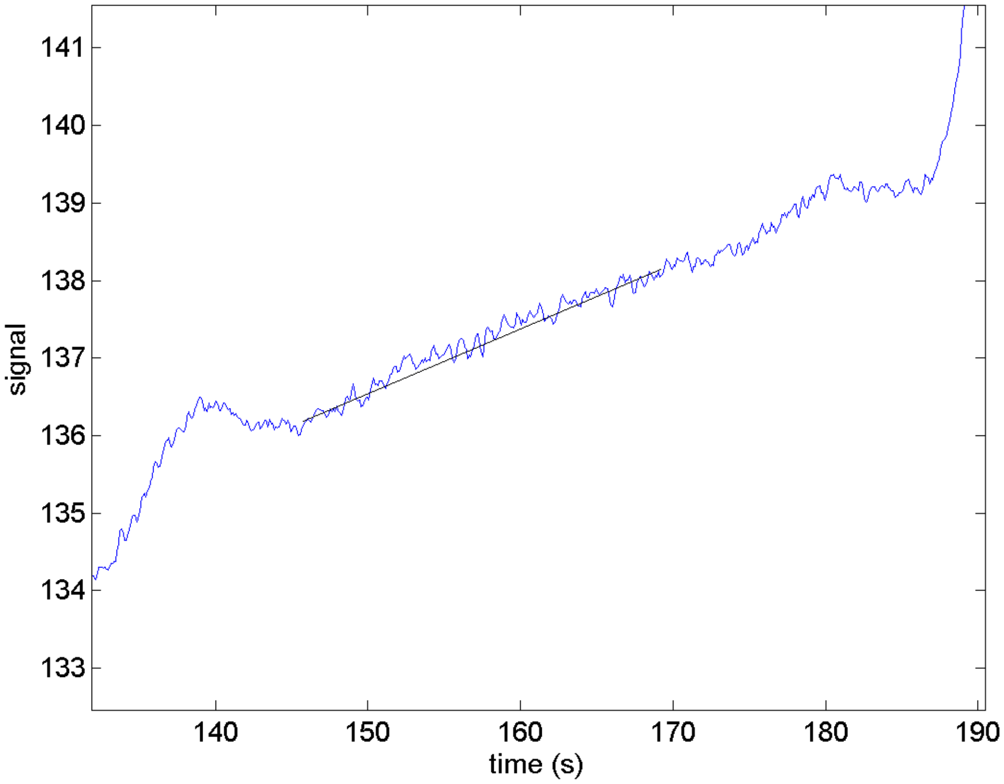


Figure 3.12. Detail of the raw chromatogram for Niskin 1, Cast 22, from the UEA system. A line segment has been drawn to estimate a baseline over the same time interval in which the peak in Figure 3.11 appears.

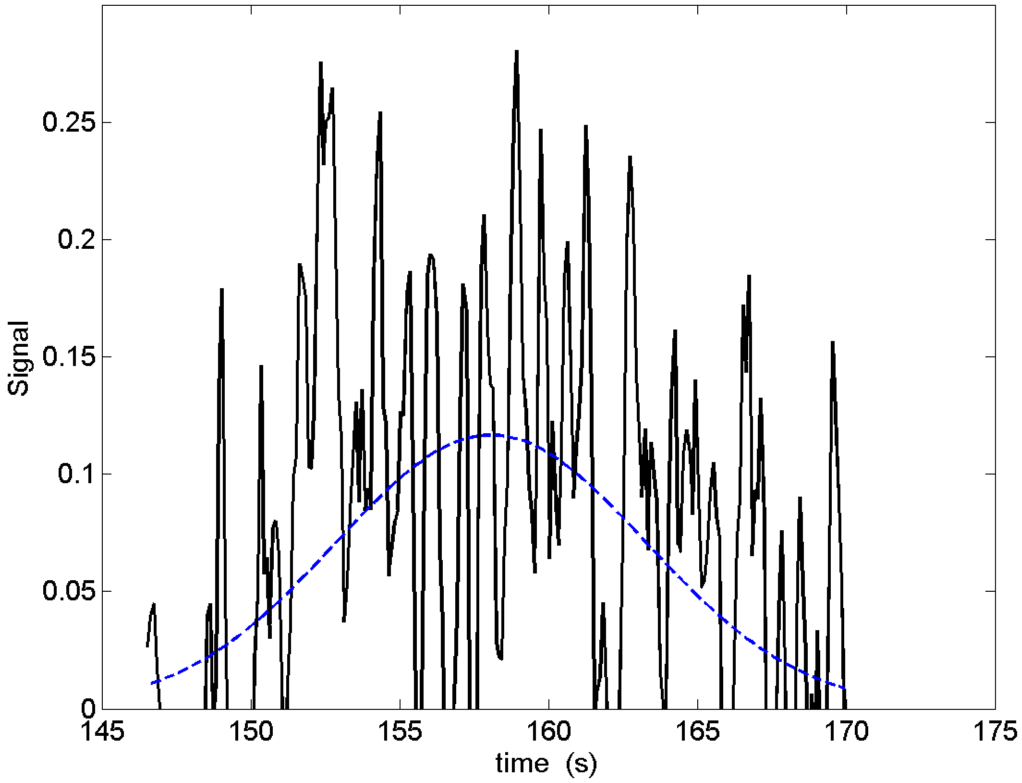


Figure 3.13. An attempt to integrate a "peak" in the time interval delineated in Figure 3.12.

4.1 CTD Operations and Calibration Procedures

Jean-Baptiste Sallée, Paul Provost et al.

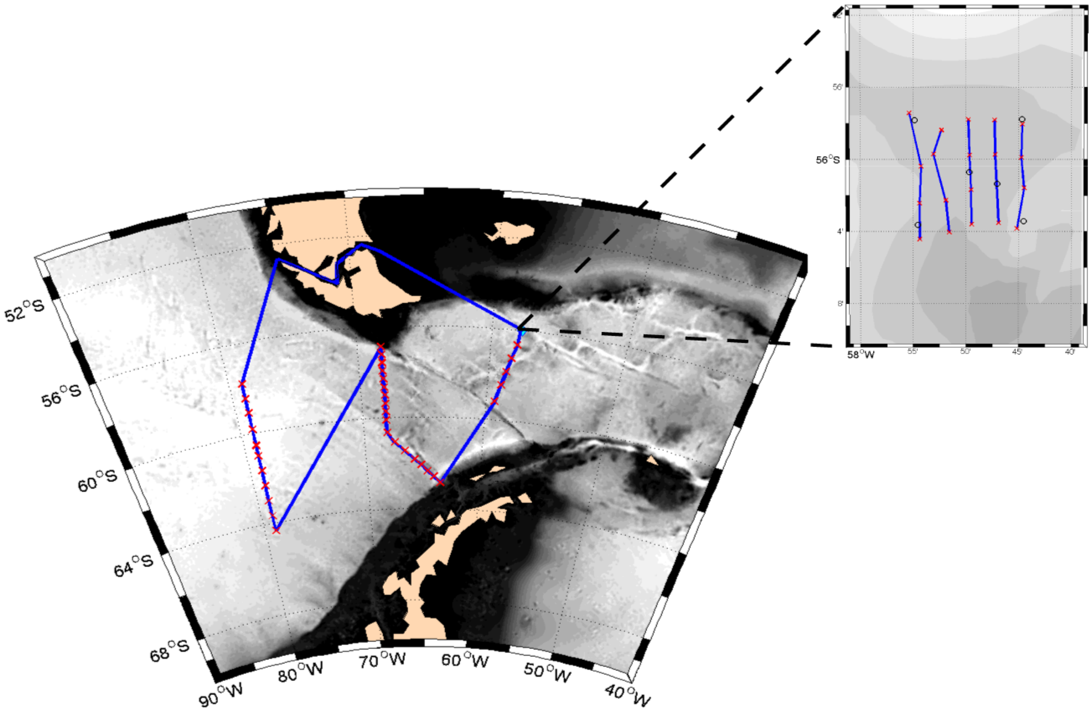


Figure 4.1. Cruise track (blue), CTD stations (red crosses) and mooring site (black circles).

4.1.1 Introduction and Aims

Fifty-five Conductivity-Temperature-Depth (CTD), 24-bottle rosette stations were occupied during cruise JC054 (Table 4.1). This survey had three main goals for the DIMES program:-

1) Give the hydrographic context in terms of water mass, front localisation and transport, for analysis of the other components of the program: e.g. microstructure measurements; tracer sampling; RAFOS and APEX floats; mooring cluster.

2) Provide hydrographic sections at choke points of the DIMES programme: through the assumed tracer's centre of mass, west of Drake Passage; at Drake Passage; and in the Scotia Sea, east of very rough bathymetry features. These sections will eventually feed an inverse model analysis to infer isopycnal and diapycnal mixing between these locations.

3) Measure the isopycnal and diapycnal dispersion of the DIMES tracer, released two years ago west of Drake Passage.

A 24-way Stainless Steel CTD (01) was used throughout the cruise, with sensors in the following configuration. Sea-Bird 9*plus* configuration file 0943.xmlcon was used for initial stainless steel frame CTD casts, with 0943_no_NMEA.xmlcon used for the back-up, simultaneous logging desktop computer.

CTD configuration:-

Sea-Bird 9plus underwater unit, s/n 09P-54047-0943

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

Sea-Bird 4C conductivity sensor, s/n 04C-3054, Frequency 1 (primary)

Digiquartz temperature compensated pressure sensor, s/n110557, Frequency 2

Sea-Bird 3P temperature sensor, s/n 03P-2919, Frequency 3 (secondary, vane mounted)

Sea-Bird 4C conductivity sensor, s/n 04C-3580, Frequency 4 (secondary, vane mounted)

Sea-Bird 5T submersible pump, s/n 05T-3607, (primary)

Sea-Bird 5T submersible pump, s/n 05T-3195, (secondary, vane mounted)

Sea-Bird 32 Carousel 24 position pylon, s/n 32-19817-0243

Sea-Bird 11plus deck unit, s/n 11P-34173-0676

Auxiliary input initial sensor configuration:-

Sea-Bird 43 dissolved oxygen sensor, s/n 43-0363 (V0)

Chelsea MKIII Aquatracka fluorometer, s/n 88-2615-124 (V2)

Benthos PSA-916T altimeter, s/n 41302 (V3)

User Supplied turbity sensor (V4)

None (V5)

WETLabs light scattering sensor, red LED, 650nm, s/n BBRTD-759R (V6)

Chelsea MKII 10cm path Alphatracka transmissometer, s/n 161050 (V7)

station #	date	lon	lat	max press (db)
1	2010-12-07 03:17:46	-57.92302	-55.95715	4279.00000
2	2010-12-08 02:13:31	-57.91346	-55.96957	2533.00000
3	2010-12-08 09:01:19	-57.90413	-56.00659	4159.00000
4	2010-12-08 17:41:37	-57.90651	-56.04065	4141.00000
5	2010-12-09 01:35:23	-57.90629	-56.07387	4009.00000
6	2010-12-09 08:12:30	-57.85926	-56.06733	3779.00000
7	2010-12-09 14:32:19	-57.86589	-56.03443	1933.00000
8	2010-12-09 17:20:54	-57.86477	-56.03789	3753.00000
9	2010-12-09 23:01:50	-57.88453	-55.99546	4111.00000
10	2010-12-10 06:31:48	-57.87160	-55.97314	4119.00000
11	2010-12-18 23:15:59	-57.75253	-56.06392	4227.00000
12	2010-12-19 05:56:15	-57.74124	-56.02623	3947.00000
13	2010-12-20 01:03:50	-57.74552	-55.99852	3851.00000
14	2010-12-20 06:31:57	-57.74415	-55.96780	4033.00000
15	2010-12-20 21:28:58	-57.78811	-55.96388	3999.00000
16	2010-12-21 02:52:20	-57.78731	-55.99573	3777.00000
17	2010-12-21 08:05:18	-57.78185	-56.05888	3981.00000
18	2010-12-21 13:29:56	-57.82418	-56.06013	3657.00000
19	2010-12-21 18:37:41	-57.82485	-56.02815	3669.00000
20	2010-12-22 00:47:12	-57.82746	-55.99640	3813.00000
21	2010-12-22 07:28:51	-57.82936	-55.96338	4005.00000
22	2010-12-23 01:49:05	-58.05090	-56.65497	2435.00000
23	2010-12-23 09:01:38	-58.36459	-57.25354	1923.00000
24	2010-12-23 15:37:56	-58.68189	-57.84902	1683.00000
25	2010-12-23 22:48:07	-58.97014	-58.44704	1441.00000
26	2010-12-24 05:24:32	-59.35598	-59.20432	967.00000
27	2010-12-25 06:51:43	-63.52256	-62.85670	1827.00000
28	2010-12-25 11:52:18	-64.08545	-62.60287	3529.00000
29	2010-12-25 19:18:03	-64.64800	-62.35086	3155.00000
30	2010-12-26 02:17:57	-65.20982	-62.09567	3051.00000
31	2010-12-26 08:51:32	-65.76395	-61.84499	3677.00000
32	2010-12-26 16:47:04	-66.59983	-61.46475	4211.00000
33	2010-12-27 01:33:06	-67.43746	-61.08263	4213.00000
34	2010-12-27 09:06:53	-68.00557	-60.65479	4185.00000
35	2010-12-27 21:39:31	-68.05752	-60.11191	1811.00000
36	2010-12-28 03:32:47	-68.06238	-59.74116	3627.00000
37	2010-12-28 10:02:45	-68.07612	-59.38238	3709.00000
38	2010-12-28 16:53:46	-68.06580	-59.01535	3573.00000
39	2010-12-29 03:09:07	-68.10781	-58.65477	2697.00000
40	2010-12-29 11:00:11	-68.13619	-58.29855	3955.00000
41	2010-12-29 21:39:40	-68.16622	-57.93721	3613.00000
42	2010-12-30 07:15:00	-68.18309	-57.58198	3913.00000
43	2010-12-30 15:33:37	-68.17921	-57.22496	4457.00000
44	2010-12-30 23:35:00	-68.21201	-56.87767	1067.00000
45	2011-01-02 03:47:54	-78.99350	-64.34539	797.00000
46	2011-01-02 13:33:52	-78.99970	-63.67820	2543.00000
47	2011-01-02 21:59:30	-78.99991	-63.01068	2535.00000
48	2011-01-03 04:53:05	-78.99864	-62.33941	4895.00000
49	2011-01-03 13:45:08	-79.00004	-61.65621	2543.00000
50	2011-01-03 20:03:11	-79.02141	-60.99884	2539.00000
51	2011-01-04 02:02:40	-78.97938	-60.52568	5081.00000
52	2011-01-04 11:47:24	-78.99998	-59.80000	2539.00000
53	2011-01-04 18:39:34	-79.00028	-59.07171	2541.00000
54	2011-01-05 01:36:24	-79.00100	-58.42929	2563.00000
55	2011-01-05 12:57:41	-78.99997	-57.78609	2537.00000

Table 4.1: List of CTD stations occupied during JC054

4.1.2. General comments and significant events

Table 4.2 refers to significant events that occurred during a CTD station, or immediately before/after. There were no major operational issues with the CTD suite during the cruise.

4.1.2.1. Bottle closing

One of the main goals of the water sampling during JC054 was to measure the concentration of the DIMES tracer in the vicinity of the isopycnal were it had been injected two years before: γ^n=27.9 (around σ_0=27.68). Therefore, on each cast the depth of the isopycnal σ_0=27.68 kg.m^{-3} was noted during the CTD downcast. Twenty-one bottles were fired at depths centred on the depth of σ_0=27.68 kg.m^{-3}, with either 20, 25 of 30 m in between each bottle, depending on station. Two bottles were allocated to the bottom of the profile, and one to the upper part of the profile.

4.1.2.2. CTD deployment duration

It should be noted that due to the nature of the winch system on *RRS James Cook* the launch and recovery of the CTD have to be done relatively slowly especially in bad weather. There is also a delay of a few minutes whilst the winch system is switched from belly box control to lab control at approximately 100 m of wire out (see Figure 4.2 for a summary of CTD deployment duration). At stations where we deployed a VMP, the CTD deployment duration had to approximately match the VMP cast duration, within 1:30 hours. This was usually not a constraint, the VMP taking always only slightly longer than the CTD. However, CTD007 had to be aborted due to early weight release of the VMP, causing it to surface much earlier than expected. Similarly, CTD035 had been limited to a shallow cast (1875 m, instead of full depth), because its deployment had to be delayed due to bad weather, while the VMP deployment was not delayed.

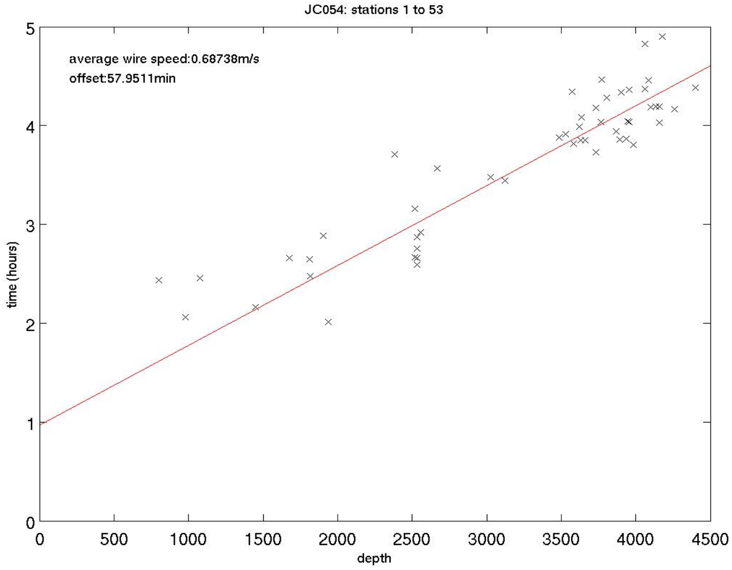


Figure 4.2: CTD time versus depth during JC054

Station	Comments
CTD007	aborted to due to early weight release of the VMP
CTD035	delayed due to rough sea: made shallow (1875 m) due to VMP time constraint
CTD027	Shallow bottom
CTD045	Problem with the hydroboom. CTD aborted.
CTD048	Seabird software crashed during the cast, and had to be restarted
CTD054	CTD stopped due to bad weather
Station	**Bottle problems**
CTD001	Bottles 2, 12 and 14 did not close
CTD003	Bottles 12, 16 leaked
CTD004	Bottle 10 did not close; 21 leaked
CTD005	Bottle 1 did not close; 2 and 17 leaked
CTD006	Bottle 2 and 13 leaked
CTD008	Bottle 10 did not close; Bottle 4 and 12 leaked
CTD009	Bottles 10, 11 and 15 leaked
CTD010	Bottles 19, 19 and 22 leaked
CTD013	Bottle 23 did not close
CTD014	Bottle 23 did not close
CTD016	Bottle 10 did not fire
CTD018	Bottles 1 and 10 did not fire
CTD019	Bottles 1 and 6 leaked
CTD022	Bottle 10 did not fire
CTD024	Bottle 1 and 10 did not fire
CTD025	Bottle 10 did not fire
CTD029	Bottle 10 leaked
CTD032	Bottles 10 and 17 did not fire
CTD035	Bottle 10 leaked
CTD037	Bottle 10 leaked
CTD038	Bottle 6 leaked
CTD040	Bottle 1 leaked
CTD041	Bottle 13 leaked
CTD042	Bottle 1 and 10 leaked; 17 did not close
CTD045	Bottle 10 leaked
CTD046	Bottle 5 did not close
CTD048	Bottle 17 did not close
CTD049	Bottles 1, 3 and 17 leaked
CTD050	Bottle 16 leaked
CTD051	Bottle 16 leaked
CTD053	Bottle 3 leaked
CTD054	Bottle 3 did not close; Bottle 13 leaked
CTD055	Bottle 3 and 17 did not close; 22 leaked

Table 4.2. Significant events and bottle problems during JC054.

4.1.2.3. Bottle leaking and firing problems

There were repeated problems of bottles leaking or having not closed when the CTD was brought back on deck. The tensions of the lanyards were slightly adjusted on some bottles by making knots. While this might have slightly reduced the problem, it did not solve it. While back in port at Punta Arenas for engine maintenance, all tensions of the lanyards were thoroughly checked and adjusted. In addition, the lanyard “loop” on the bottom cap of the Niskins were slightly elongated so while open, the cap were in a better position for a clean closure of the bottle. These changes greatly improved the bottle closure. However, bottle 10 remained problematic, with repeated leaking or firing failures. We suspect that the problem does not come from the bottle itself but from the firing mechanisms on the rosette. We highly recommend a routine maintenance and cleaning of the mechanism.

4.1.2.4. Altimetry

The Benthos altimeter worked very reliably, obtaining a good bottom return within 80-30 m of the bottom. In calm seas the CTD was deployed to around 15 m from the bottom. This was increased to approximately 20 m from the bottom in larger swell.

4.1.3. Instruments and system specification

See the NMF technicians' report for a detailed list of instruments on the rosette. The CTD package sensor configuration is given in Appendix II.

4.1.4. Data Processing and Calibration

4.1.4.1. Initial Processing using SeaBird Programs

The files outputted by Seasave (version 7.18) have appendices: .HEX, .HDR, .BL, .CON. The .CON files for each cast contain the calibration coefficients for the instrument. The .HDR files contain the information in the header of each cast file. The .HEX files are the data files for each cast, and are in hexadecimal format. The .BL files contain information on bottle firings of the rosette. Initial data processing was performed on a PC using the Seabird processing software SBE Data Processing, Version 7.18. We used the following options in the given order:

- Data Conversion
- Align CTD
- Cell Thermal Mass

Data Conversion turns the raw data into data in physical units. It takes the .CON and .HEX files and outputs a file called JC054nnn.cnv, where nnn is the station number. The surface soak was removed from the data at this point, and a surface pressure offset (obtained from the first ~30 readings) was applied to the .CON file, which was then saved as JC054nnnp.con.

Align CTD takes the .cnv file and applies temporal shifts to align the sensor readings.

Cell Thermal Mass takes the .cnv files output from Align CTD and makes corrections for the thermal mass of the cell, in an attempt to minimise salinity spiking in steep vertical gradients due to temperature/conductivity mismatch.

4.1.4.2. Second processing using MSTAR Programs

Once pre-preprocessed with the Seabird programs, the .cnv and .BL files were transferred from the CTD computer to NOSEA1, where we applied a series of processing steps using MSTAR programs. Below is a list of ctd and bottle processing we applied to each cast:

1. Create an empty bottle netcdf file with all the list of variables needed (msam_01.m)
2. Read CTD data from the .cnv file and write them into a netcdf “raw” file: ctd_jc054_nnn_raw.nc (mctd_01.m)
3. Rename variables from SBE original names to mstar variable names, and apply a hysteresis correction for oxygen (mctd2a.m and mctd2b.m)
4. Average to 1hz, calculate practical salinity and potential temperature, and create the new files: ctd_jc054_nnn_1hz.nc and ctd_jc054_nnn_psal.nc (mctd_03.m)
5. Create an empty dcs file, which is used to store information about start, bottom and end of good data in the ctd file: dcs_jc054_nnn.nc (mdcs_01.m)
6. Populate dcs file with data to identify bottom, start and end of the cast (mdcs_02.m and mdcs_03.m)
7. From GPS processed file (posmvpos), merge positions onto ctd start, bottom and end times. Create the file dcs_jc054_nnn.pos (mdcs_04.nc)
8. Apply the positions to all other netcdf files created (mdcs_05.nc)
9. Extract downcast data from the “_psal.nc” file, sort, interpolate gaps and average to 2dbar (mctd_04.m)
10. Read the .BL file from seabird and create a fir file: fir_jc054_nnn_bl.nc (mfir_01.m)
11. Merge time from ctd onto fir file using scan number (mfir_02.m)
12. Merge ctd fir data onto “fir” file and paste ctd “fir” data into “sam” file (mfir_03.m and mfir_04.m)
13. Extract data from the Techsas file for times from the start to the end of the 1hz ctd file +/- 10 minutes (mwin_01.m)
14. Merge winch wireout onto “fir” file and paste them into “sam“ file (mwin_03.m and mwin_04.m)
15. Once salinity from the bottles were analyzed, data were copied into a file: sal_jc054_nnn.nc (msal_01.m)
16. Salinity were then pasted into “sam” files (msal_02.m)
17. Once tracer concentration were analyzed, data were copied into a file: cfc_jc054_nnn.nc (mcfc_01.nc)
18. Tracer concentrations were then pasted into “sam” files (mcfc_02.m)
19. Create a file bot_jc054_nnn.nc with information about bottle position on rosette and bottle flag (WOCE flag: 2 if good – 9 if bad) (mbot_01.m)
20. Bottle flags were then pasted into “sam“ files (mbot_02.m)
21. Finally, we calculated the residuals between bottle salinity and ctd salinity and pasted them into “sam” file (msam_02.m)

All profiles were visually checked using a suite of plots (theta-S; profiles versus depth; profiles versus scan number) to detect any possible anomalies. Profiles were also plotted on top of each other for different stations, to detect possible sensor drift (mplot_ctdck.m)

In a number of casts, localized small spikes have been detected on the salinity/conductivity profiles (see Figure 4.3). Those spike were removed (replaced by NaN) using the routine mplxyed.m.

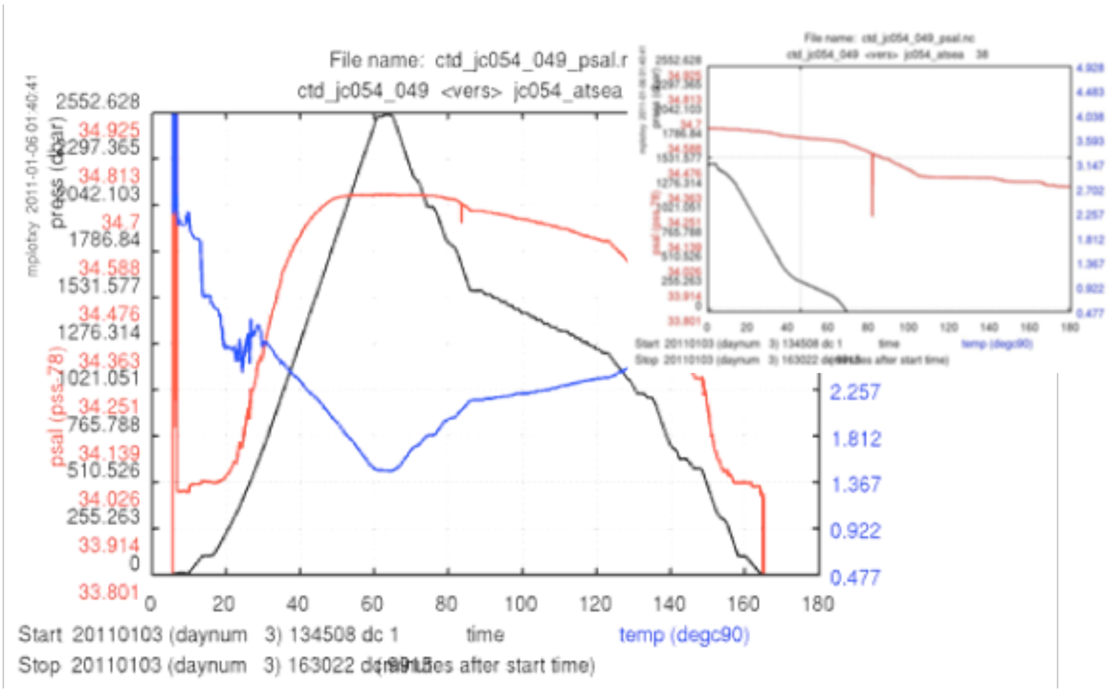


Figure 4.3. Temperature (blue), salinity (red) and pressure (black) versus time for cast CTD049. Example of a spike in a salinity profile.

4.1.4.3. Salinity Calibration

Between five and seven Niskins were sampled at all stations for salinity measurements. Surface and bottom Niskins were chosen as well as a couple of Niskins in tracer cluster depths. We chose to not sample all Niskins as 21 of them were sampling water in a narrow depth range, around the tracer depth. The salinity differences between bottle salinity and sensors salinity are relatively scattered, but overall most differences fall within +/- 0.002 psu (see Figure 4.4). We looked for pressure dependence and/or time dependence, but no clear trend or pattern emerged. In addition, both sensors were showing very similar behaviour.

We used theta-S profiles as an additional test to detect possible drift of the sensors. Bottom water hydrologic characteristic are known to be stable, so can be a good test to detect drifts. All theta-S characteristics of bottom water sampled during the cruise were found to fall in the same narrow band. However, we found profiles from the early part of the cruise to be slightly fresher than profiles at the end of the cruise (See Figure 4.5). The difference does not appear to be a constant shift in salinity, and appears to be a real change. The difference is also consistent with previous bottom water studies finding Atlantic bottom water slightly fresher than Pacific bottom water.

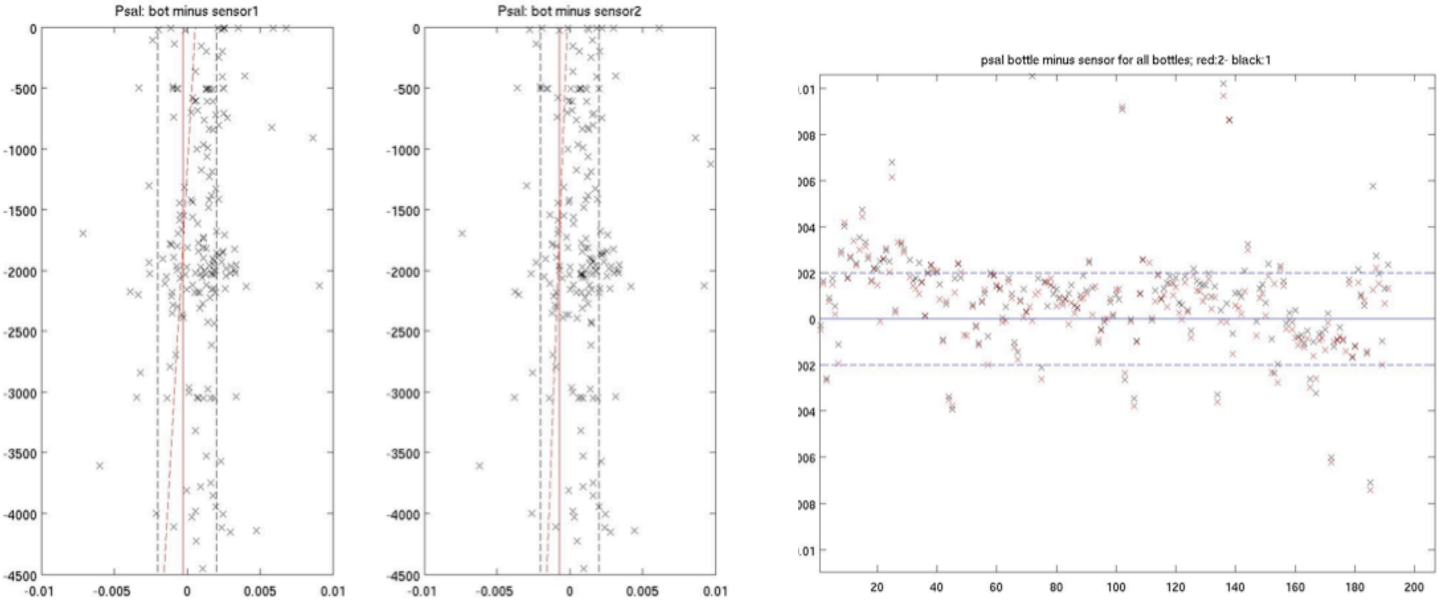


Figure 4.4. Bottle salinity minus CTD salinity sensor 1 versus pressure (left). Bottle salinity minus CTD salinity sensor 2 versus pressure (middle). Bottle salinity minus CTD salinity sensor 1 (black cross) and sensor 2 (red cross) versus time (right). Vertical red line is the average difference, and dashed red line the linear best fit. +/- 0.002 lines are shown in dashed black.

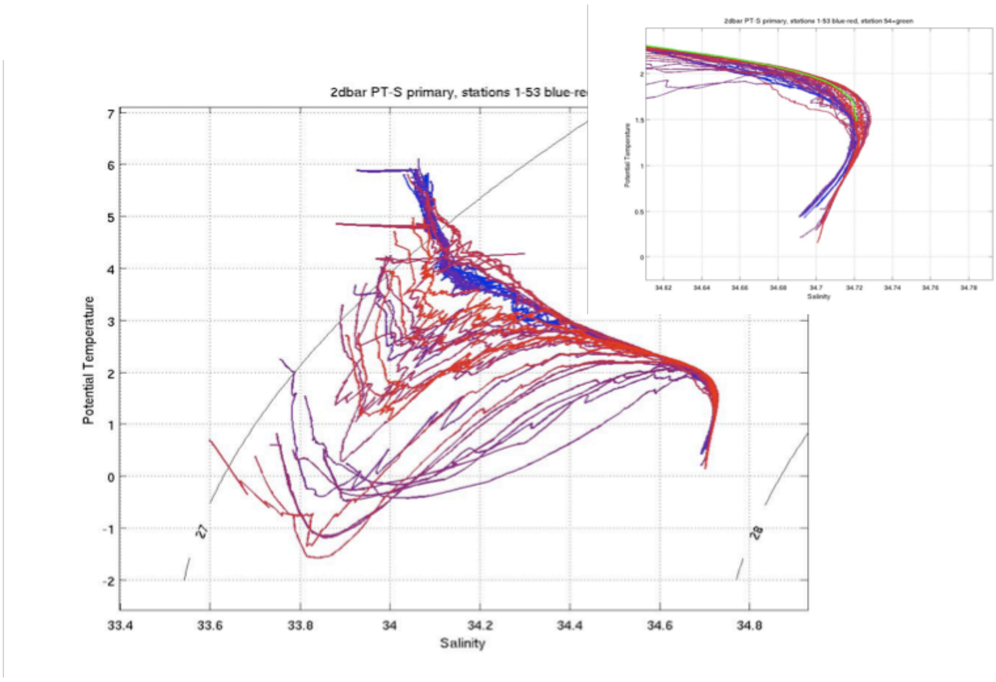


Figure 4.5. Theta-S profiles from the CTD sensor 1 of the cruise JC054. Colour reflects time, blue being early profiles and red later profiles.

Based on the analysis conducted, it was concluded that further calibration to the salinity sensors was not required. Should any calibrations have been applied, they would have been less than 0.001 psu, i.e. less than the target accuracy.

4.1.5. Recommendations

There were no major operational issues with the CTD suite or with the calibration during the cruise. However, we had repeated issues with the Niskins not closing or leaking. Moreover, the tracer teams reported a number of events where they think that the bottle samples were highly suspicious (e.g. repeated suspicious samples on Niskin 12: station 15, 17, 21, 39, 47). As noted in the report, bottle 10 had a repeated problem with closing, probably due to its firing mechanism. Therefore, we highly recommend a routine maintenance and cleaning of the rosette firing mechanism, and a routine maintenance and check of all Niskins on the rosette (especially Niskin 12). If the problem of suspicious bottles were to occur in another "tracer" cruise, we would recommend increasing the number of salinity sample (e.g. sampling suspicious bottle) so the salinity from the suspicious bottle could be compared systematically with the sensor salinity.

4.1.6. CTD Sections

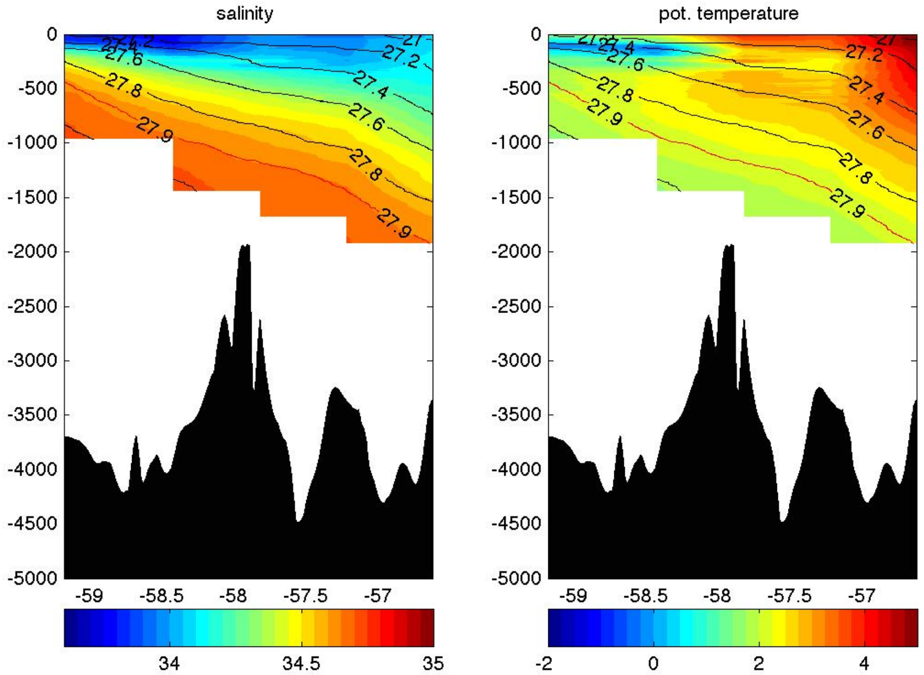


Figure 4.6: Temperature and salinity at section S0. Black contours are neutral density contours.

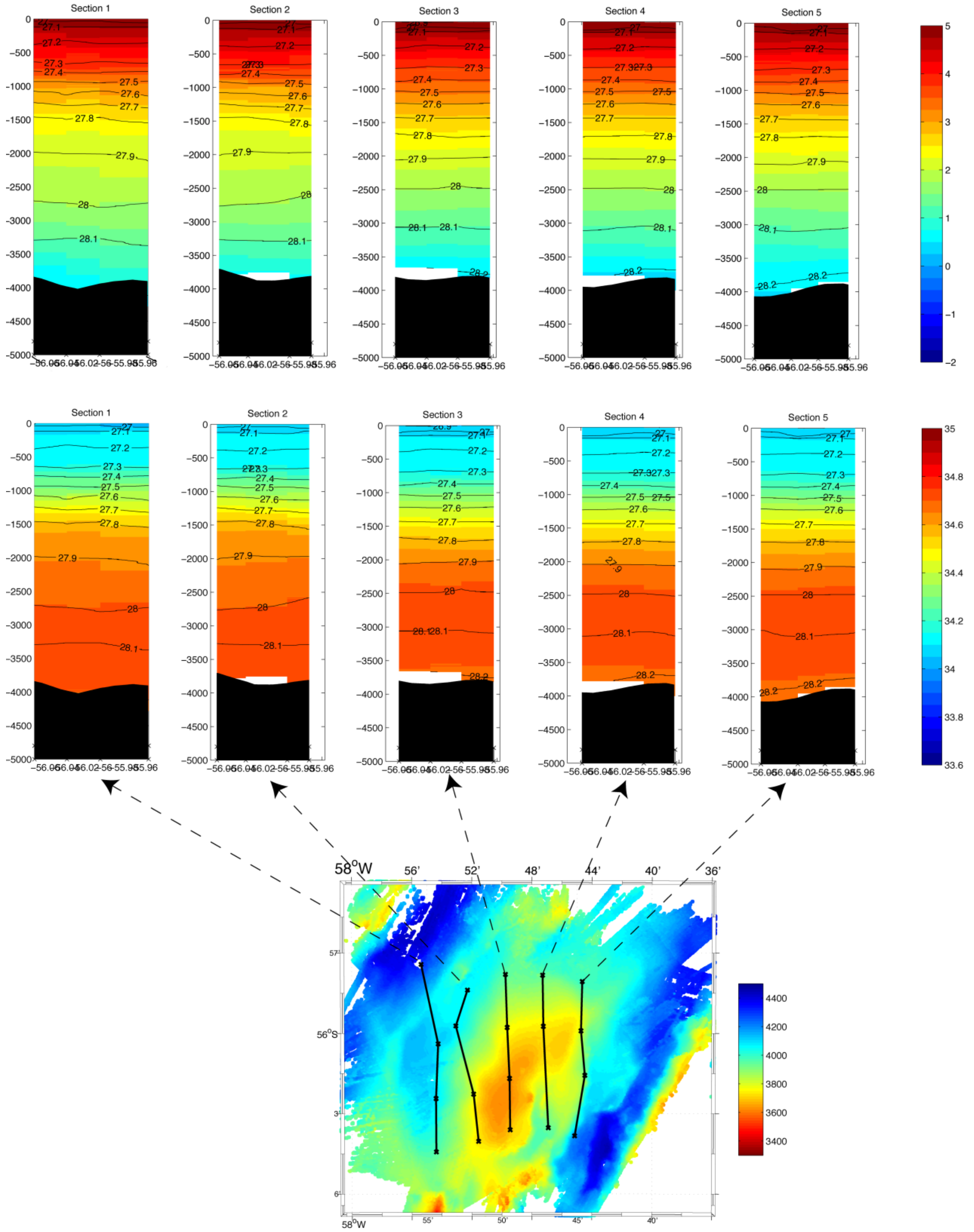


Figure 4.7: Top: temperature and salinity sections at the mooring grid. Bottom: sections superimposed on swath bathymetry. Black contours are neutral density contours.

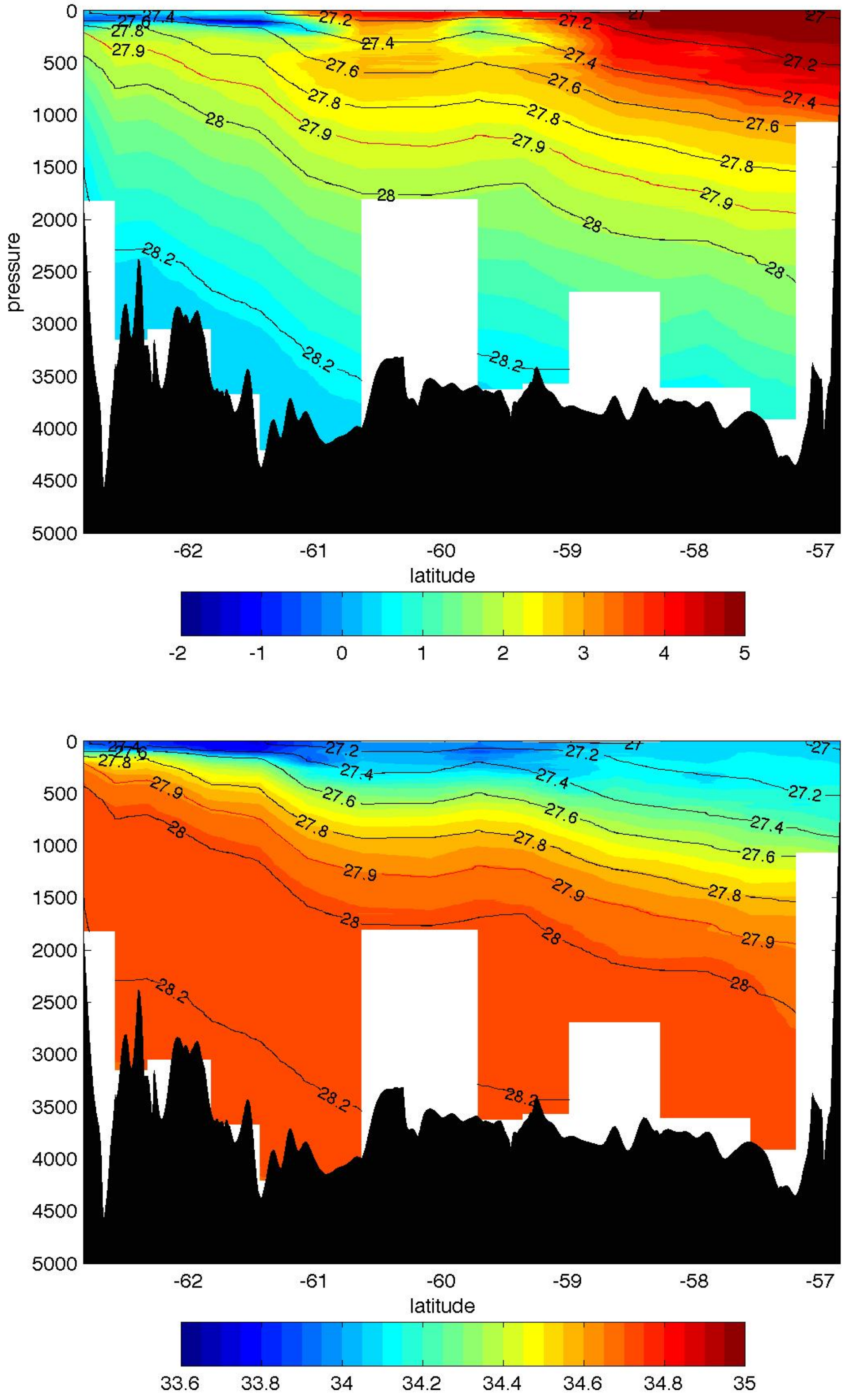


Figure 4.8: Temperature and salinity at section S1 (Drake Passage section). Black contours are neutral density contours.

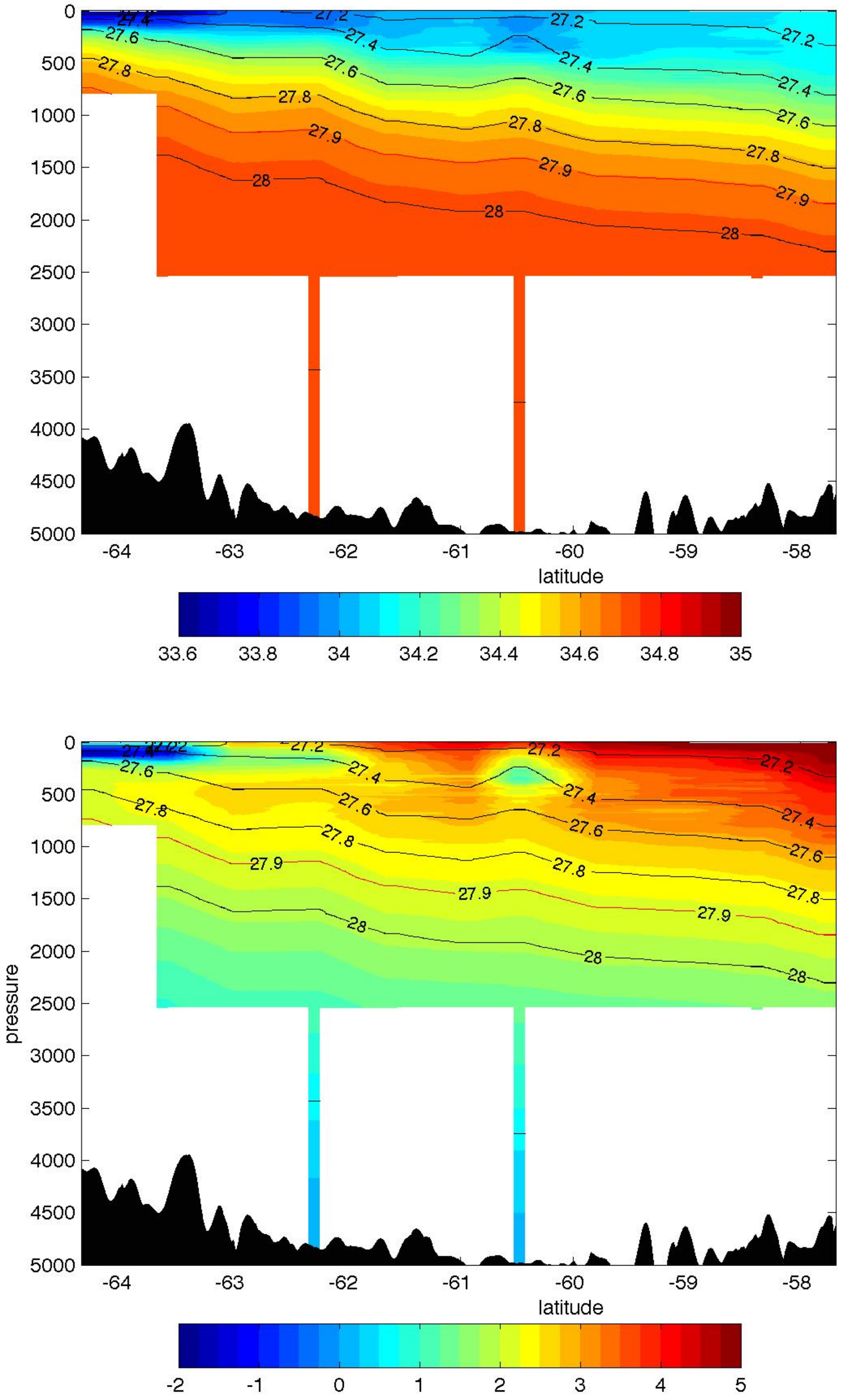


Figure 4.9: Temperature and salinity at section S2. Black contours are neutral density contours.

4.2. Lowered Acoustic Doppler Current Profiler (LADCP)

Andreas Thurnherr

The LADCP system consisted of the CTD, two ADCPs, a battery and interconnection cables mounted on the main sampling rosette. LADCP profiles were collected at all CTD stations in order to derive full-depth profiles of ocean velocity, as well as profiles of finestructure vertical shear, which will be used, in conjunction with the microstructure measurements described later in this section, to evaluate existing finestructure parameterisation methods for diapycnal mixing. LADCP operations during JC054 were supported primarily by a grant from the US National Science Foundation (OCE-1030309, PI: Andreas Thurnherr).

4.2.1. LADCP System & Processing Method

Two Teledyne/RDI Workhorse 300kHz ADCPs were mounted on the CTD rosette, one pointing downward (downlooker) and one upward (uplooker). A unique prototype high-power Workhorse ADCP (s/n 12736) from the LDEO stable was used as the downlooker throughout the entire cruise. Three different standard Workhorse instruments were used as uplookers. For stations 1-3, LDEO unit 150 was used. While this unit returned usable data, beam 4 was weak (40-50m shorter range than the others) and the instrument was therefore replaced with NOC unit 4275 on station 4. The NOC unit performed very well overall but beam 4 gradually became weaker during the cruise. After 50 stations its performance had degraded to a level similar to that of LDEO unit 150 and it was decided to replace it on station 54 with NOC unit 13400 (titanium housing) that had just been refurbished by Teledyne/RDI. Unfortunately, that unit turned out to be faulty - the instrument does not correctly determine when it is outside the water and many of the in-water velocities are seriously wrong. Therefore, NOC unit 4275 was re-installed on station 55 which was the last station occupied during JC054. The LADCP was powered with a standard NOC battery/charger system.

The first 3 stations were carried out with the standard instrument configurations supplied with the LDEO data acquisitions software - 25 x 8m bins, beam coordinates, zero blanking distance, narrow bandwidth, 2.5m/s ambiguity velocity, 1.5s/2.0s staggered ping rate. Because of large-velocity warnings during processing the ambiguity velocity was increased to 3m/s on station 4, to 3.5m/s on station 11 and to 4.0m/s on station 20. This reduced the occurrence of the large-velocity warnings although warnings were sill occasionally produced on later stations. There are no indications of any problems in the final velocity profiles, though. In an attempt to increase sampling the pinging interval was decreased to 1.0s/1.3s on station 20. Inspection of the raw ensemble times indicates that the instruments are not capable of such a high pinging rate and the rate was therefore decreased to 1.2s/1.4s on station 23 and, finally, to 1.3s/1.5s on station 33. There are no indications for any problems in the final velocity profiles associated with any of the pinging rates used. Due to a problem with the star cable, station 41 was carried out with asynchronous pinging, with a staggered rate of 1.3s/1.5s in the master and 1.0s in the slave. Note that the instrument configuration files used for each cast are saved in the raw data directory of each station.

Data acquisition was carried out using the LDEO "acquire" software, version 1.5. The software was installed on a LDEO PowerPC Mac Mini running MacOSX 4.11. The computer was configured to synchronize the clock automatically but this proved not to work reliably and the clock had to be manually synchronised occasionally. The maximum clock error observed was about 30s. Since the GPS data stream is merged with the CTD data stream in the SeaBird 11 deck box this clock offset does not affect the LADCP velocity profiles in any way. Communications between the acquisition computer and the ADCPs took place across two parallel RS-232 connections, via a KeySpan 4-port USB-to-serial adapter and a D-Link USB hub. Data backup was done automatically onto an external USB disk and, once per day, manually onto a laptop using mercurial software. This turned out to be an excellent solution as only the modified files are transferred over the network without a need for the user to keep track of which stations had already been backed up.

During each CTD/LADCP station, shipboard-ADCP (SADCP) data were collected with two separate systems (150kHz and 75kHz). Only data from the 75kHz system were used for LADCP processing. During a few of the early casts when the NOC VMP was in the water the SADCP systems were turned off during most of the cast, resulting in one instance (station 7) when the SADCP data are insufficient for calculation of a reliable average that can be used to constrain the LADCP velocities. For all following stations the protocol was changed to ensure that the SADCP systems were turned on for at least 20 minutes each near the beginning and end of each cast. For each station two separate SADCP mean profiles (with standard deviations) were provided by X. Liang: one using only 20 minute data from the beginning and the end and another with all data collected while on station. For the shipboard processing, the SADCP profiles with all data were used throughout and standard errors were estimated from the standard deviations, assuming that all the 2-minute short-term-averages going into each profile are independent.

Preliminary shipboard processing of the LADCP data was carried out with the LDEO IX_6 LADCP-processing software using uncalibrated and minimally processed (CellTM, AlignCTD) 1-s averaged CTD time series for depth- and sound-speed correction. Velocity referencing was accomplished with post-processed (i.e. non-RDI) bottom-track data, SADCP data, and GPS information in the CTD time series files. As is always the case for LADCP data collected without a blanking interval, the data from the first bin of each instrument must be discarded during processing.

4.2.2. Problems and Solutions

As is usually the case for 300kHz RDI/Workhorse data, the bottom-tracking target strength had to be increased to 30 in the LDEO processing software to avoid detection of false bottoms in casts that did not reach the seabed.

Since the ADCP used as the downlooker has the RDI LADCP mode (WM15) installed, it reports bottom-tracking data calculated from water-tracking pings. It was found, however, that this RDI bottom tracking did not work well on stations 8, 11, 13, 29, 37, 38, 40, 41, 42, 44 (and, possibly, some later stations as well). Therefore, for consistency, all profiles we re-processed with post-processed bottom tracking. The resulting profiles show no indications for any bottom-tracking problems.

During the first half of the cruise, it was noticed that each LADCP cast had to be started twice as the ladcp2 operator script invariably bombed the first time when trying to save the instrument hardware configuration before initiating pinging. Re-running the same script again always worked flawlessly. An investigation of this problem revealed that it occurred whenever the master was woken up before the slave. Similar issues had been encountered by Thurnherr on earlier cruises but only with specific instrument combinations. While a simple workaround consists in swapping the two serial cables on the USB-to-serial converter, it was decided to modify the "acquire" software to ensure that the slave is always woken up first. After that change was implemented, no more communications problems were encountered during JC054, regardless of which instrument was connected to which serial port.

During downloading of the uplooker data from station 36 and 38 a few communications glitches were observed. On station 39 the uplooker did not respond when trying to start the cast, which was therefore carried out with the downlooker alone. Changing the uplooker deck cable appeared to have solved the problem on station 40, but downloading of those data with the standard cabling setup after the cast failed. The problem was traced to a faulty star cable but, unfortunately, the main backup star cable had exactly the same problem. (This was verified by changing every other component of the LADCP system, including the uplooker ADCP.) Since communications were possible by plugging in the (powered) deck cable directly into the uplooker, cast 41 was carried out in this manner. However, it was found that, after losing power, the slave does not wake up in slave mode (i.e. it does not ping when receiving the synchronization pulse from the master). Therefore, asynchronous pinging was used during cast 41. (Also because of the power cycling, the uplooker data file for cast 41 is called 041UL001.000, rather than 041UL000.000.) For station 42 the master/slave roles of the ADCPs were switched (the uplooker becoming the master), which allowed synchronized pinging even though the uplooker still had to be power-cycled when disconnecting the deck cable and connecting the star cable at the beginning of the cast. For the remainder of the cruise, the uplooker was used as the master, which does not affect the LADCP velocity profiles in any way. On station 43 the communications problems disappeared but then reappeared after cast 44. Switching the star cable with a secondary backup solved the problems for the remainder of the cruise.

During deployment of station 55 a power pin on uplooker pigtail on the star cable broke off and remained stuck in the corresponding plug on the yellow deck cable. During the remainder of the cruise the battery charger was simply connected to the uplooker cable without requiring any other change to cabling and/or operations.

Because of the cable problems, there are no uplooker data for station 39. Because of hardware problems with one of the NOC ADCPs (see above) there are no valid uplooker data for station 54.

4.2.3. Preliminary Results

Figure 4.10 shows velocities at the tracer depth (as determined from the CTD log sheets) in the three quasi-meridional sections occupied during JC054.

Figure 4.11 shows sections of (left) zonal and (right) meridional velocities in Drake Passage. The green line indicates the depth of the tracer release isopycnal.

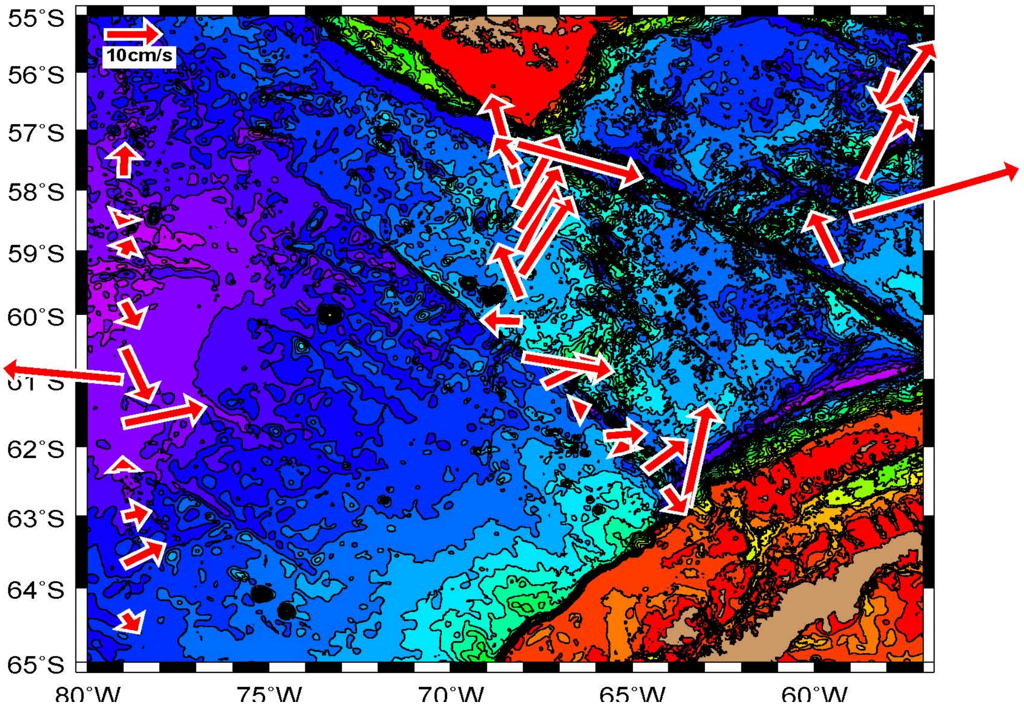


Figure 4.10. LADCP velocities at the tracer depth during JC054.

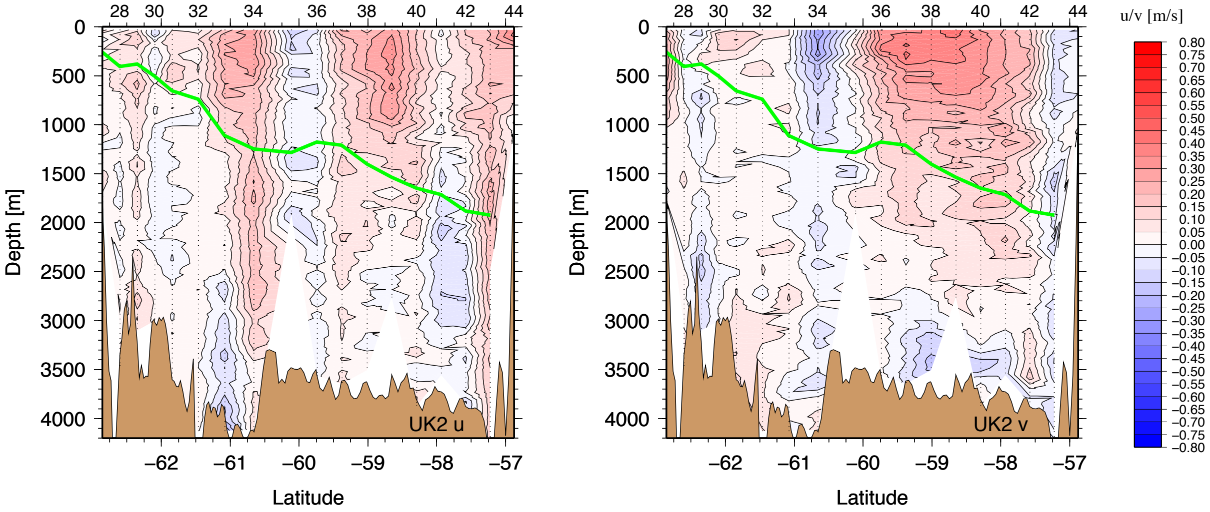


Figure 4.11. Zonal (left) and meridional (right) LADCP velocities in Drake Passage. The green line indicates the depth of the tracer release isopycnal.

4.3. Vertical Microstructure Profilers (VMP)

Alec Bogdanoff, Alex Brearley, Ken Decoteau, Alberto Naveira Garabato, Katy Sheen, David Smeed, Andreas Thurnherr and Stephanie Waterman

4.3.1. Introduction

The Vertical Microstructure Profiler (VMP-5500, VMP for short thereafter) is a novel scientific instrument manufactured by Rockland Scientific International that measures profiles of temperature, conductivity and velocity microstructure (i.e. on the length scales of the dissipation of turbulent flows, typically a few millimetres to tens of centimetres) throughout the water column. Two VMPs owned by WHOI and NOCS were used during the JC054 / UK DIMES 2 cruise. This represented the second instalment of the DIMES microstructure programme (the first set of measurements having been conducted in the US2 DIMES cruise in January – March 2010), the central goal of which is to obtain measurements of turbulent kinetic energy dissipation and mixing across a range of topographic and flow regimes in the Southeast Pacific and Southwest Atlantic sectors of the Antarctic Circumpolar Current.

Engine problems experienced by *RRS James Cook* caused a 4-day delay to the start of the cruise, which had been scheduled for 30 November. Consequently, over-the-side operations commenced on 3 December with a check for gross buoyancy of both instruments while the ship was anchored at a bunker terminal near Punta Arenas (both instruments floated without weights). This was followed on 6 December by one untethered test cast with each instrument (the NOCS VMP was deployed to 200 m in its cast 003 and the WHOI VMP was deployed to 1000 m in its cast 004) to assess the performance of the weight release mechanism and the various sensors on the instruments. The tests were successful.

The general mode of microstructure operations consisted of the alternate use of the two instruments, to prevent excessive battery discharge. Toward the end of the cruise, it was decided that the NOCS VMP would be used preferentially as it was easier to find upon completion of the cast (due to the availability of pressure telemetry information from the Ixsea transponder unit on the NOCS VMP, and to the faster fall rate of the WHOI VMP, which meant that the instrument was floating at the surface for longer whilst waiting to complete the CTD cast). Altogether, 36 VMP deployments were accomplished as part of a total of 43 planned full-depth CTD stations (out of a total of 55 CTD stations), plus a ‘double dip’ deployment of both profilers on the way back to Punta Arenas to compare noise levels. Weather and sea state were essentially as (or slightly better than) expected for this location and season, occasionally becoming severe enough to prevent VMP operations. Several deployments were conducted with winds in excess of 30 knots and sea states judged excessive for deployment of the CTD. All the stations missed by the VMP were due to weather, and none due to technical problems with the instruments. In the case of the NOCS VMP, there were two technical problems of some significance: the flooding of the EM current meter connectors, which resulted in potential internal damage to the EM amplifiers, and a communications issue attributed to a loose internal bulkhead connection. The WHOI VMP had no notable technical problems. However, there were some issues with WHOI VMP recovery aids and their interoperability with ship systems. No clear bottom impacts were registered during this cruise, although it is suspected that the WHOI VMP got very close to the sea floor in its cast 015 at S1.07. In this regard, the new weight release mechanism and logic of the NOCS VMP led to a clear improvement in performance with respect to the JC029 / SOFINE cruise, where battery and weight release problems led to multiple bottom crashes.

While the initial configuration of the two VMPs are similar, differences in recovery aids and the EM sensor have affected their flight characteristics. The WHOI VMP uses up to twice the amount of expendable ballast per cast. Fall speed is 40% faster for the WHOI VMP at 75 cm/s, compared to 54 cm/s for the NOCS VMP. Examination of all casts for the distance each VMP overshoots its target release depth does bring into question the performance of the WHOI VMP. The NOCS VMP demonstrated a consistent overshoot of 20 meters past target on pressure releases. The WHOI VMP demonstrated releases between 20 and 80 meters past target, with an average of 60 meters. More investigation into the issues with the WHOI VMP overshooting its target depth is required.

All deployments and recoveries were made from a block mounted on the parallelogram on the starboard side over the hydrographic boom. The NOCS VMP was stored in the CTD annex and the WHOI VMP was staged from the aft hanger.

4.3.2. Technical remarks on the WHOI and NOCS VMP-5500s

Configuration

The WHOI VMP-5500 s/n 008 was deployed with 2 microshear probes, one microtemperature fp07, one microconductivity, a Seabird CTD pair (3F and 4C). Flight data is provided via a pressure transducer mounted in the front bulkhead of the nose cone, a 3-axis ICSensors Accelerometer mounted just opposite the pressure transducer, and a 3-axis magnetometer located centre body of the main instrument pressure case.

The NOCS VMP-5500 s/n 016 was deployed with 2 microshear probes, 2 microtemperature probes, one microconductivity probe, one Seabird 3F fast temperature sensor (s/n 4634), one Seabird 4C conductivity sensor (s/n 3240) and the Rockland Geo-ElectroMagnetic Current Meter. Internally there was also a 3-axis accelerometer and 3-axis magnetometer.

WHOI (formerly FSU) VMP:-

Base Instrument: VMP-5500 SN 008

Microstructure Probes

- 2 shear probes
- 1 microtemperature fp07 thermistor
- 1 microconductivity

Finestructure

- Seabird 3c conductivity cell
- Seabird 4f temperature cell

Flight data streams

- IC sensors 3 axis accelerometer
- Magnetometer

- Pressure sensor

Recovery aids

- Benthos 12kHz pinger. Installed only for initial casts, and when the USBL system was inoperative.
- Sonadyne USBL HB06 transducer for shipboard active tracking.
- Novatech strobe
- Novatech Radio Directional Finder beacon.
- Novatech mounted X-cat Argos beacon. Only fitted for later stations in Drake Passage.

NOCS VMP

Base Instrument: VMP-5500 SN 016

Microstructure Probes

- 2 shear probes
- 2 microtemperature fp07 thermistors
- 1 microconductivity

Finestructure

- Seabird 3c conductivy cell
- Seabird 4f temperature cell
- Rockland Geo-ElectroMagnetic Current Meter

Flight data streams

- IC sensors 3-axis accelerometer
- Magnetometer
- Pressure sensor

Recovery aids

- Ixsea transponder
- Novatech Strobe
- Novatech Radio Directional Finder beacon
- Novatech mounted X-cat Argos beacon.

4.3.3. Deployment, Operation and Recovery

The NOCS VMP was deployed and recovered using the centre ‘trolley’ section of its cradle as securing frame on the starboard waist just aft flush hatch and using the aft Rotzler winch on the starboard gantry. The NOCS VMP was deployed using a sling around the tail bale and released with a Seacatch. It was recovered using a large aluminium pole with large ‘clip-stick’ snap shackles made fast to a polyprop pickup line. Apart from the reduced vessel motion at the midships gantry this location also kept the profiler away from thruster wash and prevented it going out of sight under the stern flare on all but one recovery. This method required somebody to steady the nose whilst the profiler was being picked up and set down on the trolley. This increases the risk of damaging the nose-mounted sensors and also puts significant bending load on the main joint between the nose and tail assembly. The consequences of this joint failing would be serious injury to personnel or loss of the nose section of the profiler. The trolley allowed the VMP to be easily moved into the CTD annex between casts. Further thought needs to be given to assisting deployment and recovery of the NOCS VMP.

The WHOI VMP was assembled on an aluminium frame cart that supports a half section of plastic drain pipe fitted with foam. Deployments and recoveries were made from this cart, which was wheeled through the starboard door onto the quarter deck. Rigging to the Seacatch from the parallelogram winch was made by a lifting strap. This lifting strap was passed through two basket straps attached to the bail of the WHOI VMP. The pair of straps on the bail allow for an even lift which does not spin the instrument. Also, this method of attachment keeps the centre of mass of the VMP closer to the boss hook of the lifting line. The WHOI cart system has proven to be a stable and reliable platform which allows pivoting on a foam block for the initial tilt from horizontal during launch and allows for the nose guard forks to be planted on plastic for recovery. The cart with instrument can be handled easily on deck by a single person, but two are usually needed to counteract ship motion safely.

4.3.3.1. Acoustic Tracking

Whilst submerged the profiler was tracked using an LBL telemetry system consisting of Ixsea TT801 deck unit s/n 175 (with firmware modification for pressure telemetry), and Ixsea Model MT861S-R-P1 LBL Acoustic Transponder with Pressure Sensor S/N 314. This allowed the slant range to the beacon and also the pressure to be determined, hence the horizontal range from the ship could be calculated. The VMP was deployed and once it had accelerated to its profiling velocity and was clear of the vessel, the CTD was deployed. The 75 kHz and 150 kHz VMADCPs were used to estimate the VMP drift direction and magnitude. The bridge were given the horizontal range to the VMP every 10-15 min and tried to keep the range between 300 and 800 m. When the VMP was near the bottom it was ‘pinged’ more frequently to catch turnaround. When the VMP was a few hundred metres from the surface the bridge were given more frequent updates. While this system is useful, caution must be taken when trying to reduce range below 300m. At least one occasion (NOCS VMP cast number 28) the instrument came up within a ship length on the side opposite that estimated by the ADCP / current / transponder analysis. At CTD station 7 (NOCS VMP cast 7) on Grid station 2.3, the Ixsea system alerted users of an early abort of the VMP cast. The information was learned with sufficient time to modify the CTD cast and recover the NOCS VMP with limited impact on cruise time.

The WHOI VMP was initially fitted with a Benthos acoustic pinger (12kHz) for early casts. This unit has in past cruises (DIMES US2, BPRS, LADDER3, etc.) provided a similar level of information to that of the Ixsea beacon used on the NOCS profiler through the ship based echosounder. Normally, the pings from Benthos unit show clearly enough to identify trends in fall speed and weight release events as well as bottom approaches. For some reason, which was never identified, this beacon proved to be incompatible with the ship’s systems. Efforts to track the system on the EK500 echosounder were ineffective. Partial tracking was possible with the EA600 system, although this was never reliable enough for regular use.

Due to the issues with the Benthos Pinger on the WHOI VMP, a ship-owned Sonadyne USBL transponder (HPR B06, rated to 4000m) was borrowed and used on 7 WHOI VMP casts. The side effect of switching to the USBL system was a decrease in surface time of the VMP before the CTD cast completion. The Sonadyne USBL transponder worked for 4 casts before developing a problem. It was never determined whether the issue with the USBL system was due to battery problems, charger system, or the ship-based components. The Benthos pinger was reinstalled for the last two casts of the WHOI VMP.

4.3.3.2. Recovery Aids

A flag on a mast was used with the following recovery aids:-

- Seimac Ltd Novatech Model ST-400A Strobe S/N U03-042 Seimac Ltd Novatech Model
- RF-700A1 RDF Beacon S/N U03-040 Seimac Ltd Novatech Model AS-900A
- Argos Beacon S/N V01-053 ID 74853

The Argos positions received via e-mail at surface largely had the lowest quality status of 1, but were occasionally 2 and even more rarely 3. It is believed that with longer time in the water the fixes will improve in quality, but this needs to be assessed in a trials situation. If the acoustic transponder could be located such that it was still submerged when the profiler was on the surface, it would further assist ranging for recovery. Only the NOCS VMP had an Argos beacon installed for all casts. Due to marginal visibility, the Argos beacon moved to the WHOI VMP for the last two casts.

Both VMPs were fitted with identical Novatech RDF beacons. *RRS James Cook* did not have an on-board RDF system so a pair of hand-held RDF locators (DF500s) were used on the bridge and forecastle decks. On almost every cast, the RDF units alerted watchers of the surfacing of the VMPs. For recovery operations with poor visibility conditions, the RDF units provided a useful extra data point for determining bearing of the surfaced VMP.

The Novatech strobes are by far the most immediately useful aids to recovery. However, given the location and time of year for the DIMES UK2 cruise, the window for the effectiveness of the strobe beacons was limited to only a few hours per day. It may be advisable for future austral summer cruises to change strobe behaviour to defeat the optic sensor which turns the Novatech strobes off in daylight.

4.3.3.3. Nose Guard Mounting

The nose guards of the two VMPs are slightly different. The WHOI VMP has the original nose guard and pressure case, which has the chance of distributing some of the load of manually handing the nose onto the o-rings and sealing faces. When the EM sensor was installed on the NOCS VMP, machining was performed on the pressure case to allow for the use of four spacers that act to lock the nose guard (and nose cone) to the pressure case and mitigate stresses placed on the O-rings and sealing faces. In handling, this upgrade has proven effective. On a past cruise, one of the WHOI VMPs experienced a slight blow to the nose guard, which allowed the electronics tray to shift to the side and caused one of the accelerometer channels to be destroyed. It is likely that on DIMES UK2, the upgrade to the NOCS VMP nose guard and pressure case prevented this same sort of damage from occurring. However, there is still room for improvement on the nose cone design in terms of limiting sites for corrosion.

4.3.3.4. Main System Battery

There were early concerns during this cruise about the battery life of the VMPs, prompted by the problematic initial casts of both profilers. The grid section posed a challenge for VMP operations due to station spacing times often below 1 hour. It is impractical to recharge the VMP main and weight release batteries from a 4-5 hour deployment in under an hour. This is exacerbated by the fact that these batteries are located in the pressure case and must be charged with care as overcharging can create a dangerous situation. The first change made to deal with this issue was a modification from the original plan of running 2 NOCS VMP casts to 1 WHOI cast to a simpler method of alternating casts of the two profilers. Even with a charge window of 5-6 hours, this proved insufficient.

While there was at least one case early on of accidental full discharge of the WHOI VMP main battery, it was clear that the WHOI profiler was having less problems charging than the NOCS instrument. One thought was that this may have been caused by the different weight release logic between the two instruments. The WHOI VMP has the original weight release logic. It will fire 4 times about 20 seconds after pressure target or maximum time has been reached. If the pressure doesn't start decreasing, it will make further attempts until the instrument has began its ascent. The NOCS instrument, in contrast, will fire continuously on intervals until the instrument is turned off after a long maximum time has elapsed. It was later proven that the modified release behaviour did not seriously impact the battery performance of the NOCS VMP. It is more likely that the flooding of the EM bulkhead connection (covered next) was responsible for the early problems.

Of note; the WHOI VMP was charged by a 1.2A 12VDC battery tender, while the NOCS VMP was charged by a programmable power supply capable of constant voltage or current. From later casts, it is obvious that the NOCS method of using a proper power supply is ideal for providing a full charge on the VMP battery. If the battery voltage drops below 8.5 VDC (as it did on both instruments regularly with 5 hour deployments) the smart battery tender will not attempt to charge the battery. In these cases, with the WHOI VMP, a spare 12V cell or power supply must be used to kick the battery voltage over 8.5 VDC for the charger to begin work.

The benefits of using the battery tender are really only seen in cases where the open power supply may be damaged by salt spray. The tenders are relatively sealed, self-contained units, which are more durable and able to handle physical situations that a proper programmable power supply can not. In either case, there is a strong recommendation to add the ability to actively monitor the temperature of the internal battery and provide some means of a thermal cutoff to prevent overcharging. As part of this, it would be advisable to provide a more direct or controllable means of charging the weight release cell.

4.3.3.5. EM Current Meter

It is suspected that the NOCS VMP EM rear bulkhead connection (Impulse MCP7) flooded in one of the first 5 casts. On cast number 7, the VMP aborted early with a weight release event at 1369 meters. When the VMP was recovered, the battery voltage was recorded at below 6 VDC, indicating that the main battery was completely depleted. Running odas4ir in calibration mode indicated a potential short in channels 35-37, which correspond to Ux, Uy and vBat channels; all of which are provided by the GEM board (a part of the EM upgrade). When the flotation elements were removed to inspect the rear bulkhead, the EM connector was obviously loose. Removing the connector from the bulkhead released a fair amount of seawater. This flooded connection point most likely caused some of the battery life issues in the early casts.

A spare EM cable was installed and tests were made with the instrument on deck and fully assembled. It was inconclusive at this time whether there was any damage caused by the connection point flood. The instrument was disassembled and carefully checked from the GEM board through to the back bulkhead. All internal components appeared to be intact and functioning as intended; both via checking voltages at all test points and running odas4ir in calibration mode to check output of channels 35-37. With the EM collar disconnected, channels appeared normal. With the collar connected, channel 35 seemed normal, but 36 and 37 were reading full scale. This indicated a potential problem with the EM collar itself.

The EM collar was left off for the remainder of the NOCS VMP casts in the grid section. This required the addition of about 3 kg of weight to account for the loss of weight by removing the EM collar, shroud and cable. With the EM collar removed, the NOCS VMP was able to get a full charge and perform several casts without battery issues.

After completing the grid sections and beginning transit to the Drake Passage section, the EM collar was reinstalled for a final attempt at diagnosing the issue. The prior indication that the problem was external to the instrument pressure case was still observed. An attempt was made to verify the condition of the small WSK bulkhead connection on the EM collar itself. Unfortunately, a bad assumption was made about whether the internal wiring was potted up to the bulkhead connector. In the attempt to remove the connector, all internal wires were severed and the collar was rendered definitely inoperable. As part of packing the NOCS VMP for demobilization, all parts of the EM system will be removed and packed to send back to Rockland for repairs. If possible, an attempt will be made to reintegrate the EM sensor back on the NOCS VMP for the *RRS James Clark Ross* recovery cruise in April 2011.

4.3.3.6. Finding the VMP after surfacing

During CTD casts the ship normally moves with the currents to maintain the correct angle of the CTD wire; this has the additional benefit of helping keep the distance between ship and VMP small. However, due to vertical shear and temporal changes of the currents, the distance between the ship and the VMP can increase, making recovery difficult. Two aids were used to assist in tracking the VMP below the surface. On some casts a USBL beacon was placed on the WHOI VMP. The NOCS VMP was fitted with an acoustic transponder. The use of the USBL is described in Section 7.

An Ixsea TT801 transponder deck unit was connected to the single element of the EA500 on the starboard drop keel. Data from the deck unit was fed into a Windows XP PC with a serial connection and recorded in NMFD developed “VMP Logger” software. When pinged from the Ixsea transponder the VMP transmitted its pressure, which, when combined with the acoustically determined slant range, enabled an estimate of the horizontal range using by the VMP Logger software.

When the distance between the ship and the VMP became large (> ~500m) the bearing was estimated by examining the ADCP current data and the bridge was asked to navigate towards the assumed position of the VMP.

A simple Matlab script was used to combine the Ixsea range and depth data with the GPS position of the ship. This was used to improve the estimation of the direction of the VMP from the ship. A number of lessons were learned:-

- When the VMP is deep (below ca. 3500m) the range estimates are not reliable.
- For a number of reasons (in particular the current shear and the fact that the ship generally moves along a straight line during the cast) triangulating the position of the VMP is very uncertain.
- Generally the surface currents are larger than those deeper and so the VMP can move quickly when at the surface. In these cases the best strategy is, if possible, to position the ship downstream of the expected surface position.

4.3.4. NOCS VMP-5500 processing procedure.

VMP logsheets and operation instruction sheets are given in Appendix III. Data processing instructions that were followed are given here:-

- If it is the first cast of the cruise, ensure you have the right coefficients for the Seabird variables, pressure variables, accelerometer variables, magnetometer variables, microtemperature variables, and EM variables. If all goes to plan, these should not change during the cruise.
- First, create a directory structure to deal with the data. Under a parent cruise directory (e.g., 'JC054'), make a 'VMP' directory. Under 'VMP', create a 'raw' data directory, a 'programs' directory, a 'processing' directory, and a 'final' directory.
- When you finish a cast, create a subdirectory called 'nnn' below 'raw' and take the raw data file (e.g., 'jc054_nnn_ccc.p', where nnn is the VMP cast number and ccc is a data file number), the cast's log file (e.g., 'jc054_nnn_.txt') and the cast's setup file ('setup.txt') there.
- Change to the 'raw/nnn' directory and run 'firstlook_jc054' or equivalent. If this is the first cast of the cruise, make sure all the pathnames are correct in 'firstlook_jc054'. This stage will allow a quick look at the (largely uncalibrated) data to check data quality, fall rate, maximum pressure, etc., and will write a file called 'jc054_nnn_ccc_firstlooked' in the 'processing' directory, and create a folder of firstlooked figures called 'processing/nnn/firstlook_figures'.
- At this stage, back up the raw and processing directories.
- Create a 'setup_calibrated.txt' file in the 'raw/nnn' directory, and update calibration coefficients for sh1, sh2, and write down the name of the probes used in the header of the file. If it is the first cast of the cruise, make sure you have the right calibration coefficients for all the accelerometer, T*, pressure, conductivity, Seabird, magnetometer and EM variables.
- Check that you are in the 'processing/nnn' directory. Run 'fine_structure_processing_routine'. This creates a 'VMP_CTD.mat' file that contains, amongst other variables, T, C and S data (t_ave, c_ave and s_ave) averaged in a regular 0.5 dbar pressure grid (P_grid) starting at 0.25 dbar. It also creates a folder of finestructure processing figures under 'processing/nnn/finestructure_figures'.

- Check that you are in the ‘processing/nnn’ directory. If this is the first cast in the cruise, check that the right pressure and shear variables differentiator gains are set in ‘process_micro_j054.m’. Then run that script to process the microstructure data. This will produce locally a ‘micro_nnn.mat’ file containing the processed microstructure data in an approximately 0.5 dbar (1 s) grid, and a ‘final_grid_nnn.mat’ file under the final directory with processed fine- and microstructure data in a 0.5 dbar grid.
- In the end, you’ll need to produce a final file with all the processed cruise data by running ‘make_cruise_data’ in the ‘VMP’ directory, after entering all the relevant time and location information and selecting which of the microshear or microtemperature channels are of superior quality.

4.3.5. Processing

The NOCS and WHOI teams each had their own set of processing routines. Only NOCS data was processed using the NOCS processing routines. WHOI data has yet to be processed, but will be in the near future.

4.3.5.1. NOCS Processing

First, an initial check of the data of each cast was performed using the ‘firstlook_jc054’ matlab routine. This routine reads in the raw data from the cast, converts it to a matlab file and produces a series of diagnostic plots useful for checking the probes and instrument before the next cast. These plots include: the velocity of the profiler with the extracted downcast used for further processing indicated, the battery voltage, the pressure and ‘ground’, raw data from the microtemperature, microconductivity and shear probes, the profiles acceleration and rotation and the seabird temperature and conductivity.

Secondly, the seabird finestructure data was processed using ‘finestructure_processing_routine.m’. The end product is temperature and salinity that are:

1. truncated to include data only below 10 dB;

2. adjusted to account for the spatial displacement between the pressure sensor (at the VMP nose) and the CTD sensors (on the VMP body);

3. despiked;

4. corrected for short-term (sensor response) and long-term (thermal inertia) mismatch errors in T and C;

5. corrected to account for the thermal expansion and pressure contraction of the conductivity cell;

6. low-pass filtered to remove high-frequency noise;

7. block-averaged in 0.5 dB pressure bins

Thirdly, the microstucture data were processed using the routine ‘process_micro_jc054.m’. Data are converted to real units and calibrated to the seabird data. The epsilon and chi values are estimated by integrating the power spectra of the shear and the microtemperature gradient, respectively. The data are averaged into regular 0.5 dbar bins.

Note that this program used various microstructure parameters, which should be checked before each cruise. The shear probe sensitivities are read from the file ‘setup_calibration.txt’ which should be updated for each cast.

There is also a diagnostics program which plots computed epsilon and chi values. Measured shear spectra are binned into TKE dissipation rates and compared to the corresponding Naysmyth spectrum. Calculated microT and microC data are compared with the Batchelor spectra corresponding to the estimated chi values.

Finally, the data were averaged into 1 dbar bins and saved as a matlab structure file using the program ‘make_cruise_data_set.m’. The average results from the two shear or microtemperature probes were used, unless a probe was noisy, in which case the noisy probe data was discarded. Deployment location, time, station number and corresponding CTD cast numbers were added to the dataset. Both WHOI-processed WHOI casts, and NOCS-processed NOCS casts were included in this file.

4.3.5.2. WHOI processing

The WHOI team processed both NOCS and WHOI casts to extract dissipation and diffusivity values. Therefore, comparisons of the processing are only done on NOCS casts.
A “process0” script converts the raw data to physical units, generates quick plots for evaluative use, and saves a matlab file with the variables of interest. A fall speed is also calculated. If a visual inspection of the data alludes to no apparent problems, a “process1” script is run. This process filters the data and parses only the downcast. The “process2” script bins the data in 1 dbar bins, calculates shear spectra and chi intervals to provide dissipation values. The remaining process plots the final variables and saves an updated matlab file with the downcast data and key intermediates used for later analysis.

4.3.6. Initial Results for Grid and Drake Passage line S1

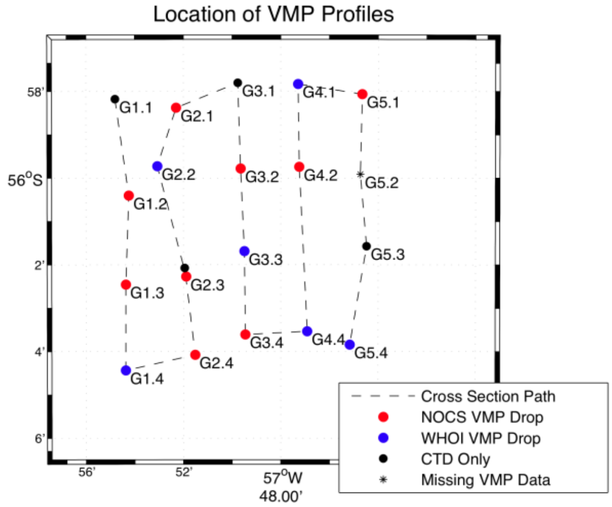


Figure 4.12: Location map of grid VMP and CTD casts

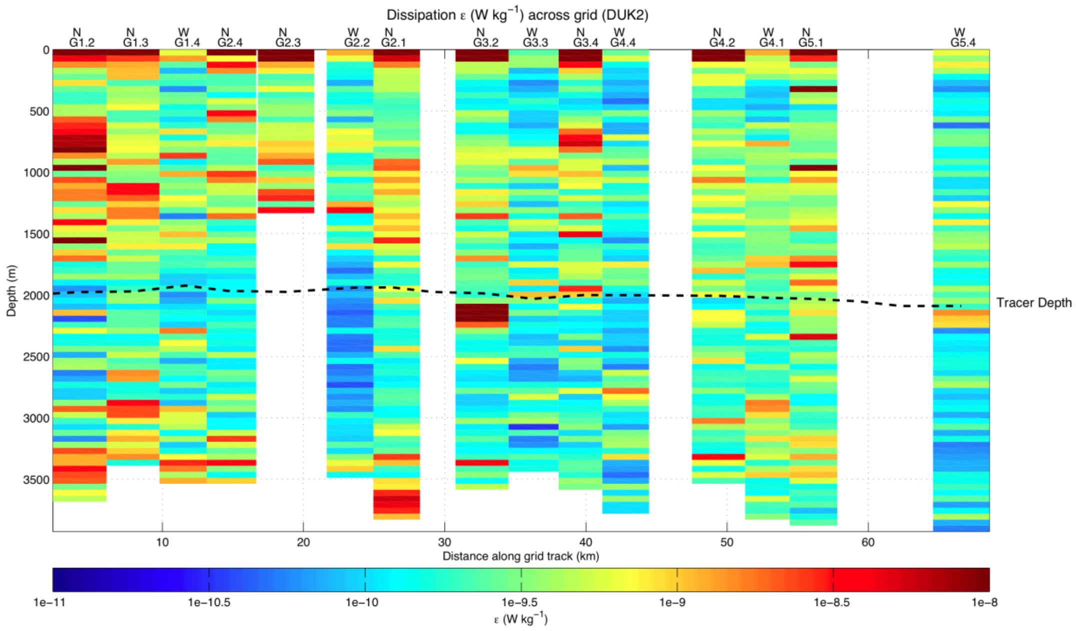


Figure 4.13: Vertical section of grid showing estimated TKE dissipation for WHOI-processed VMP casts. NOCS profiles are marked with N, WHOI profiles with W. Shear probe data have been averaged for all casts.

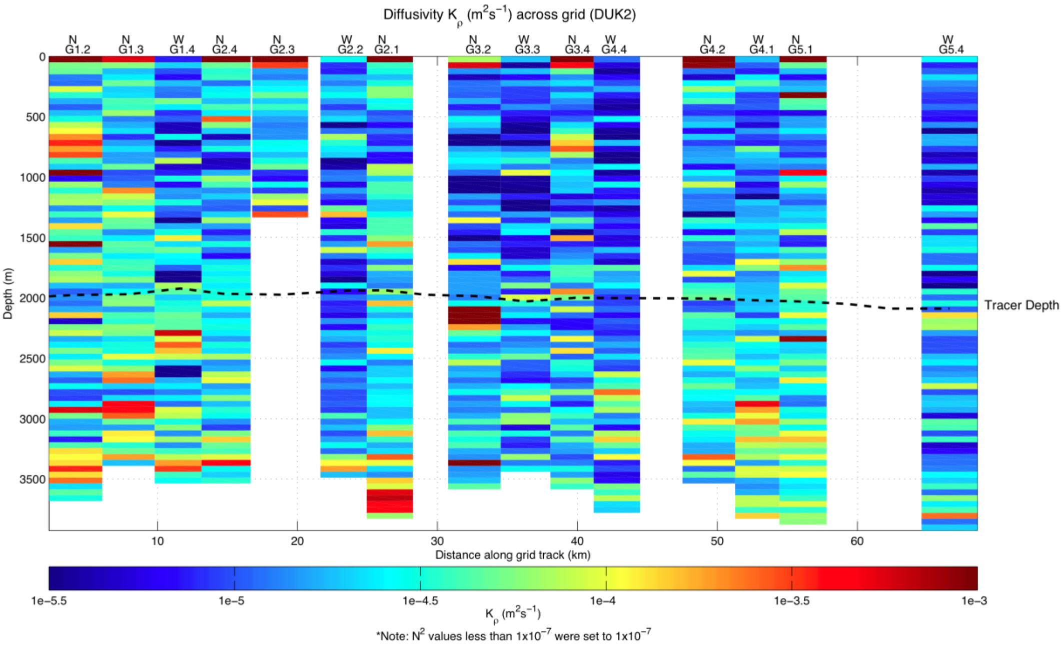


Figure 4.14: Vertical section of grid showing diapycnal diffusivity for WHOI-processed data

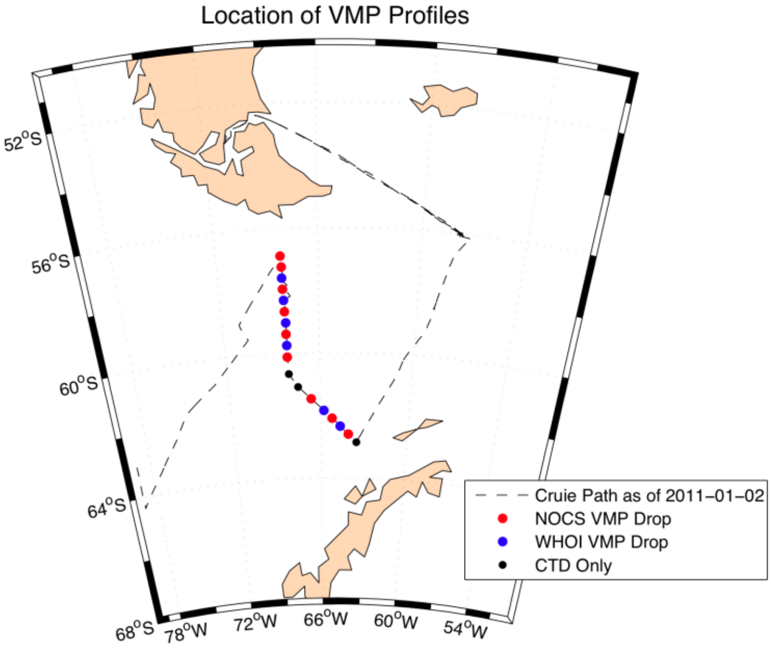


Figure 4.15: Location map of VMP and CTD sections along Drake Passage section S1

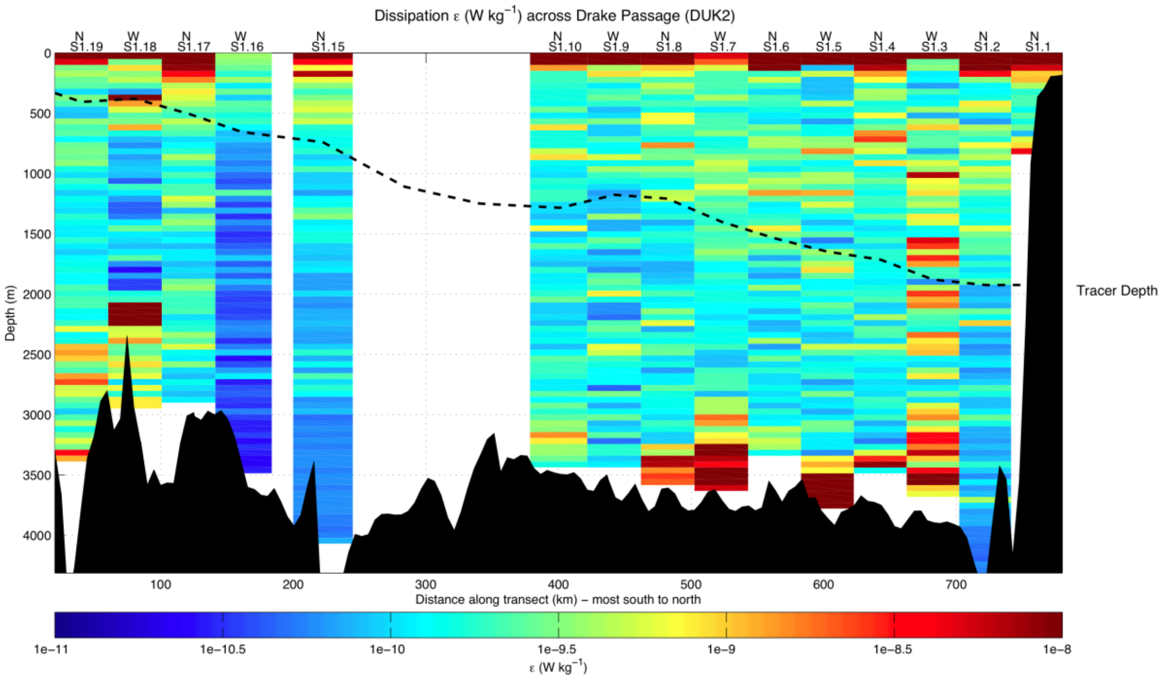


Figure 4.16: Dissipation, ε across Drake Passage line S1 for WHOI processed data. NOCS casts are marked with N and WHOI casts with W. Shear probe data has been averaged for all casts.

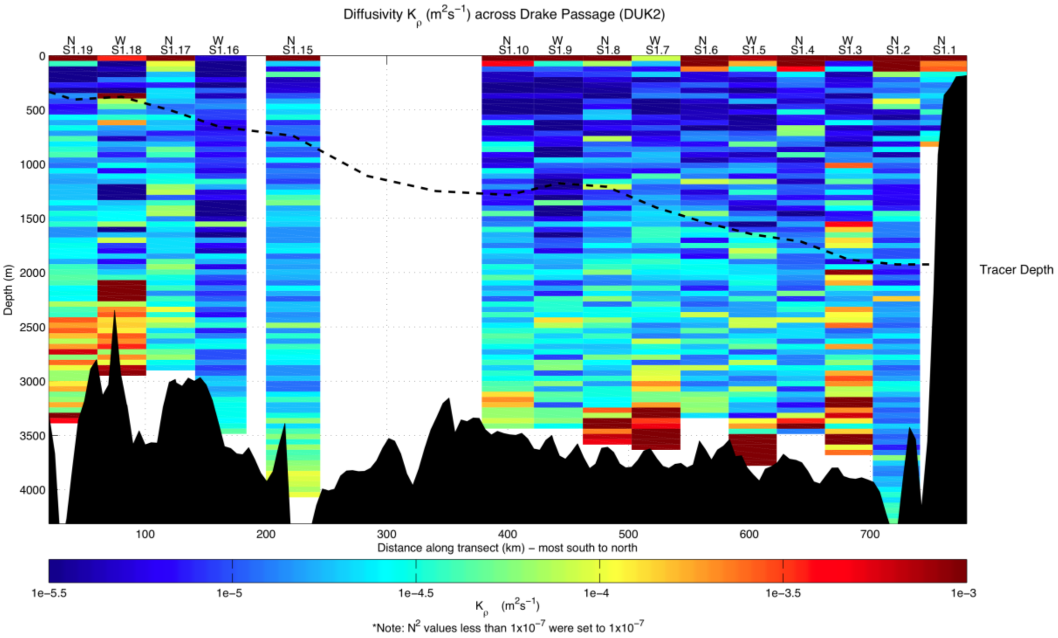


Figure 4.17: Diapycnal diffusivity across Drake Passage section S1 for WHOI-processed data

4.3.7. Comparison of WHOI and NOCS VMP profilers

The average dissipation values across grid and Drake Passage section S1 for WHOI and NOCS casts are plotted in Figures 4.18 and 4.19, respectively. Within the grid, the NOCS averaged data appears a little higher than that of the WHOI measurements. Increased noise in the NOCS profiler may due to noisy probes or variations in the profiler drop speeds (Figure 4.20). The data here do not exclude noisy probes as in the final structure matlab file. The better match across the Drake Passage section is possibly a result of the higher signal to noise ratio here. For a robust comparison, at the end of the cruise both profilers were deployed together. The data from this 'double dip' have not yet been analysed.

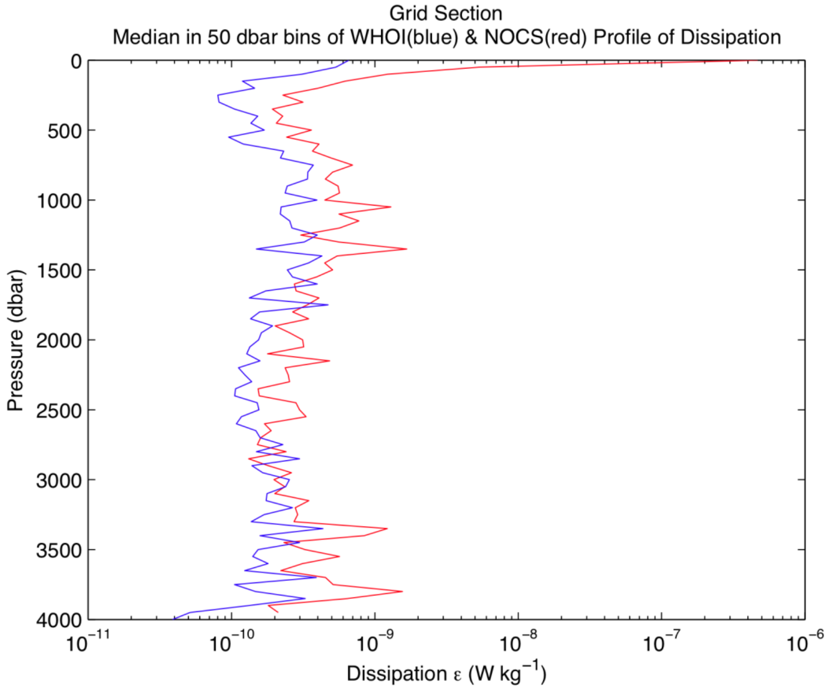


Figure 4.18: Median dissipation values across grid for WHOI-processed data

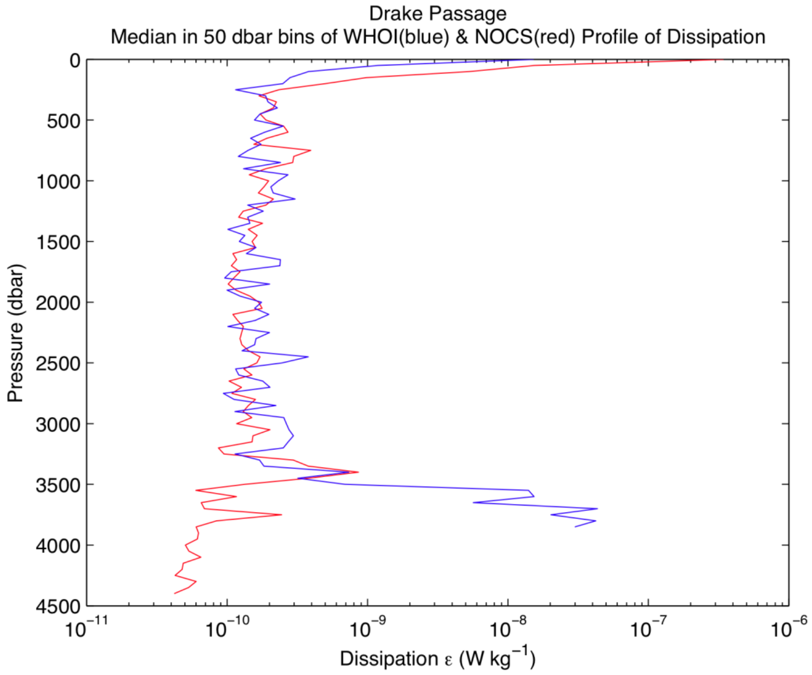


Figure 4.19: Median dissipation across Drake Passage S1 for WHOI processed casts

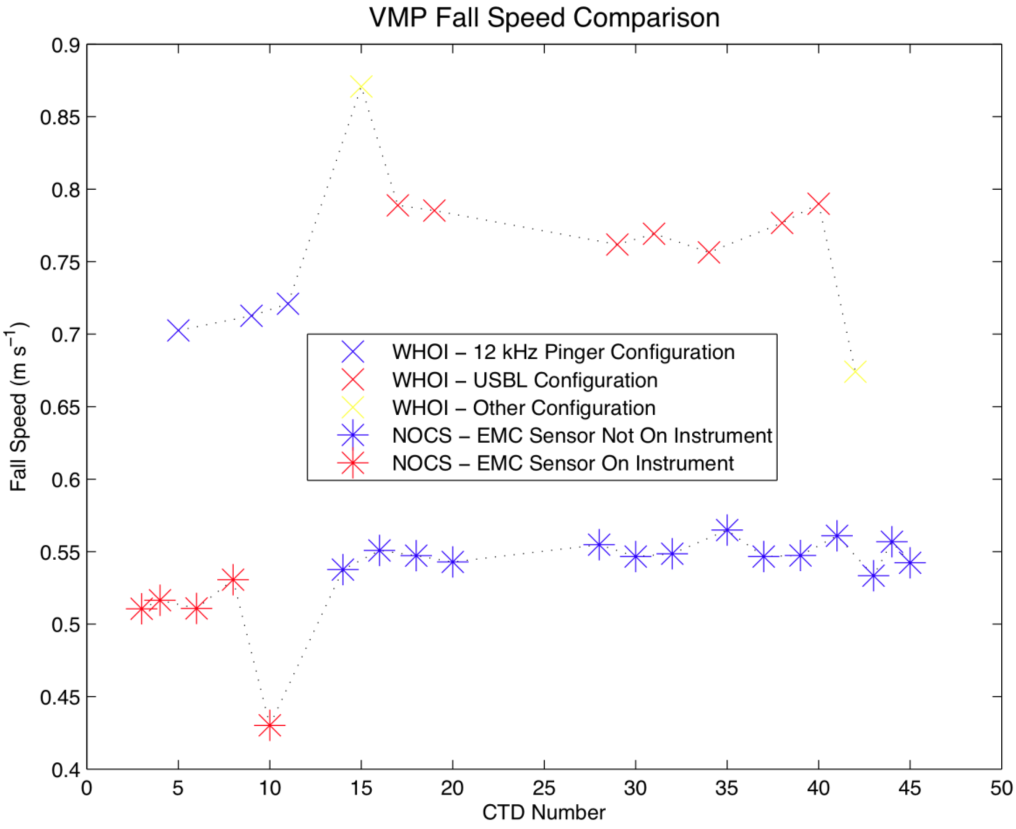


Figure 4.20: VMP profile fall speeds

4.3.8. Comparison of WHOI and NOCS processing routines

Epsilon and chi values, processed using NOCS and WHOI routines for casts are plotted in Figures 4.21 and 4.22, respectively. Casts at CTD station 20 and 43 are shown as typical examples. The mean, median, upper and lower quartiles over pressure bins of 50 dbar are shown. Peak values for epsilon match well. The NOCS processed data consistently show higher noise levels. It is likely that the difference is due to slightly harsher smoothing or low-pass filtering in the WHOI routines.

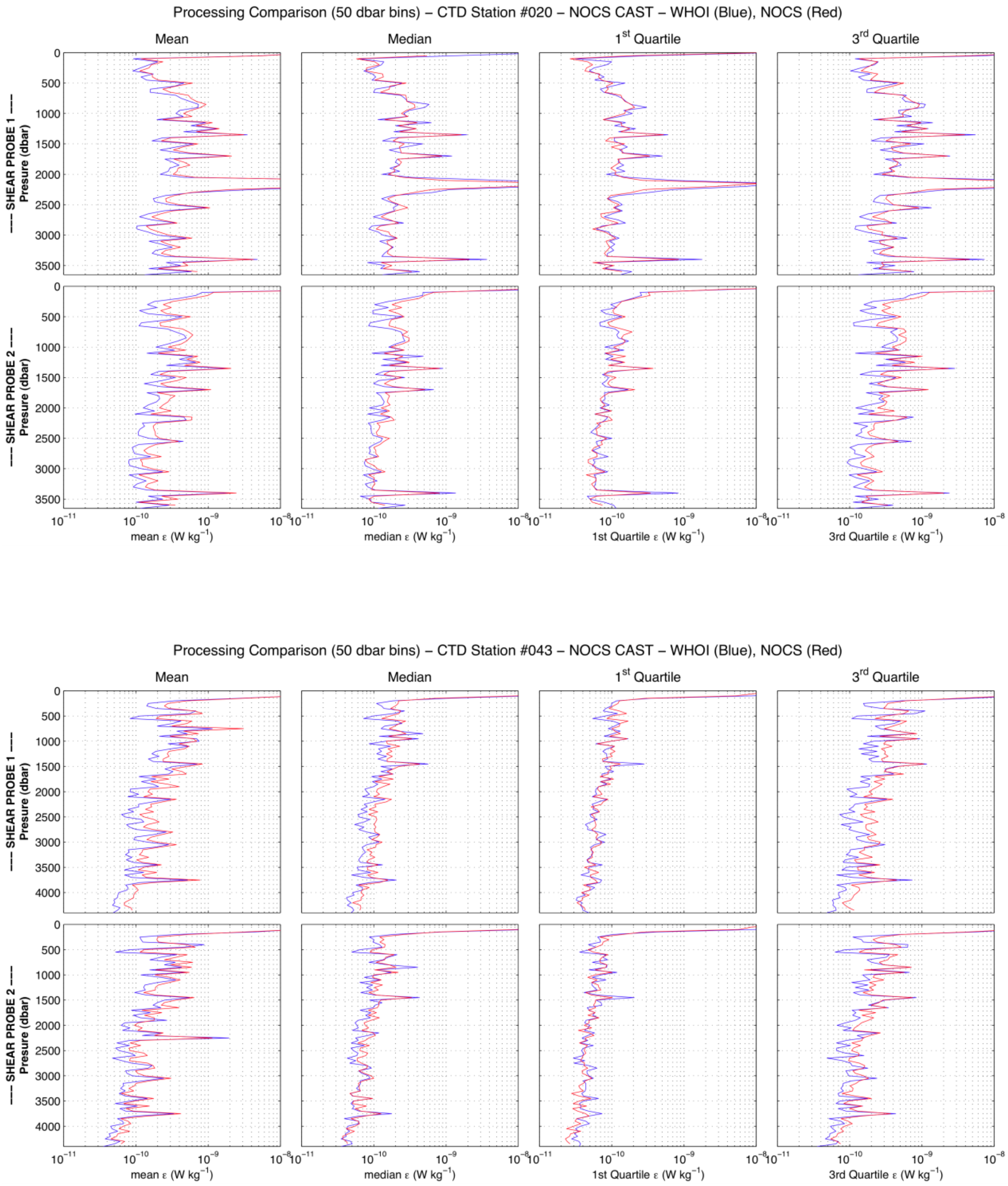


Figure 4.21: Comparison of WHOI and NOCS processing of TKE dissipation for two example casts

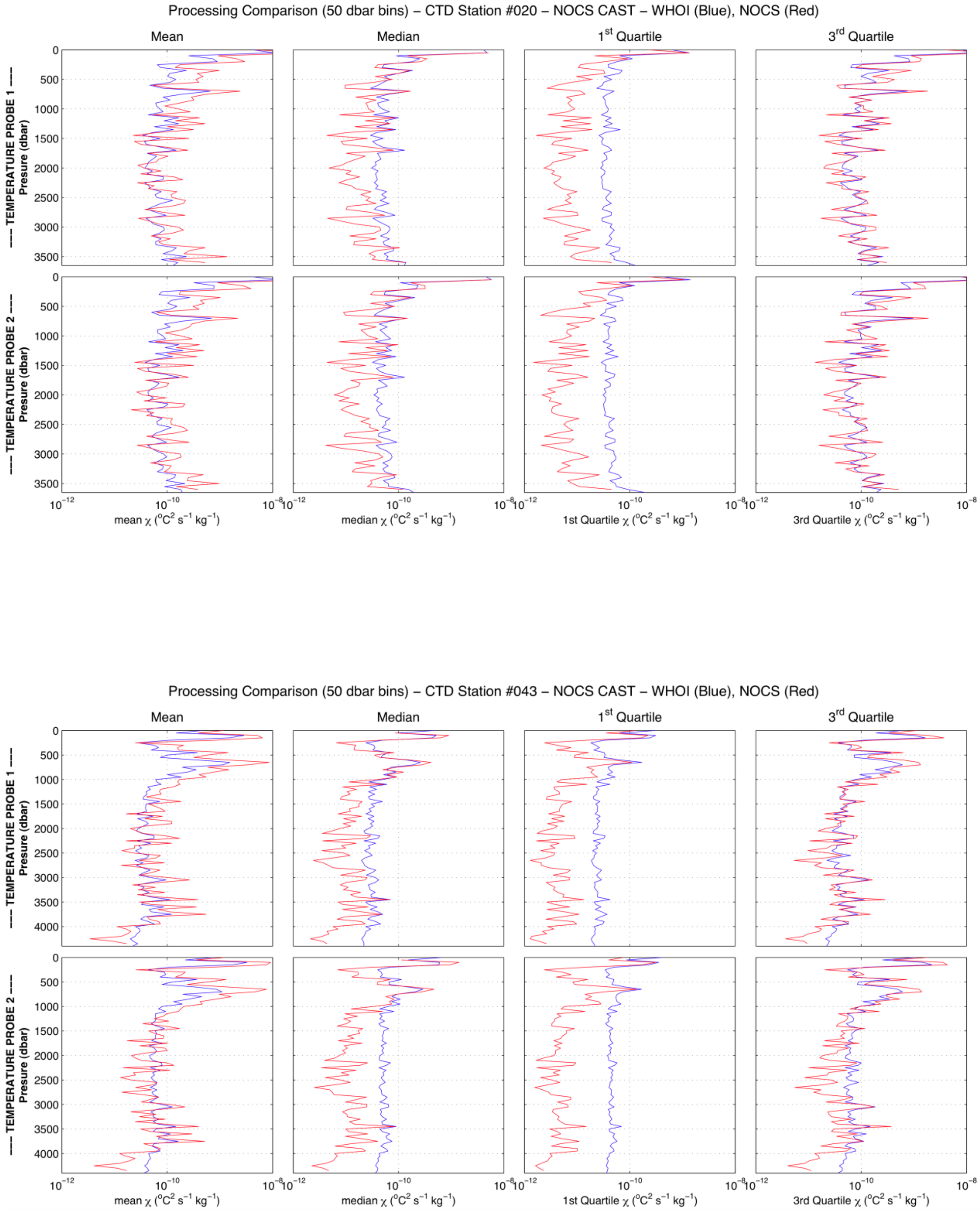
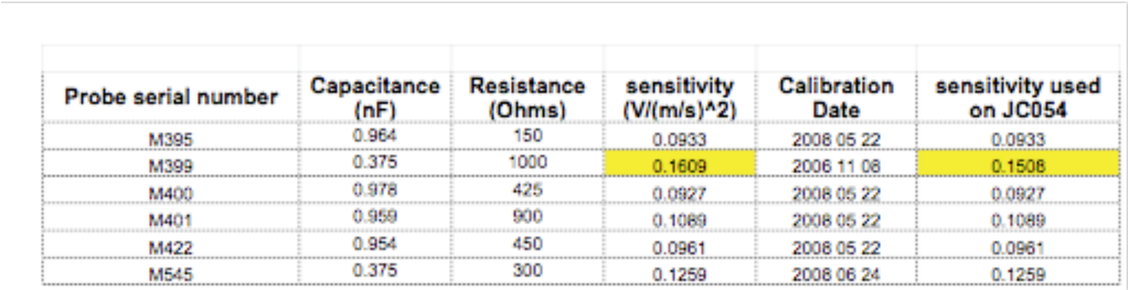


Figure 4.22: Comparison of WHOI and NOCS processing of chi for two example casts



Probe serial number	Capacitance (nF)	Resistance (Ohms)	sensitivity (V/(m/s)^2)	Calibration Date	sensitivity used on JC054
M395	0.964	150	0.0933	2008 05 22	0.0933
M399	0.375	1000	0.1609	2006 11 08	0.1508
M400	0.978	425	0.0927	2008 05 22	0.0927
M401	0.959	900	0.1089	2008 05 22	0.1089
M422	0.954	450	0.0961	2008 05 22	0.0961
M545	0.375	300	0.1259	2008 06 24	0.1259

Table 4.3: Calibration info for shear probes used by the NOCS VMP. Note the mismatch in the sensitivity of shear probe 399 taken from the calibration sheet (0.1609) and taken from the label on the shear probe case (0.1508). Given that the calibration sheet for M399 is old (2006) we assume the sensitivity on the probe case (0.1508) is the correct one to use.

5. Moorings

Alexander Brearley, Paul Provost, Alberto Naveira Garabato, Katy Sheen.

As the second UK cruise of the DIMES Project, recovery of moorings deployed during JC041 was conducted on 6th and 7th December 2010. Data were downloaded from each of the recovered instruments and servicing performed on most of the instruments in preparation for redeployment. This took place between 18th and 20th December 2010. Paul Provost headed the technical team.

5.1. Recovery Operations

5.1.1. NE Mooring

The mooring was released at 0712 on 6th December 2010, at 55.9674°S, 57.7433°W. The top flotation of the mooring was not found; instead the mooring was recovered bottom-first. Table 5.1 lists the times and positions of instruments on deck, with operations complete by 1131. One current meter deployed at 3410 m (RCM11 #300) was flooded on recovery and for safety reasons was jettisoned.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Benthos		MISSING	-	-
Xenon Flash/Argos Beacon		1131	55.9433	57.7019
Seaguard	113	1102	55.9516	57.7086
SBE37 SMP	7292	1102	55.9516	57.7086
Seaguard	116	1116	55.9501	57.7107
SBE37 SMP	7293	1116	55.9501	57.7107
Seaguard	118	1042	55.9535	57.7140
SBE37 SMP	7294	1042	55.9535	57.7140
Nortek	5883	1025	55.9563	57.7215
SBE37 SMP	7295	1025	55.9563	57.7215
RCM-11	300	0957	55.9610	57.7300
SBE37 IMP	4063	0957	55.9610	57.7300
Ixsea	321	0939	55.9645	57.7361

Table 5.1: Times and positions of recovery for NE mooring.

5.1.2. SE Mooring

The mooring was released at 1310 on 6th December 2010. Recovery commenced at 1420, at 56.006°S, 57.7466°W. All instruments and flotation were recovered successfully, with the exception of Sontek #290, which was missing from the mooring chain. Operations were complete by 1556. Table 5.2 lists the times and positions of instruments on deck.

Instrument and Equipment	**Serial Number**	**Time (UTC) Onboard**	**Latitude Onboard (°S)**	**Longitude Onboard (°W)**
Benthos		1425	56.0583	57.7417
Xenon Flash/Argos Beacon	S01-180/016-111	1425	56.0583	57.7417
Seaguard	119	1432	56.0569	57.7398
SBE37 SMP	7296	1432	56.0569	57.7398
Seaguard	120	1439	56.0552	57.7373
SBE37 SMP	7297	1439	56.0552	57.7373
Seaguard	121	1455	56.0529	57.7329
SBE37 SMP	7298	1455	56.0529	57.7329
Seaguard	122	1510	56.0507	57.7294
SBE37 SMP	7299	1510	56.0507	57.7294
Sontek	290	MISSING	-	-
SBE37 IMP	4069	1539	56.0457	57.7240
Ixsea	439	1556	56.0436	57.7226

Table 5.2: Times and positions of recovery for NE mooring.

5.1.3. M Mooring

The mooring was released at 1733 on 6th December 2010, at 56.0233°S, 57.7867°W. Recovery commenced at 1825, with all instruments and flotation recovered successfully. Table 5.3 lists the time and positions of instruments on deck, with operations completed by 2033.

Instrument and Equipment	Serial Number	Time (UTC) Overside	Latitude Overside (°S)	Longitude Overside (°W)
Benthos		1825	56.0234	57.7808
Xenon Flash/Argos Beacon	W10-027/054087	1825	56.0234	57.7808
RAFOS Sound Source		1859	56.0201	57.7710
Sontek	272	1924	56.0166	57.7615
SBE37 IMP	3889	1920	56.0173	57.7632
MMP	12305-01	1945	56.0135	57.7609
Sontek	278	1945	56.0135	57.7609
SBE37 IMP	4061	1945	56.0135	57.7609
MMP	11794-03	2023	56.0079	57.7556
Ixsea	474 & 311	2033	56.0057	57.7525

Table 5.3: Times and positions of recovery for the M mooring. Note the SBE37 IMP 3889 was recovered prior to Sontek 272. Furthermore, the upper MMP (12305-01) was recovered with Sontek 278 and SBE37 IMP 4061.

5.1.4. SW Mooring

The mooring was released at 0826 on 7th December 2010, at 56.063°S, 57.900°W. As with the NE mooring, the top flotation was lost along with a Xenon light beacon; the mooring was thus again recovered bottom-first. Recovery commenced at 1100 and was complete by 1242. The wire above the uppermost Seaguard (#123) was tangled. All the instruments were recovered, with their times and positions onboard in Table 5.4.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Benthos		1227	56.0759	57.9226
Xenon Flash/Argos Beacon	W10-028/054-086	1227	56.0759	57.9226
Seaguard	123	1227	56.0759	57.9226
SBE37 SMP	7300	1227	56.0759	57.9226
Seaguard	124	1220	56.0757	57.9200
SBE37 SMP	7301	1220	56.0757	57.9200
Seaguard	069	1213	56.0757	57.9168
SBE37 SMP	7302	1213	56.0757	57.9168
Nortek	1415	1157	56.0761	57.9121
SBE37 SMP	8079	1157	56.0761	57.9121
Seaguard	127	1125	56.0736	57.9027
SBE37 SMP	7303	1125	56.0736	57.9027
Ixsea	830	1100	56.0708	57.8964

Table 5.4: Times and positions of recovery for the SW mooring.

5.1.5. C Mooring

The mooring was released at 1425 on 7th December 2010, at 56.013°S, 57.820°W. Recovery commenced at 1617, with all instruments and flotation successfully recovered by 1829. Table 5.5 lists the time and position of instruments on deck.

Instrument and Equipment	**Serial Number**	**Time (UTC) Overside**	**Latitude Overside (°S)**	**Longitude Overside (°W)**
Xenon Flash	W10-029	1617	56.0194	57.8209
Argos Sercel Beacon	054-088	1617	56.0194	57.8209
Nortek	6178	1626	56.0204	57.8265
SBE37 SMP	7304	1626	56.0204	57.8265
Nortek	6181	1637	56.0215	57.8300
SBE37 SMP	7305	1637	56.0215	57.8300
Nortek	6182	1644	56.0219	57.8315
SBE37 SMP	7306	1644	56.0219	57.8315
Nortek	6203	1650	56.0223	57.8325
SBE37 SMP	7307	1650	56.0223	57.8325
Nortek	6212	1700	56.0235	57.8351
SBE37 SMP	7309	1700	56.0235	57.8351
Nortek	6213	1707	56.0239	57.8372
SBE37 SMP	7310	1707	56.0239	57.8372
Nortek	6224	1719	56.0245	57.8415
SBE37 SMP	7311	1719	56.0245	57.8415
Nortek	6225	1727	56.0248	57.8433
SBE37 SMP	7312	1727	56.0248	57.8433
Nortek	6242	1733	56.0247	57.8456

SBE37 SMP	7313	1733	56.0247	57.8456
Nortek	6273	1740	56.0251	57.8481
SBE37 SMP	7314	1740	56.0251	57.8481
Long Ranger ADCP	3301	1757	56.0252	57.8536
Nortek	6275	1815	56.0250	57.8575
SBE37 SMP	7315	1815	56.0250	57.8575
Nortek	6276	1822	56.0251	57.8591
SBE37 SMP	7316	1822	56.0251	57.8591
IXSEA	831 & 832	1945	55.9734	57.8660

Table 5.5: Times and positions of recovery for the C mooring.

5.1.6. NW Mooring

The mooring was released at 2030 on 7th December 2010, at 55.962°S, 57.69°W. Recovery started a 2151 and was complete by 2320. All instruments and flotation were successfully brought on board, with the times and positions given in Table 5.6.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Benthos		2151	55.9767	57.9143
Xenon Flash/Argos Sercel	W06-006/016-110	2151	55.9767	57.9143
Seaguard	109	2159	55.9768	57.9165
SBE37 SMP	7288	2159	55.9768	57.9165
Seaguard	110	2204	55.9775	57.9181
SBE37 SMP	7289	2204	55.9775	57.9181
Sontek	332	2219	55.9802	57.9259
SBE37 SMP	7308	2219	55.9802	57.9259
Seaguard	111	2236	55.9821	57.9337
SBE37 SMP	7290	2236	55.9821	57.9337
Seaguard	112	2302	55.9852	57.9423
SBE37 SMP	7291	2302	55.9852	57.9423
Ixsea	255	2320	55.9878	57.9478

Table 5.6: Times and positions of recovery for the NW mooring.

5.1.7. Data Download

Having recovered the instruments, data were downloaded from them. Downloading was done by Peter Keen, Paul Provost, Terry Edwards, Katy Sheen, Stephanie White and Alexander Brearley. A record of data download was kept in the file 'jc041 recovered instruments_jc054.xls' on the technicians' laptop and backed up to the Drobo file storage system. Data from the SMPs and IMPs were downloaded using Seabird's SeaTerm program, with Seaguard and Nortek data being downloaded in Seaguard Studio and Aquadopp DW respectively. Data from the Sontek current meters were downloaded using SonUtils3 and the MMP profiles were downloaded in WinADCP. Following data download, the data files were converted to the appropriate file type for analysis in Matlab, typically either ascii .txt or .cnv files. Details of the most relevant files are given in Table 5.7. These were then backed up to the drobo file storage.

Mooring	Instrument Type and Serial No.	Original download file(s)	Other files produced
SE	Seaguard 113	RCM_113_20091207_1200 (directory)	DCS #217.csv
	Seaguard 116	RCM_116_20091207_1200 (directory)	DCS #220.csv
	Seaguard 118	RCM_118_20091207_1200 (directory)	DCS #222.csv
	Nortek 5883	N588301.dat	N588301.aqd, .hdr, .dia
	RCM11 300	Instrument disposed	-
	SBE37 SMP 7292	SBE37-RS232_03707292_2010_12_06.cnv	7292.cap/7292_b.cap
	SBE37 SMP 7293	SBE37-RS232_03707293_2010_12_06.cnv	7293.cap
	SBE37 SMP 7294	SBE37-RS232_03707294_2010_12_06.cnv	7294.cap
	SBE37 SMP 7295	SBE37-RS232_03707295_2010_12_06.cnv	7295.cap
	SBE37 IMP 4063	4063.asc	4063.cap
NE	Seaguard 119	RCM_119_20091207_1200 (directory)	DCS #243.csv
	Seaguard 120	RCM_120_20091207_1200 (directory)	DCS #246.csv
	Seaguard 121	RCM_121_20091207_1200 (directory)	DCS #99.csv
	Seaguard 122	RCM_122_20091207_1200 (directory)	DCS #238.csv
	Sontek 290	Missing	-
	SBE37 SMP 7296	SBE37-RS232_03707296_2010_12_06.cnv	7296.cap
	SBE37 SMP 7297	SBE37-RS232_03707297_2010_12_06.cnv	7297.cap
	SBE37 SMP 7298	SBE37-RS232_03707298_2010_12_06.cnv	7298.cap
	SBE37 SMP 7299	SBE37-RS232_03707299_2010_12_06.cnv	7299.cap

	SBE37 IMP 4069	4069.asc	4069.cap
NW	Seaguard 109	RCM_109_20091207_1200 (directory)	DCS #213.csv
	Seaguard 110	RCM_110_20091207_1200 (directory)	DCS #214.csv
	Seaguard 111	RCM_111_20091207_1200 (directory)	DCS #215.csv
	Seaguard 112	RCM_112_20091207_1200 (directory)	DCS #216.csv
	Sontek 332	D332M001.arg	D332001asc.dat, .ctl
	SBE37 SMP 7288	SBE37-RS232_03707288_2010_12_08.cnv	7288.cap
	SBE37 SMP 7289	SBE37-RS232_03707289_2010_12_08.cnv	7289.cap
	SBE37 SMP 7308	SBE37-RS232_03707308_2010_12_07.cnv	7308.cap
	SBE37 SMP 7290	SBE37-RS232_03707290_2010_12_07.cnv	7290.cap
	SBE37 SMP 7291	SBE37-RS232_03707291_2010_12_08.cnv	7291.cap
7C	Nortek 6178	N617801.dat	N617801.aqd, .hdr, .dia
	Nortek 6181	N618101.dat	N618101.aqd, .hdr, .dia
	Nortek 6182	N618201.dat	N618201.aqd, .hdr, .dia
	Nortek 6203	N620301.dat	N620301.aqd, .hdr, .dia
	Nortek 6212	N621201.dat	N621201.aqd, .hdr, .dia
	Nortek 6213	N621301.dat	N621301.aqd, .hdr, .dia
	Nortek 6224	N622401.dat	N622401.aqd, .hdr, .dia
	Nortek 6225	N622501.dat	N622501.aqd, .hdr, .dia
	Nortek 6242	N624201.dat	N624201.aqd, .hdr, .dia
	Nortek 6273	N627301.dat	N627301.aqd, .hdr, .dia
	Nortek 6275	N627501.dat	N627501.aqd, .hdr, .dia
	Nortek 6276	N627601.dat	N627601.aqd, .hdr, .dia
	LR-ADCP 3301	D3301000.000	jc054_longranger.mat
	SBE37 SMP 7304	SBE37-RS232_03707304_2010_12_07.cnv	7304.cap
	SBE37 SMP 7305	SBE37-RS232_03707305_2010_12_07.cnv	7305.cap
	SBE37 SMP 7306	SBE37-RS232_03707306_2010_12_07.cnv	7306.cap
	SBE37 SMP 7307	SBE37-RS232_03707307_2010_12_07.cnv	7307.cap
	SBE37 SMP 7309	SBE37-RS232_03707309_2010_12_07.cnv	7309.cap
	SBE37 SMP 7310	SBE37-RS232_03707310_2010_12_07.cnv	7310.cap
	SBE37 SMP 7311	SBE37-RS232_03707311_2010_12_07.cnv	7311.cap

	SBE37 SMP 7312	SBE37-RS232_03707312_2010_12_07.cnv	7312.cap
	SBE37 SMP 7313	SBE37-RS232_03707313_2010_12_07.cnv	7313.cap
	SBE37 SMP 7314	SBE37-RS232_03707314_2010_12_07.cnv	7314.cap
	SBE37 SMP 7315	SBE37-RS232_03707315_2010_12_07.cnv	7315.cap
	SBE37 SMP 7316	SBE37-RS232_03707316_2010_12_07.cnv	7316.cap
SW	Seaguard 123	RCM_123_20091207_1200 (directory)	DCS #213.csv
	Seaguard 124	RCM_124_20091207_1200 (directory)	DCS #214.csv
	Seaguard 125	RCM_125_20091207_1200 (directory)	DCS #215.csv
	Seaguard 127	RCM_127_20091207_1200 (directory)	DCS #216.csv
	Sontek 298	D298001.arg	D298001.dat, .ctl
	SBE37 SMP 7300	SBE37-RS232_03707300_2010_12_07.cnv	7300.cap
	SBE37 SMP 7301	SBE37-RS232_03707301_2010_12_07.cnv	7301.cap
	SBE37 SMP 7302	SBE37-RS232_03707302_2010_12_07.cnv	7302.cap
	SBE37 SMP 7303	SBE37-RS232_03707303_2010_12_07.cnv	7303.cap
	SBE37 IMP 4465$^+$	4465_2.asc (4465_jan6_2.asc)	4465_2.cap (4462_jan6.cap)
M	Sontek 272	D272001.arg	D272001.dat, .ctl
	Sontek 278	D278001.arg	D278001.dat, .ctl
	SBE37 IMP 3889$^+$	3889.asc (3889_jan6_2.asc)	3889.cap (3889_jan6.cap)
	SBE37 IMP 4061	4061.asc	4061.cap
	MMP 12305-01	11794_03 proc data (directory)*	11794_03 raw data*
	MMP 11794-03	12305_01 proc data (directory)*	12305_01 raw data*

Table 5.7: Downloaded data files from each instrument recovered from the DIMES mooring array. Other files include capture files for the SMPs/IMPs, header and control files for the Norteks, .csv data files for the Seaguards, *The data directories for the MMPs contain A* files containing current meter data, C* files containing CTD data and E* files containing engineering information. Other MMP files include the deploy.txt file, which holds the setup information. + Note that the data from IMPs 3889 and 4465 were downloaded twice. Figures in this report were compiled from the original data download, which missed the first 23 days of data. The corrected files, downloaded just prior to the end of the cruise, are given in brackets.

5.2. Data Checking

Prior to redeployment of the moorings, the data collected during 2009-2010 were inspected to identify any failing instruments. For example, instrument failure might be manifested as jumps or drift, or alternatively as the output becoming fixed on a single value. To make it easier to identify problems, temperature, salinity, pressure and velocity from all instruments on a mooring were examined together.

5.2.1. Results from Microcats

Both SMPs and IMPs, manufactured by Seabird, were used on the first year's deployment. In total, 29 SMPs and 5 IMPs were deployed, all of which were recovered successfully. Initially, the pressure records from these instruments were analysed to understand what happened to the SW and NE moorings that caused them to lose their top buoyancy.

5.2.1.1. NE mooring

The pressure record from the NE mooring is shown in Figure 5.1. All instruments fell successfully to their desired deployment depth, and remained there until January 27th. The mooring endured severe knockdown (~200 dbar at the uppermost instrument) on January 24th, but recovered its position by 26th January. However, it would appear a second knockdown event on 27th January caused the top buoyancy to implode, meaning that all of the mooring above the bottom IMP fell to near the bottom. The bottom IMP (4063) only dropped by ~50 dbar, presumably dragged down by the other instruments.

For the remainder of the year, the arrangement of instruments was as follows. The bottom IMP (4063) remained close to its deployment pressure at ~3500 dbar, whilst the third SMP (7294, in green) fell right to the bottom and remained there until recovery. The other instruments (7292, 7293 and 7295) all stayed around 100 m above the bottom, with 7295 (black line) displaying the most pressure variability, suggesting that this instrument was less entangled than the others.

The temperature record from each Microcat on the NE mooring is shown in Figure 5.2. Both temperature and pressure records from the top three instruments (in blue, red and green respectively) are closely correlated, suggesting changes in the upper 1200 m are equivalent barotropic. For the pressure field, these barotropic changes extend to 2000 dbar, but this is less clear for temperature. After the four upper instruments fall to the bottom, the temperature fields of all are closely correlated, suggesting good data quality throughout the deployment.

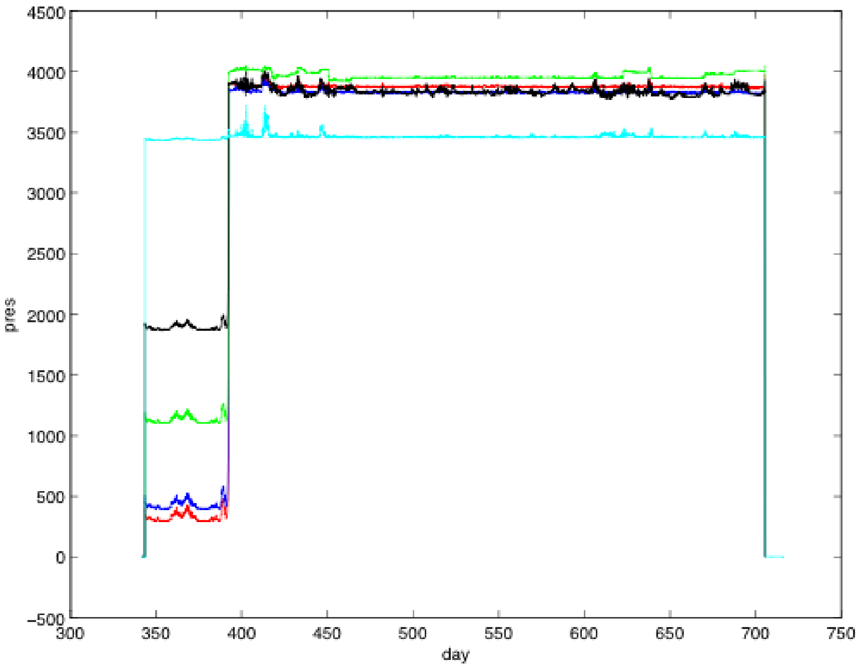


Figure 5.1: Annual pressure record at the NE mooring site showing successful deployment and coherent pressure features across the five instruments for the first 6 weeks. The four upper instruments then sink to at or near the bottom. Serial numbers are 7292 (red), 7293 (blue), 7294 (black), 7295 (green) and 4063 (cyan, IMP).

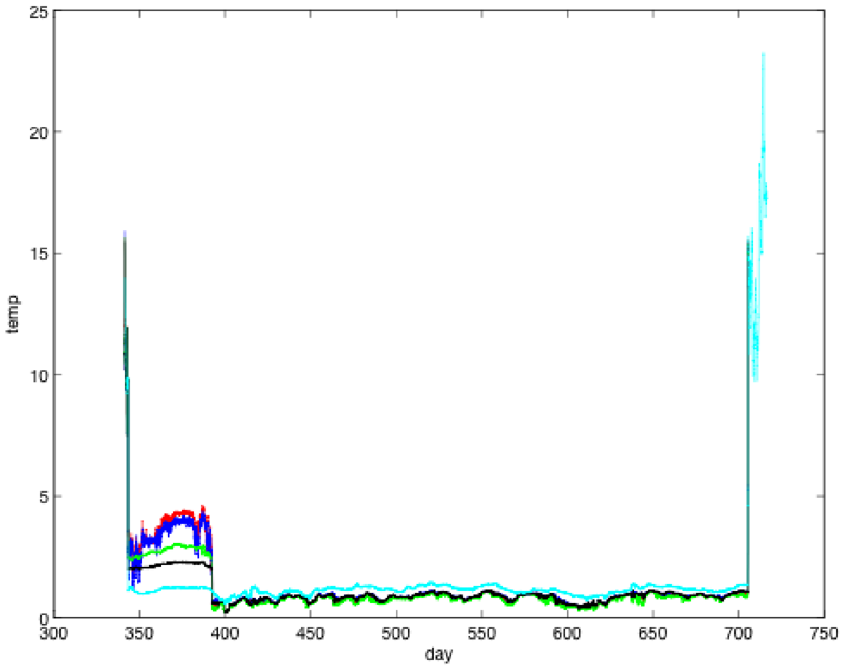


Figure 5.2: Annual temperature record in degrees Celsius for the NE mooring site. Colours are as in Figure 5.1.

Salinity was also checked on each of the four SMPs (Figure 5.3), with good quality data being observed at all four pressure levels. Salinity changes appear less barotropic than for temperature, with contrasting trends between the two near-surface instruments. Nevertheless, the consistency of measurements when all the instruments were near the bottom implies that these differences are real.

Unfortunately, the IMP download does not offer the user the opportunity to compute salinity directly, meaning a direct comparison with the SMPs could not be done immediately. Nevertheless, the conductivity values from the IMP did seem reasonable.

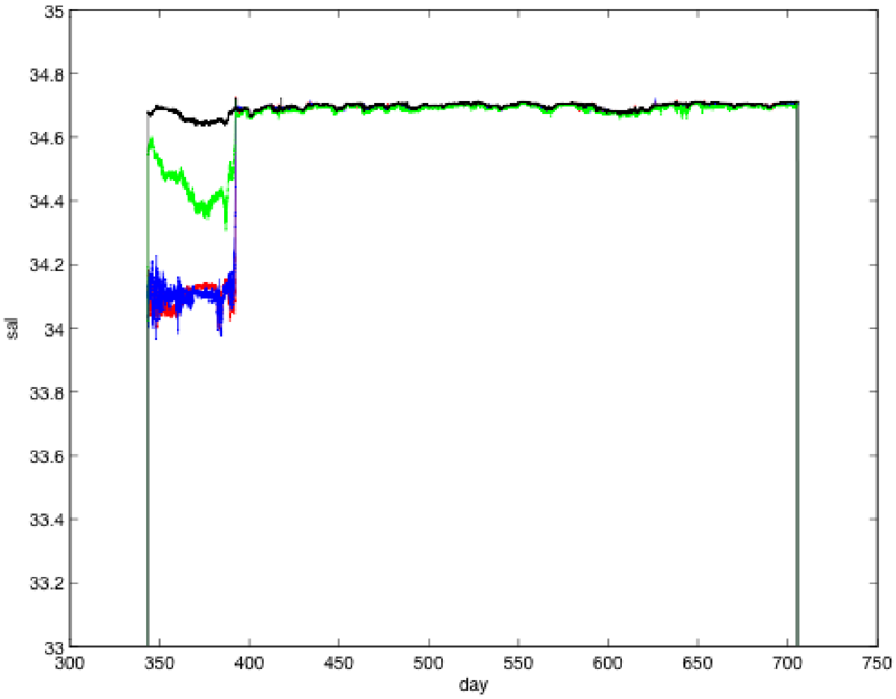


Figure 5.3: Salinity for the four SMPs on the NE mooring. For colour key see Figure 5.1.

5.2.1.2. SE Mooring

Similar analysis was conducted for the four SMPs and one IMP on the SE mooring. This time, the instruments all remained at the desired pressure level for the entire deployment (Figure 5.4). Strong vertical pressure coherence is observed throughout the water column. It is also found that the event that caused the implosion of the top buoyancy of moorings NE and SW was a 600 m knockdown. This was the largest such event of the year, though several others of 300-500 m were also observed.

A similar equivalent barotropic structure was observed in temperature at this mooring (Figure 5.5), with this being particularly strong for the top two instruments (7296 and 7297 in red and blue respectively). All temperature sensors appeared to have performed well.

With the exception of the occasional obvious spike on 7296 and 7297, the salinity measurements of the SMPs all appear good, with fairly strong coherence at all pressure levels (more so than at NE). However, some baroclinic changes are observed (e.g. in the uppermost instrument around day 630). Changes are generally density-compensating with temperature. The conductivity record from IMP 4069 also seems good (not shown).

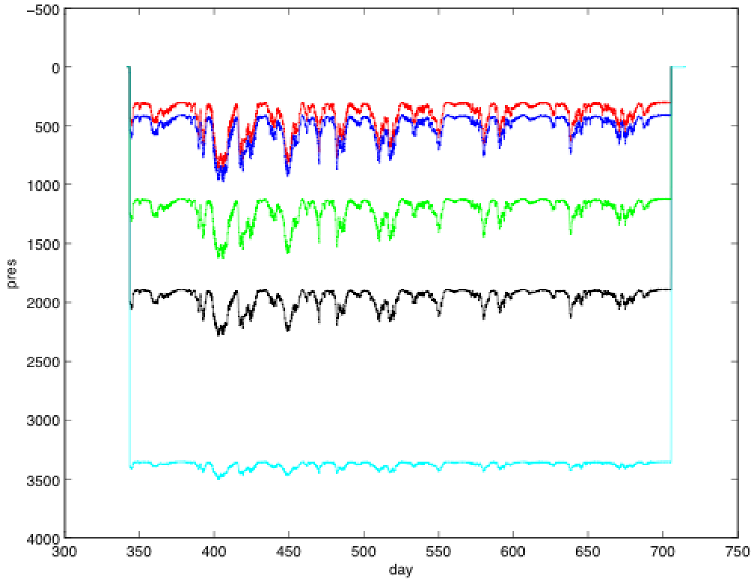


Figure 5.4: Pressure record for Microcats on the SE mooring. The instruments are 7296 (red), 7297 (blue), 7298 (green), 7299 (black) and 4069 (IMP, cyan).

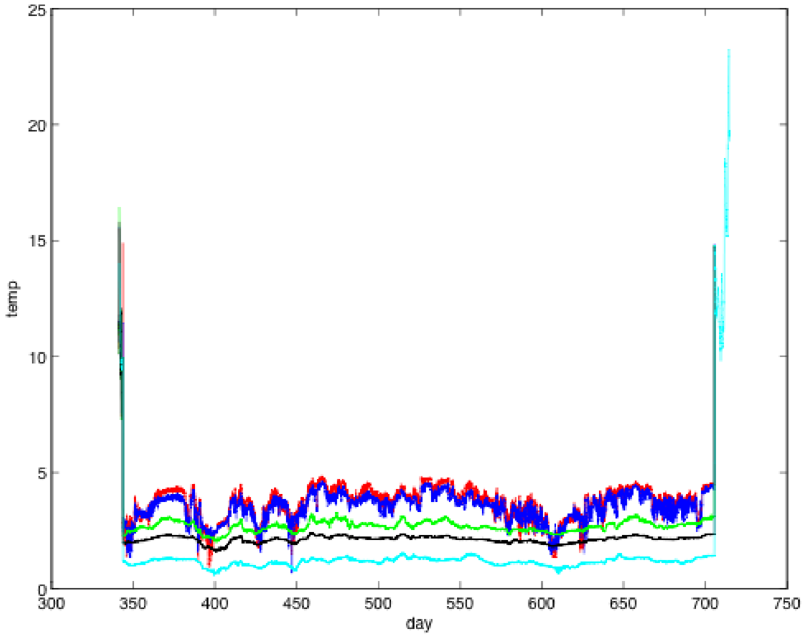


Figure 5.5: Temperature record for Microcats on the SE mooring. For colour information see Figure 5.4.

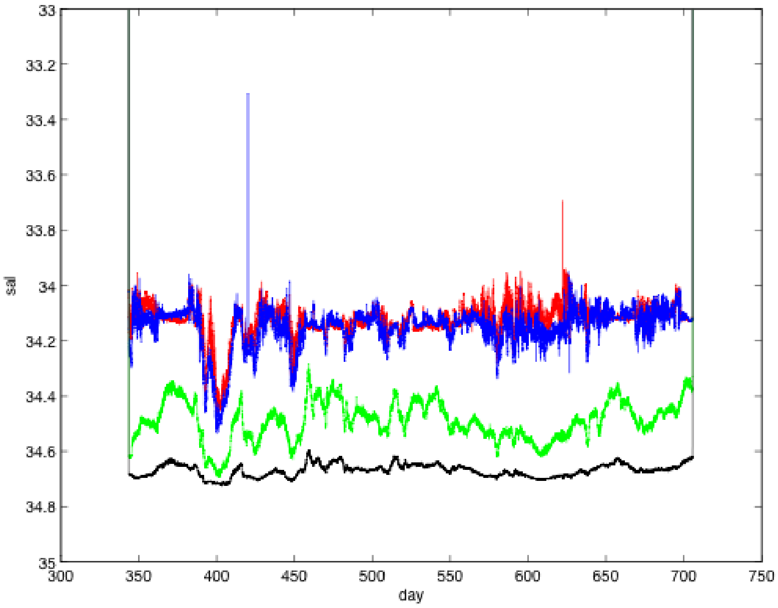


Figure 5.6: Salinity record for SMPs on the SE Mooring. For colour information see Figure 5.4.

5.2.1.3. M Mooring

Two IMPs were placed on the M mooring, at 1656 m and 2675 m respectively. The pressure plot (Figure 5.7) shows successful full-year deployments of both instruments, with several knockdown episodes again observed (up to 400 m on the shallower IMP). The temperature records of both instruments (Figure 5.8) also appear good.

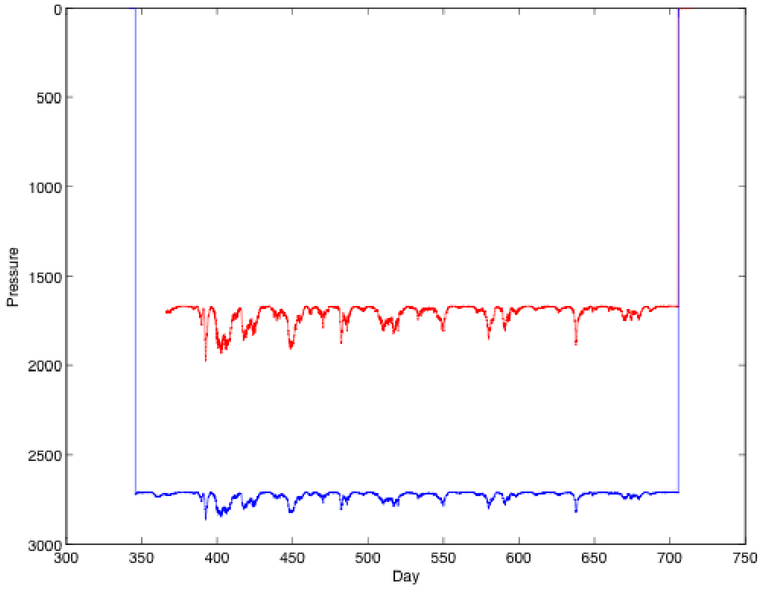


Figure 5.7: Pressure record for IMPs on the M mooring. The red line denotes IMP 3889 and the blue line demotes IMP 4061.

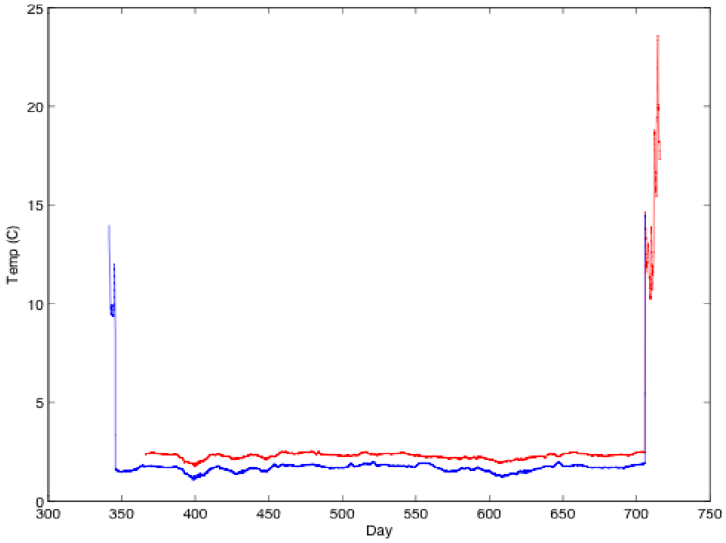


Figure 5.8: Temperature record for IMPs from the M mooring. The red line denotes IMP 3889 and the blue line demotes IMP 4061.

5.2.1.4. SW Mooring

This mooring suffered a similar fate to the NE mooring, successfully collecting data at the desired pressure level until 3rd February (one week later than NE). At this time, a large knockdown event (the second in a few days) caused the four uppermost instruments to fall close to the bottom, where they remained for the rest of the deployment (Figure 5.9). As with the NE mooring, the third SMP down the mooring wire (7302) remained on the bottom, with the two Microcats above and one below located up to 100 m above. The bottom SMP (7303) was not dragged down significantly by the mooring collapse and continued to make good-quality pressure readings at ~3400 m.

It is clear that the bottom IMP (4465) failed on 3rd June, when the pressure dropped dramatically to 4124 m and remained locked at that value until the end of the deployment. The temperature sensors (Figure 5.10) all performed well whilst the mooring was upright, showing equivalent barotropic behaviour over the top three SMPs. The salinity changes are less equivalent in depth (Figure 5.11), yet the close agreement between the individual instruments for the period where they are close to the bottom suggests the overall data quality is good. Moreover, the conductivity record from the IMP appears sound (not shown).

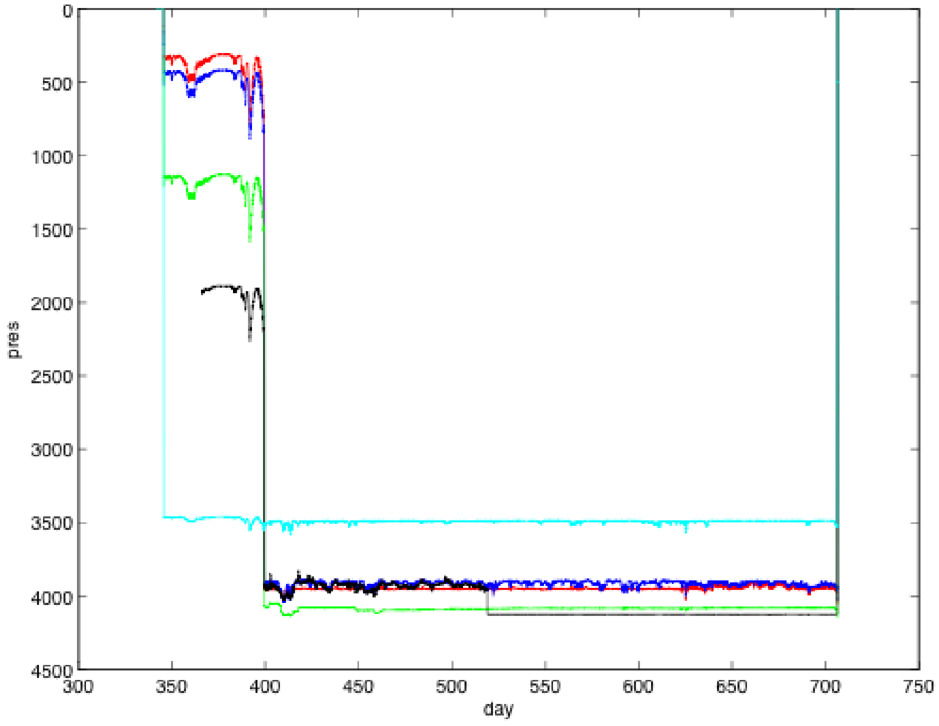


Figure 5.9: Pressure record for the SW mooring. The instruments are 7300 (red), 7301 (blue), 7302 (green), 4465 (IMP, black) and 7303 (cyan).

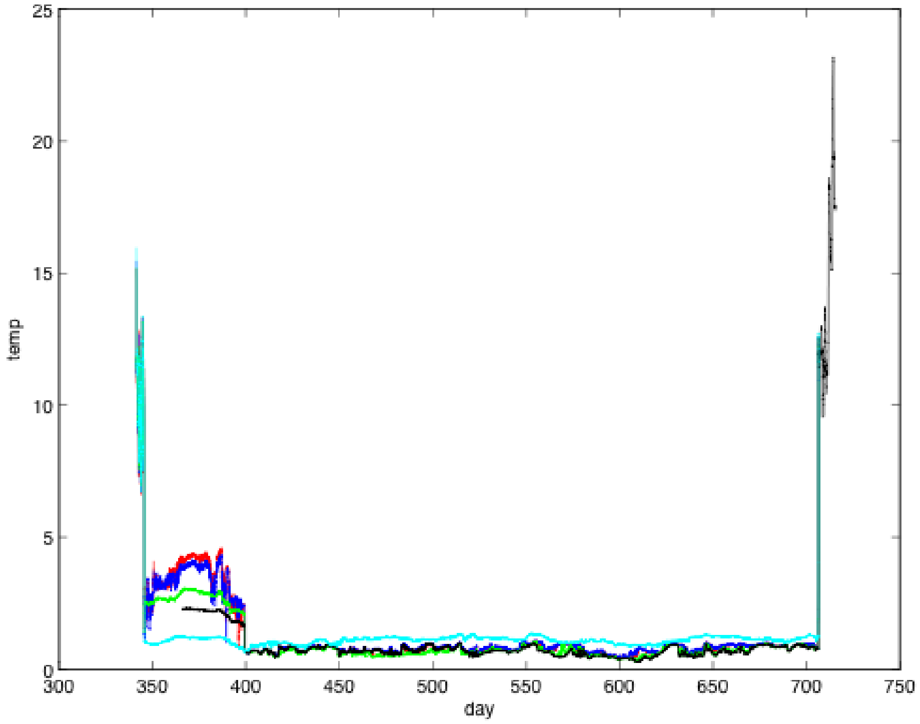


Figure 5.10: Temperature record for the SW mooring. The colour code is in Figure 5.9.

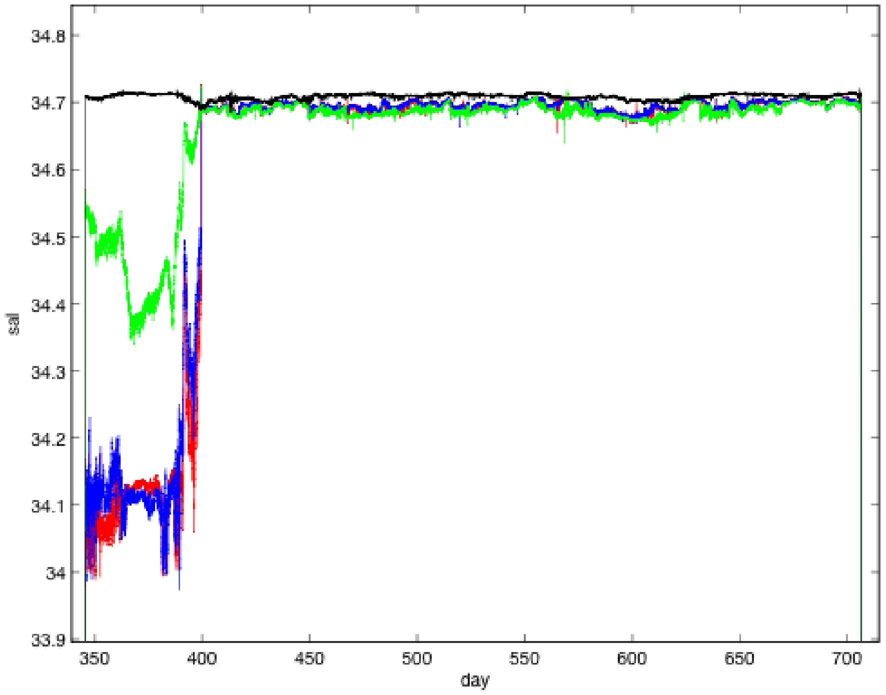


Figure 5.11: Salinity record for the four SMPs on the SW mooring. The colour code is red (7300), blue (7301), green (7302) and black (7303).

5.2.1.5. C Mooring

All 12 SMPs on the C mooring successfully recorded at the desired pressure depth for the entire deployment (Figure 5.12). Over the top 2500 dbar, the pressure changes recorded by each instrument were equivalent barotropic in nature, with the bottom instruments being affected to a lesser extent by the knockdown features. The temperature data (Figure 5.13) were also good, with the strongest variability in the top 600 m (red lines). The temperature changes are also less barotropic than for pressure.

The salinity measurements acquired by each SMP (Figure 5.14) also appear to be good, with consistent salinity values from instruments at similar depths. Again, the changes are largely barotropic in the upper 2000 m, but with strong deviations from this pattern in the bottom instruments (black lines).

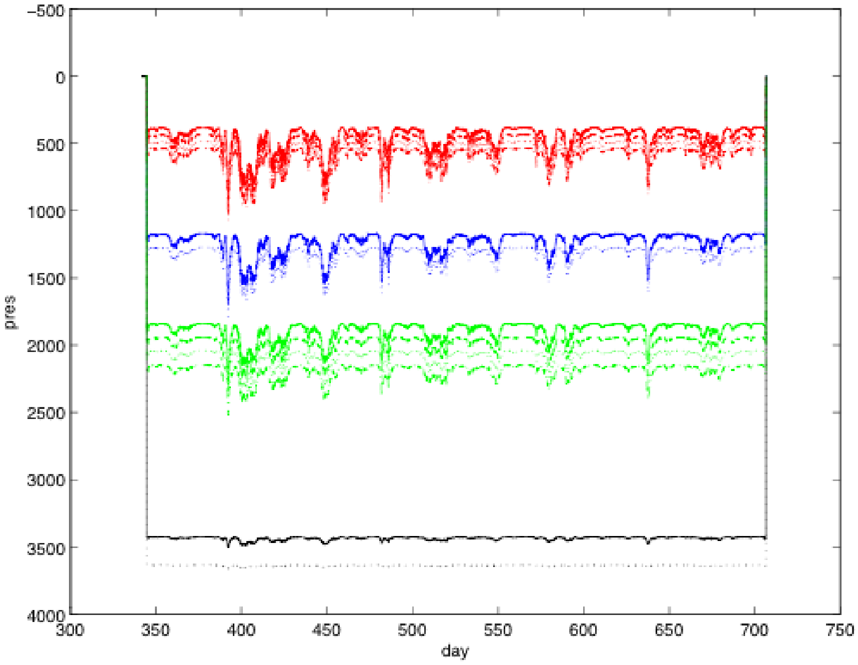


Figure 5.12: Pressure record for SMPs deployed on the C mooring. The colours show the individual groups of instruments. The four red lines (solid, dashed, dotted and dash-dot) denote instruments 7304, 7305, 7306 and 7307. The blue red lines (solid and dashed) denote 7309 and 7310. The green lines (solid, dashed, dotted and dash-dot) denote instruments 7311, 7312, 7313 and 7314. The black lines (solid and dashed) show instruments 7315 and 7316.

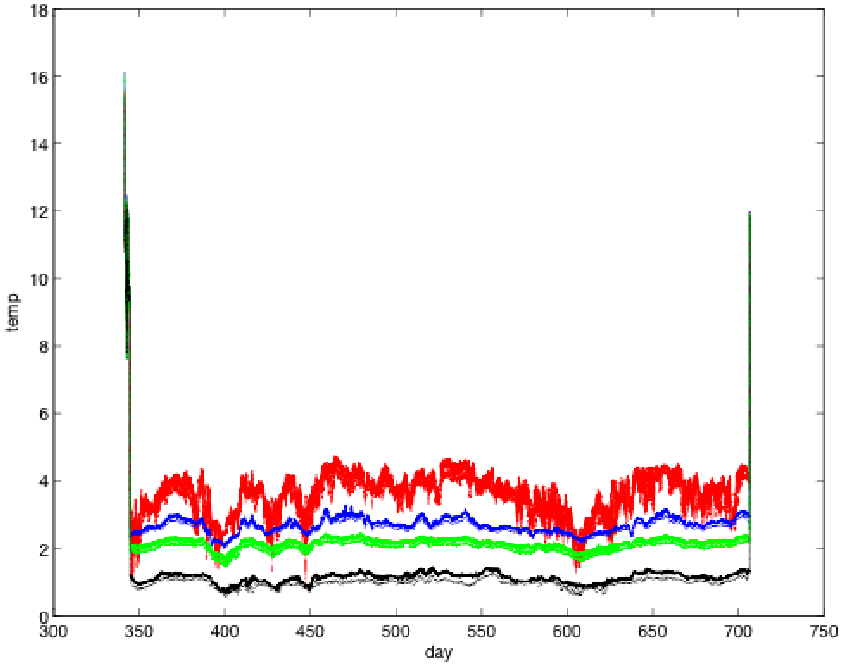


Figure 5.13: Temperature record for SMPs deployed on the C mooring. The colour coding is given in Figure 5.12.

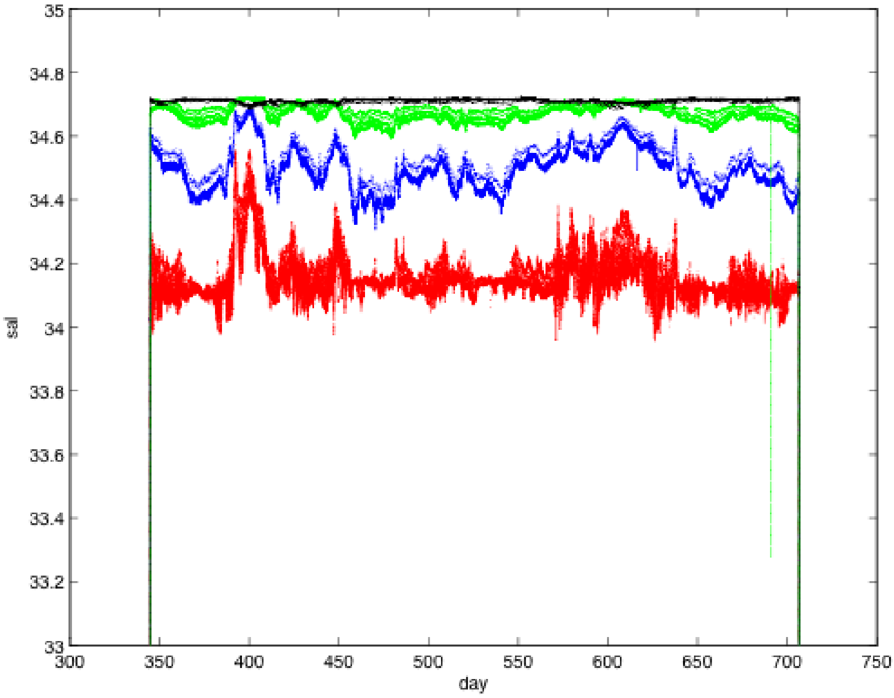


Figure 5.14: Salinity from SMPs on the C Mooring. Colour coding is given in Figure 5.12.

5.2.1.6. NW Mooring

The pressure results for the 5 SMPs on the NW mooring are displayed in Figure 5.15. All instruments remained at the desired pressure level for the full period of the deployment. The temperature record (Figure 5.16) also suggests that the temperature sensors on the SMPs were stable throughout, with most changes again being barotropic in the upper ocean. The conductivity sensors also remained stable throughout, with the exception of a single large spike on SMP 7308 at the beginning of April 2010. As with the SE Mooring, there are opposing salinity trends between the top two layers in late summer 2010, with barotropic variability at other times (Figure 5.17).

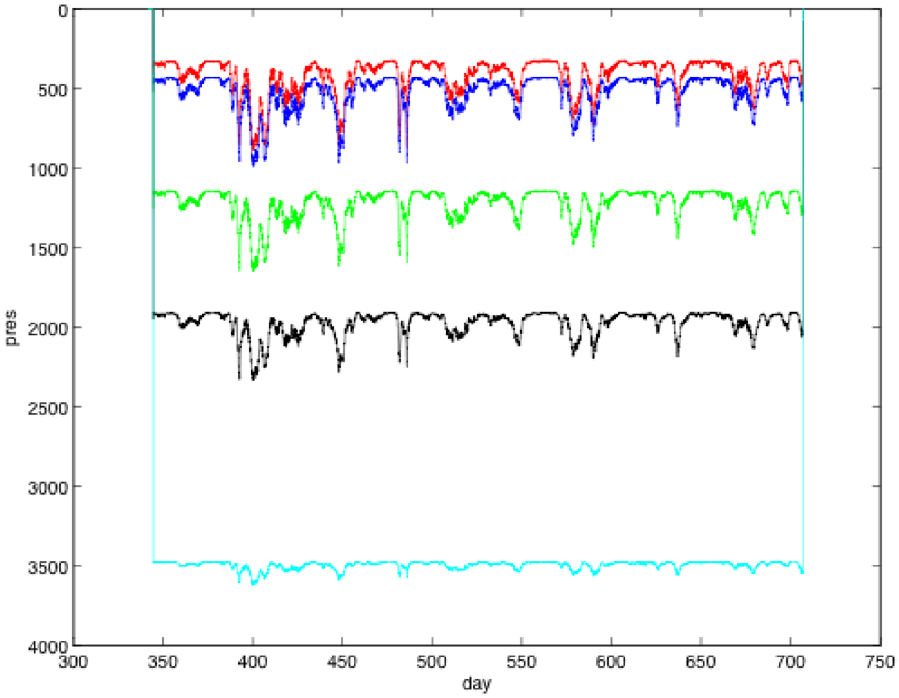


Figure 5.15: Pressure from SMPs on the NW mooring. The instruments are as follows: red (7288), blue (7289), green (7308), black (7290) and cyan (7291).

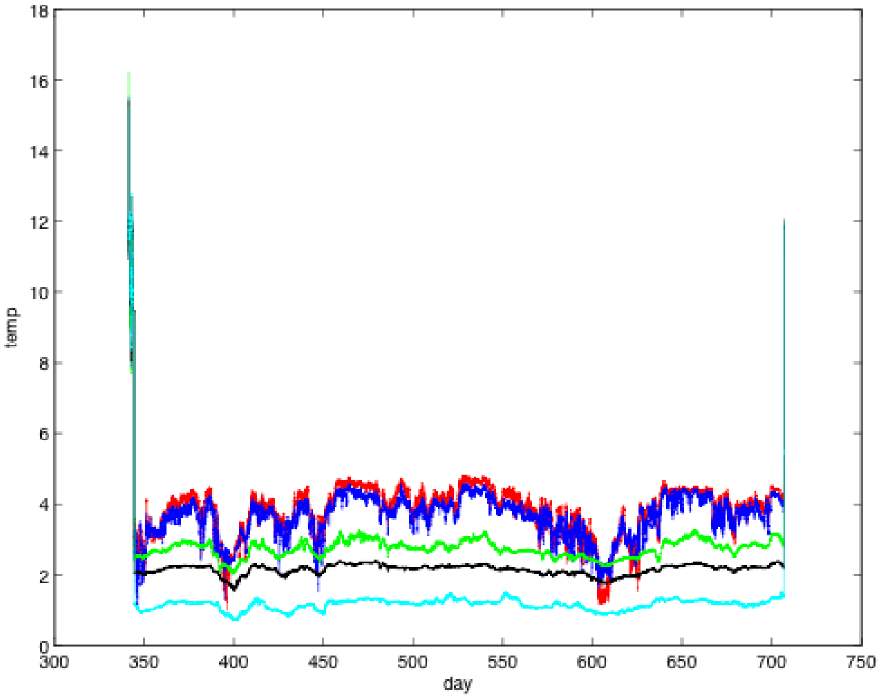


Figure 5.16: Temperature from SMPs on the NW mooring. The instruments are as in Figure 5.15.

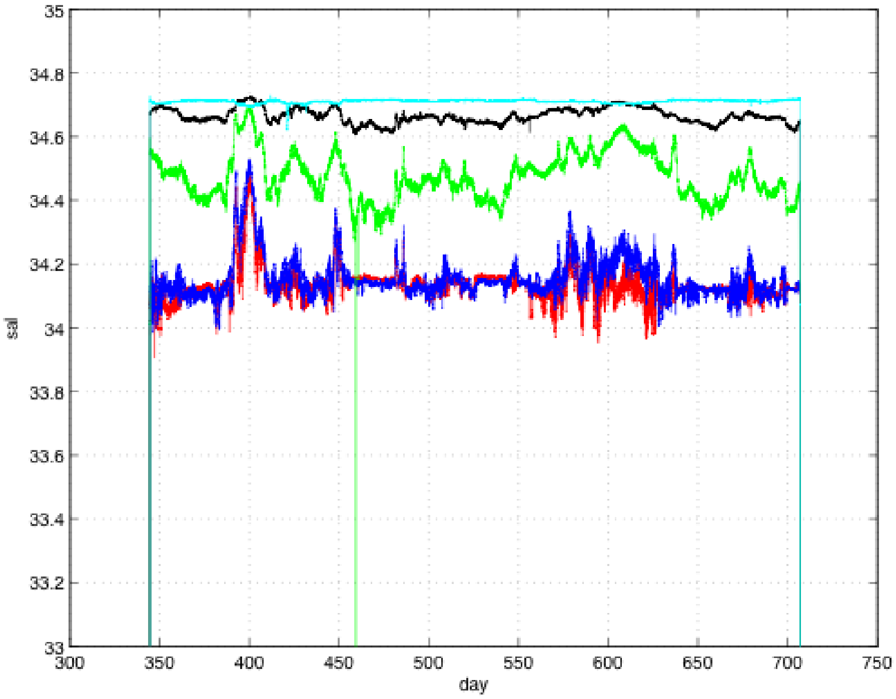


Figure 5.17: Salinity from SMPs on the NW mooring. The colour key is in Figure 5.14.

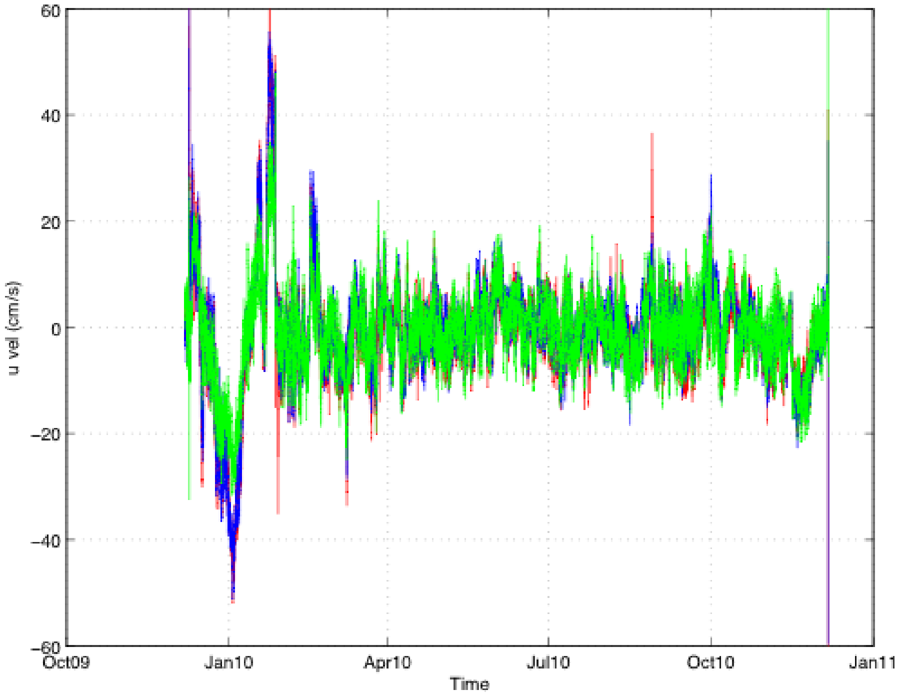
5.2.2. Current Meters

A combination of 13 Nortek, 15 Seaguard, 5 Sontek and 1 RCM11 current meters were used as part of the mooring array. Most of the instruments were deployed at the same depth as accompanying Microcats. 1 Sontek (290) was not recovered and 1 RCM11 (300) was flooded and had to be disposed of. Once again, data were examined by mooring to help identify any anomalous readings.

5.2.2.1. NE Mooring

Data from the Seaguards on the NE Mooring (113, 116 and 118) are displayed in Figure 5.18. The current meters show good internal consistency. A period of high current speeds occurred on all three instruments at the start of the record, initially directed NE, then SW. After the knockdown event, the size of the current variability in all instruments decreases rapidly, but the time series are well correlated implying the instruments performed successfully for the entire deployment. The data from the Nortek (5883) were qualitatively similar (not shown) to that from the Seaguards, suggesting equivalent barotropic velocity changes throughout the water column. The RCM11 was flooded and no data were recovered.

The period after January 27th when the instruments fell down to near the bottom is clearly shown in the x tilt plot from the Seaguards (Figure 5.19). Whilst the early period is characterised by each instrument moving freely with up to ~20° of tilt, the later period has the instruments in almost fixed positions, with Seaguard 118 tilted ~7° to the x axis.



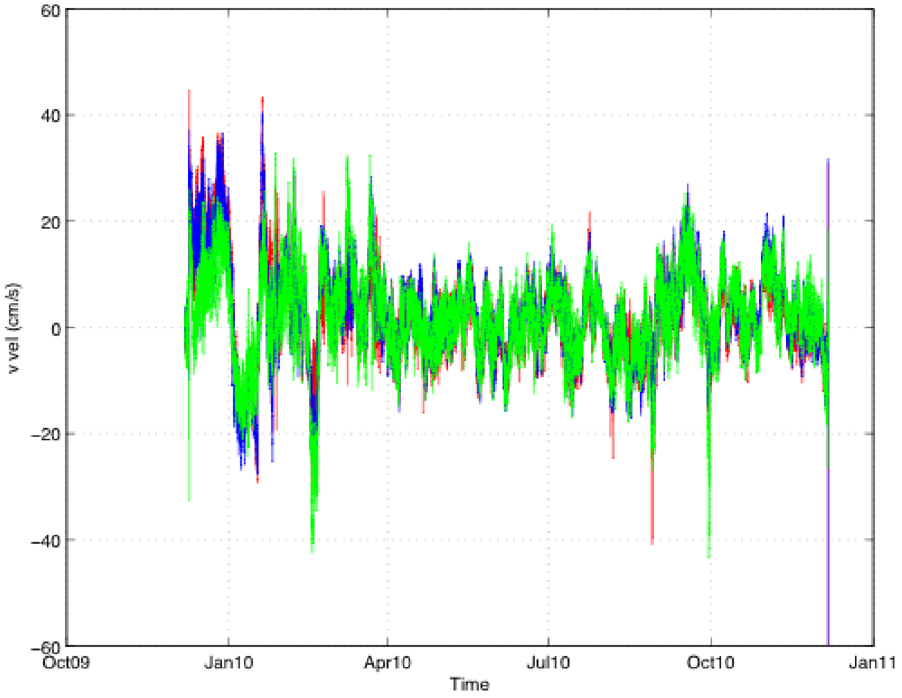


Figure 5.18: u (upper) and v (lower) velocity records for the Seaguard current meters on the NE mooring. The red line denotes Seaguard 113, the blue line Seaguard 116 and the green line Seaguard 118.

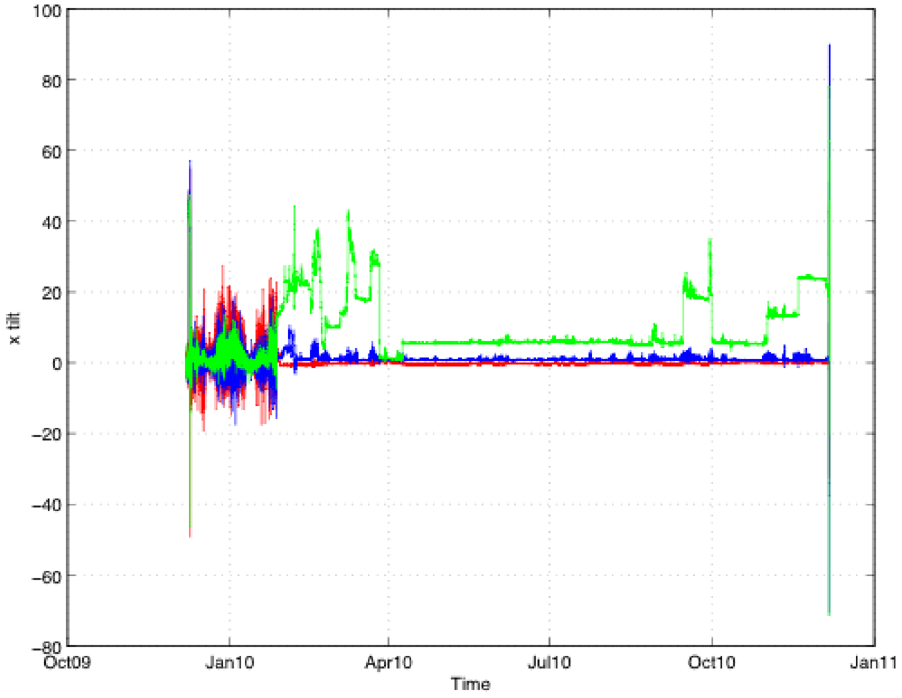


Figure 5.19: x tilt (in degrees) for the Seaguard current meters on the NE mooring. Colours are defined in Figure 5.17.

5.2.2.2. SE Mooring

The current speed from the Seaguards on the SE mooring is shown in Figure 5.20. Current speeds reach a maximum of 70 cm/s in early February (at the time of the knockdown event on NE and SW moorings). Once again, there is good agreement between velocities from different depths, indicating an equivalent barotropic structure. No obvious spikes or anomalous values were found. Sontek 290 was not recovered as it was missing from the mooring wire.

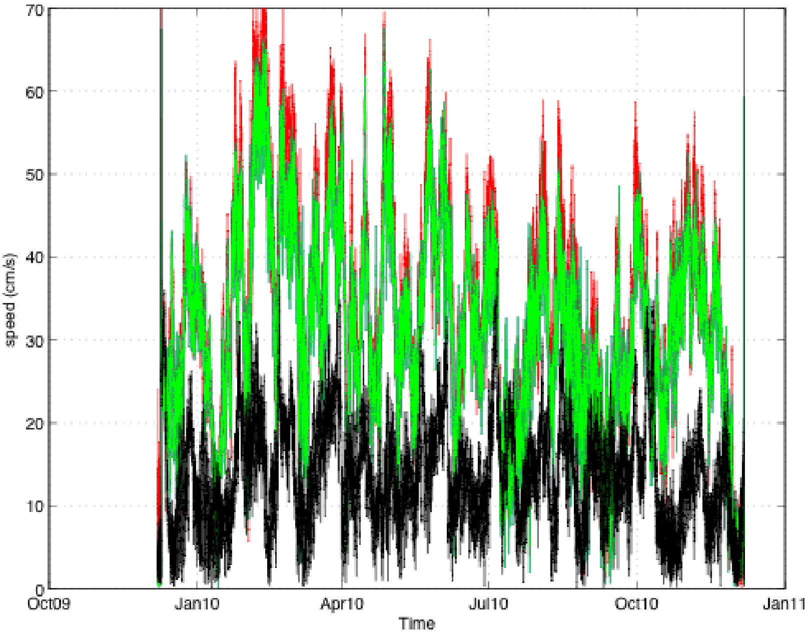


Figure 5.20: Current speed record from SE Mooring. Velocities in the upper 1200 m peak near 70 cm/s. The red line denotes Seaguard 109, the blue line (not clearly visible) Seaguard 110, the green line 111 and the black line 112.

5.2.2.3. M Mooring

The middle mooring contained only two current meters – both Sonteks – at 1656 m and 2674 m. The current speeds from these instruments are given in Figure 5.21. The size of the values is consistent with those on other moorings (e.g. the NW mooring) for these pressure levels. Unfortunately, Sontek 278 did not record any data after October 2010, so there is a two-month gap at the end of the record.

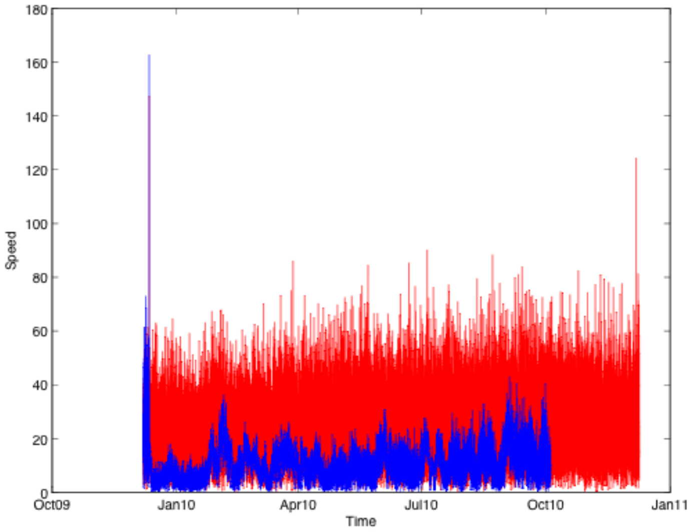


Figure 5.21: Current speed record from Sonteks 272 (red) and 278 (blue) on the M mooring. Speed is in cm/s.

5.2.2.4. SW Mooring

The SW mooring contained five current meters, comprising four Seaguards and one Sontek. Current speed results from the Seaguards (Figure 5.22) agree with other moorings in having a period of alternating strong NE and SW velocity at the start of the record, before the instruments were knocked down to the bottom. A few spikes can be seen in some of the records but they generally appear good (if not at the desired pressure level).

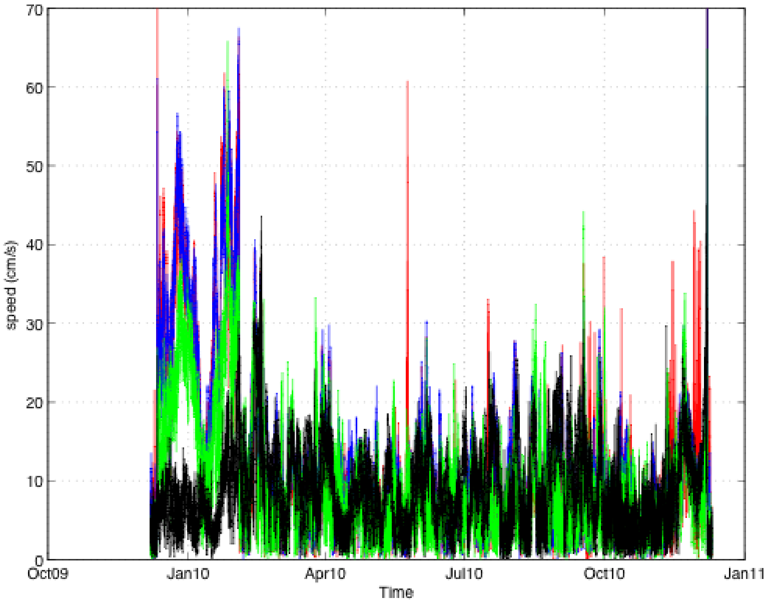


Figure 5.22: Current speed from Seaguard current meters on the SW mooring. The colours are red (123), blue (124), green (125) and black (127).

One Sontek (298) was also deployed on the SW Mooring, at 2009 m (Figure 5.23). The instrument appeared to perform successfully until early June 2010, when the noise of the time series suddenly increased by a factor of ~2, meaning the data after this time are questionable.

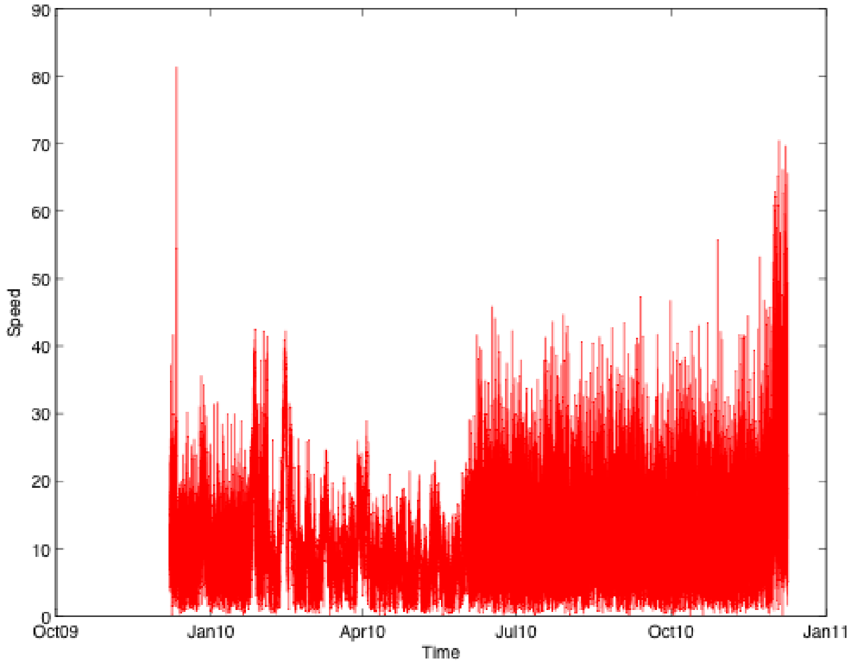


Figure 5.23: Current speed (in cm/s) from the Sontek D298 on the SW mooring.

5.2.2.5. C Mooring

The C mooring was equipped with 12 Nortek current meters paired with the SMPs (Figure 5.24). All instruments appeared to perform successfully throughout the deployment period, with maximum current speeds near the surface of ~80 cm/s. As at the other sites, the changes are generally equivalent barotropic, especially in the top 2000 m.

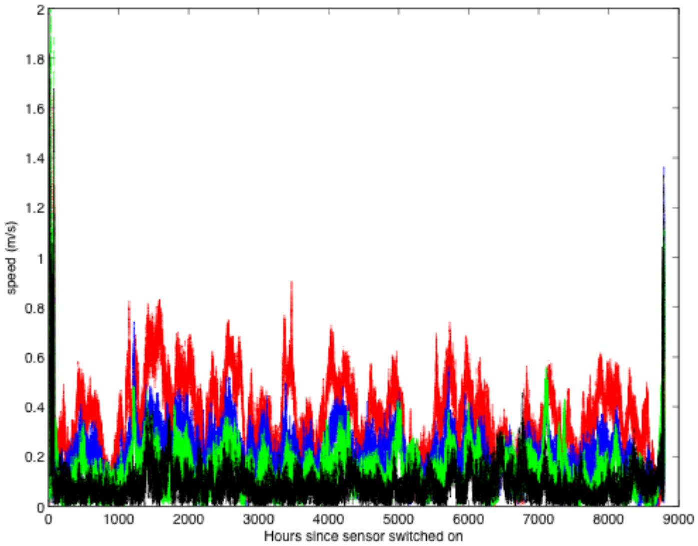


Figure 5.24: Current speed (in cm/s) from the 12 Nortek current meters on the C mooring. The four uppermost Norteks (6178, 6181, 6182 and 6203) are plotted in red, the next two (6212 and 6213) are plotted in blue, the next four (6224, 6225, 6242 and 6273) in green and the last two (6275 and 6276) in black.

Unfortunately, an accident in the Deck Lab shortly after recovery meant that 10 Norteks from this mooring were dropped from the bench onto the floor. Whilst all the data were successfully recovered, it will only be after the next year that we will be able to assess the damage to any internal parts on these current meters. The dropped instruments had serial numbers 6178, 6181, 6182, 6213, 6224, 6225, 6242, 6273, 6275 and 6276.

5.2.2.6. NW Mooring

Four Seaguards (109, 110, 111 and 112) and one Sontek (332) were deployed on this mooring. All the instruments were recovered successfully and their data appear to be of good quality. The current speed from the Seaguards is shown in Figure 5.25. Maximum values reached ~70 cm/s on the 450 m and 550 m instruments (109 and 110 respectively), with changes being largely equivalent barotropic between these levels. There are some baroclinic changes on the deeper instruments (e.g. in September 2010), when large bottom velocities coincide with weak surface velocities.

In addition, a Sontek current meter was placed on the mooring at 1252 m (332). The data from this instrument (not shown) appear consistent with those collected by the Seaguards. A single spike is observed at the start of the time series, but the remainder of the data appear good with no anomalous drift.

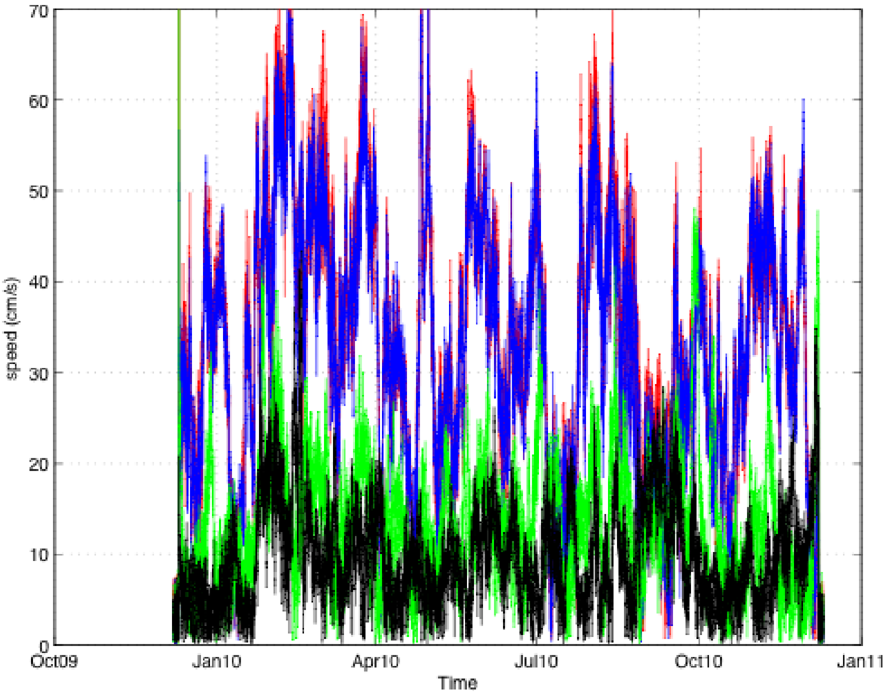


Figure 5.25: Current speeds (in cm/s) from the four Seaguard instruments located on the NW Mooring. The serial numbers are 109 (red), 110 (blue), 111 (green) and 112 (black).

5.2.3. Long Ranger ADCP

The C Mooring was equipped with a Long Ranger Downward Looking ADCP, located at 2803 m. The instrument collected an ensemble every 30 minutes for the period of the deployment, resulting in 17436 individual velocity estimates. The plots of u velocity, v velocity and current speed are given in Figures 5.26, 5.27 and 5.28 respectively. For the sake of computation efficiency, these were interpolated to create a daily time series prior to plotting.

Inspecting Figure 5.28, it is apparent that the knockdown event which caused the collapse of the SW and NE moorings was associated with strong deep velocities of 25-30 cm/s. Whilst this event did not appear particularly outstanding in many of the current meter records, the ADCP suggests it was a unique event in terms of high deep velocities.

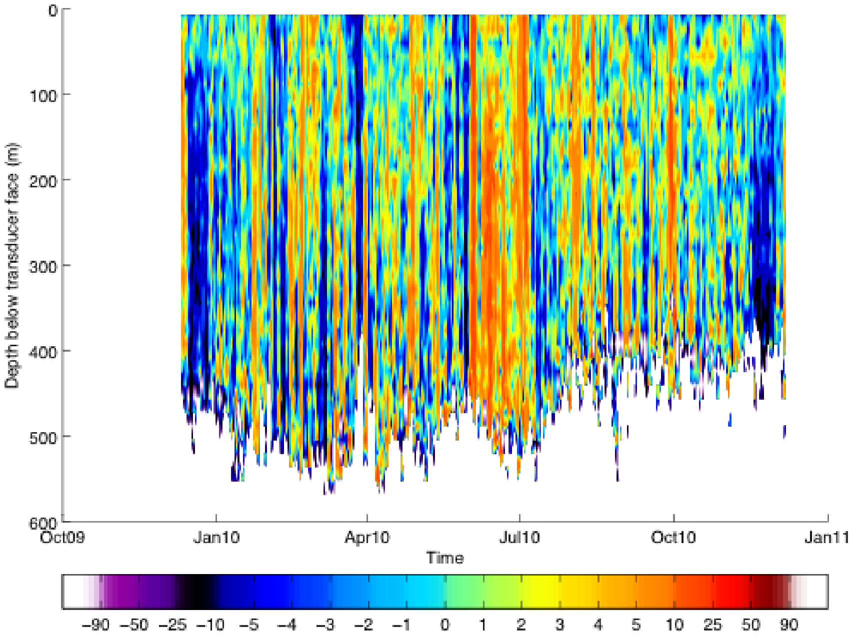


Figure 5.26: Daily u velocity from the Long Ranger ADCP mounted on the C mooring. Units are in cm/s.

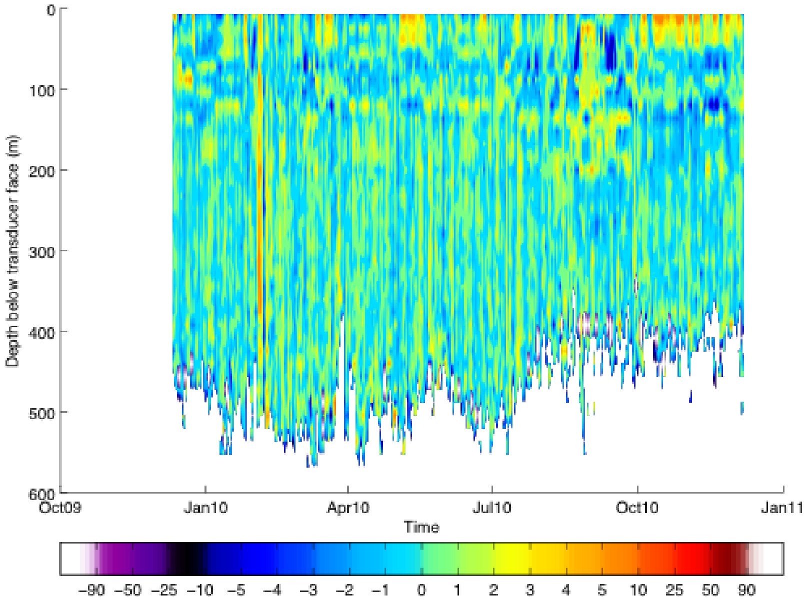


Figure 5.27: Daily v velocity from Long Ranger ADCP on the C mooring (in cm/s).

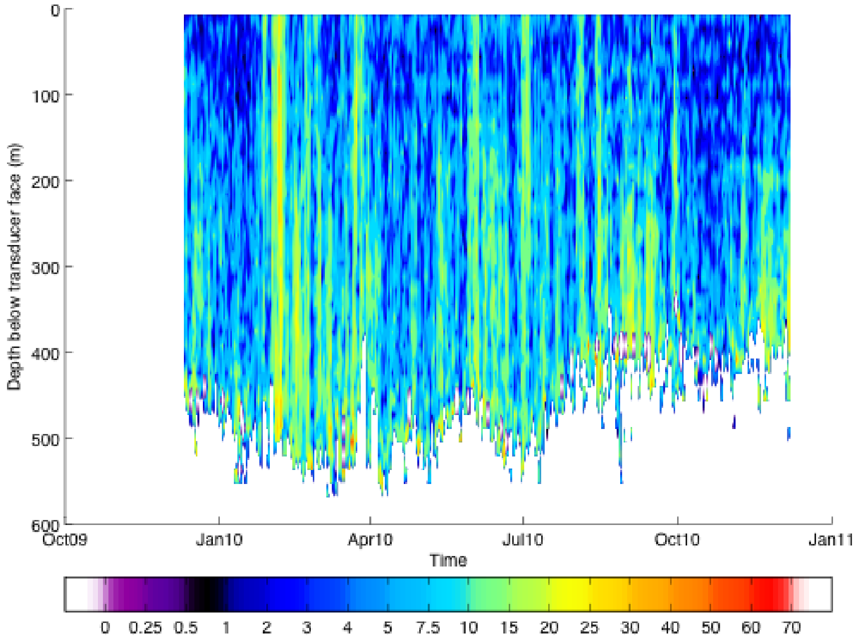


Figure 5.28: Current speed (in cm/s) from the Long Ranger ADCP on the C mooring.

5.2.4. McLane Moored Profilers

The M mooring was equipped with two McLane Moored Profilers, initially positioned 1656 and 2675 m down the mooring wire. These instruments were intended to profile up and down the mooring wire between 2778 and 3757 dbar and between 1770 and 2712 dbar. The interval between sampling bursts was 25 days, with a total of 46 profiles per burst. During these sampling periods, the instrument was programmed to record temperature, pressure, conductivity and current speed/direction continually.

Unfortunately, both MMPs failed to profile at all for the entire year, becoming stuck at ~1670 dbar and 2700 dbar respectively. In the case of the shallower instrument (12305-01), the instrument turned on twice for burst sampling but failed to profile at all. Temperature, conductivity and current meter measurements were recorded during the two bursts (on 22nd December 2009 and 13th January 2010), but no subsequent sampling was done (Figure 5.29).

For the deeper instrument (11794-03), 15 burst samples were obtained with temperature, conductivity, pressure and current meter measurements. However, the instrument did not profile (Figure 5.30).

In both cases, investigatory work was carried out to determine the cause of the failure. In the case of the deeper MMP, the phrase “Backtrack performed, possible obstruction” occurred repeatedly in the each engineering file. For the shallower MMP, much of the engineering file appeared corrupted, with large apparent time jumps between many of the entries.

To attempt to understand the problems, we entered into email communication with Tim Shanahan at McLane. He diagnosed from the engineering files that no power was getting to the circuit in either of the instruments. Unfortunately, he was not able to suggest why this should occur. We deployed two different MMPs in the hope that the problems might be resolved on the redeployment.

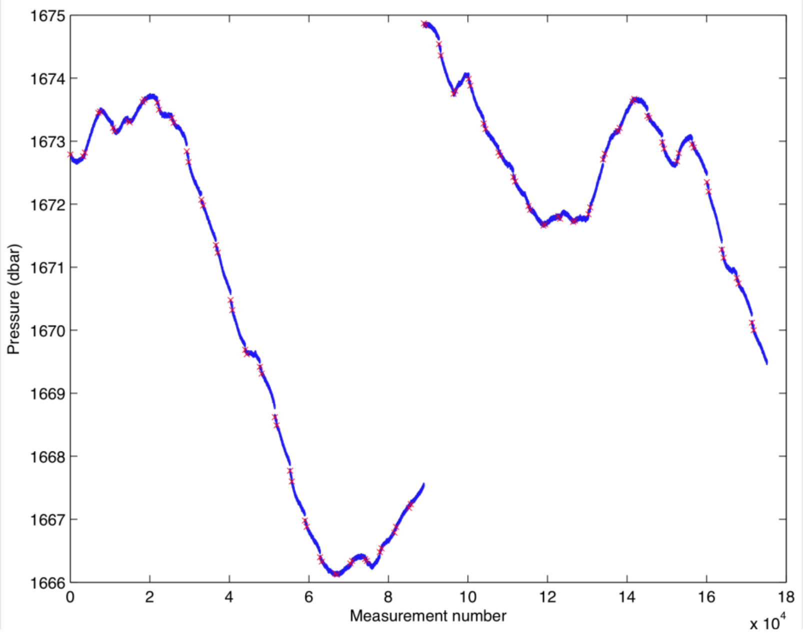


Figure 5.29: Pressure measurements for the two measurement cycles of MMP 12305-01. The instrument failed to profile.

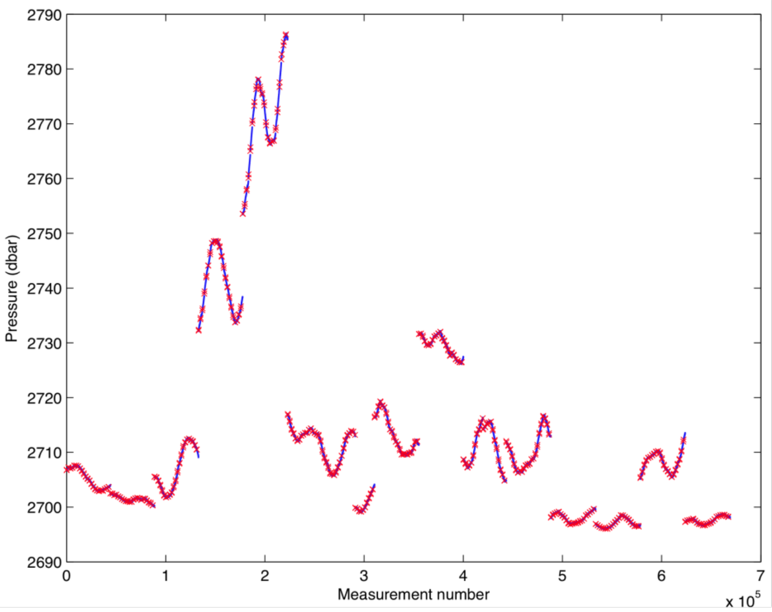


Figure 5.30: Pressure measurements for the MMP 11794-03. The instrument failed to profile.

5.3. Microcat Calibration

Prior to servicing and redeploying the SMPs for the second year, most of the instruments were calibrated by strapping the instruments to the CTD frame and collecting data at a number of extended bottle stops. In each case, the sampling rate on the SMPs was set to 30 s, and 6 six-minute stops were used. Extended bottle stops are required as the sensors on the SMP CTD have a much slower response rate than the CTD on the frame, so requires several minutes to come into equilibrium with the ambient water. Details of the SMPs dipped are given in Table 5.8 along with the file names. Time constraints on the cruise prevented analysis of these data straight away, so the instruments dipped and filenames are given below for post-cruise analysis.

Instrument Serial Number	CTD cast number where dipped	Downloaded data file	Capture file
7304	6	SBE37SM-RS232_03707304_2010_12_09_dip.xml	7304_dip.cap
7305	6	SBE37SM-RS232_03707305_2010_12_09_dip.xml	7305_dip.cap
7306	6	SBE37SM-RS232_03707306_2010_12_09_dip.xml	7306_dip.cap
7307	6	SBE37SM-RS232_03707307_2010_12_09_dip.xml	7307_dip.cap
7309	6	SBE37SM-RS232_03707309_2010_12_09_dip.xml	7309_dip.cap
7310	6	SBE37SM-RS232_03707310_2010_12_09_dip.xml	7310_dip.cap
7311	7*	SBE37SM-RS232_03707311_2010_12_09_dip.xml	7311_dip.cap
7312	7*	SBE37SM-RS232_03707312_2010_12_09_dip.xml	7312_dip.cap
7313	7*	SBE37SM-RS232_03707313_2010_12_09_dip.xml	7313_dip.cap
7314	7*	SBE37SM-RS232_03707314_2010_12_09_dip.xml	7314_dip.cap

7315	7*	SBE37SM-RS232_03707315_2010_12_09_dip.xml	7315_dip.cap
7316	7*	SBE37SM-RS232_03707316_2010_12_09_dip.xml	7316_dip.cap
7292	8	SBE37SM-RS232_03707292_2010_12_09_dip.xml	7292_dip.cap
7293	8	SBE37SM-RS232_03707293_2010_12_09_dip.xml	7293_dip.cap
7294	8	SBE37SM-RS232_03707294_2010_12_09_dip.xml	7294_dip.cap
7295	8	SBE37SM-RS232_03707295_2010_12_09_dip.xml	7295_dip.cap
7296	8	SBE37SM-RS232_03707296_2010_12_09_dip.xml	7296_dip.cap
7297	8	SBE37SM-RS232_03707297_2010_12_09_dip.xml	7297_dip.cap
7288	10	SBE37SM-RS232_03707288_2010_12_10_dip.xml	7288_dip.cap
7301	10	SBE37SM-RS232_03707301_2010_12_10_dip.xml	7301_dip.cap
7303	10	SBE37SM-RS232_03707303_2010_12_10_dip.xml	7303_dip.cap
7291	10	SBE37SM-RS232_03707291_2010_12_10_dip.xml	7291_dip.cap
7290	10	SBE37SM-RS232_03707290_2010_12_10_dip.xml	7290_dip.cap
7298	11	SBE37SM-RS232_03707298_2010_12_20_dip.xml	7298_dip.cap
7299	11	SBE37SM-RS232_03707299_2010_12_20_dip.xml	7299_dip.cap

Table 5.8: Record of dipped Microcats for calibration. Note that the SMPs marked with an asterisk only had three extended bottle stops as the cast had to be terminated early due to an early recovery of the VMP. Note that SMPs 7289, 7300, 7302 and 7308 were not dipped.

5.4. Mooring Redeployment

Following mooring recovery, the technical team, led by Paul Provost, serviced the instruments. As part of the DIMES science brief, a short-term mooring was established in a location close to the recovered C mooring, known hereafter as the SAMS mooring. After the recovery of this instrument, the full mooring redeployment activities started. These operations commenced on 18th December 2010 and were completed on 20th December 2010 and were led by Paul Provost with help from NMF technicians. As in 2009, the moorings were deployed using a double barrel winch in a 'top-first, anchor-last' fashion, allowing the buoyancy to stream away from the vessel during deployment. Ship speed varied during deployment but was generally close to 1 knot.

5.4.1. SAMS Mooring

Mooring operations commenced at 1505 on 8th December 2010 at 56.0167°S, 57.8095°W, with the anchor released at 1512 at 56.0167°S, 57.8095°W. The mooring was recovered at 1608 on 18th December 2010 at 56.0219°S, 57.8256°W. No triangulation was done on this mooring. Comprising a thermistor chain and Workhorse Sentinel ADCP, the data were later downloaded but not further analysed during the cruise.

5.4.2. C Mooring

The C Mooring (Figure 5.31) was redeployed on 18th December 2010, with the same nominal position of 56.01°S, 57.83°W. Mooring operations commenced at 1725, at 56.0850°S, 57.7810°W. The instrument deployment times are given in Table 5.9. The mooring comprises 12 Microcat/current meter pairs along with a downward-looking Long Ranger ADCP.

After attachment of the instruments to the mooring, the mooring was towed to a position approximately 456 m past the intended position where the anchor was released. This allowed the mooring to fall back during release and descent.

Instrument and Equipment	Serial Number	Time (UTC) Overside	Latitude Overside (°S)	Longitude Overside (°W)
Xenon Flash	W10-029	1726	56.0851	57.7812
Argos Sercel Beacon	016-112	1726	56.0851	57.7812
Nortek	6178	1730	56.0839	57.7821
SBE37 SMP	7304	1730	56.0839	57.7821

Nortek	6181	1735	56.0831	57.7817
SBE37 SMP	7305	1735	56.0831	57.7817
Nortek	6182	1741	56.0817	57.7810
SBE37 SMP	7306	1741	56.0817	57.7810
Nortek	6203	1746	56.0804	57.7799
SBE37 SMP	7307	1746	56.0804	57.7799
Nortek	6212	1811	56.0750	57.7840
SBE37 SMP	7309	1811	56.0750	57.7840
Nortek	6213	1818	56.0731	57.7851
SBE37 SMP	7310	1818	56.0731	57.7851
Nortek	6224	1834	56.0690	57.7879
SBE37 SMP	7311	1834	56.0690	57.7879
Nortek	6225	1839	56.0677	57.7888
SBE37 SMP	7312	1839	56.0677	57.7888
Nortek	6242	1845	56.0661	57.7898
SBE37 SMP	7313	1845	56.0661	57.7898
Nortek	6273	1851	56.0646	57.7908
SBE37 SMP	7314	1851	56.0646	57.7951
Long Ranger ADCP	3301	1911	56.0580	57.7951
Nortek	6275	1925	56.0580	57.7982
SBE37 SMP	7315	1925	56.0533	57.7982
Nortek	6276	1935	56.0499	57.8005
SBE37 SMP	7316	1935	56.0499	57.8005
IXSEA	1134 & 1135	1945	56.0466	57.8027
Anchor (2200 kg dry weight)		2110	56.0088	57.8296

Table 5.9: Deployment times and positions for instruments on the C Mooring.

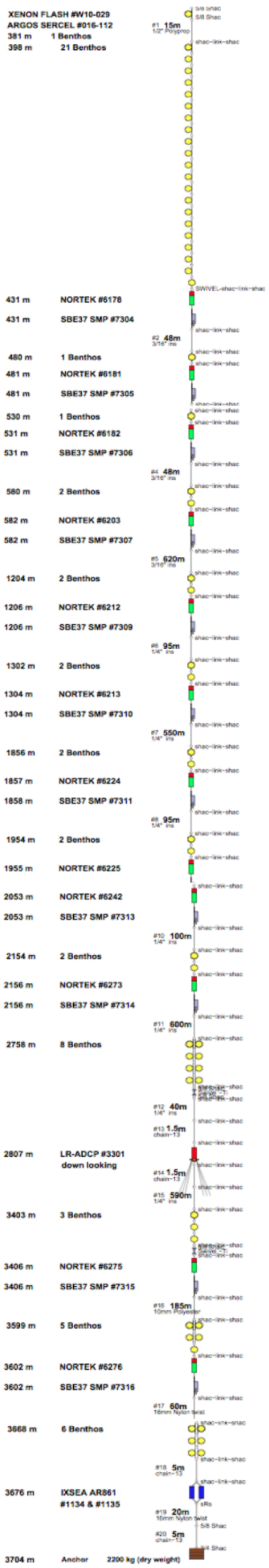


Figure 5.31: Mooring diagram of the C Mooring.

An estimated final location of 56.0114°S, 57.8286°W was determined via triangulation from seven independent ranging locations. The fallback on the mooring was 296 m, making it 232 m from the target position (Figure 5.32).

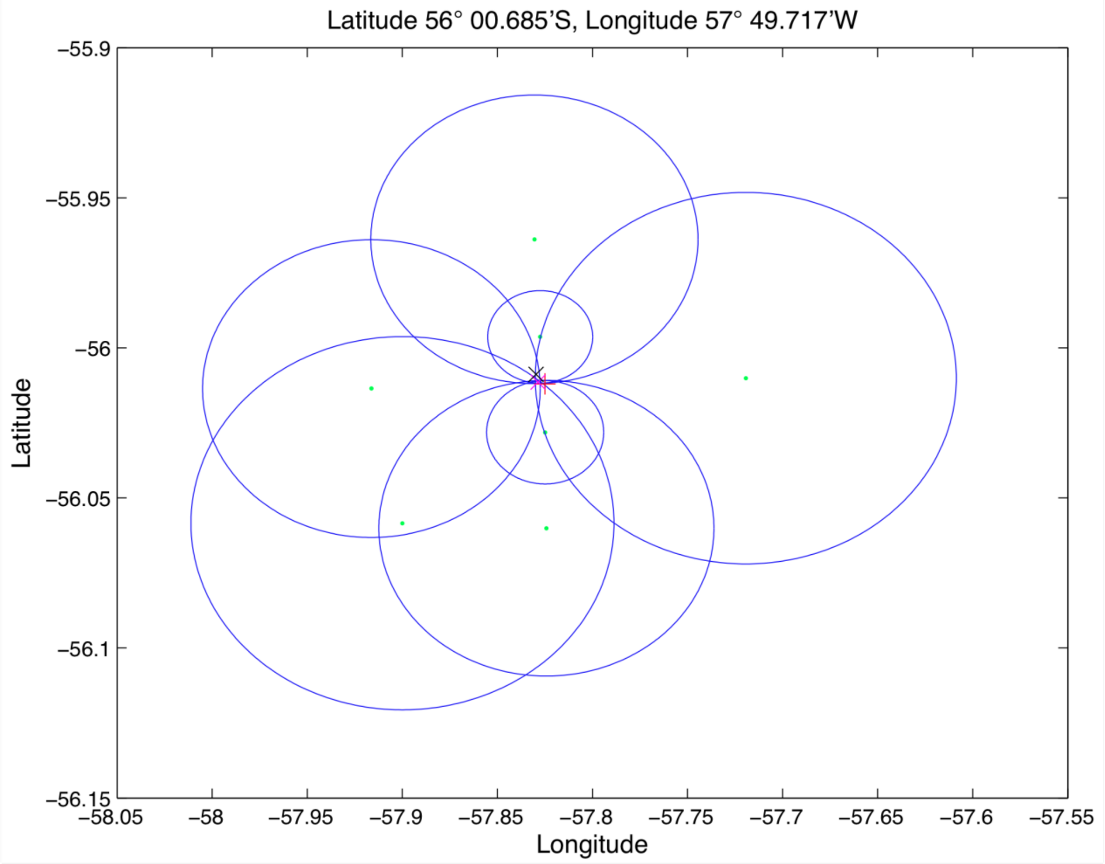


Figure 5.32: Triangulation of the C mooring. The red symbol represents the nominal position, the magenta cross the most likely actual position and the black cross the anchor release position (from Table 5.9).

5.4.3. NW Mooring

The NW Mooring (Figure 5.34) was redeployed on 19th December 2010, with the unaltered nominal position of 55.964°S, 57.910°W. Mooring operations commenced at 1130 UTC, with the location being 56.0098°S, 57.8838°W. The instrument deployment times are given in Table 5.10. The mooring comprises 5 Microcat/current meter pairs.

After attachment of the instruments to the mooring, the mooring was towed to a position approximately 408 m past the intended position where the anchor was released. This allowed the mooring to fall back during release and descent.

An estimated final location of 55.9834°S, 57.9133°W was determined via triangulation from three independent ranging locations (Figure 5.33). Unfortunately, one of the ranges was clearly in error, so the final selection of most likely position was made with reference to the target position and the two other fixes. The fallback on the mooring was 235 m, making it 213 m from the target position.

Instrument and Equipment	Serial Number	Time (UTC) Overside	Latitude Overside (°S)	Longitude Overside (°W)
Benthos		1131	56.0097	57.8839
Seaguard	109	1135	56.0087	57.8846
SBE37 SMP	7288	1135	56.0087	57.8846
Seaguard	110	1139	56.0076	57.8852
SBE37 SMP	7289	1139	56.0076	57.8852
Nortek	1430	1202	56.0010	57.8897
SBE37 SMP	7308	1202	56.0010	57.8897
Seaguard	111	1221	55.9948	57.8939
SBE37 SMP	7290	1221	55.9948	57.8939
Seaguard	112	1245	55.9845	57.9008
SBE37 SMP	7291	1245	55.9845	57.9008
Ixsea	1140	1303	55.9761	57.9065
Anchor (1970 kg dry Weight)		1332	55.9615	57.9148

Table 5.10: Deployment times and positions for instruments on the NW Mooring,

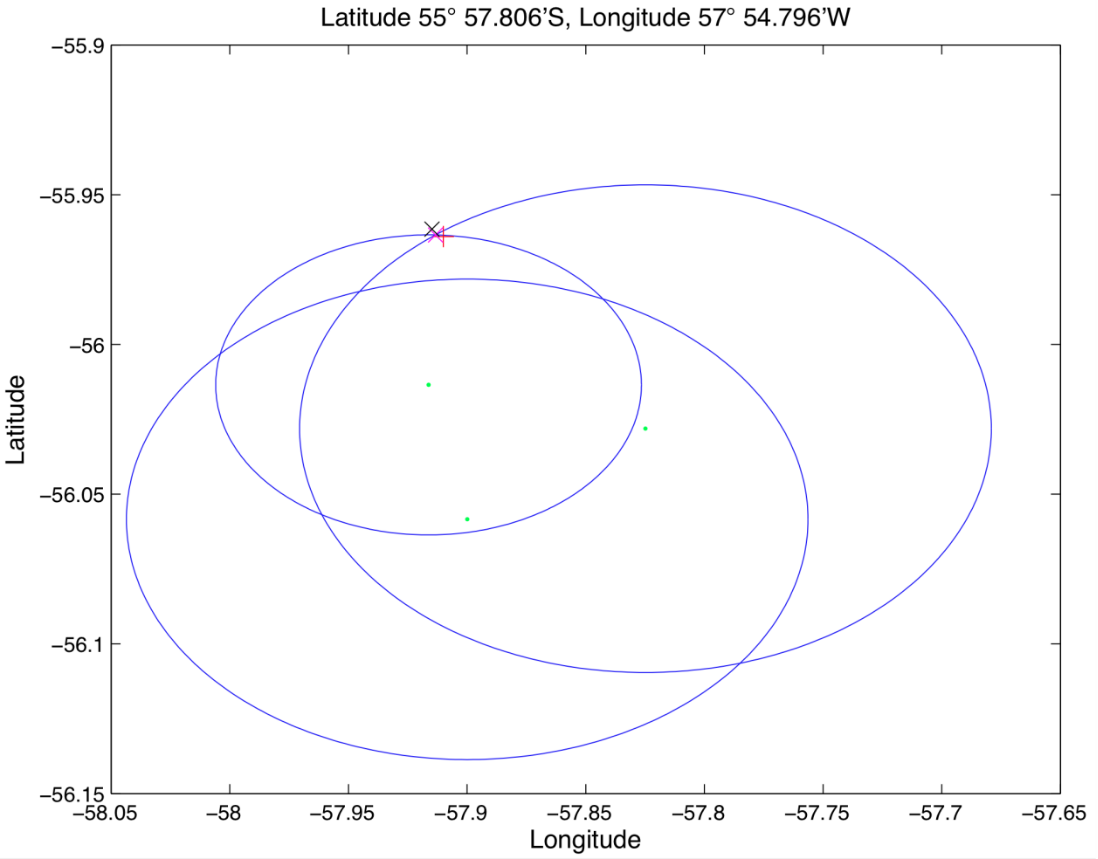


Figure 5.33: Triangulation of the NW mooring. The red symbol represents the nominal position, the magenta cross the most likely actual position and the black cross the anchor release position (from Table 5.10).

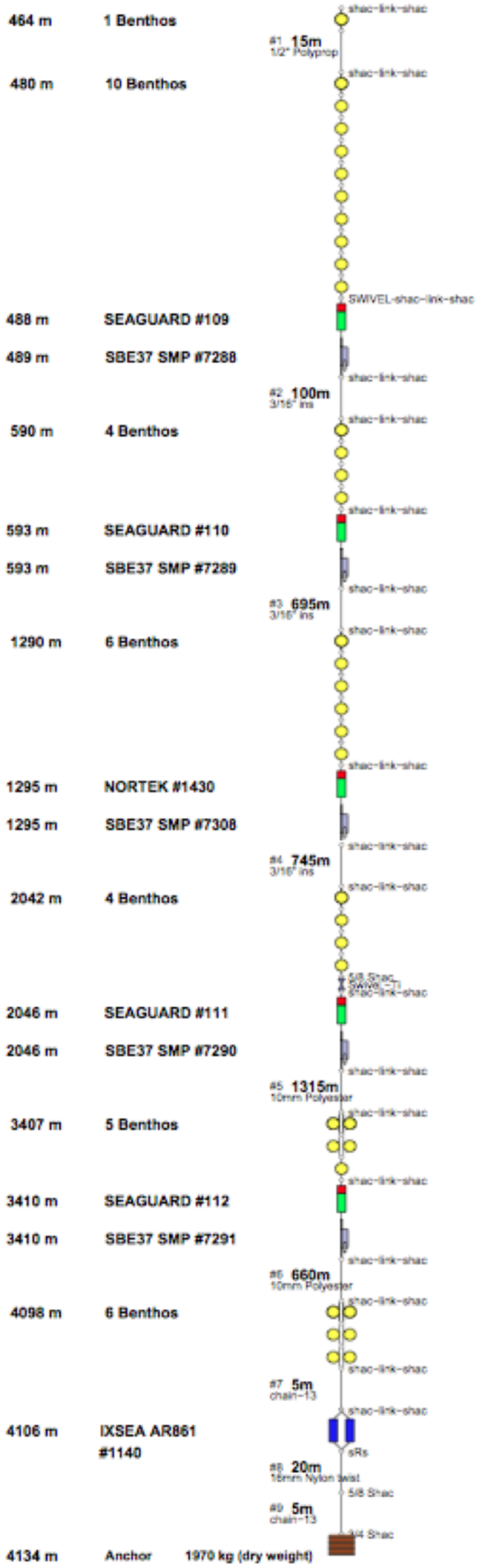


Figure 5.34: Mooring diagram of the NW Mooring.

5.4.4. M Mooring

The M Mooring (Figure 5.35) was redeployed on 19th December 2010, with the same nominal position of 56.022°S, 57.787°W. Mooring operations commenced at 1545 UTC, with the location being 56.0427°S, 57.7543°W. The instrument deployment times are given in Table 5.11. The mooring comprises 2 Microcat/current meter pairs and 2 McLane Moored profilers programmed to profile between 2778 and 3757 dbar and 1770 and 2712 dbar respectively. The MMPs are set to perform 46 burst samples over 2 days, every 25 days. The lower MMP is equipped with an SBE8 thermistor provided by the Scottish Association for Marine Science. The mooring also included a RAFOS sound source at 1050 m.

After attachment of the instruments to the mooring, the mooring was towed to a position approximately 223 m past the intended position where the anchor was released. This was intended to allow the mooring to fall back during release and descent.

An estimated final location of 56.0219°S, 57.7832°W was determined via triangulation from seven independent ranging locations. The fallback on the mooring was 309 m, making it 225 m from the target position (Figure 5.36).

Instrument and Equipment	Serial Number	Time (UTC) Overside	Latitude Overside (°S)	Longitude Overside (°W)
Benthos		1542	56.0427	57.7543
RAFOS sound source		1557	56.0405	57.7574
Nortek	8059	1612	56.0383	57.7606
SBE37 SMP	8075	1612	56.0383	57.7606
MMP	11794-02	1623	56.0369	57.7626
Nortek	8080	1650	56.0314	57.7705
SBE37 SMP	8076	1650	56.0314	57.7705
MMP with SBE8 (SAMS)	11672-01	1702	56.0295	57.7733
Ixsea	1137 & 1138	1719	56.0276	57.7760
Anchor (2320 kg dry Weight)		1757	56.0200	57.7868

Table 5.11: Deployment times and positions for instruments on the M mooring.

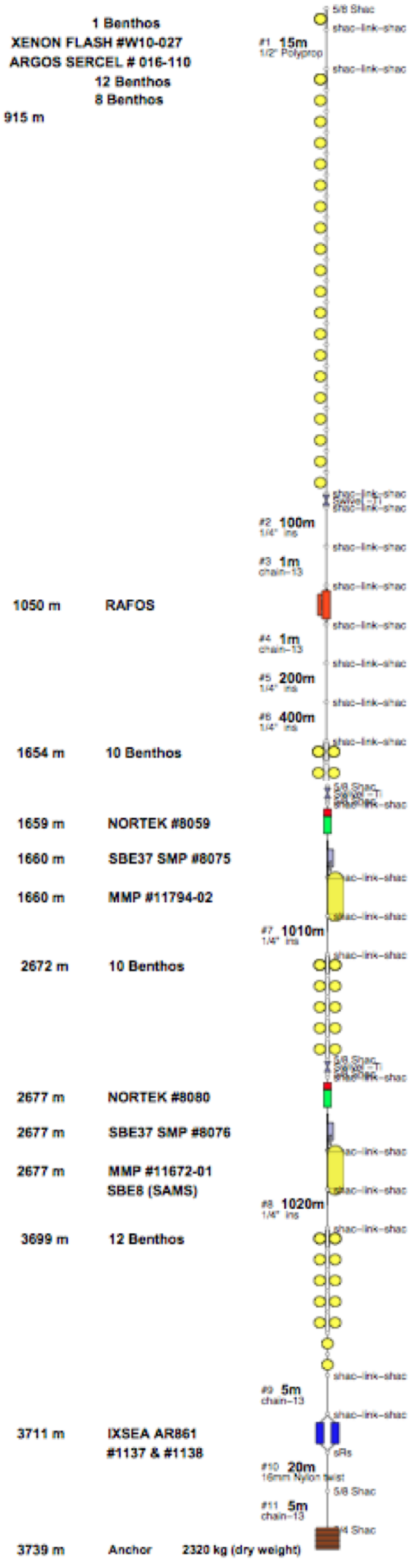


Figure 5.35: Mooring diagram of the M Mooring.

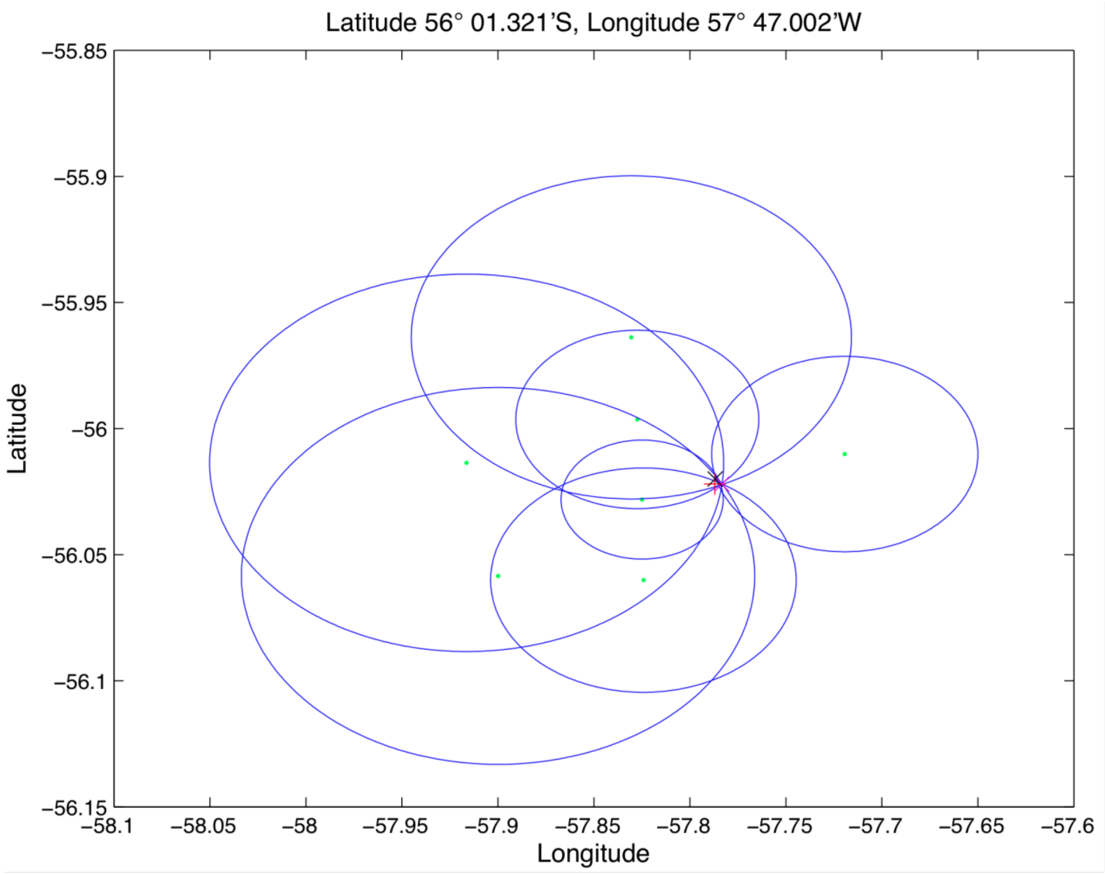


Figure 5.36: Triangulation of the M mooring. The red symbol represents the nominal position, the magenta cross the most likely actual position and the black cross the anchor release position (from Table 5.11).

5.4.5. SW Mooring

The SW Mooring (Figure 5.38) was redeployed on 19th December 2010, with the same nominal position of 56.06°S, 57.91°W. Mooring operations commenced at 2126 UTC, with the location being 56.0683°S, 57.8587°W. The instrument deployment times are given in Table 5.12. The mooring comprised 5 Microcat/current meter pairs.

After attachment of the instruments to the mooring, the mooring was towed to a position approximately 293 m past the intended position where the anchor was released. This allowed the mooring to fall back during release and descent.

An estimated final location of 56.0614°S, 57.9128°W was determined via triangulation from four independent ranging locations. The fallback on the mooring was 221 m, making it 228 m from the target position (Figure 5.37).

Instrument and Equipment	Serial Number	Time (UTC) Overside	Latitude Overside	Longitude Overside
Benthos		2128	56.0682	57.8591
Seaguard	123	2128	56.0682	57.8591
SBE37 SMP	7300	2128	56.0682	57.8591
Seaguard	124	2135	56.0677	57.8621
SBE37 SMP	7301	2135	56.0677	57.8621
Seaguard	069	2153	56.0659	57.8744
SBE37 SMP	7302	2153	56.0659	57.8744
Nortek	1415	2208	56.0643	57.8848
SBE37 SMP	8079	2208	56.0643	57.8848
Seaguard	127	2231	56.0619	57.9005
SBE37 SMP	7303	2231	56.0619	57.9005
Ixsea	1142	2240	56.0610	57.9062
Anchor		2255	56.0597	57.9147

Table 5.12: Deployment times and positions for instruments on the SW mooring.

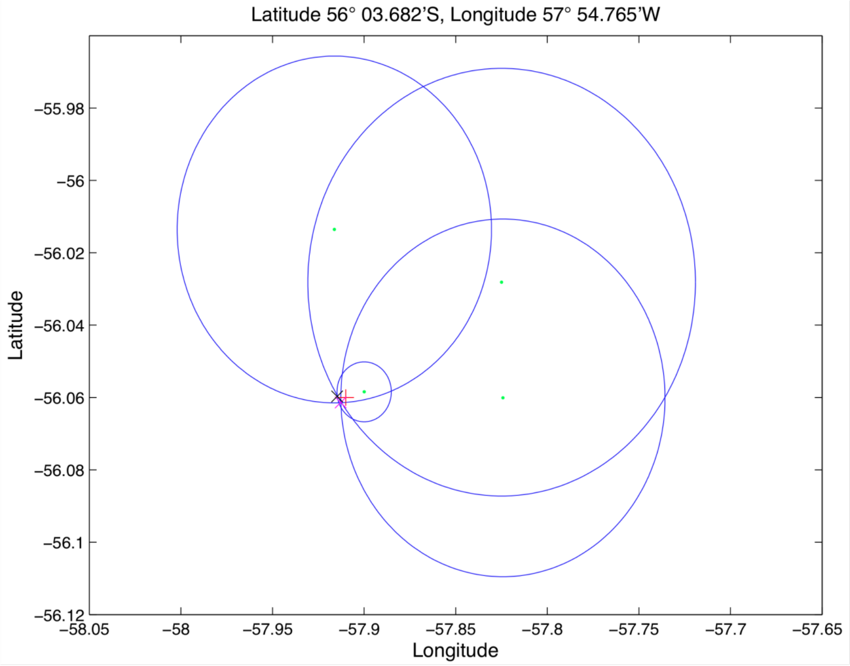


Figure 5.37: Triangulation of the SW mooring. The red symbol represents the nominal position, the magenta cross the most likely actual position and the black cross the anchor release position (from Table 5.12).

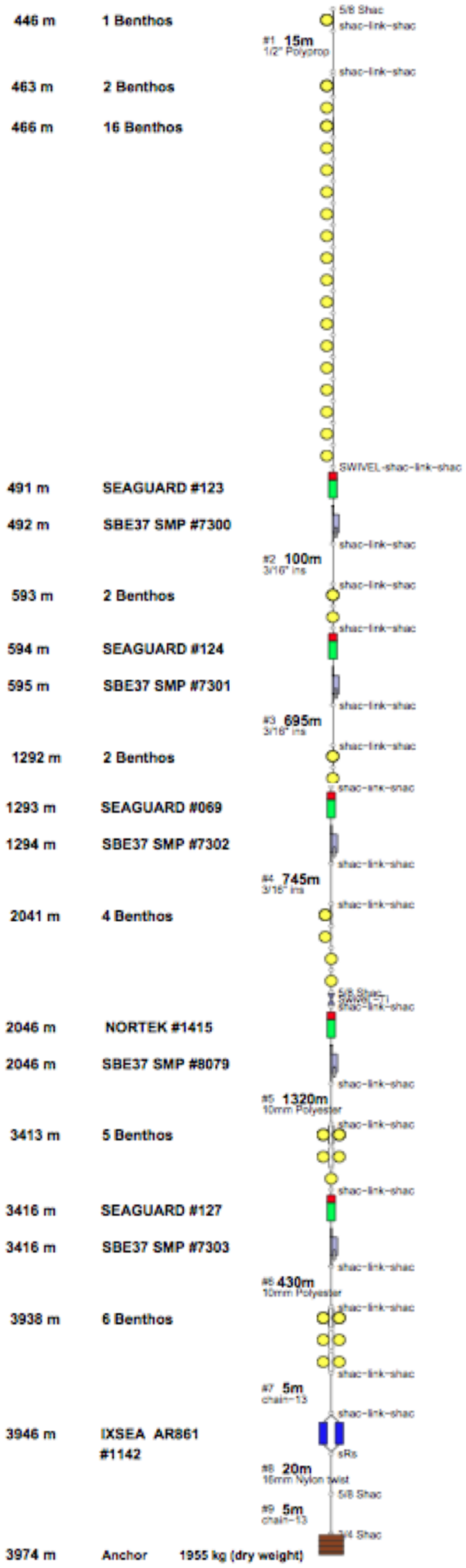


Figure 5.38: Mooring diagram of the SW Mooring.

5.4.6. SE Mooring

The SE Mooring (Figure 5.39) was redeployed on 20th December 2010, with the same nominal position of 56.006°S, 57.74°W. Mooring operations commenced at 1400 UTC, with the location being 56.0718°S, 57.6859°W. The instrument deployment times are given in Table 5.13. The mooring comprised 5 Microcat/current meter pairs.

After attachment of the instruments to the mooring, the mooring was towed to a position approximately 878 m past the intended position where the anchor was released. This allowed the mooring to fall back during release and descent.

An estimated final location of 56.0557°S, 57.7504°W was determined via triangulation from three independent ranging locations. The fallback on the mooring was 96 m, making it 808 m from the target position (Figure 5.40).

Instrument and Equipment	Serial Number	Time (UTC) Overside	Latitude Overside (°S)	Longitude Overside (°W)
Benthos		1400	56.0718	57.6859
Seaguard	119	1400	56.0718	57.6859
SBE37 SMP	7296	1400	56.0718	57.6859
Seaguard	120	1409	56.0703	57.6917
SBE37 SMP	7297	1409	56.0703	57.6917
Seaguard	121	1425	56.0673	57.7031
SBE37 SMP	7298	1425	56.0673	57.7031
Seaguard	122	1440	56.0643	57.7144
SBE37 SMP	7299	1440	56.0643	57.7144
Nortek	1404	1505	56.0589	57.7340
SBE37 SMP	8078	1505	56.0589	57.7340
Ixsea	1142	1520	56.0567	57.7450
Anchor (1970 kg dry Weight)		1535	56.0558	57.7520

Table 5.13: Deployment times and positions for instruments on the SE mooring.

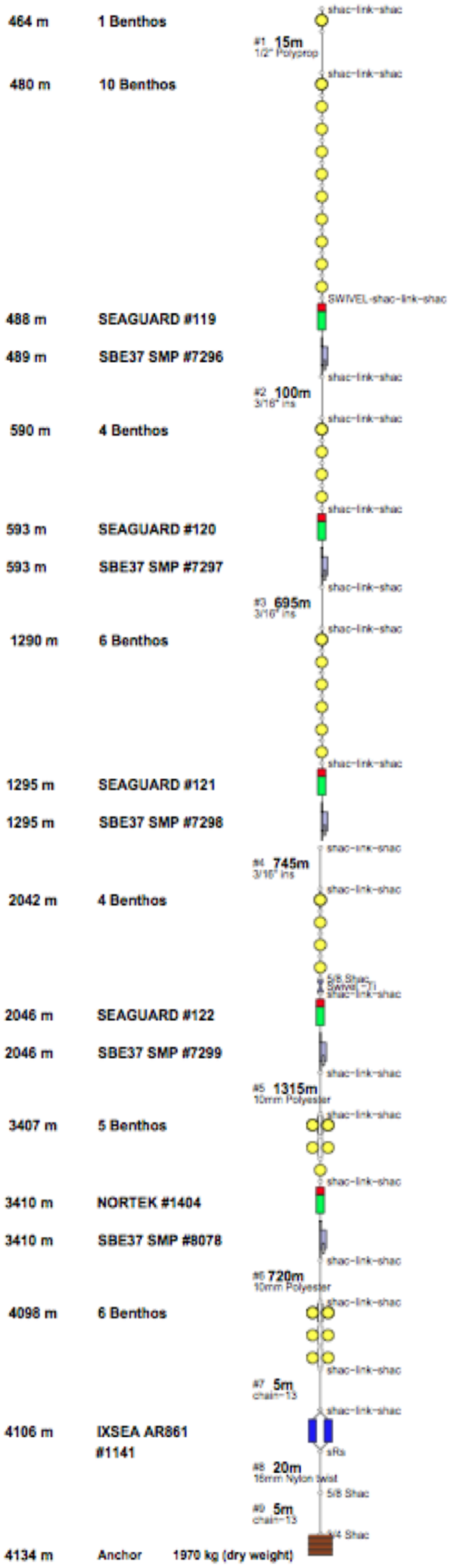


Figure 5.39: Mooring diagram of the SE Mooring.

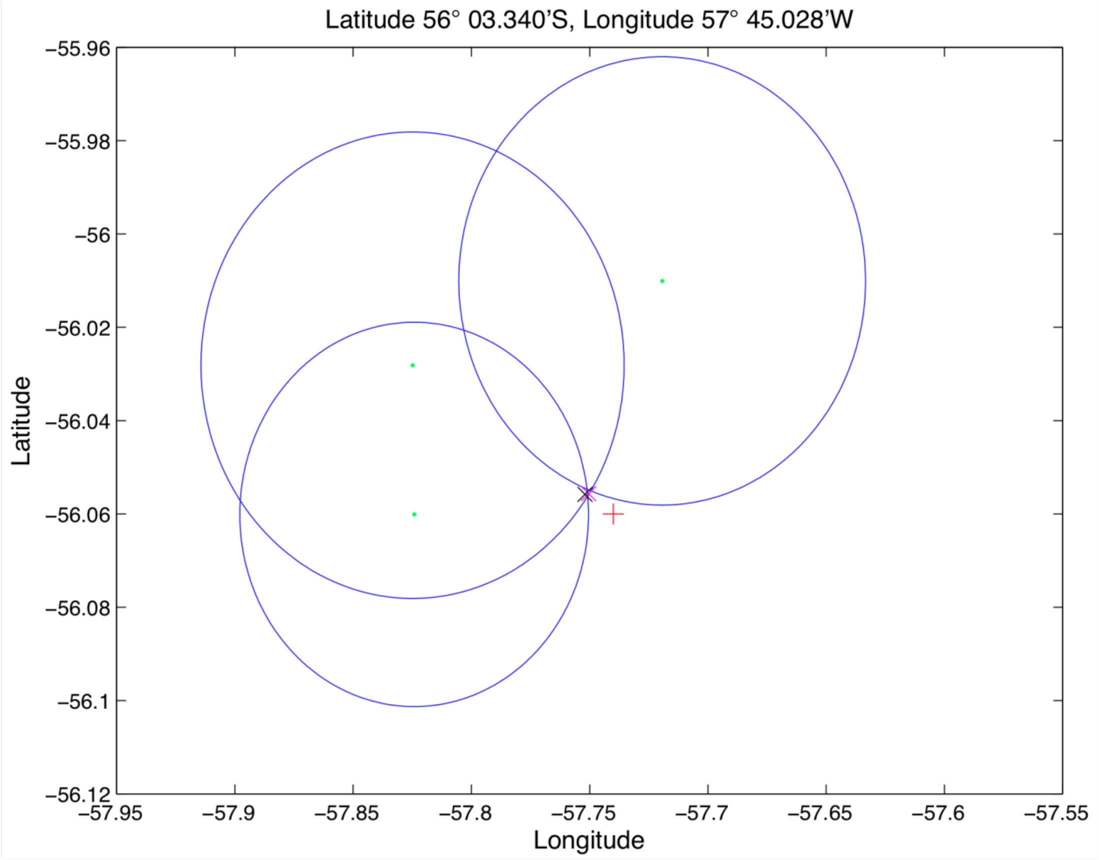


Figure 5.40: Triangulation of the SE mooring. The red symbol represents the nominal position, the magenta cross the most likely actual position and the black cross the anchor release position (from Table 5.13).

5.4.7. NE Mooring

The NE Mooring (Figure 5.42) was redeployed on 20th December 2010, with the same nominal position of 55.964°S, 57.74°W. Mooring operations commenced at 1824 UTC, with the location being 55.9930°S, 57.7090°W. The instrument deployment times are given in Table 5.14. The mooring comprised 5 Microcat/current meter pairs.

After attachment of the instruments to the mooring, the mooring was towed to a position approximately 459 m past the intended position where the anchor was released. This allowed the mooring to fall back during release and descent.

An estimated final location of 56.0220°S, 57.7834°W was determined via triangulation from three independent ranging locations. The fallback on the mooring was 44 m, making it 451 m from the target position (Figure 5.41).

Instrument and Equipment	Serial Number	Time (UTC) Overside	Latitude S Overside	Longitude W Overside
Benthos		1824	55.9930	57.7090
Seaguard	113	1828	55.9924	57.7098
SBE37 SMP	7292	1828	55.9924	57.7098
Seaguard	116	1833	55.9916	57.7107
SBE37 SMP	7293	1833	55.9916	57.7107
Seaguard	118	1849	55.9890	57.7138
SBE37 SMP	7294	1849	55.9890	57.7138
Nortek	5883	1905	55.9864	57.7168
SBE37 SMP	7295	1905	55.9864	57.7168
Nortek	1420	1930	55.9782	57.7265
SBE37 SMP	8077	1930	55.9782	57.7265
Ixsea	861	1945	55.9731	57.7325
Anchor		2015	55.9616	57.7460

Table 5.14: Deployment times and positions for instruments on the NE mooring.

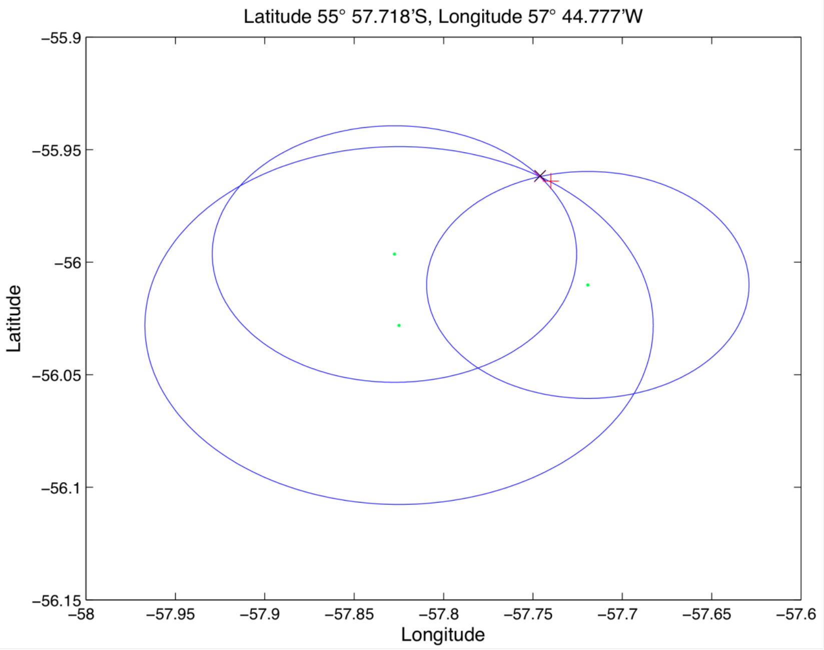


Figure 5.41: Triangulation of the NE mooring. The red symbol represents the nominal position, the magenta cross the most likely actual position and the black cross the anchor release position (from Table 5.14).

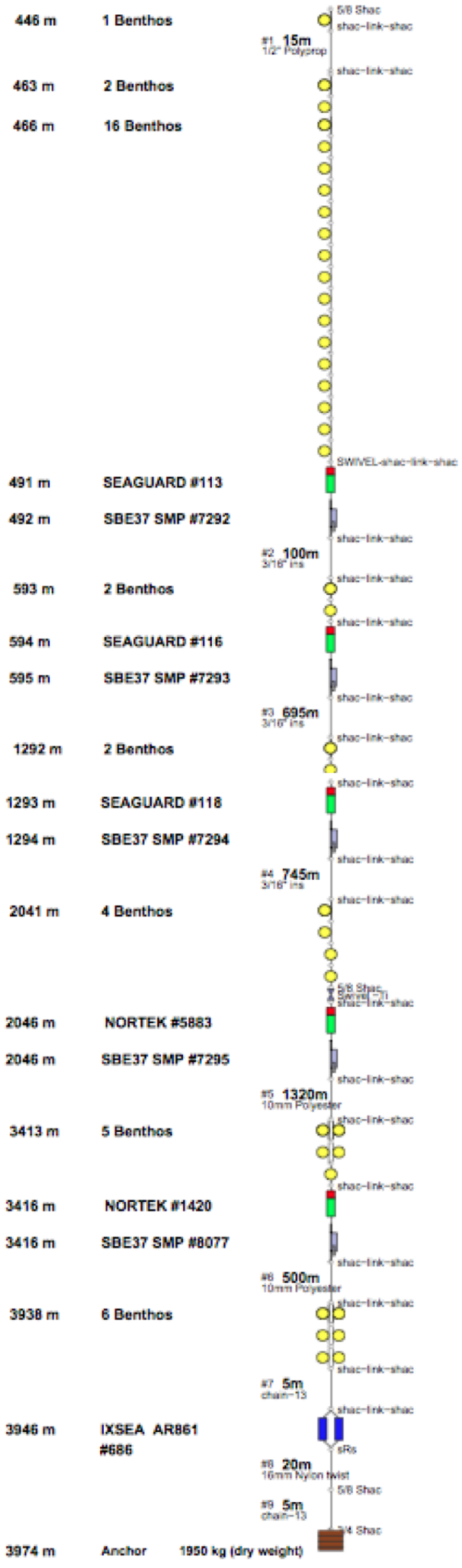


Figure 5.42: Mooring diagram of the NE Mooring.

5.5. Final Comments

Following the severe knockdown event that caused the surface buoyancy on moorings NE and SW to implode in early 2010, modifications were made to the design. Whilst steel spheres rated to 500 dbar were used for the top buoyancy in the first year, the new moorings each have glass spheres rated to 6000 dbar. This should enable the moorings to withstand events such as that at the end of January 2010 without collapsing.

The IMPs recovered in December 2010 but not redeployed will be recalibrated at NOC Southampton after the cruise. The new moorings are scheduled to be recovered by *RRS James Cook* in January 2012.

6. Drifters and Floats

6.1. Drifters

Stephanie White

Drifting buoys provide surface velocity measurements and sea surface temperature data for climate prediction models. The Global Drifter Program is a branch of the National Oceanic and Atmospheric Administration (NOAA). The NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML) coordinates deployment and processes/archives the data. Nineteen drifters were deployed during this cruise (Table 6.1). The surface float houses the alkaline D-cell batteries, a transmitter, a thermistor, and a tether strain sensor to verify the presence of the drogue. The drogue is centred at 15m beneath the surface to measure mixed layer currents in the upper ocean. The drogue is made of nylon cloth in 7 sections, for a total length of 6.44m. Throughout the drogue, rigid rings with spokes support the drogue's cylindrical shape. Each drogue section contains two opposing holes, which are rotated 90 degrees from one section to the next. These holes disrupt the formation of organized lee vortices. The batteries of a deployed drifter last an average of 400 days before ceasing transmission. In addition to position the drifter collects sea surface temperature, which is averaged over a window of about 90 seconds and transmits the data at 401.65 MHz. Each drifter transmitter is assigned a Platform Terminal Transmitter (PTT) code, often referred to as the drifter ID for the Argos tracking satellite system. To track a drifter, view http://www.aoml.noaa.gov/phod/dac/gdp_track.php

Drifter ID #	AOML WMO#	Date (mm/dd/yy)	Time (hh:mm GMT)	Latitude (DDmm.mm S)	Longitude (DDmm.mm W)	Project
36919	33549	12/10/10	15:51	55°50.94	58°10.30	AARDVARK
36314	33689	12/10/10	16:05	55°49.77	58°14.06	AARDVARK
39285	33553	12/10/10	16:15	55°48.92	58°16.67	AARDVARK
39280	33554	12/10/10	16:31	55°47.51	58°20.99	AARDVARK
36284	33658	12/22/10	16:23	56°02.63	58°03.49	AARDVARK
39281	33683	12/22/10	17:40	56°03.46	57°53.63	AARDVARK
39284	33909	12/22/10	19:16	56°04.20	57°44.41	AARDVARK
39288	33534	12/22/10	20:08	56°05.32	57°34.90	AARDVARK
39292	33592	12/22/10	21:00	56°06.11	57°25.36	AARDVARK

36420	33688	12/22/10	21:46	56°07.07	57°15.74	AARDVARK
36907	71637	01/03/11	00:54	63°00.64	78°59.97	DIMES
36916	71639	01/03/11	10:18	62°19.78	78°59.99	DIMES
39273	71642	01/03/11	23:04	60°59.92	79°04.07	DIMES
36911	71646	01/04/11	07:56	60°31.95	78°56.96	DIMES
36971	71647	01/04/11	14:36	59°47.85	78°59.98	DIMES
36906	71648	01/04/11	21:34	59°04.31	79°60.03	DIMES
36965		01/05/11	07:58	58°26.01	78°58.29	DIMES
39263		01/05/11	21:18	57°08.31	79°00.19	DIMES
39259		01/06/11	07:26	56°31.30	79°12.00	DIMES

Table 6.1. JC054 drifter deployments.

6.2. RAFOS floats and sound sources

Stephanie White

6.2.1 RAFOS floats

Sound Fixing and Ranging (RAFOS) floats manufactured by SeaScan are used to track the velocity of the ocean at a particular density over a wide spatial area. The float provides temperature and salinity data plus high-resolution trajectories. The float will listen for and record sound signals from the twelve moored sound sources in the area. Twenty-four shallow level (isopycnal surface 27.21) Iridium RAFOS floats were deployed on this cruise (Table 6.2). Three floats are for the AARDVARK experiment (see Section 6.3) and have a mission of 180 days, the other floats were all deployed on the western most transect line (79°W) and have a mission of 365 days. At the end of the mission the float will drop the ballast weight and rise to the surface to transmit all mission data. The 2m glass tube floats were lowered into the water by crane using a protective launch tube or by hand off the stern. Three of the floats abandoned their missions after going beyond the maximum depth of 2500m four hours after deployment. The data shows that the failures were caused by malfunctioning compressees. Please contact Dr. Kevin Speer (kspeer@fsu.edu) for more information and data access.

Mission configuration for AARDVARK RAFOS floats:-

SCHEDULER TASK TABLE

```
Number of windows to acquire (<1000) = 180
Open window at =  00 00:00:00
Offset  00 00:55:00   GetParam
Offset  00 01:00:00   Listen Rcvr 0 Duration 60
Offset  00 02:05:00   GetCorr from Rcvr 0
Offset  00 02:10:00   End of Window
R0 Sweep Length= 261 (Samples) Corr Sampling period= 30750 (x10 microS)
R1 Sweep Length= -1 (Samples) Corr Sampling period= -1 (x10 microS)
Number of correlations to retain= 6
Press Launch Threshold in dBars= 5
Surface assumed if T > 25000 mDegC and P < 100 dBars
Max_Depth= 2500 dbars
Forced_Start= 1920
```

Mission configuration for DIMES RAFOS floats:-

```
SCHEDULER TASK TABLE
Number of windows to acquire (<1000) = 365
Open window at =  00 00:00:00
Offset  00 00:55:00   GetParam
Offset  00 01:00:00   Listen Rcvr 0 Duration 60
Offset  00 02:05:00   GetCorr from Rcvr 0
Offset  00 02:10:00   End of Window
R0 Sweep Length= 261 (Samples) Corr Sampling period= 30750 (x10 microS)
R1 Sweep Length= -1 (Samples) Corr Sampling period= -1 (x10 microS)
Number of correlations to retain= 6
Press Launch Threshold in dBars= 5
Surface assumed if T > 25000 mDegC and P < 100 dBars
Max_Depth= 2500 dbars
Forced_Start= 1920
```

RAFOS s/n	Date (mm/dd/yy)	Time (hh:mm GMT)	Latitude (DD mm.mm S)	Longitude (DD mm.mm W)	Iridium ID #	
990	12/22/10	20:05	56°05.25	57°34.85	300034013320240	AARDVARK *surfaced
974	12/22/10	20:59	56°06.09	57°25.38	300034013324230	AARDVARK
973	12/22/10	21:45	56°07.06	57°15.77	300034013323250	AARDVARK
995	01/03/11	22:53	60'59.92	79'04.07	300034013322170	DIMES
996	01/03/11	22:56	60'59.92	79'04.07	300034013324130	DIMES
989	01/03/11	22:59	60'59.92	79'04.07	300034013325240	DIMES
978	01/04/11	02:30	60'31.86	78'59.85	300034013324630	DIMES *surfaced
993	01/04/11	02:34	60'31.86	78'59.85	300034013322130	DIMES
994	01/04/11	02:37	60'31.86	78'59.85	300034013320190	DIMES
983	01/04/11	21:20	59'04.31	79'60.03	300034013325640	DIMES
984	01/04/11	21:25	59'04.31	79'60.03	300034013326170	DIMES
977	01/04/11	21:30	59'04.31	79'60.03	300034013326240	DIMES
999	01/05/11	18:32	58'25.70	79'00.00	300034013323630	DIMES
1000	01/05/11	18:37	58'25.70	79'00.00	300034013327180	DIMES
976	01/05/11	18:45	58'25.70	79'00.00	300034013324180	DIMES
975	01/05/11	16:45	57'47.16	79'00.07	300034013322230	DIMES
981	01/05/11	16:28	57'47.16	79'00.07	300034013329630	DIMES
982	01/05/11	16:38	57'47.16	79'00.07	300034013327130	DIMES
985	01/06/11	03:35	56'53.43	79'18.09	300034013322240	DIMES *surfaced
971	01/06/11	03:35	56'53.43	79'18.09	300034013321140	DIMES
972	01/06/11	03:35	56'53.43	79'18.09	300034013323230	DIMES
986	01/06/11	07:31	56'31.30	79'12.00	300034013321240	DIMES

Table 6.2. JC054 RAFOS float deployments

6.2.2 RAFOS Sound Source

A Webb RAFOS sound source, located on the M mooring, was retrieved on December 6, 2010 at 19:00 GMT. The RAFOS moored sound source is designed to provide precisely timed underwater acoustic navigation signals for RAFOS and APEX floats. The source consists of two parts: the resonator pipe and the electronics module that houses both the electronic circuitry and the battery pack. The two are linked via a DSS-2 underwater power cable. The length of the pipe has been trimmed very carefully to be resonant at a frequency of 261Hz. The sound source s/n 56 was interrogated and reset for redeployment in the DIMES grid on December 12, 2010 at 15:57 GMT. The sound source is deployed at 1050m depth on M mooring at 56°01.313 S, 57°46.994 W. The pong transmission of the sound source is at 01:45:00 to 01:46:20 GMT daily.

Mission configuration for RAFOS sound source (s/n 56):-

TASK SCHEDULER TABLE

```
 Number of windows to execute = 9999
 Open window at = 00:00:00...
Offset 0000:01:44:00...Arm waveform nb 2
Offset 0000:01:45:00...Transmit
Offset 0000:01:50:00...End of Window
```

6.3. AARDVARK

Jean-Baptiste Sallée and Stephanie White

6.3.1. Introduction and aim

Ten surface drifters drogued at 15 m have been deployed in targeted locations using satellite altimetry information and a custom-designed deployment configuration based on ideas from dynamical systems research. The main goal of these deployments is to map out unstable manifolds (places where pairs of floats experience a fast exponential separation) and then examining how we can use this information to tell us about mixing, transport and the quantification of diffusivities. Near real-time satellite altimetry maps are downloaded each day and used in a backward finite size Lyapunov exponent calculations, informing us about the approximate position of unstable manifold near the ship track. See sections 6.1 and 6.2 for details of drifters and RAFOS float technologies used in AARDVARK.

6.3.2. Data processing and problems

Drifter ids have been registered by NOAA, which processes their trajectory and temperature and make available the data. RAFOS floats transmit their data at the end of their mission. The data will be processed and calibrated by Nicolas Wienders and Kevin Speer (Florida State University).

One of the three RAFOS floats deployed came back at the surface 4 hours after its deployment. The plot of pressure versus time (blue curve, Figure 6.1) shows a change of slope at around 500m and the float heading down faster than previously. It exceeded the maximum pressure (2500 dbars) and then ascended. This could point to a compressee failure (e.g. loss of the oil or piston seal failure)

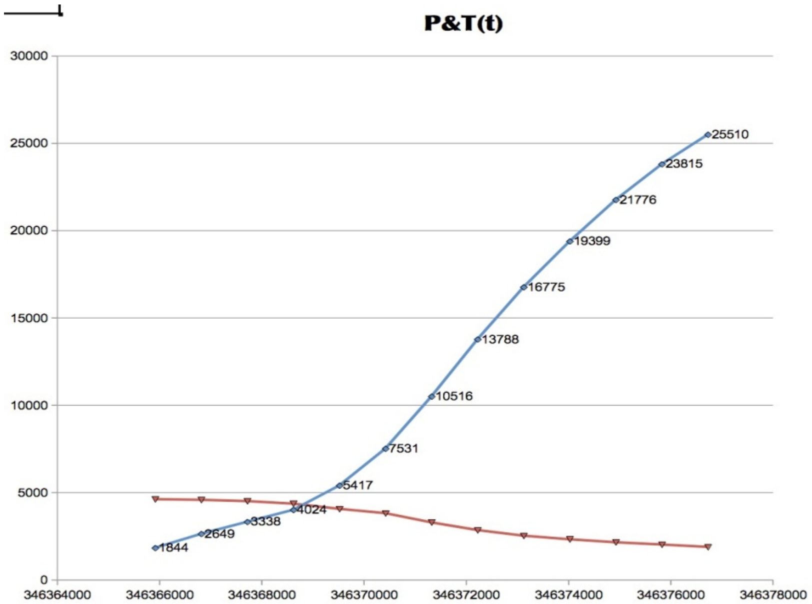


Figure 6.1: Pressure versus time (blue) for the problematic RAFOS float.

6.3.3. Deployment

We targeted a filament centred around 55.8 S, 58.3 W (north west of the DIMES moorings cluster) on the 12th Dec 2010. The first few days of trajectories show clear exponential separations that look promising (Figure 6.2). In a second experiment we released 6 drifters along with three isopycnal RAFOS floats to target a filament centred on the DIMES mooring cluster. The location of this second experiment coincides with the high resolution CTD and microstructure profile survey that we have conducted around the mooring cluster.

Two other experiments involving 6 RAFOS and 6 drifters, and one last experiment with 5 drifters have been postponed to April 2011 to be done aboard *RRS James Clark Ross.*

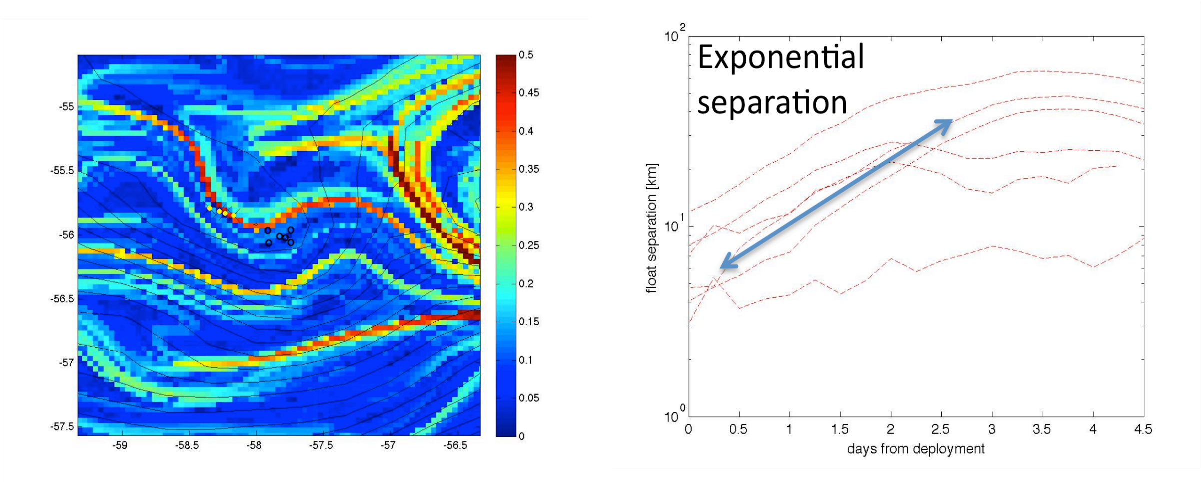


Figure 6.2: Finite Size Lyaponov Exponent map for 12/12/2010, along with deployment position of drifters (yellow dots). Black contours show the near real time sea surface height from AVISO. Black circles are the positions of the DIMES moorings. (Right) Float-pair separations (km) for the first four and half days.

6.3.4. Recommendations

Drifter and float deployments went well and every technical aspect worked as expected, except for the one RAFOS float that failed. The deployment planning and strategy could be improved by better spotting the unstable manifold and hyperbolic point. The unstable manifold localisation can be improved by using near-real time chlorophyll concentration maps and high-resolution sea surface temperature imagery. However, these data are not available when cloud cover is significant, which might be a major constraint in the Southern Ocean. Hyperbolic points are at the intersection of unstable and stable manifold. However stable manifold can only be estimated using a forward time FSLE. A rough estimate of the position of the stable manifold could be calculated by running a forward time FSLE with frozen velocity field from the latest near-real time altimetry field.

6.4. EM-APEX and APEX floats

Byron Kilbourne and Stephanie White

6.4.1. EM-APEX floats

6.4.1.1. Background and operations

Two EM-APEX (Electro-Magnetic Autonomous Profiling Explorer) floats were deployed during DIMES UK2. The EM-APEX float is a modified version of the standard APEX float manufactured by Webb Research Company (WRC). The floats are modified to measure water velocities while vertically profiling using electric currents generated by motional induction of seawater. These floats differ externally from the original APEX model (see section 6.4.2) by the addition of electrodes and vanes. Five electrodes are mounted externally. Four electrodes are mounted orthogonal to the vertical axis of the float and to each other. The fifth electrode serves as a reference. Vanes rotate the float as it moves vertically through the water column. These floats contain an internal buoyancy control system for profiling and parking at depths of up to 2000 m. The floats are equipped with a Sea-Bird SBE 41 CTD, magnetic compass, tilt sensor, GPS, and an Iridium satellite modem for communication with shore. The EM-APEX floats weigh 28 kg and are cylindrical in shape with a 16.5 cm diameter and 135 cm height without antenna. The expected operational endurance of the float is 150 profiles from the surface to parking depth and back.

These floats are set to profile continuously from the surface to 1500m depth and then to the surface. This sampling program gives a separation in time of 7 hours and 5 minutes between each successive up and down profile. The local inertial period is 14 hours and 16 minutes, thus one half the inertial period 7 hours and 8 minutes. Sampling at one half the inertial period allows for the separation of the inertial velocity signal from the background, low frequency flow field.

Both EM-APEX floats were deployed together from the port aft quarter of the ship. As shipped, the floats do not include attachment points for deployment. Previous DIMES EM-APEX floats were equipped with a deployment point, usually a small loop of monofilament line, while on shore. A new technique was developed for launching floats without attachment points. The floats were secured to a quick release hook with a 1.5 m length of thin (8mm) line. The line was tied off to the shackle at the base of the quick release, wound around the float base once then made into a loop and locked into the release. The float was hoisted over the side using the port quarter crane and lowered until the antenna and CTD were submerged. The float was then released inverted where it quickly righted before sinking. This method of deployment is advantageous for two reasons. The float was not equipped with an external mount point and thus did not need to be re-ballasted. The process of ballasting the float requires disassembling the float to add or remove weights, reassembly of the float requires special tools takes time. Most research ships have a quick release available which reduces the amount of specialised equipment require to deploy the float. Figure 6.3 shows the technique used to deploy the float.

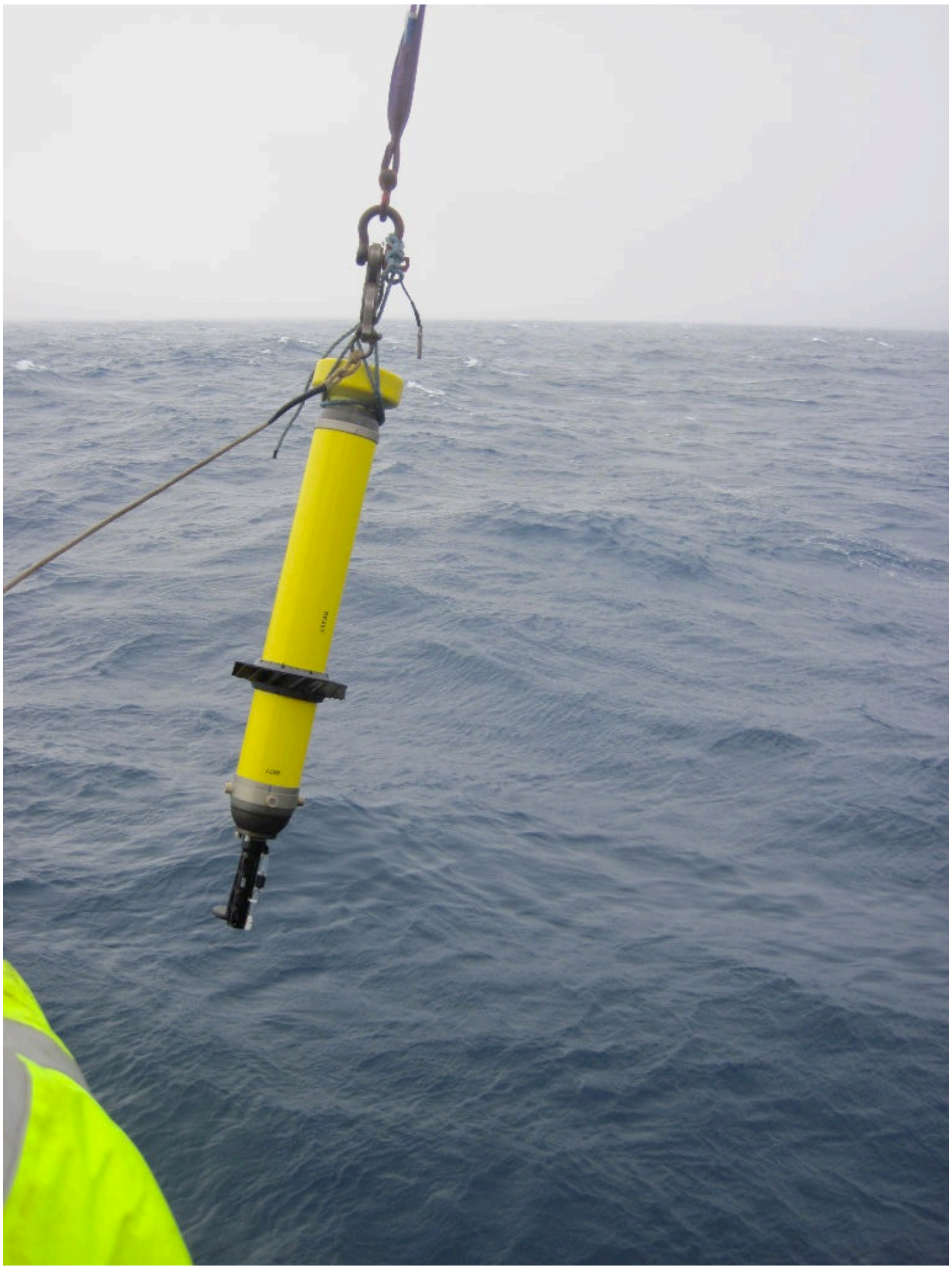


Figure 6.3. ***Float deployment on JC054.***

Float numbers 4976 and 4977 were deployed at 1218 GMT on 31 December 2010. The deployment location was 57° 34’ 14.9” S 68° 11’ 1.4” W. The floats are programmed to start profiling when they are deployed via a pressure switch. Both floats sank directly after deployment and began measuring within the upper 50m.

At the time of this report the floats are operating normally and are expected to continue to operate up to the endurance of the instrument, about 150 round trip profiles or 50 days under the current schedule. Float 4976 did not get good GPS positions at the surface for the fourth through sixth profile pairs, but seems to be operating normally now.

6.4.1.2. Data

EM-APEX floats provide vertical profiles of temperature, salinity, and pressure from the Sea-Bird SBE41 CTD with 2 m vertical resolution and horizontal velocity with 3 m resolution.

The floats transmit the velocity, CTD, and other data by Iridium connection to servers at the University of Washington Applied Physics Laboratory (APL). The data is available to approved users from a web site maintained by John Dunlap (dunlap@apl.washington.edu). EM current meter data are processed into horizontal velocities by automated servers at APL. Initial velocities are in coordinates relative to the local magnetic field and do not include the time invariant mean flow. The data available from APL includes the necessary data to make these corrections but do not include the absolute velocities.

The EM-APEX floats were deployed following a shipboard CTD cast including a lowered acoustic Doppler current profiler (LADCP). Comparison of the shipboard data to the float was made to determine the accuracy of the float's measurements. Figures 6.4 and 6.5 show these comparisons for the CTD and EM current meters. The CTD comparison shows that the EM-APEX CTDs are working properly and agree to the level of instrument noise with the shipboard CTD. The velocity comparison shows the LADCP, shipboard ADCP, and both floats. The floats were deployed after the CTD cast was finished. The time difference between the LADCP upcast and the first float measurement is approximately one hour. The ship ADCP velocities plotted are an average of one hour of two minute ensembles covering the end of the CTD cast through the float deployment. The float velocities are validated by time integral to match the surface GPS positions. The disagreement between the ADCP velocities and float velocities can be attributed to time varying currents and does not indicate that the float current meters are inaccurate.

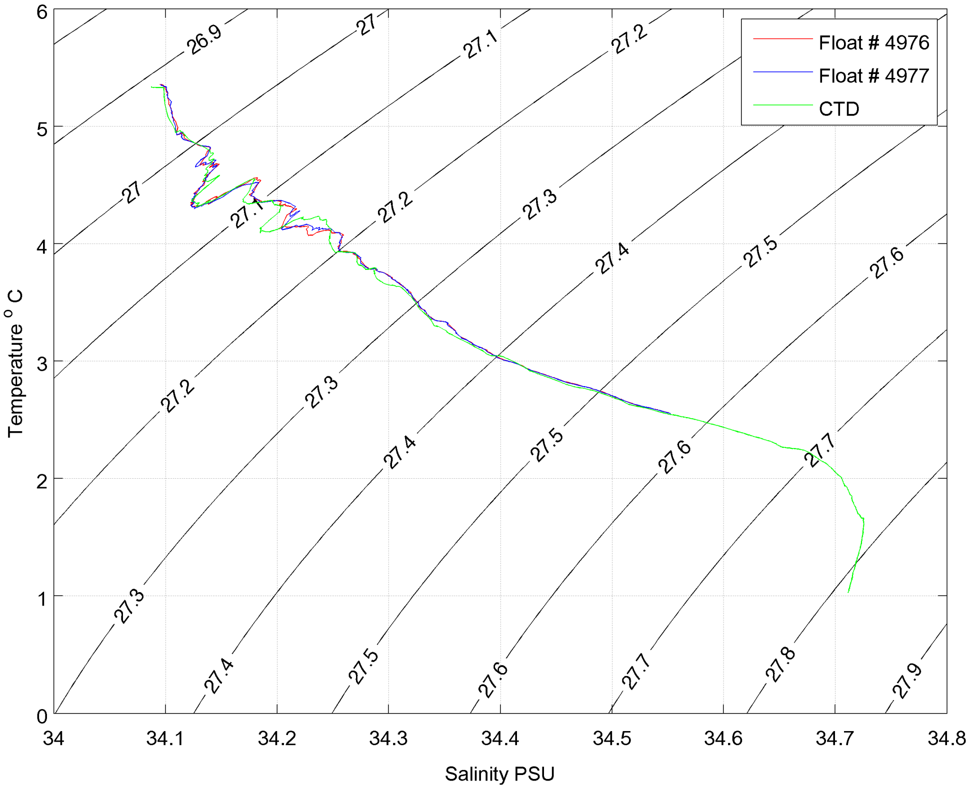


Figure 6.4. Comparison of EM-APEX data with shipboard CTD data from JC054.

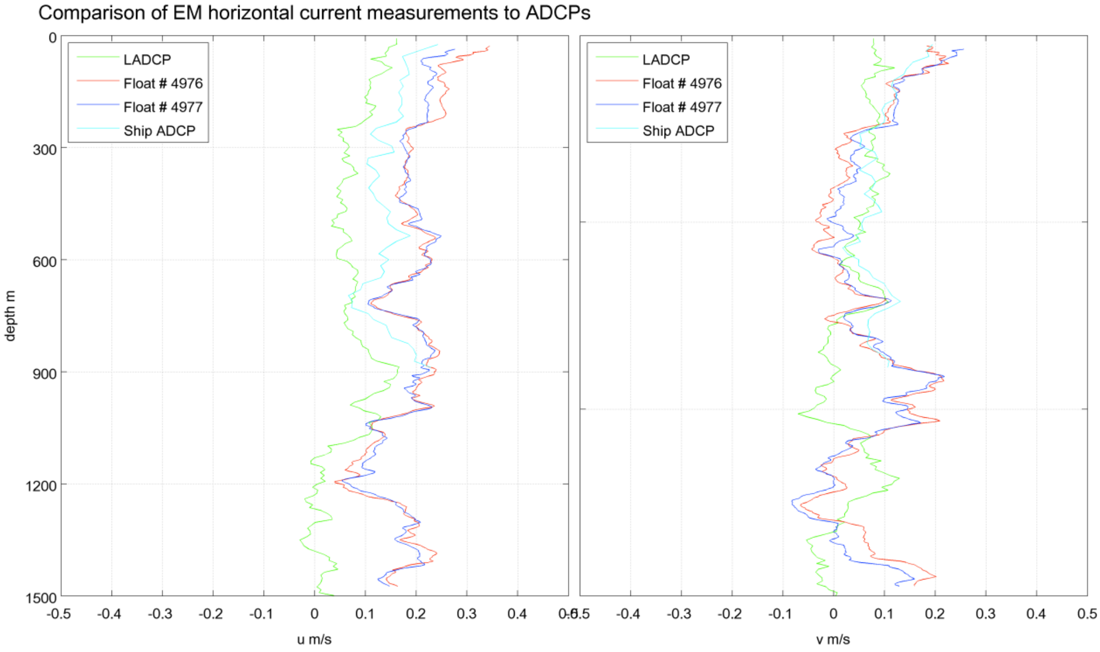


Figure 6.5. Comparison of EM-APEX data with Lowered ADCP data from JC054.

6.4.2. APEX floats

Along with the two EM-APEX floats, two standard Webb Autonomous Profiling Explorer (APEX) floats were deployed to provide information about the RAFOS sound sources and additional CTD data. These are Iridium and RAFOS enabled versions of the standard APEX float, with a Sea-Bird SBE41 CTD. During testing a third APEX float had inconsistent telemetry and was not deployed. The two floats were deployed at 57°34.4 S, 68°11.1 W on December 30, 2010 at 12:17 GMT. The floats are set to profile and listen to the moored sound sources daily at a max depth of 1200dbar. The floats were lowered into the sea by hand using the attached deployment ring. The data is available daily through an ftp site. Please contact Dr. Kevin Speer (kspeer@fsu.edu) for more information and data access.

Mission configuration for APEX (s/n 4781):-

```
AscentTimeOut(310) [min]
AtDialCmd(AT+CBST=71,0,1;DT0088160000509) [primary]
AltDialCmd(ATDT0012066163256) [alternate]
BuoyancyNudge(10) [count]
BuoyancyNudgeInitial(22) [count]
ConnectTimeOut(60) [sec]
CpActivationP(1200) [dbar]
DeepProfileDescentTime(360) [min]
DeepProfilePistonPos(16) [count]
DeepProfilePressure(1200) [dbar]
DownTime(1010) [min]
FloatId(4781)
FullExtension(226) [count]
FullRetraction(9) [count]
IceMLTCritical(-1.80)
IceMonths(0xFFD)
MaxAirBladder(124) [count]
MaxLogKb(60) [KByte]
MissionPrelude(360) [min]
OkVacuum(96) [count]
PActivationPistonPosition(16) [count]
ParkDescentTime(360) [min]
ParkPistonPos(19) [count]
ParkPressure(1200) [dbar]
```

```
PnPCycleLen(254)
RafosWindowN(1)
RafosWindows(60;60) [min]
TelemetryRetry(15) [min]
TimeOfDay(DISABLED) [min]
UpTime(430) [min]
Verbosity(3)
DebugBits(0x0003)
```

Mission configuration for APEX (s/n 4782):-

```
AscentTimeOut(310) [min]
AtDialCmd(AT+CBST=71,0,1;DT0088160000509) [primary]
AltDialCmd(ATDT0012066163256) [alternate]
BuoyancyNudge(10) [count]
BuoyancyNudgeInitial(22) [count]
ConnectTimeOut(60) [sec]
CpActivationP(1200) [dbar]
DeepProfileDescentTime(360) [min]
DeepProfilePistonPos(16) [count]
DeepProfilePressure(1200) [dbar]
DownTime(1010) [min]
FloatId(4782)
FullExtension(227) [count]
FullRetraction(9) [count]
IceMLTCritical(-1.80)
IceMonths(0xFFD)
MaxAirBladder(124) [count]
MaxLogKb(60) [KByte]
MissionPrelude(360) [min]
OkVacuum(96) [count]
PActivationPistonPosition(16) [count]
ParkDescentTime(360) [min]
ParkPistonPos(19) [count]
ParkPressure(1200) [dbar]
PnPCycleLen(254)
```

```
RafosWindowN(1)
RafosWindows(60;60) [min]
TelemetryRetry(15) [min]
TimeOfDay(DISABLED) [min]
UpTime(430) [min]
Verbosity(3)
DebugBits(0x0003)
```

7. IT and Science Systems Report

Leighton Rolley

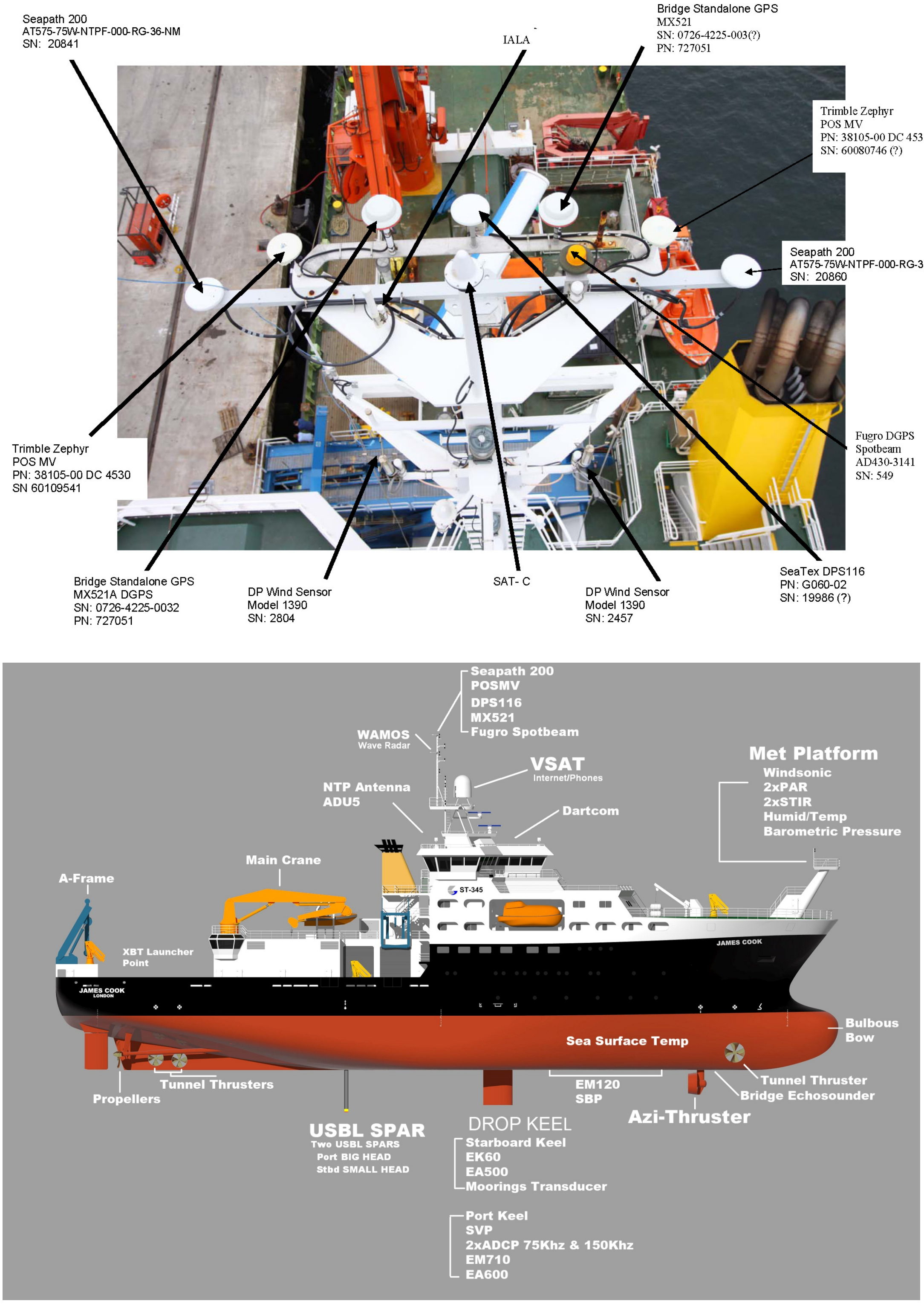


Figure 7.1. RRS James Cook GPS antennae (upper) and ship systems (lower).

7.1 Descriptions of Science Systems

This report details the setup and operation of the James Cook's onboard scientific systems during cruise JC054, with emphasis on performance.

During the mobilisation period in Punta Arenas a number of unscheduled blackouts occurred onboard the vessel with detrimental affects to a number of onboard science systems. Systems that sustained hardware, operating system corruption or operational issues included:-

Cook 4 - Disk Errors, fixed running os disk utility

Cook-cache1 - Disk Errors, fixed running os disk utility

Jc-logger1 - PSU Issue, PSU alarming see below

Wifi Death - Loss of configuration settings

Analysis of the clean power supply showed noticeable spikes in the power to numerous systems. During the return to Punta Arenas for engine trials all science systems and the VSAT communications were powered down to protect them against power spikes whilst the issues with the ship were investigated and tested. No further blackouts were encountered for the remainder of the cruise. It is evident from experience during this period that there is the potential for the systems to be damaged. From the number of external power supplies that have failed on laptops and other devices during this cruise, it is concluded that spikes in the power may have shortened some hardware's lifespan.

7.1.1. COOKFS, Drobo and daily data backup

Backups were made daily from all active systems to the COOKFS server. In addition copies of the data were also loaded onto the drobo NAS as required by the scientific party. This backup scenario was ideal as both copies were held in different locations, both physically and on different hardware. The techsas folder /data/JC54 was shared with read permissions only on jc-logger1 so that the scientific party had access to the data. This was mounted on the scientific Sun station nosea1.

A Dell data server was delivered to the ship to act as a new file storage system for cruise data. The server was installed below the phone exchange patch panels and configured to use the screen mounted above the phone exchange. The system was not added to avocent, but was enabled for remote desktop access from both networks.

The drobo NAS was utilised by the scientific part as the main science data store. When large numbers of users were accessing the drobo its responsiveness decreased as expected. This was not significant enough to prevent access as with the old drobo. The drobo will most likely be superseded by COOKFS at the end of this cruise.

7.1.2. Chernikief

The Chernikief log appears to be reading quite high values – usually about 10-20% higher than the GPS or Skipper Log. The system was fully calibrated on leaving the vessel refit (October 2010). The system should have retained its calibration for this period. However, we did experience quite significant currents in the area when deploying the VMP. More tests will be conducted on future cruises to assess the calibration.

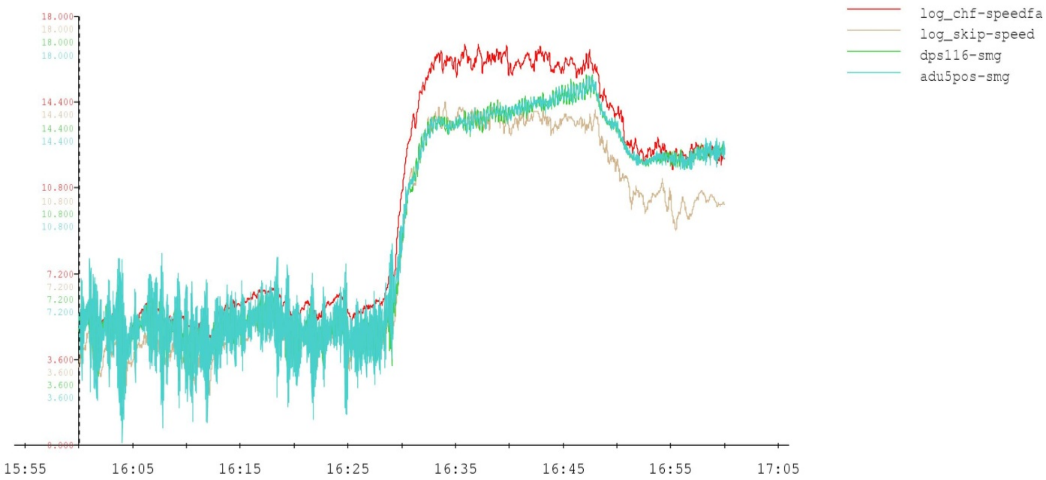


Figure 7.2: Graph showing the differences in speed logged by each system

7.1.3. Sound Velocity Profiles

Three SVPs were onboard the vessel for this cruise:-

Valeport	22356	6000dbar
Valeport	22241	5000dbar
AML	3501	5000dbar

A number of issues have been experienced with the AML probe on previous cruises. A number of tests were carried out on the probe. It was determined that the probe needed to be used in a certain way in order to collect data:-

1. Launch SVP Talk on the PC
2. Plug the data cable from the PC into the probe.
3. Plug the power plug into the probe
4. Select and configure the probe in smart talk
5. Remove the red power plug
6. Remove the data plug
7. When ready for deployment install the data plug then the red plug to activate the probe
8. On recover remove the power then the data plug.

9. Plug the data cable from the Pc into the probe
10. Plug the power plug into the probe
11. Select the probe
12. Download data

However, despite getting the probe to log on each deployment, the data logged by the AML was not a full up and down cast. On a number of occasions the probe would only start logging after it had exceeded 10m under the water. This is not good as we want to log the biggest changes in the first few meters. Secondly, the probe never successfully logged an entire upward cast. Most times the downward cast was fully recorded (with the exception of the first 9m). Once the probe began the journey to the surface it would log 200-400m of the upward cast and then stop. This does not appear to be batteries as the probe would successfully download using the internal batteries at the end of the cast.

The SVP was regularly mounted on the CTD by the SST and generally the insertion of plugs was undertaken by the SST. On one instance the CTD was nearly deployed without the power plug in the SVP as the SST was with the PI. To prevent the CTD being deployed with no caps in the SVP a large plastic sine was cable tied around the SVP prior to each cast with a warning attached to the plug.

Throughout the cruise the Valeports were used with a “Continous 4hz” configuration. This proved ample for producing the necessary sound speed profiles. Sound speed profiles were loaded into EM120, EA600 and USBL (when utilised).

7.1.4. Surfmet

The following sensors were used during the cruise:-

Sensor	Serial Number	Calibration Due
Transmissometer	CST 1132PR *	June 2011
Fluorimeter	WS3S-246	July 2011
Thermosalinograph	4548881-0233	March 2011
Remote Temperature	SBE3853440-0416	March 2011
PPAR	28561 †	April 2011
SPAR	28562 until November 10th 28560 thereafter	April 2011 April 2011
PTIR	973134	April 2011
STIR	973155	April 2011
Pressure	R0450005	September 2011
Anenometer	064537	N/A
Temperature and Humidity	C1320001	April 2011

Table 7.1. Surfmet sensors used on JC054.

The non-toxic supply to this system was only operated when the vessel was clear of coastal waters (and Argentina for the purpose of this cruise). The entire system was thoroughly cleaned each time we left port. The SST discussed cleaning arrangements with the PSO and he said that cleaning would take place if changes occurred in the data. Cleaning was conducted roughly ever 5 days.

Water was found in small quantities at the bottom of the junction box located on the met platform. The humidity sensor failed and was replaced. Logging resumed with no further problems

A latency of up to 2 minutes has been identified in the Surfmet data. When comparing SBE45 data to the data acquired by Surfmet a visible latency is displayed. For the duration of the cruise this was usually only a few seconds. However, there were a number of instances at the start of the cruise when the latency increased to around 100 seconds.

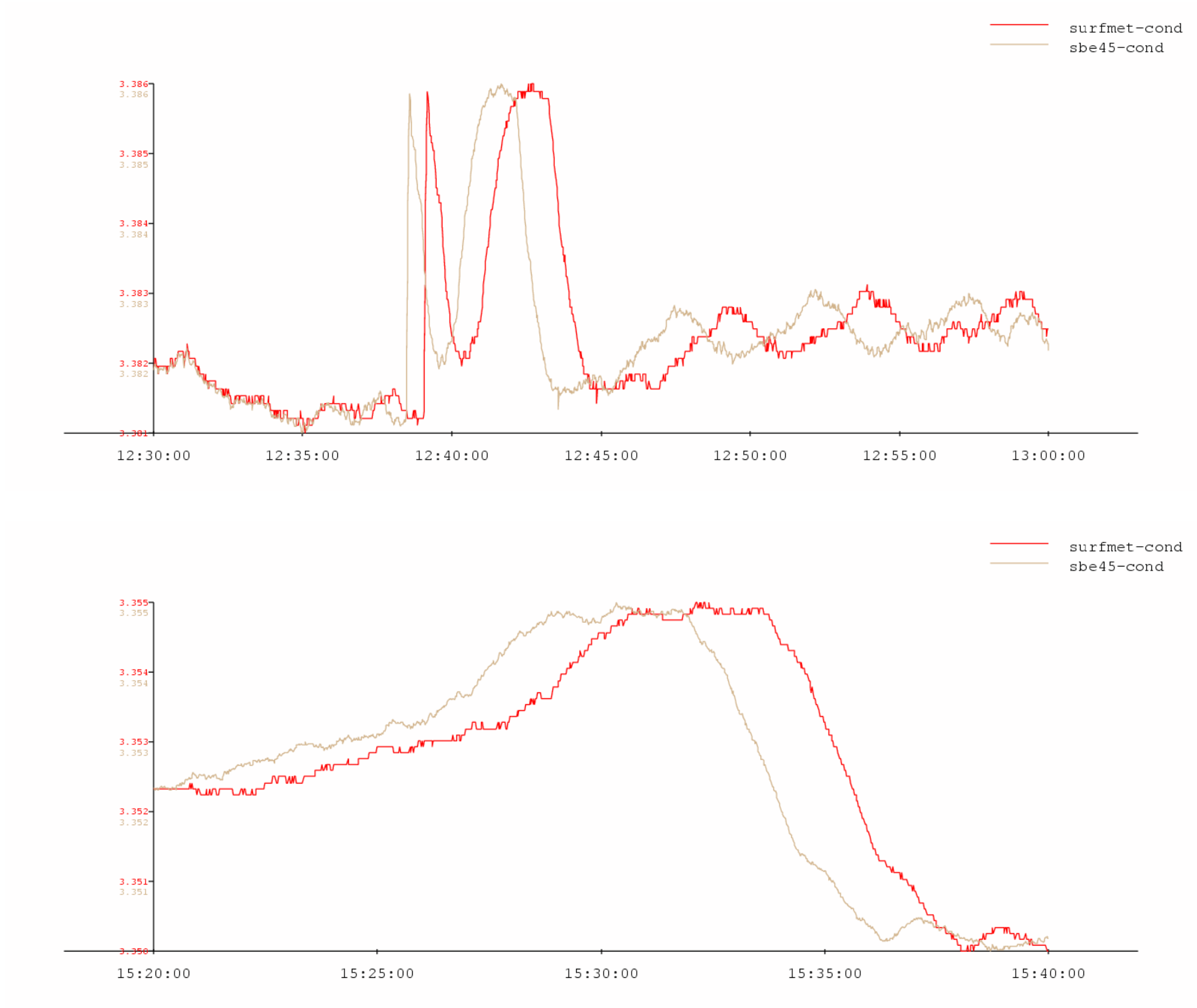


Figure 7.3: Examples of latency in the Surfmet data

Once the cause of the latency was identified, it was minimised to a few seconds by limiting the samples held in memory and adjusting the graph update rate.

7.1.5. Temperature/Pressure Sensor Issues

A number of issues were encountered with the temperature/pressure sensors. Periodically the air temperature values in the main lab would increase sufficiently to become inaccurate. On one occasion the temperature increased to in excess of 100C. On the first instance of the airtemp values becoming unbelievable the sensor was swapped for the spare brought out for this cruise. Replacing the probe seemed to have solved the problem - both humidity and temperature displayed believable values in the Surfmet GUI and were cross-referenced with the bridges met system. On the second occurrence, testing both sensors showed the same values. Examination of the wiring showed no apparent damage. The connector on the JB located on the met platform was examined. The self-amalgamating tape seems to have come loose. There was no seal into the plug as the cable is rs232 and too small for the gland. Whilst the connector itself did not show any damage externally, it was decided to open the connector. Once opened, severe corrosion was found. The connector was replaced and tested, with normal values being displayed.

As with the previous and in high winds, turning the vessel affected the wind speed and to an extent, the temperature. This is most likely due to the wind blowing up the bow of the vessel and past the instruments.

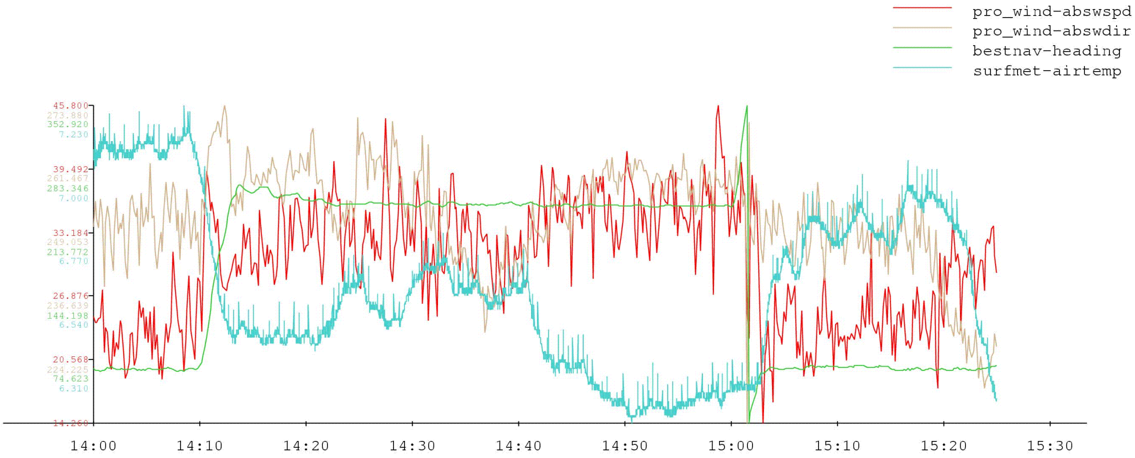


Figure 7.4: A section of wind, heading and air temperature data during JC054, showing the impact of turning the vessel on met data.

7.1.6. Installation of Replacement Seapath 200

During JC053 the Seapath 200 control (which supplies backup navigation and positional data to the Kongsberg acoustic suite as well as the secondary GPS input to the bridge) failed. A replacement system was dispatched by Kongsberg and was subsequently delayed in transit by customs. As the ship was delayed in leaving Punta Arenas the Seapath 200 arrived with a few minutes to spare. It was fitted on the transit out to the first worksite. This is the control unit and no alterations were made to antennas that would affect system offsets.

The system was configured with the setup file from the failed unit so that the settings should be consistent. However, it appears that since the backup the Seapath's UDP broadcast has changed and this was reconfigured in the Seapath 200 control application on the XBT/SVP machine in the main lab which is also connected to the 200.

7.1.7. Level-C

The level-C system captures Techsas broadcast and populates data streams against which queries can be executed. The system crashed twice during the cruise. No apparent cause could be determined. The scientific party used their own streams on nosea1 for the duration of this cruise with dedicated daily analysis of the data.

GPS/Attitude

posmvpos

- lat
- lon
- alt
- prec
- mode
- cmg
- smg

posmvtss

- heading
- roll
- pitch
- heave
- acc_roll
- acc_ptch
- acc_hdg

gyropmv

- heading

sb-pos

- lat
- lon

dps116

- lat
- lon
- alt
- prec
- mode
- cmg
- smg

surfmet

- temp_h
- temp_r
- cond
- fluo
- trans
- press
- ppar
- spar
- speed
- direct
- airtemp
- humidity
- ptir
- stir

log_chf

- speedfa
- speedps

gravity

- grav_av
- sprint
- xcup
- beam
- vc
- al
- ax
- ve
- ax2
- xac2
- lac2
- xac
- lac
- eotcor
- lat
- lon
- heading
- vel

sbe45

- temp_h
- cond
- salin
- sndspeed
- temp_r

gyro_s

- heading

ea600m

- depth

winch

- cabltype
- tension
- cableout
- rate
- btension
- Angle

Table 7.2. Level C data streams on JC054

7.1.8. Techsas Data Logger

The Ifremer Techsas system is the primary data logger for all navigation, Surfmet and winch data. The Techsas software is installed on an industrial based system with a high level of redundancy. The operating system is Centos. The system itself logs data on to a RAID 0 disk mirror and also logs to the backup logger. The Techsas interface displays the status of all incoming data streams and provides alerts if the incoming data is lost. The ability exists to broadcast live data across the network via NMEA.

The storage method used for data storage is NetCDF (binary which is a self describing file and is OS independent) and also pseudo-NMEA (ASCII). The NetCDF data files are currently automatically parsed through an application in order to convert them to RVS Format for data processing.

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

1) Applanix POSMV System (Converted to RVS Format as posmvpos, posmvatt, posmvsat)
2) Applanix POSMV System Heading
3) Kongsberg Seatex DPS-116 (Converted to RVS Format as dps116p and dps116s)
4) Chernikeef EM speed log (converted to RVS format as log_chf)
5) Skipper EM Speed Log (converted to RVS Format as log_skip)
6) Ships Gyrocompass (converted to RVS format as gyronmea)
7) Simrad EA600 Precision Echo Sounder (Converted to RVS Format as ea600)
8) NMFD Surface-water and Meteorology instrument suite (Converted to RVS as sm_surf, sm_met and sm_light)
9) ASHTECH ADU-5 Attitude Detection Unit Converted to RVS Format as adu5pat and adu5pos)
7) NMFSS Cable Logging and Monitoring (Converted to RVS as winch)

During the port calls in Punta Arenas a number of issues were found with the ship's voltage sets which resulted in a number of unplanned blackouts of the ship's clean supply. This caused issues with Techsas, which although on an UPS supply shutdown and would not reboot. Symptoms were rapid flashing lights on PSU and motherboard, and alarm noise emanating from PSU. Only after swapping the hot swap supply would the system reboot.

7.1.9. EA500, EA600, EM120

Bathymetric data were recorded throughout the cruise with the ship's EA500, EA600 and EM120 echosounder systems (see section 2). During the cruise there were discrepancies between depths reported on each of these systems. Whilst on station the EM120 and EA600 were generally within 10m of each other and could be relied to give good complementary depths. However, during transit the differences in depth were much greater and sometimes up to and in excess of 100m.

Investigations have identified a number of reasons for this, including:-

1. The EA500 has an average water column sound speed value and has no compensation for pitch heave and roll of the vessel
2. The EA600 uses a profile that consists of around 200 points. Like the EA500 the system does not have motion correction incorporated into it.
3. The EM120 is fully integrated with both the POSMV and Seapath 200 motion reference units as well as accepting profiles with up to 500 points.

Attempts were made to add real-time Simrad 3000 inputs to the EA600 system. However, the POSMV outputs at 100hz, which creates too many data for the EA600 system. Using data from the USB splitter in the main lab would introduce a latency of around 1 second. The system was left in its current configuration for the remainder of the cruise with no pitch, roll or heave compensation

The EM120 was used throughout the cruise, with settings:-

Max Angle Port	70
Max Angle Stbd	70

Max Coverage Port	10000
Max Coverage Stbd	10000
Angular Coverage Mode:	Auto
Beam Spacing:	EqDist
Ping mode	Auto

BIST's (Built in Systems Tests) were run prior to departure and again when the vessel departed after engine troubles. Both BISTS completed with no issues. Swath was conducted once the vessel had cleared Argentinean waters and then for the duration of the cruise – with the exception of when the vessel returned to Punta and the systems were shut off on the journey back in.

7.1.9.1. EM120 data issues

A number of data quality issues were encountered due to vessel motion in the Southern Ocean and aeration along the hull. Sea state played a significant role in poor quality swath during this cruise.

The hull design of the James Cook can produce a significant entrained stream of air bubbles at normal survey speeds and in moderate weather conditions. This tendency has been apparent since the vessel's early sea trials and was investigated as early as JC005. This investigation used hull mounted and drop keel mounted cameras to monitor bubble activity. The cameras indicated that bubbles were formed at or near the bulbous bow.

It has been clear since this time that any pitching of the vessel greatly increases bubble formation and will drive the bubbles under the hull, where they remained entrained passing under and around the vessel. It was also apparent from these tests that moderate levels of pitching can drive bubbles under the hull and past the drop keel even when the drop keel is fully extended.

During the above trials cruise, trimming of the vessel was also investigated. The James Cook's bulbous bow holds one of the vessel's main trimming tanks and performance comparisons were made with the vessel in different states of trim. The results showed that whilst variation in trim affected the performance of the vessel the mitigation of the bubble problem was minimal. The benefits of trimming the bow down were confined to the extent this controlled pitching. As pitching is also influenced by sea state and by wind and wave direction as well as speed then trimming the vessel is neither particularly effective nor practical as a means of improving performance. At best it can provide a little fine-tuning to the conditions with the proviso that the conditions then need to stay broadly the same and some time would be required to establish the best trim for the survey.

Following this camera exercise a series of hydrodynamic tests were made with a 1:25 scale model of the James Cook. These tests were conducted by the Wolfson Unit of Southampton University at the GKN Aerospace 200m test tank on the Isle of Wight. The tests were made with the vessels Original Bow and with a modified Chisel Bow. These tests proved inconclusive, it was apparent that simply removing the current bow would not guarantee any significant improvement in performance.

Since coming into service no physical modification has been made to the vessel and no investigation has resulted in an action that has changed its dynamic performance, however over time a great deal of first-hand experience has been gained in operating the vessel within the constraints that the hull design. The good news is we have collected a significant amount of good data; the bad news is there is no ready reckoner for this.

During 2009 the vessel collected good swath data during both JC036 and JC041. On JC036 it was possible to collect good data whilst steaming into a force 6 at seven knots whilst on JC041 in similar force 6 conditions it was not and data had to be collected at one point on downwind legs only. The difference between the two surveys was the swell, both in magnitude and period, and the effect it had on vessel pitching. During JC036 and JC041 good swath survey data was in general collected at or above six knots in conditions below force six. In contrast during the JC034 trials, when weather conditions were near perfect, survey speeds of 8 knots were achieved along with excellent data quality.

The collection of swath data is an easy dynamic representation of the entrained bubble problem; the same observations can also be made with regard to quality and collection of Vessel Mounted ADCP data, Sub-bottom Profiler data, or EK60 data. Entrained bubbles have also been an issue in surface water sampling through the ships non-toxic seawater system, where it was necessary to use an extra de-bubbler tank.

In summary it is unlikely that good acoustic data will be collected on the James Cook above a force six. Methods for improving the swath quality were communicated to the PSO but deemed out of scope for this cruise due to time limitations imposed after engine troubles and delays suffered earlier in the cruise.

The swath system was kept running in conditions where data acquisition would not normally be possible at the request of the science party, to capture possible occasions when the data might improve. However, operation in higher sea states caused a number of issues that could only be resolved by restarting pinging. It appears that when a lot of air passes along the transducer the system subsequently has issues re-acquiring the bottom in areas where it already has bad data.

During the previous cruise issues were encountered with the vessel's drop-keel mounted Sound Velocity Profiler. This was changed at the start of the cruise. Throughout the cruise it was observed that the keel mounted SVP would "jump" e.g 1490-1550 m/s occasionally and often resulted in the sound speed at transducer being derived from the last profile and not real-time data from the hull mounted sensor. It is believed that this "jumping" is because air is becoming trapped in the drop keel mounted tube in which the probe is situated. We cannot raise the drop keel at sea or monitor this problem.

The EM120 was usually left recording during CTD stations resulting in high concentrations of swath data for these sites. However, use of the azimuthal and bow tunnel thrusters resulted in degradation of some data acquired at these sites. The ship's crew are generally well versed in using the thrusters and when acquiring data they tend to use the system in "Environmental mode" which minimises the amount of interference over the transducers. However, in some instances bow thruster activity was in excess of 65%, which results in poor quality depth measurements.

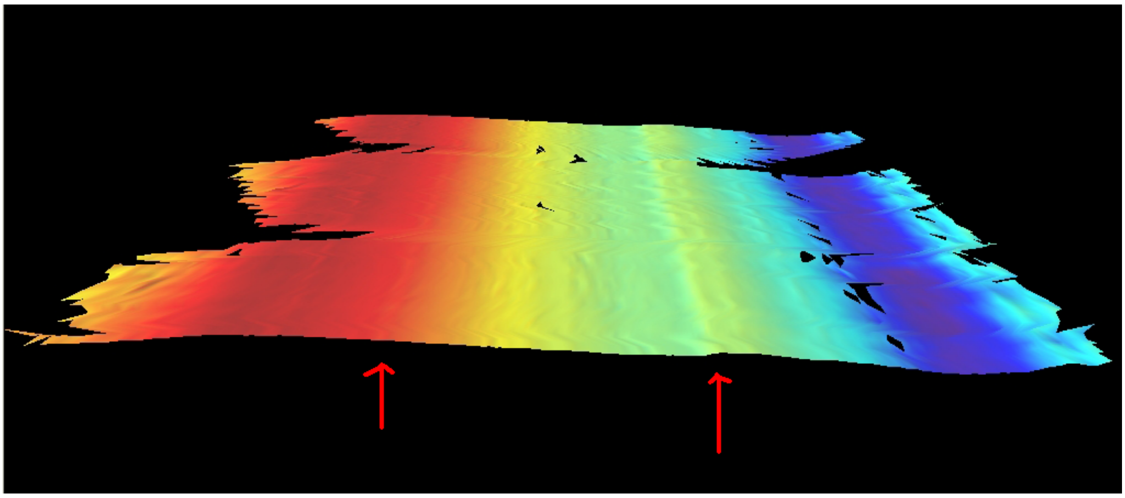


Figure 7.5 Banding on an EM120 seabed image.

Visible banding on data has been an issue since the vessel's delivery (e.g. Figure 7.5). Kongsberg have been investigating this and recently visited the vessel. During the refit a new TX card was installed in the EM120. Whilst this appears to have reduced the banding on the swath it is still evident in some of the data.

Throughout this cruise profiles were acquired from both the Valeport SVPs and derived from CTD data collected at each station. Transits on average of 40 miles between stations in the vicinity of the Antarctic convergence would mean that data quality was affected by quite large water column changes. In some instances we saw temperature changes of up to 2.2 degrees between stations. Temperature is the major influence on sound velocity in water. A 1°C change is equal to approximately a 4m/sec change in velocity. Generally, we were working in water depths around 3000-4500. Given that sound travels at around 1490m/s in this area, in 4000m of water we could be theoretically looking at inaccuracies easily in excess of 10-15m.

7.1.10. Clam

Clam crashed during one of the CTD deployments. The application crash related to a lack of space on the external media that is used to log system messages. This type of error should not effect winch operations or crash the Clam system and is a result of bad error handling in the software. When attempting to write a log to the file the system should check the validity of the path and the free space as a minimum. If an error is thrown sufficient error handling should be present in the program. Clam is now coming to the end of its useful life and we should be looking at a more robust replacement

7.1.11. VMP tracking: Pinger and USBL

The WHOI VMP is fitted with a 12khz pinger. Attempts to track this with the ship's EA600 system did not produce any repeatable results. Out of all the deployments, only 2 tracked with any degree of accuracy, the majority of other casts failed to locate the pinger or only tracked for a limited period.

To use a pinger the EA600 must become synchronised with the beacon. To synchronise the beacon would be lowered down to a known depth, say 100m, and the EA600 would then listen for the pinger. Once an EA600 has been synchronised it can then track the pinger with a greater degree of accuracy. However, this system is only designed to be used underneath the ship's hull and often the VMPs were in excess of 500m away from the ship, thus making tracking impossible. If the pinger system had worked it would have been able to give us a depth and indicate when the VMP was returning to the surface, not a direction or bearing

Due to poor tracking with the EA600 in pinger mode, we attempted a number of deployments with the Sonardyne USBL beacons:-

Super Sub Mini MF Directional 4000m	67180-04	68037-004	7970-000-02
Super Sub Mini MF Directional 4000m	67180-03	68037-003	7970-000-02

The beacon was mounted on the WHOI VMP, and a letter guaranteeing replacement in the event of loss was issue by the PSO.

USBL tracking for the first three dives was good and we were able to successfully follow the VMP down to depths of 3700m when in excess of 1km away. These were better results than we have experienced before with the super sub minis. The USBL transponder link to the bridge was also initialised so the bridge could follow the VMP on their own screen.

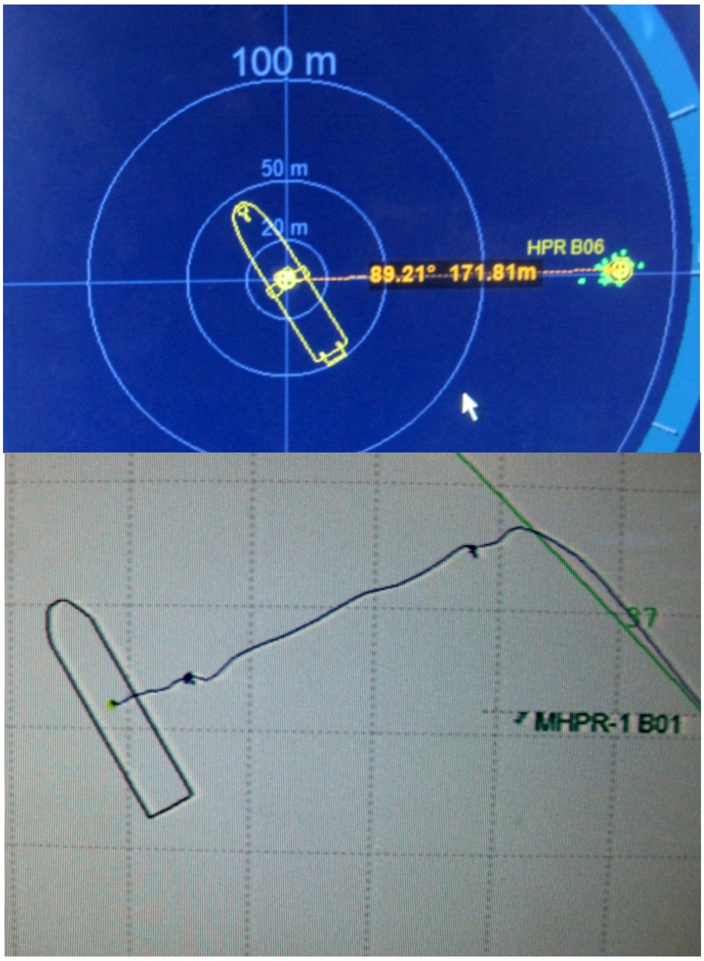


Figure 7.6. The USBL tracking system and the bridge screen showing beacon

Issues were experienced with the USBL tracking and the bridge, mainly from inexperience using the link:-

1. The beacon was initially setup as reference beacons. These were displayed as BHPR06 (06 is the address) on the DP screen. However, the reference setting is usually only used for static targets, not moving targets such as the VMP. The fact the transponder was moving caused the system to alarm frequently as the reference beacon changed position. The "reference" option was quickly unchecked and became MHPR-1 B06 - The M stands for mobile.

2. At greater depths when tracking was poor, the alarm indicating poor quality fixes from a reference system would alarm each time the transponder signal was lost. This could get annoying.

Tracking generally got poorer when the VMP returned to the surface. This is probably due to the distance the beacon was away from the vessel and the coverage cone. At around 300m and when the transponder was 400-500m away from the vessel, tracking would become poor. The mounting of the transponder was not ideal for this and probably contributed to the poor tracking as the VMP rotated as it came to the surface. Generally the heading returned as the VMP came to the surface was correct. However, the distance was sometimes 100m off. This is probably due to the transponder being at the edge of the coverage cone and the fact that at this depth the acoustics are travelling almost horizontally through the water column and probably subjected to more inaccuracies

At the start of this cruise two beacons were onboard the vessel. Beacon 68037-004 was known to have issues during tracking especially at depth. The second beacon was deployed on channel 06 was deemed to be working within spec. However, after the third cast the beacon ceased to function at around 500m. The transponder was fully charged and re-mounted on the VMP. During the next deployment it failed to track throughout the entireity of the cast. Without tracking it was a lot harder to pinpoint the location of the VMP. However, this would have been the case if attempting to use the VMP’s pinger, which has also proven to be ineffective. Two test deployments of both transponders were conducted without success.

Appendix I. VM-ADCP operation and calibration details

A1.1. OS75

Sequence #	Ensemble #	Tracking Mod	Start Day	Start Time	End Day	End Time
1						
2	25617	bottom	338	11:39	339	17:10
3	798	bottom	339	17:19	339	18:26
4	16117	water	339	18:31	340	07:56
5	2993	water	340	10:25	340	12:54
6	4349	water	340	13:37	340	17:15
7	15116	water	340	20:05	341	08:41
8	3205	water	341	10:20	341	14:16
9	2968	water	341	16:34	341	20:12
10	3	water	341	21:08	341	21:08
11	12020	water	341	21:22	342	11:56
12	1401	water	342	13:35	342	15:17
13	76	water	342	19:07	342	19:14
14	42	water	342	19:17	342	19:20
15	10116	water	342	20:16	343	08:29
16	2524	water	343	12:15	343	14:21
17	18968	water	343	14:52	344	06:40
18	5312	water	344	10:37	344	15:02
19						
20						
21	13712	bottom	351	17:17	352	11:06
22	4082	water	352	11:08	352	14:23
23	6995	water	352	15:40	352	21:31
24	16486	water	352	21:50	353	11:34
25	712	water	353	11:41	353	12:17
26	1612	water	353	12:18	353	13:39
27	4866	water	353	14:02	353	18:13
28	5493	water	353	18:23	353	22:57
29	8367	water	354	00:39	354	07:31
30	6481	water	354	10:10	354	15:32
31	5204	water	354	16:00	354	20:15
32	7744	water	354	20:58	355	03:25
33	5886	water	355	06:11	355	11:05
34	15850	water	355	11:41	356	00:53
35	5276	water	356	03:40	356	08:04
36	4463	water	356	08:09	356	11:52
37	772	water	356	16:29	356	17:08
38	24190	water	356	19:24	357	15:34
39	49680	water	356	15:38	359	09:02
40	57619	water	359	09:06	361	09:08
41	51356	water	361	09:12:00	363	04:00:00
42	78621	water	363	06:19:00	365	23:50:00
43	34886	water	1	00:43:00	2	05:24:00
44	25084	water	2	08:43:00	3	05:37:00

Appendix I (cont.). VM-ADCP operation and calibration details

A1.1 (cont.) OS75

Sequence #	Cal point #	Amp_med	Amp_mean	Amp_Std	Phase_med	Phase_mean	Phase_Std
1							
2	286	1.0043	1.0045	0.0020	-8.9572	-8.9421	0.2194
3	11	1.0052	0.9587	0.1072	-8.9402	-8.8224	0.2738
4							
5							
6	1	1.0400	1.0400	0.0000	-7.1200	-7.1200	0.0000
7							
8							
9							
10							
11	1	0.9700	0.9700	0.0000	-10.9290	-10.9290	0.0000
12							
13							
14							
15	1	1.0290	1.0290	0.0000	-11.8960	-11.8960	0.0000
16							
17	1	1.0820	1.0820	0.0000	-9.3450	-9.3450	0.0000
18							
19							
20							
21	96	1.0051	1.0054	0.0027	-8.7967	-8.7673	0.3459
22							
23	2	1.0160	1.0160	0.0042	-7.9135	-7.9135	0.1209
24	1	1.0250	1.0250	0.0000	-8.9650	-8.9650	0.0000
25							
26							
27	1	0.9820	0.9820	0.0000	-10.5740	-10.5740	0.0000
28							
29							
30	2	1.0195	1.0195	0.0233	-6.9985	-6.9985	3.2435
31	1	1.0160	1.0160	0.0000	-7.8660	-7.8660	0.0000
32							
33							
34							
35							
36							
37							
38	4	1.0035	1.0065	0.0070	0.2655	0.1695	0.4835
39	5	1.0140	1.0130	0.0114	0.0120	-0.0182	1.1398
40	5	1.0090	1.0016	0.0191	0.4360	0.0316	0.7387
41	6	1.0170	1.0162	0.0050	-0.4185	-0.4013	1.1764
42	4	1.0095	1.0128	0.0185	0.2670	0.5663	1.0677
43							
44	4	1.0130	1.0140	0.0074	-1.2995	-1.4322	1.2573

Appendix I (cont.). VM-ADCP operation and calibration details

A1.2. OS150

Sequence	Ensemble #	Tracking Mode	Start Day	Start Time	End Day	End Time
1	38059	bottom	338	12:06	339	18:24
2	24208	water	339	18:30	340	07:56
3						
4	4374	water	340	10:29	340	12:55
5	6523	water	340	13:37	340	13:38
6	22623	water	340	20:07	341	08:41
7	7297	water	341	10:12	341	14:16
8	6567	water	341	16:34	341	20:13
9	26246	water	341	21:22	342	11:57
10	3068	water	342	13:35	342	15:17
11	13	water	342	19:12	342	19:12
12	6795	water	343	04:41	343	08:29
13	3678	water	343	12:17	343	14:20
14	25986	water	343	16:15	344	06:40
15	8114	water	344	10:33	344	15:03
16	2997	?	349	11:45	349	13:25
17	19127	bottom	351	17:26	352	11:11
18	5990	bottom	352	11:13	352	14:23
19	10451	water	352	15:42	352	21:31
20	28322	water	352	21:55	353	13:39
21	7169	water	353	14:05	353	18:04
22	8173	water	353	18:25	353	22:57
23	12578	water	354	00:34	354	07:31
24	9668	water	354	10:10	00:00	15:32
25	7784	water	354	16:01	354	20:15
26	11613	water	354	20:58	355	03:25
27	33698	water	355	06:09	356	00:53
28	7799	water	356	03:44	356	08:04
29	6638	water	356	08:11	356	11:52
30	1160	water	356	16:29	356	17:08
31	64171	water	356	19:26	358	07:05
32	46867	water	358	07:35	359	09:37
33	85379	water	359	09:41	361	09:08
34	77089	water	361	09:09:00	363	03:59:00
35	93563	water	363	06:21:00	365	10:20:00
36	21833	water	365	11:43:00	365	23:50:00
37	52355	water	1	00:19:00	2	05:24:00
38	36174	water	2	08:35:00	3	04:41:00
39	1567	water	3	04:45:00	3	05:37:00

Appendix I (cont.). VM-ADCP operation and calibration details

A1.2 (cont.) OS150

Sequence #	Cal point #	Amp_med	Amp_mean	Amp_Std	Phase_med	Phase_mean	Phase_Std
1	279	1.0031	1.0044	0.0038	-0.3352	-0.3172	0.1914
2	1	0.9950	0.9950	0.0000	-0.4780	-0.4780	0.0000
3							
4							
5							
6							
7							
8	2	1.0360	1.0360	0.0042	-1.4045	-1.4045	0.2411
9	2	1.0035	1.0035	0.0148	-0.0430	-0.0430	0.6647
10							
11							
12	1	1.0390	1.0390	0.0000	-4.0250	-4.0250	0.0000
13							
14	4	1.0560	1.0585	0.0222	-1.0575	-1.2110	1.5916
15	1	1.0200	1.0200	0.0000	-0.6020	-0.6020	0.0000
16							
17	82	1.0037	1.0040	0.0023	-0.1154	-0.1169	0.2557
18							
19	1	1.0230	1.0230	0.0000	0.4980	0.4980	0.0000
20	3	1.0120	1.0313	0.0388	-0.0540	-0.0693	0.1925
21	1	1.0120	1.0120	0.0000	-0.1360	-0.1360	0.0000
22	1	1.0950	1.0950	0.0000	-2.4940	2.4940	0.0000
23							
24	1	1.0050	1.0050	0.0000	-0.5240	-0.5240	0.0000
25	1	1.0170	1.0170	0.0000	0.3760	0.3760	0.0000
26							
27	1	1.0160	1.0160	0.0000	1.4860	1.4860	0.0000
28							
29							
30							
31	13	1.0060	1.0071	0.0092	0.0790	0.0084	0.7508
32	1	1.0100	1.0100	0.0000	-0.9460	-0.9460	0.0000
33	9	1.0100	1.0171	0.0217	-0.6650	-0.5622	0.3966
34	4	1.0220	1.0252	0.0110	-1.1450	-0.6670	1.0558
35	7	1.0230	1.0211	0.0238	-1.0120	0.9516	0.8060
36	1	1.0160	1.0160	0.0000	0.1470	0.1470	0.0000
37	1	1.0280	1.0280	0.0000	-0.6860	-0.6860	0.0000
38	4	1.0105	1.0072	0.0131	-0.8905	-0.8527	0.7602
39							

Appendix II: CTD package configuration

```
PSA file: C:\Program Files\Sea-Bird\SeasaveV7\JC054\stainless_NMEA_deep.psa

Instrument configuration file: C:\Program Files\Sea-Bird\SeasaveV7\JC054\SBE con and text
files\0943\0943.xmlcon

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

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

1) Frequency 0, Temperature

   Serial number : 4151
   Calibrated on : 1 September 2010
   G          : 4.39923289e-003
   H          : 6.69852717e-004
   I          : 2.50957714e-005
   J          : 2.03483182e-006
   F0         : 1000.000
   Slope      : 1.00000000
   Offset     : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3054
   Calibrated on : 10 August 2010
   G          : -1.01867138e+001
   H          : 1.40029518e+000
   I          : 4.16358772e-004
   J          : 3.49045297e-005
   CTcor      : 3.2500e-006
   CPcor      : -9.57000000e-008
   Slope      : 1.00000000
   Offset     : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 110557
   Calibrated on : 26 April 2009
   C1         : -6.010548e+004
   C2         : -1.565601e+000
   C3         : 1.823100e-002
   D1         : 2.668300e-002
   D2         : 0.000000e+000
```

T1 : 3.020528e+001
T2 : -6.718318e-004
T3 : 4.457980e-006
T4 : 1.203850e-009
T5 : 0.000000e+000
Slope : 1.00000000
Offset : 0.00000
AD590M : 1.280700e-002
AD590B : -9.299644e+000

4) Frequency 3, Temperature, 2

Serial number : 2919
Calibrated on : 31 August 2010
G : 4.31699759e-003
H : 6.44483745e-004
I : 2.28457056e-005
J : 2.14323650e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 3580
Calibrated on : 28 July 2010
G : -9.68126813e+000
H : 1.16885619e+000
I : -1.43850961e-003
J : 1.49000253e-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 : 0621
Calibrated on : 26 August 2010
Equation : Sea-Bird
Soc : 4.05900e-001
Offset : -4.86500e-001
A : -3.04460e-003
B : 1.70820e-004
C : -2.50240e-006
E : 3.60000e-002
Tau20 : 1.03000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Fluorometer, Chelsea Aqua 3

Serial number : 088195

```
   Calibrated on : 08 September 2010

   VB           : 0.275800
   V1           : 2.154100
   Vacetone      : 0.313700
   Scale factor  : 1.000000
   Slope         : 1.000000
   Offset        : 0.000000

9) A/D voltage 3, Altimeter

   Serial number : 41302
   Calibrated on : 20 April 2007
   Scale factor  : 15.000
   Offset        : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Turbidity Meter, WET Labs, ECO-BB

    Serial number : BBRTD-758R
    Calibrated on : 18 May 2010
    ScaleFactor   : 0.003255
    DarkVoltage   : 0.063000

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

    Serial number : 161050
    Calibrated on : 3 May 2001
    M             : 22.8945
    B             : -0.3343
    Path length   : 0.100

Scan length                  : 41
-------------------------------------------
Pump Control
   This setting is only applicable to a custom build of the SBE 9plus.
   Enable pump on / pump off commands: NO
-------------------------------------------
Data Acquisition:
   Archive data:                  YES
   Delay archiving:                NO
   Data archive:                  C:\Program Files\Sea-Bird\SeasaveV7\JC054\raw data\JC054055.hex
   Timeout (seconds) at startup:     10
   Timeout (seconds) between scans: 10
-------------------------------------------
Instrument port configuration:
   Port      = COM1
   Baud rate = 19200
   Parity    = N
   Data bits = 8
   Stop bits = 1
-------------------------------------------
Water Sampler Data:
   Water Sampler Type:   SBE Carousel
   Number of bottles:    32
```

```
  Port:            COM3
  Enable remote firing: NO
  Firing sequence:    User input
  Tone for bottle fire confirmation uses PC internal speakers.
--------------------------------------------
Header information:
  Header Choice = Prompt for Header Information
    prompt 0 = Ship: RRS James Cook
    prompt 1 = Cruise: JC054
    prompt 2 = Station ID:
    prompt 3 = CTD Cast:
    prompt 4 = Date:
    prompt 5 = Julian Day:
    prompt 6 = Time (GMT):
    prompt 7 = Latitude:
    prompt 8 = Longitude:
    prompt 9 = Depth (uncorrected):
    prompt 10 = Prinicpal Scientist: M.Meridith
    prompt 11 = Operator:
--------------------------------------------
TCP/IP - port numbers:
  Data acquisition:
    Data port:        49163
    Status port:      49165
    Command port:       49164
  Remote bottle firing:
    Command port:       49167
    Status port:      49168
  Remote data publishing:
    Converted data port:  49161
    Raw data port:     49160
--------------------------------------------
Miscellaneous data for calculations
  Depth and Average Sound Velocity
    Latitude when NMEA is not available: 0.000
  Average Sound Velocity
    Minimum pressure [db]:           20.000
    Minimum salinity [psu]:         20.000
    Pressure window size [db]:        20.000
    Time window size [s]:           60.000
  Descent and Acceleration
    Window size [s]:              2.000
  Plume Anomaly
    Theta-B:                   0.000
    Salinity-B                  0.000
    Theta-Z / Salinity-Z             0.000
    Reference pressure [db]            0.000
  Oxygen
    Window size [s]:              2.000
    Apply hysteresis correction:        1
    Apply Tau correction:           1
  Potential Temperature Anomaly
    A0:                     0.000
    A1:                     0.000
    A1 Multiplier:                Salinity
--------------------------------------------
Serial Data Output:
  Output data to serial port: NO
```

```
--------------------------------------------
Mark Variables:
  Variables:
  Digits   Variable Name [units]
  ------   --------------------
  0        Scan Count
  4        Depth [salt water, m]
  7        Conductivity [S/m]
  5        Salinity, Practical [PSU]
--------------------------------------------
Shared File Output:
  Output data to shared file: NO
--------------------------------------------
TCP/IP Output:
  Raw data:
    Output raw data to socket:             NO
    XML wrapper and settings:              NO
    Seconds between raw data updates:       0.000
  Converted data:
    Output converted data to socket:        NO
    XML format:                            NO
--------------------------------------------
SBE 11plus Deck Unit Alarms
  Enable minimum pressure alarm:    NO
  Enable maximum pressure alarm:    NO
  Enable altimeter alarm:           NO
--------------------------------------------
SBE 14 Remote Display
  Enable SBE 14 Remote Display:     NO
--------------------------------------------
PC Alarms
  Enable minimum pressure alarm:    NO
  Enable maximum pressure alarm:    NO
  Enable altimeter alarm:           NO
  Enable bottom contact alarm:      NO
  Alarm uses PC sound card.
--------------------------------------------
Options:
  Prompt to save program setup changes: YES
  Automatically save program setup changes on exit: NO
  Confirm instrument configuration change: YES
  Confirm display setup changes: YES
  Confirm output file overwrite: YES
  Check scan length: NO
  Compare serial numbers: NO
  Maximized plot may cover Seasave: NO
```

Appendix III: VMP Logsheets and Instructions

NOCS VMP-5500 Logsheet

VMP – 5500 Dive LOG

Cruise: JC054	Station Number:	Year and Day of Year:

Sensor Information

Fine. Var.	Channel	Used		Micro. Var.	Channel	Used		Probe
GND1	0			Ax	1			
T1	4			Ay	2			
T2	6			Az	3			
P	10			T1_dT1	5			
SBT1E	16			T2_dT2	7			
SBT1O	17			Sh1	8			
SBC1E	18			Sh2	9			
SBC1O	19			P_dP	11			
Mz	32			C_dC	12			
My	33							
Mx	34							
EMvel1	35							
EMvel2	36							
Vbat	37							

Sensor Notes:

Deployment Name:

Time instrument turned on:		Deployment position:	

Acoustic depth (m):		Bottom press. P_{bot} (db):	
On-deck press. P_{deck} (db):		Assumed overshoot P_{over} (db):	
Safety allowance P_{safe} (db, ≥ 50db recommended):		Specified max. press. (db, must not exceed $P_{bot} + P_{deck} – P_{over} - P_{safe}$):	
Estimated dive time (s, at a dive rate of ~0.55 s^{-1}):		Specified max. time (s):	
Available memory (/root/data):		Enough (at ca. 50Mb /1000 m)?:	
Memory cleared?:		If not, most recent data file in memory:	
Main battery voltage (V, should be ≥ 12.8V)		Dive start time i.e. LED flashing (GMT):	
Ship position when VMP released:		Time when VMP released (GMT):	
		Expected surface time (GMT):	

Comments:

Recovery Name:

Station Number:		DOY / time VMP spotted:	
Range / bearing at which VMP spotted:		Ship position when VMP spotted:	
Date / time VMP on deck:		Recovery position:	
Acoustic depth (m) /			

corrected bottom pressure:			
Post-dive main battery voltage (V):		Time charging started (GMT):	
Estimated charging end time (GMT):		Time charging ended (GMT):	
Voltage after charging:			
Name of data file:		Size of data file:	
Method of dive end:		Max. pressure of dive:	

Comments:

Appendix III (cont.)

NOCS VMP-5500 instructions for launch and recovery

VMP Sequence for Launch

UK DIMES v1, JC054, 2nd December 2010

At the Laptop Station At ~30 minutes prior to launch:	**On Deck**
1. **Start a new log sheet in the VMP dive log**: enter cruise (JC054), station number, date	
2. **IF the instrument isn't already plugged in and charging, plug the instrument in and connect Ethernet cable:** connect one end of the E/CRG charging cable to the instrument and the other end to the charger (~1A, ~13.8 V). connect the charger to the power supply and turn the power supply on plug the Ethernet cable in.	1. **Turn on and test the recovery aids**: for each: loosen clamps remove instruments for two antennas and strobe light, switch on with obvious on/off switch on shaft for pressure transducer, test by setting to “test” and listen for 2 pings ~6 s apart (6 s indicates good battery charge, less than 6 indicates battery charge is low) then set to F3. OR take into lab and check communicating on F3 replace instrument; keep strobe sticking out tighten clamps test radio by ensuring RAF sees the instrument
3. **Turn the instrument on and start the weight battery charging:** connect the on-off switch (plastic plug) on the E/CRG cable.	2. **Remove tube protecting the SeaBird conductivity cell**

note the time on the log sheet - the instrument needs to be turned on and plugged into computer to allow the weight battery to be charged for at least 20-30 minutes before launch	
4. Get the laptop talking to the instrument: open terminal window and check location is set to VMP. Type ‘telnet 192.168.2.2’ log on with login=“root” and password=rglr0x (zero not 'o')	**3. Remove the tape from the EM current meter ports (5)**
5. Make sure there is enough free file space on the instrument for the next profile: type 'df' in the terminal window to get memory available record “Available” memory in the “root/data” directory on the log sheet determine if there is enough memory for the next profile (you require ~ 100 000 kB per 1000 m depth of dive) **IF** required, make space by deleting all data files (.p) except for the most recent; otherwise note most recent data file (.p) in memory on the log sheet	**4. WHEN the Laptop Station work is done, disconnect the E/CRG cable from the instrument and install the dummy plugs (on both ends)** wait 36 s (the weight release mechanism will fire as part of normal procedure)
6. Check channels and get the pressure on deck from the instrument: - type “odas4ir -f setup.txt –c all –s 1024” in the terminal window. This gives a list of channel numbers and the standard deviation and mean of the measurements over 1024 counts. Check these values look sensible. - type ‘odas4ir –f setup.txt’ in the terminal window. multiple readings of the on-deck pressure will be printed to the screen (should be close to 0) record to nearest first decimal point as “On-deck press P_{deck}” on log sheet exit with CRTL-C	**5. Install the weights:** check the magnetism of the weights demagnetize if greater than 2G check the state of the magnesium safety clip, replace if necessary and note on log sheet install the weights (2) and check the cable tension

7. **Make the specified max. pressure and specified max. time calculations for this dive:** **when you have arrived on station,** make a decision about the water depth and the safety factor for this dive run “calculate_max_press_and_time” in matlab on laptop record “Bottom press P_{bot}”, “Assumed overshoot P_{over}”, “Safety allowance P_{safe}”, “Specified max. press.”, “Estimated dive time” and “Specified max. time” from Matlab output on log sheet take a second and make sure it makes sense	6. **Turn the instrument ON:** turn the instrument on by replacing the dummy plug by the shorting plug watch for the LED on the tip of the probe to start flashing (~ 30s) record the time as the “Dive start time” on the log sheet (i.e. when flashing).
8. Enter this dive's information in the 'setup.txt' file on the instrument: open setup.txt file by typing “edit setup.txt” in terminal window update the prefix field with station number (prefix format='jc29_station#_') enter max_time and max_pressure as calculated above into the appropriate fields save and exit by hitting “ESC” and hitting enter once to select “Leave Editor” and enter again to select “Save Changes”	7. **Throw it in the water** note time and position when VMP is released and estimate expected surface time on log sheet make an offering to the VMP gods
9. Test the setup.txt file: type “odas4ir -f setup.txt” at command line in terminal window check for any error messages if all is well, exit with “CTRL-C”	
10. Turn off the instrument and disconnect from the power supply: type “shutdown now” in the terminal window close the Putty terminal window wait 30 seconds **IF** the weight release battery has been charging for at least 20 minutes, turn instrument off by	

disconnecting the white plastic on-off switch turn off the power supply	
11. Test the instrument battery voltage: disconnect the instrument from the power supply using the voltmeter test the instrument battery voltage by measuring the voltage at the connector to the power supply (stick voltage meter probes where wires enter the plastic connector) record the main battery voltage on the log sheet **IF** voltage >~ 12.8 V OK to deploy; if less charge more (with plastic on-off switch disconnected)	

Appendix III (cont.)

VMP Sequence for Recovery

V1, UK DIMES2, 2nd December 2010

At the Laptop Station	On Deck
	1. ~ 10 minutes prior to expected surface time: send a look-out with the RAF to the top of the bridge all others to the bridge for look-out i.
	2. Find it! record date, time, ship position and range and bearing when spotted in the log sheet
	3. Get it on the deck: record the date, time and ship's position in the log sheet
1. Test the instrument battery voltage: connect the E/CRG cable to the instrument using the voltmeter test the instrument battery voltage by measuring the voltage at the instrument's connector to the power supply record the recovery battery voltage on the log sheet	**4. Turn the 4 recovery aids off and replace.**
2. Plug the instrument in and start it charging: connect the E/CRG charging cable to the power charger and turn on the power supply	**5. Replace tube full of millipore water from the wet lab on SeaBird conductivity cell**
3. Get the laptop talking to the instrument: **IF** it is not already connected, connect the ethernet cable on the E/CRG cable to the laptop	**6. Replace tape over 5 EM current meter probes**

turn the instrument on by connecting the plastic plug on the E/CRG cable	
4. FTP the data and log file from the instrument to the laptop: cd to /Users/mstar/JC054/VMPdata_NOCS/raw create new directory with station number as name cd to the new directory. ftp to the instrument: root@ 192.168.2.2, password rglr0x type prompt type 'mget jc054_station#*' type 'get setup.txt' type 'quit'	**7. Rinse with fresh water:** be gentle with the flow rate over the shear probes!
5. Once the file transfer is complete, turn off the instrument: disconnect the white plastic on-off switch on the E/CRG cable so it is in the “off” position leave the instrument plugged in to charge for the next dive note on log sheet when charging started and estimated completion time. Assign someone to turn it off and note who on log sheet.	**8. Turn the instrument off:** remove the shorting plug and connect the E/CRG charging cable to the instrument
6. Do a quick look of the data in Matlab on laptop: in station directory on matlab run “firstlook_jc054” inspect output and check for broken microstructure probes – IF microstructure probe needs replacing record on log sheet record max pressure of dive on log sheet (outputted at command line of matlab window) **IF** a probe needs to be replaced, note failed probe number, cause of failure, new probe number, channel on instrument, and calibration info for new probe if required on the log sheet and VMP probe log book. Update shear probe coefficients in template setup_calibration.txt file (in VMPdata dir). Copy template setup_calibration.txt to station directory (…/raw/station_no)	**9. Inspect the magnesium safety pin on the weight release** IF needed, replace and record on the log sheet. (Replace about every 2nd time)
7. Record remaining recovery details in the log sheet: record name and size of data files (.p) on log sheet open station .txt file and note method of dive end (pressure release? time release? other?) record on log sheet	

8. Archive: As soon as there is time: backup new station directory (raw data, .mat files and firstlook figs) print output figures from “firstlook_jc054” and put in red VMP binder with log sheet	

Appendix IV. Cruise Summary Report (ROSCOP)

CRUISE SUMMARY REPORT	*FOR COLLATING CENTRE USE* **Centre: BODC Ref. No.:** Is data exchange restricted ☐ Yes ☐ In part ☐ No

SHIP enter the full name and international radio call sign of the ship from which the data were collected, and indicate the type of ship, for example, research ship; ship of opportunity, naval survey vessel; etc.

Name: RRS James Cook **Call Sign: MLRM6**

Type of ship: Research Vessel

CRUISE NO. / NAME JC054 enter the unique number, name or acronym assigned to the cruise (or cruise leg, if appropriate).

CRUISE PERIOD start 28/Nov/2010 to 8/Jan/2011 end
(set sail) day/ month/ year day/ month/ year (return to port)

PORT OF DEPARTURE (enter name and country) **Punta Arenas, Chile**

PORT OF RETURN (enter name and country) **Punta Arenas, Chile**

RESPONSIBLE LABORATORY enter name and address of the laboratory responsible for coordinating the scientific planning of the cruise

Name: National Oceanography Centre
Address: NOC, European Way, Empress Dock, Southampton SO14 3ZH
Country: U.K.

CHIEF SCIENTIST(S) enter name and laboratory of the person(s) in charge of the scientific work (chief of mission) during the cruise.

Dr. Michael Meredith, British Antarctic Survey

OBJECTIVES AND BRIEF NARRATIVE OF CRUISE enter sufficient information about the purpose and nature of the cruise so as to provide the context in which the report data were collected.

This cruise was the second UK cruise undertaken as part of the joint UK-US DIMES (Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean) programme. DIMES is motivated by a need to quantify and understand the rates of mixing in the Southern Ocean, so as to better determine the impacts on large-scale ocean circulation and climate. The fieldwork element of the DIMES programme involves a tracer release in the SE Pacific sector of the Southern Ocean, with a number of subsequent cruises tracking the spreading and mixing of the tracer as it flows over the relatively smooth topography up to Drake Passage, and then the rougher topography through Drake Passage and into and through the Scotia Sea. There are also large-scale deployments of RAFOS floats, surface drifters, and some EM-APEX float deployments, as well as hydrographic and mooring elements, and vertical profiling of turbulence with VMPs.

The UK2 DIMES cruise had the objectives of:-

1) retrieving and redeploying the DIMES mooring cluster in the eastern Drake Passage/Scotia Sea
2) conducting a short deployment of a mooring supplied by the Scottish Association for Marine Science (SAMS)
3) conducting a grid of CTD/VMP/tracer measurements at the site of the moorings cluster
4) conducting sections of CTD/VMP/tracer stations in Drake Passage, and along lines at 79W and 88W in the SE Pacific
5) deploying RAFOS floats, surface drifters and EM-APEX floats to enhance the DIMES float & drifter programmes, and to retrieve high temporal resolution vertical profiles of hydrographic properties and velocity.

PROJECT (IF APPLICABLE) if the cruise is designated as part of a larger scale cooperative project (or expedition), then enter the name of the project, and of organisation responsible for co-ordinating the project.

Project name: Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES)

Coordinating body: Natural Environment Research Council (UK); National Science Foundation (US)

PRINCIPAL INVESTIGATORS: Enter the name and address of the Principal Investigators responsible for the data collected on the cruise and who may be contacted for further information about the data. (The letter assigned below against each Principal Investigator is used on pages 2 and 3, under the column heading ‘PI‘, to identify the data sets for which he/she is responsible)

A. Jean-Baptiste Sallee, British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, U.K.

B. Marie-Jose Messias, University of East Anglia, Norwich, NR4 7TJ, U.K.

C. Jim Ledwell, Department of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, U.S.A.

D. Alberto Naveira Garabato, National Oceanography Centre, European Way, Southampton, SO14 3ZH, U.K.

E. Kevin Speer & Stephanie White, Department of Oceanography, Florida State University, Florida, U.S.A.

F. Andreas Thurnherr, Lamont-Doherty Earth Observatory, Palisades, NY 10964, U.S.A.

G. Mark Inall, Scottish Association for Marine Science (SAMS), Oban, Scotland, U.K.

MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS

This section should be used for reporting moorings, bottom mounted gear and drifting systems (both surface and deep) deployed and/or recovered during the cruise. Separate entries should be made for each location (only deployment positions need be given for drifting systems). This section may also be used to report data collected at fixed locations which are returned to routinely in order to construct ‘long time series‘.

PI	APPROXIMATE POSITION						DATA TYPE	DESCRIPTION
	LATITUDE			LONGITUDE			enter code(s) from list on last page.	Identify, as appropriate, the nature of the instrumentation the parameters (to be) measured, the number of instruments and their depths, whether deployed and/or recovered, dates of deployments and/or recovery, and any identifiers given to the site.
See top of page.	deg	min	N/S	deg	min	E/W		
D	55	58.04	S	57	44.60	W	D01,D90	Site NE, recovered 0712 6 December 2010 Redeployed 2010 December 2010 SBE37 SMP (4), SBE37 IMP (1), Seaguard CM (3), Nortek CM (1), RCM-11 (1)
D	56	0.36	S	57	44.80	W	D01,D90	Site SE, recovered 1310 6 December 2010 Redeployed 20 December 2010 Seaguard CM (4), SBE37 SMP (4), SBE37 IMP (1), Sontek CM (1)
D	56	1.39	S	57	47.20	W	D01,D90	Site M, recovered 1733 7 December 2010 Redeployed 19 December 2010 RAFOS sound source (1), Sontek CM (2), SBE37 IMP (2), McClane Moored Profiler (2)
D	56	3.78	S	57	54.0	W	D01,D90	Site SW, recovered 0826 7 December 2010 Redeployed 19 December 2010 Seaguard CM (4), SBE37 SMP (5), Nortek CM (1)
D	56	0.78	S	57	49.2	W	D01,D90	Site C, recovered 1425 7 December 2010 Redeployed 18 December 2010 SBE37 SMP (12), Nortek CM (12), Long Ranger ADCP (1)
D	55	57.72	S	57	41.4	W	D01,D90	Site NW, recovered 2030 7 December 2010 Redeployed 19 December 2010 Seaguard CM (4), SBE37 SMP (5), Sontek CM (1)
G	56	1.002	S	57	48.57	W	D01,D90	SAMS mooring, Deployed 1505, 8 December 2010 Recovered 1608, 18 December 2010 Thermistor chain, Workhorse Sentinel ADCP
E	55	50.94	S	58	10.30	W	D05	10/12/10 15:51
E	55	49.77	S	58	14.06	W	D05	10/12/10 16:05

E	55	48.92	S	58	16.67	W	D05	10/12/10 16:15
E	55	47.51	S	58	20.99	W	D05	10/12/10 16:31
E	56	02.63	S	58	03.49	W	D05	22/12/10 16:23
E	56	03.46	S	57	53.63	W	D05	22/12/10 17:40
E	56	04.20	S	57	44.41	W	D05	22/12/10 19:16
E	56	05.32	S	57	34.90	W	D05	22/12/10 20:08
E	56	06.11	S	57	25.36	W	D05	22/12/10 21:00
E	56	07.07	S	57	15.74	W	D05	22/12/10 21:46
E	63	00.64	S	78	59.97	W	D05	03/01/11 00:54
E	62	19.78	S	78	59.99	W	D05	03/01/11 10:18
E	60	59.92	S	79	04.07	W	D05	03/01/11 23:04
E	60	31.95	S	78	56.96	W	D05	04/01/11 07:56
E	59	47.85	S	78	59.98	W	D05	04/01/11 14:36
E	59	04.31	S	79	60.03	W	D05	04/01/11 21:34
E	58	26.01	S	78	58.29	W	D05	05/01/11 07:58
E	57	08.31	S	79	00.19	W	D05	05/01/11 21:18
E	56	31.30	S	79	12.00	W	D05	06/01/11 07:26
								CONTINUED ON SEPARATE SHEET
								Please continue on separate sheet if necessary

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN

Except for the data already described on page 2 under 'Moorings, Bottom Mounted Gear and Drifting Systems', this section should include a summary of all data collected on the cruise, whether they be measurements (e.g. temperature, salinity values) or samples (e.g. cores, net hauls).

Separate entries should be made for each distinct and coherent set of measurements or samples. Different modes of data collection (e.g. vertical profiles as opposed to underway measurements) should be clearly distinguished, as should measurements/sampling techniques that imply distinctly different accuracy's or spatial/temporal resolutions. Thus, for example, separate entries would be created for i) BT drops, ii) water bottle stations, iii) CTD casts, iv) towed CTD, v) towed undulating CTD profiler, vi) surface water intake measurements, etc.

Each data set entry should start on a new line – it's description may extend over several lines if necessary.

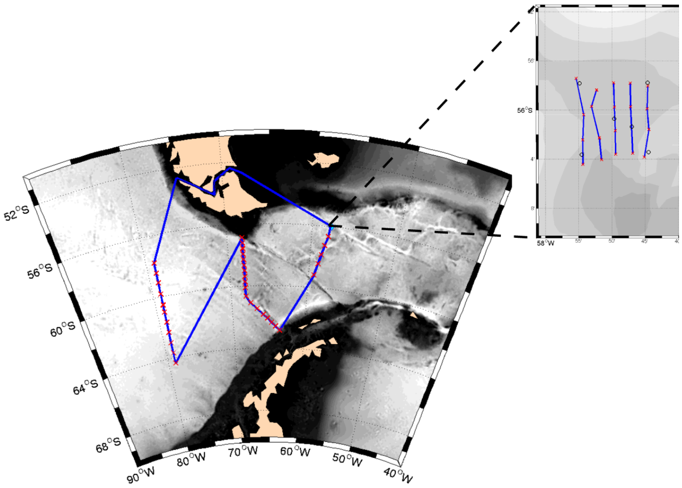
NO, UNITS : for each data set, enter the estimated amount of data collected expressed in terms of the number of 'stations'; miles' of track; 'days' of recording; 'cores' taken; net 'hauls'; balloon 'ascents'; or whatever unit is most appropriate to the data. The amount should be entered under 'NO' and the counting unit should be identified in plain text under 'UNITS'.

PI see page 2	NO see above	UNITS see above	DATA TYPE Enter code(s) from list on last page	DESCRIPTION Identify, as appropriate, the nature of the data and of the instrumentation/sampling gear and list the parameters measured. Include any supplementary information that may be appropriate, e. g. vertical or horizontal profiles, depth horizons, continuous recording or discrete samples, etc. For samples taken for later analysis on shore, an indication should be given of the type of analysis planned, i.e. the purpose for which the samples were taken.
A	57	Stations	H10	CTD stations conducted with SBE911+ profiler mounted on a 24-bottle rosette frame. Salt samples taken for calibration for each station from a subset of the 24 bottles available.
F	57	Stations	D71	Lowered ADCP measurements were recovered at each of the CTD sites
D	36	Stations	H10, D90	Vertical turbulence and hydrographic measurements conducted with WHOI and NOC Vertical Microstructure Profilers
B	57	Stations	H73	Water samples were drawn from each station and analysed by gas chromatography for concentration of the purposefully-released DIMES tracer, trifluoromethyl sulphur pentafluoride
D			H71 G73 G74 M90 M06	Underway thermosalinograph, shipboard ADCP, single-beam echosounder, multibeam echosounder and meteorological measurements were made along the shiptrack.

TRACK CHART: **You are strongly encouraged to submit, with the completed report, an annotated track chart illustrating the route followed and the points where measurements were taken.**

Insert a tick(✔) in this box if a track chart is supplied ☑

Cruise track (blue), CTD/tracer stations (red cross) and mooring sites (black circle).:-



GENERAL OCEAN AREA(S): Enter the names of the oceans and/or seas in which data were collected during the cruise – please use commonly recognised names (see, for example, International Hydrographic Bureau Special Publication No. 23, 'Limits of Oceans and Seas').

Scotia Sea, Drake Passage, Southeast Pacific

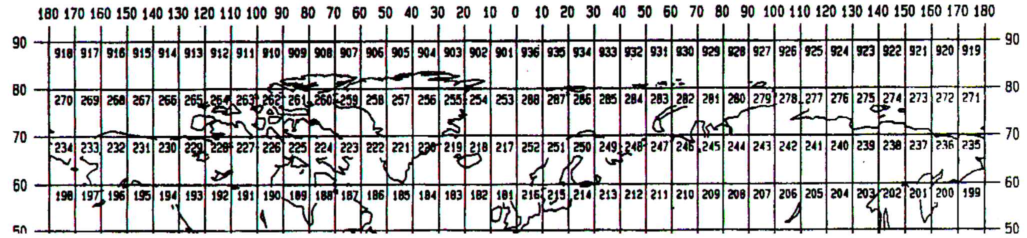
SPECIFIC AREAS: If the cruise activities were concentrated in a specific area(s) of an ocean or sea, then enter a description of the area(s). Such descriptions may include references to local geographic areas, to sea floor features, or to geographic coordinates.

Please insert here the number of each square in which data were collected from the below given chart

486, 485, 522, 523, 487,

GEOGRAPHIC COVERAGE - INSERT 'X' IN EACH SQUARE IN WHICH DATA WERE COLLECTED

°West see above °East



918	917	916	915	914	913	912	911	910	909	908	907	906	905	904	903	902	901	936	935	934	933	932	931	930	929	928	927	926	925	924	923	922	921	920	919
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PARAMETER CODES

METEOROLOGY

M01	Upper air observations
M02	Incident radiation
M05	Occasional standard measurements
M06	Routine standard measurements
M71	Atmospheric chemistry
M90	Other meteorological measurements

PHYSICAL OCEANOGRAPHY

H71	Surface measurements underway (T,S)
H13	Bathythermograph
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T,S)
H72	Thermistor chain
H16	Transparency (eg transmissometer)
H17	Optics (eg underwater light levels)
H73	Geochemical tracers (eg freons)
D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys
D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements

CHEMICAL OCEANOGRAPHY

H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total - P
H24	Nitrate
H25	Nitrite
H75	Total - N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

MARINE CONTAMINANTS/POLLUTION

P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements

MARINE BIOLOGY/FISHERIES

B01	Primary productivity
B02	Phytoplankton pigments (eg chlorophyll, fluorescence)
B71	Particulate organic matter (inc POC, PON)
B06	Dissolved organic matter (inc DOC)
B72	Biochemical measurements (eg lipids, amino acids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs & larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements

MARINE GEOLOGY/GEOPHYSICS

G01	Dredge
G02	Grab
G03	Core - rock
G04	Core - soft bottom
G08	Bottom photography
G71	In-situ seafloor measurement/sampling
G72	Geophysical measurements made at depth
G73	Single-beam echosounding
G74	Multi-beam echosounding
G24	Long/short range side scan sonar
G75	Single channel seismic reflection
G76	Multichannel seismic reflection
G26	Seismic refraction
G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements

MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS (CONTINUED)

This section should be used for reporting moorings, bottom mounted gear and drifting systems (both surface and deep) deployed and/or recovered during the cruise. Separate entries should be made for each location (only deployment positions need be given for drifting systems). This section may also be used to report data collected at fixed locations which are returned to routinely in order to construct 'long time series'.

PI	APPROXIMATE POSITION						DATA TYPE	DESCRIPTION
	LATITUDE			LONGITUDE				
See top of page.	deg	min	N/S	deg	min	E/W	enter code(s) from list on last page.	Identify, as appropriate, the nature of the instrumentation the parameters (to be) measured, the number of instruments and their depths, whether deployed and/or recovered, dates of deployments and/or recovery, and any identifiers given to the site.
E	56	05.25	S	57	34.85	W	D06	RAFOS float; 22/12/10 20:05
E	56	06.09	S	57	15.77	W	D06	RAFOS float; 22/12/10 20:59
E	60	59.92	S	79	04.07	W	D06	3x RAFOS floats; 03/01/11 22:53
E	60	31.86	S	78	59.85	W	D06	3x RAFOS floats; 04/01/11 02:30
E	59	04.31	S	79	60.03	W	D06	3x RAFOS floats; 04/01/11 21:20
E	58	25.70	S	79	00.00	W	D06	3x RAFOS floats; 05/01/11 18:32
E	57	47.16	S	79	00.07	W	D06	3x RAFOS floats; 05/01/11 16:28
E	56	53.43	S	79	18.09	W	D06	3x RAFOS floats; 06/01/11 03:35
E	56	31.30	S	79	12.00	W	D06	RAFOS float; 06/01/11 07:31
D	57	34.25	S	68	11.02	W	D01, D05, D90	2x EM-APEX floats (4976 & 4977); 31/12/10 12:18
E	57	34.4	S	68	11.1	W	D05, D90	2x APEX floats; 31/12/10 12:17
								Please continue on separate sheet if necessary