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Cruise Report No. 38

RRS *James Clark Ross* Cruise JR15003

17 DEC – 13 JAN 2016

Hydrographic measurements on GO-SHIP line SR1b
and investigations of circulation and isotope cycles
in coastal West Antarctica

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2016

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ABSTRACT

This cruise comprised work contributing to five projects. The twenty-first complete occupation of the Drake Passage GO-SHIP section SR1b obtained full-depth temperature, salinity, and lowered ADCP velocity profiles at 28 stations, along with underway measurements, with the objectives of investigating and monitoring interannual variability and trends in Antarctic Circumpolar Current structure and property transports and Southern Ocean water mass properties. Turnarounds of bottom pressure recorder (BPR) moorings contributed to the long time series of bottom pressure in Drake Passage.

Biogeochemically-equipped Argo floats were deployed as part of the Southern Ocean Carbon and Climate Observations and Modelling (SOCCOM) project to increase climate-quality observations in the Southern Ocean. Gliders were deployed over the Western Antarctic Peninsula continental shelf to measure properties and circulation with the aim of understanding flow and mixing of warm waters onto the shelf. Hydrographic profiles and water column and sediment samples taken over the continental shelf will be used to investigate stable isotope nutrient cycling processes.

KEYWORDS

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1 Personnel

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Derek Lee	Senior Steward
James Newall	Steward
Thomas Patterson	Steward
Roger Route	Steward

2 Itinerary and Cruise Track

JR15003 sailed from Port Stanley, Falkland Islands on 17 December 2015, called at three of the South Orkney Islands December 20-22, at Rothera 28 December - 2 January, 2016, at Vernadsky on 4 January, and returned to Port Stanley on 13 January 2016. Science operations were conducted on both the southbound leg along the western Antarctic Peninsula between 24 December and 28 December, and the northbound leg in Drake Passage between 6 January and 11 January, along with standard underway sampling during much of the time at sea. The cruise track and sites of science work are shown in Figure 2.

3 Objectives

RRS *James Clark Ross* cruise JR15003 included work contributing to five projects:

- What causes the influx and mixing of warm waters on polar ocean shelves?
  A Brearley, M Meredith, and M Inall, BAS
  To deploy gliders to measure water mass properties and circulation on the West Antarctic Peninsula continental shelf.

- Understanding the cycling of stable isotopes in coastal Antarctic waters
  K Hendry and L Cassarino, U Bristol; S Henley, U Edinburgh; Y Firing, NOC; R Mills and T Stichel, U Southampton; M Meredith, BAS
  To sample the stable isotope composition of nitrogen, silicon, and neodymium through the water column and in the upper sediments in order to understand the key biological and non-biological processes setting these profiles in different parts of the western Antarctic Peninsula continental shelf.

- Continuous Ocean Monitoring Methods: Drake Passage
  S Mack, NOC
  To maintain the long time-series of transport through Drake Passage by recovering and redeploying two bottom pressure recorders (BPRs), one on either side of the passage.

- Hydrographic measurements in Drake Passage
  Y Firing, NOC
  To make high-quality repeat hydrographic measurements on GO-SHIP line SR1b, continuing a near-annual time series begun in 1993, as part of the Drake Passage repeat hydrography National Capability programme designed to monitor Southern Ocean watermasses and Antarctic Circumpolar Current volume and property transport; to obtain complementary station and underway currents and underway meteorology.

- Southern Ocean Carbon and Climate Observations and Measurements (SOCCOM)
  L Talley and A Dickson, Scripps Institution of Oceanography; S Riser, U Washington; K Johnson, MBARI; E Boss, U Maine; R Feely, NOAA PMEL; L Juranek, Oregon State U; J Sarmiento and R Key, Princeton U
  To increase the sampling of physical and biogeochemical parameters in the Southern Ocean by deploying four biogeochem-equipped Apex floats and acquiring climate-quality calibration measurements.

The glider work was funded by NERC. The BPR and hydrography components are part of National Capability projects funded by NERC. The isotope cycling experiment was funded by NERC through the BAS Collaborative Gearing Scheme (CGS, now Collaborative Antarctic Science Scheme). SOCCOM is funded by the USA National Science Foundation and float deployment was performed opportunistically alongside the NERC-funded hydrography.

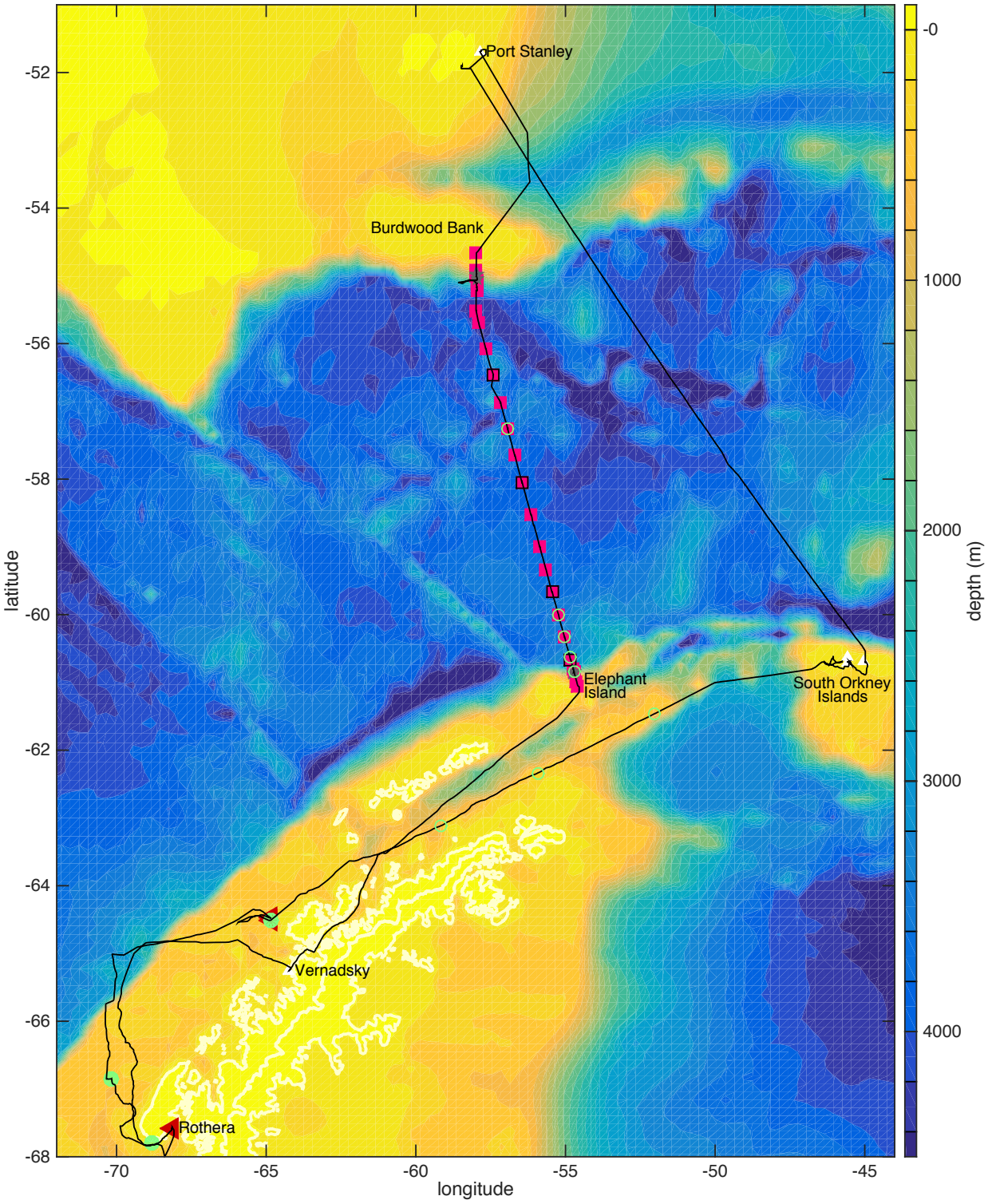

Figure 1: JR15003 cruise track with glider deployment sites (red triangles), CGS CTD sites (filled green circles), CGS underway surface Nd sampling (open green circles), BPRs (gray stars), SR1b CTD sites (magenta squares), and float deployment sites (black square outlines).

4 Narrative

Yvonne Firing

JR15003 sailed from Port Stanley, Falkland Islands the evening of 17 December 2015 in calm conditions, headed for the South Orkney Islands. Underway data logging, including VMADCP and tsg, commenced on 18 December. It took a bit of trial and error to find a useable configuration of the acoustic sampling run through the k-sync program, as the previous year's configuration did not seem to work. The ship called at South Powell Island on 20th December, dropping off a field party of three, and allowing some of the scientists and fids to visit the island for a few hours. At Signy the following day four fids disembarked, and most science and passengers visited the station, where we were kindly provided with a tour of the area. Finding and setting up a camp at Coronation Island on 22 December proved challenging due to ice conditions (which slowed operations around the South Orkneys in general), but in the end the two scientists and their gear were landed and settled in. Late on the 22nd we were again underway headed for the first planned glider deployment site off Anvers Island. Some wind, sea, and swell were encountered on the 24th, and the VMADCP was turned off in favour of obtaining swath bathymetry data along a new track.

Due to ice conditions the JCR took a course outside Anvers Island, and we decided to move the first glider deployment location and CTD/sediment core site from Palmer Deep to off the western tip of Anvers Island. The first glider deployment, in the early hours of 25 December, went smoothly, with a successful test dive. We did a CTD cast including water sampling for nutrients and trace metals adjacent to the glider deployment site, followed by a sediment core. However, as we were continuing southward several hours later, the glider data indicated that it had leaked. We therefore returned to recover it, and deployed the second glider at that site. A forensic examination of the first glider did not reveal a reason for the leak. Up-to-date satellite imagery was limited due to cloud cover but appeared to indicate continued heavy ice over the continental shelf; therefore we abandoned plans to deploy a second glider and CTD with nutrient sampling between Anvers and Adelaide and attempted to go around the ice until closer to Adelaide Island. Progress toward Rothera was slow through 3/10 to 8/10 ice, exacerbated by a problem with one of the two main engines. Our next planned CTD site was completely ice-covered but we found open water just 6 kilometers to the southeast, and were able to conduct a CTD cast and sediment core at a comparable depth there on 27th December.

As the first glider hull appeared to be in good shape and the electronics undamaged, o-rings were changed and it was decided to deploy it in Ryder Bay for test dives, with the hope that it could then be sent out onto the shelf to complete some of the original sampling plan throughout the summer. Upon our arrival in Ryder Bay early on the morning of the 28th, we found that our last southbound CTD site, the RaTS site, was also too icy, and therefore moved to the backup RaTS site a few km away to redeploy the first glider and do a CTD cast and sediment core. On the first two core attempts a small rock was stuck in the corer jaws, so the sediment leaked out; however the third attempt recovered enough mud to work with.

The JCR was alongside at Rothera from 28th December to 2nd January, 2016, performing cargo resupply for the station. The NOCL technicians also serviced the Rothera tide gauge during this call. Due to ice damage to the wharf the fore and aft decks had to be offloaded separately. The station personnel generously organised crevassing and skiing expeditions for the ship party and welcomed us to their New Year's Eve celebrations as well as dinner exchanges with outgoing and incoming winterers. During the Rothera call the glider in Ryder Bay became stuck under ice, but otherwise at first appeared to be functioning as designed. On the 1st, however, the leak detect flagged again. The glider was therefore recovered by the JCR upon departure from Rothera on the morning of 2nd January.

We then headed offshore, emerging from the ice late on the 3rd, and coming into Verndasky the morning of the 4th. There the NOCL technicians serviced the tide gauge and the science party, officers, and crew were treated to the station hospitality. We departed Vernadsky on the evening of the 4th and passed Elephant Island early on the 6th. The SR1b CTD stations were begun at 0600 on the 6th. CTD casts over the slope were only conducted to 30 m above the bottom due to fluctuating echosounder depth readings. The SACCF appears to have been relatively far south, as the influence of CDW was visible

early on, before SR1b site 6 (cast 009). At this point it was discovered that the LADCP beam 2 had been bad (unnoticed earlier, as reasonable solutions were still obtained from 3 beams). The LADCP was switched for the spare unit before cast 007.

The south slope BPR at first did not respond to acoustic transmissions, but did respond to the ship's transponder, implying an issue with the NOCL deck unit. Following this the release and recovery, and deployment of the replacement, went smoothly.

The CTD power cable between the rosette swivel and the CTD had to be replaced as it was smashed (broken connector and bent pin) just below the swivel, apparently due to hitting the insufficently-opened roller door over the water sampling bay. The data do not appear to have been affected.

Floats were deployed following CTD casts 009, 012, 016, and 020 (SR1b sites 6, 9, 13, and 17). In addition to the calibration water samples taken at the four float deployment stations, oxygen samples were taken at 11 additional sites (casts 004, 006, 008, 010, 011, 015, 017, 019, 021, 028 and 029) for calibration of the CTD oxygen sensor.

Following some misfired bottles on early casts we decided to rinse and clean the bottle carousel more frequently. The CTD secondary temperature and conductivity sensors on cast 016 looked bad, but the problem was solved by flushing with a detergent solution.

In mid-passage the passage the weather worsened, with forecasts predicting rougher conditions toward the end of our science time. We had a weather delay of approximately 4 hours on the 8th, moving on after the 10th SR1b station (13th cast of the cruise) to a station halfway between the originally-planned 11th and 12th SR1b stations, and then to the originally-planned 13th station (thus, a spacing of 2 rather than 3 stations over 70 km). Following this, with the forecast still predicting more heavy weather, station spacing was increased from the nominal 20 nm to 25 nm to make progress across the passage.

We stopped work and hove to for weather mid-day on the 10th, stopping the underway sampling at approximately 2000Z as we approached the Argentine EEZ. We resumed at 0900Z on the 11th with a CTD cast in 2200 m, still in some wind and swell. As the conditions were then improved enough to consider BPR operations, we first visited the BPR at 2000 m to check its communications and battery levels, which were good. We then moved on to the 1000 m BPR, which was successfully recovered and replaced. A nearby BPR which failed to release in 2013 proved to be still communicating, but did not release. CTD stations were resumed starting at 1700 m, and finished at 2100 on 11 January. The swell picked up for our steam over Burdwood Bank, supplying additional liveliness to the end-of-cruise festivities, but by the following day wind and seas had abated enough for the ship to take care of unwinding and respooling a winch cable from a previous cruise. We returned to Port Stanley the morning of the 13th.

5 Slocum glider deployments

Alexander Brearley, Alvaro Lorenzo Lopez

Two Slocum gliders from the National Marine Equipment Pool were deployed on the southbound leg of JR15003, as part of the project "What causes the influx and mixing of warm waters on polar ocean shelves?", led by Alexander Brearley. The first glider, serial number 438 and named Frazil, incorporated pumped Seabird CTD, WetLabs Ecopuck, Satlantic PAR sensor, Aanderaa oxygen optode and thruster. The second, serial number 331 and named Coprolite, incorporated unpumped Seabird CTD, WetLabs Ecopuck and oxygen optode. Both gliders had previously been ballasted in Oban during the BAS trials week on 22 to 26 June 2015. Standard functional checkouts were completed on the transit south from Stanley at the start of the cruise.

5.1 Glider 438

It was initially planned to deploy 438 in Palmer Deep, and 331 just to the northwest of Adelaide Island. However, inspection of in situ ice conditions and SAR satellite images of the Peninsula revealed extensive sea ice close to the planned deployment sites. The first deployment site was thus moved to west of Anvers Island and Glider 438 was deployed at 64°30.478S, 64°50.868W at 0430Z on 25 December 2015. The ice coping software was loaded onto the gliders using loadmission ice.mi, and the mission filename for this season is shelf.mi. A concurrent CTD was completed at the site.

Unfortunately, at 0956Z, the glider aborted for a leak in the aft compartment. The JCR scrambled and recovered the glider at 1454Z on 25 December 2015. Subsequent inspection of the aft compartment revealed a trickle of salt crystals from close to the rear leak detector into the rear hull, and a significant pool of water sitting under the Teflon protecting the steatite battery. No evidence of O-ring damage was apparent, but we removed and changed out all the aft compartment O-rings as a precaution. As we had not definitively determined the root cause of the leak, we decided to redeploy in Ryder Bay where small-boat support was available from Rothera.

The glider was redeployed at 67°34.476S, 68°08.392W on 28 December 2015 at 0910Z (immediately before the final CTD site). We chose two closely spaced waypoints in Ryder Bay. Unfortunately, after two dives, the glider became stuck under a layer of sea ice, and no communications were received until 0541Z on 29th December (abort for MS_ABORT_NO_TICKLE_ICE). By this time, the glider had drifted significantly to a point between Leonie and Kirsty Island. Efforts to get the glider back into Ryder Bay were inhibited by further glider aborts for the thruster and digifin (presumably because both became stuck in ice). The glider finally returned to deep water around 2000Z on the 29th December, but aborted again for a leak in the aft compartment at round 2130Z at 277 m depth. An unsuccessful attempt to recover the glider was made early on the 30th using the Rothera rib Nimrod, but the site could not be reached because of heavy sea ice. Leaving the glider on a surface callback script, we tracked the glider as it drifted quickly southwards over the next three days (on lastgasp.mi), ultimately reaching a position to the south of Adelaide Island. By this stage, we were concerned that the glider was approaching a line of heavy sea ice, beyond which it may have become unrecoverable. We thus programmed the glider to do shallow dives (initially to 10 m, later to 100 m, with 3 yos) to prevent further southward drift. The glider was collected by the JCR after its departure from Rothera after relief, at around 1345Z on January 2nd, at a position of 67°59.567S, 68°23.449W. The source of the leak has still not been identified, so we will conduct a closer analysis once back in the UK.

5.2 Glider 331

It had initially been planned to deploy 331 to the northwest of Adelaide Island. However, upon the failure of 438, it was deployed close to the original deployment position of 438, at 64°28.700S, 64°50.787W at 1600Z. No significant issues were encountered with 331 during the duration of the cruise, other than the altimeter terminating dives slightly early (∼100-200 m from the bottom). We resolved this

by setting:
sensor: u_alt_reqd_good_in_a_row(nodim) 5
in the yo11.ma file.

Piloting logs

Piloting notes for each glider were maintained on the Cambridge dockserver, under /home/localuser/438_pilot_log and /home/localuser/331_pilot_log.

6 CGS: Understanding the cycling of stable isotopes in coastal Antarctic waters

Sian Henley, Lucie Cassarino, Tianyu Chen, Yvonne Firing

6.1 Objectives

The aim of this CGS project was to examine the biogeochemical cycling of silicon (Si) and nitrogen (N) in surface waters, throughout the water column and in sediments along the west Antarctic Peninsula. Stable isotopic signatures of silicon and nitrogen in each of the different biogeochemical system components will be used to understand biological production, remineralisation and nutrient recycling processes occurring during sinking and sedimentation of organic matter. Neodymium (Nd) isotopes will be used to trace relevant water masses and local freshwater inputs, with relevance for trace metal fluxes to the water column. These two work packages combined will inform on processes influencing biological drawdown of carbon in this climatically and environmentally-sensitive region, as well as providing insight into the past.

6.2 Project report

Water column sampling and sediment box-coring were conducted at three sites along the Antarctic Peninsula, listed in Table 1 and shown in Figure 2.

Table 1: CGS CTD and sediment core sites.

Station	Latitude	Longitude	Depth (EM122)
001	64 30.5391S	64 50.8731W	594 m
002	66 50.9766S	70 09.9624W	565 m
003	67 34.9440S	68 08.7666W	388 m

Water column samples were taken in full depth profiles and were processed in the main laboratory. Oxygen isotope samples were taken first, followed by nutrients, particulates, Nd isotopes and salts. Oxygen isotope samples were taken into glass bottles, which were crimp-sealed immediately and stored in the dark at +4C. Nutrient samples were filtered through 0.2 um supor membrane filters. Nutrient and nitrate isotope samples were snap-frozen at -80C then stored at -20C. Silicic acid samples were stored in the dark at +4C. Particulate organic carbon (POC) and nitrogen (PON) samples were obtained by filtration using GF/F filters and a custom-built overpressure system. Samples were snap-frozen at -80C and stored at -20C. This large volume filtration was also conducted using polycarbonate filters; filtrate was acidified with HCl (1mL/L) and stored in the dark for Nd isotope analysis, whilst filters were stored in the dark at +4C for biogenic silica analysis. Salts samples to calibrate the shipboard CTD were taken into glass bottles, brought to room temperature at least overnight and analysed onboard using the ships Guildline Autosal instrument (described in Section 8.2).

Upper sediment samples were collected at each CTD station by box-coring. Interface waters were collected immediately, then sub-cores were taken from the box core for pore fluid extraction and core sectioning. Pore fluids were extracted using rhizon syringe filters every 2 cm and were stored for analysis of nutrient concentrations, Si isotopes and N isotopes as for sea water samples. Separate cores were sectioned in 2 cm intervals, and stored at +4C, for analysis of sedimentary Si and N isotopes.

All samples have been processed and shipped back to the UK for analysis. As such, there are no preliminary results to be included in this cruise report.

6.3 Comments and recommendations

CGS-109 was completed successfully as part of cruise JR15003. Ice conditions dictated that all three proposed sites had to be moved, but this was done in consultation with the Captain, and without

compromising the scientific objectives. A fourth water column sampling station was lost due to logistic constraints, but this again did not compromise the objectives set out in the bid.

All sampling and processing was completed successfully within the time constraints of the cruise. Large volume filtration of water column samples was time-consuming and could be optimised for future work of this type. Nutrient filtrations were complete within one hour of sampling and POC filtrations were complete within four hours. Samples were kept in the dark at +4 C to limit biological activity and upper ocean samples were processed first. For Station 001, Nd and biogenic silica filtrations were completed within 12 hours of sampling. For Stations 002 and 003, samples were kept in the dark at +4 C and were processed within 36 hours of sampling. For future cruises where samples for both biogenic silica and Nd are required, a recommendation would be that these filtrations should not be combined. Nd samples should be filtered through large-diameter filters, due to their large volume requirement, whilst biogenic silica samples should be filtered using 25 mm polycarbonate filters.

Box cores were taken successfully at all three stations. At Station 003, three attempts were necessary to take a successful box core, due to rocks preventing full closure on the first two attempts. More detailed echo-sounding using the TOPAS system onboard JCR might be used in future to prevent this occurrence, although the presence of small dropstones is an inevitable possibility in the nearshore Antarctic.

All samples are expected to be analysed and the data available 24 months from sampling, in agreement with NERC protocols.

7 Continuous Ocean Monitoring Methods: Drake Passage

Jeff Pugh and Emlyn Jones

A BPR was recovered and a new one deployed at both the south and north sides of the passage. Communications with the BPR at 2000 m on the northern slope were successful. Details are available in NOC cruise report No. 58, "Sea Level and Bottom Pressure Measurements in Drake Passage and the Southern Ocean".

8 Hydrographic Measurements

Yvonne Firing

The 31 CTD casts, including 3 contributing to the CGS project and 28 on SR1b, are summarised in Table 2.

Table 2: CTD stations times and positions, with number of bottle salinity and oxygen samples obtained for calibrating CTD sensors.

station	date	bottom time (UTC)	latitude	longitude	water depth	CTD max press	N_{salt}	N_{oxy}
1	2015/12/25	06:12	-64.5090	-64.8479	589	587	6	0
2	2015/12/27	06:12	-66.8497	-70.1708	566	562	6	0
3	2015/12/28	10:12	-67.8036	-68.8146	387	383	6	0
4	2016/01/06	09:01	-61.0500	-54.5878	361	356	6	6
5	2016/01/06	11:01	-60.9811	-54.6299	582	580	6	0
6	2016/01/06	13:01	-60.8502	-54.7102	974	975	8	6
7	2016/01/06	18:01	-60.8332	-54.7217	1735	1731	10	0
8	2016/01/06	20:01	-60.7995	-54.7424	2649	2664	8	6
9	2016/01/07	01:01	-60.6666	-54.8248	3094	3136	24	24
10	2016/01/07	06:01	-60.3333	-55.0313	3437	3489	12	6
11	2016/01/07	11:01	-60.0112	-55.2300	3496	3548	11	7
12	2016/01/07	16:01	-59.6667	-55.4444	3674	3732	23	24
13	2016/01/07	20:01	-59.3332	-55.6512	3755	3815	12	0
14	2016/01/08	01:01	-58.9998	-55.8581	3776	3833	12	0
15	2016/01/08	10:01	-58.5246	-56.1543	3787	3845	10	6
16	2016/01/08	16:01	-58.0500	-56.4466	3970	4035	23	23
17	2016/01/08	21:01	-57.6537	-56.6892	3467	3518	12	6
18	2016/01/09	02:01	-57.2588	-56.9334	3949	4013	12	0
19	2016/01/09	08:01	-56.8639	-57.1778	3014	3053	12	6
20	2016/01/09	13:01	-56.4685	-57.4128	3826	3886	24	24
21	2016/01/09	18:01	-56.0756	-57.6656	3847	3908	13	6
22	2016/01/10	00:01	-55.6817	-57.9093	4524	4604	11	0
23	2016/01/10	04:01	-55.5167	-57.9829	4211	4279	12	0
24	2016/01/10	09:01	-55.2154	-57.9622	3928	3985	12	0
25	2016/01/10	12:01	-55.1686	-57.9680	3106	3148	11	0
26	2016/01/10	15:01	-55.1171	-57.9682	2691	2721	8	0
27	2016/01/11	10:01	-55.0685	-57.9750	2186	2209	8	0
28	2016/01/11	12:01	-55.0067	-57.9782	1673	1683	8	8
29	2016/01/11	17:01	-54.9779	-57.9827	1062	1063	8	8
30	2016/01/11	18:01	-54.9224	-57.9825	712	711	6	0
31	2016/01/11	20:01	-54.6668	-57.9830	166	158	4	0

8.1 CTD Systems Operation

One stainless steel CTD system was prepared with a 24-way carousel. The details of the instrumentation are given in Section 11.

The instrumentation on the underwater package operated normally on the 31 stations conducted during the cruise, with two exceptions. 1) During station 16, both temperature and conductivity sensor pairs diverged. Comparison with bottle salinity data showed that the secondary sensor was in error, and as the processed data default to using the primary sensor, no change to processing was required. Flushing with

a detergent solution fixed the problem, so no further action was taken. 2) One beam of the LADCP was not functioning (zero amplitude) during the first four casts; the LADCP was switched for a backup unit (see Section 11).

8.1.1 CTD operation and processing

Data were acquired with SeaSave V 7.22.3.

SBE35 temperature data were uploaded using SeaTerm immediately after finishing a cast. SBE35 temperature data can be logged when a Niskin bottle is fired. If the SBE35 is set to 8 samples, it requires approximately 13 seconds to make a measurement, calculated as 8 * 1.1 seconds plus an overhead. Data are stored internally and must be downloaded at the CTD deck unit as a separate process from the CTD data transfer. The SBE35 data are then transferred as a collection of ASCII files. The SBE35 clock was initially set to the wrong date, requiring editing of the files after the fact (the processing matches by bottle number and merely searches for SBE35 data within a few days of the CTD casts to be compared, so accurate time stamps are not required).

After each cast SBE processing software was run in three steps to export as text file (.cnv), to apply time alignment of oxygen data (5s for sbeox0Mm/Kg and sbeox0V, but note that the hysteresis correction is applied later in mexec processing, NOT here), and to apply a cell thermal mass correction for conductivity (alpha = 0.03. tau = 7.0000 on both primary and secondary). The resulting files have suffix _align_ctm. Following this processing, a batch script, BASSvp, was run to prepare a sound velocity profile and a CTD listing for transmission to the UK Met Office. This batch script also copied the raw and processed data onto the network drive, legdata.

8.1.2 Data Processing

The CTD data processing followed the methods used on previous SR1b and other NOC MPOC cruises, using the mexec software suite. The initial SeaBird data conversion, align, and cell thermal mass corrections were performed using SBE Data Processing, Version 7.22.2 software. The network data drive, legdata, was linked to ctd/ASCII_FILES/jcrfs_ctd and ctd_linkscript was used to copy files to fola and set up additional symbolic links to filenames following mstar convention.

For each cast the following m-files were then run, using wrapper script ctd_all_part1: mctd_01, mctd_02a, mctd_02b, mctd_03, mdcs_01, mdcs_02.

The processes completed by these scripts include
read ASCII cnv data from ctd/ASCII_FILES/ctd_jr15003_001_ctm.cnv
convert variable names from SBE names to mexec names using data/templates/ctd_jr15003_renamelist.csv
copy raw file to 24hz file
make oxygen hysteresis adjustment on 24hz file
average to 1hz
calculate dereived variables psal, potemp
extract information from bottom of cast identified by maximum pressure.

Subsequently mdcs_03g was run to inspect the profiles and hand-select cast start and end times. The way oxygen time lag is handled in the SBE align algorithm, and the weak dependence of oxygen calculation on salinity, means that when air is ingested into the conductivity cell at the end of the cast, the oxygen becomes biased a few seconds earlier than the psal. Care should therefore be taken to select a cast end time for which all the important variables are free from bias. The mdscs_03g program was modified so that the pressure record is coloured red at times when the CTD pumps status indicated that the pumps were off. This highlighted one instance (station 15) where the pumps went off when the package was hauled too close to the surface after soaking. On that station it was necessary to delete approximately the first 27 metres of the downcast, until the pumps restarted and the sensors stabilised.

The start, bottom and end data cycles are stored in files with names like dcs_jr15003_001.nc. After selecting the limits for start and end, ctd_all_part2 was then run, executing mctd_04, mfir_01, mfir_02,

mwin_01, mwin_03, mwin_04. The processes completed by these scripts include
Extract down and upcasts using scan numbers stored in dcs_jr15003_001, and average into 2 dbar files (2db and 2up)
Read the data/ctd/ASCII_FILES/ctd_jr15003_001.bl file and extract scan numbers corresponding to bottle firing events.
Add time from CTD file, merging on scan number
Add CTD upcast data (P,T1,T2,S1,S2, etc) corresponding to bottle firing events
Paste these data into the master sample file data/ctd/sam_jr15003_001.nc
Load winch telemetry data from winch SCS file
Add winch wireout data to the fir_jr15003_001 file
Paste winch wireout data into the master sample file

Processed data could then be examined using mctd_checkplots to view sensor and up-down cast differences as well as compare nearby profiles, with particular attention paid to any drift in deep temperature or salinity (expected to be relatively stable) over time. The 24-Hz data were checked for spikes in either of the temperature or conductivity sensors using mctd_rawshow and, if necessary, edited using mctd_rawedit.

A variety of extra steps is available after other processing has been carried out; these steps can be run in any order.

After LADCP processing has been completed there is a best estimate of water depth available from the LDEO IX processing. This is found in cast processing log files by searching for "bottom found at"; the list of stations and depths is placed in station_depths/station_depths.txt. populate_station_depths can be run to convert station_depths_jr15003.txt to station_depths_jr15003.mat, which is the file required by mdep_01. populate_station_depths.m also allows missing depths to be set or bad depths to be overwritten using switch/case for each cruise.

After navigation data processing has been completed the file data/nav/seapos/bst_jr15003_01 will be available. mdcs_04 will generate files dcs_jr15003_001_pos.nc which include position at start, bottom and end of profiles. mdcs_05 will then paste the position at the bottom of the cast into the header of all relevant files in data/ctd.

mdep_01 and mdcs_05 can be run multiple times. The headers will not be updated if the updating values are identical to the values already in the file.

8.2 Water Sample Analysis

Dissolved oxygen analysis is described in Section 9.

For each CTD cast, one water sample was drawn per Niskin bottle for salinity analysis, from bottles that were fired, up to 12 per station. The distribution of bottle sample locations in Drake Passage is shown in Figure 2 and 3. Samples were taken in 200ml glass sample bottles, which were rinsed three times and sealed with a new clean dry disposable plastic stopper, after drying the neck of the bottle. The crate was then transferred to the bench in the Prep Lab. Caps were rinsed in freshwater and dried before being added to secure the stoppers. Samples were stored in the Bio Lab for a minimum of 8 hours before analysis to allow equilibration to the laboratory temperature (the conductivity ratio drift mentioned above did not appear to be connected to length of time samples had been in the lab). A logsheet was maintained of when crates were moved into the Bio Lab to keep track of when they would be ready to analyse.

Salinity sample analysis was performed on the BAS Guildline 8400B Salinometer, Serial No. 65763, in the Bio Lab. The temperature of the ship air conditioning fluctuated throughout the cruise and we had considerable trouble keeping the autosal lab within the desired temperature range. We started by using a bath temperature of 24 C and attempting to keep the lab temperature between 21 and 22.5 C, but towards the end of the cruise we were unable to get the lab temperature above 17 C, so we switched the bath temperature to 21 C. The autosal did appear to be able to maintain a constant bath temperature, with the heater lights switching on and off as expected while it was in use. However, conductivity ratio readings for many sets of samples took an unusually long time to stablise.

All watchkeepers carried out the analysis following standard procedure. A sample of IAPSO Standard Seawater was run before and after each set of up to 24 samples for salinometer calibration. We used Standard Seawater batches P156 and P158, with K15 values of 0.99984 and 0.99970, respectively. Standard seawater batch P156 was used to analyse samples from stations 1-14 and the first set of tsg samples, and batch P158 was used for stations 158 and the second set of tsg samples. We flushed the volume with expired P155 before starting new sets of runs to bring it closer to the standard salinity, and with milli-Q for intervals between runs.

Bottle sample conductivity readings were read from the autosal and logged by hand as we did not have a laptop capable of running autosal_2009 or connecting to the autosal. Three readings were taken for each sample. In some cases, where the values did not stabilise (see above), four or more readings were taken, but, because drawing down the sample bottle volume permits more evaporation, readings past the third were not used. Due to the stabilisation problem (see above) all readings were examined, and a few outlier readings were excluded.

Before comparison with the CTD data, the sample readings are adjusted for the salinometer offset, or the difference between the standard reading and its label value, by linearly interpolating between the initial and final standard for each set of samples. These offsets ranged from 1.03×10^{-3} to 1.41×10^{-3} (2xK15) for all but the last two sets of samples, with drifts within a sample set of 0.05×10^{-3} to 0.10×10^{-3}. Offsets for the last two sets of samples, run at a higher bath temperature, were 3.8×10^{-3} to 5.8×10^{-3} (2xK15). These sets comprised the second set of tsg samples and CTD casts 30 and 31. Bottle-sensor conductivity differences for stations 30 and 31 were not different from those for other stations. Samples from sets analysed using batch P156 (stations 1-14) were further adjusted for the batch-batch offset between P156 and P158. This offset of 0.6×10^{-3} psu was supplied by H. Uchida (pers. comm.) based on laboratory measurements following *Kawano et al.* (2006). The scatter in bottle-CTD comparisons was too large for this offset to be visible in this dataset.

8.3 Data calibration

After calibration sample data were obtained, they were read in using msbe35_01, msbe35_02, msal_01y, msal_02, moxy_01y, moxy_02, and concatenated into master sample file sam_jr15003_all.nc for comparison with sensor temperature, salinity, and oxygen. These comparisons were made ashore after the cruise. The locations of calibration samples from Drake Passage are shown in Figures 2, 3, and 4.

Constant temperature offsets of -4×10^{-4}°C (-8×10^{-4}°C) were applied first using temp_apply_cal.

344 Niskin bottle salinities samples were analysed. During comparison with CTD conductivities using ctd_evaluate_sensors, 20 of these comparisons were judged to be questionable or bad, either due to questionable bottle analysis or to strong salinity gradients, and were flagged accordingly. Based on the 324 good conductivity comparisons calibration factors with linear pressure and station number dependence were applied to the two sensors to minimise the median of the bottle conductivity to CTD conductivity ratio. These factors, applied using cond_apply_cal, were approximately equivalent to salinity offsets of (5.38 to 4.09)$\times10^{-3}$ psu at the surface and (0.6 to -0.69)$\times10^{-3}$ psu at 5000 dbar for the primary sensor, and (2.48 to 1.64)$\times10^{-3}$ psu at the surface and (-3.73 to -4.57)$\times10^{-3}$ psu at 5000 dbar for the secondary sensor (with factors in both cases decreasing over time).

After temperature and conductivity calibrations were applied, oxygen was converted from μmol/L to μmol/kg using msam_oxykg, and bottle and sensor values compared using ctd_evaluate_oxygen. 166 bottles were analysed for oxygen, but 2 of the comparisons were flagged as questionable. The calibration function obtained by least-squares fitting to the bottle data, and applied by oxy_apply_cal, was $O_{cal} = O_0(1.0603 + 0.0005N) + (1.0384 + 0.0007P)$, where O_o is the uncalibrated CTD oxygen, N is the station number (1 to 31), and P is pressure.

8.4 Lowered Acoustic Doppler Current Profiler (LADCP)

8.4.1 Instrument setup and performance

The 300-kHz Workhorse LADCP was installed in a downward-looking configuration on the CTD rosette (see Section 11). The instrument was configured (Table 3) to sample 16 x 10m bins, with data collected in beam co-ordinates and rotated to earth co-ordinates during processing. The LADCP was connected to a charger and by a serial cable to a BAS AME-supplied laptop in the Chem Lab for programming prior to each station and data download after each station, using BBTalk. Pre-deployment tests were performed at least once daily. Data downloaded after each station were copied to the legwork portion of the network drive in ladcp/JR15003, with names of the form JR15003_NNN.000, along with deployment logs, JR15003_NNN.txt.

Table 3: LADCP deployment commands, contained in JR15003_ladcp.cmd.

```
CR1
RN JR15003
WM15
TC2
LP1
TB 00:00:02.80
TP 00:00.00
TE 00:00:01.30
LN25
LS0800
LF0
LW1
LV400
SM1
SA011
SB0
SW5500
SI0
EZ0011101
EX00100
CF11101
CK
CS
```

8.4.2 Data processing

Data for each station were processed on fola using the LDEO-IX software package, developed at Lamont-Doherty Earth Observatory (LDEO). The software uses an inverse method to calculate velocity profiles, optionally including LADCP bottom tracking and/or VMADCP upper ocean velocities as constraints. At-sea processing was performed using only ship navigation (ladcp/ix/DL_GPS) or navigation and bottom tracking (ladcp/ix/DL_BT). The LADCP profiles in Drake Passage produced by the LDEO-IX inverse including navigation and bottom tracking are shown in Figure 5.

There is a link to the ladcp directory on legdata:
cruise/data/ladcp/raw/rawdata → ../../jcrfs/current/work/ladcp/JR15003/. After a cast, unix script exec/lad_linkscript_ix is run to update the raw data directory (calling exec/lad_syncscript) and making links to files with IX processing name convention files. lad_linkscript_ix will need to be edited for the cruise name.

Linking to CTD data

Each processing suite also expects CTD filenames to have a certain form. 1-Hz CTD data can be exported from mexec into ascii using the mexec command list_ctd_1hz(nnn) for station number nnn. This exports the variables time, press, temp, psal, latitude, longitude. Note that lat and lon are required for the IX processing, and become the source of navigation data for that suite. If list_ctd_1hz has been run from Matlab, then ladctd_linkscript_ix will make those ascii files available to the IX processing in the correct locations and with the correct file names. In IX, links to CTD data are made in ladcp/ix/data/CTD/1Hz/ctd → ctd and ladcp/ix/data/CTD/1Hz/ctd_jr15003_028_1hz_txt → ctd/ctd_jr15003_028_1hz_txt. ladctd_linkscript_ix should not require modification for each cruise.

Edits to .m files required at start of a cruise for IX processing

In addition to setting up directories, links and linkscripts, the set_cast_params*.m files must be edited with cruise details. These scripts reside in data/ladcp/ix/data/.
Edits required (lines from jr15003 set_cast_params.m shown):
f.sadcp = sprintf('SADCP/os75_jr15003_ctd_%03d.mat',stn);
f.ctd = sprintf('CTD/1Hz/ctd_jr15003_%03d_1hz_txt',stn);
p.cruise_id = 'jr15003';
p.whoami = 'Y. Firing';
The different versions of set_cast_params*.m are called by different versions of process_cast*.m to run IX processing of the LADCP data with different constraints:

- process_cast_v5.m calls set_cast_params_v5.m to include only navigation data
- process_cast_v4.m calls set_cast_params_v4.m to include navigation and bottom tracking data
- process_cast_v3.m calls set_cast_params_v3.m to include navigation, bottom tracking, and VMADCP data

set_cast_params.m (and thus process_cast.m) are currently set to use v5 (navigation only).

Quick look notes for LADCP processing in IX

1. Make sure the raw file is on legdata:
   cd /cruise/data/ladcp/raw
   ls ld rawdata/* (see files on legdata)
   ls ld * (see files on fola)
   The latest station should have a name like rawdata/JR15003_002m.000.
2. Run unix script lad_linkscript_ix. This will find any files in legdata that aren't on fola, copy them across to the correct place on fola using rsync, and create links in the IX processing tree so that IX is aware of the raw files: ladcp/ix/data/raw/002/002DL000.000 → ../rawdata/JR15003_002m.000 and so on. This script can be run from anywhere, and will echo to the screen the identity of any files copied and any links made. Check again using step 1 if you wish.
3. Run unix script ladctd_linkscript_ix. If the CTD 1-Hz ASCII file is available, this will make a link in the IX processing tree so that IX is aware of the CTD data:
   ladcp/ix/data/CTD/1Hz/ctd_jr15003_nnn_1hz.txt → ctd/ctd_jr15003_nnn_1hz.txt. IX can be run without CTD data for first-look checking, but it will produce an error in calculating the magnetic variation, because position is unknown and is found in the CTD 1-Hz file. If you know the CTD file is not available, skip this step.
4. If you intend to run process_cast_v3 to use VMADCP data, check that
   ladcp/ix/data/SADCP/os75_jr15003_ctd_028.mat is available.
5. Run the IX process:
   cd ladcp/ix/data or cd /cruise/data/ix (an abbreviation: ix → ladcp/ix/data)
   matlab &
   >> ixpath
   >> process_cast(nnn), where nnn is the station number.

6. Repeat steps 3, 4 and 5 as CTD and VMADCP data become available.
7. Note that on jr15003 there are three versions of process_cast available.
   process_cast_v5 calls set_cast_params_v5, and processes data into DL_GPS/. Navigation is used but no BT or VMADCP constraint.
   process_cast_v4 calls set_cast_params_4, and processes data into DL_BT. Navigation and BT are used but no VMADCP constraint.
   process_cast_v3 calls set_cast_params_v3, and processes data into DL_BT_GPS. Navigation, BT, and VMADCP are all used.

8.5 References

Kawano, Takeshi, Michio Aoyama, Terry Joyce, Hiroshi Uchida, Yasushi Takatsuki, and Masao Fukasawa, 2006, *J. Oceanogr.*, **62**, 777-792.

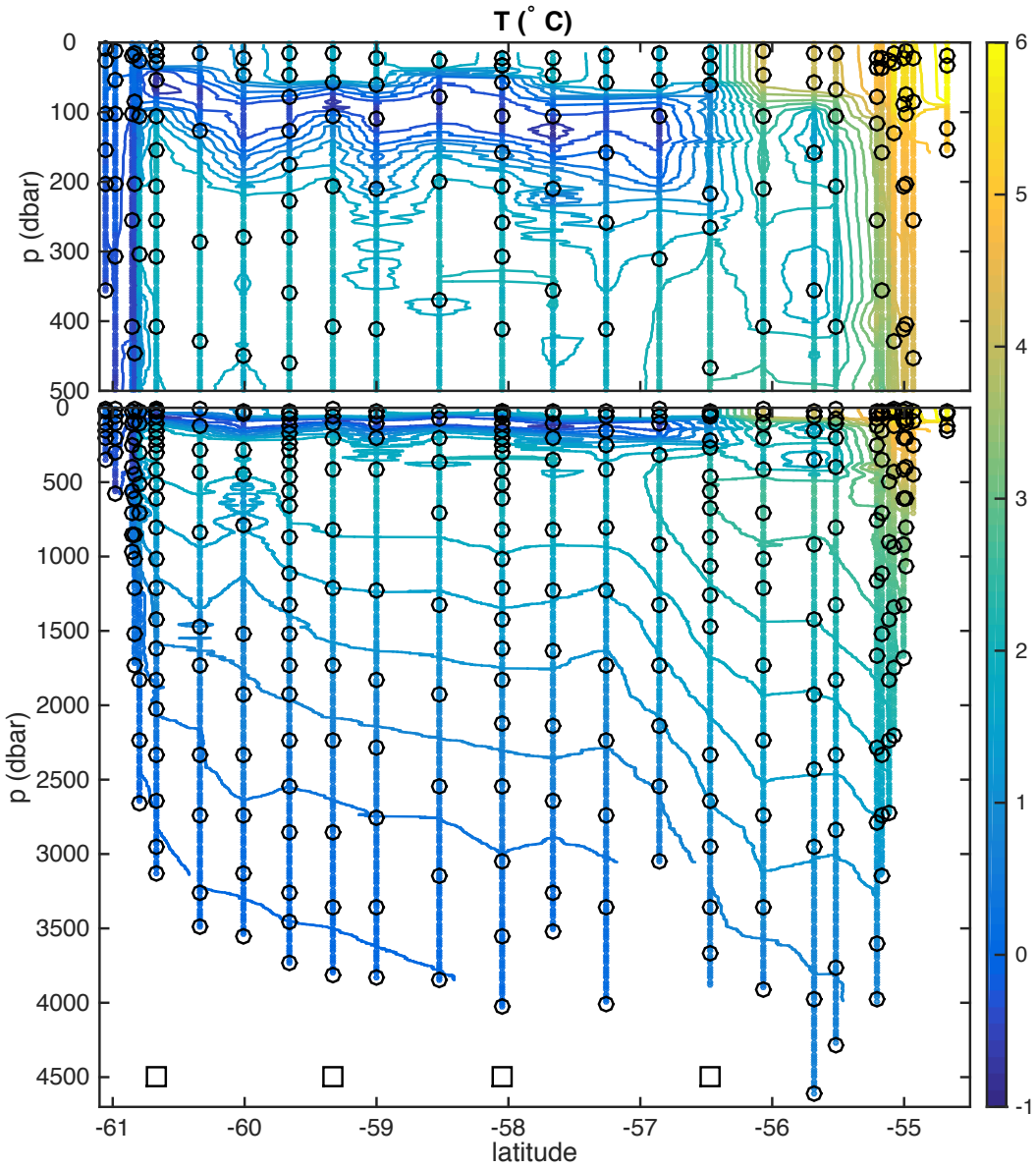

Figure 2: Calibrated temperature on SR1b, with bottle firings (corresponding to SBE35 samples) shown by black circles and float deployment stations by squares.

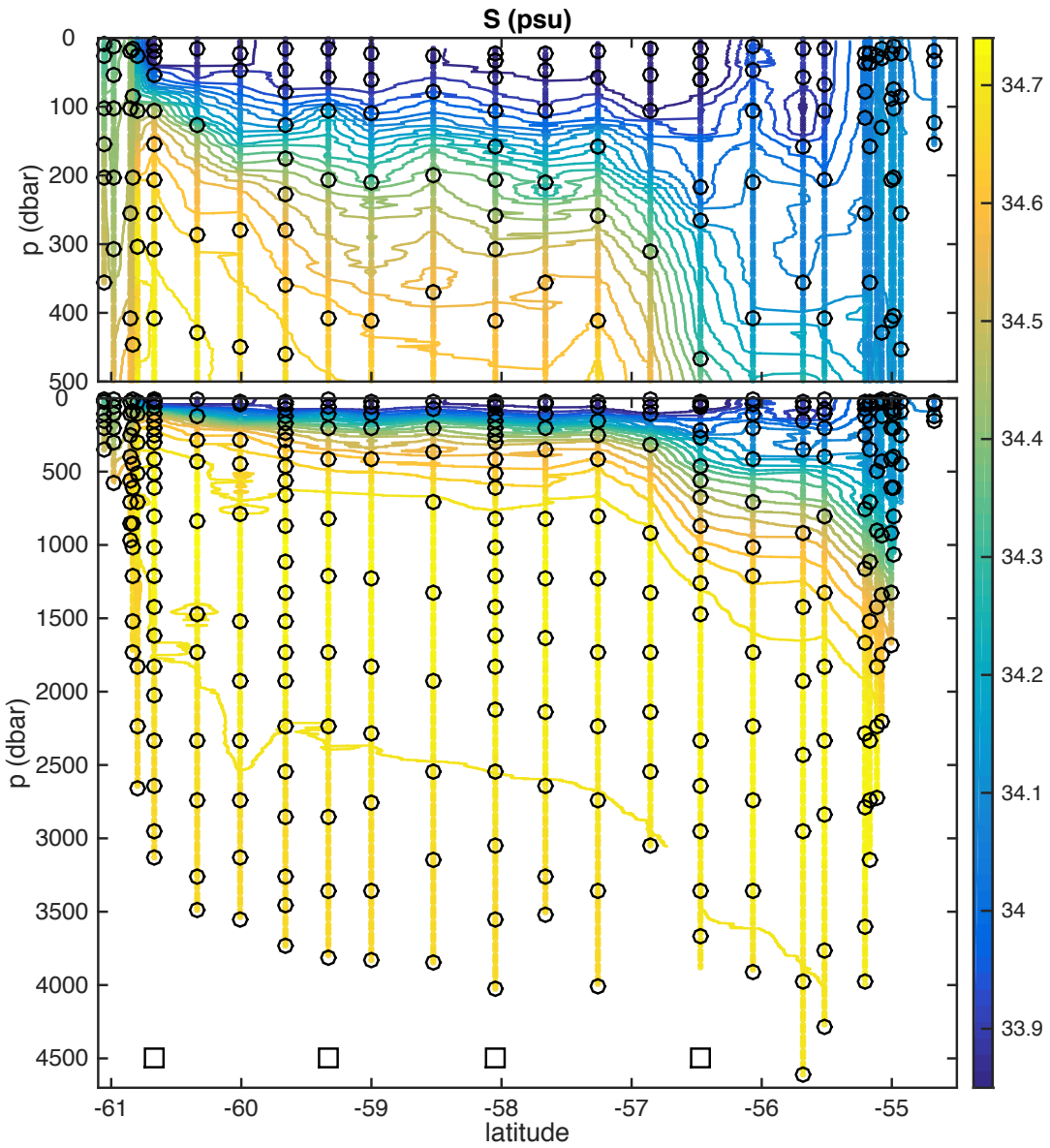

Figure 3: Calibrated salinity on SR1b, with bottle salinity samples shown by black circles and float deployment stations by squares.

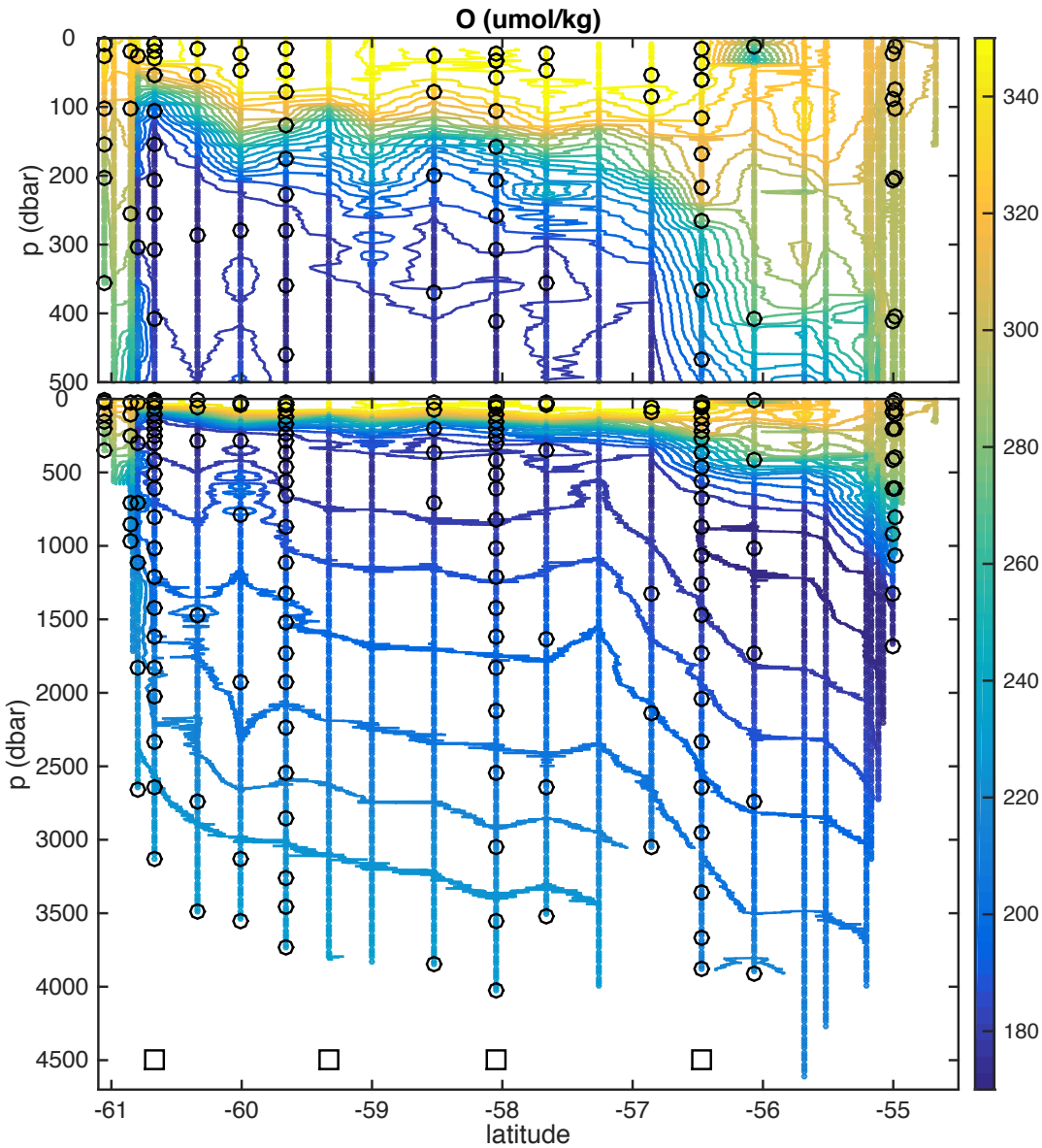

Figure 4: Calibrated dissolved oxygen on SR1b, with bottle oxygen samples shown by black circles and float deployment stations by squares.

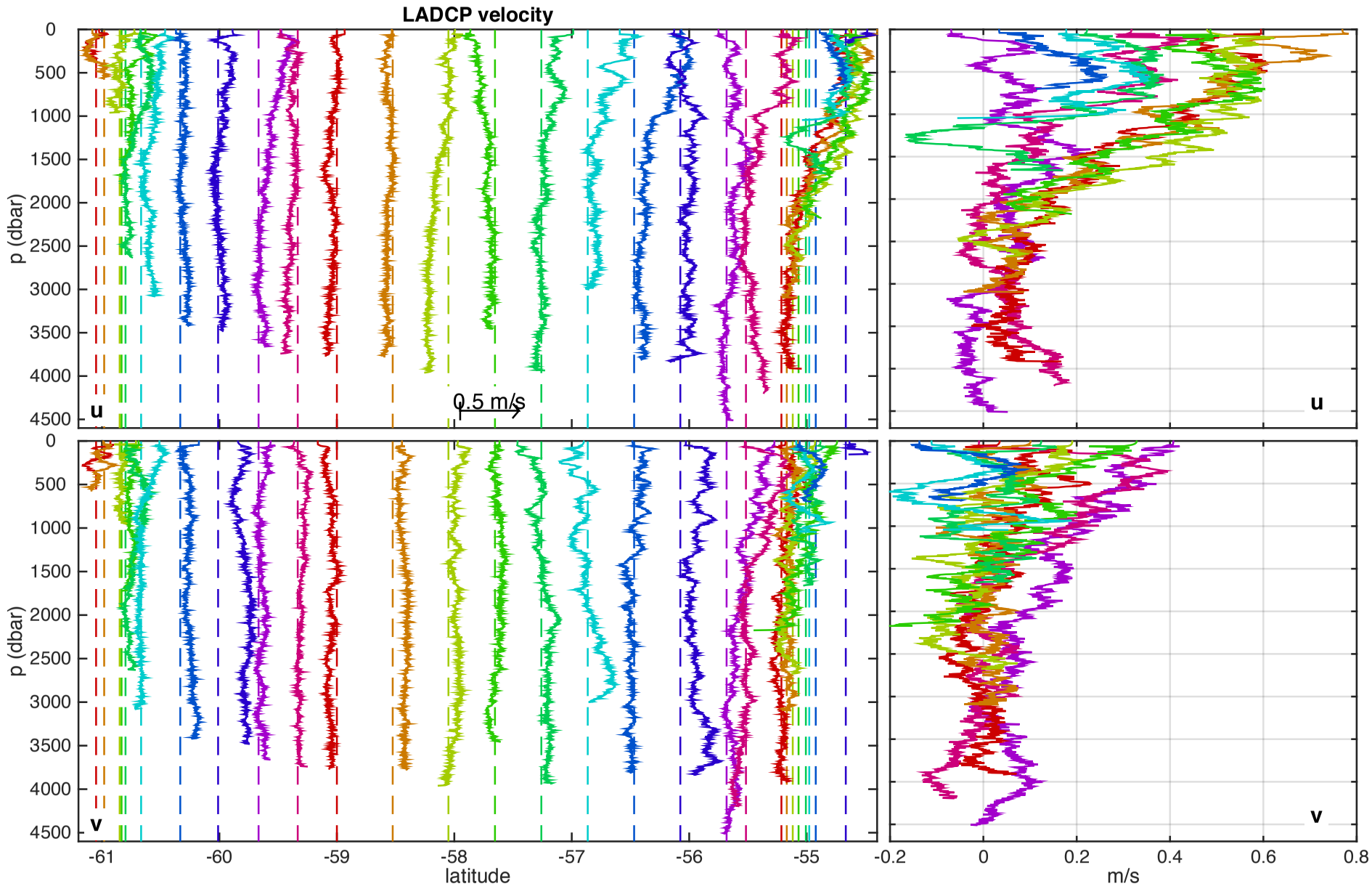

Figure 5: Profiles of zonal (top) and meridional (bottom) velocity from LADCP at each station in Drake Passage, offset to the latitude of that station, with dashed zero lines. Right hand panels show northern profiles including the Subantarctic Front jet, with a common zero line.

9 SOCCOM (Southern Ocean Carbon and Climate Observations and Modeling) float deployments and CTD stations

Daniel Schuller

The SOCCOM (Southern Ocean Carbon and Climate Observations and Modelling) project implements sustained observations of the carbon cycle, together with mesoscale eddying models linked to the observations. 180 to 200 autonomous profiling floats with biogeochemical sensors (oxygen, nitrate, pH and optical sensors in addition to temperature/salinity) and sea-ice avoidance software will be deployed throughout the Southern Ocean during this project. These floats will extend current seasonally limited observations of biogeochemical properties into nearly continuous coverage in time, with horizontal spatial coverage over the entire Southern Ocean and vertical coverage to 2000 m. These float deployments must take place from research ships with CTD/rosette sampling in order to collect water samples (to be analysed for oxygen, nutrients, pH, alkalinity, HPLC, POC) for float profile calibration. This is the 2nd year of the project; multiple floats have been deployed from foreign and domestic research vessels including *Nathaniel B Palmer*, *Polarstern*, and *James Clark Ross*. All floats deployed are operating well as of the end of the cruise, with data reported in near real-time and publicly available from: http://www.mbari.org/chemsensor/floatviz.htm.

The pH sensor technology, which was developed recently, is proving to be very robust. The T/S data are part of the Argo float data set.

The USA National Science Foundation (NSF) funds all measurements and calibration measurements, with the exception of the optical measurements. Optical measurements included in this plan have been proposed to NASA.

The 4 floats deployed from JCR will contribute to the international Southern Ocean Observing System (SOOS) and the Argo database.

9.1 Float Deployments

4 SOCCOM floats deployed on JR15003 according to Table 4:

Table 4: SOCCOM floats with deployment times and positions. I = ice enabled; O = oxygen sensor; N = nitrate sensor; F = fluorometer (WetLabs FLBB); p = pH sensor.

Float ID	Sensors	CTD station	Deploy. date	Deploy. time	Lat	Lon	Deployer name
1, 9652 Apex	IONpF	009	7 Jan 2016	0335Z	60.66637 S	54.82753 W	Schuller
2, 9657 Apex	IONpF	012	7 Jan 2016	1732Z	59.66695 S	55.44552 W	Schuller
3, 9655 Apex	IONp	016	8 Jan 2016	1743Z	58.05023 S	56.44734 W	Schuller
4, 9662 Apex	IONp	020	9 Jan 2016	1502Z	56.46764 S	57.40497 W	Schuller

9.2 CTD/Rosette Sampling

CTD casts were completed at each SOCCOM float deployment location for a total of 4 profiles. Full water column bottle samples were taken for dissolved oxygen, pH/alkalinity, dissolved inorganic nutrients, salinity, HPLC and POC at each station in that order. Dissolved oxygen was analysed on board. NOCS sampled and analysed water samples for salinity at these locations.

9.3 Dissolved Oxygen

Samples were analyzed for oxygen at 4 SOCCOM stations and 11 additional stations.

9.4 Sampling and Data Processing

Samples were collected for dissolved oxygen analyses as the first sample after the rosette was brought on board. Using a Tygon drawing tube, nominal 125ml volume-calibrated iodine flasks were rinsed three times then filled and allowed to overflow for approximately three flask volumes. The sample draw temperature was measured with a small thermometer embedded in the drawing tube. Reagents (MnCl2 and NaOH/NaI) were added to fix the oxygen before stoppering. The flasks were shaken twice to assure thorough dispersion of the precipitate, once immediately after drawing, and then again after about 20 minutes. The samples were usually analyzed within several hours of collection. Thiosulfate normalities were calculated from each standardization and corrected to 20C. The 20C normalities and the blanks were plotted versus time and were reviewed for possible problems. Oxygens were converted from milliliters per liter to micromoles per kilogram using the sampling draw temperature and the samples salinity.

9.5 Equipment and Techniques

Dissolved oxygen analyses were performed with an ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by LabView software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. The ODF method used a whole-bottle modified-Winkler titration following the technique of Carpenter (1965) with modifications by Culberson (1991), but with higher concentrations of potassium iodate standard (approximately 0.012N) and thiosulfate solution (55 g/l). Standard KIO3 solutions prepared ashore were run at the beginning of each run. Reagent and distilled water blanks were determined, to account for presence of oxidizing or reducing materials.

9.6 Volumetric Calibration

Oxygen flask volumes were determined gravimetrically with degassed deionized water to determine flask volumes at ODFs chemistry laboratory. This was done once before using flasks for the first time and periodically thereafter when a suspect bottle volume was detected. The volumetric flasks used in preparing standards were volume-calibrated by the same method, as was the 10 ml Dosimat buret used to dispense standard iodate solution.

9.7 Standards

Potassium iodate was obtained from Johnson Matthey Chemical Co. and was reported by the supplier to be >99.4% pure.

9.8 pH/Alkalinity

Samples were taken from 4 SOCCOM stations and 1 additional station. Approximately 10% of samples were duplicates. Nominal 500 mL samples were drawn from the Niskin bottles, preserved with mercury (II) chloride and packed for shipping via air freight back for analysis at Scripps Institution of Oceanography.

9.9 Nutrients

Samples were taken from 4 SOCCOM stations. Nominal 30 mL samples were drawn from the Niskin bottles into rinsed centrifuge tubes. They were immediately frozen in -20C freezer. Upon JCRs return to UK the nutrient samples will be shipped on dry ice via air freight for analysis at Scripps Institution of Oceanography.

9.10 Salinity

Salinity samples were collected at all depths from the 4 SOCCOM CTD stations. Samples were analyzed shipboard by NOCS using JCRs Guildline 8400B autosal.

9.11 HPLC and POC

HPLC/POC samples were taken from 4 SOCCOM stations and 6 additional stations. Samples were taken from the surface and cholorophyll maximum Niskin bottles. A duplicate sample was taken alternating between surface and chlorophyll maximum depths at each station as well. 1 L of seawater was filtered in the dark through glass fiber filters. Filters were immediately stored in aluminium foil packages in a dewar of liquid nitrogen. Filters and aluminium foil packets were pre-combusted for POC samples. Samples were moved to -80C freezer at the conclusion of the cruise. Upon JCRs return to UK samples will be shipped in a dry shipper back to Scripps Institution of Oceanography for analysis.

9.12 References

Carpenter, J. H., "The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method," Limnology and Oceanography, 10, pp. 141-143 (1965).

Culberson, C. H., Knapp, G., Stalcup, M., Williams, R.T., and Zemlyak, F., "A comparison of methods for the determination of dissolved oxygen in seawater," Report WHPO 91-2, WOCE Hydrographic Programme Office (Aug 1991).

10 Underway Data Collection and Processing

10.1 Computing and SCS data processing

10.1.1 Configuration of linux workstation 'fola'

The NOC MPOC OCP group brought a linux workstation (fola), which was the primary platform for data analysis during the cruise. The jcr cruise data directory was made available by mounting on fola. That directory includes SCS data streams, data from other sources such as CTD, LADCP, VMADCP, and the legwork directory. The network data directory was mounted on fola so that /mnt/data/cruise/jcr was the parent directory of the individual cruise data directories identified by date. Cruise jr15003 was current → 20151217.

A link was made on fola in /local/users/pstar/cruise/data so that data/jcrfs → /mnt/data/cruise/jcr. This enabled access to the legdata directory as well as the legwork part of it. Since the current/ cruise directory sits below /mnt/data/cruise/jcr, useful directories could be accessed using the following example links:
data/ctd/ASCII_FILES/jcrfs_ctd → ../../jcrfs/current/ctd/JR15003
data/legwork → jcrfs/current/work
data/vmadcp/jcrfs_adcp75 → ../jcrfs/current/adcp
data/scs_raw_ship → jcrfs/current/scs/Compress

Workstation fola was backed up on a daily basis. A complete dump of cruise data and software was copied using rsync from fola to one of two Transcend portable hard drives. These drives were used to carry data back to NOC at the end of the cruise, including a final identical backup of fola on two drives.

10.1.2 SCS data streams

The SCS data streams (ashtech [nav/ash], ea600 [sim], anemometer [met/surfmet], oceanlogger [ocl], emlog-vhw [chf], gyro [nav/gyros], seatex-gll [nav/seapos], em122 [em122], seatex-hdt [nav/seahead]) were processed on fola during the cruise. Most were processed in 24-hour segments, using m_jr15003_daily_processing.m, with cleaning and appending as required. Winch data were processed by CTD station as part of standard CTD processing (ctd_all_part2.m).

10.1.3 Access to SCS data

SCS data are stored in *.ACO files, which are plain text. However, non-numeric characters make these slow to parse in Matlab. An ad hoc but fairly robust and quick-running system has evolved to make these data more easily readable for mexec processing.

1. Parse the ACO files with linux sed, to remove non-numerical characters. Input SCS files are in data/scs_raw. On the ship and during the cruise, data/scs_raw → scs_raw_ship, data/scs_raw_ship → jcrfs/current/scs/Compress. At the end of the cruise, the contents of scs_raw_ship are copied to a local directory, data/sca_raw_postcruise. Then the link is changed so data/scs_raw → scs_raw_postcruise, so that raw SCS files can be accessed after the cruise.
   The sed parsing allows continually-filling SCS files to be continually edited into data/scs_sed/. Parsing is started and stopped with linux commands sedexec_startall and sedexec_stopall. If there is a problem with any aspect of sed processing, the safest action is to delete all of scs_sed/*ACO and stop and restart sedexec processing.
   The sedexec scripts live in data/exec/jcr. sedexec_startall needs a list of ACO files to parse. This can be generated by a Matlab script, data/exec/jcr/make_list_for_sedexec_startall.m. This will make list_jr15003, linked to by data/exec/jcr/list.

SCS files note 1 The SCS data consist of .ACO files and .TPL files. The TPL files contain lists of variables. When a cruise begins, the data/scs_raw/*.TPL should be copied to data/scs_sed. oceanlogger.TPL needs to be manually edited, as oceanlogger.ACO has time information for which the number of fields changes when parsed through sed. The original oceanlogger.TPL begins

thus:
126,oceanlogger-sampletime,YYY DDD HH:MM:SS
127,oceanlogger-airtemp1,celsius
128,oceanlogger-humidity1,
129,oceanlogger-par1,umol/S.m2
so the first line must be replaced with 3 lines thus:
126,oceanlogger-sampletimeyyyy,YYYY
126,oceanlogger-sampletimeddd,DDD
126,oceanlogger-sampletimehhmmss,HH:MM:SS
127,oceanlogger-airtemp1,celsius
128,oceanlogger-humidity1,
129,oceanlogger-par1,umol/S.m2

SCS files note 2 The default SCS variable names include the name of the data stream for each variable. e.g. oceanlogger-humidity1. The daily processing of SCS files removes the extra part of the variable name. The new names need to be in lookup template .csv files in data/templates. For example the first few lines of the oceanlogger template,
data/templates/scs_jr15003_renamelist_oceanlogger.csv, are
oceanlogger_sampletimeyyyy,sampletimeyyyy,YYYY
oceanlogger_sampletimeddd,sampletimeddd,DDD
oceanlogger_sampletimehhmmss,sampletimehhmmss,HH:MM:SS
oceanlogger_airtemp1,airtemp1,celsius
oceanlogger_humidity1,humidity1,
The set of required template files can be made in Matlab with
ms_generate_varname_translation_all.m, which makes successive calls to
ms_generate_varname_translation(stream). If this script fails, templates can be copied from a previous cruise. The template contents will be unchanged unless the variables in the SCS file have changed, e.g. a new sensor in the oceanlogger stream.

2. Convert ACO text files to Matlab.
Even the clean and numeric ACO files are too slow to routinely read into Matlab to access data 'on demand'. Therefore a process is run in which Matlab versions of the SCS data are accumulated into data/scs_mat/. In a Matlab window, the command ms_update_aco_to_mat('ea600') will read data from data/scs_sed/ea600.ACO and save the data in data/scs_mat/ea600.mat. This process also notes the number of bytes of the ACO file converted. Next time the process is run, those bytes are skipped so that only new data are converted.
The command update_allmat will update all the SCS streams with multiple calls to
ms_update_aco_to_mat. update_allmat will need to be edited to add new streams if new SCS streams are required, otherwise it does not require any modification at the start of a cruise. Some Matlab scripts (eg mday_00.m) that read data 'up to the present' call the update script before loading data. Sometimes it is necessary to run the update script manually from the command prompt, to ensure all ACO data are available to following scripts.
If the scs_sed files have got into a mess and been regenerated or scs_sed parsing restarted, the safest course of action is to delete the contents of scs_mat and run update_allmat. This takes a few minutes at the start of a cruise and rather longer, maybe up to half an hour, if 30 or 40 days data are waiting to be parsed. This is necessary because the scs_mat file keeps a count of the number of bytes of the ACO file parsed. If the ACO file has been altered before that byte count, the ms_update_aco_to_mat process may fail to copy the data correctly, but may not give an error.

10.1.4 The mscs source directory

The mscs source directory cruise/sw/mexec_v2/source/mscs contains the scripts for accessing the SCS data either directly or via scs_mat. Some of the scripts, e.g. scs_to_mstar2.m are called by wrapper

scripts such as mday_00.m. Some of the scripts can provide quick access to SCS data that have not yet been processed into mexec files. Examples include: msgaps, mslast, mslistit, msload, mslookd (usually run as mslookd f), msnames, msposinfo, msposinfo_noup (quick version for finding ship position at earlier time so not necessary to update scs_mat/ first), msvars. See help mscs for further information. The techsas equivalent library has help mtechsas which has extra documentation and help.

10.2 Underway surface water sampling

10.2.1 Underway surface thermosalinograph

The list of oceanlogger variables is as follows:

mexec directory	mexec short name	mexec directory abbreviation	mexec file root	variables
ocl	oceanlogger	M_OCL	ocl	tstemp
				conductivity
				salinity
				sound_velocity
				chlorophyll
				sampletemp
				flowrate
				sstemp
				trans
				sstemp2

Note the alternative temperatures: sstemp and sstemp2 for seawater intake, sampletemp for fluorometer sample temperature, tstemp for the SBE housing temperature for calculation of salinity.

A total of 41 underway samples were analysed for oceanlogger salinity calibration. Samples were drawn from the underway supply in the Prep Lab as often as every 4 hours during science time in ice-free areas, following the same procedure as for Niskin bottle samples, and the time noted in a logsheet to the nearest minute. Samples were analysed following the procedure described for CTD salinity samples.

Data were read in as part of the daily processing. Data were set to absent at any time that the pumps were known to be off, either close to port, in ice, or where the flowrate indicated there was little or fluctuating supply. Relatively simple cleaning has been applied to the appended dataset using mtsg_medav_clean_cal and mtsg_findbad. Based on comparison with the bottle salinities an offset of 0.06 psu was applied to the oceanlogger salinity record using mtsg_apply_salcal.

10.3 Surface water sampling for Nd isotope analysis

In Bransfield Strait and Drake Passage, several samples from the pumped surface water supply were taken in 10 L cubitainers, acidified, and stored for Nd isotope analysis ashore.

10.4 Daily processing of SCS streams

As part of the regular watchkeeping logging every 4 hours, we checked that the SCS streams were updating with reasonable values. Data were transferred from the onboard logging system (SCS) to fola daily using mday_00_get_all.m. This script also appends daily data files for streams other than bathymetry (see below).

Table 5: Times (from log sheet) and locations (from ship track) of surface water samples for Nd isotope analysis

Sample Name	Date	Time	Latitude (S)	Longitude (W)	Sampler
Surface-01	23.12.2015	1600Z	61°27.77'	52°01.62'	TC
Surface-02	24.12.2015	0215Z	62°20.27'	55°55.86'	TC
Surface-03	24.12.2015	1145Z	63°06.69'	59°08.58'	TC
Surface-04	06.01.2016	1249Z	60°50.94'	54°42.45'	YF
Surface-05	07.01.2016	0354Z	60°37.84'	54°51.05'	YF
Surface-06	07.01.2016	0822Z	60°19.08'	55°02.44'	CdL
Surface-07	07.01.2016	1249Z	60°00.07'	55°13.92'	CdL
Surface-08	09.01.2016	0428Z	57°15.50'	56°56.27'	DB

10.4.1 Navigation

The list of navigation streams processed from SCS was given in Section 10.1.2. After daily processing of SCS streams, navigation processing steps can be completed on the appended xxx_jr15003_01.nc files. The steps are combined into a single wrapper mbest_all.m. This script performs tasks such as subsampling to 30-second intervals, adding ship speed and course over ground, and merging on ship heading. Ship headings are properly vector averaged when subsampled. A best navigation file, data/nav/seapos/bst_jr15003_01.nc, is the final output.

10.4.2 Surface meteorological sampling (SURFMET)

RRS *James Clark Ross* is equipped with a variety of meteorological sensors to measure air temperature and humidity, atmospheric pressure, total irradiance, photosynthetically active radiation, wind speed and wind direction throughout the cruise. The radiation and pressure variables were logged in data/met/surflight/. The remaining data were logged in /met/surfmet. The raw data files have extensions of the form _jr15003_dNNN_raw.nc, where NNN represents the day number.

Once the best navigation file is available, mtruew_01.m is run to combine ship navigation data with relative data from the anemometer to produce absolute and relative winds averaged to 1-minute resolution. As with best navigation, all headings are properly vector averaged, and the final product is the file data/met/surfmet/ met_jr15003_trueav.nc.

10.4.3 Bathymetry

The EM122 swath echosounder was turned off for the SR1b section (along which bathymetry has been measured on many previous cruises) in an attempt to improve the noisy VMADCP data (see below).

The raw data files have extensions of the form _jr15003_dNNN.nc where NNN is the number of the Julian day. msim_01.m was run to remove data outside a tolerated range and apply a 5-minute median despiking, outputting the file sim_jr15003_dNNN_smooth.nc. msim_plot.m copied the smoothed sim data to the file sim_jr15003_dNNN_edited.nc and called mplxyed to allow a manual removal of the remaining spikes in sim data; mem122_plot.m was run to do the same for the em122 data (note that each script must be used to edit the correct data type; sim must be edited in msim_plot and em122 in mem122_plot).

Two bathymetry streams are available via SCS: the ea600 single-beam echo sounder, and the centre beam of the em122 multibeam (swath) system. Data are read in by the daily processing (mday_00_get_all.m); for day number 014 (for instance), ea600 and em122 data are read into sim/sim_jr15003_d014.nc and em122/em122_jr15003_d014.nc, respectively. For streams other than bathymetry, daily processing appends each day onto a growing appended file, but the bathymetry records require manual editing before they can be appended, so there is no append action for sim or em122 in the daily processing. After editing (see below) they are appended using mday_02.

The bathymetry streams inevitably contain bad data where the automatic digital determination of depth has failed to correctly infer depth from the analog signals. As the original analog records are not generally available to the person doing data editing/cleanup, some judgement is required to decide what are good or bad data. In order to aid this process, there is a display of both of the two data streams, along with an estimate of bathymetry from satellite gravity data. Thus the ea600 data are edited by reference to em122 data, and vice versa. There is a symmetric set of scripts for cleaning the two data streams.

The first step is to do some automated cleanup of both the ea600 and em122 streams, with msim_01 and mem122_01. Both must be run before proceeding with manual graphical editing.

10.4.4 EA600

For ea600, the process is as follows:

- msim_01
  reads raw data for the day (from e.g. sim_jr15003_d014_raw.nc);
  picks data in the depth range 5 to 10000, to discard zeros;
  takes the median depth over 300-second bins, to discard noise (example output file: sim_jr15003_d014_smooth.nc)
  makes duplicate file in sim_jr15003_d014_edited.nc
- msim_02
  merges on swath centre beam data for the day (if available) to be used in cleaning. Note that mem122_01.m must be run before this step.
- msim_plot
  calls mplxyed for manual removal of bad data. Note that the files are set up so this file is used to edit bad data in the ea600 file. The equivalent file in the em122 sequence should be used to edit bad data in the em122 stream.
  msim_plot displays an extra window with the full ea600 data, to guide the use of mplxyed.
  EA600 data quality: data editing was done somewhat conservatively, so the cleaned records likely still contain noise.
- After cleaning in mplxyed, daily files were appended into a single file, sim_jr15003_01.nc, by running mday_02 (see mday_02_run_all). At this stage, the em122 depths used for data quality checking are discarded.
- Next, using the script mmerge_sim_nav_jr15003, navigation was added, in sim_jr15003_01_nav.nc, and a Carter area correction applied, using mcalc, in sim_jr15003_01_nav_cordep.nc. This last file is therefore the master EA600 file, containing corrected bottom depths in 5 minute bins.

10.4.5 EM122

Em122 centre beam depths were logged in SCS and downloaded in daily files to em122/. Two scripts are used to reduce and edit EM122 data, based on the scripts for EA600:

- mem120_01
  reads raw data (from e.g. em122_jr15003_d014_raw.nc),
  runs mdatpik to require depth > 20 m,
  runs mavmed to take the median over 300-s bins, producing em122_jr15003_d014_smooth.nc, and
  copies the file to an 'edited' version (em122_jr15003_d014_edited.nc) ready for manual editing.
- mem120_02
  merges on ea600 for display in mplxyed for QC.
- mem120_plot
  plots data for editing: if all the relevant files exist, displays the Matlab window with EM120, EA600 and satellite bathymetry, then enters mplxyed on the edited file. This step can be repeated as often as required. The Matlab plot window displays the data as found in the most recently updated 'edited' file. The cleaned data are then appended using mday_02 (see above).

10.4.6 Chernikeef EM log

Chernikeef EM log data were recorded and downloaded daily. Besides appending the files, no further processing was carried out and the calibration of the EM log was not checked.

10.5 Vessel Mounted ADCP

A vessel-mounted 75-kHz Teledyne RD Instruments (RDI) OceanSurveyor Acoustic Doppler Current Profiler (ADCP) was run throughout the cruise to measure horizontal velocity from 30 m to approximately 400-800 m. The depth of the transducer is 5 m. The phased-array transducer should be insensitive to sound speed (temperature) changes (but see discussion below). The data may be particularly affected by bubbles under a certain range of ship heading relative to the seas, which appears to have dramatically reduced data quality at a few of the CTD stations. Coordinating pinging with the EM122 was not successful in deeper water (see below), and in some cases there appeared to be intereference from or with the bathymetric echosounders. The data quality is generally uncertain and the data will be reprocessed, edited, and evaluated ashore.

10.5.1 Real-time data acquisition and VMDAS files

The data from the instrument were acquired using the RDI VMDAS software package version 1.42, installed on a PC in the main laboratory. 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. A perl script to subsample ship navigation data, NavigationRepeater, must be run on the same machine throughout data collection. VMDAS was run using a selection of preset configuration files (selected under "edit data options") which allowed the instrument to be promptly switched between bottom tracking and water tracking; set for different depth ranges; and self-triggered or triggered by the K-sync unit (see below) so as not to interfere with other acoustic measurements. More detail on settings is given below. Data collection was typically stopped and restarted, generating a new file segment number, daily during the cruise, to facilitate incremental processing. Files were automatically placed on the network legdata/adcp directory and rsynced to fola daily using vmadcp_linkscript.

The files produced have names of the form JR15003 os75nnn_mmmm.ext, where nnn is the file sequence number, mmmm is the number of the segment file within the sequence and ext is the extension. A new segment file is automatically started when one of the file types reaches a size of 10 Mb. VmDas automatically increments the file segment number every time data collection is stopped and restarted.

The 'R', 'S' and 'L' tabs on the VmDas menu bar allow the user 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, while 'S' (short-term average) and 'L' (long-term average) modes display currents averaged over 2 or 10 minutes, in Earth coordinates. Various display options are available but data were generally monitored in either raw or short-term average form, and checked in more detail following daily processing. During the every-4-hours regular watchkeeping tasks the VMADCP ensemble number was checked to ensure the expected amount of data recording. As on previous cruise JR306, the ensemble number reset itself at various points, for unknown reasons (i.e., not wrapping over at any obvious or consistent number). We did not check if this led to any missed pings; 5-minute ensemble averages did not appear to be affected.

10.5.2 Settings

The VMADCP was run in single-ping mode, with an 8-m pulse, 100 8-m bins, and an 8-m blanking distance. In shallow water (<500 m generally), the instrument was run in bottom track mode to obtain phase and amplitude calibrations, and set to have fewer bins (reduced depth range) to enable more-frequent pinging. In deeper water the instrument was switched to watertrack mode, and watertrack calibration data were obtained during CTD station-keeping. The island stops on this cruise resulted in a number of potential bottom track segments.

For some of the cruise the VMADCP was set to be triggered by the K-sync system in order not to interfere with the bathymetric echosounders.

In deeper water (in Drake Passage) the EM122 triggered so infrequently that the ADCP repeatedly timed out while waiting for a ping command, resulting in resetting, and collecting little to no data. When the EM122 was set to ping at a set interval, with the ADCP pinging in between, data quality of both instruments degraded. Where possible, therefore, we turned off the EM122 (for instance along SR1b, where swath bathymetry has been collected on the identical track many times before). K-sync settings were modified as follows (saved as physics800):
disable EM122 in uncheck "echo sounder is master"
enable EA600, OS75
set fixed periods: EA600 1 s, OS75 3.5 s (necessary interval for 800 m range)
trigger groups 1, 2, 3: OS75
trigger group 4: EA600

At times there also seemed to be interference in the EA600, which was attributed to the OS75, although it is unclear whether this was actually the cause. Since bathymetry data were most wanted outside Drake Passage (where the tracks we followed have been covered multiple times already), we switched off the VMADCP for those segments.

11 Instrumentation, extracted from AME Report

Paul Morgan

Table 6: Lab instruments used

Instrument	S/N Used	Comments
Autosal	63360	

Table 7: Acoustic instruments used

Instrument	S/N Used	Comments
ADCP	Y	
EM122	Y	
TOPAS	Y	
EK80	Y	
10kHz IOS pinger		
Benthos 12kHz pinger + bracket	1316	

Table 8: Oceanlogger

Instrument	S/N Used	Comments
Barometer1(UIC)	5002	
Barometer1(UIC)	5003	
Foremast Sensors		
Air humidity & temp1	3898	
Air humidity & temp2	3896	
TIR1 sensor (pyranometer)	2993	Not working
TIR2 sensor (pyranometer)	2992	Not working
PAR1 sensor	0127	
PAR2 sensor	0126	
prep lab		
Thermosalinograph SBE45	0016	
Transmissometer	396	
Fluorometer	1100243	
Flow meter	811950	
Seawater temp 1 SBE38	0601	
Seawater temp 2 SBE38	0599	

Table 9: CTD

Instrument	S/N Used	Comments
Deck unit 1 SBE11plus	0458	
Underwater unit SBE9plus	0707	
Temp1 sensor SBE3plus	2705	
Temp2 sensor SBE3plus	5766	
Cond1 sensor SBE 4C	2248	
Cond2 sensor SBE 4C	4471	
Pump1 SBE5T	1807	
Pump2 SBE5T	7606	
Standards Thermometer SBE35 0024		
Transmissometer C-Star	846	
Oxygen sensor SBE43	0676	
PAR sensor	7274	
Fluorometer Aquatracka	088-249	
Altimeter PA200	163162	
LADCP	15060/14897	Changed to 14897 due to loss of beam intensity
CTD swivel linkage		Changed due to damage when CTD stowed away
Pylon SBE32	0636	

Table 10: AME unsupported instruments logged

Instrument	S/N Used	Comments
EA600	Y	
Anemometer	Y	
Gyro	Y	
DopplerLog	Y	
EMLog	Y	

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