National Oceanography Centre

Cruise Report No. 41

RRS *James Clark Ross* Cruise JR16002

10 NOV – 03 DEC 2016

Hydrographic measurements on GO-SHIP line SR1b

Principal Scientist

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2017

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ABSTRACT

RRS *James Clark Ross* cruise JR16002 included work contributing to two National Capability projects.

Bottom pressure recorder (BPR) landers previously deployed on the northern and southern continental slopes of Drake Passage to monitor ACC transport as part of Antarctic Circumpolar Current Levels from Altimetry and Island Measurement (ACCLAIM) were recovered, wrapping up a 28-year time series. The twenty-second complete occupation of the Drake Passage GO-SHIP section SR1b obtained full-depth temperature, salinity, and lowered ADCP velocity profiles at 30 stations, along with water column samples for oxygen isotope analysis and 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 as part of Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports (ORCHESTRA). Deployment of three Deep Apex autonomous profiling floats was also intended to contribute to ORCHESTRA as well as the global Deep Argo programme.

KEYWORDS

ISSUING ORGANISATION

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Douglas Stacey	BAS	Nicholas Greenwood	Steward
Jennifer Symmons	BAS	Graham Raworth	Steward
Alexander Taylor	BAS	Rodney Morton	Steward

2 Itinerary and Cruise Track

The cruise track and science operation sites are shown in Figure 2.

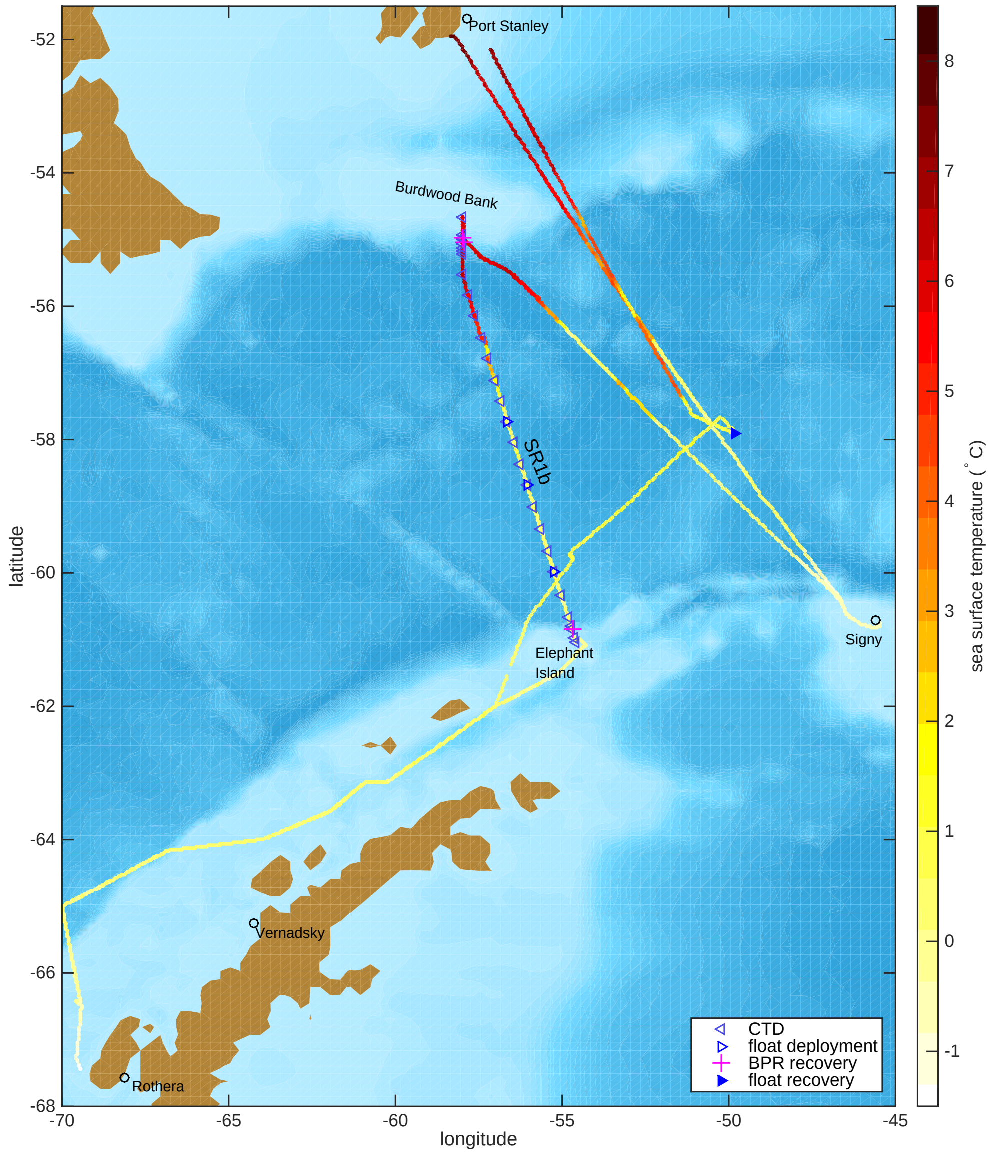

Figure 1: JR16002 cruise track

3 Objectives

RRS *James Clark Ross* cruise JR16002 was a combination of logistics and two science projects:

- Continuous Ocean Monitoring Methods: Drake Passage
  A Hibbert, NOC
  Aim: To recover five bottom pressure recorder (BPR) landers from the continental slopes on either side of the passage, contributing to the long time-series of Antarctic Circumpolar Current transport through Drake Passage; to maintain tide gauges at Stanley, Vernadsky, and Rothera.
  Funded by NERC National Capability ACCLAIM.

- Hydrographic measurements in Drake Passage
  Y Firing, NOC
  Aim: To make high-quality repeat hydrographic measurements on GO-SHIP line SR1b, continuing a near-annual time series begun in 1993, to obtain complementary station and underway currents and underway meteorology data, and to deploy deep profiling floats, in order to monitor Southern Ocean watermasses and circulation pathways and Antarctic Circumpolar Current volume and property transport.
  Funded by NERC National Capability LTS-M ORCHESTRA

4 Narrative

The JCR's planned departure from the Falkland Islands on 8 November was delayed by fueling schedules, but we left Mare Harbour on 10 November, headed for Signy. Underway data collection was started when we reached open water. A test CTD/LADCP cast to 1000 m was conducted on the way to Signy, mid-day on the 12th, in order to test equipment, systems, and instruments (all of which performed nominally); it was also useful for showing the hydrography volunteers how to conduct casts, water sampling, and data processing. Some weather was encountered during the crossing to the South Orkneys.

We reached Signy on the 13th, and the initial station party went ashore in a Humber, determining that (fortunately) the bay and dock were clear of ice, and ice/snow cover at the station was also lower than average. Over the next two and a half days, with the assistance of work parties from the science and other SPPs, the snow and ice was cleared away, station supplies were brought ashore from the cargo tender and carried to their destinations, and the station made ready for occupation and operation. On the 15th, some personnel were taken to neighboring Gourlay Point to assist in setting up for penguin colony monitoring by moving nest-marking bricks to the colonies, as well as see the nesting Adelies and Gentoos up close. With the station in good condition (in particular, with operating generator and radio), the JCR departed Signy in the late afternoon of the 15th and headed back northwest toward Burdwood Bank to start the hydrography and BPR work.

As we were approaching Burdwood Bank and the start of the SR1b section, it was discovered that there had been more serious damage than previously realised to the CTD winch wire on the preceding cruise. BAS AME headquarters instructed the ship to switch from this wire to a secondary drum, which turned out to require a day of work on the part of the engineers and AME tech to get it to a working state. In the interim, since we could not begin the CTD section, we proceeded to the BPRs on the northern continental slope, visiting all three through the day on the 18th, although only two were successfully recovered (Section 5).

We then returned to the 200-m isobath and started SR1b CTDs on the evening of the 18th, proceeding quickly through the stations over the next days. The weather was exceptionally good during this part of the cruise, such that we had no weather delays on the entire section. The plan for the floats was to deploy all three south of the Polar Front, to keep them from being swept quickly out of the area. It appeared we had crossed the Polar Front at station 14, but currents were still strong at stations 14 and 15, so the first float was deployed at station 16, in the early hours of the 21st, and the second at station 19, later the same day.

On station 22, communications with the CTD failed while it was ascending at about 500 m. They returned at about 250 m, and the CTD was recovered to deck normally. Given the issues earlier in the cruise, as well as more energetic seas in the preceding hours, the initial hypothesis was that the problem was in the CTD winch wire. This was reterminated twice, as described in Section 9, until the termination tests passed, adding a short delay before starting station 23.

On station 23, CTD communications failed again, this time when the upcast had just started, at about 3430 m; they returned around 2300 m, and were briefly lost again around 2100 m. The upcast proceeded from there, and once the CTD was recovered the Sea Unit was swapped out for a spare, along with the dissolved oxygen sensor (which had briefly appeared to give erroneous readings after the comms failure).

For both stations 22 and 23, no bottles were able to be fired during the communications dropouts, and scans were not incremented, but otherwise the records appeared nominal, and as the downcasts were complete we did not attempt to redo the stations. The last float was deployed following station 23, on the evening of the 22nd, and we continued with the CTD section.

Stations 24 and 25 ran normally. On station 26, CTD communications were lost in the middle of the downcast, and did not resume; therefore the CTD was recovered for additional testing. The CTD winch wire again appeared slightly deformed, so was reterminated in a series of stages (Section 9). Tests were run with various configurations of the wire, Sea unit, and CTD sensors, which eventually led to checking the SBE32/SBE35 Y-cable beneath the CTD, and finding it to be damaged. Once this cable was replaced, the communications problems did not recur.

During this process, we visited the two southern Drake Passage BPRs, which were conveniently nearby at this point, and successfully recovered one of the two. Since the previous cast had been incomplete, we returned to station 26 and conducted a second cast, this one and the rest of the stations were successful. Station 30 was completed very early on the 24th, marking just under 5 days from the start of the section.

The second float deployed had leaked on the 23rd, and we considered returning to recover it after completing SR1b, given the current and forecast weather conditions, and the desire not to delay the Rothera call further, we decided to head for Rothera and attempt a recovery on the return.

After steaming through the Bransfield Strait, we headed out to the continental slope to skirt around the ice on the way to Adelaide Island. Although the ice had appeared to be thinning and we had hoped a storm during our transit would blow it offshore, the island was still surrounded by porridge ice. We made it to within 55 (as-the-crow-flies) nautical miles of Rothera, but were turned back by increasing ice pressure on both the morning of the 27th and the morning of the 28th. After consultation with Cambridge, the decision was made to return to Stanley, fly people and limited supplies into Rothera via the DASH, and attempt the rest of the base relief at a later date.

The leaking float was by this time drifting rapidly eastward, but fortunately we were given the authorisation to detour to recover it, and reached it on 1 December. The sea state was not ideal but the float was eventually spotted, lost, and spotted again with the help of an updated GPS fix. A heroic recovery followed, and, having determined the water had not leaked into the battery and turned it into a bomb, we secured the float and proceeded back to Port Stanley.

Underway data collection was stopped when we reached the continental shelf on the evening of 2 December, and we docked at Port Stanley on the morning of the 3rd.

5 Bottom pressure recorder landers

Geoff Hargreaves

Personnel from National Oceanography Centre (Liverpool) were present on cruise JR16002 to attempt the recovery of five bottom pressure recorder (BPR) landers that had been deployed in the Drake Passage during the previous twenty-four months, as part of an ongoing National Capability research programme. This programme has now finished so the equipment that is already in place has to be recovered.

There were five landers deployed across Drake Passage, three in the northern section near Burdwood Bank and two in the southern section near Elephant Island. The recovery of the BPRs was be undertaken during the hydrography transect as the deployment positions are on the SR1b CTD line. The hydrography section began in the northern part of Drake Passage and as such, the three northern BPRs were to be recovered first. There were two BPRs to recover from the 1100m contour line on the slope of Burdwood Bank and one from 2000m depth.

Three landers, deployed in January 2015, were recovered, while the two deployed in January 2016 failed to rise from the seabed, although communications were successful and all release units (two on each lander) were responsive. Details follow, with the landers designated 1 - 5 in the order in which they were visited on JR16002.

5.1 Lander 1

The first BPR position the ship went to was 54° 58.800 S, 57° 58.031 W; this BPR was deployed in January 2015. The acoustic deck unit was connected to the ships hull transducer and the EA600 echo sounder and swath bathymetry were deactivated making acoustic conditions perfect and quiet. Communication with both of the acoustic release units on the lander was clear and trouble free. The release command was transmitted to both acoustic units and both responded by indicating the command had been received and activated.

The release system on the landers is a burn wire-based system that requires a voltage to be applied to a piece of Inconel wire loop and a current then passes through the water to a cathode. The Inconel wire gradually dissolves and once completed, the release module (which is held together by a pin passing through the Inconel loop) separates and the release gate can open, dropping the ballast weight that secures the lander to the seabed. The frame, which is now positively buoyant, ascends to the surface where it can be recovered. Five minutes after transmitting the release commands the lander had released from the seabed; it ascended at 0.5 m s^{-1} to the surface where it was recovered.

5.2 Lander 2

The ship then repositioned to the next lander position at 54° 58.817 S, 57° 59.309 W; this lander was deployed in January 2016. Once again acoustic conditions were excellent and both acoustic units on the lander were activated and sent the command to activate the release. The acoustic release units on the lander behave as transponders, in that they reply on a certain frequency when they detect a signal on a different frequency. Each unit responds to different frequencies and this allows the operator on the ship to communicate with more than one device. In normal operation, one ping is transmitted when it detects the correct frequency signal. Once the release command is received, four pings are transmitted.

Both of the acoustic release units on the lander were responding with four pings after having received the release command. Since the acoustic conditions were very good, this could be heard through the headphones of the acoustic deck unit and also observed on the display. After an hour on station, pinging to the acoustic units on the seabed, there was still no sign of the lander releasing and coming back to the surface. All of the signs were that the acoustic releases were working normally but the lander hadnt separated from the ballast weight. The recovery attempt was halted and the ship proceeded to the next site.

5.3 Lander 3

The third lander visited was located at -55.03909 S, -5794898 W at a depth of 2000 m. The lander deployed at this location in January 2015 was a different design from the previous two and required the use of an over side transducer or dunker unit, rather than the hull transducer. This acoustic system transmits a coded signal to the sea unit. Communication was established and the release sequence initiated. This involved transmitting a sequence of commands to the sea unit, culminating in the release command. This unit uses a motor driven release mechanism. It was necessary to interrogate the unit again to determine if the release operation had been successful, which it had. This lander ascended at about 1 m s° to the surface and once spotted on the surface was quickly recovered.

5.4 Lander 4

At the southern end of the Drake Passage there were two BPRs to recover, both at a depth of 1000 m. The BPR at 60° 50.9842 S, 54° 41.9039 W, deployed in January 2015, was attempted first. Both acoustic releases were communicating well and the first unit was sent the release command and responded to indicate it had received the command. The second unit was sent the release command and it appeared to indicate it had received the command. The ship moved a few hundred metres away from the deployment position whilst the acoustics were monitored for sign of the lander releasing from the seabed. One acoustic was responding with four pings and the other was responding with a single ping. The release command was sent several times to the second unit to try and activate the release mode but without success. After nearly an hour on station, the lander still had not released and the ship was repositioned to be directly above the BPR. The release command was transmitted again to both sea units and both units responded positively to indicate that it had been received. Eight minutes later and the lander released from the seabed, ascended to the surface at about 1 m s° and was recovered onto the ship.

5.5 Lander 5

The ship then positioned itself at the site of the final BPR, deployed in January 2016, at 60° 51.1070 S, 54° 43.7376 W. Once again the release commands were transmitted to both release units and both replied to indicate they had received the command. The units were periodically interrogated to determine if the lander had released from the seabed but this did not happen. After an hour of trying to recover the lander, the ship left the site and headed north to continue with the CTD stations. About six hours after leaving the BPR site, the ship was back again to undertake the CTD cast at that position. This allowed the acoustic sea units to be checked and both were found to be responding, indicating that the frame was still on the seabed.

6 Hydrographic Measurements

Yvonne Firing, Madeline Miller, Eric Sánchez Muñoz

The 30 CTD/LADCP casts on SR1b are summarised in Table 1.

Table 1: SR1b CTD/LADCP stations.

station	bottom date, time (UTC)	start time	end time	latitude (S)	longitude (W)	max CTD press (dbar)	Niskins	float
001	16/11/18 2302	2255	2309	54° 40.02’	57° 58.95’	157	4	
002	16/11/19 0123	0108	0144	54° 55.31’	57° 59.01’	711	6	
003	16/11/19 0253	0234	0318	54° 58.58’	57° 58.96’	981	6	
004	16/11/19 0437	0406	0516	55° 00.40’	57° 59.00’	1675	8	
005	16/11/19 0647	0608	0733	55° 04.19’	57° 58.97’	2239	8	
006	16/11/19 0910	0821	1006	55° 07.28’	57° 58.99’	2777	8	
007	16/11/19 1148	1053	1250	55° 10.21’	57° 59.01’	3159	10	
008	16/11/19 1444	1334	1610	55° 12.86’	57° 59.00’	4068	12	
009	16/11/19 1935	1824	2102	55° 31.01’	57° 59.06’	4284	12	
010	16/11/20 0049	2323	0226	55° 50.04’	57° 49.20’	4832	12	
011	16/11/20 0556	0456	0705	56° 09.02’	57° 37.30’	3438	10	
012	16/11/20 1038	0931	1156	56° 28.13’	57° 23.47’	3859	12	
013	16/11/20 1502	1408	1605	56° 47.00’	57° 13.86’	3242	10	
014	16/11/20 1927	1821	2044	57° 06.82’	57° 00.65’	3791	12	
015	16/11/20 2345	2242	0100	57° 25.28’	56° 49.81’	3727	12	
016	16/11/21 0438	0337	0603	57° 44.19’	56° 38.70’	3585	24	0015
017	16/11/21 1000	0848	1140	58° 03.04’	56° 26.85’	4010	12	
018	16/11/21 1532	1426	1651	58° 22.24’	56° 14.87’	3951	12	
019	16/11/21 2027	1924	2157	58° 40.98’	56° 03.26’	3809	24	0013
020	16/11/22 0238	0115	0358	59° 00.20’	55° 51.50’	3836	12	
021	16/11/22 0827	0719	0945	59° 20.03’	55° 39.07’	3818	12	
022	16/11/22 1409	1307	1516	59° 39.79’	55° 26.75’	3737	9	
023	16/11/22 2142	2034	2233	59° 59.43’	55° 14.05’	3552	18	0012
024	16/11/23 0307	0208	0416	60° 19.92’	55° 02.06’	3488	10	
025	16/11/23 0750	0657	0855	60° 40.05’	54° 49.52’	3148	12	
026	16/11/23 2011	1927	2112	60° 47.98’	54° 44.52’	2618	15	
027	16/11/23 2252	2222	2334	60° 50.00’	54° 43.26’	1750	12	
028	16/11/24 0043	0026	0110	60° 51.04’	54° 42.55’	958	8	
029	16/11/24 0242	0231	0300	60° 58.96’	54° 37.65’	579	7	
030	16/11/24 0415	0407	0426	61° 02.94’	54° 34.97’	348	4	

One stainless steel CTD system was prepared with a 24-way carousel. Details of the instrumentation are given in Section 9. Operation was normal on the 30 stations conducted during the cruise, with the following exceptions.

- During station 20, the bow thruster failed when the rosette was descending around 600 m, leading to the CTD being recalled; however, as the reset was successful by the time the CTD had reached about 150 m, the downcast was recommenced. Not returning the CTD all the way to the surface meant that the downcast depth profile for station 20 was discontinuous.
- On station 22, communications between the underwater package and the deck unit failed between 505 and 250 m on the upcast.

- On station 23, they failed on the upcast between approximately 3428 m (shortly after starting up from the bottom) and 2300 m, and again briefly around 2100 m.
- On the first cast at station 26, a CTD fault on the downcast at 1630 m (in 2540 msw) led to recovery of the CTD; this station was revisited and a successful full-depth cast conducted following BPR operations and repairs to the CTD cables.

The CTD communications failures are discussed in Section 9, and their handling in data processing in Section 6.3.1.

6.1 CTD operation

Data were acquired with SeaSave V 7.22.3.

After each cast, two batch scripts were run: BASsvp, which prepares a sound velocity profile and a CTD listing for transmission to the UK Met Office; and JR16002_sbeproc, which, in three steps, exports as text file (.cnv), applies 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 applies 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. The batch scripts also copied the raw and processed data onto the network drive, legdata.

SBE35 temperature data were uploaded using SeaTerm 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; the procedure followed for bottle firing was therefore to wait 30 s for equilibration, fire a bottle, and wait 15 s to ensure the SBE35 measurement had been taken. 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.

6.2 Lowered Acoustic Doppler Current Profiler (LADCP) operation

The 300-kHz Workhorse LADCP was installed in a downward-looking configuration on the CTD rosette (see Section 9). The instrument was configured (right) to sample 25 x 8-m 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 the CTD computer in the UIC for programming prior to each station and data download after each station, using BBTalk. Pre-deployment tests were performed at least once daily, generally once per 12-hour watch.

Data downloaded after each station were copied to the network data drive in ladcp/JR16002, with names of the form JR16002_NNN.000, along with deployment logs, JR16002_NNN.txt.

LADCP command file:

```
CR1
RN JR16002
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
```

6.3 Data Processing

6.3.1 CTD processing for each cast

The CTD data processing followed the methods used on previous SR1b and other NOC MPOC cruises, using the Mexec software suite (“A User Guide for Mexec, v3.0”, available from the NOC Marine Physics and Ocean Climate group). The version used in this case, mexec_processing_scripts_v3, streamlines the setting of cruise-specific options but does not change the processing steps from previous versions. The Mexec processing follows the initial SeaBird conversions and corrections described above. The necessary directories and links were set up at the beginning of the cruise using conf_script_jr16002 (found in the home directory on fola, see Section 8). After each cast, ctd_linkscript was used to copy files to fola and set up additional symbolic links to filenames following mstar convention.

For each cast the initial processing was done by running ctd_all_part1, mdcs_03g, and ctd_all_part2. The scripts called by these wrapper scripts, and the corrections, averaging, and calculations completed and files generated by each, are detailed in the Mexec user guide (v3.0) and in cruise reports for JR306 and JR15003. mdcs_03g requires hand-selection of cast start and end times (generally based on pressure and oxygen fields; see JR15003 report).

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. In this case, a few spikes in either primary or secondary conductivity or both were removed from stations 1, 2, 3, 5, 8, 10, 12, 13, 14, 15, 20, and 27.

On station 20, an issue with the winch around 600 m led to the downcast being aborted; the issue resolved itself around 150 m and the downcast was resumed from there. While simple depth-bin averaging of the downcast T, S, O time series did not produce large discontinuities at either end of the repeated depth range, it did result in an unusually wiggly section around the lower end. The 2-dbar average version of record for this station therefore comes from the upcast.

CTD communications failures (Section 9.2) on stations 22 and 23 produced not only missing data but also extremely large spikes, followed in some cases by oscillating bad values, in all or most parameters for a range of scans around the complete comms dropouts. Because some of the bad values were so far out of range, it was difficult to use the mctd_rawedit graphical interface to remove all the bad data. Therefore code was added to mctd_rawedit and to its cruise-specific options to set all variables measured by the CTD to NaN for the ranges of scans where one or more parameters were bad, as determined by examination of the raw file. This code was modeled on similar code to edit the 24hz file in mctd_03. Note that because the cause of the communications failure was in the underwater unit, scans were not incremented during the dropouts, so that the pressure record is discontinuous. A precise record of the dropout lengths is not available.

For casts where the raw data were edited using mctd_rawedit, smallscript_postedit was run to regenerate the derived files.

6.3.2 LADCP processing for each cast

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).

Directories, links, and parameter files for LADCP processing were set up at the beginning of the cruise using conf_script_jr16002, and by running lad_linkscript_ix after each cast. Once a 1-hz ctd file has been generated (by ctd_all_part1), list_ctd_1hz(nnn) can be run to export time, lat, lon, press, temp, psal into ascii to be used by the LDEO processing; ladctd_linkscript_ix makes links to these files. While the LADCP processing can be run without the CTD data, position from the CTD 1-hz file is used to compute the magnetic deviation.

Matlab script ixpath sets up the necessary paths for LDEO-IX LADCP processing, which should be run from ladcp/ix/data/. 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

For stations 22 and 23, where CTD communications failures led to discontinuous pressure time series, processing version 4 produces erroneous profiles. The LADCP profiles in Drake Passage produced by the LDEO-IX inverse using navigation and bottom tracking (or, for stations 22 and 23, navigation only), are shown in Figures 2 to 4. The erroneous surface layer segment (and large error bounds) visible at station 26 results from a small gap in the LADCP data; a more complete profile might be recoverable by modified processing.

6.4 Water sample collection and analysis

Water samples were drawn from the Niskin bottles in the following order: dissolved oxygen sample and any duplicates; oxygen isotope sample and any duplicates; salinity sample. The distributions of water samples, along with SBE35 temperature calibration points, are shown in Figure 5. Niskin firing depths were chosen based on the downcast profiles in an attempt to cover the pressure, temperature, salinity, and oxygen ranges, while taking samples both in regions of low variability (for calibration), and at extrema (including the bottom layer, the surface mixed layer, and subsurface temperature, salinity, and oxygen extrema, where these features appeared).

In general samples for all quantities were drawn from all good Niskins (and an SBE35 sample was collected whenever a Niskin fired), except that extra samples were drawn for oxygen on the last few casts after the oxygen sensor was switched out (Section 9.2). Outliers were flagged as 3 (questionable) where a large difference between CTD and calibration value appeared attributable to a property gradient, and as 4 (bad) where errors in sampling or analysis were noted (for the most part, errors in sample drawing for O_2, and incomplete sealing of stoppers for salinity). Flagged SBE35 samples might indicate that the Niskin was closed too quickly for a good, equilibrated reading. Oxygen isotope samples were taken in plastic bottles, with duplicates in glass bottles taken at the deepest and shallowest Niskin on most casts. On a few later casts a triplicate oxygen isotope sample (in a plastic bottle) was taken as well.

6.4.1 Dissolved oxygen analysis

Sampling and analysis procedures closely followed the GO-SHIP manual procedures for dissolved oxygen (*Langdon*, 2010).

After collection, a Milli-Q water seal was applied to the neck of the sample flasks and samples. 30 minutes after sample collection was completed, the flasks were shaken again, using the vigorous wrist-snapping inversion motion to ensure that the reaction was complete. Samples were generally in the lab for a minimum of 1 hour before titration. When ready to titrate, the water seal was dried with a Kimwipe and the stopper of the flask carefully unsealed by gently twisting back and forth. A 1 mL aliquot of H_2SO_4 from the bottle-top dispenser was added to the flask, immediately followed by a clean magnetic stir bar. The flask was placed on the stir plate and the electrode and burette were carefully inserted to place the tips in the lower-middle depth of the sample flask. The initial volume of $Na_2S_2O_3$ for each sample was 0.3 mL, after which the titration proceeded using the pre-set program on the Metrohm automatic titration system, with amperometric determination of the titration endpoint.

Duplicates

For each cast, at least one Niskin bottle was sampled in duplicate and analyzed for oxygen concentration. During the casts that corresponded to float release, at least two Niskin bottles were sampled in duplicate.

Blanks and standards

A set of blanks and standards was analyzed at least once every 24 hours (more frequently at the beginning of the analyses) during the cruise sampling and analysis period to monitor the evolution of the concentration of the batch of $Na_2S_2O_3$ (this did not need to be refilled). One set of blanks was three flasks prepared as described by *Langdon* (2010), Section 7.1. After the first titration endpoint was reached in each flask (with the volume of $Na_2S_2O_3$ added to reach the endpoint recorded as V1), a second 1 mL aliquot of KIO_3 was added to the same flask and the titration was repeated and recorded as V2. The initial volume addition of $Na_2S_2O_3$ at the beginning of the titration was set to 0 mL for the blanks.

One set of standards was five successive flasks with 10 mL iodate standard (0.01 N/1.667 mM KIO_3 from OSIL) prepared as described in *Langdon* (2010), Section 7.2. The initial volume addition of $Na_2S_2O_3$ during the titration was 0.3 mL for the standards.

Calculations and conversions

The conversion from titre volume to moles of oxygen to oxygen concentration was computed following *Langdon* (2010) and references therein. Density based on the sample bottle draw temperature and calibrated CTD salinity was used to convert from μmol L^{-1} to μmol kg^{-1} as part of Mexec processing.

At least one duplicate was taken at each station (two for 24-bottle casts). The duplicate for the first station showed a large disagreement, so that both values were flagged as bad. Otherwise, the duplicate rms difference was 1.6 μmol L^{-1} (compare with sample oxygen concentrations ranging from 170 to 360 μmol L^{-1}).

6.4.2 Salinity analysis

Between 4 and 24 water samples for salinity analysis were drawn for each CTD cast (one per Niskin bottle fired). The distribution of bottle sample locations in Drake Passage is shown in Figure 8 and 9. Samples were taken in 200ml glass sample bottles, which were rinsed three times before filling to the shoulder, and sealed with a clean dry disposable plastic stopper after drying the neck of the bottle. Clean (freshwater rinsed) and dry caps were added to secure the stoppers. Once filled, crates of samples were stored in the Bio Lab for a minimum of 8 hours before analysis to allow equilibration to the laboratory temperature.

Salinity sample analysis was performed, by various watchstanders, on the BAS Guildline 8400B Salinometer, Serial No. 68533, in the Bio Lab, using a bath temperature of 24°C and attempting to keep the room temperature around 21.5°C. Standard procedures were followed: A sample of IAPSO Standard Seawater, batch P158 (K15 $= 0.99970$) was run before and after each set of up to 24 samples for salinometer calibration. We flushed the volume with expired P155 or previously opened bottles of P158 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. Three readings were taken for each sample and standard. In some cases, the first reading was obviously different from the second two, and was discarded as having been insufficiently flushed. A few other outlier readings were also discarded, but otherwise the three readings were averaged.

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 offsets derived from the initial and (where completed) final standard analysis for each set of samples. These offsets ranged from 0.7×10^{-4} to 2.7×10^{-4} (median 1×10^{-4}), generally decreasing through the cruise; values larger than 2×10^{-4} corresponded to underway samples. Drifts within a sample set were up to $\pm0.6 \times 10^{-4}$, with a median absolute value of $< 0.1 \times 10^{-4}$.

6.5 CTD data calibration and results

A variety of extra steps is available after other processing has been carried out, as described in “A User Guide for Mexec, v3.0”, to add navigation and sample data to the files. On JR16002 we ran these steps together once all casts were completed and all salinity and oxygen calibration data had been obtained.

Temperature, salinity, and oxygen were calibrated on JR16002, using samples taken at locations shown in Figure 5. We first evaluated the comparison between CTD temperatures and the 315 good SBE35 readings, and applied temperature offsets increasing over the course of the cruise from -1.3 to +1.6 m°C (sensor 1) and from -0.3 to +2.6 m°C (sensor 2).

We then evaluated the comparison between CTD salinities and 280 good bottle salinities. The comparison was done in conductivity space, by converting bottle salinities to conductivity at the calibrated CTD temperatures. CTD conductivity adjustments with station number dependence and piecewise linear pressure dependence were chosen to minimise the median and standard deviation of the bottle conductivity to CTD conductivity ratio, and are approximately equivalent to salinity offsets ranging from -2.65$\times 10^{-3}$ to 1.33$\times 10^{-3}$ (sensor 1) or -4.33$\times 10^{-3}$ to -1.12$\times 10^{-3}$. Post-calibration comparisons between CTD and SBE35/bottle temperature/salinity are shown in Figure 6.

Finally, we used the calibrated salinity to compute density and convert oxygen concentrations to μmol kg^{-1} for comparison with CTD oxygen. 260 good bottle oxygen values from stations 1 through 23 were compared to the first CTD oxygen sensor, used up through station 23, and 62 good bottle oxygen values from stations 24 through 30 were compared to the second CTD oxygen sensor, used from station 24 on. We least-squares fit a calibration function, $O_0(a_1+a_2N)+a_3+a_4P$, where O_0 is the uncalibrated CTD oxygen, N is the station number (1 to 30), and P is pressure, to the bottle data from stations 1-23, producing $O_{cal}(N \leq 23) = O_0(1.04-4\times10^{-4}N)+3.1+12\times10^{-4}P$. Because we had relatively few samples available to calibrate the second sensor, and their depth range in particular was limited (as the last stations were over the continental slope), for stations 24-27 we did not include pressure dependence, resulting in $O_{cal}(N \geq 24) = O_0(1.33 - 10.4\times10^{-3}N) + 15.1$. Post-calibration comparisons between CTD oxygen and bottle oxygen are shown in Figure 7.

Sections of calibrated temperature (Figure 8), salinity (Figure 9), and oxygen (Figure 10) show a number of features, including the northerly position of the Polar Front and cold, dense, young shelf water not only at the top of the Antarctic continental slope but also in blobs found offshore at the base of the slope between 200 and 800 m depth.

6.6 References

Langdon, C., 2010. Determination of Dissolved Oxygen in Seawater by Winkler Titration Using the Amperometric Technique. In The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines. Hood, E.M., C.L. Sabine, and B.M. Sloyan, eds. IOCCP Report Number 14, ICPO Publication Series Number 134. Available online at: http://go-ship.org/HydroMan.html.

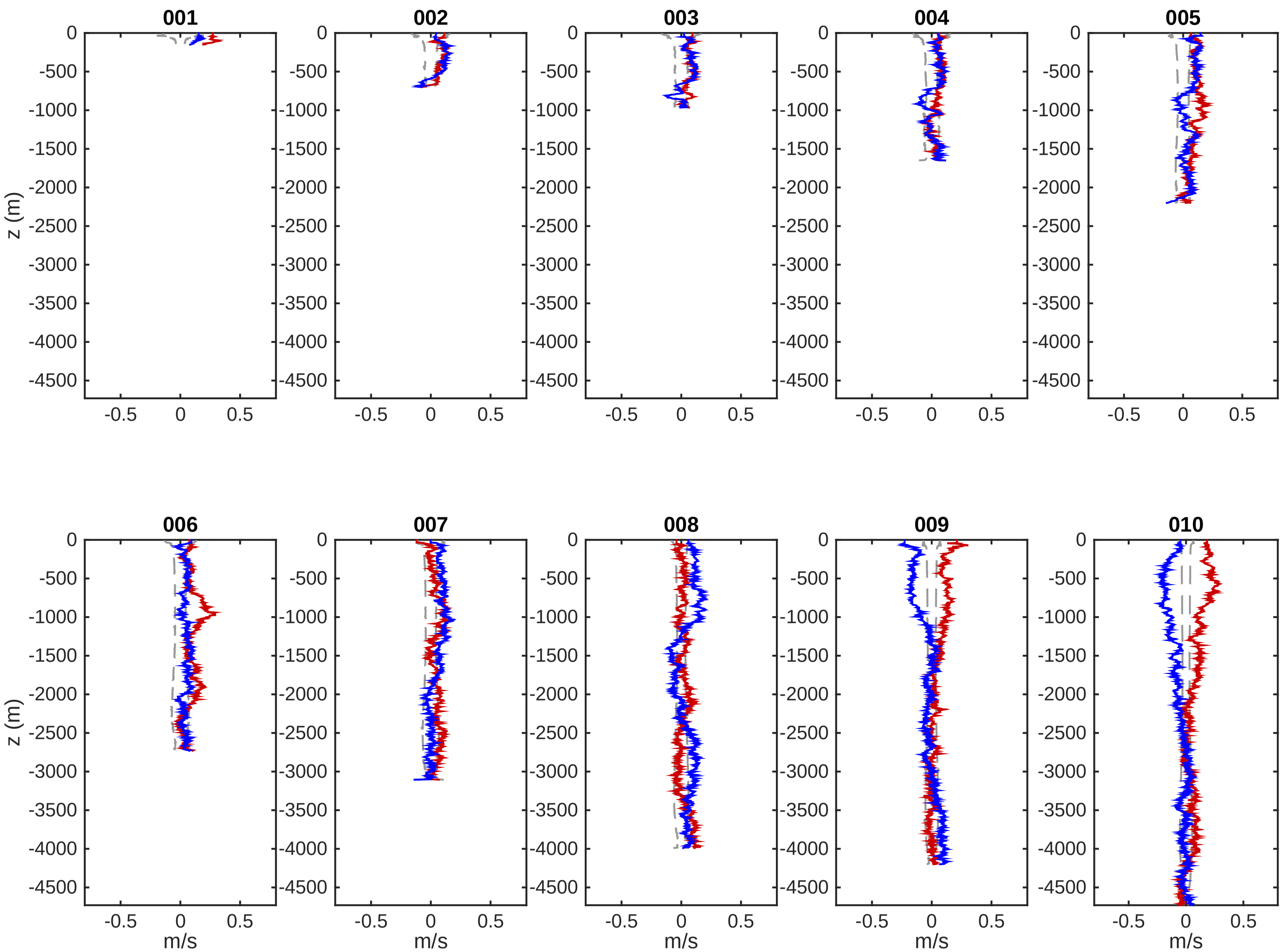

Figure 2: Stations 1-10: LADCP zonal (u, blue) and meridional (v, red) velocity profiles and error amplitude (gray dashed) based on LDEO IX inversion using navigation data and bottom tracking.

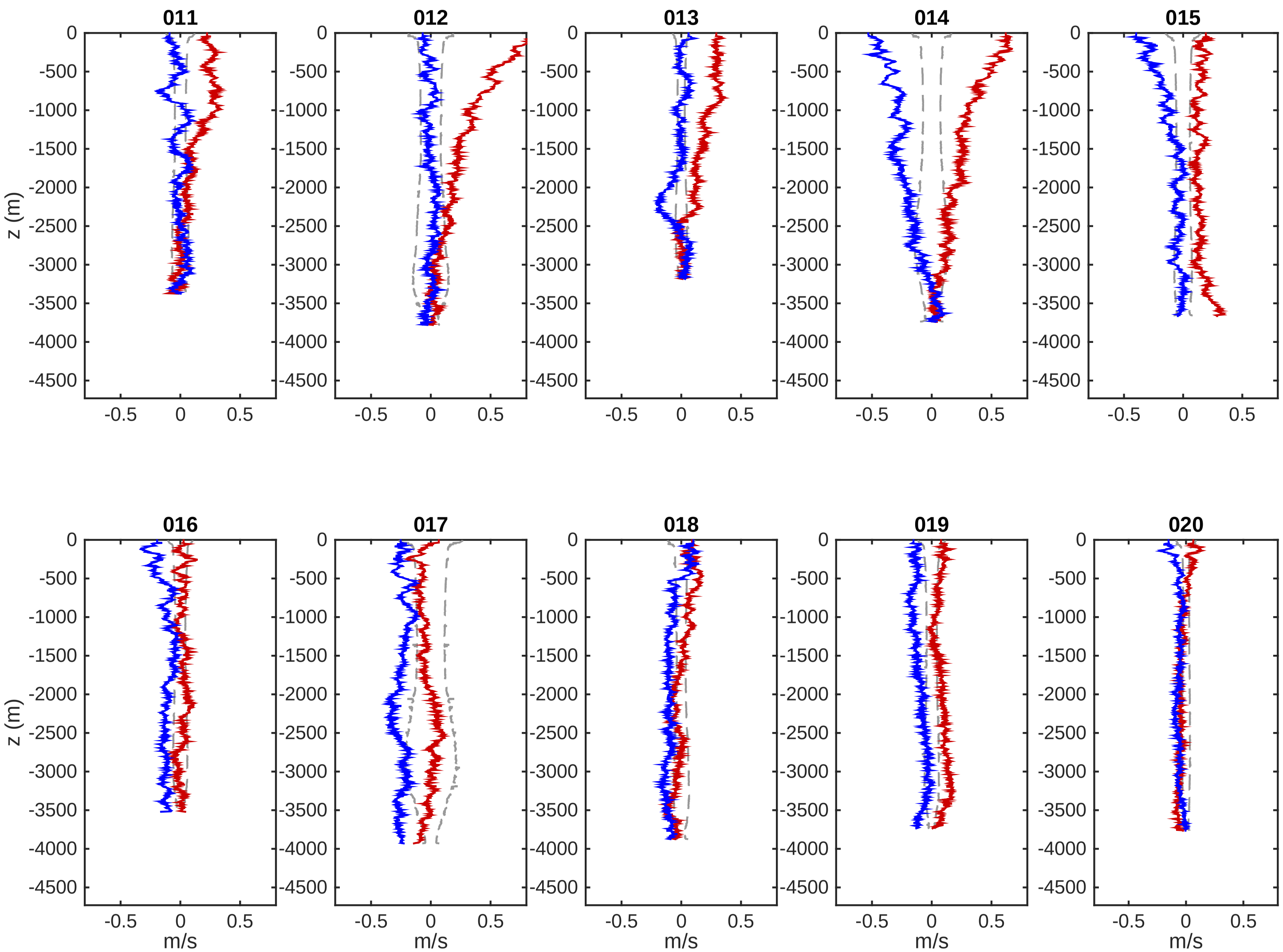

Figure 3: Stations 11-20: LADCP zonal (u, blue) and meridional (v, red) velocity profiles and error amplitude (gray dashed) based on LDEO IX inversion using navigation data and bottom tracking.

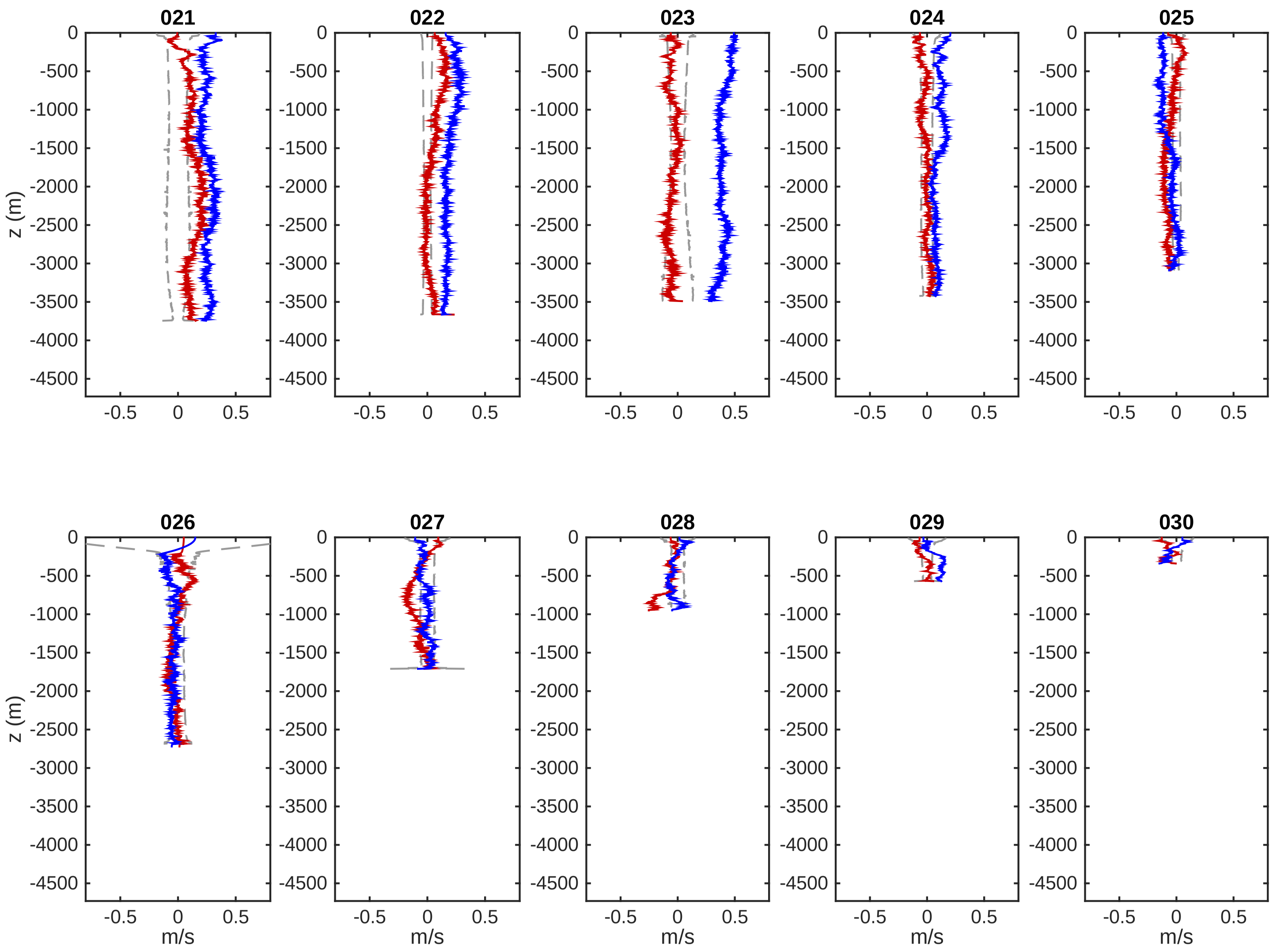

Figure 4: Stations 21-30: LADCP zonal (u, blue) and meridional (v, red) velocity profiles and error amplitude (gray dashed) based on LDEO IX inversion using navigation data (all stations) and bottom tracking (all except 22 and 23).

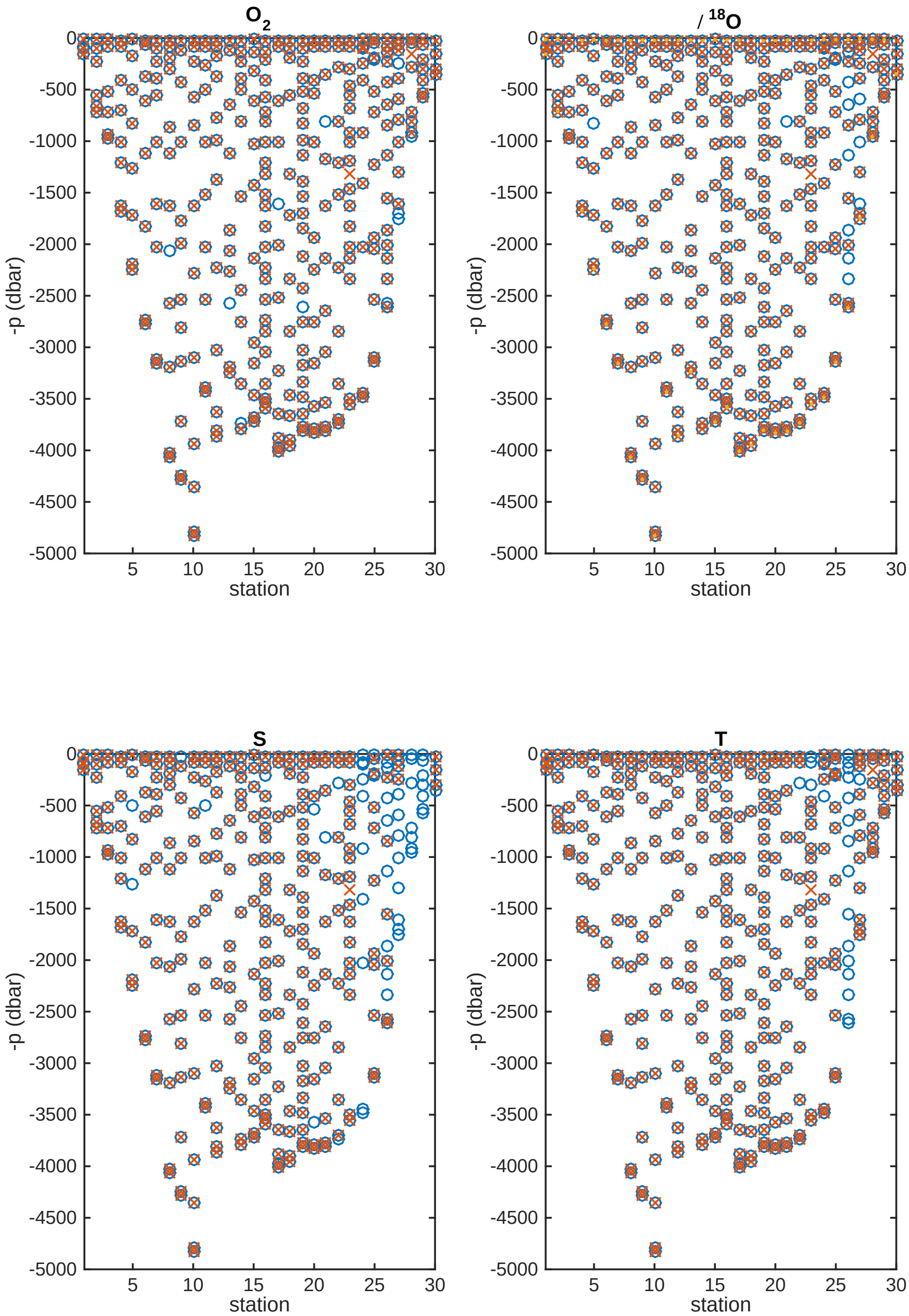

Figure 5: Good Niskin bottles (blue circles) and good samples (red xes) measured (for SBE35 T), analysed (for salinity and O_2), or stored (for δ^{18}O; duplicates indicated by yellow dots).

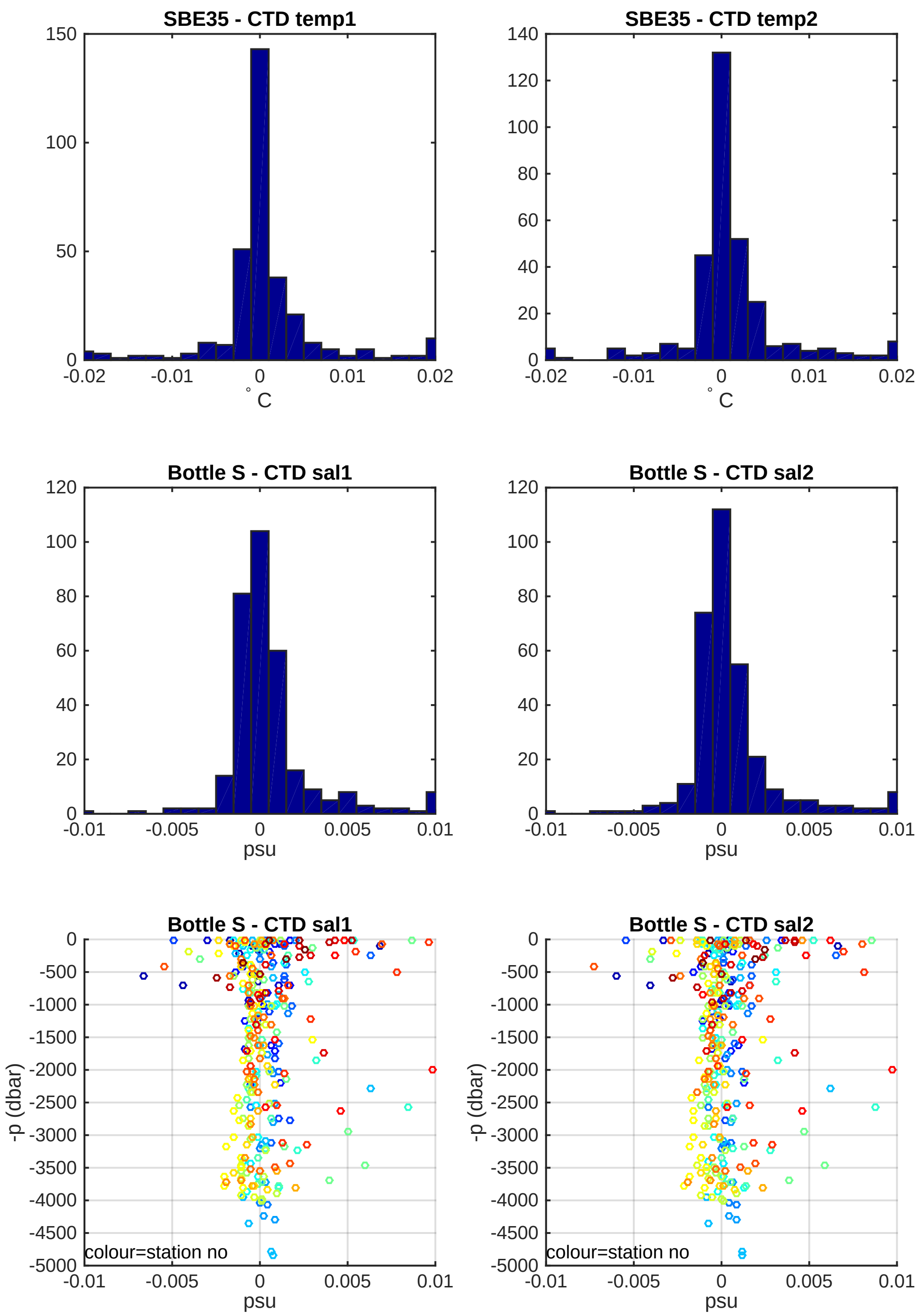

Figure 6: Histograms of temperature and salinity residuals, and depth profiles of salinity residuals with colour indicating station number (blue to red).

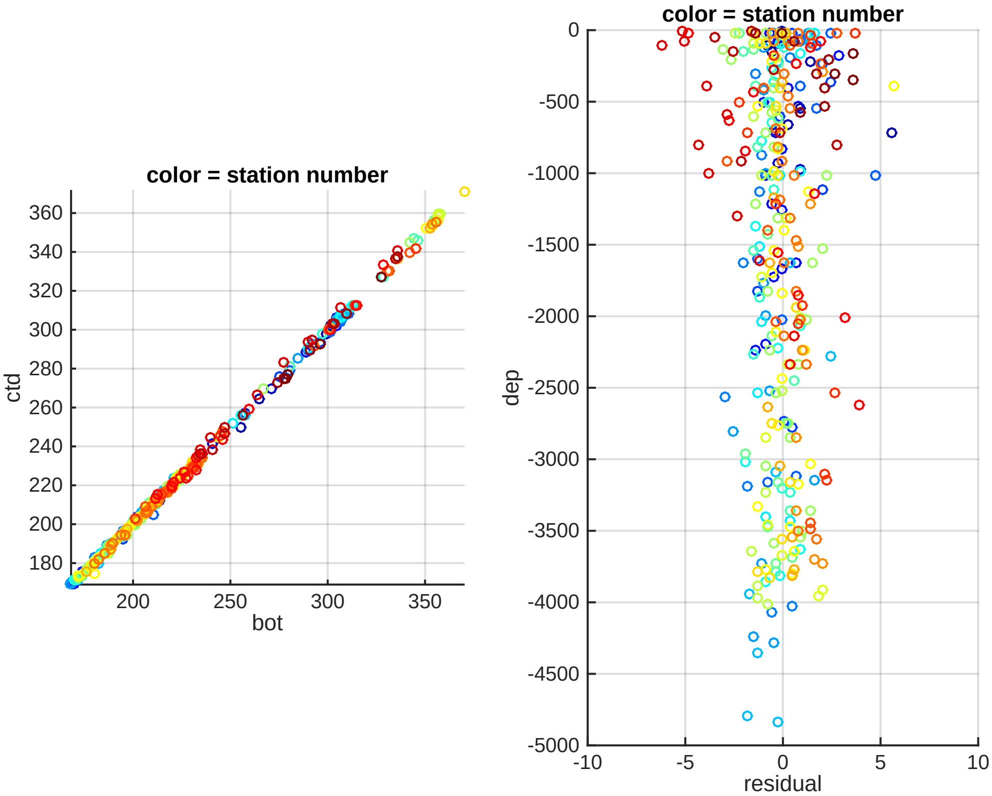

Figure 7: Scatter plot of bottle and calibrated CTD oxygen (left, μmol kg^{-1}), and residuals (μmol kg^{-1}) as a function of depth, with colour indicating station number (blue to red).

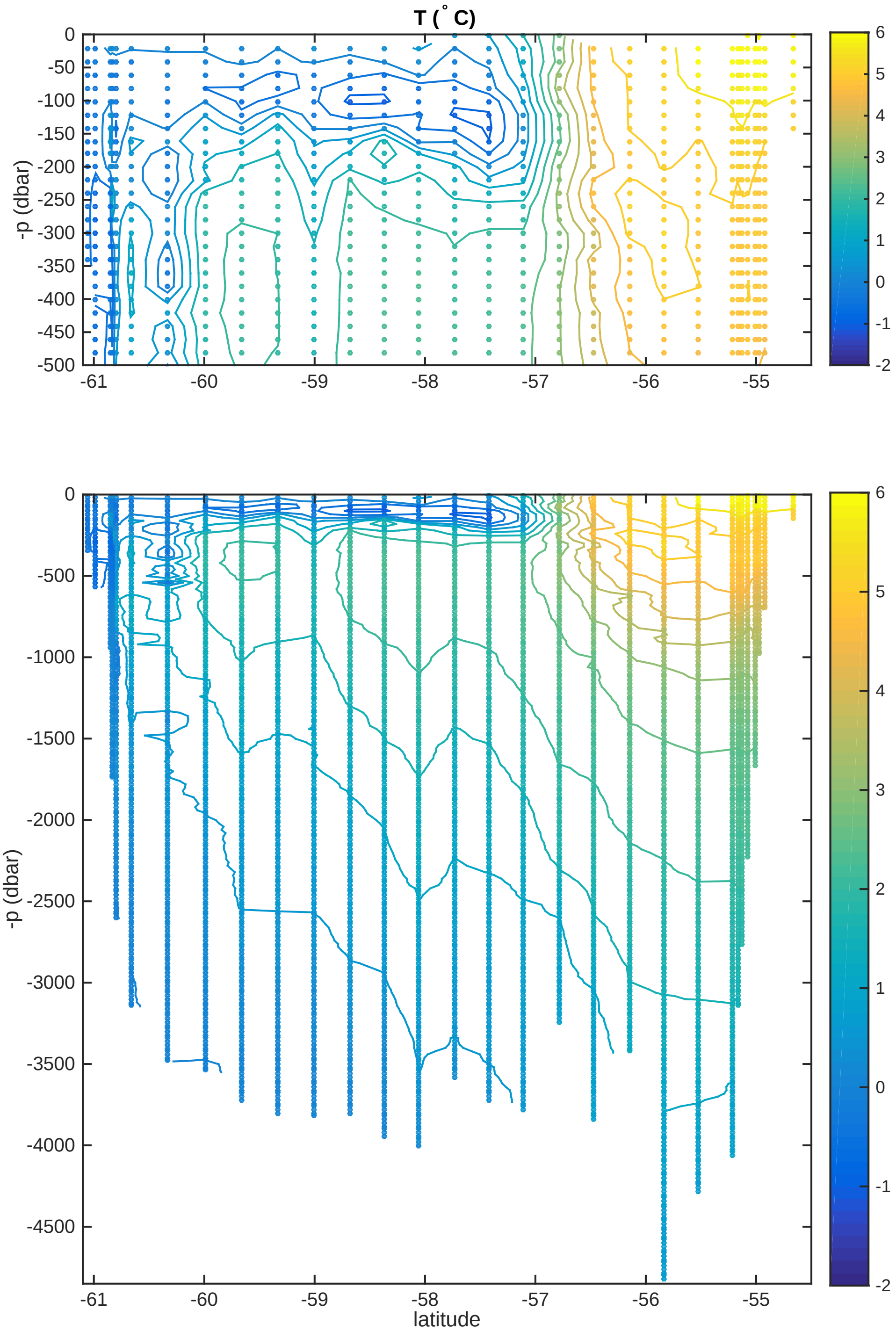

Figure 8: Calibrated temperature on SR1b, 18-24 November 2016. The contours and columns of filled cirles both come from the 2-dbar profiles (downcast profiles except where otherwise noted in the text).

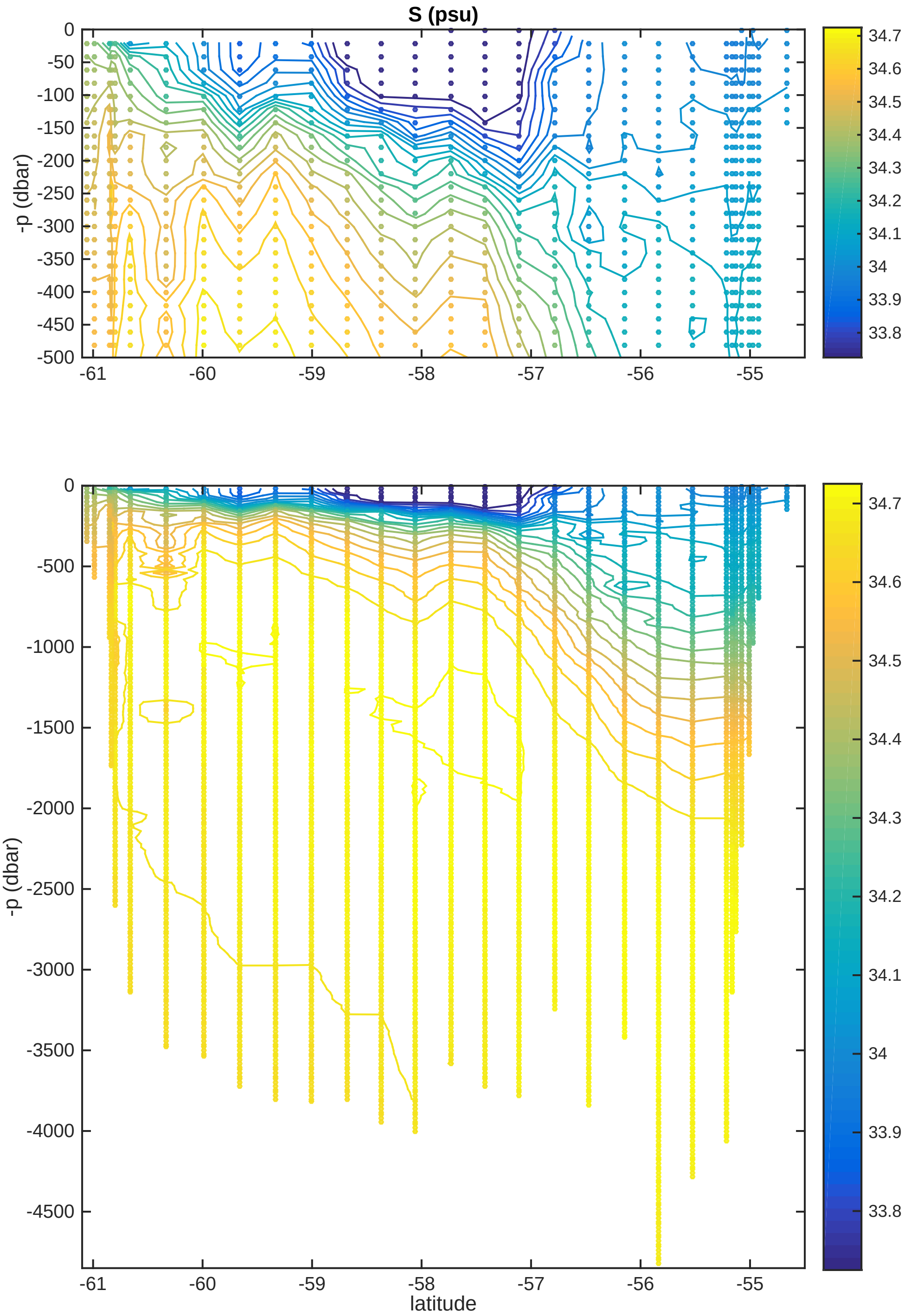

Figure 9: Calibrated salinity on SR1b, 18-24 November 2016. The contours and columns of filled cirles both come from the 2-dbar profiles (downcast profiles except where otherwise noted in the text).

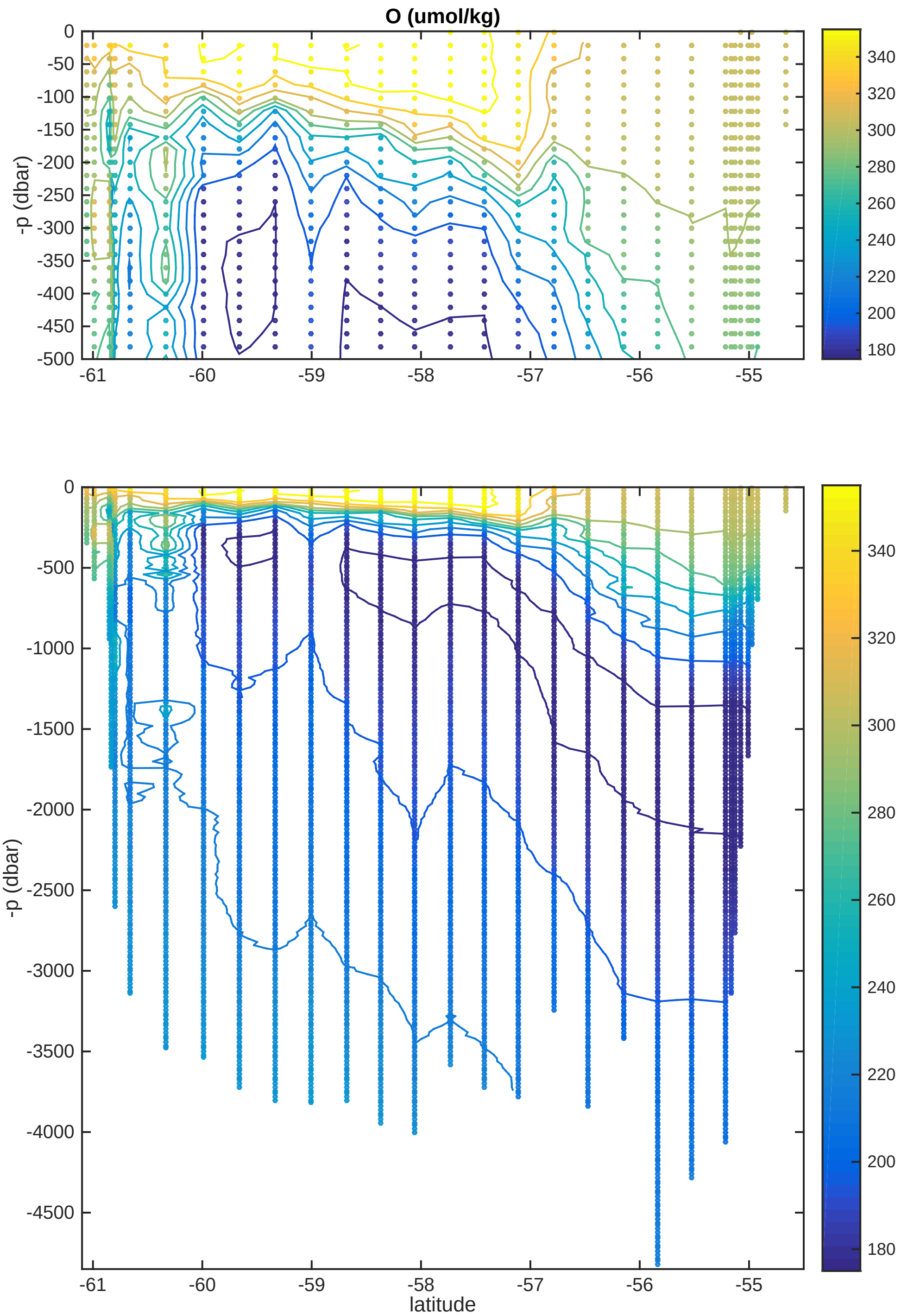

Figure 10: Calibrated dissolved oxygen on SR1b, 18-24 November 2016. The contours and columns of filled cirles both come from the 2-dbar profiles (downcast profiles except where otherwise noted in the text).

7 Deep APEX autonomous profiling floats

Yvonne Firing

Three Deep APEX (Teledyne Webb Research) 6000-m depth-rated autonomous profiling floats were deployed in southern Drake Passage on SR1b, intended to contribute to monitoring deep water properties and pathways for ORCHESTRA, as well as to the global Deep Argo program. All three floats leaked within days to weeks of deployment and had to be recovered. Common aspects of the operations are summarised here, with more specifics for each float in the subsections below.

The initial mission.cfg loaded to the floats was:
ActivateRecoveryMode off
AscentRate 0.12
AscentTimeout 608
AscentTimerInterval 300
BuoyancyNudge 70
DeepDescentCount 2000
DeepDescentPressure 3500
DeepDescentTimeout 5
DeepDescentTimerInterval 60
DeepProfileFirst on
DownTime 3809
EmergencyTimerInterval 3600
IceBreakupDays 14
IceCriticalT -1.78
IceDetectionP 50.00
IceEvasionP 20.00
IceMonths 0000
IdleTimerInterval 3600
InitialBuoyancyNudge 300
LeakDetect on
LogVerbosity 5
MActivationCount 2000
MActivationPressure 25.00
MinBuoyancyCount 800
MinVacuum 7
ParkBuoyancyNudge 10
ParkDeadBand 50
ParkDescentCount 2000
ParkDescentTimeout 911
ParkDescentTimerInterval 3600
ParkPressure 3500
ParkTimerInterval 3600
PnPCycleLen 1
PreludeSelfTest on
PreludeTime 120
SurfacePressure 5.00
TelemetryRetryInterval 900
UpTime 728

This mission DeepDescentCount and ParkDescentCount had to be revised when they proved to be much too high to allow the floats to dive to the target pressure of 3500 dbar (see below). They were changed to 1250 before deployment of the 3rd float (0012), and for the other two floats when they downloaded updated .cfg files from the server upon resurfacing following their initial missions.

The sample.cfg, intended to record CTD and oxygen measurements while in park phase, at the hourly ParkTimerInterval setting, in addition to the profiles, was:
<PARK>
SAMPLE CTD 6500 5 0.0 DBAR
SAMPLE OPT 6500 0 0.0 DBAR
<ASCENT>
SAMPLE OPT 6500 300 20.0 DBAR
SAMPLE OPT 300 100 10.0 DBAR
SAMPLE OPT 100 0 5.0 DBAR
<SURFACE>
SAMPLE OPT 6500 0 0.0 DBAR
<ASCENT>
PROFILE CTD 6500 0 2.0 1.00 #Regime:1

Before the cruise started, all three floats were tested on the ship using sys_self_test. For each, the top of the crate was removed and the deck box cable plugged into the float comms port and by a serial-usb connector or serial-ethernet connector to a macbook pro running miniterm.py. The line feed must initially be set to CR, by typing Ctrl-T Ctrl-L twice, for some input to be recognised correctly. The float is then woken by pressing the deck box reset button, and is put into console mode by typing m_console. sys_emerg_clr can be run in case the float has gone into emergency mode, but will put in idle state, so it must be followed by m_console. su root allows verbosity to be set by typing dbg_verbosity 5 (this appears to be necessary only once unless the float is completely reset). With dbg_verbosity set to 5, sys_self_test was run. This includes a variety of platform (voltage, vacuum, and engine) tests, sensor tests, and satellite communications tests comprising both transmit and receive attempts through both RUDICS and dialup. All the floats had some trouble seeing the sky and/or establishing sufficient communications in their securing location in the forward section of the aft deck (near the superstructure), so were moved as far aft as possible to retry the comms tests. The floats were moved around in their crates either with a pallet jack or (for short distances) by walking the crates.

The floats were then secured on the aft deck for the transit to Signy, Signy call, recrossing to Burdwood Bank, and the northern part of the station. They were stored with their lids on except when performing additional tests (described below), which could take a number of hours.

Before deployment (4 to 12 hours prior), the conductivity sensors were flushed using a weak solution of triton cleaner (supplied by SeaBird for the ship CTD and available from the AME department), following as closely as possible the procedure outlined by TWR. The T-C Duct top, Anti-Foulant Device, and T-C Duct base were removed, exposing the top of the conductivity cell. It was not possible to attach tygon tubing to the conductivity cell port (although the same tubing fit over the rosette CTD port), so the cleaning solution was dripped into the cell using a syringe until the cell was filled. This did produce a small amount of spillage down the sides of the CTD, which was rinsed. It was allowed to sit for 1 hour and then the exhaust tube on the pump outlet was removed to allow the cleaning solution to drain. MilliQ water was then flushed through in the same way (without the soaking time).

Each deployment followed a CTD cast. One side of the crate was removed, then the remaining 3 together (by removing the base screws). A strop through the lifting bail, secured over a wooden fid, was used with the Effer crane to lift each float over the starboard rail, lowering it into the water while the ship was slowly underway, and releasing by pulling out the fid.

7.1 Float S/N 0015 (rudics ID 0046)

0015 passed its initial tests (on 9 November) except for the communications test. It failed the Iridium receive test, and then became stuck in a loop of "Modem not responding to 'AT' command. Power cycling modem." and "Iridium modem not enabled." TWR attempted to troubleshoot by having additional commands run. Running modem_test on its own produced the same result a number of times over several days, while modem_show followed by modem_chat and manually inputing the AT command ran without error. After a few days, modem_test stopped producing the error (and ran successfully multiple times), and TWR concluded it had solved itself and the float could be deployed.

During the CTD cast at station 16, m_deploy was run, producing successful sensor and buoyancy tests and successfully transfering configuration files from the server. It transitioned into parkdescent mode well before the cast finished, but due to a misunderstanding of the acceptable order of operations and different timeouts, was reset (using the deckbox) to run m_deploy again. It initially went into emergency mode, presumably (see below) due to the air bladder not quite reaching target pressure due to the low temperature, but on a second try passed the tests except the communications tests. Since it had previously downloaded the up-to-date configuration files from the server, the float was put into idle mode to deflate its bladders and be deployed for pressure activation. It was deployed at 0640 UTC (0340 local) on 21 November and observed to sink.

The float initially dove only 1500 m (see above). After mission updates it successfully dived deeper, but on mission 7 it descended substantially deeper than expected (3946 m), likely hit the bottom, and subsequently leaked while in park phase. It then went into emergency mode and surfaced. As the humidity levels subsequently recovered, indicating the desicant had absorbed the moisture, TWR decided to attempt a short mission, which aborted due to further leaking at 850 dbar. 0015 was recovered by the US Antarctic Program ARSV Laurence M. Gould on the morning of 17 December, to be returned to TWR for diagnosis and repair or replacement.

7.2 Float S/N 0013 (rudics ID 0049)

0013 passed its initial tests (on 9 November); although it threw up the "Modem not responding to 'AT' command. Power cycling modem." error once, the power cycle appeared to work as it continued without further error (not counting partial transmission failures, resolved by moving the float away from the superstructure).

During the CTD cast at station 19, m_deploy was run and all tests passed, except the dialup test (which was judged to be due to the float position near the superstructure). Having passed the tests, it started to deflate the bladders, and was deployed following the CTD cast at 2213 UTC on 21 November. Although it did not sink right away, it subsequently sank and completed an initial cycle to 1500 m (due to the incorrect DescentCount settings).

During its second cycle, 0013 detected a leak, entered emergency mode, and returned to the surface shortly before the end of the SR1b CTD section. It was recovered, by detouring on the return from Rothera to Stanley, at 1407 UTC on 1 December. Due to the rough sea state the initial attempts to hook the lifting bail with a boathook were unsuccessful, so it was grappled through one of the hardhat handholds and recovered by hand. Upon recovery it had a visible amount of water in the glass sphere, but this water did not appear to have contacted the electronics or battery, as the float was still communicative. It was repacked in its wooden crate and consigned to FIPASS at the end of the cruise for return to TWR.

7.3 Float S/N 0012 (rudics ID 0048)

0012 was initially intended to be deployed second, but failed tests in m_deploy and went into emergency mode. This was diagnosed by TWR as being due to the air bladder not quite reaching the expected pressure in cold temperatures (its initial test, like that of float 15, occurred in the early hours of the morning). As sys_self_test showed all other tests passing, TWR suggested switching off the PreludeSelfTest setting. After doing this, and updating the DeepDescentCount (see above), m_deploy was run during the CTD cast at station 23. Although all tests passed, the float did not transition out of prelude to parkdescent state after 120 minutes, but rather remained in prelude state, with the reply to m_state including the message that "PRELUDE state timeout has occurred", and the bladders remaining fully inflated. m_idle was not effective in getting it out of prelude state, but sys_emerg_clr was able to put it into idle mode and start deflation of the bladders. The float was deployed (in idle/pressure activation mode) when the bladders had partially deflated, at 2314 UTC on 22 November. It did not sink right away but successfully dove to 3644 dbar in its first cycle.

0012 also leaked after 7 missions, and was recovered by the Gould on the evening of 16 December, to be returned to TWR.

8 Underway Data Collection and Processing

Yvonne Firing

8.1 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 jr16002 was current → 20161106.

The script conf_script_jr16002 set up the data and processing directories, symbolic links, and templates required for data syncing and processing in Mexec and otherwise, including links to the legdata directory and its legwork subdirectory.

Workstation fola was backed up on a daily basis during the active part of the cruise. The JR16002 part of the legwork directory was copied over to fola at the end of the cruise. 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.

8.2 SCS data streams

A selection of underway data streams on the JCR are made available on the ship network through the SCS system. The SCS data streams (ashtech [nav/ash], ea600 [sim], anemometer [met/surfmet], oceanlogger [ocl], gyro [nav/gyros], seatex-gll [nav/seapos], em122 [em122], seatex-hdt [nav/seahead]) were processed on fola during the cruise. The gyrocompass, underway fluorometer, and TIR sensors were not functioning for all or much of JR16002. The emlog, gravity, usbl, tsshrp and furuno navigation data were collected but not processed.

Preliminary stream parsing was started at the beginning of the cruise by running conf_script_TPL followed by sedexec_startall. Most SCS data were processed in 24-hour segments, using m_daily_proc, which processes and averages each day's data (including vector averaging for wind), producing averaged, appended files for the SCS streams. Winch data were processed by CTD station as part of standard CTD processing (ctd_all_part2.m). Additional processing for bathymetry and oceanlogger thermosalinograph data is described below. At the end of the cruise data parsing on fola was stopped by sedexec_startall.

More details on SCS data on the JCR, and on processing steps for underway data, are given in the cruise reports for JR306 and JR15003.

8.3 Underway surface thermosalinograph and salinity calibration

TSG data read in as part of the daily procssing were set to absent when the pumps were off, or where flowrate indicated unreliable supply. At the end of the cruise the full record was cleaned by running mtsg_medav_clean_cal to perform initial processing; mtsg_findbad to interactively find bad times, and mtsg_medav_clean_cal again to remove them in ocl/ocl_jr16002_01_medav_clean.nc.

A total of 59 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. They were analysed following the procedure described for CTD salinity samples. Nine were flagged as outliers (in all but two cases, at times of strong salinity gradients); the median offset of +0.005 psu based on the remaining 50 samples was added to the oceanlogger time series using mtsg_apply_salcal, producing ocl/ocl_jr16002_01_medav_clean_cal.nc.

8.4 Bathymetry

Two bathymetry streams are available via SCS: the ea600 single-beam echo sounder, and the centre beam of the em122 multibeam (swath) system. The EA600 data were frequently bad because the automatic bottom detector failed to detect the correct return. To maximise use of other acoustic instruments (see below), the EM122 swath echosounder was turned off for much of the SR1b section (for later CTD stations, it was only turned on briefly when coming on station to get a good depth fix), and was not logged there nor in other areas where swath bathymetry had been collected previously.

Following the daily processing, msim_plot and mem120_plot were called to select and flag bad data from the EA600 and the EM122 centre beam. This flagging is interactive, based partially on comparison between the EA600 and EM122, when both were available, as well as with historic bathymetry data. After editing, mday_02('M_SIM','sim',day) and mday_02('M_EM122','em122',day) are run to add each day to the appended files. The full swath data are reported but not cleaned or otherwise quality-controlled aboard the ship.

8.5 Vessel Mounted ADCP

A vessel-mounted 75-kHz Teledyne RD Instruments (RDI) OceanSurveyor Acoustic Doppler Current Profiler (ADCP), with 30° beamangle, a transducer depth of 5 m, and a heading alignment of 60.08°, was run throughout the cruise to measure horizontal velocity. The range of the instrument is up to 800 m, depending on scatterers, sea state, and the ship's motion. The instrument was run through the RDI VMDAS system, collecting single-ping ENR data and 10-minute average LTA data, as well as parsing position and heading data from the seatex and (when available) the synchro gyrocompass.

8.5.1 Configuration and K-sync

Configuration parameters were input using a set of files corresponding to either watertrack or bottom track mode and to either independent triggering or triggering by the Simrad K-sync. The instrument was set to sample up to 800-m depth, except for one interval during which it was mistakenly set to look only to 500 m. When in water depths shallower than 800 m for some period of time, sampling was (re)started in bottom track mode, in which each second ping is a bottom-tracking ping, used to calibrate the heading alignment. In deeper water, watertrack mode was used to maximise the number of pings.

When sampling with the EK60 or the EM122 (or both), the Simrad K-sync was used to coordinate pinging. When the EM122 was in use the following K-sync settings were required to obtain a reasonable number of ADCP pings:

1. Uncheck "echosounder is master" in the swath settings

2. Set the ADCP to be triggered every 3.4 s (the setting here must be $\geq$ the ping separation it would require on its own, or it will miss pinging on alternate triggers)

3. Use three or more trigger groups, with only one including the EM122; this way, the long wait the EM122 forces in deep water only occurs every few ADCP pings, and only decreases the number of ADCP pings by $\sim$20%

When only VMADCP and EK60 were on, the ADCP was set to ping every 3.4 s, with the EK60 pinging at twice the rate.

8.5.2 Data quality

During some periods of higher sea state, the data quality was noticeably affected by bubbles. The reduction in quality depends not only on the sea state but also on the ship's heading relative to the seas, and is generally less serious when on-station as the ship tends to maintain a position that minimises motion. Occasional spikes in amplitude in the middle of the VMADCP depth range might have been due to the EK60.

The principal obstacle to obtaining high-quality VMADCP data on this cruise was the lack of high-quality, high-frequency synchro gyro heading data. The LTA files were processed using the UH CODAS software (available from http://currents.soest.hawaii.edu), but more extensive processing and editing of ENR data is required and will be performed ashore.

8.6 EK60

The Simrad EK60 is a multifrequency echosounder designed to detect different species of zooplankton or fish. Acoustic backscatter data at 38, 70, 120, and 200 kHz were collected opportunistically for most of the cruise, with the EK60 triggered twice per VMADCP ping. These data have not been processed in any way.

9 AME Report

William Clark, AME support engineer

9.1 Instrumentation

LAB Instruments

Instrument	S/N Used	Comments
AutoSal	68533	Lab temp PC freezes occasionally; hard reset gets it working. IT investigating.
Scintillation counter	N	
Magnetometer STCM 1	N	
XBT	N	

ACOUSTIC

Instrument	S/N Used	Comments
ADCP	Y	
PES	N	
EM120	Y	
TOPAS	N	
EK60	Y	Tripped breaker when power cycling; user error. Turn off in UIC before unplugging/replugging.
EK80	N	
SSU	N	
USBL	Y	
10 kHz IOS pinger	N	
Benthos 12 kHz pinger S/N 1316 + bracket	N	
Benthos 12 kHz pinger S/N 1317 + bracket	N	
MORS 10 kHz transponder	N	

OCEANLOGGER

Instrument	S/N Used	Comments
Barometer1(UIC)	V1450002	
Barometer1(UIC)	V1450003	
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	4524698-0018	
Transmissometer	527DR	
Fluorometer (10AU)	1100243	
Flow meter	811950	
Seawater temp 1 SBE38	0767	
Seawater temp 2 SBE38	0771	Sensor swapped; was 0765 (not configured)
		* Serial numbers with an asterisk not personally observed

CTD (all kept in cage/ sci hold when not in use)

Instrument	S/N Used	Comments
Deck unit 1 SBE11plus	0458	
Underwater unit SBE9plus	0771	S/N 0541 used for casts 024, 025, 026
Temp1 sensor SBE3plus	5623	
Temp2 sensor SBE3plus	4874	
Cond1 sensor SBE 4C	3491	
Cond2 sensor SBE 4C	1912	
Pump1 SBE5T	2395	
Pump2 SBE5T	1807	
Standards Thermometer SBE35	0051	
Transmissometer C-Star	1505DR	
Oxygen sensor SBE43	0242	S/N 0620 used until cast 023.
PAR sensor	70636	Initial incorrect calibration; data reprocessed.
Fluorometer Aquatracka	12-8513-003	
Altimeter PA200	26993	
LADCP	14443	
CTD swivel linkage	1961018	Test cast with S/N 196115.
Pylon SBE32	1106	
Notes on any other part of CTD e.g. faulty cables, wire drum slip ring, bottles, swivel, frame, tubing etc.		

AME UNSUPPORTED INSTRUMENTS BUT LOGGED

Instrument	Working?	Comments
EA600	Y	
Anemometer	Y	
Gyro	Y	
DopplerLog	Y	
EMLog	Y	

9.2 CTD Communications Issues

Symptoms

The CTD Deck Unit lost communications with the Sea Unit during the deployment.

The Deck Unit Error alarm was active but not constant (random beeping) and communications sometimes resumed allowing the cast to be completed. The winch operator observed this was not like previous cable issues he had seen, when the alarm is steady.

There was no obvious relation to depth; most failures occurred on the up-cast at varying depths and time elapsed.

Solution

The issue was found to be the Y cable connecting the SBE9plus unit to the SBE35 and SBE32, which was damaged in two places allowing water ingress.

In case of future communication issues which manifest themselves with the CTD on the deck, a recommended debugging step would be to disconnect ALL instruments from the 9plus (leaving only the sea cable connected) and attempt communications; if the problem is with a cable or instrument, communications should be successful with the faulty part unplugged. Each sensor can then be tried in turn to identify the exact culprit.

Diagnosis and repair

After recovery to deck after the first occurrence, an Insulation Resistance (IR) test was performed. This gave a result worse than expected (exact value wasnt recorded) so the decision was made to re-terminate the cable. The initial failure appeared to coincide with the ship rolling, casting further doubt on the wire, however later failures did not. This was probably a coincidence, if not a faulty recollection.

As is standard procedure, the cable was IR tested one the termination was complete. This gave a reading in the region of 22 MΩ. The pass mark for this test is 10 MΩ (higher is better); however, memory suggested we usually get results much higher than this. A resistance test confirmed no short circuit.

Due to this lower than expected result, another re-termination is performed immediately (i.e. CTD not deployed in between.) This again gave an IR test result in the region of 22 MΩ. A resistance test confirmed no short circuit.

To further narrow the fault location, the communications cable was disconnected in the Traction Winch room (as the next disconnect point above the termination) and the cable tested from the UIC to the Traction Winch room. The test result is >4000 MΩ (beyond tester range) suggesting no fault.

The test was then performed from the Traction Winch room down, through the sea cable. This again gave a result in the region of 22 MΩ, confirming the issue to be at some point on the sea cable. The slip rings were checked and cleaned with the Deck Engineer; the IR test was performed again with no change to the result.

As the termination tests passed, albeit not as well as expected, the decision was made to deploy the CTD and observe the results.

The CTD reached the bottom (3800 m) without issue; however, the issue reoccurred not long after beginning the up-cast. Once again, communications were restored during the cast, with a further drop out and restoration of communications later. The Dissolved Oxygen sensor (SBE43 S/N 0620) was observed to give erroneous readings.

One recovered to deck, the cable was immediately IR tested. The measurement was initially erratic, measuring between 5 MΩ and 45 MΩ, eventually setting around the 20 to 22 MΩ point. This was considered a pass, as the erroneous sensor data suggested this was not necessarily a cable fault.

At this point the 9plus Sea Unit was replaced. This is underwater part with which the deck unit communicates and it was thought a fault with this might produce the observed errors—erratic communications and an invalid sensor reading. Also replaced was the dissolved oxygen sensor, in case the fault was in fact with this—testing later proved the sensor to be fine (CTD cast JR16002_999).

No changes were made to the cable or termination at this point.

The CTD was deployed to approximately 3500 m with no issues.

The CTD was again deployed again to approximately 3500 m, with no issues.

The CTD was deployed to a target depth of 2500 m, with communications lost at approximately 2100 m on the down-cast. Error alarm intermittent again, but communications did not resume. CTD recovered to deck and cable immediately IR tested. Readings approximately 5 MΩ.

Careful inspection of the termination revealed slight cable deformation through the cable grips (Figures 11 and 9.2).

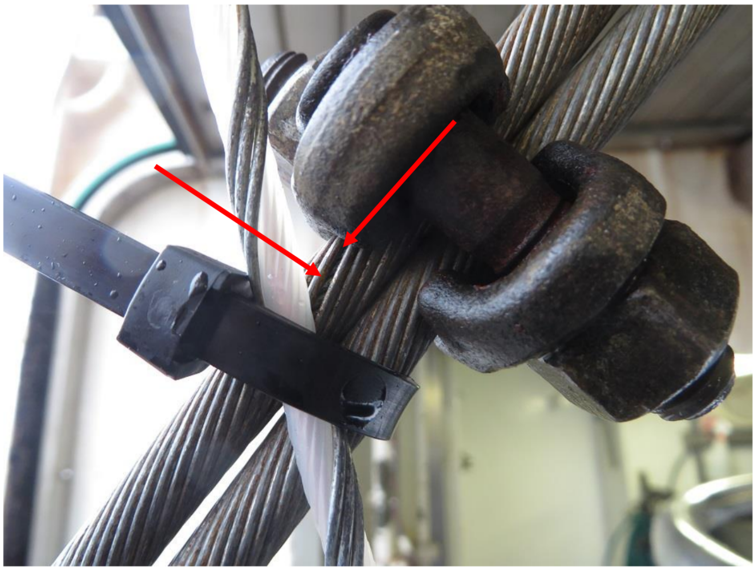

Figure 11: CTD wire termination with arrows indicating deformation of the cable.

The decision was made to methodically trim the cable back through the termination (Figure 9.2), performing IR test between every grip point. The cable was cut with a grinder, allowing a clean cut which measured open-circuit.
Test results:

- Pigtail removed: 0.5 MΩ
- Cut past grip 3, CTD side: 0.3 MΩ
- Cut past grip 2, CTD side: 0.3 MΩ
- Cut past grip 1, CTD side: 0.01 MΩ
- Cut past grip 1, ship side: 0.3 MΩ
- Cut past grip 2, ship side: 0.5 to >4000 MΩ (Unstable)
- Cut past grip 3, ship side: 0.2 MΩ
- Extra 2 m cable removed: >4000 MΩ

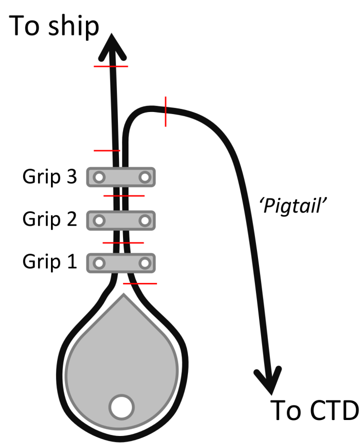

Figure 11. Termination diagram.

This suggested there may have been some damage in this section. As the bulldog grips are tightened to specific torque settings and had been used for a large number of terminations this year alone, they were replaced with new units supplied by the Deck Engineer. The cable was again re-terminated and the IR test result was good (≈1000 MΩ), but the CTD communications tests failed (9plus S/N 0541). A number of tests were conducted in sequence:

- Short circuit cable test passes (R $\approx$ 100 Ω.)
- Open circuit cable test passes (R $>$ 4000 Ω.)
- Buzz-test comparison with old pigtail confirms correct conductor wiring.
  - Cable/termination has now passed every test.
- Plugged cable into second 9plus beside CTD—communications succeed (9plus S/N 0771).
  - Suspect faulty 9plus, but suspicious as to why this might be.
- Swapped 9plus units on CTD, communications fail (9plus S/N 0771).
  - Suspect faulty sensor.
- Unplugged Oxygen, Altimeter, PAR, Transmissometer and Fluorometer; communication fails.
- Unplugged SBE32/SBE35 Y-cable—communication passes.
  - Suspect faulty SBE32 and/or SBE35.
- Reconnected all except SBE32/SBE35—communication passes.
- Unplugged SBE32 and SBE35 independently, communication fails each time.
  - Suspect faulty cable.
- Replace SBE35/SBE32 cable—communications pass.

Removal of old SBE32/SBE35 Y-cable revealed damage to outer with inner cable insulation visible (Figure 13).

Figure 13: SME32/SBE35 Y-cable with damage visible.

Aftermath

After replacing the SBE9plus/SBE35/SBE32 cable, the CTD has performed as normal. The testing above leaves me with the following thoughts/suggestions:

- SBE 9plus (S/N 0541)—Used during testing, probably OK.
- SBE 45 (S/N 0620)—Removed during testing, later tested to be OK.
- What are good values for the IR test? In this case the termination may have been a red herring, but where has the 10 MΩ value come from if we typically measure orders of magnitude more?
- All cables on CTD have since been removed and checked for damage; none give cause for concern.

9.3 Additional notes and recommendations for change / future work

CTD

On instruction from Cambridge, the CTD cable was swapped with the spare drum and the spare swivel installed. This process was complicated by the fact the spare system had not been properly tested and so was not in a fully working state.

To allow communications via the new cable, the BNC connection in Scientific Wiring junction box J.B. F10 (traction winch room) has been swapped from CTD Wire 1 to CTD Wire 2, on BNC port 1. Other wiring remains the same.

A recommendation going forward would be, as a matter of course, to swap the drum in use every one or two years to keep them tested. This is also suggested for other duplicated equipment, as it is extremely inconvenient to be fault-finding during a scientific cruise.

Having swapped the swivel, data from the LADCP was used to see how, if at all, the CTD was rotating. The CTD appears to rotate freely, predominantly on the down-cast and consistently clockwise. The lack of any issues arising from this rotation suggests all is as it should be. (Plots for all casts available on request.)

A problem was experienced which caused loss of communication with the CTD while deployed (see Section 9.2). This was initially thought to be a problem with the termination of the sea cable, although repeated attempts at reterminating did not solve the issue.

The problem was traced to a Y-cable on the CTD, connecting the SBE9plus Underwater Unit with the SBE32 Rosette and SBE35 Thermometer. Two points of damage were observed (Section 9.2) allowing water ingress. Replacing this cable solved the issue. All other cables on the CTD have since been removed and inspected—while there are minor signs of wear, this seems to be consistent with normal use and is not expected to cause another issue. I would suggest all the cables be inspected at least once a year, ideally during installation at the start of the season.

In case of future communication problems, unplugging instruments from the SBE 9plus would be a quick and relatively easy test before the more cumbersome task of re-terminating the sea cable—although this test requires the problem to manifest itself with the CTD on the deck.

CTD PAR Sensor

PAR calibration noticed to be incorrect after CTD cast 014. Correct calibration found and entered before cast 015 and previous casts reprocessed.

CTD Dissolved Oxygen Sensor

During cast 023 the Dissolved Oxygen sensor (SBE43) produced erroneous values on the up-cast. This was assumed to be related to the ongoing communication issues, however the sensor was swapped before the next cast as a precaution.

Interestingly, when attempting to review the failure after the CTD work was completed, replaying the archived data in Seasave did not show the data anomaly.

While the ship was loitering near Rothera a test CTD cast was performed with both SBE43 sensors attached to the CTD—one per T/C duct. These gave very similar readings which strongly suggest that the removed sensor is good to use, as was suspected. Data archived as cast JR16002_999.

CTD Depth Ratings

Having changed the CTD to a longer (circa 8000m) sea cable, and knowing some instruments were definitely not rated to 8000m, I researched the maximum depth rating for the equipment we currently use, tabulated below in depth order:

Instrument	Model	Max Depth (m)
Deck unit	SBE 11plus	N/A
Fluorometer	Aquatracka Mk III	6,000
Transmissometer	Wet Labs C-Star	6,000
LADCP	Workhorse Sentinel	6,000
Underwater unit	SBE 9plus	6,800
Temperature	SBE 3plus	6,800
Conductivity	SBE 4C	6,800
PAR	QCP2350	6,800
Altimeter	PA200	6,800
Standards Thermometer	SBE 35	6,800
Pylon	SBE 32	6,800
Dissolved oxygen	SBE 43	7,000
Pump	SBE 5T	10,500

I do not know the extent of interest for conducting CTD casts past 6000m, however many of the default CTD instruments we use are not rated to the current capacity of the JCR winch system—this should be kept in mind if deep casts are performed to prevent equipment damage.

CLAM

SCS now provides echosounder depth information to CLAM winch screen. This is formatted using a variation on the EA600 data format (format previously hardcoded into CLAM), but provides EM122 depth as the winch operators indicated a preference for the more accurate EM122 over the more frequently active EA600.

However, the SCS system has been set up ready to provide either the EA600 or EM122 data. IT can facilitate changing the source.

Ideally CLAM would be modified to identify which echosounder is available and preferentially choose the EM122, but modifying the software has not proved straightforward.

CLAM froze for unknown reason before cast 020 and unfroze for similarly unobvious reason while searching for the issue; it was possibly power cycling the electronics box in the Traction Winch Room which resolved it. This is not a major problem as it has only happened once and the winch can be driven from the winch console screen with the CTD providing depth information.

USBL

The USBL was used primarily because, having experienced issues during cruise JR15007, I was keen to see if it was working better after the Sonardyne repairs/calibration. It additionally served as another reference point for CTD depth and position when using an untested CTD wire/winch.

The beacon was attached to the CTD for a number of deployments to test; the summary is below:

- Beacon 1 used (BAS beacons have been given arbitrary numbers for easy identification)
- No configuration changes were made (to beacon or software) from those set JR15007I do not know the extent of interest for conducting CTD casts past 6000m, however many of the default CTD instruments we use are not rated to the current capacity of the JCR winch system—this should be kept in mind if deep casts are performed to prevent equipment damage.
- Tracking was good with USBL head flush to hull and fully extended
  - Becomes unreliable at less than 50m depth; presumably due to (known limited) beam angles.
  - Appears to work well with SWATH running.
- USBL, CTD and CLAM wire depths typically matching to within 10m, often better (some difference to be expected.)

From the tests conducted, I am satisfied that the USBL is currently working correctly and could be used for locating items. As the beacons are preconfigured, hopefully it should also be straightforward to use. A USBL cue card has been produced and left near the USBL station, written with the target user being an AME engineer (i.e. some knowledge of ship assumed)—feedback is encouraged.

Oceanlogger

Sea water temperature sensor 2 was not returning a value. After swapping sensor cables around for testing, it was suggested this might be because the sensor address is not correctly configured—after unsuccessful attempts to change the address, the sensor (S/N 0765) was swapped with the spare (S/N 0771) which worked immediately. It seems we were just unlucky that the two of the three installed included the unconfigured one.

XBT

Monitor found to be faulty; replaced with spare from stock. No XBTs launched this cruise.

10 Acknowledgments

Many thanks are due to the Master, officers, and crew of the JCR, and to the BAS technical staff, in particular for their extra efforts to make sure the science could be completed despite technical and logistical challenges, and to recover the float that leaked during the cruise. Y. Firing also thanks Geoff Hargreaves and Emlyn Jones for assistance with float troubleshooting and deployment, and volunteers Anastasiia Domina, Giuseppe Foti, Madeline Miller, Eric Sanchez, Eleni Tzortzi and Hugh Venables for running the hydrographic section; with special thanks to Hugh Venables and Elaine Fitzcharles for assisting with the hydrography and sample analysis in addition to their original duties on the trip. We are also grateful and indebted to the US Antarctic Program, the officers and crew of the ARSV Laurence M. Gould, and April Brown and the other Antarctic Services Contractor technical staff aboard and supporting the LMG, for going out of their way to recover two more of the floats deployed during JR16002.