Cruise Report
RRS James Cook
JC211
2 February – 7 March 2021

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British Antarctic Survey
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Cover photo by Yvonne Firing

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Introduction

Cruise JC211 was merged from three different SMEs, which were originally supposed to be two separate cruises on RRS Discovery, one with a biological focus, and one physical oceanography (hydrography) cruise. All comprised long-term monitoring, funded through National Capability single- and multi-centre funding streams to the British Antarctic Survey (BAS) and National Oceanography Centre (NOC).

The Polar Ocean Ecosystems Time Series (POETS) Western Core Box (WCB)/Scotia sea Open-Ocean Biological laboratoriES (SCOOBIES) work focused on monitoring the ocean and ecosystem near South Georgia using acoustic transects, bongo net casts, and moorings with current meters and profilers, sediment traps, acoustic monitoring devices, and temperature/conductivity recorders. The physical oceanography SMEs, part of the Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports (ORCHESTRA) programme, comprised two CTD/LADCP sections, the A23 section from South Georgia to the northern Weddell Sea, and SR1b, from Elephant Island to Burdwood Bank, crossing Drake Passage.

Because of the Covid pandemic, and the strict restrictions on the number of personnel that could be accommodated on board with social distancing (in the event of an outbreak), these were merged into a single cruise, with a minimal science party. This was originally supposed to comprise one BAS biologist, three physical oceanographers (two NOC, one BAS), a BAS Antarctic and Marine Engineering (AME) mechanical engineer, and science support from NOC National Marine Facilities (NMF). When two additional spaces became available, an additional physical oceanographer from NOC and a trainee NMF SSS technician were added to the team.

Toward the end of 2020, iceberg A-68A, which calved from Larsen C Ice Shelf in 2017, was approaching South Georgia, and there was concern that it would run aground, possibly impacting the ecosystems of the island. In response, funding was secured from the Government of South Georgia and the South Sandwich Islands, the UK Government Blue Belt Programme, and NERC, to deploy two gliders around the iceberg to measure its impact in the months after the cruise had taken place. Two gliders were prepared at very short notice by MARS, and loaded onto the vessel just before it left the UK. While we had envisaged that the iceberg might run aground, instead it broke up in the weeks leading up to the cruise, with the remaining large icebergs circulating in the fronts southeast of South Georgia. However, two gliders were deployed here, and the intention is to recover them from fishery patrol vessel Pharos SG or other vessels of opportunity operating in the area in late May.

In the end, one participant was sadly unable to join the vessel because of Covid, and her backup was unable to take her place. Since we had no biologists on board, some of the planned activities, such as zooplankton incubations and respiration experiments were not carried out, along with the majority of the planned bongo net casts. On the day of the southbound flights, there was a snowstorm in Madrid, closing the airport. Thus, the ship's doctor was not able to fly to the UK for the connecting flight to the Falkland Islands. Since the following flight was a "clean flight" for MOD personnel only, this resulted in a week's delay and a corresponding loss of ship time. Mobilisation was also complicated by differences in Covid procedures between NOC and BAS, resulting in BAS personnel quarantining ashore in full isolation while NOC personnel maintained enhanced social distancing on board for 14 days. There were no positive test results among the personnel who travelled south for the cruise, although other cases were identified on our flight.

We were fortunate that the weather was favourable enough to allow most of the planned activities to take place in spite of the delay. However, our tight schedule didn't allow for additional acoustic transects near South Georgia (the Eastern Core Box), and necessitated skipping two stations on the A23 transect. In the end, the weather in Drake Passage was better than forecast, allowing us to complete the SR1b section slightly ahead of schedule. With little time for demobilisation, a few additional CTD stations between Burdwood Bank and the Falkland Islands were occupied, and additional ADCP bottom track data were collected on the shelf east of the Falkland Islands, while demobilisation began, before the ship returned to port.

Overall, this was a successful cruise, in spite of the unusual circumstances, the small team on board, and the limited ship time. Excellent communications between the teams on board and the biologists at BAS and glider pilots at NOC enabled these activities to be carried out with outstanding remote assistance. I would like to thank those involved in planning, funding, and organising the cruise, at NERC HQ, NMF, and BAS, for allowing this cruise to take place this year, contributing another data point to our long time series in spite of the pandemic. And I would especially like to thank all on board, crew and science party alike, for their admirable dedication to completing the science objectives and helping out with other groups' research. The successful outcomes of this cruise are a result of everyone's contributions and hard work.

Povl Abrahamsen

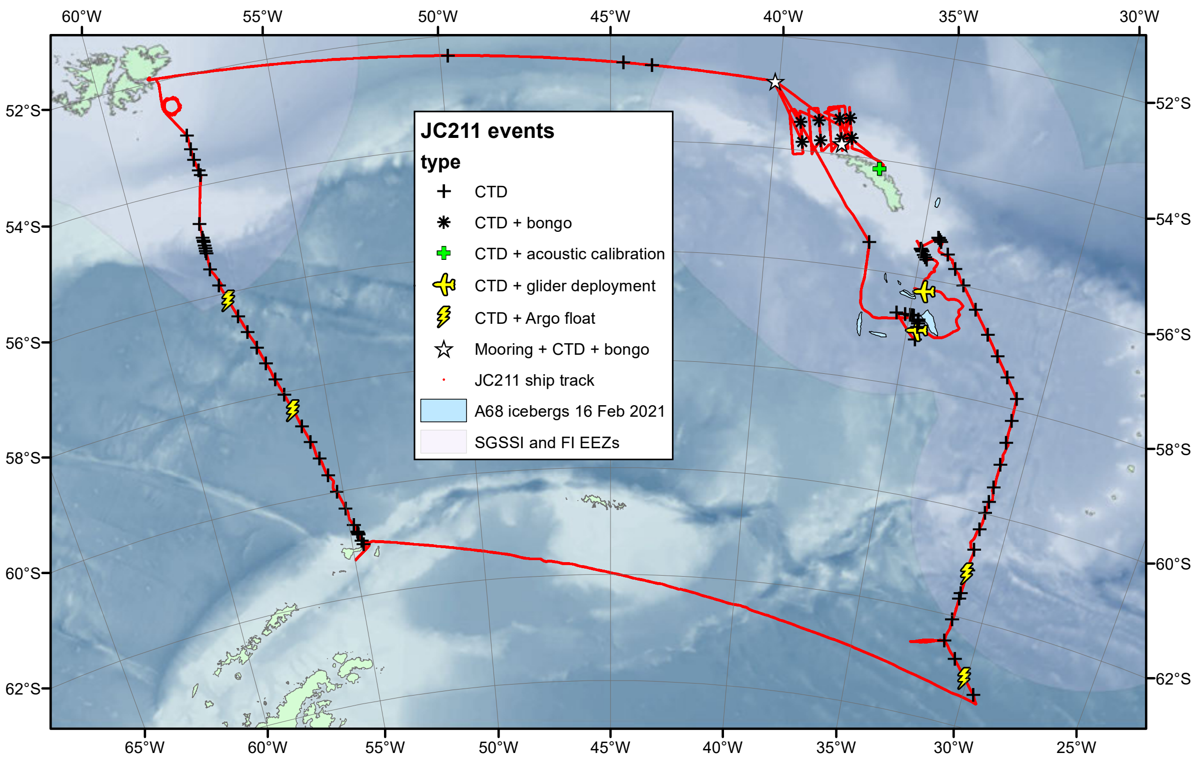


Figure 1: Overview of the cruise track and stations occupied on JC211

Cruise personnel

Science party

Povl Abrahamsen, PSO (BAS)
Bjørg Apeland (BAS AME)
Tom Ballinger (NMF S&M)
Yvonne Firing (NOC)
Brian King (NOC)
Alice Marzocchi (NOC)
Emmy McGarry (NMF SSS)
Andrew Moore (NMF SSS)
Dougal Mountifield (NMF S&M)
Richie Phipps (NMF mechanical)
Jon Short, senior tech (NMF S&M)

Figure 2. The JC211 science party. Left to right: Povl, Bjørg, Brian, Richie, Jon, Tom, Emmy, Dougal, Alice, Andrew, and Yvonne.

Officers and crew

James Gwinnell, Master
Andrew Mahon, Chief Officer
Declan Morrow, 2nd Officer
Bryn Beaurain, 3rd Officer
Chris Uttley, Chief Engineer
Michael Murren, 2nd Engineer
Edin Siladjzic, 3rd Engineer
Gary Slater, 3rd Engineer
David Hawksworth, ETO
Paul Lucas, Purser
Dilia Martínez-Méndez, Doctor
Martin Harrison, CPOS
Nathan Gregory, CPOD
David Mackenzie, POD
Iain Forbes, POS
Scott Agnew, SG1a
John Allen, SG1a
Brian ("Burt") Burton, SG1a
Sean Angus, ERPO
Michael ("Spike") Leigh, Head Chef
Jacqui Waterhouse, Chef
Jane Bradbury, Steward
Peter O'Toole, Asst. Steward

Cruise narrative

Povl Abrahamsen

Unless otherwise noted, all times are local (UTC-3).

Sun 10 Jan: All cruise personnel checked in at RAF Brize Norton for flight RR2230. The ship's doctor unfortunately was unable to reach the UK, because of snow in Madrid.

Mon 11 Jan: Flight RR2230 took off at 01:10 UTC, refuelled in Dakar, and landed at RAF Mount Pleasant just ahead of the scheduled time of 17:30 local (UTC-3). Mariners, NMF technicians, and NOC scientists were taken directly to the ship at Mare Harbour. BAS personnel were taken to quarantine ashore at Malvina House Hotel in Stanley.

Tues 12 Jan: Personnel on board were PCR tested (day 1). Social distancing (but not full isolation for scientists and technicians) maintained on board. "Four seasons in one day": everything from drizzle to hail to occasional sunshine.

Wed 13 Jan: BAS personnel PCR tested (day 2). A nice day, with dolphins observed both on board and in Stanley.

Thurs 14 Jan: Results of first onboard PCR tests received in the evening: all negative. A bit windy during the day, calming down later.

Fri 15 Jan: Mobilisation on board commences, while social distancing is maintained.

Sat 16 Jan: More mobilisation on the ship, and isolation ashore. A bit chillier.

Sun 17 Jan: Glorious sunshine in the morning – a "dingle day" in Antarctic parlance. Overcast in the afternoon, but calm.

Mon 18 Jan: Mobilisation continues on board. A bit of drizzle. Second PCR test for BAS personnel ashore (day 7). Doctor flies south on flight RR2230 at 01:10 UTC, lands at RAF Mount Pleasant on schedule at 17:30.

Tues 19 Jan: Yet more mobilisation. A rare calm day in the Falklands.

Wed 20 Jan: Very, very windy! Ship's VSAT performance declined in afternoon/evening, occasional e-mails and WhatsApp messages getting through.

Thurs 21 Jan: A beautiful sunny day in the Falklands! Still problems with the VSAT.

Fri 22 Jan: NOC personnel PCR tested (day 11). Notification of one positive case on the southbound flight. BAS approves updated NOC Covid procedures (as issued 10-11 Jan 2021).

Sat 23 Jan: Started out drizzly, but turned into another beautiful sunny day! Mobilisation continues on board, isolation continues ashore.

Sun 24 Jan: BAS personnel PCR tested (day 13). Another windy day. Fire alarm ashore.

Mon 25 Jan: Doctor PCR tested (day 7). A beautiful sunny day!

Tues 26 Jan: PCR test results received: all negative on board and ashore. BAS personnel move on board in morning. Ship familiarisation and safety briefing in afternoon.

Wed 27 Jan: Mobilisation continues; BAS container un-stuffed, unpacking and lab setup commences. Usual Falklands mix of alternating hail, drizzle, and sunshine, with occasional dolphin visits.

Thurs 28 Jan: More mobilisation. Gliders un-boxed, bongo assembly started. Mixed weather, with low winds.

Fri 29 Jan: Mobilisation continues, otherwise fairly uneventful.

Sat 30 Jan: Yet more mobilisation. Morning FRC exercise postponed because of weather – pretty windy! Presentation to all on board about cruise plans after lunch in lounge.

Sun 31 Jan: Mobilisation continues, and ship gradually prepared for sea. Good turnout of dolphins throughout the day; windy but otherwise pleasant.

Mon 1 Feb: Last day alongside! Securing for sea continues.

Tues 2 Feb: Doctor moves on board. Ship departs Mare Harbour at 08:30, on passage toward P3. Acoustic systems gradually started, with marine mammal observations commencing at 10:54, first multibeam ping at 11:26. Boat drill at 16:00.

Wed 3 Feb: Test station at 12:30. CTD deployed, but swivel failed at ~700 m depth (event 1); bongo deployed without net attached (event 2). Poor visibility, with waves increasing through day.

Thurs 4 Feb: Test station at 9:15. CTD deployed without swivel (event 3), scrolling on winch failed. Third CTD test after lunch (event 4); successful cast with water samples collected. Continued steaming toward P3.

Fri 5 Feb: Arrived one mile from P3 in early morning (~5 am). CTD deployed (event 5). Mooring successfully recovered (event 6). Evening CTD and bongo at W1.2CTDS (events 7 & 8).

Sat 6 Feb: Night-time bongo and CTD at W1.2CTDN (events 9 & 10). Acoustic transects W1.1 and W1.2 during the day (events 11 & 12), then evening CTD and bongo (simultaneously) at W2.2CTDN (events 13 & 14). In the evening RVDAS stopped logging, resulting in a data gap from 20:24:59 to 23:24:32 local.

Sun 7 Feb: Night-time CTD and bongo at W2.2CTDS (events 15 & 16). Acoustic transects W2.1 and W2.2 during the day (events 17 & 18). Recovered mooring WCB after dinner (event 19), followed by CTD and bongo on site (events 20 & 21). Then steamed to W3.2CTDS for bongo (event 22), and waited until 2 am for CTD cast. Occasional views of the western islands of South Georgia in the late afternoon, with humpback whales and fur seals around.

Mon 8 Feb: CTD cast at W3.2CTDS at 2 am (event 23). Acoustic transects W3.1 completed in the morning (event 24), but wind increased rapidly around lunch, causing the vessel to wait for weather from 11:45 am to 5 pm. Wind then decreased rapidly; CTD and bongo deployed concurrently at W3.2CTDN at 7 pm (events 25 & 26).

Tues 9 Feb: CTD and bongo at W4.2CTDS (events 27 & 28). Then acoustic transects W3.2 and W4.1 (events 29 & 30). CTD was deployed at the WCB mooring site just before dinner (event 31), followed by a post-dinner mooring deployment (event 32). The day started out foggy, but ended up sunny, with great views of South Georgia and occasional whales. Evening power outage on the clean power supply (22:15-22:35 local) resulted in screens going black in the main lab and some data streams having gaps. Bongo and CTD were deployed after the power outage at W4.2CTDN (events 33 & 34).

Wed 10 Feb: The final acoustic transect, W4.2, was started at 5:15 in the morning (event 35). This allowed us to steam into Stromness for the acoustic calibration in the afternoon. Winds dropped down, and we had a lovely afternoon and evening on DP in

Stromness Harbour, while the CTD was deployed (event 35) and the EK60 was calibrated (event 36). There was an excellent display of stars at night.

Thurs 11 Feb: The calibration was completed just before 1 am, and the vessel departed for P3 shortly afterwards. After arriving on site, the CTD was deployed, followed by the mooring deployment, the final bongo cast of the cruise, and triangulation of the mooring (events 38-41).

Fri 12 Feb: Triangulation was completed just before 2:30 am. Almost the entire day was spent in transit from P3 toward the iceberg – mostly steaming downwind. Sunny, pleasant morning. The gliders were taken outside for comms testing after lunch. In the afternoon, we passed over the region where we believe the iceberg grounded in mid-December, breaking off A-68D. The weather deteriorated considerably in the evening. While we had been following the seas, the strength of the wind was quite apparent when we turned onto the first station (Iceberg_far). Because of the wind, the deployment was delayed for three hours, until a lull allowed the CTD to be deployed at 11:30 pm (event 42).

Sat 13 Feb: A wet, windy, and cloudy day in the Southern Ocean. Icebergs A-68G and A-68M were visible in the radar, and the freeboard of the bergs could just be glimpsed through the cloud in the morning. Much of the day was spent steaming toward A-68A. We arrived at the iceberg in the afternoon, in rather dull, flat light. Section Iceberg_W was started from the edge of the berg along 65°42' S, with stations at distances of 1, 2.5, 5, 10, and 20 nautical miles as measured by radar (events 43-47). Because James Cook's radar has a range of around 12 miles, the last station was based on distance to the previous one.

Sun 14 Feb: Foggy! While the initial intention was for the southern section to be at 034°20'W, a minor mistake by the PSO accidentally put it at 034°40' instead. The initial station (nominally at 20 miles, event 48) was based on a previous radar target, and was actually about 23 miles south of the ice edge. The glider was deployed at the 10-mile station (actually 13 miles south of the berg), followed by a CTD cast (events 49-50). The station that was supposed to be nominally one mile from the ice was actually 2.5 miles away, but because of thick fog, we did not approach closer on this transect. The edge of the iceberg occasionally appeared through the fog, but the views were rather underwhelming. Still, we completed CTDs here (event 51), and nominally 2.5, 5, and 9 miles from the ice (actually closer to 4, 6.5, and 10.5 miles from the edge, events 52-54). The wind was steady F7, occasionally gusting 8. Section completed at 11:30 pm.

Mon 15 Feb: Steamed slowly around the iceberg overnight. Held off until first light before "rounding the corner". Because of ice, we took a very long route east before turning north and eventually west. Our original glider site, 10 miles north of the iceberg, was inaccessible because of bergy bits and brash. We steamed westward, seeing if we could deploy northwest of A, "in front of" A-68J and P. However, the preference from the glider pilots was to deploy to the east of P instead. So we turned around, backtracked about an hour, and then deployed quite close to our original 20-mile station on the northern section, near the north-eastern corner of A-68P. Although the day started out misty, visibility gradually improved, ending in sunshine by the time we deployed the glider and took a CTD cast on site (events 55-56). By this time, daylight was running low, and instead of doing a CTD section directly north or northeast from our position, we steamed north, out of the ice, to do a section across the shelf break, in the wake of iceberg A-68H, southwest of A23, to be followed by an ADCP bottom track calibration.

However, because ice forced the ship to slow down, we only started this section in the early hours of the morning. A nice sunset while leaving the icebergs around A-68P.

Tues 16 Feb: CTD casts started in early morning, and the section continued through the day (events 57-62). Because of yet more icebergs on the shelf, the ADCP calibration was unable to be completed on the shelf, and had to be moved offshore, into deeper water less suitable for bottom tracking. We steamed north to the start of A23, where the first cast started at 10:30 pm (event 63), slightly deeper than planned because of icebergs.

Wed 17 Feb: First full day of A23. Six casts from shallow to deeper water (events 64-69). All going well; wire starting to show signs of bird-caging, but still holding up. Still more icebergs around.

Thurs 18 Feb: Ice and fog caused yet another slow overnight steam. Three CTD casts (events 70-72). Before the second the lifeboat was luffed out for exercise purposes, and a 500-kg weight was lowered on the CTD wire with a swivel to remove some of the twists in the wire.

Fri 19 Feb: A foggy, reasonably calm day. More CTDs (events 73-77). Just before lunch, clean power was briefly switched off, because of a bearing failure on a motor-generator set. Acoustics were briefly shut down for the power changeover, with little interruption to the scientific programme.

Sat 20 Feb: Weather much colder, after crossing the polar front. More CTDs (events 78-81). Spare -80° freezer not working.

Sun 21 Feb: More CTDs (events 82-85). Started out sunny and cold, with weather gradually worsening through the day. Humpback whales spotted near ship in the afternoon. Argo float 9007 deployed in the evening at CTD 59 (events 86). Oxygen titrations finally working well, with second unit.

Mon 22 Feb: Two CTDs completed overnight (events 87-88). On arrival at the next station, A23-28, conditions had worsened, and the ship decided to wait on weather from 10:25. Oxygen sample backlog run, but no further science done. Because of increased strange shear solutions from the up-looking LADCP, this LADCP was replaced while waiting for the weather.

Tues 23 Feb: Sea gradually dropped overnight. First CTD cast (event 89) deployed at 8:10, but DP desk failed at 8:45, requiring recovery of the rosette. Subsequent CTD casts (events 90&91) were successful and reasonably uneventful.

Wed 24 Feb: Overnight CTD cast (event 92) was followed by deployment of Argo float 8991 (event 93). Weather deteriorated considerably, with conditions snowy and marginal at the start of the next CTD (event 94). After recovering the CTD, we started steaming toward the final planned station on the A23 section, but when it was apparent that the weather was not dropping, we turned at 10:15 around 63° 30.0' S 29° 21.5' W, heading for Elephant Island. After lunch the engineers noticed that the second -80° freezer had also failed, and was running close to -20°. Subsequently, all POM and chlorophyll samples were moved into the -20° freezer. Weather remained “Antarctic” through the day, with winds dropping in the evening.

Thurs 25 Feb: A calmer, sunnier day. Roller shutters in hangar failed overnight. CTD wire re-terminated. Safety meeting at 10:30, humpback whales after lunch, pub quiz 19:30.

Fri 26 Feb: Weather picked up considerably overnight to a steady F8. Rolly morning, with weather gradually decreasing through day. CTD wire re-terminated again, since first attempt didn't pass muster.

Sat 27 Feb: We arrived on station at 6:30, and started with a load test on the reterminated wire, followed by a CTD cast (event 95). However, as the weather was steadily deteriorating (F7-8 winds, wave height increasing from 4 m to >6.5 m), we were unable to complete the next CTD cast, and instead sought shelter in the lee of Elephant Island, running VMADCP bottom track calibration lines. After dinner we returned to SR1b-30, and found workable conditions. CTD casts continued overnight (events 96-98). VSAT not working all day; limited FBB allowed for sporadic e-mail access.

Sun 28 Feb: More CTD casts (events 99-103). VSAT back at 3 am, but not quite as quick as before. Sunny evening.

Mon 1 Mar: Sunny day; slightly wavy. More CTDs (events 104-107). Weather forecast improved from earlier predictions.

Tues 2 Mar: Night-time Argo deployment (event 108). Then a few more CTDs (events 109-112). Weather settling down.

Wed 3 Mar: Yet more CTDs (events 113-115,117). Argo float deployed in the evening (event 116). Otherwise little of note. BAS container partially re-stuffed.

Thurs 4 Mar: Both Milli-Q machines broken with "A10 error 9". More CTD casts (events 118-123). Glider 405 reappears miraculously, after weeks under iceberg A-68A!

Fri 5 Mar: SR1b section completed (events 124-126). Additional CTDs started north across shelf (events 127-130). Milli-Q machines gradually coming back to life after chlorination and repeated cleaning.

Sat 6 Mar: Final CTD cast (event 131), followed by ADCP bottom track calibration lines for rest of day, east of Sea Lion Island. Post-cruise assessment discussion meeting at 10:30.

Sun 7 Mar: Ship returns to Mare Harbour; pilot on board at 8:30 am. Acoustics stopped in the morning, data logging stopped, cleaning, packing and report writing through the day.

Mon 8 Mar: Although we were scheduled to disembark for accommodation ashore, the southbound MOD Airbridge flight was initially postponed by "at least 24 hours", then "at least 48 hours", and finally cancelled. Once the cancellation was confirmed, all transfers to Stanley were cancelled, and everyone remained on board overnight. Some people went for walks to Bertha's Beach, and the Harbour Lights was opened especially for the ship's personnel in the evening for drinks ashore.

Tues 9 Mar: Scientists and technicians were booked to fly north on Friday 12 Mar, but we were told that the incoming crew rotation could not take place before Monday-Tuesday. BAS personnel were offered the option to move into Stanley, which Bjørg Apeland opted to do; other personnel remained onboard. Data processing and report writing continued.

Wed 10 Mar: In the morning we were told that the crew rotation would in fact take place on Thursday, and that everyone would fly north on Friday. Report writing and penguin spotting continued on board.

Thurs 11 Mar: Scientists and technicians transferred to Stanley at 10 am; crew followed in the evening (except Edin, who remained on board for the northbound leg).

Fri 12 Mar: After a very early breakfast, all personnel board a bus for transfer to Mount Pleasant Airfield at 6:00. The bus doesn’t start, but a replacement is quickly found. Apart from a spontaneous opening of the front door en route to Mount Pleasant, all goes smoothly, and flight RR2233 departs slightly late from its scheduled departure at 10:40, refuelling in Dakar in the evening.

Sat 13 Mar: After a quick refuelling stop and good tailwind from Dakar, all personnel land at RAF Brize Norton at 7:30 UTC , ahead of the scheduled arrival time of 9:45 UTC.

Profiling Conductivity Temperature Depth (CTD) measurements

Brian King

A total of 100 CTD stations were completed, with samples drawn for salinity and dissolved oxygen analysis on board, and a variety of samples processed and preserved for shore analysis.

The mexec processing path for CTD data followed previous cruises. The sequence was

ctd_linkscript on linux, to copy cnv, hex and other files from NMF and create link names, and then on Matlab:

```
>> ctd_all_part1
>> mdcs_03g
>> ctd_all_part2
>> mctd_checkplots
>> mctd_rawshow
>> mctd_rawedit
>> mctd_all_postedit
```

The *mctd_all_postedit* script was only run if edits were made to the raw data in *mctd_rawedit*. *mctd_all_postedit* repeated all the steps needed to take data from edited raw data to finished 2dbar files. *mctd_all_postedit* was also run after inserting T, C or O calibrations into *opt_jc211.m*.

The *ctd_all* scripts call a sequence of other *mctd* scripts. The new *mfsave* command was inserted into several of those scripts to reduce the number of individual steps required. The overall functionality was largely unchanged.

Choice of sensors

On this cruise, the primary sensors, temp1, cond1, oxygen1 were on the vane of the CTD frame. These sensors provided much cleaner data than the frame sensors, especially in the presence of strong vertical gradients in the upper 100dbar, when the heave compensator was not engaged. Secondary sensors were on the lower part of the frame. The primary sensors are reported for all stations except 74. On that cast, the primary sensors became badly fouled by the presence of gelatinous material in the duct. Secondary sensor data are reported instead. Secondary oxygen is also reported for station 63.

CTD temperature calibration

Inspection of early stations revealed a small offset between CTD temp1 and temp2, with that offset having a weak pressure dependence. temp1 and temp2 were compared with SBE35 data up to station 65. It was decided that temp2 showed the small pressure dependence. The following adjustments were entered into *opt_jc211.m, case mctd_02b, case ctdcals:*

```
'dcal.temp1 = d0.temp1 - 0.001;'
'dcal.temp2 = d0.temp2 - 0.0005*d0.press/4000;'
```

Thus the pressure dependence on temp2 was adjusted by 0.5 mK over 4000 dbar, and temp1 had an single adjustment of 1.0 mK. These adjustments were applied to all stations.

CTD conductivity calibration

A total of 828 bottle salinity samples were analysed. A salinity sample was drawn and analysed to match every O18 sample drawn. The drawing of O18 samples therefore guided the location of salinity samples, and provided a more than adequate dataset for CTD salinity calibration.

The first adjustment to cond1 and cond2 was determined from stations up to 73. A pressure dependent factor for cond1 and cond2 was determined as follows, and entered into *opt_jc211.m, case mctd_02b, case ctdcals:*

```
'dcal.cond1 = d0.cond1.*(1 + interp1([-10 0  2500  5000  8000],(1.0*[0.0
0.0 -1.25  -1.0  -1.0 ] - 0.5)/1e3,d0.press)/35);'
'dcal.cond2 = d0.cond2.*(1 + interp1([-10 0  2500  5000  8000],(1.0*[0.0
0.0 -0.625 +0.25 +0.25 ] + 1.2)/1e3,d0.press)/35);'
```

A review of the residuals around this calibration after the last station suggested that the sensors had drifted slightly in the latter part of the cruise. An extra adjustment was determined for station numbers greater than 90, with that adjustment ramping up between station 75 and 90. The new calibration string, applied for stations >= 75, involved a factor stnfac that ramped up from 0 to 1 between stations 75 and 90. The second part of the adjustment is carried forward from stations 1 to 74, with an extra station-dependent and pressure-dependent part defined over pressure 0 to 5000 dbar.

```
'dcal.cond1 = []; stnfac = (min(stnlocal,90)-75)/(90-75); dcal.cond1 =
d0.cond1.*(1 + (stnfac*interp1([-10 0  1000  5000],(1*[-1.5 -1.5 -0.5 -0.5]
- 0.0)/1e3,d0.press) + interp1([-10 0  2500  5000  8000],(1.0*[0.0 0.0 -
1.25  -1.0  -1.0 ] + 0.5)/1e3,d0.press))/35);'
'dcal.cond2 = []; stnfac = (min(stnlocal,90)-75)/(90-75); dcal.cond2 =
d0.cond2.*(1 + (stnfac*interp1([-10 0  1000  5000],(1*[-1.0 -1.0 -0.5 -0.5]
- 0.0)/1e3,d0.press) + interp1([-10 0  2500  5000  8000],(1.0*[0.0 0.0 -
0.625 +0.25 +0.25 ] + 1.2)/1e3,d0.press))/35);'
```

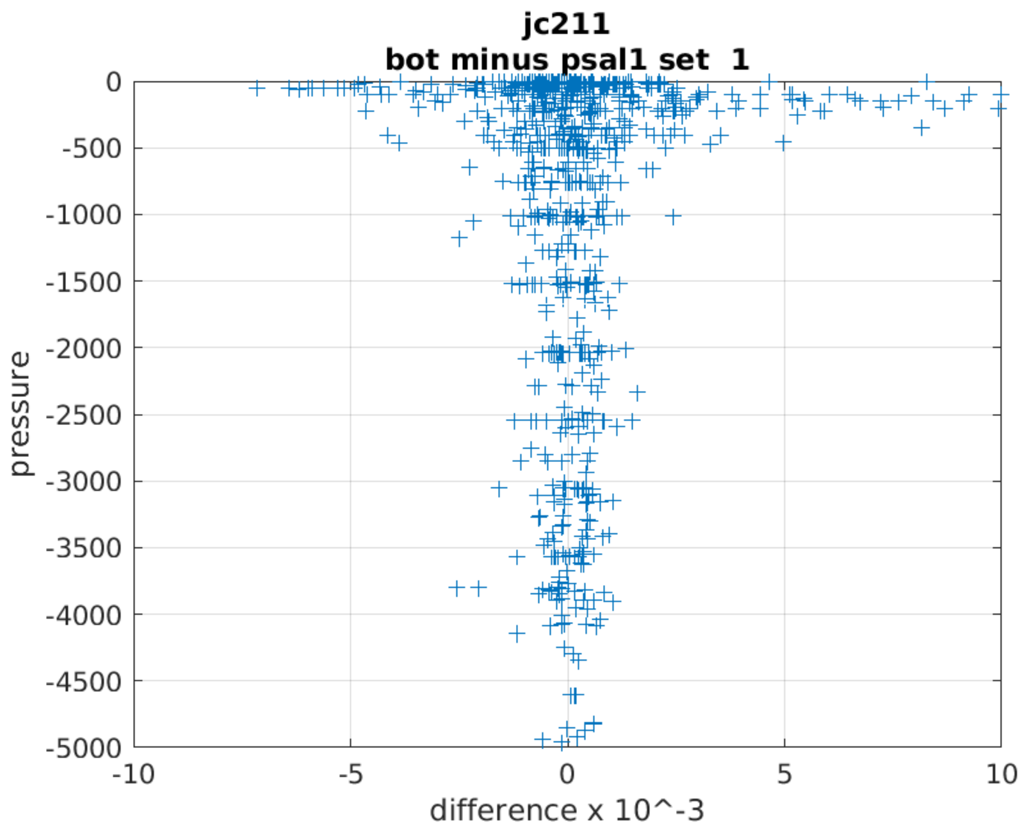


Figure 3. Bottle minus CTD psal1, distribution over pressure.

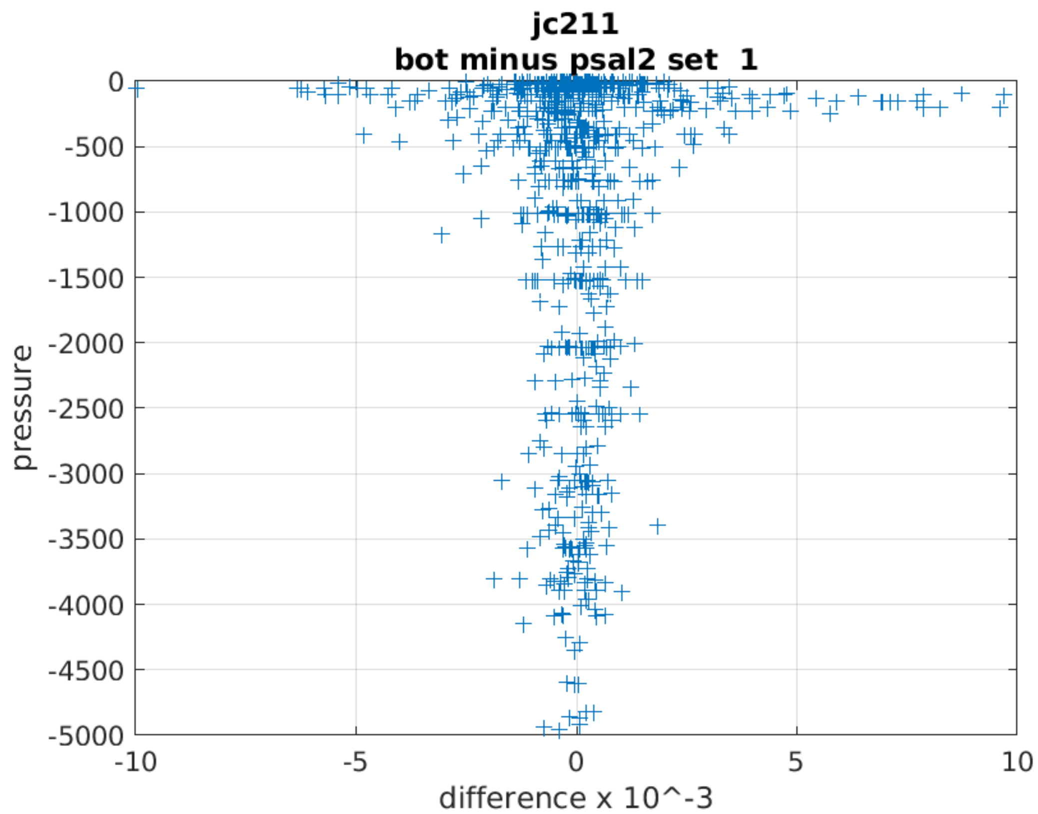


Figure 4. Bottle minus CTD psal2, distribution over pressure

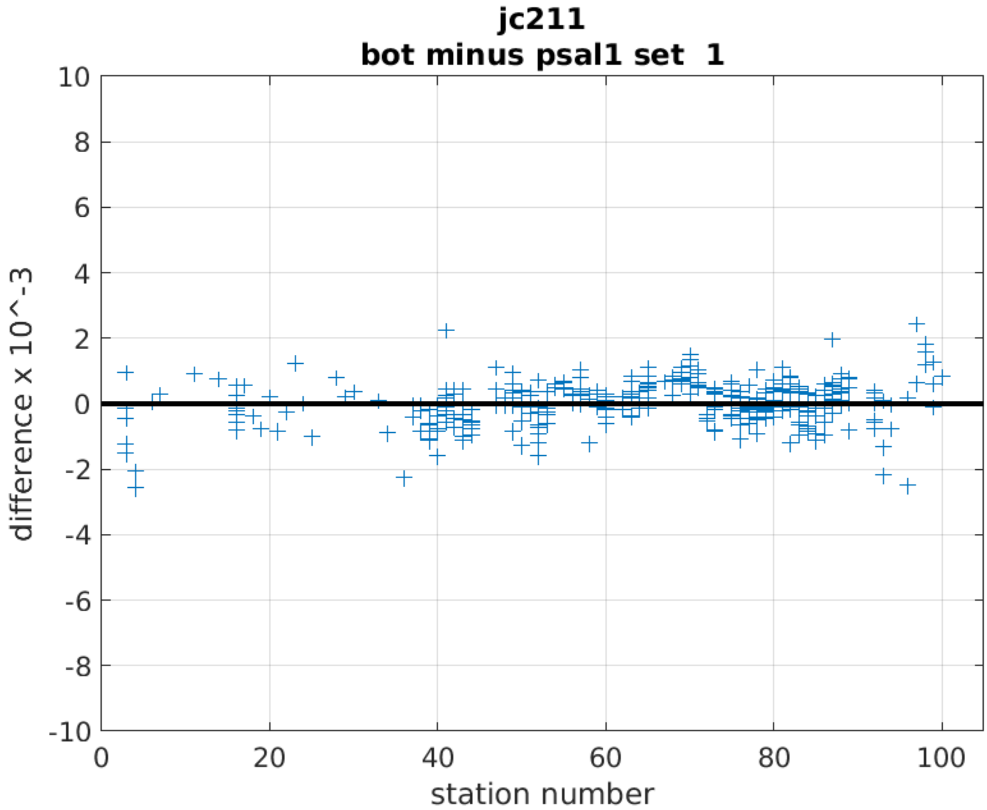


Figure 5. Bottle minus CTD psal1, all bottles below 500 dbar, distribution over station number.

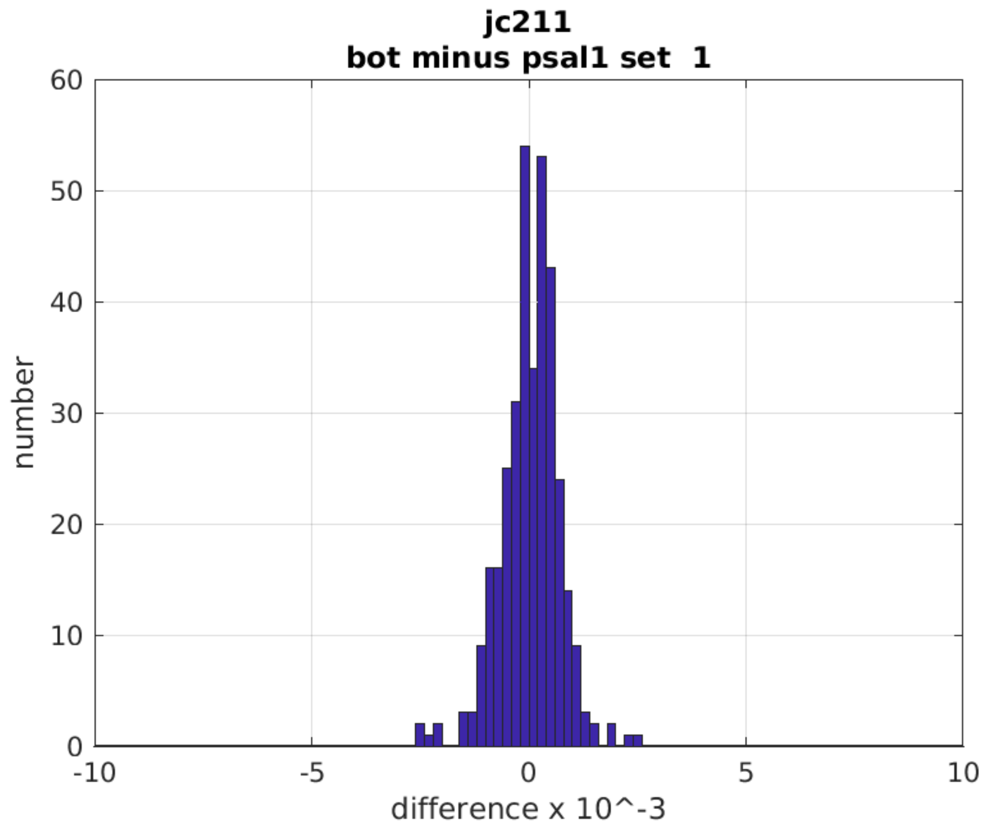


Figure 6. Histogram of differences in Figure 5. 360 samples. Mean = -0.00002; std = 0.0015; iqr = 0.0008.

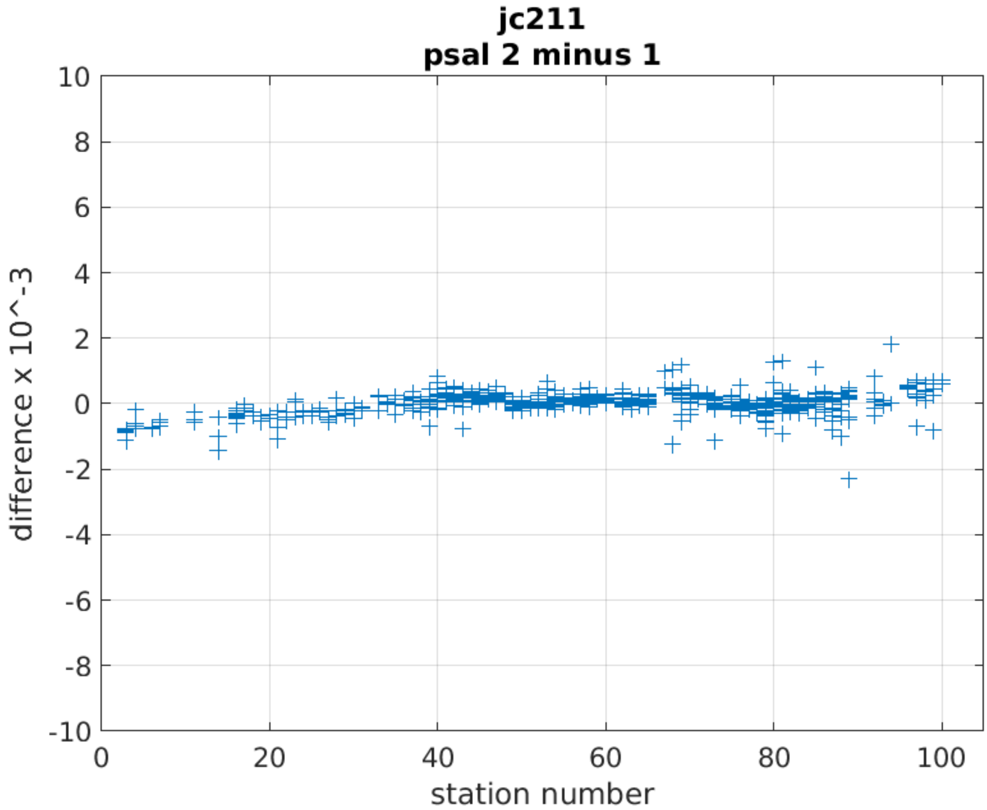


Figure 7. CTD psal2 minus CTD psal1, at bottle stops deeper than 500 dbar. There is small systematic difference, less than 0.001, over early stations. Early stations have a majority of shallow bottles, and we did not discern a reliable adjustment to either sensor for those stations.

CTD dissolved oxygen calibration

Oxygen sensor hysteresis

CTD oxygen sensor data are extracted from SeaSave as cnv files without oxygen hysteresis being applied. Oxygen hysteresis is applied in mctd_02b, with coefficients chosen to minimise hysteresis, that usually differ slightly from SeaBird defaults, especially in the H3 coefficient.

For this cruise, default parameters of H1 = -0.033 and H2 = 5000 were found to be satisfactory. A pressure-dependence table for H3 was entered in opt_jc211.m, case mctd_02b, case oxyhyst. This differed from the SBE default of 1450 in the upper ocean, thus:

```
h3tab =[
-10 700
1000 700
1001 1000
2500 1000
2501 1450
9000 1450];
```

Application of these parameters generally reduced the upcast/downcast difference to less than 1 µmol/kg.

Oxygen sensor calibration

Yvonne Firing

Sample data were ingested in one step using moxy_01.m to load csv files of bottle sample/titration parameters and combine them with averaged values from log_blanks_standards.csv; convert to concentrations; sort out duplicate samples; and convert to µmol/kg based on CTD salinity from the sam_jc211_all.nc file.

The ratio between bottle and CTD oxygen was first inspected as a function of sample number, pressure, temperature, and oxygen value. For both sensors, a fairly simple pressure-dependent factor with 3 inflection points appeared appropriate to describe the ratios:

```
dcal.oxygen1 = d0.oxygen1.*interp1([0 2000 4000 5000],[1.03 1.04 1.043
1.042],d0.press);
dcal.oxygen2 = d0.oxygen2.*interp1([0 1500 4000 5000],[1.03 1.043 1.051
1.05],d0.press);
```

After this factor was applied, inspection of differences revealed only small residuals (Figure 8 andFigure 9), so no further offset was applied.

The calibration is applied by specifying functions above in the mctd_02b, ctdcals case of opt_jc211, and setting oxygencal=1 in the mctd_02b, raw_corrs case of opt_jc211. Running ctd_all_postedit reruns mctd_02b as well as subsequent steps to propagate the calibrated ctd data through to the sample file and 2 dbar averaged files.

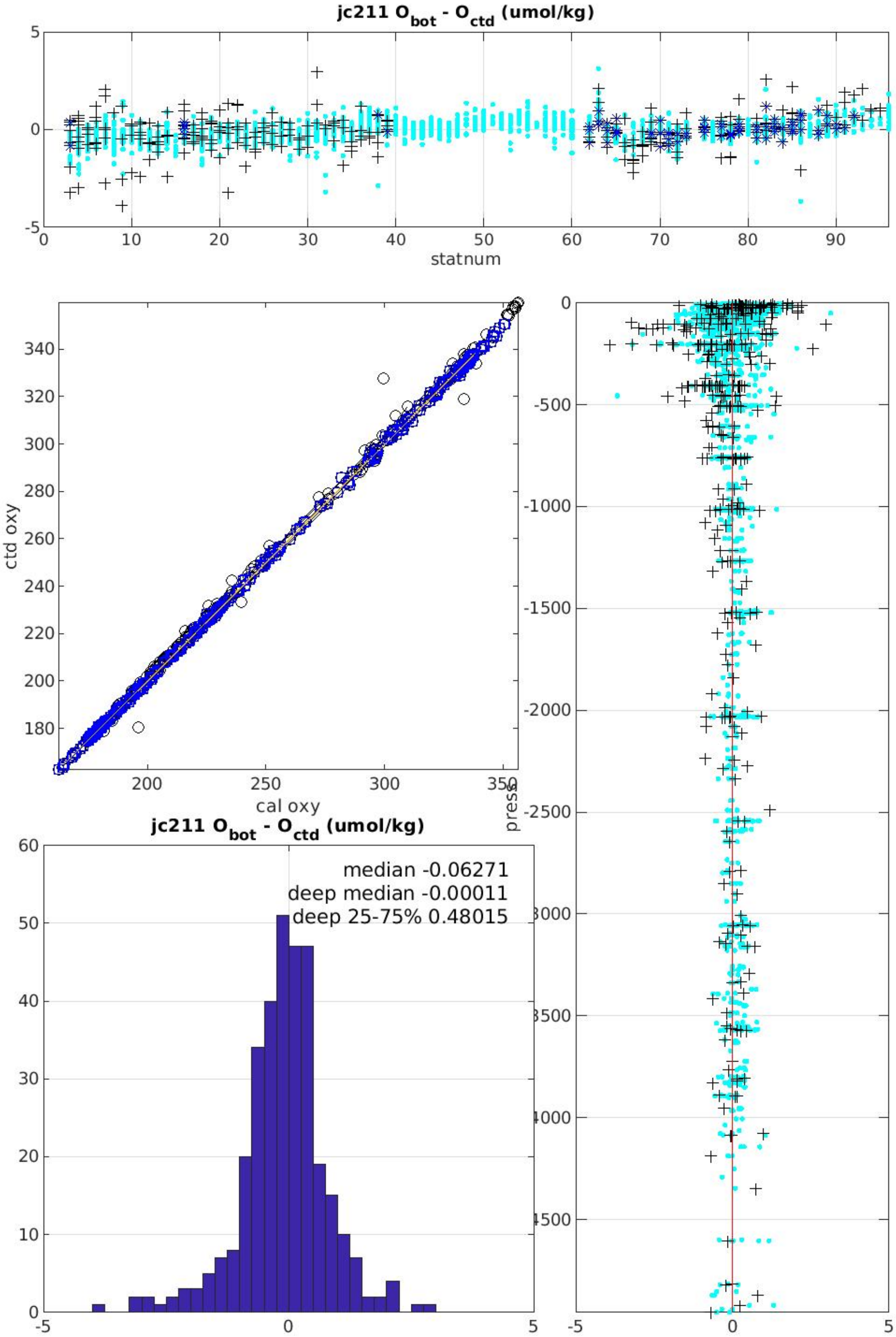


Figure 8. Oxygen differences between CTD1 and CTD2 (cyan dots) and between bottle and CTD1 (black +, blue x on top panel indicates deeper samples).

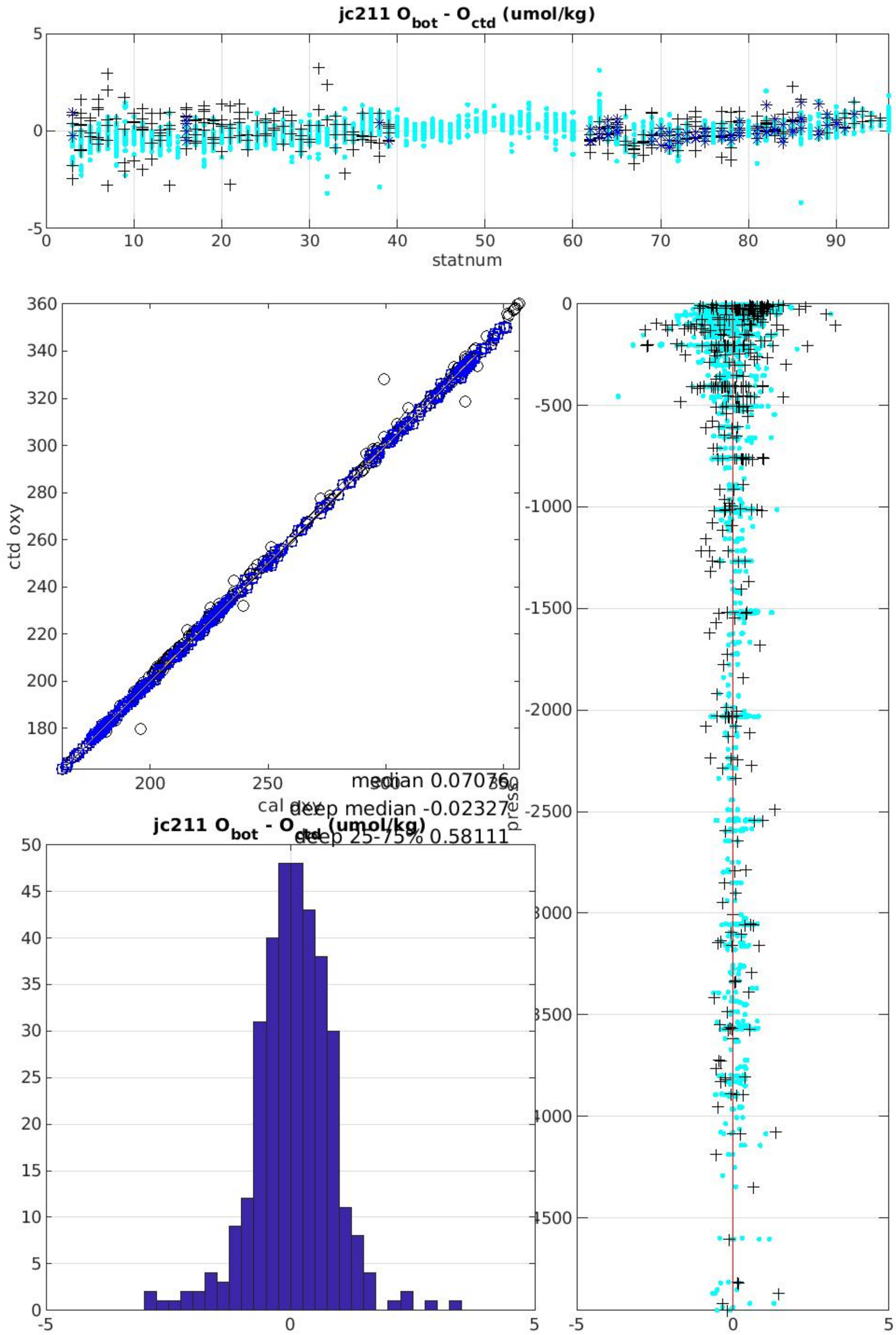


Figure 9. As Figure 8 for CTD2.

Other sensors

The CTD frame was also equipped with fluorometer, transmissometer, turbidity, up and downlooking PAR. These data streams had factory calibrations applied, but no further calibration or investigation.

Display of CTD data during the cast

There is a long-standing issue of scientists wanting to be able to see and inspect the CTD trace during the cast to choose bottle closing depths, which results in people crowding round the CTD deck unit, often unhelpfully. This problem has been partly solved in the past by having a remote mirror of the CTD operator's display. The problem was solved on JC211 by having a copy of SeaSave running on a remote machine. The incoming CTD data signal was split at the deck unit and sent to a remote machine where scientists could have their own copy of SeaSave completely independent of the CTD data acquisition or operator display. This is described in the NMF report. Also, that remote copy of SeaSave created a shared cnv file on a network drive in real time. A Matlab program, "*rtctd.m*" for "real-time-CTD" read the shared file and updated plots of CTD data on koaeula. Three figures of 3 panels each displayed temp, salinity, oxygen, fluor, trans, turbidity, par1, par2 and altimeter, with pressure as the independent variable. The user can use Matlab zoom on any of the panels to inspect particular depths and features. Between updates of the plots at 2Hz, *rtctd* looked for clicks of buttons in the figures to allow zooming of panels so all panels had the same zoom, or to reset Matlab autolims on all panels.

Issues and anomalies

On station 74 the primary sensor duct was blocked with gelatinous material, rendering the T, C and O data unusable. Secondary sensor data are reported instead.

On station 91, the SeaSave data acquisition hung up. The software was restarted and the station recorded in two parts, which were processed as station '501' and '502'. These were combined into a full station 091.

Heave compensator

The heave compensator on the CTD winch system was engaged deeper then 100 metres. In the upper 100 metres it could not be used. The stations in the early part of the cruise had strong gradients, especially in salinity and temperature, between about 50 and 100 metres. These data are badly contaminated by ship motion causing acceleration and deceleration of the package descent. The vane sensors are badly affected and the frame sensors even worse. Whenever the package decelerates, i.e. slows the rate of descent because the sheave is heaved upwards, entrained water from a shallower depth rushes past the sensors and contaminates the data. Note that full reversal of the package motion is not required for this effect, just deceleration. Figure 10 illustrates the problem. In that figure the red and black curves are CTD temperature from the vane (black) and frame (red) sensors on station 050. The temperature data have been offset by 1 degree for clarity. The cyan curve is CTD package descent rate in metres per second. The winch is paying out at 30 metres per minute, or 0.5 metres per second. Each time the package descent rate slows to near zero, because the sheave has heaved up, there is a major spike upwards in the red curve as entrained warmer water from a shallower depth overtakes the package. The biggest contamination is around 62 metres. This effect is smaller, but present, in the black curve for the vane sensors. Contamination is obvious at 54, 58 and 62 metres. But looking closely at the descent from 68 to 80 metres, the temperature appears to be descending in a series of 'steps'. Although there is no full 'reversal' of the black curve, this is almost certainly an artefact of the package motion, and the gradient should be steady not stepped. Furthermore, while the CTD temperature and conductivity can be mounted on the vane, the other sensors, fluorometer, transmissometer, etc., are mounted on the frame and will be subject to the full contamination shown in the red curve.

This effect is massively improved by the heave compensation below 100 metres. Every effort should be made to try to find a safe way to engage the heave compensator from a shallower depth, especially on downcasts. The advantage to the quality of data would be considerable.

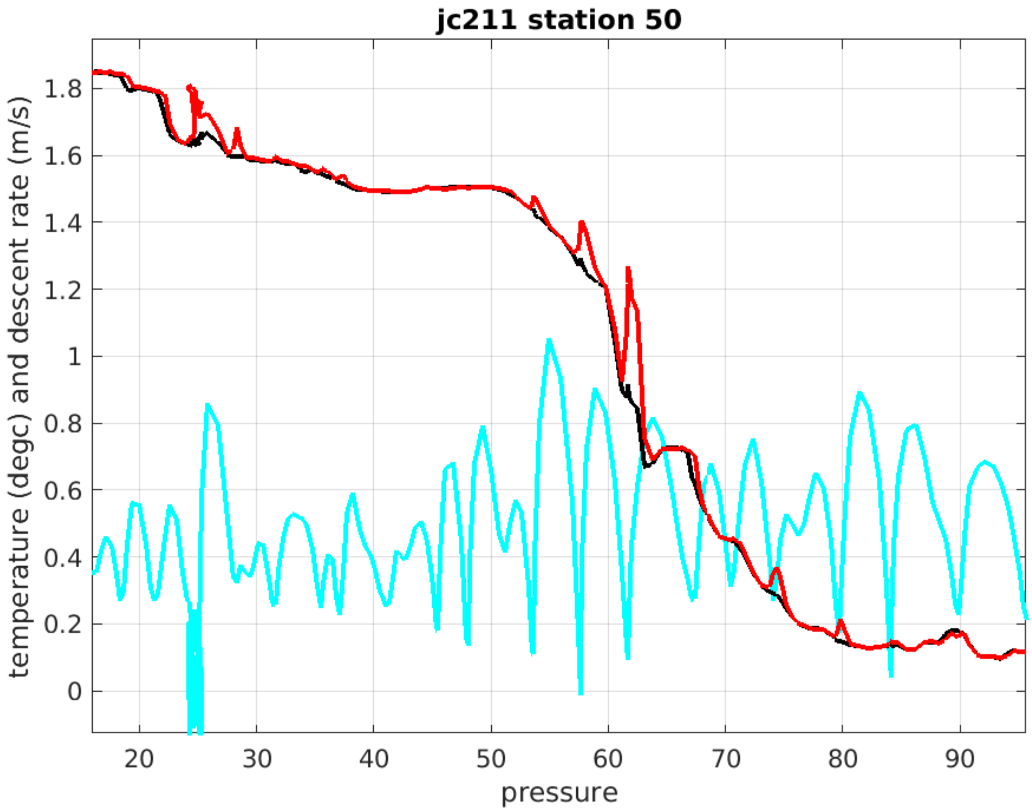


Figure 10. Effect of package heave on CTD data quality.

Dissolved oxygen analyses

Yvonne Firing

Sampling

Samples for dissolved oxygen were taken from 476 Niskins on 81 of the CTD casts (Figure 11), including the test cast. Dissolved oxygen was the first sample drawn, using a length of tubing to fill flasks from the base while minimizing bubbles, allowing them to overflow at least 3 filling-times, and measuring the temperature while filling. Samples were fixed by the addition of 1 mL of manganous chloride solution and 1 mL of alkaline iodide solution using volume-calibrated dispensettes attached to the reagent bottles, caps inserted, and inspected for bubbles. After every two samples they were shaken for 30 seconds, inverting the flasks with each shake; it was judged that this delay of a few minutes in shaking the first sample would not affect the reaction since the bottles were sealed. A few small bubbles were found in a few samples and noted on the log sheet (producing a flag of 3 on loading the data), but generally they were not a problem. Flasks were "sealed" with milli-Q following shaking. After at least 30 minutes, samples were shaken again, had milli-Q reapplied, then left in the chemistry lab to settle for at least two hours before analysis.

Analysis

Sample analysis procedure and calculation of reagent blanks and standards generally followed the JR18002 cruise report and the GO-SHIP manual. Samples from stations 3 through 39 were analysed on the CUSTARD Metrohm Ti-touch, those from stations 40-55 and 59-95 on the ABC Ti-touch, and those from stations 56-58 on a combination (see below).

Blanks and standards were run each day on which samples were run, at least 3 blanks and 5 standards, with additional iterations after running a crate or two of samples in some cases to check for stability.

Issues: blanks and standards

For the first days, the blanks were persistently high, averaging 0.014 to 0.019, with large standard deviations. Using the standard-curve method described in the GO-SHIP manual produced consistent, reproducible/low standard deviation, but still too-high blanks of ~0.011. Meanwhile, standards were consistent over sets of 5 and across days. When data from the first 25 or so stations were loaded and compared with CTD oxygen, they were found to be about 5% higher than both CTD sensors, and also nearly 5% over the oxygen saturation level in the surface mixed layer. It was thought this could be because blanks were too high.

A few bubbles were observed stuck to the pistons of the exchange units and an attempt was made to clear them, since they were not cleared by repeated use of the prepare function or the empty or dosing fixed volume functions. A solution of triton followed by milli-Q was run through to attempt to clean them but did not change the persistence of bubbles. Finally, nearly all bubbles were cleared by dint of unscrewing the dosing units from the reagent bottles, upending them with their intake straws immersed in solution (from a small bottle; empty standards bottles were used), dosing and refilling with the

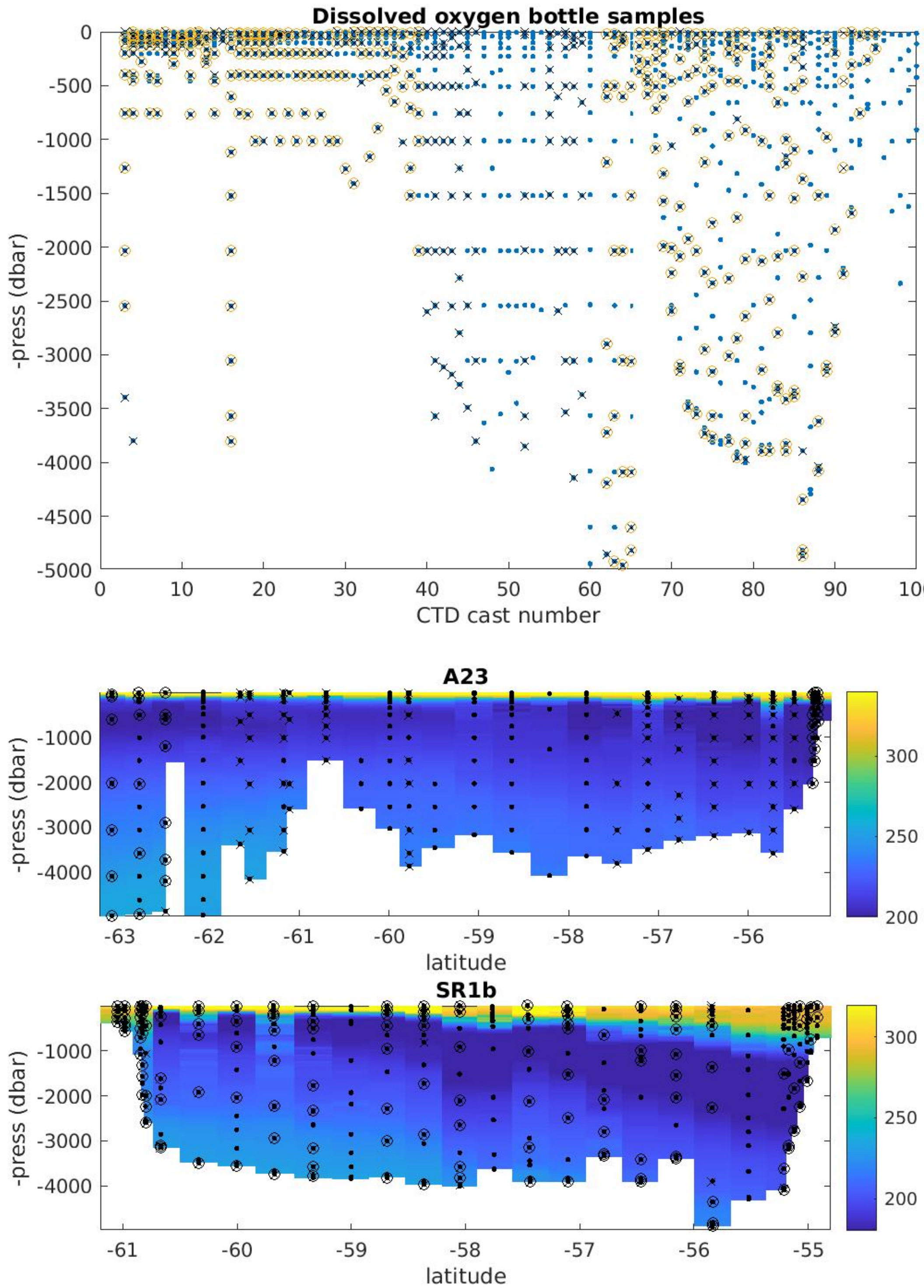


Figure 11. Distribution of bottle oxygen samples over all stations (top) and on A23 and SR1b sections (bottom). Dots indicate where Niskins were fired, xes where dissolved oxygen samples were drawn, and circles indicate bottle oxygens eventually flagged as good (note most of A23 oxygen samples were run with suspicious thiosulfate standard values and therefore flagged as bad).

dosing port upwards and tapping gently, and then reattaching to the normal standard and titrant bottles without allowing any air into the intake straw (this only worked because the bottles were not too full).

Stirring time before addition of each reagent or standard was increased to 20 s (timed). The electrode was also cleaned with milli-Q and a Kimwipe, and bottles of pickling reagents and acid were changed, but blanks did not improve.

At this point we switched to the second machine, the ABC Ti-touch. Exchange units were filled and prepared by the same process as above to minimise bubbles, although there were still a few small ones; preparing seems to consolidate but not remove them. We used the methods pre-loaded on this machine, which did not include stirring by the magnetic stirrer before addition of standard; therefore blanks were vigorously hand-swirled before each addition. Blanks were immediately much improved, to around 1e-3 (Figure 12). The first run of the standard method on the ABC machine produced higher values than before, about 0.51, but inspection of the method revealed the initial addition was 0.5, causing it to overshoot. Reducing the initial addition to 0.3 produced more consistent results around 0.47. The other methods were also checked to make sure the initial addition was well under the expected titrant volume. The standard-curve method on this machine also produced appropriately low blanks and very linear dependence of titrant volume on standard volume.

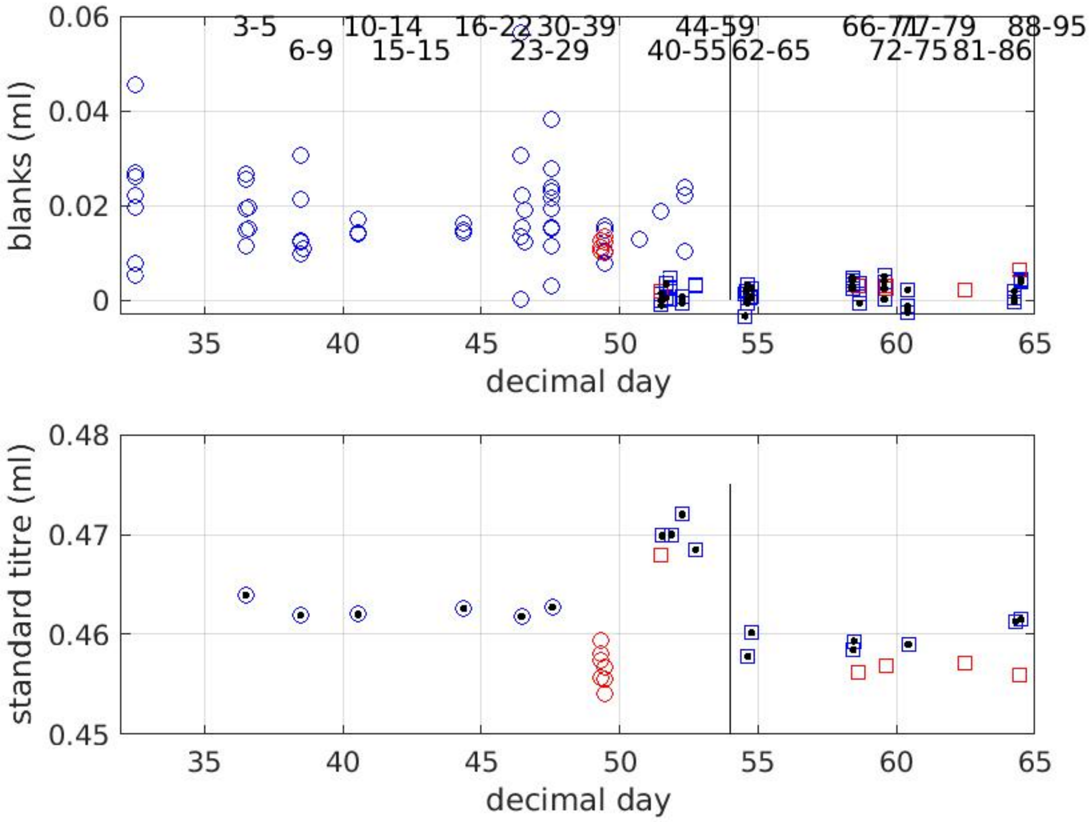


Figure 12. Blanks (top) and standards (bottom) from the CUSTARD (circles) and ABC (squares) ti-touches, with values from the standard-curve method in red and from the Carpenter method in blue; black dots indicate values that were averaged and used for a given set of stations. Text on top panel indicates ranges of stations run on the day of each set of blanks; vertical black line is where the thiosulfate solution was changed (between station 59 and station 62).

The most noticeable difference between the two machines was that blanks take much longer to run on the second one (about 5 times as long); in addition, the stirring on the second machine was more vigorous despite the stir setting being lower (the ABC machine has an external magnetic stir pad whereas the CUSTARD machine's is built-in). The only difference in programs to account for the first difference seems to be under control parameters, where the ABC blank method has a user-defined titration rate with dynamics 10 µA, max rate 1 mL/min, min rate 2 µL/min, whereas the CUSTARD blank method has "optimal titration rate".

Because the fixing reagents and acid were each made up in one large batch before being decanted into 500 ml dispensing bottles, we decided to use the average blank values from the new machine for all samples analysed with the first batch of thiosulfate. To address doubts about sample values we collected and analysed 17 pairs of duplicates from three CTD casts, pseudo-randomly allocating each first- and second-drawn sample to each machine. These revealed (Figure 13) a consistent offset between the machines, with the ABC machine being about 1 µmol/L higher. The differences were larger than those between duplicates run on the same machine (Figure 13), but still small enough that we decided to use both sets of samples.

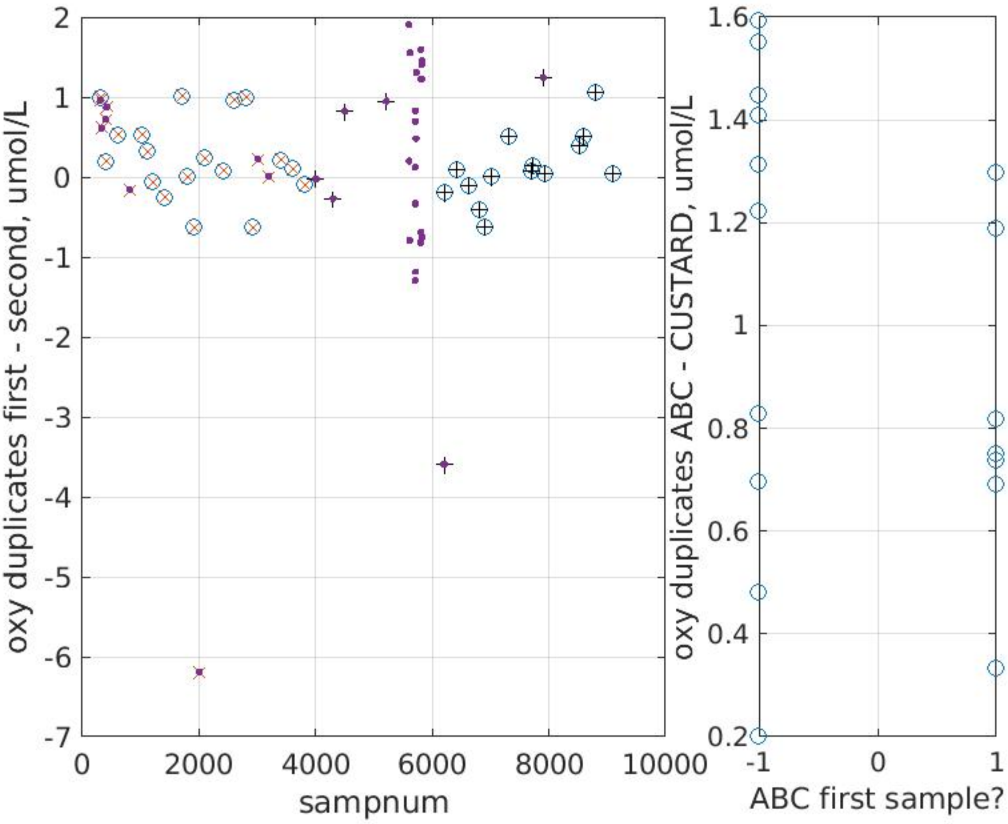


Figure 13. Comparisons between duplicate samples analysed on CUSTARD machine (red x) or ABC machine (black +), with blue circles indicating good duplicates and purple dots questionable duplicates (or those analysed on two different machines). Duplicates analysed across machines are shown on the right panel.

Initial runs of blanks by EPA on this machine produced somewhat higher values than those obtained by YLF (0.003 rather than 0.001), apparently due to less vigorous stirring, so these were discarded from the averages. The standard-curve method produced similar blanks but lower standards, and as the GO-SHIP manual states it is less reliable than the Carpenter method, these values were not included in the averages either. The average blanks used were 5e-4 and 1.8e-3 for the first and second thiosulfate batches, respectively; the average standards for these batches were 0.4625 and 0.4595.

Sixty-six duplicates ("b" samples) were collected, of which 49 were analysed on the same machine as the corresponding "a" samples, and 17 pairs analysed across the ABC and CUSTARD ti-touches to compare their readings. For the normal duplicates (Figure 13 left panel), 32 pairs of samples (not flagged as questionable) agreed to within 1 µmol/L, with a mean offset smaller than 0.1 µmol/L and standard deviation of 0.47 µmol/L.

The standards values first run on the ABC machine, with the first batch of thiosulfate, were noticeably higher than the earlier standards, and also than the standards values of the second batch run on the ABC machine starting a few days later. This produced samples that were obviously out of line with the rest in terms of differences from either CTD sensor (Figure 14). Using the earlier, lower standards values, however, produced results out of line in the other direction. Since the two CTD sensors appeared to be stable relative to each other, and the bottle-CTD comparisons for other stations were also fairly stable, we decided to flag these samples and not use them for calibration.

Fifteen other samples were also flagged as outliers based on comparison with CTD data, and given flags of 3 or 4. Where there were large differences from the CTD value at Niskin firing time, but the 1 Hz trace during the bottle stop passed through the bottle oxygen value, the bottle oxygen flag was kept as 2 (good). Since oxygen was not taken from every Niskin depth, most oxygen samples were drawn where gradients were relatively low, and there were thus not many cases of large differences; they were simply ignored in choosing the calibration function.

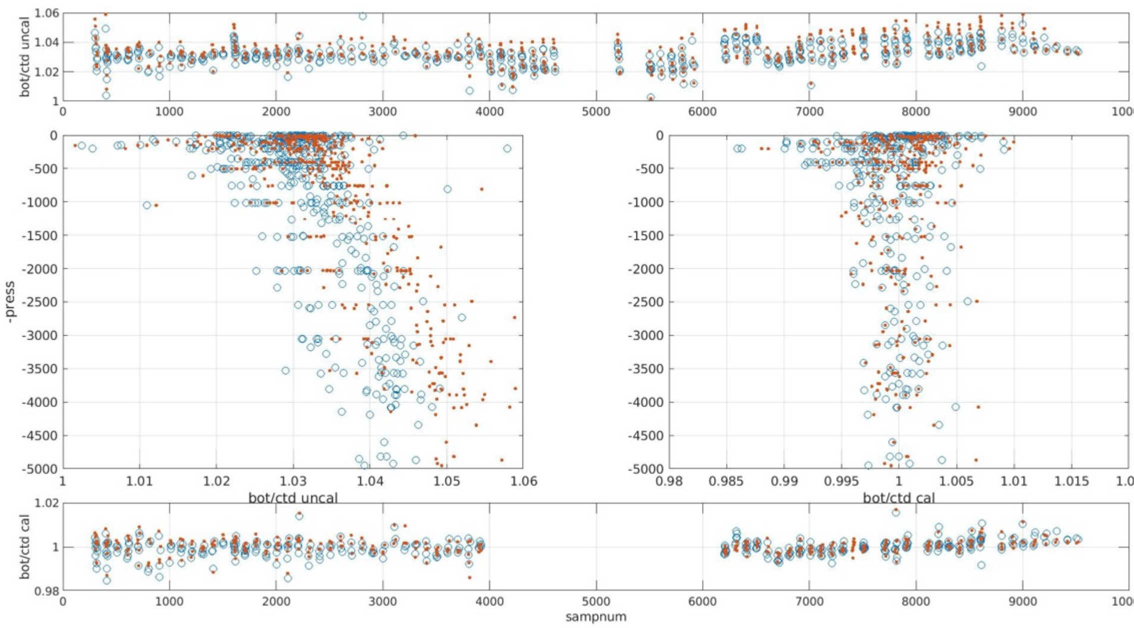


Figure 14. Ratio between bottle and CTD oxygen (CTD 1 blue circles, CTD 2 red dots), as a function of sample number before calibration (top panel) and after calibration (bottom panel) and of pressure before calibration (left) and after calibration (right). Samples from stations 40-60 have been left out of the pressure comparisons and flagged in the final calibrated data because they appeared to be outliers, and standards run during that time period were also outliers.

As another check on the bottle oxygens, they were compared to previous cruises and the GLODAP dataset from the south Atlantic (between 40° and 70° S), in two ways. First, values near the surface were compared to the (temperature-dependent) oxygen saturation level (Figure 15); while the JC211 bottle oxygens were above this level, and higher than the DY113 data, they were within the envelope of GLODAP data, and similar to the JR18002 data. Second, oxygen as a function of temperature in the Upper Circumpolar Deep Water layer shows the JC211 bottle oxygens well-aligned with GLODAP, 2018 GO-SHIP cruise JR18002, and last year's SR1b-A23 cruise DY113, although offset from 2008 GO-SHIP cruise JC31.

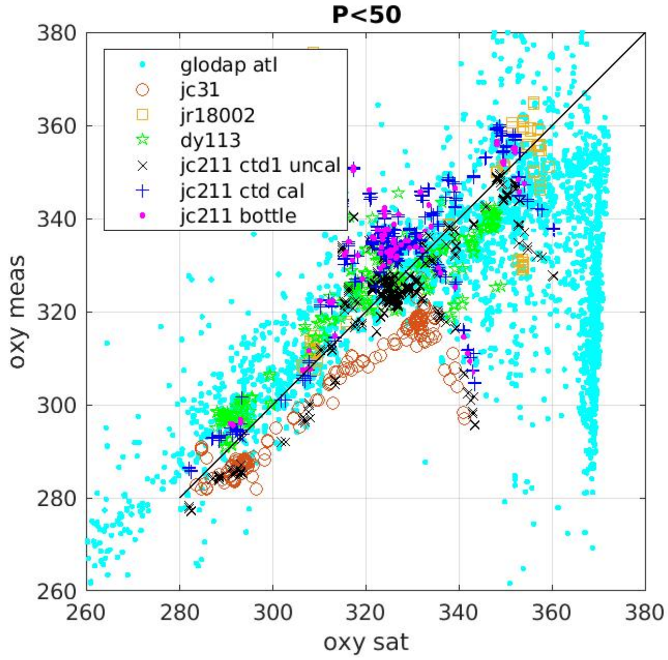


Figure 15. Comparison between measured dissolved oxygen (CTD or bottle) and oxygen saturation level for points above 50 dbar.

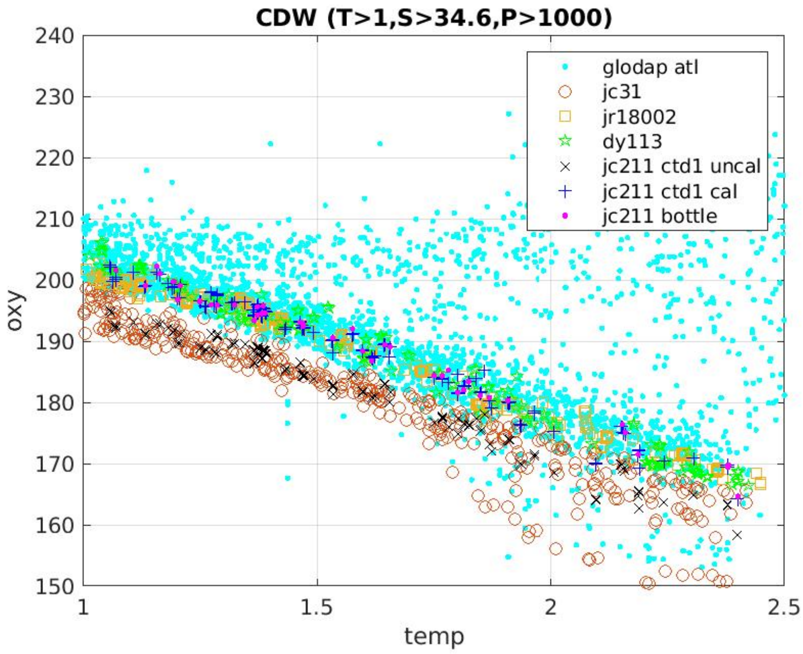


Figure 16. Temperature-oxygen curves for (a subset of) old, stable circumpolar deep water, from the GLODAP dataset and from several previous SR1b/A23 occupations.

Salinity analyses

Alice Marzocchi

Sampling

A total of 828 salinity samples were drawn at different depths in 97 out of 100 casts (there were no bottle stops in three aborted casts: 1, 2 and 61), for CTD calibration and to obtain known salinities for every $\delta^{18}O$ sample. Seawater samples were collected from the Niskin bottles in 200-ml glass bottles, which were first rinsed three times and then filled up to the shoulder; the bottles' rims were wiped dry and closed with a single-use plastic stopper and a screw cap. After a 24-bottle crate was full, it was moved into the electronics lab and left for 24 hours to equilibrate to the ambient temperature (20-21°C) before being analysed.

The selected depths for the salinity samples varied between stations/time series:

- WCB stations: fixed depths required for the biology samples and any other depth where DO samples were collected (e.g. the bottom when this was not sampled for biology).
- Iceberg and A23 stations: fixed depths determined for the $\delta^{18}O$.
- SR1b stations: fixed depths determined for the $\delta^{18}O$, but these were flexible and varied slightly depending on what was chosen for DO samples and to avoid strong gradients in T and S (and oxygen), as chosen by the watchkeeper.
- Mooring and acoustic calibration stations: chosen by the watchkeeper as above.

A total of 170 salinity samples were also drawn from the underway system as part of the routine watchkeeping checks (every ~4 hours or when possible), in the same way as described above for the CTD samples. This was done to enable calibration of the TSG system. The underway samples were stored together in a separate crate and analysed only once the crate had been filled, but were otherwise treated in the same way as the CTD samples.

Analysis

All salinity samples were run by the science team on the same salinometer (Guildline Autosal, SN: 72227) after switching from a different machine (SN: 71126) due to standardisation issues (see NMF report). The suspicion was that the control of bath temperature was poor, even though the heaters were cycling normally. Standardisation, maintenance and cleaning of the salinometer, and setup of the Autosal software were performed by the NMF technicians. The Autosal was standardised before running the first crate of samples, but otherwise the standardisation settings were not changed for the duration of the cruise. The bath temperature was set to 24°C, and the lab temperature (electronics workshop) maintained between 20 and 21°C, creeping up above 21°C at the end of the cruise. Lab temperature was monitored as part of the 4-hourly watchkeeping checks.

To track any salinometer offsets or drifts during the analysis, a seawater standard (OSIL IAPSO standard seawater batch P164, K_{15}=0.99985) was run at the start and end of each crate. Two or three crates were run in succession, so the reading from one standard was used for both the end of one crate and the start of the next. Before starting one crate of samples, the cell was first flushed through with previously opened bottles of standard (or older batches) and for intervals between runs the machine was flushed with milli-Q water. 80 ampoules of batch P164 SSW were available, expiry date 23 March 2023, 68 of which were used during the cruise leaving 12 spare. A further 20 ampoules of batch P163, still before expiry but with an earlier expiry date, were available. 14 were used for pre-standardisation and for investigation of 71126, but not for standardization of JC211 samples.

For each CTD/TSG sample the cell was flushed and filled three times before the first reading, and once more before each of the following two readings. Three readings and their mean and standard deviation were recorded by the software, but also logged by hand as a backup. In case of outliers (std > 0.0003) one of the readings was taken again and sometimes this would be the first one, due to insufficient flushing of the cell after the previous sample.

Autosal measurements were logged with the NMF salinometer logging software, transferred to a Mac Mini where sample numbers were added in Excel, saved as csv, and then read into mexec on Linux workstation koaeula. Standards had bottle numbers starting 901 in the OSIL software and sample numbers 999901 in mexec. CTD samples had sample numbers of SSSNN where SSS is station number and NN is rosette position number, and TSG samples had sample number of minus 1 times the event entry in the NMF TSG event log.

After initial standardisation, the Rs set dial was left unaltered on 72227 throughout the cruise. The Guildline ratio for each standard was recorded. An entry in *opt_jc211.m* recorded the adjustment to Guildline ratio required for each standard. This adjustment was interpolated onto samples by time of standard and sample run, recorded in the csv spreadsheets from the OSIL software. In general, the adjustment applied was the adjustment that would bring the standard measurement to the 2*label value of 1.99970. In a few cases this adjustment was changed by 1 or 2 Guildline counts to smooth out the adjustment over a few standards.

Figure 17 shows the adjustment applied based on each standard numbered up to 64. There is a slow rise and then fall over the course of the cruise, but also a striking pattern within groups of 3, or occasionally 4, standards run in one session, around 2 or 3 crates. Most notably from 49 onwards each group of 3 consists of a 'low' standard followed by a notably higher one followed by a slightly higher one, e.g. standards 62 to 64 had Guildline values 1.99972, 1.99978, 1.99979 with adjustments -2, -8, -9. This pattern has been noted before on cruises and the reason is unknown. It is possible that the bath warms slightly over the course of a session. The 'low standard first' was not attributed to simple flushing issues after the cell was resting with milli-Q. It occurred even when the cell was pre-flushed 4 times with old standard, and there was no persistent gradient within the 3 readings of the first standard of a session.

Discussion over the course of the cruise highlighted the desirability of direct measurements of bath temperature during a session at sea with a very stable thermometer. The thermometer would need to be stable to about 0.2 mK, equivalent to 1 Guildline count, over the many hours of a session, and preferably over days, so that the effect of bath temperature on measurements could be identified, and even corrected for.

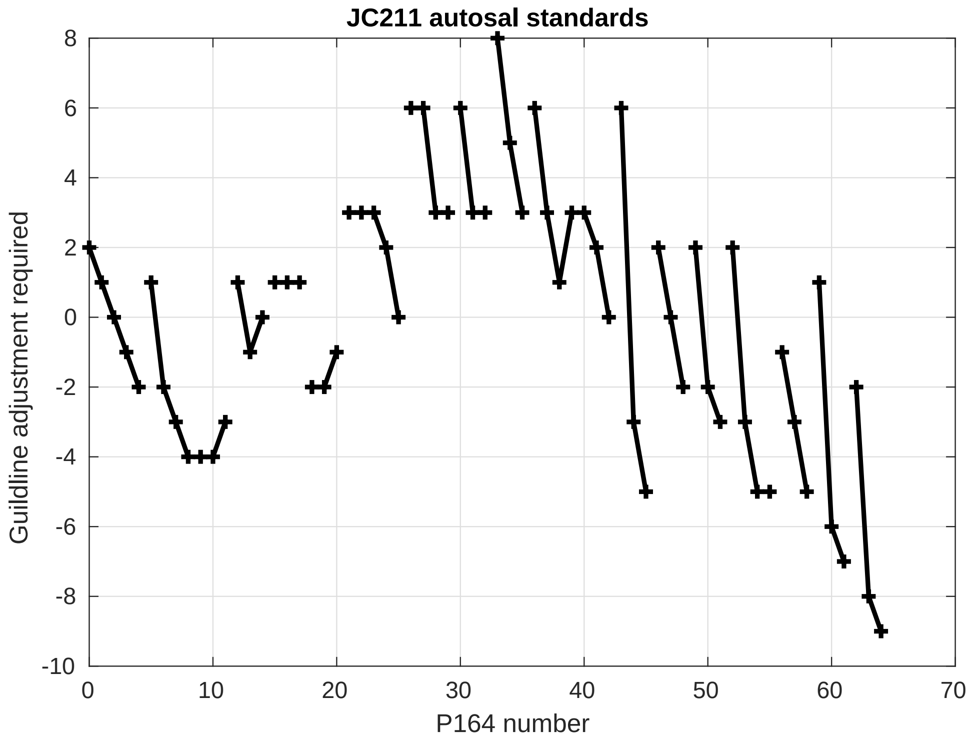


Figure 17. Adjustment calculated and used for each P164 standard. The adjustment is in counts on the Guildline display, e.g 1.99978 is adjusted by -8 to give the label value of 1.99970. Thus, the adjustment to conductivity ratio is the displayed quantity * 0.5 * 1e-5. Solid lines connect groups of 3 or 4 standards run in a single session. The cell rested filled with milli-Q water between groups of standards.

Oxygen isotope sampling

Povl Abrahamsen

Sampling

Samples for stable isotopes of oxygen in seawater ($\delta^{18}O$) were collected from the Niskin bottles into 30-ml HDPE wide-neck Nalgene bottles, filling the bottles as high as possible before the cap was screwed on. The lid was then screwed on tightly, trying to leave as little headspace as possible, though some air bubbles were always present. After drying the bottles, the caps were re-tightened, and vinyl electrical tape was wrapped tightly clockwise from the lid onto the body of the bottle, with 50% overlap. Finally, a permanent marker was used to draw a vertical line across the tape to indicate if the lid or tape slipped before analysis.

Some samples were also collected from the uncontaminated (underway) seawater supply near iceberg A-68A, drawn from the seawater taps in the water sampling lab. The times and positions of these samples are listed in Table 1, and noted in science event log "Uway_d18O_samples".

Each sample was labelled with a unique bottle number from 1 to 735. Bottles 1-2 were collected on test station 3, bottles 3-226 on A23, bottles 227-600 on SR1b, and bottles 601-735 were sampled around iceberg A-68A. Around iceberg A-68A samples were collected at fixed depths of 400, 200, 100, chlorophyll maximum/50, 25, and 5 m. On A23, samples were collected at predetermined stations and depths, with a subset of stations sampled, while all stations on SR1b were sampled at varying depths.

Table 1. Underway $\delta^{18}O$ sample numbers, with time and position

Bottle	Date	Time	Latitude	Longitude	
607	2021-02-13	08:12	55° 54.346'S	036° 39.371'W	
608	2021-02-13	15:49	56° 48.790'S	035° 36.452'W	
633	2021-02-14	03:58	56° 42.007'S	035° 16.561'W	
640	2021-02-14	07:48	56° 48.640'S	035° 14.849'W	
647	2021-02-14	12:05	57° 07.441'S	034° 40.107'W	
678	2021-02-15	03:29	56° 55.219'S	034° 30.237'W	
679	2021-02-15	04:31	56° 57.217'S	034° 21.616'W	
680	2021-02-15	05:30	56° 59.262'S	034° 13.630'W	
681	2021-02-15	06:29	57° 01.121'S	034° 05.537'W	
682	2021-02-15	07:29	56° 59.721'S	033° 46.377'W	
683	2021-02-15	08:30	56° 52.273'S	033° 28.559'W	
684	2021-02-15	09:24	56° 44.873'S	033° 18.766'W	
685	2021-02-15	10:26	56° 33.733'S	033° 22.904'W	
686	2021-02-15	11:27	56° 24.231'S	033° 20.474'W	
687	2021-02-15	12:44	56° 16.022'S	033° 35.718'W	
689*	2021-02-15	13:45	56° 15.959'S	033° 56.012'W	note swapped sample
688*	2021-02-15	14:35	56° 10.886'S	034° 10.454'W	order!
690	2021-02-15	15:32	56° 11.225'S	034° 30.082'W	
691	2021-02-15	16:31	56° 13.144'S	034° 50.994'W	
692	2021-02-15	17:39	56° 12.560'S	034° 44.957'W	
693	2021-02-15	19:10	56° 14.568'S	034° 40.714'W	

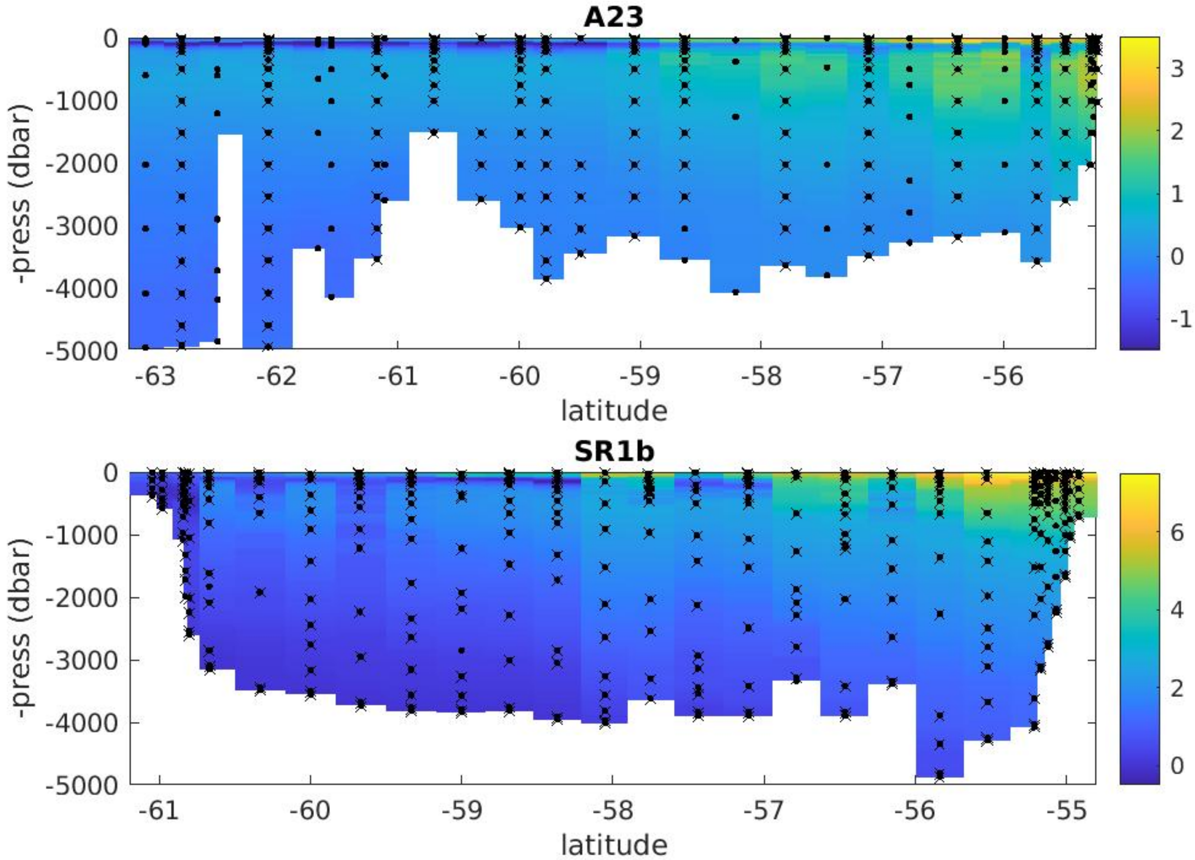


Figure 18. Distribution of δ18O samples on the A23 and SR1b sections. Bottles fired are denoted with a dot, δ18O samples with an X.

Analysis

The sample bottles will be refrigerated in the controlled environment laboratory on the northward transit through the tropics and shipped to the NERC Isotope Geosciences Laboratory at BGS Keyworth from NOC for analysis using a mass spectrometer.

Biological sampling from the CTD rosette

Bjorg Apeland, Gabi Stowasser, Cecilia Liszka

Please see ashore sample spreadsheet for stations and depths.

Particulate Organic Matter (POM): stable isotope analysis

The use of stable isotopes as dietary tracers is based on the principle that isotopic concentrations of consumer diets can be related to those of consumer tissues in a predictable fashion. It has been extensively applied in the investigation of trophic relationships in various marine ecosystems and has been used to determine feeding migrations in numerous species. The stepwise enrichment of both carbon and nitrogen in a predator relative to its prey suggests that the predator will reflect the isotopic composition in the prey and isotope values can be used to identify the trophic position of species in the food web investigated. Additionally, $\delta^{13}C$ values can successfully be used to identify carbon pathways and sources of primary productivity.

To monitor changes in the isotopic baseline in the region over time we collect Particulate organic matter on a routine basis at three stations during our yearly Western Core Box cruise (P3 Mooring station, Western Core Box mooring station and one off-shelf station within the Western Core Box perimeter). Additionally, this year samples were taken along a transect towards iceberg A-68A to monitor the influence of freshwater input into the region.

POM samples were obtained through filtering waters collected by Niskin bottles deployed via a CTD rosette. Water was taken from various depths at each station. All water samples collected from Niskin bottles were processed on board. Depending on the expected density of particles, varying volumes of seawater per depth were filtered onto 47mm GF/F filters and the filters stored frozen at -80°C. Unfortunately, the -80°C freezer failed on 24 Feb, and samples were transferred into the -20°C freezer for transportation to the UK.

A total of 455 POM samples were taken from CTD stations 3 – 21.

Chlorophyll

Water samples for chlorophyll analysis were collected from the CTD at six depths over the top 400 m at each of the cruise stations. Samples were filtered and frozen immediately to preserve them for later analysis of chlorophyll-a and phaeopigments. Samples were initially frozen at -80°C, but transferred to the -20°C freezers after the -80°C freezers failed. Chlorophyll is a key pigment present in marine phytoplankton and its measurement allows the estimation of phytoplankton biomass. This will be used in conjunction with CTD fluorescence and Lugol's samples to understand phytoplankton distribution around South Georgia.

A total of 104 samples were taken from CTD stations 3 – 14.

Silicon Isotopes

Silicate samples were collected from the CTD at six depths over the top 400 m at each of the WCB and Iceberg stations. Samples were either filtered *in situ* or frozen at -20°C for later filtration back in the UK. Samples will be analysed for the presence of silicon isotopes.

A total of 168 samples were taken from CTD station 3 – 38. Station 3 – 17 includes filtering, whilst station 18 – 38 water was collected for freezing.

Nutrient Sampling

Nutrient samples were collected directly from the Niskin bottles for the purpose of determining the concentrations and distributions of key bio-limiting elements and zooplankton waste products. Samples were collected from 6 depths across the top 400 m of the water column in waters around the WCB, P3 mooring site, and iceberg A-68A. They will be analysed for NO_2, NO_3, NH_4 and PO_4. This will allow us to understand the dynamics of primary and secondary production, potential sources of nutrients, and the potential influence of A-68A on biological productivity.

A total of 150 nutrient samples were taken from CTD stations 3 – 39, as well as 20 underway samples.

Lugol's sampling

Phytoplankton samples were collected from the CTD at six depths over the top 400 m at each of the selected stations, and fixed with Lugol's iodine to preserve cells for later analysis. Samples will be analysed for phytoplankton community composition and distribution. The results will be used to i) investigate the hypothesised fertilisation effect of A-68A on surrounding waters, and the influence of A-68A on phytoplankton type, impacts on higher trophic levels and carbon flux and ii) assess spatial and interannual variability in phytoplankton composition around South Georgia.

A total of 151 samples were taken from CTD stations 3 – 35.

Lowered Acoustic Doppler Current Profiler

Alice Marzocchi

Configuration and pre/post deployment

Two 300-kHz Teledyne RDI Workhorse Monitor lowered acoustic Doppler current profilers (LADCPs) were fitted on the CTD rosette in a downward facing (downlooker, master, SN: 24466) and upward facing (uplooker, slave, SN: 24465 on casts 1-60, 15288 on casts 61-100) orientation. The data were collected in beam coordinates (25x8-m bins) and converted to Earth coordinates during processing.

Prior to each cast, pre-deployment and deployment scripts were run to detect any faults in the LADCP, set the required parameters and start pinging, where the slave LADCP pings in response to the master LADCP to reduce interference between the two. After CTD recovery, both LADCPs were connected to a laptop in the deck lab for charging, downloading data from the cast and initial quality checking. The pre and post deployment was carried out by the NMF technicians who also operate the CTD.

Separate files for the master and the slave associated with the cast number were saved and the raw data were then copied over from the Sensors and Moorings drive for processing, using a shell script (*lad_linkscript_ix*) that generates symbolic links to the original files and stores them in: /local/users/pstar/cruise/data/ladcp/ix/raw.

Data processing

Data for each station were processed using the Lamont-Doherty Earth Observatory LDEO-IX v13 Matlab package. The software uses an inverse method to calculate velocity profiles from the LADCP data, optionally including a set of additional constraints: 1) ship navigation and position data from the GPS, which is used to derive the cast-averaged velocity; 2) bottom tracking velocities, which are calculated by the instrument when the cast reaches the bottom; 3) shipboard ADCP velocities in the upper ocean. The effect of the different constraints is checked by adding them one at a time in succession:

1. Ship navigation (ladcp/ix/DLUL_GPS)
2. Ship navigation and bottom tracking (ladcp/ix/DLUL_GPS_BT)
3. Ship navigation, bottom tracking and VMADCP (ladcp/ix/DLUL_GPS_BT_SADCP)

In addition, the navigation only constraints are applied individually to the downlooker and uplooker (ladcp/ix/DL_GPS and ladcp/ix/UL_GPS) to investigate the individual instrument performance, and the calculations with bottom track and VMADCP are also applied to the downlooker only (ladcp/ix/DL_GPS_BT and ladc/ix/DL_GPS_BT_SADCP).

SADCP/VMADCP data processing is described in the VMADCP chapter. The edited data were averaged over the duration of each cast into separate files from the 75 kHz and 150 kHz instruments. The 150 kHz data appeared to be the most reliable and were used as the final default constraint for all JC211 casts. The VMADCP constraint improves the quality of the data, but not substantially, since these are already well-constrained by the GPS and bottom track. For casts that did not reach the bottom, listed in the opt_jc211.m cruise options file, bottom track is explicitly disabled when cast processing parameters are set (*set_cast_params_cfgstr.m*), and step 2 above is skipped. Each of the different constraints led to slightly different velocity profiles, but when looking at both the A23 and SR1b full sections the effect of the constraints did not change the overall position of fronts and currents, only varying their strength slightly (not shown). Velocity sections with all constraints applied for A23 and SR1b are shown in Figure 19 and Figure 20.

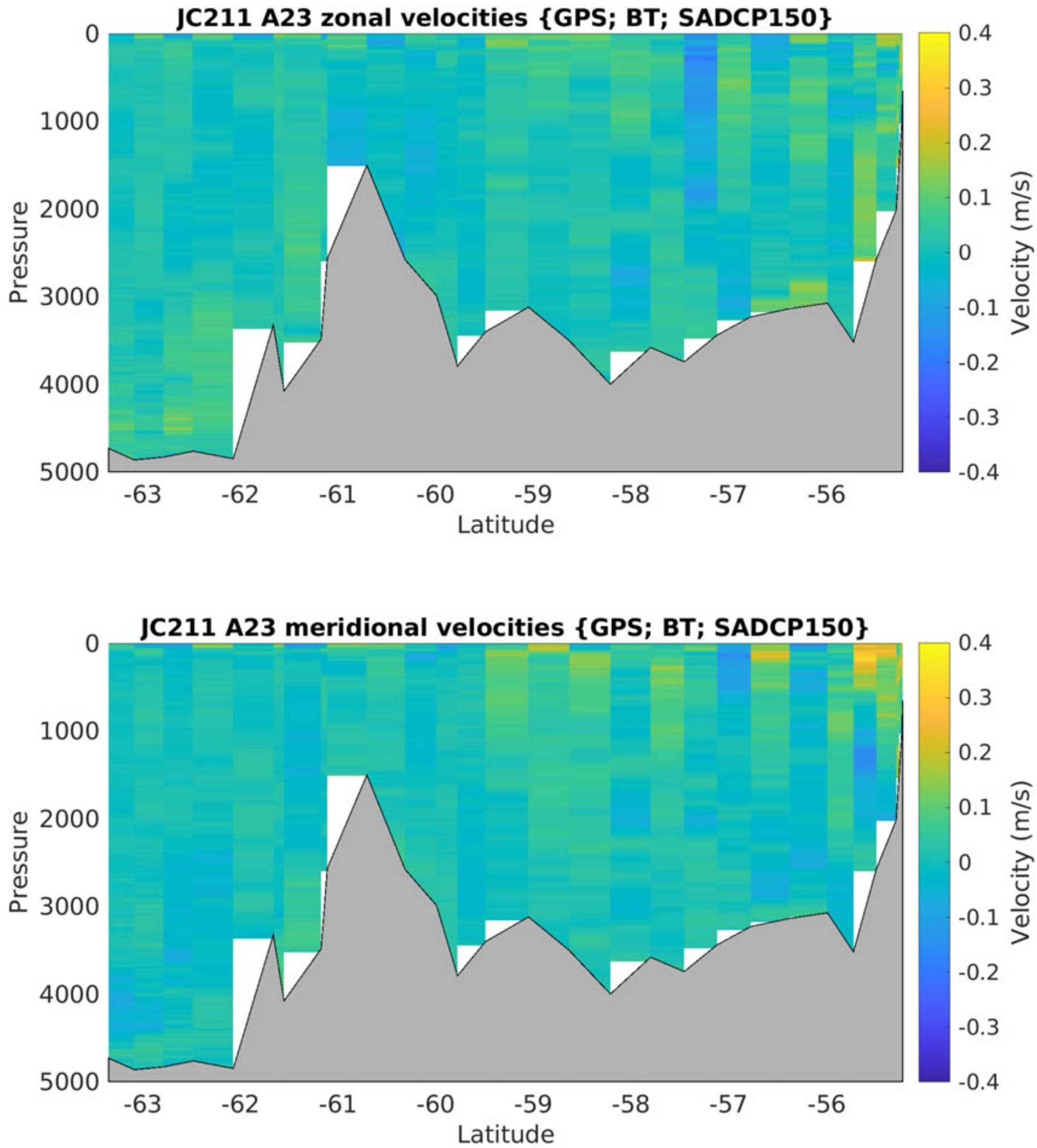


Figure 19. Zonal (top) and meridional (bottom) velocities for the A23 hydrographic section.

Exceptions from the default

Both the uplooker and downlooker files were used for the processing of all casts, with the exception of cast 57, where the uplooker could not be deployed and so only the down-looking instrument recorded data. However, for the shallow/short casts (mostly WCB) including the uplooker did not appear to be productive, as the second surface bounce would bias the data, meaning that the DL_GPS_BT_SADCP constraints were the most realistic ones. Particularly in cast 13, the double-bottom bounce appeared to not be removed in processing.

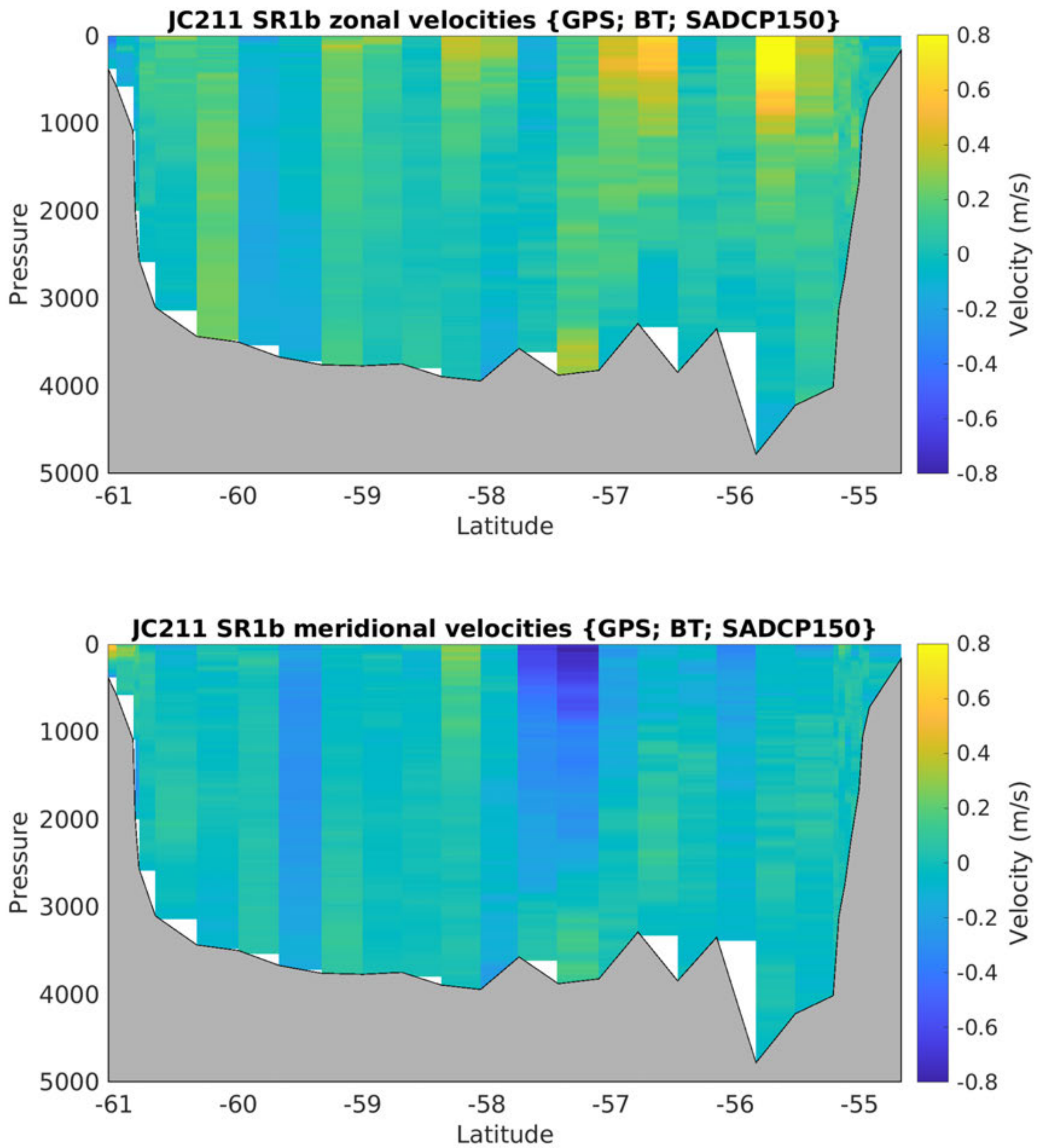


Figure 20. Zonal (top) and meridional (bottom) velocities for the SR1b hydrographic section.

For casts where the CTD did not reach the bottom (1, 2 and 61 – aborted casts – and most WCB stations only requiring the top 750/1000 m) the bottom track constraint could not be applied, so the VMADCP constraints were the most realistic ones (DLUL_GPS_SADCP).

When deploying cast 57, the uplooker suffered a communications failure and could not be started, so only the downlooker was available. A check/warning for a missing uplooker file (but with an option to continue the data processing) was added to the processing steps (DL_GPS_BT_SADCP).

In cast 69, the first memory card in the downlooker filled up, and the data file was split across the two cards, resulting in two data files. Once these files were concatenated (using shell command "cat"), processing was carried out as normal after that initial step.

Processing warnings and data quality

Most casts produced minor or no processing warnings and provided very good quality LADCP data. But for 20/100 casts the software did generate warnings, which are listed below.

Cast 1: removed 30 pressure spikes during: 2 scans
Cast 2: removed 74 pressure spikes during: 4 scans
Cast 4: found 191 (2.4% of total) velocity measurements > 3.3 m/s
Cast 5: removed 38 pressure spikes during: 2 scans
Cast 6: found 118 (2.8% of total) velocity measurements > 3.3 m/s
Cast 8: removed 54 pressure spikes during: 2 scans
Cast 10: removed 106 pressure spikes during: 4 scans
Cast 12: removed 92 pressure spikes during: 4 scans
Cast 13: removed 56 pressure spikes during: 3 scans
Cast 26: cast duration differs in downlooker/uplooker data
Cast 58: increased error because of shear - inverse difference
Cast 59: increased error because of shear - inverse difference
Cast 60: increased error because of shear - inverse difference
Cast 62: increased error because of shear - inverse difference
Cast 63: increased error because of shear - inverse difference
Cast 64: increased error because of shear - inverse difference
Cast 65: increased error because of shear - inverse difference
Cast 75: increased error because of shear - inverse difference
Cast 82: increased error because of shear - inverse difference
Cast 95: removed 44 pressure spikes during: 3 scans

Two warnings that can be ignored (not included in the list) are often produced when processing the uplooker files individually: one about an uplooking instrument in the downward-looking ADCP file (this is inherent to the LDEO software) and one about bottom track bias (there is no bottom track data from the uplooker).

In cast 26, the uplooker record starts 15 seconds before downlooker (the instrument appears to have been accidentally triggered before the downlooker was started, resulting in one spurious ping before the main data begin), but the software then appears to be matching times correctly and the data quality looks good. This did not reoccur in the following casts either, so we did not consider this a major issue.

In both casts 4 and 6, the warning is restricted to a very low percentage of the total velocities found. This warning has also been detected previously (see, e.g., DY113 cruise report, 2020) so we did not consider this a major issue either.

The 8 casts (1, 2, 5, 8, 10, 12, 13, 95) detecting pressure spikes are all shallow casts with active heave, as the CTD is never going very fast. Here, the processing software is applying the stdev(w) criterion even when the deviation is very small and this triggers the warning. In addition, this only applies to a very small number of scans, so the error can be ignored.

In cast 1 (aborted test cast) the upcast surface was not being edited out during processing, possibly due to the technical failure and the lack of CTD pressure reading in the upcast.

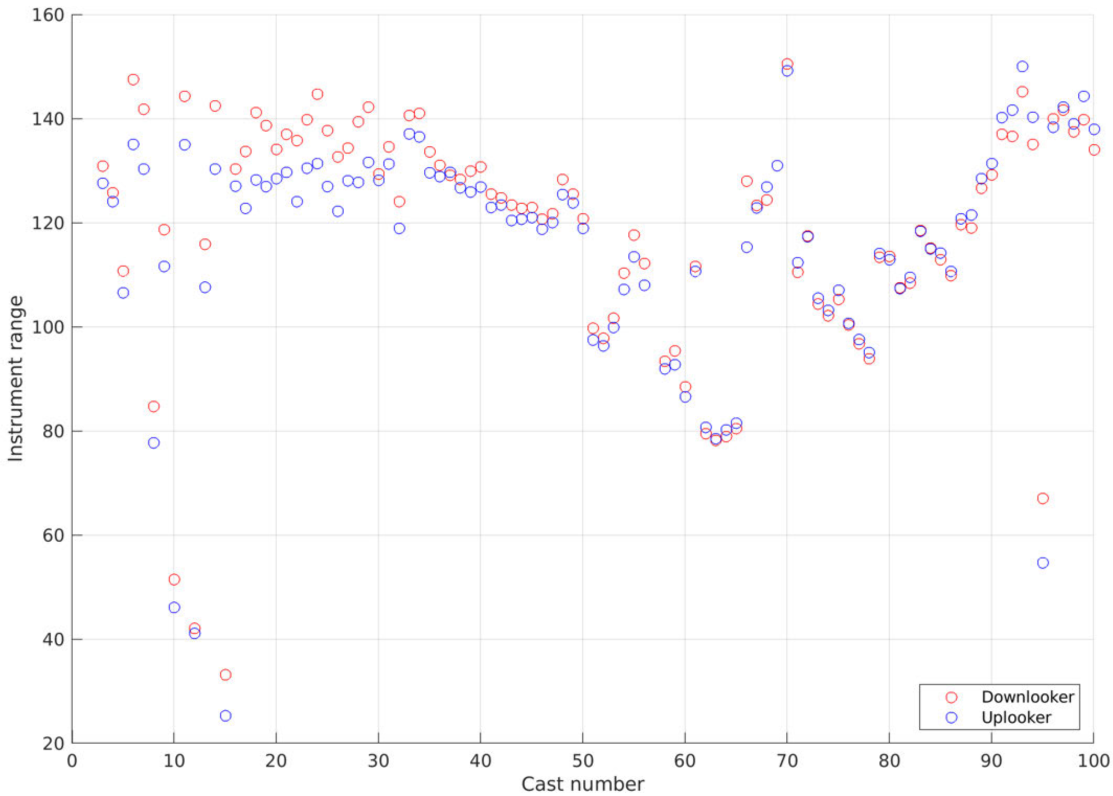


Figure 21. Instrument ranges (m) plotted against cast number Red dots are from the downlooker and blue ones are from the uplooker.

The instrument range was checked as an indicator of data quality, as areas of low backscatter can affect the range of the instrument and reduce the quality of the data. In most casts, the instrument range was higher than 80 m (Figure 21). Casts showing a lower instrument range are generally the shallow ones and/or where the weather was rough. In particular, some of the A23 section casts (58-60, 62-65) showing a lower instrument range are those that also triggered a shear difference warning during processing. However, this appeared to apply to only a very small number of points near the bottom to which the calculation was applied. The rest of the profile appeared to be realistic, suggesting that the overall quality of the data for these casts was still good.

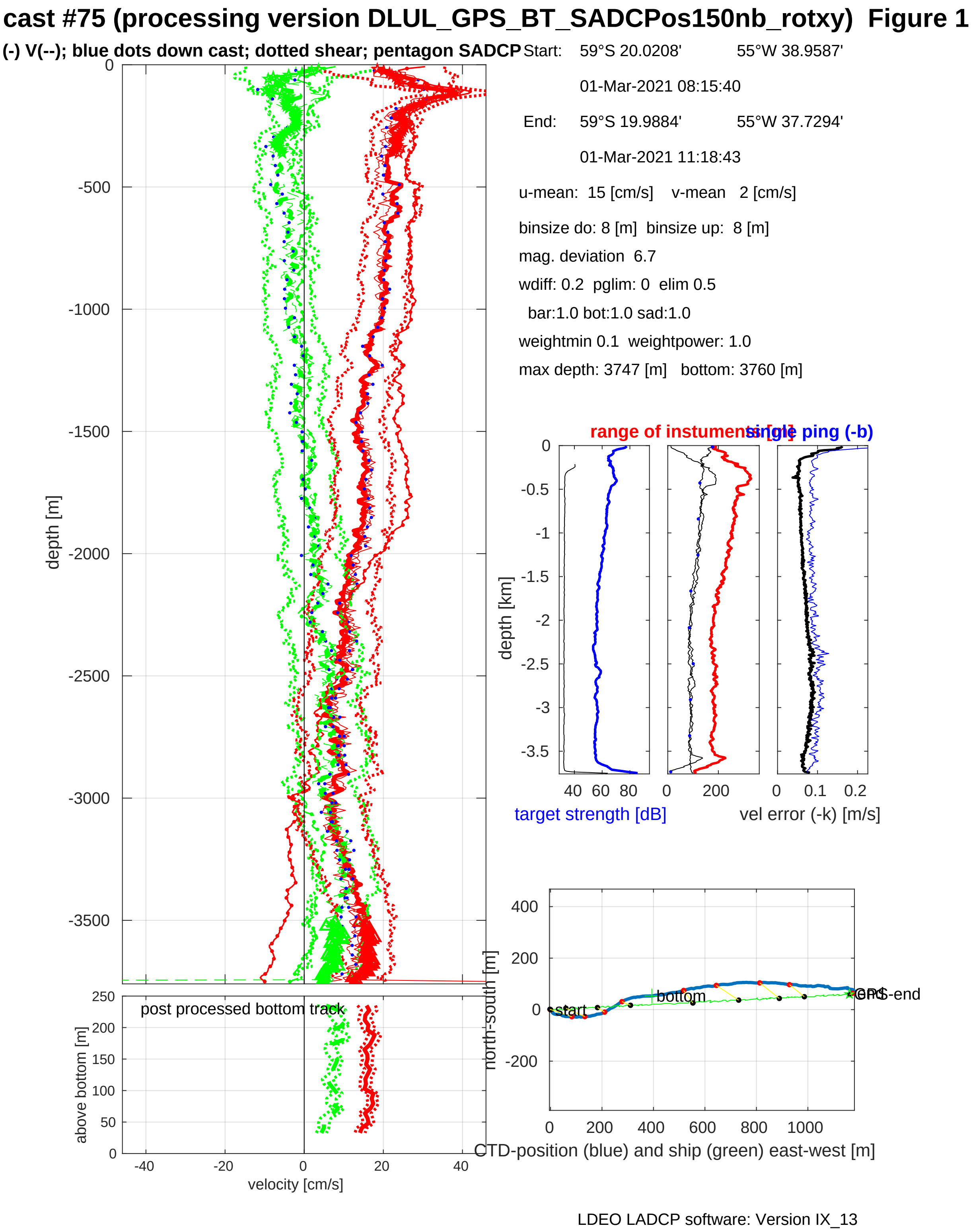


Figure 22. ***Profiles using both downlooker and uplooker data and all constraints (ship's motion/depth-mean velocity, smoothing, bottom track data, and upper ocean velocities from the os150nb SADCP) from cast 75 showing remaining influence of erroneous large shear near the bottom.***

Warnings about large shear-inverse difference are also mentioned in the DY113 cruise report, where it was noted that the shear method used to calculate velocities is not well maintained and updated in the LDEO software, meaning that it may not be as good at calculating velocities as the inverse method. However, inspection of the original shear data ensembles (before averaging) from casts with this warning provided more information: even when the instrument range is acceptable (75, 82), some or much of the cast had relatively little good data (presumably because of a lack of scatterers), particularly from the uplooker. The data going into the shear solution as well as the inversion therefore were noisier and in some cases even contained a shear bias. The solution is improved by using both instruments, and particularly by adding constraints, except in one case (cast 75, Figure 22) where a single extremely large uplooker shear value at the bottom makes it into the combined inverse solution.

The rms velocity difference between LADCP profiles without the SADCP constraint applied and the VMADCP velocities themselves was also used as an additional metric to check for the accuracy and quality of the data. Most casts have an rms difference below ~0.05 m/s (Figure 23) which indicates that the data gathered has a very good accuracy and quality (see also DY113 cruise report, 2020).

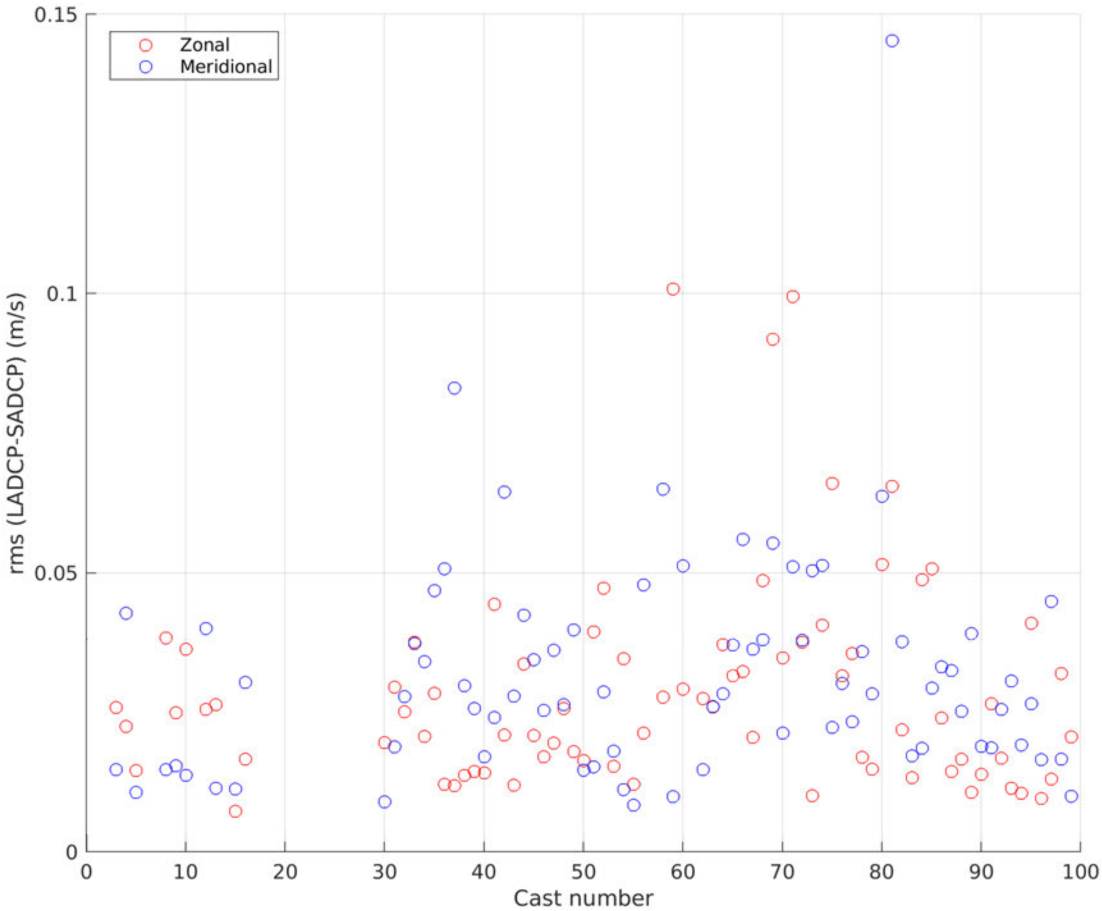


Figure 23. Rms difference between LADCP velocities processed without the SADCP constraint and VMADCP velocities (m/s) plotted against cast number. Red dots represent zonal velocities and blue ones represent meridional velocities.

Finally, it should be noted that we initially encountered inconsistencies in the processing steps using Matlab version 2015b, where the processing output and warnings changed on subsequent runs of the same casts without any changes in the parameters. This stopped when we switched to Matlab version 2020b. However, this was noted during the WCB casts, which were often not full-depth. So this issue could have been linked to having run the processing with the bottom track constraint or with the RDI BT solution. Nevertheless, version 2020b was used for the processing of all casts.

Vessel-mounted Acoustic Doppler Current Profiler

Povl Abrahamsen

RRS James Cook is fitted with two Teledyne RDI Ocean Surveyor Acoustic Doppler Current Profilers, operating at 75 and 150 kHz. Both were operated continuously through the cruise in narrowband mode. Data were acquired using the University of Hawaii Data Acquisition System (UHDAS; https://currents.soest.hawaii.edu/docs/adcp_doc/), running on a dedicated computer in the main lab. Both instruments have 30-degree beam angles, run firmware version 23.19 (Dec. 2014, latest version available), and are mounted on the port drop keel of the vessel (see Figure 45 in Appendix D). Throughout the cruise, this keel was kept flush with the hull; however, the starboard keel was lowered during the WCB acoustic surveys. During these times it interfered with the starboard beam (beam 2) of the 75-kHz ADCP, requiring special processing for this instrument. Bottom tracking was used when in shallow water, except during the WCB (to minimise interference with the EK-60). At other times, bottom track was switched off to maximise the water ping rate.

Following acquisition, data were transferred onto NOC Linux workstation koaeula for postprocessing using CODAS. Editing was performed using *dataviewer.py*, and bottom-track and water-track data were used to estimate scale factors, rotation angles, and offsets from the GPS sensors, to correct the data. Once these corrections were applied using *quick_adcp.py*, data were exported to NetCDF files, and loaded into mstar using script *mvad_01*. Current profiles during CTD stations were extracted using *mvad_03*, and converted for LADCP processing using *mvad_for_ladcp* for the 150-kHz ADCP. This enabled LADCP processing to be re-run using the VMADCP as a near-surface constraint (see the LADCP chapter).

150-kHz processing

Processing for the 150-kHz data was relatively straight forward, as described above. Data quality for this instrument did not seem to be affected when the starboard keel was lowered, and generally this instrument seemed less sensitive to weather and thruster bubbles than the 75-kHz ADCP, which experienced lengthy dropouts when the ship was on station in rough weather. For this reason, the 150-kHz ADCP was the preferred instrument for LADCP processing, even though its maximum range is lower than that of the 75-kHz ADCP.

75-kHz processing

In addition to the reduced range when on station in rough weather, the 75-kHz ADCP was affected by the starboard keel being down. Initial tests of the keel were done on 4 Feb in transit to P3. The keel was fully lowered (2.4 m) at 18:51, raised to 1.2 m at 20:59, and raised to flush at 23:00. During the time when the keel was lowered, the error velocity on the 75-kHz ADCP was strongly negative, and there was a negative bias in the port component of velocity, especially when the vessel was moving. The forward velocity was not significantly affected by the keel position. For comparison, single-ping processing was carried out on koaeula, with the command-line option "--badbeam 2". This calculated three-beam solutions for the whole time series. A comparison between this time series and the final dataset (with the same scale factor, rotation, and offsets applied) are shown in Figure 24. The difference in port velocity and the 4-beam error velocity are shown in the bottom two panels.

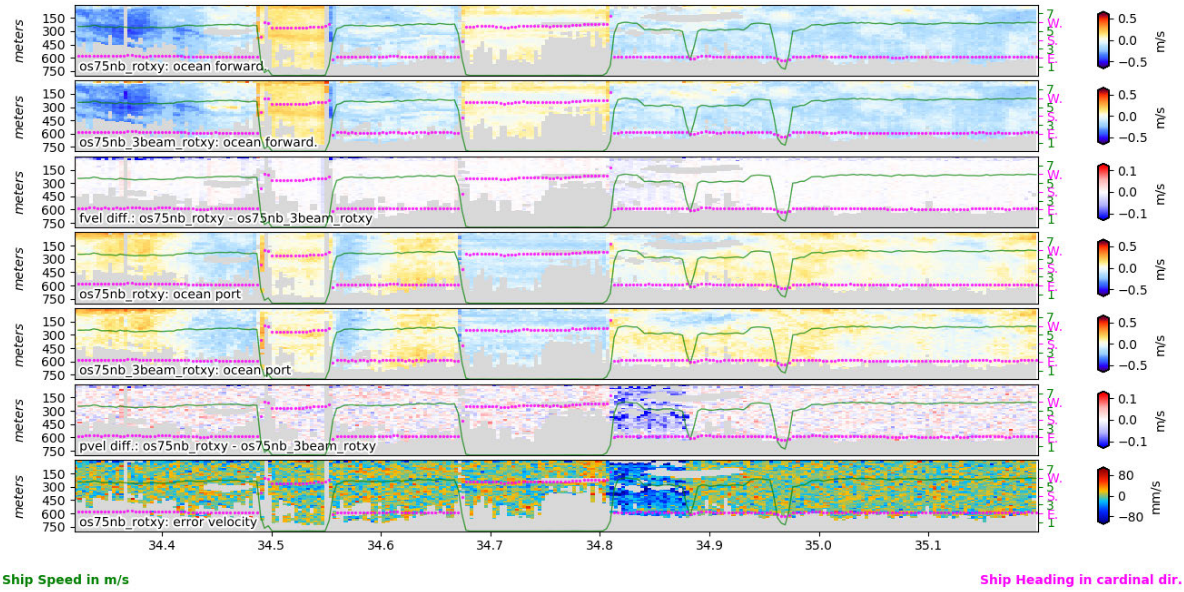


Figure 24. Comparison between 4-beam and 3-beam solutions for the 75-kHz ADCP during keel tests. The keel was fully lowered at 34.79, raised halfway around 34.88, and raised to flush around 34.97.

As a consequence, single-ping processing was run for the whole time series, with 3-beam solutions for the times when the keel was fully lowered, and 4-beam solutions for the rest of the time. This was done by setting up a directory for the single-ping processing following the UHDAS/CODAS instructions, and then incrementally running the processing for each segment. Whenever quick_adcp.py is run with "--badbeam", dbinfo.txt is updated to flag the beam as bad. So this file needs to be reverted to ensure that 4-beam processing is applied after a beam has previously been flagged as bad. Editing was performed on the "regular" version of the data, and the edit files copied into the single-ping processing directory and applied to the reprocessed dataset. Further edits were made to the reprocessed dataset, before scale factors and offsets were calculated and then applied. Even after these offsets had been applied, artifacts were still visible in the 75-kHz dataset when the ship turned onto station. Offsets from previous cruises were tried, in addition to the offsets recommended by UHDAS. In the end, the UHDAS recommendations were followed (from the reprocessed dataset), but some artifacts remained, and were edited out. The basic script for processing the 75-kHz data, as suggested by Jules Hummon from University of Hawaii, is shown in Script 1.

Problems from the power outage on 10 Feb

On 10 Feb (early UTC – late on 9 Feb local), the clean power supply on the ship was interrupted. Unfortunately, the UHDAS computers were not on a UPS, and when the power was lost, they wrote some extra characters to the end of the CNAV, gyro, PosMV, and SeaPath data files. These were turned into appended zeros in the binary files, causing problems for the single-ping reprocessing. On Jules Hummon's suggestion, the corresponding log files were edited on koaeula, *make_rawlogbin.py* was run to generate new .bin files, and this enabled the reprocessing to take place. This problem was notified to the University of Hawaii under ticket 4726. In the post-cruise assessment, a recommendation was made to put the UHDAS computers on a UPS, so they can be cleanly shut down in the event of a power failure.

```
mv jc211/gbin jc211/gbin.orig
rm -rf os75nb jc211/gbin_reprocessed
adcptree.py  os75nb --datatype uhdas --cruisename jc211
cp q_py.cnt os75nb/
cd os75nb

# start of cruise; keel flush
quick_adcp.py --cntfile q_py.cnt --dday_bailout 34.7857 --auto
cp dbinfo.txt dbinfo_4beams.txt

# keel lowered for testing on 4 Feb
quick_adcp.py --cntfile q_py.cnt --badbeam 2 --dday_bailout 34.97 --auto
cp dbinfo.txt dbinfo_3beams.txt

# keel flush after tests ended
cp dbinfo_4beams.txt dbinfo.txt
quick_adcp.py --cntfile q_py.cnt --dday_bailout 35.8802 --auto

# keel down during WCB
cp dbinfo_3beams.txt dbinfo.txt
quick_adcp.py --cntfile q_py.cnt --badbeam 2 --dday_bailout 40.5404 --auto

# keel flush in transit to Stromness
cp dbinfo_4beams.txt dbinfo.txt
quick_adcp.py --cntfile q_py.cnt --dday_bailout 40.8125 --auto

# keel down during EK60 calibration
cp dbinfo_3beams.txt dbinfo.txt
quick_adcp.py --cntfile q_py.cnt --badbeam 2 --dday_bailout 41.1648 --auto

# run to end (keel flush for rest of cruise)
cp dbinfo_4beams.txt dbinfo.txt
quick_adcp.py --cntfile q_py.cnt --auto

cp ../../postprocessing/JC211/proc_archive/os75nb/edit/ab* edit/
quick_adcp.py --auto --steps2rerun rotate:apply_edit:navsteps:calib
adcp_nc.py adcpdb contour/os75nb jc211 os75nb

cd ..
cp -Rp os75nb os75nb_rotxy
cd os75nb_rotxy

quick_adcp.py --steps2rerun apply_edit:rotate:navsteps:calib --xducer_dx -2 \
  --xducer_dy 8 --rotate_amplitude 1.0005  --rotate_angle 0.0584 --auto
adcp_nc.py adcpdb contour/os75nb_rotxy jc211 os75nb_rotxy

cd ..
mv jc211/gbin jc211/gbin_reprocessed
```

Script 1. Incremental single-ping processing for 75-kHz ADCP with keel down, blocking beam 2, at times.

Problems common to both ADCPs

Strong reflections from krill swarms affected both ADCPS. The UHDAS acquisition software sometimes recognised the krill swarms themselves as the bottom, flagging all data below them. This was fixed using the “reset editing” feature in *dataviewer.py*, and selecting the affected scans.

In addition to false bottoms being detected, the reflectors also caused velocity biases, similar to those shown in the “scattering layer” page in the “signatures of bad data” section of the ADCP documentation. These had to be edited out by hand, and it was sometime difficult to determine how much data to remove.

In heavy weather, along-ship biases were visible in the near-surface bins on both ADCPs. Again, these needed to be edited by hand. Data quality was verified and artifacts identified by comparing the processed 75-kHz and 150-kHz data using "*dataviewer -c*".

Offsets, scale factors, and rotation angles applied

The final scale factors, rotation angles, and GPS offsets are given in Table 2. These have been applied to the folders with suffix "_rotxy". The final versions of the data are os150nb_rotxy for the 150-kHz ADCP, and os75nb_spp_rotxy for the 75-kHz ADCP (with single-ping reprocessing as described above).

Table 2. Scale factors, rotation angles, and GPS offsets for the ADCPs

	Scale factor	Rotation angle*	X offset	Y offset
75-kHz ADCP	1.0005	0.0584	-2	+ 8
150-kHz ADCP	1.0067	0.03	+1	+9

* Rotation angles are in addition to the heading alignment angles set during data acquisition using the "EA" command: +8.20° for the 75-kHz ADCP, -0.12° for the 150-kHz ADCP.

Bottom track calibration

To obtain more bottom track calibration points, lines were run at varying headings with bottom track enabled multiple during the cruise. The most extensive bottom-track exercise was at the end of the cruise, where a sequence of 12-mile lines at headings incremented by 75 degrees was run for 18 hours, before we returned to port. This pattern yielded more bottom track data that helped improve the final calibration of the instruments. This survey pattern is shown in Figure 25.

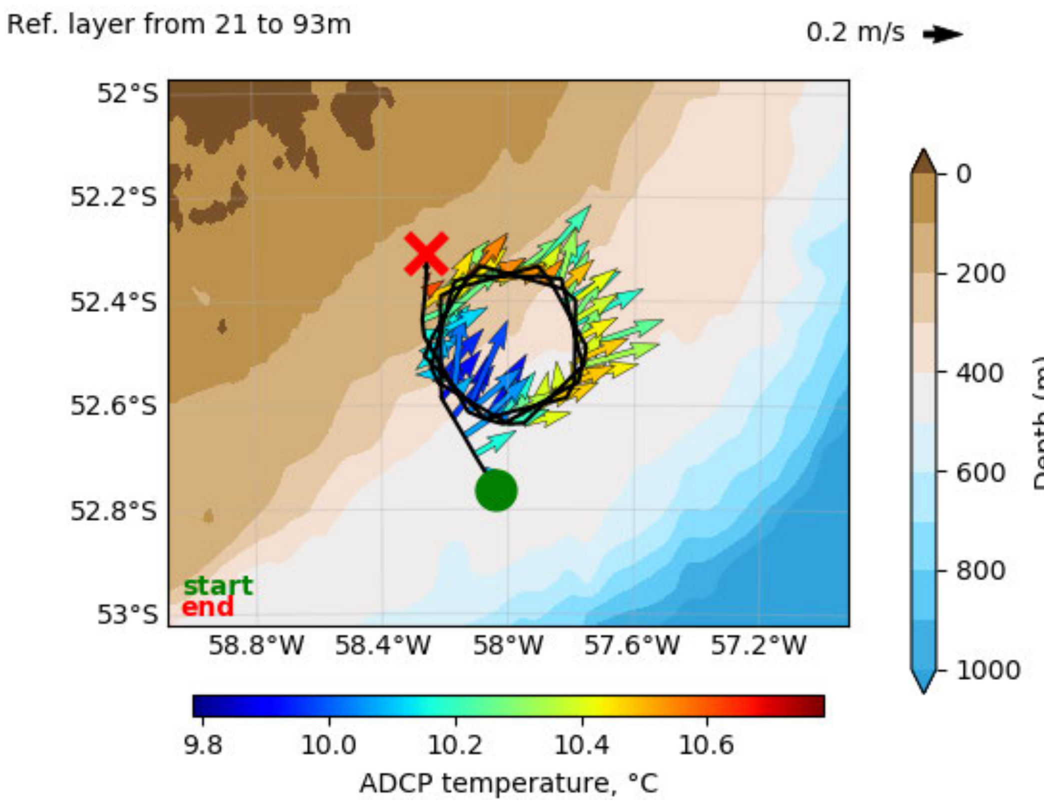


Figure 25. Bottom track calibration on the shelf southeast of the Falkland Islands.

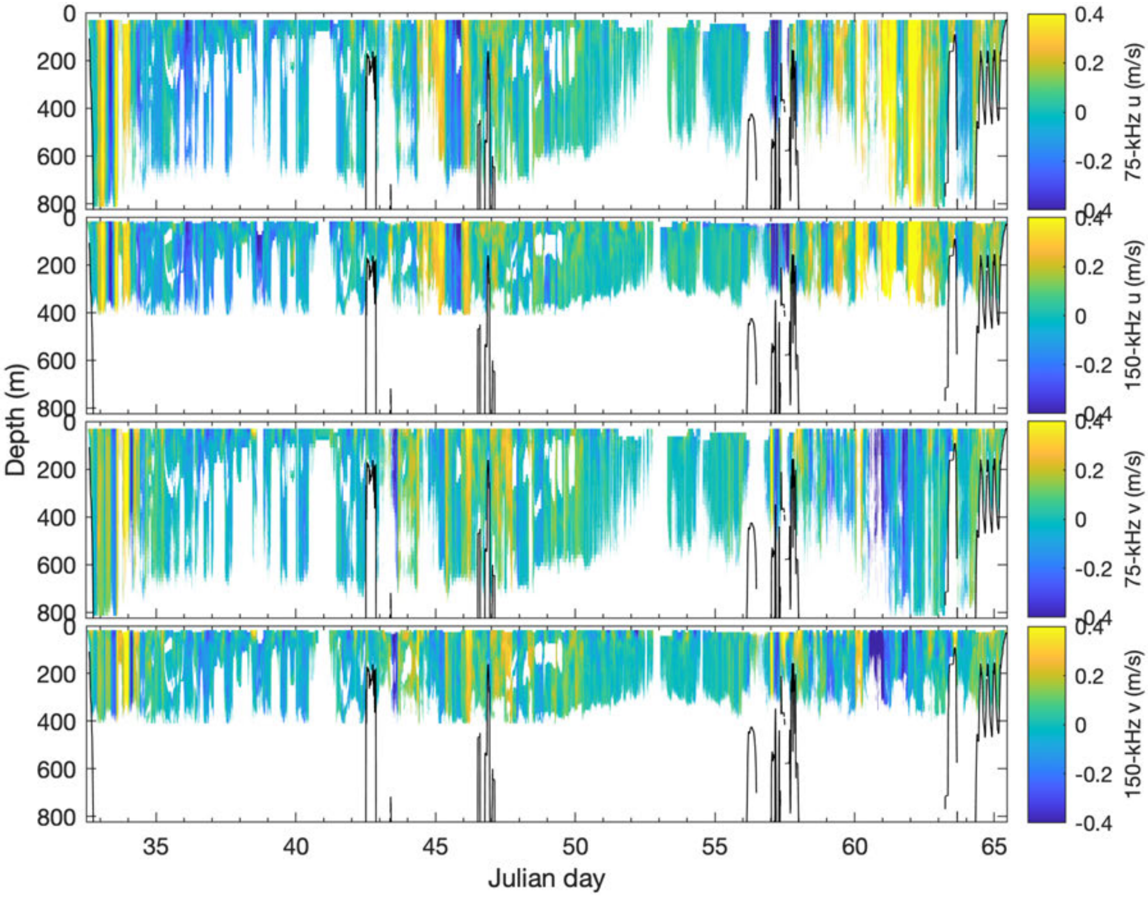


Figure 26. Zonal (u) and meridional (v) currents from the 75- and 150-kHz ADCPs. The black line indicates the EM122 centre-beam depth, when the multibeam was active (i.e not during WCB).

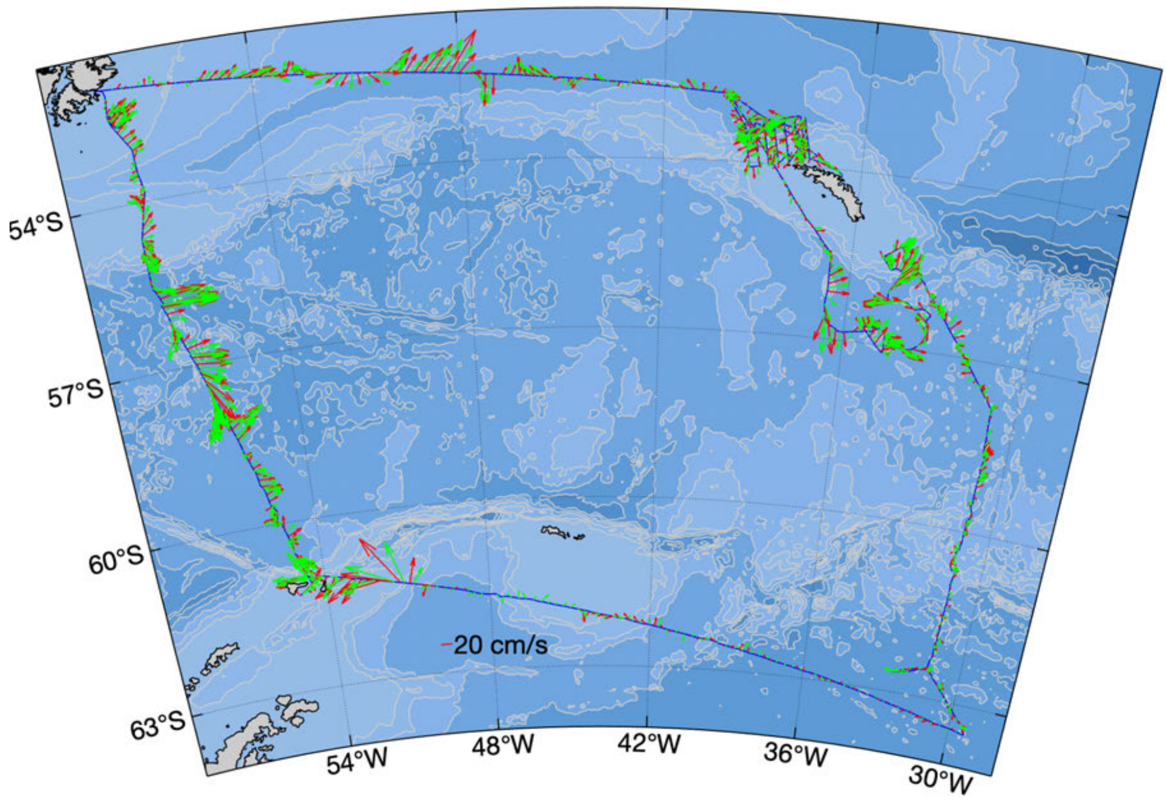


Figure 27. Current vectors averaged between 50 and 150 m depth from the 75- (red) and 150-kHz (green) ADCPs. Vectors are plotted at interleaved times to avoid overlap, but show comparable directions and magnitudes.

JC211 Use of RVDAS

Brian King

At the start of the cruise the decision was taken to use RVDAS as the source of data for mexec processing. An interface was written comparable to the mtechsas and mscs interfaces, with a set of programs collected as mrvdas. Equivalents to mtechsas included *mrload*, *mrlookd*, *mrlistit*, *mrvars*, *mrposinfo,* etc. There is a *Contents.m* file that lists all the mrvdas programs, with a summary of what each program does. Type "help mrvdas". Each program has extensive help with syntax and examples. The parsing of arguments is now very flexible, and is described by "help *mrparseargs*".

RVDAS stores data in a PostgreSQL database. On JC211 data were pulled across the network with commands like

```
psql -h rvdas.cook.local -U rvdas -d "JC211" -c "\copy (select * from
posmv_pos_gpgga order by time asc) to
''/local/users/pstar/jc211/mcruise/data/rvdas/rvdas_csv_archive/posmv_pos_g
pgga.csv'' csv header"
```

where *posmv_pos_gpgga* is the name of a data table in RVDAS.
This example command executed on koaeula pulls data into a local csv file, from where data are loaded into Matlab.

The script *mrnames.m* maintains a lookup between RVDAS database table names and mexec abbreviations, shown below, mexec name on the left, RVDAS table name on the right. There are a total of around 70 RVDAS data tables, many of which store the same NMEA messages, e.g. posmv_att_gpgga.csv, posmv_gyro_gpgga.csv, posmv_pos_gpgga.csv.

```
    {'hdtgyro'  }    {'ships_gyro_hehdt'       }
    {'winch'    }    {'nmf_winch_winch'        }
    {'hdtpmv'   }    {'posmv_gyro_gphdt'       }
    {'attpmv'   }    {'posmv_att_pashr'        }
    {'pospmv'   }    {'posmv_pos_gpgga'        }
    {'vtgpmv'   }    {'posmv_pos_gpvtg'        }
    {'surfmet'  }    {'nmf_surfmet_gpxsm'      }
    {'windsonic'}    {'windsonic_nmea_iimwv'   }
    {'poscnav'  }    {'cnav_gps_gngga'         }
    {'vtgcnav'  }    {'cnav_gps_gnvtg'         }
    {'dopcnav'  }    {'cnav_gps_gngsa'         }
    {'posdps'   }    {'dps116_gps_gpgga'       }
    {'em120'    }    {'em120_depth_kidpt'      }
    {'ea600'    }    {'em600_depth_sddbs'      }
    {'envtemp'  }    {'env_temp_wimta'         }
    {'envhumid' }    {'env_temp_wimhu'         }
    {'posranger'}    {'ranger2_usbl_gpgga'     }
    {'tsg'      }    {'sbe45_tsg_nanan'        }
    {'hdtsea'   }    {'seapath_pos_inhdt'      }
    {'possea'   }    {'seapath_pos_ingga'      }
    {'dopsea'   }    {'seapath_pos_ingsa'      }
    {'vtgsea'   }    {'seapath_pos_invtg'      }
    {'attsea'   }    {'seapath_att_psxn23'     }
    {'logchf'   }    {'ships_chernikeef_vmvbw'}
    {'logskip'  }    {'ships_skipperlog_vdvbw'}
```

```
    {'gravity'  }    {'u12_at1m_uw'           }
    {'mag'      }    {'seaspy_mag_inmag'      }
```

Access to RVDAS database:

File ~/.pgpass contained:

```
#hostname:port:database:username:password
rvdas.cook.local:5432:JC192:rvdas:rvdas
rvdas.cook.local:5432:JC209:rvdas:rvdas
rvdas.cook.local:5432:preJC211:rvdas:rvdas
rvdas.cook.local:5432:preJC211_2:rvdas:rvdas
rvdas.cook.local:5432:JC211:rvdas:rvdas
```

which provided authentication for the network *psql* commands.

On JC211, the PostgreSQL database did not contain units or other metadata for the variables. A collection of json files on the RVDAS machine defined the variable names and units for the database. These were parsed with some of the mrvdas programs so that data pulled into mexec had units added. It is anticipated that this part of the interface will evolve on future cruises as the RVDAS team complete the user interface for RVDAS. The json files were read with the Matlab built-in command *jsondecode* called from *mrjason2mat.m*. The *jsondecode* command was not available in Matlab 2015 that was installed at the start of the cruise. This step was run on a macbook. Later in the cruise, Matlab 2020b was installed on koaeula.

Some of the RVDAS data tables contained variables that we did not wish to read into mexec. The program *mrtables_from_json.m* was prepared with a list of every table that mexec was interested in reading, and every variable in that table. Lines were commented out to avoid reading variables that mexec did not want to read. For example:

```
rtables.cnav_gps_gngga = {  % from cnav_gps-jc.json
    'cnav_gps_gngga' 14  % fields
    'utcTime'                        ''
    'latitude' 'degrees, minutes and decimal minutes'
    'latDir'                        ''
    'longitude' 'degrees, minutes and decimal minutes'
    'lonDir'                        ''
    'ggaQual'                        ''
    'numSat'                        ''
    'hdop'                        ''
    'altitude'                      'metres'
    %      'unitsOfMeasureAntenna'                           ''
    %      'geoidAltitude'                        'metres'
    %      'unitsOfMeasureGeoid'                           ''
    %      'diffcAge'                        'seconds'
    %      'dgnssRefId'                           ''
    };
```

The *psql* commands produce time (always present) as a character string in the intermediate csv files. A number of experiments were conducted on the fastest way to convert these strings to numerical times. There are options for exporting from PostgreSQL as numerical times, but conversion before export from RVDAS made the process slower than parsing the character strings inside Matlab. Also, a ‘native Matlab

PostgreSQL interface' was installed but this was also slower than the csv export and Matlab read. The psql csv files were read with the Matlab '*dataset*' command, which was the fastest way found to read the csv files that contained a mixture of character strings and numerical values. Further experiments could be conducted to improve the speed of load into Matlab. But in general, the speed of load for 24 hours of data from one RVDAS data table to mexec was a few seconds, which was acceptable.

The intermediate csv files were stored in
/local/users/pstar/jc211/mcruise/data/rvdas/rvdas_csv_tmp
and deleted by the calling program. If that program was interrupted, files would be left in that directory which could be tidied by hand.

At the end of the cruise, all the RVDAS data tables (70 of them) were exported to csv files, one file per table. This process took 23 minutes and generated 32 GB of csv files. These files were gzipped down to 2.4 GB. This represents a full raw archive of data that mexec might want to access.

Conclusions and notes

RVDAS was a robust source of data for mexec. If RVDAS is running on NMF and BAS ships, this would be a major advance, avoiding the need to maintain several data interfaces (historically TechSAS and SCS). There was just one instance of RVDAS hanging up, resulting in 3 hours' data loss from RVDAS. RVDAS needs a robust set of monitoring tools, comparable to TechSAS, preferably with an audible alarm to indicate data acquisition failure. A Grafana display of numerical data in the main lab was a great help in monitoring RVDAS. We recommend that the SSDS display and functionality should switch from TechSAS to RVDAS as soon as convenient.

The RVDAS development team should be encouraged and resourced to finish the user interface to make RVDAS more easily useable for a range of users. The PostgreSQL access over the network was robust and acceptably fast for mexec, but might not suit all users. Access via NetCDF files, or another widely used format, would make it more user friendly and avoid the need for database knowledge.

The RVDAS development team should be encouraged to include metadata, especially variable units, in the database as soon as possible. This is probably a higher priority than the user interface.

The Matlab native PostgreSQL interface did not seem to be very quick for large data requests. Possibly we did not have it well configured, but there seemed to be many reports of this slowness in internet searches. Possibly a python interface would work quicker. Until then, export via csv works ok.

Underway navigational, oceanographic, and meteorological data

Brian King

Daily underway processing was run with *m_daily_proc.m*. This underwent suitable revision to follow the switch to RVDAS. A number of file prefixes and variable names were changed. We decided not to maintain backwards compatibility with TechSAS/SCS names, many of which had been chosen to be backwards compatible with previous data acquisition systems, but to choose appropriate names for the interface with RVDAS going forwards.

Logging to the JC211 RVDAS database began at 027/191920 alongside before the cruise and prior to departure at 033/1130. The last run of daily processing was at 066/124036, after arrival 066/1220.

The new function *mfsave.m* was used in several places to reduce the number of steps required for some operations. A comprehensive list of changed scripts has not been compiled. The overall pathway for underway processing is comparable to previous cruises.

Underway processing included multiple navigation streams, single-beam echo sounder, referred to generically as '*ea600*', centre-beam from swath *'em120'*, pumped seawater thermosalinograph '*tsg'* and the '*surfmet'* stream. The single *surfmet* stream contains *fluorometer* and *transmissometer*, as well as wind speed and direction, and incoming *par* and *tir*.

Manufacturer-provided calibrations for radiometers were entered in *opt_jc211.m*, case *mday_01_fcal* . Note that the cal coefficients from the cal sheets are sensitivities, and must divide the raw value not multiply it, e.g.:

```
'y=x1/1.015' % port PAR: s/n 28556 cal 3 Sep 2019
```

RVDAS data gap

RVDAS data logging hung up from 037/232459 to 038/022432. Most of those data would be available from the TechSAS NetCDF files, but have not been read into mexec. The navigation data gap was filled, as described below.

Navigation

Stream pospmv was regarded as the primary navigation stream, and attpmv was the primary attitude stream. *mbest_all.m* produced the usual bst_jc211_01 summary navigation file. Many of the nav streams were renamed compared with mtechsas, with a general pattern of the type of nav data followed by the source, e.g. *hdtgyro* for headingtrue-gyro, *attsea* for attitude-seapath, *pospmv* for position-posmv, *dopcnav* for hdop-cnav. The Applanix posmv is abbreviated pmv.

Gaps in pospmv and attpmv

Four gaps arose in the posmv datastreams logged into RVDAS. One was on day 030, while alongside before the cruise. Some experiments were being carried out and there was a data gap from 030/120802 to 030/120917. The hangup in RVDAS resulted in the loss of 3 hours of data in RVDAS from 037/232459 to 038/022432. A lab clean power failure meant the loss of some datastreams in RVDAS from 041/011543 to 041/013607.

For example, the posmv stopped sending data but the cnav continued. Finally, another interruption in clean power in the main lab resulted in a loss of data from 050/143905 to 050/144024. In all these instances, cnav position and seapath attitude were available in TechSAS. Latitude, longitude and heading were extracted from TechSAS cnav and seapath to fill the gaps and inserted into the *pospmv_jc211_01.nc* and *attpmv_jc211_01.nc* files. *mbest_all* was run to create a complete 30-second nav file.

Anemometer direction and wind processing

There has been a long-standing issue in which the sonic anemometer that supplies surfmet wind direction has reported occasional values near 180 degrees as the wind direction passes from 0 to 360, both directions being wind arriving over the bow. This was attributed to the A/D conversion that takes place between the instrument and the data logging. As an experiment, a second sonic anemometer was installed on the met mast, with direct digital output recorded as data stream *windsonic* in RVDAS, and bypassing A/D conversion. The issue is solved by this configuration. Clearly the main wind direction data path into surfmet should be revised to avoid A/D conversion, which is presumably a legacy path from before the sonic anemometer. *mtruew_01* produced an absolute wind file, as usual, from the main surfmet anemometer.

Anemometer data glitches

Occasionally during the cruise, the anemometer would enter a period of sending bad data, characterised by wind speeds of 0 or 50 m/s. Sometimes there was a plausible reason, e.g. likely freezing of water on the sensor, sometimes the reason was not apparent. These were identified by displaying each day of data, and bad data periods were edited out with *mplxyed*, followed by *mday_02* to insert edited data into the appended cruise file.

Bathymetry editing

The script *mbathy_plot.m* now undertakes merging of the em120 onto ea600 and ea600 onto em120, to aid editing of bad data. *mbathy_plot* then enters into two calls to *mplxyed*, the first to edit ea600 and the second to edit em120. At the end of *mbathy_plot*, *mday_02* is called to insert the edited daily data into the appended cruise files.

There were several possible data tables for 10 kHz/12 kHz single-point bathymetry, all starting em600_depth. The centre-beam swath was in em120_depth_kidpt. The possible tables were _sddbs (from 12 kHz), _sddbt (from 12 kHz), _sddpt (12 and 10 kHz). 'bs' and 'bt' refer to depth below surface and below transducer respectively. sddbs has depth below surface in feet, metres and fathoms. sddbt has depth below transducer in feet, metres and fathoms, sddpt has depth below transducer in metres, and transducer offset depth in metres. Transducer offset depth varies with ship heave. depth_below_surface = depth_below_tranducer + transducer_offset. The ea600-ea640 stream in TechSAS has all the 10/12 kHz messages. On JC211 we selected the 'sddbs' stream, which was provided by the 12kHz sounder. It would be possible to extract the 10 kHz only in the 'sddpt' by matching the 12kHz pings from the 'sddbt' and removing them from 'sddpt', but this was not done during the cruise. In future it would be better if the 10- and 12-kHz data were in different RVDAS tables.

Editing of underway fluor and trans

Underway flowrate, fluor and trans were displayed daily. Periods when the seawater pumps were off for cleaning were identified, and fluor and trans edited out with *mplxyed*. Some further spikes that were clearly not representative of the ocean conditions were further edited out with *mplxyed*. Fluor and trans are raw data converted with factory cals. The fluorometer and transmissometer instruments were cleaned before departure and on 12, 20 and 27 Feb.

Thermosalinograph temperature and salinity

The datastream 'tsg' includes housing temperature and salinity, and remote temperature. These have unambiguous names from RVDAS. Remote temperature was accepted as a measure of sea surface temperature. Salinity was adjusted after comparison with bottles samples, mainly collected 4-hourly. A total of 170 bottle samples were drawn and analysed. The TSG was cleaned in port before departure and again while the seawater pumps were off on 27 Feb. Seawater pumps were off on 12 and 20 Feb for cleaning of the fluor and trans. The relevant times are entered into *opt_jc211.m* in case '*mtsg_cleanup*', case '*tsg_badlims*'.

The time of each bottle sample was recorded in the TSG samples event log, and cut and pasted into a file *data/ctd/BOTTLE_SAL/tsg_event_log_jc211_01.txt*. Commas were added after time and event number, so that the file could be read with comma-delimiters. From there data were read in by *msal_01*, and saved in *met/tsg/tsg_jc211_all.nc*. The sampnum given to underway bottle samples in the Autosal csv spreadsheet was a negative number, -1 times the event number in the event log file. Thus underway bottle samples could be distinguished from standards and CTD samples, and merged with the event log time. The event log .txt file was read inside *msal_01.m*.

When bottle samples were compared with TSG salinity, it was noted that, unsurprisingly, the largest residuals occurred when the time-gradient of TSG salinity was strongest, and that bottle salinity often corresponded to TSG salinity shortly afterwards. The time of bottle samples was generally recorded to the nearest minute, with a sample collected from a hose that branched off the TSG supply at the start of the TSG plumbing circuit, which was therefore earlier than the time when the equivalent water passed through the TSG. Accordingly, one minute was added to the recorded bottle sample time before comparison with TSG salinity. This offset is applied in mtsg_bottle_compare at this line:

```
db.time = db.time/3600/24+1+1/1440;
```

The offset could be adjusted for other cruises. This one-minute offset reduced the size of the largest residuals, and improved the statistics of residuals, as noted below.

msal_01.m read all Autosal spreadsheets each time it was run. Samples were sorted into standards, CTD samples placed in *sam_jc211_all*, and underway samples. The adjustment to be applied to each crate of samples, from either CTD or underway, was set in *opt_jc211.m*, *case msal_01, case sal_off*. In the file of underway bottle samples, *salinity* refers to the calculation within the Autosal spreadsheet without regard to standard adjustment, and *salinity_adj* refers to the bottle salinity adjusted for standards. This is the bottle salinity to be used. Further discussion of the Autosal standard offsets is found in the Autosal section of this report.

Automatic editing and averaging of TSG data was by script *mtsg_medav_clean_cal*, and comparison with bottle samples in *mtsg_bottle_compare*, following the path of previous cruises. The comparison with bottle samples could be done with a choice of raw TSG data or calibrated TSG data. The choice is set in *opt_jc211.m*, with case *'mtsg_bottle_compare'*, case *'tsg_usecal'* with usecal = 0 to examine raw data and calculate a calibration adjustment, and usecal = 1 to check residuals between bottles and calibrated data. The recommended calibration adjustment is calculated from a smoothed version of individual bottle residuals. Breakpoints are allowed for, to correspond to times when the seawater pumps were off and the TSG cleaned: *opt_jc211.m* case *'tsg_timebreaks'*. Breakpoints were allowed on 20 and 27 Feb. The TSG data end when the seawater pumps were switched off at 1030 on 7 March, prior to being alongside at 1220.

Summary of TSG salinity calibration statistics

Calibration statistics were examined for bottle samples up to day 059/1244. At that time there were 143 bottle samples available. After applying a smoothed adjustment to the TSG salinity, equivalent to smoothing over 41 samples, but allowing breakpoints when the pumps were off, just 2 out of 143 samples had a salinity residual greater than 0.01, and 13/143 greater than 0.005. The remaining residuals were better than 0.005. The iqr was 0.0022 [-0.0007 to +0.0015] and the standard deviation was 0.0028. Without the 1-minute delay applied to bottle sample times, the corresponding figures were 12/143 residuals greater than 0.01, 23/143 greater than 0.005, iqr = 0.0028 and standard deviation 0.0054. The timing delay removed most of the large residuals. We conclude that the TSG salinity is calibrated to around 0.003 relative to analysed bottle samples.

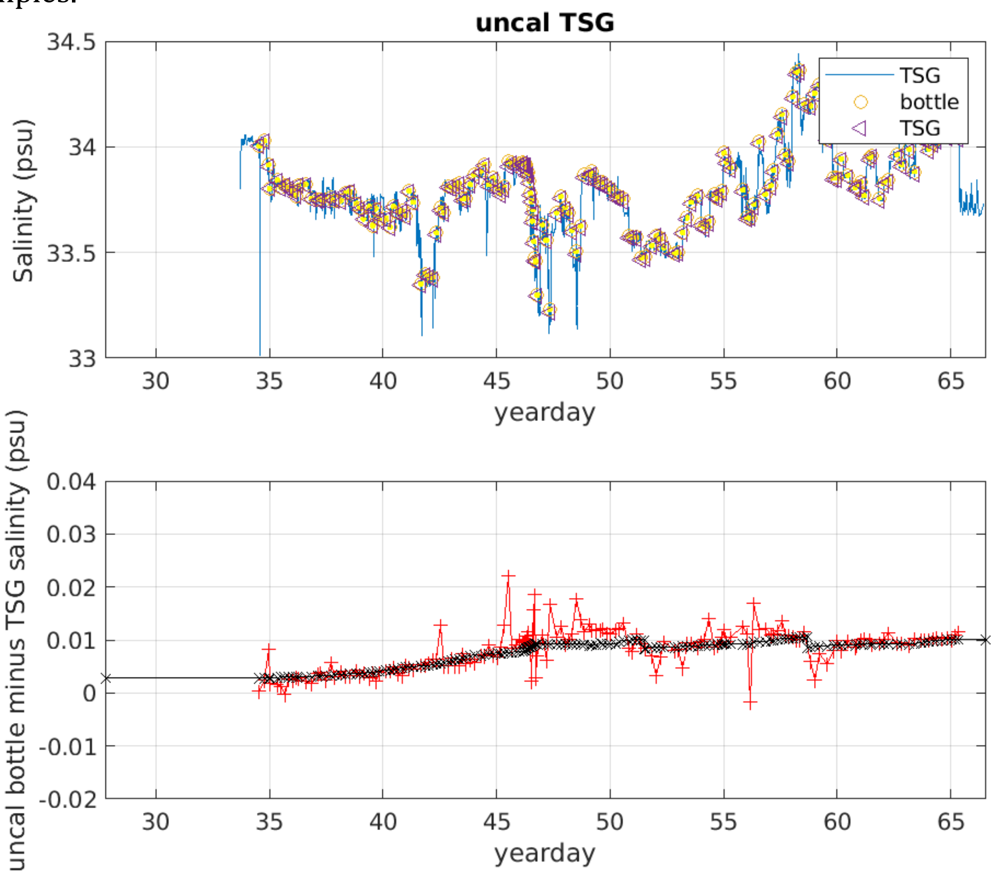


Figure 28. Uncalibrated TSG data. Lower panel is bottle minus TSG salinity. Black crosses show smoothed adjustment that is then applied to TSG data.

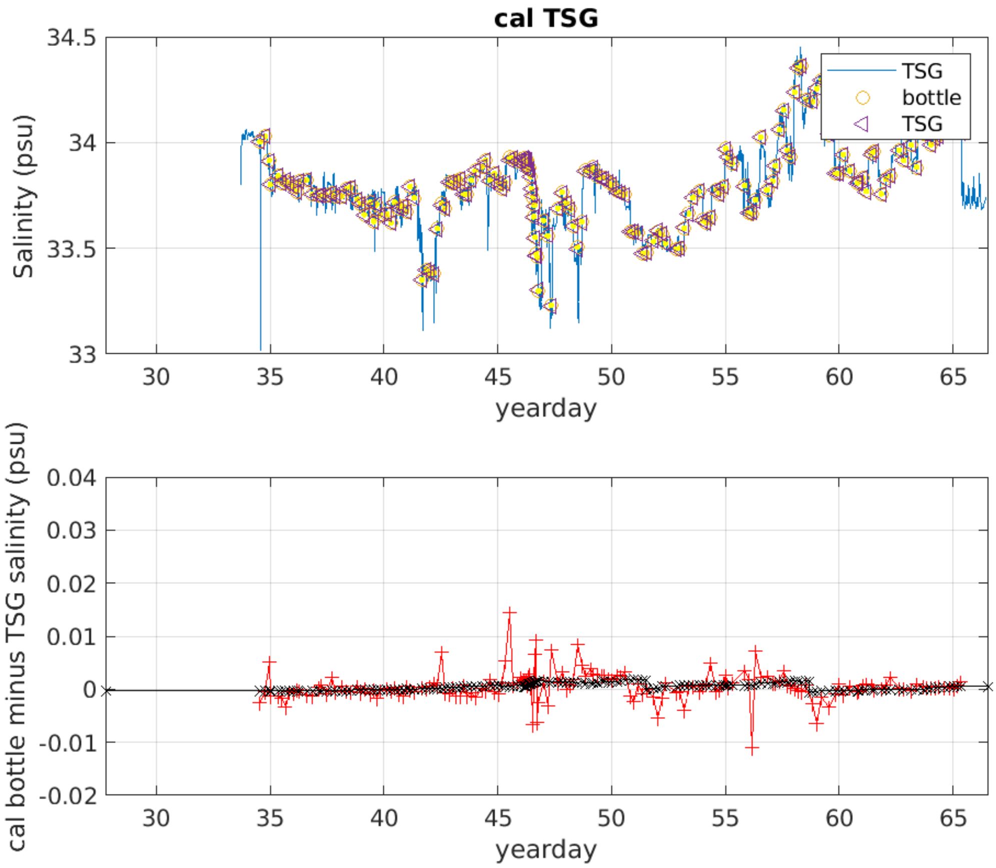


Figure 29. Calibrated TSG data. Lower panel is bottle minus TSG salinity, after calibrating TSG salinity.

Chernikeef EM-log and Skipper Doppler log

These were read into mexec from RVDAS but not analysed.

Moorings

Bjorg Apeland

Two moorings were recovered and redeployed on JC211: P3, in deep water NW of South Georgia, and WCB, in shallow water inside the Western Core Box.

P3

Recovery

The P3 mooring was recovered on the 5th of Feb. 2021.
Last year's position: 52° 48.47' S, 040° 06.92' W
The mooring was recovered successfully and was onboard at 14.24.
The sediment trap (ML11966-02) seemed to only have sediment in the first three bottles, and bottle no. 17 came off completely in transit, and its content lost. The third bottle had a fish in it and could explain why the rest of the bottles did not fire as expected. This sediment trap was not re-deployed and will be returned to Cambridge. The deployment data was backed up and stored on the ship's network.
Some of the AquaMonitor bags had come loose, and the contents may or may not have been saved. Bag no. 35 had a completely broken cap and was discarded as it could not be closed properly. It was also noted that the pressure compensator seems flat, and there is a fair bit if corrosion that must be investigated when back at base.
Two off the deep Trimsyn buoys had been damaged under too much pressure, suggesting the buoys had been deployed at the wrong depth. One of the Trimsyn buoys was replaced with a spare, and the other one taken home. Hence, the shallow Trimsyn buoy cluster consists of only 3 buoys on the redeployed mooring.

Recovered Instruments:

Item	SN	Condition	Data Downloaded
Acoustic Release	93	Good	n/a
Acoustic Release	2060	Good	n/a
SeaGuard Current Meter Deep	1309	Good	Z:\JC211\data\P3 Mooring
Sediment Trap Deep		Good	Z:\JC211\data\P3 Mooring
SeaBird CTD	4548	Good	Z:\JC211\data\P3 Mooring
SeaGuard Current Meter Shallow	1307	Good	Z:\JC211\data\P3 Mooring
AquaMonitor		Medium	n/a
SeaBird CTD	11807	Good	Z:\JC211\data\P3 Mooring
ADCP	15548	Good	Z:\JC211\data\P3 Mooring
VHF Combo Beacon	R090 020	Good	n/a
Argos Beacon	280	Good	n/a
Iridium Beacon	13901110	Good	n/a

Redeployment

The P3 mooring was redeployed on 12/02/21, at fixed position **52° 48.452'S 040° 06.868'W**. At 3760 m depth.
The mooring was deployed with new rope.

Triangulation Positions and Range:

	Lat	**Long**	**Range**
Anchor In	52° 47.866' S	040° 07.234'	3975 m
1st range	52° 48.747' S	040° 06.406'	3878 m
2nd range	52° 48.751' S	040° 08.060'	4062 m
3rd range	52° 48.750' S	040° 08.059'	4032 m

Acoustic Releases: 93 + 2060

- ◻ New batteries
- ◻ Tested
- ◻ New dropping bar
- ◻ Clean and lubricate O-rings
- ◻ Check for corrosion on linking bars

Iridium Beacon: IMEI: 300034013901110

- ◻ New batteries
- ◻ Clean and lubricate O-rings
- ◻ Turn on before deployment

Argos Beacon: SN 280, ID: 60210

- ◻ New batteries
- ◻ Clean and lubricate O-rings
- ◻ Tested
- ◻ Turn on before deployment

Novatech Combo Beacon: R090-020, Ch. B, 159.480 MHz

- ◻ New batteries
- ◻ Clean and lubricate O-rings
- ◻ Tested
- ◻ Turn on before deployment

ADCP Serial Number: 15548

- ◻ Download data
- ◻ New batteries
- ◻ Check and lubricate O-rings
- ◻ Set up instrument for redeployment
    - o Erase data
    - o Start WinSC for set-up of instrument
    - o Set up instrument:
        - Number of bins: 25 (1-128)
        - Bin size (m): 8 (0.2-16)
        - Pings per ensemble: 10
        - Interval: 15 min
        - Duration: 550 days
        - Transducer depth: 200 m
        - Save deployment settings
        - Start Time: 14.02.2021. 00.00.00 – Start after deployment
        - Set up ADCP real time clock to PC clock

    - Don't verify the compass
    - Run pre-deployment test to check instrument

CTD on main buoy SN: 37-11807

- ☐ Download data
- ☐ New batteries
- ☐ Clean and lubricate O-rings
- ☐ Set up instrument for re-deployment
- ☐ Set real time clock to PC clock
- ☐ Set up instrument for "autonomous sampling" following instructions in the manual. Started 00.00 14/02/2021
- ☐ Samplenum = 0 automatically makes entire memory available for recording.
- ☐ Sample interval = 900 s
- ☐ Check instrument is OK and set up properly by using "DS" command

CTD 37 SMP 43742: 4548 below lower Trimsyn buoys

- ☐ Download data
- ☐ New batteries
- ☐ Clean and lubricate O-rings
- ☐ Set up instrument for re-deployment
- ☐ Set real time clock to PC clock
- ☐ Set up instrument for "autonomous sampling" following instructions in the manual. Started 00.00 14/02/2021
- ☐ Samplenum = 0 automatically makes entire memory available for recording.
- ☐ Sample interval = 900 s
- ☐ Check instrument is OK and set up properly by using "DS" command

SeaGuard current meter w. O_2 sensor: 1307 Shallow

- ☐ Current meter sensor: 851
- ☐ Optode: 1561
- ☐ Download data
- ☐ The SeaGuard current meter with O_2 sensor does not output a setup file
- ☐ Deployment settings:
    - o The sampling interval was set to 2 hrs, as this resulted in a deployment time of 560 days. All other settings were left at the manufacturer's settings. It was checked that the current meter was set in burst mode (optimal for long term battery use). It is assumed a deployment file will be logged on the memory card for download on retrieval.
- ☐ New Batteries
- ☐ Check and lubricate O-rings
- ☐ Started recording 14.02.2021

There is a lack of battery casings for the lithium battery, two new casings should be bought. The current method is to solder the battery on, but this can be avoided by buying a battery box.

Seaguard Current meter with O_2 sensor: 1309, Deep

- ☐ SN: 1309
- ☐ Current meter sensor: 851
- ☐ Optode: 1561
- ☐ Data downloaded.
- ☐ The Seaguard current meter with O_2 sensor does not output a setup file.
- ☐ Deployment settings:
  - o The sampling interval was set to 2 hrs, as this resulted in a deployment time of 560 days. All other settings were left at the manufacture's settings. It was checked that the current meter was set in burst mode (optimal for long term battery use).
- ☐ New batteries
- ☐ Check and lubricate O-rings
- ☐ Started recording 13.02.21 – 01.45.00

Sediment Trap Shallow - Serial No: 13136-01

The sediment trap was set up in Cambridge prior to shipping, and was deployed without interference on the ship.

- ☐ Always disconnect the cable on the sediment trap first, before unplugging the computer end
- ☐ Set up sediment trap with sample tubes
- ☐ Download data
- ☐ Clean and lubricate O-rings
- ☐ Check rope and shackles

Sediment Trap Deep – Serial No: 13136-02

The sediment trap was set up in Cambridge prior to shipping and was deployed without interference on the ship.

- ☐ New batteries
- ☐ Do NOT remove both batteries at the same time.
- ☐ Always disconnect the cable on the sediment trap first, before unplugging the computer end
- ☐ Set up sediment trap with sample tubes
- ☐ Download data
- ☐ Clean and lubricate O-rings
- ☐ Check rope and shackles

SAMI pH

The SAMI pH sensor was set up in Cambridge prior and was deployed directly.

SonoVault, 25161

Set up by manufacturer. Batteries inserted and instrument turned on before deployment. The magnet for turning the instrument on and off with can be found in the Mooring Instruments Toolbox.

Hardware

- Checked and/or changed all shackles
- Checked and/or changed all chain

- Trimsyn buoys
- Chain on buoy

- Checked and/or changed all rope
- Checked titanium swivel
- Changed ALL stainless steel shackles
- Done a once-over on all parts of mooring buoy
- Replaced screws on clamps

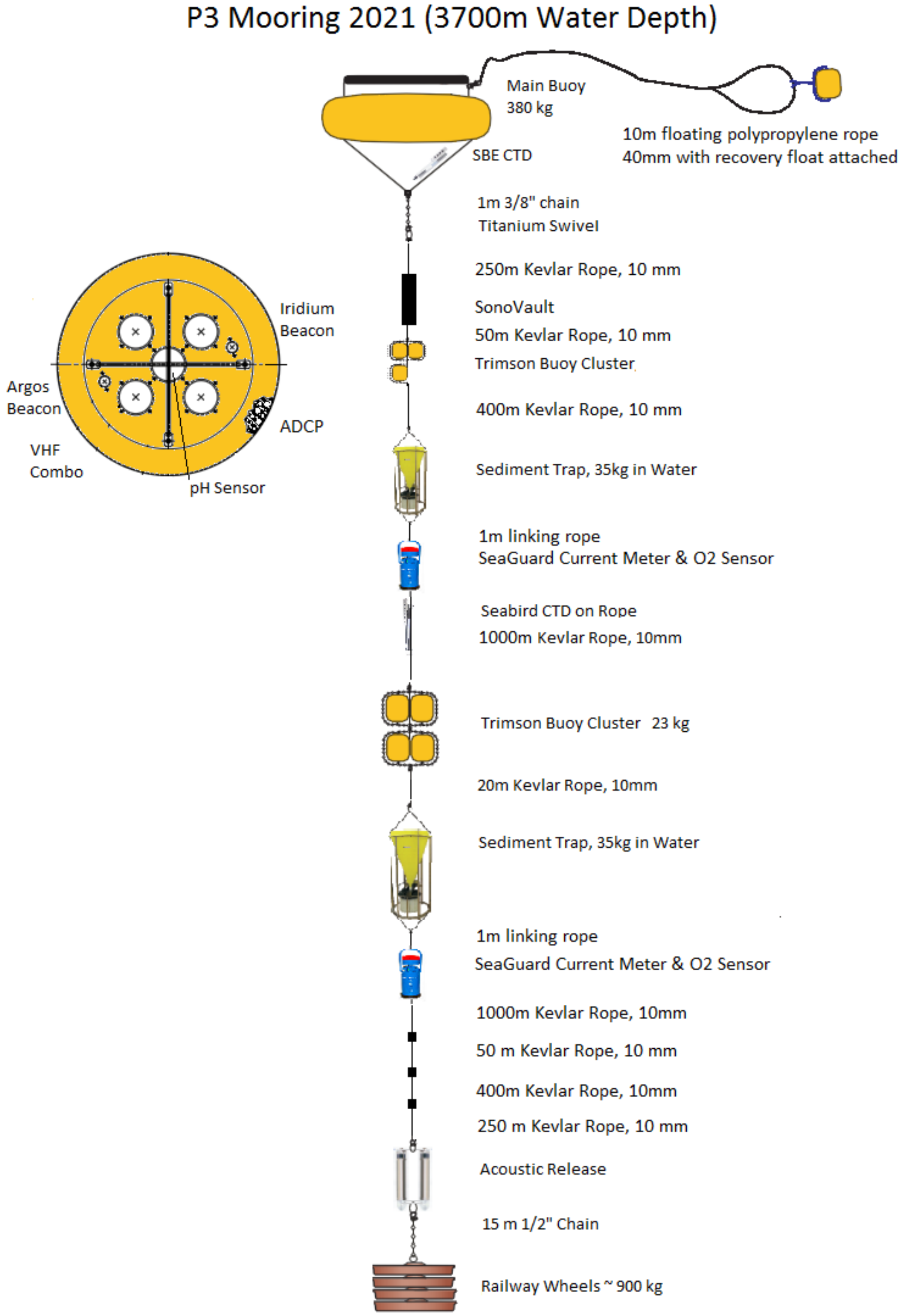


Figure 30. P3 mooring diagram, as deployed in 2021.

WCB

Recovery

The WCB mooring was released on 7/2/2021 at 21:55 and sighted at 22:01. Release **2006** was used for releasing. The recovery was completed at 22:46.
All beacons and instruments appeared to be in working order. The recovery line had come undone from the float and wrapped itself around the mooring line making recovery more difficult, with a snatch hook the float was recovered without using the recovery line. The recovery line had come off because of a swivel failure between the rope and the main buoy. The swivel was replaced with a shackle to avoid the same happening in the future.

Recovered Items:

Item	**SN**	**Recovered Condition**	**Data Downloaded**
Acoustic Release	2006	Good	n/a
Acoustic Release	2062	Good	n/a
SonoVault Acoustic Device		Good	Memory Cards taken home, and back up on portable hard drive.
SBE CTD	50488	Good	Z:\JC211\data\WCB Mooring\CTD
WBAT	127	Good	Z:\JC211\data\WCB Mooring\WBAT
Iridium Beacon	300834012098770	Good	n/a
ADCP	17273	Good	Z:\JC211\data\WCB Mooring\ADCP_17273
SoundTrap ST300		Good	Data stored on unit and backed up on portable hard drive.
VHF Combo	R090-020	Needs new anode, swapped beacon with another one.	n/a
Argos Beacon	251	Good	n/a

Redeployment

The WCB mooring was redeployed on 9/2/2021 at 22:14 at **53° 47.887' S 037° 53.153' W.**
The following instruments were redeployed:

Acoustic Releases: 2006 + 2062

- ◻ New batteries
- ◻ Deck tested
- ◻ New dropping bar
- ◻ Clean and lubricate O-rings.
- ◻ Linking bars changed

Iridium Beacon: IMEI: 300834012098770

- □ New Batteries
- □ Clean and lubricate O-rings
- □ Tested
- □ Turn on before deployment

Argos Beacon: SN 251, ID: 35520

- □ New batteries
- □ Clean and lubricate O-rings
- □ Tested
- □ Turn on before deployment

Novatech Combo Beacon, D07 019, Ch. C, 160.72500 MHz:

- □ New batteries
- □ Clean and lubricate O-rings
- □ Tested
- □ Turn on before deployment

ADCP WHS300-I-UG161 Serial Number: 17273

- □ Downloaded data
- □ New batteries
- □ Check and lubricate O-rings
- □ Set up instrument for redeployment
    - o Erase data
    - o Start WinSC for set-up of instrument
    - o Set up instrument:
        - Number of bins: 25 (1-128)
        - Bin Size (m): 8 (0.2-16)
        - Pings per ensemble: 10
        - Interval: 15 min
        - Duration: 550 days
        - Transducer depth: 200 m
        - Save deployment settings
        - Start after deployment
        - Set up ADCP real time clock to PC clock
            - Don't verify the compass
            - Run pre-deployment test to check instrument

SonoVault:

The existing SonoVault will be swapped with a new, already configured, SonoVault.

New SonoVault, SN 25168:

- □ Insert batteries
- □ Inspect and lubricate O-rings
- □ Assemble
- □ Turn on just before deployment!

Old SonoVault:

- ☐ Remove and dispose of batteries
- ☐ Make sure SD Cards are happy and free of moist
- ☐ SD Cards Backed up
- ☐ Clean
- ☐ Check for any sign of corrosion or other maintenance work

Sediment Trap Deep - No: 11966-01

The sediment trap was set up in Cambridge prior to shipping and was deployed without interference on the ship.

- ☐ Always disconnect the cable on the sediment trap first, before unplugging the computer end
- ☐ Set up sediment trap with sample tubes
- ☐ Download data
- ☐ Clean and lubricate O-rings
- ☐ Check rope and shackles

CTD on main buoy SN: 37-11807

- ☐ Download data
- ☐ New batteries
- ☐ Clean and lubricate O-rings
- ☐ Set up instrument for re-deployment
- ☐ Set real time clock to PC clock
- ☐ Set up instrument for "autonomous sampling" following instructions in the manual. Started 00.00 14/02/2021
- ☐ Samplenum = 0 automatically makes entire memory available for recording.
- ☐ Sample interval = 900 s
- ☐ Check instrument is OK and set up properly by using "DS" command

Simrad WBAT Serial Number: 240826 and 120kHz transducer serial number: 127

- ☐ Download data file from USB drive: Z:\JC211\data\WCB Mooring\WBAT
- ☐ New batteries
- ☐ Set up instrument for redeployment
  - New batteries
  - Erase USB Stick
  - Start Mission Planner
  - Send New Mission to WBT to include:
    - Start Time / End Time (to not ping in water)
    - Ping ensembles including CW/FM pings (15 each)
    - Event start interval (1 hour)
    - Range 250 m
- ☐ Note firmware was not upgraded and WBAT is operating using Storage Controller FW v2.4.0-130, Storage Controller driver v0.6.92, mission controller FW v2.2.5.0, mission controller FPGA v10. These files can only be viewed in EK80 software version 1.11.

Aquadopp Current Meter – SN: P20222-1

Head ID: A2L 1792
Hardware ID: AQD 2018

Setup:

- Measurement interval(s): 900
- Average interval(s): 60
- Measurement load(%): AUTO
- Blanking Distance(m): 0.5
- Compass upd. Rate(s): 900
- Coordinate System: ENU
- File wrapping: Disabled
- Raw. Mag data: Disabled
- Speed of Sound: Measured
- Salinity (ppt): 34
- Diagnostics: Disabled

Deployment Planning:

- Battery Pack: Lithium
- Battery Capacity (Wh.): 165
- Assumed Duration Days: 550
- Battery utilization (% of capacity): 73
- Memory required (MB): 2.1
- Vertical vel. Prec. (cm/s): 1.4
- Horizontal vel. Prec.(cm/s): 0.9
- NO external inputs

Hardware:

- □ Checked and/or changed all shackles
- □ Checked and/or changed all chain
    - o Trimsyn buoys
    - o Chain on buoy
- □ Checked and/or changed all rope
- □ Checked titanium swivel
- □ Changed ALL stainless steel shackles
- □ Done a once-over on all parts of mooring buoy
- □ Replaced screws on clamps

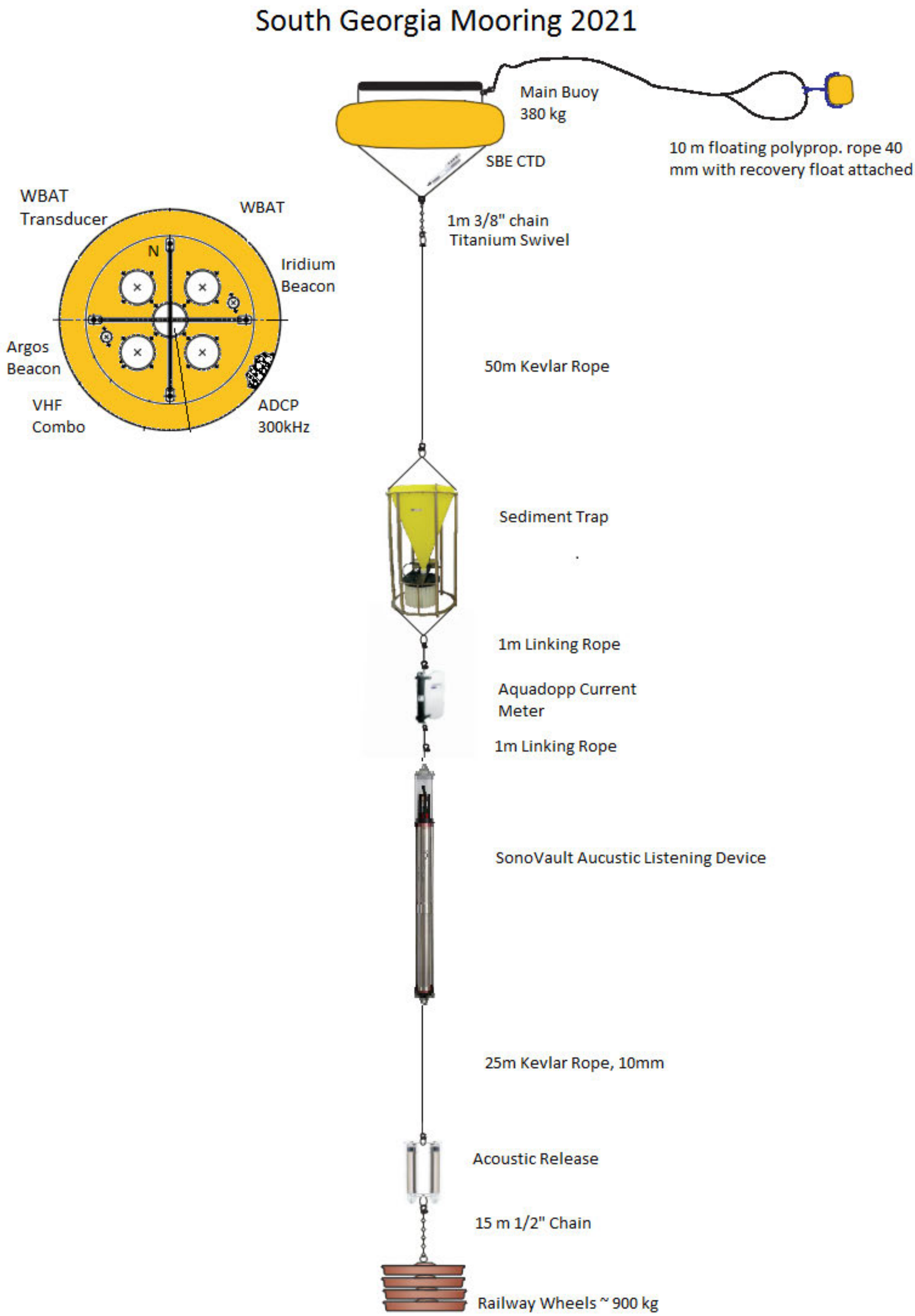


Figure 31. P3 mooring diagram, as deployed in 2021.

Glider deployments

Povl Abrahamsen

A central part of the work around iceberg A-68A will be performed by two Teledyne Webb Research Slocum G2 gliders. These have been provided by the Marine Autonomous and Robotic Systems group at NOC, and are being piloted jointly by BAS and NOC, with one pilot from each institution on duty at any one time. The main piloting interface is the new C2 Command and Control system, developed at NOC as part of the Oceanids programme (https://projects.noc.ac.uk/oceanids/).

The science bay of each glider is fitted with a Seabird Scientific pumped Glider Payload CTD (GPCTD) and an ECO Puck combined CDOM/chlorophyll A fluorometer and backscatter sensor. In addition, they have a recovery line and downward-looking altimeter in the nose section, and both are fitted with thrusters. On 405, the CTD is on the starboard side and the ECO Puck on port; this is reversed on 439. Both gliders were ballasted at NOC before shipping.

Tests on board

The two gliders were initially unboxed and brought into the Deck Lab on RRS James Cook on 28 Jan. Initial tests in the deck lab, checking Freewave communications, "wiggle" (moving all internal and external control surfaces), and checking the thruster operation, were performed on 30 Jan. While communications with both gliders worked well, the thruster on glider 405 had some visible rust around the edge of the plastic sleeve/bushing on the inside of the thruster assembly, the plastic sleeve was visibly deformed, and the thruster did not turn freely. When the thruster was activated, it made a horrible grating sound, and did not rotate smoothly. In contrast, the thruster on glider 439 worked smoothly and did not have any surface rust.

On advice from NOC, the thruster was disassembled, surface rust removed with solvent, and the whole assembly cleaned, greased with (dry) silicone lubricant spray, and reassembled. After this procedure, the thruster was tested again, and turned smoothly and silently. The rust may have been caused by seawater trapped beneath the plastic sleeve during the previous deployment. It might be advisable to disassemble and soak the thrusters in freshwater after recovery to prevent this happening in the future.

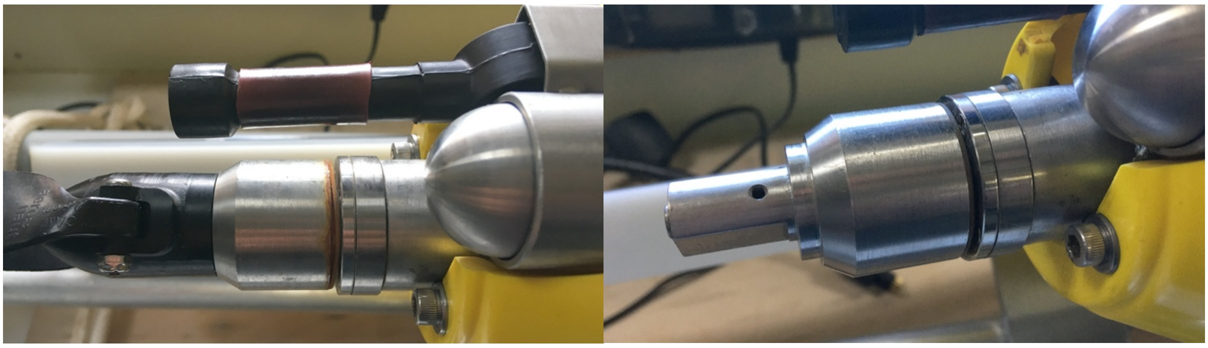


Figure 32. Thruster assembly on glider 405 before (left) and after (right) cleaning and lubrication.

On 12 Feb, in transit from P3 toward the iceberg, the gliders were taken onto deck, and tested remotely via Iridium. A WhatsApp group with the glider pilots and other personnel at MARS was used to facilitate communications between EPA on the ship, and personnel at MARS during testing and deployment, and is also being used for piloting.

Deployments

The initial plan for the glider deployments was for one to measure ahead (upstream) of A-68A, and another to measure in the wake of the berg, to measure its effect on the upper ocean and ecosystem. Since the expectation was that the iceberg would move north or west, the first glider, 405, was deployed approx. 10 nautical miles south of the iceberg on 14 Feb, at station Iceberg_S10. The intention was to deploy the second glider at a corresponding site north of the iceberg. However, the large number of bergy bits and icebergs north of the iceberg prevented access to the planned northern section, and the vessel had to stay north of iceberg A-68J and A-68P. After consultation with the glider pilots in the UK (and after Steve Woodward and Alex Brearley discussed the situation by phone), the option of deploying the second glider southwest of A-68P was discounted, and instead the glider was deployed northeast of A-68P, which was moving quickly to the west. This was approximately 20 miles north of A-68A. Times and positions of deployment are given in Table 3.

Table 3. Deployment times and positions of gliders on JC211.

Serial number	Name	Deployment Event	Date/time	Latitude	Longitude
405	Doombar	49	2021/02/14 14:13	56° 57.584' S	034° 40.202' W
439	HSB	55	2021/02/15 18:35	56° 14.180' S	034° 39.012' W

Both gliders were deployed using a new trolley release system built at NOC. This consists of a syntactic foam block beneath the trolley, which can slide toward the tail end of the glider, releasing a pin that secures a plastic-coated wire over the glider, in place of the webbing strap usually mounted on the glider trolley. The whole assembly was lifted outboard from a strop on the starboard aft crane. Initially the trolley failed to release; this was because the ship was moving too fast relative to the water, effectively dragging the glider trolley. Once thrust was reduced, the trolley released immediately, smoothly deploying the glider.

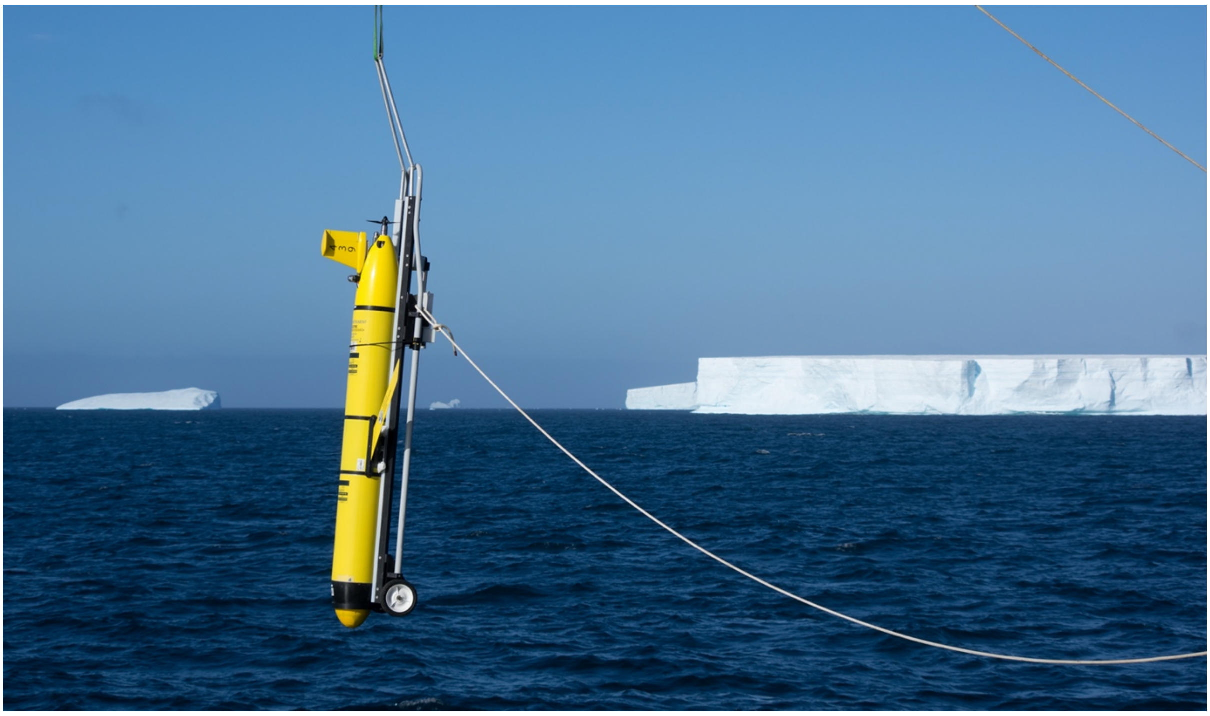


Figure 33. Glider 439 in the deployment trolley, with the white syntactic foam block visible beneath the glider.

Initial piloting and preliminary results

Although we expected A-68A to move north or west, it instead rotated and moved eastward and slightly south. Thus, it ended up overtaking glider 405 on 16 Feb. The glider did not re-appear until 4 Mar, after spending over two weeks under the iceberg, at a depth of approximately 160 m. It does not appear to have sustained any damage, and continued to operate well until the end of the deployment. After staying near iceberg A-68A at the start of the deployment, the glider was piloted toward South Georgia at the end of March, and conducted several transects across the shelf break.

Glider 439 was initially piloted to stay clear of iceberg A-68J and P, and then to follow A-68A toward the east. However, communications were lost with the iceberg after the evening of 27 Feb. There is no indication of any problems with the glider prior to this date, nor any indication that large icebergs were present near its last position. We remain cautiously optimistic that it will re-appear in the future.

Data from the gliders are publicly available in near-realtime through BODC at https://www.bodc.ac.uk/data/bodc_database/gliders/, and hydrographic profiles are also being transmitted to GTS. An initial overview of the glider data is shown in Figure 34 and Figure 35.

Recovery

Glider 405 was recovered by fishery patrol vessel Pharos SG at 15:07 UTC on 6 May 2021 in position 53° 51.965' S 036° 33.708' W. It will be sent back to the UK via the Falkland Islands, and the full data files will be downloaded at NOC.

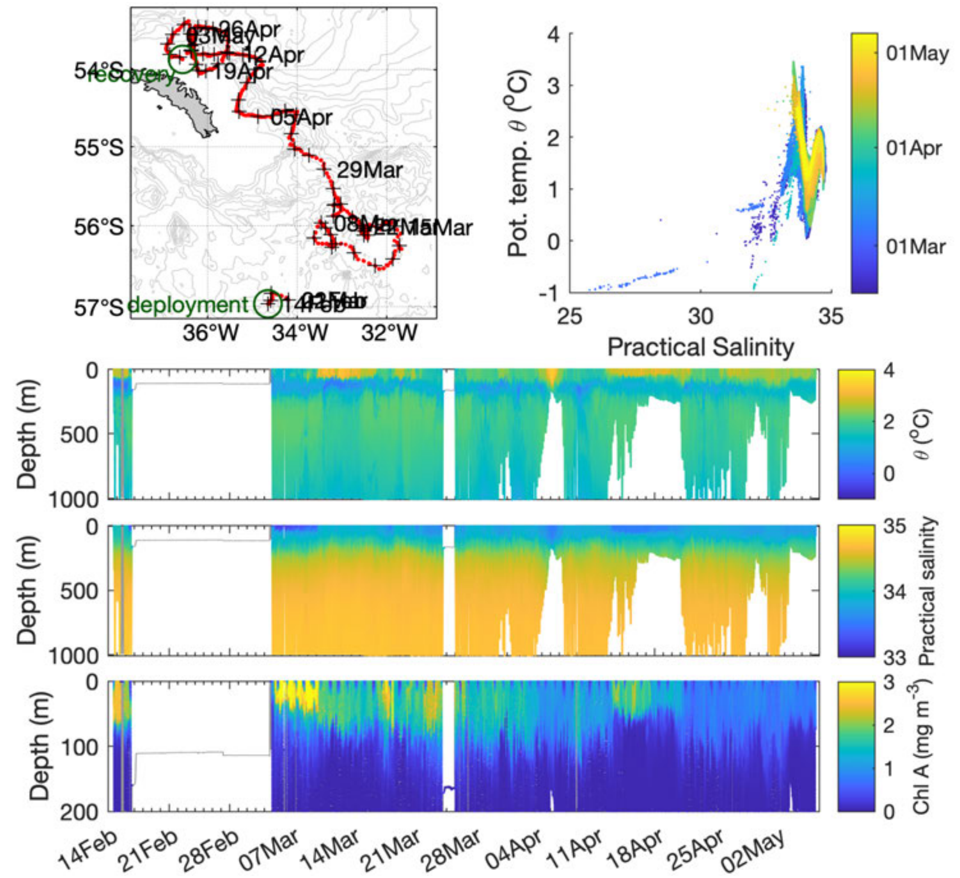


Figure 34. Preliminary oceanographic data from glider 405: surface positions (top left, red dots), θ/S diagram (top right), dive profiles with θ, S, and Chl A data in colour, grey when sensor not measuring (lower three panels).

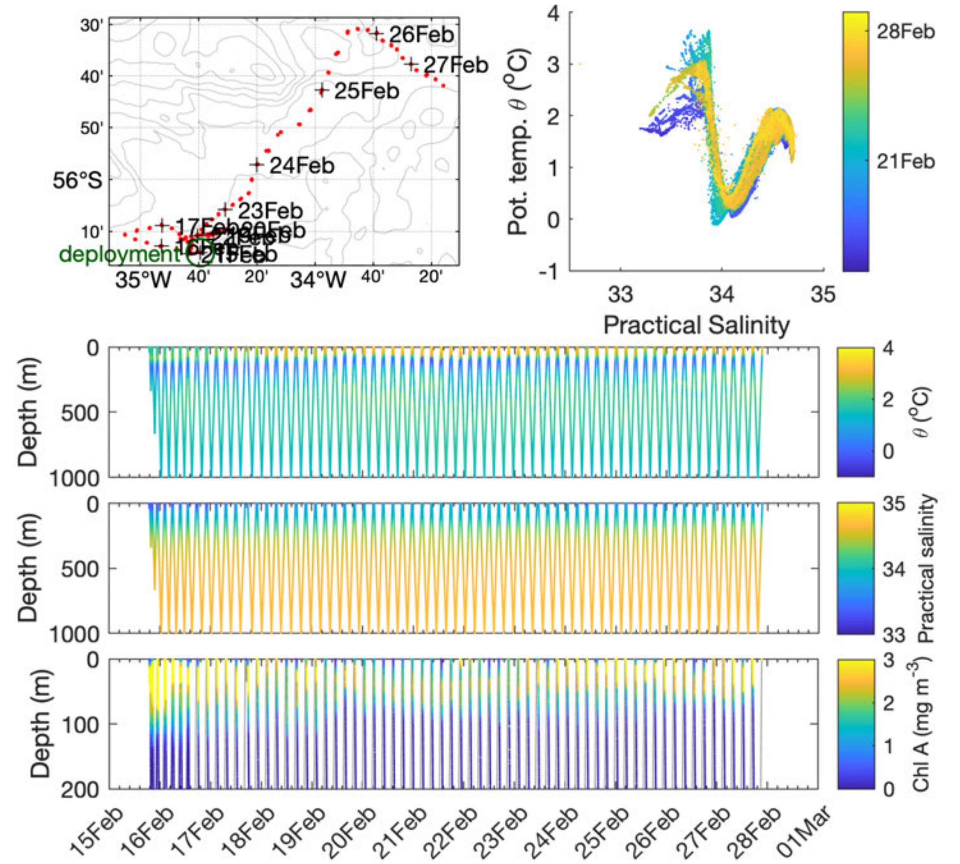


Figure 35. As Figure 34, for glider 439.

Argo float deployments

Povl Abrahamsen

Four Teledyne Webb Research Apex profiling floats were deployed during JC211 on behalf of the UK Met Office, two on the SR1b section and two on A23. These floats will follow the standard Argo pattern of parking at 1000 dbar, diving to 2000 dbar, then measuring temperature, conductivity, and pressure during ascent to the surface, and transmitting the data via satellite before diving to 1000 dbar. The cycle is repeated every 10 days. The first two float deployed transmit by Iridium, the next two by Argos.

The floats were removed from their crates and plugs removed from the SBE-41 CTD sensor, before they were lowered into the sea on a length of thin polypropylene rope from the starboard quarter while the ship was slowly steaming ahead. The floats automatically activate on contact with the water. Deployment information is given in Table 4.

The floats' data will be freely available through the Argo Data Assembly Centres or https://www.ocean-ops.org. Further information is also on https://www.ukargo.net.

Table 4. Argo floats deployed on JC211.

Ser. no.	WMO no.	Deployment time	Latitude	Longitude	Station	CTD	Event
9007 (i)	1901928	2021/02/21 22:54	61° 33.06' S	031° 06.07' W	A23-31	58	86
8991 (i)	1901927	2021/02/24 05:14	63° 05.03' S	030° 06.02' W	A23-26	64	93
8576 (a)	1901926	2021/03/02 05:01	58° 21.96' S	056° 13.35' W	SR1b_18	78	108
8575 (a)	1901925	2021/03/03 21:12	56° 09.43' S	057° 36.69' W	SR1b_11	85	116

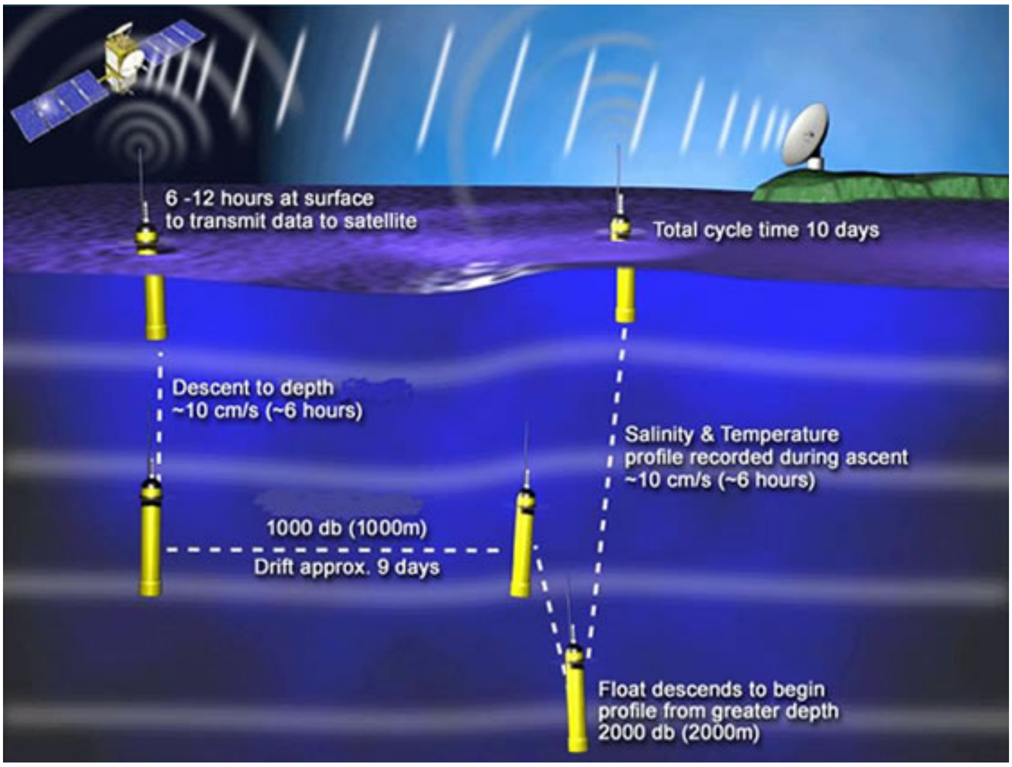


Figure 36. Measurement/dive cycle for Argo floats. Credit: UK Argo, https://www.ukargo.net

Swath bathymetry

Povl Abrahamsen

RRS James Cook is fitted with two Kongsberg multibeam systems, a deep-water EM112 12-kHz 1x1° system (mounted on the hull), and a medium-range EM710 70-100 kHz 2x2° system (mounted on the port drop keel – see Figure 45 in Appendix D). Both systems were used on JC211, with the EM710 only used in shallow water on the continental shelf south of South Georgia. EM122 centre-beam depths were logged to TechSAS and RVDAS whenever the instrument was pinging; processing is described in the chapter on underway data. Full swath data were not logged during most of the SR1b and A23 transects, or when passing over other areas that have been covered before. However, data were logged during some of the transits, and if we moved outside regions of multibeam coverage on the sections because of icebergs. Background images showing coverage of BAS multibeam data holdings were imported into the SIS data acquisition software on both multibeam systems, to help determine when to log data. The times that full data were recorded, and the corresponding station names or events are listed in Table 5 and Table 6 (for EM122 and EM710, respectively).

At different times, CTD casts, SVP casts, or profiles from the World Ocean Atlas 2013 climatology were used for speed of sound profiles. These are shown in Table 9 in Appendix D.

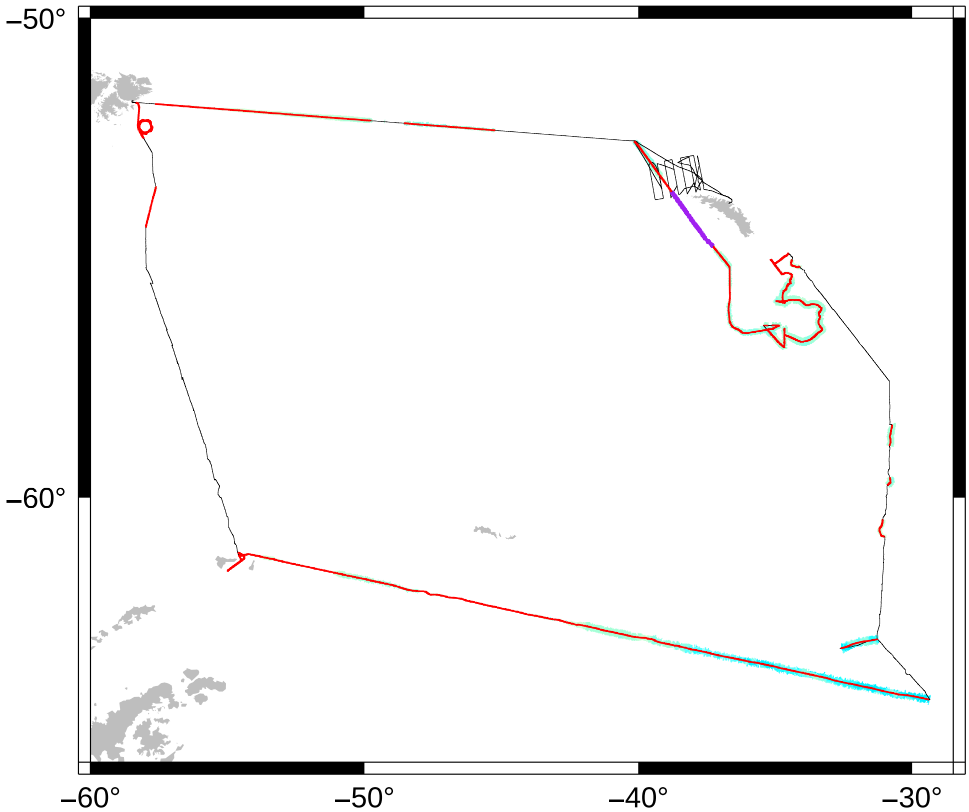


Figure 37. Overview of multibeam data collected on JC211. Red line segments show times when EM122 was logging; the purple segment shows when EM710 was also logging. EM122 was pinging, but not logging for much of the remaining ship track except during the Western Core Box.

Echosounder operations and environmental mitigation measures

The JC211 environmental impact assessment, performed by Anna Bird (Durham University), required marine mammal observations to be performed before use of the 12-kHz multibeam system, in line with Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury to marine mammals from geophysical surveys (available to download from https://hub.jncc.gov.uk/). Consequently, the PSO undertook a JNCC-approved Marine Mammal Observer training course online, prior to the cruise. Observations were performed twice during the cruise: 13:54-14:42 on 2/2/2021, before the EM122 was initially started, and 19:33-20:53 on 11/2/2021, after P3 had been deployed and before the EM122 was re-started. The EM122 was operating continuously from 14:26 on 2/2 until 11:28 on 5/2, and from 20:35 on 11/2 until 10:53 on 7 Mar. Any gaps in pinging during these intervals were less than 10 minutes, and thus did not require further marine mammal observations. When the EM122 was started, this was with a 15-minute power ramp. When possible, the power level of both systems was reduced, as long as data quality was still acceptable. Changes in power and other events relating to the MMO documentation were logged on the NMF event logger in the science/MMO log. Changes in sound speed profiles and operational events (including restarts of the SIS software and other short gaps in pinging) were logged in the tech/acoustic events log. On the advice of Anna Bird, full details of these changes were not included in the final JNCC spreadsheet, though the comments state that multiple changes of power were made, and short gaps in pinging occurred.

Table 5. Overview of EM122 data files

Line	Date (y/m/d)	Comments/location
0	21/2/2 14:49	In transit from the Falkland Islands to P3.
27	21/2/3 16:02	Stopped recording because data coverage on this route is good.
28	21/2/3 20:16	Not sure why logging was started…
28	21/2/3 20:17	… and then stopped immediately.
29	21/2/3 22:33	Started logging because of miscommunication with evening shift.
40	21/2/4 09:42	Stopped recording because data coverage on this route is good.
41	21/2/12 05:31	In transit from P3 to iceberg A-68.
59	21/2/12 23:53	Arriving station “Iceberg_far”, waiting on weather
60	21/2/13 03:42	Leaving station “Iceberg_far”
74	21/2/13 18:34	On station “Iceberg_W1”
75	21/2/13 19:38	Transit from station “Iceberg_W1” …
75	21/2/13 20:28	… to station “Iceberg “W2.5”
76	21/2/13 21:41	Transit from station “Iceberg_W2.5” …
79	21/2/14 01:19	… to station “Iceberg_W10”
80	21/2/14 03:50	Transit from station “Iceberg_W10” …
81	21/2/14 05:13	… to station “Iceberg_W20”
82	21/2/14 07:41	Transit from station “Iceberg_W20” …
85	21/2/14 10:43	… to station “Iceberg_S20”
86	21/2/14 12:11	Transit from station “Iceberg_S20” …
88	21/2/14 15:09	… to station “Iceberg_S10”
89	21/2/14 16:25	Transit from station “Iceberg_S10” …
90	21/2/14 18:13	… to station “Iceberg_S1”
91	21/2/14 19:19	Transit from station “Iceberg_S1” …
91	21/2/14 20:10	… to station “Iceberg_S2.5”
92	21/2/14 21:27	Transit from station “Iceberg_S2.5” …
93	21/2/14 22:58	… to station “Iceberg_S5”
94	21/2/15 00:24	Transit from station “Iceberg_S5” …
94	21/2/15 00:51	… to station “Iceberg_S9”
95	21/2/15 01:59	Transit from station “Iceberg_S9” …
112	21/2/15 19:26	… to station “Iceberg_N20”

Line	Date (y/m/d)	Comments/location
113	21/2/15 21:20	Transit from station “Iceberg_N20” …
124	21/2/16 08:56	… to station “Iceberg_H1”
125	21/2/16 09:25	Transit from station “Iceberg_H1” …
125	21/2/16 10:02	… to station “Iceberg_H2”
126	21/2/16 11:54	Transit from station “Iceberg_H2” …
126	21/2/16 12:45	… to station “Iceberg_H3”
127	21/2/16 14:04	Transit from station “Iceberg_H3” …
127	21/2/16 14:46	… to station “Iceberg_H4”
128	21/2/16 16:08	Transit from station “Iceberg_H4” …
128	21/2/16 16:57	… to station “Iceberg_H5”
129	21/2/16 18:10	Transit from station “Iceberg_H5” …
129	21/2/16 18:38	… to station “Iceberg_H6”
130	21/2/16 19:57	Transit from station “Iceberg_H6” …
135	21/2/17 01:15	… to station “A23-52”
136	21/2/17 11:40	Transit from station “A23-50A” …
137	21/2/17 13:25	… to station “A23-50”, moving outside previous swath coverage
138	21/2/19 23:39	Transit from station “A23-41” …
140	21/2/20 02:02	… to station “A23-40”, moving outside previous swath coverage
141	21/2/20 12:47	Transit from station “A23-39” …
142	21/2/20 13:49	… to station “A23-37”, moving outside previous swath coverage
143	21/2/21 03:26	Transit from station “A23-35” …
147	21/2/21 07:28	… to station “A23-34”, moving outside previous swath coverage
148	21/2/23 07:00	After waiting on weather …
151	21/2/23 10:44	… steaming back toward station “A23-28”
152	21/2/24 13:18	Transit from somewhere between stations “A23-25” and “A23-24”…
219	21/2/27 09:17	… to station “SR1b_30”
220	21/2/27 15:43	Waiting for weather south of Elephant Island …
225	21/2/27 21:24	… to station “SR1b_29”
227	21/3/5 11:49	Transit from station “SR1b_1” …
232	21/3/5 17:08	… to station “SR1b_N1”
233	21/3/6 10:02	After station “SR1_N5”, performing ADCP bottom-track calibration…
257	21/3/7 10:51	… until EM122 switched off at entrance to Choiseul Sound.

Table 6. Overview of EM710 data files

Line	Date (y/m/d)	Comments/location
0	21/2/12 13:37	In transit from P3 to iceberg A-68, passing over the continental shelf S of South
13	21/2/12 20:56	Georgia, where Iceberg A-68A may have grounded

Pelagic (bongo) nets

Bjorg Apeland

The bongo nets were deployed 11 times. The bongo was deployed of the starboard side of the aft deck using a block on the starboard aft crane and a deck winch. The bongo, before lifting, was resting at 30 degrees and was lifted from near horizontal to vertical, before being swung overboard. This setup works, but is not ideal. The bongo is not designed to be lifted from near-horizontal, but designed to be lifted from the vertical. This results in a non-optimal bend radius on the lifting wire. It is recommended that if deploying this way again, a design change is made, or a frame for vertical deployments is built.

Bongo Sampling

A summary of the bongo net samples can be seen below.

After the nets were back on board the cod ends were emptied into buckets and brought into the deck lab where the cod ends were carefully cleaned with seawater to get the full sample. The samples were then filtered through a 200 µm sieve and transferred to an appropriately sized Nalgene bottle so that the net sample did not fill more than 10% of the Nalgene bottle. The sample bottle was then filled to the top with 99% Ethanol, leaving some room for ullage. Finally, the sample bottles were placed in the controlled environment lab for refrigeration at +4°C or as cold as the lab could go.

Table 7. Bongo net samples

Event	Depth (m)	Sample Bottles Net 1	Sample Bottles Net 2	Comment
8	200	1	2	Jelly taken out of Net 2
9	200	1	2	1 Cod-End divided into bottle 2 and 3
14	200	1	1	
16	175	1	1	
21	200	2	1	Salp taken out of Net 1
22	100	1	1	
26	200	1	1	
27	75	1	1	
33	200	1	1	
40	200	1	1	

Appendix A: Event log

This table is adapted from the bridge event log. Times are the range of times for each event noted in the bridge log. The positions for the CTDs are updated from the table in Appendix B, and the positions of moorings are the triangulated positions.

Event	Event type	CTD no	Waypoint	yy/mm/dd hhmm	lat deg min	lon deg min	Comment
1	CTD	1	Test 1	21/02/03 1530-1653	52° 21.183' S	049° 46.226' W	Failed – swivel
2	Bongo		Test 1	21/02/03 1719-1740	52° 21.184' S	049° 46.225' W	Frame only – no net
3	CTD	2	Test 2	21/02/04 1212-1243	52° 35.621' S	044° 37.325' W	Failed – winch scrolling
4	CTD	3	Test 3	21/02/04 1629-1909	52° 38.252' S	043° 46.858' W	
5	CTD	4	P3	21/02/05 0819-1124	52° 47.753' S	040° 06.269' W	
6	Mooring recovery		P3	21/02/05 1233-1424	52° 48.520' S	040° 06.830' W	
7	CTD	5	W1.2CTDS	21/02/05 2119-2214	53° 50.842' S	039° 08.522' W	
8	Bongo		W1.2CTDS	21/02/05 2233-2257	53° 50.842' S	039° 08.523' W	
9	Bongo		W1.2CTDN	21/02/06 0204-0224	53° 29.588' S	039° 14.981' W	
10	CTD	6	W1.2CTDN	21/02/06 0510-0636	53° 29.602' S	039° 15.041' W	
11	Acoustic transect		W1.1	21/02/06 0910- 1327	53° 20.516' S 54° 03.083' S	039° 36.238' W 039° 23.602' W	
12	Acoustic transect		W1.2	21/02/06 1447- 1902	54° 01.467' S 53° 18.749' S	039° 05.323' W 039° 18.304' W	
13	CTD	7	W2.2CTDN	21/02/06 2130-2314	53° 25.913' S	038° 41.764' W	
14	Bongo		W2.2CTDN	21/02/06 2205-2226	53° 25.913' S	038° 41.764' W	Concurrent with CTD
15	CTD	8	W2.2CTDS	21/02/07 0219-0320	53° 47.056' S	038° 35.059' W	
16	Bongo		W2.2CTDS	21/02/07 0334-0406	53° 47.055' S	038° 35.059' W	
17	Acoustic transect		W2.1	21/02/07 0903- 1325	53° 59.718' S 53° 17.351' S	038° 49.120' W 039° 02.249' W	

Event	Event type	CTD no	Waypoint	yy/mm/dd hhmm	lat deg min	lon deg min	Comment
18	Acoustic transect		W2.2	21/02/07 1456-	53° 15.471' S	038° 45.003' W	
				1912	53° 57.480' S	038° 31.683' W	
19	Mooring recovery		WCB	21/02/07 2144-2246	53° 47.870' S	037° 56.140' W	
20	CTD	9	WCB	21/02/07 2319-0009	53° 47.798' S	037° 56.115' W	
21	Bongo		WCB	21/02/08 0023-0056	53° 47.798' S	037° 56.115' W	
22	Bongo		W3.2CTDS	21/02/08 0211-0232	53° 42.878' S	037° 57.850' W	
23	CTD	10	W3.2CTDS	21/02/08 0510-0605	53° 42.878' S	037° 57.848' W	
24	Acoustic transect		W3.1	21/02/08 0854-	53° 55.576' S	038° 13.287' W	
				1312	53° 13.346' S	038° 26.930' W	
25	CTD	11	W3.2CTDN	21/02/08 2157-2347	53° 21.588' S	038° 05.242' W	
26	Bongo		W3.2CTDN	21/02/08 2232-2253	53° 21.585' S	038° 05.241' W	Concurrent with CTD
27	Bongo		W4.2CTDS	21/02/08 0406-0425	53° 40.628' S	037° 39.190' W	
28	CTD	12	W4.2CTDS	21/02/09 0452-0541	53° 40.629' S	037° 39.189' W	
29	Acoustic transect		W3.2	21/02/09 0832-	53° 53.486' S	037° 54.381' W	
				1253	53° 11.175' S	038° 08.400' W	
30	Acoustic transect		W4.1	21/02/09 1358-	53° 09.760' S	037° 57.891' W	
				1819	53° 52.023' S	037° 43.715' W	
31	CTD	13	WCB	21/02/09 1921-2019	53° 47.866' S	037° 56.142' W	
32	Mooring deployment		WCB	21/02/09 2139-2233	53° 47.887' S	037° 56.153' W	
33	Bongo		W4.2CTDN	21/02/10 0151-0215	53° 19.499' S	037° 46.506' W	
34	CTD	14	W4.2CTDN	21/02/10 0232-0413	53° 19.499' S	037° 46.505' W	
35	Acoustic transect		W4.2	21/02/10 0811-	53° 08.858' S	037° 50.710' W	
				1235	53° 51.127' S	037° 36.602' W	
36	CTD	15	Stromness	21/02/10 1727-1804	54° 09.591' S	036° 41.579' W	
37	Acoustic calibration		Stromness	21/01/10 1826-0438	54° 09.590' S	036° 41.579' W	
38	CTD	16	P3	21/02/11 1944-2250	52° 48.531' S	040° 06.778' W	

Event	Event type	CTD no	Waypoint	yy/mm/dd hhmm	lat deg min	lon deg min	Comment
39	Mooring deployment		P3	21/02/11 2318-0323	52° 48.452' S	040° 06.868' W	
40	Bongo		P3	21/02/12 0333-0355	52° 48.410' S	040° 07.520' W	
41	Mooring triangulation		P3	21/02/12 0406-0526	variable		
42	CTD	17	Iceberg_far	21/02/13 0238-0344	55° 30.031' S	036°40.050' W	
43	CTD	18	Iceberg_W1	21/02/13 1811-1944	56° 41.832' S	034°50.787' W	1.1 nm from berg
44	CTD	19	Iceberg_W2.5	21/02/13 2010-2143	56° 41.786' S	034°53.465' W	
45	CTD	20	Iceberg_W5	21/02/13 2231-0004	56° 41.784' S	034°57.970' W	
46	CTD	21	Iceberg_W10	21/02/14 0116-0251	56° 41.908' S	035°08.079' W	
47	CTD	22	Iceberg_W20	21/02/14 0508-0649	56° 41.963' S	035°25.955' W	
48	CTD	23	Iceberg_S20	21/02/14 1027-1258	57° 07.601' S	034°39.813' W	23 nm from berg
49	Glider deployment		Iceberg_S10	21/02/14 1332-1413	56° 57.584' S	034°40.202' W	13 nm from berg
50	CTD	24	Iceberg_S10	21/02/14 1502-1630	56° 57.107' S	034°40.095' W	13 nm from berg
51	CTD	25	Iceberg_S1	21/02/14 1817-1936	56° 45.506' S	034°39.935' W	2.5 nm from berg
52	CTD	26	Iceberg_S2.5	21/02/14 2010-2138	56° 47.067' S	034°40.136' W	4 nm from berg
53	CTD	27	Iceberg_S5	21/02/14 2222-2356	56° 49.613' S	034°39.637' W	6.5 nm from berg
54	CTD	28	Iceberg_S9	21/02/15 0048-0222	56° 53.548' S	034°39.772' W	10.5 nm from berg
55	Glider deployment		Iceberg_N20	21/02/15 1815-1835	56° 14.180' S	034°39.012' W	Near A-68P
56	CTD	29	Iceberg_N20	21/02/15 1912-2125	56° 14.578' S	034°40.976' W	
57	CTD	30	Iceberg_H1	21/02/16 0741-0931	55° 39.191' S	034°45.089' W	
58	CTD	31	Iceberg_H2	21/02/16 1002-1203	55° 36.658' S	034°48.808' W	
59	CTD	32	Iceberg_H3	21/02/16 1233-1403	55° 34.349' S	034°51.855' W	
60	CTD	33	Iceberg_H4	21/02/16 1433-1623	55° 31.249' S	034°56.083' W	
61	CTD	34	Iceberg_H5	21/02/16 1645-1815	55° 29.671' S	034°58.120' W	
62	CTD	35	Iceberg_H6	21/02/16 1836-2006	55° 28.479' S	034°59.858' W	
63	CTD	36	A23-52	21/02/17 0108-0235	55° 13.242' S	034°30.670' W	Slightly deeper because of berg
64	CTD	37	A23-51A	21/02/17 0255-0504	55° 13.708' S	034°29.367' W	

Event	Event type	CTD no	Waypoint	yy/mm/dd hhmm	lat deg min	lon deg min	Comment
65	CTD	38	A23-51	21/02/17 0551-0746	55° 15.560' S	034°26.583' W	
66	CTD	39	A23-50A	21/02/17 0819-1055	55° 17.108' S	034°24.074' W	
67	CTD	40	A23-50	21/02/17 1324-1600	55° 29.369' S	034°06.436' W	1 mile off because of berg
68	CTD	41	A23-49	21/02/17 1807-2116	55° 43.481' S	033°47.173' W	
69	CTD	42	A23-48	21/02/17 2340-0224	55° 59.496' S	033°25.181' W	
70	CTD	43	A23-47	21/02/18 0815-1105	56° 22.759' S	032°52.312' W	
71	CTD	44	A23-46	21/02/18 1638-1916	56° 46.528' S	032°18.233' W	Weight lowered to 3000m on CTD wire before cast to remove twists.
72	CTD	45	A23-45	21/02/18 2144-0049	57° 07.088' S	031°48.862' W	
73	CTD	46	A23-44	21/02/19 0049-0628	57° 27.481' S	031°19.731' W	
74	CTD	47	A23-43	21/02/19 0902-1222	57° 48.080' S	030°49.966' W	
75	CTD	48	A23-42	21/02/19 1437-1747	58° 12.753' S	030°49.257' W	With USBL & SVP on rosette
76	CTD	49	A23-41	21/02/19 2013-2320	58° 38.029' S	030°49.296' W	
77	CTD	50	A23-40	21/02/20 0220-0522	59° 03.032' S	030°49.778' W	
78	CTD	51	A23-39	21/02/20 0912-1156	59° 29.471' S	030°51.894' W	Moved 3 miles south because of berg
79	CTD	52	A23-37	21/02/20 1348-1701	59° 46.672' S	030°53.922' W	Moved 0.8 miles south because of berg
80	CTD	53	A23-36	21/02/20 1839-2138	59° 59.520' S	030°56.196' W	
81	CTD	54	A23-35	21/02/20 2344-0213	60° 18.792' S	030°59.425' W	
82	CTD	55	A23-34	21/02/21 0646-0848	60° 42.268' S	031°00.645' W	
83	CTD	56	A23-33	21/02/21 1120-1323	61° 06.553' S	031°02.363' W	Uplooker not working.
84	CTD	57	A23-32	21/02/21 1353-1706	61° 10.326' S	031°02.792' W	
85	CTD	58	A23-31	21/02/21 1930-2244	61° 33.076' S	031°06.050' W	
86	Argo float deployment		A23-31	21/02/21 2253-2257	61° 33.063' S	031°06.067' W	SN 9007, WMO no. 1901928
87	CTD	59	A23-30	21/02/21 2352-0236	61° 39.724' S	031°06.227' W	
88	CTD	60	A23-29	21/02/22 0617-1030	62° 04.304' S	031°10.845' W	
89	CTD	61	A23-28	21/02/23 1054-1213	62° 29.355' S	031°15.651' W	Cast to 1500 m, no bottles (DP desk failure). New uplooker.

Event	Event type	CTD no	Waypoint	yy/mm/dd hhmm	lat deg min	lon deg min	Comment
90	CTD	62	A23-28	21/02/23 1241-1604	62° 29.401' S	031°15.659' W	
91	CTD	63	A23-27	21/02/23 1845-2229	62° 46.971' S	030°41.489' W	
92	CTD	64	A23-26	21/02/24 0123-0459	63° 05.088' S	030°06.780' W	
93	Argo float deployment		A23-26	21/02/24 0505-0514	63° 05.029' S	030°06.017' W	SN 8991, WMO no. 1901927
94	CTD	65	A23-25	21/02/24 0744-1141	63° 20.844' S	029°33.992' W	
95	CTD	66	SR1b_30	21/02/27 1104-1152	61° 02.800' S	054°35.398' W	
96	CTD	67	SR1b_29	21/02/27 2152-2302	60° 58.840' S	054°37.844' W	
97	CTD	68	SR1b_28	21/02/28 0003-0136	60° 50.811' S	054°42.741' W	
98	CTD	69	SR1b_27	21/02/28 0152-0425	60° 49.771' S	054°43.725' W	
99	CTD	70	SR1b_26	21/02/28 0444-0738	60° 48.033' S	054°44.408' W	
100	CTD	71	SR1b_25	21/02/28 0852-1151	60° 40.146' S	054°49.156' W	
101	CTD	72	SR1b_24	21/02/28 1440-1737	60° 20.125' S	055°01.519' W	With USBL on rosette
102	CTD	73	SR1b_23	21/02/28 1957-2305	60° 00.083' S	055°14.605' W	
103	CTD	74	SR1b_22	21/03/01 0143-0508	59° 40.198' S	055°26.747' W	
104	CTD	75	SR1b_21	21/03/01 0753-1121	59° 20.009' S	055°38.510' W	
105	CTD	76	SR1b_20	21/03/01 1359-1717	59° 00.020' S	055°50.886' W	
106	CTD	77	SR1b_19	21/03/01 1935-2328	58° 41.102' S	056°03.182' W	
107	CTD	78	SR1b_18	21/03/02 0136-0455	58° 21.959' S	056°14.299' W	
108	Argo float deployment		SR1b_18	21/03/02 0458-0506	58° 21.964' S	056°13.390' W	SN 8576, WMO no. 1901926
109	CTD	79	SR1b_17	21/03/02 0725-1050	58° 03.098' S	056°26.342' W	
110	CTD	80	SR1b_16	21/03/02 1319-1628	57° 44.960' S	056°38.593' W	
111	CTD	81	SR1b_15	21/03/02 1919-2259	57° 26.134' S	056°49.746' W	
112	CTD	82	SR1b_14	21/03/03 0144-0518	57° 06.089' S	057°00.764' W	
113	CTD	83	SR1b_13	21/03/03 0745-1035	56° 47.192' S	057°12.756' W	
114	CTD	84	SR1b_12	21/03/03 1245-1607	56° 27.967' S	057°25.688' W	
115	CTD	85	SR1b_11	21/03/03 1820-2102	56° 09.235' S	057°37.008' W	

Event	Event type	CTD no	Waypoint	yy/mm/dd hhmm	lat deg min	lon deg min	Comment
116	Argo float deployment		SR1b_11	21/03/03 2111-2113	56° 09.428' S	057°36.685' W	SN 8575, WMO no. 1901925
117	CTD	86	SR1b_10	21/03/03 2321-0311	55° 50.225' S	057°46.507' W	
118	CTD	87	SR1b_9	21/03/04 0528-0850	55° 31.271' S	057°58.273' W	
119	CTD	88	SR1b_8	21/03/04 1049-1416	55° 12.890' S	057°59.010' W	
120	CTD	89	SR1b_7	21/03/04 1442-1735	55° 10.198' S	057°58.801' W	
121	CTD	90	SR1b_6	21/03/04 1802-2050	55° 07.295' S	057°58.726' W	
122	CTD	91	SR1b_5	21/03/04 2117-0000	55° 04.208' S	057°59.058' W	
123	CTD	92	SR1b_4	21/03/05 0035-0257	55° 00.428' S	057°58.963' W	
124	CTD	93	SR1b_3	21/03/05 0325-0525	54° 58.670' S	057°58.998' W	
125	CTD	94	SR1b_2	21/03/05 0600-0803	54° 55.340' S	057°59.000' W	
126	CTD	95	SR1b_1	21/03/05 0949-1150	54° 40.040' S	057°58.880' W	
127	CTD	96	SR1b_N1	21/03/05 1715-1832	53° 48.412' S	057°36.941' W	
128	CTD	97	SR1b_N2	21/03/05 1917-2116	53° 43.219' S	057°38.744' W	
129	CTD	98	SR1b_N3	21/03/05 2244-0112	53° 30.972' S	057°43.019' W	
130	CTD	99	SR1b_N4	21/03/06 0234-0431	53° 18.883' S	057°44.004' W	
131	CTD	100	SR1b_N5	21/03/06 0619-0740	53° 03.443' S	057°45.096' W	
132	ADCP bottom-track calibration			21/03/06 1107-0513	variable		

Appendix B: CTD casts

The three times are start of downcast, bottom (or maximum wire out), and end of data acquisition on upcast. Positions are given at maximum wire out. cordep = corrected bottom depth; maxd = maximum CTD depth; minalt = minimum altimeter altitude; ndpth = number of bottle firing depths; nsal = number of salinity samples drawn; noxy = number of oxygen samples drawn; nnut = number of nutrient and silicate isotope samples drawn; no18 = number of $\delta^{18}O$ samples drawn; nlug = number of Lugol's samples drawn; npom = number of particulate organic matter samples drawn; nchl = number of chlorophyll samples drawn

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
1	Test 1	1	21/02/03 1609 21/02/03 1630 21/02/03 1630	52° 21.183'S	049° 46.226'W	3126	675	n/a	0	0	0	0	0	0	0	0
3	Test 2	2	21/02/04 1223 21/02/04 1232 21/02/04 1241	52° 35.621'S	044° 37.325'W	3368	106	n/a	0	0	0	0	0	0	0	0
4	Test 3	3	21/02/04 1633 21/02/04 1741 21/02/04 1907	52° 38.252'S	043° 46.858'W	3346	3336	9	10	10	10	2	2	2	0	0
5	P3	4	21/02/05 0827 21/02/05 0941 21/02/05 1122	52° 47.753'S	040° 06.269'W	3746	3733	11	12	14	12	6	0	6	9	6
7	W1.2CTDS	5	21/02/05 2124 21/02/05 2141 21/02/05 2211	53° 50.842'S	039° 08.522'W	283	276	8	8	1	4	5	0	5	7	5
10	W1.2CTDN	6	21/02/06 0515 21/02/06 0536 21/02/06 0632	53° 29.602'S	039° 15.041'W	3111	1003	n/a	11	6	6	6	0	6	7	6

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
13	W2.2CTDN	7	21/02/06 2151 21/02/06 2215 21/02/06 2302	53° 25.913'S	038° 41.764'W	3457	1005	n/a	10	6	6	5	0	5	8	5
15	W2.2CTDS	8	21/02/07 0239 21/02/07 0250 21/02/07 0318	53° 47.056'S	038° 35.059'W	208	199	8	7	4	4	5	0	5	6	5
20	WCB	9	21/02/07 2323 21/02/07 2337 21/02/08 0007	53° 47.798'S	037° 56.115'W	307	297	9	9	4	4	5	0	5	7	5
23	W3.2CTDS	10	21/02/08 0515 21/02/08 0523 21/02/08 0550	53° 42.878'S	037° 57.848'W	136	124	10	6	7	4	4	0	4	6	4
25	W3.2CTDN	11	21/02/08 2221 21/02/08 2245 21/02/08 2334	53° 21.588'S	038° 05.242'W	2612	1006	n/a	10	6	6	6	0	6	8	6
28	W4.2CTDS	12	21/02/09 0457 21/02/09 0501 21/02/09 0526	53° 40.629'S	037° 39.189'W	118	106	9	6	4	4	4	0	4	5	4
31	WCB	13	21/02/09 1940 21/02/09 1951 21/02/09 2018	53° 47.866'S	037° 56.142'W	296	285	9	5	5	5	0	0	0	0	0
34	W4.2CTDN	14	21/02/10 0238 21/02/10 0301 21/02/10 0355	53° 19.499'S	037° 46.505'W	2790	1004	n/a	10	6	6	6	0	6	8	6

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
36	Stromness	15	21/02/10 1748 21/02/10 1753 21/02/10 1802	54° 09.591'S	036° 41.579'W	89	77	10	3	3	3	0	0	0	0	0
38	P3	16	21/02/11 2001 21/02/11 2116 21/02/11 2249	52° 48.531'S	040° 06.778'W	3749	3737	11	12	12	12	0	0	0	0	0
42	Iceberg_far	17	21/02/13 0241 21/02/13 0307 21/02/13 0343	55° 30.031'S	036° 40.050'W	3403	1000	n/a	7	7	6	6	6	6	4	0
43	Iceberg_W1	18	21/02/13 1833 21/02/13 1853 21/02/13 1937	56° 41.832'S	034° 50.787'W	3540	1006	n/a	7	7	6	5	6	5	4	0
44	Iceberg_W2.5	19	21/02/13 2039 21/02/13 2100 21/02/13 2142	56° 41.786'S	034° 53.465'W	3651	1006	n/a	7	7	6	5	6	5	0	0
45	Iceberg_W5	20	21/02/13 2248 21/02/13 2309 21/02/13 2352	56° 41.784'S	034° 57.970'W	3674	1005	n/a	7	7	6	5	6	5	0	0
46	Iceberg_W10	21	21/02/14 0137 21/02/14 0158 21/02/14 0242	56° 41.908'S	035° 08.079'W	3735	1003	n/a	7	7	6	5	6	5	4	0
47	Iceberg_W20	22	21/02/14 0527 21/02/14 0550 21/02/14 0631	56° 41.963'S	035° 25.955'W	3373	1001	n/a	7	7	6	5	6	5	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
48	Iceberg_S20	23	21/02/14 1040 21/02/14 1101 21/02/14 1146	57° 07.601'S	034° 39.813'W	3208	1005	n/a	7	7	4	5	6	5	0	0
50	Iceberg_S10	24	21/02/14 1527 21/02/14 1550 21/02/14 1629	56° 57.107'S	034° 40.095'W	2757	1002	n/a	7	7	4	5	6	5	0	0
51	Iceberg_S1	25	21/02/14 1828 21/02/14 1851 21/02/14 1935	56° 45.506'S	034° 39.935'W	3399	1001	n/a	8	7	4	5	6	5	0	0
52	Iceberg_S2.5	26	21/02/14 2029 21/02/14 2052 21/02/14 2136	56° 47.067'S	034° 40.136'W	3328	1007	n/a	7	6	4	5	6	5	0	0
53	Iceberg_S5	27	21/02/14 2239 21/02/14 2300 21/02/14 2344	56° 49.613'S	034° 39.637'W	3158	1006	n/a	7	6	3	5	6	5	0	0
54	Iceberg_S9	28	21/02/15 0108 21/02/15 0131 21/02/15 0213	56° 53.548'S	034° 39.772'W	2749	1004	n/a	7	6	3	5	6	5	0	0
56	Iceberg_N20	29	21/02/15 1948 21/02/15 2015 21/02/15 2102	56° 14.578'S	034° 40.976'W	3678	1005	n/a	7	7	4	5	6	5	0	0
57	Iceberg_H1	30	21/02/16 0802 21/02/16 0833 21/02/16 0921	55° 39.191'S	034° 45.089'W	1266	1254	9	8	7	3	5	6	5	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
58	Iceberg_H2	31	21/02/16 1034 21/02/16 1106 21/02/16 1156	55° 36.658'S	034° 48.808'W	1401	1389	10	7	6	3	5	6	5	0	0
59	Iceberg_H3	32	21/02/16 1304 21/02/16 1320 21/02/16 1358	55° 34.349'S	034° 51.855'W	471	460	10	7	7	3	5	6	5	0	0
60	Iceberg_H4	33	21/02/16 1500 21/02/16 1531 21/02/16 1613	55° 31.249'S	034° 56.083'W	1155	1143	10	7	7	4	5	6	5	0	0
61	Iceberg_H5	34	21/02/16 1709 21/02/16 1731 21/02/16 1810	55° 29.671'S	034° 58.120'W	893	881	10	7	7	4	5	6	5	0	0
62	Iceberg_H6	35	21/02/16 1902 21/02/16 1918 21/02/16 1956	55° 28.479'S	034° 59.858'W	548	535	11	7	6	4	6	6	6	0	0
63	A23-52	36	21/02/17 0129 21/02/17 0147 21/02/17 0231	55° 13.242'S	034° 30.670'W	656	641	9	8	8	4	5	8	0	0	0
64	A23-51A	37	21/02/17 0334 21/02/17 0404 21/02/17 0451	55° 13.708'S	034° 29.367'W	1026	1015	10	7	7	4	5	7	0	0	0
65	A23-51	38	21/02/17 0613 21/02/17 0645 21/02/17 0742	55° 15.560'S	034° 26.583'W	1514	1502	11	8	6	6	4	0	0	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
66	A23-50A	39	21/02/17 0845 21/02/17 0931 21/02/17 1043	55° 17.108'S	034° 24.074'W	2022	2002	12	12	12	6	5	12	0	0	0
67	A23-50	40	21/02/17 1344 21/02/17 1438 21/02/17 1557	55° 29.369'S	034° 06.436'W	2574	2558	11	10	10	0	0	10	0	0	0
68	A23-49	41	21/02/17 1828 21/02/17 1936 21/02/17 2114	55° 43.481'S	033° 47.173'W	3521	3508	10	15	15	0	0	15	0	0	0
69	A23-48	42	21/02/17 2356 21/02/18 0056 21/02/18 0217	55° 59.496'S	033° 25.181'W	3076	3060	13	8	8	0	0	0	0	0	0
70	A23-47	43	21/02/18 0828 21/02/18 0928 21/02/18 1101	56° 22.759'S	032° 52.312'W	3140	3127	10	11	12	0	0	11	0	0	0
71	A23-46	44	21/02/18 1641 21/02/18 1742 21/02/18 1915	56° 46.528'S	032° 18.233'W	3232	3220	10	8	8	0	0	0	0	0	0
72	A23-45	45	21/02/18 2201 21/02/18 2305 21/02/19 0044	57° 07.088'S	031° 48.862'W	3439	3426	11	15	0	0	0	15	0	0	0
73	A23-44	46	21/02/19 0342 21/02/19 0455 21/02/19 0617	57° 27.481'S	031° 19.731'W	3746	3734	10	5	0	0	0	0	0	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
74	A23-43	47	21/02/19 0920 21/02/19 1032 21/02/19 1216	57° 48.080'S	030° 49.966'W	3582	3569	11	12	8	0	0	12	0	0	0
75	A23-42	48	21/02/19 1504 21/02/19 1619 21/02/19 1741	58° 12.753'S	030° 49.257'W	4001	3987	11	4	4	0	0	0	0	0	0
76	A23-41	49	21/02/19 2028 21/02/19 2133 21/02/19 2316	58° 38.029'S	030° 49.296'W	3504	3489	11	15	14	0	0	13	0	0	0
77	A23-40	50	21/02/20 0249 21/02/20 0347 21/02/20 0520	59° 03.032'S	030° 49.778'W	3122	3110	10	11	11	0	0	11	0	0	0
78	A23-39	51	21/02/20 0929 21/02/20 1036 21/02/20 1153	59° 29.471'S	030° 51.894'W	3404	3390	10	5	5	0	0	5	0	0	0
79	A23-37	52	21/02/20 1404 21/02/20 1514 21/02/20 1659	59° 46.672'S	030° 53.922'W	3793	3780	11	13	13	0	0	13	0	0	0
80	A23-36	53	21/02/20 1858 21/02/20 1959 21/02/20 2131	59° 59.520'S	030° 56.196'W	2991	2977	11	14	14	0	0	14	0	0	0
81	A23-35	54	21/02/21 0005 21/02/21 0102 21/02/21 0203	60° 18.792'S	030° 59.425'W	2580	2545	5	4	3	0	0	4	0	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
82	A23-34	55	21/02/21 0705 21/02/21 0740 21/02/21 0838	60° 42.268'S	031° 00.645'W	1504	1492	10	11	11	0	0	11	0	0	0
83	A23-33	56	21/02/21 1129 21/02/21 1223 21/02/21 1321	61° 06.553'S	031° 02.363'W	2566	2552	11	4	4	0	0	0	0	0	0
84	A23-32	57	21/02/21 1414 21/02/21 1529 21/02/21 1656	61° 10.326'S	031° 02.792'W	3485	3469	12	13	12	0	0	12	0	0	0
85	A23-31	58	21/02/21 1944 21/02/21 2107 21/02/21 2242	61° 33.076'S	031° 06.050'W	4079	4064	13	8	4	0	0	0	0	0	0
87	A23-30	59	21/02/22 0010 21/02/22 0117 21/02/22 0228	61° 39.724'S	031° 06.227'W	3325	3311	9	5	5	0	0	0	0	0	0
88	A23-29	60	21/02/22 0638 21/02/22 0807 21/02/22 1024	62° 04.304'S	031° 10.845'W	4851	4838	10	18	18	0	0	18	0	0	0
89	A23-28	61	21/02/23 1114 21/02/23 1143 21/02/23 1213	62° 29.355'S	031° 15.651'W	4763	1534	n/a	0	0	0	0	0	0	0	0
90	A23-28	62	21/02/23 1245 21/02/23 1414 21/02/23 1601	62° 29.401'S	031° 15.659'W	4767	4753	12	8	4	8	0	0	0	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
91	A23-27	63	21/02/23 1851 21/02/23 2019 21/02/23 2223	62° 46.971'S	030° 41.489'W	4833	4818	12	15	15	6	0	15	0	0	0
92	A23-26	64	21/02/24 0138 21/02/24 0306 21/02/24 0457	63° 05.088'S	030° 06.780'W	4865	4851	11	8	4	8	0	0	0	0	0
94	A23-25	65	21/02/24 0800 21/02/24 0927 21/02/24 1133	63° 20.844'S	029° 33.992'W	4734	4720	11	17	17	6	0	17	0	0	0
95	SR1b_30	66	21/02/27 1111 21/02/27 1123 21/02/27 1145	61° 02.800'S	054° 35.398'W	383	369	12	4	4	4	0	4	0	0	0
96	SR1b_29	67	21/02/27 2207 21/02/27 2225 21/02/27 2254	60° 58.840'S	054° 37.844'W	582	570	10	6	6	6	0	6	0	0	0
97	SR1b_28	68	21/02/28 0019 21/02/28 0048 21/02/28 0131	60° 50.811'S	054° 42.741'W	1088	1066	13	8	8	6	0	8	0	0	0
98	SR1b_27	69	21/02/28 0217 21/02/28 0259 21/02/28 0411	60° 49.771'S	054° 43.725'W	1983	1959	19	14	14	8	0	14	0	0	0
99	SR1b_26	70	21/02/28 0524 21/02/28 0620 21/02/28 0728	60° 48.033'S	054° 44.408'W	2563	2554	14	8	8	6	0	8	0	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
100	SR1b_25	71	21/02/28 0912 21/02/28 1011 21/02/28 1146	60° 40.146'S	054° 49.156'W	3106	3093	12	13	13	6	0	12	0	0	0
101	SR1b_24	72	21/02/28 1457 21/02/28 1559 21/02/28 1728	60° 20.125'S	055° 01.519'W	3437	3423	12	11	11	6	0	11	0	0	0
102	SR1b_23	73	21/02/28 2015 21/02/28 2124 21/02/28 2259	60° 00.083'S	055° 14.605'W	3501	3489	10	12	12	6	0	12	0	0	0
103	SR1b_22	74	21/03/01 0157 21/03/01 0308 21/03/01 0455	59° 40.198'S	055° 26.747'W	3673	3662	10	14	13	8	0	14	0	0	0
104	SR1b_21	75	21/03/01 0815 21/03/01 0929 21/03/01 1119	59° 20.009'S	055° 38.510'W	3760	3747	12	16	16	8	0	16	0	0	0
105	SR1b_20	76	21/03/01 1416 21/03/01 1528 21/03/01 1707	59° 00.020'S	055° 50.886'W	3773	3761	9	12	12	0	0	12	0	0	0
106	SR1b_19	77	21/03/01 1949 21/03/01 2059 21/03/01 2241	58° 41.102'S	056° 03.182'W	3751	3739	9	14	14	8	0	14	0	0	0
107	SR1b_18	78	21/03/02 0149 21/03/02 0301 21/03/02 0452	58° 21.959'S	056° 14.299'W	3896	3882	11	15	16	8	0	16	0	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
109	SR1b_17	79	21/03/02 0741 21/03/02 0856 21/03/02 1043	58° 03.098'S	056° 26.342'W	3946	3932	10	12	11	8	0	12	0	0	0
110	SR1b_16	80	21/03/02 1331 21/03/02 1442 21/03/02 1621	57° 44.960'S	056° 38.593'W	3574	3560	9	14	14	0	0	14	0	0	0
111	SR1b_15	81	21/03/02 1942 21/03/02 2104 21/03/02 2248	57° 26.134'S	056° 49.746'W	3880	3826	11	13	13	6	0	13	0	0	0
112	SR1b_14	82	21/03/03 0202 21/03/03 0315 21/03/03 0502	57° 06.089'S	057° 00.764'W	3825	3820	9	14	14	8	0	14	0	0	0
113	SR1b_13	83	21/03/03 0758 21/03/03 0904 21/03/03 1026	56° 47.192'S	057° 12.756'W	3289	3276	12	10	10	6	0	9	0	0	0
114	SR1b_12	84	21/03/03 1302 21/03/03 1417 21/03/03 1601	56° 27.967'S	057° 25.688'W	3848	3823	11	13	13	7	0	13	0	0	0
115	SR1b_11	85	21/03/03 1831 21/03/03 1934 21/03/03 2101	56° 09.235'S	057° 37.008'W	3349	3332	13	10	10	9	0	10	0	0	0
117	SR1b_10	86	21/03/03 2333 21/03/04 0103 21/03/04 0301	55° 50.225'S	057° 46.507'W	4783	4772	9	14	14	10	0	14	0	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
118	SR1b_9	87	21/03/04 0539 21/03/04 0657 21/03/04 0840	55° 31.271'S	057° 58.273'W	4224	4210	11	12	12	0	0	12	0	0	0
119	SR1b_8	88	21/03/04 1103 21/03/04 1221 21/03/04 1406	55° 12.890'S	057° 59.010'W	4017	4003	11	14	14	4	0	14	0	0	0
120	SR1b_7	89	21/03/04 1506 21/03/04 1606 21/03/04 1729	55° 10.198'S	057° 58.801'W	3117	3105	9	10	10	4	0	10	0	0	0
121	SR1b_6	90	21/03/04 1828 21/03/04 1921 21/03/04 2045	55° 07.295'S	057° 58.726'W	2749	2748	99	15	15	4	0	15	0	0	0
122	SR1b_5	91	21/03/04 2154 21/03/04 2241 21/03/04 2351	55° 04.208'S	057° 59.058'W	2224	2211	11	8	8	4	0	2	0	0	0
123	SR1b_4	92	21/03/05 0103 21/03/05 0141 21/03/05 0245	55° 00.428'S	057° 58.963'W	1673	1658	12	15	15	3	0	15	0	0	0
124	SR1b_3	93	21/03/05 0411 21/03/05 0438 21/03/05 0513	54° 58.670'S	057° 58.998'W	1057	1036	10	6	6	2	0	6	0	0	0
125	SR1b_2	94	21/03/05 0622 21/03/05 0641 21/03/05 0713	54° 55.340'S	057° 59.000'W	717	705	10	6	6	2	0	6	0	0	0

Event	Waypoint	stn	y/m/d hhmm	lat deg min	lon deg min	cordep	maxd	minalt	ndpth	nsal	noxy	nnut	no18	nlug	npom	nchl
126	SR1b_1	95	21/03/05 1002 21/03/05 1014 21/03/05 1028	54° 40.040'S	057° 58.880'W	167	154	11	4	4	2	0	4	0	0	0
127	SR1b_N1	96	21/03/05 1727 21/03/05 1754 21/03/05 1827	53° 48.412'S	057° 36.941'W	1169	1156	11	4	4	0	0	0	0	0	0
128	SR1b_N2	97	21/03/05 1931 21/03/05 2015 21/03/05 2108	53° 43.219'S	057° 38.744'W	2060	2046	10	4	4	0	0	0	0	0	0
129	SR1b_N3	98	21/03/05 2306 21/03/05 2358 21/03/06 0059	53° 30.972'S	057° 43.019'W	2539	2528	10	5	5	0	0	0	0	0	0
130	SR1b_N4	99	21/03/06 0253 21/03/06 0328 21/03/06 0422	53° 18.883'S	057° 44.004'W	1731	1719	11	6	6	0	0	0	0	0	0
131	SR1b_N5	100	21/03/06 0633 21/03/06 0653 21/03/06 0729	53° 03.443'S	057° 45.096'W	925	913	10	5	5	0	0	0	0	0	0

Appendix C: Sensors and Moorings report

Dougal Mountifield, Tom Ballinger & Jon Short

CTD Summary

The JC211 CTD work included a re-occupation of the A23 and SR1b transects that were completed on DY113 (Feb-March 2020). There were also a series of CTD deployments at the WCB sites NE of South Georgia and the P3 & WCB mooring sites. In addition, three short transects were completed in the vicinity of iceberg A68.

100 CTD casts were undertaken with an NMF 24-way Stainless Steel CTD frame with 24 off 10-l OTE water samplers. Dual SBE 43 dissolved oxygen sensors were used as on DY113. The temperature, conductivity and dissolved oxygen sensors mounted to the vane were connected to the primary channel unlike DY113.

The WETLabs BBrtd sensor was mounted in a horizontal orientation on the vane and a SBE35 was mounted on a vertical stanchion of the CTD frame as per DY113. A pair of TRDI Workhorse 300-kHz LADCPs used in a down-looking master, up-looking slave configuration powered by an NMF LADCP battery pack with a titanium housing.

The ODIM winch system Active Heave Compensation (AHC) system was used on all casts apart from shallower casts. The AHC system is currently engaged at the 100 m changeover depth where winch control is changed from belly-box manual mode to HMI automatic mode.

Three test-casts were completed, with the first two aborted. The first test cast suffered from electrical failure of the EM swivel, the second due to winch HMI communications problems.

Mooring recovery and re-deployment calibration casts were undertaken at each of the P3 and WCB mooring sites and a further eight casts completed during the WCB EK60 acoustic survey. A single cast was undertaken in Stromness Harbour for EK60 calibration.

19 casts were completed in the vicinity of Iceberg A-68A over three short transects. The first transect to the west of the iceberg, the second to the south. The northern transect was aborted due to ice conditions and a third 'H' transect was completed instead.

Thirty CTD profiles were completed at 29 stations on the A23 line. The transect was worked from north to south. Two stations were turned, one due to the proximity of a station that was relocated due to ice, and the second due to weather. One station was aborted and subsequently repeated due to vessel DP desk problems.

All thirty stations of the SR1b line were completed often in arduous conditions and a big swell peaking at 6-7 m. An additional three stations were occupied on the NSR line from DY113 plus an additional two intermediate stations.

The deepest cast was CTD064 at station A23_26 which descended to 4851 m. The shallowest cast was CTD015 in Stromness Harbour for EK60 calibration which descended to 77 m.

Stainless Steel CTD Configuration

Instrument Package

The following sensors were installed on the CTD frame:

CTD Underwater Unit	Seabird SBE 9plus	09p-1257
Primary Temperature Sensor	Seabird SBE 3P	3p-2729
Primary Conductivity Sensor	Seabird SBE 4C	4c-3054
Pressure sensor	Paroscientific Digiquartz	134949
Secondary Temperature Sensor	Seabird SBE 3P	3p-4814
Secondary Conductivity Sensor	Seabird SBE 4C	4c-3567
Primary Pump	Seabird SBE 5T	05-7514
Secondary Pump	Seabird SBE 5T	05-7516
Primary Dissolved Oxygen Sensor	Seabird SBE 43	43-1882
Secondary Dissolved Oxygen Sensor	Seabird SBE 43	43-2575
Altimeter	Tritech PA200	6196.118171
Back Scattering Sensor	WETLabs BBrtd	5690
Transmissometer	WET Labs C-Star	1602DR
Fluorimeter	CTG Aquatracka MKIII	088185
PAR Down-looking UWIRR	Biospherical QCP-2350-HP	70520
PAR Up-looking DWIRR	Biospherical QCP-2350-HP	70510
Deep Ocean Standards Thermometer	Seabird SBE 35 DOST	35-34173-0048
Down-looking Master LADCP	TRDI Workhorse 300kHz	24466
Up-looking Slave LADCP	TRDI Workhorse 300kHz	24465
Spare Up-looking Slave LADCP	TRDI Workhorse 300kHz	15288

Often, end-users of CTD data interpret the terms ***primary*** and ***secondary*** as relating to quality; primary meaning 'most important' and secondary meaning 'less important'. The vane-mounted sensors usually produce cleaner measurements. They are sited in a flow of primary quality because they are less subject to package wake effects. The frame-mounted sensors are usually subject to greater package wake effects and should be considered of secondary quality.

The normal working practice has been to connect the vane sensors to the secondary channel. This does not follow the plain-English interpretation of the term 'secondary' and is a common source of confusion.

Following the plain-English interpretation, the primary T, C & DO sensors with associated pump were mounted on the vane. The secondary T, C & DO sensors with associated pump were mounted within the frame attached to the 9plus underwater unit.

This is different to the historical arrangement used on DY113 where the primary sensors were on the 9plus and the secondary sensors on the vane.

For clarity, the terms primary and secondary do not normally refer to the absolute accuracy, stability, or noise of the sensors themselves, although it could if the sensors were selected specifically for these properties.

The WETLabs BBrtd backscatter sensor was relocated from a down-looking orientation within the CTD frame to a side-looking orientation on the CTD vane to site it in cleaner water-flow. This is the same arrangement as used on DY113. The rationale was to improve the signal to noise ratio and reduce offset between down-cast and up-cast that has been observed in the past. The centre of the BBrtd face was located **0.77m above the pressure sensor**.

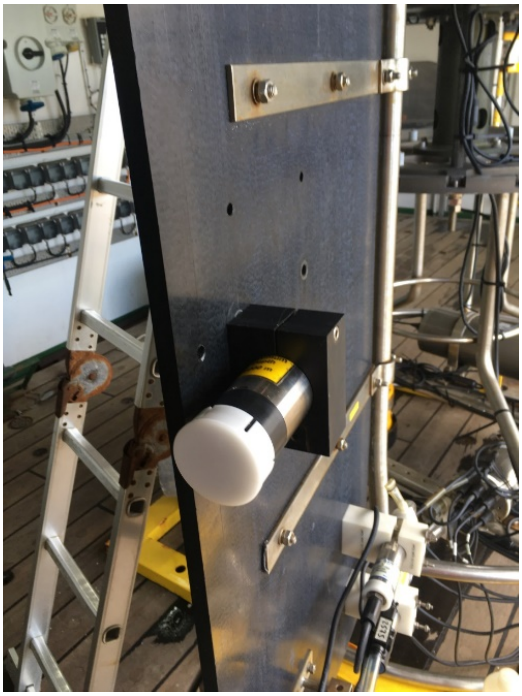


Figure 38. WETLabs BBrtd backscatter sensor mounting location – same as DY113.

The down-looking TRDI Workhorse LADCP was located at the centre of the CTD frame. The up-looking unit was mounted within an out-rigger sub-frame on the opposite side of the CTD frame to the vane.

All instrument serial numbers and all channels of the 9plus underwater unit checked prior to completing the Sensor Information Sheets for JC211.

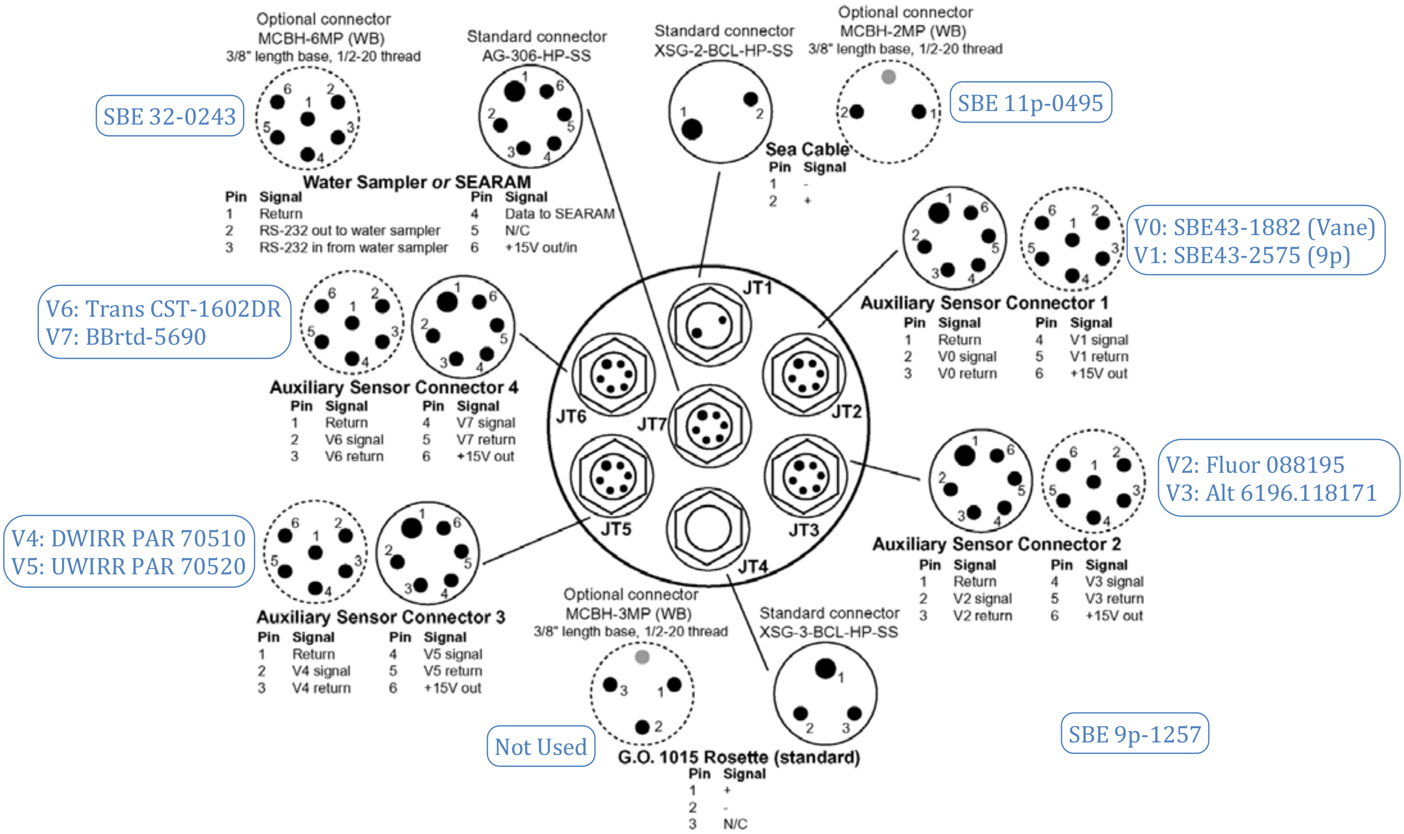


Figure 39. SBE 9plus CTD Top End Cap Configuration.

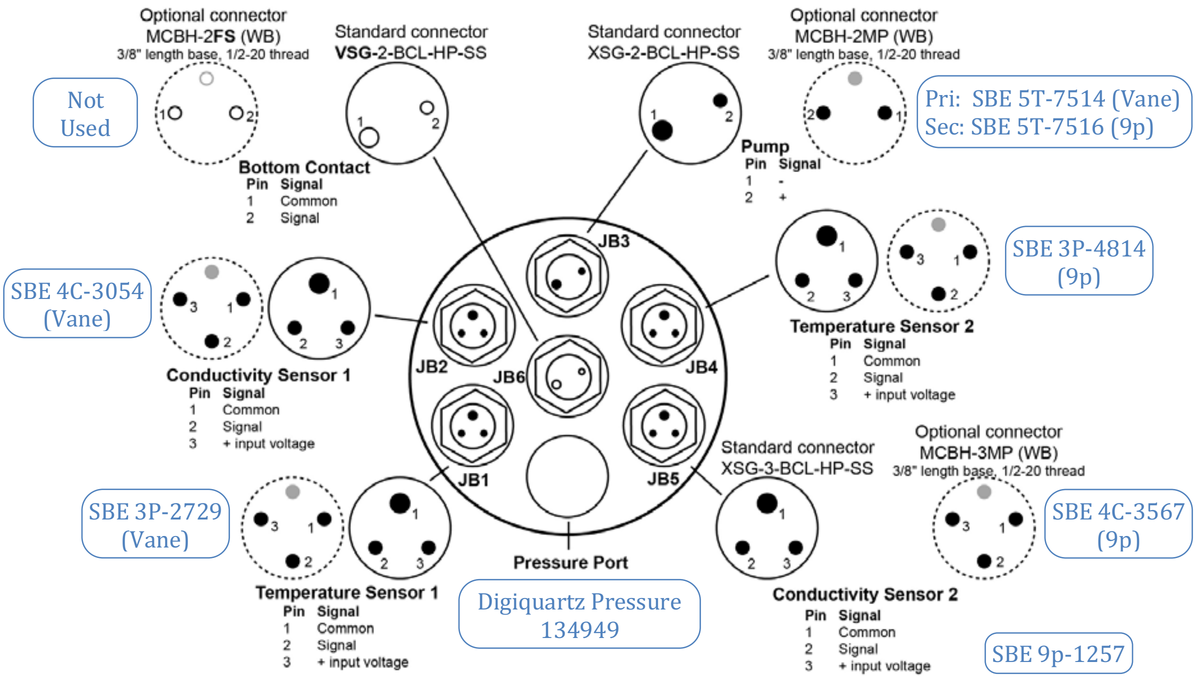


Figure 40. SBE 9plus CTD Bottom End Cap Configuration.

Seasave Configuration & Instrument Calibrations

The Seasave Instrument Configuration file used for all casts was JC211_1257_SS_nmea.xmlcon

```
Date: 01/30/2021

Instrument configuration file:
C:\Users\sandm\Documents\Cruises\JC211\Data\Seasave Setup
Files\JC211_1257_SS_nmea.xmlcon

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

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Deck unit                     : SBE11plus Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : PC
Surface PAR voltage added     : No
Scan time added               : Yes

1) Frequency 0, Temperature

   Serial number : 2729
   Calibrated on : 11-Jul-19
   G             : 4.35519545e-003
   H             : 6.41791295e-004
   I             : 2.33034275e-005
   J             : 2.25073602e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3054
   Calibrated on : 27-Jun-19
   G             : -9.80448346e+000
   H             : 1.42115323e+000
   I             : 1.50714886e-004
   J             : 6.41082496e-005
   CTcor         : -9.5700e-008
   CPcor         : 3.25000000e-006
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 134949
   Calibrated on : 25-Mar-19
   C1            : -3.695717e+004
   C2            : -2.691791e-001
   C3            : 1.143300e-002
   D1            : 3.349300e-002
   D2            : 0.000000e+000
   T1            : 3.049225e+001
   T2            : -3.372510e-004
   T3            : 3.990980e-006
```

```
   T4             : 3.875890e-009
   T5             : 0.000000e+000
   Slope          : 0.99992000
   Offset         : -0.73690
   AD590M         : 1.280330e-002
   AD590B         : -9.092840e+000

4) Frequency 3, Temperature, 2

   Serial number : 4814
   Calibrated on : 22-Nov-19
   G              : 4.30116603e-003
   H              : 6.24862552e-004
   I              : 1.87158072e-005
   J              : 1.31907445e-006
   F0             : 1000.000
   Slope          : 1.00000000
   Offset         : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 3567
   Calibrated on : 27-Jun-19
   G              : -1.04172144e+001
   H              : 1.25284529e+000
   I              : -1.45044812e-003
   J              : 1.57017101e-004
   CTcor          : 3.2500e-006
   CPcor          : -9.57000000e-008
   Slope          : 1.00000000
   Offset         : 0.00000

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

   Serial number : 1882
   Calibrated on : 21-Dec-19
   Equation       : Sea-Bird
   Soc            : 4.56800e-001
   Offset         : -4.89600e-001
   A              : -4.26840e-003
   B              : 1.80740e-004
   C              : -2.43670e-006
   E              : 3.60000e-002
   Tau20          : 1.06000e+000
   D1             : 1.92634e-004
   D2             : -4.64803e-002
   H1             : -3.30000e-002
   H2             : 5.00000e+003
   H3             : 1.45000e+003

7) A/D voltage 1, Oxygen, SBE 43, 2

   Serial number : 2575
   Calibrated on : 23-Jul-20
   Equation       : Sea-Bird
   Soc            : 4.33200e-001
   Offset         : -4.63300e-001
   A              : -4.64700e-003
   B              : 2.34650e-004
   C              : -3.22030e-006
   E              : 3.60000e-002
   Tau20          : 9.30000e-001
   D1             : 1.92634e-004
   D2             : -4.64803e-002
```

```
   H1             : -3.30000e-002
   H2             : 5.00000e+003
   H3             : 1.45000e+003

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

   Serial number : 088195
   Calibrated on : 06 August 2020
   VB            : 0.248537
   V1            : 1.957390
   Vacetone      : 0.277470
   Scale factor  : 1.000000
   Slope         : 1.000000
   Offset        : 0.000000

9) A/D voltage 3, Altimeter

   Serial number : 6196.118171
   Calibrated on : 14/11/06
   Scale factor  : 15.000
   Offset        : 0.000

10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor

    Serial number        : 70510
    Calibrated on        : 27/06/2019
    M                    : 1.00000000
    B                    : 0.00000000
    Calibration constant : 20325200000.00000000
    Conversion units     : umol photons/m^2/sec
    Multiplier           : 1.00000000
    Offset               : -0.05009162

11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2

    Serial number        : 70520
    Calibrated on        : 27/06/2019
    M                    : 1.00000000
    B                    : 0.00000000
    Calibration constant : 19920300000.00000000
    Conversion units     : umol photons/m^2/sec
    Multiplier           : 1.00000000
    Offset               : -0.05148773

12) A/D voltage 6, Transmissometer, WET Labs C-Star

    Serial number : 1602DR
    Calibrated on : 18 July 2019
    M             : 21.2520
    B             : -0.1296
    Path length   : 0.250

13) A/D voltage 7, OBS, WET Labs, ECO-BB

    Serial number : 5690
    Calibrated on : 15 May 2019
    ScaleFactor   : 0.003521
    Dark output   : 0.067000

Scan length                    : 41
```

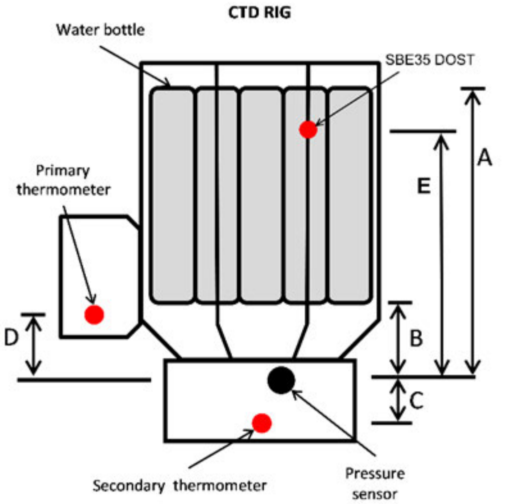
Sea-Bird SBE35 DOST Configuration

The SBE35 was connected to the SBE9plus underwater unit and the SBE32 carousel using its 'Y'-cable. It was configured to take 8 temperature samples each time that a bottle was fired.

```
* SBE35 V 2.0a    SERIAL NO. 0048   02 Feb 2021  11:22:17
* number of measurement cycles to average = 8
* number of data points stored in memory = 0
* bottle confirm interface = SBE 911plus

* SBE35 V 2.0a    SERIAL NO. 0048
* 11-oct-17
* A0 =  4.210149330e-03
* A1 = -1.128277560e-03
* A2 =  1.740129100e-04
* A3 = -9.730303090e-06
* A4 =  2.090325760e-07
* SLOPE =  1.000003
* OFFSET = -0.001170
```

Stainless Steel CTD Frame Geometry



ID	Vertical distance from pressure sensor (m positive-up)
A	1.2 (Top of water samplers)
B	0.34 (Bottom of water samplers)
C	-0.075 (***Secondary T mounted on 9p***)
D	0.085 (***Primary T mounted on Vane***)
E	1.025 (SBE35 DOST probe sheath tip)

Figure 41. Vertical offsets of main CTD sensors from pressure sensor.

Figure 42. Seabird SBE 35 DOST mounting location overview – same as DY113.

CTD Operations

CTD Deployment Method

The CTD was operated out of the Water Sampling Laboratory at the forward end of the hangar. It was deployed on the 11.43mm conducting CTD wire (CTD1 storage drum) using the hydro-boom.

To provide shelter to the science party whilst sampling, the CTD was transferred to the water-sampling laboratory using the hydro-boom once inboard. Closing the roller shutter door also allowed for the ship to be kept as dark as possible at night to minimise the risk of bird-strikes. This incurred a small time overhead for each deployment but allows the vessel to move off station more promptly. There was one occasion where the CTD was not recovered to the Water Sampling Laboratory between casts: After the recovery of the aborted cast CTD061 at station A23_28, a quick turnaround was required for the repeat cast at the station. The CTD was landed on deck to allow prompt redeployment for CTD062.

A normal operating range of 10m for the CTD package from seabed was used at the end of the down-cast and the winch operator was notified of the maximum wire-out. During stations with steep bottom topography or otherwise lower acoustic reflectivity, the time spent finding the bottom was extended. Shorter veer calls were issued at slower wire speeds to provide additional safety margin. When there was a strong current, and the vessel was moving over the ground, the proximity to the bottom at the end of the downcast was marginally increased for similar reasons.

Flooding of MDS EM Swivel

The NMF MDS EM swivel failed by flooding early in the first test-cast. No spare was available due to the loss of an MDS EM Swivel on JC190. Hence the CTD termination was shackled directly to the CTD frame lifting bale and a swivel was not used. The CTD wire was frequently insulation tested after disconnecting the sea-cable extension from termination pigtail. The CTD wire maintained an insulation resistance of >999MΩ at 250V throughout the cruise.

CTD Sensor Cleaning Protocol

During the mobilisation, both TC ducts were cleaned with Triton-X and dilute bleach solutions agitated with a syringe. The TC ducts were thoroughly flushed with Milli-Q after each cleaning solution. All optical instruments (PARs, Fluorimeter, Transmissometer, BBrtd) were rinsed with MilliQ, squirted with Triton-X solution, dried with Kimwipes, then polished with Optic Prep wipes.

Between casts the TC & DO sensor pairs were flushed with Milli-Q three times and drained before installation of caps on the TC-duct inlet and pump exhaust of both sensor ducts. When air or sea surface temperatures were approaching zero, Milli-Q flushing was stopped, and the TC ducts were drained of seawater after each cast by sucking the residual water out using a syringe.

The optical instrument faces were frequently rinsed with MilliQ after recovery. A full clean with MilliQ, Triton-X, Kim wipes and a final polish with Optic Prep wipes was carried out when the interval between casts was greater than a few hours.

Between transects, the whole CTD package was rinsed with fresh water to prevent salt crystals forming on the sensors, associated tubing and particularly the carousel latch assembly.

The TC-ducts were not cleaned with Triton-X or bleach solutions during the cruise unless fouling was observed. There were two sensor fouling events during the cruise. After each of these fouling events both CTD ducts were syringe-cleaned with both bleach and Triton-X solutions and well flushed with MilliQ.

Firstly, during cast CTD074, the primary vane-mounted sensor duct fouled with the CTD package 20 m above the seabed before proceeding to the bottom of the down-cast 10 m deeper. The primary salinity shifted ~1.1 PSU low, the primary temperature shifted ~0.005°C high and the primary oxygen concentration ~10 µmol/kg low. The sensor time constants were observed to be markedly slow, clearly seen during bottle stops during the upcast. During the upcast, the offsets reduced but did not fully recover. The sensor package was inspected after recovery to deck. The vane-mounted primary duct was found to be nearly completely blocked with pink jelly.

The second sensor fouling event was during cast CTD090 when the CTD package contacted the seabed. During this event, the secondary (frame-mounted) salinity reduced by ~ 0.009 PSU, which was caused by a reduction in measured conductivity. This offset continued throughout the upcast. The secondary temperature and oxygen measurements were not affected, nor were the primary, vane-mounted sensors.

Sea-Bird Seasave GUI Crash

The Sea-Bird Seasave CTD GUI software crashed during CTD091 at 22:45UTC. The CTD package was at 2100 m on the upcast. The Seasave data acquisition process continued running and recorded data in the data file until it was stopped at 22:58UTC with the CTD package at 1963 decibar (~1935 m). The Seasave data acquisition process was terminated, and the software restarted with a new file suffix 'a' at 23:01 with the CTD still at 1963 decibar (~1935 m).

Sea-Bird SBE35 Deployment & Date Error Prior to CTD011

The SBE35 data was downloaded after each cast using Seaterm and the memory pointer reset using the samplenum=0 command.

Unfortunately, the SBE35 date-stamps were incorrect prior to CTD011 because the SBE35 clock was reset without resetting the date first. There is no SBE35 data for the aborted test-casts CTD001 & CTD002 as no bottles were fired. For casts CTD003-CTD010 the SBE35 date-stamp is 10 days earlier than the actual deployment date.

The actual deployment dates and incorrectly reported SBE35 date-stamps were as follows:

- CTD003, 004 & 005 deployed 05 Feb - SBE35 date-stamp: 25 Jan
- CTD006 & 007 deployed 06 Feb - SBE35 date-stamp: 26 Jan
- CTD008 deployed 07 Feb - SBE35 date-stamp: 27 Jan
- CTD009 & 010 deployed 08 Feb - SBE35 date-stamp: 28 Jan

The time-stamps for the affected casts were correct.

The SBE35 date and time was reset correctly after CTD010, hence SBE35 date-stamps were correct from CTD011 onwards.

All discrete salinity samples were taken and analysed by the science party.

CTD Performance, Technical Issues & Instrument Changes

There were no major technical issues with the CTD suite during the cruise and no scientific instruments required changing for spares. There was no noticeable change in the differences indicated in Seasave between the primary and secondary sensors for temperature (<0.001 °C), salinity (<0.003 PSU), and dissolved oxygen (<1 μmol/kg) during data acquisition. There was negligible drift in all SBE 3P, 4C and 43 sensors throughout the cruise when comparing them to discrete bottle samples. The two fouling events that necessitated cleaning the sensors resulted in a small shift (<0.003 in salinity) in their offset to the discrete salinity samples.

CTD Suite Spares Availability

Two full suites of spare instruments were available for use. One complete suite of instruments was installed on the titanium CTD frame during the mobilisation to provide a ready-to-go spare CTD system. The spare system would have required using the TMF water samplers, one set of which was available onboard.

The PAR sensors that were used were Biospherical Quantum QCP-2350-HP cosine units which have a depth rating of 10,000 m and were fitted throughout the cruise. The two sets of spare PAR sensors available for use were CTG 2π hemispherical scalar units which have a significantly reduced depth rating of 500 m.

CTD Wire Condition & Induced Torque

A full drum of spare CTD wire was available on the CTD2 secondary storage drum. CTD1 storage drum was used on the cruise. Following the failure of the EM swivel, the use of a direct mechanical connection to the CTD frame re-exposed the long-standing issue with torque being induced in the CTD wire.

The compass data from the LADCP instruments on the CTD frame was reviewed. The compass data indicate that the vane is doing its job – orienting the CTD package into the prevailing water current. A cast may have around eight rotations of the CTD frame during the downcast of a 4,000 m cast. All but one or two of these rotations will be unwound by opposite rotation on the upcast, i.e. it is not the CTD package which is creating residual torque in the wire.

It is thought that the residual torque is being induced by the hydro-boom head-sheave. The hydro-boom head-sheave orientation is fixed i.e. it does not flag or float in the direction of the outboard load. Pitching of the vessel and current induced lead of the wire frequently causes the wire to contact the flange of the sheave and roll into the root of the groove. This rubbing on the flange and rolling into the root of the groove is associated with a clearly audible ticking, pinging or graunching sound on deck. When hauling, this rolling of the wire induces torque in the wire which is subsequently stored on the storage drum.

A gap is visible in the outer armour of the wire on most of the outer-most lay on the storage drum. At the working deck with no tension on the wire, the outer armour becomes loose against the inner armour. Furthermore, when the out-haulers are engaged at 100 m they concentrate any residual torque in the last 100 m section of wire by sweeping it towards the CTD termination. This results in loose strands which often jump across the gap that is present in the outer armour. Apparently, the flat rubber out-hauler wheels that are currently in use have a considerably higher clamping force than the previous grooved 'air-craft' tyres. The flat out-hauler tyres also visibly flatten the wire cross-section as it passes the out-haulers.

The CTD termination was routinely disconnected after each cast to relief the torque and encourage the loose strands to bed back down. Often 30 m or more of slack had to be pulled down after each cast to relieve the torque. The condition of the wire was continuously monitored using the cameras and periodic inspection on the hangar top and outboard. The CTD wire was streamed to 3,000 m in 3,225 m of water at station A23_46 prior to CTD044 on Jday 049. This successfully relieved the stored torque in the wire and improved its visual condition on the hangar top and at the CTD termination.

Following the streaming of the wire its condition continued to deteriorate, before stabilising during a period of better weather and an associated reduction in vessel pitching. Once the weather deteriorated again and vessel pitching returned, the condition of the wire continued to deteriorate.

CTD1 wire has been in service for over 3 years and is now at the end of its life. It is recommended that CTD1 wire be removed from service and replaced with a new wire at the first opportunity. CTD2 wire will need to be reeved prior to the next cruise. Note that CTD2 wire is still quite greasy.

A spare CTD mechanical termination was available onboard. The Deep-tow wire was terminated during the mobilisation using the Sensors & Moorings Evergrip termination. Both the CTD1 and Deep Tow wires were load-tested, and functionally tested prior to use. The Deep Tow termination has not been deployed and therefore has not yet been in the water.

Water Sampler and Carousel Maintenance

All the water sampler bottles were leak-tested during the mobilisation by filling with fresh water, seating the end caps, closing the vents, and opening the taps. Weeping or dripping taps thus indicated if the bottle has an air leak. All were good.

During the mobilisation, the carousel head latch assemblies on both CTD frames were removed, dismantled, and thoroughly cleaned. Then the head assembly was reassembled and refitted to the carousel.

The lanyards were replaced on 11 bottles (#13-23) to make them 3 cm longer at 93 cm eye–eye. The existing lanyards were too short which made cocking the bottles difficult and was putting excessive strain on the end-cap monofil guide blocks.

The carousel latches were frequently rinsed with MilliQ and exercised to keep them free.

There were some frequent issues with the lower endcap of bottles #3 and #10 leaking when they did not seat properly on the 'o'-ring. All nylon monofil lengths were set at the same lengths as the other bottles, and the springs at similar tension on all bottles but the problem persisted. On cast CTD003, 004, 007, 009, 046 and CTD049, the lower endcap of bottle #3 did not seat properly. On cast CTD010, 018, 019, 021, 071, 073, 076, and CTD080 the lower endcap of bottle #10 did not seat properly. Both these problematic bottles are from the 'C' set, with all other bottles from the 'D' set.

The 'C' set bottles had a longer style springs fitted. These were replaced on bottle #3 (prior to CTD010) and #10 (prior to CTD011) with shorter springs, as fitted to the 'D' set, along with the related monofil sections through each end cap. The lower endcap 'o'-rings were replaced on these two bottles. This did not resolve the issue with their lower endcaps not seating properly. This will require further investigation before the next use.

At the end of the cruise all bottles were leak tested again after cleaning throughout with fresh water, and no leaks were observed.

CTD Cast Events

'Shake-down' Test-Casts

3 'shake-down' test-casts were completed early in the cruise. The day after sailing, a test-cast undertaken in 3135 m of water for verification of system functionality at depth (CTD001 – Jday 034). CTD communication failed 26 minutes after deployment with the CTD at approximately 675 m during the downcast and the cast was aborted. Visual inspection, electrical & functional testing confirmed that the EM swivel had flooded creating a seawater short on the sea-cable.

A spare EM swivel was not available due to its loss on JC190. The failed unit has no history of problems and had been serviced by the manufacturer as planned maintenance prior to JC211. Due to the recent service, the failure is particularly frustrating. As the EM swivel is not field-serviceable, and with no alternative, it was removed from the system and the CTD termination was shackled directly to the CTD frame.

The following day (Jday 035) CTD002 was undertaken as a second test-cast in 3361m of water. This cast was also aborted. At 100 m on the downcast, the winch operator could not establish control at the winch HMI. Following resolution of this problem, CTD003 was completed in full as the test-cast proper in 3345 m of water.

WCB EK60 Survey and WCB & P3 Moorings

Following the 3 test casts, 13 casts were completed in the WCB work area including the EK60 calibration profile in Stromness Harbour.

Cast	Station	Jul. Day	Max Depth	Altimeter	Notes
001	TEST_CAST	034	675	-	Aborted - EM swivel failed at 675 m
002	TEST_CAST_2	035	100	-	Aborted - winch HMI comms failure
003	TEST_CAST_3	035	3335	9	
004	P3	036	3732	12	P3 mooring recovery calibration cast
005	W1.2CTDS	036	273	10	Commence EK60 survey

Cast	Station	Jul. Day	Max Depth	Altimeter	Notes
006	W1.2CTDN	037	1000	-	Profile to 1000 m in 3110 m of water
007	W2.2CTDN	037	1000	-	Profile to 1000 m in 3456 m of water
008	W2.2CTDS	038	195	10	Shallow – no AHC
009	WCB	038	296	10	WCB mooring recovery calibration cast
010	W3.2CTDS	039	123	11	19 bottles fired
011	W3.2CTDN	039	1000	-	Profile to 1000 m in 2599 m of water
012	W4.2CTDS	040	105	10	18 bottles fired
013	WCB	040	283	10	WCB mooring deployment calibration cast
014	W4.2CTDN	041	1000	-	Profile to 1000 m in 2787 m of water
015	STROMNESS	041	77	10	EK60 calibration – 6 bottles fired
016	P3	042	3736	11	P3 mooring deployment calibration cast

Iceberg A68a Survey

19 stations were occupied during a series of three short transects that were undertaken in the vicinity of iceberg A68a before occupying the A23 line.

Cast	Station	Jul. Day	Max Depth	Altimeter	Notes
017	ICEBERG_FAR	044	1000	-	Profile to 1000 m in 3400 m of water
018	ICEBERG_W1	044	1000	-	Profile to 1000 m in 3540 m of water
019	ICEBERG_W2.5	044	1000	-	Profile to 1000 m in 3650 m of water
020	ICEBERG_W5	044	1000	-	Profile to 1000 m in 3360 m of water
021	ICEBERG_W10	045	1000	-	Profile to 1000 m in 3720 m of water
022	ICEBERG_W20	045	1000	-	Profile to 1000 m in 3340 m of water
023	ICEBERG_S20	045	1000	-	Profile to 1000 m in 3200 m of water
024	ICEBERG_S10	045	1000	-	Profile to 1000 m in 2750 m of water
025	ICEBERG_S1	045	1000	-	Profile to 1000 m in 3390 m of water
026	ICEBERG_S2.5	045	1000	-	Profile to 1000 m in 3320 m of water
027	ICEBERG_S5	045	1000	-	Profile to 1000 m in 2990 m of water
028	ICEBERG_S9	046	1000	-	Profile to 1000 m in 2750 m of water
029	ICEBERG_N20	046	1000	-	'N' transect curtailed due to ice conditions
030	ICEBERG_H1	047	1254	9	21 bottles fired
031	ICEBERG_H2	047	1389	10	21 bottles fired
032	ICEBERG_H3	047	459	11	21 bottles fired
033	ICEBERG_H4	047	1142	10	21 bottles fired
034	ICEBERG_H5	047	880	10	21 bottles fired
035	ICEBERG_H6	047	535	12	21 bottles fired

Southward A23 Transect – South Georgia through the Scotia Sea to 64°S in the Weddell Sea

30 casts were completed at twenty-nine stations on the A23 line.

Cast	Station	Jul. Day	Max Depth	Altimeter	Notes
036	A23_52	047	640	9	BBRTD & transmissometer Y cable replaced
037	A23_51a	048	1015	11	21 bottles fired
038	A23_51	048	1501	11	16 bottles fired
039	A23_50a	048	2002	20 down to 13	VSL speed over the ground 0.5 kt
040	A23_50	048	2559	14	20 bottles fired
041	A23_49	048	3510	10	24 bottles fired
042	A23_48	048	3060	13-14	24 bottles fired
043	A23_47	049	3127	10	22 bottles fired
044	A23_46	049	3220	10	24 bottles fired
045	A23_45	049	3425	11	24 bottles fired
046	A23_44	050	3733	10	10 bottles fired
047	A23_43	050	3568	11	24 bottles fired
048	A23_42	050	3990	11	8 bottles fired
049	A23_41	050	3489	11	24 bottles fired
050	A23_40	051	3109	10	24 bottles fired
051	A23_39	051	3390	11	Station re-located ~3.3nm to avoid heavy ice
-	A23_38	-	-	-	Not occupied due to proximity to A23_39
052	A23_37	051	3779	11	24 bottles fired
053	A23_36	051	2977	11	24 bottles fired
054	A23_35	051-052	2540	22	24 bottles fired
055	A23_34	052	1492	10	22 bottles fired
056	A23_33	052	2551	11	8 bottles fired
057	A23_32	052	3468	12	Comms issues with Slave LADCP
058	A23_31	052	4063	13	24 bottles fired
059	A23_30	053	3310	10	8 bottles fired
060	A23_29	053	4839	10	Slave LADCP replaced after this cast
061	A23_28	054	1527	-	Cast delayed due to weather (40-50 kts) Cast aborted at 1527 m due to VSL DP issues
062	A23_28	054	4753	12	Repeat of A23_28
063	A23_27	054	4818	12	24 bottles fired
064	A23_26	055	4851	11	16 bottles fired
065	A23_25	055	4719	11	23 bottles fired
-	A23_24	-	-	-	Station not occupied due to weather

Station A23_39 (CTD051) had to be relocated some 3.3nm from the nominal position due to ice conditions, therefore station A23_38 was not occupied due to its very close proximity to the relocated A23_39.

CTD061 at A23_28 was aborted at 1527 m on the down-cast due to vessel DP problems. CTD062 was a repeat cast at A23_28 shortly after recovery of CTD061.
Station A23_24 was not occupied due to weather and time constraints. The vessel broke off the approach to station A23_24 at 63° 30’ S, 029° 21’ W to make passage to the SR1b line.

Northward SR1b Drake Passage Transect - Elephant Island to Burdwood Bank

35 casts were completed on the SR1b line including an additional 5 stations.

Cast	Station	Jul. Day	Max Depth	Altimeter	Notes
066	SR1b_30	058	368	13-14	New CTD-wire termination
067	SR1b_29	058	570	10	Cast delayed due to weather - 12 bottles fired
068	SR1b_28	059	1065	14-17	16 bottles fired
069	SR1b_27	059	1958	20-25	24 bottles fired
070	SR1b_26	059	2554	17	16 bottles fired
071	SR1b_25	059	3093	12	TC ducts & Optics flushed with MilliQ
072	SR1b_24	059	3428	12	24 bottles fired
073	SR1b_23	059	3488	10	24 bottles fired
074	SR1b_22	060	3661	11	Primary duct fouled at bottom of cast
075	SR1b_21	060	3747	12	Both ducts cleaned prior to this cast
076	SR1b_20	060	3760	10	24 bottles fired
077	SR1b_19	060	3739	10	24 bottles fired
078	SR1b_18	061	3882	12	24 bottles fired
079	SR1b_17	061	3932	11	24 bottles fired
080	SR1b_16	061	3558	10	Winch stopped at 2290 m due to HMI comms
081	SR1b_15	061	3825	11	Water depth decreasing at bottom of cast
082	SR1b_14	062	3819	10	Water depth decreasing at bottom of cast
083	SR1b_13	062	3275	12	10 bottles fired
084	SR1b_12	062	3826	10	24 bottles fired
085	SR1b_11	062	3331	13	20 bottles fired
086	SR1b_10	062	4771	9	15 bottles fired
087	SR1b_09	063	4210	10	12 bottles fired
088	SR1b_08	063	4002	10	14 bottles fired
089	SR1b_07	063	3104	10	20 bottles fired
090	SR1b_06	063	2750	0	CTD package contacted seabed
091	SR1b_05	063	2211	11	Seasave crash on upcast @2100 m ~22:45
092	SR1b_04	064	1657	12	15 bottles fired
093	SR1b_03	064	1035	10	6 bottles fired
094	SR1b_02	064	705	10	CTD struck ship's side due to sharp VSL roll
095	SR1b_01	064	153	11	4 bottles fired
096	SR1b_N1	064	1155	11	NSR_27 (DY113) - 8 bottles fired + 6
097	SR1b_N2	064	2041	10	New intermediate station - 8 bottles fired
098	SR1b_N3	064	2524	10	NSR_28 (DY113) - 10 bottles fired
099	SR1b_N4	065	1719	10	New intermediate station - 12 bottles fired
100	SR1b_N5	065	914	10	NSR_29 (DY113) - 10 bottles fired

Three of the NSR stations (NSR_27, 28 and 29) from DY113 were re-occupied (SR1b_N1, N3 and N5) and an additional two intermediate stations were established on JC211 (SR1b_N2 and N4).

Data Processing

At the request of the science party, basic Sea-Bird CTD data pre-processing of the raw data was completed using Sea-Bird Data Processing software. The science party undertook full data processing using their tools, and they will be submitting the definitive quality-controlled processed dataset to BODC in due course.

The pre-processing order used was:

- Data Conversion
- AlignCTD 6 s on oxygen channels only
- CellTM

Scan count, elapsed time (seconds), NMEA latitude and longitude, and all instrument channels in engineering units were selected for data conversion. The primary and secondary oxygen channels were output in µmol/kg and SBE raw V. The pressure hysteresis correction was de-selected in the conversion as it was applied later in the data processing workflow by the science party.

The 6 s advance that was applied in AlignCTD was applied to both primary and secondary oxygen channels for both the µmol/kg and SBE raw V fields.

The default parameter values were applied for the CellTM processing module.

There was also a requirement to produce 25 m binned speed of sound profiles for correcting multi-beam swath data. The Bin Averaged files are named in the form JC211_CTDxxx_align_ctm_SV_25m.cnv and contain the Chen-Millero (m/s) speed of sound algorithm on the secondary channel.

Workhorse 300-kHz LADCP

Instrument Configuration

Two self-logging Teledyne RDI Workhorse 300-kHz ADCPs were installed on the CTD frame. Both units had the Lowered mode option installed and were used as an up/down pair with RDS3 synchronisation via the second serial interface via the star cable also installed on the CTD frame. The Master unit signals the pinging of the Slave by sending a synchronisation pulse over the second serial interface. The Slave unit pings immediately upon receipt of the synch pulse. The Master unit, on the other hand, waits 0.5 seconds after sending the synch pulse before it pings, i.e. for each ping, the slave will ping first. This reduces acoustic interference between the two LADCPs.

The down-looking unit (S/N: 24466) was sited at the centre of the frame with its transducers just above the bottom tube of the CTD frame. The up-looking unit (S/N: 24465 or 15288) was located within an outrigger frame with its transducers just below the top tube of the CTD frame.

The instruments were powered with NMF Workhorse Battery Pack serial number WH011T.

Due to cable routing constraints, the instrument heads did not have their beams aligned in azimuth and therefore an offset will be observed between the compass headings of the two units. By convention, the down-looking unit is deployed as the master, and the up-looking unit as the slave.

Both instruments were configured with 25 off 8-m bins and a 4-m blank for a maximum range of 204 m. Both instruments were set to a minimum ping interval of 1 s, which in practice means that they ping as fast as they can. The ping period is limited by the sum of the ping, listening, processing and data storage times which in practice is of the order of 1.55 seconds (~0.645 Hz).

The LADCPs were configured with 330 cm/s for the Ambiguity Velocity (LV330), which was the value that was eventually used on DY113. 330 cm/s is the maximum that LV can be set to in Narrowband mode (LW1).

Comments on SB0 Command

The recommendation in the 'Workhorse Commands and Output Data Format' manual (March 2016) for the use of SB0 to use Master/Slave setup was adhered to. This disables hardware-break detection on Channel B:

'Set SB0 to prevent noise from being processed as a <Break> on the RS-422 lines. This command is used when another system is connected to the ADCP over the RS-422 lines. In this configuration, disconnecting or connecting the other system can cause the ADCP to interpret this as a <Break> over Channel B. A break will cause the ADCP to stop pinging and the deployment will be interrupted.'

The manual also states: *'The SB command must be set to SB0 to use the Master/Slave setup.'*

The SB0 command was used on DY113, but this caused some issues with the master instrument locking up when processing its command script. For JC211, the SB0 command was omitted.

The host laptop that was used for BBTalk was NTP time synchronised to the Discovery GPS clock using the Meinberg PC port of the UNIX NTP client. Thus, using the BBTalk script command $T to set the LADCP clock to the PC time at the start of the command files ensures that the RTC of the Workhorses remain a close as feasible to UTC.

Deployment Command Scripts

Down-looking Master	Up-looking Slave
; JC211 Abrahamsen, BAS. LADCP Master	; JC211 Abrahamsen, BAS. LADCP Slave
; Dougal Mountifield & Povl Abrahamsen	; Dougal Mountifield & Povl Abrahamsen
$T ; Set LADCP Clock to PC Time	$T ; Set LADCP Clock to PC Time
PS0 ; Display System Configuration	PS0 ; Display System Configuration
CR1 ; Restore Factory Defaults	CR1 ; Restore Factory Defaults
WM15 ; LADCP Water Mode 15	WM15 ; LADCP Water Mode 15
CF11101 ; Disable Serial Output	CF11101 ; Disable Serial Output
EA00000 ; Zero Beam 3 Misalignment (default)	EA00000 ; Zero Beam 3 Misalignment (default)
EB00000 ; Zero Heading Bias (default)	EB00000 ; Zero Heading Bias (default)
EC1500 ; Speed of sound 1500 m/s (default)	EC1500 ; Speed of sound 1500 m/s (default)
ED00000 ; Zero Transducer Depth (default)	ED00000 ; Zero Transducer Depth (default)
ES35 ; Salinity 35PSU (default)	ES35 ; Salinity 35PSU (default)
EX00100 ; Beam Coordinates, use tilts	EX00100 ; Beam Coordinates, use tilts
EZ0011101 ; Use temp, heading and tilt sensors	EZ0011101 ; Use temp, heading and tilt sensors
(use EC speed of sound, ED depth,	(use EC speed of sound, ED depth,
ES salinity)	ES salinity)
TE00:00:01.00 ; 1 Second Minimum Time Per Ensemble	TE00:00:01.00 ; 1 Second Minimum Time Per Ensemble
(default for WM15)	(default for WM15)
TP00:01.00 ; 1 Second Minimum Time Between Pings	TP00:01.00 ; 1 Second Minimum Time Between Pings
(default for WM15)	(default for WM15)
LP00001 ; 1 Ping Per Ensemble (default)	LP00001 ; 1 Ping Per Ensemble (default)
LD111100000 ; Collect and Process all data	LD111100000 ; Collect and Process all data
(default)	(default)
LF0400 ; LADCP 4 m Blank	LF0400 ; LADCP 4 m Blank
LN025 ; LADCP 25 Bins	LN025 ; LADCP 25 Bins
LS0800 ; LADCP 8 m Bins	LS0800 ; LADCP 8 m Bins
LV330 ; LADCP 330 cm/s Ambiguity Velocity	LV330 ; LADCP 330 cm/s Ambiguity Velocity
(limited to max 330 in LW1 mode)	(limited to max 330 in LW1 mode)
LJ1 ; LADCP High Receiver Gain (default)	LJ1 ; LADCP High Receiver Gain (default)
LW1 ; LADCP Narrow Bandwidth (default)	LW1 ; LADCP Narrow Bandwidth (default)
LZ30,220 ; LADCP Default Bottom Detect and	LZ30,220 ; LADCP Default Bottom Detect and
Correlation Thresholds	Correlation Thresholds
SM1 ; RDS3 Master	SM2 ; RDS3 Slave
SA001 ; Send Sync Pulse Before Water Ping	SA001 ; Wait for Sync Pulse Before Water
(default)	Ping (default)
SW05000 ; Ping 500 ms after Sending Sync	ST0 ; Wait Indefinitely For Sync Pulse
Pulse	From Master (default)
RN MAST_ ; Set file name header to MAST_	RN SLAV_ ; Set filename header to SLAV_
CK ; Save As User Defaults	CK ; Save As User Defaults
CS ; Start Pinging	CS ; Start Pinging

Script 2. LADCP deployment scripts.

LADCP Deployment & Recovery Procedure

Prior to each deployment the following standard checklist was followed:

Pre-deployment

- Baud rate changed to 9600 baud (**CB411**) to ensure correct parsing of command script file.
- Logging started **(F3)** to create deployment terminal capture log files named in the form *JC211_CTDxxxM.txt* for the master and *JC211_CTDxxxS.txt* for the slave.
- Instrument time checked **(TS?)** by comparing to GPS time. Manual setting of the instrument time was not required as the **$T** script command was used in the command files.
- Free data storage available was checked and recorded **(RS?)**, reformatting the card if required.

- The number of deployments on instrument storage card **(RA?)** was recorded.
- Three pre-deployment tests **(PA, PT200 and PC2)** were run being mindful of humidity sensor value.

Note that some of these tests are intended to be run with the instrument submerged in still water and can therefore be expected to fail in air.

- The command script files were sent to the instruments **(F2)** to deploy them and start them pinging. The slave was started first using *JC211_Slave.TXT*, followed by the master using *JC211_Master.TXT*. Finally the logging to the terminal capture was stopped **(F3)**.
- The battery was then taken off charge, the deck-cables were disconnected and star-cable dummies installed ready for deployment.
- Prior to deployment pinging was confirmed by listening to the buzzers in the instruments.

Post-recovery

- Pinging was confirmed by listening to the buzzers in the instruments.
- Star-cable dummies were removed and deck-cables reconnected after drying the cables and connectors.
- The instruments were stopped pinging by sending a break to each in BBTalk, master first.
- The battery pack was put on charge (58V boost charge until 0.1A, then float at 55V).
- The baud rate was changed to 115200 baud **(CB811)** to reduce the data download time.
- The number of deployments on instrument storage card **(RA?)** was recorded.
- Download of data was started using BBTalk **'File>Recover Recorder'** menu command, selecting appropriate file(s) and noting their number in the default filename sequence *MAST_xxx.000* and *SLAV_xxx.000*.
- The baud rate was changed to 9600 baud (**CB411**) to ensure correct parsing of command script file.

The downloaded files were renamed using the form JC211_CTDxxxM.000 for master and JC211_CTDxxxS.000 for the slave. The files were then backed up to the network archive.

Data File Integrity & Data Quality Checks

Both the master and slave data files were checked using WinADCP. A region of data with high echo intensity (near bottom for master, near surface for slave) was selected. All four beams were checked for consistent echo intensity and beam correlation. Further similar checks were also done mid water-column and near the end of the profile. The start and stop times of the data files were checked for correspondence with the log-sheet deployment and recovery times. The number of pings (ensembles) in each data file was recorded on the log-sheet.

LADCP Deployment Comments

Instrument Terminal Lock-up During Deployment

Issues persisted with the command script files not being parsed correctly by the instruments during deployment. This caused one instrument to lock up. When multiple breaks were sent to the other instrument, the locked-up instrument would process each remaining line in the command file, then eventually say Wake-up B, then Wake-up AB, then finally Wake-up A.

The cause is still undetermined, but the work-around was to send both instruments to sleep (CZ), then send a break to the Master first to wake it up, then a break to the Slave to wake it up, then (most importantly) send a second break to the Master. Then the command script files were sent to the slave followed by the master to deploy them. This process was used for the rest of the cruise and worked without exception.

Reported Number of Deployments (RA) Bug
Whilst the instruments were being tested during the mobilisation, it was noticed that the instruments were reporting the number of deployments (RA) incorrectly. The response to the RA command was double the number of deployments present on the recorder cards. The file numbering incremented by one, but the RA response incremented by two. To isolate the problem, the deployment configuration was simplified to a set defaults (CR1) followed by start pinging (CS) on a single instrument, but the issue remained. The instruments continued to double the number of deployments until CTD015 where the problem resolved itself. The pre-deployment RA response was 30 for 15 files on the recorder. The post-deployment RA response was 16 for 16 files on the recorder. This is obviously a bug with the instrument firmware.

Spares Availability and Replacement of Slave Instrument with s/n: 15288
Two full sets of LADCP pairs (4 instruments) were available as spares on-board. The instruments performed well, but s/n: 24465 was replaced with s/n: 15288 after cast CTD060. The science party were using a shear method for integrating the profiles and experienced a bias or offset in the velocities on the up-looking slave instrument. The instrument was replaced at their request, but the shear bias persisted. The cause of the bias was eventually found in their software configuration. The science party confirmed that all three instruments used were operating normally with no identified issues.

Salinometry
Following each CTD cast, discrete salinity samples were taken from the OTE 10l water samplers by the science party. The science party also did all the analysis of these samples using the NMF provided Autosal salinometers. The salinometers were operated in the Electronics Workshop with the bath temperature set to 24°C. The HVAC plant in the Electronics Workshop was set at 21.5°C to achieve an ambient temperature of 21-22°C.

Salinity Sample Summary
1,025 discrete salinity samples were taken during the cruise filling 43 crates. 36 crates of CTD samples were analysed comprising 855 discrete samples. 7 crates of TSG samples were analysed comprising 170 samples. Only a single crate was analysed on Autosal s/n: 71126 before it developed stability problems. All other samples were analysed using Autosal s/n: 72227.

The analysis protocol was to run a standard as a sample before and after each crate of samples as a control. The RS pot was not changed during the cruise and the machine was not re-standardised using the software.

A data file from the analysis software was produced for each crate as an Excel spreadsheet. All raw double conductivity measurements were also logged manually by the analyst on paper log-sheets. These log-sheets were scanned to pdf format by the science party. There were 50 sheets of salinity rough logs in total including the standardisation and testing sheets.

Electronics Workshop HVAC Configuration

Changes were made to the configuration of the HVAC system in the Electronics Workshop to improve the temperature stability of the space. The ***E-17*** Exhaust Fan was ***started*** to ensure a flow of air past the temperature sensor. The remote temperature set point control by the door also houses the room temperature sensor the control system. The Exhaust fan intake is above this in the deckhead.
Due to the prevailing cold climate, the ***EL.Heating Coil in FC-3*** switch was set in the ***ON*** position to enable the heating subsystem of the HVAC in the space. The ***FC-5 Supply Fan*** Main switch was set in the ***ON*** position and the fan was confirmed to be running. To provide a fresh air supply to the Electronics Workshop, the deckhead mounted air damper was set to provide a gentle trickle of fresh air.

The ***RWC62*** Temperature Controller settings were changed to reduce dead-band and overshoot and to increase the assertiveness of the control. The ***xDZ*** dead-band setting was reduced from 1.0 °C to ***0 °C***. The ***TN*** Integral time was increased from 256 seconds to ***1024 seconds,*** this yields integral action over 17 minutes. The ***xP1*** Heat proportional band was reduced from 15 °C to ***3.0 °C*** and the ***XP2*** Cool proportional band reduced from 15 °C to ***5.0 °C***.

The Danfoss ***VLT2800*** fan controller settings were changed to increase the exhaust air temperature during the heat cycle, reduce re-ingestion of condensate and prevent controller trip-out during fan start. The following parameters were changed:

- ***102*** – Motor Power set to the face-plate value of ***0.66kW***
- ***204*** – Output Freq low limit increased to ***10*** from 0 (this prevents the slow speed trip properly)
- ***205*** – Output Few high limit reduced from 50 to ***35*** (this prevents condensate being re-ingested from the trap)
- ***204-212*** Ramp times increased from 3 seconds to ***5*** secs
- ***213*** Jog frequency set to ***20*** (this is the fixed fan speed in 'jog' mode when the heater relay is active.
- ***640*** noted the software version is ***2.84***
- ***405*** reset function changed from manual to ***auto 3*** attempts
- ***406*** auto-restart time ***5s*** (default)
- ***002*** local/remote set to ***0*** (remote)

IAPSO Standard Seawater Batch

IAPSO Standard Seawater batch ***P164*** was used during the cruise:

Batch Date: 23rd March 2020
Expiry Date: 23rd March 2023
K15 = 0.99985 ± 0.00001 (2xK15 = 1.99970 ± 0.00002)
Practical Salinity = 34.994 ± 0.001

80 bottles of P164 standard were available and 20 bottles of older P163 standard were also available for testing purposes. P163 has the same label conductivity ratio and Practical Salinity as P164 and was still within its expiry date. No difference in conductivity ratio was observed when P163 was compared to P164 using the Autosal.

Autosal Analysis Software

The NMF Labview Autosal program was checked to ensure correct read/write access and function of the standardisation .ini file on both machines. Both machines functioned correctly, writing the correct offset to the file at standardisation and reading the correct offset during analysis of samples.

Guildline Autosal 8400B s/n: 71126

Guildline Autosal 8400B S/N 71126 was commissioned during the mobilisation. During commissioning, the cell-drain tubing at the right-hand side of the cell was found to be disconnected. This had occurred with this unit once already after the recent service of this unit by OSIL and the unit had been returned to OSIL again for rectification. The conclusion is that this is happening in transit which is both frustrating and inconvenient. OSIL have stated that this has recently been experienced by other customers as well. OSIL have also stated that they have replaced their cable-tie stock with higher quality parts and are investigating batch to batch variation in tubing ID.

The instrument bath lid was removed to allow the replacement of the cell-drain tubing. The heater lamps were also inspected at this time, and one lamp was found to be significantly darkened. This lamp was replaced with a new lamp before re-assembling the instrument.

Standardisation

A pre-standardisation stability check was completed by Tom Ballinger on 6 February with the instrument found to be measuring 0.00008 high in double conductivity ratio (RS 593, standby 6159/6160). The unit was standardised using P164 by Dougal Mountifield on 8 February (RS 580, standby 6151) with the instrument reading 0.00001 low in double conductivity ratio. A further stability check using P163 was done at the same time. An additional 'pre-sample run' stability check was completed by Dougal Mountifield on 10 February using P163. The unit was found to be stable (RS 580, standby 6150/6151) and reading 0.00001 – 0.00002 low in ratio.

Autosal s/n: 71126 was initially used by Dougal Mountifield on 10 February for analysing 1 crate of 24 samples with the standard deviation limit set to 0.00002 (RS 580, standby 6150). The pre-run P164 standard measured 1.99968 and the post-run P164 standard measured 1.99969 and the machine stability was good.

Instrument Stability Problems

Problems were encountered by Brian King on 12 February after running three pre-standards and three samples. The instrument read 0.00016 high for the first (P164) standard, 0.00020 high for the second (P164) standard and 0.00019 high for a third (P163) standard. When measuring the samples, jumps of between 0.00005 and 0.00030 were observed in double conductivity ratio. The ambient temperature was 22.4 – 22.9 °C and the heater lamp cycling indicated that the bath temperature was being well controlled. The measurement noise was normal with the problem being jumps in the measurement, then a short period of stability before another jump.

The cell was cleaned thoroughly with Triton-X and bleach solutions and flushed thoroughly with Milli-Q and the instrument stability and ambient temperature assessed again on 13 February. The instrument continued to exhibit unstable, jumpy measurements of up to 0.00030 in double conductivity ratio and therefore its use was discontinued. Due to the problems with measurement stability, Autosal s/n: 71126 was decommissioned on 14 February. This instrument will be returned to OSIL for assessment and repair after return to Southampton.

Guildline Autosal 8400B s/n: 72227

The spare Guildline Autosal 8400B S/N 72227 was commissioned by Brian King as a replacement for s/n: 71126 on 14 February. Autosal s/n: 72227 was standardised by Brian King on 14 February (RS 547, standby 6032), and checked by Dougal Mountifield on 15 February (RS 547, standby 6031) using a standard deviation limit of 0.00003 as suggested by Brian King. On both occasions the Autosal offset from standard was < ± 0.00002. Use of Autosal s/n: 72227 for analysing samples began on the 15 February with 2 crates analysed by Dougal Mountifield, 1 crate by Yvonne Firing and 4 crates by Brian King. The instrument performed excellently and continued to do so for the remainder of the cruise.

Millipore Integral Lab Water Supply

Large quantities of MilliQ water are routinely required during mobilisation to fill salinometer water baths and clean CTD sensors and SBE32 carousel latch assemblies as required. It is helpful to leave the Millipore units in a state that requires minimal time to commission them during mobilisations.

During the cruise mobilisation, the Integral 15 systems in the Deck Lab and Chemistry Lab were commissioned. Both feed-water strainers were checked to be clear. The pre-filter pack in the Deck Lab was flushed through its inlet and outlet drains. An RO chlorine tablet cleaning cycle was done twice on both units along with two RO flushes and two A10 cleaning cycles. The tanks were then flushed 3 times, i.e. approx. 200l of RO produced from each unit. The unit in the Chemistry Lab obtained 15 MOhm RO and 2-3 ppb TOC MilliQ after about 3 days.

Cleaning of Deck Lab RO Tank

The unit in the Deck Lab was producing high (>70 ppb) TOC water – the manual specifies <5 ppb. The inside of the tank was inspected and found to be coated in a thick green algal growth below the water line. The tank was clean above the water line. The unit was put into standby mode and the tank was drained and removed for cleaning.

The tank was relocated to the sink in the Chemistry Lab adjacent to the other Integral 15 system. The tank was scrubbed to loosen the algal growth and flushed with MilliQ. The cleaning method detailed in the tank manual was then followed. The tank was sterilised with a 100 ppm sodium hypochlorite solution in MilliQ water. 40ml of 15% sodium hypochlorite (provided by the vessel) was dissolved in 60l of MilliQ from the Chemistry lab system. The bleach solution was run through all valves, taps and the overflow tubing. The solution was then left to sterilise the tank for 12 hours. The solution was once again run through all valves, taps and overflow tubing before draining the tank of the bleach solution. The tank was then flushed 3 times with MilliQ, again flushing all valves etc. before being re-installed in the Deck Lab. The overflow tubing was found to be full of black mould and was replaced with new tubing. The existing overflow non-return valve was cleaned and refitted.

Level Sensor Fault in Deck Lab RO Tank

The level sensor for the Deck Lab Millipore tank system was observed to indicate a full tank when the tank was in fact empty. This prevented the unit from producing RO. The level sensor jack connector was removed to allow the system to produce RO, and then was subsequently re-connected. Problems with the level sensor continued with it producing noisy and jumpy tank-level readings. The jack connector was inspected and cleaned but the problem continued. Close inspection of the level sensor rod showed water ingress within the potted electronics. Some corrosion was evident on the reed-switch PCB. The level sensor and float were replaced with a spare. The new level sensor correctly indicates an empty tank and produces stable level readings.

High TOC Event Following Potable Water Filter Change

Near the end of the cruise, the Integral 15 unit in the Deck Lab suddenly indicated an A10 fault and very high TOC. Within hours, the unit in the Chemistry Lab developed the same fault and overscale TOC. Eventually the cause of the high TOC event was linked to the vessel engineers bypassing a filter on the ship's potable water system to replace the filter cartridge. This filter is normally scheduled for replacement during port-calls.

The potable water taps adjacent to each Integral feed-water supply were run for 5 minutes to flush the pipes. The pre-filter in the Deck Lab was flushed once more by opening the inlet and outlet drain valves. The water from the pre-filter drain valves was a weak tea colour. After numerous cleaning and flushing cycles and emptying and flushing the RO tanks, the TOC started to reduce slowly.

The delay in the development of the fault between the two systems is because the Chemistry Lab unit had a full tank and was not producing RO at the time of the feed-water poisoning event. The pre-filter in the Deck Lab did not protect the Integral unit from the high TOC feed-water. We have experienced problems with high TOC during mobilisations and de-mobilisations in the past, but have not been aware of the sensitivity of the Integral units to feedwater TOC quality until now.

Use of Lab Closed Mode for Passage

Due to the long passage at the end of this cruise, and therefore of the next planned use of the Millipore units, both units were put in Lab Closed mode with the tanks drained and the tank valve left open. Lab closed mode configures the Millipore unit to produce RO water for 30 minutes each day. As the tank drain valve is open, this will be discharged to the sink. Lab Closed mode also configures the unit to perform a flush for 3 minutes every 3 hours. The use of Lab Closed mode should reduce the time to commission the units when next required for use. Before draining the tanks, a new threaded inline hose barb fitting and new drain hose were fitted to the drain valve of both Millipore RO tanks. It was confirmed that both units remained in Lab Closed mode after a power cycle. Both units were left powered on the 'dirty' power as the vessel MG sets were switched off for the passage North.

Millipore Consumables Used

- 1 off Level sensor for 60l tank

Millipore Consumables Required

- 2 off Level sensor for 60l tank.
- 4 off Tank vent filter
- 6 off Biopak Q-pod polishing filter
- 2 off Tubs of chlorine cleaning tablets for RO maintenance

Software Used

Sea-Bird SeaTerm v1.59 (SBE 35 operation and data upload)
Sea-Bird Seasave 7.26.7.121 (SBE 9/11plus data acquisition)
Sea-Bird SBE Data Processing 7.26.7.121 (SBE 9/11plus data processing)
Notepad ++ 7.6 (Data-file and Header viewing)
Moxa PComm Terminal Emulator 2.10 (Serial port testing)

Appendix D: Scientific Ship Systems report

Andrew Moore and Emmy McGarry

Cruise overview

Cruise	Departure	Arrival	Technician(s)
JC211	11JAN2021 (mob) 02FEB2021 (sailed)	07MAR2021	Andrew Moore & Emmy McGarry

Ship Scientific Systems (SSS) is responsible for operating and managing the Ship's scientific information technology infrastructure, data acquisition, compilation and delivery, and the suite of ship-fitted instruments and sensors in support of the Marine Facilities Programme (MFP)

All times in this report are in UTC.

Scientific computer systems

Underway data acquisition

Data from the suite of ship-fitted scientific instrumentation was aggregated onto a network drive on the ship's file server. This was available throughout the voyage in read-only mode to permit scientists to work with the data as they were acquired. A Public network folder was also available for scientists to share files.
A copy of these two drives are written to the end-of-cruise disks that are provided to the Principal Scientist and the British Oceanographic Data Centre (BODC).

List of logged ship-fitted scientific systems:
`/Cruise_Reports/_Ship_fitted_information_sheet.docx`

The data acquisition systems used on this cruise are detailed in the table below. The data and data description documents are filed per system in the *Data* and *Documentation* directories respectively within Ship Systems folder on the cruise data disk.

Table 8 Data acquisition systems used on this cruise.

Data acquisition system	*Usage*	*Data products*	*Directory system name*
Ifremer TechSAS	Continuous	NetCDF ASCII pseudo-NMEA	/TechSAS/
NMF RVDAS	Continuous	ASCII Raw NMEA	/RVDAS/
Kongsberg SIS (EM122)	Continuous	Kongsberg .all	/Acoustics/EM-122/
Kongsberg SIS (EM710)	Discrete	Kongsberg .all	/Acoustics/EM-710/
Kongsberg SBP	Unused	None	/Acoustics/SBP-120/
Kongsberg EA640	Continuous	Kongsberg.raw/.XYZ	/Acoustics/EA-640/
Kongsberg EK60	Continuous	Kongsberg.raw(.idx/.bot)	/Acoustics/EK-60/
UHDAS (ADCPs)	Continuous	ASCII raw, RBIN, GBIN, CODAS files	/Acoustics/ADCP/
VMDAS (ADCPs)	Unused		/Acoustics/ADCP/

Data acquisition system	*Usage*	*Data products*	*Directory system name*
Sonardyne Ranger2	Discrete	None, redirected to Techsas/RVDAS RAM	/Acoustics/USBL/

Data description documents per system:
/Ship_Systems/Documentation/[System]/Data_Description

Data directories per system:
/Ship_Systems/Data/[System]/

Significant acquisition events and gaps
On this cruise, the NMF Event Logger was used with CSV records of events saved to the cruise data directory.

Path and pattern to event log CSV files:
/Cruise_Reports/Eventlogs/server/current_csv_logs/[logName]/*.csv

Summary of main events

Date	*Time start**	*Time end**	*Event*
27JAN2021	17:50	N/A	Start of TECHSAS acquisition (main logger)
27JAN2021	19:20	N/A	Start of RAM/RVDAS (secondary logger)
30JAN2021	21:12	N/A	Start of Level-C (legacy logger)
02FEB2021	11:30	N/A	Departure from Mare Harbour
07MAR2021	10:30	N/A	Underway water supply off
07MAR2021	13:00	N/A	Arrival to Mare Harbour
07MAR2021	13:00	N/A	End of TECHSAS acquisition
07MAR2021	13:00	N/A	End of RAM/RVDAS
07MAR2021	13:00	N/A	End of Level-C (legacy logger)

Summary of data gaps

Date	*Time start*	*Time end*	*Event*
02FEB2021	17:56	17:59	Techsas VM GUI became unresponsive, restarted gdm service
06FEB2021-07FEB2021	23:24	02:19	RVDAS centos-home capacity full.
10FEB2021	01:14	01:36	Clean power lost. Some systems affected.
18FEB2021	14:06	14:08	Techsas VM GUI became unresponsive, restarted.

Internet provision
Satellite communications were provided with both the VSat and Fleet Broadband systems.
While underway, the ship operated with bandwidth controls to prioritise business use.

Instrumentation

Coordinate reference

Path to ship survey files:
`/Ship_Systems/Documentation/Vessel_Survey`

Origin (RRS James Cook)

The common coordinate reference was defined by the Blom Maritime survey (2006) as:

1. The reference plane is parallel with the main deck abeam (transversely) and with the baseline (keel) fore- and aft-ways (longitudinally).
2. Datum (X = 0, Y = 0, Z = 0) is centre topside of the Applanix motion reference unit (MRU) chassis.

Multibeam

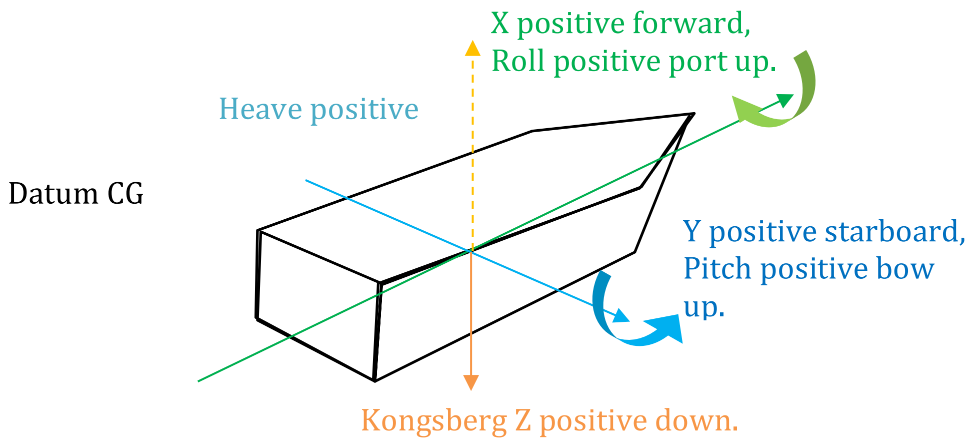


Figure 43. Conventions used for position and attitude. On the Cook the Datum is on the centre, topside of the Applanix MRU.

The Kongsberg axes reference conventions are (see Figure 43) as follows:

1. X positive forward,
2. Y positive starboard,
3. Z positive downward.

The rotational sense for the multibeam systems and Seapath is set to follow the convention of Applanix PosMV (the primary scientific position and attitude system), as per Figure 43.

Primary scientific position and attitude system

The translations and rotations provided by this system (Applanix PosMV) have the following convention:

1. Roll positive port up,

2. Pitch positive bow up,
3. Heading true,
4. Heave positive up.

Position, attitude and time

System	**Navigation (Position, attitude, time)**		
Statement of Capability	*/Ship_Systems/Documentation/GPS_and_Attitude*		
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Pseudo-NMEA: */Ship_Systems/Data/TechSAS/NMEA/* Raw NMEA: */Ship_Systems/Data/RVDAS/NMEA/*		
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*		
Other documentation	*/Ship_Systems/Documentation/GPS_and_Attitude*		
Component	*Purpose*	*Outputs*	*Headline Specifications*
Applanix PosMV	Primary GPS and attitude.	Serial NMEA to acquisition systems and multibeam	Positional accuracy within 2 m.
Kongsberg Seapath 330+	Secondary GPS and attitude.	Serial and UDP NMEA to acquisition systems and multibeam	Positional accuracy within 1 m.
Oceaneering CNav 3050	Correction service for primary and secondary GPS and dynamic positioning.	-	Positional accuracy within 0.15 m.
Meinberg NTP Clock	Provide network time	NTP protocol over the local network.	-

Significant position, attitude or time events or losses

Date	*Time start**	*Time end**	*Event*
N/A			

Ocean and atmosphere monitoring systems

SURFMET

System	**SURFMET (Surface water and atmospheric monitoring)**
Statement of Capability	*/Ship_Systems/Documentation/Surfmet*
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Pseudo-NMEA: */Ship_Systems/Data/TechSAS/NMEA/* Raw NMEA: */Ship_Systems/Data/RVDAS/NMEA/*
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*
Other documentation	*/Ship_Systems/Documentation/Surfmet*
Calibration info	See Ship Fitted Sensor sheet for calibration info for each sensor.

Component	*Purpose*	*Outputs*
Inlet temperature probe (SBE38)	Measure temperature of water at hull inlet (remote temperature)	Serial to Interface Box
Thermosalinograph (SBE45)	Measure temp, sal and conductivity at sampling board (housing temperature)	Serial to Interface Box
Interface Box (SBE 90402)	Signals management	Serial to Moxa
Debubbler	Reduces bubbles through instruments.	N/A
Transmissometer (CST)	Measure of transmittance	Analogue voltage to ADC (Nudam)
Fluorometer (WS3S)	Measure of fluorescence	Analogue voltage to ADC (Nudam)
Air temperature and humidity probe (HMP45)	Temperature and humidity at met platform	Analogue voltage to ADC (Nudam)
Ambient light sensors (PAR, TIR)	Ambient light at met platform	Analogue voltage to ADC (Nudam)
Barometer (PTB110)	Atmospheric pressure at met platform	Analogue voltage to ADC (Nudam)
Anemometer (Windsonic) - Starboard	Wind speed and direction at met platform	Analogue voltages to ADC (Nudam)
Anemometer (Windsonic) - Port	Wind speed and direction at met platform	Serial NMEA to Techsas Moxa UDP NMEA to RVDAS
NUDAM	A/D converter	Serial NMEA to Moxa
Moxa (Surfmet)	Serial to UDP converter	UDP NMEA to Surfmet VM
Surfmet Virtual Machine	Data management	UDP NMEA to TechSAS, RVDAS

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port, and whilst alongside. Please see the separate information sheet for details of the sensors used and whether their recorded data have calibrations applied or not.

Surface water sampling board maintenance

Date	*Start*	*End*	*Event*	*Trans high (V)*	*Trans low (V)*	*Fluoro (V)*	*Salinity (PSU)*
12FEB2021	14:03	14:25	Cleaning	4.78	0.06	0.12	33.76
20FEB2021	12:23	12:32	Cleaning	4.3	0.06	0.19	33.52
27FEB2021	15:59	16:22	Cleaning	4.74	0.06	0.17	34.18

The system was cleaned prior to the cruise.

Wave radar

System	**WAMOS Wave Radar**		
Statement of Capability	/Ship_Systems/Documentation/Wamos		
Data product(s)	NetCDF: /Ship_Systems/Data/TechSAS/NetCDF/ Raw NMEA: /Ship_Systems/Data/RVDAS/NMEA/ Raw: /Ship_Systems/Data/Wamos/		
Data description	/Ship_Systems/Documentation/TechSAS /Ship_Systems/Documentation/RVDAS		
Other documentation	/Ship_Systems/Documentation/Wamos		
Component	*Purpose*	*Outputs*	*Headline Specifications*
Rutter OceanWaves WAMOS	Measure wave height, direction, period and spectra.	Summary statistics in NMEA to TechSAS and RVDAS. Spectra files.	
Furuno Radar	Measures radar reflection on sea surface.	Radar data to WAMOS.	

The wave radar magnetron requires annual replacement. Following replacement, WAMOS needs to collect wave data within 5 km of another wave height sensor over the full range of sea-states in order to derive wave height calibration coefficients for the new magnetron. This reference dataset can be derived by examining the ship's track for wave buoys and downloading their data.

Significant ocean and atmosphere monitoring events or losses

Date	*Time start**	*Time end**	*Event*
N/A			

Hydroacoustic systems

System	**Acoustics**		
Statement of Capability	/Ship_Systems/Documentation/Acoustics		
Data product(s)	Raw: /Ship_Systems/Data/Acoustics NetCDF (EA640, EM122cb): /Ship_Systems/Data/TechSAS NMEA (EA640, EM122cb): /Ship_Systems/Data/RVDAS		
Data description	/Ship_Systems/Documentation/Acoustics		
Other documentation	/Ship_Systems/Documentation/Acoustics		
Component	*Purpose*	*Outputs*	*Operation*
10/12 kHz Single beam (Kongsberg EA-640)	Primary depth sounder	NMEA over serial, raw/XYZ files	Continuous Synchronised
12 kHz Multibeam (Kongsberg EM-122)	Full-ocean-depth multibeam swath.	Binary swath, centre-beam NMEA, *.all files, optional water column data	Continuous Synchronised

70 kHz Multibeam (Kongsberg EM-710)	Coastal/shallow multibeam swath.	Binary swath, centre-beam NMEA, *.all files.	Discrete
Sub-bottom Profiler (Kongsberg SBP-120)	Multi-frequency echogram to provide along-track sub-bottom imagery.	BMP, raw files, optional water column data.	Unused
Drop keel sound velocity sensor	Provide sound velocity at transducer depth	Value over serial to Kongsberg SIS.	Continuous
Sound velocity profilers (Valeport Midas)	Direct measurement of sound velocity in water column.	ASCII pressure vs sound velocity files. Manually loaded into Kongsberg SIS or Sonardyne Ranger2.	Discrete (See deployment event log, below)
EK60 (SIMRAD)	Fisheries Echosounder (18kHz, 38kHz, 70kHz, 120kHz, 200kHz)	Kongsberg.raw(.idx/.bot)	Continuous Synchronised
75 kHz ADCP (Teledyne OS75)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running
150 kHz ADCP (Teledyne OS150)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running
USBL (Sonardyne Ranger2)	Underwater positioning system to track deployed packages or vehicles.	NMEA over serial	Discrete (See deployment event log, below)
CARIS	Post-processing	CARIS Project file. CARIS Vessel files	Discrete
MB-System	Post-processing	XYZ, SegY files	Unused

Marine Mammal Protection

Path to Marine Mammal Observation logs:
`/Cruise_Reports/Eventlogs/server/current_csv_logs/scilogs/MMO_log.csv`

System	*Actions taken to protect mammals, in compliance with NERC and JNCC protocols*
12 kHz Multibeam (Kongsberg EM-122)	45-minute observation by MMO. Marine mammal protection 15 minute ramped start (-20dB) initiated at 30 minutes into observation if no mammals sighted. Clock restarted if mammals sighted.
Sub-bottom Profiler (Kongsberg SBP-120)	System not used.

Sound velocity profiles

Sound velocity profiles were collected with the Midas SVP probe (S/N:75525), derived from CTD, or calculated from the WOA13 model using Ifremer DORIS.

Path of sound velocity profile data on the cruise datastore:
`/Ship_Systems/Data/Acoustics/Sound_Velocity`

Details of when sound velocity profiles were taken and applied are shown in the table below:

Table 9. Sound velocity profiles applied to EM122.

Date/Time	*event*	*comment*
02/02/2021 14:35	EM122 - SVP Updated	Applied SVP 'WOA-2FEB' to EM122
02/02/2021 23:01	EM122 - SVP Updated	Applied SVP 'WOA-2FEB_2' to EM122
03/02/2021 21:09	EM122 - SVP Updated	Applied WOA3FEB to EM122
04/02/2021 10:52	EM122 - SVP updated	SVP WOA-4FEB applied to EM122
11/02/2021 19:47	EM122 SVP applied	JC211_CTD004_align_ctm_SV_25m.asvp applied.
13/02/2021 14:42	EM122 new SVP	Applied WOA_13FEB.asvp
13/02/2021 21:22	EM122 applied SVP	Applied WOA13_13FEB2021_2.asvp
16/02/2021 15:26	EM122 SVP profile	JC211_CTD032.asvp applied
17/02/2021 16:59	EM122 SVP profile updated	JC211_CTD040.asvp applied
19/02/2021 21:19	SV Updated	EM122/710 - loaded with 'FILE2' SVP profile (from MIDAS SVP)
20/02/2021 11:07	EM122 SVP update	Applied CTD050
21/02/2021 11:12	EM122 SVP update	Applied reduced CTD055
23/02/2021 13:43	EM122 new SVP	Applied CTD-060 reduced
26/02/2021 13:53	EM122 new SVP	WOA_26FEB applied
01/03/2021 13:47	EM122 new SVP	Applied CTD-075
02/03/2021 11:17	EM122 new SVP	Applied CTD-079
2021-03-01 13:47	EM122 - SVP	CTD075 applied
2021-03-02 11:17	EM122 - SVP	CTD079 applied
2021-03-02 23:45	EM122 - SVP	CTD081 applied
2021-03-03 10:17	EM122 - SVP	CTD082 applied
2021-03-04 09:49	EM122 - SVP	CTD087 applied

Significant acoustic events or losses

Date	*Time start**	*Time end**	*Event*
N/A			

Equipment-specific comments

ADCPs

Path of ADCP data on the cruise datastore:
`/Ship_Systems/Data/Acoustics/ADCP`

Attribute	*Value*
Acquisition software	UHDAS
Frequencies used	75 kHz and 150 kHz
Running mode	Free-running (untriggered)
Configuration details	Bin size, blanking distance, 150 kHz: Narrow band, 50 bins, length 8m, 4m blanking 75kHz: Narrow band, 50 bins, length 16, 8m blanking

Bottom tracking was run from leaving Mare Harbour until 18:11UTC 02/02/2021 (water depth of >1000m).

Drop Keel Deployments:
During the cruise the starboard drop keel was lowered to different depths to investigate the effect on the EK60 data quality. This instrument was the priority for the WCB section of the cruise. It was understood that this would likely have an impact on the ADCP data (both instruments are mounted on the port drop keel – which remained flush to the vessel baseline for the entirety of the cruise). Y.Firing and J. Hummon identified from the investigation that there may be reprocessing methods (3-beam solutions, single-ping processing) which can be applied to use the ADCP data in situations where the starboard drop keel is deployed. The 'mid' position (1.2m) does not have a significant impact on ADCP data, however the EK60 data was not satisfactory (worse than when in flush position). Further investigation still may identify a position between 1.2m and 2.4m where both instruments could obtain good data without the need for alternative ADCP processing.

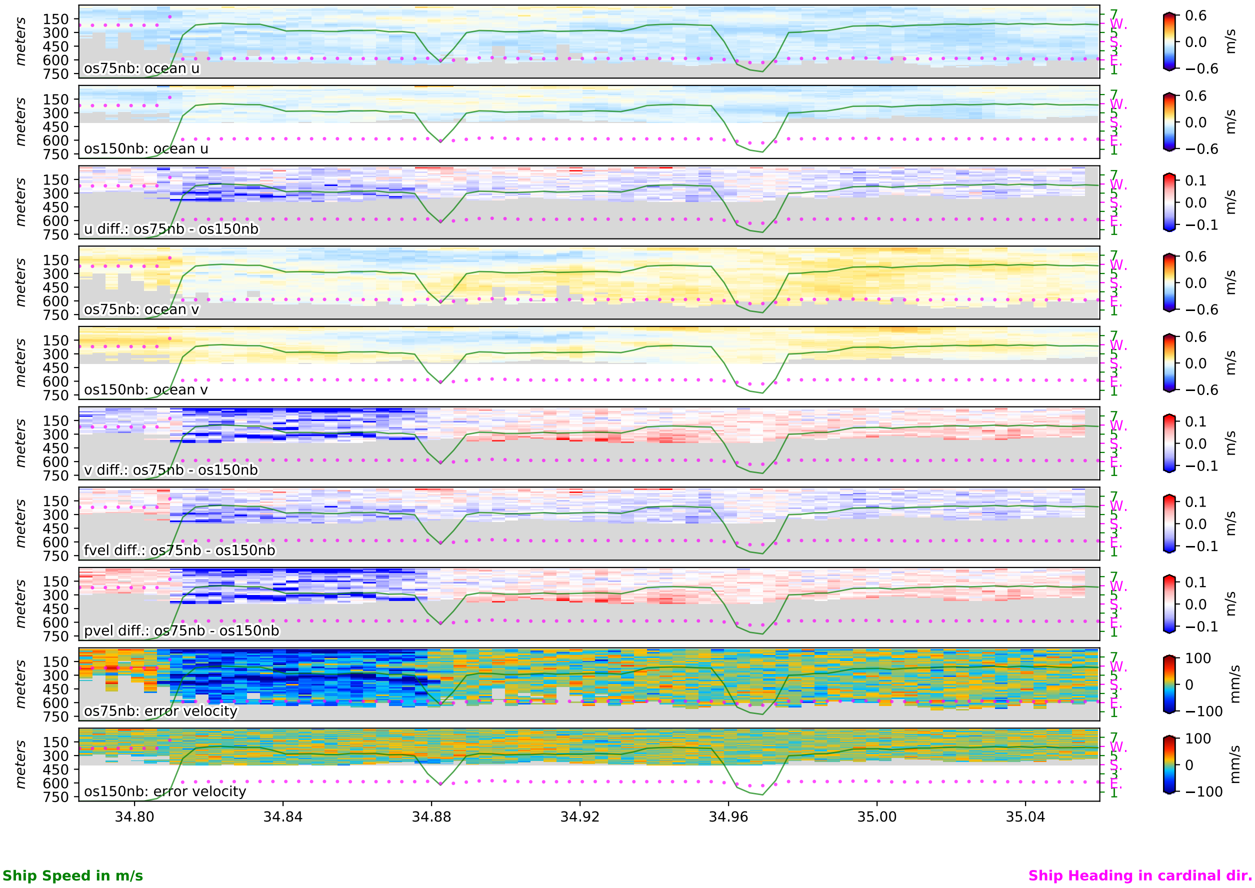


Figure 44 Starboard drop keel investigation into EK60 and ADCP data quality. (by Y. Firing)

Variation in ship speed in Figure 44 indicate periods of drop keel adjustment. There were 3 main periods of investigation:
1 – Initially (18:51UTC 04FEB2021) the starboard drop keel deployed to 2.4m below vessel baseline. Data collected for approx. 2 hour (first hour at passage speed of approx. 12kts, second hour at 10kts).
2 – Drop keel raised to 1.2m depth below baseline (20:59UTC 04FEB2021). Data collected for approximately a further 2 hours (first hour at 10kts, second hour at passage speed of approx. 12kts).
3 – Drop keel raised back to the flush position (23:00UTC 04FEB2021), and resuming passage at approx. 12kts [conclusion of investigation].

Additionally, during the WCB survey (06FEB2021-13:00 10FEB2021) and during the EK60 calibration (17:30 10FEB2021 – 04:00 11FEB2021) the starboard drop keel was lowered to optimise EK60 operation.

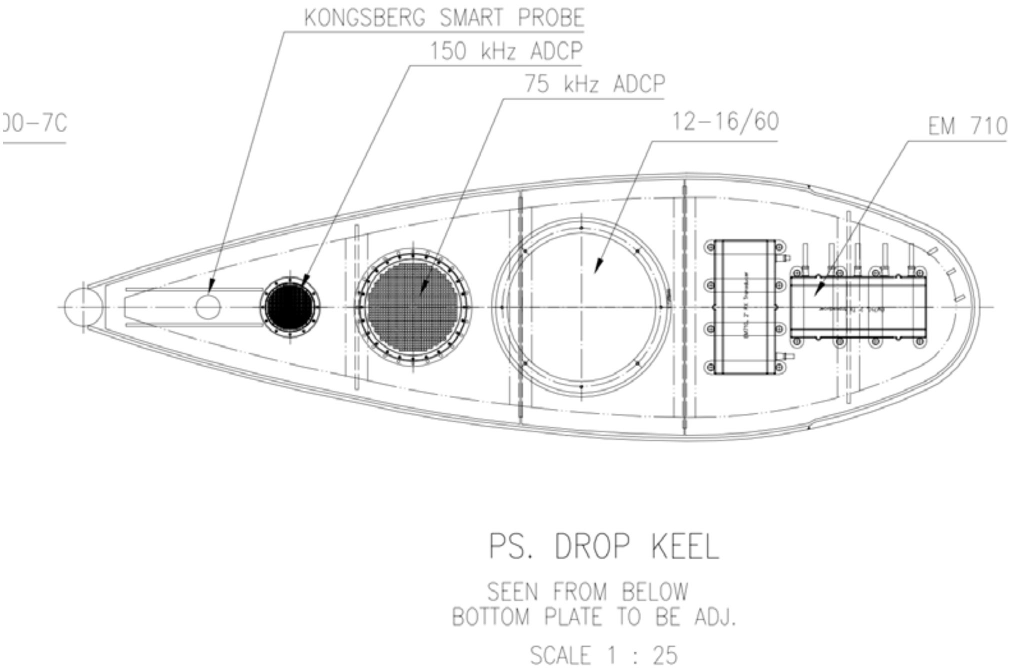


Figure 45 RRS James Cook port drop keel instrumentation arrangement.

EM-122 Configuration and Surveys

Path of Multibeam data on the cruise datastore:
`/Ship_Systems/Data/Acoustics/EM-122`

Attribute	*Value*
Number of surveys	1
Date of patch test	N/A
Offsets and rotations	(see tables below)
Post-processing undertaken	

Offsets and rotations:

Item	*X (m, + Forward)*	*Y (m, + Starboard)*	*Z (m, + Down)*
Tx transducer	19.205	1.830	6.934
Rx transducer	14.094	0.950	6.932
Att 1 (Applanix)	0	0	0
Att 2 (Seapath)	-0.35	0.056	-0.373
Waterline (distance from Att 1 to W/L)			1.432

Item	*Roll (deg)*	*Pitch (deg)*	*Yaw (deg)*
Tx transducer	-0.35	-0.1	0.19
Rx transducer	-0.06	0.1	0.15
Att 1 (Applanix)	0.15	0.12	-0.2
Att 2 (Seapath)	0.06	0.16	0.03

Survey information – note any particular transducer settings (e.g. beam spacing) in comments:

Survey Site Name	*SIS Survey Name*	*Datetime Start*	*Datetime End*	*Vessel survey speed (kts)*	*SVP(s) Used (Filename)*	*Comments*
JC211	JC211				See section 3.4.2	

EM-710 Configuration and Surveys

Path of Multibeam data on the cruise datastore:
`/Ship_Systems/Data/Acoustics/EM-710`

Attribute	*Value*
Number of surveys	1
Date of patch test	N/A
Offsets and rotations	(see tables below)
Post-processing undertaken	

Offsets and rotations:

Item	*X (m, + Forward)*	*Y (m, + Starboard)*	*Z (m, + Down)*
Tx transducer	5.415	-0.015	6.965
Rx transducer	4.988	0.013	6.965
Att 1 (Applanix)	0	0	0
Att 2 (Seapath)	-0.35	0.056	-0.373
Waterline (distance from Att 1 to W/L)			1.465

Item	*Roll (deg)*	*Pitch (deg)*	*Yaw (deg)*
Tx transducer	-0.418	0.228	0
Rx transducer	0.130	0	0
Att 1 (Applanix)	-0.45	0.68	-0.38
Att 2 (Seapath)	-0.46	0.39	-1.01

Survey information – note any particular transducer settings (e.g. beam spacing) in comments:

Survey Site Name	*SIS Survey Name*	*Datetime Start*	*Datetime End*	*Vessel survey speed (kts)*	*SVP(s) Used (Filename)*	*Comments*
N/A						

EK-60 Configuration and surveys

Path of fisheries echosounder data on the cruise datastore:
`/Ship_Systems/Data/Acoustics/EK-60`

Attribute	*Value*
Number of surveys	1 (additional data collected pre/post WCB survey)
Datetime of CTD dip	CTD (Event 36) deployed 17:41UTC 10/02/2021 (75m)
Mean temperature from transducer (~7.9m) to depth of sphere	3.46°C
Mean salinity from ship's baseline to depth of sphere	33.58
Calibration info	(see table below)

Calibration info:

Frequency (kHz)	18	38	70	120	200
Datetime	10/02/2021	10/02/2021	10/02/2021	10/02/2021	10/02/2021
Ref. target strength (dB)	-42.963	-42.204	-40.777	-39.651	-39.519

Survey information:

Survey Site Name	*Datetime Start*	*Datetime End*	*Comments*
WCB	09:12 06/02/2021	12:42 10/02/2021	2 sec ping
Pre-WCB	12:04 02/02/2021	(Start of WCB)	
Post-WCB	(End of WCB)	End of cruise	6 sec ping

Western Core Box (WCB) Survey Events

Time (UTC)	Event	Comment
05/02/2021 22:43		log started
06/02/2021 09:12	Start of line	W1.1N
06/02/2021 13:30	End of line	Line completed - W1.1S
06/02/2021 13:32	Start of turn	Turning to W1.2S position
06/02/2021 14:42	End of turn	Running into SOL WP W1.2S
06/02/2021 14:47	Start of line	W1.2S Waypoint
06/02/2021 15:41	Bridge turned off Echosounder	Removed interfernce on 38kHz
06/02/2021 16:37	Bridge echosounder back on briefly	Interference on 38. Will only now be used <200 m
06/02/2021 19:01	End of W1.2 line	Passed W1.2N
07/02/2021 09:03	Start of line	Start of W2.1
07/02/2021 09:50	Bridge Echosounder	Echosounder power reduced from 51 to 37% to attempt to reduce 38kHz noise (wd approx 200m))
07/02/2021 10:31	Bridge Echosounder - OFF	Turned off as water depth decreasing from approx 380m (EK 38kHz visibly improved)
07/02/2021 13:26	End of line W2.1	W1.2N waypoint crossed
07/02/2021 14:55	Start of line W2.2	Crossed waypoint W2.2N
07/02/2021 18:43	Bridge Echosounder turned on	(depth 165m) - 38kHz interference
07/02/2021 19:13	Finished W2.2	Crossed waypoint W2.2N
08/02/2021 08:49	W3.1S - Approaching wp	Approaching (1nm) W3.1S waypoint for start of line (day 3 of survey)
08/02/2021 08:54	Start of Line - Course change	Course change on SOL 3.1 to avoid growlers
08/02/2021 09:02	Course change	Back on W3.1 line/course
08/02/2021 12:17	EK60 stopped logging	5 minute gap in data caught at 12:22
08/02/2021 13:13	End of W3.1 line	Crossed W3.1N waypoint
08/02/2021 14:45	Course change - hove to	Turning and slowing (near to W3.2N) 5m swell on beam
08/02/2021 18:46	Suspension of survey	EK60 not logging, line suspended due to excessive swell.
09/02/2021 08:24	Approaching SOL	Approaching start of line at W3.2S waypoint
09/02/2021 08:32	Start of line W3.2	Passing waypoint W3.2S
09/02/2021 12:53	End of line	EOL- W3.2 (Passing W3.2N waypoint)
09/02/2021 13:58	Started line W4.1	Crossed waypoint W4.1N
09/02/2021 15:45	Course change	Start of deviation for iceberg on survey line.

09/02/2021 16:51	Course change	Deviation from survey line due to iceberg
09/02/2021 17:07	Mid-point of correction	Course change to begin the return to survey line (iceberg).
09/02/2021 17:26	Resumed survey line	Deviation due to iceberg completed
09/02/2021 18:19	End of line	W4.1N waypoint - W4.1 line completed
10/02/2021 08:06	Approaching waypoint - deviation	0.5nm from W4.2N. May miss start of line due to 6mile iceberg
10/02/2021 08:13	Start of line	Passed W4.2N approx 0.5nm west due to iceberg
10/02/2021 08:24	Resumed original survey line	Onto W4.2 approx 2nm from SOL waypoint
10/02/2021 11:28	Altering course	Detouring to starboard around ice
10/02/2021 11:57	Resumed survey line	Back on W4.2 after about 6nm
10/02/2021 12:22	Altering course	Detouring starboard around bergy bit
10/02/2021 12:37	Completed W4.2 line	Off course - about 0.6 nm from waypoint W4.2S
10/02/2021 12:42	Crossing W4.2 line	About 0.5nm south of EOL waypoint

WCB Survey

Starboard drop keel deployed to 2.4m on 2100UTC 05/02/2021 (whilst on station for CTD event 007). Drop keel recovered to flush position (vessel baseline) 1258UTC 10/02/2021 following the completion of the WCB survey, for the passage to Stromness harbour.

Environment settings of 4°C, 34.6 PSU were used for the WCB survey and any prior acquired data. 3.5°C and 33.6 PSU were applied during the post-survey calibration and remained in the system for the remainder of the cruise (low-resolution data approx. 6 second ping collected).

Transducer parameters (‘2way beam angle [dB]’, ‘Angle parameters - Alongship’, ‘Angle parameters - Athwartship’) were reset to initial settings (from Simrad’s original transducer data sheets) prior to the start of the cruise. This was due to the many years since this operation was last completed onboard resulting in uncertainty of how the parameters currently in the system had been derived.

Data was acquired for all frequencies to 1200m during all WCB survey lines. This related to a ping rate of approx. 2 seconds. K-sync was used to trigger the EK60 software. 75 & 150kHz ADCPs were also collecting data during WCB survey (free-running). ADCP data may be reprocessed to attempt to take into account drop keel deployment (refer also to notes elsewhere regarding starboard drop keel investigations into ADCP data quality). EA640 single beam data was also collected (K-sync triggered).

Table 10. EK60 pre-calibration settings (includes some factory default parameters).

Variable	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz
Transducer type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C
Transducer Serial No.	2067	30637	130	345	313
Transducer depth (m)	7.9	7.9	7.9	7.9	7.9
Transducer Serial No.	009072058c91	009072058cb6	009072058ca5	009072058ca6	009072058cb8
Transducer power (W)	1400	1000	700	200	100
Pulse length (us)	1024	1024	1024	1024	1024
2-way beam angle (dB)	-17.3	-21.0	-21.0	-20.9	-20.9
Transducer gain (dB)	22.51	23.60	26.76	26.47	25.14
Sa correction (dB)	-0.70	-0.51	-0.27	-0.42	-0.28
3dB beam along (°)	10.3	6.6	6.8	6.9	6.8
3dB beam athwart (°)	10.6	6.9	6.7	6.9	7.0
Along offset (°)	0.09	0.07	-0.02	0.13	0
Athwart offset (°)	0.07	-0.03	-0.05	0.09	0

Calibration

Calibration of the EK60 system was completed 10FEB2021 in Stromness Harbour, South Georgia [Position: -54.1598, -36.6929].

A CTD (Event 36) was deployed at 17:41UTC to 75m. Following the completion of this operation the EK60 calibration equipment was set up from 18:26UTC to deploy a 38.1mm tungsten carbide sphere. Following the observation of the sphere in the transducer beam, the starboard drop keel was deployed to 2.4m below vessel baseline (reproducing the conditions for the WCB acoustic survey). This resulted in a transducer depth below surface of 7.9m (5.5m baseline draft + 2.4m drop keel deployment), which was applied in the installation set up (table below).

Temperature and salinity were averaged from the transducer to 55m (depth of calibration sphere) and were 3.46^{o}C and 33.58 PSU.

Data was collected to 600m for the duration of the calibration, relating to a 1 second ping rate.

The calibration process included applying the new parameters to the system (table below). Calibration was completed for all five transducers using a single 38.1mm tungsten carbide deployment.

Table 11. EK60 post-calibration settings.

Variable	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz **
Transducer type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C
Transducer Serial No.	2067	30637	130	345	313
Transducer depth (m)	7.9	7.9	7.9	7.9	7.9
Transducer Serial No.	009072058c91	009072058cb6	009072058ca5	009072058ca6	009072058cb8
Transducer power (W)	1400	1000	700	200	100
Pulse length (us)	1024	1024	1024	1024	1024
2-way beam angle (dB)	-17.3	-21.0	-21.0	-20.9	-20.9
Transducer gain (dB)	22.65	24.46	26.99	27.02	25.44
Sa correction (dB)	-0.68	-0.53	-0.35	-0.28	-0.37
3dB beam along (°)	10.85	7.10	6.38	6.52	6.90
3dB beam athwart (°)	11.18	7.17	6.43	6.55	6.90
Along offset (°)	0.01	0.15	0.06	0.03	0.02
Athwart offset (°)	0.10	-0.16	-0.03	-0.01	-0.01

Calibration Quality

Below shows the RMS values of 'Data Deviation from Beam/Polynomial Model' for the calibration output files produced. These were all completed using a **Ts deviation of 5dB**. The output for the 200kHz is particularly high, however replaying the data using a lower Ts deviation of 0.5dB produced RMS values <0.2dB from >260 data points.

Note: the replayed calibration data (with reduced Ts deviation) was not applied during the remainder of the cruise but demonstrates that there is sufficient data available from the operation to produce better calibration settings.

Table 12. RMS data deviations from beam & polynomial models. Note improvement for replayed 200kHz using reduced Ts deviation.

Transducer type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C	ES200-7C (Replay)
Ts deviation (dB)	5	5	5	5	5	0.5
RMS Data Deviation from Beam Model (dB)	0.17	0.28	0.31	0.37	0.75	0.14
RMS Data Deviation from Polynomial Model (dB)	0.10	0.27	0.27	0.36	0.71	0.13

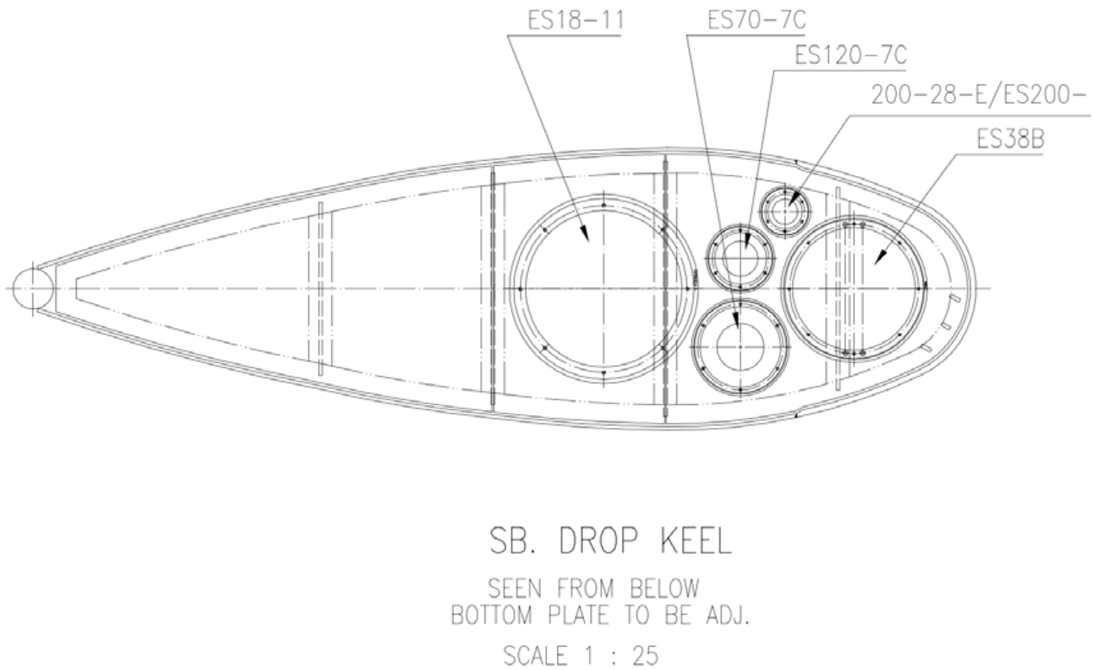


Figure 46 RRS James Cook, starboard drop keel instrumentation arrangement