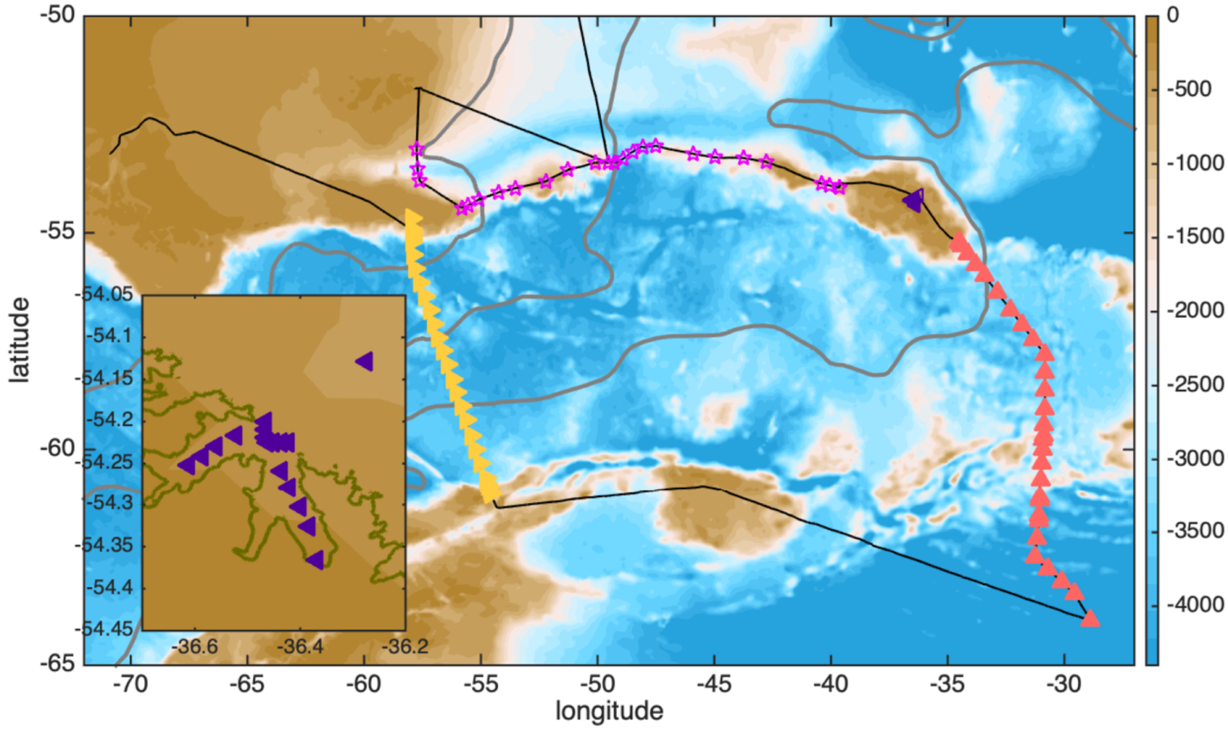
CRUISE REPORT: A23, SR1B

(Updated JUN 2020)



Highlights

Cruise Summary Information

Section Designation	**A23, SR1B**
Expedition designation (ExpoCodes)	**74EQ20200203**
Chief Scientists	**Yvonne Firing / NOC**
Dates	2020 February 3 – 2020 March 13
Ship	RRS Discovery
Ports of call	Punta Arenas, Chile - Grytviken, South Georgia - Stanley, Falkland Islands - Montevideo, Uruguay
Geographic Boundaries	-52.99212 -57.96812 -28.87766 -63.96534
Stations	30 - SR1B Drake Passage stations 31 - A23 Transect stations 17 - Cumberland Bay (CUMB) stations 25 - North Scotia Ridge (NSR) Transect Stations
Floats and drifters deployed	4 Argo floats deployed
Moorings deployed or recovered	0

Contact Information

Yvonne L. Firing

National Oceanography Centre, Southampton • University of Southampton Waterfront Campus

European Way • Southampton • SO14 3ZH • UK

Tel: +44 (0)23 80599 669 • Email: yvonne.firing@noc.ac.uk

Final report assembly by Jerry Kappa, SIO/UCSD

National Oceanography Centre

National Oceanography Centre

Cruise Report No. 67

RRS Discovery Cruise DY113

3 February – 13 March 2020

Repeat hydrographic measurements on GO-SHIP lines SR1b and A23

Principal Scientist
Y L Firing

National Oceanography Centre, Southampton
University of Southampton Waterfront Campus
European Way
Southampton
SO14 3ZH
UK

Tel: +44 (0)23 80599 669
Email: yvonne.firing@noc.ac.uk

DOCUMENT DATA SHEET

AUTHOR

Y L Firing, E P Abrahamsen, N Ensor, D Menzel, A Mountford, C Pimm, P Punter

PUBLICATION DATE 2020

TITLE

RRS Discovery Cruise DY113, 3 February – 13 March 2020. Repeat hydrographic measurements on GO-SHIP lines SR1b and A23

REFERENCE

Southampton, UK: National Oceanography Centre, Southampton, 116pp.
(National Oceanography Centre Cruise Report, No. 67)

ABSTRACT

Cruise DY113 comprised occupations of two repeat hydrographic sections, SR1b across Drake Passage from Burdwood Bank to Elephant Island, and A23 from the northern Weddell Sea across the Scotia Sea to South Georgia. Ocean physical measurements are made on these two sections annually funded by NERC as National Capability, currently through the ORCHESTRA (Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports) programme, in order to monitor and understand variability of Antarctic Circumpolar Current transports and Antarctic Bottom Water properties and volumes. In addition to the 62 CTD/LADCP casts on SR1b and A23, a CTD survey was made over 17 sites in Cumberland Bay, South Georgia, and a section along the North Scotia Ridge also occupied on cruise JR299 was revisited, bringing the total to 104 CTD/LADCP casts including one test cast and one other repeat. Water column samples were collected for calibration of CTD salinity and dissolved oxygen (most stations) as well as for measurements of oxygen isotopes (SR1b, A23, Cumberland Bay), nutrient (N and Si) isotopes (SR1b), nutrient (NO2+NO3, NO3, Si, P; SR1b, A23) concentrations, microplastics (SR1b, A23, Cumberland Bay), and environmental DNA (SR1b). Standard underway measurements including underway surface ocean and meteorological data and upper ocean vessel-mounted current measurements were collected throughout, while multibeam swath bathymetry data was recorded on the transit between SR1b and A23 (south of the South Orkney Islands), in Cumberland Bay, and on previously-unsurveyed parts of the North Scotia Ridge transect and between there and the Falkland Islands. Four standard Argo autonomous profiling floats were also deployed, two on SR1b and two on A23.

KEYWORDS

Repeat hydrography, CTD, LADCP, VMADCP, nutrients, isotopes, microplastics, ocean observation

ISSUING ORGANISATION

National Oceanography Centre
University of Southampton Waterfront Campus
European Way
Southampton SO14 3ZH
UK
Tel: +44(0)23 80596116 Email: nol@noc.soton.ac.uk

(This page intentionally left blank)

Contents

List of Figures

List of Tables

1. Personnel

Scientific Personnel

Yvonne Firing	NOC	PSO
Povl Abrahamsen	BAS	PI, A23
Natalie Ensor	BAS	Oxygen
David Menzel	Geomar	Physics
Alethea Mountford	U. Newcastle	Microplastics
Ciara Pimm	U. Liverpool	Physics
Philip Punter	U. Edinburgh	Oxygen, nutrient isotopes

Technical Personnel

Martin Bridger	Scientific ship systems
Mark Maltby	Sensors and moorings
Dougal Mountifield	Sensors and moorings

Ship's Personnel

Antonio Gatti	Master
Robert Ovenden	Chief Officer
Graham Stringfellow	2nd Officer
Rachael Astell	3rd Officer
James Bills	Chief Engineer
Christopher Kemp	2nd Engineer
Daniel Evans	3rd Engineer
Sean Rooney	3rd Engineer
Christopher Howard	ETO
Valerija Forbes-Simpson	Purser
Jonathan Porter	Medic
Craig Lapsley	CPOS
Robert Spencer	CPOD
Craig Gilfillan	POD
Christopher Devitt	AB
Andrew Dwyer	AB
Robert Leech	AB
Paul McLean	AB
Emlyn Williams	ERPO
Mark Ashfield	Head Chef
Michael Leigh	Chef
Carl Piper	Steward
Brian Winton	Assistant Steward
Michael Hutchinson	Deck Cadet
Jake Maloney	Deck Cadet

2. Itinerary and Cruise Track

DY113 departed Punta Arenas, Chile, on 4 February, 2020, and crossed Drake Passage from Burdwood Bank to Elephant Island occupying the SR1b section from 7 to 12 February. We then transited between Elephant and Clarence Islands and south of the South Orkney Islands to occupy the A23 section from the Weddell Sea (64°S) to South Georgia from 16 to 23 February. These two sections comprised the initially-planned, funded work on the cruise; since we were unusually lucky with the weather we had time to add opportunistic CTD surveys in two areas. We conducted CTDs in both eastern (repeating measurements made previously on JR272A and JR15006) and western arms of Cumberland Bay, South Georgia, on 24 and 25 February, with a visit to Grytviken on the 25th. We then transited along the north side of South Georgia to the Shag Rocks Passage where we began the final CTD section working westward along the North Scotia Ridge (repeating measurements made on JR299, skipping some sites due to time constraints) on 27 February, breaking midway through on 1 March to visit Stanley, Falkland Islands, from 2 to 5 March, and finishing the NSR section from west back to the middle from 5 to 8 March. Finally we headed for Montevideo, Uruguay, arriving on 13 March, 2020.

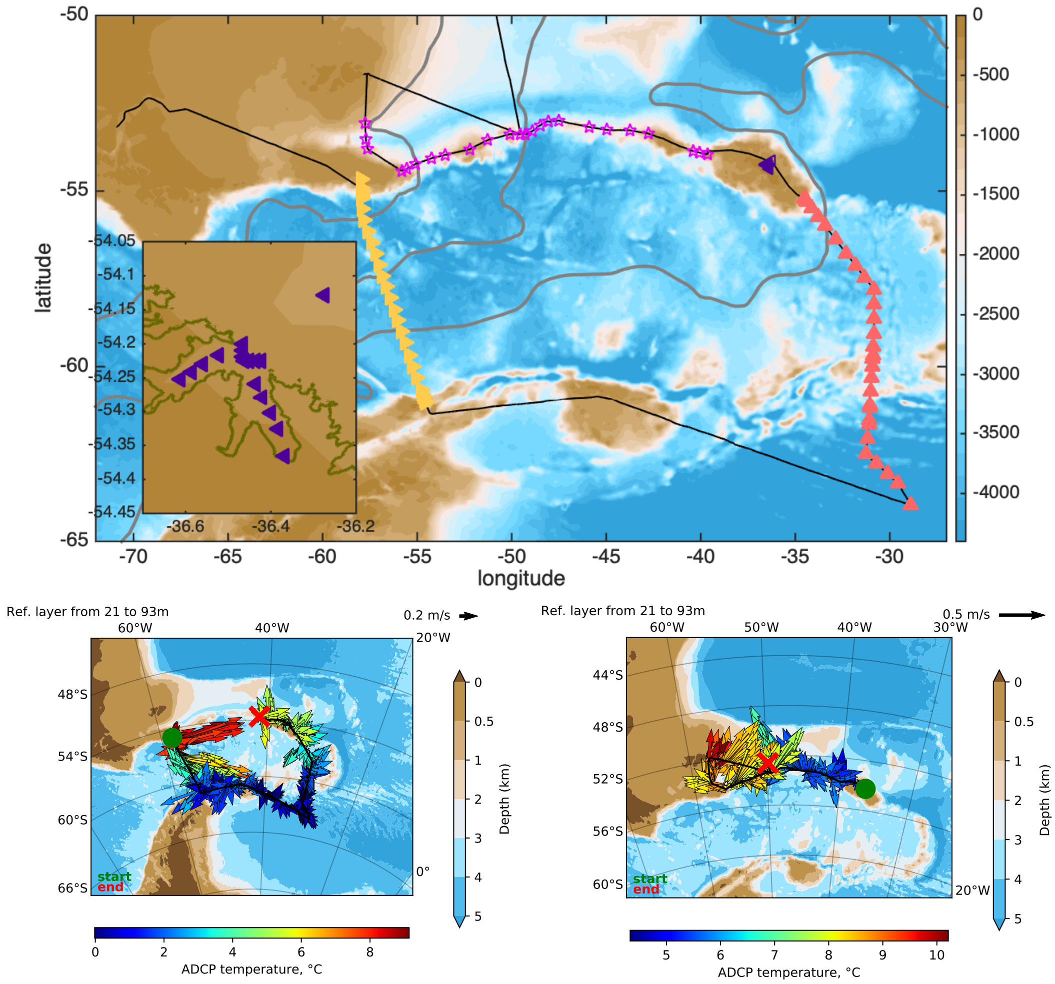


Figure 2.1: DY113 cruise track with CTD stations of SR1b (yellow triangles), A23 (red triangles), and NSR (pink stars), with Cumberland Bay stations (purple) in inset (top); DY113 cruise track segments with upper ocean velocity vectors coloured by temperature (bottom).

3. Objectives

DY113 was a combination of two long-term annual repeat hydrographic sections funded by NERC under the ORCHESTRA programme (Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports, NERC LTS-M grant NE/N018095/1), as well as six opportunistic projects (four sets of opportunistic sampling, and two additional sets of CTD measurements). ORCHESTRA aims to quantify and understand how the Southern Ocean and its interactions with the atmosphere and ice affect the oceans uptake and storage of heat and carbon.

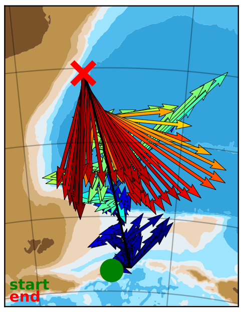
- SR1b repeat hydrographic section
  PI: Yvonne Firing, NOC
  Objective: To make high-quality repeat hydrographic measurements on GO-SHIP line SR1b, continuing a near-annual time series of physical measurements ongoing since 1993, in order to monitor the volume and property transports of the Antarctic Circumpolar Current.
- A23 repeat hydrographic section
  PI: Povl Abrahamsen, BAS
  Objective: To make high-quality repeat hydrographic measurements on the A23 section from the northern Weddell Sea through the Scotia Sea, to monitor the properties and volumes of Antarctic Bottom Water and its precursors in the Weddell Sea.
- Microplastics in Drake Passage
  Lead: Alethea Mountford, Newcastle (PI: Miguel-Angel Morales Maqueda, Newcastle)
  Objective: To make repeat measurements of microplastic concentrations across Drake Passage to validate numerical modelling of microplastic pollution dispersion.
- Nutrient isotopes
  Lead: Philip Punter, Edinburgh (PI: Robyn Tuerena, Edinburgh)
  Objective: To quantify N and Si regeneration within the mixed layer and upper ocean across the Antarctic Circumpolar Current, and its relationship to physical variability.
- Environmental DNA in the ACC
  Lead: Yvonne Firing, NOC (PI: Will Goodall-Copestake, CEH/SAMS)
  Objective: To determine the relationship between species distribution and water masses of the Antarctic Circumpolar Current on both sides of the Polar Front.
- Underway CO_2 fluxes
  Lead: Povl Abrahamsen, BAS (PI: Mingxi Yang, PML)
  Objective: To expand the dataset of measurements of air-sea CO_2 fluxes to better understand the ocean's role in the carbon cycle.
- CTD survey of Cumberland Bay, South Georgia
  Objective: To add to the dataset of coastal water properties around South Georgia including the relative contribution of glacial melt by repeating measurements made on JR272A and JR15006 of water mass properties in the eastern arm of Cumberland Bay, and collecting hydrographic measurements in the western arm for the first time.
- North Scotia Ridge hydrographic section
  Objective: To learn about along-stream and temporal variability in the ACC by repeating measurements made on JR299 that resample (downstream of SR1b) the warm portion of the ACC and capture the part of the transport that passes west of South Georgia rather than across A23.

4. Narrative

Yvonne Firing (NOC, yvonne.firing@noc.ac.uk)

All times UTC

31 Jan begin mobilisation (techs, PSO)
1 Feb rest of science party arrives
3 Feb leave Muelle Prat, wait for Argo floats previously held up in Santiago customs to arrive
4 Feb sailed, left Straits of Magellan afternoon, to some swell 6 Feb test cast at SR1b_08 in 3000 msw, then steam back to Burdwood Bank to begin section proper at SR1b_01 in 200 msw; VSAT disappears
9 Feb deploy Argo float
11 Feb deploy Argo float
12 Feb finish SR1b, passage between Elephant and Clarence Islands
14 Feb pass South Orkney Islands; moderately foggy as usual
16 Feb start A23; deploy Argo float
17 Feb first wait on weather, 0200-1400
18 Feb big tabular iceberg near station
19 Feb highly scenic day with iceberg half made of dark green marine ice, plus humpback whales hanging about on CTD stations, and Argo float deployment
20 Feb more visiting humpbacks, plus bottom contact by CTD rosette; wire may have been wrapped under LADCP bracket but no evident damage to instruments, frame or wire
23 Feb finish A23, head in toward South Georgia
24 Feb CTDs in western arm of Cumberland Bay, overnight in Jason Harbour
25 Feb CTDs in eastern arm of Cumberland Bay, visit to Grytviken in the rain, more CTDs
26 Feb steaming along north side of South Georgia, some rolling but also sunshine
27 Feb short wait on weather, 0600-0700, then start North Scotia Ridge section
28 Feb start using AHC on winch
01 Mar break off NSR section to head for Falklands
02 Mar arrive Stanley in the evening; VSAT mysteriously working well again
03 Mar penguins, swimming, civilisation
04 Mar see above
05 Mar leave Stanley and start extension of NSR line across to Burdwood Bank
8 Mar finish NSR with repeat of NSR_16, turn northwards, Tischkickertournier semi-finals and quiz
9 Mar Tischkickertournier finals
10 Mar a bit more rolling
11 Mar strong (1.5 m/s) southward current results in SOG of 8 kt for much of the day, down to 6 kt at times; underway science data collection suspended afternoon (TSG)/evening (acoustics, CO_2 flux system) before entering Argentinian EEZ
12 Mar end of cruise sunset, stars and socialising
13 Mar arrive Montevideo, demobilisation



5. CTD

Yvonne Firing (NOC, yvonne.firing@noc.ac.uk) and Ciara Pimm (Liverpool, ciara.pimm@liverpool.ac.uk)

The CTD was configured and operated by the NMF Sensors & Moorings technicians. CTD instrumentation, setup, and operation are described in Section 12. Data were converted and and output as ascii files, and align and cell thermal mass corrections were applied, in the SBE software.

CTD data processing was run on the Linux workstation koaeula using the mexec Matlab routines developed at NOC, described in "A User Guide to Mexec v3" (rev. 20200313) as well as in cruise reports for JR306 and JC159. The routines as at the end of the cruise (as well as various versions during the cruise) will be preserved on git.noc.ac.uk/MEXEC in branch dy113. Cruise-specific parameters are set in a file opt_dy113.m.

The secondary CTD, located on the fin, was used as the main sensor (that is, temp, cond, oxygen are equal to temp2, cond2, oxygen2, etc.) except on cast 20 when a salp was sucked into the secondary duct.

5.1 Changes to processing on DY113

Changes to mexec CTD processing made on DY113 can be tracked using git, but three major categories, prompted by discussion with Hugh Venables and Povl Abrahamsen and comparison with the BAS CTD-procGEN routines (Section 5.3), are listed here with the scripts they affect (all may also affect the scripts used to set cruise-specific parameters, get_cropt.m and opt_dy113.m):

1. Average from 24 Hz to 2 dbar directly rather than first averaging to 1 Hz; add options to fill gaps up to a certain length in 24 Hz data before averaging and fill or not fill gaps up to a certain length in 2 dbar data after averaging (mctd_03.m, mctd_04.m). Only one 1 Hz file, ctd_dy113_*nnn*_psal.nc, is saved. A file containing derived variables at 24 Hz is saved temporarily by mctd_03.m but removed at the end of mctd_04.m; this means that if mctd_04.m is to be rerun, mctd_03.m must be rerun first.

2. Have the option to apply loop-editing to downcasts to remove times when the pressure went back down (CTD package went back up) past a certain threshold (mctd_04.m, m_loopedit.m). This is set to be applied for DY113 but is not presently the default for other cruises in the dy113 branch.

3. For upcast data to be extracted for comparison with calibration samples, take the median over five 1-s mean samples corresponding to the 5 s following Niskin firing, rather than interpolating from 1 Hz data to the Niskin firing time (mfir_03.m).

In addition, edits to scripts made on JC191 to use Matlab-native netcdf tools and to detect bottle stops when using winch heave compensation were implemented on DY113 as well. Changes to mexec underway data processing are described in Section 9.

CTD casts are listed in Table 5.1.

5.2 Sample data comparison and CTD calibration

Collection and analysis of salinity and oxygen bottle sample data are described in Sections 6.1 and 6.2.

5.2.1 Sample data file preparation and QC

For salinity, the Autosal output spreadsheets were saved as .csv, the .csv files were copied to koaeula in data/ctd/BOTTLE_SAL, and were edited to add two columns: sample number and flag. Sample number (sampnum) has the format CCCNN where CCC is the CTD cast number and NN the Niskin position; for standards the numbers were 9990XX where XX is the sequential standard number in the order in which they were run throughout the cruise. Some old standards from a different batch were run and designated 9980YY. Flags corresponded to the WOCE conventions, with 2 for good, 3 for questionable, and 4 for bad.

A symbolic link was then created to a file with name of form sal_dy113_??_??.csv where ?? represents the two sequential standards that were run at the start and end of the crate. Then all the sal_dy113_??_??.csv files were concatenated to make a sal_dy113_all.csv file. Next, in Matlab the script msam_standarise_avg.m was run to check for and exclude outlier readings from the salinometer, as well as mis-transcribed bottle or sample numbers. Outliers were excluded using opt_dy113.m.

After oxygen samples were processed they were copied to koaeula in data/ctd/BOTTLE_OXY, with names of form oxy_dy113_XXX.csv, where XXX represents the CTD number. Files were checked to be sure that the same number of commas were in each line and that flags were added correctly. When loaded by the mexec functions, moxy_ccalc.m converts from titre volumes to oxygen concentration, using the blank and standard titres set in opt_dy113.m, and the sample bottle volumes from the spreadsheets. On this cruise we used one average set of blank and standard values for stations 1 through 39, at which point the thiosulfate was changed, and another for the remaining stations.

In Matlab smallscript load_botcaldata was run for all stations for which Niskins were fired. Next, msam_checkbottles_01 was run for stations with new salinity and oxygen data for each section, to look for outliers either in pressure or property space. If any samples were seen to be bad here, by either not following the trend or having high anomaly, they were added to the script data/ctd/ASCII_FILES/bottle_data_flags.txt. This file is used by msam_02b.m to change flags either from good to bad or bad to good. Next msam_checkbottles_02.m was run for all the station where we had new calibration data. This would plot the top 500 m of each profile and pause, then show the full depth profile. Here we were checking to see if any data points did not fit the CTD profile, if they did not they were also added to bottle_data_flags.txt.

5.2.2 Selecting calibration functions

Finally, ctd_evaluate_sensors was run to see what calibrations would be best for our data. For comparison, this script calculates conductivity corresponding to analysed bottle salinities at the CTD temperature and pressure. For oxygen, the conversion from titre volume to μmol/kg at the relevant density happens during the sample ingestion process. It then plots calibration data against CTD data and allows calibra-tions set in opt_dy113.m to be tested before being applied to the saved files. It also has a step that allows for another check for bad sample data, although at this stage most large disagreements between CTD and calibration data were mainly due to large gradients and thus were not flagged. For temperature (offset) and conductivity (ratio) we looked for functions of time and pressure. For oxygen we looked for a scale factor and an offset, both possibly time- and/or pressure-dependent. Dependence on temperature was also examined but is not clearly distinguished from dependence on other variables in this dataset because of the relatively small temperature range.

The calibrations applied corrected for small time trends in both temperature and oxygen sensors. The oxygen comparison from the first three stations appeared offset from the rest (for both sensors, Figure 5.3) but since the reliability of early analyses was more questionable we did not consider this likely to represent a real time dependence and did not try to correct for it. Linear pressure dependence was used for temperature 1, both conductivity sensors, and oxygen 1, and a piecewise linear correction for oxygen 2. A scale factor of 2.5-2.9% was also applied to the oxygen sensors. The calibration functions, specified in opt_dy113.m, were:

$$T_1 = T_1 - 1.5\times10^{-5}N + (P/5000)(-1.5\times10^{-3}) - 1.1\times10^{-4}, \quad (5.1)$$
$$T_2 = T_2 - 1\times10^{-5}N - 3.8\times10^{-4}, \quad (5.2)$$
$$C_1 = C_1\left(1 + [(P/5000)(-4.7\times10^{-3}) - 2.52\times10^{-3}]/35\right), \quad (5.3)$$
$$C_2 = C_2\left(1 + [(P/5000)(-3.4\times10^{-3}) - 5.6\times10^{-3}]/35\right), \quad (5.4)$$
$$O_1 = O_1(1.025) + (P/5000)\times12.8 + 1.8 - 0.015N, \quad (5.5)$$
$$O_2(P\le500) = O_2(P\le500)(1.029) + (P/500)\times0.3 + 0.5 + 0.01N,$$
$$O_2(P>500) = O_2(P>500)(1.029) + ([P-500]/4500)\times8.2 + 0.8 + 0.01N, \quad (5.6)$$

where P is pressure and N is cast number. The distributions of temperature, conductivity, and oxygen differences after calibration are shown in Figures 5.1 to 5.3.

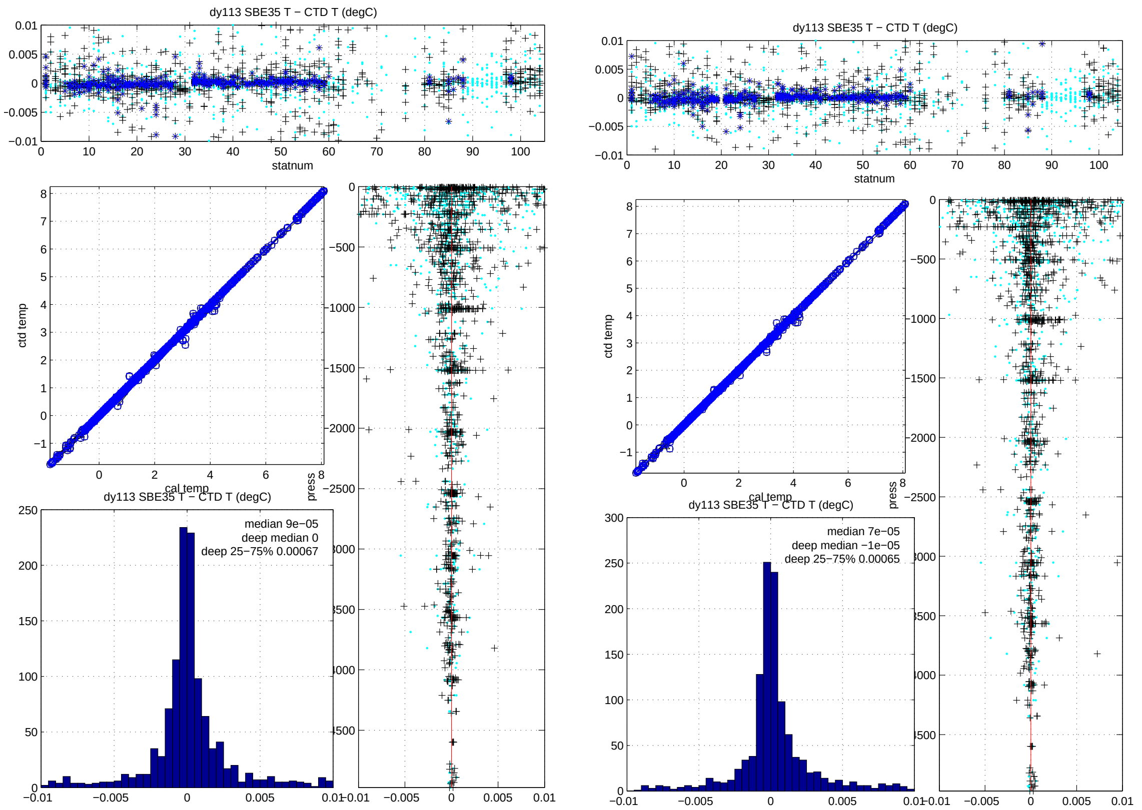


Figure 5.1: Post-calibration differences between CTD 1 (left) or 2 (right) and SBE35 temperature values.

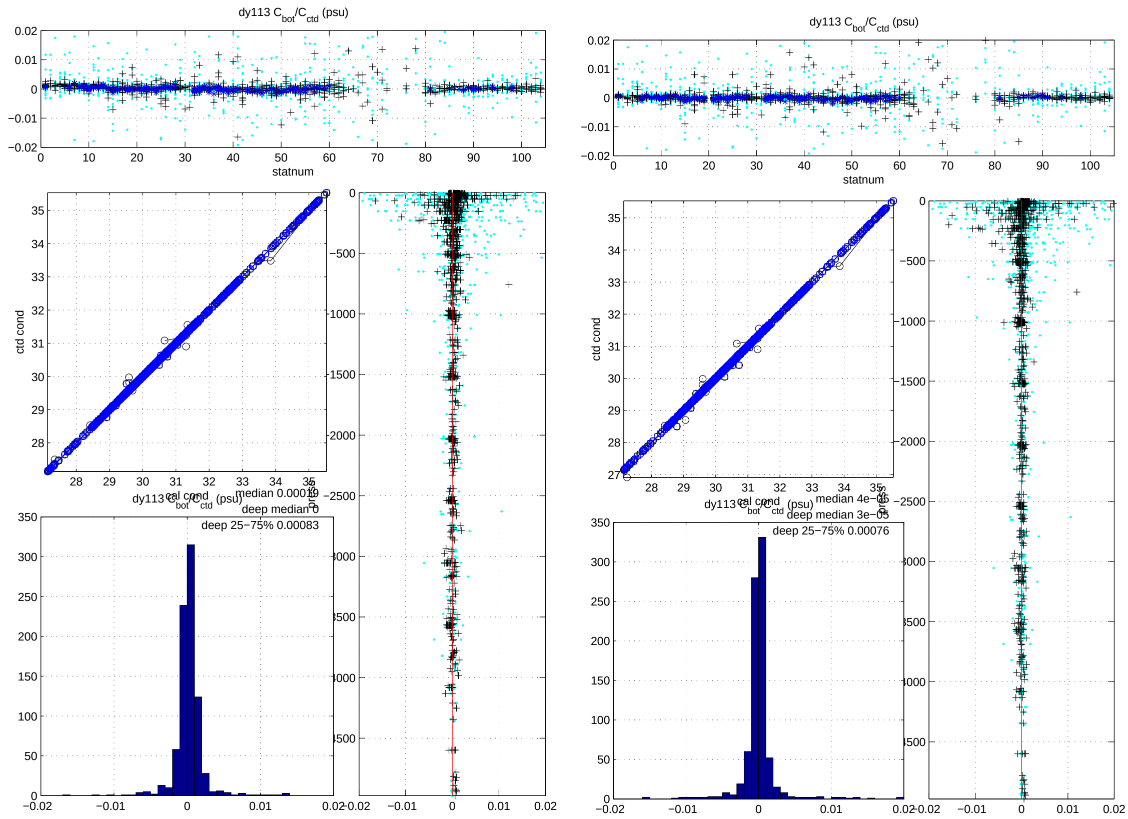


Figure 5.2: Post-calibration differences between conductivity from CTD 1 (left) or 2 (right) and bottle salinity.

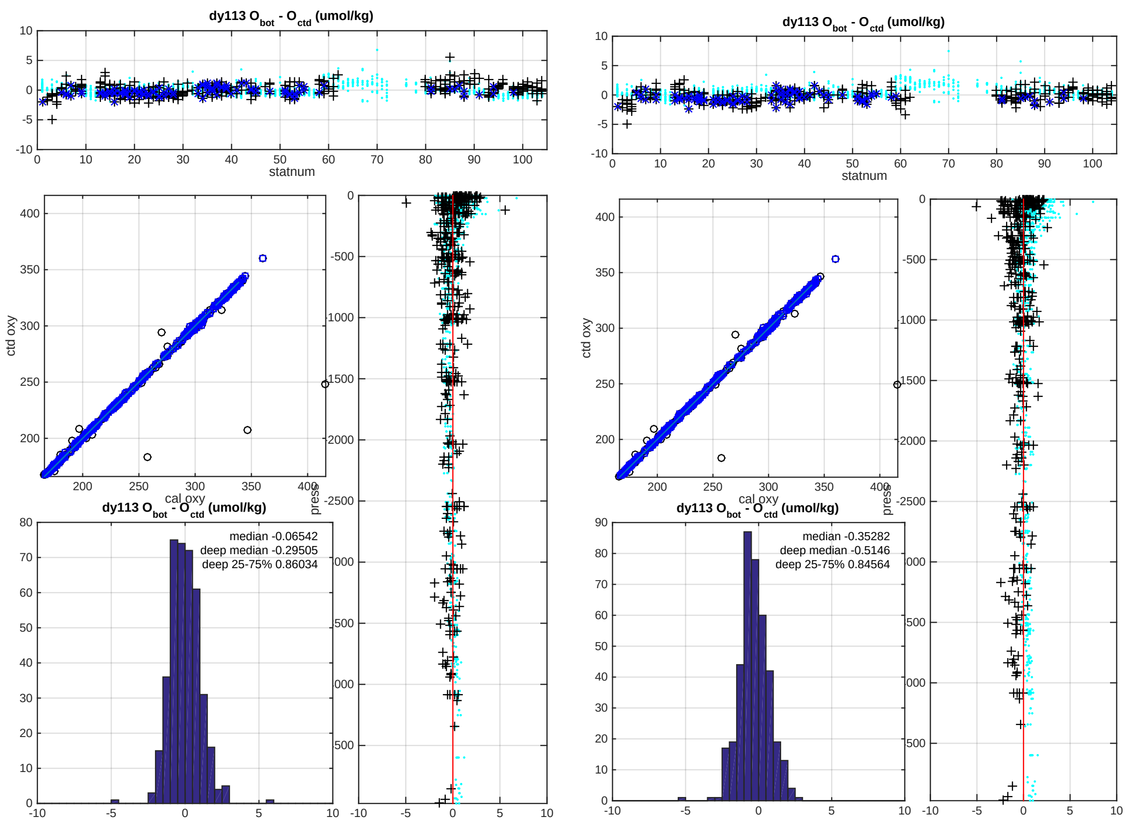


Figure 5.3: Post-calibration differences between CTD 1 (left) or 2 (right) and bottle oxygen.

5.3 Comparison of NOC (mexec) and BAS processing

Data were also processed using the BAS CTDcodeGEN Matlab scripts, developed initially at UEA and modified by Hugh Venables, Povl Abrahamsen, and others. Comparison of the results showed only small differences, principally due to:

- Whether or not loop-editing was applied to downcast data before averaging to 2 dbar. This was not previously part of the mexec processing but has now been implemented and was used for the final data from this cruise. As expected, loop-editing has a larger effect on CTD1 data (Figure 5.4), since this CTD is more affected by rosette-generated turbulence. Loop-editing did not reduce the (low) incidence of static instability in the 2 dbar data (not shown).

- Whether upcast CTD data for comparison with calibration data were the mean over 1 s (as originally in mexec) or the median over 5.0417 s (as in BAS processing, which averages the 121 scans in the SBE .ros file). The differences here are small and mostly scatter but there is a potential for bias in the upper ocean where gradients tend to go in one direction. For comparison between CTD and SBE35 temperature, a 5 s average clearly makes the most sense as the SBE35 averages 8 measurements over that interval. For comparison between CTD and Niskin samples it is less clear, since the offset between the CTD and the Niskin, the height of the Niskin, and different levels of mixing around different parts of the frame (CTD1 is mounted in the lower part of the frame, and CTD2 on the fin) will all affect the comparison in ways that are not completely quantifiable. For simplicity here we settled on using the median of 5 1-s means; the residual difference from the median over 121 24-Hz scans (Figure 5.5) is negligible even compared to other small corrections like standard seawater batch offsets.

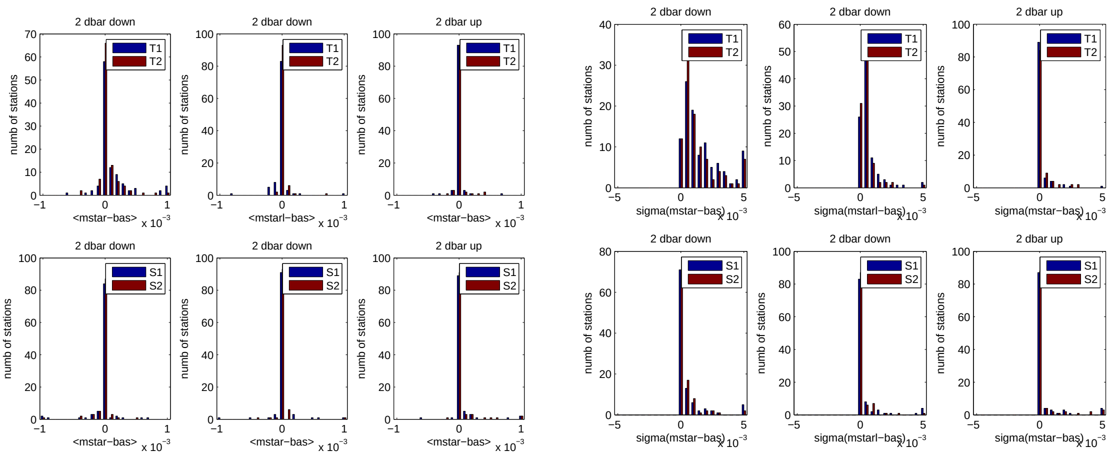


Figure 5.4: Comparison between 2 dbar downcast data processed with BAS CTDprocGEN, with mexec without loopediting, and with mexec with loopediting (mexecl): mean differences (left) and standard deviation of differences (right).

5.4 Active heave compensation system

The active heave compensation (AHC) system is attached to the winch system. In theory its objective is to maintain a steady rate of change of depth at the end of the wire by changing the speed and direction of cable payout/in in response to the ship's motion. The AHC on the Discovery uses its own inertial measurement and calculating unit associated with the winch, although we are not certain of its location or parameters. A similar system has recently been used very successfully on the RRS James Cook on JC191.

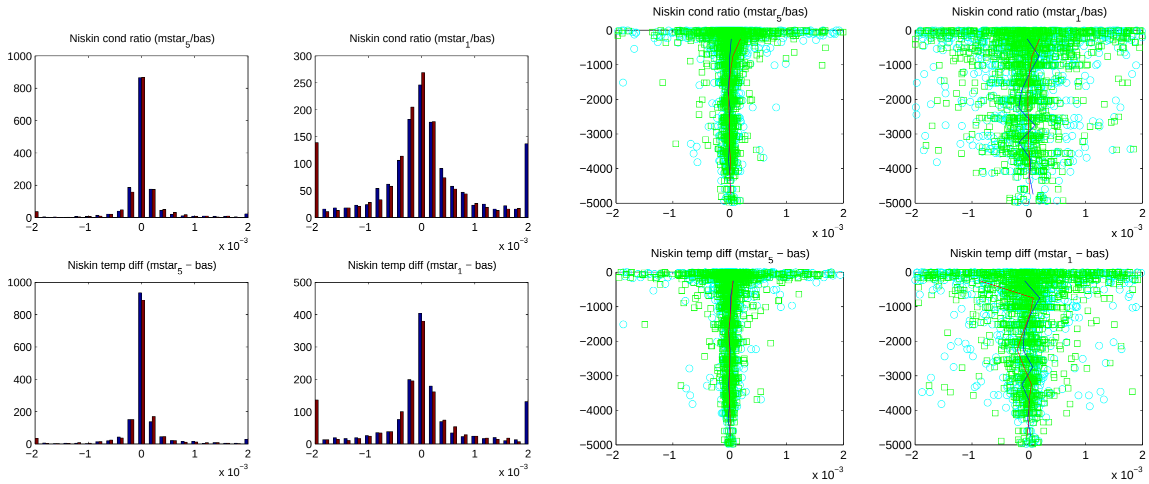


Figure 5.5: Comparison between upcast Niskin firing data (for comparison with calibration samples) processed with BAS CTDprocGEN, mexec by interpolating from 1 Hz means to Niskin firing time ($mexec_1$), and mexec by averaging over 5 s ($mexec_5$).

Following successful completion of the SR1b and A23 sections, we decided to devote some time to familiarisation with the AHC and testing of its performance in different conditions in case it could improve data quality both on the remainder of DY113 and on future cruises where the weather and seas might not be so calm. After a dead weight cast (Section 12) the AHC was used on casts 85-86 and 88-104. Here we compare CTD motion and measurements with and without AHC. Because we encountered more weather in the last segment of the cruise, when the AHC was used, than earlier when it was not, we first compare with the ship's motion to attempt to account for how that varies.

The three different attitude systems read into techsas – Applanix, Seapath, and Phins – all agree (once a sign error in Phins is corrected for, see Section 9). We first used Seapath attitude to predict vertical motion at the winch head sheave (hearafter "ship-driven heave") based on the ship's drawings, assuming the techsas attitudes had been referenced to the ship's centre of buoyancy. We compared with CTD heaving calculated by subtracting smoothed depth (running 5-s Gaussian-weighted averages) from 1 Hz depth. This (not shown) does not produce a very good correlation; a better result is obtained by multiplying ship heave by -1. This was also necessary to produce the best fit between CTD and ship motion on the RRS James Cook on JC191, although no reason for the sign reversal was found in techsas (B. King., pers. comm.). Along with $-1\times$ pitch, to reproduce the DY113 CTD heave (for casts without AHC) the best fit amplitude for pitch averages about $+6$ m and for roll about -12 m (close to the nominal value of -13.5 m), although both vary by ± 7 m on individual casts (Figure 5.6 top).

AHC clearly has an effect, reducing the correlation between ship-driven and CTD heave from around 0.8 to around 0.3 (Figure 5.6 bottom). This effect is about equally pronounced whether veering, hauling, or on bottle stops (Figure 5.6 right).

The effect of AHC can most clearly be seen in the time-varying power spectral densities of ship-driven and CTD heave, and their ratio (Figure 5.7). While the different characteristics and treatment of the two series (for instance, the CTD heave has low-frequency energy removed by subtracting 5-s weighted averages, but some residual, especially coming onto and off of bottle stops, will be aliased) make the comparison imprecise, qualitatively there is relatively less CTD heave at a range of frequencies with AHC than without, both between casts and within individual casts (Figure 5.8). In addition, AHC makes more of a difference when there is more ship motion.

Whether AHC improves the data is more ambigous. Differences between CTD sensors are one indicator, since CTD1, located beneath the rosette, is subject to more turbulence than CTD2, located on the fin.

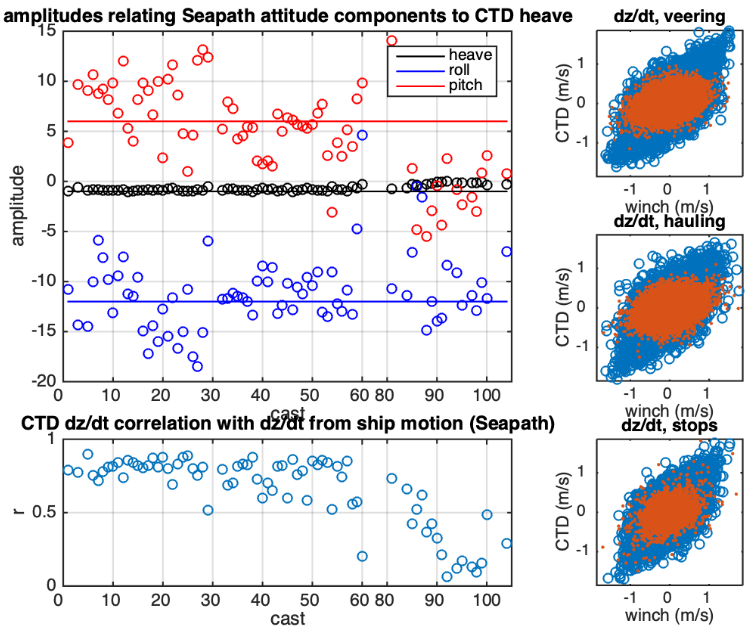


Figure 5.6: Comparison, for casts at least 60 min long, of CTD heaving with ship-derived heaving. Casts 1-84 and 87 had no AHC, 88 and 100 had intermittent AHC, and the rest used it between 100 m and 100 mab, and from departing the max wireout up to 100 m. Top panel: best fit amplitudes to predict CTD heave from ship attitude, with approximate average values denoted by solid lines. Bottom: correlation between CTD heave and winch head sheave heave predicted using the average amplitudes for each attitude component. Right: scatter plots while veering, hauling, or on bottle stops.

On cast 100 AHC was switched on for a segment of the downcast and a different segment of the upcast, allowing for two comparisons over the same segments of the water column (Figure 5.9). In the deeper segment, the sensor-sensor differences are smaller with AHC, while in the shallower segment they are larger. Comparison with the down and upcast sensor-sensor differences from the same range on cast 1 (dashed lines, Figure 5.9) shows that this likely reflects the tendency for larger differences on the upcast in general. Overall, AHC appears to reduce standard deviations of salinity differences but not of temperature differences (Figure 5.10). More data to compare over different parts of the water column and T-S curve, as well as in different water depths and sea states, would be useful.

A comparison of the effect on bottle stops was attempted on cast 88 by turning the AHC off for 3 minutes then back on for 3 minutes. Having the AHC on produced a little less variation in properties and sensor-sensor differences than with it off (not shown), although we note that when the AHC was switched on the rosette had already been bobbing on the stop for 3 minutes, which is not representative of most bottle stops.

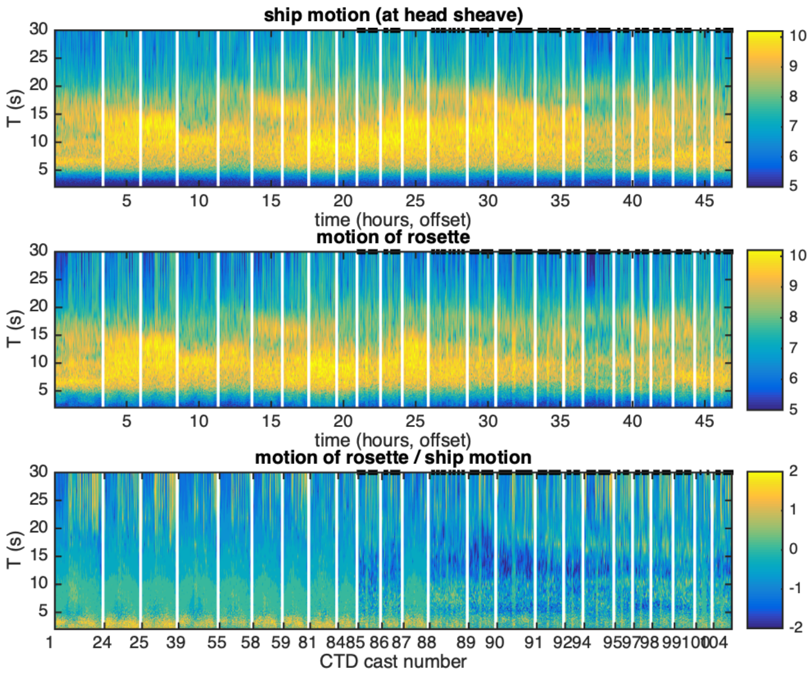


Figure 5.7: Log_{10} of running power spectral densities calculated from half-overlapping windows of 240 s length (only frequencies higher than 0.0333 Hz shown), and of their ratio, for casts with AHC as well as a subset of casts without AHC (chosen for comparable ship motion levels). Black bars at $T = 30$ s indicate AHC on.

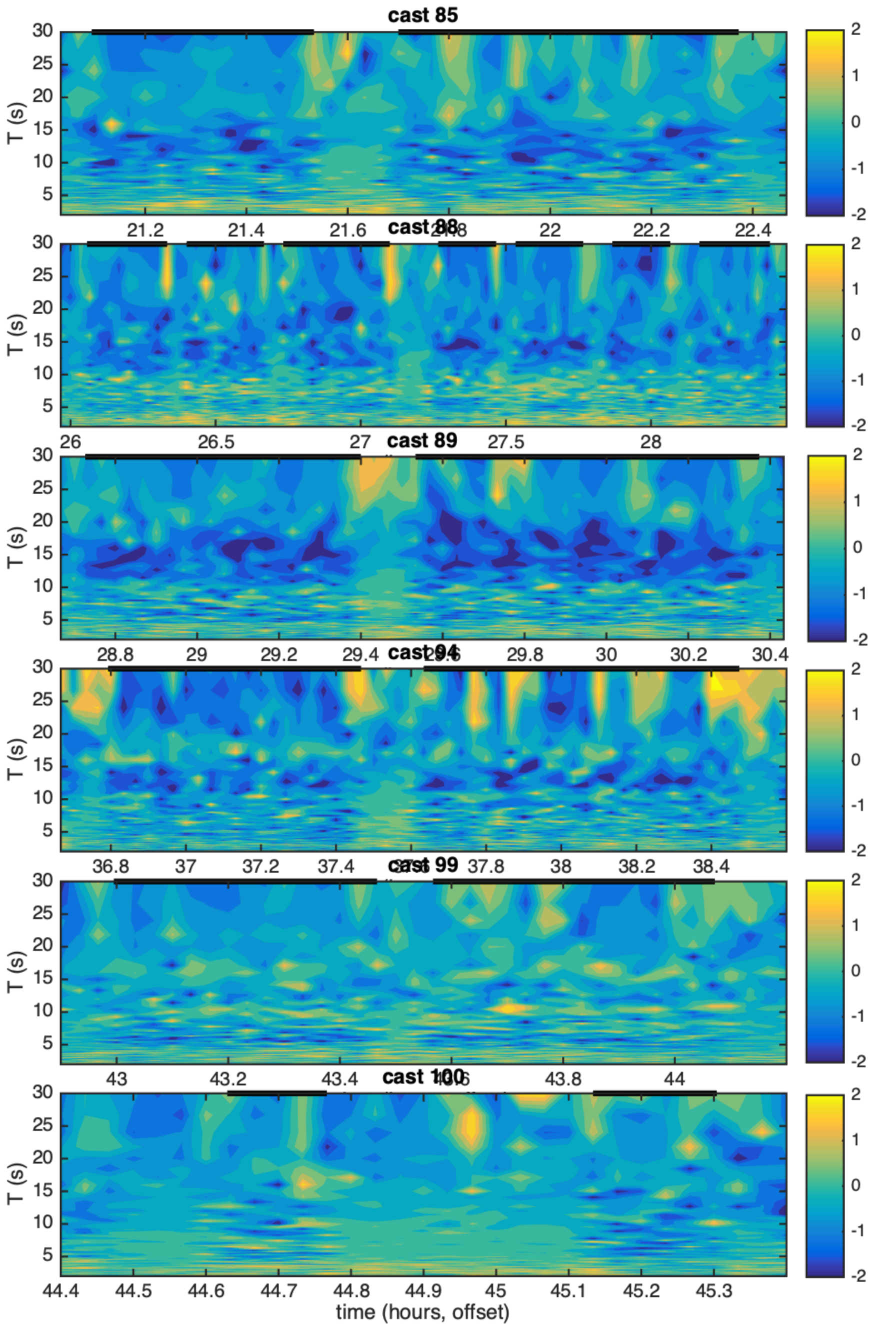


Figure 5.8: Log_{10} of time-varying PSD ratios as in Figure 5.7 for selected casts.

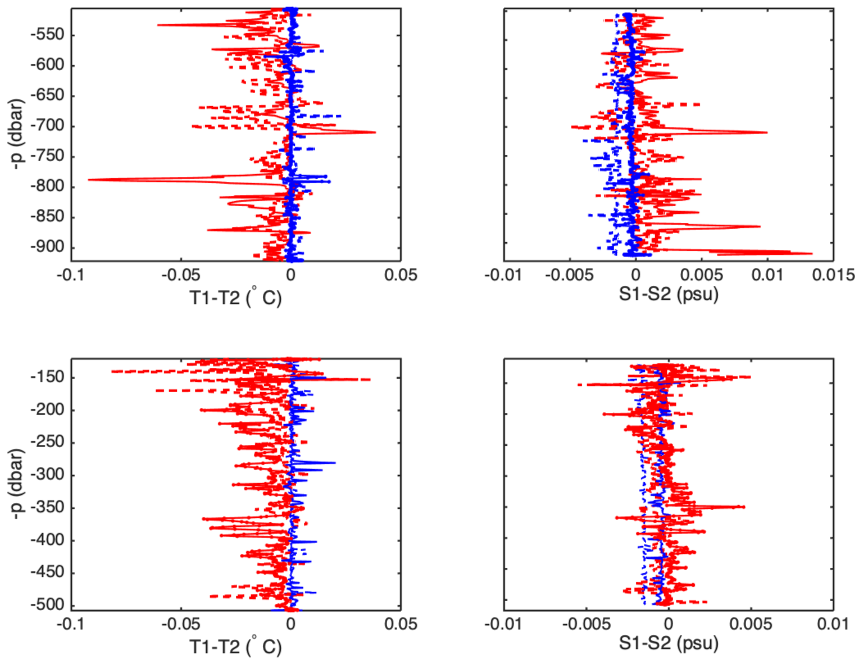


Figure 5.9: Differences between CTD1 and CTD2 from cast 1 (dashed) and cast 100 (solid), downcast (blue) and upcast (red), with AHC on marked by dots (downcast 100 in the top panels, upcast 100 in the bottom panels).

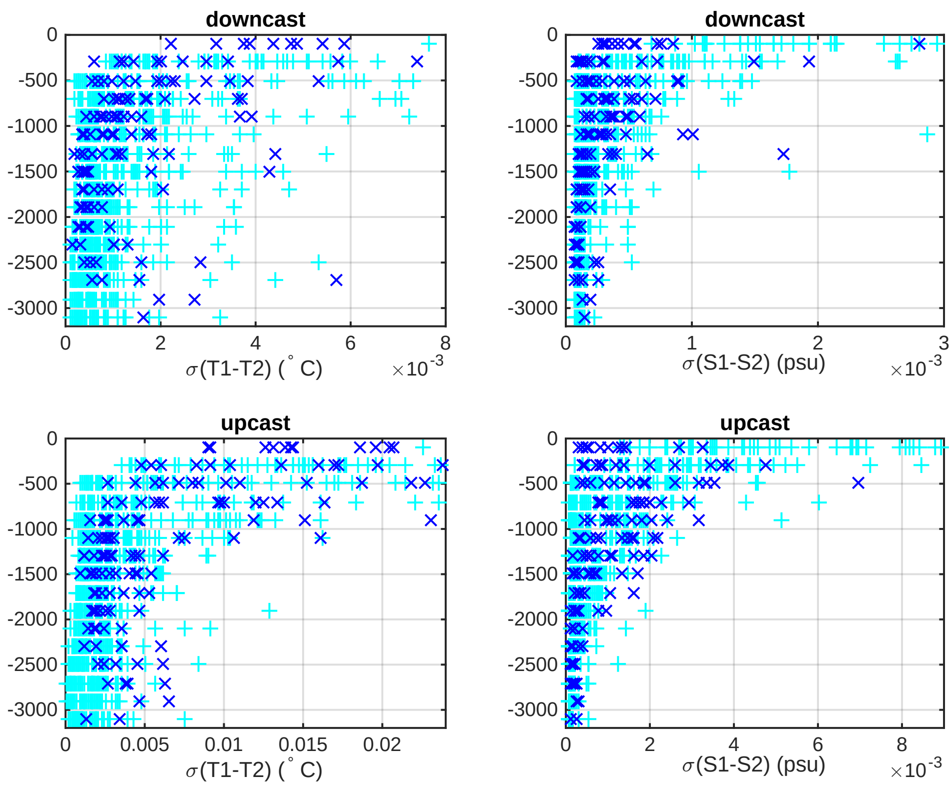


Figure 5.10: Standard deviation of CTD1-CTD2 differences with (blue x) or without (cyan +) AHC.

5.5 Results

Temperature, salinity, and dissolved oxygen on the three sections are shown in Figures 5.11 to 5.13. Profiles and T-S curves from Cumberland Bay are shown in Figure 5.14.

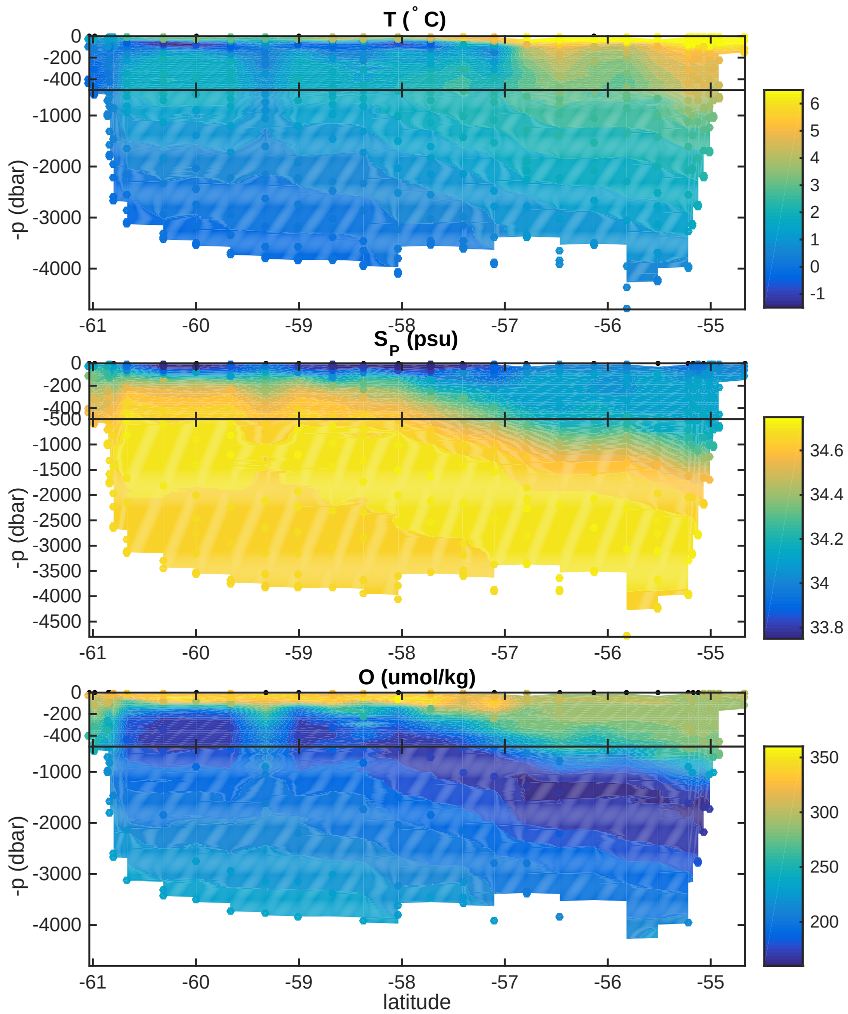


Figure 5.11: Calibrated temperature, salinity, and oxygen along the SR1b section (filled contours) with calibration data as coloured dots.

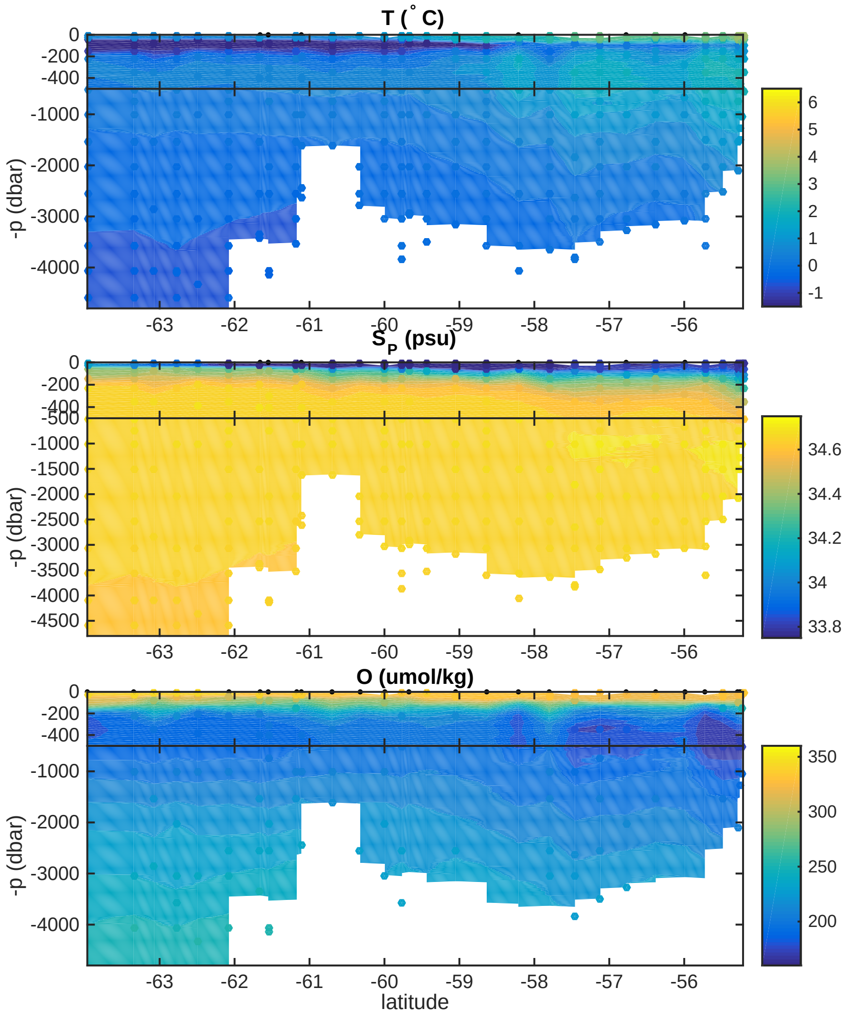


Figure 5.12: Calibrated temperature, salinity, and oxygen along the A23 section (filled contours) with calibration data as coloured dots.

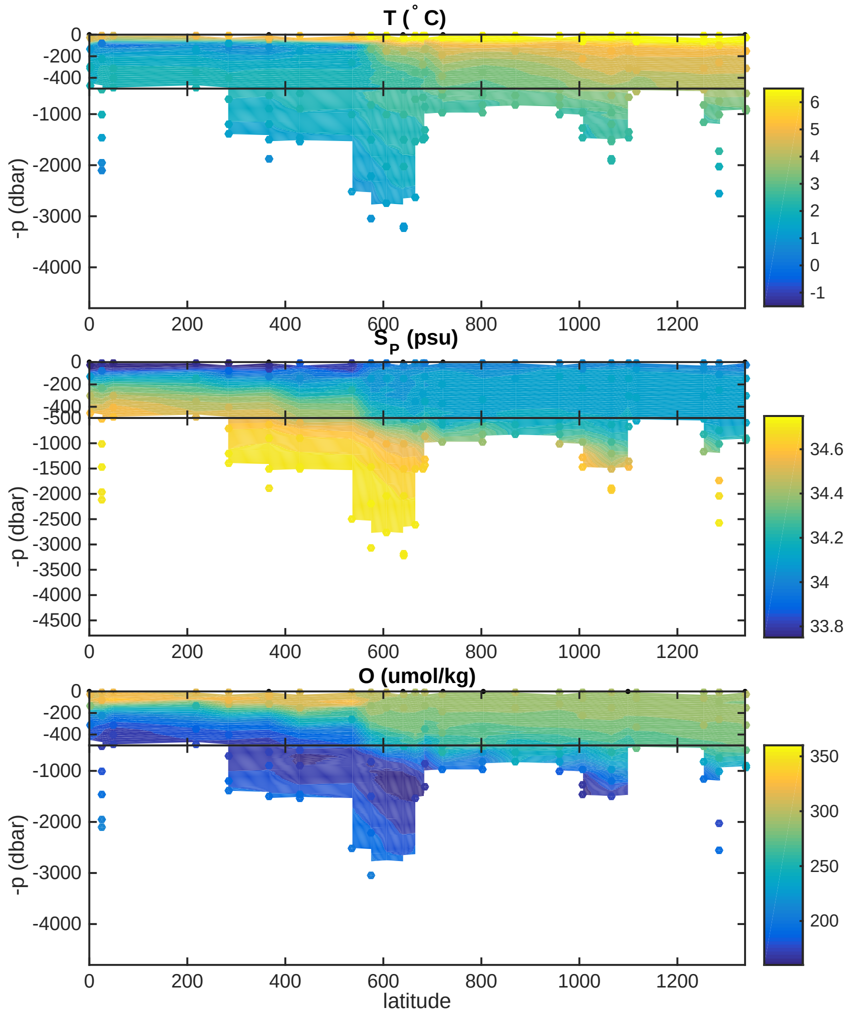


Figure 5.13: Calibrated temperature, salinity, and oxygen along the North Scotia Ridge section (filled contours) with calibration data as coloured dots.

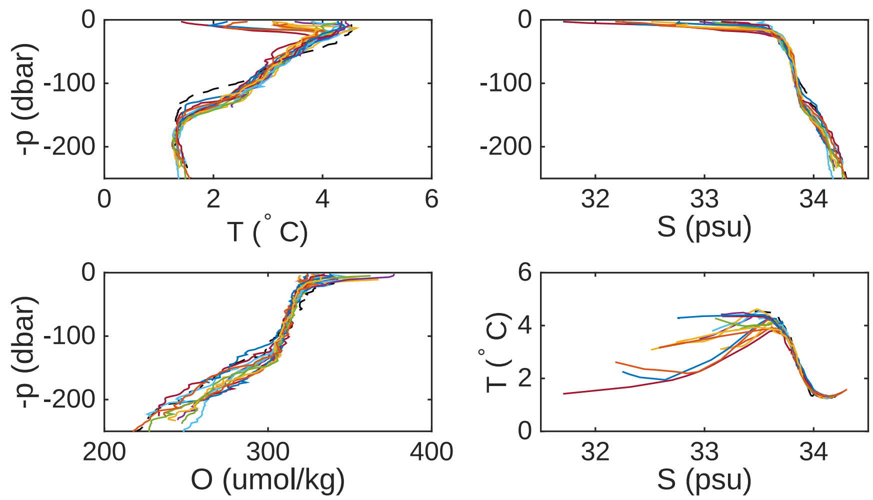


Figure 5.14: Calibrated temperature, salinity, and oxygen profiles from Cumberland Bay.

Table 5.1: CTD/LADCP stations, with water depth H_{cor} (m), maximum CTD depth $-z_{max}$ (m), number of Niskins fired, and number of samples.

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
SR1b_08	02/06	1725	55°12.79′S	057°57.96′W											
001	02/06	1858	55°12.69′S	057°57.29′W	3760	3753	19	17	5	0	0	1	2	0	Test station
	02/06	2046	55°12.56′S	057°56.49′W											
SR1b_01	02/07	0043	54°40.01′S	057°58.05′W											
002	02/07	0052	54°40.00′S	057°58.05′W	167	158	4	4	4	4	4	0	4	0	Start SR1b
	02/07	0104	54°40.00′S	057°58.05′W											
SR1b_02	02/07	0952	54°55.35′S	057°58.09′W											
003	02/07	1020	54°55.35′S	057°58.09′W	694	678	6	6	5	6	6	0	6	0	
	02/07	1054	54°55.35′S	057°58.09′W											
SR1b_03	02/07	1213	54°58.66′S	057°58.07′W											
004	02/07	1237	54°58.66′S	057°58.07′W	1048	1037	6	6	6	6	6	0	6	0	
	02/07	1309	54°58.66′S	057°58.07′W											
SR1b_04	02/07	1425	55°00.37′S	057°58.08′W											
005	02/07	1459	55°00.37′S	057°58.08′W	1703	1692	16	15	4	15	15	11	0	0	
	02/07	1555	55°00.37′S	057°58.08′W											
SR1b_05	02/07	1721	55°04.19′S	057°58.07′W											
006	02/07	1805	55°04.19′S	057°58.08′W	2182	2175	8	9	4	8	8	0	6	0	
	02/07	1858	55°04.19′S	057°58.08′W											
SR1b_06	02/07	2012	55°07.26′S	057°58.09′W											
007	02/07	2107	55°07.26′S	057°58.09′W	2752	2746	16	15	4	15	15	12	0	0	
	02/07	2224	55°07.05′S	057°57.87′W											
SR1b_07	02/07	2341	55°10.19′S	057°58.09′W											
008	02/08	0040	55°10.29′S	057°57.80′W	3128	3117	10	9	4	10	10	0	6	2	
	02/08	0149	55°10.40′S	057°57.47′W											
SR1b_08	02/08	0301	55°12.84′S	057°58.09′W											
009	02/08	0431	55°13.12′S	057°57.27′W	3973	3912	19	13	7	17	16	12	0	2	
	02/08	0618	55°13.76′S	057°55.69′W											
SR1b_09	02/08	0843	55°31.01′S	057°58.08′W											
010	02/08	1011	55°30.75′S	057°56.09′W	4184	4173	12	10	0	12	12	0	6	1	
	02/08	1154	55°30.62′S	057°54.56′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
SR1b_10	02/08	1420	55°49.10′S	057°49.16′W											
011	02/08	1546	55°49.10′S	057°49.16′W	4737	4726	19	18	0	19	14	12	0	1	
	02/08	1733	55°49.10′S	057°49.16′W											
SR1b_11	02/08	2025	56°08.08′S	057°37.43′W											
012	02/08	2130	56°08.08′S	057°37.43′W	3473	3462	10	10	0	10	10	0	6	1	
	02/08	2248	56°08.08′S	057°37.43′W											
SR1b_12	02/09	0204	56°27.96′S	057°25.61′W											
013	02/09	0352	56°27.96′S	057°25.61′W	3839	3827	19	12	8	18	13	12	0	2	
	02/09	0543	56°27.96′S	057°25.61′W											
SR1b_13	02/09	0822	56°47.04′S	057°13.77′W											
014	02/09	0948	56°47.54′S	057°12.08′W	3324	3313	10	10	8	10	10	0	6	1	
	02/09	1112	56°47.95′S	057°10.67′W											
SR1b_14	02/09	1403	57°06.00′S	057°02.01′W											
015	02/09	1512	57°06.10′S	057°01.13′W	3854	3854	19	14	8	19	14	12	0	1	
	02/09	1645	57°06.93′S	057°00.08′W											
SR1b_15	02/09	1905	57°24.33′S	056°52.16′W											
016	02/09	2014	57°24.65′S	056°51.29′W	3552	3548	12	12	8	12	12	0	6	2	
	02/09	2140	57°25.05′S	056°50.19′W											
SR1b_16	02/09	2358	57°42.72′S	056°39.12′W											
017	02/10	0103	57°42.99′S	056°38.24′W	3506	3492	21	13	8	19	13	12	0	1	
	02/10	0229	57°43.24′S	056°37.43′W											
SR1b_17	02/10	0910	58°01.75′S	056°28.02′W											
018	02/10	1025	58°01.98′S	056°27.23′W	4029	4020	12	12	7	12	12	0	5	2	
	02/10	1211	58°02.31′S	056°26.07′W											
SR1b_18	02/10	1437	58°21.76′S	056°15.52′W											
019	02/10	1546	58°22.28′S	056°14.62′W	3891	3882	20	15	7	19	14	12	0	1	
	02/10	1717	58°22.98′S	056°13.56′W											
SR1b_19	02/10	1939	58°40.10′S	056°03.19′W											
020	02/10	2048	58°40.10′S	056°03.21′W	3771	3761	20	14	8	20	14	12	0	2	
	02/10	2226	58°40.10′S	056°03.21′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
SR1b_20	02/11	0102	59°00.00′S	055°51.42′W											
021	02/11	0211	59°00.00′S	055°51.42′W	3774	3767	12	12	6	12	12	12	6	1	
	02/11	0344	59°00.00′S	055°51.42′W											
SR1b_21	02/11	0636	59°19.08′S	055°39.04′W											
022	02/11	0747	59°19.17′S	055°38.94′W	3758	3748	21	19	6	22	12	12	0	1	
	02/11	0943	59°19.17′S	055°38.94′W											
SR1b_22	02/11	1232	59°39.97′S	055°26.59′W											
023	02/11	1339	59°39.97′S	055°26.60′W	3677	3668	20	12	8	19	14	11	0	1	
	02/11	1517	59°39.97′S	055°26.59′W											
SR1b_23	02/11	1802	60°00.01′S	055°14.26′W											
024	02/11	1907	59°59.66′S	055°14.77′W	3502	3493	12	12	6	12	12	0	6	1	
	02/11	2031	59°59.04′S	055°15.69′W											
SR1b_24	02/11	2320	60°19.10′S	055°01.87′W											
025	02/12	0021	60°19.04′S	055°02.05′W	3391	3383	19	11	8	16	11	12	0	1	
	02/12	0145	60°18.98′S	055°02.29′W											
SR1b_25	02/12	0454	60°40.03′S	054°49.32′W											
026	02/12	0552	60°40.00′S	054°48.02′W	3089	3080	19	15	4	17	11	12	0	1	
	02/12	0728	60°40.10′S	054°45.50′W											
SR1b_26	02/12	0914	60°47.51′S	054°45.27′W											
027	02/12	1023	60°47.90′S	054°44.67′W	2650	2628	8	8	4	8	8	0	6	0	
	02/12	1128	60°48.11′S	054°44.35′W											
SR1b_27	02/12	1245	60°49.98′S	054°43.30′W											
028	02/12	1404	60°49.98′S	054°43.30′W	1788	1764	16	14	8	16	14	0	0	0	
	02/12	1500	60°49.98′S	054°43.30′W											
SR1b_28	02/12	1600	60°51.03′S	054°42.64′W											
029	02/12	1628	60°51.03′S	054°42.64′W	1008	1002	8	8	8	8	8	0	6	0	
	02/12	1700	60°51.03′S	054°42.64′W											
SR1b_29	02/12	1851	60°58.93′S	054°38.01′W											
030	02/12	1908	60°58.93′S	054°38.01′W	582	575	6	6	6	6	6	0	6	0	
	02/12	1931	60°58.93′S	054°38.01′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
SR1b_30	02/12	2033	61°02.10′S	054°35.14′W											
031	02/12	2046	61°02.10′S	054°35.14′W	447	438	4	4	4	4	4	0	4	0	End SR1b
	02/12	2104	61°02.10′S	054°35.14′W											
A23_23	02/16	1917	63°57.92′S	028°52.66′W											
032	02/16	2044	63°57.92′S	028°52.66′W	4800	4790	15	16	4	15	15	0	2	0	Start A23
	02/16	2232	63°57.92′S	028°52.66′W											
A23_24	02/17	1625	63°20.80′S	029°34.17′W											
033	02/17	1753	63°20.80′S	029°34.14′W	4726	4718	18	19	8	18	18	0	0	0	
	02/17	1939	63°20.80′S	029°34.16′W											
A23_25	02/17	2303	63°04.34′S	030°06.95′W											
034	02/18	0026	63°04.35′S	030°06.94′W	4880	4870	8	8	8	0	0	0	2	0	
	02/18	0201	63°04.35′S	030°06.95′W											
A23_26	02/18	0516	62°46.97′S	030°41.70′W											
035	02/18	0642	62°46.97′S	030°41.66′W	4829	4818	15	10	8	15	15	0	1	0	
	02/18	0832	62°46.97′S	030°41.66′W											
A23_27	02/18	1302	62°29.47′S	031°15.67′W											
036	02/18	1425	62°29.47′S	031°15.67′W	4762	4752	8	8	8	0	0	0	2	0	
	02/18	1600	62°29.47′S	031°15.67′W											
A23_28	02/18	1911	62°04.53′S	031°11.09′W											
037	02/18	2038	62°04.53′S	031°11.09′W	4849	4840	18	18	8	18	18	0	0	0	
	02/18	2228	62°04.53′S	031°11.09′W											
A23_29	02/19	0146	61°39.61′S	031°06.54′W											
038	02/19	0254	61°39.61′S	031°06.54′W	3387	3376	8	8	8	0	0	0	2	0	
	02/19	0410	61°39.60′S	031°06.54′W											
A23_30	02/19	0540	61°33.05′S	031°06.26′W											
039	02/19	0653	61°33.06′S	031°06.25′W	4065	4054	8	11	8	0	0	0	0	0	
	02/19	0824	61°33.05′S	031°06.25′W											
A23_31	02/19	1130	61°10.22′S	031°02.74′W											
040	02/19	1234	61°10.23′S	031°02.74′W	3477	3465	12	12	6	12	12	0	2	0	
	02/19	1359	61°10.13′S	031°02.64′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
A23_32	02/19	1547	61°06.57′S	031°02.46′W											
041	02/19	1651	61°06.56′S	031°02.42′W	2588	2574	8	8	5	0	0	0	0	0	
	02/19	1751	61°06.56′S	031°02.42′W											
A23_33	02/19	2048	60°41.99′S	031°00.62′W											
042	02/19	2128	60°41.99′S	031°00.62′W	1617	1608	11	11	3	11	11	0	2	0	
	02/19	2215	60°41.99′S	031°00.62′W											
A23_35	02/20	0103	60°19.41′S	030°58.33′W											
043	02/20	0200	60°19.41′S	030°58.33′W	2774	2756	4	4	3	4	4	0	0	0	moved for
	02/20	0257	60°19.41′S	030°58.33′W											iceberg
A23_36	02/20	0604	59°59.66′S	030°55.83′W											
044	02/20	0704	59°59.66′S	030°55.83′W	2992	2982	14	14	7	11	14	0	2	0	
	02/20	0824	59°59.66′S	030°55.83′W											
A23_37	02/20	1015	59°45.99′S	030°54.33′W											
045	02/20	1126	59°45.99′S	030°54.34′W	3791	3791	13	12	6	12	12	0	0	0	
	02/20	1300	59°45.99′S	030°54.33′W											
A23_38	02/20	1505	59°40.43′S	030°53.81′W											
046	02/20	1615	59°40.43′S	030°53.80′W	2936	2928	8	8	0	0	0	0	2	0	
	02/20	1718	59°40.43′S	030°53.80′W											
A23_39	02/20	1934	59°26.18′S	030°51.64′W											
047	02/20	2040	59°26.18′S	030°51.64′W	3456	3446	8	8	5	5	5	0	0	0	
	02/20	2154	59°26.18′S	030°51.64′W											
A23_40	02/21	0052	59°03.05′S	030°49.83′W											
048	02/21	0150	59°03.05′S	030°49.83′W	3122	3113	11	11	6	11	11	0	2	0	
	02/21	0307	59°03.05′S	030°49.83′W											
A23_41	02/21	0621	58°38.13′S	030°49.47′W											
049	02/21	0736	58°38.13′S	030°49.46′W	3535	3524	15	15	0	15	15	0	0	0	
	02/21	0910	58°38.13′S	030°49.46′W											
A23_42	02/21	1207	58°12.79′S	030°49.22′W											
050	02/21	1320	58°12.79′S	030°49.22′W	4002	3992	8	8	0	0	0	0	2	0	
	02/21	1443	58°12.79′S	030°49.22′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
A23_43	02/21	1735	57°48.10′S	030°49.91′W											
051	02/21	1853	57°48.10′S	030°49.91′W	3587	3576	12	12	8	12	12	0	0	0	
	02/21	2019	57°48.10′S	030°49.91′W											
A23_44	02/21	2322	57°27.51′S	031°19.64′W											
052	02/22	0033	57°27.51′S	031°19.64′W	3773	3763	10	10	8	0	0	0	2	0	
	02/22	0153	57°27.51′S	031°19.64′W											
A23_45	02/22	0500	57°07.13′S	031°48.97′W											
053	02/22	0621	57°07.13′S	031°48.96′W	3454	3445	15	15	6	15	15	0	0	0	
	02/22	0752	57°07.13′S	031°48.96′W											
A23_46	02/22	1100	56°46.52′S	032°18.31′W											
054	02/22	1202	56°46.52′S	032°18.31′W	3228	3219	8	8	8	0	0	0	2	0	
	02/22	1317	56°46.52′S	032°18.31′W											
A23_47	02/22	1644	56°22.85′S	032°52.40′W											
055	02/22	1741	56°22.85′S	032°52.39′W	3137	3127	11	11	6	11	11	0	0	0	
	02/22	1857	56°22.85′S	032°52.38′W											
A23_48	02/22	2218	55°59.39′S	033°25.11′W											
056	02/22	2316	55°59.39′S	033°25.11′W	3042	3033	6	6	0	0	0	0	2	0	
	02/23	0017	55°59.39′S	033°25.12′W											
A23_49	02/23	0247	55°43.49′S	033°47.17′W											
057	02/23	0403	55°43.49′S	033°47.17′W	3533	3523	15	15	0	15	15	0	0	0	
	02/23	0533	55°43.49′S	033°47.16′W											
A23_50	02/23	0756	55°29.06′S	034°07.11′W											
058	02/23	0846	55°29.06′S	034°07.11′W	2482	2473	10	10	6	10	10	0	2	0	
	02/23	0954	55°29.06′S	034°07.11′W											
A23_50a	02/23	1219	55°17.35′S	034°24.02′W											
059	02/23	1301	55°17.35′S	034°24.02′W	2072	2063	12	12	6	12	12	0	0	0	
	02/23	1403	55°17.35′S	034°24.02′W											
A23_51	02/23	1500	55°15.52′S	034°26.56′W											
060	02/23	1533	55°15.52′S	034°26.57′W	1508	1500	6	6	5	0	0	0	2	0	
	02/23	1609	55°15.52′S	034°26.56′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
A23_51a	02/23	1700	55°13.79′S	034°29.35′W											
061	02/23	1723	55°13.79′S	034°29.35′W	1026	1020	7	7	4	7	7	0	0	0	
	02/23	1753	55°13.79′S	034°29.35′W											
A23_52	02/23	1842	55°12.89′S	034°30.48′W											
062	02/23	1857	55°12.89′S	034°30.48′W	543	534	8	8	5	8	8	0	2	0	End A23
	02/23	1922	55°12.89′S	034°30.48′W											
Cumb_01	02/24	0709	54°07.72′S	036°16.50′W											Start
063	02/24	0722	54°07.72′S	036°16.50′W	275	267	4	4	0	0	1	0	2	0	Cumberland
	02/24	0739	54°07.72′S	036°16.50′W											Bay
Cumb_13	02/24	1134	54°21.93′S	036°22.10′W											
064	02/24	1140	54°21.93′S	036°22.10′W	86	76	4	4	0	0	4	0	2	0	
	02/24	1152	54°21.93′S	036°22.10′W											
Cumb_12	02/24	1250	54°19.54′S	036°23.04′W											
065	02/24	1259	54°19.54′S	036°23.04′W	187	178	4	4	0	0	4	0	2	0	
	02/24	1315	54°19.54′S	036°23.04′W											
Cumb_11	02/24	1355	54°18.15′S	036°24.04′W											
066	02/24	1402	54°18.15′S	036°24.04′W	238	229	4	4	0	0	4	0	2	0	
	02/24	1413	54°18.15′S	036°24.04′W											
Cumb_10	02/24	1446	54°16.70′S	036°25.23′W											
067	02/24	1454	54°16.70′S	036°25.23′W	244	235	4	4	0	0	4	0	2	0	
	02/24	1505	54°16.70′S	036°25.23′W											
Cumb_09	02/24	1554	54°15.55′S	036°26.11′W											
068	02/24	1603	54°15.55′S	036°26.10′W	263	255	4	4	0	0	4	0	2	0	
	02/24	1615	54°15.55′S	036°26.10′W											
Cumb_17	02/24	1745	54°15.14′S	036°36.70′W											
069	02/24	1754	54°15.14′S	036°36.70′W	206	198	4	4	0	0	4	0	2	0	
	02/24	1806	54°15.14′S	036°36.70′W											
Cumb_16	02/24	1842	54°14.46′S	036°35.21′W											
070	02/24	1851	54°14.46′S	036°35.21′W	212	205	4	4	0	0	4	0	2	0	
	02/24	1903	54°14.46′S	036°35.21′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
Cumb_15	02/24	1936	54°13.78′S	036°33.60′W											
071	02/24	1944	54°13.78′S	036°33.60′W	232	224	4	4	0	0	4	0	2	0	
	02/24	1957	54°13.78′S	036°33.60′W											
Cumb_14	02/24	2033	54°13.03′S	036°31.30′W											
072	02/24	2040	54°13.03′S	036°31.30′W	240	231	4	4	0	0	4	0	2	0	
	02/24	2052	54°13.03′S	036°31.30′W											
Cumb_05	02/24	2127	54°13.51′S	036°27.77′W											
073	02/24	2133	54°13.51′S	036°27.76′W	147	136	0	0	0	0	0	0	0	0	
	02/24	2137	54°13.51′S	036°27.76′W											
Cumb_04	02/24	2204	54°13.13′S	036°27.96′W											
074	02/24	2212	54°13.13′S	036°27.96′W	256	248	0	0	0	0	0	0	0	0	
	02/24	2217	54°13.13′S	036°27.96′W											
Cumb_06	02/25	0758	54°13.50′S	036°27.05′W											
075	02/25	0805	54°13.50′S	036°27.05′W	233	224	0	0	0	0	0	0	0	0	
	02/25	0813	54°13.50′S	036°27.06′W											
Cumb_07	02/25	0832	54°13.52′S	036°26.19′W											
076	02/25	0841	54°13.52′S	036°26.19′W	233	224	4	4	0	0	4	0	2	0	
	02/25	0854	54°13.53′S	036°26.21′W											
Cumb_08	02/25	0924	54°13.47′S	036°25.39′W											
077	02/25	0930	54°13.47′S	036°25.39′W	178	172	0	0	0	0	0	0	0	0	
	02/25	0937	54°13.47′S	036°25.39′W											
Cumb_03	02/25	1902	54°12.60′S	036°27.95′W											
078	02/25	1910	54°12.60′S	036°27.95′W	260	252	4	4	0	0	4	0	2	0	
	02/25	1923	54°12.59′S	036°27.94′W											
Cumb_02	02/25	2001	54°11.99′S	036°27.97′W											End
079	02/25	2007	54°11.99′S	036°27.97′W	132	124	0	0	0	0	0	0	0	0	Cumberland
	02/25	2010	54°11.99′S	036°27.97′W											Bay
NSR_01	02/27	1003	53°57.24′S	039°38.58′W											
080	02/27	1027	53°57.24′S	039°38.58′W	475	462	4	4	4	0	0	0	0	0	Start NSR
	02/27	1050	53°57.24′S	039°38.58′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
NSR_02	02/27	1338	53°54.77′S	040°02.77′W											
081	02/27	1436	53°54.68′S	040°02.80′W	2090	2085	8	8	8	0	0	0	0	0	
	02/27	1526	53°54.56′S	040°02.80′W											
NSR_03	02/27	1726	53°52.26′S	040°22.93′W											
082	02/27	1743	53°52.26′S	040°22.93′W	493	486	4	4	4	0	0	0	0	0	
	02/27	1758	53°52.26′S	040°22.93′W											
NSR_04	02/28	0445	53°21.51′S	042°46.25′W											
083	02/28	0500	53°21.51′S	042°46.25′W	490	484	4	4	4	0	0	0	0	0	
	02/28	0519	53°21.51′S	042°46.25′W											
NSR_05	02/28	0938	53°16.29′S	043°44.97′W											
084	02/28	1011	53°16.30′S	043°44.97′W	1397	1391	7	7	7	0	0	0	0	0	
	02/28	1055	53°16.29′S	043°44.97′W											
NSR_07	02/28	2009	53°15.48′S	044°59.50′W											
085	02/28	2048	53°15.48′S	044°59.51′W	1879	1869	8	9	8	0	0	0	0	0	
	02/28	2140	53°15.48′S	044°59.50′W											
NSR_08	02/29	0142	53°10.46′S	045°54.87′W											
086	02/29	0220	53°10.46′S	045°54.89′W	1515	1506	6	6	6	0	0	0	0	0	
	02/29	0305	53°10.46′S	045°54.89′W											
NSR_10	02/29	0942	52°59.55′S	047°30.09′W											
087	02/29	1032	52°59.53′S	047°30.13′W	2485	2476	4	3	3	0	0	0	0	0	
	02/29	1122	52°59.53′S	047°30.13′W											
NSR_12	02/29	1426	53°01.52′S	048°03.12′W											
088	02/29	1542	53°01.05′S	048°04.14′W	3014	3008	6	6	6	0	0	0	0	0	
	02/29	1701	53°00.49′S	048°05.39′W											
NSR_13	02/29	1926	53°08.03′S	048°29.87′W											
089	02/29	2018	53°07.77′S	048°30.09′W	2727	2720	5	5	5	0	0	0	0	0	
	02/29	2117	53°07.61′S	048°30.21′W											
NSR_14	02/29	2346	53°17.76′S	048°55.21′W											
090	03/01	0102	53°17.75′S	048°55.19′W	3175	3170	8	8	8	0	0	0	0	0	
	03/01	0224	53°17.75′S	048°55.19′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
NSR_15	03/01	0432	53°22.73′S	049°16.07′W											
091	03/01	0526	53°22.51′S	049°16.22′W	2603	2591	5	5	5	0	0	0	0	0	
	03/01	0623	53°22.27′S	049°16.41′W											
NSR_16	03/01	0803	53°23.23′S	049°31.83′W											Break)
092	03/01	0838	53°23.23′S	049°31.83′W	1488	1480	4	4	2	0	0	0	0	0	(after) for
	03/01	0916	53°23.23′S	049°31.82′W											Falklands
NSR_29	03/05	2138	53°03.44′S	057°45.10′W											Resume
093	03/05	2201	53°03.45′S	057°45.12′W	925	916	6	6	6	0	0	0	0	0	NSR near
	03/05	2229	53°03.45′S	057°45.12′W											Falklands
NSR_28	03/06	0138	53°30.93′S	057°43.07′W											
094	03/06	0235	53°30.93′S	057°43.07′W	2539	2530	8	8	8	0	0	0	0	0	
	03/06	0340	53°30.93′S	057°43.07′W											
NSR_27	03/06	0607	53°48.41′S	057°36.94′W											
095	03/06	0640	53°48.36′S	057°36.97′W	1165	1157	6	6	6	0	0	0	0	0	
	03/06	0717	53°48.30′S	057°37.01′W											
NSR_26	03/06	1523	54°25.55′S	055°49.19′W											
096	03/06	1540	54°25.55′S	055°49.18′W	544	535	4	4	4	0	0	0	0	0	
	03/06	1559	54°25.55′S	055°49.18′W											
NSR_25	03/06	1738	54°21.80′S	055°33.15′W											
097	03/06	1810	54°21.80′S	055°33.15′W	1467	1461	6	6	0	0	0	0	0	0	
	03/06	1847	54°21.80′S	055°33.15′W											
NSR_24	03/06	2107	54°13.81′S	055°05.69′W											
098	03/06	2142	54°13.81′S	055°05.69′W	1911	1906	8	8	8	0	0	0	0	0	
	03/06	2232	54°13.81′S	055°05.69′W											
NSR_23	03/07	0231	54°04.17′S	054°14.99′W											
099	03/07	0313	54°03.97′S	054°14.87′W	1492	1461	6	6	6	0	0	0	0	0	
	03/07	0355	54°03.58′S	054°15.02′W											
NSR_22	03/07	0746	53°58.11′S	053°30.70′W											
100	03/07	0814	53°58.11′S	053°30.70′W	1005	997	6	6	6	0	0	0	0	0	
	03/07	0850	53°58.11′S	053°30.70′W											

stn	mo/dd	hhmm	lat	lon	H_{cor}	$-z_{max}$	Nisk	sal	oxy	nut	O18	N15	MP	eDNA	Comments
NSR_20	03/07	1422	53°48.51′S	052°12.34′W											
101	03/07	1446	53°48.51′S	052°12.33′W	835	826	4	4	4	0	0	0	0	0	
	03/07	1510	53°48.51′S	052°12.34′W											
NSR_19	03/07	1923	53°33.13′S	051°17.94′W											
102	03/07	1946	53°33.13′S	051°17.94′W	975	967	6	6	5	0	0	0	0	0	
	03/07	2013	53°33.13′S	051°17.94′W											
NSR_17	03/08	0053	53°22.68′S	050°05.63′W											
103	03/08	0117	53°22.68′S	050°05.63′W	969	963	6	6	6	0	0	0	0	0	
	03/08	0149	53°22.68′S	050°05.63′W											
NSR_16	03/08	0419	53°23.15′S	049°31.71′W											
104	03/08	0458	53°22.72′S	049°31.33′W	1442	1430	6	6	6	0	0	0	0	0	Join NSR
	03/08	0540	53°22.24′S	049°30.56′W											

6. Water column samples

Yvonne Firing (NOC, yvonne.firing@noc.ac.uk), Natalie Ensor (BAS, nator@bas.ac.uk), Alethea Mountford (Newcastle, a.s.mountford@ncl.ac.uk), Ciara Pimm (Liverpool, ciara.pimm@liverpool.ac.uk), Philip Punter (Edinburgh, p.b.p@ed.ac.uk)

Water samples were collected from CTD Niskins, starting with the deepest Niskins, in the following order: dissolved oxygen, oxygen isotopes, nutrients, nutrient isotopes, salinity, microplastics, and eDNA. Not every sample was collected from every Niskin or depth. Duplicate Niskins at a single depth were generally used for microplastics because of the larger volumes required. Sample distribution is shown in Figures 6.1 through 6.3.

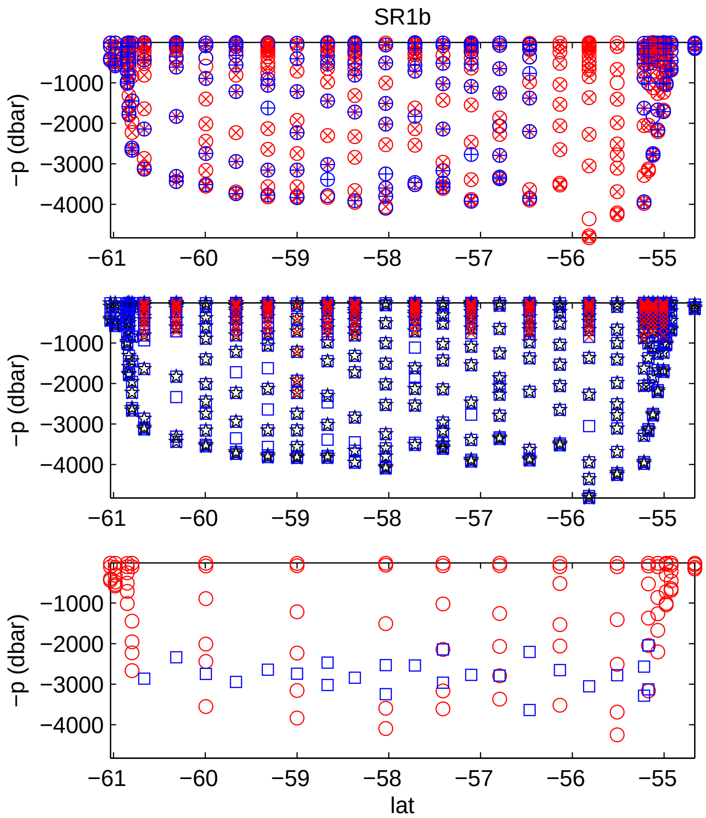


Figure 6.1: Samples on SR1b, by latitude. Top panel: salinity (red, xes indicate good samples), oxygen (blue, pluses indicate good samples), middle panel: O18 (black), nutrients (blue), nutrient isotopes (red), bottom panel: microplastics (red), eDNA (blue).

Salinity and oxygen were analysed onboard the ship and used to calibrate the CTD (Section 5.2). Other samples were preserved and stored for analysis ashore.

6.1 Salinity

Salinity samples were taken on every cast except 73, 74, 75, 77 and 79, as these shallow CTDs were conducted without any bottle stops to save time. They were taken in 200 ml glass sample bottles, which were rinsed three times before filling to the shoulder. The tops of the bottles were then dried with blue

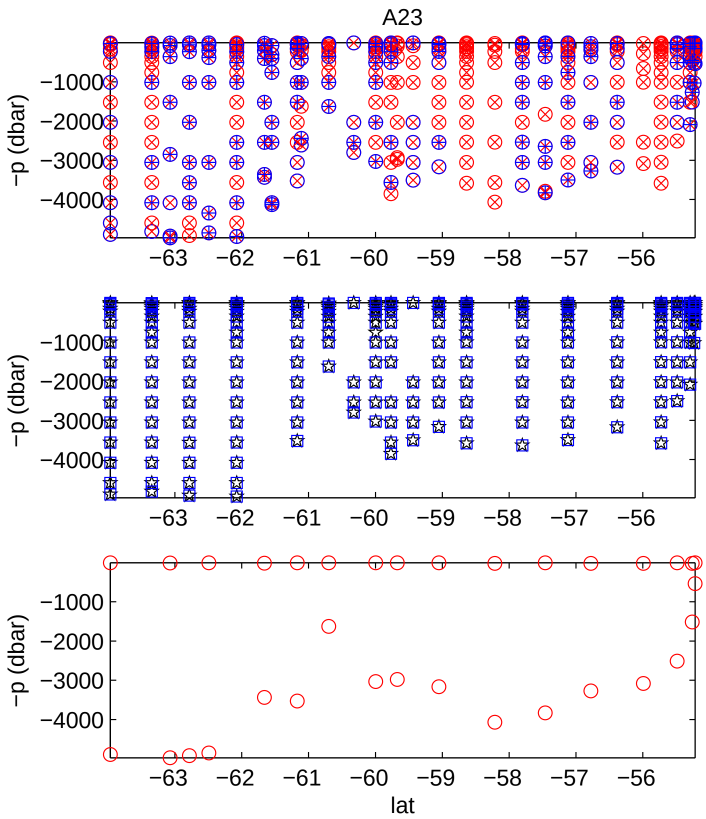


Figure 6.2: Samples on A23, by latitude, as in Figure 6.1.

roll, before adding a one-use stopper and then putting the lids on. Full crates of 24 bottles were stored in the salinometer room for at least 24 hours before being analysed, to let the samples come to room temperature (approximately 19 C).

Samples were then run on one of the the Autosals (SN: 65764 for crates 1 to 4, SN: 68426 for the rest) by the entire science team. Before the very first crate, and after cleaning of SN 68426 due to excessive bubbles, each salinometer had to be standardised, but otherwise the standardisation settings on the Autosals were not changed for the duration of the cruise; instead standards offsets from nominal values were tracked by running standard seawater at the start and end of each crate. Standardisation, maintenance/cleaning, and setup of the computer was performed by the NMF techs, and details are given in Section 12.

Before starting to analyse samples the machine was flushed through with previously opened bottles of standard or standard from a previous cruise with a different K value. Then before and after each crate a Standard Seawater sample (P163, K = 0.99985) was run, so that the salinometer could be checked for drift. If two crates were run straight after each other, a standard bottle could be saved by using the reading of the one from the end of the previous crate as the start of the new crate. If additional flushes and readings were performed after an interval, these readings were given a flag of 3 and not used as standards. Each sample was then flushed through the machine three times before being read three times. The computer would read each sample for 10 seconds and find the mean. Then the mean and standard deviation of all three was taken by the computer; if the standard deviation was higher than 0.0002, one of the readings would be chosen to be taken again. Usually this would be the first reading and would be down to insufficient flushing of the sample before reading.

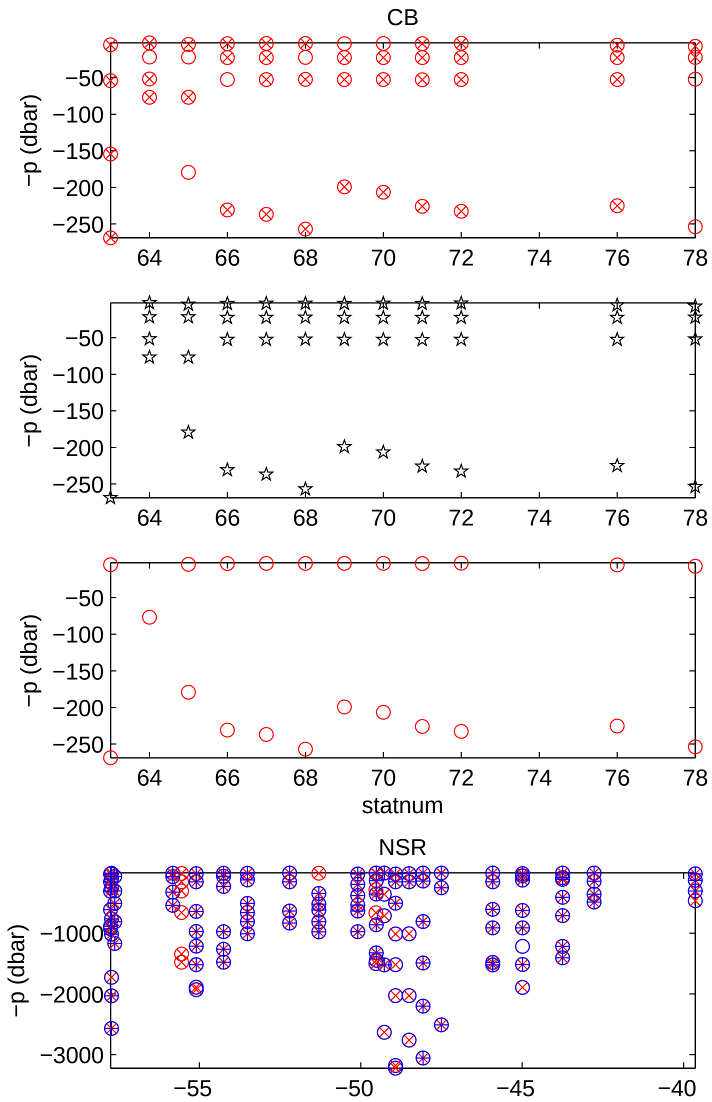


Figure 6.3: Samples in Cumberland Bay (by station) and on the North Scotia Ridge stations (by longitude), as in Figure 6.1.

6.2 Dissolved Oxygen

6.2.1 Sampling

During the DY113 cruise, water samples were taken from the CTD Niskins and titrated to determine dissolved oxygen concentrations to calibrate the CTD oxygen sensors and check for drift over time. Samples were taken at multiple depths on most, but not all, stations with additional replicates of 10%(of the overall number of samples taken). Tables 6.1 through 6.3 show the stations sampled for oxygen titration on each transect as well as the number of samples collected and titrated.

6.2.2 Methods: sampling

Most samples were collected by Natalie, Philip, and Yvonne, and a few by other science party members, with training on bubble prevention provided before sampling began. Oxygen samples were collected first

Cast Number	Station	Latitude	Longitude	Depths sampled	Replicates
001	Test Cast	55°12.79’ S	057°57.96’ W	6	2
002	SR1b_01	54°40.00’ S	057°58.05’ W	4	1
003	SR1b_02	54°55.34’ S	057°58.08’ W	6	1
004	SR1b_03	54°58.66’ S	057°58.07’ W	6	1
005	SR1b_04	55°00.37’ S	057°58.08’ W	4	0
006	SR1b_05	55°04.19’ S	057°58.07’ W	4	0
007	SR1b_06	55°07.26’ S	057°58.09’ W	4	0
008	SR1b_07	55°10.19’ S	057°58.09’ W	4	0
009	SR1b_08	55°12.84’ S	057°58.09’ W	7	1
013	SR1b_12	56°27.96’ S	057°25.61’ W	8	1
014	SR1b_13	56°47.04’ S	057°13.76’ W	8	1
015	SR1b_14	57°06.00’ S	057°02.00’ W	8	1
016	SR1b_15	57°24.33’ S	056°12.16’ W	8	1
017	SR1b_16	57°42.71’ S	056°39.13’ W	8	1
018	SR1b_17	58°01.75’ S	056°28.01’ W	8	0
019	SR1b_18	58°21.72’ S	056°15.63’ W	7	1
020	SR1b_19	58°40.10’ S	056°03.18’ W	8	2
021	SR1b_20	59°00.01’ S	055°51.42’ W	6	2
022	SR1b_21	59°19.08’ S	055°39.04’ W	6	2
023	SR1b_22	59°39.97’ S	055°26.59’ W	8	1
024	SR1b_23	60°00.01’ S	055°14.26’ W	6	1
025	SR1b_24	60°19.09’ S	055°01.87’ W	8	1
026	SR1b_25	60°40.05’ S	054°49.33’ W	4	0
027	SR1b_26	60°47.50’ S	054°45.28’ W	4	1
028	SR1b_27	60°49.98’ S	054°43.30’ W	8	0
029	SR1b_28	60°51.03’ S	054°42.61’ W	8	2
030	SR1b_29	60°58.92’ S	054°38.00’ W	6	2
031	SR1b_30	61°02.10’ S	054° 35.14’ W	5	2

Table 6.1: Oxygen samples from SR1b section.

in the sampling order, from selected Niskin bottles using teflon tubing (stored in Milli-Q between casts). The 125 ml pre-calibrated glass titration bottles were rinsed by overflowing the bottle with seawater equating to at least 3 times the bottle volume. To prevent oxygen bubbles forming in the bottle at the beginning of sampling, the bottle was initially filled at an angle and gradually straightened.

Once the temperature had been taken with a handheld temperature probe, and the collector was happy the sample contained no visible bubbles, the fixing chemicals were added (first Manganese II Chloride followed by the Alkaline Iodide solution) and the stopper inserted. Samples were shaken, with inversion, for 30 seconds each to mix the chemicals and seawater evenly, either once all the samples were collected, or after each sample or two samples. The samples then had a Milli-Q seal added around the stopper to prevent any additional oxygen entering the sample.

The fixed samples were then transported into the lab and left for at least 30 minutes before being shaken for a further 30 seconds. Once this had occurred the Milli-Q seal was replaced and the samples were placed in a dark box to equilibrate with the lab temperature for at least 12 hours. This was to ensure that the samples were titrated at the same temperature as the blanks and standards.

Cast Number	Station	Latitude	Longitude	Depths sampled	Replicates
032	A23_24	63°57.96' S	028°52.62' W	8	2
033	A23_25	63°20.80' S	029°34.13' W	8	1
034	A23_26	63°04.37' S	030°06.92' W	8	1
035	A23_27	62°46.97' S	030°41.63' W	8	1
036	A23_28	62°29.47' S	031°15.69' W	8	1
037	A23_29	62°04.52' S	031°11.01' W	8	1
038	A23_30	61°39.67' S	031°06.66' W	8	1
039	A23_31	61°33.06' S	031°06.23' W	8	1
040	A23_32	61°10.26' S	031°02.76' W	8	1
041	A23_33	61°06.56' S	031°02.48' W	5	0
042	A23_34	60°41.97' S	031°00.59' W	5	0
043	A23_35	60°18.91' S	030°57.51' W	4	1
044	A23_36	59°59.68' S	030°55.79' W	7	0
045	A23_37	59°45.97' S	030°54.33' W	6	1
047	A23_39	59°26.14' S	030°51.61' W	5	0
048	A23_40	59°03.02' S	030°49.82' W	6	1
051	A23_43	57°48.09' S	030°49.96' W	8	1
052	A23_44	57°27.49' S	031°19.67' W	8	1
053	A23_45	57°07.11' S	031°48.88' W	6	3
054	A23_46	56°46.54' S	032°18.24' W	8	1
055	A23_47	56°22.86' S	032°52.37' W	6	3
058	A23_50	55°29.08' S	034°08.00' W	6	2
059	A23_50A	55°17.40' S	034°24.00' W	6	2
060	A23_51	55°15.57' S	034°26.62' W	5	2
061	A23_51A	55°13.80' S	034°29.40' W	4	1
062	A23_52	55°12.91' S	034°30.48' W	4	1

Table 6.2: Oxygen samples from A23 section.

6.2.3 Methods: titration

The standard Amperometric method taken from Langdon (2010) was used to titrate the oxygen samples. This was also used the previous year on JR18002. For the Metrohm Ti-Touch system set up, we used the same parameters as used in the previous cruise. The majority of chemicals were pre-made ashore but the Sodium thiosulphate was mixed on board as needed, at least 24 hours before use.

Once the samples were at the correct temperature they were analysed in batches. At the beginning of each analysis batch a set of blanks (3) and standards (3-5) were run (Table 6.4). Sample bottles were inspected for any bubbles before they were opened and the size and amount were recorded, categorised and flagged. Following this check, the bottles could then be opened, acidified and titrated.

Once the samples were processed, the bottles were rinsed 3 times with Milli-Q water to prevent residue build up.

6.2.4 Problems encountered

Below the problems encountered during this cruise are described to help with future work.

1. Dirty bottles
   On sampling of the test cast (CTD001), a number of the calibrated sample bottles were noted to

Cast Number	Station	Latitude	Longitude	Depths sampled	Replicates
080	NSR_01	53°57.23’ S	039°38.59’ W	4	0
081	NSR_02	53°54.78’ S	040°02.08’ W	8	1
082	NSR_03	53°52.25’ S	040°22.93’ W	4	1
083	NSR_04	53°21.51’ S	042°46.29’ W	4	1
084	NSR_05	53°16.29’ S	043°45.03’ W	7	2
085	NSR_07	53°15.48’ S	044°59.52’ W	8	2
086	NSR_08	53°10.51’ S	045°54.87’ W	6	2
087	NSR_10	52°59.55’ S	047°30.11’ W	3	1
088	NSR_12	53°01.58’ S	048°03.08’ W	6	1
089	NSR_13	53°08.05’ S	048°29.89’ W	5	0
090	NSR_14	53°17.71’ S	048°55.21’ W	8	1
091	NSR_15	53°22.74’ S	049°16.16’ W	5	0
092	NSR_16	53°23.02’ S	049°31.83’ W	2	0
093	NSR_29	53°03.44’ S	057°45.09’ W	6	1
094	NSR_28	53°30.93’ S	057°43.06’ W	8	1
095	NSR_27	53°48.41’ S	057°36.94’ W	6	1
096	NSR_26	54°25.55’ S	055°49.18’ W	4	1
098	NSR_24	54°13.80’ S	055°05.70’ W	8	1
099	NSR_23	54°04.17’ S	054°14.99’ W	6	0
100	NSR_22	53°58.11’ S	053°30.70’ W	6	1
101	NSR_20	53°48.51’ S	052°12.34’ W	4	1
102	NSR_19	53°33.13’ S	051°17.94’ W	5	2
103	NSR_17	53°22.69’ S	050°05.71’ W	6	0
104	NSR_16	53°23.15’ S	049°31.71’ W	6	0

Table 6.3: Oxygen samples from NSR section.

have a brownish residue, presumably retained from the previous cruise. Two samples had been collected but once the problem was identified the remaining sample bottles and stoppers were rinsed with Milli-Q before samples were taken. This process was then completed at the end of each titration to prevent this occurring again.

2. Electrode Check
   During our initial blank set, an error message from the Metrohm system 011-003 Electrode check kept appearing. This indicated that the electrode was either not connected or broken. However, after changing both the electrode and the system itself, this error message persisted. It was resolved by disabling the electrode check on the blanks and standards programme and was saved to prevent the issue recurring. The electrode check remained enabled in the Winkler titration programming and never flagged an error.

3. Standard and Blanks
   At the beginning of the cruise, we were unable to achieve consistent blanks and standards. This inconsistency occurred mainly between operators but also between samples from the same operator. This inconsistency was caused by an oversight in the SOP of the standards and blanks and was rectified by ensuring that the reagents were well mixed between additions (REMEMBER: mix sample after adding each reagent).

4. Potassium Iodate
   In attempts to resolve the above issues with the standards and blanks, more Potassium iodate had been used than expected. In order to ensure enough remained, the number of standards carried out

Analysis Set	Jday	Blank	Standard	molarity	CTDs
1	20039	0.0538(±0.0439)	0.4708(±0.0162)	0.2398	1-4
2	20040	0.0617(±0.0301)	0.4768(±0.0197)	0.2409	5-9
3	20040	0.0533(±0.0117)	0.4568(±0.0106)	0.2479	13-15
4	20041	0.0200(±0.0080)	0.4724(±0.0147)	0.2211	16-18
5	20042	0.0443(±0.0280)	0.4852(±0.0313)	0.2269	19-21
6	20042	0.0827(±0.0445)	0.4696(±0.0097)	0.2585	22-24
7	20043	-0.0050(±0.0017)	0.4432(±0.0066)	0.2232	25-28
8	20044	-0.0075(±0.0047)	0.4416(±0.0084)	0.2227	29-31
9	20049	-0.0030(±0.0030)	0.4436(±0.0059)	0.2240	32-35
10	20050	-0.0057(±0.0021)	0.4467(±0.0046)	0.2211	36-39
11	20052	-0.0007(±0.0006)	0.4433(±0.0061)	0.2253	40-48
12	20053	-0.0020(±0.0028)	0.4447(±0.0050)	0.2239	51-53
13	20057	0.0003(±0.0015)	0.4513(±0.0012)	0.2218	54-55, 58-62
14	20059	0.0010(±0.0026)	0.4556(±0.0009)	0.2200	80-84
15	20061	-0.0017(±0.0021)	0.4540(±0.0024)	0.2195	85-88
16	20066	-0.0003(±0.0012)	0.4456(±0.0057)	0.2243	89-95
17	20068	-0.0010(±0.0041)	0.4492(±0.0063)	0.2222	96, 98-104

Table 6.4: Blanks (averaged over 3 blanks) and standards (averaged over 3-5 standards) over the course of the cruise. The thiosulfate batch was changed after run 10. Reagent bottles were changed several times but not tracked. Runs 1 through 6 had incorrect blanks due to a methodological error (one that did not affect analysis of samples). The mean values of blanks and standards from runs 7 through 10 were used for all stations up to (and including) 39, while the mean values from runs 11 through 17 were used for subsequent stations.

on 4 batches were decreased from 5 to 3; however the standard deviation remained less than 0.005.

6.2.5 Data Processing

Before samples were titrated they were inspected for the presence of bubbles, which may have formed after fixing. Any bubbles present were recorded and the sample was flagged by the following criteria:
2 no bubbles present
2.3 tiny or small bubbles present
3 medium to large bubbles present
4 bad sample as bubbles were present at fixing

The flags used at this stage differed from the WOCE flags in order to allow us to check whether the tiny bubbles were making a difference to the result. As replicates with and without tiny bubbles did not differ, we concluded that these samples could be used, and they were re-flagged as 2 (good). Only data from samples eventually categorised as good were used in the analysis and compared to the oxygen data obtained from the sensor on the CTD rosette. Using these data calibration functions for the CTD oxygen sensors were selected (Section 5.2).

6.3 Nutrient isotopes

6.3.1 Objectives

Samples were collected to investigate the changes to nutrient distributions in the Southern Ocean caused by regeneration of nutrients within the upper ocean of the Drake Passage using stable isotope techniques. These techniques will exploit the isotopic fractionation associated with the biological uptake and regeneration of nitrate (N) and silicate (Si). Southern Ocean mode waters have high N concentrations which are depleted of Si. These waters sustain productivity in the ocean gyres through the upper ocean overturning circulation. The disparity between N and Si is attributed to the high Si:N uptake in the Southern Ocean following diatom blooms. The role of mixed layer recycling is thought to be important to sustain productivity but is difficult to quantify. The data collected here will be used to quantify the changes to N and Si regeneration indicating how on-going climatic changes may affect nutrient delivery to ocean gyres. This work will be part of a larger compilation of stable isotope data from ORCHESTRA, GEOTRACES, and UKOA cruises.

6.3.2 Methods

N isotope samples were collected from 14 stations at 12 depths in the upper 800 m of the water column. Samples were filtered inline from the Niskin using an Acropak filter and collected in 15 ml sterile falcon tubes following three rinses with water from the same Niskin. Samples were then frozen and stored at $-20°$C.

Si isotopes were collected from 11 stations at 8 depths also in the upper 800m of the water column. Water was filtered inline from the Niskin using an Acropak filter and collected in 250 ml acid-cleaned bottles following three rinses with water from the same Niskin. Samples were then acidificed by addition of 230 L of 20% HCl (trace metal clean), parafilmed and stored in the dark at $+4°$C.

Subsequent nutrient isotope analysis will be conducted at the University of Edinburgh (Isotope Ratio Mass Spectrometry for nitrate N analysis; Multicollector ICP-MS for Si isotope analysis) using standard GEOTRACES protocols (Tuerena et al. 2015; GEOTRACES International Data Product).

6.4 Nutrients

Samples were taken from most unique depths on SR1b and A23, with 10% duplicates, and frozen at $-20°$C to be returned to shore and analysed for nitrate, nitrite, phosphate, and silicate opportunistically. Either neoprene or vinyl gloves were worn by the samplers and each vial was rinsed 3 times before filling to approximately the 400 ml mark to allow space for expansion.

6.5 Oxygen isotopes

Samples to be analysed for δ^{18}O (the ratio of ^{18}O to ^{16}O in the seawater) were taken from 330 Niskins on SR1b, 240 on A23, and 45 in Cumberland Bay, with 10% duplicates. Each bottle was rinsed 3 times, filled carefully to prevent generation of bubbles right up to the top with a meniscus, and capped. After sampling lids were tightened and taped with electrical tape, with a line drawn in marker pen to indicate before analysis if they might have loosened in storage or transport. Samples were stored in the $+5°$C controlled temperature laboratory for return to the UK. They will be analysed by BGS and along with salinity values used to determine the relative contributions of glacial melt, local sea ice melt, and local/remote precipitation to freshwater on the ORCHESTRA sections SR1b and A23 and within Cumberland Bay.

6.6 eDNA

Following up on the previous two SR1b transects, seawater from around 2500 m depth was filtered to be analysed for eDNA. Samplers wore gloves to collect approximately 1 L of water in plastic bottles, and as soon as possible after sample collection filtered the water through Sterivex filters using a marked syringe to track the volume filtered. Filters were frozen at −80°C and will be returned to the UK for analysis.

Table 6.5: Volume filtered for eDNA analysis (per filter).

Cast	Niskin	Filters	Volume (ml)
8	3	1	500
8	5	1	500
9	3	1	1050
9	4	1	1050
10	10	2	1000
11	5	1	1000
12	5	1	1000
13	3	1	1050
13	5	1	1050
14	5	2	1000
15	4	2	1000
16	9	1	1050
16	11	1	1000
17	5	1	1000
18	12	1	1000
18	10	1	1000
19	5	1	1000
20	4	1	1000
20	5	1	1000
21	9	1	1000
22	6	1	1000
23	4	1	1000
24	8	1	1000
25	5	1	1000
26	3	1	1000

6.7 Microplastics

Microplastics sampling was conducted along the SR1b transect in Drake Passage, with samples taken at a total of 16 stations at depths ranging from 15 to over 4000 metres (summarised in Table 6.6). Opportunistic sampling was conducted along the A23 transect across the northern Weddell Sea, with samples taken at a total of 16 stations at depths from 2 to over 4800 metres summarised in Table 6.7). Opportunistic sampling was also conducted in Cumberland Bay, South Georgia, with samples taken at a total of 12 stations at depths from 1 to just over 250 m (summarised in Table 6.8). Seawater samples were collected from CTD rosette Niskin bottles; Tygon tubing was attached to the spigots, rinsed through, then fed into 5L translucent white plastic bottles. Tygon tubing was used for ease of collection and in an effort to minimise atmospheric contamination. Samples were collected once all other samples had been collected, and with as little interference as possible. A total of 5 litres of water was collected per sampled depth at every station, and samples were processed as soon as possible after collection to prevent algal and other biological growth. Collection bottles were rinsed three times with clean seawater and once with Milli-Q water between sampling.

The seawater samples were filtered using a desktop vacuum pump (KNF Neuberger Laboport) attached to a 5L Buchner flask and glass filter holder (Millipore) through 1.2-m gridded filters (Merck Millipore S-Pak Nitrocellulose) in a contained filtering system (see Figure **6**.4b). All equipment was rinsed with Milli-Q water in between sample filtering, and was kept covered with aluminium foil when not in use. 5 litre Milli-Q blanks were conducted at the beginning of each day prior to any sample processing in order to account for any contamination within the filtering system itself. Atmospheric controls, in the form of a damp filter paper being kept out during filtering of each station, were conducted to monitor any atmospheric contamination. Filters collected during the SR1b transect were stored in labelled glass petri dishes, fully sealed with tape. However, due to a limited number of petri dishes, all filters collected during the A23 transect and in Cumberland Bay were folded in half in on themselves and then stored in folded aluminium foil. The filters were folded in on themselves to avoid transference of plastic particles onto the aluminium foil.

Analysis of all samples will be conducted back in the UK using a compound microscope and Fourier-transform infrared spectroscopy.

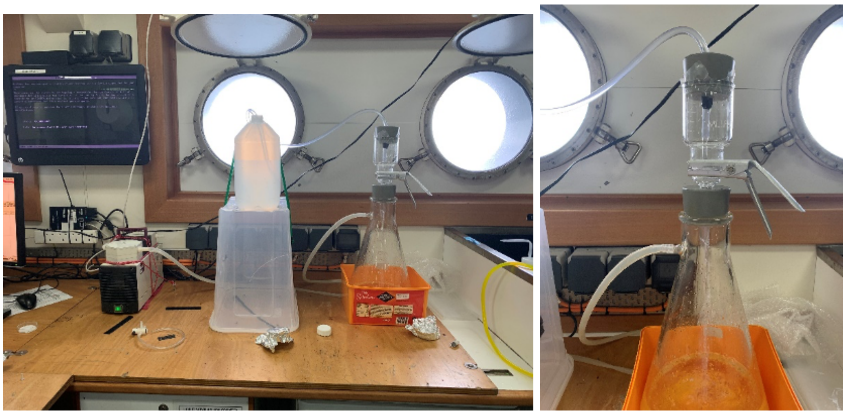


Figure 6.4: (a) Full microplastics filtering set up (b) Close up of enclosed filtering system.

Table 6.6: Microplastics samples from SR1b.

Date	Latitude	Longitude	Time	Cast	Station	Depth
06/02/2020	55° 4.20 S	57° 59.00 W	20:38	001	test cast	60
			20:44			5
07/02/2020	54° 40.00 S	57° 59.00 W	00:53	002	SR1b_01	155
			00:56			115
			01:00			50
			01:03			15
07/02/2020	54° 55.34 S	57° 59.00 W	10:20	003	SR1b_02	677
			10:26			637
			10:34			450
			10:40			220
			10:47			70
			10:52			20
07/02/2020	54° 58.67 S	57° 59.00 W	12:37	004	SR1b_03	1035

Date	Latitude	Longitude	Time	Cast	Station	Depth
			12:40			995
			12:47			710
			12:56			300
			13:04			40
			13:07			15
07/02/2020	55° 4.20 S	57° 59.00 W	18:05	006	SR1b_05	2175
			18:17			1650
			18:26			1250
			18:34			850
			18:50			100
			18:56			15
08/02/2020	55° 10.20 S	57° 59.00 W	00:40	008	SR1b_07	3115
			01:01			2020
			01:14			1360
			01:31			520
			01:45			80
			01:47			15
08/02/2020	55° 31.00 S	57 59.00 W	10:12	010	SR1b_09	4170
			10:28			3660
			10:57			2490
			11:20			1390
			11:49			100
			11:53			15
08/02/2020	56°9.00 S	57° 37.45 W	21:30	012	SR1b_11	3457
			22:01			2030
			22:12			1510
			22:33			510
			22:43			100
			22:47			15
09/02/2020	56° 47.00 S	57° 13.90 W	09:48	014	SR1b_13	3310
			10:03			2760
			10:22			2040
			10:42			1240
			11:08			75
			11:11			15
09/02/2020	57° 25.00 S	56° 50.35 W	20:13	016	SR1b_15	3543
			20:28			3110
			20:49			2110
			21:13			1010
			21:35			75
			21:38			15
10/02/2020	58° 3.00 S	56° 26.79 W	10:26	018	SR1b_17	4019
			10:47			3530
			11:33			1490
			12:07			60
			12:10			15
10/02/2020	59° 0.00 S	55° 51.47 W	02:12	021	SR1b_20	3765
			02:30			3100
			02:49			2200
			03:11			1200

Date	Latitude	Longitude	Time	Cast	Station	Depth
			03:39			80
			03:43			20
11/02/2020	60° 0.00 S	55° 14.28 W	19:07	024	SR1b_23	3487
			19:34			2400
			19:44			1980
			20:06			880
			20:26			80
			20:30			15
12/02/2020	60° 47.97 S	54° 44.55 W	10:23	027	SR1b_26	2628
			10:36			2200
			10:45			1930
			10:56			1430
			11:23			100
			11:27			15
12/02/2020	60° 51.02 S	54° 42.66 W	16:28	029	SR1b_28	1000
			16:37			700
			16:42			500
			16:50			250
			16:55			100
			16:59			20
12/02/2020	60° 58.86 S	54° 37.80 W	19:08	030	SR1b_29	570
			19:12			530
			19:15			470
			19:20			310
			19:24			120
			19:29			15
12/02/2020	61° 3.00 S	54° 35.23 W	20:46	031	SR1b_30	434
			20:50			394
			20:58			100
			21:02			15

Table 6.7: Microplastics samples from A23.

Date	Latitude	Longitude	Time	Cast	Station	Depth
16/02/2020	63° 57.93 S	28° 52.62 W	20:44	032	A23-24	4782
			22:30			4
17/02/2020	63° 04.37 S	30° 06.92 W	00:27	034	A23-26	4862
			02:00			10
18/02/2020	62 29.47 S	31 15.69 W	14:25	036	A23-28	4744
			15:58			5
18/02/2020	61° 39.67 S	31° 06.66 W	02:56	038	A23-30	3375
			04:09			15
19/02/2020	61° 10.26 S	31° 02.76 W	12:35	040	A23-32	3464
			13:58			5
19/02/2020	60° 41.97 S	31° 00.59 W	21:27	042	A23-34	1605
			22:13			2
20/02/2020	59° 59.68 S	30° 55.79 W	07:05	044	A23-36	2980
			08:23			5
20/02/2020	59° 40.43 S	30° 53.79 W	16:14	046	A23-38	2923

Date	Latitude	Longitude	Time	Cast	Station	Depth
			17:17			2
21/02/2020	59° 03.02 S	30° 49.82 W	01:51	048	A23-40	3107
			03:07			5
21/02/2020	58° 12.78 S	30° 49.32 W	13:20	050	A23-42	3991
			14:41			20
22/02/2020	57° 27.49 S	31°19.67 W	00:33	052	A23-44	3758
			01:52			2
22/02/2020	56° 46.54 S	32° 18.24 W	12:04	054	A23-46	3217
			13:15			20
22/02/2020	55° 59.42 S	33° 25.17 W	23:16	056	A23-48	3030
			00:15			20
23/02/2020	55° 29.08 S	34° 08.00 W	08:46	058	A23-50	2472
			09:53			7
23/02/2020	55° 15.57 S	34° 26.62 W	15:32	060	A23-51	1497
			16:07			20
23/02/2020	55° 12.91 S	34° 30.48 W	18:57	062	A23-52	528
			19:21			3

Table 6.8: Microplastics samples from Cumberland Bay.

Date	Latitude	Longitude	Time	Cast	Station	Depth
24/02/2020	54° 7.72	36° 16.46	07:21	063	Cumb_01	265
			07:38			5
25/02/2020	54° 12.57	36° 27.96	19:11	078	Cumb_03	250
			19:22			5
25/02/2020	54° 13.53	36° 26.19	08:40	076	Cumb_07	222
			08:53			5
24/02/2020	54° 15.55	36° 26.10	16:02	068	Cumb_09	253
			16:14			1
24/02/2020	54° 16.69	36° 25.24	14:54	067	Cumb_10	233
			15:04			1
24/02/2020	54° 18.14	36° 24.05	14:03	066	Cumb_11	227
			14:13			1
24/02/2020	54° 19.51	36° 23.05	12:59	065	Cumb_12	177
			13:12			3
24/02/2020	54° 21.93	36° 22.26	11:40	064	Cumb_13	76
			11:51			2.5
24/02/2020	54° 13.00	36° 31.30	20:40	072	Cumb_14	229
			20:51			1
24/02/2020	54° 13.75	36° 33.60	19:44	071	Cumb_15	222
			19:56			1
24/02/2020	54° 14.70	36° 35.80	18:50	070	Cumb_16	203
			19:03			1
24/02/2020	54° 15.80	36° 38.20	17:54	069	Cumb_17	196
			18:05			1

7. LADCP

Ciara Pimm (Liverpool, ciara.pimm@liverpool.ac.uk)

7.1 Configuration, deployment, and processing

Two 300-kHz Teledyne RDI Workhorse Monitor lowered acoustic Doppler current profilers (LADCPs) were installed on the CTD rosette in a downward looking (Master, SN:23444), and upward looking (Slave, SN: 12369) configuration. The data was collected in beam coordinates with 25 x 8 m bins, which were converted to earth coordinates during processing. The LADCP deployment was carried out by the NMF CTD technicians. Prior to each cast pre-deployment and deployment scripts were run to check for any faults in the LADCP, set ping, bin, and transformation parameters, and to start the LADCP heads pinging. 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, data downloading and initial quality checking, carried out by the NMF technicians. The files were saved with names of the form DY113_CTDXXXM.000 and DY113_CTDXXXS.000 for master and slave respectively, where XXX is the CTD number, and copied to the networked Sensors and Moorings drive. More details may be found in Section 12.

7.2 Data processing

The data were copied from the Sensors and Moorings drive to local/users/pstar/cruise/data/ladcp/ix/raw for processing by running shell script lad_linkscript_ix, which also made symbolic links with names of the form DLXXX000.000 and ULXXX000.000. Processing was completed by the physics team using version 13 of the LADCP-processing matlab package, LDEO_IX, developed at Lamont-Doherty Earth Observatory (LDEO) by Martin Visbeck and maintained by Andreas Thurnherr. This software uses an inverse method to compute velocity profiles from the LADCP data plus additional constraints: 1) position data from the ship GPS (posmv) with which cast-averaged velocity is derived; 2) bottom tracking velocities (in most cases, calculated in the instrument; for exceptions see below); 3) shipboard ADCP velocities in the upper ocean. To check the effect of the different constraints, we added them in succession, starting with a solution using only GPS, then one using GPS and bottom tracking, and finally solutions using GPS, bottom tracking, and VMADCP velocities from either of the two instruments (75 kHz and 150 kHz). To simplify running the processing with multiple constraints, versions of the two front-end LDEO_IX scripts, process_cast.m and set_cast_params.m, were modified to accept input arguments determining which constraints would be used, and saved as process_cast_cfgstr.m and set_cast_params_cfgstr.m, respectively. The processing steps for a cast in Matlab therefore looked like this:

>> cfgstr.orient = DLUL;
>> cfgstr.constraints = GPS;
>> process_cast_cfgstr(stn, cfgstr);
>> cfgstr.constraints = GPS, BT;
>> process_cast_cfgstr(stn, cfgstr);
And following generation of the VMADCP profiles (described in Section 8):
>> cfgstr.constraints = GPS, BT, SADCP75nb;

```
>> process_cast_cfgstr(stn, cfgstr);
>> cfgstr.constraints = GPS, BT, SADCP150nb;
>> process_cast_cfgstr(stn, cfgstr);
```

Because the 75-kHz VMADCP on the Discovery during DY113 (and previous cruises) suffers from range-reducing noise, the last version, processed with the 150-kHz data as well as GPS and bottom tracking, is the version of record (except for CTD 079).

7.2.1 Incorporating VMADCP data

VMADCP data processing is described in Section 8. Edited data were averaged over the duration of each cast into separate files in local/users/pstar/cruise/data/vmadcp/mproc, with names of the form os75nb_dy113_ctd_XXX_forladcp.mat or os150nb_dy113_ctd_XXX_forladcp.mat, where XXX represents the CTD number.

7.2.2 Changes to default parameters

The first five casts produced a number of warnings about velocities exceeding the ambiguity velocity, so from cast 5 onward the deployment scripts and the corresponding processing parameters p.vlim and p.ambiguity (note the latter is only used in a diagnostic plot) were changed from the default of 2.5 m/s to 3.3 m/s, using a call to opt_dy113.m within set_cast_params.m. For cast 085, the automatic bottom tracking and bottom detection failed for unknown reasons, so p.btrk_mode was set to 2 (rather than the default of 3) to search for the bottom in processing.

7.2.3 LADCP warnings

In general, the quality of the LADCP data is very good, in fact 74 casts produced no processing warnings at all. However, some casts encounter warnings given by the processing software. During cast 001, the LADCP did not collect a full depth profile. However, this was the test cast and was therefore repeated later in the cruise, so has been removed from any further calculations. The most common warning is that there is increased error because of shear inverse difference, which happens on 22 of the casts. This error was mainly ignored as later as further work on data quality shows that these casts are still gathering good data. The shear method used to calculate velocities is not well maintained and also is not as good at calculating velocities as the inverse method. Another common warning encountered was that there were velocity measurements of greater than 2.5 m/s, which occurred on 3 casts or 3.3 m/s which occurred on 5 casts. Mainly these were a very low percentage of the total velocities found and therefore the error was ignored. Another error which occurred in 4 casts was that there were a number of pressure spikes removed. On casts 077, 078, 079, 096 the processing software would not find the surface or the bottom correctly and this would lead to bad beams being found. This could be due to a number of reasons, such as it being a very shallow cast (except for 096), or the sea state being rough, generating bubbles and turbulence.

This list shows any warnings generated by processing with three constraints: GPS, bottom tracking, and VMADCP150nb.
001 - found 114 (4.9% of total) velocity measurements > 2.5 m/s, LADCP processing warnings: first LADCP depth is 1261 last LADCP depth is 3485. The time offset was probably selected wrong by the software, but since this cast (the test cast) did not get a full depth LADCP profile, the data are not being used.
002 - found 207 (8.3% of total) velocity measurements > 2.5 m/s, removed 26 pressure spikes during: 3

scans, shifted ADCP timeseries by 13 seconds
003 - found 196 (4.8% of total) velocity measurements > 2.5 m/s, removed 52 pressure spikes during: 3 scans
022 - found 143 (1.6% of total) velocity measurements > 3.3 m/s, increased error because of shear inverse difference
024 - found 112 (1.3% of total) velocity measurements > 3.3 m/s
028 - found 102 (1.6% of total) velocity measurements > 3.3 m/s
080 - found 101 (3.1% of total) velocity measurements > 3.3 m/s, removed 58 pressure spikes during: 3 scans
083 - removed 42 pressure spikes during: 3 scans
092 - found 108 (2.5% of total) velocity measurements > 3.3 m/s
In addition, casts 9, 10, 11, 13, 14, 18, 19, 20, 21, 23, 25, 26, 33, 34, 36, 37, 52, 53, 54, 56, 57 generated the warning “increased error because of shear inverse difference”.

7.3 Results

7.3.1 Effect of different constraints

Each of the three different constraints led to slightly different velocity profiles. The effect of the constraints did not change overall positions of fronts or jets but did change the strength of them slightly. The difference between LADCP processed with all three constraints and LADCP processed with only the GPS constraint was the biggest, with differences in velocity of up to 0.2 m/s in some places. These big differences are mainly at the bottom of the water column. The difference between the LADCP processed with all three constraints and LADCP processed with GPS and BT was much smaller with differences of up to 0.12 m/s but it was mainly much less at around 0.08 m/s. This suggests that the VMADCP does improve the quality of the data but not by that much as the data is already well constrained by only the GPS and BT constraints. The difference between LADCP processed with VMADCP150 and VMADCP75 was very small, with differences of maximum of only 0.04 m/s.

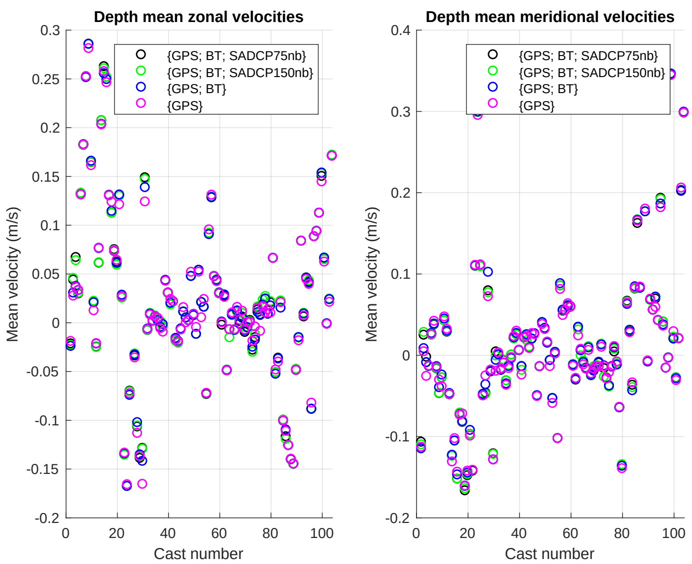


Figure 7.1: Differences in velocity reference (depth-mean) due to including different constraints.

7.3.2 Data quality and comparison to VMADCP

The rms difference is found between the LADCP velocities processed without being constrained by VMADCP and the VMADCP velocities themselves. This has previously been shown to be a good indicator of data quality. Most casts were found to have an rms difference of less than 0.06 m/s, seen in figure 5, which indicates a very high quality of data. The instrument range was checked as another indicator of data quality, as areas of low backscatter can affect the range of the instrument and therefore the quality of the data. In most cases the instrument range was over 80 m, except casts 002, and many of the Cumberland Bay casts 063 079, as seen in figure 6. All of these casts are very shallow, and towards the end of the Cumberland Bay section the weather was rough, which may have led to the low instrument range.

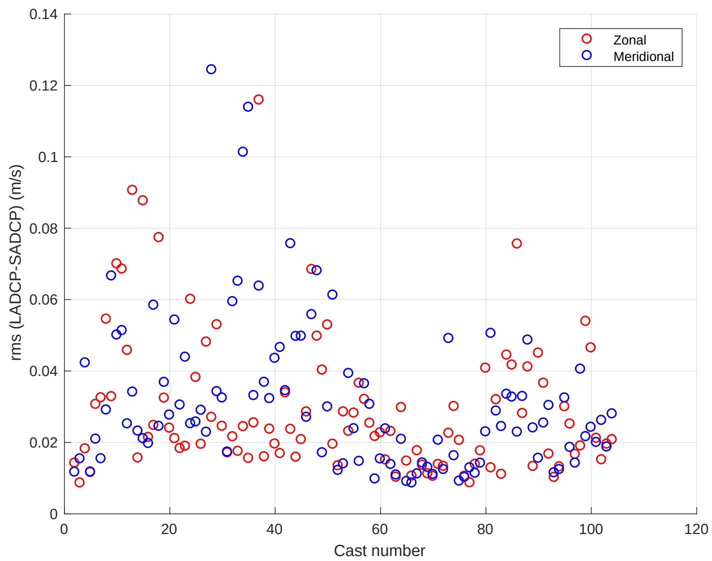


Figure 7.2: RMS difference of LADCP velocities processed without being constrained by VMADCP data and VMADCP velocities (m/s) against cast number, where red represents zonal velocities and blue represents meridional velocities.

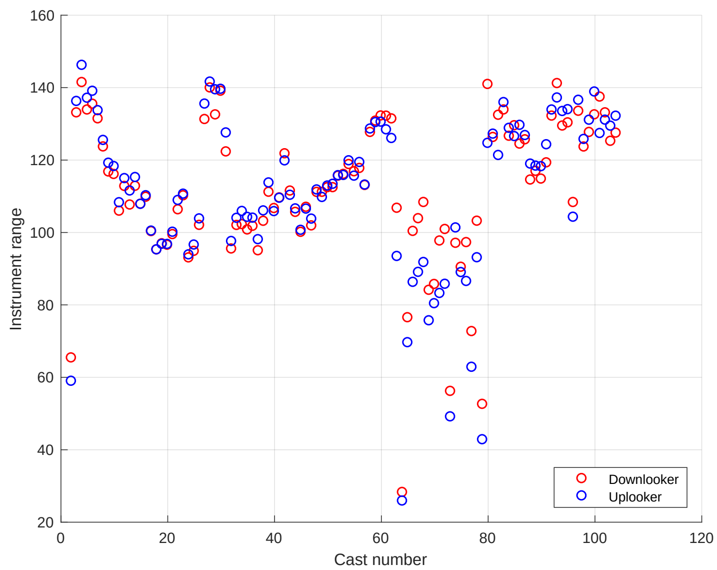


Figure 7.3: Instrument ranges (m) against cast number.

7.3.3 Velocity sections

The velocity profiles were found using a matlab script which reads in the data from each cast, then interpolates to regular depths and plots the velocities against latitude and depth. The velocity profiles have been split up into the four sections that were completed on this cruise, so it is easier to see them.

For the SR1b section the zonal velocities are stronger than the meridional velocities, with some clear indications of some of the fronts of the ACC. Interestingly in cast 024, we get the strongest meridional velocities and the minimum zonal velocities which could indicate that the Antarctic Slope Current was present here.

Next, we considered the meridional and zonal velocities for the A23 section, seen in figure 2. Velocities along A23 are in general weaker than SR1b, and the zonal and meridional velocities are of a similar magnitude.

Then we consider the Cumberland Bay section, this section involves a series of very shallow casts, which can cause problems for LADCP data. The data collected from Cumberland Bay was troublesome for the LADCP, with the instrument not getting a very good range. For these shallow casts the LADCP constraints did not make much difference at all as the LADCP is constrained through the whole water column using only the GPS data. This can be seen in figure 7 where all 3 constraints depth mean are basically the same. Finally, we look at the North Scotia Ridge section of the cruise, velocities here are plotted along longitude rather that latitude.

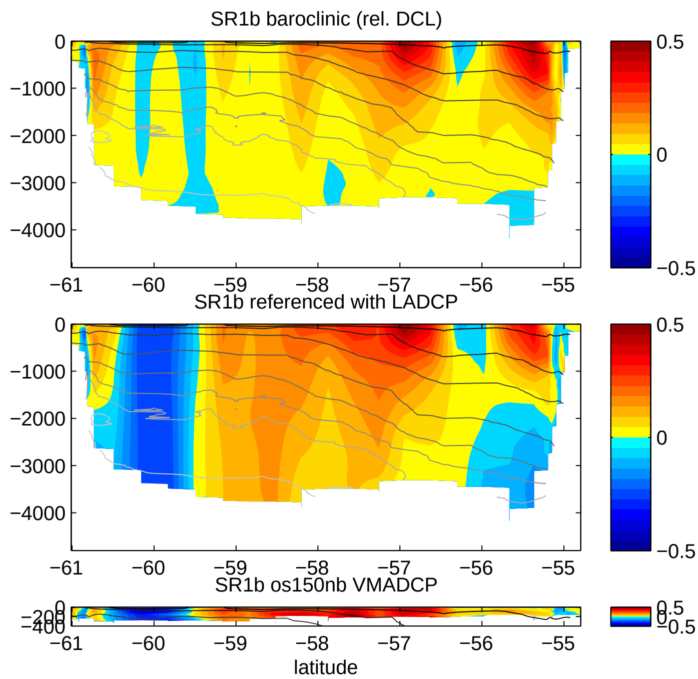


Figure 7.4: Velocity comparison on SR1b: CTD baroclinic velocity (top), CTD geostrophic velocity referenced with LADCP (middle), VMADCP upper ocean total velocity (bottom).

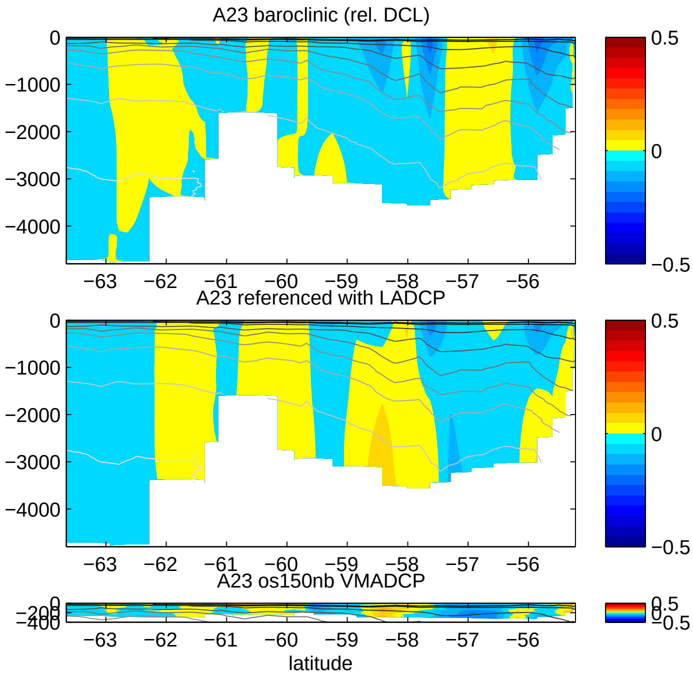


Figure 7.5: Velocity comparison on A23: CTD baroclinic velocity (top), CTD geostrophic velocity referenced with LADCP (middle), VMADCP upper ocean total velocity (bottom).

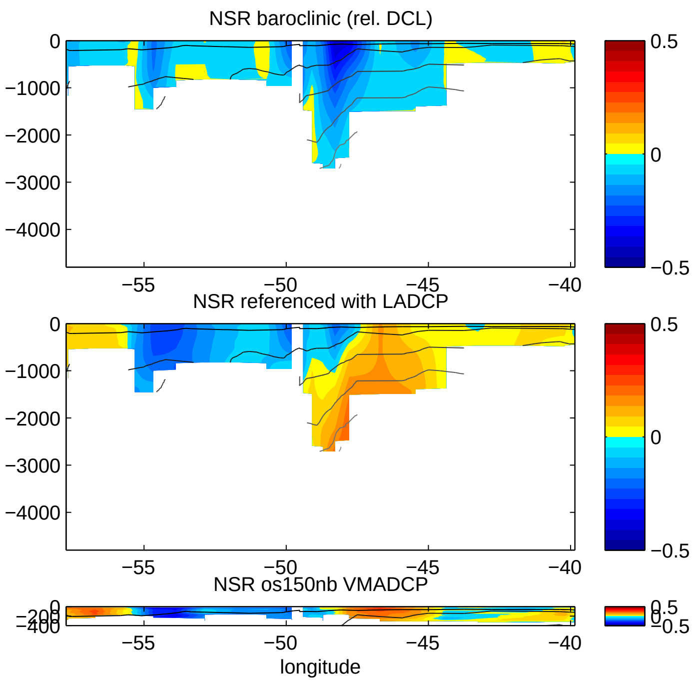


Figure 7.6: Velocity comparison on North Scotia Ridge section: CTD baroclinic velocity (top), CTD geostrophic velocity referenced with LADCP (middle), VMADCP upper ocean total velocity (bottom).

8. VMADCP

David Menzel (Geomar, dmjmenzel@gmail.com)

8.1 Data acquisition, processing, editing, and calibration

Two Vessel Mounted Acoustic Doppler Current Profilers (VMADCPs), 75 kHz and 150 kHz, were configured and run by UHDAS to sample in narrowband mode throughout the cruise. (Initially they alternated with broadband pings for a short time but these data were not processed.) The data were processed using CODAS (http://currents.soest.hawaii.edu/docs/adcp_doc/codas_doc/index.html). We synced the data to Linux workstation koaeula and applied postprocessing and calibrations. Before editing the new data, we removed our old copy to start the calibrations fresh and avoid double-applying them. The command uhdas_01 was used to synchronise the data from the acquisition computer to the workstation, uhdas_02 to synchronise to the folder postprocessing/DY113/proc_editing and make links if necessary and uhdas_03 was used to copy previously made edits, which were archived in proc_archive, to proc_editing, so they would be applied to the newly expanded dataset and to add the new data to the dataset.

The data was analysed visually using dataviewer.py, which also offers the option to mask and remove bad data using thresholds or manual selection using the editing mode and compare two datasets by using the compare mode. While underway, the turbulences and bubbles caused by the engines and the ships movement sometimes led to corrupted data in the upper bins. Most of this data could be removed using the ringing and ships speed threshold, setting it at removing one (sometimes up to three) bin with the speed threshold set to 3 mm/s. Sometimes more accurate manual selection had to be applied. The wire interference threshold was applied while on station by default, with an error velocity of 120 mm/s. If necessary an additional error velocity threshold was applied for near bottom velocities. Some instances of scattering layer bias were observed and removed. Isolated points were removed if they were very few or if the velocities looked wrong. The 75 kHz was far noisier than the 150, therefore more editing was necessary. The changes were applied using
quick_adcp.py - - steps2rerun apply_edit:navsteps:calib - -auto.

After the visual editing, the needed amplitude and phase calibration was determined from watertrack data by inspecting cal/watertrk/adcpcal.out and applied using
quick_adcp - -steps2rerun apply_edit:rotate:navsteps:calib - -rotate_amplitude amp - -rotate_angle ang. The result was compared to a previously made copy without the calibrations to see if the calibrations had the wanted effect. There were larger calibrations needed on the 75 kHz (amplitude = 1.023, angle = 0.0525) than on the 150 kHz (amplitude = 1.011, angle = 0.027). Full list below. Additionally a transducer offset calibration was evaluated based on cal/watertrk/guess_xducerxy.out and applied using quick_adcp.py - -steps2rerun apply_edit:rotate:navsteps:calib - -xducer_dx dx - -xducer_dy dy with no big effect.

After the calibrations, the two instruments were compared using the compare mode from dataviewer.py to check if more editing was needed. If everything looked fine, the command uhdas_04 was used to generate .nc files in proc_editing/os**nb/contour and uhdas_05 to synchronise proc_editing to proc_archive. The data was further processed in Matlab using the function vmadcp_stations_to_ladcp(start_station, end_station) which contains the functions mvad_01, which makes mstar format files containing madcap data in vmadcp/mproc, mvad_03, for upper ocean velocity profiles corresponding to ctd station, mvad_for_ladcp which makes a file of station data to be used as constraint in LADCP processing. Finally cfgstr.orient = DLUL; cfgstr.constraint = {GPS;BT;SADCP}; process_cast_cfgstr(station,cfgstr) adds the VMADCP constraint to the LADCP inversion (Section 7).

DAY	Calibrations				
	Amplitude		Angle		Transducer offset
	150 kHz	75 kHz	150 kHz	75 kHz	
45	1.01	1.023	0.27	0.16	(3, -5)
46	10.11	1.023	0.1225	0.1620	
48	1.011	1.0225	0.165	0.1495	
49	1.012	1.023	0.165	0.1495	
50	1.011	1.023	0.027	0.1345	
51	1.012	1.023	0.023	0.11	
53	1.011	1.023	0.08	0.1	
54	1.011	1.023	0.072	0.1035	
57	1.011	1.023	0.027	0.0695	
58	1.011	1.024	0.027	0.056	
60	1.011	1.023	0.027	0.054	(2, -3)
61	1.011	1.023	0.027	0.0525	
66	1.011	1.023	0.022	0.054	
67	1.011	1.023	0.022	0.0525	
68	1.011	1.023	0.023	0.054	(2, -3)
70	1.011	1.023	0.063	0.044	(2, -3)

Table 8.1: Additional calibrations applied to VMADCPs following editing and processing up to the indicated day. Transducer offsets were the same for both instruments.

8.2 Results

Other than the reduced range of the 75 kHz, the data quality from both instruments after CODAS automatic editing appeared generally good, thanks to the good weather. Some differences between the two instruments persist in the edited version, in cases where it was not clear which was better. Despite calibration, for some stretches of time the 75 kHz appears to have on- and off-station biases. Additional postprocessing, including possibly single-ping processing, is planned for after the cruise.

Velocity vectors and sections are shown here. The plots were made using quick_plots.py, which uses a sectinfofile.txt in which the properties for the vector plots are defined. We have been measuring in four main sections, S1Rb, transfer between S1Rb and A23, A23, and NSR (Northern Scotia Ridge). Velocities from the shallow waters of Cumberland Bay are not shown. Comparisons to LADCP velocities and to CTD geostrophic velocity are in Section 7.

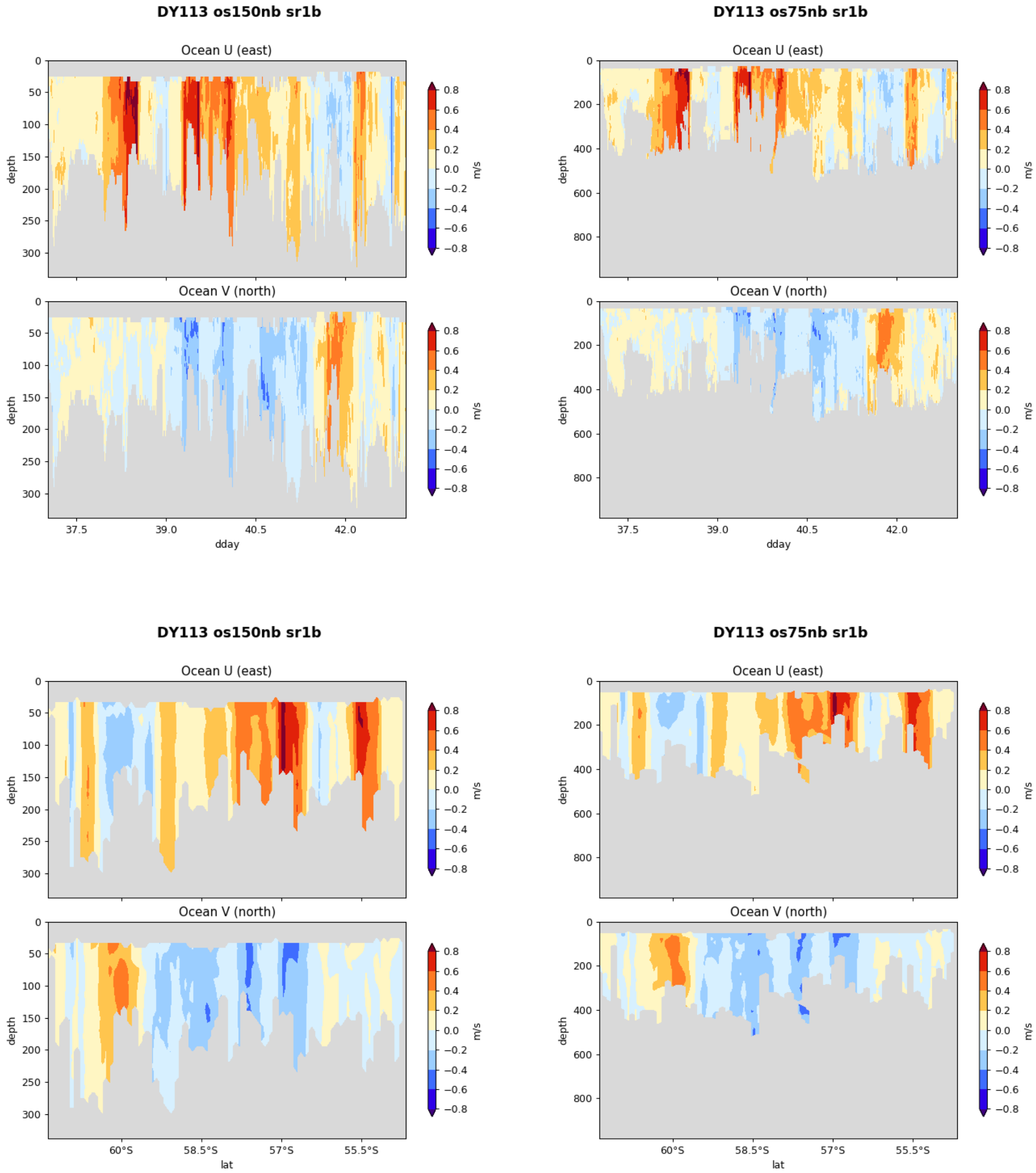


Figure 8.1: SR1b VMADCP zonal and meridional velocity sections, from both instruments, as a function of time and gridded by latitude.

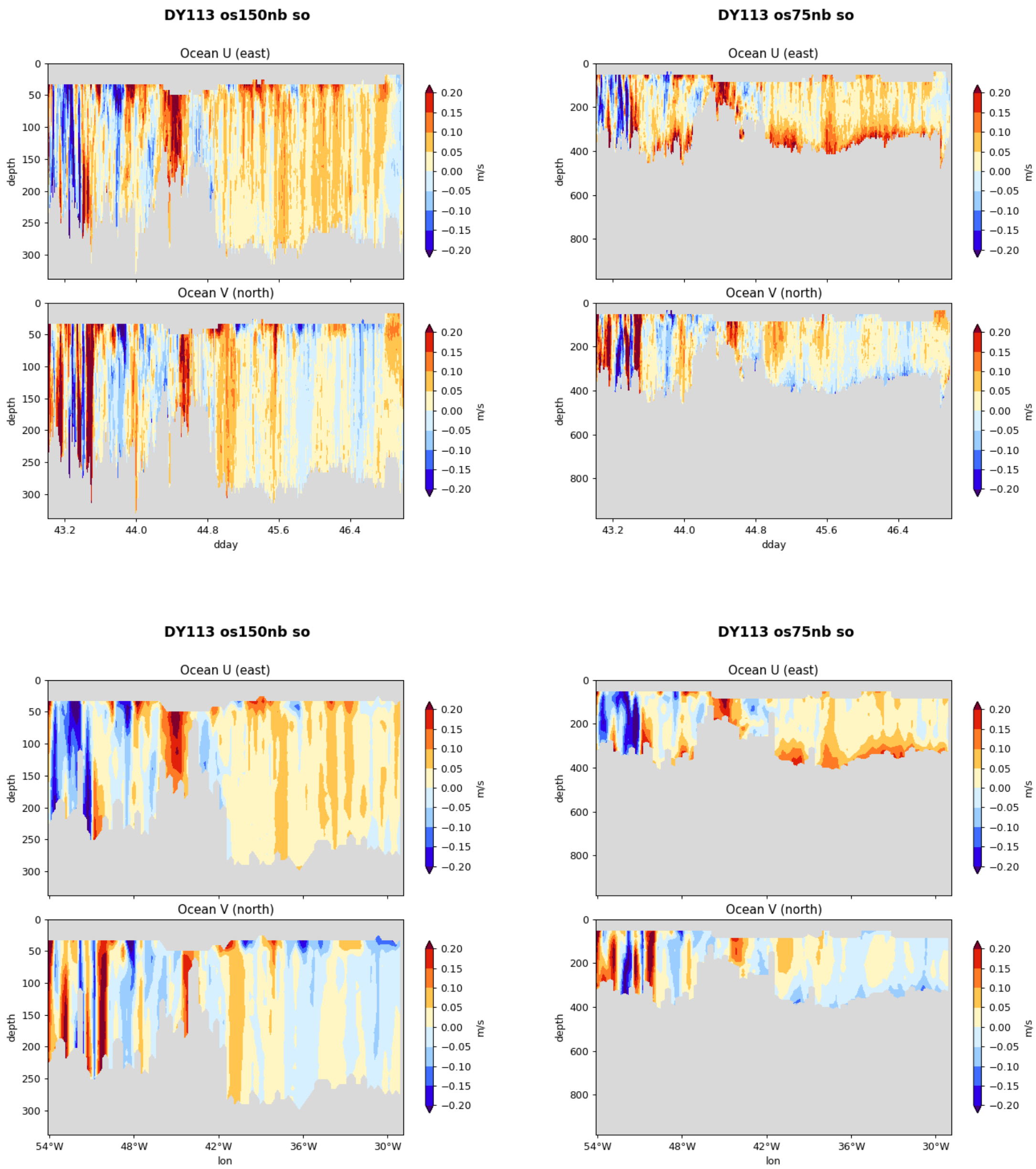


Figure 8.2: As in Figure 8.1, for the transit between Elephant Island and A23, with gridding vs. longitude.

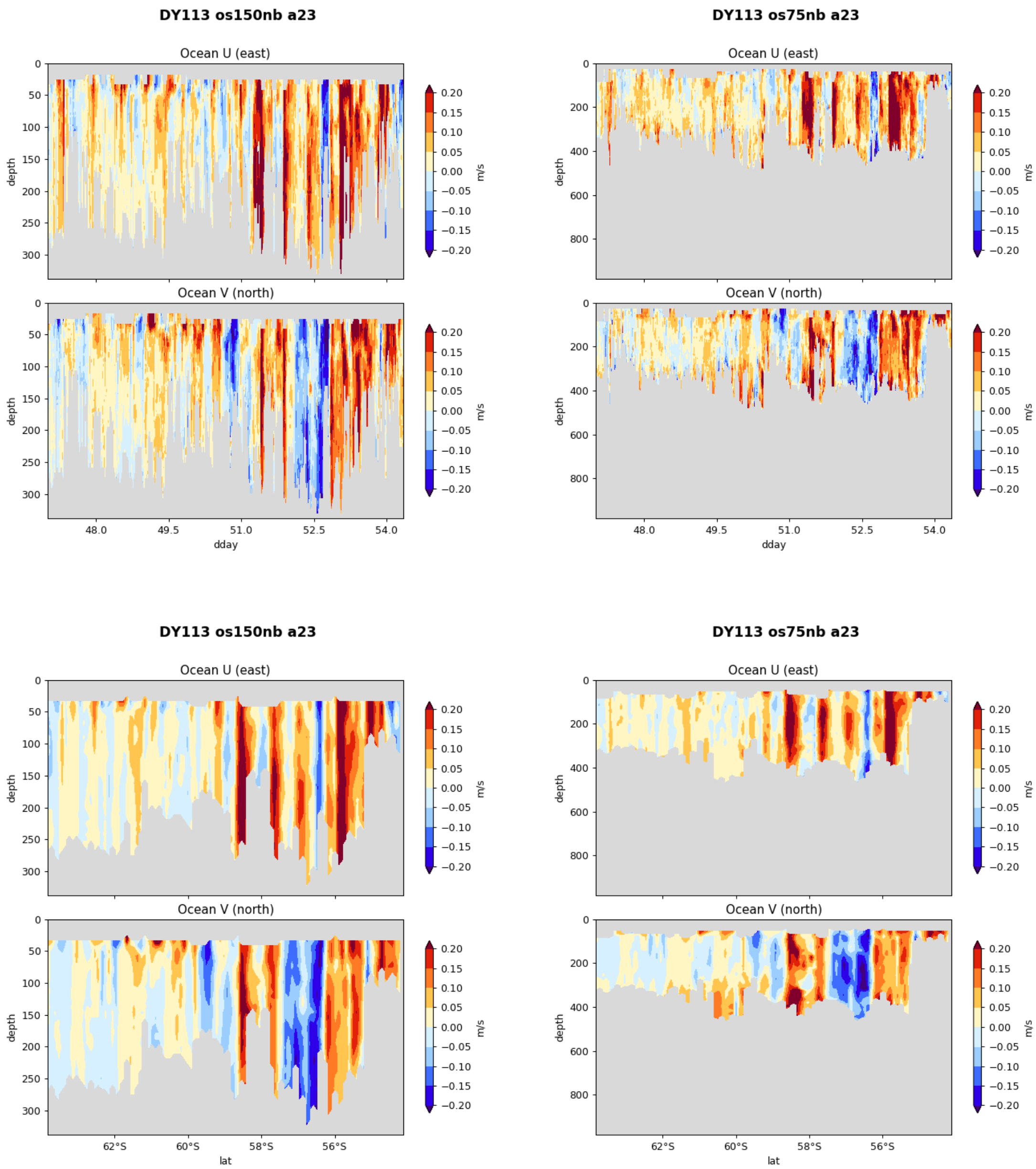


Figure 8.3: As in Figure 8.1, for A23.

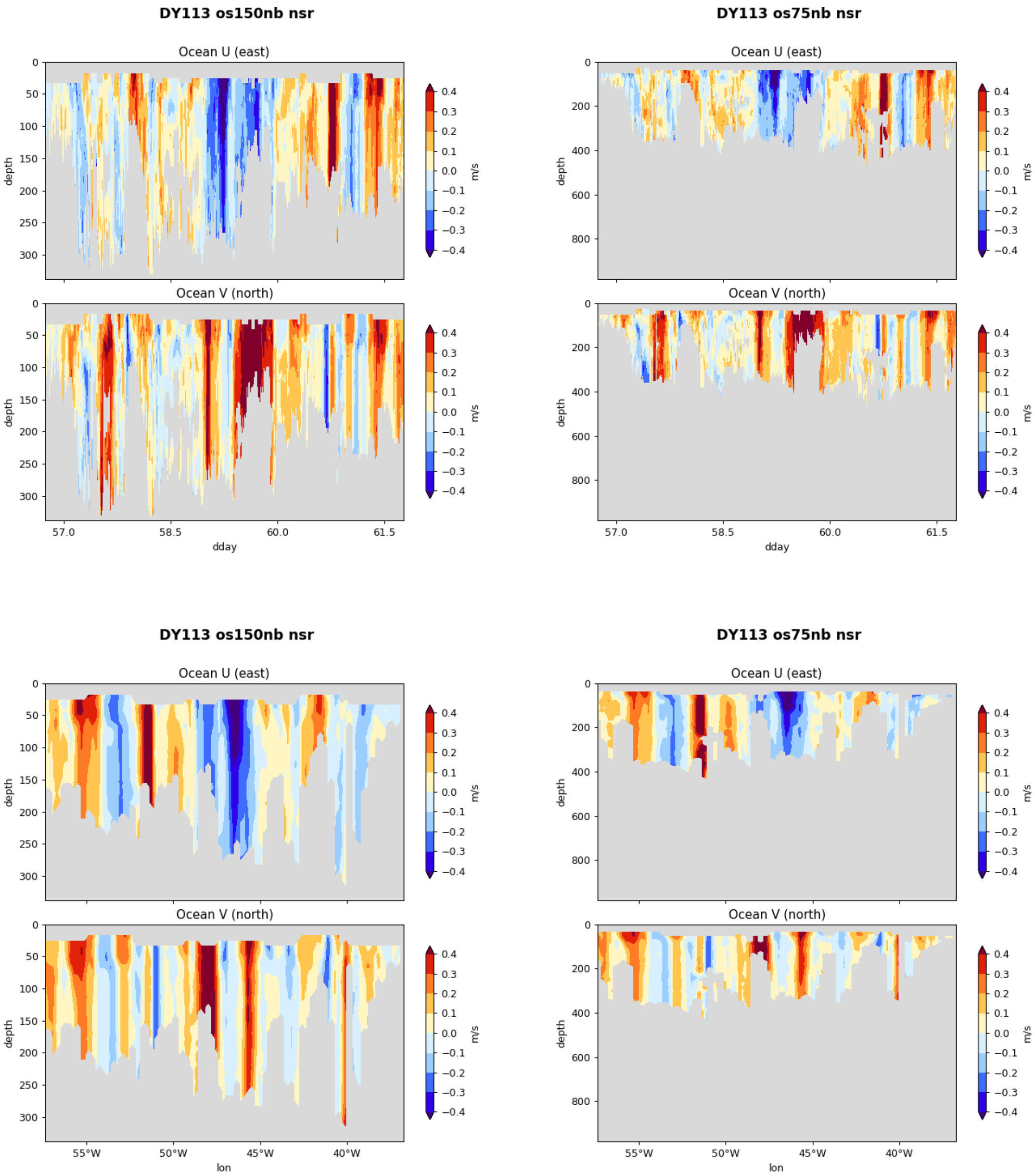


Figure 8.4: As in Figure 8.1, for the NSR, with gridding vs. longitude.

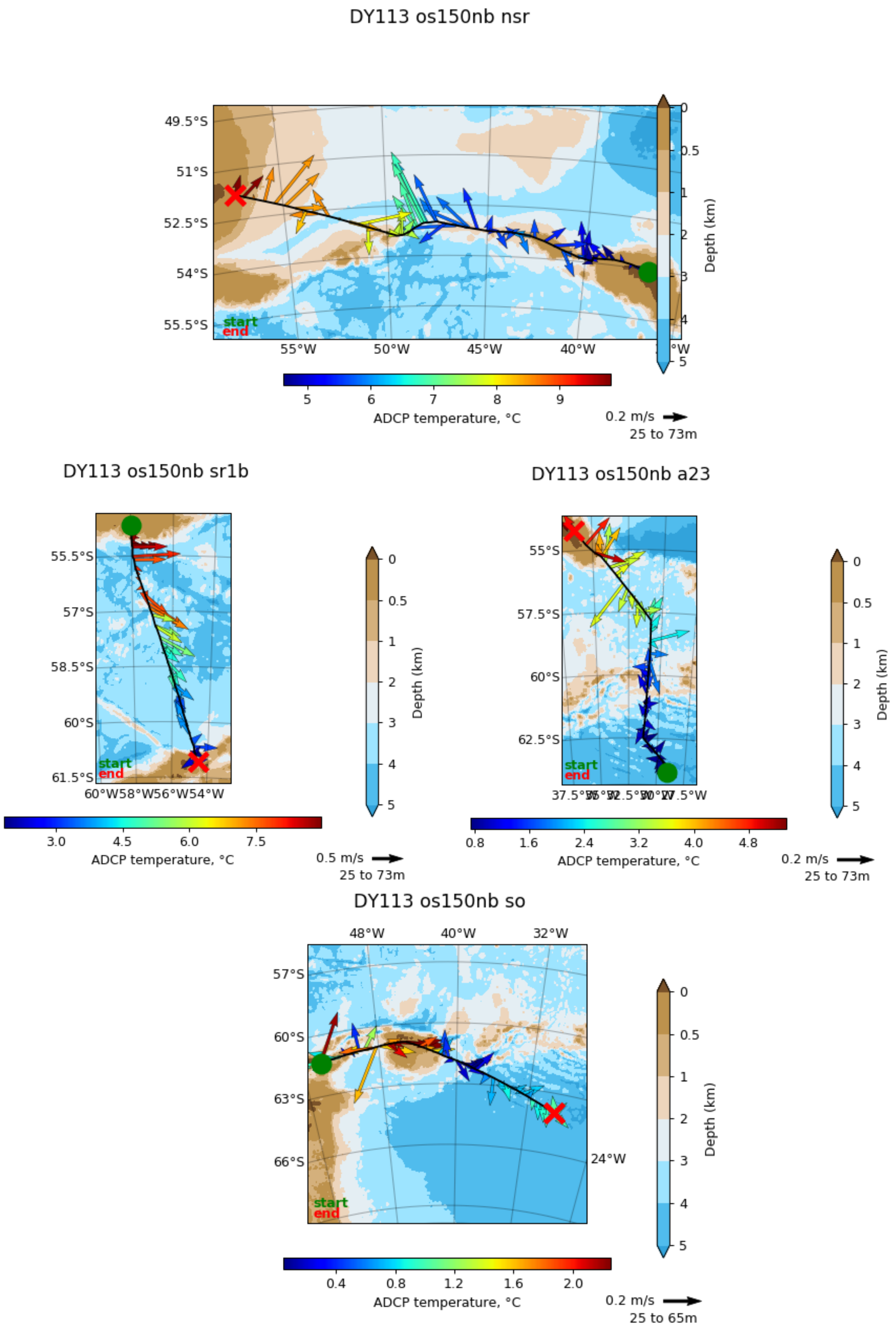


Figure 8.5: Velocity vectors averaged over the indicated depth range from NSR (top), SR1b (left), A23 (right), and transit between SR1b and A23 (bottom).

9. Underway data

Povl Abrahamsen (BAS, epab@bas.ac.uk)

9.1 Introduction

On RRS Discovery, underway data streams are logged using Ifremer's TechSAS software, version 5.11. On DY113 we loaded, processed, and averaged some of these streams using NOC's mstar routines, running on Linux workstation koaeula. This chapter describes the ships data streams and observed issues with the ship systems, our data processing on the cruise (including modifications to the mstar processing scripts made on this cruise), and our calibration of underway temperature/salinity measurements.

9.2 Instrumentation

TechSAS collects data from many different sources on board. These include:

- Attitude data from PosMV, Seapath (+ auxiliary Seapath), and Phins systems
- Depth data from EM120 centre beam and EA640 10 kHz transducer note: the EM710 and EA640 12 kHz depths are not logged!
- Position data from PosMV, Seapath, CNAV, and Fugro GPS
- Heading data from the ships gyroscope (and attitude sensors above)
- Log data from the Skipper log
- Meteorological sensors (air temperature, pressure, humidity, wind, TIR and PAR) through the SurfMet data collection system
- Flow rate, transmissometer and fluorometer from the clean seawater lab, also logged through SurfMet
- Seawater conductivity and temperature from the SBE-45 thermosalinograph and remote SBE-38 temperature sensor (near the inlet to the clean seawater supply)
- Winch data from CLAM
- Systems not in use on this cruise, including the magnetometer and wave radar

9.2.1 Observed issues with onboard instrumentation

Twice daily spikes in TSG temperature (spiking high) were observed, along with a near sinusoidal wiggle in computed salinity and a small spike in fluorescence. These were found to correspond to the times when the two pumps for the clean seawater system switch over (on average every 11 hours, 59 minutes, and 30.6 seconds; see example in Figure 9.1). TSG and other underway seawater measurements (except the remote temperature sensor, which is not affected) from the first minutes after these changeovers should be treated as suspect.

A large offset between CTD temperatures at 5.5 dbar and remote (SBE-38) temperature measurements was observed, of approximately 0.27C before our port call in Stanley and 0.39C after Stanley. We can only surmise that the change in offset may be caused by a change in temperature in the water tanks or other factors that we cannot easily correct for. For a lack of better options, we applied an offset of 0.266C before Stanley, and 0.387C afterwards. Ideally, a temperature sensor could be located closer to flush with the hull to minimise these differences. The sensor is about 75 cm from the tank top, as shown

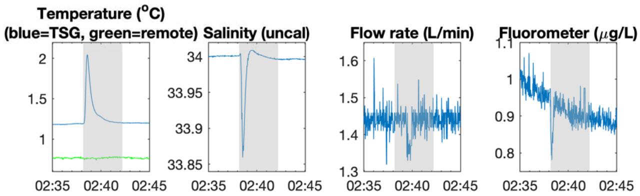


Figure 9.1: Pump switchover on the morning of 16 Feb 2020. The shaded grey area is the time cut from the processed data files.

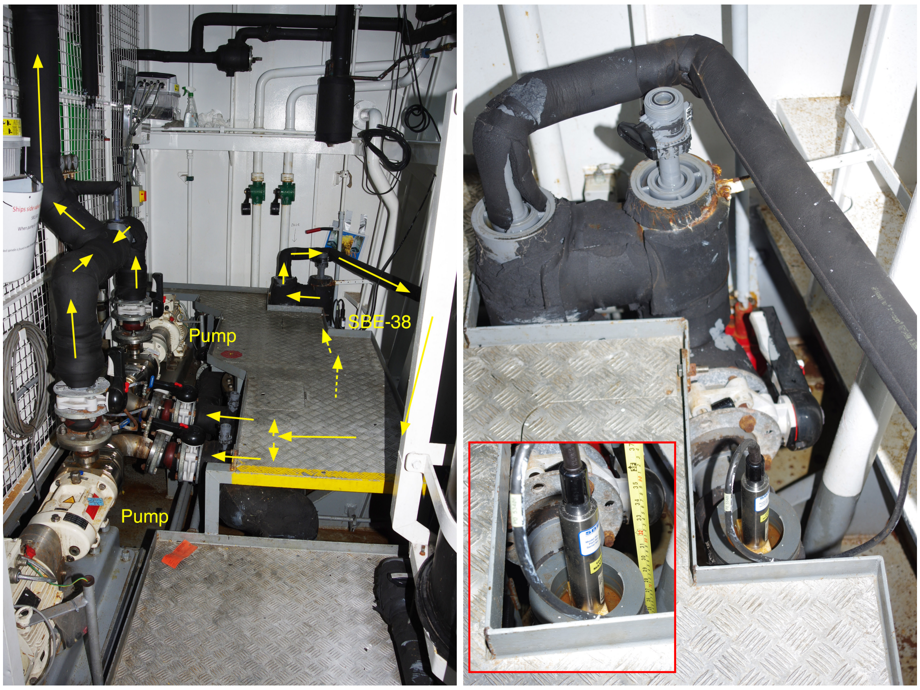


Figure 9.2: Pump room for clean seawater. Left shows the layout of the room with inlet + SBE-38 and pumps, right shows SBE-38 with inset showing the height of the instrument from the tank top (360 cm above hull baseline).

in Figure 9.2; assuming that the intake is at 5.5 m depth as specified, this gives a distance of 30 cm where the intake pipe protrudes from the hull, and approximately 230 cm where the pipe passes through the tank before entering the clean seawater pump room and an approximate path length of 335 cm (in a 114-mm diameter stainless steel pipe liner) from the intake to the SBE-38.

The Phins attitude system uses a different sign convention for pitch and heave than the PosMV and Seapath but the same sign for roll. It uses the (Applanix proprietary) PASHR NMEA message to output to TechSAS, and the Phins manual specifies that the convention for pitch and heave in this sentence is opposite to usual, but roll is the same. However, the sign of the roll in the output sentence is actually opposite, leading us to conclude that they accidentally have also reversed the sign of this field. So the data logged in TechSAS are incorrect, but we correct for this in our data processing (as described later in this chapter).

On 6 Feb 2020 at 13:45 the Nudam ADC unit for the four radiometers on the foremast was replaced, as the old one failed. While the output of the new ADC appears to be well calibrated and valid, many values are missing; the Surfmet system copies the previous value from all four sensors, resulting in apparent steps in the data. The underlying cause of the problem is not yet known. As part of our data processing, we have located any steps of more than two samples (seconds) length, where all four radiometers show the same value as in the previous time step, and replaced these duplicated data (except the first data point) with NaN. This code was added to opt_dy113.m, and will hopefully not be needed on future cruises.

Unlike on JCR and many other vessels, factory calibrations are not applied for the transmissometer, fluorometer, TIR, and PAR sensors. The fluorometer and transmissometer values are logged by TechSAS with unit volt, while TIR and PAR have been multiplied by 100 (from the original values in millivolts), resulting in a unit of $\times 10^{-5}$ volt. This corresponds roughly to the engineering value of radiation in W/m^2, and is displayed on the SSDS screens as nominal W/m^2. I would strongly recommend that the latest factory calibrations are applied to all sensors by default. Or, alternatively, that the radiometer values are logged in unit volt so that no misapprehension is made about conversion to engineering values. We have modified our workflow to include conversion of these fields in our processed data.

Currently the EM710 centre-beam depth and EA640 12-kHz depths are not logged. TechSAS does not document which frequency sonar is being used for EA640 depth. It might be useful to add the EM710 centre-beam to the list of TechSAS streams, and to log 10-KHz and 12-Khz depths separately, clearly differentiating between the two sources.

9.3 Data processing

The mstar processing scripts for underway data streams are held in the mexec_processing_scripts/uway subdirectory of the cruise data directory. The shell script techsas_linkscript must be run daily before loading data; it updates the local symbolic links in /local/users/pstar/mounts/techsas. Initial setup for the cruise is done by running m_setudir.m, which looks for data streams and creates an editable file m_udirs.m with a lookup table of streams (based on information in mtnames.m), with mstar and corresponding TechSAS stream names, and mstar directories to use. This file needs to be edited, or m_setudir.m rerun, if additional streams come online during the cruise (e.g. when EM120 and the TSG were switched on).

Daily processing takes place by running m_daily_proc.m, which in turn calls mday_01.m and mday_01_clean_av.m for each stream. These functions load the data from the TechSAS streams, and then apply preliminary processing and cleaning of data (checking against predefined ranges for each variable). This now includes applying factory calibrations to variables that are stored as raw voltages (described in more detail below), or other custom functions specified in the cruise option files get_cropt.m or opt_dy113.m. For this cruise, we have also multiplied the Phins roll by -1 to correct for the output bug described above. If this bug is not fixed by Ixsea or addressed in TechSAS, future cruises on the Discovery should do the same. Scripts msim_02.m and mem120_02.m are called by m_daily_proc.m to copy multibeam centre depths into single-beam bathymetry files and vice versa. On Discovery, the SBE-45 and SBE-38 data are written to stream tsg while other seawater instruments are written to met_tsg. We have now implemented a merging step, so that the tsg variables are merged into met_tsg for consistency with data from James Cook and JCR. Then mday_02.m appends each day of data to a single file for each stream.

The final steps, run once for each call of m_daily_proc even when multiple days are processed at once, are to run mbest_all.m, which averages the best navigation stream (in our case from PosMV) to 30 seconds, calculates speed, course, and distance run, merges in gyro headings, and does some fancy vector averaging of PosMV headings, which are also merged in. Then true wind is calculated from the anemometer and (bestnav) heading and speed by mtruew_01.m. And finally, the TSG data are averaged to one minute, salinity calibrations are applied, and temperature adjustments made by mtsg_medav_clean_cal.m.

9.4 TSG calibration

A total of 123 salinity samples were taken from the clean seawater supply and analysed in the salinometer (see Section 6.1). 119 of these were used to calibrate the TSG salinities; two were outliers, and two were taken during the pump changeovers when TSG values were unusable.

To determine the thermosalinograph (TSG) salinity calibration values, mtsg_01.m loads the salinity bottle files for the underway, which are plotted with mtsg_bottle_compare.m. The calibration values are entered into the tsgsal_apply_cal section of opt_dy113.m. In this case, we observed a slow linear drift in calibration at the start of the cruise, but with marked shifts on 20 Feb when the TSG was cleaned, and after leaving Stanley. We calculated linear regressions for the time before the first cleaning, between the cleaning and Stanley, and from leaving Stanley until the clean seawater supply was switched off, and have applied piecewise linear corrections (as a function of time) for the times before, between, and after these events. The offsets and calibration applied are shown in Figure 9.3.

The median offset between the TSG and bottle salinities before calibration was 0.006, with a standard deviation of 0.005. After calibration there was no mean or median offset, and a standard deviation of 0.002.

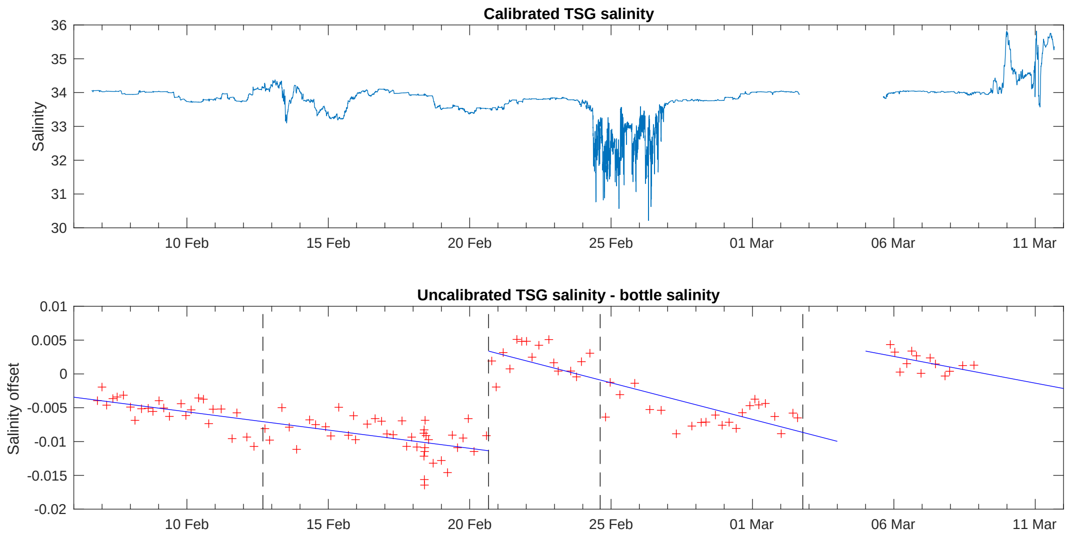


Figure 9.3: Calibrated salinity from the thermosalinograph (upper panel), with offsets between uncalibrated TSG and bottle salinities (lower panel, red crosses) and the piecewise linear offsets subtracted from raw TSG salinities (blue lines). Black dashed lines indicate when the underway sensors were cleaned; on 12 and 24 Feb only the fluorometer and transmissometer were cleaned.

In addition, we compared the remote temperature and (calibrated) salinity values against CTD casts at 5.5 dbar depth. These showed a good agreement for salinity, but an offset averaging 0.267C (with a standard deviation of 0.044C) for the stations before the port call in Stanley, and 0.3910.030C for the remaining stations. While ideally the remote temperature sensor would be repositioned to avoid such a large effect from the hull and water tanks, some more advanced correction to take into account the thermal mass of the ship and freshwater tanks (if their temperature is measured) might be possible. Initially we performed a linear regression as a function of log(8.5C temp_r), resulting in a median offset between CTD and TSG temperatures of -0.006C with a standard deviation of 0.033C. However, as the offset shifted after our port call, we simply applied constant offsets of the average temperatures above to the temperature sensor, resulting in a median offset between CTD and TSG of 0.009C (and 0 mean) with a standard deviation of 0.042C, for those data points where the standard deviation of 1-Hz CTD temperature within 1 dbar of 5.5 dbar pressure is less than 0.0025C.

The median offset between the calibrated TSG salinity measurements and CTD salinities is 0.003 with a standard deviation of 0.004 for those data points where the standard deviation of 1-Hz CTD salinity within 1 dbar of 5.5 dbar pressure is less than 0.001.

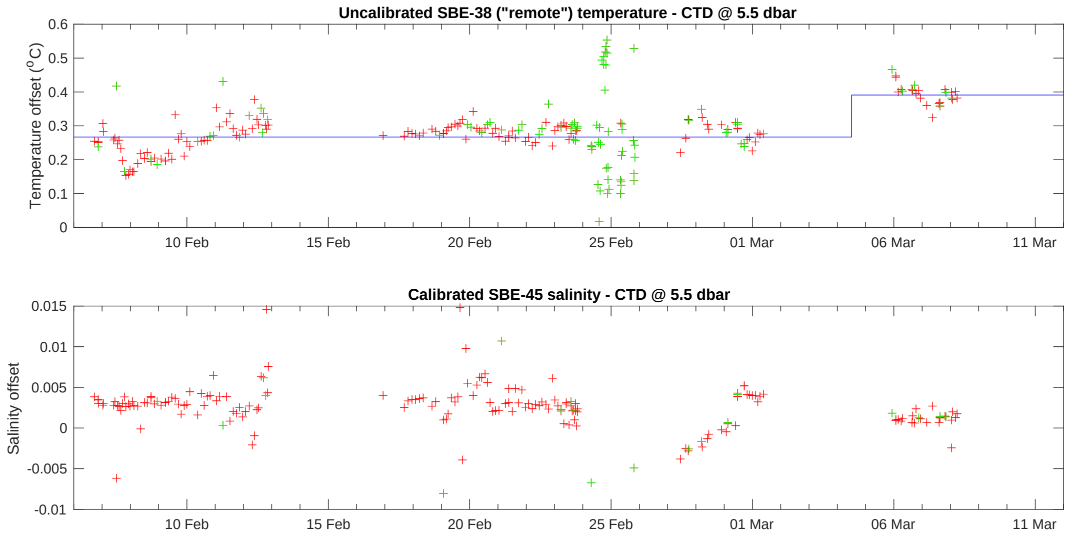


Figure 9.4: Upper panel shows offsets between the remote SBE-38 temperature sensor and CTD temperatures at 5.5 dbar; red points indicate that CTD temperature standard deviation within 1 dbar of 5.5 dbar is less than 0.0025°C. The blue line indicates the offset applied to the temperature sensor (by subtracting these offsets). Lower panel shows the difference between calibrated SBE-45 salinity (for offsets, see Figure 9.3) and CTD salinities at 5.5 dbar; red points indicate that the CTD salinity standard deviation within 1 dbar of 5.5 dbar is less than 0.001.

9.5 Output files

As I have previously struggled to make sense of the mstar output files, I am including a list of output files and variables that may be helpful to a reader unfamiliar with mstar. All of the output files are in NetCDF format; the time variable is called time and is in seconds since midnight UTC on 1 Jan 2020. The key output files and variables are:

- nav/posmvpos/bst_dy113_01.nc bestnav processed PosMV position, speed, and heading
  - lat, long: latitude and longitude (decimal degree)
  - smg: speed over ground (m/s)
  - cmg: course over ground (T)
  - distrun: distance run (km)
  - heading_av: heading (T)
- nav/cnav/cnav_dy113_01.nc CNAV GPS position, course, and speed
- nav/gps/gpsfugro_dy113_01.nc Fugro (bridge) GPS position, course, and speed
- nav/posmvpos/posmvpos_dy113_01.nc PosMV position, course, heading (but no speed!)
- nav/seapos/seapos_dy113_01.nc Seapath position, heading, course, and speed
- nav/posmvatt/attposmv_dy113_01.nc PosMV attitude (heading, pitch, roll)
- nav/seaatt/attsea_dy113_01.nc Seapath attitude
- nav/phinsatt/attphins_dy113_01.nc Phins attitude
- nav/gyros/gyro_s_dy113_01.nc ships (bridge) gyro heading
- nav/log/log_skip_dy113_01.nc Skipper (bridge) Doppler logs * 2 (port & stb)
- ocl/tsg/met_tsg_dy113_01.nc full-resolution, uncleaned, underway water measurements:
  - temp_r: remote SBE-38 temperature (C)
  - temp_h: temperature in SBE-45 thermosalinograph (C)
  - psal: practical salinity from SBE-45 thermosalinograph (psu)

    - flow1: flow rate through thermosalinograph (L/min)
    - fluo: Chl fluorescence (g/L)
    - trans: beam transmission (%)
- ocl/tsg/met_tsg_dy113_01_medav_clean.nc one-minute median, cleaned, underway water measurements (variables as above)
- ocl/tsg/met_tsg_dy113_01_medav_clean_cal.nc one-minute median, cleaned, underway water measurements with salinity calibration and temperature adjustment applied (variables as above plus the following):
    - psal_cal: calibrated practical salinity (psu)
    - temp_r_adj: adjusted SBE-38 temperature (C)
- met/surflight/surflight_dy113_01.nc radiometers (TIR and PAR in W/m2) and pressure
- met/surfmet/surfmet_dy113_01.nc air temperature, humidity, relative wind speed and direction
- met/surfmet/surfmet_dy113_true.nc true wind:
    - truwind_u: eastward component of true wind (m/s)
    - truwind_v: northward component of true wind (m/s)
    - truwind_spd: speed of true wind (m/s)
    - truwind_dir: true (measured CW from geographic north) direction that true wind is blowing toward (T)
- met/surfmet/surfmet_dy113_trueav.nc one-minute averaged true wind (variables as above)
- bathy/sim/sim_dy113_01.nc EA640 10-kHz depth
    - depth_uncor: uncorrected depth, using 1500 m/s speed of sound (m)
    - depth: depth corrected with Carter tables (m)
    - swath_depth: EM122 centre-beam depth, using EM122 speed of sound profile (m)
- bathy/em120/em120_dy113_01.nc EM122 centre-beam depth
    - swath_depth: EM122 centre-beam depth, using EM122 speed of sound profile (m)
    - depth: EA640 10-kHz depth, corrected with Carter tables (m)

9.6 Changes made to mstar processing scripts

m_daily_proc.m: the variable restart_uway_append is cleared after running m_daily_proc to prevent files to be inadvertently deleted the next time the script is run. On Discovery, data are merged from tsg (temperatures, and salinities) into met_tsg (fluorometer, transmissometer, flow rate). If a TSG file does not exist, blank variables are added to the file, so later appending works necessary if the TSG is switched off at the start of a cruise. When mtsg_medav_clean_cal is called and no TSG data exist, it now fails more gracefully.

m_setudir.m: added Phins to the list of attitude streams. Moved the ships log from ocl to nav.

mtnames.m: added Phins and updated TSG and Seapath names for Discovery

mday_01_clean_av.m: old code to correct positions in the cnav streams has been removed and placed into get_cropt.m. Instead, we now have a new section that looks into the cruise option files (get_cropt.m and opt_dy113.m) for calibration functions to apply. In the case of DY113, we have added factory calibrations for the radiometers (PAR and TIR), fluorometer, and transmissometer. In addition, the checks for the cnav bug have been moved into get_cropt.m; a bug resulting in the fix never being applied when either latitude or longitude is negative has also been squashed. Variable names for underway salinity are updated to psal for consistency with CTD and James Cook setup. Acceptable seawater temperature ranges for all channels updated from [0 50] to [-2 50] for polar conditions. Code for calculating underway salinity cleaned up slightly. Even if salinity already exists (calculated in the SBE-45), it is renamed and recalculated using the GSW toolbox. Renaming the variable ensures that we dont get two different salinity variables in the file.

mday_plots.m: names of streams and variables for Discovery have been updated. Plots are now exported as PDFs in directory [data_root]/plots/uway.

msim_02 and mem120_02: both of these scripts merge one depth source into another file, creating variables swath_depth or depth, respectively. If the opposite source file does not exist, they previously used mcalib to create a blank variable, resulting in overwriting an existing variable in the file. This bug has been fixed by changing to a call to mcalc, which creates a new variable in the file. Stream names have also been updated for Discovery.

mtsg_medav_clean_cal.m: added code to adjust the temperature; this is written to variable temp_r_adj similarly to the salinity calibration is applied to variable psal_cal. A new function tsgsal_apply_temp_cal.m has been created, corresponding to tsgal_apply_cal.m for salinity.

mtruew_01.m: updated the code to use the same variables as on James Cook. Previously the (hard-coded) variable numbers made the script swap wind speed and direction, resulting in wrong true wind being computed on Discovery!

9.7 PML CO_2 flux system

A system to measure air-sea fluxes of CO_2, sensible heat, and momentum was installed on the foredeck of RRS Discovery by Plymouth Marine Laboratory. The main points of contact at PML are Mingxi Yang (miya@pml.ac.uk), Tom Bell, and Tim Smyth. During DY113 the system was monitored as part of the routine science rounds, but data have not been checked or viewed. This chapter provides a quick overview of the instrumentation and data collection system, but further queries should be directed toward the investigators at PML.

9.7.1 Instrumentation

The main instrumentation for the flux system is mounted on the meteorological mast on the foredeck of Discovery. Two Gill sonic anemometers provide 3-dimensional wind and air temperature measurements. Two LPMS motion sensors provide acceleration and rotation. A Licor 7200 CO_2/H_2O instrument provides high-frequency measurements of CO_2 concentrations. The inlet for the Licor is directly forward of the starboard anemometer and LPMS; tubing brings the air down to the platform below, where the air is drawn past a 2-micron particle filter, through a Naflon dryer into the Licor sensor. The outlet air is recirculated through the outside of the dryer, and then goes into the mooring space, where an air pump is mounted in a plastic cool box, secured on top of the electrical circuit box at the base of the stairs. Because the air is passed through the dryer before sampling by the Licor, the H_2O concentrations are not valid.

A Campbell CR6 data logger is continuously logging the accelerometer, wind, temperature, and Licor data. As long as the Campbell Loggernet software is running, the computer connects hourly to the logger and downloads any data that haven't previously been downloaded. Simultaneously, data logging for the Licor takes place through TeraTerm, on a Fitlet mini PC running Windows 7. Every hour, on the hour, an instance of TeraTerm is opened that logs the data from COM33 into a file. After 3599 seconds, this process is terminated, and a new instance opens on the next hour. These data replicate those collected on the CR6, and are secondary source of information.

Data are saved to two external hard drives connected to the PC, and backed up to current_cruise/Third_Party/pml_co2-flux, where data from the CR6 and Licor are stored in two separate subdirectories. A hourly cron job summarises these data and sends an e-mail back to PML with information. The Transcend Elite software must be running to sync files from the D drive to the E drive. After rebooting, it is important to ensure that file sharing is enabled on the E drive, with share name DiscoData, as this will ensure that data are backed up onto the central file server.

Normally the PC can be accessed remotely via TeamViewer by PML. However, as the VSAT was not working during almost all of DY113, this was not possible during the cruise, except during the port call at FIPASS, when Mingxi Yang logged in and modified the CR6 data collection program.

9.7.2 Operation on DY113

At the start of the cruise, after leaving the Argentinean EEZ, the instrumentation and pump were switched on around 15:15 on 6 Feb. Since the CR6 had been logging data even when the computer was shut down at the end of DY112, there was a long backlog of data to download from the logger to the PC. Much of this data will presumably be unusable, as the pump for the Licor was switched off.

The system ran well for most of the cruise. A few hours of TeraTerm data are missing (e.g. hours starting 06:00 10 Feb, 23:00 16 Feb, 30:00 22 Feb, 16:00 25 Feb, 03:00 27 Feb, 05:00 and 11:00 1 Mar).

Since we observed that the PC did not restart TeraTerm twice on the morning of 1 Mar, we rebooted the PC at 11:55, and data collection started as usual at 12:00.

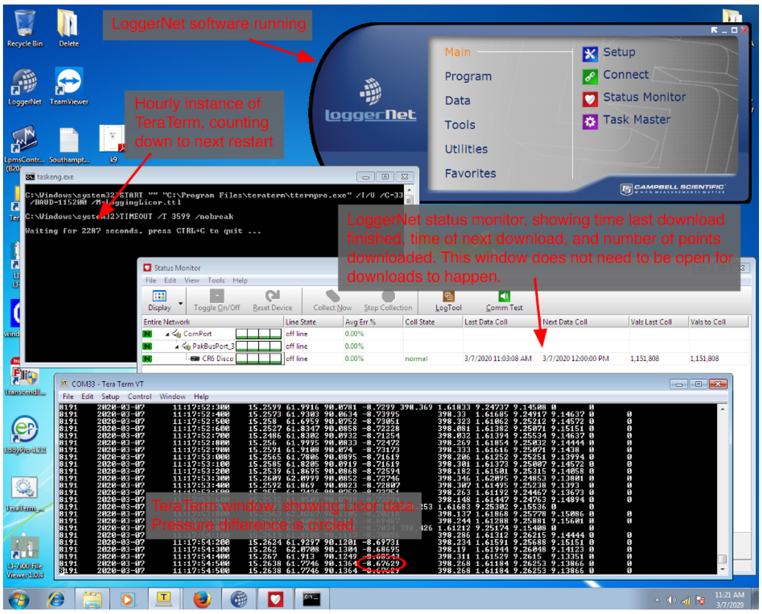


Figure 9.5: Annotated screenshot of Fitlet computer logging data from the CR6 and Licor instruments.

9.7.3 Filter change

The pressure difference on the Licor was generally around -9.0 kPa, which is described as normal in the documentation from PML. This dropped to -9.6 kPa from 29 Feb to 1 Mar, but then returned to -9.4 kPa on 2 Mar. Mingxi Yang requested that we change the filter in the Falklands, and this was done at 11:23 on 3 Mar. When the pump was switched back on, the pressure difference was -8.7 kPa.

9.8 Multibeam bathymetry

RRS Discovery is fitted with two Kongsberg multibeam systems, a deep-water EM112 12-kHz 1x1° system, and a medium-range EM710 70-100 kHz 2x2° system. Both systems were used on DY113, with

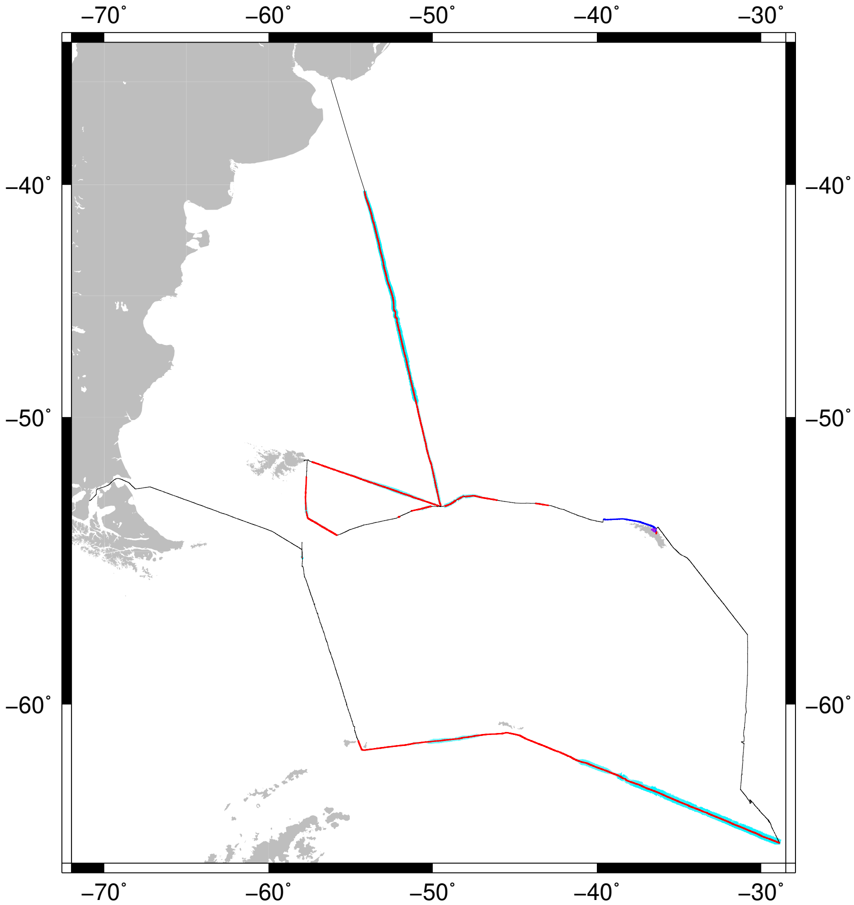


Figure 9.6: Figure 1. Overview of multibeam data collected on DY113. Red lines show times when EM122 was logging; blue lines show EM710 logging. EM122 was pinging, but not logging for much of the remaining ship track when outside EEZs.

the EM710 only used in shallow water in Cumberland bay and on the continental shelf north of South Georgia. Data collection for both instruments was performed using Kongsbergs SIS (Seafloor Information System) software, version 4.3.2. EM122 centre-beam depths were logged to TechSAS whenever the instrument was pinging; we did not log full swath data during the SR1b and A23 transects, or when following the JR299 track along North Scotia Ridge, as these have been covered before. However, data were logged during most of the remainder of the cruise, with raw data files and sound velocity profiles backed up to the ships network drive in the directories
current_cruise/Ship_Fitted_Scientific_Systems/Acoustics/[EM122 or EM710]/Raw. CTD casts were generally used for speed of sound profiles, with WOA13 used on the transit toward Montevideo. When possible, the power level of both systems was reduced, as long as data quality was still acceptable. Before starting the EM122 pinging, marine mammal observations were conducted from the bridge, with at least 20 minutes from the last cetacean observation before multibeam was started up, with a 15-minute power ramp applied. Changes in power and other events were logged on the NMF event logger; a summary of these events is in Tables 9.1 and 9.2 for EM122 and EM710, respectively.

Data quality generally appears good, but no detailed data processing or cleaning has been performed on board. While approaching the Falkland Islands, and during the passage from Stanley to station 93 (NSR_29), CTD 88 was still used as speed of sound profile. This resulted in slightly “frowny” data near the Falkland Islands, and a more appropriate profile (e.g. from WOA climatology) should be applied in post-processing.

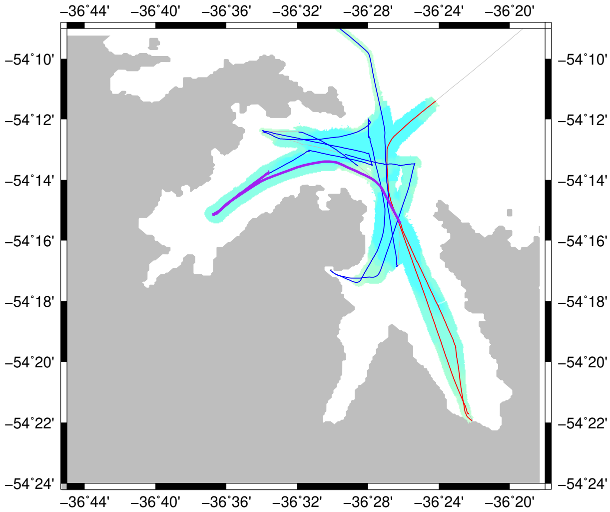


Figure 9.7: Multibeam data collected within Cumberland Bay. Red lines show times when EM122 was logging data; blue lines show EM710 logging. The thicker purple segment shows when both were logging.

9.8.1 Echosounder operations and MEMP

The DY113 environmental impact assessment, performed by Anna Bird (Durham University), suggested measures to reduce any impact of the use of bathymetric acoustics on marine mammals (the VMADCPs were not an issue because of their relatively high frequency/low power). These included observations for marine mammals before startup and after any gap of 10 minutes or longer in pinging, as well as soft starts as described above.

Before the first switch-on of the EM122, non-dedicated observations were made from the bridge; no marine mammals were observed (nor had they been for the previous day). On the first CTD cast the CTD altimeter and the single-beam echosounders were having trouble detecting the bottom, with interference from the EM122 visible on the 12-kHz channel of the EA640. To help with CTD near-bottom operations the EM122 pinging was turned off for 52 minutes near the bottom of cast 1, and for additional testing on 6-7 Feb. To reduce interference from the EM122, the ping rate was reduced to 20 or 30 s, and the EA640 set to a ping rate of minimum 1 s; the ping rate was increased in transit. To test whether the EM122 was interfering with the operation of the Benthos altimeter on the CTD, the EM122 was also stopped near the bottom at stations 50, 51, and 53, but here we stopped pinging only for short intervals on the bottom approach, sending several pings to restart the clock when necessary. We concluded that the EM122 does not interfere with operation of the altimeters, but that the Benthos altimeters generally performed poorly on the cruise, with very limited range.

On reaching Cumberland Bay, we first turned on the EM710, then when both data sources appeared to agree, turned off the EM122 for the rest of the time in shallow water. The EM710 is lower power and gives better results in shallow depths.

The EM122 was turned off when we reached 200 m depth on the way into the Falkland Islands, and turned on upon leaving after an hour of dedicated marine mammal observations from the bridge by a student volunteer who happened to be trained as an MMO.

A list of marine mammal sightings kept by the bridge, based on non-systematic, non-dedicated observations during part of the cruise is in Figure 9.8. The EM122 was pinging during this entire stretch.

Table 9.1: Summary of EM122 multibeam data and speed of sound profiles used. All times UTC.

Date	Time	Lines	event	SVP	CTD
6/2	16:52	1	EM122 switched on, logging	from WOA13	1
	17:25	2	Stop logging		
	17:30		Stop pinging (interfering with 12-kHz EA640)		
	18:22		Start pinging		
6/2	22:25	n/a	Stop pinging (interfering with 12-kHz EA640)		
	23:35		Start pinging		
7/2	08:35	n/a	Stop pinging (interfering with 12-kHz EA640)		
	09:51		Start pinging		
9/2	13:57	n/a	SVP change	DY113 CTD 14	
9/2	17:59	n/a	SVP change	DY113 CTD 15	
10/2	18:57	n/a	SVP change	DY113 CTD 19	
11/2	18:32	n/a	SVP change	DY113 CTD 23	
12/2	15:24	n/a	SVP change	DY113 CTD 28	
12/2	21:47	3	Start logging		31
14/2	16:02		SVP change	JR17003 CTD 6	
16/2	19:08	188	Stop logging		32
17/2	01:29	n/a	SVP change	DY113 CTD 32	
19/2	01:52	n/a	SVP change	DY113 CTD 37	
20/2	15:42	n/a	SVP change	DY113 CTD 42	
21/2	12:53	n/a	Tx power change to -20 dB		
21/2	13:14	n/a	Stop pinging, to investigate effect on altimeter		50
	13:23		Start pinging		
21/2	15:41	n/a	Tx power change to -10 dB		
	15:50		SVP change	DY113 CTD 50	
21/2	18:35	n/a	Stop pinging		51
	18:44		Start pinging		
	18:45		Stop pinging		
	18:54		Start pinging		
22/2	06:02	n/a	Stop pinging		53
	06:09		Start pinging		
	06:10		Stop pinging		
	06:15		Start pinging		
	06:17		Stop pinging		
	06:20		Start pinging		
22/2	20:39	n/a	SVP change	DY113 CTD 55	
23/2	15:29	n/a	SVP change	DY113 CTD 59	
23/2	18:16	n/a	Tx power change to -20 dB		
23/2	21:03	n/a	SVP change	DY113 CTD 62	
24/2	08:37	189	Start logging (approaching Cumberland Bay)		
	10:52	193	Stop logging		64
24/2	11:57	194	Start logging		64
	12:40	195	Stop logging		65
24/2	13:13	196	Start logging		65
	13:45	197	Stop logging		66
24/2	14:18	198	Start logging		66
	14:40	198	Stop logging		67
24/2	15:24	199	Start logging		67
	15:53	199	Stop logging		68

Date	Time	Lines	event	SVP	CTD
24/2	16:25	200	Start logging		68
	17:30	202	Stop logging		69
24/2	18:09	203	Start logging		69
	18:39	203	Stop logging		70
24/2	19:14	204	Start logging		70
	19:34	204	Stop logging		71
24/2	20:01	205	Start logging		71
	20:02	205	Stop logging and pinging (using EM710 instead)		
27/2	07:15	n/a	Start pinging, -20 dB power		
	13:23	n/a	Tx power change to maximum		
27/2	15:57	n/a	SVP change	DY113 CTD 81	
27/2	16:45	n/a	Tx power change to -10 dB		
28/2	05:00	n/a	Ping interval increased to 30 s		
28/2	06:08	206	Start logging; ping interval to 5 s		after 83
	09:31	212	Stop logging; ping interval to 30 s		84
29/2	03:57	213	Start logging		after 86
	09:32	224	Stop logging		87
29/2	11:40	225	Start logging		87
	14:08	229	Stop logging		88
29/2	17:07	230	Start logging		88
	17:35		SVP change	DY113 CTD 88	
	20:13	236	Stop logging		89
29/2	22:55	237	Start logging		after 89
	23:45	240	Stop logging		90
1/3	02:31	241	Start logging		90
	05:15	246	Stop logging		91
1/3	09:58	247	Start logging		92
2/3	17:33		Tx power change to -20 dB		
	17:38		Ping interval set to calculated + 5 s		
	18:25	311	Stop logging and pinging; 200 m depth		
5/3	16:48		Start pinging; -20 dB power		
	16:50	312	Start logging		
	21:33	321	Stop logging		93
5/3	22:41	322	Start logging		93
	22:47	322	Stop logging for SVP change		
	22:48		SVP change	DY113 CTD 93	
	22:48	323	Start logging		
	23:38		Ping interval set to calculated + 10 s		
	23:40		Tx power change to -10 dB		
6/3	01:34	328	Stop logging		94
6/3	04:18	329	Start logging		94
	05:57	332	Stop logging		95
6/3	07:34	333	Start logging		95
	15:03	347	Stop logging		96
6/3	19:11	n/a	SVP change	DY113 CTD 97	
7/3	15:50	348	Start logging		
	16:14	348	Stop logging		
7/3	20:20	349	Start logging		102
8/3	00:43	357	Stop logging		103

Date	Time	Lines	event	SVP	CTD
8/3	06:01	358	Start logging		104
9/3	01:59		Tx power change to maximum		
	10:22		SVP change[1]	WOA13 49.28°S 51.07°W	
	20:08	434	Stop logging for SVP change		
	20:08		SVP change	WOA13 47.79°S 51.58°W	
	20:12	435	Start logging		
10/3	13:00	468	Stop logging for SVP change		
	13:00		SVP change	WOA13 45.14°S 52.42°W	
	13:01	469	Start logging		
	23:19	489	Stop logging for SVP change		
	23:19		SVP change	WOA13 43.41°S 53.05°W	
	23:19	490	Start logging		
11/3	10:26	512	Stop logging for SVP change		
	10:26		SVP change	WOA13 41.83°S 53.57°W	
	10:27	513	Start logging		
11/3	23:30	539	Stop logging and pinging; EM122 off		

Table 9.2: Summary of EM710 multibeam data and speed of sound profiles used. All times UTC.

Date	Time	Lines	event	SVP	CTD
24/2	16:00		EM710 switched on, full power	DY113 CTD 62	68
24/2	16:25	0	Start logging		68
	17:30	2	Stop logging		69
24/2	18:09	3	Start logging		69
	18:39	3	Stop logging		70
24/2	19:14	4	Start logging		70
	19:34	4	Stop logging		71
24/2	20:01	5	Start logging		71
	20:28	6	Stop logging		72
24/2	20:57	7	Start logging		72
	21:21	7	Stop logging		73
24/2	21:40	8	Start logging		73
	21:55	8	Stop logging		74
24/2	22:23	9	Start logging		74
	23:10	9	Stop logging (stopped for the night)		Jason Hrb.
25/2	07:22	10	Start logging		Jason Hrb.
	07:49	10	Stop logging		75
25/2	08:15	11	Start logging		75
	08:28	11	Stop logging		76
25/2	08:57	12	Start logging		76
	09:07	12	Stop logging		77
25/2	09:41	13	Start logging		77
	10:31		Tx power change to -10 dB		
	10:45	15	Stop logging		K. E. Cove
25/2	17:45	16	Start logging		K. E. Cove
	18:38	17	Stop logging		78
25/2	19:25	18	Start logging		78
	20:07	19	Stop logging		79

[1] abs. coefficient file did not update correctly, because ASVP file name contained dots!

Date	Time	Lines	event SVP	CTD
25/2	20:13	20	Start logging	79
	21:13	21	Stop logging (stopped for the night)	Jason Hrb.
26/2	09:59	22	Start logging	Jason Hrb.
	11:27	23	EM710 frozen; no data in line 24	
26/2	12:54	25	EM710 restarted, logging	
	13:00		Tx power change to maximum	
	13:18	25	Stop logging; on DP waiting on weather	
26/2	15:15	26	Start logging; leaving Cumberland Bay	
27/2	07:07	57	Stop logging and pinging	
27/2	07:10	n/a	Start pinging	
	07:17		Stop pinging; EM710 off	

Sheet: 1

Marine Mammal Sightings

DY113

DATE	TIME GMT	LAT	LONG	BLOW / BODY	TYPE	NUMBER	REMARKS
11 Feb	1940	59°59'4 S	055°15'1 W	BODY	WHALE (FIN)	3	70% SURE OF SPECIES
12-Feb	0815	60°45'1 S	054°45'8 W	BLOW	WHALE	1	RIGHT UNDER BOW <50m OFF.
12-Feb	2150	61°05'2 S	054°32'4 W	BODY	FUR SEAL	2	100%
12-FEB	1930	61°12.1 S	054°26.3 W	BLOW	WHALE	1	
12-FEB	1930	61°12.1 S	054°26.3 W	BODY	FUR SEAL	3	<50m
12-FEB	2010	61°16.5 S	054 23.3 W	BLOW	WHALE	2	
13-Feb	0846	61°10'0 S	051°09'1 W	BLOW	WHALE	1	
13-Feb	1025	61°08'2 S	050°37'5 W	BODY	FIN WHALE	1	
13-Feb	1053	61°07'7 S	050°28'6 W	BODY	FUR SEAL	2	<50m
13-Feb	1055	61°07'6 S	050°28'0 W	BLOW	WHALE	1	
13-Feb	1110	61°07.5'S	050°23.0'W	BLOW	WHALE	1	
13-Feb	1150	61°07.01'S	050°09.01'W	Blow	WHALE	2	
13-FEB	1205	61°06.63 S	050°03.51 W	BLOW / BODY	WHALE	1	100m to port
13-FEB	1250	61°05.56'S	049°34.97'W	Body	WHALE	2	
13-Feb	1323	61°04 00	049 13.5 W	Blow	whales	3	
13 FEB 20	1308	61°03.6'S	049°03.8'W	Blow & BODY	WHALE	1	~150m TO PORT
"	1840	61°01.7'S	048°28.2'W	BLOW	WHALE	1 OR 2	
13 FEB	2000	60°58.02'S	047°38.9W	BLOW	WHALE	1	
13 FEB	2100	60°36.69 S	047°24.7 W	BLOW/BODY	WHALE	6 (ish)	MAYBE MORE. 100m.
14	0824	60°52'5 S	045°45'6 W	BLOW/BODY	WHALE (FIN)	3	1000m STBD
14 Feb	0840	60°52'1 S	045°41'5 W	BLOW	WHALE	8	3000m PORT BOW
14 Feb	0847	60°51'9 S	045°39'4 W	BLOW	WHALE	6	2000m STBD BOW
14 Feb	0849	60°51'8 S	045°38'6 W	BODY	FIN/MINKE	4	~~3000~~ 300m PORT SIDE
14 Feb	0905	60°51'3 S	045°33'0 W	BLOW	WHALES	3	2000m PORT BOW
14 Feb	0931	60°51'5 S	045°23'9 W	BODY	FIN WHALE	1	100m AHEAD 70% SURE
14 Feb	0939	60°51'7 S	045°21'0 W	BLOW & BODY	WHALES	10+	2000m STBD BOW
14 Feb	0933	60°52'3 S	045°16'2 W	BODY & BLOW	WHALES	6	200m AHEAD
"	"	"	"	"	"	4	100m STBD SIDE
14 Feb	0958	60°52'5 S	045°14'2 W	BODY	FUR SEAL	2	50m STBD SIDE
14 Feb	1011	60°52'9 S	045°09'5 W	BLOW	WHALES	20-25	1000m STBD BOW
14 Feb	1032	60°53'7 S	045°02'2 W	BLOW/BODY	WHALES	12	500m PORT SIDE
14 Feb	1043	60°54'1 S	044°58'0 W	BODY	FIN WHALES	6	200m PORT BOW
14 Feb	1051	60°54'5 S	044°55'3 W	BLOW	WHALES	10	1500m PORT BOW.
14 Feb	1108	60°55.1'S	044°49.2'W	Body & Blow	WHALES	5	
14 Feb	1220	61°00.53 S	044°26.87 W	Blow	WHALES	2	
14 FEB	1450	61°11.02 S	043°32.18 W	BLOW/BODY	WHALE	1	<50m
14 Feb	1726	61 19.9 S	042 46.4 W	Blow	whale	1	30m port Side.
14 Feb 20	1900	61°25.9'S	042°13.5 W	BODY	WHALE	1	~30m STBD SIDE
14 Feb	1903	61°25'9 S	042°13'4 W	BODY	HUMPBACK	1	~~70m port~~
15 Feb	0630	61 38 7.2 S	39° 21	Body / Blow		1	70m port
15 FEB	1355	62°15.9'S	38°02.69 W	Body/Blow	WHALES	4	
15 Feb	1618	62°23.0 S	37°19.3 W	Body / Blow	whales	6	

Figure 9.8: Record of marine mammal sightings kept by the bridge for the first part of DY113.

10. Argo float deployments

Povl Abrahamsen (BAS, epab@bas.ac.uk)

Four Teledyne Webb Research Apex profiling floats were deployed during DY113 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 Argos satellite before diving to 1000 dbar. The cycle is repeated every 10 days.

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 1.

The floats data are not yet publicly available, but will soon be freely available through ftp://usgodae.org/pub/outgoing/argo/dac/bodc/[WMO no.]/, with their status and last profile also viewable on https://www.ukargo.net/floats/current_status/.

Serial no.	WMO no.	Deployment time (UTC)	Latitude	Longitude	Station	Cast
8574	3901553	2020/02/09 11:50	56° 47.07’ S	57° 13.74’ W	SR1b_13	14
8472	3901554	2020/02/11 04:03	59° 00.00’ S	55° 51.46’ W	SR1b_20	21
8474	3901556	2020/02/16 22:50	63° 57.92’ S	28° 52.64’ W	A23_24	24
8473	3901555	2020/02/19 08:42	61° 33.05’ S	31° 06.28’ W	A23_31	39

Table 10.1: Argo floats deployed on DY113.

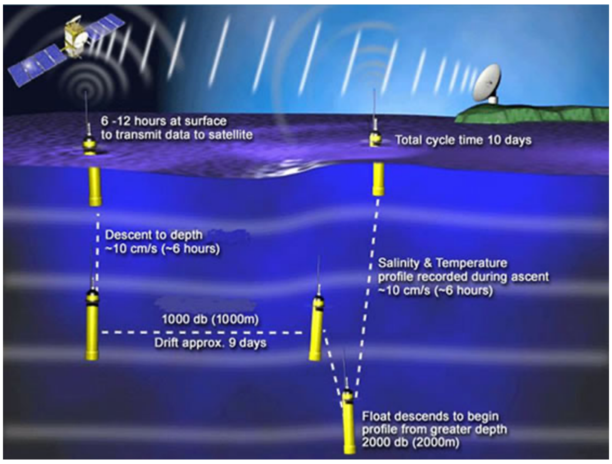
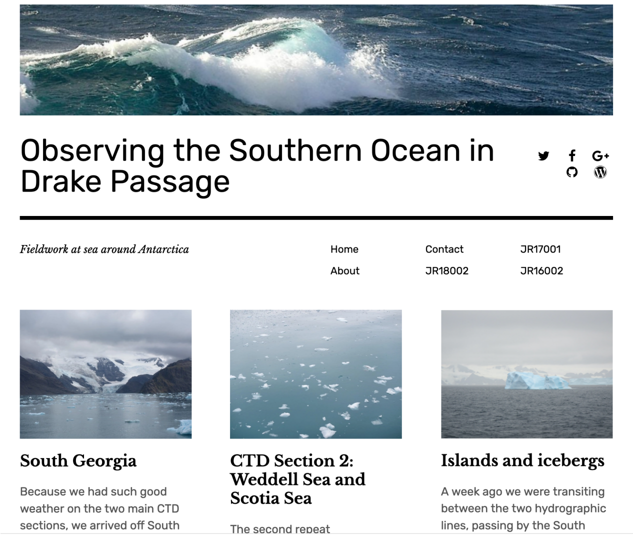


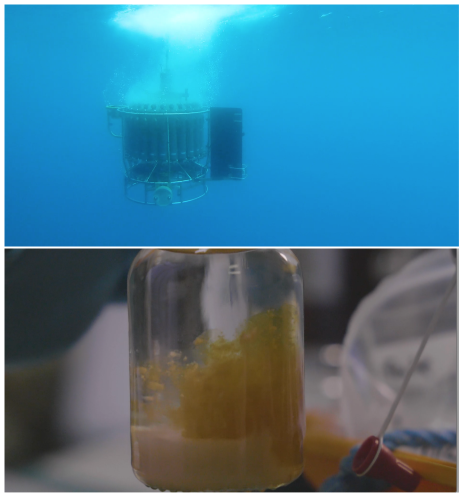
Figure 10.1: Measurement/dive cycle for Argo floats. Credit: UK Argo, https://www.ukargo.net

11. Outreach

Yvonne Firing (NOC, yvonne.firing@noc.ac.uk)

Despite the limited connectivity, during the cruise updates were posted to drakepassageblog.wordpress.com by email (with editing by Alice Marzocchi at NOC) and promoted on twitter by friends of the blog.





From the DY113 outreach video, credit: David Menzel.

During the cruise David Menzel also made an 8-minute video about the work we do on these cruises and why, targeted at students who are interested in science. A draft of the video was screened at the end of the cruise and it will be available on project websites drakepassageblog.wordpress.com, projects.noc.ac.uk/drake-passage, and orchestra.ac.uk.

12. National Oceanography Centre NMF Sensors and Moorings CTD, LADCP, Salinometry & Millipore Cruise Report DY113

Dougal Mountifield & Mark Maltby
3 February - 13 March 2020

12.1 CTD Transect Summary

104 CTD casts were undertaken with an NMF 24-way Stainless Steel CTD frame with 24 off 10l OTE water samplers. All instrument serial numbers were checked and all channels of the 9plus underwater unit checked prior to completing the Sensor Information Sheets for DY113. Dual SBE 43 dissolved oxygen sensors were used. The temperature, conductivity and dissolved oxygen sensors mounted to the vane were connected to the secondary channel. A pair of TRDI Workhorse 300kHz LADCPs were mounted on the CTD frame in down-looking master, up-looking slave configuration powered by an NMF LADCP battery pack with an aluminium housing.

CTD001 was a test cast undertaken in 3760m of water for verification of system functionality at depth. The LADCP star cable failed 36 minutes after deployment of the CTD during this test cast with the CTD at approximately 1750m on the downcast. The cable developed a short circuit between the power lines. Both instruments stopped recording at 17:57 UTC and the fuse in the LADCP battery pack blew. The star cable was replaced with a spare and the fuse was replaced in the battery pack. No further issues were encountered with the LADCP sub-system.

30 stations were occupied on the SR1b transect across Drake Passage from Burdwood Bank to Elephant Island. The second transect saw 31 stations being occupied on the A23 line from 64 S in the Weddell Sea through the Scotia Sea to South Georgia. The third transect saw 17 stations being occupied in Cumberland Bay, South Georgia. Finally, 25 stations were occupied on the fourth transect along the North Scotia Ridge (NSR) from South Georgia back to Burdwood Bank. The NSR transect was completed in two parts with after breaking off the line at NSR_16 (CTD092) for a 2.5 day port-call in Port Stanley, Falkland Islands. There was a four day break in CTD work before the remaining part of the NSR line was occupied in reverse order commencing with NSR_29. Five stations were turned on the NSR transect to ensure the completion of the line (NSR_06, 9, 11, 18 and 21). The 25th station on the NSR line was a re-occupation of NSR_16 that was previously occupied by CTD092.

The ODIM winch system Active Heave Compensation (AHC) system was functionally tested with a clump weight in 1400m of water at NSR_05 after CTD084 had been completed. Subsequently AHC was used on all casts apart from CTD087. AHC was used on 19 CTD casts in total. CTD088 (NSR_12) included an inter-comparison between AHC off for 3 minutes and AHC on for 3 minutes at each of 5 stops, with 2 of the stops on the downcast. CTD100 (NSR_22) included an inter-comparison between AHC off and AHC on whilst hauling and veering. AHC was disabled on the downcast until 500m when it was enabled. AHC was disabled from the bottom until 500m on the up-cast when it was enabled.

The deepest cast was CTD034 on A23 line which descended to 4862m. The shallowest cast was CTD064 at 76m in Cumberland Bay. A total of 233 km of downcast water profiles were obtained, therefore approx. 466km of wire was worked with the CTD package during the cruise.

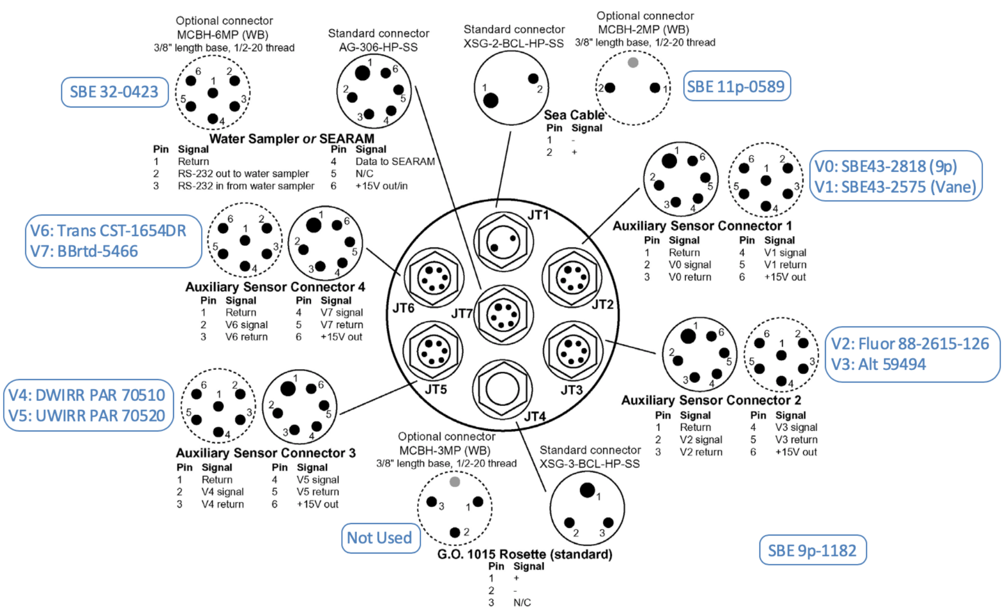
12.2 Stainless Steel CTD Configuration

12.2.1 Instrument Package

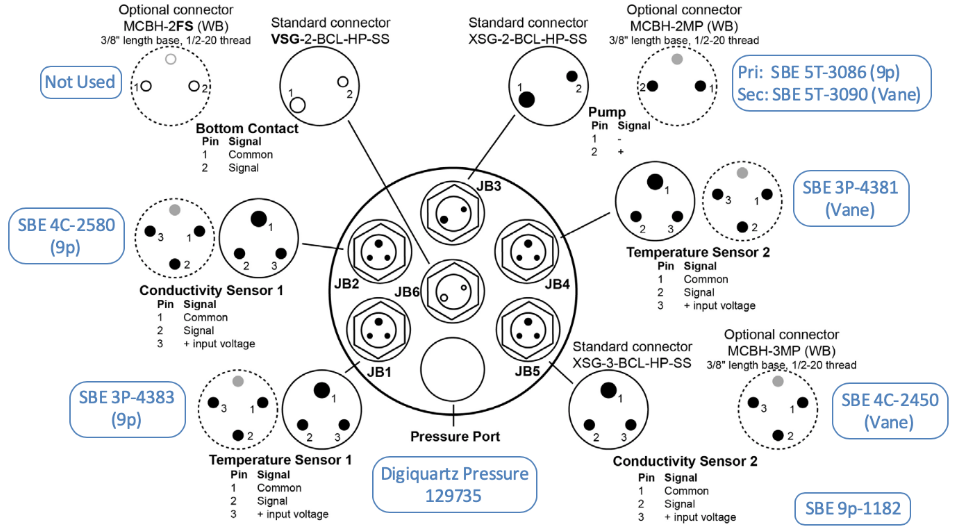
The following sensors were installed on the CTD frame:

CTD Underwater Unit	Seabird SBE 9plus	09p-1182
Primary Temperature Sensor	Seabird SBE 3P	3p-4383
Primary Conductivity Sensor	Seabird SBE 4C	4c-2580
Pressure sensor	Paroscientific Digiquartz	129735
Secondary Temperature Sensor	Seabird SBE 3P	3p-4381
Secondary Conductivity Sensor	Seabird SBE 4C	4c-2450
Primary Pump	Seabird SBE 5T	05-3086
Secondary Pump	Seabird SBE 5T	05-3090
Primary Dissolved Oxygen Sensor	Seabird SBE 43	43-2818
Secondary Dissolved Oxygen Sensor	Seabird SBE 43	43-2575
Altimeter	Teledyne Benthos PSA-916T	59494
Back Scattering Sensor	WETLabs BBrtd	5466
Transmissometer	WET Labs C-Star	1654DR
Fluorimeter	CTG Aquatracka MKIII	88-2615-126
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	23444
Up-looking Slave LADCP	TRDI Workhorse 300kHz	12369

12.2.1.1 SBE 9plus CTD Top End Cap Configuration



12.2.1.2 SBE 9plus CTD Bottom End Cap Configuration



12.2.2 Seasave Configuration & Instrument Calibrations

The Seasave Instrument Configuration file used for all casts was DY113_1182_SS.xmlcon

Date: 02/03/2020

Instrument configuration file:
C:\Users\sandm\Documents\Cruises\DY113\Data\Seasave Setup Files\DY113_1182_SS.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 : 03P-4383
Calibrated on : 11 July 2018
G : 4.39862417e-003
H : 6.55304958e-004
I : 2.41428164e-005
J : 1.98844984e-006

F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-2580
Calibrated on : 11 July 2018
G : -1.04804926e+001
H : 1.54201240e+000
I : -2.36431999e-004
J : 1.01511916e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 129735
Calibrated on : 3 November 2017
C1 : -6.064446e+004
C2 : 6.966022e-002
C3 : 1.971200e-002
D1 : 2.882500e-002
D2 : 0.000000e+000
T1 : 3.029594e+001
T2 : -6.713680e-005
T3 : 4.165390e-006
T4 : 0.000000e+000
T5 : 0.000000e+000
Slope : 0.99982000
Offset : -1.48930
AD590M : 1.279180e-002
AD590B : -8.821250e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-4381
Calibrated on : 25 July 2018
G : 4.42359439e-003
H : 6.44950441e-004
I : 2.26922968e-005
J : 1.98186505e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-2450
Calibrated on : 14 June 2018
G : -1.04375764e+001
H : 1.66338115e+000
I : -1.95407131e-003
J : 2.78452913e-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 : 43-2818
Calibrated on : 24 August 2017
Equation : Sea-Bird
Soc : 4.65400e-001
Offset : -4.98300e-001
A : -4.41050e-003
B : 2.34710e-004
C : -3.56300e-006
E : 3.60000e-002
Tau20 : 1.38000e+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 : 43-2575
Calibrated on : 27 July 2019
Equation : Sea-Bird
Soc : 4.42900e-001
Offset : -4.68700e-001
A : -5.40510e-003
B : 2.38200e-004
C : -3.26400e-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

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

Serial number : 88-2615-126
Calibrated on : 16 August 2018
VB : 0.593340
V1 : 2.105980
Vacetone : 0.756140
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

9) A/D voltage 3, Altimeter

Serial number : 59494
Calibrated on : 25 March 2013
Scale factor : 15.000
Offset : 0.000

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

Serial number : 70510
Calibrated on : 27 June 2019
M : 1.00000000
B : 0.00000000
Calibration constant : 20325200000.00000000
Conversion units : μ*mol 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 June 2019
M : 1.00000000
B : 0.00000000
Calibration constant : 19920300000.00000000
Conversion units : μ*mol photons/m*^{2}*/sec*
Multiplier : 1.00000000
Offset : -0.05148773

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

Serial number : CST-1654DR
Calibrated on : 7 April 2017
M : 21.2419
B : -0.1487

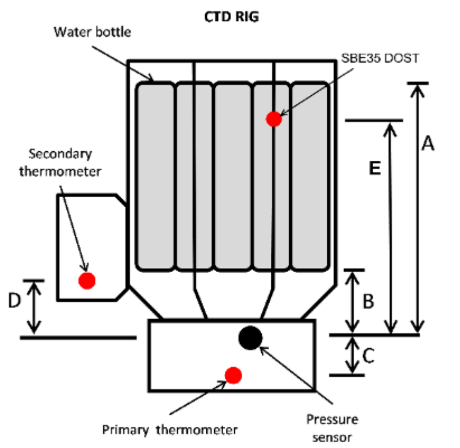
Path length : 0.250

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

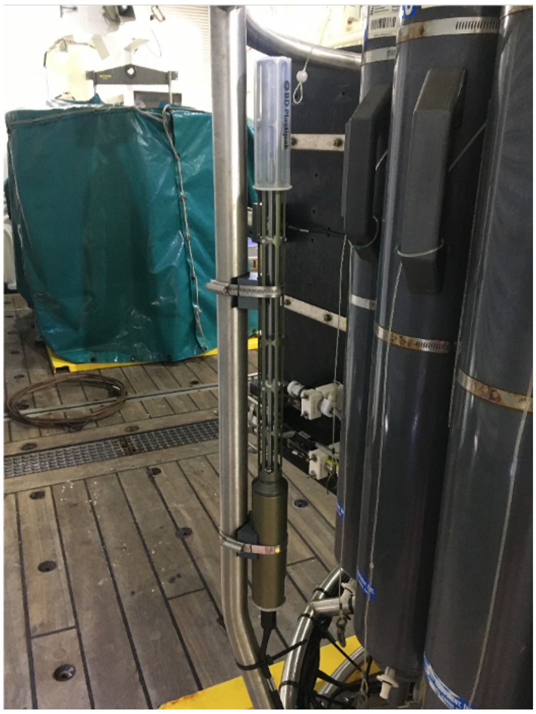
Serial number : BBRTD-5466
Calibrated on : 4 February 2019
ScaleFactor : 0.003307
Dark output : 0.051000

Scan length : 41

12.2.3 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 (Primary T mounted on 9p)
D	0.085 (Secondary T mounted on Vane)
E	1.025 (SBE35 DOST probe sheath tip)

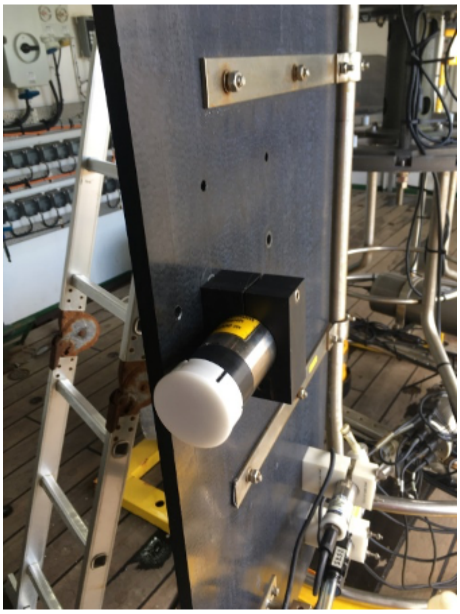


Seabird SBE 35 DOST Mounting Location Overview

12.3 CTD Operations

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

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. 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**.



WETLabs BBrtd Backscatter Sensor Mounting Location

During DY111, the down-looking TRDI Workhorse LADCP had been installed in a location offset from centre to allow the fitment of a user-supplied UVP optical instrument. For DY113 the down-looking LADCP was relocated to the centre of the CTD frame to reduce the risk of the instrument being damaged by contact with the inboard CTD bed-frame claw.

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.

The CTD was operated out of the Water Sampling Annex at the forward end of the hangar using the overhead hoist to move the package between the annex and the working deck. It was deployed on the 11.43mm conducting CTD wire (CTD1 storage drum) using the starboard P-Frame.

The NMF MDS EM swivel was used for all casts. The CTD wire with swivel attached was frequently insulation tested after disconnecting the sea-cable extension from the bottom of the swivel. The CTD wire with swivel in-line maintained an insulation resistance of $> 999\text{M}\Omega$ at 250V throughout the cruise.

To provide shelter to the science party whilst sampling, the CTD was moved to the water-sampling annex using the overhead hoist after recovery to deck. This incurs a small time overhead for each deployment, but allows the vessel to move off station more promptly. For the sheltered casts in Cumberland Bay, South Georgia where sampling time was short and a quick turnaround was required, the CTD was landed on deck for sampling prior to prompt redeployment.

When moving the CTD frame between the working deck and the water-sampling annex, the CTD termination and sea-cable tail was left connected to the top of the EM swivel, pulling down sufficient slack wire after landing the CTD package on deck. The sea-cable extension cable was disconnected from the bottom of the swivel and dummied off. A **split section of reinforced hose was fitted under the lifting bale** to protect against the sharp edge of the bale plate. A **single 2m 3t SWL continuous sling** was then rigged as a **basket lift either side of the swivel**. Care was taken to ensure that the sea-cable pigtail was not crushed and that the sling did not foul the EM swivel underwater connectors or the load-pin R-clips. The swivel was observed to swivel under load upon deployment and recovery throughout the cruise. No noticeable torque was observed building up in the CTD wire.

A normal range of 10m for the CTD package from sea-bed was used when the maximum wire-out call was issued. During stations with steep bottom topography where altimeter range was reduced, the time spent finding the bottom was extended. Also 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 increased for similar reasons.

Between casts sensors 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 suspended and the TC ducts were drained of seawater after each cast by sucking the residual water out using a syringe.

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

12.3.1 CTD sea-bed contact during CTD045

During CTD045 on Julian Day 051 (20/02/2020) the winch was initially veered from the surface to 3700 m wire out. The vessel was stationary over the ground in DP throughout the cast and three stable consistent echo-sounding were being obtained from the 10kHz and 12kHz EA640 (when corrected with Carters tables) and the EM122 swath centre beam (already corrected for speed of sound with contemporary SVP). Previous CTD data from the station also agreed closely with the current soundings.

When stopped with 3700 m wire out and the CTD at 3704 m depth salt water (DSW), a call was made to veer another 50 m to 3750 m wire out. Again, once stopped with the CTD at 3754 m, another call was made to continue veering another 20 m to 3770 m. During this veer the altimeter obtained a ping-return at 3765 m wire out (CTD DSW 3769 m) at a range of 22m from the sea-bed. Once stopped at 3770 m wire out (CTD DSW 3774 m) this put the CTD package at 17m range from the sea-bed.

A final approach call was made for a last veer of 7m to 3777 m wire out which was acknowledged by the winch driver. Once stopped at 3777 m wire out, this put the CTD at 3781 m DSW with an altimeter range of 10 m from the sea-bed at 11:23 UTC and maximum wire out was called to the winch driver which was acknowledged.

After firing the first two bottles at 11:24 UTC with the CTD DSW still indicating 3781m a call to start hauling up to 3500 m was issued at 11:25, which the winch driver acknowledged. The altimeter then briefly decreased to 8.9 m, went full scale to 100 m, then back down to 2.7m which is the minimum range of the altimeter. The outboard wire tension had reduced from 1.95 t to 1.3 t at 11:26 UTC. The CTD package weighs 0.65 t and the wire 0.34 t/km in sea-water. This all happened in 10 seconds as the winch was being veered at 1 ms-1 exceeding the max wire out call. A call was made to the winch driver that the CTD was on the bottom. The veer continued for another 10 seconds and another 10m wire out to 3797 m putting 10 m of slack wire on the sea-bed.

The winch was then abruptly hauled despite calls of easy...easy at 1.2 m s^{-1} resulting in a pull-out tension peak of 2.6 t. The CTD had spent about 30 seconds on the sea-bed (10 seconds of paying out 10 m of wire, 10 seconds of the winch speed ramping down, then up again and another 10 seconds of hauling back in the 10 m of slack wire). The winch was then briefly stopped whilst the winch driver asked for confirmation of the target haul depth of 3500m, the outboard tension was normal at 1.95 t again. Hauling then recommenced and the up-cast continued.

During the up-cast, all sensor data appeared normal. Bottle firing was continued as planned. Personnel were warned to be cautious as the package was recovered to deck. All was inboard at 13:01 UTC.

The CTD package was carefully inspected including the down-looking LADCP underneath the package. There was a minor kink in the CTD wire near the termination. There was a fresh mark in one of the lead ballast weights where it is likely that the slack bight of wire became snagged. There was no equipment loss and no other damage. There was no indication of mud or sediment other than slightly muddy water draining from the CTD frame drain holes. All bottles had closed and were in-tact. The TC-ducts were filled with Milli-Q and drained back into the syringe to check for mud particulates, none were observed in either duct. The tilt/roll attitude sensors in the two LADCPs on the CTD frame indicated that the package remained upright throughout with a maximum tilt of 2°.

The wire had no broken or displaced strands. The CTD termination was closely inspected, and bolt torque checked ok. The CTD wire was insulation tested ok. The CTD wire and termination was load-tested to 2T for 10 minutes followed by a further inspection, torque check and insulation test. 30 m of slack wire was pulled off for close inspection for other damage. None damage was found aside from minor polishing. The CTD wire was therefore put back into service with close inspection between each cast. No further deterioration in the wire condition was observed.

12.3.2 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 offset between the primary and secondary sensors for temperature (< 0.001°C), salinity (-0.003 PSU), and dissolved oxygen ($< 1\mu$mol/kg) indicated in Seasave during data acquisition. Analysis by the science party showed a stable positive offset of 0.003°C of both SBE 3P temperature sensors above the SBE 35 DOST bottle averaged data. There was a stable positive offset of 0.004 PSU in salinity from the primary SBE 4C conductivity sensors above the discrete Autosal bottle data and negligible offset for the secondary SBE 4C. There was a stable negative offset of 7μmol/kg for both SBE 43 dissolved oxygen sensors below the discrete oxygen titrations. There was negligible drift in all SBE 3P, 4C and 43 sensors throughout the cruise when comparing them to discrete bottle samples.

12.3.2.1 Reduced Operating Range of Benthos Altimeters

However, the performance of the Benthos PSA-916T altimeter s/n: 59594 was variable, but generally poor. Occasionally, but very rarely, the altimeter range was acceptable (50-60m). On one cast an echo-return was obtained at 85m (CTD010). However, the altimeters working range was often poor (30m) and sometimes very poor (15-20m). This resulted in protracted bottom-searching times, and made shelf-break work interesting when prevailing currents required moving the vessel over the ground to manage the CTD wire lead. The operational latency in calling for haul via radio, with the associated radio acknowledgement, followed by the winch operator writing their log entry had to be taken into account by increasing the range above bottom that the CTD package was worked when necessary.

After cast CTD048, the altimeter cable was removed for cleaning and inspection and was in excellent condition. The altimeter was replaced with the spare Benthos PSA-916T unit s/n: 62679. The performance of this instrument was similarly poor.

It is of course possible, and arguably more likely that the cable is at fault rather than two altimeters. Regardless, it would be prudent to return both altimeters to the manufacturer for assessment and possible refurbishment.

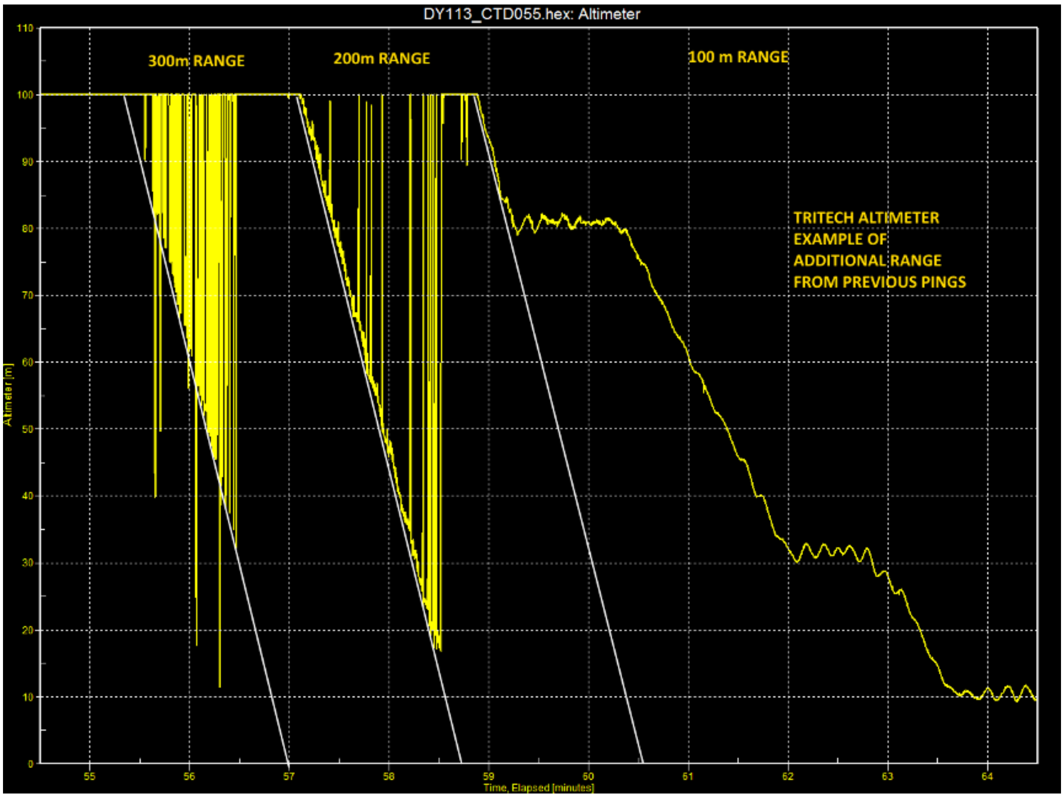
12.3.2.2 Extended Operating Range of Tritech Altimeter

After cast CTD054, the Benthos altimeter and its associated cable were replaced with a Tritech PA-200 altimeter s/n: 6196.112522. The performance of the Tritech was excellent with a working range of 100m without exception.

However, the Tritech altimeter had some functional characteristics that should be noted: as currently configured, it was so effective that it also measured an anomalous echo-return at 200m range, and occasionally 300m range aliased from previous pings.

Each of the echo-returns had a slightly different characteristic that allowed them to be distinguished. In the 300m range the echo-return baseline is 100m, with very spiky intermittent echo-return to the aliased range. Often, no echo-return was received at all in the 300m range. Within the 200m range, the baseline is the aliased depth, initially stable but noisy, then progressively spiking up to 100m, before returning to the 100m baseline at 15-20m. Sometimes the spiking in the 200m range didnt occur until 20-25m range and the return was quite clean which made it more difficult to distinguish between this and the un-aliased 100m real range. The 200m range aliased depth was observed on all casts with the Tritech installed. Therefore utmost care was required to ensure that the approach to 0m range at the end of the assumed 200m range was not actually the 100m range and therefore the sea-floor!

It may be possible to remove the previous pings by reconfiguring the instrument to a reduced ping-rate of 2Hz via an RS-232 terminal. However as currently configured (the Tritech default is 5Hz), and with experience of the echo-return characteristics, the additional range is operationally very useful. Note that the Y-cable was not replaced when the Tritech altimeter was fitted, i.e. the same Y-cable was used for both Benthos altimeters and the Tritech altimeter.



Tritech Altimeter Example of Additional Range from Previous Pings

12.3.2.3 Intermittent failure of WETLabs BBrtd Channel

There were four casts with temporary intermittent spiking and saturation of the WETLabs BBrtd backscatter channel (V7). This happened on CTD001, but did not return again until CTD082. It also occurred on CTD085 and CTD086. Prior to CTD087, the instrument cable and Y-cable were removed. The cables and the bulkhead connectors on the BBrtd and SBE 9plus were cleaned and inspected. Both bulkhead connectors and the instrument cable were in excellent condition. However, corrosion damage was found on the Y-cable connector on the BBrtd leg. This cable was replaced and no further issues were encountered. It is recommended to treat all BBrtd data prior to CTD087 as suspect until it has been carefully screened for quality. The Y-cable was shared with the WETLabs C-Star beam transmissometer (V6), but there was no indication of any similar issues with the beam transmission channel.

12.3.2.4 CTD Suite Spares Availability & CTD Wire Condition

Two full suites of spare instruments were available for use, with the exception of the fluorimeter for which we only had one spare due to an instrument failure of s/n: 88-2960-163 on DY110. 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 2 hemispherical scalar units which have a significantly reduced depth rating of 500m. This would have prevented their use for the majority of casts (only 22 of the 104 casts were shallower than 500m). Two spare CTD frames were also available on board, though they were Titanium CTD packages that would have required using the TMF water samplers, two full sets of which were also on-board. A full drum of spare CTD wire was available on the CTD2 secondary storage drum. Both wires are in excellent condition, though first 50m of the wire on the CTD1 storage drum that was used during DY113 is at its service limit for corrosion. It is recommended that 50m of wire be removed from the outboard end of CTD1 drum to bring clean un-corroded wire to the termination prior to next usage. A spare CTD wire termination was available and an Evergrip termination was also available for use with the Deep-tow wire as a backup.

12.3.2.5 Water Sampler and Carousel Maintenance

All the Niskins 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 with the exception of bottle #4 and #7. The tap was replaced on both bottles with a new tap and new seals. The two end-cap o-rings were also replaced on both bottles. The four nylon screws in the mono-fil guides were snugged down. The leak on bottle #4 then ceased, but the leak in #7 remained. The leak in #7 was isolated to the top-right nylon screw. The screw was removed and the hole inspected with an eye-glass. Several radial cracks were found radiating from the screw-hole. The PVC around the hole and the nylon screw itself were cleaned with IPA, then the screw was bonded in with PVC cement. After allowing 24hrs to cure, the bottle was leak tested again and was found to be good.

It had been recently reported that bottles were not firing due to sticking latches on the carousel fitted to the CTD. During the mobilisation, the carousel head latch assembly was removed, dismantled and thoroughly cleaned. Then the head assembly was reassembled and refitted to the carousel. On cast CTD007, bottles #6 & #9 did not fire. The carousel head latch assembly was washed with Triton-X solution and lots of fresh water whilst in situ. No further problems were encountered with position #6 and #9. On cast CTD013, CTD021, and CTD026, bottle #4 did not fire, even though it was being frequently rinsed in-situ with fresh water.

During the passage to A23 via Signy at the end of the SR1b transect, the head assembly was removed for a second time for another thorough wash. Before dismantling, the position #4 latch was marked with permanent marker pen. After cleaning, the marked latch from position #4 was installed in position #5 to test whether the problem was with the latch or the solenoid coil. No further problems with bottles not firing were encountered provided that the carousel was rinsed with fresh water when there were longer passages between stations. Also the latches were frequently exercised to keep them free.

There were some very occasional issues with the bottom end-cap of bottles leaking when they did not seat properly on the o-ring. There was no observed pattern to this and the springs provided similar tension on all bottles.

During the passage between SR1b and A23 lines, the lanyard on bottle #7 was replaced to lengthen it by 5-10mm as the bottom end-cap was sitting to high when cocked. Prior to the last cast, the lanyard on bottle #4 parted during cocking and a new lanyard was fitted to the bottle. The usual wear on the mono-fil where it rubs on the adaptor plates has reached the point where the other lanyards can be expected to fail soon. All lanyards should be replaced before next use apart from bottle #4 and #7 which have already been done.

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

12.3.3 Cast Summary

12.3.3.1 SR1b Drake Passage Transect, Burdwood Bank to Elephant Island

Cast	Station	Julian Day	Max Wire Out/m	Altimeter /m	Notes
001	TEST_CAST	37	3750	8	LADCP star-cable failed at 1750m
002	SR1b_01	37	155	9	
003	SR1b_02	38	674	10	
004	SR1b_03	38	1035	11	
005	SR1b_04	38	1690	10	
006	SR1b_05	38	2175	8	
007	SR1b_06	38	2750	7	
008	SR1b_07	38	3116	10	
009	SR1b_08	39	3915	50	No altimeter contact - range from LADCP
010	SR1b_09	39	4170	10	Altimeter contact at 85m range
011	SR1b_10	39	4720	10	
012	SR1b_11	39	3457	10	
013	SR1b_12	40	3825	11	
014	SR1b_13	40	3313	10	
015	SR1b_14	40	3850	5	
016	SR1b_15	40	3543	8	
017	SR1b_16	40	3491	10	
018	SR1b_17	41	4019	11	Delayed for winch test after slack on CTCU
019	SR1b_18	41	3885	10	
020	SR1b_19	41	3760	10	Secondary TC&DO fouled by salp at 100m
021	SR1b_20	42	3765	8	
022	SR1b_21	42	3747	10	
023	SR1b_22	42	3667	10	
024	SR1b_23	42	3487	10	
025	SR1b_24	42	3376	10	
026	SR1b_25	43	3078	10	
027	SR1b_26	43	2628	12	
028	SR1b_27	43	1761	30	No altimeter contact - range from LADCP
029	SR1b_28	43	1000	10	
030	SR1b_29	43	570	7	
031	SR1b_30	43	434	10	

12.3.3.2 A23 Transect Weddell Sea through Scotia Sea to South Georgia

Cast	Station	Julian Day	Max Wire Out/m	Altimeter /m	Notes
32	A23_24	47	4782	10	
33	A23_25	48	4710	9	
34	A23_26	48	4862	10	
35	A23_27	49	4818	10	
36	A23_28	49	4744	10	
37	A23_29	49	4832	10	
38	A23_30	50	3375	10	
39	A23_31	50	4054	10	
40	A23_32	50	3464	10	
41	A23_33	50	2570	10	
42	A23_34	50	1605	9	
43	A23_35	51	2754	10	
44	A23_36	51	2980	10	
45	A23_37	51	3781	10	Seabed contact after bottom bottles fired
46	A23_38	51	2923	10	
47	A23_39	51	3443	9	
48	A23_40	52	3107	10	
49	A23_41	52	3523	10	Benthos altimeter 62579 fitted
50	A23_42	52	3991	10	
51	A23_43	52	3571	10	
52	A23_44	52	3758	10	
53	A23_45	53	3444	10	
54	A23_46	53	3217	10	
55	A23_47	53	3122	10	Tritech altimeter 6196.112522 fitted
56	A23_48	53	3030	10	
57	A23_49	54	3522	10	
58	A23_50	54	2472	10	
59	A23_50a	54	2061	10	
60	A23_51	54	1497	9	
61	A23_51a	54	1016	10	
62	A23_52	54	528	10	

12.3.3.3 Cumberland Bay Survey, South Georgia

Cast	Station	Julian Day	Max Wire Out/m	Altimeter /m	Notes
63	CUMB_01	55	266	10	
64	CUMB_13	55	76	10	
65	CUMB_12	55	177	10	
66	CUMB_11	55	227	10	
67	CUMB_10	55	233	9	
68	CUMB_09	55	253	10	
69	CUMB_17	55	196	10	
70	CUMB_16	55	203	10	
71	CUMB_15	55	222	9	
72	CUMB_14	55	229	10	
73	CUMB_05	55	133	10	Profile only, no bottles fired
74	CUMB_04	55	246	9	Profile only, no bottles fired
75	CUMB_06	56	223	10	Profile only, no bottles fired
76	CUMB_07	56	223	10	
77	CUMB_08	56	170	10	Profile only, no bottles fired
78	CUMB_03	56	250	10	
79	CUMB_02	56	122	10	Profile only, no bottles fired

12.3.3.4 North Scotia Ridge (NSR) Transect

Cast	Station	Julian Day	Max Wire Out/m	Altimeter /m	Notes
80	NSR_01	58	460	17	
81	NSR_02	58	2092	10	
82	NSR_03	58	482	9	
83	NSR_04	59	481	10	
84	NSR_05	59	1389	10	AHC clump trial to 1000 m after this cast
85	NSR_07	59	1870	12	First Cast with AHC
86	NSR_08	60	1504	12	AHC - BBrtd drop-out on downcast
87	NSR_10	60	2474	12	No AHC - BBrtd/Trans Y cable replaced
88	NSR_12	60	3012	9	AHC 5 stops: 3 min normal, then 3 min AHC
89	NSR_13	60	2719	10	AHC - BBrtd cap not removed in error
90	NSR_14	60	3165	10	AHC
91	NSR_15	61	2590	13	AHC
92	NSR_16	61	1479	11	AHC
93	NSR_29	65	913	10	AHC
94	NSR_28	66	2528	10	AHC
95	NSR_27	66	1155	11	AHC
96	NSR_26	66	532	10	AHC
97	NSR_25	66	1460	10	AHC
98	NSR_24	66	1903	9	AHC
99	NSR_23	67	1460	20	AHC
100	NSR_22	67	996	10	AHC on/off 500m haul & veer comparison
101	NSR_20	67	824	12	AHC
102	NSR_19	67	966	10	AHC
103	NSR_17	68	962	9	AHC
104	NSR_16	68	1429	15	AHC, repeat of NSR_16 occupied by CTD092

12.3.4 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 will be submitting the definitive quality-controlled processed data-set to BODC in due course.

The pre-processing order used was:

- Data Conversion
- AlignCTD 6s 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 work-flow by the science party.

The 6s 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 25m binned speed of sound profiles for correcting multi-beam swath data. The Bin Averaged files are named in the form DY113_CTDxxx_align_ctm_SV_25m.cnv and contain the Chen-Millero (m/s) speed of sound algorithm on the secondary channel.

12.4 LADCP

12.4.1 Instrument Configuration

Two self-logging Teledyne RDI Workhorse 300kHz 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, whereas the Master unit 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: 23444) 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: 12369) 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 WH007.

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 8m bins and a 4m blank for a maximum range of 204m. Both instruments were set to 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 (0.645Hz).

Initially the LADCPs were configured with 250cm/s for the Ambiguity Velocity (LV250). This was subsequently increased to 330cm/s (LV330) for cast CTD005 onwards. 330cm/s is the maximum that LV can be set to in Narrowband mode (LW1).

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 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.

12.4.2 Deployment Command Scripts

Down-looking Master		**Up-looking Slave**	
; DY113 Firing, NOC. LADCP Master		; DY113 Firing, NOC. 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 (use EC speed of sound, ED depth, ES salinity)	EZ0011101	; Use temp, heading and tilt sensors (use EC speed of sound, ED depth, ES salinity)
TE00:00:01.00	; 1 Second Minimum Time Per Ensemble (default for WM15)	TE00:00:01.00	; 1 Second Minimum Time Per Ensemble (default for WM15)
TP00:01.00	; 1 Second Minimum Time Between Pings (default for WM15)	TP00:01.00	; 1 Second Minimum Time Between Pings (default for WM15)
LP00001	; 1 Ping Per Ensemble (default)	LP00001	; 1 Ping Per Ensemble (default)
LD111100000	; Collect and Process all data (default)	LD111100000	; Collect and Process all data (default)
LF0400	; LADCP 4m Blank	LF0400	; LADCP 4m Blank
LN025	; LADCP 25 Bins	LN025	; LADCP 25 Bins
LS0800	; LADCP 8m Bins	LS0800	; LADCP 8m Bins
LV330	; LADCP 330cm/s Ambiguity Velocity (limited to max 330 in LW1 mode)	LV330	; LADCP 330cm/s Ambiguity Velocity (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 Correlation Thresholds	LZ30,220	; LADCP Default Bottom Detect and Correlation Thresholds
SM1	; RDS3 Master	SM2	; RDS3 Slave
SA001	; Send Sync Pulse Before Water Ping (default)	SA001	; Wait for Sync Pulse Before Water Ping (default)
SB0	; Disable hardware break detection on channel B	SB0	; Disable hardware break detection on channel B
SW05000	; Ping 500ms after Sending Sync Pulse	ST0	; Wait Indefinitely For Sync 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

12.4.3 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 DY113_CTDxxxM.txt for the master and DY113_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 DY113_Slave.TXT, followed by the master using DY113_Master.TXT. Finally the logging to the terminal capture was stopped (F3).
- The battery was then taken off charge and the deck-cables 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 DY113_CTDxxxM.000 for master and DY113_CTDxxxS.000 for the slave. The files were then backed up to the network archive.

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.

12.4.4 LADCP Deployment Comments

Communications problems were experienced with LADCPs during set-up for cast CTD001 but the instruments were eventually deployed successfully. The star cable subsequently failed during the cast and was replaced. 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.

Two full sets of LADCP pairs (4 instruments) were available as spares on-board. However, the instruments performed well and there was no requirement to replace LADCP instruments with spares.

12.5 Salinometry

After 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 dedicated salinometer room with the dedicated AC plant set at 18.7°C for an ambient temperature of $19 - 20$°C. The salinometer baths were filled with 0.1% bleach Milli-Q solution (20 ml thin bleach : 20 l Milli-Q) to prevent marine growth within the tank.

The Autosals was standardised using IAPSO Standard Seawater batch P163 (Use By: 10th April 2022, K15=0.99985, 2xK15=1.99970, 34.994 PSU). The salinometers had their baths filled and were powered up on 30 January and an initial standardisation check was completed on 1 February.

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 65764 was commissioned during the mobilisation, and was initially intended as the main unit. This unit was pre-standardised by Dougal Mountifield (STO) on 1 February 2020. This machine had a leak at the junction between the peristaltic pump and the sample needle which was resolved. This unit was initially used on 8, 9 and 10 February for analysing 6 crates of samples but problems were encountered with an intermittent and deteriorating air-leak in the air-pump manifold which periodically causes the sample cell to draw in air to at least one and often more side-branches. The cell was cleaned thoroughly with Triton-X and bleach solutions and flushed thoroughly with Milli-Q but the problem remained.

Guildline Autosal 8400B S/N 68426 was also commissioned during the mobilisation. During commissioning the stirrer of this unit would not start. The unit was withdrawn from its housing and the stirrer was rotated by hand. The shaft bushing was initially marginally less free than usual, but quickly freed up, and subsequently worked smoothly. The unit was pre-standardised by Mark Maltby (SST sailing as CTD tech) and checked by Dougal Mountifield (STO) on 1 February. This machine also had a leak at the junction between the peristaltic pump and the sample needle which was resolved.

Use of this Autosal started on 10 February after the airlock problems in the side-branches of 65764. However the analyst immediately had problems with noisy readings when attempting to standardise the machine. It was observed that there is a filament of organic matter at the sample entry end of the cell. The cell was cleaned thoroughly with Triton-X and bleach solutions and flushed thoroughly with Milli-Q. The organic growth was reduced in size, but was still present and the noise remained. After confirming that the stirrer was still functioning, the salinometer was switched off to inspect the heater lamps. Both heater lamps were blackened and were replaced with new spare tubes. The machine was then switched back on and left a few hours to stabilise before assessing again for noise. The machine was then used to run samples with no problems for a few days.

At the same time as the heater lamps were replaced on 68426, the lamps in 65764 were also inspected. These were found to be very blackened and were also replaced with spares even though the machine was currently out of service due to the air-locks in the cell side-branches.

On the 12 February the analyst reported that the heater lamps on 68426 were staying on much more than they were going off. The STO inspected the salinometer and found that the front heater lamp that had recently been replaced had failed. The failed lamp was replaced with another spare.

On the 14 February the analyst reported that the salinometer (68426) was reading too high (2.00059 when 1.99970 expected) when running the post-standard at the end of a crate. The cell was cleaned by the STO but the standard was still reading too high. A new standard was opened and the Autosal read bottle value at 1.99970 repeatedly. It is suspected that the previous standard had been opened for some time and the increase in salinity was caused by evaporation of the standard.

A standard was run as a sample before and after each crate of samples as a control.

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 also scanned to pdf format by the science party.

12.6 Millipore Integral Lab Water Supply

On arrival on-board we found two operational Milli-Q systems, Serial No. F3AA22649A Deck Lab and Serial No. F4MA94816C Inv No. 250009175 GP Lab. In the CT Lab Serial No. F3AA82270D was found to be non-operational. Only near the end of the cruise another operational system was found in the Clean Chemistry Lab Serial No. F3AA82270E

During mobilisation large quantities of water were used from both operational systems in the Deck Lab and GP Lab to fill the salinometers water baths. The GP Lab system refilled the tank without issue.

The Deck Lab system however initially started filling the tank but was later found with a low feed pressure alarm. The unit stated that this could be due to low feed water pressure or blocked ProGard. The manual states Check Feed-water pressure and rectify and Go to STANDBY Mode and go to READY Mode to release trapped air.

The feed water pressure was checked at the sink and found to be good and the unit itself measured the water pressure at 2.1 bar which is within the required range of 1-6 bar. The inlet strainer was checked and found to be clear, there were no spare ProGards on-board, so it was changed with the CT labs non-operational system, but this was found not to help so was switched back to the original. The system was cycled from STANDBY to READY mode countless times and eventually the system produced water and filled the tank. During this process we also sanitised to RO with a CL2 clean and performed RO flushes. The unit was seen to refill the tank a couple of times while in port.

Once we sailed and the Milli-Q systems were being used by the scientists the Deck Lab system once more failed with the low feed pressure alarm and the GP lab unit was found to leak from the bottom left side. As the GP lab unit was at this point the only known system on-board producing water and the leak wasnt interfering with any of the systems electronics there was initially no attempt made to repair the system. With the Deck Lab system, the same procedure that had seemingly worked in port was employed but to no avail. The system did however produce a full tank of water at the end of the first CTD line while in very calm flat waters in the lee of Elephant Island but once in rolling seas again failed with the low feed pressure alarm. It is though that there may be a solenoid valve that is sticky and doesnt work correctly while at sea. Due to time pressures and workload of the technicians on-board it was decided to decommission Serial No. F3AA22649A from the Deck Lab and commission the new spare Serial No. F7AA49258C Inv No. 260004513 rather than continue with investigating the unit, this was done during the passage between the CTD lines. The new system was initially commission with the consumables from the previous system but due to poor water quality a new Quantum and Bio-pak were eventually used. It took 3 days to commission the unit to produce water with quality as per the manual.

This system Serial No. F7AA49258C has since worked without issues and is left in place in the Deck Lab.

Attentions were then drawn to the CT Lab system and its leak. It had been found that the system only leaked during water production and not during dispensing, so while it was the only system known on-board making water the scientists had continued to use the water as long as the tank wasnt drained below 80%. A technician had been periodically draining the tank below 80% so the system would make water and checked that the leak wasnt getting any worse. The side panels were removed from the system with it still in situ and the tank was drained to force water production so the cause of the leak could be found, eventually the source was found to be the electro deionization module, the module looks to be made up of many sections which are sealed together. The module was weeping from in between these sections in many places barely visible but the quantity of water leaking during the production of 12l was probably 250ml. The EDI module was changed, and the system now produces water without leaking. Later on, the Quantum was changed to the old Deck lab unit after the system requested replacement.

The system in the Clean Chemistry Lab was found near the end of the cruise. This was found in operational READY state with a full tank. The quality of the water looked to be good. The tank was drained and allowed to refill.

Due to the long period between the end of this cruise and the start of the next all units have been put in Lab Closed mode with the tanks drained and the tank valve left open.

List of consumables used

1 off	Quantum TEX Cart QTUM0TEX1
1 off	Ultrafilter CDUFBI001
1 off	Elix 15 LPH EDI Module ZLX0EDI15

12.7 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)

13. Scientific Ship Systems

Martin Bridger
Scientific Ship Systems
National Marine Facilities, National Oceanography Centre
15 March 2020

13.1 CRUISE OVERVIEW

Cruise	Departure	Arrival	Technician(s)
DY113	03/02/2020 (Punta Arenas)	13/03/2020 (Montevideo)	Martin Bridger

Ship Scientific Systems (SSS) is responsible for operating and managing the Ships 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 report are UTC unless otherwise stated

13.2 SCIENTIFIC COMPUTER SYSTEMS

13.2.1 ACQUISITION

Network drives were set up on the on-board file server; firstly a read-only drive of the ships instruments data (current_cruise) and a second drive (Public) for the scientific party. Both were combined at the end of the cruise and copied to disks for the PSO and Chief Scientist. A disk is also produced of the current_cruise for BODC.

Data was logged by the Techsas 5.11 data acquisition system. The system creates NetCDF and ASCII output data files located in the below TechSAS directory. The format of the data files is given per instrument in the Data Description directory:

Cruise Disk Location:
.../Cruise_Documentation/Data_Description_Documents/
.../Ship_Fitted_Scientific_Systems/TechSAS

The logged ship-fitted instruments are listed in the file in the below location (includes BODC notes):

Cruise Disk Location:
.../Cruise_Documentation/DY113_BODC_ship_fitted_information_sheet_DY113

13.2.1.1 TIMEKEEPING

Acquisition computers and systems were synchronised with the shipboard NTP Time Server (Meinberg LANTIME M300 GNS).

13.2.1.2 EVENTS

Cruise events may be recorded by cruise participants accessing the NMF Discovery Event Logger webpage. This produces a selection of EventLog files that may be located in the below cruise directory. These files are csv.

Cruise Disk Location:
.../Cruise_Documentation/EventLogs/current_csv_logs/

13.2.1.2.1 Main Acquisition Period Techsas logging for DY113 commenced 02/02/2020 (J033) 17:41 whilst alongside in the port (Punta Arenas, CL). Basic positional, meteorological and depth data were logged from this time. All other acoustics and underway instrumentation were started in International Waters on 06/02/2020 (J037) 16:27.

Underway instrumentation was stopped prior to arrival transit to Punta Arenas on 11/03/2020 (J071) 16:00. Acoustics were stopped on 11/03/2020 (J071) 23:59 before entering Uruguay waters, leaving just navigation and Surf(MET) instruments enabled. All logging was stopped 13/03/2020 (J073) 18:00 after arriving in Montevideo, Uruguay.

13.2.1.3 RAW NMEA

The NMF RVDAS/ingester raw data logger also records raw data streams as a backup/QC option to the primary Techsas logger. These raw ASCII files are located in the below cruise directory:

Cruise Disk Location:
.../Ship_Fitted_Scientific_Systems/RAM/

13.2.2 COMMUNICATIONS

On board for the cruise were marine staff, 3 NMF technicians, and members of the science party.

13.2.2.1 INTERNET PROVISION

Satellite Communications was provided with the VSAT system. The VSAT has a guaranteed speed of 1.5 Mbps, bursts greater than this when there is space on the satellite, and unlimited data (and provides 3 on board phone lines to cabins/work areas).

The VSAT had major outages after departing from Punta Arenas, until an unscheduled call in Stanley, Falkland Island, where the VSAT began working again. Despite several attempts to restore connection, including rebooting, checking and changing configurations, swapping the IBUC unit, testing cable connections and swapping over cables, the connection was unrecoverable. The previous cruise in nearby work area had experienced similar problems. On transit to Montevideo the service was partially restored but still patchy. During VSAT outages, the vessel used the FBB backup, which is available with a maximum un-guaranteed speed of 512kbps and a 15GB monthly plan. Speeds on the FBB were much lower than the maximum speed, usually struggling to reach 256 kbps inbound and 98 kbps outbound. Early on, this quota ran out, and had to be topped-up. At the lower latitudes, even the FBB struggled to maintain a connection with elevations of around 3 degrees.

When the VSAT was working, maximum inbound data rates of around 3.5 Mbps was achieveable, with an average throughput of approximately 2 Mbps.

13.2.2.2 EMAIL PROVISION

Email communications were provided primarily through user email clients and web-browser clients. There is no longer an onboard email system this is the forth cruise where the legacy AMS system has not been available. In practice with very limited internet access IMAP (as used by AMS) and POP email protocol results in a more reliable email exchange compared to Outlook, or Web based email.

13.3 INSTRUMENTATION

13.3.1 COORDINATE REFERENCE DATUM

The common coordinate reference was defined by the Parker Maritime survey (2013) 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) used in all systems is that of the coordinate reference system 2 with CRP at CG.

This common reference point is physically located in the gravity meter room (Refer to the Parker Report, 2013 - Enclosure 3/Coordinate System 2), which can be found in
.../Equipment_Documentation/Vessel_Survey_Information.

13.3.2 POSITION AND ATTITUDE

GPS and attitude measurement systems were ran throughout the cruise.

13.3.2.1 APPLANIX POSMV

The Applanix POSMV system is the vessel's primary scientific GPS system, outputting the position of the ship's common reference point in the gravity meter room. The POSMV is available to be sent to all scientific systems and is repeated around the vessel. The position fixes, attitude and gyro data were logged to the Techsas system. Raw NMEA data were logged with the NMF RVDAS raw logger.

Cruise Disk Location:
Techsas:
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/aplnx/
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/GPS/*Applanix*
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/ATT/*Applanix*
RVDAS Raw Logger:
.../Ship_Fitted_Scientific_Systems/RAM/DY113_POSMV*

13.3.2.2 KONGSBERG SEAPATH 330

The Kongsberg Seapath 300 system is the vessels secondary GPS system. It provides an input to the Gravity meter (when used) due to the POSMV not having vessel course available in its RMC NMEA message. Position fixes and attitude data are logged to the Techsas system. Raw NMEA data were logged with the NMF RVDAS raw logger.

Cruise Disk Location:
Techsas:
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/sppos/
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/spatt/
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/GPS/*Seapath330*
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/ATT/*Seapath*
RVDAS Raw Logger:
.../Ship_Fitted_Scientific_Systems/RAM/DY113_SEAPATH*

13.3.2.3 C-NAV 3050

The CNav 3050 GPS system is a differential correction service. It provides the Applanix POSMV system with RTCM DGPS corrections (greater than 1m accuracy). The position fixes data are logged to the Techsas system. Raw NMEA data were logged with the NMF RVDAS raw logger.

Cruise Disk Location:
Techsas:
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/CNAVJ/
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/GPS/*CNAV*
RVDAS Raw Logger:
.../Ship_Fitted_Scientific_Systems/RAM/DY113_CNAV_GPS*

13.3.2.4 FUGRO SEASTAR 9205

The Fugro Seastar 9205 GPS system is a differential correction service. It provides the Seapath system with RTCM DGPS corrections. Fugro NMEA output messages are logged to the Techsas system. Raw NMEA data were logged with the NMF RVDAS raw logger.

Cruise Disk Location:
Techsas:
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/FUGRO/
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/GPS/*FUGRO*
RVDAS Raw Logger:
.../Ship_Fitted_Scientific_Systems/RAM/DY113_FUGRO_GPS*

13.3.3 METEOROLOGY AND SEA SURFACE MONITORING PACKAGE

The complete NMF Surfmet system was run whilst in International Waters. The Met part of Surfmet was run for the duration of the cruise.

The Surfmet system is comprised of:

1. Hull water inlet temperature probe (SBE38).
2. Sampling board conductivity, temperature salinity sensor (SBE45).
3. Sampling board transmissometer (CST).
4. Sampling board fluorometer (WS3S)
5. Met platform temperature and humidity probe (HMP45).
6. Met platform port and starboard ambient light sensors (PAR, TIR).
7. Met platform atmospheric pressure sensor (PTB210).
8. Met platform anemometer (Windsonic).

Surfmet was rebooted 12/03/2020 18:35 for troubleshooting (light sensors)

Please see the separate information sheet for details of the sensors used and whether calibrations values have been applied (Instrument calibration sheets are also included within this directory):

Cruise Disk Location:
.../Ship_Fitted_Scientific_Systems/Surfmet/DY113_Surfmet_sensor_information_sheet.pdf
Techsas:
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/WAMOS
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/SBE45/
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/SURFMETV3/
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/TSG/
RVDAS Raw Logger:
.../Ship_Fitted_Scientific_Systems/RAM/DY113_NMF_SURFMET*
.../Ship_Fitted_Scientific_Systems/RAM/DY113_SBE45_TSG*

Events, including cleaning and any observed issues/flow adjustments were recorded using the NMF EventLog.

EventLog:
.../Cruise_Documentation/EventLogs/current_csv_logs/techlogs/Surfmet.csv

Underway TSG samples were collected daily by scientific party. The instrument flow rate (approx. 1.7-1.8 L/min.) is also logged by the ships acquisition systems.

13.3.4 KONGSBERG EA640 10 & 12 KHZ SINGLE-BEAM

The EA640 single-beam echo-sounder was run throughout the cruise, with raw recording turned on in International Waters. The 10 kHz active mode & 12 kHz active mode transducers were both used. The 10 kHz gave the better result throughout the cruise.

The system used a constant sound velocity of 1500 ms-1 throughout the water column to allow it to be corrected for sound velocity in post processing if required.

Salinity (35 PSU) and Temperature (10degreeC) and Conditions (salt water) were also left as constant values for the cruise duration.

Raw NMEA depth data were logged with the NMF RVDAS raw logger. EA640 RAW data was logged on the EA640 PC, however, the scientists decided that the RAW data was not valuable to them, so RAW logging was disabled, and the data deleted.

Cruise Disk Location:
.../Ship_Fitted_Scientific_Systems/Acoustics/EA640/raw/
Techsas:
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/EA600/
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/EA600/
RVDAS Raw Logger:
.../Ship_Fitted_Scientific_Systems/RAM/DY113_EM640_DEPTH*

EventLog:
.../Cruise_Documentation/EventLogs/current_csv_logs/techlogs/EA640.csv

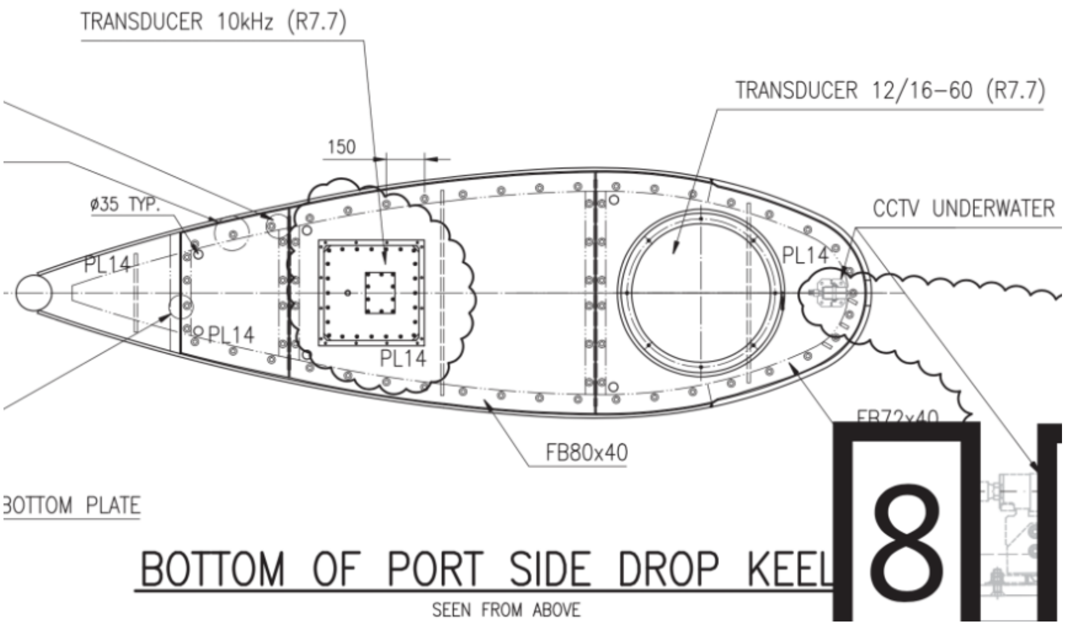


Figure 13.1: Port Drop Keel: 10 & 12KHz Transducer location

13.3.5 DROP KEEL SOUND VELOCITY SENSOR

The surface Sound Velocity (SV) sensor (AML SmartSV) mounted on the drop keel was used throughout providing surface SV data to the EM122. The port drop keel remained flush with the hull for the duration of the cruise.

13.3.6 EM122 MULTIBEAM ECHOSOUNDER

The EM122 s/n:123 Multibeam echo-sounder was run whilst in International Waters, or where permission was granted.

Changes to operating modes, sound velocity profiles and data quality are included in the event log for this system. Kongsberg *.raw files (100MB maximum file size) and *.xyz files are logged and depths were logged to Techsas.

> *EventLog:*
> .../Cruise_Documentation/EventLogs/current_csv_logs/techlogs/EM122.csv

13.3.6.1 DATA FEEDS

Position and attitude data was supplied from the Applanix PosMV and True Heave *.ath files are logged to allow for inclusion during reprocessing.

13.3.6.2 CONFIGURATION

The following figures show the system installation configuration. The values are from the ships Parker survey report, which is included on the data disk.

Location offset (m)

	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1:	0.00	0.00	0.00
Pos, COM3:	0.00	0.00	0.00
Pos, COM4/UDP2:	0.00	0.00	0.00
TX Transducer:	39.910	0.885	7.426
RX Transducer:	35.219	-0.005	7.438
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Waterline:			1.34

Figure 13.2: EM122 transducer locations

Offset angles (deg.)

	Roll	Pitch	Heading
TX Transducer:	0.07	0.15	0.05
RX Transducer:	0.05	0.37	359.98
Attitude 1, COM2/UDP5:	-0.10	0.00	-0.85
Attitude 2, COM3/UDP6:	0.00	0.00	0.00
Stand-alone Heading:			0.00

Figure 13.3: EM122 transducer offsets

13.3.6.3 AXES REFERENCE CONVENTIONS

The Kongsberg axes reference conventions are (see below figure) as follows:
3. X positive forward,
4. Y positive starboard,
5. Z positive downward.
The roll reference is set to follow the convention of Applanix PosMV.

The translations and rotations provided by the Applanix PosMV Primary scientific position and attitude system have the following convention:
6. Roll positive port up,
7. Pitch positive bow up,
8. Heading true,
9. Heave positive up.

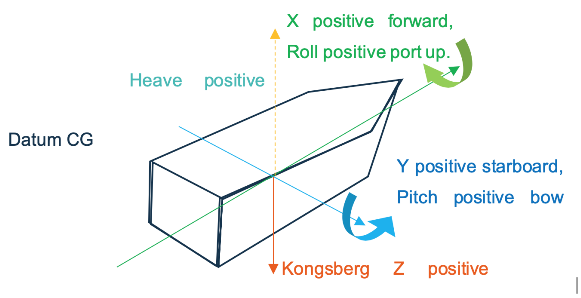


Figure 13.4: Conventions used for position and attitude.

13.3.6.4 SOUND VELOCITY PROFILES

Statistical sound velocity profiles were obtained from CTD casts, then processed using the Ifremer DORIS software (see Equipment_Documentation/Sound_Velocity for more information).

The profiles were used were logged in the EventLog.

Cruise Disk Location:
.../Ship_Fitted_Scientific_Systems/Acoustics/Sound_Velocity_Profiles/DORIS/

13.3.6.5 SAVED DATA

Cruise Disk Location:
.../Ship_Fitted_Scientific_Systems/Acoustics/EM122/
Techsas:
.../Ship_Fitted_Scientific_Systems/TechSAS/NMEA/EM1_1/
.../Ship_Fitted_Scientific_Systems/TechSAS/NetCDF/DEPTH/
RVDAS Raw Logger:
.../Ship_Fitted_Scientific_Systems/RAM/DY113_EM122_DEPTH*

13.3.7 ADCP; OS75KHZ & OS150KHZ (RDI TELEDYNE)

The RDI Teledyne Ocean Surveyor 75 KHz and 150 KHz ADCPs were used in International Waters. The UHDAS suite of programs and processes was used to perform data acquisition, processing and monitoring.

UHDAS (University of Hawaii Data Acquisition System) acquires data from RDI ADCPs and ancillary sensors (eg. gps, gyrocompass, gps and inertial attitude sensors.) and uses CODAS processing to incrementally build a dataset of averaged, edited ocean velocities for each ADCP and ping type specified. Processed data and plots are served on the shipboard network, and daily status summaries are emailed.

UHDAS + CODAS documentation can be found online at
http://currents.soest.hawaii.edu/docs/adcp_doc/index.html and are also served on the shipboard network.

13.3.7.1 DATA FEEDS

- GGA (Ship Position) and VTG (Ship Speed) were provided by the Applanix POS-MV.
- Heading and Tilt was provided by the iXSea PHINS MRU (PRDID NMEA message).

13.3.7.2 CONFIGURATION

The ADCP was configured to run in Narrow Band (NB) mode throughout

13.3.7.3 SAVED DATA

Cruise Disk Location:
.../Ship_Fitted_Scientific_Systems/Acoustics/ADCP-UHDAS/
EventLogs:
.../Cruise_Documentation/EventLogs/current_csv_logs/techlogs/ADCP OS75.csv
.../Cruise_Documentation/EventLogs/current_csv_logs/techlogs/ADCP OS150.csv

13.3.7.4 BOTTOM TRACKING

Initially the ADCPs were configured to run in Bottom-Tracking (BT) mode during the departure from Punta Arenas. This data will allow for the calibration of transducer alignment. Once enough data was collected, the systems were switched to Narrow Band mode.

Cruise Disk Location:
.../Ship_Fitted_Scientific_Systems/Acoustics/ADCP-UHDAS-DY113_cal/

14. Acknowledgments

We gratefully acknowledge the assistance of the Master, officers, crew, NMF technicians, and volunteers, without whose work the cruise and successful data collection would not have been possible. We particularly appreciate everyone's hard work and positive attitudes toward additional opportunistic data collection despite the difficulties caused by the lack of communications.