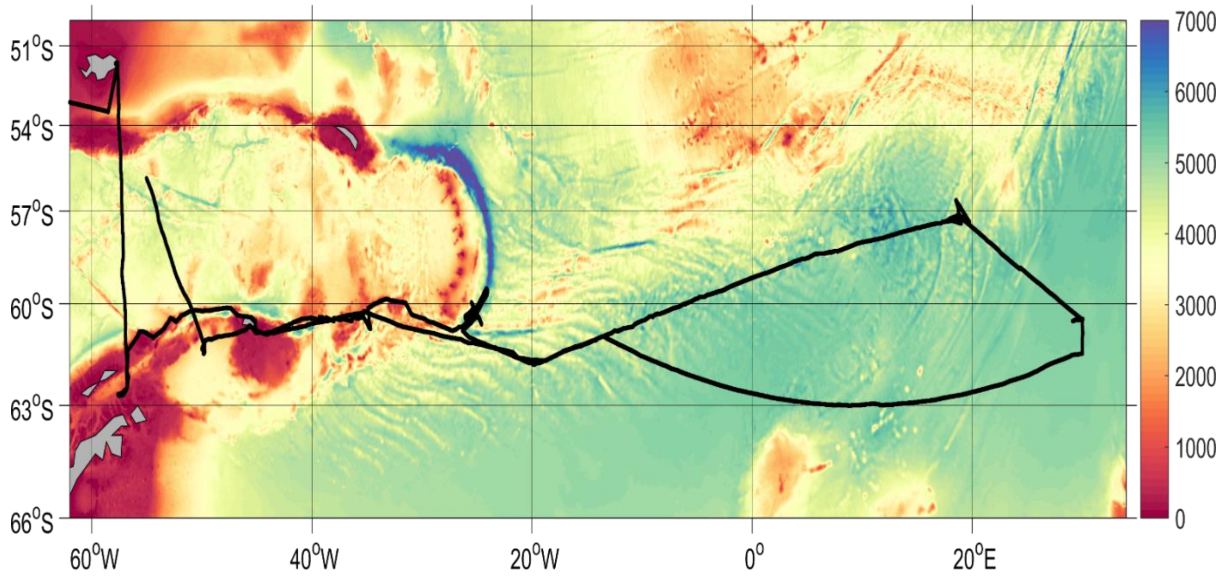
Cruise Report JR18005

ANDREXII

21 February to 15 April 2019

Royal Research Ship, James Clark Ross

Principal Scientific Officer: Andrew Meijers



Frontispiece: (top) JR18005 ANDREXII scientific cruise track as of 14-April-2019, overlaying regional bathymetry and (bottom), the JCR passing through Lewthwaite Strait in the South Orkney Islands (photo William Clark).

Front cover: Cruise cross stitch showing all science conducted on JR18005 (whole scientific team, led by Rachael Sanders).

Acknowledgements: It is a pleasure to thank some of the many people and groups that helped to make JR18005 the success that it was. Particular thanks are owed to Graham Chapman and the officers and crew of the JCR, for keeping us moving in the right direction, often in marginal and trying conditions while seeing that we were safe, fed, and happy.

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1 Introduction

Andrew Meijers, British Antarctic Survey

1.1 Synopsis

JR18005 (ANDREXII) was a hydrographic and biogeochemical voyage aboard the Royal Research Ship James Clark Ross occupying ~100 full depth CTD stations extending from the tip of the Antarctic Peninsula eastwards to 30^{o}E. ANDREXII repeated the stations of two earlier voyages in 2009/10 and forms part of the ORCHESTRA (Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports) multi-centre collaboration by NERC examining heat and carbon uptake in the South Atlantic and Southern Ocean. In addition CFC/SF_6 measurements were taken for the TICTOC (Transient tracer-based Investigation of Circulation and Thermal Ocean Change) NERC large grant in partnership with ORCHESTRA. The voyage departed Punta Arenas on the 21st of February 2019 and was overflown twice by the BAS MASIN meteorological aircraft on the 23rd of February in order to conduct calibration measurements.

The JCR then called at Stanley on the 24th for half a day to transfer cargo before heading south to the tip of the Antarctic Peninsula. CTD operations commenced on the 28th of February and continued uninterrupted towards the east until the 10th of March. At this point the JCR diverted north over the South Sandwich Trench to conduct swathing operations and a CTD section across the 'shallow' 6000 m sills revealed by the survey. Further deep stations in the trench were postponed until the end of the voyage due to concerns about the impact of extreme depth on the CTD conducting wire. From the 13th of March the JCR returned to the ANDREXII hydrographic line. CTDs 73-78 were not successfully occupied on the eastward leg due to a technical fault with the CTD wire. This was rectified and CTDs 78-92 were occupied without break between 18th-23rd March. Poor weather along the planned stations between station 93 and 30^{o}E forced the diversion of the line southwards, eventually reaching 30^{o}E at 60.5^{o}S on the 28th of March. Three stations were occupied on 30^{o}E to intersect with the I6S line being occupied by US partners in April 2019 for calibration purposes. Six SOCCOM and two Deep Arvor floats were deployed intermittently along the eastwards track.

The JCR then returned west to the missed stations 78-73 and reoccupied them (dropping 74 due to time constraints). A winch failure immediately upon completing the missed stations forced suspension of deep CTD operations and the cancellation of the planned extremely deep stations in the South Sandwich Trench. The JCR then proceeded east, recovering a BAS Slocum glider, deployed on JR18004, on the 9th of April. Finally the voyage occupied a single shallow CTD station within the growing sea-ice south-west of the South Orkney Islands on the 11th of April to examine air-sea fluxes, before arriving at Mare Harbour on the 15th of April.

1.2 Cruise overview and rationale

ORCHESTRA (Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports) is a BAS led NERC funded LTSM (Long Term Science-Multiple Centre) programme (PI A. Meijers). This combines researchers and equipment from several UK research centres, including NOC, PML, BGS, SMRU, CPOM and the Met Office to deliver a large scale assessment and improved understanding of heat and carbon uptake by the Southern Ocean using observational, modelling and theoretical approaches. The flagship observational effort comprises of three coordinated hydrographic sections collecting full GO-SHIP suites of physical and biogeochemical tracers. These, along with the US run I6S line at 30ºE, form two closed boxes around the south Atlantic and Weddell sea (Figure 1.1).

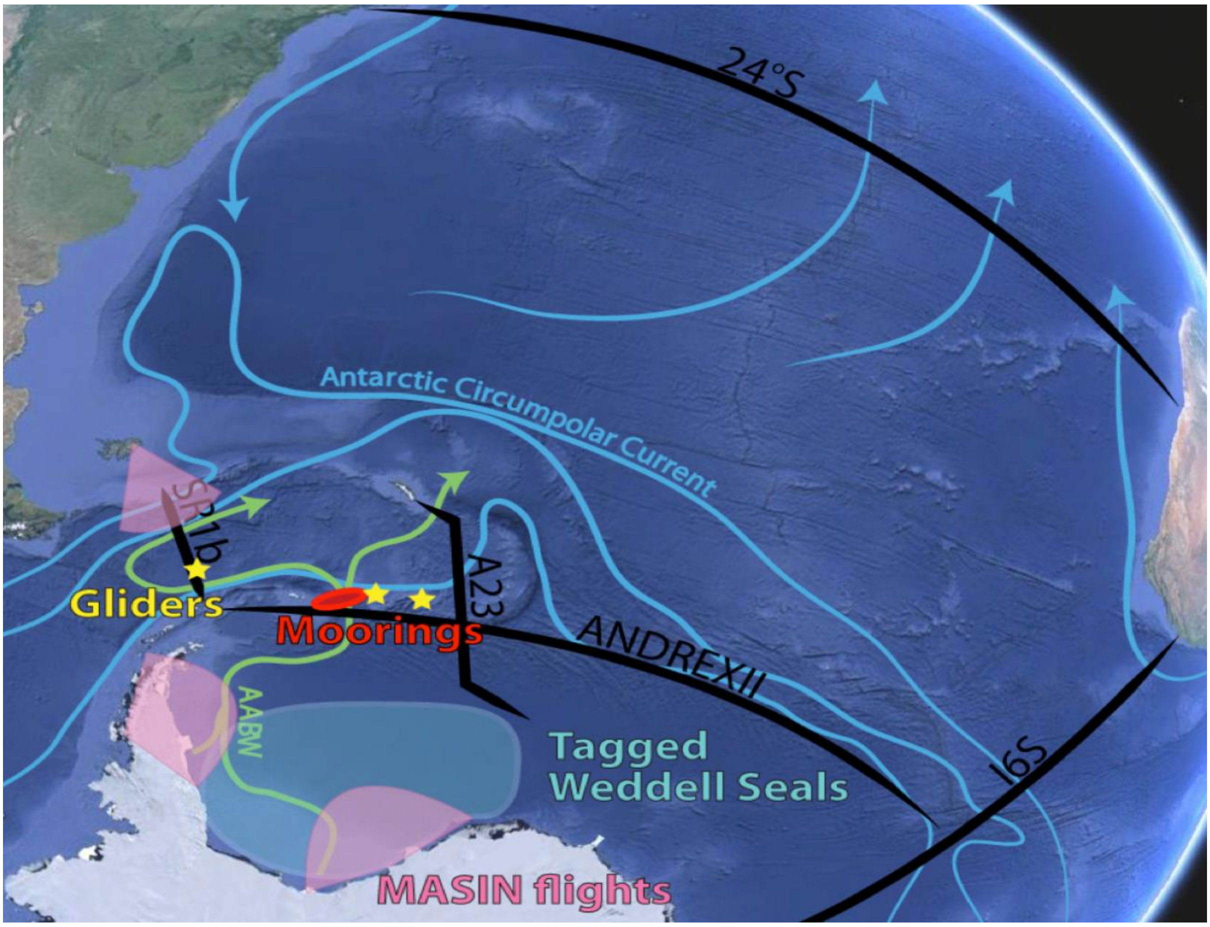

Figure 1.1: ORCHESTRA field programme plan. Bold black lines show the approximate locations of hydrographic sections, including ANDREXII.

By using inverse approaches this two box technique allows the estimations of surface fluxes, interior mixing, storage and export between and from the boxes for a number of climatically and biologically relevant variables. These include heat, freshwater, CO_2, oxygen and nutrients. Also measured on all of these voyages was isotopic oxygen ratios in the seawater molecules (d18O). These allows the estimation of the relative contribution of meteoric (precipitation, glacial) vs sea-ice melt to freshwater in the ocean. These ORCHESTRA cruises were conducted in collaboration with the TICTOC (Transient tracer-based Investigation of Circulation and Thermal Ocean Change) NERC funded large grant (PI E. McDonagh). The TICTOC component of the voyages measured CFC/SF_6 concentrations in the water column, allowing the estimation of the approximate time since water has interacted with the atmosphere. Finally these voyages served as the platform for numerous other opportunistic and CASS funded projects, including measurements of ocean plastics, chlorophyll, OVOCs, isotopic nutrient ratios, bomb radiocarbon and the deployment of numerous floats and gliders for international and UK programmes.

ANDREXII is itself a repeat of the original ANDREX (ANtarctic Deep water Rates of Export) line. This experiment sought to estimate the transformation processes within the Weddell Sea that lead to the formation, mixing and export of deep and bottom waters. These waters, combined with similar exports from elsewhere around the Antarctic margins, form the deepest and densest water masses in the global ocean. They ultimately spread as far as the north Pacific and form the ‘bottom cell’ of the global overturning circulation (Marshall and Speer 2012). These water masses, as they have been in relatively recent contact with the atmosphere, form an important route for the subduction and storage of atmospheric properties, including heat and anthoropogenic carbon. Once subducted in bottom water these tracers may be trapped in the ocean for several hundred or even thousands of years. Several studies show that the properties and volumes of Antarctic Bottom Water are changing on decadal timescales (e.g. Purkey and Johnson 2010, Purkey and Johnson 2013) and this is suspected to be due to changes in their formation regions. However formation occurs in the depth of austral winter within regions that are extremely difficult to access, so direct observations are very rare. Instead, large scale inverse studies like ANDREX allow the indirect inference of formation rates and property uptake by these key water masses via the measurement of all water flowing into and out of the Weddell Sea.

The original ANDREX line was conducted in two parts. The first was undertaken in January 2009 on the RRS James Cook (JC30, Bacon and Jullion 2011) and occupied stations from 30^{o}E westward to approximately 27^{o}E (JR18005 station 69), before a medical evacuation forced the abandonment of that voyage. A recovery voyage was hastily scheduled for the following year aboard the RRS James Clark Ross and was conducted in March-April 2010 (JR239, Meredith 2010). The station plan of these two voyages is shown in Figure 1.2, as well as two associated voyages (I6S and SR4).

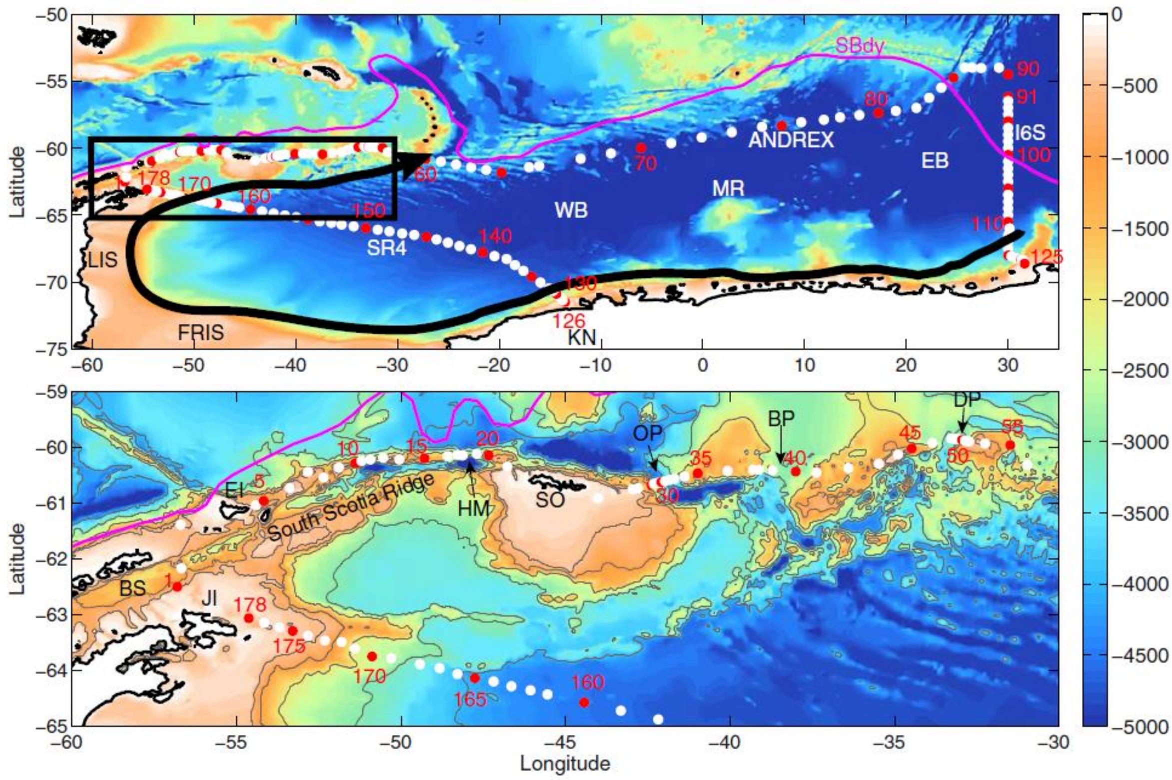

Figure 1.2: Station plan of the original ANDREX section, made by combining the lines of JC30 and JR239. Two additional sections are also shown. I6S at 30E and SR4 across the central Weddell Sea. I6S was also conducted at the time of ANDREXII. Note the black arrow showing the schematic circulation of the Weddell Gyre and slope current. Figure reproduced from Jullion et al., (2014).

The hydrographic data collected on the original ANDREX and I6S lines is shown in Figure 1.3. Notable is the presence of a positive gradient in temperature and salinity beginning at approximately 20ºE and peaking at 30ºE. In Figure 1.2 this can be seen to be due to the presence of the Southern Boundary of the Antarctic Circumpolar Current (ACC). The ACC has sharp meridional gradients in temperature and is associated with much stronger currents than the northern boundary of the Weddell Gyre where the current is relatively broad and slow. As the section clips the eastward flowing ACC, which immediately then exits the 'box' via the I6S line, this create a strong in and out transport signal, which while powerful, does not significantly modify the interior properties of the Weddell Sea box. This therefore is a source of significant error in the large scale inversion of both physical properties such as heat and freshwater (Jullion et al., 2014) as well as biogeochemical tracers like dissolved inorganic carbon (DIC) (Brown et al., 2015).

In order to avoid such a strong contrast in properties and velocities the ANDREXII line deflected polewards to the east of 20ºE (ANDREXII station 93), eventually intersecting 30ºE at 60.5ºS. This largely avoided the strongest currents, although a notable temperature and salinity gradient was still apparent. Other than this planned deviation the cruise plan for ANDREXII aimed to reoccupy each of the original ANDREX stations as closely as possible, a goal that was largely met.

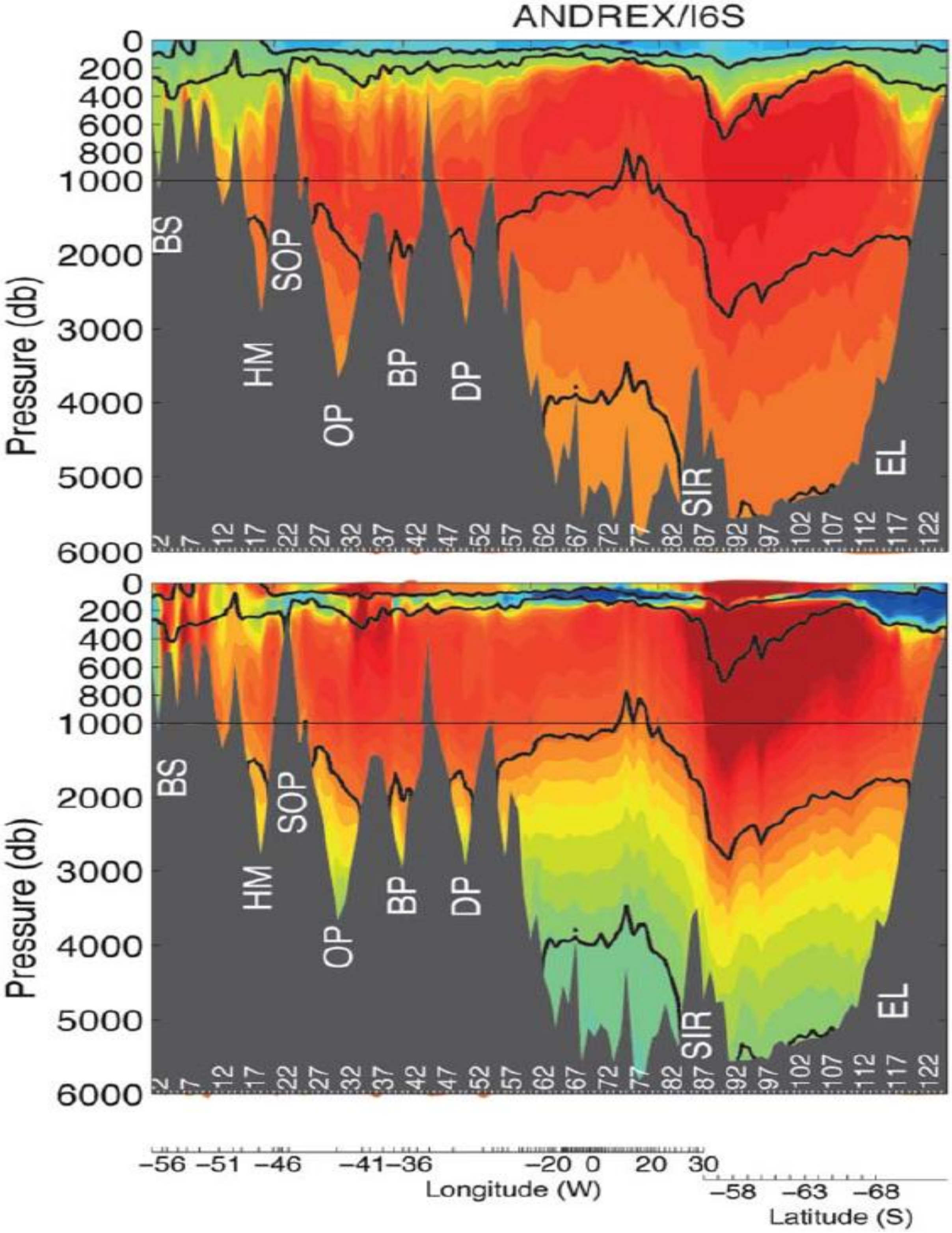

Figure 1.3: Salinity and temperature hydrography from the original ANDREX and I6S lines. Note tempreature and salinty increases at the intersection of ANDREX and I6S (Jullion et al., 2014)

As part of the ORCHESTRA programme ANDREXII collected underway hydrographic and meterological observations and on CTD stations measured temperature, salinity, oxygen and water velocity through the water column to full depth. Niskin bottle samples (24 per station) were taken and were sampled for DIC, pH, O_2, nutrients, C_{13} and d18O. CFC/SF_6 bottle samples were collected by the TICTOC team. Further samples were taken in support of four opportunistic projects: 1) Volatile Organic compounds (OVOC) were collected in support of a PML PhD studentship, from the underway supply, an air probe mounted in front of the bridge and from CTD Niskin bottles. 2) Isotopes of Si and N were collected from Niskin bottles by and for Edinburgh University. 3) Bomb C_{14} isotopes were sampled in support of Princeton University (USA), in collaboration with ORCHESTRA. 4) Finally eDNA sampled were taken from Niskin bottles in the mixed layer in support of a BAS project.

ANDREXII included some secondary scientific goals that influenced the cruise design and track. First amongst these was the observation of air-sea turbulent heat and pCO_2 fluxes using an underway system mounted in the foremast and maintained by PML. This system, installed in 2018, provides the JCR with continuous measurements of these important but poorly observed fluxes. Although primarily intended to operate autonomously, this voyage included a dedicated PML team member to operate the system and conduct complimentary air-sea flux experiments. Additionally overflights from the BAS MASIN meteorological aircraft were conducted from the Falkland Islands. These collected complimentary air-sea flux data at the same time/location as the ship, allowing calibration and cross comparison of existing aircraft and ship datasets. A further aim for the shipboard flux system was to conduct observations in varying sea states, including sea ice cover.

Secondly ANDREXII deployed six SOCCOM (Southern Ocean Carbon and Climate Observations and Modeling project) floats at selected locations along the cruise track. These required specific calibration measurements from the water column where they were deployed. A FLBB (fluorometer and backscatter) instrument supplied by the Scripps Institute of Oceanography (San Diego, USA) was attached to the CTD frame, supplementing the existing instruments. Niskin bottles were sampled for carbon (pH and alkalinity) and HPLC/POC in the surface 2000 m and chlorophyll max/surface. Two further ‘Deep Arvor’ floats were deployed in support of the Wapiti programme (Sorbonne University, France). These are specially designed floats which track the bottom using ADCP data and were released together in the Orkney Passage with the intention of tracking the pathway of exported Weddell Sea Deep Water.

Finally, if time allowed, the proximity of the voyage track to the South Sandwich Trench system and the presence of the CFC/SF_6 team aboard presented an exciting opportunity to sample some of the deepest waters in the Southern Ocean. The South Sandwich Trench lies directly in the outflow path of the densest Weddell Sea waters, but its remoteness and depth has precluded sampling, or even proper survey. Instead analysis of variability of Weddell Sea deep and bottom waters often come from the significantly shallower Orkney Passage, which ANDREXII would also occupy. The opportunity to contrast these measurements, and survey the trench system to support future science plans, was a great opportunity on ANDREXII.

1.3 References

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1.4 Cruise participants

Scientific party

Name	Institute	Primary Responsibility
Andrew Meijers	BAS	Principle Scientist
Hugh Venables	BAS	CTD lead/processing
Rachael Sanders	BAS	CTD operation
Christina McKenna	BAS	CTD operations
Ciara Pimm	UoL/BAS	CTD operations
Natalie Freeman	Scripps	CTD operations/SOCCOM
Marie-Jose Messias	UoE	CFC/SF_6 team lead
Herlé Mercier	INSU	CFC/SF_6 team
Gen Hinde	UoE	CFC/SF_6 team
Jack Hughes	UoE	CFC/SF_6 team
Gary Murphy	UoE	CFC/SF_6 team
Alan Kennedy-Asser	UoB	CFC/SF_6 team
Malcolm Woodward	PML	Nutrient team lead
Sarah Breimann	UoS	Nutrient team
Ian Brown	PML	DIC/O_2 team lead
Mary Chris Lagumen	POGO	DIC/O_2 team
Mingxi Yang	PML	Air-sea fluxes
Charel Wohl	PML	OVOC
Carrol Arrowsmith	BGS	d18O/C13/C14 isotopes
Margot Debyser	UoEd	S, Ni isotopes
Aisling Smith	BGS	Lab Manager
William Clark	BAS	AME
David Hunter	BAS	IT
Richard Phipps	NMF	LN2 generators

BAS: British Antarctic Survey

Scripps: Scripps Institute of Oceanography, San Diego USA.

UoL: University of Liverpool

UoE: University of Exeter

INSU: Institut National des Sciences de l'Univers

UoB: University of Bristol

BGS: British Geological Survey

POGO: POGO research fellow

NMF: National Marine Facilities

1.5 James Clark Ross officers and crew

Name	Role
Graham Chapman	Master
Annalaara Kirkaldy-Willis	Chief Officer
Sam Vargas	2nd Officer
Scott Cramman	3rd Officer
Gail MacGregor	3rd Officer
Patrick O'hara	ETO comms
Andris Kubulins	Chief Engineer/Mountain
Christopher Donaldson	2nd Engineer
Aleksandr Hardy	3rd Engineer
Steven Eadie	4th Engineer
Robert Sutton	Deck Engineer
Lloyd Sutton	Purser
Amber Chadwick	Doctor
Clifford Mullaney	Bosun Science
Noel Littlehales	Bosun
John O'Duffy	Bosun's Mate
Stephen Pictor	Motorman
Carlos Vargas Leon	Motorman
Arnis Macans	Motorman
Martins Neilands	SG1A
Paula Munoz Garcia	SG1B
Colin McMaster	SG1A
Craig Lennon	SG1A
Alan Howard	SG1A
Samuel Fish	Chief Cook
Victoria Stone	2nd Cook
Derek Lee	Senior Steward
Eric Bourne	Steward
Oliver Burch	Steward
Kevin Ward	Steward

1.6 Principal Scientist's narrative

Andrew Meijers

Hello ANDREX fans! The following is a retelling of the trials and tribulations of the 54 souls undertaking a voyage that will surely become legend in the annals of Antarctic exploration. You may have heard stories, but let me tell you, they are nothing compared to the deprivation, horror, triumph, disappointment and ultimate enlightenment hidden in these coffee stained pages. Dear ocean fancier, please read on.

16-21st Feb: After arriving in Punta Arenas following 36 hours of Iberia and LAN flights, including a race across the Atlantic by the science party split across two separate aircraft, the tired group collapsed in a hotel on the 17th of Feb. The following four days of mobilisation (penguin watching for some) went, on the whole, smoothly for most of the compliment. The exception was the CTD wire. On JR18002 it was noted that the shiny and recently purchased cable came heavily lubricated. This was found to be unsuitable for use on a traction winch which experienced serious slippage once below a few thousand m. A new, very explicitly ungreased, cable was ordered and the whole season rearranged around changing the cable over in Punta. Two engineers were specially flown down for the task. However, upon popping open the new cable drum they found it just as greasy as the last. Previous experience had showed that trying to degrease the cable by hand was a Sisyphean task, so the engineers promptly sealed the drum back up, downed tools and headed back to the UK. Their commentary on the matter was largely unprintable.

While this may ultimately be our undoing, we do have secondary cable options. The deep tow (conducting wire) cable performed well enough on deep casts on the previous voyage as an *ad hoc* CTD cable, and there is still an old, rusty, but ungreased regular CTD cable available for depths shallower than 3800 m. Our hope is that the short cable will work for the first half of the voyage, where depths are rarely deeper than 3500 m, while the deep tow should ‘hopefully’ carry on working for the deeper eastern end of ANDREXII. However without a backup, should the deep tow cable fail, the science goals of the trip would be unachievable. So it was with trepidation that we set sail at 1400L on the 21st on the first leg of our trip. Heading out the strait of Magellan towards the Falkland Islands we watched dolphins frolic in the sun and hoped for the best. Running with the tide the ship made a very impressive 22.5 knots out through the narrows.

22nd Feb: Clearer skies this morning and continued good progress cheer the science party, who busy themselves with final setup and meetings to plan CTD operations. The deck engineer and colleagues have been working extremely hard to ready the CTD winch for operations after it sprung an oil leak, and labor through the day. The hope is that it will be ready for a test cast tomorrow afternoon. Final preparations and locations for the overflight of the BAS MASIN aircraft tomorrow are made, and hopefully we will see the red Twin Otter overhead tomorrow morning, to make co-located pCO2 flux measurements. The first of many birthday cakes this trip is consumed in the bar in the evening, and a general good mood pervades.

23rd Feb: Winds in the low 20kts greet us this morning and we can finally switch our instruments on, now we are clear of Argentine waters. VMADCP goes on, with the hope of putting it in bottom track mode as soon as we are in shallow waters to get some calibration data. The underway system also is turned on, just in time to get some pCO2 ocean data to go alongside the air-sea flux and turbulent flux data coming from the foremast and the aircraft. Although there are some glitches with comms the red BAS twin otter overflies the ship bang on time and commences several passes perpendicular to the ship, which is holding station with the head into the wind. To the delight of the many gawkers on the monkey island the passes are extremely low, at least mast height if not lower, as the atmospheric physicists gather flux data as low in the boundary layer as possible. Ming is happy with the ship measurements too, and after the aircraft departs around 12:30 local we proceed further east towards the Falklands Trough for our test CTD. The aircraft makes it back at around 1530 local and the show is repeated, with similarly successful data collection. Around this time the deck engineer finally succeeds in getting the CTD winch back together (a leak in one of the engines) and BAS AMT Will Clark gets the CTD terminated and prepped. Following a quick deck tension test and a 40 m cast, at 1800 CTD 001 hits the water. The usual horde of entertainment starved scientists cluster in the winch annex to annoy the winch operator and stare at wiggly coloured lines as they inch their way down the CTD data PC displays to ~2100 m.   Following a successful cast water is taken to calibrate the CFC GC and the nutrient autoanalyser. Training on sampling techniques for all the newcomers is also carried out and the sample cop log sheets found to be wanting. Lots learned, we head to Stanley overnight.

24th Feb: We awake to 30 knots from the south and squalling rain as we enter the Stanley heads around 0730 local and come onto FIPASS just after 0830. People are away quickly to enjoy the cosmopolitan joys of Stanley, or trailing after the determined strides of Hugh Venables on a mission to find some penguins. The aircraft flight crew, engineers and scientists visit the ship to compare notes and instruments with Ming. Charel Wohl’s mass spec, the cause of considerable angst over shipping timetables in past weeks, arrives bang on time and is unceremoniously man handled into position in the main lab, where it is quickly lashed down and plumbed in. Finally all planned science is mobilised and set up on ANDREXII! Shore leave finishes at 12, boat tests are conducted and with that we are away south again. The PSO give a long and rambling, but politely received, science talk and general cruise briefing, followed by the more enthusiastically attended quiz night run by Amber the ship’s doctor/most eligible bachelorette.   The first rough seas are encountered as we clear the FI, and it seems we may be in for a bumpy night.

25th Feb: Sea state 5-6 and a fresh southerly greet us this am, and the ship is bouncing its way towards CTD #002, a cast immediately south of Burwood bank in the deep water of Drake Passage. This is to find circumpolar deep water to sample on all bottles at one depth, in order for M-J Messias and her CFC team to take 'blanks' to calibrate their gas chromatograph with.   The winds ease through the day and we reach the station at around 1800 local. Lower CDW is found at over 3200 m, and all bottles fired. Slight winch issues on recovery but nothing too worrying. CTD back on deck at just after 2015 and we are off south again. All bottles sampled and one taken for sparging. Charel has tuned and calibrated the MS brought aboard yesterday and all is well with the world. Weather is looking positive for the next few days, all aboard are now keen to get on with it!

26th Feb: Calm seas this morning for our last passage day for some time. CTD training continues, and watchkeeping begins in earnest. LADCP data is processed, as is VMADCP and the ship underway instruments.   Ship much quieter now as people progress onto their 24 hour watches.

27th Feb: Bright skies belie rough conditions, with strong and persistent southerlies kicking up a very short wavelength swell and making our trek to the southernmost station hard going. We reach it (CTD 003) around noon, but despite the captain wrestling the ship onto station on DP the swell eventually forced us to admit that a CTD would not be going in today. Winds averaging 40-50 kts and wavy spray filled seas continue through the day. Long bands of sea ice make for good viewing, as do many icebergs. We hold position overnight and hope for better weather in the am.

28th Feb: Similar conditions to yesterday, but wind is marginally weaker. Brave winch driving sees CTD 003 go in at around 0730 despite winds 35-40 kts and angry short wavelength whitecaps. Weather eases through day and by CTD 005 things are considerably easier. Lots of sunshine, bergs, whales and sightings of islands in the distance make it a great day to finally get some science done. Sampling goes surprisingly smoothly and each station is done in around an hour. However, they are shallow and have many duplicate bottles, so future stations will be slower.   Slight concern about engine reliability, as a few false alarms are triggered and one of the main engines is reluctant to start when asked...later fixed but an eye is kept on them!

1st Mar Light winds, good visibility and easy working conditions. We get numerous CTDs done today. Bottle 21 continues to leak, so is replaced prior to CTD 10. On CTDs 008 and 009 bottle 24 fails to close, but problem does not appear to continue after a rinse down with freshwater.   Hoping progress continues this well in the future.

2nd Mar: On we progress. CTD 019 is aborted at 2000 m due to an electical failure. Following a swift retermination by AME Will it is back in the water (dud cast renamed to CTD919) and working well. Otherwise things proceed swiftly with calm seas and efficient sampling.   First SOCCOM float goes in the water at around 2200, followed by a marathon sampling and processing effort by Natalie, taking her through to 0730 in the morning!

3rd Mar: Calm weather continues, and we have a nice 10 hour break in sampling as we pass over the Orkney Plateau. Happily the fastest route takes us through the Lewthwaite Strait in the Orkney islands and we are greeted by gorgeous sunshine, warm temperatures, stunning scenery and plentiful wildlife. All aboard enjoy sightseeing as we pass with glaciers on both sides and whales and penguins in all directions. A drone flight captures it all as we pass on our way to a very shallow CTD024. A welcome diversion from sampling. Up LADCP head fails on this cast, but a deck trial afterwards suggests it was a one off fault.

4th Mar: Bright sunshine, but rising winds. Still easily workable. CTDs progress continues apace and we are ripping through the schedule now. Orkney Passage sees the deployment of three floats, one SOCCOM and two AVISOR Deep floats, designed to sit just off the bottom and follow the deep cascades of WSDW off the sill and into the Scotia Sea. Pump failure on CTD 032 on probes 1 and 2, but otherwise things appear to be working well and we are now ahead of schedule.

5th Mar: Increasing swell and sea mist make this a lumpy and dull day. Rapid progress on CTDs is now putting the CFC team well in arrears for processing. We try to slow the tempo of sampling by instituting a 7 kt speed limit on the ship, and increase the time on station to give them a chance of catching up. Shiptime advanced an hour as we march steadily east.

6th Mar: Heavy seas from the north across our track force dog legs between stations, and a fairly sleepless night, slowing us down appreciably. Slightly longer between stations is good for the CFC teams however as they are still well behind and risking running out of bottles.

7th Mar: Overcast but slightly lighter swells. Spent most of today swathing “Bett’s Bump”, or “Brearley’s Bane”; an uncharted seamount on Discovery bank that unexpectedly went from 1500 m to just 41 m in water charted at over 400 m on the previous voyage, causing some consternation. In order to give the CFC team time to reduce their backlog of samples we undertook a 12 hr detour and swathed the seamount, mapping it well aside from its very peak, which disappointingly was obstructed by two freshly grounded bergs. CTDs recommended at 1940 local.

8th Mar: Fairly uneventful day, with CTDs continuing to be knocked off quickly. The last of the closely spaced, relatively shallow stations are finished in the evening. Over half the planned CTDs are now completed, but barely a third of the ‘wire out’ has been completed due to the depth disparity in the first and second stages of the voyage.

9th Mar: Curious humpbacks put on a show close to the ship at several of the CTD stations today. Spyhopping and fluke waving to the joy of all aboard. An issue with

Niskin bottles 21 and 23 emerges. Now that data is being processed it appears that on several station the bottles have appeared to have shut properly, but the water inside has curious properties, ranging from quite deep water to mid depths, but certainly not surface water as it should be. The problem appears to be due to new, longer, lanyards allowing the bottom cap to partially close before firing, trapping water inside with only the top to escape from. Upcasts then produce an odd integration of the water column before the lid is closed at the surface. Shortening the lanyards prior to station 055 will hopefully solve the issue. SOCCOM float #3 deployed in the afternoon as we pass over deeper water in a passage near Bruce Bank.

10th Mar: Final CTDs of the first phase pass uneventfully. Before beginning a few days down time swathing we change the CTD cable over to the deep tow, as all casts from now on will be greater than 4000 m and too long for the old cable. The deep tow works, but the winch is hard work to drive due to tensioning issues, and recovery and deployment is obviously going to be difficult in heavy weather. Fraying issues at the termination add to the list of problems that will need to be sorted over the next few days of swathing before CTDs begin again. SOCCOM #4 goes out smoothly. Finally an evening with no work for people (aside from the CFC team, frantically working their way through the backlog of samples) so the bar is well populated for a change.

11th Mar: We finally have the best part of a day off CTDs as we steam up the middle of the South Sandwich Trench. We successfully identify two sills, where satellite gravity missions had suggested they were. Annoyingly the two sills aren't ideal candidates for observations. The first is a neat pinch, but has a deep central channel down to 6500. The second has its shallowest point at 6000 m, observable, but has a complicated multi-channel structure. We carry on past the sills to a northern limit where a previous swath pass has been, before steaming south. Once back at the southern swathing limit we turn back to the northern most sill and begin CTDs, starting at 3000 m on the western edge, and planning on working down to two deep 6000 m casts, before coming back up the eastern edge. Improvements to the deployment/recovery technique means the deep tow is a bit better to use, though still significantly more difficult than the CTD wire.

12th Mar: Casts carry on overnight and into the new day. A CTD conductivity probe is replaced, but reads incorrectly on the next cast which was conducted with one remaining 'good' sensor. This fault was later traced to the incorrect probe being swapped on the rosette, and the application of inappropriate calibration settings on the deck unit, resulting in one broken probe being used (broken, though only with a small offset) and one new probe with the wrong calibration. Fortunately the issue can be repaired in post processing, and 14 salinity samples were taken to aid this. Following during the 6000 m cast (on the way up) a problem was noted by the deck engineer Rob. The 'deep tow' conducting cable being used in the stead of a CTD wire apparently is only safely rated to just below 5000 m with a CTD package weight on it. This means the casts we had just completed risked damaging the cable and potentially finishing the expedition very early...The decision was then taken to abort the next planned CTD cast, and particularly the very scientifically exciting 6800 m dips into the SST. Instead we will take two more shallower profiles in the trench before carrying on with the ANDREXII line. The hope is if we finish it early we can pick up these casts on the way back when there is less consequences for damaging the cable. C'est la vie.

13-17th Mar: A stressful series of days for all, but particularly BAS AME Will Clark. It began with a loss of contact with the 5000 m CTD in the SST, exhibiting as a blown fuse on the CTD deck unit. Upon returning to deck and replacing the fuse the instrument performed perfectly. The next cast at 4000 m was conducted before returning to the 5000 m cast and repeating it. Upon returning to the ANDREXI line we began to encounter more and more issues with the instrument, always in the form of a blown fuse and lost contact at some depth greater than 2000 m. Each time the whole cast was lost, except in one instance where replacing the fuse with the instrument still in the water managed to recover the rest of the cast with only the loss of a few 100 m on the upcast. Repeating this trick did not work on the next cast. Close examination of the CTD wire revealed damage to the exterior where the earlier replacement of swivel resulted in fraying of the cables near the termination. Mechanical and electrical retermination promised to fix the problem, but unfortunately the next cast failed in exactly the same way. Will re-did the electrical termination, but again, this did not solve the problem. All aboard are perplexed by the issue. While not on station testing the wire we continue to steam east along the line, in the hope that we can pick up the missed stations on the way back, and so as not to lose time sitting still while solutions are sought.   A particularly low point occurs on a 0300 cast, where I am called out of bed to attempt a previously discussed trial with progressively heavier and slower fuses. Unfortunately all this achieves is blowing three CTD fuses and then the deck unit one! All potentially problematic parts have been swapped out on the CTD itself now, and clutching at straws begins in earnest. An apparent solution is finally found when we remove the entire CTD swivel and just run with the wire directly coupled to the CTD frame. This means rotations will twist the wire, but to our joy we complete a whole cast without issue. As we carry on the long steam to the next station a St Patrick's Day ceilidh is held in honour of the patron saint of CTDs...dancing and singing carry on long into the night, fueled by not a little Guinness and the great musical and MCing talents of Alan Kennedy-Asser!

18th Mar: CTDs continue successfully to the relief of all. Calculations show we've only lost a day overall to the multiple failed casts. Though the pain was spread across several days our steaming east means we have mostly just swapped an eastward CTD leg and westward return for an eastward steam and westward CTDs. Analysis of LADCP logs suggest that on the whole the CTD twists in both directions, resulting in relatively few turns overall (approx 44 clockwise over 5 km of wire).

Slight concern when a kink is noted immediately above the frame in the evening, but the wire appears otherwise undamaged and electrically sound. In the ‘to watch’ basket for now.

19th Mar: CTDs carry on smoothly, though they continue to accrue clockwise rotations on the wire. The kink above the CTD is suspected to be due to mishandling on deck rather than the wire twisting. It appears fine, so we carry on. An interesting site greets us today. Four or more oil barrels were sighted floating past as we steam east, crossing the meridian late in the day. Long lenes and quick reactions allowed us to get a snap of these as they passed. Clearly legible on the diesel and aviation gasoline drums were stencils saying ‘Operation Deep Freeze II’ and ‘Task Force 43’. These are relics of the 1956/57 US operation to establish bases in the Antarctic. Some googling revealed that the barrels may have come from either Ellsworth Base or Little America V base, both established and resupplied on ODFII. Both bases were subsequently abandoned, buried in the snow/ice and eventually calved off of ice shelves in the 1980s. We suspect that Ellsworth base, on the Filchner Ice shelf is the more likely candidate as the closer of the two. It seems most likely that these were recently deposited in the ocean by one of the many rapidly melting bergs that we are transiting through. A fascinating and unexpected bit of Antarctic history!

20th Mar: CTDs carrying on smoothly. The kink does not appear to be getting worse and we keep track of the number of turns on the wire via the LADCP record. They appear to be largely clockwise, which will result in a loosening of the outer wire and tightening of the inner. A frayed area has appeared immediately above the CTD termination, but below the kink. Both deck engineer and AME are happy that we can carry on with it. Another couple of floating barrels were spotted today.

21st Mar: More CTDs. On these long legs between casts (10 hours!) and very deep casts (>5000 m) the day passes quite slowly. Some casts turn almost exclusively anti-clockwise now, so it appears there is only so much twist that can be put on the wire before it starts fighting back. One more barrel in the afternoon. Bridge crew sufficiently bored by the long casts that they ask a scientist to check that all the freezers are running. Upon dashing through the ship and then answering that, yes, they’re running, the bridge informs the scientist that they’d better go and catch them! Revenge is plotted.

22nd Mar: A glassy sea greets us this morning, with distant clouds making the edge of the sky and sea blur together. Almost zero wind forebodes a calm before the storm, which we see gathering in the met obs. A solitary barrel greets us and we are forced to move the morning cast slightly to avoid an inconveniently placed iceberg. Happy scientists sampling with the door open as we come off station. Wire still in one piece. Wire twist appear to be causing slippage on the winch drum, particularly at depth, forcing speed down to 50 m/min above 5000 m, and 35 m/min below. Slowing things down a bit.

23rd Mar: CTDs carrying on. Another kink has appeared in the wire overnight, further up than the previous one. However the wire and instruments continue to behave. Weather forecast for the next week is looking grim, starting tomorrow. Hopefully we can continue to work a little longer.

24th Mar: And it isn't to be. The dawn sees the ship hove to with winds and swell just on the wrong side of workable. The ship holds station over CTD92# and we wait. Conditions deteriorate over the day, though everyone does appreciate the break.

25th Mar: A slight let up in the morning quickly deteriorates and we encounter the heaviest seas of the trip so far, with rolls of up to 20 degrees in either direction. We remain on station, but have decided the forecast is too grim along our planned track to continue with that plan. Instead we will get this station in a small gap forecast tomorrow, and then head to 30E along a more southerly route, hopefully taking stations along the way as weather allows. Though the gaps in the angry red wind and wave charts look quite small.

26th Mar: The weather is thankfully clearer this morning and we manage to get the CTD into the water. We then plough onwards, heading towards 60.5oS in the hope of remaining in the eye of the storm and being able to continue working as we head to 30oE. Another CTD at 2100 this evening gives hope that this may be the case. Annoyingly this is parked directly on a seamount, so does not capture the deepest layers, but the decision is made to take it rather than waste more time looking for another site in the face of deteriorating conditions.

27th Mar: The weather remains borderline, but we carry on on course, getting another of our ad hoc spaced stations done at midday. We are still in the eye of the storm, but our luck cannot hold much longer as we must cross its edge at some point.

28th Mar: Unsettled seas carry on, but the final station before reaching 30E is finished in the morning. We arrive, finally, at 30E at around 2000 this evening, but conditions are too unsettled to deploy, and the decision is made to wait for the morning to reassess. A request from Gothenburg. One of their Southern Ocean gliders is stuck at the surface and needs saving. The scheduled pick up by a NPI vessel has been diverted due to ice, so they are asking us to rescue the glider. At 0E, 60S it isn't far off our return track and we are already geared up for collecting kit, so we say yes assuming all goes well.

29th Mar: After a very bumpy night we wake to very lively sea and the ship struggling to hold station. After continued delays and 'reassessments' we finally get the instrument into the very unsettled chop at 1300, after a long delay with it dangling precariously over the side waiting for a gap in the rollers. Unfortunately the wire was not set properly in the block and we needed to retrieve and straighten it, resulting in another long tense wait for the instrument to go back in. Finally it is in and the last

SOCCOM float follows it. As the weather clears we also collect the penultimate cast at around 2100.

30th Mar: Final CTD at 30E achieved by 11 am, and to universal sighs of relief the ship is off to the west at last. We are notified that the lost glider will be recovered by NPI so we are free to take a more southerly and faster great circle route to our missed CTD stations on the ANDREX line. Three birthdays are celebrated in the evening, and with folk coming off shifts and the prospect of a few days of down time, it becomes quite lively!

31s Mar: Steaming day, making good progress to try and recover as much time as possible for the final spell of science.

1st Apr: A strange new island is sighted at dawn, uncharted on any maps or satellite obs available to us. We send a party via small boat to scout out the new land, a grim and dark peak growing ominously from the sea. Radio contact is lost almost immediately upon their landing and disappearing into the wilderness of cyclopean blocks that seem to make up the landscape discernible from the ship. Many hours pass and as dusk falls we are just preparing a retrieval party when the first expedition returns. To the shock of all aboard several of the group are missing, and those that remain sport blank, sunken eyes and unsettling beards where only this morning there were none. The survivors, for that is how we now think of them, are listless and will not be drawn into conversation, muttering only one thing, over and again: "*Iä! Iä! Cthulhu fhtagn!".* A sense of cosmic horror creeps over the ship.

April first sees a series of pranks all over the ship, and none are safe, not even the cruise report. Later in the day we are contacted by Gothenburg University, in a much more serious mood. Apparently NPI can no longer pick up the glider. Unfortunately we have taken such a southerly route on the great circle that we will lose far too much time if we divert now. We consult BAS ops, but I believe we are too far away now and would risk ORCHESTRA science to pick it up.

2nd Apr: Still steaming fast towards final ANDREX stations. BAS ops has said they have received no official request for glider pickup, and can’t sanction a diversion without one. We appologise to Gothenburg and carry on. Hugh Venables receives his belated one year aboard the JCR ceremony. The crew and scientists have produced a very nice trophy, an old crushed Niskin bottle with an illustrated and engraved plaque!

3rd Apr: Getting close now, it now looks like we’ll arrive on station tomorrow 12 hours early, excellent progress! Even better the weather forecast is looking remarkably clear in our area of operations for a change.

4th Apr: We are informed that NPI eventually diverted and recovered the glider after all, so all’s well that ends well. For us anyway! Despite lumpy swells overnight and a five day steam, we still arrive on station bang on lunchtime, as is traditional.   CTD proceeds smoothly and we retire to the bar for yet another birthday!

5th Apr: Aaand it's broken again. This section of ocean, which forced the original ANDREX to turn back with a medevac and broke our CTD for several days on the outbound leg, is surely cursed. We awake to find that overnight the CTD alarmed at 10 m in the water. It was brought back on, tested, and then once load put back on, alarmed again. Given the degree of twisting and kinking of the wire, a failure in the few meters above the instrument is immediately suspected ans a re-termination was carried out at around 4 am. By 9 pm the electrical termination is judged to have set well enough to go in, but unfortunately the wire fails its initial tests and a new discovery is made; the actual cause of the failure was the slip ring joining the wire spool to the ship electrical systems. The 'slip' had failed, resulting in the fixed ship end of the wire twisting and parting. This was rapidly remedied by AME and deck engineer and a CTD hit the water in the early hours of the 6th. The retermination may possibly have been unnecessary, but ultimately needed to be done anyway. So at least we are well prepared for the very deep CTDs to come.   Unfortunately the loss of a day means that we are now unlikely to get to the sea-ice, to the disappointment of all.

6th Apr: CTDs continue smoothly today, in blessedly calm conditions, and we finish the two penultimate casts of the ANDREXII line. Bottle 1 is noted to have closed early on these two casts, but the problem does not persist. Icebergs and penguins are back, and with the sunshine the mood is definitely lifted. A successful night time drone flight captures the ship in calm night conditions with dramatic lighting.

7th Apr: The final cast of the ANDREXII line is finished just before lunch, to general celebration, and we set course northwards to the deep South Sandwich Trench stations. Almost immediately though a discovery is made that will alter the rest of the voyage. The traction winch that has been driving the conducting wire (deep tow) for the CTD has split a sheath. This is judged unrepairable at this time and so, just like that, we cannot conduct any further deep CTDs. This means the 6000m + casts of the SST are now impossible, so we are forced to drop this potentially very exciting science and instead head to pick up the glider.   While disappointing, we are glad that we still managed to finish the ANDREXII line, as this problem could easily have appeared a few casts earlier!   Oddly the science team don't share the PSO's upset, and there is general acclaim when it is announced that we will instead try for the ice for CO_2 air-sea flux measurements.

8th Apr: A quiet day as we make our way to the BAS glider location at Discovery Bank, deployed on the previous voyage JR18004. It has been sent on a southerly course to meet us. As we are now a day earlier than expected the glider won't quite make it, but we will not need to divert far. Comms are established with the glider and Hugh takes control over from Cambridge.

9th Apr: We arrive at the glider location at 6 am, and immediately conduct a calibration CTD. This is in much shallower water than expect (550 m vs 3500+m) as the glider is a day short of its intended pickup location. The thermocline proves to be shallow enough however to collect decent calibration data. Turning on the glider strobe it is quickly picked up in the pre-dawn dark, and once light allows it is swiftly brought aboard. As we are ahead of schedule for arriving at the ice, and not wanting to go in before dawn we have a few hours to spare. We will therefore use the opportunity to call in the sheltered waters near Signy and open the rear science hold hatch to begin the long demoblisation process. Otherwise there will be very little time to do so in port before the science party departs. The evening sees another pub quiz, and the world premiere of the musical 'Fergus and Finn', penned by the unreasonably talented Alan Kennedy-Asser, and performed by the less than talented scientists and crew.

10th Apr: A passage day towards the sea ice, but broken up with a call into the South Orkney Islands along the way. The calm water immediately off Signy base allows the rear hatch to be opened to the science hold, and boxes transferred up to allow the CFC team to complete their demobilisation before arriving in the Falkland Islands where there would be significant time pressure. Several boxes from teams in the main lab are taken down to the hold and securely stowed. Everyone enjoys the views of the first land we've seen since the third of March. By 1800 we are off out of sight of the islands again and heading towards the sea ice.

11th Apr: Dawn breaks with us just north of the ice edge. Strong nor-westers have pushed the ice edge away from the satellite indicated location, and it isn't until approximately 0900 that we find it. The science goal of measuring the wind and pCO2/heat fluxes across sea ice means that we need to skirt around the south western edge of the ice before turning into it, to ensure the wind has blown across as sufficient area of ice to be meaningful. We enter the ice at 1000 shiptime, encountering a mashed up mix of new and multi-year ice and large amounts of brash. Large numbers of seals, including fur, crabeater and leopard meet us, as well as assorted Minkes and a lone Adelie penguin. A suitable air-sea flux station is eventually found around 1100 and we settle onto it. After lunch we move the ship to an open lead in the lee of a very large berg and a CTD is conducted to 500 m for the CFC and air-sea flux/OVOC teams. Following the CTD we move closer into the lee of the burg to shelter from the wind, gusting above 35 kts. Here we break out the BBQ onto the rear deck and begin the end of cruise party! Much fun is had by all in the surreal conditions amongst the drifting ice as the local Australian and South African are set to work on the grill. After sunset we leave the ice and all retire to the bar for a well-deserved drink and several ceilidh dances.

12th Apr: Heading back across Drake Passage. A bright, sunny day slowly warms up the compliment of the JCR, who are moving remarkably slowly this morning for reasons unknown. The business of packing up begins in earnest. Underway sampling is suspended by the physical oceanography team although the CFC lab is still running samples and Charlie remains fixated on the underway water supply.

13th Apr: Drake Passage reminds us that the cruise isn't quite over yet, and headwinds over 40kts and heavy seas make progress very slow. The strongest rolls yet encountered (22+ degrees either way) make packing messier than it needs to be! Sea state improves in the evening and we continue with the business of tidying up two months of work and life aboard. Completion of the cruise cross stich occurs in the evening. The cross stitch, which forms the cover image of this report, has been led by Rachael Sanders and has had hundreds of person hours poured into it. There has rarely been a moment in the last three weeks (remembering we have been working 24 hours a day) where someone aboard was not stitching it or themselves. Getting it done on time, along with a frame also made and engraved by the science party, is a great testament to the enthusiasm and team spirit of all aboard.

14th Apr: A final days run into Stanley sees much calmer weather and the continuation of tidying up and BoLing before our final call in. The presentation of the cruise cross stitch to the ship occurs in the evening to the acclaim of all.

15th Apr: Dawn arrival into the incomparable beauty of the Mare Harbour naval fueling depo. Final jobs are finished up early and the science party escapes onto dry land for the first time in eight weeks. Some head up to Volunteer Point to view the King Penguin colony there, while others head to Bertha's Beach. Relative warmth and actual sunshine even encourage some souls to go for a brief dip and surf in the breakers. A fittingly social and happy end to a great voyage with an excellent team.

2 Profiling Conductivity Temperature Depth (CTD) measurements

Hugh Venables, British Antarctic Survey

2.1 Introduction

A Conductivity-Temperature-Depth (CTD) unit was used to vertically profile the water column. 105 CTDs were carried out in total, with 99 fully successful and station 74, now processed as 974 reaching the bottom and not being repeated on our return west. The other stations where the CTD failed and were repeated. Cast 71 became split as the CTD failed and was then recovered while still at depth, leading to 871 being the second part of the same cast.

2.2 CTD instrumentation and deployment

The Sea-Bird Scientific SBE9plus CTD was mounted on a rosette with a SBE32 carousel water sampler and 24 12-litre Niskin bottles, and was connected through the sea cable to a SBE11plus deck unit in the UIC. The SBE9plus unit contains a Paroscientific pressure sensor and was connected to dual independent CT ducts with SBE3plus temperature and SBE4C conductivity sensors and an SBE5T submersible pump. A SBE35 Deep Ocean Standards Thermometer makes temperature measurements each time a bottle is fired, logging time, bottle position, and temperature, allowing comparison of the SBE35 readings with the CTD and bottle data. Additional sensors included a Tritech PA200 altimeter, a Chelsea Technologies Group AquaTracka Mk III fluorometer, an SBE43 dissolved oxygen sensor plumbed into the secondary CT duct [note that it was believed on JR18004 to be on the primary duct but was not], a Biospherical QCP2350 photosynthetically active radiation (PAR) sensor, and a WETLabs C-Star transmissometer and a WETLabs FLBB added for the SOCCUM float deployments.

The altimeter returns real-time accurate measurements of height off the seabed within approximately 100 m of the bottom. This allows more accurate determination of the position of the CTD with respect to the seabed than is possible with the Simrad EA600 system, which sometimes loses the bottom or reverts to default values (approximately multiples of 500 m) and, in deep water, often returns depths that are several tens of metres different from the true bottom depth. A fin was attached to the CTD frame to reduce rotation of the package underwater. The CTD package was deployed from the mid-ships gantry on a cable connected to the CTD through a conducting swivel until cast 78, after which the swivel was removed.

CTD data were collected at 24 Hz and logged via the deck unit to a PC running Seasave version 7.22.3 (Sea-Bird Scientific), which allows real-time viewing of the data. The procedure was to start data logging during deployment of the CTD, then stop the instrument at 10 m wire out, where the CTD package was left for at least two minutes to allow the conductivity-activated pumps to switch on and the sensors to equilibrate with ambient conditions. The pumps consistently switched on 60 seconds after the instrument entered the water, as they should.

After the 10-m soak, the CTD was raised to as close to the surface as sea conditions allowed and then lowered to within 10 m of the seabed. Bottles were fired on the upcast, where the procedure was to stop the CTD winch, hold the CTD for a few seconds to allow sensors to equilibrate, and then fire a bottle. The CTD was left at this depth for ~10 seconds to allow the SBE35 temperature sensor to take readings over 8 data cycles. The sensor averages these readings to produce one value for each bottle fire. If duplicate bottles were fired at any depth the SBE35 does not take readings unless there is a 10-second gap between firings. The water sampler needs time to recharge between firings but can cope with at least two in succession.

2.3 Data acquisition and preliminary processing

The CTD data were recorded using Seasave version 7.22.3, which created four files:

JR18005_[NNN].hex hex data file

JR18005_[NNN].XMLCON ascii configuration file containing calibration information

JR18005_[NNN].hdr ascii header file containing sensor information

JR18005_[NNN].bl ascii file containing bottle fire information where NNN is the CTD number.

The SBE Data Processing module *Datcnv* was used to convert the hex file to ascii. *Align* was then used to account for the time lag of the oxygen sensor, with data being advanced by 5 seconds. The cell thermal mass *(celltm)* module was then used to remove the conductivity cell thermal mass effects from the measured conductivity. This rederives the pressure and conductivity, taking into account the temperature of the pressure sensor and the action of pressure on the conductivity cell. The output of this process is an ascii file, named as *JR18005_[NNN]_align_ctm.cnv*.

2.4 CTD data processing

Further processing of CTD data was carried out in Matlab using existing programs, predominantly written by Mike Meredith and Karen Heywood, with modifications by numerous others, and further significant changes made on JR177 and JR307. Further significant changes, mostly generalising the code to reduce the number of adjustments needed between cruises were made on JR17003a and covered in more detail in that cruise report. The scripts mentioned are setup to be non-cruise specific, however they are summarised in respect to JR18005 below:

CTDvarn sets up the cruise-specific details for the processing. These include:

Cruise name. directory paths, file-name conventions, sensors present on the CTD and their position in the SeaBird output described above, which casts to use the secondary sensors.

As this is called in the scripts, the naming must be the same between cruises, but a copy should be kept as CTDvarn_##### as a record and for reprocessing.

- *ctdreadGEN* – Reads in JR18005_ctd_align_ctd.cnv file. Data is then stored in Matlab arrays. The output file is JR18005_ctd_NNN.red.
- *editctdGEN* - reads in *JR18005_ctd_NNN.red* and removes the 10-m soak prior to the CTD cast, through finding the minimum pressure after the soak and asking for user confirmation after displaying the full pressure plot for the cast. Data collected at the end of the upcast when the CTD was out of the water is removed graphically by selecting bad conductivities when the package is out of the water, these going wrong before pumps are switched off and at pressures either side of zero depending on pressure sensor offsets. The selected data points are set to NaN for all scientific sensors. Primary and secondary conductivity are also despiked using the interactive editor at the same time, with the option to edit the temperature profiles and T/S plots (where small conductivity spikes can be more obvious).Selected data points are set to NaN. Output is JR18005_ctd_NNN.edt.
- offpressGEN was run, with pressure offsets applied to the CTD until problems meant that the 9plus underwater unit was changed, after cast 72. The new pressure sensor showed little offset at the end of a cast, but often a large offset at the start but rapidly decaying down so no offset was applied.
- *batch_ctdGEN* - Runs a series of scripts in one go*, deriveGEN, onehzctdGEN, splitcastGEN, fallrateGEN* and *gridctdGEN. OnehzctdGEN* averages data from a 24hz CTD profile to 1 hz for LADCP processing, so creates file JR18005_ctd_NNN.1hz and JR18005_align_ctm_1hz.cnv. *SplitcastGEN* splits a CTD file into an upcast and a downcast, JR18005_ctd_NNN.var.dn and JR18005_ctd_NNN.var.up. *FallrateGEN* fallrate is a matlab version of the seapath loopedit script. It has to be run after the initial soak is removed as it removes any data point on the downcast where pressure is less than one previously recorded or if the fall rate is <0.25 ms-1. Loopedit flags such points (excluding the initial soak if set to) but these flags are not subsequently used in the processing and often did erroneously include the initial soak. This process results in smoother density profiles with fewer apparent overturns. Input and output is JR18005_ctd_NNN.var.dn. *GridctdGEN* reads in both *JR18005_ctd_NNN.var.dn* and *JR18005_ctd_NNN.var.up*, and averages the data into 2-dbar bins. Data are padded with NaNs to 5999dbar, thereby ensuring that arrays for all CTDs are the same size. Outputs are *JR18005_ctd_NNN.2db.mat* and *JR18005_ctd_NNN.2db.up.mat*.

- *makebotGEN, sb35readGEN* were then run, along with *bot2excel* to quickly provide bottle detaiuls to other scientists on board.
- *batch_botGEN* – Once salinity samples have been run, this runs a series of scripts *readsalGEN, addsalGEN, salcalGEN* and *mergebotGEN. MakebotGEN* reads in *JR18005_NNN.ros* and *JR18005_NNN.BL*, and extracts CTD pressure, temperature (1 & 2), conductivity (1 & 2), transmission, fluorescence, oxygen and PAR for each bottle fired. It also calculates the standard deviation for pressure, temperature and conductivity, and writes a warning to the screen if those for temperature and conductivity are greater than 0.001. Salinity and potential temperature are calculated from both primary and secondary temperature and conductivity using *ds_salt* and *ds_ptmp*. Results are saved in *JR18005_bot_NNN.1st*. Sb35readGEN loads *JR18005_NNN_sbe35.asc*, *JR18005_bot_NNN.1st* and *JR18005_ctd_NNN.cal*. The SBE35 data are saved in *JR18005_bot_NNN.sb35* and SBE35 temperature minus CTD temperature is saved in *tempcals.all.mat*.

Once this batch of scripts is has been run for all CTD casts, the offset can be decided, using tempcal_decide and salcal_decide. These values are then entered into *salcalappGEN* as a cruise specific case. This applies any temperature and conductivity offset and salinity is recalculated. As the conductivity calibration points need to be back-calculated with temperature, the temperature calibration needs to be decided first. The uncalibrated values are then saved with _uncal added to the variable name. All programs following salcalappGEN must then be re-run with versions including the _uncal variables. This is all done via the script *batch_calGEN.* The chosen calibrations were linear pressure-dependent offsets for the two temperature sensors, while two different piecewise linear offsets, were chosen for the three conductivity sensors. For specific details on the chosen calibrations see salcalappGEN. The replacement C1 sensor from cast 67 was placed in the C2 position for cast 66. The old C1 was bad for casts 65 and 66.

The offsets are checked to be compatible with the sensor differences and the calibration can then be checked by plotting T1-T2 and C1-C2 for relevant casts through the cruise. These should be centred on zero, showing calibration is correct and applied in the correct direction.

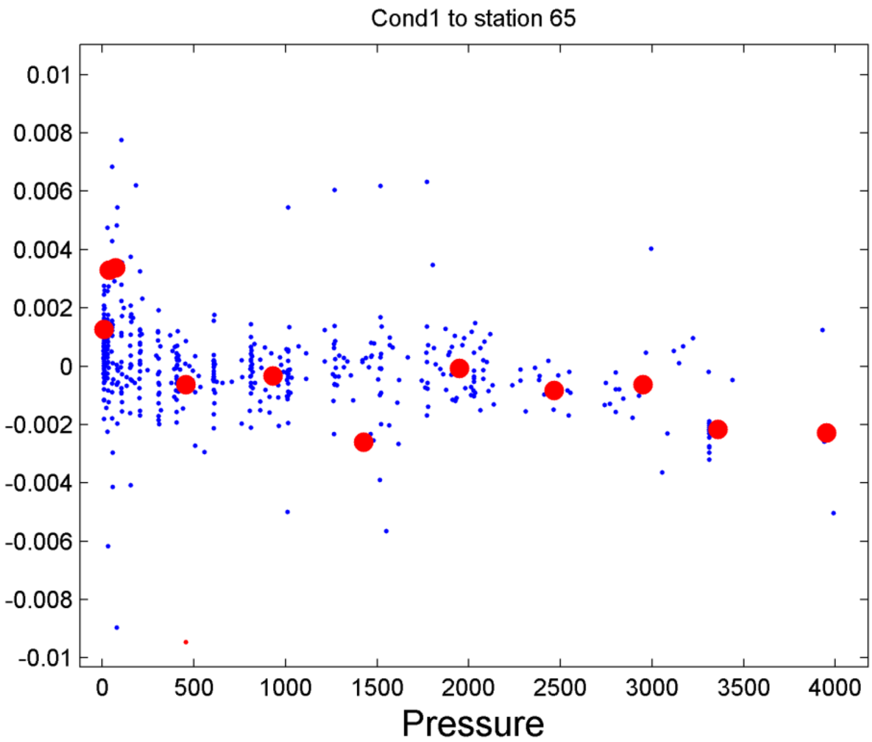

Figure 2.1: Sample-derived conductivity minus CTD Cond1 until sensor was swapped out for failing on cast 65. Dots are averages within depth bands with outliers removed. No offset was applied.

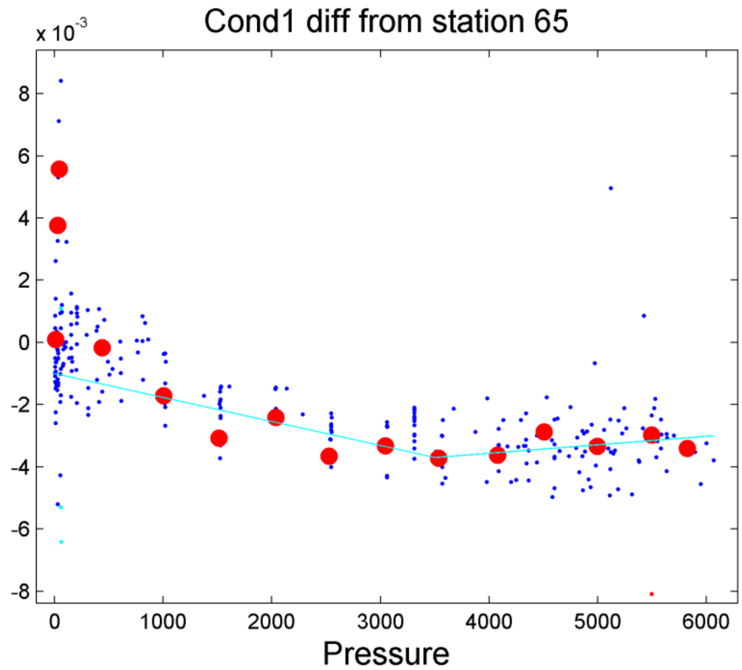

Figure 2.2: Sample-derived conductivity minus CTD Cond1 for the replacement sensor. Dots are averages within depth bands with outliers removed. The line shows the offset applied.

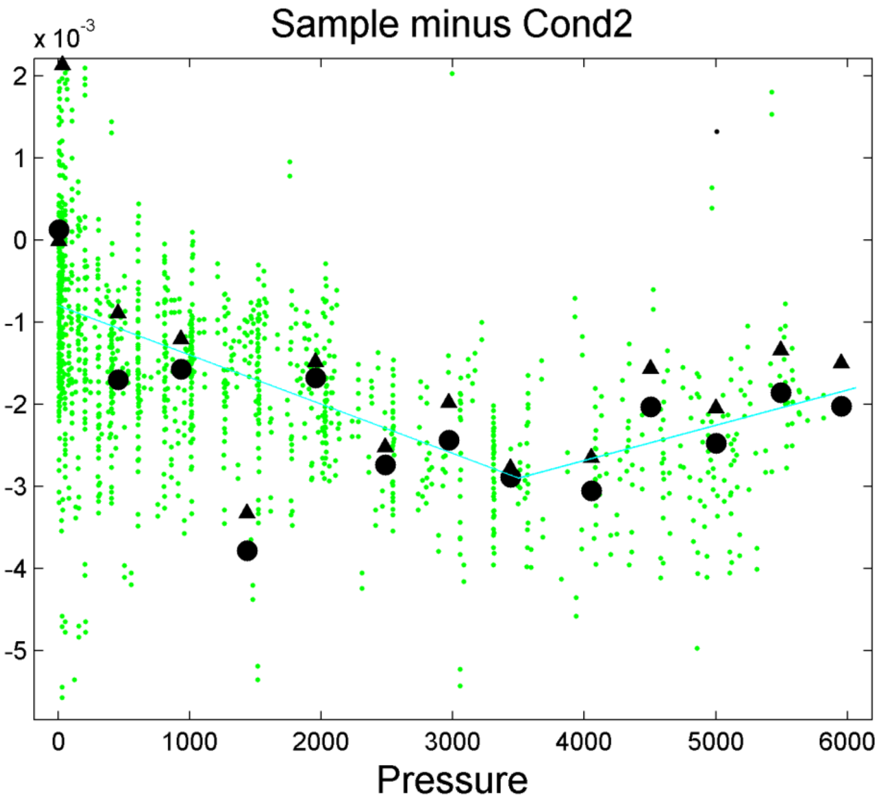

Figure 2.3: Sample-derived conductivity minus CTD Cond1. Dots are averages within depth bands with outliers removed. The triangles take account of an estimate of the effect of the conductivity gradient and the vertical offset between bottles and the sensors, which is the same for both sensors. The line shows the offset applied.

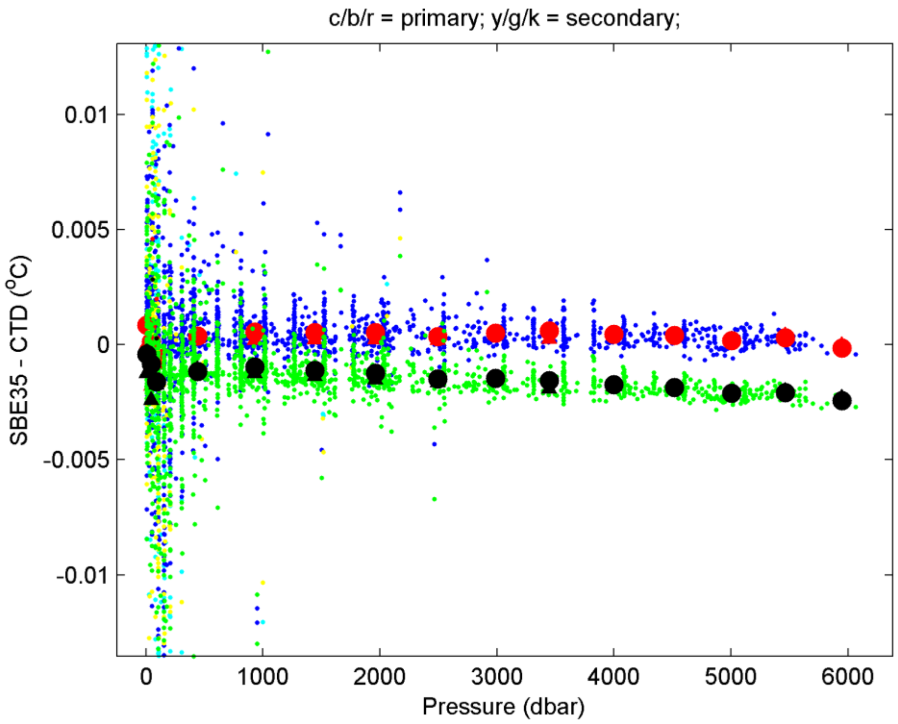

Figure 2.4: SBE35 minus CTD T1 and T2, with depth-band averages after removal of outliers (circles) and taking account of the vertical offset between T1/T2 and the SBE35 thermometer (triangles).

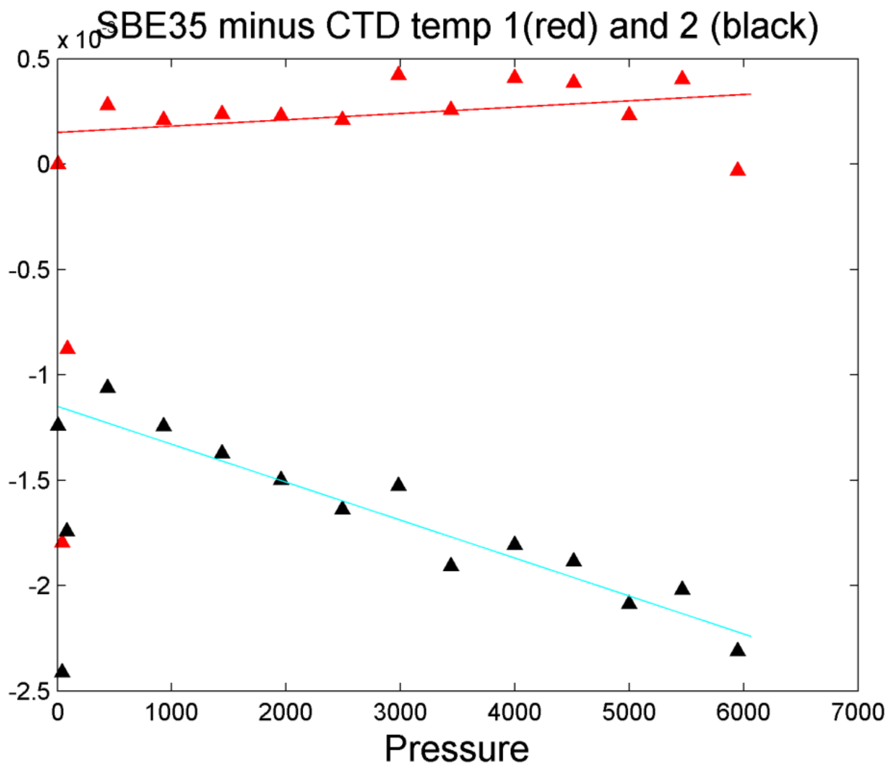

Figure 2.5: Average gradient-adjusted offsets for T1 and T2, with the line marking the offsets applied.

3 Underway Data Processing

Rachael Sanders, British Antarctic Survey/University of Southampton

3.1 Data collection

Throughout the cruise, underway data was collected and recorded using the SCS system on server JRLB. Surface and meteorological data were collected every five seconds. The flow rate of the underway system, was set to 1.4 l min^{-1}. The following instruments were used:

- WET Labs WSCHL Fluorometer
- WET Labs C-Star Transmissometer
- Two SBE38 Sea-Bird Sea Surface Temperature Probes placed at the inlet of the system
- SBE45 Sea-Bird Thermosalinograph
- Kongsberg Seatex Seapath 300
- EA600 Hull Mounted Kongsberg Simrad Hydrographic 12kHz Echo Sounder

Approximately every four hours, surface water samples were also taken and analysed using a Guildine Autosal 8400B Salinometer in order to calibrate the underway salinity measurements.

On 28th March (Julian day 087), the fluorescence sensor was cleaned after the difference between CTD and underway chlorophyll measurements was noted.

3.2 Data processing

Processing of the underway data was completed daily on the data collected the previous day. The first processing steps were done using Linux to produce files that could be further processed via Matlab. The following scripts were run to download the oceanlogger and seatex streams into the described daily ASCII files, where 'XXX' is the Julian day the data was collected.

- *get_underway* – calls the scripts *get_oceanlog*, *get_anemom* and *get_truewind* to retrieve the underway data, and produces the files oceanlog.XXX and anemom.XXX
- *get_seatex* – downloads the seatex data to produce the files seatex.XXX, seahead.XXX and seaspeed.XXX

Following this, the script *loadunderway* was run in Matlab, which in turn calls the following scripts:

- *loadoceanlog* – Reads in oceanlogger data to produce oceanlogXXX.mat files
- *cleanoceanlog* – removes data when the flow rate was not between 0.3 and 1.8 l min^{-1} and sets unrealistic values to NaN. Then allows interactive editing

of the conductivity, SST, fluorescence, transport, and salinity datasets in order to remove any spikes and outliers, The remaining cromulent data is saved in the file oceanlogXXXclean.mat.

- *loadanenom* – Reads in the daily anemometer data to produce anemomXXX.mat files
- *load_daily_seatex* – Reads in daily seatex data to produce seatexXXX files
- *load_daily_seahead* – Reads in daily seahead data to produce seaheadXXX files
- *load_daily_seaspeed* – Reads in daily seaspeed data to produce seaspeedXXX files
- *truewindderive* – Calculates the true wind speed and direction, produces the files anemomXXXtrue.mat

The script *plot_oceanlog_daily* was then used to compute one minute averages and plot maps of sea surface temperature, salinity and fluorescence for each day. These are saved as oceanlog_XXX.png.

Once data collection had been completed, the script *plot_oceanlog_all* was run which repeats the same steps as above but with the entire underway data for this cruise. The cleaned underway data files for the entire cruise was then concatenated using the script *underwayall.m* and saved as *underwayAll_jr18005.mat*. This file contains the following variables:

anemom	year	year	calendar year
	time_jday	days	Julian day (starting at zero on 1 Jan)
	time_secs	seconds	seconds since midnight on 1 Jan
	wind_dir	degrees	relative wind direction (zero at the bow of the ship)
	wind_spd	knots	relative wind speed
	wind_spd_ms	m/s	relative wind speed
	windvel_east	m/s	true wind speed component toward the east
	windvel_north	m/s	true wind speed component toward the north
	windspeed_true	m/s	true wind speed
	winddirection_true_TO	deg T	true wind direction that the wind blows toward
	winddirection_true_FROM	deg T	true wind direction that the wind blows from
oceanlogcal	year	year	calendar year
	time_jday	days	Julian day (starting at zero on 1 Jan)
	time_secs	seconds	seconds since midnight on 1 Jan
	atemp1	deg C	air temperature 1
	atemp2	deg C	air temperature 2
	hum1	%	relative humidity 1
	hum2	%	relative humidity 2
	par1	µmol/s/m^2	PAR (photosynthetically available radiation) 1
	par2	µmol/s/m^2	PAR (photosynthetically available radiation) 2
	tir1	W/m^2	TIR (total incoming radiation) 1

	tir2	W/m^2	TIR (total incoming radiation) 2
	press1	hPa	atmospheric pressure 1
	press2	hPa	atmospheric pressure 2
	sst	deg C	sea surface temperature 1 (at inlet)
	sst2	deg C	sea surface temperature 2 (at inlet)
	flow	L/min	flow through thermosalinograph, transmissometer, and fluorometer
	trans	%	light transmission (from transmissometer)
	fluor	µg/l	Chl. A fluorescence (from fluorometer)
	saltemp	deg C	temperature in thermosalinograph
	sal_uncal		uncalibrated salinity from thermosalinograph
	cond	S/m	uncalibrated conductivity from thermosalinograph
	speed	m/s	speed of sound through water (from uncalibrated thermosalinograph T/S)
	sal		salinity from thermosalinograph
	lon	deg E	longitude (interpolated from Seapath)
	lat	deg N	latitude (interpolated from Seapath)

3.3 ea600 processing

The daily ea600 data was initially retrieved by calling the *get_ea600* script on Linux to produce ASCII files. Using Matlab, the script *loadea600* was then used to read the data and produce .mat files named ea600_XXX.mat where XXX is the Julian day the data was recorded. The script *cleanea600* is then used to clean up the data, with values outside of chosen minimum and maximum values removed, and interactive removal of any spikes is completed if necessary.

3.4 Underway T,S calibration

The underway data was compared to calibrated CTD data from 7m at the start and end of each CTD cast and, for salts, against 222 salinity samples taken from the underway supply, or a bucket. The two underway temperature sensors showed considerable variation (Figure 3.1) and the CTD comparison was insufficient to determine the full behavior (Figure 3.2). Two simple offsets were therefore applied but there is considerable spread in the data.

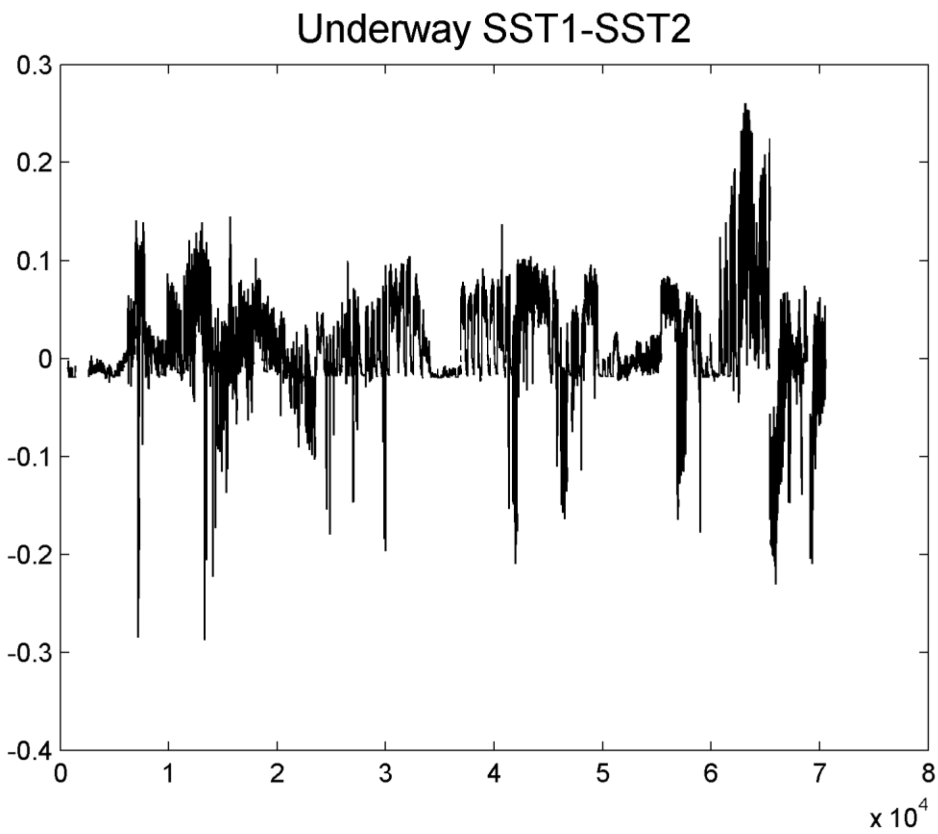

Figure 3.1: Intercomparison between the two underway sensors, showing a worrying variability. The CTD intercomparison (Figure 3.2) suggests both sensors contribute to the differences

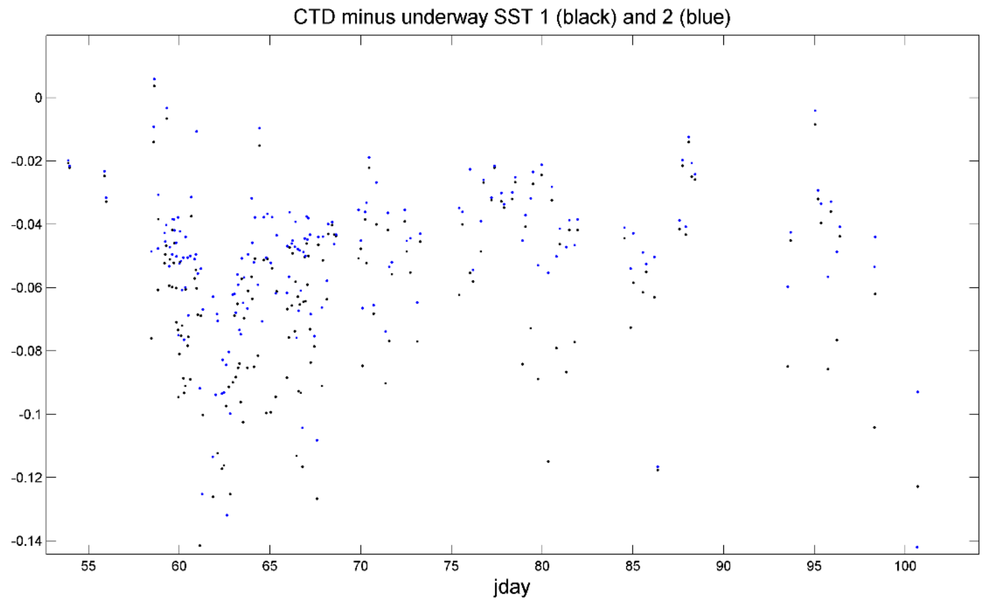

Figure 3.2: Intercomparison between CTD 7m temperature and the two underway temperature sensors

For salinity, the data shows a close match until jday 90, after which the offsets show an unusual pattern of divergence and jumps. These are shown by comparison to both CTDs and underway samples, showing it is the oceanlogger data rather than issues with the salinometer. A fit has been applied (figure 3.3) but the data after the last sample are clearly very suspect. Calibrated underway temperature and salinity for the cruise are shown in figures 3.4 and 3.5.

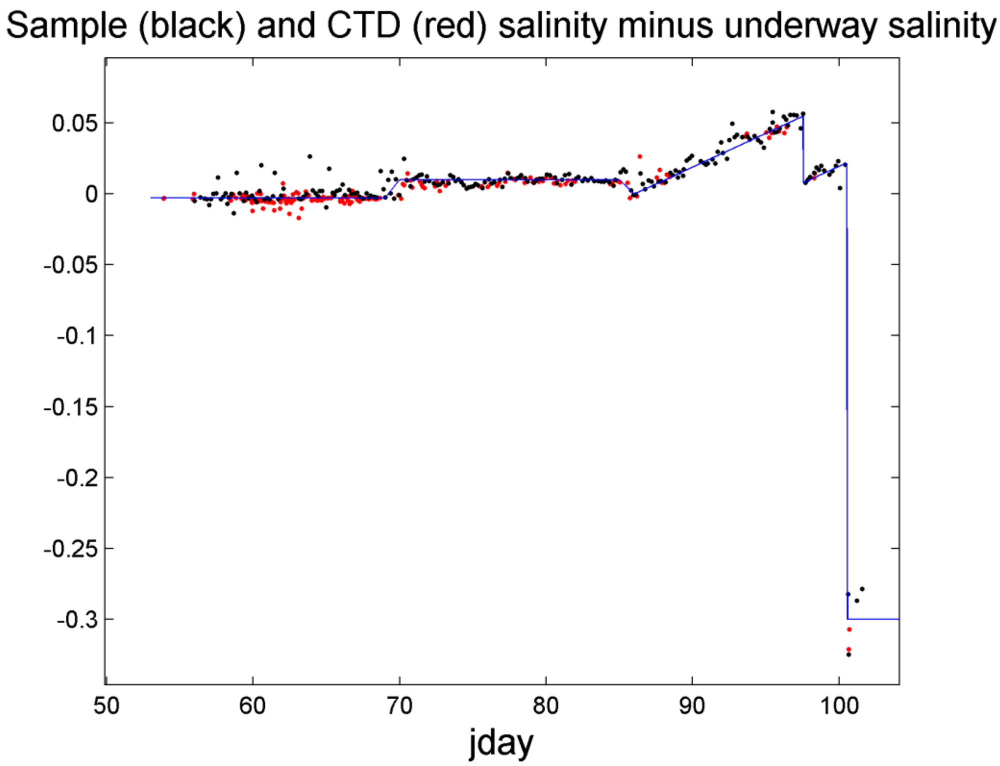

Figure 3.3: Underway salinity compared to CTD 7m values and underway samples. Both CTD and samples agree with the shifts, including the last step. As with SST, the variability and magnitude of the offsets is worrying.

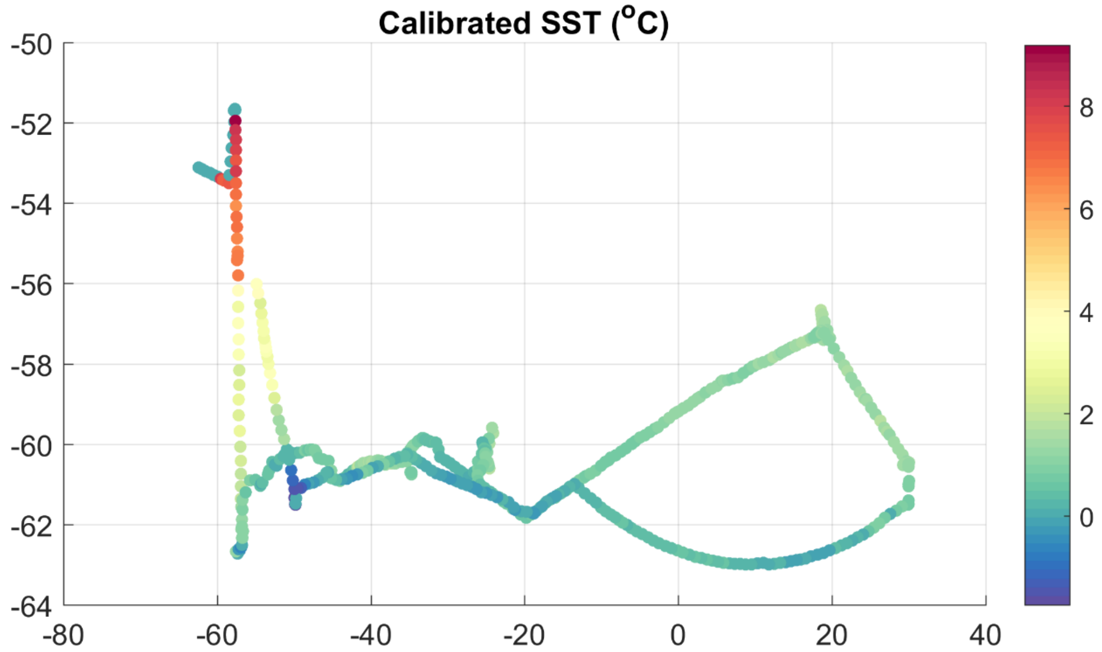

Figure 3.4: Calibrated underway SST for JR18005

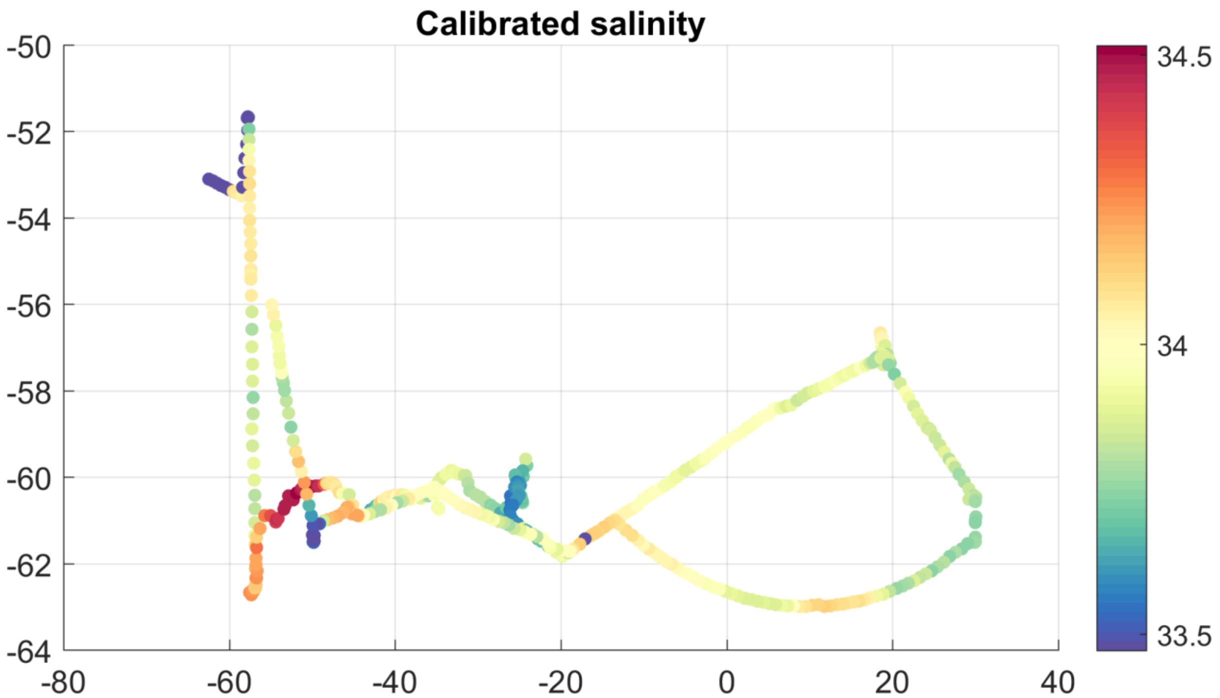

Figure 3.5: Calibrated underway salinity for JR18005

4 Salinometry

Christine McKenna, British Antarctic Survey/University of Cambridge

Two sets of salinity samples were taken for calibration purposes: one for the instruments used for CTD casts, and another for the underway data.

4.1 Standard seawater

To calibrate the readings from the salinometer, IAPSO P-series standard seawater was used. This is because this water has a precisely known electrical conductivity ratio. The specific details of the batch used in this process are given below:

Provider	OSIL
Batch Number	P162
K_{15}	0.99983
Practical salinity	34.993
Expiry date	16th April 2021

4.2 Salinometer

The salinometer used on the JR18005 cruise was the Guildline Autosal 8400B s/n 63360, with a peristaltic pump attached to the intake tube.

4.3 CTD calibration

Sea-water samples for CTD calibration were collected using Niskin bottles fired at various depths during a CTD cast. The depths at which samples were taken were decided by the CTD operator, but tended to be chosen where there were low salinity gradients. For most CTD casts 8 samples were collected, but on the SOCCOM float casts samples were taken from near the bottom of the water column, and from every Niskin above 2000 m to calibrate the SOCCOM float data. For a few casts, one or two Niskin bottles were suspected of misfiring at the wrong depth (see Table 4.1) and so the relevant samples for these were not used in the calibrations.

Table 4.1: CTD Niskin bottles suspected of misfiring – information from nutrient profiles

CTD number	Suspect Niskin bottle	Salt sample?
27	1	N
40	21	N
42	21	Y
44	21, 23	N, N
45	21	N
49	23	Y
53	21, 23	N, Y
54	21, 23	Y, N
77	1	N
78	1	Y
95	23	N

Once the CTD had been recovered onto the deck and secured in the water bottle annex, water samples from the Niskin bottles for each chosen depth were collected in 200 ml bottles. The bottles were initially stored in crates of 24. The sample bottles were first rinsed out three times with the Niskin bottle water, then filled to the neck so that the air gap was small enough to reduce the effects of evaporation on the salinity, but large enough to minimise the stratification that occurs when the bottles are left to stand. The threads of the bottles would then be wiped dry with blue roll to prevent build-up of salt crystals, a plastic stopper inserted, and the bottle screw-cap reattached. The samples were then placed back into the crate. Once this crate was filled with samples, it was moved into a temperature-controlled room (the Rad laboratory) and left for at least 24 hours to acclimatise to room temperature. The room temperature was kept at around 22-23°C, but did vary by approximately ±1°C, especially when people were present in the room. The salinometer cell temperature was set to 24°C, so that it was higher than the acclimatised sample temperature; this enabled the salinometer to give stable readings. When running a crate, the laboratory did sometimes become too close to 24°C, which caused readings to drift considerably. When this happened, a break would be taken during the run and/or the laboratory door would be wedged open, to reduce the laboratory temperature.

Once acclimatised, the salinity samples were run with a standardised procedure. At the start of a run, the cell was flushed with a part used/old bottle of standard seawater to bring the salinity of the water in the cell closer to that of the standard. A new bottle of standard seawater was then analysed. Before testing any bottle, it was first gently agitated by slowly tilting it upside down repeatedly; this was to mix out any stratification that may have occurred while the sample was resting. The intake tube was then wiped clean with a Kim-wipe, and the top of the bottle cleaned with another Kim-wipe if any salt crystals had developed, before the plastic stopper was removed. This was to prevent any contaminants from affecting the salinity reading. Whilst on the standby setting, the cell was then flushed three times with the sample, ensuring that each time it was filled past the conductivity sensors. A reading was then taken, before taking two further readings, where the cell was flushed once more between each reading. Three readings were generally taken for each sample, but sometimes four or five were taken if the variance of the first three was too high (larger than ±0.00002). Before each reading was taken, it was important to check that no bubbles had formed on the conductivity sensors, as these could affect the reading. This procedure was then repeated for the following samples until the crate was finished. At the end of a run, the cell was once again flushed with a part used/old bottle of standard seawater, before analysing a new bottle of standard seawater. If multiple crates were analysed in succession, a single standard was used between analysing each crate, with the values duplicated on the log sheets. If no more crates were to be analysed, the salinometer was left on standby with the cell filled with milli-Q (after flushing it around five times), and the intake pipe was left sitting in a bottle of milli-Q.

4.4 Underway calibration

As with the CTD calibration, salinity samples were taken in order to calibrate the conductivity measurements given by the underway thermosalinograph. These samples were collected from water that was pumped from under the ship directly into a sink in the preparation lab. Each sample was taken roughly every four hours, but preferentially between CTD stations. These were taken using the same procedure as for the CTD samples, and the sampling time and bottle number was noted on the watchkeeping log sheets.

4.5 Problems with the salinometer

Around the 11th March, it was noted that for many of the runs in the previous week a large bubble was often forming in the cell and sitting against the entrance. This was noted on the relevant salinometer log sheets. Sometimes it was possible to get rid of this by just flushing the cell, but often the bubble would reform, which could affect the readings and also made the runs more time-consuming. It was thought that the bubble was being caused by a build-up of biological matter, so the cell was soaked in an ethanol decon mixture for 24 hours on the 12th March to clean it out, as recommended by OSIL. Following this, the issue was fixed and a bubble only occasionally formed during subsequent runs.

On the 16th March, a run was started in which the readings did not stabilise, and continued to drift up and down considerably. It was found that this was because the belt broke for the salinometer fan, which prevented mixing of water in the tank and caused an issue with regulation of the water temperature. Therefore, the belt was replaced and the issue fixed on the same day.

Only three sample measurements were lost (CTD number 59; Niskin bottles 11, 13 and 15) and following this there were no similar issues.

5 Ship-mounted Acoustic Doppler Current Profiler

Hugh Venables, British Antarctic Survey

5.1 Introduction

Ocean current velocities from 8m to 1000m depth were measured via 75-KHz Teledyne RDI Ocean Surveyor ship-mounted acoustic Doppler current profiler (SADCP). Data were acquired, displayed and logged via the RDI VmDas software (version 1.42) and subsequently processed via a series of bespoke Matlab routines developed from previous cruises.

5.2 Set-up

Throughout the cruise, the SADCP was set to run in narrowband mode (as opposed to broadband mode) and was run independently so as not to go through the System Synchronisation Unit (SSU). For much of the cruise, the acquisition was in *Water Tracking* (WT) mode; when the vessel was sailing in water less than 1000m depth for a prolonged duration, the acquisition was switched to *Bottom Tracking* (BT) mode. To prevent individual file sizes from become too large (and thus impeding subsequent processing), the SADCP was periodically stopped and restarted to allow a new file to start logging. On average, this was carried out at least once in a 24-hour period. Note that it was imperative that the SADCP was always logging during CTD casts; the SADCP data were subsequently used to process data from the upward- and downward-facing lowered ADCPs (LADCPs) onboard the CTD carousel.

5.3 Data output

The VmDas software saved the data files with the file naming nomenclature of "JR18005_xxx_000nnn.aaa" where xxx = the file sequence number starting at 000, nnn = the file number within that sequence and aaa = the file type. For each sequence, 9 different file types were created:

Extension	**Description**	**Type**
*.ENR	Raw ADCP data file	Binary
*.ENS	ADCP data screened (by VmDas or user) with *.NMS navigation data added.	Binary
*.ENX	ADCP single-ping data and navigation data after bin-mapping and transform to Earth coordinates. Screened for error velocity, vertical velocity and false targets.	Binary
*.LOG	All output logging and error messages	ASCII

*.LTA	Long-time average of ADCP data (averaging time period specified in VmDas software options – in this case, 600 seconds).	Binary
*.N1R	Raw National Marine Electronics Association (NMEA) navigation data from Seatex GPS system.	ASCII
*.NMS	Navigation data after screening and pre-averaging.	Binary
*.STA	Short-time average of ADCP data (averaging time period specified in VmDas software options – in this case, 120 seconds)	Binary
*.VMO	Options settings for data collection	ASCII

5.4 Post-processing

The raw SADCP files were processed via series of Matlab scripts originally obtained from IFM Kiel but adapted accordingly for use on the JCR by various researchers most notably Angelika Renner and Deb Shoosmith. As such, should in-depth information on the processing protocol and subroutines be required, it is recommended that you refer to cruise report JR165 from December 2007. The JR165 report provides extensive explanations of the processing flow accompanied by thorough explanation of the processing protocol.

The main processing script was updated from JR18004, with updated cruise name. Within OS75_JCR_JR18005.m', the following are allocated:

1. The file location of the raw SADCP output files [RAWPATH] and the location of the processed files [PATH].
2. The filename prefix 'JR18005_000_000000' and the cruise name 'JR18005'.
3. Sets of file numbers were made, distinguishing between files that were bottom-tracked and with useful water-track calibration points as well as all file sequence numbers . Files with fairly constant velocity in deep water have no calibration points.
4. The averaging period 'superaverage' (using the default of 120 seconds), the starting year of the cruise (2019) were assigned.
5. The upper (ref_uplim) and lower (ref_lowlim) reference depth limits for the water track calibration of 300m and 500m respectively. Note that the defaults for this are typically 400m and 600m; the shallower reference depths were decided upon from observing the stability of the SADCP profiles in VmDas over the course of the cruise in preparation for VMP deployments. Discussions with Andreas Thurnherr and EPA concluded that the shallower and more stable reference depths were to be used.
6. The narrowband misalignment angle and amplitude scaling factor corrections (misalignment_nb and amplitude_nb) were set to 0 and 1 respectively for the

initial run. Note that the broadband equivalent [*_bb] can be ignored here as narrowband mode was used at all times. The alignment and amplitude offsets are calculated during the initial runs. Once the offsets are generated, filtered and decided on, they are entered and the script re-run to apply them.

7. Modifications were made to calib_calc_wt.m. Firstly extra lines were added to remove default calibration values that sometimes slip through the processing, leading to blips in the histograms at 0 and 1 that will affect the median calculated:

```
iiz=a_alp(1,:)==0;  %misalignment

a_alp(1,iiz)=NaN;

iio=a_alp(14,:)==1; %amplitude

a_alp(14,iio)=NaN;
```

The values output by the processing on the calibration plots have had an initial filtering, with data greater than 1.8 standard deviations from the median removed. A slight change was made to this to use nmedian rather than median. This is more robust and allows iteration of the step:

```
i=find(abs(a_alp(1,:))-nmedian(a_alp(1,:))>(cstd*nstd(a_alp(1,:))));

a_alp(1,i)=NaN.*ones(size(i));
```

This allows a further recalculation of the median, with values of -0.1035 output by initial processing, decreasing to -0.1040 with rogue zeroes removed and then increasing with iterations of the filtering to -0.1019, -0.0988, -0.0961 and -0.0927. This process takes away almost any effect of skewed noise in the estimates.

For amplitude the same process yielded estimates of 1.0186 (as per original processing and with values of exactly 1 removed), then 1.0179, 1.0174, 1.0172 and 1.0171. The convergence matches the removal of skewed noise, which is evident in figure

These values were added to the main processing script and the files reprocessed, with stripiness of the plots on/off CTD stations removed, giving confidence in the values found. It is worth noting that the effect of the amplitude correction is considerably greater than the misalignment, with the amplitude alone sufficient to remove the stripiness.

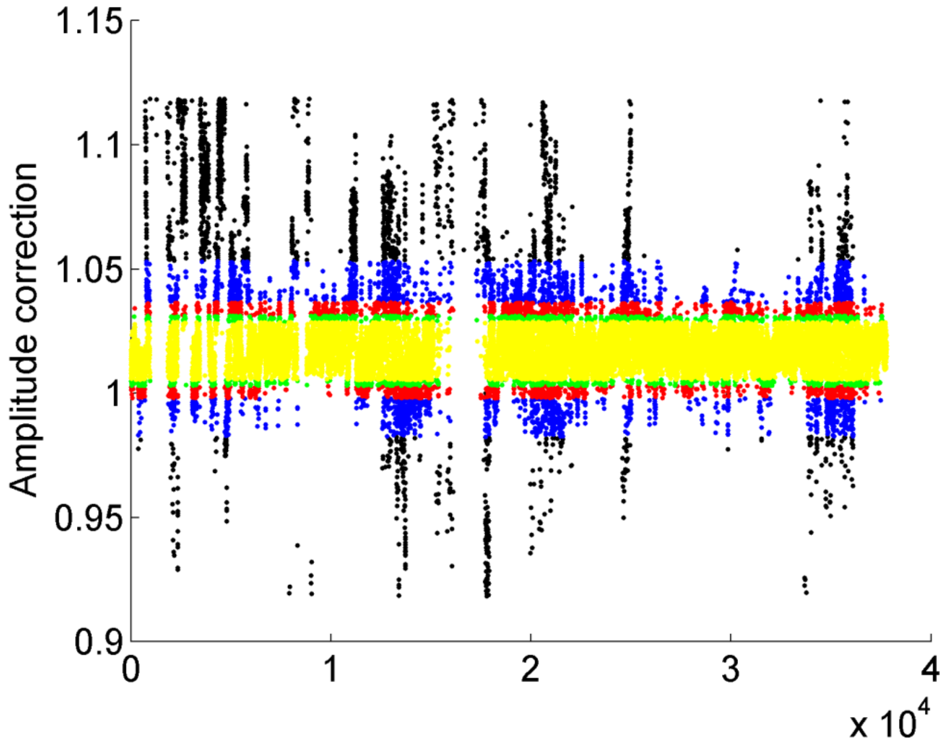

Figure 5.1: Amplitude correction, with iterated medians to account for skewed spread of data from water track calibration.

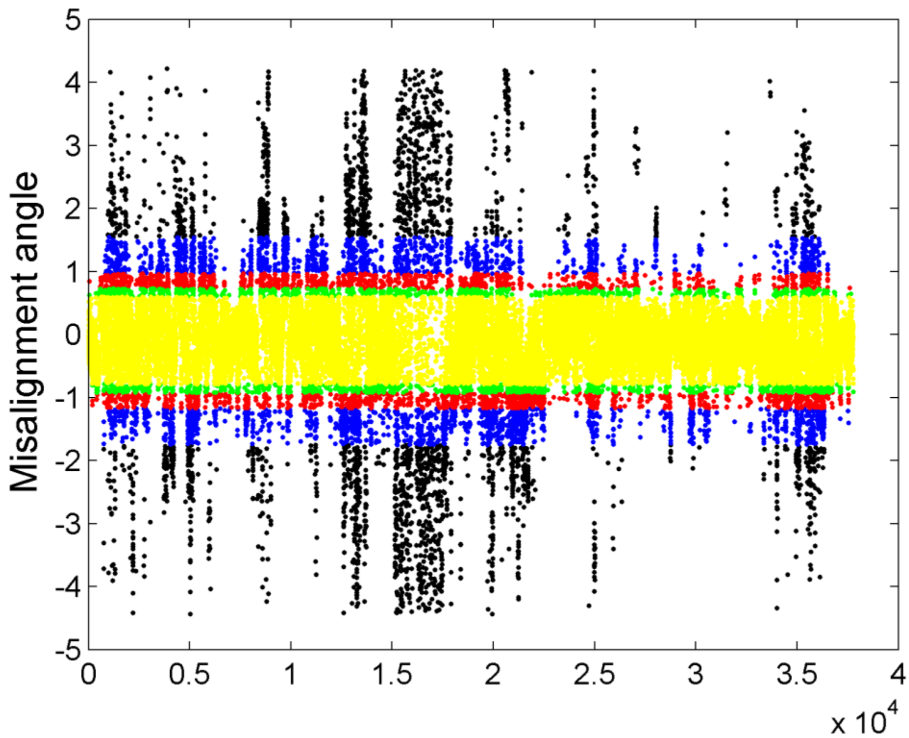

Figure 5.2: Misalignment angle correction, with iterated medians to account for skewed spread of data from water track calibration.

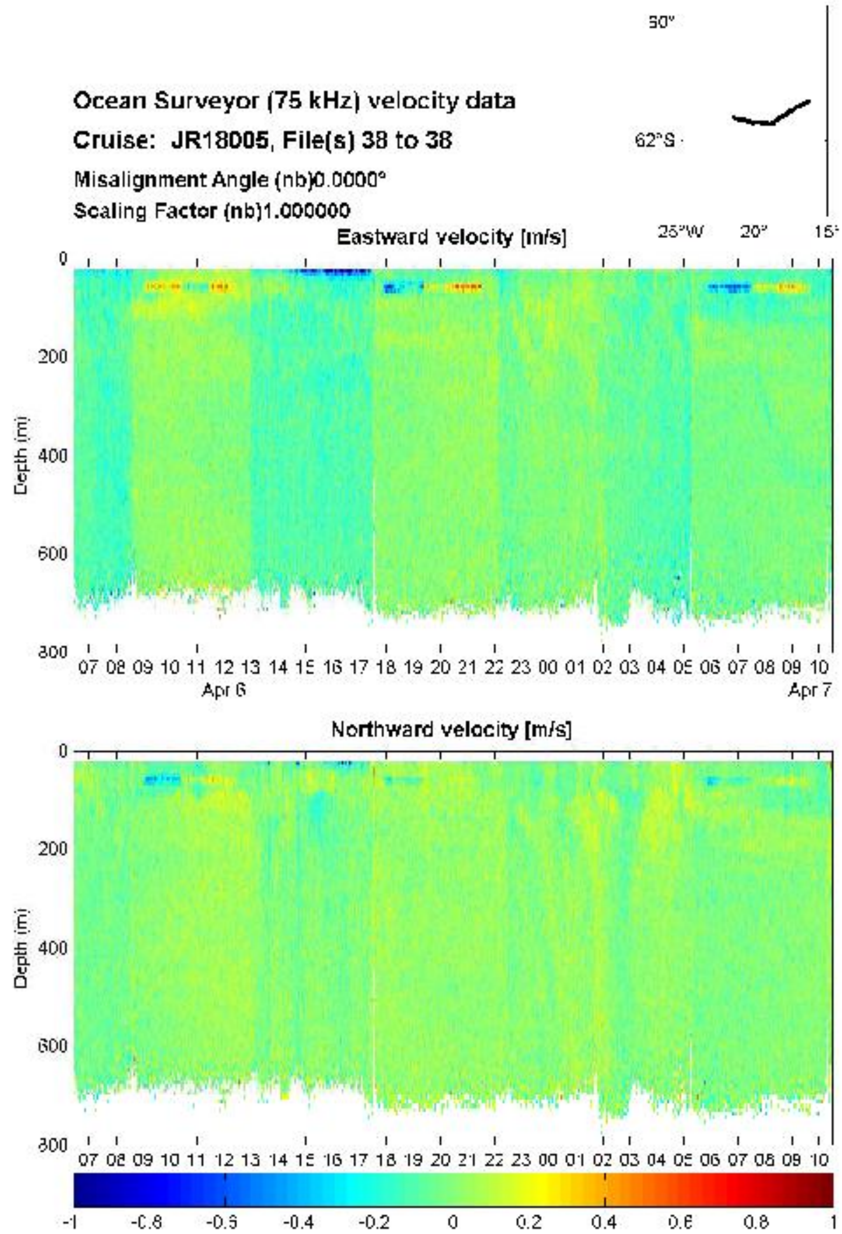

Figure 5.3: Uncalibrated ADCP currents for file 38, showing stripiness on and off CTD stations. The shallow anomalies on station are due to the ADCP beam intersecting the CTD cable, hence the reversal between paying out cable and hauling

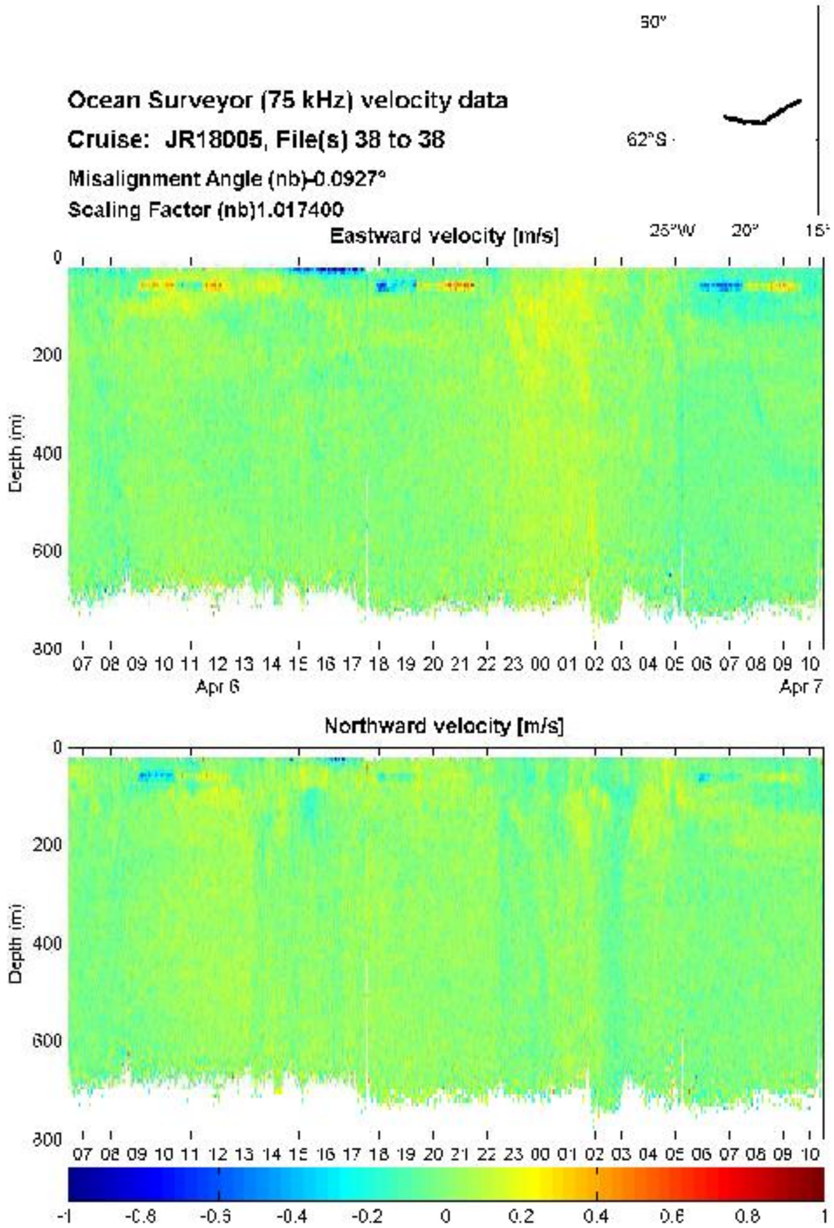

Figure 5.4: Calibrated ADCP currents for file 38, showing removal of stripiness on and off CTD stations.

6 Lowered Acoustic Doppler Current Profiler (LADCP)

Ciara Pimm, University of Liverpool/British Antarctic Survey

6.1 Instrument configuration

Two Teledyne RDI 300-kHz Workhorse LADCPs were mounted on the CTD in a downlooker/Master (Serial Number: 14443), and uplooker/Slave (Serial Number: 15060) configuration. Alternating ping intervals of 1.3 s and 1.5 s were used to minimise inference from previous pings. Then the slave LADCP pings in response to the master LADCP. The LADCP was run with a blanking distance of zero and 8 m bins. The data was collected in beam co-ordinates and rotated to earth co-ordinates during processing. Both LADCP cables are connected to a charger in the Chem lab after each cast is completed. Before and after each cast the voltage of the LADCP is recorded in the CTD log. Pre-deployment tests were run before each cast using BBtalk installed on the computer in the winch control room, to check the internal electronics were working correctly. Then the memory and moisture of each LADCP was recorded in the CTD log. Then the deployment scripts were run to start the LADCPs pinging. Finally the LADCPs were unplugged from the charger, and the blanking plugs fitted. The pre-deployment test script and deployment script are included in Section 6.4. After this no more commands were sent to the LADCPs until the CTD was recovered back to the deck and the LADCPs were plugged into the charger. Data was downloaded from both LADCPs to the local computer and then copied to legdata/ladcp/Data. The file names are of form; JR18005_XXX_M.000 for master, and JR18005_XXX_S.000 for Slave, where XXX represents the cast number.

6.1.1 Issues during Deployment/Troubleshooting

The most common problem encountered during the deployment of the LADCPs was that the LADCPs kept freezing. This would occur during the pre-deployment tests, the deployment script, and during downloading the data. This problem was solved by unplugging the LADCP, wiping dry and plugging it in again. This would normally solve the problem and then the script would either continue running or be run again. The slave LADCP encountered this problem most often and so the cable was changed. This did help the problem but did not solve it completely. During cast 071 the LADCP was not charged properly, and the voltage was not recorded before the cast, therefore the data from that cast was not recorded properly. Occasionally due to operator error the wrong deployment script was run on the LADCP COM, however this was fixed during processing.

6.2 Data processing

The data from legdata/ladcp/Data is copied to legwork/scientific_work_areas/LADCP/processing/raw for processing. Processing was completed using version IX_13 of the matlab package developed at Lamont-Doherty Earth Observatory (LDEO) based on code by Martin Visbeck and maintained by Andreas Thurnherr. The package uses both inverse and shear methods to calculate velocity profiles. The data is constrained by the vessel-mounted ADCP (VMADCP), bottom-tracking on the CTD, and GPS from the ship. The data was also processed without using VMADCP data to constrain the surface velocities, so that the rms difference could be calculated as a measure of quality of the LADCP data.

6.2.1 Linking to CTD data

CTD data was processed by Hugh Venables, and saved to legwork/scientific_work_areas/ctd/proc, with file names of form JR18005_ctd_XXX.1hz, where XXX represents CTD cast number. The CTD data was then copied to legdata/scientific_work_areas/LADCP/processing/ctd. The CTD data file is converted to an ascii file using the script convert_CTD_to_ascii.m written by Andrew Meijers.

6.2.2 Linking to VMADCP data

VMADCP data was also processed by Hugh Venables, and was saved to legwork/scientific_work_areas/sadcp/Processed with file names of form JR18005_000_000000_XX_abs.mat, where XX represents a two digit number. The VMADCP files were processed and saved in batches, so several casts' worth of VMADCP data are saved in the same file. The correct VMADCP times for the casts are found by the set_cast_params.m script.

6.2.3 Edits to set_cast_params.m

General edits were made to the script to include the cruise details and to link to the correct directories and files for this cruise. In certain cases the master and slave files need to be swapped or omitted completely and this is reflected using a loop in the script. For cast 032 the processing produced a matlab error in process_cast.m, so this cast is processed with p.getdepth = 1, and this is edited into the script in a loop. The next edit converts the CTD data from a .1hz file to a .ascii file before use. The most up-to-date VMADCP data needs to be used for each cast and this is found though a series of loops edited into the code. The final edit is to save the output files in an individual directory for each cast.

6.2.4 Counting CTD rotations

After cast 079 the CTD was run without a swivel, as it had broken and had to be removed. Also after several casts without the swivel the wire had two kinks in it and some of the outer core was seen to be unwinding from itself. Due to this we wanted to monitor the rotations of the CTD and we used the LADCP data to do this. Figure 2 in the standard outputs from our processing of the LADCP data shows the heading, tilt, and vertical velocity of the CTD itself. An example is shown in figure 6.1. We counted the net rotations for each cast and the total rotations the on wire, so we could see how much twisting and strain the wire was undergoing. In general we found the CTD was spinning a lot with normally clockwise spinning on the way down and anticlockwise on the way up. In general we found more rotations were performed clockwise rather than anticlockwise.

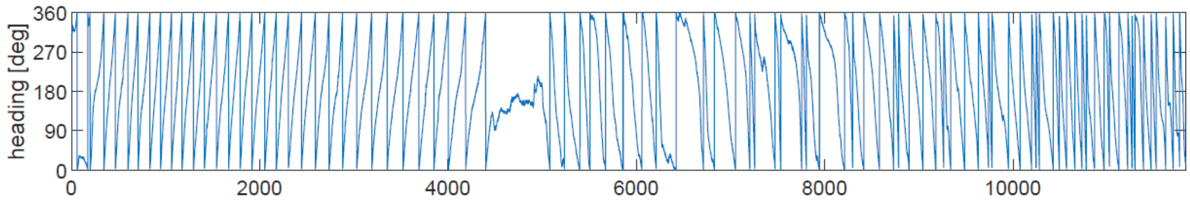

Figure 6.1: Exert from LADCP data processing Figure 2 for cast 088 showing the amount rotations the CTD had performed. During this cast the CTD span 31 times clockwise, 58 times anticlockwise, giving a total of -27 rotations clockwise for this cast.

6.2.5 Quality of data/ Warnings

In general the quality of the LADCP data is very good. However most casts encounter some warnings given by the processing software. The warnings for each cast are contained in Section 6.5. Cast 024 gives bad data due to the cast being very shallow, at only 250 m deep. Cast 048 also does not give very good data due to the master LADCP not running correctly. Casts 064 and 066 have large errors due to the increased error because of shear. Cast 071 has bad data due to the LADCP not being charged properly before the cast. Some common warnings have been chosen to be ignored as they do not seem to have any impact on the quality of the data given. In 37 casts there are velocities that are thought to be too large by the processing software, however as long as the amount was under 8% we ignored this warning. Another common error was that the cast duration and mean ping rates differed in the uplooking and downlooking LADCP heads. This was chosen to be mainly ignored as long as the velocity profiles in figure 1 and figure 14 were consistent. Another error encountered on a few occasions was that there was large error due to shear. We contacted Andreas Thurnherr about this error and he suggested completing an rms difference relative to the VMADCP to check these casts are still valid. Hence in the Results section we consider the rms difference of each cast, to further check the quality of the data. There are a few other errors encountered in the LADCP processing, however these are mainly to do with the issues we had with the CTD not communicating and not the fault of the LADCP itself. Hence casts 967, and 971 are not full LADCP profiles and are only complete up to where the CTD failed. Some other casts did not have full depth LADCP profiles, however these CTDs were rerun, apart from cast 974, which is no longer included in our section.

6.3 Results

6.3.1 Velocity profiles

The velocity profiles were found using a matlab script first written by Andrew Meijers. The main edits to the code were; that the section could be plotted with along track distance instead of longitude, and so that the velocity vectors were rotated from north-south and east-west, to cross track and along track respectively. Also the correct data and paths had to be used for this cruise. The velocity profiles for our section are shown in Figure 6.2, where positive denotes south to north and negative denotes north to south transport.

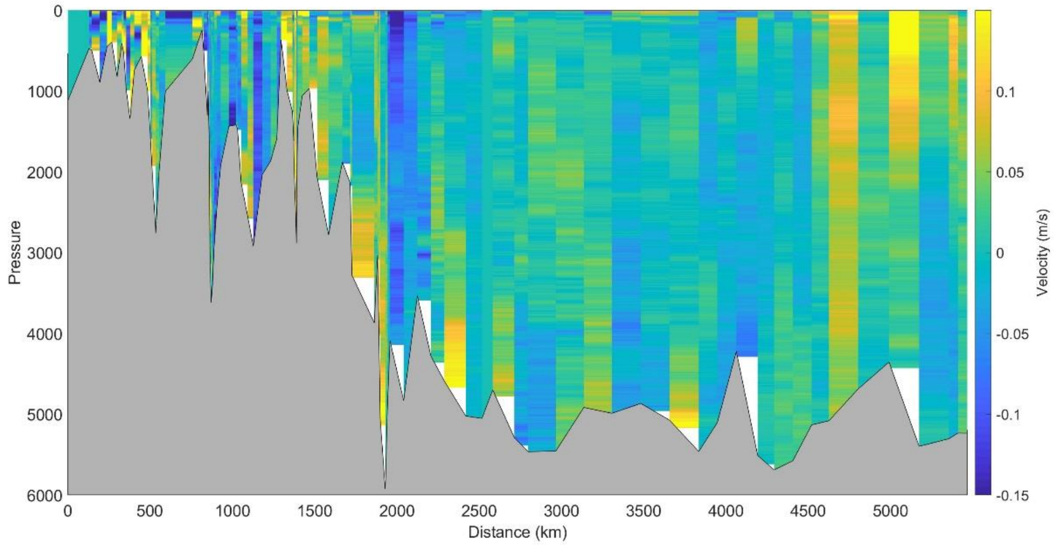

Figure 6.2: Across track velocities (m/s) plotted as a function of along track distance (km) against depth (m).

6.3.2 Root-mean-square (rms) difference

The rms difference is found between the LADCP velocities processed without being constrained by VMADCP velocities and the VMADCP velocities. This has been shown to be a good indicator or data quality previously. Almost all casts were found to have an rms difference of below 0.06 m/s, which indicates good quality of data. This can be seen in Figure 6.3, where we plot rms difference against CTD cast number. Casts 011, 012, and 016 have an rms difference of over 0.3 m/s. Firstly we wanted to consider if this was due to the instrument range on these casts, as low backscatter can affect the instrument range and lead to high rms differences. Figure 6.4 shows the instrument range for both the downlooking and uplooking LADCP. The instrument range is always over 65 m, which is an indicator of good data. Next we considered the mean zonal (u) and meridional (v) velocities. Casts 011, 012, and 016 can be seen to have high mean velocities in Figure 6.5, hence this could be the reason for the high rms difference in these cases.

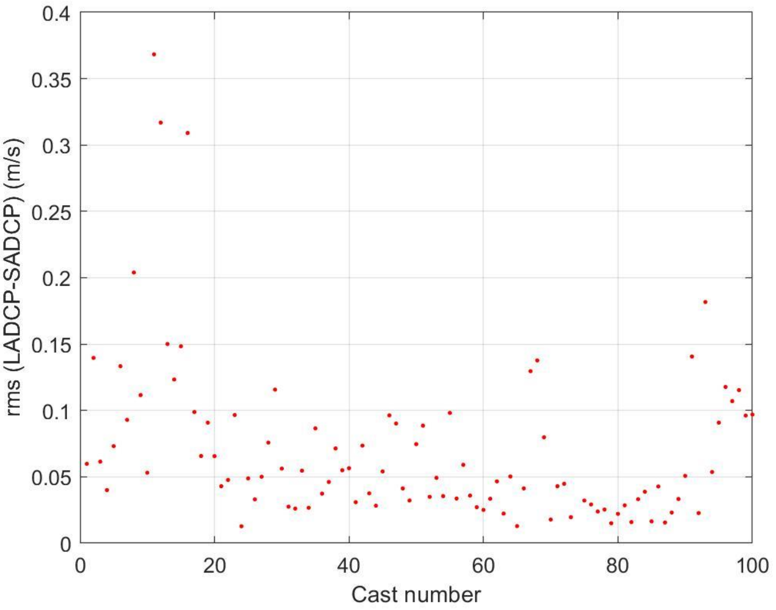

Figure 6.3: RMS difference of LADCP velocities processed without being constrained by VMADCP data and VMADCP velocities (m/s) against cast number.

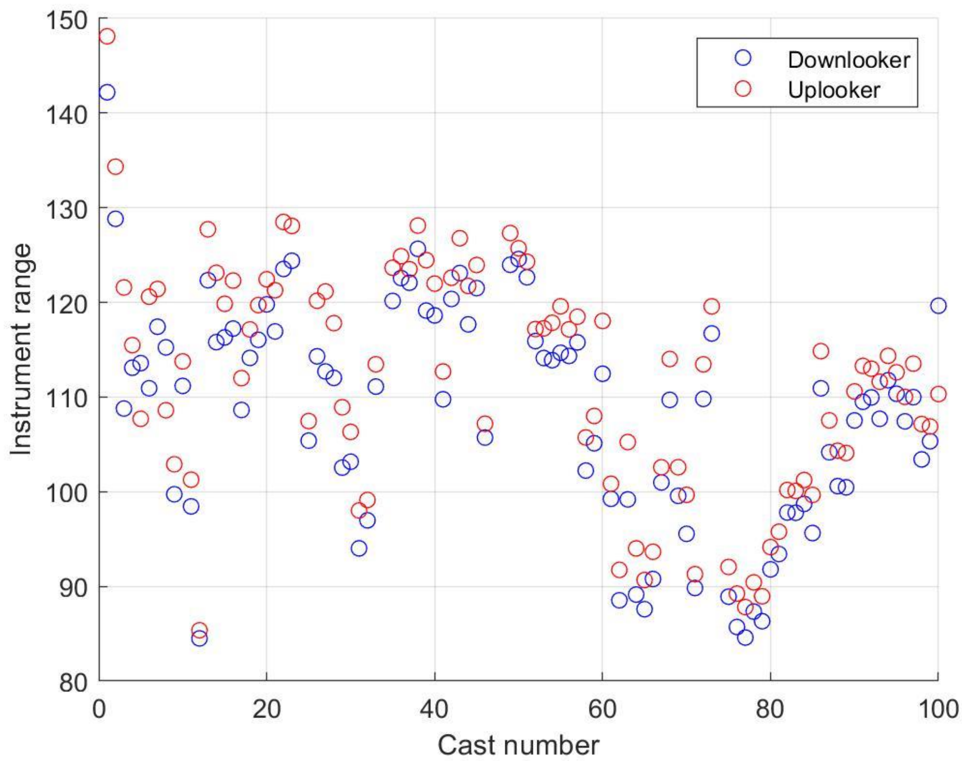

Figure 6.4: Instrument range against cast number, where blue refers to the downlooker range and red refers to uplooker range.

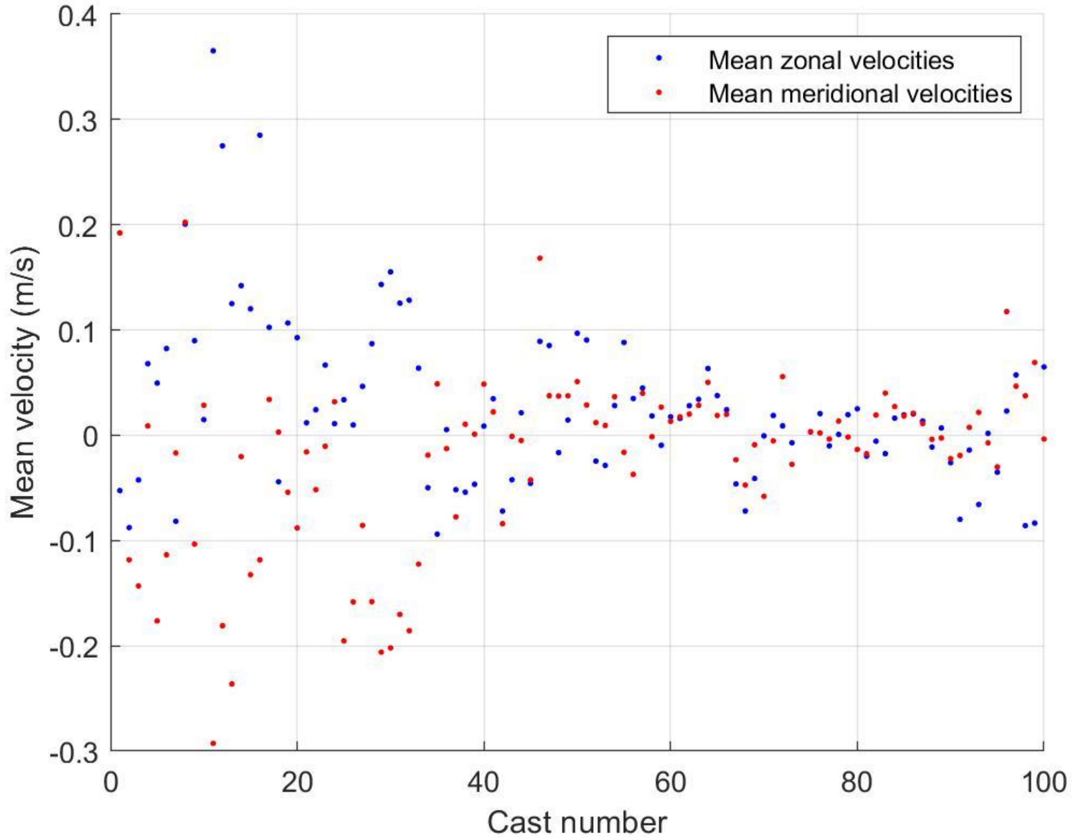

Figure 6.5: Mean velocity (m/s) against cast number, where blue refers to mean meridional velocities and red refers to mean zonal velocities.

6.4 Appendix 6.1 - LADCP instrument set up files

6.4.1 Pre - deployment Script

The pre-deployment script was run on both the master and slave LADCPs before each cast, using the following commands.

Command	Description
PSO	Print system configuration
PA	Run pre-deploy tests
PT200	Run built in tests (Record internal moisture in CTD log – start with 9 or 8)
PC2	Display sensor output
RS	Display memory used, free space (Recorded memory in CTD log)

6.4.2 Master and Slave Deployment Scripts

Master	Slave	Description
CR1	CR1	Reset to factory settings
RN M1805	RN S1805	Rename scripts
$T	$T	Update/sync time with PC time
WM15	WM15	Water mode 15
TC2		Ensembles per burst
LP1	LP1	Pings per ensemble

TB 00:0:02.80		Time per burst
TE 00:00:01.30	TE 00:00:00.00	Time per ensemble
TP 00:00.00	TP 00:00.00	Time between pings
LN25	LN25	Number of depth cells
LS0800	LS0800	Bin size (cm)
LFO	LFO	Blank after transmit (cm)
	WB1	Narrow bandwidth mode 1
LW1	LW1	Narrow bandwidth LADCP mode
Print system con	LV400	Ambiguity velocity (cm)
SM1		Master
	SM2	Slave
SA011	SA011	Send pulse before each ensemble
SBO	SBO	Disable hardware-break detection on Channel B (ICN118)
SW5500		Wait .5500 s after sending sync pulse
SIO		Number of ensembles to wait before sending sync pulse
EZ0011101	EZ0011101	Sensor source
EX00100	EX00100	Coordinate transformation
CF1101	CF11101	Flow control
CK	CK	Save parameters as defaults
CS	CS	Start pinging

6.5 Appendix 6.2 – LADCP processing warnings for each cast

This file contains any warnings or interesting features of the processed LADCP data for the ANDREX II cruise.

For all following casts SADCP data is found in file JR18005_000_000000_42_abs.mat.

- **001** – LADCP profile OK.
- **002** – LADCP profile OK.
- **003** – LADCP profile OK.
- **004** – LADCP profile OK.
- **005** – LADCP profile OK.
- **006** – LADCP profile OK.
- **006** – LADCP profile OK.
- **007** – LADCP profile OK.
- **008** – LADCP profile OK.
- **009** – Warnings: mean ping rates differ in uplooker/downooker, cast duration differ in uplooker/downlooker. (These warnings were decided to be ignored as in Figure 14, the right amount of data is cut out). 5.5% total velocities > 2.5m/s. (We have decided to ignore this error if the total velocities that are too big are less than 8%.). Cast is quite shallow so gets some bad data.
- **010** – Warnings: mean ping rates differ in uplooker/downooker, cast duration differs in uplooker/downlooker.
- **011** – Warning: 5.2% of total velocities > 2.5m/s.
- **012** – Warning: 4.9% of total velocities > 2.5 m/s.
- **013** – Warning: 3.8% of total velocities > 2.5m/s.
- **014** – Warnings: mean ping rates differ in uplooker/downooker, cast duration differs in uplooker/downlooker.

- **015** – LADCP profile OK.
- **016** – LADCP profile OK.
- **017** – LADCP profile OK.
- **018** – LADCP profile OK.
- **019** – LADCP profile OK.
- **020** - Warnings: mean ping rates differ in uplooker/downooker, cast duration differs in uplooker/downlooker.
- **021** – LADCP profile OK. Heading of CTD changes a lot, the CTD is spinning a lot in this cast.
- **022** – Warning: 3.2% of total velocities were > 2.5 m/s.
- **023** – LADCP profile OK.
- **024** - Warnings: mean ping rates differ in uplooker/downooker, cast duration differs in uplooker/downlooker, large compass deviation: 71.7957. The errors introduced in this plot are due to the slave LADCP head not running properly. This was noted in the CTD log at the time. The cast was then run without using the slave head, however this data is still very noisy. Fig 9 produces an error – SADCP data is more than 0.1 degree from LADCP. Fig 14 – code does don't edit out correct data points – leaves some data that should be taken away. Fig 1 – has very large error bars in both up and down casts. Some of these problems could be due to the cast being very shallow – only 250m.
- **025** - Warnings: mean ping rates differ in uplooker/downooker, cast duration differs in uplooker/downlooker.
- **026** – LADCP profile OK.
- **027** – LADCP profile OK.
- **028** – Warning: 2.6% of total velocities > 2.5 m/s. The CTD also travels 100m from the ship during the cast.
- **029** – LADCP profile OK. CTD travels 200m from the ship during the cast.
- **030** – Warning: increased error because of shear – inverse difference. The CTD travels 300m from the ship. However data collected seems to be in line with other casts of this depth.
- **031** – LADCP profile OK. CTD travels 2050m from the ship.
- **032** – Matlab Error: error in process_cast (line 294). Non-finite values in d.izm --- try processing with p.getdepth == 1. In cast 032 there was an issue on the upcast, as one of the pumps broke at around 1500m. Set p.getdepth = 1; in set_cast_params.m. This change works, so now the LADCP profile OK. CTD travels 400m from the ships.
- **033** – Matlab Error: error using matlab.rgaphics.axis.Axes/set. Process_cast (line 320). P = plotraw(d, p). On this cast the Master script was run on COM8 (which is for the slave), and the Slave script was run on COM7 (which is for the master). Now the file names have been swapped round to reflect this, the data has been processed without any warnings or errors. The CTD travels around 300m from the ship.
- **034** – No slave head LADCP data collected as it did not deploy properly. The cast was processed without slave data and found quite good data using only the master.
- **035** – LADCP profile OK.
- **036** – LADCP profile OK.

- **037** - Warnings: mean ping rates differ in uplooker/downooker, cast duration differs in uplooker/downlooker.
- **038** – LADCP profile OK.
- **039** – Warning: mean ping rates differ in uplooker/downlooker.
- **040** – LADCP profile OK.
- **041** – LADCP profile OK.
- **042** – Warning: 1.8% of total velocities > 2.5 m/s.
- **043** – Warning: 3.4% of total velocities > 2.5m/s.
- **044** – LADCP profile OK.
- **045** – Warning: 3.3% of total velocities > 2.5 m/s. Figure 1 – large error bars. CTD spinning a lot. Quite large tilt of CTD. CTD heading changes a lot in up and down cast.
- **046** – LADCP profile OK. ADCP has large variations around 600 – 800m.
- **047** – Warnings: Large compass deviation: 133.1005, down looking instrument detected in up-file. Now set_cast_params.m run with no M file, but with S file as ladcpdo. Now LADCP profile OK. ADCP has large variations around 600 – 800m.
- **048** – Warnings: Large compass deviation: 121.7688, uplooking instrument detected in do-file. Now set_cast_params.m run with no M file, but with S file as ladcpdo. Now Warnings are: 3.3% of total velocities > 2.5 m/s, up looking instrument detected in do-file. Fig 14 – data cut out incorrectly. Other figures are also incorrect.
- **049** – LADCP profile OK. CTD heading changing consistently, more on downcast. Large(ish) tilt of CTD, however ship roll and pitch is large too. ADCP has large variations around 600 – 800m.
- **050** – Warnings: mean ping rates differ in uplooker/downlooker, cast duration differs in uplooker/downlooker. Heading of CTD changes a lot on down cast. ADCP has large variations around 600 – 800m.
- **051** – Warnings: mean ping rates differ in uplooker/downlooker, cast duration differs in uplooker/downlooker. ADCP has large variations around 600 – 800m.
- **052** – Warnings: Cast duration differs in uplooker/downlooker, 1.7% total velocities > 2.5 m/s. CTD spinning on down and up casts. ADCP has large variations around 600 – 800m.
- **053** - Warnings: 2.3% total velocities > 2.5 m/s. CTD spinning on down and up casts. ADCP has large variations around 600 – 800m.
- **054** – LADCP profile OK. ADCP has large variations around 600 – 800m. ADCP -4m above bottom.
- **055** – Warnings: Mean ping rates differ in uplooker/downlooker, 3.7% total velocities > 2.5 m/s. ADCP has large variations around 600 – 800m.
- **056** – LADCP profile OK. ADCP has large variations around 200m and again at around 700 – 800m.
- **057** - Warnings: mean ping rates differ in uplooker/downlooker, cast duration differs in uplooker/downlooker.
- **058** – LADCP profile OK. CTD spinning on down/up cast. ADCP has large variations around 600 – 800m.
- **059** – LADCP profile OK. ADCP 1m above bottom. CTD spinning a lot on down/up cast. ADCP has large variations around 600 – 800m.

- **060 -** LADCP profile OK. CTD spinning a lot on down/up cast. ADCP has large variations around 600 – 800m.
- **061** – LADCP profile OK. CTD spinning on down/up cast. ADCP -12m above bottom.
- **062** – LADCP profile OK.
- **063** (SST [South Sandwich Trench] 1) – Warnings: mean ping rates differ in uplooker/downlooker, 2.7% total velocities > 2.5 m/s. CTD 100m from ship. ADCP has large variations around 600 – 800m.
- **064** (SST 2) – Warning: increased error because of shear – inverse difference. ADCP -5m above bottom. ADCP has large variations around 600 – 800m.
- **065** (SST 3) – Warnings: 2.2% total velocities > 2.5 m/s, increased error because of shear – inverse difference. CTD spinning. CTD 120m from ship. ADCP has large variations around 600 – 800m.
- **066** (SST 4) – Warnings: 2.6% velocities > 2.5 m/s, increased error because of shear – inverse difference. CTD heading changes a lot. Fig 1 – large error bars. Email sent to Andreas Thurnherr about this warning and large errors in data.
- **067** (SST 5) – CTD lost communication after 3795m, and was then recovered. Warnings: 2.2% total velocities > 2.5 m/s, last LADCP depth is -3797. Fig 14- cuts out after CTD stops communicating. CTD spinning more on upcast than down. ADCP has large variations around 600 – 800m.
  When CTD data is taken out, the warnings are 2.2% total velocities > 2.5 m/s, and magnetic deviation = NaN. However CTD still spinning and we still have large ADCP variations around 600 – 800m.
  We have decided it would be better to keep the profiles containing less depths as they still use the CTD data and therefore will be more accurate. However it is interesting to see the full depth LADCP profiles given without the CTD data too.
- **068** (SST6) – Warning: 2.2% total velocities > 2.5 m/s. ADCP -10m above bottom. CTD spinning. ADCP has large variations around 600 – 800m.
- **069** – Repeat of cast 067. Warnings: mean ping rates differ in uplooker/downlooker, cast duration differs in uplooker/downlooker. CTD spinning a lot. ADCP has large variations around 600 – 800m.
- **970** – CTD stopped communicating at 2615m, on downcast and was then recovered. – Gets bad data, however it does not matter as we have another cast at the same station. So this data was not properly processed. LADCP was not turned off properly and ran for some extra time giving some bad/irrelevant data at the end of the cast.
- **070** – Repeat of 970, at same station. Warning: 1.9% total velocities > 2.5 m/s. CTD is spinning.
- **071** – CTD stopped communication 100m off bottom, then came back online half way back up. Warnings: mean ping rates differ in downlooker/uplooker, 1.9% total velocities > 2.5 m/s. removed 269 pressure spikes during 4 scans, increased error because of shear – inverse difference, low battery, last LADCP depth is -4156m. This cast has lots of error due to multiple reasons. One reason is that the LADCP was not charged properly before the cast. Also the ongoing problems with CTD communication are an issue here too.
- **871 -** Cast 071 was saved as 871 from Niskin bottle 8 onwards.

- **072** – LADCP profile OK. CTD spinning. CTD 120m from ship. ADCP has large variations around 600 – 800m.
- **973** – CTD stopped communicating at 4352m on downcast, and was then recovered. Warnings: removed 2748 pressure spikes during: 5 scans, shifted ADCP timeseries by 12 seconds, last LADCP depth is – 4351. The CTD is also spinning a lot in this cast. If the CTD data is taken out of the processing then we get the full depth profile, however now the warnings are: magnetic deviation = NaN. This is due to the magnetic deviation coming for the CTD file. This also gives the shear solution only in figure 1.
- **974** – CTD stopped communicating at 3663m on upcast, and then was recovered. Warnings: last LADCP depth is -3687m. The CTD is spinning. When the CTD data is removed from processing we get a magnetic deviation warning, but we get the whole up and down profile of the cast.
- **977** – CTD stopped communicating at 1848m on downcast, and was then recovered to deck. Also there is no CTD data for this cast? Figure 1 gives shear solution only.
- **978** – CTD stopped communicating at 4225m on downcast, and was then recovered to deck. Warnings: removed 1188 pressure spikes during: 9 scans, shifted ADCP timeseries by 56 seconds, last LADCP depth is -4215m.

The CTD is now being run without the swivel, so we are keeping better track of the amount of spins the CTD is doing.

- **079** – Warnings: 1.7% total velocities > 2.5m/s, increased error because of shear – inverse difference. The CTD span 44 times clockwise on the down cast and 34 times anticlockwise on the up cast.
- **080** – Warnings: mean ping rates differ in uplooker/downlooker, 2% total velocities > 2.5 m/s. The CTD mainly span clockwise during the whole cast, with only around 3-4 anticlockwise during the whole cast. The CTD span less consistently on the downcast and kept a consistent heading for first 2000m.
- **081** – LADCP profile OK. CTD spinning approximately evenly clockwise and anticlockwise. ADCP was 0m above bottom.

- **082** – Warning: 1% total velocities > 2.5 m/s. CTD is mainly spinning clockwise. ADCP seems to have very different readings to LADCP near surface.
- **083** – LADCP profile OK.
- **084** – LADCP profile OK.
- **085** – Warning: 1.1% total velocities > 2.5 m/s. ADCP has large variations around 600 – 800m.
- **086** – Warning: 1.3% total velocities > 2.5 m/s.
- **087** – Warning: 1.3% total velocities > 2.5 m/s. ADCP has large variations around 600 – 800m.
- **088** – Warning: 0.9% total velocities > 2.5 m/s.
- **089** – Warning: 1.4% total velocities > 2.5 m/s. ADCP has large variations around 600 – 800m.
- **090** – Warning: 1.1% total velocities > 2.5 m/s. ADCP has large variations around 600 – 800m.
- **091** - Warning: 1.5% total velocities > 2.5 m/s. ADCP has large variations around 600 – 800m.

- **092 -** Warnings: Cast duration differs in uplooker/downlooker, 1.9% total velocities > 2.5 m/s. Issue on Figure 14, takes away valid data, find pattern that isn't really there.
- **093** – Warning: 3.9% total velocities > 2.5 m/s. ADCP has large variations around 600 – 800m.
- **094** – Warnings: 3.1% total velocities > 2.5 m/s, removed 12 pressure spikes during: 2 scans.
- **095** – Warnings: 2.7% total velocities > 2.5 m/s, removed 24 pressure spikes during: 2 scans.
- **096** – Warning: 1.8% total velocities > 2.5 m/s. ADCP has large variations around 600 – 800m.
- **097** – Warnings: Mean ping rates differ in uplooker/downlooker, 2.3% total velocities > 2.5 m/s.
- **098** – LADCP profile OK.
- **078** – Warning: 2.1% total velocities > 2.5 m/s.
- **077** – Warning: increased error because of shear – inverse difference. ADCP has large variations around 600 – 800m.
- **076** – Warnings: mean ping rates differ in uplooker/downlooker, increased error because of shear – inverse difference. ADCP has large variations around 600 – 800m.
- **075** – LADCP profile OK.
- **073** – Warning: 1.1% total velocities > 2.5 m/s.

After this the conducting wire that had been used was broken, so we swapped back to the shorter CTD wire, however we were still not running the CTD with a swivel.

- **099** – LADCP profile OK.
- **100** – Warning: mean ping rates differ in uplooker/downlooker. Figure 14 does not cut out some data that it should.

7 Carbonate System: Dissolved Inorganic Carbon (DIC), pH (pHT) and Oxygen

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7.1 Rationale

Carbon dioxide (CO2) is a long-lived trace gas in the atmosphere contributing to the greenhouse effect. Atmospheric CO2 has increased by approximately 45% since pre-industrial times due to anthropogenic emissions from fossil fuel combustion, cement production and land use changes. While CO2 has been accumulating in the atmosphere, the oceans and land have acted as a sink over the same period taking up about half of anthropogenic CO2 emissions (Le Quéré et al., 2015). The work undertaken during JR18005 contributes to the ongoing effort to determine the role of the Southern Ocean in this respect.

Atmospheric CO_2 reacts with water in a series of amphidromous reactions forming carbonic acid, bicarbonate and carbonate ions with a concomitant release of H^+:

1. $CO_{2(aq)} + H_2O \leftrightarrow H_2CO_3$
2. $H_2CO_3 + H_2O \leftrightarrow HCO_3^- + H^+$
3. $HCO_3^- + H_2O \leftrightarrow CO_3^{2-} + H^+$

In a typical surface seawater 91 % of DIC is HCO_3^-, 8 % is CO_3^{2-} and only 0.5 % is $CO_{2(aq)} + H_2CO_3$ (the latter are analytically hard to distinguish).

These reactions from the seawater carbonate system which is described by the following four parameters:

- **pH**: - log [H^+], measured on different scales - the "Total scale" is more suitable for seawater and used here (pH_T).
- ***p*CO₂**: CO_2 partial pressure, in *µatm*.
- **TA** (Total Alkalinity): Sum of weak bases (anions) in seawater, in *µmol/L* or *µmol/kg seawater* (e.g. TA = $SO_4^{2-} + PO_4^{3-}$ + …)
- **DIC** (Dissolved Inorganic Carbon): Sum of $CO_{2(aq)}$, H_2CO_3, HCO_3^- and CO_3^{2-}

During JR18005, we measured DIC, seawater pH and surface CO_2 partial pressure (pCO_2).

In addition, the concentration of Oxygen (O_2) was determined in discrete samples for the purpose of calibrating the O_2-sensor on the CTD-hydrocast. A list of stations and samples collected are in Appendix 1.

7.2 Methods

7.2.1 pCO_2

The PML Dartcom *Live p*CO2system encompasses a non-dispersive infrared detector (LiCor, Li840), showerhead equilibrator (vented through a parallel second equilibrator), Peltierdryer, gas-sampling and electronics hardware (Kitidis et al., 2017). The system was connected to the underway-seawater flow and set up to sample every 20 min. The intake of the ship's underway-seawater system is located at approximately 7 m depth. The *Live p*CO2 system was calibrated using secondary CO_2 standards every hour (BOC gases Ltd; nominal 0, 250 and 450 ppmv CO_2 in synthetic air). In turn, these were calibrated against NOAA certified primary reference standards (National Oceanic and Atmospheric Administration; 244.9 and 444.4 ppmv CO_2).

7.2.2 pH

The spectrophotometric pH method works on the principle of adding a dye (meta-cresol-purple; MCP) which has two absorbance maxima (at 434 nm and 578 nm; A2 and A1 respectively). The absorbance ratio at the two maxima depends on pH (Dickson et al., 2007). pH is thereby calculated from the absorbance ratio (A2/A1) for a given volume and molarity of added dye, sample volume, salinity, and temperatures (measurement-T and *in situ*-T). The system uses a high-precision burette to aspirate (and mix) known volumes of sample and dye. The solution is then expelled into a flow-through cell for absorbance and temperature measurements (T_{meas}). pH data are expressed on the total scale. Certified reference materials from the Scripps Institute of Oceanography (A.G. Dickson; batch 69) were used to reference the results. Preliminary results are shown in figure 7.1.

7.2.3 DIC

DIC samples were analysed according to Kitidis et al. (2017) following the recommendations by Dickson et al (2007).. Samples were collected for DIC into 250 mL clear glass bottles straight from the Niskin bottles using dilute-HCl-cleaned Si-tubing. The bottles were sealed with glass stoppers which were lightly greased using Apiezon H grease (Sigma-Aldrich, Z273562-1EA). The samples were immediately analysed using an Apollo SciTech AS-C3 DIC analyser. The analyser draws a pre-defined volume of sample which is acidified with H3PO4 to convert all DIC into CO2 which is sparged with N_2 and passed through a solid state infrared detector (LiCor, LI7000). DIC were calibrated using certified reference materials from the Scripps Institute of Oceanography (A.G. Dickson; batch 69). Further processing of the data will be carried out after the cruise with final results available shortly after.

7.2.4 Oxygen

The concentration of O_2 was determined by automated Winkler titration (Carritt and Carpenter 1966). Briefly, O_2 is precipitated with alkaline iodide (NaOH + NaI) and $MnSO_4$ and the samples stored in a water bath at room temperature until analysis usualy within 36 h. The precipitate is dissolved by addition of H_2SO_4 and titrated against thiosulfate (transmission endpoint detection). The thiosulfate was calibrated every 2–3 d against 0.1 mol L^{-1} KIO_3 standards (34273, Sigma-Aldrich).
O_2 saturation with respect to atmospheric equilibrium was calculated from the solubility of O_2 at in situ temperature, salinity, and pressure (Benson and Krause 1984; Garcia and Gordon 1992). Due to some instrumentation issues a final calibration of the CTD was not possible on the cruise. Further processing will be carried out of the data and instrumentation at the end of the cruise with data available within 6 months of the end of the cruise.

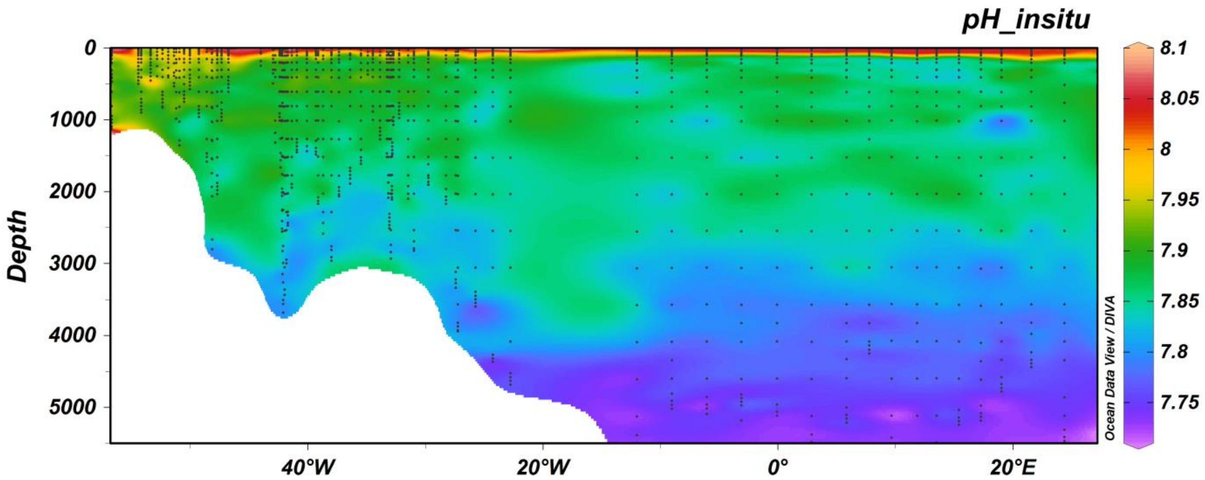

Figure 7.1. Preliminary pH data

7.3 References

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8 Nutrients

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8.1 Objectives

The cruise ANDREX II was to examine the Antarctic Deep water rates of export, and is a repeat of the original ANDREX voyage in 2010, which produced the first estimates of the Weddell Sea overturning and property budgets. The central element of this ANDREX II will be a cruise along the northern rim of the Weddell gyre between the Antarctic Peninsula and 30E, to survey the gyre's northern rim with complete measurements of the major macronutrients, Nitrate, Nitrite, Silicate, Phosphate and Ammonium. These will complement measurements of other water mass properties, biogeochemical, and carbonate parameters, as well as air-sea gas measurements.

The nutrients will be measured from taking CTD bottle samples from the full depth sampling CTD's and as with GO-SHIP protocols samples were taken from all bottles on all CTD casts.

The cruise commenced at the tip of the Antarctic Peninsula and proceeded eastward along the crest of the South Scotia Ridge, including a survey of the Orkney Passage, the deepest gap in the ridge. The sampling continued eastwards, following the Weddell gyre's northern boundary, but avoiding the South Sandwich Trench, and skirting the flank of the ridge system that limits the gyre to the north.

At 30^0 East we then sampled cruise cross-over stations that will also be occupied by the CLIVAR US repeat hydrography cruise. I06, later in April 2019, and nutrient comparisons will be made to confirm results from both cruises.

8.2 Sampling methodology

Acid clean 60ml HDPE Nalgene bottles were used for all the nutrient sampling. These were aged, acid washed and cleaned initially, and stored containing a 10% acid solution between sampling. Water column depth profile samples were taken from the 12 litre OTE CTD bottles from the Stainless Steel CTD/Rosette system and sub-sampled into the Nalgene nutrient bottles. The sample bottle was washed 3 times before taking the final sample, and capping tightly. These were then taken immediately to the nutrient analyser in the laboratory and analysis conducted as soon as possible after sampling. Nutrient free (Semperguard) gloves were used and other clean handling protocols were adopted as close to those according to the GO-SHIP nutrient manual protocols (Becker et al, 2019; in review).

8.3 Analytical methods

The micro-molar segmented flow colorimetric auto-analyser used was the PML 5-channel (nitrate, nitrite, phosphate, ammonium and silicate) Bran and Luebbe AAIII system, using classical proven analytical techniques.

The instrument was calibrated with home produced nutrient stock standards and then compared daily against Certified Nutrient Reference Materials, from SCOR/Jamstec and KANSO Technos, Japan, for quality control and checking of analytical standardisation. Specifically batch CV was used during the cruise.

The analytical chemical methodologies used were according to Brewer and Riley (1965) for nitrate, Grasshoff (1976) for nitrite, Mantoura and Woodward (1983) for ammonium, and Kirkwood (1989) for silicate and phosphate.

8.4 References

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8.5 Samples analysed

8.5.1 CTD Samples Analysed by AAIII Nitrate, Nitrite, Silicate, Phosphate and Ammonium Micromolar analysis

Date	CTD /Station	Position	Preliminary water bottle depths. All 24 CTD bottles were analysed except where noted.
24/02/19	CTD_001	53^{0}30.105'S 58^{0}29.730'W	2107,2107,1789,1789,1589,1589,993,993,748,747,501,501,253,253,154,154,104,104,54,54,39,39,10,9,
25/02/19	CTD_003	62^{0}30.284'S 56^{0}47.730'W	532,503,453,453,403,403,304,304,203,204,179,179,154,154,154,104,80,69,55,54,30,30,10,10
25/02/19	CTD_004	62^{0}10.15'S 56^{0}40.3'W	1114,1114,1079,1079,1030,1030,985,986,936,936,802,802,602,602,402,303,204,154,104,84,54,34,6,6
28/02/19	CTD_005	61^{0}23.555'S 56^{0}41.619'W	471,470,460,462,412,411,363,363,308,307,203,202,153,153,103,103,78,78,53,52,28,18,8,8,
01/03/19	CTD_006	61^{0}02.43'S 54^{0}24.30'W	491,491,451,450,401,401,351,351,302,252,202,202,152,151,102,102,77,77,52,52,27,28,17,7,
01/03/19	CTD_007	60^{0}57.839'S 54^{0}10.358'W	891,891,851,850,799,800,751,750,701,700,601,601,402,402,302,301,202,152,103,77,53,52,28,9,
01/03/19	CTD_008	60^{0}44.095'S 53^{0}22.46'W	447,447,389,390,340,341,291,291,241,241,202,201,151,151,102,102,77,78,52,52,27,27,7, Bottle 24 Misfire
01/03/19	CTD_009	60^{0}25.5'S 52^{0}49.8'W	392,391,350,350,300,301,251,251,201,201,152,152,131,131,101,101,82,82,52,51,32,31,7,7, Bottle 24 Misfire
01/03/19	CTD_010	60^{0}32.9'S 52^{0}21.18'W	821,821,800,800,750,749,700,700,649,649,600,600,400,400,301,201,151,101,77,52,28,27,7,6

01/03/19	CTD_011	60^{0}22.23’S 51^{0}53.18’W	405,405,379,380,325,325,277,277,228,228,200,200,150,150,100,101,76,77,51,51,27,27,6,8,
01/03/19	CTD_012	60^{0}17.3’S 51^{0}23.2’W	527,526,485,485,435,435,386,386,338,337,307,308,209,210,161,160,105,106,82,82,56,32,11,12,
01/03/19	CTD_013	60^{0}15.18’S 51^{0}11.64’W	975,973,933,933,878,878,829,828,765,765,606,607,409,410,311,310,206,156,107,82,57,32,12,13,
01/03/19	CTD_014	60^{0}13.44’S 50^{0}55.91’W	1338,1338,1322,1321,1271,1272,1223,1221,1172,1172,1013,1013,809,610,411,312,213,152,107,82,57,32,8,8
01/03/19	CTD_015	60^{0}11.90’S 50^{0}30.79’W	742,743,698,699,649,649,599,599,499,499,400,400,301,302,202,201,151,152,102,76,52,27,7,7
01/03/19	CTD_016	60^{0}13.55’S 50^{0}02.61’W	570,570,519,519,470,470,420,419,372,372,298,298,200,199,151,152,101,101,77,76,51,26,7, Bottle 23 Misfire
01/03/19	CTD_017	60^{0}12.4’S 49^{0}16.82’W	995,995,949,949,900,900,851,850,801,800,601,600,402,301,202,202,152,152,83,83,52,52,28,8
02/03/19	CTD_018	60^{0}09.930’S 48^{0}35.077’W	1563,1563,1499,1499,1450,1449,1400,1400,1350,1250,1001,801,602,402,303,203,154,103,79,54,54,29,14,13, Bottle 24 Misfire
02/03/19	CTD_019	60^{0}06.51’S 48^{0}09.96’W	1904,1904,1878,1878,1823,1822,1718,1719,1518,1264,1011,811,612,407,407,308,203,153,103,78,53,53,29,9,
02/03/19	CTD_020	60^{0}08.9’S 48^{0}07.5’W	2756,2757,2725,2674,2625,2286,2032,1778,1528,1275,1020,822,617,413,314,214,164,114,64,34,34,19,10,10,
03/03/19	CTD_021	60^{0}07.61’S 47^{0}41.67’W	2006,2005,1949,1950,1899,1900,1849,1849,1750,1501,1251,1002,803,603,404,304,204,154,104,79,54,29,10,10,
03/03/19	CTD_022	60^{0}08.856’S 47^{0}20.094’W	1000,1000,949,948,900,900,849,850,750,600,401,400,301,301,201,152,102,77,52,52,27,27,7,7
03/03/19	CTD_023	60^{0}08.911’S 47^{0}20.177’W	603,603,550,550,500,501,450,400,401,301,301,200,201,151,151,101,101,77,51,51,27,27,7,7
03/03/19	CTD_024	60^{0}45.65’S 43^{0}59.8’W	244,244,244,207,207,207,182,182,182,152,152,152,102,102,102,77,77,52,52,27,27,8,8,8,
03/03/19	CTD_025	60^{0}44.4’S 47^{0}20.094’W	489,489,450,449,400,400,350,350,301,301,201,201,151,151,101,102,77,76,52,52,26,27,7,7,
03/03/19	CTD_026	60^{0}08.856’S 42^{0}47.4’W	1302,1302,1247,1247,1198,1198,1168,1168,1098,999,999,799,799,601,402,302,203,152,102,102,78,53,28,8
03/03/19	CTD_027	60^{0}40.801’S 42^{0}23.215’W	998,998,949,950,900,900,849,850,800,800,601,600,401,401,302,202,152,102,78,7,52,27,8,8
03/03/19	CTD_028	60^{0}39.61’S 42^{0}18.60’W	1641,1641,1594,1594,1545,1545,1495,1495,1444,1246,998,799,599,401,302,202,152,102,77,77,52,27,8,8,
03/03/19	CTD_029	60^{0}39.422’S 42^{0}11.827’W	2028,2028,1983,1983,1932,1882,1832,1732,1483,1238,994,994,798,600,403,303,204,154,104,104,79,54,30,10,
03/03/19	CTD_030	60^{0}39.368’S 42^{0}10.560’W	2513,2513,2476,2425,2374,2323,221,1969,1746,1481,1241,1241,1006,801,603,404,305,205,155,105,86,56,31,5,
03/03/19	CTD_031	60^{0}39.136’S 42^{0}09.008’W	3094,3054,3003,2928,2878,2777,2477,2230,1982,1736,1492,1001,754,405,306,202,156,106,72,71,56,31,5,5,
04/03/19	CTD_032	60^{0}38.41’S 42^{0}06.15’W	3617,3550,3498,3447,3397,3205,2943,2713,2467,2222,1981,1738,1494,1002,803,604,406,306,206,156,106,86,37,12,
04/03/19	CTD_033	60^{0}37.24’S 41^{0}59.29’W	3378,3378,3334,3303,3251,3201,2999,2507,2006,1754,1506,1252,1003,804,605,405,305,205,156,106,86,61,36,11,
04/03/19	CTD_034	60^{0}36.36’S 41^{0}49.68’W	2945,2945,2896,2845,2795,2496,2247,1999,1750,1500,1248,1002,802,603,403,303,203,153,104,104,79,54,29,9,
04/03/19	CTD_035	60^{0}24.198’S 41^{0}41.42’W	2429,2428,2395,2346,2296,2246,1996,1748,1498,1249,1000,800,602,402,302,202,202,152,103,103,78,52,28,8,
04/03/19	CTD_036	60^{0}31.774’S 41^{0}23.64’W	1918,1918,1867,1817,1747,1499,1499,1249,1001,801,601,402,302,203,153,103,103,78,53,53,29,28,8,9,
05/03/19	CTD_037	60^{0}28.2’S 40^{0}58.8’W	1435,1435,1399,1399,1348,1348,1299,1299,1249,1249,1000,999,800,602,402,302,203,152,103,83,53,28,9,8,
05/03/19	CTD_038	60^{0}25.811’S 40^{0}04.209’W	1418,1417,1349,1349,1300,1300,1250,1250,1201,1201,1001,1001,802,603,403,303,204,153,103,79,54,29,8,10,

05/03/19	CTD_039	60^{0}24.59’S 39^{0}18.0’W	1464,1463,1425,1424,1374,1374,1319,1319,1274,1275,1000,1001,800,601,402,302,203,153,102,78,52,29,8,9,
05/03/19	CTD_040	60^{0}24.60’S 39^{0}07.18’W	2137,2137,2097,2047,2047,1999,1749,1491,1251,1000,800,601,403,302,203,153,152,102,78,78,53,28,8,8,
05/03/19	CTD_041	60^{0}25.16’S 38^{0}42.58’W	2545,2544,2498,2448,2397,2349,2247,1999,1750,1498,1250,999,803,603,403,302,203,153,105,103,80,55,29,9,
05/03/19	CTD_042	60^{0}26.4’S 37^{0}59.9’W	2914,2917,2865,2816,2766,2715,2496,2248,1997,1749,1500,1252,1002,801,602,404,305,204,155,104,79,56,29,10,
06/03/19	CTD_043	60^{0}28.32’S 37^{0}21.42’W	2033,2031,2009,2011,1961,1960,1910,1862,1754,1505,1257,1007,806,607,409,304,203,155,104,79,56,31,15,15,
06/03/19	CTD_044	60^{0}22.7’S 36^{0}24.1’W	1861,1859,1794,1792,1742,1742,1689,1643,1492,1249,1001,801,601,403,301,203,202,153,103,104,79,54,28,8,
06/03/19	CTD_045	60^{0}18.186’S 35^{0}28.537’W	1589,1588,1548,1549,1500,1500,1447,1400,1251,1000,801,600,402,302,204,152,104,103,78,78,54,29,10,8,
07/03/19	CTD_046	60^{0}22.7’S 36^{0}24.1’W	365,362,310,312,262,261,211,212,175,176,152,152,101,102,77,77,53,52,26,27,26,7,7,8,
07/03/19	CTD_047	60^{0}01.82’S 34^{0}28.31’W	989,991,919,917,873,875,823,824,799,799,599,599,401,401,301,202,150,101,75,76,50,27,11,12,
08/03/19	CTD_048	59^{0}55.811’S 33^{0}50.991’W	1255,1255,1199,1196,1149,1149,1097,1098,1000,801,600,400,301,202,150,101,101,76,76,53,26,27,6,8
07/03/19	CTD_049	59^{0}50.932’S 33^{0}16.696’W	1595,1595,1548,1548,1497,1497,1448,1447,1249,998,999,799,600,401,301,200,152,151,101,102,76,50,26,8
07/03/19	CTD_050	59^{0}51.606’S 33^{0}09.585’W	2052,2054,1996,1945,1896,1846,1746,1497,1248,1001,1000,800,600,401,402,301,203,152,102,102,82,59,33,8,
07/03/19	CTD_051	59^{0}51.617’S 33^{0}04.252’W	2470,2470,2425,2425,2376,2374,2325,2326,2276,1996,1746,1499,1250,1000,801,602,402,202,152,103,83,53,28,9,
07/03/19	CTD_052	59^{0}52.805’S 32^{0}56.981’W	2881,2880,2846,2795,2745,2695,2497,2247,1998,1749,1499,1250,1001,802,602,402,303,203,153,105,79,54,29,10
08/03/19	CTD_053	59^{0}53.41’S 32^{0}51.58’W	2077,2079,2049,2052,2000,1948,1898,1744,1494,1245,996,793,599,397,301,199,151,102,76,76,52,26,10,10,
08/03/19	CTD_054	59^{0}54.0’S 32^{0}48.5’W	1460,1462,1449,1449,1402,1405,1354,1356,1300,1299,1002,999,795,601,403,303,201,153,102,101,77,52,29,14,
08/03/19	CTD_055	59^{0}54.02’S 32^{0}43.85’W	1056,1057,1009,1008,956,960,910,800,601,598,399,302,301,201,152,101,99,77,76,52,26,27,7,7,
08/03/19	CTD_056	59^{0}56.39’S 32^{0}14.44’W	965,965,910,909,858,859,808,809,757,600,601,402,300,200,153,101,100,76,76,51,52,26,7,7,
08/03/19	CTD_057	59^{0}58.155’S 31^{0}28.779’W	2068,2068,2048,1997,1948,1898,1748,1497,1249,1000,800,601,402,302,202,152,153,103,79,54,28,29,9,8,
08/03/19	CTD_058	60^{0}19.171’S 50^{0}57.649’W	2775,2746,2694,2645,2595,2496,2246,1997,1747,1498,1250,999,801,600,402,302,204,153,103,78,78,53,6,5,
08/03/19	CTD_059	60^{0}28.13’S 29^{0}44.16’W	1878,1878,1836,1837,1782,1747,1597,1498,1249,1000,800,600,400,301,201,152,101,102,77,52,52,26,7,8,
10/03/19	CTD_060	60^{0}41.13’S 28^{0}15.799’W	2135,2135,2087,2037,2036,1987,1937,1748,1499,1249,1000,800,601,402,302,202,202,152,103103,77,53,28,8,
10/03/19	CTD_061	60^{0}47.833’S 27^{0}25.336’W	3278,3215,3166,3115,3065,2495,1998,1749,1499,1249,1001,801,602,403,303,203,153,152,104,104,79,54,28,10,
10/03/19	CTD_062	60^{0}49.610’S 27^{0}13.698’W	3868,855,3804,3755,3503,3004,2503,2004,1753,1504,1254,1006,804,604,404,304,203,154,104,54,54,30,4,5,
12/03/19	CTD_063	59^{0}57.46’S 25^{0}29.507’W	3031,3032,2983,2903,2803,2702,2603,2502,2403,2202,1854,1504,1253,1004,804,504,305,205,130,81,55,30,9,9,
12/03/19	CTD_064	60^{0}06.69’S 25^{0}18.72’W	3964,3914,3865,3814,3755,3505,3254,3004,2754,2504,2006,1503,1006,805,606,407,306,206,156,106,81,56,32,11,
12/03/19	CTD_065	60^{0}10.614’S 25^{0}13.827’W	5050,5007,4957,4906,4858,4758,4506,4257,4006,3756,3506,3007,2506,2005,1506,1007,607,308,207,108,81,57,33,8,
12/03/19	CTD_066	60^{0}13.276’S 25^{0}07.940’W	5922,5859,5809,5760,5507,5256,5008,4758,4506,4256,4007,3506,3006,2506,2005,1507,1007,756,507,307,157,82,47,13

13/03/19	CTD_067	60^{0}26.296’S 24^{0}46.789’W	4841,4841,4797,4748,4701,4651,4552,4300,4051,3801, Comms lost on bottles 11-24.
13/03/19	CTD_068	60^{0}33.378’S 24^{0}40.289’W	4088,4036,3985,3936,3885,3755,3504,3255,3005,2505,2004,1504,1004,804,605,407,306,206,157,106,82,55,31,8,
13/03/19	CTD_069	60^{0}26.281’S 24^{0}46.733’W	4829,4778,4728,4678,4626,4508,4256,4006,3756,3505,3255,3007,2504,2005,1505,1006,506,407,207,106,83,57,33,12, Bottle 24 Misfire
14/03/19	CTD_070	61^{0}00.889’S 25^{0}44.229’W	3531,3532,3486,3434,3385,3335,3255,3004,2505,2005,1505,1006,806,606,406,306,205,156,107,82,81,56,31,6, Bottle 24 Misfire
14/03/19	CTD_071	61^{0}13.846’S 24^{0}15.573’W	11,12,32,57,81,105,157,206,308,407,607,806,1005,1506,2010,2505,3005,4186,4237,4278
14/03/19	CTD_072	61^{0}25.811’S 22^{0}46.248’W	4590,4536,4486,4436,4006,3506,3006,2506,2006,1506,1006,807,607,407,307,207,157,158,108,82,58,33,13,13,
07/04/19	CTD_073	61^{0}37.863’S 21^{0}17.055’W	5021,4978,4928,4879,4759,4509,4258,4008,3757,3507,3257,3007,2006,1006,607,407,307,208,157,108,83,58,33,13,
15/03/19	CTD_074	61^{0}49.957’S 19^{0}47.825’W	4460,4407,4358,4302,4101,4008,3730,Comms Lost Bottles 8 to 24
06/04/19	CTD_075	61^{0}43.273’S 18^{0}49.535’W	5050,5000,4899,4749,4498,3998,3748,3497,3001,2501,2001,1501,1250,1001,801,601,401,251,152,102,77,52,27,12,
06/04/19	CTD_076	61^{0}25.858’S 17^{0}04.484’W	4698,4657,4607,4557,4507,4006,3755,3505,3255,2755,2255,1755,1254,1004,805,605,404,205,155,105,80,56,30,10,
06/04/19	CTD_077	61^{0}17.858’S 15^{0}52.516’W	5288,5240,5189,5140,5009,4759,4508,4007,3758,3507,3007,2506,2006,1007,608,408,308,208,158,99,73,49,23,5,
04/04/19	CTD_078	60^{0}59.836’S 13^{0}30.370’W	5460,5408,5358,5308,5007,4505,4256,4005,3757,3004,2504,2004,1505,1006,805,606,406,206,156,106,80,56,32,12,
17/03/19	CTD_079	60^{0}48.014’S 12^{0}01.172’W	5455,5421,5371,5271,5020,4517,4018,3515,3013,2514,2012,1512,1011,811,610,411,310,210,160,110,85,60,35,7,
17/03/19	CTD_080	60^{0}24.029’S 09^{0}02.500’W	4914,4861,4810,4710,4510,4260,4009,3510,3008,2508,2008,1507,1008,809,609,409,309,210,161,109,84,59,25,5,
18/03/19	CTD_081	60^{0}00.04’S 06^{0}03.091’W	4985,4909,4857,4757,4506,4006,3506,3004,2504,2004,1502,1004,804,605,404,304,204,154,104,105,80,55,30,10,
19/03/19	CTD_082	59^{0}37.083’S 03^{0}06.592’W	4866,4821,4772,4720,4511,4011,3758,3509,3008,2508,2007,1508,1008,808,609,408,309,209,159,107,85,59,26,6
19/03/19	CTD_083	59^{0}12.102’S 00^{0}06.207’W	5073,5008,4958,4859,4508,4007,3757,3507,3006,2506,2006,1756,1504,1005,805,605,404,205,155,105,73,50,24,8,
20/03/19	CTD_084	58^{0}49.016’S 02^{0}51.447’E	5460,5414,5363,5262,5011,4511,4010,3510,3011,2510,2010,1509,1010,811,611,410,311,211,161,111,86,62,36,6,
21/03/19	CTD_085	58^{0}24.925’S 05^{0}49.670’E	5100,5049,5000,4900,4506,4247,4007,3758,3507,3006,2506,2005,1504,1005,606,405,305,206,155,100,75,50,26,5,
21/03/19	CTD_086	58^{0}19.872’S 07^{0}45.568’E	Bottle 1 Did not Fire,4223,4167,4119,4059,4008,3758,3507,3008,2506,2006,1506,1256,1006,806,606,406,306,206,157,106,81,56,32,6,
21/03/19	CTD_087	58^{0}04.002’S 09^{0}39.664’E	5507,5458,5407,5306,5011,4510,4000,3500,2999,2498,1998,1498,998,799,599,399,304,204,155,105,79,55,30,11
22/03/19	CTD_088	57^{0}53.982’S 11^{0}50.491’E	5690,5641,5511,5408,5009,4508,4007,3757,3507,3007,2506,2006,1506,1006,804,605,405,205,154,104,80,54,30,6,
22/03/19	CTD_089	57^{0}42.795’S 13^{0}29.326’E	5572,5516,5468,5367,5007,4505,4000,3500,2999,2500,2001,1499,1000,798,601,401,300,201,152,103,79,54,28,14,
23/03/19	CTD_090	57^{0}32.255’S 15^{0}22.493’E	5130,5081,5032,4930,4510,4009,3508,3008,2508,2007,1507,1007,807,607,407,307,207,156,107,68,67,33,7,6
23/03/19	CTD_091	57^{0}22.134’S 17^{0}15.538’E	5078,5023,4974,4876,4525,4275,4025,3523,3023,2498,2001,1752,1501,1001,803,602,403,295,203,154,104,78,55,11,
26/03/19	CTD_092	57^{0}13.807’S 18^{0}59.403’E	4686,4635,4584,4489,4256,4007,3755,3504,3005,2505,2004,1505,1004,804,605,406,305,203,155,105,80,55,29,6,
26/03/19	CTD_093	58^{0}02.322’S 21^{0}33.467’E	4353,4306,4254,4156,3904,3756,3504,3006,2504,2005,1755,1503,1005,805,605,405,304,204,154,105,80,54,30,10,

27/03/19	CTD_094	58^{0}52.356'S 24^{0}22.247'E	5395,5347,5296,5197,5010,4761,4258,4007,3760,3507,3007,2506,2006,1506,1005,756,507,207,157,106,83,57,32,12,
28/03/19	CTD_095	59^{0}41.272'S 27^{0}10.080'E	5301,5250,5199,5150,5006,4510,4011,3505,3008,2504,2001,1508,1005,805,605,405,306,206,155,104,82,54,32,6,
29/03/19	CTD_096	60^{0}29.992'S 30^{0}00.000'E	5229,5005,4806,4606,4105,3806,3205,2906,2606,001,1500,1004,804,605,404,207,158,107,79,79,58,34,11,12,
30/03/19	CTD_097	61^{0}00.002'S 30^{0}00.002'E	5231,5145,4948,4750,4351,4055,3759,3449,2853,2247,1763,1357,958,758,559,434,334,233,149,89,70,39,24,7,
30/03/19	CTD_098	61^{0}30.016'S 29^{0}59.985'E	5194,5108,4908,4707,4509,4208,3908,3608,3006,2607,2006,1506,1007,807,607,406,307,207,157,107,82,57,32,6,

8.5.2 Margot Debyser: Surface underway samples for stable isotope work

Date	Time	Longitude [East], Latitude [North]	Underway ID
27/02/19	n/a	-56.7833, -62.4833	Underway 1
27/02/19	n/a	-56.7833, -62.5	Underway 2
28/02/19	19:28	-56.6833, -61.3833	Underway 3
28/02/19	19:38	-56.6833, -61.3833	Underway 4
01/03/19	16:54	-52.35, -60.5333	Underway 5
01/03/19	17:09	-52.35, -60.5333	Underway 6
02/03/19	22:28	-48.1166, -60.1333	Underway 7
02/03/19	22:30	-48.1166, -60.1333	Underway 8
03/03/19	23:58	-42.95, -60.75	Underway 9
03/03/19	00:10	-42.95, -60.75	Underway 10
04/03/19	14:42	-42.15, -60.65	Underway 11
04/03/19	14:43	-41.9833, -60.6166	Underway 12
04/03/19	23:12	-40.0666, -60.4166	Underway 13
05/03/19	17:30	-40.0666, -60.4166	Underway 14
05/03/19	17:31	-38, -60.4333	Underway 15
06/03/19	13:30	-38, -60.4333	Underway 16
06/03/19	13:40	-34.7833, -60.1	Underway 17
07/03/19	23:26	-34.7833, -60.1	Underway 18
07/03/19	23:28	-34.7833, -60.1	Underway 19
08/03/19	16:19	-32.9333, -59.8666	Underway 20
08/03/19	16:25	-32.9333, -59.8666	Underway 21
09/03/19	17:59	-30.3666, -60.4	Underway 22
09/03/19	18:06	-30.3, -60.4	Underway 23
09/03/19	22:42	-29.5833, -60.5	Underway 24-25
10/03/19	14:12	-27.2166,-60.8166	Underway 26
10/03/19	14:20	-27.2166, -60.8166	Underway 27
13/03/19	14:42	-24.7666, -60.4333	Underway 28
13/03/19	14:52	-24.7666, -60.4333	Underway 29
13/03/19	21:48	-25.7, -60.6333	Underway 30
14/03/19	15:04	-24.925, -61.1333	Underway 31
15/03/19	14:25	-21.2833, -61.6166	Underway 32
15/03/19	20:54	-19.7833, -61.8166	Underway 33
16/03/19	14:35	-16.0666, -61.3166	Underway 34
16/03/19	21:45	-6.05, -60	Underway 35
18/03/19	16:21	-1.15, -59.3333	Underway 36
18/03/19	16:21	n/a	Milli Q test
19/03/19	14:21	-1.15, -59.3333	Underway 37
19/03/19	20:35	-0.1, -59.2	Underway 38
20/03/19	13:40	3.3, -58.75	Underway 39
20/03/19	19:43	5.3833, -59.4833	Underway 40

21/03/19	14:00	8.35, -58.2333	Underway 41
21/03/19	19:46	9.65, -58.0666	Underway 42
22/03/19	11:59	11.8333, -57.8833	Underway 43
22/03/19	19:30	13.4833, -57.7	Underway 44
23/03/19	14:54	16.2166, -57.45	Underway 45
26/03/19	12:21	18.9833, -57.2166	Underway 46
26/03/19	21:27	21.55, -58.0333	Underway 47
27/03/19	13:29	24.3666, -58.8666	Underway 48
27/03/19	22:08	25.5666, -59.2166	Underway 49
28/03/19	13:39	28.4166, -60.0333	Underway 50
28/03/19	19:55	29.9666, -60.4833	Underway 51
29/03/19	14:09	30, -60.5	Underway 52
29/03/19	21:06	30, -60.9833	Underway 53
30/03/19	12:17	29.1833, -61.5333	Underway 54
31/03/19	13:50	19.95, -62.6166	Underway 55
31/03/19	20:37	17.2666, -62.7833	Underway 56
04/04/19	13:20	-13.5000, -60.9833	Underway 57
04/04/19	20:48	-14.9167, -61.1833	Underway 58
05/04/19	15:07	-15.8667, -61.2833	Underway 59
06/04/19	19:13	-18.8167, -61.7167	Underway 60

8.5.3 SOCCOM floats

Nitrate concentrations reported to SCRIPPS Institution (USA) for calibration of the SOCCOM Floats that were launched during the cruise: CTD's: 20, 31, 58, 62, 90, 96.

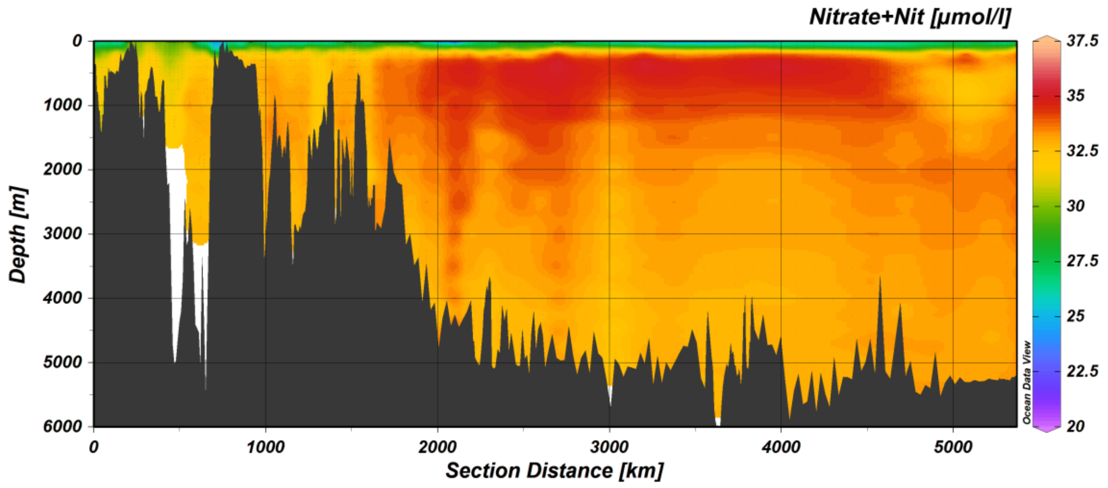
8.6 Cruise summary, preliminary results

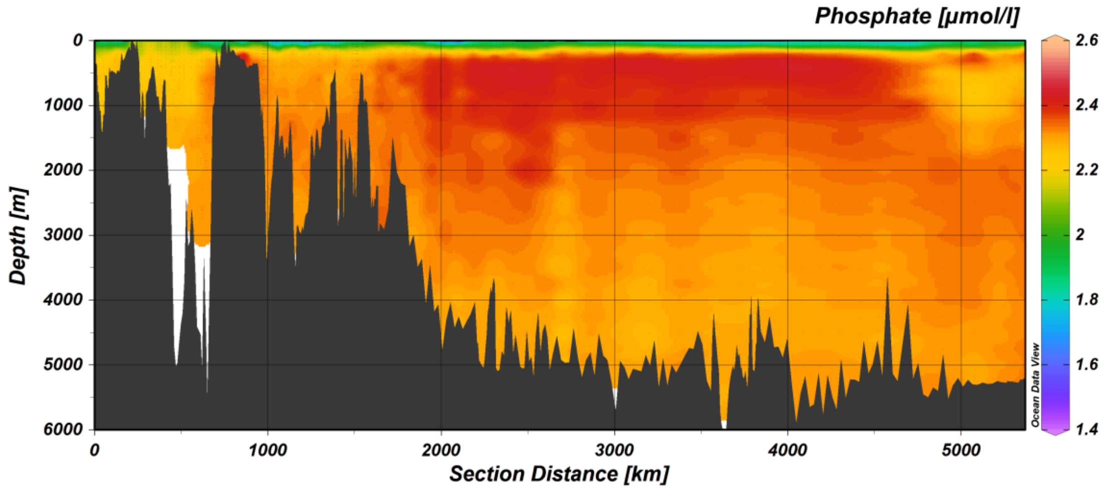
The 5-channel nutrient autoanalyser analyser worked generally well throughout the cruise, except for some Cadmium reduction column issues early on, and also a number of packets of the Nitrite sample delivery pump tubing was found to be defective causing issues until the problem was diagnosed and a different lot number of tubing was used. One of the automatic pipettes was also unreliable early on until the problem was again isolated and corrected. KANSO Certified nutrient reference materials (almost exclusively Batch BV) were run with every analysis run to check the auto-analyser integrity and analytical continuity from one day to the next, these results demonstrating very good overall analytical performance from the results of the analysis of these reference materials for Nitrate, Nitrite Silicate and Phosphate concentrations.

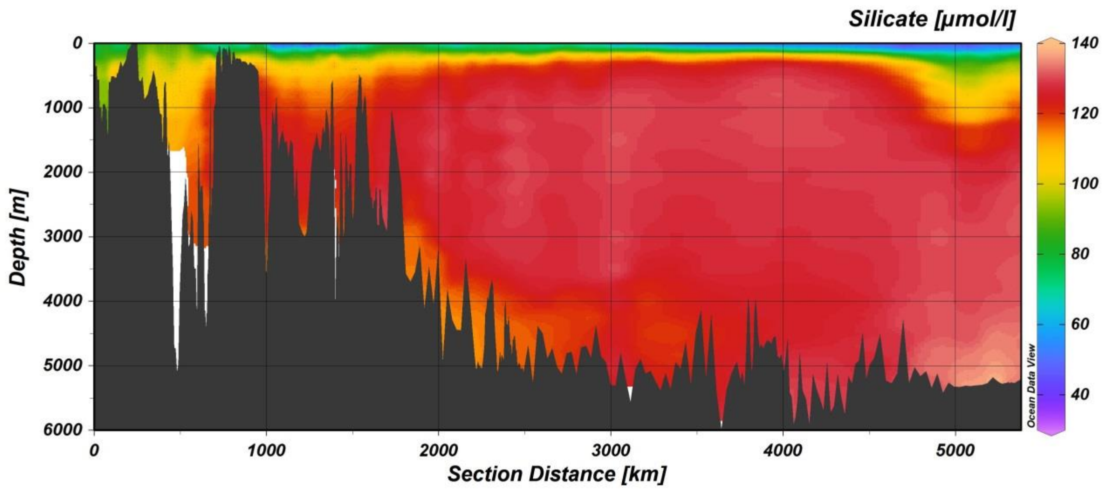
Preliminary results for the depth profiles of the individual nutrients are shown below for the full water column, and also upper 400m, depths. From the full depth results the various water masses like the Weddell Deep, Weddell Sea Deep, and Weddell Sea Bottom water can be identified. To the far east of the transect the influence of the Antarctic Circumpolar current with higher water temperatures, linked with a lowering in the upper approx. 1500m water with lower Nitrate, Silicate and Phosphate concentrations.

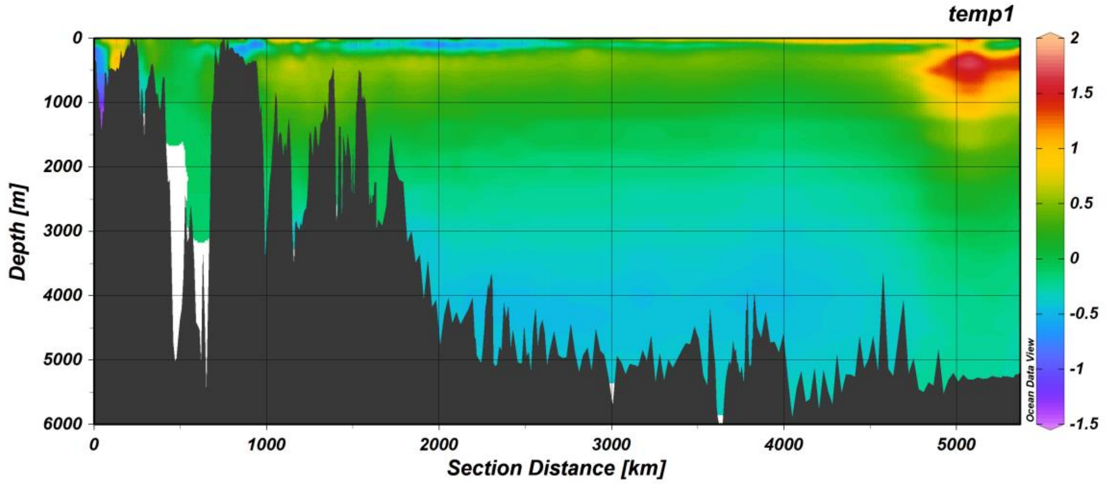
The upper 400m water column sections then show the more productive regions of the transect with regard to the good comparisons of the Ammonium, Nitrite and

Fluorescence profiles. It can be seen that the surface concentrations of the Nitrate, Silicate and Phosphate are all depleted in this surface water compared to the deep.

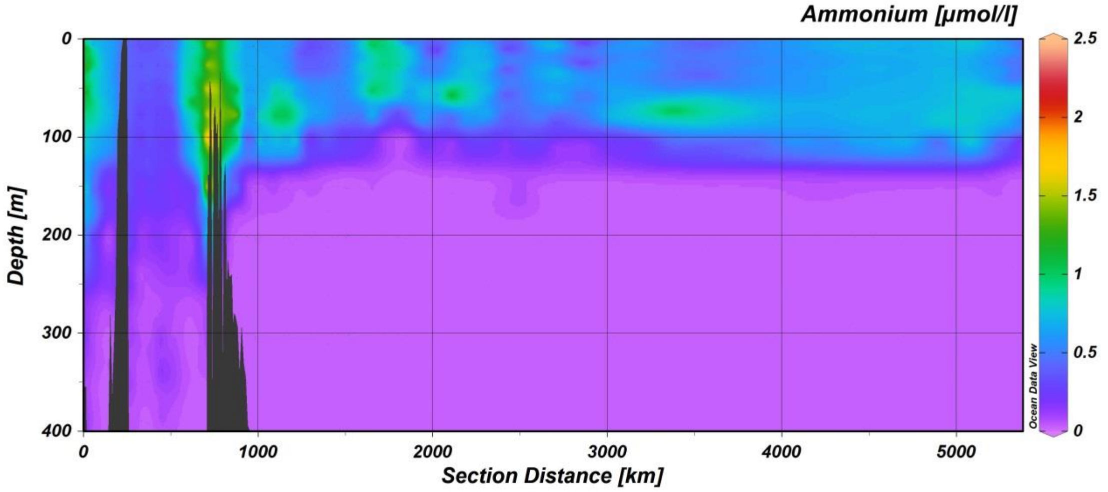


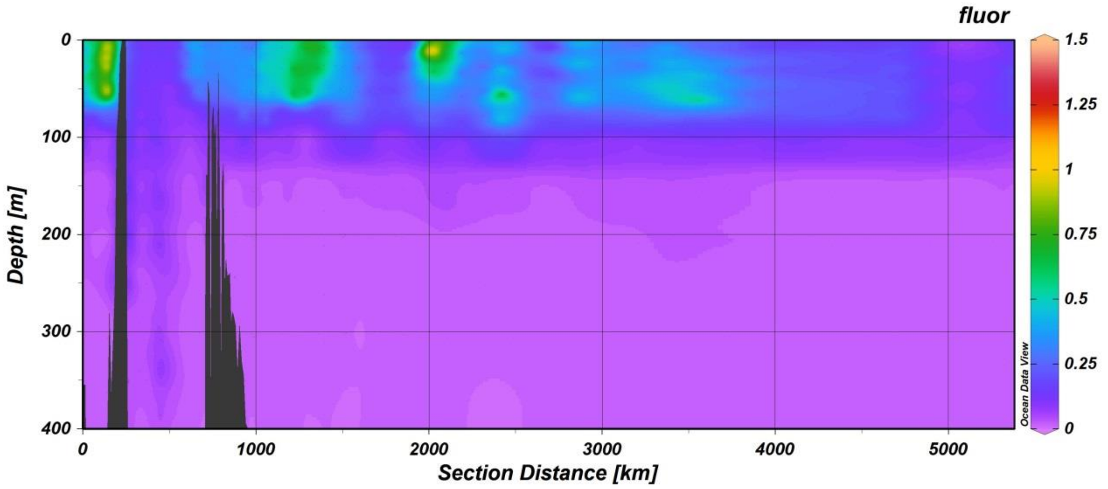


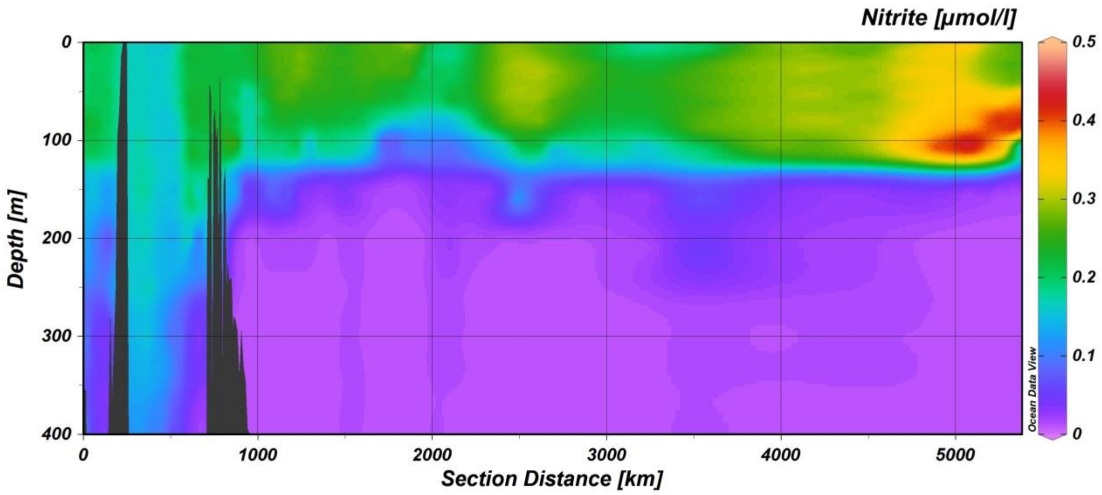


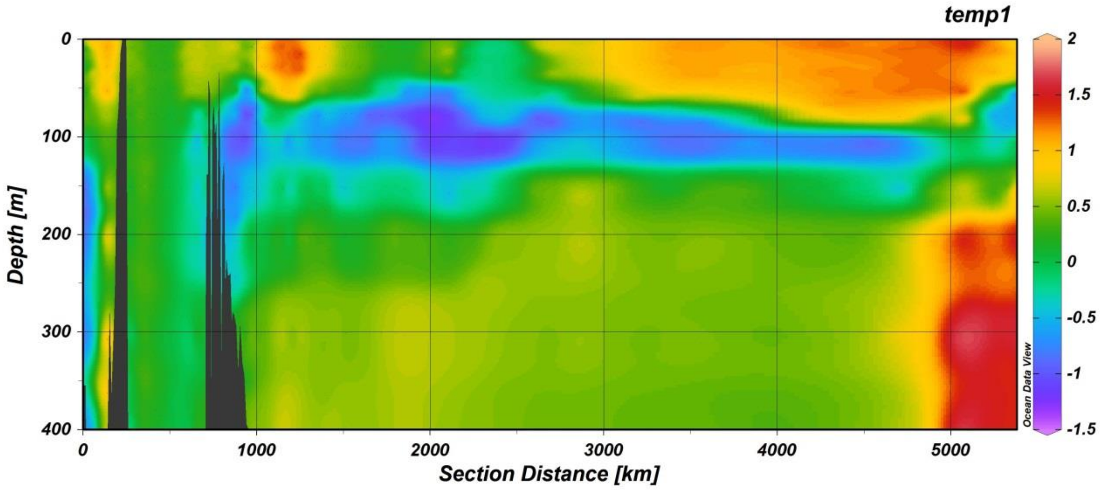


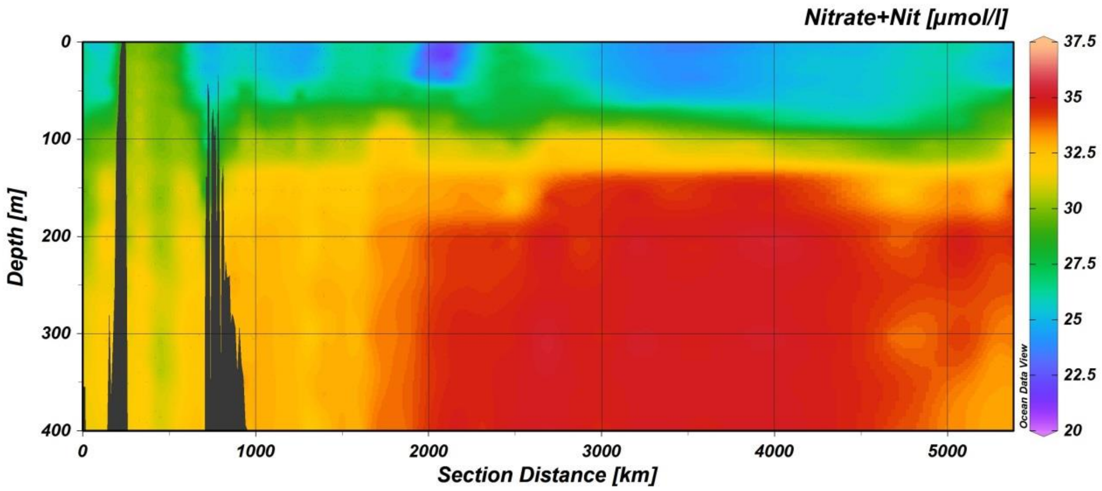
8.6.1 Upper 400m Water Column

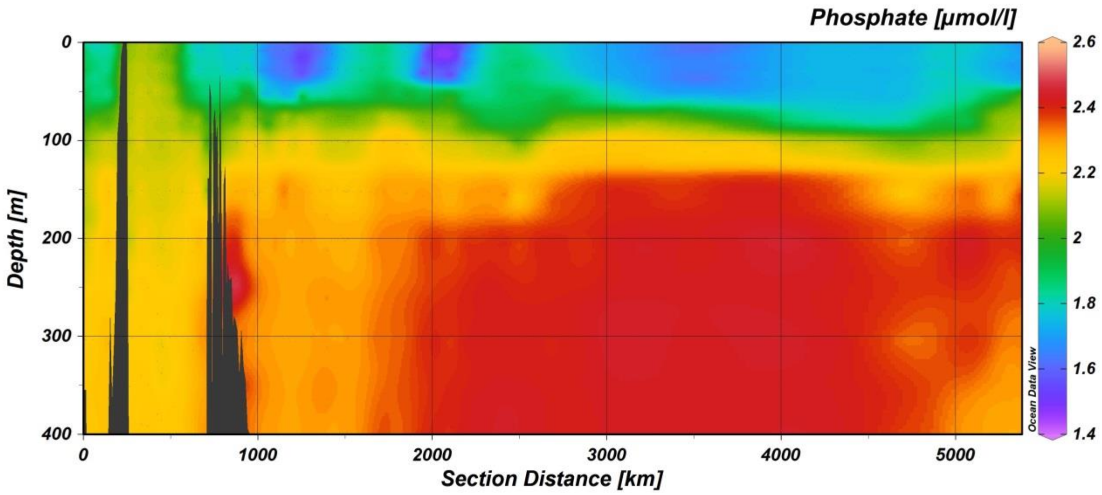





Nitrite [µmol/l]
Depth [m]
Section Distance [km]
Ocean Data View


temp1
Depth [m]
Section Distance [km]
Ocean Data View


Nitrate+Nit [µmol/l]
Depth [m]
Section Distance [km]
Ocean Data View



8.7 Thanks

To the officers, crew and engineers of the RRS James Clark Ross for a safe and enjoyable voyage, especially the catering team who continually produced high quality food despite the long voyage, an example to many other ships catering teams of what can be achieved without resorting to frying everything after week 2 !

9 Chlorofluorocarbons (CFCs) and sulphur hexafluoride (SF6) measurements

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A series of three halocarbons (dichlorodifluoromethane – CFC-12, trichlorofluoromethane - CFC-11, and trichlorotrifluoroethane - CFC-113), carbon tetrachloride (CCl4) and sulphur hexafluoride (SF_6) were measured by shipboard electron capture gas chromatography (EC-GC) coupled to an extraction-and-trap system. The method combines the Lamont Doherty Earth Observatory CFC method [Smethie et al., 2000] and the Plymouth Marine Laboratory SF_6 method [Law et al. 1994] tied together with a common valve for the introduction of gas and water samples. This system has the advantage of a simultaneous analysis of SF_6, CFCs and CCl4 from the same water sample with a running time per sample of 20 minutes. The system was set up in the temperature controlled Exeter container which was installed on the after deck of the James Clark Ross (JCR) to reduce the possibility of contamination from high levels of CFCs and radio waves frequently present inside research vessels.

9.1 Sample collection

Water samples were collected from the 12-l Niskin bottles as soon as the CTD sampling rosette was on board. When taken, water samples for CFC analysis were the first samples drawn from the bottle. The Niskin nitrile 'O' rings were conditioned by a isopropanol wash and a baking in a vacuum oven for 24 hours to remove susceptible contamination before installation in Niskin bottles. The trigger system of the bottles was external stainless steel springs. Water samples were collected in 500 ml ground glass stoppered bottles that were filled from the bottom using conditioned Tygon tubing and overflowed 3 times to expel all water exposed to the air. Immediately after sampling, the samples were immersed in a cool box of clean cold deep seawater and stored in the cold room (~5°C) to prevent degassing and hydrolysis of the CCl4 and CFC-113 until their analysis.

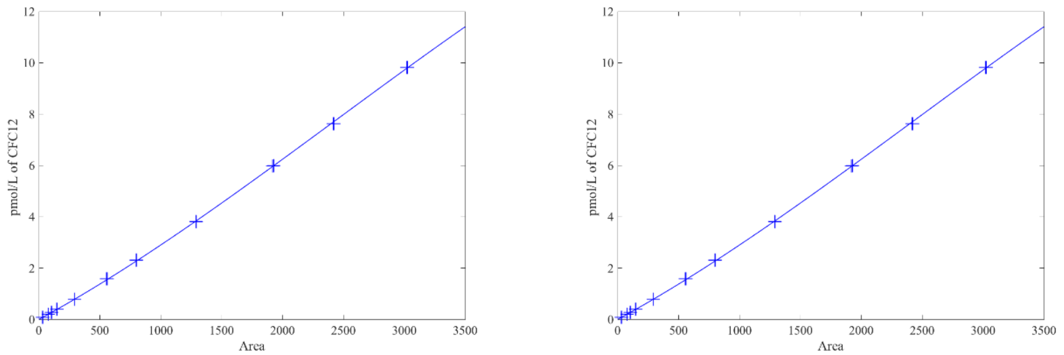
For air sampling, ¼” o.d. Dekabon tubing was run from the JCR monkey island into the container. Air was pumped through the line to the instrument using a DA1 SE Charles Austen pump, with the line being flushed for approximately 30 minutes before beginning analysis.

9.2 Analysis technique

Sample analysis was performed on board using a coupled SF_6 and CFCs system with a common valve for the introduction of gas and water samples. Samples were introduced to the system by applying nitrogen (N_2) pressure to the top of the sample bottles, forcing the water to flow through and fill a 27 cm^3 calibrated volume for CFCs and a 300 cm^3 volume for SF_6. The measured volumes of seawater were then transferred to separate purge and trap systems, before being stripped with N_2 and trapped at -110°C on a Unibeads 2S trap (for CFCs) and at -75 °C on a Porapak Q trap (for SF_6) each immerged in the headspace of liquid nitrogen. Each purge and trap system was interfaced to an Agilent 6890N gas chromatograph with electron capture detector (GC-ECD). The traps were heated to 100° C for CFCs and 65°C for SF_6 and injected into the respective gas chromatographs. The SF_6 separation was achieved using a molecular sieve packed 2 meters main column and 1meter buffer column. The CFCs separation was achieved using a 1m Porasil B packed pre-column and a 1.5m carbograph AC main column. The carrier gas was pure nitrogen, which was cleaned by a series of purity traps. Liquid nitrogen was used as the cryogenic cooling material for the sample traps, and was provided by two on-board liquid nitrogen generator located in the workshop of the JCR. Around 12L of NL_2 were used per day when the instrument was running at full time.

9.3 Calibrations

The CFCs and SF_6 concentrations in air and water were calibrated using two external gaseous standard supplied by NOAA (Brad Hall, December 2015) in 29L Aculife-treated aluminum cylinders (Table 9.1). The final data set will be converted to mol/kg on the SIO-98 scale using NOAA's comparison tables to SIO (http://www.esrl.noaa.gov/gmd/hats/ihalace/index.html). The calibration curves were made by multiple injections of different volumes (0.1, 0.25, 0.3, 0.5, 1, 2, 3, 5, 8, 10 and 12 ml) of standard to span the range of tracers measured in the water (Figure 9.1). The changes in the sensitivity of the system for each compound were tracked by injections of a fixed volume of standard gas and used to adjust the calibration curves respectively.



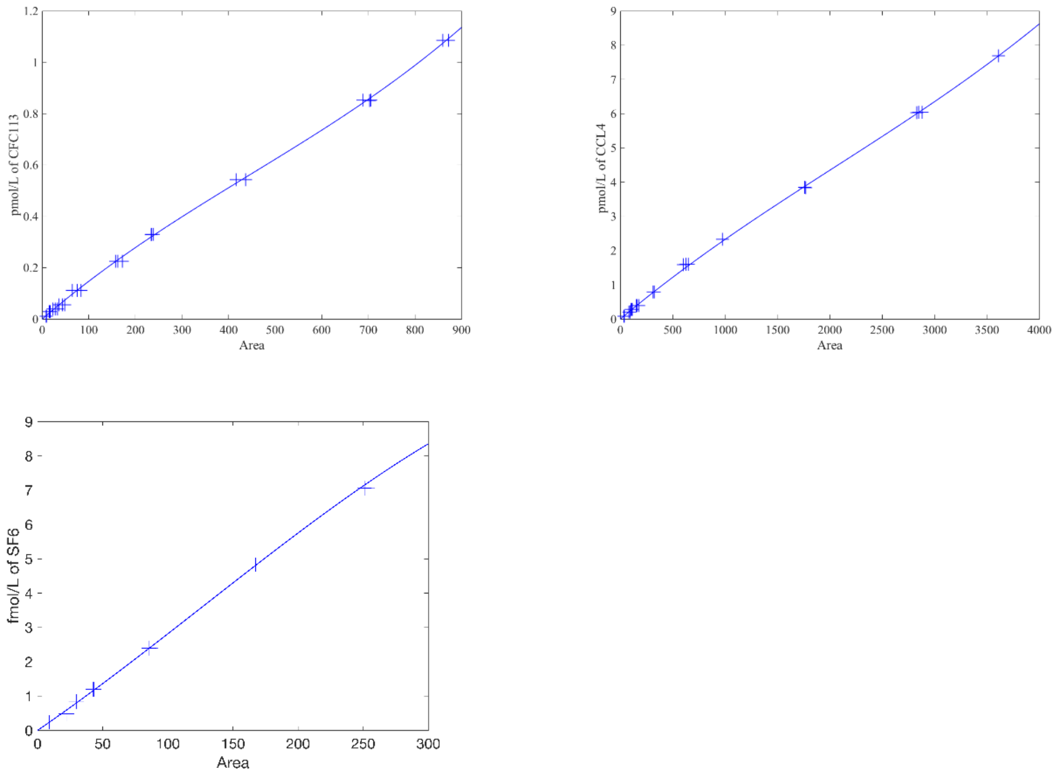


Figure 9.1: Calibration curves for CFC-12, CFC-11, CFC-113, CCl_4 and SF_6 for the 9th of April 2019.

Table 9.1: Concentrations of the used NOAA 2017 standards in ppt.

	NOAA2017 – cylinder CC456893 **Air spiked for CFC-11 , CCl_4, SF_6**	**NOAA2017 - cylinder CC456907** **Air**
SF_6	17.61	8.70
CFC-11	1031	232.4
CFC-12	516.6	516.6
CFC-113	75.2	73.5
CCl_4	521	83.1

9.4 Precision and detection limit

9.4.1 Precision or reproducibility

The precision (or reproducibility) for the water sample measurements can be determined from two samples drawn from the same Niskin bottle. Here, 81 duplicates taken along the cruise were used (146 samples from Niskins and 16 samples from underway/surface bucket sampling). The preliminary precisions estimated from average of absolute difference are presented Table 9.2.

Table 9.2: Average of absolute differences for duplicates.

	Surface Values	Lower values
SF_6	1.26%	0.02 fmol kg $^{-1}$ for values < 0.25 fmol kg $^{-1}$
CFC-12	0.51 %	0.0024 pmol kg -1 for values < 0.25 pmol kg -1
CFC-11	0.94%	0.0051 pmol kg -1 for values < 0.50 pmol kg -1
CFC-113	4.83%	0.0064 pmol kg -1 for values < 0.25 pmol kg -1
CCl_4	2.59%	0.0436 pmol kg -1 for values < 2 pmol kg -1

9.4.2 Test stations and sample blank correction

The blank correction is to compensate for any contamination of CFCs/SF_6 originating from the sampling bottles, handling and from the measurement procedure. This correction is normally best estimated from analysis of CFC-free water when available. Here, we used samples from a full 12L Niskin discharged of its gases through a continual sparge ~ until concentrations have reached a steady-state value. Based on the measurements of a 4 hours sparged full Niskin, blank corrections of 0.014 pmol kg^{-1} for CFC-11, 0.005 pmol kg^{-1} for CFC-12 and 0.096 pmol kg^{-1} for CCL4 will be applied to the data set. No blank corrections were required for the CFC113 and SF_6 data. If the measured CFC concentration for a sample is very low, subtracting a blank can result in a very small negative number reported. Additionally, a 'test' station (station 2, see Table 9.2) was carried out in 'CFC-low' deep waters to test the 'blank' of the Niskin bottles and sampling procedure by firing all the Niskin at the same depth. The tracer standard deviation at Station 2 is similar to the standard deviation of the duplicates drawn from the same Niskin (see section above), so no contamination could be assigned per Niskin bottles.

Table 9.3: Results of the 'Niskin test' at station 2 (58° 18.93 S 57° 22.61 W) in pmol kg $^{-1}$ for CFCs and in fmol kg^{-1} (1 fmol =10^{-15} mole) for SF_6. For this station, all the Niskin bottles were closed at a same depth of 3264 m. Mean tracer concentration and standard deviation of the sample concentrations are indicated. Leaking Niskin bottles and instrumental problems are not included in those statistics.

	SF_6	**CFC-12**	**CFC-11**	**CFC-113**	**CCL4**
Mean Station 2	2.66e-02	5.963e-02	1.369e-01	5.799e-03	9.309e-01
Std Station 2	4.93e-03	3.095e-03	5.119e-03	3.333e-03	6.577e-02

9.4.3 Sparging efficiency

The sparging efficiency was evaluated by re-stripping high concentration surface water samples until results did not change (having reached the system blank) at a number of different flow rates. Comparing those residual concentrations to the initial concentrations, the re-sparge values were approximately <2% of the initial sample concentration for CFC-12, CFC-11 and CFC-113 and below <9% for CCl_4 for a sparging of 5 min at 85 ml/min and 3°C. The SF_6 re-sparge value was < 8% for a 4 min sparging going up to 120 ml/min and 3°C. It is expected that these values will improve once final calibrations have been completed and blank corrections have been included. A fit of the re-sparging efficiency as a function of sample temperature and flow rate will be applied to the final data set.

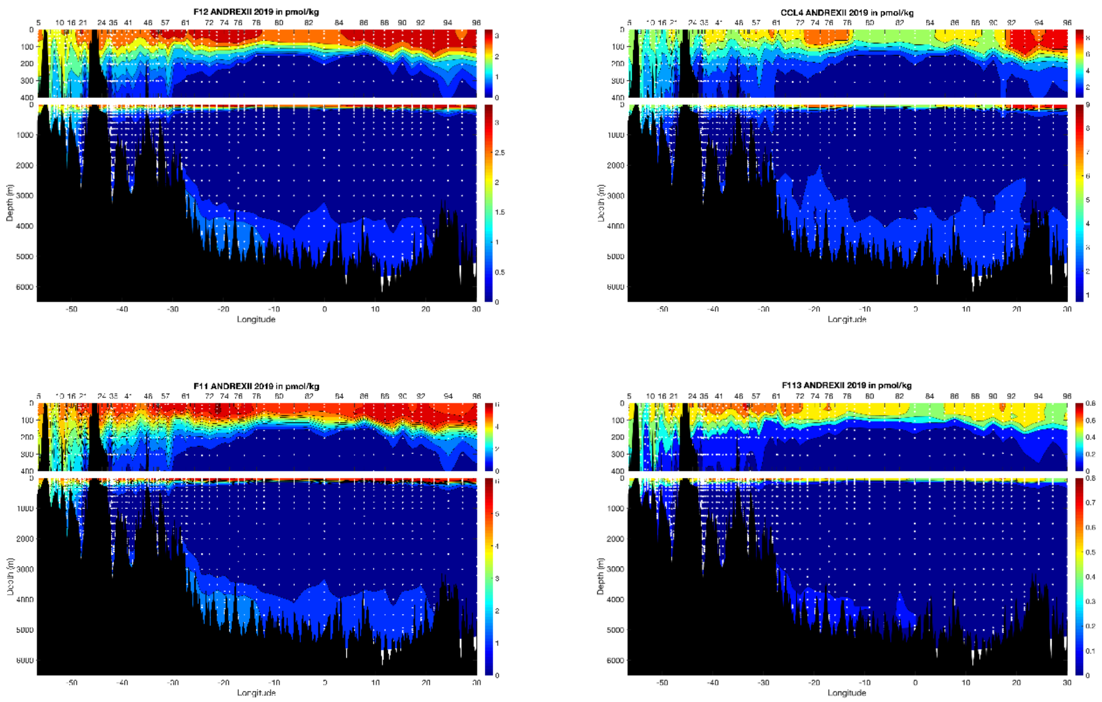
Table 9.4: Initial sparging efficiencies estimated for the tracers under investigation during ANDREXII.

	CFC-12	**CFC-11**	**CFC-113**	**SF_6**	**CCl_4**
Sparge efficiency %	98.2	98.1	100	92.3	88.9

These effects will all be assessed in more detail and accounted for in the final data set, but have not yet been addressed. Additional factors affecting accuracy include chromatographic considerations, such as interferences and baseline variation. Those will also be checked for the final data set. Particular difficulty was noted for CCl_4 and CFC-113 where larger changes in instrument response were noted than for the other tracers.

9.5 Data

In total, 98 of 100 stations were sampled (stations 11 and 99 were omitted), totaling to 2053 seawater samples including duplicates. All seawater samples were analysed for both CFCs and SF_6. Preliminary results are presented below in Fig.2 for the ANDREXII main transect. The distributions of the CFCs and SF_6 seen here are consistent with previous studies and in particular with the original ANDREX (JC30) and ANDREX Recovery (JR239) cruises. They show a broad near surface maximum, relatively high concentration in the ventilated Antarctic Bottom Water at the bottom, and low concentration in the circumpolar waters.



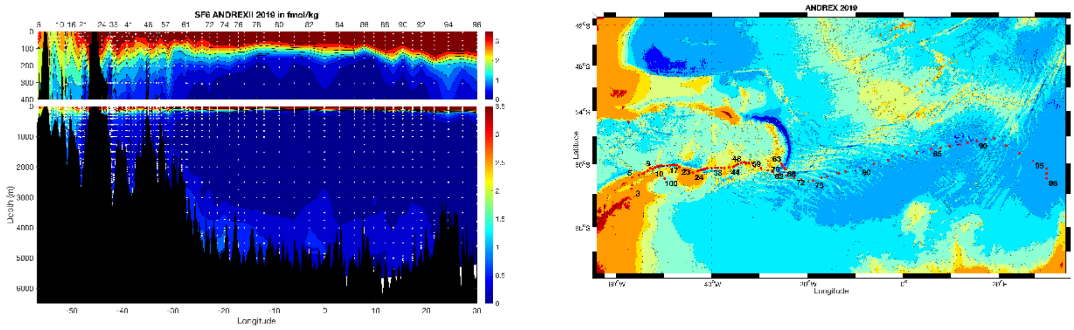


Figure 9.2: Map of stations (lower right) and preliminary vertical distributions of CFC-12, CFC-11, CFC-113, CCl_4 and SF_6 along the track of the ANDREXII cruise at the northern boundary of the Weddell Sea. Data are uncalibrated and so only internally consistent.

10 Air-sea CO_2/heat flux system

Mingxi Yang, Plymouth Marine Laboratory

10.1 General description

We are continuously measuring air-sea fluxes of CO_2, sensible heat, latent heat (H_2O) and momentum on the JCR using the eddy covariance (EC) method. This requires rapid (>= 10 Hz) sampling of the following:

- 3-dimensional wind velocities and air temperature using a Metek sonic anemometer
- 3-dimensional acceleration and rotation using two separate instruments (a LPMS motion sensor and a Systron Donner Motionpak II, also referred to as 'Sysdon' or 'MPII')
- CO_2 mixing ratio in the atmosphere (Picarro G2311-f CO_2 / CH_4 / H_2O analyzer)
- H_2O mixing ratio in the atmosphere (Licor 7500 analyzer)

In the EC method, the turbulent flux is defined as : Flux = <c'W'>, where c is the parameter of interest (e.g. horizontal velocity for momentum flux, temperature for sensible heat flux, and gas mixing ratio for gas fluxes)), and W is the vertical wind velocity. Here <> represents time average (here we use a 20-min averaging internal. The prime indicates deviation from the mean. The motion data are used to removal the ship's motion from the measured winds to get true winds.

Note: the Picarro also detects H_2O, but a Nafion dryer (stainless steel tube mounted vertically above the instrument rack in the mail room) is used to remove water vapor from its sampling line. The Licor also measures CO_2, but at a lower accuracy/precision.

All of the instruments except the Picarro are mounted on the bird table on top of the ship's foremast. The Picarro is rack mounted in the mail room. The Picarro sub-samples from a ½ inch teflon inlet tube that runs from the mail room up to the bird table. A Gast vacuum pump (referred here as the inlet pump, just behind the instrument rack in the mail room) is used to rapidly draw air from the foremast into the mail room. The Picarro instrument requires a sample pump (Vaccubrand) to maintain cavity cell pressure. Prior to February 2019, this sample pump was located inside of the enclosure. This caused very high temperatures in the enclosure, especially in the tropics. In February 2019, this sample pump was moved outside of the enclosure, next to the Gast inlet pump. This has reduced the heating of the enclosure.

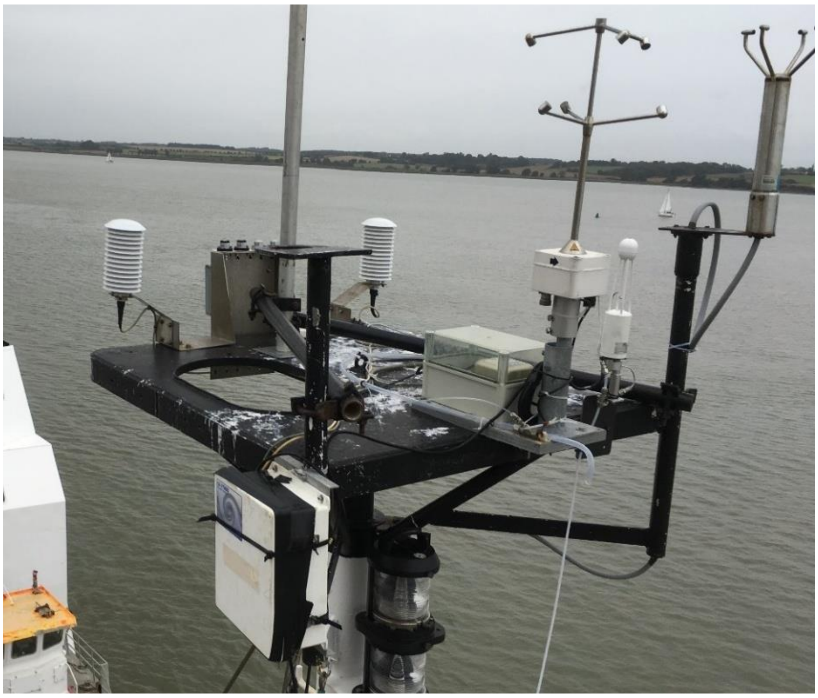


Figure 10.1. Bird table setup (left photo): Metek sonic anemometer, motion sensors, and inlet tube in the middle, with Licor on the port side of the Metek (in between the Metek and ship's sonic anemometer).

Figure 10.2: Mail room setup (right photo): Monitor (for the Dell PC and the Picarro internal PC) on the top shelf, Dell PC & UPS on the shelf below, and the Picarro on the lowest shelf (above two boxes of spares on the floor).

A Waterwatcher device is used to sense if water has entered the ½ inch teflon tube. Two 3-way valves are switched when the Waterwatcher is triggered, meaning that air is pushed out the inlet in the reverse direction by the Gast pump.

Data cables run between the mail room and the bird table. Data are collected on the Picarro PC, a Dell PC, and two Campbell loggers (CR6 and CR800) connected to the Dell PC. All PCs and loggers are housed inside the instrument rack in the mail room.

10.2 Changes made in February 2019

- Moved the sample pump (Vaccubrand) from inside to outside of the enclosure
- Swapped to the other Gast inlet pump
- Replaced main (HEPA) and subsample (Swagelok) particle filters
- Installed Waterwatcher, Latch Relay, and two fast-response solenoid valves into the inlet line
- Installed two new Campbell data loggers: CR6 for logging Metek wind, LPMS motion, and Licor data; and CR800 for logging Waterwatcher data
- Uninstalled Tardis2000 program from both PCs (used for time syncing but didn't work), and installed K9NT instead for the same purpose
- Stop logging Licor data on Picarro and stopped streaming Picarro data to Dell PC

10.3 Preliminary results

Overall the eddy covariance flux system worked pretty well on JR18005. Momentum flux agrees well with bulk parameterizations. Sensible heat flux was well resolved and largely out of the ocean. Though occasionally during stable conditions the sensible heat flux was slightly negative.

CO2 flux agrees in sign with the measured pCO2, with influx near the South Sandwich islands and efflux near the Elephant island. The motion sensitivity of the Picarro instrument complicates the data processing. A first order correction is applied by linearly decorrelating the Picarro gas measurements against cavity pressure as well as ship motion. Further post-cruise corrections are needed to fully remove the motion effect.

The Licor measurements of H2O (or latent heat) flux did not work very well. It gave somewhat sensible values in dry conditions. However whenever there was precipitation/high humidity/ice freeze, the measured H2O fluxes (as well as mean mixing ratio) become completely unusable. A close scrutiny of the H2O fluxes will be necessary to remove all bad data.

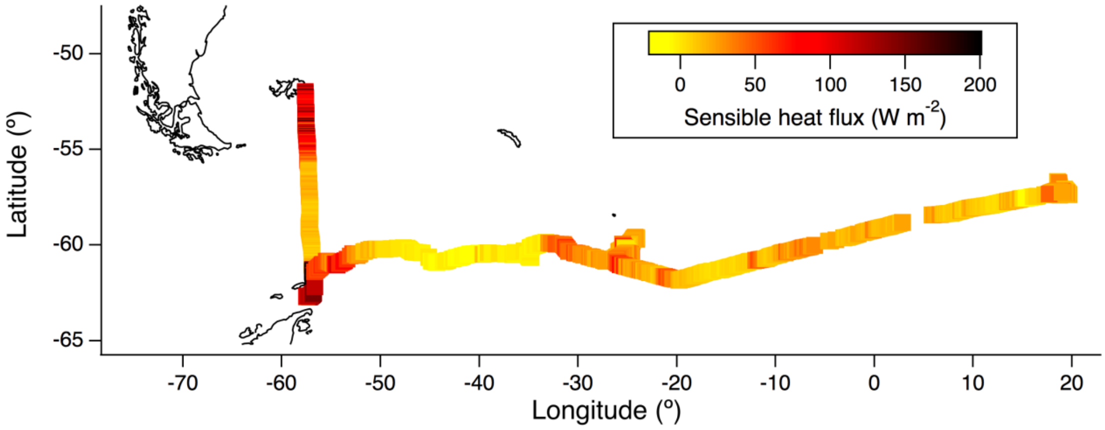


Figure10.3: Cruise track color coded by sensible heat flux.

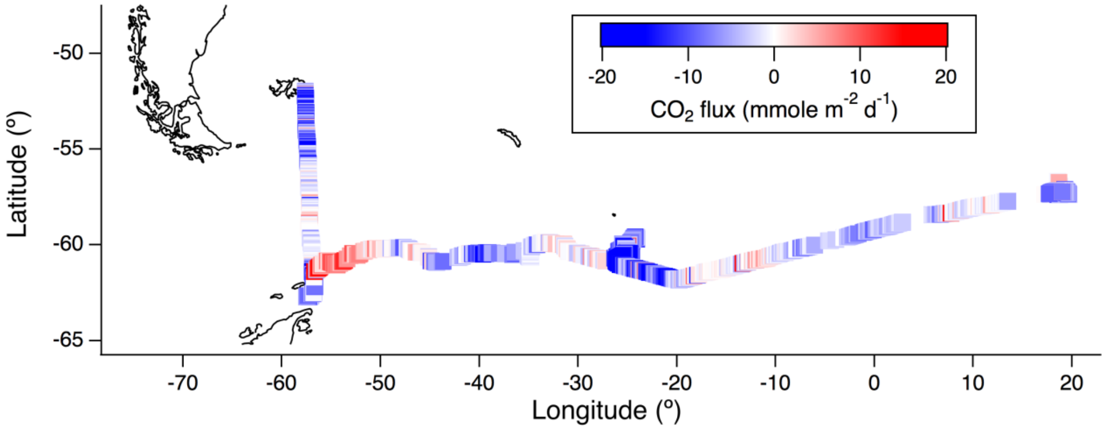


Figure 10.4: Cruise track color coded by CO2 flux.

11 Measurements of fast underway pCO2 and gas exchange efficiency

Mingxi Yang, Plymouth Marine Laboratory

11.1 Background

Underway pCO2 is usually made with a shower-head equilibrator, which has a response time (or integration time) of on the order of 10-20 minutes. Here we experiment with a relatively novel equilibration system to measure underway pCO2 with a response time of ca. 1 minute, here named fast underway pCO2. This is useful for example to map out the spatial heterogeneity in surface ocean pCO2 and relating it to other physical and biogeochemical parameters (e.g. temperature, salinity, chlorophyll).

In addition to the fast underway pCO2 measurement, we attempt to quantity the intrinsic gas exchange efficiency also in the underway seawater. The objective here is to try to quantify the impact of surfactants (e.g. derived from biogeonic activities) on air-sea gas exchange. This gas exchange efficiency will be related to the direct air-sea CO2 flux measurements by the eddy covariance method in order to assess the importance of surfactants on air-sea gas exchange velocity.

11.2 Methods

Measurements of fast underway pCO2 and gas exchange efficiency were made with two segmented flow coil equilibration (SFCE) systems on the ANDREX II cruise. The SFCE has been described in detail by Wohl et al. 2019. Briefly, underway seawater was piped to a ~200 mL glass sampling bottle via a ~1 m long 3/8'' Teflon tube and allowed to overflow rapidly into the sink. For each SFCE system, water was extracted from the bottom the glass sampling bottle with a peristaltic pump (via a ~0.5 m long ¼'' Teflon tube and a ~15 cm long Pumpsil soft tube). Synthetic air (essentially free of CO2) joined the sample water at a Teflon 'tee' piece, naturally forming distinct segments of water and air. These segments traveled in the same direction through a length of ¼'' Teflon coil (during which time gas exchange occurs), and were then separated in an air-water separator (fashioned out of a ½'' Teflon 'tee' piece). The sample air left the separator from the top and went towards the CO2 analyzer (Licor7000), while the sampled water was drained from the bottom of the separator into the sink.

Two SFCE systems were deployed in parallel and CO2 was measured with the Licor7000 alternately every five minutes (controlled by a solenoid valve). The continuous water flow rate was set by a peristaltic pump to be about 100 mL/min for each SFCE. The total synthetic airflow rate was set by a mass flow controller to be 50 standard cubic centimeter per minute (referenced to zero degree Celsius). Two needle valves were used to evenly split this airflow towards the two SFCE systems (i.e. a volumetric flow of about 25 mL/min at zero degree Celsius). The airflow rate was verified by measuring the sample outflow of the Licor analyzer. The sample air was dried with a Nafion drier and filtered with a Swagelok particle filter to reduce the influence of humidity and particulates on the CO2 measurement.

The two SFCE systems were identical except for the length of the gas exchange coil. The long coil was about 20 m in length, and submersed in a bucket that was overflowed with underway seawater. This was to keep the temperature as close to ambient sea surface temperature (SST) as possible. Laboratory experiments and field measurements indicate that 20 m is a few times longer than necessary for complete equilibration of CO2. Measurements from this long coil thus correspond to the seawater pCO2. The system theoretically has a response time of ca. 1 minute. In practice, since the two SFCE systems were measured alternately for five minutes each, the temporal resolution of the reported fast pCO2 is every 10 minutes. These results will be compared with those from PML's underway pCO2 system (which uses a shower-head equilibrator).

The length of the short coil was initially set to be 2 m, and subsequently cut even shorter to be about 40 cm. This length was chosen purposely such that CO2 did not come to full equilibration in the short coil. The short coil was insulated with foam to keep the temperature close to SST. Since essentially CO2-free synthetic air was being equilibrated with seawater, we can calculate the gas exchange efficiency (or equilibration efficiency) as the ratio between the measured CO2 from the short coil and the measured CO2 from the long coil. The physical natures of the two SFCEs (e.g. degree of internal turbulence, temperature, flow rates) were designed to be identical. We thus expect any changes in equilibration efficiency to be due to changes in the measure water itself, e.g. biologically derived surfactants.

The two coils were washed with 10% hydrochloric acid every few days to prevent internal biological growth. The Pumpsil soft tubes for the two peristaltic pumps were replaced daily. Due to the constant usage and wear on the Pumpsil tubes, within a day the flow rate usually decreased by about 5-10 ml/min. We correct our measurement for these flow rate changes. The Licor7000 was not rigorously calibrated during the ANDREX II cruise. Instead, atmospheric CO2 mixing ratio was measured with the Licor7000 once a day. This daily measurement will be compared to the well-calibrated atmospheric CO2 measurements on the ship (including PML's underway pCO2 system and BAS's Picarro CO2 & CH4 analyzer). And the resulting calibration factors will be applied to the seawater measurements from the SFCE.

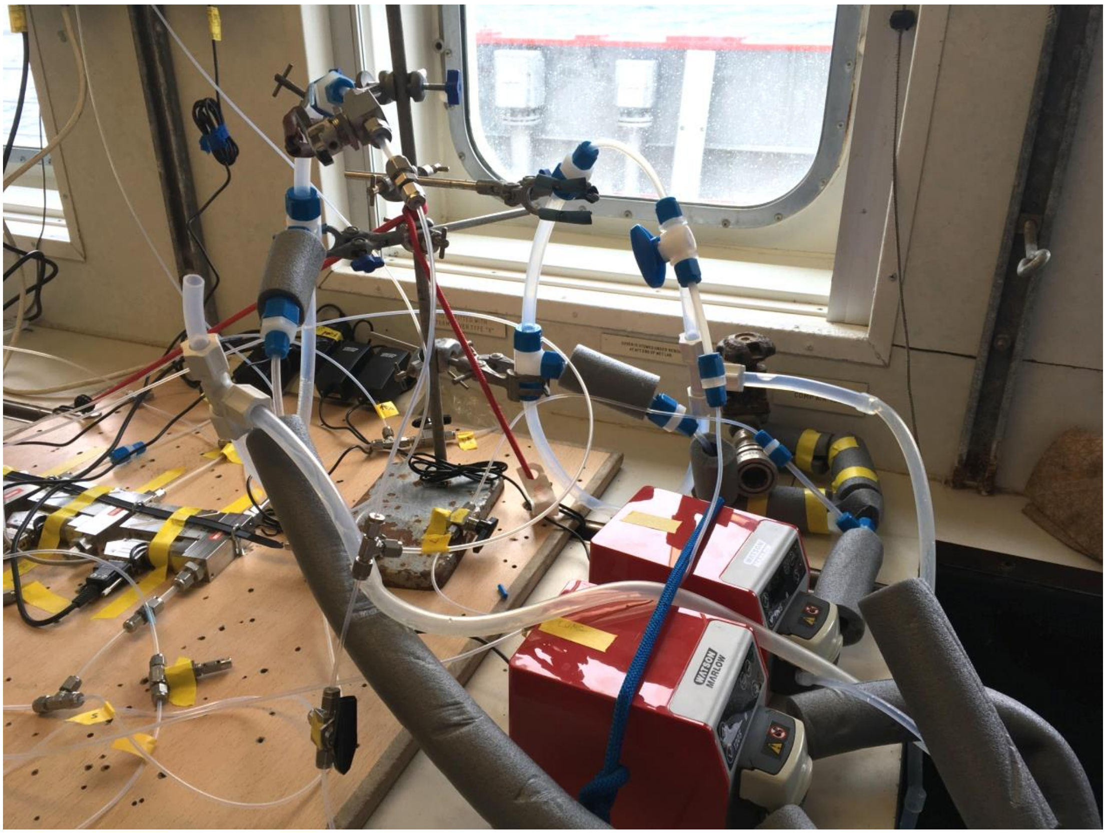


Figure 11.1: The two SFCE equilibration systems.

11.3 Initial Results

11.3.1 Fast underway pCO2

Because of the use of essentially CO2-free air as the carrier gas, the fully equilibrated air in the long coil corresponds to an aqueous concentration that is lower than the initial ambient concentration. We can define the purge factor (PF) as the aqueous concentration before equilibration divided by the aqueous concentration after equilibration. As shown by Wohl et al. (2019),

$$PF = 1 + 1/(H*Fw/Fa) \qquad (1)$$

Here Fw and Fa indicate the flow rates of water and air, respectively. H is the dimensionless solubility of /CO2 (water to air). For zero degree seawater, PF is computed to be 1.182 for CO2 at a water flow rate of 100 mL/min and airflow rate of 25 ml/min.

Fast underway pCO2 is computed as:

$$pCO2 = xCO2 * (p_{eq} - pH2O) * PF \qquad (2)$$

where xCO2 is the mixing ratio of CO2 from the long coil, P_{eq} is pressure in the equilibrator (taken to be the measured pressure by the Licor), and pH2O the saturation vapor pressure of water (computed as a function of water temperature and salinity).

The cruise track showing the fast pCO2 (data processed thus far) is shown in Figure 11.2.

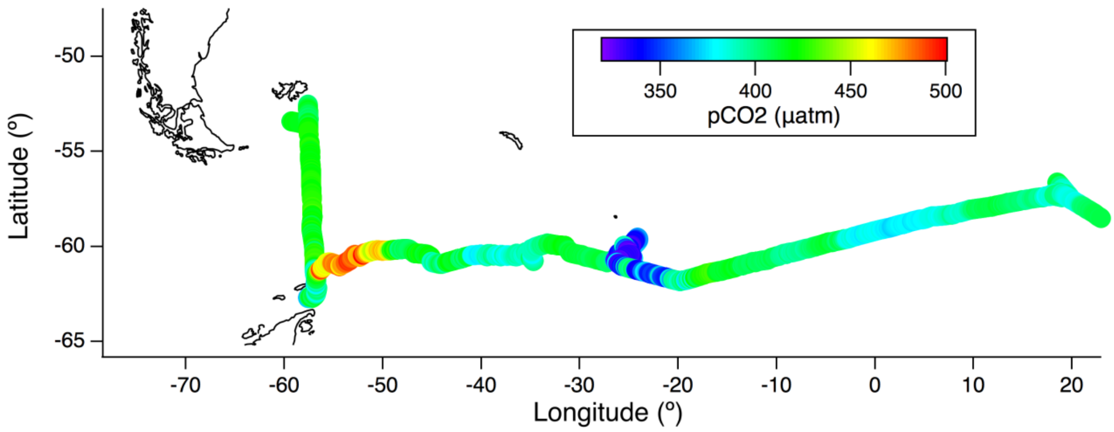


Figure 11.2: Cruise track color coded by fast underway pCO2 (preliminary data, not fully corrected).

11.3.2 Gas exchange efficiency

With the short coil being about 40 cm, the equilibration efficiency was typically between 0.6 and 0.7. A short time series of the SFCE measurements is shown in Figure 3 (top). A brief decrease in pCO2 between about 0100 and 0300 on the 28th of February is reflected by reductions in the measured CO2 in both the long coil and the short coil. Interestingly, the ratio (or equilibration efficiency) also decreased during these two hours. As shown in Figure 11.3 (bottom), temperature and chlorophyll increased during this period. We expect an increase in temperature to slightly increase the gas exchange efficiency (see below). The fact that the opposite trend is observed here suggests that the cause for the reduction in equilibration efficiency is instead due to biologically derived surfactants.

A sample of deep water (from 1000 m or more) was measured a few times a week. The deep seawater (usually within a degree in temperature with the surface water) consistently yielded equilibration efficiency that was a few percent higher than those of surface waters. This suggests that biologically derived surfactants are absent or less abundant in deep water.

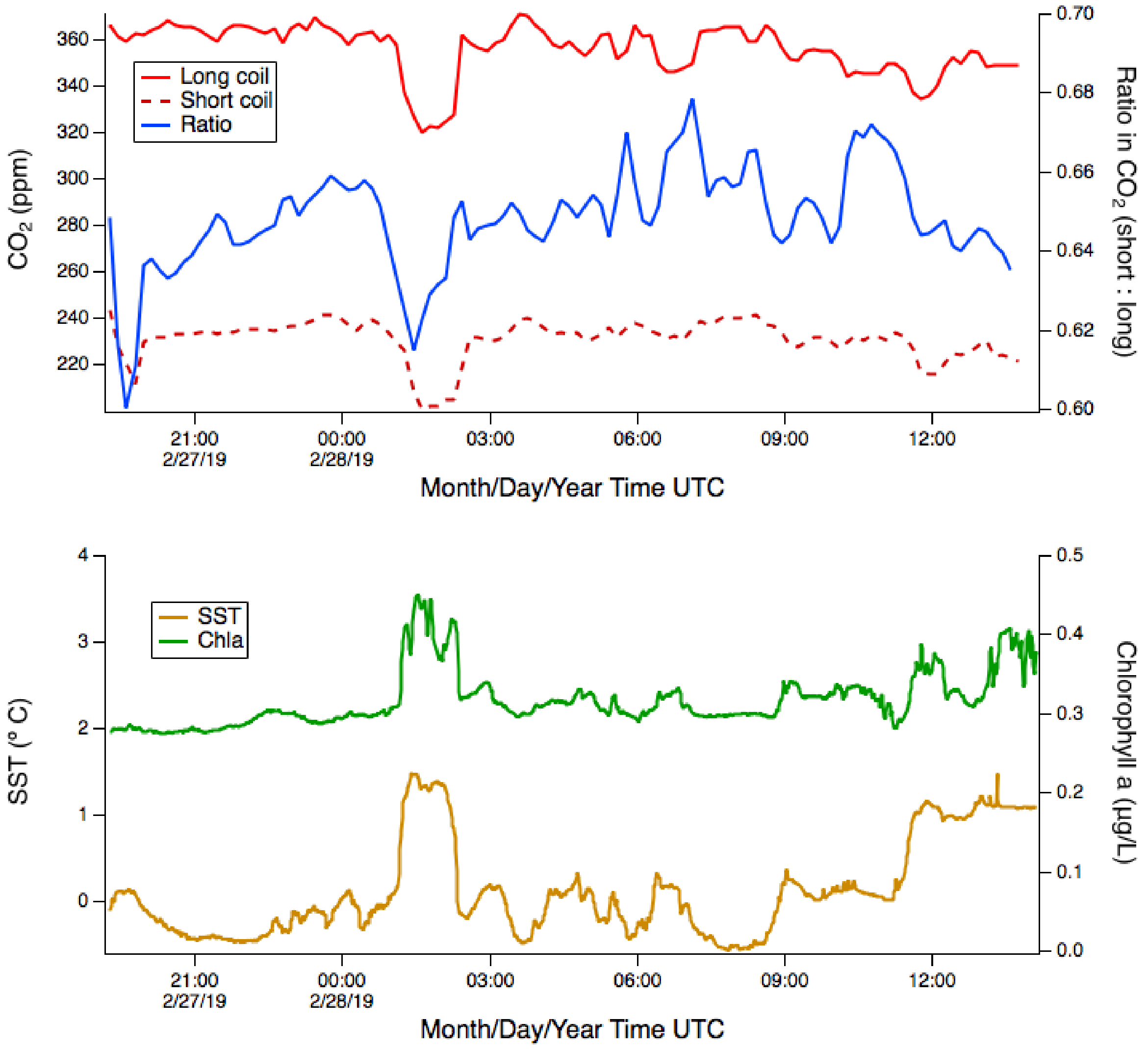


Figure 11.3: (top) A short time series of CO2 from the long and short coils, as well as the ratio between the short coil and long coil; (bottom) underway Chlorophyll a and SST during the same period.

The cruise track showing the gas exchange efficiency (data processed thus far) is shown in Figure 11.4.

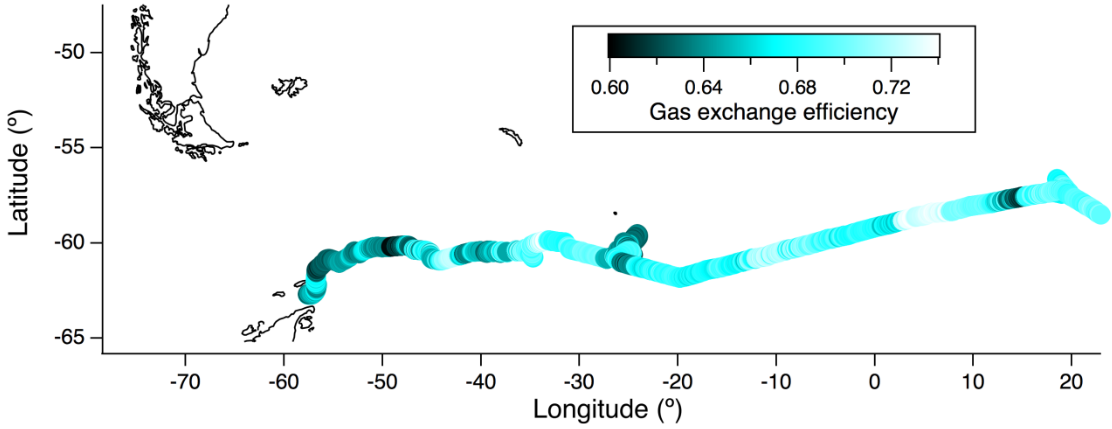


Figure 11.4: Cruise track color coded by the gas exchange efficiency.

11.4 References:

Wohl, C., Capelle, D., Jones, A., Sturges, W. T., Nightingale, P. D., Else, B. G. T., & Yang, M.: Segmented flow coil equilibrator coupled to a Proton Transfer Reaction Mass Spectrometer for measurements of a broad range of Volatile Organic Compounds in seawater, Ocean Sci., 1–37, 2019.

12 Oxygen and carbon isotopes

Carol Arrowsmith, BGS

Aim: To collect samples for the determination of stable oxygen and carbon isotopes, and radiocarbon samples along the ANDREXII (JR18005) cruisetrack.

As in the ANDREXI cruise, sampling was intensified toward the start of the cruise, since the region close to the Antarctic Peninsula is the area of the cruise where the meteoric water signal (especially due to glacial melt) is expected to be strongest, and oceanographically most significant. Sampling was spread out toward the eastern end of the section.

However, in ANDREXI, the near-surface layers (where freshwater is most prevalent), and the deepest layers (where Antarctic Bottom Water of different flavours often resides) were targeted as there was a limit as to how many samples could be taken. On ANDREXII no limit was in place so all unique depths were sampled at every station.

In addition, 7 stations were sampled along the South Sandwich Trench in order to examine the outflow of Antarctic Bottom Water east of the South Scotia Ridge, and assess water trapped in the deep trench.

In total, 1882 samples were collected including 18 duplicates.

The intention is to use this data (in combination with other data (notably the measured salinity) to quantify the freshwater export from the Weddell gyre, to separately deduce how much of this export is from sea ice and meteoric sources.

All samples will be transported back to the UK, and will be delivered to the NERC Isotope Geosciences Laboratory, Keyworth, for laboratory analysis.

12.1 Sample Collection and Storage

Water samples for oxygen isotopic ratio (18O/16O, or δ18O) and stable carbon isotopic ratio Samples were collected using 30 ml wide-mouth HDPE bottles, and then poisoned using 8ml of saturated mercuric chloride ($HgCl_2$) solution (provided by BGS) to inhibit biological activity and reliably preserve the carbon isotope ratios for later analysis. Pre-printed labels were filled out per station with the station number and the niskin bottle number. Samples will be shipped back to the BGS labs in Nottingham to determine their δ 18O and δ 13C via isotope ratio mass spectroscopy, with both variables being measured from the same individual 30 mL sample bottle. This report only details the ship-based sampling procedure and preservation, not the final results.

The following sampling procedure was used to collect, preserve and store the δ 18O and δ 13C samples.

1. Collect the upcoming station depths to decide how many bottles will be needed at the station.

2. With a permanent marker number sample bottles with the station and niskin number and place in a holder to carry to the CTD.

3. Wear nitrile gloves while sampling (this protects the hands from the cold water).

4. Select correct sample bottle to match with appropriate niskin bottle.

5. Begin bottle rinsing by half filling sample bottle to the top with niskin water directly from the small spigot (i.e. no need to use a sampling tube), replace lid, shake sample bottle and discard contents.

6. Collect sample. Fill sample bottle as full as possible with niskin water, it may be necessary to reduce the flow from the niskin bottle to achieve this and to ensure no bubbles in the bottle. Surface tension will allow a large dome of water to form in the top of the sample bottle, but a couple of droplets from this were poured away, as otherwise when poisoning, the mercuric chloride solution had a tendency to overflow the bottle.

7. Screw on sample bottle lid, and try to limit the time when the sample in the bottle does not have a lid on.

8. Place sample back in holder.

9. If a niskin has failed for any reason, just leave the sample bottle empty, make a note on the log sheet of what has happened, then move onto the next niskin and sample bottle.

10. When all samples have been collected, transfer sample bottles to a fridge to keep cold until poisoning canmbe carried out, or continue immediately with poisoning.

11. When ready to begin poisoning, put on lab coat and nitrile gloves.

12. Transfer 30 ml sample bottles to a fume cupboard, or appropriately ventilated space.

13. Lay down sample tray with spill mat, gather mercuric chloride solution and pipette for use, and add new tip to pipette (an Elkay Exelpette variable volume 10-100l pipette was used).

14. Remove 30ml sample bottle lid (recall that the lid should stay off for as short a time as possible).

15. Pipette 8µl of mercuric chloride solution into sample (hover the pipette over the top of the water but don't touch it, to avoid cross-contamination between samples).

16. Replace bottle lid, ensure is hand tight.

17. Repeat steps 15-17 for all samples.

18. After poisoning, clear away mercuric chloride solution and pipette tips, and ensure surface working area is wiped down. Any used pipette tips, or tissues used to wipe down the surface or come into contact with the mercuric chloride should be disposed of in a hazardous (UN) waste bin.

19. Use electrical tape (c. 2 times around the cap) cover the seal. Add a vertical mark which will indicate if any movement occurs during transport.

20. Stack bottle samples in appropriate storage container (zarges aluminium trunks) to be shipped back to the UK, include BoL information. The Bill of Lading should indicate cool stow across the Tropics (ie not above 25oC).

13 Radiocarbon (14C)

Carol Arrowsmith, British Geological Survey

13.1 Sample Collection and Storage

Water samples for onshore (Woods Hole Oceanographic Institute, WHOI, USA) radiocarbon analysis were collected from 12-litre niskin bottles attached to the CTD sampling rosette. This report covers the ship-based sampling procedure as supplied by 14C PI and TICTOC project partner Prof. Robert Key. The radiocarbon (14C) data are expected between six months to two years after the cruise. Data will be reported in 14C notation, which represents the sample 14C/C ratio normalized to the Modern standard and corrected for fractionation and sample age (in Stuiver and Polach, 1977). The sample collection bottles (plus other equipment) and method were provided by WHOI. These samples will be analysed at the National Ocean Sciences Accelerator Mass Spectrometry (NOSAMS) laboratory at WHOI. The recommended sampling procedure followed exactly the McNichol et al. (2010) guidance.

We collected 349 flask samples, including 3 in duplicate.

A sampling strategy was developed in advance to ensure good coverage both horizontally and vertically across the ANDREXII transect and also at the South Sandwich Trench, with the intention of assessing bomb radiocarbon concentrations in deep Weddell Sea Bottom water and thus infer water mass ages and mixing rates. The samples were collected from 25 stations.

Our method:

1. Collect the upcoming station depths to decide which depths to be sampled and assign flask numbers.
2. Take the following to the CTD:
(a) The crate of ordered flasks
(b) The sampling tube (tubing provided by WHOI)
(c) Wear nitrile gloves (provided by WHOI) for sampling.
3. Select correct flask from crate for each station/niskin and go to CTD.
4. Attach open end of sampling tube to the niskin spigot.
5. Turn on spigot and flush sampling tube with niskin water for approx. 10 seconds (50 ml).
6. While the sampling tube is being flushed, work along the length of tube squeezing to ensure there
are no air bubbles fixed to the inside of the tube.
7. Insert tube into bottom of the vessel, and fill with approx. 50ml of water, gently swirl around the

sides of the bottle and discard, repeat.

8. With the tube still in the bottom of the vessel, fill the vessel 1.5 times (ie overflow).

9. Carefully remove the tube from the vessel, rinse the vessel top, and stopper the vessel.

10. Turn off niskin spigot, and remove the tube.

11. Ensure sampling tube is empty of niskin water in preparation for next sample.

12. Return the vessel to the crate.

13. Once all samples from a cast have been obtained remove the crate to a bench to continuing the preparation of the sample. For each vessel in turn, dry the outside of the vessel, remove the stopper, wipe clean and dry (with lab wipes provided by WHOI), apply a thin layer of grease (provided by WHOI) in a wavy pattern around the stopper, set aside. Pour away c. 10mls of sample water to create a headspace in the vessel. Using the Eppendorf pipette (tips provided by WHOI), add 100□l of the standard HgCl2 solution (provided by NOC) to the vessel. Carefully wipe the inside of the ground glass joint using lab wipes and place the stopper in the vessel. Twist the stopper while applying pressure to ensure a good seal with an even layer of grease. Secure the vessel top with a rubber band (provided by WHOI) over the entire vessel.

14. After all the samples have been sealed, the data sheets should be completed and checked, ensuring the correct niskin, depth, sample bottle. The flasks in the shipping crates should be packed with all original packing material, the Bol information and sealed. The Bill of Lading should indicate cool stow across the Tropics (ie not above 25oC to ensure the working temperature of the grease seal). Away from the tropics the crates will likely be stored in the ships hold.

13.2 References

McNichol A. P., P. D. Quay, A. R. Gagnon, J. R. Burton, 2010. Collection and Measurement of Carbon Isotopes in Seawater DIC. The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines. IOCCP Report No. 14, ICPO Publication Series No. 134, Version 1, 2010. Available from http://www.go-ship.org/Manual/McNichol_C1314.pdf.

Stuiver, M. and H. A. Polach, 1977. Discussion reporting of 14C Data. Radiocarbon, 19, 3, 355-363, doi:10.1017/S0033822200003672.

14 SOCCOM floats

Natalie M. Freeman, Scripps Institution of Oceanography, University of California San Diego

14.1 Objectives

Deploy 6 Biogeochemical-Argo (BGC-Argo) floats as part of the Southern Ocean Climate and Carbon Observations and Modeling (SOCCOM) program; floats were strategically placed along the ANDREXII cruise track to fill current gaps in the SOCCOM data array. Collect and analyze parameters important for SOCCOM sensor calibration, validation, and reference database, including fluorescence and backscatter (FLBB), Particulate Organic Carbon (POC) and High Performance Liquid Chromatography (HPLC), pH and total alkalinity (TA), salinity, dissolved inorganic nutrients, and oxygen.

14.2 Deployments:

6 BGC-Argo floats were deployed using the starboard crane and quick-release pin along the ANDREXII cruise track as follows:

CTD station #	float ID	date (dd/mm/yy; UTC)	approx. time (UTC)	latitude	longitude
20	12707	03/03/19	00:35	60° 08.8 S	48° 07.4 W
31	12752	04/03/19	17:30	60° 39.136 S	42° 09.007 W
58	12786	09/03/19	15:55	60° 19.173 S	30° 57.653 W
62	12884	10/03/19	15:30	60° 49.606 S	27° 13.700 W
90	12879	23/03/19	11:55	57° 32.252 S	15° 22.487 E
96	12880	29/03/19	17:45	60° 29.997 S	29° 59.840 E

14.3 POC/HPLC sampling

For the CTD casts immediately before float deployments, niskin bottles that were closed at the chlorophyll maximum and surface were sampled for POC/HPLC filtration, 1-2 L for each variable and at each depth, with duplicates, totaling 9-12 L per station. Samples were filtered under vacuum, flash frozen in liquid nitrogen, and stored in the -80 C freezer for future analysis on land TBD.

CTD station #	niskin bottle #	corresponding sample depth (m)
20	20, 24	35, 9
31	19, 23	75, 5
58	20, 23	77, 5
62	20, 24	54, 5
90	20, 23	67, 6
96	19, 23	79, 11

14.4 pH/TA sampling

For the CTD casts immediately before float deployments, 500 mL of water from each niskin bottle in the upper 2000 m was pickled with mercuric chloride and sealed with a greased ground glass stopper. Two duplicates were taken each cast at random depths. Samples were stored in the 4 C fridge and will be analyzed by Andrew Dickson's (Scripps) lab at a future date TBD.

CTD station #	niskin bottle #	duplicate niskin #
20	7-20, 22, 24	15, 18
31	9-24	10, 19
58	8-20, 22, 24	10, 19
62	8-20, 22, 24	12, 15
90	10-20, 22-23	12, 17
96	10-19, 21-23	13, 21

14.5 FLBB

A Wet Labs FLBB-RTD sensor was mounted on the CTD at the beginning of the ANDREXII cruise for the purpose of comparison to the FLBB sensor on each float deployed. To mate the instrument to the CTD, a custom cable that was previously fabricated for AMT28 earlier in the season was used. A dark cast, where the detectors are covered with black tape, was performed at CTD stations 12 and 65. Care should be taken when using fluorescence data due to a persistent flatlining issue at low signal during all ANDREXII CTD stations (as well as during AMT28; see also Section 20.7.2); cause(s) for the issue to be investigated on land TBD.

15 DEEP ARVOR float deployment

Andrew Meijers & William Clark, British Antarctic Survey

15.1 Overview

Two Deep Arvor floats were deployed on behalf of the University of Sorbonne led ERC WAPITI project (PI J.-B. Sallee). These experimental floats combine a strengthened pressure casing with a downward looking ADCP instrument in order to follow the flow of water masses along the ocean bottom. In addition to recording vertical temperature profiles similar to a standard Argo float the ADCP in bottom track mode, combined with GPS fixes at the surface, allows the float to map out its track between surfacing. This give unprecedented observations of lagrangian pathways for such dynamically interesting processes such as downslope cascades of dense water.

One such cascade occurs in the Orkney Passage in the South Scotia Ridge. Here dense Weddell Sea Deep Water escapes from the Weddell Gyre and into the Scotia Sea. On the northern side of the Orkney Passage the bathymetry drops away rapidly, producing a cascade of dense water into the Scotia Sea. This has been the subject of several studies, including the NERC DynOPO experiment (PI A. Naveira-Garabato) and ORCHESTRA Orkney Passage mooring array. The two Deep Arvor floats were targeted at this outflow.

15.2 Preparation

The two floats were assembled the day prior to deployment by BAS AME William Clark, assisted by Andrew Meijers and Ciara Pimm. Preparation consisted of connecting the Deep Arvor float pressure casing to the DVL frame mounting the ADCP head and battery pack. This was done on the rear deck with the float in a vertical position, following the instructions in the G600617A_Assembly_instructions.pdf document supplied. All bolts were tightened as recommended and the power pack connected to the Arvor casing. The floats were then stored horizontally in the ship wet lab, with packing material preventing the heavy DVL frame from twisting relative to the Arvor pressure casing.

15.3 Deployment

Deployment proceedures outlined in G601025c_Deep_Arvor_Wapiti_Deployment_procedure.pdf supplied by WAPITI were followed. This consisted of removing the CTD protective covers, followed by the on/off magnet. This initiated a series of self and satellite tests, which were recognized as successful by a series of phonetically described sounds emanating from the hull casing. The doctor’s stethoscope was procured to aide in identifying the sounds. Both floats passed their test, initiated approximately an hour before deployment. This was initinated as the CTD conducted at the same station

(CTD#031) was nearing the surface. The floats were deployed following the SOCCOM float, in the same manner. A looped rope hung from the starboard quarter Effer crane was passed through the lifting point, and a pin on a pull rope placed in the loop. Once weight was taken up by the crane the pin was pulled tight by the loop against the float lifting point, securing it in place. The float was then lowered over the side and, while the ship was steaming at 2 kts through the water, the pin rope given a sharp pull. This released the float which then drifted free of the ship. The procedure was then repeated for the second float. All three floats (SOCCOM#12752 were deployed near in space and time to the CTD in order to be calibrated. Details of the deployment are listed in Table 15.1.

Table 15.1: Deep Arvor deployment details

CTD number	Latitude	Longitude	Date	Time	Float ID
031	-60.6503	-42.15157	04/03/2019	17:48:00	#FR002
031	-60.65124	-42.15285	04/03/2019	17:53:00	#FR003

15.4 Results

Both floats conducted their initial profiles successfully and at the time of writing are presently moving off westward on the northern side of Orkney Plateau. One float is moving appreciably faster than the other.

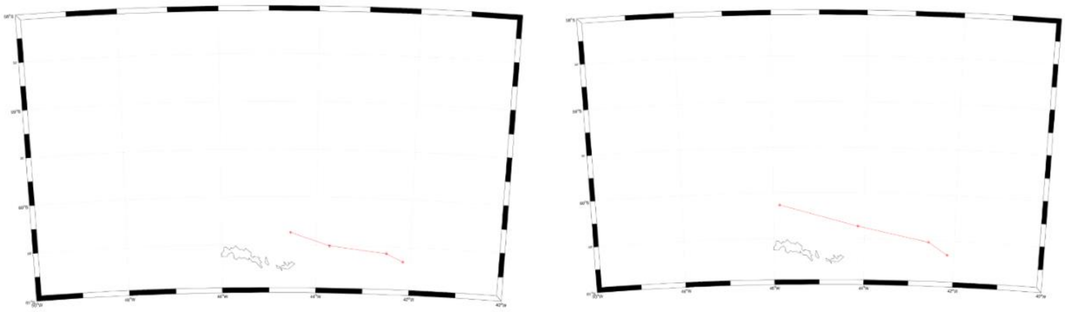


Figure 15.1: Initial Deep Arvor profile locations. Deployment location in the south-east of the graphics.

16 Nitrogen and silicon isotopes

Margot Debyser, University of Edinburgh

16.1 Objectives

To characterise the variability in nitrogen and silicon isotope signatures across the Southern Ocean at 60ºS. The data will be used to determine how recycling processes change across the transect and the variation in preformed and remineralised nitrate and silicate in the intermediate and deep water mass formation.

16.2 Nutrient isotopes (dissolved)

Samples were collected throughout the transect (CTDs 1, 3, 5, 8, 14, 20, 22, 31, 42, 52, 57, 62, 66, 72, 74-75, 77, 79, 81-82, 85, 87, 89, 92, 94, 98), across the ANDREXII line, full water column profiles were collected with higher resolution in the upper 500m. Samples were filtered inline from the CTD using an acropak filter.

Nitrate isotope samples were collected into 25-50ml centrifuge tubes and frozen at -20°C. Si isotope samples were collected into 50ml bottles and acidified with 50ul of 20% HCl (trace metal clean). Samples caps were parafilmed and then stored at +4°C.

All isotope analyses on water samples will be carried out at the University of Edinburgh (Isotope Ratio Mass Spectrometry for nitrate N & O analysis; Multicollector ICP-MS for Si isotope analysis) following standard GEOTRACES protocols (Tuerena et al., 2015, GEOTRACES International Data Product).

16.3 Particulate organic matter isotopes (d13C, d15N and d30Si)

Water samples were collected from both the underway system (5m) along the profile along with nutrient samples (see Table 16.1). Water was collected into 10L carboys and pressure filtered onto filters (precombusted GF/F for N and polycarbonate for Si). Filters were stored in pre-combusted foil, frozen at -20°C freezer and transported back to the UK in the -20°C storage.

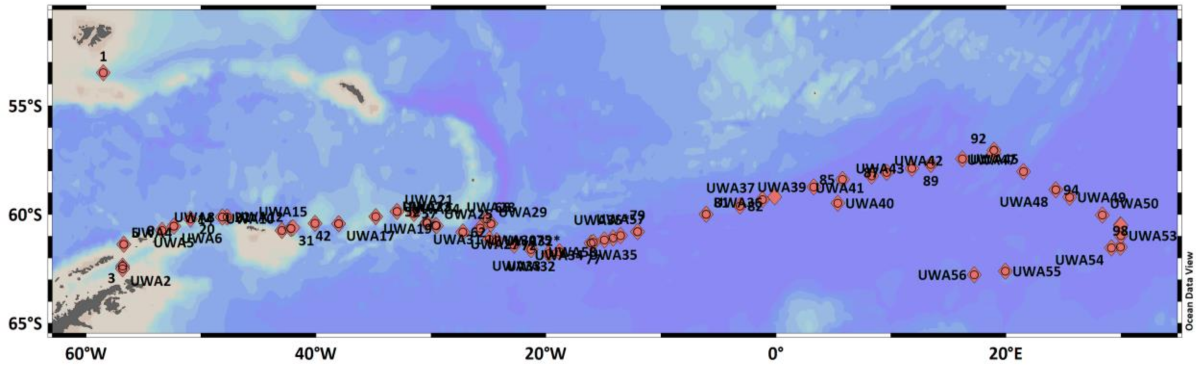
For any further information regarding analysis, please contact Robyn Tuerena (rtuerena@ed.ac.uk).

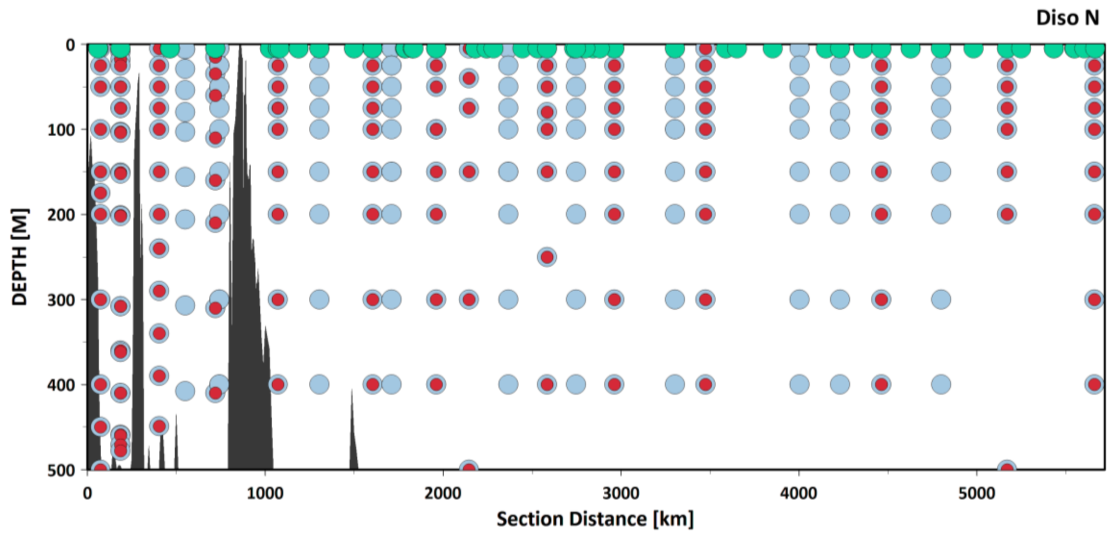
Table 16.1: Underway particulate organic matter isotope sample location

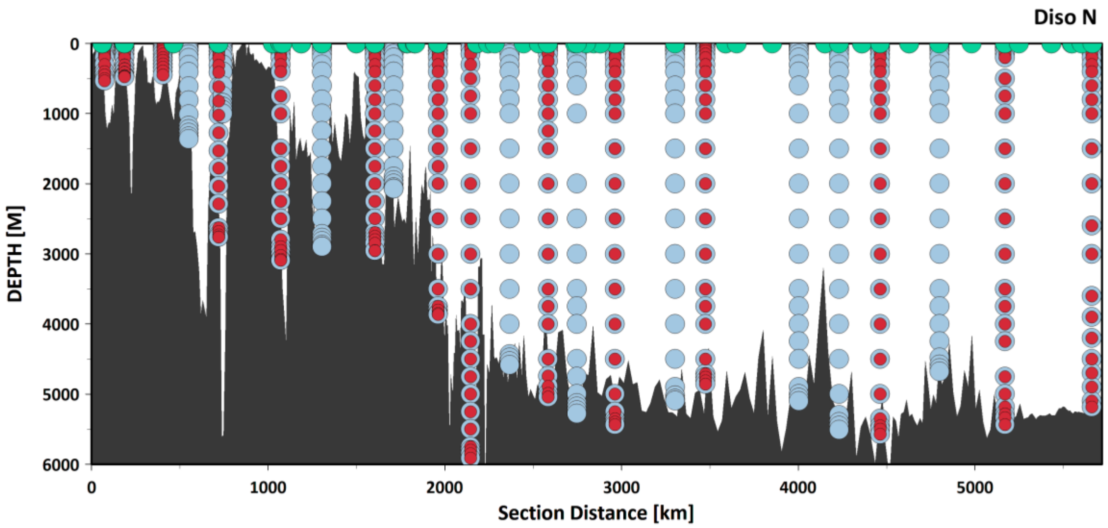
JR18005	UWA1	B	27/02/2019	-56.7833	-62.4833
JR18005	UWA2	B	27/02/2019	-56.7833	-62.5
JR18005	UWA3	B	28/02/2019	-56.6833	-61.3833
JR18005	UWA4	B	28/02/2019	-56.6833	-61.3833
JR18005	UWA5	B	01/03/2019	-52.35	-60.5333
JR18005	UWA6	B	01/03/2019	-52.35	-60.5333

JR18005	UWA7	B	02/03/2019	-48.1167	-60.1333
JR18005	UWA8	B	02/03/2019	-48.1167	-60.1333
JR18005	UWA9	B	03/03/2019	-42.95	-60.75
JR18005	UWA10	B	04/03/2019	-42.95	-60.75
JR18005	UWA11	B	04/03/2019	-42.15	-60.65
JR18005	UWA12	B	04/03/2019	-42.15	-60.65
JR18005	UWA13	B	04/03/2019	-41.9833	-60.6167
JR18005	UWA14	B	05/03/2019	-40.0667	-60.4167
JR18005	UWA15	B	05/03/2019	-40.0667	-60.4167
JR18005	UWA16	B	06/03/2019	-38	-60.4333
JR18005	UWA17	B	06/03/2019	-38	-60.4333
JR18005	UWA18	B	07/03/2019	-34.7833	-60.1
JR18005	UWA19	B	07/03/2019	-34.7833	-60.1
JR18005	UWA20	B	08/03/2019	-32.9333	-59.8667
JR18005	UWA21	B	08/03/2019	-32.9333	-59.8667
JR18005	UWA22	B	09/03/2019	-30.3667	-60.4
JR18005	UWA23	B	09/03/2019	-30.3	-60.4
JR18005	UWA24	B	09/03/2019	-29.5833	-60.5
JR18005	UWA25	B	09/03/2019	-29.5167	-60.5167
JR18005	UWA26	B	10/03/2019	-27.2167	-60.8167
JR18005	UWA27	B	10/03/2019	-27.2167	-60.8167
JR18005	UWA28	B	13/03/2019	-24.7667	-60.4333
JR18005	UWA29	B	13/03/2019	-24.7667	-60.4333
JR18005	UWA30	B	13/03/2019	-25.7	-60.6333
JR18005	UWA31	B	14/03/2019	-24.925	-61.1333
JR18005	UWA32*	B	14/03/2019	-24.25	-61.2167
JR18005	UWA32	B	15/03/2019	-21.2833	-61.6167
JR18005	UWA33	B	15/03/2019	-19.7833	-61.8167
JR18005	UWA34	B	16/03/2019	-16.0667	-61.3167
JR18005	UWA35	B	16/03/2019	-14.1333	-61.0833
JR18005	UWA35*	B	27/03/2019	-12.0167	-60.8
JR18005	UWA36	B	18/03/2019	-6.05	-60
JR18005	UWA37	B	19/03/2019	-1.15	-59.3333
JR18005	UWA38	B	19/03/2019	-0.1	-59.2
JR18005	UWA39	B	20/03/2019	3.3	-58.75
JR18005	UWA40	B	20/03/2019	5.383333	-59.4833
JR18005	UWA41	B	21/03/2019	8.35	-58.2333
JR18005	UWA42	B	21/03/2019	9.65	-58.0667
JR18005	UWA43	B	22/03/2019	11.83333	-57.8833
JR18005	UWA44	B	22/03/2019	13.48333	-57.7
JR18005	UWA45	B	23/03/2019	16.21667	-57.45
JR18005	UWA46	B	26/03/2019	18.98333	-57.2167
JR18005	UWA47	B	26/03/2019	21.55	-58.0333
JR18005	UWA48	B	27/03/2019	24.36667	-58.8667
JR18005	UWA49	B	27/03/2019	25.56667	-59.2167
JR18005	UWA50	B	28/03/2019	28.41667	-60.0333

JR18005	UWA51	B	28/03/2019	29.96667	-60.4833
JR18005	UWA52	B	29/03/2019	30	-60.5
JR18005	UWA53	B	29/03/2019	30	-60.9833
JR18005	UWA54	B	30/03/2019	29.18333	-61.5333
JR18005	UWA55	B	31/03/2019	19.95	-62.6167
JR18005	UWA56	B	31/03/2019	17.26667	-62.7833
JR18005	UWA57	B	04/04/2019	-13.5	-60.9833
JR18005	UWA58	B	04/04/2019	-14.9167	-61.1833
JR18005	UWA59	B	05/04/2019	-15.8667	-61.2833
JR18005	UWA60	B	06/04/2019	-18.8167	-61.7167






Diso N
DEPTH [M]
0
1000
2000
3000
4000
5000
6000
0
1000
2000
3000
4000
5000
Section Distance [km]

17 Volatile Organic compounds (VOCs)

Charel Wohl, Plymouth Marine Laboratory

Measurements of a variety of VOCs (alcohols, ketones, aldehydes, biogenic compounds and organic pollutants) in seawater and atmosphere of the southern ocean using PTR-MS coupled to segmented flow coil equilibrator (SFCE).

17.1 Introduction and objectives

Of the non-methane organic carbon in marine air, Acetone, acetaldehyde and methanol consume 80% of the OH radicals in the maritime atmosphere (Lewis et al., 2005) and affect ozone concentrations, a major air pollutant. Owing to the high solubility and in situ production of Oxygenated Volatile Organic Compounds (OVOCs), the oceans have an enormous potential to act as a source or a sink. The reactivity, ubiquity, high solubility and low concentrations make detection of OVOCs challenging. Previous atmospheric measurements of these compounds in remote regions show that observed concentrations could not be explained by air mass transport alone, pointing towards local sources (Grannas et al., 2002).

In addition to OVOCs, a variety of climate active gases are measured e.g. DMS, Isoprene. The oxidation products of these gases could act as cloud condensation nuclei especially in the marine atmosphere of the Southern Ocean and hence lead to cloud formation and influence the radiation balance of our planet.

Moreover, we measured common pollutants such as benzene and toluene. In part this was done as a tracer to spot contaminated samples and improve sampling techniques. However we also calibrate for these compounds and are thus able to publicize measured concentrations. These compounds are commonly found in the water near oil spills or in the air due to anthropogenic activities. They are a major air pollutant as they create mutations in the DNA by intercalating between the DNA base pairs.

The aim of this field campaign is to measure these gases in the air, in the continuous seawater supply and from CTD Rosette and evaluate these data in conjunction with the ozone measurements. This will give us a holistic view of the impacts of the ocean on the Antarctic atmosphere and climate.

17.2 Operations conducted during Leg/Methodology

We have developed a segmented flow coil equilibrator(Wohl et al., 2019) (Figure 17.1), which allows for continuous extraction of these compounds from the seawater. The segmented flow coil equilibrator was coupled to Proton-Transfer-Reaction Mass Spectrometer (PTR-MS) and deployed on board. The PTR-MS switches between underway water and air measurement of these compounds, enabling estimations of the gas fluxes between the atmosphere and the ocean. Air is sampled through an airline from a 30 cm pole pointing out in front of the bridge of the ship to the main lab. Underway seawater is analysed from the seawater tap in the main lab.

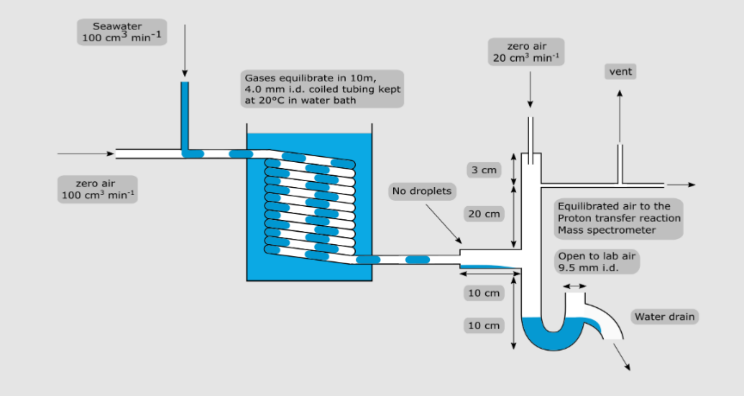


Figure 17.1: Segmented flow coil equilibrator; Sea water and clean synthetic air mix in a 10m long coil submerged in a water bath. While travelling through the coil, the water and the carrier gas equilibrate with the neighbouring section of air. The equilibrated carrier gas is analysed by PTR-MS.

At stations, we sampled the surface and the bottom. The surface water sample was used to assess if the underway water supply was clean and the bottom water was used as a blank for some of these compounds. We find that the underway water supply is very clean, and concentrations compare very well. This came as a positive surprise how clean the underway water supply was especially since some of these compounds (benzene, toluene, acetone) are commonly used in laboratories and in paint. However in some of the productive areas, with high phytoplankton, it is possible that the pump was rupturing some of the cells leading to measurement of higher than actual concentrations of DMS. Seawater was collected from the rosette from various stations to produce a 6 to 12 point depth profile (See Appendix 1 for a list of stations and sample numbers).

Grannas, A. M., Shepson, P. B., Guimbaud, C., Sumner, A. L., Albert, M., Simpson, W., … Zhou, X.: A study of photochemical and physical processes affecting carbonyl compounds in the Arctic atmospheric boundary layer, Atmos. Environ., 36, 2733–2742, https://doi.org/10.1016/S1352-2310(02)00134-6, 2002.

Lewis, A. C., Hopkins, J. R., Carpenter, L. J., Stanton, J., Read, K. A., & Pilling, M. J.: Sources and sinks of acetone, methanol, and acetaldehyde in North Atlantic marine air, Atmos. Chem. Phys., 5, 1963–1974, https://doi.org/10.5194/acp-5-1963-2005, 2005.

Wohl, C., Capelle, D., Jones, A., Sturges, W. T., Nightingale, P. D., Else, B. G. T., & Yang, M.: Segmented flow coil equilibrator coupled to a Proton Transfer Reaction Mass Spectrometer for measurements of a broad range of Volatile Organic Compounds in seawater, Ocean Sci., 1–37

18 SeaDNA sampling – JR18005

Aisling Smith and Geraint Tarling, British Antarctic Survey

The ANDREXII cruise, JR18005, accommodated an additional opportunistic sampling project of environmental DNA (eDNA) collection from the CTD once all other water had been collected. The target depths were from <200 m and most commonly sampled depth was from 70 m and above. The eDNA project (NE/N00616X/1) aims to develop and refine detection methods of DNA from the marine environment and this sampling programme offered a unique opportunity to collect data from a remote and data poor location. Once processed, eDNA results may compliment the observations of the OVOC team, possibly informing the presence of species of interest to their measurements.

The sampling protocol is adapted from the projects' methodology to account for available equipment. A known volume of water is passed through a Sterivex™ filter, a 0.22 µm enclosed luer-lok filter unit, and frozen at -20 ºC for later DNA extraction. Sample water was collected in bleach-cleaned 10 L UN jerrycan. For each sampling location 3 replicates and a blank were taken where possible. The 10 L bottle was rinsed 3 times with ~300 ml of sample water before filling. On filling, the water was pre-filtered through a 250 µm mesh, notes on the contents of this mesh were recorded. Niskin bottles were sampled in descending depth order until 8 L of water was collected. The 10 L jerrycan was then stored in a chilled container until filtering (ideally within 6 h of the sample being taken).

Prior to each set of replicate samples being run, a sample blank was filtered. The same procedure was followed for the samples, but MilliQ water was used. The blank sample was always the first sample to be filtered through the 250 µm mesh funnel before the 3 replicate samples were filtered.

Two sampling processing procedures were followed during this cruise. For both methods the homogenated sample was decanted into a bleached cleaned 2 L Nalgene bottle. The first used a 60 ml luer-lok syringe, passing a known volume of sample water through the Sterivex™ by hand. Once 1.5 L of sample had been passed through the Sterivex™, the cartridge was flushed with air to remove residual water. The filter cartridge was removed and placed into a Whirl-pack sample pack and immediately placed in -20 ºC storage.

The second method used a vacuum pump system. Sample water was syphoned from a bleach cleaned 2 L Nagene into a 60 ml syringe attached to the Sterivex™. The narrow end of the sterivex was then attached to the vacuum by a small section of Tygon® tubing which in turn connected to vacuum hosing.

Note: the same piece of silicon tubing was used to filter the blank and all three samples. The blank was always filtered first so that any contamination in the tubing or sample bottles could be identified within the blank.

Once completed, the mesh-funnel, the 250 µm mesh and the silicon tubing were placed in bath containing 1 part bleach (Domestos – 4.5% Sodium hypochlorite) to 3 parts MilliQ water and left for at least 3 hours. Approximately 50 ml of the same solution was introduced into each sample bottle and vigorously shaken and also left for a minimum of 3 hours. The equipment was then treble rinsed with MilliQ water. In addition, the 2L sample bottles were completely filled with MilliQ water and left for at least a further 3 hours before the water was tipped away.

Water was collected opportunistically over the duration of the cruise in the following order of preference.

1. <200 m depth CTD
2. >200 m depth CTD
3. Surface uncontaminated underway

Figure 18.1: Sampling arrangement for vacuum filtering during JR18005 cruise.

We would like to thank Natalie Freeman of SCRIPPS for the kind use of her vacuum pump system, which greatly increased the number of stations that could be sampled.

For information on this project please contact Geraint Tarling (gant@bas.ac.uk).

19 Swath Bathymetry

William Clark, British Antarctic Survey

The Kongsberg EM122 multi-beam echosounder (S/N: 120) was run opportunistically throughout the cruise once outside of the Argentine EEZ; there is large overlap with previous BAS datasets, particularly in the first half of the cruise, although a number of holes in the existing data were filled. In addition to the opportunistic data collection, two locations were specifically targeted for survey: a shallow sounding observed on cruise JR18004 and the South Sandwich Trench.

The Sound Velocity Profile was updated throughout the cruise using data from the CTD. During the opportunistic collection the SVP was updated intermittently, either after a relatively deep CTD cast or when the display looked to be affected. The profile was specifically updated with the latest data before the targeted swathing. However, as the EM122 logs raw data and the sound velocity profile applied during the cruise only affects the data display at the time, the same or a different SVP may be applied for post-processing.

No data processing or cleaning was completed during the cruise. There are a couple of areas where the data was seen to contain probable errors and some areas of increased noise/reduced coverage due to adverse weather conditions – particularly towards the end of the cruise - however the data appears generally good.

19.1 Setup

The acquisition computer is a Windows 7 workstation running Kongsberg's SIS software (version 4.1.3) for data collection and a 'Helmsman' display for the benefit of the bridge officers. The survey was configured based on the recommended settings in the "Using the EM122 on an Opportunistic Basis V3.3" document. The depth and beam width settings were adjusted as needed to maximise data quality throughout the cruise.

To prevent mutual interference, the EM122 was synchronised with the EA600 (single-beam echosounder) throughout the cruise, using the Kongsberg K-Sync system.

19.2 Survey Targets

19.2.1 Shallow Sounding

During cruise JR18004 a depth measurement of 42 meters was observed in an area otherwise charted as 4000m deep. A previous Swath track nearby also showed significantly reduced depth in the vicinity so, as this cruise passed close by, the chance was taken to better survey this area and assess any possible navigation hazard. The presence of two grounded icebergs prevented a complete survey of the location however the majority of the shallowest area was covered.

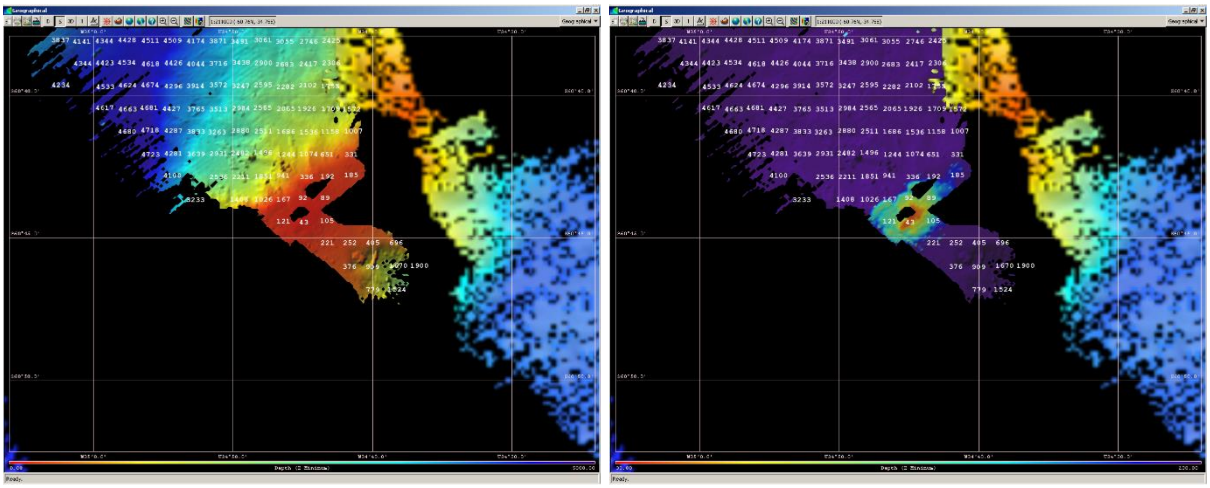


Figure 19.1: Approximate location: Latitude -60.74°, Longitude -34.75°.

Depth: 43m at shallowest point surveyed (grounded icebergs prevented full survey.)

Screenshots of feature: Depth scale 0-5000m (left), 30-200m (right) (background data 0-5000m)

19.2.2 South Sandwich Trench

A secondary objective of the cruise was to collect bathymetry data of the South Sandwich Trench. The survey began on the afternoon of the 10th March for just under 4 days, including a series of CTDs conducted across the centre of the survey area where a ridge at 6000m segmented the deep water. The sound velocity profile was updated just before entering the area and again during the transect across the centre. Some rough weather affected the data collection towards the end and a number of icebergs prevented the preferred course however the whole of the target area was successfully surveyed.

Approximate location: Latitude -60.25°, Longitude -25.00°.

Depth: 7500m at deepest point surveyed.

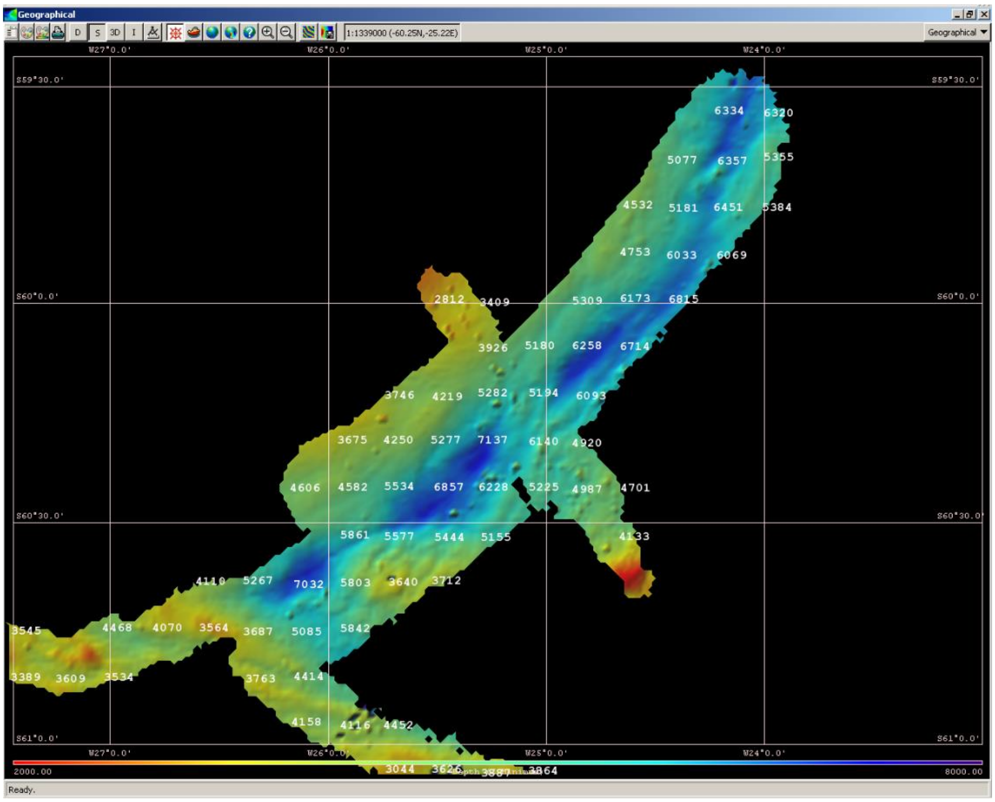


Figure 19.2: Screenshot of South Sandwich Trench area: Scale 2000-8000m

19.3 EM122 event Log

Time	Lat	Lon	Heading	Depth	Surface SV	Comment
17:06:19 04/04/2019	-60.99874	-13.52184	255.94	5506.67	1451.615000	Update SVP from CTD (JR18005_078a)
09:57:39 28/03/2019	-59.72476	27.32292	119.60	5349.94	1456.004000	Update SVP from CTD (JR18005_095) Active SVP was JR18005_079, not _085
11:25:29 21/03/2019	-58.33117	7.75950	232.43	4489.35	1454.827000	Update SVP from CTD (JR18005_085)
22:20:11 17/03/2019	-60.44067	-9.50989	66.87	5418.49	1453.817000	Update SVP from CTD (JR18005_079)
01:22:49 14/03/2019	-60.82771	-26.29285	127.29	4355.14	1452.348000	Departing South Sandwich Trench. Survey JR18005_a, line 0429 5.
17:32:43 13/03/2019	-60.44076	-24.79635	277.23	4990.98	1455.438000	Update SVP from CTD (JR18005_069)
00:03:04 12/03/2019	-59.95766	-25.49177	8.22	3045.58	1451.485000	Update SVP from CTD (JR18005_063)
16:18:05 10/03/2019	-60.82452	-27.23366	74.83	3759.09	1450.937000	Approaching South Sandwich Trench. Survey JR18005_a, line 0348, 10.
16:17:15 10/03/2019	-60.82502	-27.23720	76.01	3800.64	1450.943000	Update SVP from CTD (JR18005_062)
20:56:36 09/03/2019	-60.46885	-29.73627	250.68	1898.48	1451.513000	Update SVP from CTD (JR18005_058)
18:55:58 07/03/2019	-60.58136	-34.78432	353.56	3740.37	1454.675000	Departing Swath target around shallow (42m) sounding. Survey JR18005_a, line 279 32.
11:45:33 07/03/2019	-60.64024	-34.92209	141.63	4512.71	1453.683000	Approaching Swath target around shallow (42m) sounding. Survey JR18005_a, line 0272, 60.
21:33:12 06/03/2019	-60.46836	-37.11285	99.45	1628.81	1456.852000	Update SVP from CTD (JR18005_043)
01:15:13 05/03/2019	-60.62057	-41.98822	343.68	3378.91	1452.812000	Update SVP from CTD (JR18005_033)
14:11:42 04/03/2019	-60.65459	-42.15856	102.21	2994.99	1452.382000	Update SVP from CTD (JR18005_030)
16:55:26 02/03/2019	-60.14569	-48.27681	300.76	1913.35	1454.436000	Update SVP from CTD (JR18005_018)
17:59:16 01/03/2019	-60.54717	-52.33153	50.77	804.97	1451.862000	Update SVP from CTD (JR18005_010)
17:25:05 28/02/2019	-61.77217	-56.75421	6.64	421.80	1455.468000	Start pinging & logging
11:08:14 28/02/2019	-62.50477	-56.79209	182.33	539.98	1450.770000	Started logging - pinging failed.
11:07:46 28/02/2019	-62.50472	-56.79202	181.15	537.75	1450.757000	Update SVP from CTD (JR18005_003)
23:13:51 27/02/2019	-62.71072	-57.17709	233.87		1448.779000	Stopped logging
19:35:00 24/02/2019	-51.88158	-57.64533	180.95	127.31	1514.204000	Turn off dual ping as EA600 getting confused.
18:24:00 24/02/2019	-51.68399	-57.65124	180.67	66.47	1513.875000	Start logging and pinging (departing Stanley.)
10:15:00 24/02/2019	-51.66135	-57.68336	265.42	66.47	1504.384000	Stop logging and pinging (approaching Stanley.) Bad data collected overnight due to incorrect 'Min Depth' setting.
22:54:00 23/02/2019	-53.50095	-58.49701	12.17	2114.65	1480.736000	Update SVP from CTD (JR18005_001)

20 Antarctic Marine Engineering (AME) cruise summary

William Clark, British Antarctic Survey

Cruise	Departure	Arrival	AME Engineer(s)
JR18005	21/02/19 (Punta Arenas)	15/04/19 (Stanley)	William Clark (wilcla@bas.ac.uk)

This cruise is part of the ANDREXII science program.

20.1 Instrumentation

20.1.1 Systems used on cruise

Instrument	#SN if Used	Make and Model	Comments
Lab Instruments			
AutoSal	63360	OSIL 8400B	
Scintillation counter	No	PERKINELMER TRI-CARB 2910TR	
XBT	No		
Acoustic			
ADCP	Yes		
EM122	Yes		
TOPAS	No		
EK60/80	No		
K-Sync	Yes		
SSU	No		
USBL	No	Sonardyne Ranger 2	
10kHz IOS Pinger	No		
Benthos 12kHz Pinger	No		
Benthos 14kHz Pinger	No		
Mors 10kHz Transponder	No		
EA600	Yes		Bridge Equipment but logged
Oceanlogger			
Barometer1	V145002	VAISALA PTB210B1A2B	Inside the UIC
Barometer2	V145003	VAISALA PTB210B1A2B	Inside the UIC
Air humidity & temp1	61019333	Rotronic Hygroclip 2	On Foremast
Air humidity & temp2	61019251	Rotronic Hygroclip 2	On Foremast
TIR1 (pyranometer)	172882	Kipp & Zonen Sp Lite2	On Foremast
TIR2 (pyranometer)	172883	Kipp & Zonen Sp Lite2	On Foremast
PAR1	160959	Kipp & Zonen PQS-1	On Foremast
PAR2	160960	Kipp & Zonen PQS-1	On Foremast
Thermosalinograph	0018	SBE45	PrepLab
Transmissometer	1497DR	CST-846DR	PrepLab
Flourometer	1498	WSCHL-1498	PrepLab
Flow meter	05/811950	LitreMeter F112-P-HC-AP-OR-PP	PrepLab
Seawater temp 1	0765	SBE38	Sea Inlet
Seawater temp 2	0771	SBE38	Sea Inlet

(Continued on next page)

Instrument	#SN if Used	Make and Model	Comments
CTD			
Deck unit 1	0458	SBE11plus	
Underwater Comms/ Depth	0541	SBE9plus	Was: 1225 (001-071)
Temp1	5645	SBE3plus	
Temp2	2191	SBE3plus	
Cond1	1913	SBE 4C	Was: 3248 (001-066)
Cond2	4126	SBE 4C	Was: 1913 (066 only)
Pump1	1807	SBE5T	
Pump2	4458	SBE5T	Was: 7966 (001-032)
Standards Thermometer	0061	SBE35	
Transmissometer	CST-527DR	C-Star	
Oxygen sensor	0620	SBE43	On water duct 2 (i.e. T2/C2/P2)
PAR sensor	70442	QCP2350	
Flourometer	12-8513-001	CTG Aqua Tracker MkIII	
Altimeter	244739	Tritech S10127 232	Scratched on bad deck landing
CTD swivel linkage	-	Focal Technologies Group	Was: 196111 (001-063) Was: 1961018 (064-073)
LADCP Master Down	14443	TeleDyne WHM300	
LADCP Slave Up	15060	TeleDyne WHM300	
Pylon	0636	SBE32	
Other ship's systems (non-AME)			
Anemometer	Yes		Bridge Equipment, logged
Ships Gyro	Yes		Bridge Equipment, logged
System(s) brought by science team (non-AME)			
Fluorometer & Backscatter ('FL/BB')	4795	SeaBird ECO	Low signal flat-lining on FL

20.2 Notes for Heading and Course Instruments

20.2.1 Seatex

20.2.2 Ships Gyro

20.3 Notes for Lab Instruments used

20.3.1 AutoSal

20.3.2 Scintillation Counter

20.3.3 Ran DG's mechanical test procedure successfully.

20.4 Notes for Deck Systems

20.4.1 Winch Counter

20.4.2 XBT

Basic Stats			
Number Deployed	0	Number of Successful Casts	-

Number of Failures	-

20.4.3 CLAM

As has been noted on previous cruises, CLAM does not retain values when restarted. A few settings differ from the defaults and need entering before use (some of these are also documented elsewhere, but are copied here for completeness):

30T outboard load cell coefficients: Gain = 0.035 Offset = -55.16

Conducting wire inboard load cell alarm points: Min tension: 230 Max tension: 1870 *(These values don't prevent alarms during normal operation, but reduces the frequency somewhat)*

20.5 Notes for Acoustic Systems used

20.5.1 ADCP

20.5.2 EM122

Early in the cruise the EM122 started showing a "Failed to ping" error and would not acquire data. Restarting the system had no effect, nor did the normal power off / on procedure. The issue resolved after turning off and on electrical supply to the transceiver hardware; although this might have been coincidental.

20.5.3 Topas

20.5.4 EK60/80

20.5.5 K-Sync

On one occasion (2019-03-17, at about 18:30) the K-Sync was observed to be adding in an extra EA600 ping between the EA600/EM122 synchronised ping; as if an extra ping group was configured with just the EA600 (although, none was.) Adjusting K-Sync settings made no difference, but closing K-Sync, resetting the configurations and restarting the software resolved this behaviour.

20.5.6 SSU

20.5.7 USBL

20.5.8 10 KHz Pinger

20.5.9 Benthos Pingers

20.5.9.1 12kHz Pinger

20.5.9.2 14kHz Pinger

20.5.10 MORS 10 KHz Transponder

20.5.11 EA600

20.6 Notes about the Oceanlogger

20.6.1 Transmissometer

20.6.2 Flow Meter

20.6.3 Flourometer

The underway flourometer was cleaned on the 28th March at 08:00 due to a steady rise in background signal. This was during a CTD cast, so the CTD and underway flourometers can be compared before and after cleaning using the up- and down-cast data. While turned off for this cleaning, the whole underway system was flushed with Triton.

20.6.4 SBE45

20.6.5 PAR

20.6.6 Temperature and Humidity

20.6.7 TIR

20.6.8 UIC Display and Data management

20.7 Notes about the CTD

Basic Stats			
Number Of Casts	108	Number of Successful Casts	99
Max Depth	5923 m	Min Depth	244 m
Cable Removed (m) [CTD]	0	Re-terminations (elect.) [CTD]	1
Cable Removed (m) [Conductivity]	15	Re-terminations (elect.) [Conduct.]	3

20.7.1 Bottles

BAS 12l bottles were used for this cruise, along with O-Rings specially cleaned for CFC measurements.

A number of problems were had with the bottle lanyards. Two broke and were replaced pre-deployment and one broke in the water – the latter having been recently replaced. Therefore, the standard of acceptable wear for a lanyard was reduced and most were replaced pre-emptively. Bottle 24 failed to fire 4 times – a full lanyard replacement on this bottle resolved the issue. Bottle 24 required three long lanyard replacements in total due to wear; no other bottle needed more than one replacement so this one should be monitored.

On a number of casts, analysis of collected water showed bottles 21 and 23 were closing too early. It was suspected the long lanyard may have stretched slightly, allowing rough weather to close bottom cap prematurely; this appears confirmed, as adding a couple of knots solved the issue.

Two bottles (21 and 17) were replaced – independently of each other - due to leaks and these were fitted will full sets of new lanyards before use.

There were 7 recorded instances of a bottle misfiring (SBE32 unlatched but not released) and one instance of a bottle not firing (SBE32 not unlatched) when all others did.

20.7.2 Sensors

On cast 032 an offset was observed in T1/T2 and C1/C2 values, which increased when hauling and settled when stopped. This was thought likely to be an issue with pump 1 and a pump was replaced after the cast. Due to confusion over which side was duct 1, pump 2 was inadvertently replaced; however, the problem has not occurred since and bench-testing of the removed pump was successful – there may have been an external factor which caused the pump to stall which has not repeated.

Conductivity cell 1 started drifting on cast 065 so the decision was taken to replace it – this is when the aforementioned misidentification of the duct numbers was noticed, as C2 was replaced instead of the faulty C1. Therefore, the conductivity sensors used (by serial number) and their respective casts are as follows:

Cast #	Conductivity 1	Conductivity 2
Cast 001 to 064	3248	4126
Cast 065	3248 (faulty)	4126
Cast 066	3248 (faulty)	1913
Cast 067	1913	4126
Cast 068 to end	1913	4126

In all cases, C2 produced good data while C1 produced bad data for casts 065 and 066.

The FL/BB sensor, on loan from the Scripps Institution of Oceanography (University of California, San Diego), showed unexpected behaviour as the flourometer signal flat-lined at zero on a low signal. When the signal was large enough for data to be produced, it agreed closely with the BAS flourometer – which continued to measure when the FL/BB was below range; as the backscatter part appeared to be working well and the BAS flourometer was available no attempt was made to fix this issue to avoid affecting the backscatter measurements. In addition, this effect was also present when the sensor was used on cruise JR18001 and has apparently caused no concern.

20.7.3 Swivel & cable

Faults with both swivels and swapping from the CTD wire to the conducting wire (before cast 063) caused some confusion and several unsuccessful CTD casts while attempts were made to locate the problem.

The first swivel was found to be leaking from the bottom connector before cast 064 and was replaced with the spare from the cage. The CTD then worked without issue until cast 070.

Cast 70 failed with lost comms. Sea cable tested OK so cable SBE171995 (9plus-32-35) was replaced as this had several splices and patches. The second attempt at cast 70 succeeded.

Cast 071 failed with lost comms. Replacing the sea cable fuse allowed the cast to finish. In lieu of an obvious cause, the SBE9plus was replaced before next cast (in case it had been affected by an earlier issue); cast 072 succeeded.

Cast 073 failed with lost comms. Full retermination of cable made no difference, nor did a second electrical retermination or reinforcing the electrical termination with skotchkote and self-amalgamating tape. Different value fuses (within a sensible range of the nominal) did not help.

The replacement swivel was removed before cast 079, which succeeded – and resolved the issue. LADCP rotation data was then monitored with no swivel in use; there was comparatively more rotation on first few casts but it settled down shortly thereafter. Two cable kinks appeared, one after cast 081 and one after cast 089 – but there was no apparent damage or weakening of cable and no effect on IR values so was not considered an issue.

20.7.4 Conducting Wire Slip Ring

The slip ring on the conducting wire failed when a restraining rod to hold the outer part stationary became detached; it is not clear when this happened – the wires may have been strong enough to fight the rotation themselves for a while. Fortunately enough wire remained for soldering on new tails, allowing continued use of this cable drum.

20.7.5 LADCP

There were regular communication hangs, predominantly with the slave LADCP. In one instance BBTalk completely froze and required a PC restart – this was probably a Windows / serial port issue rather than an LADCP issue.

One cast did not record data as the battery had not been charging – highlighting the importance of the battery voltage pre- and post-deployment check & turning the charger off for this (to measure battery voltage rather than charger voltage.) The ship-side of the slave cable was replaced to resolve the battery charging issue.

20.7.6 End of cruise

As there is no scientific work planned for the next couple of months; the following CTD storage tasks were completed:

- Cable termination removed (end in office) and cable stored on drum, at request of crew
- SBE35 and PAR sensor repositioned to inside the frame (for protection from knocks)
- Slave (up) LACDP and frame removed
- T&C ducts flushed with Triton and MilliQ; left dry (as freezing risk) but T end capped
- Thorough fresh water rinse (incl. inside bottles)

20.7.7 CTD Deployment Procedure

Prior to deployment all bottles are cocked and the deionised water is vented from the T/C sensors, if present. Pre-deployment technical tests are carried out on the LADCP's and are logged. The LADCP is then activated and starts logging.

Once the Deck crew and winch operator are ready the CTD is lifted into the water and lowered to 10m, where power is started and logging begins. It is held here until the pumps start and the difference between T1 and T2 stabilizes. This can take some time, especially if the air temperature and sea temperature are far apart. In some circumstances, mainly turbulent surface waters it can be necessary to lower the CTD to 20m or further where the temperature is more stable, this is at the operator's discretion. Once stable, the CTD is lifted to as near to the surface as the winch op deems safe, to get the surface profile, then is lowered to the required depth or bottom without stopping. The bottom depth is an approximation from the best echo sounder available, commonly the EM122. If bottom depth is required then the altimeter will start working from under 100m of the sea bed and is used to stop no less than 10m from the sea bed. Once the down cast is complete bottles are fired at requested depths, in order, deepest first. When each bottle is fired 30 seconds are given to ensure that the independent standards thermometer has time to take a reading.

Once on the surface the CTD is returned to the vessel, the T/C sensors are filled with deionised water to avoid damage. All data is backed up as soon as possible.

20.8 Additional work completed on cruise

20.8.1 DeepTrekker ROV

Batteries charged as a PM task; ROV not used.

An extension cable was used to get power from the sockets on the far side of the explosives locker door into the cage for charging – this was much easier than getting the ROV box upstairs to charge, then back down again.

20.8.2 Inspire 2 UAS

The entire system (aircraft, tablets, etc.) was updated to the latest version, in accordance with the UK CAA recommendation regarding the 2018 TB50 battery issue. The UAS was flown on three occasions, including 1 night flight with the ship on DP and once (2 flights) while moving at 10 knots, without issue. All batteries discharged to 50% for storage.

20.8.3 NavMet

A few updates were made to the NavMet screen to improve resilience. It now periodically automatically restarts (and retains data across restarts); although, this probably shouldn't be necessary.

To manually reset saved values to zero (e.g. at the start of a new leg), stop NavMet and delete the file "C:\Users\ame\Desktop\NavMet\data.npy"; you can then restart NavMet.

20.9 AME Department notes

20.9.1 Priority needs and Notices

20.9.2 Pre-cruise tasks

Task	Status
Download AME_Eng/Platform_Specific/JCR	N
Check cruise planning meeting notes	N
Number of hours hand over with previous ships AME Engineer	18

20.9.3 Daily & weekly tasks

Task	Frequency	Status
Sanity check the Oceanlogger data	Daily	Y
Check the Following Fans: Oceanlogger Acoustic Rack Seapath EM122 (Tween) Topas (Tween)	Daily	Y

Mega test CTD cable	Weekly	Y

20.9.4

20.9.5 End of cruise checks

Task	Status
XBT left in cage, in a suitable state	N/A
The salinity bottles have been cleaned, if used	Y
CTD left in suitable state - Ducts cleaned with Triton and deionised water, blanking plugs installed and system washed with water	Y
CTD Slip Ring have been cleaned	Y
Office is tidy, with manuals and files returned and items stowed for sea	Y
Clean the following fans: Oceanlogger Acoustic Rack Seapath EM122 (Tween) Topas (Tween)	Y
Scintillation Counter test Procedure	Y

20.10

20.11 Items to be purchased

Item	Supplier	Quantity	Use

20.12

20.13 Additional notes and changes/future work

20.14 End of cruise Notes

The AME office PC (jr-amelab-d1) started blue-screening regularly on the last cruise so new HDD installed and upgraded to Windows 10 by IT. IT may be necessary to bring installers if there is a specific bit of software you might want.

21 IT Systems

David Hunter, British Antarctic Survey

21.1 Network Infrastructure

21.1.1 Local Area Network

There are no significant issues to report regarding Local Area Networking from this cruise.

21.1.2 Wide Area Network

21.2 VSAT issues

21.3 Windows Infrastructure

21.3.1 Servers

No significant server issues to report.

21.3.2 Workstations

Domain PCs often still not using WSUS, instead using internet services and flooding the WAN connectivity.

21.4 Unix Infrastructure

21.4.1 Servers

No significant server issues to report.

21.4.2 Workstations

No significant workstation issues to report.

21.5 Underway Infrastructure

21.5.1 Navigation

21.5.1.1 EA600 (Single Beam Echosounder)

There are no significant issues to report regarding EA600 from this cruise.

21.5.1.2 Microplot (Electronic Nautical Charts)

There are no significant issues to report regarding Microplot from this cruise.

21.5.1.3 NavMet

Will CLARK of AME had brought a second revision of NavMet he developed and is supporting.

21.5.2 Communication

21.5.2.1 VSAT (Very Small Aperture Terminal)

Regular, prolonged outages in WAN connectivity due to frequent Easterly courses causing interference with the dome. Issues from last cruises seem resolved as when able to reach a satellite, the connection itself was notably stable.

21.5.2.2 Telephony (VoIP & POTS)

No significant issues to report regarding telephony this cruise.

21.5.2.3 HF/VHF/UHF

No significant IT involvement from this cruise.

21.5.3 Scientific Instrumentation

21.5.3.1 SCS (Scientific Collection System)

There are no significant issues to report regarding the SCS from this cruise.

21.5.3.2 CTD (Conductivity, Temperature, Depth)

There are no significant issues to report regarding the CTD from this cruise.

21.5.3.3 EM122 (Multibeam Echosounder)

There are no significant issues to report regarding EM122 from this cruise.

21.5.3.4 EK60/EK80

There are no significant issues to report regarding EK60/EK80 from this cruise.

21.5.3.5 ADCP (Acoustic Doppler Current Profiler)

There are no significant issues to report regarding the ADCP from this cruise.

21.6 Appendices

21.6.1 Recommendations

No recommendations for action.

21.6.2 Notes

JR18005 has suffered severe setbacks as a result of repeated issues with the CTD. Once again, a replacement traction cable arrived greased rendering it unserviceable. Towards the later stages of the cruise, adverse weather also affected the science schedule.

21.6.3 Figures

No figures referenced.

22 Appendix 1: CTD sample master table

				Deploy Bottom Recover												# bottles							
Event #	CTD #	M	D	Time	Lat.	Lon.	Depth	Note	Bad bottle #	CFC	O2	OVOC	C	pH	SOCCOM pH/Alk	Nutrients	Si	N	C14	O18/ C13	Sal	SOCCOM HPLC/ POC	DNA
		2	23	21:07:10	-53 30.18	-58 29.73		Test															
9	1	2	23	21:46:43	-53 30.18	-58 29.73	2108			24						24	11	11			10		
		2	23	22:35:56	-53 30.18	-58 29.73																	
		2	25	21:08:45	-55 18.93	-57 22.61		Test															
10	2	2	25	22:13:11	-55 18.99	-57 23.01	3257	Not to bottom		24						0					14		
		2	25	23:14:39	-55 19.00	-57 23.31																	
		2	28	10:04:26	-62 30.28	-56 47.52																	
11	3	2	28	10:24:45	-62 30.29	-56 47.52	533			14	2	7	14	14		24	12			24	8		
		2	28	10:56:18	-62 30.28	-56 47.53																	
		2	28	13:47:22	-62 10.24	-56 40.22																	
12	4	2	28	14:23:17	-62 10.16	-56 40.29	1115			16	5	7	16	16		24			11	24	8		
		2	28	15:06:17	-62 10.16	-56 40.30																	
		2	28	19:34:28	-61 23.53	-56 41.65																	
13	5	2	28	19:52:16	-61 23.53	-56 41.65	473			13	4		12	12		24	9	9		24	8		1
		2	28	20:13:49	-61 23.53	-56 41.64																	
		3	1	04:28:16	-61 02.44	-54 24.31																	
14	6	3	1	04:43:51	-61 02.44	-54 24.31	492			14	5		14	14		24				14	8		
		3	1	05:10:03	-61 02.44	-54 24.31																	
		3	1	06:47:19	-60 57.83	-54 10.31																	
15	7	3	1	07:06:16	-60 57.84	-54 10.31	893			14	3		15	15		24				15	8		
		3	1	07:39:36	-60 57.83	-54 10.31																	
		3	1	10:37:24	-60 44.09	-53 22.46																	
16	8	3	1	10:52:20	-60 44.10	-53 22.46	448			8	3	6	8	12		23	12	12	8	12	8		

		3	1	11:17:17	-60 44.10	-53 22.45																	
		3	1	14:14:23	-60 26.54	-52 49.89																	
17	9	3	1	14:27:28	-60 26.58	-52 49.86	393			11	3		3	6		23				12	8		
		3	1	14:54:13	-60 26.62	-52 49.83																	
		3	1	16:46:13	-60 32.92	-52 21.18																	
18	10	3	1	17:06:51	-60 32.92	-52 21.18	823			13	3		6	12		24			11	15	8		
		3	1	17:41:53	-60 32.92	-52 21.18																	
		3	1	19:37:08	-60 22.21	-51 53.19																	
19	11	3	1	19:51:13	-60 22.23	-51 53.16	406			0	2		6	8		24				12	8		1
		3	1	20:13:31	-60 22.22	-51 53.15																	
		3	1	22:04:33	-60 17.31	-51 23.21																	
20	12	3	1	22:19:45	-60 17.31	-51 23.22	528			11	3		5	8		24			9	13	8		
		3	1	22:43:27	-60 17.31	-51 23.21																	
		3	1	23:57:25	-60 15.18	-51 11.63																	
21	13	3	2	00:18:53	-60 15.18	-51 11.64	976			12	2		6	9						16	8		
		3	2	00:50:59	-60 15.18	-51 11.64																	
		3	2	02:17:33	-60 13.44	-50 55.91																	
22	14	3	2	02:43:49	-60 13.44	-50 55.91	1340			14	2		6	11		24	13		9	17	8		
		3	2	03:23:57	-60 13.44	-50 55.91																	
		3	2	05:28:17	-60 11.90	-50 30.75																	
23	15	3	2	05:45:08	-60 11.90	-50 30.75	744			11	2		7	14		24				14	8		1
		3	2	06:13:01	-60 11.90	-50 30.75																	
		3	2	07:54:25	-60 13.55	-50 02.61																	
25	16	3	2	08:08:38	-60 13.55	-50 02.62	572	Event 24 also refers to this CTD		10	2		6	13		23				13	8		
		3	2	08:34:01	-60 13.56	-50 02.62																	
		3	2	11:04:02	-60 12.44	-49 16.82																	
26	17	3	2	11:27:26	-60 12.44	-49 16.82	995			12		7	7	14		24				15	8		

		3	2	12:05:47	-60 12.44	-49 16.83																	
		3	2	14:20:10	-60 09.93	-48 35.08																	
27	18	3	2	14:53:53	-60 09.93	-48 35.08	1564			13		6	6	9		23				18	8		
		3	2	15:45:04	-60 09.93	-48 35.08																	
		3	2	17:01:43	-60 08.74	-48 16.61																	
28	919	3	2	17:38:33	-60 08.74	-48 16.61	1908	Failed on downcast													8		
		3	2	17:57:04	-60 08.74	-48 16.61																	
		3	2	20:15:49	-60 08.74	-48 16.61																	
28	19	3	2	20:52:34	-60 08.74	-48 16.61	1905			15	3		6	11		24				18	8		
		3	2	21:43:43	-60 08.74	-48 16.61																	
		3	2	22:39:01	-60 08.89	-48 07.46																	
30	20	3	2	23:27:07	-60 08.89	-48 07.46	2758	SOCCOM float		17	2		6	13	16 [2 duplicate]	24	13		9	21	19	2 [2 duplicate]	
		3	3	00:35:20	-60 08.89	-48 07.45																	
		3	3	02:58:35	-60 07.61	-47 41.67																	
31	21	3	3	03:34:53	-60 07.61	-47 41.67	2006			16	5		7	19		24				20	8		
		3	3	04:27:55	-60 07.60	-47 41.67																	
		3	3	06:07:15	-60 08.86	-47 20.09																	
32	22	3	3	06:29:08	-60 08.85	-47 20.10	1001			12	5		7	15		24	11		7	15	8		
		3	3	07:03:23	-60 08.85	-47 20.09																	
		3	3	09:38:47	-60 21.24	-46 46.08																	
33	23	3	3	09:58:42	-60 21.24	-46 46.08	604			10	4		5	13		24				13	4		
		3	3	10:27:58	-60 21.24	-46 46.08																	
		3	3	20:05:38	-60 55.17	-43 59.92																	
35	24	3	3	20:14:08	-60 55.17	-43 59.93	244			8	2	6	3	5		24				9	8		
		3	3	20:34:52	-60 55.17	-43 59.93																	
		3	4	00:01:31	-60 45.58	-42 57.58																	
36	25	3	4	00:13:41	-60 45.58	-42 57.58	490			10	3	6	5	8		24				12	8		

		3	4	00:35:28	-60 45.58	-42 57.58																	
		3	4	01:37:13	-60 44.40	-42 47.39																	
37	26	3	4	02:02:10	-60 44.40	-42 47.40	1303			15	3		5	8		24				16	8		
		3	4	02:38:51	-60 44.40	-42 47.39																	
		3	4	04:25:23	-60 40.80	-42 23.41																	
38	27	3	4	04:48:56	-60 40.80	-42 23.41	998		1	12	4		5	12		24			8	15	8		
		3	4	05:26:10	-60 40.80	-42 23.41																	
		3	4	06:34:12	-60 39.61	-42 18.59																	
39	28	3	4	07:18:43	-60 39.61	-42 18.60	1642			15	3		6	14		24				18	8		
		3	4	08:12:27	-60 39.61	-42 18.59																	
		3	4	09:15:42	-60 39.42	-42 11.83																	
40	29	3	4	09:57:27	-60 39.42	-42 11.83	2029			17	3		7	16		24				20	8		
		3	4	10:59:18	-60 39.42	-42 11.83																	
		3	4	11:52:07	-60 39.37	-42 10.55																	
41	30	3	4	12:39:59	-60 39.37	-42 10.56	2514			18	5	6	6	13		24			8	22	8		
		3	4	13:52:31	-60 39.37	-42 10.56																	
		3	4	15:03:56	-60 39.14	-42 09.01																	
42	31	3	4	16:00:55	-60 39.14	-42 09.01	3096	SOCCOM + 2 x Arvor		20	3		6	14	16 [2 duplicate]	24	15	15	8	23	18	2 [2 duplicate]	1
		3	4	17:24:38	-60 39.14	-42 09.01																	
		3	4	19:03:50	-60 38.41	-42 06.15																	
46	32	3	4	20:10:54	-60 38.41	-42 06.15	3618			21	3		8	14		24			10	24	8		
		3	4	21:45:28	-60 38.41	-42 06.15																	
		3	4	22:47:08	-60 37.24	-41 59.29																	
47	33	3	4	23:44:35	-60 37.24	-41 59.29	3379			20	3		7	15		24				22	8		
		3	5	01:09:14	-60 37.23	-41 59.29																	
		3	5	02:37:22	-60 36.28	-41 49.95																	
48	34	3	5	03:29:37	-60 36.26	-41 50.04	2946			17	3		7	17		24				23	8		
		3	5	04:42:30	-60 36.26	-41 50.04																	

		3	5	05:48:40	-60 34.20	-41 41.47																	
49	35	3	5	06:31:20	-60 34.20	-41 41.48	2430			17	3		7	17		24				21	8		
		3	5	07:34:31	-60 34.20	-41 41.48																	
		3	5	09:08:15	-60 31.77	-41 22.65																	
50	36	3	5	09:47:17	-60 31.77	-41 22.65	1919			15	3	7	6	14		24				18	8		
		3	5	10:38:19	-60 31.77	-41 22.65																	
		3	5	12:26:39	-60 28.22	-40 58.85																	
51	37	3	5	12:56:51	-60 28.20	-40 58.81	1436			14	4	6	6	14		24				17	5		
		3	5	13:44:44	-60 28.19	-40 58.81																	
		3	5	17:41:23	-60 25.73	-40 04.18																	
13	38	3	5	18:11:42	-60 25.73	-40 04.21	1419			13	3	6	7	12		24			8	17	8		1
		3	5	19:00:59	-60 25.78	-40 04.19																	
		3	5	23:28:54	-60 24.59	-39 18.01																	
53	39	3	5	23:57:53	-60 24.60	-39 18.01	1465			14	4		8	15		24				17	8		
		3	6	00:44:23	-60 24.59	-39 18.01																	
		3	6	02:31:35	-60 24.60	-39 07.18																	
54	40	3	6	03:11:38	-60 24.60	-39 07.18	2139		21	15	4		7	15		24				19	8		
		3	6	04:13:42	-60 24.60	-39 07.17																	
		3	6	08:05:11	-60 25.16	-38 42.58																	
55	41	3	6	08:54:34	-60 25.16	-38 42.58	2547			19	5		7	14		24				22	8		1
		3	6	10:03:55	-60 25.15	-38 42.58																	
		3	6	13:37:05	-60 26.41	-37 59.96																	
56	42	3	6	14:31:32	-60 26.41	-38 0.010	2919		21	21	4	6	9	17		24	16	2	16	23	8		
		3	6	15:47:42	-60 26.41	-38 0.010																	
		3	6	18:40:56	-60 27.61	-37 22.13																	
57	43	3	6	19:27:05	-60 27.62	-37 22.12	2034			17	4		8	15		24				20	8		
		3	6	20:30:35	-60 27.62	-37 22.13																	
		3	7	01:03:33	-60 22.74	-36 24.08																	
58	44	3	7	01:42:05	-60 22.73	-36 24.07	1864		21,23	16	3		8	15		24				19	8		

		3	7	02:33:18	-60 22.73	-36 24.08																	
		3	7	07:39:01	-60 18.19	-35 28.54																	
59	45	3	7	08:11:39	-60 18.19	-35 28.54	1594		21	14	3		7	14		24				18	8		1
		3	7	08:57:14	-60 18.18	-35 28.54																	
		3	7	22:13:39	-60 08.34	-34 53.43																	
61	46	3	7	22:25:03	-60 08.36	-34 53.44	367			8	2		4	6		24				11	8		
		3	7	22:46:48	-60 08.36	-34 53.44																	
		3	8	00:50:02	-60 01.82	-34 28.31																	
62	47	3	8	01:12:21	-60 01.82	-34 28.31	994			12	4		6	12		24				15	7		
		3	8	01:49:39	-60 01.82	-34 28.31																	
		3	8	04:39:36	-59 55.81	-33 50.99																	
63	48	3	8	05:05:14	-59 55.81	-33 50.99	1256			13	3		7	13		24				16	8		
		3	8	05:44:17	-59 55.81	-33 50.99																	
		3	8	08:34:07	-59 50.94	-33 16.72																	
64	49	3	8	09:08:54	-59 50.94	-33 16.72	1598		23	14	5		7	14		24				18	8		
		3	8	09:54:39	-59 50.94	-33 16.72																	
		3	8	10:55:03	-59 51.60	-33 09.59																	
65	50	3	8	11:36:49	-59 51.60	-33 09.59	2055			13	5	6	7	15		24				20	8		1
		3	8	12:34:50	-59 51.60	-33 09.59																	
		3	8	13:34:23	-59 51.61	-33 04.25																	
66	51	3	8	14:21:48	-59 51.62	-33 04.26	2471			9	4	6	8	14		24				20	8		
		3	8	15:29:15	-59 51.52	-33 04.27																	
		3	8	16:27:32	-59 52.81	-32 56.98																	
67	52	3	8	17:23:24	-59 52.80	-32 56.98	2884			16	4		7	16		24	16	16	16	23	8		
		3	8	18:39:48	-59 52.81	-32 56.98																	
		3	8	20:07:56	-59 53.41	-32 51.58																	
68	53	3	8	20:48:29	-59 53.42	-32 51.58	2082		21,23	9	4		7	14		24				20	8		
		3	8	21:51:26	-59 53.41	-32 51.57																	
		3	8	22:55:27	-59 54.00	-32 48.49																	

69	54	3	8	23:25:47	-59 54.00	-32 48.49	1464		21,23	9	4		6	11		24				17	8		
		3	9	00:23:30	-59 54.00	-32 48.49																	
		3	9	01:27:30	-59 54.02	-32 43.86																	
70	55	3	9	01:51:26	-59 54.02	-32 43.85	1059			6	4		6	12		24				15	10		
		3	9	02:35:23	-59 54.02	-32 43.86																	
		3	9	04:52:02	-59 56.39	-32 14.43																	
71	56	3	9	05:15:57	-59 56.40	-32 14.47	967			9	4		7	13		24				15	10		
		3	9	05:54:06	-59 56.40	-32 14.47																	
		3	9	09:00:19	-59 58.16	-31 28.78																	
72	57	3	9	09:42:50	-59 58.16	-31 28.78	2070			16	5	6	8	14		24	15			20	8		
		3	9	10:42:53	-59 58.16	-31 28.78																	
		3	9	13:43:09	-60 19.17	-30 57.63																	
73	58	3	9	14:38:20	-60 19.17	-30 57.65	2779	SOCCOM float		15	5		8	17	15 [2 duplicate]	24			16	21	17	2 [2 duplicate]	1
		3	9	15:54:56	-60 19.17	-30 57.65																	
		3	9	20:18:55	-60 28.13	-29 44.17																	
75	59	3	9	20:55:15	-60 28.13	-29 44.17	1879			15	5		9	18		24				20	8		
		3	9	21:52:01	-60 28.13	-29 44.17																	
		3	10	03:06:18	-60 41.13	-28 15.80																	
76	60	3	10	03:45:18	-60 41.13	-28 15.80	2138			16	5		8	15		24				20	8		
		3	10	04:45:38	-60 41.13	-28 15.80																	
		3	10	07:53:47	-60 47.83	-27 25.54																	
77	61	3	10	08:54:48	-60 47.83	-27 25.54	3280			16	5		9	17		24				22	8		
		3	10	10:14:27	-60 47.83	-27 25.53																	
		3	10	12:29:35	-60 49.61	-27 13.70																	
78	62	3	10	13:45:44	-60 49.61	-27 13.70	3870	SOCCOM float		19	6		10	20	15 [2 duplicate]	24	16	16		22	18	2 [2 duplicate]	1
		3	10	15:29:05	-60 49.61	-27 13.70																	
		3	11	21:10:30	-59 57.46	-25 29.51																	

82	63	3	11	22:11:17	-59 57.46	-25 29.51	3033	South Sandwich Trench		19	5	6	11	20		24				24	8		
		3	11	23:53:27	-59 57.46	-25 29.51																	
		3	12	02:20:11	-60 06.69	-25 18.72																	
83	64	3	12	03:36:38	-60 06.69	-25 18.73	3968			19	5	6	12	22		24				24	8		
		3	12	05:34:38	-60 06.70	-25 18.72																	
		3	12	07:20:58	-60 10.61	-25 13.83																	
84	65	3	12	09:02:24	-60 10.62	-25 13.83	5051			20	5		12	23		24				24	8		
		3	12	11:10:39	-60 10.62	-25 13.83																	
		3	12	12:25:38	-60 13.28	-25 07.94																	
85	66	3	12	14:26:50	-60 13.28	-25 07.94	5924			22	5	7	8	24		24	16	16	16	24	14		1
		3	12	17:17:03	-60 13.29	-25 07.95																	
		3	12	20:21:36	-60 26.30	-24 46.79																	
86	67	3	12	22:11:43	-60 26.30	-24 46.79	4842			9				9		24					8		
		3	12	22:49:26	-60 26.30	-24 46.79																	
		3	13	08:50:05	-60 33.38	-24 40.29																	
87	68	3	13	10:11:01	-60 33.38	-24 40.29	4090			24	5	9	8	24		10				24	8		1
		3	13	12:00:41	-60 33.38	-24 40.29																	
		3	13	13:29:36	-60 26.28	-24 46.74																	
88	69	3	13	14:59:46	-60 26.28	-24 46.74	4832	End of South Sandwich Trench		20	6		7	23		24				23	8		
		3	13	17:06:23	-60 26.28	-24 46.74																	
		3	14	03:48:46	-61 00.89	-25 44.79																	
89	970	3	14	04:47:41	-61 00.89	-25 44.79	2505	Failed on downcast								23					0		
		3	14	04:47:41	-61 00.89	-25 44.79																	
		3	14	09:52:55	-61 00.89	-25 44.78																	
90	70	3	14	11:01:23	-61 00.89	-25 44.79	3534	Andrex II		21	5		7	22		23				24	8		
		3	14	12:37:34	-61 00.85	-25 44.84																	

		3	14	17:33:55	-61 13.85	-24 15.66																	
91	71	3	14	18:59:07	-61 13.85	-24 15.66	4281			19	1	2	2	3		20				19	8		
		3	14	19:05:21	-61 13.85	-24 15.66																	
		3	14	19:33:07	-61 13.85	-24 15.66																	
91	871	3	14	19:33:07	-61 13.85	-24 15.66	3403	CTD back on after break during cast			4		5	17		17					0		
		3	14	21:07:46	-61 13.85	-24 15.67																	
		3	15	02:38:19	-61 25.81	-22 46.25																	
92	72	3	15	04:21:16	-61 25.81	-22 46.25	4591			21	5		8	22		24	15		16	22	8		
		3	15	06:39:36	-61 25.81	-22 46.25																	
		3	15	11:16:15	-61 37.85	-21 17.01		Failed on downcast															
93	973	3	15	12:34:35	-61 37.87	-21 17.02	4354			0											0		
		3	15	12:34:35	-61 37.87	-21 17.02																	
		4	7	05:38:01	-61 37.86	-21 17.05																	
125	73	4	7	07:29:28	-61 37.86	-21 17.05	5022	Filled in on return west			8		24	24		24				24	8		
		4	7	09:47:53	-61 37.87	-21 17.06																	
		3	15	21:53:46	-61 49.96	-19 47.82																	
94	974	3	15	23:33:16	-61 49.96	-19 47.82	4461	Failed on upcast		6				7		7				7	4		
		3	15	00:02:50	-61 49.96	-19 47.82																	
		4	6	17:43:01	-61 43.27	-18 49.53																	
123	75	4	6	19:22:36	-61 43.27	-18 49.41	5053	Filled in on return west		24			17	24		24	17	17	16	24	8		
		4	6	21:41:41	-61 43.27	-18 49.41																	
		4	6	08:51:31	-61 25.86	-17 04.48																	
122	76	4	6	10:23:25	-61 25.86	-17 04.49	4700	Filled in on return west		24	12		18	24		24			16	24	8		

		4	6	12:34:58	-61 25.86	-17 04.48																	
		3	16	14:17:29	-61 19.81	-16 04.83																	
95	977	3	16	14:56:16	-61 19.81	-16 04.86	1837	Failed on downcast													0		
		3	16	14:56:16	-61 19.81	-16 04.86																	
		4	6	00:44:06	-61 17.86	-15 52.52																	
121	77	4	6	02:37:44	-61 17.86	-15 52.51	5289	Filled in on return west	1	24	10		19	24		24	14			24	8		
		4	6	04:58:10	-61 17.86	-15 52.52																	
		3	17	00:21:41	-60 59.59	-13 27.99																	
96	978	3	17	01:53:54	-60 59.59	-13 27.99	4217	Failed on downcast													0		
		3	17	01:53:54	-60 59.59	-13 27.99																	
		4	4	12:30:30	-60 59.84	-13 30.37																	
119	78	4	4	14:16:33	-60 59.84	-13 30.37	5464	Filled in on return west	1	23	8		16	24		24			16	24	8		
		4	4	16:43:52	-60 59.83	-13 30.37																	
		3	17	10:11:33	-60 48.02	-12 01.17																	
97	79	3	17	11:59:01	-60 48.01	-12 01.17	5457			24	6	2	0	24		24	19	3		24	8		1
		3	17	14:25:57	-60 48.00	-12 01.17																	
		3	18	00:31:18	-60 24.03	-9 02.50																	
98	80	3	18	02:20:59	-60 24.04	-9 02.43	4916			24	5			24		24				24	8		1
		3	18	04:37:06	-60 24.04	-9 02.43																	
		3	18	14:53:34	-60 00.04	-6 03.10																	
99	81	3	18	16:30:55	-60 00.05	-6 03.09	4989			24	7		9	23		24	18		16	24	8		1
		3	18	18:35:14	-60 00.04	-6 03.10																	
		3	19	04:47:41	-59 37.08	-3 06.59																	
100	82	3	19	06:35:03	-59 37.08	-3 06.60	4867			24	5	7	9	24		24	15	15		24	8		1
		3	19	08:55:15	-59 37.08	-3 06.59																	
		3	19	17:42:41	-59 12.11	0 06.18																	

101	83	3	19	19:23:02	-59 12.12	0 06.18	5074			24	8		8	24		24			16	24	8		1
		3	19	21:40:12	-59 12.11	0 06.18																	
		3	20	08:05:06	-58 49.02	2 51.45																	
102	84	3	20	09:53:07	-58 49.02	2 51.45	5462			24	7		8	24		24				24	8		1
		3	20	12:10:48	-58 49.02	2 51.45																	
		3	20	21:49:13	-58 24.97	5 49.56																	
103	85	3	20	23:40:30	-58 24.97	5 49.57	5103			24	6		9	24		24	15	15	16	24	8		1
		3	21	01:56:35	-58 24.98	5 49.56																	
		3	21	08:38:48	-58 19.87	7 45.57																	
104	86	3	21	10:01:44	-58 19.87	7 45.57	4224			23	6	7	8	23		24				23	8		1
		3	21	12:02:10	-58 19.87	7 45.57																	
		3	21	18:29:45	-58 04.00	9 39.66																	
105	87	3	21	20:44:51	-58 04.00	9 39.66	5511			24	8		9	24		24	18			24	12		
		3	21	23:23:40	-58 04.00	9 39.67																	
		3	22	07:46:36	-57 53.98	11 50.49																	
106	88	3	22	09:54:23	-57 53.98	11 50.49	5690			24	7	7	8	24		24				24	8		1
		3	22	12:40:12	-57 53.98	11 50.49																	
		3	22	18:37:39	-57 42.79	13 29.33																	
107	89	3	22	20:45:29	-57 42.80	13 29.33	5576			22	9		8	24		24	19	19	16	24	8		
		3	22	23:22:20	-57 42.80	13 29.34																	
		3	23	07:40:12	-57 32.25	15 22.49																	
108	90	3	23	09:32:54	-57 32.25	15 22.49	5132	SOCCOM float		22	8	2	8	24	13 [2 duplicate]	24				22	17	2 [2 duplicate]	1
		3	23	11:52:47	-57 32.25	15 22.49																	
		3	23	18:41:56	-57 22.14	17 15.54																	
110	91	3	23	20:31:49	-57 22.13	17 15.54	5081			24	9		8	24		24				24	8		
		3	23	22:53:33	-57 22.13	17 15.55																	
		3	26	08:33:27	-57 13.81	18 59.40																	
111	92	3	26	10:23:03	-57 13.80	18 59.39	4688			24	9	7	8	24		24	18		16	24	7		1

		3	26	12:39:17	-57 13.80	18 59.39																	
		3	26	20:51:15	-58 02.32	21 33.47																	
112	93	3	26	22:27:57	-58 02.32	21 33.48	4355			24	8		8	24		24				24	8		
		3	27	00:29:37	-58 02.35	21 33.49																	
		3	27	12:56:04	-58 52.36	24 22.25																	
113	94	3	27	14:57:13	-58 52.35	24 22.24	5398			23	13	7	21	24		24	17	3	16	24	8		1
		3	27	17:25:08	-58 52.35	24 22.25																	
		3	28	04:31:42	-59 41.27	27 10.08																	
114	95	3	28	06:34:25	-59 41.27	27 10.08	5304		23	24	12	7	23	24		24				24	8		1
		3	28	08:58:12	-59 41.27	27 10.08																	
		3	29	13:13:37	-60 30.00	30 00.00		Andrex II end															
115	96	3	29	15:15:25	-60 30.00	30 00.00	5233	I6S		22	12		19	24	13 [2 duplicate]	24				22	16	2 [2 duplicate]	
		3	29	17:41:15	-60 30.00	29 059.84		SOCCOM float															
		3	29	21:36:38	-61 00.00	30 00.00																	
117	97	3	29	23:29:47	-61 00.00	30 00.00	5234	I6S		24	12		23	24		24				23	8		
		3	30	01:54:45	-61 00.00	30 00.00																	
		3	30	05:43:50	-61 30.02	29 59.98																	
118	98	3	30	07:38:11	-61 30.02	29 59.99	5196	I6S		24	12	7	23	24		24	18	18	16	24	8		1
		3	30	10:00:43	-61 30.02	29 59.99																	
		4	9	07:16:58	-60 13.78	-35 18.61																	
126	99	4	9	07:34:47	-60 13.78	-35 18.61	527	Glider recovery			12	7									8		1
		4	9	08:10:55	-60 13.78	-35 18.61																	
		4	11	15:38:39	-61 31.21	-49 49.44																	
129	100	4	11	15:51:19	-61 31.17	-49 49.42	500	Sea ice		23		7					4		4		8		1
		4	11	16:39:11	-61 30.99	-49 49.29		Not to bottom															

23 Appendix 2: Bridge science log

Time	Event	Lat	Lon	Comment
11/04/2019 22:00		-61.4332	-49.7161	Exit ice edge
11/04/2019 20:18	129	-61.4916	-49.8287	Uncontaminated seawater off
11/04/2019 20:06	129	-61.4961	-49.8528	Vessel out of DP
11/04/2019 17:45	129	-61.506	-49.8713	Vessel on DP
11/04/2019 17:02	129	-61.5163	-49.8217	Uncomtaminated seawater in mid position
11/04/2019 17:02	129	-61.5163	-49.8217	Vessel off DP
11/04/2019 16:48	129	-61.5165	-49.8215	Gantry lashed
11/04/2019 16:43	129	-61.5165	-49.8215	CTD#100 in the water bottle annex and gantry stowed
11/04/2019 16:41	129	-61.5165	-49.8215	CTD#100 on deck
11/04/2019 16:39	129	-61.5165	-49.8215	CTD#100 out of the water
11/04/2019 15:51	129	-61.5195	-49.8238	CTD#100 stopped at 500m
11/04/2019 15:41	129	-61.5201	-49.8241	CTD#100 at surface veering to 500m. EA600 at 3227m
11/04/2019 15:37	129	-61.5201	-49.8241	CTD#100 in the water; soaking
11/04/2019 15:35	129	-61.5202	-49.8241	CTD#100 off deck
11/04/2019 15:29	129	-61.5202	-49.8241	Uncontaminated seawater on
11/04/2019 15:22	129	-61.5202	-49.8239	Vessel on DP for CTD#100
11/04/2019 15:07	128	-61.5096	-49.8126	Gantry unlashed
11/04/2019 15:06	128	-61.5098	-49.8131	Vessel off DP
11/04/2019 15:03	128	-61.5098	-49.8124	Underway uncontaminated seawater system off and valve closed
11/04/2019 13:30	128	-61.5098	-49.8131	Uncontaminated seawater system on
11/04/2019 13:20	128	-61.4054	-49.875	On DP
11/04/2019 12:10	128	-61.2461	-49.8078	Enter pack ice
10/04/2019 18:38		-60.699	-45.5818	Vessel off DP
10/04/2019 18:12		-60.6983	-45.5876	Science hatch closed
10/04/2019 16:18		-60.7918	-45.3099	Science hatch open for demob ops
10/04/2019 16:15		-60.7979	-45.2969	Vessel in DP in lee of Signy Island
09/04/2019 09:30	127	-60.2652	-35.2428	Off DP
09/04/2019 09:18	127	-60.2653	-35.2427	Glider on deck
09/04/2019 09:16	127	-60.2657	-35.2427	Glider in net
09/04/2019 09:10	127	-60.2662	-35.2429	net in water
09/04/2019 09:08	127	-60.2665	-35.2426	Net in air
09/04/2019 08:54	127	-60.2651	-35.2469	Vessel on DP for glider recovery
09/04/2019 08:24	126	-60.2296	-35.3102	Gantry lashed
09/04/2019 08:24	126	-60.2296	-35.3102	Vessel out of DP
09/04/2019 08:12	126	-60.2296	-35.3101	CTD back in garage/ gantry stowed
09/04/2019 08:10	126	-60.2296	-35.3101	CTD #99 out of the water
09/04/2019 07:33	126	-60.2296	-35.3102	CTD #99 stopped at 524m
09/04/2019 07:23	126	-60.2296	-35.3102	CTD #99 deploying to 500m
09/04/2019 07:18	126	-60.2296	-35.3102	CTD #99 in the water

09/04/2019 07:12	126	-60.2296	-35.3102	Gantry unlashed
09/04/2019 07:00	126	-60.2291	-35.3088	Vessel on DP for CTD #99
07/04/2019 11:48		-61.4631	-21.7845	30 tonne traction winch wheel issue unfixable in time scale. South Sandwich Trench deep CTD's cancelled and vessel set course for glider recovery position.
07/04/2019 10:18		-61.6299	-21.285	Investigating problem with 30 tonne traction winch wheels securing.
07/04/2019 10:15	125	-61.6302	-21.2843	Gantry lashed
07/04/2019 10:15	125	-61.6311	-21.2842	Off DP
07/04/2019 09:50	125	-61.6311	-21.2843	CTD#73 on deck
07/04/2019 09:47	125	-61.6311	-21.2842	CTD#73 in the air
07/04/2019 07:28	125	-61.6311	-21.2842	CTD #73 stopped at 5012m
07/04/2019 05:42	125	-61.6311	-21.2842	CTD #73 deploying to 5000m
07/04/2019 05:39	125	-61.6311	-21.2843	CTD #73 in the water
07/04/2019 05:30	125	-61.6311	-21.2845	Gantry unlashed
07/04/2019 05:24	125	-61.6309	-21.2854	Vessel on DP at CTD #73
06/04/2019 22:04	123	-61.7221	-18.8263	Off DP
06/04/2019 21:57	123	-61.7212	-18.8235	Gantry lashed
06/04/2019 21:42	123	-61.7212	-18.8234	CTD#75 on deck
06/04/2019 21:00	124	-61.7212	-18.8235	Drone on deck
06/04/2019 20:40	124	-61.7212	-18.8235	Drone in the air
06/04/2019 19:21	123	-61.7212	-18.8235	CTD #75 stopped at 5042m
06/04/2019 17:47	123	-61.7212	-18.8256	CTD #75 deploying to 5000m
06/04/2019 17:44	123	-61.7212	-18.8256	CTD #75 in the water
06/04/2019 17:42	123	-61.7212	-18.8256	CTD #75 off deck
06/04/2019 17:36	123	-61.721	-18.8265	Vessel on DP at CTD #75
06/04/2019 17:36	123	-61.721	-18.8265	Gantry unlashed
06/04/2019 12:56	122	-61.4317	-17.0764	Vessel off DP
06/04/2019 12:55	122	-61.4316	-17.0757	Gantry lashed
06/04/2019 12:41	122	-61.431	-17.0746	CTD in water bottle annex
06/04/2019 12:38	122	-61.431	-17.0746	CTD#76 on deck
06/04/2019 12:34	122	-61.431	-17.0747	CTD#76 out of the water
06/04/2019 10:23	122	-61.431	-17.0748	CTD#76 stopped at 4691m and hauling
06/04/2019 08:56	122	-61.431	-17.0748	CTD#76 going to 4700m
06/04/2019 08:54	122	-61.431	-17.0748	CTD#76 in water
06/04/2019 08:45	122	-61.431	-17.0748	Gantry unlashed
06/04/2019 08:38	122	-61.4315	-17.0738	Vessel on DP
06/04/2019 05:12	121	-61.2979	-15.8751	Vessel out of DP
06/04/2019 05:09	121	-61.2977	-15.8753	Gantry lashed
06/04/2019 05:03	121	-61.2976	-15.8753	CTD in garage/ gantry stowed
06/04/2019 04:57	121	-61.2976	-15.8753	CTD #77 out of the water
06/04/2019 02:37	121	-61.2976	-15.8753	CTD#77 max wire out 5279m
06/04/2019 00:46	121	-61.2976	-15.8752	CTD#77 at surface veering to ~5300m. EA600 at 5325m

06/04/2019 00:42	121	-61.2976	-15.8752	CTD#77 in the water; soaking
06/04/2019 00:40	121	-61.2976	-15.8753	CTD#77 off deck
06/04/2019 00:28	120	-61.2976	-15.8753	Load test complete at 3.4T
06/04/2019 00:16	120	-61.2976	-15.8753	Start load test of CTD termination of conductivity wire
05/04/2019 21:45	120	-61.2976	-15.8752	Problem found with slip ring
05/04/2019 02:09	120	-61.2976	-15.8754	CTD#77 on deck. Beginning retermination
05/04/2019 02:07	120	-61.2976	-15.8754	CTD#77 off deck
05/04/2019 01:55	120	-61.2976	-15.8754	CTD repaired
05/04/2019 00:22	120	-61.2975	-15.8754	CTD in water bottle annex; problem being investigated
05/04/2019 00:19	120	-61.2976	-15.8754	CTD#77 on deck
05/04/2019 00:15	120	-61.2975	-15.8754	CTD#77 recovering to deck
05/04/2019 00:12	120	-61.2976	-15.8754	CTD#77 lost comms
05/04/2019 00:08	120	-61.2976	-15.8754	CTD#77 in the water; soaking
05/04/2019 00:06	120	-61.2976	-15.8754	CTD#77 off deck
04/04/2019 23:50	120	-61.2974	-15.8761	On DP
04/04/2019 23:30	120	-61.2864	-15.8252	Gantry unlashed
04/04/2019 17:00	119	-60.9973	-13.5062	Gantry lashed
04/04/2019 17:00	119	-60.9973	-13.5062	Vessel out of DP
04/04/2019 16:48	119	-60.9973	-13.5062	CTD in garage/ gantry stowed
04/04/2019 16:42	119	-60.9972	-13.5062	CTD #78 out of the water
04/04/2019 14:15	119	-60.9973	-13.5062	CTD stopped at 5454m
04/04/2019 12:35	119	-60.9973	-13.5062	CTD#78 at surface veering to ~5400m. EA600 at 5495m
04/04/2019 12:31	119	-60.9973	-13.5062	CTD#78 in the water; soaking
04/04/2019 12:29	119	-60.9973	-13.5062	CTD#78 off deck
04/04/2019 12:20	119	-60.9977	-13.5069	LDCP bolts noted one missing
04/04/2019 12:13	119	-60.9985	-13.5082	Gantry unlashed
04/04/2019 12:06	119	-60.9983	-13.5076	Vessel on DP for CTD#78
30/03/2019 10:12	118	-61.5003	29.99981	Off DP
30/03/2019 10:11	118	-61.5003	29.99978	Gantry lashed
30/03/2019 10:04	118	-61.5003	29.99978	CTD#98 on deck
30/03/2019 07:38	118	-61.5003	29.99977	CTD #98 stopped at 5185m
30/03/2019 05:48	118	-61.5003	29.9997	CTD #98 deploying to 5200m
30/03/2019 05:45	118	-61.5003	29.99967	CTD #98 in the water
30/03/2019 05:36	118	-61.5005	29.9997	Gantry unlashed
30/03/2019 05:18	118	-61.5016	30.00098	Vessel on DP at CTD #98
30/03/2019 02:12	117	-60.9999	29.9996	Vessel off DP
30/03/2019 02:10	117	-61.0001	30.00005	Gantry secure
30/03/2019 01:56	117	-61	30.00002	CTD#97 on deck
29/03/2019 23:30	117	-61	30.00004	CTD#97 stopped at 5220m and hauling
29/03/2019 21:42	117	-61.0001	30.00005	CTD#97 going to 5200m
29/03/2019 21:37	117	-61	30.00008	CTD#97 in water

29/03/2019 21:24	117	-61	30.00048	Gantry unlashed
29/03/2019 21:12	117	-60.9999	30.00303	On DP
29/03/2019 18:06	116	-60.4995	29.99242	Vessel out of DP
29/03/2019 18:00	116	-60.8478	30.0338	Float deployed- vessel at 0.7kts
29/03/2019 17:57	116	-60.4999	29.99685	Float off deck- S/N 12880 Apex Float
29/03/2019 17:54	115	-60.5	29.99729	Gantry lashed
29/03/2019 17:54	116	-60.5	29.99729	Start moving ahead for float deployment
29/03/2019 17:48	115	-60.5	29.99723	CTD back in garage/ gantry stowed
29/03/2019 17:42	115	-60.4999	29.99728	CTD #96 out of the water
29/03/2019 15:15	115	-60.5	30.00008	CTD#96 stopped at 5222m. Hauling
29/03/2019 13:26	115	-60.5	30.00005	CTD#96 at surface veering to ~5200m. EA600 at 5284m
29/03/2019 13:22	115	-60.4999	30.00005	CTD#96 back in the water
29/03/2019 13:13	115	-60.4999	30.00012	CTD#96 out of the water; block straightened going back in
29/03/2019 13:10	115	-60.5	30.00005	CTD#96 recovering to deck to straighten block on midships gantry
29/03/2019 13:06	115	-60.5	30.00003	CTD#96 at 10m. Conductivity wire touching the cheek of the block; investigating
29/03/2019 13:04	115	-60.4999	30.00002	CTD#96 in the water
29/03/2019 12:59	115	-60.4999	30.00002	CTD#96 off deck
29/03/2019 12:52	115	-60.4999	30.00004	Gantry unlashed; clear to deploy
29/03/2019 09:15		-60.4987	30.00469	Vessel on DP for station CTD#96; assessing weather conditions
28/03/2019 19:42		-60.4997	29.99586	Vessel hove to at CTD #96
28/03/2019 09:16	114	-59.6879	27.16822	off DP
28/03/2019 09:15	114	-59.6879	27.16824	Gantry lashed
28/03/2019 09:02	114	-59.6878	27.16793	CTD#95 on deck
28/03/2019 08:58	114	-59.6878	27.16795	CTD#95 in the air
28/03/2019 06:33	114	-59.6879	27.16798	CTD #95 stopped at 5292m
28/03/2019 04:36	114	-59.6879	27.168	CTD #95 deploying to 5300m
28/03/2019 04:33	114	-59.6879	27.16794	CTD #95 in the water
28/03/2019 04:12	114	-59.6879	27.16795	Gantry unlashed
28/03/2019 03:54	114	-59.6894	27.16979	Vessel on DP for station CTD#95
27/03/2019 17:42	113	-58.8726	24.37068	Vessel out of DP
27/03/2019 17:36	113	-58.8726	24.37073	Gantry lashed
27/03/2019 17:30	113	-58.8725	24.37075	CTD back in garage/ gantry stowed
27/03/2019 17:24	113	-58.8726	24.37074	CTD #94 out of the water
27/03/2019 14:57	113	-58.8725	24.37075	CTD stopped at 5385m
27/03/2019 13:00	113	-58.8726	24.37081	CTD#94 in the water
27/03/2019 12:55	113	-58.8726	24.37078	CTD#94 off deck
27/03/2019 12:34	113	-58.8726	24.3708	Clear to deploy CTD#94
27/03/2019 11:33	113	-58.8736	24.37023	Vessel on DP for station CTD#94; assessing conditions
27/03/2019 00:48	112	-58.0393	21.5582	Gantry secure; vessel off DP
27/03/2019 00:36	112	-58.0392	21.5581	CTD in water bottle annex

27/03/2019 00:31	112	-58.0393	21.55813	CTD#93 on deck
27/03/2019 00:29	112	-58.0393	21.55816	CTD#93 out of the water
26/03/2019 22:27	112	-58.0387	21.55788	CTD#93 stopped at 4347m and hauling
26/03/2019 20:55	112	-58.0387	21.55783	CTD#93 going to 4300m
26/03/2019 20:50	112	-58.0387	21.55785	CTD#93 in the water
26/03/2019 20:35	112	-58.0387	21.55782	Gantry unlashed
26/03/2019 20:21	112	-58.0386	21.55635	On DP
26/03/2019 12:54	111	-57.2299	18.98993	Gantry secure
26/03/2019 12:42	111	-57.2299	18.98986	CTD#92 on deck
26/03/2019 12:39	111	-57.2299	18.98989	CTD#92 out of the water
26/03/2019 10:22	111	-57.2299	18.98993	CTD#92 stopped at 4678m and hauling
26/03/2019 08:44	111	-57.2301	18.99008	CTD#92 going to 4650m
26/03/2019 08:40	111	-57.2301	18.99008	CTD#92 in the water
26/03/2019 08:30	111	-57.2303	18.98999	CTD#92 in the air
26/03/2019 08:26	111	-57.2303	18.99002	Gantry unlashed
26/03/2019 07:30	111	-57.2301	18.99056	Vessel on station at CTD #92- continuing to assess weather conditions
26/03/2019 06:12	111	-57.2285	19.0049	Vessel on DP off CTD #92- assessing weather conditions
24/03/2019 05:48		-57.3292	18.9762	Vessel hove to
24/03/2019 05:48		-57.3292	18.9762	Vessel at Station #92 but strong winds and building sea. Vessel hove to WOW
23/03/2019 23:06	110	-57.3688	17.25935	Gantry lashed
23/03/2019 23:06	110	-57.3688	17.25935	Off DP
23/03/2019 22:55	110	-57.3688	17.25931	CTD#91 on deck
23/03/2019 22:54	110	-57.3689	17.25928	CTD#91 clear of water
23/03/2019 20:30	110	-57.3689	17.25894	CTD#91 stopped at 5069M and hauling
23/03/2019 18:42	110	-57.3689	17.25901	CTD #91 deploying to 5000m
23/03/2019 18:39	110	-57.3689	17.25903	CTD #91 in the water
23/03/2019 18:30	110	-57.3693	17.25898	Gantry unlashed
23/03/2019 18:24	110	-57.3699	17.25898	Vessel on DP at CTD #91
23/03/2019 12:20		-57.5352	15.37575	Vessel off DP
23/03/2019 12:14	109	-57.5371	15.37489	Apex float #12879 released at 0.8kts
23/03/2019 11:57	108	-57.5375	15.37477	CTD#90 on Deck
23/03/2019 11:53	108	-57.5375	15.37477	CTD#90 out of the water
23/03/2019 09:33	108	-57.5375	15.37483	CTD#90 stopped at 5120m and hauling
23/03/2019 07:45	108	-57.5376	15.37488	CTD #90 deploying to 5100m
23/03/2019 07:42	108	-57.5376	15.37491	CTD #90 in the water
23/03/2019 07:30	108	-57.5376	15.3749	Gantry unlashed
23/03/2019 07:12	108	-57.538	15.37376	Vessel on DP at CTD #90
22/03/2019 23:45	107	-57.7132	13.4888	Off DP
22/03/2019 23:42	107	-57.7133	13.48898	Gantry lashed
22/03/2019 23:24	107	-57.7134	13.48901	CTD#89 on deck
22/03/2019 20:45	107	-57.7133	13.48879	CTD#89 stopped at 5559m and hauling
22/03/2019 18:42	107	-57.7182	13.44546	CTD #89 deploying to 5580m

22/03/2019 18:37	107	-57.7132	13.48879	CTD #89 in the water
22/03/2019 18:12	107	-57.7133	13.48885	Gantry unlashed
22/03/2019 18:06	107	-57.7133	13.48886	Vessel on DP at CTD #89
22/03/2019 12:54	106	-57.8997	11.8416	Vessel off DP
22/03/2019 12:46	106	-57.8997	11.84159	CTD in water bottle annex; Gantry stowed
22/03/2019 12:42	106	-57.8996	11.84159	CTD#88 on deck
22/03/2019 09:54	106	-57.8997	11.84155	CTD#88 stopped at 5679m and hauling
22/03/2019 07:52	106	-57.8997	11.84154	CTD #88 deploying to 5700m
22/03/2019 07:48	106	-57.8997	11.84151	CTD #88 in the water
22/03/2019 07:36	106	-57.8989	11.8438	Vessel on DP
22/03/2019 07:30	106	-57.9027	11.85641	Gantry unlashed
22/03/2019 06:15	106	-57.9088	11.71521	Inform UIC Iceberg on CTD Station
21/03/2019 23:44	105	-58.0667	9.66119	off DP
21/03/2019 23:43	105	-58.0667	9.6612	Gantry secured
21/03/2019 23:24	105	-58.0667	9.66119	CTD#87 on deck
21/03/2019 20:45	105	-58.0667	9.66109	CTD#87 stopped at 5497m and hauling
21/03/2019 18:33	105	-58.0667	9.66108	CTD #87 deploying to 5500m
21/03/2019 18:30	105	-58.0667	9.66105	CTD #87 in the water
21/03/2019 18:12	105	-58.0671	9.66156	Gantry unlashed
21/03/2019 18:06	105	-58.0668	9.66112	Vessel on DP at CTD #87
21/03/2019 12:16	104	-58.3312	7.7595	Vessel off DP
21/03/2019 12:05	104	-58.3312	7.75948	CTD#86 on deck
21/03/2019 10:00	104	-58.3312	7.75947	CTD#86 stopped at 4214m and hauling
21/03/2019 08:42	104	-58.3312	7.75949	CTD#86 going to 4150m
21/03/2019 08:36	104	-58.3312	7.7595	CTD#86 in the water
21/03/2019 08:26	104	-58.3311	7.75951	Gantry unlashed
21/03/2019 08:18	104	-58.3301	7.7597	On DP
21/03/2019 02:13	103	-58.4162	5.82609	Vessel off DP
21/03/2019 02:12	103	-58.4163	5.82609	Gantry secure
21/03/2019 02:04	103	-58.4163	5.82609	Gantry stowed
21/03/2019 01:58	103	-58.4163	5.82607	CTD#85 on deck
20/03/2019 23:40	103	-58.4163	5.82615	CTD#85 stopped at 5092m and hauling
20/03/2019 21:50	103	-58.4162	5.82614	CTD#85 going to near bottom
20/03/2019 21:47	103	-58.4162	5.82603	CTD#85 in the water
20/03/2019 21:36	103	-58.4162	5.82604	Gantry unlashed
20/03/2019 21:20	103	-58.4149	5.83016	On DP
20/03/2019 12:24	102	-58.8169	2.85747	Vessel off DP
20/03/2019 12:13	102	-58.8169	2.85745	CTD#84 on deck
20/03/2019 09:54	102	-58.817	2.85749	CTD#84 stopped at 5447m and hauling
20/03/2019 08:10	102	-58.8169	2.85745	CTD#84 deploying to 5400m
20/03/2019 08:06	102	-58.8169	2.85746	CTD #84 in the water
20/03/2019 08:03	102	-58.8169	2.85747	Resume CTD ops
20/03/2019 07:48	102	-58.8169	2.85752	Suspend CTD ops to inspect wire
20/03/2019 07:42	102	-58.8169	2.85755	Gantry unlashed

20/03/2019 07:36	102	-58.8169	2.85741	Vessel on DP at CTD #84
19/03/2019 22:02	101	-59.2037	-0.10444	Off DP
19/03/2019 22:00	101	-59.2027	-0.10438	Gantry lashed
19/03/2019 21:42	101	-59.2019	-0.10299	CTD#83 on deck
19/03/2019 19:23	101	-59.2019	-0.10297	CTD #83 stopped at 5064m
19/03/2019 17:48	101	-59.2019	-0.10301	CTD #83 deploying to 5100m
19/03/2019 17:45	101	-59.2019	-0.10293	CTD #83 in the water
19/03/2019 17:33	101	-59.2017	-0.10336	Gantry unlashed
19/03/2019 17:24	101	-59.2011	-0.10339	Vessel on DP
19/03/2019 09:06	100	-59.6181	-3.10985	Gantry lashed
19/03/2019 09:06	100	-59.6181	-3.10985	Vessel out of DP
19/03/2019 09:00	100	-59.6181	-3.10985	CTD back in the garage/ gantry stowed
19/03/2019 08:54	100	-59.618	-3.10984	CTD #82 out of the water
19/03/2019 06:34	100	-59.618	-3.10986	CTD #82 all stopped at 4855m
19/03/2019 04:52	100	-59.6181	-3.10987	CTD#82 at surface veering to ~4850m. EA600 at 4918m
19/03/2019 04:48	100	-59.6181	-3.10987	CTD#82 in the water
19/03/2019 04:30	100	-59.6164	-3.104	Vessel in DP
18/03/2019 18:48	99	-60.0008	-6.05155	Gantry lashed
18/03/2019 18:48	99	-60.0008	-6.05155	Vessel out of DP
18/03/2019 18:41	99	-60.0007	-6.05154	CTD in the garage/ gantry stowed
18/03/2019 18:34	99	-60.0008	-6.05157	CTD #81 out of the water
18/03/2019 16:29	99	-60.0008	-6.05154	CTD#81 stopped at 4979m
18/03/2019 15:01	99	-60.0007	-6.05163	CTD#81 at surface veering to ~5000m. EA600 at 4741m
18/03/2019 14:58	99	-60.0007	-6.05162	CTD#81 in the water
18/03/2019 14:38	99	-59.9991	-6.05399	Vessel in DP on station
18/03/2019 05:12	98	-60.4006	-9.04043	Vessel off DP
18/03/2019 04:39	98	-60.4006	-9.04051	CTD#80 on deck
18/03/2019 02:20	98	-60.4006	-9.04052	CTD#80 stopped at 4903m
18/03/2019 00:41	98	-60.4005	-9.04172	CTD#80 going to 4900m
18/03/2019 00:32	98	-60.4005	-9.04166	CTD#80 in the water
18/03/2019 00:18	98	-60.4005	-9.04181	Gantry unlashed
18/03/2019 00:05	98	-60.3986	-9.03797	On DP
17/03/2019 14:36	97	-60.8001	-12.0185	Vessel off DP
17/03/2019 14:36	97	-60.8001	-12.0185	CTD secure in water bottle annex
17/03/2019 14:28	97	-60.8002	-12.0195	CTD#79 on deck
17/03/2019 11:00	97	-60.8003	-12.0196	CTD#79 stopped at 5434m and hauling
17/03/2019 10:21	97	-60.8002	-12.0195	CTD#79 going to 5400m
17/03/2019 10:12	97	-60.8003	-12.0196	CTD#79 in water
17/03/2019 09:38	97	-60.8	-12.0197	Gantry unlashed
17/03/2019 09:20	97	-60.7977	-12.0251	On DP
17/03/2019 03:48	96	-60.9929	-13.4665	Vessel off DP
17/03/2019 03:37	96	-60.9929	-13.4666	CTD#78 on deck
17/03/2019 02:08	96	-60.9932	-13.4664	CTD#78 returning to deck

17/03/2019 02:04	96	-60.9932	-13.4665	CTD#78 hauling
17/03/2019 02:00	96	-60.9931	-13.4665	CTD#78 veering
17/03/2019 01:57	96	-60.9932	-13.4664	CTD#78 fault at 4224m
17/03/2019 00:30	96	-60.9931	-13.4664	CTD#78 going to 5000m
17/03/2019 00:22	96	-60.9931	-13.4664	CTD#78 in the water
17/03/2019 00:20	96	-60.9931	-13.4664	CTD#78 in the air
16/03/2019 23:58	96			On DP
16/03/2019 23:03	96	-61.0169	-13.7443	Gantry unlashed
16/03/2019 15:54	95	-61.3264	-16.0856	Vessel off DP
16/03/2019 15:33	95	-61.3303	-16.081	CTD#77 on deck
16/03/2019 14:57	95	-61.3302	-16.0809	CTD#77 fault at 1848m. Returning to deck.
16/03/2019 14:24	95	-61.3301	-16.0805	CTD#77 at surface veering to 3700m. EA600 4527m
16/03/2019 14:19	95	-61.3301	-16.0805	CTD#77 in the water
16/03/2019 14:00	95	-61.3298	-16.0801	Vessel in DP for station CTD#77
16/03/2019 01:42	94	-61.832	-19.7946	Vessel off DP
16/03/2019 01:27	94	-61.8327	-19.797	CTD#75 on deck
16/03/2019 00:07	94	-61.8326	-19.7971	CTD#75 stopped at 3601M due to comms issue and hauling
15/03/2019 23:33	94	-61.8326	-19.797	CTD#75 stopped at 4451m and hauling
15/03/2019 22:00	94	-61.8327	-19.797	CTD#75 going to 4430m
15/03/2019 21:54	94	-61.8327	-19.7971	CTD#75 in water
15/03/2019 21:15	94	-61.8326	-19.7971	Gantry unlashed
15/03/2019 20:24	94	-61.8326	-19.7924	Vessel on DP
15/03/2019 16:10	93	-61.6313	-21.2836	Gantry lashed. Vessel off DP. Proceed to station CTD#74
15/03/2019 15:38	93	-61.6312	-21.2836	CTD problem identified. Beginning retermination
15/03/2019 13:57	93	-61.6312	-21.2836	CTD#73 recovered to deck
15/03/2019 12:35	93	-61.6312	-21.2836	Problem with CTD#73 stopped at 4340m and hauling
15/03/2019 11:22	93	-61.6312	-21.2837	CTD#73 going to 5000m
15/03/2019 11:18	93	-61.6311	-21.2837	CTD#73 in the water
15/03/2019 11:16	93	-61.6309	-21.2835	CTD#73 in the air
15/03/2019 11:08	93	-61.6302	-21.2832	Gantry unlashed
15/03/2019 11:06	93	-61.6306	-21.2831	On DP
15/03/2019 06:54	92	-61.4302	-22.7709	Gantry lashed
15/03/2019 06:54	92	-61.4302	-22.7709	Vessel out of DP
15/03/2019 06:48	92	-61.4302	-22.7709	CTD back in garage/ gantry stowed
15/03/2019 06:38	92	-61.4302	-22.7709	CTD #72 out of the water
15/03/2019 04:21	92	-61.4302	-22.7709	CTD#72 all stopped at 4582m
15/03/2019 02:43	92	-61.4302	-22.7708	CTD#72 at surface veering to ~4500m. EA600 at 4506m
15/03/2019 02:39	92	-61.4302	-22.7708	CTD#72 in the water
15/03/2019 02:18	92	-61.4301	-22.7705	Vessel in DP
14/03/2019 21:28	91	-61.2308	-24.261	Gantry lashed
14/03/2019 21:28	91	-61.2308	-24.2611	Off DP

14/03/2019 21:10	91	-61.2308	-24.261	CTD#71 on deck
14/03/2019 21:06	91	-61.2308	-24.2611	CTD#71 clear of water
14/03/2019 19:42	91	-61.2308	-24.261	CTD comms resumed at 2926m
14/03/2019 19:12	91	-61.2308	-24.261	CTD #71 comms fault- returning to deck
14/03/2019 19:00	91	-61.2308	-24.2609	CTD #71 stopped at 4272m
14/03/2019 17:40	91	-61.2308	-24.2611	CTD #71 deploying to 4250m
14/03/2019 17:36	91	-61.2308	-24.2611	CTD #71 in the water
14/03/2019 17:30	91	-61.2308	-24.2611	CTD #71 off dcek
14/03/2019 17:24	91	-61.2308	-24.2605	Gantry unlashed
14/03/2019 17:12	91	-61.2308	-24.2594	Vessel on DP
14/03/2019 12:50	90	-61.0142	-25.7473	Gantry lashed
14/03/2019 12:50	90	-61.0142	-25.7473	Off DP
14/03/2019 12:40	90	-61.0142	-25.7473	Gantry and CTD stowed
14/03/2019 12:37	90	-61.0142	-25.7474	CTD#70 clear of water
14/03/2019 11:00	90	-61.0148	-25.7464	CTD#70 stopped at 3526m and hauling
14/03/2019 10:00	90	-61.0148	-25.7464	CTD#70 going to 3500m
14/03/2019 09:56	90	-61.0148	-25.7464	CTD#70 in the water
14/03/2019 09:52	90	-61.0148	-25.7464	CTD#70 in the air
14/03/2019 09:45	90	-61.0148	-25.7463	Gantry unlashed
14/03/2019 06:15	89	-61.0148	-25.7464	Gantry lashed
14/03/2019 05:58	89	-61.0148	-25.7465	CTD in garage/ gantry stowed- fault finding
14/03/2019 05:46	89	-61.0148	-25.7464	CTD #70 on deck
14/03/2019 04:51	89	-61.0149	-25.7464	Comms lost with CTD#70 at 2615m. Returning to deck
14/03/2019 03:53	89	-61.0148	-25.7464	CTD#70 at surface veering to 3500m. EA600 at 3597m
14/03/2019 03:49	89	-61.0148	-25.7464	CTD#70 in the water
14/03/2019 03:24	89	-61.0044	-25.7632	Vessel on DP for station CTD#70
14/03/2019 01:00	88	-60.7513	-26.0921	End of swath
13/03/2019 17:21	88	-60.438	-24.779	Vessel out of DP- continue swath
13/03/2019 17:18	88	-60.4251	-24.9491	Gantry lashed
13/03/2019 17:15	88	-60.438	-24.779	CTD back in the garage/ gantry stowed
13/03/2019 17:06	88	-60.438	-24.779	CTD #69 out of the water
13/03/2019 15:00	88	-60.438	-24.779	CTD#69 stopped at 4822m
13/03/2019 13:35	88	-60.438	-24.7789	CTD#69 at surface veering to 4800m. EA600 at 4898m
13/03/2019 13:32	88	-60.438	-24.7789	CTD#69 in the water
13/03/2019 13:18	88	-60.4381	-24.7784	Vessel on station in DP
13/03/2019 12:16	87	-60.5563	-24.6715	Gantry lashed
13/03/2019 12:16	87	-60.5563	-24.6715	Off DP
13/03/2019 12:06	87	-60.5563	-24.6715	CTD#68 on deck
13/03/2019 10:10	87	-60.5563	-24.6714	CTD#68 stopped at 4040m and hauling
13/03/2019 08:58	87	-60.5563	-24.6715	CTD #68 deploying to 4000m
13/03/2019 08:54	87	-60.5563	-24.6715	CTD #68 in the water
13/03/2019 08:42	87	-60.5563	-24.6715	CTD #68 issue resolved
13/03/2019 08:42	87	-60.5563	-24.6715	Gantry unlashed

13/03/2019 08:12	87	-60.5564	-24.6721	Vessel on DP for CTD #68
13/03/2019 02:00	86	-60.4832	-24.7622	Swathing suspended due to heavy weather. Hove to
13/03/2019 00:40	86	-60.4385	-24.7794	Vessel off DP
13/03/2019 00:18	86	-60.4383	-24.7798	Gantry and CTD stowed
13/03/2019 00:12	86	-60.4383	-24.7799	CTD#67 on deck
12/03/2019 22:50		-60.4383	-24.7798	Contact lost with CTD#67 hauling all the way in
12/03/2019 22:12	86	-60.4383	-24.7798	CTD#67 stopped at 4833m and hauling
12/03/2019 20:28	86	-60.4383	-24.7798	CTD #67 deploying to 4860m
12/03/2019 20:22	86	-60.4383	-24.7798	CTD #67 in the water
12/03/2019 19:54	86	-60.4383	-24.7798	Gantry unlashed
12/03/2019 19:42	86	-60.438	-24.7797	Vessel on DP at CTD #67
12/03/2019 17:30	85	-60.2214	-25.1325	Gantry lashed
12/03/2019 17:30	85	-60.2214	-25.1325	Vessel out of DP
12/03/2019 17:24	85	-60.2215	-25.1325	CTD back in garage/ gantry stowed
12/03/2019 17:16	85	-60.2215	-25.1326	CTD #66 out of the water
12/03/2019 14:26	85	-60.2213	-25.1323	CTD#66 stopped at 5912m
12/03/2019 12:32	85	-60.2213	-25.1323	CTD#66 going to 5950m
12/03/2019 12:27	85	-60.2213	-25.1324	CTD#66 in the water
12/03/2019 12:25	85	-60.2213	-25.1324	CTD#66 in the air
12/03/2019 12:12	85	-60.2212	-25.1318	On DP
12/03/2019 11:30	84	-60.1765	-25.2286	Off DP
12/03/2019 11:26	84	-60.177	-25.2305	Gantry lashed
12/03/2019 11:12	84	-60.1769	-25.2305	CTD#65 on deck
12/03/2019 09:02	84	-60.1769	-25.2305	CTD#65 stopped at 5040m and hauling
12/03/2019 07:24	84	-60.1769	-25.2305	CTD #65 deploying to 5000m
12/03/2019 07:21	84	-60.1769	-25.2304	CTD #65 in the water
12/03/2019 07:06	84	-60.1769	-25.2305	Gantry unlashed
12/03/2019 07:00	84	-60.1769	-25.2305	Vessel on DP at CTD #65
12/03/2019 06:00	83	-60.1116	-25.3121	Vessel out of DP
12/03/2019 05:58	83	-60.1116	-25.3121	Gantry lashed
12/03/2019 05:42	83	-60.1116	-25.3121	CTD back in garage/ gantry stowed
12/03/2019 05:34	83	-60.1117	-25.3121	CTD #64 out of the water
12/03/2019 03:36	83	-60.1116	-25.3121	CTD#64 stopped at 3961m
12/03/2019 02:24	83	-60.1115	-25.3121	CTD#64 at surface veering to 3950m. EA600 at 4838m.
12/03/2019 02:21	83	-60.1116	-25.312	CTD#64 in the water
12/03/2019 02:00	83	-60.1121	-25.3119	Vessel on DP
12/03/2019 00:24	82	-59.9576	-25.4919	Off DP
12/03/2019 00:20	82	-59.9576	-25.4918	Gantry lashed
12/03/2019 00:00	82	-59.9577	-25.4918	Gantry and CTD stowed
11/03/2019 23:55	82	-59.9577	-25.4918	CTD#63 on deck
11/03/2019 22:10	82	-59.9577	-25.4918	CTD#63 stopped at 3028m and hauling
11/03/2019 21:12	82	-59.9577	-25.4918	CTD #63 deploying to 3000m
11/03/2019 21:10	82	-59.9577	-25.4918	CTD #63 in the water

11/03/2019 20:48	81	-59.9577	-25.4918	Suspend swath survey for CTD deployment
11/03/2019 20:48	82	-59.9577	-25.4918	Vessel on DP at CTD #63
10/03/2019 19:15	81	-60.6872	-26.2788	Commenced swath survey of trench
10/03/2019 16:12	80	-60.827	-27.233	Vessel off DP
10/03/2019 16:07	80	-60.8269	-27.23	Crane stowed
10/03/2019 16:04	80	-60.8268	-27.229	Apex Argo #12884 released
10/03/2019 15:54	79	-60.8268	-27.2284	Drone flight abandoned due to calibration issues
10/03/2019 15:33	78	-60.8268	-27.2283	CTD#62 on deck
10/03/2019 13:46	78	-60.8268	-27.2283	CTD stopped at 3865m and hauling
10/03/2019 12:38	78	-60.8268	-27.2283	CTD#62 going to 3800m
10/03/2019 12:34	78	-60.8268	-27.2283	CTD#62 in the water
10/03/2019 12:30	78	-60.8268	-27.2283	CTD#62 in the air
10/03/2019 11:15	78	-60.8261	-27.2304	On DP
10/03/2019 10:30	77	-60.7995	-27.4279	Off DP
10/03/2019 10:22	77	-60.7972	-27.4256	CTD#61 and gantry lashed
10/03/2019 10:14	77	-60.7972	-27.4256	CTD#61 on deck
10/03/2019 10:12	77	-60.7972	-27.4256	CTD#61 in the air
10/03/2019 08:54	77	-60.7972	-27.4256	CTD #61 stopped at 3283m
10/03/2019 08:00	77	-60.7972	-27.4256	CTD #61 deploying to 3200m
10/03/2019 07:56	77	-60.7972	-27.4256	CTD #61 in the water
10/03/2019 07:48	77	-60.7969	-27.4256	Gantry Unlashed
10/03/2019 07:42	77	-60.797	-27.4225	Vessel on DP at CTD #61
10/03/2019 04:54	76			Gantry lashed
10/03/2019 04:47	76	-60.6856	-28.2634	CTD#60 on deck
10/03/2019 03:45	76	-60.6856	-28.2633	CTD#60 stopped at 2139m
10/03/2019 03:11	76	-60.6855	-28.2633	CTD#60 at surface veering to about 2100m. EA600 at 2279m
10/03/2019 03:07	76	-60.6855	-28.2634	CTD#60 in the water
10/03/2019 02:58	76	-60.6853	-28.263	Gantry unlashed
10/03/2019 02:54	76	-60.6858	-28.2628	Vessel in DP
09/03/2019 22:00	75	-60.4688	-29.7362	Gantry lashed
09/03/2019 22:00	75	-60.4675	-29.735	Vessel off DP
09/03/2019 21:56	75	-60.4688	-29.7363	CTD back in garage/ gantry stowed
09/03/2019 21:52	75	-60.4688	-29.7362	CTD #59 out of the water
09/03/2019 20:54	75	-60.4688	-29.7362	CTD #59 stopped at 1880m
09/03/2019 20:24	75	-60.4688	-29.7362	CTD #59 deploying to 1850m
09/03/2019 20:18	75	-60.4688	-29.7362	CTD #59 in the water
09/03/2019 20:06	75	-60.4686	-29.735	Gantry Unlashed
09/03/2019 20:00	75	-60.4675	-29.735	Vessel on DP at CTD #59
09/03/2019 16:18	74	-60.3203	-30.9632	Vessel off DP
09/03/2019 16:14	74	-60.3198	-30.9616	APEX #12786 released at 0.8kts
09/03/2019 15:56	73	-60.3196	-30.9609	CTD#58 on deck
09/03/2019 14:37	73	-60.3196	-30.9609	CTD#58 at depth 2275m
09/03/2019 13:50	73	-60.3196	-30.9609	CTD#58 going to 2300m
09/03/2019 13:47	73	-60.3196	-30.9609	CTD#58 in water

09/03/2019 13:42	73	-60.3194	-30.9605	CTD#58 in the air
09/03/2019 13:36	73	-60.3192	-30.9599	Gantry unlashed
09/03/2019 13:30	73	-60.3155	-30.957	On DP
09/03/2019 10:54	72	-59.9693	-31.4796	Off DP
09/03/2019 10:52	72	-59.9693	-31.4795	Gantry lashed
09/03/2019 10:47	72	-59.9693	-31.4796	CTD#57 and gantry stowed
09/03/2019 10:45	72	-59.9693	-31.4796	CTD#57 on deck
09/03/2019 09:42	72	-59.9693	-31.4797	CTD #57 stopped at 2071m
09/03/2019 09:06	72	-59.9693	-31.4797	CTD #57 deploying to 2050m
09/03/2019 09:00	72	-59.9693	-31.4797	CTD #57 in the water
09/03/2019 08:52	72	-59.9693	-31.4796	Gantry Unlashed
09/03/2019 08:48	72	-59.9692	-31.4795	Vessel on DP at CTD #57
09/03/2019 06:06	71	-59.94	-32.2411	Gantry lashed
09/03/2019 06:06	71	-59.94	-32.2411	Vessel out of DP
09/03/2019 06:00	71	-59.94	-32.2411	Gantry stowed/ CTD back in garage
09/03/2019 05:54	71	-59.94	-32.2411	CTD #56 out of the water
09/03/2019 05:15	71	-59.94	-32.2412	CTD#56 stopped at 966m
09/03/2019 04:55	71	-59.9398	-32.2404	CTD#56 at surface veering to 970m. EA600 at 1011m
09/03/2019 04:52	71	-59.9398	-32.2404	CTD#56 in the water
09/03/2019 04:38	71	-59.9394	-32.2347	Vessel in DP for CTD#56
09/03/2019 02:48	70	-59.8993	-32.7307	Vessel off DP
09/03/2019 02:37	70	-59.9003	-32.7309	CTD#55 on deck
09/03/2019 01:52	70	-59.9004	-32.7309	CTD#55 stopped at 1054m and hauling
09/03/2019 01:36	70	-59.9003	-32.7309	CTD#55 going to 1050m
09/03/2019 01:30	70	-59.9004	-32.7309	CTD#55 in water
09/03/2019 01:12	70	-59.9002	-32.7306	Gantry unlashed
09/03/2019 01:06	70	-59.8999	-32.7303	On DP
09/03/2019 00:32	69	-59.9001	-32.8082	Off DP
09/03/2019 00:30	69	-59.9004	-32.7309	Gantry lashed
09/03/2019 00:24	69	-59.9001	-32.8082	CTD#54 back on deck.
08/03/2019 23:26	69	-59.9	-32.8081	CTD#54 stopped at 1463m and hauling
08/03/2019 23:02	69	-59.9001	-32.8082	CTD#54 GOING TO 1470M
08/03/2019 22:54	69	-59.9001	-32.8081	CTD#54 in water
08/03/2019 22:49	69	-59.9001	-32.8082	Gantry unlashed
08/03/2019 22:36	69	-59.9	-32.8079	On DP
08/03/2019 22:00	68	-59.8903	-32.8597	Vessel out of DP
08/03/2019 21:00	68	-59.8903	-32.8597	Gantry Lashed
08/03/2019 20:50	68	-59.8903	-32.8597	CTD #53 out of the water
08/03/2019 20:48	68	-59.8903	-32.8597	CTD #53 all stopped at 2083m
08/03/2019 20:15	68	-59.8903	-32.8597	CTD #53 deploying to 2070
08/03/2019 20:08	68	-59.8902	-32.8596	CTD #53 in the water
08/03/2019 19:52	68	-59.8902	-32.8597	Gantry Unlashed
08/03/2019 19:24	68	-59.8914	-32.8582	Vessel on DP at CTD #53
08/03/2019 18:54	67	-59.8812	-32.952	Vessel off DP

08/03/2019 18:48	67	-59.8803	-32.9501	Gantry Lashed
08/03/2019 18:44	67	-59.8801	-32.9498	CTD in garage/ gantry stowed
08/03/2019 18:40	67	-59.8801	-32.9497	CTD #52 out of the water
08/03/2019 17:23	67	-59.8801	-32.9497	CTD#52 stopped at 2885m
08/03/2019 16:34	67	-59.8801	-32.9497	CTD#52 at surface veering to 2850m. EA600 at 2954m.
08/03/2019 16:30	67	-59.8801	-32.9497	CTD#52 in the water
08/03/2019 16:14	67	-59.8793	-32.9504	Vessel on DP
08/03/2019 15:36	66	-59.8583	-33.0713	Off DP
08/03/2019 15:31	66	-59.8585	-33.0713	CTD#51 on deck
08/03/2019 14:21	66	-59.8603	-33.0709	CTD#51 stopped at 2475m
08/03/2019 13:40	66	-59.8603	-33.0709	CTD#51 going to 2400m
08/03/2019 13:36	66	-59.8603	-33.0709	CTD#51 in water
08/03/2019 13:26	66	-59.86	-33.0711	Gantry unlashed
08/03/2019 13:18	66	-59.8611	-33.0725	On DP
08/03/2019 12:50	65	-59.8603	-33.0709	Off DP
08/03/2019 12:45	65	-59.8601	-33.1597	Gantry lashed
08/03/2019 12:37	65	-59.8601	-33.1598	CTD#50 on deck
08/03/2019 11:36	65	-59.8601	-33.1598	CTD#50 stopped at 2057m and hauling
08/03/2019 11:00	65	-59.8601	-33.1598	CTD#50 going to 2000m
08/03/2019 10:57	65	-59.8601	-33.1598	CTD#50 in water
08/03/2019 10:54	65	-59.8601	-33.1598	CTD#50 in the air
08/03/2019 10:48	65	-59.8599	-33.1589	Gantry unlashed
08/03/2019 10:42	65	-59.8622	-33.1582	On DP
08/03/2019 10:03	64	-59.8487	-33.2789	Gantry lashed
08/03/2019 10:03	64	-59.849	-33.2786	Vessel out of DP
08/03/2019 10:00	64	-59.849	-33.2786	CTD in garage and gantry stowed
08/03/2019 09:54	64	-59.8489	-33.2786	CTD #49 out of the water
08/03/2019 09:08	64	-59.849	-33.2787	CTD #49 stopped at 1599m
08/03/2019 08:40	64	-59.849	-33.2787	CTD #49 deploying to 1600m
08/03/2019 08:36	64	-59.849	-33.2786	CTD #49 in the water
08/03/2019 08:27	64	-59.849	-33.2785	Gantry unlashed
08/03/2019 08:24	64	-59.8489	-33.2783	Vessel on DP at CTD #49
08/03/2019 05:54	63	-59.9302	-33.8499	Vessel off DP
08/03/2019 05:48	63	-59.9302	-33.8498	CTD#48 on deck
08/03/2019 05:12		-59.9302	-33.8498	Vessel off DP
08/03/2019 05:04	63	-59.9302	-33.8499	CTD#48 stopped at 1257m
08/03/2019 04:43	63	-59.9302	-33.8498	CTD#48 at surface veering to 1200m. EA600m at 1301m
08/03/2019 04:40	63	-59.9302	-33.8499	CTD#48 in the water
08/03/2019 04:18	63	-59.9306	-33.8465	Vessel on DP for CTD#48
08/03/2019 02:00	62	-60.0304	-34.4718	Off DP
08/03/2019 01:57	62	-60.0304	-34.4718	Gantry lashed
08/03/2019 01:51	62	-60.0304	-34.4718	CTD#47 on deck
08/03/2019 01:12	62	-60.0304	-34.4718	CTD#47 stopped at 992m and hauling

08/03/2019 00:55	62	-60.0304	-34.4719	CTD#47 going to 980m
08/03/2019 00:50	62	-60.0304	-34.4718	CTD#47 in water
08/03/2019 00:36	62	-60.0319	-34.4688	On DP
08/03/2019 00:30	62	-60.0369	-34.4809	Gantry unlashed
07/03/2019 23:01	61	-60.1391	-34.8907	Off DP
07/03/2019 22:58	61	-60.1394	-34.8906	Gantry lashed
07/03/2019 22:50	61	-60.1394	-34.8906	CTD#46 on deck
07/03/2019 22:26	61	-60.1394	-34.8906	CTD#46 stopped at 364m and hauling
07/03/2019 22:12	61	-60.1388	-34.8903	CTD#46 in the water
07/03/2019 21:56	61	-60.1376	-34.8901	Gantry unlashed
07/03/2019 21:48	61	-60.1373	-34.8902	Vessel on DP at CTD #46
07/03/2019 18:00	60	-60.7325	-34.7734	End of swath survey
07/03/2019 12:00	60	-60.6732	-34.8754	Start swath survey of uncharted shallow
07/03/2019 10:18	51	-60.4398	-35.2611	CTD#46 going to 360m
07/03/2019 09:06	59	-60.3031	-35.4757	Gantry lashed
07/03/2019 09:06	59	-60.3031	-35.4757	Vessel off DP
07/03/2019 09:02	59	-60.3031	-35.4757	CTD back in garage/ gantry stowed
07/03/2019 08:56	59	-60.3031	-35.4757	CTD #45 out of the water
07/03/2019 08:12	59	-60.3031	-35.4757	CTD #45 stopped at 1592m
07/03/2019 07:42	59	-60.3031	-35.4756	CTD #45 deploying to 1600m
07/03/2019 07:40	59	-60.3031	-35.4757	CTD #45 in the water
07/03/2019 07:32	59	-60.3031	-35.4756	GPS reference systems stable in DP- resume operation of CTD #45
07/03/2019 07:22	59	-60.3032	-35.4757	GPS Dropout on DP- UIC informed
07/03/2019 07:18	59	-60.3045	-35.4717	Gantry unlashed
07/03/2019 07:12	59	-60.3045	-35.4717	Vessel on DP at CTD #45
07/03/2019 02:42	58	-60.3789	-36.4013	Vessel off DP
07/03/2019 02:34	58	-60.3789	-36.4013	CTD#44 on deck
07/03/2019 01:41	58	-60.3789	-36.4013	CTD#44 stopped at 1863m
07/03/2019 01:12	58	-60.3789	-36.4013	CTD#44 going to 1860m
07/03/2019 01:06	58	-60.3788	-36.4012	CTD#44 in the water
07/03/2019 01:03	58	-60.3789	-36.4012	CTD#44 in the air
07/03/2019 00:52	58	-60.3788	-36.4008	Gantry unlashed
07/03/2019 00:48	58	-60.3789	-36.4	On DP
06/03/2019 20:42	57	-60.4602	-37.3687	Gantry lashed
06/03/2019 20:42	57	-60.4602	-37.3687	Vessel out of DP
06/03/2019 20:36	57	-60.4603	-37.3688	CTD Gantry stowed
06/03/2019 20:30	57	-60.4603	-37.3688	CTD #43 out of the water
06/03/2019 18:52	57	-60.4602	-37.3687	CTD #43 deploying to 1800m
06/03/2019 18:46	57	-60.4603	-37.3687	CTD #43 in the water
06/03/2019 18:32	57	-60.4606	-37.3684	Gantry Unlashed
06/03/2019 18:30	57	-60.4615	-37.3671	Vessel on DP at CTD #43

06/03/2019 16:00	56	-60.44	-38.0003	Gantry secure
06/03/2019 15:49	56	-60.4402	-38.0002	CTD on deck
06/03/2019 14:31	56	-60.4402	-38.0001	CTD#42 stopped at 2921m
06/03/2019 13:42	56	-60.4402	-37.9998	CTD#42 going to 2850m
06/03/2019 13:36	56	-60.4403	-37.9991	CTD#42 in water
06/03/2019 13:30	56	-60.441	-37.9976	Vessel on DP
06/03/2019 13:25	56	-60.4443	-37.9927	Gantry unlashed
06/03/2019 10:12	55	-60.4193	-38.7096	out of DP
06/03/2019 10:08	55	-60.4192	-38.7096	Gantry / CTD#41 stowed
06/03/2019 10:06	55	-60.4192	-38.7097	CTD#41 on deck
06/03/2019 10:03	55	-60.4192	-38.7096	CTD#41 out of water
06/03/2019 08:54	55	-60.4193	-38.7096	CTD #41 stopped at 2548m
06/03/2019 08:12	55	-60.4193	-38.7096	CTD #41 deploying to 2500m
06/03/2019 08:06	55	-60.4193	-38.7096	CTD #41 in the water
06/03/2019 07:54	55	-60.4193	-38.7097	Gantry unlashed
06/03/2019 07:42	55	-60.4193	-38.7096	Vessel on DP at CTD #41
06/03/2019 05:00	54	-60.4101	-39.1196	Finished sampling. Off DP
06/03/2019 04:23		-60.4101	-39.1196	Gantry lashed
06/03/2019 04:15	54	-60.41	-39.1196	CTD#40 on deck
06/03/2019 03:12	54	-60.4101	-39.1196	CTD#40 stopped at 2140m
06/03/2019 02:36	54	-60.41	-39.1197	CTD#40 going to 2120m
06/03/2019 02:33	54	-60.41	-39.1197	CTD#40 in water
06/03/2019 02:30	54	-60.41	-39.1196	CTD#40 in the air
06/03/2019 02:07	54	-60.4093	-39.1204	On DP
06/03/2019 00:57	53	-60.4099	-39.3002	Off DP
06/03/2019 00:49	53	-60.4099	-39.3001	CTD#39 and gantry lashed
06/03/2019 00:46	53	-60.4099	-39.3001	CTD#39 on deck
05/03/2019 23:57	53	-60.4099	-39.3001	CTD#39 stopped at 1465m and hauling
05/03/2019 23:36	53	-60.4099	-39.3001	CTD#39 going to 1450m
05/03/2019 23:29	53	-60.4099	-39.3002	CTD#39 in the water
05/03/2019 23:27	53	-60.4099	-39.3001	CTD#39 in the air
05/03/2019 23:06	53	-60.4104	-39.3012	On DP
05/03/2019 19:18	52	-60.4291	-40.0703	Vessel out of DP
05/03/2019 19:12	52	-60.4297	-40.0699	Gantry lashed
05/03/2019 19:06	52	-60.4297	-40.0699	CTD Gantry stowed/ CTD in garage
05/03/2019 19:00	52	-60.4297	-40.0699	CTD #38 out of the water
05/03/2019 18:12	52	-60.4288	-40.0701	CTD #38 stopped at 1418m
05/03/2019 17:47	52	-60.4288	-40.0698	CTD #38 at surface veering to 1350m. EA600 4700m
05/03/2019 17:45	52	-60.4289	-40.0697	CTD in the water

05/03/2019 17:30	52	-60.4303	-40.0702	On DP. Assessing ice conditions. Move ahead 200m to clear ice.
05/03/2019 13:55	51	-60.47	-40.9801	Off DP
05/03/2019 13:52	51	-60.4699	-40.9802	Gantry and CTD#36 lashed
05/03/2019 13:48	51	-60.4699	-40.9801	CTD#37 on deck
05/03/2019 12:54	51	-60.4699	-40.9801	CTD#37 stopped at 1437m and hauling
05/03/2019 12:32	51	-60.4702	-40.9805	CTD#37 going to 1350m
05/03/2019 12:30	51	-60.4703	-40.9807	CTD#37 in water
05/03/2019 12:22	51	-60.4707	-40.9811	Gantry unlashed
05/03/2019 12:18	51	-60.4707	-40.9813	Vessel on DP
05/03/2019 10:48	50	-60.5296	-41.3774	Gantry lashed
05/03/2019 10:48	50	-60.5296	-41.3774	Vessel out of DP
05/03/2019 10:42	50	-60.5296	-41.3775	CTD gantry stowed/ CTD in garage
05/03/2019 10:38	50	-60.5295	-41.3774	CTD #36 out of the water
05/03/2019 09:46	50	-60.5296	-41.3775	CTD #36 stopped at 1921m
05/03/2019 09:13	50	-60.5296	-41.3775	CTD #36 deploying to 1900m
05/03/2019 09:10	50	-60.5296	-41.3775	CTD #36 in the water
05/03/2019 09:00	50	-60.5296	-41.3774	Gantry unlashed
05/03/2019 08:54	50	-60.5301	-41.3777	Vessel on DP at CTD #36
05/03/2019 07:48		-60.5684	-41.6883	Vessel off DP
05/03/2019 07:33	49	-60.5699	-41.6913	CTD #35 out of the water
05/03/2019 06:31	49	-60.57	-41.6913	CTD #35 stopped at 2434m
05/03/2019 05:51	49	-60.57	-41.6913	CTD #35 at surface veering to 2400m. EA600 at 2764m.
05/03/2019 05:49	49	-60.57	-41.6913	CTD #35 in the water
05/03/2019 05:36	49	-60.5698	-41.6909	Vessel in DP. Gantry unlashed
05/03/2019 04:54	48	-60.6043	-41.834	Gantry lashed
05/03/2019 04:43	48	-60.6043	-41.8339	CTD #34 on deck
05/03/2019 03:29	48	-60.6043	-41.8339	CTD#34 stopped at 2950m
05/03/2019 02:52	48	-60.6043	-41.8338	CTD#34 going to 2940
05/03/2019 02:38	48	-60.6047	-41.8325	CTD#34 in water
05/03/2019 02:15	48	-60.6059	-41.8303	On DP
05/03/2019 02:10	48	-60.6043	-41.8338	Gantry unlashed
05/03/2019 01:20	47	-60.6214	-41.9879	Off DP
05/03/2019 01:16	47	-60.6206	-41.9882	Gantry lashed
05/03/2019 01:10	37	-60.6206	-41.9882	CTD#33 on deck
04/03/2019 23:45	47	-60.6206	-41.9882	CTD#33 at 3393m and hauling
04/03/2019 22:50	47	-60.6206	-41.9882	CTD #33 deploying to 3370m
04/03/2019 22:48	47	-60.6206	-41.9882	CTD #33 in the water
04/03/2019 22:46	47	-60.6206	-41.9883	CTD #33 off deck
04/03/2019 22:32	47	-60.6206	-41.9881	Gantry unlashed
04/03/2019 22:28	47	-60.6207	-41.988	Vessel on DP for CTD #33
04/03/2019 21:54	46	-60.6403	-42.1025	Gantry Lashed
04/03/2019 21:54	46	-60.6403	-42.1025	Vessel out of DP
04/03/2019 21:50	46	-60.6206	-41.9882	CTD Gantry stowed/CTD back in the annex

04/03/2019 21:45	46	-60.6402	-42.1025	CTD #32 out of the water
04/03/2019 20:10	46	-60.6403	-42.1025	CTD #32 stopped at 3644m
04/03/2019 19:09	46	-60.6402	-42.1025	CTD #32 deploying to 3590m
04/03/2019 19:06	46	-60.6402	-42.1025	CTD #32 in the water
04/03/2019 19:03	46	-60.6402	-42.1025	CTD #32 off deck
04/03/2019 19:00	46	-60.6402	-42.1025	CTD Gantry unstowed
04/03/2019 18:15	46	-60.6407	-42.1021	Vessel on DP.
04/03/2019 17:54	45	-60.6501	-42.1532	Vessel off DP
04/03/2019 17:53	45	-60.6504	-42.1529	ARVAR Deep #FR003 released at 1.0kt
04/03/2019 17:48	44	-60.6512	-42.1516	ARVAR Deep #FR002 released at 0.8kts
04/03/2019 17:43	43	-60.6521	-42.1504	Socomm float #12752 released at 0.5kts
04/03/2019 17:26	42	-60.6523	-42.1501	CTD #31 on deck
04/03/2019 16:00	42	-60.6523	-42.1501	CTD #31 stopped at 3115m
04/03/2019 15:09	42	-60.6523	-42.1502	CTD #31 at the surface veering to 3100m. EA600 at 3099m (multibeam at 3133m)
04/03/2019 15:05	42	-60.6523	-42.1501	CTD #31 in the water
04/03/2019 14:20	42	-60.6534	-42.1474	On DP
04/03/2019 14:03	41	-60.6558	-42.1745	Off DP
04/03/2019 13:56	41	-60.6562	-42.176	CTD and gantry stowed
04/03/2019 13:54	41	-60.6528	-42.1484	CTD#30 on deck
04/03/2019 12:42	41	-60.6561	-42.176	CTD#30 stopped at 2536M and hauling
04/03/2019 11:58	41	-60.6562	-42.176	CTD#30 going to 2400m
04/03/2019 11:54	41	-60.6561	-42.176	CTD#30 IN the water
04/03/2019 11:52	41	-60.6562	-42.1759	CTD#30 in air
04/03/2019 11:25	41	-60.6569	-42.1721	Vessel on DP
04/03/2019 11:06	40	-60.6571	-42.1971	CTD Gantry stowed and CTD trolley lashed
04/03/2019 11:06	40	-60.6571	-42.1971	Vessel out of DP
04/03/2019 11:02	40	-60.657	-42.1971	CTD #29 on deck
04/03/2019 11:00	40	-60.657	-42.1971	CTD #29 out of the water
04/03/2019 09:56	40	-60.657	-42.1971	CTD stopped at 2044m
04/03/2019 09:22	40	-60.6601	-42.3099	CTD #29 deploying to 2000m
04/03/2019 09:18	40	-60.657	-42.1971	CTD #29 in the water
04/03/2019 09:12	40	-60.657	-42.1971	CTD Gantry Unlashed
04/03/2019 09:00	40	-60.6572	-42.1969	Vessel on DP for CTD #29
04/03/2019 08:24	39	-60.6601	-42.3099	Vessel off DP
04/03/2019 08:18	39	-60.6601	-42.3099	CTD Gantry stowed
04/03/2019 08:12	39	-60.6601	-42.3099	CTD #28 out of the water
04/03/2019 07:17	39	-60.6601	-42.3099	CTD #28 stopped at 1647m
04/03/2019 06:52	39	-60.6601	-42.3099	Continuing veering
04/03/2019 06:48	39	-60.6601	-42.3099	CTD stopped at 111m. Investigating vibration in compensator in winch room.
04/03/2019 06:44	39	-60.6601	-42.3099	CTD #28 at surface veering to 1600m. EA600 at 1655.
04/03/2019 06:40	39	-60.6601	-42.3099	CTD #28 in the water

04/03/2019 06:30	39	-60.6601	-42.3099	CTD #28 over the bulwark. Aborted and returned to deck due to fault.
04/03/2019 06:15	39	-60.6601	-42.3099	Gantry unlashed
04/03/2019 06:06	39	-60.6606	-42.308	Vessel in DP
04/03/2019 05:36	38	-60.6801	-42.3902	Gantry lashed
04/03/2019 05:31	38	-60.6801	-42.3902	Gantry stowed and CTD in water bottle annex
04/03/2019 05:27	38	-60.6801	-42.3901	CTD #27 on deck
04/03/2019 04:48	38	-60.6801	-42.3902	CTD #27 stopped at 999m
04/03/2019 04:29	38	-60.6801	-42.3902	CTD #27 at surface veering to 1000m. EA600 at 1007m
04/03/2019 04:28	38	-60.6801	-42.3902	CTD #27 in the water
04/03/2019 04:19	38	-60.6801	-42.3891	Gantry unlashed
04/03/2019 04:18	38	-60.6802	-42.388	Vessel on DP
04/03/2019 02:50	37	-60.74	-42.7897	Vessel off DP
04/03/2019 02:48	37	-60.74	-42.7898	Gantry lashed
04/03/2019 02:38	37	-60.7401	-42.7899	CTD#26 on deck
04/03/2019 02:00	37	-60.7401	-42.7899	CTD#26 stopped at 1305m and hauling
04/03/2019 01:42	37	-60.7401	-42.7899	CTD#26 going to 1300m
04/03/2019 01:37	37	-60.7401	-42.7899	CTD#26 in water
04/03/2019 01:36	37	-60.7401	-42.7899	CTD#26 in the air
04/03/2019 01:28	37	-60.741	-42.7862	Gantry unlashed
04/03/2019 01:20	37	-60.7457	-42.8038	Vessel on DP
04/03/2019 00:45	36	-60.7596	-42.9599	Vessel off DP
04/03/2019 00:34	36	-60.7596	-42.9596	CTD#25 in air
04/03/2019 00:12	36	-60.7597	-42.9597	CTD#25 stopped at 490m and hauling
04/03/2019 00:06	36	-60.7596	-42.9596	CTD#25 going to 480m
04/03/2019 00:02	36	-60.7596	-42.9597	CTD#25 in the water
04/03/2019 00:00	36	-60.7597	-42.9597	Gantry unlashed
03/03/2019 23:54	36	-60.7591	-42.9562	Vessel on DP
03/03/2019 20:42	35	-60.9196	-43.9987	CTD Gantry lashed
03/03/2019 20:42	35	-60.9196	-43.9987	Vessel out of DP
03/03/2019 20:33	35	-60.9196	-43.9988	CTD #24 out of the water
03/03/2019 20:14	35	-60.9196	-43.9988	CDT #24 stopped at 242m
03/03/2019 20:08	35	-60.9195	-43.9987	CTD #24 deploying to 240m
03/03/2019 20:05	35	-60.9195	-43.9987	CTD #24 in the water
03/03/2019 20:00	35	-60.9203	-43.9976	Vessel on DP at CTD #24
03/03/2019 20:00	35	-60.9203	-43.9976	Gantry Unlashed
03/03/2019 16:22	34	-60.6888	-45.132	Drone lands on after deck
03/03/2019 16:10	34	-60.6566	-45.1321	Drone takes off from after deck
03/03/2019 16:05	34	-60.6443	-45.1315	Drone lands on after deck
03/03/2019 15:52	34	-60.6157	-45.129	Drone takes off from after deck
03/03/2019 10:42	33	-60.3539	-46.7678	Vessel out of DP
03/03/2019 10:36	33	-60.354	-46.768	CTD Gantry Lashed
03/03/2019 10:28	33	-60.354	-46.768	CTD #23 Out of the Water
03/03/2019 09:56	33	-60.3541	-46.768	CTD #23 stopped at 604m

03/03/2019 09:43	33	-60.3541	-46.768	CTD deploying to 550m
03/03/2019 09:40	33	-60.3541	-46.768	CTD #23 in the water
03/03/2019 09:30	33	-60.3544	-46.768	Vessel on DP at CTD #23
03/03/2019 09:24	33	-60.358	-46.7696	CTD Gantry Unlashed
03/03/2019 07:18	32	-60.1476	-47.3349	Vessel off DP
03/03/2019 07:03	32	-60.1476	-47.3349	CTD #22 Out of the Water
03/03/2019 06:29	32	-60.1476	-47.3349	CTD #22 stopped at 1001m
03/03/2019 06:11	32	-60.1476	-47.3349	CTD #22 at surface veering to 1000m. EA600 at 1029m
03/03/2019 06:07	32	-60.1476	-47.3349	CTD #22 in the water
03/03/2019 05:57	32	-60.1474	-47.3347	Vessel in DP
03/03/2019 04:33	31	-60.1268	-47.6947	Gantry secure
03/03/2019 04:29	31	-60.1267	-47.6946	CTD #21 landed on deck
03/03/2019 04:27	31	-60.1267	-47.6946	CTD #21 out of the water
03/03/2019 03:34	31	-60.1268	-47.6946	CTD #21 stopped at 2007m
03/03/2019 03:00	31	-60.1268	-47.6946	CTD #21 at surface veering to 2000m. EA600 at 2040m.
03/03/2019 02:59	31	-60.1268	-47.6946	CTD #21 in the water
03/03/2019 02:35	31	-60.1243	-47.6983	On DP
03/03/2019 01:12	30	-60.1481	-48.1266	Off Dp
03/03/2019 01:05	30	-60.1481	-48.1246	Soccon float deployed
03/03/2019 00:46	30	-60.1482	-48.1243	CTD#20 and gantry lashed
03/03/2019 00:38	30	-60.1481	-48.1243	CTD#20 landed on deck
03/03/2019 00:36	30	-60.1481	-48.1243	CTD#20 clear of water
02/03/2019 23:26	30	-60.1481	-48.1243	CTD#20 at 2767m and hauling
02/03/2019 22:42	30	-60.1481	-48.1243	CTD # 20 deploying to 2760m EA600 displaying 2819m
02/03/2019 22:38	30	-60.1481	-48.1243	CTD #20 in the water
02/03/2019 22:28	30	-60.1482	-48.1242	CTD Gantry Unlashed
02/03/2019 22:24	30	-60.1493	-48.1242	Vessel on DP for CTD #20
02/03/2019 20:52	28	-60.1457	-48.2769	CTD #19 stopped at 1907m
02/03/2019 20:20	28	-60.1457	-48.2768	CTD #19 deploying to 1900m- EA600 displaying 2049m
02/03/2019 20:16	28	-60.1457	-48.2768	CTD #19 in the water
02/03/2019 20:12	28	-60.1457	-48.2769	CTD #19 off deck for redeployment
02/03/2019 20:10	28	-60.1457	-48.2769	CTD electrical cable reterminated- issue resolved
02/03/2019 18:24	28	-60.1457	-48.2768	CTD moved into watter bottle annex. Gantry stowed. Problem being investigated
02/03/2019 18:21	28	-60.1457	-48.2768	CTD #19A landed on deck
02/03/2019 17:59	28	-60.1457	-48.2768	CTD termination problem at 1160m. Returning to deck.
02/03/2019 17:55	29	-60.1457	-48.2768	Drone landed on after deck
02/03/2019 17:41	29	-60.1457	-48.2768	Drone takes off after deck
02/03/2019 17:38	28	-60.1457	-48.2768	CTD #19A stopped at 1908m
02/03/2019 17:06	28	-60.1457	-48.2768	CTD #19A veering to 1850m. EA600 at 1957m.
02/03/2019 17:03	28	-60.1457	-48.2768	CTD #19A in the water

02/03/2019 16:48	28	-60.1481	-48.2772	Vessel on DP
02/03/2019 15:54	27	-60.1671	-48.5839	Gantry lashed
02/03/2019 15:47	27	-60.1655	-48.5846	CTD #18 on deck
02/03/2019 14:53	27	-60.1655	-48.5846	CTD #18 at 1546m and hauling
02/03/2019 14:39	27	-60.1655	-48.5846	CTD #18 in the water
02/03/2019 14:26	27	-60.1655	-48.5846	CTD #18 Going to 1500M
02/03/2019 14:21	27	-60.1655	-48.5846	CTD #18 in the air
02/03/2019 14:16	27	-60.1655	-48.5846	Gantry unlashed
02/03/2019 14:15	27	-60.1655	-48.5846	Vessel in DP
02/03/2019 12:18	26	-60.2082	-49.2788	Vessel off DP
02/03/2019 12:12	26	-60.2074	-49.2804	CTD #17 and gantry stowed
02/03/2019 12:07	26	-60.2074	-49.2804	CTD #17 landed on deck
02/03/2019 12:06	26	-60.2074	-49.2804	CTD #17 clear of water
02/03/2019 11:27	26	-60.2074	-49.2804	CTD #17 stopped at 995m and hauling
02/03/2019 11:09	26	-60.2074	-49.2804	CTD #17 going to 950m
02/03/2019 11:06	26	-60.2074	-49.2804	CTD #17 in water
02/03/2019 11:03	26	-60.2074	-49.2804	CTD #17 lifted
02/03/2019 11:00	26	-60.2074	-49.2804	CTD Gantry Unlashed
02/03/2019 10:50	26	-60.2064	-49.2814	Vessel on DP for CTD #17
02/03/2019 08:48	25	-60.225	-50.0468	Vessel Out of DP
02/03/2019 08:42	25	-60.226	-50.0436	CTD Gantry lashed
02/03/2019 08:34	25	-60.2259	-50.0436	CTD #16 out of the water
02/03/2019 08:08	25	-60.2259	-50.0436	CTD #16 stopped at 576m
02/03/2019 07:58	25	-60.2259	-50.0435	CTD #16 deploying to 550m-EA600 displaying 594m
02/03/2019 07:54	25	-60.2259	-50.0436	CTD #16 in the water
02/03/2019 07:44	24	-60.2259	-50.0436	Gantry Unlashed
02/03/2019 07:42	24	-60.2254	-50.0432	Vessel on DP at CTD16
02/03/2019 06:24	23	-60.1997	-50.5066	Gantry secure
02/03/2019 06:14	23	-60.1984	-50.5125	CTD #15 on deck
02/03/2019 05:45	23	-60.1984	-50.5125	CTD #15 stopped at 745m
02/03/2019 05:32	23	-60.1984	-50.5125	CTD #15 at surface veering to 700m. EA600 at 738m.
02/03/2019 05:28	23	-60.1984	-50.5125	CTD #15 in the water
02/03/2019 05:18	23	-60.1977	-50.5124	Vessel on DP; clear to deploy
02/03/2019 05:06	23	-60.1936	-50.5446	Off DP move to safe position
02/03/2019 04:54	23	-60.1934	-50.5446	Vessel on DP. Assessing situation - iceberg closing onto station
02/03/2019 03:36		-60.2241	-50.9319	Gantry secure
02/03/2019 03:25	22	-60.2241	-50.9319	CTD #14 on deck
02/03/2019 02:44	22	-60.2241	-50.9318	CTD #14 stopped at 1343m and hauling
02/03/2019 02:24	22	-60.2241	-50.9319	CTD #14 to 1340m EA600 at 1384m
02/03/2019 02:18	22	-60.2241	-50.9319	CTD #14 in water
02/03/2019 02:16	22	-60.2241	-50.9319	CTD #14 lifted
02/03/2019 02:02	22	-60.224	-50.9326	Gantry unlashed

02/03/2019 01:54	22	-60.224	-50.9452	On DP
02/03/2019 01:03	21	-60.253	-51.1936	Vessel off DP
02/03/2019 01:00	21	-60.253	-51.1939	CTD #13 and gantry stowed
02/03/2019 00:50	21	-60.253	-51.1939	CTD #13 clear of water
02/03/2019 00:18	21	-60.253	-51.1939	CTD #13 stopped at 982m and hauling
02/03/2019 00:02	21	-60.253	-51.1939	CTD #13 going to 950m
02/03/2019 00:00	21	-60.253	-51.1939	CTD #13 in water
01/03/2019 23:54	21	-60.253	-51.1938	CTD #13 in air
01/03/2019 23:50	21	-60.2529	-51.193	Gantry unlashed
01/03/2019 23:36	21	-60.2524	-51.1905	Vessel on dp
01/03/2019 22:54	20	-60.2889	-51.385	Vessel out of DP
01/03/2019 22:51	20	-60.2885	-51.3869	CTD Gantry lashed
01/03/2019 22:42	20	-60.2885	-51.3869	CTD #12 out of the water
01/03/2019 22:20	20	-60.2885	-51.3869	CTD #12 stopped at 532m
01/03/2019 22:10	20	-60.2885	-51.3869	CTD #12 deploying to 525m EA600 displaying 550.1m
01/03/2019 22:02	20	-60.2885	-51.3869	CTD #12 in the water
01/03/2019 21:48	20	-60.2883	-51.3868	Vessel on DP for CTD #12
01/03/2019 21:46	20	-60.2883	-51.3898	CTD Gantry Unlashed
01/03/2019 20:24	19	-60.3708	-51.8848	Vessel out of DP
01/03/2019 20:19	20	-60.3704	-51.8859	Gantry lashed
01/03/2019 20:17	19	-60.3704	-51.8859	CTD #11 out of the water
01/03/2019 19:51	19	-60.3705	-51.8859	CTD #11 stopped at 411m
01/03/2019 19:42	19	-60.3703	-51.8861	CTD #11 deploying to 400m EA600 displaying 422m
01/03/2019 19:38	19	-60.3701	-51.8864	CTD #11 in the water
01/03/2019 19:32	19	-60.3699	-51.8869	CTD Gantry Unlashed
01/03/2019 19:28	19	-60.3682	-51.8878	Vessel on DP
01/03/2019 17:54	18	-60.5508	-52.3516	Gantry lashed
01/03/2019 17:44	18	-60.5487	-52.353	CTD #10 on deck
01/03/2019 17:06	18	-60.5487	-52.353	CTD #10 stopped at 822m
01/03/2019 16:50	18	-60.5486	-52.353	CTD #10 at surface veering to 800m EA600 at 852m
01/03/2019 16:47	18	-60.5486	-52.353	CTD #10 in the water
01/03/2019 16:36	18	-60.5467	-52.3541	Vessel on DP
01/03/2019 15:06	17	-60.4441	-52.8304	Vessel off DP
01/03/2019 15:02	17	-60.4437	-52.8305	Gantry lashed
01/03/2019 14:56	17	-60.4437	-52.8306	CTD #9 landed on deck
01/03/2019 14:54	17	-60.4437	-52.8306	CTD #9 clear of water
01/03/2019 14:28	17	-60.443	-52.8311	CTD #9 stopped at 392m and hauling
01/03/2019 14:20	17	-60.4426	-52.8314	CTD9 going to 350m EA600 at 410m
01/03/2019 14:16	17	-60.4424	-52.8315	CTD #9 In water
01/03/2019 14:13	17	-60.4422	-52.8317	CTD #9 lifted
01/03/2019 14:06	17	-60.4421	-52.831	Vessel on DP
01/03/2019 11:30	16	-60.7337	-53.3689	Vessel off DP

01/03/2019 11:20	16	-60.735	-53.3743	CTD landed on deck
01/03/2019 11:17	16	-60.735	-53.3743	CTD #8 clear of water
01/03/2019 10:51	16	-60.7349	-53.3743	CTD #8 stopped at 448m
01/03/2019 10:42	16	-60.7349	-53.3743	CTD #8 deploying to 400m- EA 600 displaying 467.2m
01/03/2019 10:38	16	-60.7349	-53.3743	CTD #8 in the water
01/03/2019 10:29	16	-60.7349	-53.3743	CTD #8 gantry unlashed
01/03/2019 10:23	16	-60.7349	-53.3742	Vessel on DP
01/03/2019 07:53	15	-60.9638	-54.1718	Vessel out of DP
01/03/2019 07:51	15	-60.9639	-54.1717	CTD Gantry lashed
01/03/2019 07:40	15	-60.9639	-54.1718	CTD out of the water
01/03/2019 07:06	15	-60.9639	-54.1718	CTD #7 at 892m
01/03/2019 06:50	15	-60.9639	-54.1718	CTD #7 at surface veering to 875m. EA600 at 932m
01/03/2019 06:47	15	-60.9639	-54.1718	CTD #7 in the water
01/03/2019 06:46	15	-60.9639	-54.1718	CTD #7 off deck
01/03/2019 06:30	15	-60.9639	-54.1718	Vessel on station in DP
01/03/2019 06:18	15	-60.9564	-54.1853	Vesel slowing down for station
01/03/2019 05:24	14	-61.0406	-54.4051	Gantry secure
01/03/2019 05:12	14	-61.0406	-54.4051	CTD #6 on deck
01/03/2019 05:10	14	-61.0406	-54.4051	CTD #6 out of the water
01/03/2019 04:41	14	-61.0406	-54.4051	CTD6 at 491m; hauling
01/03/2019 04:32	14	-61.0406	-54.4051	CTD #6 at surface veering to 480m. EA600 at 512m
01/03/2019 04:28	14	-61.0406	-54.4051	CTD #6 in the water
01/03/2019 04:26	14	-61.0406	-54.4051	CTD #6 off the deck
01/03/2019 04:12	14	-61.0402	-54.4045	Vessel on DP
01/03/2019 04:00	14	-61.0265	-54.4155	Vessel slowing down for station
28/02/2019 20:30	13	-61.3922	-56.6949	Vessel out of DP
28/02/2019 20:23	13	-61.3922	-56.6941	CTD gantry lashed
28/02/2019 20:13	13	-61.3922	-56.6941	CTD out of the water
28/02/2019 19:51	13	-61.3921	-56.6942	CTD stopped at 470m
28/02/2019 19:43	13	-61.3922	-56.6942	CTD deploying to 450m- EA600 displaying 490m
28/02/2019 19:37	13	-61.3921	-56.6941	CTD in the water
28/02/2019 19:26	13	-61.392	-56.6943	Gantry unlashed
28/02/2019 19:22	13	-61.39	-56.6952	Vessel stopped on DP
28/02/2019 15:12		-62.1697	-56.6717	Gantry lashed
28/02/2019 15:06	12	-62.1693	-56.6717	CTD #4 out of the water
28/02/2019 14:23	12	-62.1693	-56.6716	CTD stopped at 1114m and hauling
28/02/2019 14:05	12	-62.1693	-56.6717	CTD going to 1050m
28/02/2019 14:00	12	-62.1693	-56.6717	CTD in water
28/02/2019 13:50	12	-62.1695	-56.6716	CTD #4 in air
28/02/2019 13:30	12	-62.1707	-56.6702	Gantry unlashed
28/02/2019 13:24	12	-62.1708	-56.6701	Vessel stopped on DP
28/02/2019 11:10	11	-62.505	-56.7922	Vessel off DP

28/02/2019 11:05	11	-62.5047	-56.7921	CTD #3 stowed and gantry lashed
28/02/2019 10:55	11	-62.5047	-56.792	CTD out of the water
28/02/2019 10:24	11	-62.5047	-56.792	CTD stopped at 531m
28/02/2019 10:06	11	-62.5048	-56.7921	CTD in the water
28/02/2019 09:55	11	-62.5048	-56.792	CTD #3 gantry unlashed
28/02/2019 09:45	11	-62.5048	-56.792	Decision made to deploy CTD3
28/02/2019 09:16		-62.5047	-56.803	Vessel stopped on DP at station- assessing conditions
27/02/2019 18:18		-62.504	-56.7964	Vessel off DP -- waiting on weather
27/02/2019 17:20		-62.5032	-56.7918	Vessel on DP
27/02/2019 17:06		-62.4908	-56.7898	Vessel slowing down for station
25/02/2019 23:23		-55.3167	-57.3886	Vessel off DP
25/02/2019 23:20	10	-55.3167	-57.3886	CTD #2 landed on deck
25/02/2019 23:16	10	-55.3167	-57.3886	CTD #2 clear of water
25/02/2019 22:17	10	-55.3164	-57.3839	All bottles fired- CTD recovering to deck
25/02/2019 22:08	10	-55.3164	-57.3828	CTD stopped at 3264m
25/02/2019 21:10	10	-55.3155	-57.3769	CTD deployed in the water
25/02/2019 21:00	10	-55.3154	-57.3769	CTD #2 gantry unlashed
25/02/2019 20:50	10	-55.3151	-57.3769	Vessel stopped on DP- EA600 depth 4059m
24/02/2019 19:56	9	-51.9332	-57.6433	Uncontaminated Seawater On
23/02/2019 22:45	9	-53.5031	-58.4956	CTD #1 gantry lashed and stowed
23/02/2019 22:36	9	-53.5031	-58.4955	CTD out of the water
23/02/2019 21:48	9	-53.5031	-58.4956	Commence CTD recovery
23/02/2019 21:47	9	-53.5031	-58.4956	CTD stopped at 2122m
23/02/2019 21:06	9	-53.5031	-58.4955	CTD #1 deployed
23/02/2019 20:10		-53.503	-58.4956	VP-FAZ complete last pass- bound for MPA
23/02/2019 20:10	8	-53.503	-58.4956	CDT recovered on deck
23/02/2019 20:03	8	-53.503	-58.4956	CDT deployed for winch system checks
23/02/2019 19:59	7	-53.503	-58.4956	VP-FAZ #Cal 2 Final fly over
23/02/2019 19:50		-53.503	-58.4956	Complete Load Test of CDT Wire
23/02/2019 19:30	6	-53.503	-58.4956	VP-FAZ cal#2 third fly over
23/02/2019 18:55	5	-53.503	-58.4956	VP-FAZ cal#2 second fly over
23/02/2019 18:20	4	-53.503	-58.4956	VP-FAZ cal#2 first fly over
23/02/2019 18:00		-53.503	-58.4956	Vessel in position in DP
23/02/2019 15:30		-53.4165	-59.2669	VAZ completes last leg. Vessel off DP and proceeding.
23/02/2019 15:15	3	-53.4165	-59.2669	VP-FAZ cal#1 third fly over
23/02/2019 14:43	2	-53.4165	-59.2668	VP-FAZ cal#1 second fly over
23/02/2019 14:02	1	-53.4165	-59.2668	VP-FAZ cal#1 first fly over
23/02/2019 13:00		-53.4148	-59.2691	Vessel stopped on DP