National
Oceanography Centre
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National Oceanography Centre
Cruise Report No. 60
RRS *James Cook* Cruise JC159

28 FEBRUARY - 11 APRIL 2018

Hydrographic sections from the Brazil to the Benguela Current across 24S in the Atlantic

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DOCUMENT DATA SHEET

AUTHOR KING, B.A. et al.	*PUBLICATION DATE* 2019

TITLE

RRS *James Cook* Cruise JC159 28 Februar - 11 April 2018. Hydrographic sections from the Brazil to the Benguela Current across 24S in the Atlantic

REFERENCE

Southampton, UK: National Oceanography Centre, Southampton, 193pp.
(National Oceanography Centre Cruise Report, No. 60)

ABSTRACT

A Hydrographic section was occupied at a nominal latitude of 24°S in the Atlantic Ocean during March and April 2018 on Cruise JC159 of RRS James Cook. The primary objective of this cruise was to measure ocean physical, chemical and biological parameters in order to establish regional budgets of heat, freshwater and carbon, and to infer decadal variability. In addition, 371 Niskin Bottles were sampled for microplastics, reflecting increasing awareness of plastics pollution in the oceans.

A total of 121 CTD/LADCP stations were conducted, including one test station and two CFC bottle blank stations. In addition to temperature, salinity and oxygen profiles from the sensors on the CTD package, water samples from a 24 x 20 litre rosette were analysed for the following parameters at all stations: salinity; dissolved oxygen; inorganic nutrients; alkalinity and dissolved inorganic carbon; CFCs. Samples were collected for shore analysis for oxygen and carbon isotopes (del-18O, del13C and del-14C). Samples were collected and filtered for pigments (shore analysis) at 44 stations and for microplastics at 45 stations. 8 Argo floats were deployed, including two Bio-PROVOR floats and 2 Deep ARVORs.

In addition, samples were collected from the ships' underway system to calibrate and compliment the data continually collected by the TSG (thermosalinograph). Full depth velocity measurements were made at every station by LADCP (Lowered Acoustic Doppler Current Profiler) mounted on the frame of the rosette. Throughout the cruise, velocity data in the upper few hundred metres of the water column were collected by the ship's VMADCP (Vessel Mounted Acoustic Doppler Current Profiler) transducers (75Hz and 150Hz) mounted on one of the two drop keels. Meteorological variables were monitored using the onboard surface water and meteorological sampling system (SURFMET). Bathymetric data were collected using the Kongsberg EM122 multibeam system and the EA640 echo sounder.

This report describes the methods used to acquire and process the data on board the ship during cruise JC159.

KEYWORDS

ADCP, Angola Basin, Argo, biogeochemical budgets, Brazil Basin, Brazil Current, Benguela Current, C14, C13, carbon budgets, Carbon, CFC, James Cook, chlorophyll, Circulation, climatic changes, cruise JC159 2018, CTD, d18O, 13C, 14C, Deep Western Boundary Current, hydrographic section, hydrography, Lowered ADCP, Meridional Overturning Circulation, microplastics, Namibia Basin, nutrients, O18, oxygen, profiling floats, radiocarbon, shipboard ADCP, South Atlantic, stable isotopes, Sulphur Hexafluoride, Vessel Mounted ADCP, Walvis Basin

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Gadaffi Liswaniso	Physics	University of Namibia
Jack Giddings	Physics	UEA
Peter Brown	DIC/TA	NOC
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Pablo Trucco Pignata	DIC/TA	Universidad Autonoma de Baja California
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Nina Faure Beaulieu	Plastics	NOC
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NOC = National Oceanography Centre
UEA = University of East Anglia
UOE = University of Exeter
NMF = National Marine Facilities
IC = Imperial College

Technical Personnel

Name	Position	Affiliation
Mark Maltby	IT/Ship systems Technician	NMF
Eleanor Darlington	IT Technician	NMF
Jeffrey Benson	CTD Technician	NMF
Matthew Tialho	CTD Technician	NMF

Howard King	CTD Technician	NMF
William Platt	CTD Technician	NMF

Ship’s Personnel

Name	Position/Rank
John Leask	Master
Andrew Mahon	Chief Officer/Security
Michael Hood	2nd Officer/Medical
Thomas Williams	3rd Officer
Christopher Uttley	Chief Engineer/Safety
Michael Murray	2nd Engineer
Gary Slater	3rd Engineer
Gavin Nicholson	3rd Engineer
Sebastian Martin Ulbricht	ETO
Valerija Forbes-Simpson	Purser
Andrew Maclean	CPOD
Martin Harrison	CPOS
Steven Duncan	POD
Nicholas Evans	SG1A
William Strudley	SG1A
Craig Lapsley	SG1A
Jarrod Welton	SG1A
Brian Conteh	ERPO
John Haughton	Head Chef
Jacqueline Waterhouse	Chef
Jane Bradbury	Steward
Kevin Mason	Assistant Steward

Background, Objectives and Overview

RRS James Cook Cruise JC159 was a repeat occupation of the Atlantic hydrographic section at a nominal latitude of 24°S. As a repeat section it will enable the study of decadal variability, of the present circulation, and the present transports of heat, freshwater, and biogeochemical tracers. The previous occupation of this line was James Cook Cruise JC032 (2009). The cruise was a contribution to the project: Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports (ORCHESTRA) (https://www.bas.ac.uk /project/orchestra). End-of-cruise data have been submitted to the CLIVAR and Carbon Hydrographic Data Office (CCHDO).

The data collected during JC159 came from four main scientific teams, physics, chemistry (nutrients and oxygen), carbon, and CFCs. Four more sets of samples were gathered for analysis ashore: Stored water samples for isotopes of carbon (del13C and del14C) and oxygen (del18O). Also stored filters from filtering for Chlorophyll A and for microplastics.

Principal Scientist's acknowledgement

As Principal Scientist I would like to acknowledge the efforts of all the ship's personnel. All the ship side and technical support worked hard to help achieve the objectives of the cruise. I was very appreciative of how quickly everyone got to grips with the scientific rhythm of the station/steaming periods, and embraced it. By any estimation, long CTD cruises are very repetitive. With so many stations, significant amounts of time can be won or lost by the bridge not giving word promptly when we are on station, the deck or the techs not being quite ready, and so on. A few minutes persistently lost here and there because of a casual approach easily adds up to a day of ship time. Once the rhythm was found, the performance of all concerned, maintained with an appropriate level of intensity throughout a long cruise, was excellent. Cues are always taken from the top, so the example and attitude set by the Master for the bridge, and the CPOS and CPOD for the deck was critical. The Engineering department stepped up when needed to keep things going with the wires and gantries. I had sailed with many of the tech staff before and find them to be highly self-motivated needing no extra encouragement from me to deliver what was required. The visiting scientists' most frequent interactions were with the deck crew and tech staff. The unfailing good humour of all of them, during long hours of concentration at the winch controls and CTD deck unit, resulted in safe and efficient operations. My team found them agreeable and helpful in all interactions: a great experience for everyone from myself to the first-time PhD students.

Cruise Track

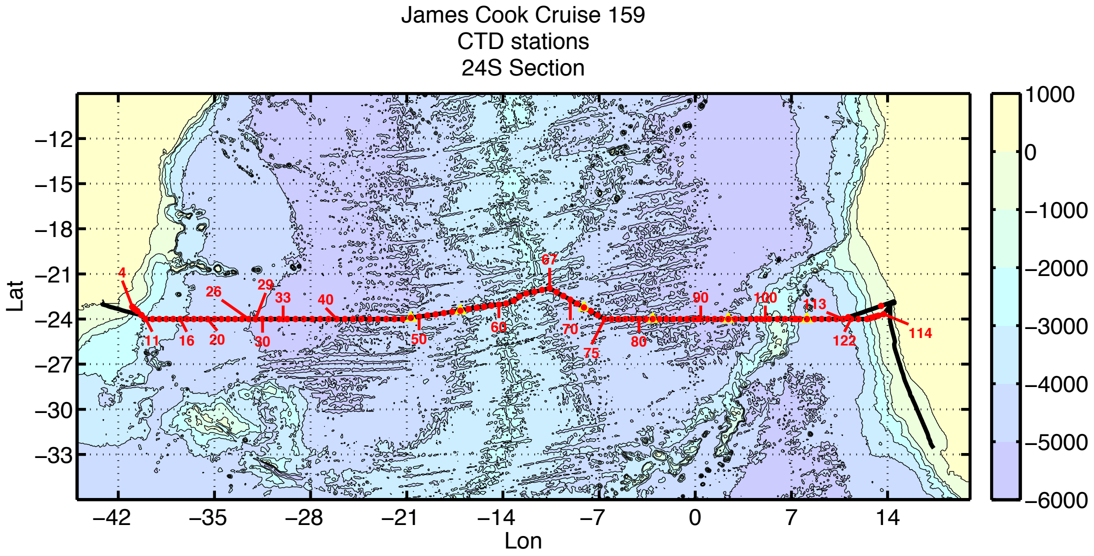


Figure 0.1: Entire cruise track

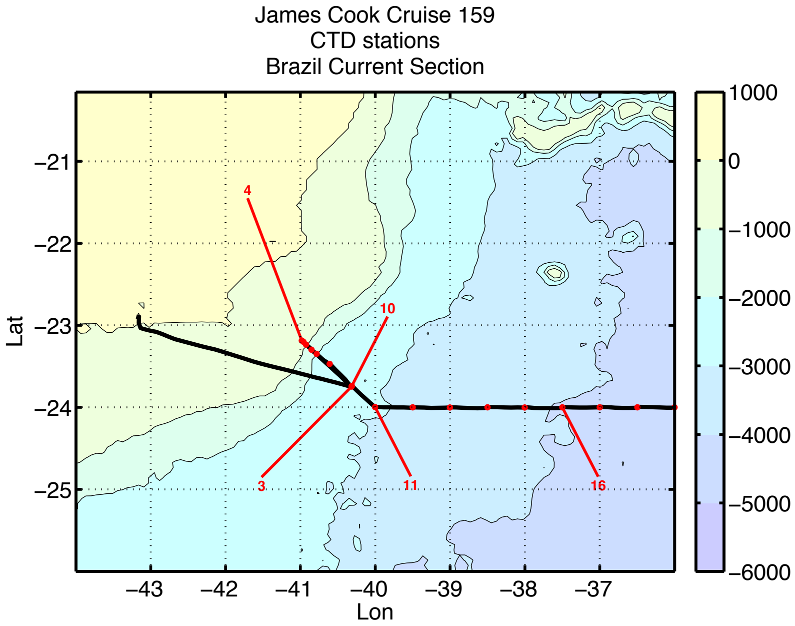


Figure 0.2: Brazil Current section

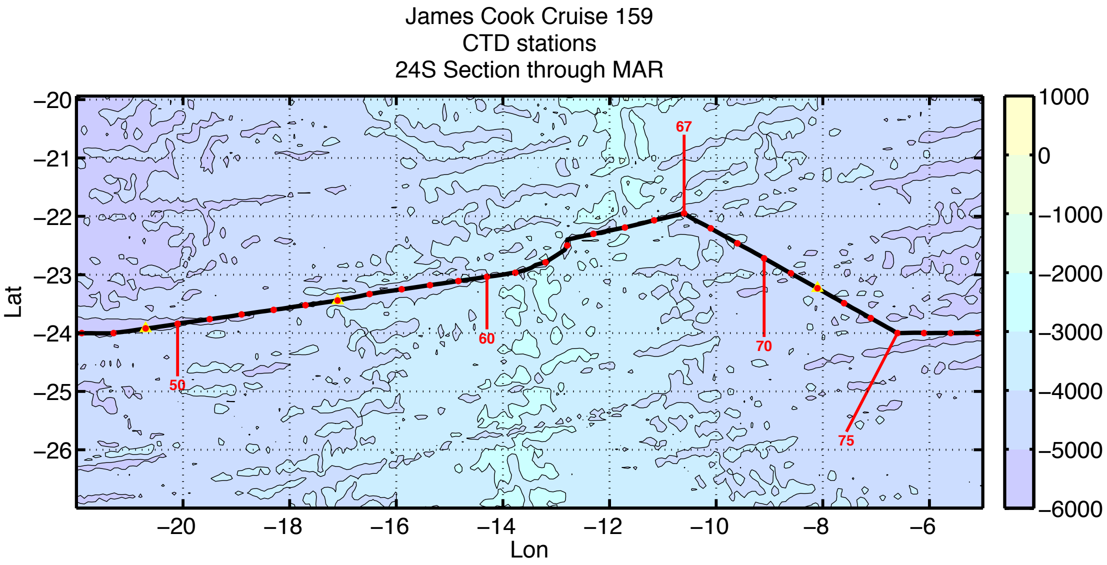


Figure 0.3: Mid-Atlantic Ridge section

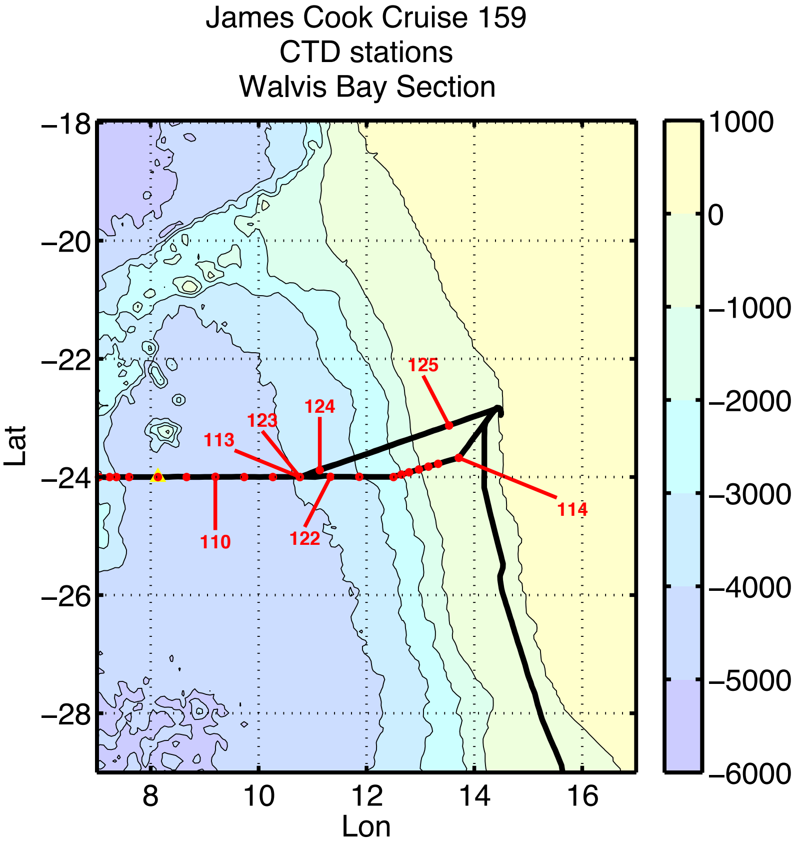


Figure 0.4: Walvis Bay section

Diary

J055 24th February – In port
Scientific party arrived in Rio de Janeiro, Brazil at 06:30 local time (09:30 UTC) and were escorted to the ship, which was berthed at a commercial dock.

Mobilization was initiated. Containers were emptied and boxes distributed around labs.

Techsas logging was started at 21:28 UTC.

J056 25th February – In port
Full day of mobilization.

Safety briefing (given by purser) at 08:30 local time (11:30 UTC).

J057 26th February – In port
Full day of mobilization. CFCs container was set up.

In the afternoon, the ship was moved to the cruise liner berth nearest to the Museu do Amanha. Ship moved between 12:00 and 13:00 UTC. Spectacular views.

Preparations were made for the reception aboard the ship for the visiting party due on the 27th March. Preparations included the printing of science posters using the ship's a0 printer and the hanging of a banner on the ship's starboard side, so that the 'Science is great' could be projected from a shoreside data projector. UK's colours were also projected on the side of the ship.

J058 27th February – In port
Day of outreach aboard the ship, which included 2 school parties in the morning and various scientific tours for Museu do Amanha staff and navy personnel. Science tours were given by members of the scientific party and the PSO, Brian King; Professor Frederico Brandini did coverage of the cruise objectives for national television. Final bits of mobilization also carried out.

In the early evening, a VIP tour was held on ship for Navy Officials and ambassadors. This included British ambassador, Dr. Vijay Rangarajan. After the VIP tour, a reception was held at Museu do Amanha to celebrate the UK-Brazil 'Year of Science and Innovation'. Director Ed Hill made a speech on behalf of NERC.

We were also pleased to welcome aboard Brazilian navy observer, Lt. Vanessa Bach.

J059 28th February – Departed Rio de Janeiro, Brazil

Day of departure.
One of the NMF techs had been suffering from fever for a couple of days. It was decided to delay to departure while he was checked out at the local medical clinic. Nothing serious was diagnosed. He was cleared for duty and the ship left the berth 15:45 local time (18:45 UTC). Physics team met to organize science party working shifts.

The ship's departure from Rio was accompanied by a small boat carrying a drone pilot. Spectacular views of Sugarloaf and Christ the Redeemer were slightly marred by overcast/low cloud skies.

J060 1st March

We arrived on the first station at 12:35 UTC. CTD Stations 1 and 2 were done to test the swivel. Testing was finishing at 16:35 UTC.

CTD Station 003: 2859m water (19:40 UTC) was a test station to ensure all equipment and instruments setup correctly. This was also an opportunity to establish a 'sampling dynamic' and for newcomers to gain experience under a no-pressure environment.

Safety drill (muster and lifeboats) at 16:15 local time (19:15 UTC).

We initiated steam toward inshore end of the main section, located on the shelf at 23°11S and 40°59W.

J061 2nd March

Depths in parenthesis are depths report by Atlas bathymetry. Otherwise, they are the depths reported by the EM122 multi-beam.

CTD Station 004: 148 (89)m depth (02:13 UTC)
CTD Station 005: 470 (496)m depth (05:16 UTC)
CTD Station 006: 1084 (903)m depth (08:41 UTC)
CTD Station 007: 1577 (1523)m depth (12:46 UTC)
CTD Station 008: 1993 (2005)m depth (16:42 UTC)
CTD Station 009: 2522 (2502)m depth (21:04 UTC)

Recorded depths are from CTD and LADCP. In parentheses, depths from the atlas bathymetry (used for planning and prediction) are noted.

J062 3rd March

CTD Station 010: 2857 (2842)m depth (02:43 UTC) – start of alternating (i.e. A/B) stations
CTD Station 011: 3013 (2983)m depth (08:03 UTC)
CTD Station 012: 3026 (3171)m depth (14:26 UTC)
CTD Station 013: 3438 (3368)m depth (20:19 UTC)

Clocks change overnight from UTC-3 to UTC-2 hour.

J063 4th March
CTD Station 014: 3484 (3481)m depth (03:00 UTC)
CTD Station 015: 3598 (3611)m depth (09:03 UTC)
CTD Station 016: 4064 (4049)m depth (15:30 UTC)
CTD Station 017: 4042 (4043)m depth (21:37 UTC)

J064 5th March
CTD Station 018: 4073 (4056)m depth (04:09 UTC)
CTD Station 019: 4116 (4149)m depth (10:28 UTC)
CTD Station 020: 4199 (4233)m depth (16:58 UTC)
CTD Station 021: 4230 (4223)m depth (23:28 UTC) – raining during sampling.

J065 6th March
CTD Station 022: 4396 (4345)m depth (06:06 UTC)
CTD Station 023: 4612 (4519)m depth (12:56 UTC)
CTD Station 024: 4625 (4620)m depth (19:44 UTC) – raining during sampling.

J066 7th March
CTD Station 025: 4791 (4803)m depth (02:51 UTC)
CTD Station 026: 4998 (4978)m depth (09:41 UTC)
CTD Station 027: The CTD lost comms at ~600 m and was recovered for re-termination (~13:20 UTC).
CTD Station 028: The CTD lost comms again at ~125m and was recovered for diagnostics. After some deliberation, the NMF team decided to do another re-termination.

The deep-tow cable was run out from the winch room and terminated to be placed on stand-by. The deep-tow cable was run out over the P-frame; it was setup to be run out at the same time as the CTD wire.

J067 8th March
CTD Station 029: 5063 (5112)m depth (10:51 UTC)
CTD Station 030: 5155 (5178)m depth (17:56 UTC)

International Women's Day was observed. Several videos of the female scientists and technicians were posted on twitter (and other media) for outreach.

J068 9th March
CTD Station 031: 5213 (5205)m depth (01:32 UTC)
CTD Station 032: 5300 (5284)m depth (09:03 UTC)
CTD Station 033: 5300 (5233)m depth (14:09 UTC) – bottle blank station. All 24 bottles of the CTD were fired at 4077m so CFCs, DO, DIC/TA, Nutrients, O18,

salts and plastics could get a control sample. An extra 21 salts samples were taken from niskin 1 to address the issue of creep with the autosal.
CTD Station 034: 5363 (5401)m depth (20:21 UTC)

Safety drill: immersion suits and life-rafts at 16:15 local time (18:15 UTC).

J069 10th March
Overcast day with some heavy rain throughout the afternoon and evening.

CTD Station 035: 5452 (5478)m depth (04:087UTC). Because of uncertainty in the oxygen titrations, a secondary oxygen sensor was added to the CTD package.
CTD Station 036: 5516 (5405)m depth (12:38 UTC)
CTD Station 037: 5360 (5515)m depth (19:55 UTC)

J070 11th March
Overcast day

CTD Station 038: 5643 (5646)m depth (03:40 UTC)
CTD Station 039: 5689 (5882)m depth (11:28 UTC)
CTD Station 040: 5695 (5912)m depth (18:55 UTC)

Clocks changed overnight from UTC-2 to UTC-1 hour.

J071 12th March
CTD Station 041: 5708 (5685)m depth (02:52 UTC)
CTD Station 042: 4353 (5112)m depth (10:08 UTC)
CTD Station 043: 5400 (5587)m depth (17:44 UTC)

J072 13th March
CTD Station 044: 5343 (5501)m depth (01:41 UTC)
CTD Station 045: 5236 (5211)m depth (09:28 UTC)
CTD Station 046: 5242 (5271)m depth (17:15 UTC)

Planned deployment of the Argo float. Float failed to communicate so we delayed the deployment to allow time for troubleshooting.

J073 14th March
CTD Station 047: 4802 (5127)m depth (00:51 UTC)
CTD Station 048: 5115(5111)m depth (08:17 UTC)
CTD Station 049: 4767 (5273)m depth (17:03 UTC) – First Argo float (provor 101) deployed successfully. Drone video of deployment, however, was less successful.

Issues with the pinging of the CTD cable continued. These were likely related to the previously noted broken strand on the wire (found at > 4000 m). This raised some concerns about the integrity of the cable, so for depths greater than 4000 m the deep-tow cable switched in (i.e. after CTD station 49).

J074 15th March
CTD Station 050: 5193 (5231)m depth (00:57 UTC) – deep-tow wire effective until further notice.
CTD Station 051: 5650 (5664)m depth (08:28 UTC)
CTD Station 052: 4961 (4936)m depth (15:53 UTC)
CTD Station 053: 4786 (4814)m depth (22:58 UTC)

It was noted that outboard travel on the P-frame was slower than usual. Valves were switched around on the P-frame to little effect.

J075 16th March
CTD Station 054: 4953 (4904)m depth (06:17 UTC)
CTD Station 055: 4971 (4990)m depth (13:45 UTC) – Provor float 102 successfully deployed after a few hours worth of troubleshooting the Bluetooth communications (note to self: 2 magnets is better than 1). Drone footage of deployment, also successful, declared wildly exciting and very cool.
CTD Station 056: 4738 (4782)m depth (21:17 UTC)

J076 17th March
Mid-cruise BBQ! St. Paddy's day was also observed.

CTD Station 057: 4268 (4372)m depth (04:31 UTC)
CTD Station 058: 4238 (4127)m depth (11:10 UTC)
CTD Station 059: 4388 (4188)m depth (17:49 UTC) – upon recovery of the CTD, it was discovered that niskin bottle caps had not been fastened properly (about 15 caps total were lost and the remainder were not secure). Crestfallen scientists were forced to abandon attempts to sample and join the BBQ earlier than expected. The station was written off for sampling.

A green flash was observed at sunset. Skeptics became believers.

J077 18th March
CTD Station 060: 4116 (4078)m depth (02:50 UTC)
CTD Station 061: 3632 (3724)m depth (09:05 UTC)
CTD Station 062: 3708 (3709)m depth (15:56 UTC)
CTD Station 063: 4419 (4402)m depth (22:40 UTC) – first station in MAR channel

Toilets not working. Issues with vacuum. Problem sorted a few hours later. Station 62 slightly overshot channel target by 2 nmi (slightly north to the deepest part of the channel).

Clocks to change overnight from UTC-1 to UTC time.

J078 19th March
CTD Station 064: 5253 (5244)m depth (05:58 UTC)
CTD Station 065: 4426 (4230)m depth (13:08 UTC)
CTD Station 066: 4393 (4400)m depth (19:51 UTC)

J079 20th March
CTD Station 67: 4247 (4475)m depth (02:34 UTC) – northernmost point in transect and end of MAR channel
CTD Station 068: 4071 (4174)m depth (09:13 UTC)
CTD Station 069: 4161 (4064)m depth (15:37 UTC)
CTD Station 070: 4444 (4457)m depth (22:32 UTC)

J080 21st March
CTD Station 071: 5193 (4925)m depth (05:40 UTC)
CTD Station 072: 4989 (4736)m depth (12:48 UTC) – deployment of deep Argo float, Arvor 103.
CTD Station 073: 5402 (4709)m depth (20:19 UTC)

J081 22nd March
CTD Station 074: 4934 (4996)m depth (03:17 UTC) – A lot of spiky data apparent on the surface couple of hundred meters of the upcast. Decision made to re-terminate (deep-tow cable).
CTD Station 075: 4716 (4518)m depth (16:32 UTC)
CTD Station 076: 4639 (4585)m depth (23:07 UTC)

Fire safety drill at 16:15 local

J082 23rd March
CTD Station 077: 4972 (4889)m depth (05:51 UTC)
CTD Station 078: 5244 (5433)m depth (12:44 UTC)
CTD Station 079: 5435 (5247)m depth (19:31 UTC)

J083 24th March
CTD Station 080: 5185 (5069)m depth (02:24 UTC) – cups station!
CTD Station 081: 4885 (4618)m depth (09:07 UTC)
CTD Station 082: 4742 (4676)m depth (15:34 UTC) – deployment of deep Argo float, Arvor 105.
CTD Station 083: 4915 (4918)m depth (22:11 UTC)

Clocks to change overnight from UTC to UTC + 1hr.

J084 25th March
CTD Station 084: 5324 (5400)m depth (05:03 UTC)

CTD Station 085: 5519 (5193)m depth (12:04 UTC)- bottles firing sequence was rotated, such that niskin 13 was the deepest and 12 the shallowest (until further notice).
CTD Station 086: 4674 (4830)m depth (19:10 UTC) – There was a slight delay (~40 minute) at this station in order to clean grease off CTD. Marie-Jose Messias reported seeing contamination in her samples from niskins 5 and 6, and Billy Platt reported a thin film of grease coming from the water being sampled by the autosal. A visual inspection of the CTD and the rollers on the P-frame showed there was a lot of grease dropping on the CTD while it was sitting on deck. Grease was even found inside the niskin bottles, which was consistent with Marie-Jose's reports. We used alcohol and blue roll to clean the outside of the niskin bottles and the inside of the top end caps.

J085 26th March
Crossover to the eastern hemisphere.

CTD Station 087: 5467 (5134)m depth (0157 UTC)
CTD Station 088: 4921 (4882)m depth (08:43 UTC)
CTD Station 089: 5200 (5045)m depth (13:22 UTC) – bottle blank station
CTD Station 090: 5343 (5514)m depth (18:41 UTC) – On the upcast (~600 m) of station 90, the SBE deck unit signaled open circuit at several locations. Once the CTD was on deck, diagnostics were found to be inconclusive (i.e. nothing could be found wrong with the cable). An extended discussion resulted in moving the clamps on the deep tow cable to a fresh piece of cable and to loop the 'pinched' cable up, instead of an electrical retermination. Several load tests were performed successfully; however, as soon as the CTD was moved out to the water for deployment, the deck unit signaled an open circuit again. A decision was made to bring the CTD back in and do an electrical retermination on the part of the cable that was believed to be damaged by the clamps. Whilst prepping the cable for electrical retermination on the CTD, the NMF technicians discovered issues (open circuit) with the slip ring on the cable in the winch room end of the deep tow retermination. The engineers addressed the issues at the winch room, and the NMF technicians completed the electrical retermination on the CTD end. No further open or short circuits were found after this. Since the open circuit was found on the winch drum, it was likely the sea-end termination was ok and did not need to be cut off. Total delay came up to ~12.5 hrs.

J086 27th March
CTD Station 091: 5325 (5552)m depth (14:44 UTC)
CTD Station 092: 5264 (5241)m depth (21:34 UTC)

J087 28th March
CTD Station 093: 5219 (5033)m depth (04:17 UTC)
CTD Station 094: 5275 (5182)m depth (11:07 UTC) – Double Argo float deployment, TWR Apex 8145 and SBE Navis 0656
CTD Station 095: 5194 (5257)m depth (17:46 UTC)

J088 29th March
Start ascent up the Namibian Ridge. Note change in timing/spacing between stations in order to capture the 500 m contours up the ridge.

CTD Station 096: 5241 (5315)m depth (00:27 UTC)
CTD Station 097: 4180 (4697)m depth (07:03 UTC)
CTD Station 098: 3645 (3824)m depth (12:36 UTC)
CTD Station 099: 3009 (3002)m depth (17:02 UTC) – switch of deep-tow cable to original CTD cable (effective for this cast)
CTD Station 100: 2463(2602)m depth (21:27 UTC) – CFCs sparging exercise using niskin 1.

J089 30th March
CTD Station 101: 2063 (1907)m depth (01:12 UTC)
CTD Station 102: 1643 (1737)m depth (06:10 UTC) – shallowest profile on the ridge
CTD Station 103: 2516 (2632)m depth (11:31 UTC)
CTD Station 104: 2951 (2938)m depth (16:40 UTC) – CFCs sparging exercise using niskin 2. Fire emergency/muster related to a burning bread bag in the fish room – the bag had come into contact with a heating element used for defrosting the freezer space - interrupted sampling. This caused a delay of ~30 mins.
CTD Station 105: 3498 (3390)m depth (21:18 UTC)

J090 31st March
CTD Station 106: 4246 (4078)m depth (02:29 UTC) – switch of original CTD cable to deep-tow (effective for this cast). Extra time sitting on station to finish sampling and switching cables amounted to a delay of ~85 mins
CTD Station 107: 4713 (4806)m depth (07:39 UTC) – end of Ridge waypoints and back to normal spacing.
CTD Station 108: 4676 (4661)m depth (14:11 UTC)
CTD Station 109: 4685 (4541)m depth (21:00 UTC)

Clocks to change overnight from UTC +1 hr to UTC + 2hr in preparation for Walvis Bay.

J091 1st April
April Fools Day was observed!

CTD Station 110: 4547 (4541)m depth (03:41 UTC)
CTD Station 111: 4304 (4323)m depth (10:14 UTC)
CTD Station 112: 4144 (4146)m depth (16:27 UTC)
CTD Station 113: 3921 (3919)m depth (22:34 UTC) - At the end of this station, the deep-tow wire was switched back to the original CTD wire. Then CTD wire was reterminated before the swap.

Several on the science and NMF team transferred from NERC to UKRI after many long years of service.

Easter egg decorating competition resulted in a variety of skilled and comedic entries. The Captain and the PSO had a hard time judging all the talent.

J092 2nd April
Steam toward Walvis Bay. Break off point at 200 nmi limit to obtain diplomatic clearance before commencing work in Namibian waters.

J093 3rd April
Arrival in Walvis Bay port at ~08:00 UTC (guided by Namibian pilots)

The galley took on fresh supplies of fruits, vegetables, fish and marmite.
Immigration and customs was cleared without incidents.
Departure from Walvis Bay at ~13:00 UTC to initiate section in Namibian waters.
Alongside operations lasted ~5 hrs.

CTD Station 114: 203 (194)m depth (21:59 UTC)

J094 4th April
CTD Station 115: 304 (301)m depth (02:16 UTC)
CTD Station 116: 498 (508)m depth (05:30 UTC)
CTD Station 117: 1003 (998)m depth (09:09 UTC)
CTD Station 118: 1520 (1503)m depth (12:37 UTC)
CTD Station 119: 1916 (1920)m depth (15:53 UTC)
CTD Station 120: 2235 (2236)m depth (19:51 UTC)

J095 5th April
CTD Station 121: 3035 (3029)m depth (01:56 UTC)
CTD Station 122: 3511 (3539)m depth (07:47 UTC) – switch of original CTD cable back to deep-tow cable (effective for this cast)
CTD Station 123: 3922 (3919)m depth (13:55 UTC)

Drop keel lifted at start of station 123 to compare currents on station with and without it. Drop keel remained lifted on the steam back into Walvis Bay, Namibia.

Extra stations for bulk sampling of microplastics at shallow (~5m) depths executed offshore.

Underway salinity sampling ended at 19:00 UTC.

J096 6th April
Arrival into Walvis Bay for the second time at 11:35 UTC

Departed Walvis Bay port at ~14:00 UTC having disembarked our two Namibian collaborators (and their biological samples) after a prolonged and tearful farewell.

Other underway logging (except nav) to stop upon departure of Namibian waters at $28^{o}30$ S.

J097 7th April
Steam to Cape Town.

Several teams/labs have initiated packing of equipment.

J098 8th April
Steam to Cape Town

Labs continue to pack.

Retirement party for head chef, John, very successful. Crew also said goodbye to ETO, Martin, who is moving on to greener pastures.

J099 9th April
Steam to Cape Town

Cruise report starts to come together.

Wind experiments between at 07:00 and 09:00 UTC.

Live linkup for commonwealth event hosted at NOC at 13:30 local.

J100 10th April
Arrival in Cape Town at ~11:30 local.

A. Sanchez-Franks and B. A. King

1. CTD System Configurations

1.1 CTD Sensors

1) One CTD system was prepared. The water sampling arrangement was a 24-way stainless steel frame system (s/n SBE CTD9), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-87077-1257
Sea-Bird 3P temperature sensor, s/n 03P-4814, Frequency 1 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-3874, Frequency 2 (primary)
Digiquartz temperature compensated pressure sensor, s/n 134949 Frequency 3
Sea-Bird 3P temperature sensor, s/n 03P-4381, Frequency 4 (secondary)
Sea-Bird 4C conductivity sensor, s/n 04C-2450, Frequency 5 (secondary)
Sea-Bird 5T submersible pump, s/n 05T-3609, (primary)
Sea-Bird 5T submersible pump, s/n 05T-4539, (secondary)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-19817-0243
Sea-Bird 11plus deck unit, s/n 11P-22559-0495 (main)
Sea-Bird 11plus deck unit, s/n 11P-22559-0532 (back-up logging)

2) The auxiliary input initial sensor configuration was as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-0709 (V0)
Sea-Bird 43 dissolved oxygen sensor, s/n 43-0363
WETLabs light scattering sensor, s/n BBRTD-182 (V2)
Benthos PSA-916T altimeter, s/n 41302 (V3)
Wet Labs C-Star, s/n CST-1654DR, (V6)
Chelsea Aquatracka MKIII fluorometer, s/n 88-2050-095 (V7) Casts 001-027
Chelsea Aquatracka MKIII fluorometer, s/n 088244 (V7) Casts 028-125

3) Sea-Bird 9*plus* configuration file JC159_1257.xmlcon was used for the stainless steel frame CTD casts 001 – 027.

Sea-Bird 9*plus* configuration file JC159_1257_fl.xmlcon was used for the stainless steel frame CTD casts 028 – 036.

Sea-Bird 9*plus* configuration file JC159_1257_fl_oxy.xmlcon was used for the stainless steel frame CTD casts 036 – 040.

Sea-Bird 9*plus* configuration file JC159_1257_fl.xmlcon was used for the remaining stainless steel frame CTD casts.

4) The second water sampling arrangement was a 24-way stainless steel frame system (s/n SBE CTD6). The spare sensors were as follows:

Sea-Bird 9plus underwater unit, s/n 09P-39607-0803 and 09P-71442-1142
Sea-Bird 3P temperature sensor, s/n 03P-4384, 03P-5494 and 03P-5785.
Sea-Bird 4C conductivity sensor, s/n 04C-2571 and 04C-2580, 04C-4139 and 04C-4143.
Digiquartz temperature compensated pressure sensor, s/n 93896 and 124216
Sea-Bird 5T submersible pump, s/n 05T-3088, 05T-3607, 05T-4510 and 05T-5301.
Sea-Bird 32 Carousel 24 position pylon, s/n 32-71442-0940 and 32-77801-1005.

6) The auxiliary input initial sensor configuration was as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-0363 and 43-0619.
Benthos PSA-916T altimeter, s/n 47597, 59493 and Tritech PSA-200 s/n 6196.118171
WETLabs light scattering sensor, s/n BBRTD-759R and BBRTD-1163.
Chelsea Aquatracka MKIII fluorometer, s/n 88-2615-124
Wet Labs C-Star, s/n CST-1720TR and 1797TR

Total number of casts – 125
Casts deeper than 2000m - 108
Deepest cast - 5698m

1.2 Lowered ADCP

Two command files were used during the cruise, one for the Master and one for the Slave systems. These were provided by the PSO as used on JC032 where relatively low scattering water was likely. Small alterations were made to accommodate syncronisation between the two LADCP's, and to prevent ping interference.

The Master instrument for the duration of the cruise was s/n 15288. Periodically, after verifying all data files had been duplicated, the recorder memory card (512Mb) was erased to ensure sufficient space for the next deployments. There were no issues with data files for any casts with the exception of JC159_009, where there were communication problems prior to the Master command file being sent. As a result no data was logged for this deployment.

The initial Slave instrument was s/n 24465; this was replaced with s/n 24466 prior to cast JC159_062. As neither unit had been deployed prior to this cruise, both were installed in the lesser important Slave position to test their respective functions. As above, there was no Slave data for cast JC159_009. For deployments JC159_113 and _120, the Slave instrument stopped recording approximately 10 minutes (during the upcast) prior to the Master. In both cases the Slave would not communicate upon recovery to deck, and the unit had to be disconnected from the battery pack for more than 45 minutes for communications to be restored. As the CTD frame mounted Star cable has been in use for over 150 deployments on two consecutive cruises, the source of the failures to record is likely to be this cable.

1.3 CTD Technical Detail

S/S CTD on CTD1 and Deep Tow and two brand new Titanium swivels.

CTD wire 1 was inspected before the start of the cruise and re-terminated with the normal S&M CTD termination; it was load tested by following the standard procedure of being pulled at 0.5T, 1.0T, 1.5T and 2.0T. The termination assembly was held for 5 minutes at each and re-torqued between each. It had a 'megger' value of 524 MOhms and internal resistance of 73.6 Ohms.

Casts 001 and 002 were tests, with a clump weight attached, of the integrity of each of new swivels to ensure they didn't leak when subjected to water pressure. Both swivels survived being deployed to 3000m.

During cast 027 the termination failed, short circuit, at approximately 500m during the downcast. 100m of wire was chopped off and then re-terminated with a final megger value of 72 MOhms and internal resistance of 72.3 Ohms. During the previous casts it was noticed that on the upcast the fluorometer didn't appear to read correctly even though it seemed ok on the downcast, so it was decided to replace it with the spare. This remained for the duration of the cruise.
During CTD cast 028, at 123m on the downcast, the new termination failed short circuit. The fault was found to be in the termination so the wire was re-terminated again.

During routine inspection of the wire by the CPOS it was noticed that a strand of wire had broken loose on the outer amour of the CTD wire at approximately 4000m. The strand was snipped off and the wire clued and taped to prevent further fraying. This was inspected and re-taped periodically by the CPOS.

For casts 036 - 040 a secondary oxygen sensor was fitted, on the vane, in line with the secondary temperature and conductivity sensors to prove the accuracy of the primary oxygen sensor. No issues were found so it was removed after cast 040.

During the previous casts a banging noise was heard emanating from the CTD winch/wire between approximately 4200m and 4700m. After investigation it was found to be coming from the area around the traction winch and spurling pipe although the exact area and cause was never identified. Due to this and previous experience of the Master with a similar issue it was decided not to use the CTD wire on any further casts over 4000m.

The deep tow had already been terminated as a back-up as CTD 2 was unusable due to the quantity of grease on the wire when it was installed on the ship. As there was plenty of time to do this termination it was done by potting it with polyurethane (PU) in a mold and left to cure for 24 hrs. The usual mechanical termination for the deep tow could not be found so it was made with three bull dog grips and tightened to 25Nm. This was an educated guess after discussion between the technical team and ships side and seemed to suffice. The wire was noticed to be fairly crushed by the clamps but communication with the CTD was still possible so it was agreed this was ok. Deployments were switched to the deep tow for CTD cast 050.

Upon recovery of CTD cast 059 it was discovered that the air vent screws on the water samplers had not been tighten and 15 of them had come loose and were lost to the ocean. 12 spares were found in the 20litre and 10litre water-sampler-spares boxes and 3 more taken from the spare 10litre water samplers. These were given to the CFC team to clean and fitted to the bottles for the following cast.

As both the swivels used on this cruise were brand new they were both trialed to prove their reliability. After cast 064 the swivel, s/n 1253-2, was deemed to be sufficiently tested and working well. It was swapped with swivel s/n 1253-1. They both worked fine and encountered no issues.

Two brand new LADCP's were used as the upward-looking unit during the cruise. After CTD cast 061 s/n 24465 was deemed to have proved itself as a reliable unit and was swapped for unit s/n 24466 so as to prove them both. There were a few issues with both units being used as slaves but on the whole they worked well and proved themselves fit for purpose.

On CTD cast 074 the termination failed on the deep tow. The electrical termination was re-done in the usual S&M CTD method as it wasn't appropriate to stop the science schedule for 24hrs while the PU cured.

On CTD cast 090 the termination appeared to fail as communication with the 11plus was interrupted several times during the upcast. Upon inspection of the wire, termination, and rotating junction box in the winch no fault could be found and full communication with the 11plus was possible. It was discussed with the PI whether he wanted the termination cut off and re-done or if there was any merit in simply re-doing the mechanical termination in a slightly different place in case the conductors had been crushed but not permanently damaged and thus save 4-5 hours doing the electrical termination. This course of action was agreed upon and the mechanical termination re-done.

It was suspected that the bull dog clamps may be too tight for the wire and were crushing the inner conductors as lots of errors and missed packets of data had been encountered on the previous few casts and the clamps had been re-tightened to 25Nm several times. For this reason a fourth clamp was added and they were all tightened to a lower torque value. They were tightened to 10Nm and load tested. The mechanical termination slipped slightly so was re-tightened to 11NM. This process was repeated until a satisfactory torque was achieved where the wire didn't slip and the cable wasn't visibly crushed too much. This was 10Nm on the first clamp nearest to the tear drop and 12Nm on the other three.

As soon as the CTD package was lifted over the side of the ship for CTD 075 communication with the 11plus was lost again and the wire found to be open circuit. The package had not yet touched the water. After an hour of testing the fault was not identified and the termination cut off. The wire was no longer open circuit. During the process of preparing the wire for termination it was tested again and found to be open circuit thus proving that the fault had not been in the original termination. After several further hours of testing a broken wire was found at the back of the rotating junction box inside the winch drum that leads to the slip ring. The earth wire was also found to have damage to its outer sheave that had previously been taped over. The chief engineer and ETO repaired the wire with a temporary butt splice and the termination process was finished off by the CTD techs as previously.

The deep tow was used until CTD cast 098 when the water depth had become less than 4000m and it was deemed suitable, by the master, to switch back to using CTD 1 for the casts shallower than 4000m. This was done to try and reduce the risk of having a termination fail and causing down time for science while it was repaired. By using the CTD wire when suitable it was possible to immediately switch back to the deep tow should the CTD termination fail as we had this wire ready to use.
For cast 106 to 114 the deep tow was used again as the water depth had increased above 4000m.

CTD casts 124 and 125 were 5-10m deployments for the purpose of surface water collection and filming the bottles close as part of an outreach video prepared by one of the scientists.

1.4 Summary of CTD casts per wire

Summary of which CTD casts were done of which wire:

CTD1
1-27
28 failed termination
29-49 winch stopped due to banging
99-105 over Namibian ridge
114-121

Deep Tow
50-74, re-termination
75-90, re-termination plus winch drum wire repair
91-98
106-113
122-125

1.5 Additional Notes

The deep tow wire installed on the James Cook during this cruise was previously supplied packed with grease. During use of this wire as a back up to both CTD wires the grease on the deep tow was regularly oozing out of the wire and dripping off the sheaves, rollers, P-frame and wire, and raining down onto all elements of the CTD package thus covering them in grease. Grease was found on the water samplers, the frame, most of the instrumentation and their associated cabling.

The quantity of grease was such that the CTD had to be spot cleaned with rag/blue roll before most deployments to remove the worst of the grease from the water samplers. It was not feasible to wash the CTD frame, bottles, instruments, etc. with hot soapy water before every cast as there was a risk of contaminating the bottles with respect to the CFC science that was taking place.

Around cast 080 or so it was decided to properly clean the water samplers with isopropanol as the quantity of grease was high and grease was being found on the water sampler lids, air-vent screws, sampling spigots and inside the bottles around the top o-rings. This was done jointly by the science team and technical team and under the guidance of the CFC team leader to ensure that no further contamination of the water bottles was incurred. No sooner had this been finished a large splurge of grease was found on a bottle that had been cleaned only minutes before.

From this point onwards it was agreed with the ship side that the P-frame would be left slightly outboard so that the falling grease would hopefully no longer land on the CTD package and scientists whilst they were sampling. Also the CPOS and chief mate took up a regular cleaning regime by using, initially the fire hose and thereafter, the pressure washer, to blast the grease off the P-frame rollers and the most out-board sheave of the P-frame. This washed a lot of the grease that was ‘rung’ out of the wire on each cast into the sea and reduced the amount that fell on the CTD package. It should be noted that grease was still regularly falling onto the CTD package and scientists but in a reduced quantity.

The pictures at the end of this report show some of the grease that was found on the CTD package after the above cleaning and new procedures for stowing the P-frame and cleaning it were introduced.

There is a definite risk of causing contamination of samples when the core wire is being used alongside the CTD package with the current levels of grease on the wire.

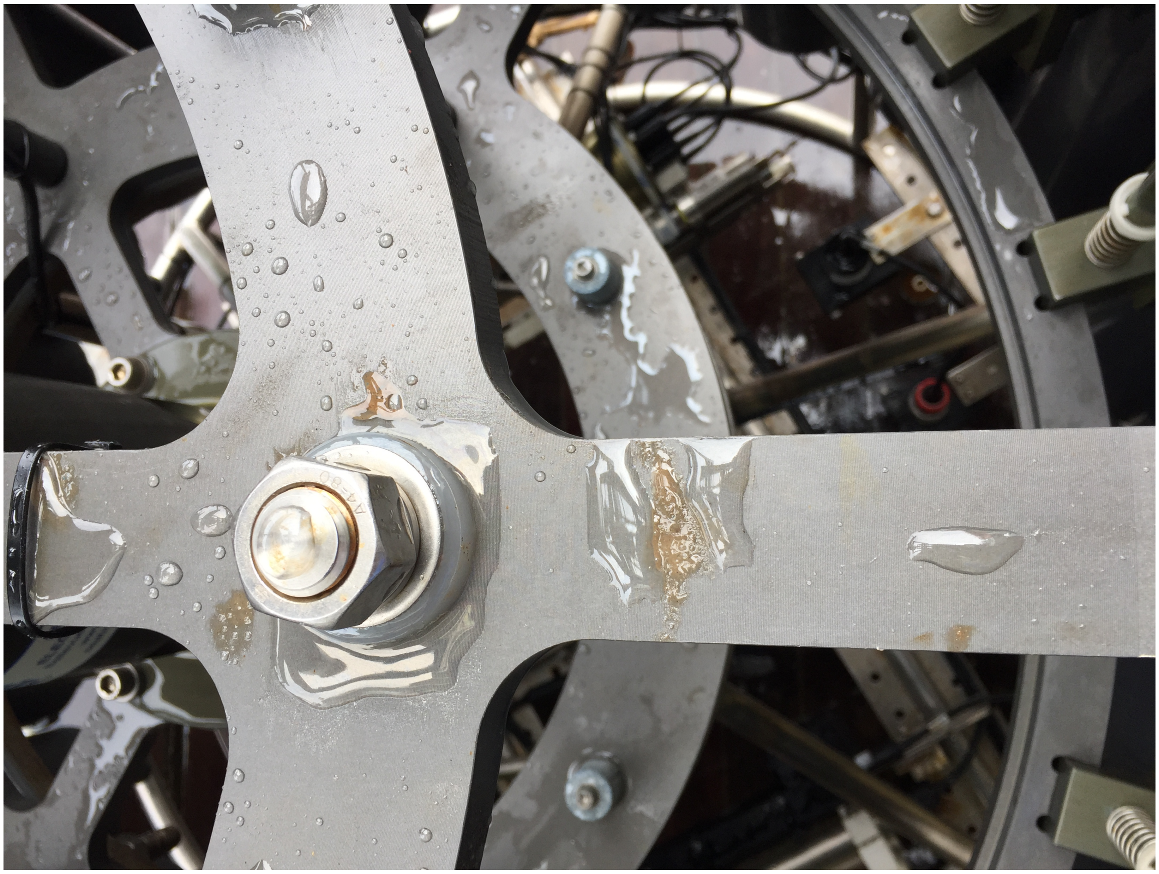


Figure 1.1: Top central section of CTD frame viewed from above.

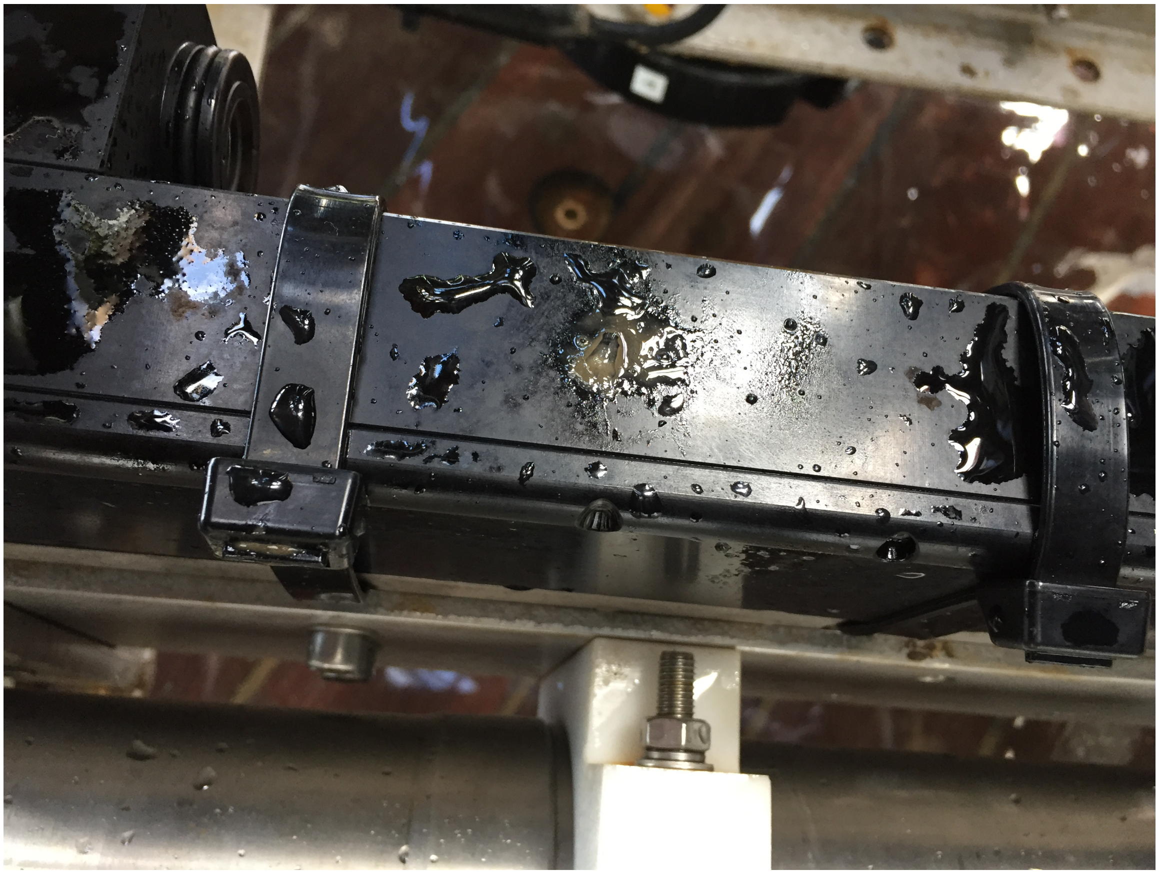


Figure 1.2: Top face of transmissometer

Figure 1.3: Downward-looking LADCP and mounting bracket viewed from above

Figure 1.4: LADCP battery pack viewed from inside the CTD frame

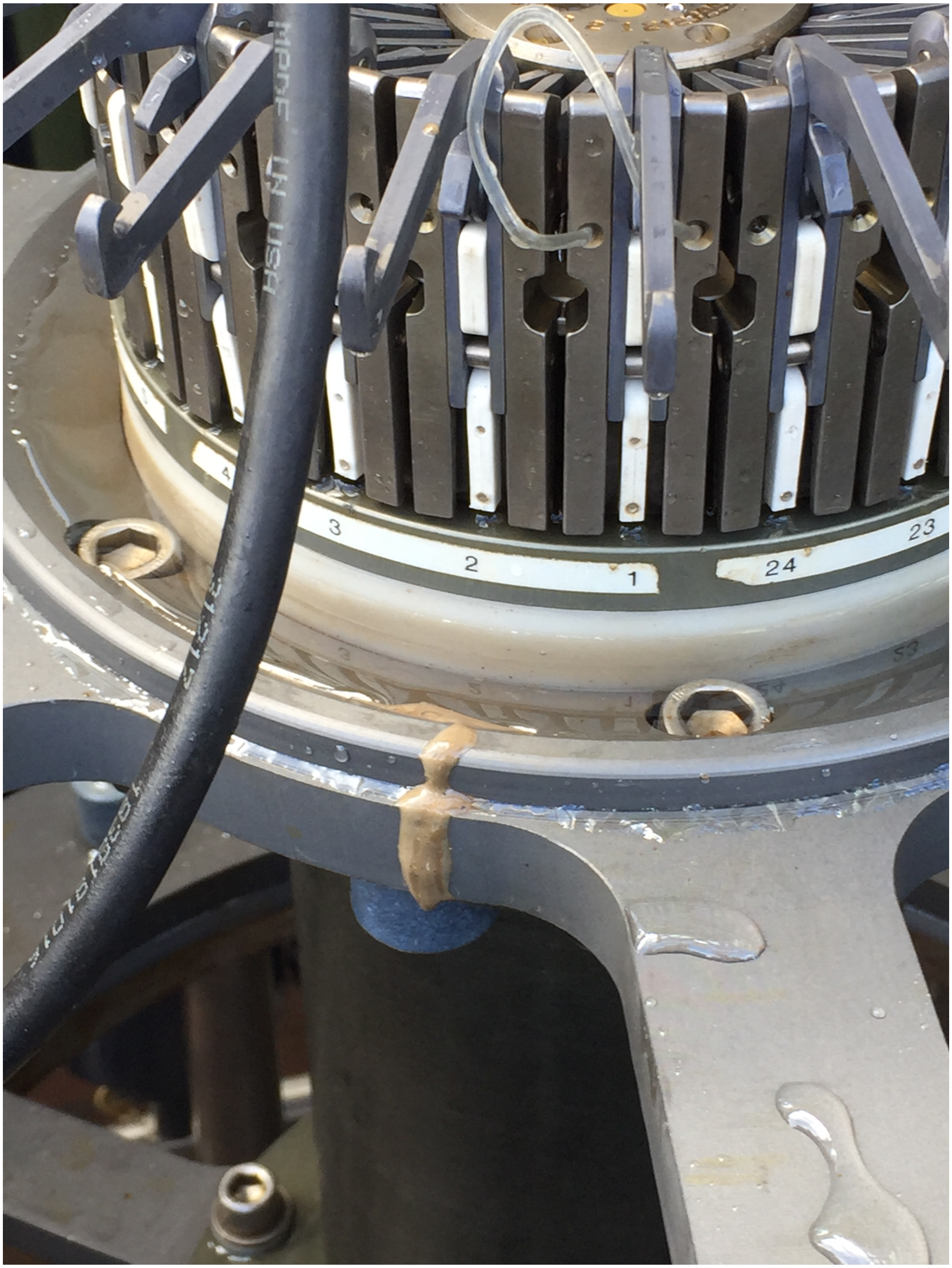


Figure 1.5: The SBE32

Figure 1.6: Typical example of the state of the water samplers

William Platt and Jeffrey Benson

2. CTD Processing and Calibration

The sensors on the JC159 CTD package are: temp1, temp2, cond1, cond2, oxygen1, fluorometer, transmissometer, backscatter (turbidity), and two lowered Acoustic Doppler Current Profilers (LADCPs). For stations 036 to 040 there was an additional oxygen sensor, oxygen2.

2.1 SBE Data Program: Initial Processing

The NMF team does the initial CTD processing using the SBE Data Processing software at the end of every cast by running the following options:

Data Conversion – converts the raw frequency and voltage data to engineering units where applicable by applying factory calibrations from the CON file. The converted downcast and upcast data is then saved to the ctd_jc159_nnn.cnv output file.

Align CTD – takes the .cnv file as input and applies an alignment to the oxygen sensor in time relative to pressure.

Cell Thermal Mass – takes the CTD_JC159_nnn_align.cnv file as input and applies a thermal correction of the conductivity cell to minimize bad salinity readings in steep vertical gradients due to temperature/conductivity discrepancies. What were the constants applied? This file is saved as ctd_jc159_nnn_align_ctm.cnv

Files we get from SBE processing:
JC159_nnn.bl
JC159_nnn.ros
JC159_nnn.cnv
JC159_nnn.btl
JC159_nnn_Align.cnv
JC159_nnn_Align_CTM.cnv
JC159_nnn_Align_CTM_Dve.cnv
JC159_nnn_Align_CTM_Dve_2Hz.cnv
JC159_nnn_Align_CTM_Dve_Strip.cnv
JC159_nnn_Align_CTM_Dve_2Hz_Strip.cnv

The above files are copied to Mexec processing directory by running ctd_linkscript on the eriu terminal. The Dve files are sent to BODC automatically.

2.2 Mexec CTD Processing

The Mexec processing suite is a set of Matlab and shell scripts developed by Brian King (NOC) and updated by numerous users, including substantial recent updates by Yvonne Firing. All CTD processing and calibration for JC159 was executed using Mexec v3.2. The four principal file types are:

- ctd_*.nc, containing all CTD time series -- raw, 24Hz, 1Hz, psal -- and profiles -- 2db and 2up;
- dcs_*.nc, containing information about the cast start, bottom and end points: scan, time, and position;
- fir_*.nc, containing information about bottle firing scans, times, and CTD data;
- sam_*.nc, containing CTD data from bottle firing times along with corresponding calibration sample data and flags.

Additional files generated for sample data, feeding into the sam_*.nc files, are listed in Section 2.4.

2.3 JC159 CTD Processing Procedure

After the files were converted and synced from the remote directory to the processing directory using ctd_linkscript, the output files: ctd_jc159_nnn.bl, ctd_jc159_nnn_ctm.cnv, and ctd_jc159_nnn_noctm.cnv were ready to be used for post-processing after each CTD cast.

The first step was to initialize the environment for Mexec processing by running m_setup in Matlab. We also noted any flags for Niskin bottles (e.g. misfired, not fired, or leaking; see Section 2.4.1) in the mbot_01 case of the opt_jc159.m script.

The steps run after each CTD cast are shown in Table 2.1. The steps covered by the wrapper scripts are summarized here.

ctd_all_part1: This script sets up an empty sam_jc159_nnn.nc (using sam_jc159_varlist.csv); loads and parses data to ctd_jc159_nnn_raw.nc (from 24Hz ascii .cnv CTD data files produced by the SBE processing software and ctd_jc159_renamelist.csv); ctd_jc159_nnn_24Hz.nc (after applying oxygen hysteresis correction); ctd_jc159_1hz.nc (from averaging data to 1Hz); ctd_jc159_nnn_psal.nc (calculate derived variables from 1Hz); dcs_jc159_nnn.nc (data identifying the bottom time of the CTD cast); and ***ctd_jc159_nnn_1hz.txt (ascii listing of the 1hz to be used for LADCP processing).

mdcs_03g: Graphical interface for choosing the start of the CTD downcast (lowest pressure post-soak) and the end of the upcast (oxygen becomes out of water first). Scans written to dcs_jc159_nnn.nc *ctd_all_part2:* This script extracts and parses data to ctd_jc159_2db.nc and ctd_jc159_nnn_2up.nc (by dividing the psal file into down and up casts using info from the dcs file; sorting, interpolating over gaps and averaging to 2db), fir_jc159_nnn_time.nc (using/from SBE .bl file and CTD upcast data – the CTD fir data then gets pasted into sam_jc159_nnn.nc); win file with winch data (from ctd_jc159_nnn_1hz.nc. Winch data also gets emerged into fir file); sam_jc159_nnn.nc gets updated with winch fir data, default niskin bottle numbers and firing flags.

mctd_checkplots; Generates plots of raw, 1hz, 2db data and shows a user defined series of casts to be plotted together.

mctd_rawshow; Generates plots of raw and 1hz data to allow the user to examine/check the quality of the data.

If spikes in pressure, temperature, conductivity, or oxygen were evident,
mctd_rawedit; Graphical interface that allows the user to manually select spikes in the temp, cond, and oxygen sensors. Outputs data to ctd_jc159_nnn_cleaned.nc (symbolically linked to ctd_jc159_raw.nc)

smallscript_postedit; Regenerates derived files from ctd_all_part1 and 2.

Alternatively, if the spikes were too large or too time consuming for manual edits, the mctd_rawedit case in opt_jc159.m could be edited to set bad scans to NaN for all the variables, or to despike***. Temperature-specific spikes could be edited in the mctd_01 case of opt_jc159.m cruise an rerun from the beginning.

lad_linkscript_ix; This script syncs data from the remote directory o the processing directory structure and creates links with Mexec conventional filenames pointing to these data files.
cd /local/users/pstar/cruise/data/ladcp/ix; cfgstr.orient = ‘DL’; %set to LADCP downlooker for processing

process_cast_noinv_cfgstr(nnn,cfgstr); This script processed data from the LADCP. For any missing LADCP data, the populate_station_depths case in opt_jc159.m was edited to set water depths for some stations

klist = [n:p]; smallscript_botnav; runs populate_station_depths to get the depth from the LADCP if available, the CTD depth + altimeter if not, or opt_jc159 if specified. Then this script takes in for one or multiple files, the depth, navigation and bottle data, and paste bottle firing quality flags from bot_jc159_01.csv to bot_jc159_nnn.nc; paste bottle firing codes into sam_jc159_nnn.nc; paste water depth information into headers of all CTD files, paste lat and lon from navigation into dcs_jc159_nnn_pos.nc; and lat and lon at the bottom of cast into headers of all CTD files.

		station number
always	eriu>	ctd_linkscript
always	>> stn = n;	ctd_all_part1
always	>> stn = n;	mdcs_03g
always	>> stn = n;	ctd_all_part2
always	>> stn = n;	mctd_checkplots
always	>> stn = n;	mctd_rawshow
as needed	>> stn = n;	mctd_rawedit
as needed	>> klist = n;	smallscript_postedit
always	eriu>	lad_linkscript_ix
always	>>	cd cruise/data/ladcp/ix; cfgstr.orient = ‘DL’; process_cast_noinv_cfgstr(n, cfgstr); cd ../..
as needed	edit populate station_depths case in opt_jc159.m to set water depths if LADCP doesn’t get them right edit mbot_01 case in opt_jc159.m to set Niskin flags if necessary	
always	>> klist = n;	smallscript_botnav

Table 2.1: Post-cast processing checklist based on the CTD processing logsheet

Refer to A User Guide Guide to Mexec v3.2 for further details.

2.3.1 CTD processing choices and new additions for this cruise

Cruise-specific options (see the Mexec User Guide) used are summarised in Table 2.2 below.

In addition to the standard hand-editing of isolated, moderate spikes in mctd_rawedit.m, automatic editing of the raw files can be done either at the mctd_rawedit stage or at the mctd_02a stage. The latter is appropriate if there are large spikes in temperature or if the pumps switched off; in this case to avoid contamination of the conductivity and oxygen fields it is necessary to load the original .cnv file with no cell thermal mass or align corrections applied yet, edit out the bad data, and then apply the align and cell thermal mass corrections. Stations for which this processing path was followed are listed in Table 2.2 below. Generally it is evident by the mdcs_03g stage if this path will be necessary; in any case, it requires removing the ctd_jc159_nnn_raw.nc file, changing a flag in the mctd_01 case of opt_jc159.m (see Table 2.2) and restarting from ctd_all_part1. Parameters for editing out-of-range values, despiking, and editing out data affected by pumps turning off (including a delay of half a second to restore good temperature and conductivity data, and 8 seconds to restore good oxygen data) were included in the mctd_02a case of opt_jc159.m

The correction for oxygen sensor hysteresis was applied in the Mexec software (mctd_02b) rather than in the SBE data processing software. The SBE default parameters were used, leaving in deep downcast-upcast differences of no more than 1 umol/kg, with no significant trend over time. Applying the correction in the Mexec software allowed us to edit out spikes first, as discussed above.

It was observed that the precision of the turbidity stream output in the .cnv files by SBE Processing was truncated. We added code to mctd_02b to calculate turbidity from turbidity volts (also output, at full precision).

Primary sensor: There were 2 SBE911 CTDs on the JC159 CTD frame. CTD one was attached to the bottom part of the rosette, and CTD two was attached to the protruding fin between Niskin bottles 8 and 9 on the CTD frame. Because of their placement under the rosette, the first set of sensors are much more affected by the package wake, producing wavy profiles. For this reason, CTD two was chosen to be the "primary" sensor. Neither conductivity nor temperature showed significant pressure hysteresis, and with the exception of some minor noisiness, both sets of sensors remained stable throughout the cruise. There was no need to replace any of the temperature or conductivity sensors with spares.

scriptname	oopt	default (from get_cropt.m)	
mctd_01	redoctm	start processing from the _align_ctm.cnv file (corrections for oxygen sensor alignment and cell thermal mass made in SBE Processing software)	for stations 52, 53, 58, 60, 66, 69, 74, 77, 81, 90, start from the basic .cnv file before align or ctm corrections applied (they will instead be applied in mctd_02a, after automatic editing)
mctd_02a	corraw	no automatic edits applied to raw file	for stations listed above, apply editing to remove: scans when pumps were off (plus some time afterwards); out-of-range values; spikes
mctd_02b	calibs_to_do	oxygen hysteresis	oxygen hysteresis and conversion from turbidity volts to turbidity
mctd_03	s_choice	s_choice = 1; %sensor 1 is primary (for both	s_choice = 2; %sensor 2 is primary

		T and C)	
mfir_01	fixbl		on station 74, termination was failing so .bl and .btl files erroneously recorded the scan for position 21 as being for 2 (in addition to the existing good value for position 2); fix this
mfir_03			fillstr = ‘10’; %max gap length to fill is 10 s
mbot_00	nispos		list of niskin inventory numbers in position order (changed at station 51, 101, 104)
mwin_03			When winch is switched from auto control to manual control for recovery, usually around 100 metres, the winch telemetry is off for a few seconds, which sometimes shows up as zero wireout at the bottle closure time. Fix for stations 5, 6, 16, 16.
mctd_rawedit	autoeditpars		on station 90, despike at this stage
populate_ station_ depths	fnin		by default get depths from a text file based on LDEO IX LADCP bottom depths
	bestdeps		manually set depths for stations 9 (no LADCP), 27, 28 (aborted casts), 33, 89, 124, 125 (shallow stations), 41, 63, 77, 78
mbot_01	botflags		set some Niskin flags to 3 or 4 if leaking or misfired, or 9 if they were fired but no samples were drawn
cond_apply_ cal			sensor 1: condout = cond.*(1+interp1([0 1500 6000],[1 1 0]*1e-3,press)/35) sensor 2: condout = cond.*(1+interp1([0 1500 3000 6000],[-1.6 0.8 -0.7 -2.2]*1e-3,press)/35)

oxy_apply_cal	oxyout = oxyin.*(1.036 + interp1([0 800 6000],[1 0 -2]*1e-4,press).*stn) + interp1([0 400 1250 2000 3000 4000 6000],[-2.7 0.25 2.75 5.6 7.5 8 7.1],press)

Table 2.2: Summary of JC159- specific options related to Mexec CTD processing (see Mexec v3.2 User Guide and opt_jc159.m for more).

2.4 Niskin Bottle Sample Data

2.4.1 Niskin Bottles

All 24 niskin bottles on the rosette had 20 L capacity. After each cast all bottles were checked to ensure they had fired properly and any issues with misfires, leaking or dribbling were noted in the sample log and, where appropriate, annotated in the mbot_01 case of the opt_jc159.m script. All bottles started with an initial flag of 2 and during CTD processing new quality control flags were assigned to bottles that had been flagged either during sampling or during data checks described in Section 2.4.2.

Following WOCE standards, quality control flags were assigned as follows:
Flag 2 = No problems noted (default)
Flag 3 = Leaking (note this was interpreted to mean leaking obviously, e.g. from around the end cap, not just dripping from the spigot)
Flag 4 = Misfire (wrong depth), did not fire at all, pumps were off, or did not trip correctly
Flag 9 = Samples not drawn from this bottle

Where the Niskin was flagged as either 3 or 4, all bottle samples were also flagged 4 (bad). A total of 35 were flagged as 3 or 4 based on observation around the rosette, with an additional 10 flagged as 4 based on sample values that suggested the bottle had closed at a shallower depth, and 2 flagged as 4 because the CTD pumps were off at the time the bottle fired (due to wire glitches).

Upon recovery of the CTD at station 59, it was discovered that niskin bottle caps had not been fastened properly (about 15 caps total were lost and the remainder were not secure); therefore no samples were taken for this station.

Before station 51, the Niskin bottles were shifted one slot over around the rosette, while still being hooked to the same firing positions (such that the wires formerly running up and half a space to the right subsequently ran up and half a space to the left). The exception to this was the bottles in positions 18 and 19, which were switched. Upon recovery of station 100, the CFC team conducted a sparging exercise, taking the bottle from position 1 and replacing it with a spare (for station 101 on). Upon recovery of station 103, the sparged bottle was returned to position 1, and the niskin from position 2 was removed for sparging; the spare bottle was put in position 2. Within the Mexec processing the Niskin bottles were tracked using the last 4 digits of their unique inventory numbers.

At station 85 the CFC analysts reported seeing contamination in their samples, so at station 86 a thorough visual inspection of the CTD rosette was done. It was apparent that there was grease outside and inside some of the niskin bottles (particularly 5 and 6). This was cleaned away with alcohol and subsequently the P-frame was moved away (by rolling out slightly) from the CTD to minimize the CTD's exposure to grease dripping from the rollers on the P-frame. After the cleaning and change in procedures, no further issues were reported from the CFC team.

In an attempt to discover the effects of any contaminated bottles (particularly for CFCs), and then to mitigate the effects of the grease (which tended to be found preferentially on bottles 5 and 6) on deep samples, starting from station 85 the bottle firing sequence was shifted, so that niskin 13 was the deepest and 12 the shallowest.

2.4.2 Mexec Sample Files

At the start of the cruise, empty sam_jc159_nnn.nc files were created for each station, as well as the appended sam_jc159_all.nc. As chemistry and tracer data from Niskin samples analysed aboard the ship became available, they were loaded into mstar files for each sample type group: sal_* for salinity, oxy_* for oxygen, nut_* for silicate, phosphate, nitrate and nitrite, co2_* for total alkalinity and DIC, and cfc_* for transient tracers. They were then merged with the CTD, winch, and Niskin flag data in the sam_jc159_nnn.nc files.

This was accomplished by calling smallscript_load_botcaldata.m was configured to perform the two or more required steps for given stations for each sample type, including computing standards offsets for salinity and oxygen concentrations, converting from per L to per kg where applicable, and the final step of applying bad flags to sample values where indicated by the Niskin flag or by opt_jc159, and pasting the updated contents of each sam_jc159_nnn.nc file into the appended sam_jc159_all.nc file. See the Mexec v3.2 User Guide for more details.

Total good samples reported for each type at each station are included in Appendix A. After quality control (2.4.3), not counting misfired Niskins, 99% of salinity samples, 91% of oxygen samples, 99.9% of nutrient samples, and 99% of carbon samples were good.

The chlorophyll filtration and isotope sample data to be analysed ashore were assigned a flag of 1 where collected, using msam_ashore_flags.m to read in the logsheets provided by the respective samplers.

2.4.3 Mexec quality control for sample values

Bottle sample data are checked using three primary scripts:

msam_checkbottles_01 plots one sample type for a range of stations, as well as residuals from the CTD values (for salinity and oxygen) or from the mapped values (for other quantities; see Section 2.6). Already-flagged points are marked, and points for further investigation can be selected using the GUI interface.

msam_checkbottles_02 plots profiles of several sample types for a single station, as well as neighbouring stations' values and the CTD or mapped profiles for comparison.

ctd_evaluate_sensors.m (for salinity and oxygen) allows comparison of bottle sample values against CTD 1 Hz data as well as the CTD values at bottle firing times; this is helpful to distinguish good samples which simply have a large residual from the CTD values due to strong gradients or high variability

Flags on sample values determined at this stage were incorporated into the sam*.nc files by adding them to a file, ctd/ASCII_FILES/bottle_data_flags.txt and rerunning msam_02b and msam_updateall. Because each line in this file is used only once, they were later added to the appropriate cases (e.g. mnut_01, moxy_01, etc.) in opt_jc159, so that if data were reloaded the modified flags would persist.

2.5 CTD Sensor Calibration

2.5.1 Calibration of the Conductivity Sensors

Both conductivity sensors were calibrated by comparing the upcast data at bottle firing times with conductivity from the analysed bottle sample salinities (section 3, Autosal). The CTD-bottle residuals showed some pressure dependence (Figure 2.1; the sensor 1 plots, not shown, are similar). In addition, deep residuals (below 1500 m, where salinity stratification is relatively low and the CTD and bottle values can be expected to compare well) were quite stable from station 3 to station 85, and then stable at a different level from approximately station 90 to station 123. The fact that the difference between the two CTD sensors (Figure 2.1, cyan dots) did not change, however, suggests an issue with the bottle salinity analyses (possibly an undetected shift in standardization) rather than a (sudden, and shared) shift in the CTD calibration.

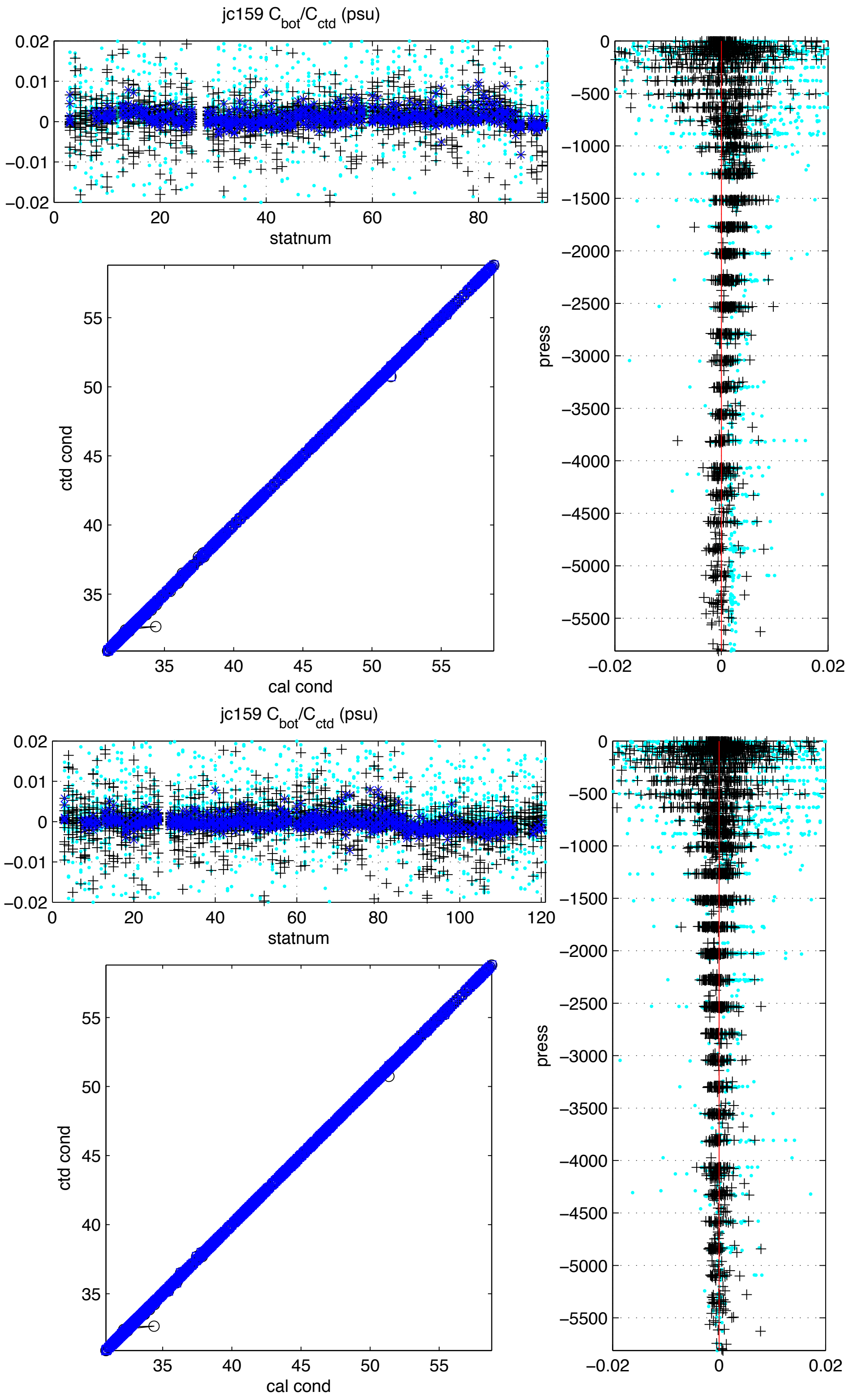


Figure 2.1: Comparison of bottle and CTD2 conductivity (in salinity equivalent units) before (top) and after (bottom) calibration. The top left panels show residuals as a function of time, with values deeper than 1500 m plotted in blue. Cyan dots are the differences between the two CTD sensors.

Based on stations 3-85, we derived the offsets listed in Table 2.2 above. These offsets were applied to the 24-Hz CTD conductivities for the entire cruise; the averaging and profile-construction steps were then re-run starting from the calibrated 24 Hz data. The final residuals over all stations (Figure 2.2) had an average of zero, with 50% of the values being less than +/- 0.002 psu.

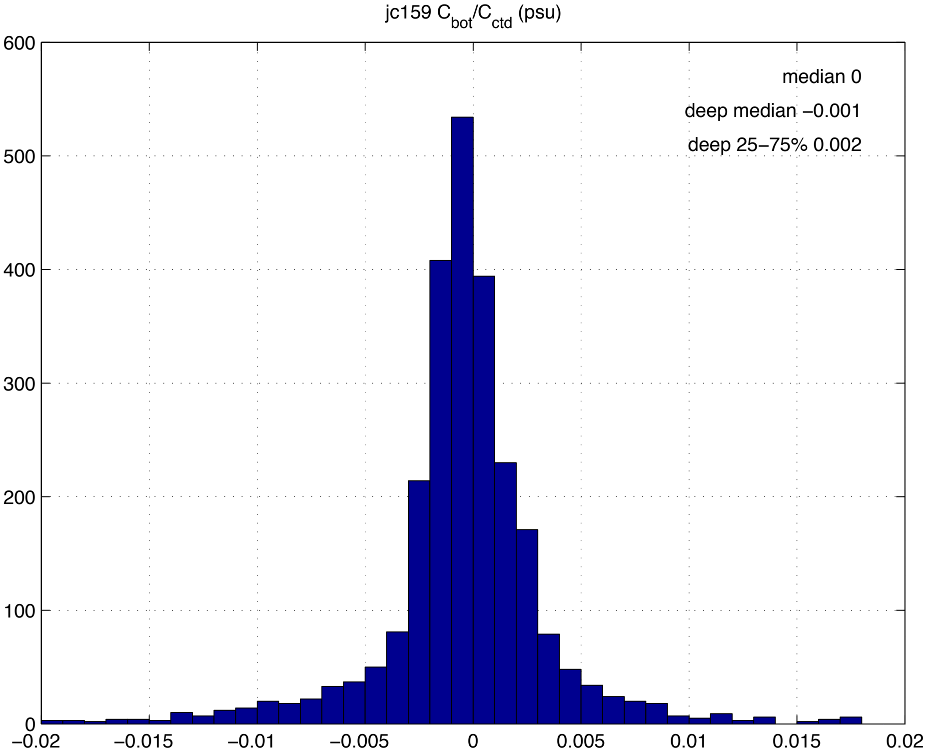


Figure 2.2: Histogram of calibrated conductivity residuals (in salinity equivalent units).

2.5.2 Calibration of the Oxygen Sensor

Because of uncertainty in the bottle oxygen titrations from the initial stations, a secondary oxygen sensor was added to the CTD package from CTD station 36 to CTD station 40. The secondary was then removed from the frame to preserve the spare in case anything happened to the CTD package or instrumentation, since only three sensors were available. The secondary oxygen sensor was not calibrated.

The oxygen sensor data from bottle firing times (on the upcast) were compared with 2288 oxygen bottle sample values to derive a calibration function to be applied to the CTD oxygen time series (both down- and up-cast; note that the hysteresis correction was applied at an earlier step). The initial residuals (Figure 2.3) were around 5 umol/L, with a small depth-varying trend and a dependence on pressure as well as oxygen value. Larger residuals were observed for stations up to 33, when there was reason to doubt the accuracy of the oxygen titration values (see Section 5), while from station 35 on the CTD-bottle comparisons were relatively stable. Therefore, to avoid overfitting to uncertain results, data from stations 35-123 were used to choose the CTD oxygen calibration function for the entire cruise.

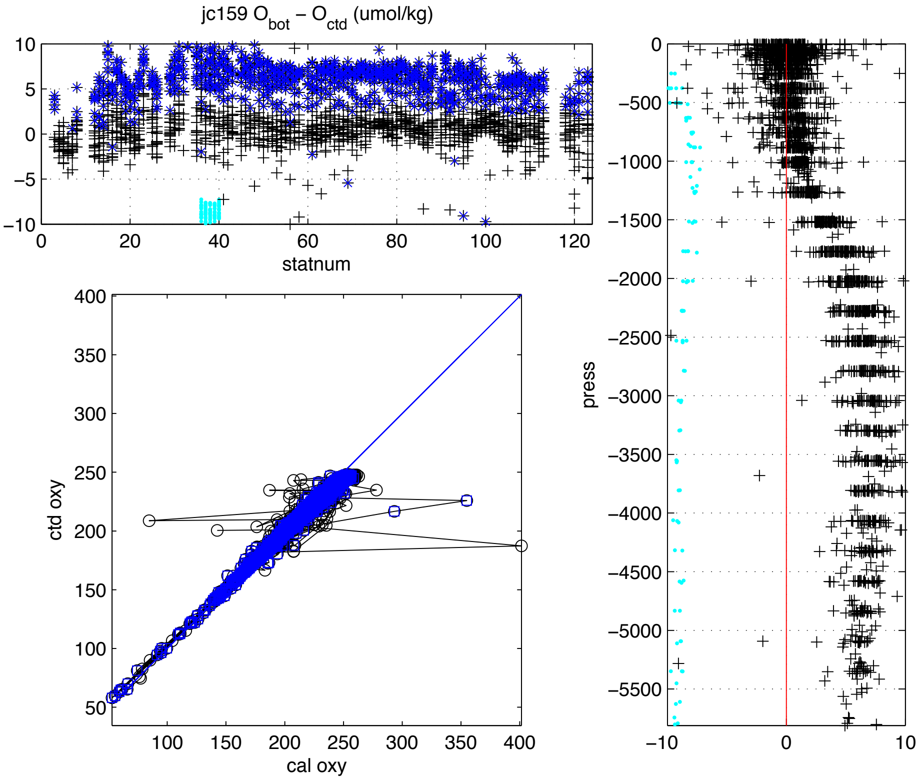


Figure 2.3: Comparison of bottle and CTD oxygen before calibration; as in Figure 2.1, values deeper than 1500 m are plotted in blue on the time series and scatter plots, and differences between the two CTD oxygen sensors (on the few casts with two sensors) in cyan.

The calibration function took the form of a pressure- and time-varying scale factor plus a pressure-varying offset (because of the strong correlation between temperature and pressure in this dataset, we did not attempt to fit a separate temperature dependence). The calibration is given in Table 2.2. Following calibration, residuals had a median of < 0.1 umol/L and a 50% range of 1.335 over all stations (Figure 2.4) or 1.071 over stations 35-123.

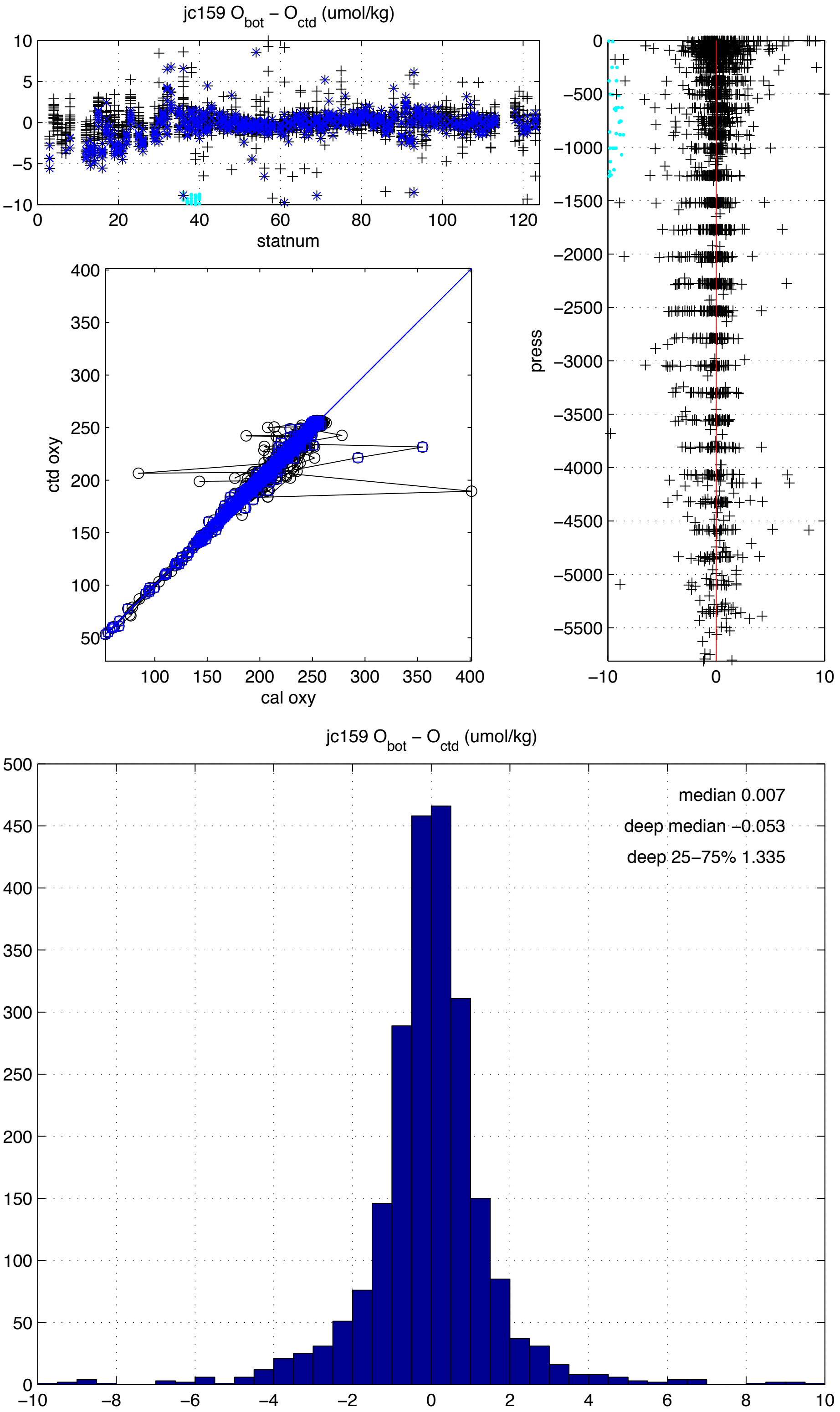


Figure 2.4: Comparison of bottle and CTD oxygen after calibration, as in Figure 2.3 (top panels), and histogram of calibrated residuals (bottom).

2.5.3 Other Sensors

The CTD temperature, fluorescence, transmittance, and turbidity sensors were not calibrated. Temperature sensor differences were stable throughout the cruise. 118 Niskin samples from 44 stations were filtered for chlorophyll A to be analysed ashore, which may enable later calibration of fluorescence.

2.6 Output Files

Throughout the cruise, comma-separated-value files of CTD bottle-firing data were produced for use by the sample analysts by running mctd_makelists.m; as sample values were made available they were updated with these values and flags as well. Script mout_sam_csv produces a list in reverse depth order to match the nutrient analysis order.

Finally, 2-decibar averaged downcast data (from ctd_*2db.nc files) and CTD and bottle sample data (from sam_jc159_all.nc) were output as WOCE exchange-format files suitable for submission to CCHDO.

A gridded CTD file and mapped bottle data file was produced by msec_run_mgridp, and used to make updated section plots throughout the cruise (Figure 2.5), and as the background from which to compute residuals for msam_checkbottles_01 and msam_checkbottles_02 (2.4.3).

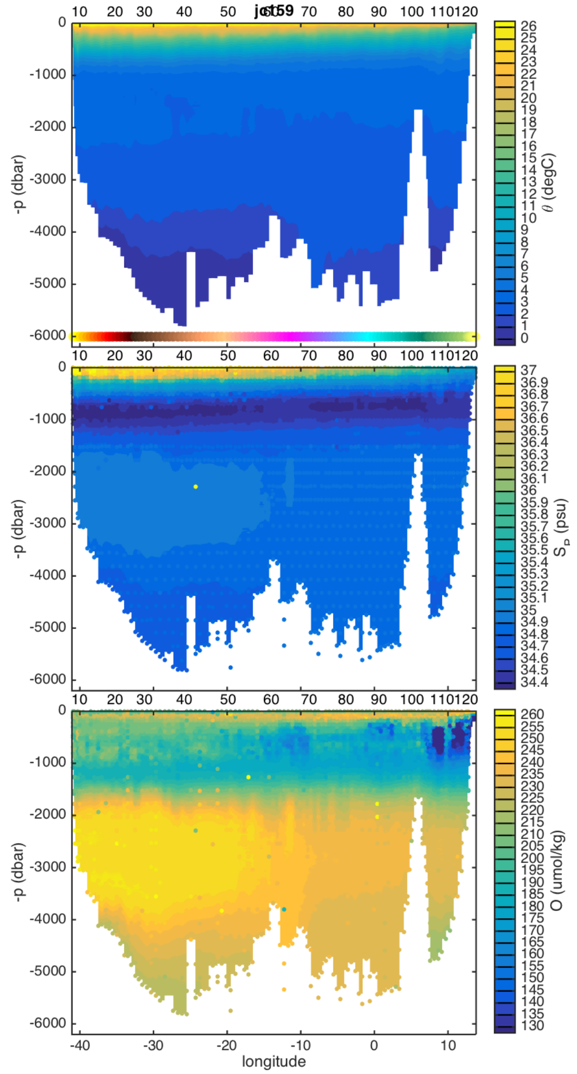


Figure 2.5. Gridded CTD temperature, calibrated salinity, and calibrated oxygen, with salinity and oxygen Niskin sample values as dots.

Yvonne Firing and Alejandra Sanchez-Franks

3. Autosal: Water Sample Salinity

A Guildline 8400B, s/n 65764, was installed in the Electronics Workshop as the main instrument for salinity analysis. The Autosal set point was 21C, and samples were processed according to WOCE cruise guidelines: The salinometer was standardized at the beginning of the first set of samples, and checked with an additional standard analysed prior to setting the RS. Once standardized the Autosal was not adjusted for the duration of sampling.

A standard was analysed after each crate of samples to monitor & record drift. Standards were labeled sequentially and increasing, beginning with number 9000. Standard deviation set to 0.00002. 125 crates of salinity samples were analysed, with 190 bottles of standard used to monitor the instrument drift.

The electronic standby value after the standardisation was stable at 6096 to 6097 for most of the cruise, until the conductivity cell began to have difficulty re-filling all the arms following flushing. These problems are typically associated with analyzing large numbers of samples; the cell can have residual build-up of deposits that prevent the smooth flow of water through the glass. A further problem developed with water no longer being completely flushed from the capillary tubes and the large bore Tygon tubing connected to the capillaries. The unit front cover was opened after securing the power, and all tubing removed, cleaned and dried. Turning the power off resulted in the standby value decreasing significantly. The value then increased daily, eventually recovering to 6096-6097 at the end of sampling. A second flush, clean and dry of the capillary tubing assembly was undertaken, but without securing the power, to avoid the standby drift and to limit the amount of down time before sample analysis could be resumed. The instrument will be returned for investigation and resolution of the standby drift, conductivity cell adhesion, possible internal pump reduction in flushing capability and capillary tubing assembly contamination with sample water.

The spare salinometer, s/n 68426, was not considered usable in its present state, as at the end of the previous cruise the stirrer motor was not operating consistently. Evaluation of the motor, the tightness or looseness of the belt, possible stirrer shaft corrosion, etc. will be undertaken ashore.

William Platt and Jeffrey Benson

4. Inorganic Nutrient Analysis

A 4-channel Seal Analytical AA3 autoanalyser was set up in the Chemistry lab of the RRS James Cook for the analysis of micro-molar concentrations of dissolved inorganic nutrients (silicate, phosphate, nitrate plus nitrite and nitrite). As part of the ORCHESTRA fieldwork programme the objectives of JC159 was to measure the special and temporal variation of dissolved inorganic nutrient along the 24 south line in accordance with GO-SHIP protocols. Between the 2nd of March and the 5th of April, 115 hydrographic stations and 2616 samples were analysed.

4.1 Methods

Samples were collected directly from the 24 x 20 L stainless steel rosette after the TA/DIC into pre-labelled 15ml centrifuge tubes (rinsed three times with water from the same Niskin). Samples were analysed directly from the collection tubes within 2-8 hour and measured from the lowest to the highest concentration (surface to deep) to reduce any carry over effects. Milli-Q water was used for the baseline and wash solution during each run. All unique sampling depths were sampled and analysed.

Seal Analytical chemistry and cleaning procedure protocols used during JC159 were:

i) Silicate in seawater method No. G-177-96 Rev 10 (Multitest MT19).
ii) Phosphate in water method No. G-175-96 Rev. 15 (Multitest MT 18).
iii) Nitrate and nitrite in seawater method No. G-172-96 Rev. 13 (Multitest MT19).
iv) Nitrite in seawater method No. G-062-92 Rev. 3.

Standards were prepared fresh every one – two days by diluting the stock solutions of the different nutrients (table 1) in ASW (35 g/l sodium chloride plus 0.2 g/l sodium hydrogen carbonate).

Each run of the system had a 6-point calibration series. Prior to analysis all samples and standards were brought to room temperature of ~20° C. Concentrations of the working standards was adjusted throughout the cruise for silicate and phosphate depending on the high values measured in the bottom waters (Table 4.2).

Compound	**Weight (g)**	**Molarity stock solution**
Potassium Nitrate	0.5075 in 1L	5.0148
Sodium Nitrite	0.3508 in 1L	5.0841
Potassium Dihydrogen Phosphate	0.6784 in 1L	4.9882
Sodium Metasilicate pentahydrate (St. 1-86)	2.13375 in 500ml	20.116

Sodium Metasilicate pentahydrate (St. 87-123)	2.12242 in 500 ml	20.009

Table 4.1: Compounds used to prepare stock standard solutions, weight dissolved in 1 L or 500 ml of Milli-Q water and Molarity of the solution.

Chemistry	Stations	Standard 1 (μM/L)	Standard 2 (μM/L)	Standard 3 (μM/L)	Standard 4 (μM/L)	Standard 5 (μM/L)	Standard 6 (μM/L)
NO3+NO2	St. 4-13	2.41	10.84	21.28	31.72	42.15	-
	St. 14-123	1.10	2.21	10.44	20.67	30.90	41.14
SiO2	St. 4-13	10.08	25.20	50.40	75.60	131.04	-
	St. 14-47	1.01	10.08	25.20	50.40	75.60	131.04
	St. 48-62	1.01	10.06	25.15	50.29	75.44	110.64
	St. 63-104	1.00	10.00	20.12	30.17	50.29	70.41
	St. 105-113	1.00	10.00	25.01	50.02	75.04	110.05
	St. 114-123	1.00	10.00	20.01	30.01	50.03	70.03
NO2	St. 4-13	0.41	0.81	1.22	1.63	2.03	-
	St. 14-20	0.102	0.203	0.407	0.610	0.813	1.017
PO4	St. 4-13	0.10	0.40	0.80	1.60	2.49	-
	St. 14-47	0.05	0.10	0.40	0.80	1.60	2.49
	St. 48-66	0.05	0.10	0.40	0.80	1.60	2.10
	St. 67-123	0.05	0.10	0.40	0.80	1.60	2.49

Table 4.2: The standard concentrations used for each chemistry during JC159.

On the 26/3/2018 station 87 after the calibration series it was noted the slope of the correlation coefficient had changed for silicate from an average of 7.58E+02 to 8.2E+02 for the same standard range. Remaking the working standards did not resolve the problem. After many test we concluded the primary silicate standard had become unstable/contaminated (unknown reason). A new Si stock solution solved the problem.

4.2 Maintenance

At the start of the cruise, installation of the AA3 took approximately two days, involving the fitting of new pump tubing and new cadmium column and making all regents.

Prior to the cruise all labware was washed with 10% HCl and rinsed with Milli-Q water. Once on board, all labware was re-rinsed several times before use.

Following each run, each analytical channel was flushed with wash solutions and the autosampler with Milli-Q water following Seal Analytical cleaning protocols. At least once per week the instrument was re-tubed and thoroughly cleaned with sodium hypochlorite for approximately 30 minutes (nitrite, nitrate, phosphate and silicate line).

Batches of ASW were prepared every two days and the different chemical reagents were prepared from daily, to every 2 or 3 days. Milli-Q water used for the baseline/wash was not stored in a carboy for > 24h.

4.3 Quality Controls (QCs)/ Analyser Performance

Cadmium column reduction efficiency: The reduction of the nitrate (NO3-) present in a sample to nitrite (NO2-) is achieved by passing the sample through a column filled with granular cadmium (cadmium column); cadmium is oxidised and nitrate is reduced. With use, the capacity of the cadmium column to reduce nitrate diminishes. The reduction efficiency was determined in every run by measuring nitrite and nitrate standards of similar concentrations (5 µM L-1). The ratio of nitrate to nitrite expressed as a percentage provides an indication of the reduction efficiency of the cadmium column. For the analysis to produce reliable results, the oxidation efficiency needs to be >90%. When the efficiency is lower, the cadmium column is typically replaced. New cadmium columns are conditioned by passing a high nitrite standards (2mM L-1) followed by flushing with ammonium chloride. Throughout JC159 the efficiency of the columns did not drop below 95 % however in total we used 7 Cd columns. In each case, the column was replaced due to a build-up of backpressure probably caused by air entering the column.

CRM: In order to test the accuracy and precision of the analyses, CRMs from The General Environmental Technos Co., Ltd., (KANSO) were measured in triplicate in every run. For the duration of JC159 KANSO CRMs lot CD, CJ and lot CB were used; certified concentrations are shown in Table 4.3. However, our methods seem to overestimate nitrite.

	Nitrate	Nitrite	Silicate	Phosphate
KANSO CB	36.7 ± 0.27	0.119 ± 0.0057	111.9 ± 0.62	2.6 ± 0.022
KANSO CJ	16.6 ± 0.2	0.032 ± 0.007	39.43 ± 0.4	1.22 ± 0.02
KANSO CD	5.6 ± 0.050	0.018 ± 0.0044	14.3 ± 0.099	0.46 ± 0.0082
Measured CB	36.9 ± 0.26	0.151 ± 0.01	112.1 ± 1	2.7 ± 0.05
Measured CJ	16.6 ± 0.13	0.06 ± 0.02	39.8 ± 0.7	1.25 ± 0.02
Measured CD	5.5 ± 0.05	0.05 ± 0.01	14.5 ± 0.282	0.47 ± 0.01

Table 4.3: Certified concentrations converted from µmol kg-1 to µmol L-1 of KANSO CRMs used during JC159 and our results for each lot (in mmol L-1).

The units of the CRM's (CD, CJ and CB) were converted from µMole/kg to µmole/L and the measured values throughout the cruise were plotted in control charts, showing trends in data with time (Figures 4.1).

Figure 4.1: Shows the certified value (vn-blue line) for A) CRM CD, B) CRM CJ, C) CRM CB plotted against measured values throughout JC159 (yellow dots). Red lines are upper and lower warning levels (UWL and LWL = vn +/- 2*5/100*vn (5%)). In all cases the measured CRM values lie between the UWL and LWL

Correlation Coefficient: The correlation coefficient shows how close the standards are to a true linear calibration. The stated correlation coefficient value for high accuracy is greater than 0.9990, the highest possible value is 1. As can be seen in figure 2 the correlation coefficient for all chemistries during all runs was higher than 0.9990. In fact, the lowest value seen throughout JC159 was 0.9991 for NO2.

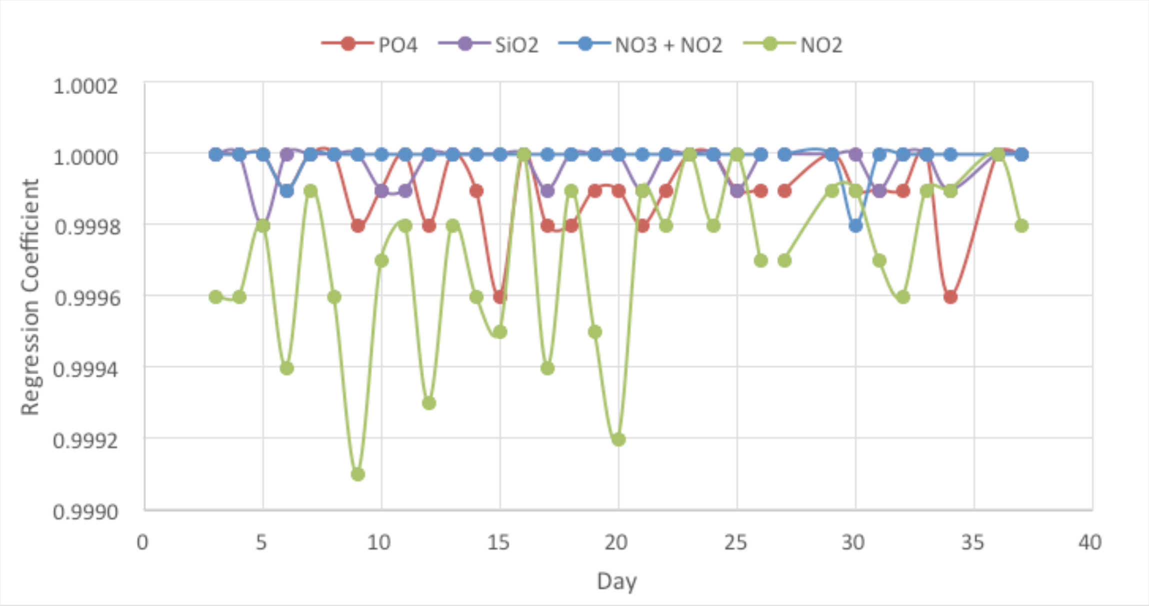


Figure 4.2: Correlation coefficients for all the chemistries during DY086.

Replicates: precision control.

Ten replicates are collected at 22 different stations to assess the reproducibility of our methods. These replicates were sampled throughout the cruise and at different dissolved inorganic nutrient concentrations (low, mid and high)

<u>12 replicats series in the low range :</u>

0-10 µMole/L for silicates
0-1,4 µMole/L for phosphates
0-18 µMole/L for nitrates

<u>6 replicats series in the mid-range :</u>

30-50 µMole/L for silicates
1,4-2,4 µMole/L for phosphates
20-35 µMole/L for nitrates

<u>4 replicats series in the mid-range :</u>

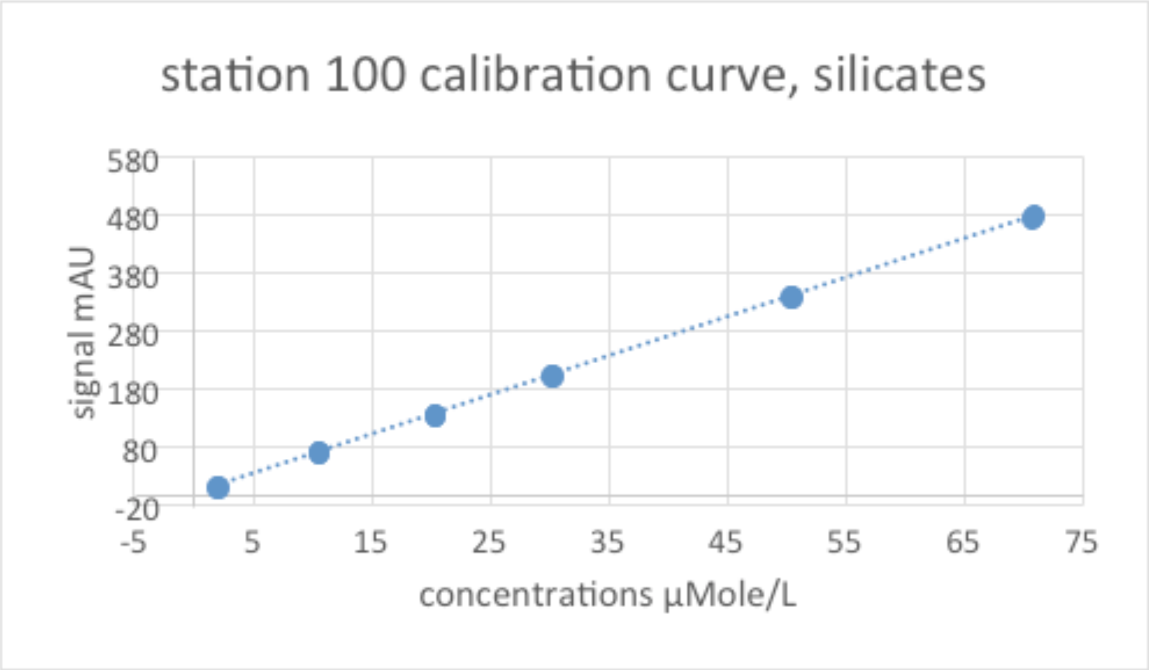
50-130 µMole/L for silicates
1,6-2,4 µMole/L for phosphates
25-35 µMole/L for nitrates

Results :

RANGE		Si µM	PO4 µm	NO3 µm
low range	SD µMole/L	0,06	0,01	0,04
	variability coefficient %	1,52	1,20	0,52
mid range	SD µMole/L	0,23	0,01	0,07
	variability coefficient %	0,55	0,43	0,24
high range	SD µMole/L	0,47	0,01	0,09
	variability coefficient %	0,53	0,52	0,32

Detection limit and quantification limit :

To calculate the detection limit, we used the calibration curves of each parameters (concentrations vs data in mAU, provided in the raw data of AACE software). Here we present this calculation for 10 randomly selected stations along the cruise track.
For a more realistic approach, we report limit of detection (LD) and limit of quantification (LQ).
We used the function « LINEST » in excel.
Example :



C µMole/L	signal mAU
1,9935	13,48
1,8621	12,59
10,4902	70,95
10,5406	71,29
20,2876	137,21
20,2465	136,93
30,1036	203,59
30,2429	204,53
50,273	340
50,4403	341,13
70,6522	477,82

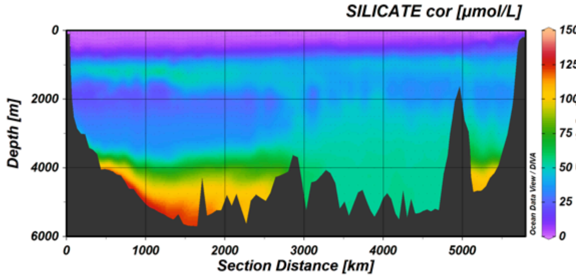
70,7836	478,71

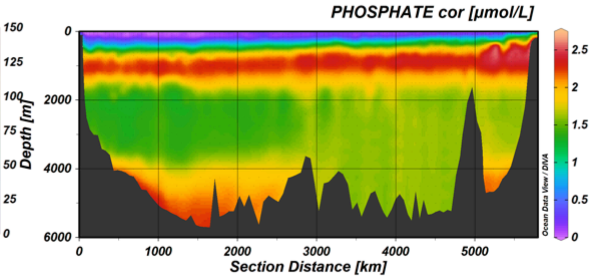
6,763000724	0,00109577	**SLOPE**
3,86496E-05	**0,00149459**	**SD OF INTERCEPT**
1	0,00315519	
30618853592	10	
304818,3853	9,9553E-05	

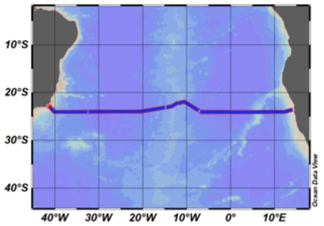
LD =	0,00493214	mAU
	0,00072928	µmole/L
LQ =	0,01494587	mAU
	0,00220995	µmole/L

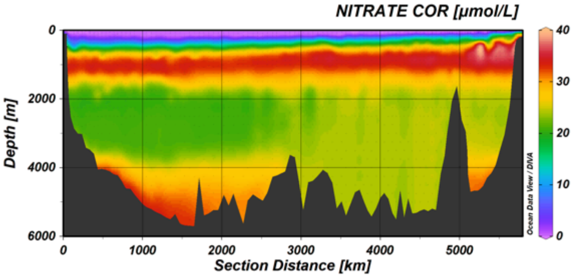
LD = 3,3*sd of intercept in mAU and (3,3*sd of intercept in mAU) / slope in µMole/L.
LQ = 10 * sd of intercept

		SILICATES	PHOSPHATES	NITRATES
DATE				
02/03/2018	LD µm	0,5528	0,0147	0,1311
	LQ µm	1,6752	0,0446	0,3973
05/03/2018	LD µm	0,0006	0,0002	0,0003
	LQ µm	0,0018	0,0005	0,0009
09/03/2018	LD µm	0,0007	0,0002	0,0002
	LQ µm	0,0021	0,0005	0,0005
11/03/2018	LD µm	0,0007	0,0002	0,0002
	LQ µm	0,0022	0,0007	0,0006
15/03/2018	LD µm	0,0006	0,0002	0,0001
	LQ µm	0,0018	0,0006	0,0003
21/03/2018	LD µm	0,0007	0,0002	0,0002
	LQ µm	0,0022	0,0006	0,0006
24/03/2018	LD µm	0,0005	0,0002	0,0002
	LQ µm	0,0016	0,0007	0,0007
28/03/2018	LD µm	0,0005	0,0002	0,0002
	LQ µm	0,0014	0,0006	0,0006
30/03/2018	LD µm	0,0007	0,0002	0,0002
	LQ µm	0,0022	0,0007	0,0005
05/04/2018	LD µm	0,0007	0,0002	0,0002
	LQ µm	0,0020	0,0007	0,0005









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Edward Mawji and Thierry Cariou

5. Dissolved Oxygen Analysis

All stations occupied during JC159 were sampled for dissolved oxygen (DO) to calibrate the dissolved oxygen sensor on the CTD. DO samples were collected as soon as possible, straight after CFCs. Seawater was collected directly into pre-calibrated Pyrex 'Iodine titration' flasks. Before the sample was drawn, bottles were flushed with seawater for several seconds (approximately 3 times the volume of the bottle) and the temperature of the water was recorded simultaneously using a handheld digital thermometer (Hanna Instruments) and recorded onto a log sheet.

The fixing reagents (i.e., manganese chloride and sodium hydroxide/sodium iodide solutions) were then added. Care was taken to avoid bubbles inside the sampling tube and sampling bottle. Samples were thoroughly mixed following the addition of the fixing reagents and were then kept in a dark plastic crate for 30-40 min to allow the precipitate to settle. After collection, a Milli-Q water seal was applied to the neck of the sample flasks in order to prevent ingress of air.
Once the precipitate had settled all samples were thoroughly mixed for a second time in order to ensure that the reaction was complete, water seal was replaced. Analyses were carried out as soon as possible normally within two to ten hours of sample collection.

When ready to titrate, the water seal was dried and the stopper of the flask carefully removed. A 1 mL aliquot of 5 M sulphuric acid was added to the flask, immediately followed by a clean magnetic stir bar. The flask was placed on the stir plate and the electrode and burette were carefully inserted to place the tips in the lower-middle depth of the sample flask. The initial volume of Na2S2O3 for each sample was 0.3 mL before continuing to be titrated at 0.0005 ml intervals using an electrode with amperometic end-point detection (Culberson and Huang, 1987) with an end current of 0.1µA. The resultant volume of titrant was recorded both by manual logging and on the Titrino. Following this the value was converted to a dissolved oxygen concentration.

For each cast, at least one Niskin bottle was sampled in duplicate and analyzed for oxygen concentration.

Thiosulphate calibrations and reagent blank checks were carried out for each CTD station following the GO-SHIP protocols (Langdon, 2010). At least two blank checks of the reagents and one standardisation of the sodium thiosulphate was completed using using a 1.667µmol L-1 certified OSIL iodate standard every cast. This number was increased to at least 5 standardisations following the changing of the thiosulphate. These results can be seen in Table 5.1.

5.1 Observations and problems encountered

Generally, replicate measurements of randomly selected samples are carried out in order to test for reproducibility. At least 1 Niskin bottle is always sampled in duplicate. During JC159 155 replicates were made from 310 samples. The mean difference between replicates was 0.5 µmol-O2 L-

During the first two weeks of JC159 problems were encountered whilst using the 916 ti touch for the analysis of dissolved oxygen. Firstly, titration values (thiosulphate) were highly variable for blanks and standards with ranges beyond what would be expected (for blacks 0.09 ml +/- 0.0001, and standards 0.455 ml +/- 0.005). Titration values for samples particularly at stations 9 to 14 were also high when compared to the seabird 911 sensor, especially through the deep oxygen maximum zone.

The problem was traced to the ingress of air into the dosino automatic dosing devise for both the thiosulphate and the KIO3 standard solution, which caused bubbles to form in the dosing cylinder. The cause was unevenly distributed paraffin grease applied by the manufacture when setting up the devise. The problem was corrected by deconstructing the dosino, as per the cleaning instructions available on Metrohm website, and redistributing the grease more evenly between the centring tube and dosing cylinder. During the process the dosino was also cleaned. Following this no further variability problems were encountered due to air ingress.

Within the final week of the cruise standards shifted to 0.01ml higher than expected and blanks became more variable, although not to the same degree as in the first two weeks.

Finally, throughout the cruise on a non-regular basis the ti touch machine crashed. This usually occurred during the addition of thiosulphate and resulted in loss of data for that sample. Rebooting the machine resolves the problem, but as yet the problem is infrequently reoccurring.

Chemical reagents were prepared in advance at NOCS following the procedures described by Dickson (1994). For JC159, 5 litres of each reagent are prepared and homogenised at NOC using 5 L glass volumetric flasks, this reduce the batch effect and allowed us to change reagent during analysis. Thiosulphate was weight into 27.4 g at NOC and all solutions were made during the cruise. Thiosulphate solutions were made at least two days in advance.

New labels for the calibrated oxygen bottles are required; labels would frequently need replacing with electrical tape.

Date range	Number of standards	Average Vol. Na2S2O3	Std Dev	Stations this value used for
01.03.18 07.03.18	32	0.4563	0.0010	4-26
08/03/18 16/03/18	64	0.4554	0.00126	27-55
16/03/18 24/03/18	51	0.4548	0.001	55-84
24/03/18 31/03/18	63	0.4591	0.002	85-108
01/04/18 end	32	0.4592	0.001	109-123

Table 5.1: The average volume of sodium thiosulphate required to titrate 5ml of the potassium iodate standard for the standardisation procedure.

Calibration of the dissolved oxygen sensor can be found in the CTD calibration section.

Edward Mawji

6. Inorganic Carbon Parameters

6.1 Analysis Background

The analytical equipment for the carbon parameters was set up in the controlled environment laboratory, with discrete CTD samples being analysed for both total dissolved inorganic carbon (DIC) and total alkalinity (TA). Two Versatile Instruments for the Detection of Titration Alkalinity (VINDTA) systems (Mintrop, 2004), version 3C serial numbers #11 & #24 coupled to UIC coulometers were used to this end during JC159. These systems draw water from a single sample and autonomously separate it into two independent analysis lines, one analysing for total alkalinity by potentiometric acid titration, the other quantifying for DIC by the acid-derived extraction of carbon dioxide and subsequent coulometric titration (Johnson et al, 1985,; Johnson et al, 1987; Johnson et al, 1993).

6.2 CTD Sampling Strategy for Inorganic Carbon

Water samples for the determination of DIC and TA were drawn from the 20L Niskin bottles on the CTD rosette and collected in 250ml and 500 ml glass bottles according to the Standard Operating Procedure (SOP) # 01 (Dickson et al., 2007), to avoid gas exchange with the air. All samples were poisoned with mercuric chloride (20 µl per 50 ml of sample) to kill all organisms that may alter the chemistry of the sample. Samples were kept at room temperature in the dark until they were placed into a 25°C water bath to bring to this temperature prior to analysis. A total of 3035 samples were drawn from 118 CTD stations (first station number 3, last station number 123, stations 27,28 & 59 failing) with a further 65 samples taken from the underway system as we steamed between stations. Samples for DIC and alkalinity were not taken from all niskins on all stations, but all depths were sampled for. Duplicate samples were collected on all stations, totalling 698 in all. The aim was to meet the GO-SHIP-stated recommendation of 10% of niskins, but we also collected duplicate bottles at all depths across four stations in order to assist in the moving from one batch of alkalinity titration acid to the next. All samples were analysed during the cruise. Figure 6.1 shows the depth-longitude grid of samples analysed for DIC and TA during the cruise.

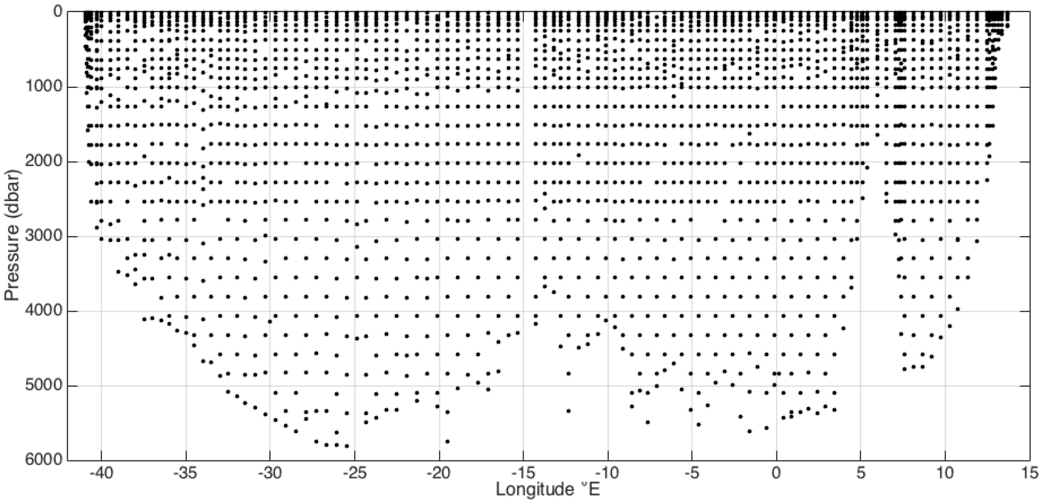

Figure 6.1: Locations of sampling for the dissolved inorganic carbon system on JC159

6.3 Total Dissolved Inorganic Carbon

Total inorganic carbon was analysed by coulometry. All inorganic carbonate was converted to CO2 (gas) by addition of excess phosphoric acid (1 M, 8.5%, made by dilution on ship of 85% phosphoric acid) to a calibrated volume of seawater sample. Oxygen-free-Nitrogen (OfN) gas was passed through a soda lime trap to remove any traces of CO2 prior to entry into the system; the gas was then used to both empty the DIC pipette, and to flush and carry the evolving CO_2 from the sample to the coulometer cell. Here, CO2 is quantitatively absorbed by a dimtheylsulfoxide-ethanolamine mixture forming an acid and changing the colour of the solution, which is coulometrically titrated to return it to its original transmittance.

The coulometry solutions accumulate CO_2 over time and thus need to be changed regularly to ensure high performance. On JC159 they were changed every 24 hours, with a set of 8 cells being used in rotation. Two of these were removed immediately following issues with their performance (possibly due to holes in their glass frits, indicated by very quick cleaning times), and a further cell was also removed from circulation when its titration times deteriorated quickly.
Cell preparation was conducted by the addition of cathode and anode solutions (UIC Corp.) to their individual chambers, solid potassium iodide to the anode chamber and a stirrer bar to the main chamber. Platinum (cathode) and silver (anode) electrodes were also used in rotation. As the silver anode is consumed during the analysis, these had to be replaced on occasion with new. Cells were cleaned by Milli-Q water, before passing Milli-Q water through the glass frit under vacuum followed by acetone and then Milli-Q water again, until all ran clear. Cells were then dried at 65degC in an oven prior to next use. Silver anodes were cleaned with milli-Q water, platinum electrodes were cleaned first with water, then by dipping in 50% Nitric acid for 10 seconds, followed by a water rinse.

Four bottles of anode solution were used and three of cathode solution. One anode solution bottle was found to be of a poor quality due to it dissolving the potassium iodide crystals upon addition; this was removed from use. Solutions were kept in the dark, and were discarded when their levels became low – as they are hygroscopic in the nature, the absorption of atmospheric water was found to make the cells they were used in very noisy and slow to settle prior to use.

The oxygen-free nitrogen gas was piped from 90L cylinders located in the gas cylinder storage facility off the CTD annex. The pressure of the gas cylinder in use was regularly checked (every 1-2 days) to ensure that sufficient pressure was available for normal operation and that the inlet pressure did not exceed 1.5 bar. It was found that the inlet pressure would rise of its own accord between checks, necessitating remedial action to bring it back into line. Cylinders were changed when their pressure reached approximately 350psi, with three cylinders being used in total across the cruise.

Issues encountered - #11

The sample flow peristaltic pump wore through its tubing on the first day of the cruise. This led to water leaking on to the top of the mass flow controller, and its performance becoming impaired. While it was removed, dried, and subsequently replaced, it did not reach its previous ability and so it was decided to remove it from the system entirely and to replace it with a needle valve. A manual flow meter was used to periodically check for a flow of 150mL / minute

Tubing below valve 8 leaked periodically towards the beginning of the cruise by its worn attachment to a plastic fitting. Tubing and fitting were removed and replaced with new.

Low-to-no flow was observed at some points in the cell. Flow rate checks of the gas moving through the system revealed that blockage of the gas line in the coulometry cell was the cause. Removal, thorough cleaning and replacement retrieved the situation.

Jumping background levels revealed that the Peltier element was not cold enough. Although it was receiving current, it was not able to cool the gas flow. Investigations found that the water bath had frozen as its chiller was on, but its heater was not. Melting/removal of ice, enabled the bath to be refilled and restarted.

Issues encountered - #24

Initial connection of the coulometer with the PC was problematic. It was thought that the PCI board connection was unstable, and so a RS232 to USB dongle was used in its stead. No further issues with connection were experienced.

There were sporadic issues with low DIC outputs being produced due to the DIC pipette either not fully filling, or not fully transferring to the stripper. The former was caused by the overflow not emptying properly during the analysis, and was fixed by completely separating its waste line from that of the rest of the system. The latter was found to be due to pinched tubing not allowing sufficient gas flow to expel the sample from the pipette.

6.4 Standardisation

The accuracy of the DIC analyses was determined regularly by measuring certified reference material (CRM), supplied by Dr. A. Dickson of Scripps Institution of Oceanography (SIO), Batches #161 and #170. These were usually shared between instruments with the initial aim running one CRM every 12 hours extended to every 8 hours halfway through the cruise. This ensured that 2-3 CRM analyses were conducted on each coulometric cell. Typically, it was possible to get three combined DIC/TA analyses from a single CRM 500 mL bottle, but the third analysis was usually poor for DIC due to this water having had time to interact with the local atmosphere. These latter analyses were discarded for DIC. Control charts for the outputs of the CRMs analyses (in counts per mole of CO_2) are shown in Figure 6.2, suggesting the analysis was within control, with a few outliers. Quality control for DIC is thus ongoing.

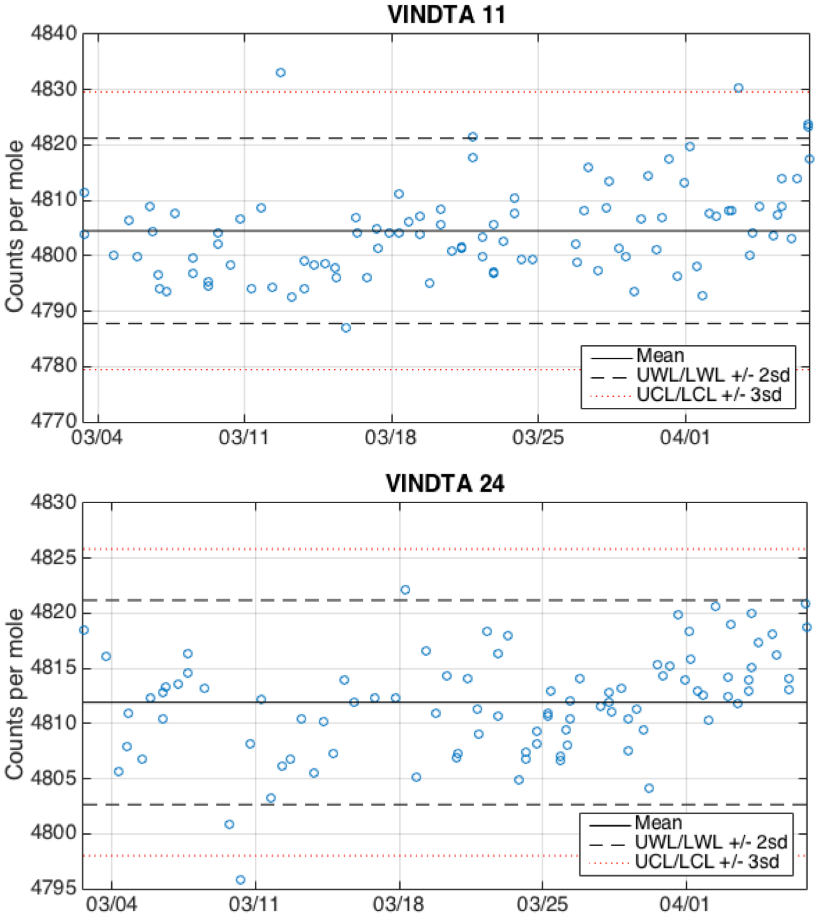

Figure 6.2: DIC CRM Control charts

An initial preliminary plot of the DIC distribution is given in Figure 6.3.

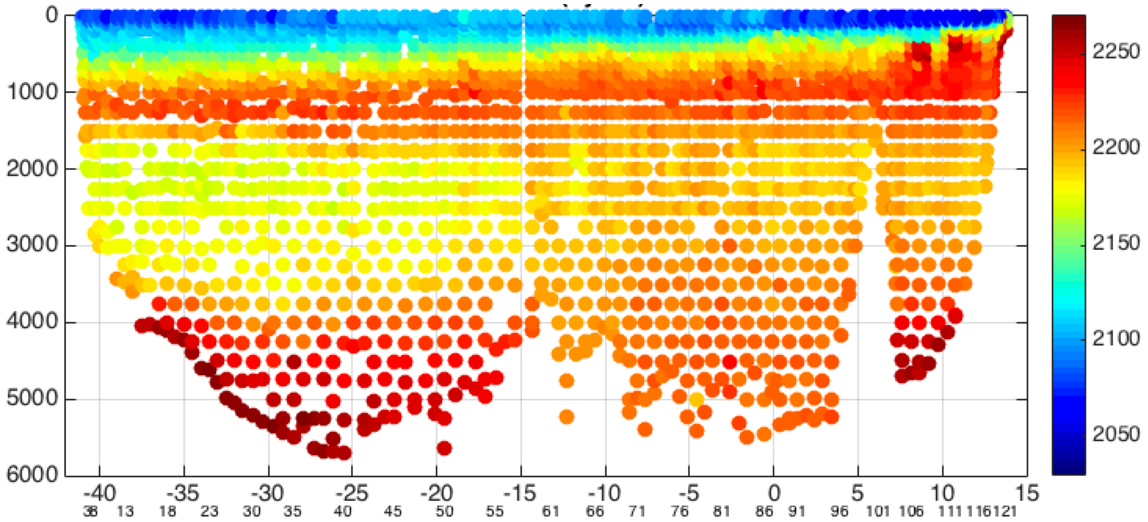

Figure 6.3: Initial DIC distribution across 24S

6.5 Total Alkalinity

The alkalinity measurements were made by potentiometric titration. The s-shaped titration curve produced by potential of a proton sensitive electrode shows two inflection points, characterising the protonation of carbonate and bicarbonate, respectively. The acid consumption up to the second point is equal to the titration alkalinity. From this value, the carbonate alkalinity is calculated by subtracting the contributions of other ions present in the seawater, i.e. nutrients. The systems use highly precise Metrohm Titrinos for adding acid, an ORION-Ross pH electrode and a Metrohm reference electrode. The burette, the pipette (volume approximately 100 ml), and the analysis cell have a water jacket around them that house constantly flowing 25degC water. Two batches of acid titrant (~0.1 M hydrochloric acid, HCl) were used; one was made at NOC in a 20L batch, the other was purchased in a calibrated form in 2x 1L bottles from Dr. A. Dickson of Scripps Institution of Oceanography (SIO), batch A11. Four stations were double sampled to enable them all to be analysed with NOC acid and Scripps acid. Electrodes were refilled with 3M KCl and 0.7M NaCl solutions daily. Every 2 weeks the solutions were completely removed and replaced with fresh.

Alkalinity data was calibrated with CRMs, shown in Figure 6.4. However, the calculation method is dependent on a realistically estimated ratio of acid factor and pipette calibration, since the same calibration factor can also be obtained with various combinations of these two parameters, but the quality of the curve fit will be different. Therefore a re-calibration of the pipette and exact calculation of the acid factor will be processed post cruise. Changes that would exceed the mean standard deviation of the method are not likely.

Issues encountered - #24

On #24, the pipette was found at one point to not fully empty, leading to an anomalously low alkalinity concentration. It was found that this was caused by a slight blockage in the tubing leading from the bottom of the pipette, that was alleviated by massaging.

On both instruments, bubbles were occasionally seen to be present in the titration tubing. This necessitated regular flushing of the lines to remove them.

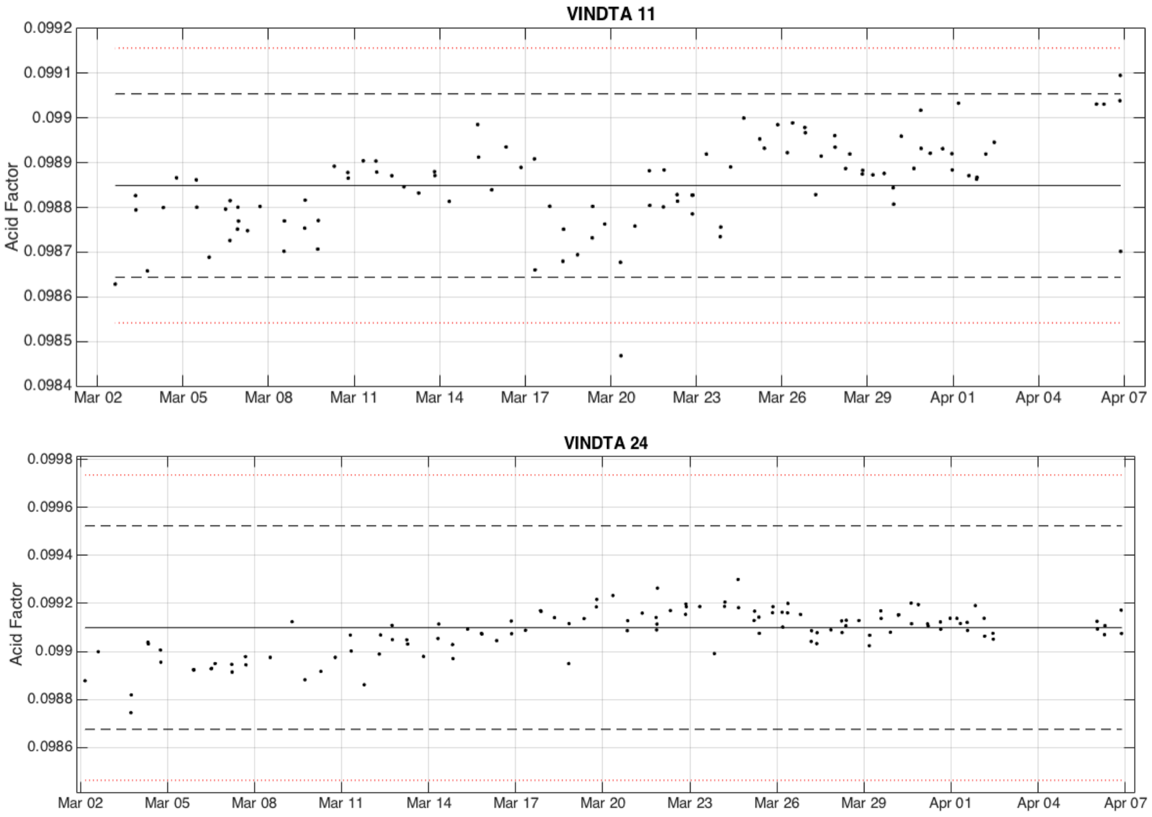

Figure 6.4: Control charts for NOC acid titrant 20L batch acid factor

An initial estimate of the alkalinity distribution is given in Figure 6.5. Final alkalinity data await further quality control and final nutrient data.

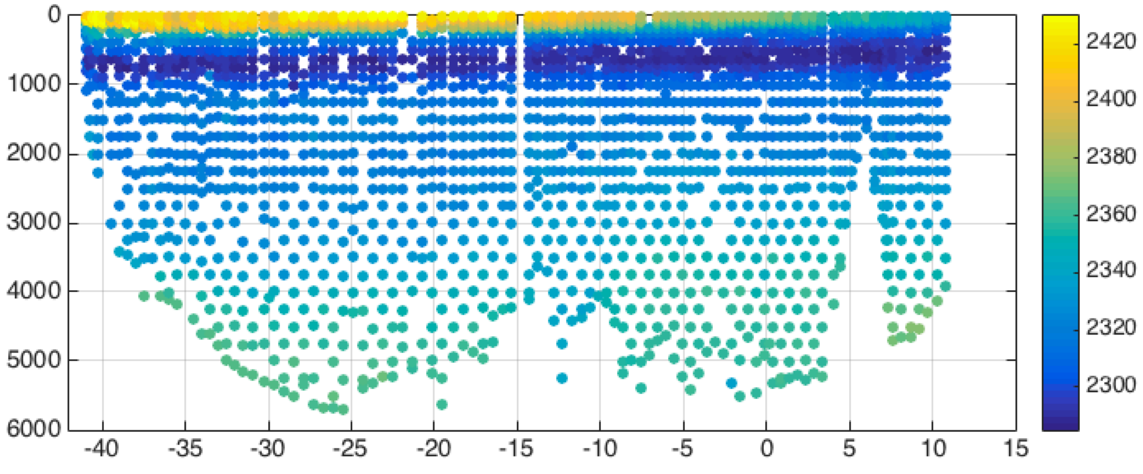

Figure 6.5: Initial alkalinity field

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Peter Brown

7. Chlorofluorocarbons (CFCs) and Sulphur Hexafluoride (SF_6)

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 to reduce the possibility of contamination from high levels of CFCs and radio waves frequently present inside research vessels.

7.1 Instrumentation

Water samples were collected from the 20-litre 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, 1 o.d. Dekabon tubing was run from the foredeck 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.

7.2 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 (N2) 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 N2 and trapped at -100°C on a Unibeads 3S trap (for CFCs) and at -80°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.

References

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Smethie, W. M., R. A. Fine, A. Putzka, E. P. Jones, 2000. Tracing the flow of North Atlantic Deep Water using chlorofluorocarbons. *J. Geophys. Res.*, 105, C6, 14297-14323, doi:10.1029/1999jc900274.

Marie-José Messias

8. Scientific Computer Systems and Instrumentation

Scientific Ship Systems (SSS) is responsible for managing the Ship's network infrastructure, data acquisition, compilation and delivery, the email system and a range of ship-fitted instruments and sensors.

8.1 Scientific Computer Systems

8.1.1 Acquisition

Network drives were setup on the on-board file server; firstly a read-only drive of the ships instruments data and a second scratch drive for the scientific party. Both were combined at the end of the cruise and copied to disks for the PSO and BODC.

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

Data descriptors: ***'JC159/Ship_Systems/TECHSAS/Data Description/'***

The format of the raw NMEA ASCII which Techsas uses to build its data products is also included in the Data Description documents. This raw data set is also stored on the disk should the scientists wish to reprocess these themselves.

Raw data: ***'JC159/Ship_Systems/Raw_NMEA'***

Main Acquisition Events/Data Losses
06/04/2018 08:15 – 08:30 No EM122 bathymetry

8.1.2 Internet Provision

Satellite Communications were provided with both the Vsat and Fleet Broadband (FBB) systems. The Vsat had a guaranteed speed of 1.5 Mbps, bursts greater than this when there is space on the satellite, and unlimited data. The FBB had a maximum un-guaranteed speed of 256 kbps with a fair use policy that equates to 15 GB of data a month. A solid service was available until the final week. During this time service was interrupted due to heading, less satellite signal strength and additional interference during port calls.

Unrestricted internet was provided during mobilisation. On sailing, the restricted system was in place throughout the ship. A six-hour captive portal was used.
An unrestricted wi-fi hot spot was trialed in the lounge/bar, with a one-hour captive portal.

Videos were uploaded to shore using the NOC ftp server.

Four skype calls for outreach were conducted: Natural History Museum (08/04/2018) and the Commonwealth Marine Science event (09/04/2018).

8.1.3 Email Provision

Email communications were primarily provided by whitelisting institutional pages and encouraging their use through Outlook and Apple Mail desktop clients. AMS was set up as a back-up service for all UK institutional addresses supplied.

8.2 Instrumentation

8.2.1 Position and Attitude

GPS and attitude measurement systems were run throughout the cruise.

The ***Applanix POSMV*** system is the vessel's primary GPS system, outputting the position of the ship's common reference point in the gravity meter room. The POSMV is available to be sent to all systems and is repeated around the vessel. The position fixes attitude and gyro data are logged to the Techsas system. True Heave is logged by the Kongsberg EM122 systems.

The ***Kongsberg Seapath 300+*** system is the vessel’s secondary GPS system. This was the position and attitude source that was initially used by the EM122 due to its superior real-time heave data. Position fixes and attitude data are logged to the Techsas system.

The ***CNav 3050*** GPS system is the vessel’s differential correction service. It provides the Applanix POSMV and Seapath330+ system with RTCM DGPS corrections (greater than 1 m accuracy). The position fixes data are logged to the Techsas system.

8.2.2 Meteorology and Sea Surface Monitoring Package

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port and whilst alongside. Please see the separate information sheet for details of the sensors used and whether calibrations values have been applied:

‘JC159_Surfmet_sensor_information_sheet.docx’
Cruise Disk Location: ***‘JC159/CRUISE_REPORTS/’***

Instrument calibration sheets are included in the directory:

Cruise Disk Location: ***‘JC159/Ship_Systems/Met/SURFMET/calibrationsl’***

Date	**Start Time**	**Stop Time**	**Cleaned**	**Transmissivity (v)**			**Fluro**
				Norm	High	Low	
Non-Toxic started on departing BRRIO							
28/02/2018	22:21	--	Yes		4.6692	0.0597	
07/03/2018	--	13:17		4.4990	--	--	0.0730
07/03/2018	13:40	--	Yes	4.5050	4.6645	0.0584	0.0750
14/03/2018	--	14:22		4.4763	--	--	0.0716
14/03/2018	14:05	--	Yes	4.4962		0.0536	0.0720
21/03/2018	--	16:42		4.4255	--	--	0.0708
21/03/2018	17:09		Yes	4.5027	4.6617	0.0586	0.0723
28/03/2018		15:20		4.4237			0.0790
28/03/2018	16:10		Yes	4.4826	4.6565	0.0591	0.0790
02/04/2018		18:00	Stopped for port call at Walvis Bay				
03/04/2018	14:55		Yes	3.7602	4.6536	0.0586	0.3485
06/04/2018		12:15	Stopped for port call at Walvis Bay				
06/04/2018	14:50		Restarted after port call at Walvis Bay				
08/04/2018		07:00	Stopped on entry to South African waters				

Table 8.1: Non-Toxic Events

8.2.3 Konsberg EA640 10/12 kHz Single-Beam

The EA640 single-beam echo-sounder was run throughout the cruise. The 10 kHz was run in free-running mode, while the 12 kHz remained in passive. Pulse parameters were altered during the cruise in response to changing depth.
It was used with a constant sound velocity of 1500 ms^{-1} throughout the water column to allow it to be corrected for sound velocity in post processing. Kongsberg Raw files and xyz files are logged and depths were logged to Techsas NetCDF and Raw NMEA.

Cruise Disk Location: ***‘JC159/Ship_Systems/Acoustics/*EA-640/’**

8.2.4 Konsberg EM122 Multi-Beam Echosounder

The EM122 multibeam echo-sounder was run throughout the cruise in free-running mode. The position and attitude data was initially supplied from the Seapath 300+ due to its superior real-time heave.

Sound velocity profiles were input once a day, derived from the CTD data. In shallower water, through the mid-Atlantic ridge, and over the Walvis Ridge they were input with each CTD cast. Data collection was continuous during the cruise, apart from on re-entry to Walvis Bay on 06/04/2018 owing to rapid changes in the depth. Lines 1698 – 1702 have no bathymetry data.

Bathymetry data were cleaned in CARIS until line 1702 the final entry to Walvis Bay on 06/04/2018. During passage south from Walvis bay to the Namibian – South African border weather conditions were poor and the depth shallow, resulting in poor data outputs.

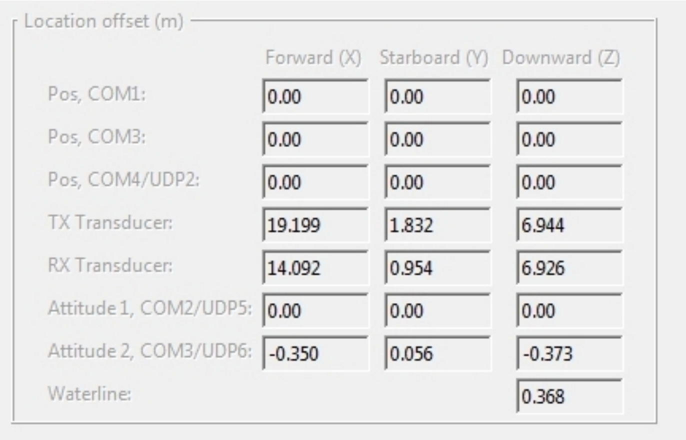
The following figures show the system installation configuration. The values are from the ships Parker survey report, which is included on the data disk. The attitude angular corrections for use with the Seapath 300+ system were derived from a post refit trial calibration on JC108 Sept 2014. The attitude angular corrections for use with the Applanix Posmv system are from calibration during JC103 May 2014.

Contact has been made with Lamont-Doherty Earth Observatory in order to share these data with the Global Sea Floor Mapping programme.

8.2.4.1 Drop Keel Sound Velocity Sensor

The surface Sound Velocity (SV) sensor (AML SmartSV) mounted on the drop keel was used throughout providing SV data to the EM122. The port drop keel was lowered shortly after departing BRRIO and remained lowered for the duration, apart from port calls.

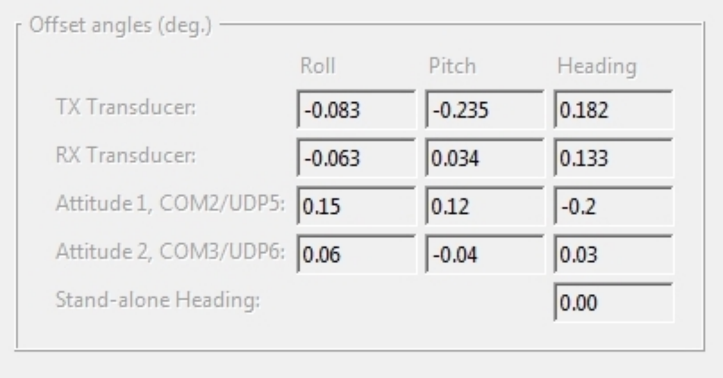
Cruise Disk Location: ***‘JC159/Ship_Systems/Acoustics/*EM-122/’**



Location offset (m)

	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1:	0.00	0.00	0.00
Pos, COM3:	0.00	0.00	0.00
Pos, COM4/UDP2:	0.00	0.00	0.00
TX Transducer:	19.199	1.832	6.944
RX Transducer:	14.092	0.954	6.926
Attitude 1, COM2/UDP5:	0.00	0.00	0.00
Attitude 2, COM3/UDP6:	-0.350	0.056	-0.373
Waterline:			0.368

Figure 8.1: EM122 Transducer locations.



Offset angles (deg.)

	Roll	Pitch	Heading
TX Transducer:	-0.083	-0.235	0.182
RX Transducer:	-0.063	0.034	0.133
Attitude 1, COM2/UDP5:	0.15	0.12	-0.2
Attitude 2, COM3/UDP6:	0.06	-0.04	0.03
Stand-alone Heading:			0.00

Figure 8.2: EM122 Transducer offsets.

8.2.5 Sound Velocity Profiles

Sound velocity profiles were derived from data from the CTD. These were processed with Sea Bird data processing, followed by Ifremer’s DORIS programme. These were input to the EM122 on a daily basis in deep water, and for each CTD cast in shallower waters as we neared Walvis Bay.

Cruise Disk Location:
‘JC159/Ship_Systems/Acoustics/**Sound_Velocity_Profiles/CTD_Derived’**

8.2.6 ADCPs

Both the 150 and 75 kHz ADCP’s were run with the drop keel lowered, as below. These were set up in broadband, bottom track off and were run freely. The set-up parameters were defined by the science party.

Port drop keel lowered	28/02/2018	17:17	2.593 m
Port drop keel raised	03/04/2018	06:00	Flush
Port drop keel lowered	03/04/2018	14:50	2.593 m
Port drop keel raised	05/04/2018	11:00	Flush

Cruise Disk Location:
***‘JC159/Ship_Systems/Acoustics/*OS75kHz/’**
***‘JC159/Ship_Systems/Acoustics/*OS150kHz/’**

8.2.7 Wamos Wave Radar

The Wamos wave radar was run throughout the cruise but the system is currently not calibrated and over-reading wave height. Summary data files (including Significant wave height and period) were transferred to the cruise data disk.

Cruise Disk Location: ***‘JC159/Ship_Systems/Met/*Wamos/’**

8.2.8 EM Speed Logs

The single axis bridge Skipper Log and the dual axis Chernikeef science log were logged throughout the cruise. The Chernikeef log was calibrated in December 2017 offshore of Tenerife.

21/03/2018 It was observed that the Chernikeef reading had started to drift, reading ~1 kt higher than the Skipper Log. This is likely due to the change of temperature and salinity, compared to the conditions in which the sensor was calibrated.

Brian King provided a linear calibration to be applied of 0.91 to the true speeds, and two additional speeds, one low and one high, were also applied.

RPM	True Speed	True Speed (21/03/18)	Measured Speed
R0030	S0301	0274	A0079
R0050	S0500	0455	A0126
R0080	S0767	0698	A0192
R0110	S1015	0924	A0257
R0001	N/A	S0001	A0001
R0140	N/A	S1617	A0450

8.2.9 Sonardyne USBL

A WMT beacon was fixed to the CTD frame to enhance precision of the package location. Following initial problems with the recovery of the USBL pole (05-06/03/2018) the beacon was used consistently on each CTD cast from 18/03/2018 – 04/04/2018. These data were recorded in Techsas.

8.2.10 CTD2MET

CTD profiles were converted and thinned to be ingested into the Met Office CTD2MET programme to improve short-term weather forecasting models. This is a PML/NMF/Met Office collaboration, coordinated between Tim Smyth (PML), Fiona Carse (Met Office) and Andrew Moore (NMF). This was up and running from CTD_037 to CTD_123. CTD_90 was excluded due to CTD wire fault.

8.2.11 Real Time Data Share with BODC

Surface water and meteorological data was summarised and daily sent to BODC.

Eleanor Darlington and Mark Maltby

9. Underway Temperature and Salinity

9.1 TSG Processing and Quality Control

The underway TSG data were read in to a Mstar format file on a daily basis, and processed every few days, using Mexec Matlab scripts.

9.2 TSG Salinity Calibration

There were 197 samples analysed from the underway seawater supply, taken approximately every 4 hours throughout most of the cruise, were analysed for salinity. The differences between the bottle and the TSG (SBE45) salinities were compared using mtsg_bottle_compare.m, where they were smoothed using a three-step filtering procedure. The resulting smooth curve was added to the TSG salinities, with the offsets applied ranging from -0.015 to -0.022 psu over time, resulting in a post-calibration residual with zero mean and a standard deviation of 0.0015 psu.

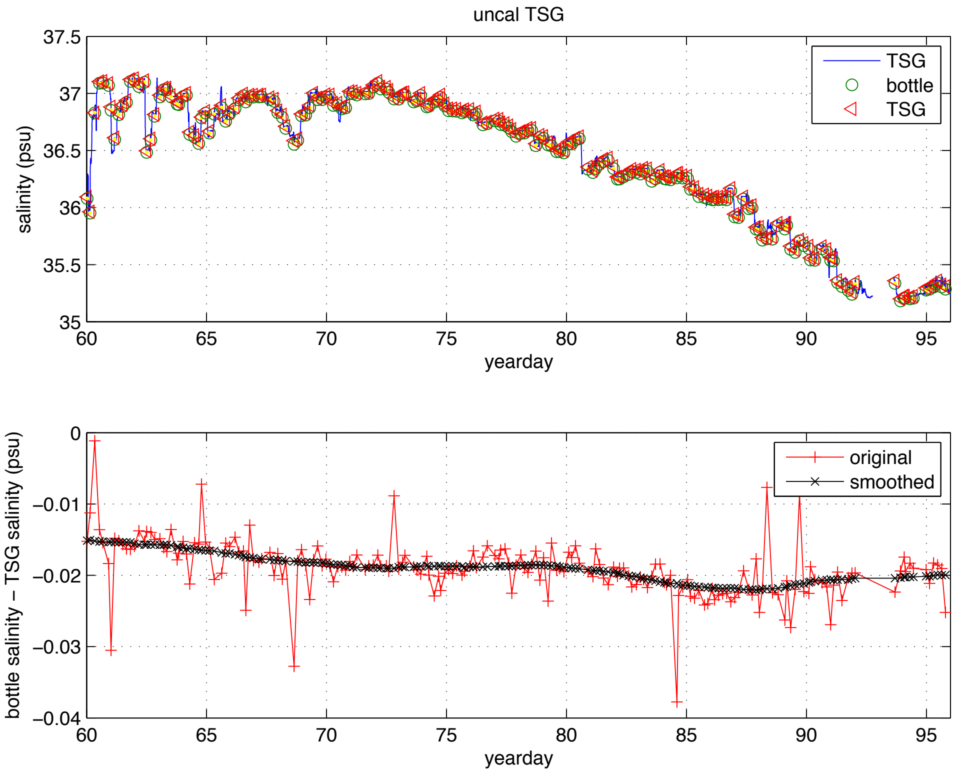


Figure 9.1. TSG and bottle salinities before calibration (top), with differences (bottom); the smoothed function (black) was used to calibrate the TSG record.

Alejandra Sanchez-Franks and Yvonne Firing

10. Surface Meteorological Sampling System (SURFMET)

10.1 Overview of Synoptic Atmospheric Conditions

During the first couple of weeks into the cruise, the James Cook intercepted the South American Convergence Zone (SACZ), a seasonal low pressure trough extending south eastwards from the Amazon basin, across the Brazilian coast and over the South Atlantic. Conditions associated with the SACZ were recorded as a decrease in measured surface pressure and increased observed cloud cover and rainfall. Throughout the rest of cruise, a region of high surface pressure was located over Tropical South Atlantic, bringing largely settled conditions. Infrequent shower bands under the region of high surface pressure were observed moving westwards increasing cloud cover and rainfall for a brief period of time.

10.2 Wind Data

Wind data was read into Python panda data-frame from surfmet_jc159_trueav.nc. Wind and ship variables included speed, direction and u and v components. CTD start and end times from dcs_jc159_all.nc were used to group data into station and steaming time periods. For each period, data + 30 mins and – 30 mins was selected from the median time. This was to ensure a 60 mins period of constant ship and true wind speed and direction for every CTD station and steaming period. Wind variables could then be averaged by an hour. Figure 10.1 shows the hour-averaged components of true wind speed (truwind_u, truwind_v) for each CTD station along 24°S. The quiver represents the speed

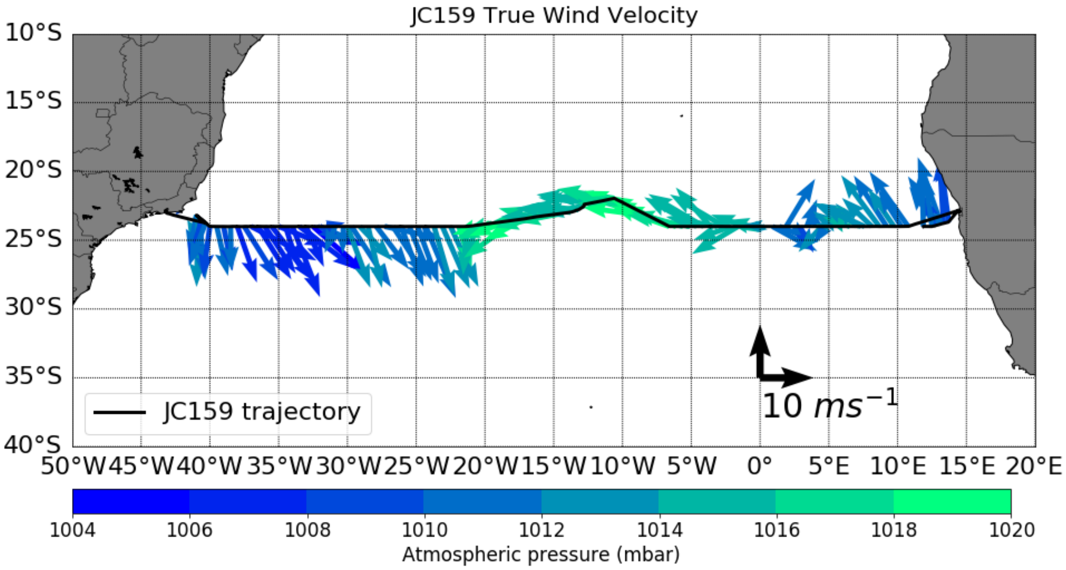


Figure 10.1: Hour-averaged true wind velocity quivers, coloured by measured atmospheric pressure, for each CTD station along the JC159 cruise route.

and direction in degrees relative to North. Each quiver is coloured by the hour-averaged atmospheric pressure measured by the on-board barometer. Initially, the winds approached from the north as the James Cook crossed the westward side of the high pressure system, as indicated by an increase in surface pressure. By the end of the cruise the winds had backed to a southerly as the ship crossed the eastern side of the high-pressure system.

Figures 10.2 and 10.3 show box and whisker subplots of relative wind speed and true wind speed against relative wind direction respectively. Wind speed data was extracted from the specified 60 mins periods, both on and off station. Wind speeds were then sorted into 10° bins from 0° - 360°. Relative wind and true wind are greatest when the wind approaches from the ship bow and decreases in magnitude as the wind direction approaches from the aft of the ship, around the ship's superstructure. Relative winds are strongest during steaming periods over the bow when the ship's motion into the wind adds to the magnitude of the measured wind. The largest true winds approach the bow at a relative wind direction of 90°. Figure 4 shows the number of data points of relative wind speed in each relative wind direction bin. For station periods, most of the relative wind speed observations were measured with the wind approaching directly over the

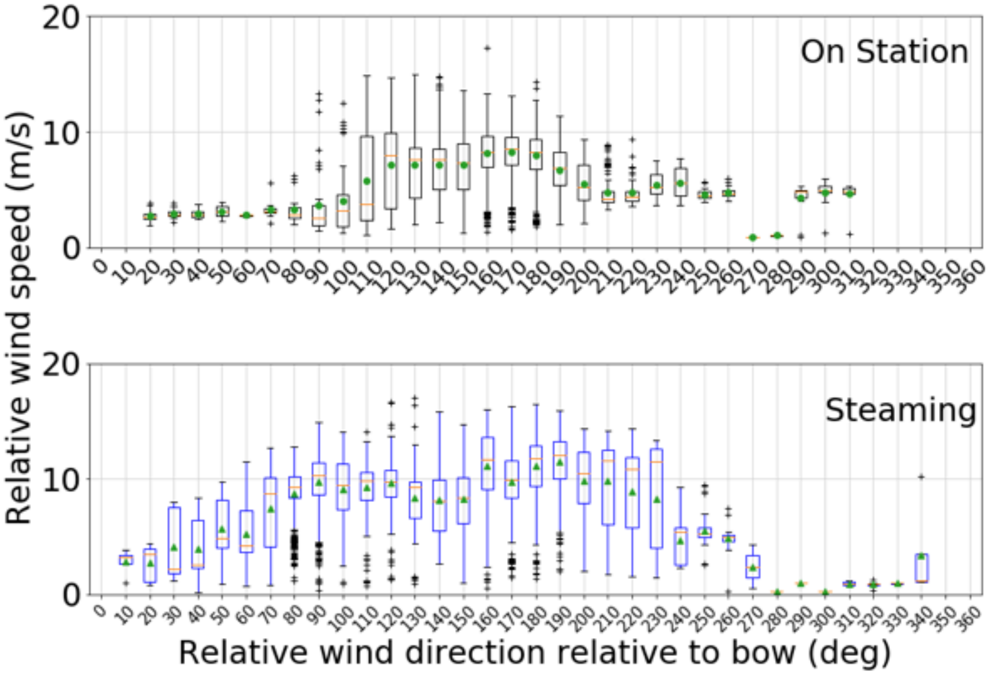


Figure 10.2: Two subplots showing box and whiskers of relative wind speed (m/s) binned by relative wind direction between 0° - 360°. The top plot shows relative wind speed during 60 mins periods when on CTD station and the bottom plot when steaming between stations. The box edges show interquartile ranges, the orange line represents the median, black whisker tops show the data ranges, the black crosses show the data outliers and the green symbols for the average value of each data bin.

bow, due to the ship positioning itself parallel the oncoming wind during CTD operations. When steaming, relative wind speed measurements were recorded either directly over the bow or approaching from the port side of the ship, reflecting the northerly and easterly prevailing wind direction associated with the high surface pressure system dominating the weather conditions for the cruise period.

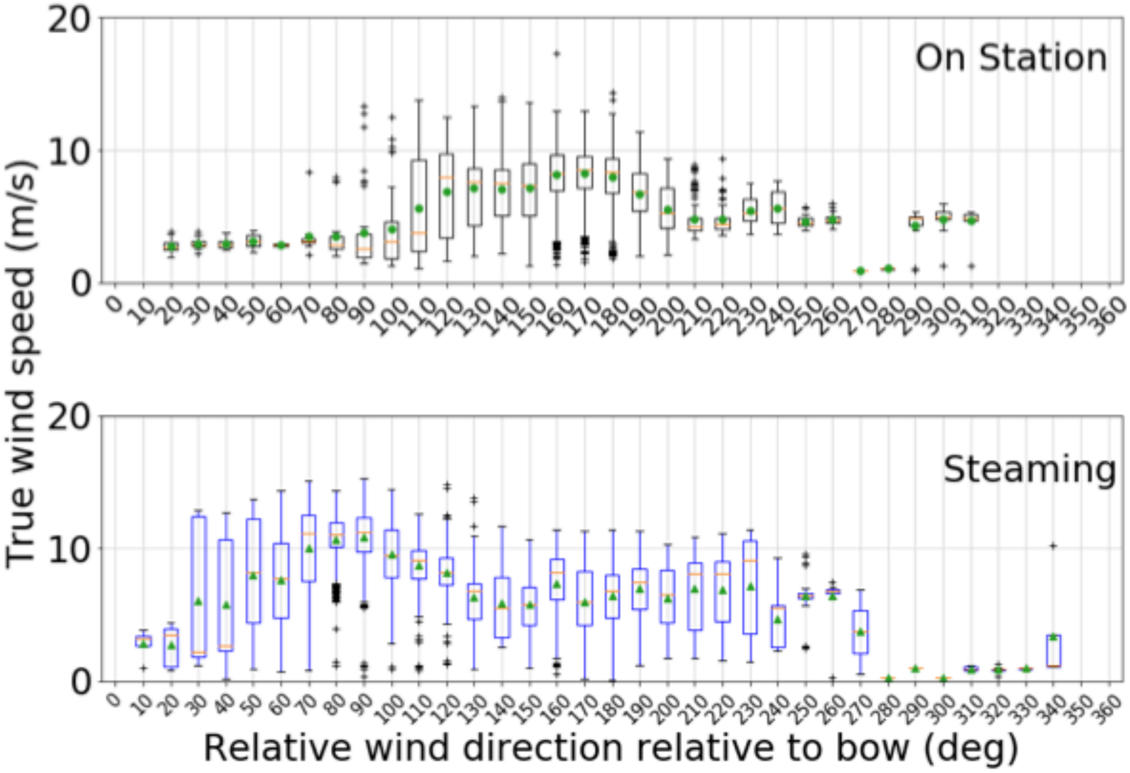


Figure 10.3: Two subplots showing box and whiskers of true wind speed (m/s) binned by relative wind direction between 0° - 360°. The top plot shows true wind speed during 60 mins periods when on CTD station and the bottom plot when steaming between stations.

Investigating possible biases of the measured relative wind speed (v_m) due to disrupted airflow over the bow of the ship, where the anemometer is located, actual relative wind speed (v_a) was calculated by subtracting the ship speed (v_s) from the true wind speed (v_t) [$v_a = v_t - v_s$]. Figure 10.5 shows the ratio between the measured relative wind speed and the actual relative wind speed (v_m / v_a) against relative wind direction. Relative wind data was selected for both 60 mins sections for both station and steaming periods and binned by relative wind direction. While there is no difference between measured and actual relative wind speeds when the ship is on station (ratio ≈ 1), larger discrepancies arise when the ship is steaming between stations. Differences can be seen when relative wind approaches from port and starboard, across the bow. Measured relative wind speeds are larger than actual relative wind speeds at angles 220° - 270° and 90° - 130°. Between 130° - 220°, the discrepancy becomes unclear as there is a large spread in measured relative wind speeds to actual relative wind speeds.

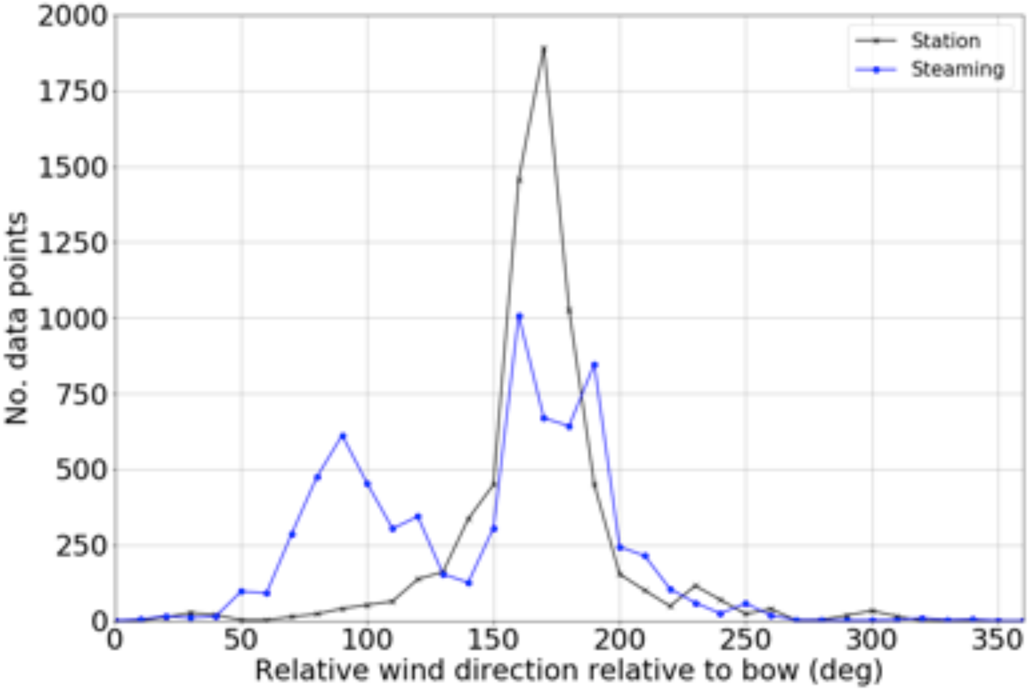


Figure 10.4: The number of data points for each relative wind direction bin during station and steaming periods.

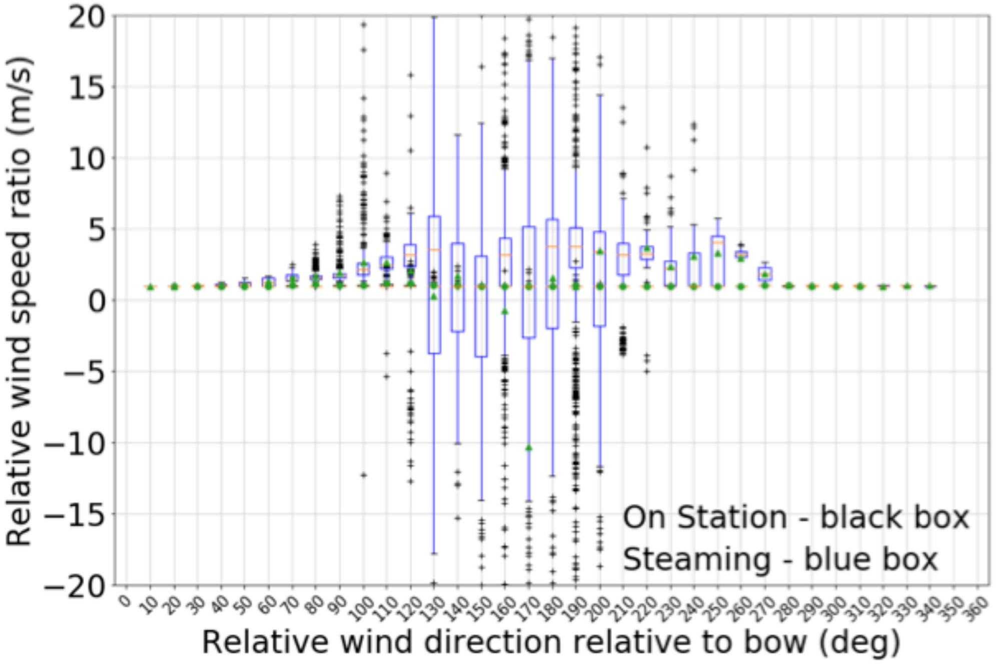


Figure 10.5: Box and whisker plot of the ratio of measured relative wind speed to actual relative wind speed, against measured relative wind direction binned between 0° - 360°.

Wind data over a 60 mins period was selected for both station and steaming times. On station data plotted with black boxes with data average plotted with a green circle. Off station data plotted with blue boxes with data average plotted with a green triangle.

10.3 Light Data

Light data accessed from Light-SURFMET.nc contains port and starboard PAR and total irradiance measurements. Light data was averaged every 1 min to smooth out spikes in the dataset. Figure 10.6 shows the port and starboard PAR measurements in hKV between February 25th – April 5th. Figure 10.7 shows the port and starboard total downwelling irradiance measurements in hKV between February 25th – April 5th.

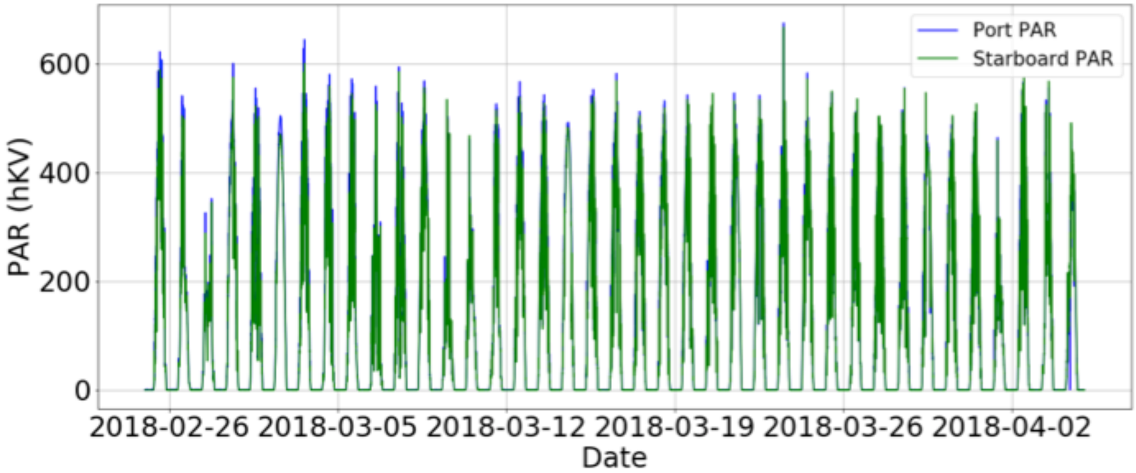


Figure 10.6: Plot of port (blue) and starboard (green) PAR measured in hKV between February 25th – April 5th.

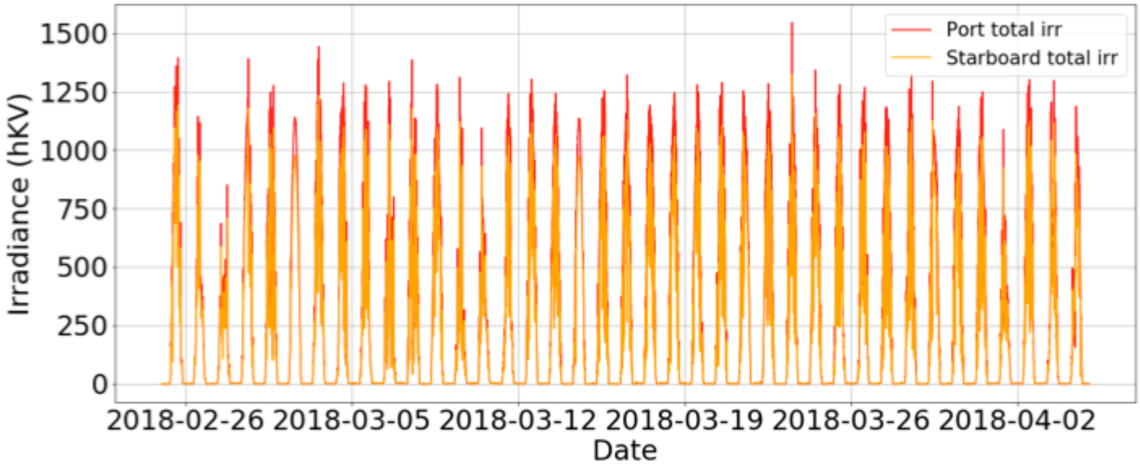


Figure 10.7: Plot of port (red) and starboard (orange) total downwelling irradiance measured in hKV between February 25th – April 5th.

Figure 10.8 shows the difference between the two PAR instruments on the port and starboard side (calculated as port - starboard) plotted as the black line.

Python package ‘Pysolar’ was used to find the solar elevation angle (angle between sun and horizon, θ) and solar azimuth angle (angle of sun projected onto the horizontal plane relative to North, ϕ) using latitude, longitude and datetime measurements from surfmet_jc159_trueav.nc. Solar angles were plotted with the PAR difference to see the daily solar cycle in the tropical South Atlantic. The largest positive differences occur at mid-morning to midday (θ = 70°, ϕ = 180°). Negative differences were most likely to occur in the afternoon.

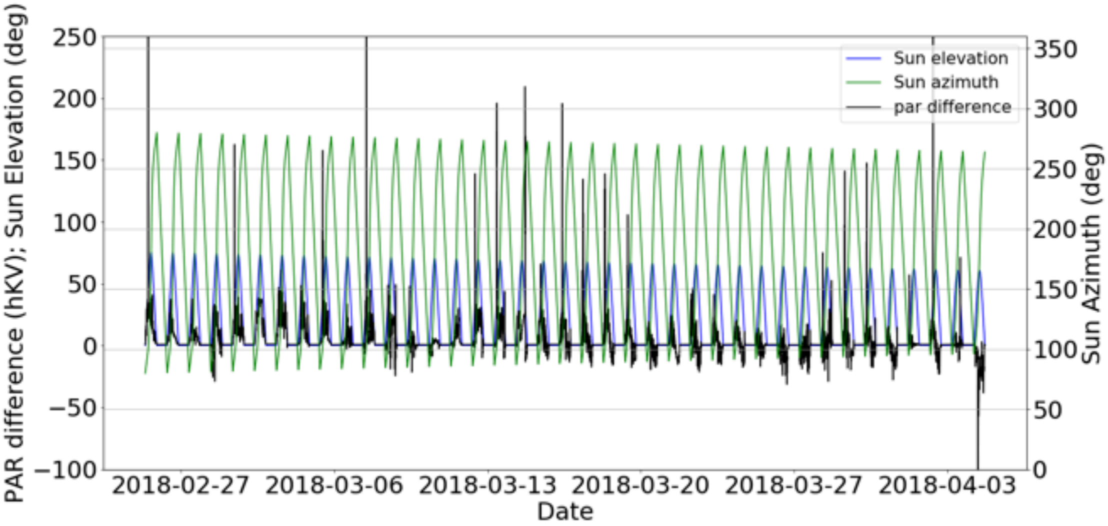


Figure 10.8: PAR measurement difference (port - starboard) between February 25th – April 5th. Solar elevation angle and solar azimuth angle are plotted to show daily solar cycle in the tropical South Atlantic.

Solar elevation angle was used to remove nighttime PAR measurements (elevation < 0) and using azimuth angle, data was grouped into morning (ϕ < 135°), midday (135° < ϕ < 225°) and evening (ϕ > 225°) periods. Figure 9 shows PAR difference plotted for morning, midday and evening. PAR differences are mostly positive in the morning and midday, but negative in the afternoon. PAR differences are constrained by the solar elevation angle, with the largest differences occurring when the sun is highest in the sky.

Together with solar azimuth angle and ship direction relative to north, the sun’s angle relative to ship bow was calculated. Figure 10 shows PAR difference during the morning (top plot), midday (middle plot) and evening (bottom plot) against the sun’s angle relative to the ship bow binned from 0° - 360°. During the morning hours median positive PAR difference of 16 hKV are clustered around 10° relative to the ship bow. By midday median positive PAR differences of 14 hKV at 180° and 10 hKV at 30° relative to the bow was found. In the afternoon hours a large positive PAR difference of 37 hKV at 220° can be seen, including a slight negative difference of -5 hKV at 190° relative to the bow indicating shadowing from the ship superstructure when steaming eastwards. PAR differences show a possible calibration offset between port and starboard sensors with the port sensor measuring 7 hKV more irradiance than the starboard side on average.

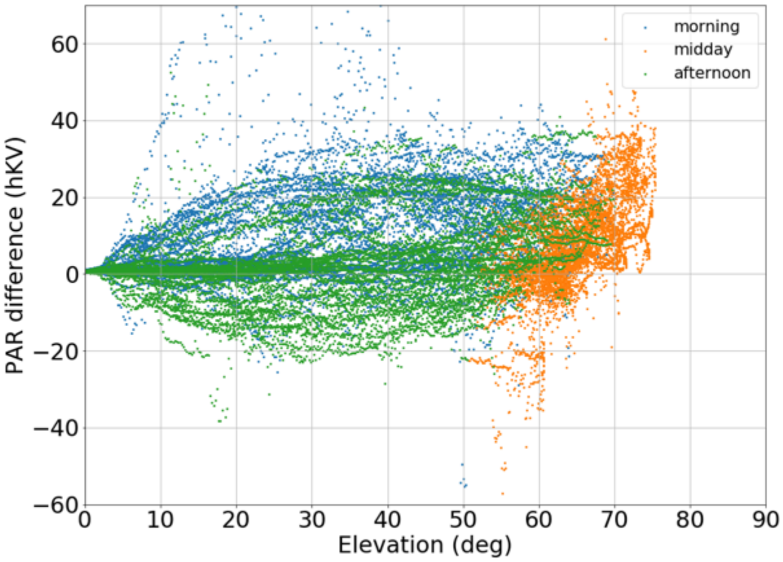


Figure 10.9: PAR difference plotted against elevation angle and coloured by morning, midday and evening times.

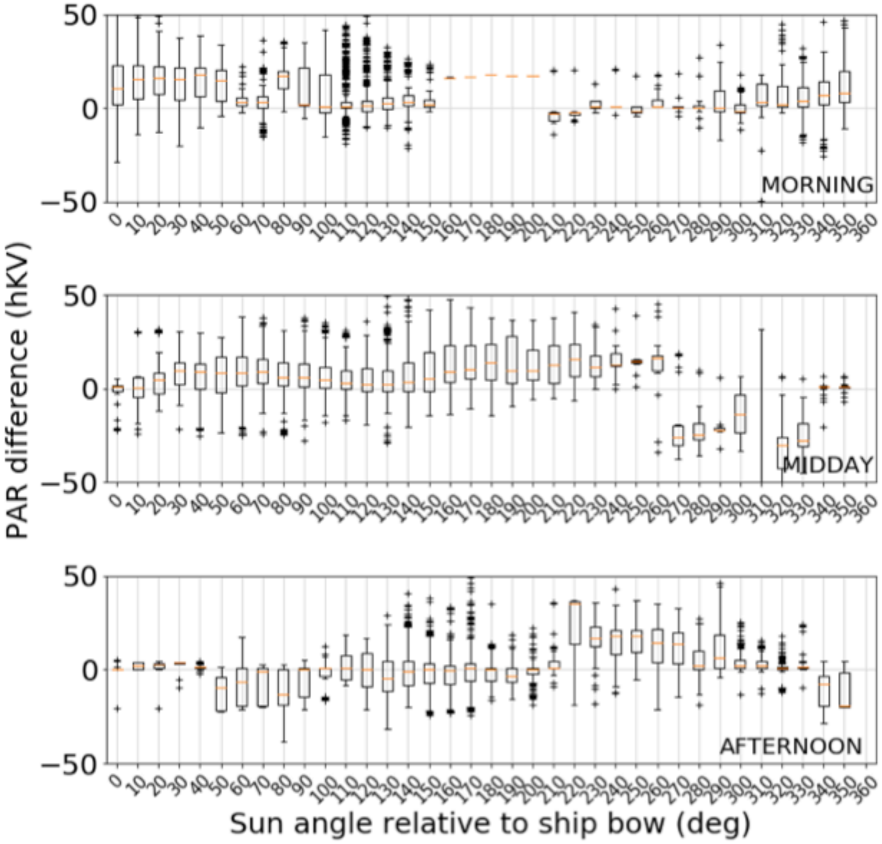


Figure 10.10: Three box and whisker plots of PAR difference against sun angle relative to ship bow during the morning, midday and afternoon. No night time measurements are included.

10.4 Air-Sea Surface Properties

Calibrated datasets of air temperature (T_a) and relative humidity (R_h) was accessed from MET-SURFMET.nc and sea surface temperature (T_w), practical salinity (psal) and fluorescence was accessed from met_tsg_jc159_01_medav_clean_cal.nc.

Figure 11 shows a time series of T_a, T_w and R_h from February 25th – April 5th. As the James Cook progressed eastwards both T_a and T_w decreased from a maximum of 27.5°C to a minimum of 15°C indicative of the backing winds around the region of high surface pressure advecting warmer, tropical air southwards during the start of the cruise and advecting cooler, sub-polar air northwards during the end of the cruise. Relative humidity spikes > 90%, coinciding with a sudden drop in air temperature are indicative of rainfall events. Relative humidity remains high between March 5th – March 10th due to the ship's positioning under the SACZ monsoon trough where warm, humid air from the continent protrudes out into the tropical South Atlantic. Missing data during March 3rd can be attributed to the shutdown of the underway when entering Namibian waters.

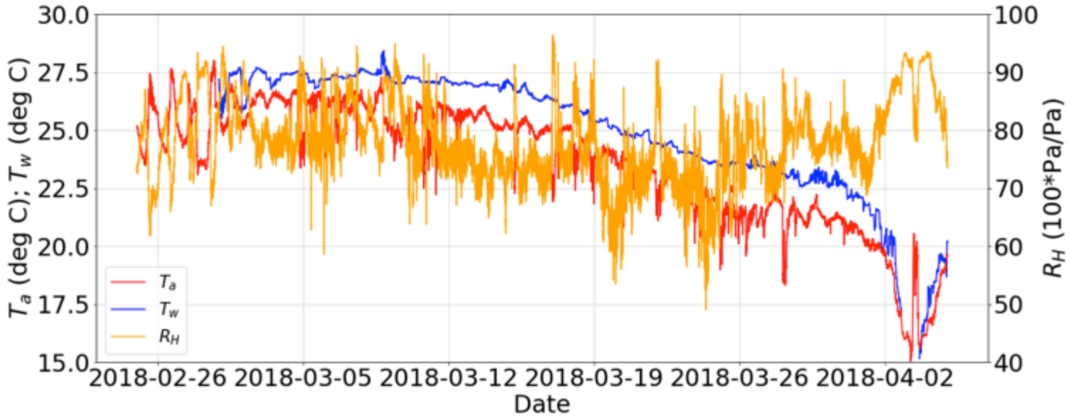


Figure 10.11: Time series of air temperature, sea surface temperature and relative humidity between February 25th – April 5th.

Figure 12 shows a time series of T_w, psal and fluorescence between February 25th – April 5th. T_w and psal remain constant during for the first two weeks into the cruise. Then there is a gradual cooling of temperature and freshening of surface water as the ship neared the Namibian coast. Fluorescence signal increases where there is the largest decrease in water temperature and salinity associated with cooler, nutrient rich water upwelling off the Namibian coastline.

Jack Giddings

11 Bathymetry

Bathymetry data were obtained/measured from the a Konsberg EA640 single-beam and a Kongsberg EM122 multi-beam echosounder. Both instruments remained on throughout the cruise (and were compared with Atlas bathymetry). Output from both instruments was processed daily and checked/cleaned up for spikes. No significant issues arose from either instrument. In general, there EA640 single-beam was noisier and we relied more (in terms of winch and CTD depths) on the EM122 multi-beam.

Data output from both instruments was processes/absorbed, along with other underway data (e.g. TSG and nav) by m_daily_proc.m. The loaded data would get processed and stored as daily files in individual (per instrument) directories. For the Kongsber EA640 single-beam echosounder, the daily files were logged under /bathy/sim/sim_jc159_dnnn_raw.nc and for the Konsberg EM122 multi-beam echo sounder, daily files were logged under /bathy/em120/ em120_jc159_dnnn.nc.

11.1 Konsberg EA640 Single-Beam Echo Sounder

The Konsberg EA640 single-beam echo sounder measured continuous bathymetric data at 10 kHz (free-running) and 12 kHz (passive) throughout the cruise. Sound speed corrections remained constant. After daily processing was finished, the script msim_plot.m was called to load the daily bathymetric data from the single-beam echo sounder and spikes and other bad data was manually/interactively removed. For comparison, data from the EM122 multi-beam echo sounder and atlas bathymetry was also plotted. It was useful to refer to the Carter Table of sound velocity to account for any constant differences in depths between the single-beam and multi-beam echo sounders. The cleaned data was appended at the end of the cruise.

11.2 Konsberg EM122 Multi-Beam Echo Sounder

Similar to the single-beam echo sounder, the EM122 multi-beam echo sounder was run continuously throughout the cruise. However, unlike the single-beam, the multi-beam was corrected with sound velocity profiles (CTD-derived) daily. After daily processing was finished, the script mem120_plot.m was called to load the daily bathymetric data from the multi-beam echo sounder and spikes and other bad data was manually/interactively removed. For comparison, data from the EA640 single-beam echo sounder and atlas bathymetry was also plotted. The cleaned data was appended at the end of the cruise.

A. Sanchez-Franks

12 Lowered Acoustic Doppler Current Profiler (LADCP)

13.1 Instrument Setup

For the JC159 cruise, the ship was equipped with two LADCPs installed in the rosette, one facing downward and the other upward. Both are titanium casing Teledyne RDI 300kHz Workhorse ADCPs. The down-looker was mounted just off centre at the bottom of the CTD frame and the up-looker, installed at the side of the frame. The LADCPs were configured to have a standard 25 x 8 m bins, with one water track and one bottom track ping in a two second ensemble, and no blanking distance. The two instruments were configured to ping in coordination, with the down-looker as the "master" and the up-looker as the "slave". The up-looker was switched to a spare instrument partway through the cruise, just to test the spare.

Prior to each station the ADCPs were connected to a laptop in the deck lab (via a serial port USB adapter) for pre-deployment tests and programming. After the end of each station they were reconnected to the laptop for the data retrieval. The battery package was charged between stations. The table below shows the parameters used to configure the ADCPs.

CR1	retrieve parameters (1 = On)
RN JC159	cruise name JC159
WM15	sets some defaults for lowered ADCP
CF11101	flow control
EA00000	heading alignment (-179.99 to 180 deg)
ES35	salinity (0 to 40)
EX00100	coordinate transformation (none: leave in beam coordinates)
EZ0011101	sensor source: internal heading, pitch, tilt, temp
TB00:00:02.80	time interval per burst of pings (hh:mm:ss)
TC2	two ensembles per burst
TE00:00:01.30	time per ensemble (hh:mm:ss)
TP00:00.00	minimum time between pings (mm:ss)
LP1	single ping per ensemble
LN25	number of depth cells
LS0800	size of depth cells (cm)
LF0	blank after transmit
LW1	narrow band
LV400	ambiguity velocity (cm/s radial)
SM2	RDS3 mode select (2 = slave)
SA001	synchronise: wait for pulse before a water ping
ST0	slave timeout
SB0	disable hardware-break detection on channel B
CK	keep parameters as user defaults
CS	start pinging

Table 12.1: From file JC159_ladcp_slave.cmd, where the parameters for the operation of the uplooker LADCP are defined.

13.2 Instrument Performance

We had two stations with problems regarding acquiring the LADCP data. For Station 9, only the Slave file was generated and for Station 44, only the Master file. For stations 27 and 28, both files were generated, however due to electrical problems with the CTD cable, these stations were aborted early on in the downcast, and there were no useful LADCP data.

Data quality and processing issues are discussed in Section 13.4.

13.3 Data Processing

LADCP data were processed on the workstation eriu. Following each station, data were synced from the network computer to eriu:/local/users/pstar/cruise/data/ladcp/rawdata/ by running lad_linkscript_ix and lad_linkscript_uh in the terminal. These shell scripts also made links to the raw data (.000 files) in the subdirectories ix/ and uh/, for processing by the LDEO IX inversion method or the UH WOCE shear method, respectively. Both methods also use ascii files of CTD data, which are generated as part of the standard CTD processing (Section 2).

The LADCP data can be processed using two different methods. We started by using a software library developed at Lamont-Doherty Earth Observatory (LDEO). This set of programs is used to obtain bottom track profiles, monitor the beams of the instruments to estimate the velocities by the inversion method (for reference, see LDEO IX How-To.pdf). A second software package from the University of Hawai`i (UH) was used to calculate the current velocities and provide information about the heading and tilt of the CTD package.

All the processing for the LADCP was carried out on eriu, a Linux operating system machine. The sequence of the routine processing for the LADCP data is outlined below.

13.3.1 LDEO Processing

The LDEO processing can first be carried out without the CTD data to monitor the results and performance of the beams. The LDEO processing is carried out on Matlab.

1. Initially, type “~/cruise/data/exec/linkscript_ix” on the command line to create symbolic links from the binary *000 files to the real raw file.
2. Navigate to “~/cruise/data/ladcp/ix/” and start a Matlab session.

3. Run “m_setup” to define the paths necessary to run the scripts in the current Matlab session.
4. Type “cfgstr.orient=’DL’ ” where “DL” refers to the files from the downlooker LADCP. The same Matlab structure could be defined for the up-looker files, “UL”. Finally, both LADCP files could be processed together by defining “cfgstr.orient=’DLUL’ ”.
5. Run the following command: “process_cast_cfgstr(nnn,cfgstr)”.
6. Files generated in this process includes figures (.ps and .png), log files and .mat files which are stored at “cruise/data/ladcp/ix/proc_IX_12/DL_GPS/processed/nnn” for each “nnn” station for the “DL” LADCP. The up-looker and combined results are in “UL_GPS” and “DLUL_GPS” directories, respectively.
7. We first processed the data without the inclusion of the vessel mounted ADCP to verify how the data performed.

The steps above should then be repeated to include the CTD data after it has been processed. The format of the CTD data required is the same for both LDEO and UH processing and when CTD data are available the processing will automatically use it.

Among the products generated by the LDEO processing, Figure XX.1 shows the zonal and meridional velocity components profiles and some other information for the Station 008, down-looker LADCP.

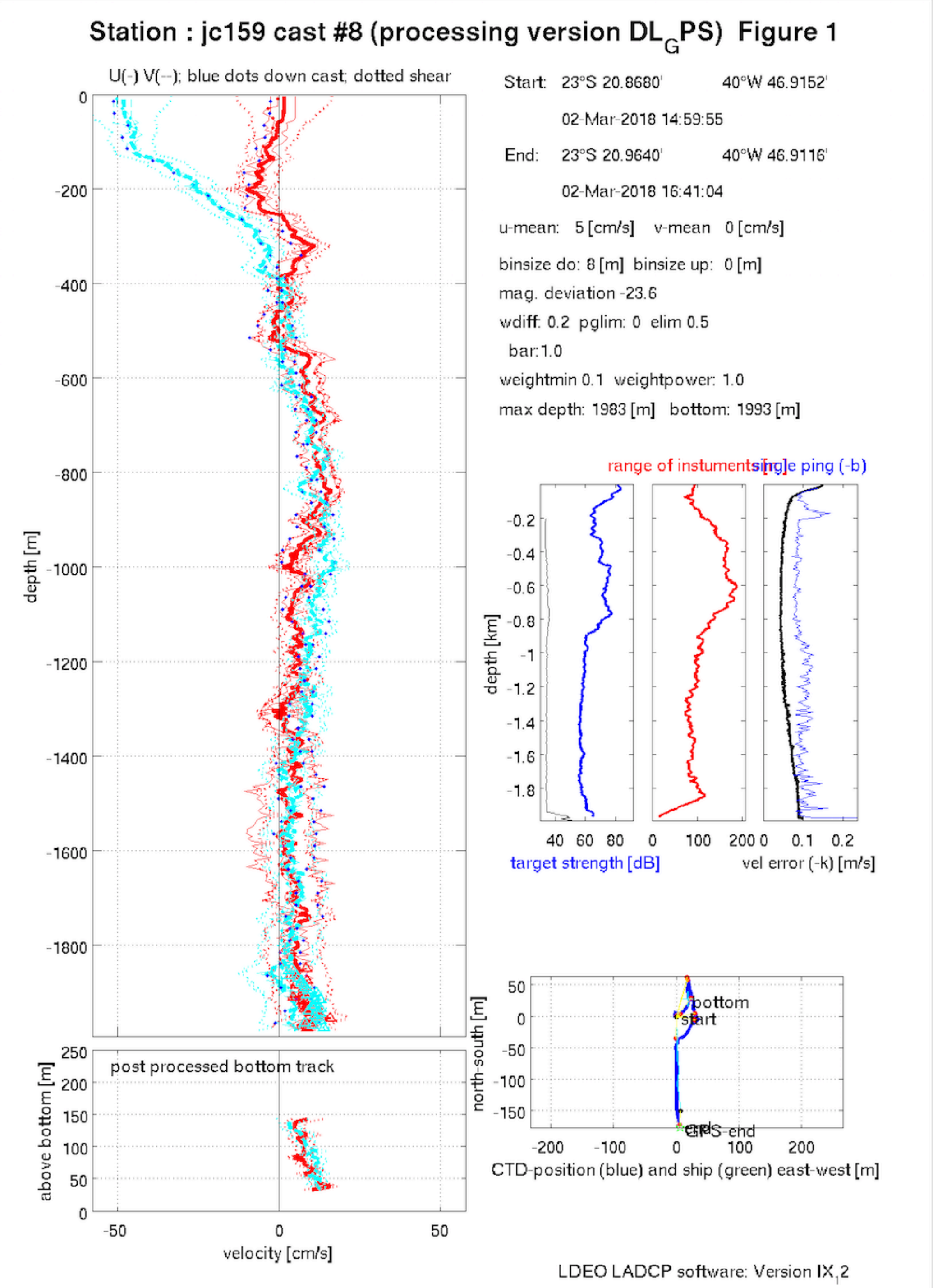


Figure 12.1: Eastward (red) and northward (green) velocities in full solution with error bars, and down and up cast solutions, shear solution, bottom-track (up-left panel) for Station 008 of the JC159 cruise, using LDEO software. The bottom track post processed solution is shown in the bottom-left panel. The plot also shows the ship and CTD drift during cast (bottom right) and the target-strength, range and error profiles (center right panel). The top-right text includes the meta-data and velocity referencing constraints used for processing.

13.3.2 UH Processing

The initial stages of processing allow the user to examine the quality of the data and to calculate relative velocity profiles in the absence of CTD data. These are the steps:

1. In the terminal, change to the directory ~/cruise/data/ladcp/uh, type “source LADall” to set up the paths required for the processing. After this, one can simply type “cd proc” from anywhere to go directly to the processing directory. Note: do not type the “. They are just to distinguish the command from text.
2. Type “~/cruise/data/exec/linkscript_uh” on the command line to create symbolic links from the binary *000 files to the real raw file. Change to the directory “cd proc/Rlad” to access the raw files.
3. Following are a series of commands to be executed in the command line (terminal) and in Matlab. In the next lines, the letters “T” or “M” will indicate where to run the commands.
4. (M): Start a Matlab session in the “proc” directory. Run “m_setup.m” to create in the current session the paths necessary to process the data.
5. (T): In the directory “proc”, type “perl -S scan.prl nnn_02”, where nnn is the station number, to scan the raw data and create a station specific directory in the proc/casts directory. Data printed to screen should be checked to ensure the details of the cast (i.e. depth, downcast/up cast times) agree approximately with the CTD log sheet.
6. (M): Station position and the magnetic variation correction are entered by typing “uhlad_putpos(nnn,02)”. This updates stations.asc and magvar.tab for the donw-looker LADCP (02).
7. (T): Type “perl –S load.prl nnn_02” to load the raw data, correcting for magvar.tab to start processing. It is very important that this step is only carried out once. If it needs to be repeated the database files (~/cruise/data/ladcp/uh/pro/jc1802/ladcp/casts/jnnn_02/scdb) must be deleted first.
8. (T): Type “perl –S domerge.prl -c0 nnn_02” to merge the velocity shear profiles from individual pings into full upcast and downcast profiles. The option -c0 refers to the fact that CTD data has not yet been included.
9. (M): Enter the Rnav directory (“cd Rnav”) and run “make_sm” to update the navigation file. Then backup one level to the “proc” directory.
10. (M): Change back to the “proc” directory and set the variable “plist=nnn.02” and run “do_abs” to calculate relative velocity profiles. A series of plots are generated. Check that these plots look sensible, i.e. reasonable agreement between downcast and upcast and that the vertical velocity changes sign between downcast and upcast (it may be necessary to rescale some of the plots). Also check the plot on Figure 78 to monitor the number of pings throughout the profile. Once the CTD data has been processed this can be incorporated into the LADCP processing to make

more accurate estimates of depth and sound velocity and to obtain a final absolute velocity profile.

11. (M): The inclusion of CTD data requires an ASCII file containing 1Hz CTD data for the station created in Matlab. If this is present navigate to “proc/Pctd”. Run “ctd_in(nnn_02)” which will read the 1Hz CTD data in. Set “plist=nnn.02” and run “fd” to align the LADCP and CTD data sets in time.
12. (T): In the “proc” directory, type “perl –S add_ctd.prl nnn_02” to add the CTD data to the “*.blk” LADCP files in the “casts/jnnn_02/scdb” directory.
13. (T): Merge the single pings into corrected shear profiles by running “perl –S domerge.prl –c1 nnn_02” where the “-c1” option now states that we have included CTD data.
14. (M) Finally in Matlab, once again set “plist=nnn.02” and run “do_abs” to produce the final absolute velocity profiles.
15. Repeat the steps from 4 to 14 for the up-looker LADCP processing, and define the file names as “nnn_03”.

Figure 13.2 shows an example of the zonal and meridional velocity component profiles for Station 064, down-looker LADCP.

13.3.2.1 Inclusion of True Depths

In the UH processing, the depth for the station in question was then noted along with its error and the proc.dat file located in “proc” directory was edited to include these values. The original depths were left in place but commented out so they were not used when the file was read. When the “perl –S domerge.prl –c1 nnn_02” step was done, it incorporates the new depth in Matlab using “plist=nnn.02” and “do_abs” re-run. The plots produced show the corrected depth and may be printed.

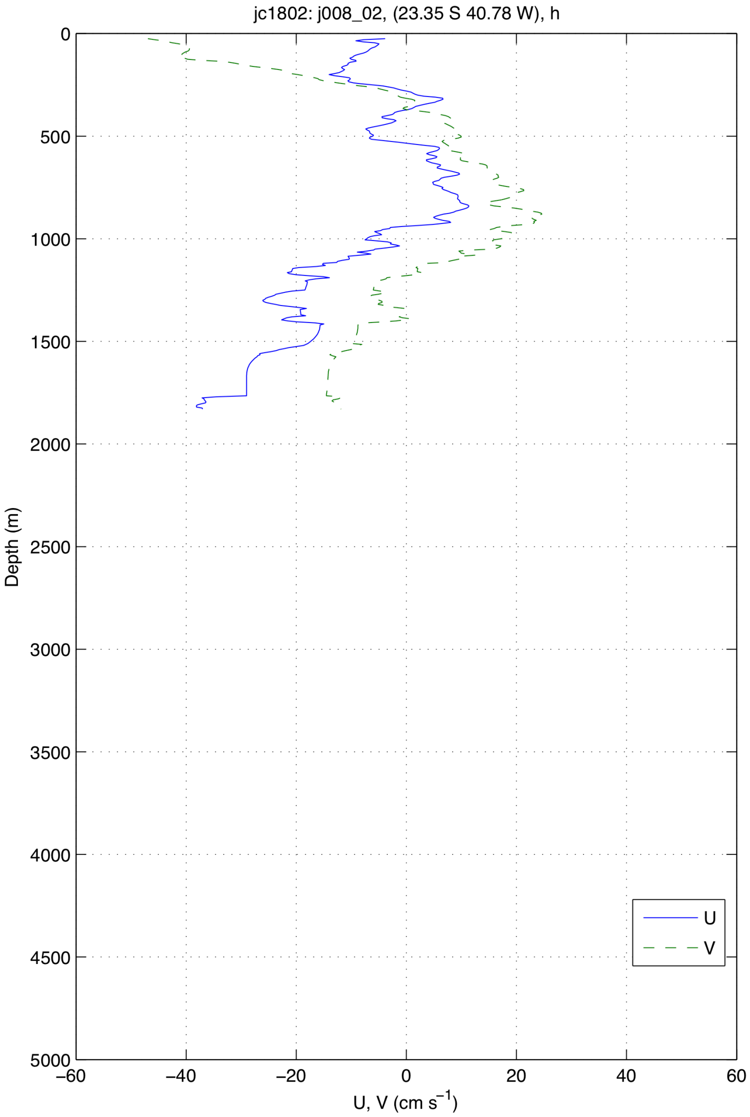


Figure 12.2: Mean zonal and meridional velocity components for Station 064, down-looked LADCP using the UH software. The mean is estimating by averaging the down and up cast profiles.

13.4 Preliminary Results and Brief Overview of Issues

13.4.1 Comparison of LADCP (UH and LDEO) with no VMADCP

Figures 13.1 and 13.2 shows the solution for the velocity profiles for Station 08. By comparing them, their variability and magnitude, one can conclude that the use of both solutions produces very similar results, as it should be. As it was mentioned before, we started processing the LADCP data using the LDEO software. After we reached deeper stations, the shear solutions became more unstable due to the lack of scattered materials in the water column. As a result, after Station 19, the bottom track and the shear velocity profiles became much larger than expected, as it is depicted in Figure 13.3 which shows the velocity profiles for Station 050.

At that point, we have not included the data for the vessel mounted ADCP in the processing.

We ran the LDEO software up to Station 073 to examine how the *velocity inversion method* would perform. After that, we decided to change to the *shear velocity method* from UH.

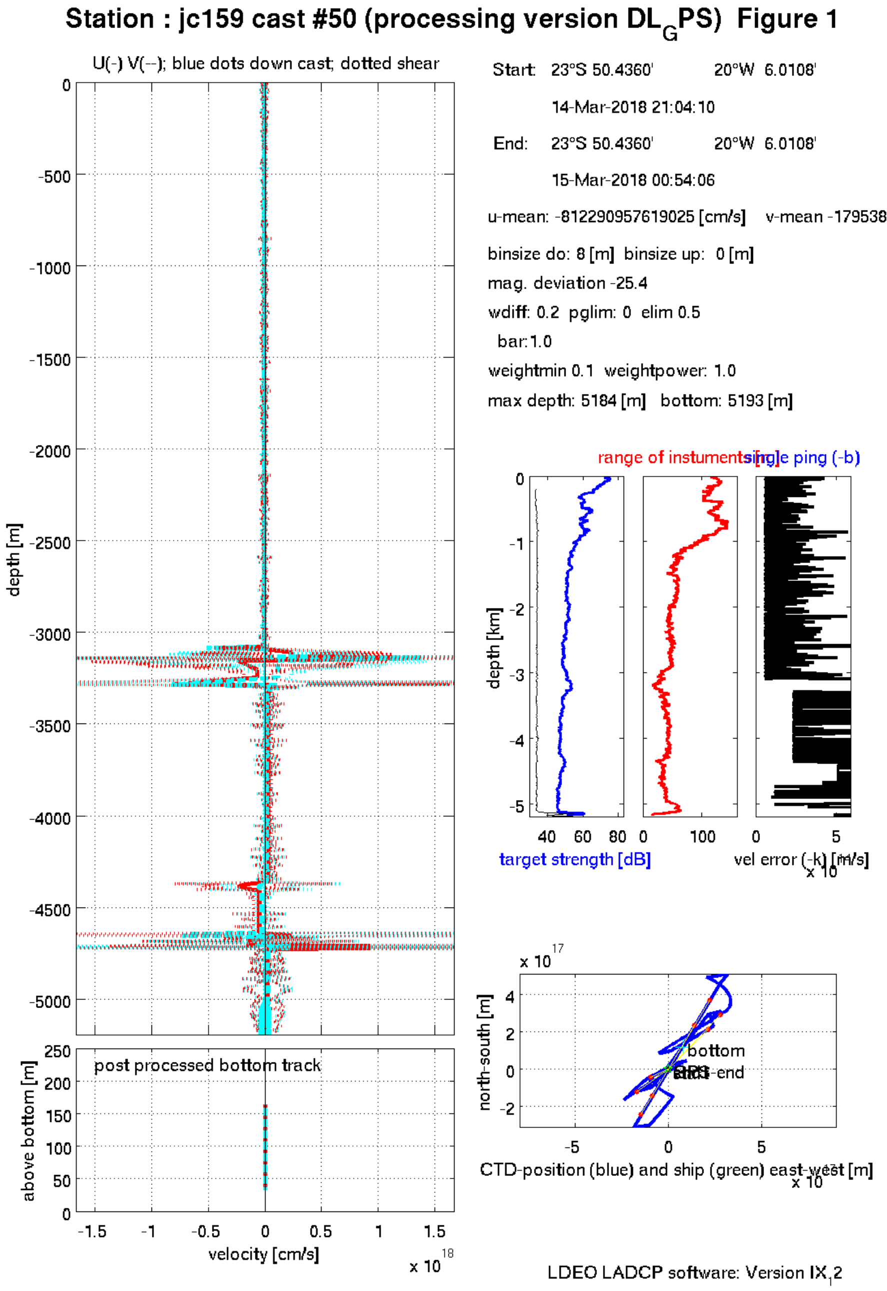


Figure 12.3: Similar to Figure 13.2 but for Station 050.

13.4.2 Shear

As can be observed from the Figure 13.4, that the shear velocities agree very well in the range of comparison. It should be noted that in the deeper ocean, the agreement was not as good, but this was largely due to the fact that there was little good data below 1500m depth. There does not appear to be any great difference between the agreements of the shear velocities in the u and v components.

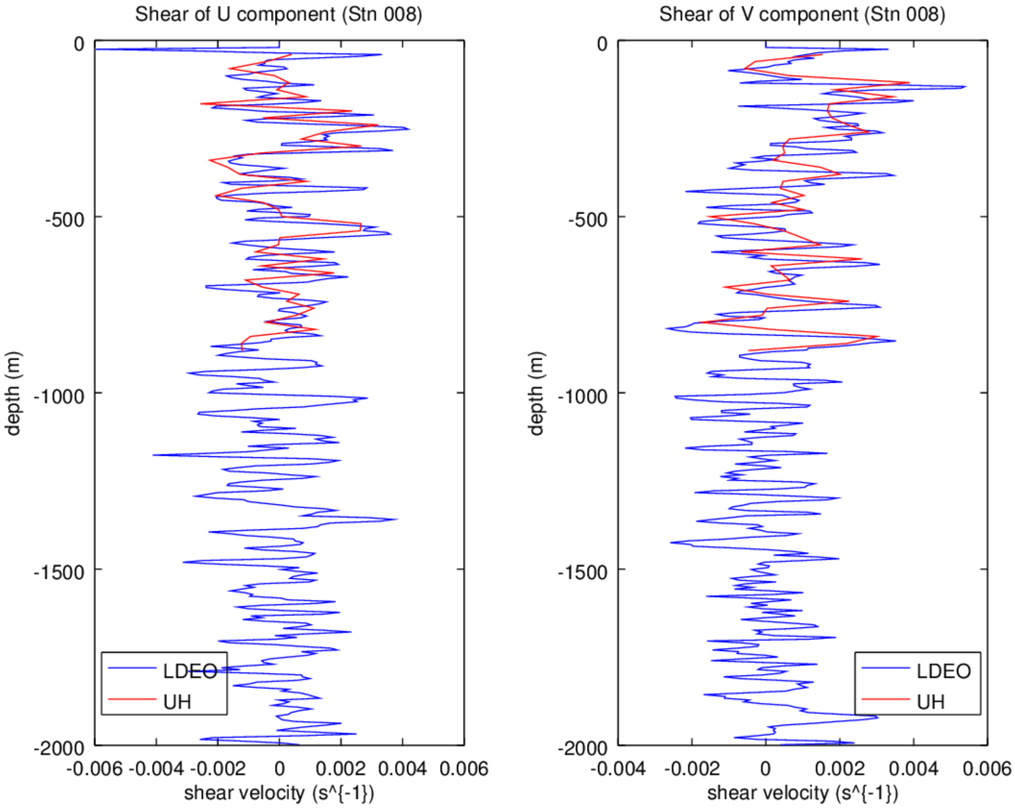


Figure 12.4: An example of the plots produced for ADCP shear velocities, using as an example Station 08.

13.4.3 Near-bottom velocities

We continued to save the bottom track velocities extracted by the IX functions (Figure 13.5). At most stations bottom tracking velocities could be extracted up to 140 m from the bottom. Near-bottom flow is mostly northward. Stronger velocities are observed in the channel in the mid-Atlantic ridge; closer examination of data quality is probably required, however (see Section 13.4.5).

Figure (vel_btrk_vecs.png***): Velocities at the bottom and 100 m above the bottom from the IX processing of RDI bottom tracking velocities.

13.4.4 Comparison with VMADCP and geostrophic velocities

The UH method produces separate shear profiles for the down and up cast for each instrument. These were inspected and suspect values or bins were removed before re-averaging to a mean shear profile and integrating to obtain velocity relative to the shallowest bin. For the results shown here we have chosen not to fill gaps in the shear profiles, so that the velocity profiles extend only as far as the first bad bin. To compare with the VMADCP observations and with geostrophic flow from the CTD profiles (Figure 13.6), the average velocity between 150 and 300 m was subtracted, and the average VMADCP (OS75) velocity in the same depth range added in. There is generally good agreement with the station-averaged VMADCP, and with the large-scale patterns of geostrophic shear.

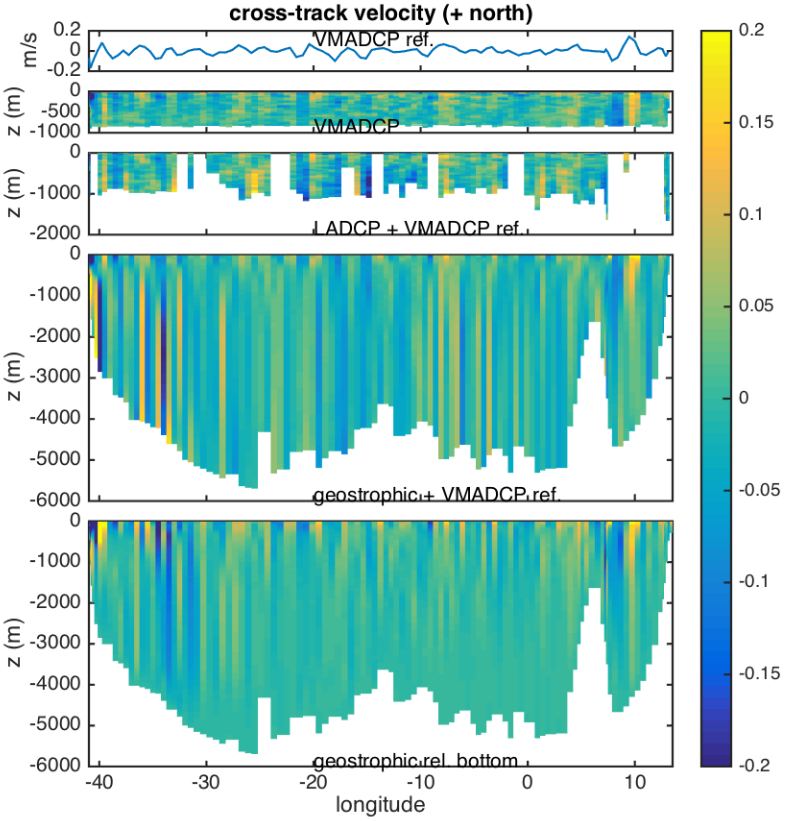


Figure 12.5: cross-track velocity (m/s) over the section from the VMADCP (top, averaged between 150 and 300 m; second panel, as a function of depth), the LADCP (third panel, with the VMADCP used to reference edited shear profiles), and CTD-derived geostrophic shear (fourth panel, referenced to the VMADCP; bottom panel, referenced to zero at the bottom).

13.4.5 Problems

A lack of scatterers below about 1000 m depth led to very poor data quality over much of the water column. In the UH processing, this shows up as segments of apparently constant velocity associated with a low number of pings per bin. In the IX processing it can cause the solution to blow up, introducing wildly large shears. In both cases, the depth-averaged shear will be erroneous and therefore the mean velocity, referenced using navigation (by adjusting the instrument-measured net movement to the ship net movement) or bottom tracking, will be incorrect as well.

Possibly relatedly, on a number of profiles, the IX processing failed at the stage of matrix inversion. We hypothesized that this might be due to too many zeros (or rather, near-zeros) in the matrix, but did not manage to determine during the cruise exactly what was going wrong in the inversion or preparation stages. This was one reason for switching to the UH shear method as the primary processing path, and for editing and applying a VMADCP-based reference velocity by hand.

Additional processing and quality control ashore are required.

Olga Sato and Yvonne Firing

14 Vessel Mounted ADCP

14.1 Introduction

The RRS James Cook holds two vessel-mounted Acoustic Doppler Current Profiler (vmADCP) instruments, which were used throughout the cruise to measure the velocity of the upper layers of the water column. The instruments are both Ocean Surveyor (OS) by Teledyne RD Instruments, working with different frequencies. One is 75 kHz, which provides thicker bins (lower resolution) but penetrates deeper in the water column (in this cruise, this was typically 850 m). The other instrument works on 150 kHz, which renders a higher resolution but dissipates at a shallower threshold (in this cruise, at around 240 m).

The transducers of both instruments are installed in the port-side keel of the ship. The segment of keel can be lowered down into the ocean, a setting known as “dropped keel”. This increases the transducers' depth by 2.593 m, from a typical depth of 6.0 meters below the waterline to approximately 8.6 m. The vmADCPs can be run in either position, dropped or retracted, and in this cruise both were used. Steaming with the keel retracted allows for higher speeds. However, measurements with the keel dropped are generally of better quality as the instruments are submerged deeper down, away from the surface. This reduces surface interferences such as bubbles, especially in rough weather.

14.2 Initialization and Data Acquisition

The control of the instruments was carried out from the two vmADCP designated computers in the main lab. Three software components are provided for this: BBTalk (for communication with the instrument), VmDas (for data collection) and WinADCP (for data pre-visualisation).

14.1.1 Initialization of Instruments and Acquisition

At the beginning of the cruise (or any time that the Ocean Surveyor instruments need to be started) the BBTalk software can be used to communicate with the instruments and to test them. Software version 3.09 was used in this cruise. To first communicate with the instruments, the adequate device, COM port and baude rate need to be selected when initialising BBTalk. In this case, both instruments are 'Narrow Band', the ADCP input is through port 'COM1' and the baud rate is '9600'. When an instrument is detected, a script with test commands can be sent from the file menu. For the OS instruments, the file used is 'testOS.rds', provided by Teledyne. The results of our test at the beginning of the cruise were saved into the files named 'JC159_PreChecks_280218.txt' (OS75) and 'pre-checks_280218' (OS150). The instrument checks were positive and also output useful data, such as the beam angle of the transducers (30 degrees) and the receive bandwidth of each beam (showing all beams worked correctly).

Data were collected using the VmDas software, version 1.48. Note that it is necessary to exit BBTalk so that VmDas is able to use the vmADCP's COM port. VmDas collects and stores real-time single ping data, and averages profiles in short and long term averages. The averaging periods are defined in the configuration and are useful for data pre-visualisation in VmDas or WinRiver. However, the final data averaging is carried out from single-ping data and the averaging period can be changed or set later. A standard averaging period and the one we used later in the processing was 5 minutes (300 seconds).

14.1.2 Configuration of the Data Acquisition

The program's configuration for the data acquisition can be set up in the 'Options' menu. Preferably this is done with a configuration file that contains all the setting commands. In this cruise, we had four different setups for each instrument, depending on whether bottom track was set on or off, and whether the keel was dropped or retrieved. However, we only used two configuration files (bottom track on and bottom track off). The position of the keel only changes the depth of the transducer, and this can be specified later during the post-processing, as well. The following configuration commands were used for the OS75 instrument, with bottom track on. However, here we also specify where commands differ in other settings:

CR1 >> This restores the default configuration before doing any changes.
CB411 >> This sets baud rate to 9600 bps, with no parity, one stop bit and 8 data bits.
NN060 >> 60 bins, in narrowband mode (40 for the os150)
NP00001 >> Ping in narrowband single-ping profile mode.
NS1600 >> Bin size (in cm) (800 for the os150).
NF0800 >> Data blanking distance below the instrument (in cm): (400 for the os150).
BP001 >> Bottom track enabled (when 001), or disabled (when 000).
BX10000 >> Maximum bottom depth search (in dm). (05000, or 500 m, for the os150) for the os75, and 500 m for the os150.
WD111100000>> Output velocity configuration
TP000150 >> Time (in centiseconds) between bottom and water pings. (100 for the os150)
TE00000200 >> Time between ensembles—however, a setting in vmDAS was used to tell the instruments to ping as fast as possible, and the output is single pings, so this will have no effect.
EZ1000001 >> Speed of sound calculated with the temperature sensor in the instrument.
EX00000 >> Output beam coordinates
EA00900 >> Transducer misalignment correction (in 1/100 degrees). (0 for

the os150). This is only applied to average profiles displayed in vmDAS; the single-ping data are output in beam coordinates.

ED00086 >> Transducer depth (decimeters). This is 8.6 m for the keel down. When the keel is up, this was changed during postprocessing.

ES35 >> Salinity (for calculating the speed of sound) set to 35 ppt.

CX 0,1 >> ADCP triggers itself (rather than waiting for an external trigger). We did not try to coordinate pinging among the different acoustic instruments, because we only used the ADCPs and the bathymetric sonars (which operate at very different frequencies).

CK >> Store configuration to non-volatile ADCP memory, so that it remains there after re-launching.

To begin recording data after starting VmDas, we clicked on the 'collect data' option under the 'file' menu. Then, the configuration can be introduced from the file specified in the 'Edit Data Options', in the 'Options' menu. This is the right menu to specify the name of the output files and the beginning of the sequence (1 to start, or any sequential number if continuing a dataset). Note that, each time data recording is stopped and restarted, the sequence number should automatically increment. However, if the program is exited or changes are applied, it needs to be ensured that the sequence is updated and it will not overwrite previous files. For processing using CODAS (see below), it is important that the alphanumeric order of the filenames corresponds to the time order—therefore it is better to skip a sequence number than to risk overwriting or going back.

The file naming protocol we followed includes the cruise name, the instrument frequency and the sequence. An example of our file naming is JC159_OS75_NNN_NNNNNN.EXT, where NNN is the sequence number (in increasing monotonic order), NNNNNN the subsequence number (vmDAS automatically starts new files when a certain size is reached) and EXT is the extension. After choosing the desired configuration and file naming, data collection is started by pressing the blue “play” button or by clicking 'Go' in the 'Command' window. Sequences were stopped and restarted typically once a day to keep files manageable and with a similar size. Data collection was also stopped and resumed every time the configuration was changed (when the keel is moved or when the bottom track option is changed), as the configuration can only be changed when data archiving is off.

14.1.3 Output Data

VmDas outputs a set of different files with different extensions for every data sequence. Those files are described below:

- ENR files are binary and contain the raw single ping data.
- N1R, N2R, (N3R...) are ASCII text files and contain raw data from the NMEA strings. The number in the extension specifies which NMEA string it is.
- NMS are binary and contain navigation data extracted from the N#R files.

Then, ENR files are processed by VmDas with NMS files and produce:

- ENS files, which contain processed ADCP data merged with navigation, in beam coordinates.
- ENX files, which are further processed. They are bin-mapped, screened for error and for vertical velocity, they also include navigation data and are transformed to Earth coordinates.

Finally, ENX files are further processed and averaged into:

- STA files, which are short-term averages (we set this to be 120 seconds)
- LTA files, which are long-term averages (we set this to be 600 seconds)

Other output files include ASCII logs about configurations and errors:

- VMO files contain the setup used for data recording (this should be the same or very similar to the configuration file used).
- LOG files log all the output messages and errors.

14.1.4 Data Quality Monitoring

The correct functioning of the ADCP was monitored periodically. First, the VmDas display was checked every 4 hours to ensure that the program was running correctly. The number of recorded ensembles was logged and compared with previous checks to ensure that it was increasing at the correct rate (one ensemble every 2 or 3 seconds for the OS150, and every 3-4 seconds for the OS75, in the real-time data display). Other parts of the display were analysed as indicators of possible errors, such as the ensemble and navigation indicators at the bottom of the VmDas display (green were they are good, red for bad) and the velocity profiles for each beam. When on station, all real-time profiles should be centred in the screen with similar velocity magnitudes. When steaming, typically two profiles remain centred and the other two present symmetric and strong velocities, one positive and one negative, reflecting the ship’s motion.

Additionally, sequences of data can be checked using WinADCP (version 1.14 was available in this cruise). This software allows the display of different sections of the data, regardless of whether it is still recording them. Different velocity components, errors and other properties can be shown, and different preliminary processing can be included to remove the ship's motion. Displaying data with WinADCP at the early stages of the cruise is very useful to gain insight on the data quality, the transducer misalignment and, most importantly, that data are being recorded with the adequate settings. To complete the monitoring, several LTA sequences were post-processed to check the overall performance of the data recording and to obtain the first estimates of bottom track calibration.

14.2 Processing of Data

Data were post-processed using the CODAS software. The Common Ocean Data Access System (CODAS) processing is a set of programs designed to work on ADCP data together with ancillary data (navigation data and attitude sensors) in the context of UHDAS (University of Hawai'i Data Acquisition System). UHDAS is a complete system of programs and configurations aimed to collect ADCP data. Although the software used for data acquisition was VmDas, these data can be transformed to UHDAS and processed with the CODAS software. This section covers the installation of the CODAS software and the processing of data. However, for more detailed instructions it is recommended to follow the CODAS manual, available at https://currents.soest.hawaii.edu/docs/ adcp_doc/codas_doc/.

14.2.1 CODAS Processing Software Setup

The set of CODAS programs are written in python and are available online at https://currents.soest.hawaii.edu/docs/adcp_doc/codas_setup/index.html.
Several installation options are available, but we used the recommended one: the installation of a virtual machine with all the configurations and programs already set up. For this cruise, the latest version available was the CODAS xenial v32 (2017-09-20). This was installed within the Oracle VM VirtualBox manager on workstation banba, following the instructions in the CODAS documentation, including creating a shared folder (see next section).

The CODAS programs come pre-installed on the virtual machine; however, we realised that an update was required to fix a bug in the vmdas to uhdas conversion portion of the processing. With the help of the NMF IT techs we were able to get codaspy on the open network and pull the latest versions of the pycurrents and codas3 libraries from the mercurial repository. The updated versions were:
pycurrents:
changeset: 2464:613202ad940e
codas3:
changeset: 270:b861d232b272

We then re-installed these libraries following the CODAS documentation.

14.2.2 Directory Strategy

In order to carry out the processing, raw data and processed data were organised into a standard directory structure that is described here. First of all, there are two main working directories to consider. The main one is the shared folder created in the previous subsection. This is '/media/sf_codas_shared' from the codaspy virtual machine, or '/local/users/pstar/codas_shared' from the main computer, which in this cruise was banba. The additional working directory is only found in the codaspy machine and it is '/home/adcpproc/jc159'. We kept the vmDAS data and the processing directories in the shared folder. However, we encountered problems when trying to work with UHDAS data outside of the local codaspy drive. For this reason, we saved our (converted-from-vmDAS) UHDAS data in /home/adcpproc/jc159/.

Inside the shared directory, we set a new folder with the cruise name (jc159) and a subfolder for each instrument type: 'jc159_os75' and 'jc159_os150'. For each instrument there is a folder for processing (adcp_pyproc) and one where we copy all the raw VmDas data sequences (vmdas_data). Additionally, when a single or a specific group of sequences was processed (for instance, to process one bottom tracking sequence at a time), we created a new folder that contained the data for those sequences alone (e.g. vmdas_data_043_048). Note that data for these sequences were not copied again; instead the shell script vmadcp_linkscript_vmdas_data was used to make links to files in the vmdas_data/ directory.

The processing folder (adcp_pyproc) had a subfolder for each processing chunk. To identify which data were processed, the folder names included theinstrument (os75 or os150), followed by the type of data (lta for long-term averages or enr for single-ping) and finally the sequence number or the first and last of a set of sequences being processed. An example of this is 'os75_enr_002_041', for sequences 2-41 from the os75. Inside of each processing directory, a main processing folder was created with adcptree.py and also a configuration folder (config) for enr data only. This will be explained later as a step of the processing.

In the codaspy computer, the additional processing local directory only contained a folder named 'fake_uhdas_data'. This is a required space to save VmDas data that have been converted to the UHDAS format. Inside the fake data folder, there is a subfolder for each processing sequence with a matching name. Note that these folders are created as part of one of the processing steps and need to not be created beforehand.

14.2.3 File Synchronization

Data are collected on dedicated computers and regularly synced to the ship’s networked data servers, where they can be found in JC159/Ship Systems/Acoustics/OS75/ and OS150/. Because of the multi-step syncing, it is important to allow for some time (20 to 30 minutes) after stopping a vmadcp sequence before transferring the data so that all files are either complete or still being updated.

The transfer of data is done by running the shell script vmadcp_linkscript_jc on workstation eriu. This syncs the data from the network to the cruise processing directory on eriu; syncs it from there to the shared folder on banba/codaspy; and syncs processed data from the shared folder back to eriu. Therefore this script was run before and after each set of processing.

14.2.4 LTA Processing

The long-term averaged data allows little room for post-processing, as single-ping profiles are averaged before any changes are applied. However, it provides a useful tool to quickly visualise the first sequences of data, to spot any possible issues and to primarily assess the misalignment of the transducer from the ship's axis.

In the adcp_pyproc directory, we create a new folder for the LTA sequence to be processed (for example 'os150_lta_017') and, within this, we generate a processing directory using the adcp_tree.py command. This command creates a subset of folders designed to contain all the processed data and information. It is run in the form:

```
<adcp_tree.py os150nb --datatype lta --cruisename os150_lta_017>
```

Inside the new folder (os150nb in this example) we also write a control file named 'q_py.cnt', which contains the information to start the processing. This file has the following information:

```
 --yearbase 2018
--cruisename os150_lta_017
 --dbname a15017
 --datatype lta
 --sonar os150nb
 --ens_len  300        (this will be our LTA time average)
```

Now the basic CODAS processing can be run using the quick_adcp.py command. This is done with the command file as:

```
<quick_adcp.py --cntfile q_py.cnt --auto>
```

The 'auto' option runs all the steps automatically and it was the preferred choice during the cruise. This option can be omitted in order to choose which individual processing steps are to be run.

After the main processing is run, we can examine different plots to visualise the data and to ensure that they are in the desired form. First, plotting the navigation helps determining that the NMEA data are being read and processed adequately. This is done running the command <plot_nav.py nav/a15017.gps>. The name of the navigation file (in the 'nav' folder) contains the database name (in this example it is a15017) with the extension 'gps'. This will plot the trajectory of the ship during the ADCP sequence and it will also plot latitude and longitude as a function of time. Finally, to visualise the actual data, the command <dataviewer.py> provides the best tool to plot velocity data. This script opens a GUI that allows the selection of variables (different velocity components and data quality metrics) together with information about the navigation (speed and heading).

These preliminary plots were used in this cruise to ensure data were being recorded adequately and to find out how deep the instruments could measure. They also informed about misalignment of the transducers, as changes in ship speed or heading result in sharp changes in the velocity sections when the instrument is not correctly aligned. Finally, this is also a useful tool to identify sources of bad data (such as bottom reflection, possible acoustic interferences, low scatter layers, interference of bubbles at the surface, etc.).

In our case we found that data presented good quality, even as long-term averaged profiles. They required some post-processing at the single-ping level but with little manual editing expected. We also identified the need to correct the transducers' angles, as we expected from other cruises using these instruments.

14.2.5 ENR Processing

Best quality of data is achieved when the processing is done at single-ping data, before these are averaged into consistent profiles. This allows the removal of bad data and misalignment errors at individual pings. VmDas records these data in the files with the ENR extension. However, the CODAS processing software does not support the direct processing of this data type. In order to do so, data need to be converted into the UHDAS format. In this section we explain how ENR data are converted to UHDAS and how those are processed.

Detailed instructions are available at:
https://currents.soest.hawaii.edu/docs/adcp_doc/codas_doc/qpy_demos/examples/04_enr_fromscratch/enr_fromscratch_instructions.html
The first steps occur within the 'config' folder in the enr processing folder of the sequence to process. The command <reform_vmdas.py ../../..> prompts a GUI that allows the selection of the VmDas data folder and the 'fake_uhdas_data' where to dump the converted data. Note that the path given after 'reform_vmdas.py' will be the starting directory from where to browse the VmDas and UHDAS data. After running the GUI, it generates a file with the variable names to use later (reform_defs.py) and a program to be run next (vmdas2uhdas.py). Running the command <python vmdas2uhdas.py> converts the data into UHDAS. It first recasts the NMEA data within the VmDas data folder and then it does the conversion of data to UHDAS, inside the 'fake_uhdas_data' folder.

Before running the actual processing, a UHDAS configuration file is also required. This file is generated with another GUI, by running the command <proc_starter.py reform_defs.py>. This GUI requires some information about the ADCP instruments, such as the beam angle, the transducer depth and its angle correction (if any is required or known). Note that the angle correction can be done later. However, if it is too big, this will introduce a big bias and it will prevent from further manual post-processing. In this cruise, we set the angle correction to 0 for the os150, but we used an initial correction of 8.5º to the os75 (known from previous cruise reports). This allowed us to further process the data before determining a more accurate correction.

With the new configuration file we can continue with the processing in a similar way to the LTA data. First, an adcp_tree.py folder is created (this time for UHDAS data, as we converted our ENR data to UHDAS). A similar q_py.cnt control file is written for UHDAS data, with the addition of the following lines:

```
--update_gbin
--configtype  python
--max_search_depth 1500   (maximum depth where the bottom is searched)
```

Finally, the quick_adcp.py command can be run to carry out the main processing steps. A detailed description of the quick_adcp.py processing steps can be found at https://currents.soest.hawaii.edu/docs/adcp_doc/codas_doc/quickadcp_overview.html

14.2.6 Manual Post-Processing

Data were further processed with visual inspection of all sequences and the removal of bad bins and profiles. This is carried out with 'gautoedit.py', from the 'edit' directory within the tree directory. Gautoedit is a GUI for manual editing of data. It allows the display of sections of different velocity components and navigation, and different options to select and remove spurious data. First, different quality standards can be applied to automatically remove low quality data. In this cruise, we used the standard criteria given by Gautoedit. Then, after visual inspection, the removal of bad bins could be done with a box, by clicking and dragging the cursor, or by selecting complete profiles to be removed.

The quality of the data was good through most of the cruise and little manual editing was required. Most of the bad bins were found near the bottom in the shelves, where the instruments reached the seafloor. The reflection of the acoustic signal from the seafloor is generally identified and removed, but sometimes it introduces a bias at the bottom layer, especially in the slopes when the depth approaches the limit of the instrument's skill to detect the bottom. The spurious data are identified as a few of the bottom bins (3 to 6 bins) showing an abnormal high velocity, sometimes with a direction incoherent with the rest of the profile.

When the ship changed sharply its heading and speed, when approaching or leaving some stations, it would also produce some bad data. This was identified as a sequence of 1 to 3 profiles with strong velocities throughout the full water column. The sharp changes could not be adequately removed by the instrument and resulted in anomalous data. Note that this effect is different to a transducer misalignment. These bad profiles irrupted occasionally between coherent velocity sections, regardless of whether it changed from transit to on-station. The misalignment effect shows consistently, as a strong velocity contrast between sections of different ship speed and are fixed separately with an angle correction.

Finally, further editing was applied to single anomalous pings. Especially in the last transect, from Walvis Bay to Cape Town. We encountered rougher weather conditions and the effect of bubbles could be clearly seen as abnormal strong velocity bins towards the surface layers. These were also removed. It is interesting to note that this transect was carried out with the drop keel up, being more susceptible to surface interferences. However, because we did not face rough conditions in any transect with the keel down, it is hard to assess how much better data could have been with the drop keel down.

The edits saved with gautoedit are saved as ASCII files. To apply those to the database, quick_adcp needs to be run again in the form:

```
<quick_adcp.py --steps2rerun apply_edit:navsteps:calib  --auto>
```

This will apply the changes and change the ASCII files to log files.

14.2.7 Misalignment Correction

Ideally, the ADCP transducers installed in the keel are perfectly aligned with the ship's axis, so that the ship's motion can be easily subtracted from the water velocity recorded by the instruments. However, this is not generally the case and a component of the ship's velocity is introduced in the ADCP data. As a rule of thumb, a misalignment of one degree generally introduces a bias of 10 cm/s when steaming at 10 knots (typical ship speed between stations). This bias is important, especially for the calculation of transports, and therefore it needs to be corrected for.

The processing carried out by quick_adcp.py considers this and computes the angle misalignment with two different methods: water and bottom tracks. Water track calculates the difference in the water velocity every time that the ship stops or resumes transit (every time that it approaches and leaves a station). Assuming that the water column does not change in that short amount of time, the bias is calculated from this difference, considering that this is added by the ship's motion. Bottom track, however, offers a more precise method but it is limited to shallower waters (where the depth is no greater than 1.5 times the reach of the instruments). When bottom track is on, it sends an additional acoustic ping after the water velocity ping to find the bottom. This results in an effective reading of the motion of the seafloor relative to the vessel. The difference with the actual ship's motion gives a reliable measure of the transducer's misalignment.

For the os75 instrument, sequences 002, 004, 038 and 039 contain bottom track information with the drop-keel down. This is stored in the file 'btcaluv.out' within the 'cal/bottomtrack/' folder. The angle misalignment, calculated as the average of the medians of each sequence, weighted by the number of points is of -0.0144º (relative to the initially accounted deviation of 8.5º, applied at the 'h_align' input in the ENR processing). This is a very small deviation, smaller than the standard deviations, which range from 0.15 to 0.3. We can conclude that, with the drop-keel down, the misalignment of the os75 transducer is of 8.5 degrees (as initially applied). This was the angle correction applied to all the processed sequences for this instrument.

For the os150 instrument, sequences 018, 051, 052 provided bottom track data with the keel down. In this case, the weighted and averaged medians of each sequence's misalignment was of -0.3317º. This time no previous correction had been applied. Considering this result, a correction of -0.3 was applied to the os150 instrument. It is interesting to note that angle corrections can be applied to already processed sequences using the command

```
<quick_adcp.py --steps2rerun rotate:navsteps:calib --rotate_angle -0.3 --auto>
```

For new sequences, this value is introduced in the 'h_align' input for the UHDAS configuration file, as part of the ENR processing.

The keel was brought up shortly after station 123 until the end of the cruise. New ADCP sequences were started then; 042 for the os75 and 055 for the 150. For these sections, the same angle corrections were applied. However, bottom track calibration was analysed again to assess whether lifting the keel and the instruments had any impact on their alignment. For the os75 instrument, sequences 043 to 048 provided bottom track information with the keel up. The median angle misalignment was of -0.0094. This is a very small value and below the standard deviation (0.2921). We can conclude that the misalignment for the os75 transducer remains the same regardless of the keel's position. Similarly, sequences 056 to 058 for the os150 instrument also had bottom track on with the keel up. The median phase deviation was of 0.0372, again a small value and below the standard deviation (0.1970). For the os150 transducer we also conclude that its deviation is invariable to the position of the keel.

14.2.8 Merging of data sequences and export

It is easier to carry out the processing underway, a few sequences at a time, so that no big chunks of data are manually edited. At the end of the cruises, all the edits can be merged together. First, all the ENR sequences are processed together following the instructions in section 3.5. The final misalignment corrections can be included here so that all ensembles are corrected at once from the beginning. Then, to re-apply previous manual edits, the ASCII files containing those edits can be copied into the 'edit' folder within the new adcp_tree folder. Edits are saved in two files: 'abadbin.asc' and 'abadprf.asc'. If they had been originally applied, the extension will now be '.asclog' and needs to be changed back to '.asc' when transferred over. To include edits from different sequences, these files can be renamed with a sequence number (e.g.

abadbin1.asc, abadbin2.asc, etc.). Finally, the edits can be applied at once by running the command:

```
<quick_adcp.py --steps2rerun apply_edit:navsteps:calib  --auto>
```

To export the data as Matlab files, this can be achieved running the following command:

```
<quick_adcp.py --steps2rerun matfiles --auto>
```

This will generate Matlab matrices with vector data (vector/vector_uv.mat, and vector/vector_xy.mat), with contour or sectional data (contour/contour_uv.mat, and contour/contour_xy.mat) and also a matrix with all the bins (contour/allbins_*.mat).

To generate netcdf files, this can be done running the command:

```
<adcp_nc.py adcpdb  contour/os75nb  cruise_name_and_sequences>
```

or with os150nb for the other instrument.

These netcdf files are then read into the Mexec system by running mvad_01 (to produce an appended Mstar file), mvad_list_station (to determine station times), and mvad_03 (to produce station averages). The Mstar files were placed in eriu:/local/users/pstar/cruise/data/vmadcp/mproc/.

14.3 Results

Velocity sections (u and v components), the signal return and the ship's navigation (speed and heading) are shown for both instruments, in Figures 14.1 (os75) and 14.2 (os150). They show the full section from Rio de Janeiro to Walvis Bay. The most remarkable feature is the Brazil current, with strong southward velocities, higher than 0.6 m/s. Subsurface velocity vectors are shown in figure 14.3 (for the os75 instrument, at the 40 m to 184 m layer) and figure 14.4 (for the os150 instrument, at the 24 m to 96 m layer).

We sailed across the Brazil current two times. One on the way out from Rio into the test station. This was at constant speed and without stopping at any station. The velocity sections for that transect from the os75 instrument are shown in figure 14.5. This figure shows possible tidal currents on the shelf, a northward flow over the slope and a strong southward flow seaward of the shelf. The second time we crossed the current was at the beginning of the transect (from station 4 onwards). In this case, we stopped to carry out casts. The velocity section is shown in figure 14.6 for the os150 instrument. The wider aspect of the current is the result of stopping at the different stations, as the horizontal axis is time.

Another interesting feature observed during the cruise was the appearance of inertial oscillations at the surface throughout the section. An example of this is shown in figure 14.7. This figure shows subsurface velocity vectors (40 m to 184 m) for a transect of the os75 instrument. The oscillations are seen as relatively small currents that gradually change in direction over the inertial period (29.5 hours at 24º).

Near Walvis Bay, a structure similar to an eddy was crossed. This is shown as os75 velocity sections in figure 14.8, identified as a column of negative v velocity (and small and positive u velocity), followed by a column of little motion and then by a column of positive v velocity (and small and negative u velocity). It is interesting to note that stations in this area showed horizontal gradients in several properties (e.g. dissolved oxygen and inorganic carbon) that could be related to this feature.

Finally, examples of bad data that was edited out are shown. First, figure 14.9 shows the effect of bottom interference in the data. This is seen by anomalous bottom velocity near 300 m (towards the range of the os150 instrument). Also when manoeuvring around Walvis Bay, where water depth is below 60 m. Those bad bins and profiles were removed with gautoedit. Another example of bad data is shown in figure 10, for the os150 instrument. This shows the last transect, from Walvis Bay towards Cape Town with the keel up. We encountered rough weather and the effect of this is easily seen in the data quality (percent good section) and also shown by a weaker signal return. The sudden change in quality and signal return coincide with the time when we encountered the bigger swell. The interference caused by surface bubbles can be identified in the surface layers by a sequence of abnormal strong velocity bins in the first 3 layers. These data were also edited out.

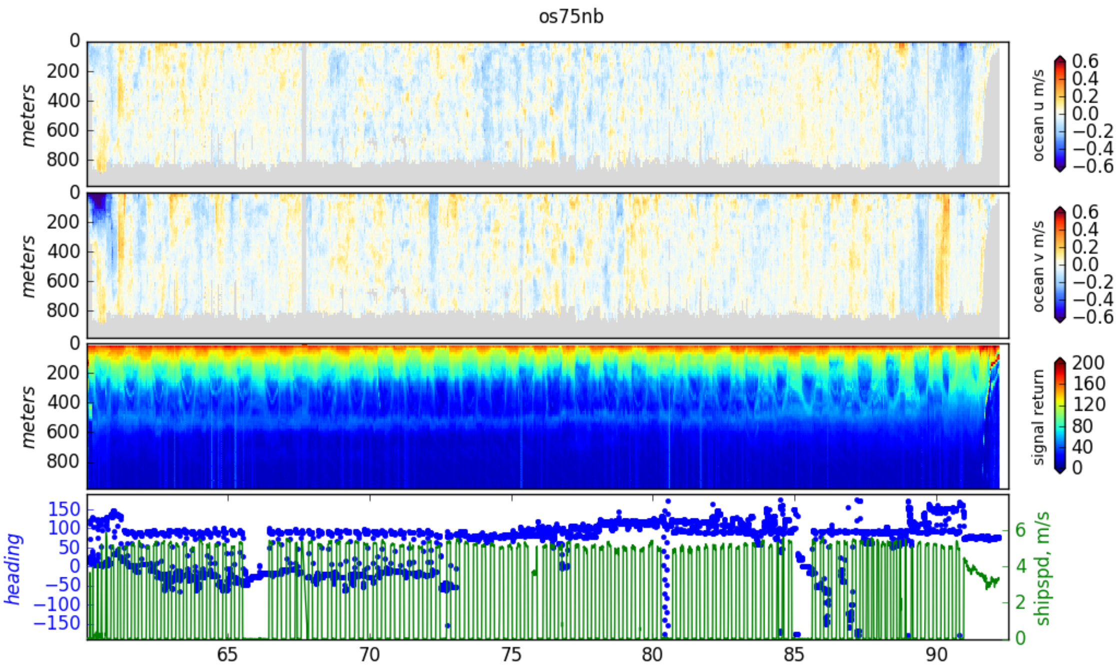

os75nb

Figure 14.1: Transect from Rio de Janeiro to Walvis Bay, from the os75 ADCP. The first panel shows the zonal component of the velocity and the second one displays the meridional component. The third panel shows the acoustic signal return and the fourth panel shows the ship speed and heading.

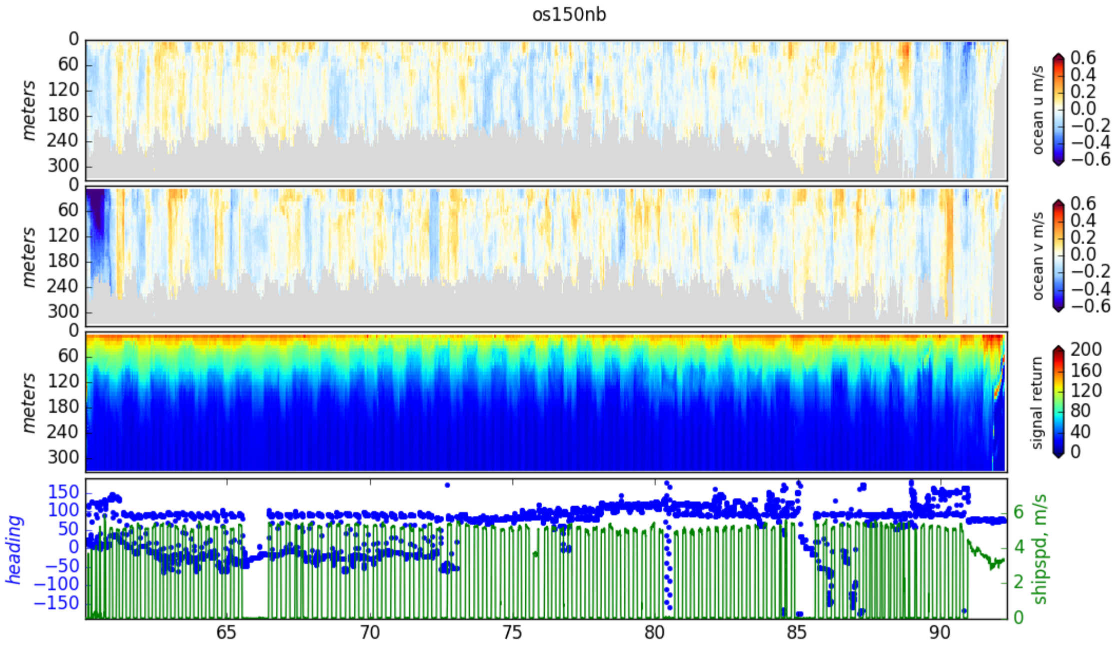

os150nb

Figure 14.2: Transect from Rio de Janeiro to Wallis Bay, from the os150 ADCP, panels as in Figure 14.1.

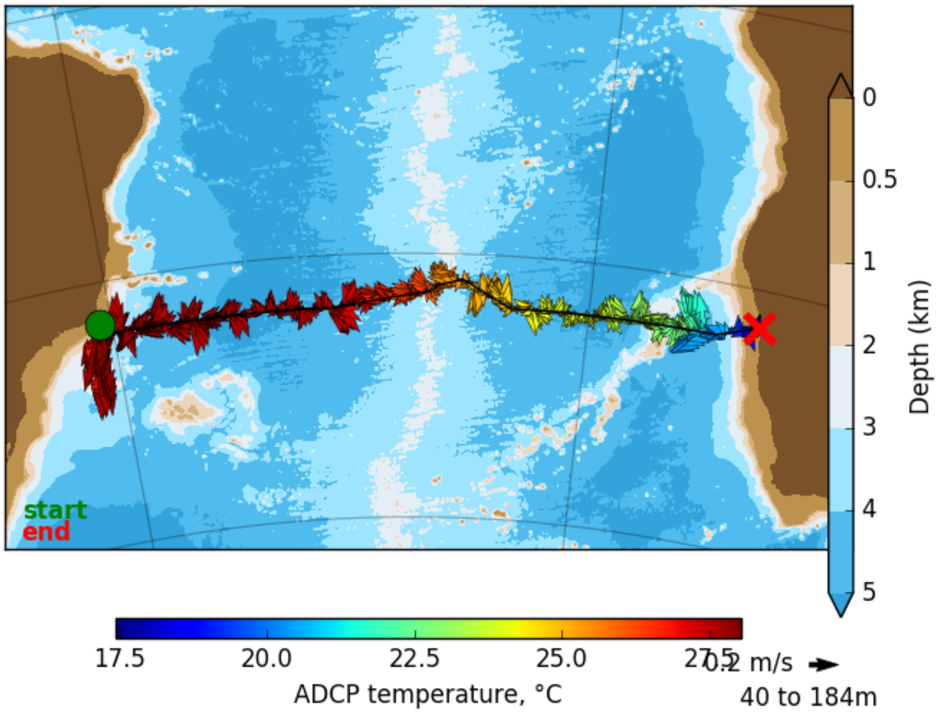


Figure 14.3**: Subsurface (40m to 184m average) velocity vectors for the transect from Rio de Janeiro to Walvis Bay, for the os75 instrument. The colour of the arrows depicts the temperature recorded** at **the ADCP transducer.**

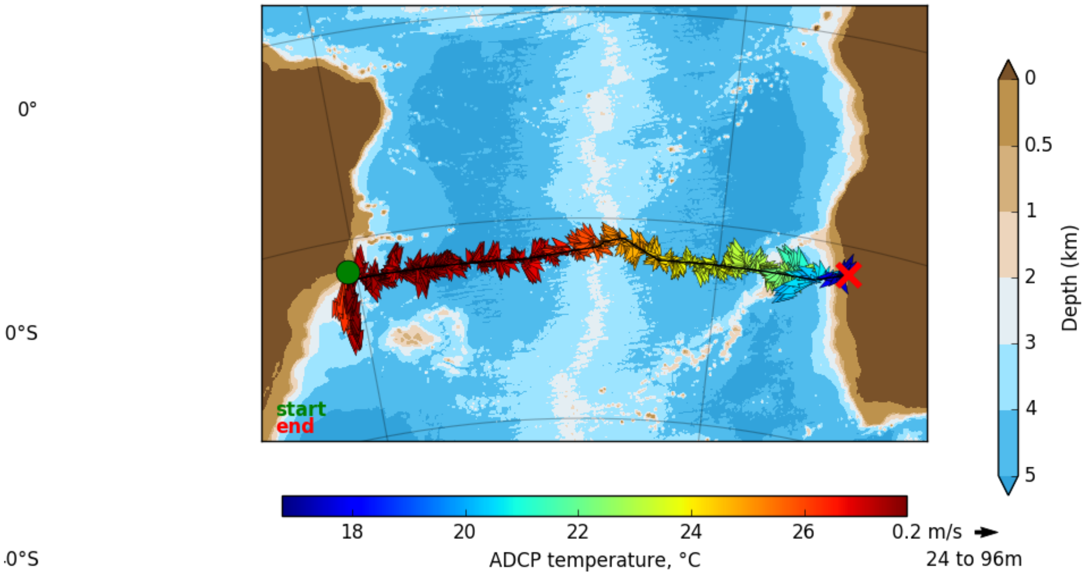


Figure 14.4: Subsurface (24m to 96m average) velocity vectors for the transect from Rio de Janeiro to Walvis Bay, for the os150 instrument, colours as in Figure 14.3.

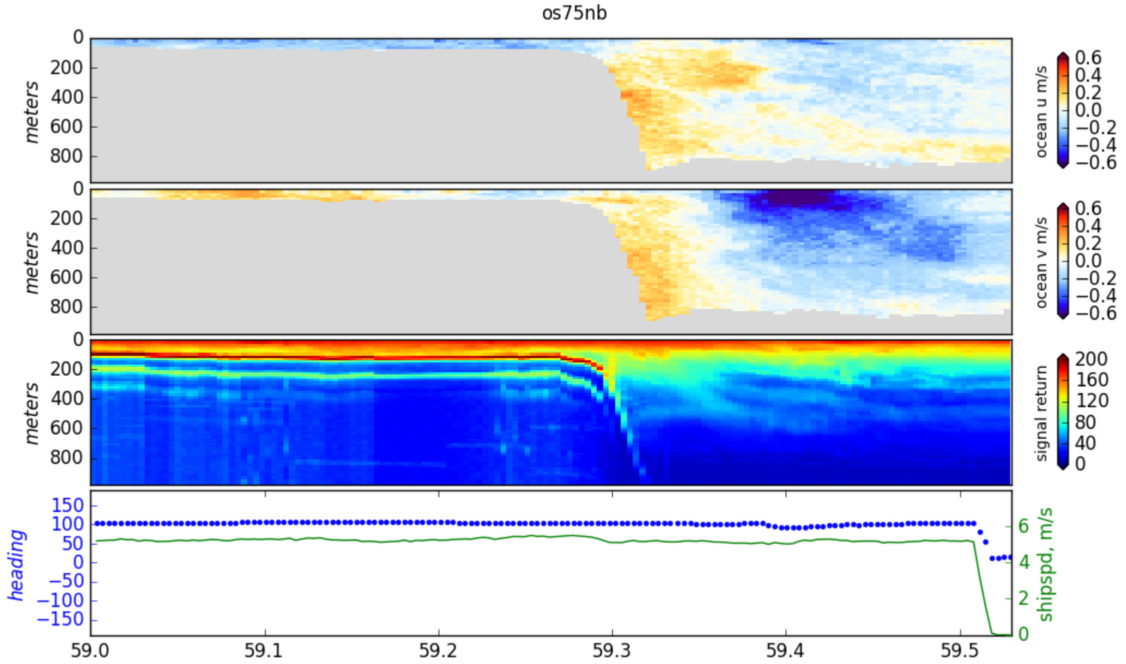


Figure 14.5: Close up of the Brazil current in the os75 ADCP. This was steaming-only transect from Rio de Janeiro to the test station off the shelf. The first panel shows the zonal component of the velocity (positive eastwards) and the second one the meridional component (positive northwards). The third panel shows acoustic signal return amplitude and the fourth panel shows the ship speed and heading.

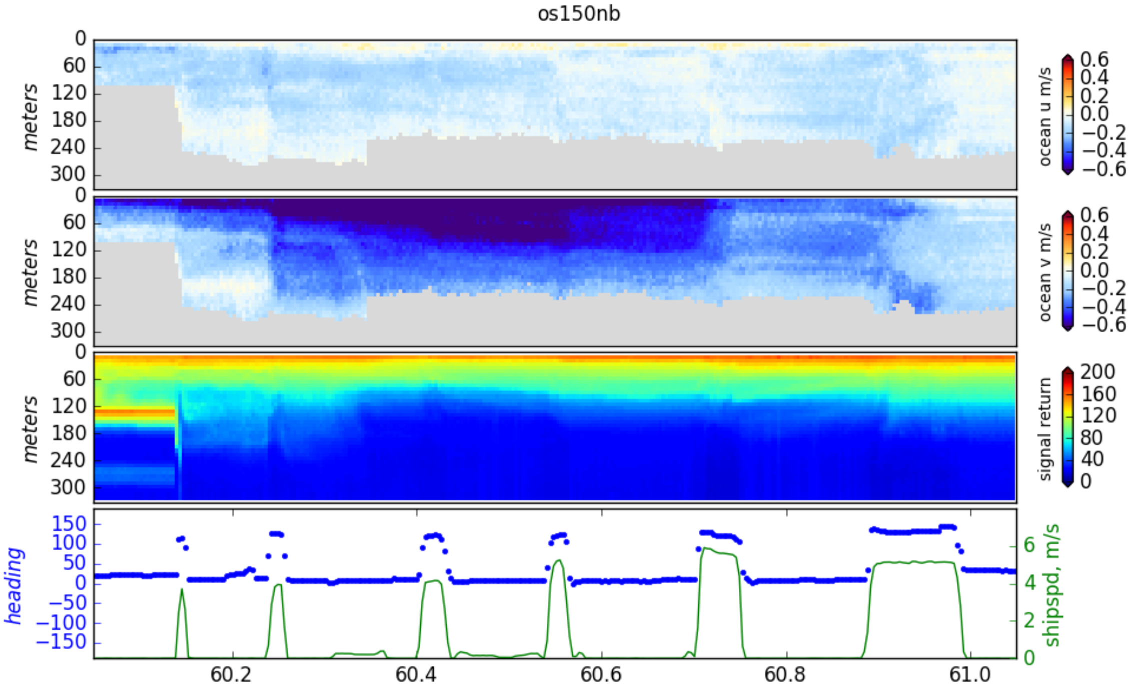


Figure 14.6: Close up of the Brazil current in the os150 ADCP. This was the beginning of the transect from Rio de Janeiro to Walvis Bay, and shows data from early stations and the transit between them. Panels as in Figure 14.5.

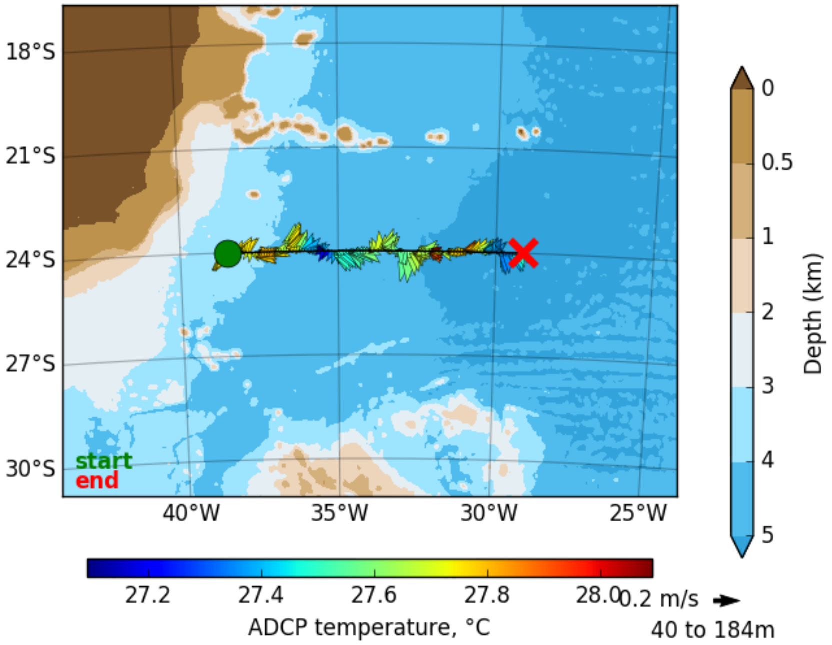


Figure 14.7: Subsurface (40m to 184m average) velocity vectors for a part off the section off the Brazilian shelf, from the os75 instrument, colours as in Figure 14.3. The velocity direction seems to indicate the presence of inertial oscillations.

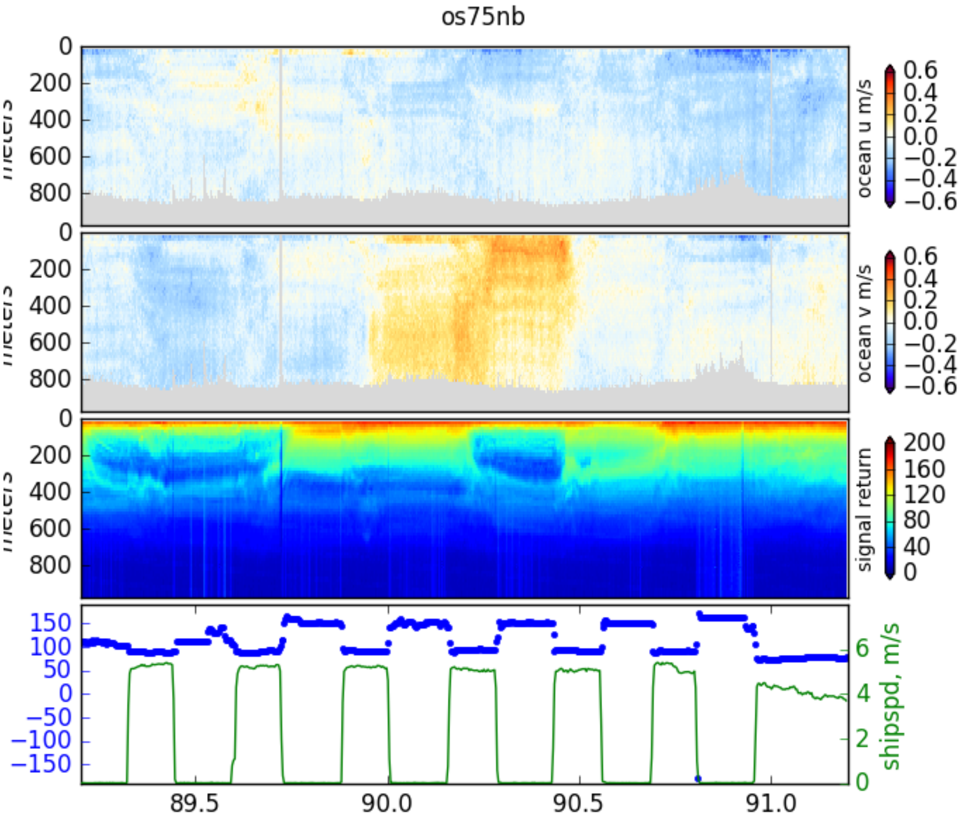


Figure 14.8: Short transect (~2 days) near Walvis Bay, panels as in Figure 14.5. The velocity sections, especially the v component, show a distribution similar to an eddy structure.

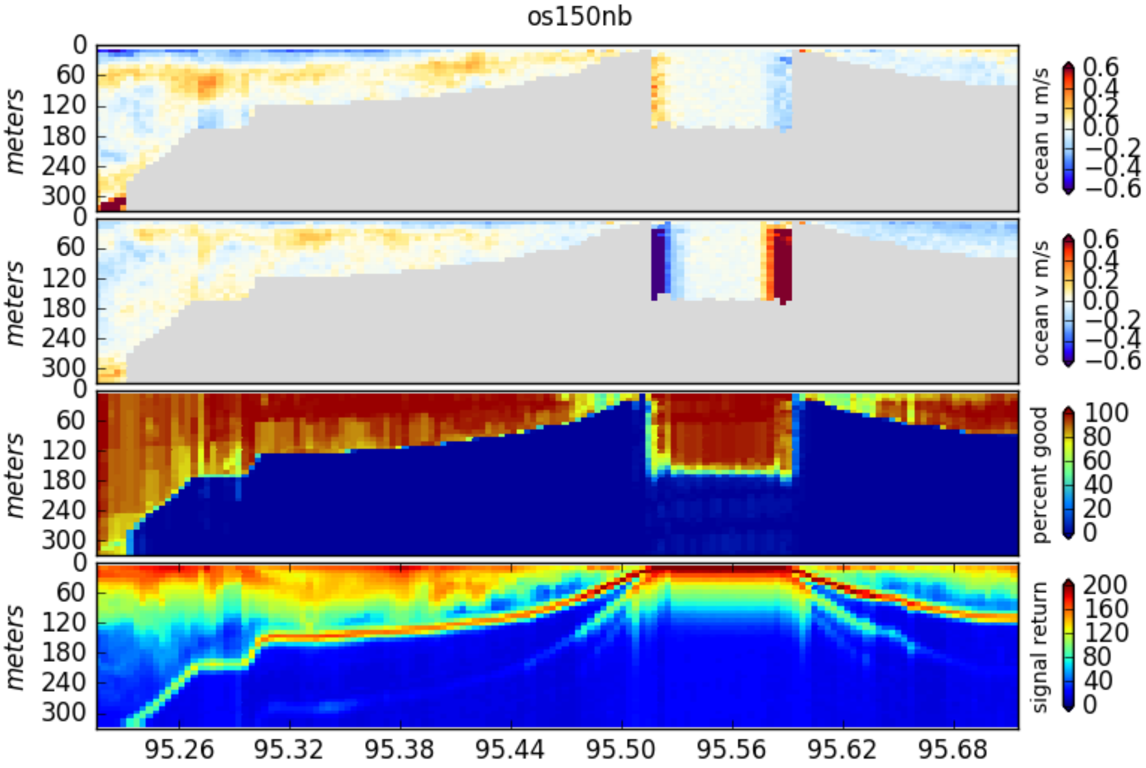


Figure 14.9: Section going in and out of Walvis Bay for the second time in the os150 instrument. The data shown here are prior to the manual editing. The first panel shows the zonal component of the velocity and the second one displays the meridional component. The third panel shows the quality of the data (percent good) and the fourth panel shows the acoustic signal return. There are clear indications of anomalous velocities near the bottom at the beginning of the section, and when near the port.

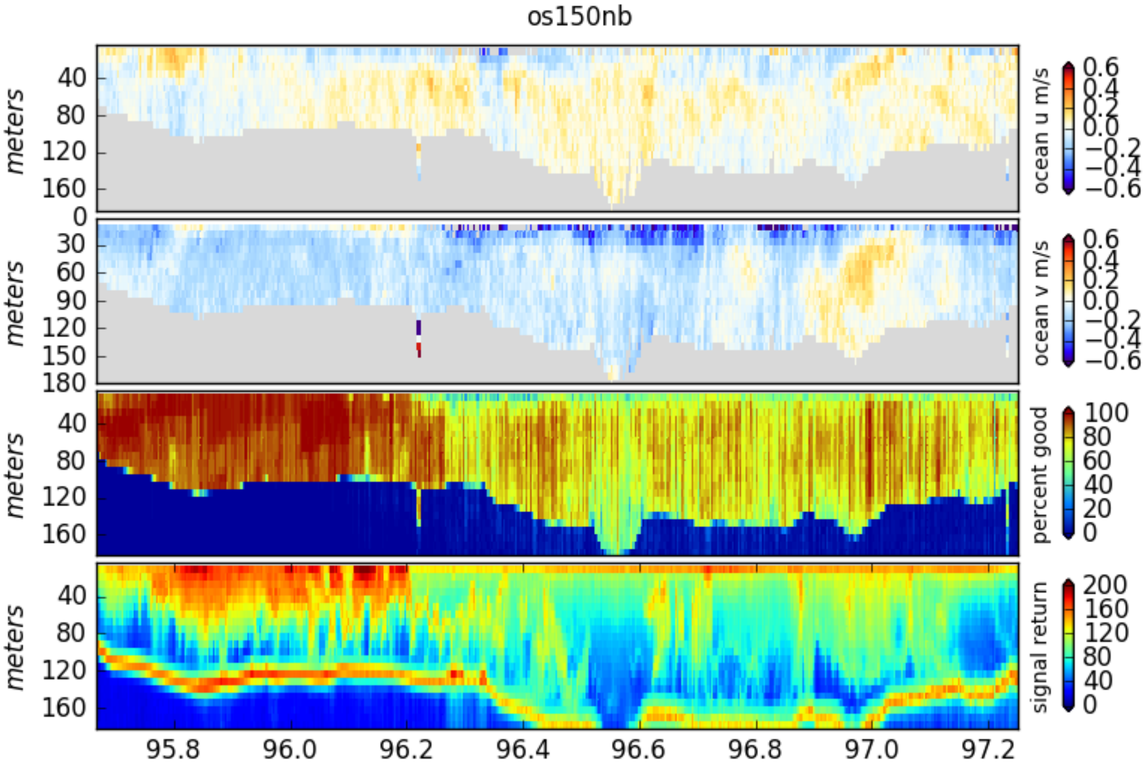


Figure 14.10: Section from the beginning of the steam from Walvis Bay to Cape Town, from the os150 instrument. The data shown here are prior to the manual editing. The first panel shows the zonal component of the velocity and the second one displays the meridional component. The third panel shows the quality of the data (percent good) and the fourth panel shows the acoustic signal return. The data quality panel serves to indicate when the rough weather was encountered by the ship, as the quality drops through the water column. As a consequence, surface bins are affected with spurious data, presumably by bubbles near the surface.

Cristian Florindo Lopez and Yvonne Firing

15 Biological and Additional Nutrient Biogeochemistry Sampling

15.1 Phytoplankton biomass

Water samples were collected from the CTD at discrete depths (including the fluorescence and oxygen maxima) from 44 stations (see Appendix A) for total chlorophyll-*a* analysis. 250ml of each depth was filtered through 25mm, 0.7μm filters in duplicate (Munktell glass-fibre filters Grade: MGF), placed in Eppendorf tubes and stored at -80 ^{0}C. The total chlorophyll will be analysed on shore using 90% acetone for extraction, followed by centrifugation, and analysed with a fluorometer (model 10 AU, Turner Designs Inc., Sunnyvale, Ca., USA), according to Welshmeyer (1994) and Jeffrey and Humphrey (1975). Pure chlorophyll a (sigma) will be used for quality assurance.

15.2 Phytoplankton identification

Phytoplankton samples were collected at defined depths from stations listed in Appendix A. These samples were preserved with Lugols solution in 200 ml brown plastic bottles. They will be used to establish the taxonomic composition and enumeration of the phytoplankton community.

Chibola Chikwililwa

16 Radiocarbon

16.1 Sample Collection and Storage

Water samples to be used for onshore radiocarbon analysis were collected from 20 litre Niskin bottles attached to the CTD sampling rosette. This report covers the ship-based sampling procedure. The radiocarbon (^{14}C) data will be available in six months to two years after the cruise. Data will be reported in $\Delta^{14}C$ notation, which represents the sample $^{14}C/C$ ratio normalized to the Modern standard and corrected for fractionation and sample age (Δ in Stuiver and Polach, 1977).

Two methods of sample collection were used. The primary sample collection method follows Bryant et al. (2013). Seawater samples are collected in foil bags and preserved by freezing. These samples will be analysed at the NERC Radiocarbon Facility in East Kilbride, Scotland. Further details on this method are given later in this section. The second sample collection method uses glass flasks from Woods Hole Oceanographic Institute (WHOI) and samples are preserved by poisoning. These samples will be analysed at the National Ocean Sciences Accelerator Mass Spectrometry (NOSAMS) laboratory at WHOI in Woods Hole, USA. The recommended sampling procedure for flasks for NOSAMS was used, exactly as stated in the guidance report “Collection and Measurement of Carbon Isotopes in Seawater DIC” (McNichol et al., 2010). The samples collected in flasks for NOSAMS are for intercomparison with the samples collected in bags for the NERC Radiocarbon Facility. NOSAMS have been collecting and analysing seawater flask samples for radiocarbon for many years, whereas the foil bag sampling is a relatively new technique.

We collected 394 foil bag samples and 32 flask samples. A sampling strategy was developed in advance to ensure the most relevant of the 124 stations and depths on JC159 were sampled and that the intercomparison flask samples covered different depths and locations. The sampling strategy was designed based on where radiocarbon data were collected on previous nearby hydrographic surveys (A09 in 1992, A10 in 1992 and 2003), and the oceanographic features along the section. The samples were collected on 18 stations that are shown in Figure 16.1, along with the locations of the intercomparison flask sample locations. A number of foil bag duplicates were also collected, at random stations and depths.

For foil bag sampling, seawater samples of approx. 0.5 litres were collected in 1 litre foil bags (see Figure 16.2a, FlexFoil Plus cat no. 253-01), composed of 4 layers (polypropylene, polyethylene, aluminium foil, and polyethylene). The foil bags were modified at Imperial College London to allow easy introduction of the liquid sample by removing the stainless steel fitting and the rubber septum, leaving only a stainless steel tube inlet to the bag. Approximately 10 cm length of Tygon® tubing (Tygon E3603, 9.6 mm outer diameter (OD), 6.4 mm internal diameter (ID), P/N ACF00017-C) was attached to the stainless steel tube and secured in place with a cable tie. A 6.4 mm ID acetal plastic inline valved female hose barb (cat no. cPMCD17-04) was added to the end of tubing and the sample bags were flushed two times with nitrogen gas. A 6.4 mm ID acetal plastic inline valved male hose barb (cat no. cPMCD22-04) connected to more Tygon tubing was used to connect the Nitrogen gas supply to the foil bags for flushing. Then the bag was filled with nitrogen gas and sealed to check for leaks. To seal the bag, the male coupling was removed and a plastic clip (WeLoc PA 50 white, cat no. 1205001) fastened across the tubing. Bags were left for several hours to check for deflation that would indicate a leak in the bag. If no leaks were found, the bag was flattened to remove the nitrogen gas and prepare for shipping. The bags were shipped with the plastic clip fastened over the tubing and the female coupling in place at the end of the tubing.

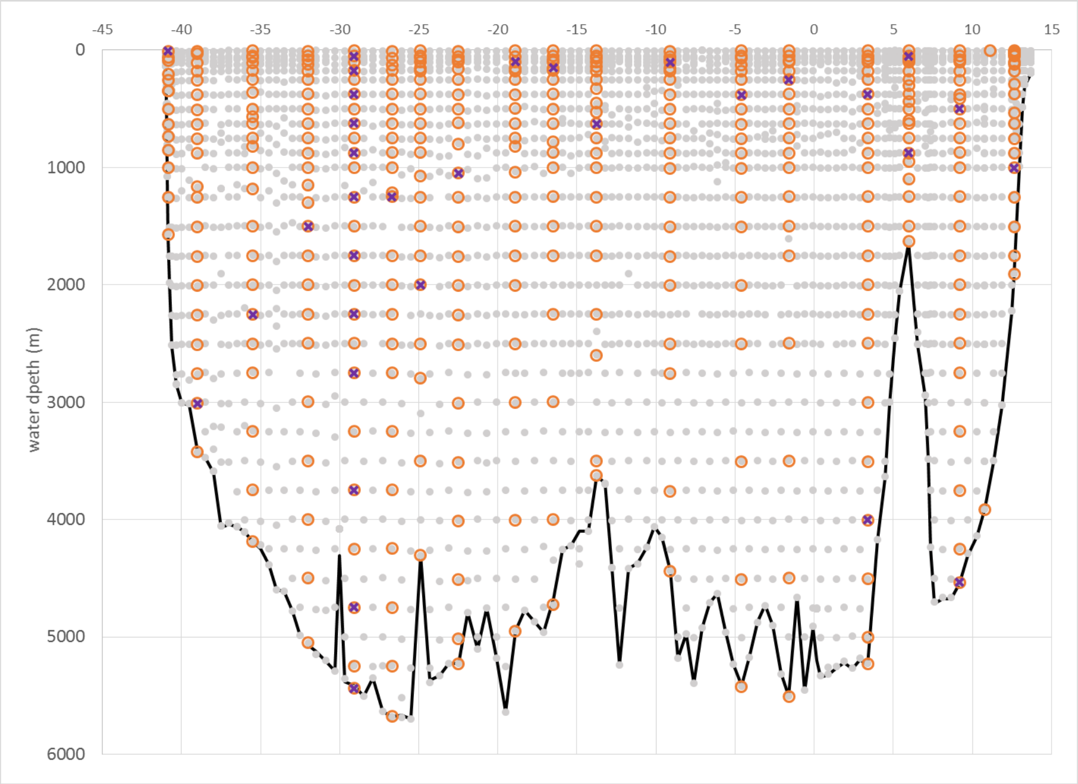


Figure 16.1 Locations of samples collected for radiocarbon analysis at the NERC Radiocarbon Facility (orange circles) and at NOSAMS (purple crosses). For reference, the locations of all CTD samples are shown in grey dots and the seabed as a black line.

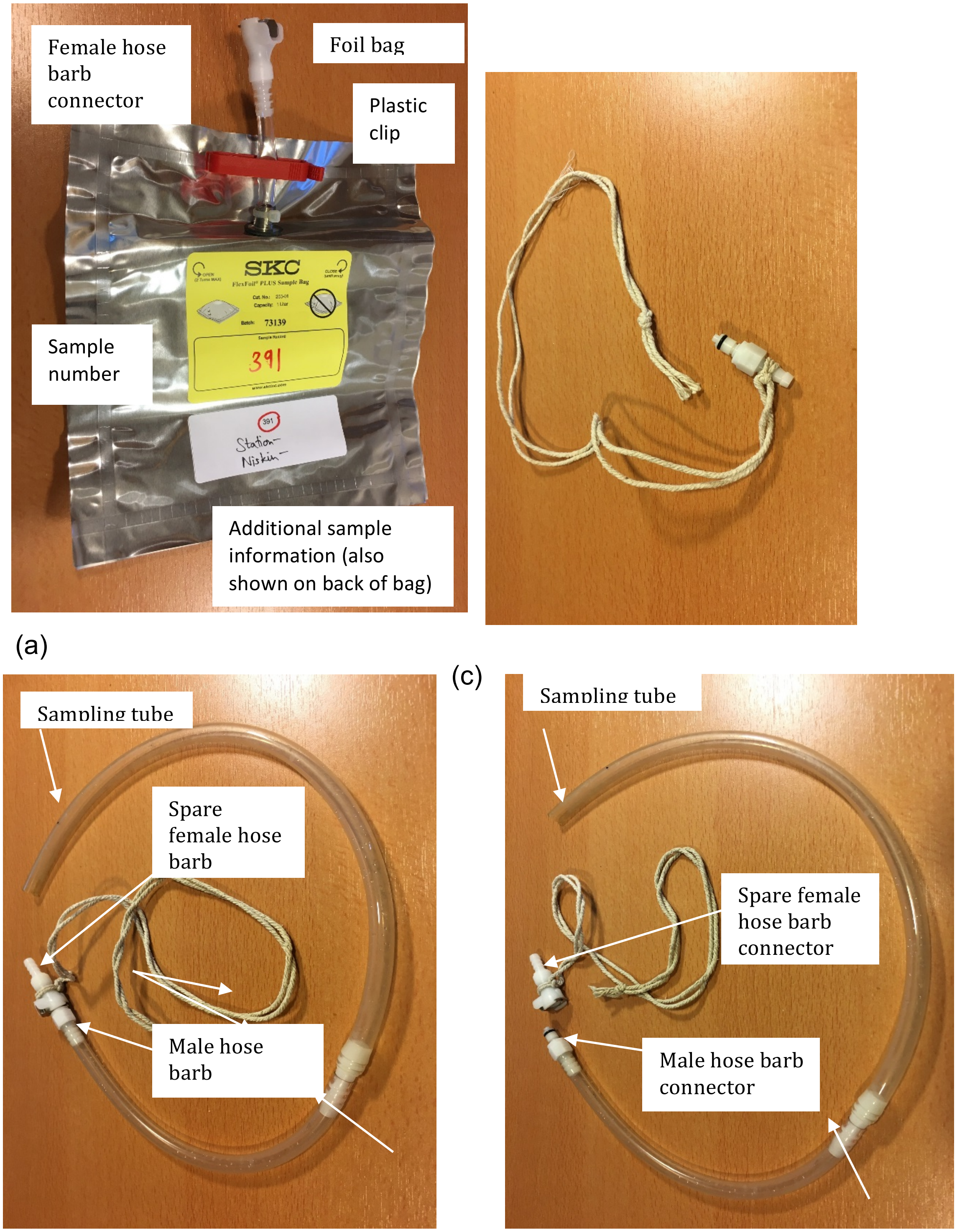
To connect the foil bags to the Niskin bottle spigot, an adapter was needed because the Niskin bottle spigot uses larger Tygon tubing than the foil bag inlet. The tubing connected to the Niskin bottle spigot has an ID of 7.9 mm (Tygon E3603, 11.1 mm OD, P/N ACF00022-C), whereas the connectors to the foil bag require tubing with ID of 6.4 mm. A step-down connector (one from an assortment of polypropylene straight and straight-stepped tubing connectors, Bel-Art™ H19570-0000) was used to join the two different tube diameters together (see Figure 16.2c and d). The final total sampling tube length was approximately 68 cm, made from around 25 cm of the smaller diameter tubing, and around 43 cm of the larger diameter tubing.

The foil sample bags were labelled sequentially from 001 to 396, while additional information about station and Niskin bottle number were recorded on each bag. The foil bag sampling method used on JC159 is outlined below.

1. Collect the upcoming station depths to decide how many bags will be needed at the station.
2. Fill out sample bag labels in advance of sampling to save time while at the station, and because the labels can be difficult to write on after they get wet.
3. Take the following to the CTD:
    a. Two large plastic tubs with clip-on lids with correct number of foil bags for the station inside the tub. When the bags are empty the wind on deck can easily carry them away.
    b. The sampling tube, with male hose barb connector fixed to end (Figure 2c).
    c. A single female hose barb connector (see Figure 2b) to flush the sampling tube (I had attached to some string which I could hang around my neck).
    d. Scales.
    e. A clipboard with log sheets, permanent marker and pencil.
4. Put on nitrile gloves for sampling.
5. Select correct bag from plastic tub for station/Niskin and go to CTD.
6. Attach open end of sampling tube to Niskin spigot.
7. Turn on spigot and flush sampling tube with Niskin water for approx. 10 seconds (sampling tube should have spare female connector attached to the end as per Figure 2c).
8. 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.
9. Disconnect the spare female hose barb from the end of the sampling tube (see Figure 2d) which will stop the flow of water, using metal release button on the female hose barb connector.
10. Attach the male hose barb connector at the end of the sampling tube to the female hose barb connector on the foil bag, and remove the plastic clip on the foil bag tubing to allow the Niskin water to enter the bag. Note: the foil bags have a capacity of 1 litre, but Bryant et al. (2013) specify that each bag should only be filled to around 500 ml capacity when frozen, to ensure they do not burst in in the freezer. Similar guidance from the NERC radiocarbon facility suggested the bags should be filled to between 500 to 800 ml when frozen. I therefore deemed that a range of between 500 and 650 ml would be an acceptable sample volume to freeze.
11. Initially overfill the foil bag with between 650 and 800 ml of Niskin water (I give a range because it is difficult to fill to an exact amount by eye). The

excess sample will later be used to flush out any remaining N in the bag, but for now reattach plastic clip back to the foil bag tube to stop flow and seal sample.

12. Disconnect sampling tube from foil bag using metal release button on female hose barb connector.
13. Turn off Niskin spigot, reattach the spare female hose barb connector to the male hose barb connector on the sampling tube (as per Figure 2c), then remove sampling tube from Niskin bottle.
14. Empty sampling tube of Niskin water in preparation for next sample, then stow sampling tube for next sample (I would drape it around my neck).
15. Weigh foil bag sample to check it contains between 650 and 800 ml of seawater. Recall that each foil bag weighs approximately 35 grams when empty, the plastic clip weighs around 5 grams. [1 ml of seawater ≈ 1 gram].
16. To squeeze out the excess seawater, and any N or air that remains in the foil bag after sampling (visible as bubbles in the Tygon tubing attached to the foil bag), remove plastic clip sealing foil bag tubing.
17. Attach release hose barb to foil bag barb, and maintaining a gentle pressure on the face of the bag at all times to ensure no air enters the bag, squeeze out any bubbles which may've collected at the top of the bag.
18. Straighten out the bag, and repeat the squeeze again, as usually a new batch of bubbles will emerge. When finished, between 500 and 650 ml of sample should still be in the foil bag.
19. Maintain gentle pressure on the bag to ensure no air enters the bag, and remove the spare male hose barb which will seal the bag.
20. Check the sample still weighs between 500 and 650 ml. If too much sample has been removed from the foil bag, return to the correct Niskin bottle and top up the sample using the procedure previously described. If the sample weighs more than 650 ml, continue to squeeze out any excess until the correct weight is reached.
21. Reattach plastic clip to seal sample.
22. Remove the female hose barb fixed into the end of the foil bag tube, so the sharp parts cannot damage the foil bags while in storage.
23. Place foil bag into plastic tub ready to carry to freezers. I carried them to the freezers in batches of 12 (thus the need for 2 tubs at a station of 24 Niskin bottles), so the weight is manageable and time isn't wasted going to the freezer after each Niskin.
24. When arranging the foil bags in the freezer, I found that they were best placed face down, so the foil bag tubing doesn't freeze pointing upwards, as can make it difficult to stack more bags on top.



(a)

(c)

(d)

Figure 16.2 (a) Foil sample bag showing female hose barb connector, foil bag tube and plastic clip (b) spare male hose barb, used for draining foil bags to remove bubbles, which was hung around the neck to keep handy (c) sampling tube with spare female hose barb attached to allow sampling tube to flush and drain (d) sampling tube with spare female hose barb removed, ready to connect to foil bag

16.2 Possible Improvements

Pre-preparing 800 labels (to budget two per foil bag, one for the front one for the back), with the following information would've saved time in creating the labels on the boat.

Cruise……………
Sample…………
Station…………
Niskin……………

It was relatively slow to collect radiocarbon samples relative to the other variables, so it would've been good to find ways to speed up the foil bag sampling process. Some suggestions are:

- Have more sampling tubes, to allow more than one bag to fill up at the same time.
- Have one continuous sampling tube, rather than two tubes joined together, so there is no reduction in flow at the junction.
- Have a shorter sampling tube, but this was problematic because I found it necessary for the bags to be flat on the ground to gauge when they were full, which would be difficult were the sampling tube shorter.

It may have been better for foil bag sample organisation and onwards storage, if they'd been stored in individual stacking plastic tubs in the freezers, rather than being stacked directly in the freezers. This would've made it less likely for the foil bags to suffer any damage, and would perhaps make it easier for the analysis team to separate out the stations.

16.3 References

Bryant, C. L., S. F. Henley, C. Murray, R. S. Ganeshram, R. Shanks, 2014. Storage and Hydroanalysis of Seawater Samples for Inorganic Carbon Isotope Analysis. Proceedings of the 21st International Radiocarbon Conference edited by A. J. T. Jull & C. Hatté. RADIOCARBON, Vol 55, Nr 2–3, 2013, p 401-409.

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.

Joanna Lester

17 ^{18}O and ^{13}C

17.1 Sample Collection and Storage

Water samples for oxygen ($^{18}O/^{16}O$, defined as $\delta^{18}O$) and stable carbon isotope ($^{13}C/^{12}C$, defined as $\delta^{13}C$) were collected from 20 litre niskin bottles attached to the CTD sampling rosette. Samples were collected using 30 ml wide-mouth HDPE bottles (cat no-2104-0001, see Figure 1a), and then poisoned using 8 μl of saturated mercuric chloride ($HgCl_2$) solution to inhibit biological activity and reliably preserve the carbon isotope ratios for later analysis. Pre-printed labels were filled out per station with a unique incrementing sample number, the station number and the niskin bottle number. Samples will be shipped back to the British Geological Society (BGS) labs in Nottingham to determine their $\delta^{18}O$ and $\delta^{13}C$ 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 $\delta^{18}O$ and $\delta^{13}C$ samples.

1. Collect the upcoming station depths to decide how many bottles will be needed at the station, as is best to complete the labels and log sheet in advance of sampling to save time while at the station, and because the labels can be difficult to write on after they get wet.
2. Pre-label 24 sample bottles for station and arrange into polystyrene holder to carry to the CTD (see Figure 1b).
3. No need to wear gloves while sampling.
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. Continue bottle rinsing by filling sample to the top with niskin water and discard contents, while also rinsing lid again.
7. 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 (see Figure 1c). 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 (see Figure 1d), as otherwise when poisoning, the mercuric chloride solution had a tendency to overflow the bottle.
8. Screw on sample bottle lid, and try to limit the time when the sample in the bottle does not have a lid on.
9. Place sample back in polystyrene holder.
10. 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.

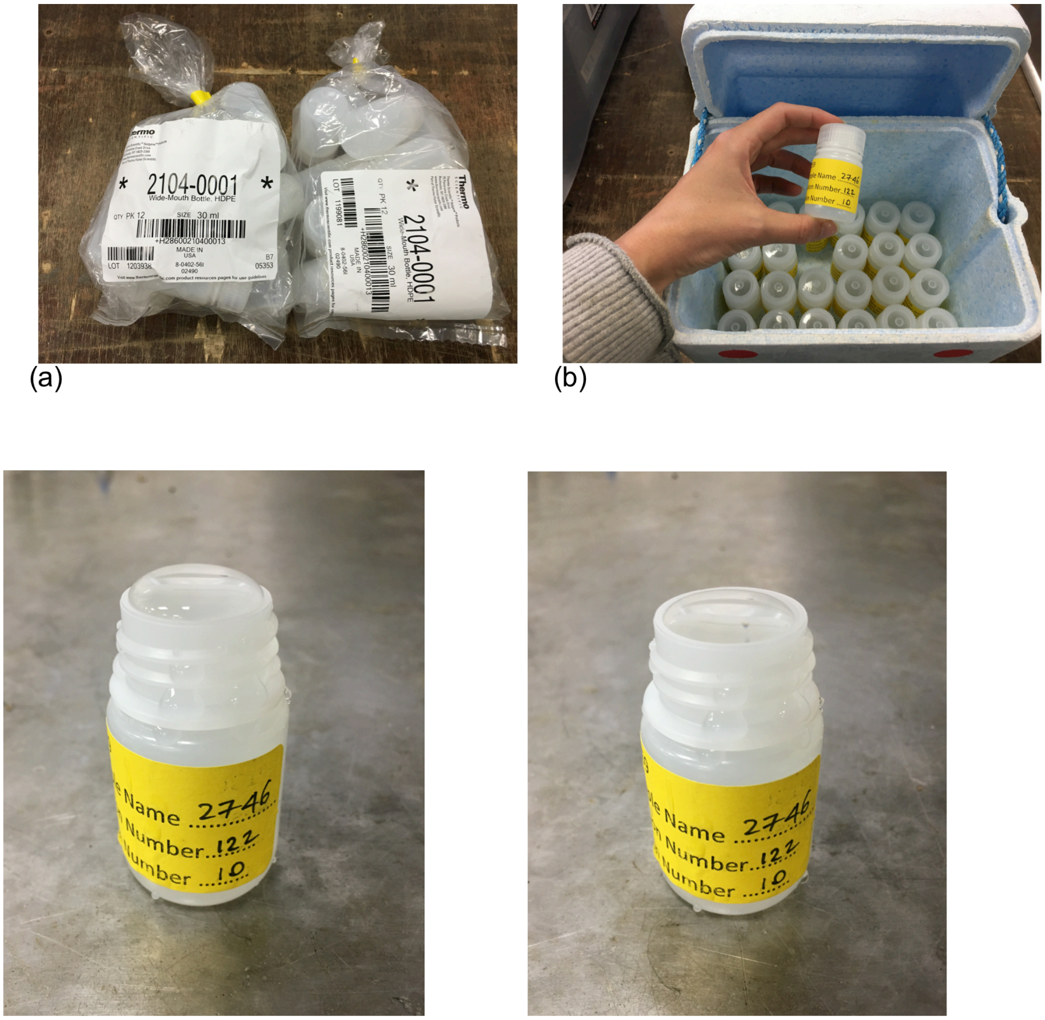

(a)
(b)

Figure 17.1: (a) Bags of 12 empty 30 ml sample bottles (b) sample bottles labelled and arranged in holder for station (c) sample bottle filled to capacity with niskin water (d) sample bottle with a few droplets emptied out at correct level for poisoning.

11. When all samples have been collected, transfer sample bottles to a fridge to keep cold until poisoning can be carried out, or continue immediately with poisoning.
12. When ready to begin poisoning, put on lab coat and nitrile gloves.
13. Transfer 30 ml sample bottles to a fume cupboard, or appropriately ventilated space.
14. Lay down blueroll in the fume cupboard, gather mercuric chloride solution and pipette for use, and add new tip to pipette (an Elkay Exelpette variable volume 10-100μl pipette was used).
15. Remove 30ml sample bottle lid (recall that the lid should stay off for as short a time as possible).
16. 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).

17. Replace bottle lid, ensure is really tight, hand tight is good but not finger tight.
18. Repeat steps 15-17 for all samples.
19. 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 waste bin.
20. Stack bottle samples in appropriate storage container to be shipped back to the UK, using card to separate layers as each layer becomes full.

The sampling strategy for δ^{18}O and δ^{13}C was to collect a sample at every station and every unique water depth, so if two niskin bottles were fired at the same depth, a sample was only taken from the first of the niskin bottles or whichever niskin bottle was sampled by the other teams for comparison. It was not necessary to collect any duplicate bottle samples, as any duplicate tests can be processed from the same 30 ml sample bottle. However, duplicate samples were collected at the blank stations where all niskin bottles were fired at the same depth (e.g. station 33, 89), in case they were useful for analysis. Samples were labelled sequentially from 0001 to 2784. The final 123 sampled stations are shown in Figure 17.2.

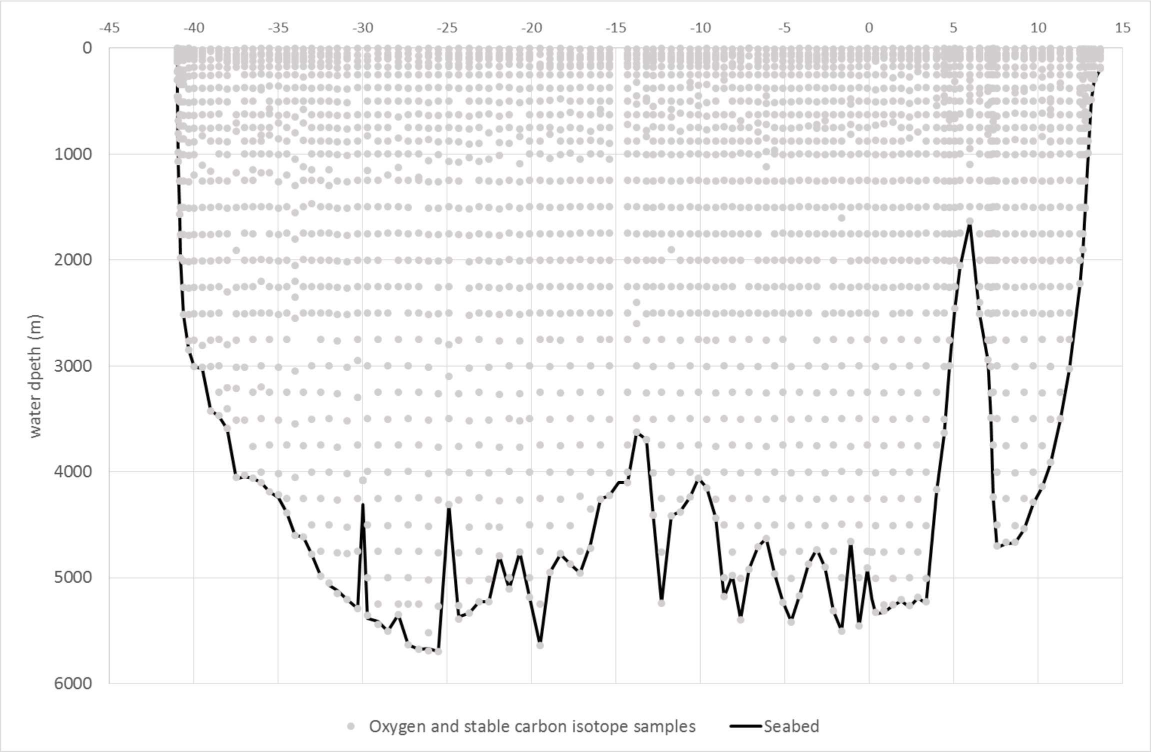


Figure 17.2: Oxygen and stable carbon isotope sampling locations

17.2 Possible Improvements

It is convenient to have some intermediate sized storage tubs for samples waiting to be processed in the fridge, as moving the individual sample bottles is time consuming. Plastic tubs from the ships galley were used to very good effect in this case, but bear this in mind for future cruises.

Joanna Lester

18 Microplastics

Opportunistic sampling for microplastics (plastic pieces < 5mm) was carried out on JC159. Since the teams on-board would not require all the water from the CTD at every cast it was decided that it would be worth filtering what was left for microplastics. This sort of opportunistic sampling added onto existing cruises could prove to be a successful way for the fast development of marine microplastic research.

Sea water samples were recovered from two different sources: (1) variable depths down the water column thanks to CTD sampling and (2) a fixed depth of 6m from the underway system. All samples were filtered on board onto 55µm stainless steel filters (50mm diameter). A subset of samples was also filtered onto 1µm polycarbonate filters (50mm diameter).

The filters will be analysed for microplastic abundance and composition later in the year at the National Oceanography Centre Southampton (NOC) using Fourier Transform Infra-Red (FT-IR) spectroscopy and imaging.

This report will first outline the experimental setup required for microplastics work on a ship. This is an important aspect of microplastic work, which requires clean conditions to prevent contamination from airborne particles e.g. synthetic fibres shed from clothes. The methodology used for both the 50µm and 1µm filtrations will then be discussed.

18.1 Laboratory Setup

Samples left to the open air could easily be contaminated by airborne synthetic fibres and particles. Therefore, several contamination control measures had to be taken.

(1) A clean tent was set using large plastic sheets bought and set up in the ship’s deck lab whilst in Rio de Janeiro, Brazil (Figure 18.1). This semi enclosed area would minimise airborne fibres from deck lab traffic to affect samples. The clean tent would also be entered by one person only throughout the expedition and only if wearing 100% cotton clothing.

(2) A laminar flow hood was present in the clean tent and used for filtering equipment manipulation. Once the clean tent was set up. the laminar flow was cleaned with acetone prior to the start of the expedition.

Figure 18.1: Microplastic work carried out by Nina Faure Beaulieu at the laminar flow within the clean tent. The clothing worn is 100% cotton.

18.2 Filtering Methodology

18.2.1 55µm filtration

CTD Sampling:
45 CTD stations were sampled for microplastics along the transect. Seawater samples were filtered directly from 20L Niskin bottles onto 50µm stainless steel filters in a set-up which limited the possibility for filter contamination by airborne particles. Each filter was enclosed in a filtering unit which consisted of a filter holder (In-Line Filter Holders, Polycarbonate, 50mm diameter, 12.5cm^2 filtration area) connected to a 25-30cm piece of polyvinylchloride (PVC) tube (RS Pro PET, PVC Flexible tubing; 14mm External Diameter; Reinforced, 50mm bend radius) (Figure 18.2). The filtering unit was prepared under the laminar flow hood and the tube end was covered until just before sampling the Niskin.

To sample a Niskin bottle, both the Niskin tap and tube end (once the cover was removed) was rinsed with deionized water (MilliQ). The tube was then connected to the tap and water flowed through the filter holder and was recovered in 20L carboys. The carboys were graded and used to measure and record the volume filtered (Figure 18.3). The water was the discarded over board.

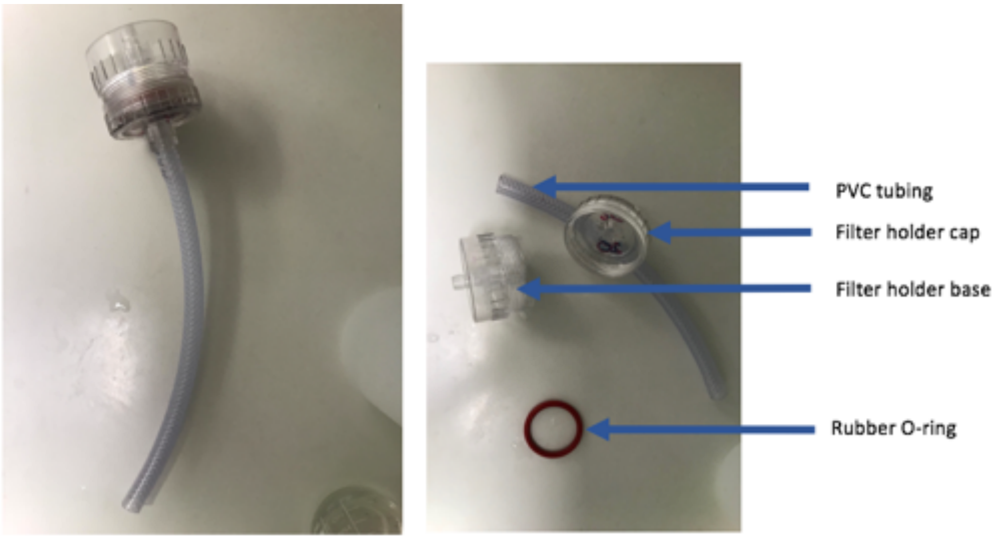


Figure 18.2: Filtering unit (left) and its components (right) inside the laminar flow. The 55µm filter sits on the base and below the rubber O-ring. The whole unit was always mounted under the laminar flow hood.

Figure 18.3: CTD sampling for microplastics via a 55µm filter

Once the Niskin bottle was emptied. The filtering unit was covered once again and brought back to the laminar flow. Within the laminar flow, MilliQ was used to rinse the inner lining of the tube and get any remaining particles onto the filter. The filter was then transferred to a plastic petridish. All petridishes were soaked for 24h in 10% hydrochloric acid (HCL) prior to being used. The filtering unit was then thoroughly washed with MilliQ prior to being reused and every week the whole filtering unit was acid washed in 10% HCL.

The number of Niskin bottles sampled from each station is outlined in Table 18.1, for more detailed parameters on each station refer to Appendix A. Since this was opportunistic sampling, the volume recovered from each Niskin was not fixed and consisted of the remaining water once the other teams had sampled. Remaining water remained within a constant range of between 10-20L per bottle except for shallow stations where duplicate bottles meant larger volumes available per depth (up to 50L). When sampling multiple bottles of the same depth, the same filter holder was used and simply switched to the next Niskin when the one being sampled was empty.

The depths sampled focused on the top 100m of the water column and two deep depths, 1000m and the bottom depth, were also taken at every station. There is little to no knowledge on the distribution of microplastics down the water column so these depths aimed to maximise the vertical resolution for the top 100m.

Station	# Niskins (55µm)	# Niskins (1µm)
4	12	0
5	11	0
6	8	0
9	8	0
13	8	0
16	10	0
19	8	0
21	8	0
23	7	1
26	6	0
29	6	0
31	6	0
33	17	0
36	6	1
39	7	1
43	6	1
46	6	1
48	6	1
51	7	1
52	5	1
56	7	1
58	7	1
61	7	1
65	7	1
68	7	1
71	8	1
77	6	1
78	7	1
81	7	1

Station	# Niskins (55µm)	# Niskins (1µm)
84	5	1
89	23	1
91	7	1
95	5	1
97	7	1
99	10	1
102	11	1
107	7	1
109	6	1
110	6	1
114	9	1
116	12	0
117	9	0
119	8	0
121	10	1
124	15	0

Table 18.1: Number of Niskin bottles sampled for microplastics via a 55µm and 1µm filter on each station.

Underway sampling:

21 underway samples of 240L were taken throughout the expedition and these only started after station 43. Underway sampling started as the CTD was lowered in the water at the start of a station. Sampling was carried out in the same manner as CTD sampling. The only difference was that instead of connecting the filtering unit to the Niskin tap it was connected to the outflow pipe hose (Figure 4). The carboy collecting the filtered water was placed in the sink. When water reached the 20L mark, the filtering unit was switched to a ready and empty carboy in the sink without disconnecting it from the outflow hose. Meanwhile, the full carboy was emptied overboard and placed back ready to take in the next 20L sample. Overall this resulted in the continuous filling and discarding of carboys as water was flowing through the 55µm filters. Each filtering unit filtered through 60L. This resulted in 4 consecutive 55µm filters (4 x 60L = 240L). Sampling took on average 1h30 from start to finish and was usually over before the CTD was back on deck.

Figure 18.4: Underway sampling using the outflow pipe. The PVC tube slots into the underway pipe

To switch filter holders, the outflow hose was shut and the filtering unit was removed and covered. The next filtering unit was then connected to the outflow hose, which was switched back on at the same flow rate. The flow rate was monitored by timing each 20L sample (~8-10min for 20L).
The decision to take four consecutive 60L samples rather than a single 240L one was to account for any variation in underway water over time. It was hypothesized that the seawater drawn at the start of sampling might contain water sitting in the system since the previous sample. It was also hypothesized that as sampling progressed the water drawn from the underway might be different because the ship had been sitting on station for a while.

Large volume sampling events:
On three occasions during the cruise, there was the opportunity to filter a very large volume of water of >200L.

Two of these opportunities were because the CFC team carried out bottle blanks which consisted of firing all the Niskin bottles at the same depth. This was taken as an opportunity to collect a large volume from a deep depth and maximise the chances of sampling above detection limit for marine microplastics.

Station 33:
Depth: 4077m
Number of Niskin bottles sampled: 17
Volume filtered by 55µm: 219L
Number of 55µm filters: 17
Average volume per 55µm filter: 13L (range: 10L to 15L)
Volume filtered (1µm): 0L

Station 89:
Depth: 40750m
Number of Niskin bottles sampled: 23
Volume filtered (55µm): 330.55L
Number of 55µm filters: 7
Average volume per 55µm filter: 47L (range: 42.5L to 57.5L)
Volume filtered (1µm): 19L
Number of 1µm filters: 4
Average volume per 1µm filter: 5L (range 4L to 5L)

At the end of the expedition, station 124 was dedicated to shallow water microplastics sampling. In this case, all the bottles were fired at 5m.

Station 124:
Depth: 5m
Number of Niskin bottles sampled: 15
Volume filtered (55µm): 300L
Number of filters: 5
Average volume per 55µm filter: 60L (range: 60L)
Volume filtered (1µm): 0L

18.2.2 1µm filtration

A subset of samples from both the underway and CTD stations was kept for subsequent filtrations through a 1µm polycarbonate filter. This methodology took some development during the start of the cruise and so was only put in place at later stations.

For CTD sampling (from stations 36 onwards), the shallowest depth was retained for 1µm filtrations. For underway sampling (from stations 43 onwards), the last 20L were retained. For 1µm filtrations, water needs to remain uncontaminated as it flows out of the filtering unit and into a clean carboy. This was achieved by allowing the water to flow through a closed carboy lid modified with a barbed fitting (VWR Barbed bulkhead fitting f/bottle cap fits 6mm id tub) (Figure 18.5). These modified lids were constructed whilst in port in Rio de Janeiro.

Figure 18.5: Carboy lid modified with a barbed fitting. The PVC tube connects to the barbed fitting and transfers the water without having to open the carboy

The carboys used for this step were thoroughly washed with MilliQ prior to sampling and the receiving end was covered until just before sampling the Niskin bottle for every CTD cast. The carboy is then carried inside the deck lab to where the filtration rig is set up.

Since the deck lab is not a clean lab, measures were taken to limit sample contamination from airborne particles. Brian King (PI) and Howard King (Engineer), helped develop and construct a closed filtering system where water would be filtered directly from the carboy. Two holes were drilled inside a carboy lid and used to create an air inlet and water outlet. The water outlet was fitted with a small valve to control water flow. The air inlet consisted of a long tube going from the lid to the carboy base so that when the carboy was overturned air could get in and prevent the formation of a vacuum inside the carboy (Figure 18.6).

Figure 18.6: Modified filtering unit for 1µm filtrations. The valve on the water outlet tube allowed for flow regulation during filtrations so that the 300ml filtering beaker did not overflow

Equipment manipulation was carried out inside the laminar flow within the clean tent. This included mounting the filter onto the glass fritted support with the clamp and 300ml filter funnel (Figure 18.7). The 300ml funnel was then covered with the filtration stopper before being brought out of the clean tent.

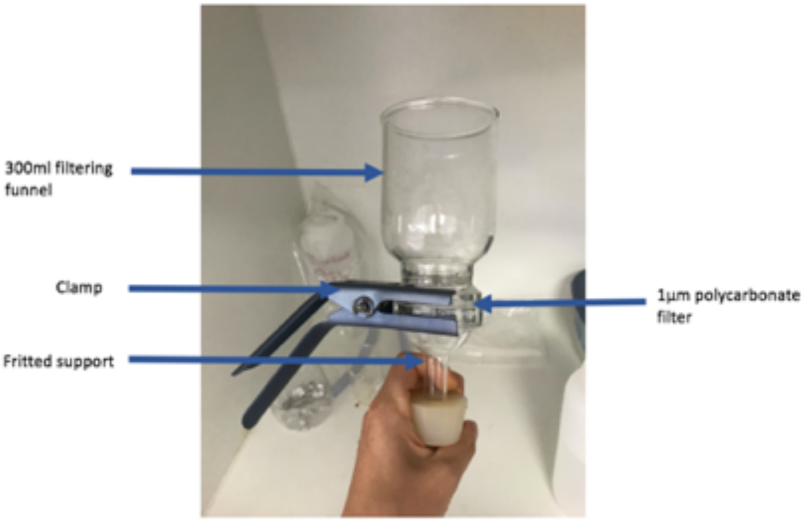


Figure 18.7: 1µm filtration unit prepared under the lamina flow hood

The initial filtration stopper was modified after station 39 after a contamination issue was noticed. It consisted of a rubber bung covered in parafilm with a hole drilled through the middle. A tube going through the hole allowed water to flow from the carboy into the filtering funnel (**Figure 8**). This design was changed from station 39 onwards after a small orange fragment was found on one of the polycarbonate filters, which probably originated from the rubber bung. The second stopper consisted of a modified beaker with a hole drilled through its base. A barbed fitting was then passed through the hole to allow a tube to feed water through (Figure 18.8). All the samples filtered with the first stopper will be examined for contamination from the stopper when back at Southampton.

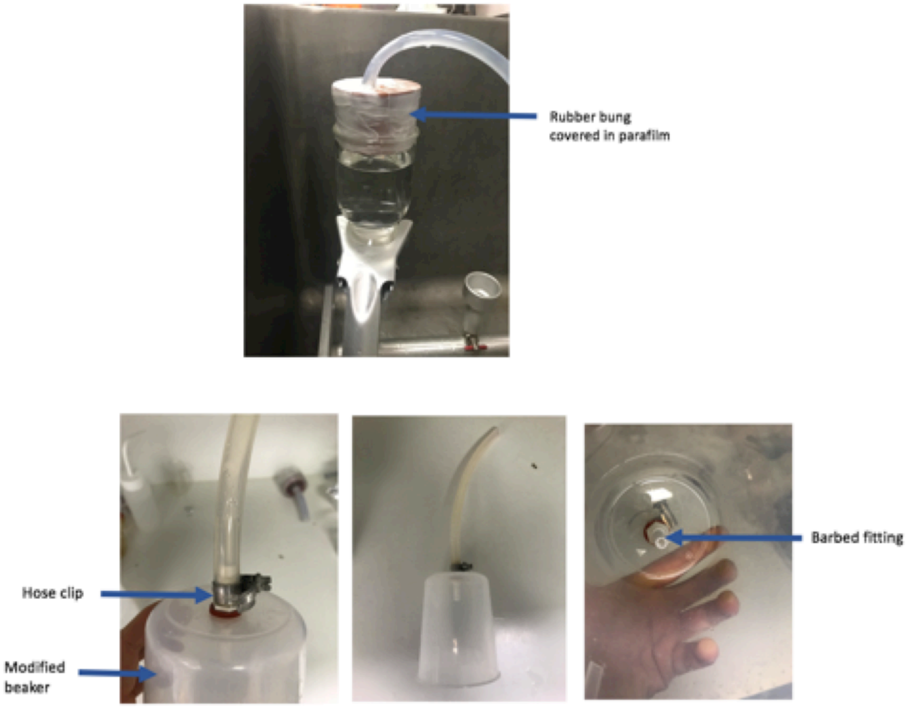


Figure 18.8: Filtration stopper design #1 (above) and design #2 (below)

This filtration set up (Figure 18.9) meant the only time that the water sample came into potential contact with the outside was during the brief period where the carboy lid was unscrewed and replaced with the modified 1μm filtration lid.

Figure 18.9: 1µm filtration unit with stopper design #1 (left) and #2 (right). A 1µm control is being carried out alongside an actual filtration (right).

Each polycarbonate filter was used to filter through 5 litres of water at a time. Once the 5L waste funnel was full, the water flow was stopped and the inside of the tube was rinsed with MilliQ water to wash down any potential particles from the tube linings. The pump was then stopped and the beaker and filter stopper were brought back to the laminar flow so that the filter could be loaded into a petridish. A new filter was then used to filter another 5L.

18.3 Contamination Controls

Controls were carried out to ensure that each sample had a respective blank sample to be compared to. This was carried out for every station to account for any equipment changes over time that might affects the sample (chipping of plastic from the filter holders or tubing)

55µm controls: Every CTD and underway station sampled was accompanied by a control 55µm filter. This control has no water filtered through it so any microplastics found on this filter should account for contamination that would occur during filter holder manipulation.

1µm controls: 1µm filter controls were covered and placed on one of the filtration rig sockets during an actual 1µm filtration (Figure 18.9 (right)). No water was filtered through these to account for any contamination during preparation.

MilliQ controls: At several occasions during the transect, a 10-12L deionized water (MilliQ) control was carried (Figure 18.10). Both 55µm and 1µm filtrations were carried out in the same manner as it would for normal samples. The only difference being that the first 55µm stage was carried out inside the deck lab to connect the filtration unit to the MilliQ outlet. This control was to account for contamination coming from inside the carboy which is not accounted for in the above two filter controls.

Figure 18.10: MilliQ control. Water is flowing from the MilliQ outlet into the carboy as it would for CTD or underway sampling.

Nina Faure Beaulieu

19. Argo Floats

19.1 Introduction

A total of 8 Argo floats were deployed on the JC159 cruise. All floats were equipped with pressure, temperature, salinity and oxygen sensors. Additionally two floats, of type NKE provor, had backscatter, CDOM, fluorometer and radiometer capabilities. Two other floats, of type NKE arvor, had 4000 m dive capabilities.

The Argo floats deployed on this cruise will form part of the international Argo float program, which is composed of an array of nearly 4,000 active profiling floats measuring temperature and salinity in the upper (>2000 m) global ocean. The standard Argo float, upon deployment, will activate when it reaches a pressure of 25 dbar. It will then sink to a nominal park pressure of 1000 dbar using a buoyancy engine which pumps fluid (oil) into the external bladder when it wants to ascend and out when it wants to sink. The float will remain at 1000 dbar (neutrally buoyant) until the 10th day (or whatever the user tells it) and then it will sink to 2000 dbar and begin to profile as it ascends to the surface. The standard Argo float is programmed to profile every 10 days and has a lifespan of 3-5 years.

19.2 Objectives

For this cruise, two NKE Provor floats were deployed in the western basin, close to the Mid-Atlantic Ridge (Table 19.1). The two deep NKE Arvor floats were deployed as the ship exited the MAR and entered the Angola basin. And finally the last 4 floats were deployed near the Namibian ridge (2 before and 2 after). These last 4 were deployed in pairs of 1 navis and 1 apex. The reason for deploying these floats in pairs was to compare the performances of the different oxygen sensors on each floats. The navises was equipped with an SBE63 sensor which measure oxygen from a controlled float (i.e. through the pumped water) and the apex was equipped with an aanderaa 4330 sensor which measures oxygen of free-flowing water over the sensor.

19.3 Float Deployment Details

	WMO ID	Float ID	Max Pressure	Time (UTC)	Latitude	Longitude	CTD Station
1		NKE Provor 101	2,000	073/17:13	23 55.25 S	20 42.11 W	049
2		NKE Provor 102	2,000	075/13:55	23 26.54 S	17 05.89 W	055
3		NKE Arvor 103	4,000	080/12:58	23 13.93 S	08 5.90 W	072
4		NKE Arvor 105	4,000	083/15:45	24 00.05 S	03 0.81 W	082
5	1901893	TWR Apex 8145	2,000	087/11:15	23 59.99 S	02 24.09 E	094
6	1901894	SBE Navis	2,000	087/11:20	23 59.98 S	02 24.31 E	094

		0656					
7	1901895	TWR Apex 8144	2,000	090/14:16	24 00.00 S	08 08.01 E	108
8	1901896	SBE Navis 0653	2,000	090/14:22	24 00.09 S	08 08.28 E	108

Table 19.1: Float identification and deployment details

19.4 Pre-deployment Testing

At the beginning of the cruise full testing was done for all floats in order to ensure all floats were fit for deployment and to maximize troubleshooting time in the event any issues arose. For testing, all floats were secured to the moorings winch on the aft deck as it had clear view of the sky, necessary for satellite communications. Once the float was secure, the CTD cell was filled with milliQ water until it overflowed.

All floats have similar testing procedures, requiring connecting a laptop computer to the float to open a line of communication where the user could issue self-test commands.
1) For the UK-Argo floats (e.g. TWR Apex and SBE Navis) the laptop-float connection was established using serial-usb connection (20mA dongle) with alligator clips clamped on the pressure port and anode located on the float's end cap. On the laptop, commands were sent using 'Z-term' program, which allows for serial communications. For the SBE Navises, the parameters for communication were baudrate = 9600, parity = none, and data bits = 8, and for the TWR Apexes the baudrate = 19200, parity = none, and data bits = 8. (Occasionally the program miniterm.py was used instead of Z-term using the same parameter settings as above).
2) For the NKE Euro-Argo floats, communication with the float was established using a Bluetooth connection. On the float, the magnet located on the ON/OFF position is removed and placed on the BT position located below the damping plate. After a period of 30 seconds, a new BT device would appear on the laptop, which could be connected to (though we had a PIN code (0000) ready to input, the connection didn't seem to require it). Once, the BT connection was established, Z-term was used again to talk to the float. Parameter settings were baudrate = 9600, parity = none, and data bits = 8.

All floats test for the following:

- Instrument/sensor check (physical checks: once the CTD pump starts, the milliq water briefly flows out. In the case of the BGC floats, the fluoremeter flashes blue light.)

- Float inflation/hydraulic pump (physical checks: you should be able to hear the hydraulic pump running)

- GPS check (acquisition of a GPS signal. It can take up to ~10-15 minutes the first time the float downloads the almanac post-shipping. Subsequent tests usually only take about 30 seconds.)

- RUDICS server (communication with the server involves the float downloading and uploading test log files. The server should always be checked to ensure files are being transmitted correctly.)

All testing was recorded and saved to text files. Once all floats have passed these tests/checks they are ready to be deployed. Because these checks are usually run fairly early on in the cruise in order to flag issues and allow time to diagnose and solve the issues, floats are put back to sleep (or on stand-by, or pressure activation) once the testing is done.

19.5 Deployment

All Argo floats were deployed upon completion of the CTD cast (i.e. when it was brought on deck after completing a station) in order to optimize comparison of Argo float profile and CTD profile, and also to avoid having to unnecessarily slow down to deploy floats in between stations.

Final pre-deployment testing – An hour before deployment, the float was lashed to the mooring winch on the aft deck with a clear view of the sky and final testing (i.e. a self-test and a mission initiation sequence) was completed. In the case of the Euro-Argo floats (i.e. the two BGC provors and the deep arvors) the pre-deployment test involved removing all plugs, caps and a finally the magnet. The removal of the magnet signaled a mission start with 5 slow clicks. The float then checks its internal system, the GPS modem, Iridium communications and the sensors. The float starts its mission (about 6 minutes later), which it signals with 5 fast electrovalve clicks. The 5 quick clicks are easy to miss, so it was important to minimize noise and distraction during pre-deployment testing. After the 5 clicks, there was a 30-minute window in which the float had to be deployed. During this window, we communicated with Euro-Argo/CLS and awaited notification that the float had successfully transmitted a message to the CLS servers. Once someone from the Euro-Argo team had given the green light, the floats were ready to deploy. For the Apex floats, we carried out no further self tests (we made sure they were in ‘idle mode’), and for the SBE navises, a final self test was done using serial connection and put into activation mode (‘a’ command).

Physical deployment of the floats – All floats were deployed over the starboard quarter. Once the float deployment party was in position with a secured float, the bridge was asked to move off at a speed of 1-2 knot. When the bridge reached the desired speed, it notified the float party that they were ready for deployment, and the float would then be lowered into the water using a rope tied off to the ship. The float streamed aft and the rope recovered. The first two floats, of type

‘Provor BGC’ were too heavy for manual deployment. A small crane operation with no-load release was required (Fig. 19.2).

Figure 19.1: Deployment of Argo float of type NKE Provor using a small crane.

19.6 Pre-deployment Issues

All pre-deployment issues are described in full here:

- NKE BGC Provor 101 failed all initial comms tests. The full autotest was run using the BT connection and failed consistently several times. Primarily, the float failed to pass the tests because it was not able to communicate with the server. In particular, the float would try <TEST MODEM RUDICS CONNECTION> and then after an hour of unsuccessfully trying to communicate with the server, the float would time out and stop the transmission, displaying the message <RUDICS: FAIL>. After several different attempts and experiments, CLS reported that they had detected that the float login was incorrectly set with special characters. Therefore we reset the float login and password whilst carefully making sure that no mistakes were made (since any mistake would require a backspace meaning the login/password would register the incorrect character and the backspace, as well as the new corrected character). After the login and password were correctly reset, all comms tests using BT were successful.

- The second issue with the NKE Provors occurred right before deployment, again concerning difficulties establishing comms. Forty minutes before deployment time, the float was taken out where it had clear view of the sky. The magnet was removed and 5 slow clicks were heard. About 8 minutes passed and the float made no further sound. At this point, it was decided to remove a crane that was overhead which could have possibly been obstructing the float's view of the sky. Then the magnet was put back on to stop the test, and then removed again. Again, the 5 slow clicks were heard, but after 20 minutes still nothing else happened and no files showed up on the server. The operation was called off and we steamed to the next CTD station. The issue was reported to Euro-Argo and NKE who reported back saying they'd discovered there was a bug in the software which meant the floats could not be deployed manually (i.e. by simply removing the magnet). The workaround for this involved connecting with the floats again using BT comms and forcing the float to begin its mission by issuing the 'G!' command. This workaround solved the issue and Provor 101 was deployed without further problems.

- Provor 102 showed the same bug as Provor 101, so it also required BT communication to force mission initiation sequence. Unfortunately, removing the magnet from the on/off position to the BT position did not work and the laptop was not able to detect the BT signal from the float. After many unsuccessful attempts involving different computers and terminal configurations, PSO Brian King suggested adding another magnet on top of the first one. This solved the issue and BT comms were established enabling us to put the float into its mission initiation sequence.

- The TWR APEXs showed no issue during testing other than that it took 2 hours for a full check due to some manufacturer preset on the APF-11 controller that requires the float to time out (even if everything is successful) before returning a command line. Thus once all tests had been passed in the initial testing phase at the beginning of the cruise, a decision was made to deploy them without further checks other than to make sure they were in 'idle mode'.

- The SBE Navises were deployed without incident. We note here that these were refurbished Navises that had previously shown issues with the buoyancy engine and the air bladder. Extensive testing during the beginning of this cruise showed all issues had been resolved in factory.

19.7 Post-deployment

Post-deployment all floats were monitored to ensure they the prelude mission files and the standard profile and log files were transmitted correctly.

We note that after the deployment of the first TWR Apex float (id 8145), it was discovered that the 'DeepProfileFirst' parameter was set to off (shipped this way by the manufacturer). This meant we had to wait 10 days to see if the float was profiling as expected. Consequently, for the following TWR Apex float (id 8144) the ‘DeepProfileFirst’ parameter was changed to on before deployment.

19.8 Additional Deployment Details

Float id: NKE Provor 101
Lat: 23 55.25 S
Lon: 20 42.11 W
Time: J073 (14th March 2018) 17:13 UTC
CTD cast: James Cook cruise 159 station 49
Depth: 4738 m
Wind speed: 4.43 m/s
Ship speed: 0.8 knots
Sea state: low swell
Sensors/measurements: Pressure, temperature, conductivity, oxygen, radiometer, backscatter, CDOM, and fluorometer
Max depth: 2000 m

Float: NKE Provor 102
Lat: 23 26.54 S
Lon: 17 05.89 W
Time: J075 (16th March 2018) 13:55
CTD cast: James Cook cruise 159 station 55
Depth: 4898 m
Wind speed: 7.26 m/s
Ship speed: 1.2 knots
Sea state: low swell
Sensors/measurements: Pressure, temperature, conductivity, oxygen, radiometer, backscatter, CDOM, and fluorometer
Max depth: 2000 m

Float Id: NKE Arvor 103
Lat: 23 13.93 S
Lon: 8 5.90 W
Time: J080 (21st March 2018) 12:58 UTC
CTD cast: James Cook cruise 159 station 72
Depth: 4997 m
Wind speed: 11.56 m/s
Ship speed: 2.3 knots
Sea state: low swell
Sensors/measurements: Pressure, temperature, conductivity and oxygen
Max depth: 4000 m

Float Id: NKE Arvor 105
Lat: 24 0.05 S
Lon: 3 0.81 W

Time: J083 (24th March 2018) 15:45 UTC
CTD cast: James Cook cruise 159 station 82
Depth: 4721 m
Wind speed: 7.6 m/s
Ship speed: 1.2 knots
Sea state: low swell
Cycle time: 10 days
Max depth: 2000 dbar
Park depth: 1000 dbar
Sensors/measurements: Pressure, temperature, conductivity and oxygen

Float Id: TWR Apex 8145
Comm number: 00072
Lat: 23 59.99 S
Lon: 2 24.09 E
Time: J087 (28th March 2018) 11:15 UTC
CTD cast: James Cook cruise 159 station 94
Depth: 5271 m
Wind speed: 4.4 m/s
Ship speed: 1.0 knots
Sea state: low swell
Optode: Aanderaa 4330
Cycle time: 10 days
Max depth: 2000 dbar
Park depth: 1000 dbar
Sensors/measurements: Pressure, temperature, conductivity and oxygen

Float Id: SBE Navis 0656
Lat: 23 59.98 S
Lon: 2 24.31 E
Time: J087 (28th March 2018) 11:20 UTC
CTD cast: James Cook cruise 159 station 94
Depth: 5261 m
Wind speed: 3.04 m/s
Ship speed: 3.1 knots
Sea state: low swell
Optode: SBE63
Cycle time: 10 days
Max depth: 2000 dbar
Park depth: 1000 dbar
Sensors/measurements: Pressure, temperature, conductivity and oxygen

Float Id: TWR Apex 8144
Comm number: 00071
Lat: 24 00.00 S
Lon: 8 08.01 E

Time: J090 (31st March 2018) 14:16 UTC
CTD cast: James Cook cruise 159 station 108
Depth: 4687 m
Wind speed: 8.15 m/s
Ship speed: 1.8 knots
Sea state: low swell
Optode: Aanderaa 4330
Cycle time: 10 days
Max depth: 2000 dbar
Park depth: 1000 dbar
Sensors/measurements: Pressure, temperature, conductivity and oxygen

Float Id: SBE Navis 0653
Lat: 24 00.09 S
Lon: 8 08.28 E
Time: J090 (31st March 2018) 14:22 UTC
CTD cast: James Cook cruise 159 station 108
Depth: 4667 m
Wind speed: 7.34 m/s
Ship speed: 1.8 knots
Sea state: low swell
Optode: SBE63
Cycle time: 10 days
Max depth: 2000 dbar
Park depth: 1000 dbar
Sensors/measurements: Pressure, temperature, conductivity and oxygen

A. Sanchez-Franks

20. Outreach

Research expeditions are an important opportunity for public outreach and science communication. Outreach was an important aspect of JC159 as it coincided with numerous public engagement events including: the pre-launch to the year of science and innovation between Brazil and the UK (27/03/18), international women's day (09/04/18), and the commonwealth marine science event at the National Oceanography Centre Southampton (NOC) (09/04/18). The following report provides evidence on the potential for cruise based outreach to reach the wider public and maximise the impact of the research carried out on board.

The main outreach platforms used throughout the expedition were twitter, the ship's blog and live link ups with land to both the National Oceanography Centre Southampton (NOC) and the Natural History Museum (NHM) in London. This content was then all successfully shared with the public from the ship thanks to the recent investment in the C/band satellite communications (VSAT) and two incredibly helpful technicians (Eleanor Darlington and Mark Maltby).

20.1 Equipment and Setup

The material was produced thanks to the dedicated outreach equipment brought on board as well as personal devices brought by members of the ship (i.e. cameras and phones).

Outreach equipment:

- DJI Drone (x1)
- Microphones (x2): Zoom H5 Handy Recorder (x1); RøDE VideoMic^{TM} (x1)
- Go Pros (x3): GoPro 5 (x1); GoPro 6 (x2)
- Go Pro accessories (i.e. flexible tripod. Pressure proof casing for underwater filming)
- MacBook Pro (x1) with downloaded editing software i.e. Final Cut Pro, iMovie

20.2 Drone Footage

The drone, piloted by Pete Brown, was an incredibly valuable piece of equipment and provided some very high -quality footage. This footage was used to film spectacular birds eye views of the ship during Argo deployments, sunsets and CTD launches (Figure 19.1). Many of these videos were used during the commonwealth event at NOC and are very likely to be used as promotional and outreach footage for years to come. For example, drone footage taken during JC136 by Alex Nimo Smith is still being used today as a promotional video for NERC cruises.

Figure 20.1: Outreach equipment used during an Argo float launch (GoPro with image stabiliser being used by Nina Faure Beaulieu and DJI drone piloted by Pete Brown). Right: Image capture of Drone footage.

20.3 Twitter

The twitter account was created on the 15th of February 2018 and was the platform used to share cruise content with the public. The content posted was in the form of videos, pictures, and written tweets (i.e. announcing new blog posts). The videos had various themes: instructive, fun, time lapses, and women in science interviews. The most successful video in terms of views was a 38 second introduction to CTDs with 1,265 views. These videos were retweeted not only by the public but also by companies themselves such as Ocean Scientific for example, which maximises their exposure beyond the cruise twitter account's audience.

Evidence for the videos success came from twitter analytics (Figure 2).
Twitter analytics since the account was created (15/02/18):
Total tweets: 75
Total videos: 21
Total video views: 8,200
Number of followers: 126
Total Impressions (number of times a tweet is seen on twitter): 79,600
Avg. Engagement rate (interaction with tweet i.e. clicks on any part of the tweet): 3.1%
Retweets: 209 (avg.: 4 a day)
Likes: 487 (avg.: 9 a day)

The women in science interviews were particularly successful. 8 interviews of ~2mins were produced to promote women in science as well as 1 male interview to promote the commonwealth event. These were all filmed using a go pro and microphone and were meant to showcase women aboard the ship as well as the breadth of science being carried out on the ship. Evidence of their success came from their use by various external organisations (Figure 3). Prof. Olga Sato's interview was used by the Oceanographic Institute of Sao Paulo's website. Gen Hinde's interview was featured at her old primary school's reunion programme in front of schoolchildren to promote their science week. Nina Faure Beaulieu's microplastic interview was featured on the NOC microplastic page. Prof. Frederico Brandini was also interviewed on board and once edited this will be showcased by the oceanographic institute in Sao Paulo which he was director of for 5 years.

They were also used by the National Oceanography Centre (NOC) Southampton to promote both International Women's Day (IWD) and the marine commonwealth event on the 9th of April. Both Prof. Olga Sato's interview and Lnt. Vanessa Bach's interview were also used by the British embassy in Brazil to promote the year of science and innovation between the UK and Brazil.

More interviews will be released post cruise thanks to footage taken on board and to be edited on land.

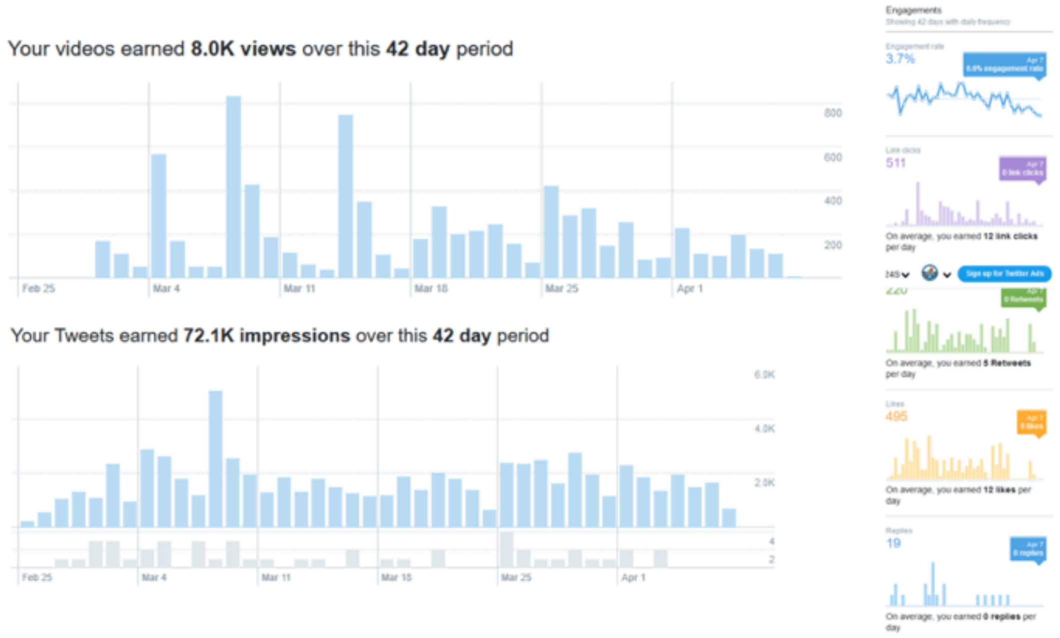


Figure 20.2: Twitter analytics figures. The 42-day period starts on the 25th of February and ends on the 7th of April.


Etchingham CE School
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Headteacher: Margaret Williams

Weekly Bulletin
2017-2018
March 26th 2018
Information and Reminders

Learning at Etchingham

Following on from British Science week and in keeping with our science themed learning journey, Boudicca Class were visited by our school Governor Phil Hinde. Phil gave an inspiring presentation to the class which covered his daughter's work as an oceanographer; she is currently measuring CO_2 samples from the Southern Ocean. Gen is a former pupil of Etchingham School! He also talked about his own work as an engineer on the Crossrail project and wider innovation on the railways. Mr Hinde was impressed by the perceptiveness of the children's questions and responses.

How to filter microplastics out of the ocean

This week NOC scientist Nina Faure Beaulieu has taken some time out of her busy schedule of research at sea to put together a video outlining the processes she is using to filter microplastics out of the South Atlantic ocean. To watch Nina's video click here, alternatively you can learn more about the microplastics research we do at the NOC by reading about it on our website here.

Mulheres na ciência - entrevista com Olga Sato a bordo do James Cook

Publicado: Quinta, 29 Março 2018

No vídeo, obtido a bordo do RRS James Cook, a professora Olga Sato do Instituto Oceanográfico da USP fala sobre sua atividade de pesquisa no navio, comenta sobre a coleta de dados, seu vínculo institucional com o IOUSP bem como sua trajetória profissional. Por fim, fala sobre o que gosta de sua profissão e o que mais a encanta nas pesquisas oceanográficas.

Figure 20.3: Evidence of women in science videos reaching the wider public. From left to right: Gen Hinde in Etchingham School's programme; Nina Faure Beaulieu on the NOCNEWS newsletter; Prof. Olga Sato on the Oceanographic Institute of Sao Paulo's website.

20.4 Live Links

Two live links were undertaken whilst on the expedition. The first was on the 8th of April with the Natural History Museum in London as part of NERC's Operation Earth Programme (Figure 19.4). The NHM has an event called Nature Live which aims to discuss various aspects of science with families and it also involves a Q&A where the public can ask questions to the scientist on the live link.

The second live link was conducted with the National Oceanography Centre (NOC) Southampton as part of the Commonwealth Marine Science Event and was an interview from the environmental minister Therese Coffey (Figure 19.5). This live link was conducted so that the minister could ask both the Master (John) and PI (Brian King) of the ship about the science being undertaken on board. In addition, one of the videos made during the cruise was used as an introduction to the live link back at NOC. This video will also be used as promotional footage for following cruise events.

Figure 20.4: Live link with the Natural History Museum (NHM) in London featuring Nina Faure Beaulieu talking about microplastics.

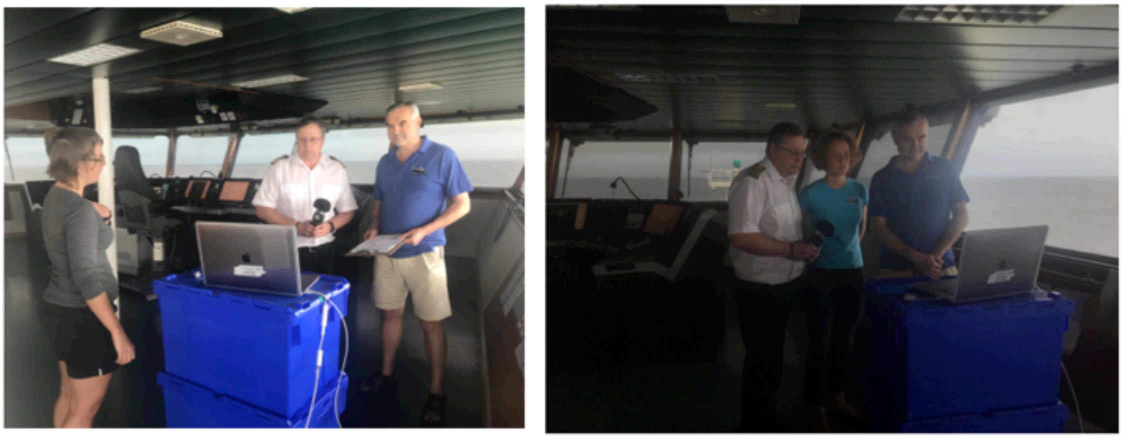

Figure 20.5: Live link with the National Oceanography Centre (NOC) Southampton to Minister Therese Coffey as part of the Marine commonwealth event. Left picture: (from left to right) Dr. Eleanor Darlington, John (Master) and Brian King (PI). Right picture: (from left to right) John Leask, Nina Faure Beaulieu, Brian King

Nina Faure Beaulieu

Appendix A: Station Summary

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
001	18/03/01 1235 18/03/01 1339 18/03/01 1433	23 44.76 S	40 18.94 W	2859	-999	-9	-999	2500	-999	0	0	0	0	0	0	0	0	0	Test station with swivel; no CTD
002	18/03/01 1448 18/03/01 1545 18/03/01 1634	23 44.76 S	40 18.94 W	2859	-999	-9	-999	2500	-999	0	0	0	0	0	0	0	0	0	Test station with swivel; no CTD
003	18/03/01 1711 18/03/01 1806 18/03/01 1938	23 44.76 S	40 18.94 W	2859	2848	9	-3	2840	2885	12	23	11	0	13	0	23	0	2	Test station with CTD
004	18/03/02 0127 18/03/02 0140 18/03/02 0213	23 11.16 S	40 58.87 W	148	134	13	-1	130	135	7	22	20	7	7	7	22	0	5	Start of section
005	18/03/02 0426 18/03/02 0445 18/03/02 0516	23 11.97 S	40 57.59 W	470	459	12	1	455	462	8	22	24	16	8	6	24	0	4	
006	18/03/02 0726 18/03/02 0756 18/03/02 0841	23 14.12 S	40 55.43 W	1084	1073	6	-4	1070	1083	12	12	12	22	11	12	13	0	0	
007	18/03/02 1037 18/03/02 1126 18/03/02 1246	23 17.79 S	40 51.07 W	1577	1571	10	3	1567	1587	13	13	13	24	13	13	15	14	0	
008	18/03/02 1459 18/03/02 1545 18/03/02 1642	23 20.87 S	40 46.91 W	1993	1983	9	-1	1975	2005	15	23	15	22	14	8	16	0	0	
009	18/03/02 1902 18/03/02 1955 18/03/02 2104	23 28.22 S	40 36.56 W	2522	2513	10	1	2502	2544	19	23	19	22	16	15	19	0	4	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
010	18/03/03 0000 18/03/03 0108 18/03/03 0243	23 44.34 S	40 18.74 W	2857	2848	9	-0	2831	2886	21	23	22	24	20	16	22	0	0	
011	18/03/03 0537 18/03/03 0639 18/03/03 0803	23 59.78 S	40 00.16 W	3013	3005	8	-0	2994	3046	21	22	20	24	17	14	22	0	0	
012	18/03/03 1127 18/03/03 1246 18/03/03 1426	23 59.97 S	39 30.01 W	3026	3015	6	-5	3005	3056	21	24	21	24	20	16	19	0	3	
013	18/03/03 1745 18/03/03 1854 18/03/03 2019	24 00.07 S	39 00.19 W	3438	3425	14	1	3415	3475	21	23	17	23	19	0	20	20	0	
014	18/03/03 2359 18/03/04 0110 18/03/04 0300	23 59.95 S	38 29.97 W	3484	3473	11	-0	3460	3525	23	24	22	24	18	15	23	0	0	
015	18/03/04 0617 18/03/04 0734 18/03/04 0903	24 00.09 S	38 00.22 W	3598	3590	8	-0	3585	3644	21	21	21	24	20	15	21	0	3	
016	18/03/04 1219 18/03/04 1344 18/03/04 1530	24 00.03 S	37 29.98 W	4064	4053	11	-0	4040	4118	20	23	20	23	20	17	20	0	0	
017	18/03/04 1840 18/03/04 1958 18/03/04 2137	23 59.98 S	37 00.00 W	4042	4032	6	-4	4019	4097	22	24	22	23	20	18	22	0	3	
018	18/03/05 0053 18/03/05 0220 18/03/05 0409	23 59.97 S	36 29.88 W	4073	4063	10	-1	4048	4128	23	24	23	24	23	17	23	0	0	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
019	18/03/05 0724 18/03/05 0841 18/03/05 1028	24 00.00 S	36 00.02 W	4116	4107	6	-3	4095	4174	23	24	23	24	23	19	23	0	0	
020	18/03/05 1340 18/03/05 1503 18/03/05 1658	24 00.00 S	35 30.00 W	4199	4191	9	-0	4175	4260	23	24	23	24	23	16	23	23	3	
021	18/03/05 2015 18/03/05 2137 18/03/05 2328	24 00.03 S	34 59.89 W	4230	4220	10	-0	4204	4289	23	24	22	24	23	15	23	0	0	
022	18/03/06 0253 18/03/06 0414 18/03/06 0606	24 00.06 S	34 29.99 W	4396	4386	9	-0	4370	4461	24	23	24	24	23	18	24	0	1	
023	18/03/06 0925 18/03/06 1100 18/03/06 1256	24 00.00 S	33 59.80 W	4612	4601	11	0	4584	4681	23	23	23	24	24	15	23	0	0	
024	18/03/06 1608 18/03/06 1739 18/03/06 1944	23 59.96 S	33 29.90 W	4625	4615	9	-0	4598	4696	23	24	24	24	22	19	23	0	2	
025	18/03/06 2308 18/03/07 0049 18/03/07 0251	23 59.97 S	33 00.00 W	4791	4782	9	-0	4760	4867	24	24	24	23	23	17	24	0	0	
026	18/03/07 0607 18/03/07 0739 18/03/07 0941	24 00.09 S	32 30.15 W	4998	4990	8	-0	4970	5081	24	24	24	24	23	17	24	0	0	Termination OK
027	18/03/07 1259 18/03/07 1314 18/03/07 1338	23 59.93 S	31 59.92 W	5063	538	-9	-999	662	542	0	0	0	0	0	0	0	0	0	Aborted; CTD termination failed

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
028	18/03/07 2213 18/03/07 2221 18/03/07 2231	23 59.93 S	31 59.92 W	5063	123	-9	-999	125	124	0	0	0	0	0	0	0	0	0	Aborted; CTD termination failed
029	18/03/08 0715 18/03/08 0846 18/03/08 1051	24 00.00 S	32 00.00 W	5063	5049	12	-1	5030	5143	24	24	24	24	24	18	24	24	0	New termination CTD 1
030	18/03/08 1358 18/03/08 1532 18/03/08 1756	24 00.01 S	31 30.00 W	5155	5146	8	-1	5128	5243	24	24	24	24	24	20	24	0	2	
031	18/03/08 2140 18/03/08 2322 18/03/09 0132	23 59.97 S	30 54.02 W	5213	5204	9	0	5182	5302	24	24	24	24	24	18	24	0	0	
032	18/03/09 0507 18/03/09 0656 18/03/09 0903	24 00.03 S	30 18.07 W	5300	5290	9	-1	5270	5391	24	23	20	23	23	20	23	0	2	
033	18/03/09 1110 18/03/09 1237 18/03/09 1409	23 59.99 S	30 00.00 W	5300	4317	-9	-999	4300	4389	1	24	8	0	23	24	24	0	0	CFC bottle blanks
034	18/03/09 1627 18/03/09 1808 18/03/09 2021	24 00.04 S	29 42.00 W	5363	5354	9	-1	5335	5457	24	24	23	24	24	19	24	0	2	
035	18/03/10 0006 18/03/10 0150 18/03/10 0407	24 00.00 S	29 05.96 W	5452	5439	12	-0	5420	5545	24	24	24	24	23	20	24	24	0	Second oxygen sensor added
036	18/03/10 0822 18/03/10 1012 18/03/10 1238	23 59.99 S	28 29.95 W	5516	5503	11	-1	5483	5611	24	23	22	23	23	17	23	0	0	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
037	18/03/10 1615 18/03/10 1752 18/03/10 1955	24 00.01 S	27 53.99 W	5360	5350	10	-1	5330	5452	24	24	22	24	24	20	24	0	2	
038	18/03/10 2339 18/03/11 0129 18/03/11 0340	24 00.00 S	27 17.97 W	5643	5633	10	-1	5610	5745	24	24	24	24	22	19	24	0	0	
039	18/03/11 0722 18/03/11 0913 18/03/11 1128	23 59.94 S	26 41.84 W	5689	5681	9	0	5660	5794	24	24	24	24	23	20	24	24	0	
040	18/03/11 1504 18/03/11 1646 18/03/11 1855	24 00.02 S	26 05.98 W	5695	5689	10	4	5668	5803	24	24	20	24	24	18	24	0	2	
041	18/03/11 2247 18/03/12 0036 18/03/12 0252	23 59.99 S	25 29.95 W	5708	5698	10	0	5677	5812	24	24	24	24	22	20	24	0	0	
042	18/03/12 0642 18/03/12 0811 18/03/12 1008	24 00.01 S	24 53.93 W	4353	4307	42	-3	4290	4379	24	24	24	24	23	17	24	21	2	
043	18/03/12 1342 18/03/12 1525 18/03/12 1744	24 00.04 S	24 18.04 W	5400	5390	7	-3	5372	5494	24	23	23	22	22	18	22	0	0	
044	18/03/12 2136 18/03/12 2322 18/03/13 0141	23 59.99 S	23 42.01 W	5343	5332	10	-1	5305	5434	24	24	24	24	24	9	24	0	0	
045	18/03/13 0531 18/03/13 0718 18/03/13 0928	24 00.02 S	23 05.99 W	5236	5229	8	1	5210	5328	24	24	24	24	24	20	24	0	2	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
046	18/03/13 1338 18/03/13 1513 18/03/13 1715	24 00.08 S	22 30.07 W	5242	5230	10	-2	5213	5329	23	24	21	24	24	11	23	23	0	
047	18/03/13 2126 18/03/13 2257 18/03/14 0051	24 00.01 S	21 53.99 W	4802	4793	10	0	4770	4879	24	24	24	24	21	20	24	0	0	
048	18/03/14 0426 18/03/14 0613 18/03/14 0807	24 00.03 S	21 18.04 W	5115	5107	6	-3	5090	5202	24	22	23	22	24	9	22	0	0	
049	18/03/14 1306 18/03/14 1433 18/03/14 1703	23 55.23 S	20 42.01 W	4767	4757	10	1	4737	4842	23	23	23	23	23	20	22	0	2	End use CTD 1
050	18/03/14 2104 18/03/14 2240 18/03/15 0057	23 50.44 S	20 06.01 W	5193	5184	6	-3	5176	5282	24	24	24	24	23	18	24	0	0	Start use Deep Tow
051	18/03/15 0434 18/03/15 0618 18/03/15 0828	23 45.66 S	19 29.96 W	5650	5640	10	-0	5630	5752	24	24	24	24	24	21	24	0	0	
052	18/03/15 1212 18/03/15 1348 18/03/15 1553	23 40.89 S	18 54.02 W	4961	4950	11	-1	4943	5040	24	24	24	24	24	10	24	20	2	
053	18/03/15 1933 18/03/15 2101 18/03/15 2258	23 36.10 S	18 18.02 W	4786	4778	10	2	4769	4863	24	24	24	24	24	20	24	0	0	
054	18/03/16 0246 18/03/16 0424 18/03/16 0617	23 31.36 S	17 42.07 W	4953	4870	83	-0	4860	4957	24	24	24	24	24	17	24	0	0	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
055	18/03/16 1003 18/03/16 1139 18/03/16 1345	23 26.56 S	17 05.99 W	4971	4962	8	-0	4954	5053	24	24	24	24	24	19	24	0	2	
056	18/03/16 1749 18/03/16 1914 18/03/16 2117	23 19.77 S	16 30.01 W	4738	4726	10	-1	4717	4810	23	24	24	24	24	13	24	20	0	
057	18/03/17 0119 18/03/17 0243 18/03/17 0431	23 15.03 S	15 53.98 W	4268	4259	9	-0	4250	4329	24	24	24	24	24	17	24	0	0	
058	18/03/17 0755 18/03/17 0919 18/03/17 1110	23 10.77 S	15 22.08 W	4238	4225	6	-7	4216	4295	24	24	22	24	24	18	24	0	0	
059	18/03/17 1434 18/03/17 1558 18/03/17 1749	23 06.48 S	14 50.06 W	4388	4378	10	-0	4370	4452	24	0	0	0	0	0	0	0	0	
060	18/03/17 2348 18/03/18 0112 18/03/18 0250	23 02.21 S	14 17.97 W	4116	4105	9	-2	4098	4171	24	24	24	24	24	19	24	0	0	
061	18/03/18 0618 18/03/18 0724 18/03/18 0905	22 58.00 S	13 46.02 W	3632	3626	10	4	3620	3680	24	24	24	24	24	17	24	21	0	
062	18/03/18 1254 18/03/18 1420 18/03/18 1556	22 47.28 S	13 12.00 W	3708	3696	10	-2	3690	3753	23	24	23	24	24	19	24	0	2	
063	18/03/18 1925 18/03/18 2046 18/03/18 2240	22 29.98 S	12 47.70 W	4419	4410	10	1	4402	4484	23	24	23	24	24	17	24	0	0	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
064	18/03/19 0223 18/03/19 0402 18/03/19 0558	22 17.99 S	12 18.02 W	5253	5243	10	-0	5235	5342	24	24	24	24	24	19	24	0	0	
065	18/03/19 0943 18/03/19 1115 18/03/19 1308	22 11.50 S	11 42.70 W	4426	4419	9	2	4413	4494	24	24	24	24	24	16	24	0	0	
066	18/03/19 1648 18/03/19 1807 18/03/19 1951	22 04.06 S	11 09.85 W	4393	4380	11	-3	4372	4454	24	24	24	24	24	19	24	0	2	
067	18/03/19 2337 18/03/20 0058 18/03/20 0234	21 57.01 S	10 36.01 W	4247	4237	10	-0	4230	4307	24	24	23	24	24	17	24	0	0	
068	18/03/20 0615 18/03/20 0727 18/03/20 0913	22 12.37 S	10 06.07 W	4071	4062	9	-0	4054	4127	24	24	24	24	24	18	24	0	0	
069	18/03/20 1243 18/03/20 1357 18/03/20 1537	22 27.74 S	9 36.08 W	4161	4152	9	0	4145	4220	24	24	24	24	24	19	24	0	2	
070	18/03/20 1921 18/03/20 2042 18/03/20 2232	22 43.12 S	9 06.07 W	4444	4440	6	2	4430	4516	24	24	24	24	24	17	24	21	0	
071	18/03/21 0211 18/03/21 0346 18/03/21 0540	22 58.50 S	8 36.00 W	5193	5183	10	-0	5173	5280	24	24	23	24	24	19	24	0	0	
072	18/03/21 0917 18/03/21 1048 18/03/21 1248	23 13.87 S	8 06.01 W	4989	4979	10	0	4970	5070	24	24	24	24	24	20	24	0	2	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
073	18/03/21 1636 18/03/21 1813 18/03/21 2019	23 29.24 S	7 36.00 W	5402	5395	5	-2	5385	5499	24	24	24	24	23	19	24	0	0	
074	18/03/21 2352 18/03/22 0121 18/03/22 0317	23 44.64 S	7 05.99 W	4934	4923	7	-4	4910	5012	20	22	19	19	21	18	22	0	0	Termination failing, station OK
075	18/03/22 1311 18/03/22 1437 18/03/22 1632	24 00.00 S	6 36.01 W	4716	4709	8	1	4700	4792	24	24	24	24	24	18	24	0	2	New Termination Deep Tow
076	18/03/22 1948 18/03/22 2110 18/03/22 2307	24 00.01 S	6 06.03 W	4639	4630	9	-0	4620	4711	24	23	23	23	23	16	23	0	0	
077	18/03/23 0219 18/03/23 0351 18/03/23 0551	23 59.99 S	5 36.02 W	4972	4963	9	1	4953	5054	24	24	24	24	24	18	24	0	0	
078	18/03/23 0906 18/03/23 1041 18/03/23 1244	23 59.99 S	5 06.02 W	5244	5233	6	-5	5222	5332	24	24	24	24	24	20	24	0	0	
079	18/03/23 1556 18/03/23 1731 18/03/23 1931	23 59.99 S	4 36.10 W	5435	5425	10	-0	5415	5530	24	24	23	24	24	18	24	19	2	
080	18/03/23 2240 18/03/24 0033 18/03/24 0224	24 00.01 S	4 06.00 W	5185	5174	10	-2	5165	5271	24	23	23	23	23	19	23	0	0	
081	18/03/24 0539 18/03/24 0711 18/03/24 0907	23 59.96 S	3 36.06 W	4885	4875	10	-0	4866	4963	24	24	24	24	23	18	24	0	0	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
082	18/03/24 1217 18/03/24 1347 18/03/24 1534	24 00.00 S	3 06.00 W	4742	4734	9	1	4725	4818	24	24	24	24	23	18	24	0	2	
083	18/03/24 1842 18/03/24 2011 18/03/24 2211	23 59.99 S	2 36.02 W	4915	4905	9	-0	4895	4994	24	23	23	23	22	16	23	0	0	
084	18/03/25 0125 18/03/25 0303 18/03/25 0502	24 00.02 S	2 06.02 W	5324	5316	9	0	5305	5417	24	24	24	0	24	20	24	0	0	
085	18/03/25 0805 18/03/25 0955 18/03/25 1204	24 00.03 S	1 35.98 W	5519	5509	6	-4	5497	5616	24	24	24	24	24	19	24	19	2	
086	18/03/25 1546 18/03/25 1711 18/03/25 1910	23 59.99 S	1 06.00 W	4674	4664	10	0	4653	4747	24	24	24	24	23	18	24	0	0	
087	18/03/25 2215 18/03/25 2358 18/03/26 0157	24 00.00 S	0 36.00 W	5467	5458	10	1	5447	5564	24	24	24	24	24	19	24	0	0	
088	18/03/26 0508 18/03/26 0643 18/03/26 0843	24 00.01 S	0 06.02 W	4921	4911	10	0	4901	5000	24	24	24	24	23	20	24	0	0	
089	18/03/26 1030 18/03/26 1158 18/03/26 1322	24 00.01 S	0 09.00 E	5200	4761	-9	-999	4750	4846	1	23	0	0	19	23	23	0	0	CFC bottle blanks
090	18/03/26 1503 18/03/26 1639 18/03/26 1841	24 00.01 S	0 24.02 E	5343	5331	12	0	5320	5433	24	24	22	24	22	19	24	0	2	Bad electrical connection

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
091	18/03/27 1107 18/03/27 1242 18/03/27 1444	24 00.00 S	0 54.00 E	5325	5314	9	-2	5305	5416	24	24	24	24	24	19	24	0	0	New Termination Deep Tow
092	18/03/27 1746 18/03/27 1920 18/03/27 2134	24 00.00 S	1 24.02 E	5264	5254	10	-0	5245	5353	24	24	24	24	23	19	24	0	2	
093	18/03/28 0034 18/03/28 0213 18/03/28 0417	24 00.01 S	1 54.02 E	5219	5210	6	-3	5200	5308	24	24	22	24	24	20	24	0	0	
094	18/03/28 0724 18/03/28 0904 18/03/28 1107	24 00.00 S	2 24.05 E	5275	5265	10	-0	5257	5365	24	24	24	24	24	19	24	0	2	
095	18/03/28 1415 18/03/28 1547 18/03/28 1746	23 59.95 S	2 53.79 E	5194	5185	9	-1	5175	5282	24	24	24	24	24	19	24	0	0	
096	18/03/28 2053 18/03/28 2229 18/03/29 0027	24 00.00 S	3 24.02 E	5241	5230	11	-0	5222	5329	24	24	24	24	24	19	24	24	0	
097	18/03/29 0403 18/03/29 0521 18/03/29 0703	23 59.98 S	3 59.87 E	4180	4170	9	0	4163	4239	24	24	24	24	23	18	24	0	0	
098	18/03/29 0954 18/03/29 1102 18/03/29 1236	24 00.00 S	4 28.05 E	3645	3635	9	-0	3630	3691	24	24	24	24	22	17	23	0	2	End use Deep Tow
099	18/03/29 1441 18/03/29 1546 18/03/29 1702	24 00.01 S	4 47.06 E	3009	3001	9	1	2993	3042	20	24	24	24	23	15	18	0	0	CTD 1 until 105

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
100	18/03/29 1902 18/03/29 1958 18/03/29 2127	23 59.98 S	5 05.87 E	2463	2455	9	1	2450	2485	21	23	23	21	21	14	21	0	0	
101	18/03/29 2324 18/03/30 0007 18/03/30 0112	24 00.02 S	5 24.00 E	2063	2055	9	1	2050	2078	17	24	24	17	17	11	17	0	0	
102	18/03/30 0442 18/03/30 0517 18/03/30 0610	23 59.99 S	5 58.99 E	1643	1635	9	1	1630	1652	20	23	20	0	20	12	20	20	0	
103	18/03/30 0925 18/03/30 1019 18/03/30 1131	24 00.01 S	6 32.00 E	2516	2508	8	0	2505	2540	22	24	22	24	22	15	24	0	2	
104	18/03/30 1429 18/03/30 1524 18/03/30 1640	23 59.99 S	7 02.28 E	2951	2942	9	0	2937	2982	22	23	22	22	22	15	22	0	2	
105	18/03/30 1827 18/03/30 1930 18/03/30 2118	24 00.00 S	7 14.27 E	3498	3488	10	0	3481	3540	23	24	24	23	22	17	23	0	0	
106	18/03/30 2315 18/03/31 0043 18/03/31 0229	24 00.00 S	7 21.75 E	4246	4236	11	1	4230	4307	24	24	24	24	23	16	24	0	0	Deep Tow until 113
107	18/03/31 0417 18/03/31 0541 18/03/31 0737	23 59.99 S	7 35.96 E	4713	4703	11	1	4693	4786	24	24	24	24	24	18	24	0	0	
108	18/03/31 1051 18/03/31 1220 18/03/31 1411	24 00.00 S	8 08.00 E	4676	4668	9	1	4660	4750	24	23	24	24	24	19	24	0	2	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
109	18/03/31 1738 18/03/31 1902 18/03/31 2100	23 59.98 S	8 39.98 E	4675	4666	9	-0	4656	4748	24	24	24	24	24	17	24	0	0	
110	18/04/01 0017 18/04/01 0139 18/04/01 0341	23 59.96 S	9 11.91 E	4547	4538	9	0	4530	4616	24	24	23	24	24	19	24	24	0	
111	18/04/01 0705 18/04/01 0828 18/04/01 1014	23 59.98 S	9 44.00 E	4304	4293	12	1	4285	4364	24	24	24	24	24	17	24	0	5	
112	18/04/01 1331 18/04/01 1445 18/04/01 1627	23 59.99 S	10 15.96 E	4144	4138	7	1	4130	4205	24	23	23	23	23	17	23	0	0	
113	18/04/01 1940 18/04/01 2056 18/04/01 2234	23 59.98 S	10 45.94 E	3921	3912	6	-3	3906	3974	24	23	22	23	23	16	23	0	5	Last before Walvis Bay
114	18/04/03 2118 18/04/03 2131 18/04/03 2159	23 40.62 S	13 42.79 E	203	194	9	-0	192	196	9	6	9	9	9	4	9	0	5	Top of slope; CTD 1 until 121
115	18/04/04 0138 18/04/04 0151 18/04/04 0216	23 46.65 S	13 19.72 E	304	294	9	-1	292	296	8	8	8	7	8	4	8	0	4	
116	18/04/04 0449 18/04/04 0503 18/04/04 0530	23 49.51 S	13 08.94 E	498	489	9	-0	486	493	10	10	10	9	10	6	10	0	0	
117	18/04/04 0801 18/04/04 0825 18/04/04 0909	23 52.47 S	12 58.32 E	1003	994	10	1	991	1003	13	13	13	13	13	12	13	0	3	

stn	yy/mo/dd hhmm	deg min lat	deg min lon	cordep	maxd	minalt	resid	maxw	maxp	ndpths	nsal	noxy	nnut	nco2	ncfc	no18	nc13	nchl	Comments
118	18/04/04 1112 18/04/04 1144 18/04/04 1237	23 55.33 S	12 47.38 E	1520	1514	7	1	1510	1530	18	24	18	18	18	12	18	0	3	
119	18/04/04 1414 18/04/04 1455 18/04/04 1553	23 57.57 S	12 39.02 E	1916	1908	6	-3	1903	1929	19	24	19	19	19	14	19	19	5	
120	18/04/04 1755 18/04/04 1846 18/04/04 1951	23 59.99 S	12 30.03 E	2235	2226	6	-3	2221	2252	18	24	18	24	18	0	19	0	0	
121	18/04/04 2341 18/04/05 0039 18/04/05 0156	23 59.97 S	11 51.98 E	3035	3027	9	0	3020	3068	20	20	20	20	20	16	20	0	0	
122	18/04/05 0511 18/04/05 0618 18/04/05 0747	23 59.97 S	11 19.93 E	3511	3501	10	1	3494	3553	22	22	22	22	21	19	22	0	3	Last in section; Deep Tow until 124
123	18/04/05 1108 18/04/05 1218 18/04/05 1355	24 00.00 S	10 46.00 E	3922	3914	9	0	3905	3976	23	24	24	24	23	17	24	1	5	Repeat of 113
124	18/04/05 1629 18/04/05 1630 18/04/05 1637	23 53.02 S	11 08.06 E	3624	13	-9	-999	10	13	1	0	0	0	0	0	0	1	0	Shallow station for bulk surface water
125	18/04/06 0645 18/04/06 0652 18/04/06 0656	23 07.76 S	13 31.86 E	204	6	-9	-999	4	6	1	0	0	0	0	0	0	0	0	Test station for video recording; CTD 1

Appendix B: CTD Configuration Files

Stainless CTD frame:

Cast 001 – 027

```
Date: 02/28/2018

Instrument configuration file: C:\Users\sandm\Documents\Cruises\JC159\SeaSave setup files\JC159_1257.xmlcon

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

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

1) Frequency 0, Temperature

   Serial number : 03P-4814
   Calibrated on : 27 September 2017
   G             : 4.30107340e-003
   H             : 6.24622221e-004
   I             : 1.85363935e-005
   J             : 1.27405015e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-3874
   Calibrated on : 27 September 2017
   G             : -1.05037768e+001
   H             : 1.38964711e+000
   I             : -1.15396947e-003
   J             : 1.49149852e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
```

```
   Offset       : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 134949
   Calibrated on : 9 November 2015
   C1           : -3.695717e+004
   C2           : -2.691791e-001
   C3           : 1.143300e-002
   D1           : 3.349300e-002
   D2           : 0.000000e+000
   T1           : 3.049225e+001
   T2           : -3.372510e-004
   T3           : 3.990980e-006
   T4           : 3.875890e-009
   T5           : 0.000000e+000
   Slope         : 1.00000000
   Offset       : 0.00000
   AD590M        : 1.280300e-002
   AD590B        : -9.092836e+000

4) Frequency 3, Temperature, 2

   Serial number : 03P-4380
   Calibrated on : 27 September 2017
   G            : 4.37185723e-003
   H            : 6.54525694e-004
   I           : 2.34454625e-005
   J           : 1.79971689e-006
   F0           : 1000.000
   Slope         : 1.00000000
   Offset       : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 04C-2450
   Calibrated on : 27 September 2017
   G            : -1.04354157e+001
   H            : 1.66243970e+000
   I           : -1.64537042e-003
   J           : 2.51935586e-004
   CTcor        : 3.2500e-006
   CPcor        : -9.57000000e-008
   Slope         : 1.00000000
   Offset       : 0.00000

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

   Serial number : 43-0709
   Calibrated on : 29 September 2017
   Equation      : Sea-Bird
```

Soc : 4.35300e-001
Offset : -5.01700e-001
A : -3.19430e-003
B : 2.20190e-004
C : -3.19100e-006
E : 3.60000e-002
Tau20 : 1.34000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, OBS, WET Labs, ECO-BB

Serial number : BBRTD-182
Calibrated on : 6 March 2017
ScaleFactor : 0.003343
Dark output : 0.066000

9) A/D voltage 3, Altimeter

Serial number : 41302
Calibrated on : 13 March 2006
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

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

Serial number : CST-1654DR
Calibrated on : 16 April 2017
M : 21.2217
B : -0.1295
Path length : 0.250

13) A/D voltage 7, Fluorometer, Chelsea Aqua 3

Serial number : 88-2050-095
Calibrated on : 13 October 2017
VB : 0.294700
V1 : 2.036300
Vacetone : 0.420200
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

```
Scan length                  : 41
```

Cast 028 - 036 Fluorometer changed to s/n 088244

Date: 03/08/2018

Instrument configuration file: C:\Users\sandm\Documents\Cruises\JC159\SeaSave setup files\JC159_1257_fl.xmlcon

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

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

1) Frequency 0, Temperature

   Serial number : 03P-4814
   Calibrated on : 27 September 2017
   G             : 4.30107340e-003
   H             : 6.24622221e-004
   I             : 1.85363935e-005
   J             : 1.27405015e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-3874
   Calibrated on : 27 September 2017
   G             : -1.05037768e+001
   H             : 1.38964711e+000
   I             : -1.15396947e-003
   J             : 1.49149852e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000
```

```
3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 134949
   Calibrated on : 9 November 2015
   C1          : -3.695717e+004
   C2          : -2.691791e-001
   C3          : 1.143300e-002
   D1          : 3.349300e-002
   D2          : 0.000000e+000
   T1          : 3.049225e+001
   T2          : -3.372510e-004
   T3          : 3.990980e-006
   T4          : 3.875890e-009
   T5          : 0.000000e+000
   Slope        : 1.00000000
   Offset       : 0.00000
   AD590M       : 1.280300e-002
   AD590B       : -9.092836e+000

4) Frequency 3, Temperature, 2

   Serial number : 03P-4380
   Calibrated on : 27 September 2017
   G           : 4.37185723e-003
   H           : 6.54525694e-004
   I          : 2.34454625e-005
   J          : 1.79971689e-006
   F0          : 1000.000
   Slope        : 1.00000000
   Offset       : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 04C-2450
   Calibrated on : 27 September 2017
   G           : -1.04354157e+001
   H           : 1.66243970e+000
   I          : -1.64537042e-003
   J          : 2.51935586e-004
   CTcor        : 3.2500e-006
   CPcor        : -9.57000000e-008
   Slope        : 1.00000000
   Offset       : 0.00000

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

   Serial number : 43-0709
   Calibrated on : 29 September 2017
   Equation     : Sea-Bird
   Soc         : 4.35300e-001
   Offset       : -5.01700e-001
```

A : -3.19430e-003
B : 2.20190e-004
C : -3.19100e-006
E : 3.60000e-002
Tau20 : 1.34000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, OBS, WET Labs, ECO-BB

Serial number : BBRTD-182
Calibrated on : 6 March 2017
ScaleFactor : 0.003343
Dark output : 0.066000

9) A/D voltage 3, Altimeter

Serial number : 41302
Calibrated on : 13 March 2006
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

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

Serial number : CST-1654DR
Calibrated on : 16 April 2017
M : 21.2217
B : -0.1295
Path length : 0.250

13) A/D voltage 7, Fluorometer, Chelsea Aqua 3

Serial number : 088244
Calibrated on : 29 September 2016
VB : 0.185700
V1 : 2.079400
Vacetone : 0.342300
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

Scan length : 41

Cast 036 – 040 Secondary Oxygen sensor fitted s/n 43-0363

Date: 03/10/2018

Instrument configuration file: C:\Users\sandm\Documents\Cruises\JC159\SeaSave setup files\JC159_1257_fl_oxy.xmlcon

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

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

1) Frequency 0, Temperature

   Serial number : 03P-4814
   Calibrated on : 27 September 2017
   G            : 4.30107340e-003
   H            : 6.24622221e-004
   I            : 1.85363935e-005
   J            : 1.27405015e-006
   F0           : 1000.000
   Slope        : 1.00000000
   Offset       : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-3874
   Calibrated on : 27 September 2017
   G            : -1.05037768e+001
   H            : 1.38964711e+000
   I            : -1.15396947e-003
   J            : 1.49149852e-004
   CTcor        : 3.2500e-006
   CPcor        : -9.57000000e-008
   Slope        : 1.00000000
   Offset       : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 134949
```

Calibrated on : 9 November 2015
C1 : -3.695717e+004
C2 : -2.691791e-001
C3 : 1.143300e-002
D1 : 3.349300e-002
D2 : 0.000000e+000
T1 : 3.049225e+001
T2 : -3.372510e-004
T3 : 3.990980e-006
T4 : 3.875890e-009
T5 : 0.000000e+000
Slope : 1.00000000
Offset : 0.00000
AD590M : 1.280300e-002
AD590B : -9.092836e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-4380
Calibrated on : 27 September 2017
G : 4.37185723e-003
H : 6.54525694e-004
I : 2.34454625e-005
J : 1.79971689e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-2450
Calibrated on : 27 September 2017
G : -1.04354157e+001
H : 1.66243970e+000
I : -1.64537042e-003
J : 2.51935586e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-0709
Calibrated on : 29 September 2017
Equation : Sea-Bird
Soc : 4.35300e-001
Offset : -5.01700e-001
A : -3.19430e-003
B : 2.20190e-004
C : -3.19100e-006

E : 3.60000e-002
Tau20 : 1.34000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, OBS, WET Labs, ECO-BB

Serial number : BBRTD-182
Calibrated on : 6 March 2017
ScaleFactor : 0.003343
Dark output : 0.066000

9) A/D voltage 3, Altimeter

Serial number : 41302
Calibrated on : 13 March 2006
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, Oxygen, SBE 43, 2

Serial number : 43-0363
Calibrated on : 2 March 2016
Equation : Sea-Bird
Soc : 4.51700e-001
Offset : -5.11300e-001
A : -3.78410e-003
B : 1.79750e-004
C : -2.57770e-006
E : 3.60000e-002
Tau20 : 1.14000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

11) A/D voltage 5, Free

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

Serial number : CST-1654DR
Calibrated on : 16 April 2017
M : 21.2217
B : -0.1295
Path length : 0.250

```
13) A/D voltage 7, Fluorometer, Chelsea Aqua 3

    Serial number : 088244
    Calibrated on : 29 September 2016
    VB            : 0.185700
    V1            : 2.079400
    Vacetone      : 0.342300
    Scale factor  : 1.000000
    Slope         : 1.000000
    Offset        : 0.000000

Scan length                   : 41
```

Cast 040 – 125 Secondary Oxygen sensor s/n 43-0363 removed

Date: 03/08/2018

Instrument configuration file: C:\Users\sandm\Documents\Cruises\JC159\SeaSave setup files\JC159_1257_fl.xmlcon

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

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

1) Frequency 0, Temperature

   Serial number : 03P-4814
   Calibrated on : 27 September 2017
   G             : 4.30107340e-003
   H             : 6.24622221e-004
   I             : 1.85363935e-005
   J             : 1.27405015e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity
```

```
  Serial number : 04C-3874
  Calibrated on : 27 September 2017
  G            : -1.05037768e+001
  H            : 1.38964711e+000
  I           : -1.15396947e-003
  J           : 1.49149852e-004
  CTcor        : 3.2500e-006
  CPcor        : -9.57000000e-008
  Slope        : 1.00000000
  Offset       : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

  Serial number : 134949
  Calibrated on : 9 November 2015
  C1           : -3.695717e+004
  C2           : -2.691791e-001
  C3           : 1.143300e-002
  D1           : 3.349300e-002
  D2           : 0.000000e+000
  T1           : 3.049225e+001
  T2           : -3.372510e-004
  T3           : 3.990980e-006
  T4           : 3.875890e-009
  T5           : 0.000000e+000
  Slope        : 1.00000000
  Offset       : 0.00000
  AD590M       : 1.280300e-002
  AD590B       : -9.092836e+000

4) Frequency 3, Temperature, 2

  Serial number : 03P-4380
  Calibrated on : 27 September 2017
  G            : 4.37185723e-003
  H            : 6.54525694e-004
  I           : 2.34454625e-005
  J           : 1.79971689e-006
  F0           : 1000.000
  Slope        : 1.00000000
  Offset       : 0.0000

5) Frequency 4, Conductivity, 2

  Serial number : 04C-2450
  Calibrated on : 27 September 2017
  G            : -1.04354157e+001
  H            : 1.66243970e+000
  I           : -1.64537042e-003
  J           : 2.51935586e-004
  CTcor        : 3.2500e-006
```

CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-0709
Calibrated on : 29 September 2017
Equation : Sea-Bird
Soc : 4.35300e-001
Offset : -5.01700e-001
A : -3.19430e-003
B : 2.20190e-004
C : -3.19100e-006
E : 3.60000e-002
Tau20 : 1.34000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, OBS, WET Labs, ECO-BB

Serial number : BBRTD-182
Calibrated on : 6 March 2017
ScaleFactor : 0.003343
Dark output : 0.066000

9) A/D voltage 3, Altimeter

Serial number : 41302
Calibrated on : 13 March 2006
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

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

Serial number : CST-1654DR
Calibrated on : 16 April 2017
M : 21.2217
B : -0.1295
Path length : 0.250

13) A/D voltage 7, Fluorometer, Chelsea Aqua 3

```
   Serial number : 088244
   Calibrated on : 29 September 2016
   VB           : 0.185700
   V1           : 2.079400
   Vacetone      : 0.342300
   Scale factor  : 1.000000
   Slope         : 1.000000
   Offset        : 0.000000

Scan length                   : 41
```

LADCP command files:

Master

```
CR1                            ; retrieve parameters (1 = On)
RN JC159                       ; cruise name JC159
WM15                           ; sets some defaults for lowered ADCP
CF11101                        ; flow control
EA00000                        ; heading alignment (-179.99 to 180 deg)
ES35                           ; salinity (0 to 40)
EX00100                        ; coordinate transformation (none: leave in beam
coordinates)
EZ0011101                      ; sensor source: internal heading, pitch, tilt, temp
TB00:00:02.80                  ; time interval per burst of pings (hh:mm:ss)
TC2                            ; two ensembles per burst
TE00:00:01.30                  ; time per ensemble (hh:mm:ss)
TP00:00.00                     ; minimum time between pings (mm:ss)
LP1                            ; single ping per ensemble
LN25                           ; number of depth cells
LS0800                         ; size of depth cells (cm)
LF0                            ; blank after transmit
LW1                            ; narrow band
LV400                          ; ambiguity velocity (cm/s radial)
SM1                            ; RDS3 mode select (1 = master)
SA011                          ; synchronise: send pulse before a water ping
SB0                            ; disable hardware-break detection on channel B
CK                             ; keep parameters as user defaults
CS                             ; start pinging
```

Slave

```
CR1                            ; retrieve parameters (1 = On)
RN JC159                       ; cruise name JC159
WM15                           ; sets some defaults for lowered ADCP
CF11101                        ; flow control
EA00000                        ; heading alignment (-179.99 to 180 deg)
```

```
ES35                        ; salinity (0 to 40)
EX00100                     ; coordinate transformation (none: leave in beam
coordinates)
EZ0011101                   ; sensor source: internal heading, pitch, tilt, temp
TB00:00:02.80               ; time interval per burst of pings (hh:mm:ss)
TC2                         ; two ensembles per burst
TE00:00:01.30               ; time per ensemble (hh:mm:ss)
TP00:00.00                  ; minimum time between pings (mm:ss)
LP1                         ; single ping per ensemble
LN25                        ; number of depth cells
LS0800                      ; size of depth cells (cm)
LF0                         ; blank after transmit
LW1                         ; narrow band
LV400                       ; ambiguity velocity (cm/s radial)
SM2                         ; RDS3 mode select (2 = slave)
SA001                       ; synchronise: wait for pulse before a water ping
ST0                         ; slave timeout
SB0                         ; disable hardware-break detection on channel B
CK                          ; keep parameters as user defaults
CS                          ; start pinging
```

Examples of the grease found on the CTD frame after the P-frame was left outboard and the rollers/sheaves had been jet washed several times

William Platt and Jeffrey Benson

Appendix C: CTD Sensor Information

SHIP: RRS James Cook	CRUISE: JC159

Main Stainless Steel 24-way CTD frame as used for JC159

Checked By: Billy Platt/Jeff Benson	DATE: 11 April 2018

Instrument / Sensor:	Model:	Serial No:	Channel:	Casts Used:
Stainless steel 24-way frame	NOCS	SBE CTD9	N/A	All casts
24-way Carousel	SBE 32	32-19817-0243	N/A	All casts
Primary CTD deck unit	SBE 11plus	11p-19817-0495	N/A	All casts
CTD Underwater Unit	SBE 9plus	09p-87077-1257	N/A	All casts
Primary Temperature Sensor	SBE 3P	03p-4814	F1	All casts
Primary Conductivity Sensor	SBE 4C	04c-3874	F2	All casts
Digiquartz Pressure sensor	Paroscientific	134949	F3	All casts
Secondary Temperature Sensor	SBE 3P	03p-4380	F4	All casts
Secondary Conductivity Sensor	SBE 4C	04c-2450	F5	All casts
Primary Pump	SBE 5T	05t-3609	N/A	All casts
Secondary Pump	SBE 5T	05t-4539	N/A	All casts
Primary Dissolved Oxygen Sensor	SBE 43	43-0709	V0	All casts
Secondary Dissolved Oxygen Sensor	SBE 43	43-0363	V4	Casts 036-040
Light Scattering Sensor	WETLabs BBRTD	BBRTD-182	V2	All casts
Altimeter	Benthos 916T	41302	V3	All casts
Transmissometer	WET Labs C-Star	CST-1654DR	V6	All casts
Fluorometer	CTG Aquatracka MKIII	88-2050-095	V7	Casts 001-027
Fluorometer	CTG Aquatracka MKIII	088244	V7	Casts 028-125
20L Water Samplers	OTE	1A-24A	N/A	All casts
Down-looking Master LADCP (Aluminium)	TRDI/WHM300kHz	15288	N/A	All Casts
Up-looking Slave LADCP (Aluminium)	TRDI/WHM300kHz	24465	N/A	Casts 001-061
Up-looking Slave LADCP (Aluminium)	TRDI/WHM300kHz	24466	N/A	Casts 062-125
LADCP battery pack pressure case	NOCS	WH010T	N/A	All Casts
Titanium CTD swivel	MDS	1253-2	N/A	Casts 001-064
Titanium CTD swivel	MDS	1253-1	N/A	Casts 065-125

William Platt and Jeffrey Benson