National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre

Cruise Report No. 53

RRS *Discovery* Cruise DY090

23 May – 28 June 2018
Walvis Bay, Namibia – Cape Town, South Africa

COMICS2: Controls over Ocean Mesopelagic Interior Carbon Storage

Principal Scientist
Stephanie Henson

2018

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

Tel: +44 (0)23 80596044
Email: S.Henson@noc.ac.uk

DOCUMENT DATA SHEET

AUTHOR	*PUBLICATION DATE*
HENSON, S. et al	2018

TITLE

RRS *Discovery Cruise* DY090, 23 May – 28 June 2018, Walvis Bay, Namibia – Cape Town, South Africa. COMICS2: Controls over Ocean Mesopelagic Interior Carbon Storage

REFERENCE

Southampton, UK: National Oceanography Centre, Southampton, 370pp.
(National Oceanography Centre Cruise Report, No. 53)

ABSTRACT

The purpose of the COMICS programme (Controls over Oceanic Mesopelagic Interior Carbon Storage) is to investigate three leading hypotheses on controls over the remineralisation depth of organic carbon. The remineralisation depth is key to setting the air-sea balance of CO2 and thus in regulating Earth's climate. Nevertheless, the dominant controls on spatial and temporal variability in remineralisation depth remain unclear. The three potential controls are: temperature, oxygen concentration and ecosystem structure.

The COMICS programme includes 2 cruises to contrasting oceanic regions: DY086 which sampled the high productivity region downstream of South Georgia in November/December 2017, and this cruise, DY090, which targeted the low oxygen region offshore of Namibia in May/June 2018. The sampling strategy for DY090 was to conduct long stations (~6 days) in contrasting mesopelagic oxygen conditions. The two main stations were BS (Benguela South) at 21.5S, 9.5E and BN (Benguela North) at 18S, 11E. The original plan was to shuttle between the 2 sites multiple times, but after completing one cycle of the station at each of the BS and BN sites we decided instead to remain at the BN site and undertake a sequence of the 6 day station cycle to capture the temporal evolution of the mesopelagic oxygen minimum and consequent influence on remineralisation depth.

DY090 completed 1 cycle of the super-station at BS, 3 cycles at BN, and additionally completed some other random bits and bobs at the end of the cruise. In total, 464 events were completed in 4 weeks of science time.

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

A pdf of this report is available for download at: http://eprints.soton.ac.uk

(This page intentionally left blank)

Table of Contents

List of Personnel

Scientific Personnel

Henson, Stephanie (Principal Scientist)	National Oceanography Centre
Ainsworth, Joanne	University of Southampton
Ashurst, Daniel	British Antarctic Survey
Baker, Chelsey	National Oceanography Centre
Belcher, Anna	British Antarctic Survey
Briggs, Nathan	National Oceanography Centre
Carvalho, Ana Filipa	National Oceanography Centre
Cook, Kathryn	National Oceanography Centre
Duret, Manon	University of Southampton
Fielding, Sophie	British Antarctic Survey
Fuessel, Jessika	University of Southampton
Giering, Sarah	National Oceanography Centre
Hemsley, Victoria	Queen Mary University, London
Hubot, Nathan	University of Southampton
Klawonn, Isabell	IGB-Berlin
Poulton, Alex	Heriot-Watt University
Preece, Calum	University of Liverpool
Rayne, Rachel	University of Southampton
Saunders, Ryan	British Antarctic Survey
Saw, Kevin	National Oceanography Centre
Stinchcombe, Mark	National Oceanography Centre
Stowasser, Gabriele	British Antarctic Survey
Trimmer, Mark	Queen Mary University, London
Winkelbauer, Helge	Heriot-Watt University

Technical Personnel

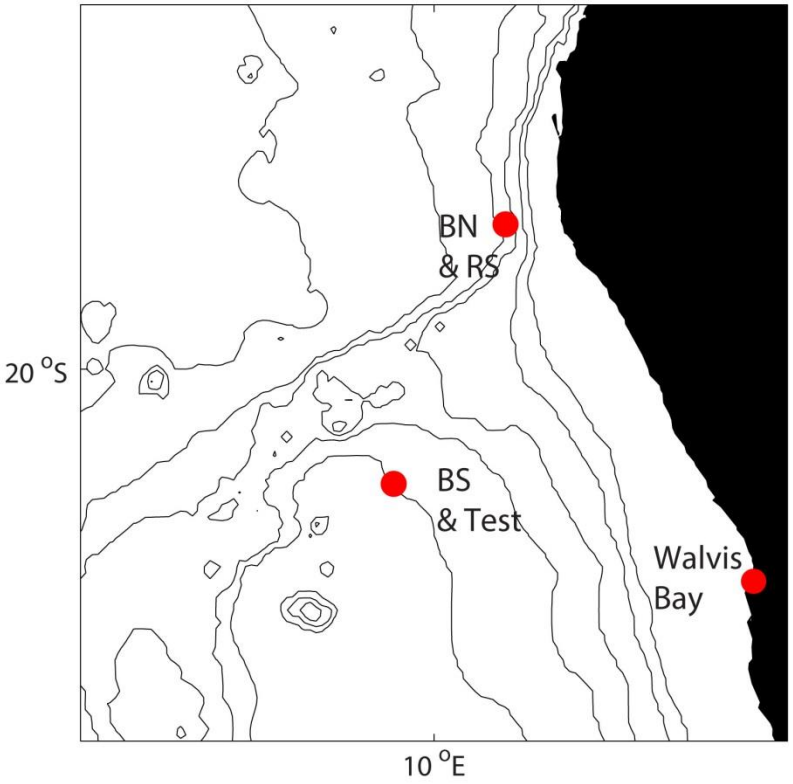
Short, Jonathan (Senior Technician)	National Oceanography Centre
Bridger, Martin	National Oceanography Centre
Cameron, Candice	National Oceanography Centre
Leadbeater, Andrew	National Oceanography Centre

Ward-Neale, Jennifer	National Oceanography Centre
Wynar, John	National Oceanography Centre

Ship's Personnel

Cox, Joanna	Master
Gauld, Philip	C/O
Morrow, Declan	2/O
Norrish, Nicholas	3/O
Lewtas, Andrew	C/E
Hay, Derek	2/E
Silajdzic, Edin	3/E
Longworth, Taylor	3/E
Brazier, Thomas	ETO
Bullimore, Graham	Purser
Smith, Stephen	CPOS
Cook, Stuart	CPOD
Peppin, Christopher	POD
Crabb, Gary	SG1A
Willcox, Simon	SG1A
Dwyer, Andrew	SG1A
Gilfillan, Craig	SG1A
Sproul, Bryan (Steve)	ERPO
Lynch, Peter	H/Chef
Noble, David (Steve)	Chef
Carrilho, Clementina	Stwd
Williams, Denzil	A/Stwd

Itinerary



Map of the two DY090 sampling sites. Station BS1 was occupied between 26th and 31st May 2018 (preceded by Test station from 24th May at same site). Stations BN1-BN3 were occupied between 1st and 19th June 2018 (followed by station RS to 21st June 2018 at same site). See Event Log for details.

Objectives

The purpose of the COMICS programme (Controls over Oceanic Mesopelagic Interior Carbon Storage) is to investigate three leading hypotheses on controls over the remineralisation depth of organic carbon. The remineralisation depth is key to setting the air-sea balance of CO_2 and thus in regulating Earth's climate. Nevertheless, the dominant controls on spatial and temporal variability in remineralisation depth remain unclear. The three potential controls are: temperature, oxygen concentration and ecosystem structure.

The COMICS programme includes 2 cruises to contrasting oceanic regions: DY086 which sampled the high productivity region downstream of South Georgia in November/December 2017, and this cruise, DY090, which targeted the low oxygen region offshore of Namibia in May/June 2018. The sampling strategy for DY090 was to conduct long stations (~6 days) in contrasting mesopelagic oxygen conditions. The two main stations were BS (Benguela South) at 21.5S, 9.5E and BN (Benguela North) at 18S, 11E. The original plan was to shuttle between the 2 sites multiple times, but after completing one cycle of the station at each of the BS and BN sites we decided instead to remain at the BN site and undertake a sequence of the 6 day station cycle to capture the temporal evolution of the mesopelagic oxygen minimum and consequent influence on remineralisation depth.

DY090 completed 1 cycle of the super-station at BS, 3 cycles at BN, and additionally completed some other random bits and bobs at the end of the cruise. In total, 464 events were completed in 4 weeks of science time.

Narrative

Sunday 20th May

Clear and sunny all day. Set-up of labs begun, all running smoothly so far as we kept the lab plan basically the same. Both CTDs reterminated.

Monday 21st May

Foggy morning, but clearing after lunch. Mob continues smoothly, although TM CTD termination fails. Net termination completed successfully.

Tuesday 22nd May

Foggy morning, but clearing after lunch. Missing chemicals and MSC arrive safely. Some of the scientific party take the opportunity to go on a desert tour. Lab tidy-up and lashing down starts prior to our departure tomorrow. Net termination broken again. Pelagras not talking.

Wednesday 23rd May

Beautiful clear morning for sailing. Hydrogen peroxide finally arrived. Sailed approx 09:30, heading northeast along shelf (300-500m depth) for ADCP calibration. Net termination fixed again.

Thursday 24th May

Weather continues fair with seas picking up. Continuing to test station at southern site, arrive 21:30. Stainless steel CTD worked flawlessly. RMT deployed but termination unfortunately failed again in trials. 5 Pelagras deployed for 20 hour deployment @ 80,120, 200, 450, 750m. Bongos successfully deployed.

Friday 25th May

Trace metal CTD trial goes smoothly. First MSCs go in for the rates team (75m) – some issues with leaking MSCs due to mismatching plungers. Red Camera Frame goes in to 250 and 500m without a hitch. The MSCs are all tested by Sari and Calum to ensure they are all functioning correctly. Repairs on the termination for the RMT25 and MOCNESS continue and the issues are (hopefully) successfully resolved. Bongos and Mammoth are successfully deployed. Pelagras start popping up by 23:00 and all 5 are recovered easily by 02:00, including one with a large fish stuck in the funnel.

Saturday 26th May

Start of station BS1: TM CTD – minor issue with the winch stopping when operated from the belly box, but won't prevent deployments. MSC rates are deployed to 500m. 2 MSCs are also fired to collect

water for RESPIRE array @ 120 and 200m. RESPIRE array deployed, not as smoothly as on DY086, but some modifications will be made for following deployments (in particular attaching the last part (bungee to buoy) by hand rather than winding onto the North Sea winch). MOCNESS had some problems with the release mechanism which were fixed on deck, however on deployment the pressure sensor wasn't reporting. The cable was replaced which fixed the problem and MOCNESS was redeployed, however on recovery it was found that the motor hadn't turned resulting in no depth-stratified samples. Due to a miscalculation in programming the timing, 3 Pelagras were deployed at 18:00, followed by the remaining 2 Pelagras at 23:00. In between the RMT25 was deployed successfully – full of salps!

Sunday 27th May

Pre-dawn CTD followed by 2 x camera frame deployments. First deployment of the SAPS – the 4 NMF SAPS worked fine but unfortunately the Liverpool SAPS (nicknamed 'Ringo') didn't pump (80 m depth). Mammoth net deployed successfully. Bongos deployed to max 450m. MSC profile completed. RMT25 deployed but failed with a comms issue and recovered. BAS team worked on it for a couple of hours but couldn't fix the issue in the time frame available.

Monday 28th May

Red Camera Frame followed by TM CTD and MSC for rates (120 m). The Bongo nets were lost at ~ 10:30 when the Bongo wire sheared just below the ferrule. BAS team have plans to cobble together a replacement from spares. A MSC profile for geochemistry is completed before the MOCNESS is deployed (in lieu of the malfunctioning RMT25). Unfortunately the MOCNESS nets didn't close and so only a depth integrated sample (0-750m) was collected. A 2nd stainless CTD to 1000m was carried out to collect water for Th/Po. The MOCNESS and RMT25 termination bottles were swapped out and RMT was successfully deployed.

Tuesday 29th May

2 Red Camera Frame deployments were followed by a pre-dawn stainless CTD cast, and then another one to collect water for Gabi. SAPS were deployed and the Liverpool one failed again (deployed at 200m). A MSC profile was collected, followed by deployment of the Mammoth net which failed to close. RESPIRE recovery then commenced and was successfully completed. All 5 Pelagras were recovered in the space of 2.5 hours!

Wednesday 30th May

After Pelagra recovery we then repositioned and did a JellyNet for Nathan H followed by MSC deployments for rates. Unfortunately the bearing on the aft Rexroth (used for Mammoth) broke during

Pelagra recovery and started spewing oil during JellyNet. The bearing needs to be replaced, but in the meantime may impact on deploying Mammoth. The B plan is to deploy Mammoth from the A-frame. The daytime acoustic survey was then started. The Mammoth net mesh (ordinarily 300um) was replaced with Bongo net mesh (100um) for this cast, so nicknamed the Mango net. The night time acoustic survey was then commenced.

Thursday 31st May

Acoustic survey concluded, followed by a full-depth CTD. A MSC profile for fluxes followed. A near-miss accident occurred as Sari was resetting the MSCs when the green Catcher became jammed. A full incident report and witness statements will be filed. Mitigation measures have been put in place, however the MSC redesign will need to have been completed before they are used again on CUSTARD. RMT25 was deployed, but recovered again shortly after due to a faulty circuit board. This was replaced quickly and the RMT25 deployed twice more. We then departed the BS1 station at ~ 20:30.

Friday 1st June

Passage continues towards station BN1. We stopped southwest of the station at the start of the planned acoustic/ADCP survey and did a stainless CTD which showed an oxygen minimum of ~ 50 umol/kg at ~ 350 m depth. We then performed an overnight acoustic/ADCP survey heading to station BN1 to the northeast. Currents were revealed to be ~ 0.15 m/s suggesting the Pelagras and RESPIRE will move around 30km northward in a 3 day deployment. As we will be working ~ 100km from the Angolan border, I deemed this a safe distance.

Saturday 2nd June

A TM CTD was done on arrival at BN1 – the fluorometer did not record data, but we did find oxygen concentrations of ~ 20 umol/kg at 70-100 m and a secondary oxygen minimum of ~ 40 umol/kg at ~ 350 m depth. A series of MSCs then started (for rates), but there were repeated leaks and mis-fires although eventually all MSCs were collected as planned. This was the first trial of the new operating procedure in light of Sari's near miss on Thursday. On the basis of evidence from the ADCP survey, we then relocated to 18 16.56 S, 10 56.12E where the predominant flows are south/west to ensure the drifting instruments would not whiz north over the Angolan border. On arrival we deployed the cobbled-together Bongo net made by Dan which worked beautifully. This was followed by a MOCNESS trial, in which the nets again did not close. The RESPIRE array was then successfully deployed with 2 traps at 125 and 250m. 5 Pelagras were deployed, set to depths of 60, 120, 250, 350 and 750m. We then relocated to the main BN station at 18 S, 11 E in worsening weather. On arrival an MSC profile was undertaken. By the time it had completed, 4 Pelagras were reporting they were at surface so we steamed south again to recover them.

Sunday 3rd June

4 Pelagras were recovered within a small radius of each other. The 5th was believed spotted sitting below the surface but then disappeared again (the 750m trap). Initial analysis by Kev showed that all traps sank to 100m, released their weights and then immediately popped up suggesting that either the water properties had changed sufficiently in time/space between the CTD to check water properties (event 106), or that the traps were improperly ballasted. We steamed back to the main BN station in long swells with occasional very large waves causing big rolls. During a particularly big roll (17.7 degrees) Claire's liquid scintillation counter came off its table and the cooling unit sheared off. Claire's LSC was not working when we left Walvis Bay and instead we had been using NMF's, so this will have no impact on the planned work. However, investigation found that although a ratchet strap was around the top of the LSC, it had not been secured properly to the table. Alex checked the sealed radiation source and found it to be intact. A near miss incident report was filed. Work at the station was suspended until the weather eased off, with a stainless CTD going in at 13:30. This was followed by MSC profile for geochemistry. The planned Red Camera Frame was aborted due to continuing lumpy weather. However, we were able to deploy the MOCNESS at 19:00. After repositioning back to the main station, a Bongo net was deployed.

Monday 4th June

From midnight, the 4 Pelagras which had unexpectedly popped up in the early morning the previous day were redeployed. This was followed by a pre-dawn CTD, a series of MSCs for rates and two casts of the Red Camera Frame. The TM CTD was deployed, followed by the SAPS, although Ringo again didn't pump. A Mammoth deployment to 850 m took place; during recovery the wire jumped the sheath but was quickly re-seated. This was followed by MSCs for flux profile work, an RMT25 tow, which wasn't successful and a trial of the IsaNet (Isabell's tiny plankton net). The RMT25 was then deployed again, this time successfully.

Tuesday 5th June

Sophie's birthday! Early morning Red Camera Frame profiles were followed by another IsaNet and a stainless CTD to collect water for Gabi, Kathryn and Jessika & co. The JellyNet was then deployed followed by Bongo nets. Two successful RMT25 tows followed, before we headed ~20 nm southwest to recover the RESPIRE array. The RESPIRE array was recovered successfully although it was found that oxygen data had not recorded on one trap and only partially on the other. Pelagra hunting then commenced; vagrant P9 eventually reported position after a long anxious wait. The other 4 Pelagras behaved themselves and all were on board by 4am.

Wednesday 6th June

An early morning stainless CTD was conducted near the location of the glider before we relocated back to the main station for another stainless CTD for Th/Po. A pair of Bongos were then performed followed by a MOCNESS, which is still misbehaving; because it isn't closing properly the only option is open trawls from surface down (in the case to 125 m). We then deployed 2 Mangos and Mammoth, interspersed with a MSC profile for geochemistry.

Thursday 7th June

An early morning Red Camera Frame deployment was followed by a pre-dawn CTD and shallow MSCs to collect water for Mark T and Manon. We then began a 16 hour acoustic survey centred on the main BN station. The RMT25 was deployed, thus concluding station BN1.

Friday 8th June

A mesoscale ADCP survey was conducted overnight to try and constrain the small scale advection evident in the CTD data. This was followed by MSCs for rates and a series of JellyNets. Bongo nets were then deployed, followed by another set of MSCs for Rachel/Chelsey. A 100 m CTD cast was performed before the acoustic calibration was attempted in the open ocean in very calm conditions. During the calibration a couple of JellyNets were deployed.

Saturday 9th June

A MOCNESS (still with problems closing) was followed by a Red Camera Frame, stainless CTD and a TM CTD. The SAPS were then deployed (Ringo failed again and this time so did Wendy), followed by a pair of Bongos and a MOCNESS. The RESPIRE array was then deployed, followed by all 5 Pelagras. An RMT25 tow followed.

Sunday 10th June

IsaNet was deployed three times, before the bridge noticed strobe lights on the horizon. On reaching the location, it was found that P4 (programmed for 100 m) had unexpectedly popped up. P4 was recovered before we repositioned back to the main station for a Red Camera Frame to 750 m. A series of MSCs to 750 m for rates was then undertaken, followed by a stainless CTD for Gabi. Pelagra P4 was redeployed at 11:45 ship's time. Unfortunately this meant that the planned MSC day time profile could not be completed, although we hope to do it later at this station. A Mammoth net, followed by Mango was then done. A profile of MSCs was then done, another Mango (which failed due to duff batteries), followed by yet another Mango (which was successful).

Monday 11th June

A stainless CTD was done for Th/Po work, followed by another pre-dawn stainless CTD. A MSC profile for rates was collected, followed by a Red Camera Frame. A couple of JellyNet dips were followed by some IsaNets and a shallow profile of MSCs. An RMT25 tow followed and another profile of MSCs (deep). Bongo nets were deployed, followed by another Mammoth net.

Tuesday 12th June

An early morning Red Camera Frame deployment was followed by a TM CTD and SAPS. Ringo was not deployed and the 5 NMEP SAPS all worked. Another Red Camera Frame followed, then a pair of Bongos and a MSC profile. The RESPIRE array was then recovered, although the 250m trap was found not to have worked properly again (likely water ingress to the cable). All 5 Pelagras were then recovered, having drifted south of the main station, apparently all within a low chlorophyll filament.

Wednesday 13th June

An early morning MSC profile for the rates team was then done, followed by a pre-dawn stainless CTD and a Red Camera Frame deployment. A further set of MSCs was then undertaken for the bacterial respiration team followed by another Red Camera Frame. A 20 hour acoustic survey was then commenced.

Thursday 14th June

At the end of the acoustic survey, we repositioned to BN again to commence work on BN3. A TM CTD was followed by JellyNets and Bongos. A Mammoth deployment followed, and then an impromptu IsaNet, a MSC profile, another Mammoth and a Mango….

Friday 15th June

An early morning set of MSCs for the rates team was followed by a pre-dawn CTD and a Red Camera Frame. A SAPS then followed in which all pumps operated successfully (Liverpool pump has been relegated to the scrap heap). The RESPIRE array was deployed successfully for a 2 day period, followed by a Mango. Three IsaNet deployments were followed by deployment of all 5 Pelagras (2 day period) and a MSC profile. A night-time MOCNESS took place before Pelagra P4 (@100m depth) was spotted nearby, having unexpectedly come to the surface.

Saturday 16th June

After recovery of the errant Pelagra, 2 Red Camera Frame profiles followed and a MSC profile for the rates team. P4 was then redeployed and a full-depth CTD for Th/Po was completed. As the CTD was being stowed away, a Pelagra flag was spotted just at the surface, no more than 30 m from the ship. So

Pelagra P4 was recovered again just 3 hours after being deployed and was banished to the hangar for being a naughty boy. A pair of Bongo nets followed, then a daytime MOCNESS and a partial daytime RMT25 (with the remainder to be completed the following day). A MSC profile was then followed by a night time RMT25.

Sunday 17th June

Two Red Camera Frames followed and then a pre-dawn stainless CTD (last one!) and a set of deep MSCs for the rates team. A SAPS deployment followed (all pumped successfully) and the TM wire was then streamed out to remove a wobble in the scrolling (frame and sensors attached, but no bottles). The 2nd part of the daytime RMT25 (leftover from previous day) was then completed followed by a MSC profile. The RESPIRE array was then recovered with both traps having operated successfully for the first time thanks to John having spliced in a new optode cable. Pelagra hunting then commenced.

Monday 18th June

All 4 Pelagras were recovered and all had operated as planned. A stainless CTD was deployed to collect water for various experiments (Gabi, Jessika). This was followed by MSCs at 175m for Rachel and Chelsey and then a series of JellyNets. The RESPIRE array was then redeployed for a 2 day period. A pair of Bongos was followed by a pair of Red Camera Frame deployments, and then redeployment of 5 Pelagras for a 2 day period. This was followed by a MSC profile, more Bongos and IsaNets.

Tuesday 19th June

A 10 hour mesoscale ADCP survey was commenced at midnight. The survey marked the end of station BN3. From here on, work is on station RS (Random S**t) at the same location as the rest of the BN work. Day/night pairs of MOCNESS, MSC and Red Camera Frame were then started in an attempt to capture diel differences in faecal pellet production. The MOCNESS was followed by a MSC profile, then RCF. We then relocated to the glider position and as glider commenced a dive to 250 m, we deployed the stainless CTD for a 500 m calibration cast. The glider 'Doombar' was then successfully recovered to deck after its 4.5 month mission. A series of IsaNet deployments were followed by a MOCNESS, MSCs and a Red Camera Frame, which completed the day/night pairs.

Wednesday 20th June

Early morning MSCs were deployed for the rates team before we commenced steaming out to deep water to collect water for DOM experiments. In the 4.5 hour steaming time we had available, water of ~ 3600 m depth was reached (18° 20.57 S, 10° 30.27 E). A stainless CTD was undertaken before we steamed back to the main station again. On arrival, another stainless CTD for Th/Po was deployed before we moved off to recover the RESPIRE array. Both traps operated as hoped.

Thursday 21st June

All 5 Pelagras were successfully recovered, followed by a series of stainless CTDs for calibration purposes. On the first dip, the RESPIRE optodes, Seabird CTs and RBR were attached and the CTD deployed to 250 m. Unfortunately the first cast wasn't successful, so the CTD was repeated and samples for oxygen and nutrients were taken. On the 2nd dip, only the CTs and RBR were attached and the CTD deployed to 500 m. Samples for salinity, chlorophyll and POC were taken. A SAPS deployment followed, and then a MSC profile. This marked the end of science with 464 events completed! We then headed to Walvis Bay in order to clear customs before leaving Namibian waters.

Friday 22nd June

Packing up commences under clear blue skies as we passage to Walvis Bay to clear customs.

Saturday 23rd June

We clear customs in Walvis Bay and set sail for Cape Town at 12:30.

Sunday 24th-Wednesday 27th June

On passage to Cape Town as we pack up our gear and stow in containers. Chelsey's birthday and RCP on 25th June!

Thursday 28th June

Arrival into Cape Town at ~ 10:00.

DY090 Event Log

Event	Station	Bridge notes	Deployment #	Date	Day of year	Time	Lat	Lon	Notes
1	Test	On stn. Azi down. Prepping CTD MF		24/05/2018	143	19:40:00	-21.498646	9.499504	
1	Test	CTD MF in water. ship hdg 150G	CTD001 SS	24/05/2018	143	19:55:00	-21.499438	9.499878	bridge incorrectly logged as TM
1	Test	ctd mf @ 1000m ascending		24/05/2018	143	20:22:00	-21.499715	9.500039	
1	Test	ctd mf on deck		24/05/2018	143	21:08:00	-21.499729	9.500032	
2	Test	Incr water speed 2.0kts.		24/05/2018	143	22:41:00	-21.49971	9.500035	
2	Test	RMT 25 Net Deployed	RMT001	24/05/2018	143	23:00:00	-21.506488	9.504477	termination failed
2	Test	Comms Issue		24/05/2018	143	23:18:00	-21.514575	9.509591	
2	Test	Net & Ends on deck		24/05/2018	143	23:51:00	-21.525278	9.515621	
3	Test	Pelegra OB	Pelagra001	25/05/2018	144	01:07:00	-21.52539	9.515662	
3	Test	Pelagra In the water		25/05/2018	144	01:09:00	-21.525374	9.515651	
4	Test	Pelagra OB	Pelagra002	25/05/2018	144	01:19:00	-21.525391	9.515659	
4	Test	Pelagra In the water		25/05/2018	144	01:23:00	-21.525384	9.51566	
5	Test	Pelagra OB	Pelagra003	25/05/2018	144	01:37:00	-21.525371	9.51567	
5	Test	Pelagra In the water		25/05/2018	144	01:39:00	-21.525365	9.515678	
6	Test	Pelagra OB	Pelagra004	25/05/2018	144	01:49:00	-21.525367	9.515669	
6	Test	Pelagra In the water		25/05/2018	144	01:50:00	-21.525348	9.515663	
7	Test	Pelagra In the water	Pelagra005	25/05/2018	144	02:05:00	-21.525378	9.515682	
	Test			25/05/2018	144	04:23:00	-21.542196	9.523216	
8	Test	Bongo net in water	Bongo001	25/05/2018	144	04:24:00	-21.542191	9.523203	
8	Test	Bongo net IB		25/05/2018	144	04:41:00	-21.542175	9.523199	
	Test			25/05/2018	144	05:01:00	-21.536803	9.525299	
9	Test	ctd mf outboard	CTD002 TM	25/05/2018	144	06:33:00	-21.525435	9.515662	
9	Test	on deck		25/05/2018	144	07:35:00	-21.525448	9.515642	

10	Test	msc outboard	MSC001	25/05/2018	144	08:23:00	-21.525442	9.515652	Rates
10	Test	msc inboard		25/05/2018	144	08:29:00	-21.525451	9.515654	
11	Test	msc outboard	MSC002	25/05/2018	144	08:41:00	-21.525451	9.515662	Rates
11	Test	msc inboard		25/05/2018	144	08:51:00	-21.525442	9.51565	
12	Test	msc outboard	MSC003	25/05/2018	144	09:00:00	-21.525429	9.515666	Rates
12	Test	msc inboard		25/05/2018	144	09:06:00	-21.525432	9.515674	
13	Test	msc outboard	MSC004	25/05/2018	144	09:21:00	-21.525433	9.515655	Rates
13	Test	msc inboard		25/05/2018	144	09:26:00	-21.525424	9.515658	
14	Test	Red Camera O/B	RCF001	25/05/2018	144	10:59:00	-21.525426	9.515647	
14	Test	Red Camera I/B		25/05/2018	144	11:35:00	-21.525426	9.515657	
15	Test	Red Camera O/B	RCF002	25/05/2018	144	11:50:00	-21.525462	9.51567	
15	Test	Red Camera I/B		25/05/2018	144	12:46:00	-21.525453	9.515643	
16	Test	MSC Profile OB	MSC005	25/05/2018	144	13:21:00	-21.525445	9.515647	Fluxes
16	Test	MSC Profile IB		25/05/2018	144	13:33:00	-21.525432	9.515638	
17	Test	MSC Profile OB	MSC006	25/05/2018	144	13:39:00	-21.525452	9.515649	Fluxes
17	Test	MSC Profile IB		25/05/2018	144	13:43:00	-21.525436	9.515643	
18	Test	MSC Profile OB	MSC007	25/05/2018	144	13:50:00	-21.525417	9.515626	Fluxes
18	Test	MSC Profile IB		25/05/2018	144	13:54:00	-21.525443	9.515627	
19	Test	MSC Profile OB	MSC008	25/05/2018	144	14:05:00	-21.525452	9.515637	Fluxes
19	Test	MSC Profile IB		25/05/2018	144	14:08:00	-21.525457	9.515625	
20	Test	MSC Profile OB	MSC009	25/05/2018	144	14:18:00	-21.52545	9.515682	Fluxes
20	Test	MSC Profile IB		25/05/2018	144	14:43:00	-21.52543	9.515668	
21	Test	Bongo net in water	Bongo002	25/05/2018	144	16:20:00	-21.525432	9.515686	
21	Test	Bongo net IB		25/05/2018	144	16:39:00	-21.525433	9.5157	
22	Test	Bongo net in water	Bongo003	25/05/2018	144	16:43:00	-21.525428	9.515694	
22	Test	Bongo net IB		25/05/2018	144	17:31:00	-21.525413	9.515693	
23	Test	mammoth net outboard	Mammoth001	25/05/2018	144	18:21:00	-21.525413	9.5157	

23	Test	mammoth net @850m hauling		25/05/2018	144	19:12:00	-21.525417	9.515706	
23	Test	mammoth net inboard		25/05/2018	144	20:29:00	-21.525436	9.515701	
24	Test	Pelagra IB P6	PelagraRecover	25/05/2018	144	22:07:00	-21.535894	9.46562	
25	Test	Pelagra IB P9	PelagraRecover	25/05/2018	144	22:51:00	-21.540223	9.469476	
26	Test	Pelagra IB P7	PelagraRecover	25/05/2018	144	23:14:00	-21.554013	9.478325	
27	Test	Pelagra IB P4	PelagraRecover	25/05/2018	144	23:42:00	-21.557323	9.455534	
28	Test	Pelagra IB P2	PelagraRecover	26/05/2018	145	00:12:00	-21.554826	9.430044	
29	BS1	tm ctd ob	CTD003 TM	26/05/2018	145	02:24:00	-21.554813	9.430123	
29	BS1	tm ctd ib		26/05/2018	145	03:44:00	-21.554834	9.430053	
30	BS1	msc outboard	MSC010	26/05/2018	145	06:10:00	-21.554849	9.430065	Rates
30	BS1	msc inboard		26/05/2018	145	06:17:00	-21.55484	9.430039	
31	BS1	msc outboard	MSC011	26/05/2018	145	06:22:00	-21.554849	9.430036	Rates
31	BS1	msc inboard		26/05/2018	145	06:33:00	-21.554849	9.430053	
32	BS1	msc outboard	MSC012	26/05/2018	145	06:39:00	-21.554832	9.430006	Rates
32	BS1	msc inboard		26/05/2018	145	07:04:00	-21.554849	9.430031	
33	BS1	msc outboard	MSC013	26/05/2018	145	07:13:00	-21.554877	9.430049	Rates
33	BS1	msc inboard		26/05/2018	145	07:37:00	-21.554874	9.430037	
34	BS1	msc outboard	MSC014	26/05/2018	145	07:44:00	-21.554875	9.430043	Rates
34	BS1	msc inboard		26/05/2018	145	08:08:00	-21.554881	9.430042	
35	BS1	msc outboard	MSC015	26/05/2018	145	08:12:00	-21.554841	9.430048	Rates
35	BS1	msc inboard		26/05/2018	145	08:34:00	-21.554836	9.430071	
36	BS1	msc outboard	MSC016	26/05/2018	145	08:39:00	-21.554846	9.43007	Rates
36	BS1	msc inboard		26/05/2018	145	09:03:00	-21.554832	9.430061	
37	BS1	RESPIRE Deployment Ship Spd 1.0kt through water	RESPIRE001	26/05/2018	145	10:08:00	-21.55617	9.431228	
37	BS1	RESPIRE top float OB		26/05/2018	145	10:52:00	-21.56177	9.43674	
37	BS1	RESPIRE top float OB		26/05/2018	145	10:52:00	-21.56177	9.43674	

37	BS1	RESPIRE top float OB		26/05/2018	145	10:52:00	-21.56177	9.43674	
37	BS1	RESPIRE Float Released		26/05/2018	145	10:55:00	-21.562269	9.437161	
38	BS1	MOCNESS - Ship Speed 2.0kt through water	MOCNESS001	26/05/2018	145	13:19:00	-21.589085	9.464977	pressure sensor not reporting
38	BS1	MOCNESS OB		26/05/2018	145	13:25:00	-21.591032	9.466675	
38	BS1	MOCNESS - Commence Recovery		26/05/2018	145	13:32:00	-21.593437	9.468754	
38	BS1	MOCNESS IB		26/05/2018	145	13:45:00	-21.59792	9.472723	
39	BS1	MOCNESS OB	MOCNESS002	26/05/2018	145	14:02:00	-21.605023	9.477763	did not fire in water
39	BS1	548m hauling		26/05/2018	145	14:41:00	-21.620496	9.487428	
39	BS1	Mocness IB - Stop V/L		26/05/2018	145	15:34:00	-21.637971	9.501295	
40	BS1	Pelagra OB	Pelagra006	26/05/2018	145	16:14:00	-21.638415	9.501743	
41	BS1	Pelagra OB	Pelagra007	26/05/2018	145	16:38:00	-21.640118	9.505207	
42	BS1	Pelagra OB	Pelagra008	26/05/2018	145	17:13:00	-21.643363	9.512819	
43	BS1	deploying rmt25 net @2kts stw	RMT002	26/05/2018	145	18:11:00	-21.661014	9.526398	
43	BS1	rmt25 net @308m hauling		26/05/2018	145	18:44:00	-21.673614	9.536658	
43	BS1	rmt net inboard		26/05/2018	145	20:00:00	-21.697266	9.55413	
44	BS1	pelagra away	Pelagra009	26/05/2018	145	21:04:00	-21.640236	9.509175	
45	BS1	pelagra away	Pelagra010	26/05/2018	145	21:22:00	-21.642318	9.510542	
46	BS1	STAINLESS CTD OB	CTD004 SS	27/05/2018	146	01:02:00	-21.64269	9.510746	
46	BS1	STAINLESS CTD IB		27/05/2018	146	02:22:00	-21.642701	9.510764	
47	BS1	Red Camera O/B	RCF003	27/05/2018	146	03:11:00	-21.642696	9.510768	
47	BS1	Red Camera I/B		27/05/2018	146	03:51:00	-21.642699	9.510759	
48	BS1	Red Camera O/B	RCF004	27/05/2018	146	04:02:00	-21.642709	9.510767	
48	BS1	Red Camera I/B		27/05/2018	146	04:50:00	-21.642706	9.510758	
49	BS1	saps outboard	SAPS001	27/05/2018	146	07:48:00	-21.642703	9.510756	Liverpool SAPS did not pump
49	BS1	saps @450m		27/05/2018	146	08:15:00	-21.642715	9.510737	

49	BS1	SAPS IB		27/05/2018	146	10:45:00	-21.642717	9.510746	
50	BS1	mammoth net outboard	Mammoth002	27/05/2018	146	11:41:00	-21.642729	9.510729	
50	BS1	mammoth net inboard		27/05/2018	146	14:20:00	-21.637296	9.504986	
51	BS1	Bongo net in water	Bongo004	27/05/2018	146	14:52:00	-21.637294	9.504981	
51	BS1	Bongo net IB		27/05/2018	146	15:37:00	-21.637306	9.504994	
52	BS1	Bongo net in water	Bongo005	27/05/2018	146	15:41:00	-21.637301	9.504988	
52	BS1	Bongo net IB		27/05/2018	146	15:58:00	-21.637294	9.504992	
53	BS1	msc outboard	MSC017	27/05/2018	146	16:36:00	-21.63728	9.50498	Fluxes
53	BS1	msc inboard		27/05/2018	146	16:59:00	-21.637291	9.504972	
54	BS1	msc outboard	MSC018	27/05/2018	146	17:12:00	-21.637307	9.504992	Fluxes
54	BS1	msc inboard		27/05/2018	146	17:21:00	-21.637293	9.504987	
55	BS1	msc outboard	MSC019	27/05/2018	146	17:31:00	-21.637288	9.504987	Fluxes
55	BS1	msc inboard		27/05/2018	146	17:39:00	-21.637282	9.504984	
56	BS1	msc outboard	MSC020	27/05/2018	146	17:47:00	-21.637292	9.504979	Fluxes
56	BS1	msc inboard		27/05/2018	146	17:54:00	-21.637298	9.504983	
57	BS1	rmt25 net deployed	RMT003	27/05/2018	146	18:33:00	-21.649282	9.509763	Failed with comms issue
57	BS1	rmt25 net partially recovered - comms fault		27/05/2018	146	18:49:00	-21.657263	9.512889	
57	BS1	rmt25 net fully recovered to deck. v/l stopped		27/05/2018	146	19:27:00	-21.673047	9.519477	
58	BS1	red camera frame outboard	RCF005	27/05/2018	146	20:41:00	-21.641111	9.505568	
58	BS1	red camera frame inboard		27/05/2018	146	21:32:00	-21.641112	9.505564	
59	BS1	red camera frame outboard	RCF006	27/05/2018	146	21:52:00	-21.641107	9.505564	
59	BS1	red camera frame inboard		27/05/2018	146	22:53:00	-21.641102	9.505563	
60	BS1	tm ctd ob	CTD005 TM	28/05/2018	147	03:22:00	-21.641106	9.505582	
60	BS1	tm ctd i/b		28/05/2018	147	04:27:00	-21.6411	9.505575	
61	BS1	msc outboard	MSC021	28/05/2018	147	05:01:00	-21.641105	9.505579	Rates

61	BS1	msc inboard		28/05/2018	147	05:06:00	-21.641102	9.505579	
62	BS1	msc outboard	MSC022	28/05/2018	147	05:11:00	-21.641103	9.505587	Rates
62	BS1	msc inboard		28/05/2018	147	05:22:00	-21.641102	9.505579	
63	BS1	msc outboard	MSC023	28/05/2018	147	05:27:00	-21.641098	9.505577	Rates
63	BS1	msc inboard		28/05/2018	147	05:38:00	-21.641099	9.505582	
64	BS1	msc outboard	MSC024	28/05/2018	147	05:43:00	-21.641101	9.505573	Rates
64	BS1	msc inboard		28/05/2018	147	05:52:00	-21.641101	9.505586	
65	BS1	Bongo net in water	Bongo006	28/05/2018	147	07:32:00	-21.641105	9.505579	Bongo nets lost; wire sheared below ferrule
65	BS1	bongo net inboard / lost		28/05/2018	147	08:39:00	-21.641104	9.505579	
66	BS1	msc outboard	MSC025	28/05/2018	147	09:48:00	-21.641124	9.505543	Geochem
66	BS1	msc inboard		28/05/2018	147	09:57:00	-21.641118	9.505548	
67	BS1	msc outboard	MSC026	28/05/2018	147	10:07:00	-21.641119	9.505545	Geochem
67	BS1	msc inboard		28/05/2018	147	10:15:00	-21.64111	9.505542	
68	BS1	msc outboard	MSC027	28/05/2018	147	10:22:00	-21.641116	9.505549	Geochem
68	BS1	msc inboard		28/05/2018	147	10:33:00	-21.641112	9.505548	
69	BS1	msc outboard	MSC028	28/05/2018	147	10:41:00	-21.641109	9.505545	Geochem
69	BS1	msc inboard		28/05/2018	147	11:02:00	-21.641112	9.505536	
70	BS1	MOCNESS OB	MOCNESS003	28/05/2018	147	12:21:00	-21.644435	9.507078	Did not fire sequentially, so no depth stratification
70	BS1	MOCNESS IB		28/05/2018	147	15:27:00	-21.729202	9.555194	
71	BS1	STAINLESS CTD OB	CTD006 SS	28/05/2018	147	16:00:00	-21.730788	9.556038	Th/Po
71	BS1	STAINLESS CTD IB		28/05/2018	147	17:06:00	-21.730778	9.556027	
72	BS1	rmt25 net deployed	RMT004	28/05/2018	147	19:33:00	-21.741152	9.562628	Successful
72	BS1	rmt25 net @1022m hauling		28/05/2018	147	20:37:00	-21.772399	9.580662	
72	BS1	rmt net inboard		28/05/2018	147	22:47:00	-21.830224	9.615123	
73	BS1	Red Camera O/B	RCF007	28/05/2018	147	23:21:00	-21.831566	9.615936	
73	BS1	Red Camera I/B		29/05/2018	148	00:06:00	-21.831557	9.615957	

74	BS1	Red Camera O/B	RCF008	29/05/2018	148	00:28:00	-21.831564	9.615941	
74	BS1	Red Camera I/B		29/05/2018	148	01:23:00	-21.83157	9.61594	
75	BS1	STAINLESS CTD OB	CTD007 SS	29/05/2018	148	02:05:00	-21.831563	9.615937	
75	BS1	STAINLESS CTD IB		29/05/2018	148	03:03:00	-21.83157	9.615931	
76	BS1	STAINLESS CTD OB	CTD008 SS	29/05/2018	148	05:31:00	-21.54206	9.507141	Gabi CTD
76	BS1	STAINLESS CTD IB		29/05/2018	148	06:30:00	-21.542058	9.50715	
77	BS1	saps outboard	SAPS002	29/05/2018	148	07:39:00	-21.542059	9.507152	Liverpool SAPS did not pump
77	BS1	saps wire trapped in sheave. ops ceased to fix problem		29/05/2018	148	07:42:00	-21.542065	9.507139	
77	BS1	saps resumes deployment		29/05/2018	148	08:05:00	-21.542055	9.507145	
77	BS1	saps at 450m		29/05/2018	148	08:28:00	-21.542055	9.507149	
77	BS1	commence hauling saps		29/05/2018	148	09:48:00	-21.54205	9.507147	
77	BS1	SAPS IB		29/05/2018	148	10:19:00	-21.542055	9.507148	
78	BS1	msc outboard	MSC029	29/05/2018	148	10:34:00	-21.542046	9.507156	Fluxes
78	BS1	msc inboard		29/05/2018	148	11:07:00	-21.542054	9.507154	
79	BS1	msc outboard	MSC030	29/05/2018	148	11:15:00	-21.542052	9.507149	Fluxes
79	BS1	msc inboard		29/05/2018	148	11:35:00	-21.54206	9.50715	
80	BS1	msc outboard	MSC031	29/05/2018	148	11:42:00	-21.542051	9.507148	Fluxes
80	BS1	msc inboard		29/05/2018	148	11:52:00	-21.542071	9.507136	
81	BS1	msc outboard	MSC032	29/05/2018	148	11:58:00	-21.542077	9.507128	Fluxes
81	BS1	msc inboard		29/05/2018	148	12:05:00	-21.542066	9.507132	
82	BS1	msc outboard	MSC033	29/05/2018	148	12:13:00	-21.542067	9.507138	Fluxes
82	BS1	msc inboard		29/05/2018	148	12:17:00	-21.542072	9.507129	
83	BS1	mammoth net outboard	Mammoth003	29/05/2018	148	12:55:00	-21.542068	9.507134	Failed to close
83	BS1	mammoth net inboard		29/05/2018	148	13:33:00	-21.540165	9.505865	
84	BS1	RESPIRE MOORING I/B	RESPIRErecover	29/05/2018	148	17:40:00	-21.593678	9.171798	
85	BS1	pelagra 7 recovered	PelagraRecover	29/05/2018	148	19:57:00	-21.564545	9.438712	

86	BS1	pelagra 9 inboard	PelagraRecover	29/05/2018	148	20:33:00	-21.593326	9.415604	
87	BS1	pelagra p2 inboard	PelagraRecover	29/05/2018	148	21:10:00	-21.600469	9.458371	
88	BS1	pelagra 4 inboard	PelagraRecover	29/05/2018	148	21:48:00	-21.610954	9.48855	
89	BS1	pelagra p6 inboard	PelagraRecover	29/05/2018	148	22:33:00	-21.575329	9.456597	
90	BS1	Jelly Fish Catcher OB	JellyNet001	30/05/2018	149	01:20:00	-21.558263	9.466387	
90	BS1	Jelly Fish Catcher IB		30/05/2018	149	01:34:00	-21.558267	9.466381	
91	BS1	msc outboard	MSC034	30/05/2018	149	03:06:00	-21.558248	9.466449	Rates
91	BS1	msc inboard		30/05/2018	149	03:13:00	-21.558241	9.466453	
92	BS1	msc outboard	MSC035	30/05/2018	149	03:20:00	-21.558239	9.466461	Rates
92	BS1	msc inboard		30/05/2018	149	03:27:00	-21.558246	9.466454	
93	BS1	msc outboard	MSC036	30/05/2018	149	03:36:00	-21.558238	9.466452	Rates
93	BS1	msc inboard		30/05/2018	149	03:41:00	-21.558242	9.466458	
94	BS1	msc outboard	MSC037	30/05/2018	149	03:47:00	-21.558247	9.466459	Rates
94	BS1	msc inboard		30/05/2018	149	03:55:00	-21.558245	9.466456	
95	BS1	commence survey 270T <10kts	Survey001	30/05/2018	149	06:14:00	-21.725126	9.654887	
95	BS1	Complete survey leg 1		30/05/2018	149	08:21:00	-21.725139	9.300449	
95	BS1	Commence survey leg 2 - 090		30/05/2018	149	09:27:00	-21.558459	9.298848	
95	BS1	End of Line. AC to 000		30/05/2018	149	11:40:00	-21.558088	9.662425	
95	BS1	Commence Survey Line 3. Course 270		30/05/2018	149	12:41:00	-21.392179	9.662319	
95	BS1	Survey completed. Final WP.		30/05/2018	149	14:43:00	-21.392183	9.302275	
96	BS1	mammoth net outboard	Mango001	30/05/2018	149	17:02:00	-21.557736	9.466834	Mammoth nets replaced with Bongo nets to create the Mango
96	BS1	mammoth @850m hauling		30/05/2018	149	17:56:00	-21.557727	9.466838	
96	BS1	mammoth net inboard		30/05/2018	149	19:13:00	-21.557728	9.466832	
97	BS1	commence survey leg 1 270t	Survey002	30/05/2018	149	21:31:00	-21.725214	9.661669	

97	BS1	End of Line. AC to 000		30/05/2018	149	23:38:00	-21.725192	9.305928	
97	BS1	End of Line. AC to 090		31/05/2018	150	00:41:00	-21.567699	9.282153	
97	BS1	Commence survey leg 2 - 090		31/05/2018	150	00:48:00	-21.558962	9.296157	
97	BS1	End of Line. AC to 000		31/05/2018	150	03:03:00	-21.557856	9.667993	
97	BS1	End of Line. AC to 270		31/05/2018	150	04:00:00	-21.40017	9.677646	
97	BS1	Commence Survey Line 3. Course 270		31/05/2018	150	04:08:00	-21.391142	9.660962	
97	BS1	Break off survey proceed to CTD posn		31/05/2018	150	04:20:00	-21.391572	9.624866	
98	BS1	STAINLESS CTD OB	CTD009 SS	31/05/2018	150	06:10:00	-21.558295	9.465808	Deep CTD
98	BS1	ctd @3965m hauling		31/05/2018	150	07:32:00	-21.55812	9.466524	
98	BS1	ctd inboard		31/05/2018	150	09:07:00	-21.558124	9.466527	
99	BS1	msc outboard	MSC038	31/05/2018	150	09:30:00	-21.558122	9.466533	
99	BS1	msc inboard		31/05/2018	150	09:34:00	-21.558128	9.466522	
100	BS1	msc outboard	MSC039	31/05/2018	150	09:43:00	-21.558135	9.466507	
100	BS1	msc inboard		31/05/2018	150	09:49:00	-21.558142	9.466508	
101	BS1	msc outboard	MSC040	31/05/2018	150	09:59:00	-21.558133	9.466511	
101	BS1	msc inboard		31/05/2018	150	10:09:00	-21.558136	9.466507	
102	BS1	msc outboard	MSC041	31/05/2018	150	10:16:00	-21.55814	9.466505	
102	BS1	msc inboard		31/05/2018	150	10:47:00	-21.558133	9.46652	
103	BS1	Ship Speed 2.0 kts through water		31/05/2018	150	11:39:00	-21.558344	9.466698	
103	BS1	RMT Net Outboard	RMT005	31/05/2018	150	11:43:00	-21.560129	9.468063	Faulty circuit board, replaced and redeployed
103	BS1	RMT commence recovery		31/05/2018	150	11:57:00	-21.565727	9.472471	
104	BS1	RMT Net Outboard	RMT006	31/05/2018	150	12:30:00	-21.575345	9.479655	
104	BS1	RMT net recovered to deck		31/05/2018	150	14:17:00	-21.613412	9.509551	
105	BS1	Ship speed 2.0 kts		31/05/2018	150	14:43:00	-21.622678	9.514451	
105	BS1	RMT deployed	RMT007	31/05/2018	150	15:05:00	-21.634487	9.517978	

105	BS1	rmt net @984m hauling		31/05/2018	150	16:03:00	-21.660553	9.52625	
105	BS1	RMT net recovered to deck		31/05/2018	150	17:48:00	-21.709848	9.544101	
106	BN1	STAINLESS CTD OB	CTD010 SS	01/06/2018	151	17:12:00	-18.27106	10.745455	southwest of main BN station
106	BN1	ctd inboard		01/06/2018	151	18:14:00	-18.270088	10.745262	
106	BN1	off station		01/06/2018	151	18:20:00	-18.268534	10.745033	
107	BN1	commence survey line 1	Survey003	01/06/2018	151	18:42:00	-18.272464	10.743726	
107	BN1	start survey line 2		01/06/2018	151	21:11:00	-18.146501	11.006873	
107	BN1	End of Line. AC to 000		01/06/2018	151	22:46:00	-18.146061	10.745441	
107	BN1	Start Survey Line 3. Course 090		01/06/2018	151	23:29:00	-18.025277	10.725955	
107	BN1	End of Survey.		02/06/2018	152	01:16:00	-18.019912	11.00795	
108	BN1	tm ctd ob	CTD011 TM	02/06/2018	152	04:08:00	-18.0198	11.008275	
108	BN1	tm ctd i/b		02/06/2018	152	05:22:00	-18.019321	11.008189	
109	BN1	msc outboard	MSC042	02/06/2018	152	06:00:00	-18.019323	11.008189	Rates
109	BN1	msc inboard		02/06/2018	152	06:04:00	-18.019344	11.00817	
110	BN1	msc outboard	MSC043	02/06/2018	152	06:15:00	-18.019316	11.008156	Rates
110	BN1	msc inboard		02/06/2018	152	06:30:00	-18.019331	11.008177	
111	BN1	msc outboard	MSC044F	02/06/2018	152	06:33:00	-18.019336	11.008176	Failed, not recorded in MSC logbook, and messed up MSC numbering, so ignore
111	BN1	msc inboard		02/06/2018	152	06:45:00	-18.019329	11.008168	
112	BN1	msc outboard	MSC044	02/06/2018	152	06:50:00	-18.019316	11.008162	Rates
112	BN1	msc inboard		02/06/2018	152	07:03:00	-18.019315	11.008168	
113	BN1	msc outboard	MSC045	02/06/2018	152	07:09:00	-18.019332	11.008169	Rates
113	BN1	msc inboard		02/06/2018	152	07:15:00	-18.019336	11.00817	
114	BN1	msc outboard	MSC046	02/06/2018	152	07:25:00	-18.019326	11.008172	Rates
114	BN1	msc inboard		02/06/2018	152	07:29:00	-18.019334	11.008164	
115	BN1	msc outboard	MSC047	02/06/2018	152	07:42:00	-18.019349	11.008169	Rates
115	BN1	msc inboard		02/06/2018	152	07:45:00	-18.019336	11.008167	

116	BN1	msc outboard	MSC048	02/06/2018	152	07:54:00	-18.019329	11.008173	Rates
116	BN1	msc inboard		02/06/2018	152	07:57:00	-18.019341	11.008175	
117	BN1	msc outboard	MSC049	02/06/2018	152	08:02:00	-18.01932	11.008179	Rates
117	BN1	msc inboard		02/06/2018	152	08:06:00	-18.019316	11.008164	
117	BN1	reposition		02/06/2018	152	08:14:00	-18.020221	11.008132	
118	BN1	Vsl in DP Auto Posn		02/06/2018	152	10:20:00	-18.272095	10.933299	
118	BN1	Bongo net OB	Bongo007	02/06/2018	152	10:35:00	-18.2721	10.933284	New Bongos made by Dan!
118	BN1	Bongo net IB		02/06/2018	152	10:51:00	-18.272106	10.933296	
119	BN1	Bongo net in water	Bongo008	02/06/2018	152	10:57:00	-18.272119	10.933284	
119	BN1	Bongo net IB		02/06/2018	152	11:13:00	-18.272102	10.933279	
120	BN1	Ship Speed 2.0 kts through water		02/06/2018	152	11:50:00	-18.272424	10.933461	
120	BN1	MOCNESS OB	MOCNESS004	02/06/2018	152	11:57:00	-18.274527	10.934532	Did not fire sequentially, so no depth stratification
120	BN1	Commence recovery		02/06/2018	152	12:26:00	-18.283086	10.939326	
120	BN1	MOCNESS IB		02/06/2018	152	12:43:00	-18.287994	10.942101	
121	BN1	Ship Speed 1.0 kt through water		02/06/2018	152	13:32:00	-18.288438	10.942418	
121	BN1	RESPIRE Anchor Away	RESPIRE002	02/06/2018	152	13:35:00	-18.288946	10.942563	
121	BN1	RESPIRE Float Released		02/06/2018	152	14:14:00	-18.297489	10.94465	
122	BN1	Pelagra In the water	Pelagra011	02/06/2018	152	15:38:00	-18.316341	10.940225	
123	BN1	Pelagra In the water	Pelagra012	02/06/2018	152	15:50:00	-18.319319	10.940721	
124	BN1	Pelagra In the water	Pelagra013	02/06/2018	152	16:07:00	-18.323249	10.94137	
125	BN1	Pelagra In the water	Pelagra014	02/06/2018	152	16:18:00	-18.324799	10.941488	
126	BN1	Pelagra In the water	Pelagra015	02/06/2018	152	16:42:00	-18.331061	10.941887	
127	BN1	on station		02/06/2018	152	19:16:00	-18.019905	11.008317	
127	BN1	msc outboard	MSC050	02/06/2018	152	19:30:00	-18.019939	11.008364	Fluxes
127	BN1	msc inboard		02/06/2018	152	19:40:00	-18.019949	11.008377	
128	BN1	msc outboard	MSC051	02/06/2018	152	20:09:00	-18.019937	11.008377	Fluxes

128	BN1	msc inboard		02/06/2018	152	20:15:00	-18.019915	11.008374	
129	BN1	msc outboard	MSC052	02/06/2018	152	20:28:00	-18.019931	11.008385	Fluxes
129	BN1	msc inboard		02/06/2018	152	20:42:00	-18.019945	11.008364	
130	BN1	msc outboard	MSC053	02/06/2018	152	20:50:00	-18.019913	11.008392	Fluxes
130	BN1	msc inboard		02/06/2018	152	21:13:00	-18.019897	11.008373	
130	BN1	reposition for pelagra recovery		02/06/2018	152	21:22:00	-18.020077	11.008293	
131	BN1	Pelagra IB	PelagraRecover	03/06/2018	153	01:51:00	-18.315061	10.80838	Aborted mission
132	BN1	Pelagra IB	PelagraRecover	03/06/2018	153	02:16:00	-18.31537	10.802226	Aborted mission
133	BN1	Pelagra IB	PelagraRecover	03/06/2018	153	03:02:00	-18.319159	10.79431	Aborted mission
134	BN1	Pelagra IB	PelagraRecover	03/06/2018	153	03:36:00	-18.321757	10.789584	Aborted mission
135	BN1	CTD OB	CTD012 SS	03/06/2018	153	11:32:00	-18.019758	11.008451	
135	BN1	CTD IB		03/06/2018	153	12:51:00	-18.019716	11.008448	
136	BN1	msc outboard	MSC054	03/06/2018	153	13:58:00	-18.019767	11.008462	Geochem
136	BN1	msc outboard		03/06/2018	153	14:04:00	-18.019765	11.008453	
137	BN1	msc outboard	MSC055	03/06/2018	153	14:14:00	-18.019751	11.008479	Geochem
137	BN1	msc inboard		03/06/2018	153	14:21:00	-18.01974	11.00848	
138	BN1	msc outboard	MSC056	03/06/2018	153	14:29:00	-18.019759	11.008476	Geochem
138	BN1	msc inboard		03/06/2018	153	14:42:00	-18.019763	11.008482	
139	BN1	msc outboard	MSC057	03/06/2018	153	14:54:00	-18.019752	11.008478	Geochem
139	BN1	msc inboard		03/06/2018	153	15:13:00	-18.019775	11.008473	
140	BN1	MOCNESS OB	MOCNESS005	03/06/2018	153	17:11:00	-18.027735	11.008323	
140	BN1	MOCNESS IB		03/06/2018	153	18:05:00	-18.053072	11.014204	
141	BN1	MOCNESS outboard	MOCNESS006	03/06/2018	153	18:20:00	-18.056551	11.015375	
141	BN1	MOCNESS inboard		03/06/2018	153	18:24:00	-18.058419	11.016184	
142	BN1	MOCNESS outboard	MOCNESS007	03/06/2018	153	18:32:00	-18.060116	11.016839	
142	BN1	MOCNESS inboard		03/06/2018	153	18:48:00	-18.067601	11.01999	

142	BN1	reposition to main station		03/06/2018	153	19:15:00	-18.068791	11.020565	
142	BN1	on station		03/06/2018	153	20:05:00	-18.019812	11.008435	
143	BN1	Bongo net outboard	Bongo009	03/06/2018	153	20:41:00	-18.019833	11.008424	
143	BN1	bongo net inboard		03/06/2018	153	21:05:00	-18.019825	11.008428	
144	BN1	Pelagra OB	Pelagra016	03/06/2018	153	22:09:00	-18.02008	11.008621	Redeployment of 4 aborted Pelagras
145	BN1	Pelagra OB	Pelagra017	03/06/2018	153	22:22:00	-18.022231	11.010709	
146	BN1	Pelagra OB	Pelagra018	03/06/2018	153	22:37:00	-18.023962	11.012861	
147	BN1	Pelagra OB	Pelagra019	03/06/2018	153	22:56:00	-18.026309	11.014641	
148	BN1	STAINLESS CTD OB	CTD013 SS	04/06/2018	154	01:02:00	-18.019742	11.008387	
148	BN1	STAINLESS CTD IB		04/06/2018	154	02:16:00	-18.019757	11.008403	
149	BN1	msc outboard	MSC058	04/06/2018	154	02:48:00	-18.019733	11.008394	Rates
149	BN1	msc inboard		04/06/2018	154	02:54:00	-18.019746	11.0084	
150	BN1	msc outboard	MSC059	04/06/2018	154	03:00:00	-18.019742	11.008397	Rates
150	BN1	msc inboard		04/06/2018	154	03:07:00	-18.019743	11.008391	
151	BN1	msc outboard	MSC060	04/06/2018	154	03:13:00	-18.019751	11.008385	Rates
151	BN1	msc inboard		04/06/2018	154	03:20:00	-18.01975	11.008388	
152	BN1	msc outboard	MSC061	04/06/2018	154	03:29:00	-18.019747	11.008401	Rates
152	BN1	msc inboard		04/06/2018	154	03:35:00	-18.019745	11.008387	
153	BN1	msc outboard	MSC062	04/06/2018	154	03:39:00	-18.019741	11.008402	Rates
153	BN1	msc inboard		04/06/2018	154	03:46:00	-18.019747	11.00839	
154	BN1	Red Camera O/B	RCF009	04/06/2018	154	05:03:00	-18.019753	11.008399	Rates
154	BN1	Red Camera I/B		04/06/2018	154	05:47:00	-18.01975	11.008399	
155	BN1	Red Camera outboard	RCF010	04/06/2018	154	06:08:00	-18.019738	11.008394	Rates
155	BN1	Red Camera inboard		04/06/2018	154	07:30:00	-18.019734	11.008389	
156	BN1	ctd mf outboard	CTD014 TM	04/06/2018	154	08:00:00	-18.019738	11.00839	
156	BN1	ctd mf @ 1000m ascending		04/06/2018	154	08:24:00	-18.019753	11.008406	

156	BN1	ctd mf inboard		04/06/2018	154	09:27:00	-18.019744	11.008404	
157	BN1	SAPS OB	SAPS003	04/06/2018	154	10:03:00	-18.01975	11.008395	Liverpool SAPS did not pump
157	BN1	SAPS @400m		04/06/2018	154	10:42:00	-18.019746	11.008404	
157	BN1	Commence recovery		04/06/2018	154	12:00:00	-18.019746	11.008438	
157	BN1	SAPS IB		04/06/2018	154	12:26:00	-18.019756	11.008433	
158	BN1	mammoth net outboard	Mammoth004	04/06/2018	154	13:10:00	-18.019741	11.008442	
158	BN1	max. wire out. hauling		04/06/2018	154	14:19:00	-18.017515	11.008042	
158	BN1	mammoth net inboard		04/06/2018	154	15:59:00	-18.017517	11.008045	
159	BN1	msc outboard	MSC063	04/06/2018	154	17:06:00	-18.019781	11.008188	Fluxes
159	BN1	msc inboard		04/06/2018	154	17:11:00	-18.01977	11.008202	
160	BN1	msc outboard	MSC064	04/06/2018	154	17:19:00	-18.019784	11.008197	Fluxes
160	BN1	msc inboard		04/06/2018	154	17:25:00	-18.019769	11.008192	
161	BN1	msc outboard	MSC065	04/06/2018	154	17:34:00	-18.019785	11.008196	Fluxes
161	BN1	msc inboard		04/06/2018	154	17:44:00	-18.019772	11.008212	
162	BN1	msc outboard	MSC066	04/06/2018	154	17:54:00	-18.019762	11.008215	Fluxes
162	BN1	msc inboard		04/06/2018	154	18:17:00	-18.01978	11.008194	
163	BN1	v/l spd 2kts stw for rmt25 deployment		04/06/2018	154	19:07:00	-18.020283	11.008471	
163	BN1	rmt25 outboard	RMT008	04/06/2018	154	19:12:00	-18.023187	11.009897	Unsuccessful
163	BN1	rmt25 net @351m hauling		04/06/2018	154	19:49:00	-18.044425	11.019679	
163	BN1	rmt25 net inboard		04/06/2018	154	20:34:00	-18.072455	11.031368	
163	BN1	rmt25 net fully recovered to deck. v/l stopped		04/06/2018	154	20:50:00	-18.08212	11.035367	
164	BN1	ISANET outboard	IsaNet001	04/06/2018	154	21:07:00	-18.074301	11.031978	
164	BN1	ISANET inboard		04/06/2018	154	21:10:00	-18.074295	11.031983	
165	BN1	ISANET outboard	IsaNet002	04/06/2018	154	21:13:00	-18.074301	11.031982	
165	BN1	ISANET inboard		04/06/2018	154	21:16:00	-18.074296	11.031976	

166	BN1	v/l spd 2kts stw for rmt25 deployment		04/06/2018	154	21:29:00	-18.075605	11.032651	
166	BN1	RMT Net Outboard	RMT009	04/06/2018	154	21:35:00	-18.079718	11.034439	Successful
166	BN1	@359m Commence Hauling		04/06/2018	154	22:06:00	-18.098085	11.043681	
166	BN1	rmt net inboard		04/06/2018	154	23:15:00	-18.129514	11.065603	
167	BN1	Red Camera O/B	RCF011	05/06/2018	155	00:56:00	-18.019666	11.008448	
167	BN1	Red Camera I/B		05/06/2018	155	01:43:00	-18.01967	11.00845	
168	BN1	Red Camera O/B	RCF012	05/06/2018	155	02:02:00	-18.019669	11.008458	
168	BN1	Red Camera I/B		05/06/2018	155	03:52:00	-18.019669	11.008462	
169	BN1	ISANET outboard	IsaNet003	05/06/2018	155	04:01:00	-18.019658	11.008589	
169	BN1	ISANET inboard		05/06/2018	155	04:04:00	-18.019661	11.008937	
170	BN1	ISANET outboard	IsaNet004	05/06/2018	155	04:05:00	-18.019672	11.00906	
170	BN1	ISANET inboard		05/06/2018	155	04:08:00	-18.019675	11.009415	
171	BN1	ISANET outboard	IsaNet005	05/06/2018	155	04:10:00	-18.019663	11.009656	
171	BN1	ISANET inboard		05/06/2018	155	04:13:00	-18.019672	11.010001	
172	BN1	STAINLESS CTD OB	CTD015 SS	05/06/2018	155	04:47:00	-18.019658	11.008509	Gabi
172	BN1	STAINLESS CTD IB		05/06/2018	155	05:48:00	-18.019646	11.008513	
173	BN1	jellyfish net outboard	JellyNet002	05/06/2018	155	07:02:00	-18.019657	11.008937	
173	BN1	jellyfish net inboard		05/06/2018	155	07:27:00	-18.021179	11.01075	
174	BN1	jellyfish net outboard	JellyNet003	05/06/2018	155	07:34:00	-18.021615	11.011141	
174	BN1	jellyfish net inboard		05/06/2018	155	08:02:00	-18.023423	11.012714	
175	BN1	Bongo net outboard	Bongo010	05/06/2018	155	08:19:00	-18.02359	11.012874	
175	BN1	bongo net inboard		05/06/2018	155	08:34:00	-18.024275	11.013382	
176	BN1	Bongo net outboard	Bongo011	05/06/2018	155	08:42:00	-18.024651	11.013643	
176	BN1	bongo net inboard		05/06/2018	155	08:55:00	-18.025234	11.014084	
177	BN1	Ship Speed 2.0 kts through water		05/06/2018	155	10:18:00	-18.019908	11.00844	
177	BN1	RMT Net Outboard	RMT010	05/06/2018	155	10:26:00	-18.023538	11.006631	

177	BN1	@339m Commence Haul		05/06/2018	155	11:06:00	-18.043631	10.995283	
177	BN1	rmt net inboard		05/06/2018	155	12:03:00	-18.069068	10.981784	
178	BN1	Ship Speed 2.0 kts through water		05/06/2018	155	12:22:00	-18.066566	10.982494	
178	BN1	RMT Net Outboard	RMT011	05/06/2018	155	12:45:00	-18.078983	10.974847	
178	BN1	RMT net recovered to deck		05/06/2018	155	15:54:00	-18.159243	10.916987	
179	BN1	RESPIRE grappled	RESPIRErecover	05/06/2018	155	18:10:00	-18.205125	10.665792	
179	BN1	commence stern recovery of RESPIRE		05/06/2018	155	18:17:00	-18.206696	10.665712	
179	BN1	RESPIRE fully recovered		05/06/2018	155	18:51:00	-18.210436	10.664716	
180	BN1	Pelagra IB	PelagraRecover	05/06/2018	155	22:07:00	-18.27059	10.915129	
181	BN1	Pelagra 2 IB	PelagraRecover	06/06/2018	156	00:25:00	-18.163479	11.092981	
182	BN1	Pelagra 6 IB	PelagraRecover	06/06/2018	156	01:43:00	-18.093537	11.026727	
183	BN1	Pelagra IB P4	PelagraRecover	06/06/2018	156	02:19:00	-18.085458	11.006965	
184	BN1	Pelagra IB P7	PelagraRecover	06/06/2018	156	03:15:00	-18.034653	11.042032	
185	BN1	STAINLESS CTD OB	CTD016 SS	06/06/2018	156	04:16:00	-18.097863	11.013407	
185	BN1	STAINLESS CTD IB		06/06/2018	156	05:13:00	-18.097804	11.013371	
186	BN1	ctd outboard	CTD017 SS	06/06/2018	156	06:35:00	-18.019682	11.008331	Th/Po
186	BN1	ctd @1000m hauling		06/06/2018	156	07:12:00	-18.019683	11.008328	
186	BN1	ctd inboard		06/06/2018	156	08:14:00	-18.019675	11.00833	
187	BN1	Bongo net outboard	Bongo012	06/06/2018	156	08:35:00	-18.019683	11.008325	
187	BN1	bongo net inboard		06/06/2018	156	08:50:00	-18.019685	11.008327	
188	BN1	Bongo net outboard	Bongo013	06/06/2018	156	08:55:00	-18.019682	11.008327	
188	BN1	bongo net inboard		06/06/2018	156	09:09:00	-18.019687	11.008306	
189	BN1	v/l spd 2kts stw for mocness deployment		06/06/2018	156	09:48:00	-18.020044	11.008404	
189	BN1	MOCNESS outboard	MOCNESS008	06/06/2018	156	09:50:00	-18.021362	11.009017	Open trawls from surface to 125m from now on
189	BN1	MOCNESS IB		06/06/2018	156	10:30:00	-18.043161	11.021683	

	BN1	reposition to main station		06/06/2018	156	10:36:00	-18.046301	11.023651	
	BN1	V/L on DP @ main station		06/06/2018	156	11:01:00	-18.019709	11.00802	
190	BN1	Commence Mango deployment	Mango002	06/06/2018	156	12:11:00	-18.01963	11.008156	
190	BN1	Mango deployed		06/06/2018	156	12:26:00	-18.019631	11.008162	
190	BN1	mango i/b		06/06/2018	156	15:02:00	-18.019631	11.008175	
191	BN1	msc outboard	MSC067	06/06/2018	156	15:17:00	-18.019618	11.008207	Geochem
191	BN1	msc inboard		06/06/2018	156	15:21:00	-18.019616	11.008228	
192	BN1	msc outboard	MSC068	06/06/2018	156	15:34:00	-18.01962	11.00823	Geochem
192	BN1	msc inboard		06/06/2018	156	15:38:00	-18.019612	11.008229	
193	BN1	msc outboard	MSC069	06/06/2018	156	15:44:00	-18.019613	11.008233	Geochem
193	BN1	msc inboard		06/06/2018	156	15:50:00	-18.01961	11.008232	
194	BN1	msc outboard	MSC070	06/06/2018	156	15:56:00	-18.019618	11.008231	Geochem
194	BN1	msc inboard		06/06/2018	156	16:10:00	-18.019619	11.008231	
195	BN1	msc outboard	MSC071	06/06/2018	156	16:19:00	-18.017582	11.008178	Geochem
195	BN1	msc inboard		06/06/2018	156	16:42:00	-18.01759	11.008191	
196	BN1	mango o/b	Mango003	06/06/2018	156	17:02:00	-18.01961	11.008236	
196	BN1	mango inboard		06/06/2018	156	19:15:00	-18.019608	11.008233	
197	BN1	mammoth net outboard	Mammoth005	06/06/2018	156	20:11:00	-18.019604	11.008236	
197	BN1	mammoth @850m hauling		06/06/2018	156	21:05:00	-18.021677	11.008591	
197	BN1	mammoth net inboard		06/06/2018	156	22:23:00	-18.025618	11.009282	
198	BN1	Red Camera O/B	RCF013	06/06/2018	156	23:16:00	-18.01962	11.008218	
198	BN1	Red Camera I/B		07/06/2018	157	00:05:00	-18.019622	11.008218	
199	BN1	STAINLESS CTD OB	CTD018 SS	07/06/2018	157	00:59:00	-18.019619	11.008253	
199	BN1	@1000m		07/06/2018	157	01:26:00	-18.02071	11.008387	
199	BN1	STAINLESS CTD IB		07/06/2018	157	02:16:00	-18.023481	11.008683	
200	BN1	msc outboard	MSC072	07/06/2018	157	02:50:00	-18.023506	11.008708	Rates

200	BN1	msc inboard		07/06/2018	157	02:54:00	-18.023504	11.008707	
201	BN1	msc outboard	MSC073	07/06/2018	157	03:03:00	-18.023505	11.008705	Rates
201	BN1	msc inboard		07/06/2018	157	03:07:00	-18.023508	11.008705	
202	BN1	msc outboard	MSC074	07/06/2018	157	03:15:00	-18.023506	11.008705	Rates
202	BN1	msc inboard		07/06/2018	157	03:18:00	-18.023506	11.008706	
203	BN1	Commence acoustic survey line 1.	Survey004	07/06/2018	157	04:50:00	-17.853447	10.885143	
203	BN1	alter course 180T to start leg 2		07/06/2018	157	06:32:00	-17.858171	11.174638	
203	BN1	alter course 270T start leg 3		07/06/2018	157	07:35:00	-18.020238	11.167069	
203	BN1	alter course 180T start leg 4		07/06/2018	157	09:28:00	-18.025333	10.841997	
203	BN1	End of Line. AC to 090. Start Leg 5		07/06/2018	157	10:27:00	-18.178171	10.841571	
203	BN1	End of Line. AC to 180.Start Leg 6		07/06/2018	157	12:21:00	-18.186689	11.160283	
203	BN1	End of Line. AC to 270.Start Leg 7		07/06/2018	157	13:20:00	-18.344216	11.174698	
203	BN1	Complete acoustic survey.		07/06/2018	157	15:11:00	-18.353664	10.84359	
204	BN1	At RMT position.	RMT012	07/06/2018	157	17:36:00	-18.019788	11.008617	
204	BN1	Ship speed 2.0 kts		07/06/2018	157	17:52:00	-18.021113	11.008539	
204	BN1	rmt25 net @1183m hauling		07/06/2018	157	19:14:00	-18.067602	10.98677	
204	BN1	rmt25 net inboard		07/06/2018	157	21:11:00	-18.127837	10.978973	
205	BN2	Commence Survey Line 1 Course 000	Survey005	07/06/2018	157	22:07:00	-18.105639	11.110546	
	BN2			07/06/2018	157	23:05:00	-17.943829	11.113457	
205	BN2	End of Line. AC to 270		07/06/2018	157	23:05:00	-17.943829	11.113457	
205	BN2	End of Line. AC to 180.		07/06/2018	157	23:23:00	-17.937119	11.069201	
205	BN2	End of Line. AC to 270		08/06/2018	158	00:23:00	-18.097419	11.06098	
205	BN2	End of Line. AC to 000		08/06/2018	158	00:40:00	-18.102983	11.014865	

205	BN2	End of Line. AC to 270		08/06/2018	158	01:36:00	-17.944603	11.008587	
205	BN2	End of Line. AC to 180.		08/06/2018	158	01:53:00	-17.936974	10.963579	
205	BN2	End of Line. AC to 270		08/06/2018	158	02:53:00	-18.097427	10.955954	
205	BN2	End of Line. AC to 000		08/06/2018	158	03:10:00	-18.103199	10.909513	
205	BN2	Break off survey proceed to main station		08/06/2018	158	03:55:00	-17.973833	10.903266	
206	BN2	msc outboard	MSC075	08/06/2018	158	05:03:00	-18.019723	11.008114	Rates
206	BN2	msc inboard		08/06/2018	158	05:18:00	-18.019714	11.008122	
207	BN2	msc outboard	MSC076	08/06/2018	158	05:26:00	-18.019718	11.008119	Rates
207	BN2	msc inboard		08/06/2018	158	05:39:00	-18.019714	11.008118	
208	BN2	msc outboard	MSC077	08/06/2018	158	05:43:00	-18.019718	11.008124	Rates
208	BN2	msc inboard		08/06/2018	158	05:56:00	-18.01972	11.008119	
209	BN2	jellyfish net outboard	JellyNet004	08/06/2018	158	06:22:00	-18.019791	11.008093	
209	BN2	jellyfish net inboard		08/06/2018	158	06:42:00	-18.020891	11.008275	
210	BN2	jellyfish net outboard	JellyNet005	08/06/2018	158	06:48:00	-18.021221	11.008339	
210	BN2	jellyfish net inboard		08/06/2018	158	07:09:00	-18.022375	11.008543	
211	BN2	jellyfish net outboard	JellyNet006	08/06/2018	158	07:15:00	-18.022704	11.008602	
211	BN2	jellyfish net inboard		08/06/2018	158	07:35:00	-18.023802	11.008795	
212	BN2	jellyfish net outboard	JellyNet007	08/06/2018	158	07:42:00	-18.024193	11.008864	
212	BN2	jellyfish net inboard		08/06/2018	158	08:08:00	-18.025623	11.009124	
213	BN2	jellyfish net outboard	JellyNet008	08/06/2018	158	08:16:00	-18.026062	11.009204	
213	BN2	jellyfish net inboard		08/06/2018	158	08:43:00	-18.027541	11.009466	
214	BN2	Bongo net outboard	Bongo014	08/06/2018	158	09:00:00	-18.027664	11.009489	
214	BN2	bongo net inboard		08/06/2018	158	09:13:00	-18.027663	11.009487	
215	BN2	Bongo net outboard	Bongo015	08/06/2018	158	09:19:00	-18.027661	11.009489	
215	BN2	bongo net inboard		08/06/2018	158	09:33:00	-18.027658	11.009487	
216	BN2	msc outboard	MSC078	08/06/2018	158	09:44:00	-18.027662	11.009485	Rachel/Chelsey
216	BN2	msc inboard		08/06/2018	158	09:58:00	-18.027659	11.009486	

217	BN2	msc outboard	MSC079	08/06/2018	158	10:06:00	-18.027664	11.009485	Rachel/Chelsey
217	BN2	msc inboard		08/06/2018	158	10:16:00	-18.027666	11.009482	
218	BN2	msc outboard	MSC080F	08/06/2018	158	10:25:00	-18.027662	11.009483	Failed, not recorded as separate event on bridge log
218	BN2	msc inboard		08/06/2018	158	10:42:00	-18.027659	11.009485	
218	BN2	msc redeployed	MSC080	08/06/2018	158	10:43:00	-18.027668	11.009482	Rachel/Chelsey
218	BN2	msc inboard		08/06/2018	158	10:55:00	-18.027663	11.009479	
219	BN2	msc outboard	MSC081	08/06/2018	158	11:00:00	-18.027664	11.009482	Rachel/Chelsey
219	BN2	msc inboard		08/06/2018	158	11:14:00	-18.027669	11.009442	
220	BN2	msc outboard	MSC082	08/06/2018	158	11:19:00	-18.027689	11.009408	Rachel/Chelsey
220	BN2	msc inboard		08/06/2018	158	11:32:00	-18.027687	11.009412	
221	BN2	STAINLESS CTD OB	CTD019 SS	08/06/2018	158	12:04:00	-18.027691	11.009416	100m dip for Sophie's cal
221	BN2	STAINLESS CTD IB		08/06/2018	158	12:12:00	-18.027687	11.009414	
222	BN2	Acoustic Calibration Commence deployment	Sophie's Balls	08/06/2018	158	12:30:00	-18.027775	11.009558	
223	BN2	jelly fish net o/b ford	JellyNet009	08/06/2018	158	14:12:00	-18.029926	11.009585	
223	BN2	jelly fish net i/b ford		08/06/2018	158	15:12:00	-18.032395	11.010927	
224	BN2	jellyfish net outboard	JellyNet010	08/06/2018	158	15:24:00	-18.033093	11.011314	
224	BN2	jellyfish net inboard		08/06/2018	158	15:40:00	-18.032739	11.011673	
222	BN2	acoustic calibration complete		08/06/2018	158	20:35:00	-18.033706	11.009735	
222	BN2	all gear recovered		08/06/2018	158	21:00:00	-18.033337	11.010086	
225	BN2	MOCNESS outboard	MOCNESS009	08/06/2018	158	21:29:00	-18.035332	11.011445	
225	BN2	MOCNESS IB		08/06/2018	158	22:15:00	-18.059501	11.026646	
226	BN2	Vessel on Station for Red Camera Frame		08/06/2018	158	23:00:00	-18.019888	11.008295	
226	BN2	Red Camera O/B	RCF014	08/06/2018	158	23:12:00	-18.019781	11.008219	
226	BN2	Red Camera I/B		09/06/2018	159	00:43:00	-18.019784	11.008218	
227	BN2	Red Camera O/B	RCF015	09/06/2018	159	00:59:00	-18.019774	11.00822	
227	BN2	Red Camera I/B		09/06/2018	159	01:57:00	-18.019785	11.008218	

228	BN2	STAINLESS CTD OB	CTD020 SS	09/06/2018	159	02:20:00	-18.019776	11.008217	
228	BN2	STAINLESS CTD IB		09/06/2018	159	03:24:00	-18.019776	11.008224	
229	BN2	tm ctd ob	CTD021 TM	09/06/2018	159	05:14:00	-18.01978	11.008222	
229	BN2	tm ctd inboard		09/06/2018	159	06:27:00	-18.019768	11.008258	
230	BN2	saps outboard	SAPS004	09/06/2018	159	07:13:00	-18.019759	11.008269	Liverpool SAPS and Wendy did not pump
230	BN2	saps @500m		09/06/2018	159	07:40:00	-18.019759	11.008273	
230	BN2	hauling saps		09/06/2018	159	09:05:00	-18.019759	11.008272	
230	BN2	saps inboard		09/06/2018	159	09:30:00	-18.019755	11.008274	
231	BN2	Bongo net OB	Bongo016	09/06/2018	159	10:14:00	-18.019762	11.00827	
231	BN2	Bongo net IB		09/06/2018	159	10:26:00	-18.019761	11.008274	
232	BN2	Bongo net OB	Bongo017	09/06/2018	159	10:32:00	-18.019762	11.008271	
232	BN2	Bongo net IB		09/06/2018	159	10:48:00	-18.019763	11.008268	
233	BN2	Ship Speed 2.0 kts through water		09/06/2018	159	11:07:00	-18.019757	11.008273	
233	BN2	MOCNESS OB	MOCNESS010	09/06/2018	159	11:12:00	-18.021884	11.008983	
233	BN2	MOCNESS IB		09/06/2018	159	11:50:00	-18.043114	11.016791	
233	BN2	Reposition to main station		09/06/2018	159	11:50:00	-18.043114	11.016791	
234	BN2	Commence deploy RESPIRE	RESPIRE003	09/06/2018	159	14:33:00	-18.020012	11.008321	
234	BN2	RESPIRE deployed.		09/06/2018	159	14:57:00	-18.026207	11.009043	
235	BN2	Pelagra In the water	Pelagra020	09/06/2018	159	16:16:00	-18.030155	11.008232	
236	BN2	Pelagra In the water	Pelagra021	09/06/2018	159	16:32:00	-18.033142	11.010765	
237	BN2	Pelagra In the water	Pelagra022	09/06/2018	159	16:51:00	-18.036686	11.015247	
238	BN2	Pelagra In the water	Pelagra023	09/06/2018	159	16:57:00	-18.037559	11.016601	
239	BN2	Pelagra In the water	Pelagra024	09/06/2018	159	17:09:00	-18.039239	11.019089	
240	BN2	Commence deploy RMT	RMT013	09/06/2018	159	17:43:00	-18.055943	11.029729	
240	BN2	333m hauling		09/06/2018	159	18:29:00	-18.077967	11.043717	

240	BN2	rmt25 net fully recovered to deck		09/06/2018	159	19:25:00	-18.10411	11.062058	
241	BN2	RMT Net Outboard		09/06/2018	159	19:47:00	-18.113639	11.069019	
241	BN2	rmt net fully deployed after technical adjustment	RMT014	09/06/2018	159	20:00:00	-18.120973	11.073822	
241	BN2	rmt @1210m hauling		09/06/2018	159	21:10:00	-18.159066	11.09881	
241	BN2	RMT net recovered to deck		09/06/2018	159	23:15:00	-18.224602	11.142818	
241	BN2	Returning to Main Station		09/06/2018	159	23:30:00	-18.222689	11.142218	
242	BN2	Vessel on Station		10/06/2018	160	01:22:00	-18.019715	11.007767	
242	BN2	ISANET outboard	IsaNet006	10/06/2018	160	01:44:00	-18.019757	11.008204	
242	BN2	ISANET inboard		10/06/2018	160	01:50:00	-18.019756	11.008202	
243	BN2	ISANET outboard	IsaNet007	10/06/2018	160	01:51:00	-18.01976	11.008202	
243	BN2	ISANET inboard		10/06/2018	160	01:53:00	-18.019761	11.0082	
244	BN2	ISANET outboard	IsaNet008	10/06/2018	160	01:55:00	-18.019763	11.0082	
244	BN2	ISANET inboard		10/06/2018	160	01:59:00	-18.019753	11.008209	
245	BN2	Pelagra IB	PelagraRecover	10/06/2018	160	04:04:00	-18.005068	10.940377	P4 malfunction
246	BN2	Red Camera O/B	RCF016	10/06/2018	160	04:58:00	-18.019771	11.00816	
246	BN2	Red Camera inboard		10/06/2018	160	06:25:00	-18.019761	11.008162	
247	BN2	msc outboard	MSC083	10/06/2018	160	06:35:00	-18.019771	11.008162	Rates
247	BN2	msc inboard		10/06/2018	160	06:58:00	-18.019763	11.008196	
248	BN2	msc outboard	MSC084	10/06/2018	160	07:04:00	-18.019762	11.008201	Rates
248	BN2	msc inboard		10/06/2018	160	07:32:00	-18.019748	11.008204	
249	BN2	msc outboard	MSC085	10/06/2018	160	07:39:00	-18.019758	11.008195	Rates
249	BN2	msc inboard		10/06/2018	160	08:01:00	-18.019761	11.008198	
250	BN2	ctd outboard	CTD022 SS	10/06/2018	160	08:19:00	-18.019758	11.008202	Gabi
250	BN2	ctd @1000m hauling		10/06/2018	160	08:43:00	-18.019755	11.008199	
250	BN2	ctd inboard		10/06/2018	160	09:17:00	-18.019758	11.008202	

251	BN2	Pelagra Outboard	Pelagra025	10/06/2018	160	09:56:00	-18.020274	11.009018	P4 redeployed
252	BN2	mammoth net outboard	Mammoth006	10/06/2018	160	11:07:00	-18.019772	11.008264	
252	BN2	mammoth @850m		10/06/2018	160	12:12:00	-18.019763	11.008278	
252	BN2	mammoth net inboard		10/06/2018	160	13:27:00	-18.01977	11.008254	
253	BN2	Commence Mango deployment	Mango004	10/06/2018	160	14:10:00	-18.019774	11.008262	
253	BN2	mango inboard		10/06/2018	160	16:19:00	-18.019783	11.008258	
254	BN2	msc outboard	MSC086	10/06/2018	160	16:35:00	-18.019774	11.008257	Fluxes
254	BN2	msc inboard		10/06/2018	160	16:40:00	-18.019776	11.008252	
255	BN2	msc inboard	MSC087	10/06/2018	160	16:57:00	-18.019772	11.008258	Fluxes
256	BN2	msc outboard	MSC088	10/06/2018	160	17:04:00	-18.019781	11.008257	Fluxes
256	BN2	msc inboard		10/06/2018	160	17:27:00	-18.019774	11.008252	
257	BN2	msc outboard	MSC089	10/06/2018	160	17:35:00	-18.019778	11.008257	Fluxes
	BN2			10/06/2018	160	18:07:00	-18.019781	11.008221	
257	BN2	msc inboard		10/06/2018	160	18:07:00	-18.019781	11.008221	
258	BN2	mango outboard	Mango005	10/06/2018	160	18:25:00	-18.019786	11.008227	Battery failure
258	BN2	mango@ 850m hauling		10/06/2018	160	19:17:00	-18.01977	11.008258	
258	BN2	mango inboard		10/06/2018	160	20:31:00	-18.019775	11.00826	
259	BN2	mango outboard	Mango006	10/06/2018	160	20:55:00	-18.019779	11.008255	Successful
259	BN2	mango@ 850m hauling		10/06/2018	160	21:47:00	-18.01977	11.008261	
259	BN2	mango inboard		10/06/2018	160	23:00:00	-18.019772	11.008256	
260	BN2	STAINLESS CTD OB	CTD023 SS	11/06/2018	161	00:12:00	-18.019774	11.008256	Th/Po
260	BN2	CTD 1000m		11/06/2018	161	00:39:00	-18.019781	11.008255	
260	BN2	STAINLESS CTD IB		11/06/2018	161	01:10:00	-18.019766	11.00825	
261	BN2	STAINLESS CTD OB	CTD024 SS	11/06/2018	161	01:44:00	-18.019776	11.008254	
261	BN2	CTD 1000m		11/06/2018	161	02:08:00	-18.019773	11.008262	
261	BN2	STAINLESS CTD IB		11/06/2018	161	02:47:00	-18.019776	11.008256	

262	BN2	msc outboard	MSC090	11/06/2018	161	03:08:00	-18.019782	11.008257	Rates
262	BN2	msc inboard		11/06/2018	161	03:16:00	-18.019779	11.008254	
263	BN2	msc outboard	MSC091	11/06/2018	161	03:20:00	-18.019777	11.008255	Rates
263	BN2	msc inboard		11/06/2018	161	03:24:00	-18.019777	11.008258	
264	BN2	msc outboard	MSC092	11/06/2018	161	03:33:00	-18.01978	11.008259	Rates
264	BN2	msc inboard		11/06/2018	161	03:38:00	-18.019773	11.008255	
265	BN2	Red Camera O/B	RCF017	11/06/2018	161	04:25:00	-18.019762	11.00825	
265	BN2	Red Camera I/B		11/06/2018	161	05:49:00	-18.019777	11.008261	
266	BN2	jelly net outboard	JellyNet011	11/06/2018	161	06:11:00	-18.019781	11.008253	
266	BN2	jelly net inboard		11/06/2018	161	06:37:00	-18.019777	11.008254	
267	BN2	jelly net outboard	JellyNet012	11/06/2018	161	06:44:00	-18.019776	11.008256	
267	BN2	jelly net inboard		11/06/2018	161	07:09:00	-18.019779	11.008257	
268	BN2	jelly net outboard	JellyNet013	11/06/2018	161	07:14:00	-18.019768	11.008262	
268	BN2	jelly net inboard		11/06/2018	161	07:35:00	-18.019772	11.008258	
269	BN2	jelly net outboard	JellyNet014	11/06/2018	161	07:40:00	-18.019779	11.00826	
269	BN2	jelly net inboard		11/06/2018	161	08:00:00	-18.01978	11.008257	
270	BN2	ISANET outboard	IsaNet009	11/06/2018	161	08:02:00	-18.019781	11.008261	
270	BN2	ISANET inboard		11/06/2018	161	08:06:00	-18.019776	11.00826	
271	BN2	ISANET outboard	IsaNet010	11/06/2018	161	08:08:00	-18.019774	11.008258	
271	BN2	ISANET inboard		11/06/2018	161	08:11:00	-18.019775	11.008259	
272	BN2	ISANET outboard	IsaNet011	11/06/2018	161	08:13:00	-18.01976	11.008256	
272	BN2	ISANET inboard		11/06/2018	161	08:19:00	-18.019776	11.008262	
273	BN2	msc outboard	MSC093	11/06/2018	161	08:48:00	-18.019773	11.008257	Fluxes
273	BN2	msc inboard		11/06/2018	161	08:52:00	-18.019778	11.008255	
274	BN2	msc outboard	MSC094	11/06/2018	161	09:00:00	-18.019773	11.008259	Fluxes
274	BN2	msc inboard		11/06/2018	161	09:05:00	-18.019767	11.008254	
275	BN2	msc outboard	MSC095	11/06/2018	161	09:11:00	-18.019772	11.00826	Fluxes

275	BN2	msc inboard		11/06/2018	161	09:15:00	-18.019776	11.008262	
276	BN2	msc outboard	MSC096	11/06/2018	161	09:25:00	-18.019778	11.008258	Fluxes
276	BN2	msc inboard		11/06/2018	161	09:31:00	-18.019781	11.008257	
277	BN2	Ship Speed 2.0 kts through water		11/06/2018	161	10:06:00	-18.019769	11.008265	
277	BN2	RMT Net Outboard	RMT015	11/06/2018	161	10:12:00	-18.022558	11.009492	
277	BN2	RMT Net Inboard		11/06/2018	161	11:29:00	-18.057751	11.027245	
278	BN2	Ship Speed 2.0 kts through water		11/06/2018	161	11:52:00	-18.052795	11.026428	
278	BN2	RMT net recovered to deck		11/06/2018	161	15:11:00	-18.158868	11.053935	
	BN2	V/L off DP reposition to main station		11/06/2018	161	15:35:00	-18.16019	11.054683	
279	BN2	msc outboard	MSC097	11/06/2018	161	16:59:00	-18.019855	11.008356	Fluxes
279	BN2	msc inboard		11/06/2018	161	17:02:00	-18.019854	11.008355	
280	BN2	msc outboard	MSC098	11/06/2018	161	17:07:00	-18.019852	11.008352	Fluxes
280	BN2	msc inboard		11/06/2018	161	17:13:00	-18.019856	11.008312	
281	BN2	msc outboard	MSC099	11/06/2018	161	17:19:00	-18.019851	11.008311	Fluxes
281	BN2	msc inboard		11/06/2018	161	17:30:00	-18.019849	11.008317	
282	BN2	msc outboard	MSC100	11/06/2018	161	17:37:00	-18.019851	11.008312	Fluxes
282	BN2	msc inboard		11/06/2018	161	18:00:00	-18.019857	11.008277	
283	BN2	msc outboard	MSC101	11/06/2018	161	18:08:00	-18.019863	11.008271	Fluxes
283	BN2	msc inboard		11/06/2018	161	18:40:00	-18.019866	11.008276	
284	BN2	msc outboard	MSC102	11/06/2018	161	18:50:00	-18.01986	11.008276	Fluxes
284	BN2	msc inboard		11/06/2018	161	18:57:00	-18.019864	11.008273	
285	BN2	Bongo net outboard	Bongo018	11/06/2018	161	19:05:00	-18.019868	11.008277	
285	BN2	bongo net inboard		11/06/2018	161	19:20:00	-18.019868	11.008272	
286	BN2	Bongo net outboard	Bongo019	11/06/2018	161	19:24:00	-18.019857	11.008266	
286	BN2	bongo net inboard		11/06/2018	161	19:38:00	-18.019859	11.008276	

287	BN2	mammoth net outboard	Mammoth007	11/06/2018	161	20:01:00	-18.019863	11.008266	
287	BN2	mammoth @850m hauling		11/06/2018	161	20:53:00	-18.019863	11.00827	
287	BN2	mammoth net inboard		11/06/2018	161	22:07:00	-18.019863	11.008268	
288	BN2	Red Camera O/B	RCF018	11/06/2018	161	22:51:00	-18.019862	11.008266	
288	BN2	Red Camera I/B		11/06/2018	161	23:39:00	-18.019858	11.008269	
289	BN2	Red Camera O/B	RCF019	11/06/2018	161	23:58:00	-18.019863	11.00827	
289	BN2	Red Camera I/B		12/06/2018	162	01:24:00	-18.019866	11.008274	
290	BN2	tm ctd ob	CTD025 TM	12/06/2018	162	02:17:00	-18.019862	11.008266	
290	BN2	tm ctd i/b		12/06/2018	162	03:19:00	-18.019868	11.008275	
291	BN2	saps outboard	SAPS005	12/06/2018	162	06:05:00	-18.019869	11.008277	Liverpool SAPS not deployed
291	BN2	saps @500m hauling		12/06/2018	162	08:01:00	-18.019865	11.008274	
291	BN2	saps inboard		12/06/2018	162	08:26:00	-18.019862	11.008271	
292	BN2	Red Camera outboard	RCF020	12/06/2018	162	08:47:00	-18.019866	11.008268	
292	BN2	Red Camera I/B		12/06/2018	162	10:16:00	-18.019869	11.008275	
293	BN2	Bongo net OB	Bongo020	12/06/2018	162	10:29:00	-18.019862	11.008273	
293	BN2	Bongo net IB		12/06/2018	162	10:43:00	-18.019874	11.008274	
294	BN2	Bongo net OB	Bongo021	12/06/2018	162	10:49:00	-18.019867	11.00827	
294	BN2	Bongo net IB		12/06/2018	162	11:04:00	-18.019865	11.008273	
295	BN2	msc outboard	MSC103	12/06/2018	162	11:32:00	-18.019866	11.008272	Fluxes
295	BN2	msc inboard		12/06/2018	162	12:04:00	-18.019866	11.008268	
296	BN2	msc outboard	MSC104	12/06/2018	162	12:12:00	-18.019865	11.00827	Fluxes
296	BN2	msc inboard		12/06/2018	162	12:34:00	-18.019866	11.008272	
297	BN2	msc outboard	MSC105	12/06/2018	162	12:39:00	-18.019867	11.008274	Fluxes
297	BN2	msc inboard		12/06/2018	162	12:51:00	-18.019863	11.00827	
298	BN2	msc outboard	MSC106	12/06/2018	162	13:00:00	-18.019862	11.008272	Fluxes
298	BN2	msc inboard		12/06/2018	162	13:06:00	-18.019862	11.008272	

299	BN2	RESPIRE fully recovered	RESPIRErecover	12/06/2018	162	15:18:00	-17.95729	10.936254	
	BN2	v/l off DP Pelagra hunting		12/06/2018	162	15:39:00	-17.955651	10.938818	
300	BN2	Pelagra IB	PelagraRecover	12/06/2018	162	17:18:00	-18.114565	11.008667	
301	BN2	Pelagra IB	PelagraRecover	12/06/2018	162	18:15:00	-18.099619	11.020205	
302	BN2	Pelagra IB	PelagraRecover	12/06/2018	162	19:30:00	-18.222516	11.000676	
303	BN2	Pelagra IB	PelagraRecover	12/06/2018	162	20:13:00	-18.286582	11.020043	
304	BN2	Pelagra IB	PelagraRecover	12/06/2018	162	21:09:00	-18.378827	11.054123	
305	BN2	msc outboard	MSC107	12/06/2018	162	23:40:00	-18.019666	11.008286	Rates
305	BN2	msc inboard		12/06/2018	162	23:47:00	-18.01967	11.00829	
306	BN2	msc outboard	MSC108	12/06/2018	162	23:54:00	-18.019721	11.008382	Rates
306	BN2	msc inboard		13/06/2018	163	00:00:00	-18.019725	11.008379	
307	BN2	msc outboard	MSC109	13/06/2018	163	00:08:00	-18.019725	11.008383	Rates
307	BN2	msc inboard		13/06/2018	163	00:13:00	-18.01972	11.008379	
308	BN2	msc outboard	MSC110	13/06/2018	163	00:18:00	-18.019726	11.008383	Rates
308	BN2	msc inboard		13/06/2018	163	00:24:00	-18.01972	11.008385	
309	BN2	msc outboard	MSC111	13/06/2018	163	00:29:00	-18.019724	11.008382	Rates
309	BN2	msc inboard		13/06/2018	163	00:34:00	-18.019725	11.008382	
310	BN2	STAINLESS CTD OB	CTD026 SS	13/06/2018	163	01:05:00	-18.01972	11.008385	
310	BN2	STAINLESS CTD IB		13/06/2018	163	02:14:00	-18.019715	11.008374	
311	BN2	Red Camera O/B	RCF021	13/06/2018	163	03:33:00	-18.019719	11.008366	
311	BN2	Red Camera I/B		13/06/2018	163	05:08:00	-18.019718	11.008366	
312	BN2	msc outboard	MSC112	13/06/2018	163	06:01:00	-18.01972	11.00837	Rachel/Chelsey
312	BN2	msc inboard		13/06/2018	163	06:14:00	-18.019716	11.00837	
313	BN2	msc outboard	MSC113	13/06/2018	163	06:21:00	-18.019714	11.008368	Rachel/Chelsey
313	BN2	msc inboard		13/06/2018	163	06:35:00	-18.019713	11.008374	
314	BN2	msc outboard	MSC114	13/06/2018	163	06:43:00	-18.019717	11.00837	Rachel/Chelsey
314	BN2	msc inboard		13/06/2018	163	06:56:00	-18.01972	11.008372	

315	BN2	msc outboard	MSC115	13/06/2018	163	07:00:00	-18.019715	11.008373	Rachel/Chelsey
315	BN2	msc inboard		13/06/2018	163	07:11:00	-18.019712	11.00837	
316	BN2	msc outboard	MSC116	13/06/2018	163	07:18:00	-18.019712	11.008371	Rachel/Chelsey
316	BN2	msc inboard		13/06/2018	163	07:31:00	-18.019713	11.008368	
317	BN2	Red Camera outboard	RCF022	13/06/2018	163	08:16:00	-18.019717	11.008372	
317	BN2	Red Camera inboard		13/06/2018	163	09:10:00	-18.019714	11.00837	
318	BN2	Red Camera outboard	RCF023	13/06/2018	163	09:25:00	-18.019711	11.008331	
318	BN2	Red Camera I/B		13/06/2018	163	10:43:00	-18.019708	11.00833	
	BN2	Vessel proceeding to start of acoustic survey		13/06/2018	163	10:47:00	-18.019917	11.00827	
319	BN2	Start of Acoustic Survey. Co 090	Survey006	13/06/2018	163	12:20:00	-17.853467	10.841608	
319	BN2	start survey line 2		13/06/2018	163	14:16:00	-17.856825	11.173841	
319	BN2	start survey line 3		13/06/2018	163	15:21:00	-18.019357	11.17163	
319	BN2	start survey line 4		13/06/2018	163	17:18:00	-18.024813	10.84187	
319	BN2	start line 5		13/06/2018	163	18:21:00	-18.186329	10.846994	
319	BN2	start line 6		13/06/2018	163	20:28:00	-18.186426	11.179177	
319	BN2	Start Line 7 Co = 000		13/06/2018	163	22:25:00	-18.185244	10.843996	
319	BN2	Start Line 8 . Co = 090		13/06/2018	163	23:27:00	-18.019496	10.835163	
319	BN2	Start Line 9 . Co = 000		14/06/2018	164	01:30:00	-18.020105	11.178507	
319	BN2	start survey line 10		14/06/2018	164	02:31:00	-17.853475	11.176246	
319	BN2	End of Survey.		14/06/2018	164	04:28:00	-17.853242	10.843786	
320	BN3	ctd mf outboard	CTD027 TM	14/06/2018	164	06:55:00	-18.019811	11.008303	
320	BN3	ctd mf @ 1000m hauling		14/06/2018	164	07:29:00	-18.019808	11.0083	
321	BN3	jelly net outboard	JellyNet015	14/06/2018	164	08:41:00	-18.019816	11.008309	
321	BN3	jelly net inboard		14/06/2018	164	09:01:00	-18.01982	11.008303	
322	BN3	jelly net outboard	JellyNet016	14/06/2018	164	09:03:00	-18.019815	11.008301	
322	BN3	jelly net inboard		14/06/2018	164	09:35:00	-18.019814	11.008306	

323	BN3	jelly net outboard	JellyNet017	14/06/2018	164	09:40:00	-18.019814	11.008304	
323	BN3	jelly net inboard		14/06/2018	164	10:08:00	-18.019821	11.008286	
324	BN3	Bongo net OB	Bongo022	14/06/2018	164	10:28:00	-18.019821	11.008304	
324	BN3	Bongo net IB		14/06/2018	164	10:43:00	-18.019811	11.008301	
325	BN3	Bongo net OB	Bongo023	14/06/2018	164	10:50:00	-18.019813	11.008299	
325	BN3	Bongo net IB		14/06/2018	164	11:06:00	-18.019812	11.008294	
326	BN3	mammoth net outboard	Mammoth008	14/06/2018	164	11:37:00	-18.01981	11.008291	
326	BN3	@850m		14/06/2018	164	12:25:00	-18.019817	11.008294	
326	BN3	mammoth net inboard		14/06/2018	164	13:41:00	-18.019831	11.008254	
327	BN3	ISANET outboard	IsaNet012	14/06/2018	164	13:52:00	-18.019835	11.008238	
327	BN3	ISANET inboard		14/06/2018	164	13:55:00	-18.019832	11.008247	
328	BN3	ISANET outboard	IsaNet013	14/06/2018	164	13:58:00	-18.019833	11.008247	
328	BN3	ISANET inboard		14/06/2018	164	14:03:00	-18.019412	11.00801	
329	BN3	ISANET outboard	IsaNet014	14/06/2018	164	14:04:00	-18.019313	11.007954	
329	BN3	ISANET inboard		14/06/2018	164	14:09:00	-18.018879	11.007728	
330	BN3	msc outboard	MSC117	14/06/2018	164	14:29:00	-18.019801	11.008284	Fluxes
330	BN3	msc inboard		14/06/2018	164	14:33:00	-18.019802	11.00829	
331	BN3	msc outboard	MSC118	14/06/2018	164	14:40:00	-18.019805	11.008298	Fluxes
331	BN3	msc inboard		14/06/2018	164	14:47:00	-18.019803	11.008306	
332	BN3	msc outboard	MSC119	14/06/2018	164	14:54:00	-18.019801	11.008294	Fluxes
332	BN3	msc inboard		14/06/2018	164	14:59:00	-18.019798	11.008304	
333	BN3	msc outboard	MSC120	14/06/2018	164	15:10:00	-18.019808	11.008299	Fluxes
333	BN3	msc inboard		14/06/2018	164	15:13:00	-18.019801	11.008302	
334	BN3	msc outboard	MSC121	14/06/2018	164	15:18:00	-18.019801	11.008304	Fluxes
334	BN3	msc inboard		14/06/2018	164	15:30:00	-18.019801	11.008297	
335	BN3	msc outboard	MSC122	14/06/2018	164	15:35:00	-18.019794	11.008302	Fluxes
335	BN3	msc inboard		14/06/2018	164	15:57:00	-18.019802	11.008294	

336	BN3	mammoth net outboard	Mammoth009	14/06/2018	164	16:26:00	-18.019799	11.008318	
336	BN3	mammoth @850m		14/06/2018	164	17:21:00	-18.019799	11.008294	
336	BN3	mammoth net inboard		14/06/2018	164	18:40:00	-18.019798	11.008316	
337	BN3	mango net outboard	Mango007	14/06/2018	164	19:34:00	-18.019798	11.008315	
337	BN3	mango@ 850m hauling		14/06/2018	164	20:25:00	-18.019796	11.008316	
337	BN3	mango inboard		14/06/2018	164	21:36:00	-18.019799	11.008336	
338	BN3	msc outboard	MSC123	14/06/2018	164	22:59:00	-18.0198	11.008338	Rates
338	BN3	msc inboard		14/06/2018	164	23:05:00	-18.019798	11.008341	
339	BN3	msc outboard	MSC124	14/06/2018	164	23:13:00	-18.019793	11.008337	Rates
339	BN3	msc inboard		14/06/2018	164	23:20:00	-18.019788	11.008344	
340	BN3	msc outboard	MSC125	14/06/2018	164	23:27:00	-18.019794	11.008339	Rates
340	BN3	msc inboard		14/06/2018	164	23:33:00	-18.019795	11.008335	
341	BN3	msc outboard	MSC126	14/06/2018	164	23:38:00	-18.019794	11.008337	Rates
341	BN3	msc inboard		14/06/2018	164	23:44:00	-18.0198	11.00834	
342	BN3	STAINLESS CTD OB	CTD028 SS	15/06/2018	165	00:55:00	-18.019798	11.008361	
342	BN3	STAINLESS CTD IB		15/06/2018	165	02:15:00	-18.019797	11.008371	
343	BN3	Red Camera O/B	RCF024	15/06/2018	165	03:15:00	-18.019808	11.008349	
343	BN3	Red Camera I/B		15/06/2018	165	04:08:00	-18.019792	11.008342	
344	BN3	Red Camera O/B	RCF025	15/06/2018	165	04:22:00	-18.019793	11.008335	
344	BN3	Red Camera I/B		15/06/2018	165	05:39:00	-18.019803	11.00834	
345	BN3	saps outboard	SAPS006	15/06/2018	165	06:06:00	-18.019787	11.008311	
345	BN3	saps @500m hauling		15/06/2018	165	08:10:00	-18.019793	11.008316	
345	BN3	saps inboard		15/06/2018	165	08:35:00	-18.019796	11.008325	
346	BN3	Ship Speed 1.0 kt through water		15/06/2018	165	10:26:00	-18.019887	11.008294	
346	BN3	RESPIRE Anchor Away	RESPIRE004	15/06/2018	165	10:27:00	-18.027671	11.010126	
346	BN3	RESPIRE Float Released		15/06/2018	165	10:50:00	-18.026374	11.009791	

347	BN3	mango outboard	Mango008	15/06/2018	165	12:15:00	-18.02411	11.010318	
347	BN3	mango inboard		15/06/2018	165	14:23:00	-18.02384	11.010287	
348	BN3	ISANET outboard	IsaNet015	15/06/2018	165	14:34:00	-18.023834	11.010288	
348	BN3	ISANET inboard		15/06/2018	165	14:38:00	-18.023836	11.0103	
349	BN3	ISANET outboard	IsaNet016	15/06/2018	165	14:39:00	-18.023843	11.010292	
349	BN3	ISANET inboard		15/06/2018	165	14:46:00	-18.023587	11.010242	
350	BN3	ISANET outboard	IsaNet017	15/06/2018	165	14:48:00	-18.023372	11.010231	
350	BN3	ISANET inboard		15/06/2018	165	14:54:00	-18.022917	11.010201	
351	BN3	Pelagra OB P9	Pelagra026	15/06/2018	165	16:10:00	-18.022196	11.010392	
352	BN3	Pelagra OB P7	Pelagra027	15/06/2018	165	16:25:00	-18.023885	11.011496	
353	BN3	Pelagra OB P6	Pelagra028	15/06/2018	165	16:38:00	-18.024927	11.012042	
354	BN3	Pelagra OB P4	Pelagra029	15/06/2018	165	16:51:00	-18.026093	11.012664	
355	BN3	Pelagra OB P2	Pelagra030	15/06/2018	165	17:03:00	-18.027743	11.013454	
356	BN3	msc outboard	MSC127	15/06/2018	165	18:06:00	-18.02797	11.013571	Fluxes
356	BN3	msc inboard		15/06/2018	165	18:39:00	-18.027976	11.01358	
357	BN3	msc outboard	MSC128	15/06/2018	165	18:45:00	-18.027988	11.013585	Fluxes
357	BN3	msc inboard		15/06/2018	165	19:07:00	-18.027998	11.013571	
358	BN3	msc outboard	MSC129	15/06/2018	165	19:17:00	-18.027988	11.013568	Fluxes
358	BN3	msc inboard		15/06/2018	165	19:30:00	-18.027984	11.013582	
359	BN3	msc outboard	MSC130	15/06/2018	165	19:38:00	-18.027983	11.013575	Fluxes
359	BN3	msc inboard		15/06/2018	165	19:44:00	-18.027989	11.013575	
360	BN3	MOCNESS outboard. v/l spd 2kts stw	MOCNESS011	15/06/2018	165	20:14:00	-18.03015	11.013563	
360	BN3	MOCNESS inboard		15/06/2018	165	20:48:00	-18.048888	11.01658	
361	BN3	Pelagra IB	PelagraRecover	15/06/2018	165	21:02:00	-18.049724	11.016646	P4 malfunction
362	BN3	Red Camera O/B	RCF026	15/06/2018	165	22:47:00	-18.019744	11.008292	
362	BN3	Red Camera I/B		15/06/2018	165	23:36:00	-18.019755	11.008288	

363	BN3	Red Camera O/B	RCF027	15/06/2018	165	23:55:00	-18.019751	11.00829	
363	BN3	Red Camera I/B		16/06/2018	166	01:30:00	-18.01974	11.00829	
364	BN3	tm ctd ob	CTD029 TM	16/06/2018	166	03:08:00	-18.019749	11.00832	
364	BN3	tm ctd i/b		16/06/2018	166	04:37:00	-18.019748	11.00832	
365	BN3	msc outboard	MSC131	16/06/2018	166	05:07:00	-18.019744	11.008296	Rates
365	BN3	msc inboard		16/06/2018	166	05:10:00	-18.01974	11.00831	
366	BN3	msc outboard	MSC132	16/06/2018	166	05:18:00	-18.019746	11.0083	Rates
366	BN3	msc inboard		16/06/2018	166	05:20:00	-18.019743	11.008297	
367	BN3	msc outboard	MSC133	16/06/2018	166	05:31:00	-18.019755	11.008282	Rates
367	BN3	msc inboard		16/06/2018	166	05:38:00	-18.019742	11.008287	
368	BN3	pelagra outboard	Pelagra031	16/06/2018	166	06:21:00	-18.019811	11.008294	P4 redeployed
369	BN3	ctd outboard	CTD030 SS	16/06/2018	166	06:42:00	-18.019805	11.008313	Th/Po
369	BN3	ctd @2500m hauling		16/06/2018	166	07:33:00	-18.019802	11.0083	
369	BN3	ctd inboard		16/06/2018	166	08:53:00	-18.019795	11.008301	
370	BN3	pelagra inboard	Pelagra032	16/06/2018	166	09:43:00	-18.020257	11.007397	P4 up again
371	BN3	Bongo net outboard	Bongo024	16/06/2018	166	09:54:00	-18.020012	11.007854	
371	BN3	Bongo net IB		16/06/2018	166	10:09:00	-18.019796	11.008253	
372	BN3	Bongo net OB	Bongo025	16/06/2018	166	10:14:00	-18.019795	11.008252	
372	BN3	Bongo net IB		16/06/2018	166	10:30:00	-18.019788	11.008256	
373	BN3	Ship Speed 2.0 kts through water		16/06/2018	166	10:53:00	-18.021913	11.008829	
373	BN3	MOCNESS OB	MOCNESS012	16/06/2018	166	10:57:00	-18.022007	11.008859	
373	BN3	MOCNESS IB		16/06/2018	166	11:46:00	-18.041226	11.014936	
374	BN3	Ship Speed 2.0 kts through water		16/06/2018	166	12:51:00	-18.04124	11.01494	
374	BN3	RMT Net Outboard	RMT016	16/06/2018	166	12:56:00	-18.042851	11.015447	
374	BN3	RMT net recovered to deck		16/06/2018	166	14:19:00	-18.078778	11.023741	

	BN3	V/L off DP reposition to main station		16/06/2018	166	14:23:00	-18.079977	11.024079	
	BN3	V/L on DP @ main station		16/06/2018	166	15:04:00	-18.019197	11.00815	
375	BN3	msc outboard	MSC134	16/06/2018	166	15:24:00	-18.019534	11.008212	Fluxes
375	BN3	msc inboard		16/06/2018	166	15:27:00	-18.019524	11.008207	
376	BN3	msc outboard	MSC135	16/06/2018	166	15:34:00	-18.019524	11.008207	Fluxes
376	BN3	msc inboard		16/06/2018	166	15:39:00	-18.019533	11.008214	
377	BN3	msc outboard	MSC136	16/06/2018	166	15:45:00	-18.019536	11.008214	Fluxes
377	BN3	msc inboard		16/06/2018	166	15:51:00	-18.019519	11.008213	
378	BN3	msc outboard	MSC137	16/06/2018	166	15:56:00	-18.019524	11.008213	Fluxes
378	BN3	msc inboard		16/06/2018	166	16:08:00	-18.01952	11.008231	
379	BN3	RMT Net Outboard	RMT017	16/06/2018	166	16:44:00	-18.020612	11.008108	
379	BN3	rmt net inboard		16/06/2018	166	18:06:00	-18.05493	11.010736	
380	BN3	RMT Net Outboard	RMT018	16/06/2018	166	18:32:00	-18.045389	11.010641	
380	BN3	@930m hauling		16/06/2018	166	19:45:00	-18.080467	11.019745	
380	BN3	rmt net inboard		16/06/2018	166	21:36:00	-18.136047	11.037605	
	BN3	Vessel repositioning to main station		16/06/2018	166	21:53:00	-18.127779	11.036087	
	BN3	Vessel on Station		16/06/2018	166	22:49:00	-18.019752	11.008288	
381	BN3	Red Camera O/B	RCF028	16/06/2018	166	22:52:00	-18.019748	11.008283	
381	BN3	Red Camera I/B		16/06/2018	166	23:44:00	-18.019749	11.008287	
382	BN3	Red Camera O/B	RCF029	17/06/2018	167	00:00:00	-18.019752	11.008284	
382	BN3	Red Camera I/B		17/06/2018	167	01:07:00	-18.01975	11.008283	
383	BN3	STAINLESS CTD OB	CTD031 SS	17/06/2018	167	01:21:00	-18.019738	11.008285	
383	BN3	STAINLESS CTD IB		17/06/2018	167	02:28:00	-18.01974	11.008282	
384	BN3	msc outboard	MSC138	17/06/2018	167	03:08:00	-18.019754	11.008282	Rates
384	BN3	msc inboard		17/06/2018	167	03:43:00	-18.019748	11.008281	
385	BN3	msc outboard	MSC139	17/06/2018	167	03:51:00	-18.019759	11.008278	Rates

385	BN3	msc inboard		17/06/2018	167	04:24:00	-18.01974	11.008276	
386	BN3	msc outboard	MSC140	17/06/2018	167	04:32:00	-18.019743	11.008286	Rates
386	BN3	msc inboard		17/06/2018	167	05:10:00	-18.019751	11.008281	
387	BN3	saps outboard	SAPS007	17/06/2018	167	06:03:00	-18.019752	11.008278	
387	BN3	saps @500m hauling		17/06/2018	167	08:05:00	-18.019749	11.008277	
387	BN3	saps inboard		17/06/2018	167	08:27:00	-18.019748	11.008281	
388	BN3	tm frame outboard	CTD032 TM	17/06/2018	167	09:01:00	-18.019751	11.008253	Stream of TM wire to removed wobble
388	BN3	@1000m hauling		17/06/2018	167	09:28:00	-18.019746	11.008271	
388	BN3	TM CTD I/B		17/06/2018	167	09:56:00	-18.019751	11.008263	
389	BN3	Commence deploy RMT	RMT019	17/06/2018	167	11:00:00	-18.020482	11.008236	
389	BN3	RMT deployed		17/06/2018	167	11:07:00	-18.024696	11.009189	
389	BN3	@ 892m		17/06/2018	167	12:41:00	-18.066703	11.017753	
389	BN3	RMT net recovered to deck		17/06/2018	167	14:08:00	-18.106562	11.02263	
390	BN3	msc outboard	MSC141	17/06/2018	167	15:33:00	-18.019734	11.008313	Fluxes
390	BN3	msc inboard		17/06/2018	167	15:38:00	-18.019724	11.008311	
391	BN3	msc outboard	MSC142	17/06/2018	167	15:45:00	-18.019735	11.008313	Fluxes
391	BN3	msc inboard		17/06/2018	167	15:57:00	-18.019734	11.008312	
392	BN3	msc outboard	MSC143	17/06/2018	167	16:07:00	-18.019734	11.008305	Fluxes
392	BN3	msc inboard		17/06/2018	167	16:30:00	-18.01973	11.008304	
393	BN3	msc outboard	MSC144	17/06/2018	167	16:36:00	-18.019735	11.008302	Fluxes
393	BN3	msc inboard		17/06/2018	167	17:10:00	-18.019728	11.008309	
394	BN3	respire grappled	RESPIRErecover	17/06/2018	167	19:05:00	-17.933553	10.834398	
394	BN3	commence stern recovery of RESPIRE		17/06/2018	167	19:08:00	-17.934052	10.834335	
394	BN3	RESPIRE fully recovered		17/06/2018	167	19:31:00	-17.936751	10.83552	
395	BN3	pelagra inboard	PelagraRecover	17/06/2018	167	21:39:00	-18.065594	10.942035	
396	BN3	Pelagra IB	PelagraRecover	17/06/2018	167	22:50:00	-18.07378	10.890575	

397	BN3	Pelagra IB	PelagraRecover	17/06/2018	167	23:36:00	-18.069193	10.851625	
398	BN3	Pelagra IB	PelagraRecover	18/06/2018	168	01:00:00	-18.011624	10.790587	
	BN3	Proceed to Main Station		18/06/2018	168	01:10:00	-18.011782	10.789652	
399	BN3	STAINLESS CTD OB	CTD033 SS	18/06/2018	168	03:48:00	-18.019838	11.008287	Gabi
399	BN3	STAINLESS CTD IB		18/06/2018	168	04:44:00	-18.019827	11.008273	
400	BN3	msc outboard	MSC145	18/06/2018	168	06:08:00	-18.019839	11.008275	Rachel/Chelsey
400	BN3	msc inboard		18/06/2018	168	06:18:00	-18.019839	11.008288	
401	BN3	msc outboard	MSC146	18/06/2018	168	06:27:00	-18.019839	11.008283	Rachel/Chelsey
401	BN3	msc inboard		18/06/2018	168	06:36:00	-18.019826	11.008276	
402	BN3	msc outboard	MSC147	18/06/2018	168	06:44:00	-18.019841	11.008284	Rachel/Chelsey
402	BN3	msc inboard		18/06/2018	168	06:54:00	-18.019836	11.00828	
403	BN3	msc outboard	MSC148	18/06/2018	168	07:02:00	-18.019831	11.008295	Rachel/Chelsey
403	BN3	msc inboard		18/06/2018	168	07:11:00	-18.019838	11.008281	
404	BN3	jelly net outboard	JellyNet018	18/06/2018	168	07:55:00	-18.019828	11.00828	
404	BN3	jelly net inboard		18/06/2018	168	08:20:00	-18.021583	11.009339	
405	BN3	jelly net outboard	JellyNet019	18/06/2018	168	08:24:00	-18.021977	11.009566	
405	BN3	jelly net inboard		18/06/2018	168	08:48:00	-18.024384	11.011001	
406	BN3	jelly net outboard	JellyNet020	18/06/2018	168	08:53:00	-18.024796	11.011237	
406	BN3	jelly net inboard. reposition		18/06/2018	168	09:16:00	-18.027006	11.012556	
	BN3	On station 2.0km west of main station		18/06/2018	168	09:48:00	-18.025638	10.988798	
407	BN3	Ship Speed 1.0 kt through water		18/06/2018	168	10:47:00	-18.019284	10.988641	
407	BN3	RESPIRE Anchor Away	RESPIRE005	18/06/2018	168	10:59:00	-18.022888	10.988518	
407	BN3	RESPIRE Buoy Away		18/06/2018	168	11:11:00	-18.02738	10.989065	
	BN3	reposition to main station		18/06/2018	168	11:15:00	-18.029315	10.989572	
408	BN3	Bongo net OB. Ship moving ahead 0.2kts	Bongo026	18/06/2018	168	11:45:00	-18.019677	11.008179	

408	BN3	Bongo net IB		18/06/2018	168	12:00:00	-18.020246	11.008285	
409	BN3	Bongo net OB	Bongo027	18/06/2018	168	12:04:00	-18.020278	11.008303	
409	BN3	Bongo net IB		18/06/2018	168	12:19:00	-18.021162	11.008453	
410	BN3	Red Camera O/B	RCF030	18/06/2018	168	13:38:00	-18.0198	11.008297	
410	BN3	Red Camera I/B		18/06/2018	168	14:32:00	-18.019796	11.008298	
411	BN3	Red Camera O/B	RCF031	18/06/2018	168	14:47:00	-18.019815	11.008299	
411	BN3	Red Camera I/B		18/06/2018	168	15:48:00	-18.019789	11.008288	
412	BN3	Pelagra OB P9	Pelagra033	18/06/2018	168	16:11:00	-18.021017	11.008845	
413	BN3	Pelagra OB P7	Pelagra034	18/06/2018	168	16:28:00	-18.02275	11.010182	
414	BN3	Pelagra OB P6	Pelagra035	18/06/2018	168	16:47:00	-18.025035	11.011619	
415	BN3	Pelagra OB P4	Pelagra036	18/06/2018	168	16:56:00	-18.026735	11.012823	
416	BN3	Pelagra OB P2	Pelagra037	18/06/2018	168	17:03:00	-18.029383	11.01458	
417	BN3	msc outboard	MSC149	18/06/2018	168	18:01:00	-18.0199	11.008415	Fluxes
417	BN3	msc inboard		18/06/2018	168	18:05:00	-18.01992	11.008426	
418	BN3	msc outboard	MSC150	18/06/2018	168	18:11:00	-18.01992	11.008423	Fluxes
418	BN3	msc inboard		18/06/2018	168	18:16:00	-18.019899	11.008419	
419	BN3	msc outboard	MSC151	18/06/2018	168	18:22:00	-18.019917	11.008429	Fluxes
419	BN3	msc inboard		18/06/2018	168	18:28:00	-18.019896	11.008413	
420	BN3	msc outboard	MSC152	18/06/2018	168	18:34:00	-18.019915	11.008426	Fluxes
420	BN3	msc inboard		18/06/2018	168	18:46:00	-18.019929	11.008408	
421	BN3	Bongo net outboard	Bongo028	18/06/2018	168	19:06:00	-18.019914	11.008408	
421	BN3	bongo net inboard		18/06/2018	168	19:22:00	-18.019919	11.008403	
422	BN3	Bongo net outboard	Bongo029	18/06/2018	168	19:26:00	-18.019919	11.008401	
422	BN3	bongo net inboard		18/06/2018	168	19:41:00	-18.019912	11.008397	
423	BN3	ISANET outboard	IsaNet018	18/06/2018	168	20:53:00	-18.019908	11.008402	
423	BN3	ISANET inboard		18/06/2018	168	20:56:00	-18.019911	11.008398	
424	BN3	ISANET outboard	IsaNet019	18/06/2018	168	20:58:00	-18.019916	11.008406	

424	BN3	ISANET inboard		18/06/2018	168	21:02:00	-18.019924	11.008408	
425	BN3	ISANET outboard	IsaNet020	18/06/2018	168	21:03:00	-18.01992	11.008415	
425	BN3	ISANET inboard		18/06/2018	168	21:07:00	-18.019921	11.008401	
426	BN3	Commence ADCP Survey. Line 1 090	Survey007	18/06/2018	168	22:19:00	-17.936654	10.925664	
426	BN3	Start Line 2 180		18/06/2018	168	23:25:00	-18.103584	10.937571	
426	BN3	Start Line 3 270		19/06/2018	169	00:00:00	-18.012662	11.091719	
426	BN3	Start Line 4 180		19/06/2018	169	01:01:00	-18.019861	10.934727	
426	BN3	Start Line 5 090		19/06/2018	169	01:36:00	-18.094543	10.925142	
426	BN3	Start Line 6 270		19/06/2018	169	02:43:00	-18.103145	11.083261	
426	BN3	Start Line 7 270		19/06/2018	169	03:18:00	-18.179712	11.091792	
426	BN3	Start Line 8 180		19/06/2018	169	04:21:00	-18.186567	10.931352	
426	BN3	Start Line 9 090		19/06/2018	169	04:55:00	-18.262052	10.925072	
	BN3	finish survey. repos to main stn		19/06/2018	169	06:10:00	-18.265543	11.095547	
	BN3	on stn		19/06/2018	169	07:59:00	-18.023345	11.009667	
427	RS	MOCNESS outboard	MOCNESS013	19/06/2018	169	08:25:00	-18.023371	11.009686	
427	RS	MOCNESS inboard		19/06/2018	169	08:57:00	-18.04228	11.016811	
	RS	V/L on DP @ main station		19/06/2018	169	09:30:00	-18.019821	11.008204	
428	RS	msc outboard	MSC153	19/06/2018	169	10:08:00	-18.019808	11.00819	Fluxes
428	RS	msc inboard		19/06/2018	169	10:14:00	-18.01982	11.008194	
429	RS	msc outboard	MSC154	19/06/2018	169	10:19:00	-18.019824	11.008201	Fluxes
429	RS	msc inboard		19/06/2018	169	10:24:00	-18.019823	11.008205	
430	RS	msc outboard	MSC155	19/06/2018	169	10:30:00	-18.019829	11.008199	Fluxes
430	RS	msc inboard		19/06/2018	169	10:34:00	-18.019807	11.008214	
431	RS	msc outboard	MSC156	19/06/2018	169	10:39:00	-18.01981	11.008228	Fluxes
431	RS	msc inboard		19/06/2018	169	10:45:00	-18.019809	11.008229	
432	RS	Red Camera O/B	RCF032	19/06/2018	169	11:31:00	-18.019814	11.008237	

432	RS	Red Camera I/B		19/06/2018	169	12:40:00	-18.019803	11.008225	
433	RS	Red Camera O/B	RCF033	19/06/2018	169	12:53:00	-18.01981	11.00823	
434	RS	STAINLESS CTD OB	CTD034 SS	19/06/2018	169	14:56:00	-18.024699	10.992839	Glider calibration
434	RS	STAINLESS CTD IB		19/06/2018	169	15:38:00	-18.024659	10.992816	
	RS	V/L off DP proceeding for glider recovery		19/06/2018	169	15:44:00	-18.024657	10.992891	
435	RS	Glider recovered to deck	Glider Recovery	19/06/2018	169	16:26:00	-18.034622	10.980286	Doombar recovered
	RS	Reposition to main station		19/06/2018	169	16:40:00	-18.033138	10.978049	
	RS	Vessel on Station		19/06/2018	169	17:15:00	-18.019871	11.007908	
436	RS	ISANET outboard	IsaNet021	19/06/2018	169	17:30:00	-18.019867	11.008151	
436	RS	ISANET inboard		19/06/2018	169	17:34:00	-18.01986	11.008146	
437	RS	ISANET outboard	IsaNet022	19/06/2018	169	17:37:00	-18.019849	11.008161	
437	RS	ISANET inboard		19/06/2018	169	17:41:00	-18.019848	11.008164	
438	RS	ISANET outboard	IsaNet023	19/06/2018	169	17:44:00	-18.019858	11.008163	
438	RS	ISANET inboard		19/06/2018	169	17:48:00	-18.019866	11.008169	
439	RS	MOCNESS outboard. v/l spd 2kts stw	MOCNESS014	19/06/2018	169	18:38:00	-18.021041	11.008621	
439	RS	MOCNESS inboard		19/06/2018	169	19:16:00	-18.040896	11.01774	
440	RS	msc outboard	MSC157	19/06/2018	169	19:55:00	-18.019837	11.008208	Fluxes
440	RS	msc inboard		19/06/2018	169	19:59:00	-18.019849	11.008207	
441	RS	msc outboard	MSC158	19/06/2018	169	20:06:00	-18.01982	11.008214	Fluxes
441	RS	msc inboard		19/06/2018	169	20:10:00	-18.019819	11.00822	
442	RS	msc outboard	MSC159	19/06/2018	169	20:15:00	-18.019823	11.008229	Fluxes
442	RS	msc inboard		19/06/2018	169	20:21:00	-18.019819	11.008225	
443	RS	msc outboard	MSC160	19/06/2018	169	20:26:00	-18.019824	11.008223	Fluxes
443	RS	msc inboard		19/06/2018	169	20:32:00	-18.01982	11.008221	
444	RS	Red Camera outboard	RCF034	19/06/2018	169	20:59:00	-18.019828	11.00823	
444	RS	Red Camera inboard		19/06/2018	169	21:47:00	-18.019819	11.008219	

445	RS	Red Camera O/B	RCF035	19/06/2018	169	22:05:00	-18.019819	11.008205	
445	RS	Red Camera I/B		19/06/2018	169	23:42:00	-18.019813	11.008242	
446	RS	msc outboard	MSC161	20/06/2018	170	01:03:00	-18.019827	11.008235	Rates
446	RS	msc inboard		20/06/2018	170	01:38:00	-18.019814	11.008241	
447	RS	msc outboard	MSC162	20/06/2018	170	01:46:00	-18.019801	11.008235	Rates
447	RS	msc inboard		20/06/2018	170	02:20:00	-18.019814	11.008229	
448	RS	msc outboard	MSC163	20/06/2018	170	02:25:00	-18.01983	11.00823	Rates
448	RS	msc inboard		20/06/2018	170	03:03:00	-18.019811	11.00824	
	RS	Station complete. Procced to CTD site.		20/06/2018	170	03:11:00	-18.019831	11.008247	
	RS	Reduce speed		20/06/2018	170	04:48:00	-18.123014	10.840573	
	RS	Full speed		20/06/2018	170	05:41:00	-18.170546	10.802678	
449	RS	ctd outboard	CTD035 SS	20/06/2018	170	08:25:00	-18.34288	10.504458	Deep CTD
449	RS	ctd @3585m hauling		20/06/2018	170	09:45:00	-18.342872	10.50446	
449	RS	ctd inboard		20/06/2018	170	11:20:00	-18.342774	10.504391	
	RS	Proceeding to Main Station		20/06/2018	170	11:34:00	-18.343061	10.504383	
450	RS	on station		20/06/2018	170	16:06:00	-18.019663	11.008017	
450	RS	STAINLESS CTD OB	CTD036 SS	20/06/2018	170	16:33:00	-18.019634	11.00803	Th/Po
450	RS	STAINLESS CTD IB		20/06/2018	170	17:35:00	-18.019639	11.008039	
	RS	Proceed to RESPIRE		20/06/2018	170	17:45:00	-18.01821	11.007113	
451	RS	respire grappled	RESPIRErecover	20/06/2018	170	20:07:00	-18.048779	10.719058	
451	RS	commence stern recovery of RESPIRE		20/06/2018	170	20:10:00	-18.04923	10.719368	
451	RS	RESPIRE fully recovered		20/06/2018	170	20:32:00	-18.051383	10.720727	
452	RS	Pelagra IB P4	PelagraRecover	20/06/2018	170	22:45:00	-18.12847	10.856523	
453	RS	Pelagra IB P2	PelagraRecover	20/06/2018	170	23:34:00	-18.173176	10.860141	
454	RS	Pelagra IB P6	PelagraRecover	21/06/2018	171	00:18:00	-18.151606	10.876058	
455	RS	Pelagra IB P7	PelagraRecover	21/06/2018	171	01:00:00	-18.151576	10.908209	

456	RS	Pelagra IB P9	PelagraRecover	21/06/2018	171	01:25:00	-18.151597	10.91889	
	RS	Proceed to Main Station		21/06/2018	171	01:46:00	-18.154387	10.91941	
	RS	Vessel on Station		21/06/2018	171	03:14:00	-18.019868	11.008304	
457	RS	STAINLESS CTD OB	CTD037 SS	21/06/2018	171	04:08:00	-18.019863	11.00836	RESPIRE optode cal (unsuccessful)
457	RS	STAINLESS CTD IB. Instrument error.		21/06/2018	171	05:06:00	-18.019859	11.008349	
458	RS	ctd outboard	CTD038 SS	21/06/2018	171	06:00:00	-18.019843	11.008352	RESPIRE optode cal (successful)
458	RS	ctd inboard		21/06/2018	171	07:03:00	-18.019838	11.008347	
459	RS	ctd outboard	CTD039 SS	21/06/2018	171	07:48:00	-18.019835	11.008357	RBR and Seabird CTs cal
459	RS	ctd inboard		21/06/2018	171	09:01:00	-18.019855	11.008341	
460	RS	saps outboard	SAPS008	21/06/2018	171	09:42:00	-18.019856	11.008337	
460	RS	saps inboard		21/06/2018	171	12:11:00	-18.01986	11.00833	
461	RS	msc outboard	MSC164	21/06/2018	171	13:11:00	-18.019869	11.008352	Geochem
461	RS	msc inboard		21/06/2018	171	13:14:00	-18.019862	11.008353	
462	RS	msc outboard	MSC165	21/06/2018	171	13:19:00	-18.019858	11.008349	Geochem
462	RS	msc inboard		21/06/2018	171	13:23:00	-18.019853	11.008346	
463	RS	msc outboard	MSC166	21/06/2018	171	13:33:00	-18.177144	11.088512	Geochem
463	RS	msc inboard		21/06/2018	171	13:39:00	-18.019868	11.008349	
464	RS	msc outboard	MSC167	21/06/2018	171	13:45:00	-18.019868	11.008349	Geochem
464	RS	msc inboard		21/06/2018	171	13:58:00	-18.019868	11.008349	
		END OF SCIENCE DY090. V/l set on to Walvis Bay Namibia		21/06/2018	171	14:06:00	-18.019868	11.008349	

Satellite data

Nathan Briggs, Filipa Carvalho and Stephanie Henson (NOC)

Introduction

Satellite data was provided as a bulletin by the NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) on a daily basis.

Data provided included weekly composites and daily images (when coverage was available) of ocean colour, sea surface temperature (SST) and mean sea level anomaly (MSLA) in netcdf format and a png (low resolution). Additionally, a full_area dataset was also provided

The following datasets were available:

- From VIIRS, MODIS and OLCI:
    - Chlorophyll daily (chlor_a)
    - Chlorophyll weekly (chlor_a).
- From VIIRS and MODIS
    - chlorophyll present in cells between 0.2 micrometres and 2 micrometres daily (c02to2)
    - chlorophyll present in cells between 2 micrometres and 20 micrometres daily (c2to20)
    - chlorophyll present in cells between 20 micrometres and 200 micrometres daily (c20to200)
    - NASA standard PIC (from November 11th)
- From MW+IR and MUR:
    - sea surface temperature daily
- MSLA product distributed by CMEMS.
    - Msla and geostrophic currents

Data availability during the cruise

Data were downloaded daily via FTP from:

ftp://neodaas19:hiH2ap1Iuje6tohshai8Y@ftp.rsg.pml.ac.uk/2018/mmmdd, where ‘mmm’ is the month (the first 3 letters) and ‘dd’ is the day (2 digits).

Data was plotted daily. PNGs were generated daily with cruise track and glider area overlaid and available in the public drive.

Matlab routines

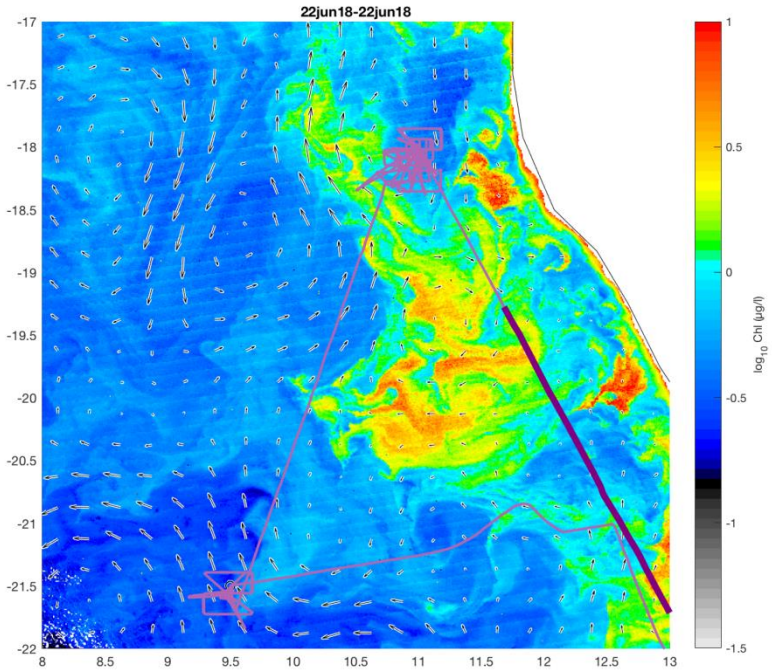
Several functions were written to import the netcdf file to a struct variable in Matlab:

dy090_COMICS_download_neodas19.m: download NEODAAS data

NEODAAS_plots.m: plots NEODAAS products

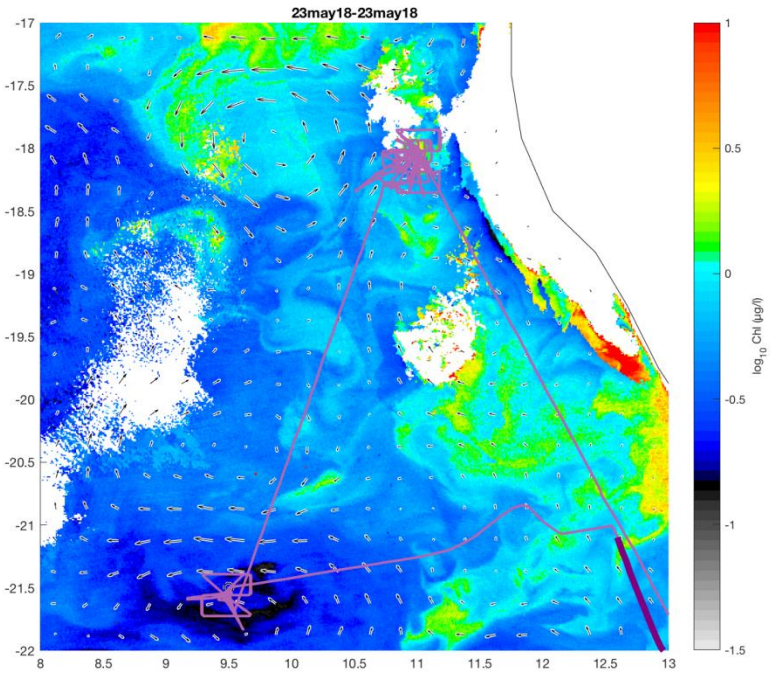
Example Satellite imagery

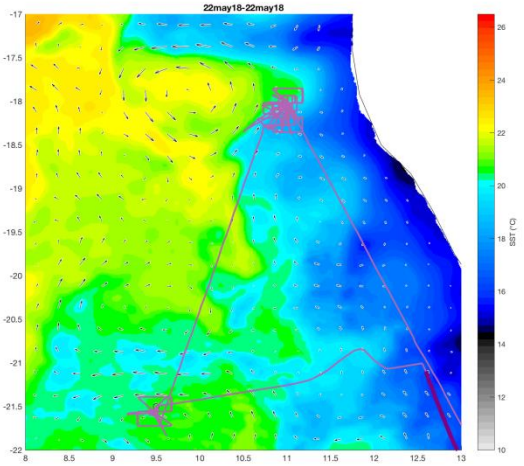
Chl (currents overlaid)

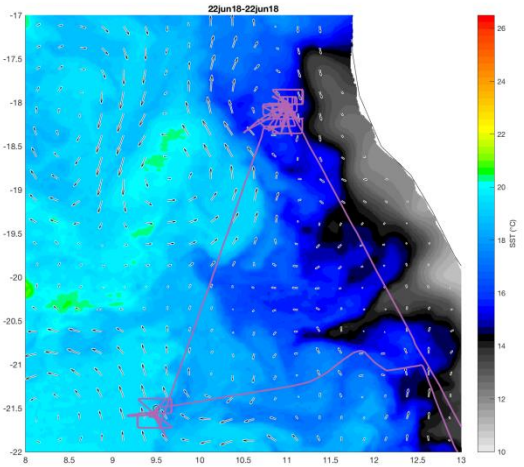


Currents show distance per day. Cruise track is purple with the day of the image in bold. Data from beginning (1 day prior to first station) and end (1 day after last station) are shown as examples. Chl was consistently lower and SST consistently higher in southern station. Northern station was more productive and colder (signature of upwelling) and also highly dynamic, with narrow filaments of high and low chlorophyll passing through.

SST (currents overlaid)




22may18-22may18
SST (°C)


22jun18-22jun18
SST (°C)

Glider operations

Stephanie Henson, Filipa Carvalho, Nathan Briggs (OBE, NOC), Ashley Morris, Stephen Woodward, and David White (MARS, NOC)

Personnel in the field: Filipa Carvalho, Nathan Briggs, Stephanie Henson (NOC)

Objectives

Glider operations onboard *RSS Discovery* during COMICS 2 (DY090) consisted of supporting the ERC funded grant GOCART (Gauging Ocean organic Carbon fluxes using Autonomous Robotic Technologies) project.

Two gliders were used to characterize the temporal variability of organic carbon flux and the remineralisation depth during the spring bloom in a highly productive but low oxygen region in the Benguela Current, off the Namibian coast. Gliders used were 2 Teledyne Webb Research Slocum gliders from MARS, National Oceanography Centre (NOC): Unit-405 (Doombar) and Unit-409 (Grease, a.k.a. 'Guinness'). The two gliders were deployed by Filipa Carvalho on board RV Mirabilis during the second leg of the 2018 Hake Survey (HakeMOM 1802) in February 2018. This report includes details of the entire GOCART deployment that spans beyond DY090.

Mission details can be found at https://mars.noc.ac.uk/.

Glider survey description

Gliders were tasked to survey a triangle with 12 km sides (**Error! Reference source not found.**). The location of the triangle was chosen based on low currents to help constrain advective processes and the predominantly westward surface currents in the region (climatology for February-June 2003-2016 using OSCAR currents). By having gliders fly in opposite directions, we maximized the number of inter-calibrations between gliders (they crossed paths roughly once every 1.5-2 days).

Table 1: Coordinates of glider waypoints.

	GOCART 1	GOCART 2	GOCART 3

Latitude	**18.3 °S**	**18.**2065 **°S**	**18.**2065 **°S**
Longitude	**10.8 °E**	**10.8569 °E**	**10.7431 °E**

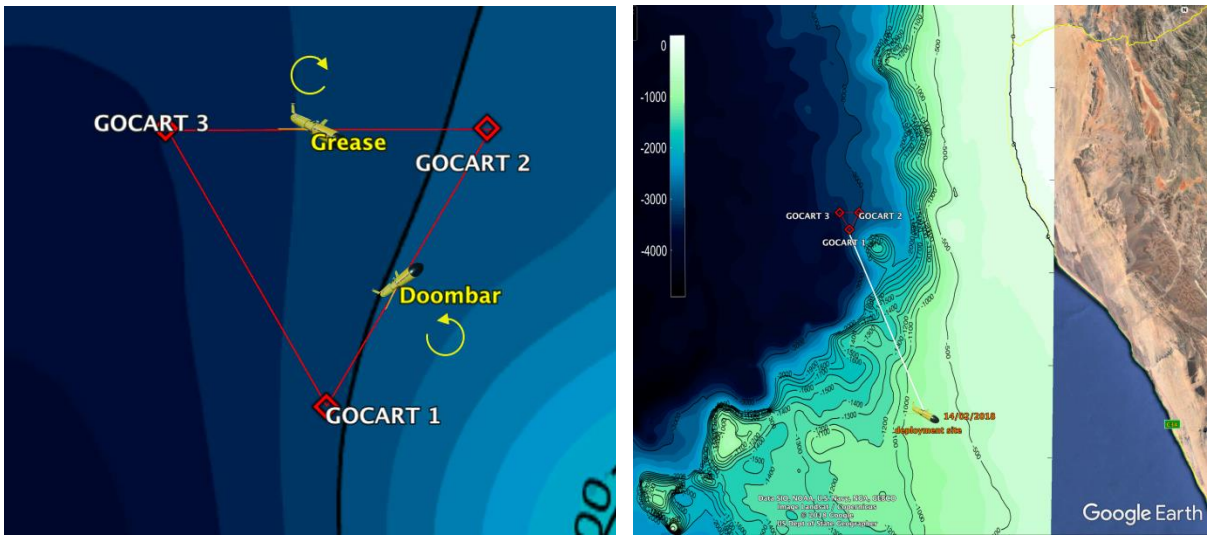


Figure 1: (left) flight track (red) for both gliders. Waypoints are shown in the vertices of the triangle; (right) deployment site and transit line (white) to the survey area.

Sensor Packages

Similarly to the gliders used in the South Georgia Deployments (Pancake and Churchill), gliders deployed in the Benguela Current (Doombar and Grease) were fitted with a custom made Wetlabs Environmental Characterization (ECO) Triplet Puck, measuring backscatter at 532 and 700 nm together with the standard chlorophyll fluorescence.

The following tables summarise the serial numbers, last calibration date, measured variables and additional notes for each sensor on each glider. Doombar was fitted with a strobe light to facilitate locating the glider in the dark.

GREASE

Sensor	S/N	Last cal	Variables measured	Notes
SeaBird CTD			Conductivity, Temperature, Depth	
Wetlabs Eco Puck			Backscatter at 532, 700 nm; chlorophyll fluorescence	

Oxygen Optode			Dissolved oxygen	
Satlantic PAR			Photosynthetic Active Radiation	

DOOMBAR

Sensor	S/N	Last cal	Variables measured	Notes
SeaBird CTD			Conductivity, Temperature, Depth	
Wetlabs Eco Puck			Backscatter at 532, 700 nm; chlorophyll fluorescence	
Aanderaa Oxygen Optode			Dissolved oxygen	

Deployment operations

Some functional checks were conducted on both Slocum gliders while in port in Walvis Bay on February 2nd by Steph and Filipa in the pier and by Dave back at NOC via iridium. Same checks were performed again the day before deployment. Both gliders passed their functional checks with flying colours.

Figure 2: Doombar and Grease during functional checkouts: (top) in port in Walvis Bay before the cruise start. (bottom) at sea, the day before deployment.

Both Slocum gliders were scheduled to be deployed around 18.5°S, as far west as possible (beyond trawl depth) during the cruise to minimize (1) transit time and (2) chances of being captured in a trawl or hit by a fishing vessel. Trawls in the region tend to be restricted to depths 700m and shallower, so a decision was made to deploy beyond at least the 800 m isobaths and the Captain was kind enough to accommodate our request. Dave White was the point of contact handling the deployment back on MARS base. Last functional checks (e.g. running status.mi) were done a couple of hours prior to deployment as per Dave's instructions.

Because the cruise was advancing faster than initially planned, and in order to maximize the time the Mirabilis was in the area around the gliders before steaming back south, we requested the gliders to be deployed a bit further south. Ideally, we want the ship to be in the area for at least 4-5 days after deployment in case an emergency recovery is necessary.

Both deployment options were discussed with the officers of the RV Mirabilis prior to the beginning of the cruise and small boat operations were requested if weather permitting.

Table 2: Glider deployment characteristics.

Glider	Deployment	WPT direction
Doombar (unit-405)	**2018-02-14 16:30 GMT LAT: 19° 19.89' S LON: 11° 13.58' E**	**1-2-3 (anti-clockwise)**
Grease (unit-409)	**2018-02-14 16:45 GMT LAT: 19° 19.89' S LON: 11° 13.58' E**	**3-2-1 (clockwise)**

Based on location and a good weather window, gliders were scheduled to be deployed on the afternoon of 14 February. We steamed west for 2h30min to the deployment site after finishing a trawl. Gliders were put on deck during the steam to run final checks before deployment. The big work boat on the Mirabilis (located on the port side of the ship) was used for the deployment to accommodate the length of both gliders and carts. The boat was lowered to the height of the back deck and gliders were loaded onto the boat while alongside in mid-air. Boat was then lowered to the water and we then relocated to around 300 m to the starboard side of the ship.
Because Grease was still uploading a sbd file, Doombar went first. Glider (and cart) were set across the rail of the boat, wings were screwed in, nose ring was unpinned from the cart and glider successfully launched to the water. Due to the sea state (waves looked much smaller from the big ship), 4 people were required to secure the glider/cart during deployment.
Dave sent Doombar on a 30 m dive. While waiting for it to dive, Grease finished transferring the file and Dave gave us the OK to deploy. Same procedures were followed to deploy Grease. We hung around the gliders to see both successfully finish their 30 m test dive and a 100 m dive. Wind and waves got a bit bigger, so after Dave confirming gliders were flying well we returned to the ship. The bosun showed incredible driving skills manoeuvring the boat through the waves and crew was amazingly helpful during both glider deployments.

Figure 3: Gliders during deployment, {left} Both Doombar and Grease with the R/V Mirabilis on the background; (right): Filipa with 2 crew members from the Mirabilis with Doombar on the background.

Future deployment recommendations

Deployment using small boats was very successful. Very little risk for the gliders while being deployed, plus the ability to pick them up easily if necessary is a plus.

Calibration casts during deployment

Calibration casts were conducted at deployment. A fluoroprobe was used to evaluate the total chlorophyll concentration in the water column, as there is no fluorometer on the CTD rosette. The fluoroprobe was sent down to 80 m. Deep Chlorophyll Maximum was located at 10 m and most phytoplankton were located in the upper 50 m. Mixed layer depth was about 10 m.

Table 3: Detail of the calibration casts between the Slocum gliders and the ship's CTD and Fluoroprobe

	Fluoroprobe Cast	CTD Cast 1	CTD Cast 2
Date	2018-02-14	2018-02-14	2018-02-14
Time			
Latitude	19° **19.895' S**	19° **19.895' S**	19° **19.895' S**
Longitude	11° **13.580' W**	11° **13.580' W**	11° **13.580' W**
Cast name		Glider Station 1	Glider Station 2

Data file name

Table 4: CTD sampling details

Sample #	Depth (db)	Notes	Cast #
1	785	Bottom	1
2	474		1
3	238	Oxygen maximum peak	1
4	194	Oxygen minimum peak	1
9	150	Oxygen maximum peak	2
5	83	Oxygen minimum peak	1
6	53	Bottom chlorophyll profile	1
7	26		1
8	12	DCM, MLD	1
10	6		2
11	1	surface	2

Table 5: Cast 1 details

Bottle fire order	Niskin #	Depth (db)	Notes
1	17	785	Didn’t fire
2	8	785	
3	9	474	
4	10	301	Didn’t fire
9	11	238	
5	12	194	
6	7	150	Didn’t fire
7	24	83	
8	19	53	

10	21	26	
11	22	12	
12	23	5	Didn't fire

Table 6: Cast 2 details

Bottle fire order	Niskin #	Depth (db)	Notes
1	17	250	Didn't fire
2	8	250	Already have this depth
3	9	151	Sampled. Not enough for POC
4	10	10	Already have this depth
9	11	10	
5	12	6	sampled
6	7	6	
7	24	1	sampled
8	19	1	
10	21	1	

***In situ* sampling**

Bottles were fired at several depths throughout the water column and water samples were collected for oxygen, total chlorophyll concentration, HPLC, POC, nutrients and water samples preserved for phytoplankton taxonomy in the upper 26 m.

Saskia and Sharon were extremely helpful during the calibration cast, assisting during the CTD deployment, Niskin sample and water filtration. Since there were no big bottles available, we had to use multiple 200ml amber bottles per sample to collect water from the rosette.

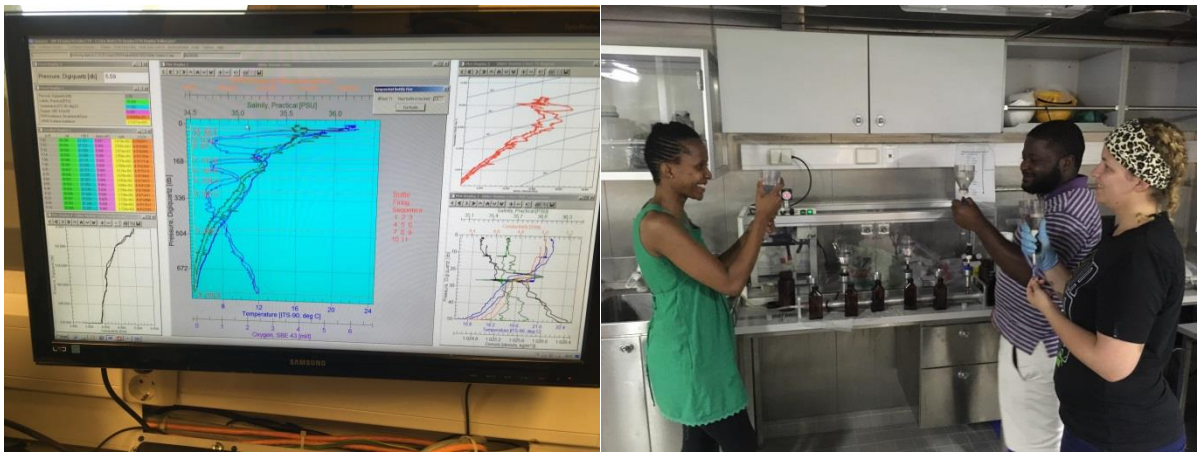


Figure 4: (left) CTD screen during calibration cast; (right) gravity filtering to collect filtrate for nutrient analysis

Table 7: Sampled/stored volumes (ml) for Particulate Organic Carbon (POC), chlorophyll concentration (CHL), phytoplankton pigments (HPLC), nutrients (NUT) and phytoplankton taxonomy (TAX).

Sample #	Depth	POC	CHL	HPLC	NUT	TAX	notes
1	785	800	500	500	12	-	
2	474	800	480	500	12	-	
3	238	800	500	500	12	-	
4	194	800	500	500	12	-	
5	83	800	500	500	12	-	
6	53	800	400	400	12	-	
7	26	600	400	400	12	200	
8	12	600	400	400	12	200	TAX: 1 bottle from cast 1 (8); 1 bottle from cast 2 (8a)
9	151	-	400	400	12	-	Niskin leaked. No POC
10	6	600	400	400	12	200	
11	1	600	400	400	12	200	

Chlorophyll (filters in 2 ml cryovials) and HPLC (filters in aluminium foil) were stored in the liquid nitrogen dewar (located in the -20°C freezer downstairs to minimize liquid N_2 loss). POC (filters in 2 ml cryovials) and nutrient (filtered seawater in 12 ml tubes) samples were stored in the -20°C freezer in the analytic lab. Phytoplankton taxonomy samples were fixed in lugol in 200ml amber bottles.

Chlorophyll extraction

During calibration cast, water was filtered in 25mm GF/F, filter placed in 2 ml cryovials and stored in liquid nitrogen for the duration of the cruise. Upon returning to shore (21 February, late AM), filters were transferred to 15 ml falcon tubes with 9ml of 90% acetone, homogenised and placed in the -20 freezer for 24 hours. Set of vials were wrapped in aluminium foil to prevent pigment degradation from light exposure.

The following day (22 February), after lunchtime, and one hour before measurement, tubes were removed from the freezer to acclimate to room temperature and placed in a dark location. Fluorometer was turned on half an hour before measurements. Measurements were done in the dark to prevent pigment degradation.

Method used to measure Chlorophyll-a (Chl-a) concentration was based on Arar and Collins1997; Arar 1997; Welschmeyer 1994. I've previously used the acidification method, but the settings (light and filters) as well as calibration were set for the non-acidification method. Before running the samples, a set of standards were measured to assure the accuracy of the instrument and to evaluate any drift since the last calibration. Values with residuals less than 5% are considered acceptable. This fluorometer was calibrated to be more sensitive to medium to high chlorophyll concentrations (they usually only sample up to 30m depth).

Blank (90% acetone only) = 0.511

Standards

Table 8:

Standard #	Actual Concentration	Measured concentration
0	0	-0.0
1	5	4.67
2	10	9.62
3	20	20.5
4	50	46.3
5	100	92.6*
6	120	113.0

Table 9: Fluorometer sensitivity test using solid standards (to evaluate drift between the beginning and after all the measurements)

	Beginning	End

High	56.9	55.84
Low	7.8	7.66

Using a pipete, around 7-8ml of solution from the sample tubes were transferred to a culture tube. Tube was cleaned and placed in the fluorometer and value was recorded. Samples with values over 100 were afterwards diluted, by mixing 1 ml of the solution with 5 ml of 90% acetone in a separate tube, and values recorded. Samples within the MLD had to be diluted (see Table 8). A blank (filtered seawater filter placed in 90% acetone) value was also collected. The blank used by Deon involves just measuring fluorescence of 90% acetone (no filter). This value is set in the fluorometer and the value is automatically subtracted from the fluorescence signal.

Table 10: Filtration details.

Sample #	Depth (m)	Volume water sampled	Volume acetone (extraction)	Fluorescence signal (raw)	Fluorescence signal (raw) after dilution	Chlorophyll concentration (ug/l)
1	785	500	9	1.07	-	0.018
2	474	480	9	0.64	-	0.011
3	238	500	9	1.52	-	0.026
4	194	500	9	2.5	-	0.042
5	83	500	9	5.9	-	0.099
6	53	400	9	7.4	-	0.156
7	26	400	9	179.4*	-	3.777
8	12	400	9	over	31.2	3.916
9	151	400	9	2.4	-	0.051
10	6	400	9	162.2	24.6	3.108
11	1	400	9	161.3	27.1	3.424
blank	-	500	9	0.015	-	0

*I missed that the raw value of sample 7 (179.4) was above 100 and didn't dilute it and run again. Going to evaluate if I can extrapolate using the before and after dilution values from samples 10 & 11 and compare it to the fluoroprobe profile.

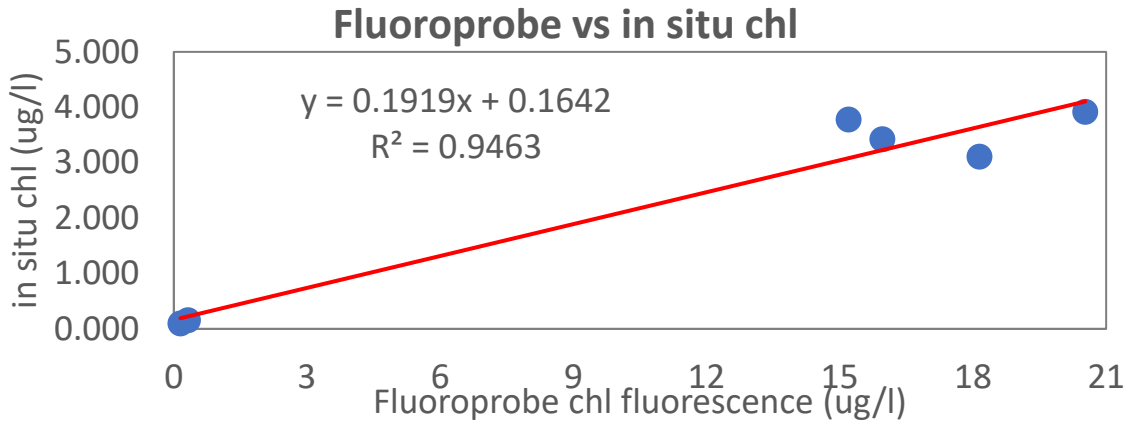


Figure 5: Regression used to correct fluoroprobe fluorescence data based on in situ chlorophyll samples.

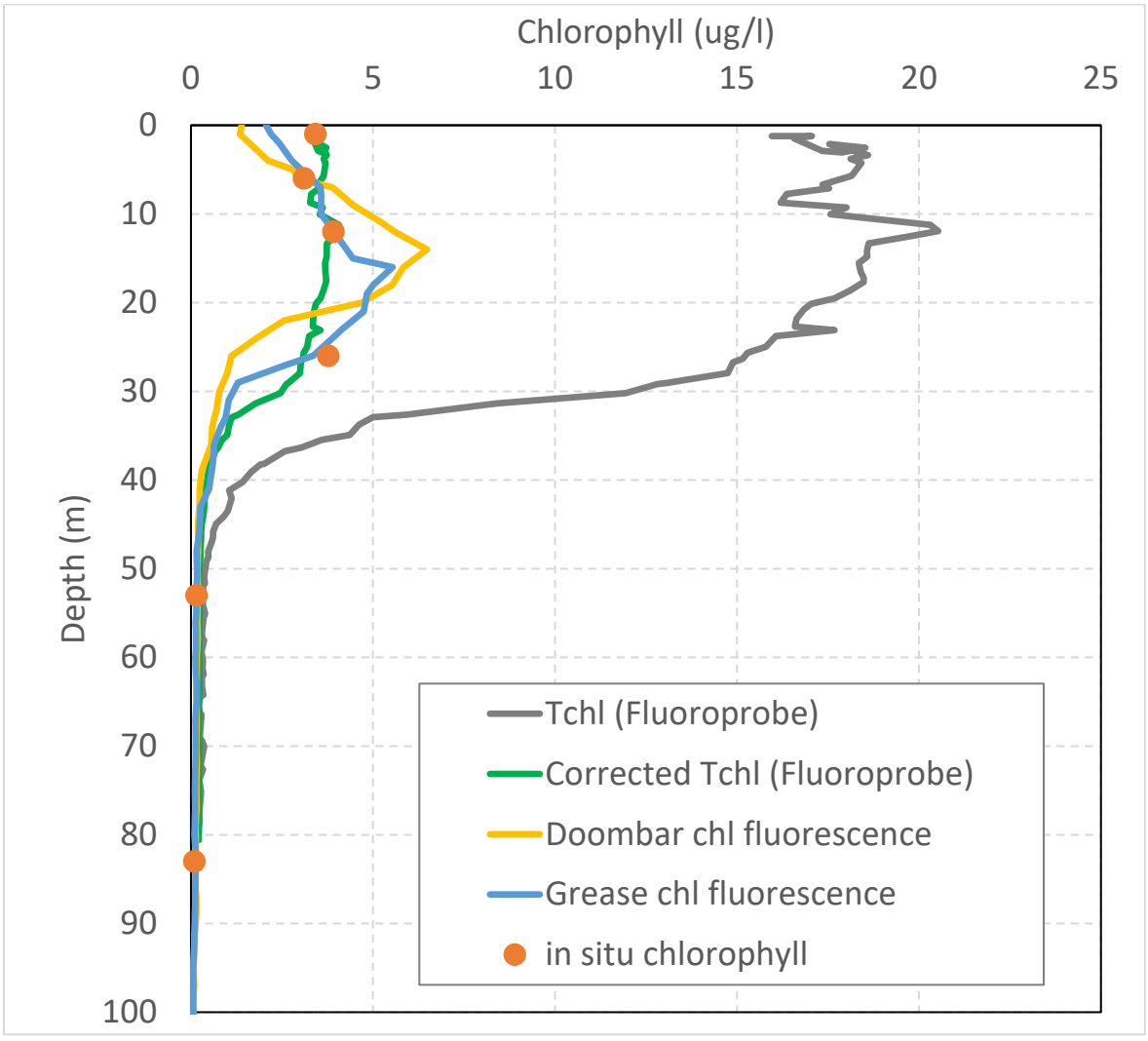


Figure 6: Gliders' chlorophyll fluorescence against corrected fluoroprobe data and in situ chlorophyll samples from the CTD rosette collected during the calibration cast during the deployment.

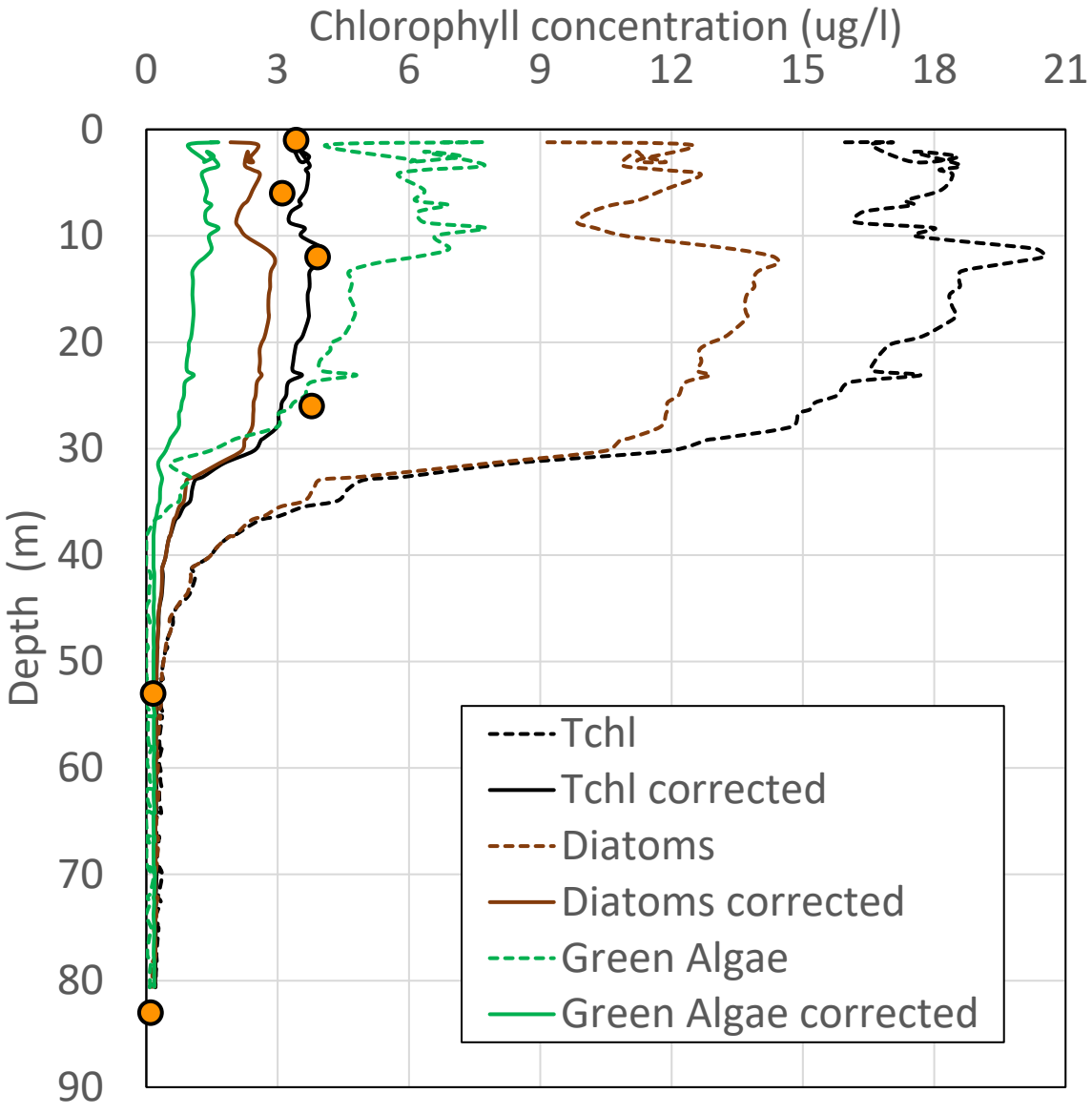


Figure 7: Fluoroprobe data before (dashed line) and after (solid line) correction using in situ chlorophyll samples. Major phytoplankton groups are shown (diatoms and green algae most abundant). Fluoroprobe curve was corrected by applying a linear regression between fluoroprobe data and in situ chlorophyll concentrations.

Grease's early abort

Unfortunately, after three weeks at sea, Grease had a leak and aborted. Unable to fly again and without any other recovery options, Grease drifted NW until it was picked up about a month later by the RSS James Cook on its way back to Southampton. Glider was brought back to NOC, opened and inspected for water leaks. Large salt trails were found near the science bay. MARS technician Mike opened the glider with Filipa. Glider also showed scratched paint and a “polished” PAR sensor (Figure 8).

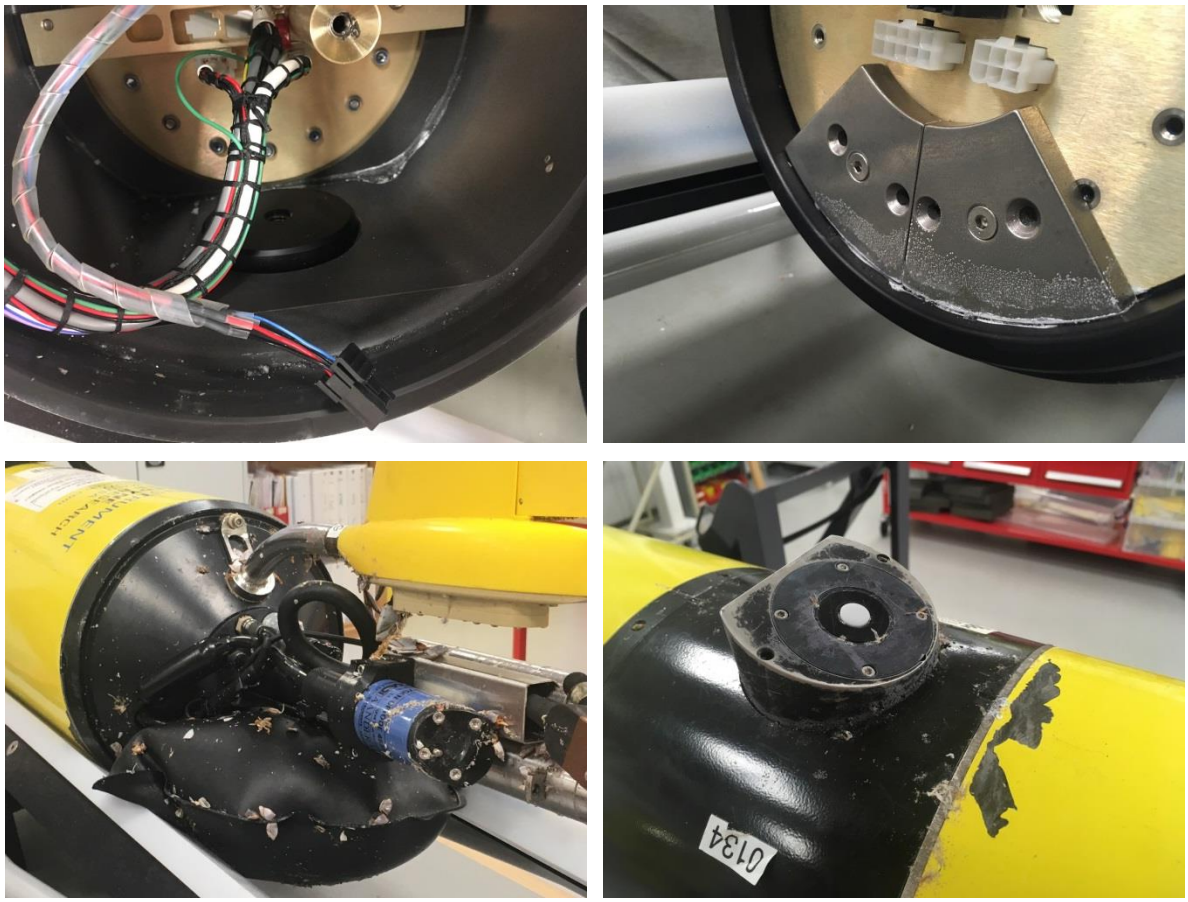


Figure 8: Details of Grease (unit-409) inspection after recovery.

GOCART during DY090

During DY090, glider operations per se were restricted to the recovery of Doombar at the end of the cruise. However, glider data was often used during the cruise to evaluate the oxygen profiles at the Northern Station. The exact location of the Northern station of the cruise was picked based on the glider location.

Throughout its deployment, Doombar gradually reduced its speed from about 4km per 1000m dive to about 1.5km. This meant that the glider could no longer cover the triangle in less than 2 days. So, after the first week of the cruise (after completing BS station and started heading

north to BN) we decided to assign Doombar a station keeping mission. After we arrived at Doombar's station keeping location, now BN station (previous NE corner triangle, with the lowest oxygen), and to avoid the risk of hitting the glider, Doombar's station keeping point was set 1.5 km North of the cruise station, meaning all further casts at BN would be considered calibration casts for Doombar, including CTD, marine snow catchers, red camera frame, etc. Full timeseries of oxygen, chlorophyll and backscattering are shown in Figures 9-11.

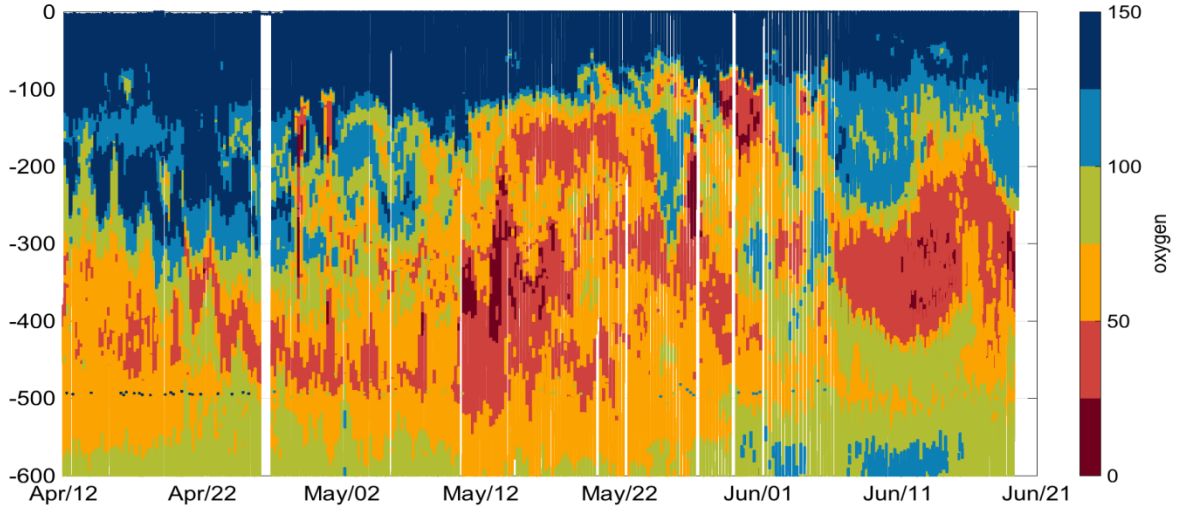


Figure 9: Oxygen concentration (uM) calculated using calphase and corrected for temperature, salinity and pressure).

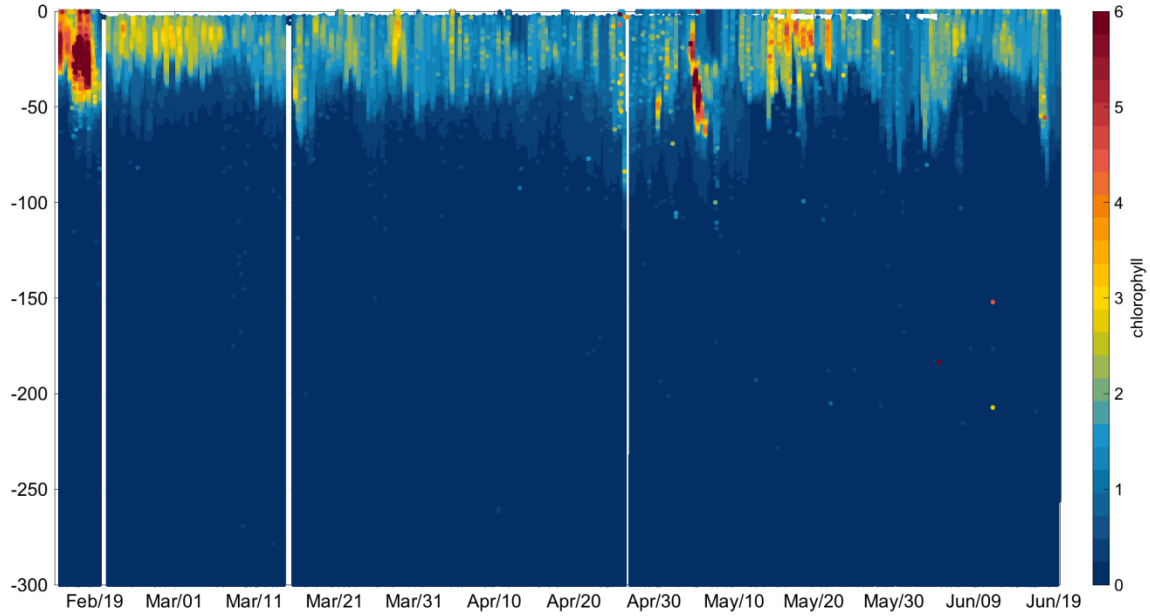


Figure 10: Timeseries of chlorophyll (in ug/l) in the upper 300 metres

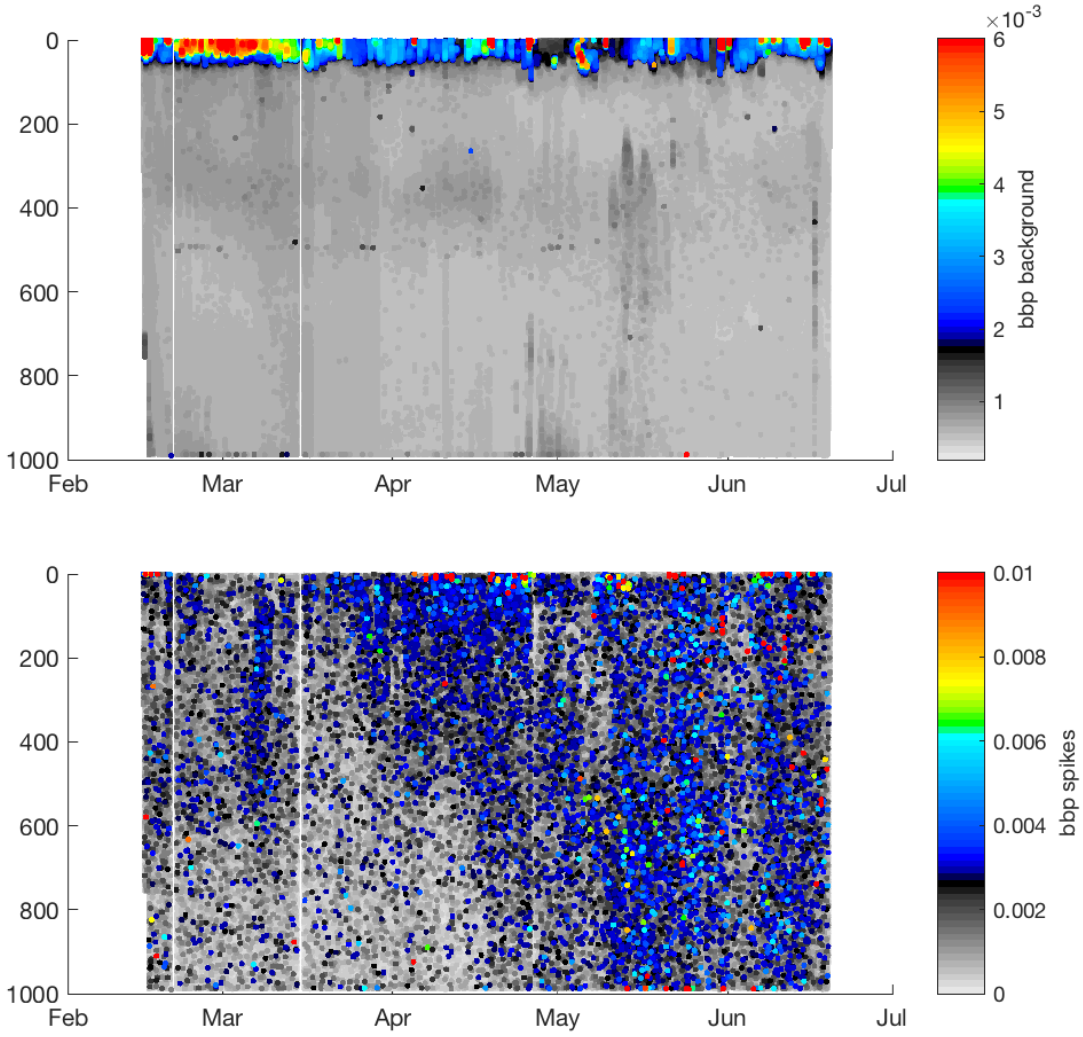
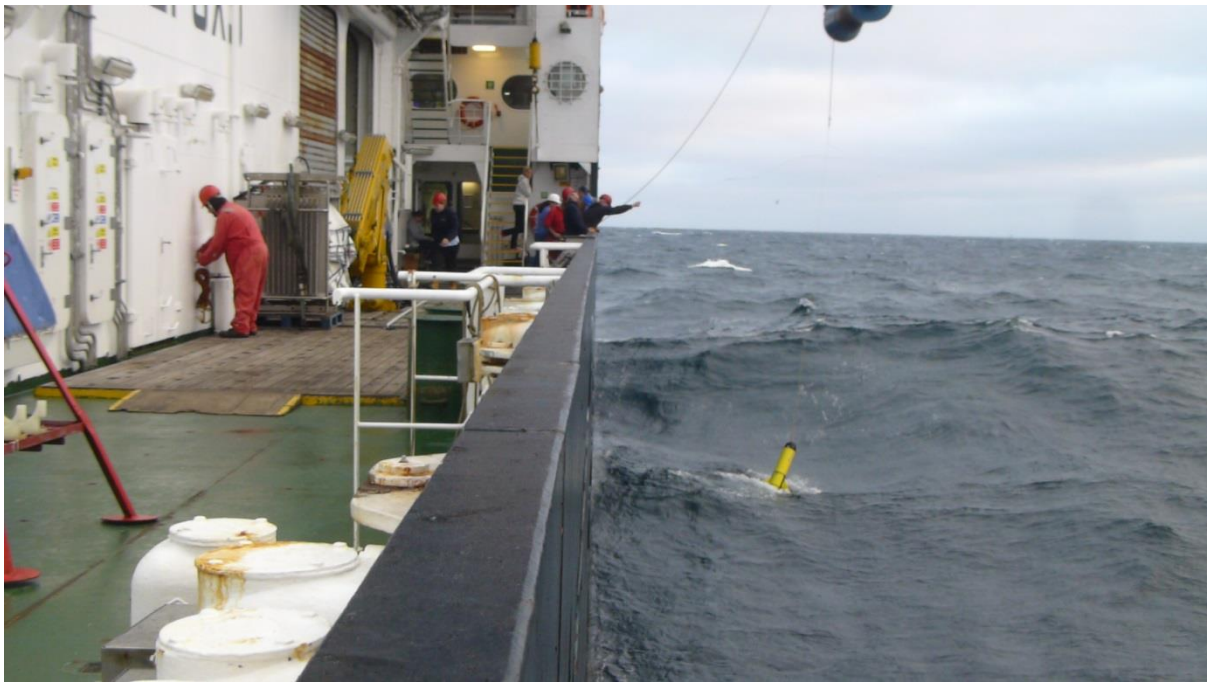


Figure 11: Backscattering timeseries. (top) baseline; (bottom) spikes showing increase of particles at depth.

Doombar's recovery

Doombar was recovered on the 19th of June, after spending over 4 months at sea. Point of contact back at base from MARS was Ashley Morris. Glider was tasked to do shallow dives (250m) from midday, to provide some flexibility in recovery process. When ship got closer to the last glider position, MARS was asked to keep the glider at the surface to have one last dive together with a close CTD cast. Before we had a visual on the glider (ship about 500m from the glider's last position), glider left the surface on its last dive. CTD was then put in the water and a 500 m cast was done on that location. Samples were collected for oxygen, POC, chlorophyll, nutrients, FRR. Glider surfaced about a mile from the ship. When CTD was secured on deck, we went to the glider's position. Recovery went according to plan. Once we had a visual and ship got close enough, MARS sent the command to release the nose. After

about 10 minutes, the rope unspooled from the nose and a pole was used to grab it. Glider was brought on deck, inspected for biofouling, cleaned, oxygen cap was put on and secured in the hangar. No major biofouling was found on the sensors apart from some small barnacles on the edges of the oxygen sensor’s foil.




SLOCUM


nography Cent
NVIRONMENT RESEARCH CO

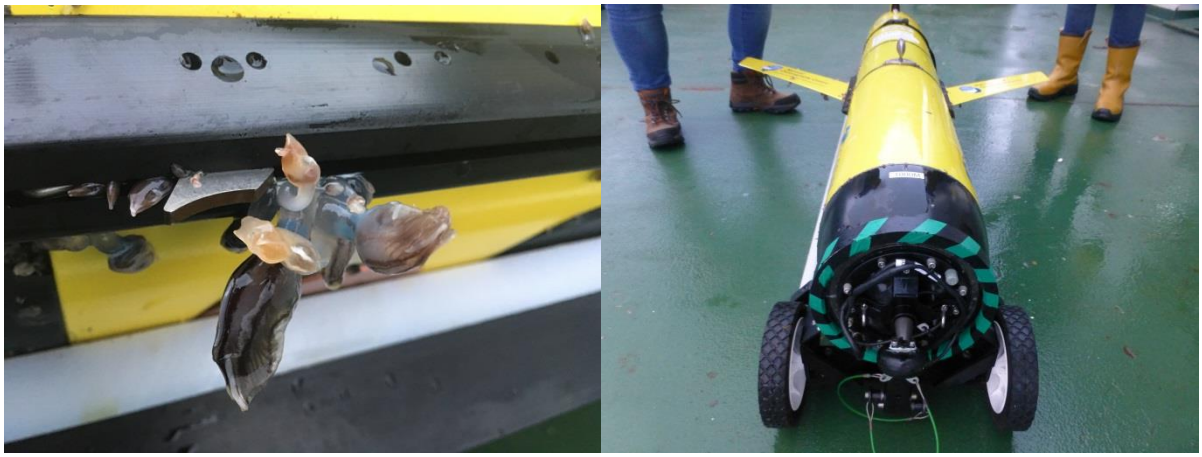
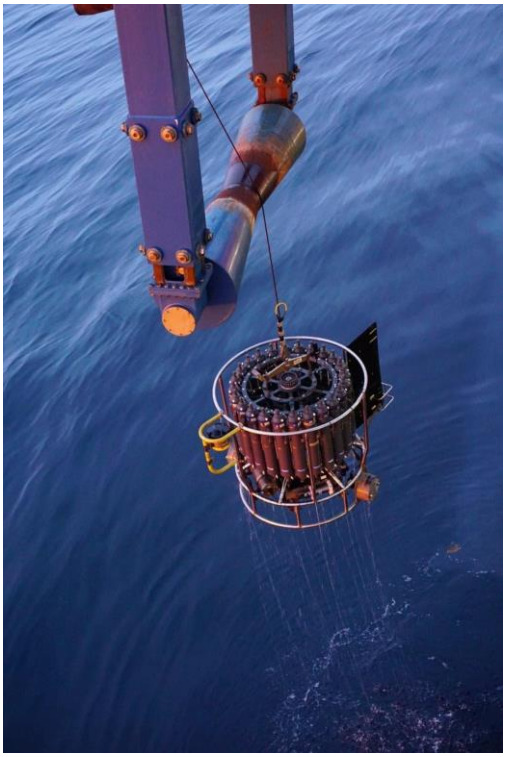


Figure 12: Glider (Doombar) shots during recovery, showing some of the biofouling – gooseneck barnacles

Later on, Candice (NMF technician) and Filipa opened the glider to remove the data cards. All connectors were disconnected and taped following advice from MARS. Glider was then closed. We tried to pull vacuum on the glider to prep it for shipping but did not have the proper tools to achieve it. Glider was secured in its box together with the toolbox.

National Oceanography Centre NMF Sensors and Moorings CTD, LADCP & SAPs Cruise Report DY090



Walvis Bay, Namibia – Cape Town, South Africa
23 May - 28 June 2018

---------- Report written by Candice Cameron ----------

-------- Final version: 24 June 2018

1 Table of Contents

2 Technical team

Senior Technical Officer: Jon Short (JS)

Ocean Engineering Group: Andy Leadbeater (AL)

Sensors and Moorings: John Wynar (JW) and Candice Cameron

(cander) Scientific Ship Systems: Martin Bridger and Jennifer Ward

Neale

3 Summary of CTD operations

A total of 39 CTD casts were completed during DY090; 30 casts were with the 24-way Stainless Steel (SS) frame and 9 casts were with the 24-way titanium, Trace Metal Free (TMF). A MDS CTD swivel was fitted to the SS frame; it was left attached to the frame between casts. During mobilisation a new electrical and mechanical termination was performed on the wire from ships winch "CTD1". Once complete the termination was tested and gave good continuity of 67-79ohms and an insulation test value of >999Mohms; this wire and termination was used through- out the cruise for the SS CTD. Due to water ingress having been discovered during testing a new electrical termination was performed during mobilisation on the TMF wire from the Lebus containerised winch. Following re-termination insulation tests gave approximately 4-6Mohms open circuit and 305Mohms short circuited; this termination was used through-out the cruise for the TMF CTD.

24 x 20litre Niskin water sample bottles were fitted to the SS frame and depending on scientist requirements between 12-14 "clean" (acid washed) 10litre Niskin water sample bottles were fitted to the TMF frame.

Upon embarkation both frames already had sensors attached as they had remained in place following DY086. Any outstanding sensors were added, all instrument serial numbers and all channels on the 9plus underwater unit checked. Subsequently "Sensor Information Sheets" were written and a configuration file built for each frame.

Between casts sensors were flushed with MilliQ three times before installation of caps on the TC-duct of both sensors. After the rosette had been sampled or in the case of the TMF frame bottles removed, the whole CTD package was rinsed with fresh water to prevent salt crystals forming in the sensors, associated

tubing and particularly the carousel latch assembly. Due to the frequent use of the CTD package and moderate temperatures, the TC-ducts were only cleaned once during the cruise with dilute bleach and Triton-X solutions.

The deepest cast descended to 3970m and the shallowest cast to 100m. A log sheet was completed for each cast and scanned; they are named with the following convention DY090_CTD###SS or DY090_CTD###TMF.pdf.

4 Stainless Steel (SS) CTD

4.1 SS CTD Operation

The SS CTD was operated from the forward Water Sampling Annex of the hangar. It was deployed on the 11.43mm conducting CTD wire - CTD1 - using the starboard P-Frame. The CTD was moved from the annex to the deck using overhead gantry crane 3; the swivel was left connected to the frame at all times with a strop linking the hook of the crane to the swivel and thereby the frame.

Once on deck the unit was connected to the CTD wire via the swivel, additional wire slack was taken up and when the winch operator, deck team and CTD operator were ready the CTD was powered up ready for deployment.

The reverse was done during recovery, returning the frame back into the hanger with the exception being when sampling time was short, a quick turnaround was required and weather permitted. On these occasions the CTD was landed on deck for sampling prior to prompt redeployment.

Logging of the LADCP was started either whilst the CTD was still in the hanger or, to reduce the acquisition of "deck data", once it had been moved onto deck. The LADCP was stopped and the data downloaded once the CTD frame was secure and back in the hanger. This was with the exception of when a quick turnaround was required, in these circumstances data was downloaded and the unit re-deployed with the CTD frame on deck.

Most casts sampled the top 1000m of water column. At stations where the CTD was sent to full depth the altimeter was used to identify the bottom and stop a safe distance from the seabed – nominally, 10m away.

After the first few casts Active Heave Control was used during the up-cast and then, subsequently during both the down and up-casts. This caused no mechanical problems and noticeably improved data stability during bottle stops.

Salinity sampling of the rosette was conducted by either the technical or science party depending on respective workloads.

4.2 SS CTD Configuration

4.2.1 **Frame Geometry**Error! Reference source not found.

Primary temperature, conductivity and a dissolved oxygen sensor were mounted within the frame, attached to the 9plus underwater unit. The secondary temperature and conductivity sensors were mounted on the vane.

The pressure sensor was located 16cm below the bottom and approximately 71cm below the centre of the 20L water sampling bottles.

4.2.2 Sensor and Instrument List

The following sensors were installed on the SS CTD frame:

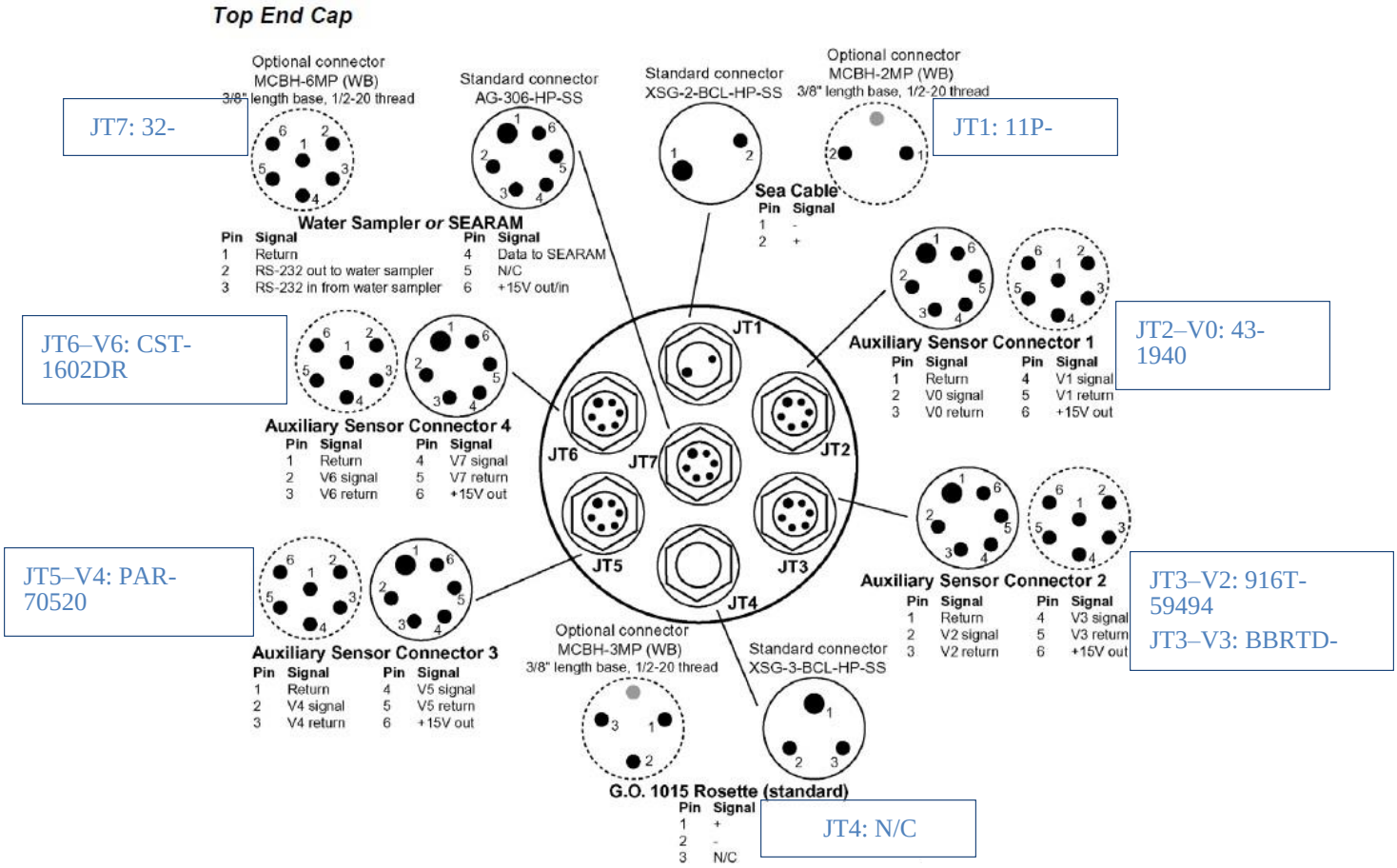
Instrument / Sensor:	Model:	Serial No:	Casts Used:
CTD Underwater Unit	SBE 9plus	09P-0943	All casts
Primary Temperature Sensor	SBE 3P	3P-4116	All casts
Primary Conductivity Sensor	SBE 4C	4C-3272	All casts
Digiquartz Pressure sensor	Paroscientific	110557	All casts
Secondary Temperature Sensor	SBE 3P	3P-4593	All casts
Secondary Conductivity Sensor	SBE 4C	4C-3768	All casts
Primary Pump	SBE 5T	05-7514	All casts
Secondary Pump	SBE 5T	05-3090	All casts
Dissolved Oxygen Sensor	SBE 43	43-1940	All casts
Altimeter	Benthos 916T	59494	All casts
Light Scattering Sensor	WETLabs BBRTD	BBRTD-169	001 – 009
Light Scattering Sensor	WETLabs BBRTD	BBRTD-1055	010 - 039
PAR Down-looking DWIRR	Biospherical QCP Cosine	70520	All casts
PAR Up-looking DWIRR	Biospherical QCP Cosine	70510	All casts
Transmissometer	WET Labs C-Star	CST-1602DR	All casts
Fluorometer	CTG Aquatracka MKIII	88-2615-126	All casts
Down-looking Master LADCP	TRDI/WHM300kHz	4275	All casts

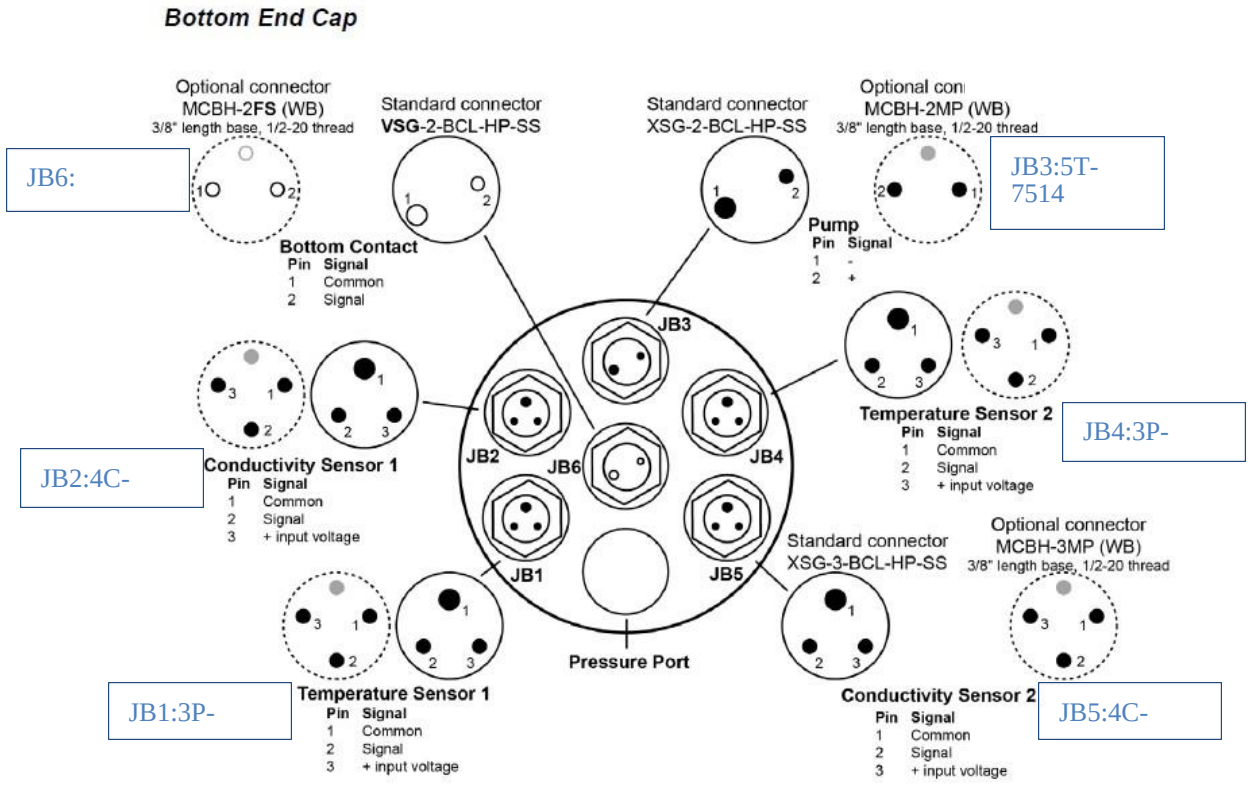
A scientist provided EcoPuck was fitted to the vane for most deployments (see science logs for detail) and a SBE 19plus for casts 006 and 007.

Casts 037 and 038 were calibration dips. For these, additional to the scientist provide EcoPuck, 2x optode's from the Respire mooring (vane), a scientist provided RBR sensor package (frame) and 4 x NMEP SBE39's (frame) were attached to the CTD.

For the final cast – 039 – just the scientist provided EcoPuck, RBR sensor package and NMEP SBE39's were attached.

4.2.3 9Plus connections and channels





Note: An SBE 9*plus* with dual temperature and conductivity sensors is supplied with two pumps, one for each TC pair. JB3 connects to both pumps with a Y-cable.

4.2.4 Instrument configuration file

The Seasave Instrument Configuration file used for casts 001 – 009 was DY090_SS.xmlcon. Subsequent to the switching out of BBRTD-169 for BBRTD-1055 Seasave Instrument Configuration DY090_SSa.xmlcon was used for casts 010 – 039.

4.2.4.1 DY090_SS.xmlcon

```
PSA file: C:\Users\sandm\AppData\Local\Sea-Bird\Seasave\Seasave_12.psa
Date: 06/23/2018
Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY090\Data\Seasave
Setup Files\DY090_SS.xmlcon
Configuration report for SBE 911plus/917plus CTD
-------------------------------------------------
Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Deck unit                     : SBE11plus Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : No
NMEA device connected to      : PC
Surface PAR voltage added     : No
Scan time added               : Yes

1) Frequency  0,  Temperature
   Serial  number  :  03P-4116
   Calibrated on : 13-MAR-2018
   G             : 4.42586592e-003
   H             : 6.84202885e-004
   I             : 2.43126463e-005
   J             : 1.98366466e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency  1,  Conductivity
   Serial  number  :  04C-3272
   Calibrated on : 13-MAR-2018
   G             : -9.77733495e+000
   H             : 1.27328893e+000
   I             : -1.46925898e-004
   J             : 7.04739172e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz
with TC
   Serial number : 110557
   Calibrated on : 3-Nov-2016
   C1            : -6.010548e+004
   C2            : -1.565601e+000
   C3            : 1.823090e-002
   D1            : 2.668300e-002
   D2            : 0.000000e+000
   T1            : 3.020528e+001
   T2            : -6.718318e-004
```

T3 : 4.457980e-006
T4 : 1.203850e-009
T5 : 0.000000e+000
Slope : 1.00000000
Offset : -0.09301
AD590M : 1.280700e-002
AD590B : -9.299640e+000

4) **Frequency 3, Temperature, 2** Serial number : 03P-4593
Calibrated on : 09-MAR-2018
G : 4.35402572e-003
H : 6.44553261e-004
I : 2.17659012e-005
J : 1.75622331e-006
F0 : 1000.000
Slope : 1.00000000Offset : 0.0000

5) **Frequency 4, Conductivity, 2** Serial number : 04C-3768
Calibrated on : 13-MAR-2018
G : -1.02294195e+001
H : 1.49894983e+000
I : -1.43376595e-003
J : 2.00310154e-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 : 43-1940
Calibrated on : 13-MAR-2018
Equation : Sea-Bird
Soc : 5.28200e-001
Offset : -5.04800e-001
A : -3.93550e-003
B : 1.90010e-004
C : -2.88950e-006
E : 3.60000e-002
Tau20 : 1.22000e+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, Altimeter

Serial number : 59494
Calibrated on :
Scale factor : 15.000
Offset : 0.000

9) A/D voltage 3, OBS, WET Labs, ECO-BB

Serial number : 169
Calibrated on : 09 August-2016
ScaleFactor : 0.005228
Dark output : 0.089000

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

Serial number : 70520
Calibrated on : 24-Jan-2017
M : 1.00000000
B : 0.00000000
Calibration constant : 16835016800.00000000
Multiplier : 1.00000000
Offset : -0.06092372

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

Serial number : 70510
Calibrated on : 24-Jan-2017
M : 1.00000000
B : 0.00000000
Calibration constant : 20449897800.00000000
Multiplier : 1.00000000
Offset : -0.04979765

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

Serial number : CST-1602DR
Calibrated on : 24-May-2016
M : 21.3038
B : -0.1065
Path length : 0.250

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

Serial number : 88-2615-126
Calibrated on : 22-July-2016
VB : 0.210900
V1 : 2.186200
Vacetone : 0.303700
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

Scan length : 41

Pump Control
This setting is only applicable to a custom build of the SBE 9plus.
Enable pump on / pump off commands: NO

Data Acquisition:
Archive data: YES
Delay archiving: NO
Data archive: C:\Users\sandm\Documents\Cruises\DY090\Data\CTD Raw Data\ctd_DY090_039.hex
Timeout (seconds) at startup: 60
Timeout (seconds) between scans: 20

Instrument port configuration:
Port = COM4
Baud rate = 19200
Parity = N
Data bits = 8
Stop bits = 1

Water Sampler Data:
Water Sampler Type: SBE Carousel
Number of bottles: 36

```
Port:                   COM5
Enable remote firing: NO
```

```
   Firing sequence:      User input
   Tone for bottle fire confirmation uses PC sound card.
-----------------------------------------
Header information:
   Header Choice = Prompt for Header Information
      prompt 0 = Ship: RRS Discovery
      prompt 1 = Cruise: DY090
      prompt 2 = Cast:
      prompt 3 = Station:
      prompt 4 = Julian Day:
      prompt 5 = Date:
      prompt 6 = Time:
      prompt 7 = Latitude:
      prompt 8 = Longitude:
      prompt 9 = Depth (uncorr m):
      prompt 10 = Principal Scientist: S Henson
      prompt 11 = Operator:
-----------------------------------------
TCP/IP - port numbers:
   Data acquisition:
      Data port:            49163
      Status port:          49165
      Command port:         49164
   Remote bottle firing:
      Command port:         49167
      Status port:          49168
   Remote data publishing:
      Converted data port:  49161
      Raw data port:        49160
-----------------------------------------
Miscellaneous data for calculations
   Depth, Average Sound Velocity, and TEOS-10
      Latitude when NMEA is not available:  58.900000
      Longitude when NMEA is not available: 0.000000
   Average Sound Velocity
      Minimum pressure [db]:                20.000000
      Minimum salinity [psu]:               20.000000
      Pressure window size [db]:            20.000000
      Time window size [s]:                 60.000000
   Descent and Acceleration
      Window size [s]:                      2.000000
   Plume Anomaly
      Theta-B:                              0.000000
      Salinity-B                            0.000000
      Theta-Z / Salinity-Z                  0.000000
      Reference pressure [db]               0.000000
   Oxygen
      Window size [s]:                      2.000000
      Apply hysteresis correction:          1
      Apply Tau correction:                 1
   Potential Temperature Anomaly
      A0:                                   0.000000
      A1:                                   0.000000
      A1 Multiplier:                        Salinity
-----------------------------------------
Serial Data Output:
   Output data to serial port: YES
   Seconds between updates:    0.000000
   Port      = COM3
   Baud rate = 9600
   Parity    = N
   Data bits = 8
   Stop bits = 1
```

```
   Variables:
   Digits   Variable Name [units]
   ------   --------------------
   1        Depth [salt water, m]
   1        Pressure, Digiquartz [db]
   4        Temperature [ITS-90, deg C]
   4        Temperature, 2 [ITS-90, deg C]
   4        Temperature Difference, 2 - 1 [ITS-90, deg C]
   4        Conductivity [mS/cm]
   4        Conductivity, 2 [mS/cm]
   4        Conductivity Difference, 2 - 1 [mS/cm]
   4        Salinity, Practical [PSU]
   4        Salinity, Practical, 2 [PSU]
   4        Salinity, Practical, Difference, 2 - 1 [PSU]
   1        Oxygen, SBE 43 [% saturation]
   2        Oxygen, SBE 43 [umol/kg]
   5        Beam Transmission, WET Labs C-Star [%]
   3        Oxygen, SBE 43 [% saturation]
-----------------------------------------------
Mark Variables:
   No variables are selected.
-----------------------------------------------
Shared File Output:
   Output data to shared file: NO
-----------------------------------------------
TCP/IP Output:
   Raw data:
      Output raw data to socket:              NO
      XML wrapper and settings:               NO
      Seconds between raw data updates:       0.000000
   Converted data:
      Output converted data to socket:        NO
      XML format:                             NO
-----------------------------------------------
SBE 11plus Deck Unit Alarms
   Enable  minimum  pressure  alarm:  NO
   Enable  maximum  pressure  alarm:  NO
   Enable altimeter alarm:           NO
-----------------------------------------------
SBE 14 Remote Display
   Enable SBE 14 Remote Display:     NO
-----------------------------------------------
PC Alarms
   Enable  minimum  pressure  alarm:  NO
   Enable  maximum  pressure  alarm:  NO
   Enable altimeter alarm:           NO
   Enable  bottom  contact  alarm:   NO
   Alarm uses PC sound card.
-----------------------------------------------
Options:
   Prompt to save program setup changes: YES
   Automatically save program setup changes on exit: NO
   Confirm instrument configuration change: YES
   Confirm display setup changes: YES
   Confirm output file overwrite: YES
   Check scan length: YES
   Compare serial numbers: YES
   Maximized plot may cover Seasave: NO
```

4.2.4.2 *DY090_SSa.xmlcon*

This configuration file was the same as DY090_SS.xmlcon with the exception of:

```
9) A/D voltage 3, OBS, WET Labs, ECO-BB
   Serial number : 1055
   Calibrated on : 30 March 2016
   ScaleFactor   : 0.003648
   Dark output   : 0.041600
```

4.2.5 LADCP Configuration

TRDI WHM 300kHz LADCP serial number 4275 was deployed in a downward-looking orientation on the SS CTD frame. Battery voltage from WH007 could not be monitored as the cable was diode protected. Log files (F3) were recorded for each deployment and built-in pre-deployment tests PA, PT200 and PC2 were run prior to each cast. As these tests are intended to be run with the instrument submerged in still water some elements are expected to fail in air. Shortly before deployment the following command file was sent (F2):

Master command file (DY090_Master.txt)

```
; Master WH300 LADCP
; modified EX from 11111 to 00100
; removed commands already set by default
; 6/29/2016 AEH
; copied from DY086. RNdy86_ changed to RNdy90_
; 24/05/2018 cander
;
WV250             ; ambiguity velocity [cm/s]
WN25              ; number of depth cells; NBP0402
WS1000            ; bin size [cm]; NBP0402: WS1000
WF0               ; blank after transmit [cm]; NBP0402
WB1               ; narrow bandwidth mode
EZ0011101         ; Sensor source: (NBP0402: EZ0111111)
EX00100           ; coordinate transformation: (NBP0402: 11111)
WP1               ; single-ping ensembles; NBP0402: WP3 most of the time
TP 00:00.00       ; time between pings; NBP0402
TE 00:00:01.50    ; time per ensemble
CF11101           ; Flow control:
SM1               ; set to master
SA011             ; send pulse before ensemble
SW5500            ; master waits .5500 s after sending sync pulse
RNdy90_
CK                ; keep params as user defaults (across power failures)
CS                ; start pinging
```

No problems were encountered with the LADCP. WH007 was vented prior to every cast.

4.3 SS CTD Sensor Failures

During cast 009 it was noticed that the up-cast of BBTRD-169 exhibited a substantially larger negative offset from the down-cast to the offset previously seen (Figures 1, 2, 3). Consequently BBRTD-169 was

swapped for BBRTD- 1055 prior to cast 010 and although a negative offset remained it was reduced to what had previously been seen on both SS and TMF casts.

Figure 1: DY090_CTD008SS

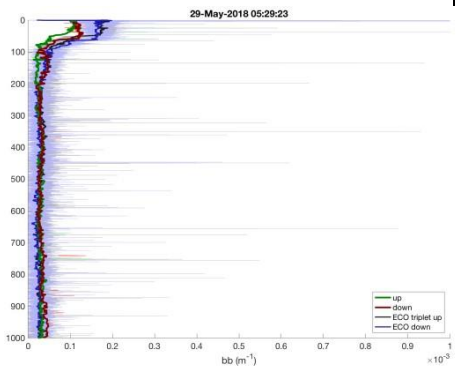


Figure 2: DY090_CTD009SS

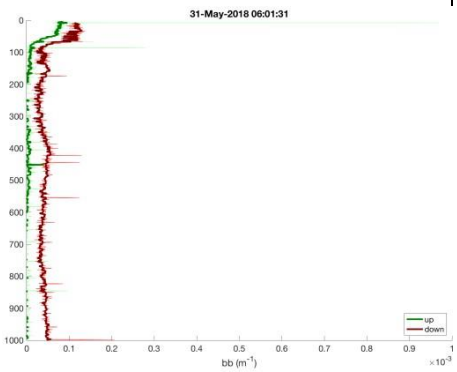
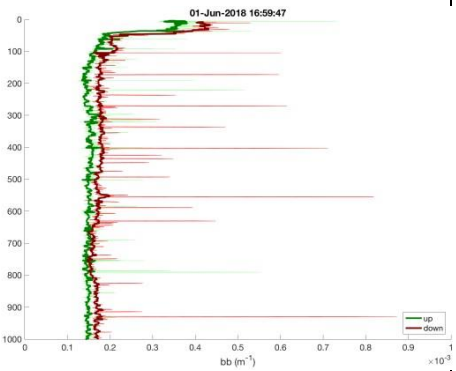


Figure 3: DY090_CTD010SS



4.4 SS CTD Niskin bottles

Niskin bottle number matched carousel position. There were some occasional issues with some bottles not firing. The majority were resolved by ensuring the carousel was thoroughly rinsed after and prior to each cast. An extension lanyard was fitted to the carousel for bottle 8 and resolved the issue.

Carousel position	**Cast** *(All were due to the catch on the carousel not releasing unless otherwise stated).*
5	18
7	12, 15
8	1, 18, 20, 24
9	4, 12, 13, 15, 16
12	33 (leak - bottom o'ring fell out and got trapped by the lid: replaced o'ring)
18	1, 9, 16
19	26
21	22, 34
23	18

Several of the o'rings on the taps of the bottles required replacing during the cruise. The number seemed unusually high – the blue o'rings appear to perish more quickly than the black ones.

4.5 SS CTD Cast summary

Julian day	Station number	Event number	Cast number	Max wire out (m)	Operator
144			001	1000	JW
147	BS1	46	004	1000	JS/CANDER
148			006	1000	JW
149	BS1	75	007	1000	JS/CANDER
149	BS1	76	008	1000	JS/CANDER
151	BS1	98	009	3970	JS/CANDER
152			010	1000	JW
154	BN1	135	012	1000	JW
155	BN1	148	013	1000	JS/CANDER
156	BN1	156	015	1000	JS/CANDER
157	BN1	185	016	1000	JS/CANDER
157	BN1	186	017	1000	JS/CANDER
158	BN1	199	018	1000	JS/CANDER
159			019	100	JW
160	BN2	228	020	1000	JS/CANDER
161	BN2	250	022	1000	JS/CANDER
162	BN2	260	023	1000	JS/CANDER
162	BN2	261	024	1000	JS/CANDER
164	BN2	310	026	1000	JS/CANDER
166	BN3	342	028	1000	JS/CANDER
167	BN3	369	030	2500	JS/CANDER
168	BN3	383	031	1000	JS/CANDER
169	BN3	399	033	1000	JS/CANDER
170	RS		034	500	JW
171	RS	449	035	3590	JS/CANDER
171			036	1000	JW
172	RS	457	037	250	JS/CANDER
172	RS	458	038	250	JS/CANDER
172	RS	459	039	500	JS/CANDER

Total wire out: 32,600m

4.6 SS CTD Data Processing

Basic post-processing of the CTD cast data was carried out to guidelines established with BODC using Sea-Bird Data Processing software. See document "BODC Basic_onboard_SBE_CTD_data_processing_guidelines.doc"

Data conversion, Bottle file generation, Align CTD, Cell thermal mass and Binaverage at 2Hz were the processes requested by the Chief Scientist.

Additionally the data was also processed (Data conversion only) for the Met Office.

5 Trace Metal Free (TMF) CTD

5.1 TMF CTD Operation

The TMF CTD was operated out of the aft Water Sampling Annex of the hangar. It was deployed on the Kevlar wire from the containerised Lebus Winch. The wire was left connected to the CTD through-out the cruise. The CTD was moved from the annex to the deck using overhead gantry crane 4 with a strop looped around either side of the bail.

Once on deck the TMF bottles were moved from the lab and secured to the frame, once the scientists, the winch operator, deck team and CTD operator were ready the CTD was powered up ready for deployment. The reverse was done on recovery, returning the frame back into the hanger.

All casts sampled the top 1000m of the water column only. Salinity sampling was conducted by the scientific party.

5.2 TMF CTD Configuration

5.2.1 Frame Geometry

Primary temperature, conductivity and a dissolved oxygen sensor were mounted within the frame, attached to the 9plus underwater unit. The secondary temperature and conductivity sensors were mounted on the vane.

The pressure sensor was located 33cm below the bottom and approximately 72cm below the centre of the 10L water sampling bottles.

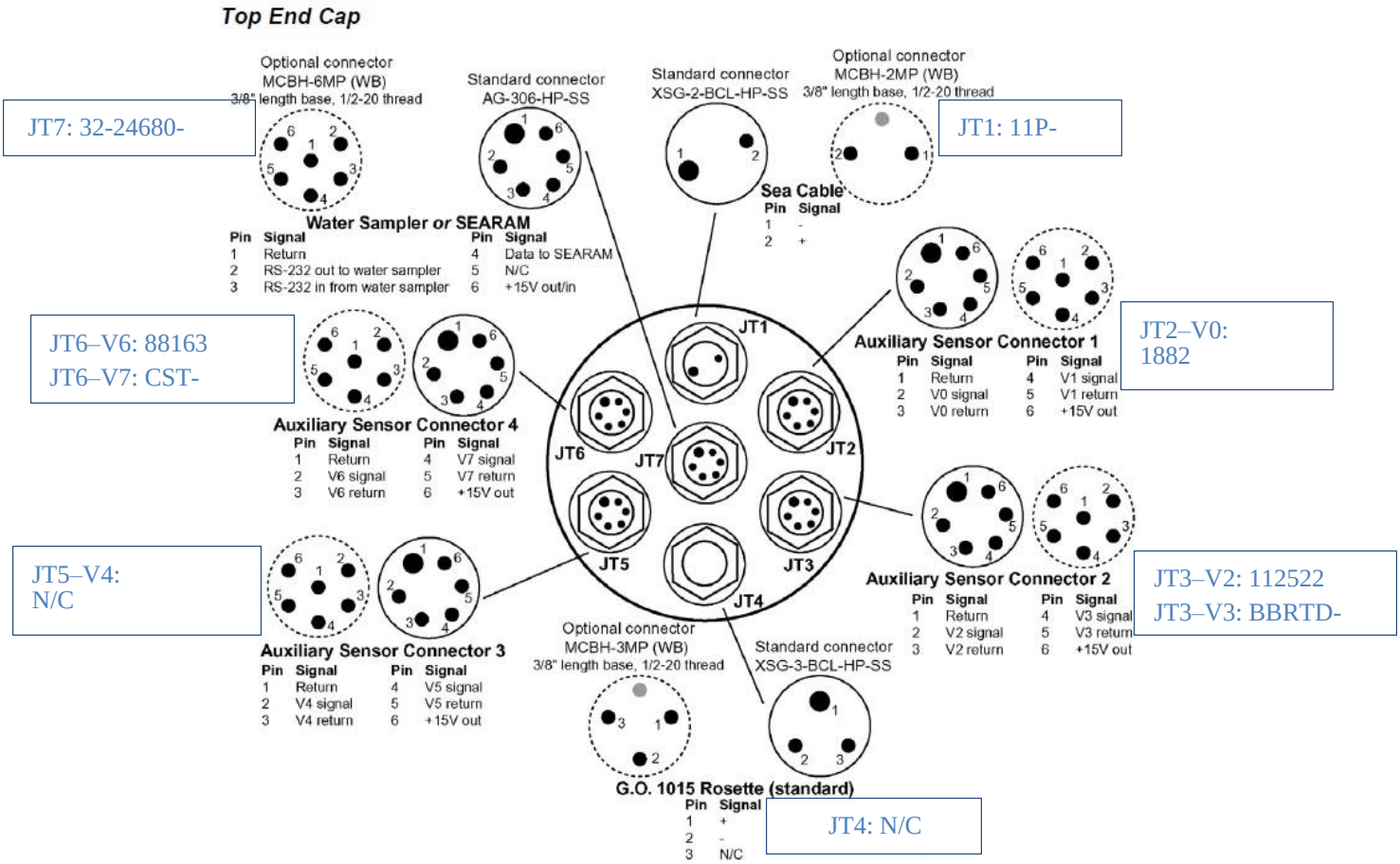
5.2.2 Sensor and Instrument List

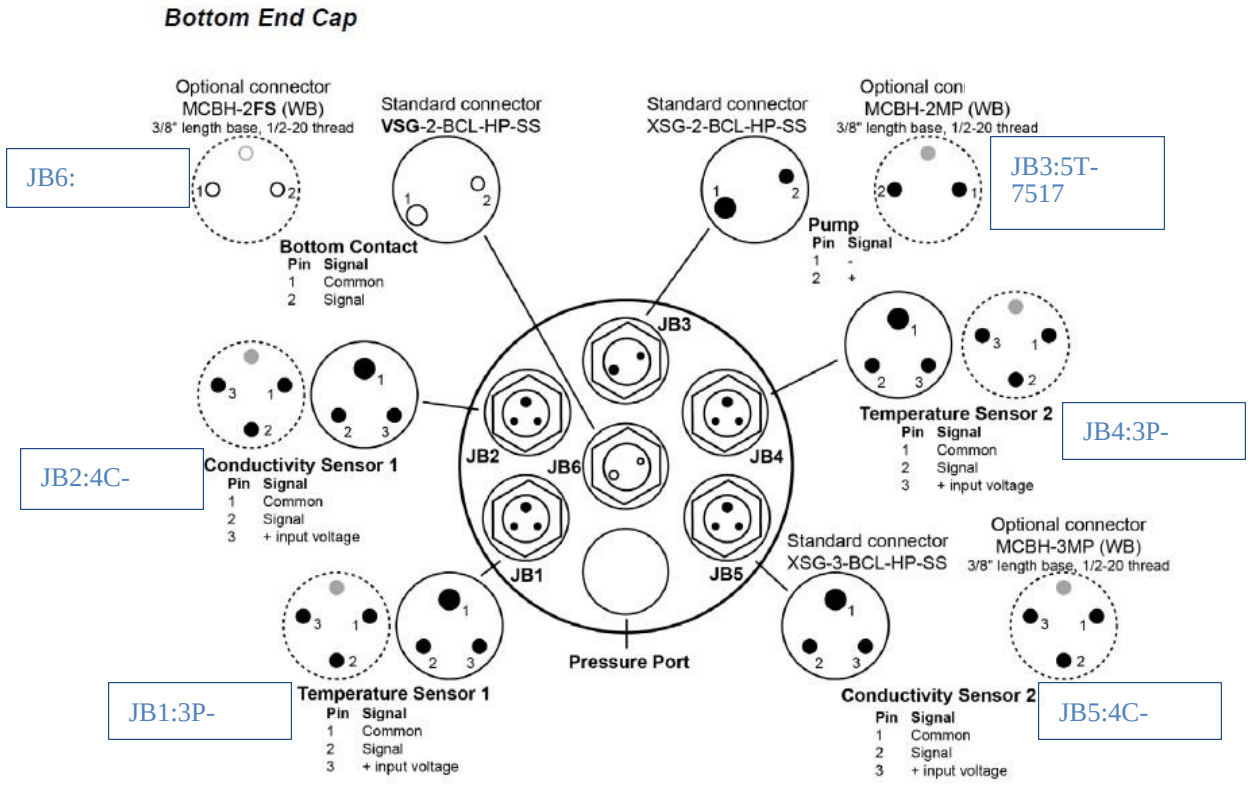
The following sensors were installed on the TMF CTD frame:

Instrument / Sensor:	Model:	Serial No:	Casts Used:
Primary CTD deck unit	SBE 11plus	11P-0589	All TMF casts
CTD Underwater Unit	SBE 9plus	09P-34173-0758	All TMF casts
Primary Temperature Sensor	SBE 3P	3P-4381	All TMF casts
Primary Conductivity Sensor	SBE 4C	4C-2164	All TMF casts
Digiquartz Pressure sensor	Paroscientific	90074	All TMF casts
Secondary Temperature Sensor	SBE 3P	3P-4712	All TMF casts
Secondary Conductivity Sensor	SBE 4C	4C-2858	All TMF casts
Primary Pump	SBE 5T	05-7517	All TMF casts
Secondary Pump	SBE 5T	05-7516	All TMF casts
Dissolved Oxygen Sensor	SBE 43	43-1882	All TMF casts
Altimeter	Benthos 916T	112522	All TMF casts
Light Scattering Sensor	WETLabs BBRTD	BBRTD-758	All TMF casts
Fluorimeter	CTG Aquatracka MKIII	88163	All TMF casts
Transmissometer	WET Labs C-Star	1759TR	All TMF casts

No additional sensors were added to the frame.

5.2.3 9Plus connections and channels





Note: An SBE 9*plus* with dual temperature and conductivity sensors is supplied with two pumps, one for each TC pair. JB3 connects to both pumps with a Y-cable.

5.2.4 Instrument configuration file

The Seasave Instrument Configuration file used for all casts was DY090_TITAa.xmlcon.

(Initial casts used DY090_TITA.xmlcon however the transmissometer calibration coefficients were found to be incorrect; they were corrected and the data was re-processed with the correct coefficients)

5.2.4.1 DY090_TITAa.xmlcon

```
PSA file: C:\Users\sandm\AppData\Local\Sea-Bird\Seasave\Seasave_12.psa

Date: 06/23/2018

Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY090\Data\Seasave
Setup Files\DY090_TITAa.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-4381
   Calibrated on : 09-MAR-2018
   G             : 4.42367025e-003
   H             : 6.45091240e-004
   I             : 2.27808121e-005
   J             : 2.00010594e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency  1,  Conductivity
   Serial  number  :  04C-2164
   Calibrated on : 13-MAR-2018
   G             : -1.02257511e+001
   H             : 1.41034910e+000
   I             : -2.83401684e-003
   J             : 2.66631033e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz
with TC
   Serial number : 0758
   Calibrated on : 26-May-15
   C1            : -6.571123e+004
   C2            : 2.050504e-001
   C3            : 1.612220e-002
   D1            : 2.883800e-002
   D2            : 0.000000e+000
   T1            : 2.986693e+001
   T2            : -2.678465e-004
   T3            : 3.986390e-006
   T4            : 7.472100e-010
   T5            : 0.000000e+000
   Slope         : 1.00000000
   Offset        : -0.23180
   AD590M        : 1.250000e-002
   AD590B        : -1.000000e+001

4) Frequency 3, Temperature, 2
   Serial  number  :  03P-4712
   Calibrated on : 09-MAR-2018
   G             : 4.40415489e-003
   H             : 6.33455385e-004
```

I : 1.92215273e-005
J : 1.18009555e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-2858
Calibrated on : 13-MAR-2018
G : -1.02383575e+001
H : 1.43969757e+000
I : 2.51516786e-004
J : 5.40818050e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-1882
Calibrated on : 13-MAR-2018
Equation : Sea-Bird
Soc : 4.83400e-001
Offset : -4.99800e-001
A : -4.83170e-003
B : 2.32770e-004
C : -3.35670e-006
E : 3.60000e-002
Tau20 : 1.26000e+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, Altimeter

Serial number : 11255
Calibrated on : 15 July 2013
Scale factor : 15.000
Offset : 0.000

9) A/D voltage 3, OBS, WET Labs, ECO-BB

Serial number : BBRTD-758
Calibrated on : 16 Aug 2016
ScaleFactor : 0.004068
Dark output : 0.051000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Fluorometer, Chelsea Aqua 3

Serial number : 088163
Calibrated on : 22 July 2016
VB : 0.057900
V1 : 2.111100
Vacetone : 0.240700
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

13) A/D voltage 7, Transmissometer, WET Labs C-Star

Serial number : CST-1759TR
Calibrated on : 22 December 2015
M : 21.3081
B : -0.1705
Path length : 0.250

```
Scan length                   : 41
-----------------------------------------
Pump Control
   This setting is only applicable to a custom build of the SBE 9plus.
   Enable pump on / pump off commands: NO
-----------------------------------------
Data Acquisition:
   Archive data:                    YES
   Delay archiving:                 NO
   Data archive:                    C:\Users\sandm\Documents\Cruises\DY090\Data\CTD
Raw Data\ctd_DY090_039.hex
   Timeout (seconds) at startup:    60
   Timeout (seconds) between scans: 20
-----------------------------------------
Instrument port configuration:
   Port      = COM4
   Baud rate = 19200
   Parity    = N
   Data bits = 8
   Stop bits = 1
-----------------------------------------
Water Sampler Data:
   Water Sampler Type:   SBE Carousel
   Number of bottles:    36
   Port:                 COM5
   Enable remote firing: NO
   Firing sequence:      User input
   Tone for bottle fire confirmation uses PC sound card.
-----------------------------------------
Header information:
   Header Choice = Prompt for Header Information
      prompt 0 = Ship: RRS Discovery
      prompt 1 = Cruise: DY090
      prompt 2 = Cast:
      prompt 3 = Station:
      prompt 4 = Julian Day:
      prompt 5 = Date:
      prompt 6 = Time:
      prompt 7 = Latitude:
      prompt 8 = Longitude:
      prompt 9 = Depth (uncorr m):
      prompt 10 = Principal Scientist: S Henson
      prompt 11 = Operator:
-----------------------------------------
TCP/IP - port numbers:
   Data acquisition:
      Data port:            49163
      Status port:          49165
      Command port:         49164
   Remote bottle firing:
      Command port:         49167
      Status port:          49168
   Remote data publishing:
      Converted data port:  49161
      Raw data port:        49160
-----------------------------------------
Miscellaneous data for calculations
```

```
Depth, Average Sound Velocity, and TEOS-10
   Latitude when NMEA is not available:  58.900
   Longitude when NMEA is not available: 0.000
Average Sound Velocity
   Minimum pressure [db]:                20.000
   Minimum salinity [psu]:               20.000
   Pressure window size [db]:            20.000
   Time window size [s]:                 60.000
Descent and Acceleration
   Window size [s]:                      2.000
Plume Anomaly
   Theta-B:                              0.000
   Salinity-B                            0.000
   Theta-Z / Salinity-Z                  0.000
   Reference pressure [db]               0.000
Oxygen
```

```
      Window size [s]:                      2.000
      Apply hysteresis correction:          1
      Apply Tau correction:                 1
   Potential Temperature Anomaly
      A0:                                   0.000
      A1:                                   0.000
      A1 Multiplier:                        Salinity
-------------------------------------------
Serial Data Output:
   Output data to serial port: YES
   Seconds between updates:    0.000
   Port      = COM3
   Baud rate = 9600
   Parity    = N
   Data bits = 8
   Stop bits = 1
   Variables:
   Digits   Variable Name [units]
   ------   ---------------------
   1        Depth [salt water, m]
   1        Pressure, Digiquartz [db]
   4        Temperature [ITS-90, deg C]
   4        Temperature, 2 [ITS-90, deg C]
   4        Temperature Difference, 2 - 1 [ITS-90, deg C]
   4        Conductivity [mS/cm]
   4        Conductivity, 2 [mS/cm]
   4        Conductivity Difference, 2 - 1 [mS/cm]
   4        Salinity, Practical [PSU]
   4        Salinity, Practical, 2 [PSU]
   4        Salinity, Practical, Difference, 2 - 1 [PSU]
   1        Oxygen, SBE 43 [% saturation]
   2        Oxygen, SBE 43 [umol/kg]
   5        Beam Transmission, WET Labs C-Star [%]
   3        Oxygen, SBE 43 [% saturation]
-------------------------------------------
Mark Variables:
   No variables are selected.
-------------------------------------------
Shared File Output:
   Output data to shared file: NO
-------------------------------------------
TCP/IP Output:
   Raw data:
      Output raw data to socket:            NO
      XML wrapper and settings:             NO
      Seconds between raw data updates:     0.000
   Converted data:
      Output converted data to socket:      NO
      XML format:                           NO
-------------------------------------------
SBE 11plus Deck Unit Alarms
   Enable minimum pressure alarm:  NO
   Enable maximum pressure alarm:  NO
   Enable altimeter alarm:         NO
-------------------------------------------
```

```
SBE 14 Remote Display
   Enable SBE 14 Remote Display:     NO
-----------------------------------------
PC Alarms
   Enable  minimum  pressure  alarm:  NO
   Enable  maximum  pressure  alarm:  NO
   Enable altimeter alarm:           NO
   Enable  bottom  contact  alarm:   NO
   Alarm uses PC sound card.
-----------------------------------------
Options:
   Prompt to save program setup changes: YES
   Automatically save program setup changes on exit: NO
   Confirm instrument configuration change: YES
   Confirm display setup changes: YES
   Confirm output file overwrite: YES
   Check scan length: YES
   Compare serial numbers: YES
   Maximized plot may cover Seasave: NO
```

5.3 TMF CTD Sensor Failures

During cast 005 a step change in the Fluorescence data was noted; upon investigation water ingress and significant corrosion was found at the connector between the Y-splice cable and cable to the sensor. Both the Y cable and sensor cable were replaced and the problem was resolved.

A similar step in Fluorescence was again exhibited during cast 021 – this time there was no sign of water ingress at the cable but the connectors at the sensor and Y-splice cable were cleaned, silicone applied and re-mated. This resolved the problem and no further issues were experienced through-out the cruise.

5.4 TMF CTD Niskin bottles

Between 12 and 14 “clean” Niskin bottles were attached to the frame prior to each deployment – the bottle number matched carousel position. There were no issues with the bottles firing or closing.

5.5 TMF CTD Cast summary

Julian day	Station number	Event number	Cast number	Max wire out (m)	Operator
145	Test	9	002	1000	JS/CANDER
146	BS1	29	003	1000	JS/CANDER
148	BS1	60	005	1000	JS/CANDER
153	BN1	108	011	1000	JS/CANDER
155	BN1	156	014	1000	JS/CANDER

160	BN2	229	021	1000	JS/CANDER
163	BN2	290	025	1000	JS/CANDER
165	BN3	320	027	1000	JS/CANDER
168	Wire stream	388	032	1000	JS/CANDER

Total wire out: 9,000m

Note: Between 1000-750m, during cast CTD027 the wire picked up a little slack which in turn resulted in uneven scrolling. As two water bottles - one at 1000m and one at 750m - had been fired it would have contaminated the 750m sample to descend again. The scrolling was assessed and it was decided that it should not cause too much of a problem and so ascent was continued with scrolling closely monitored. The CTD was successfully recovered and an extra deployment, without bottles was conducted to stream the wire and resolve the scrolling issue (CTD032).

5.6 TMF CTD Data Processing

Basic post-processing of the CTD cast data was carried out to guidelines established with BODC using Sea-Bird Data Processing software. See document "BODC Basic_onboard_SBE_CTD_data_processing_guidelines.doc"

Data conversion, Bottle file generation, Align CTD, Cell thermal mass and Binaverage at 2Hz were the processes requested by the Chief Scientist.

Additionally the data was also processed (Data conversion only) for the Met Office.

6 BBTRD offset investigation

During the first few casts it was noted by a scientist that the BBRTD on both the TMF and SS frames exhibit a negative offset between the down and up-cast and that this is unexpected. The scientist provided EcoPuck, mounted of the vane showed no such offset.

With no scientist having taken such an interest in turbidity data during the past experience of the technicians on- board such a profile was what was expected. Both technicians and scientist were perplexed by the disparity.

Technicians with greater experience were emailed enquiring as to whether they knew of the cause – no one did.

After much discussion and consideration it was hypothesised that the offset was being generated by the movement of the CTD frame through the water column causing particles to behave differently between descent and ascent.

To test this hypothesis BBRTD-758 on the TMF frame was changed from being mounted vertically to horizontally prior to the final cast, CTD029TMF. A simple check using a blank piece of white paper on a clip-board was conducted to check that the beam would not be interrupted by any other instruments or the frame itself.

This change in orientation reduced the offset previously seen and the up-cast profile closely followed that of the down-cast. Plots demonstrating this follow.

Figure 4: CTD025TMF - BBRTD orientation = vertical

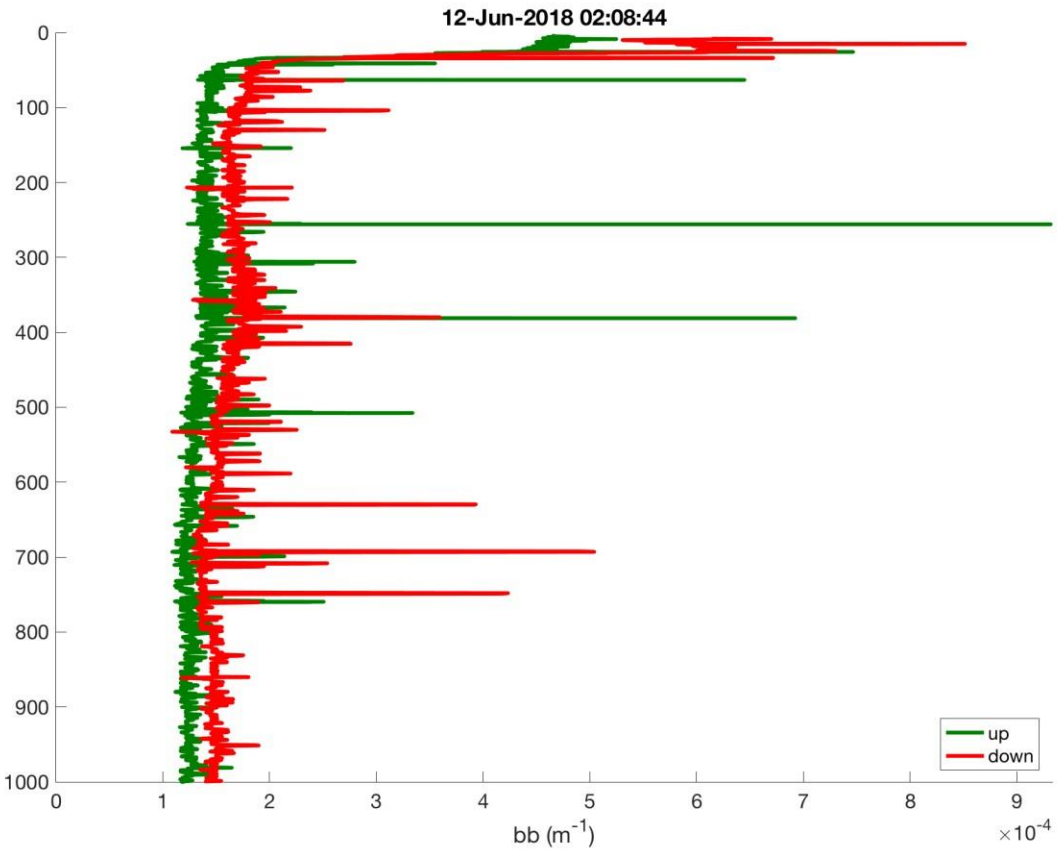


Figure 5: CTD027TMF - BBRTD orientation = vertical

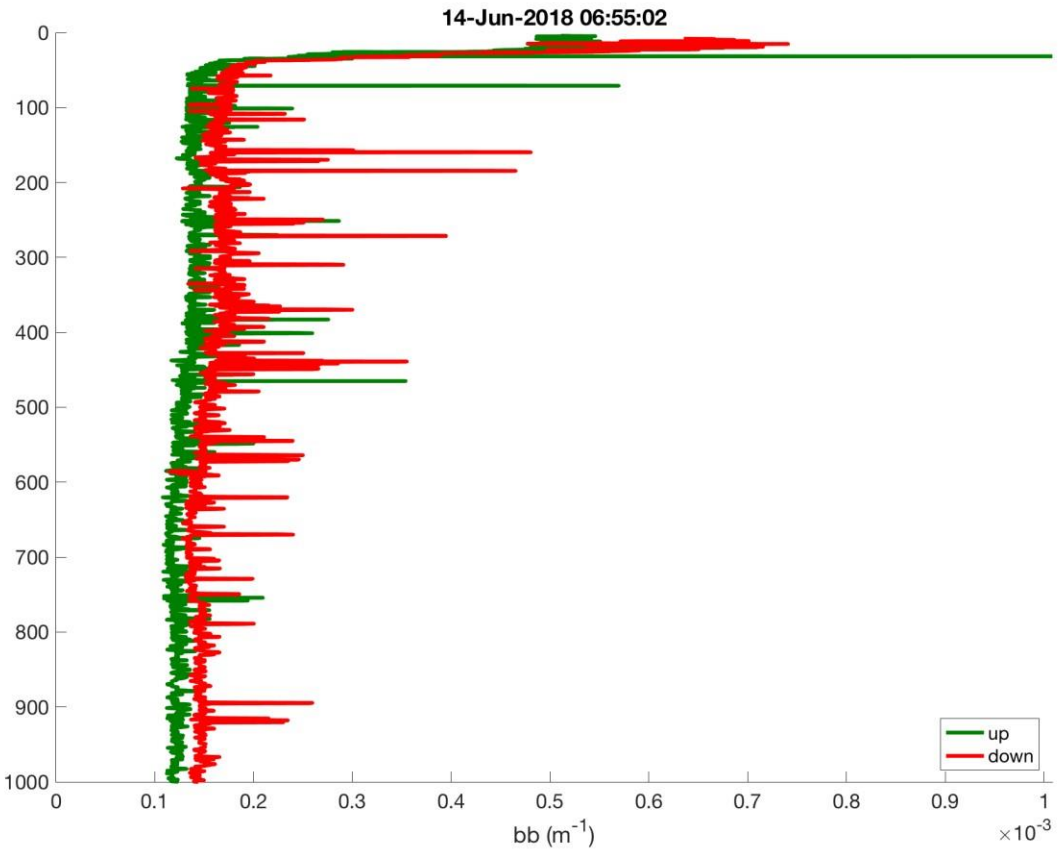
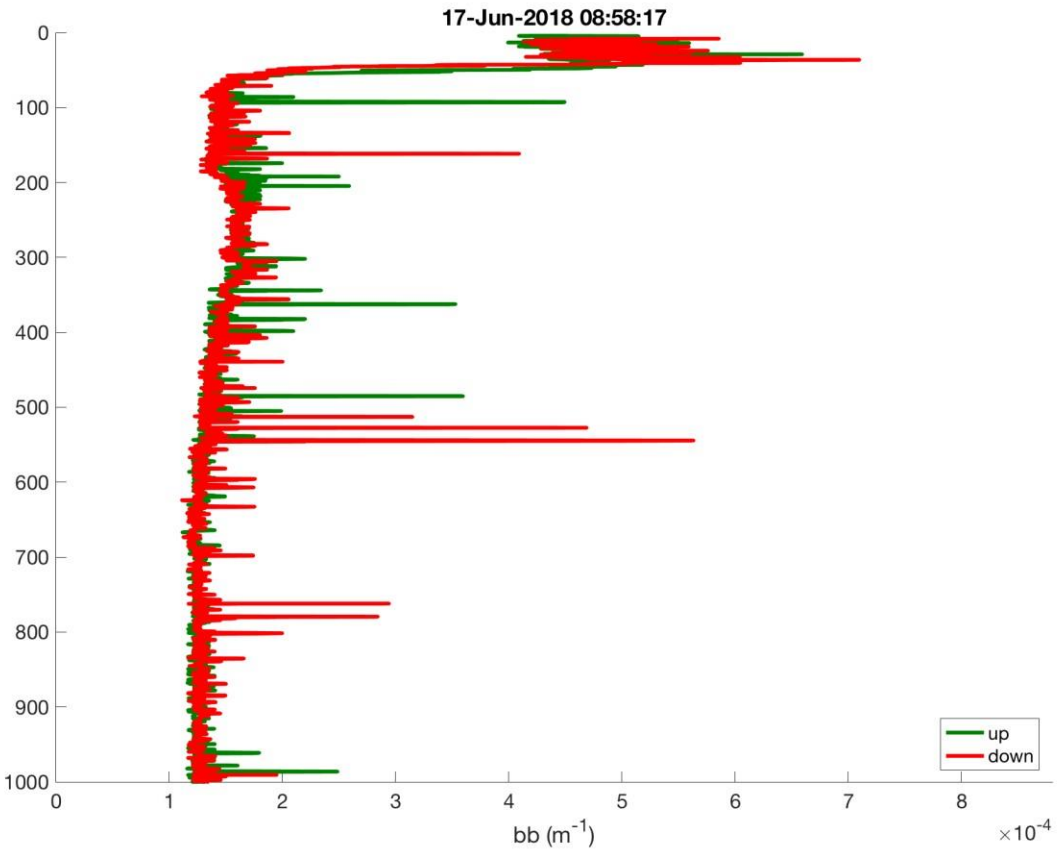


Figure 6: CTD032TMF - BBRTD orientation = horizontal



Following the success of mounting the BBRTD on the TMF frame horizontally the orientation of BBRTD-1055 on the SS frame was also changed prior to cast 033.

Initial results comparing previous SS to CTD033 were positive. The negative offset between the down and up-cast seems to have been resolved between 1000m and 300m however the disparity remains between approximately 300m to 100m. This is also reflected in profile 036.

It is difficult to compare casts 034, 037, 038 and 039 as these were shallow profiles of 250m or 500m depth however the data does show a similar trend of the down and up-casts matching at the bottom of the profile and diverging towards the surface.

Cast 035 is an anomaly as it exhibits either a positive offset on the down-cast or a negative offset on the up-cast for the entire profile, a feature that has not been seen previously.

Figure 7: CTD030SS - BBRTD orientation = vertical

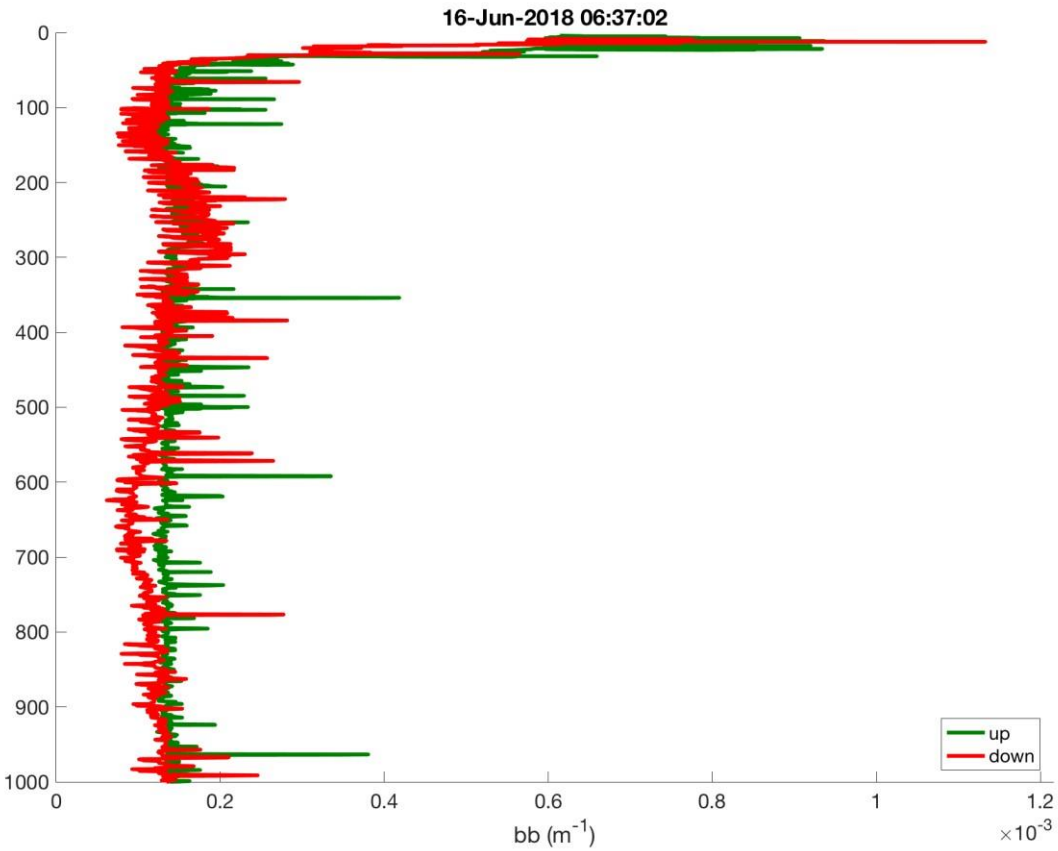


Figure 8: CTD031SS - BBRTD orientation = vertical

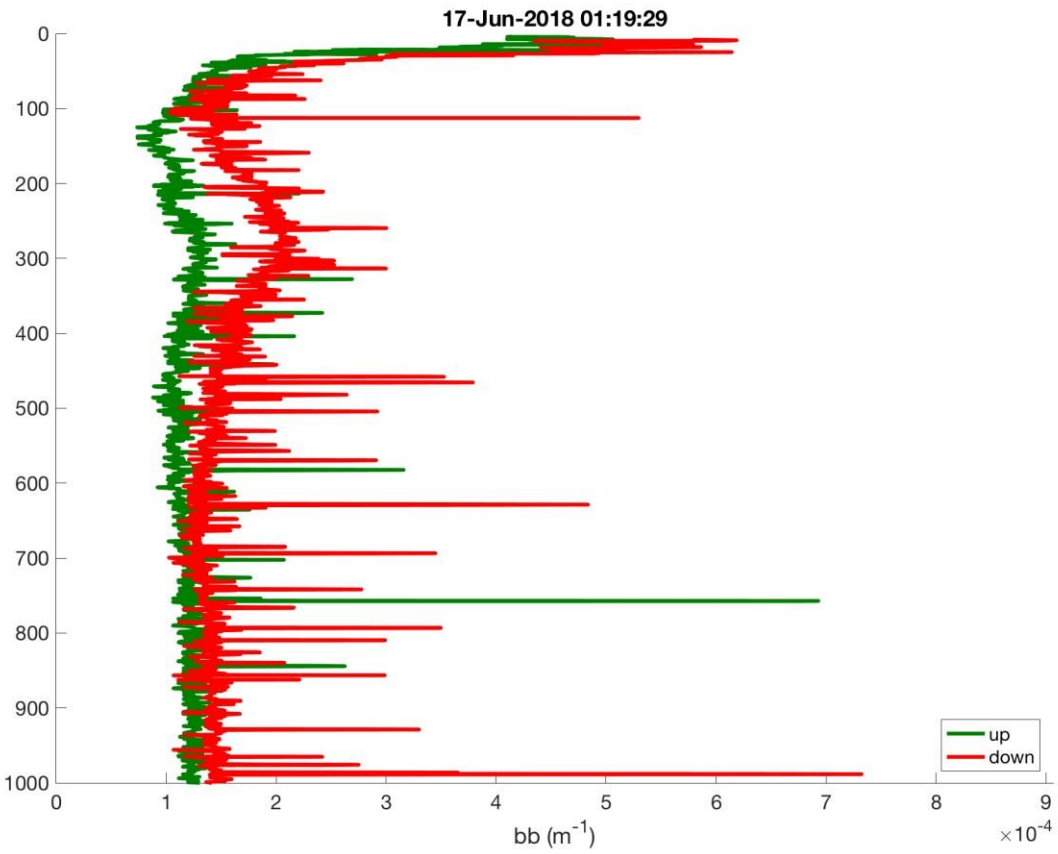


Figure 9: CTD0033SS - BBRTD orientation = horizontal

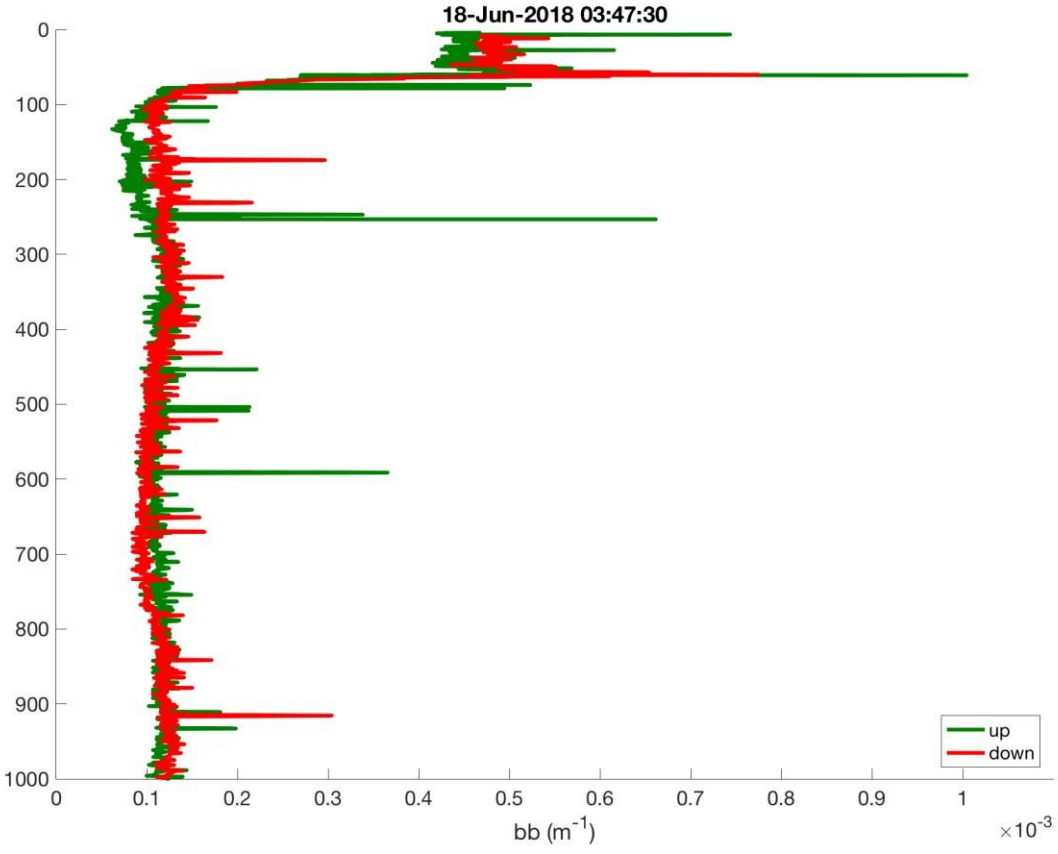


Figure 10: CTD034SS - BBRTD orientation = horizontal

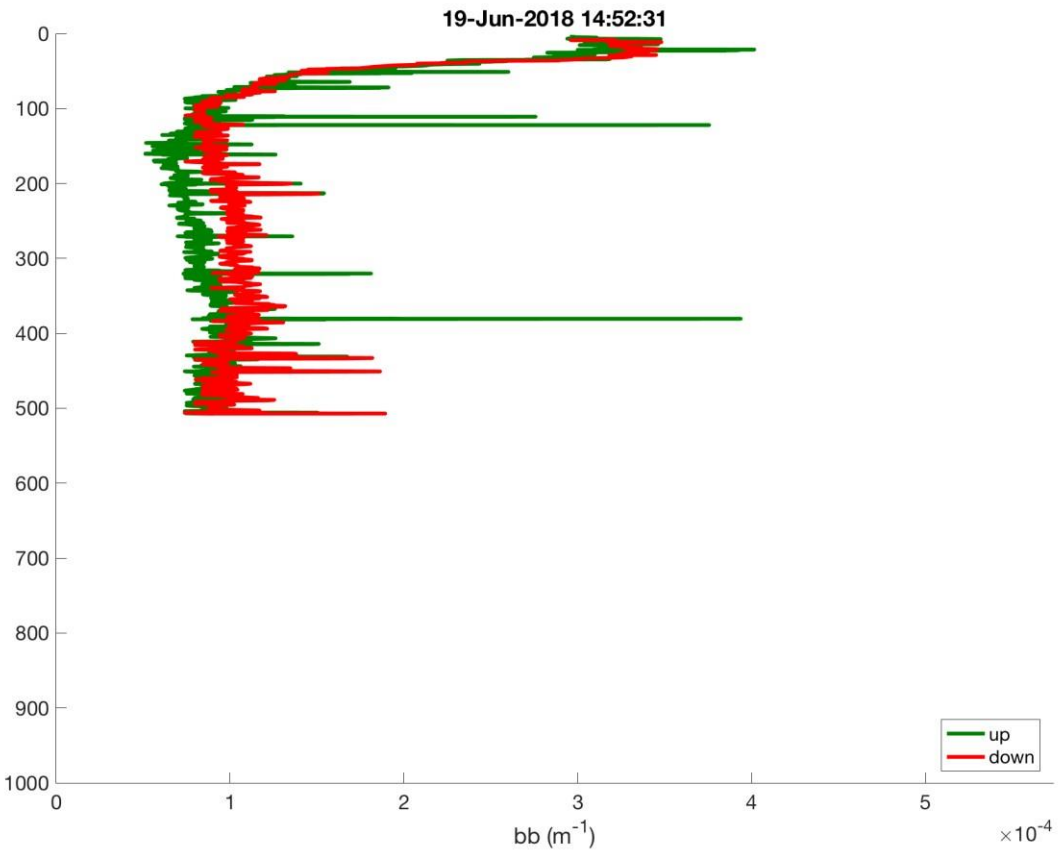


Figure 11: CTD035SS - BBRTD orientation = horizontal

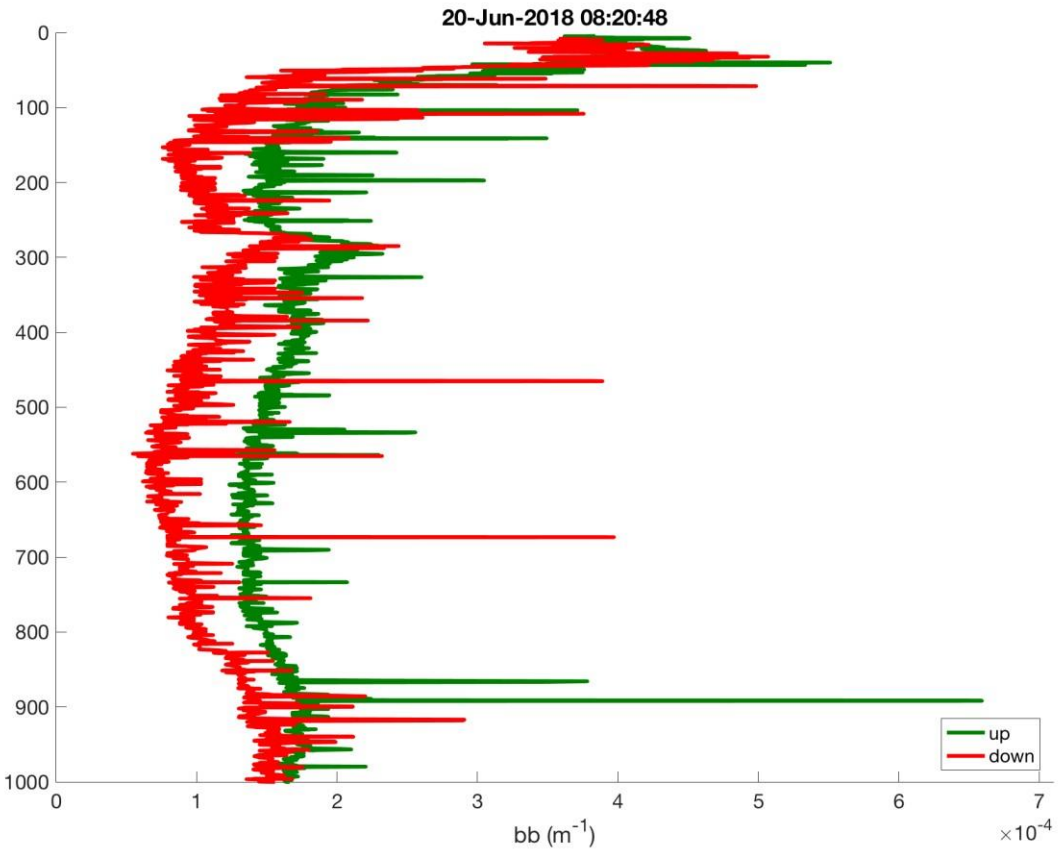


Figure 12: CTD036SS - BBRTD orientation = horizontal

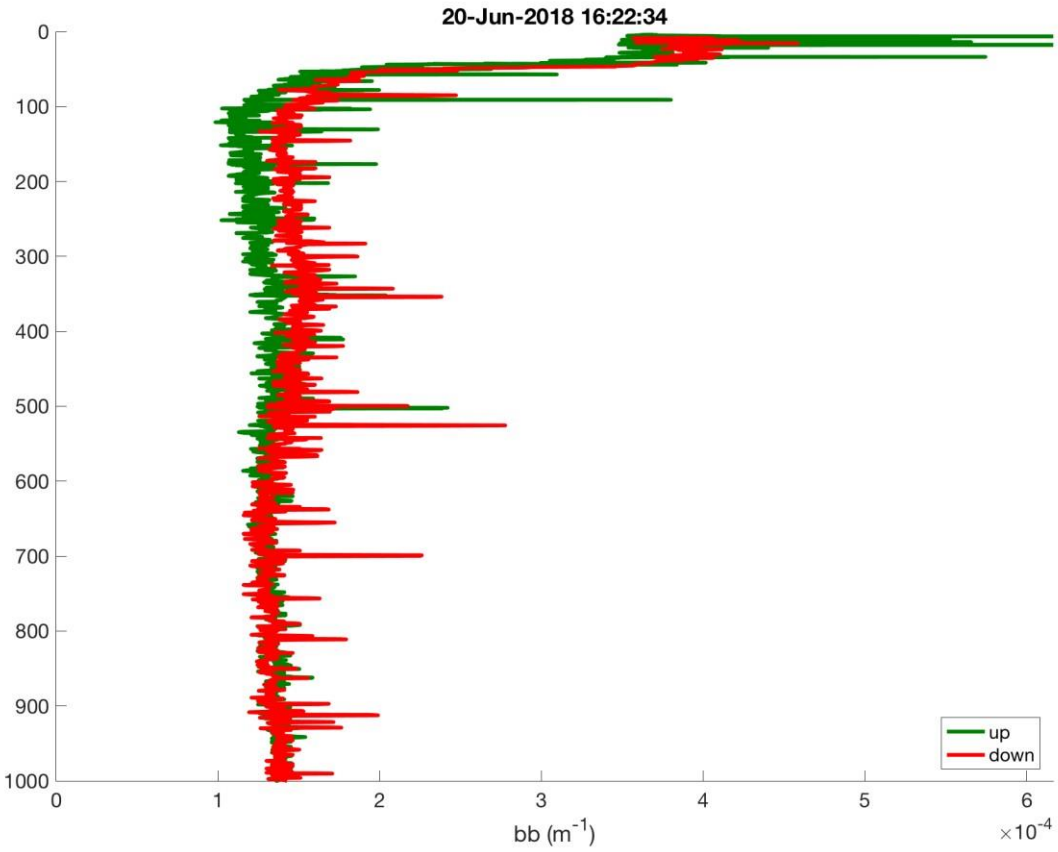


Figure 13: CTD037SS - BBRTD orientation = horizontal

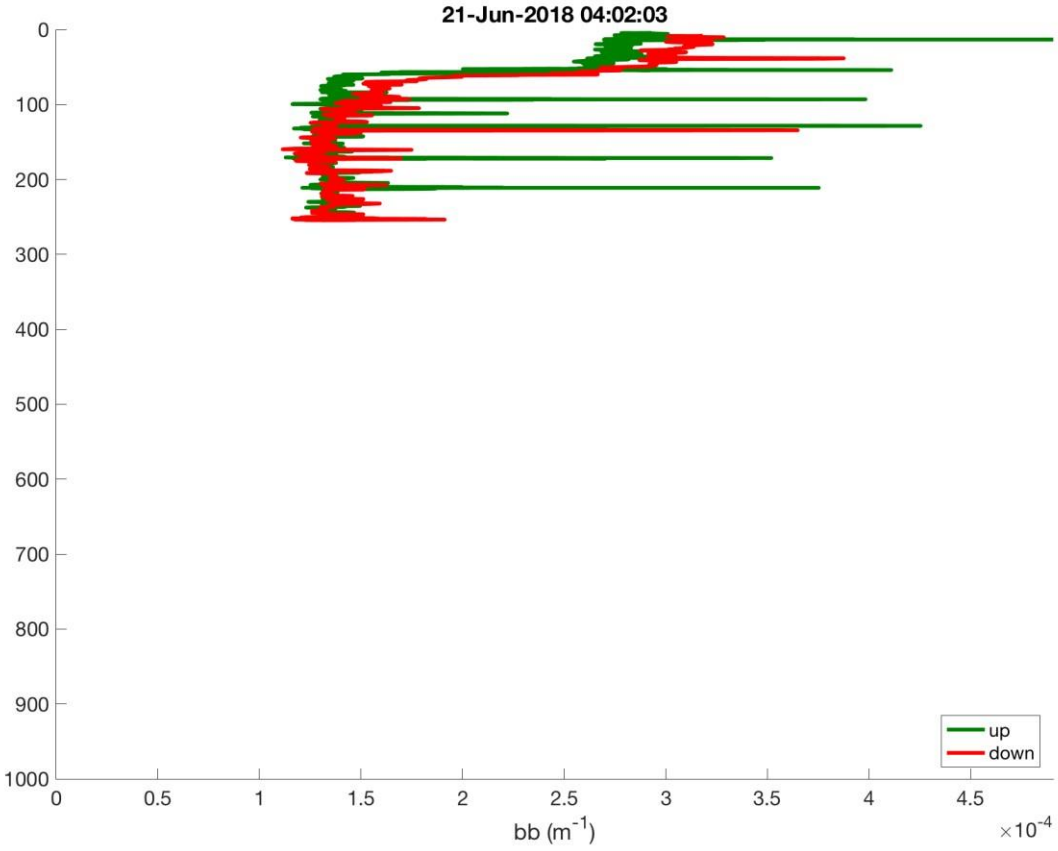


Figure 14: CTD038SS - BBRTD orientation = horizontal

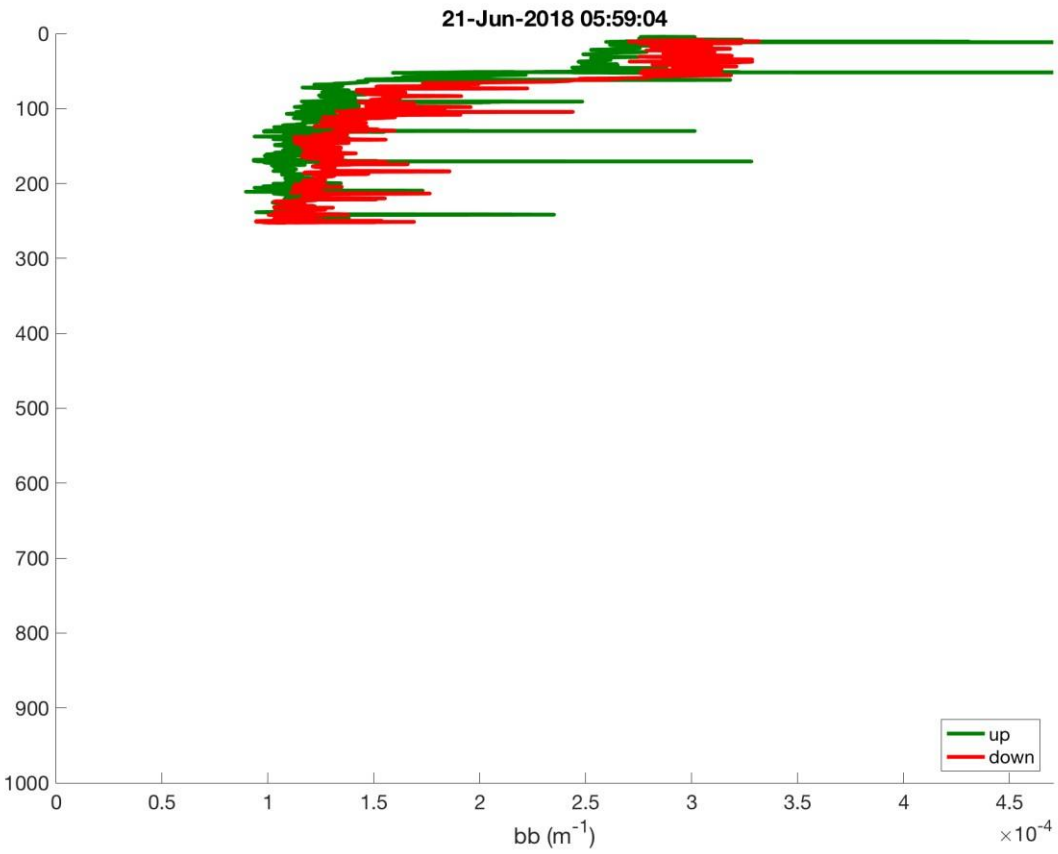
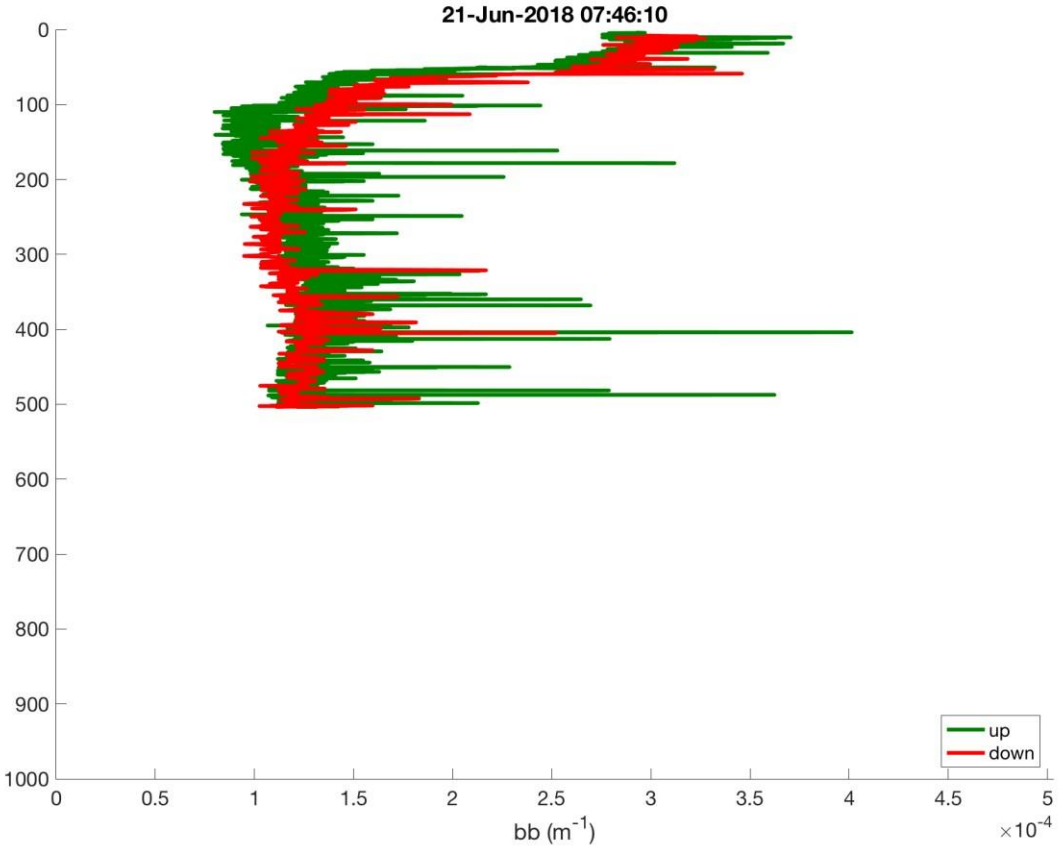


Figure 15: CTD039SS - BBRTD orientation = horizontal



It is surmised that mounting BBTRDs horizontally does provide more accurate data with the up-cast data matching that of the down-cast. It is thought that this is because by mounting the sensor in this way the difference in the effect of the CTD frame moving through the water column between the down and up-casts is lessened.

The effect of changing the sensor orientation was less conclusive on the SS frame than that demonstrated on the TMF frame. As CTD032TMF was deployed without bottles whilst the SS frame still had bottles attached, it is further hypothesised that the presence or otherwise of Niskin bottles may also effect BBRTD data and therefore that the best placement for BBTRDs maybe horizontally on the vane.

Consequent to the above further investigation is recommended with the following tests suggested:

- Determine more conclusively whether having a BBRTD mounted vertically or horizontally does indeed effect a positive change in data quality.
  - Perform further comparative casts between the BBRTD being mounted vertically versus horizontally within the frame.
  - Ideally two BBRTDs (one mounted vertically and the other horizontally) acquiring data on the same frame and at the same time.
  - It is suggested that the two sensors swap positions after a few casts to demonstrate that any observed difference is due to orientation and not sensor differences.
- Determine whether having a BBRTD mounted away from the influence of the frame/ bottles has a positive effect on data accuracy.
  - Comparative casts between a BBTRD mounted in its normal position within the frame versus a BBTRD mounted on the vane.
  - Ideally two BBTRDs acquiring data on the same frame and at the same time.
  - It is suggested that the two sensors swap positions after a few casts to demonstrate that any observed difference is due to location and not sensor differences.
  - It is suggested that this experiment is carried out with the sensors mounted vertically and then horizontally to demonstrate further whether orientation impacts data quality.

In the meantime ensuing from conversations with the scientist on-board it is recommended that BBTRDs are mounted in their normal position either vertically or horizontally but that only down-cast data should be used.

7 Salt Analysis

127 salinity samples were analysed. 108 were taken from the SS frame; these were taken by both scientists and technicians whilst the 19 taken from the TMF frame were solely taken by the scientists.

All samples were analysed on Guildline Autosal 8400B serial number 71185 by John Wynar (NMF).

A standard was run as a sample before and after each crate of samples as a control; IAPSO Standard Seawater batch P160 (K15=0.99983, 2xK15=1.99966, 34.993 PSU) was used.

A data file from the analysis software is supplied for each crate as an Excel spreadsheet.

8 In-Situ Pumps (SAPs)

Six Challenger Oceanic Stand Alone Pumps were used on the cruise:

Serial Number	Name
03-01	Chloe
03-02	Minnie
02-003	Polly
02-004	Sandie
04-13	Wendy
	Ringo

SAPs Chloe, Minnie, Polly, Sandie and Wendy belong the NMEP. SAP Ringo was provided by the scientific party.

8.1 SAP Configuration

For the first deployment all SAP units were configured to pump for 1hour with a delay time of 1.5hr. All proceeding casts the SAPs were configured to pump for 1hour with a delay time of 1hr.

293mm double chamber pancake filter housings were used with a 90 degree elbow on the inlet and the outlet plumbed directly into the flow-meter. The filters were supplied and fitted by the scientist. The inlet elbows were protected by small zip-lock bags until just before deployment.

For all deployments a 500kg weight was used as ballast.

Recovery was begun approximately 5 minutes after the anticipated completion time of pumping.

8.2 Sea-Bird SBE 39 Temperature & Pressure Loggers

For deployments 001 and 002 each SAP (except for Ringo) was fitted with a SBE39 logger. Subsequent to this some of the SBE39's were used on red camera frame and RESPIRE mooring deployments. This is recorded in the next section "Deployment summary".

Sample interval was set to 60 seconds, real-time output was enabled to confirm logging pre and post deployment and the instruments were configured to record temperature and pressure. Data was downloaded in ASCII using Sea-term to obtain .asc data files.

8.3 Deployment Summary

A total of 8 deployments were completed.

X = deployed

Deployment	Chloe	Minnie	Polly	Sandie	Wendy	Ringo
1	X SBE39-6756	X SBE39-6755	X SBE39-6757	X SBE39-6754		X
2	X SBE39-6756	X SBE39-6755	X SBE39-6757	X SBE39-6754		X
3	X	X SBE39-6755	X SBE39-6757	X	X	X
4	X	X SBE39-6755	X SBE39-6757	X	X	X
5	X	X SBE39-6755	X SBE39-6757	X	X	
6	X	X SBE39-6755	X SBE39-6757	X	X	
7	X	X SBE39-6755	X SBE39-6757	X	X	
8	X	X	X	X	X	

Detailed summary:

POLLY

Date	Station	Event	Cast	Voltage	Depth (m)	Delay Time	Pump Time	Time On	Pump Start	Pump End Time	Time (mins) Pumped	Start Count (L)	End Count (L)	Amount Pumped
27-May	BS1	49	1	17.0	450	01:30	01:00	09:23	10:53	11:53	60	357300	357842	542
29-May	BS1	77	2	17.3	450	01:00	01:00	09:22	10:22	11:22	60	357844	358410	566
04-Jun	BN1	157	3	17.0	400	01:00	01:00	09:45	10:45	11:45	60	358413	358954	541
09-Jun	BN2	230	4	17.2	500	01:00	01:00	08:53	09:53	10:53	60	358955	359471	516
12-Jun	BN2	291	5	17.4	500	01:00	01:00	07:48	08:48	09:48	60	359473	359922	449
15-Jun	BN3	345	6	17.5	500	01:00	01:00	07:55	08:55	09:55	60	359924	360375	451
17-Jun	BN3	387	7	17.3	500	01:00	01:00	07:54	08:54	09:54	60	360377	360847	470
21-Jun	RS	460	8	17.6	250	01:00	01:00	11:28	12:28	13:28	60	360845	361288	443
													TOTAL Amount Pumped	3978

CHLOE

Date	Station	Event	Cast	Voltage	Depth (m)	Delay Time	Pump Time	Time On	Pump Start	Pump End Time	Time (mins) Pumped	Start Count (L)	End Count (L)	Amount Pumped
27-May	BS1	49	1	17.0	200	01:30	01:00	09:24	10:54	11:54	39	258790	259250	460
29-May	BS1	77	2	16.8	200	01:00	01:00	09:23	10:23	11:23	34	259253	259665	412
04-Jun	BN1	157	3	17.1	250	01:00	01:00	09:48	10:48	11:48	60	259666	260395	729
09-Jun	BN2	230	4	17.1	250	01:00	01:00	08:54	09:54	10:54	60	260397	261072	675
12-Jun	BN2	291	5	17.2	250	01:00	01:00	07:49	08:49	09:49	60	261075	261708	633
15-Jun	BN3	345	6	17.3	250	01:00	01:00	07:56	08:56	09:56	60	261769	262465	696
17-Jun	BN3	387	7	17.2	250	01:00	01:00	07:55	08:55	09:55	60	262461	263141	680
21-Jun	RS	460	8	17.2	100	01:00	01:00	11:29	12:29	13:29	60	263163	263827	664
													TOTAL Amount Pumped	4949

MINNIE

Date	Station	Event	Cast	Voltage	Depth (m)	Delay Time	Pump Time	Time On	Pump Start	Pump End Time	Time (mins) Pumped	Start Count (L)	End Count (L)	Amount Pumped
27-May	BS1	49	1	17.5	120	01:30	01:00	09:39	11:09	12:09	60	169650	170419	769
29-May	BS1	77	2	16.8	120	01:00	01:00	09:23	10:23	11:23	60	170417	171088	671
04-Jun	BN1	157	3	17.2	117	01:00	01:00	09:48	10:48	11:48	60	171099	171781	682
09-Jun	BN2	230	4	16.9	100	01:00	01:00	08:54	09:54	10:54	60	171774	172324	550
12-Jun	BN2	291	5	17.3	100	01:00	01:00	07:50	08:50	09:50	60	172326	172888	562
15-Jun	BN3	345	6	17.4	100	01:00	01:00	07:57	08:57	09:57	60	172878	173471	593
17-Jun	BN3	387	7	17.2	100	01:00	01:00	07:55	08:55	09:55	60	173472	174027	555
21-Jun	RS	460	8	17.4	75	01:00	01:00	11:30	12:30	13:30	60	174029	174620	591
													TOTAL Amount Pumped	4973

SANDIE

Date	Station	Event	Cast	Voltage	Depth (m)	Delay Time	Pump Time	Time On	Pump Start	Pump End Time	Time (mins) Pumped	Start Count (L)	End Count (L)	Amount Pumped
27-May	BS1	49	1	17.5	80	01:30	01:00	09:30	11:00	12:00	60	90559	91264	705
29-May	BS1	77	2	NR	30	01:00	01:00	09:33	10:33	11:33	60	91267	91896	629
04-Jun	BN1	157	3	17.2	80	01:00	01:00	09:49	10:49	11:49	60	91899	92497	598
09-Jun	BN2	92491	4	17.2	20	01:00	01:00	08:58	09:58	10:58	60	92491	92971	480
12-Jun	BN2	291	5	17.4	35	01:00	01:00	07:54	08:54	09:54	60	92172	93477	1305
15-Jun	BN3	345	6	17.3	35	01:00	01:00	07:59	08:59	09:59	60	93478	93961	483
17-Jun	BN3	387	7	17.2	35	01:00	01:00	07:57	08:57	09:57	60	93963	94445	482
21-Jun	RS	460	8	17.4	35	01:00	01:00	11:31	12:31	13:31	60	94446	94963	517
													TOTAL Amount Pumped	5199

WENDY

Date	Station	Event	Cast	Voltage	Depth (m)	Delay Time	Pump Time	Time On	Pump Start	Pump End Time	Time (mins) Pumped	Start Count (L)	End Count (L)	Amount Pumped
04-Jun	BN1	157	3	NC	30	01:00	01:00	09:52	10:52	11:52	60	126880	126771	109
09-Jun	BN2	230	4	NC	50	01:00	01:00	08:55	09:55	10:55	60	126769	126769	0
12-Jun	BN2	291	5	17.2	75	01:00	01:00	07:53	08:53	09:53	60	251020	251788	768
15-Jun	BN3	345	6	17.2	75	01:00	01:00	07:58	08:58	09:58	60	251790	252557	767
17-Jun	BN3	387	7	17.1	75	01:00	01:00	07:56	08:56	09:56	60	252558	253404	846
21-Jun	RS	460	8	17.2	500	01:00	01:00	11:27	12:27	13:27	60	253405	253408	3
													TOTAL Amount Pumped	2493

RINGO

Date	Station	Event	Cast	Voltage	Depth (m)	Delay Time	Pump Time	Time On	Pump Start	Pump End Time	Start Count (L)	End Count (L)	Amount Pumped
27-May	BS1	49	1	NC	30	01:30	01:00	09:39	11:09	12:09	108770	108750	-20
29-May	BS1	77	2	NC	80	01:00	01:00	09:30	10:30	11:30	108750	108748	-2
04-Jun	BN1	157	3	NC	60	01:00	01:00	09:52	10:52	11:52	108748	108744	-4
09-Jun	BN2	230	4	NC	30	01:00	01:00	08:59	09:59	10:59	108744	108749	5
												TOTAL Amount Pumped	-21

8.4 Technical Issues

Chloe, Polly, Minnie and Sandie pumped well for all of the 8 deployments.

Ringo did not pump for the first 4 deployments; following investigation by JW it was found that the impellor was broken and without spares, un-repairable. Therefore it was not deployed again.

Wendy was not operational at the beginning of the trip but was built up from scratch by JW in the first week of the cruise. Wendy did not pump successfully during its first couple of deployments. This was discovered to be because the flow meter was fitted the wrong way round, following rectification

Wendy went on to pump successfully for casts 5-7 but failed to pump for cast 8 – it is suspected that the impellor is the cause.

-- END OF DOCUMENT --

CTD data processing and calibration

Nathan Briggs and Stephanie Henson (NOC)

Data Processing

All data processing was performed on workstation Eriu supplied by MPOC using the mexec software suite. Multiple changes to the standard set of mexec scripts were required to process the ship's datastreams. All changes are commented with %DY090 in the relevant file. Some errors required help from Brian King and Yvonne Firing who were able to ssh into Eriu remotely.

The CTD data processing followed the methods used on previous MPOC cruises, using the mexec software suite. The initial SeaBird data conversion, align, and cell thermal mass corrections were performed using SBE Data Processing.
To match the file structure expected by mexec, the following was requested from the NMF techs running the CTD (Candice Cameron and John Wynar).

1. ***Data Conversion*** *to convert the raw frequency and voltage data to engineering units as appropriate by applying the manufacturer's calibrations stored in the CON file and save both downcast and upcast to an ASCII format file, including hysteresis correction using SBE parameters.*
   - *Name the output files* ***ctd_dy090_nnn.cnv****, where nnn is CTD number, i.e. 001, 002, 003 etc….*

2. ***Align CTD*** *to align the oxygen sensor in time relative to pressure.*
   - *Name the output files* ***ctd_dy090_nnn_align.cnv***

3. ***Cell Thermal Mass*** *to correct the pressure and conductivity.*
   - *Name the output files* ***ctd_dy090_nnn_align_ctm.cnv***

These files can then be copied across into: discofs/Sensors_And_Moorings/CTD/Data/CTDProData

The same naming convention should also be applied to the raw data files (.hdr, .hex etc.), which should be copied into: discofs/Sensors_And_Moorings/CTD/Data/CTDRawData

ctd_linkscript was used to copy files from the NMF discofs mount to Eriu and set up additional symbolic links to filenames following mstar convention.

For each cast the following m-files were then run, using wrapper script ctd_all_part1:
mctd_01, mctd_02a, mctd_02b, mctd_03, mdcs_01, mdcs_02.
The processes completed by wrapper ctd_all_part1.m include:

- read ASCII cnv data from ctd/ASCII_FILES/ctd_dy090_001_ctm.cnv
- convert variable names from SBE names to mexec names using data/templates/ctd_dy090_renamelist.csv (**this file had to be adjusted to reflect the sensors mounted on the CTD frame – added 2 PAR sensors, only 1 oxygen sensor mounted. Normally 2 oxygen sensors are mounted, and this change caused much messiness in the scripts, which Brian was called in to fix. For DY090, this may need putting back if 2 oxygen sensors are in place).
- Copy raw file to 24hz file. Make oxygen hysteresis adjustment on 24hz file average to 1hz calculate derived variables psal, potemp. Extract information from bottom of cast identified by maximum pressure.

Subsequently mdcs_03g was run to inspect the profiles and hand-select cast start and end times. The way oxygen time lag is handled in the SBE align algorithm, and the weak dependence of oxygen calculation on salinity, means that when air is ingested into the conductivity cell at the end of the cast, the oxygen becomes biased a few seconds earlier than the psal. Care should therefore be taken to select a cast end time for which all the important variables are free from bias.
The start, bottom and end data cycles are stored in files with names like dcs_dy090_001.nc. After selecting the limits for start and end, ctd_all_part2 was then run, executing mctd_04, mfir_01, mfir_02, mwin_01, mwin_03, mwin_04. The processes completed by these scripts include:

- Extract down and upcasts using scan numbers stored in dcs_dy090_001, and average into 2 dbar files (2db and 2up)
- Read the data/ctd/ASCII_FILES/ctd_dy090_001.bl file and extract scan numbers corresponding to bottle firing events.

- Add time from CTD file, merging on scan number
- Add CTD upcast data corresponding to bottle firing events
- Paste these data into the master sample file data/ctd/sam_dy090_001.nc
- Load winch telemetry data from winch SCS file
- Add winch wireout data to the fir_dy090_001 file
- Paste winch wireout data into the master sample file

A change was made during DY090 to get ctd_all_data_part2 working: cludge for the file directory structure in mfir_01.m

The 24-Hz data were checked for spikes in either of the temperature, conductivity or oxygen sensors and, if necessary, edited using mctd_rawedit. (mctd_checkplots was also edited for DY090 to account for only one oxygen sensor). If spikes are removed, the derived files have to be regenerated using smallscript_postedit.m

A variety of extra steps is available after other processing has been carried out; these steps can be run in any order.

Populate_station_depths.m can be run to add station depths to CTD files.

Smallscript_botnav.m adds the depth, navigation and bottle data. Only run this *after* the navigation data has been processed, as this will save you from having to re-run all the CTD processing when you realise it hasn't been ingesting lat/lon….

Smallscript_botnav.m runs the following scripts:

Mbot_01, mbot_02, mdep_01,mdcs_04, mdcs_05

Mdcs_04 will generate files dcs_dy090_001_pos.nc which include position at start, bottom and end of profiles. Mdcs_05 will then paste the position at the bottom of the cast into the header of all relevant files in data/ctd.

Merging bottle data with CTD data

Bottle oxygen and nutrient data were entered into .csv files by Mark Stinchcombe according to a standard format to facilitate import into mstar, following guidance from DY086. Conductivity data were provided by Candice Cameron and John Wynar from samples run on a Guildline Autosal. Chlorophyll data were provided by Alex Poulton. By the end of the cruise, only the oxygen data had been successfully imported into mstar, using the routines found in caldata_all_part2. Fit was very good, other than two large outliers (see Fig.1).

Other data will be merged after the cruise, including samples, such as POC, processed afterwards.

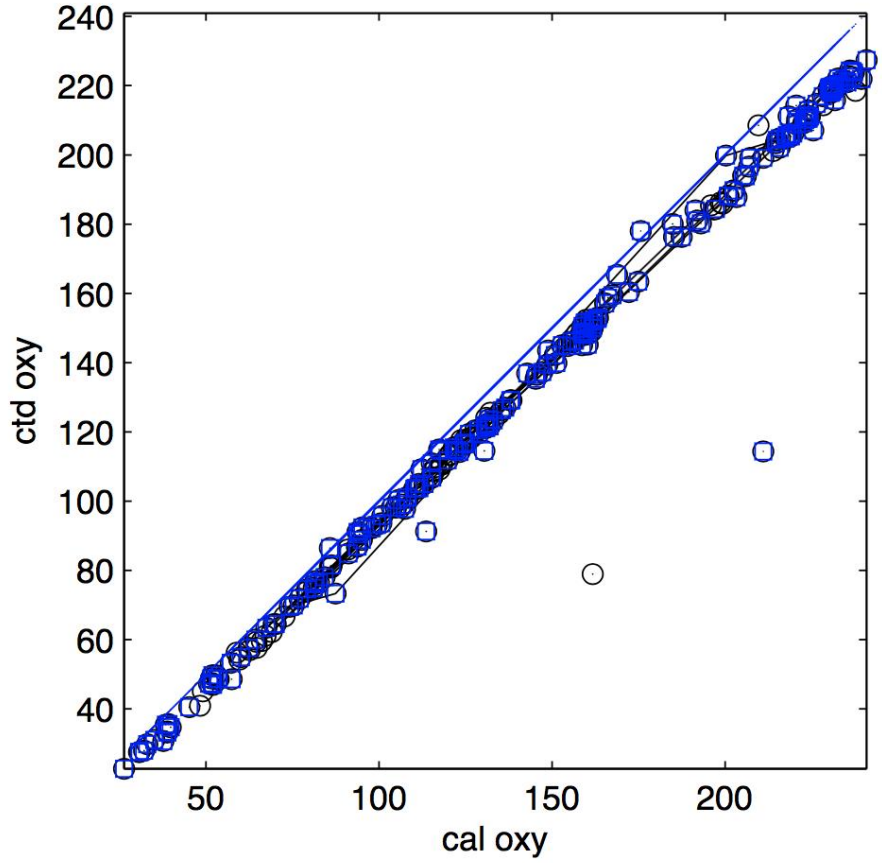


Fig. 1. Bottle O_2 (x-axis) vs CTD O_2

Dissolved oxygen analysis

Mark Stinchcombe (NOC)

Methods and Equipment

Dissolved oxygen was measured on the majority of stainless steel CTD casts during DY090 to calibrate the dissolved oxygen sensor on the CTD. A full list of casts and the number of samples and duplicates can be found in Table 1. Samples for dissolved oxygen were taken first from each cast, the deepest Niskin being sampled first. A piece of silicon tubing, approximately 20cm long and kept in a bucket of water between casts, was attached to the spigot of the Niskin bottle. Water was collected into wide neck borosilicate glass bottles, the tube being put to the bottom of the bottle and being allowed to overflow, using the tube to wash down the insides of the bottles. Once washed the tube was kept stationary at the bottom of the tube and the bottle was allowed to overflow for approximately three times as long as it takes to fill up, i.e. being flushed by at least three times its volume, before the tube was pinched to stop the flow of water and carefully removed from the sample bottle.

Once filled, the temperature of the sample is measured using a Checktemp Electronic Thermometer by Hanna Instruments (Code: HI98509) and recorded onto a logsheet. The sample was then fixed by adding 1ml of a manganese (II) chloride solution (600g/l) using an automatic dispenser, followed by 1ml of an alkaline iodide solution (320g/l sodium hydroxide and 600g/l sodium iodide) also via an automatic dispenser. The nozzles of the dispensers were placed gently below the surface of the sample to prevent bubbles being drawn into the sample. The lids of the bottles were gently inserted into the bottle at a slight angle, again to prevent bubbles being trapped in the bottle with the sample. The now filled sample bottles were shaken vigorously for approximately 30 seconds to allow the reagents to mix and form the precipitate before being placed back in the crate. The sample bottles were allowed to sit for approximately an hour to let the precipitate settle before being shaken again for approximately 30 seconds and allowed to settle for a second time. Once settled, again approximately 1 hour, the samples were ready for analysis.

The analysis was done using a Metrohm 716 DMS Titrino. 1ml of 280ml/L sulphuric acid was added to the sample, as well as a stirring bar, and put on a magnetic stirrer. It was then titrated with 25g/L sodium thiosulphate solution using an electrode with amperometic end-point detection. The resultant volume of titrant was converted to a dissolved oxygen concentration. Four times during DY090 a blank check of the reagents and a standardisation of the sodium

thiosulphate was completed using potassium iodate standard from OSIL. These results can be seen in tables 1b and 1c.

Table 1: The number of depths sampled for dissolved oxygen for each CTD cast and the number of duplicates sampled.

Event	CTD	Depths Sampled	Number of Duplicates
	001	13	4
	004	14	4
	006	8	4
	007	13	4
	008	9	4
	009	10	4
	010	12	4
	012	12	3
	013	13	4
	015	8	4
	016	11	3
	017	11	3
	018	13	3
	020	11	3
	022	9	9
	024	20	4
	026	12	4
	028	11	4
	030	20	4
	031	11	4
	033	11	3
	034	12	4
	035	10	3
	037	7	13
	038	7	14

Table 1b: The volume sodium thiosulphate required to titrate 5ml of the potassium iodate standard for the standardisation procedure. The figures marked with an * are not used in the final calculation.

Date	**Volume of Sodium Thiosulphate**									**Average**	**Std Dev**
25.05.18	0.5055*	0.4995	0.5020	0.5075*	0.50015	0.5010	0.5055*	0.5005	0.5020	0.5011	0.0010
01.06.18	0.5000	0.5005	0.4985	0.4995	0.5005	0.4980				0.4995	0.0010
08.06.18	0.4985	0.4990	0.5010	0.5000	0.4990	0.4985	0.4985			0.4992	0.0010
14.06.18	0.4910*	0.4975	0.4985	0.4975	0.4985	0.4990				0.4982	0.0007

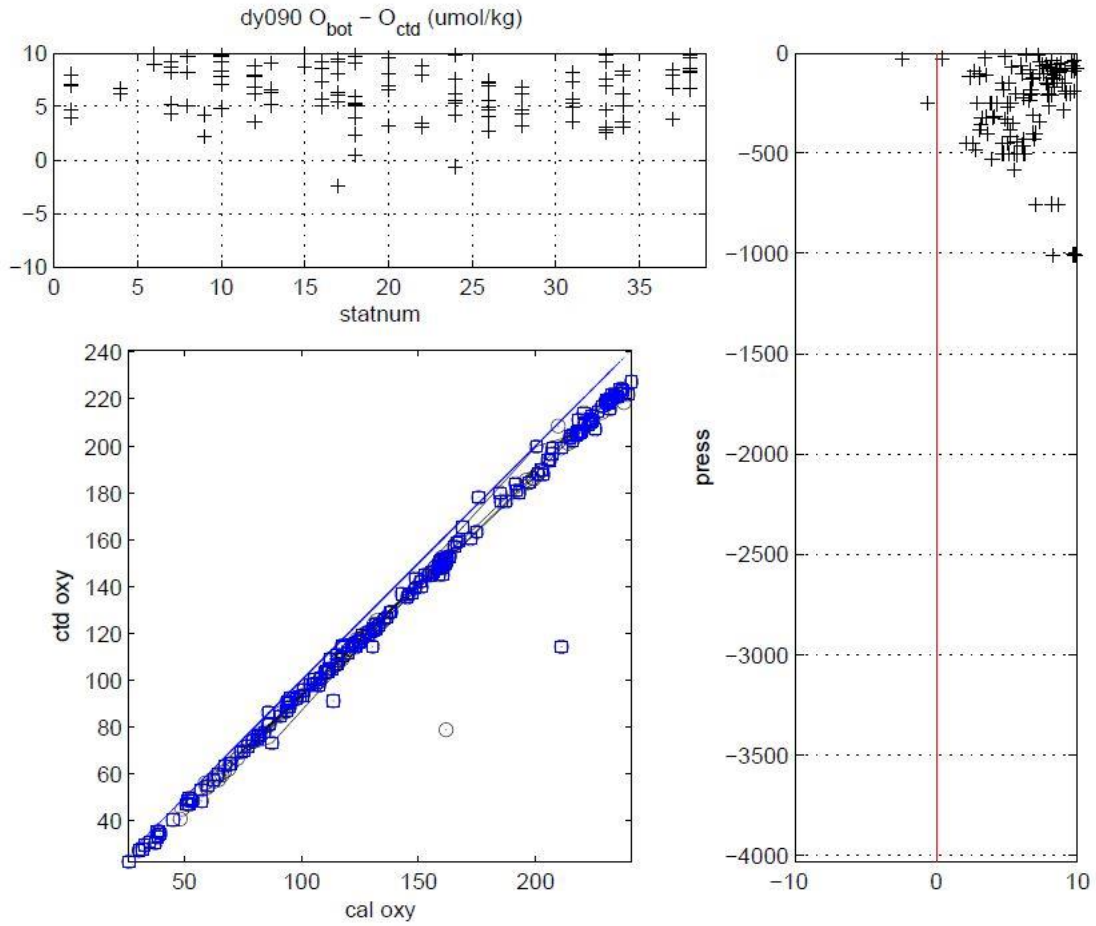
Table 1c: The volume of sodium thiosulphate required to titrate 1ml of potassium iodate standard for the reagent blanks.

Date	**Volume of Sodium Thiosulphate**			**1st – Avg(2nd&3rd)**	**Average**	**Std Dev**
	1st	**2nd**	**3rd**			
25.05.2018	0.1035	0.1005	0.1015	0.0025	0.0024	0.0006
	0.1075	0.1010	0.1010	0.0065*		
	0.1035	0.1010	0.1010	0.0025		
	0.1025	0.1010	0.1010	0.0015		
	0.1035	0.1005	0.1010	0.0027		
	0.1040	0.1015	0.1005	0.0030		
01.06.2018	0.1030	0.1015	0.1020	0.0012	0.0022	0.0007
	0.1040	0.1015	0.1020	0.0022		
	0.1055	0.1010	0.1010	0.0045		
	0.1040	0.1010	0.1015	0.0027		
	0.1040	0.1020	0.1010	0.0025		
08.06.2018	0.1020	0.1015	0.1010	0.0007	0.0019	0.0008
	0.1040	0.1010	0.1010	0.0030		
	0.1040	0.1015	0.1010	0.0027		

	0.1025	0.1010	0.1010	0.0015		
	0.1025	0.1010	0.1010	0.0015		
	0.1030	0.1010	0.1010	0.0020		
14.06.2018	0.1040	0.1015	0.1010	0.0027	0.0022	0.0008
	0.1025	0.1010	0.1015	0.0012		
	0.1030	0.1010	0.1010	0.0020		
	0.1040	0.1015	0.1005	0.003		

Full calibration of the dissolved oxygen sensor on the CTD will take place back at the NOC, however some preliminary comparisons were performed between the sensor data and the discrete sample data. These can be seen in figure 1 which shows comparisons between the residuals and station number and depth (a and c) and CTD oxygen against discrete oxygen (b). The residual value is just the difference between the sensor and the discrete samples and it should be noted that these are prior to calibration.

Figure 1: Plots of residual value against station number (a, top left), CTD value against discrete sample value (b, bottom left) and residual values against depth (c, right).



Inorganic Nutrients analysis

Mark Stinchcombe (NOC)

Methods and Equipment

During DY090 water samples were analysed for the determination of inorganic nutrient concentrations. The analyses were for nitrate and nitrite (NO3+NO2), silicate (SiO2), nitrite (NO2) and phosphate (PO4). The water samples were drawn from Niskin bottles from the majority of the stainless steel and titanium CTDs, Marine Snow Catchers and experimental water samples from other scientific personnel as well as a few other samples when requested.

Sampling protocols used were similar regardless of where the samples were drawn from. From the Niskin bottles for example, pre-labelled 15ml centrifuge tubes were rinsed three times with water from the same Niskin that was being sampled, before being filled to between the 10-15ml marks. All samples were stored in pre-labelled centrifuge tubes that had been rinsed 3 times with the same water as the sample was taken from.

Analysis was within 24 hours of the samples being taken and on a QuAAtro 39 segmented flow autoanalyser linked to a XY-2 Sampler, both by SEAL Analytical UK Ltd, and controlled via a DELL Latitude laptop using the appropriate software package supplied by SEAL, called AACE 7.09. The chemistry methods used were also supplied by SEAL and can be seen in table 1a.

During runs ultra-pure water (MilliQ) was used as a wash, to provide the baseline and was also the matrix that the mixed calibrants were made up in. This differs to COMICS I (DY086) where an artificial seawater solution was used. The switch followed trials back at the NOC and on a previous cruise. It was found that using MilliQ water gave a far more stable baseline and less error in the standards as there is no need to calculate the nutrient concentration prior to use. It is just assumed to be 0µmoles/L. This also allows us to use a pure MilliQ sample as a 0 standard for all chemistries. To counter-act any possible density effects in the flowcell we increased the sampling time from 45 seconds to 68 seconds per sample, this equated to 40 per hour instead of 60 per hour. This ensured a nice stable section reading with no interference from density gradients.

Table 1a: Inorganic nutrient method documents used during DY090 for QuAAtro applications as supplied by SEAL Analytical UK Ltd.

Channel Number	Method Name	Method Number	Low Range	High Range
1	Nitrate and nitrite in water and seawater (with Cd coil)	Q-068-05 Rev. 11	0 – 5µmol/L	0 – 250µmol/L

2	Silicate in water and seawater	Q-066-05 Rev. 5	0 – 5µmol/L	0 – 165µmol/L
3	Nitrite in water and seawater	Q-070-05 Rev. 6	0 – 1µmol/L	0 – 45µmol/L
4	Phosphate in water and seawater	Q-064-05 Rev. 8	0 – 1.3µmol/L	0 – 6µmol/L

Analyser Performance

During DY090 36 analytical runs were completed. Certain parameters were noted for every run to determine how well the system was behaving. Here are the parameters recorded and a brief description of their meaning and how they are calculated:

Baseline/Offset – sets the baseline to 5% of the chart window. During a run, the AACE software shows data as a percentage of the chart window so that the Y-axis is always 0-100%.

Gain – sets the top standard to 90% of the chart window. The higher the standard the smaller the gain as less change is required to set the chart window.

Correlation Coefficient – a measurement of the accuracy with which the calibration standards fit the linear calibration used during DY086. A correlation coefficient of >0.999 is required for high accuracy.

Sensitivity – calculated for the primer on each run using the following formula, where AD is absorbance:

$$E_{\text{Primer}} = \frac{(AD_{\text{Primer}} - AD_{\text{Base}}) \cdot 10}{MaxAD \cdot \text{Gain}}$$

Coefficient of Variation – in each run, twenty replicates of the top standard were analysed to calculate this as a percentage.

Detection Limit – AACE uses the procedure described in US EPA document Pt. 136 App B. for 'Method Detection Limit', which is defined as the standard deviation of multiple measurements of a near-zero sample multiplied by a factor between 2.3 and 3.1 depending on the number of measurements. Twenty replicates of the lowest standard were used.

Cadmium Coil Efficiency – for NO3+NO2 analysis, NO3 is reduced to NO2 using cadmium in a coil. The efficiency of this reduction is calculated by comparing a NO2 sample of known concentration to an identical concentration NO3 sample. Efficiency should be above 90%.

The following sections show plots of each of the above parameters with a description of any important features or changes seen over the course of DY090. Please note that although during DY090 36 analytical runs were completed, not all of these were for inorganic nutrients. Some of the runs were for biogenic silica (BSi) samples. Please see biogenic silica cruise report for methods and during these runs only channel 2 (SiO2) was used. This explains the apparent gaps in recorded parameters for NO3+NO2, NO2 and PO4.

Baseline/Offset

The baseline (or offset) of the wash solution is always set at 5% of the chart window. However, recording the actual absorbance values for the baseline can give an indication of stability of the wash solution as the values may change if a higher or lower wash is used. It may also change if there are changes in the reagents, although some variation is to be expected. Figure 1 show the baseline values for all four nutrient chemistries. They remained stable throughout DY090 with only minor variation and were lower than for DY086, which highlights the difference between using MilliQ as a baseline instead of artificial seawater.

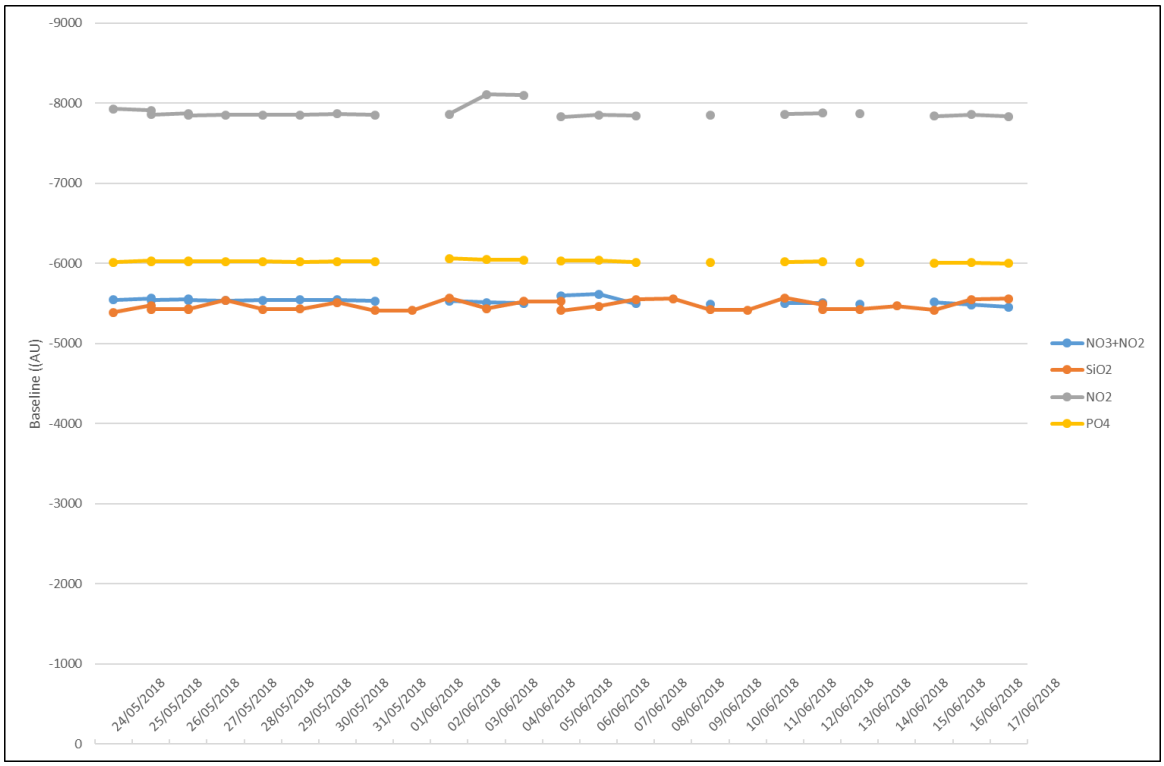


Figure 1: Baseline values for all chemistries during DY090.

Gain

The gain is set by running the highest sample through the system and selecting 'set gain' in the software. The chart window is then automatically adjusted so that the top standard peak sits at the 90% point. If there were problems with the standards or reagents, as well as the cadmium coil efficiency for the NO3+NO2, then the gain would start varying. Figure 2 shows the gain values for each chemistry throughout DY090. The gain for all chemistries was extremely stable throughout the cruise. The only changes, at the start of DY090 after a few runs, was due to a slight change in the standard concentrations used once we got a better understanding of the required concentration range.

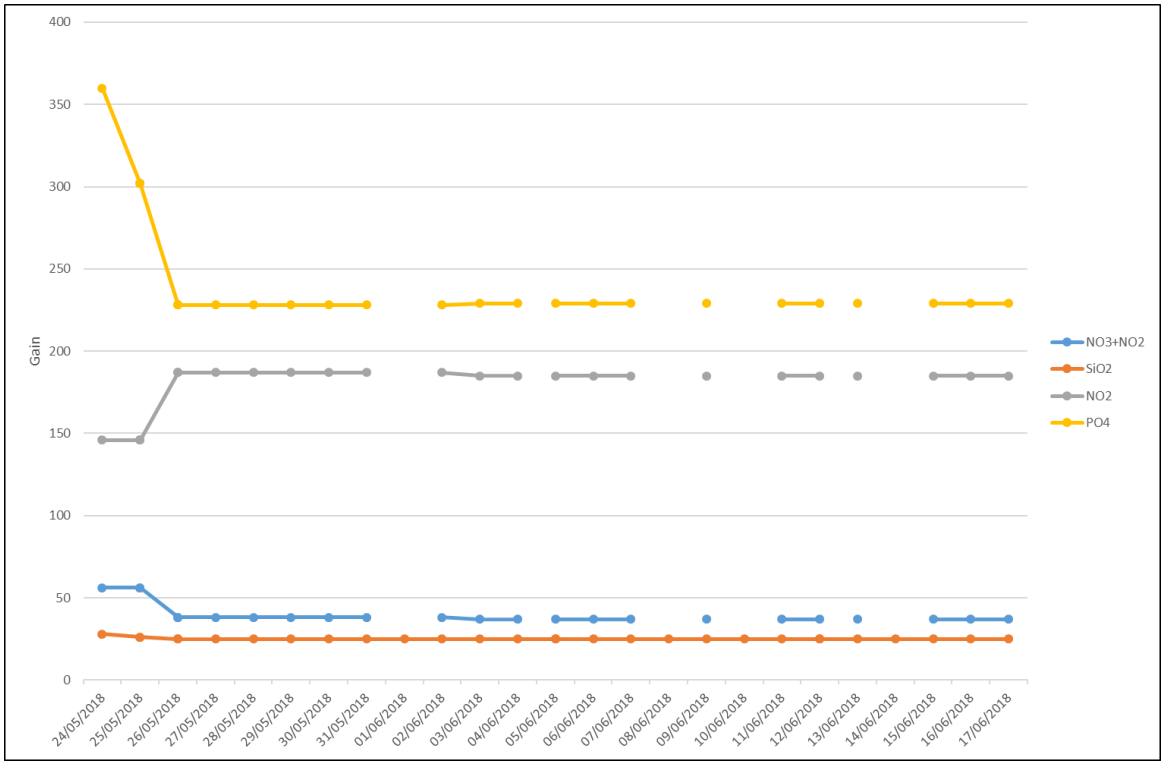


Figure 2: The gain values for all the chemistries throughout DY090.

Correlation Coefficient

The correlation coefficient shows how close the standards are to a true linear calibration. The standard concentrations used during DY090 can be seen in table 2. The concentrations were amended after the first couple of runs to best cover the sample range. These early standard concentrations are not shown here as these runs were either standard test runs or the samples were rerun with the new standards. 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 3 the correlation coefficient for all chemistries during all runs was higher than 0.9990. In fact, the lowest value seen throughout DY090 was 0.9997 and this low value only occurred once. All other values were 0.9999 or higher.

Table 2: The standard concentrations used for each chemistry during DY090. These were used for all but the first couple of runs.

Chemistry	Baseline	Standard 1 (µmoles/L)	Standard 2 (µmoles/L)	Standard 3 (µmoles/L)	Standard 4 (µmoles/L)	Standard 5 (µmoles/L)
NO3+NO2	0.00	8.23	16.56	25.08	33.61	42.14
SiO2	0.00	10.09	20.17	30.26	40.35	50.44
NO2	0.00	0.20	0.49	0.99	1.48	1.98
PO4	0.00	0.20	0.75	1.51	2.26	3.02

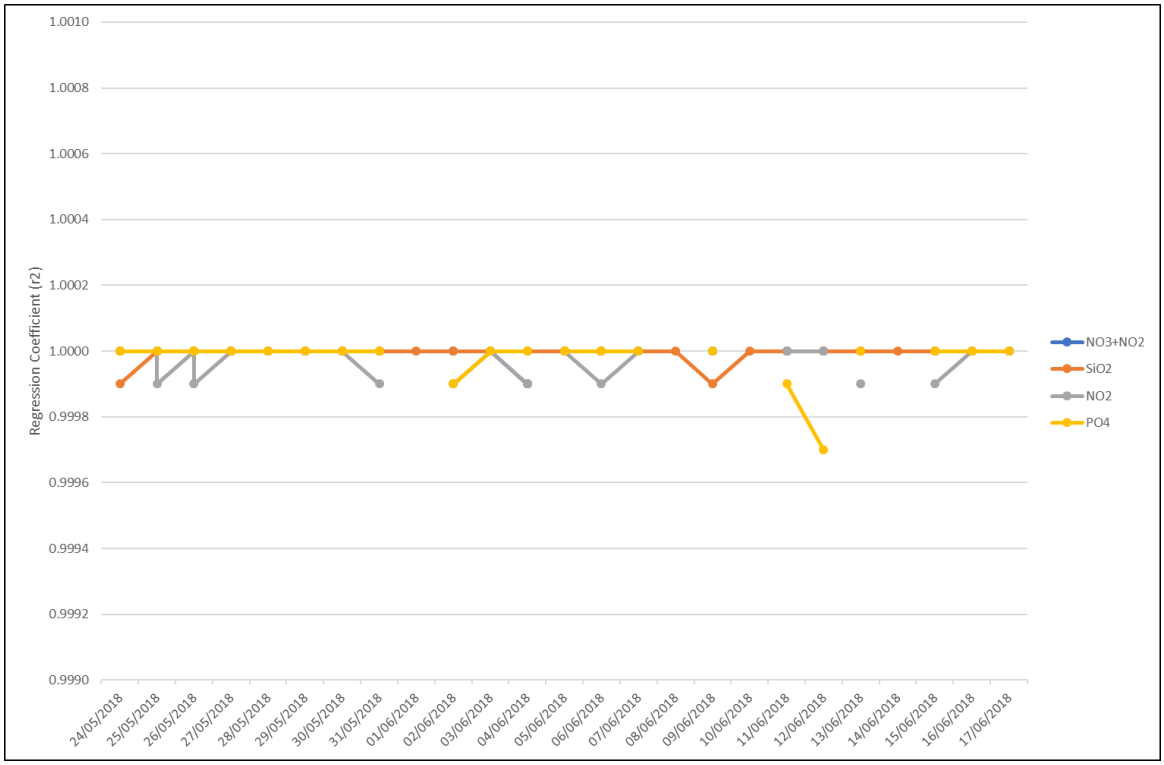


Figure 3: Correlation coefficients for all the chemistries during DY090.

Sensitivity

The sensitivity is a ratio of the absorbance units for the primer peak against the total absorbance units possible and is calculated using the equation at the start of this section. The methods have a target sensitivity range and the sensitivity of the runs should be within ±15% of this range. The target range, and the ±15% acceptance limits, can be seen in table 3. The sensitivity values for each chemistry across the whole of DY090 can be seen in figure 4. This shows that the sensitivity for SiO2, NO2 and PO4 in each run is within the acceptable bounds of the methods. The sensitivity for NO3+NO2 is a little high, averaging at about 0.225 when it should be no higher than 0.185 but this was not thought to be an issue as all NO3+NO2 concentrations were above the calculated detection limit.

Table 3:

Chemistry	**Method Sensitivity Range (at top standard concentration)**	**±15% acceptance limit**
NO3+NO2	0.139 - 0.160	0.118 - 0.185
SiO2	0.250 - 0.300	0.213 - 0.345
NO2	0.040 - 0.048	0.034 - 0.055
PO4	0.038 - 0.053	0.032 - 0.059

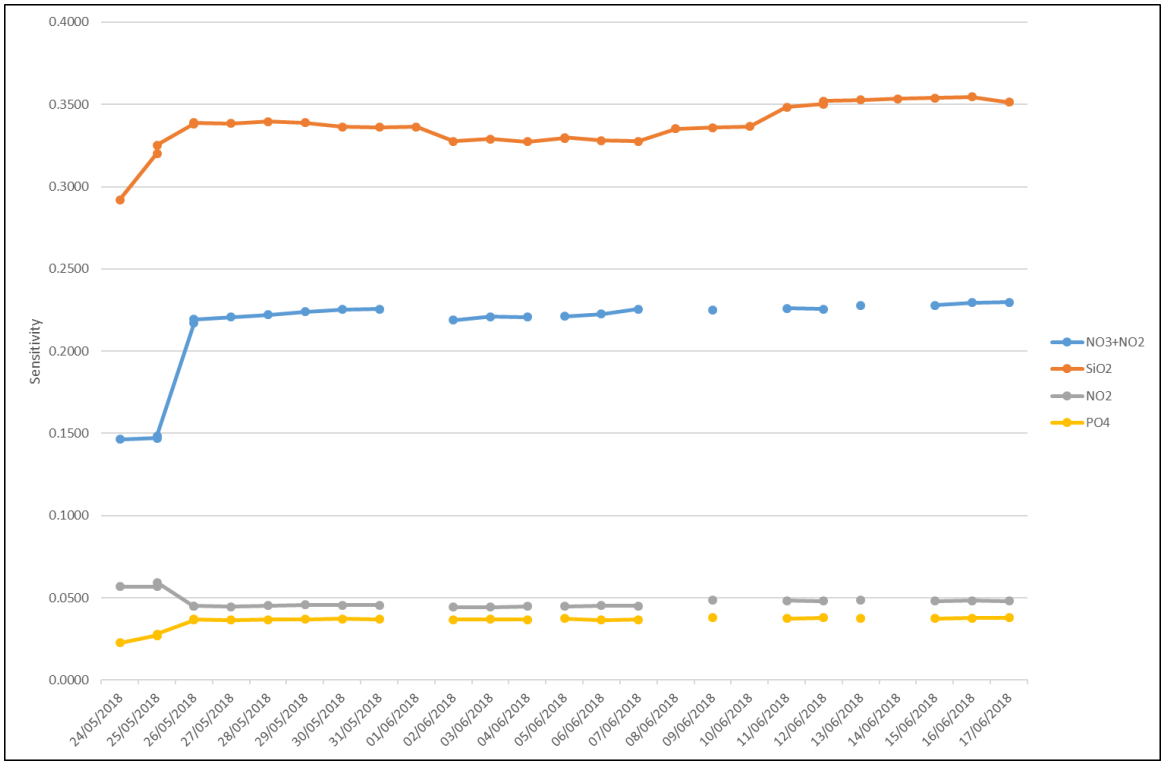


Figure 4: Method sensitivities for each chemistry during DY090.

Coefficient of Variation

The coefficient of variation was determined at the high standard concentration during every run by analysing 20 replicates of the high standard. This would allow the reproducibility at the high end of the concentration range to be calculated. The coefficient of variation values for each chemistry can be seen in figure 5. The coefficient of variation was mostly below 0.5% for almost all runs and chemistries.

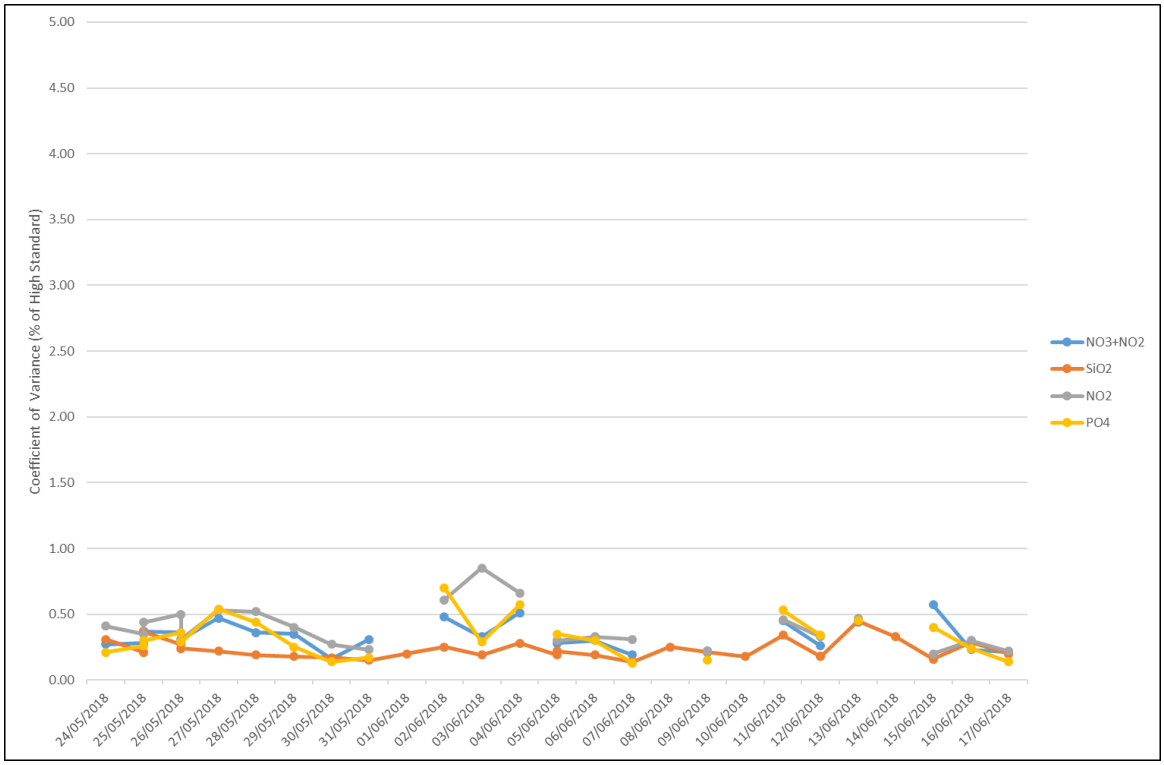


Figure 5: Coefficient of variation values for all the chemistries during DY090.

Detection Limit

The detection limit was calculated from 20 replicates of the lowest concentration standard for each run. The detection limit for each chemistry during DY086 can be seen in figure 6. For NO2 and PO4 he detection limit stayed stable throughout DY086 at approximately 0.00µmol/L and 0.01µmol/L respectively. The detection limit for NO3+NO2 and SiO2 varied a bit more at the start of DY086 but became stable from the 23rd November onwards. Even with the variation of 0.02 – 0.16µmol/L for NO3+NO2 and 0.02 – 0.11µmol/L for SiO2, the samples analysed were never below detection. The large spike in the NO3+NO2 coincides with the drop in cadmium coil efficiency.

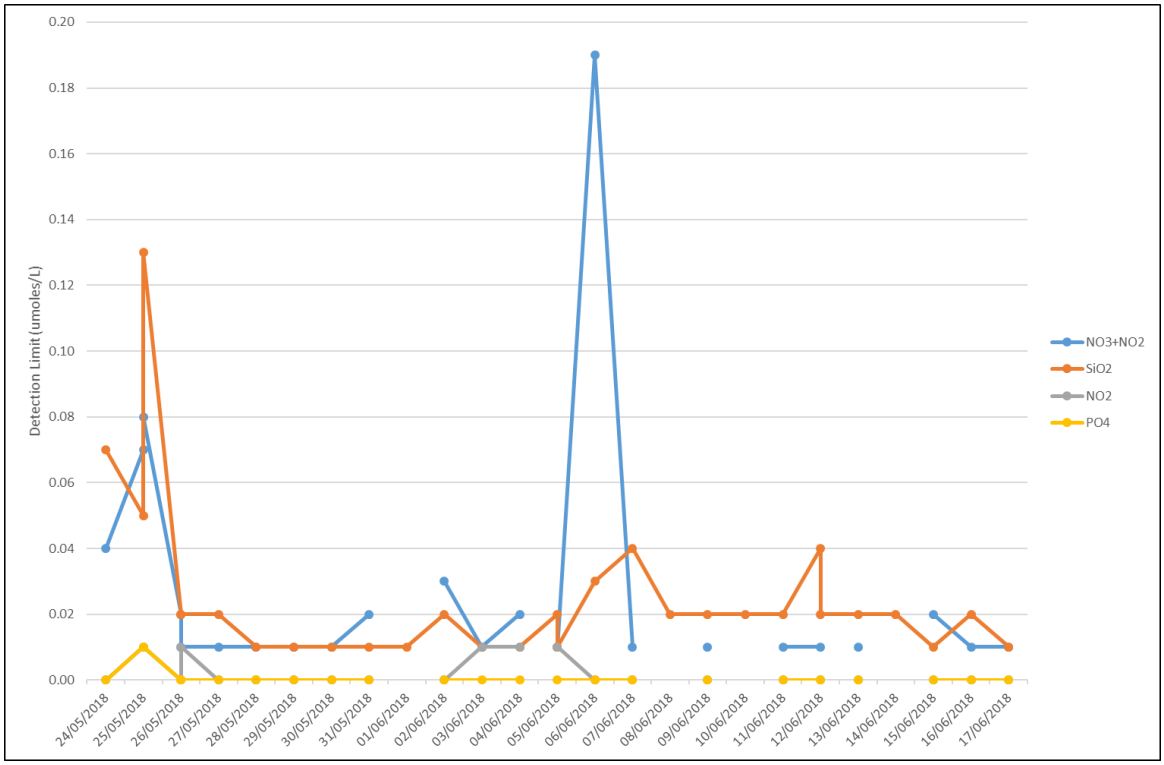


Figure 6: Detection limits for each chemistry throughout DY090.

Cadmium Coil Reduction Efficiency

Throughout DY090 the efficiency of the reduction from NO3 to NO2 by the cadmium coil was calculated by comparing a single NO2 standard against a single NO3 standard (Figure 7). If the efficiency started reducing then the NO2 standard would start increasing in size compared to the NO3 standard. The efficient should be kept as close to 100% as possible and certainly above 90%. During DY090 the efficiency never dropped below 100%.

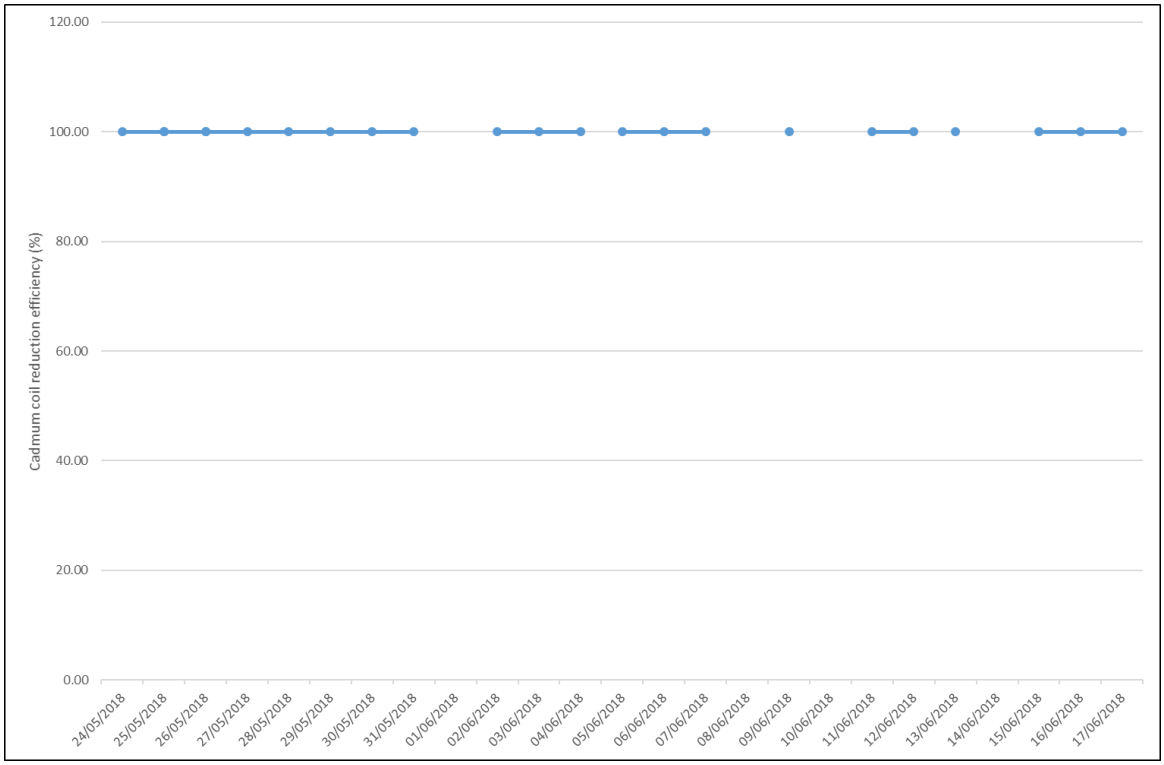


Figure 7: The cadmium coil reduction efficiency during DY090.

CTD Niskin Misfires

The nutrient profile can be used to check whether the CTD Niskin bottles fired at the correct depth. If there was a misfire there would be a high concentration where a low cocnetration would be expected, or vice versa. All the misfired Niskins can be seen in table 4. CTD009 seemed to have an odd profile and the bottle data should be checked against the oxygen profiles as well.

Table 4: DY090 CTD Niskin bottle misfires.

CTD	**Niskin misfired**	**Depth should have been?**	**Approximate depth actually closed…**
CTD006	3	498m	200m
CTD009	8 and 9?	?	?
CTD013	17	50m	90-100m
CTD039	5	450m	100-150m

Biogenic Silica Cruise Report

Mark Stinchcombe (NOC)

Method

Filters for the determination of biogenic silica were placed in a 15ml centrifuge tube. The tubes were put in an oven set at 50°C for at least twelve hours to dry completely. The tubes were then sealed and the sample was stable at room temperature until they could be analysed.

To be analysed the biogenic silica first needed to be digested and in solution. They were digested by adding 5ml of a 0.2M sodium hydroxide solution to the 15ml tube and then incubated in an oven at 85°C for two hours. Once removed they were allowed to cool to room temperature before being neutralised by adding 0.2M hydrochloric acid solution. This solution then was analysed using normal colourimetric techniques for silicate analysis. See Brown et al (2003) for a full description of the biogenic silica method and inorganic nutrients cruise report on the analytical methods used for silicate analysis during DY090

.

Underway data processing

Nathan Briggs (NOC)

Ship's data streams

The SCS data streams (anemometer [met/surfmet], oceanlogger [ocl], gyro [nav/gyros, nav/gyropmv], seatext-gell [nav/seapos], position [nav/posmvpos, nav/posmvatt], em120 [em122]) were processed on eriu during the cruise. Most were processed in 24-hour segments, using m_daily_proc.m, with cleaning and appending as required.

Daily processing generates a best navigation file, data/nav/posmvpos/**bst_dy090_01.nc**.

The final surface meteorological data file is data/met/surfmet/**surfmet_dy090_truav.nc**.

Underway calibration samples

A total of 21 underway samples were analysed for oceanlogger salinity calibration. Samples were drawn from the underway supply in the Underway Lab nominally every 5 minutes during passage back towards Cape Town on 25 June. Samples were analysed following the procedure described for CTD salinity samples.

Underway salinity sample files have not yet been copied into mstar.

Aside from reading in the data daily using m_daily_proc and merging with the navigation data, no further processing was done with the underway data streams. This means that the data are currently uncalibrated.

Vessel Mounted Acoustic Doppler Current Profiler

Filipa Carvalho (NOC)

Introduction

Two Teledyne RDI vessel-mounted Acoustic Doppler Current Profilers (ADCPs) were operated on *RRS Discovery* throughout the DY086 cruise to measure the horizontal velocity field. The two instruments, a 75 kHz and a 150 kHz Ocean Surveyor VMADCP have different depth ranges and resolutions. The 150 kHz provides good vertical resolution, but the signal is more rapidly attenuated and it will only penetrate typically to depths up to 400 m. The 75 kHz instrument does not provide as good vertical resolution, but it penetrates deeper in the water column, to depths around 800 m.

Transducers are fitted to the hull of the *RRS Discovery* at a depth of 6.6 m. Beam 3 (Y-axis) is rotated -45 degrees (anticlockwise) relative to the ships central line, i.e. the mounting angle of the transducers is -45 degrees. This needs to be taken into account during post-processing to remove the ships velocity from the data. This is set in the command files run by VMDAS and the opt_dy086.m cruise options script for post-processing.

VMADCP file types

Files produced have names of the form *OStt_DY090nnn_mmmmmm.ext*, where *tt* is either the 75 kHz instrument or the 150 kHz, *nnn* is the file sequence number, *mmmmmm* is the number of the segment file within the sequence and ext is the extension. VMDAS automatically increments the file segment number every time data collection was stopped and restarted.

List of files produced have the following extensions:

*.ENR files: the binary raw data files (beam coordinates).

*.ENS files: binary ADCP data after being screened for RSSI and correlation, with navigation data included.

*.ENX files: ADCP single ping and navigation data after having been bin-mapped, transformed to Earth coordinates and screened for error velocity and false targets.

*.STA files: binary files of short-term average ADCP data (120 sec, user-specified in VmDas).

*.LTA files: binary files of long-term average ADCP data (600 sec, user-specified in VmDas).

*.N1R files: ASCII text files of raw NMEA navigation data from the NMEA1 stream.

*.NMS files: binary files of navigation data after screening.

*.VMO files: ASCII text files specifying the option settings used for the data collection.

*.LOG files: ASCII text files logging all output and error

Raw files were automatically synchronized to the discofs science network (smb://discofs.discovery.local/DY090/Ship_Fitted_Scientific_Systems/Acoustics/OS*tt*kHxz/, where *tt*

is 75 or 150) and manually resynced Filipa's computer. A folder per each set of files and for each intrument was created (same number, e.g. vmdas_data_os75_001 included all the files 001 from instrument os75)

Real-time data acquisition

Data was acquired from the instrument using the RDI VMDAS software, version 1.48, installed in a computer in the computer room. Software carried out preliminary screening and transformation of the data, from beam to earth coordinates. A default configuration file was set to facilitate interchange depth ranges, bottom track to water track and whether the information was synced with the other acoustic instruments (K-sync unit).

During the cruise, both instruments were managed using the K-sync unit. Data collection was typically stopped and restarted to generate a new file segment number on a daily basis, thus facilitating the incremental processing in both instruments.

At the beginning of the cruise, in shallow water (broadly <700 m, in and out of Walvis), the instrument was run in bottom track mode to obtain phase (angle) and amplitude calibrations. So the first and last file collected from each instrument are bottom track (file 001). An example of a bottom track file is OS075_DY090_ Sync_20171112T231252_001_000000.*. On this cruise (contrary to DY086) no NB, BT nor NoBT was added to the file name to facilitate batch processing in date order (no option of putting BT at the end), where NB is narrowband and BT is bottom track on.

DY090 OS75 setup

All command files used with K-sync:

DY090_OS75_NB_BT_with_sync_16m

Used to calibrate the instrument (misalignment angle calculation)

narrowband single-ping profile mode (NP), 100 (NN) 8 meter bins (NS), 8 meter blanking distance (NF)

DY090_OS75_NB_NO_BT_with_sync_16m

narrowband single-ping profile mode (NP), 45 (NN) 8 meter bins (NS), 8 meter blanking distance (NF)

DY090 OS150 setup

All command files used with K-sync:

DY090_OS150_NB_BT_with_sync_8m

Used to calibrate the instrument (misalignment angle calculation)

narrowband single-ping profile mode (NP), 96 (NN) 8 meter bins (NS), 4 meter blanking distance (NF)

DY090_OS150_NB_NO_BT_with_sync_8m

narrowband single-ping profile mode (NP), 45 (NN) 8 meter bins (NS), 8 meter blanking distance (NF)

Common to all configuration files:

NMEA Ship Position (GGA) Source: NMEA1

NMEA Ship Speed (VTG) Source: NMEA1

Transform: Heading/tilt source: PRDID; NMEA2

Custom NMEA from C:\\RDI\VmDas

ADCP misalignment correction: -45 degrees

Data post-processing

Onboard post-processing was done using the new Python version of CODAS (Common Ocean Data Access System) suite of software provided by the University of Hawaii. The four main steps that characterizes the CODAS VMADCP processing:

Removal of the ship velocity;

Correction of the gyro heading with GPS-derived heading;

Estimate the heading misalignment from either bottom track (BT) or water-track (WT) data;

Manual inspection/editing of bad data.

VMADCP Processing using Python CODAS

A few steps that help the VMADCP processing:

> ln -s ~/adcpcode/topog topog

Create a codaspy_proc_dy090 folder on:

> cd ../Data/VMADCP/

> mkdir codaspy_proc_dy090

Create a fake_uhdas_data directory:

> cd codaspy_proc_dy090/

> mkdir fake_uhdas_data

Link raw data to the new directories under codaspy_proc_dy086/vmdas_data_os*

> ln -s ../VMADCP/ VMADCP_data/OS75kHz/raw_data vmdas_data_os75

Check if the links are working

> ls vmdas_data_os75/

Create a vmdas_data_os*_00*. This should indicate the OS (instrument, os75 or os150) and file number

> mkdir vmdas_data_os75_001

Copy files from the raw data folder to this new subfolder, isolating one filename at a time (it includes multiple filetypes with the same name)

> cp vmdas_data_os75/OS075_DY090_NB_BT_Sync_2018*_001_0*.* vmdas_data_os75_001/

> ls vmdas_data_os75_001

Inside the codaspy_proc_dy090 folder, navigate to adcp_pyproc/ and create an enrproc_os*_00* folder. Inside create a config folder

> cd adcp_pyproc/

> mkdir enrproc_os75_001

> mkdir enrproc_os75_001/config

> cd enrproc_os75_001/

Then create an info file for the LTA datatype. Check the text file info using more command

> vmdas_info.py --logfile lta_info.txt os ../../vmdas_data_os75_001/*LTA

> more lta_info.txt

Do the same thing for the ENR files

> vmdas_info.py --logfile enr_info.txt os ../../vmdas_data_os75_001/*ENR

> more enr_info.txt

Go to the config directory and create the following files reform_defs.py and vmdas2uhdas.py by using the GUI window.

cd config

> pythonw `which reform_vmdas.py` ../../..

In the GUI window:

Vmdas source: where your data is, e.g. …/VMADCP/codaspy_proc_dy086/ vmdas_data_os75_bottomtrack

Uhdas dir: …/ VMADCP/codaspy_proc_dy086/fake_uhdas_data

Ship ID: zzz

Instrument: os150

Cruise name: dy090_os75_bottomtrack

Filename: variable definitions: reform_defs.py

Filename for translation: vmdas2uhdas.py

Make config files

> python vmdas2uhdas.py

Go to …/VMADCP/codaspy_proc_dy086/ adcp_pyproc/enrproc_os75_001/config (you should be there)
> pythonw `which proc_starter.py` reform_defs.py

In the GUI window:
Transducer angle: -45
Transducer depth: n6
Position: N1R, gps
Heading: N1R, hdg
Make config file

Run the treeadcp.py to create the folders inside enrproc_* folder
> cd ..
> adcptree.py os75nb --datatype uhdas --cruisename dy090_os75_001

Create the q_py.cnt file OR copy from another folder of the same instrument and edit the cruise name – easier to copy and edit the different file name. Make sure to remove the ping_headcorr line from the q_py.cnt file)
> ``vim q_py.cnt``

If we are re-running the same dataset again and we are happy with gpin data, delete that line from the q_py.cnt file or if we want to rerun everything again, need to delete the gbin subdirectory (~/codaspy_proc_dy086/fake_uhdas_data/dy090_os75_001/gbin

To run quick_adcp, go to the os75nb folder and:
> cd os75nb
> quick_adcp.py --cntfile q_py.cnt --auto

Check bottom track and water track data (Cal folder – see below).
Apply corrections if necessary – these are the values used for the DY090 cruise
> quick_adcp.py --steps2rerun rotate:navsteps:calib --rotate_amplitude 1.026 --rotate_angle 2.3

Calibration

The calibration values are created in the first round of processing. They are located at dy090NNNnbenx/cal/watertrk/adcpcal.out and dy090NNNnbenx/cal/botmtrk/btcaluv.out
A bottom-track cal file looks like this:

```
ADCP dy086001nbenx step size 1
   Time range 315.98 to 316.08
   Calculation done at 2017-11-25  23:40
    step: 1
    min_depth:  25   max_depth: 1500
    min_speed:  2.0 m/s   max_sig:  2.5 std devs
    max_gap:  0.10 minutes   tol_dt: 0.02 (fraction)
unedited: 30 points
edited:   29 points, 2.0 min speed, 2.5 max dev
            median      mean       std
amplitude   1.0053   1.0052   0.0046
phase      45.2936  45.2224   0.3838
```

For the second stage of the processing we require calibration files collected during bottom-track mode. The following step reprocesses the data by applying amplitude and/or phase corrections.

> quick_adcp.py --steps2rerun rotate:navsteps:calib --rotate_amplitude 1.026 --rotate_angle 2.3

Acoustic Surveys

Several acoustic surveys (mostly attempts, aborted because of bad weather) integrating several acoustic instruments (See acoustic measurements section for more details) were conducted throughout the cruise. The following table summarises them.

Event Number	Start date/time (GMT)	End date/time (GMT)	Comment
095	2018/05/30 06:14	2018/05/30 14:43	BS1 night
097	2018/05/30 21:30	2018/05/31 04:20	BS1 night
107	2018/06/01 18:42	2018/06/02 01:16	BN1
203	2018/06/07 04:50	2018/06/07 15:11	BN1
205	2018/06/07 22:07	2018/06/08 03:55	BN2
319	2018/06/13 12:20	2018/06/14 04:28	BN3
426	2018/06/18 22:19	2018/06/19 06:10	BN3

Output plot

Using the shortcuts setup during codas installation, running ‘dv’ shows a GUI with maps

> dv

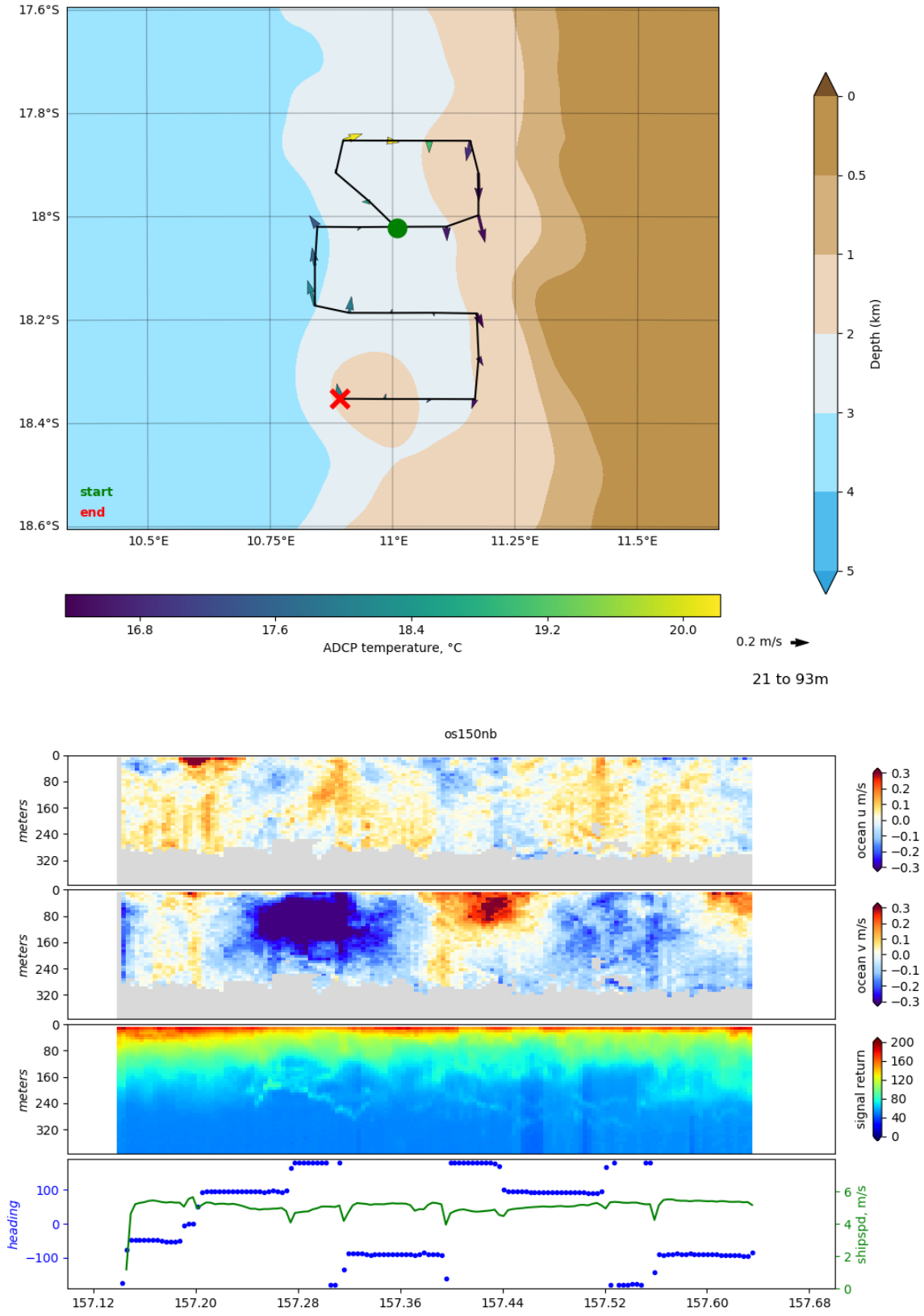


Figure 13: Large survey from 7th June, collected by the instrument os150.

Upper ocean pelagic sampling for chlorophyll, particulate organic carbon and nitrogen, particulate inorganic carbon, particulate silica and plankton taxonomy

Joanna Ainsworth (University of Southampton), Alex Poulton (Herriot Watt University), Mark Stinchcombe (NOC), Helge Winkelbauer (Herriot Watt University)

Introduction

The composition, size-structure and activity of upper ocean plankton communities has a strong influence on the magnitude and nature of sinking organic and inorganic material. As part of the COMICS project, work package 2 (Pelagic Biogeochemistry) is addressing the linkages between surface plankton communities and the export of material out of the upper ocean (considered the euphotic zone) and through the upper mesopelagic (<1 km). One of the key COMICS hypotheses relates water column oxygen concentrations to the efficiency with which organic carbon penetrates into the ocean interior, with changes in Diel Vertical Migration (DVM) or a reduction in bacterial respiration rates affecting the remineralisation length scale of the sinking material. To address these hypotheses, DY090 sampled the Oxygen Minimum Zone in the Benguela Upwelling Region – an oceanic region with a distinctly different upper ocean plankton community to that at South Georgia.

To examine relationships between surface plankton and deep-sea fluxes, a series of measurements were collected on DY090 to assess: levels of phytoplankton biomass (chlorophyll-*a*, carbon), community composition (preserved and filtered water samples for microscopy, size-fractionated chlorophyll-a, flow cytometry (see R Rayne/C Baker section), diagnostic pigments (via High-Performance-Liquid-Chromatography), primary and biomineral (calcite, opal) production (see A Poulton section), biomineral standing stocks, nitrate uptake, and total particulate organic carbon and nitrogen concentrations. As well as measurements in the upper euphotic zone (<50 m), profiles of all of these parameters were collected throughout the upper 1000 m to examine deep-sea trends between sampling stations and time-points. Furthermore, large-volume (500 mL) acidic Lugol's samples were collected from the deep-sea to examine microzooplankton biomass and their potential contribution to respiration and remineralisation.

CTD Sampling

For each stainless steel CTD cast (CTDs), seawater was typically collected from 12 depths from the near surface down to ~1000 m to incubate for rate measurements (see section by Poulton) or to filter for pigments (chlorophyll-a via fluorometric analysis, carotenoids via High-Performance-Liquid-Chromatography), particulate organic and inorganic carbon (POC, PIC), particulate organic nitrogen

(PON) and biogenic silica ($bSiO_2$). Additionally, seawater was collected and processed for evaluation of phytoplankton community structure determined by microscopy from preserved (acidic Lugol's solution) and filtered (Scanning Electron Microscopy) samples. Water samples were also sequentially filtered to determine chlorophyll-a concentrations in different size-fractions (0.2-2 µm, 2-10 µm, >10 µm). Sampling and protocols typically followed those employed previously and described in detail elsewhere (see e.g. Moore et al. 2007a&b; Poulton et al. 2006, 2013).

An overall list of samples collected is provided here:

Table 1

Date	Site	Event	CTD cast	Niskin Bottle	Nominal Depth (m)	Variables Filtered
24/05/18	Test	001	001	3, 4, 6, 9, 10, 12, 14, 16, 19, 21, 24	1000, 750, 450, 260, 200, 120, 80, 70, 35, 15, 6	Chl-a, SF Chl-a, POC/N, BSi, PIC, HPLC
27/05/18	BS1	046	004	1, 2, 4, 8, 11, 14, 16, 17, 18, 19, 21, 24	1000, 750, 450, 250, 200, 120, 80, 70, 60, 50, 30, 6	Chl-a, SF Chl-a, POC/N, BSi, PIC, HPLC
29/05/18	BS1	075	007	1, 2, 4, 6, 8, 11, 14, 15, 17, 20, 21, 24	1000, 750, 450, 380, 300, 200, 120, 80, 62, 57, 30, 6	Chl-a, SF Chl-a, POC/N, BSi, PIC, HPLC
03/06/18	BN1	135	012	1, 2, 4, 8, 10, 11, 13, 15, 17, 19, 21, 23	1000, 750, 500, 388, 265, 200, 108, 80, 55, 35, 20, 6	Chl-a
04/06/18	BN1	148	013	1, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24	1000, 700, 500, 400, 285, 245, 150, 80, 50, 40, 25, 5	Chl-a, SF Chl-a, POC/N, BSi, PIC
06/06/18	BN1	185	016	1, 3, 5, 8, 10, 12, 13, 16, 17, 20, 22, 24	1000, 700, 505, 440, 340, 250, 190, 150, 110, 55, 35, 5	Chl-a, SF Chl-a, POC/N, BSi, PIC, HPLC
07/06/18	BN1	199	018	1, 3, 6, 7, 9, 11, 13, 15, 17, 18, 19, 21, 24	1000, 700, 500, 420, 350, 250, 120, 75, 60, 27, 22, 13, 5	Chl-a, SF Chl-a, POC/N, BSi, PIC, HPLC

Date	Site	Event	CTD cast	Niskin Bottle	Nominal Depth (m)	Variables Filtered
09/06/18	BN2	228	020	2, 4, 7, 10, 12, 14, 16, 18, 20, 22, 24	750, 430, 360, 235, 125, 70, 45, 18, 8, surface	Chl-a, SF Chl-a, POC/N, BSi, PIC
11/06/18	BN2	261	024	2, 4, 6, 7, 10, 12, 14, 16, 18, 20, 22, 24	1000, 750, 500, 460, 320, 250, 100, 70, 35, 24, 15, 5	Chl-a, SF Chl-a, POC/N, BSi, PIC, HPLC
13/06/18	BN2	310	026	2, 4, 6, 8, 10, 11, 14, 16, 18, 20, 22, 24	1000, 750, 580, 480, 400, 325, 150, 90, 40, 18, 9, surface	Chl-a, SF Chl-a, POC/N, BSi, PIC
15/06/18	BN3	342	028	1, 2, 6, 8, 12, 14, 16, 18, 20, 22, 24	1000, 700, 425, 320, 250, 180, 125, 60, 40, 27, 5	Chl-a, SF Chl-a, POC/N, BSi, PIC
17/06/18	BN3	383	031	2, 4, 5, 8, 10, 12, 14, 16, 18, 20, 22, 24	1000, 750, 500, 400, 325, 250, 200, 100, 35, 26, 12, 5	Chl-a, SF Chl-a, POC/N, BSi, PIC, HPLC
19/06/18	BN3	434	034	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 22, 23	500, 450, 430, 380, 320, 270, 200, 160, 110, 70, 50, 20	Chl-a, POC/N
20/06/18	RS	449	035	2, 5, 8, 10, 12, 14, 16, 18, 20, 22, 24	3590, 3453, 3000, 2000, 1400, 1130, 560, 250, 140, 40, 6	Chl-a, POC/N
21/06/18	RS	459	039	3, 5, 7, 9, 11, 13, 15, 17, 20, 22, 24	500, 447, 400, 350, 300, 250, 200, 150, 100, 50, 10	Chl-a, POC/N

Particulate Organic Carbon and Nitrogen (POC/N)

POC/N samples were collected from the CTD. For POC/N, 1 to 2 L of seawater was filtered onto pre-ashed (400^{o}C, 12 h) Whatman GF/F filters. These were then placed in clean Eppendorf tubes, and dried overnight (50°C) for storage prior to analyses back at Queens Mary University.

Particulate Silica ($bSiO_2$)

Particulate silica ($bSiO_2$) water samples were collected from the CTD for 10 to 12 depths. For $bSiO_2$, 500 mL of seawater was filtered onto Whatman 0.8 µm polycarbonate filters. After filtration, the filters were placed into plastic 15 mL centrifuge tubes, dried overnight in an oven prior to digestion and analysis onboard (see separate section on nutrient analyses by M Stinchcombe).

Particulate Inorganic Carbon (PIC)

PIC samples were collected from the CTD for 10 to 12 depths. For PIC, 500 mL of seawater was filtered onto Whatman 0.8 µm polycarbonate filters that were then rinsed with pH-adjusted MilliQ (pH ~8.5-9) to remove saltwater residue. The filters were placed in 50 mL centrifuge tubes and oven dried (50^{o}C, overnight) prior to later digestion and analyses at NOC via ICP-OES.

High Performance Liquid Chromatography (HPLC)

For phytoplankton pigment analysis (chlorophylls, carotenoids), 1000 mL of seawater was filtered onto Whatman GF/F filters for later extraction and analysis of pigments by HPLC. After filtration, HPLC filters were placed into Nunc™ CryoTube™ vials and stored at -80°C prior to later analyses.

Scanning Electron Microscopy (SEM)

For SEM samples, 500 mL was filtered onto Whatman 0.8 µm polycarbonate filters. These were rinsed with pH-adjusted MilliQ to remove saltwater and prevent salt crystal growth. The filters were placed in Millipore Petri slides and dried overnight at 50°C before being stored at room temperature for later analysis at Heriot-Watt University.

Preserved phytoplankton (acidic Lugol's solution)

Water samples of 100 and 500 mL were preserved in brown bottles with acidic Lugol's solution (0.5-1% final solution) for later enumeration and identification of plankton species by inverted light microscopy.

Chlorophyll-*a* analysis

In order to provide an index of overall phytoplankton biomass, water samples for the determination of chlorophyll-*a* concentrations were collected from:

i) CTD deployments
ii) Marine Snow Catchers (see S Giering section)

Further details specific to different sampling types can be found in the corresponding sections of the cruise report, but briefly:

i) CTD samples: The stainless steel CTD was used to collect samples from 1000 m to the surface, typically at 10 to 12 different depths (See Table 1). 250 mL of seawater were

filtered onto Whatman glass fibre GF/F filters for total chlorophyll-*a* concentration and sequentially through polycarbonate 0.2 µm, 2 µm and 10 µm filters for size-fractionated chlorophyll-*a*. The trace metal (TM) free CTD was used to collect water from the surface and upper mesopelagic (<200 m) for remineralisation experiments (see J. Ainsworth section) and chlorophyll-*a* samples were taken using the same process as for the stainless steel CTD to determine growth and biomass after nutrient injection.

ii) For the MSC samples between 50 and 600 mL were filtered from the various fractions collected (see separate section by S Giering).

In all cases, chlorophyll-*a* was extracted in 6 mL of 90 % acetone over 18 to 24 hours at 4°C in a fridge in the dark. Measurements of chlorophyll-*a* were subsequently made on board using a Turner Designs Trilogy fluorometer set up with a non-acidification kit (after Welschmeyer, 1994). The fluorometer was calibration against a pure chlorophyll-*a* extract in 2015 (and will be recalibrated on return of the fluorometer to NOC in 2018). A Turner solid standard (Part No. 8000-952) was used at the start and end of each set of readings as well as an 90% acetone blank sample to monitor for instrument drift. Both of these readings are subsequently used in the calculations to determine chlorophyll-*a* concentrations (see Equation 1).

Chlorophyll-*a* concentrations in mg m^{-3} (µg L^{-1}) were calculated as:

$$Chl\ a = Dilution * (R)adj * (F - blank) * (\frac{v}{V}) \quad \text{Equation (1)}$$

Dilution = 1 (unless required for an over-range sample)

(R) adj = response factor adjusted for the shift in the solid standard

F = sample fluorescence

blank = acetone blank reading

v = acetone extracted volume (6 mL)

V = filtered sample volume in mL

Phytoplankton nets

Isabell Klawonn (IGB-Berlin)

The aim was to collect phytoplankton cells from surface waters and screen those for parasitic fungal infections.

A hand-held plankton net (Hydrobios, 25 µm mesh size) was deployed to collected phytoplankton integrated from 0–30 m water depth on various occasions (Table 1). The phytoplankton community was pre-screened for its composition (under a Brunel Inverted Microscope) and fungal infections (under a fluorescence microscope). Sub-samples were fixed with Lugol solution and stored at 4°C in darkness until further procedure.

Table 1. Net deployment times and locations.

Date_Time (GMT) dd/mm/yyy hh:mm	Date_Time (ship time) dd/mm/yyy hh:mm	Event	Latitude	Longitude
04/06/2018 21:10	04/06/2018 23:10	164	-18.074295	11.031983
04/06/2018 21:16	04/06/2018 23:16	165	-18.074296	11.031976
05/06/2018 04:04	05/06/2018 06:04	169	-18.019661	11.008937
05/06/2018 04:08	05/06/2018 06:08	170	-18.019675	11.009415
05/06/2018 04:13	05/06/2018 06:13	171	-18.019672	11.010001
10/06/2018 01:50	10/06/2018 03:50	242	-18.019756	11.008202
10/06/2018 01:53	10/06/2018 03:53	243	-18.019761	11.008200
10/06/2018 01:59	10/06/2018 03:59	244	-18.019753	11.008209
11/06/2018 08:06	11/06/2018 10:06	270	-18.019776	11.008260
11/06/2018 08:11	11/06/2018 10:11	271	-18.019775	11.008259
11/06/2018 08:19	11/06/2018 10:19	272	-18.019776	11.008262
14/06/2018 13:55	14/06/2018 15:55	327	-18.019832	11.008247
14/06/2018 14:03	14/06/2018 16:03	328	-18.019412	11.008010
14/06/2018 14:09	14/06/2018 16:09	329	-18.018879	11.007728
15/06/2018 14:38	15/06/2018 16:38	348	-18.023836	11.010300
15/06/2018 14:46	15/06/2018 16:46	349	-18.023587	11.010242
15/06/2018 14:54	15/06/2018 16:54	350	-18.022917	11.010201
18/06/2018 20:56	18/06/2018 22:56	423	-18.019911	11.008398
18/06/2018 21:02	18/06/2018 23:02	424	-18.019924	11.008408
18/06/2018 21:07	18/06/2018 23:07	425	-18.019921	11.008401
19/06/2018 17:34	19/06/2018 19:34	436	-18.01986	11.008146
19/06/2018 17:41	19/06/2018 19:41	437	-18.019848	11.008164
19/06/2018 17:48	19/06/2018 19:48	438	-18.019866	11.008169

The phytoplankton community was dominated by diatoms which are believed to be predominately susceptible to parasitic fungal infections. Fungal infections were likely present (at low prevalence, <1%) but final confirmation of fungal infections and prevalence can only be given after further microscopy of fixed Lugol samples.

Titanium CTD rosette ('Trace Metal Free, TM') sampling operations

Joanna Ainsworth (University of Southampton), Alex Poulton (Heriot-Watt University), Mark Stinchcombe (NOC), Helge Winkelbauer (Heriot-Watt University)

Introduction

The COMICS II cruise sampled the Benguela upwelling region, in terms of 2 different stations, one in high oxygen and the other in lower oxygen waters. DY090 tested the hypothesis that the reduced oxygen results in greater remineralisation length scales of the organic carbon due to changes in Diel Vertical Migration (DVM) or a reduction in aggregate respiration rates (Sanders et al., 2016). In order to both provide context for the overall work performed within COMICS and investigate the potential interactions between the carbon and major nutrient cycles and trace-metals within the mesopelagic, a series of trace-metal sampling and experimental work was implemented during DY090.

Trace metal CTD operations

A Titanium framed CTD rosette and associated clean bottles was used for trace metal clean sampling for state variables and experiments. The Titanium CTD was fitted with 24 x 10 L OTE bottles that have been modified for trace metal work by use of epoxy coated external springs, coating of stainless ferrules and fitting of PTFE taps. Trace metal clean protocols were employed in the deployment and sampling of the TM CTD. Briefly, bottles were clean from the prior cruise and were hence just given a soak cast (water collected from 200 m depth and left in bottles for 4 hrs before being drained). Bottles were subsequently then only opened within a dedicated class-100 air-filtered clean lab (for sampling) or on deck immediately prior to the CTD being deployed over the side. Handling of the TM CTD bottles was only performed with clean vinyl gloves, all sampling hoses and attachments were acid washed prior to use and subsequent sampling/experimental bottles were also acid washed and were double plastic bagged if/when moved outside of a filtered air environment. The TM lab was set to 12^{o}C to replicate the temperature in the mesopelagic zone and humidity of ~45%.

Table 3 provides a listing of samples collected from the TM CTD listed by the event ID, CTD number, OTE bottle and nominal depth of firing.

Table 3: State variable sampling from TM CTD:

Date	Site	Event	CTD cast	OTE Bottle	Nominal Depth (m)	Variables
26/05/18	BS.1	29	3	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 23, 24	1000, 750, 450, 380, 200, 120, 80, 60, 50, 30, 25	All depths: dFe, TFe, nutrients 7 depths of pFe Surface depth: Chl (total and size fractionated), POC, FRRF, lugols
28/05/18	BS.1	60	5	1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 23, 24	1000, 750, 450, 360, 280, 200, 120, 80, 65, 50, 30, 25	All depths: dFe, TFe, nutrients 7 depths of pFe Upper Mesopelagic: Chl (total), POC, sterivex
02/06/18	BN.1	108	11	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 23, 24	1000, 750, 450, 360, 320, 250, 120, 78, 60, 40, 25, 20	All depths: dFe, TFe, nutrients 6 depths of pFe Surface depth: Chl (total and size fractionated), POC, FRRF, lugols
04/06/18	BN.1	156	14	1, 2, 4, 6, 8, 10, 12, 14, 16,	1000, 750, 500, 427, 250, 158,	All depths: dFe, TFe, nutrients

Date	Site	Event	CTD cast	OTE Bottle	Nominal Depth (m)	Variables
				18, 20, 22, 23, 24	120, 80, 70, 40, 30, 25	7 depths of pFe Upper Mesopelagic: Chl (total), POC, sterivex
09/06/18	BN.2	229	21	1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 23, 24	1000, 750, 500, 350, 220, 125, 100, 70, 50, 35, 20, 15	All depths: dFe, TFe, nutrients 7 depths of pFe Upper Mesopelagic: POC, sterivex, AFC
12/06/18	BN.2	290	25	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 23, 24	750, 500, 375, 300, 250, 150, 100, 60, 40 30, 22	All depths: dFe, TFe, nutrients 7 depths of pFe Surface depth: Chl (total and size fractionated), POC, FRRF, lugols
14/06/18	BN.3	320	27	1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 23, 24	1000, 750, 460, 380, 250, 125, 100, 70, 35, 25, 20, 18	All depths: dFe, TFe, nutrients 7 depths of pFe Upper Mesopelagic:

Date	Site	Event	CTD cast	OTE Bottle	Nominal Depth (m)	Variables
						Chl (total and size fractioned), POC, sterivex, AFC
16/06/18	BN.3	364	29	1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 23, 24	1000, 750, 500, 400, 270, 125, 100, 80, 50, 30, 25, 20	All depths: dFe, TFe, nutrients 8 depths of pFe Upper Mesopelagic: Chl (total and size fractioned), POC, sterivex, AFC

Relative remineralisation/partitioning rates of carbon, silicate and iron

In order to investigate the remineralisation potential of fresh surface organic material, a series of experiments were performed to follow the partitioning between dissolved and (size fractionated) particulate phases, adapting the protocols of Azam and Biddle (1999) and Boyd et al. (2010). Additionally, remineralisation of both live and dead cells (through a freeze/thaw process) were evaluated. Within phase 1 of this experiment the uptake rates of iron, carbon and silica within the surface phytoplankton/microbial community were measured through radio-labelling and subsequent incubation. The larger size fraction (>2 µm or >5 µm) of this isotopically labelled community was then harvested to determine the subsequent remineralisation potential of this material at depth by the meso-pelagic microbial community, through determination of the fractional (re-)distribution of each radio-isotope/element within the various dissolved and particulate organic and inorganic phases measured.

Protocol:

Phase 1:

Near surface samples (20-30m, see Table 6) were collected into triplicate acid-washed 125 mL Nalgene polycarbonate bottles for each isotope (^{14}C, ^{32}Si and ^{55}Fe). In order to promote the active uptake of isotopes through the generation of fresh organic material, all samples were also amended with 2nM Fe (added as 25 µL of 10 µM7 $FeCl_3$ in 10 % HCl), 5 µM nitrate, 5 µM silicate, 0.6 µM phosphate and 0.5 µM ammonia. Samples were then spiked with the radio-isotopes (^{55}Fe – 2 kBq: ^{14}C – 740 kBq: ^{32}Si – 3 kBq) and placed in an incubator in the light at ~280 micro Einstein's m^{-2} s^{-1}, at 18^{o}C for BS and BN1

and 20^{o}C for BN2 and B3 on a 12:12 Light:Dark cycle for 48 hrs before evaluating the overall uptake of each isotope. Sub-samples were then harvested through filtration onto 0.2 µm and 5 µm (2 µm for the first experiment at BS due to a smaller community structure) polycarbonate filters, in order to measure both total community and >5 µm (or >2 µm at site BS) community uptake. Additional samples were also collected for overall activities and dissolved (through a 0.22 µm syringe filter) for all 3 isotopes. To differentiate between uptake into cells relative to apparent uptake due to adsorption of ^{55}Fe onto external cell surfaces, subsets of filters and cells were rinsed at the end of the sample filtration with a buffered Ti-EDTA-citrate solution which scavenges adhered ^{55}Fe (Hudson and Morel, 1989). Filter samples were then placed in 6 mL Ultima Gold scintillation cocktail before being counted on a liquid scintillation counter (Perkin Elmer TriCarb 3180 TR/SL) on board ship.

Phase 2:

Live cells: At the termination of stage 1, the remainder of the samples not used for measuring total uptake (see above) were harvested by gravity filtration through a 47 mm, 5 µm polycarbonate filter (or 2 µm for the first experiment). Particulate material was then rinsed extensively with clean filtered (0.2 µm) meso-pelagic water before being resuspended in unfiltered mesopelagic water to create triplicate samples for 3 or 5 subsequent harvesting time steps for each isotope (see table 6). Within the standard experimental treatments, resuspension was performed with whole (i.e. unfiltered / unamended) mesopelagic water. All phase 2 samples were incubated in the dark at in situ temperatures within a refrigerated container and processed at 3 or 5 time steps (see Table 6) to determine the resultant activity in each phase of remineralisation using methods similar to the end-point measurements at the termination of experimental phase 1.

Dead cells: Similar to the live cell experiments all the particulates (total uptake not required as phase 1 is the same as the live cells) were harvested by gravity filtration through a 47 mm, 5 µm polycarbonate filter. Particulate material was then rinsed extensively with clean filtered (0.2 µm) meso-pelagic water and the filter placed in a vial with 15 mL filtered (0.2 µm) meso-pelagic water, agitated to release the harvested particulates into the water and then the filter removed. The vials was placed a plastic box in a -20^{o}C freezer. The cells were frozen for between 48 and 124 hrs. The samples were then thawed at room temperature (12^{o}C) for at least 15 hours until fully liquid. The particulates (dead cells) were harvested by gravity filtration through a 47 mm, 5 µm polycarbonate filter (or 2 µm for the first experiment). Particulate material was then rinsed twice with clean filtered (0.2 µm) meso-pelagic water before being resuspended in unfiltered mesopelagic water to create triplicate samples for 3 or 5 subsequent harvesting time steps for each isotope. Within the standard experimental treatments, resuspension was performed with whole (i.e. unfiltered / unamended) mesopelagic water. All phase 2 samples were incubated in the dark at in situ temperatures within a refrigerated container and processed at 3 or 5 time steps (see Table 6) to determine the resultant activity in each phase of remineralisation using methods similar to the end-point measurements at the termination of experimental phase 1.

Table 6: Experimental remineralisation potential

Date	Site	Event	CTD cast	OTE Bottle	Nominal Depth (m)	Variables	Size fraction	Time step dates
26/05/18	BS	029	003	23	25	Remin R4 (Phase 1)		T0 – 28/05
28/05/18	BS	060	005	12	120	Remin R4 (Phase 2) – live cells		T1 – 30/05 T2 – 01/06 T3 – 03/06 T4 – 05/06 T5 – 07/06
02/06/18	BN.1	108	011	23	20	Remin R5 (Phase 1)		T0 – 04/06
04/06/18	BN.1	156	014	12	120	Remin R5 (Phase 2) – live cells		T1 – 06/06 T2 – 08/06 T3 – 10/06 T4 – 12/06 T5 – 14/06
02/06/18	BN.1	108	011	23	20	Remin R6 (Phase 1) - note; used the same surface phase 1 as R5		T0 – 04/06
09/06/18	BN.2	229	021	10	125	Remin R6 (Phase 2) – dead cells		T1 – 11/06 T2 – 13/06 T3 – 15/06 T4 – 17/06 T5 – 19/06
12/06/18	BN.2	290	025	22	22	Remin R7 (Phase 1)		T0 – 14/06
14/06/18	BN.3	320	027	10	125	Remin R7 (Phase 2) – live cells		T1 – 16/06 T2 – 18/06 T3 – 20/06
12/06/18	BN.3	290	025	22	22	Remin R8 (Phase 1) - note; used the same surface phase 1 as R7		T0 – 14/06

Date	Site	Event	CTD cast	OTE Bottle	Nominal Depth (m)	Variables	Size fraction	Time step dates
16/06/18	BN.3	364	029	10	125	Remin R8 (Phase 2) – dead cells		T1 – 18/06 T2 – 20/06 T3 – 22/06

Nitrate uptake rates estimated using $^{15}NO_3$
Alex Poulton (Herriot Watt University), Helge Winkelbauer (Herriot Watt University)

Daily nitrate uptake rates were estimated for the 'pre-dawn' stainless steel CTD casts through collection of water samples to measure the incorporation of ^{15}N labelled nitrate into particulate material. Briefly, 500 mL samples were collected in triplicate from the upper 4 sampled depths on the 'pre-dawn CTD' (see section by Poulton) and spiked with 22 to 33 µl of a 2.33 nm/µl $^{15}NO_3$ stock, hence to a final $^{15}NO_3$ concentration of 1 to 2 µM, corresponding to around a 9% enrichment of the ambient pool. Samples were then placed within the refrigerated container at irradiances approximating the in situ daily light does (see section by Poulton) and incubated for ~24 hrs (Table 6) before being terminated by filtration onto pre-ashed Whatman GF/F filters. These were then placed in Eppendorf tubes and dried overnight in an oven at 50°C for storage prior to analyses back at NOC.

Table 7: Incubations for 15NO3 uptake

CTD cast (Event #)	Sampled depths (nominal, m)	Start date	Start time (ship)	Start time (GMT)	End date	End time (ship)	End time (GMT)
013 (148)	5, 25, 40	4/6/18	07.10	05.10	5/6/18	07.10	05.10
018 (199)	5, 15	7/6/18	07.00	06.00	8/6/18	08.00	06.00
020 (228)	3, 8, 18	9/6/18	08.10	06.10	10/6/18	08.30	06.30
024 (261)	5, 15, 24	11/6/18	07.25	05.25	12/6/18	08.20	06.20
026 (310)	3, 9, 18	13/6/18	07.00	05.00	14/6/18	06.35	04.35
028 (342)	5, 30, 40	16/6/18	07.10	05.10	17/6/18	08.10	06.10
031 (383)	5, 12, 20	17/6/18	07.05	05.05	18/6/18	07.50	05.50

Active chlorophyll fluorescence measurements
Joanna Ainsworth (University of Southampton), Mark Stinchcombe (NOCS)

Chlorophyll fluorescence, using techniques such as Fast Repetition Rate fluorometry (FRRf), can provide a useful non-destructive and rapid index of the physiological status of phytoplankton (e.g. Moore et al. 2007). Instruments such as FRR fluorometers are capable of measuring a suite of parameters pertaining to the photosynthetic physiology of the entire phytoplankton community, most commonly including the photosynthetic energy transfer efficiency (Fv/Fm) which can provide a proxy of the overall photosynthetic 'health' of the community and in particular an indication of nutrient limitation. The FRRf technique measures in real time, in situ and at high sensitivity.

A developmental 'Single turnover active fluorescence (STAF)' system based on a CTG 'FastBallast' fluorometer (S/N 16-0550-011) was employed in discrete measurements of sub-samples from both the remineralisation experiments (see section xxx) and in measurements of samples drawn from the Marine Snow Catchers, RESPIRE and Pelagra traps.

The developmental 'STAF' system employed the following settings:

Saturation pulse (SP) duration = 120us

Relaxation pulse (RP) duration = 120us

Shortest gap (between SP and RP) = 80us

Longest gap (between SP and RP) = 2000us

Sequence interval = 100ms

Sequences per acquisition = 20

Acquisitions per super-acquisition = 2

Gap steps = 8

The following LED combinations were used:

455nm = 420 mA,

470nm = 420 mA

The gain was set using the instruments auto-ranging mode. Data quality will be assessed in detail following the cruise.

References:

Biddle and Azam 1999 Nature 397 508-512

Blain et al. 2007 Nature 446 1070–1074

Boyd et al. 2010 Limnology and Oceanography 55 1271–1288

Hudson and Morel 1989 L&O 34 1113-1120

Kolber et al. 1998 Biochimica et Biophysica Acta 1367 88-106

Nielsdottir et al. 2012 Marine Chemistry 130–131 62–72

Moore et al. 2007a Deep-Sea Research II 54 2045–2065

Moore et al. 2007b Deep-Sea Research II 54 2066–2084

Pollard et al. 2009 Nature 457 577-580

Poulton et al. 2006 Deep-Sea Research II 54 2085–2105

Poulton et al. 2013 Global Biogeochemical Cycles 27, 1-11, doi: 10.1002/2013GB004641.

Sanders et al., 2016 Frontiers of Marine Science. 3:136.

Welschmeyer 1994 Limnology and Oceanography 39 1985–1992

Primary production, calcite production and particulate silica production

Alex Poulton (Heriot-Watt University)

Upper ocean rates of primary production (PP), calcite production (CP) and particulate silica production (ρP) were measured from pre-dawn (0200-0400 local time) CTD casts at nine stations (Table 1). Water samples (1.5 L) from four light levels (60, 25, 5 and 1% of surface irradiance) in the upper mixed layer were collected. Uptake of ^{14}C into particulates measured primary production and calcite production, while the isotope ^{32}Si was used to measure ρP.

Rates of PP were measured over long-term (24 h; 'Net primary production', NPP) incubations in a temperature controlled (18 ± 2^{o}C) Fytoscope FS130 laboratory incubator (Photon System Instr., Czech Republic) with a white LED light panel and a mixture of misty blue and neutral density light filters (Lee Filters^{TM}) to recreate the required light doses (after Poulton et al., 2017). Each incubation depth was supplied with a daily (12 h; 0700-1900) light dose equivalent to the average light dose for May and June at that light depth, as determined from MODIS satellite PAR data. Light doses were 19.0 mol quanta m^{-2} d^{-1} (60% surface irradiance), 6.5 mol quanta m^{-2} d^{-1} (25%), 1.7 mol quanta m^{-2} d^{-1} (5%) and 0.4 mol quanta m^{-2} d^{-1} (1%).

Rates were determined following Poulton et al. (2006) for size-fractionated (SF) NPP (0.2-2, 2-10 and >10 µm), Poulton et al. (2014) for CP (and also NPP) and Krause et al. (2010) for ρP.

Table 1. Sampling stations and measurements.

Sampling details							
Date	**Event No.**	**CTD No.**	**Bottles sampled**	**Site**	**SF-NPP**	**CP/NPP**	**ρP**
27-May	046	004	23, 21, 19, 16	BS1	X	X	X
29-May	075	007	24, 22, 20, 17	BS1	X	X	X
04-June	148	013	24, 22, 20, 17	BN1	X	X	X
07-June	199	018	24, 22, 20, 17	BN1	X	X	X
09-June	228	020	24, 22, 20, 17	BN2	X	X	X

11-June	261	024	24, 17	22,	20,	BN2	X	X	X
13-June	310	026	24, 17	22,	20,	BN2	X	X	X
15-June	342	028	24, 17	22,	20,	BN3	X	X	X
17-June	383	031	24, 17	22,	20,	BN3	X	X	X

References

Krause et al. (2010). Production, dissolution, accumulation, and potential export of biogenic silica in a Sargasso Sea mode-water eddy. *Limnology and Oceanography* **55**, 569-579.

Poulton et al. (2006). Phytoplankton carbon fixation, chlorophyll-biomass and diagnostic pigments in the Atlantic Ocean. *Deep-Sea Research* II **53**, 1593-1610.

Poulton et al. (2014). Coccolithophores on the north-west European shelf: calcification rates and environmental controls. *Biogeosciences* **11**, 3919-3940, doi: 10.5194/bg-11-3919-2014.

Poulton et al. (2017). Seasonal phosphorus and carbon dynamics in a temperate shelf sea (Celtic Sea). *Progress in Oceanography*, https://doi: 10.org/10.1016/j.pocean.2017.11.001.

Pelagra Cruise Report (technical)

Kevin Saw (NOC), Isabell Klawonn (IGB-Berlin), Sari Giering (NOC)

Five Pelagra traps were on board for DY090: P2, P4, P6, P7 and P9. P4 and P7 each carry two conventional sediment funnels, two non-funnelled collectors for gel sampling and a camera/flash system for capturing time-lapse images of sinking particles. P2, P6 and P9 each carry four conventional sediment funnels.

All traps were as deployed on COMICS 1 (DY086) except that P2 was fitted with a new lifting frame as the previous one was damaged on DY086. Mass and volume changes due to the new frame were taken into account for ballasting.

Ballasting for DY090 was based on successful deployments on DY086. Deployment 7 was used to establish baselines for each trap and the ballast spreadsheets, using these baselines, were used to calculate required ballast. Compressibility and thermal expansion coefficients were modified based on findings from actual deployments during DY086.

The broad strategy for DY086 was to make simultaneous deployments of all five traps at initial depths of 80 m, 120 m, 200 m, 450 m and 750 m. Depths would be reviewed during the cruise based on findings.

All times are reported in GMT.

Ballast trial deployment 0 (25 May 2018) Station BS1

All traps were deployed to test they were ballasted correctly. This deployment was not intended to deliver any science. The intention was to use one cam on each trap such that each cup would open sequentially for 30 minutes each. For P9 and P6, all four cams were unintentionally left in place so for these two traps all four cups opened simultaneously for four sequential 30 minute periods.

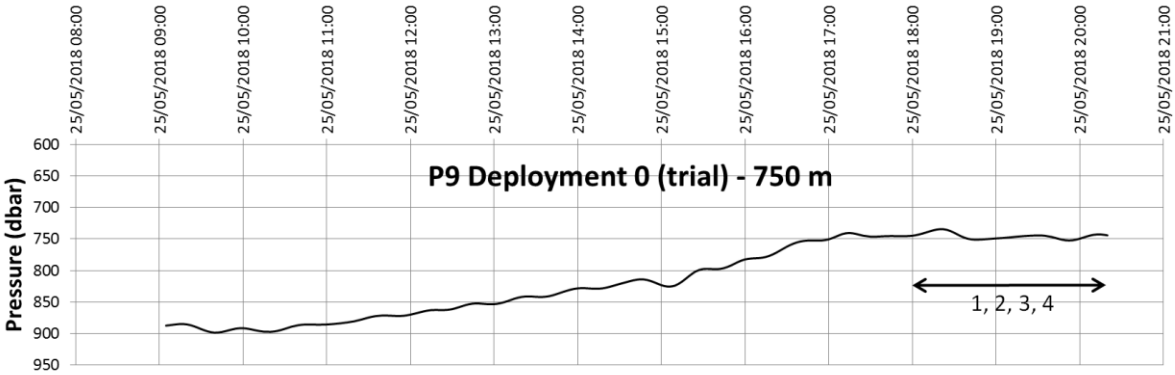
P9 (standard trap)

Station:	BS1, event 3
Target depth:	750 m
Target temp:	5.1°C
In situ density:	1030.697 kg m^{-3}
Sampling strategy:	Cups 1, 2, 3 and 4 open 25/05/18 18:00, close 25/05/18 18:30 *(30 minutes)*
	Cups 1, 2, 3 and 4, open 25/05/18 18:35, close 25/05/18 19:05 *(30 minutes)*
	Cups 1, 2, 3 and 4, open 25/05/18 19:10, close 25/05/18 19:40 *(30 minutes)*
	Cups 1, 2, 3 and 4, open 25/05/18 19:45, close 25/05/18 20:15 *(30 minutes)*
	See notes below plot.
Cup additives:	Cups 1, 2, 3 and 4: formalin
Added ballast:	4218 g

Park Piston Posn Mbp: 115

Deployment time: 25/05/18 01:00

Deployment posn: 21.526° S, 9.516° E



P9 was over-ballasted by ~42 piston counts but stabilised at 750 m before sampling began. Based on this, the next deployment will use a Park Piston Position of 157.

It was intended that the four cups would open sequentially for 30 minutes each but all four cams were left on by mistake so in fact all four cups opened simultaneously for four sequential 30 minute periods. There was an offset between the APEX and Idronaut pressure sensors with the Idronaut reading ~30 dbar higher than the APEX (APEX data shown here). P9 Idronaut also reported a few anomalous temperature readings; these were deleted from the Deployment Plots but remain in the raw data files.

P7 (camera trap)

Station: BS1, event 4

Target depth: 450 m

Target temp: 8.4°C

In situ density: 1029.031 kg m^{-3}

Sampling strategy: Cup G1, open 25/05/18 18:00, close 25/05/18 18:30 *(30 minutes)*

Cup 2, open 25/05/18 18:35, close 25/05/18 19:05 *(30 minutes)*

Cup G3, open 25/05/18 19:10, close 25/05/18 19:40 *(30 minutes)*

Cup 4, open 25/05/18 19:45, close 25/05/18 20:15 *(30 minutes)*

Cup additives: Cups G1 and G3: gel

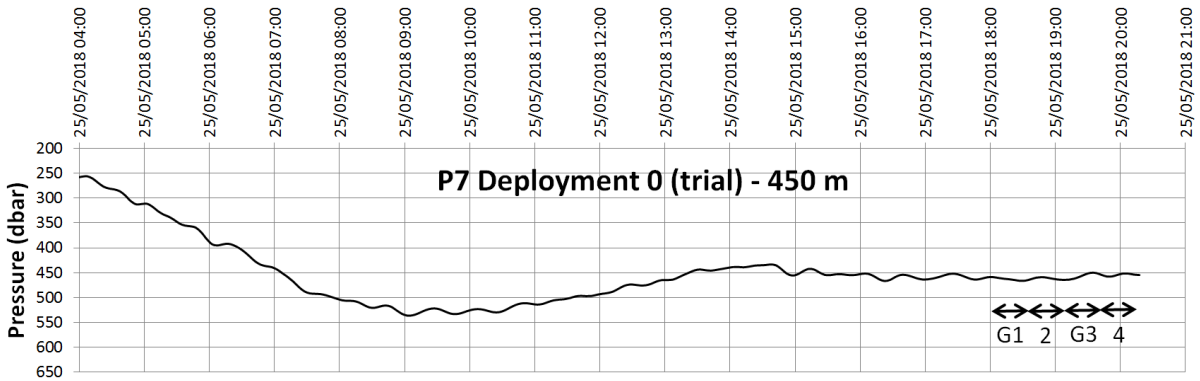
Cups 2 and 4: formalin

Added ballast: 3661 g

Park Piston Posn Mbp: 115

Deployment time: 25/05/18 01:15

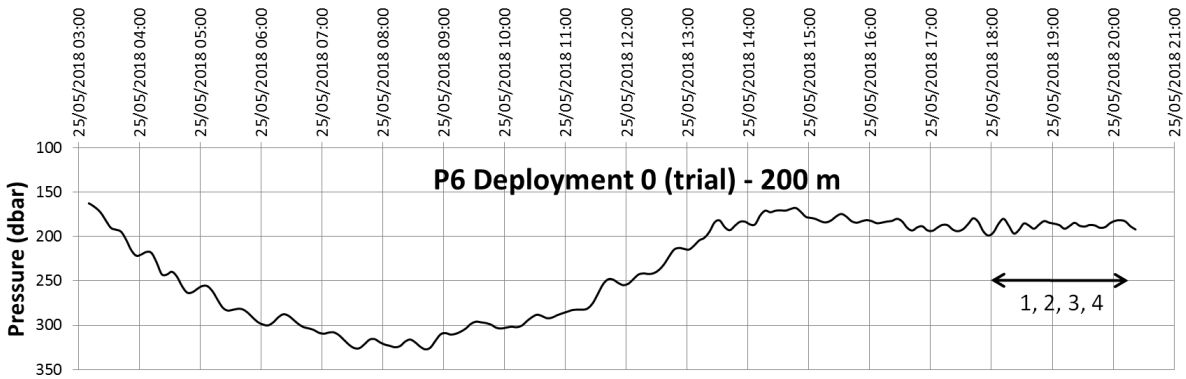
Deployment posn: 21.526° S, 9.516° E



P7 was over-ballasted by ~10 piston counts but stabilised at 450 m before sampling began. Based on this, the next deployment will use a Park Piston Position of 125. All sample cups operated as planned.

P6 (standard trap)

Station:	BS1, event 5
Target depth:	200 m
Target temp:	13.0°C
In situ density:	1027.400 kg m^{-3}
Sampling strategy:	Cup 1, open 25/05/18 18:00, close 25/05/18 18:30 *(30 minutes)*
	Cup 2, open 25/05/18 18:35, close 25/05/18 19:05 *(30 minutes)*
	Cup 3, open 25/05/18 19:10, close 25/05/18 19:40 *(30 minutes)*
	Cup 4, open 25/05/18 19:45, close 25/05/18 20:15 *(30 minutes)*
Cup additives:	Cups 1, 2, 3 and 4: formalin
Added ballast:	3954 g
Park Piston Posn Mbp:	115
Deployment time:	25/05/18 01:30
Deployment posn:	21.526° S, 9.516° E

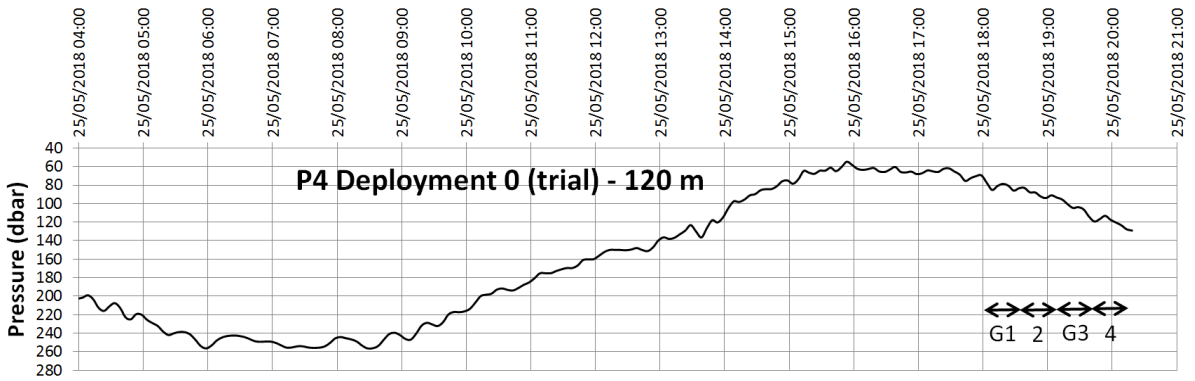


P6 was over-ballasted by ~44 piston counts but stabilised at about 190 m before sampling began. Based on this, the next deployment will use a Park Piston Position of 159. All sample cups operated as planned.

It was intended that the four cups would open sequentially for 30 minutes each but all four cams were left on by mistake so in fact all four cups opened simultaneously for four sequential 30 minute periods.

P4 (camera trap)

Station:	BS1, event 6
Target depth:	120 m
Target temp:	15.6°C
In situ density:	1026.689 kg m^{-3}
Sampling strategy:	Cup G1, open 25/05/18 18:00, close 25/05/18 18:30 *(30 minutes)*
	Cup 2, open 25/05/18 18:35, close 25/05/18 19:05 *(30 minutes)*
	Cup G3, open 25/05/18 19:10, close 25/05/18 19:40 *(30 minutes)*
	Cup 4, open 25/05/18 19:45, close 25/05/18 20:15 *(30 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3560 g
Park Piston Posn Mbp:	115
Deployment time:	25/05/17 01:45
Deployment posn:	21.526° S, 9.516° E



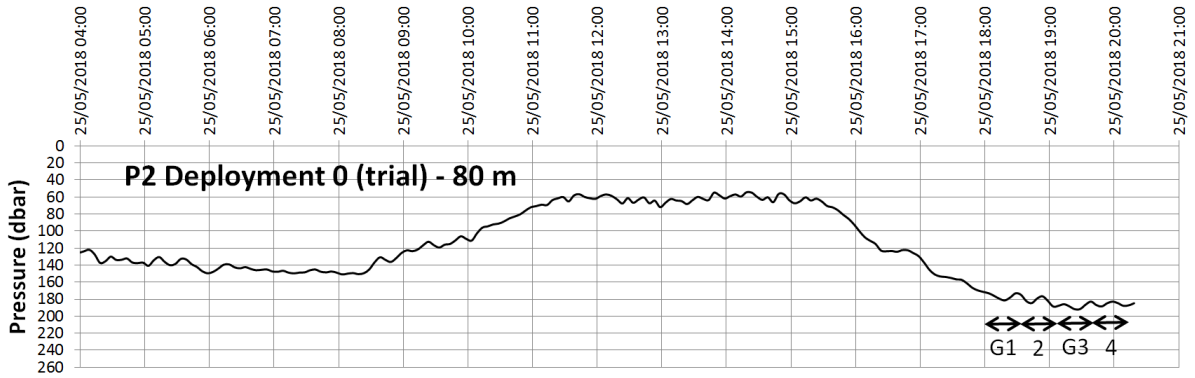
P4 was over-ballasted and oscillated between 120 m and 60 m without reaching stabilisation within the deployment period. However, a piston position approximately midway between the oscillations, 160 counts, was selected as Park Piston Position for the next deployment. All sample cups operated as planned.

There was an offset between the APEX and Idronaut pressure sensors with the Idronaut reading ~3 dbar higher than the APEX.

P2 (standard trap)

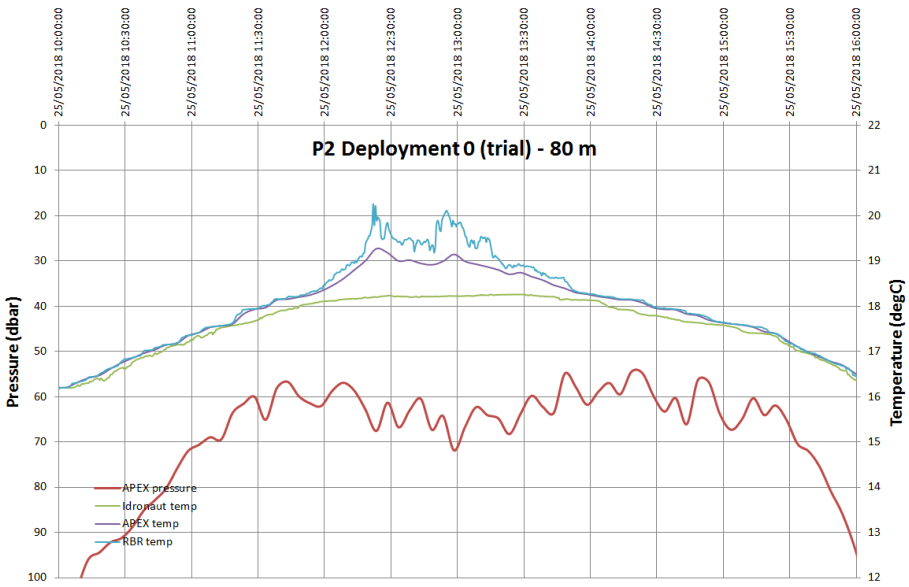
Station: BS1, event 7

Target depth:	80 m
Target temp:	17.2°C
In situ density:	1026.271 kg m^{-3}
Sampling strategy:	Cup 1, open 25/05/18 18:00, close 25/05/18 18:30 *(30 minutes)*
	Cup 2, open 25/05/18 18:35, close 25/05/18 19:05 *(30 minutes)*
	Cup 3, open 25/05/18 19:10, close 25/05/18 19:40 *(30 minutes)*
	Cup 4, open 25/05/18 19:45, close 25/05/18 20:15 *(30 minutes)*
Cup additives:	Cups 1, 2, 3 and 4: formalin
Added ballast:	3998 g
Park Piston Posn Mbp:	115
Deployment time:	25/05/18 02:00
Deployment posn:	21.526° S, 9.516° E

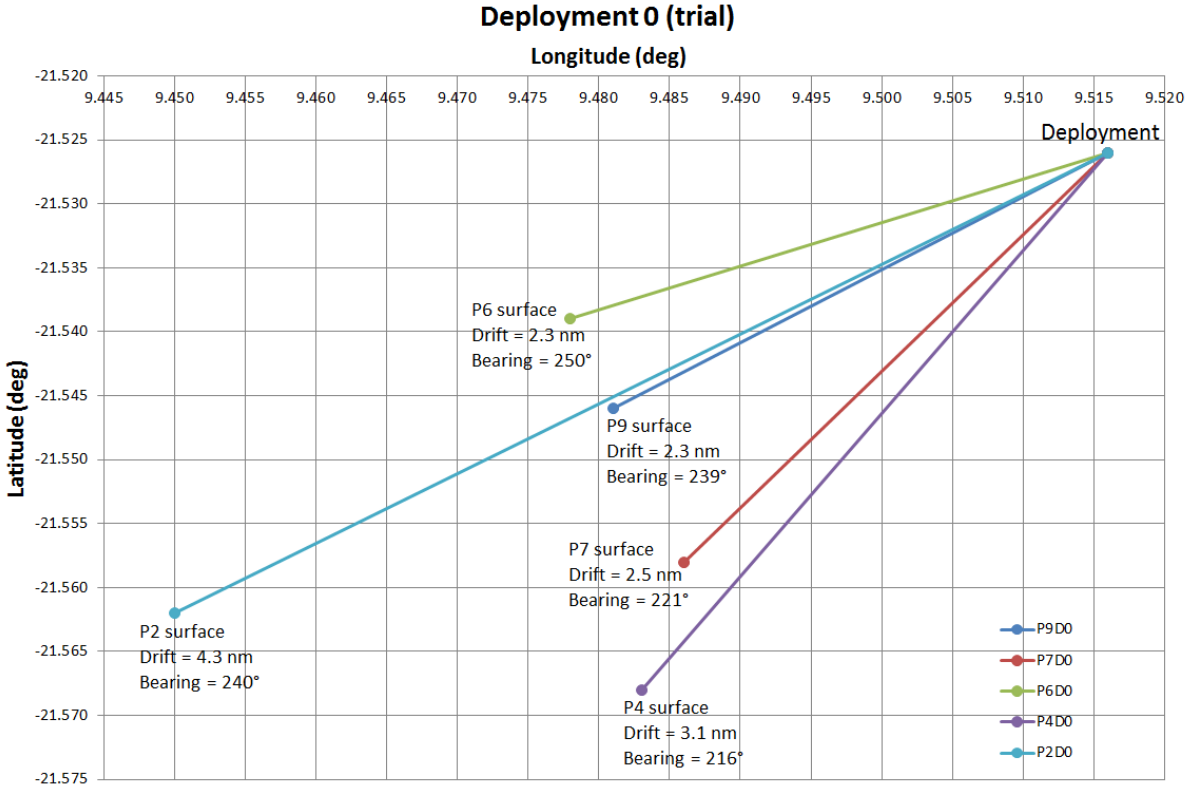


P2 was over-ballasted and oscillated between 150 m and 60 m without reaching stabilisation within the deployment period. However, a piston position approximately midway between the oscillations, 145 counts, was selected as Park Piston Position for the next deployment. All sample cups operated as planned.

Between 11:30 and 15:30 the P2 pressure plot plateaus around 60 m; this demarks an abrupt density gradient at the base of the mixed layer. During this time the APEX buoyancy engine reduced buoyancy by 24 piston counts; this equates to a volume reduction of 27.7 ml and a Pelagra density increase of about 0.216 kg m^{-3}. Despite this, P2 was firmly stuck on this density layer and unable to sink. The temperature data (see plot below) obtained by P2 during this time also reveals a large vertical temperature gradient over the height of the trap.



The blue curve represents the temperature recorded by the RBR logger situated right at the top of the lifting frame; the purple curve was recorded at the top of the APEX float and the green curve by the Idronaut logger at the base of the trap. The vertical separation between the Idronaut and APEX loggers is 1.5 m and the RBR logger is a further 0.6 m above that. The peak temperature difference between the Idronaut and RBR loggers is 2°C.



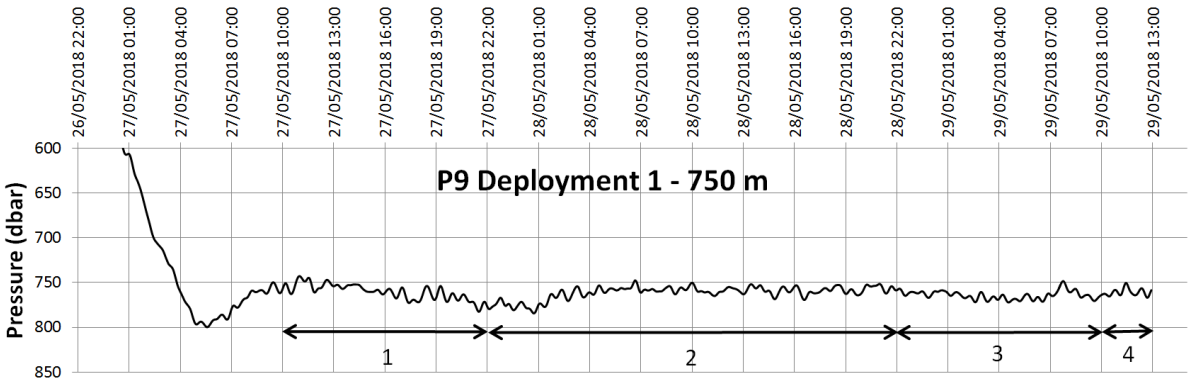
Deployment 1 (26 May 2018) Station BS1

All five traps were deployed to the same depths as for the trial deployment. In all cases the added ballast was kept the same and adjustments were made to the Park Piston Position to compensate for previous over-ballasting.

Cup openings were timed to coincide with local midnight and local noon (local time is GMT + 2 hours). The traps were intended to be deployed in the same order as previously. However, due to a set-up error in traps P4 and P7, deployment of these was postponed for five hours to allow re-setting.

P9 (standard trap)

Station:	BS1, event 40
Target depth:	750 m
Target temp:	5.1°C
In situ density:	1030.697 kg m^{-3}
Sampling strategy:	Cup 1 open 27/05/18 10:00, close 27/05/18 21:55 *(11 hours, 55 minutes)*
	Cup 2, open 27/05/18 22:00, close 28/05/18 21:55 *(23 hours, 55 minutes)*
	Cup 3, open 28/05/18 22:00, close 29/05/18 09:55 *(11 hours, 55 minutes)*
	Cup 4, open 29/05/18 10:00, close 29/05/18 12:55 *(2 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)
Added ballast:	4218 g
Park Piston Posn Mbp:	157
Deployment time:	26/05/18 16:00
Deployment posn:	21.639° S, 9.502° E

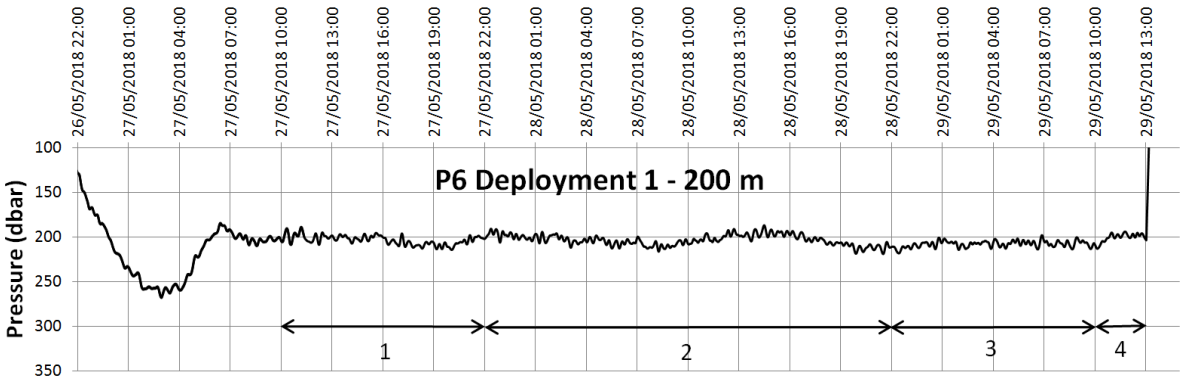


P9 was very well ballasted with an average piston count of ~158 during its stabilised drift period, just 1 count more buoyant than the selected Park Piston Position. All sample cups operated as planned.

There was an offset between the APEX and Idronaut pressure sensors with the Idronaut reading ~30 dbar higher than the APEX (APEX data shown here). P9 Idronaut also reported a few anomalous temperature readings; these were deleted from the Deployment Plots but remain in the raw data files.

P6 (standard trap)

Station:	BS1, event 41
Target depth:	200 m
Target temp:	13.0°C
In situ density:	1027.400 kg m^{-3}
Sampling strategy:	Cup 1 open 27/05/18 10:00, close 27/05/18 21:55 *(11 hours, 55 minutes)*
	Cup 2, open 27/05/18 22:00, close 28/05/18 21:55 *(23 hours, 55 minutes)*
	Cup 3, open 28/05/18 22:00, close 29/05/18 09:55 *(11 hours, 55 minutes)*
	Cup 4, open 29/05/18 10:00, close 29/05/18 12:55 *(2 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)
Added ballast:	3954 g
Park Piston Posn Mbp:	159
Deployment time:	26/05/18 16:30
Deployment posn:	21.640° S, 9.506° E

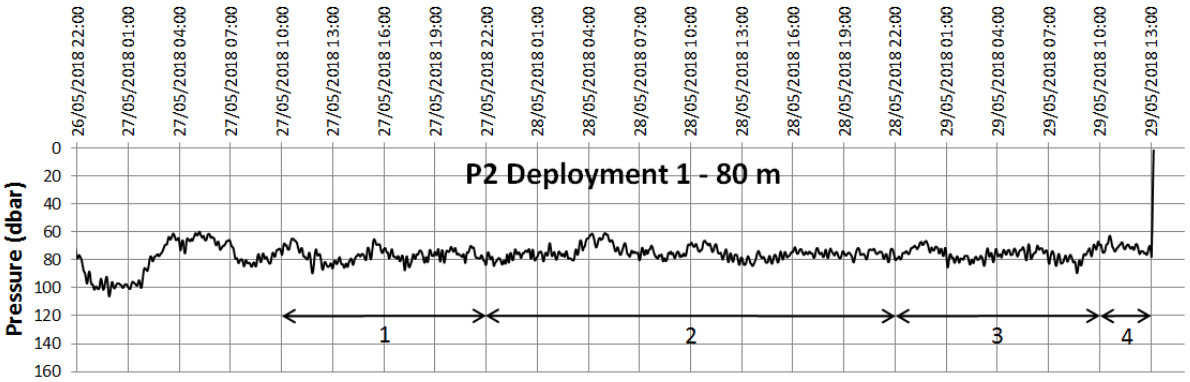


P6 was well ballasted with an average piston count of ~151 during its stabilised drift period, just 8 counts less buoyant than the selected Park Piston Position. All sample cups operated as planned.

P2 (standard trap)

Station:	BS1, event 42
Target depth:	80 m
Target temp:	17.2°C
In situ density:	1026.271 kg m^{-3}
Sampling strategy:	Cup 1 open 27/05/18 10:00, close 27/05/18 21:55 *(11 hours, 55 minutes)*

	Cup 2, open 27/05/18 22:00, close 28/05/18 21:55 *(23 hours, 55 minutes)*
	Cup 3, open 28/05/18 22:00, close 29/05/18 09:55 *(11 hours, 55 minutes)*
	Cup 4, open 29/05/18 10:00, close 29/05/18 12:55 *(2 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)
Added ballast:	3998 g
Park Piston Posn Mbp:	145
Deployment time:	26/05/18 17:00
Deployment posn:	21.644° S, 9.513° E



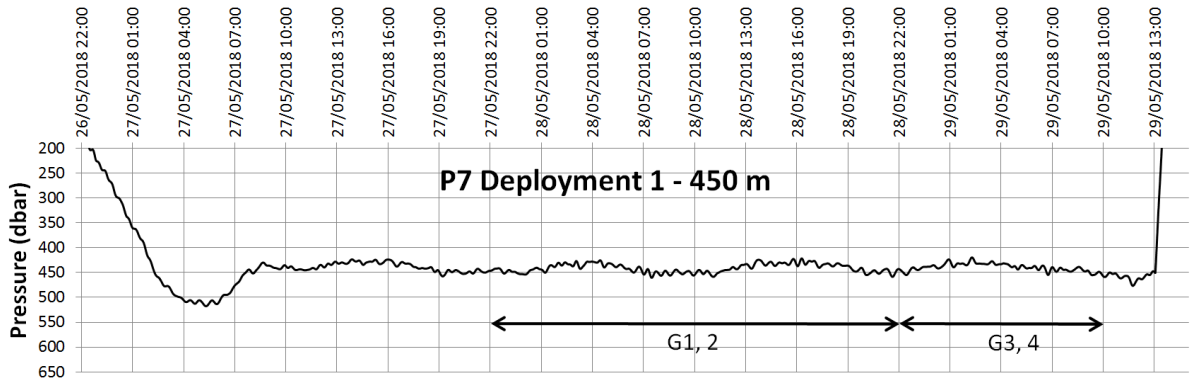
P2 was ballasted as well as could be expected with an average piston count of ~150 during its stabilised drift period, just 5 counts more buoyant than the selected Park Piston Position. Despite a few initial oscillations between 60 and 100 m, stabilisation was achieved at around 80 m as intended before the first cup opened at 10:00 on 27 May. All sample cups operated as planned.

P7 (camera trap)

Note that for both camera traps, although the intention was to open cups G1 and 2 for 24 hours followed by cups G3 and 4 for 12 hours, the operation of the opening mechanism is such that there must be incidental openings of 2 and G3 and of 4 and G1, each for 5 minutes – see below.

Station:	BS1, event 44
Target depth:	450 m
Target temp:	8.4°C
In situ density:	1029.031 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 27/05/18 22:00, close 28/05/18 21:45 *(23 hrs, 45 mins)*
	Cup 2 and G3, open 28/05/18 21:50, close 28/05/18 21:55 *(5 minutes)*
	Cup G3 and 4, open 28/05/18 22:00, close 29/05/18 09:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 29/05/18 09:50, close 29/05/18 09:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel

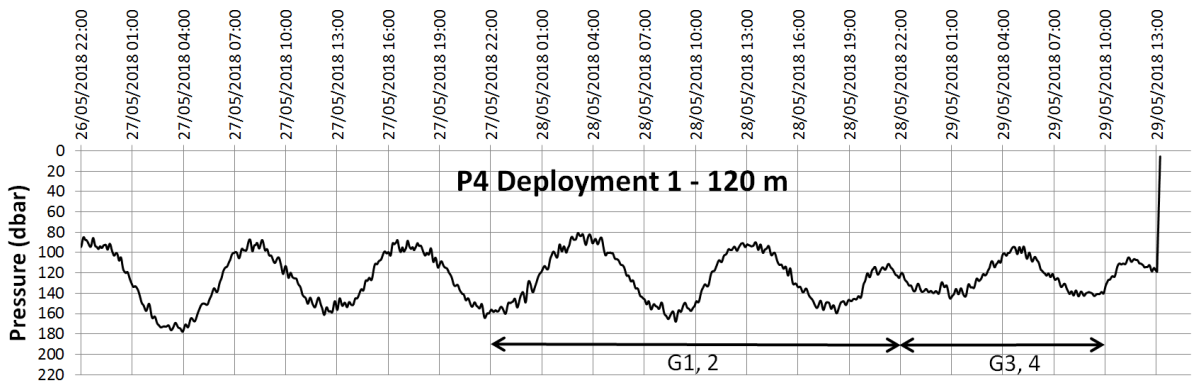
	Cups 2 and 4: formalin
Added ballast:	3661 g
Park Piston Posn Mbp:	125
Deployment time:	26/05/18 21:00
Deployment posn:	21.641° S, 9.509° E



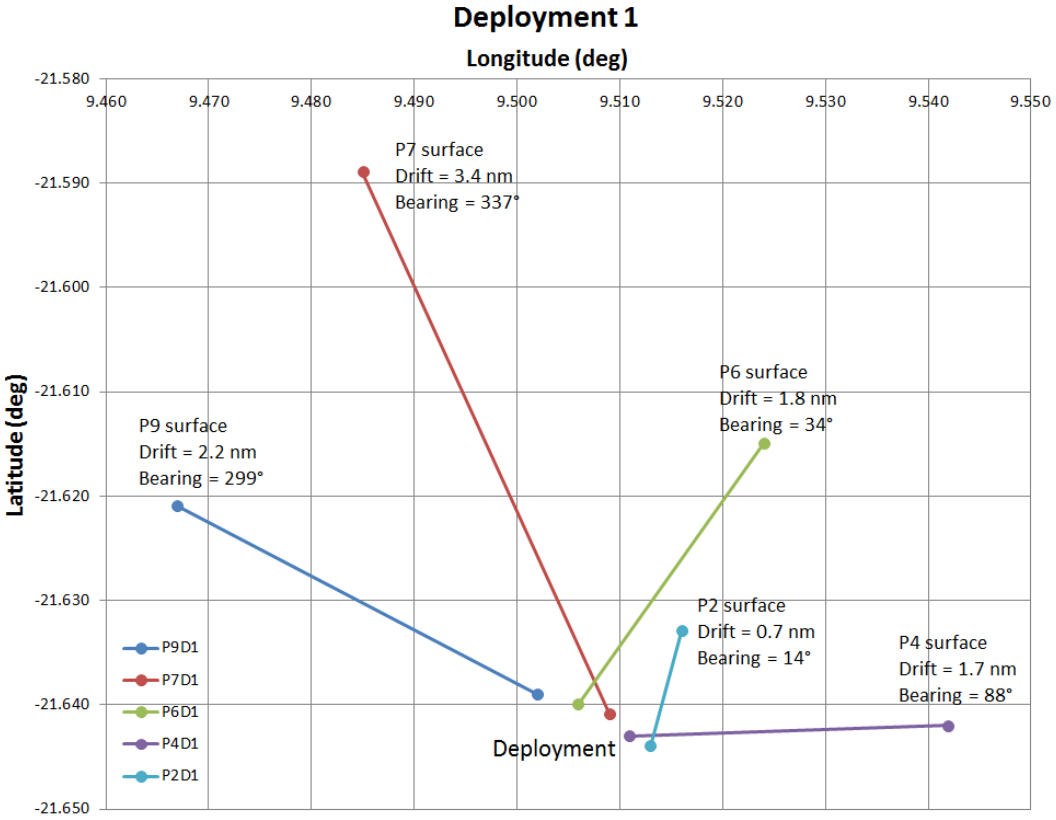
P6 was reasonably well ballasted with an average piston count of ~142 during its stabilised drift period; this was 17 counts more buoyant than the selected Park Piston Position of 125 counts. All sample cups operated as planned.

P4 (camera trap)

Station:	BS1, event 45
Target depth:	120 m
Target temp:	15.6°C
In situ density:	1026.689 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 27/05/18 22:00, close 28/05/18 21:45 *(23 hrs, 45 mins)*
	Cup 2 and G3, open 28/05/18 21:50, close 28/05/18 21:55 *(5 minutes)*
	Cup G3 and 4, open 28/05/18 22:00, close 29/05/18 09:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 29/05/18 09:50, close 29/05/18 09:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3560 g
Park Piston Posn Mbp:	160
Deployment time:	26/05/17 21:15
Deployment posn:	21.643° S, 9.511° E



P4 failed to stabilise and oscillated between 80 and 160 m throughout the deployment. The oscillations appear to have been caused by continual over-compensation of the buoyancy engine while attempting to maintain steady sigma-theta. The average piston position throughout was ~170 counts, just 10 counts off from the selected Park Piston Position. All sample cups operated as planned.

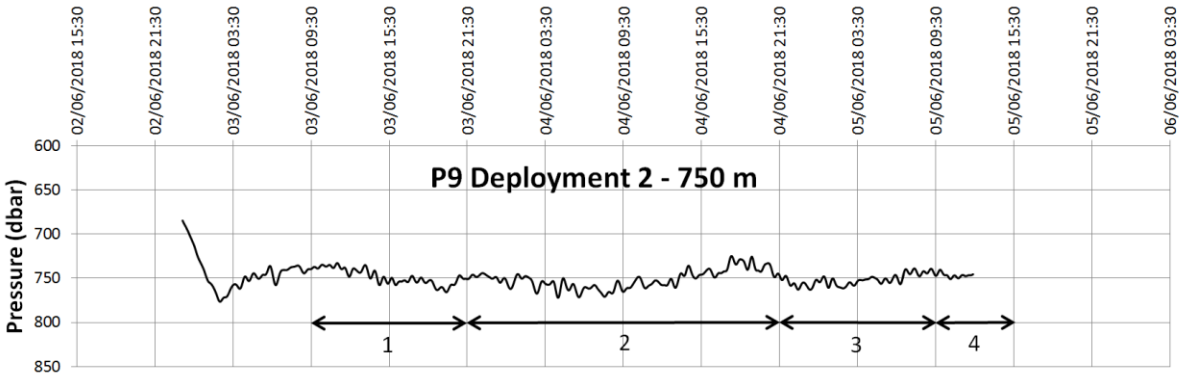


Deployment 2 (2 June 2018) Station BN1

All five traps were deployed with some depths modified as follows: P9 = 750 m; P7 = 350 m; P6 = 250 m; P4 = 120 m; P2 = 60 m. P2 was targeted to 60 m because the base of the mixed depth layer was at 40 m; shallower than at BS1. The water properties were not far different from at BS1 but slightly cooler. The Pelagras were reballasted for the new depths using the ballast spreadsheets but with Park Piston Positions set to the equilibrium positions obtained during Deployment 1. Sampling times were as Deployment 1 but with the live cups on P9, P6 and P2 set to open for 6 hours instead of 3.

P9 (standard trap)

Station:	BN1, event 122
Target depth:	750 m
Target temp:	4.8°C
In situ density:	1030.740 kg m^{-3}
Sampling strategy:	Cup 1 open 03/06/18 09:30, close 03/06/18 21:25 *(11 hours, 55 minutes)*
	Cup 2, open 03/05/18 21:30, close 04/06/18 21:25 *(23 hours, 55 minutes)*
	Cup 3, open 04/06/18 21:30, close 05/06/18 09:25 *(11 hours, 55 minutes)*
	Cup 4, open 05/06/18 09:30, close 05/06/18 15:25 *(5 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)
Added ballast:	4215 g
Park Piston Posn Mbp:	155
Deployment time:	02/06/18 15:30
Deployment posn:	18.317° S, 10.940° E



P9 was well ballasted with an average piston count of ~158 during its stabilised drift period, just 3 counts more buoyant than the selected Park Piston Position of 155. All sample cups operated as planned.

There was an offset between the APEX and Idronaut pressure sensors with the Idronaut reading ~30 dbar higher than the APEX (APEX data shown here). P9 Idronaut also reported a few anomalous temperature readings; these were deleted from the Deployment Plots but remain in the raw data files.

P7 (camera trap)

P7's camera cable was found to be faulty so was replaced with spare cable 'G'. 15 g was deducted from the added ballast to compensate for the slightly longer cable.

Station:	BN1, event 123
Target depth:	350 m
Target temp:	9.1°C
In situ density:	1028.501 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 03/06/18 21:30, close 04/06/18 21:15 *(23 hrs, 45 mins)*
	Cup 2 and G3, open 04/06/18 21:20, close 04/06/18 21:25 *(5 minutes)*
	Cup G3 and 4, open 04/06/18 21:30, close 05/06/18 09:15 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 05/06/18 09:20, close 05/06/18 09:25 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3629 g
Park Piston Posn Mbp:	142
Deployment time:	02/06/18 15:45
Deployment posn:	18.319° S, 10.941° E

P7 was under-ballasted and returned directly to the surface after releasing its depressor weight at 100 m. No Iridium transmissions were received. This trap was redeployed the next day as Deployment 2a.

P6 (standard trap)

Station:	BN1, event 124
Target depth:	250 m
Target temp:	11.2°C
In situ density:	1027.868 kg m^{-3}
Sampling strategy:	Cup 1 open 03/06/18 09:30, close 03/06/18 21:25 *(11 hours, 55 minutes)*
	Cup 2, open 03/05/18 21:30, close 04/06/18 21:25 *(23 hours, 55 minutes)*
	Cup 3, open 04/06/18 21:30, close 05/06/18 09:25 *(11 hours, 55 minutes)*
	Cup 4, open 05/06/18 09:30, close 05/06/18 15:25 *(5 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)

Added ballast:	3955 g
Park Piston Posn Mbp:	151
Deployment time:	02/06/18 16:00
Deployment posn:	18.323° S, 10.941° E

P6 was under-ballasted and returned directly to the surface after releasing its depressor weight at 100 m. First Iridium transmission received 02/06/18 20:31 – no position. This trap was redeployed the next day as Deployment 2a.

P4 (camera trap)

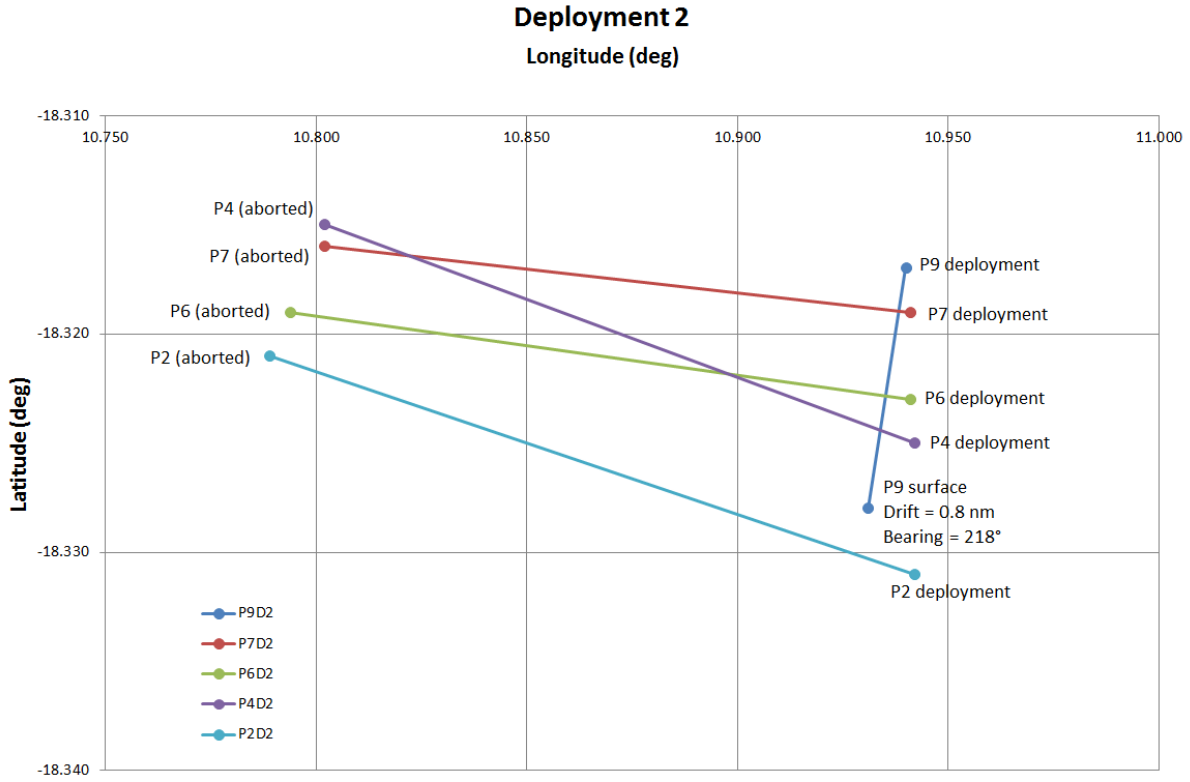
Station:	BN1, event 125
Target depth:	120 m
Target temp:	13.8°C
In situ density:	1026.942 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 03/06/18 21:30, close 04/06/18 21:15 *(23 hrs, 45 mins)*
	Cup 2 and G3, open 04/06/18 21:20, close 04/06/18 21:25 *(5 minutes)*
	Cup G3 and 4, open 04/06/18 21:30, close 05/06/18 09:15 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 05/06/18 09:20, close 05/06/18 09:25 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3540 g
Park Piston Posn Mbp:	170
Deployment time:	02/06/17 16:15
Deployment posn:	18.325° S, 10.942° E

P4 was under-ballasted and returned directly to the surface after releasing its depressor weight at 100 m. No Iridium transmissions were received. This trap was redeployed the next day as Deployment 2a.

P2 (standard trap)

Station:	BN1, event 126
Target depth:	60 m
Target temp:	17.2°C
In situ density:	1026.236 kg m^{-3}
Sampling strategy:	Cup 1 open 03/06/18 09:30, close 03/06/18 21:25 *(11 hours, 55 minutes)*
	Cup 2, open 03/05/18 21:30, close 04/06/18 21:25 *(23 hours, 55 minutes)*
	Cup 3, open 04/06/18 21:30, close 05/06/18 09:25 *(11 hours, 55 minutes)*
	Cup 4, open 05/06/18 09:30, close 05/06/18 15:25 *(5 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)
Added ballast:	4000 g
Park Piston Posn Mbp:	148
Deployment time:	02/06/18 16:30
Deployment posn:	18.331° S, 10.942° E

P2 was under-ballasted and returned directly to the surface after releasing its depressor weight at 100 m. First Iridium transmission received 02/06/18 21:51 – no position. This trap was redeployed the next day as Deployment 2a.



Deployment 2a (3 June 2018) Station BN1

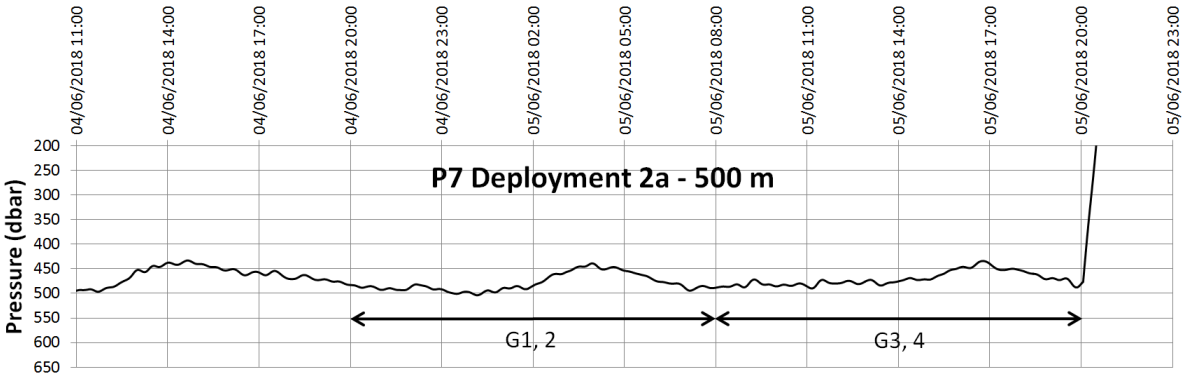
Redeployment of P7, P6, P4 and P2 following aborted Deployment 2. This time the ballast spreadsheets were used to calculate ballast using new CTD data and setting Park Piston Position to 115 in all cases.

P7 (camera trap)

P7's original camera cable and the camera and flash connectors were successfully cleaned and the cable operated properly. The original cable was used for this deployment so no ballast adjustments were necessary.

Station:	BN1, event 144
Target depth:	500 m
Target temp:	6.8°C
In situ density:	1029.397 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 04/06/18 20:00, close 05/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 2 and G3, open 05/06/18 07:50, close 05/06/18 07:55 *(5 minutes)*
	Cup G3 and 4, open 05/06/18 08:00, close 05/06/18 19:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 05/06/18 19:50, close 05/06/18 19:55 *(5 minutes)*

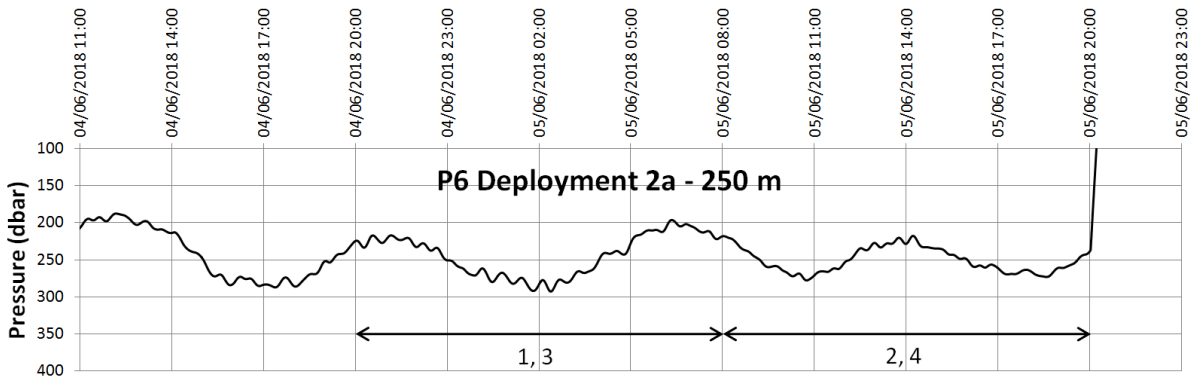
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3640 g
Park Piston Posn Mbp:	115
Deployment time:	03/06/18 22:00
Deployment posn:	18.020° S, 11.009° E



P7 was well ballasted with an average piston position of ~120, just 5 counts more buoyant that the set value. However, P7 struggled to maintain a steady sigma-theta leading to several depth oscillations between 450 and 500 m. All sample cups operated as planned.

P6 (standard trap)

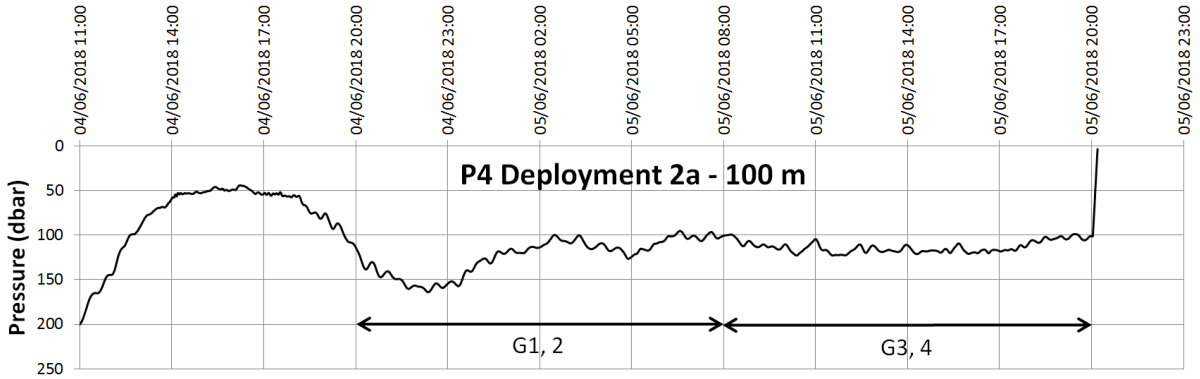
Station:	BN1, event 145
Target depth:	250 m
Target temp:	10.9°C
In situ density:	1027.880 kg m^{-3}
Sampling strategy:	Cups 1 and 3, open 04/06/18 20:00, close 05/06/18 07:55 *(11 hrs, 55 mins)*
	Cups 2 and 4, open 05/06/18 08:00, close 05/06/18 19:55 *(11 hrs, 55 mins)*
Cup additives:	Cups 1, 2: formalin
	Cups 3, 4: none (live)
Added ballast:	3949 g
Park Piston Posn Mbp:	115
Deployment time:	03/06/18 22:15
Deployment posn:	18.022° S, 11.011° E



P6 failed to stabilise properly but oscillated between 200 and 280 m throughout the deployment. Average piston position was ~140 counts. All sample cups operated as planned.

P4 (camera trap)

Station:	BN1, event 146
Target depth:	100 m
Target temp:	14.6°C
In situ density:	1026.852 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 04/06/18 20:00, close 05/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 2 and G3, open 05/06/18 07:50, close 05/06/18 07:55 *(5 minutes)*
	Cup G3 and 4, open 05/06/18 08:00, close 05/06/18 19:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 05/06/18 19:50, close 05/06/18 19:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3563 g
Park Piston Posn Mbp:	115
Deployment time:	03/06/17 22:30
Deployment posn:	18.024° S, 11.013° E

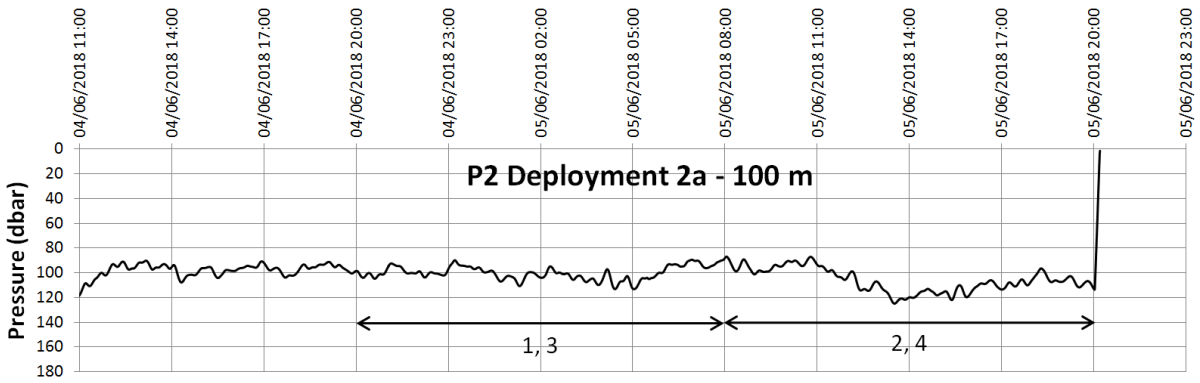


P4 was over-ballasted and oscillated between 380 m and 40 m before eventually stabilising at about 110 m but not quite before the first sampling cups had opened. Piston position during the stable drift period was ~182 counts. All sample cups operated as planned.

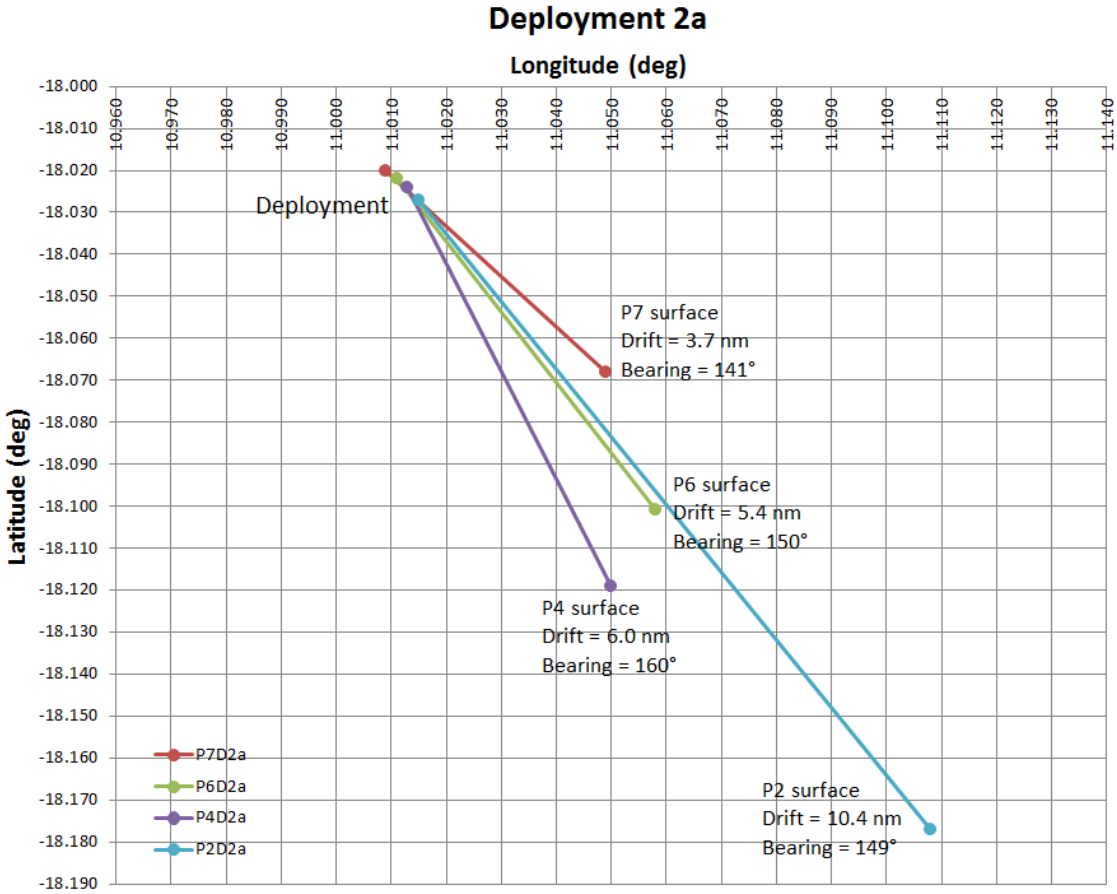
P2 (standard trap)

Station:	BN1, event 147
Target depth:	100 m
Target temp:	14.6°C
In situ density:	1026.852 kg m^{-3}
Sampling strategy:	Cups 1 and 3, open 04/06/18 20:00, close 05/06/18 07:55 *(11 hrs, 55 mins)*
	Cups 2 and 4, open 05/06/18 08:00, close 05/06/18 19:55 *(11 hrs, 55 mins)*

Cup additives:	Cups 1, 2: formalin
	Cups 3, 4: none (live)
Added ballast:	4005 g
Park Piston Posn Mbp:	115
Deployment time:	03/06/18 22:45
Deployment posn:	18.027° S, 11.015° E



P2 was well ballasted but underwent a couple of oscillations before finally stabilising after 15 hours. Despite some depth deviation during the deployment, sigma-theta was followed closely with an average piston position of about 144 counts. All sample cups operated as planned.

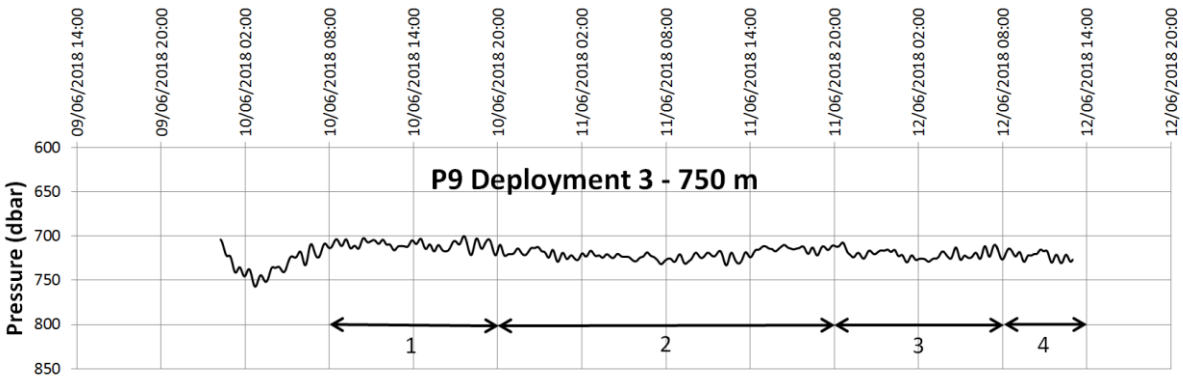

Deployment 2a
Longitude (deg)
Latitude (deg)
-18.000
-18.010
-18.020
-18.030
-18.040
-18.050
-18.060
-18.070
-18.080
-18.090
-18.100
-18.110
-18.120
-18.130
-18.140
-18.150
-18.160
-18.170
-18.180
-18.190
10.960
10.970
10.980
10.990
11.000
11.010
11.020
11.030
11.040
11.050
11.060
11.070
11.080
11.090
11.100
11.110
11.120
11.130
11.140
Deployment
P7 surface
Drift = 3.7 nm
Bearing = 141°
P6 surface
Drift = 5.4 nm
Bearing = 150°
P4 surface
Drift = 6.0 nm
Bearing = 160°
P2 surface
Drift = 10.4 nm
Bearing = 149°
P7D2a
P6D2a
P4D2a
P2D2a

Deployment 3 (9 June 2018) Station BN2

All five traps were deployed with the same ballast as for D2 and D2a but with Park Piston Positions adjusted accordingly.

P9 (standard trap)

Station:	BN2, event 235
Target depth:	750 m
Target temp:	4.8°C
In situ density:	1030.739 kg m^{-3}
Sampling strategy:	Cup 1 open 10/06/18 08:00, close 10/06/18 19:55 *(11 hours, 55 minutes)*
	Cup 2, open 10/05/18 20:00, close 11/06/18 19:55 *(23 hours, 55 minutes)*
	Cup 3, open 11/06/18 20:00, close 12/06/18 07:55 *(11 hours, 55 minutes)*
	Cup 4, open 12/06/18 08:00, close 12/06/18 13:55 *(5 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)
Added ballast:	4215 g
Park Piston Posn Mbp:	158
Deployment time:	09/06/18 16:00
Deployment posn:	18.030° S, 11.008° E

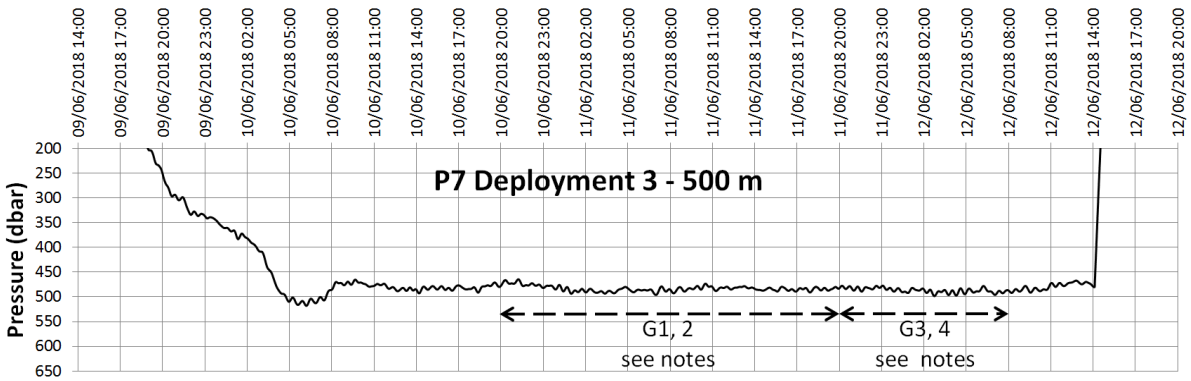


P9 performed well with Park Piston Position at 158 counts. Stabilisation was achieved although slightly shallower than 750 m. All sample cups operated as planned.

There was an offset between the APEX and Idronaut pressure sensors with the Idronaut reading ~30 dbar higher than the APEX (APEX data shown here). P9 Idronaut also reported a few anomalous temperature readings; these were deleted from the Deployment Plots but remain in the raw data files.

P7 (camera trap)

Station:	BN2, event 236
Target depth:	500 m
Target temp:	7.1°C
In situ density:	1029.394 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 10/06/18 20:00, close 11/06/18 19:45 *(23 hrs, 45 mins)*
	Cup 2 and G3, open 11/06/18 19:50, close 11/06/18 19:55 *(5 minutes)*
	Cup G3 and 4, open 11/06/18 20:00, close 12/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 12/06/18 07:50, close 12/06/18 07:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3640 g
Park Piston Posn Mbp:	120
Deployment time:	09/06/18 16:15
Deployment posn:	18.033° S, 11.015° E



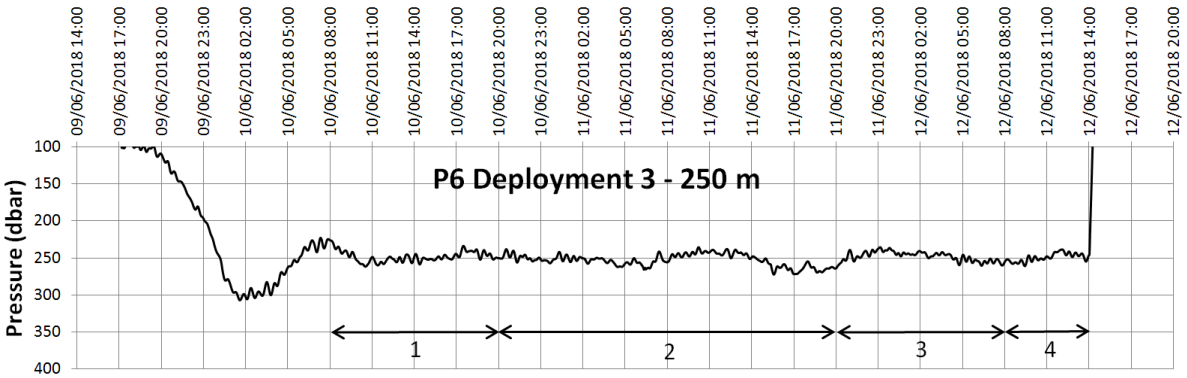
P7 was well-ballasted and stabilised slightly shallower than 500 m. On recovery, sample cups 2 and G3 were found to be open; the timer sequence had apparently stopped during the 5 minute transition sequence between the two sampling periods. This meant that cup G1 sampled correctly; cups 2 and G3 were both compromised and unusable and cup 4 never opened.

A conclusive reason for the timer sequence stopping was not found. The burnwire had released as planned; the timer batteries were at 11.45 V, which is within the normal range; no evidence of worm gear obstruction was found (although the trap had already been hosed off with fresh water); on re-start, the timer reported “Status Word: 11: RELEASED”, which is normal. Intuition suggests the most feasible cause would be physical jamming of the worm gear although no evidence was found to support this.

The P7 timer and sample cup mechanism were tested on deck and no issues were found.

P6 (standard trap)

Station:	BN2, event 238
Target depth:	250 m
Target temp:	10.6°C
In situ density:	1027.916 kg m^{-3}
Sampling strategy:	Cup 1 open 10/06/18 08:00, close 10/06/18 19:55 *(11 hours, 55 minutes)*
	Cup 2, open 10/05/18 20:00, close 11/06/18 19:55 *(23 hours, 55 minutes)*
	Cup 3, open 11/06/18 20:00, close 12/06/18 07:55 *(11 hours, 55 minutes)*
	Cup 4, open 12/06/18 08:00, close 12/06/18 13:55 *(5 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)
Added ballast:	3949 g
Park Piston Posn Mbp:	140
Deployment time:	09/06/18 16:30
Deployment posn:	18.038° S, 11.017° E



P6 was ballasted correctly and stabilised at about 250 m before the first sampling period. All sample cups operated as planned.

P4 (camera trap)

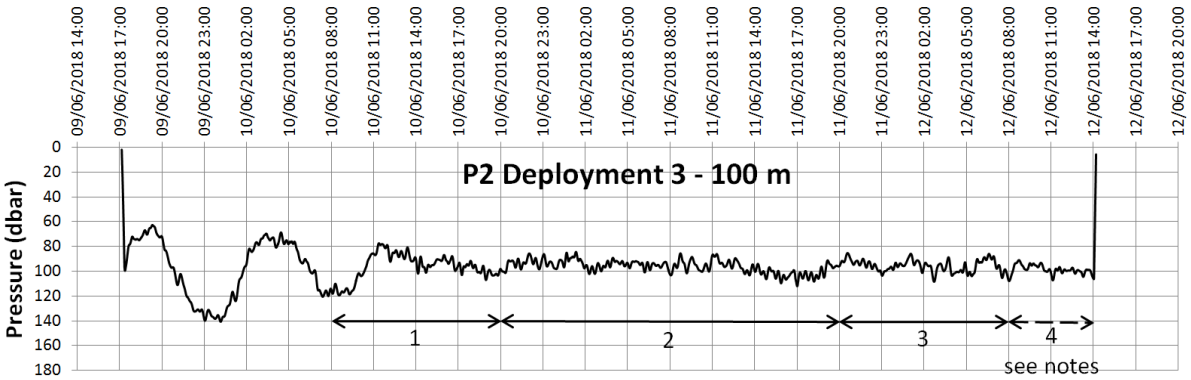
Station:	BN2, event 237
Target depth:	100 m
Target temp:	13.6°C
In situ density:	1026.900 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 10/06/18 20:00, close 11/06/18 19:45 *(23 hrs, 45 mins)*

	Cup 2 and G3, open 11/06/18 19:50, close 11/06/18 19:55 *(5 minutes)*
	Cup G3 and 4, open 11/06/18 20:00, close 12/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 12/06/18 07:50, close 12/06/18 07:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3563 g
Park Piston Posn Mbp:	182
Deployment time:	09/06/18 16:45
Deployment posn:	18.037° S, 11.015° E

P4 was under-ballasted and returned directly to the surface after releasing its depressor weight at 100 m. No Iridium transmissions were received as the antenna remained under-water. This trap was redeployed the next day as Deployment 3a.

P2 (standard trap)

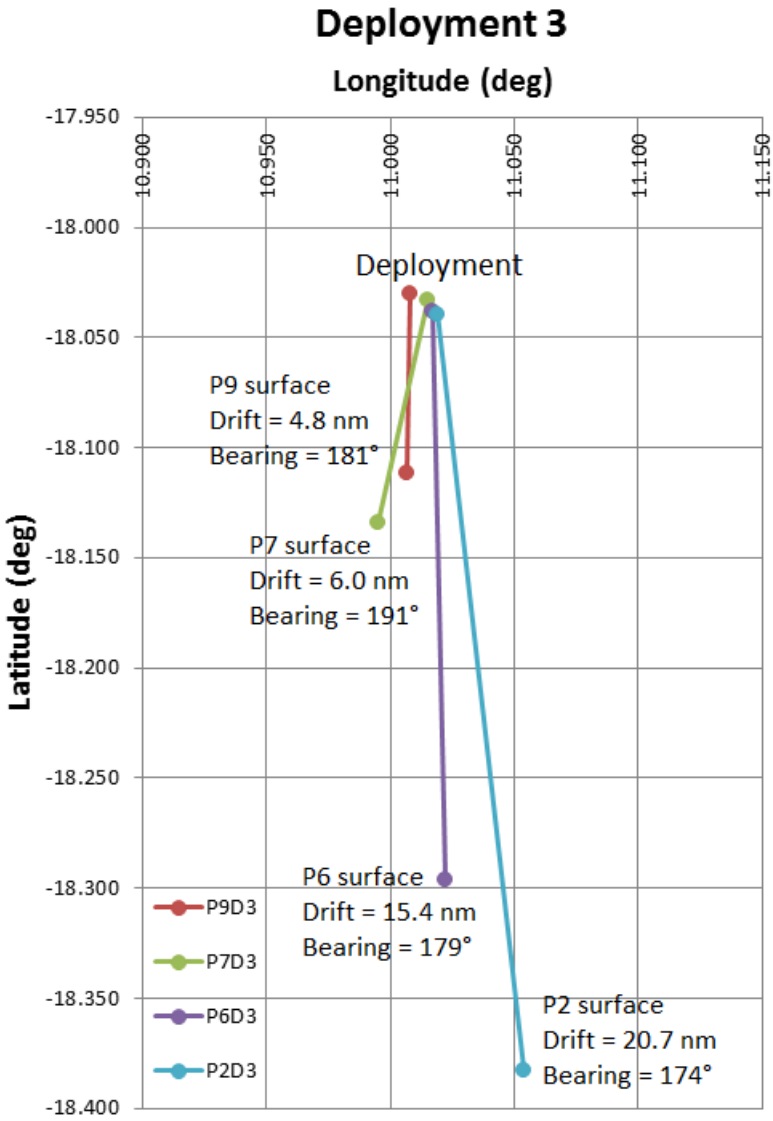
Station:	BN2, event 239
Target depth:	100 m
Target temp:	13.6°C
In situ density:	1026.900 kg m^{-3}
Sampling strategy:	Cup 1 open 10/06/18 08:00, close 10/06/18 19:55 *(11 hours, 55 minutes)*
	Cup 2, open 10/05/18 20:00, close 11/06/18 19:55 *(23 hours, 55 minutes)*
	Cup 3, open 11/06/18 20:00, close 12/06/18 07:55 *(11 hours, 55 minutes)*
	Cup 4, open 12/06/18 08:00, close 12/06/18 13:55 *(5 hours, 55 minutes)*
Cup additives:	Cups 1, 2 and 3: formalin
	Cup 4: none (live)
Added ballast:	4005 g
Park Piston Posn Mbp:	144
Deployment time:	09/06/18 17:00
Deployment posn:	18.039° S, 11.019° E



P2 was well ballasted and, apart from an oscillation between 120 and 80 m during the first 3 hours of sampling, stabilised successfully at around 100 m.

On recovery, sample cup four was found to be fully open. Cups 1, 2 and 3 appear to have worked as planned. As for P4 and P7, no conclusive reason was found to explain this. The burnwire had released as planned; the timer batteries were at 11.46 V, which is within the normal range; no evidence of worm gear obstruction was found (although the trap had already been hosed off with fresh water); on re-start, the timer reported “Status Word: 11: RELEASED”, which is normal. Intuition suggests the most feasible cause would be physical jamming of the worm gear although again, no evidence was found to support this.

The P2 timer and sample cup mechanism were tested on deck and no issues were found.



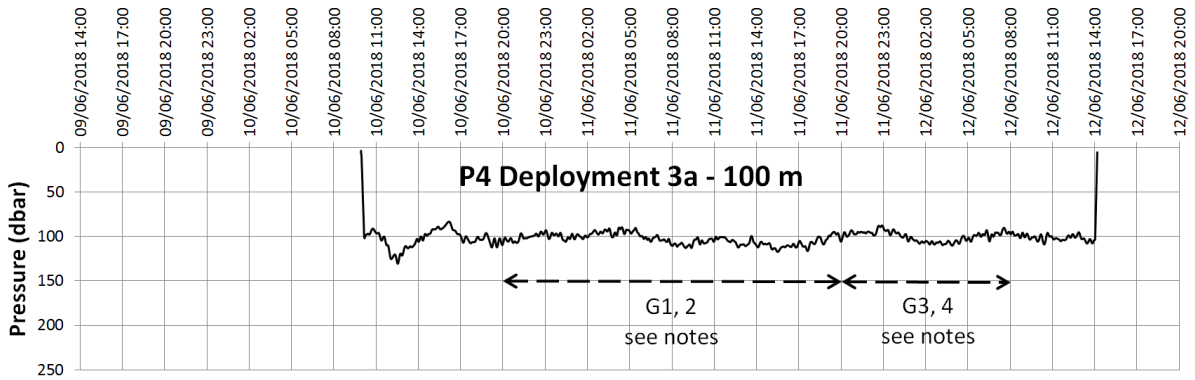
Deployment 3a (10 June 2018) Station BN2

Redeployment of P4 following aborted deployment D3. P4 was underballasted – redeployed with same added ballast and Park Piston Position at 165 (reduced from 182). Cups had not opened yet so timer was not reset. APEX float reprogramed and restarted accordingly.

P4 (camera trap)

Station:	BN2, event 251
Target depth:	100 m
Target temp:	13.6°C
In situ density:	1026.900 kg m^{-3}

Sampling strategy:	Cup G1 and 2, open 10/06/18 20:00, close 11/06/18 19:45 *(23 hrs, 45 mins)*
	Cup 2 and G3, open 11/06/18 19:50, close 11/06/18 19:55 *(5 minutes)*
	Cup G3 and 4, open 11/06/18 20:00, close 12/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 12/06/18 07:50, close 12/06/18 07:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3563 g
Park Piston Posn Mbp:	165
Deployment time:	10/06/18 09:45
Deployment posn:	18.020° S, 11.009° E



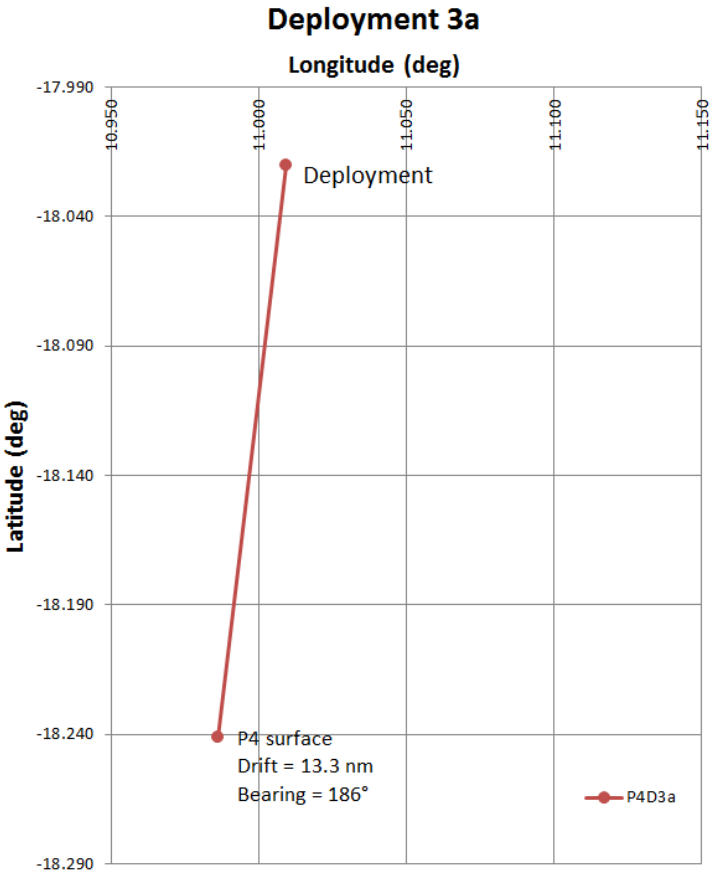
P4 was re-deployed 17 hours late due to the aborted Deployment 3. Despite this, it managed to stabilise well and in time for the first sampling period. However, on recovery sample cups G1 and 2 were found to be partly open with the cam carousel stopped and the cams on the 'opening' ramp. Cups G1 and 2 were therefore compromised and of no scientific use. It is interesting to note that there was evidence of particles in cup 4 which would suggest that it had been open at some time.

A conclusive reason for the timer sequence stopping was not found. The burnwire had released as planned; the timer batteries were at 11.40 V, which is within the normal range; no evidence of worm gear obstruction was found (although the trap had already been hosed off with fresh water); on re-start, the timer reported "Status Word: 11: RELEASED", which is normal. Intuition suggests the most feasible cause, as with P7, would be physical jamming of the worm gear although again, no evidence was found to support this. However, as cup 4 appeared to have been open at some point, it may be possible that the carousel on P4 was not in its correct starting position on deployment. This is unlikely however, as to have stopped where it did the same two cups must have been partly open on deployment (because the timer sequence turns a full 360°) and it is inconceivable that this would not have been noticed when the sample cups were put in place.

There was evidence of a high abundance of zooplankton in the water column. This supposition was supported by a significant number of zooplankton species trapped under the camera and flash housings on P4 and P7, despite both traps having been hosed off. This is something that has not been evident on previous deployments and certainly not on previous deployments during DY090. Although by no means conclusive, one hypothesis is that the worm gear became jammed with zooplankton that got washed out when the traps were hosed off.

Whilst the above is speculative, it is curious that the sampling cups have operated as intended until deployments 3 and 3a where three out of five Pelagra traps have malfunctioned in similar ways during the same time period (although not at precisely the same time in each case). Identifying some phenomenon common to all three malfunctioned traps but unique to this deployment period may hold the answer.

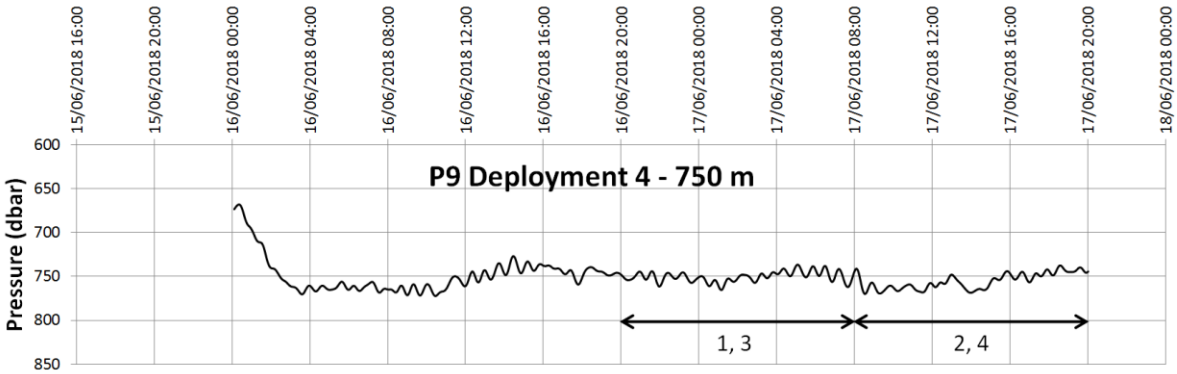
The P4 timer and sample cup mechanism were tested on deck and no issues were found.



Deployment 4 (15 June 2018) Station BN3

P9 (standard trap)

Station:	BN3, event 351
Target depth:	750 m
Target temp:	4.9°C
In situ density:	1030.735 kg m^{-3}
Sampling strategy:	Cups 1 and 3, open 16/06/18 20:00, close 17/06/18 07:55 *(11 hrs, 55 mins)*
	Cups 2 and 4, open 17/06/18 08:00, close 17/06/18 19:55 *(11 hrs, 55 mins)*
Cup additives:	Cups 1 and 2: formalin
	Cups 3 and 4: none (live)
Added ballast:	4215 g
Park Piston Posn Mbp:	158
Deployment time:	15/06/18 16:00
Deployment posn:	18.022° S, 11.010° E



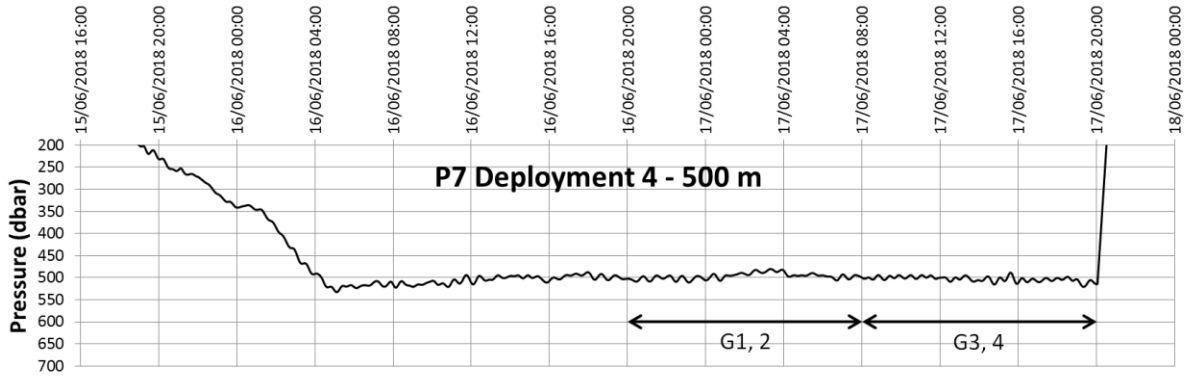
P9 performed well with Park Piston Position between 162 and 152 counts. Stabilisation was achieved at 750 m. All sample cups operated as planned.

There was an offset between the APEX and Idronaut pressure sensors with the Idronaut reading ~30 dbar higher than the APEX (APEX data shown here). P9 Idronaut also reported a few anomalous temperature readings; these were deleted from the Deployment Plots but remain in the raw data files.

P7 (camera trap)

Station:	BN3, event 352
Target depth:	500 m
Target temp:	7.0°C
In situ density:	1029.394 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 16/06/18 20:00, close 17/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 2 and G3, open 17/06/18 07:50, close 17/06/18 07:55 *(5 minutes)*
	Cup G3 and 4, open 17/06/18 08:00, close 17/06/18 19:45 *(11 hrs, 45 mins)*

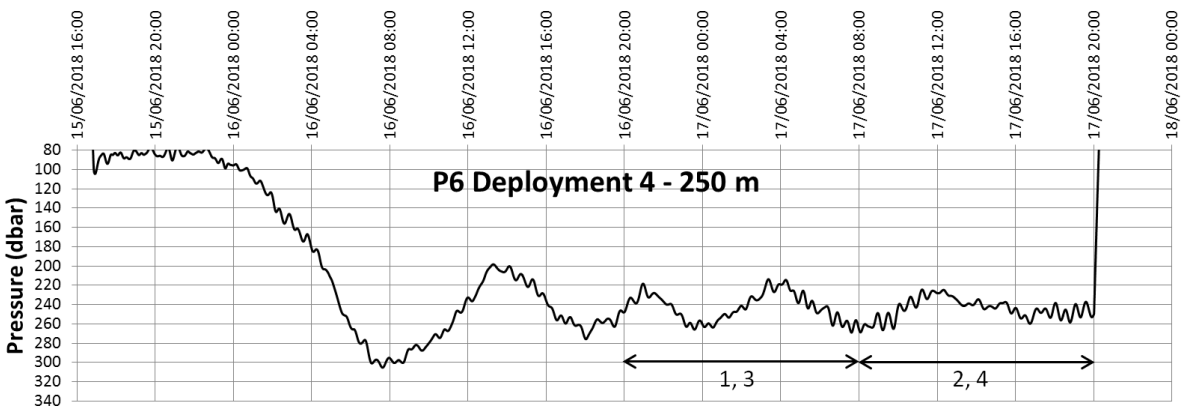
	Cup 4 and G1, open 17/06/18 19:50, close 17/06/18 19:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3640 g
Park Piston Posn Mbp:	120
Deployment time:	15/06/18 16:15
Deployment posn:	18.024° S, 11.011° E



P7 performed well with Park Piston Position around 112 counts. Stabilisation was achieved at 500 m. All sample cups operated as planned.

P6 (standard trap)

Station:	BN3, event 353
Target depth:	250 m
Target temp:	11.0°C
In situ density:	1027.904 kg m^{-3}
Sampling strategy:	Cups 1 and 3, open 16/06/18 20:00, close 17/06/18 07:55 *(11 hrs, 55 mins)*
	Cups 2 and 4, open 17/06/18 08:00, close 17/06/18 19:55 *(11 hrs, 55 mins)*
Cup additives:	Cups 1 and 2: formalin
	Cups 3 and 4: none (live)
Added ballast:	3949 g
Park Piston Posn Mbp:	145
Deployment time:	15/06/18 16:30
Deployment posn:	18.025° S, 11.012° E



P6 was ballasted reasonably well but oscillated between 220 and 270 m for the early part of the sampling period. Good stabilisation was achieved close to 250 m for the final 8 hours or so with Park Piston Position of 137 counts. All sample cups operated as planned.

P4 (camera trap)

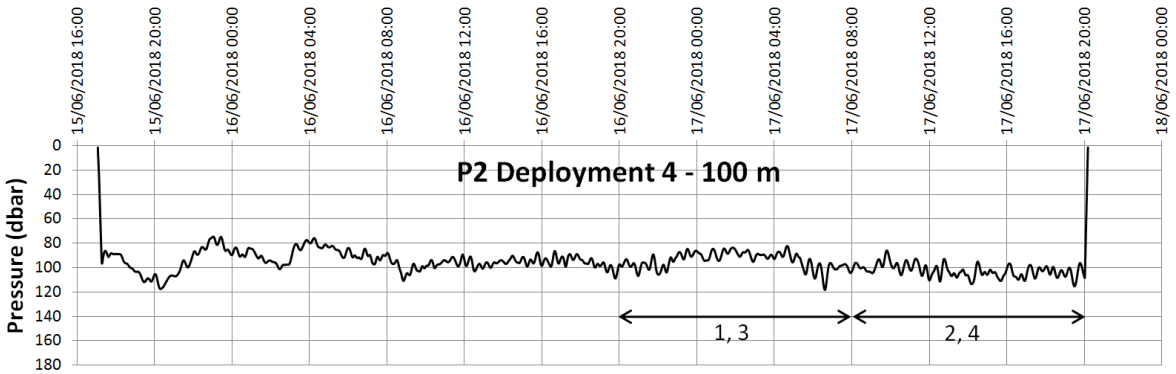
Station:	BN3, event 354
Target depth:	100 m
Target temp:	13.6°C
In situ density:	1026.909 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 16/06/18 20:00, close 17/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 2 and G3, open 17/06/18 07:50, close 17/06/18 07:55 *(5 minutes)*
	Cup G3 and 4, open 17/06/18 08:00, close 17/06/18 19:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 17/06/18 19:50, close 17/06/18 19:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3563 g
Park Piston Posn Mbp:	170
Deployment time:	15/06/18 16:45
Deployment posn:	18.026° S, 11.013° E

P4 was under-ballasted and returned directly to the surface after dropping its depressor weight at 100 m. A Park Piston Position adjustment of + 5 counts was made for this deployment based on the stabilised piston count for Deployment 3a; this was clearly not suitable and the Park Piston Position was set back to 165 counts for the redeployment, D4a.

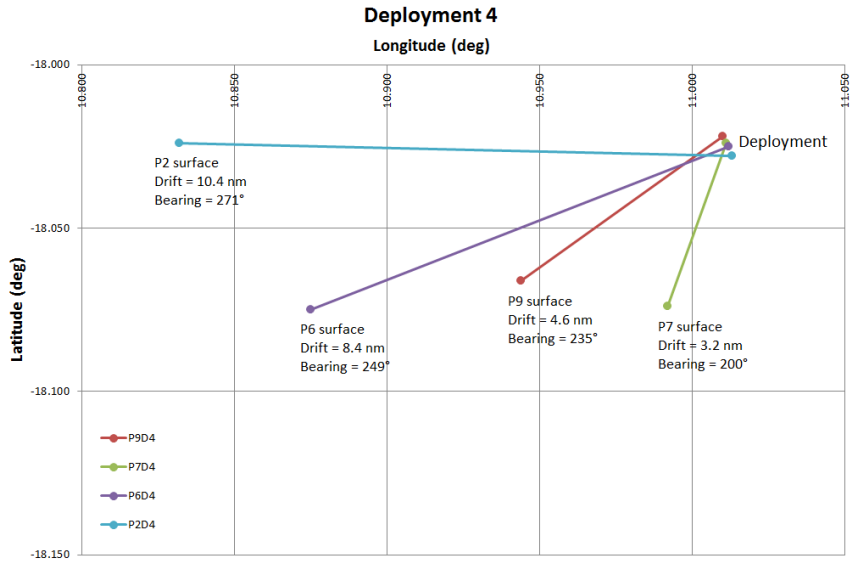
P2 (standard trap)

Station:	BN3, event 355

Target depth:	100 m
Target temp:	13.6°C
In situ density:	1026.909 kg m^{-3}
Sampling strategy:	Cups 1 and 3, open 16/06/18 20:00, close 17/06/18 07:55 *(11 hrs, 55 mins)*
	Cups 2 and 4, open 17/06/18 08:00, close 17/06/18 19:55 *(11 hrs, 55 mins)*
Cup additives:	Cups 1 and 2: formalin
	Cups 3 and 4: none (live)
Added ballast:	4005 g
Park Piston Posn Mbp:	135
Deployment time:	15/06/18 17:00
Deployment posn:	18.028° S, 11.013° E



P2 was ballasted fairly well and, despite some early oscillations, stabilised at around 100 m with Park Piston Position of between 151 and 157 by the time sampling had begun. All sampling cups operated as planned.



Deployment 4a (16 June 2018) Station BN3

Redeployment of P4, Deployment 4. Sampling not due to start until 16/06/18 20:00 so there should be plenty of time remaining to reach stabilisation.

P4 (camera trap)

Station:	BN3, event 368
Target depth:	100 m
Target temp:	13.6°C
In situ density:	1026.909 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 16/06/18 20:00, close 17/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 2 and G3, open 17/06/18 07:50, close 17/06/18 07:55 *(5 minutes)*
	Cup G3 and 4, open 17/06/18 08:00, close 17/06/18 19:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 17/06/18 19:50, close 17/06/18 19:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3563 g
Park Piston Posn Mbp:	165
Deployment time:	16/06/18 08:15
Deployment posn:	18.020° S, 11.008° E

P4 was again under-ballasted and returned directly to the surface after dropping its depressor weight at 100 m despite Park Piston Position being set back to 165 counts as per Deployment 3a. It was noted that the in situ water density encountered by this deployment was about 0.072 kg m^{-3} denser than for Deployment 3a. This is equal to a ballasting error of order 10 g.

It was decided that P4 would not be redeployed as the risk of further failures could waste valuable ship time.

P4 was left on deck after recovery and the timer was left connected and running as a check for proper operation. The first event, opening of cups G1 and 2, was witnessed and worked as intended just a few seconds past the programmed time of 16/06/18 22:00. The trap was checked again at about 09:30 on 17/06; at this time cups G3 and 4 should have been open (programmed for 17/06/18 08:00) but both were closed. Inspection revealed that the cams had advanced past cups G3 and 4 meaning they had already opened and closed. The timer was connected to a terminal program which revealed the timer clock was running OK. Part of the log follows:

001 18:55.54 0.00
001 18:55.54 0.00
001 18:55.55 0.00
001 18:55.55 0.00
001 18:55.55 0.00
001 18:55.56 0.00
001 18:55.56 0.00
001 18:55.57 0.00
001 18:55.57 0.00
001 18:55.58 0.00
001 18:55.58 0.00
001 18:55.58 0.00
001 18:55.59 0.00
001 18:55.59 0.00
001 18:56.00 0.00
001 18:56.00 0.00
001 18:56.01 0.00
001 18:56.01 0.00
001 18:56.02 0.00
001 18:56.02 0.00
001 18:56.02 0.00
001 18:56.03 0.00
Checking internal burn registers against RTC
Actual RTC time: 001 18:56.03
Programmed burn alarm: 002 05:50.00
Not time to burn the wire yet!
001 18:56.03 0.00
001 18:56.04 0.00
001 18:56.04 0.00

The timer and cup mechanism were tested on deck repeatedly with short programs and all worked fine.

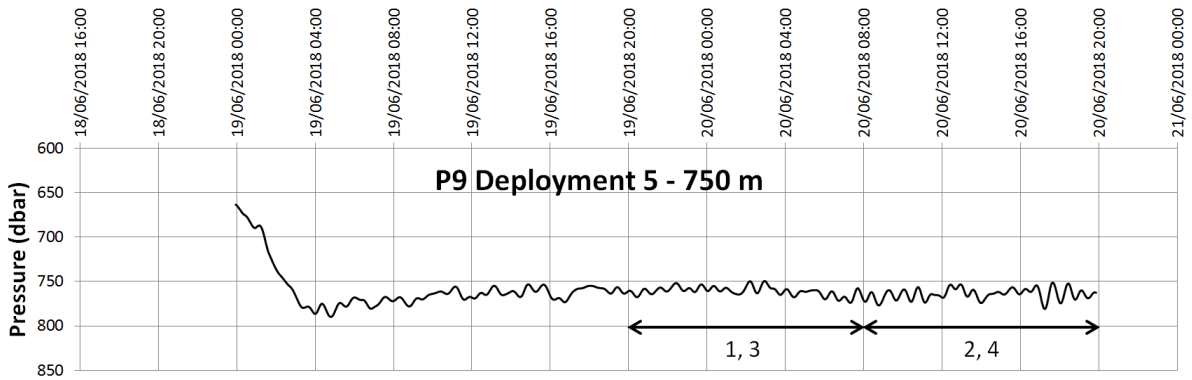
One possible explanation for the cup mechanism to be *ahead* of the timer program could be that the drive motor encoder malfunctioned intermittently and was not reporting counts to the program correctly. This would cause the motor to turn for longer than expected, resulting in the mechanism being ahead of the program. A faulty motor encoder had been found on another trap some time ago.

The motor was replaced with a new one and a fully rigged deck test was performed with 6 hour opening periods and all worked fine. Based on this it was decided that P4 would be redeployed for Deployment 5.

Deployment 5 (18 June 2018) Station RS

P9 (standard trap)

Station:	RS, event 412
Target depth:	750 m
Target temp:	4.9°C
In situ density:	1030.735 kg m^{-3}
Sampling strategy:	Cups 1 and 3, open 19/06/18 20:00, close 19/06/18 07:55 *(11 hrs, 55 mins)*
	Cups 2 and 4, open 20/06/18 08:00, close 20/06/18 19:55 *(11 hrs, 55 mins)*
Cup additives:	Cups 1 and 2: formalin
	Cups 3 and 4: none (live)
Added ballast:	4215 g
Park Piston Posn Mbp:	158
Deployment time:	18/06/18 16:00
Deployment posn:	18.021° S, 11.009° E



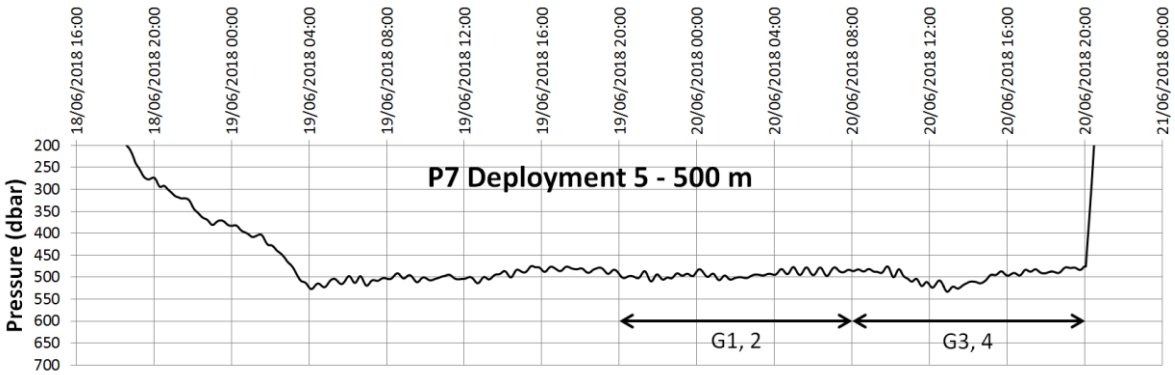
P9 performed very well with Park Piston Position at 152 counts for the majority of the deployment. Stabilisation was achieved at around 760 m. All sample cups operated as planned.

There was an offset between the APEX and Idronaut pressure sensors with the Idronaut reading ~30 dbar higher than the APEX (APEX data shown here). P9 Idronaut also reported a few anomalous temperature readings; these were deleted from the Deployment Plots but remain in the raw data files.

P7 (camera trap)

Station: RS, event 413

Target depth:	500 m
Target temp:	6.9°C
In situ density:	1029.395 kg m^{-3}
Sampling strategy:	Cup G1 and 2, open 19/06/18 20:00, close 20/06/18 07:45 *(11 hrs, 45 mins)*
	Cup 2 and G3, open 20/06/18 07:50, close 20/06/18 07:55 *(5 minutes)*
	Cup G3 and 4, open 20/06/18 08:00, close 20/06/18 19:45 *(11 hrs, 45 mins)*
	Cup 4 and G1, open 20/06/18 19:50, close 20/06/18 19:55 *(5 minutes)*
Cup additives:	Cups G1 and G3: gel
	Cups 2 and 4: formalin
Added ballast:	3640 g
Park Piston Posn Mbp:	120
Deployment time:	18/06/18 16:15
Deployment posn:	18.023° S, 11.010° E

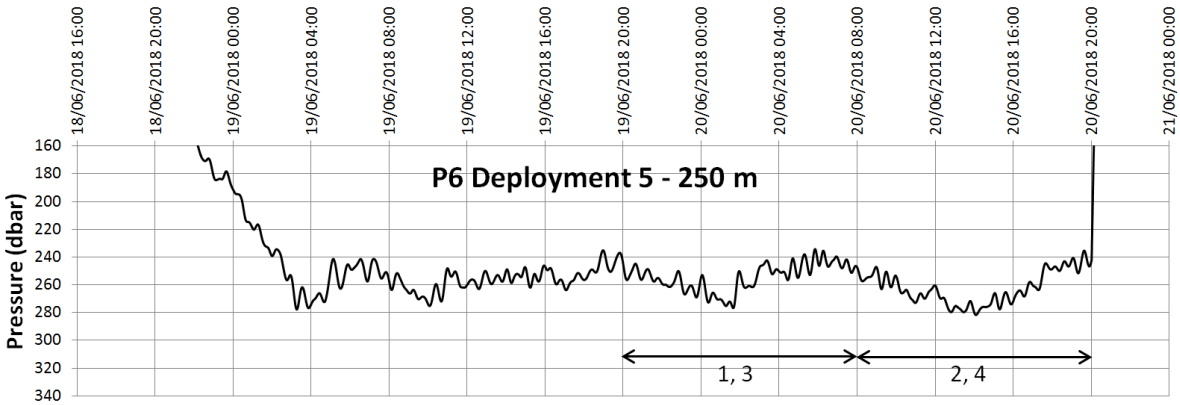


P7 performed well with Park Piston Position between 109 to 125 counts. Stabilisation was achieved at around 500 m. All sample cups operated as planned.

P6 (standard trap)

Station:	RS, event 414
Target depth:	250 m
Target temp:	11.1°C
In situ density:	1027.909 kg m^{-3}
Sampling strategy:	Cups 1 and 3, open 19/06/18 20:00, close 20/06/18 07:55 *(11 hrs, 55 mins)*
	Cups 2 and 4, open 20/06/18 08:00, close 20/06/18 19:55 *(11 hrs, 55 mins)*
Cup additives:	Cups 1 and 2: formalin
	Cups 3 and 4: none (live)
Added ballast:	3949 g
Park Piston Posn Mbp:	136
Deployment time:	18/06/18 16:30

Deployment posn: 18.025° S, 11.012° E



P6 was a little under-ballasted but recovered well. Stabilisation depth was a bit erratic between 240 and 280 m but sigma-theta was tracked well. Park Piston Position was between 133 and 145 counts. All sample cups operated as planned.

P4 (camera trap)

Station: RS, event 415

Target depth: 150 m

Target temp: 12.8°C

In situ density: 1027.242 kg m^{-3}

Sampling strategy: Cup G1 and 2, open 19/06/18 20:00, close 20/06/18 07:45 *(11 hrs, 45 mins)*

Cup 2 and G3, open 20/06/18 07:50, close 20/06/18 07:55 *(5 minutes)*

Cup G3 and 4, open 20/06/18 08:00, close 20/06/18 19:45 *(11 hrs, 45 mins)*

Cup 4 and G1, open 20/06/18 19:50, close 20/06/18 19:55 *(5 minutes)*

Cup additives: Cups G1 and G3: gel

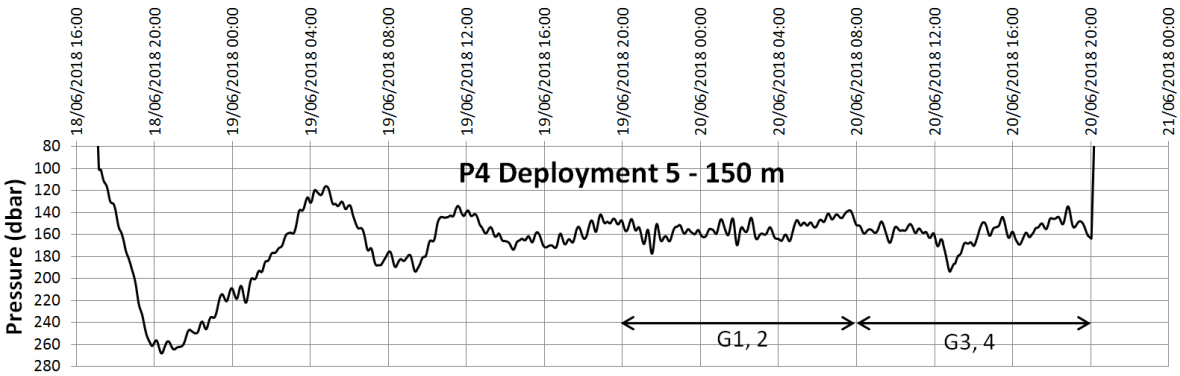
Cups 2 and 4: formalin

Added ballast: 3541 g

Park Piston Posn Mbp: 115

Deployment time: 18/06/18 16:45

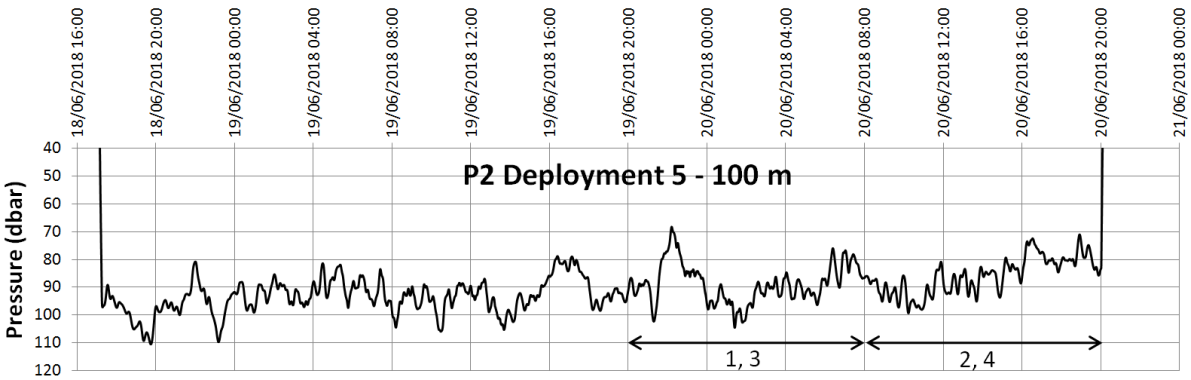
Deployment posn: 18.027° S, 11.013° E



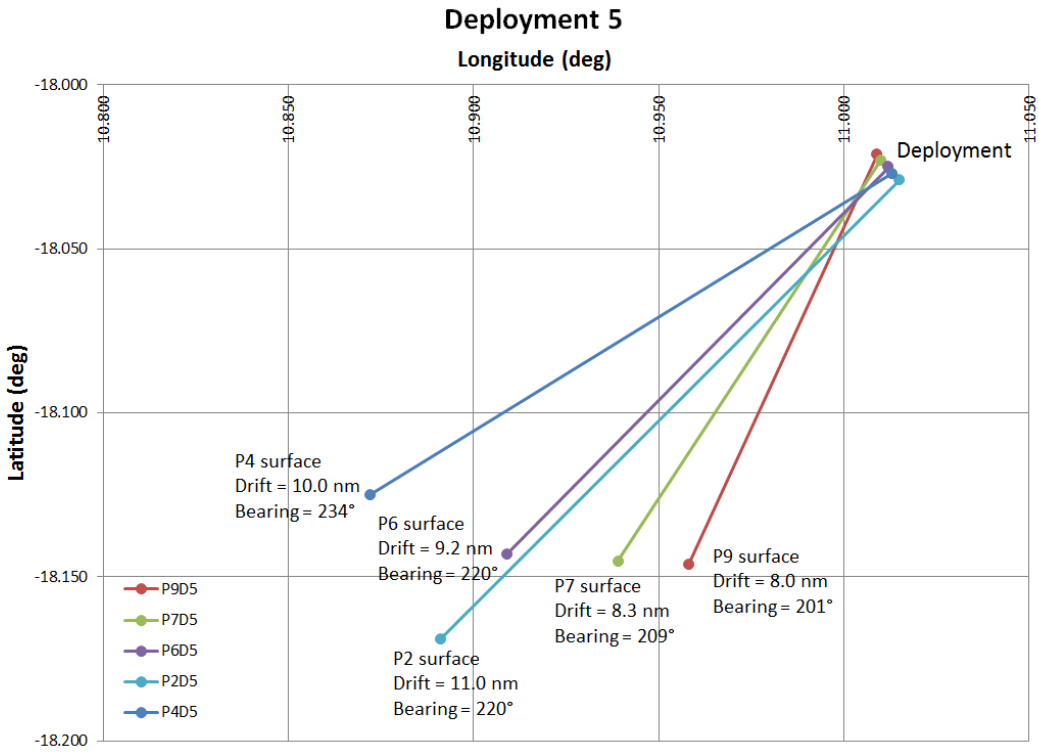
P4 was over-ballasted but recovered successfully to stabilise at around 150 m with Park Piston Position between 151 and 165 counts. All sample cups operated as planned.

P2 (standard trap)

Station:	RS, event 416
Target depth:	100 m
Target temp:	13.8°C
In situ density:	1026.888 kg m^{-3}
Sampling strategy:	Cups 1 and 3, open 19/06/18 20:00, close 20/06/18 07:55 *(11 hrs, 55 mins)*
	Cups 2 and 4, open 20/06/18 08:00, close 20/06/18 19:55 *(11 hrs, 55 mins)*
Cup additives:	Cups 1 and 2: formalin
	Cups 3 and 4: none (live)
Added ballast:	4005 g
Park Piston Posn Mbp:	135
Deployment time:	18/06/18 17:00
Deployment posn:	18.029° S, 11.015° E

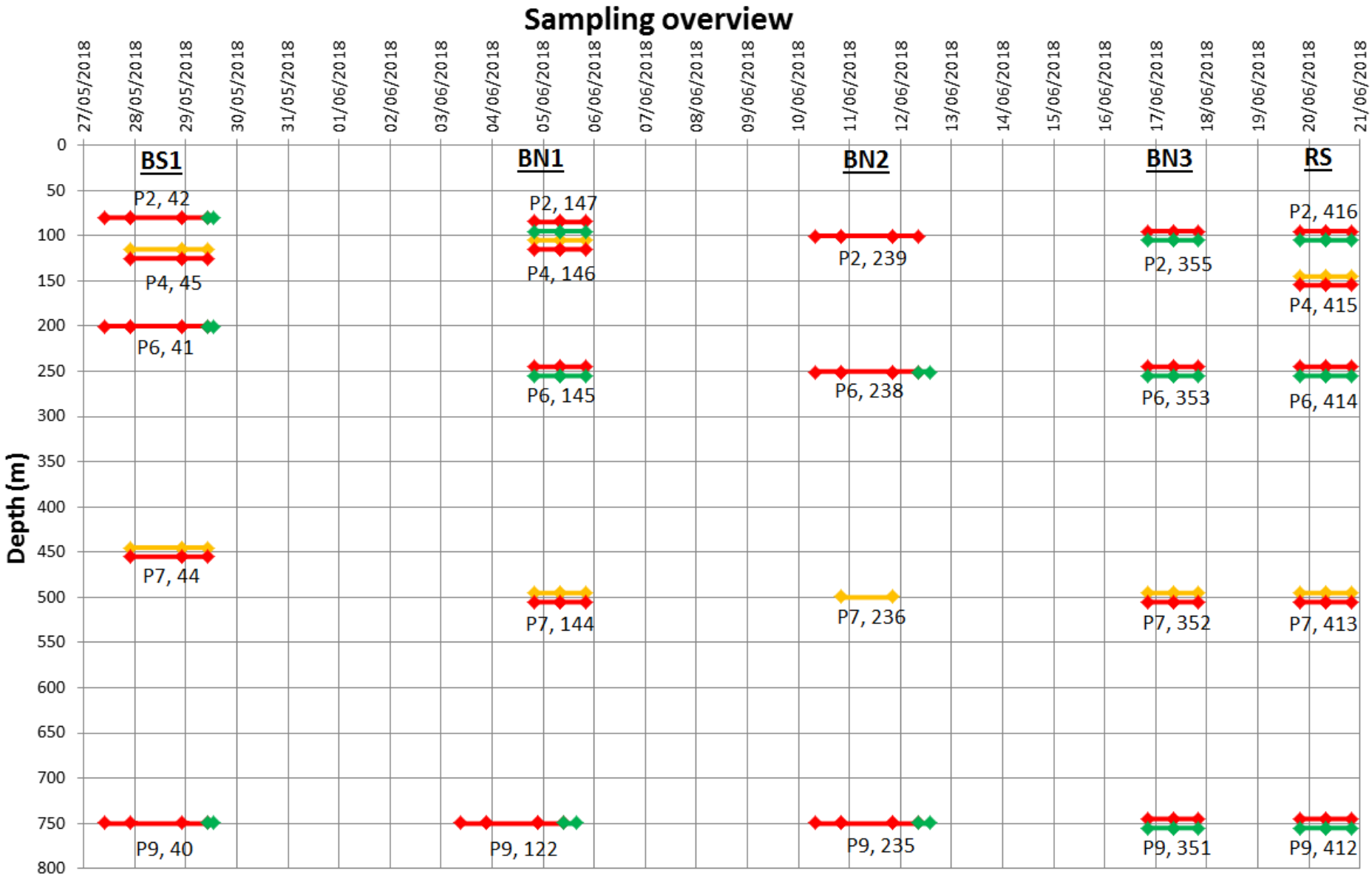


P2 was slightly under-ballasted but stabilised reasonably well around 80 to 90 m by the time sampling began. Park Piston Position was around 160 counts during this period. All sample cups operated as planned.



Acknowledgement

Thanks are extended to Teledyne Webb Research, North Falmouth, MA, USA for kindly providing Iridium data hosting services during both COMICS 1 and COMICS 2 science expeditions.


Sampling overview
27/05/2018
28/05/2018
29/05/2018
30/05/2018
31/05/2018
01/06/2018
02/06/2018
03/06/2018
04/06/2018
05/06/2018
06/06/2018
07/06/2018
08/06/2018
09/06/2018
10/06/2018
11/06/2018
12/06/2018
13/06/2018
14/06/2018
15/06/2018
16/06/2018
17/06/2018
18/06/2018
19/06/2018
20/06/2018
21/06/2018
Depth (m)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
BS1
P2, 42
P4, 45
P6, 41
P7, 44
P9, 40
BN1
P2, 147
P4, 146
P6, 145
P7, 144
P9, 122
BN2
P2, 239
P6, 238
P7, 236
P9, 235
BN3
P2, 355
P6, 353
P7, 352
P9, 351
RS
P2, 416
P4, 415
P6, 414
P7, 413
P9, 412

Red = poisoned cups; Green = live cups; Orange = gel cups

* denotes aborted deployment

Deployments								**Surface**							**Recoveries**				
Station	**Event**	**Deployment**	**Date**	**Time**	**Lat (S)**	**Lon (E)**		**Date**	**Time**	**Lat (S)**	**Lon (E)**	**Drift (nm)**	**Brg**		**Event**	**Date**	**Time**	**Lat (S)**	**Lon (E)**
		Dep 0 (trial)																	
BS1	3	P9 – 750 m	25/05/18	01:00	21.526	9.516		25/05/18	21:38	21.546	9.481	2.3	239°		25	25/05/18	22:51	21.540	9.470
BS1	4	P7 – 450 m	25/05/18	01:15	21.526	9.516		25/05/18	22:23	21.558	9.486	2.5	221°		26	25/05/18	23:14	21.554	9.478
BS1	5	P6 – 200 m	25/05/18	01:30	21.526	9.516		25/05/18	20:51	21.539	9.478	2.3	250°		24	25/05/18	22:07	21.536	9.465
BS1	6	P4 – 120 m	25/05/18	01:45	21.526	9.516		25/05/18	20:46	21.568	9.483	3.1	216°		27	25/05/18	23:42	21.558	9.455
BS1	7	P2 – 80 m	25/05/18	02:00	21.526	9.516		25/05/18	22:02	21.562	9.450	4.3	240°		28	26/05/18	00:12	21.555	9.430
		Dep 1																	
BS1	40	P9 – 750 m	26/05/18	16:00	21.639	9.502		29/5/18	14:20	21.621	9.467	4.3	301°		86	29/5/18	20:33	21.593	9.416
BS1	41	P6 – 200 m	26/05/18	16:30	21.640	9.506		29/5/18	13:31	21.615	9.524	3.2	344°		89	29/5/18	22:33	21.575	9.457
BS1	42	P2 – 80 m	26/05/18	17:00	21.644	9.513		29/5/18	13:27	21.633	9.516	2.8	317°		87	29/5/18	21:10	21.600	9.458
BS1	44	P7 – 450 m	26/05/18	21:00	21.641	9.509		29/5/18	13:56	21.589	9.485	5.3	325°		85	29/5/18	19:57	21.569	9.437
BS1	45	P4 – 120 m	26/05/18	21:15	21.643	9.511		29/5/18	13:24	21.642	9.542	1.4	353°		88	29/5/18	21:48	21.611	9.489
		Dep 2																	
BN1	122	P9 – 750 m	02/06/18	15:30	18.317	10.940		05/06/18	16:54	18.328	10.931	0.8	218°		180	05/06/18	22:07	18.271	10.915
BN1	123	P7 – 450 m	02/06/18	15:45	18.319	10.941		02/06/18	-	-	-	-	-		132*	03/06/18	02:16	18.316	10.802
BN1	124	P6 – 200 m	02/06/18	16:00	18.323	10.941		02/06/18	20:31	-	-	-	-		133*	03/06/18	03:02	18.319	10.794
BN1	125	P4 – 120 m	02/06/18	16:15	18.325	10.942		02/06/18	-	-	-	-	-		131*	03/06/18	01:51	18.315	10.802
BN1	126	P2 – 80 m	02/06/18	16:30	18.331	10.942		02/06/18	21:51	-	-	-	-		134*	03/06/18	03:36	18.321	10.789

		Dep 2a																	
BN1	144	P7 – 500 m	03/06/18	22:00	18.020	11.009		05/06/18	21:00	18.068	11.049	3.7	141°		184	06/06/18	03:15	18.034	11.042
BN1	145	P6 – 250 m	03/06/18	22:15	18.022	11.011		05/06/18	20:34	18.101	11.058	5.4	150°		182	06/06/18	01:43	18.094	11.027
BN1	146	P4 – 100 m	03/06/18	22:30	18.024	11.013		05/06/18	20:22	18.119	11.050	6.0	160°		183	06/06/18	02:19	18.085	11.007
BN1	147	P2 – 100 m	03/06/18	22:45	18.027	11.015		05/06/18	20:22	18.177	11.108	10.4	149°		181	06/06/18	00:25	18.163	11.093
		Dep 3																	
BN2	235	P9 – 750 m	09/06/18	16:00	18.030	11.008		12/06/18	15:16	18.111	11.007	4.8	181°		301	12/06/18	18:15	18.100	11.020
BN2	236	P7 – 500 m	09/06/18	16:15	18.033	11.015		12/06/18	15:01	18.134	10.995	6.0	191°		300	12/06/18	17:18	18.115	11.009
BN2	238	P6 – 250 m	09/06/18	16:30	18.038	11.017		12/06/18	14:35	18.296	11.022	15.4	179°		303	12/06/18	20:13	18.287	11.020
BN2	237	P4 – 100 m	09/06/18	16:45	18.037	11.015		09/06/18	18:28	18.039	11.013	-	-		245*	10/06/18	04:04	18.005	10.940
BN2	239	P2 – 100 m	09/06/18	17:00	18.039	11.019		12/06/18	14:22	18.383	11.054	20.7	174°		304	12/06/18	21:09	18.379	11.054
		Dep 3a																	
BN2	251	P4 – 100 m	10/06/18	09:45	18.020	11.009		12/06/18	14:22	18.241	10.986	13.3	186°		302	12/06/18	19:30	18.223	11.001
		Dep 4																	
BN3	351	P9 – 750 m	15/06/18	16:00	18.022	11.010		17/06/18	21:17	18.066	10.944	4.6	235°		395	17/06/18	21:39	18.066	10.942
BN3	352	P7 – 500 m	15/06/18	16:15	18.024	11.011		17/06/18	21:02	18.074	10.992	3.2	200°		396	17/06/18	22:50	18.074	10.891
BN3	353	P6 – 250 m	15/06/18	16:30	18.025	11.012		17/06/18	20:36	18.075	10.875	8.4	249°		397	17/06/18	23:36	18.069	10.852
BN3	354	P4 – 100 m	15/06/18	16:45	18.026	11.013		15/06/18	19:30	-	-	-	-		361*	15/06/18	21:02	18.050	11.017
BN3	355	P2 – 100 m	15/06/18	17:00	18.028	11.013		17/06/18	20:24	18.024	10.832	10.4	271°		398	18/06/18	01:10	18.012	10.790

		Dep 4a																	
BN3	368	P4 – 100 m	16/06/18	06:15	18.020	11.008		16/06/18	08:52	-	-	-	-		370*	16/06/18	09:43	18.020	11.007
		Dep 5																	
RS	412	P9 – 750 m	18/06/18	16:00	18.021	11.009		20/06/18	21:25	18.146	10.958	8.0	201°		456	21/06/18	01:25	18.152	10.919
RS	413	P7 – 500 m	18/06/18	16:15	18.023	11.010		20/06/18	21:00	18.145	10.939	8.3	209°		455	21/06/18	01:00	18.152	10.908
RS	414	P6 – 250 m	18/06/18	16:30	18.025	11.012		20/06/18	20:35	18.143	10.909	9.2	220°		454	21/06/18	00:18	18.152	10.876
RS	415	P4 – 150 m	18/06/18	16:45	18.027	11.013		20/06/18	20:30	18.125	10.872	10.0	234°		452	20/06/18	22:45	18.128	10.856
RS	416	P2 – 100 m	18/06/18	17:00	18.029	11.015		20/06/18	20:22	18.169	10.891	11.0	220°		453	20/06/18	23:34	18.173	10.860

PELAGRA cruise report (scientific)

Isabell Klawonn (IGB-Berlin), Kev Saw & Sari Giering (NOC)

Objective

PELAGRA traps were used in order to make direct measurements of downward particle flux between the base of the upper mixed layer and 750 m depth, a depth layer over which the most rapid attenuation in flux is usually observed.

The traps were deployed for several days (2–3 days) at pre-determined depths at both, the Benguela Southern (BS) and Benguela Northern (BN) sites. Two types of PELAGRA were used: 3x Standard traps with four collecting funnels and 2x Camera traps with two collecting funnels, two openings for Gel cups and a particle camera system (P-Cam, see below). The deployment times, locations, depths, cup opening times, trajectories and further details are documented in the cruise report "Pelagra cruise report – technical" (by Kev Saw).

Figure: Standard PELAGRA with four collection funnels (left) and Camera PELAGRA with two funnels, one particle camera system (P-Cam) and two gel cups (right).

Collection cup preparation

Seawater was sampled freshly one day before each deployment from 500 m depth at the deployment site and sterile filtered through a Sterivex filter unit (0.22 µm pore size) using a peristaltic pump. Collection cups were filled beforehand with 500 mL of the following solution:

DEAD cups: 0.22 µm-filtered seawater amended with 5 g L^{-1} salt and borax-buffered formalin (final conc. 3.6%)

LIVE cups: 0.22 µm-filtered seawater

Gel cups: bottom: 3 mm gel, middle: 3 mm gel–0.22 µm-filtered seawater mix (50:50), top: 0.22 µm-filtered seawater

The filled cups were attached onto the PELEGRA traps approx. 10 min before deployment and filled up with 200 mL of 0.22 µm-filtered seawater to reduce the presence of trapped air in the cups. Thus, the final concentration of formalin and added salt in the DEAD cups was: 2.6% formalin and 3.6 g L^{-1} added salt.

Sample processing

DEAD cups:

Upon recovery, all cups were carefully removed and stored in the walk-in fridge at 4˚C until further processing (typically within 24 h). All cups were photographed for an initial overview. Gelatinous organisms were then removed from the samples when possible. However, during later deployments, gelatinous zooplankton in the cups were covered in large amounts of detritus, and we decided to record their abundance but leave them in the cups in order to not remove relatively large amounts of sinking detritus. The collected material was decanted in 1-L plastic jars and 40 mL of concentrated formalin added in case the initial formalin concentration had decreased by diffusion during deployment. On recovery an aroma of formalin was usually apparent in the cups and the brine solution could be seen in the lower half of the sample cups indicating that preservation was successful.

2 mL of concentrated particulate material were examined in a 2.97 mL Utermoehl chamber under a Brunel inverted microscope. Images (15 per sample) were taken randomly to provide an initial visual impression of the deposited material. After microscopy the sub-samples were added back to the 1 L plastic jars and stored at 4°C in darkness until further procedure.

GEL cups:

Two of the PELAGRA sediment traps (P4 and P7) were equipped with camera systems (P-Cam, see below) and gel traps. The gel traps were equipped with a viscous gel that preserved the structure, shape and size of the fragile particles settling into it. The particles collected in the gel were photographed at three different magnifications:

1) overview images (using a 16 mega-pixel Panasonic DMC-TZ22 compact camera and black background with illumination from two sides)

2) individual particles (magnified under a Brunel dissection microscope and imaged with a CANON EOS 1100D with a black background and illumination from two sides), Examples of single particles are given in Figure 2.
3) individual particles (magnified under a Brunel inverted microscope and imaged with a 12 mega-pixel Basler camera with background illumination)

After photography/microscopy, the gels were frozen at -20°C until further procedure.

Figure: Individual particles imaged under a dissection microscope. Left: Compact marine snow aggregates. Centre: Coagulation of fluffy detritus and faecal pellets (both collected in gel traps at 100 m water depth). Right: Highly porous marine snow aggregate (collected in gel traps at 500 m water depth).

LIVE cups:
Non-preserved material was used for a variety of analyses, e.g., respiration analyses, molecular analyses and nitrogen transformation processes (Manon Duret, Jessika Fuessel, Victoria Hemsley, Mark Trimmer), lipid analyses (Callum Preece) and (Jo Ainsworth).

P-Cam

P-Cam systems were deployed on two of the PELAGRA sediment traps (P4 and P7). The image sequences from the P-Cams provide in situ particle size-distribution, abundance, and size- and type-specific settling velocities.
The P-Cams consisted of a Canon EOS 6D digital SLR camera equipped with a 50 mm macro lens and a Canon Speedlite 600EX RT flash gun. The camera and the flash gun were places perpendicular to each other to provide illumination from the right side of the captured images. The P-Cam was timed to take ten images with two seconds intervals every hour, using a Hahnel Giga T Pro II remote timer. The camera was put in manual mode and the settings were adjusted to have an ISO of 2500, a shutter speed of 1/160 seconds, an aperture of f/32, and the lens focus was put to 1.5 feet. The flash was also in manual mode and put for straight flash direction and a flash output of 1/8.

The pixel size of the images changed depending on whether the particles were in the front or back of the field of depth. We determined a pixel size of 33 µm per pixel in the front of the depth of field (as seen from the camera) and a pixel size of 61 µm per pixel at the back of the depth of field. This suggested an average pixel size of 47 µm per pixel. The field of view for each image was 157 mm width, 101 mm height, and 135 mm depth.

Preliminary results

36 PELAGRA deployments were made during the cruise, including one successful test deployment and one sampling deployment at BS (BS-test and BS-1) as well as four sampling deployments at BN (BN-1, BS-2, and 2xBN-3). The deployments successfully provided material for a wide range of biogeochemical, molecular and microscopic analyses to characterise the particle flux regime in the Benguela Upwelling system. Export flux appeared rather low, despite substantial primary production in the surface water, indicating high remineralisation rates as well as high secondary production and grazing pressure on settling material in the upper 500 m water column.

Table. List of formaldehyde-preserved samples

Deployment	Deployment Date	Event	Station	PELAGRA	Target Depth (m)	Cup	Label	Collection time (h)
0 (trial)	25/06/2018	3	BS1	P9	750	1	Dead#1	2
						2	Dead#2	2
						3	Dead#3	2
						4	Dead#4	2
		4	BS1	P7	450	2	Dead#1	2
						4	Dead#2	2
		5	BS1	P6	200	1	Dead#1	2
						2	Dead#2	2
						3	Dead#3	2
						4	Dead#4	2
		6	BS1	P4	120	2	Dead#1	2
						4	Dead#2	2
		7	BS1	P2	80	1	Dead#1	2
						2	Dead#2	2
						3	Dead#3	2

						4	Dead#4	2
1	26/06/2018	40	BS1	P9	750	1	Dead#1	12
						2	Dead#2	24
						3	Dead#3	12
		41	BS1	P6	200	1	Dead#1	12
						2	Dead#2	24
						3	Dead#3	12
		42	BS1	P2	80	1	Dead#1	12
						2	Dead#2	24
						3	Dead#3	12
		44	BS1	P7	450	2	Dead#1	24
						4	Dead#2	12
		45	BS1	P4	120	2	Dead#1	24
						4	Dead#2	12
2	02/06/2018	122	BN1	P9	750	1	Dead#1	12
						2	Dead#2	24
						3	Dead#3	12
2a	03/06/2018	144	BN1	P7	500	2	Dead#1	12
						4	Dead#2	12
		145	BN1	P6	250	1	Dead#1	12
						2	Dead#2	12
		146	BN1	P4	100	2	Dead#1	12
						4	Dead#2	12
		147	BN1	P2	100	1	Dead#1	12
						2	Dead#2	12
3	09/06/2018	235	BN2	P9	750	1	Dead#1	12
						2	Dead#2	24
						3	Dead#3	12
		236	BN2	P7	500	2	Dead#1*	24
						4	Dead#2*	12
		238	BN2	P6	250	1	Dead#1	12
						2	Dead#2	24
						3	Dead#3	12

		239	BN2	P2	100	1	Dead#1	12
						2	Dead#2	24
						3	Dead#3	12
3a	10/06/2018	251	BN2	P4	100	2*	Dead#1	24
						4*	Dead#2	12
4	15/06/2018	351	BN3	P9	750	1	Dead#1	12
						2	Dead#2	12
		352	BN3	P7	500	2	Dead#1	12
						4	Dead#2	12
		353	BN3	P6	250	1	Dead#1	12
						2	Dead#2	12
		355	BN3	P2	100	1	Dead#1	12
						2	Dead#2	12
5	28/06/2018	412	RS	P9	750	1	Dead#1	12
						2	Dead#2	12
		413	RS	P7	500	2	Dead#1	12
						4	Dead#2	12
		414	RS	P6	250	1	Dead#1	12
						2	Dead#2	12
		415	RS	P4	150	2	Dead#1	12
						4	Dead#2	12
		416	RS	P2	100	1	Dead#1	12
						2	Dead#2	12

* Potentially incorrect sampling. See technical cruise report.

Marine Snow Catcher

Sari Giering (NOC)

Profiles of suspended, slow-sinking and fast-sinking particles were collected using the Marine Snow Catcher (MSC) between 25th May – 21th Jun 2018 during COMICS cruise DY090 aboard the *RRS Discovery*.

Particle collection

At each superstation, three particle profiles were collected with 4-5 depths chosen based on the mixed layer depth. Typically, these depths were, MLD+10m, MLD+50m, MLD+100m, 250m and 500m. Opportunistically, other depths (intermediate or 1000 m) were also sampled. All MSCs for an individual profile were deployed within 2 hours of each other, though variability between profiles collected during each superstation was low.

A full description of the MSC and its assumptions are described in Riley et al. [2012] and Giering et al. [2016]. We did, however, alter the sampling strategy for the fast-sinking particles to reduce user bias. Briefly, for t_{zero} and suspended particles 5 L each were collected from a tap positioned in the middle of the top section. After a 2-h settling period, the suspended particle sample was taken from the middle tap, and the tap was left running until the upper half of the top section was empty (approximately 5 min). The bottom tap on the top section was then opened by approximately 30° to allow the top section to drain slowly, reducing resuspension of slow-sinking material. Draining the bottom half of the MSC typically took 30 min. We placed trays on the bottom (18.5 cm diameter, 4 cm height, total volume ~1000 mL). Particles in the water above the tray were considered slow-sinking, and were removed by carefully siphoning the water off (4-5 L). A lid was then placed on the tray, and the tray was removed.

Concentrations of suspended, slow-sinking and fast-sinking particles ($p_{suspended}$, p_{slow} and p_{fast}, respectively) are calculated as follows:

$$p_{suspended} = p_{top} \quad (1)$$

$$p_{slow} = (p_{bottom} - p_{top}) \times V_{base} / V_{MSC} \quad (2)$$

$$p_{fast} = (p_{tray} - p_{bottom}) \times V_{tray} / (A_{tray} \times h_{MSC}) \quad (3)$$

where p is the particle concentration in the top, bottom or tray (p_{top}, p_{bottom} and p_{tray}, respectively), V_{base} is the volume of the base section (8 L), V_{tray} is the volume of the tray (typically ~1 L), V_{MSC} is the volume of the MSC (95 L), A_{tray} is the area of the tray (0.026 m^2), and h_{MSC} is the height of the MSC (1.58 m). The fraction of the tray that was analysed for a particular parameter was 5-30% of the tray volume, depending on the parameter.

Sample preparation

Dry weight, particular organic carbon and nitrogen, stable isotopes - Samples were filtered onto pre-combusted (24 h at 450°C), pre-weighed GF/F filters (nominal pore-size 0.7 µm, 25 mm diameter, Whatman), briefly rinsed with pH-adjusted MilliQ water (180 µL 25% ammonium in 1 L MilliQ), dried in the oven (overnight at 50°C), and stored in a dark place. Blanks were prepared by filtering 1000 mL MilliQ and preparing the filter as described above. For t_{zero}, suspended and slow-sinking particles, 1000 mL were filtered in duplicates. For fast-sinking particles, 150-350 mL were filtered in duplicates.

Particulate inorganic carbon - Samples were filtered onto polycarbonate filters (0.8-µm pore size; Whatman) and briefly rinsed with pH-adjusted MilliQ water (pH 8.5; 180 µL 25% ammonium in 1 L MilliQ) to remove any salt. For t_{zero}, suspended and slow-sinking particles, 500 mL were filtered each. For fast-sinking particles, 50-100 mL were filtered. Blanks were prepared by filtering 500 mL of MilliQ through a filter and preparing the filter as described. Filters were placed into 50 mL corning tubes, dried (overnight at 50°C) and stored.

Biogenic silica - Samples were filtered onto polycarbonate filters (0.8-µm pore size; Whatman) and briefly rinsed with pH-adjusted MilliQ water (pH 8.5; 180 µL 25% ammonium in 1 L MilliQ) to remove any salt. For t_{zero}, suspended and slow-sinking particles, 500 mL were filtered each. For fast-sinking particles, 50-100 mL were filtered. Blanks were prepared by filtering 500 mL of MilliQ through a filter and preparing the filter as described. Filters were placed into 15 mL corning tubes, dried (overnight at 50°C) and analyzed on board as described by Stinchcombe.

Chlorophyll a – Samples were filtered onto GF/F filters (nominal pore-size 0.7 µm, 25 mm diameter, Whatman), placed into glass vials filled with 6 mL acetone (90%, HPLC), and pigments extracted for 24 h at 4°C. Fluorescence was analyzed on board as described in the report section on pelagic sampling.

Photosynthetic health (F_v:F_m) – 15-50 mL of sample water were filled into corning tubes and stored in darkness at 4°C until analysis (typically within 12 h after sample collection). F_v:F_m was determined on board as described in the report section on pelagic sampling.

Microbial community composition – 1.8 mL sample were transferred into cryovials and stored in darkness at 4°C until fixation with 100 µL paraformaldehyde (20%) (typically within 12 hours of sample collection). Fixed samples were frozen in liquid nitrogen -80°C until on-shore analysis.

Microplankton community composition – 50-200 mL sample were transferred into glass bottles, fixed with a final concentration of 3.6% formaldehyde (buffered with di-sodium tetraborate). Samples were stored in darkness in a cool place until onshore analysis.

MSC deployment table

CRUISE CODE	GEAR CODE	STN NBR	CASTNO	MSC NBR	SITE	Description	Time at Bottom								Other					COMMENTS
							Date (GMT)	Time fired (GMT)	Time t0 (GMT)	Latitude		Longitude		Depth (m)	Echo depth (m)	SST (°C)	Air temp (°C)	Wind (knots)	Sea State (Beaufort)	
DY090	MSC	010	MSC001	5	Test	Rates	25/05/2018	08:20	08:29	21	31.52	9	30.93	75	3955	20.8	19.2	19	5	
DY090	MSC	011	MSC002	1	Test	Rates	25/05/2018	08:48	-	21	31.52	9	30.93	75	3955	20.8	19.2	23	6	leaked
DY090	MSC	012	MSC003	4	Test	Rates	25/05/2018	09:02	09:26	21	31.52	9	30.94	75	3956	20.8	19.3	23	4	
DY090	MSC	013	MSC004	3	Test	Rates	25/05/2018	09:23	09:34	21	31.52	9	30.94	75	3956	20.8	19.3	20	5	middle tap open
DY090	MSC	016	MSC005	2	Test	Test	25/05/2018	13:23	-	21	31.53	9	30.94	10	3955	20.9	19.7	22	5	
DY090	MSC	017	MSC006	5	Test	Test	25/05/2018	13:40	-	21	31.53	9	30.94	10	3955	20.9	19.8	23	5	
DY090	MSC	018	MSC007	4	Test	Test	25/05/2018	13:55	-	21	31.53	9	30.94	10	3955	20.9	19.6	20	5	
DY090	MSC	019	MSC008	3	Test	Test	25/05/2018	14:05	-	21	31.53	9	30.94	10	3955	20.9	19.8	18	5	
DY090	MSC	020	MSC009	1	Test	Water for PELAGRA	25/05/2018	14:30	14:40	21	31.53	9	30.94	500	3954	20.9	19.8	18	5	
DY090	MSC	030	MSC010	1	BS1	Water for RESPIRE	26/05/2018	08:15	-	-	-	-	-	125	3954	20.9	-	-	5	
DY090	MSC	031	MSC011	-	BS1	Water for RESPIRE	26/05/2018	08:26	-	-	-	-	-	200	-	-	-	-	-	
DY090	MSC	032	MSC012	-	BS1	Rates	26/05/2018	08:42	-	-	-	-	-	500	-	-	-	-	-	
DY090	MSC	033	MSC013	-	BS1	Rates	26/05/2018	09:27	09:45	-	-	-	-	500	-	-	-	-	-	
DY090	MSC	034	MSC014	2	BS1	Rates	26/05/2018	09:56	10:10	-	-	-	-	500	-	-	-	-	-	
DY090	MSC	035	MSC015	4	BS1	Rates	26/05/2018	10:22	10:40	-	-	-	-	500	-	-	-	-	-	
DY090	MSC	026	MSC016	-	BS1	Molecular	26/05/2018	10:50	11:06	-	-	-	-	500	-	-	-	-	-	
DY090	MSC	053	MSC017	1	BS1	Fluxes	27/05/2018	16:47	17:02	21	38.23	9	30.29	450	3995	20.7	19.3	18	5	
DY090	MSC	054	MSC018	4	BS1	Fluxes	27/05/2018	17:15	17:24	21	38.23	9	30.29	200	3994	20.7	19.3	17	5	
DY090	MSC	055	MSC019	5	BS1	Fluxes	27/05/2018	17:35	17:40	21	38.23	9	30.29	120	3994	20.7	19.4	19	5	No RBR
DY090	MSC	056	MSC020	2	BS1	Fluxes	27/05/2018	17:50	17:55	21	38.23	9	30.29	80	3994	20.7	19.4	18	5	
DY090	MSC	061	MSC021	1	BS1	Water for zooplankton incub.	28/05/2018	07:00	07:10	21	38.47	9	30.33	60	3998	20.7	19.1	16	5	
DY090	MSC	062	MSC022	2	BS1	Molecular	28/05/2018	07:15	07:10	21	38.47	9	30.33	200	3998	20.7	19.1	16	5	
DY090	MSC	063	MSC023	4	BS1	Rates	28/05/2018	07:30	07:45	21	38.47	9	30.33	200	3998	20.7	19.1	16	5	
DY090	MSC	064	MSC024	4	BS1	Rates	28/05/2018	07:45	07:55	21	38.47	9	30.33	200	3998	20.7	19.1	16	5	
DY090	MSC	066	MSC025	1	BS1	Fluxes/Geochem	28/05/2018	09:50	09:59	21	38.47	9	30.33	80	3997	20.7	19.2	20	5	No RBR
DY090	MSC	067	MSC026	4	BS1	Fluxes/Geochem	28/05/2018	10:10	10:28	21	38.47	9	30.33	120	3997	20.7	19.1	16	5	
DY090	MSC	068	MSC027	2	BS1	Fluxes/Geochem	28/05/2018	10:26	10:36	21	38.47	9	30.33	200	3999	20.7	19.3	17	4	
DY090	MSC	069	MSC028	5	BS1	Fluxes/Geochem	28/05/2018	10:50	11:05	21	38.47	9	30.33	450	3998	20.7	19.2	15	4	
DY090	MSC	078	MSC029	1	BS1	Fluxes	29/05/2018	10:56	11:14	21	32.52	9	30.43	750	3966	20.5	19.7	17	4	
DY090	MSC	079	MSC030	2	BS1	Fluxes	29/05/2018	11:25	11:38	21	32.52	9	30.43	450	3966	20.5	19.7	17	4	
DY090	MSC	080	MSC031	3	BS1	Fluxes/Geochem	29/05/2018	11:48	11:58	21	32.52	9	30.43	200	3967	20.5	19.9	17	5	
DY090	MSC	081	MSC032	4	BS1	Fluxes	29/05/2018	12:01	12:08	21	32.52	9	30.43	120	3967	20.5	19.8	14	5	
DY090	MSC	082	MSC033	5	BS1	Fluxes	29/05/2018	12:15	12:19	21	32.50	9	30.43	80	3966	20.5	19.7	16	4	
DY090	MSC	091	MSC034	2	BS1	Rates	30/05/2018	05:12	05:15	-	-	-	-	120	-	-	-	-	-	
DY090	MSC	092	MSC035	3	BS1	Rates	30/05/2018	05:25	05:35	-	-	-	-	120	-	-	-	-	-	
DY090	MSC	093	MSC036	5	BS1	Rates	30/05/2018	05:38	?	-	-	-	-	120	-	-	-	-	-	
DY090	MSC	094	MSC037	4	BS1	Rates	30/05/2018	05:52	05:56	-	-	-	-	120	-	-	-	-	-	
DY090	MSC	099	MSC038	1	BS1	Fluxes/Geochem	31/05/2018	09:32	09:38	21	33.48	9	27.99	80	3984	20.4	18.9	16	4	
DY090	MSC	100	MSC039	2	BS1	Fluxes/Geochem	31/05/2018	09:45	09:50	21	33.48	9	28.00	120	3984	20.4	18.9	16	4	
DY090	MSC	101	MSC040	3	BS1	Fluxes/Geochem	31/05/2018	10:00	10:10	21	33.48	9	27.99	200	3985	20.4	18.8	16	4	
DY090	MSC	102	MSC041	4	BS1	Fluxes/Geochem	31/05/2018	10:30	10:50	21	33.48	9	27.99	750	3985	20.4	18.8	16	4	
DY090	MSC	109	MSC042	4	BN1	Water for zooplankton incub.	02/06/2018	08:00	-	18	1.16	11	0.49	45	2567	17.9	16.6	26	6	
DY090	MSC	110	MSC043	4	BN1	Water for RESPIRE	02/06/2018	08:20	-	-	-	-	-	250	-	-	-	-	-	Misfired
DY090	MSC	111	MSC044F	4	BN1	Water for RESPIRE	02/06/2018	08:46	-	-	-	-	-	250	-	-	-	-	-	Misfired
DY090	MSC	112	MSC044	2	BN1	Water for RESPIRE	02/06/2018	08:55	-	-	-	-	-	250	-	-	-	-	-	
DY090	MSC	113	MSC045		BN1	Water for RESPIRE	02/06/2018	09:12	-	-	-	-	-	120	-	-	-	-	-	
DY090	MSC	114	MSC046	2	BN1	Rates	02/06/2018	09:25	-	-	-	-	-	45	-	-	-	-	-	leaking
DY090	MSC	115	MSC047	2	BN1	Rates	02/06/2018	09:45	09:50	-	-	-	-	45	-	-	-	-	-	
DY090	MSC	116	MSC048	1	BN1	Rates	02/06/2018	09:55	10:05	-	-	-	-	45	-	-	-	-	-	
DY090	MSC	117	MSC049	5	BN1	Rates	02/06/2018	10:05	10:15	-	-	-	-	45	-	-	-	-	-	
DY090	MSC	127	MSC050	4	BN1	Fluxes	02/06/2018	19:37	19:42	18	1.20	11	0.50	60	2559	17.5	16.8	25	6	
DY090	MSC	128	MSC051	5	BN1	Fluxes	02/06/2018	20:09	20:15	18	1.20	11	0.50	120	2559	17.5	16.8	25	5	
DY090	MSC	129	MSC052	1	BN1	Fluxes	02/06/2018	20:35	20:50	18	1.20	11	0.50	250	2557	17.5	16.8	23	6	
DY090	MSC	130	MSC053	2	BN1	Fluxes	02/06/2018	21:00	21:15	18	1.20	11	0.50	350	2557	17.5	16.7	25	6	
DY090	MSC	136	MSC054	2	BN1	Fluxes/Geochem	03/06/2018	14:01	14:10	18	1.19	11	0.51	80	2559	17.4	17	24	6	
DY090	MSC	137	MSC055	1	BN1	Fluxes/Geochem	03/06/2018	14:15	14:25	18	1.18	11	0.50	120	2557	17.4	17	28	6	
DY090	MSC	138	MSC056	4	BN1	Fluxes/Geochem	03/06/2018	14:35	14:43	18	1.18	11	0.50	250	2566	17.4	17	24	6	leaked
DY090	MSC	139	MSC057	5	BN1	Fluxes/Geochem	03/06/2018	15:05	15:16	18	1.18	11	0.50	400	2557	17.4	17	24	7	
DY090	MSC	149	MSC058	1	BN1	Rates	04/06/2018	04:53	05:15	18	1.18	11	0.50	100	2558	17.5	16.7	21	6	
DY090	MSC	150	MSC059	2	BN1	Rates	04/06/2018	05:05	-	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	151	MSC060	5	BN1	Rates	04/06/2018	05:16	-	-	-	-	-	100	-	-	-	-	-	did not fire
DY090	MSC	152	MSC061	2	BN1	Rates	04/06/2018	05:32	05:41	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	153	MSC062	5	BN1	Rates	04/06/2018	05:44	05:50	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	159	MSC063	2	BN1	Fluxes	04/06/2018	17:09	17:15	18	1.18	11	0.49	50	2567	17.4	17	17	4	
DY090	MSC	160	MSC064	1	BN1	Fluxes	04/06/2018	17:22	17:30	18	1.18	11	0.49	100	2568	17.5	17.1	22	5	
DY090	MSC	161	MSC065	4	BN1	Fluxes	04/06/2018	17:40	17:48	18	1.18	11	0.49	250	2566	17.4	17	20	5	
DY090	MSC	162	MSC066	5	BN1	Fluxes	04/06/2018	18:07	18:20	18	1.18	11	0.49	500	2568	17.4	16.9	22	5	
DY090	MSC	191	MSC067	1	BN1	Fluxes/Geochem	06/06/2018	15:19	-	18	1.18	11	0.50	50	2558	18.8	22.5	10	4	Misfired
DY090	MSC	192	MSC068	1	BN1	Fluxes/Geochem	06/06/2018	15:36	15:40	18	1.18	11	0.49	50	2558	18.8	22.5	11	4	
DY090	MSC	193	MSC069	2	BN1	Fluxes/Geochem	06/06/2018	15:47	15:53	18	1.18	11	0.49	100	2559	18.8	22.8	10	4	
DY090	MSC	194	MSC070	4	BN1	Fluxes/Geochem	06/06/2018	16:03	16:09	18	1.18	11	0.49	250	2559	18.8	23	14	4	
DY090	MSC	195	MSC071	5	BN1	Fluxes/Geochem	06/06/2018	16:30	16:45	18	1.06	11	0.49	500	2559	18.8	23.2	13	4	
DY090	MSC	200	MSC072	1	BN1	Rates	07/06/2018	04:53	-	-	-	-	-	45	-	-	-	-	-	
DY090	MSC	201	MSC073	2	BN1	Rates	07/06/2018	05:05	-	-	-	-	-	45	-	-	-	-	-	

DY090	MSC	202	MSC074	5	BN1	Rates	07/06/2018	05:17	-	-	-	-	-	45	-	-	-	-	-	
DY090	MSC	206	MSC075	1	BN2	Rates	08/06/2018	07:12	07:25	18	1.18	11	0.48	250	2559	18.5	17.9	12	4	
DY090	MSC	207	MSC076	2	BN2	Rates	08/06/2018	07:38	07:45	18	1.18	11	0.48	250	2559	18.5	17.9	12	4	
DY090	MSC	208	MSC077	3	BN2	Rates	08/06/2018	07:48	07:55	-	-	-	-	250	-	-	-	-	-	
DY090	MSC	216	MSC078	1	BN2	Production	08/06/2018	09:45	-	18	1.66	11	0.57	250	2569	18	18.4	8	3	Did not trigger. Not sampled.
DY090	MSC	217	MSC079	1	BN2	Production	08/06/2018	10:13	-	18	1.66	11	0.59	250	2569	18	18.6	8	3	RBR two dip (first did not trigger)
DY090	MSC	218	MSC080	2	BN2	Production	08/06/2018	10:49	-	18	1.66	11	0.57	250	2570	18.1	18.8	8	3	Note, two MSC080 in bridge log - first one marked as fail
DY090	MSC	219	MSC081	4	BN2	Production	08/06/2018	11:08	-	18	1.66	11	0.57	250	2569	18.4	18.4	7	3	
DY090	MSC	220	MSC082	5	BN2	Production/Fluxes	08/06/2018	11:27	11:32	18	1.66	11	0.56	250	2569	18.3	18.7	8	3	
DY090	MSC	247	MSC083	1	BN2	Rates	10/06/2018	08:45	09:00	18	1.18	11	0.48	500	2567	18.5	16.9	22	5	
DY090	MSC	248	MSC084	2	BN2	Rates	10/06/2018	09:15	09:35	18	1.18	11	0.48	500	2567	18.5	16.9	22	5	
DY090	MSC	249	MSC085	3	BN2	Rates	10/06/2018	09:50	10:10	18	1.18	11	0.48	500	2567	18.5	16.9	22	5	
DY090	MSC	254	MSC086	1	BN2	Fluxes	10/06/2018	16:37	16:44	18	1.19	11	0.50	100	2562	18.5	17.4	12	4	
DY090	MSC	255	MSC087	2	BN2	Fluxes	10/06/2018	16:51	17:00	18	1.18	11	0.49	250	2566	18.5	17.3	13	4	
DY090	MSC	256	MSC088	4	BN2	Fluxes	10/06/2018	17:14	17:30	18	1.18	11	0.49	500	2565	18.5	17.3	12	4	
DY090	MSC	257	MSC089	5	BN2	Fluxes	10/06/2018	17:51	18:00	18	1.18	11	0.49	750	2565	18.4	17.1	16	4	
DY090	MSC	262	MSC090	1	BN2	Rates	11/06/2018	03:10	-	18	1.18	11	0.49	100	2565	17.8	16.9	11	4	
DY090	MSC	263	MSC091	1	BN2	Rates	11/06/2018	03:25	-	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	264	MSC092	5	BN2	Rates	11/06/2018	03:35	03:38	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	273	MSC093	1	BN2	Fluxes/Geochem	11/06/2018	08:50	08:54	18	1.18	11	0.49	15	2565	17.8	17	7	3	
DY090	MSC	274	MSC094	2	BN2	Fluxes/Geochem	11/06/2018	09:03	09:08	18	1.18	11	0.49	35	2565	17.8	17	7	3	
DY090	MSC	275	MSC095	4	BN2	Fluxes/Geochem	11/06/2018	09:13	09:17	18	1.18	11	0.49	55	2565	17.8	17	7	3	
DY090	MSC	276	MSC096	5	BN2	Fluxes/Geochem	11/06/2018	09:29	09:33	18	1.18	11	0.49	75	2565	17.8	17	5	2	
DY090	MSC	279	MSC097	5	BN2	Water for zooplankton incub.	11/06/2018	17:01	-	18	1.19	11	0.50	20	2567	18.7	18,4	0	1	
DY090	MSC	280	MSC098	1	BN2	Fluxes/Geochem	11/06/2018	17:12	17:17	18	1.19	11	0.50	100	2558	18	18.3	1	1	Leaked. Not sampled.
DY090	MSC	281	MSC099	2	BN2	Fluxes/Geochem	11/06/2018	17:25	17:35	18	1.19	11	0.49	250	2567	18.4	18.5	4	1	
DY090	MSC	282	MSC100	4	BN2	Fluxes/Geochem	11/06/2018	17:49	18:00	18	1.19	11	0.49	500	2567	18.3	18	4	2	
DY090	MSC	283	MSC101	5	BN2	Fluxes/Geochem	11/06/2018	18:24	18:48	18	1.19	11	0.50	750	2559	18.5	16.1	8	3	Leaking bottom tap
DY090	MSC	284	MSC102	1	BN2	Fluxes/Geochem	11/06/2018	18:53	19:00	18	1.19	11	0.50	100	2559	18.5	16.2	8	3	
DY090	MSC	295	MSC103	5	BN2	Fluxes/Geochem	12/06/2018	11:48	12:06	18	1.19	11	0.49	750	2560	18.3	18.7	7	3	No RBR (depth)
DY090	MSC	296	MSC104	4	BN2	Fluxes/Geochem	12/06/2018	12:22	12:35	18	1.19	11	0.49	500	2560	18.3	18.7	7	3	
DY090	MSC	297	MSC105	2	BN2	Fluxes/Geochem	12/06/2018	12:46	13:00	18	1.19	11	0.49	250	2559	19.5	18.9	7	3	
DY090	MSC	298	MSC106	1	BN2	Fluxes/Geochem	12/06/2018	13:02	13:07	18	1.19	11	0.49	100	2559	19.5	18.9	7	3	
DY090	MSC	305	MSC107	1	BN2	Rates	13/06/2018	01:43	-	18	1.12	11	0.40	100	2559	19.3	18.1	11	3	Failed.
DY090	MSC	306	MSC108	1	BN2	Rates	13/06/2018	01:50	02:00	18	1.12	11	0.40	100	2559	19.3	18.1	11	3	
DY090	MSC	307	MSC109	2	BN2	Rates	13/06/2018	02:10	02:18	18	1.12	11	0.40	100	2559	19.3	18.1	11	3	
DY090	MSC	308	MSC110	4	BN2	Rates	13/06/2018	02:21	02:29	18	1.12	11	0.40	100	2559	19.3	18.1	11	3	
DY090	MSC	309	MSC111	5	BN2	Rates	13/06/2018	02:30	02:40	18	1.12	11	0.40	100	2559	19.3	18.1	11	3	
DY090	MSC	312	MSC112	1	BN2	Production	13/06/2018	08:05	08:15	18	1.18	11	0.50	250	-	-	-	-	-	
DY090	MSC	313	MSC113	2	BN2	Production	13/06/2018	08:25	08:35	18	1.18	11	0.50	250	-	-	-	-	-	
DY090	MSC	314	MSC114		BN2	Production	13/06/2018	-	-	-	-	-	-	-	-	-	-	-	-	In bridge log, but not in MSC deployment book.
DY090	MSC	315	MSC115	4	BN2	Production	13/06/2018	09:06	09:11	18	1.18	11	0.50	250	-	-	-	-	-	
DY090	MSC	316	MSC116	5	BN2	Production/Fluxes	13/06/2018	09:26	09:33	18	1.18	11	0.50	250	-	-	-	-	-	
DY090	MSC	330	MSC117	1	BN3	Fluxes/Geochem	14/06/2018	14:32	14:36	18	1.19	11	0.50	35	2560	19.7	16.6	16	4	
DY090	MSC	331	MSC118	2	BN3	Fluxes/Geochem	14/06/2018	14:45	14:49	18	1.19	11	0.50	100	2560	19.7	16.6	18	4	
DY090	MSC	332	MSC119	5	BN3	Water for zooplankton incub.	14/06/2018	14:59	-	18	1.19	11	0.50	20	2560	19.7	16.7	16	4	Misfired. Repaired.
DY090	MSC	333	MSC120	5	BN3	Water for zooplankton incub.	14/06/2018	15:11	-	18	1.19	11	0.49	20	2567	19.7	16.7	18	5	
DY090	MSC	334	MSC121	4	BN3	Fluxes/Geochem	14/06/2018	15:24	14:34	18	1.19	11	0.50	250	2559	19.7	16.7	20	5	
DY090	MSC	335	MSC122	5	BN3	Fluxes/Geochem	14/06/2018	15:46	15:59	18	1.19	11	0.50	500	2560	19.7	16.6	20	5	
DY090	MSC	338	MSC123	1	BN3	Rates	15/06/2018	01:00	-	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	339	MSC124	2	BN3	Rates	15/06/2018	01:17	-	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	340	MSC125	4	BN3	Rates	15/06/2018	01:32	-	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	341	MSC126	5	BN3	Rates	15/06/2018	01:38	-	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	356	MSC127	1	BN3	Fluxes	15/06/2018	18:22	18:45	18	1.67	11	0.18	750	2554	19.1	17.1	18	5	
DY090	MSC	357	MSC128	2	BN3	Fluxes	15/06/2018	18:56	19:20	18	1.67	11	0.18	500	2554	19.1	17	15	5	
DY090	MSC	358	MSC129	4	BN3	Fluxes	15/06/2018	19:23	19:36	18	1.67	11	0.18	250	2553	18.9	17	20	5	
DY090	MSC	359	MSC130	5	BN3	Fluxes	15/06/2018	19:41	19:47	18	1.67	11	0.18	100	2552	19.1	16.9	18	5	
DY090	MSC	365	MSC131		BN3	Water for zooplankton incub.	16/06/2018	07:10	-	-	-	-	-	20	-	-	-	-	-	
DY090	MSC	366	MSC132		BN3	Water for zooplankton incub.	16/06/2018	07:28	-	-	-	-	-	10	-	-	-	-	-	
DY090	MSC	267	MSC133	2	BN3	Rates	16/06/2018	05:35	-	-	-	-	-	100	-	-	-	-	-	
DY090	MSC	375	MSC134	1	BN3	Fluxes	16/06/2018	15:25	15:30	18	1.17	11	0.49	35	2560	18.3	16.3	15	4	
DY090	MSC	376	MSC135	2	BN3	Fluxes	16/06/2018	15:37	15:41	18	1.17	11	0.49	75	2560	18.3	16.3	14	4	
DY090	MSC	377	MSC136	4	BN3	Fluxes	16/06/2018	15:49	15:58	18	1.17	11	0.49	100	2560	18.3	16.3	15	4	
DY090	MSC	378	MSC137	5	BN3	Fluxes	16/06/2018	16:02	16:10	18	1.17	11	0.49	250	2560	18.3	16.3	14	4	
DY090	MSC	384	MSC138	1	BN3	Rates	17/06/2018	05:27	05:50	18	1.18	11	0.49	750	2567	17.4	16.4	15	4	
DY090	MSC	385	MSC139	2	BN3	Rates	17/06/2018	06:03	06:34	18	1.18	11	0.49	750	2567	17.5	16.9	20	4	
DY090	MSC	386	MSC140	4	BN3	Rates	17/06/2018	06:46	07:12	18	1.18	11	0.49	750	2567	17.5	16.8	20	4	
DY090	MSC	390	MSC141	1	BN3	Fluxes/Geochem	17/06/2018	15:36	15:40	18	1.18	11	0.50	100	2568	17.3	16.5	21	6	
DY090	MSC	391	MSC142	2	BN3	Fluxes/Geochem	17/06/2018	15:50	16:00	18	1.18	11	0.50	250	2568	17.3	16.4	21	5	
DY090	MSC	392	MSC143	4	BN3	Fluxes/Geochem	17/06/2018	16:20	16:32	18	1.18	11	0.50	500	2565	17.3	16.5	22	6	
DY090	MSC	393	MSC144	5	BN3	Fluxes/Geochem	17/06/2018	16:51	17:01	18	1.18	11	0.49	750	2567	17.3	16.5	22	6	
DY090	MSC	400	MSC145	1	BN3	Production	18/06/2018	08:14	08:30	18	1.19	11	0.50	175	2560	17.4	16	21	5	
DY090	MSC	401	MSC146	2	BN3	Production	18/06/2018	08:32	08:43	18	1.19	11	0.50	175	2558	17.4	16	21	5	
DY090	MSC	402	MSC147	4	BN3	Production	18/06/2018	08:49	08:55	18	1.19	11	0.50	175	2558	17.4	16	21	5	
DY090	MSC	403	MSC148	5	BN3	Production/Fluxes	18/06/2018	09:07	09:15	18	1.19	11	0.50	175	2558	17.4	16	21	5	
DY090	MSC	417	MSC149	1	BN3	Fluxes/Geochem	18/06/2018	18:03	18:07	18	1.19	11	0.51	35	2559	17.4	16.4	24	6	
DY090	MSC	418	MSC150	2	BN3	Fluxes/Geochem	18/06/2018	18:14	18:16	18	1.19	11	0.51	75	2559	17.4	16.7	26	6	
DY090	MSC	419	MSC151	4	BN3	Fluxes/Geochem	18/06/2018	18:25	18:29	18	1.19	11	0.50	100	2559	17.3	16.2	21	6	
DY090	MSC	420	MSC152	5	BN3	Fluxes/Geochem	18/06/2018	18:40	18:48	18	1.19	11	0.50	250	2559	17.4	16.5	22	5	

DY090	MSC	428 MSC153	1	BN3	DVM study	19/06/2018	10:10	10:15	-	-	-	-	100	-	-	-	-	-
DY090	MSC	429 MSC154	2	BN3	DVM study	19/06/2018	10:23	10:28	-	-	-	-	100	-	-	-	-	-
DY090	MSC	430 MSC155	4	BN3	DVM study	19/06/2018	10:36	10:33	-	-	-	-	60	-	-	-	-	-
DY090	MSC	431 MSC156	5	BN3	DVM study	19/06/2018	10:43	10:46	-	-	-	-	60	-	-	-	-	-
DY090	MSC	440 MSC157	1	BN3	DVM study	19/06/2018	19:58	-	18	1.19	11	0.49	60	2560	17.9	15.8	24	6
DY090	MSC	441 MSC158	2	BN3	DVM study	19/06/2018	20:07	-	18	1.19	11	0.49	60	2560	17.9	15.8	23	6
DY090	MSC	442 MSC159	4	BN3	DVM study	19/06/2018	20:15	-	18	1.19	11	0.49	100	2560	17.9	15.4	25	6
DY090	MSC	443 MSC160	5	BN3	DVM study	19/06/2018	20:30	-	18	1.19	11	0.49	100	2560	17.9	15.7	25	6
DY090	MSC	446 MSC161		BN3	Rates	20/06/2018	03:22	03:45	18	1.18	11	0.49	750	2567	18	16.4	22	6
DY090	MSC	447 MSC162		BN3	Rates	20/06/2018	04:07	04:25	18	1.18	11	0.49	750	2567	18	16.4	22	6
DY090	MSC	448 MSC163		BN3	Rates	20/06/2018	04:43	05:00	18	1.18	11	0.49	750	2567	18	16.4	22	6
DY090	MSC	461 MSC164	1	RS	Fluxes/Geochem	21/06/2018	13:12	13:15	18	1.19	11	0.50	35	2560	17.6	16	20	5
DY090	MSC	462 MSC165	2	RS	Fluxes/Geochem	21/06/2018	13:21	13:24	18	1.19	11	0.50	75	2560	17.6	16	21	5
DY090	MSC	463 MSC166	4	RS	Fluxes/Geochem	21/06/2018	13:35	13:40	18	1.19	11	0.50	100	2560	17.6	16	20	5
DY090	MSC	464 MSC167	5	RS	Fluxes/Geochem	21/06/2018	13:51	14:12	18	1.19	11	0.50	250	2560	17.6	16	21	5

Red Camera Frame

Isabell Klawonn, Nathan Briggs, Filipa Carvalho, Richard Lampitt, Morten Iversen

Personnel on the field: Isabell Klawonn, Nathan Briggs & Filipa Carvalho

Objective

The Red Camera Frame carried different optical sensors which measure the characteristics of the particle field in the epipelagic and upper mesopelagic zones: LISST HOLO, P-Cam, Eco Puck and either RBR Concerto or SBE39.

Due to a 250 m depth limit on the LISST HOLO, two profiles were usually carried out at each deployment, one to 250 m and another to 500 –1000 m. The first deployment (with LISST included), both upward and downward speeds were 0.2 m s^{-1}. On the second cast, mostly due to time constrains, the descent speed was about 0.2 m s^{-1} (later on, in order to get deeper depths, the depths covered on the shallow cast were "skipped" on the deep cast, by going down at 1 m s^{-1} until 250 m and at 0.2 m s^{-1} from then on) and the ascend speed was 1.0 m s^{-1}. Before each deployment, the frame was lowered to approx. 5 m depth for 5 min in order to remove trapped bubbles.

In total, 35 Red camera frame deployments were done successfully; 8 at the Southern Benguela station (BS) and 27 at the Northern Benguela station (BN).

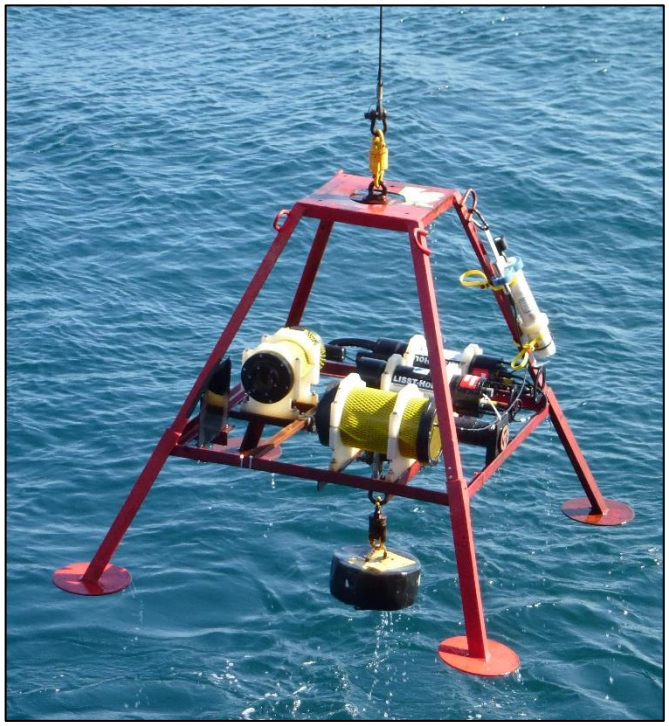


Figure 14: Deployment of Red Camera Frame with LISST HOLO, P-Cam, Eco Puck and RBR Concerto.

LISST-Holo

The LISST-HOLO is a submersible digital holographic camera. During the present cruise it was operated in a self-contained mode powered from an external battery pack. The instrument records in-line holographic images that are stored in internal flash memory or an 'external memory module' (EMM). These .PGM (portable grey map) images also code supporting data, date, time, temperature, depth, and instrument details in the file structure (see Sequoia manual section 12, p65 for details). This supporting data can be read in plain text at the end of the file using the 'HEXview' option in Irfanview (convenient software for opening and viewing the .PGM files). This is a useful feature where the file's original timestamp may have been lost on copying of file transfer.

The notional capability of the instrument is the detection and volume measuring of particles in the size range 25-2500µm equivalent spherical diameter, through a path length of 50mm, having a sampled volume of 1.86cm^3. Optical sections of the recorded image are reconstructed mathematically from the interference fringes produced by the interaction of particles with the laser illumination. Summary statistics are provided in terms of total particle volume concentration and volume concentration in size bins (note that four different bin size scales are offered – for processing on-board this cruise, the 'LISST-100X type C' was uniformly employed). Dep and Mon (Montage) images were saved but not the individual slices (100 per frame).

The Holographic system (LISST-HOLO) images 1.8 ml of water every 5 seconds providing an image approximately every metre. After careful evaluation of the "resolution" of the instrument, we found that after a series of about 32 images, there was a gap of about 25 metres where no data was recorded. So we changed the image acquisition to every 8 seconds and that helped remove data gaps.

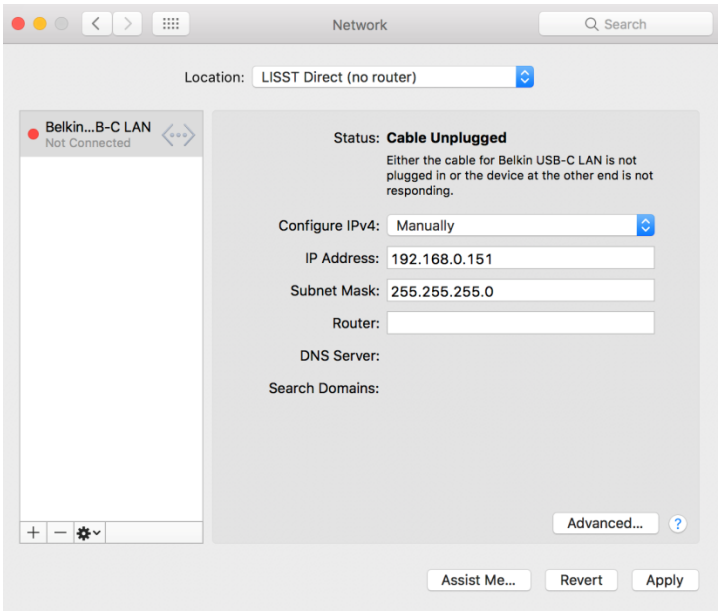
LISST-Holo Data Processing

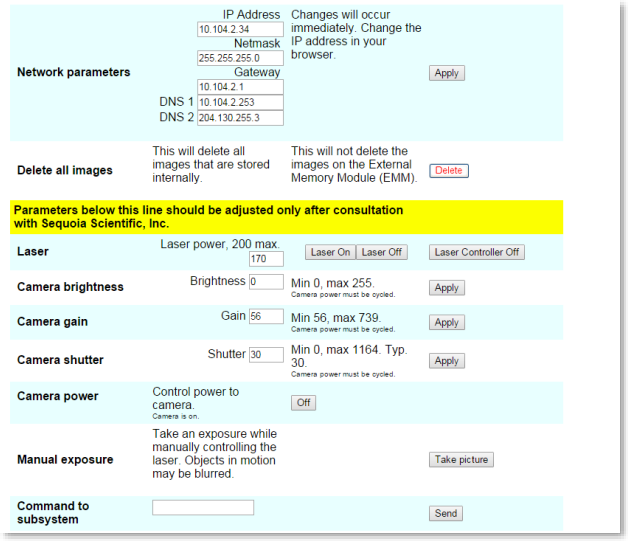
Image reconstruction and data generation requires use of Sequoia supplied software - HOLO_Batch for batch processing and data generation.

The External Memory Module (EMM) was used for all deployments, being easier to handle than the internal memory store. EMM can be treated as any normal memory stick to transfer data but taking extreme care every time only to remove it from the LISST-HOLO after it has entered "sleep mode" and to "eject the hardware" before removing it from the laptop connection. Failure to do this would have damaged the EMM.

Data downloading was done using the Ecopuck computer (Richard Sander's small PC) while communication with the instrument was done using Filipa's Macbook Pro. As connection using the supplied router was not successful, a direct connection with the LISST was setup, by plugging the yellow cable directly to the computer. With this setup, the communication with the list bypassed the router. The key setup wasto make sure the computer was in the same network as the LISST (e.g.

192.168.0.151) and on a browser we'd type 192.168.0.150. Firefox provided the most reliable connection (Safari sometimes would not connect to the LISST).





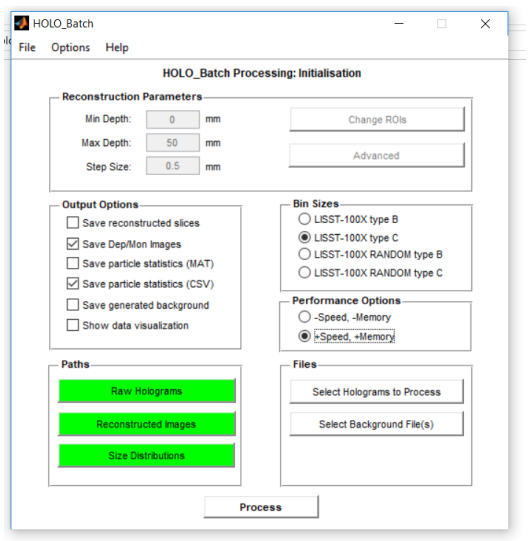


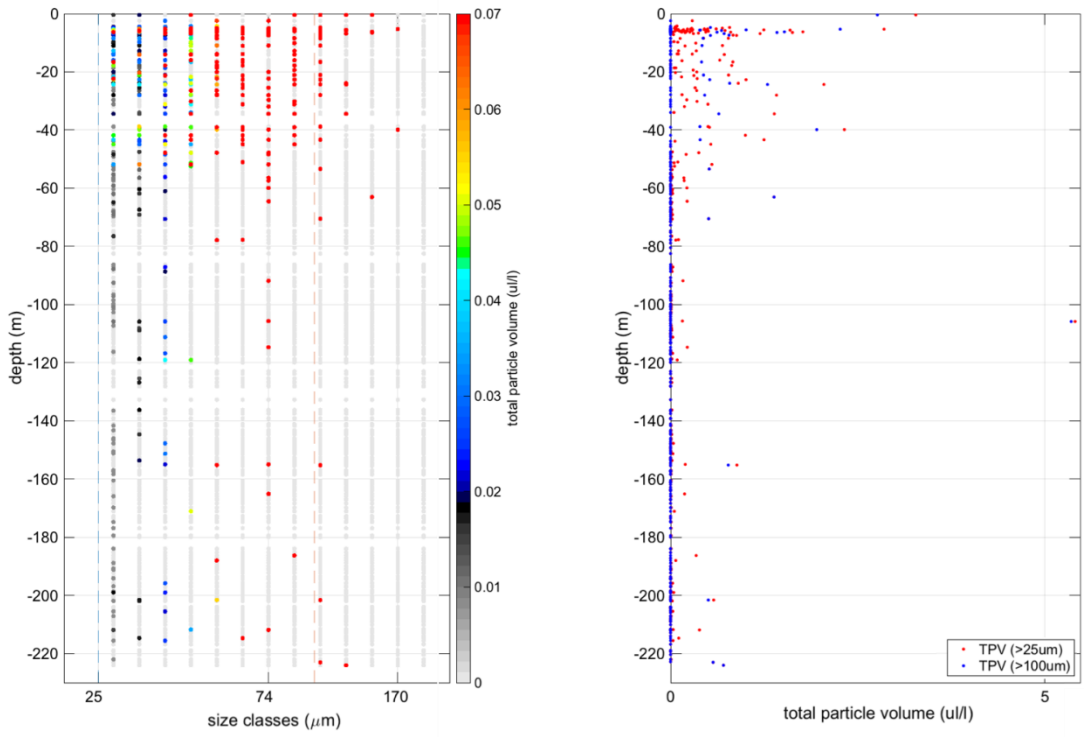
Figure 15: Screen-shots from the direct connection of the LISST to the computer (1), programming (2) and processing (3) of the LIST-HOLO images

Although the output from HOLO_Batch provides, as stated in the manual, data in 50 size bins logarithmically placed from 1.25 -4923µm, the effective resolution of the instrument is only about 25µm rendering the first 18 bins completely useless. Data (deployment composite (*-All.csv) was then imported into matlab using the script *import_lisst_holo_csv2mat.m* and ploted using *COMICS_plot_lisst_holo.m*. Some processed files were missing the "header" where the class size ranges are defined, so we had to add that to the file so all files had the same format (this "header" is pulled from the file when creating the mat file).

Data Coverage

18 deployments of the LISST HOLO (out of 35 Red Camera Frame deployments) were made during the cruise to 250 m depth with 4 deployments at the low productive southern station (test and BS) and 14 deployments at the more productive northern station (BN).

LISST-HOLO Results



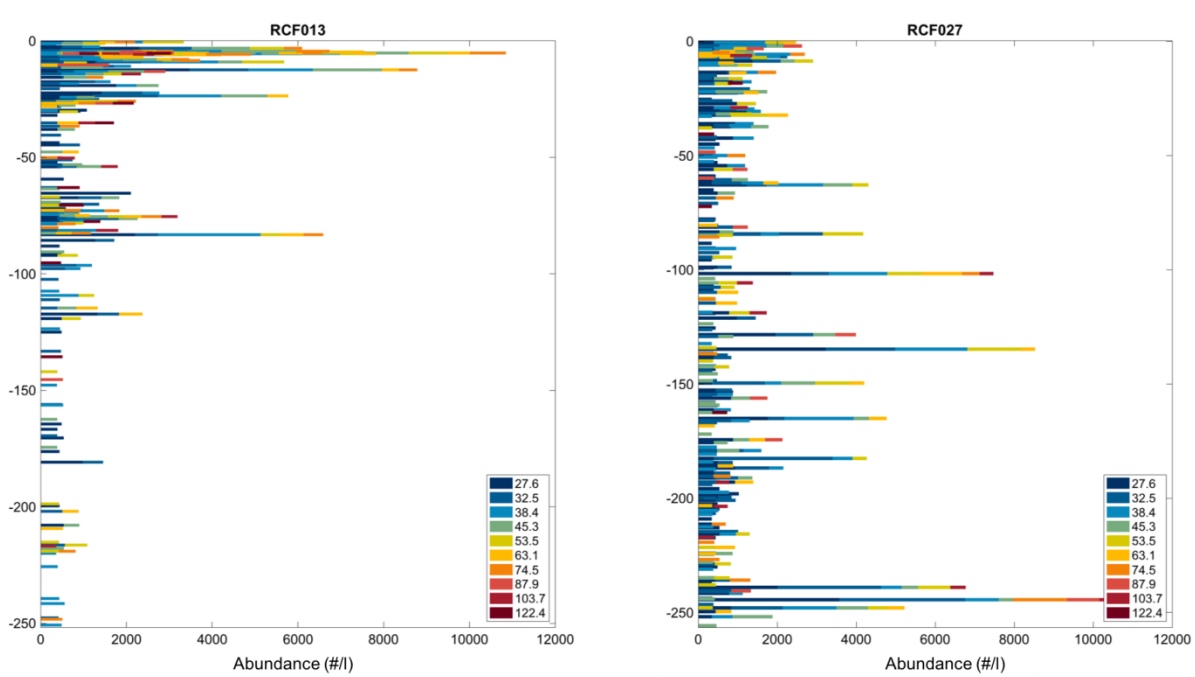


Figure 16: Example results from preliminary LISST-Holo after data processing using LISST Batch. Top left: Scatter plot indicating for each size class, and per depth, the total particle volume. Top right: total particle volume for particle over 25 µm (red) and over 100 µm (blue). Bottom: Stacked histogram plot showing for each depth the predominant size classes.

P-Cam

Description

The P-Cam consisted of a Canon EOS 6D digital SLR camera equipped with a 50 mm macro lens and a Canon Speedlite 600EX RT flash gun. The camera and the flash gun were places perpendicular to each other provide illumination from the right side of the captured images. We used a Hahnel Giga T Pro II remote timer to capture an image every 5–9 seconds.

We captured individual particles through the water column in a water volume of 2.15 L for each captured image. The pixel size of the images changed depending on whether the particles were in the front or back of the field of depth. We determined a pixel size of 33 µm per pixel in the front of the depth of field (as seen from the camera) and a pixel size of 61 µm per pixel at the back of the depth of field. This suggested an average pixel size of 47 µm per pixel. The field of view for each image was 157 mm width, 101 mm height, and 135 mm depth. The width and height of the images were determined by the cropping of each image to compensate for uneven flash illumination and might change when we do the final image processing.

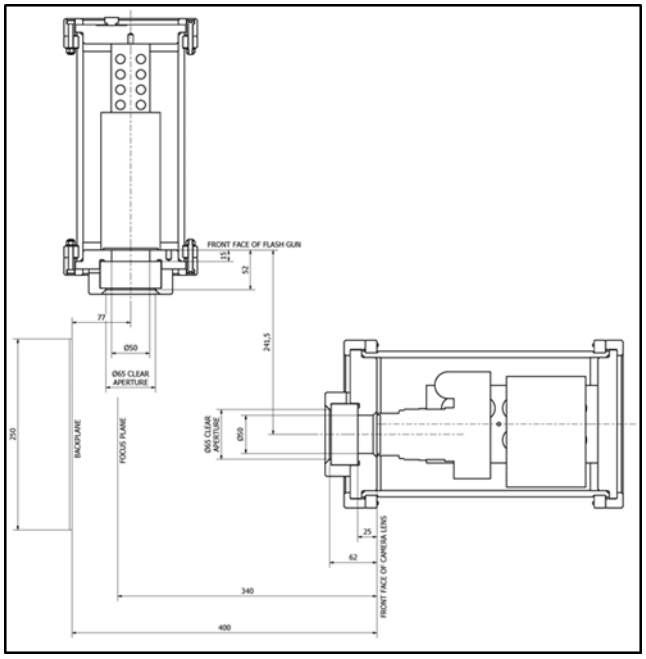


Figure 17: Overview figure of the PELAGRA Cam configuration. The pressure housing in the lower right part of the image contained the camera and the upper left pressure housing contained the flash gun.

Camera settings

Image quality:	jpeg highest quality, no raw
Beep:	Disable
Release	shutter without card: OFF
Image review:	OFF
Lens aberration correction:	Enable, Enable
External Speedlite control:	Enable, Evaluate, Auto
Mirror Lockup:	OFF
Expo. Comp./AEB:	0
ISO Speed settings:	blank
Auto lighting optimizer:	off Info selected Disable in M or B modus
White balance:	Flash
Custom White Balance: blank	
WB Shift/Bkt.:	blank 0.0/+/-0
Color space:	sRGB
Picture Style:	Auto
Long exp. Noise reduction:	OFF
High ISO speed NR:	middle (first two bars filled)
Highlight tone priority:	OFF

Dust Delete Data:	Blank
Multiple exposure:	Disable
HDR Mode:	Disable HDR
Live view shot:	Disable
AF Method:	FlexiZoneAF
Grid display:	OFF
Aspect Ratio:	3:2
Expo. Simulation:	Enable
Silent LV shoot:	Mode 1
Metering timer:	16 sec.
Highlight alert:	Disable
AF point disp.	Disable
Playback grid:	Off
Histogram disp.	Brightness
Movie play count:	Rec time
Magnification (apx):	2x
Ctrl over HDMI:	Disable

Manual mode
set time and date to GMT
ISO 2500
shutter 1/160
aperture to f/32
set the lens to manual focus: MF
focus of the lens to 1.5 feet (fixed with yellow tape)

Timer settings
continuous, every 9 sec

Delay: HH:MM:SS
Long: 00 00’ 00”
INTVL1: 00 00’ 00”
N1: 1
INTVL2: 00 00’ 09”

Flash settings

Hold Zm/C.Fn button to enter setup.

m/ft:	0: m
zZZ:	0:ON
Modelling:	0
Auto Cancel:	0
0:	0 → - → +
MODE:	0: ETTL-II/E-TTL
QUICK:	0:OFF
TEST:	0:1/32
AF:	0:ON
0:	ON
zZZ:	1:10min
zZZ:	0:8h
Remote:	0
Flash	+/-: 0
Sound:	OFF
Direction:	1: straight
Light:	1:OFF
Flash:	0

The flash was set in manual mode and put for straight flash direction and a flash output of 1/8.

ECO-Puck and RBR Concerto description

Each deployment of the Red Camera Frame was equipped with RBR Concerto CTD with Fluorescence and backscatter sensors and an ECO-Puck that measured chlorophyll fluorescence and backscatter at two wave-lengths (532 700). Both the ECO-Puck and the RBR Concerto were timed according to the ship's GMT time. Depth information for both the Ecopuck, P-Cam and LISST-Holo was obtained by matching timestamps on those instruments with the RBR Concerto and/or Seabird39 (used on deeper casts given the depth rating of 500m on the RBR).

A separate report for the Ecopuck highlights the details of the sensor on both the Red Camera Frame deployments and on the CTD.

Table 11: Deployment Events of the Red Camera Frame

Time	station	Event	RCF#	Down speed (m/s)	Up speed (m/s)	Cast depth (m)	LISST on	RBR on	PCAM on
5/25/18 10:59	test	14	RCF001	0.2	0.2	220	yes	yes	yes
5/25/18 11:50	test	15	RCF002	0.2	1	445	no	yes	yes
5/27/18 3:11	BS	47	RCF003	0.2	0.2	220	yes	yes	yes
5/27/18 4:02	BS	48	RCF004	0.2	1	450	no	yes	yes
5/27/18 20:41	BS	58	RCF005	0.2	0.2	220	yes	yes	yes
5/27/18 21:52	BS	59	RCF006	0.2	1	450	no	yes	yes
5/28/18 23:21	BS	73	RCF007	0.2	0.2	220	yes	yes	yes
5/29/18 0:28	BS	74	RCF008	0.2	1	450	no	yes	yes
6/4/18 5:03	BN	154	RCF009	0.2	0.2	220	yes	yes	yes
6/4/18 6:08	BN	155	RCF010	0.2	1	750	no	no	yes
6/5/18 0:56	BN	167	RCF011	0.2	0.2	220	yes	yes	yes
6/5/18 2:02	BN	168	RCF012	0.2	1	1000	no	no	yes
6/6/18 23:16	BN	198	RCF013	0.2	0.2	250	yes	yes	yes
6/8/18 23:12	BN	226	RCF014	0.12	0.12	250	yes	yes	yes
6/9/18 0:59	BN	227	RCF015	0.2	1	500	no	yes	yes
6/10/18 4:58	BN	246	RCF016	0.2	1	750	no	no	yes
6/11/18 4:25	BN	265	RCF017	0.2	1	750	no	no	no
6/11/18 22:51	BN	288	RCF018	0.2	0.2	250	yes	yes	yes
6/11/18 23:58	BN	289	RCF019	0.2	1	750	no	no	yes
6/12/18 8:47	BN	292	RCF020	0.2	0.2	250	yes	yes	no
6/13/18 3:33	BN	311	RCF021	0.1	0.1	250	yes	yes	yes
6/13/18 8:16	BN	317	RCF022	0.2	0.2	250	yes	yes	yes
6/13/18 9:25	BN	318	RCF023	0.2	1	750	no	no	yes
6/15/18 3:15	BN	343	RCF024	0.2	0.2	250	yes	yes	yes
6/15/18 4:22	BN	344	RCF025	0.2	1	750	no	no	yes
6/15/18 22:47	BN	362	RCF026	0.2	0.2	250	yes	yes	yes
6/15/18 23:55	BN	363	RCF027	0.2	1	1000	no	no	yes
6/16/18 22:52	BN	381	RCF028	0.2	0.2	250	yes	yes	yes

6/17/18 0:00	BN	382	RCF029	0.2	1	750	no	no	yes
6/18/18 13:38	BN	410	RCF030	0.2	1	250	yes	yes	yes
6/18/18 14:47	BN	411	RCF031	0.2	1	750	no	no	yes
6/19/18 11:31	BN	432	RCF032	0.2	1	750	no	no	yes
6/19/18 12:53	BN	433	RCF033	0.2	0.2	250	yes	yes	yes
6/19/18 20:59	BN	444	RCF034	0.2	0.2	250	yes	yes	yes
6/19/18 22:05	BN	445	RCF035	0.2	1	1000	no	no	yes

ECO Triplet Fluorometer and Backscattering Sensor

Nathan Briggs, Filipa Carvalho, Stephanie Henson (NOC)

Introduction

A 1000-m rated standalone Wetlabs Environmental Characterization Optics (ECO) Triplet Fluorometer and Backscattering Sensor, measuring backscatter at 2 wavelengths (532nm and 700 nm) and chlorophyll fluorescence was used during DY090. This sensor is the same one found on both Slocum glider deployed in February and recovered during the cruise as part of the GOCART project, and it will be used to improve calibrations between optical backscatter and chlorophyll fluorescence with in situ POC and chlorophyll concentrations data, respectively.

This ECO puck was deployed on the Red Camera Frame (RCF) as well as on the CTD rosette on profiles to a maximum of 1000 m. This instrument does not have a pressure sensor, so it relies heavily on the time variable that is then matched to the RBR or SBE39 (on the red camera frame) and the Seabird CTD (on the rosette). On both deployments, the sensor was horizontal, facing the outside. Two brackets were used to secure the instrument to the RCF. These brackets were also used to secure the instrument to the vane on the CTD rosette frame. Bolts size 17mm were used to secure the brackets onto the frames.

Calibrations

S/N: BB2FLWB-1633

Date: 9/15/2017

CHL (μg/l)= Scale Factor x (Output-Dark counts)

$\beta(\theta_c)$ $m^{-1}sr^{-1}$ = Scale Factor x (Output-Dark counts)

Table 12: Factory supplied Parameters used to convert raw data into chlorophyll fluorescence and backscatter concentrations

	ECO Chlorophyll Fluorometer	**Scattering meter at 700 nm**	**Scattering meter at 532 nm**
Scale Factor (SF)	0.0305 μg/l/count	3.004E-06 ($m^{-1}sr^{-1}$)/counts	6.974E-06 ($m^{-1}sr^{-1}$)/counts
Maximum output	4130	N/A	N/A
Dark Counts	53 counts	52 counts	53 counts
Resolution	1.2 counts	1.3 counts 3.94E-06 ($m^{-1}sr^{-1}$)	1.3 counts 8.77E-06 ($m^{-1}sr^{-1}$)

Ambient temperature during characterization	21.5 °C	N/A	N/A

Standard Operating Procedures

Prior to the deployment of the RCF and the CTD rosette, the sensor needs to be turned on. A computer with EcoView123 software is required as well as a USB to serial cable (and Windows drivers!).

Before deployment

Bring PC, comms cable and blue power plug

1. Launch EcoView123 software
2. Compare PC clock with ship's clock – if necessary, adjust PC clock (see below)
3. Remove dummy plugs from sensor
4. Attach blue power plug and comms cable
5. Attach comms cable to PC using USB to serial connector
6. Select COM port (yellow buttons top right) – COM Port 3 on RICS laptop. If different computer, check 'Device Manager'
7. Select Device File (BB2FLWB-1633.dev) from the ECO puck folder
8. Press Stop Data in EcoView123
9. Click Set Date, Set Time and/or Get Date/Time/Setup until correct time appears in top left of window
10. On Meter Setup tab, change settings to:
    a. Avg/Data Rate 1
    b. Number of Samples 0
    c. Number of Cycles N/A
    d. Cycle Interval N/A
    e. After each change click the relevant button 'Set …..' to update settings. These settings will run the sensor continuously at 1 Hz frequency until switched off again.
11. Press Turn Logging On
12. Press Store To Flash (yellow Setup not stored message in top right should disappear)
13. When ready to deploy, press Start Data
14. Disconnect comms cable and attach dummy plug
15. Take sensor cap off

Items 11 and 12 are sometimes interchangeable. If the order below doesn't work, try step 12 before step 11. During COMICS 2, logging was left ON. This allows the sensor to start recording data (and logging)

from the time it is powered on – easy to leave it all setup for an early morning CTD! To stop data acquisition just power off the sensor. When plugging the sensor to a PC, all the data should be there.
Note that step 10a represents a change from COMICS I (dy086). This change, made on 27 May of dy090, increases the sampling frequency from ~1 Hz to ~10 Hz. The purpose was to increase the precision of particle size estimates made from high frequency variability in backscattering measurements.

After deployment:

Bring PC, comms cable, dummy plug, bottle of water to rinse instrument and sensor cap

1. Connect comms cable to PC
2. Select COM port and device file, if necessary
3. Press Stop Data
4. Click Turn Logging Off
5. On Transfer Data tab, click Receive Data and save file
6. Open transferred file with text editor to verify data transfer
7. Press Erase Memory
8. Disconnect comms cable. Disconnect blue power plug.
9. Replace dummy plugs, rinse the instrument and place sensor cap.

Adjust Time

To adjust the time to the ship's time server:

1. Right click on the time on the left right corner of the Windows screen
2. Scroll down to 'Additional date, time and regional settings
3. In the 'Date and Time' menu, select 'Set the time and date'
4. On the 'Internet Time' tab, select 'Change settings'
5. Click 'Synchronize with an 'internet time server'
6. For DY086, the ship's server was 192.168.63.222

Data and operations during DY090

When the sensor was removed from box, there were signs of corrosion on the face copper plate where the sensors are. The instrument was properly cleaned and dried before being packed on COMICS 1, so no idea what caused it.
During DY090 we had memory issues as the resolution of the sensor was increased to its maximum (average of 1 as opposed to 18 used previously). Due to the small capacity in data storage (1055 Kb - REALLY?!?!), multiple casts were not possible at the highest resolution. Case by case decisions were made depending on how much memory was left in between the red camera frame profiles/CTD.

Sometimes resolution was adjusted/reduced to allow further data collection without the risk of filling the memory (we could not determine whether running out of memory causes data corruption – this happened a few times, but not all times we filled the memory). Looking at the WETLABS website, it seems like the memory cannot be upgraded.

Data corruption was likely due to battery issues. Before a deployment we were having trouble connecting to the sensor. Restarting the software or the computer did nothing. Batteries were replaced following manufacturer's instructions (batteries supplied by Kevin Saw) and connection was re-established with the instrument. Replacement batteries are not the same quality as the ones supplied by the manufacturer, so it is likely that they will need replacing sooner that the last set.

Red Camera Frame

In the following events, the RCF had the ECO puck on:

Time	Station	Event	Lat	Lon	Deployment
5/25/18 10:59	test	14	-21.525426	9.515647	RCF001
5/25/18 11:50	test	15	-21.525462	9.51567	RCF002
5/27/18 3:11	BS	47	-21.642696	9.510768	RCF003
5/27/18 4:02	BS	48	-21.642709	9.510767	RCF004
5/27/18 20:41	BS	58	-21.641111	9.505568	RCF005
5/27/18 21:52	BS	59	-21.641107	9.505564	RCF006
5/28/18 23:21	BS	73	-21.831566	9.615936	RCF007
5/29/18 0:28	BS	74	-21.831564	9.615941	RCF008
6/4/18 5:03	BN	154	-18.019753	11.008399	RCF009
6/4/18 6:08	BN	155	-18.019738	11.008394	RCF010
6/5/18 0:56	BN	167	-18.019666	11.008448	RCF011
6/5/18 2:02	BN	168	-18.019669	11.008458	RCF012
6/6/18 23:16	BN	198	-18.01962	11.008218	RCF013
6/8/18 23:12	BN	226	-18.019781	11.008219	RCF014
6/9/18 0:59	BN	227	-18.019774	11.00822	RCF015
6/10/18 4:58	BN	246	-18.019771	11.00816	RCF016
6/11/18 4:25	BN	265	-18.019762	11.00825	RCF017
6/11/18 22:51	BN	288	-18.019862	11.008266	RCF018
6/11/18 23:58	BN	289	-18.019863	11.00827	RCF019

6/12/18 8:47	BN	292	-18.019866	11.008268	RCF020
6/13/18 3:33	BN	311	-18.019719	11.008366	RCF021
6/13/18 8:16	BN	317	-18.019717	11.008372	RCF022
6/13/18 9:25	BN	318	-18.019711	11.008331	RCF023
6/15/18 3:15	BN	343	-18.019808	11.008349	RCF024
6/15/18 4:22	BN	344	-18.019793	11.008335	RCF025
6/15/18 22:47	BN	362	-18.019744	11.008292	RCF026
6/15/18 23:55	BN	363	-18.019751	11.00829	RCF027
6/16/18 22:52	BN	381	-18.019748	11.008283	RCF028
6/17/18 0:00	BN	382	-18.019752	11.008284	RCF029
6/18/18 13:38	BN	410	-18.0198	11.008297	RCF030
6/18/18 14:47	BN	411	-18.019815	11.008299	RCF031
6/19/18 11:31	BN	432	-18.019814	11.008237	RCF032
6/19/18 12:53	BN	433	-18.01981	11.00823	RCF033
6/19/18 20:59	BN	444	-18.019828	11.00823	RCF034
6/19/18 22:05	BN	445	-18.019819	11.008205	RCF035

CTD frame

The ECO puck was on the following CTD profiles:

ExcelTime	station	Event	Lat	Lon	Deployment
5/24/18 19:55	test	1	-21.499438	9.499878	CTD001
5/27/18 1:02	BS	46	-21.64269	9.510746	CTD004
5/29/18 5:31	BS	76	-21.54206	9.507141	CTD008
6/3/18 11:32	BN	135	-18.019758	11.008451	CTD012
6/4/18 1:02	BN	148	-18.019742	11.008387	CTD013
6/7/18 0:59	BN	199	-18.019619	11.008253	CTD018
6/9/18 2:20	BN	228	-18.019776	11.008217	CTD020
6/10/18 8:19	BN	250	-18.019758	11.008202	CTD022
6/11/18 0:12	BN	260	-18.019774	11.008256	CTD023
6/13/18 1:05	BN	310	-18.01972	11.008385	CTD026
6/15/18 0:55	BN	342	-18.019798	11.008361	CTD028
6/18/18 3:48	BN	399	-18.019838	11.008287	CTD033
6/20/18 16:33	BN	450	-18.019634	11.00803	CTD036

6/21/18 4:08	BN	457	-18.019863	11.00836	CTD037
6/21/18 7:48	BN	459	-18.019835	11.008357	CTD039

Data analysis

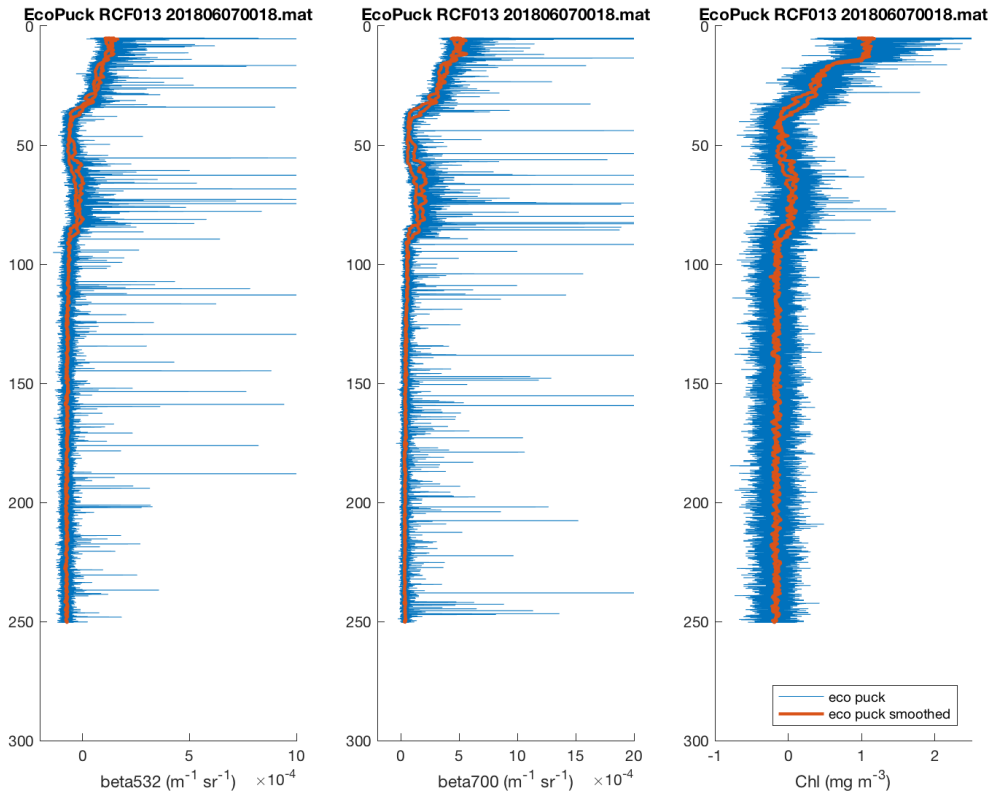


Figure 18: Depth profiles of data collected using the ECO puck on the Red Camera Frame. Blue lines are unaveraged. Red lines are smoothed using a 11-point (1 s, or 0.2 m) running median followed by a 51-point (5 s, or 1 m) running mean. Raw profiles are very noisy due to lack of internal averaging, but backscattering spikes due to large particles are very well resolved.

Example is shown for a red camera frame profile (Figure 18). Three variables measured by the ECO puck (chlorophyll fluorescence and backscatter at 532nm and 700nm) show reasonable numbers.
For the red camera frame deployments, depths were assigned to the dataset by matching timestamps on the ECO puck and the RBR concerto (for profiles ≤ 500 m) or an SBE39 (for profiles >500 m). The same process was repeated for the CTD DEPLOYMENTS using CTD pressure.

Organic Biogeochemistry

Calum Preece, University of Liverpool

Introduction

Organic biogeochemical analyses have been used to understand pelagic foodwebs for many years, although such observations focussing on the biological pump in the mesopelagic are few (Wolff et al., 2011; Salter et al., 2012). There is considerable variability in the composition, and hence fate, of exporting organic particles, potentially affecting the efficiency of the biological pump. This is driven partly by the nature of the surface primary production, but also by the function of mesopelagic ecosystems that rely upon it.

Certain organic chemicals such as fatty acids, sterols, pigments, or amino acids encountered in these particles can retain information on their biological origin (often termed biomarkers). Changes in the distributions of biomarkers and their isotopic composition can shed light on the transformations of the organic material as it sinks through the water column. In addition, biomarkers and their stable isotopic composition are often used to trace the trophic relationships of many marine communities. This may help to determine the trophic transfer efficiency (i.e. the energy transfer) of the mesopelagic ecosystems of the twilight zone, a key component in understanding loss of bioavailable carbon from the system.

Collecting particles from the water can be carried out in a variety of ways. Large volume in situ filtration systems (SAPS) and sediment traps (fixed or free drifting) have been used routinely for this purpose, recently some workers have been using marine now catchers (e.g. Cavan et al. in prep). SAPS can pump several hundred L of water through a filter in a short period of time (usually 1-2 hours), thus providing a large and presumably representative sample. The particles that are collected by SAPS can be heterogeneous with unknown but probably variable sinking speeds, whereas sediment traps are thought to better capture the vertically sinking particles. Marine now catchers (MSCs) have the potential to sample the full spectrum of particles (i.e. total, suspended, slow sinking and fast sinking) by fractionated sampling although the technique is at an early stage (see Cavan et al., in prep). Filter screens (mesh filters of a certain pore size) have occasionally been used to fractionate the particles collected by SAPS into ‘large’ and ‘small’ pools however little is known about the relationship between the SAPS and MSC fractionations. The exchange mechanisms between these different “pools” of particles are virtually unknown but can potentially affect the export of organic matter at depth. Comparison of the chemical composition between the different pools of particles sampled concurrently and at similar water depths may provide a new insight in these processes.

Particle sampling with Stand Alone Pumping Systems (SAPS)

Particulate material from 4-5 water depths was collected using standalone pumping systems. Two size fractions were recovered; the small particle fraction was collected on large pre-combusted (400 °C; 4hr) GF/F filters (293mm diameter, 0.7µm nominal pore size). Each SAPS contained two stacked GF/F filters with the bottom filter being taken as a blank. After filtering samples were folded, wrapped in foil and frozen at -80 °C before analysis back in Liverpool.

Large particles were collected on cleaned (10% HCl + 1% H_2O_2) nylon mesh screens (Nitex, pore size 53 µM) that were placed above the GF/F filters. Upon recovery the Nitex mesh was carefully rinsed into a 1L cleaned (10% acid) bottle using Thorium-free seawater. Volumes rinsed were between 0.8L and 1L. The water was then split as follows:

- ½ for organic biogeochemical work (i.e. POC, PIC, PN, lipids, amino acids, stable isotopes) to be carried out in ULIV/LJMU (filtered onto 47mm 0.7µM GF/F and frozen at -80 °C before analysis back in Liverpool)
- ¼ for Thorium analyses (see section for Thorium)
- ¼ for Polonium analyses (rinsed into 500ml acid rinsed HDPE bottle)

Five SAPS units were used on each deployment (with all deployed on the same cable) each pumping for 1hr. SAPS were placed so there was one pump in the mixed layer, one pump close to the base of the mixed layer <100m, one pump at 100m, one pump at 250m and one pump at close to 500m. Overall there were 8 SAPS deployments (2 x BN1, 2x BN2, 3x BN3 and 1 x RS), with at least 4 of the 5 pumps operating during each deployment (see table X).

Table X. SAPS sampling details

Cruise	Deployment	Date	Station	Event	SAPS name	Depth (m)	Pump (min)	Volume pumped (L)	Pumping time ship time=GMT+2 (hh.mm)		Nitex (large particles) rinse V	Lipids/POC/PIC V	234Th split V	Polonium V
									start	end				
DY090	SAPS 001	27/05/2018	BS1	49	POLLY	450	60	542	1109	1209	0.7	0.35	0.175	0.175
DY090	SAPS 001	27/05/2018	BS1	49	CHLOE	197	60	460	1109	1209	0.7	0.35	0.175	0.175
DY090	SAPS 001	27/05/2018	BS1	49	MINNIE	117	60	769	1109	1209	0.7	0.35	0.175	0.175
DY090	SAPS 001	27/05/2018	BS1	49	SANDIE	77	60	705	1109	1209	1	0.5	0.25	0.25
DY090	SAPS 001	27/05/2018	BS1	49	RINGO	30	60	0	1109	1209	-	-	-	-
DY090	SAPS 002	29/05/2018	BS1	77	POLLY	450	60	566	1033	1133	1	0.5	0.25	0.25
DY090	SAPS 002	29/05/2018	BS1	77	CHLOE	200	60	412	1033	1133	1	0.5	0.25	0.25
DY090	SAPS 002	29/05/2018	BS1	77	MINNIE	120	60	671	1033	1133	1	0.5	0.25	0.25

DY090	SAPS 002	29/05/2018	BS1	77	RINGO	80	60	0	1033	1133	-	-	-	-
DY090	SAPS 002	29/05/2018	BS1	77	SANDIE	30	60	629	1033	1133	1	0.5	0.25	0.25
DY090	SAPS 003	04/06/2018	BN1	157	WENDY	30	60	-109	1300	1400	0.8	0.4	0.2	0.2
DY090	SAPS 003	04/06/2018	BN1	157	RINGO	60	60	0	1300	1400	-	-	-	-
DY090	SAPS 003	04/06/2018	BN1	157	SANDIE	80	60	598	1300	1400	0.8	0.4	0.2	0.2
DY090	SAPS 003	04/06/2018	BN1	157	MINNIE	120	60	682	1300	1400	0.8	0.4	0.2	0.2
DY090	SAPS 003	04/06/2018	BN1	157	CHLOE	250	60	729	1300	1400	0.8	0.4	0.2	0.2
DY090	SAPS 003	04/06/2018	BN1	157	POLLY	400	60	541	1300	1400	0.8	0.4	0.2	0.2
DY090	SAPS 004	09/06/2018	BN2	230	SANDIE	20	60	480	955	1055	0.8	0.4	0.2	0.2
DY090	SAPS 004	09/06/2018	BN2	230	RINGO	30	60	0	955	1055	-	-	-	-
DY090	SAPS 004	09/06/2018	BN2	230	WENDY	50	60	0	955	1055	-	-	-	-

DY090	SAPS 004	09/06/2018	BN2	230	MINNIE	100	60	550	955	1055	0.8	0.4	0.2	0.2
DY090	SAPS 004	09/06/2018	BN2	230	CHLOE	250	60	675	955	1055	0.8	0.4	0.2	0.2
DY090	SAPS 004	09/06/2018	BN2	230	POLLY	500	60	516	955	1055	0.8	0.4	0.2	0.2
DY090	SAPS 005	12/06/2018	BN2	291	POLLY	500	60	449	854	954	0.8	0.4	0.2	0.2
DY090	SAPS 005	12/06/2018	BN2	291	CHLOE	250	60	693	854	954	0.8	0.4	0.2	0.2
DY090	SAPS 005	12/06/2018	BN2	291	MINNIE	100	60	562	854	954	0.8	0.4	0.2	0.2
DY090	SAPS 005	12/06/2018	BN2	291	WENDY	75	60	768	854	954	0.8	0.4	0.2	0.2
DY090	SAPS 005	12/06/2018	BN2	291	SANDIE	35	60	305	854	954	0.8	0.4	0.2	0.2
DY090	SAPS 006	15/06/2018	BN3	345	POLLY	500	60	451	859	959	0.8	0.4	0.2	0.2
DY090	SAPS 006	15/06/2018	BN3	345	CHLOE	250	60	696	859	959	0.8	0.4	0.2	0.2
DY090	SAPS 006	15/06/2018	BN3	345	MINNIE	100	60	593	859	959	0.8	0.4	0.2	0.2

DY090	SAPS 006	15/06/2018	BN3	345	WENDY	75	60	767	859	959	0.8	0.4	0.2	0.2
DY090	SAPS 006	15/06/2018	BN3	345	SANDIE	35	60	484	859	959	0.8	0.4	0.2	0.2
DY090	SAPS 007	17/06/2018	BN3	387	POLLY	500	60	470	857	957	0.8	0.4	0.2	0.2
DY090	SAPS 007	17/06/2018	BN3	387	CHLOE	250	60	680	857	957	0.8	0.4	0.2	0.2
DY090	SAPS 007	17/06/2018	BN3	387	MINNIE	100	60	555	857	957	0.8	0.4	0.2	0.2
DY090	SAPS 007	17/06/2018	BN3	387	WENDY	75	60	846	857	957	0.9	0.45	0.225	0.225
DY090	SAPS 007	17/06/2018	BN3	387	SANDIE	35	60	482	857	957	0.9	0.45	0.225	0.225
DY090	SAPS 008	21/06/2018	RS	460	WENDY	500	60	0	1231	1331	-	-	-	-
DY090	SAPS 008	21/06/2018	RS	460	POLLY	250	60	440	1231	1331	0.8	0.4	0.2	0.2
DY090	SAPS 008	21/06/2018	RS	460	CHLOE	100	60	664	1231	1331	0.8	0.4	0.2	0.2
DY090	SAPS 008	21/06/2018	RS	460	MINNIE	75	60	591	1231	1331	0.8	0.4	0.2	0.2

DY090	SAPS 008	21/06/2018	RS	460	SANDIE	35	60	517	1231	1331	0.9	0.45	0.225	0.225

Particle sampling with Marine Snow Catchers (MSCs)

Particulate material from 4 to 8 depth profiles was collected using four marine snow catchers (MSCs). The depths for obtaining material were between 15m and 750m with the majority of deployments collecting material at 100m, 250m, 500m and 750m (See table X1). There were 4 size fractions collected from each MSC:

- Time zero – collected immediately upon recovery from the middle tap. These presumably represent non-fractionated particles similar to samples from CTD bottles (labelled 'tzero').
- After 2hrs of settling time water from the top section of the MSC was collected using the middle tap. These represent the suspended particles (labelled 'top').
- After 2hrs of settling time water from the bottom section of the MSC, representing the slow sinking particles (labelled 'bottom') was collected.
- After 2hrs of settling time water from the tray installed at the centre of the bottom chamber of the MSC was collected, representing fast sinking particles (labelled 'tray').

Water was collected into clean 5L plastic carboys. Particles were filtered using a glass rig through pre-combusted (400 °C; 4hrs) 47mm 0.7µm GF/F filters. These were frozen at -80 °C before analysis back in Liverpool.

Table X1. Marine Snow Catcher sampling details

Cruise	**Date**	**Station**	**Event**	**MSC no**	**Depth (m)**	**V filtered (L)**			
						tzero	**top (+2h)**	**bottom (+2h)**	**tray (+2h)**
DY090	28/05/2018	BS1	66	25	80	3.7	7.7	2.6	0.75
DY090	28/05/2018	BS1	67	26	120	3.8	8.2	2.85	0.8
DY090	28/05/2018	BS1	68	27	200	3.7	7.9	3	LEAKED
DY090	28/05/2018	BS1	69	28	450	3.5	7.9	3.8	0.85
DY090	29/05/2018	BS1	80	31	200	3.25	3.2	2.75	0.83
DY090	31/05/2018	BS1	99	38	80	3.6	8.1	2.55	0.85
DY090	31/05/2018	BS1	100	39	120	3.55	8.2	2.65	0.55

DY090	31/05/2018	BS1	101	40	200	4.1	8	2.9	0.85
DY090	31/05/2018	BS1	102	41	750	3.4	7.6	2.2	0.85
DY090	03/06/2018	BN1	136	54	80	3.5	7.9	2.7	0.65
DY090	03/06/2018	BN1	137	55	120	3.6	8.3	2.5	0.75
DY090	03/06/2018	BN1	138	56	250	3.45	6.5*	2.3	0.5
DY090	03/06/2018	BN1	139	57	400	3.5	8.4	3.5	0.75
DY090	06/06/2018	BN1	192	68	50	3.4	7	3.2	0.6
DY090	06/06/2018	BN1	193	69	100	3.5	8	3.1	0.7
DY090	06/06/2018	BN1	194	70	250	3.5	6	2.8	0.7
DY090	06/06/2018	BN1	195	71	500	3.5	7	3.2	0.7
DY090	11/06/2018	BN2	273	93	15	3.75	5	3	0.7
DY090	11/06/2018	BN2	274	94	35	3.7	6	3.1	0.7
DY090	11/06/2018	BN2	275	95	55	3.65	6	3.3	0.55
DY090	11/06/2018	BN2	276	96	75	3.65	7	3.85	0.68
DY090	11/06/2018	BN2	284	102	100	3.5	8	2.9	0.7
DY090	11/06/2018	BN2	281	99	250	4	7.8	2.6	0.65
DY090	11/06/2018	BN2	282	100	500	4	8	2.75	0.7
DY090	11/06/2018	BN2	283	191	750	3.5	-	-	-

DY090	12/06/2018	BN2	295	103	750	3	6.7	2.9	0.5
DY090	14/06/2018	BN3	330	117	35	3.5	6.8	2.5	0.68
DY090	14/06/2018	BN3	331	118	100	3.5	7.8	2.3	0.7
DY090	14/06/2018	BN3	334	121	250	3.5	7	2.8	0.7
DY090	14/06/2018	BN3	335	122	500	3.75	8	3	0.7
DY090	16/06/2018	BN3	375	134	35	3.3	6	2.75	0.68
DY090	16/06/2018	BN3	376	135	75	2.95	8	2.9	0.7
DY090	16/06/2018	BN3	377	136	100	3	8	2.9	0.7
DY090	16/06/2018	BN3	378	137	250	2.85	8	3.5	0.7
DY090	17/06/2018	BN3	390	141	100	3.3	8	2.8	0.7
DY090	17/06/2018	BN3	391	142	250	3.1	8.1	3.2	0.7
DY090	17/06/2018	BN3	392	143	500	3.15	8	2.6	0.58
DY090	17/06/2018	BN3	393	144	750	3.35	8.1	2.75	0.68
DY090	18/06/2018	BN3	417	149	35	3	6	2.85	0.69
DY090	18/06/2018	BN3	418	150	75	3	7	2.75	0.68
DY090	18/06/2018	BN3	419	151	100	3.2	7	2.65	0.68
DY090	18/06/2018	BN3	420	152	250	2.95	7.6	3.5	0.68

DY090	21/06/2018	RS	461	164	35	3.1	7	2.95	0.7
DY090	21/06/2018	RS	462	165	75	3.3	7	3	0.7
DY090	21/06/2018	RS	463	166	100	3.2	7	2.9	0.6
DY090	21/06/2018	RS	464	167	250	3.1	7	3.2	0.7

Particle sampling from PELAGRA traps

Approximately a 1/8 split from the formalin-preserved and processed PELAGRA samples from all deployments are anticipated. However, since samples will remain in formalin and will not be available for several months the usefulness of these samples for organic biogeochemical analyses is questionable. Therefore, where there was the opportunity 'live' unprocessed samples were obtained (Table X2). Particles were obtained by filtration as described above for the MSCs and frozen at -80 °C before analysis back in Liverpool.

Table X2. Pelagra sampling details

Cruise	**Date**	**Station**	**Event**	**Depth (m)**	**Cup**	**Notes**
DY090	2-5 June	BS1		750m	P9 #1	
DY090	3-5 June	BN1	147	100m	P2 #1	
DY090	3-5 June	BN1	147	250m	P6 #1	
DY090	10-12 June	BN2	238	250m	P6 #1	
DY090	10-12 June	BN2	235	750m	P9 #1	
DY090	16-17 June	BN3	355	100m	P2 #1	#1 8pm to 8am
DY090	16-17 June	BN3	353	250m	P6 #1	
DY090	16-17 June	BN3	353	250m	P6 #2	#2 8am to 8pm
DY090	16-17 June	BN3	351	750m	P9 #1	
DY090	16-17 June	BN3	351	750m	P9 #2	
DY090	19 - 20 June	BN3	416	100m	P2 #1	

DY090	19 - 20 June	BN3	414	250m	P6 #1	
DY090	19 - 20 June	BN3	416	100m	P2 #2	
DY090	19 - 20 June	BN3	414	250m	P6 #2	

^{234}Th:^{238}U sampling

Calum Preece, University of Liverpool (under the instructions of Katsiaryna Pabortsava, NOC)

Introduction

^{234}Th is widely used as a natural tracer of marine particle dynamics and export. ^{234}Th is produced from natural ^{238}U which is dissolved, conservative and proportional to salinity in well-oxygenated seawater (Anderson et al., 1989). ^{234}Th is readily adsorbed onto particle surfaces and is exported out of the upper ocean as particles sink. Consequently, a radioactive disequilibrium between ^{234}Th and ^{238}U is formed, which can then be measured analytically (Loeff et al., 1997; Pike et al., 2005). Based on the known rate of ^{234}Th production and decay, the downward ^{234}Th flux can be determined and then converted into flux of any element, if the ratio of this element to ^{234}Th on sinking particles is known (Buesseler et al., 1992). ^{234}Th:^{238}U disequilibrium method can only be used to estimate shallow export flux, as the equilibrium between ^{234}Th and ^{238}U is typically restored below 100-200 m depth. The fluxes obtained with ^{234}Th method are integrals of time-scales from several days to weeks (Savoye et al., 2006).

Sampling methodology and sampling treatment on board

Samples for Thorium analysis were collected from a stainless steel CTD rosette (total activity) and SAPS (particulate activity) at each of the stations.

Total ^{234}Th from CTD casts

For total ^{234}Th 4 L water samples were collected from 15 to 17 depths to 500m, with several bottles collected from depths greater than 1000m to check the equilibrium between ^{234}Th and ^{238}U. At 2 stations 100ml of water was collected at each depth for ^{238}U analysis and acidified with 1.3ml of concentrated HCl to be analysed back in Southampton (Ev260 and Ev369).

The depths aimed for in each deployment were 5m 10m, 15m 20m, 30m, 40m, 50m, 75m, 100m, 125m, 150m, 200m, 250m, 350m and 500m (see table X4).

Upon collection the water bottles were acidified by adding 6 ml nitric acid spiked with a Thorium 230 standard, and left at room temperature for 6-8 h. The bottles were shaken in between each step of the process. After 6-8 h total ^{234}Th was precipitated by adding 7-8 ml concentrated ammonia, 50µl $KMnO_6$ (potassium permanganate), and 50µl $MnCl_2$ (manganese dichloride), whilst shaking the bottles in between the steps. After 6-8 h (minimum) the formed precipitate was filtered onto 25 mm QMA filters. The filters were then placed in plastic petri dishes dried in a mild oven. The filters were subsequently wrapped in mylar foil and counted in a Riso beta counter. A procedural blank was created out using MiiliQ water from the ship, but time constraints meant it was not run on board.

Particulate ^{234}Th from SAPS

For particulate ^{234}Th ¼ of the large particles obtained from SAPS (see relevant section) were filtered on onto 25 mm QMA filters and rinsed with MilliQ pH 8 adjusted water (table X4). The filters were then placed in plastic petri dishes dried in a mild oven. After drying at 40 °C the filters were wrapped in mylar foil and counted in a Riso beta counter.

Table X4. Thorium sampling details

Cruise	Station ID	Date	Event	Sample Type	Water depth (m)
DY090	BS1	27/05/2018	49	SAPS	80
DY090	BS1	27/05/2018	49	SAPS	120
DY090	BS1	27/05/2018	49	SAPS	200
DY090	BS1	27/05/2018	49	SAPS	400
DY090	BS1	29/05/2018	77	SAPS	30
DY090	BS1	29/05/2018	77	SAPS	120
DY090	BS1	29/05/2018	77	SAPS	200
DY090	BS1	29/05/2018	77	SAPS	400
DY090	BS1	28/05/2018	71	CTD	5
DY090	BS1	28/05/2018	71	CTD	10
DY090	BS1	28/05/2018	71	CTD	15
DY090	BS1	28/05/2018	71	CTD	20
DY090	BS1	28/05/2018	71	CTD	30
DY090	BS1	28/05/2018	71	CTD	50
DY090	BS1	28/05/2018	71	CTD	75
DY090	BS1	28/05/2018	71	CTD	100
DY090	BS1	28/05/2018	71	CTD	120
DY090	BS1	28/05/2018	71	CTD	150
DY090	BS1	28/05/2018	71	CTD	175
DY090	BS1	28/05/2018	71	CTD	200
DY090	BS1	28/05/2018	71	CTD	250
DY090	BS1	28/05/2018	71	CTD	350
DY090	BS1	28/05/2018	71	CTD	500
DY090	BS1	28/05/2018	71	CTD	1000

DY090	BS1	28/05/2018	71	CTD	1000
DY090	BS1	28/05/2018	71	CTD	1000
DY090	BN1	04/06/2018	157	SAPS	30
DY090	BN1	04/06/2018	157	SAPS	80
DY090	BN1	04/06/2018	157	SAPS	120
DY090	BN1	04/06/2018	157	SAPS	250
DY090	BN1	04/06/2018	157	SAPS	400
DY090	BN1	06/06/2018	186	CTD	10
DY090	BN1	06/06/2018	186	CTD	15
DY090	BN1	06/06/2018	186	CTD	20
DY090	BN1	06/06/2018	186	CTD	30
DY090	BN1	06/06/2018	186	CTD	40
DY090	BN1	06/06/2018	186	CTD	60
DY090	BN1	06/06/2018	186	CTD	80
DY090	BN1	06/06/2018	186	CTD	120
DY090	BN1	06/06/2018	186	CTD	150
DY090	BN1	06/06/2018	186	CTD	175
DY090	BN1	06/06/2018	186	CTD	200
DY090	BN1	06/06/2018	186	CTD	250
DY090	BN1	06/06/2018	186	CTD	350
DY090	BN1	06/06/2018	186	CTD	500
DY090	BN2	09/06/2018	230	SAPS	20
DY090	BN2	09/06/2018	230	SAPS	100
DY090	BN2	09/06/2018	230	SAPS	250
DY090	BN2	09/06/2018	230	SAPS	500
DY090	BN2	12/06/2018	291	SAPS	35
DY090	BN2	12/06/2018	291	SAPS	75
DY090	BN2	12/06/2018	291	SAPS	100
DY090	BN2	12/06/2018	291	SAPS	250
DY090	BN2	12/06/2018	291	SAPS	500

DY090	BN2	11/06/2018	260	CTD	5
DY090	BN2	11/06/2018	260	CTD	10
DY090	BN2	11/06/2018	260	CTD	15
DY090	BN2	11/06/2018	260	CTD	20
DY090	BN2	11/06/2018	260	CTD	30
DY090	BN2	11/06/2018	260	CTD	40
DY090	BN2	11/06/2018	260	CTD	60
DY090	BN2	11/06/2018	260	CTD	80
DY090	BN2	11/06/2018	260	CTD	120
DY090	BN2	11/06/2018	260	CTD	175
DY090	BN2	11/06/2018	260	CTD	200
DY090	BN2	11/06/2018	260	CTD	250
DY090	BN2	11/06/2018	260	CTD	350
DY090	BN2	11/06/2018	260	CTD	500
DY090	BN3	15/06/2018	345	SAPS	35
DY090	BN3	15/06/2018	345	SAPS	75
DY090	BN3	15/06/2018	345	SAPS	100
DY090	BN3	15/06/2018	345	SAPS	250
DY090	BN3	15/06/2018	345	SAPS	500
DY090	BN3	17/06/2018	387	SAPS	35
DY090	BN3	17/06/2018	387	SAPS	75
DY090	BN3	17/06/2018	387	SAPS	100
DY090	BN3	17/06/2018	387	SAPS	250
DY090	BN3	17/06/2018	387	SAPS	500
DY090	BN3	16/06/2018	369	CTD	2500
DY090	BN3	16/06/2018	369	CTD	1000
DY090	BN3	16/06/2018	369	CTD	500
DY090	BN3	16/06/2018	369	CTD	350
DY090	BN3	16/06/2018	369	CTD	250
DY090	BN3	16/06/2018	369	CTD	200
DY090	BN3	16/06/2018	369	CTD	175

DY090	BN3	16/06/2018	369	CTD	150
DY090	BN3	16/06/2018	369	CTD	120
DY090	BN3	16/06/2018	369	CTD	100
DY090	BN3	16/06/2018	369	CTD	80
DY090	BN3	16/06/2018	369	CTD	50
DY090	BN3	16/06/2018	369	CTD	40
DY090	BN3	16/06/2018	369	CTD	30
DY090	BN3	16/06/2018	369	CTD	20
DY090	BN3	16/06/2018	369	CTD	15
DY090	BN3	16/06/2018	369	CTD	5
DY090	RS	21/06/2018	460	SAPS	35
DY090	RS	21/06/2018	460	SAPS	75
DY090	RS	21/06/2018	460	SAPS	100
DY090	RS	21/06/2018	460	SAPS	250
DY090	RS	20/6/2018	450	CTD	5
DY090	RS	20/6/2018	450	CTD	10
DY090	RS	20/6/2018	450	CTD	15
DY090	RS	20/6/2018	450	CTD	20
DY090	RS	20/6/2018	450	CTD	30
DY090	RS	20/6/2018	450	CTD	50
DY090	RS	20/6/2018	450	CTD	75
DY090	RS	20/6/2018	450	CTD	100
DY090	RS	20/6/2018	450	CTD	120
DY090	RS	20/6/2018	450	CTD	150
DY090	RS	20/6/2018	450	CTD	175
DY090	RS	20/6/2018	450	CTD	200
DY090	RS	20/6/2018	450	CTD	250
DY090	RS	20/6/2018	450	CTD	350
DY090	RS	20/6/2018	450	CTD	500

RESPIRE array

Filipa Carvalho, Nathan Briggs, Stephanie Henson, Sari Giering, Emmanuel Laurenceau, Philip Boyd, Matthiew Bressac

Personnel on the field: Filipa Carvalho, Nathan Briggs, Stephanie Henson, Sari Giering

Description

REspiration of Sinking Particles In the subsuRface ocEan (RESPIRE) particle interceptors were deployed during the second COMICS cruise in the Benguela Current (*RRS Discovery*, 23-May to 28-Jun, 2018). RESPIRE traps were deployed on a free-drifting surface-tethered array (Fig. 1.) for an average duration of 3 days.

The 3 traps, controllers and two frames were lent by the Institute for Marine and Antarctic Studies (P. Boyd, IMAS, Tasmania, Australia). The mooring line was designed by the NOC technical team and the surface buoy lent by the Woods Hole Oceanographic Institute.

A flashing light and a flag manufactured on board by an NMF technician during the COMICS 1 cruise (DY086) were installed on the surface buoy on route to the study site. Contrary to the previous cruise, a GPS tracking system was available and was used to provide regular positions of the surface marker throughout the deployments.

Figure 19: left: RESPIRE trap waiting for deployment; right: surface buoy with light, flag and GPS tracker.

The main goal of deploying the RESPIRE traps during COMICS2 was to collect in situ rates of bacterial remineralisation on sinking particles in the mesopelagic zone. RESPIRE traps are composed by a titanium cylinder equipped with an indented rotating sphere (IRS) which collects sequentially the sinking particles during the first period of the deployment (collection period), and deposit them into a

virtually closed incubation chamber (<0.6 mm gap between IRS and trap cylinder walls), where an oxygen optode (Aanderaa 3830 series) measures dissolved oxygen concentration and temperature. The rotation of the sphere is programmed to stop after a given amount of time ("end of the collection"), and marks the beginning of the "incubation time". A "delay period" is also set to allow the traps to be deployed and settle at the right depth before the collection period starts. Oxygen concentration is measured during the whole deployment (delay, collection and incubation) and the rate of its decrease during the incubation period is a metric of particle remineralisation related to particle-attached bacteria.

Deployments during DY090

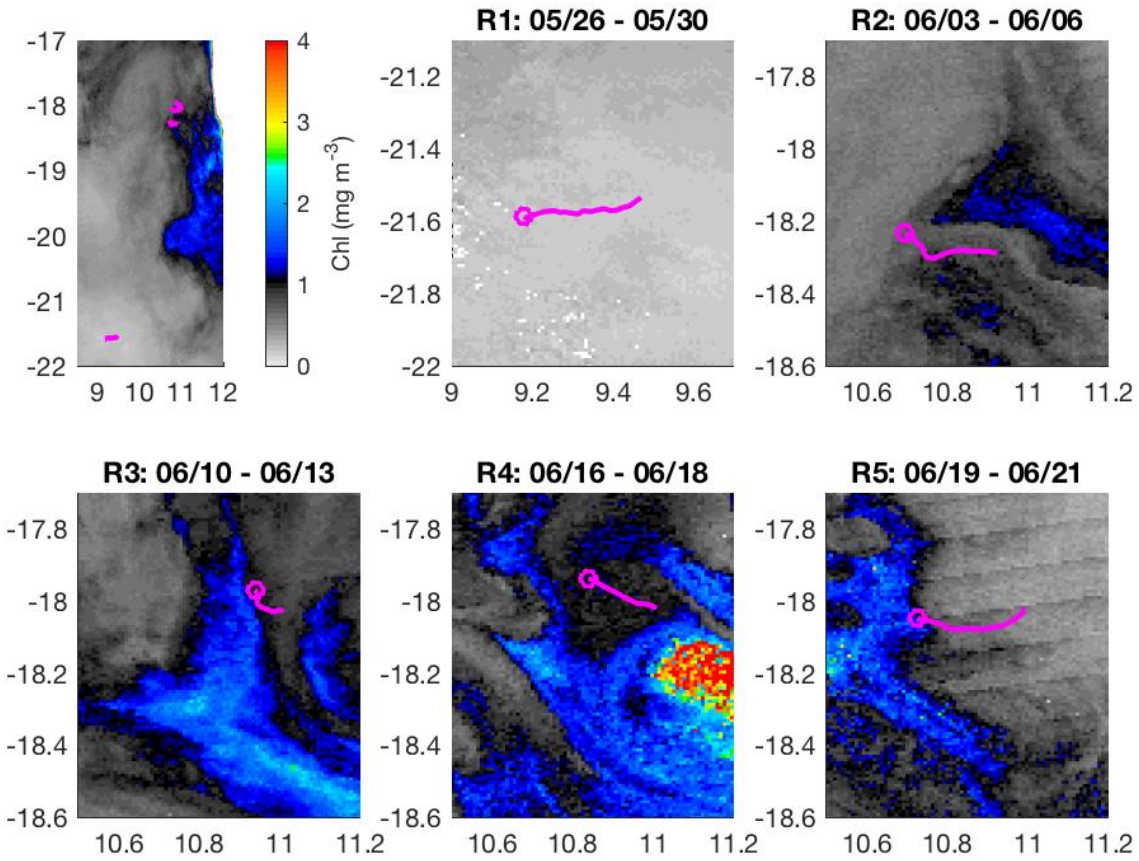


Figure 20: RESPIRE drift tracks (pink) and recovery locations (pink circles) overlaid on median satellite Chl estimates for the deployment period. Upper left shows all deployments and other panels show one deployment each.

The two functional RESPIRE traps were deployed at nominal depths of 125m and 250m (deepest trap was set to 200m on the RESPIRE001), below the mixed layer depth and out of the influence of internal waves to avoid temperature variations potentially affecting oxygen measurements. Due to a miscalculation during the mooring setup, the actual depths of the traps were about 20 metres less than initially programmed. The calculations took into account the line length (about 42 metres) as opposed to the bungee length (about 25 metres) The mooring setup was done by NMF technicians Andy, John

Wynar and Candice Cameron. Since all the labelling was done using 125 and 250 m, in this document we will continue to refer to these depths, noting though that the actual depths were 105 and 230 metres, for the shallow and deeper traps respectively. For the first deployment (RESPIRE001) we do not have depth data as no pressure sensor was attached. For the remaining missions, a Seabird39 Temperature and Pressure sensor was attached to each frame so both traps had depth and outside temperature information.

Table 13: RESPIRE deployment/recovery details during DY090

Station	RESPIRE ID	Event	Comment	Time	Lat	Long
		37	deployment	26/05/2018 10:08	-21.556	9.431
		84	recovery	29/05/2018 17:40	-21.594	9.172
		121	deployment	02/06/2018 14:14	-18.297	10.945
		179	recovery	05/06/2018 18:51	-18.210	10.665
		234	deployment	09/06/2018 14:57	-18.026	11.009
		299	recovery	12/06/2018 15:18	-17.957	10.936
		346	deployment	15/06/2018 10:50	-18.026	11.010
		394	recovery	17/06/2018 19:31	-17.937	10.835
		407	deployment	18/06/2018 11:11	-18.027	10.989
		451	recovery	20/06/2018 20:32	-18.051	10.721



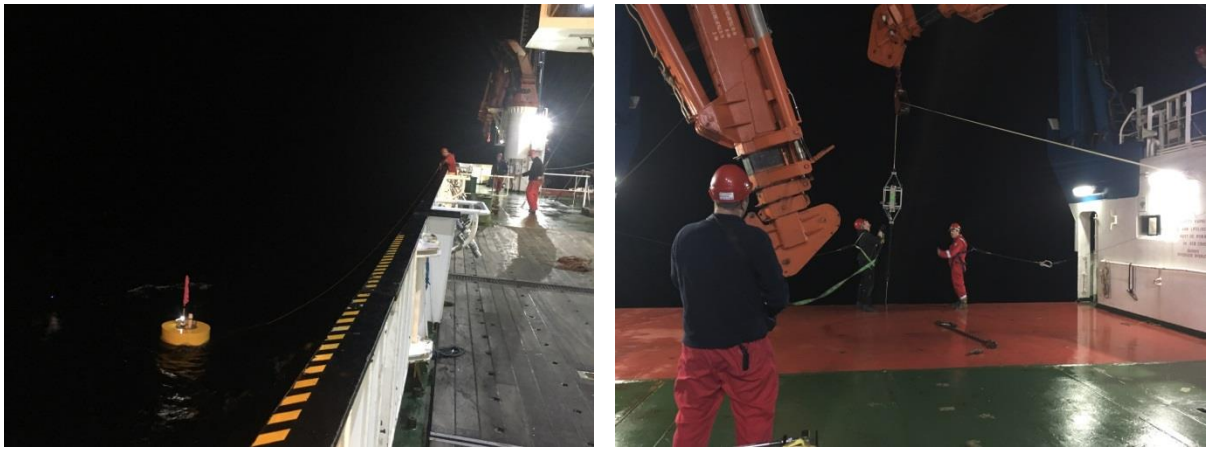


Figure 21: Action shots during RESPIRE deployment (top) and recovery (bottom).

For all missions, controllers were setup in the lab prior to deployment and mission was started in the lab before frames were moved outside.

Generally, mission was setup as follows:

IRS rotation frequency: 10 mins

IRS rotation time: 60 (deployments 001-002) and 50 secs (deployments 003-005)

dO2 Sampling period: 5 mins

Delay: 4 hours

Collection: 36 hours (due to low concentration of particles in the water)

Incubation: 24 hours

For deployments 001-003, mission ended the morning of the recovery. Recovery didn't happen until nightime to facilitate finding the surface buoy. Due to time constrains and in order to have 2 deployments at station BN3, for deployments 004-005, collection period was reduced to about 30 hours. Mission was set to end about half a day after the estimated recovery to maximize incubation time and data collection. In both deployments, incubation period was at least 22 hours.

IRS rotation time was set to 60 seconds initially as this was the time required for the sphere to turn 180 degrees. After confirming with Manu, time was set to 50 seconds to make it consistent with COMICS 1 deployments.

Table 14: RESPIRE controller mission setup before mission started

RESPIRE ID	Trap (m)	Controller/ optodeID	Controller activation	Collection period ends	Mission ends
	125	5/1034	09:32:49 05/26/18		
	200	6/1365	09:45:34 05/26/18		
	125	5/1365	12:39:49 06/02/18		

	250	6/1034	12:55:10 06/02/18	
	125	6/1034	14:10:08 06/09/18	
	250	5/1365	13:47:25 06/09/18	
	125	6/1365	10:05:24 06/15/18	
	250	5/1034	09:57:54 06/15/18	
	125	6/1034	10:38:54 06/18/18	
	250	5/1365	10:25:42 06/18/18	

Table 15: Controller setup information for additional missions (Cold room experiment and calibration cast)

Purpose	Trap ID	Controller/ optode ID	Controller activation	Mission ends
	Bottom	5/1365	00:51:08 06/08/18	22:06:42 06/08/18
	Top	6/1034	01:01:32 06/08/18	22:02:19 06/08/18
	N/A	6/1034	05:44:02 06/21/18	07:16:09 06/21/18
	N/A	5/1365	05:32:22 06/21/18	07:19:05 06/21/18

Incubation chamber water sampling

Water in the incubation chamber totals 1.6L. Water was siphoned from the top section of the trap on deck using an acid washed silicone tubbing. Water was then drained from the incubation chamber onto an acid-washed carboy by removing the screw from the bottom. Trap was then removed from the frame and brought inside for particle sample. Bottom plate was separated from the trap and particles were picked and photos were taken for qualitative characterisation. Once done, particles were put back in the carboy, contents homogenised and samples were then taken for:

bacteria microscopy counting and DNA (Manon Duret),

micro-respiration incubation experiments (Victoria Hemsley)

Fast-Repetition-Fluorometer (FRF) (Jo Ainsworth)

Particle imaging (Morten Iversen)

The remaining volume was filtered for POC. Volumes are indicated in Table 16

Table 16: Water filtering volumes (in ml) for POC

Deployment	Shallow Trap			Deep Trap		
	Filter 1	Filter 2	Filter 3	Filter 1	Filter 2	Filter 3

001	900	510	-	1050	370	-
002	360	360	360	560	560	560
003	460	460	460	450	450	450
004	530	530	530	410	410	410
005	480	480	480	470	470	470

Preliminary Results

Communication with the controllers was done using ZOC7 software for Mac. Data was printed directly from the controller and preliminary results from all deployments are shown in Figure 22. It is also shown the 2 deployments where data collection was interrupted (both traps on the second deployment – blue - and 1 trap on the third deployment - black dashed).

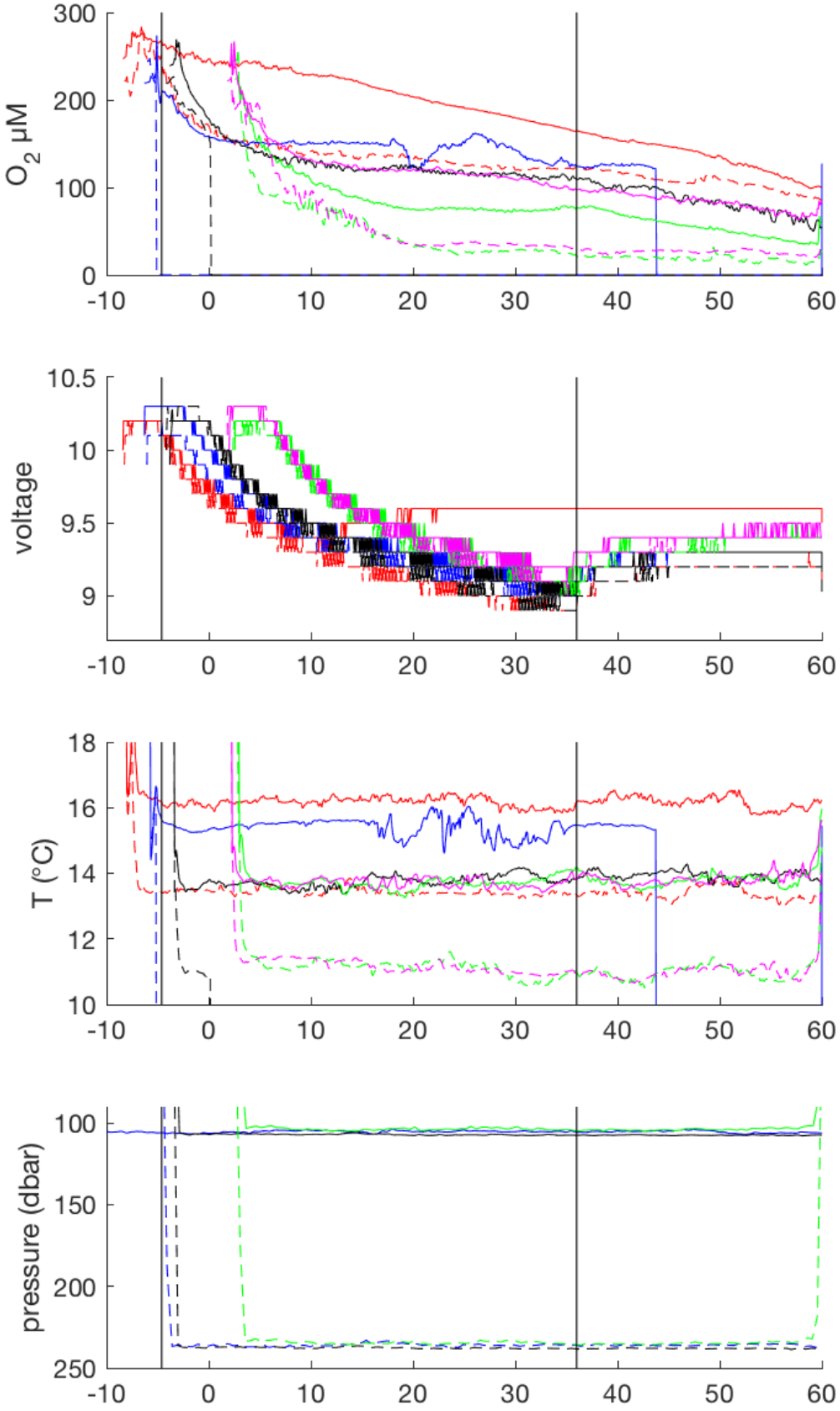


Figure 22: RESPIRE data collected during deployment 1 (red), 2 (blue), 3 (black), 4 (green) and 5 (magenta). Top: raw oxygen concentration reported by the optodes; top middle: Battery voltage as an

indication of the sphere rotation; bottom middle: Temperature reported by the optode/controller; bottom: pressure recorded by the Seabird39 attached to each frame, indicating depth of about 105 and 230 metres for shallow and deep track, respectively.

Cold room experiment

During the cruise we conducted an experiment to test the exchange of O_2 between the upper and lower chambers. Previous tests had been in laboratory conditions (trap was motionless), and we wondered whether the motion of the trap field conditions might enhance exchange between the chambers. The motion of traps secured aboard a rolling ship was considered to be a rough analogue of the motion of traps when deployed. The test was carried out via the following steps:

A RESPIRE trap was filled (upper and lower chamber) with ~7°C filtered seawater with ~100% O_2 saturation.

O_2 was removed from the upper chamber by bubbling Argon gas for ~6 minutes. Note that significant O_2 was unintentionally removed from lower chamber as well during bubbling.

In addition to the optode in the lower chamber, a second optode was secured via electrical tape in the upper chamber, ~10 cm above the sphere. Optodes were programmed to record at 3 minute intervals.

A plastic bag was placed over the top of the trap to reduce air exchange (although it was not sealed) and there was air between the bag and the water.

Trap was secured in cold room ~6°C.

After ~10 hours, O_2 was reduced in lower chamber and nearly equal in upper chamber, so O_2 was re-introduced to upper chamber by gently bubbling air. This re-introduced an O_2 gradient.

Fig. 5 shows results. During the first 3-4 hours after de-oxygenation, O_2 concentrations in the lower chamber decreased dramatically. Then concentration was stable for the remainder of the experiment (~18 hours). We attribute the initial decrease to a combination of mixing within the lower chamber and some exchange between the lower and upper chambers, most likely driven by convection as the trap and optodes were initially warmer than the water, and the air was cooler. O_2 in the upper chamber continuously increased over the duration of the experiment. We attribute this increase primarily to exchange with the air, although initially exchange with the lower chamber may have enhanced this increase. Our preliminary conclusion is that exchange between lower and upper chambers has minimal influence on the optode readings in the lower chamber of the RESPIRE, even in field conditions where the traps are moving vertically with the surface waves, as long as there are no strong temperature gradients within the trap that might cause convection.

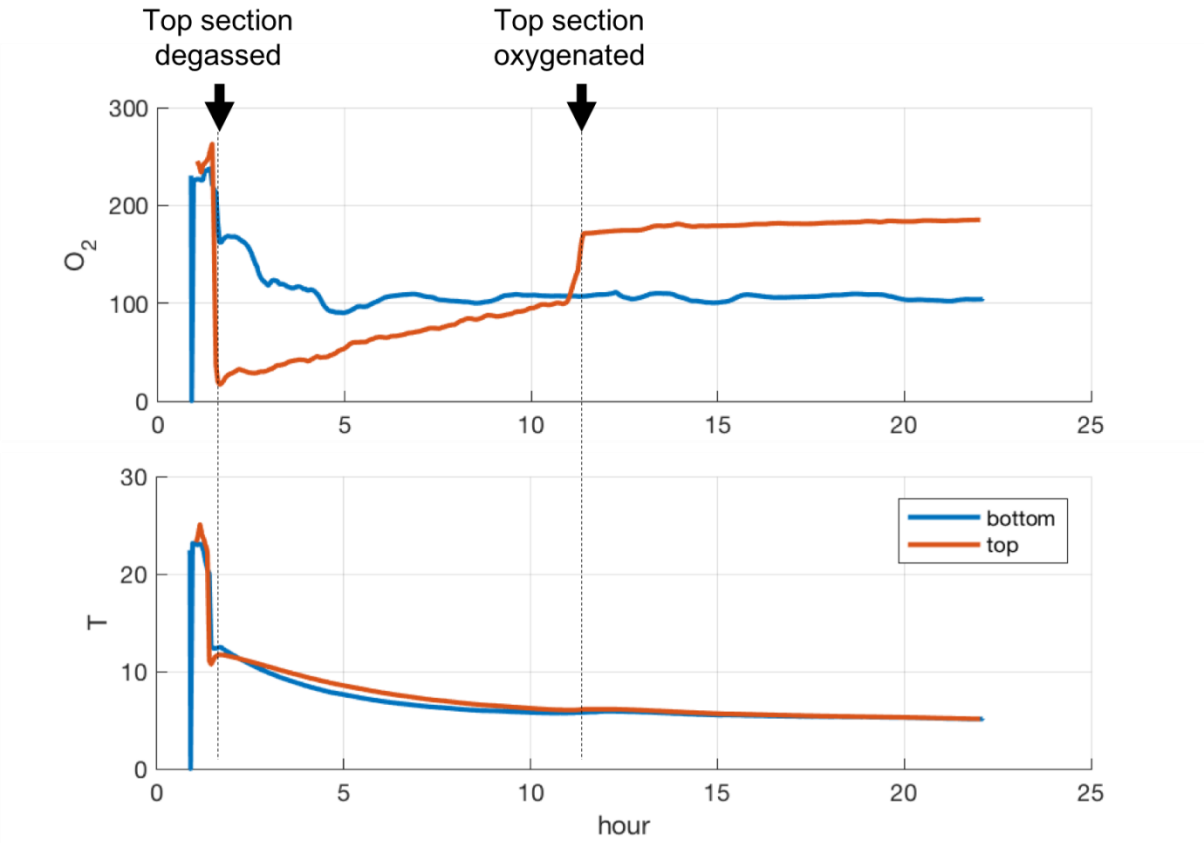


Figure 23: On deck experiment (cold room) to test oxygen exchange between upper chamber and incubation chamber

Issues encountered during DY090

Motor issues:

During the first deployment, the sphere on the deep trap stopped rotating about 24 hours into the collection period, resulting in a shorter collection and longer incubation. The voltage reported by the controller is a good indication of the ending of collection period as voltage increases after the rotation period ends. After recovery, motor was tested and it did not work. After checking with the team back in Australia, Jon Short and Kevin Saw, two of the engineers on board conducted some testing and ended up opening the motor. Both motors were tested for resistance across their power contacts and both found to be 'open circuit'. The top caps of the 'dead' motors were removed and, in both cases a very thin, transparent plastic film was found (presumably intended as an insulating film) that had become dislodged/misshapen (probably as a consequence of swelling from being immersed in oil). The dislodged film had become entangled around the commutator and was preventing electrical contact with the brushes. Once the plastic film had been removed and contact with the brushes was restored, the motors ran fine. One of the motors had some minor corrosion on the internal contacts from slight ingress of seawater at some time in the past. This was cleaned up successfully. After reassembling the motors

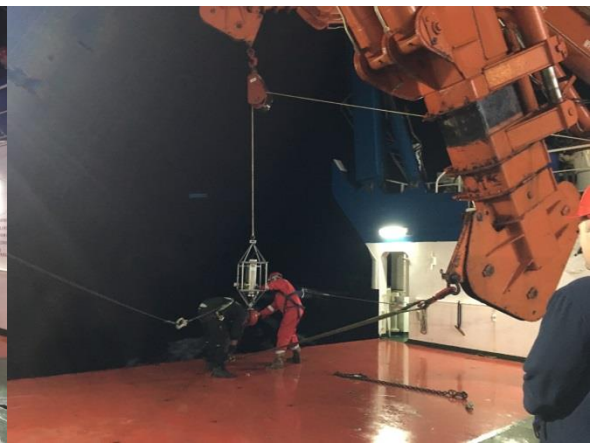
on the housing and into the trap, one of the motor was found to be running to quick (as an example, it took about 60 second for a “normal” motor to turn 180 degrees; this motor turned over 2 full 360 degrees in the same amount of time). For consistency, we decided to use the other 2 motors on the remaining deployments.

No oxygen data recorded

On both traps during deployment 2 and on one of the traps (250 m) in deployment 3, the optode stopped reporting data. Initially we believed that it had occurred due to premature disconnect of the optode before data had been printed, but after confirming with the team in Australia, that hypothesis was put aside. After the second deployment, optodes and connectors were checked by John Wynar (NMF engineer) and it was determined that improper cleaning of the o-rings on the optode side of the cable was the cause for the failure. For deployment 3, o-rings were properly cleaned (and/or replaced if needed), both optode cables as well as the optodes were thoroughly cleaned, but still, one optode failed during the following deployment. Both optodes were tested against each controller to rule out optode itself being the issue, but since one cable is potted into the controller, we could not rule out the controller itself. However, we suspected the cables were the cause of failure as this had happened in the previous cruise. The cable and especially the region where it had been previously spliced was inspected by John, and water was found inside. Since we had new Aanderaa cables (with termination to plug in optodes), we decided to replace both cables. John did the splicing and they worked great for the remaining of the deployments.

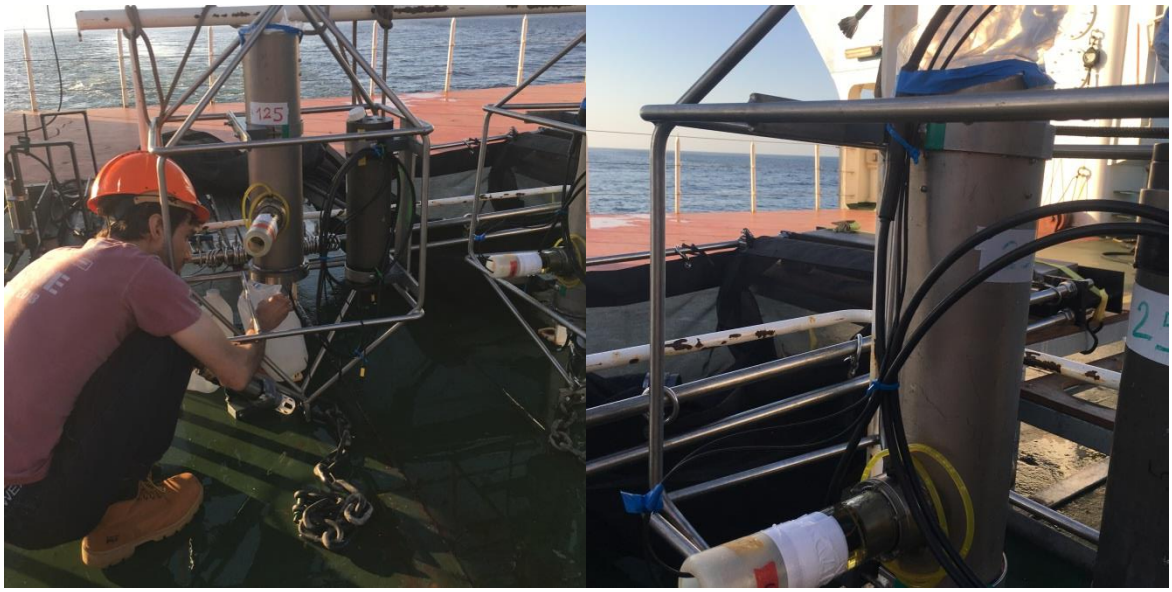
Recommendations for further deployments

Due to the weight of the mooring itself, during recovery it was quite hard to not spill water on the first trap. The addition of another crane (starboard aft crane) that secured the bottom of the trap while the top shackle was being release was very effective.



Protective “caps” (using old sample bottles) were used to give an extra layer of protection to the motor housing connector pins. This was found to be quite effecting in preventing damage during the acid wash bath, transport from the main lab to the aft deck as well as during deployment itself.

As Manu suggested, printing data from the controller on deck was easy and safer than risking disconnecting cables trying to remove traps and controller from the frame. So after printing data to a text file, controller cable was disconnected from the optode to facilitate sampling. Draining the incubation chamber on deck proved to be easier as well and allowed less disturbance of the particles left on the bottom plate.



^{210}Po-^{210}Pb profiles

Sari Giering (NOC)

Scientific motivation

^{210}Pb ($T_{1/2}$ = 22.3 years) and its daughter ^{210}Po ($T_{1/2}$ = 138.4 days) are natural particle reactive radioisotopes that can be used as tracers of particle cycling in the upper ocean. Both radioisotopes have a strong affinity for particles, but whereas ^{210}Pb is only adsorbed on particle surfaces, ^{210}Po is also incorporated into the cytoplasm of some phytoplankton and bacteria. Its partitioning is similar to that of protein and sulphur within the cell. These differences result in ^{210}Po being more efficiently removed from surface waters than ^{210}Pb via sinking particles. Hence, disequilibrium between the two radionuclides occurs when biological activity is high. The degree of disequilibrium between ^{210}Pb and ^{210}Po and the dynamics of association to particles can be used to asses scavenging rates, export fluxes and remineralisation rates. POC contents measured in sinking particles will be used to convert ^{210}Po fluxes into POC fluxes. Those results are complementary to the export fluxes that are obtained from the disequilibrium between ^{234}Th and ^{238}U.

^{210}Pb-^{210}Po disequilibrium has different characteristics than that of the pair ^{234}Th-^{238}U. ^{234}Th is attached to the surface of the particles, whereas ^{210}Po it is incorporated into organic matter. Thus, it is expected that ^{210}Po-^{210}Pb disequilibrium allows us to more accurately estimate POC fluxes (albeit over a longer time scale). Furthermore, the different half-lives of ^{234}Th (24 days) and ^{210}Po (138.4 days) allows us to compare timescales ranging from several days to several months. Recent modelling efforts further suggest that ^{210}Po-^{210}Pb disequilibria can be used to estimate bulk sinking velocities of sinking particles.

Sampling methodology and sampling treatment on board

Samples for ^{210}Po and ^{210}Pb analysis were collected from 20-L Niskin bottles mounted on a stainless steel CTD rosette. 5L water samples were collected from 10 depths between 5-1000 m:
5, 10, 50, 75, 100, 150, 250, 350, 500 and 1000 m. Uncertainties on the measurements were estimated by taking triplicate samples from 100 and 500 m (CTD036 – event 250) and from 2500 m (CTD030 – event 369). Three blanks were prepared by treating 1000 mL MilliQ the same as a sample.

Samples were immediately acidified (10 mL HNO_3) and vigorously shaken. The spikes of 200 µL ^{209}Po and 200 µL Pb^{2+} as yield tracers, and 4 mL Fe^{3+} as carrier were added, and the samples were, again, vigorously shaken. 11.5-14 mL of NH_4OH was added to neutralize the solution (to a final pH of 8.5). The solution was mixed and the pH checked. Samples were allowed to precipitate and settle for at least 24 h.

After settling, as much supernatant as possible was removed by carefully siphoning. The precipitate was transferred into 1 L HDPE bottles and left to settle for at least another 24 h. Again, the supernatant was carefully siphoned off, and the precipitate transferred into 250 mL HDPE bottles. Carboys/bottles were rinsed with pH adjusted MilliQ water (180 µL 25% NH_4OH in 1 L MilliQ water).

The radiochemical analysis of these samples will be carried out at the Universidad de Sevilla.

Deployments. *Triplicates for blanks from 100 and 500 m depth, only.

Date	**Station**	**Cast**	**GMT**	**Lat**	**Long**
28/05/2018	SB1	CTD006	16:00:00	-21.731	9.556
06/06/2018	BN1	CTD017	06:35:00	-18.020	11.008
11/06/2018	BN2	CTD023	00:12:00	-18.020	11.008
16/06/2018	BN3	CTD030	06:42:00	-18.0120	11.008
20/06/2018*	BN3/RS	CTD036	16:33:00	-18.020	11.008

Micro-respiration

Jessika Fuessel[1], Manon Duret[1], Victoria Hemsley[2] and Mark Trimmer[2]

[1]University of Southampton, [2]Queen Mary University London

The aim of this research is to quantify respiration and remineralisation on sinking material in the mesopelagic.

All micro-respiration measurements were taken using the Unisense micro-respiration system, including microelectrodes, stirrer platforms, which can hold the electrodes and 750µL or 2mL glass chambers for the samples. A chiller and tank were used to contain the system. This needed to be located in the salinometer room, as it is temperature controlled to approximate 20 ^{o}C, to prevent large changes in temperature, as oxygen saturation is easily affected by small fluctuations in temperature.

Mircoelectrodes of oxygen, nitric oxide and nitrous oxide were used. Three stirrer systems were used, each with the ability to hold eight mirco-respiration chambers. The electrodes were connected to the Unisense ampmeter, which were connected to a laptop for logging purposes. The Unisense programme Rate in the Sensor Suit was used to record changes in the three parameters.

Calibration of the mircoelectrode sensors

The oxygen electrode was calibrated as a two-point linear calibration using bubbled seawater kept in the chiller tank at the same temperature as the experiment for a 100% point. For the zero point of the calibration an oxidising solution of 0.2g sodium hydroxide and 1g ascorbic acid dissolved in 50ml of milliq was placed in the Unisense calibration chamber, left for two hours and then recorded.

The nitrous oxide sensor zero point was in milliq water kept at the same temperature as the chiller tank. A 100µmol solution was made by bubbling 2% nitrous oxide/nitrogen gas into 300ml of filtered seawater kept at the same temperature as the water bath.

The nitric oxide sensor was calibrated to zero in milliq water at the same temperature as the chiller. Helium gas was then bubbled through 1mol sodium hydroxide solution and into milliq to deoxygenate the sample. Subsequent bubbling of 5% nitric oxide through the sodium hydroxide, removes nitrate. The milliq can then be used as an approximate 80µmol sample. It is difficult to determine exactly as there is sparse literature on NO solubility.

Snow Catcher Samples

Samples were taken from snow catcher deployments (Table 2). Three snow catchers were deployed at one depth, per deployment, one for molecular biology, and the other two for rate processes. They were left to settle for at least two hours, to allow the fast and slow sinking fractions to separate into the bottom tray. The fractions used in the incubation chambers were a time zero sample, the suspended, slow and fast fractions from the snow catcher after 2 hours of settling.

A time zero sample was taken for respiration and POC filtering once the snow catcher was on deck. After two hours the catchers were emptied, with samples from the suspended fraction taken for respiration measurements and POC filtering and incubation experiments (see separate report by Jessika Füessel). The top of the catcher was then emptied, and the bottom tray taken into the cold room for inspection. Due to movement of the water when it was taken into the cold room it was left again for approximately 30 minutes to allow the fast sinking fraction to settle.

A portion of the fast sinking pellets and aggregates were transferred to Petri dishes via mouth pipettes for photographs to be taken for later analysis of volume and size. These were then carefully transferred into the micro-respiration chambers, using a mouth pipette, with small glass stirrers in the bottom to allow suspension of the particles. A portion of the slow sinking fraction was also transferred into respiration chambers. A further portion was filtered for POC.

Blanks of 0.2 micron filtered seawater was also taken for the micro-respiration chambers.

All measurements were done in at least triplicates, sometimes more depending on the number of sinking particles. After the respiration rate was obtained (typically taking 6-12 hours) the fast sinking fractions were filtered onto a pre-weighed filter for POC analysis. Sometimes rates were slow and therefore measurements over a longer time period was required. However, this was not always possible due to time constraints and snowcatcher deployments.

The collected particles for the fast sinking fraction were then filtered onto triple weighed GF/F filters for POC analysis.

Pelagra samples

Sinking material was collected from the formalin free cups from pellagra, which were opened in the last 12 hours of deployment for live material. See Table 3 for the list of samples used. Some of this material was transferred into micro-respiration chambers for triplicate rate measurements. Pelagra material was also used in oxygen manipulation experiments, see below.

RESPIRE samples

A small portion of the material collected by RESPIRE was transferred to mirco-respiration chambers, triplicates for each depth. Once POC has been analysed a comparison between the RESPIRE and micro-respiration chambers can be made. For more information on the RESPIRE traps please refer to the cruise report from Nathan Briggs.

Oxygen Manipulations

Oxygen manipulations were conducted for the suspended, slow and Pelagra samples. This was to examine how changes in ambient oxygen concentrations effect rates of respiration. Due to a lack of material we did not conduct oxygen manipulations on the fast sinking fractions.

For the slow and suspended fractions water from 100 m snow catchers was de-gassed with helium for 20 minutes in duram bottles at different volumes (Table 1). 100% saturated water was then added to make each bottle up to 250 ml to obtain different oxygen concentrations. The water was then pipetted into the microrespiration chambers, allowing overflow to reduce air contamination. These were the placed into the water bath and oxygen was measured using the microelectrodes.

For the Pelagra samples 250 µl of the mixed Pelagra material from 100 m (P2) was pipetted into the base of each microrespiration chamber. Sterile filtered seawater was then used to make up the different oxygen concentrations, as described above. This was then added to the Pelagra material in the microrespiration chambers. This method did not allow oxygen concentrations to reach such low levels, with the lowest concentration approximately 50 µmol l^{-1}.

Table 1

Desired oxygen concentration	Volume of de-gassed water
100 %	0 ml
75 %	62.5 ml
50 %	125 ml
25 %	187.5 ml
12.5 %	218.75 ml
6 %	235 ml
3 %	250 ml

Temperature Manipulations

To determine how temperature effects the rate of respiration we ran all the fractions from snow catchers deployed to 100 m in the microrespiration chambers. After a rate was obtained the temperature was changed. The incubations then had to be left for several hours until the desired temperature was reached. Overall, we obtained rates for the following temperatures; 5, 7, 9, 11, 13, 14, 15 and 18^{o}C.

Microzooplankton Respiration

As a comparison for the ETS measurements, microzooplankton, nanno calanus, collected from the bongo nets (please see cruise report by Katheryn Cook) were incubated in 4 mL microrespiration chambers. The specimens were then frozen for later analysis.

N2O Sample Collection

Water samples were taken from the pre-dawn CTD. These were collected in 15 mL exetainers and 120 mL serum bottles, with care to ensure no bubbles in the sample. The samples were fixed with zinc chloride and stored for transport back to Queen Mary University where they will be analysed. See Table 4 for the list of CTDs.

Example data

The data from the microsensors is available immediately, however the POC is needed to calculate carbon specific respiration. Figure 1 shows oxygen consumption from the different fractions at four depths at sites BN and BS. The rates are highest in the surface most likely due to larger amounts of material found in the snow catcher. The fast sinking fraction generally has higher oxygen consumption rates, due to the higher carbon content. Figure 2 shows oxygen consumption from the suspended and slow sinking fractions from the snow catchers. A lower starting oxygen concentration generally leads to reduced oxygen consumption. Figure 3 also shows results from the oxygen manipulation experiments, but from the Pelagra data. Figure 4 shows the results from the temperature manipulations, the trend shows that lower temperatures leads to reduced rates of oxygen consumption.

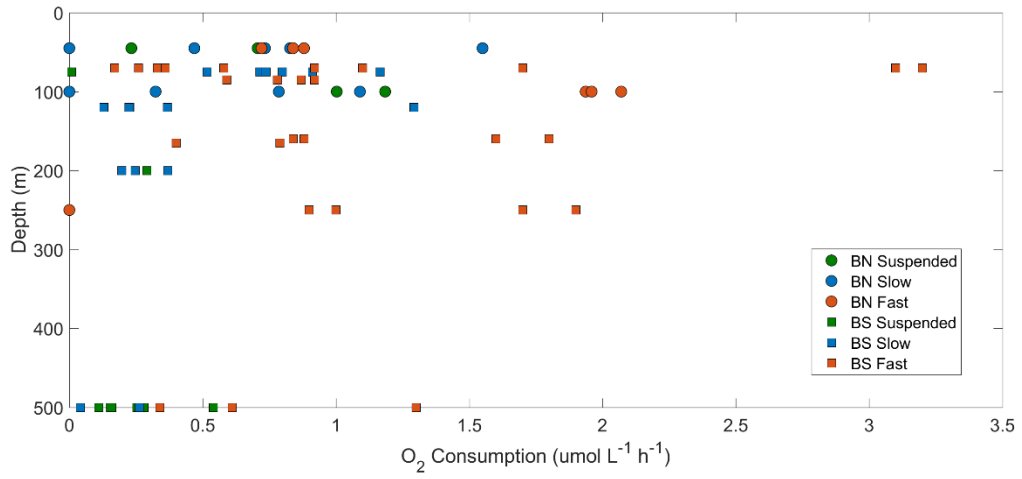


Figure 1. Rates of oxygen consumption in the different fractions from the snow catchers.

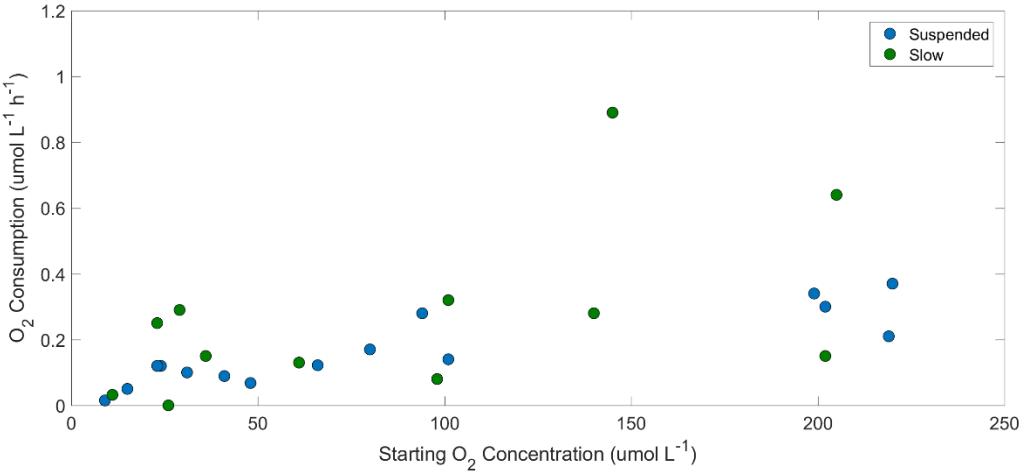


Figure 2. Rates of oxygen consumption relating to starting oxygen concentrations.

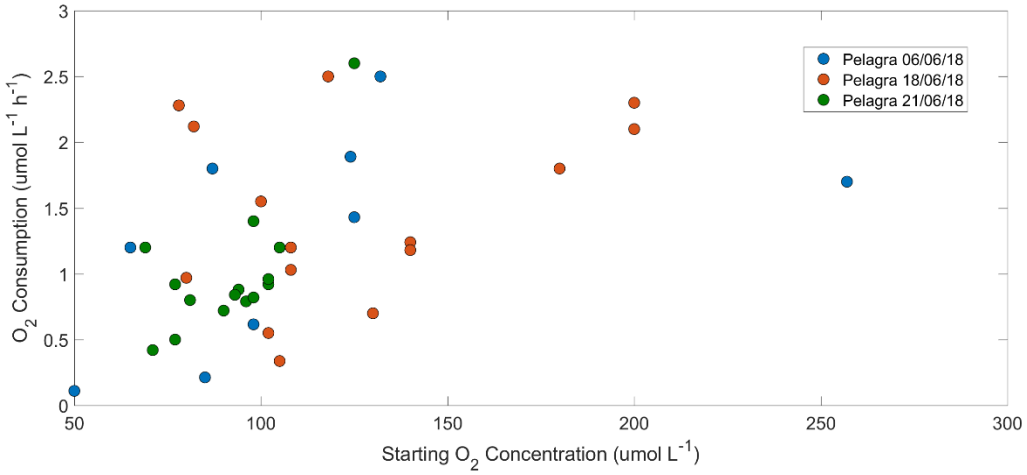


Figure 3. Rates of oxygen consumption from the Pelagra live cups relating to starting oxygen concentrations.

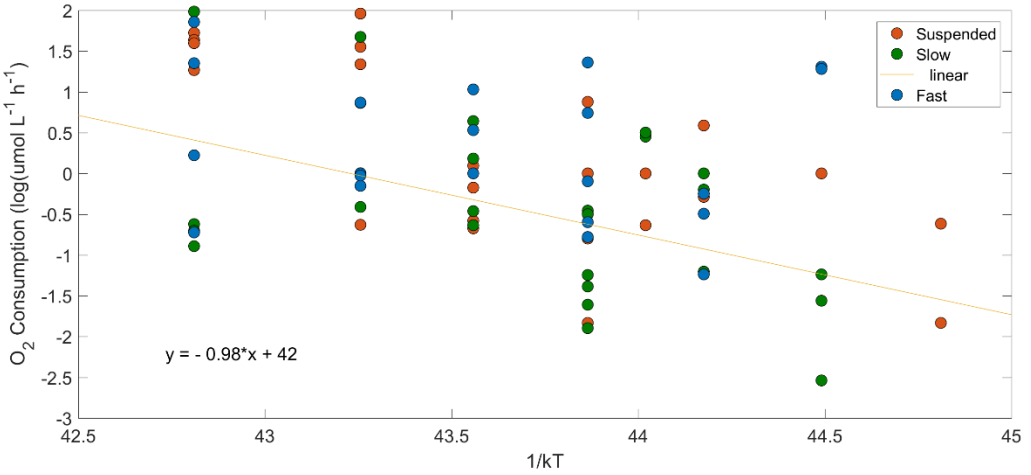


Figure 4. Rates of oxygen consumption relating to temperature from snow catchers at 100 m.

List of deployments

Table 2. MSC deployments for Process Studies and Molecular Analyses.

Event No.	Date	TIME (GMT)	LAT (N)	LON (E)	Station	MSC No.	Depth target	Depth actual
10	25/05/2018	08:23	-21.525419	9.515659	BS	1	75	72
12	25/05/2018	08:41	-21.525419	9.515659	BS	3	75	71
13	25/05/2018	09:00	-21.525419	9.515659	BS	4	75	71
32	26/05/2018	07:13	-21.554848	9.430072	BS	13	500	452
34	26/05/2018	07:44	-21.554848	9.430072	BS	14	500	450
35	26/05/2018	08:12	-21.554848	9.430072	BS	16	500	449
62	28/05/2018	05:11	-21.641101	9.50556	BS	22	200	NA
63	28/05/2018	05:27	-21.641101	9.50556	BS	23	200	NA

64	28/05/2018	05:43	-21.641101	9.50556	BS	24	200	NA
91	30/05/2018	03:06	-21.625511	9.288571	BS	34	120	112
92	30/05/2018	03:20	-21.625511	9.288571	BS	35	120	112
94	30/05/2018	03:47	-21.625511	9.288571	BS	37	120	112
115	02/06/2018	07:42	-18.01931	11.008162	BN	47	45	43
116	02/06/2018	07:54	-18.019317	11.008177	BN	48	45	44
117	02/06/2018	08:02	-18.019325	11.008174	BN	49	45	45
149	04/06/2018	02:48	-18.019733	11.008394	BN	58	100	96
152	04/06/2018	03:29	-18.019727	11.008394	BN	61	100	93
153	04/06/2018	03:39	-18.019741	11.008395	BN	62	100	92
200	07/06/2018	02:50	-18.023504	11.008704	BN	72	45	50
201	07/06/2018	03:03	-18.023505	11.008707	BN	73	45	50
202	07/06/2018	03:15	-18.023502	11.008707	BN	74	45	50
206	08/06/2018	05:03	-18.01972	11.008125	BN	75	250	249
207	08/06/2018	05:26	-18.019719	11.008124	BN	76	250	259
208	08/06/2018	05:43	-18.019718	11.008124	BN	77	250	250
247	10/06/2018	06:58	-18.019771	11.008162	BN	83	500	447
248	10/06/2018	07:04	-18.019762	11.008201	BN	84	500	447
249	10/06/2018	07:39	-18.019758	11.008195	BN	85	500	448
264	11/06/2018	03:38	-18.0198	11.00826	BN		100	
306	13/06/2018	23:54	-18.019721	11.008382	BN	108	100	NA
307	13/06/2018	00:08	-18.019725	11.008383	BN	109	100	NA
308	13/06/2018	00:18	-18.019726	11.008383	BN	110	100	NA
309	13/06/2018	00:29	-18.019724	11.008382	BN	111	100	NA
338	14/06/2018	22:59	-18.0198	11.008338	BN	123	100	96
339	14/06/2018	23:13	-18.019793	11.008337	BN	124	100	97
340	14/06/2018	23:27	-18.019794	11.008339	BN	125	100	97
341	14/06/2018	23:38	-18.019794	11.008337	BN	126	100	96
367	16/06/2018	05:38	-18.0197	11.00829	BN		100	
384	17/06/2018	04:32	-18.019754	11.008282	BN	138	750	NA
385	17/06/2018	03:51	-18.01974	11.008276	BN	139	750	NA
386	17/06/2018	03:08	-18.019743	11.008286	BN	140	750	NA
428	19/06/2018	10:08	-18.0198	11.00819	BN		100	
446	20/06/2018	01:03	-18.019827	11.008235	BN	161	750	NA
447	20/06/2018	01:46	-18.019801	11.008235	BN	162	750	NA
448	20/06/2018	03:03	-18.01983	11.00823	BN	163	750	NA

Table 3. List of PELAGRA Deployments with Live Samples Collected and RESPIRE deployment.

Recovery Event No.	Date	TIME (GMT)	LAT (N)	LON (E)	Sample ID	Depth target
						125
						200
86		20:33:00	-21.593326	9.415604	PELAGRA-P9	750
87		21:10:00	-21.600469	9.458371	PELAGRA-P2-15N	80
89		22:33:00	-21.575329	9.456597	PELAGRA-P6	200
						125
						200
181		00:25:00	-18.163479	11.092981	PELAGRA-P2-O2-1	100
182		01:43:00	-18.093537	11.026727	PELAGRA-P6	250
						125
						250
303		20:13:00	-18.286582	11.020043	PELAGRA-P6	250
301		18:15:00	-18.099619	11.020205	PELAGRA-P9	750
						125
						250
398	18/06/2018	01:00:00	-18.011624	10.790587	PELAGRA-P2-O2-2	100
						125
						250
453		23:34:00	-18.151597	10.91889	PELAGRA-P2	100
454		00:18:00	-18.151606	10.876058	PELAGRA-P6	250
456		01:25:00	-18.173176	10.860141	PELAGRA-P9-O2-3	750

Table 4. List of CTD Deployments.

Event No.	Date	TIME (GMT)	LAT (N)	LON (E)	Station	CTD No.
1	24/05/2018	21:08:00	-21.499438	9.499878	BS	CTD001SS
46	27/05/2018	02:22:00	-21.642705	9.51073	BS	CTD004SS
71	28/05/2018	17:06:00	-21.669352	9.521339	BS	CTD006SS
106	02/06/2018	18:20:00	-18.270799	10.745414	WPN	CTD010SS
135	04/06/2018	12:51:00	-18.019758	11.008451	BN	CTD012SS
148	04/06/2018	02:16:00	-18.019753	11.008395	BN	CTD013SS
228	08/06/2018	03:24:00	-18.027691	11.009416	BN	CTD020SS
261	11/06/2018	02:47:00	-18.019776	11.008217	BN	CTD024SS
342	15/06/2018	02:15:00	-18.019797	11.008371	BN	CTD028SS
383	17/06/2018	02:28:00	-18.01974	11.008282	BN	CTD031SS

Microbial interactions with particles

Jessika Fuessel[1], Manon Duret[1], Victoria Hemsley[2] and Mark Trimmer[2]

[1]University of Southampton, [2]Queen Mary University London,

Objectives

Microorganisms are master-cyclers of many elements in global oceans. They directly process *ca*. half of the organic carbon produced by marine autotrophs in the surface ocean via the so-called microbial loop, where they break down particulate organic matter (POM) into dissolved organic matter (DOM) or remineralised inorganic forms, while incorporating some into their own biomass. The microbial loop also acts on DOM release from phytoplankton and zooplankton. When POM finally sinks out from surface ocean, much is subject to remineralization by diverse microbial assemblages in the ocean's twilight zone.

Although increasing evidence show that sinking particles can be nutrient hotspots that attract microbial colonization and ectoenzymatic activities, and that they initiate the breakdown of POM, microbial production is generally considered higher in the planktonic fraction supported by the trailing plume of nutrient/DOM release from the POM. Recent metagenomic studies reveal distinct microbial community structures within particles, with greater genetic potentials to degrade complex polymeric substances (Azam and Malfatti 2007; Arístegui *et al.* 2009). However, most are observations drawn from surface ocean, with hardly any studies of the mesopelagic where the extent of remineralisation is crucial to the efficiency of the biological carbon pump. How mesopelagic microorganisms affect POM-DOM dynamics remains poorly known.

The objective of this work component is to characterise the microbial community structure, respiration and remineralisation activities within particles in the mesopelagic – via a combination of microrespiration measurements, incubation experiments with stable-isotope tracers ($^{13}C/^{15}N$), and various molecular biological analyses – in order to more accurately assess the impact of microbe-particle interactions on biological pump efficiency. The relative contribution from microbial communities associated with fast-sinking, slow-sinking and suspended particles, as well as free-living fractions are investigated. The potential use of oxidised nitrogen (NO_x^-) as an alternative electron acceptor for respiration under possible oxygen tension, ammonium (NH_4^+) release from remineralization of organic matter and chemolithoautoptrophic CO_2 fixation due to nitrification are further assessed in parallel in the various particle-fractions.

Methods

Particle Sampling

1. *Marine Snow Catchers (MSC)*

At each sampled station, samples of different particle-fractions were collected with 95-L Marine Snow Catchers, targeting 10 m and 100 m below mixed layer depth (MLD), and 250 m, 500 m and 750 m matching the depths of 5 PELAGRA deployments (see report by Saw). During each MSC deployment (Table 1), at least 3 MSCs were deployed consecutively to the same target depth, with one MSC subsequently dedicated for molecular ecological analyses while the remaining two were combined for microrespiration and incubation experiments. For most MSCs deployed, the actual deployment depth was determined with the RBR Concerto (the same used for Red Camera Frame). Once recovered on deck, the mid-column of each MSC was sampled immediately for ammonium (10 ml), inorganic nutrients (15 ml), dissolved organic carbon and nitrogen (45 ml) and particulate organic carbon and nitrogen (POC/N, 4L), and additionally for metatranscriptomics (10 L) in the MSC dedicated for molecular ecology. The MSCs were left undisturbed on deck for ca. 2 hours to let sinking particles concentrate at the base of the MSCs. Water samples with 'non-sinking particles' (NS) that remained suspended in the main MSC column were then collected from the mid-column water tap for microbial diversity and metatranscriptomics analyses (see later section on Molecular Ecological Analyses), POC/N and incubation experiments (see section below). Once samples for the NS fraction had been collected, water from the MSC columns was drained and the base of the MSC detached. The MSC bases were then transferred gently to the constant temperature controlled laboratory, and the particles were allowed to settle for 30 min. The 'fast-sinking' (FS) particle-fractions were operationally defined as the materials settled at the very bottom of the MSC base (~1.5-2L by volume) after this period, while the 'slow-sinking' (SS) fractions constituted the particulate materials above, yet within the base. Usually the FS fraction was sampled first with a siphon pump, hovering up most particles plus surrounding water at the base very gently, in attempt to minimise the fast-sinking particles being resuspended due to disturbances from sampling. Afterwards, only the top 2-3 L of the MSC base were sampled for slow-sinking particles with a siphon pump, to minimise overlap between FS and SS particle fractions.

Altogether, 41 MSCs were deployed in total for process studies, at 8 sampled depths amongst the two sampled stations, though with only 4 depths at the BS station (Table 1).

Table 1. MSC deployments for Process Studies and Molecular Analyses.

							Depth	
Event No.	**Date**	**TIME (GMT)**	**LAT (N)**	**LON (E)**	**Station**	**MSC No.**	**target**	**actual**
10	25/05/2018	08:23	-21.525419	9.515659	BS	1	75	72
12	25/05/2018	08:41	-21.525419	9.515659	BS	3	75	71

13	25/05/2018	09:00	-21.525419	9.515659	BS	4	75	71
32	26/05/2018	07:13	-21.554848	9.430072	BS	13	500	452
34	26/05/2018	07:44	-21.554848	9.430072	BS	14	500	450
35	26/05/2018	08:12	-21.554848	9.430072	BS	16	500	449
62	28/05/2018	05:11	-21.641101	9.50556	BS	22	200	NA
63	28/05/2018	05:27	-21.641101	9.50556	BS	23	200	NA
64	28/05/2018	05:43	-21.641101	9.50556	BS	24	200	NA
91	30/05/2018	03:06	-21.625511	9.288571	BS	34	120	112
92	30/05/2018	03:20	-21.625511	9.288571	BS	35	120	112
94	30/05/2018	03:47	-21.625511	9.288571	BS	37	120	112
115	02/06/2018	07:42	-18.01931	11.008162	BN	47	45	43
116	02/06/2018	07:54	-18.019317	11.008177	BN	48	45	44
117	02/06/2018	08:02	-18.019325	11.008174	BN	49	45	45
149	04/06/2018	02:48	-18.019733	11.008394	BN	58	100	96
152	04/06/2018	03:29	-18.019727	11.008394	BN	61	100	93
153	04/06/2018	03:39	-18.019741	11.008395	BN	62	100	92
200	07/06/2018	02:50	-18.023504	11.008704	BN	72	45	50
201	07/06/2018	03:03	-18.023505	11.008707	BN	73	45	50
202	07/06/2018	03:15	-18.023502	11.008707	BN	74	45	50
206	08/06/2018	05:03	-18.01972	11.008125	BN	75	250	249
207	08/06/2018	05:26	-18.019719	11.008124	BN	76	250	259
208	08/06/2018	05:43	-18.019718	11.008124	BN	77	250	250
247	10/06/2018	06:58	-18.019771	11.008162	BN	83	500	447
248	10/06/2018	07:04	-18.019762	11.008201	BN	84	500	447
249	10/06/2018	07:39	-18.019758	11.008195	BN	85	500	448
306	13/06/2018	23:54	-18.019721	11.008382	BN-O_2	108	100	NA
307	13/06/2018	00:08	-18.019725	11.008383	BN-O_2	109	100	NA
308	13/06/2018	00:18	-18.019726	11.008383	BN-O_2	110	100	NA
309	13/06/2018	00:29	-18.019724	11.008382	BN-O_2	111	100	NA
338	14/06/2018	22:59	-18.0198	11.008338	BN-O_2	123	100	96
339	14/06/2018	23:13	-18.019793	11.008337	BN-O_2	124	100	97
340	14/06/2018	23:27	-18.019794	11.008339	BN-O_2	125	100	97
341	14/06/2018	23:38	-18.019794	11.008337	BN-O_2	126	100	96
384	17/06/2018	04:32	-18.019754	11.008282	BN	138	750	NA
385	17/06/2018	03:51	-18.01974	11.008276	BN	139	750	NA
386	17/06/2018	03:08	-18.019743	11.008286	BN	140	750	NA

446	20/06/2018	01:03	-18.019827	11.008235	BN	161	750	NA
447	20/06/2018	01:46	-18.019801	11.008235	BN	162	750	NA
448	20/06/2018	03:03	-18.01983	11.00823	BN	163	750	NA

2.PELAGRA

Sinking particles collected by the PELAGRA traps that carried formalin-free cups were subsampled for both incubation experiments, microrespiration and molecular ecological analyses (Table 2). These 'live' cups were opened for sediment collections in the final 3-12 hours of deployment, the live cups were prefilled with sterile-filtered (0.2 µm-pore-sized) seawater previously collected at 100 m (for P2), 500 m (for P6) and at 750 m (for P9). Upon recovery on deck, the live cups were carefully transported to the deck lab. Subsamples were first taken for photophysiology analyses via FRRf (20 ml) (Ainsworth), and few visible discrete particles, e.g. fecal pellets, were picked for microrespiration measurements (Hemsley). Afterwards, materials within cups were gently mixed, then subsampled for bulk microrespiration measurements (Hemsley), molecular analyses (125 ml) and incubation experiments (300-800 ml). Subsamples for ammonium and nutrients analyses were also taken prior to incubation experiments. A total of 11 live samples had been taken at the sites BS and BN (Table 2).

Table 2. List of PELAGRA Deployments with Live Samples Collected and RESPIRE deployment.

Event No.	**Date**	**Recovery time (GMT)**	**LAT (N)**	**LON (E)**	**Sample ID**	**Target depth [m]**
						125
						200
86		20:33:00	-21.593326	9.415604	PELAGRA-P9	750
87		21:10:00	-21.600469	9.458371	PELAGRA-P2-^{15}N	80
89		22:33:00	-21.575329	9.456597	PELAGRA-P6	200
						125
						200
181		00:25:00	-18.163479	11.092981	PELAGRA-P2-O_2-1	100
182		01:43:00	-18.093537	11.026727	PELAGRA-P6	250
						125

						250
303		20:13:00	-18.286582	11.020043	PELAGRA-P6	250
301		18:15:00	-18.099619	11.020205	PELAGRA-P9	750
						125
						250
398	18/06/2018	01:00:00	-18.011624	10.790587	PELAGRA-P2-O_2-2	100
						125
						250
453		23:34:00	-18.151597	10.91889	PELAGRA-P2	100
454		00:18:00	-18.151606	10.876058	PELAGRA-P6	250
456		01:25:00	-18.173176	10.860141	PELAGRA-P9-O_2-3	750

Incubation Experiments

To assess microbial respiration within various particle fractions, microrespiration measurements with oxygen microsensors were conducted on all three particle-fractions collected from the MSCs – *fast-sinking (FS), slow-sinking (SS) and non-sinking (NS)* – and compared with measurements made prior to the 2h settling on deck (see separate report by Hemsley). In parallel, the potential use of nitrate/nitrite as alternative electron acceptors for respiration under oxygen tension within particles (and consequent production of N_2O) were examined via incubation experiments with ^{15}N-stable isotope tracers. Briefly, 3 parallel incubation experiments were set up for each particle-fraction, which was amended with respective ^{15}N-labeled stable isotope tracers and ^{13}C-bicarbonate listed in Table 3 to target the various nitrate-dependent respiration processes, nitrous oxide production and nitrification (including ammonia oxidation to nitrite, nitrite oxidation to nitrate), along with CO_2 fixation. Stable isotope tracers were first added into 500 ml or 250 ml water samples and evenly mixed, before distributing into 12x 28 ml combusted glass serum vials and crimp-sealed. One vial for each experiment was fixed immediately with 150 µl of saturated mercuric chloride as the T0 subsample. All remaining vials were then secured in opaque roller tanks and incubated on a rolling table to mimic sinking conditions, at *in situ* temperature (~13ºC) for 8-14 hours. In addition, a 10 ml-subsample and a 15 ml- subsample were taken for each experiment for the measurements of initial ammonium and nutrient concentrations.

At the end of incubation experiments, 3 glass vials were preserved with 150 µl of saturated mercuric chloride solution for later stable isotope analyses for N_2O, NO_x^- and NH_4^+ on a GC-IRMS back in a

shorebased laboratory, 3 were distributed for ammonium and nutrient measurements on board, and 3 were filtered onto combusted and weighed glass-fibre filters (GF/F) for the analyses of POC/N. The remaining 2 subsamples were fixed with paraformaldehyde solution (1% final concentration), incubated at 4ºC for 8-14 h before filtering onto 0.2 µm polycarbonate membrane filters for CARD-FISH analyses (see below) in a shore-based laboratory. Ammonium concentrations were measured onboard ship following the protocol by Holmes *et al.* (1999), and nutrient analyses were conducted on a nutrient autoanalyser (Stinchcomb).

For PELAGRA samples, the total volumes of samples were much less than the MSC samples, such that only a subset of experiments could be conducted (only Experiments A and C, or C only from Table 2).

Furthermore, in order to put into context ammonium concentrations measured in MSC samples relative to overall water column, ammonium concentrations were additionally measured in samples collected at the 12 sampled depths during CTD casts 001, 004, 006, 010, 012, 013, 020, 024, 028, 031 all of which were at site BN except for CTD001, 004 and 006 at the BS site (Table 3).

Table 4. Incubation Experiments with ^{15}N- and ^{13}C- Stable Isotope Tracers

	Amendment	**Major targeted process(es)**
A	$^{15}NO_3^- + {}^{14}NO_2^- + H^{13}CO_3^-$	Nitrate reduction to nitrite
B	$^{15}NO_2^- + {}^{14}NH_4^+ + H^{13}CO_3^-$	Denitrification/ anammox/DNRA/ nitrite oxidation/ N_2O production
C	$^{15}NH_4^+ + H^{13}CO_3^-$	Anammox/ nitrification/ N_2O production
D	Control (no amendment)	

Table 4. List of CTD Deployments.

Event No.	**Date**	**TIME (GMT)**	**LAT (N)**	**LON (E)**	**Station**	**CTD No.**
1	24/05/2018	21:08:00	-21.499438	9.499878	BS	CTD001SS
46	27/05/2018	02:22:00	-21.642705	9.51073	BS	CTD004SS
71	28/05/2018	17:06:00	-21.669352	9.521339	BS	CTD006SS
106	02/06/2018	18:20:00	-18.270799	10.745414	WPN	CTD010SS
135	04/06/2018	12:51:00	-18.019758	11.008451	BN	CTD012SS
148	04/06/2018	02:16:00	-18.019753	11.008395	BN	CTD013SS
228	08/06/2018	03:24:00	-18.027691	11.009416	BN	CTD020SS
261	11/06/2018	02:47:00	-18.019776	11.008217	BN	CTD024SS

342	15/06/2018	02:15:00	-18.019797	11.008371	BN	CTD028SS
383	17/06/2018	02:28:00	-18.01974	11.008282	BN	CTD031SS

Oxygen manipulation experiments

To assess the effect of oxygen concentrations on aerobic and anerobic respiration, oxygen concentrations within ^{15}N incubation experiments (see above) were manipulated to cover suboxic to fully oxygenated conditions (~20 µM, ~50 µM ,~75 µM ,~100 µM and > 200 µM O_2). These experiments were conducted once each for the slow sinking and non-sinking fractions that were obtained from MSCs deployed to 100 m at the BN site (Table 1). Highly concentrated sinking material was collected from Pelagra live traps from 100 m (twice) and 750 m (once) to cover the fast sinking fraction (Table 2). For these latter experiments water was collected from the same depth with a CTD rosette equipped with 24l Niskin bottles from the same depth and sterile filtered through 0.2 µm sterivex filters. Suspended and slow sinking fractions were degassed directly in 500 ml glass bottles for 20 min with helium and 12.5%, 25%, 50% and 75% of sample were replaced with fully oxygenated sample from the same fraction. For experiments on fast sinking particles, sterile filtered seawater was deoxygenated and oxygen levels were adjusted as described above, while 25-30 ml of well mixed sample from Pelagra live traps was added to each bottle (Table 2). The bottles were equipped with butyl stoppers and a long helium inlet needle and a short, thick outlet needle attached to a 1 ml syringe. The different $^{15}N/^{13}C$ tracer amendments for each experiment were added (table 3) and 8-12x precombusted 28 ml serum vials were filled without oxygen contamination via application of helium pressure. A total of 50 oxygen manipulation experiments was conducted.

For each O_2 concentration and each experiment one serum vial was set aside and incubated in a separate roller tank for 1-2 h in a temperature controlled room to achieve consistent temperatures (see above) and initial oxygen concentrations were determined with a microelectrode within each vial. After 10-14 h of incubation, experiments were ended as described above and oxygen concentrations in three vials of each experiment were determined.

Sampling for Molecular Ecological Analyses

1. *DNA/RNA Sampling*

Subsamples for nucleic acids (DNA and RNA) extractions were collected from the initial T0 subsamples as well as all particle-fractions of the sampled MSCs, to allow later microbial diversity studies and functional transcriptomics/ metatranscriptomics analyses, respectively. To differentiate between NS and FL microbial fractions, a 10L water subsample collected from the MSC mid-column (after 2h settling on deck) was sequentially filtered through 100 µm- and 3 µm- pore-sized membrane

filters and eventually through a 0.22 µm-pore-sized cylindrical Sterivex filter (Merck Millipore) with a peristaltic pump. Microorganisms concentrated on both 100- and 3- µm size-fractions are considered as the NS fraction, while those collected on the 0.22 µm-pore-sized filters are the FL fraction. For SS, the ca. 3L samples were also size-fractionated during filtration into the 100-/3-/0.22- µm size-fractions; while for FS, the 1L subsamples were only filtered through 3-µm and 0.22-µm-pore-sized filters. All filters were then incubated in *RNAlater*™ solutions (ThermoFisher) for 8-12h at 4ºC, after which *RNAlater*™ solutions were discarded and filters were stored at -80ºC until nucleic acids extractions back in a shorebased laboratory.

From the PELAGRA live traps, ~100-150 ml of each subsample was size-fractionated, first onto a 3 µm-pore-sized, 47-mm-diameter polycarbonate membrane filter in a polycarbonate filtration unit, and the filtrate was subsequently filtered onto 0.2µm-pore-sized 47 mm-diameter polycarbonate membrane filters in a second filtration unit. Both membrane filters were then treated with *RNAlater*™ as described above, and then stored at -80ºC until further processing onshore.

Furthermore, samples were collected from the 5 RESPIRE deployments (See report by Briggs) after recovery on deck, from which 100-150 ml subsamples drawn from each trap were filtered onto 3-µm and 0.22-µm-pore-sized membrane filters, and were treated as above for MSC and PELAGRA DNA/RNA samples.

2. Catalysed Reporter Deposition-Fluorescence In Situ Hybridisation (CARD-FISH)

For all MSC fractions, PELAGRA and RESPIRE sampled for DNA/RNA, a small subsample (28-125 ml) was collected in parallel for later CARD-FISH analyses onshore, to identify and quantify specific microbial cells actively colonizing particles by targeting their unique 16S-RNAs. Briefly, these water subsamples were filtered onto polycarbonate membrane filters. The fixed samples were first filtered through 3µm-pore-sized, 47 mm-diameter polycarbonate membrane filters in a filtration unit, and the filtrate was subsequently filtered onto 0.2 µm-pore-sized 47mm diameter polycarbonate membrane filters. Both filters were air-dried and then stored frozen at -80ºC until further analyses back onshore. Meanwhile, subsamples from the incubation experiments were directly filtered onto 0.2µm filters (25 mm diameter) without size-fractionation. The filters were then dried and stored as described above.

Provisional Results and Planned Analyses

Ammonium concentrations were found highest in surface water, coinciding with maximal Chl a concentrations. Concentrations dropped sharply to below detection limit deeper into the mesopelagic.

During the three visits to site BN, an ammonia peak developed between 300 and 400 m water depth, increasing in intensity and coinciding with the oxygen minimum (Fig. 1). This may indicate intensified deep remineralisation or organic matter within the OMZ and/or reduced assimilation of ammonia in these depths, resulting in ammonia accumulation. Net ammonia production within the OMZ, where O_2 concentrations were generally <50 µM, might indicate anaerobic respiration of organic matter such as heterotrophic nitrate reduction to nitrite.

The oxygen manipulation experiments however showed that 'net' ammonia production rates were significantly lower, when oxygen concentrations were below 150µM (Fig. 2). Figure 2 shows these rates split above and below 150 µM, where the median oxygen concentrations were 226.3 and 43.2 µM for the 'above' and 'below' respectively. 'Net' ammonification in sinking particles at the higher oxygen level was 18.4 nM h^{-1} and reduced by approximately 60 % to 11.4 nM h^{-1} at oxygen levels below 150 µM. For the suspended fraction the reduced oxygen concentration had an even higher impact on ammonification rates, with a decrease of 123 % from 14.4 nM h^{-1} at the higher oxygen concentrations to -4.3 nM h^{-1} under low oxygen conditions.

These postulations will be further investigated by nitrification, assimilation and nitrate/nitrite reduction rate measurements via stable isotope analyses of NO_x^-, NH_4^+ and POM from our incubation experiments back in the UK. In addition, community structure analyses (16S amplicon sequencing and CARD-FISH) and metatranscriptomics analyses will be able to shed light on the different biogeochemical functions likely conducted by the microbial communities residing on the different particle fractions. These rate measurements and molecular analyses are to be further evaluated with microrespiration measurements and particle flux dynamics as observed with optical data from red camera frame and gliders.

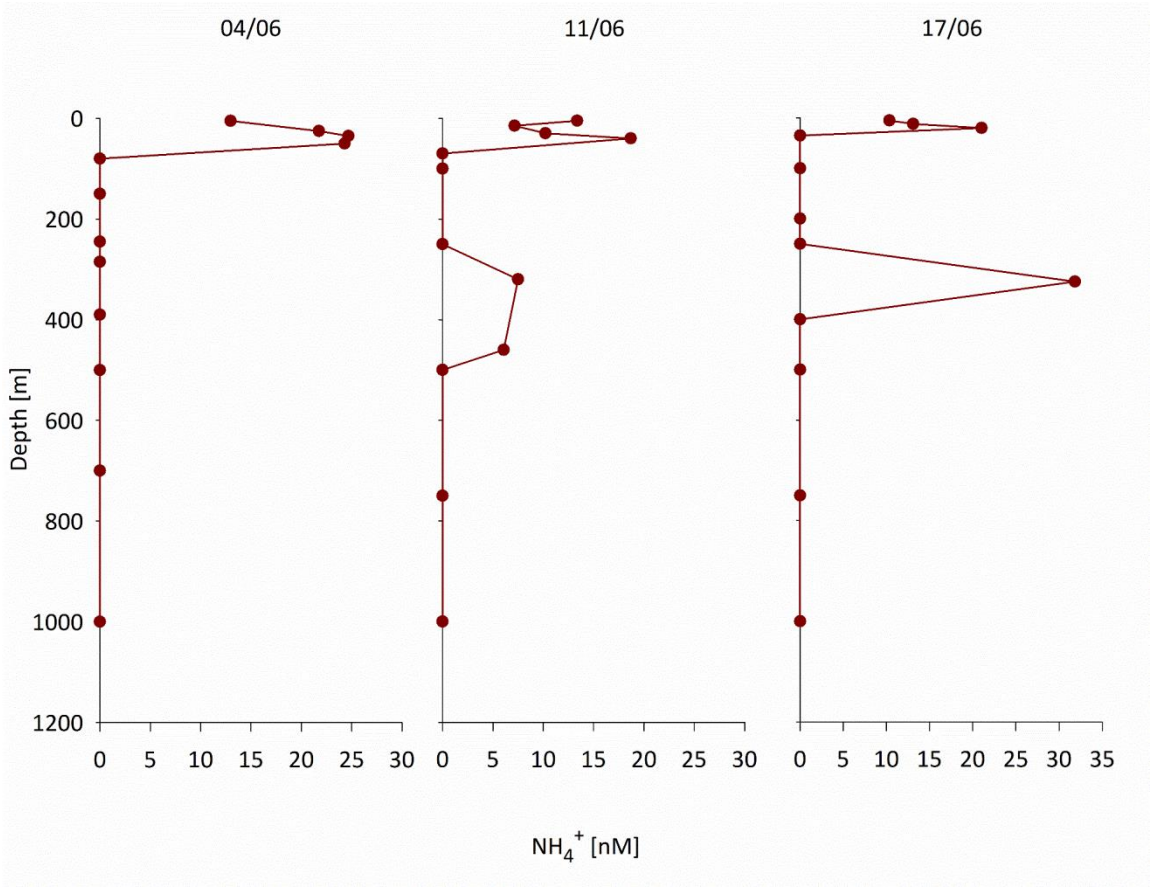


Figure 24. Ammonium Concentrations measured in CTD samples at BN during the 3 visits.

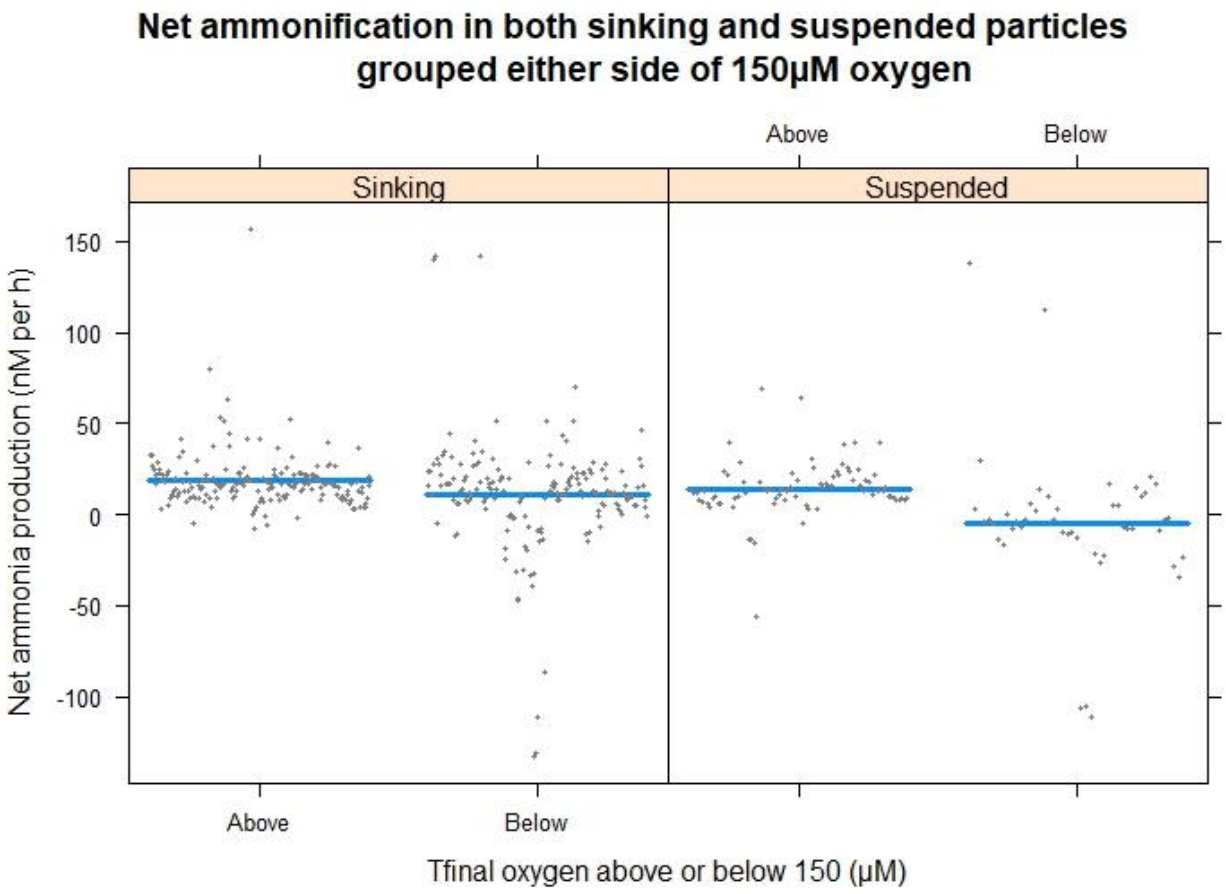


Figure 2. Net ammonium production rates measured from the sinking and suspended fractions above and below 150µM oxygen. The sinking fraction includes measurements from both the slow fraction and the live Pelagra traps.

References

Arístegui, J., Gasol, J. M., Duarte, C. M. and Herndl, G. J. (2009). Microbial oceanography of the dark ocean's pelagic realm. *Limnol. Oceanogr.* **54**(5): 1501-1529.

Azam, F. and Malfatti, F. (2007). Microbial structuring of marine ecosystems. *Nat Rev Micro* **5**(12): 966-966.

Holmes, R. M., Aminot, A., Kerouel, R., Hooker, B. A. and Peterson, B. J. (1999). A simple and precise method for measuring ammonium in marine and freshwater ecosystems. *Canadian Journal of Fisheries and Aquatic Sciences* **56**(10): 1801-1808.

Constraining Bacterial Growth Efficiency and Marine Dissolved Organic Matter Composition in the Mesopelagic

Rachel Rayne[1, 2], Chelsey Baker[1, 2], Manuela Hartman[1] & Claire Evans*[,1]

[1]National Oceanography Centre, Ocean Biogeochemistry and Ecosystems Research Group, European Way, Southampton, UK

[2]University of Southampton, Waterfront Campus, European Way, Southampton, UK

Background

Bacterial production is typically estimated from substrate uptake rates of a radiolabelled tracer, most frequently leucine at saturating concentrations (10 to 50 nM), in accordance with the method of (Simon and Azam, 1989). However, enrichment with saturating concentrations of leucine artificially elevates rates of both production and respiration in marine bacterial communities (Hill Polly et al., 2013), thus invalidating the estimates of bacterial growth efficiency calculated from them. The accuracy of in situ bacterial production estimates is improved by examining uptake of leucine at concentrations akin to those *in situ* using isotopic dilution time series bioassays (Hill Polly et al., 2013). Respiration rates specific to bacteria can also be estimated by radiotracer-based assay to quantify the conversion of ^{14}C labelled leucine into carbon dioxide. To our knowledge, these methods have only ever been applied to bacterial communities within the mixed layer at the uppermost part of ocean. Furthermore, no conversion factors exist to translate the rates these methods yield into carbon either assimilated or respired by bacteria. In the Benguela upwelling, oxygen minimum zones will be present and it is likely we will see a decrease in production and respiration rates from measurements using ^{14}C in low-oxygen water. The use of acetate as a substrate for bacterial production in aquatic systems has been studied using similar techniques (Wright and Hobbie, 1966). Here, we can test how oxygen concentration affects estimates of ^{14}C acetate derived values of bacterial production and determine whether acetate could be a preferred substrate for bacteria in low-oxygen conditions.

Oceanic bacteria utilise dissolved organic matter (DOM) as a substrate and it is still unknown as to how the DOM pool is able to accumulate given bacteria's abundance in seawater. Despite its importance as one of the largest exchangeable carbon pools on the planet with major significance to carbon cycling and climate, DOM is poorly molecularly characterised. This is because it represents a complex pool of widely ranging size and chemical characteristics and current harvesting and analysis methods capture only a fraction of the DOM pool complexity. Furthermore, what influences the suitability of various components of the DOM pool as bacterial substrates, which thereby in part determines its residence time in the oceans, isn't well understood. The fraction of DOM that accumulates in the ocean is known as the recalcitrant fraction. Recalcitrant DOM possesses average residence times of ~ 5000 years, however some molecules can exist for up to 50 000 years (Hansell, 2013). Much of the formation of these molecules will occur in shallower water, so a large dataset of mesopelagic samples will be

insightful. However, the signal of these molecules in mesopelagic water will be heavily interfered with by other organic matter. It is essential to analyse deep DOM samples that are made almost entirely of recalcitrant DOM to serve as a baseline for analysis.

Aim and objectives

We aimed to examine leucine derived bacterial growth efficiency in the mesopelagic and the surface ocean, compare acetate derived bacterial production rates in oxygenated and low-oxygen water, and determine the composition of marine dissolved organic matter (DOM) by the following objectives:

- To assess bacterial production over a depth profile from the surface waters to mid- mesopelagic via isotopic dilution time series bioassays at in situ leucine concentrations.
- To assess bacterial respiration over a depth profile from the surface waters to mid- mesopelagic via conversion of ^{14}C labelled leucine into $^{14}C0_2$.
- Compare rates of bacterial production using ^{14}C acetate between one low oxygen depth and one higher mesopelagic depth in each depth profile.
- To generate appropriate conversion factors to determine carbon assimilated and respired from the microbially-mediated rates generated and thus accurately determine BGE for the mesopelagic.
- To collect mesopelagic DOM samples alongside each depth profile so that changes in DOM composition in the mesopelagic can be examined as well as any temporal changes. Some deep DOM samples will also be collected to help inform the analyses of mesopelagic samples.
- Apply bacterial production and respiration measurements to marine snow catcher samples for comparing the free-living fractions with the particle-associated. Preliminary results from DY086 indicated that bacterial leucine uptake was inhibited from the fast and slow sinking fractions, most likely due to enriched background DOM concentrations. In DY090, DOM composition and DOC concentration data will be taken to help inform our hypotheses.
- To trial a new organic matter extraction protocol aiming to target a fraction of the recalcitrant DOM pool.

Materials and methods

For all parameters other than DOM and associated measurements, we employed a 6 depth sampling strategy encompassing surface, CM, CM +100 m, 250 m, OMZ and 500 m. These depths were selected to ensure our data could be crossed referenced with parameters collected from the Marine Snow Catchers or the pelagras. Marine snow catcher samples (MSC) were taken from four MSCs deployed to the same depth ~250 m. The contents of three of these snow catchers were pooled in order to have enough water to conduct bacterial growth efficiency experiments and to take DOM samples with other

metadata. The fourth MSC was used with aliquots of the other three to obtain POC data. Sampling by the Microbial Biogeochemistry team during DY090 can be found summarised in Table 1.

Table 17: Metadata and other parameters taken by the Microbial Geochemistry Team during DY090.

Sampling	**Depths (m) or sections sampled**	**Parameters Taken**
CTD004	6, 50, 80, 120, 250, 450	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
CTD007	6, 57, 80, 120, 380, 450	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
CTD009	6, 65, 85, 165, 250, 450, 1000, 2000, 3000, 3500, 3970	DOM, DOC, POC
CTD013	5, 25, 80, 150, 245, 500	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
CTD016	5, 25, 55, 150, 250, 505	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
CTD020	8, 18, 70, 235, 360, 500	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
CTD024	5, 24, 70, 250, 320, 500	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
CTD028	5, 30, 60, 180, 320, 500	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
CTD031	5, 25, 100, 200, 325, 500	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
CTD035	6, 40, 140, 250, 560, 1130, 1400, 2000, 3000, 3463/3453, 3590	DOM, DOC, POC

MSC078-082	Tzero, Suspended, Slow, Fast	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
MSC112-116	Tzero, Suspended, Slow, Fast	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC
MSC145-148	Tzero, Suspended, Slow, Fast	Flow Cytometry, molecular, and lysotracker samples. Bacterial production, respiration and acetate uptake. DOM, DOC, POC

Bacterial and heterotrophic nanoflagellate abundance

Samples for bacterial abundance were fixed with (1% final concentrations) paraformaldehyde for 1 hour at room temperature, before flash freezing in liquid nitrogen and storage at minus 80 °C. Samples will be analysed by flow cytometry at the NOC. Samples for heterotrophic nanoflagellate abundance were stained with Lysotracker (final concentration 50 nM) at room temperature for 3 minutes before snap freezing and storage at minus 80 °C.

Molecular Ecology

Samples for later molecular analysis of free-living key microbial groups (1.6 ml) were collected by flash freezing fixed (1% final concentrations) or unfixed seawater. These samples will be analysed at NOC by flow cytometric sorting prior to CARD-FISH analysis.

Bacterial production (^{3}H-Leucine uptake rates)

For the isotopic dilution time series bioassay L-[4,5-^{3}H]-leucine (specific activity 101 Ci mmol^{-1}) was preloaded into 2 mL polypropylene crystal clear microcentrifuge tubes (Starlab, Milton Keynes) to make a final concentration series ranging from 0.2 to 1 nM when combined with the 1.6 mL seawater samples. Immediately after collection, seawater was combined with the labelled substrate (marking the start of the experiment) and a sample from each concentration was fixed at 10, 20, 30 and 40 min by addition of 1% final concentration paraformaldehyde. Particulate matter in the samples was harvested by filtration onto 0.2 µm pore-size polycarbonate filters, which were then washed twice with 3 mL of deionised water. To determine the radioactivity of the retained particulate matter the filters were analysed by liquid scintillation counting (Tri-Carb, 3100TR, Perkin-Elmer, Beaconsfield, UK). Leucine uptake rate was calculated as previously described by (Zubkov et al., 2004). Owing to slower metabolic rates and lower leucine concentrations below the mixed layer the assay was adapted for those samples collected at depths below 75 m. Specifically lower leucine concentrations were used 0.005, 0.01, 0.025, 0.04 and 0.05 nM in combination with longer incubation periods of time (30, 60, 90 and 120 min) and larger volumes of 30 ml. The incubations were stopped by pouring the sample into 50 ml centrifuge tubes preloaded with PFA to make a final concentration of 1% and filtered as above.

In order to derive a carbon conversion factor a regrowth experiment was conducted whereby 0.6 µm filtered seawater and whole water bacterial numbers were followed in line with leucine incorporation rates over a 5 day period.

Bacterial respiration (^{14}C-Leucine respired)

The rate of ^{14}C-Leu respiration was determined from 70 ml samples incubated in 125 mL crimp sealed glass bottles. The acid cleaned bottles were rinsed three times with seawater sample and ^{14}C-Leu added at 0.4 nM. Samples were incubated at a range of times from 1.5 to 12 hours at 11^{o}C. Respiration samples were terminated by the addition of 1 mL of 10% HCl through the lid using a hypodermic needle and syringe, which also acidified the samples to <pH2, thereby

driving any $^{14}CO_2$ out of solution. Respiration bottles were bubbled for 2 h with CO_2-free air and evolved CO_2 trapped by Carbo-sorb bubblers. Radioactivity of samples was measured as disintegrations per minute (DPM) by liquid scintillation counting.

Respiration was also measured by determining changes in oxygen concentrations over time in microrespiration vials and oxygen concentration measured using microelectrodes for the purposes of intercalibration. Measurements were performed with the Unisense sensor by placing it into the chamber and allowing 10 minutes for the signal to stabilize.

Bacterial production (^{14}C-Acetate uptake rates)

Acetate samples were taken straight from niskin bottles into four 160 ml crimp seal vials per depth using gas tight tubing. Water was rinsed from the bottom of the vials three times before filling and immediately crimping. A working stock was made by bubbling N_2 through autoclaved milli-Q for 20 mins. The experiment was initiated by injecting 0.5 ml of stock into each sample through the vial septum with a hyperdermic needle to a final concentration of 16 nM. Samples from each depth were incubated for 1.5, 3, 4.5 and 6 hours at 11^{o}C before terminating the experiment by pouring the contents of each vial into separate bottles pre-loaded with PFA to make a final concentration of 1%. Acetate samples were filtered as with other uptake measurements and the level of radiation measured using a liquid scintillation counter.

Dissolved Organic Matter Harvesting

Samples for marine DOM were collected mainly alongside pre-dawn casts, with two additional full profiles of the water column. After collection, the seawater samples were filtered through 47 mm glass fibre filters (Whatman precombusted at 450 °C) and acidified to pH 2 using HCL. Samples were then extracted using either the established protocol of 1g PPL sorbent (Agilent Bond Elut PPL), or by a combination of 500 mg Oasis MAX (Anion exchange) in sequence with 1 g Oasis HLB (Waters Corporation) (Cation exchange: both Waters Corporation).

When PPL sorbent was used, after extraction samples were washed with milli-Q pH 2 and blown to dryness using N_2 gas before elution with 5 ml methanol and storage at either -4 or -80^{o} C in precombusted glass vials.

Oasis HLB cartridges were washed with 5% methanol in milli-Q and eluted with 4 ml methanol. MCX cartridges were washed with 5% formic acid in milli-Q and eluted with 5% ammonium hydroxide in methanol. MAX cartridges were washed with 5% ammonium hydroxide in milli-Q. Two elutions of MAX were carried out into separate precombusted vials. First with 4 ml methanol and the second with 4 ml of 5% formic acid in methanol.

For each extraction a DOC sample was taken and also a particulate sample collected and stored frozen for potential later analysis. Extraction efficiencies will be calculated using DOC concentrations in the extracts and chemical characterisation will be via a variety of targeted and untargeted mass spectrometry platforms.

Acknowledgements

We wish to express our gratitude to the NMF team, the scientists and the crew of *RRS Discovery* for facilitating a scientifically productive and enjoyable expedition. We extend extra thanks to Stephanie Henson for helping us get all of the sampling we needed. We would also like to thank Sarah Giering and Victoria Hemsley for assistance with snowcatcher deployments, POC data and microelectrode measurements. We would also like to express our gratitude to Alex Poulton for helping with radioisotope work.

References

HANSELL, D. A. 2013. Recalcitrant Dissolved Organic Carbon Fractions. *Annual Review of Marine Science,* 5**,** 421-445.

HILL POLLY, G., WARWICK PHILLIP, E. & ZUBKOV MIKHAIL, V. 2013. Low microbial respiration of leucine at ambient oceanic concentration in the mixed layer of the central Atlantic Ocean. *Limnology and Oceanography,* 58**,** 1597-1604.

SIMON, M. & AZAM, F. 1989. Protein content and protein synthesis rates of planktonic marine bacteria. *Marine ecology progress series. Oldendorf,* 51**,** 201-213.

WRIGHT, R. R. & HOBBIE, J. E. 1966. Use of Glucose and Acetate by Bacteria and Algae in Aquatic Ecosystems. *Ecology,* 47**,** 447-464.

ZUBKOV, M. V., TARRAN, G. A. & FUCHS, B. M. 2004. Depth related amino acid uptake by Prochlorococcus cyanobacteria in the Southern Atlantic tropical gyre. *FEMS microbiology ecology,* 50**,** 153-161.

Zooplankton and micronekton sampling and processing: Overview

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

Overview

A series of depth discrete net sampling operations were carried out in order to address the objectives of COMICS to derive *a mechanistic understanding of the key processes in, and overall function of, the mesopelagic community*. Towards this aim, we obtained samples to allow us to describe vertical profiles in the taxonomic composition, biomass and abundance of the pelagic community through epipelagic and mesopelagic depth layers. To define the respective roles of these organisms, and the structure of the pelagic community, a subset of specimens were rapidly frozen in order to determine the metabolic performance and trophic interactions through measurement of Electron Transport System (ETS) activity, Elemental (CHN) analysis, Stable Isotope analysis and Biomarker analysis. Furthermore, live specimens were incubated to establish rates and selectivities of feeding and their utilisation of storage reserves. This work compliments accompanying acoustic surveys that provide a mesoscale perspective on the distribution of pelagic biomass, as well as its diel vertical migration behaviour (see 'Acoustics' section by S Fielding)

Net sampling device overview: Our overall strategy was to sample a range of size classes of the pelagic community with different sampling devices, which comprised a Bongo net (100 um mesh, 53 cm diameter rings), Hydrobios Mammoth Net (300um and 100um mesh, 1m^2 square opening), a Multiple Open-Closing Net and Environmental Sampling System (MOCNESS) net (330um mesh, 1m^2 rectangular opening) and an RMT 25 midwater trawl (minimum of 4 mm mesh, 25 m^2 rectangular opening). The Bongo net was deployed vertically and was effective at capturing mesozooplankton, including microcopepods such as *Oithona*. The Mammoth net was also a vertical deployment that mainly captured mesozooplankton, especially calanoid copepods. The MOCNESS was deployed obliquely and has a greater capability of capturing fasting moving mesozooplankton and macrozooplankton species, such as euphausiids, fish larvae and chaetognaths. The RMT25 was most effective at capturing macrozooplankton and micronekton, particularly decapods, jellies, and mesopelagic fish, particularly myctophids and cyclothone. Notes on the deployment protocols of each of these devices is provided in later sections.

Sampling strategy overview: The main aims in deploying these devices were to obtain a depth discrete view of how the pelagic community was distributed through the epipelagic and mesopelagic layers, and to establish how these vertical distributions changed between day and night. All deployments were

carried out within the top 750 m of the water column, consistent with the maximum depth of diel vertical migration acoustic scattering layers.

Each of the devices had different capabilities in depth resolution. The original Bongo net was capable of opening and closing its two cod ends between 2 respective set depths. Although there were some variations, the most common pattern was to carry out two sequential deployments, with one opening at 120 m and closing at 5m, and the other opening at 450 m and closing at 120m. The replacement bongo net did not have an opening/closing mechanism and so was only deployed to 120m depth. The Mammoth net had either nine 300um nets or four 100um nets that open and close sequentially. These opening/closing preset depths were consistent across all deployments and divided the sampled water column into intervals. The 300um nets were fished in the following layers: 750-625, 625-500, 500-375, 375-250, 250-187, 187-125, 125-62, 62-31 and 31 – 5m. The 100um nets were fished in the following layers: 750-500, 200-250, 250-125, 125-5m. The MOCNESS net typically has 9 nets, however during DY090 the opening/closing mechanism failed to work and so only one net was towed open from the surface to 125 m and back up to the surface again. . The RMT25 has 2 nets which can be opened and closed independently of each other. Throughout COMICS II, two deployments were made per station: the first deployment was made from 750 – 500 m and 500 – 250m with 40 minutes per net. A second deployment was made from 250-125 m and 125 – 10m, with 20 minutes per net.

All of the nets were deployed both day and night.

Overview of performance of devices: The performance of each of the devices is recorded in the subsequent tables. To summarise:

RMT25 – after initial problems with the fibre optic unit, underwater comms unit and release gear, the RMT performed reliably.

MOCNESS – after several unsuccessful deployments (see gear report), it was decided to tow the MOCNESS with one open net within the oxygenated surface waters (top 125m). This was performed at all stations except BS1.

Mammoth – the mammoth ended up fitted with both 300 µm (Mammoth mode) and 100 µm (Mango mode) nets. All real deployments, except one where the battery failed, were successful and day and night sample were obtained at each site occupation.

Bongo – The opening closing bongo (OCbongo) was deployed 6 times before it was lost. On each of these occasions it was deployed first from 120 m to the surface and then from 450 to 120 m. The OC bongo was replaced with an on-ship fabricated old-fashioned 100 µm bongo. With no opening/closing mechanism, this bongo was deployed solely to 120 m.

Fate of the catch overview: T 25 catches were weighed and organisms removed for biochemical analyses. Where possible species were identified, but more frequently specimens were photographed and/or preserved for later identification of the frozen animals saved for biochemical analyses. The rest of the catch was either preserved, or sub-sampled and preserved for subsequent analysis in the home laboratory.

Preservation**:** 4% Formaldehyde, buffered with sodium tetraborate (Borax) was used to preserve: 1) the entire contents of one of the two Bongo cod-ends, 2) ½ of the contents of each of the Mammoth nets, 3) ¼ of the contents of each of the Mammoth nets (Mango mode) and 4) ½ of the contents of the MOCNESS net. The splits of the Mammoth net catches were carried out using a Folsom splitter. For the MOCNESS net catches, the ½ split was achieved by dividing the contents of a graduated bucket, thoroughly mixing the contents before division.

Freezing: Sub-samples of specimens from all devices were frozen for a number of further biochemical analyses from all of the 4 sampling devices.

ETS activity: 1) Large mesozooplankton, macrozoopankton and nekton specimens were rapidly frozen in liquid N2 from RMT25 and MOCNESS catches. 2) Mammoth catches were split with the Folsom splitter to a suitable amount of material and filtered onto a GFF filter before subsequent freezing at -80^{o}C 3) Bongo catches were size fractionated and then filtered onto a GFF filter before subsequent freezing at -80^{o}C.

Elemental and Stable Isotope Analysis: 1) Macrozoopankton and nekton specimens were extracted from RMT25 and MOCNESS catches and frozen at -80^{o}C. 2) Calanoid copepods (mainly *Eucalanus hyalinus*, *Rhincalanus nasutus*, *Calanoides carinatus*, *Nannocalanus minor*) were extracted from Mammoth and MOCNESS catches and placed onto petri dishes for subsequent freezing at -80^{o}C

Biomarker analysis: 1) Macrozoopankton and nekton specimens were extracted from RMT25 and MOCNESS catches and frozen at -80^{o}C. 2) Calanoid copepods and other mesozooplankton were extracted from MOCNESS, Mammoth and Bongo catches and placed in glass vials for freezing at -80^{o}C.

Detailed reports on each of the sampling activities and process work follow.

Zooplankton and micronekton sampling and processing: Bongo nets

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

The OCBongo net was deployed from the aft starboard using the NMF winch (850 m max wire) and starboard aft crane, which held the block. The BONGO was stored in a horizontal position and was moved gradually to the vertical during hauling in by the winch, taking in the entire length of tensioned compensation wire during the process. Once upright and clear of the deck, the net was moved outboard by the crane and the wire paid out to start the deployment (see Section 9 for a more detailed description of deployment protocols)

The net was equipped with pre-programmable open/closing cod ends. These were connected to a laptop running Oceanlab software with a RS232 cable. The cable was connected between every deployment in order to upload new instructions regarding open closing depths for the subsequent deployment.

Once the opening/closing bongo was lost, it was replaced with an on-ship fabricated replacement made from a towed bongo frame (the same as the OC bongo opening), 2 MOCNESS cod-ends (mesh replaced with 100um mesh), two 100um bongo nets and rope, weighted with the 50 kg snowcatcher weight. It was deployed using the NMF starboard winch, like the OC bongo, to 120 m and back to the surface.

The following table gives a full list of deployments and the fate of the samples:

Table 18: Bongo net deployments and fate of samples during DY090. Buckets A and B refer to respectively to the 2 buckets containing collected material in each catch. A and B may be interchanged between deployments.

Event	Station	Deployment No.	Date	Time	Latitude	Longitude	Depth sampled	A	B	Comment
8	Test	Bongo001	25/05/2018	04:24	-21.5422	9.523203	175	Experiments	Experiments	Closing mechanism didn't work
21	Test	Bongo002	25/05/2018	16:20	-21.5254	9.515686	120-5	Experiments	Formaldehyde	
22	Test	Bongo003	25/05/2018	16:43	-21.5254	9.515694	450-120	Experiments	Formaldehyde	
51	BS1	Bongo004	27/05/2018	14:52	-21.6373	9.504981	450-120	Foramanifera only	Foramanifera only	Helge Winkelbauer
52	BS1	Bongo005	27/05/2018	15:41	-21.6373	9.504988	120-5	Foramanifera only	Foramanifera only	Helge Winkelbauer
65	BS1	Bongo006	28/05/2018	07:32	-21.6411	9.505579				Bongo nets lost; wire sheared below ferrule
118	BN1	Bongo007	02/06/2018	10:35	-18.2721	10.93328	120	Experiments	Experiments	
119	BN1	Bongo008	02/06/2018	10:57	-18.2721	10.93328	120	Experiments	Experiments	Cod-end mesh split on one net
143	BN1	Bongo009	03/06/2018	20:41	-18.0198	11.00842	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
175	BN1	Bongo010	05/06/2018	08:19	-18.0236	11.01287	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
176	BN1	Bongo011	05/06/2018	08:42	-18.0247	11.01364	120	Experiments	Experiments	

187	BN1	Bongo012	06/06/2018	08:35	-18.0197	11.00833	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
188	BN1	Bongo013	06/06/2018	08:55	-18.0197	11.00833	120	Experiments	Experiments	Size fraction mesh: 2000, 1000, 500, 200, 100
214	BN2	Bongo014	08/06/2018	09:00	-18.0277	11.00949	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
215	BN2	Bongo015	08/06/2018	09:19	-18.0277	11.00949	120	Experiments	Experiments	Size fraction mesh: 2000, 1000, 500, 200, 100
231	BN2	Bongo016	09/06/2018	10:14	-18.0198	11.00827	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
232	BN2	Bongo017	09/06/2018	10:32	-18.0198	11.00827	120	Disposed	Disposed	Sample dominated by gelatinous material, very few copepods
285	BN2	Bongo018	11/06/2018	19:05	-18.0199	11.00828	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
286	BN2	Bongo019	11/06/2018	19:24	-18.0199	11.00827	120	Experiments	Experiments	
293	BN2	Bongo020	12/06/2018	10:29	-18.0199	11.00827	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
294	BN2	Bongo021	12/06/2018	10:49	-18.0199	11.00827	120	Experiments	Experiments	

324	BN3	Bongo022	14/06/2018	10:28	-18.0198	11.00831	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
325	BN3	Bongo023	14/06/2018	10:50	-18.0198	11.0083	120	Experiments	Experiments	
371	BN3	Bongo024	16/06/2018	09:54	-18.02	11.00784	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
372	BN3	Bongo025	16/06/2018	10:30	-18.0198	11.00825	120	Experiments	Experiments	
408	BN3	Bongo026	18/06/2018	11:45	-18.0197	11.00818	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
409	BN3	Bongo027	18/06/2018	12:04	-18.0203	11.0083	120	Experiments	Experiments	
421	BN3	Bongo028	18/06/2018	19:06	-18.0199	11.00841	120	Size fractionated for ETS onto 47 mm GFF	Formaldehyde	Size fraction mesh: 2000, 1000, 500, 200, 100
422	BN3	Bongo029	18/06/2018	19:26	-18.0199	11.0084	120	Experiments	Experiments	

Zooplankton and micronekton sampling and processing: Mammoth nets

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

The MAMMOTH was deployed from the mid-ships P-frame. The trawl warp was fed through the main winch, and two Rexwroth winches were used on the side wires. The trawl warp was inboard of the anti-pendulum roller attached to a swivel on the main net, whilst the two side wires for the cod-ends are out-board. The anti-pendulum roller is bent inwards to create a gap between the cod-ends and the main net body. Steady lines are used on both the cod-ends and the net frame to control the system going outboard. Once over the side, a third line is used to turn the net around so the safety bar can be disengaged prior to deployment.

Retrieval is the reverse. Care needs to be taken to stop the wires connecting the net frame to the cod-ends from becoming trapped in the door holes on the bulwark.

The net was deployed to a depth of 850m w/o, at a rate up to 0.3m/s dependent on the swell. Initial speeds were 0.1m/s. In each case the wire out was slow such that the tension on the line remained above 0.2 tonnes at all times. The haul rate on retrieval was 0.2m/s.

The MAMMOTH was run in self-logging mode. The trigger depth for the instrument to turn on depended on the mode it was operating in and pre-programmed net depths were:

Net	Mammoth (300um net)	Mango (100um net)

	Depth (m)	Depth (m)
Wake	770	780
1	750-625	775
2	625-500	770
3	500-375	765
4	375-250	760
5	250-188	755
6	188-125	750-500
7	125-63	500-250
8	63-33	250-125
9	33-5	125-5

Table 19: Nominal opening/closing depths of Mammoth net

Net Performance: The MAMMOTH net was deployed 10 times with 300um nets and 7 times with 100um nets (Table 20). Two of the 100um net deployments failed, the first test deployment when the blanking plug had not worked appropriately, and on the 10th June when the batteries failed during the deployment. Other than that the Mammoth worked solidly during the cruise. Right on the last deployment of the Mango (100um nets), net 9 suffered severe damage.

Time	Event no	Latitude	Longitude	Water depth	Mesh size	Action
25/05/2018 18:21	23	-21.5254	9.5157	3953.4	300	Standard depths of 750,625,500,375,250,188,125,62,31,5
25/05/2018 20:29	23	-21.5254	9.515701	3956.4	300	Net recovered
27/05/2018 11:41	50	-21.6427	9.510729	3996.9	300	Standard depths of 750,625,500,375,250,188,125,62,31,5
27/05/2018 14:20	50	-21.6373	9.504986	3995.8	300	Net recovered
29/05/2018 12:54	83	-21.5421	9.507126	3966.8	100	Test deployment to 100m
29/05/2018 13:33	83	-21.5402	9.505865	3965.6	100	Net recovered. Test deployment failed - blanking plug shorted
30/05/2018 17:02	96	-21.5577	9.466834	3984.4	100	Standard depths 750, 500, 250, 125, 5

30/05/2018 19:13	96	-21.5577	9.466832	3983.8	100	Net recovered
04/06/2018 13:10	158	-18.0197	11.00844	2558.1	300	Standard depths of 750,625,500,375,250,188,125,62,31,5
04/06/2018 15:59	158	-18.0175	11.00805	2556.9	300	Net recovered
06/06/2018 12:26	190	-18.0196	11.00816	2559.0	100	Standard depths 750, 500, 250, 125, 5
06/06/2018 15:02	190	-18.0196	11.00818	2558.5	100	Net recovered
06/06/2018 17:02	196	-18.0196	11.00824	2558.9	100	Standard depths 750, 500, 250, 125, 5
06/06/2018 19:15	196	-18.0196	11.00823	2559.5	100	Net recovered
06/06/2018 20:11	197	-18.0196	11.00824	2559.0	300	Standard depths of 750,625,500,375,250,188,125,62,31,5
06/06/2018 22:23	197	-18.0256	11.00928	2568.4	300	Net recovered
10/06/2018 11:07	252	-18.0198	11.00826	2561.0	300	Standard depths of 750,625,500,375,250,188,125,62,31,5
10/06/2018 13:27	252	-18.0198	11.00825	2566.7	300	Net recovered
10/06/2018 14:10	253	-18.0198	11.00826	2565.6	100	Standard depths 750, 500, 250, 125, 5
10/06/2018 16:19	253	-18.0198	11.00826	2565.3	100	Net recovered
10/06/2018 18:25	258	-18.0198	11.00823	2565.4	100	Standard depths 750, 500, 250, 125, 5
10/06/2018 20:31	258	-18.0198	11.00826	2566.0	100	Net recovered. Battery failed no nets fired
10/06/2018 20:55	259	-18.0198	11.00826	2565.0	100	Standard depths 750, 500, 250, 125, 5
10/06/2018 23:00	259	-18.0198	11.00826	2566.9	100	Net recovered
11/06/2018 20:01	287	-18.0199	11.00827	2559.4	300	Standard depths of 750,625,500,375,250,188,125,62,31,5

11/06/2018 22:07	287	-18.0199	11.00827	2559.6	300	Net recovered
14/06/2018 11:37	326	-18.0198	11.00829	2559.6	300	Standard depths of 750,625,500,375,250,188,125,62,31,5
14/06/2018 13:41	326	-18.0198	11.00825	2567.8	300	Net recovered
14/06/2018 16:26	336	-18.0198	11.00832	2559.8	300	Standard depths of 750,625,500,375,250,188,125,62,31,5
14/06/2018 18:40	336	-18.0198	11.00832	2567.2	300	Net recovered
14/06/2018 19:34	337	-18.0198	11.00832	2558.3	100	Standard net depths, 750,500,250,125,5
14/06/2018 21:36	337	-18.0198	11.00834	2558.3	100	Net recovered
15/06/2018 12:15	347	-18.0241	11.01032	2572.9	100	Standard depths 750, 500, 250, 125, 5
15/06/2018 14:23	347	-18.0238	11.01029	2562.7	100	Net recovered

Table 20: Deployments of Mammoth net

Zooplankton and micronekton sampling and processing: MOCNESS nets

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

The MOCNESS comprises of a suite of 9 nets, towed horizontally from the aft gantry. Deployment is on the fibre optic deep tow cable, with real-time communications controlling the opening and closing mechanism.

MOCNESS deployment:

- Ship speed to 2 knots.
- Trail cod-ends over the back end of the vessel.
- Steadying lines through the black stand brackets.
- Pick up frame by hauling on towing warp and/or moving gantry out.
- Lower MOCNESS into water with gantry at full(ish) extent.
- Deploy at 0.1m/s until tension is consistently above 0.3 tonnes. Increase veering speed up to 0.3 m/s when possible.
- Recover at 0.2 m/s hauling speed.
- Slow ship to 1.5 knots
- Use hooks on poles/ropes to get MOCNESS under control when coming in.
- Place weight bar on stand and use steadying lines to bring MOCNESS towing end down onto deck.

Performance: The MOCNESS motor controlling the opening and closing mechanism simply didn't work. As a result all deployments were made to 125 m using an open net. The MOCNESS was not used as station BS1 as we were still trying to problem solve the issues. Despite numerous attempts by both Dan Ashurst and Andy Leadbetter the motor could not be coaxed to work when the MOCNESS was in the water. The MOCNESS was deployed a total of 15 times, but only 8 times where the sample was used (Table 21).

Time	Event No	Action	Latitude	Longitude	Comment

26/05/2018 13:25	38	Net deployed	-21.591	9.466675	
26/05/2018 13:45	38	Net recovered	-21.5979	9.472723	Depth sensor not working, MOCNESS recovered to change sensor
26/05/2018 14:02	39	Net deployed	-21.605	9.477763	
26/05/2018 15:34	39	Net recovered	-21.6381	9.501436	No nets fired
28/05/2018 12:21	70	Net deployed	-21.6444	9.507078	
28/05/2018 15:27	70	Net recovered	-21.7292	9.555194	No nets fired
02/06/2018 11:57	120	Net deployed	-18.2745	10.93453	
02/06/2018 12:43	120	Net recovered	-18.288	10.9421	No nets fired
03/06/2018 17:11	140	Net deployed	-18.0277	11.00832	Fixed net open 0 - 125 - 0
03/06/2018 18:05	140	Net recovered	-18.0531	11.0142	Net analysed
03/06/2018 18:20	141	Net deployed	-18.0566	11.01538	Test
03/06/2018 18:24	141	Net recovered	-18.0584	11.01618	Test
03/06/2018 18:32	142	Net deployed	-18.0601	11.01684	Test
03/06/2018 18:48	142	Net recovered	-18.0676	11.01999	No nets fired
06/06/2018 09:50	189	Net deployed	-18.0214	11.00902	Fixed depth 0 - 125 - 0
06/06/2018 10:30	189	Net recovered	-18.0432	11.02168	Net recovered
08/06/2018 21:29	225	Net deployed	-18.0353	11.01145	Fixed depth 0 - 125 - 0
08/06/2018 22:15	225	Net recovered	-18.0595	11.02665	Net recovered

09/06/2018 11:12	233	Net deployed	-18.0219	11.00898	Fixed depth 0 - 125 - 0
09/06/2018 11:50	233	Net recovered	-18.0431	11.01679	Net recovered
15/06/2018 20:14	360	Net deployed	-18.0299	11.01355	Fixed depth 0 - 125 - 0
15/06/2018 20:48	360	Net recovered	-18.0489	11.01658	Net recovered
16/06/2018 10:57	373	Net deployed	-18.0209	11.00848	Fixed depth 0 - 125 - 0
16/06/2018 11:46	373	Net recovered	-18.0403	11.01472	Net recovered
19/06/2018 08:25	427	Net deployed	-18.0234	11.00969	Fixed depth 0 - 125 - 0
19/06/2018 08:57	427	Net recovered	-18.0421	11.01674	Net recovered
19/06/2018 18:38	439	Net deployed	-18.021	11.00862	Fixed depth 0 - 125 - 0
19/06/2018 19:16	439	Net recovered	-18.0405	11.01755	Net recovered

Table 21: Deployments of MOCNESS nets during DY090

Zooplankton and micronekton sampling and processing: RMT25 nets

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

The RMT25 comprises of 2 nets, towed horizontally from the aft gantry. Deployment is on the fibre optic deep tow cable, with real-time communications controlling the opening and closing mechanism using the BAS Down Wire Net Monitor (DWNM).

Deployment on the *Discovery* was developed during a trial cruise in May 2017 (RMT on Discovery.pdf appendix), and this procedure was adopted during cruise DY090. Harnesses were used fixed to a 4m strop attached to eye bolts in the deck (1 eye bolt in from the side of the red square). An additional safety feature was that on retrieval of the net, a ratchet strap was used to secure the RMT25 from accidental re-deployment whilst the cod-ends were being retrieved.

RMT25 deployment:

- Ship speed to 2 knots.
- Trail cod-ends over the back end of the vessel.
- Side wires hauled up to maximum extent without g-links going on to winches
- Pick up net by moving gantry out.
- With gantry out so the nets are vertical, lower side wires together (note *Discovery* gantry and side wires do not work at the same time!)
- Bring gantry in to switch over side wires to main towing warp
- Attach side wires to G-links on ropes in square
- Deploy at 0.1m/s initially. Increase up to 0.3 m/s as required and possible to sink net

RMT25 recovery:

- Ship speed to 1.5 knots
- Pull gantry with top towing bar is just above deck level (and rest of net below)
- Shackle over to side wires
- Put gantry out so net vertical, then haul in on both side wires at same time to raise net.
- Pull side wires up to maximum extent, put gantry in. Lower side wires if additional control need
- Ratchet strap stop the RMT nets (round the release straps) to prevent accidental redeployment
- Pull nets in using auxiliary deck winch and haul lines

Performance: The RMT25 release gear failed initially, due to a broken coupling. This was pinned and the housing rebuilt. The temperature and salinity sensors provided incorrect readings and ultimately

were left off the unit. The RMT25 underwater housing failed to communicate on a couple of hauls initially. One problem was a loose connection in the fibre optic housing, but a loose board was also found in the underwater housing. Although this was eventually tied together, the reliable MOCNESS underwater unit (using motor 2) was used to trigger the nets. This worked on all bar one occasion, where the failure was likely due to dirt or water on the connectors between the underwater unit and motor. The RMT25 was deployed a total of 17 times, with 5 failures (Table 22). On a couple of occasions one of the net links got jammed in the end of the bars causing the net to remain semi-open to the surface. Fortuitously this occurred in the surface hauls and therefore the samples were valid.

Time	Cable out	Net depth	Action	Latitude	Longitude	Event num	Comment
24/05/2018 22:41	3.9		Net deployed	-21.4997	9.500035	2	
24/05/2018 23:51	17.24		Net recovered	-21.5253	9.515621	2	Fibre optic comms issues, haul aborted
26/05/2018 18:11	15.88		Net deployed	-21.661	9.526398	43	
26/05/2018 18:36	231.48	252	Net 1 opened	-21.6706	9.534418	43	Program stopped and restarted at 18:38 to check net voltage drop
26/05/2018 18:56	196.39	125	Net 1 closed	-21.6777	9.540166	43	
26/05/2018 18:57	184.21	125	Net 2 opened	-21.678	9.540336	43	
26/05/2018 19:17	50.26	16	Net 2 closed	-21.6856	9.545905	43	
26/05/2018 20:00	17.06		Net recovered	-21.6973	9.55413	43	
27/05/2018 18:33	8.24		Net deployed	-21.6493	9.509763	57	
27/05/2018 19:27	16.61		Net recovered	-21.673	9.519477	57	U/W housing not communicating correctly
28/05/2018 19:33	12.98		Net deployed	-21.7412	9.562628	72	
28/05/2018 20:29	949.9	750	Net 1 opened	-21.7688	9.578561	72	
28/05/2018 21:10	831.88	500	Net 1 closed	-21.7868	9.589811	72	
28/05/2018 21:10	828.81	502	Net 2 opened	-21.787	9.589942	72	
28/05/2018 21:50	416	245	Net 2 closed	-21.8047	9.600133	72	
28/05/2018 22:47	19.47		Net recovered	-21.8304	9.615259	72	
31/05/2018 11:43	18.85		Net deployed	-21.5601	9.468063	103	
31/05/2018 11:56	34.61		Net recovered	-21.5653	9.472174	103	Underwater housing comms failed
31/05/2018 12:30	8.8		Net deployed	-21.5753	9.479655	104	
31/05/2018 12:52	238.4	250	Net 1 opened	-21.5831	9.485816	104	
31/05/2018 13:15	256.01	125	Net 1 closed	-21.5911	9.492595	104	
31/05/2018 13:29	133.95	125	Net 2 opened	-21.5959	9.496338	104	
31/05/2018 13:51	62.13	10	Net 2 closed	-21.6035	9.502262	104	

31/05/2018 14:17	19.24		Net recovered	-21.6134	9.509551	104	
31/05/2018 14:43	18.4		Net deployed	-21.6227	9.514451	105	
31/05/2018 15:57	931.54	750	Net 1 opened	-21.6581	9.525318	105	
31/05/2018 16:28	849.53	500	Net 1 closed	-21.6713	9.530563	105	
31/05/2018 16:29	837.7	510	Net 2 opened	-21.6717	9.53073	105	
31/05/2018 16:59	474.86	250	Net 2 closed	-21.6849	9.535651	105	
31/05/2018 17:48	18.64		Net recovered	-21.7098	9.544101	105	
04/06/2018 19:12	16.72		Net deployed	-18.0232	11.0099	163	
04/06/2018 20:50	20.04		Net recovered	-18.0821	11.03537	163	Net did not fire. No nets opened
04/06/2018 21:35	16.47		Net deployed	-18.0797	11.03444	166	
04/06/2018 22:00	313.28	252	Net 1 opened	-18.0948	11.04183	166	
04/06/2018 22:20	247.87	124	Net 1 closed	-18.1049	11.048	166	
04/06/2018 22:21	241.8	125	Net 2 opened	-18.1055	11.04834	166	
04/06/2018 22:43	58.71	13	Net 2 closed	-18.1179	11.05639	166	
04/06/2018 23:15	19.02		Net recovered	-18.1295	11.0656	166	
05/06/2018 10:26	18.77		Net deployed	-18.0235	11.00663	177	
05/06/2018 11:01	297.31	250	Net 1 opened	-18.0413	10.99656	177	
05/06/2018 11:21	192.85	125	Net 1 closed	-18.0497	10.99192	177	
05/06/2018 11:22	180.9	125	Net 2 opened	-18.0501	10.99169	177	
05/06/2018 11:42	59.28	12	Net 2 closed	-18.0588	10.98722	177	
05/06/2018 12:03	18.71		Net recovered	-18.0691	10.98178	177	
05/06/2018 12:45	16.97		Net deployed	-18.079	10.97485	178	
05/06/2018 13:43	1000.06	750	Net 1 opened	-18.1051	10.95631	178	
05/06/2018 14:23	734.93	500	Net 1 closed	-18.1194	10.94538	178	
05/06/2018 14:25	728.02	500	Net 2 opened	-18.1201	10.94475	178	

05/06/2018 15:05	472.54	250	Net 2 closed	-18.1383	10.9324	178	
05/06/2018 15:54	14.29		Net recovered	-18.1592	10.91699	178	
07/06/2018 17:52	13.79		Net deployed	-18.0211	11.00854	204	
07/06/2018 19:06	1173.75	750	Net 1 opened	-18.0637	10.98935	204	
07/06/2018 19:46	797.82	500	Net 1 closed	-18.083	10.98263	204	
07/06/2018 19:47	797.82	505	Net 2 opened	-18.0835	10.98252	204	
07/06/2018 20:27	408.24	250	Net 2 closed	-18.1042	10.97833	204	
07/06/2018 21:11	20.68		Net recovered	-18.1278	10.97897	204	
09/06/2018 17:43	20.02		Net deployed	-18.0559	11.02973	240	
09/06/2018 18:25	329.37	250	Net 1 opened	-18.0761	11.04233	240	
09/06/2018 18:45	213.93	122	Net 1 closed	-18.0853	11.04871	240	
09/06/2018 18:45	213.93	125	Net 2 opened	-18.0856	11.04887	240	
09/06/2018 19:05	31.25	10	Net 2 closed	-18.0945	11.05489	240	
09/06/2018 19:25	17.85		Net recovered	-18.1041	11.06206	240	
09/06/2018 20:00	6.59		Net deployed	-18.121	11.07382	241	
09/06/2018 21:07	1202.61	750	Net 1 opened	-18.1575	11.09783	241	
09/06/2018 21:47	843.93	500	Net 1 closed	-18.1787	11.11072	241	
09/06/2018 21:48	837.74	500	Net 2 opened	-18.1792	11.11109	241	
09/06/2018 22:28	466.11	250	Net 2 closed	-18.1999	11.1252	241	
09/06/2018 23:15	18.55		Net recovered	-18.2246	11.14282	241	
11/06/2018 10:12	16.17		Net deployed	-18.0226	11.00949	277	
11/06/2018 10:33	282.83	250	Net 1 opened	-18.0327	11.01451	277	
11/06/2018 10:53	193.49	125	Net 1 closed	-18.0412	11.0189	277	
11/06/2018 10:54	189.67	125	Net 2 opened	-18.0416	11.01914	277	
11/06/2018 11:14	22.96	125	Net 2 closed	-18.051	11.02378	277	

11/06/2018 11:29	18.61		Net recovered	-18.0578	11.02725	277	
11/06/2018 11:52	18.61		Net deployed	-18.0528	11.02643	278	
11/06/2018 13:15	1051.77	750	Net 1 opened	-18.0968	11.03921	278	
11/06/2018 13:55	808.43	500	Net 1 closed	-18.1168	11.04401	278	
11/06/2018 13:56	808.42	500	Net 2 opened	-18.1173	11.04414	278	
11/06/2018 14:37	399.67	250	Net 2 closed	-18.1389	11.04938	278	
11/06/2018 15:11	17.82		Net recovered	-18.1589	11.05394	278	Net 1 strangled
16/06/2018 12:56	11.93		Net deployed	-18.0429	11.01545	374	
16/06/2018 13:19	294.58	250	Net 1 opened	-18.0535	11.01802	374	
16/06/2018 13:40	196.13	125	Net 1 closed	-18.0624	11.02019	374	
16/06/2018 13:40	193.15	125	Net 2 opened	-18.0626	11.02023	374	
16/06/2018 14:01	23.23	10	Net 2 closed	-18.0718	11.02244	374	
16/06/2018 16:44	17.96		Net deployed	-18.0206	11.00811	379	
16/06/2018 17:05	264.39	250	Net 1 opened	-18.0288	11.00862	379	
16/06/2018 17:25	186.77	125	Net 1 closed	-18.0375	11.00955	379	
16/06/2018 17:26	174.62	125	Net 2 opened	-18.0379	11.00959	379	
16/06/2018 17:46	24.27	10	Net 2 closed	-18.0466	11.01043	379	
16/06/2018 18:32	11.57		Net deployed	-18.0454	11.01064	380	
16/06/2018 19:30	923.75	750	Net 1 opened	-18.0732	11.01803	380	
16/06/2018 20:10	807.65	500	Net 1 closed	-18.0927	11.0229	380	
16/06/2018 20:11	807.65	500	Net 2 opened	-18.0932	11.02308	380	
16/06/2018 20:51	404.7	250	Net 2 closed	-18.1129	11.02938	380	
16/06/2018 21:36	20.81		Net recovered	-18.136	11.03761	380	
17/06/2018 11:07	1.09		Net deployed	-18.0247	11.00919	389	
17/06/2018 12:07	874.06	750	Net 1 opened	-18.0536	11.01495	389	

17/06/2018 12:48	716.11	500	Net 1 closed	-18.0711	11.01942	389	
17/06/2018 12:49	703.98	502	Net 2 opened	-18.0714	11.01956	389	
17/06/2018 13:29	363.72	250	Net 2 closed	-18.0903	11.02128	389	
17/06/2018 14:08	20.12		Net recovered	-18.1066	11.02263	389	

Table 22: RMT 25 deployment details during DY090

Zooplankton and micronekton sampling and processing: Macro- and mesozooplankton communities, isotopes and ETS

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

Gear

An RMT25 net was used to sample the mesopelagic fish, squid and macrozooplankton community during the survey. Depth-discrete samples were collected across four time stations (BS1, BN1-3) between 0-750 m at intervals of 750-500m, 500-250m, 250-125m and 125-10 m. At each time station two RMT25 hauls were deployed in the hours of darkness and two in daylight, with 16 deployments being undertaken overall. The RMT25 was operated via a downwire net monitor and was equipped with a flow meter, and temperature and salinity sensors. Nets in the deep strata (750-500m and 500-250m) were sampled for approximately 40 mins. and nets in the shallow strata (250-125m, 125-10m) for approx. 20min.

The mesozooplankton community was sampled using a MOCNESS net that, due to technical difficulties with the release gear, was equipped with only one net (330 µm mesh) which was deployed open from 0m to 125m to 0m. The MOCNESS was deployed during daylight and night-time hours. The copepod community for both stable isotope (SI) and ETS analysis was also sampled from the MOCNESS.

Sample processing

The total weight of each RMT25 net haul was recorded. The most common macrozooplankton, squid and fish species were identified to species level, where possible, and numbers taken for both ETS and SI analysis were weighed and recorded. Specimens were either frozen at -80°C for stable isotope and lipid analysis or flash-frozen in liquid nitrogen for ETS. Numbers sampled from RMT25 catches for each type of biochemical analysis are listed in Table. The remainder of catches was preserved in formalin for future biomass analysis.

Of the MOCNESS catches one half aliquot of each net was retained in formalin for future biomass analysis. For stable isotope, lipid and ETS analysis samples were taken from the remaining aliquot. MAMMOTH catches were split into two aliquots for each net, with one half being retained in formalin and the other half being processed for ETS analysis (Table 6). MANGO catches were split into 4 aliquots and preserved for ETS analysis (1/4, liquid nitrogen), stable isotope analysis (1/4, -80°C), biomass (1/4, formalin) and foraminifera biochemistry (1/4, see Planktonic forminifera cruise report).

Macrozooplankton and fish catches

A total of 16 RMT25 hauls were obtained at the 4 time stations sampled. In total 1917 fish were caught and preserved (not including Cyclothone spp.). Catches were dominated by the myctophids and various as yet unidentified mesopelagic fish species . The water column below 250m was dominated by *Bathylagus* spp. and genus Melamphidae spp. The most numerous fish overall were the Cyclothone spp. which occurred in large numbers below 500m.

In deeper waters (250m-750m) the macrozooplankton component of the RMT25 net catches was mostly dominated by the Decapoda and hydromedusae of the genus Atolla spp.. Salps, smaller hydromedusa species and small euphausiids *Euphausia hanseni* and *Nematocelis megalops* dominated the shallower depths (10-250m). *Themisto spp.* were the most numerous amphipod species caught.

Stable isotope analysis

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

The objective in this study is to identify the trophic position of the dominant species in the mesopelagic layer and improve our understanding of the energy transfer between specific depth horizons. To this purpose we sampled both fish and zooplankton from discrete depth horizons. In order to establish an isotopic baseline for the depth horizons where zooplankton and fish samples originated from corresponding particulate organic matter (POM) was collected. POM samples were obtained through filtering waters collected by Niskin bottles deployed via a CTD rosette. Water was taken from various depths at each station. All water samples collected from Niskin bottles were processed on-board. Depending on the density of particles varying volumes of seawater per depth were filtered onto 47mm GF/F filters and the filters stored frozen at -80°C. Also opportunistic samples of concentrated POM were collected from Pelagra traps on two deployments.

Summary SI		**Day**				**Night**			
		125-10m	250-125m	500-250m	750-500m	125-10m	250-125m	500-250m	750-500m

Amphipoda	BS1	7	2	20		7	20	14	
	BN1	4	15	3		11	9	7*	
	BN2	12	10	9		19	8	10	
	BN3	11	4			19	19		
Bathylagidae	BS1				8			3	
	BN1							5*	5
	BN2				4		3	5	2
	BN3				5			5	5
Cephalopoda	BS1			4				3	
	BN1	5	3	5	7	13	3	7*	1
	BN2	3	2	7	3	21	6	5	
	BN3	3	1	5	3	6		4	
Chaetognatha	BS1	2				10	4		
	BN2		16						
Cyclothone	BS1			5					20
	BN1				20				
	BN2				10			10	10
	BN3			10	10			10	10
Decapoda	BS1			30	10		10	13	16
	BN1	3	2	20	24	33	29	29*	13
	BN2		6	33	19	16	28	29	10
	BN3	2	16	33	37	22	25	31	26
Euphausiacea	BS1	3		15			8		
	BN1	4	16	10	10	10	20	23*	20
	BN2			20		10	13	17	20
	BN3	10	20	4				17	14
Heteropoda	BS1	1							
	BN1		2						
	BN3		2			3	1		
Hydromedusae	BS1	2			3			5	11
	BN1	8	5		5			6*	10
	BN2		7	11	9	6	3	10	3
	BN3			5	13	7	5	10	12
Melamphidae	BS1				5				5
	BN1				2			2*	

	BN2			2	3			3	
	BN3				5			4	2
Myctophidae	BS1			11				4	
	BN1			8	5	10		6*	2
	BN2			11	5	19	8	10	
	BN3			7	5		11		2
Mysidacea	BS1					5	5		
Nemertina	BN3				1				3
Ostracoda	BN1								4
	BN2				2				
	BN3				6			1	3
Teleostei	BS1			4	1			3	2
	BN1	2	2	9	6	8	6	5*	6
	BN2			12	8	8	10	10	2
	BN3	7	5	14	12	3		14	3
Polychaeta	BS1		1						
Pteropoda	BS1			5					
	BN2	3							
	BN3					5	6		
Pyrosomata	BS1			1					
	BN1	5							
	BN2	4							
	BN3					5			
Salpa	BS1	22	2			30		15	5
	BN1	10				3	4		
	BN2	3	5			7			
	BN3					3			
Syphonophora	BS1		10						
	BN2	3	5						
	BN3	9	2			10			

Table 23: Macrozooplankton and fish species sampled and preserved for stable isotope analysis from RMT25 hauls during cruise DY090. BS =Benguela South 1 time station, BN1-3 = Benguela North time

stations 1 to 3. * indicate samples from a haul that covered 500m to the surface due to a malfunction of the net.

Summary ETS		**Day**				**Night**			
		125-10m	250-125m	500-250m	750-500m	125-10m	250-125m	500-250m	750-500m
Amphipoda	BS1	6	2	20		15	27	15	
	BN1	6	15	3		3	7	5*	
	BN2	8	11	9		18	8		
	BN3	6	3			14	18		
Bathylagidae	BS1				5			2	
	BN1				5				8
	BN2				4		3	5	3
	BN3				5			5	5
Cephalopoda	BS1	1							
	BN2	3		3					
	BN3				7	3			
Chaetognatha	BS1	2	11			10	5		
	BN2		6						
Copepoda	BN2								3
Cyclothone	BS1			5	10				20
	BN1				10				10
	BN2				10			10	10
	BN3			10	10			20	10
Decapoda	BS1			33	15		20	15	7
	BN1		2	20	21	25	31	18*	13
	BN2			25	17	22	29	23	
	BN3		15	31	30	33	40	28	18
Euphausiacea	BS1						13	12	
	BN1		9	9	9	9	18	18*	18
	BN2			18		9	13	12	18
	BN3	9	18					18	18
Heteropoda	BN3		2			4			
Hydromedusae	BS1	2			5			5	8

	BN1	5	5		5			12*	11
	BN2		4	8	9	3		10	
	BN3			5	13	10	5	10	12
Melamphidae spp.	BS1				5				9
	BN1				3			2	
	BN2				3			4*	
	BN3				5				3
Myctophidae	BS1			13			8	5	4
	BN1			10	5	10		3	1
	BN2			8	5	16	9	10	
	BN3			10	5	5	11		3
Mysidacea	BS1					5	7		
Ostracoda	BN2				2				
	BN3								3
Teleostei	BS1			2			5	3	1
	BN1	2	2	9	6	8	6		10
	BN2			10	8		4	9	2
	BN3		2	13	13			14	3
Polychaeta	BS1		1						
Pteropoda	BS1			5					
	BN3					4	6		
Pyrosomata	BS1			1					
	BN1	5							
	BN2	4							
	BN3					5			
Salpa	BS1	22	2			28		5	5
	BN1	8				3	3	10*	
	BN2	2	5			7			
	BN3					3			
Syphonophora	BS1		10						
	BN2	3	5						
	BN3	9	3			10			

Table 24: Macrozooplankton and fish species sampled and preserved for ETS analysis from RMT25 hauls during cruise DY090. BS =Benguela South 1 time station, BN1-3 = Benguela North time stations 1 to 3. * indicate samples from a haul that covered 500m to the surface due to a malfunction of the net.

Summary ETS and SI		**ETS**		**SI**	
	Station	Day	Night	Day	Night
Amphipoda	BS1	5			
	BN1				2
	BN2	10	2	12	2
	BN3	7	10	8	11
Cephalopoda	BN1				2
	BN3				2
Chaetognatha	BS1	5			
	BN1	12		20	
	BN2	10	5	10	6
	BN3	5	4	5	4
Copepoda	BS1	15			
	BN1	39		40	70
	BN2	15	15	40	80
	BN3		21		50
Decapoda	BS1	11			
	BN1		10		5
	BN2		7		7
	BN3		12	1	12
Euphausiacea	BS1	14			
	BN1	22	29	19	33
	BN2	9	18	10	20
	BN3	9	18	69	18
Gastropoda	BN3	3	4	2	4
Hydromedusae	BN1		8		14
	BN3				5
Myctophidae	BN2				10
Mysidacea	BS1	7			

Teleostei	BS1	14			
	BN1		1		1
Polychaeta	BN1	10		10	
	BN2	4	5	4	5
	BN3	2	4	2	4
Pteropoda	BS1	4			
	BN2			4	
	BN3				3
Pyrosomata	BN3			3	
Salpa	BS1	5			
	BN1		2		2
	BN2		2		2
	BN3		5		5
Syphonophora	BN3		4		4

Table 25: Macrozooplankton species sampled and preserved for ETS and stable isotope analysis from MOCNESS hauls during cruise DY090. BS =Benguela South 1 time station, BN1-3 = Benguela North time stations 1 to 3. All hauls apart from station BS1 (750m) were deployed to 125m.

Station	Event	sample depths	latitude	longitude
BS1	CTD8 Ev76	5m, 25m Chlmax (60m), 75m, 120m, 200m, 450m, 750m	-21.32.524	09.30.430
BN1	CTD15 Ev172	5m, 25m, Chlmax (20m), 75m, 125m, 200m, 450m, 750m	-18.01.179	11.00.510
BN2	CTD22 Ev250	5m, 25m, Chlmax (50m), 75m, 125m, 200m, 450m, 750m	-18.01.186	11.00.492
BN3	CTD33 Ev399	5m, 25m, Chlmax (58m), 75m, 125m, 200m, 450m, 750m	-18.01.189	11.00.497

Table 26: POM samples collected for stable isotope analysis on DY090

Zooplankton and micronekton sampling and processing: ETS measurements for respiration

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

Respiration

Zooplankton and micronekton samples were also taken for estimation of respiration (RO_2) via electron transfer system (ETS) activity. The ETS activity is the capacity of a living system to consume oxygen (or other electron acceptor), so can be thought of as the potential respiration (Φ) in the presence of surplus reactants (Owens & King, 1975; Packard & Christensen, 2004). To cover the size spectrum of zooplankton and micro nekton species samples for ETS were taken from Bongo, MAMMOTH, MOCNESS and RMT-25 nets. For macro zooplankton and micro-nekton, replicate individuals of the main species present in the RMT-25 and MOCNESS nets were picked and flash frozen in liquid nitrogen in cryovials or sample bags. Where necessary, individuals were first rinsed with filtered seawater to remove contaminating phytoplankton cells. Weights of all samples taken from the RMT-25 were taken before freezing to include in total catch biomass estimates. Once frozen samples were transferred to a -80°C freezer. All samples were frozen within 1.5-hrs of the nets coming on board. Measurements of ETS activity in frozen samples will be made in the lab and respiration calculated using literature derived ratios of RO_2 to Φ.

Owens, T. G., & King, F. D. (1975). The Measurement of Respiratory Electron-Transport-System Activity in Marine Zooplankton. *Marine Biology*, *30*, 27–36.

Packard, T. T., & Christensen, J. P. (2004). Respiration and vertical carbon Flux in the Gulf of Maine water column. *Journal or Marine Research*, *62*, 93–115.

Zooplankton and micronekton sampling and processing: Copepod grazing and physiology

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

Rationale: Zooplankton are the vector through which energy and nutrition are passed from phytoplankton to higher trophic levels, including fish, birds and mammals. Their community activities play an important role in regulating the strength of the biological carbon pump (BCP) by concurrently a) fragmenting large organic particles, b) repackaging small organic particles, c) producing dense and relatively fast-sinking faecal pellets, d) remineralising organic matter, and e) directly transporting matter to depth via vertical migration. Their effects on the BCP can therefore act in both shallow and deeper waters, and may occur both actively and passively.

The daily pattern of vertical migration typically includes ascending into surface waters to feed at night and returning to deeper, darker waters during the day time to avoid visual predation. Grazing on living phytoplankton at the surface provides zooplankton with access to food that is rich in labile substrates and micronutrients, such as omega-3 polyunsaturated fatty acids (PUFAs), which are essential for healthy growth and reproduction (Anderson & Pond, 2000). Feeding on detritus at depth may also occur, but this material typically consists of refractory substrates and is largely devoid of nutrition (Mayor et al., 2014). Fragmentation of detritus may stimulate the production of nutrient compounds by heterotrophic microbes (Mayor et al., 2014) but any nutritional gains must be balanced against the associated energetic losses (Anderson et al., 2017) and the increased risk of detection by their predators. We have previously hypothesised that migrating zooplankton ingest sufficient material in the surface at night to sustain them at depth during the day, thereby negating the need to feed at depth (Giering et al., 2014). However, this hypothesis was derived solely on the basis of zooplankton carbon demands, rather than their requirements for nutrient compounds such as omega-3 PUFAs. Boreal species of copepods of the genus *Calanus* have elevated basal turnover rates of omega-3 PUFAs, relative to other, non-essential fatty acids, suggesting that the supply of these compounds may set an important constraint on daily feeding activities.

Experiments were conducted to quantify copepod grazing rates in surface waters and additional samples were collected from all netting activities for biomarker analysis to better understand the structure of the mesopelagic zooplankton and nekton communities. During DY086, an experiment was conducted to determine the basal rates at which individual fatty acids turn over in the Southern Ocean biomass-dominant species of copepod, *Calanoides acutus*. A comparison turnover experiment on the Benguela species of *Calanoides* (identification to be confirmed, probably *C. carinatus*) was conducted on this expedition.

Hypotheses:

H1: Zooplankton grazing in the surface ocean during the night is sufficient to meet their daily demands for carbon and omega-3 PUFAs.

H2: Zooplankton turnover rates of omega-3 fatty acids are high relative to other fatty acids.

Methods: All experimental work was undertaken in the Controlled Environmental Laboratory at 8 °C or the refrigerated container at 12 °C. All of the experimental equipment was pre-soaked (>24 hrs) in seawater prior to its first use.

Experimental animals were collected with a bongo net (100 μm mesh) using a non-filtering cod end (Table 27) and were subsequently sorted using a dissection microscope. Experimental water was collected via the CTD or using a dedicated cast of the Marine Snow Catcher (Table 27) and was immediately transferred into HDPE carboys using wide-bore silicone tubing. Copepod grazing rates were examined using particle-removal experiments (Mayor et al., 2006). In brief, glass incubation bottles were filled with un-screened seawater a little at a time to maximise homogeneity. Visibly discernible copepods were removed from the incubation water via a dip-tube prior to the addition of experimental animals. Experimental animals were carefully introduced into triplicate bottles and incubated alongside triplicate control bottles in the dark on a plankton wheel rotating at 1 rpm for 24 hr. Microplankton samples (200 ml) from each of the incubated bottles were collected and preserved with acidified Lugol's iodine (1%). On occasion, the mesozooplankton community was dominated by a wide variety of very small copepod species so an aliquot of the sample that contained about 30 animals was incubated to measure community grazing.

Experiments to determine the basal rates at which carbon, nitrogen and fatty acids turnover in *Calanoides* were conducted using a previously established methodology (Mayor et al., 2011). In brief, replicate groups of 5 *Calanoides* (CV) were transferred into sterile-filtered (0.2 μm) seawater and incubated in 500ml HDPE bottles for up to 10 days. Triplicate bottles were sacrificed at the start of the experiment and every 48 hrs thereafter. Incubated animals were retrieved by gently pouring each bottle onto a 63 μm mesh filter, checked for signs of life, and transferred into 1ml glass vials or tin cups for fatty acid or elemental analysis, respectively.

Samples of zooplankton and nekton for biomarker analysis were picked from individual nets, either directly or using a dissection microscope, and stored frozen (Table 28, Table 29,

Event	158	158	158	158	158	197	197	197	197	197	197	197	197	252	252	252	252	252	287	287	287	287	287	287	287	326	326	326	326	326	326	336	336
Net #	2	3	4	8	9	1	2	3	4	5	6	7	9	2	3	4	5	9	1	2	3	4	7	8	9	3	4	5	7	8	9	3	4
Species																																	
Calanoides carinatus C5	x	x				x	x		x					x			x	x	x	x	x					x	x					x	
Eucalanus hyalinus C6F				x			x		x				x	x				x	x	x	x	x										x	
Euchaeta spp.		x					x																			x						x	
Metridia spp. C5																							x		x		x						
Metridia spp. C6F			x													x								x									
Nannocalanus minor C6F				x	x								x					x													x	x		
Nannocalanus minor C5																													x				
Pleuromamma large sp. C5																									x								
Pleuromamma large sp. C6F		x																								x	x						
Pleuromamma small sp. C6F																x								x	x		x						
Pleuromamma sp. C6F (large?)								x	x	x					x								x										
Pleuromamma sp. C6F (small?)								x				x			x																		
Rhincalanus nasutus C6F									x	x	x	x				x					x	x					x						x

Table 300). All frozen material was stored at -80 °C. Taxonomic identification of samples will be confirmed using photographs and reference specimens.

No.	Net	Net Event	Species	Stage	No. animals	Incubation vol (L)	Water collection	Water Event	Water depth (m)	Start date	End date
1	Bongo	8	*Oithona* spp.	C3-6	30	0.2	Snowcatcher	10	75	25/05/2018	26/05/2018
2	Bongo	21	*Oithona* spp.	C3-6	30	0.2	Snowcatcher	10	75	25/05/2018	26/05/2018
3	Bongo	22	*Oithona* spp.	C3-6	30	0.2	Snowcatcher	10	75	25/05/2018	26/05/2018
4	Bongo	118	*Nannocalanus*	C5	5	1.1	Snowcatcher	109	45	02/06/2018	03/06/2018
5	Bongo	118	*Calanoides*	C5	5	1.1	Snowcatcher	109	45	02/06/2018	03/06/2018
6	Bongo	118	Community		5ml of 6L	0.2	Snowcatcher	109	45	02/06/2018	03/06/2018
7	Bongo	176	*Nannocalanus*	C6F	5	1.1	CTD	172	20	05/06/2018	06/06/2018
8	Bongo	188	*Oithona* spp.	C4-5	25	0.2	CTD	172	20	06/06/2018	07/06/2018
9	Bongo	215	*Oithona* spp.	C4-5	25	0.2	CTD	227	20	08/06/2018	09/06/2018
10	Bongo	215	*Eucalanus*	C4-5	3	1.1	CTD	227	20	08/06/2018	09/06/2018
11	Bongo	215	*Nannocalanus*	C6F	5	1.1	CTD	227	20	08/06/2018	09/06/2018
12	MOCNES	233	*Calanoides*	C5	5	1.1	CTD	227	20	09/06/2018	10/06/2018
13	Bongo	286	*Pleuromamma* S	C5-6	7	1.1	Snowcatcher	279	20	11/06/2018	12/06/2018
14	Bongo	286	*Metridia*	C5-6	7	1.1	Snowcatcher	279	20	11/06/2018	12/06/2018
15	Bongo	325	*Oithona* spp.	C4-5	25	0.2	Snowcatcher	333	20	14/06/2018	15/06/2018
16	Bongo	325	*Nannocalanus*	C6F	5	1.1	Snowcatcher	333	20	14/06/2018	15/06/2018
17	Bongo	372	Community		10ml of 6L	0.2	Snowcatcher	366	10	16/06/2018	17/06/2018
18	Bongo	409	*Oithona* spp.	C4-5	25	0.2	CTD	399	58	18/06/2018	19/06/2018
19	Bongo	409	*Calanoides*	C5-6	5	0.2	CTD	399	58	18/06/2018	19/06/2018

20	Bongo	409	*Centropages*	C5-6	7	0.2	CTD	399	58	18/06/2018	19/06/2018
21	Bongo	422	*Pleuromamma* L	C6F	4	1.1	CTD	399	58	18/06/2018	19/06/2018
22	Bongo	422	*Nannocalanus*	C6F	5	1.1	CTD	399	58	18/06/2018	19/06/2018

Table 27: Copepod grazing experiments conducted with Oithona spp., Nannocalanus minor, Calanoides carinatus, Eucalanus hyalinus, Pleuromamma spp., Metridia lucens, and community aliquots (taxonomic identifications to be confirmed).

Event	43	43	72	72	104	104	105	105	166	166	177	177	178	178	204	204	240	240	241	241	277	277	278	278	374	374	379	379	380	380	389	389
Net #	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Amphipod sp. 2 Yellow				x	x				x		x					x	x	x									x	x				
Amphipod sp. 3								x										x						x			x					
Atolla spp.			x	x			x	x					x		x	x				x			x						x	x	x	
Bathylagidae							x						x		x	x	x			x			x						x	x	x	
Chaetognath spp.	x				x	x															x											
Cyclothones spp.			x				x	x					x		x				x	x			x						x	x	x	x
Decapod sp. 1								x	x	x			x			x	x	x		x				x	x		x	x	x	x	x	x
Decapod sp. 8				x						x			x	x	x	x	x	x		x			x	x					x	x	x	x
Decapod sp. 9 Sergestes									x	x				x		x	x	x						x			x					x
Decapod sp. 12 Sergia							x		x	x				x	x	x	x	x		x			x	x				x		x	x	x	x
Diaphus hudsoni?								x									x	x														
Diphyes dispar																					x	x			x							
Euphausia hanseni									x	x			x	x	x	x	x	x	x					x	x	x			x			
Gymnoscopelus spp								x		x			x	x			x	x		x			x	x			x		x		x	x
Hatchet fish													x	x	x	x	x			x				x					x		x	
Jelly sp. 1 (*Colobonema sericeum*)																x				x			x	x							x	x

Melanphidae						x																x								x	
Nematoscelis megalops								x						x	x	x		x	x				x	x				x			
Phronima spp.			x	x						x						x	x			x			x								
Purple striped jelly/purple salp	x		x		x																										
Red Acanthaphyra sp. 1							x	x	x				x										x								x
Red Acanthaphyra sp. 2							x					x	x		x	x			x			x	x					x	x	x	x
Salpa sp. 1 blue	x	x			x																										
Salpa sp. 9								x	x						x		x														
Salpa sp. 11											x				x		x			x											
Snipe eel								x					x					x	x				x								
Stomiidae													x																	x	x
Two horned Themisto			x		x			x	x	x							x			x	x				x	x	x				

Table 28: RMT-25 tissue samples for biomarker analysis. Only species taken from at least three events are shown.

Event	70	140	189	225	233	360	373
Species							
Calanoides carinatus C5		x					
Clio spp.	x						
Eucalanus hyalinus C6F	x	x	x	x	x		
Euchaeta spp.	x	x					
Metridia spp. C5	x					x	
Nannocalanus minor C6F		x	x	x	x	x	x
Ostracoda	x						
Pleuromamma spp. C6F	x						
Pleuromamma large sp. C6F		x		x		x	
Pleuromamma small sp. C6F		x				x	
Rhincalanus nasutus C6F	x		x				
Amphipod sp. 6					x		
Amphipod sp. 7					x		
Beroe cucumis		x					
Blue salp sp.	x						
Chaetognatha	x		x	x	x	x	x
Decapod sp 1		x					
Decapod sp 8				x			
Decapod sp 9		x					
Diphyes spp.						x	
Euphausia americana				x			
Euphausia hanseni		x	x	x	x	x	
Euphausia recurva	x	x					
Gastropod sp. 1							x
Myctophid larvae				x			
Mysid sp. 3	x						
Nematocelis megalops	x	x	x			x	x
Orchistoma pileus		x					
Polychaete sp. 4			x	x	x	x	
Red Acanthephyra spp.	x						
Salpa sp. 10						x	
Salpa sp. 11				x			
Stomatiidae	x						

Thysanoessa spp.	x

Table 29: MOCNESS frozen tissue samples for biomarker analysis.

Event	158	158	158	158	158	197	197	197	197	197	197	197	197	252	252	252	252	252	287	287	287	287	287	287	287	326	326	326	326
Net #	2	3	4	8	9	1	2	3	4	5	6	7	9	2	3	4	5	9	1	2	3	4	7	8	9	3	4	5	7
Species																													
Calanoides carinatus C5	x	x				x	x		x					x			x	x	x	x	x					x	x		
Eucalanus hyalinus C6F				x			x		x				x	x				x	x	x	x	x							
Euchaeta spp.		x					x																			x			
Metridia spp. C5																							x		x		x		
Metridia spp. C6F			x													x								x					
Nannocalanus minor C6F				x	x								x					x											
Nannocalanus minor C5																													x
Pleuromamma large sp. C5																									x				
Pleuromamma large sp. C6F		x																								x	x		
Pleuromamma small sp. C6F																x								x	x		x		
Pleuromamma sp. C6F (large?)								x	x	x					x								x						
Pleuromamma sp. C6F (small?)								x				x			x														
Rhincalanus nasutus C6F									x	x	x	x				x					x	x						x	

Table 30: Mammoth frozen tissue samples for biomarker analysis.

Zooplankton and micronekton sampling and processing: Specimen photographs

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

As a result of being unable to identify many organisms caught using the RMT25, the Nikon camera was used to photograph example specimens prior to freezing for ETS and stable isotope measurements. The camera was set up as follows:

Camera Setup: The following setup was used with the Nikon D810. Focus was set to **auto** by firstly ensuring that the focus switch on the lens was set to **M/A** (located at A on Figure 25) and then adjusting the camera focus mode to **automatic zone** (by pressing centre of button B and then rotating forward control wheel E until **Auto** appears in the top LCD window). Camera mode was set to **Manual** (by pressing MODE button G and then rotating rear control wheel F until **M** appears in top left corner of top LCD window). Shutter drive was set to **S** (single shot, set by rotating collar to S as shown at D in Figure 25). Exposure was set with aperture f/22 (by rotating forward control wheel E) and shutter speed 1/250 sec (by rotating rear control wheel F). Manual ISO 100 was set using ISO button and forward control wheel **E** to ensure changed from auto ISO to manual ISO and then using ISO button and rear control wheel **F** to set ISO 100. File size was set at high resolution TIFF using by holding QUAL button and rotating forward control wheel **E** to get L and TIFF on the left side of the top LCD display. Finally the flash sync cord was inserted into the socket **C** and flashes were set with control dial on **M1/4**.

Nikon D810 showing location of major controls used in setting up camera for krill photography

Figure 25: Nikon D810 showing location of major controls used in setting up camera for krill photography

Files and organism names: Photographs were saved to the shared drive (Table 31). Filenames are COM_10nnn.

Photograph Number	Event number	Net Number	Identified as	Comments
877	43	2	Blue salp sp	
881	43	1	Red Acanthaphyra	Possibly Aristeids
886	43	2	Red Salpa sp	
889	43	1	Fish A	Lampanyctus?
895	43	1	Decapod sp_1	Oplophoridae
899	43	1	Decapod sp_2	Sergia?
903	43	2	Diaphis hudsoni?	Fish
905	43	1	Two horned themisto	Themisto gaudichaudii
908	43	1	Amphipod_sp1	Vibillia
910	43	2	Sagitta Sp	
912	43	1	Decapod_sp3	Pretty sure juvenile Decapod_sp1
914	43	1	Amphipod_sp2	Yellow ball
916	43	1	Phronima	
919	43	2	Purple striped jelly	Later renamed to purple striped salp
921	43	1	Amphipod_sp3	Small two long antenna, typically orange
924	43	1	Decapod_sp5	Triacantha lookalike, no rostrum
927	43	1	Decapod_sp4	Long rostrum
929	43	1	Mysid_sp1	Think this is actually Sergestes
931	43	1	Mysid_sp2	As above
933	43	2	Salp_sp3	Black salp species (black spot)
935	43	1	Nectophore_sp1	
938	43	1	Nectophore_sp2	
940	43	2	Salp_sp4	Small salp, brown
942	43	1	Heteropod	
945	43	2	Polychaeta_sp1	Note yellow feet
948	43	2	Polychaeta_sp2	Looks like head end of Polychaeta_sp1
951	43	2	Clio_sp1	Pteropod
953	43	2	Hydromedusae_sp1	
954	43	2	Salp_sp5	Misty
956	43	2	Amphipod_sp3	
957	43	2	Amphipod_sp4	Oxy
960	43	2	Clio_sp2	
963	43	2	Squid 1	

964	43	2	Nectophore_sp3	
965	43	2	Squid 2	
967	43	2	Decapod_sp6	Same as sp4?
968			Photos from MOCNESS sample I believe	
983	72		Angler fish	Two horns, lure off chin
986	72		Decapod_sp7	Decapod on steroids.
989	72	1	Hatchet fish	
990	72	1	Winteria	
994	72	1	Decapod_sp8	Mohican rostrum
996	72	1	Sergestes_sp1	Actually - think this is sergia
998	72	1	Decapod_sp9	Think this is actually Sergestes (not mysid)
1000	72	1	Decapod_sp10	Possibly red acanthaphyra sp?
1002	72	1	Metelectrona	
1004	72	1	Stoma	
1009	72	1	Amphipod_sp5	
1012	72	1	Fish A	
1014			Amphipod from respoire trap	
1017	104	1	Nectophores_sp4	Yellow nectophores
1020			Polychaeta sp2	
1022	104	2	Purple striped salp	
1023			Small black salp	
1026			Heteropod	
1029			Brown tunicate	
1035	105	1	Red acanthaphyra_sp2	Note not curved rostrum
1037	105	2	Decapod_sp11	Looks like triacantha but has rostrum
1039	105		Decapod_sp12	Sergia? Same as Sergestes_sp1
1041	105		Decapod_sp13	Nobbly rostrum, same as decapod 8
1045	105		Fish_4	
1048	105		Hatchet fish	
1051	105		Angler fish	No horns
1053	105	1	Ghost fish	
1055	105	2	Decapod_sp14	Same as decapod 9 - sergestes sp.
1057	105	2	Salp_sp6	Yellowy orange body spots
1058	105	1	Jelly_sp1	Nathan took to identify

1060	105		Decapod_sp15	Aristidae - looks like 1, except white rostrum
1062	105	2	Fish_5	
1064	105	1	Polychaete_sp3	
1067	140	1	Ctenophore	
1069	140	1	Salp_sp8	
1071	140	1	Cool decapod	
1073	166	1	Squid	
1076	166	1	Lobster larvae	
1079	166	2	Salp sp 9	
1081	166	2	Fish 6	Identified as DW cardinal?
1084	177	2	Salp 10	
1086	177	2	Yellow medusae	
1088	177	2	Salp 11	
1090	177	1	Decapod 17	
1092	177	2	Fish 7	
1094	177	2	Pyrosoma sp1	
1096	177	2	Pteropod clio 2	
1098	177	2	Polychaeta sp3	
1101	178	2	Decapod 18	
1103	178	2	Decapod 19	
1105	178	2	Decapod 20	
1109	204	1	Decapod 21	
1111	233	1	Amphipod sp6 (like yellow one, hard small black)	
1113	233	1	Amphipod sp7 (small black soft)	
1115	241	1	Giant red copepod	
1118	241	1	Decapods sp 22	
1122	277	2	Crab 1	
1124	277	2	Albino decapod	
1126	277	2	decapod sp 22(should be 23)	Not sure whether recorded as this?
1128	278	1	Fish 8	Angler?
1130	278	1	Amphipod sp8	
1132	360		Gastropod	
1134	360		Salp 10	

1136	374	2	Fish 8	
1138	374	2	Fish 9	
1140	374	2	Fish 10	
1144			Decapod sp 24	
1147			Physonect 1	
1150	379		Heteropod sp2	
1156	379		Siphonophore	Abylidae
1157	379		Pteropod clio 3	
1159	379		Decapod sp25	
1161	379		Amphipod sp7	Note there is an earlier amphipod 7
1163	379		Amphipod sp8	
1165	379		Amphipod sp9	
1169	389		Fish sp 11	

Table 31: Photograph file names and descriptions

Zooplankton and micronekton sampling and processing: Diel vertical migration study

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

A series of marine snow catcher (MSC) and MOCNESS deployments were carried out on 19/06/2018 to measure diel changes in the flux of faecal pellets (FP), and compared FP produced by animals sampled in the MOCNESS, with those collected in the MSC. Deployment times were based on the acoustic data, which revealed DVM of euphausiids.

The MOCNESS was deployed twice for this purpose, once during the day, and once during the night (see table below), followed each time by four MSC deployments. On recovery of the MOCNESS healthy animals were picked and places in buckets of filtered sea water (Table 32). Where possible animals with full guts were sampled. The following were collected:

Event 427	**Event 439**
Euphausia spp. post larvae	*Euphausia hanseni*
Large calanoid copepods	*Nematocelis megalops*
Amphipods	*Calanoides carinatus*
Calanoides carinatus	*Nannocalanus minor*
Centropages and *Temora* spp.	*Pleuromamma* spp.
Polychaeta sp.4	

Table 32: Animals picked for fecal pellets

The animals were left in these buckets in the cold room (8 °C) for 12-24 hrs, following which time any FP produced were collected. FP were then photographed under the microscope, and where FP were sufficient, they were filtered onto combusted GF/F filters and dried in an oven at 50°C.

MSC were deployed following the MOCNESS deployments. After a 2 hour settling period, the MSC were drained and the base moved to the cold room. All FP were picked by eye before being photographed and put on a GFF filter as for FP from net collected animals. These filters will be analysed for particulate organic carbon (POC).

Date	Type	Time on Deck (GMT)	Night/Day	Event Number	Depth (m)
19/06/2018	MOCNESS	08:55	Day	427	0-125

19/06/2018	MSC	10:15	Day	428	100
19/06/2018	MSC	10:23	Day	429	100
19/06/2018	MSC	10:33	Day	430	60
19/06/2018	MSC	10:46	Day	431	60
19/06/2018	MOCNESS	19:00	Night	439	0-125
19/06/2018	MSC	19:58	Night	440	60
19/06/2018	MSC	20:07	Night	441	60
19/06/2018	MSC	20:15	Night	442	60
19/06/2018	MSC	20:£0	NIght	443	60

Table 33:marine snow catcher and MOCNESS deployments for DVM study

Zooplankton and micronekton sampling and processing: Technical report

Dan Ashurst[1], Anna Belcher[1], Kathryn Cook[2], Sophie Fielding[1], Nathan Hubot[2], Ryan Saunders[1], Gabi Stowasser[1]

[1]British Antarctic Survey, Madingley Rd, Cambridge, CB3 0ET, UK

[2]National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

DWNM: Learning from the issues of COMICS 1 with integrating the DWNM with the *Discovery*'s fibre optic systems, more care was taken to ensure that we had the right equipment and knowledge on board to successfully splice FO connectors together. This was particularly useful in that the DWNM fibre optic conversion housing was a lot more temperamental on this cruise. The FO bottle had to be reopened multiple times for several different reasons. FO cables routinely became twisted so that the attenuation was too great. The power cable pulled out on one occasion. This is because the deep tow cable was able to twist in the cable gland, meaning that every time the FO bottle was moved to and from the RMT25 and MOCNESS there was potential for twists to occur. Another recurring problem was the SFP coming loose from the multiplexer board. This was due to shock loads during deployment of the nets. Extra care must be taken during deployment and recovery to minimise shock loads.

Of the 3 fibres in the deep tow cable, only 1 and 3 (labelled on the junction box in the main lab) provided a successful connection. It is thought that fibre 2 has a broken link somewhere along the line, possibly as the slip ring? For deployments fibre 3 was once again used (as in COMICS 1) with fibre 1 being terminated with a connector for a back-up.

For future deployments of the DWNM fibre optic system aboard the *Discovery*, a number of design changes have been suggested. Rather than using a tubular housing, which was awkward for fault-finding and reassembly, a clear-lidded box would be preferential. This would allow assessment of the electronics without having to drain the oil from the housing and assembly would be less problematic. The use of a connector rather than a cable gland into the housing could also reduce problems caused by the wire twisting relative to the housing and would make assembly much easier. If possible, a non-oil-filled housing would be preferential as maintenance would be quicker and cleaner. This would be impractical if using a clear-lidded box however so design choices should be carefully thought through. The underwater units for both the RMT25 and the MOCNESS worked well however a couple of shock-loads on the RMT25 cross during deployments caused the power board to work loose a number of times, despite attempts to fix the board in place. Rather than risk the board working loose mid-deployment, it was decided that the underwater unit from the MOCNESS would be switched over along with the FO unit. To do this, a cable was made up that connected the RMT25 release motor to the MO2 port in the underwater. This was to avoid the motor triggering three times, which the MOCNESS underwater unit has been modified to do. This worked well and was the method used for the majority of deployments. The modification to the MOCNESS underwater unit where by the motor board – which creates the three

turns required for releasing the nets – worked well on bench tests and voltage drops indicated that it was still working during deployments, however net release, for whatever reason proved unsuccessful. Both the RMT25 and the MOCNESS were deployed with a reduced number of sensors. This was due to a time-out error occurring with the temperature a conductivity sensors when they were plugged in, causing the DWNM program to stop logging. The T&C, and depth sensor was reading random values many times. Finally, the T&C sensors were taken off and only depth and flow were left on both net systems. This error had also occurred on COMICS 1 and needs to be addressed before any further deployments upon the *Discovery*.

RMT25: The RMT25 net, for the most part, worked as expected. Deployments were as follows:

- Use fibre optic deep tow cable through aft gantry
- Ship speed, 2 knots through the water, head to wind.
- Trail cod-ends over the back end of the vessel. Ensure that first cod end is trailed as far as possible before deploying second cod end to reduce chance of tangling the nets. Check to see that cod ends are trailing correctly
- Side wires hauled up to maximum extent without g-links going on to winches
- Pick up net by moving gantry out.
- With gantry out so the nets are vertical, lower side wires together (note *Discovery* gantry and side wires do not work at the same time!)
- Bring gantry in to switch over side wires to main towing wire
- Attach side wires to G-links on ropes in square. Enough slack is needed on these lines to allow the gantry to fully extend out
- There is a lot more room for it to swing compared to aboard the JCR so extra care must be taken. Steady lines were fed through the towing bridles at the top spreader bar to reduce swing, however the RMT25 has a reasonable amount of weight behind it and still tend to swing if people holding the lines are not paying attention.
- Maximum pay out speed, up to 0.3 ms-1 depending on winch back-tension. Haul in speed ranged from 0.1ms-1 to 0.3ms-1 depending on how the net was towing through the water.
- Shallow deployments were 250m to 125m and 125m to surface, 20 minutes per net. Deep deployments were 750m to 500m and 500m to 250m, 40 minutes per net.

Recovery was also straight forward:

- Ship speed to 1.5 knots through the water
- Pull gantry with top towing bar is just above deck level (and rest of net below)
- Shackle over to side wires
- Put gantry out so net vertical, then haul in on both side wires at same time to raise net. As with on the JCR, the side wires often get stuck in the top bar, probably due to the position of the

auxiliary wires being wider that the top bar and so making the wires pull at an angle. Nothing that a large hammer and an angry scientist couldn't solve.

- Pull side wires up to maximum extent, put gantry in. Lower side wires if additional control need
- The position of the weight bar on recovery also meant that a lot more of the net still in the water. This meant there was greater possibility of the weight bar being dragged back, even when placed on the deck. A line was fed around the weight bar and onto the NMF recovery winch to pull the nets further in, allowing for a lot more room to sort the nets out. A ratchet strap was then fed round to hold the bars in place whilst people were behind them recovering the nets.
- Pull nets in using auxiliary deck winch and haul lines

The nets could be deployed with a minimum of 5 people: 2 BAS personnel in the square, a crew member driving the main winch, a crew member operating the auxiliary winches and the Boson coordinating the deployment. Recovery usually had an extra 3 people: 2 more BAS personnel in the square and an NMF winch driver to help with net-recovery.

The RMT25 was not without its problems. The quick links holding the nets to the side wires routinely got wedged into the side rollers, causing the net to jam open on one side. Luckily this only seemed to happen on the final net of the shallow deployments so samples were not compromised however it made recovery more problematic as the side line would jam. The solution to this was to tie the jammed bar to the top spreader bar and then free the quick link using a pry-bar.

The main bolt holding the side wires to the bottom weight bar came loose several times. This is a concern as these bolts are the only things stopping the entire net dropping off of the top spreader bar. This was solved by a simple check before each deployment but was still worrying.

The side wires have started to birdcage towards the top ends. This indicates that despite being attached to swivels, they are unable to rotate freely. As no wires had frayed, the side wires were still used successfully however it would be wise to look into replacing these before the next RMT25 cruise.

On recovery, the green net recovery lines often got caught with the cod ends, resulting in both cod ends being hauled in at once in a tangled mess. Care needs to be taken when rigging these lines as well as ensuring the nets are trailing freely during deployment to minimise this risk of this happening. It may also be worth adding more eyes on the net to guide the lines better.

Early on in the cruise, the motor unit stopped turning the release cams. Upon opening up the motor unit, it was discovered that the shaft coupling was fractured. This meant that the bolts were not tightening properly and the shaft was slipping. The coupling was modified to be pinned and once all the cogs were realigned the release gear worked well.

MOCNESS: For this cruise the MOCNESS should have been renamed to just NESS as the triggering system to open and close the nets was an abject failure. There wasn't a single successful deployment of the MOCNESS.

Deployment of the MOCNESS was as follows:

- Speed through the water 2 knots
- Two long steady lines to guide the top frame until it was in the water prevented it from spinning.
- Pick up frame by hauling in deep tow wire and bringing out gantry
- Lower net into water with gantry fully out
- Veer out at 0.1m/s until tension is consistently above 0.3 tonnes. Increase to a max of 0.3m/s when possible
- Once at depth, haul in at 0.2m/s

Recovery was straight forward:

- Speed 1.5 knots through the water
- Using snap hooks, attach steady lines to the top frame
- Haul in on the main wire and bring in the gantry until the weight bar is hanging above the table.
- Lower the main wire and, using the steady lines, guide the main frame on to deck.

The personnel required for deployment and recovery was 2 BAS scientists in the square, 1 deck crew operating the main wire and the gantry, 1 winch driver for winch speed throughout deployment.
Several attempts were made to fix the issues with the net release mechanism. Voltage outputs from the DWNM showed that the motor was receiving the fire command and attempting to rotate. However on recovery no nets had released. Initial thoughts were that the weight of the nets plus the drag through the water was creating too much load on the release keys, which the motor's torque couldn't overcome. To remedy this, the lengths of the release wires were changed so that only one key at a time was loaded. All the keys and the shaft were fettled and deburred. Bearings and spacers were ground back. Swaged ball ends were ground smooth. All parts of the mechanism were greased. Deck tests proved that the mechanism could release keys with up to 100kg load on them, however when in water the nets refused to fire a single net. Even when no release keys were engaged, the motor would not turn. This suggests that the motor itself is affected by the water pressure, however, exactly how it is affected is not known and requires further investigation before any further deployments.
The MOCNESS was still used for shallow deployments. All except one net was removed and the system was sent down to 125m water depth and back up with the net open for the full deployment.
Bongo: The Bongo net worked perfectly on all deployments except one. However this one failure was quite severe and resulted in the complete loss of the net.
Initial set up of the net was problematic as almost every stauff clamp on the net had seized up and made it near impossible to feed the frame poles through. It would be recommended that after each cruise, these clamps are fully removed to avoid this issue. Another problem was with orange buoys. Despite being marked as incorrect, some buoys with the clamps in the wrong positions were packed into the container. Others had damaged clamp mounts, with the helicoils half ripped out. With the spares available we were able to mount two buoys to the frame. Swaging the top eye was straight forward.

Rather than using the BAS swage press, the ship's ferrule jaws were used. A test cable was made and load tested. The cable snapped before ferrules pulled through at a load of 1.4 tons.

Programming of the Hydrobios unit worked well. As on the first COMICS cruise, it was important to ensure the "bottle" number was set to zero before deployment so as the valve mechanism turned correctly.

Deployment of the bongo was once again done from the NMF Romica winch with the ship's starboard aft-end crane. With the bongo initially horizontal, the wire from the motion compensation unit was taken up until the bongo frame was upright. This process was still as awkward as ever – trying to walk up the frame to its upright position without damaging the cod ends or having the top rings swinging around. Deployment was as follows:-

- Persons required - 1 crew member operating the crane, 1 crew member assisting in manoeuvring the net, 1 NMF winch operator, 1 person conducting set up and deployment
- Ship on DP
- Switch motor unit on.
- Ensure cod end taps are closed
- With crane in line with Bongo wire, winch haul in to take up compensation unit slack. Ensure that the top end of the net is controlled by person to avoid damage
- Once slack is taken up, keep hauling with winch and guide bongo to upright position. This requires two people to help manoeuvre
- Raise bongo so legs can pass over the bulwark
- Swing crane out till net is over the side. Persons guide net as needed.
- Pay out on winch till the swivel hits water surface.
- Pay out on winch to depth. Veer rate is dependent on how much slack is in the cable. Approx. 0.1m/s for the first 100m up to a max of approx. 0.3m/s
- Once at depth wait for a minute or two to allow the net to settle.

It's worth noting that the deployments had the valve mechanism activated by depth rather than time. Care must be taken to ensure that enough cable is paid out to reach the required depth.

For recovery:

- Haul in at approx. 0.3m/s
- When swivel breaches water surface slow haul rate
- Raise net so legs can pass over bulwark
- Bring crane in so net is suspended over deck
- Keep net in the air enough to be able to fit sample buckets under the cod ends. Hold the net whilst samples are taken. During this time, motor unit can be switched off.

- Veer out of winch till feet of net are on deck and net is standing vertically. The net can now be reprogrammed to another depth horizon if needed. It was usual to do two deployments in a row – a 125m to surface sample first followed by a 500m to 125m sample.
- If all deployments are concluded, persons pull at legs and walk net frame into stowing position as winch operator veers on the cable. Ensure person is keeping top and of net under control.

The loss of the Bongo net was during the first dip of a morning deployment. No visible signs of wear or fatigue were noticed on any part of the system and nothing out of the ordinary happened during deployment. Tensions on the winch were reading no more than 0.4 tons. The break occurred in the motion compensation wire just below where the hard eye had been swaged. It looks like the wire may have gotten wrapped around either itself or a part of the top frame when the tension came off the wire at some point during pay out. The motion compensation unit should account for this however so the actual cause is still not known. RIP Bongo. Gone but not forgotten.

Mammoth: As with COMICS 1, the Mammoth was deployed in OFFLINE mode off of the starboard P-frame on the coring warp.

Deployments is as follows:-

- Remove the front plate to gain access to the motor unit coms connector
- Plug laptop into the motor unit and pressure program as required.
- Turn off the motor unit and disconnect from the laptop. Put a banking plug on the exposed connector. **NOTE! Use a proper blanking plug and not the extension lead normally used to connect the mammoth to the JCR biowire. On our first deployment we did this and none of the nets fired and no data log was saved. It turns out that even though the motor was not connected, having a wired connector in place made it think it was still connected and prevented the motor switching to OFFLINE mode, which is essential for this type of deployment.**
- Nets are cocked in this position. Once they are cocked, the net is potentially dangerous. Ensure that the safety bar is engaged throughout the manoeuvring of the net until the last minute.
- Once net cod ends are correctly fastened to the bottom carousel, the CTD manoeuvring crane is used to flip the mouth of the net to its correct, upward looking orientation.
- From this position, the motor unit can be switched on.
- Haul in the Rexroth winches to raise the carousel off the deck, hauling in on the main wire to raise the mouth as required to reduce strain on the nets. Tag lines attached to the side wall are used to steady the carousel so that people are not standing between it and the net mouth. Tag lines to the mouth are fixed to eyes either side of the hangar door. In larger swells it is necessary to feed the line back through the eye to allow greater control of the net mouth.

- Bring out the gantry so the carousel is over the side and pay out on the Rexroth winches till the tension is taken on the carousel wires. Take car that ropes and wires don't get caught in the gaps and notches on the side wall.
- Once the Rexroth winches have enough slack, shackle over to link the green ropes tot the green ropes on the net mouth. A hooked pole may be needed to reach the side lines. Note: At this stage the net mouth will be just over the side wall and the carousel will be at least partially in the water. Ensure that the steady lines on the net mouth are taught to prevent it swinging into people as they shackle over. This is a particular concern in a swell.
- Attach a third tag line to the net mouth to spin it 90 degrees. The safety bar can now be disengaged.
- Bring out the gantry and pay out to depth at a max veer of 0.3ms-1.
- Hauling in rate at 0.2ms-1
- Part way through the cruise, one of the Rexroth winches broke down and was subsequently out of action. The carousel was rigged then to be lifted on the remaining one winch. This was actually beneficial as it made shackling over more straight forward. It may be worth reusing this method for future deployments.

As with the Bongo Open/Close net, a trigger depth, deeper than the first sampling depth has to be reached before any actions will take place. For a sampling depth of 500m to the surface, a trigger depth of 520m was chosen and 600m of wire was paid out.

Things to consider on recovery:

- The mammoth is on a swivel so may not be in the same orientation as when deployed. Make sure to rotate the net mouth until back in its start position.
- Before handling the release side of the net mouth, ensure that all the nets have fired. If not, keep hands free and try to put the safety catch back on.
- Get tag lines on to the net mouth as soon as safely possible and ensure they are taught to minimise movement. The net swings more on recovery than deployment, so it's important to keep control of it to minimise risk when shackling back over.
- Don't forget to turn off the motor unit. If there are any misfires, it is good to examine the data log to determine why any issues occurred.

In rougher weather, 4 BAS personnel as well as 2 deck crew were required for a safe deployment and recovery. This was so that there were two steady lines always on the top frame whilst others manoeuvred it for shackling over and releasing the safety bar. In fairer weather, this was less of an issue.

For multiple successive deployments, the mammoth was kept in its deployment orientation and rigged with the bars horizontal, affectionately known as the Sideways Cock. This saved the extra step of having to tip the net over, which when considering how long the CTD manoeuvring crane takes to get into

position, was a valuable time-saver. Sideways Cocks were awkward, often requiring someone on their hands and knees to complete the task.

One of the steel plates guarding the motor unit mysteriously disappeared, along with the 5mm Allen key that was used to remove it. Current thinking is that both are now at the bottom of the ocean. Although not essential, a replacement plate should be bought/made.

An additional problem arose from losing the Bongo net in that the only dummy plug that we had to fit the Hydrobios units was now at the bottom of the sea. A blanking plug was made by cutting and re-potting a connector, making sure to drill out the contacts to avoid any closed circuits keeping the unit in ONLINE mode. It is ESSENTIAL that more dummy plugs are sourced to prevent this shambles again.

Mango: The Mango net is simply the Mammoth net with 4x 100 micron mesh nets as opposed to the 300 micron nets usually used. This means it samples the same animals as the bongo would. The name derives from a portmanteau of Mammoth and Bongo – hence Mango. If nothing else, scientists are creative with their names.

The other main difference was the mesh on all the cod ends was swapped out for 100 micron mesh. Rather than swapping this over for every Mammoth/Mango deployment, Mammoths used the 100 micron mesh and then filtered to 300 microns in the lab.

Deployment of the net was identical to the Mammoth. Despite only using 4 nets, all 10 release bars were cocked, the logic being that the net system works when all 10 are cocked. Why risk the change?

Bongo MkII (aka Bingo): Like a phoenix from the ashes, the Bingo net was the culmination of necessity, ingenuity and plenty of rope. The make-shift net comprised of the top rings to the towed bongo system –slightly modified, a pair of MOCNESS cod ends – slightly modified, two spare 100 micro bongo nets, some rope, a large weight and a clever bracket made up by one of the NMF techs. Cod ends were suspended from ropes attached to the top frame so the weight was not on the nets. A large weight was suspended below the cod ends on a wire mounted to the centre of the top frame and the cod ends to keep the net in the correct orientation. The cod end bracket prevented the nets wrapping around one another. Despite being devilishly simple, the net worked very well, collecting samples in much better condition that the Mammoth net does.

Deployment, being very similar to the original Bongo, was as follows:

- Ship on DP
- Using NMF Romica winch, haul in until weight is high enough to clear Bulwark. 1 or 2 personnel required to steady the various components of the nets as it orientates itself into its correct position. The weight may swing – WATCH YOUR SHINS!
- Swing crane out until net is over bulwark and clear of the side of the ship
- Veer out on Romica winch to desired depth. This was always 125m (132m read out on the winch due to a 10% discrepancy). Veer speed dependent on the tension on the wire.

- Haul in speed 0.2ms-1

Bingo deployments normally came in pairs, both to the same depth. Recovery of the net involved getting the whole system onto the deck, including the top frame before collecting the sample. The cod end bracket would then have to be removed to be able to pour each sample into respective buckets separately. This would then be reattached for the second deployment. Care must be taken to avoid tangling ropes in this time as it can be potentially problematic if a line with the tension of the weight on it is pushing a cod end awkwardly. It is also worth noting that initial set up of the net for each deployment usually required time to untangle the lines and net. It is worth taking time to do this properly otherwise deployment can take twice as long. However, first thing in the morning untangling this can be a herculean task.

One of the nets ended up with a couple of small holes in it. It is thought it may have caught the central wire that holds the weight. Even though the wire was plastic coated, there were potential sharp areas where eyes had been formed. Both holes were patched using Araldite and 100 micron mesh.

Acoustic measurements (EK60)

Sophie Fielding (BAS)

Introduction:

The Simrad EK60 hull-mounted multifrequency echosounder was run throughout DY090 to collect information on the horizontal and vertical distribution of zooplankton and micronekton. A particular focus of DY090 is to parameterise diel vertical migration movement, and the mesoscale variability of organisms at the central carbon export stations.

System specification:

The Simrad EK60 echosounder operating at 18, 38, 70, 120, 200 and 333 kHz was run using Simrad ER60 v2.4.3 software. The .raw data files were logged and backed up at regular intervals. Raw data were collected to 1500 m at all times, except the calibration. The echosounder operated using a 3 second ping rate (to allow data collection to 1500m) and was coordinated with the ADCP and EA640 system using a KSYNC synchronisation unit.

The EK60 settings were checked according to the manufacturers calibration certificates supplied by NMF, the environmental parameters were initially set to 20°C and 34.5 PSU, and power, pulse duration and depth settings were as in Table 1.

The EK60 was calibrated on 08/06/2018 (see below) after which the EK60 was run on updated parameters (including temperature and salinity of 17.5°C and 35.5 PSU, c = 1526 m/s), as per Table 2. Note after the calibration, T5 became the 333kHz transducer and T6 was the 200 kHz in the data file, despite what is shown on the ER60 software.

During the whole cruise the drop keel was run in the up position. In general the weather conditions didn't seem to require it. Most surveys were run beam on to the wind, where the data quality seemed to be the best. Specific surveys were run and are recorded in Table 3.

Throughout the cruise the EK60 software crashed periodically (Table 4). In this case data was lost from a period up to 8 hours previously. There were no warnings, and the system looked like it was writing data files. The only way to ensure it actually was, was to look at the files sizes and creation on the file manager of the PC.

Mesoscale surveys:

The EK60 was run continuously throughout the cruise on a 3 second ping rate with data collection to a depth of 1500m. In order to parameterise mesoscale variability and the diurnal migration of organisms a dedicated survey was run.

EK60 calibration:

An acoustic calibration was carried out in 08/06/2018 in open water. The ship utilised DP to maintain position and all over the side water deposits were stopped. All echosounders were stopped, and the EK60 was self-triggered at a rate of 1 ping per second. The ships own echosounder was not switched

off. Each transducer was calibrated in turn, although all transducers were operating at the time. Standard ER60 calibration procedures were used where a relevant calibration sphere was moved through all quadrants of each transducer.

A CTD (Event 221) was undertaken on the morning of the calibration (Figure 1). Temperature and salinity were averaged from the 5m to 55 m (depth of the calibration sphere) and were 17 °C and 35.5 PSU resulting in a speed of sound constant of 1517 m/s (Kongsberg software calculation).

This was the second time the *RRS Discovery* EK60 was calibrated. Andrew Moore (NOC-NMF) had provided calculated wire lengths and winch positions to undertake a three-point calibration of the EK60 transducers. *RRS Discovery* is 100m long and 18 m wide, the EK60 transducers are located on the starboard drop-keel, and there are a number of protrusions projecting from the side of the ship. The calibration gear from DY086 was unchanged regarding line lengths (63.5 m). The fishing rod ends had been replaced with reels that worked brilliantly.

Two 30m pieces of rope were tied to a large shackle and lowered over the bow to connect the port and starboard winch locations. An additional rope was laid between the two starboard winches, outboard of the lifeboat. The fishing line (using an additional shackle as a weight between the fishing line and rope) was transferred from the port side to starboard aft winch position. Likewise, the fishing line from starboard forward was pulled aft. At the aft position, the 38.1mm tungsten carbide sphere was lowered first below a swivel, and then a shackle was used to weight the sphere further. With all fishing lines paid out to the 63.5 m mark the sphere appeared one of the transducers and was manoeuvred into the centre of the 38 kHz transducer beam. After calibration of the 38, 70, 120 and 200 kHz transducers using the 38.1mm tungsten carbide sphere, the sphere and shackle were switched with the 22mm tungsten carbide sphere and the 63mm copper sphere to calibrate the 333 kHz and 18 kHz respectively. Unable to locate either sphere on the echosounder, it became evident (on retrieval) that the 63mm copper sphere had fallen off its fishing line at the potted end.

The 22 mm tungsten carbide sphere was used to calibrated the 333 kHz, however it was challenging to get single target detections and within the space of 2 hours only 70 were obtained. As a result calibration of the 333 kHz was abandoned without uploading the calibration parameters. Given the loss of the 63 mm copper sphere, it was decided to try calibrating using already collected 38.1mm tungsten carbide data.

The winch system of NMF working well, although it is thought that much of the random scatter of targets within the beams was due to the ships movement and the depth of the sphere. Shallower calibrations should be investigated, particularly for the 333 kHz transducer. The 38, 70, 120 and 200 kHz calibrations were uploaded to the ER60 software. In the case of the 200kHz transducer this appeared to solve the loss of transducer parameters that had occurred during DY086.

Recommendations:

1. The winches worked well, except the clutch/break kept slipping. The barrels of the winch drum have too much play and so the break can slip out. They need some mechanism to keep them closer together.
2. Calibrating at 45 metres depth of the sphere leaves too much play in the wire for doing it in any conditions less than a complete mill pond.
3. The EK60 periodically crashes. It has an unidentifiable loss of data that did not occur during DY086. A re-install of the software may solve this, it isn't clear why it is occurring. Alternatively investigate the integrity of the data storage area.
4. You really really need hose reels for the cables. We have coiled as best we could but they are a little messy.

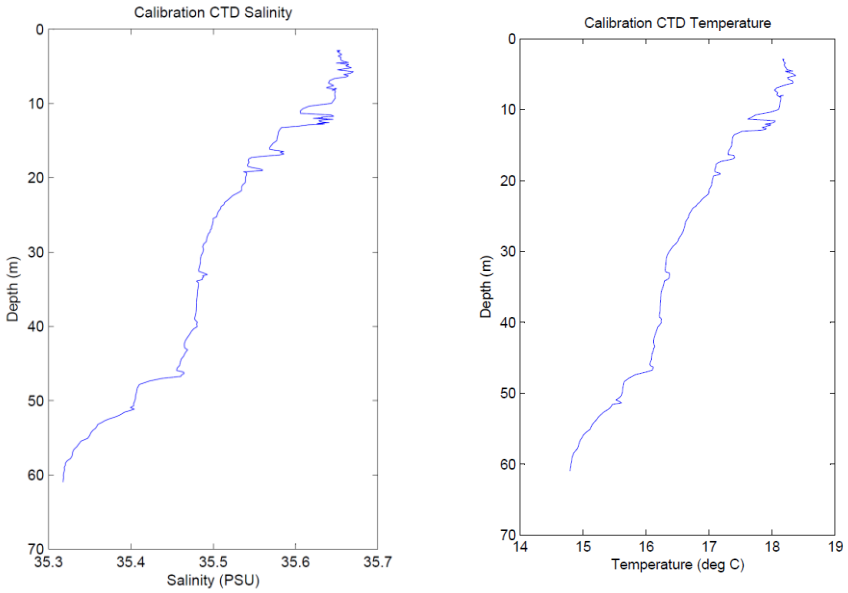


Figure 1: Temperature and salinity profiles from Event 221, calibration CTD

Table 1: EK60 initial settings

Variable	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz	333 kHz
Transducer type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Transducer Serial No.	2111	31185	258	890	533	125

Transducer depth (m)	6.6	6.6	6.6	6.6	6.6	6.6
Transceiver Serial No.	00907206dc83	00907206d08e	00907206b831	00907206ebdf	00907206b82f	00907206d0a4
Transducer power (W)	1400	1000	750	250	150	50
Pulse length (us)	1024	1024	1024	1024	1024	1024
Absorption coefficient (dB/km)	1.99	7.852	22.286	46.371	74.671	105.627
2-way beam angle (dB)	-17.1	-20.7	-20.5	-20.4	-20.3	-20.3
Transducer gain (dB)	23.10	26.11	27.0	26.94	25.48	25.10
Sa correction (dB)	-0.67	-0.66	-0.32	-0.46	-0.27	-0.64
3dB beam along (°)	10.89	6.89	6.51	6.62	6.93	6.76
3dB beam athwart (°)	10.93	6.99	6.48	6.46	6.97	6.71
Along offset (°)	-0.17	-0.13	-0.09	-0.15	0.00	-0.11
Athwart offset (°)	-0.09	-0.04	-0.02	0.02	-0.04	0.03

Table 2: EK60 calibrated settings

Variable	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz	333 kHz
Transducer type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Transducer Serial No.	2111	31185	258	890	533	125

Transducer depth (m)	6.6	6.6	6.6	6.6	6.6	6.6
Transceiver Serial No.	00907206dc83	00907206d08e	00907206b831	00907206ebdf	00907206b82f	00907206d0a4
Transducer power (W)	1400	1000	750	250	150	50
Pulse length (us)	1024	1024	1024	1024	1024	1024
Absorption coefficient (dB/km)	2.168	8.469	23.037	44.947	68.686	96.381
2-way beam angle (dB)	-17.1	-20.7	-20.5	-20.4	-20.3	-20.3
Transducer gain (dB)	23.10	25.71	27.24	26.94	26.05	25.10
Sa correction (dB)	-0.67	-0.68	-0.41	-0.37	-0.34	-0.64
3dB beam along (°)	10.93	7.07	6.45	6.63	6.92	6.71
3dB beam athwart (°)	10.89	7.17	6.65	6.67	6.63	6.76
Along offset (°)	-0.09	-0.13	-0.05	-0.16	0.06	0.03
Athwart offset (°)	-0.17	-0.10	-0.08	-0.05	-0.02	-0.11

Table 3. Mesoscale survey times

Event Num	Start date/time (GMT)	End date/time (GMT)	Comment
095	20180530 06:14	20180530 14:43	BS1 night
097	20180530 21:30	20180531 04:20	BS1 night
107	20180601 18:42	20180602 01:16	BN1
203	20180607 04:50	20180607 15:11	BN1
205	20180607 22:07	20180608 03:55	BN2

319	20180613 12:20	20180614 04:28	BN3
426	20180618 22:19	20180619 06:10	BN3

Table 4. EK60 crashes

Time	Date	Comment
23:48	28/05/18	Crashed
20:50	02/06/18	Crashed
04:28	08/06/18	Crashed
12:40	13/06/18	Crashed
11:36	18/06/18	Crashed

Table 5. Calibration parameters

Variable	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz	333 kHz
Transducer type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Transducer Serial No.	2111	31185	258	890	533	125
Transducer depth (m)	6.6	6.6	6.6	6.6	6.6	6.6
Transceiver Serial No.	00907206dc83	00907206d08e	00907206b831	00907206ebdf	00907206b82f	00907206d0a4
Transducer power (W)	1400	1000	750	250	150	50
Pulse length (us)	1024	1024	1024	1024	1024	1024
Absorption coefficient (dB/km)	3.288	10.014	18.164	26.361	39.808	72.988
Calibration sphere	38.1 mm tungsten carbide	38.1mm tungsten carbide	38.1mm tungsten carbide	38.1mm tungsten carbide	38.1mm tungsten carbide	22mm tungsten carbide
Calculated TS (dB)	-42.15	-42.40	-41.60	-39.67	-38.86	-44.30
Sphere depth (m)	51	52	53	52	51	46

RMS beam model (dB)	0.95	0.33	0.40	0.29	0.39	0.77
RMS polynomial model (dB)	0.91	0.31	0.38	0.28	0.37	0.68
Calibration applied	No	Yes	Yes	Yes	Yes	No

Report COMICS 2

General information

Name: Nathan Hubot

Date: 23/05/2018 – 28/06/2018

Location: Namibia – Benguala
current Ship: RSS Discovery

Chrysaora excretion experiments

2 specimen of *Chrysaora fulgida* collected in Walvis bay:

- Jelly 1 (Maurice): 22/05, 6.30 pm, size: approx. 12 cm
- Jelly 2 (Madelaine): 23/05, 8.30 am, size approx. 20 cm

The seawater used for the incubation came from the surface water around the ship and was filtered on the ship. The incubations were performed in the reef container at approximatively 11°C. The phosphate and nitrate measurement were provided by the Seal QuAAtro Auto-Analyser run by Mark Stinchcomb. The Ammonium concentrations were measured using the fluorescence method using OPA as reagent. The jellies were fed with the leftover of the plankton nets. However, they were starving most of the time and therefore they were losing biomass day after day.

First experiment (24/05)

No feeding before experiment. Seawater used: 0.7 µm filtered coastal water. Samples kept in the fridge and run through the QuAAtro the next day (25/05, 8pm).

Times: 30, 60, 90, 150, 210 min

Standards: 0, 2.5, 5, 10 nM

Second experiment (26/05)

Feeding before the experiment (1h), rinsed with filtered seawater (approx. 0.2µm; 30min) then incubated in 0.2 FSW.

Standards: 0, 2.5, 5, 10 nM

Third experiment (30/05)

Feeding before the experiment (1h with >100 µm zooplankton from 0-100m deep), rinsed with filtered seawater (approx. 0.2µm; 30min) then incubated in 0.2 FSW. The jellyfish was removed from incubator after 20hrs.

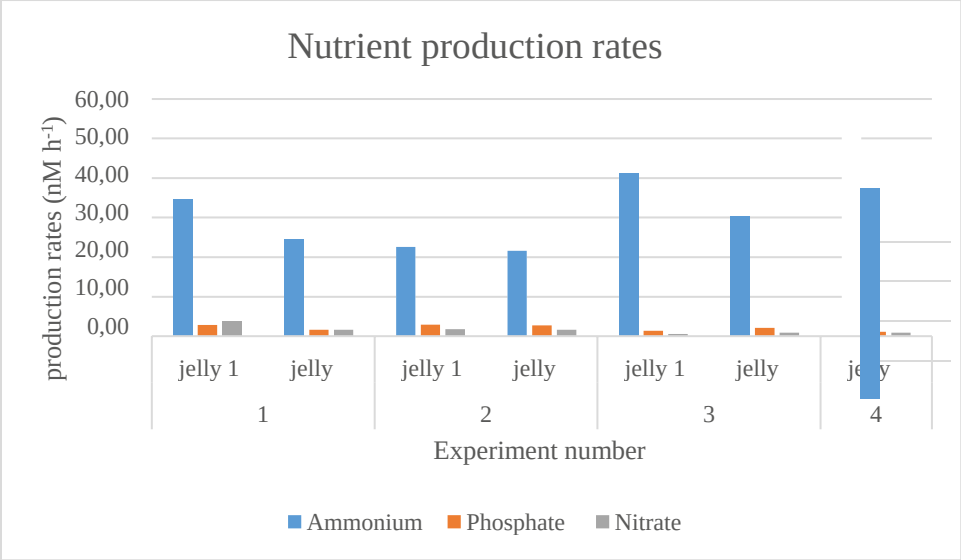
Standards: 0, 1.25, 2.5, 5, 10 nM

Fourth experiment (19/06/18)

Treatments:

- Control 1: 0.2 µm FSW
- Control 2: 0.2 µm FSW + NH4+ additions
- Treatment 1: 0.2µm FSW + jelly 1
- Treatment 2: 0.2 µm FSW + jellyfish microbial community

Results of experiments 1-4:



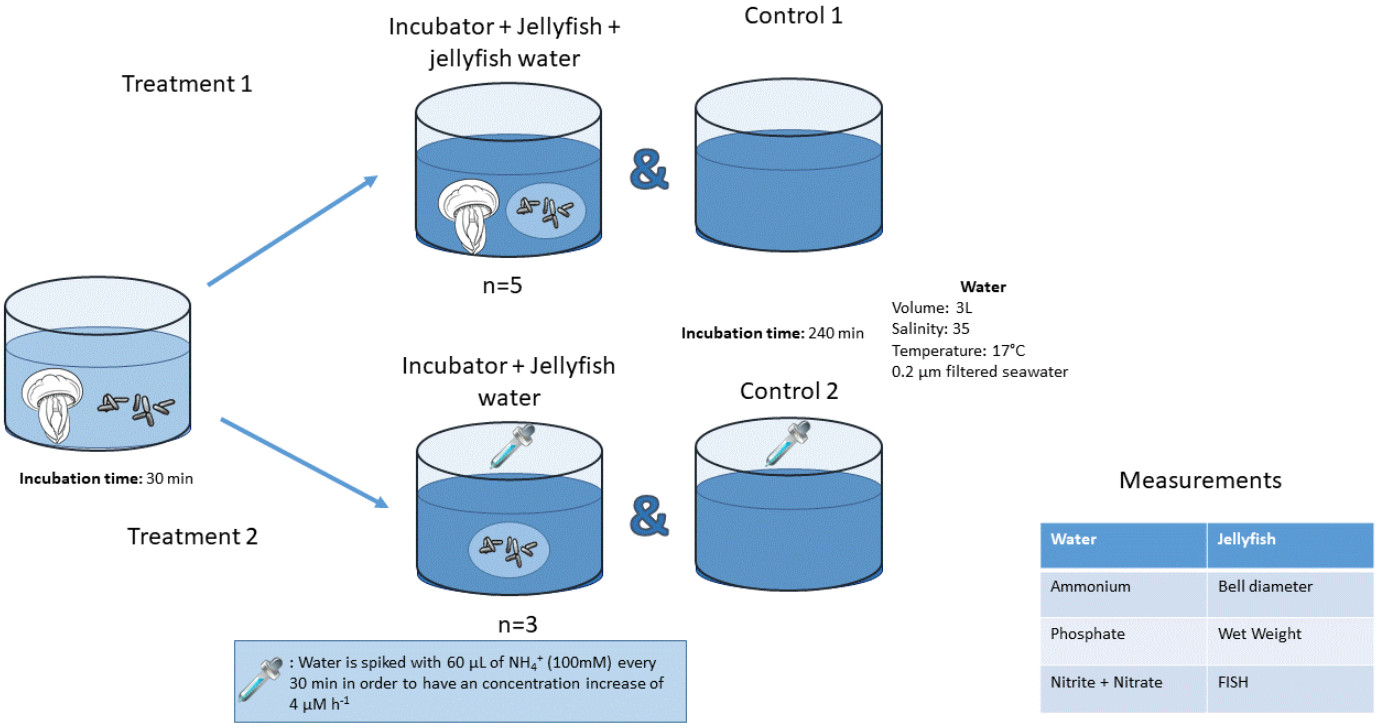
Final experiment (23/06/18)

The day before the experiment, all equipment was acid washed in 10% HCl. One specimen of the jellyfish Chrysaora fulgida were collected from the surface water of the port of Walvis Bay (Namibia) on the 23nd of June 2018 using a a bucket. The seawater was collected offshore from 1-2 m depth (BN2 station between 10 and 11 am) to prevent using water contaminated by the harbour activities. Once collected the jellyfish were transferred to a 25L bucket and incubated for 2 hr in unfiltered seawater to allow them to egest their gut content. The jellyfish were carefully transferred by hand with nitrile gloves protection in order to reduce as much as possible the transfer of nutrients and bacteria from the surrounding water. Then the jellyfish were incubated for 30 min in 0.2 µm –filtered seawater (0.2µm FSW) to decrease the concentration of surrounded POM and bacteria. Following this, the jellyfish were transferred to the incubator using a 2L graduated bucket. The first litre (without jellyfish but with micro-organisms) was transferred to a bucket for incubation (treatment 2, Fig. 1) and the remaining litre containing the jellyfish was add to another bucket (treatment 1, Fig. 1). The incubator consisted of a 5L plastic bucket filled with 3L of 0.2µm FSW.

The experiment was carried out in a 14°C temperature controlled room (same temperature as surface water). Two 10 mL samples were collected every hour, one for phosphate and one for ammonium analysis, using a previously acid washed syringe. A syringe filter is add before pouring the samples into the tubes (2x15mL Fisher polypropylene conical centrifuge tubes), in order to prevent the presence of POM and micro-organisms in the samples. The first 5mL poured out of the syringe/filter were not collected and allowed to rinse the filter tip. Different syringes were used for every treatment. After the collection of samples, 160 µL of ammonium (100mM) were add to treatment 2 in order to simulate the ammonium excretion of the jellyfish. The experimental control-1 consists of an incubator absent of jellyfish and containing only 0.2µm FSW. The control-2 consists of an incubator where the addition of the jellyfish have been mimicked by addition of 1L of water from the rinsing incubator. 160 µL of ammonium (100 mM) was added every hours to simulate the ammonium excretion from the jellyfish. The jellyfish ammonium excretion rate was estimated from a previous experiment to 4 µM h-1. After 6 hr, the jellyfish was removed but samples were still collected over 2 hr. Before collecting the sample, the water was stirred with the syringe to prevent the jellyfish from settling on the bottom and to homogenise the water. The total incubation time was 6 hr. At the end of the experiment, the jellyfish bell diameter was measured using a ruler. If the bell was not round, the average of the maximum and the minimum dimensions was used. Then, the wet weight was measured with a balance.

FISH:

After the experiment, duplicates of tissue samples from the oral arms, edge of the umbrella and the gastric pouch/gonads were collected from every replicate. The samples were then immersed in PFA (Paraformaldehyde solution) and refrigerated at 4oC for 12 hr. Then they were rinsed 3 times with 0.2 µm FSW and frozen (-20°C). Figure 1



Keeping jellyfish alive on board

Since they were collected, the jellies have been shrinking, suggesting that they were starving. Madelaine (jelly 2) died on the 28/05. Probably due to starvation and because it has been damaged when moved from one bucket to another.

Important to find the right balance between feeding and changing the water. Be careful when transferring the jellies. Using a small beaker is better than manually. It is better not to put too much food in one go. If so, water needs to be changed not long after.

Nitrification experiment

Experiment 1.1: Addition of Ammonium

- Treatment 1: 0.45µm FSW
- Treatment 2: 0.45 µm FSW + jelly bits

Concentrations of ammonium: 0, 10, 50, 500, 1000 nM

Time: 0, 3, 6, 9, 12 hr

No nitrification in the filtered seawater. Nitrification in the seawater + jelly. However, not enough to explain the rates observed during the first excretion experiments!

Experiment 1.2: Direct nitrification measurement

This isotopic method uses 14N-ammonium in order to be certain that the nitrate comes from ammonium oxidation through nitrification.

250 µL of 14N-ammonium (1mM) have been added to 500mL of water coming from the jellyfish incubator. That water has been used to fill little jars. Every 3 hours, 1 mL of mercury chlorite was added to 3 jars in order to kill the microbial community.

Times: 0, 3, 6, 9, 12 hrs
3 replicates: I, II, III

Experiment 2: Nitrification vs time and concentration

Treatments:

- Control: filtered sea water (0.2 µm)
- Jelly bits: 0.2 µm FSW + water from jelly incubator and jelly bits
- Jelly: 0.2 µm FSW + jellyfish

First NH4 addition: 15 µL of NH4+ (100mM) to reach 500 nM at t1 Second NH4 addition: 300 µL of NH4+ (100mM) to reach 10 µM Duration: 24hr

Standards: 1) 50, 100, 500, 1000 nM

2) 0.5, 1, 5, 10 µM

Jelly removed after t11 (9.20 pm)

Experiment 3: Dead jelly

The Chryaosra sp. catched by the RMT 25 during event 374 was incubate in 0.45µm FSW and 300 µL of ammonium (100mM) was added to reach a concentration of 10 µM. After, 135 min (t3) the jellyfish was removed and the water still monitored for 3 hours.

Experiment 4: Dead jelly 2

This time, nutrient concentrations were monitored during one hour prior the addition of ammonium and 3 hours after the removal of the jellyfish. Water samples were taken every 30 min. Experiment duration: 7h

Sinking particles

Egested particles

Temperature: 10.6°C, distance: 19cm

1: medium size: 83s -> 14 cm/min

2: large: 39s -> 29 cm/min

3: medium but dense: 31s -> 37 cm/min

4: large but loose: 33s -> 34 cm/min

5: medium very loose: 46s -> 25 cm/min

6: very small: 147s -> 8 cm/min

Jellyfish bits (oral arms)

Temperature: 11°C, distance 19cm

1: approx. 5mm

2: approx. 7mm, 37s

3: approx. 6mm, 30s

Salp feco-pellets

Temperature: 11°C, distance 19cm

1: 10s -> 114 cm/min; Chambre 6

2: 13s -> 88 cm/min; Chambre 5

3: 14s -> 81 cm/min; Chambre 7

Respiration rates

- Egested particles
  - Chambre 1: 3.18 nmol/s
  - Chambre 2: 3.74 nmol/s
  - Chambre 3: 6.29 nmol/s
- Jelly bits
  - Chambre 1: 6.35 nmol/s
  - Chambre 2: 8.65 nmol/s
  - Chambre 3: 6.10 nmol/s
- Feco-pellets
  - Chambre 1: 1.39 nmol/s
  - Chambre 2:
  - Chambre 3:

Salp experiment

First experiment (9/06):

32 individual collected from the Bongo net at 12.30. All gonozooids of the species Salpa maxima.

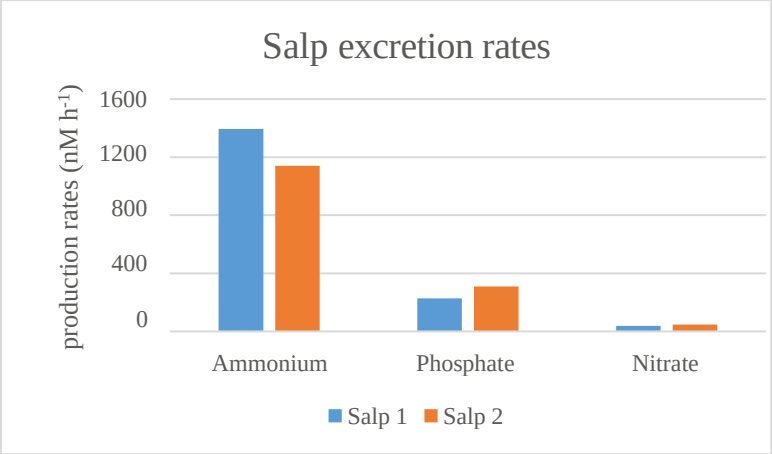
Treatments: control, salp 1 (n=16, WW=55.95g), salp 2(n=16, WW=61.30g).

Temperature: 11°C

Start: 19.20

Standards: 0, 2, 4, 6, 8 µM

Results:



Gelatinous zooplankton identification

28/5: Event 70 MOCNESS – net 1

5 Atolla: 1 *A. russeli* + 3 *A. wyvillei* + 1 *Atolla* sp. (too damaged) Trachymedusa : 2 *Halicreas minimum*
Narcomedusa: 1 *Pegantha triloba* (previously misidentified as *Cunina globosa*!) 28/5: Event 72 – RMT25 – Net 2

Trachymedusa: *Halicreas minimum* (without mesoglea)
Anthomedusa: *Moerisa* sp. ??? (not sure) Scyphomedusa:
Coronata: *Periphylla periphylla*

31/05: Event 104 – RMT25 – Net 2

Brown ring salp: Cyclosalpinae: *Cyclosalpa pinnata*
Yellow calycophoran Siphonophore (anterior nectophore): *Diphyes dispar*

Event 105 – RMT25 – net 1

Siphonophore: maresearsia praeclara
Periphylla periphylla
Colobonema sericeum (jelly sp. 1: hemispherical, strong musculature)

3/06: Event 140 – Mocness - net 1

Beroe cucumis
Orchistoma pileus

5/06: Event 177 – RMT25 - net 2

7x Salp sp. 2
Scyphomedusa: coronate: *Nausithoe punctate*

7/06: found on the fishing line of Kev

Siphonophore: Cystonectae: *Rhizophysa* sp.

Event 374 – RMT 25 – net 2

Chrysaora sp. (used for dead jelly experiment)
Zygocanna vagans

Event 380 – RMT – net 1

Euphysora gigantea

Jelly-net deploying

1) 30/05 – 3.30 am – Event 9x - 2133.49S; 927.982E – 100m: Catched 5 little blue salps (not used)
2) 05/06 – 9.00 am – 18 1.442S; 11 0.793E – 150m: Nothing interesting
3) 05/06 – 9.30 am - 18 1.442S; 11 0.793E – 150m: Nothing interesting
4) 08/06 – 8.30 am (event 209) – 18 1.235S; 11 0.493E – 150m: catch a ctenophore: beroe sp.
5) 08/06 – 9.00 am (event 210) – 18 1.326S; 11 0.509E – 200m: catch *Pegantha triloba +Aquorea pensilis + Pegantha rubiginosa*
6) 08/06 – 9.30 am (event 211) – 18 1.509S; 11 0.542E – 220m: Nothing interesting
7) 08/06 – 10.10 am (event 212) – 18 1.609S; 11 0.560E – 220m: catch a ctenophore: beroe sp.
8) 08/06 – many manual deploying (front the front deck: vertical; from the lower deck: horizontal). No success
9) 11/06 – 8.10 am (event 266) – 18 1.186S; 11 0.495E – 220m: 8x *liriope tetraphylla* (trachymedusa), tube anemone larva, Ctenophore: Cydippida: *Pleurobranchia pileus*, unidentified trachymedusa (maybe *Haliscreas conica*)
10) 11/06 – 8.40 am (event 267) - 18 1.186S; 11 0.495E – 220m: 5x *liriope tetraphylla* (trachymedusa), 6x *Aequorea pensilis* (leptomedusa), pteropod: *Cymbulia peronii*, 2x old nurse (oozooid) of doliolid, 2x *Pyrosoma aherniosum*.
11) 11/06 – 9.20 am (event 268) - 18 1.186S; 11 0.495E – 220m: 6x *liriope tetraphylla* (trachymedusa), 2x *Aequorea pensilis* (leptomedusa), *Pyrosoma atlanticum*, salp: *Ritteriella retracta*, *Orchistoma pileus* (Trachymedusa)
12) 11/06 – 9.45 am (event 269) - 18 1.186S; 11 0.495E – 220m: 2x *liriope tetraphylla* (trachymedusa), siphonophore: *Chelophyes appendiculata*, 3x *lensia* spp.
13) 18/06 – 10.00 am (event 404) – 18 1.396S; 11 0.620E: Liriope tetraphylla
14) 18/06 – 10.30 am (event 405) – 18 1.396S; 11 0.620E: nothing interesting!

Notes

Species to remember:

- *Cymbulia peronii* (Soulier de venus) – Pseudothecostomous Pteropod (with pseudo-conch)
- *Phronima* sp. (Tonnelier de mer)
- Siphonophores : calycophorans, physonects and pyrosomes

Planktonic foraminifera, sea water iodine speciation and oxygen isotope composition

Helge Winkelbauer (Heriot-Watt University)

Introduction

Iodide/calcite (I/Ca) ratios in marine carbonates (e.g. foraminifera) are believed to reflect the oxygen concentration in the seawater during calcite formation (Lu et al. 2010). Iodate is the prevailing iodine species in oxygenated waters and is incorporated into the crystal lattice of calcite. In oxygen minimum zones (OMZ) iodate is reduced to iodide, which cannot be incorporated into calcite. Planktonic foraminifera, which form calcite at various depth in the upper 1000 m of the water column, may be valuable archives of the oxygenation state in the past (Lu et al. 2016). In order to improve our knowledge of the connection between iodine speciation and foraminiferal I/Ca ratios water samples for iodate, iodide and stable oxygen isotopes were collected from 1000 m CTD casts (and two full range CTD casts) and foraminifera specimens were collected via plankton nets during the COMICS 2 cruise across different depth strata.

Iodate, Iodide and $\delta^{18}O$ water samples from CTD casts

Water samples from 10 to 12 depth from stainless steel CTD casts were collected and the filtrate collected after filtration through a 47 mm diameter 0.2 µm Nucleopore™ polycarbonate filter. Details of the sites sampled, specific CTD casts, Niskin bottles sampled and nominal depths are given in Table 1. For the iodate and iodide analyses after the cruise, the filtrate was filled into two 50 mL centrifuge tubes and subsequently frozen at −20 °C. The $\delta^{18}O$ water samples were stored in 8 mL HDPE bottles at 4°C.

Table 1: Water samples from CTD casts for Iodate, Iodide and $\delta^{18}O$ analyses.

Date	Site	Event	CTD cast	Niskin Bottle	Nominal Depth (m)	Variables sampled
24/05/18	Test	001	001	3, 4, 6, 9, 10, 12, 14, 16, 19, 21, 24	1000, 750, 450, 260, 200, 120, 80, 70, 35, 15, 6	Iodate, Iodide
27/05/18	BS1	046	004	1, 2, 4, 8, 11, 14, 16, 17, 18, 19, 21, 24	1000, 750, 450, 250, 200, 120, 80, 70, 60, 50, 30, 6	Iodate, Iodide
29/05/18	BS1	075	007	1, 2, 4, 6, 8, 11, 14, 15, 17, 20, 21, 24	1000, 750, 450, 380, 300, 200, 120, 80, 62, 57, 30, 6	Iodate, Iodide, $\delta^{18}O$

Date	Site	Event	CTD cast	Niskin Bottle	Nominal Depth (m)	Variables sampled
31/05/18	BS1	098	009	2, 4, 8, 10, 12, 14, 16, 17, 20, 22, 24	3970, 3500, 3000, 2000, 1000, 450, 250, 165, 85, 65, 6	Iodate, Iodide, $\delta^{18}O$
04/06/18	BN1	148	013	1, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24	1000, 700, 500, 400, 285, 245, 150, 80, 50, 40, 25, 5	Iodate, Iodide, $\delta^{18}O$
07/06/18	BN1	199	018	1, 3, 6, 7, 9, 11, 13, 15, 17, 18, 19, 21, 24	1000, 700, 500, 420, 350, 250, 120, 75, 60, 27, 22, 13, 5	Iodate, Iodide, $\delta^{18}O$
09/06/18	BN2	228	020	2, 4, 7, 10, 12, 14, 16, 18, 20, 22, 24	750, 430, 360, 235, 125, 70, 45, 18, 8, surface	Iodate, Iodide, $\delta^{18}O$
11/06/18	BN2	261	024	2, 4, 6, 7, 10, 12, 14, 16, 18, 20, 22, 24	1000, 750, 500, 460, 320, 250, 100, 70, 35, 24, 15, 5	Iodate, Iodide, $\delta^{18}O$
13/06/18	BN2	310	026	2, 4, 6, 8, 10, 11, 14, 16, 18, 20, 22, 24	1000, 750, 580, 480, 400, 325, 150, 90, 40, 18, 9, surface	Iodate, Iodide, $\delta^{18}O$
15/06/18	BN3	342	028	1, 2, 6, 8, 12, 14, 16, 18, 20, 22, 24	1000, 700, 425, 320, 250, 180, 125, 60, 40, 27, 5	Iodate, Iodide, $\delta^{18}O$
17/06/18	BN3	383	031	2, 4, 5, 8, 10, 12, 14, 16, 18, 20, 22, 24	1000, 750, 500, 400, 325, 250, 200, 100, 35, 26, 12, 5	Iodate, Iodide, $\delta^{18}O$
20/06/18	RS	449	035	2, 5, 8, 10, 12, 14, 16, 18, 20, 22, 24	3590, 3453, 3000, 2000, 1400, 1130, 560, 250, 140, 40, 6	Iodate, Iodide, $\delta^{18}O$

Foraminfera sampling from plankton nets

Planktonic foraminifera were collected from the two Bongo nets used on the cruises, the modified Mammoth multiple open and closing net and the MOCNESS (Table 2). Details of the different nets are given in the relevant Zooplankton sampling cruise reports. The foraminifera samples were rinsed with pH-adjusted MilliQ (pH ~8.5-9) to remove saltwater residue and then either oven dried at 40 °C for inorganic iodine analysis or frozen at −20 °C for organic iodine analysis.

Table 2: Overview of all Foraminifera samples taken.

Date	Site	Event	Net	Depth interval	Mesh size [µm]	Dried/Frozen
25/05/18	Test	8	Bongo	175 m – unknown	100	Dried
27/05/18	BS1	51	Bongo	450 m – 120 m, 120 m – surface	100	Dried
30/05/18	BS1	96	Mammoth	750 m – 500 m, 500 m – 250 m, 250 m – 125 m, 125 m – surface	100	Dried
02/06/18	BN1	118	Bongo2	125 m – surface	100	Dried
02/06/18	BN1	118	Bongo2	125 m – surface	100	Dried
05/06/18	BN1	176	Bongo2	120 m – surface	100	Dried
05/06/18	BN1	176	Bongo2	120 m – surface	100	Dried
06/06/18	BN1	188	Bongo2	120 m – surface	100	Dried
06/06/18	BN1	189	MOCNESS	120 m – surface	330	Dried
06/06/18	BN1	190	Mammoth	750 m – 500 m, 500 m – 250 m, 250 m – 125 m, 120 m – surface	100	Dried
08/06/18	BN1	214	Bongo2	120 m – surface	100	Dried
09/06/18	BN1	232	Bongo2	120 m – surface	100	Frozen
10/06/18	BN2	253	Mammoth	750 m – 500 m, 500 m – 250 m, 250 m – 125 m, 120 m – surface	100	Frozen
12/06/18	BN2	294	Bongo2	120 m – surface	100	Frozen
12/06/18	BN2	294	Bongo2	120 m – surface	100	Frozen
14/06/18	BN3	325	Bongo2	120 m – surface	100	Frozen
14/06/18	BN3	337	Mammoth	750 m – 500 m, 500 m – 250 m, 250 m – 125 m, 120 m – surface	100	Frozen
16/06/18	BN3	372	Bongo2	120 m – surface	100	Dried
18/06/18	BN3	409	Bongo2	120 m – surface	100	Dried
18/06/18	BN3	422	Bongo2	120 m – surface	100	Dried

Lu, Z.; Hoogakker, B. A.; Hillenbrand, C. D.; Zhou, X.; Thomas, E.; Gutchess, K. M. et al. (2016): Oxygen depletion recorded in upper waters of the glacial Southern Ocean. In *Nature communications* 7, p. 11146. DOI: 10.1038/ncomms11146.

Lu, Zunli; Jenkyns, Hugh C.; Rickaby, Rosalind E.M. (2010): Iodine to calcium ratios in marine carbonate as a paleo-redox proxy during oceanic anoxic events. In *Geology* 38 (12), pp. 1107–1110. DOI: 10.1130/G31145.1

Acknowledgements

This cruise was made possible by the excellent services provided by Captain Jo Cox and her team aboard *RRS Discovery*. The cruise would not have been possible without the support of the National Marine Facilities technicians, Debbie Yarrow (Ocean Biogeochemistry and Ecosystems, NOC) and colleagues at the Namibian Ministry of Fisheries and Marine Resources (in particular, Anja van der Plas).

Funding for the ship time and majority of cruise programme was provided by NERC Large Grant NE/M020835/1. Funding for the glider work was provided by ERC Consolidator Grant 724416.