National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre
Cruise Report No. 61
RRS Discovery Cruise 103

21 JUNE – 10 JULY 2019

Water column and seafloor time-series studies at the Porcupine Abyssal Plain Sustained Observatory

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ABSTRACT

RRS Discovery cruise 103 departed Southampton late afternoon on the 21 June. DY103 operated in the Porcupine Abyssal Plain Sustained Observatory area (48°50´N 016°30´W) from the evening of 24th June – 6th July (with a 3 day loss to science due to a medivac into Cork from midnight 25th June to 9pm Friday 28th). DY103 then returned to Southampton 10th July 2019, a day later than scheduled. The overarching goal of the cruise was to continue various time-series observations of the surface ocean, water column, and seafloor at the site, as first studied by NOC (then the Institute of Oceanographic Sciences) in 1985. The specific objectives of the cruise were to recovery and redeploy, or service, three mooring systems (PAP1, PAP3, Bathysnap), and conduct a range of water column and seafloor observation and sampling operations. This cruise was a contribution to the Climate Linked Atlantic Section Science (CLASS) project supported by the UK Natural Environment Research Council (grant number NE/R015953/1).

The PAP 1 mooring, a Met Office (Balmoral ODAS) buoy and Autonomous Sensor Platform (ASP) suspended 30 m below the surface buoy, was successfully retrieved just prior to the medivac. It was fully serviced and redeployed on the 3rd July. The PAP 3 mooring, a sediment trap, microcat and current meter string, was successfully deployed and recovered, including colonisation substrata and larval traps for the on-going LO3CAted (Larval Occurrences in Open Ocean: Connectivity studies in NE Atlantic and Mediterranean Sea) project. The Bathysnap seafloor time-lapse camera mooring, and associated LO3CAted samplers from JC165, were also successfully recovered. However, this was only possible by a rescue mission with the HyBIS vehicle. The Bathysnap from DY077 was still not responding, despite an attempted HyBIS rescue mission, and this is now presumed lost. Two short-term (1-2 day) amphipod trap mooring deployments were also successfully carried out during the cruise.

A series of water column observation and sampling operations were successfully carried out with a CTD instrument package and water bottle rosette, and vertically hauled zooplankton nets. The former including pre- and post-deployment calibrations of PAP 1 sensors. Seafloor sampling operations were successfully carried out with a Megacorer and otter trawl, yielding samples for a broad range of subsequent analyses (eDNA; prokaryotic and viral dynamics; biogeochemistry; microplastics; metazoan meiobenthos; macrobenthos; megabenthos; biochemistry and microbiome studies of selected megabenthic taxa). A programme of seafloor survey photography was also undertaken using the HyBIS vehicle, assessing the seafloor environment and associated fauna of the abyssal plain. A further sediment trap mooring (with ADCPs and microcats) was deployed in the Whittard Canyon, as an additional component of the CLASS project, on the return passage to Southampton.

KEYWORDS

Porcupine Abyssal Plain, Whittard Canyon, Ocean Observation, ICOS, EMSO, Biogeochemistry, CTD, time series

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1. Personnel

Scientific personnel

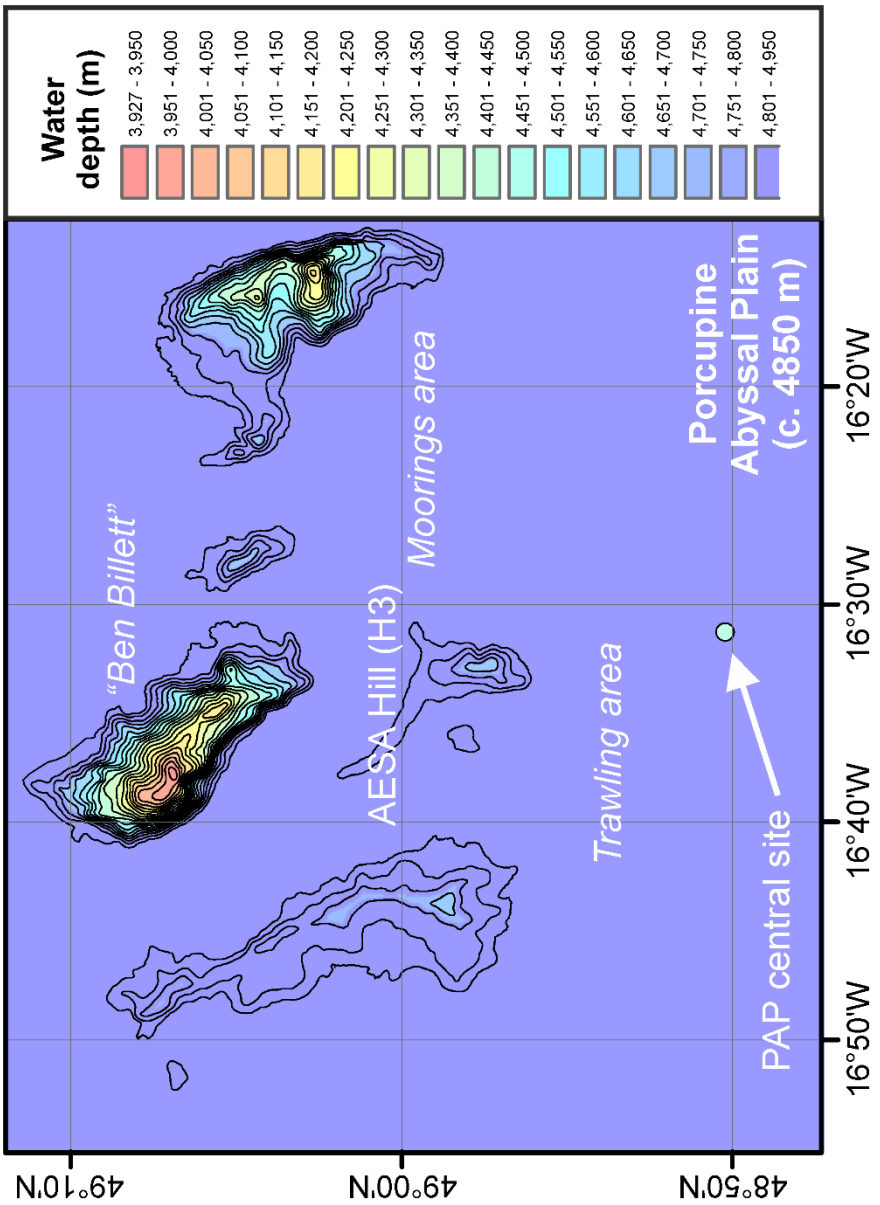
HARTMAN	SUSAN ELIZABETH	PI, NOC
BETT	BRIAN JAMES	Scientist, NOC
GATES	ANDREW RUSSELL	Scientist, NOC
THEETAERT	HANNELORE ANTONINE ROSA	Scientist, VLIZ
PEBODY	CORINNE ANNE	Scientist, NOC
CARDWELL	CHRISTOPHER	Scientist, NOC
CAMPBELL	JONATHAN MICHAEL	Scientist, COD
BIRD	KIMBERLEY ELIZABETH	Scientist, MBA
DOUGLAS	CLARA CELESTINE	Scientist, NOC
FERNANDEZ RODRIGEZ	VANESSA	Scientist, POGO
VALLS DOMEDEL	GEORGINA	Scientist, NOC
SAMUEL	ROBYN MAIRIN	Scientist, NOC
SMITH	PHILIP MARTIN	Scientist, NOC
BENOIST	NOELIE	Scientist, NOC
EAST	HANNAH LOUISE	Scientist, NOC
MORTIMER	TOBY JOE THOMAS	Scientist, Portsmouth
MCGARRY	EMMY	Scientist, NOC
ROBERTS	CORDELIA	Scientist, MBA
YOUNG III	CURTIS ROBERT	Scientist, NOC
DURDEN	JENNIFER	Scientist, NOC
WYNAR	JOHN BASIL	Tech, NOC
WHITTLE	STEPHEN PAUL	Tech, NOC
RUNDLE	NICHOLAS JAN	Tech, NOC
POOLE	BENJAMIN GEORGE	Tech, NOC
LOCKE	RUSSELL ANDREW	Tech, NOC
MCDONAGH	STEPHEN JOSEPH	Tech, NOC
POWELL	TIMOTHY	Tech, NOC
WHITE	MICHAEL	Tech, NOC
PLATT	WILLIAM	3333Tech, NOC
BRIDGER	MARTIN JOHN	Tech, NOC
OLDRIDGE	HELEN ELZABETH	Tech, NOC

Ship's personnel

GATTI	ANTONIO	Master
OVENDEN	ROBERT JOHN	C/O
LEGGETT	COLIN JAMES	2/O
STRINGFELLOW	GRAHAM ROBERT	3/O
BILLS	JAMES	C/E
KEMP	CHRISTOPHER MARTIN	2/E
LONGWORTH	TAYLOR	3/E
ROONEY	SEAN ROBERT	3/E
FISHER	CHARLES GEORGE	ETO
FORBES-SIMPSON	VALERIJA	Purser
MACDONALD	JOHN	CPOS
MACLEAN	ANDREW	CPOD
SPENCER	ROBERT GEORGE	POD
EDWARDS	BARRY	SG1A
DWYER	ANDREW	SG1A
GILFILLAN	CRAIG ROSS	SG1A
DEVITT	CHRISTOPHER GERARD	SG1A
SPROUL	BRYAN STEVEN	ERPO
CAINES	DARREN ALDOUS	H/Chef
LEIGH	MICHAEL WAYNE	Chef
PIPER	CARL	Stwd
WILLIAMS	DENZIL	A/Stwd

2. Itinerary

Sail NOC, Southampton, UK 21 June 2019.
Operations at the Porcupine Abyssal Plain Sustained Observatory, 24 June-25 June, then 28 June to 6th July following a detour to Ireland for a medivac. Dock NOC, Southampton, UK 10 July 2019



General chart of the Porcupine Abyssal Plain Sustained Observatory operations area for RRS Discovery cruise 103, indicating selected locations referred to in this cruise report.

3. Objectives

The overarching goal of RRS *Discovery* cruise 103 was to continue various time-series observations of the surface ocean, water column, and seafloor at the Porcupine Abyssal Plain Sustained Observatory site, as first studied by NOC (then the Institute of Oceanographic Sciences) in 1985. The specific objectives of the cruise were to recovery and redeploy, or service, three mooring systems (PAP1, PAP3, *Bathysnap*), and conduct a range of water column and seafloor observation and sampling operations.

4. Narrative

Friday 21st June. All on board for an early start on the solstice, however sailing was postponed until 16:45 as a result of problems with the ship's alarm systems. Had a ship familiarisation talk then spent the time setting up the labs and securing everything ready to leave.

Saturday 22nd. 1st morning on board. Everyone settling into new routines including emergency muster (lifeboat) drill followed by a science meeting and a chance to introduce ourselves. We have new staff, students and many trainee techs on board but also some old hands. Ship's time (and science time) changed to GMT (UTC) in the night.

Sunday 23rd. A little rain, some swell and grey seas. Looks like we will be well fed this trip. Had a shallow cast on the way out to PAP to test the CTD and train up the samplers.

Monday 24th. Arrive at the PAP site in the early hours for a deep CTD cast and test of the releases. All looked well with the PAP1 buoy. Last year's *Bathysnap* talked but didn't release, though the 2017 one is not responding. Spent the rest of the afternoon doing ship 'Pirouettes' near, but not around, the buoy, to assess air flow at anemometer (for comparison with the Met Office readings on the buoy). Megacores through the night.

Tuesday 25th. Transit to the PAP1 site for recovery of the surface buoy and 30 m frame. A 200 m CTD cast in the afternoon was used to test the PAP1 instruments that will be deployed this year. Then HYBIS was deployed at the coring site to take images of the seafloor, before we started a transit to Cork at midnight for a medivac.

Wednesday 26th. A rough night but work continued on the transit to Cork, as the PAP1 instruments were removed and data downloaded. The PML underway CO_2 system was successfully fixed using the dryer from the NOC system. It will run alongside the various underway carbonate systems installed for DY103 from OTEG and VLIZ. We had another emergency muster drill in the afternoon. Some pigeons took refuge on-board, waiting for land.

Thursday 27th. En route to Cork, the non-toxic seawater supply was switched off at 1pm (and resumed at 4pm) so all underway carbonate systems had to be shut down. Successful boat transfer of one crew member and one scientist ashore, and head back out to PAP. The PAP3 traps were prepared ready for deployment on Saturday and 2 OTEG carbonate systems were set up on the CTD frame.

Friday 28th. Our arrival back at PAP was further delayed as we headed into the wind. Arrived at 9pm for Megacorer sampling through the night. In total we had lost 3 days of science at the site, coupled with a days delay at the start.

Saturday 29th. HyBIS was deployed in the early hours for a rescue mission on the DY077 *Bathysnap*, but it wasn't found. A calm and sunny day with a successful deployment (and then immediate triangulation) of the PAP3 sediment traps. The 1st amphipod trap was deployed, then a 100 m CTD cast was used to validate the recovered ODO microcats. This was followed by a night of coring and some zooplankton nets.

Sunday 30th. A calm and sunny start to the day for the search and successful release of the JC165 PAP3 mooring. A deep CTD in the afternoon was followed by a single Megacore station and zooplankton nets around midnight followed by HyBIS. A small petrel sheltered on board.

Monday 1st. The overnight HyBIS mission to recover the JC165 Bathysnap was successful and the camera frame came on-board smoothly, in very calm conditions. Exceptional team work by NMF and the crew, despite being a man down. The amphipod trap was recovered, accompanied by sightings of pilot whales and a sun fish. A shallow (100 m) CTD was used to test 3 of the microcats. Two of the leaking Niskin bottles had to be replaced before the afternoon deep CTD cast. This was followed by 2 overnight Megacores and the 3rd set of midnight zooplankton nets.

Tuesday 2nd. Many tired people today as we try to fit our science into the last few days available on site. This included an almost immediate turnaround and morning deployment of the amphipod trap. The afternoon deep CTD cast was lengthened by long stops to help decipher data from the new OTEG sensors. We also had a large nutrient sampling and preservation inter comparison. PAP1 was moved into position for final preparations before deployment tomorrow. Overnight HyBIS mission, northwards across previous trawl tracks.

Wednesday 3rd. Sat on the PAP1 station all morning making last minute checks. Midday zooplankton net. Perfect weather for the mid-afternoon deployment of PAP1, with blue calm waters and some sunshine. This was followed by recovery of the amphipod trap, which was sorted as the sun set. We then moved on to an overnight HyBIS mission.

Thursday 4th. Another sunny day, quite unusual for the PAP site. A deep CTD for full profile resolution then a midday net. Slow run to PAP1 with starboard retractor under surveillance. Met sensor calibration at the site, then on to the trawl site over 2 hours away. A work around was found for the deck winch then the trawl net was deployed for an overnight run.

Friday 5th. Another calm sunny day for the trawl coming in. The catch kept the benthic group busy sorting until after dinner. Had a shallow calibration cast near the PAP1 buoy in the morning followed by a midday net. A deep CTD cast in the afternoon for final samples and calibration of microcats. A second trawl through the night.

Saturday 6th. After retrieving the trawl net, sample sorting started again but was over by 4pm. In the meantime the *Bathysnap* was deployed and reached the bottom but started to come up to the surface again. It was spotted in the calm seas and redeployed again, and after ensuring it was on the bottom we moved to the HyBIS site for a north and southbound overnight survey. The underway NOC carbonate system is now up and running.

Sunday 7th. Left PAP early as the HyBIS survey had finished by 3am. The crates were out early and some systems were being packed away but there was still lots of analysis to do throughout the day. Some whales seen very close up to the ship and they were undeterred by the swath bathymetry equipment that was on for the run up to Whittard Canyon. The equipment was switched on after an hour of seeing no whales to be on the safe side.

Monday 8th. An early morning bathymetric survey around Whittard Canyon deployment location, then the CLASS sediment trap was deployed, and triangulated, before breakfast. A day of clearing away, cruise report writing, and last underway sampling, was followed by a fun evening quiz.

Tuesday 9th. Non-toxic seawater supply switched off around 8am, underway CO_2 systems then switched off. Arrived 6pm at NOC and demobilisation started early on Wednesday morning.

suh

Photo of some of the DY103 participants

5. NMF technical report introduction

Technical Team

Sensors & Moorings:

John Wynar	CTD Pilot
Tim Powell	Trainee CTD Pilot
Steve Whittle	Moorings Coordinator
Nick Rundle	Senior Technical Officer

MARS

Russell Locke	HyBIS Pilot
Stephen Mcdonagh	HyBIS Pilot

Ship Systems:

Martyn Bridger	Technician

Ocean Engineering Group

Ben Poole	Technician
Mike White	Trainee Technician

Introduction

This year's slimmed down PAP cruise is lighter on number of deployable items similar to last year, but with less time on the work site. Many of the usual scientists and associated equipment deployed on the PAP research cruise have been utilised for the CUSTARD cruise later in the year or are temporarily not available in the equipment pool. The main focus for the NMF technical team was to turn around the PAP 1 and PAP 3 moorings, with supporting CTD calibration deployments, deploy HyBIS, deploy and retrieve amphipod traps and support trawling, nets and coring as needed. The individual group reports for each technical discipline are collated in this report. Additionally, a rescue mission was successfully undertaken to recover an unresponsive *Bathysnap* and if possible return to the seabed for another year.

Moorings

The PAP 1 mooring is a collaboration between four organisations, NMF, OBE, The Met Office and OTEG. Overall design, development and deployment of the physical system is the responsibility of the Sensors and Moorings (S&M) team within the National Marine Facilities (NMF). The surface buoy (a Balmoral ODAS buoy) complete with meteorological sensors is currently supplied by the Met Office. Ocean Technology and Engineering Group (OTEG) with extensive support from Campbell Ocean Data (COD), look after the Electronics and communications hub and real-time data stream as well as occasional trial sensor deployments. The specifications and scientific data are provided by and for the customer; Ocean Biochemistry and Ecosystems (OBE). This year a collaboration with Dynamic Load Monitoring (DLM) has also seen the inclusion of a tensile link above the sensor frame to help understand the dynamic behaviour of the system.

The mooring is over 6.5 km in length and sits in 4850 m of water giving it a 4 km plus watch circle. The majority of the scientific instruments are housed in the Autonomous Sensor Platform (ASP) suspended 30 m below the surface buoy.

This year, the ODAS buoy and the ASP and chain are all that is replaced on the PAP1 mooring, which requires stopping off the main rope with a temporary surface buoy.

PAP 3 is predominantly a sediment trap mooring, PAP 3 up until 2018 carried four Maclean sediment traps, three conventional and one inverted, with the inverted one being removed from the design this year. In addition to these there are also two Nortek current meters and one SeaBird Microcat 37IMP. The mooring is 1930 m long, approximately 2920 m from the surface.

Bathysnap and amphipod traps are both moored landers provided by OBE. The Ixsea release for the 2017 *Bathysnap* gave no response during two separate attempts to release it. It is possible that the unit was damaged during deployment but there is no evidence. The 2018 *Bathysnap* was recovered with the aid of HyBIS and redeployed.

CTD

The stainless steel CTD with 20 litre Niskin bottles was used for sensor calibration of the moored instruments and trialling the OTEG nutrient sensors. Salts were taken and run on the salinomters on board. Oxygen, Dissolved Inorganic Carbon (DIC) and Nutrient samples were also taken and run on board.

HyBIS Benthic Operations

HyBIS (Hydraulic Benthic In situ Sampler) is a modular hybrid platform which can be used with a number of bolt-on modules. It is one of the MARS suit of ROVs and AUVs. For the purposes of the PAP cruise, it was used in its most basic configuration as a benthic observation system while the ship followed a predetermined track. HyBIS connects up to the ship's fibre optic deep-tow cable for deployments over the starboard gantry ("Bullhorn" in this case). Two MARS technicians deployed HyBIS over a 12-hour watch.

The OSIL Megacorer was supplied by NMF and technicians from OEG to support it, however deployments were supervised by Brian Bett of OBE and a fleet of scientists.

The OTSB (Otter Trawl, Semi Balloon) is deployed through the main block on the gantry but supported during deployment and recovery by NMF via the two 5 T North Sea deck winches.

Ship Fitted Systems

Ship fitted systems operated with seamless efficiency with extra effort to provide better than expected internet, helping scientists with OLEX data and multibeam bathymetry at the Whittard Canyon site.

No Issues with Milli Q or underway systems.

Nick Rundle, Senior Technical Officer

6. Mooring Operations

Main objectives were to turn round PAP1 and PAP3 moorings. Standard S&M deployment and recovery methods were used for operations involving PAP1 & PAP3 moorings, winches used aboard RRS *Discovery* were the ship's trawl winch and 2 x 5 T deck winches

On the deployment of the CTD containing the IXSEA release units to 4851 m, the deck unit connected to the ship's drop keel was used, this has a transducer cable fitted from the keel to the lab. Of the eight releases on the CTD all gave good ranges and responded to release commands.

PAP 1 Mooring

The top end of the PAP1 mooring was to be completely replaced from the swivel at the bottom of the frame up.

Stage 1 retrieval

The ship approached the buoy from the stern and hooked in on the mast lifting point with a 30 T braded rope onto the trawl warp through the gantry. The buoy was then lifted onto the red zone and the chain held on the starboard 5 T winch and a deck stopper. The buoy was secured in place so that the structure could be climbed and the hook released. The connecting chain was then hauled in using the starboard mounted 5 T deck winch with a deck stopper bit by bit until the frame could be lifted on board using a strop on the starboard pedestal crane. The bottom end of the sensor frame was disconnected whilst held on the stopper. The sensor frame was then lifted out of the way and the temporary surface buoy was brought in on the crane and connected to the mooring. The buoy was then released from the starboard crane with a SeaCatch.

Stage 2 Deployment

The sensor frame was positioned in the red zone quite close to the starboard pedestal. The ship backs up to the temporary surface buoy and hooks in through the gantry on the trawl warp. The buoy is lifted on board disconnected and the main mooring is connected to the bottom of the frame via a swivel. The frame has been connected up the ODAS buoy and is positioned in the red zone. The frame is then picked up on a strop and lowered over the stern by the starboard crane until the load can be transferred to the 5 Tonne deck winch, when the remaining chain is paid out using the winch and a deck stopper. The last of the chain is slipped over the stern until the mooring load is fully transferred to the buoy. The ODAS Buoy is connected to the GP winch with a SeaCatch and released overboard on the A frame.

PAP 3 Mooring

Stage 1

The PAP 3 mooring was released via the hull transducer. The mooring surfaced two hours later and the billings float was hooked on the starboard quarter. Standard mooring procedure was used to bring the PAP 3 mooring in. The double barrelled capstan was used to bring in the main rope through the port crane with a deck stopper.

Stage 2

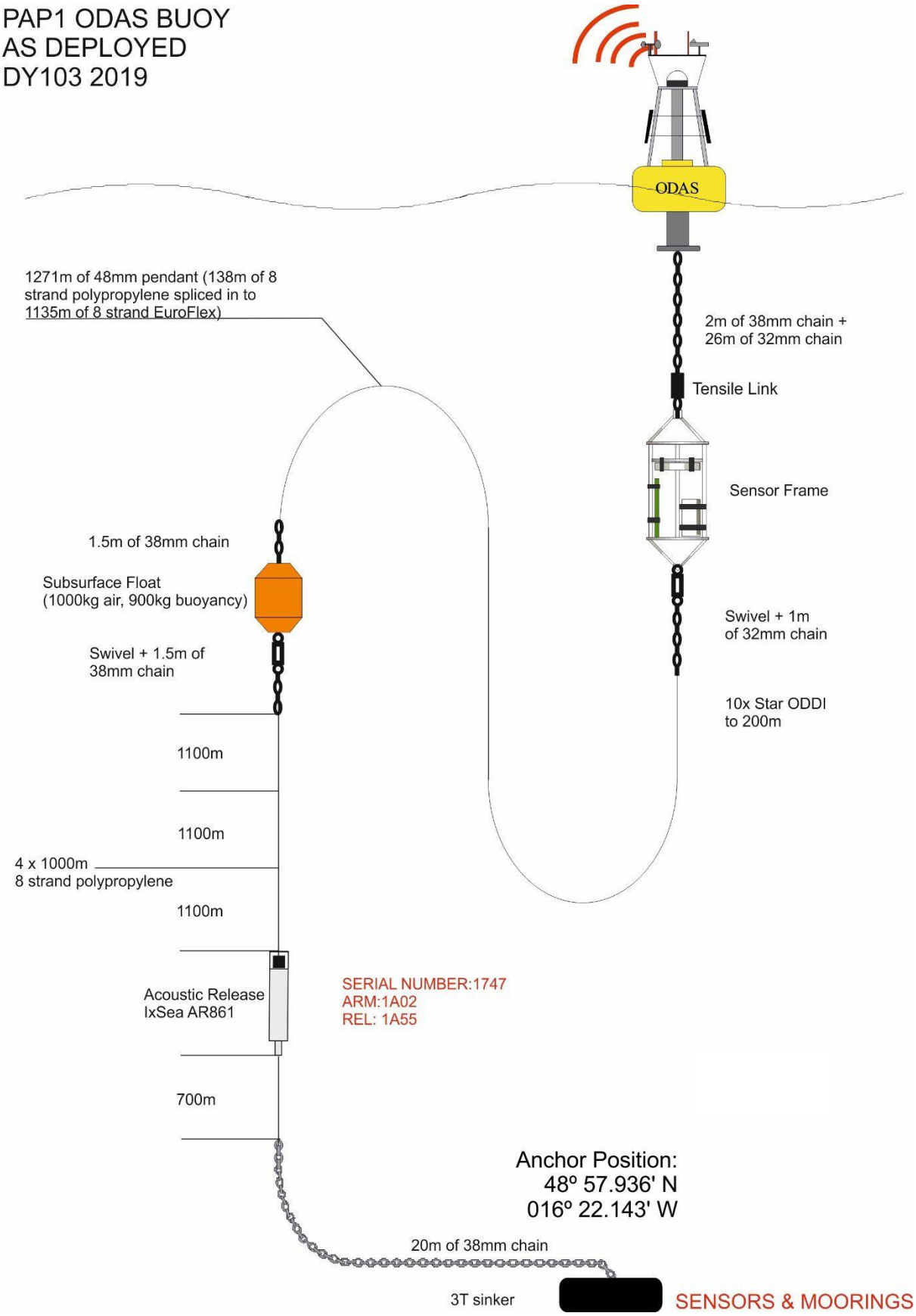
Standard mooring deployment procedure again using the double barrelled capstan with a realer winch with the wire going through a sheave on the port crane and a deck stopper. The mooring is streamed out behind the ship until the anchor is released when over the deployment site. The anchor is released from a SeaCatch from the starboard crane.

Bathysnap and Amphipod Traps

The 2018 *Bathysnap* was triumphantly rescued, but was reluctant to be redeployed. Shortly after reaching the seabed the release malfunctioned and it returned to the surface from whence it came. It was thusly retrieved to deck and a replacement release was fitted and the deployment process repeated. On the second attempt, it obligingly remained on the seabed. There were two successful deployments of the amphipod trap system with no incidents.

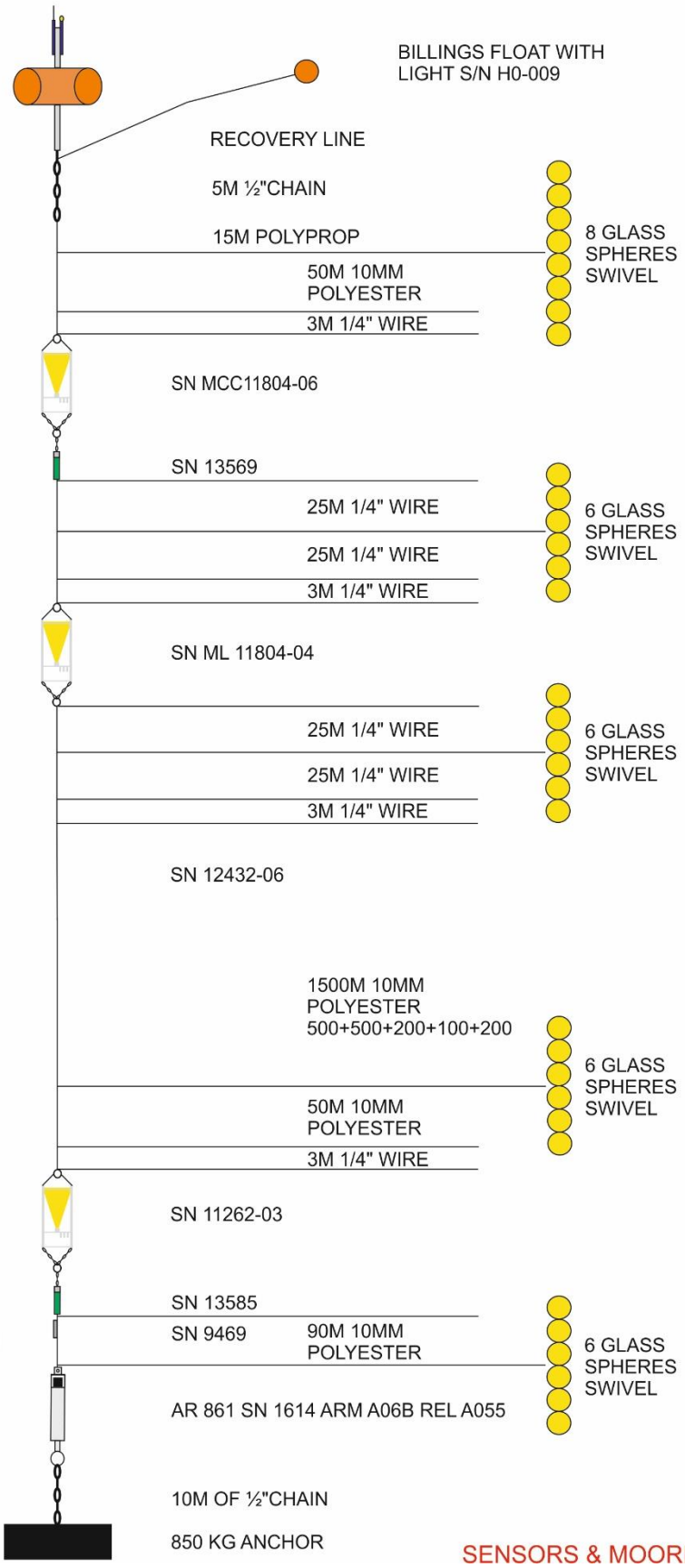
Whittard Canyon

The Whittard Canyon mooring was deployed at the end of the cruise on transit back to Southampton NOC. The 70 m rope mooring supporting a 600 KHz ADCP, 75 KHz ADCP, Sediment Trap and two microcat SBE37s, was deployed by hand with the use of both cranes for releasing the ADCP spheres and the starboard crane to release the anchor.


PAP1 ODAS BUOY
AS DEPLOYED
DY103 2019
ODAS
1271m of 48mm pendant (138m of 8 strand polypropylene spliced in to 1135m of 8 strand EuroFlex)
2m of 38mm chain + 26m of 32mm chain
Tensile Link
Sensor Frame
1.5m of 38mm chain
Subsurface Float (1000kg air, 900kg buoyancy)
Swivel + 1.5m of 38mm chain
Swivel + 1m of 32mm chain
10x Star ODDI to 200m
1100m
1100m
4 x 1000m 8 strand polypropylene
1100m
Acoustic Release IxSea AR861
SERIAL NUMBER:1747
ARM:1A02
REL: 1A55
700m
Anchor Position:
48º 57.936' N
016º 22.143' W
20m of 38mm chain
3T sinker
SENSORS & MOORINGS

PAP 3
Deployed DY103

29 June 2019
48 58.050'N
016 27.624'W
Depth: 4840m



SENSORS & MOORINGS

Buoy Anchor Position Calculator

Mooring Name:	PAP 3 2018					
Buoy Deployment Method:	Buoy First					
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Planned Seabed Position For Anchor:	49°	57.7910'	N	016°	27.8440'	W
Water Depth At Planned Seabed Anchor Position:	4,799 m					
Calculated Fall Back Distance :	686 m					
Vessels Track:	222.5°					
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Anchor Release Position (At The Stern):	48°	57.8150'	N	016°	27.7230'	W
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Estimated Fall Back Seabed Position:	48°	58.0879'	N	016°	27.3421'	W

	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
First Buoy Ranging Position:	48°	87.6380'	N	016°	27.8720'	W
First Ranging Position Ping Distance:	5,015 m					
Calculated Horizontal Distance:	1,456 m					
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Second Buoy Ranging Position:	48°	57.2850'	N	016°	26.5930'	W
Second Ranging Position Ping Distance:	5,157 m					
Calculated Horizontal Distance:	1,888 m					
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Third Buoy Ranging Position:	48°	57.3622'	N	016°	29.0212'	W
Third Ranging Position Ping Distance:	5,247 m					
Calculated Horizontal Distance:	2,121 m					

Arc Sampling Interval:	0.50°	=	15.9 m steps on the arc.			
Accuracy:	High					
1st and 2nd Range Arc Intersection Calculated:	No					
2nd and 3rd Range Arc Intersection Calculated:	Yes					
3rd and 1st Range Arc Intersection Calculated:	No					
	LATITUDE			LONGITUDE		
	00°	00.'0000	Quad	000°	00.'0000	Quad
Calculated Seabed Position	48°	58.0500'	N	016°	27.6240'	W

WARNING!. One Or More Of The Ping Ranging Distances Is In Error. The Seabed Position Of The Mooring Has Therefore Been Calculated With Limited Accuracy

Version 2.7
Tim Page 13th August 2016

Buoy Anchor Position Calculator

Mooring Name:	Whittard Canyon					
Buoy Deployment Method:	Buoy First					
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Planned Seabed Position For Anchor:	48°	37.5730'	N	010°	00.2340'	W
Water Depth At Planned Seabed Anchor Position:	1,576 m					
Calculated Fall Back Distance :	225 m					
Vessels Track:	325.0°					
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Anchor Release Position (At The Stern):	48°	37.5680'	N	010°	00.2320'	W
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Estimated Fall Back Seabed Position:	48°	37.4684'	N	010°	00.1265'	W

	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
First Buoy Ranging Position:	48°	37.7870'	N	010°	00.4820'	W
First Ranging Position Ping Distance:	1,648 m					
Calculated Horizontal Distance:	482 m					
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Second Buoy Ranging Position:	48°	37.2930'	N	010°	00.2700'	W
Second Ranging Position Ping Distance:	1,656 m					
Calculated Horizontal Distance:	508 m					
	LATITUDE			LONGITUDE		
	Degrees	Minutes	Quad	Degrees	Minutes	Quad
Third Buoy Ranging Position:	48°	37.6760'	N	009°	59.8750'	W
Third Ranging Position Ping Distance:	1,642 m					
Calculated Horizontal Distance:	461 m					

Arc Sampling Interval:	0.50°	=	4.2 m steps on the arc.			
Accuracy:	High					
1st and 2nd Range Arc Intersection Calculated:	No					
2nd and 3rd Range Arc Intersection Calculated:	Yes					
3rd and 1st Range Arc Intersection Calculated:	Yes					
	LATITUDE			LONGITUDE		
	00°	00.'0000	Quad	000°	00.'0000	Quad
Calculated Seabed Position	48°	37.5090'	N	010°	00.0680'	W

WARNING!. One Or More Of The Ping Ranging Distances Is In Error. The Seabed Position Of The Mooring Has Therefore Been Calculated With Limited Accuracy

Version 2.7
Tim Page 13th August 2016

7. CTD systems

JOHN WYNAR & TIM POWELL

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CTD System Configuration

See separate Sensor Information document.

CTD Operations

There were 12 CTD casts made, all using the stainless steel system. Log sheets were scanned and included with the data from this cruise. 20 L water samplers were used throughout except that rosette positions 1 & 24 were used for instrument testing from casts 3 to 12 inclusive. Initially other samplers were removed to allow testing of other instruments (see log sheets).

The configuration file used was DY103_1182_SS.xmlcon and is included in the appendix at the end of this report. For deep casts, the PARs were removed, and the configuration file adjusted accordingly and re-named as DY103_1182_SS_noPAR.xmlcon.

CTD1 was used for all casts. The wire was terminated at the start of the voyage giving an insulation figure of > 999 MΩ o/c and a s/c value of 70 Ω. MDS swivel s/n: 1253-2 was used for all casts and no faults occurred.

Sensor Failures

There were no sensor failures, although the DWIRR PAR did exhibit some anomalous behaviour on cast 9. PARs were not used on the remaining casts so this could not be investigated further. However, the fault was probably due to water ingress into a connector.

Data Processing

Basic post-processing of the CTD cast data was done to guidelines established with BODC (ref. Moncoiffe 7th July 2010).

Salinity measurement

A Guildline Autosal 8400B salinometer, s/n: 65764, was used for salinity measurements. The salinometer was sited in the Salinometer lab. Initially, the bath temperature was set at 21 °C, the ambient temperature being

approximately 20 °C. A bespoke program written in Labview called “Autosal” was used as the data recording program for salinity values.

Salinity samples were taken and analysed from most casts and the results tabulated in a spreadsheet SALFORM_SS.xlsx.

Due to (human) errors during sampling the rosette salinity samples 532 to 539 inc. and 541, 545 and 546 were excluded from the final analysis.

APPENDIX - *Configuration file used for the stainless system*:

```
Instrument configuration file:
C:\Users\sandm\Documents\Cruises\DY103\Data\Seasave Setup
Files\DY103_1182_SS.xmlcon

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

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

1) Frequency 0, Temperature

   Serial number : 03P-4814
   Calibrated on : 14 June 2018
   G             : 4.30111327e-003
   H             : 6.24737110e-004
   I             : 1.86297758e-005
   J             : 1.29851757e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-2165
   Calibrated on : 23 August 2017
   G             : -9.76338109e+000
   H             : 1.34212964e+000
   I             : -2.03325982e-003
   J             : 2.01310127e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

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

4) Frequency 3, Temperature, 2

   Serial number : 03P-4816
   Calibrated on : 23 August 2017
   G             : 4.30497192e-003
   H             : 6.34223731e-004
   I             : 2.17264599e-005
   J             : 2.02839765e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 04C-3258
   Calibrated on : 25 August 2017
   G             : -1.06581670e+001
   H             : 1.36071859e+000
   I             : 1.30128231e-004
   J             : 6.09502147e-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 : 43-2818
   Calibrated on : 24 August 2017
   Equation      : Sea-Bird
   Soc           : 4.65400e-001
   Offset        : -4.98300e-001
   A             : -4.41050e-003
   B             : 2.34710e-004
   C             : -3.56300e-006
   E             : 3.60000e-002
   Tau20         : 1.38000e+000
   D1            : 1.92634e-004
   D2            : -4.64803e-002
   H1            : -3.30000e-002
   H2            : 5.00000e+003
   H3            : 1.45000e+003

7) A/D voltage 1, Free

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

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

9) A/D voltage 3, Altimeter

   Serial number : 62679
   Calibrated on : 14-JAN-2014
   Scale factor  : 15.000
   Offset        : 0.000

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

    Serial number        : 05
    Calibrated on        : 03 August 2016
    M                    : 0.48127200
    B                    : 1.03452000
    Calibration constant : 1000000000000.00000000
    Multiplier           : 1.00000000
    Offset               : 0.00000000

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

    Serial number        : 04
    Calibrated on        : 8 Feb 2017
    M                    : 0.44188100
    B                    : 1.59626600
    Calibration constant : 1000000000000.00000000
    Multiplier           : 1.00000000
    Offset               : 0.00000000

12) A/D voltage 6, OBS, WET Labs, ECO-BB

    Serial number : 182
    Calibrated on : 6 March 2017
    ScaleFactor   : 0.003343
```

```
    Dark output    : 0.066000                                    M             : 21.3513
                                                                 B             : -0.1559
13) A/D voltage 7, Transmissometer, WET Labs C-Star              Path length   : 0.250

    Serial number : CST-1654DR                                Scan length                : 41
    Calibrated on : 6 April 2017
```

8. HyBIS

NMF HyBIS Team: *Russell Locke, Stephen McDonagh*

HyBIS was used during DY103 for HD video and stills seafloor surveys and to attempt recovery of two *Bathysnap* landers at the Porcupine Abyssal Plain (PAP) site.

No. of dives DY103 (Dive nos. HY44 to HY49)	6
Typical Water Depths	4850 m
Total time at seabed or survey depth:	23:06 hrs
HyBIS total time in water:	48:28 hrs
Total Video (Apple ProRes 422)	HD 2.0 TB
	PAL 1.9 TB
Scorpio Images	13595 images – 51.1 GB

Master #1 Lacie Raid unit SER# NL4103LP will be installed in the NOC media room for BODC to archive and provide access for scientists post cruise.

Backup #1 Lacie Raid unit SER# NL4104H6 will be retained by the ROV team until BODC have archived the Master unit.

The HyBIS monitors and control rack were assembled in the first bay (furthest forward) of the main lab, with the winch operator's CLAM and CCTV monitors mounted at the end of the bench. The HyBIS power supply unit was mounted on top of the portable table, inside of the High Voltage Cage. The HyBIS team were given responsibility of the HV cage key and the Chief Engineer kept the key to the key cabinet, mounted to the outside of the cage.

An Evergrip termination from a previous trip was still connected to the end of the deep tow cable. After electrical and optical testing of the termination it was found that the cable was electrically sound but the optical fibres required re-terminating. The results of the electrical and optical testing after re-termination were as follows (Optical readings were taken from the Main Lab Junction box to the terminated end of the Deep Tow):

	1310 nm	1550 nm
Red	10.41 dB	8.85 dB
Black	10.95 dB	10.49 dB
Grey	10.21 dB	9.96 dB

OTDR readings:

	1310 nm	1550 nm
Red	9.873 km	9.873 km
Black	9.966 km	9.866 km
Grey	9.859 km	9.859 km

The termination was then connected to HyBIS with the red fibre used for telemetry and the black fibre used for the Scorpio camera. The vehicle was then tested using the 240 V deck lead followed by the HV supply and all functions worked correctly.

The electrical conductor readings were taken from the Deep Tow junction box in the winch room to the terminated end of the Deep Tow.

Continuity of Conductors & Earth	**Test Results Ω**
L1 – L2	92.5
L1 – L3	92.7
L2 – L3	92.5
L1 – Earth	92.7
L2 – Earth	92.7
L3 – Earth	92.7
Insulation Resistance Test	**Test Results (GΩ)**
L1 – L2	3.49
L1 – L3	3.50
L2 – L3	3.49
L1 – Earth	1.45
L2 – Earth	1.55
L3 – Earth	1.50

HyBIS demobilisation

The HyBIS system was prepared for demobilisation during the transit from PAP back to NOC Southampton. The vehicle was stripped of lights and sensors and the cages were packed so that the HyBIS system was ready to be lifted off the ship. During the de-mobilisation, the Evergrip termination was cut off. The Evergrip termination used during DY103, along with the spare Evergrips/Retermination kits stored in the technicians workshop, were returned to the NOC ROV Hangar S1/55.

HyBIS Deep Tow Cable

Umbilical Termination

During DY103, HyBIS was the only piece of equipment attached to the deep tow cable underneath the hydroboom ("Bullhorn"), so no wire swapping was required**.** This was an advantage as it saved time pre- and-post dive and reduced the risk of damaging the fibre optics by frequent handling.

Suggestions/Recommendations

- Remove Evergrip terminations and re-termination kits from ship. Examine and service each termination where possible. Dispose of terminations that are no longer serviceable.
- There is now a working fusion splicing kit, OTDR and optical power meters on board the RRS *Discovery*, located in the technician's lab. There are, however, no tools available for the termination, so a kit should be put together and stored in the same location.

Active Heave Compensation

The ship's Active Heave Compensation (AHC) of the deep tow cable was trialled with HyBIS on cruise DY094 but the cable slipped on the traction winch when the AHC was enabled. After consultation with ODIM it was stated that the package (HyBIS plus wire) was too light for the AHC to operate. During cruise DY103, the AHC was trialled with package weights ranging from 2 to 4.2 T but the wire still slipped on the traction winch causing error alarms to appear on the winch console. It is understood that ODIM will be servicing and setting up the AHC during the next ship refit.

High Voltage Operations

The HV operations were discussed and agreed with the Chief Engineer and the ETO. It was agreed that the HV cage key would remain in the possession of the HyBIS team for the duration of the cruise. Only at a water depth of 20 m would HyBIS be powered on at high voltage and again powered off at 20 m during ascent. The bridge was notified via VHF radio each time HyBIS was powered on and powered off.

When the power to HyBIC was de-energized any capacitance/charge left in the deep tow cable was discharged via the changeover switch in the HV cage. This changeover switch turns off the 230 V supply and earths the deep tow.

A permit to work/Isolation certificate was filled out to show that the vehicle was isolated and HV probes were used each time the HV JB was opened.

When the last dive was finished, the system was proven dead with the Chief Engineer and ETO. The termination was then removed.

Suggestions/Recommendations

- The HV cage on the ship should be modified so that the front panel does not need to be dismantled each time when the HV portable system and table is installed and removed.
- It would be highly recommended that the 230 V supply in the HV cage be changed to a switched socket for isolation and lockout/tag out purposes.

Changeover switch with 230V supply and earth for cable discharge.

Deep Tow Cable Voltage

It was understood from DY94 that the HyBIS system had issues with under voltage/volt drop in the cable. The voltage on the topside transformer was 232 primary and 1500 secondary. The secondary voltage was transmitted through the deep tow cable to bottom side. There was no measuring device on the bottom side and therefore the voltage could not be measured. The primary issue was the fact that the thruster motor controller was tripping due to under voltage on the DY94 cruise.

Steps were taken back at base to rectify this and a Bender ground fault monitor was installed in the high power tube which would in turn allow the bottom side secondary voltage to be measured and read topside. A lab view GUI was also created to read the information being received from the ground fault monitor.

The new monitoring system was then used during the DY103 mobilisation. The HyBIS vehicle was powered on HV and the secondary voltage on HyBIS was measured and recorded; see below.

Hybis Voltage (Shoreside)	
Transformer Topside Tapping	Second Tapping used (240V)
No Load	232 V
Load ON – Lights & thrusters	214 V
Load ON – Both Pumps – Lights & thrusters OFF	214 V
Load ON – Pumps and lights	201 V

By powering up Hybis during the mobilisation, it was clear to see that voltage drop was an issue and the primary reason for the tripping of the motor controller.

While at sea and before HyBIS's first dive, the tapping in the HV portable power supply unit was changed from the second tapping to the first. This improved the voltage on the bottom side greatly, increasing it by approximately 13 volts.

HyBIS Voltage (Deployed)	
Transformer Topside Tapping	First Tapping used (230V)
No Load	244 V
Load ON – Lights & thrusters	225 V
Load ON – Both Pumps – Lights & thrusters OFF	227 V
Load ON – Pumps and lights	213 V

HyBIS System

During DY103 the HyBIS vehicle was stowed inside the hangar aft of the CTD slot. It was sat on a pallet and was moved out under the hydroboom ("Bullhorn") prior to each launch. The associated HyBIS spares boxes and consumables were stowed in cages in the main hangar. Deck testing was achieved using the 240 V AC deck lead plugged into a socket in the hanger. The deep tow cable was not removed from the vehicle during DY103 so during deck testing, communications were done using the deep tow fibres.

Vehicle

Hydraulic System

During the first Hybis dive, a small amount of oil was observed on the Scorpio video. After recovery, it was noticed that the hydraulic compensator had lost approximately 1/3 of its volume. Assuming the leak was similar to that observed on HyBIS cruise JC165, the band clamp on the compensator was checked and tightened. On subsequent dives, no hydraulic oil was lost. The only hydraulic function used on DY103 was the camera tilt.

Suggestions/Recommendations

- Flush and replace hydraulic oil before next HyBIS cruise.

Thrusters

During dive HY45 the port thruster stopped working at approximately 2000 m depth. The port hydraulic motor was then tried and this also failed to operate. Because of this, it was thought that there could be a problem with the with the port motor controller. Although the motor controller should auto re-start after failure, the HyBIS vehicle was then powered down and re-started to try to re-set it, but this was not successful. When HyBIS was recovered to deck, it was powered up on the deck lead and both the port thruster and port hydraulic motor worked as normal.

Because of the nature of the problem, it was decided that high power tube should be removed to examine the motor controllers. The motor controller chassis was removed from the tube and powered up in the technician's workshop. While examining the port motor controller it was noted that a small movement of the motor controller Ethernet cable resulted in the motor controller cutting out altogether. It was decided that the Ethernet cable could be the issue and should be replaced. This was done on both motor controllers. While there was access to both motor controllers it was decided to check the motor controller parameters on each to make sure that they were both configured the same, which they were. The motor controller parameters are listed below:

Moeller Motor Controller Parameters

h003	2.2kW	Motor Rating (kW)
h004	4	Number of Poles
f001	40	Frequency (Hz)
f002	2	Acceleration Rate (s)
f003	1	Deceleration Rate (s)
b001	1	Auto re-start enabled
b002	25	Permissive power downtime (s)
b003	1	Auto re-start time (s)
b004	00	Voltage failure fault signal disabled
b005	01	No limit to auto re-start after voltage failure
b012	10	Thermal overload tripping current (A)
b021	01	Motor current limitation enabled
b022	15	Tripping current of motor limitation (A)

Because it was important that the thrusters worked for the next dive (*Bathysnap* recovery), it was decided not to increase the motor running frequency to 50 Hz, just in case this raised the motor speeds enough to cause them to trip on over current, but this could be done back at NOC, prior to the next HyBIS cruise.

During dive HY46 the thruster motors were regularly checked during the descent to 4800 m. They continued to work throughout the dive and hopefully the replacement of the Ethernet cable has fixed a problem that may have been with HyBIS for a number of previous cruises.

Suggestions/Recommendations

- Drain all thrusters. Strip and check for signs of wear.

Modules

Downward video

The downward video frame was the only frame used during DY103. It was modified to accommodate an extension pole, grapple hook and lifting strop for the attempted recovery of the *Bathysnap* landers (HY45 & HY46).

Cameras

Two Super Scorpio HD cameras with Sony HDR-CX560V were made available from the Isis ROV equipment (Unit Serial# SSC103 was mounted onto HyBIS). The download of images was done with a laptop and a power supply in the hanger. During DY103, after checking with the scientists, it was decided that no white balancing was required during this cruise. During DY46 the Super Scorpio camera on HyBIS lost its saved internal memory settings and reverted back to default. It is thought that the internal battery has come to its end of life and needs to be replaced.

Two Bowtech PAL cameras were used throughout DY103. During the HY46 recovery, the upward looking camera began to flicker and cut out as HyBIS approached the surface (1000 m and above). It is thought that this was due to either a slightly loose connector, or from contact with the Billings floats that were in contact with the vehicle during the *Bathysnap* recovery dive. The camera was checked during post dive checks and did not work. A spare PAL camera lead was installed and this worked okay.

Suggestions/Recommendations

- Send Scorpio HD camera back to manufacturer for coin cell battery change.
- Order spare PAL camera lead to replace faulty lead.

Super Scorpio Specs:

HD: 1920 x 1080 / (50P), **50i,** 25p
12.3 MEGA-PIXEL quality for Ultra-High Definition (4672 x 2628-pixel) Still Images
Sensor: Exmor Back-illuminated CMOS 1/2.88" (6.2mm)
10X Optical Zoom Lens (26.3mm - 263mm in 35mm format)
Focal Distance= f= 3.8mm – 38mm
Aperture: F1.8 - F9.6
64GB Internal Flash Memory
On recovery deck download of images (Ethernet deck cable)

Lights

During video transect dives, three Cathx Aphos lights were pointed downwards to illuminate the Scorpio camera and two DSPL LED lights faced forwards for the PAL tooling camera. During the *Bathysnap* recovery dives, two Cathyx Aphos lights and one DSPL LED light faced forwards to illuminate the Scorpio camera, one Cathyx Aphos pointed down towards the package and one DSPL LED light pointed upwards towards the termination and wire.

It was noted that some of the thread inserts of the Cathyx light holders had been stripped and that the design of the light mounting brackets made them difficult to move/adjust.

The MPUS DSPL LUMOS LED lights were swapped with the ISIS DSPL lights to pressure test them during DY103. All of the lights performed correctly and were tested as follows:

Serial Number	**Dive**
12-048-00272	HY46
12-048-00263	HY46
12-048-00262	HY47
12-048-00270	HY47
12-048-00264	HY48
12-048-00258	HY48

Suggestions/Recommendations

- Fit new thread inserts into the black Cathyx light holders.
- Look into new light and camera mounting brackets to make reconfiguration and adjustment easier.

Scaling Lasers

It was found that the accuracy and parallelism of the 10 cm Sidus lasers was not good enough for the video transect dives. The NOC lasers were checked and it was found that the 10 cm beam distance and parallelism were far more accurate and so these were mounted onto HyBIS.

Suggestions/Recommendations

- Check laser bodies for corrosion

- Strip laser to check/replace o-ring seals.
- Consider using NOC lasers as main lasers, with Sidus lasers as emergency backup. Or retire Sidus lasers and make new pair of NOC lasers as spare.

Valeport VA500 Pressure / Altimeter transducers

The pressure/altimeter transducers worked well during DY103 with no problems. It was noted by one of the scientists that although the altimeter instrument reading was to two decimal places, the data recorded in the HyBIS data stream and the value on the overlay was an integer value.

Suggestions/Recommendations

- Look into modifying Labview and overlay code to increase altimeter recorded data to one or two decimal places.

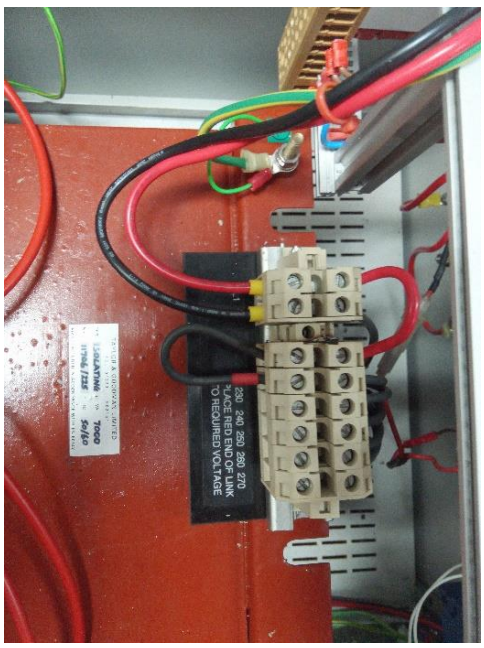
Tritech Sonar

The AUV Tritech Super SeaKing DST sonar (S.N. 08768.205314) was used during the cruise due to the working depth of 4850 m. Although it was not needed during the video transect dives, it proved very successful in finding the *Bathysnap* lander during dive HY46. The AUV Tritech sonars have been unreliable in the past but this unit worked consistently throughout the cruise.

Compass

The Xsense MTi-30 AHRS compass worked well during DY103. During the North-South video transect dives it was found that a compass offset of zero gave the best orientation of HyBIS in relation to its direction of travel. This offset was used during DY103.

HV portable supply unit



During the ascent of HY45, it was noticed that a smell was emanating from the HV PSU. After completing a permit to work and entering the PSU it was found that a loose neutral connection had melted the din rail terminal connector and the neutral cable link. This was remedied by removing the damaged connector and connecting the neutral directly into the incoming neutral terminal connector, as shown opposite. All cables were then checked for a tight connection, the PSU was closed up, and the permit to work closed out. No further problems occurred with the HV PSU for the duration of the cruise.

Current meter/ ammeter

The current meter worked correctly during DY103.

Suggestions/Recommendations

- Consider replacing with meter which has range/resolution closer to the maximum current used by HyBIS.

Lab Setup and Rack Mount Case

The rack unit and lab set-up was identical to that of HyBIS cruise DY094.

Mini HP GUI Machine

The GUI PC was used to run the Labview status displays for HyBIS.

Mini HP OFOP Machine

The OFOP PC and monitor were used to run the OFOP software. A second monitor was provided for science logging of ocean floor observations but this was not used by the scientists.

AJA KiPro video recorders

Two AJA Rackmounted KiPro units were used to record video. The Top unit was assigned to the Scorpio HD camera. The lower unit was connected to the 720P50 quad which was connected to the two PAL tooling cameras.

HD Video Overlay

The HyBIS video overlay worked well during DY103 with no freezing or crashes.

Sonardyne Beacon

One of the ROV Sonardyne WMT beacons was used for each deployment on DY103 as the ship did not have sufficient working beacons for HyBIS to use. The beacon tracked well during each dive, however, there was some confusion on the first dive as the beacon address was saved in Ranger 2 as 2709 and the ROV beacon is labelled 2712. As the Sonardyne software was not available to check the battery levels on this trip, the beacon was removed and charged after each dive.

Suggestions/Recommendations

- Consider loading Sonardyne WMT beacon software onto HyBIS laptop so that charging and battery levels can be easily monitored.

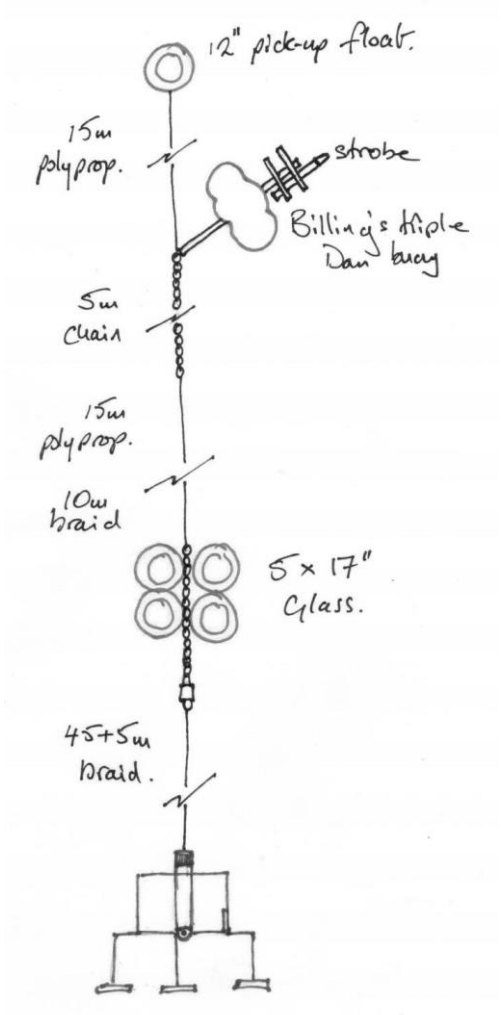
HyBIS Bathysnap DY077-084 & JC165-068 Recoveries

During DY103, attempts were made to recover two *Bathysnap* systems. The first was *Bathysnap* DY077-084 which was deployed in 2017 and failed to release in 2018. The second was *Bathysnap* JC165-068 which was deployed in 2018 and failed to rise during DY103.

Bathysnap Recovery - Vehicle Configuration

For the *Bathysnap* recovery, the vehicle configuration was changed so that the Scorpio HD camera was mounted on the hydraulic tilt bar facing forwards, with two Cathyx Aphos lights either side. One PAL tooling camera and Cathyx Aphos light was positioned downwards to look below the vehicle and one PAL tooling camera and Sealite LED was positioned upwards to look at the termination and deep tow cable.

To facilitate the recovery, an aluminium pole was fixed to the central channel of the downward video survey module. A 2 metre, 2 T strop was then attached to the centre point of the module, along the aluminium pole, to a snap hook at the end.



Bathysnap mooring sketch.

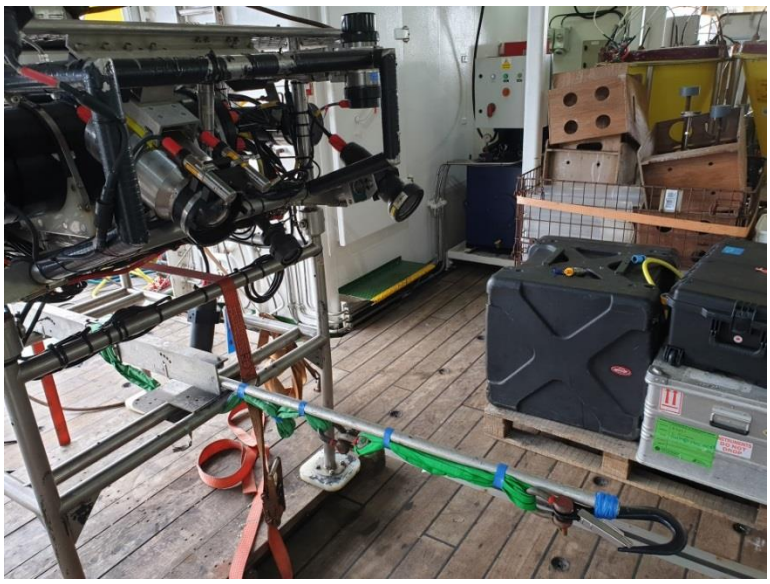
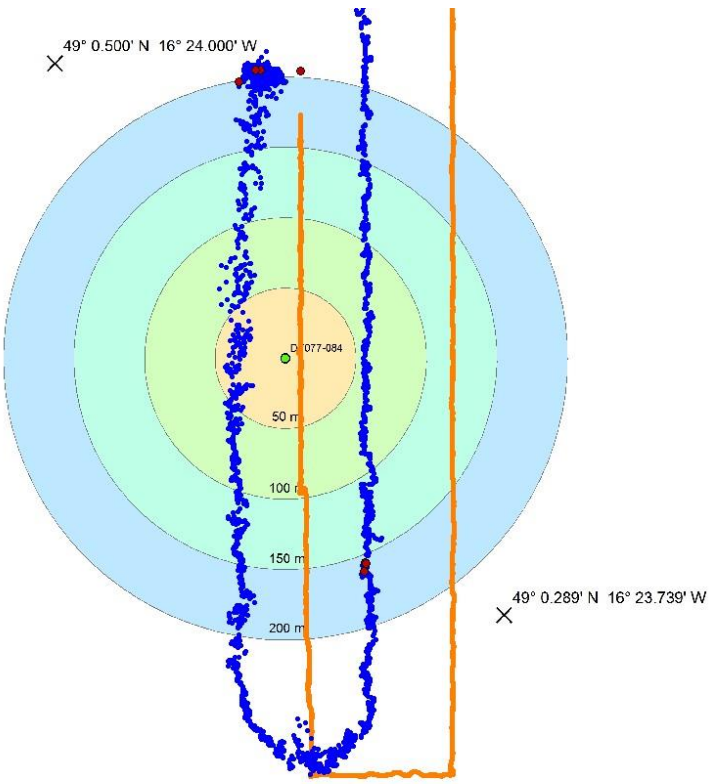


Photo showing Bathysnap recovery configuration

Bathysnap DY077-084 – Dive HY45

Bathysnap DY077-084 was deployed in 2017 and when contact was attempted in 2018 no acoustic communications could be established. On HY45 HyBIS was deployed north of the *Bathysnap* deployment position and was lowered to an altitude of 60 m above the sea bed. This altitude was chosen to offer the best chance of the Tritech sonar finding the group of glass spheres above the lander.



OFOP map showing survey lines.

The Tritech sonar was set on a large 180° forward sweep and two passes were made over the deployment site, 50 m apart. No sonar target was found and the dive was ended due to time constraints.

Bathysnap JC165-068 – Dive HY46

Bathysnap JC165-068 was deployed in 2018 and was due to be recovered during DY103. Communication was established with the lander and the release command was sent but the lander did not return to the surface so it was decided to use HyBIS to locate and recovery the lander.

HyBIS was deployed to the East of the deployment position and lowered to an altitude of 60 m above the sea bed. A transect was made in a Westerly direction with the Tritech sonar set on a 200 m 180° forward sweep. After HyBIS had passed the deployment position a small target was picked up on the sonar towards the South-West. HyBIS and the ship were directed towards the target and at about 10 m range the glass spheres of the lander came into view on the Scorpio camera.

HyBIS was then raised until the recovery hook was at the height of the chain, below the Billing's float and manoeuvred so that the recovery hook caught around the chain. As the winch was hauled the recovery hook was released and the package swung underneath the HyBIS vehicle. HyBIS and the lander were then recovered to deck.

Photo showing glass floats on *Bathysnap* mooring.

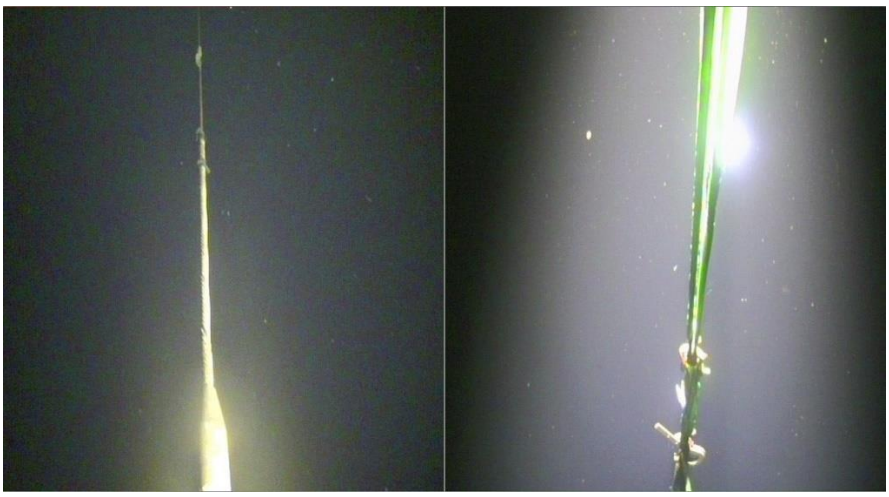


Photo showing upward looking and downward looking
PAL camera views after mooring was secured.

HyBIS Dive Hr Summary

Start Date	Station (Dive)	Time Deployed	Time Recovered	Near-seabed duration
25/06/2019	DY103-006 (HY44)	18:10	00:35	02:26
29/07/2019	DY103-008 (HY45)	03:17	10:06	02:38
01/07/2019	DY103-018 (HY46)	01:27	08:11	01:32
02/07/2019	DY103-026 (HY47)	18:52	05:46	06:38
03/07/2019	DY103-030 (HY48)	21:00	05:46	04:54
06/07/2019	DY103-040 (HY49)	18:16	03:06	04:58

HyBIS Media Data

	Scorpio Video	Pal Video	Stills:	Files
HY44	132.8	118.9	1537	5.7
HY45	251.1	246.5	1607	5.1
HY46	376.4	372.9	0	0.0
HY47	484.0	463.0	4373	16.2
HY48	400.1	360.0	3054	12.6
HY49	442.2	398.2	3024	11.5
GB	2086.6	1959.5	13595	51.1
TB	2.04	1.91		0.05

Total storage used: 4097.2 GB
Total storage used: 4.00 TB

HyBIS Suggestions and Requirements

It was noticed during DY103 that some of the ship's documentation for HyBIS may be out of date. It is recommended that the HyBIS permit to work, HyBIS risk assessment and HyBIS launch and recovery procedure be reviewed and updated on the Ship's Safety Management System, if required.

During DY103 it was noticed that the HyBIS tool chest needs to be organised and extra tools need to be purchased. Possible tools required.

- 3pc socket adaptor cordless hex drill bit.
- Insulated snips, pliers and long nose pliers (1000V rating).
- Spare bonding lead with extra lugs.
- New HV gloves.
- Wire crimping kit
- New earthing clamp (crocodile clip type)

9. Scientific Ship Systems

Martin Bridger

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

Scientific Computer Systems

Acquisition: Network drives were setup on the on-board file server; firstly a read-only drive of the ship's instruments data and a second scratch drive for the scientific party. Both were combined at the end of the cruise and copied to disks for the PSO and BODC. The Ship-fitted instruments that were logged are listed in the below file (includes BODC/Level-C notes): 'DY103_BODC_ship_fitted_information_sheet_DY.docx' Cruise Disk. Data were logged by the Techsas 5.11 data acquisition system. The system creates NetCDF and ASCII output data files. The format of the data files is given per instrument in the "Data Description" directory. Data were additionally logged into the legacy RVS Level-C format, which is also described in the

NMFSS_NetCDF_Description_Cook_v2_2.docx document. There are ASCII dumps of all the Level-C streams included on the data disk in the directory.

Internet provision: Satellite Communications were provided with both the Vsat and Fleet Broadband (FBB) systems. The Vsat had a guaranteed speed of 1.5 Mbps, bursts greater than this when there is space on the satellite, and unlimited data. The FBB had a maximum un-guaranteed speed of 256 kbps with a fair use policy that equates to 15 GB of data a month. There was solid service throughout, interrupted with a few mast blockages when on a northerly heading. Unrestricted internet was provided during mobilisation.

Email provision: E-mail communications were primarily provided by whitelisting institutional pages and encouraging their use through Outlook and Apple Mail desktop clients.

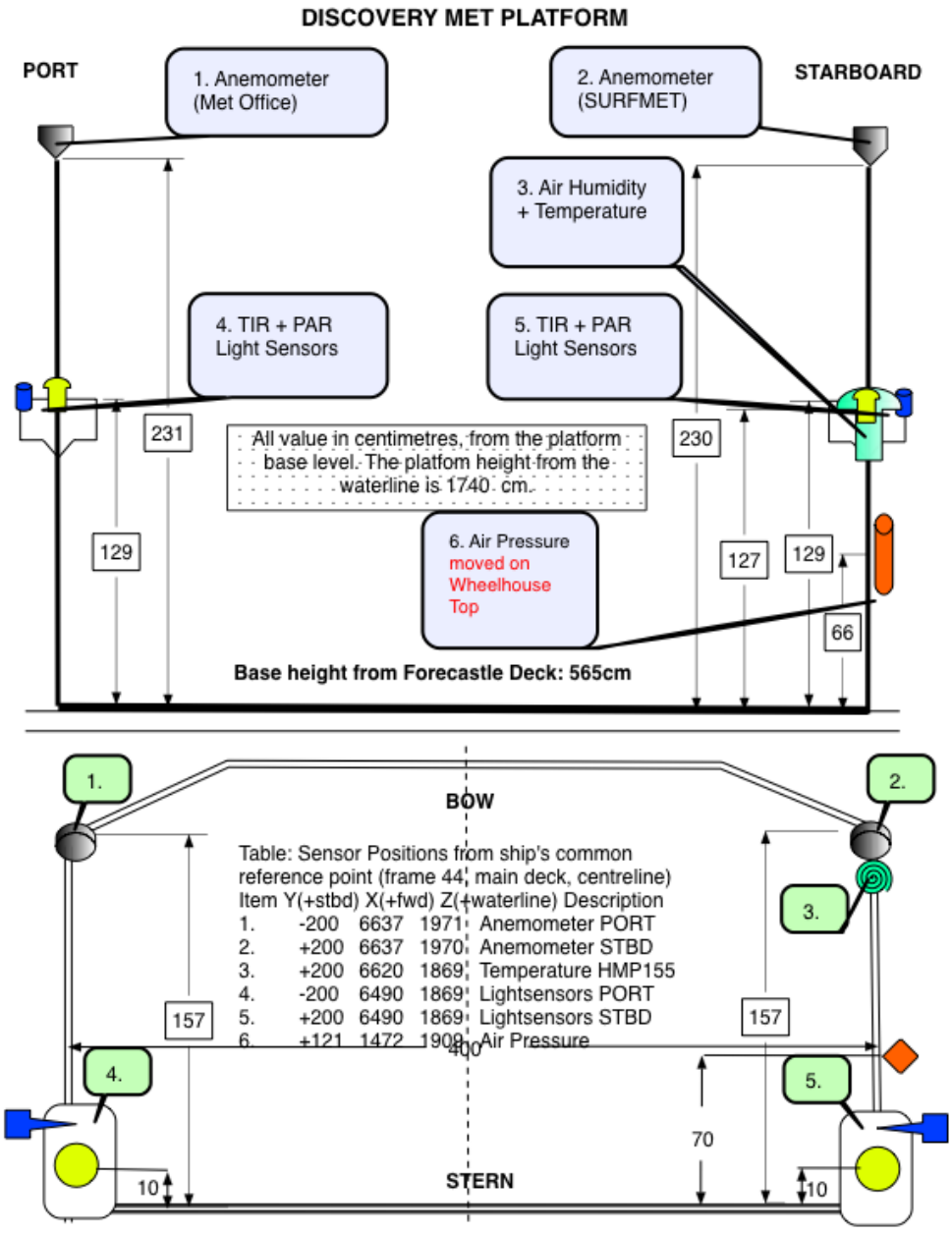
Instrumentation

MMO procedures were followed to NERC MMO guidance

Position and attitude - GPS and attitude measurement systems were run throughout the cruise. The ***Applanix POSMV*** system is the vessel's primary GPS system, outputting the position of the ship's common reference point in the gravity meter room. The POSMV is available to be sent to all systems and is repeated around the vessel. The position fixes attitude and gyro data are logged to the Techsas system. PosMV provided position and attitude feed to Kongsberg systems. Position fixes and attitude data are logged to the Techsas system. The ***CNav 3050*** GPS system is the vessel's differential correction service. It provides the Applanix POSMV and Seapath330+ system with RTCM DGPS corrections (greater than 1 m accuracy). The position fixes data are logged to the Techsas system.

Meteorology and sea surface monitoring package - The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port and whilst alongside. Please see the separate information sheet for details of the sensors used and whether calibrations values have been applied: 'current_cruise/Ship_Fitted_Scientific_Systems/Surfmet/DY103_Surfmet_sensor_information_sheet.docx'.
Pressure sensor PTB210 changed prior to cruise, all met instruments cleaned and checked. Gimbals checked, and freed a slightly stiff port bearing which should be replaced during refit. Extensive pipework modfications carried out prior to the cruise to accommodate upcoming modificatons. These modifications did not affect the operation of the system, which worked well. Underway ran with input flow 10-11 L/min to give 1.75 L/min instrument flow.

Meteorology platform (Foremast)



Pumped seawater flow rates (ml/min):	1500
Anemometer orientation on bow (deg):	0°
Seawater intake depth (m):	5.5

Fitted Sensors:

Manufacturer	Sensor	Serial No.	Comments (e.g. port)	Calibration applied?	Last calibration (DD/MM/YYYY)
AML	Micro-X Surface SV		Drop Keel SV	Yes	
Skye	PAR SKE510	28560	(Starboard)	No	01/05/2018 (2yr)
Skye	PAR SKE510	48927	(Port)	No	30/01/2018 (2yr)
Kipp & Zonen	TIR CM6B	962301	(Starboard)	No	29/08/2017 (2yr)
Kipp & Zonen	TIR CM6B	962276	(Port)	No	29/08/2017 (2yr)
Gill	Windsonic Option 3	10280018	Starboard Inv:250006705	No	N/A (tested 28/09/2015)
Vaisala	HMP155 Temp./Hum.	N1211119	260004820	No	22/10/2018
Vaisala	PTB210 Air Pres.	N093256	260004687	No	19/10/2018
Wet Labs	WS3S Fluorimeter	WS3S-134		No	24/10/2018
Wet Labs	CST Transmissometer	CST-1852PR		No	19/03/2018 (2yr)
Sea-Bird	SBE45 TSG	4548881-0231	Installed and tested 23/11/2018*	No	07/09/2017 (1yr of operation within 2yr of cal date - Expires 07/09/2019)
Sea-Bird	SBE38 Temperature	3854115-0490		No	20/09/2018

British Oceanographic Data Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Cruise DY103 Underway Log

Sheet no.

Date	Time (UTC)	Latitude	Longitude	Uncorr. Sea floor depth (m)	Temp °C	Chlorophyll	Crate no.	Salt Sample bottle no.	Chl Sample bottle no.	Comments	Analyst initials
22/06	16:17	49 37.10294	7 40.95858	124.6.	15.48	0.136 V	TSG 21	224	11	Tap? / black tube	TM, EM & CP
-	-	-	-	-	-	-	-	225	18	-	
-	16:27	4936.59	742.82	132.8	15.46	0.133V	-	226	—	Tap w/ white tube	EM/SH
23/06	8:12	49 15.94834	11 35.06898	146.7	14.20	0.298V	-	227	20		TM
-	-	-	-	←	.	-	-	228	-		
.	12:20	49 10 56	12 40.06	1234.9	15.10	0.125V	.	229	6		
-	17:40	49-7.5070	13 35.08914	3871.5	15.23	0.283V	-	230	7		
24/06	7:45	49 0.0048	16 30.02508	4806.8	15.29	0.190V	-	231	13		TM
-	12:30	48.59.3588	16 23.84772	4814.2	15.30	0.146V	-	232	1		
-	15 00	49 0.8248	16 24.55842	-	15.53	0.150	-	233	15	Depth reading was 0m	
-	18:00	48 59.16	16 31.33	4810.8	15.62	0.174V	-	234	19		
25/06	8:15	48 58.34	16 22.58	4810.8	15.21	0.204V	-	235	9		TM
-	12:15	4858.31	16 22.35	4812.0	1534	0.137V	-	236	3		
-	2:30	48 58.31	16 22.35	4811.4	15.4	0.151V	-	237	17		
-	18:00	48 49.89	16 31.43	4812.0	15.24	0.264V	-	238	5		
26/06	8:20	49 23.95	14.57,28	4509.9	15.28	0.172V	-	239	23		
-	12:15	49 45.90	13 55.16	5020.7	15.38	0.167V	-	240	10		
-	14:20	49 59.11	13 16.87	26308	15.04	0.208 V	-	241	4		
-	18:20	50 18.91	12 21.85	2350	15.11	0.148V	-	242	16		
27/06	12:20	51 36.13	8 18.78	70	14.79	0.084V	-	243	14		
18:30	14 40	51 47.62	8 15.48	<	16.14	0.084V	-	244	24	Depth reading was 0m	
27/6	12:00	51 20.85	9 6.27	100.1	15.82	0.169V	-	245	8	NON TOXIC OFF	MB
	1640						~~-~~	~~246~~		NON TOXIC ON.	MB
28/6	8:30	50 1.28	13 15.26	25481	15.26	0.176V	-	246	10		
	16:16	49 49.85	14 16.51	4186.7	5.81	0.147V	-	247	12		

30/6/19 = JDAY 181

Please add saeen salinity

DY103 Underway Logs

JDAY	Date	Time UTC	Latitude	longitude	U.Depth (m	Temp (C)	Salt	Chl	Crate no.	Salt no.	Chl No.	Comment	INITIAL
181	30/6	8:35	49 0.52	16 29.86	4809.2	15.87	35.453	0.166	22	254	21		TM
		12:35	49 2.30	16 31.81	4805.4	15.91	35.453	0.161	22	255	2		TM
		14:35	49 2.29	16 31.81	4809.0	15.99	35.457	0.151	22	256	6		TM
		18:25	48 '51.52	16 '31.54	4806	16.22	35.477	0.178	22	257	23		TM
182	1/7	8:40	49 0 '23	16 '28.00	4809.9	15.88	35.485	0.162	22	258	18		TM
		12:40	48 56.47	16'29.10	←	16.08	35.477	0.172	22	259	12		TM
		15:00	48 '59.98	16 30.00	4809	16.62	35.480	0.124	22	260	7		TM
		19:00	48 '50.21	16 '30.91	4807.3	16.55	35.475	0.165	22	261	22		TM
JDAY 183	2/7	8:45	48'58.63	16'29.10	4806.2	16.12	35.49	0.157	22	262	11		TM
		12:20	48 '59.99	16'30.02	4807.9	16.19	35.493	0.123	22	263	13		TM
		14:40	48 '59.99	16'30.02	4807.7	16.42	35.499	0.118	22	264	1		TM
		19:00	48'52.49	16 '30.72	4808.5	16.41	35.476	0.169	22	265	16		TM
JDAY 184	3/7	8:40	48.57.89	16'22.84	4808.6	16.12	35527	0.141	23	266	5		TM
		12:25	48'57.44	16'22.52	4809.6	16.21	35.526	0.113	22	267	17		TM
		15:00	48'57.69	16'22.45	4810.8	16.51	35.525	0.114	22	268	20		TM
		18:30	48'56.57	16'29.86	←	16.70	35.512	0.147	22	269	9	No depth data On screen	TM
185	4/7	8:45	49'00.00	16'30.02	4807.3	16.34	35.519	0.138	22	270	15		TM
		13:00	49'002	16'30.00	4807.7	16.65	35.525	0.098	22	271	24		
		14:45	48'58.87	16'29.94	4812.6	16.68	35.525	0.099	20	200	10		
		18:25	48'40.20	16'56.74	4752.2	17.10	35.496	0.134	20	201	17		
	5/7	13:55	49'0.00	16'30.00	4808.3	16.63	35.518	0.108	20	202	14		
		14:50	49'0.00	16'30.00	4808.5	16.69	35.527	0.110	20	203	2		
		18:35	48 42.19	17'1.55	4738.2	17.43	35.513	0.146	20	204	3		
	6/07	12:50	49'0.31	16'26.20	4807.3	16.73	35.522	0.095	20	205	8		

SALINOMETER LOGSHEET.

Ship:	DY	**Salinometer S/N:**	65764
Cruise:	103	**Lab Temp:**	20.1
Analyst:	MARTIN	**Cell Temp:**	21
Date:	8/7/19	**RS set:**	
Sheet X of Y:		**Stanby (start):**	
SSW Batch:	P160	**Stanby (end):**	
K15:	0.99983	**Zero (start):**	
2 x K15		**Zero (end):**	

Sample Number	Salinity Bottle Number	Conductivity Ratio			Average
Standard (99)		1.99968	55	56	1.99953
1	224	1.99476	73	74	1.99674
2	225	2.00918	18	19	2.00919
3	226	2.00922	21	21	2.00921
4	227	2.02372	72	74	2.02372
5	228	2.02445	44	46	2.02445
6	229	2.02555	56	56	2.02556
7	230	2.02685	85	86	2.02685
8	231	2.02255	57	56	2.02256
9	232	2.02115	14	14	2.02115
10	233	2.02135	35	35	2.02135
11	234	2.02151	53	52	2.02152
12	235	2.02231	32	33	2.02232
13	236	2.02175	76	77	2.02176
14	237	2.02207	07	10	2.02208
15	238	2.02290	89	84	2.02288
16	239	2.02430	31	30	2.02431
17	240	2.02376	75	75	2.02375
18	241	2.02313	14	15	2.02314
19	242	2.02386	87	88	2.02387
20	243	1.98239	39	41	1.98239
21	244	1.98153	54	55	1.98154
22	245	1.99797	97	97	1.99797
23	246	2.02383	82	86	2.02384
24	247	2.02137	35	36	2.02136
Standard (99)		1.99961	63	63	1.99962

Comments: 241 NOT VERY FULL
+242 +244

SALINOMETER LOGSHEET.

Ship:	D4	**Salinometer S/N:**	65764
Cruise:	103	**Lab Temp:**	20.1
Analyst:	MARTIN	**Cell Temp:**	21
Date:	7/7/19	**RS set:**	
Sheet X of Y:		**Stanby (start):**	
SSW Batch:	P160	**Stanby (end):**	
K15:	0.99983	**Zero (start):**	
2 x K15		**Zero (end):**	

Sample Number	Salinity Bottle Number	Conductivity Ratio			Average
Standard (99)		1.99956	58	61	1.99958
1	248	2.02210	15	15	2.0221
2	249	2.02226	27	29	2.02227
3	250	2.02251	51	51	2.02251
4	251	2.02263	64	63	2.02263
5	252	2.02261	62	60	2.02261
6	253	2.02300	02	01	2.02301
7	254	2.02184	85	84	2.02184
8	255	2.02176	75	76	2.02176
9	256	2.02201	01	02	2.02201
10	257	2.02296	98	98	2.02297
11	258	2.02339	41	43	2.02341
12	259	2.02296	96	96	2.02296
13	260	2.02284	84	85	2.02284
14	261	2.02286	86	86	2.02286
15	262	2.02367	67	68	2.02368
16	263	2.02377	77	77	2.02377
17	264	2.02416	16	18	2.02417
18	265	2.02303	03	04	2.02303
19	266	2.02556	58	56	2.02557
20	267	2.02547	48	47	2.02547
21	268	2.02472	73	74	2.02473
22	269	2.02495	96	96	2.02496
23	270	2.02512	13	12	2.02512
24	271	2.02545	46	41	2.02544
Standard (99)		1.99969	70	70	1.99970

Comments:
SAME STD USED FOR BEFORE + AFTER

Salinity samples were analysed on Sensors and Moorings Autosal

SALINITY DATA FILE
Cruise Number: DY103
Crate: 21
Operator: MB
Date: 08 Jul 2019
Time: 13:51
Salinometer S/N: 65764
ZERO Reading -0.00005
Reference Value: 6127
Bath Temperature: 21C

Bottle number	Date	Time	Sample 1	Sample 2	Sample 3	Average	offset	Salinity	
STD99	08/07/2019	13:58:05	1.999481	1.999550	1.999559	1.999530	0.000018	34.9911	
TSG224	08/07/2019	14:01:11	1.994742	1.994731	1.994741	1.994738	0.000018	34.8970	
TSG225	08/07/2019	14:03:51	2.009184	2.009180	2.009192	2.009185	0.000018	35.1809	
TSG226	08/07/2019	14:06:19	2.009218	2.009213	2.009214	2.009215	0.000018	35.1815	
TSG227	08/07/2019	14:08:59	2.023723	2.023718	2.023736	2.023726	0.000018	35.4670	
TSG228	08/07/2019	14:11:37	2.024450	2.024440	2.024463	2.024451	0.000018	35.4813	
TSG229	08/07/2019	14:14:24	2.025548	2.025562	2.025558	2.025556	0.000018	35.5031	
TSG230	08/07/2019	14:17:02	2.026852	2.026850	2.026859	2.026854	0.000018	35.5286	
TSG231	08/07/2019	14:19:47	2.022554	2.022566	2.022559	2.022560	0.000018	35.4441	
TSG232	08/07/2019	14:22:10	2.021150	2.021145	2.021144	2.021146	0.000018	35.4163	
TSG233	08/07/2019	14:25:01	2.021355	2.021351	2.021347	2.021351	0.000018	35.4203	
TSG234	08/07/2019	14:27:53	2.021506	2.021528	2.021523	2.021519	0.000018	35.4236	
TSG235	08/07/2019	14:30:51	2.022313	2.022322	2.022328	2.022321	0.000018	35.4394	
TSG236	08/07/2019	14:33:19	2.021749	2.021763	2.021766	2.021759	0.000018	35.4283	
TSG237	08/07/2019	14:35:47	2.022073	2.022067	2.022105	2.022082	0.000018	35.4347	
TSG238	08/07/2019	14:39:41	2.022896	2.022894	2.022841	2.022877	0.000018	35.4503	
TSG239	08/07/2019	14:42:38	2.024301	2.024312	2.024304	2.024306	0.000018	35.4785	
TSG240	08/07/2019	14:45:52	2.023759	2.023746	2.023755	2.023753	0.000018	35.4676	
TSG241	08/07/2019	14:48:47	2.023131	2.023137	2.023146	2.023138	0.000018	35.4555	
TSG242	08/07/2019	14:51:35	2.023858	2.023866	2.023879	2.023868	0.000018	35.4698	
TSG243	08/07/2019	14:54:06	1.982386	1.982387	1.982406	1.982393	0.000018	34.6547	
TSG244	08/07/2019	14:56:39	1.981532	1.981535	1.981545	1.981537	0.000018	34.6379	
TSG245	08/07/2019	14:59:08	1.997971	1.997974	1.997974	1.997973	0.000018	34.9605	
TSG246	08/07/2019	15:01:52	2.020826	2.020822	2.020863	2.020837	0.000018	35.4102	
TSG247	08/07/2019	15:04:31	2.021369	2.021352	2.021357	2.021359	0.000018	35.4205	
STD99	08/07/2019	15:07:51	1.999615	1.999631	1.999627	1.999624	0.000018	34.9930	

SALINITY DATA FILE
Cruise Number: DY103
Crate: 22
Operator: MB
Date: 07 Jul 2019
Time: 13:53
Salinometer S/N: 65764
ZERO Reading -0.00001
Reference Value: 6142
Bath Temperature: 21C

Bottle number	Date	Time	Sample 1	Sample 2	Sample 3	Average	offset	Salinity	
STD99	07/07/2019	13:56:05	1.999562	1.999577	1.999610	1.999583	0.000018	34.9922	
TSG248	07/07/2019	13:59:39	2.022102	2.022149	2.022145	2.022132	0.000018	35.4357	
TSG249	07/07/2019	14:03:09	2.022261	2.022269	2.022291	2.022274	0.000018	35.4385	
TSG250	07/07/2019	14:06:34	2.022512	2.022510	2.022522	2.022515	0.000018	35.4432	
TSG251	07/07/2019	14:09:42	2.022631	2.022642	2.022630	2.022634	0.000018	35.4456	
TSG252	07/07/2019	14:12:46	2.022610	2.022615	2.022605	2.022610	0.000018	35.4451	
TSG253	07/07/2019	14:15:57	2.023002	2.023018	2.023011	2.023010	0.000018	35.4530	
TSG254	07/07/2019	14:18:33	2.021843	2.021846	2.021838	2.021842	0.000018	35.4300	
TSG255	07/07/2019	14:21:25	2.021761	2.021754	2.021764	2.021760	0.000018	35.4283	
TSG256	07/07/2019	14:24:00	2.022008	2.022010	2.022021	2.022013	0.000018	35.4333	
TSG257	07/07/2019	14:27:09	2.022963	2.022981	2.022978	2.022974	0.000018	35.4522	
TSG258	07/07/2019	14:29:42	2.023394	2.023412	2.023433	2.023413	0.000018	35.4609	
TSG259	07/07/2019	14:32:51	2.022963	2.022961	2.022958	2.022961	0.000018	35.4520	
TSG260	07/07/2019	14:35:37	2.022841	2.022841	2.022850	2.022844	0.000018	35.4497	
TSG261	07/07/2019	14:38:18	2.022856	2.022862	2.022864	2.022861	0.000018	35.4500	
TSG262	07/07/2019	14:41:05	2.023665	2.023668	2.023683	2.023672	0.000018	35.4660	
TSG263	07/07/2019	14:43:59	2.023773	2.023771	2.023773	2.023772	0.000018	35.4680	
TSG264	07/07/2019	14:47:16	2.024157	2.024160	2.024179	2.024165	0.000018	35.4757	
TSG265	07/07/2019	14:49:45	2.023027	2.023026	2.023035	2.023029	0.000018	35.4533	
TSG266	07/07/2019	14:53:44	2.025564	2.025576	2.025562	2.025567	0.000018	35.5033	
TSG267	07/07/2019	14:56:09	2.025473	2.025478	2.025467	2.025473	0.000018	35.5015	
TSG268	07/07/2019	14:58:57	2.024719	2.024730	2.024742	2.024730	0.000018	35.4868	
TSG269	07/07/2019	15:01:40	2.024949	2.024962	2.024961	2.024957	0.000018	35.4913	
TSG270	07/07/2019	15:04:30	2.025123	2.025126	2.025119	2.025123	0.000018	35.4946	
TSG271	07/07/2019	15:07:12	2.025448	2.025458	2.025409	2.025438	0.000018	35.5008	
STD99	07/07/2019	15:10:11	1.999687	1.999700	1.999698	1.999695	0.000018	34.9944	

Cruise	DY103
Technician	Martin Bridger
Date	21/03/19 Southampton, UK – 08/07/19 Southampton, UK

BODC Ship-fitted Systems Information Sheet (Discovery)

Ship-fitted instruments:

The following table lists the logging status of ship-fitted instrumentation and suites.

Manufacturer	Model	Function/data types	Logged? (Y/N)	Comments
Meinberg	M300	GPS network time server (NTP)	N	Not logged but feeds times to other systems
Applanix	POS MV320 V5	DGPS and attitude	Y	Secondary DGPS
C-Nav	3050	DGPS and DGNSS	Y	Primary DGPS Logged
Kongsberg Seatex	Seapath 330	DGPS and attitude	Y	No attitude logged, only position
iXSea	PHINSIII	Inertial Navigation System	N	
Sonardyne	Fusion USBL	USBL	Y	
Sperry Marine		Ship gyrocompasses x 3	Y	
Kongsberg Maritime	Simrad EA640	Single beam echo sounder (hull)	Y	
Kongsberg Maritime	Simrad EM122	Multibeam echo sounder (deep)	Y	
Kongsberg Maritime	Simrad EM710	Multibeam echo sounder (shallow)	N	
Kongsberg Maritime	Simrad SBP120	Sub bottom profiler	N	
Kongsberg Maritime	Simrad EK60	Scientific echo sounder (fisheries)	N	
NMFSS	CLAM	CLAM system winch log	Y	
NMFSS	Surfmet	Meteorology suite	Y	
NMFSS	Surfmet	Surface hydrography suite	Y	
		Skipper log (ship's velocity)	Y	
OceanWaveS GmbH	WaMoS II	Wave Radar	Y	
Teledyne RD Instruments	Ocean Observer 75 kHz	VM-ADCP	Y	
Teledyne RD Instruments	Ocean Observer 150 kHz	VM-ADCP	Y	
Microg Lacoste	Air-Sea System II	Gravity	N	

***Bestnav* hierarchal ordering:**

The following table lists the order of navigational systems in the *bestnav* process for positional fix.

Rank	Order of positional fixes	Comment
1	Seapath 330	spathpos
2	PosMV V5	posmvpos
3	Cnav 3050	gps_cnav

Units of dist_run: nautical miles

Relmov* source*:

The following table lists the navigational systems that are used in the *relmov* process for ship's motion.

Navigational source of ship's motion	Comment
Gyro	gyro_s
LOG	log_dysk

RVS data processing:

The following table lists the RVS Level-C processing programs that were run.

Program	Was it run?	Comments
bestnav	Y	
*prodep***	N	
protsg	N	
relmov	Y	
satnav	N	
windcalc	N	

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

Kongsberg EA640 10/12 kHz Single-beam - The EA640 single-beam echo-sounder was run throughout the cruise. The 10 kHz & 12 kHz operated in active mode at minimum power settings to provide uncorrected depths during all operations.

Ran as MASTER on K-SYNC both 10 kHz and 12 kHz set to active. Depth for PAP was mostly in the region of 4810 metres. Power levels were kept to a minimum (400-600 W) and pulse width set to maximum. The result, solid depths even during manoeuvring and steaming.

Corrections were applied using Carter Area Correction Tables hardback. Pulse parameters were altered during the cruise in response to changing depth. It was used with a constant sound velocity of 1500 ms^{-1} throughout the water column to allow it to be corrected for sound velocity in post processing. Kongsberg Raw files are logged and depths were logged to Techsas and Level-C.

Kongsberg EM122 multi-beam echo sounder - The EM122 multibeam echo-sounder was only used during Whittard Canyon operations. The position and attitude data were initially supplied from the PosMV. Sound velocity profiles were input from full depth CTD casts.

Sound velocity profiles - Sound velocity profiles were derived from data from the CTD. These were processed with Sea Bird data processing, followed by Ifremer's DORIS programme. These were input to the EM122 and the Sonardyne USBL when required.

ADCPs - Both the 75 and 150 kHz were run consistently during the cruise, synced using K-Sync. All acoustics were turned off during mooring release. Bottom track mode was used when approaching Cork, leaving Cork, and returning to Southampton. ADCP command files were provided with PSO data.

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

Sonardyne USBL - WMT beacons were fixed to the Megacorer frame and HyBIS. These data were recorded in Techsas.

CTD2MET - CTD profiles were converted and thinned to be ingested into the Met Office CTD2MET programme. This was done for the full depth CTD casts.

The PCO2 system was not working prior to the cruise, and would stop with the HIGH LICOR HUMIDITY alarm. This pointed to either a faulty dryer unit (as previously suspected) or further issues with the Licor or other part of the system. During troubleshooting, both the Licor and the complete dryer unit were swapped out. The replacement Licor was faulty, but the replacement Dryer unit enabled the system to finally dry out. The system worked without problem for the remainder of the cruise.

The WaMoS blackbox CPU was used with the PCO2 system as this was required to allow for simultaneous sampling in the deck and chemistry labs.

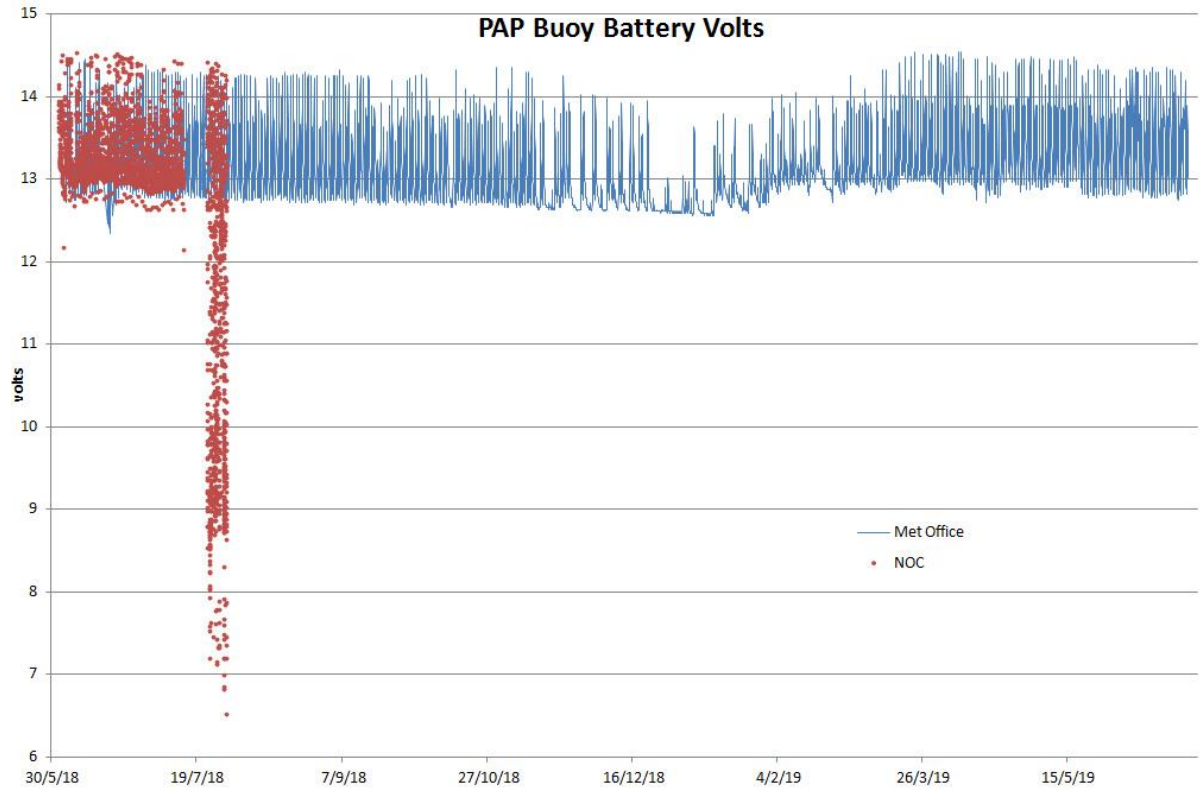
Ancillary data for the PCO_2 system can be found on the cruise disk.

10. PAP1 - Observatory scientific report

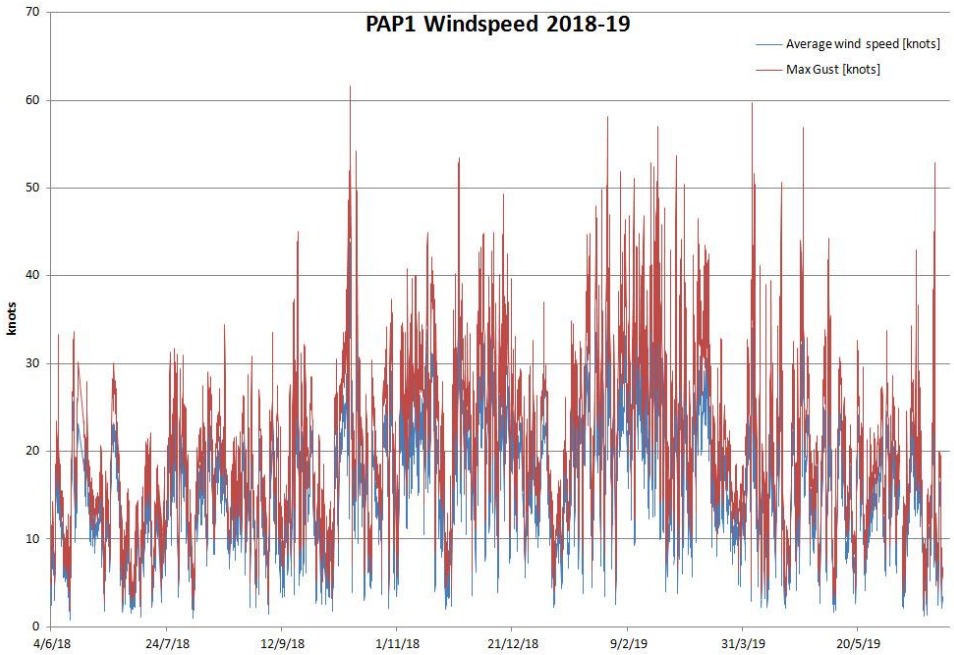
Sue Hartman, Corinne Pebody, Chris Cardwell, Jon Campbell, Hannelore Theetaert, Emmy McGarry, Toby Mortimer

The PAP1 system comprises sensors connected to either a buoy telemetry electronics unit or a frame data hub unit and their data is sent using Iridium to our server at NOC. The telemetry communication is intended to provide remote quasi-real time data. Schematic drawings of these two units as configured for the latest deployment are shown below. The buoy also hosts an entirely separate system provided by the UK Met Office, which has its own telemetry unit and a suite of meteorological sensors measuring wind velocity, wave spectra and atmospheric pressure.

The last PAP1 system was deployed on June 4th 2018 on RRS *James Cook* cruise JC165. It comprised a new anchor and mooring rope with refurbished sensor frame and a mixture of new and serviced sensors. However, the buoy was not swapped but instead redeployed for another 12 months. Unfortunately, the NOC telemetry failed 40 days into the deployment (on 14 July 2018). Upon recovery, it was discovered that the NOC system 12 V power supply from the buoy failed, probably due to internal cable damage or water ingress. The voltage measured in the NOC junction box on the mast was 0.37 V. The exact cause will not be apparent until the buoy is stripped down at NOC. (See plot of Met Office and NOC power supply voltages). It is recommended that in future a fully refurbished buoy should be deployed each year, rather than redeploying one that has already spent 12 months at sea.



The Met Office wind, sea temperature, and air pressure sensors worked satisfactorily, but the GPS, wave height, humidity and air temperature sensors malfunctioned throughout the deployment. The Met Office Iridium Short Burst Data messaging also worked normally and was used to monitor the approximate position of the buoy.



In this document, we describe the status of the system that was recovered and the new set of electronics and sensors that will be acquiring data for a year between 2019 and 2020. A refurbished Met Office buoy was used for the DY103 deployment. In both 2017 and 2018 the buoy had been painted with an antifouling coating to decrease biofouling, the new keel that was deployed in 2019 was painted at NOC before sailing. New clamps were made for several sensors this year, including the phosphate, CO_2 and GTD sensor following last year's recommendations. Most of the clamps on the keel have been re-used this year.

The main change in configuration for this year's deployment was the addition of a new load cell with integrated data logger.

Data Hub and Telemetry Unit Modifications

The Data Hub electronics were modified by adding a DC-DC converter module to provide a 20 V power supply for the load cell. The converter is switched on by the hub controller when it receives a request from the load cell.

The hub controller software was modified to interface with the load cell, and to accept slightly different data formats from the Seaguard and Hydrocycle phosphate sensors.

In an attempt to rule out potential failure modes, the Telemetry Unit was fitted with a watchdog timer circuit to restart the controller in the event of a software 'lock-up'. The controller software was modified to accommodate extra email commands for the new load cell.

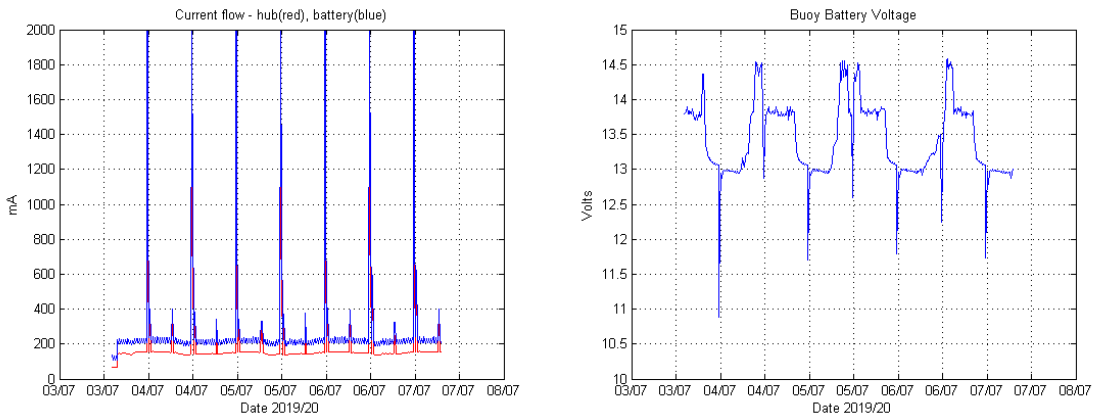
Deployment and initial performance

The PAP#1 deployment commenced at 08:00 3rd July 2019 (day 184) and continued smoothly until the buoy was released at 14:43. Data telemetered to NOC from the buoy were accessed via FTP using the ship's internet connection and indicated that all the sensors were functioning. Once the frame was in the water, e-mail commands were sent to switch on the Data Hub, the Satlantic OCR irradiance sensors, and the CO_2 sensor on the keel.

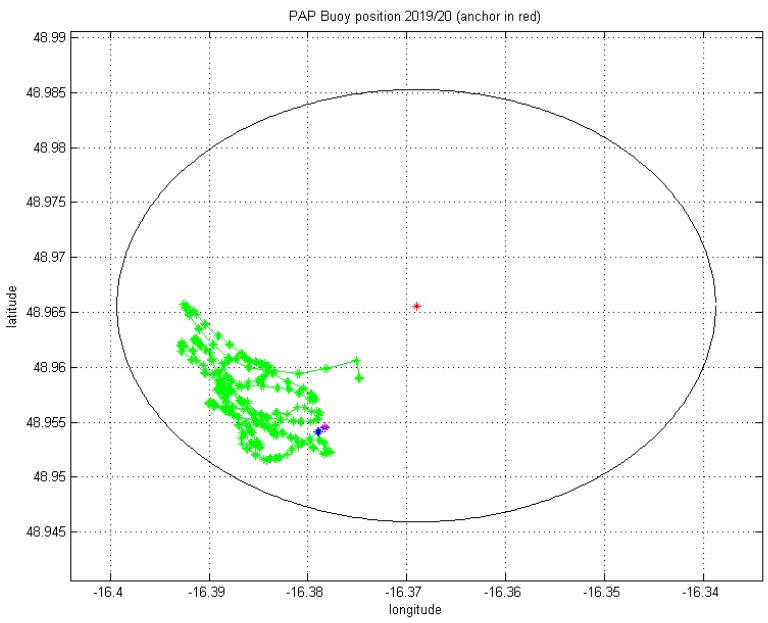
Sensor Configuration for deployment 2019-2020 is shown below.

Sensor	Serial Number	Inventory Number	Intervals (hours)	Minutes after hour
BUOY				
Pro-Oceanus CO2-Atmos	33-201-45		12	50
SeaBird SBE-37-ODO-IMP MicroCAT	16503		0.5	0
Satlantic OCR-507 ICSA (buoy) with bioshutter	226 and 230	25007461 (pair)	0.5	17
SeaBird SBE-37-IMP MicroCAT	9475		0.25	0
Satlantic SeaFET pH	63	250008425	0.5	27
Buoytracker III (Globalstar)	766518	250006106	Daily, unless outside of watch circle when hourly	
FRAME				
SeaBird SBE-37-ODO-IMP MicroCAT	10315		0.5	0
SeaBird SBE-37-IMP MicroCAT	6907		0.25	0
WETLabs FLNTUSB Fluorometer	3050	250008219	4	0
Satlantic SUNA Nitrate sensor	745	260002112	1	20
Satlantic SeaFET pH sensor	257	250009591	0.5	23
Aanderaa 4430H Seaguard	1614		1	30
Aanderaa 4330 optode in Seaguard	1278		1	30
Turner Cyclops Fluorometer in Seaguard	2103960		1	30
ZebraTech Wiper for Cyclops	NA		6	40
Satlantic OCR-507 ICSW irradiance (upwards) with Bioshutter	1428 and 219	260006058	0.5	17
Satlantic OCR-507 R10W radiance (downwards) with bioshutter	95 and 124	250006038	0.5	17
Pro-Oceanus Logging CO2-CV	38-560-75	260005920	12	52
Pro-Oceanus mini TDGP	38-505-31	260005363	0.5	21
WETLabs HydroCycle Phosphate Analyser	458		6	20

The figures below illustrate the status of the observatory and some of the parameters during the first days of deployment. We observe the same patterns as in the previous years, which imply that the observatory is progressing as expected. There is a periodic behaviour coming that depends on the daily recharge of the solar panels and the schedule of the sensor measurements.



Left: current consumption of buoy and data hub. Right: voltage of buoy batteries



Buoy positions around the anchor

Deployed PAP1 Sensors

Aanderaa Seaguard - A used Seaguard instrument (4430H, SN 1614) was sent to the manufacturer and serviced for DY103. It has an Oxygen optode (Aanderaa 4330, SN 1278) and fluorometer (Turner cyclops, SN 2103960). These were prepared for deployment as part of the PAP#1 sensor frame. Initial set-up and preliminary checks in the lab and whilst on board showed the Seaguard to be in proper working order and correctly communicating with the central Hub of PAP#1.

Pre-deployment calibration of Seaguard: The Seaguard was placed on a 100 m CTD cast (station number 003). On this pre-deployment calibration, the Seaguard took the place of one of the 20 L Niskin bottles. The Turner

Cyclops fluorometer was mounted on the top bar facing upwards out of the CTD rosette. Waters were collected from Niskin bottles and later analysed through Winkler titration for dissolved oxygen to calibrate the Aanderaa optode. The Turner Cyclops fluorometer was also calibrated against water samples that were analysed by a lab based Turner Trilogy unit. There was no RCM unit on the instrument.

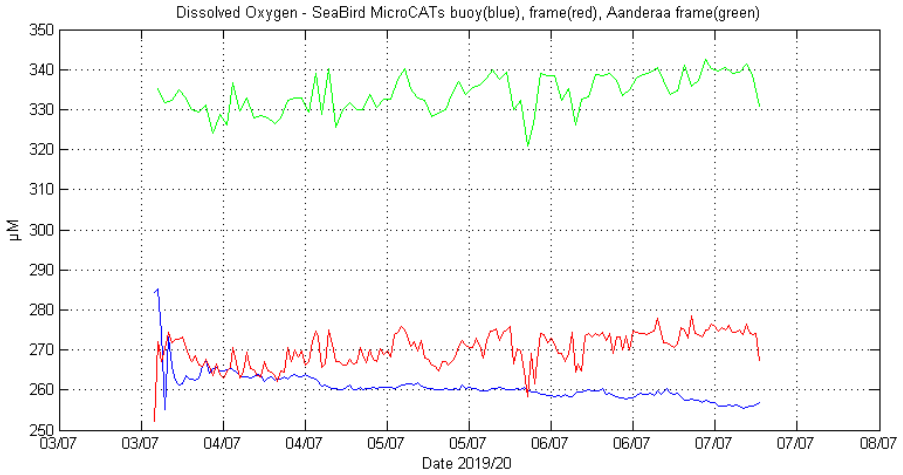
The Seaguard is powered by internal alkaline batteries and is connected to the sensor frame Datahub via cable harness 'C'.

The Seaguard ready to deploy.

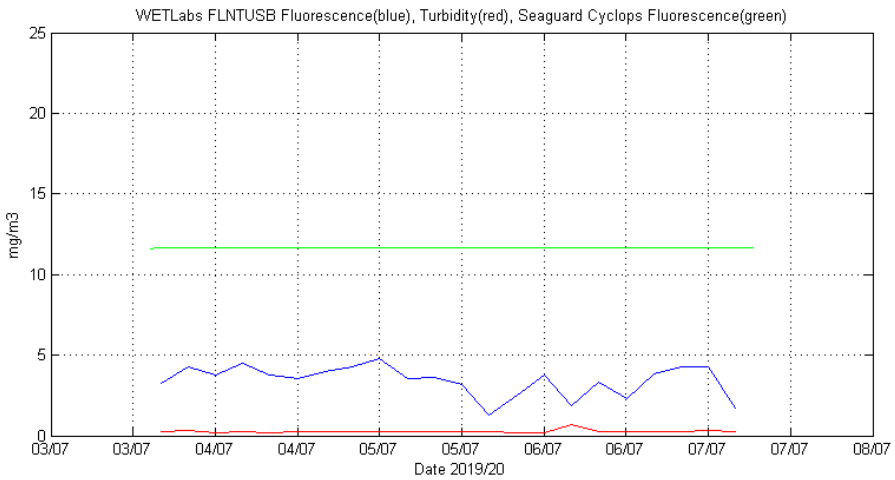
The Turner Flurometer and zebratech wiper pre-deployment.

The scheduling for deployment was to perform a measurement every hour on the half hour, so as to spread inputs to the Hub. The unit was armed to start operating before deployment to ensure correct communication to the Hub, time, and date. The Cyclops Turner fluorometer was mounted in the ZebraTech wiper and set to activate every 6 hrs. The wiper was set to activate activate on the 45th minute of the hour, to give a minimum chance that a wipe could happen at the same time as a measurement by the fluorometer, the wiper time would have to drift well beyond specification for this to be a problem. The wiper was checked 6 hours later and correctly performed a wipe. After recovery of the 2018/19 system, the controller and battery housing was found to be missing so an extra Jubilee clamp was used to secure the controller housing to the manufacturer supplied bracket.

The Seaguard was set-up and secured in its pressure housing. The unit was then integrated into the sensor frame.

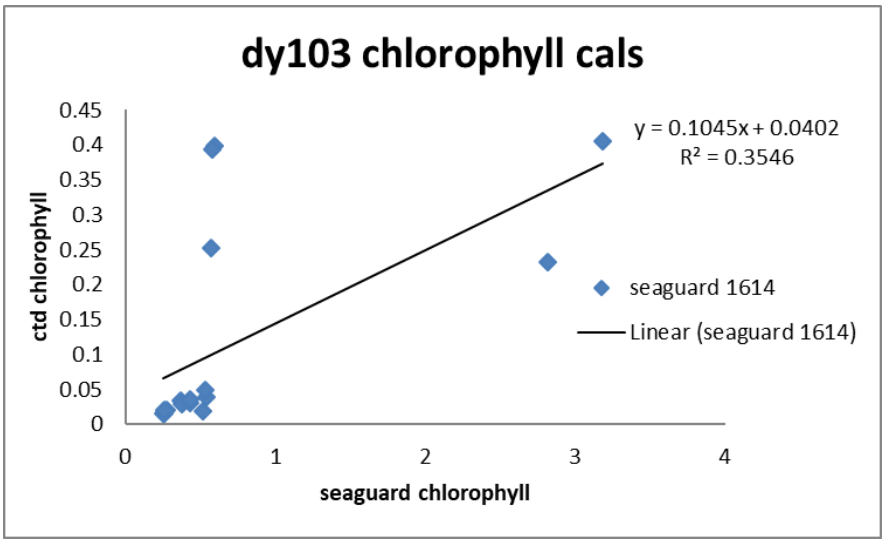


Oxygen data from the Seaguard (green) and Seabird Microcats a few days after deployment.



Uncalibrated fluorescence from the first days of deployment of the Wetlabs and Turner fluorometers

The Seaguard 1614 was calibrated prior to deployment, the chlorophyll calibrations were poor chlorophyll = 0.1045 X +0.0402 (r^2= 0.3546)



SUNA Nitrate Sensor

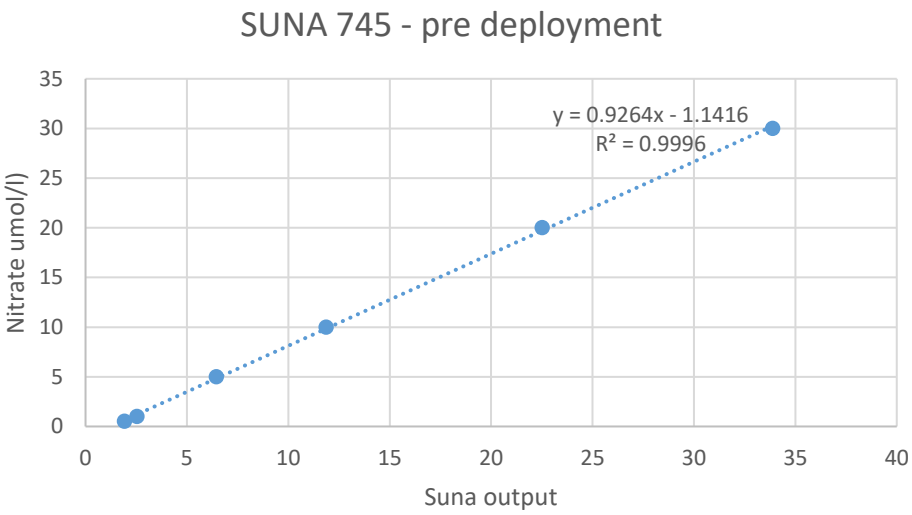
SUNA pre-deployment calibration

The initial pre calibration of the SUNA nitrate sensor SN745 (DY103 Frame) was at SATLANTIC in spring 2019. This was checked in the lab on DY103 using the Quattro working standards.

The SUNA was run in continuous mode, set up using a parafilm wrap containing in turn DIW, and 6 of the mixed working standards prepared in ASW (Artificial Seawater) measured on board. First DIW was measured in the freshwater mode of the sensor. The sensor was giving a value of 2.5 µMol. After the measurement a reference update was done and uploaded to the Suna. DIW was measured again and gave a value of 0.02 µMol. After that, the standards made up in ASW were measured.

Calibration results done in the lab on DY103 are shown in the table and figure below.

Standard	Concentration	Measured concentration
ASW	0	1.827667
0.5µM	0.5	1.915
1µM	1	2.540879
5µM	5	6.458421
10µM	10	11.86655
20µM	20	22.51224
30µM	30	33.8855

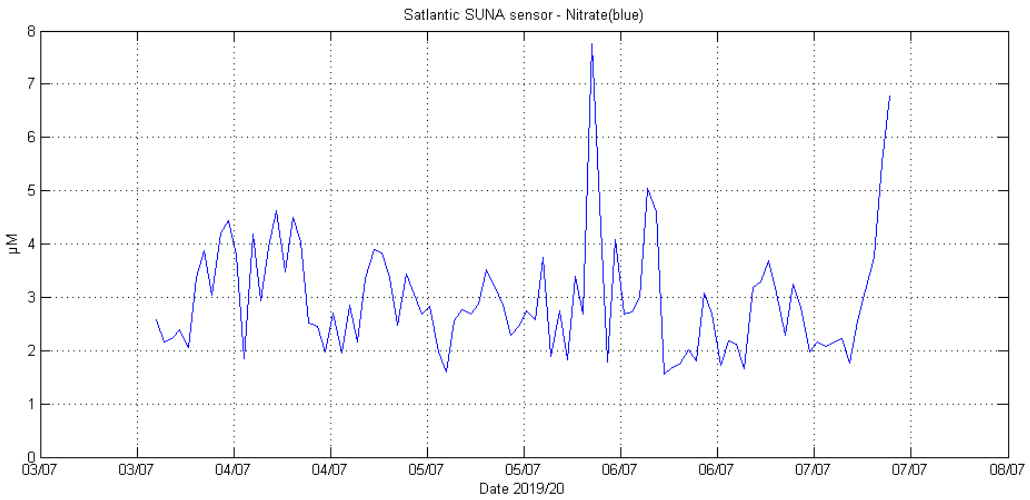


Pre-deployment calibration of SUNA SN745 nitrate sensor DY103

SUNA deployment on the sensor frame

On the sensor frame deployed at 30 m, the SUNA Nitrate sensor was configured to sample in a periodic mode/frame based operation. The sampling interval was set to 1 hour with 1200 sec (20 min) offset past the hour. Within the sampling interval, the acquisition duration was given by the number of frames. For this deployment, the chosen 1 frame operation outputs 1 dark frame then 1 light frame which is the average of 10 samples. This gives an estimated frame rate of 0.1587 frames per second (6.3 sec/frame). The integrated wiper was enabled. No screen shots of the SUNA settings were taken before deployment.

Satlantic SUNA SN 745 nitrate sensor (plastic housing, wrapped in copper tape) with integrated wiper deployed on the sensor frame



Measurements during first days of deployment

The SUNA is powered by an OceanSonics OS200 battery (S/N 2337) providing a voltage of approximately 14.4 V and 228 Ah and is connected to the sensor frame Datahub via cable harness ‘D’.

Wetlabs fluorometer deployed 3050

The fluorometer s/n 3050 was positioned horizontally on the frame with the 30 degree sampling cone unobstructed. The jumper plug was plied on the four hour interval in order to ensure that the sampling interval would be correct. It was observed to sample before the frame was deployed.

Factory cal:

The Characterization sheet is as follows: SN 3050

Thermistor calibration: temperature= (output x slope) + intercept

Where slope = -0.0056 °C/count and intercept = 70.4511° C

Pressure sensor calibration: pressure= (output x slope) + intercept

Where slope = 0.033 dBar/count and intercept = -1.87 dBar.

Chlorophyll Scale Factor: Chl(µg/l)= Scale Factor x (output – dark counts)

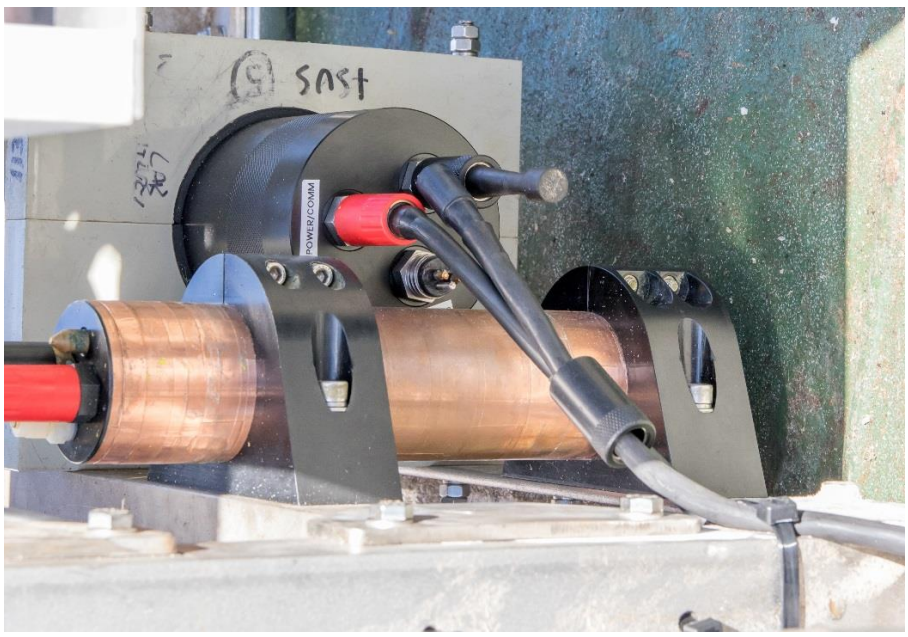
Where scale factor = 0.0069 µg/l/V and dark counts =47 counts

Nephelometric Turbidity Unit (NTU) Scale Factor = Scale Factor x (output – dark counts). Where scale factor = 0.0056NTU/V and dark counts = 49 counts).

The instrument was then calibrated against the CTD fluorometer (Chelsey aqua tracker III) which had been calibrated by bottle samples run on a Turner triology bench top fluorometer (black 2, RF 0.31). The resulting calibration is chlorophyll (mg/m^3) = 1.0934 X + 0.0019 (r^2 = 0.9839).

The instrument was positioned in the frame so the cone sample area would not be compromised by the framework (see picture below). The WETLabs Fluorometer is powered by an internal battery and is connected to the sensor frame Datahub via cable harness 'C'.

When mounting the sensor to the frame, copper tape was applied to the outer casing to aid against bio fouling.

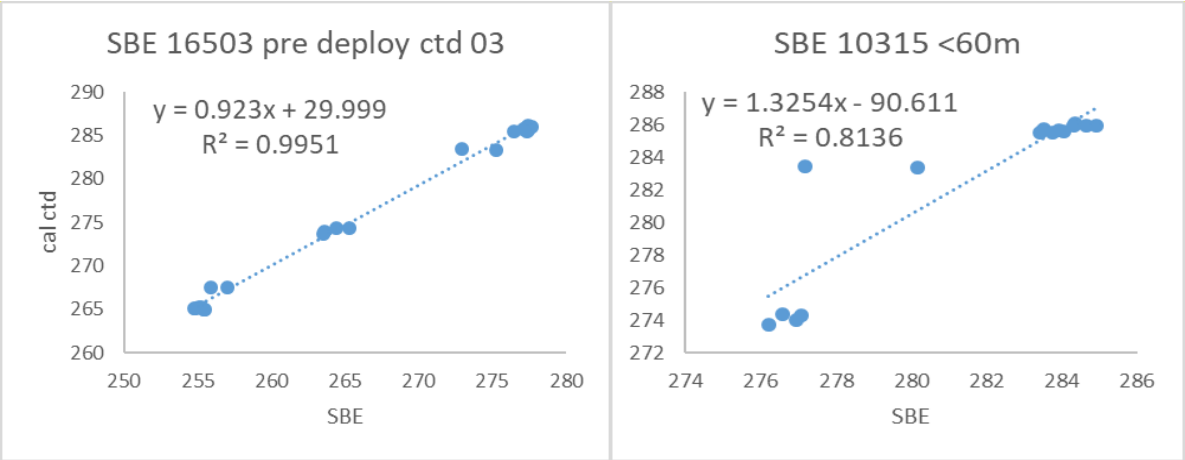


The Wetlabs FLNTSUB with copper and measurement window facing out of the frame (shown towards deck due to frame placement when photograph taken).

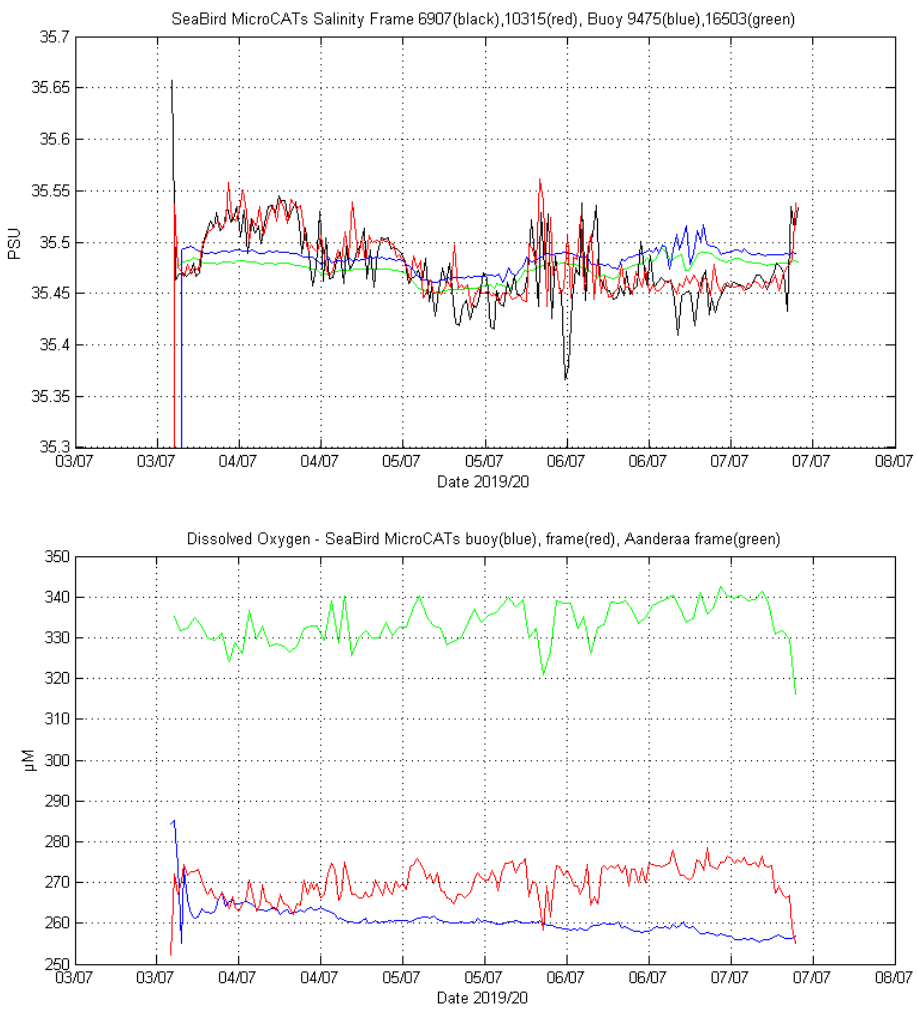
Sea-Bird SBE 37 MicroCATs

As no fresh MicroCATs with oxygen sensors were available in time for the cruise, it was necessary to reuse both the recovered SBE 37-IMP-ODO sensors (16503 and 10315). These were cleaned and fitted with fresh batteries. Both units were configured to sample every 30 minutes, with 16503 located on the buoy keel and 10315 in the sensor frame at 30m.

SBE 37-IMP sensors 6907 and 9475 were calibrated at NOC shortly before the cruise, and both were configured to sample at 15 minute intervals. Unit 9475 was located on the buoy keel and 6907 in the sensor frame.



The SBE 37 sensors were connectect to the sensor frame (S/N 10315 (ODO) and 6907), the ODAS buoy keel (S/N 16503 (ODO) and 9475). All sensors are connected to the buoy Telemetry Hub inductively and are powered internally.



Initial salinity and temperature data, for ODO oxygen see Seaguard above

Pro-Oceanus dissolved gas sensors

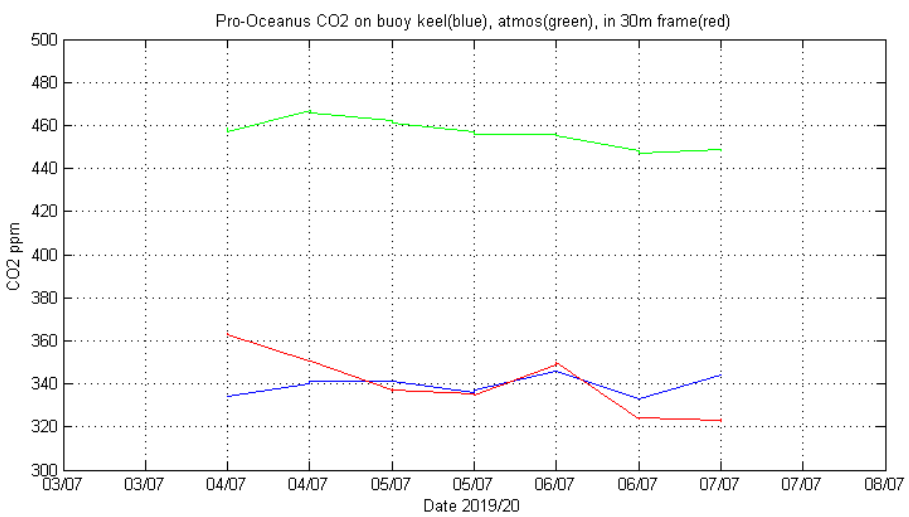
CO_2 sensor on the buoy - The atmospheric Pro-Oceanus CO_2 sensor used last year was deployed on the buoy (SN 34-201-45) after a failure of the new unit (SN 39-599-50A). It was set up to read CO_2 data twice a day (every

12 hours). This sensor follows last year as it has the ability to measure CO_2 concentrations above the sea surface as well as measuring at the sensor position (1 m below surface). To facilitate this, two lengths of yellow garden hose were passed from the keel space to upper buoy mast to protect the gas tubes on the sensor. The top housing was mounted to a clamp plate and fixed to the inner top rail of the mast (Note, fixings for housing mounts are imperial and should be procured prior to sailing). For water-based measurements, a Seabird 5P pump was fitted.

This unit was last calibrated by Pro-Oceanus on 22 Aug 2017.

Pro-CO_2 atmospheric unit showing pump and Pro-CO_2 unit on the keel and atmospheric CO_2 unit attached to the top of the buoy.

Auto Zero Point Calibrations (AZPC) was set up to occur every 23 hours, after discovering a firmware issue in the sensor last year. The figure below shows the initial performance of the CO_2 sensor after deployment.

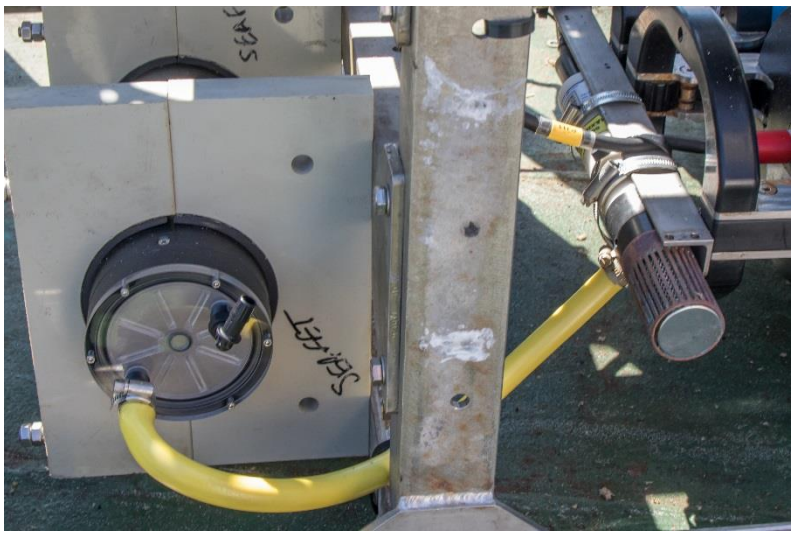


CO_2 measurements from the buoy and frame during the first days of deployment.

The buoy CO_2 sensor is connected to the Telemetry Hub directly, via cable harness 'BuoyCO_2'. Power is supplied by the Telemetry Unit and an OceanSonics battery (SN2303) supplying 14.4 V with 228 Ah capacity (150 Ah

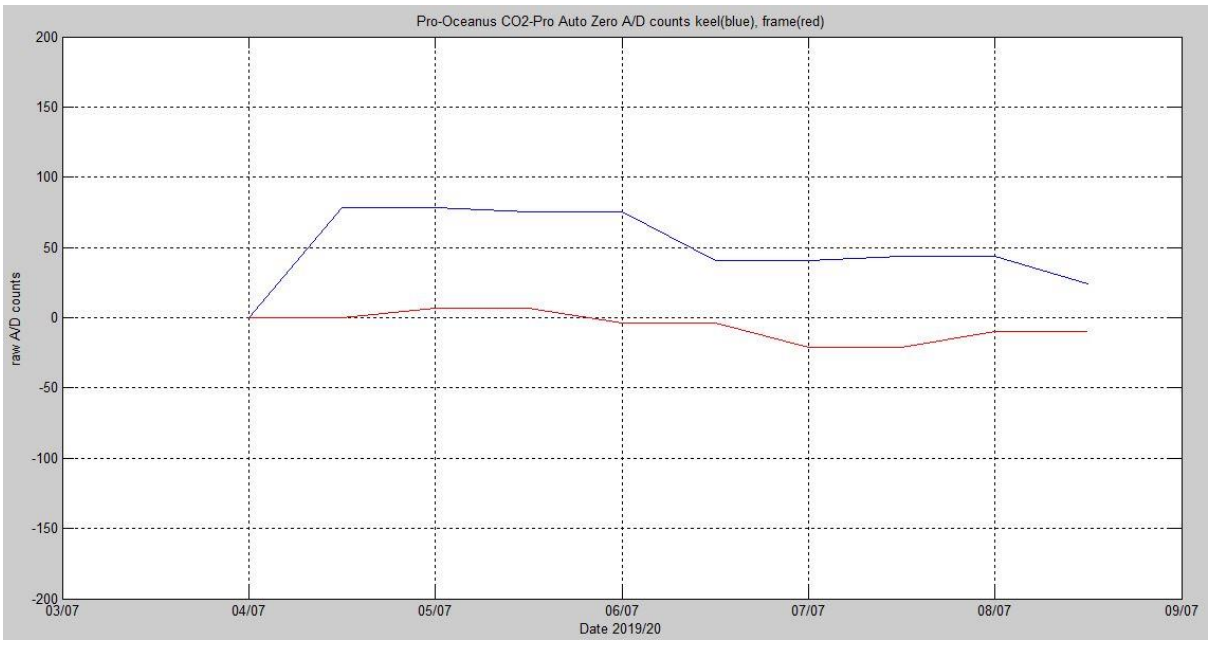
taking into account derating for temperature and safety factor).The Seabird pump is powered from the CO_2 sensor itself.

CO_2 sensor on the frame – A new self-logging Pro-Oceanus CV CO_2 sensor was deployed on the frame (SN 38-560-75). It was configured for twice a day readings (every 12 hours). This sensor was also fitted with a Seabird 5P pump. The sensor was calibrated by Pro-Oceanus on 27 Sep 2018.



Pro-CO_2 CV on the frame – with pump attached just before deployment.

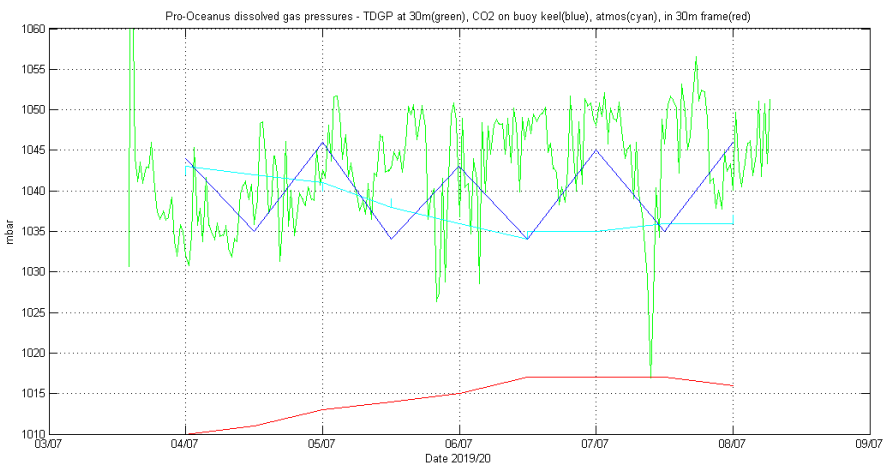
The frame mounted CO_2 sensor is powered by an OceanSonics OS200 battery (S/N 2335, situated in the middle of the three OceanSonics housings on the frame) providing a voltage of approximately 14.4 V and 228 Ah and is connected to the sensor frame Data hub via cable harness 'C'. The sensor was configured to perform an Auto Zero Point Calibration (AZPC) every 24 hours as shown below.



Zero readings from the frame and buoy CO_2 sensors on the first few days after deployment.

TDGP sensor on the frame - A mini TDGP gas tension sensor (SN 38-505-31) was attached to the sensor frame. It has a copper mesh over the membrane to reduce biofouling. It was set to log every half hour. The TDGP sensor is powered by a Wetlabs BPA50 battery (S/N 337) and is connected to the sensor frame Datahub via cable harness 'C'.

The mini-TDGP on the frame pre-deployment.



Pressure during the first days of deployment from the GTD and CO_2 sensors in frame and keel

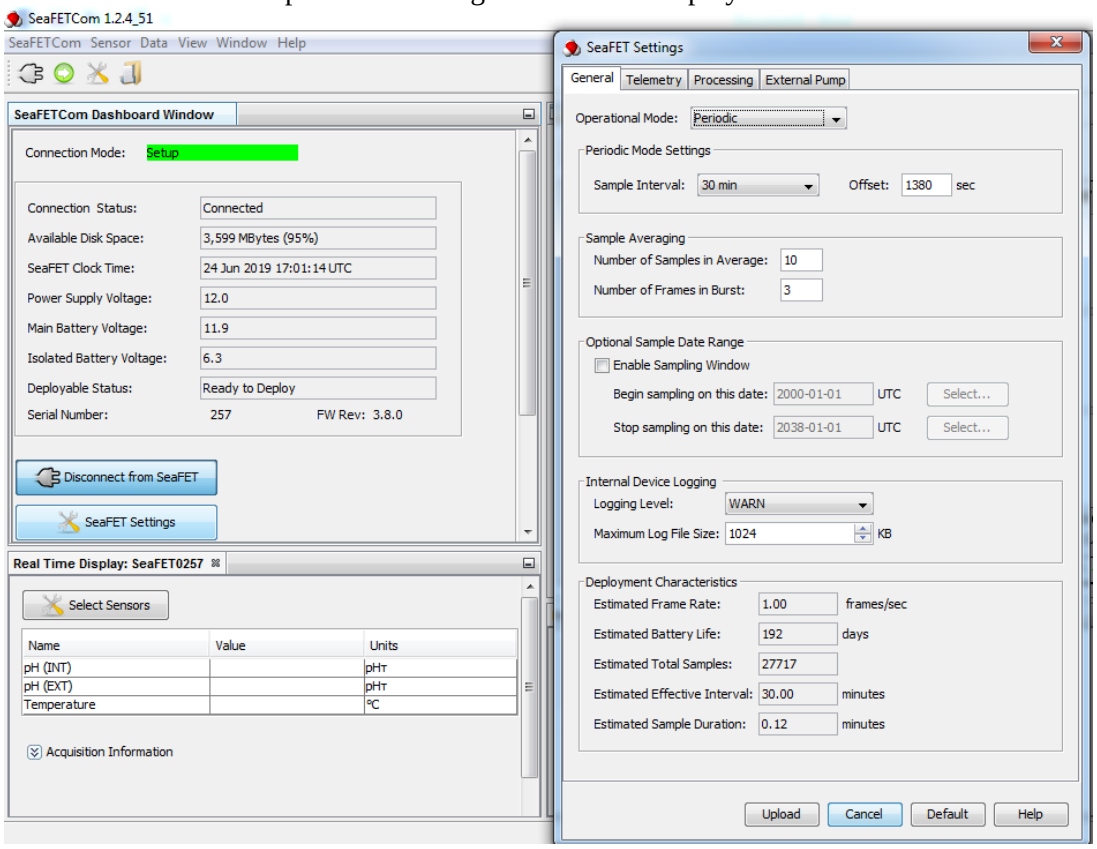
SeaFET pH sensors

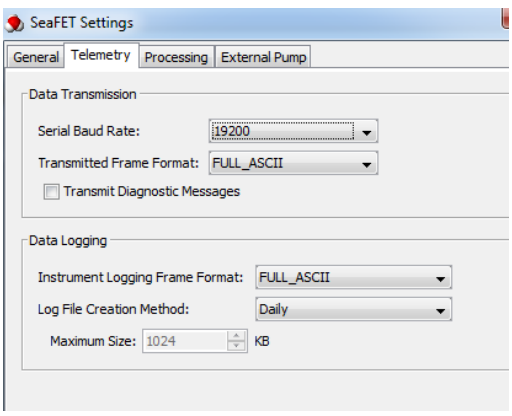
SeaFET deployment on the buoy and sensor frame - SeaFET SN 63 was deployed on the buoy and SeaFET SN 257 was deployed on the sensor frame at 30 m. The buoy mounted SeaFET was wrapped in copper tape in an attempt to reduce biofouling and is powered via an OceanSonics battery pack (S/N 252) configured for 14.4 V and 200 Ah (150Ah taking into account derating for temperature and safety factor). It is connected to the Telemetry Hub via cable harness 'BuoypH'. The sensor frame SeaFET is powered via a BPA50 16 V 50 Ah battery pack (S/N 288) and is connected to the sensor frame Datahub via cable harness 'D'.

On the frame, the SeaFET was set up to sample in periodic mode with a sampling interval of 30 min and 1380 sec offset (23 min past the hour), producing 3 Frames per burst (output of 3 samples, each is an average of 10

readings) and creating a DAILY log ASCII file. On the buoy, the SeaFET was set up to sample in PERIODIC mode with a sampling interval of 30 min and 1620 sec offset (27 min past the hour), producing 3 Frames per burst (output of 3 samples, each is an average of 10 readings) and creating a DAILY log ASCII file. Note that the sampling regimes cannot be changed remotely.

SeaFET 257 pH sensor configuration for the deployments on the frame





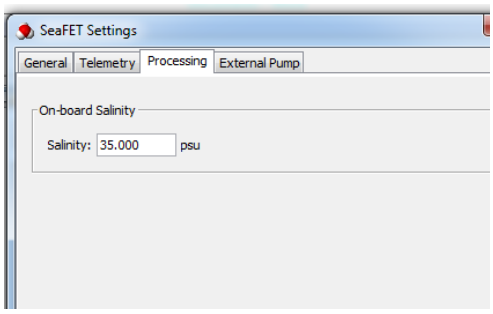
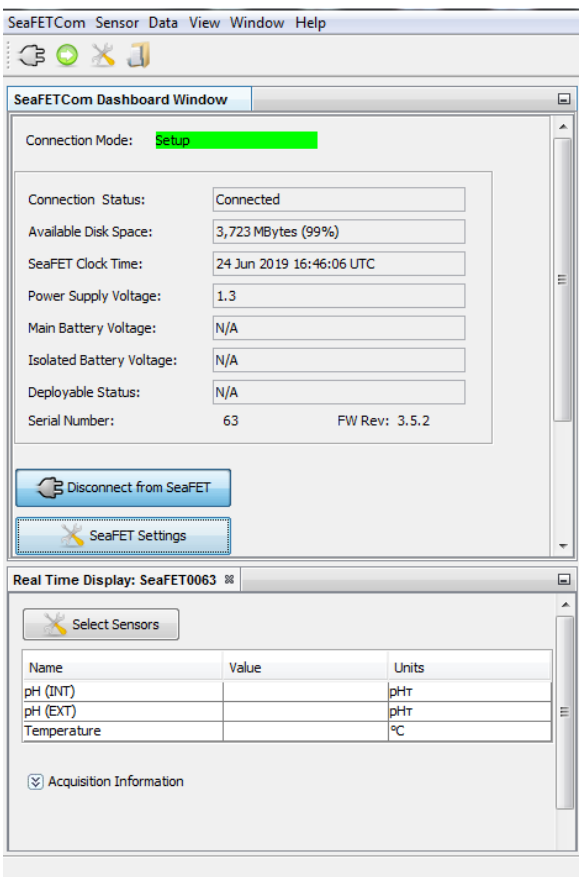
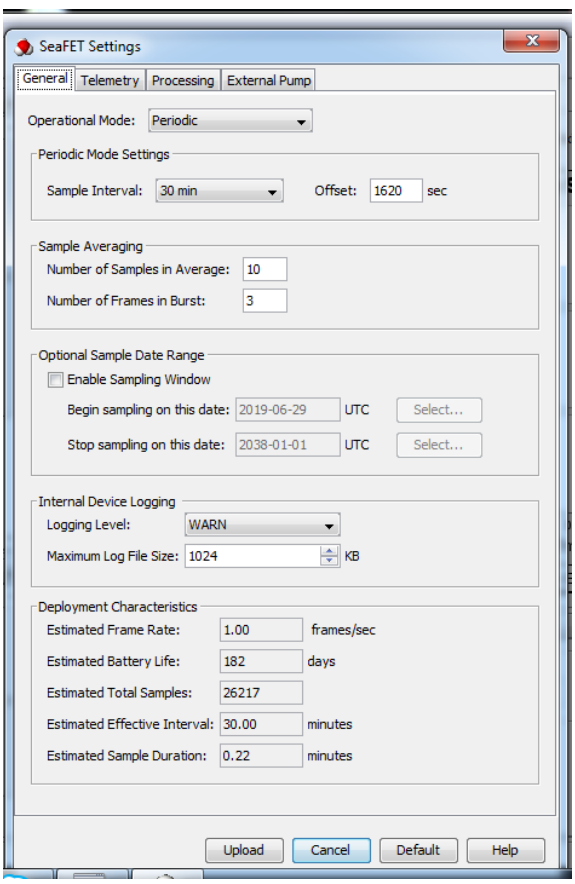
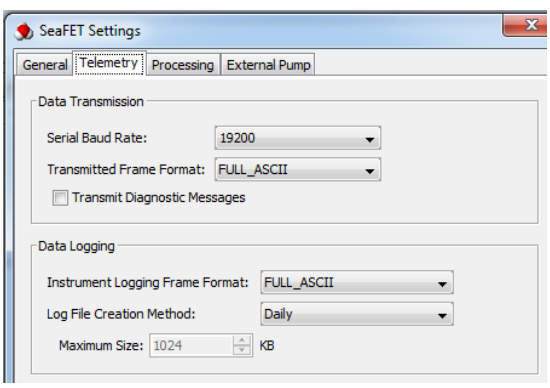


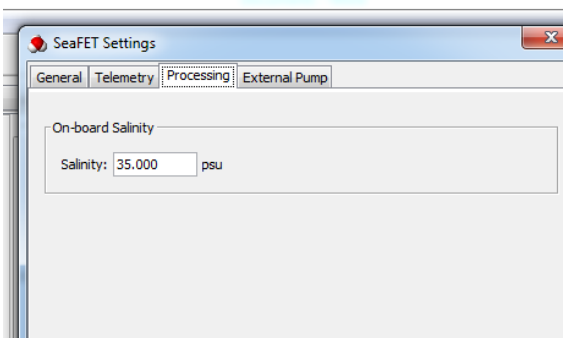
Photo of SeaFET 257 pH sensor (grey plastic housing) on the frame

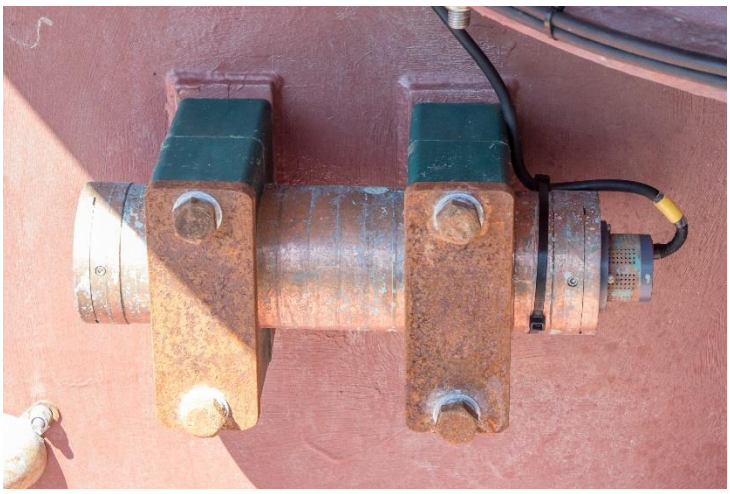
SeaFET 63 pH sensor configuration for the deployments on the buoy









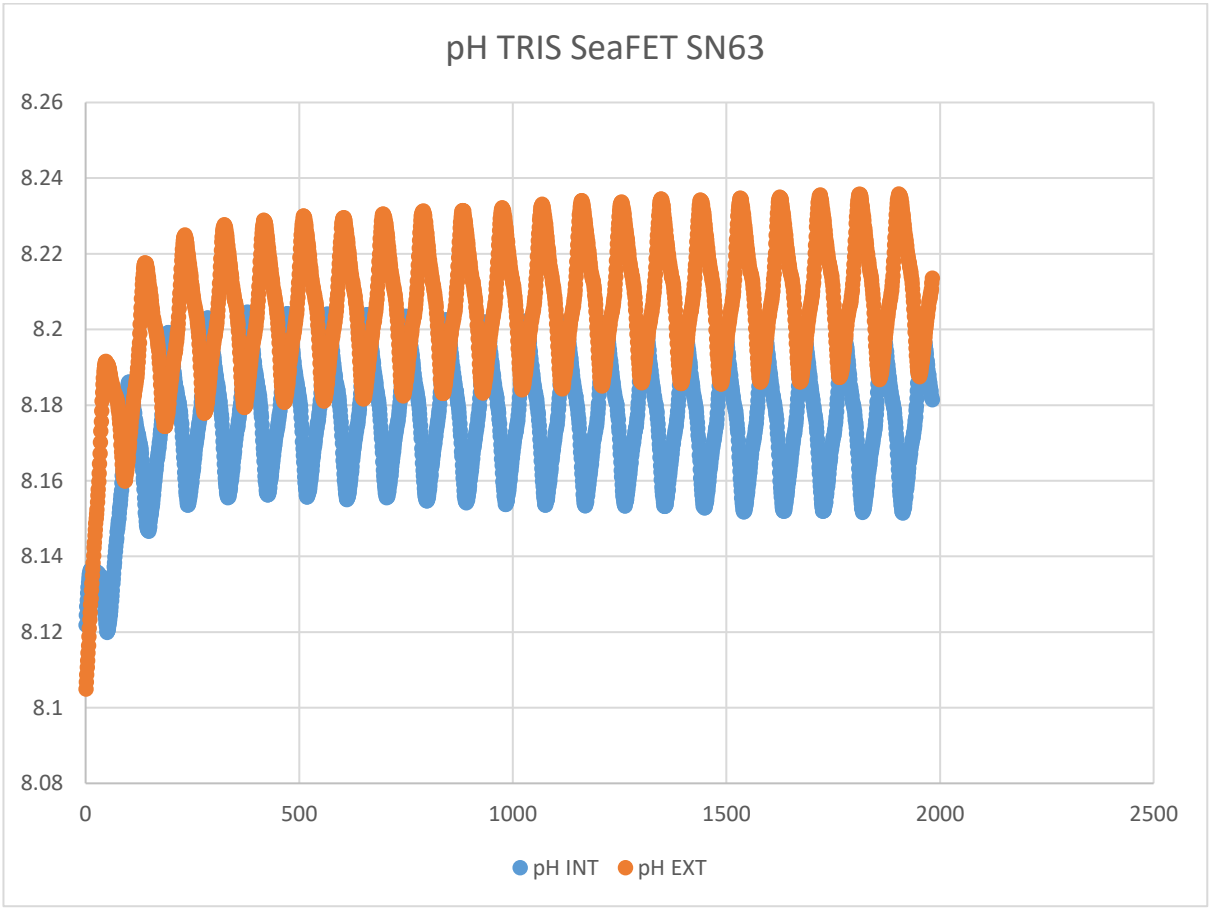


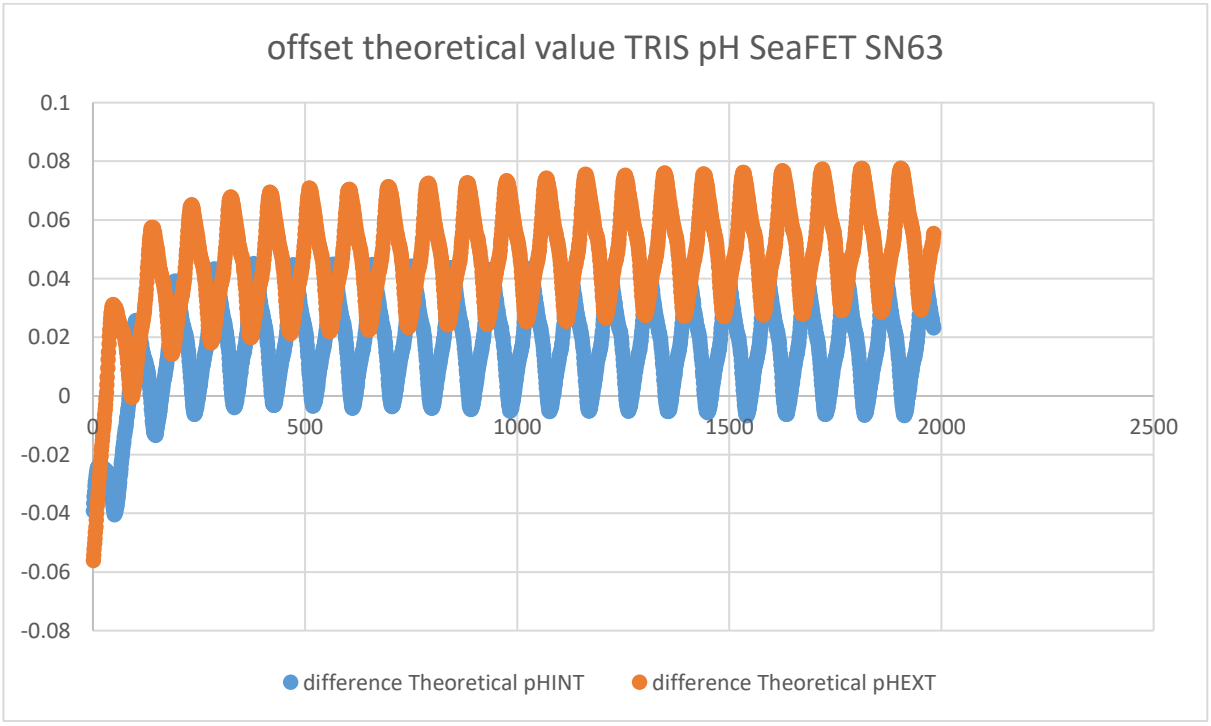
SeaFET SN63 on the keel

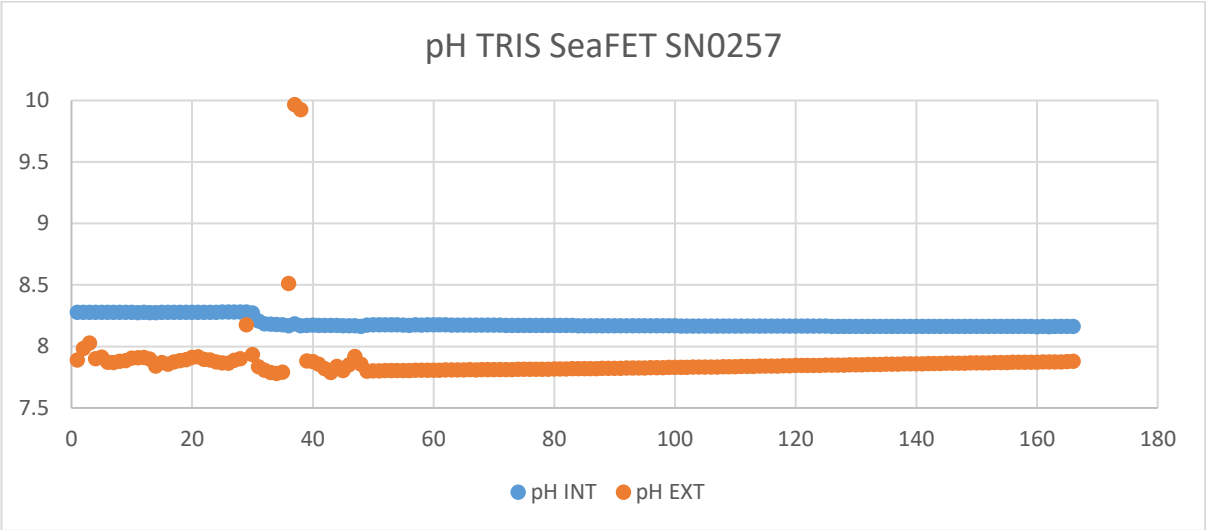
The two SeaFETs that were deployed have small internal battery packs that are sufficient to power the sensors for a month or two if the main power supply fails. These were connected the day before deployment and the copper biofouling guards were put in place on the morning of deployment. Note that the newer SeaFETs, such as s/n 257, have two internal batteries, one of which provides an uninterrupted and isolated source of power to keep the sensing element conditioned and the other requires a magnet to switch on the power supply.

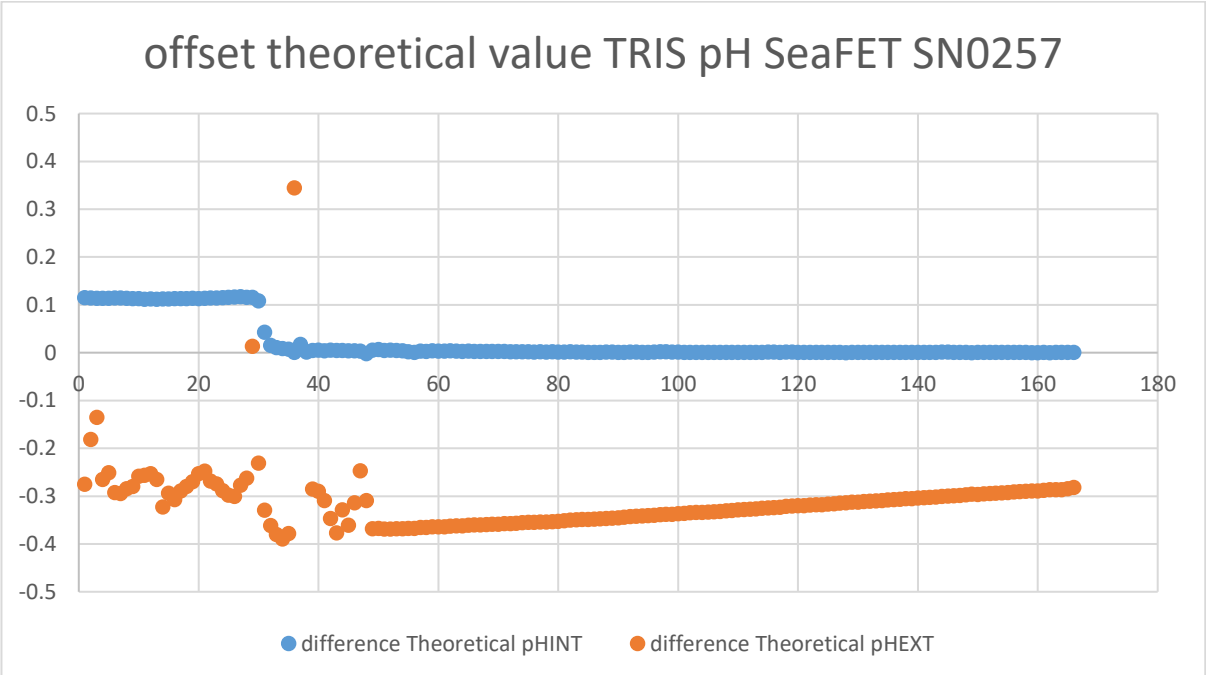
Both of the SeaFET instruments were calibrated by Seabird in April 2019. The laboratory calibration of SeaFET pH sensors (SN 63 and 257) summarised below was done on board the *Discovery* on the 24/06/2019. TRIS-buffer with salinity 35 made by VLIZ (Flanders Marine Institute) was used to calibrate the sensors. The theoretical values for the TRIS were calculated at the different temperatures and compared with the values for pH that the sensors were giving. The SeaFET sensors were switched on for minimum 1 hour then the cell of each of the SeaFETS (that was filled up with seawater) was rinsed and filled with the CRM. The ISFET temperature (measured by the SeaFETS) continued to rise over the next 2 hours (the response is slow as the sensors are within the gel of the ISFET). When the temperature had stabilised the range of pH readings was recorded for the internal and external electrode. The ISFET thermistor is not calibrated and differed to the measured temperature (as shown in the table). The results are all tabulated below.

The offset (calculated from the theoretical values of the TRIS-buffer) for each SeaFET at the DY103 laboratory calibration are shown below. SeaFET with SN0257 is not working correctly. SeaFET with SN63 seems to work OK. For the SeaFET with SN63 there is an average offset of 0.016687 for pH INT and 0.046009 for the pH EXT. For the SeaFET with SN0257 there is an average offset of 0.022594 for pH INT and -0.2873 for the pH EXT. This offset is calculated based on the theoretical values of the TRIS buffer at a certain temperature.

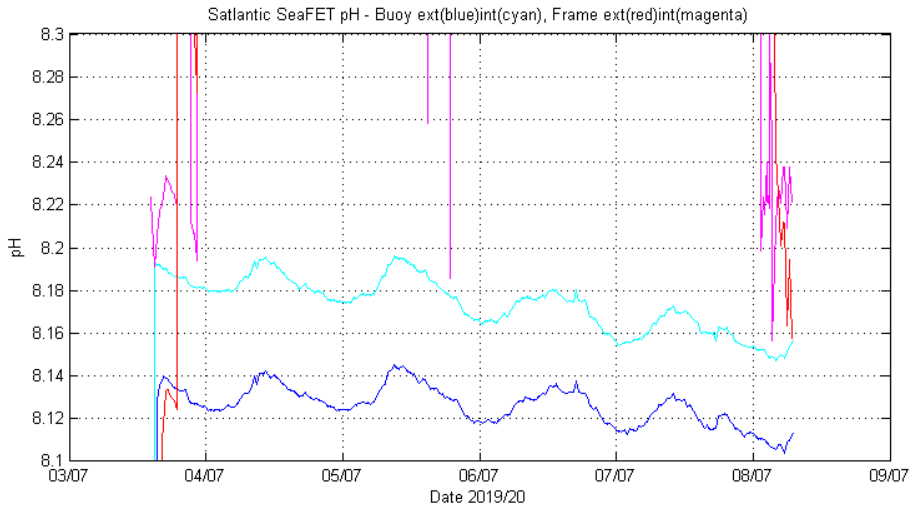

pH TRIS SeaFET SN63
8.26
8.24
8.22
8.2
8.18
8.16
8.14
8.12
8.1
8.08
0
500
1000
1500
2000
2500
pH INT
pH EXT


offset theoretical value TRIS pH SeaFET SN63
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0
500
1000
1500
2000
2500
difference Theoretical pHINT
difference Theoretical pHEXT



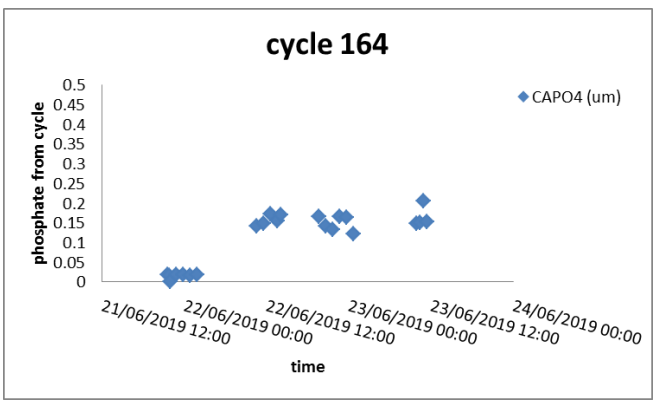


SeaFET 257 was seen during lab tests to take a long time (order of mid tens of hours) to settle. For this reason, it was placed on the 30 m frame as surface pH measurements are used in more datasets. This sensor when deployed gave debateable data for the first few days of deployment but at the time of writing looks to be settling into believable readings (see below). The suppliers have since acknowledged a general fault with the FETs on these 2 instruments.

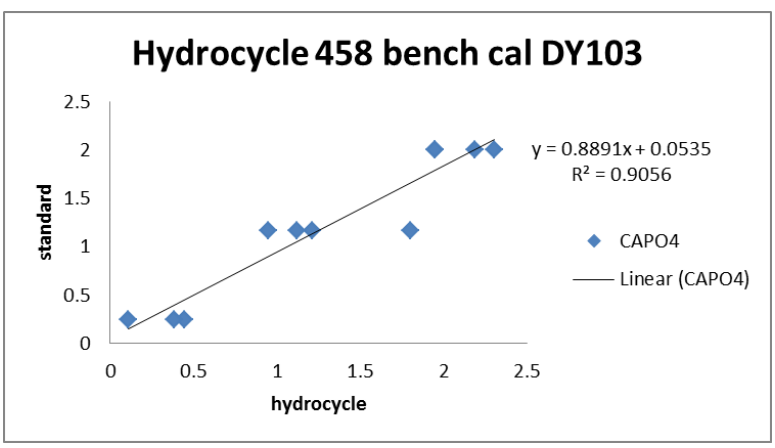


SeaFET data just after deployment

Hydrocycle Phosphate deployed



The cycle P s/n 164 was prepared for deployment. The graph shows the MQ base line and the first standards used to perform a bench calibration. Unfortunately, after the next trial of the higher concentrations the instrument failed to switch on. The cycle was opened up and examined for any obvious issues and there was a smell of burnt circuit boards. The cycle P needs external power to function, and a bench top power pack was used to supply that power and to another instrument. Although power was setup correctly to 12 volts, at some point in the bench cal, the voltage dial was turned up past 12 volts which damaged the cycle P beyond any repairs available on ship. It was decided to redeploy the hydrocycle 458.



The hydrocycle was cleaned and flushed through with MQ. The chemicals were changed for new and a series of bench cals performed to calibrate recovered data. This calibration can also be used for the DY103 deployment. The hydrocycle was tested thoroughly on the bench (with the voltage dial taped at 12 V to prevent a repeat). Then on the hub where there were issues with current because of the large draw requited to prime. This was resolved and the unit was set up to start sampling at midnight on Wednesday evening to avoid sampling dry. The 458 started sampling on time and the hub us still receiving data as of 6/07/19.

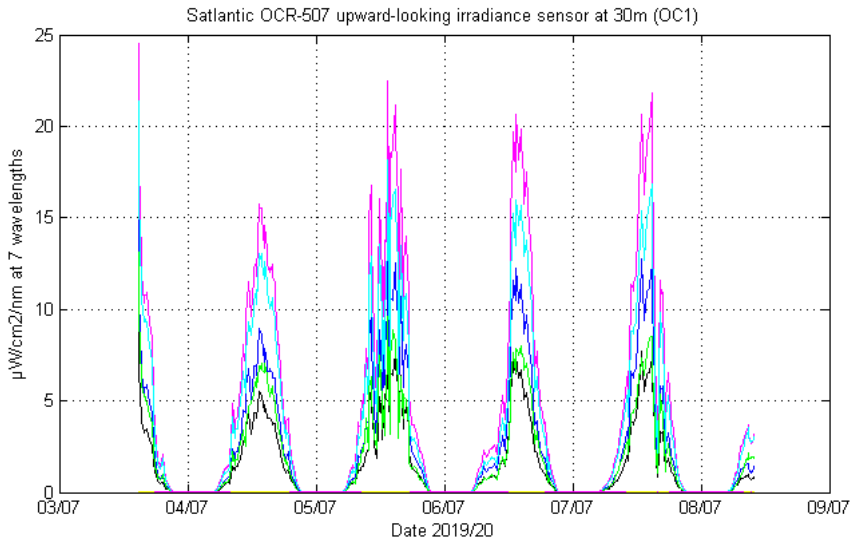
The Hydrocycle is powered by an OceanSonics OS200 battery (S/N 2336) providing a voltage of approximately 14.4 V and 228 Ah capacity (150 Ah taking into account derating for temperature and safety factor) and is connected to the sensor frame Datahub via cable harness ‘B’.

Satlantic OCR-507 Irradiance sensors

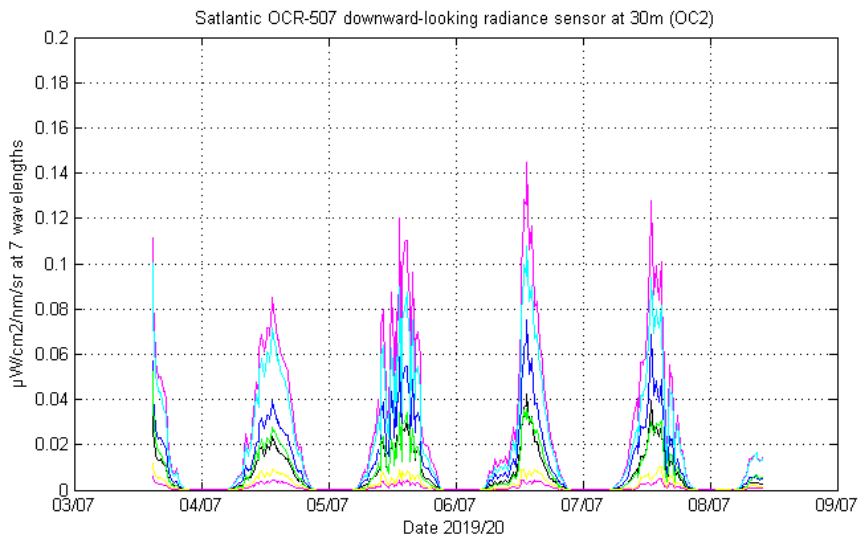
A Satlantic OCR-507 ICSA irradiance sensor (SN 226) was fitted to the buoy mast and is controlled by the Telemetry Unit. The Data Hub controls an OCR-507 ICSW upward-looking irradiance sensor (SN 1428) and an OCR-507 R10W downward-looking radiance sensor (SN 95).

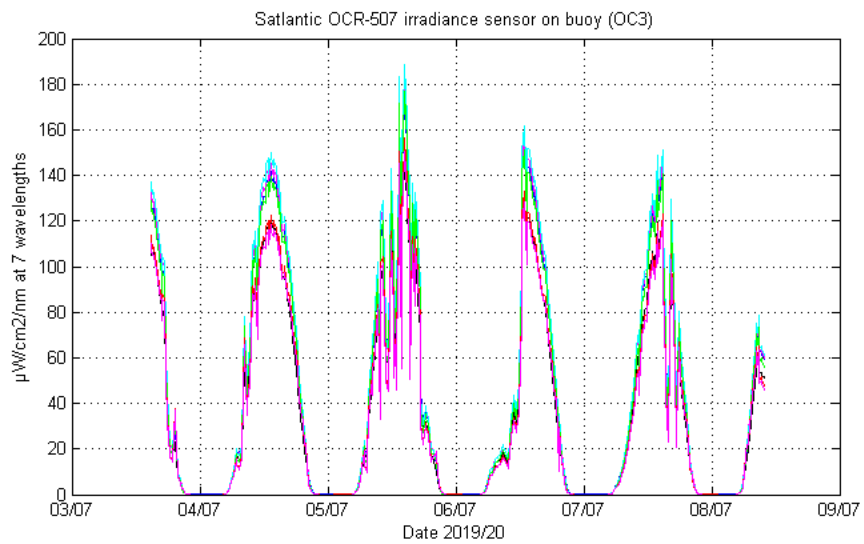
Satlantic radiometers pre-deployment on the buoy, upward and downward looking on the frame.

All 3 sensors were setup to sample every 30 minutes at the same time so that their data are coincident. The sampling intervals can be changed remotely using SBD commands. The buoy mast mounted OCR is powered via the Telemetry hub and is connected to the Telemetry hub via cable harness ‘BuoyOC3’. The sensor frame mounted OCRs are powered via the Data Hub and connect to the Datahub via cable harness ‘D’.



Data from the OCR 1 radiometer after deployment.





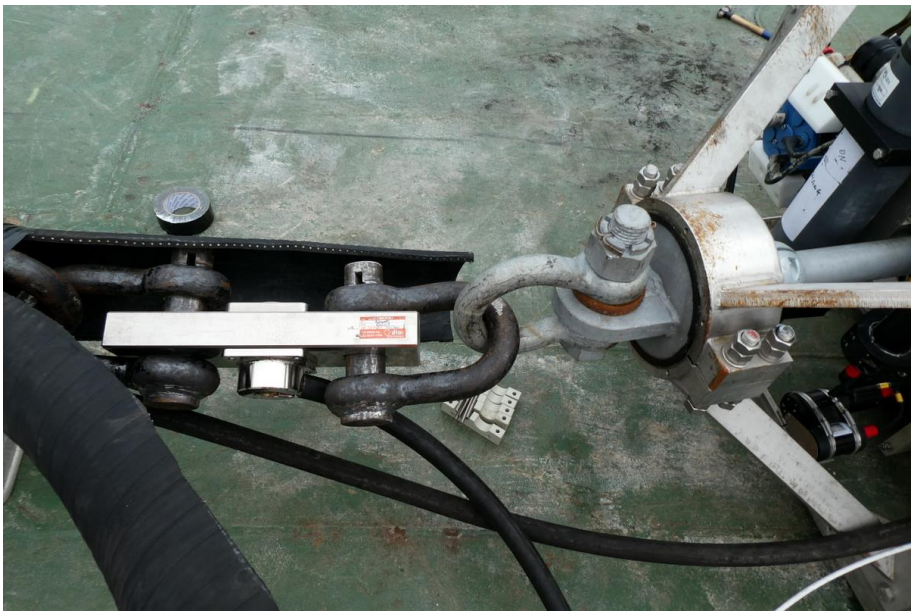
Data from the OCR 2 and 3 radiometers after deployment

DLM Load Cell (tensile link)

Dynamic Load Monitoring (UK) Ltd supplied a plated steel tensile link (SWL 25 tons) with built in load cell, 3-axis accelerometer, 3-axis gyro and data logger. This was fitted between the top of the sensor frame and the bottom of the mooring chain (see photo) in order to measure the dynamic forces on the mooring. The internal data logger runs continuously, sampling all 7 channels at 8 Hz. The unit has an internal rechargeable battery which allows for a few weeks of logging without an external power source. It is connected to a dedicated external 18 V, 150 Ah battery pack in the sensor frame, and can also request power from the hub.

The Data Hub controller periodically requests a few minutes of live data from the load cell according to a remotely configurable schedule, currently once an hour. The data from the load cell are logged in the hub and 1-minute maximum, minimum and average values for each channel are sent to the buoy for inclusion in the Iridium telemetry.

Initial results under very calm conditions (wave heights around 1 m) show an average load of around 0.6 tonnes, ranging between 0.4 and 0.8 tonnes.



Star-Oddi Pre-deployment Calibrations and Re-deployment on PAP#1

Star-Oddi sensors were calibrated on different shallow cast CTDs (200 and 100 m respectively) to be readied for attachment and redeployment of PAP#1. Casts 03 & 04 were used for these calibrations, and data for temperature and depth were collected. Prior to calibration, data were collected and wiped from each sensor using the software SeaStar, and a 10 second recording interval was programmed in to each sensor to collect necessary data.

Pre-deployment Star-Oddi calibration settings and statistics.

Serial No.	Type	CTD Depth (m)	Memory Remaining (%)	Battery Remaining (%)
S6782	DST CTD	200	90	36
S7562	DST CTD	200	90	33
S7564	DST CTD	200	90	29
S7565	DST CTD	200	90	33
S7566	DST CTD	200	90	33
S7727	DST CTD	100	36	24

Re-deploying Star Oddi sensors and their statistics.

Serial No.	Position	Batt. Remaining (%)	Mem. Used (%)	Max Depth (m)	Calibration
C8928	Buoy	76	36	52	N
S6782	5m	36	10	2045	Y
S7562	10m	33	10	521	Y
S7565	15m	33	10	521	Y
S7566	20m	33	10	521	Y
H454	Frame	47	0	276	N
H457	Frame	45	1	3063	N

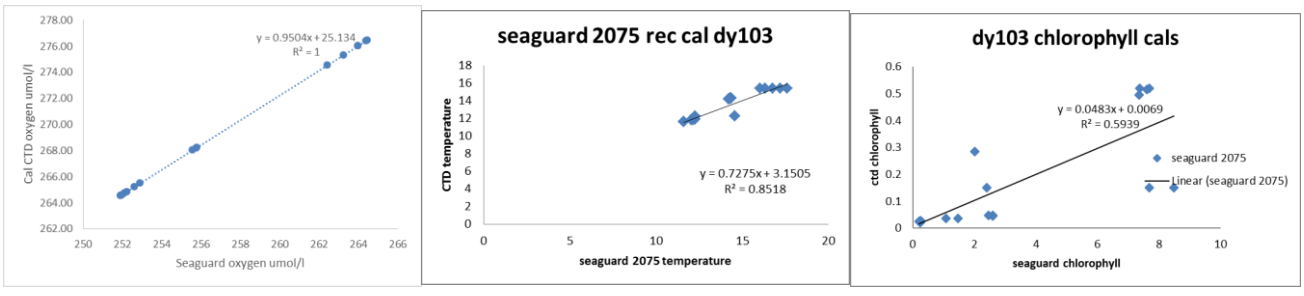
Before PAP#1 buoy was redeployed, a number of Star Oddis were attached to various locations on the buoy set up. These were placed in cases and housings before cable ties and tape secured them tightly to each location to ensure their safety on the frame for a year.

PAP1 Recovered Data Hub and Telemetry Systems

Andaara seaguard recovered

seaguard sensor s/n 2075

The seaguard was deployed on JC165 after calibration. But the temperature and chlorophyll calibrations were very poor (r^2=0.5495 and 0.5939 respectively). The seaguard was set up for post dep calibration on CTD 04 (dy103-011).



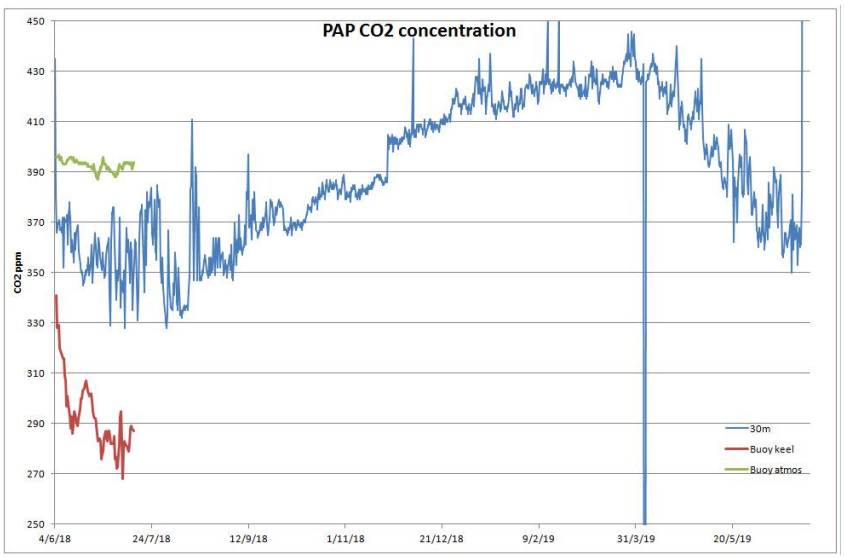
The post deployment calibrations though not good are much improved on the pre deployment calibrations. One of the issues is that because the seaguard is not fitted with a depth sensor it is very difficult to align the data.

Time is much more difficult to see where any offsets lie. Therefore, it is recommended that for future deployments the seaguard is fitted with a depth sensor – this could be easily remedied at the next service.

Pro-Oceanus sensors

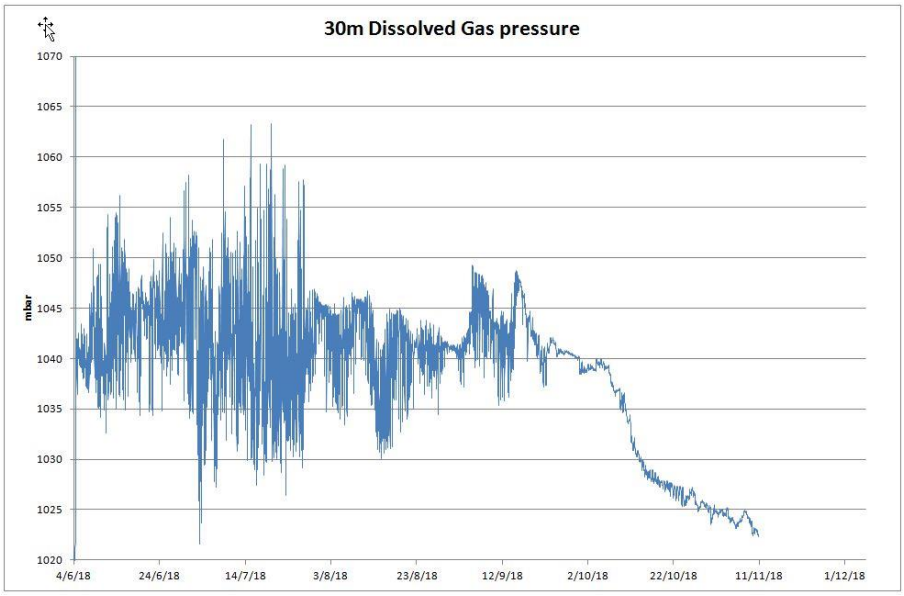
The failure of the buoy power supply meant that the CO_2 sensor on the keel (sn 34-201-45) stopped working after 40 days, whereas the sensor in the frame at 30m (sn 33-146-45) continued to work throughout the deployment thanks to its OceanSonics battery.

Due to a problem with the internal logger firmware, the keel sensor did not perform any Auto Zero Point Calibrations after deployment, and only reported CO_2 concentration to a resolution of 1 ppm, rather than the specified 0.01 ppm. An internal connector on the frame sensor (sn 33-146-45) became detached on 12 August 2018 meaning that subsequent CO_2 data was not corrected for internal gas temperature and humidity.



Pro-Oceanus CO_2 data from the buoy keel and sensor frame

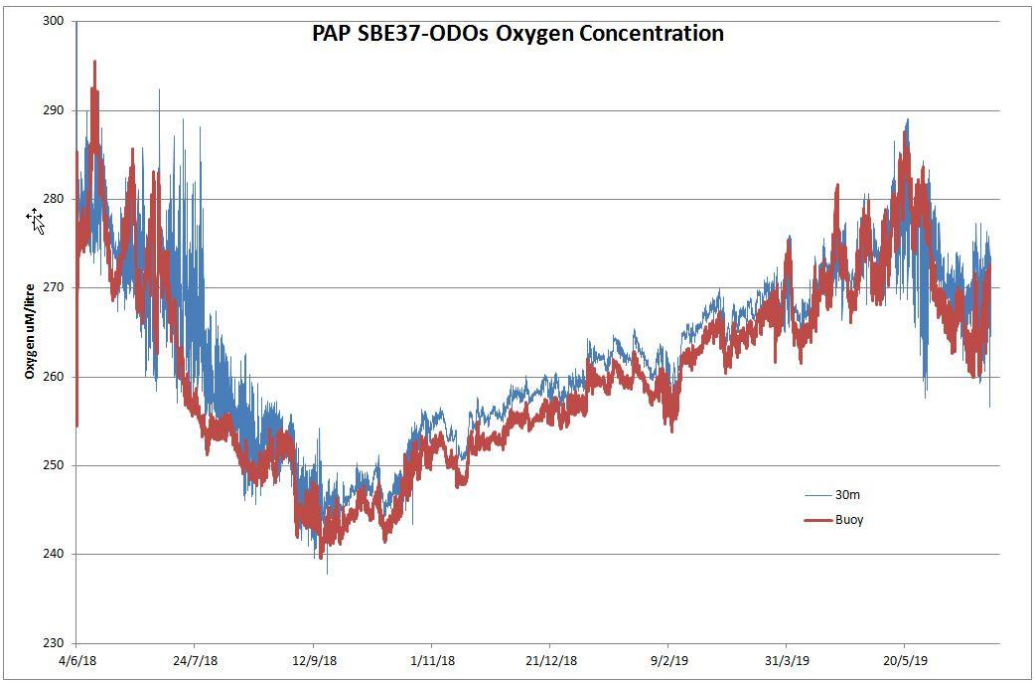
The Mini-TDGP sensor on the frame (sn 38-506-31) stopped working on 10 November 2018 after it lost power due to water ingress into its battery cable. See data plot below.



Total Dissolved Gas Pressure from Pro-Oceanus Mini TDGP at 30m

Sea-Bird SBE 37 MicroCATs

All four of the MicroCATs deployed in 2018 were recovered with full datasets. The plot below shows the oxygen concentrations recorded by the two SBE 37IMP-ODO sensors, sn 16503 on the buoy and sn 10315 in the frame at 30m. SBE 37IMP sn 6904 was also deployed in the frame while SBE 37IMP sn 6915 was attached to the buoy mast to measure air temperature in place of the faulty Met Office air temperature sensor. Both recorded full datasets.



Oxygen concentrations measured by SBE 37IMP-ODO MicroCATs

Satlantic OCR-507 Irradiance sensors

The two upward looking OCR-507 irradiance sensors worked successfully until the buoy power supply failed on 14 July 2018. The downward-looking radiance sensor (sn 113) failed earlier than this on 14 June 2018. Unlike the other two sensors it also lost its copper bioshutter plate.

Wetlabs fluorometer recovered 269

The fluorometer s/n 269 looked operational on the frame and the shutter was showing good anti fouling. It was recovered and washed in warm fresh water. The data was downloaded, and the factory calibrations applied:

Factory cal:

The Characterization sheet is as follows: SN 269

Thermistor calibration: temperature= (output x slope) + intercept

Where slope = -0.0057 °C/count and intercept = 71.5456° C

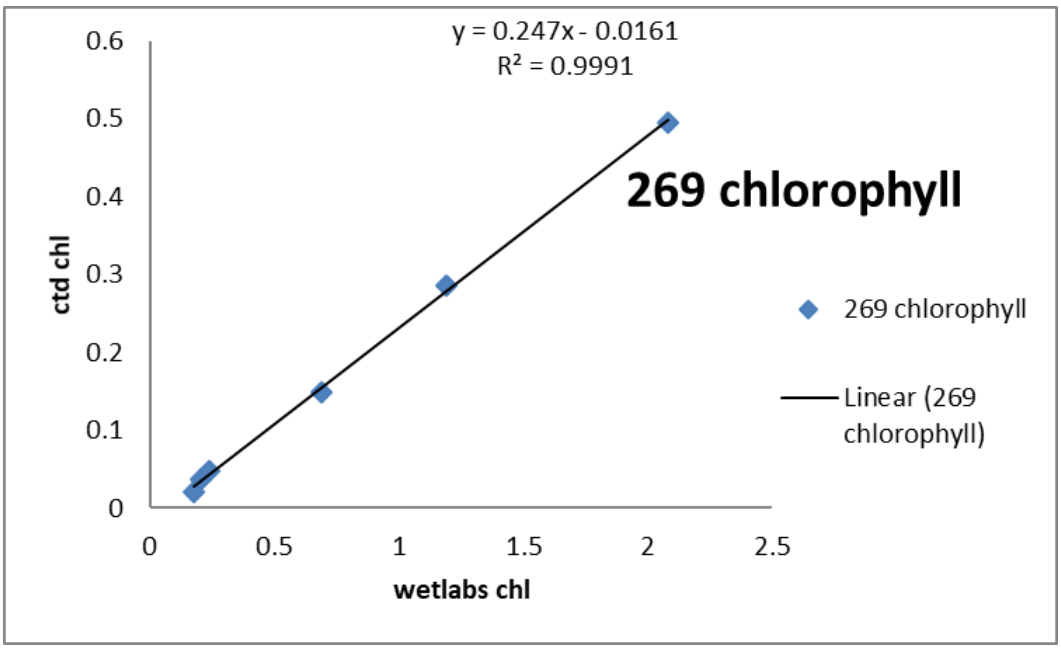
Pressure sensor calibration: pressure= (output x slope) + intercept

Where slope = 0.033 dBar/count and intercept = -4.61 dBar.

Chlorophyll Scale Factor: Chl(µg/l)= Scale Factor x (output – dark counts)

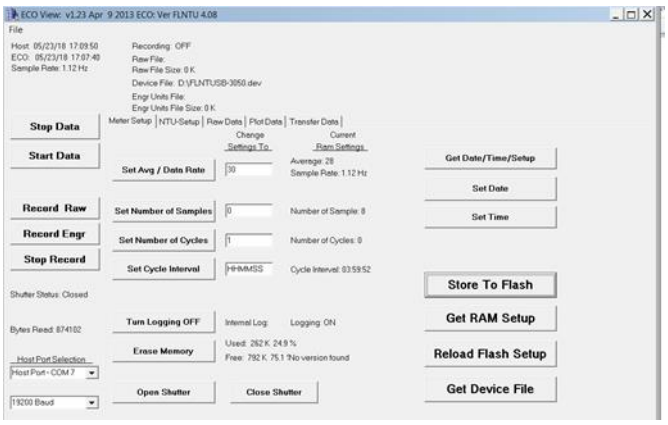
Where scale factor = 0.0098 µg/l/V and dark counts =54 counts

Nephelometric Turbidity Unit (NTU) Scale Factor = Scale Factor x (output – dark counts). Where scale factor = 0.0066NTU/V and dark counts = 73 counts).



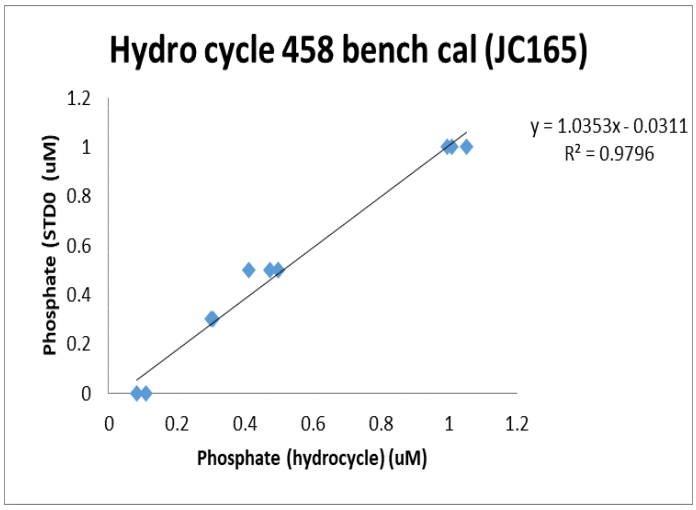
The instrument was then calibrated against the CTD fluorometer (Chelsey aqua tracker III) which had been calibrated by bottle samples run on a Turner triology bench top fluorometer (black 2, RF 0.31). The resulting calibration is chlorophyll (mg/m^3) = 0.247 X – 0.0161 (r^2=0.9991)

This is an excellent calibration for an instrument, which has been deployed for a year.


ECO View: v1.23 Apr 9 2013 ECO: Ver FLNTU 4.08
File
Host: 05/23/18 17:09:50
ECO: 05/23/18 17:07:46
Sample Rate: 1.12 Hz
Recording: OFF
Raw File:
Raw File Size: 0 K
Device File: D:\FLNTUSB-3050.dev
Engr Units File:
Engr Units File Size: 0 K
Meter Setup
NTU-Setup
Raw Data
Plot Data
Transfer Data
Stop Data
Start Data
Record Raw
Record Engr
Stop Record
Shutter Status: Closed
Bytes Read: 874102
Host Port Selection
Host Port - COM 7
19200 Baud
Change Settings To
Current Ram Settings
Set Avg / Data Rate
30
Average: 28
Sample Rate: 1.12 Hz
Set Number of Samples
0
Number of Sample: 8
Set Number of Cycles
1
Number of Cycles: 0
Set Cycle Interval
HHMMSS
Cycle Interval: 03:59:52
Turn Logging OFF
Internal Log:
Logging: ON
Erase Memory
Used: 262 K 24.9 %
Free: 792 K 75.1 %No version found
Open Shutter
Close Shutter
Get Date/Time/Setup
Set Date
Set Time
Store To Flash
Get RAM Setup
Reload Flash Setup
Get Device File

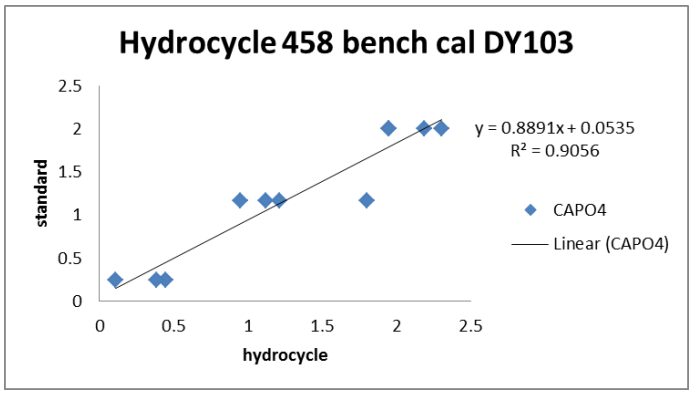
Hydrocycle Phosphate recovered

Hydro cycle phosphate sensor s/n 458. The hydrocycle was deployed on JC165 after bench calibrations.

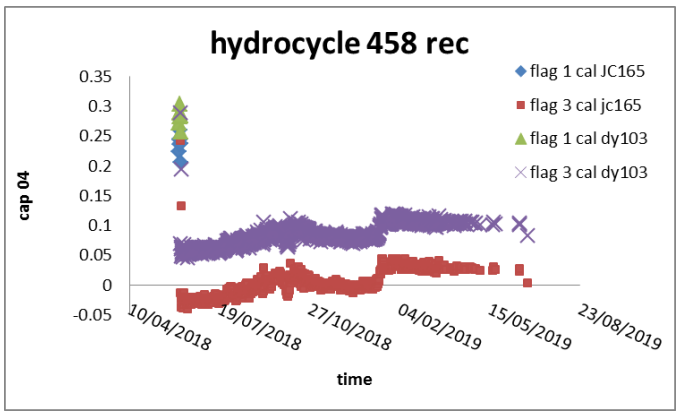


The hydrocycle was set up for deployment on 03/06/18 allowed to prime in a bucket of mq then fixed onto the frame with a first sample set for 04/06/18 18:20 and then every four hours. The hydrocycle was transmitting sensible numbers as of 06/06/18.

It was recovered on 25/06/19 and 1500 files downloaded. The summary file contained over 1500 records. Data were cleaned in three steps: 1 all nan cap04 data points were removed, 2 all data points with an overall flag of 4 (bad data) were removed, 3 remaining data points were separated into overall flag 1(good data) and 3 (suspect data) and plotted in date order.



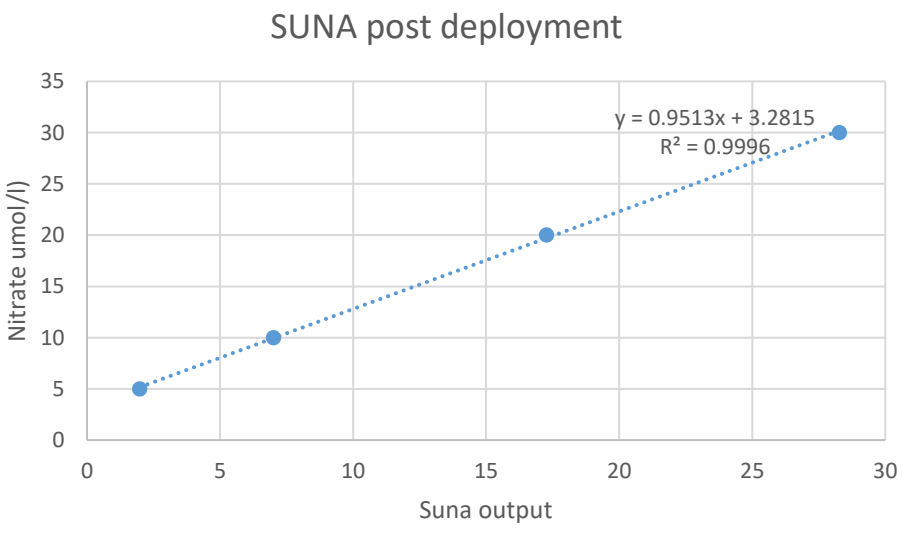
The reagents were replaced with new and a sequence of bench calibrations were used to produce a post deployment calibration.



The calibrations from both JC165 and DY103 were applied to the recovered data. It appears that the first few recordings made were within expected limits, but subsequent ones are not. So the more appropriate calibration is the first one from JC165. It is unclear why it did not work as expected on deployment, but did when returned to the lab and calibrated. The cal flag was either 2 (missing) or 4 (bad) for the calibrations and the reagents were difficult to get to latch onto the new style connections. The deployed cartridges all came back empty so the standard was used but perhaps if it did not seal properly, then the standard would not always be delivered. Looking back at the summaries from the bench cals on JC165 the cal flag was already showing so may not have been working before deployment. Unfortunately because there was an issue with cycle that was to be deployed on DY103 the 458 was turned around and deployed again.

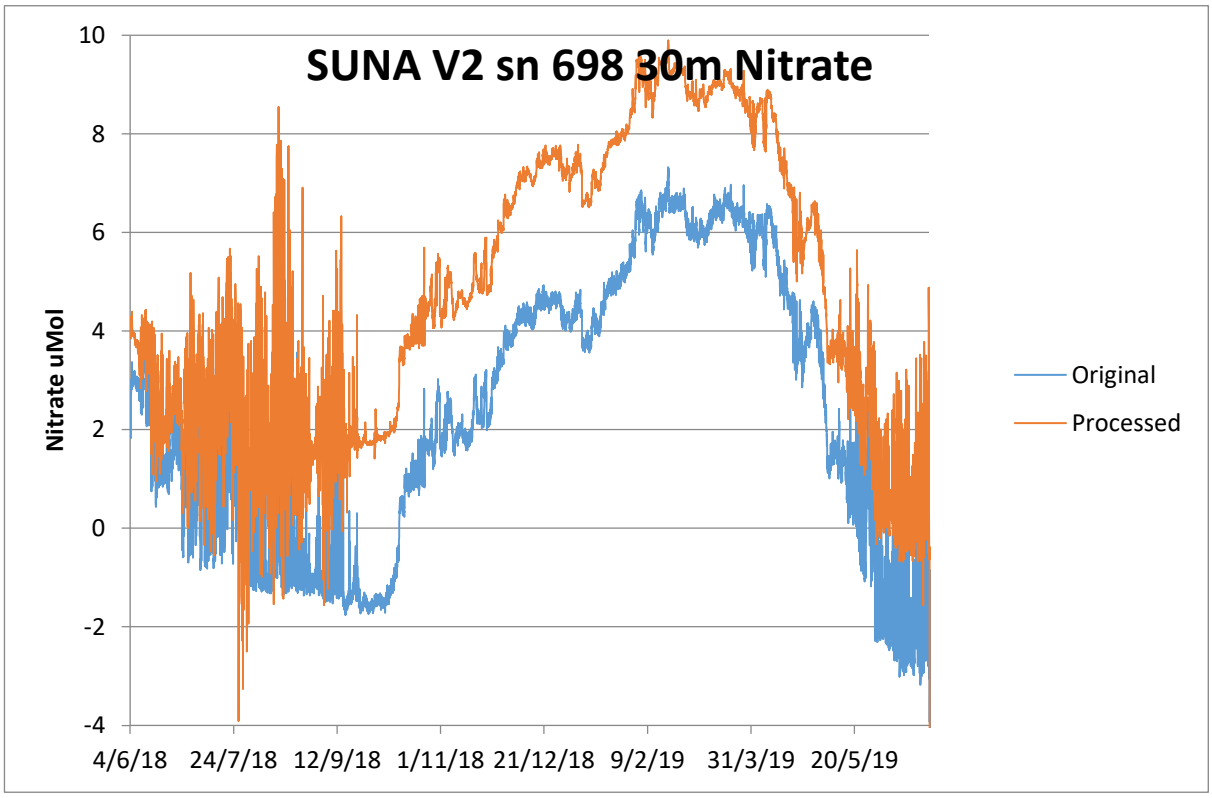
Satlantic SUNA Nitrate Sensor recovery and calibration

The metal cased SUNA (SN 0698) deployed on a sensor frame during cruise JC165 was successfully recovered on DY103. DIW water was measured in the freshwater mode and gave a reading of -1.96. To do the calibration the mode was changed to “seawater mode”. Calibration checks on the SUNA 0698 (post deployment) were done in ASW (artificial seawater) and gave a reading of -1.94 in the seawater mode. There was a check with 6 nitrate standards made up in ASW. Post-calibration has been done after cleaning. Cal curve with working standards:



Standard	Concentration	Measured concentration
ASW	0	-1.94385
5 µM	5	1.974762
10 µM	10	7.012632
20 µM	20	17.26917
30 µM	30	28.27429

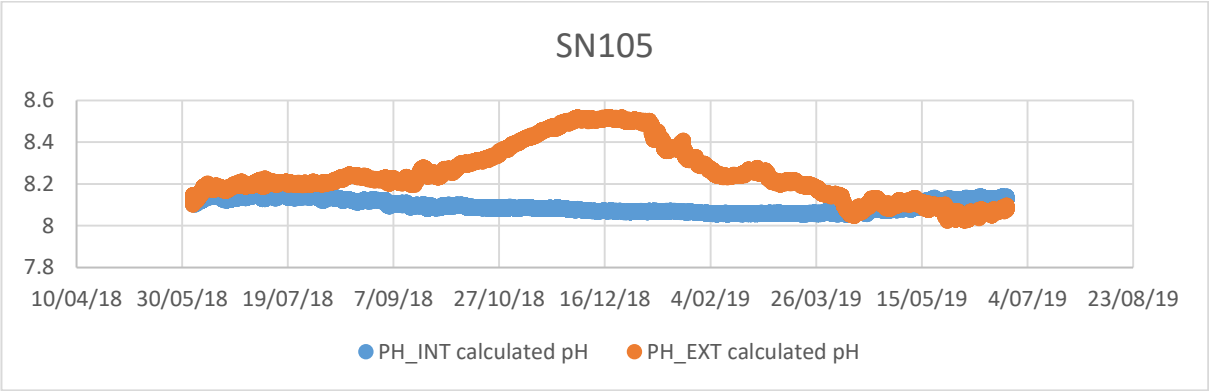
SUNA SN698 data was post processed at NOC using the 10315 30 m SBE microcat data. The post processed data matches up well with the 30 m nitrate data (0.98 µmol/l).



Satlantic SeaFET pH recovery and calibration

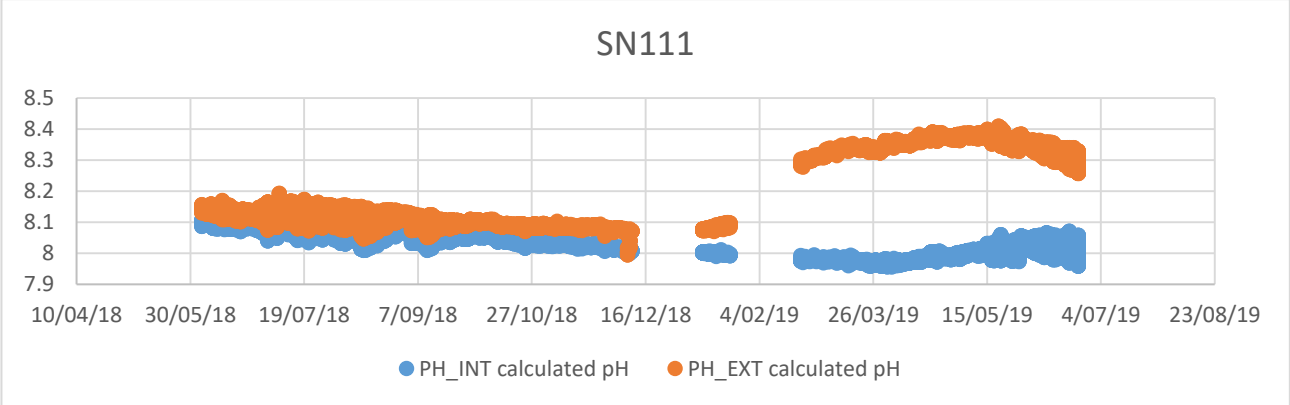
The SeaFET pH sensors SN 105 (buoy) and SN 111 (frame) were deployed in June 2018 on JC165. They were programmed to take samples every 30 min. On the frame, the SeaFET 111 was connected to an Ocean Sonics battery with 206 Ah and at the buoy the SeaFET105 was also powered by an OceanSonics battery at the keel with 206Ah. The SeaFETs were successfully recovered on DY103 (25/06/2019); Both sensors were still working and recording data.

SeaFET SN105 data (on the buoy).



The sensor produced data for the whole year. There were no drop outs. However, it seems that the external electrode of the SeaFET starts to drift after being deployed for nearly two months.

SeaFET SN111 data (on the frame).



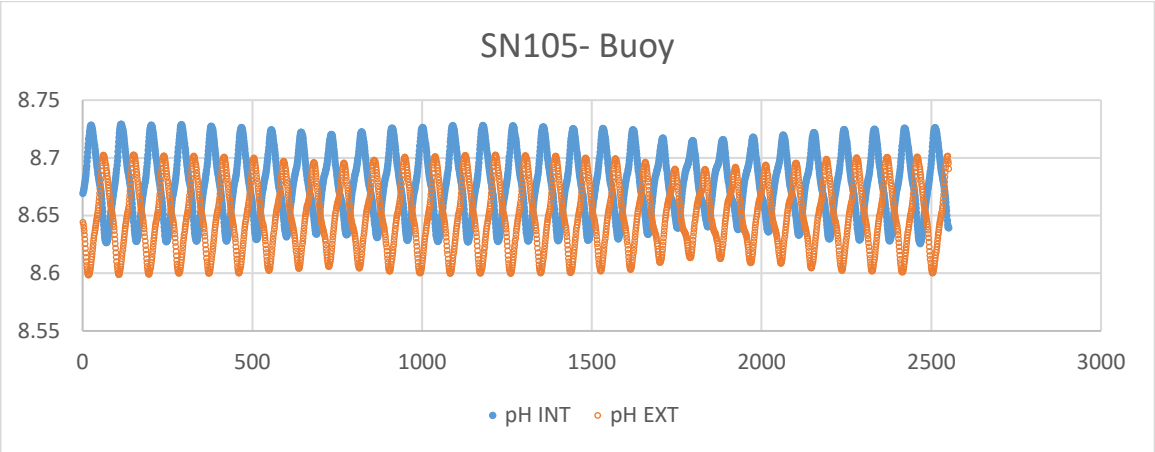
The sensor produced data for nearly the whole year. It had two drop outs. The first drop out was from the 10th of December 2018 to the 10th of January 2019. The second drop out was from the 22th of January 2019 until the 22th of February 2019. At first sight, the data until the 10th of December 2018 looks reasonable. After that it looks like the internal electrode starts to drift.

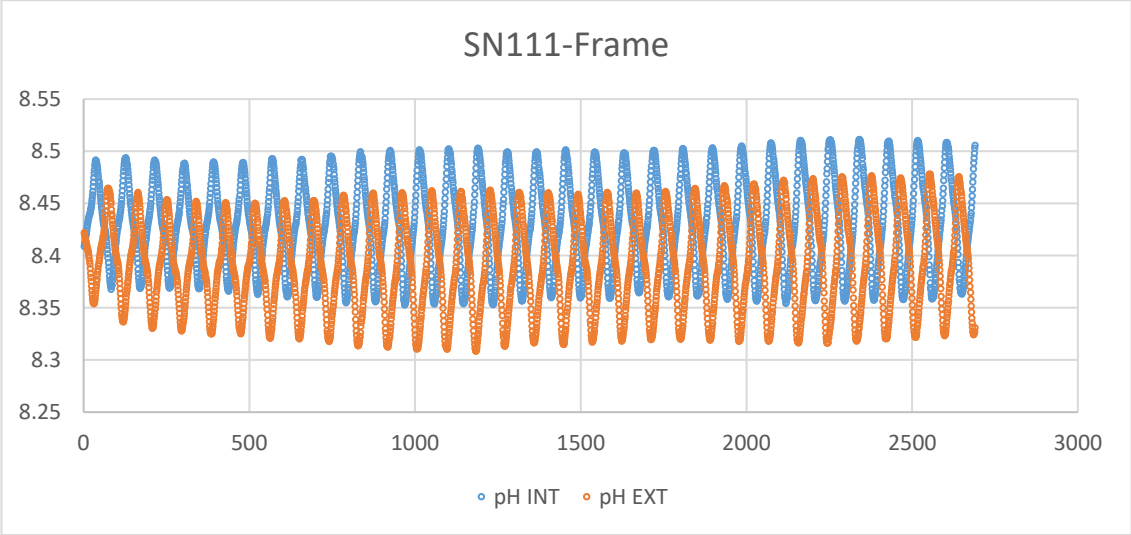
On the Buoy there was no damage to the copper cover and little visible growth on the SeaFET measurement windows (see photos under) – just a relatively thin layer of biofilm. The copper guards on both of the SeaFET's showed no damage when they were removed from the sensors.

SeaFET copper guards (left SN105 on the buoy, right SN111 on the frame)

The sensors were then left for nearly a week in the sink. After a week the calibration covers were placed on the sensors and filled up with seawater for a day to moisturize the electrodes again. From SeaFET SN105 some debris came loose from the electrodes (see picture below). SeaFET111 did not have this.

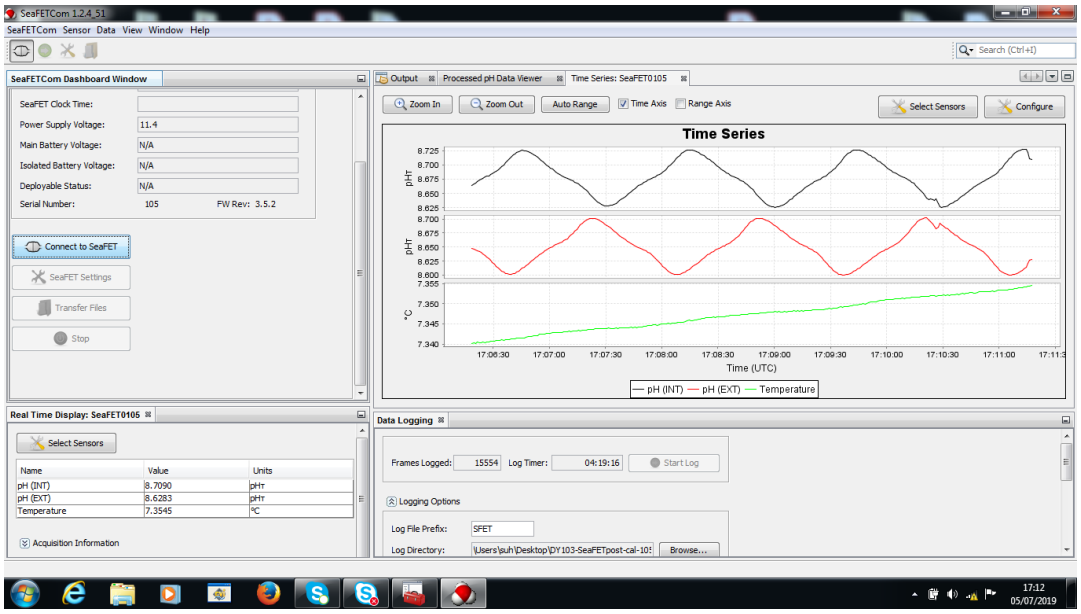
The electrodes were then left in Tris buffer (prepared at VLIZ) for a few hours before the calibration checks. The performance of the SeaFETs SN 111 (Frame) and SN 105 (Buoy) post-recovery was tested using the Tris buffer. Results of the post validation of the SeaFET sensors are recorded below.

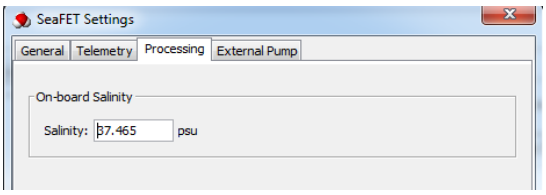




In lab post recovery calibration checks on the SeaFETs

While doing the post-calibration the sensors were both having some noise on the signal (see printscreen below). Also when changing from the "periodic" deployment mode to "continuously" measuring mode. The salinity given in in the "processing" tab was 37.465 psu, this should normally be 35 psu.





The data collected over a year of deployment was successfully downloaded from the internal memory of both instruments. Note that in the new SeaFET data processing package you can merge data files through 'data processing', in SeaFET.com software. At a later date, we can reprocess that data this way (once we have the SBE data). Current selection of 'use header for calibration' and use reference salinity of 35 (as selected) resulted in no change to the data.

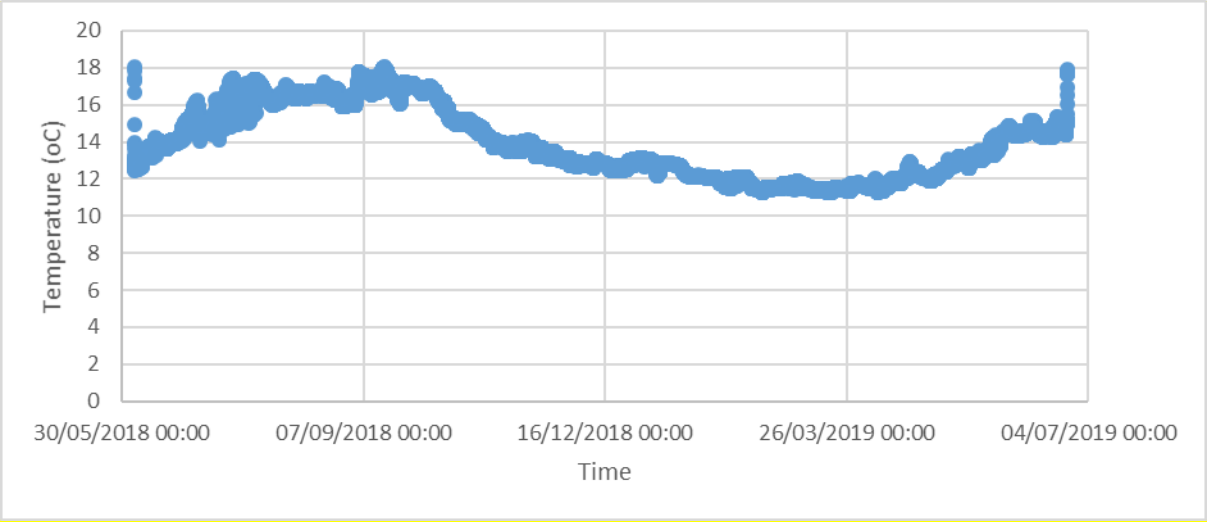
Star-Oddi post deployment retrieval from PAP#1 buoy

RRS *Discovery* Cruise DY103 retrieved the PAP#1 site buoy, as well as the Star-Oddi sensors that were placed upon it on the 6th April, 2018. Data collection intervals were set to 10 minutes, and temperature, depth and tilt angle were identified. Data were retrieved from these sensors through the communication box and their retrieval summaries can be found below.

List of post deployment Star Oddi sensors and their associated positions on buoy, interval and date retrieved.

Serial No.	Type	Depth (m)	Position	Measurement Interval	Retrieval Date
S7728	DST CTD	0	Buoy	10 min	25/06/2019
S6784	DST CTD	0	Buoy	10 min	25/06/2019
C8928	DST CENTI	5	Chain	10 min	25/06/2019
C8929	DST CENTI	10	Chain	10 min	25/06/2019
C8930	DST CENTI	15	Chain	10 min	25/06/2019
H0833	DST TILT	30	Frame	10 min	25/06/2019
S7727	DST CTD	30	Frame	10 min	25/06/2019

Example of a star oddi time series dataset. Each dot represents a temperature dataset from every 10 minutes since deployment. This star oddi was C8929.



Post deployment Star-Oddis and their functional statistics/calibrations.

Serial No.	Memory Remaining	Battery Remaining	Max Depth (m)	Calibration
S7728	35%	25%	105	No
S6784	35%	25%	2047	No
C8928	64%	76%	52	No
C8929	64%	76%	52	No
C8930	64%	76%	52	No
H0833	0%	62%	52	No
S7727	36%	24%	105	No

11. CTD and underway sampling

The CTDs were used primarily to test sensors and releases although samples were also taken to look at typical profiles in the region, for sediment trap water, micro-plastic analysis and method development. CTD cast 008 was also used for a nutrient inter-calibration. The new OTEG pH and TA analysers were also put onto the frame and triggered to start measurements once submerged. As these sensors took up room on the frame, only 22 of the 24 Niskin bottles were used during DY103. As usual, dissolved oxygen and chlorophyll were analysed on board,

in addition inorganic carbon and dissolved inorganic nutrients were also analysed on DY103. Cruise reports for each are found below alongside a report on the marine fungi sampling by the MBA.

CTD Cast	Sensor type	Serial number
001	1000m cast – test releases	
002	Deep Pre deployment sensors: Microcats	9475 and 9469
003	Shallow Pre deployment sensors: Wetlab fluorometer FLNTSUB Seaguard Star oddis	 3050 1640 6782, 7562, 7564, 7565,7566
004	Shallow Post deployment sensors: Seaguard Wetlab fluorometer FLNTSUB	
006	shallow Post deployment sensors: Microcats	 6915, 6904, 6907
07	Deep Post deployment sensors: Microcat	 7300, pap3 post cal
012	Deep cast to calibrate Whittard Canyon microcat	

In total, we had 12 CTD stations. The station numbers and positions are shown in the station table at the end of the cruise report and reproduced in the table to show the CTD cast depth for stations providing data to BODC.

CTD station positions, seabed and cast depth

CTD cast (and station)	Latitude (N	Longitude (W)]	Seabed depth (m)	Cast max. depth (m)
CTD001 (01)	49 08.272	13 03.024	2156	1000
CTD002 (02)	49 0.005	16 30.025	4845	4810
CTD003 (05)	48 58.308	16 22.354	4845	200
CTD004 (11)	48 56.57	16 29.17	4844	100
CTD005 (15)	49 2.294	16 31.811	4841	4800
CTD006 (19)	48 56.605	16 29.398	4844	100
CTD007 (20)	48 59.984	16 29.996	4842	4827
CTD08 (25)	48 59.998	16 30.061	4840	4830
CTD09 (29)	48 57.689	16 22.452	4845	4827
CTD010 (31)	48 59.999	16 30.019	4840	4830
CTD011 (34)	48 57.69	16 23.977	4844	102
CTD012 (36)	49 00.001	016 29.996	4841	4830

On each occasion that samples were taken then the order of sampling followed was: Dissolved oxygen, Dissolved Inorganic Carbon (DIC), inorganic nutrients, salinity and associated parameters from the top 200 m. The associated parameters from the surface samples were chlorophyll, SFC and PIC. These surface samples were filtered and frozen as appropriate. The PIC samples will be analysed ashore. On some casts samples were also taken for genetic analysis (see report by Rob Young).

DIC samples were preserved with100 µl of saturated mercuric chloride and were analysed on board for Dissolved Inorganic Carbon (DIC) and Total Alkalinity (TA). Duplicates were taken from each station (usually from the deepest Niskin fired). Nutrient samples were collected in centrifuge tubes and inorganic nutrients (NO_2+NO_3, phosphate and silicate) were analysed onboard using the Quattro auto-analyser (duplicate analysis). Generally, three salinity bottle samples were taken from each cast for analysis onboard. Chlorophyll samples were filtered

and frozen for analysis on DY103. The oxygen bottle samples were fixed on deck, returned to the deck laboratory and analysis was started within 4 hours of collection.

Dissolved Oxygen

Emmy McGarry

Sampling strategy and collection

Dissolved Oxygen (DO) samples were collected during DY103 in order to calibrate the recovered sensors and sensors to be deployed on the PAP buoy. Additionally, as the DO samples were collected first from the Niskin bottles the sampler was able to identify any misfired or leaking bottles. DO was sampled from every Niskin bottle at a unique depth that was not completely required for other procedures. Duplicates were usually taken from the two deepest bottles.

DO samples were the first to be collected from the CTD rosette. Seawater was collected using a tube into pre-calibrated oxygen bottles. The bottles were rinsed out, flushed with seawater for approximately 3 times bottle volume and then filled from the Niskin bottle. Throughout the sampling process, care was taken to avoid bubble formation inside the sampling tube and sampling bottle.

The fixing reagents (manganous chloride and alkalised sodium iodide solutions) were then immediately added, and the bottle sealed with a glass stopper, taking care not to introduce any air bubbles. Sample bottles were thoroughly mixed by shaking in order to homogenise the contents and then stored in a dark plastic crate for 30 to 40 minutes to allow the precipitate to settle. After settling, the samples were thoroughly mixed for a second time in order to ensure that the reaction was complete. Analyses were carried out within two to five hours of sample collection. Temperature of the Niskin bottles was taken separately with a Fisher Scientific temperature probe.

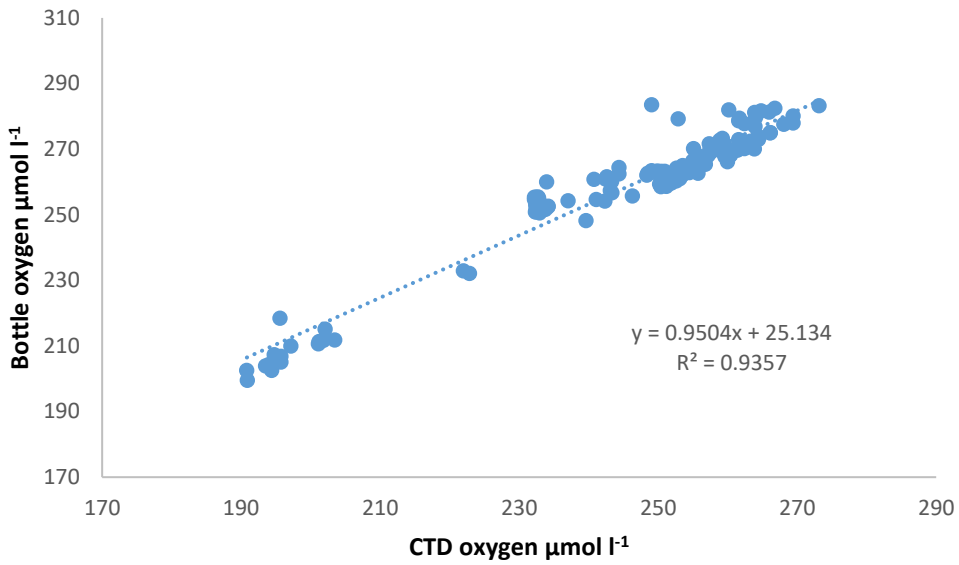
Analysis

The chemical reagents were all prepared in advance at NOC following the procedures described by Dickson (1994). When ready to titrate, the stopper of the flask was carefully removed, a clean magnetic stirrer was added and the flask was placed on the stir plate. Once the precipitate was well mixed 1 ml of 5 M sulphuric acid was dispensed into the flask and the electrode and burette were carefully inserted to place the tips in the lower-middle depth of the sample flask. The initial volume of sodium thiosulfate ($Na_2S_2O_3$) for each sample was 0.3 ml before continuing to be titrated at 0.0005 ml intervals using an electrode with amperometic end-point detection (Culberson and Huang, 1987) with an end current of 0.1×10^{-6} A. The resultant volume of titrant was recorded both by manual logging and on the Titrino (Metrohm). Following this, the value was converted to a DO concentration.

Thiosulfate calibrations and reagent blank checks were carried out for each sampling station following the GO-SHIP protocols (Langdon, 2010). At least 3 blank checks of the reagents and 3 standardisations of the sodium thiosulfate were completed using a 1.667 mol L^{-1} certified iodate standard (OSIL) every cast.

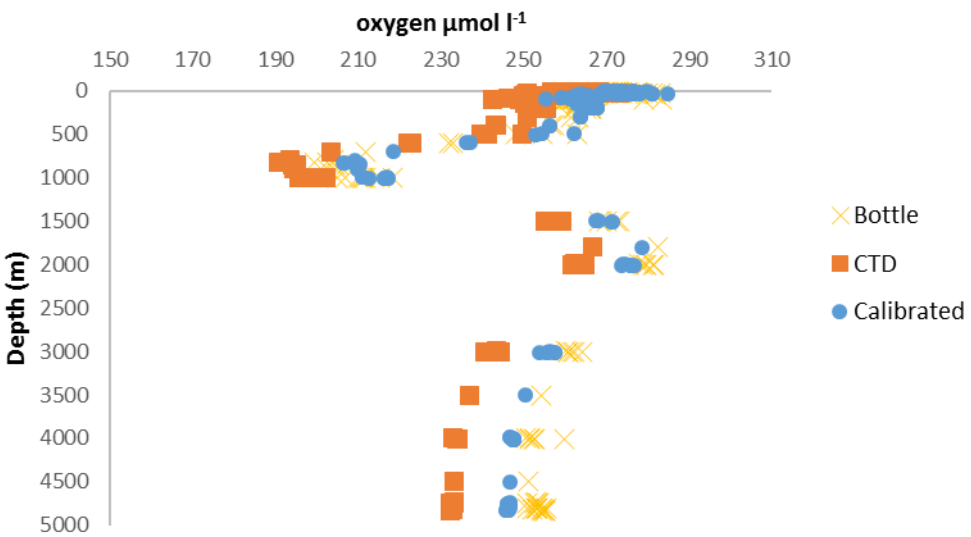
Oxygen results

Three blank measurements and three standard determinations were performed before the start of each cast of measurements. The normality of the thiosulphate was 0.0992 ± 0.0004



Overall relationship between the bottle oxygen and CTD oxygen data

The CTD oxygen was compared against the bottle oxygen results, four results were excluded due to operator error causing erroneous results. The equation found was applied to the CTD data (Figure 2).



Oxygen profiles with bottle data, CTD seabird sensor data and calibrated CTD seabird sensor data

Below 1000 m there is an offset of ~4 µmol L^{-1} and below 2000 m a consistent offset of ~6 µmol L^{-1}. However, this would not affect the calibration of the 30 m frame sensors.

Culberson, C.H. and Huang, S. (1987). Automated amperometric oxygen titration. Deep-Sea Res. Pt A 34(5-6), 875-880. doi:10.1016/0198-0149(87)90042-2. Dickson, A.G. (1994). Determination of dissolved oxygen in seawater by Winkler titration. Technical report, WOCE operations manual,

WOCE report 68/91 Revision 1 November 1994. Humphreys, M.P., Greatrix, F.M., Tynan, E., Achterberg, E.P., Griffiths, A.M., Fry, C.H., Garley, R., McDonald, A. and Boyce, A.J. (2016). Stable carbon isotopes of dissolved inorganic carbon for a zonal transect across the subpolar North Atlantic Ocean in summer 2014. Earth Syst. Sci. Data 8, 221-233. doi:10.5194/essd-8-221-2016. Langdon, C. (2010). Determination of dissolved oxygen in seawater by winkler titration using the amperometric technique. The GO-SHIP repeat hydrography manual: A collection of expert reports and guidelines, IOCCP Report No. 14, ICPO publication Series No 134, Version 1.

Inorganic Carbon Parameters

Hannelore Theetaert, Sue Hartman, Hannah East

Inorganic carbon analysis Background

Generally, on PAP cruises we send preserved carbon samples back to NOC for analysis. On DY103 we decided to analyse the carbonate variables at sea (with a subset going to VLIZ and to NOC for inter-comparison). The analytical equipment for the carbon parameters was set up in the chemistry laboratory by Hannah East and Pete Brown. Discrete samples could then be analysed for both total dissolved inorganic carbon (DIC) and total alkalinity (TA). A Versatile Instrument for the Detection of Titration Alkalinity (VINDTA) system (Mintrop, 2004), version 3C serial number #24, coupled to a UIC coulometer was used. It draws water from a single sample and autonomously separates it into two independent analysis lines, one analysing for total alkalinity by potentiometric acid titration, the other quantifying for DIC by the acid-derived extraction of carbon dioxide and subsequent coulometric titration (Johnson et al, 1985; Johnson et al, 1987; Johnson et al, 1993).

CTD Sampling Strategy for Inorganic Carbon

Water samples for the determination of DIC and TA were drawn from the 20 L Niskin bottles on the CTD rosette and collected in 250 ml glass bottles according to the Standard Operating Procedure (SOP) 01 (Dickson et al., 2007), to avoid gas exchange with the air. We found that the NOC method was to remove a head space using 2.5 ml pipette whereas VLIZ used a pinch tube method. This did not affect the results and as the pinch tube method was easier to employ we all used that technique from station DY103-011.

Table showing the analysis date for the carbonate data onboard (and duplicate samples taken for later analysis at VLIZ)

CTD cast. Station, niskins	Data analysed	Station & Niskin bottles sampled for VLIZ
1. 01, 2-18	26/6/19	1. 12,16,22
1. 01, 20-24	27/6/19	
2. 02, 2-24	27/6/19	2. 24
3. 05, 2-23	28/6/19	
2. 02, 4-24 dup	29/6/19	
4. 11, 4-22	30/6/19	4. 4,18,22
UW only	1/7/19	UW only
5. 15, 2-23	2/7/19	5. 12,20,22 +UW
6. 19, 3-21	3/7/19	
7. 20, 3-6	3/7/19	
7. 20, 8-23	4/7/19	
8. 25, 5-23	4/7/19	

9. 29, 2-9	4/7/19	9. 22 + UW
9. 29, 12-22	5/7/19	
10. 31, 2-3	5/7/19	
11. 31, 5-12	6/7/19	Change HCL
11. 31, 13-23	6/7/19	
12.		12. 5,13,23

All samples were preserved with mercuric chloride (150 µl per 250 ml of sample) to kill all organisms that may alter the chemistry of the sample. Samples were kept at room temperature in the dark until shortly before being placed into a 25 °C water bath to bring to this temperature prior to analysis. A total of 152 samples were drawn from 12 CTD stations. Samples for DIC and alkalinity were taken from up to 20 different Niskin bottles on each station. An additional 14 samples were taken by Hannelore from the CTD casts using the VLIZ bottles for analysis on DY103 (and 40 more for TA and DIC analysis back at VLIZ using the Vindta TA and AIRica DIC systems). Underway DIC/TA samples were also taken twice a day for analysis on DY103.

Total Dissolved Inorganic Carbon

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

The coulometry solutions accumulate CO_2 over time and thus need to be changed regularly to ensure high performance. Cell preparation was conducted by the addition of cathode and anode solutions (UIC Corp.) to their individual chambers, solid potassium iodide to the anode chamber and a stirrer bar to the main chamber. Two cells were used in rotation and a new cell prepared each day. As the silver anode is consumed during the analysis, one of these had to be replaced with new during the cruise. Cells were rinsed by Milli-Q water, before passing Milli-Q water through the glass frit under vacuum three times and then a final Milli-Q rinse. Cells were then dried in the laboratory prior to the next use. The silver anode and platinum electrode were also cleaned with milli-Q water.

The oxygen-free nitrogen gas was piped from the laboratory gas supply (using a 90 L cylinder located in the gas store). The pressure of the gas cylinder in use was checked each day to ensure that sufficient pressure was available for normal operation and that the inlet pressure did not exceed 1.5 bar. Only one gas cylinder was used and lasted the whole cruise.

DIC - Issues encountered

Most of the issues encountered related to the software. Since April 2019, Vindta 24 has been run using a VMware emulator. The software frequently crashed especially between the junk and dummy samples. However, it sometimes occurred in the middle of a run and some sample results (c. five) were lost (for TA and DIC) as a result of this issue. Many of the bottles were a little greasy and it was difficult to get a bubble free sample – two crates of bottles were then washed using Decon and this improved the situation. The cathode solution was changed for a new bottle on the 2/7/19 as the level was getting low (it may be best to batch up the cathode solution into 100 ml aliquots in the future). Back at NOC, the counts will be corrected for the constant blank (250) used on-board.

Total Alkalinity (TA)

The alkalinity measurements were made by potentiometric titration, following Dickson et al. (2007) SOP3a, closed cell titration. The s-shaped titration curve produced by potential of a proton sensitive electrode shows two inflection points, characterising the protonation of carbonate and bicarbonate, respectively. The acid consumption up to the second point is equal to the titration alkalinity. From this value, the carbonate alkalinity is calculated by subtracting the contributions of other ions present in the seawater, i.e. nutrients. The systems use highly precise Metrohm Titrinos for adding acid, an ORIONRoss pH electrode and a Metrohm reference electrode. The burette, the pipette (volume approximately 100 ml), and the analysis cell have a water jacket around them that house constantly flowing 25 ˚C water. One batch of acid titrant (0.1 M HCl) was used; the batch was made at NOC and the acid factor was calculated before analysis of station DY103-005 (CTD cast 3) samples. The electrode was refilled with 3 M KCl and 0.7 M NaCl solutions daily.

TA issues encountered

In addition to the software issues some TA sample results were lost when the HCL ran out on the 6th July – it was topped up using the same batch (prepared at NOC).

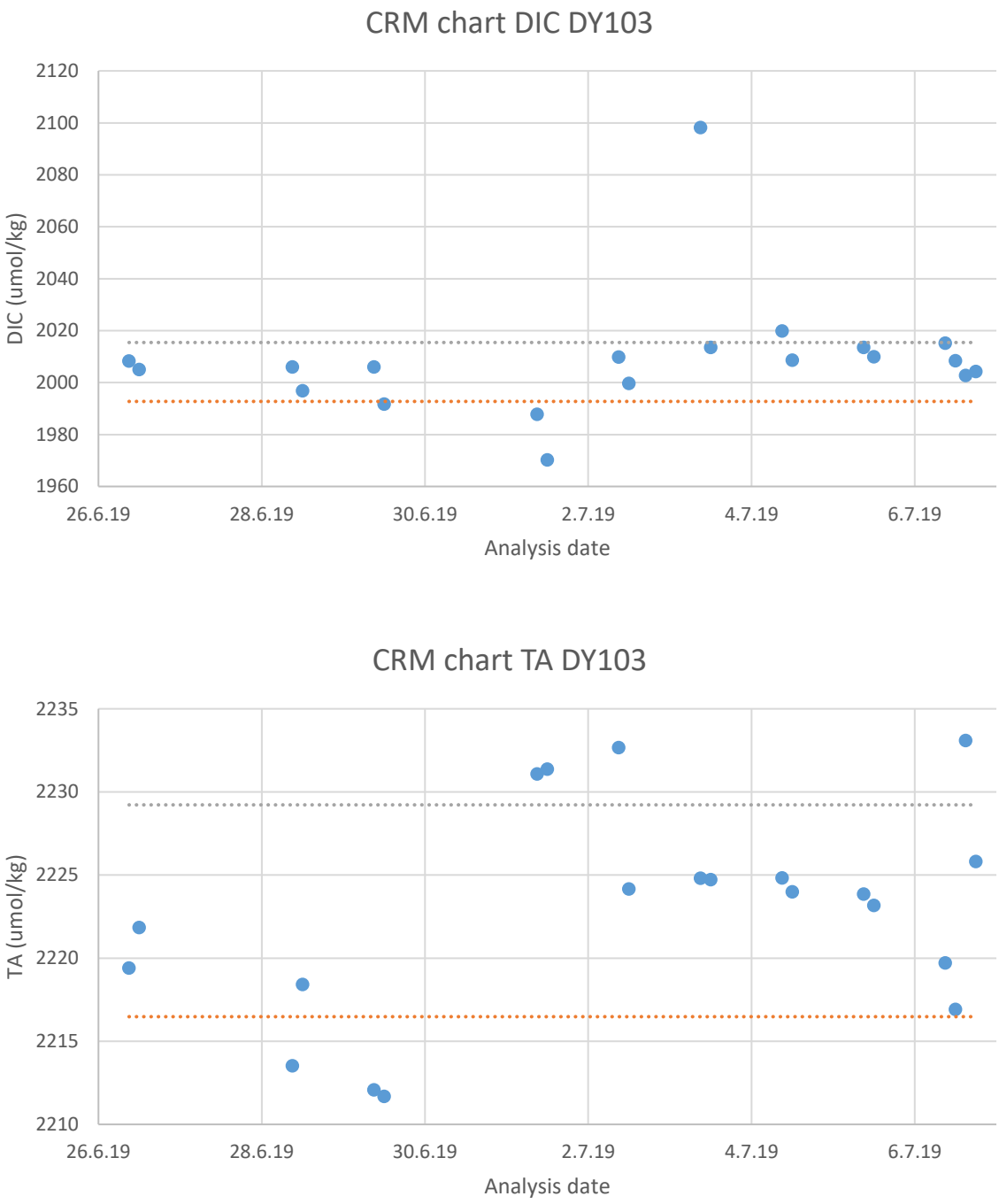
DIC and TA Standardisation

The accuracy of the DIC and TA analyses was determined regularly by measuring certified reference material (CRM), supplied by Dr. A. Dickson of Scripps Institution of Oceanography (SIO), Batch 180. The CRM was run twice at the start of each day, once the coulometer cell and software had settled down. The results were adjusted using the daily scaling factor, calculated between the measured and certified DIC values. The correction factor was calculated using the 2nd CRM measured value.

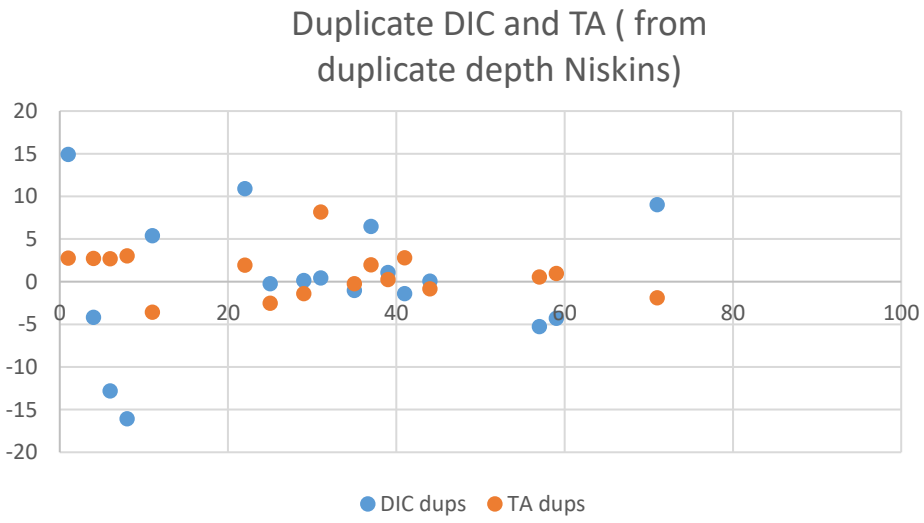
As can be seen in the range charts, the 2nd CRM of the day was always lower for DIC than the 1st value, despite being run immediately afterwards. The 1st value for the DIC CRM was out of range high on the 3rd of July but the 2nd value was in range. The 1st DIC CRM value was low and out of range on the 1st July but the duplicate was in range. For these reasons the 2nd CRM was used to calculate the results. As a consistent blank of 250 was used throughout the counts were adjusted for runtime (and average of the last 2 counts) back at NOC.

The CRM values for the TA were out of range and high on the 1/7/19 (and the 1st value was also too high on the 2/7/19). The first CRM after topping up the HCl on the 6/7/19 was also too high and out of range. The TA values

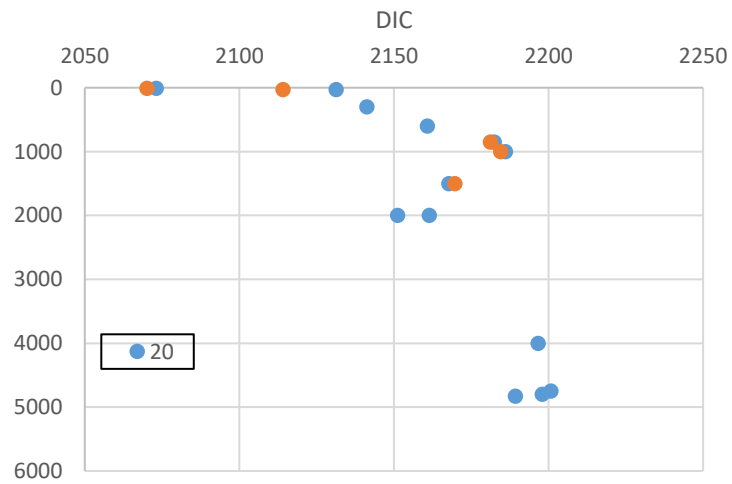
were out of range and low on the 28th June (1st reading) and for both CRM values on the 29th June. The acid factor was set (on 3 occasions: 28/6, 2/7, 6/7) to match the certified CRM value so that no scaling factor had to be applied.

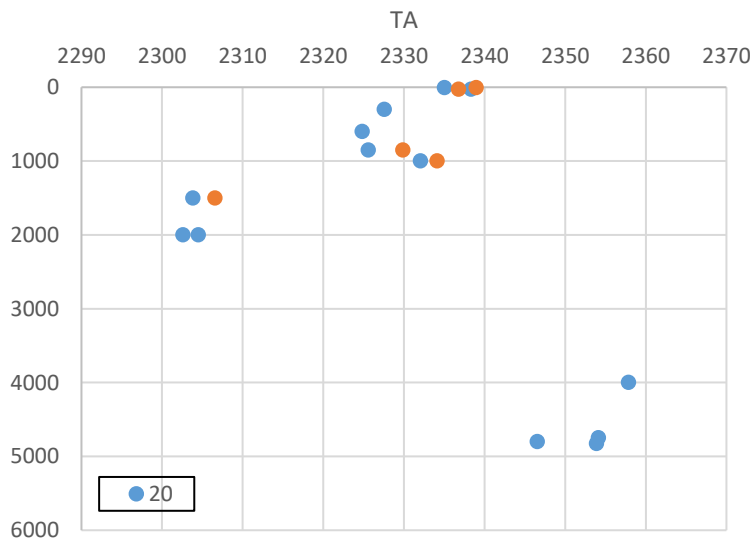


Range charts for Vindta CRM showing ±1sd of the cruise average for a) DIC and b) TA



Raw carbon data – duplicate differences





Example of repeat sampling at the same site 49N, 16.5W a) DIC and b) TA

Johnson K.M., King, A.E., Sieburth, J.M. (1985) Coulometric TCO_2 analyses for marine studies; an introduction. Marine Chemistry 16, 61-82. Johnson, K.M., Williams, P.J.leB., Brandstrom, L., Sieburth, J.M. (1987) Coulometric TCO_2 analysis for marine studies: automation and calibration. Marine Chemistry 21, 117-133. Johnson, K.M., Wills, K.D., Butler, D.B., Johnson W.K., Wong, C.S. (1993) Coulometric total carbon dioxide analysis for marine studies: maximising the performance of an automated continuous gas extraction system and coulometric detector. Marine Chemistry 44, 167-187
Mintrop, L. (2004) VINDTA, Versatile Instrument for the Determination of Titration Alkalinity. Manual for versions 3S and 3C. Version 2.0. MARine ANalytics and DAta (MARIANDA), Kiel, Germany, 45 pp. Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to best practices for Ocean CO_2 Measurements, PICES Special Publication 3, 191 pp.

Inorganic nutrients

Emmy McGarry

A 4-channel Seal Analytical QuAAtro flow-analyser with XY autosampler was set up in the Chemistry lab of the RRS *Discovery* for the analysis of micro-molar concentrations of dissolved inorganic nutrients (silicate, phosphate, nitrate plus nitrite and nitrite). These data continue the time-series of nutrient concentrations at depth at the PAP-SO site along with calibration of the phosphate sensors on the PAP sensor frame.

Samples were collected directly from the 24 x 20 L stainless steel rosette after the TA/DIC into pre- labelled sterile 15 mL centrifuge tubes (rinsed three times with water from the same Niskin). They were then analysed directly from the collection tubes within 2-24 hours and measured from the lowest to the highest concentration (surface to deep) to reduce any carry over effects. Milli-Q water was used for the baseline and wash solution during each run. All unique sampling depths were sampled. Seal Analytical chemistry and cleaning procedure protocols used during DY103 were:

1. Silicate in seawater method No. Q-066-05 Rev. 5
2. Phosphate in water method No. Q-064-05 Rev. 8
3. Nitrate and nitrite in seawater method No. Q-068-05 Rev.11
4. Nitrite in seawater method No. Q-070-05 Rev. 6

Standards were prepared every other run by diluting the stock solutions of the different nutrients (see table below) in artificial seawater (ASW) (35 g/L sodium chloride plus 0.2 g/L sodium hydrogen carbonate).

Each run of the system had a 6-point calibration series. Prior to analysis all samples and standards were brought to room temperature of ~20 °C. Concentrations of the working standards were as per table below which was based upon the range of concentrations of the nutrients found in previous years.

Standard	NO_2 (µM)	NO_3 +NO_2 (µM)	PO_4 (µM)	SiO_2 (µM)
1	0.05	0.56	0.05	0.50
2	0.10	1.11	0.10	1.00
3	0.20	5.25	0.24	5.01
4	0.40	10.51	0.49	10.02
5	0.80	21.01	0.98	25.06
6	1.59	31.91	1.95	50.12

Nutrient quality Controls (QCs)

In order to test the accuracy and precision of the analyses, CRMs from The General Environmental Technos Co., Ltd., (KANSO) were measured in duplicate at the start of every run apart from on the 25JUL2019 when lot CD was omitted. For the duration of DY103 KANSO CRMs lot CD and CJ were used; certified concentrations against the run concentrations are shown in the table below. There was an issue with the nitrite baseline on 30JUN2019 resulting in null concentrations being recorded for the samples analysed.

Certified concentration of KANSO CRMs used during DY103 and results for each run

CJ (µmol/kg)				
Date	$NO_3 + NO_2$	SiO_2	NO_2	PO_4
24/06/2019	16.88	38.7	0.1	1.18
24/06/2019	17.16	39.09	0.1	1.19
30/06/2019	17.35	39.62	0	1.26
30/06/2019	17.45	39.72	0	1.26
01/07/2019	16.78	39.28	0.06	1.26
01/07/2019	17.12	39.47	0.06	1.27
02/07/2019	16.69	38.75	0.06	1.24
02/07/2019	16.86	39.05	0.06	1.25
04/07/2019	16.73	39.47	0.06	1.25
04/07/2019	16.96	39.51	0.06	1.27
Certified	16.2	38.5	0.031	1.19

CD (µmol/kg)				
Date	$NO_3 + NO_2$	SiO_2	NO_2	PO_4
24/06/2019	6.01	14.62	0.11	0.46
24/06/2019	5.48	14.71	0.11	0.44
25/06/2019	5.82	14.15	0.07	0.46
25/06/2019	5.97	14.6	0.06	0.48
30/06/2019	5.98	14.5	0	0.44
30/06/2019	6.01	14.5	0	0.47
01/07/2019	5.71	14.27	0.05	0.44
01/07/2019	5.72	14.38	0.05	0.47
02/07/2019	5.62	14.25	0.05	0.44
02/07/2019	5.67	14.1	0.05	0.46
04/07/2019	5.64	14.53	0.05	0.46
04/07/2019	5.74	14.37	0.05	0.47
Certified	5.498	13.93	0.018	0.446

Nutrient inter- comparison

As a result of concerns about phosphate values after analysing the nutrient vials that had been frozen on previous cruises an inter-comparison was undertaken on CTD cast 008 (station DY103-025), to determine the best type of plastic and preservation technique. Several different types of vials were used for collection and will be analysed after various periods as per table below.

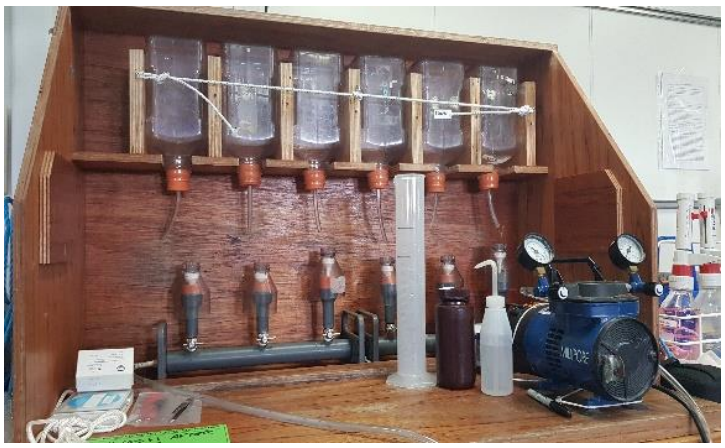
Details of vials and freezing duration, codes in brackets

Types of vials used	Duration of freezing
Polycarbonate –Nalgene – (PC) Polycarbonate- Nalgene - Acid Washed (AW) Polystyrene – round bottom (BN) Polypropylene – Grenier-Graduated (BG) Polypropylene – Grenier- Graduated - Acid Washed (AG) Diluvials – (DV) VLIZ vials – polycarbonate (VL) Filtered VLIZ vials – polycarbonate (VLF)	No freezing (DY) 24 hours (FD) 3 months (F3) 6 months (F6) 3 months –at VLIZ (VL)

Chlorophyll & POC/PIC Report

Aboard the RRS *Discovery*, cruise DY103 used a CTD rosette to collect 20 L seawater samples from depths of up to 4850 m. When back at the surface, water could be collected from siphoning off taps. Of the samples collected in carboys from 200 m or shallower (the last subjects to be collected from the Niskin bottles in order of sampling), chlorophyll filtration and analysis were performed. 200 ml of each sample were filtered through gff filters using a special pump filtration system (photo below) in duplicate from each depth. Once filtered, 8 ml of 90% acetone were added to each filter (which were placed in numbered glass vials) to and refrigerated for 20-24 hours. Upon removing from dark fridge, they were left for an hour in a dark space and a fluorometer (Turner) was used to identify raw fluorometry units (RFU). A standard (Black 2) was used, then a blank, and after running these both in triplicate the samples were then run in duplicate. Having collected all datasets, Microsoft Excel was used to analyse data, and a formula was used to convert RFU into mg/m^3.

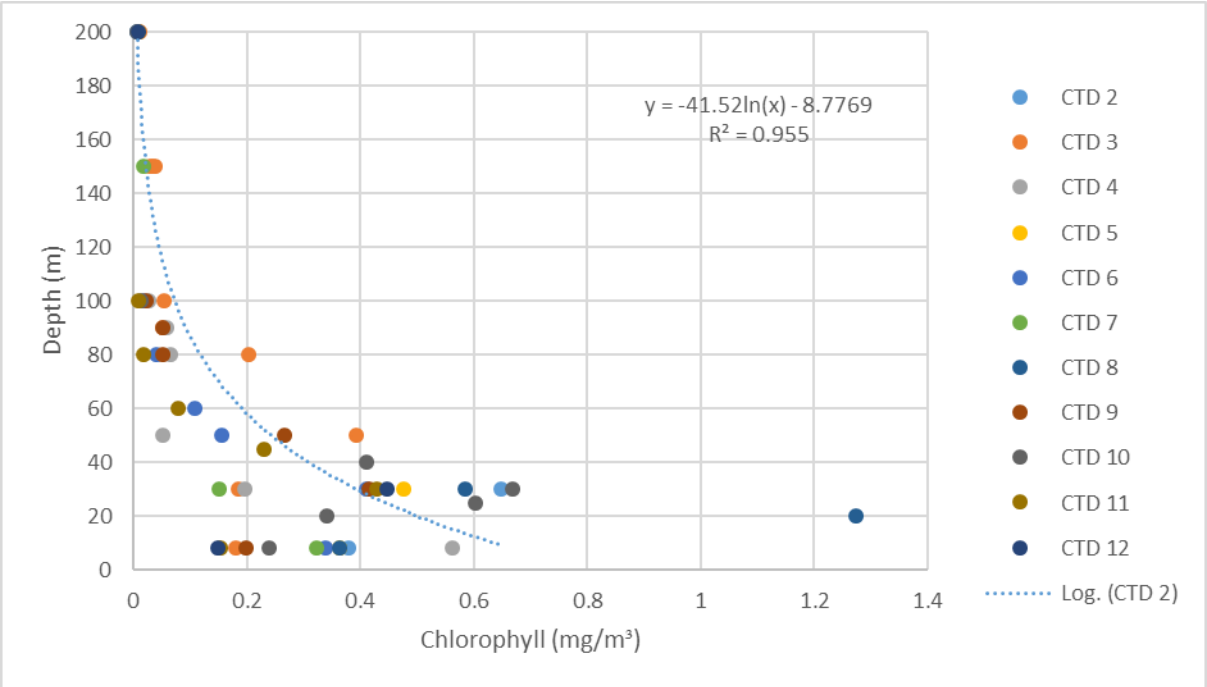
Particulate Organic and Inorganic Carbon (POC/PIC) samples were also collected from these water samples, some from depths of up to 4000 m. These water samples were also run through the filtration system, yet different filters were used (Combusted gff filters for POC, 0.04 µm filters for PIC), and using 500 ml of each water sample but not run in duplicate. POC samples were placed in labelled petri dishes, then placed in a 50 °C drying for over 24 hours. After this time, samples were sealed with white insulation table and stored for analysis at NOC. PIC filters were placed in 15 ml tubes, and these tubes were placed in bags and into a -20 °C freezer for the remainder of the cruise, also for analysis at NOC.



Filtration system used to pump water samples through filters. Large bottles were suspended above funnels feeding into the filters, allowing water to be pumped through the filters to be stored in a Nalgene waste bottle.

Chlorophyll results

Analysed Chl data identifies concentrations of chlorophyll to be highest between 40-20 m depths with 95% confidence levels (plot below). Average concentrations were calculated from the duplicate samples at each depth.



Plot of all calibrated average Chl A data from each CTD performed.

Functional biology and ecology of planktonic marine fungi

Kimberley Bird, Cordelia Roberts

Our work is being carried out under the European Research Council MYCO-CARB project (lead by Dr Michael Cunliffe) which aims to address questions around how marine planktonic fungi interact with better-studied microbes in the cycling of carbon in the sea. This cruise is our first expedition to the PAP site to sample the deep ocean, and therefore our aims were exploratory in nature with a view to returning to PAP next year to further investigate the role of mycoplankton in carbon cycling at the PAP-SO with more specific questions in mind. During this cruise, the primary aim was to collect water column samples to characterise the diversity and distribution of the active mycoplankton community throughout the water column, which is currently largely unknown. Secondary to this, on the basis that fungi are able to degrade complex substrates and are therefore likely to play an important role in the degradation of marine particles, we also aimed to collect supplementary samples to characterise particulate matter, and to carry out some pilot incubation experiments to investigate mycoplankton/particle interactions.

Water column sampling

Seawater was collected from seven CTD casts, where possible the entire 20 L volume was taken and filtered for later analysis. Between three and six depths were sampled at each cast, sample depths varied depending on the available water budget, but over the cruise we were able to get a good representation of the water column, with samples from the epipelagic, mesopelagic and bathypelagic zones. Three litres each were filtered on to GFF membranes (n = 1 per depth) for phospholipid fatty acid analysis (PLFA) and particulate organic carbon analysis (POC), both were stored at -20 °C. Three litres were filtered onto 0.2 µm cellulose nitrate membranes (n = 2 per depth) for nucleic acid extraction and stored in a nucleic acid preservative at -80 °C. Between 30 - 500 mL were filtered onto 0.4 µm polycarbonate membranes (n =2 per depth) were stained for transparent exopolymer particles using Alcian blue, (n = 2 per depth) were stained with for Coomassie stainable particles with Coomassie brilliant blue (Engel 2009). An additional n = 2 were filtered onto black membranes for use with the MESO lens microscope, further staining e.g. nucleic acid stains will be carried out on return to the MBA, all were stored at -20 °C. Two millilitre samples from each depth were also taken and preserved with 2% (final conc.) formaldehyde (n = 2 per depth) and 2.5 % (final conc.) glutaraldehyde (n = 2 per depth) for microscopic analysis and stored at 4 °C.

Particle settling

Three 20 L Niskins over 2 CTD casts (100 m, 200 m and 3000 m) were left on the CTD frame and drained at 100 mL / min onto a 30 µm nylon mesh taking ~ 2hours to empty. Particles were then washed off in sterile filtered seawater and individual particles picked (Bochdansky et al 2017). This was the

first time trying this method as an alternative to marine snow catchers that were not available for this cruise. We found that it worked reasonably well and were able to pick individual particles from which we will extract nucleic acids for genomic analysis. We also successfully embedded some particles in OCT medium that will be used for cryo-SEM.

Settling particles from 20 L Niskin bottle

Stable isotope incubation experiment

One stable isotope experiment was carried out during this cruise, 2 L of seawater from 600 m was enriched with ^{13}C labelled chitin (n = 6), additional treatments of ^{12}C chitin (n = 6) and no chitin enrichment (n = 6) were also carried out as controls. This incubation ran for 72 hours at sea temperature (~10 °C), at 48 hours and 72 hours three bottles from each treatment were harvested, 1 L from each bottle was filtered for PLFA and nucleic acids as described above.

Particle and Free-living associated communities experiment

Whilst on board an experiment was conducted focusing on particle degradation by fungi and aiming to determine differences in particle associated and free-living microbial communities at PAP. The CTD was used to sample water at three discrete depths which were representative of the surface, meso- and bathy-pelagic areas of the ocean. For each depth 1 L of water was filtered for nucleic acids to determine the initial community present, known as time point zero. To assess the community after 48 hours, for each depth 4 L of water were incubated with particles (2 L) and without particles (2 L) to assess particle versus free-living microbial communities. Within

these treatments, another treatment was setup; this included 1 L being treated with chloramphenicol to 'kill' the bacteria community and 1 L left untreated, allowing us to assess the importance of fungi in establishing microbial communities. Incubations were setup and left for 48 hours. At 48 hours, 998 mL from each treatment were filtered for nucleic acid analysis, 750 µl was spread on agar plates to isolate any fungi and 1 mL was taken and preserved with glutaraldehyde for later Scanning Electron Microscopy work. For those containing particles, the particles were also harvested and preserved for later nucleic acid analysis. A summary of treatments is provided in the table below:

Summary of treatments for each depth, each condition performed with four replicates

Depth (m)	With particles		No particles	
Surface-30	Fungi treated with Chloramphenicol	Fungi and Bacteria	Fungi + Chloramphenicol	Fungi and Bacteria
Bathypelagic-600	Fungi treated with Chloramphenicol	Fungi and Bacteria	Fungi + Chloramphenicol	Fungi and Bacteria
Mesopelagic-3000	Fungi treated with Chloramphenicol	Fungi and Bacteria	Fungi + Chloramphenicol	Fungi and Bacteria

Marine fungi isolates

If enough water was left over from the CTD casts, 250 mL was filtered onto 0.4 µm mixed cellulose ester membranes for fungal isolation. Membranes were inverted onto a selection of agar media including: Potato dextrose medium (PDM), Whickersham's yeast medium (WYM), modified marine ammonium mineral salts medium (MAMS) with either laminarin or colloidal chitin as a carbon source. One millilitre sub samples were also taken from incubation experiment bottles and spread onto MAMS colloidal chitin plates. All plates were incubated at 10 °C, by the end of the cruise we could see fungal growth on some of the earlier plates to be inoculated.

Marine fungi growing on agar plates

Opportunistic samples

We were also fortunate to collect some opportunistic surface sediment samples from the Megacorer, courtesy of the NOC benthic team, these will most likely be used for DNA extractions and mycoplankton community analysis.

Further processing and data availability

All of the samples collected will be analysed on return to the MBA, PLFA samples will be sent off for analysis by collaborators at the University of Plymouth, POC samples will also be sent off for analysis possibly in collaboration with NOC (TBC). Dual extraction of DNA and RNA will be carried out at the MBA and sent for amplicon sequencing of the ITS region. Stained particles and microscopy samples will be enumerated at the MBA. Any successfully isolated marine fungi will be added to the MBA fungal culture collection. A list of all the samples collected is available below, we estimate the majority of the samples will be processed fully with a turnaround of ~1 year.

Bochdansky, A. B., Clouse, M. A., & Herndl, G. J. (2017). Eukaryotic microbes, principally fungi and labyrinthulomycetes, dominate biomass on bathypelagic marine snow. The ISME journal, 11(2), 362–373. doi:10.1038/ismej.2016.113. Engel, A. (2009). Determination of Marine Gel Particles ,Practical guidelines for the analysis of seawater / ed. by Oliver Wurl Boca Raton [u.a.] ; CRC Press, ISBN: 978-1-420-07306-5 .

Summary of MBA samples collected

Date [dd/mm/yyy	Cruise #	Site #	Lat dec deg N	Lon dec deg W	Station STN#	CTD Number CTD###	Depth [m]	Bottle No #	Fire depth [m]	ample	PLFA	NA	POC	TEP	CSP	MESO #	Glut.	Form. #	MAMS CC #	MAMS LAM #	WYM #	PDM	Bead Inc. #	Chitin Inc. #	Settled #
24/06/2019	DY103	PAP-SO	49.00138889	16.50694444	STN002	CTD002	4810	4	4720	X	X	X	X				X	X							
24/06/2019	DY103	PAP-SO	49.00138889	16.50694444	STN002	CTD002	4810	12	1000	X	X	X	X	X	X	X	X	X	X	X	X	X			
24/06/2019	DY103	PAP-SO	49.00138889	16.50694444	STN002	CTD002	4810	14	850	X	X	X	X	X	X	X	X	X							
24/06/2019	DY103	PAP-SO	49.00138889	16.50694444	STN002	CTD002	4810	18	500	X	X	X	X	X	X	X	X	X	X	X	X	X			
24/06/2019	DY103	PAP-SO	49.00138889	16.50694444	STN002	CTD002	4810	20	200	X	X	X	X	X	X	X	X	X	X	X	X	X			
25/06/2019	DY103	PAP-SO	49.05222222	16.46500000	STN005	CTD003	200	4	200	X	X	X	X	X	X	X	X	X							
25/06/2019	DY103	PAP-SO	49.05222222	16.46500000	STN005	CTD003	200	10	100	X	X	X	X	X	X	X	X	X							
25/06/2019	DY103	PAP-SO	49.05222222	16.46500000	STN005	CTD003	200	16	50	X	X	X	X	X	X	X	X	X	X	X	X	X			
25/06/2019	DY103	PAP-SO	49.05222222	16.46500000	STN005	CTD003	200	19	30	X	X	X	X	X	X	X	X	X	X	X	X	X			
25/06/2019	DY103	PAP-SO	49.05222222	16.46500000	STN005	CTD003	200	20	30	X	X	X	X	X	X	X	X	X					X		
25/06/2019	DY103	PAP-SO	49.05222222	16.46500000	STN005	CTD003	200	21	8	X	X	X	X	X	X	X	X	X	X	X	X	X			
29/06/2019	DY103	PAP-SO	49.09166667	16.53055556	STN011	CTD004	100	2	100	X															X
29/06/2019	DY103	PAP-SO	49.09166667	16.53055556	STN011	CTD004	100	3	100	X	X	X	X	X	X	X	X	X	X	X	X	X			
29/06/2019	DY103	PAP-SO	49.09166667	16.53055556	STN011	CTD004	100	16	30	X	X	X	X	X	X	X	X	X	X	X	X	X			
29/06/2019	DY103	PAP-SO	49.09166667	16.53055556	STN011	CTD004	100	23	8	X	X	X	X	X	X	X	X	X	X	X	X	X			
30/06/2019	DY103	PAP-SO	49.11500000	16.69055556	STN015	CTD005	4800	4	4800	X	X	X	X	X	X	X	X	X	X	X	X	X			
30/06/2019	DY103	PAP-SO	49.11500000	16.69055556	STN015	CTD005	4800	8	3000	X	X	X	X	X	X	X	X	X	X	X	X	X			
30/06/2019	DY103	PAP-SO	49.11500000	16.69055556	STN015	CTD005	4800	9	2000	X	X	X	X	X	X	X	X	X	X	X	X	X			
30/06/2019	DY103	PAP-SO	49.11500000	16.69055556	STN015	CTD005	4800	14	600	X	X	X	X	X	X	X	X	X							
30/06/2019	DY103	PAP-SO	49.11500000	16.69055556	STN015	CTD005	4800	15	600	X														X	
30/06/2019	DY103	PAP-SO	49.11500000	16.69055556	STN015	CTD005	4800	16	600	X														X	
01/07/2019	DY103	PAP-SO	49.25666667	16.76000000	STN020	CTD007	4827	7	3000	X	X	X	X	X	X	X	X	X							
01/07/2019	DY103	PAP-SO	49.25666667	16.76000000	STN020	CTD007	4827	13	850	X	X	X	X	X	X	X	X	X							
01/07/2019	DY103	PAP-SO	49.25666667	16.76000000	STN020	CTD007	4827	14	850	X	X	X	X	X	X	X	X	X							
01/07/2019	DY103	PAP-SO	49.25666667	16.76000000	STN020	CTD007	4827	16	600	X													X		
01/07/2019	DY103	PAP-SO	49.25666667	16.76000000	STN020	CTD007	4827	17	600	X	X	X	X	X	X	X	X	X							
02/07/2019	DY103	PAP-SO	49.26055556	16.51694444	STN025	CTD008	4800	8	3000	X															X
02/07/2019	DY103	PAP-SO	49.26055556	16.51694444	STN025	CTD008	4800	18	200	X															X
05/07/2019	DY103	PAP-SO	49.00027778	16.76000000	STN036	CTD012	4800	6	4000	X	X	X	X	X	X	X	X	X							
05/07/2019	DY103	PAP-SO	49.00027778	16.76000000	STN036	CTD012	4800	8	3000	X	X	X	X	X	X	X	X	X							
05/07/2019	DY103	PAP-SO	49.00027778	16.76000000	STN036	CTD012	4800	9	3000	X													X		
05/07/2019	DY103	PAP-SO	49.00027778	16.76000000	STN036	CTD012	4800	16	850	X	X	X	X	X	X	X	X	X							
										Total	25	50	25	48	48	48	50	50	12	12	12	12			

Underway carbonate analysis

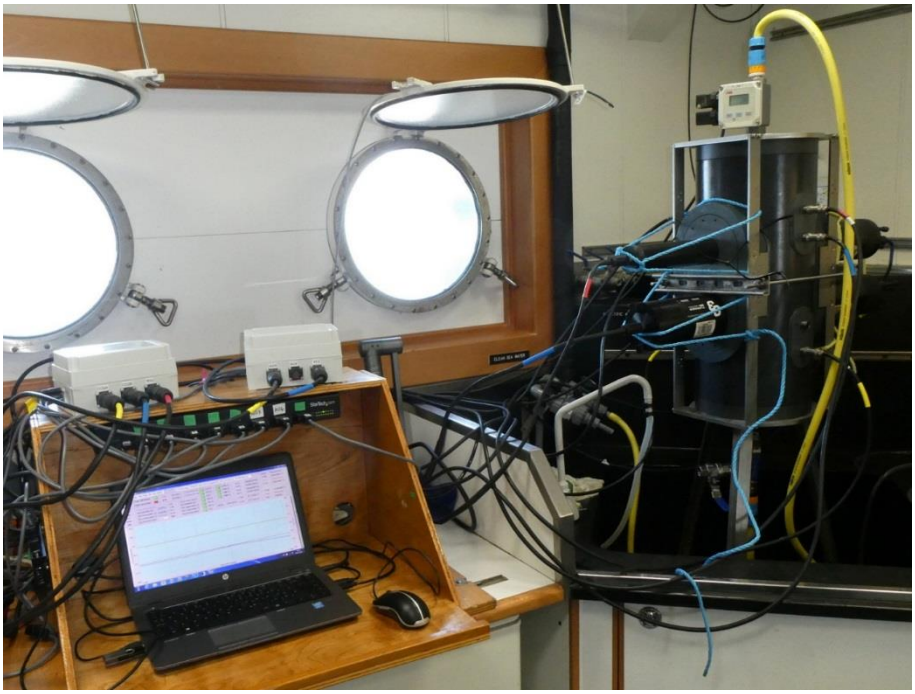
On DY103 we had underway systems from VLIZ Belguim (Picarro CO_2, Contros CO_2 and Contros TA) set up in the deck lab. The idea was to run this alongside the PML CO_2 equipment (in the Met lab) although we had some issues with the latter so may use the VLIZ Picarro to compare all other data. This includes the NOC underway system (with Pro-oceanus sensors) run on the otherside of the Deck lab and the OTEG underway TA system that was set up in the same sink as the Contros systems.

NOC Underway CO_2 system testing

Jon Campbell, Nick Rundle

The DY103 cruise to PAP presented the opportunity to test a new plastic flow-through tank developed for use on 'Ships of Opportunity'. It was also an opportunity to compare data from sensors in the tank with data from other underway systems on board *Discovery*, especially the Dartcom CO_2 system and Picarro and Contros CO_2 systems from the Flanders Marine Institute.

As shown below, the tank was set up in a sink (in the deck lab) with a clean seawater supply going in to the bottom of the tank and flowing out from the top (via a flowmeter) and in to the sink.



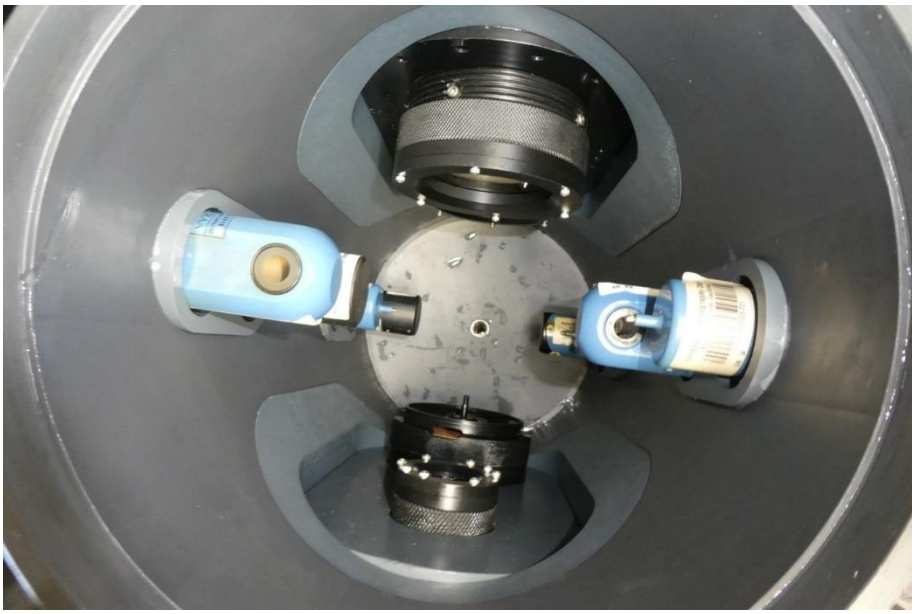
NOC Underway CO_2 system with plastic tank and logging laptop

The tank can accommodate up to 8 Aanderaa Smart sensors as well as 4 larger sensors mounted in the two hatches. The table below shows the list of sensors used for this experiment. Because of other commitments it was not possible to get the system set up and running until 6th July which only allowed for around two and a half days of measurements before the end of the cruise.

The seawater flow through the tank was adjusted so that the tank seals were just beginning to show signs of leaking, a flow rate of 14.6 litres/min. Flow rates up to 21 litres/min were tried at the end of the experiment but produced significant leakage from some of the seals. The sensor data were logged by a LabWindows C program "Underway_CO2_log.c ver 1.10" running on the laptop. The daily files were subsequently concatenated and reformatted by program "Underway_CO2_proc.c ver 1.03".

Sensor	**Serial number**
Pro-Oceanus CO2-Pro CV	38-555-75
Pro-Oceanus CO2-Pro CV	33-156-75
Pro-Oceanus Mini TDGP	38-506-31
Turner Designs C3	2300651
Aanderaa 3835 Oxygen	1357
Aanderaa 3835 Oxygen	1014
Aanderaa 4330 Oxygen	1282
ABB MINI-FLOW flowmeter	3603
Aanderaa 4050 Temperature	34
Aanderaa 4050 Temperature	25
Aanderaa 3919B SW Conductivity	955
Aanderaa 3919B SW Conductivity	674

The photo below shows the view from the top on the tank showing the various sensor heads inside the tank while all the electrical connections remain outside the tank.



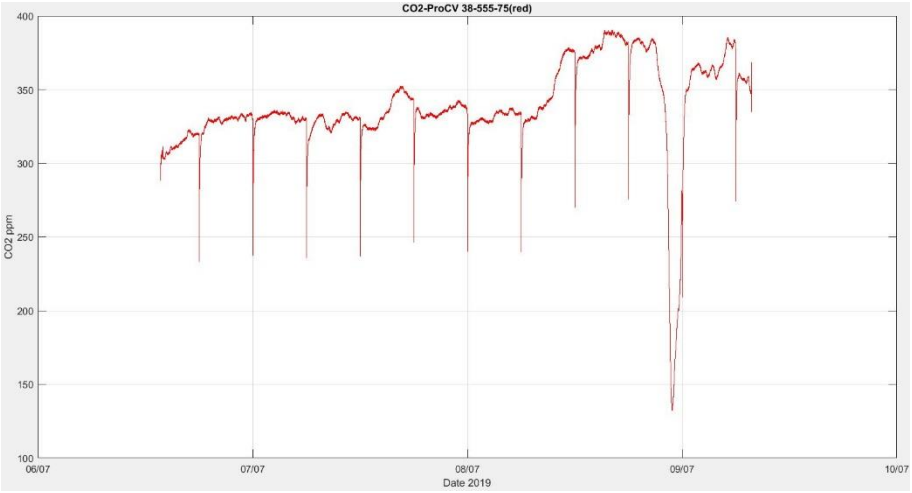
View inside the plastic tank

Results

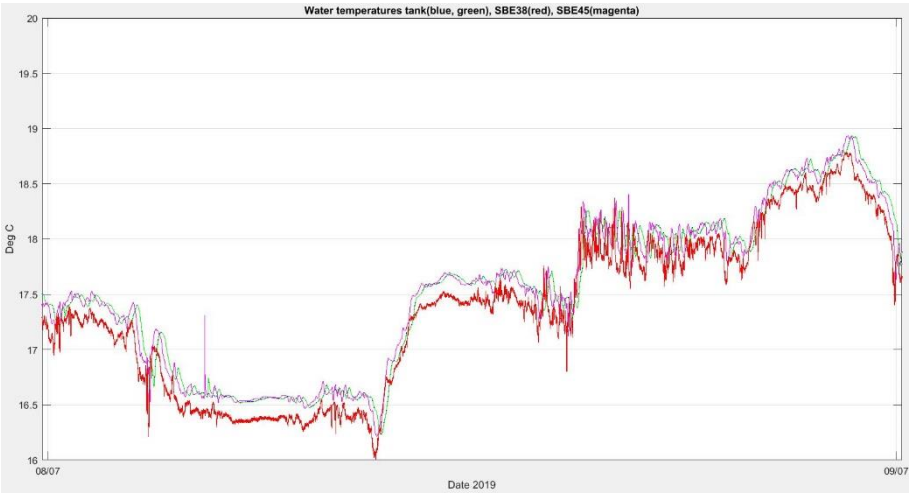
Unfortunately, all three Pro-Oceanus sensors malfunctioned at the start of the experiment. CO_2 sensor 38-555-75 was fixed by opening the sensor and reseating a loose connector but it proved impossible to repair the other CO_2 sensor. The faulty TDGP sensor was replaced with another unit (38-506-31) which had recently been recovered from the PAP mooring.

All the other sensors functioned correctly. The Turner C3 was a brand new sensor but most of the Aanderaa sensors were at least 5 years old and only one oxygen optode (1282) and the two 4050 temperature sensors had been calibrated within the past 12 months. A quick comparison with the SBE38 temperature sensor at the seawater intake close to the bow showed that the tank temperature sensors were reading around 0.12 degrees higher than the intake water. However, there seemed to be a significant lag (of the order of 10 minutes) between temperature changes at the water intake and changes in the tank.

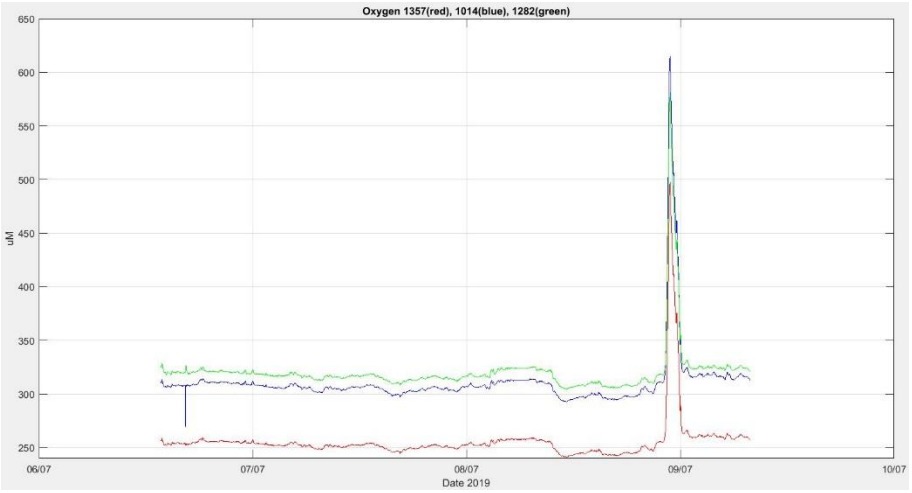
Shortly before midnight on 8th July the vessel appears to have passed through an algal bloom producing dramatic changes in CO_2, oxygen and chlorophyll concentrations, as evident in the plots below.



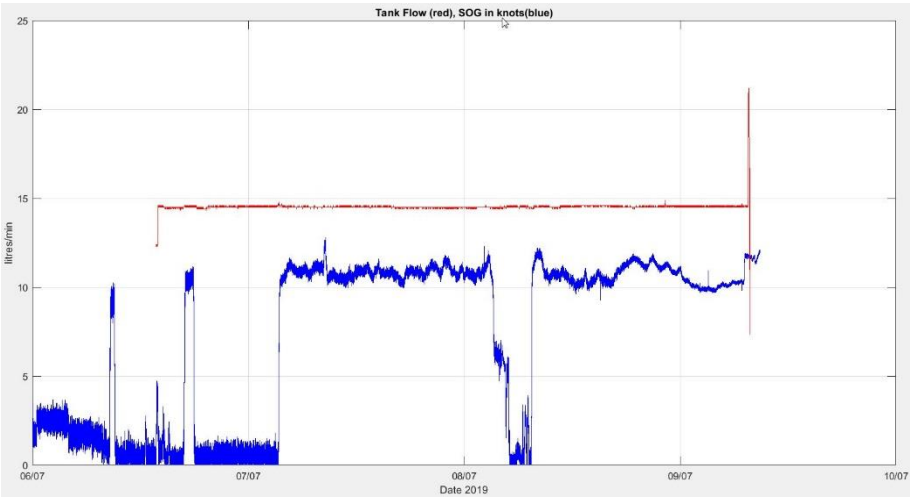
CO_2 ppm showing 6-hourly auto zero calibrations and algal bloom



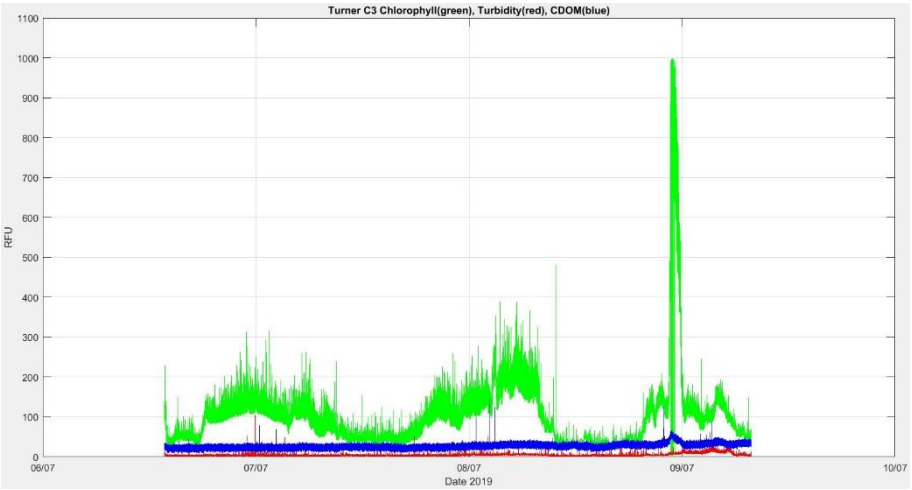
Seawater temperature over 1 day – tank sensors compared with ship's sensors



Oxygen concentration



Flow through the tank and ship's speed over the ground



Turner C3 measurements

Setup VLIZ (Flanders Marine Institute) participation.

Hannelore Theetaert

Equipment that is used on the RRS *Discovery* UW non-toxic water supply:

System	Supplier (if commercial)	Comment
UW pCO2		Equilibrator based/CRDS Picarro G2201-i
HydroC-CO2 FT	Kongsberg Contros	Membrane based
HydroFIA TA	Kongsberg Contros	In situ Total Alkalinity

The non-toxic seawater supply is coupled with a VLIZ custom made Underway pCO_2 system equipped with Picarro CRDS (G2201-i) analyzer, measuring pCO_2. The measurements are checked twice a day with 4 standard gasses (0-250-400 and 800 ppm CO_2).

Kongsberg Contros HydroC-CO2 FT measures pCO_2.

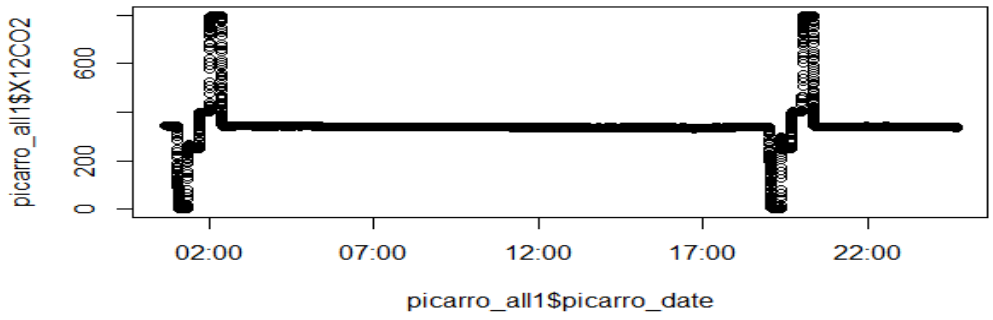
Kongsberg Contros HydroFia TA measures Total alkalinity. First days of the cruise, everyday check with CRM of Dickson, after 4 days checked every other day.

Issues for setting up the equipment:

No big issues. The biggest issue was to make sure that the equilibrator could drain freely in to the sink. Some small adjustments had to be made. The second issue were the gas connections from outside the hangar to the setup. The distance was quit big, and different tubing has been used (Sinflex and BEV-A line tubing).

Issues during the cruise:

No big issues during the whole cruise. The inlet of the water tubing, that goes to the HydroFia and the FT came loose the night of the 28th of June. This caused air to go in the equipment. Took a while before the HydroFia was measuring ok again.



Plot of data from the Picarro from 30th of June from checks and measurements

Setup of the three VLIZ systems

These systems will be compared alongside the OTEG underway alkalinity sampler that was set up in the next sink. Across the lab in another sink an underway Pro-Oceanus system was also set up in the last week of DY103. Additionally the ship fitted Dartcom (PML) pCO_2 system (standardized to 3 gases) was set up in the met lab. All of the underway systems ran until 8am on the 9th July.

Underway chlorophyll sampling

Samples were taken from the underway system in the met lab from 22/06/19 – 30/06/19 and run onboard. These will be compared to satellite passes during the same period.

12. Zooplankton nets

Corinne Pebody

The WP2, 200 µm net, was deployed to 200 m in a series of vertical hauls. Prior to each haul, the net was checked for twists and that the tap was closed, then the net was lowered over the side using the Rexroth winch on the P-frame. Maximum depth was 200 metres where the deployment was paused for a minute to allow the net to hang straight before the being brought up at approx. 10 metres per minute. On recovery the net was hosed down from the outside with seawater and the cod end emptied into a white bucket. Hosing was repeated and time allowed for zooplankton to settle into the bottom of the cod end. Samples were transferred to 2 litre bottles and preserved by adding borax buffered formaldehyde to an approximate concentration of 5%.

Future work: At NOC, formalin preserved samples will be split with a Folsom splitter. A sub-sample will be picked to remove zooplankton greater than 2 mm. Remaining meso-zooplankton will be analysed using flow cam technology to ascertain size and abundance distribution.

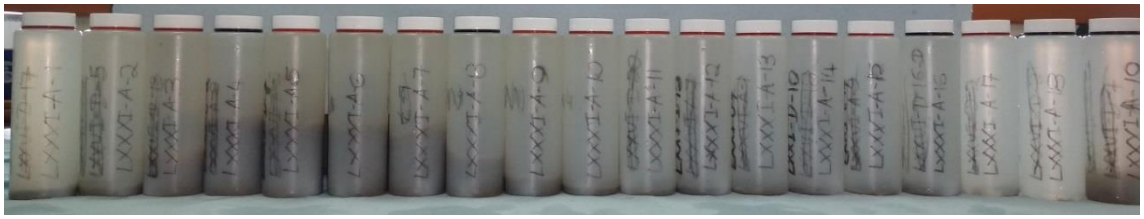
DY103-013 NET #1	Midnight sample	preserved in formalin 2 litre bottles			
net in		29/06/2019	22:38	48, 50.2816 N	16, 30.915 W
at surface		29/06/2019	23:35		
DY103-017 NET #2	Midnight sample	preserved in formalin 2 litre bottles			
net in		30/06/19	22:48	48, 50.192 N	16, 31.035 W
at surface		30/06/19	23:22		
DY103-022 NET #3	Midnight sample	preserved in formalin 2 litre bottles. Far fewer animals in sample			
net in		02/07/19	00:07	18, 50.280 N	16, 30.935 W
at surface		02/07/19	00:43		
DY103-027 NET 4	noon sample	preserved in formalin 2 litre bottles.			

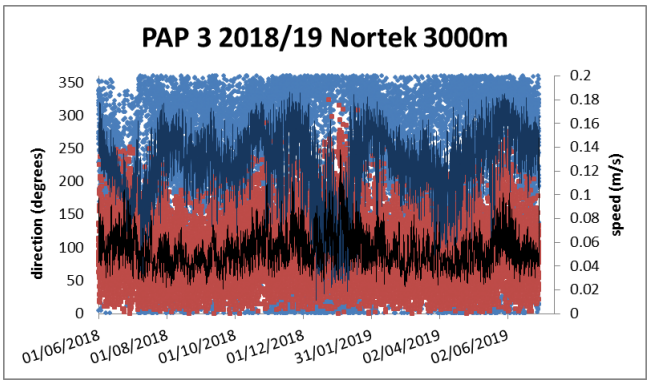
net in		03/07/19	11:55	48, 57.537 N	16, 22.584 W
at surface		03/07/19	12:24		
DY103-032 NET #5	noon sample	preserved in formalin 2 litre bottles.			
net in		04/07/19	12:19	49, 0.043N	16, 30.023 W
at surface		04/07/19	12:48		
DY103-035 NET #6	noon sample	preserved in formalin 2 litre bottles. (2 sample bottles)			
net in		05/07/19	12:12	49, 0.034 N	16, 30.037 W
at surface		05/07/19	12:38		

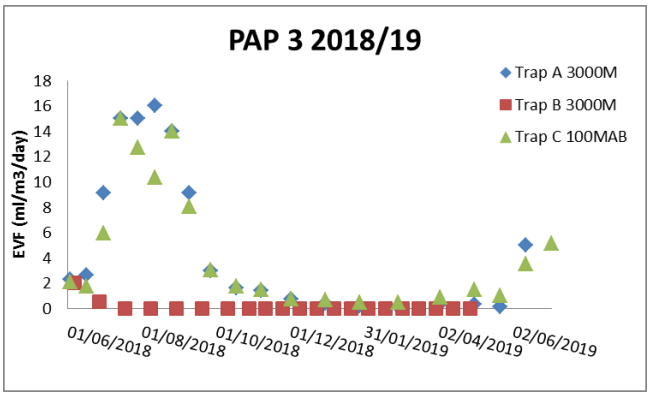
Thank you to Andy, Andy, Craig, John and Brian

13. PAP3 – sediment traps

For mooring details – see moorings report (section 6). Trap LXXXI (JC165-013) was deployed 25/05/2018 on JC165 and recovered on 30/6/19. The top package took about 45 minutes to reach the surface and all was recovered successfully. There was some tangling of ropes around trap C (100 mab), probably because of the buoyancy package associated with the release, but all was brought in safely and trap C was kept the right way up.

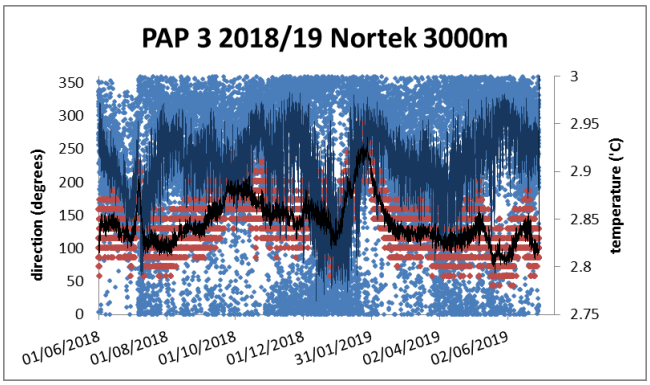




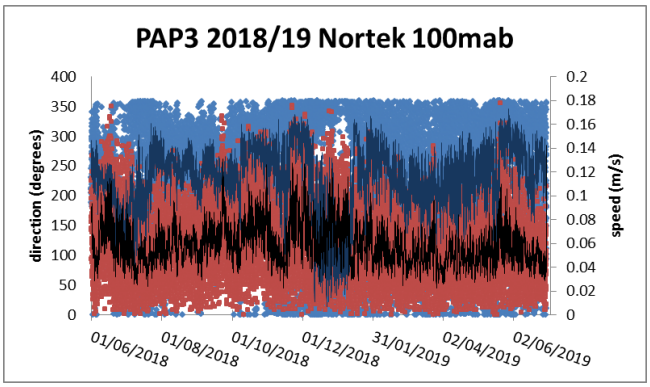


Trap A and C showed good catch and suggested a late bloom this year, but trap B failed to trap as expected despite being only approx. 50m below trap A. The first two bottles are similar to trap A then there is very little material for the rest of the deployment. The EVF plotted here show the flux at the different depths. The reason for this is not clear, its not simple shadowing because we have not seen it in previous years. The only difference is the addition of the larval traps (see deep seas section for report) but they are small and innocuous and unlike to affect the falling particles in any way.

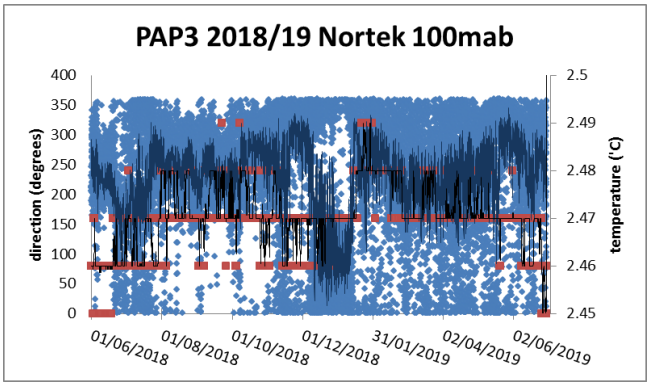
Current meters showed that the traps were at current speeds of mostly 0.1 m/s or less. The higher speeds at Christmas 2018 running to the north east and east.



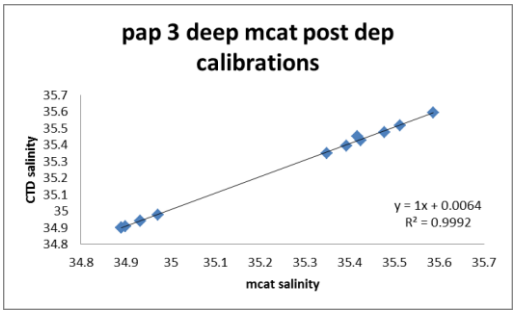
The Norteks also give (uncorrected) temperature and there is a small (see scale) but sharp warming in January when the currents swing west.

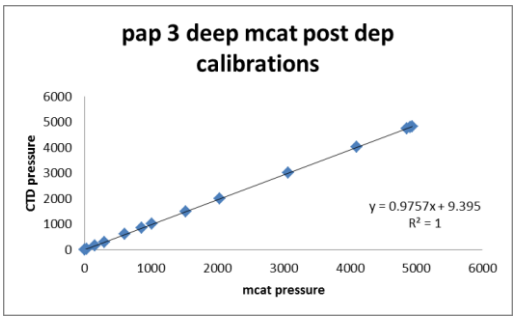


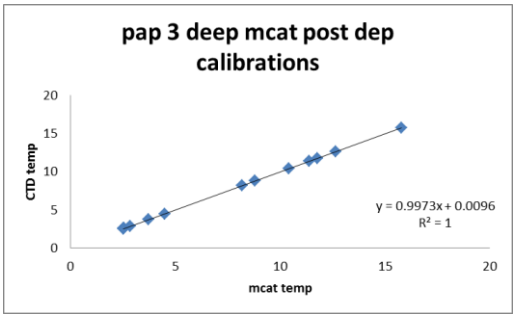
At 100 mab the direction and speed are remarkably similar to 3000 m.



The temperature at 100 mab is lower and has a smaller range, but it too shows warmer water associated with westward currents in January.







The deep microcat at 100mab, was calibrated on CTD 07. Temperature and salinity are OK with R^2 = 1 and R^2 = 0.9992 respectively. The CTD salinity was calibrated with bottle samples run on the Autosal. Although the salinities from some casts were poor, by excluding the obviously erroneous casts, the overall calibration of bottle salinity to CTD salinity were good, so the overall calibration was used.

14. Benthic systems and sampling

Brian Bett, Noëlie Benoist, Clara Douglas, Jennifer Durden Vanessa Fernandez Rodrigues, Andrew Gates, Robyn Samuel, Philip Smith, Georgina Valls Domedel, Rob Young

The benthic group aboard RRS *Discovery* cruise 103, aimed to continue time-series observations of the benthos and seafloor of the Porcupine Abyssal Plain Sustained Observatory site, originally initiated in 1985. Standard objectives for the 2018 cruise included: (i) a replicated set of seabed samples collected by Megacorer from the PAP central location to serve a variety of purposes, (ii) duplicate otter trawl samples of the megabenthos to serve a variety of purposes; (iii) duplicate amphipod trap sample sets (including incorporation of an additional trap at 15 mab); and (iv) the recovery (JC165-068) and redeployment of a long-term (1-year) *Bathysnap* time-lapse seafloor camera system, and the attempted HyBIS rescue recovery of a previously 'lost' system (DY077-084). In addition, (v) a continuation of routine seafloor photography (via the HyBIS system) at the PAP-SO area following the WASP operations of RRS *James Cook* cruise 062, Autosub6000 operations of RRS *Discovery* cruise 377/8, and HyBIS operations of RRS *James Cook* cruise 165; (vi) recovery and redeployment of larval traps and colonisation substrata associated with sediment trap and *Bathysnap* moorings (carried out on behalf of Luciana Génio, University of Aveiro). With the exception of the failure to recover the DY077-084 *Bathysnap* mooring, these objectives were largely met during the course of the cruise, as described below. The time lost to the 'medivac' diversion to Cork, primarily impacted the number of Megacorer deployments possible, with a consequent loss of 4 sample sets, and the extent of HyBIS photographic coverage (effectively loss of one deployment). This will have minimal impact on the majority of resulting analyses, though will be somewhat limiting on the macrobenthos data (note that deployments DY103-021 and -023 were largely dedicated to macrobenthos to partially compensate for the loss in total number of deployments), and on the photographic assessment of the megabenthos.

Moorings

Two small bottom moored systems were employed during the course of the cruise: "*Bathysnap*" (BSNAP), a time-lapse seafloor photography system intended for long-term deployment (c. 1-year), and an "Amphipod trap" (ATRAPx), carrying five simple baited traps for short-term deployments (1-2 day). In addition, colonisation substrata and larval traps were also recovered from, and redeployed on, moorings (sediment trap array ["PAP3"] and *Bathysnap*) as a continuation of the "Larval Occurrences in Open Ocean: Connectivity studies in NE Atlantic and Mediterranean Sea" (LO3CAted) project for Luciana Génio (University of Aveiro).

Bathysnap

A new Bathysnap system (new frame and new Kongsberg camera and flashgun) was deployed as station DY077-084, during RRS *Discovery* cruise 077, on 25 April 2017, and confirmed acoustically to be on the seafloor at 19:00 on that day. An attempt was made to contact and release the mooring during RRS

James Cook cruise 165 on 22 May 2018, no acoustic response was detected, and the mooring did not surface. An attempt was again made to contact the release during the present cruise (24 June 2019) with no response detected. Subsequently, a 'rescue' mission was undertaken using the HyBIS vehicle as station DY103-008; this involved a c. 500 m length pass through the deployed position of the *Bathysnap* system at an altitude of c. 60 mab, i.e. that of the mooring's main buoyancy pack. No sonar target returns were detected on that transit, nor on a return line offset 100 m to the east, that also made a low pass (c. 6 mab) in the vicinity of the deployed position. Consequently, the mooring and associated equipment should continue to be regarded as lost, with no new information to indicate that it is present at the deployed location.

A refurbished *Bathysnap* system (new frame and refurbished Kongsberg camera and flashgun, post flood on their first deployment at the LTER Observatory HAUSGARTEN) was deployed as station JC165-068 during RRS *James Cook* cruise 165, on 7 June 2018, and confirmed acoustically to be on the seafloor as its position was triangulated that day. Acoustic communication with the release was successfully achieved during the present cruise on 24 June 2019, and the release command sent. However, the mooring did not rise. Subsequently, an HyBIS 'rescue' mission was undertaken (DY103-018) in an attempt to locate and recover the mooring. On a first pass through the deployed location at an altitude of c. 60 mab (i.e. that of the mooring's main buoyancy pack) a sonar target was detected. An oblique move of the ship brought the sonar target closer and eventually into visual range confirming that it was the main buoyancy pack. HyBIS was lifted c. 20 m to locate the dan buoy, noting that the pick-up float was hanging down past it (the glass having failed). The 'rescue' hook on HyBIS caught directly into a link of the chain hanging below the dan buoy, and the mooring was successful brought to the surface with HyBIS. The mooring was recovered conventionally using the Rexroth winch on the bullhorn.

On power-up in the lab, the recovered *Bathysnap* camera behaved correctly, starting in "C2 Mode" and taking pictures at 15-second intervals. However, no photographs were recorded during the deployment itself. No communication could be established with the Oceanback power and timing controller for the camera system (multiple attempts from two laptops). The Oceanback pressure case was opened and the clock batteries (2 × AA cells) and primary battery pack (15 V 105 Ah) replaced. Still, no communication could be achieved with the Oceanback. The USB connector internal to the endcap was disconnected and connection to a laptop made via a female to male USB cable; this connection was immediately effective, and the system began operating at 1-hour intervals without any additional intervention. The external cable, bulkhead connector, or internal wiring to the internal USB connector may therefore be suspect.

The Oceanback system was then subject to some bench tests that appear to suggest: (a) two parameters (e.g. interval and number of repeats) need to be set to ensure the system runs, (b) high values of number of repeats (e.g. 2000) may be accepted but may not be effective (these bench test suggested that 1200

was an effective value), and (c) as previously suspected, the start cable should not be removed after setup. Consequently, the Oceanback was setup for redeployment with an interval of 8-hours and 1200 repeats, and the start cable left inserted. The camera system was setup following the protocol detailed in previous cruise reports (DY077 and JC165) and connected to the Oceanback system when mounted on the *Bathysnap* frame. A successful flash fire was noted on deck (c. 09:00 6 July 2019) prior to the mooring deployment.

The *Bathysnap* system was subject to two modifications prior to redeployment:

- A fifth sphere was added to the main buoyancy pack
- The ballast weight retaining structure was removed from the underside of the frame

Both of these modifications were undertaken in response to the failure of the mooring (JC165-068) to rise after executing a release command, and the recovered system having ultimately released the ballast weight.

The *Bathysnap* mooring was redeployed as station DY103-038; however, the mooring immediately boomeranged on arrival at the seafloor. The cause is unknown, but the release unit was suspected and replaced prior to subsequent redeployment. The mooring was then successfully deployed as station DY103-039, 49° 00.214´ N 016° 26.615´ W, 4840 m, fitted with release unit s/n 1271, ARM code 08CC, REL code 0855.

Amphipod trap

The OBE upgraded DEMAR amphipod trap (carrying four double parlour acrylic traps) was deployed in near-conventional manner on two occasions during the cruise. An additional trap was added to the mooring to be located at about 15 mab when in operation. The 'new' trap consisted of a 30 L standard sample blue barrel, with an aperture of c. 12 × 5 cm cut in the centre of the lid, with numerous drain holes drilled around the circumference of the barrel, particularly near the base, and through the base; a large shackle was fitted internally to the base as ballast, and some 'tangle' material (fine non-slip mat) and the bait attached to that shackle. For both deployments, all traps were baited with 'standard British mackerel'. The mooring was otherwise of conventional form: lazy float – 15 m polyprop – Billings dan buoy – 15 m polyprop – 10 m braid - 6-ball main buoyancy pack – 50 + 10 m braid – IXSEA Oceano 2500 B2S type release. Mooring descent rate was estimated at 60 m min^{-1}, and ascent rate at 38 m min^{-1}. Summary tabulation of amphipod trap deployments:

Stn number	Start time		End time		Depth (m)	Soak time
DY103-010	29/06/2019	15:25	01/07/2019	10:07	4846 m	41 hours
DY103-024	02/07/2019	09:13	03/07/2019	17:00	4842 m	32 hours

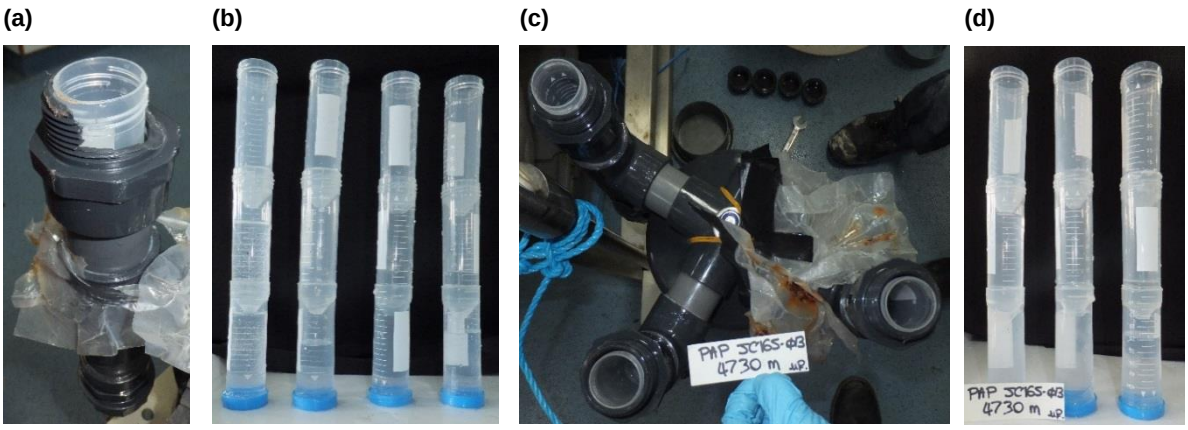
Sample processing: Each trap was photographed on the frame with the Station number and either 'top', 'bottom' or '12 m', removed from the frame, and placed in a large tray next to the sieving table. Trays were used to keep the pieces of the trap (i.e. funnel, screws, and crossed wire) together after it was dismantled to extract the amphipods. This allowed rebuilding each trap with their original pieces. Nitrile gloves were used at all times to avoid biological contamination of the samples. Amphipods were removed from the trap by gently washing the trap cylinder, funnel, and mesh, with filtered seawater above the sieving table that was used as a working station (two traps were processed at the same time in order to speed up the process). Specimens were retained on a 250 µm sieve that was placed on a tray to prevent sample loss. The bait mackerel was examined in detail (dissected if necessary) to collect amphipods within the flesh. Specimens were transferred to absolute ethanol in 1500 ml UN certified plastic bottles (one bottle per trap) and held in the 4 ºC temperature control room. Each bottle was labelled with Station number, position of the trap (i.e. top1, top2, botttom1, bottom2, 12 m), date, and preservation method (i.e. ethanol). In the traditional amphipod traps, the majority of amphipods comprised small individuals (particularly from the second deployment). On the first deployment, an extremely abundant catch was collected for the bottom 1 trap and a slightly less abundant catch was collected for bottom trap 2. A smaller volume of individuals was collected on the bottom traps from the second catch. The catches of both top traps (top 1 and top 2) were significantly lower than the catches made for the bottom traps in all deployments, with an extremely low catch (two specimens) for the top 2. Good results were obtained for the experimental barrel trap, where the majority of amphipods comprised fewer but considerably larger specimens. Examples of amphipods collected during DY103 are presented below.

Example images of amphipod catches and the remaining bait from Station DY103-010, note contrast between top and bottom trap catches.

LO^{3}CAted project

During the RRS *Discovery* cruise 103, we aimed to continue the work initiated under the scope of the FixO^3-TNA project LO^{3}CAted (**L**arval **O**ccurrences in **O**pen **O**cean: **C**onnectivity studies in NE Atlantic and Mediterranean Sea) with the following objectives: (i) recover larval traps and colonization frames from the PAP3 and the *Bathysnap* moorings deployed during the 2018 RRS *James Cook* cruise 165, and from the *Bathysnap* mooring deployed during the 2017 RRS *Discovery* cruise 077, and (ii) deploy new devices on both moorings to continue time-series sampling. With the exception of the failure to recover the DY077 *Bathysnap* mooring (deployed as station DY077-084 on 25/04/2017), these objectives were met and are described below.

JC165 PAP3 mooring recovery. On 30/06/2019, LO^{3}CAted sampling devices were recovered from the PAP3 mooring that was deployed during the RRS *James Cook* cruise 165 as station JC165-013 on 25/05/2018. The equipment arranged on the PAP3 mooring consisted of two TNA traps (two sets of three colonization chambers, i.e. net-meshed baskets, and one unit of four larval traps) placed below the upper sediment trap at 2960 m water depth, and similarly, two TNA traps below the lower sediment trap at 4730 m water depth. At recovery on deck, the bottom cap of one of the two upper TNA traps (2960 m) was broken; the three individual chambers fell off their unit. Nonetheless, the three chambers were recovered and processed as detailed below. The top edge of one of the upper four larval traps was broken prior to recovery on deck (see picture below). One of the four lower larval traps (4730 m) was lost (broken) and only three samples were recovered (see picture below). The parafilm covers placed on all the recovered larval traps (2960 m, 4730 m) had detached as expected, and tube traps generally retained small volume of DMSO-preserved sample.



Recovery of the JC165-013 LO^{3}CAted larval traps. (a) Broken top section of one of the four upper larval traps (2960 m). (b) Larval trap samples recovered from the upper frame (2690 m). (c) Three of the four lower larval traps (4730 m). (d) Larval trap samples recovered from the lower frame (4730 m).

The TNA frames were immediately processed in the wet lab.

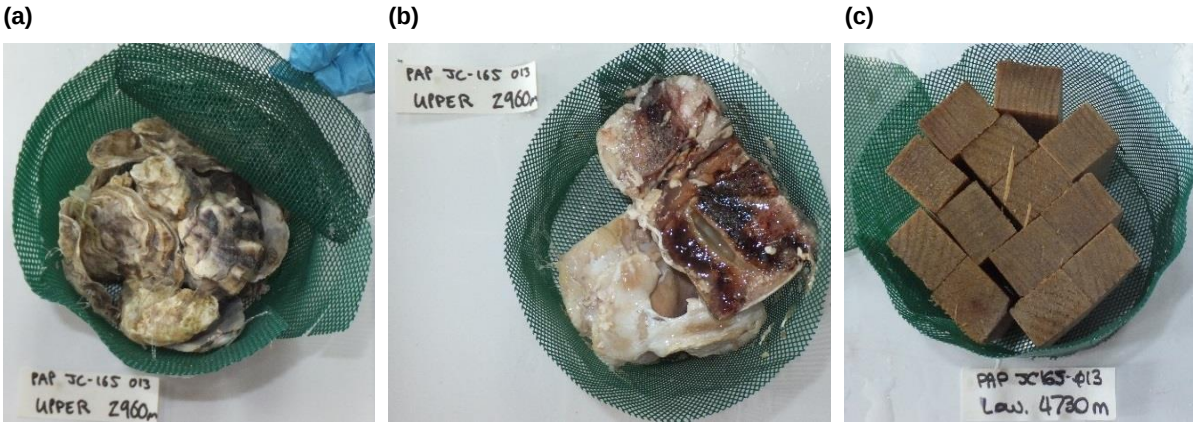
Larval traps. The falcon-tube columns containing DMSO-fixed trap samples were removed from the PVC frame, photographed (see picture above), and transferred to 120 mL labelled sample vials. Particles were visible on most of the falcon-tube bottom caps; the caps were washed into their corresponding vials with DMSO.

Biogenic substrata. The substrata used during JC165-013 consisted of (i) wood (12 pieces of 2 x 2.5 x 8.5 cm natural pinewood per basket), (ii) oyster shells (c. 20 valves per basket), and (iii) cow bones (c. 410-420 g per basket) (see summary table below). Each substratum sample was processed as follows: (1) the PVC container holding the colonization chamber was transferred to a clean plastic tray; (2) the net basket was removed from the PVC container; (3) the line securing the top of the net basket was cut and the top net cover was lifted; (4) the substrata were photographed (top view); (5) the subsamples were preserved with different fixatives (see summary table below) for future processing in the laboratory at Aveiro University, Portugal. Ethanol-cleaned scissors and forceps were used to cut the net lines and to transfer the substratum subsamples into their corresponding containers.

The experimental substrata showed no visible sign of degradation. A gelatinous mass was found on top of the bone chamber (top unit of the lower frame, 4730 m). Similarly, as last year, bone surfaces at 4730 m were generally cleaner than those at 2690 m and showed small patches of bacterial growth. No macro-organism was observed on any substratum at both deployment depths.

Distribution of JC165-013 experimental substrata subsamples among the different fixatives. 4% bF, 4% borax buffered [20 g l-1 40% formaldehyde] formaldehyde seawater solution. [1]Including the mesh net. Note the top of the mesh nets of the lower chambers located on the upper frame (2690 m) were discarded.

Substrate	95% ethanol[1]	4% bF	-80 °C
Wood	Remaining laths	2 laths	2 laths
Bone	Remaining pieces	2 pieces	2-3 pieces
Shells	Remaining valves	4 valves	4 valves

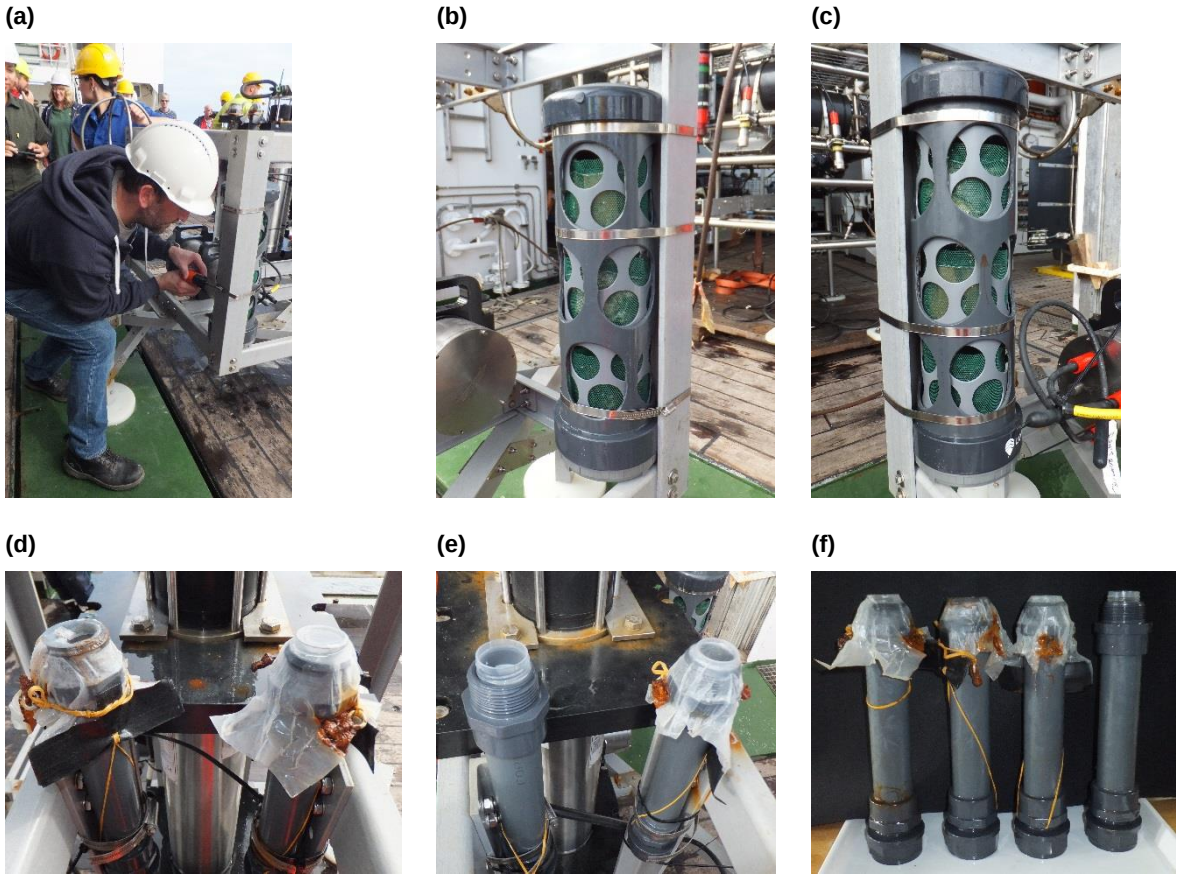


Recovery of the JC165-013 LO^{3}CAted experimental biogenic substrata as deployed on the PAP3 mooring. (a) shells and (b) bones from the upper frame (2960 m), (c) from the lower frame (4730 m).

Summary of the JC165-013 LO^{3}CAted samples collected after one-year deployment on the PAP3 mooring. EtOH, 95% ethanol; including mesh net. 4% bF, 4% borax buffered [20 g l-1 40% formaldehyde] formaldehyde seawater solution.

Depth (m)	Settlement frame	Substrate order	Substrate	Preservation
		Top	Wood	EtOH, 4% bF, -80 °C
		Middle	Shell	EtOH, 4% bF, -80 °C
		Bottom	Bone	EtOH, 4% bF, -80 °C
		Top	Wood	EtOH, 4% bF, -80 °C
		Middle	Shell	EtOH, 4% bF, -80 °C
		Bottom	Bone	EtOH, 4% bF, -80 °C
		Top	Bone	EtOH, 4% bF, -80 °C
		Middle	Wood	EtOH, 4% bF, -80 °C
		Bottom	Shell	EtOH, 4% bF, -80 °C
		Top	Shell	EtOH, 4% bF, -80 °C
		Middle	Bone	EtOH, 4% bF, -80 °C
		Bottom	Wood	EtOH, 4% bF, -80 °C

JC165 *Bathysnap* mooring recovery. On 01/07/2019, LO^{3}CAted sampling devices were recovered from the *Bathysnap* mooring that was deployed during the RRS *James Cook* cruise 165 as station JC165-068 on 07/06/2018. The equipment arranged on the mooring consisted of two TNA traps (two sets of three colonization chambers, i.e. net-meshed baskets, and four individual larval traps positioned in the centre of the mooring) placed on the mooring at 4840 m water depth. At recovery on deck, the TNA equipment was taken off the mooring and processed in a similar fashion as the JC165-013 samples. Only one of tube traps was open and retained a large volume of DMSO-preserved sample.



Recovery of the JC165-068 LO³CAted larval traps. (a) Dismantling of the colonization chamber frame. (b,c) Colonization chambers arranged on the Bathysnap *mooring. (d,e,f) Larval traps recovered from the* Bathysnap *mooring.*

The TNA frames were immediately processed in the wet lab.

Larval traps. Same processing as for the JC165-013 samples.

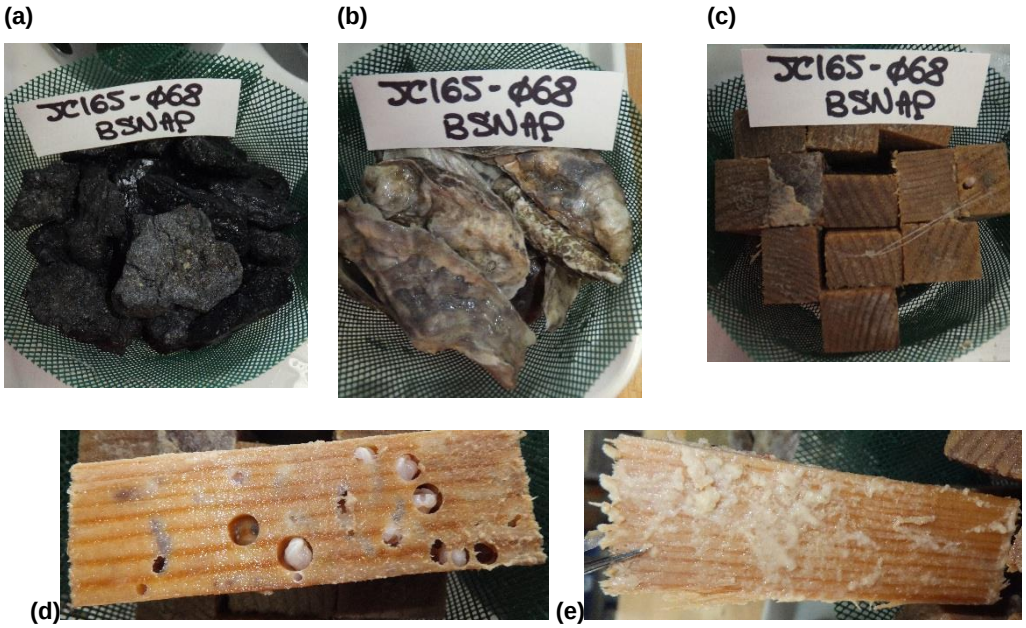
Substrata. The substrata used during JC165-068 consisted of (i) wood (12 pieces of 2 x 2.5 x 8.5 cm natural pinewood per basket), (ii) oyster shells (c. 20 valves per basket), and (iii) clinker pieces collected from the otter trawl sample (OTSB14a station JC165-064, 06/06/2018; c. 600 g per basket) (see summary table below). Each substratum sample was processed as for the JC165-013 samples.

The experimental substrata showed no visible sign of degradation with the exception of the wood laths that exhibited burrowing macro-organisms (bivalve?) and rather large patches of bacterial growth (see picture below). Particles were apparent at the bottom of the PVC containers; these were washed with ethanol with the ethanol-preserved samples.

Distribution of JC165-013 experimental substrate subsamples among the different fixatives. 4% bF, 4% borax buffered [20 g l-1 40% formaldehyde] formaldehyde

seawater solution. [1]Including the mesh net. Note the top of the mesh nets of the lower chambers located on the upper frame (2690 m) were discarded.

Substrate	4% bF	-80 °C	95% ethanol[1]
Wood	2 laths	2 laths	Remaining laths
Clinker	2 pieces	2-3 pieces	Remaining pieces
Shells	4 valves	4 valves	Remaining valves



Recovery of the JC165-068 LO[3]CAted experimental substrata as deployed on the Bathysnap *mooring. (a) clinker, (b) shells, (c) wood, (d,e) colonized wood laths.*

Summary of the JC165-068 LO[3]CAted samples collected after one-year deployment on the Bathysnap mooring. EtOH, 95% ethanol; including mesh net. 4% bF, 4% borax buffered [20 g l-1 40% formaldehyde] formaldehyde seawater solution.

Depth (m)	Settlement frame	Substrate order	Substrate	Preservation
		Top	Shell	EtOH, 4% bF, -80 °C
		Middle	Wood	EtOH, 4% bF, -80 °C
		Bottom	Clinker	EtOH, 4% bF, -80 °C
		Top	Wood	EtOH, 4% bF, -80 °C
		Middle	Shell	EtOH, 4% bF, -80 °C
		Bottom	Clinker	EtOH, 4% bF, -80 °C

DY103 PAP3 mooring deployment

Colonization chambers. Two sets of LO^{3}CAted frames were attached to the PAP3 mooring deployed as station DY103-009 on 29/06/2019. Each set included two colonization frames that each comprised three colonization chambers with experimental substrata, with the upper frame having four passive larval tube traps attached on top. All the frames were clamped to a metal bar and inserted in line, one set under NORTEK AQD at 2960 m water depth and the other set under NORTEK AQD at 4730 m water depth. The experimental substrata (wood, oyster shells, clinker) were enclosed in a 2 mm mesh net inside PVC containers with holes for flowing water. The wood (12 pieces of 2 x 2.5 x 8.5 cm natural pinewood per basket) and the oyster shells (c. 20 valves per basket) were previously prepared in the laboratory at Aveiro University, Portugal. The wood pieces were subjected to a heat shock (56 °C for 30 min), and the shells were brushed and washed with tap water and dried at 60 °C. Clinker pieces (c. 610-630 g per basket) collected during the JC165 cruise (from the otter trawl sample OTSB14a station JC165-064, 06/06/2018) were placed inside four net baskets. The experimental substrata were randomly ordered in each colonization frame. Final arrangement of substrates is shown below.

LO^{3}CAted experimental substrata order during DY103-009 as deployed on the PAP3 mooring.

Depth (m)	Settlement frame	Substrate order	Substrate
		Top	Wood
		Middle	Shell
		Bottom	Clinker
		Top	Wood
		Middle	Shell
		Bottom	Wood
		Top	Shell
		Middle	Clinker
		Bottom	Wood
		Top	Clinker
		Middle	Wood
		Bottom	Shell

Larval traps. Larval traps were filled with 20% Dimethyl sulfoxide (DMSO) saturated with NaCl (c. 50 g L^{-1}). The fixative solution was prepared in the laboratory at Aveiro University using Milli-Q water (stir for c. 1 h, let settle overnight, decant) and kept refrigerated until deployment. Falcon-tube columns (three tubes per column) were washed with Milli-Q water and dried at ambient temperature before being filled with the fixative solution. The top of the traps was covered with parafilm to prevent the fixative release during mooring descent. The parafilm was secured with rubber bands attached to a magnesium fusible link that dissolves after a few days in seawater. When the link dissolves, the rubber band pulls off the plastic film, opening the trap.

DY103 *Bathysnap* mooring deployment

Colonization chambers. Two LO^{3}CAted colonization chambers were attached to the *Bathysnap* mooring deployed as station DY103-039 on 06/07/2019. Each colonization frame comprised three colonization chambers with experimental substrata. One unit of four larval traps was clamped on the top edge of the *Bathysnap* frame. The experimental substrata (wood, oyster shells, clinker) were prepared as described previously and randomly ordered in each colonization frame. Final arrangement of substrata is shown below.

Larval traps. Larval traps were prepared as described in the previous section.

*LO^{3}CAted experimental substrates order during DY103-039 as deployed on the Bathysnap mooring. *The colonization frames deployed were numbered 1 and 6 at the bottom end.*

Depth (m)	Settlement frame*	Substrate order	Substrate
		Top	Shell
		Middle	Wood
		Bottom	Shell
		Top	Shell
		Middle	Clinker
		Bottom	Wood

Deployment of the DY103-039 LO^{3}CAted experimental substrata as deployed on the Bathysnap *mooring. The colonization chambers (numbered 1 and 6) were placed on the rear side of the mooring and the larval traps were positioned at the upper edge of the mooring.*

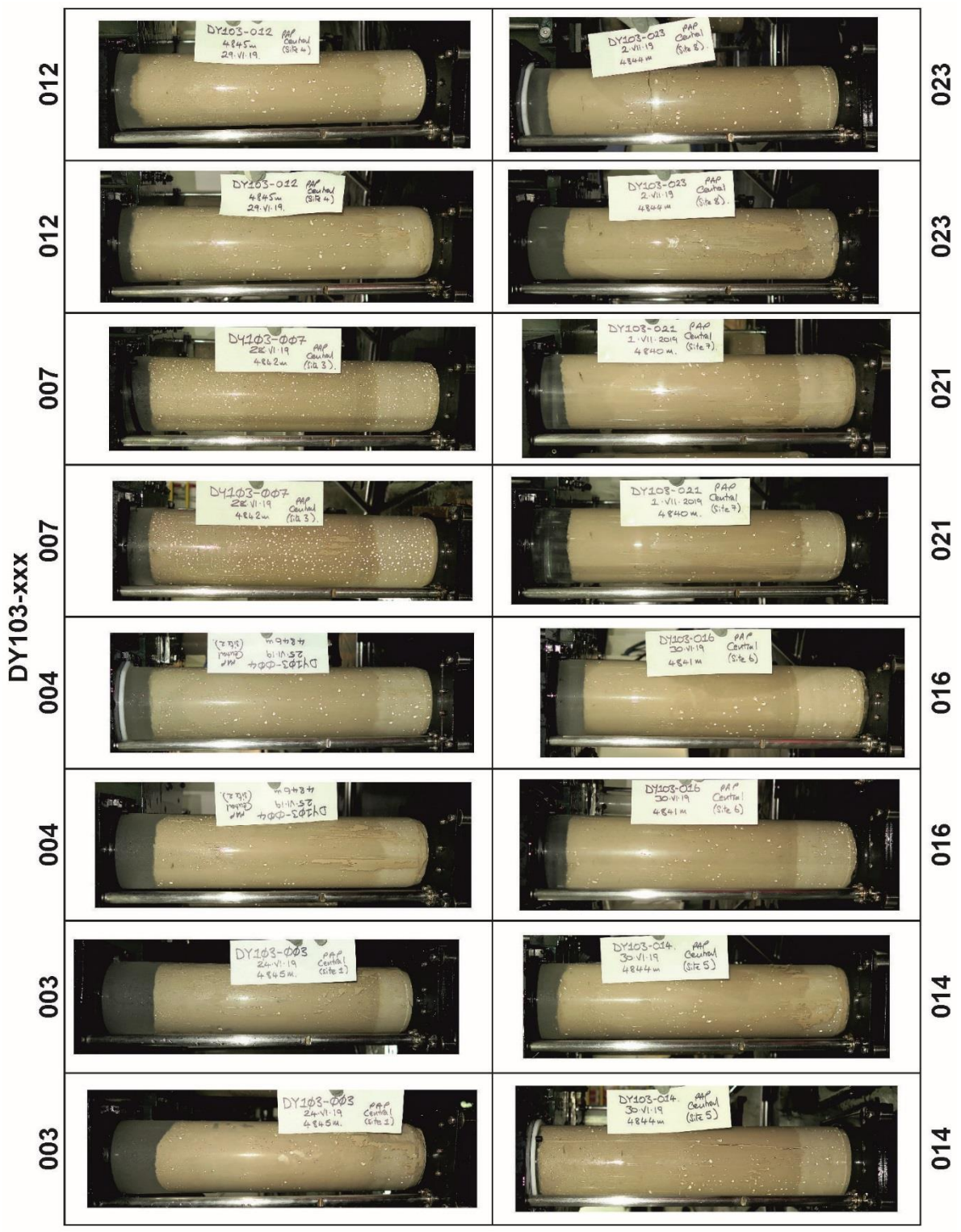
Wire deployments

Megacorer

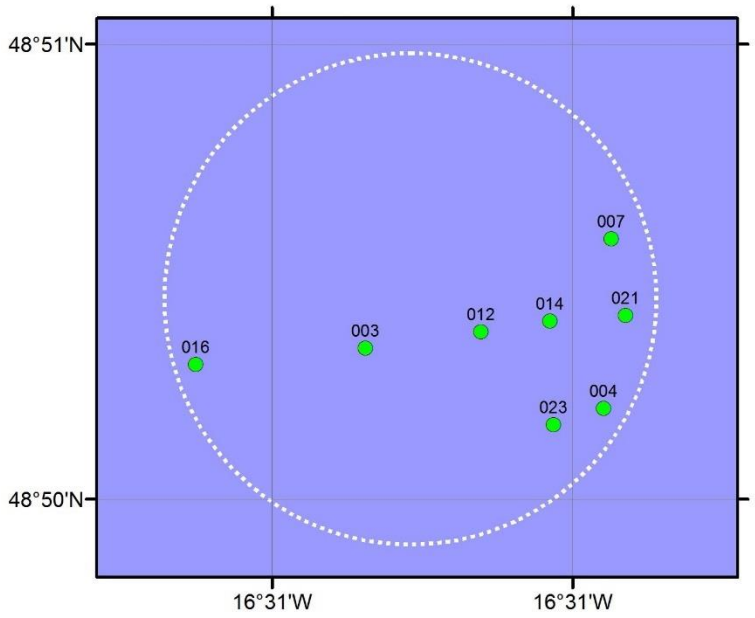
Coring operations at the PAP Central site were based on randomly selected points (ArcMAP 10.5 native function) within a 500 m radius buffer (geodesic; ArcMAP 10.5 native function) of the nominal centre of the "central coring area", 48° 50.22′ N 016° 31.27′ W. The NMF Megacorer (ex-OBE version) was used for all coring operations during the cruise. It was rigged (standard two extra layers of lead plate) and operated in conventional fashion. Monitoring was successfully achieved via a Sonardyne USBL beacon mounted directly on the frame. Both "large" (100 mm ID) and "small" (59 mm ID) units were deployed, as identified in the Station List in the conventional manner (e.g. MgCxx+y, where xx is the number of large units and y is the number of small units). General performance is noted in the following table:

Station	Gear	Pull out tension (T)	Return	Typical length (cm)[1]
DY103-003	MgC08+2	5.1	7/10 fair cores	36
DY103-004	MgC08+2	5.2	10/10 good cores	40
DY103-007	MgC08+2	5.1	10/10 good cores	41
DY103-012	MgC08+2	5.1	10/10 good cores	42
DY103-014	MgC08+2	4.9	10/10 good-fair cores	41
DY103-016	MgC08+2	5.1	8/10 good cores	40
DY103-021	MgC09+1	5.1	9/10 good cores	40
DY103-023	MgC09+1	5.3	8/10 fair cores	41

[1] Representative length of successful large cores.



Example core profile photographs from all Megacorer deployments in the PAP Central area.



Successful Megacorer stations in the 'PAP Central' coring area labelled as DY103-xxx; dotted circle is the 500 mm radius buffer defining the randomly sampled area.

Summary of Megacorer samples collected at PAP central during DY103

Station	Sampler	Depth (m)	Macrofauna	Metazoan meiofauna	Microplastics	Biogeochemistry	eDNA	PLFA	PSA	DBD (from PSA core)	Fungi MBA (from other cores)
DY103-003	MgC08+2	4845	4			1	1	1			
DY103-004	MgC08+2	4846	4	1	1	1	1	1	1	1	1
DY103-007	MgC08+2	4842	4	1	1	1	1	1	1	1	1
DY103-012	MgC08+2	4845	4	1	1	1	1	1	1	1	1
DY103-014	MgC08+2	4844	4	1	1	1	1	1	1	1	
DY103-016	MgC08+2	4841	4	1			1	1			1
DY103-021	MgC09+1	4840	7		1				1	1	1
DY103-023	MgC09+1	4844	7			1					1
TOTAL REPLICATES			8	5	5	6	6	6	5	5	6
Total cores			38	5	5	6	6	6	5	5	6

Macrofauna: Macrofauna samples were the priority for the Megacorer deployments so a minimum of four large tubes per deployment were allocated. The supernatant fluid was siphoned through a 250 µm sieve and then transferred into a bottle with the 0-1 cm sediment layer (syringes were used to extract the small volume of remaining water). Slicing rings were used to measure the following horizons: 0.0 – 1.0 cm (if the top layer was not flat, the lower part of a slope was used to define the 0-1 cm layer), 1.0 – 3.0 cm, 3.0 – 5.0 cm, 5.0 – 10.0 cm. Each layer was cut with a slicing plate, which was then rinsed (the upper side on the current layer and the downside side used as the top side for the next slice). The top three layers were transferred into the bottle using a funnel. Rings, funnels and knives were rinsed into the appropriate bottle with filtered seawater. The 0-1, 1-3 and 3-5 cm horizons were put in 500 ml UN bottles. 1500 ml UN bottles were used for the 5-10 cm layers. Each bottle was labelled on the cap and one side and a paper label was placed inside the bottle. Samples were preserved in 4% formaldehyde (½ 8% formaldehyde with borax (20 g l-1) ½ sediment/filtered seawater). If the sample filled more than half the volume of a bottle, the overlying water was passed through a 250 µm mesh sieve and the material washed back into the bottle to ensure the correct formaldehyde concentration.

Metazoan meiofauna: A small core was used. Before processing and between slices the slicing equipment was washed with filtered seawater. The top five cm of sediment and all sieved supernatant fluid were retained in 500 ml UN plastic bottles and preserved in 4% formaldehyde (½ 8% formaldehyde with borax (20 g l-1), ½ sediment/filtered seawater).

Microplastics: As soon as the sample was removed from the Megacorer, the large core allocated for microplastics analysis was covered with ashed aluminium foil or a foil-covered bung to avoid plastic contamination. Before processing and between slices, the slicing equipment was washed with Milli-Q. The supernatant fluid was siphoned through a 250 µm sieve and added to the top slice. Two 1 cm slices were retained: the 0-1 cm and the 10-11 cm (as a blank/control). Sediment in contact with the core tube was removed. Each slice was placed in a muffled glass jar, covered with ashed foil, and a screw-top lid. Samples were stored at room temperature.

eDNA: One large core was used for eDNA. All slicing equipment was sterilised in bleach prior to sample processing and washed with Milli-Q between each slice. Nitrile gloves were worn at all stages. The supernatant fluid was discarded and the following horizons were sliced: 0.0-1.0 cm, 1.0-2.0 cm, 5.0-6.0, 10.0 -11.0, 15.0-16.0 and 20.0-21.0 cm. Samples were placed in Whirlpack bags (stored at -80 °C). In all cases sediment near the edge of the core was discarded. Slicing plates had been bleach-washed prior to each slice. See additional detail in the " Molecular Ecology" section of this report.

Biogeochemistry: A large core was used for biogeochemistry. Four sections were taken at 0.5 cm horizons to 2 cm. All slicing equipment was rinsed in MilliQ water. Sediment in contact with the core tube was removed and the remaining material stored in muffled foil (preserving as much as possible the integrity of the slice) held inside labelled petri dishes, placed inside a single labelled bag per sample

and frozen at -80 °C. Nitrile gloves were worn at all stages. Where possible, phytodetritus samples were gently removed using a palette knife and stored similarly.

Phospholipids and fatty acids (PLFA): Sediments for PLFA were taken from a large core. Sediments were processed and stored in an identical fashion to the biogeochemistry cores, but sliced at different intervals. Cores were initially sliced at 0-1cm only (3 replicates), then at 0-1cm and 1-2cm (1 replicate), and finally at horizon intervals to match the eDNA cores (2 replicates).

Marine fungi. Supernatant fluid and the sediments removed from the edge of the 0-1cm horizon from the PLFA and/or biogeochemistry cores were collected, each in a 50 mL Falcon tube, and frozen at -20 °C. This material was provided to MBA scientists for marine fungi culturing / sequencing.

Dry bulk density. Supernatant fluid was removed. All slicing equipment was washed in filtered seawater. A known volume of sediment (15 mL) was measured from each slice (1 cm horizons to 5 cm) in a large-bore syringe with the tip cut off, and placed in a plastic jar lined with foil, and a screw top lid used to seal the jar. Samples were stored in the chill room.

Particle size analysis. Following removal of material from a core for dry bulk density, the remaining material from each slice was combined (0-5 cm) in a sealed plastic bag and stored in the chill room.

Labelling: All samples were labelled with Cruise ID (DY103), Station number, Date the Megacorer reached the seabed, core ID (for macrofauna only to identify the horizons from the same core tube), sediment horizon, analysis type and preservation method. The outside of every container was labelled (top and side if possible) and for macrofaunal / meiofauna, a paper label was placed inside the container.

Sample processing equipment: Megacorer equipment for a team of two persons processing a core comprised: a large, tall, bucket, in which a plunger (small or large depending on sample type) was placed to process the core; nitrile gloves (eDNA, microplastics, biogeochemistry, PLFA); a tube, a syringe, and/or a pipette, to extract the overlying water into a 250 μm sieve; slicing rings (small or large depending on sample) marked at 0.5, 1.0, 2.0, 5.0 cm; slicing plates; a funnel to transfer the sediment to the UN certified bottles (500 mL, 1500 mL); a knife or a spatula to slice the sediment horizon directly inside the bottle; at least two wash bottles filled with filtered seawater (meio- and macrofauna), and extra bottles filled with Milli-Q (eDNA, microplastics, biogeochemistry, PLFA); tweezers for extracting opportunistic specimens; three 5 L canisters filled with filtered seawater to re-fill the squeezy bottles; ethanol/waterproof pens to write on the paper labels.

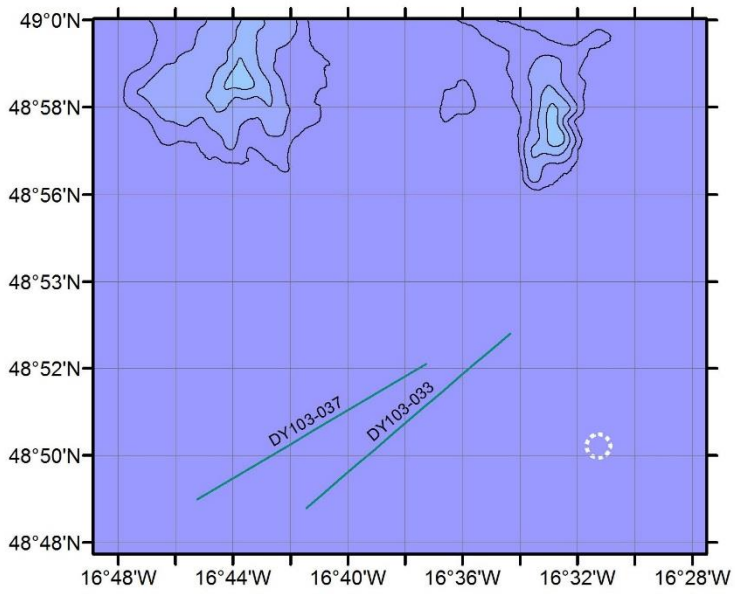
Summary of Megacorer sampling protocols, including number of cores collected for each purpose

	Macro-fauna	Metazoan meiofauna	Micro-plastics	Biogeo-chemistry	eDNA	PLFA	Particle size	Dry bulk density
Tube size	Large	Large	Large	Large	Large	Large	Small	Small
Preservative	4% bF	4% bF	None	None	RNAlater	None	None	None
Storage	Room temp.	Room temp.	Room temp.	Frozen at -80 C	Frozen at -80 C	Frozen at -80 C	Refriger ated	Refriger ated
Supernatant fluid	250 µm sieve, added to first layer	250 µm sieve, added to first layer	250 µm sieve, added to first layer	Kept for fungi analysis		Kept for fungi analysis		
Core edge				Kept for fungi analysis		Kept for fungi analysis		
0.0-0.5				6				
0.5-1.0				6				
1.0-1.5				6				
1.5-2.0				6				
2-3								5
3-4								5
4-5								5
5-6					6	2		
6-10								
10-11			5		6	2		
11-15								
15-16					6	2		
16-20								
20-21					6	2		

*Note: 24th core sliced 0-1, 1-4, 4-5cm; 4% bF, Borax buffered formaldehyde

Additional opportunistic specimen collection: a vermiform organism was retained from a non-macrofauna core at station DY103-014 (EtOH small vial). Some very small encrusting organisms were retained from the recovered *Bathysnap* frame (JC165-068) (EtOH small vial).

Otter trawl. The NMF-supplied OTSB14 (semi-balloon otter trawl, 14 m headrope) was rigged and fished in conventional fashion. Note, as per DY077 and JC165, this net appears to be a slight variant on the original pattern, having a different codend closure (no sewn in rings) and lazy decky attachment (strangling rings, not sewn in netting strop). No particular problems were encountered during launch, fishing, or recovery phases of the operations. Two trawls were successfully completed (DY103-033 and 037).



Approximate seabed tracks fished by the two otter trawls.

Trawl sample processing:

On recovery to deck the trawl catches were spilled into boxes. The catch was transferred for washing through the sieving table and sorting to broad taxonomic group. The net was examined in detail and the specimens found were added to the catch. In both trawls the catch was a fairly typical haul of megabenthic invertebrates and fishes from PAP. The holothurians *Psychropotes* sp. and *Oneirophanta* sp., actiniarians, and asteroids (*Hyphalaster* sp.) were the most abundant of the larger organisms. The specimens were preserved, and the catch was stored in containers labelled with the station number and listed below.

Thick gloves were used during the washing to avoid injury with glass and clinker. Specimens were washed and preserved as soon as possible to ensure the best quality for future identification in the lab. Clinker was put aside and later weighed and photographed for the records. Litter and artefacts found in the trawl were classified, weighed and photographed.

All crustaceans, ophiuroids, and asteroids were preserved in 100 % ethanol. Other taxa were preserved in 4% borax-buffered formaldehyde. Whenever possible, specimens were preserved by phylum but at the end of the trawl, mixed fauna were preserved together. All samples were labelled with Cruise ID (DY103), Station number, Date of the trawl, trawl used (OTSB14), taxon, and type of preservative. The outside of every container was labelled (top and side if possible) and a paper label was placed inside the container.

Treatment of select specimens:

Selected specimens were numbered and logged for temporary removal for immediate use for stable isotope analysis, genetic sequencing, and specimen photography. In general, these were intact whole specimens. The following information was logged: morphotype identification (preliminary), specimen number, measured dimension and measurement in mm (and secondary measurements, where necessary), wet weight in g, to whom the specimen was issued, associations between specimens (e.g. host specimen number for parasites), preservation method, photo numbers (where applicable). Each was labelled and placed individually in a sealed plastic bag.

Stable isotope analysis. 182 Specimens were removed from the trawl catches for stable isotope analysis by Rachel Jeffreys at Liverpool University. They included replicates of size classes for *Psychropotes* (S/M/L/XL), *Molpadiodemas villosus* (S/M/L/XL), *Oneirophanta* (S/M/L), *Hyphalaster* (S/M/L),

Amperima (S/L); and *Iosactis* and *Ellipinion* in a single size class each. Each specimen was placed in a separate sealed bag and frozen whole at -80 °C. Each specimen was weighed using a motion-compensated balance and measured: body length for holothurians, R and r for the asteroids. Some specimens of each morphotype were photographed. Specimens will be returned to the *Discovery Collections* after subsamples have been taken to confirm identifications made at sea.

Genetic sequencing. 32 Specimens were removed from the trawl catches for genetic sequencing. This included holothurians *Amperima*, *Deima*, *Ellipinion*, *Molpadiodemas*, and *Oneirophanta*. Tissue was removed from each holothurian for sequencing. Specimens of *Oneirophanta* with parasitic gastropods had the gastropods removed from the holothurian (with holothurian tissue surrounding the gastropod proboscis) and stored separately. Holothurians were then returned to the trawl catch group (in individual bags with numbers), to be fixed / preserved. See molecular ecology section for further detail.

Specimen photography. Photographs (and measurements of morphological dimensions and weight for most specimens) were taken before preservation for 110 specimens from most morphotypes across the two trawls (Figure XX1).

Examples of specimens photographed prior to preservation: Annelid (top left), holothurian Oneirophanta (centre left), decapod Crataspis (bottom left), anemone Actinauge on clinker (right).

Samples retained from trawls DY103-033 and DY103-037

Station	Morphotype	Container	Preservation
DY103-033	Pycnogonids	1500 ml UN	ETOH
DY103-033	Decapoda red shrimp	1500 ml UN	ETOH
DY103-033	Stereomastis	5 L white bucket	ETOH
DY103-033	Hyphalaster	5 L white bucket	ETOH
DY103-033	Asteroidea	1500 ml UN	ETOH
DY103-033	Cirripedia	500 ml UN	ETOH
DY103-033	Pycnogonida	1500 ml UN	ETOH
DY103-033	Brisingids	1500 ml UN	ETOH
DY103-033	Ophiuroids	500 ml UN	ETOH
DY103-033	Umbellula	500 ml UN	ETOH
DY103-033	Residue	1500 ml UN	ETOH
DY103-033	Amphipod	Falcon Tube	ETOH
DY103-033	Squat lobsters	5 L white bucket	ETOH
DY103-033	Decapoda red shrimp	1500 ml UN	ETOH
DY103-033	Decapoda red shrimp	1500 ml UN	ETOH
DY103-033	Annelida	500 ml UN	4% formaldehyde
DY103-033	Psychropotes	Blue barrel	4% formaldehyde
DY103-033	Psychropotes	Blue barrel	4% formaldehyde
DY103-033	Psychropotes	Blue barrel	4% formaldehyde
DY103-033	Psychropotes	Blue barrel	4% formaldehyde
DY103-033	Fishes	Blue barrel	4% formaldehyde
DY103-033	Molpadiodemas	Blue barrel	4% formaldehyde
DY103-033	Deima	5 L white bucket	4% formaldehyde
DY103-033	Paroriza	Large white bucket	4% formaldehyde
DY103-033	Kadosactis	500 ml UN	4% formaldehyde
DY103-033	Zoanthids	1500 ml UN	4% formaldehyde
DY103-033	Benthodytes	Large White Bucket	4% formaldehyde
DY103-033	Oneirophanta	Large White Bucket	4% formaldehyde
DY103-033	Anemones	10 L white bucket	4% formaldehyde
DY103-033	Anemones on material	10 L white bucket	4% formaldehyde
DY103-033	Corals	500 ml UN	4% formaldehyde
DY103-033	Porifera	500 ml UN	4% formaldehyde
DY103-033	Shells	500 ml UN	4% formaldehyde
DY103-033	Fishes	500 ml UN	4% formaldehyde
DY103-033	Jellyfish	small bucket	4% formaldehyde
DY103-033	Holothurians	1500 ml UN	4% formaldehyde
DY103-033	Misc	500 ml UN	4% formaldehyde
DY103-033	Misc holo	500 ml UN	4% formaldehyde
DY103-033	Small holo	10 L white bucket	4% formaldehyde
DY103-033	Scaphopod shells	500 ml UN	4% formaldehyde
DY103-033	Worm tubes	1500 ml UN	4% formaldehyde
DY103-033	Worm tubes	1500 ml UN	4% formaldehyde
DY103-033	Vermes	500 ml UN	4% formaldehyde
DY103-037	Pycnogonids	1500 ml UN	ETOH
DY103-037	Asteroidea	10 l white bucket	ETOH
DY103-037	Decapoda red	5 l white bucket	ETOH
DY103-037	Misc crustacea	small bucket	ETOH
DY103-037	Stereomastis	500 ml UN	ETOH
DY103-037	Gastropods & bivalves	1500 ml UN	ETOH
DY103-037	Crinoids, Echinoids and Culeolus	500 ml UN	ETOH
DY103-037	Umbellula	500 ml UN	ETOH
DY103-037	Ophiuroids	1500 ml UN	ETOH
DY103-037	Sponge	1500 ml UN	ETOH
DY103-037	Munidopsis	small bucket	ETOH
DY103-037	Wood	500 ml UN	ETOH
DY103-037	Misc on clinker	small bucket	ETOH
DY103-037	Asteroidea	5 L white bucket	ETOH
DY103-037	Cirripedia	500 ml UN	ETOH

DY103-037	Psychropotes	Blue barrel	4% formaldehyde
DY103-037	Psychropotes	Blue barrel	4% formaldehyde
DY103-037	Psychropotes	Blue barrel	4% formaldehyde
DY103-037	Oneirophanta	large white bucket	4% formaldehyde
DY103-037	Molpadiodemas	Blue barrel	4% formaldehyde
DY103-037	Annelida	500 ml UN	4% formaldehyde
DY103-037	Paroriza (and Kadosactis)	10 l white bucket	4% formaldehyde
DY103-037	Fishes	Blue barrel	4% formaldehyde
DY103-037	Anemones	10 L white bucket	4% formaldehyde
DY103-037	Anemones on clinker	10 L white bucket	4% formaldehyde
DY103-037	Misc	10 l white bucket	4% formaldehyde
DY103-037	Vermes	500 ml UN	4% formaldehyde
DY103-037	Coral	500 ml UN	4% formaldehyde
DY103-037	Zoanthids	500 ml UN	4% formaldehyde
DY103-037	Worm tubes	1500 ml UN	4% formaldehyde
DY103-037	Jellies	small bucket	4% formaldehyde
DY103-037	Mixed echinoderms	1500 ml UN	4% formaldehyde
DY103-037	Pelagic jelly	500 ml UN	4% formaldehyde
DY103-037	Mixed small holo	10 L white bucket	4% formaldehyde
DY103-037	Oneirophanta & Deima	10 L white bucket	4% formaldehyde
DY103-037	Molpadiodemas & Kadosactis	10 l white bucket	4% formaldehyde

Example images of artefacts recovered from the two trawls: (a) can, (b) bottles, (c) macroplastics, (d) instrument device, (e) pottery, (f) clinker.

HyBIS operations

The HyBIS system was used in two modes during the course of the cruise: (a) 'rescue' mode; and (b) seabed photographic survey mode. Rescue mode was employed as stations DY103-008 and DY103-018, respectively attempts to recovery the *Bathysnap* moorings DY077-084 and JC165-068, only the latter being successful. Video was recorded during the water column descent and search phases of these missions as exemplar material of particulates in the water column, and also recorded the occurrence of a specimen of *Bathysaurus* (lizardfish) apparently cruising at 60 m above the seafloor (DY103-008; 07:08 29.VI.19). The four other HyBIS missions were in seafloor survey mode, examining both the PAP Central area (DY103-006, DY103-030, DY103-040) and the PAP Trawl area (DY103-026).

Photographic surveys of the seafloor

HyBIS was used during DY103 for four seabed transect dives conducted at 0.3 knots. Seabed video was captured for a total of 17:29 hours with a total of 11988 still images also recorded. Five of the 11 north to south lines from the AESA fine grid survey at PAP Central were randomly selected for the HyBIS transects. The target vehicle altitude range was 2-4 mab for optimal lighting and resolution of organisms. Trawl scars were observed in all transects.

Still images (JPEG format) were captured with a downward-facing Scorpio camera at 5 second intervals, with an exposure time of 0.01 seconds. The aperture ranged from f/1.8 to f/4.0. Video was also captured with the same camera. The Scorpio camera lens was mounted 53 cm below the altimeter. Lighting of the downward frame was by three downward facing CathX Aphos lights.

The forward-facing oblique PAL video camera (PAL-1) was mounted at 45° from the vertical (lens 10 cm below the altimeter), with two DSPL LED matrix lights used for forward lighting.

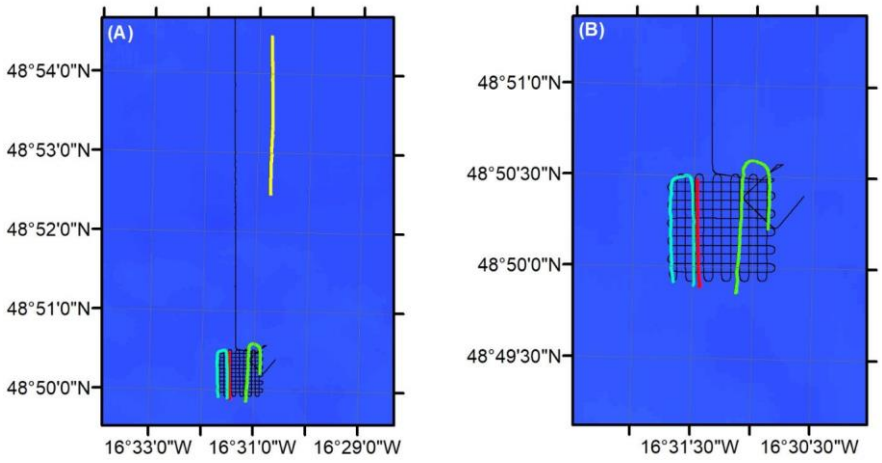
HyBIS Dive Summary

DY103-006 / HY44 (PAP Central area). The transect followed Line 4 of the AESA fine scale grid from south to north (Figure 1A). Total bottom time was 2:25 h. A total of 1430 seabed images and 2:19 h of seafloor video were captured.

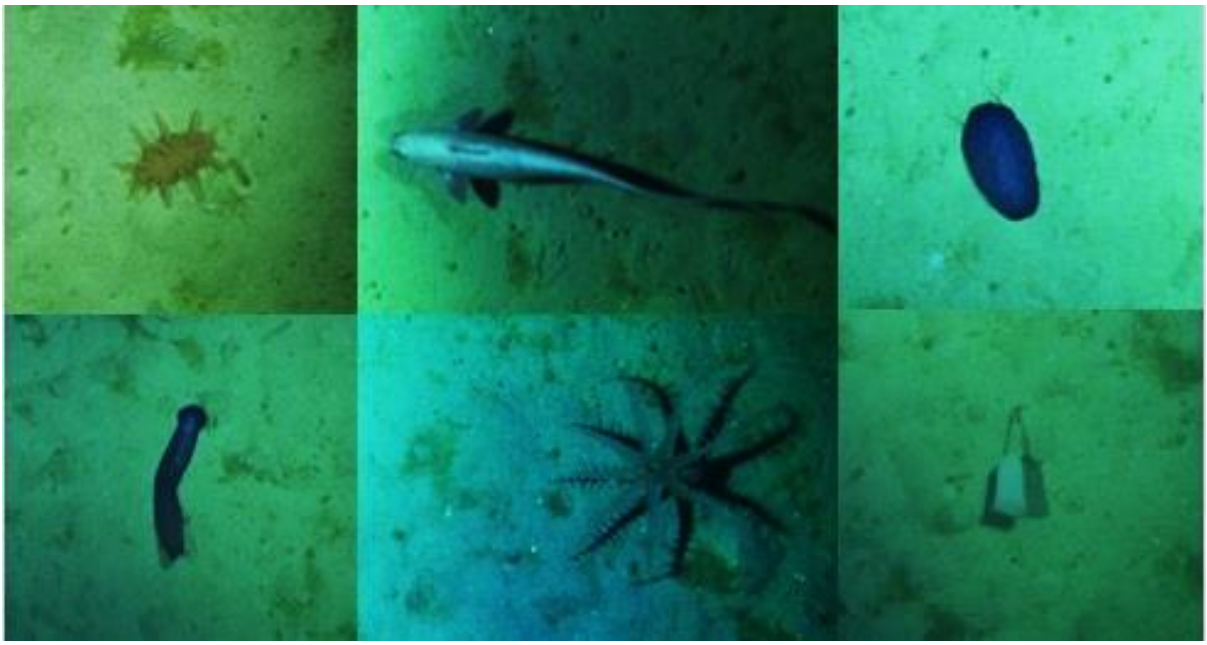
DY103-026 / HY47 (PAP Trawl area). The transect followed a track east of and parallel to the long single AESA transect north of the PAP Central fine grid for approximately 3730 m. Total bottom time was 6:59 h. A total of 3881 seabed images and 6:19 h of seabed video were captured. Note, a second oblique PAL camera (PAL-2) with one DSPL matrix light had been mounted for the *Bathysnap* rescue missions and remained on HyBIS for this dive. Lights for this camera cast a shadow on the right side of the field of view of the downward camera. The PAL-2 camera and associated light were removed for subsequent dives.

DY103-030 / HY48 (PAP Central area). The transect followed Lines 8 & 11 of the AESA fine scale grid (Figure 1A). Total bottom time was 4:57 h. A total of 3054 seabed images and 4:54 h of seabed video were captured.

DY103-040 / HY49 (PAP Central area). The transect followed Lines 1 & 3 of the AESA fine scale grid (Figure 1A). Total bottom time was 4:58 h. A total of 2816 seabed images and 4:35 h of seabed video were captured.



(A) HyBIS seafloor photography tracks conducted in the PAP Central area: DY103-006 / HY-44 (red), DY103-026 / HY-47 (yellow), DY103-030 / HY-48 (green) and DY103-040 / HY-49 (light blue). Autosub6000 photographic survey lines of AESA Project / RRS Discovery cruise 377/8 (black grid). (B) Detail of PAP central area.



Example specimen images from the HyBIS seabed photographic surveys

15. Molecular Ecology

C. R. Young, R. A. Samuel

Genetic samples were collected from the Megacorer, otter trawl, and CTD as outlined below.

Megacorer: All Megacorer samples, unless otherwise noted, were sectioned by the following intervals based on environmental genomics results from previous years: 0-1, 1-2, 5-6, 10-11, 15-16, and 20-21 cm. Spatulas, slicer, and rings were sterilized with 5% bleach and rinsed with MilliQ between cores. A different, sterile, spatula was used for each slice. Slicer and ring were rinsed in Milli-Q water between slices, and slice margins were avoided. Sediment samples were transferred to whirlpacks and frozen at -80 °C.

Megacorer samples taken

Station DY103-	Date	Gear	Bag Number	Additional information
003	24/06/2019	MgC-001	1	no obvious cracks, no 20-21 section
004	25/06/2019	MgC-002	1	full core
007	29/06/2019	MgC-003	1	full core
012	29/06/2019	MgC-004	1	full core
014	30/06/2019	MgC-005	1	full core
016	30/06/2019	MgC-006	1	full core

CTD: Water samples collected by CTD rosette were filtered through sterivex 0.22 µm cartridge filters (5 L, unless otherwise noted) and then stored at -80 °C. Collection bottles were bleach sterilized and rinsed with MilliQ water. Collection bottles were subsequently rinsed 3 times with sample water. Samples taken and the corresponding depths are summarized in the Table below. In addition, negative controls were filtered from the MilliQ water supply (1 L) and processed in the same manner. Pump tubing was bleach sterilized, flushed with MilliQ between sampling, and subsequently flushed with sample water before filtering commenced.

Additional higher volume (15 – 30 L) water samples were collected from the oxygen minimum (OM; 850 m) and processed on board, using a modified protocol for the AllPrep DNA extraction kit. AllPrep kit was selected for onboard DNA extractions, due to the simplicity of the protocol and portability of the necessary equipment. β-mercaptoethanol (β-ME) was omitted from the initial lysis step, due to the additional safety measures required when handling. The omission of β-ME should not adversely affect the extraction of DNA as β-ME is used to denature ribonucleases and is therefore only necessary when exacting RNA alongside DNA using the AllPrep Kit. A low power (6000 rpm / 2000 g) mini centrifuge was used due to its portability and centrifuge times were increased to compensate for the reduced centrifugal force.

Modified AllPrep protocol as follows:

- 700 µl RLT buffer, beads and Sterivex filter added to bead beater tube. Bead beat for 2 minutes at highest setting (MO Bio Vortex-Genie 2 and MO Bio Vortex Adapter).
- Use sterile tweezers to remove filters.
- Spin tube, to pellet beads at the bottom of the tube.
- Transfer lysate to AllPrep DNA spin column and centrifuge for 2 minutes at 2000 g. Discard flow through.
- Add 500 µl of Buffer AW1 to the spin column and centrifuge for 1 minute at 2000 g. Discard flow through.
- Add 500 µl Buffer AW2 to the spin column and centrifuge for 4 minutes at 2000 g.
- Carefully remove the spin column from the collection tube and place the spin column in a new 1.5 ml collection tube.
- Add 50 µl Buffer EB directly to the spin column membrane and incubate at room temperature for 1 minute. Centrifuge for 2 minutes at 2000 g to elute the DNA.
- Repeat with eluate.

The first elution of sample DY103-020-N13/14 (volume: 30 L) yielded lower DNA concentrations than sample DY103-002-N16 (volume: 15 L) despite having double the volume of water filtered. Visual inspection of AllPrep DNA membrane revealed brown discoloration of membrane. Therefore, six consecutive elutions, with fresh EB Buffer were completed to extract any remaining DNA on the membrane, with the 6^{th} elution containing no DNA yield. The five elutions were then combined and concentrated using a modified protocol for the Zymo DNA Clean and Concentrate Kit. However, this modified protocol was only partially successful as DNA quality was reduced (see Table below). It is therefore recommended that future cruises would benefit from the addition of a centrifuge capable of 10,000 – 16,000 g, as specified in the original Zymo Clean and Concentrate protocol.

Modified Zymo Clean and Concentrate protocol as follows:

- Add 2 volumes of DNA Binding Buffer to each volume of DNA sample. Vortex to mix.
- Transfer mixture to Zymo-Spin Column. Centrifuge for 2 minutes at 2000 g. Discard flow through.
- Add 200 µl DNA Wash Buffer to column. Centrifuge for 2 minutes at 2000 g. Discard flow through and repeat the wash step.
- Add ≥ 6 µl DNA Elution Buffer (heated to 65 ºC) directly to the column matrix and incubate at room temperature for 1 minute. Transfer the column to 1.5 µl collection tube and centrifuge for 2 minutes to elute the DNA.

The modified AllPrep protocol was also used, unsuccessfully, to extract DNA from holothurian gut contents. The DNA yield and quality were much lower than samples extracted using the Qiagen PowerSoil DNA extraction kit in previous years. DNA concentration and purity were quantified with a NanoDrop NanoVue Plus. See Table below for yield and purity information.

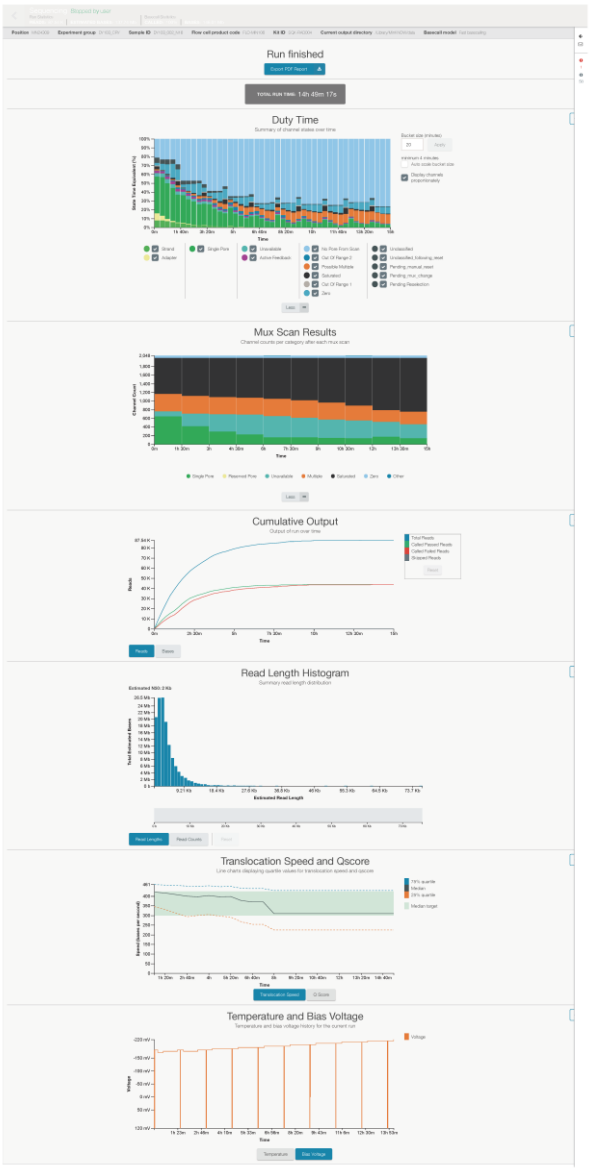
DNA extracted from sample DY103-002-N16 (pre clean and concentrate) was sequenced on board for 15 hours using the MINion and Rapid Sequencing kit and protocol (SQK-RAD004). See Figure for preliminary MinKnow output.

DNA extractions

SampleID	Depth (m)	Nanodrop DNA Concentration (ng/µl)	260/280	260/230	COMMENTS
DY103-002-N16	850	32.5-56.5	1.12-1.994	0.260-0.406	Range from 2 nanodrop readings
DY103-002-N16	850	13.1	-3.527	-0.372	Post clean and concentrate
DY103-020-N13/14	850	13.43 (SE±1.17)	2.2 (SE±0.04)	0.15 (SE±0.01)	1st Elution - Average from 3 nanodrop readings
DY103-020-N13/14	850	27.5-29	1.839–1.889	0.372–0.406	2nd Elution - Range from 2 nanodrop readings
DY103-S20-N13/14	850	21.0 – 31.5	2.079–2.045	0.656–0.453	3rd Elution - Range from 2 nanodrop readings
DY103-020-N13/14	850	28.5	1.833	0.393	4th Elution
DY103-020-N13/14	850	15.3	2.234	1.177	5th Elution
DY103-020-N13/14	850	84.0 – 91.5	2.667–2.614	-29.5 – -13.1	Combined and concentrated elution's 1-5
Holothuriun gut	4837-4840	6.2 – 3.6	1.519 – 1.440	0.028 – 0.022	Range from 2 nanodrop readings

CTD Niskin samples taken.

Station	date	Cast	sample number	additional information
002	24/06/2019	CTD-002	N13	850m (30L)
015	30/06/2019	CTD-005	N2, N3, N5, N,6, N10, N15	4830 (4.75L). 4800 (4.75L), 4750 (4.75L), 4000 (5L), 2000 (4.75L), 1000 (14L)
020	01/07/2019	CTD-007	N3, N4, N5, N6, N8, N13/14	4830m (5L), 4800m (5L), 4750m (5L), 4000m (5L), 2000m (5L), 850m (N13, N14)
025	02/07/2019	CTD-008	N2, N3, N4, N7, N11, N17	4830m (5L), 4800m (5L), 4750m (5L), 4000m (5L), 2000m (5L), 850m (5L)
036	05/07/2019	CTD-012	N2, N3, N4, N5, N11, N15	4830m (5L), 4800m (5L), 4750m (5L), 4000m (5L), 2000m (5L), 850m (5L)



MinKnow Software output for sample DY103-002-N16

Trawl: Tissue samples were taken from taxa collected from the trawl, and samples were either preserved in EtOH, RNALater, or frozen at -80 °C (see Table below). All samples taken or attempted were measured and weighed before dissection, given a unique identifier, and subsequently stored with other bulk-preserved samples (summarized in Table below). Samples taken during trawls DY103-033 and DY103-037 included five holothurians and their gut microbiomes: *Oneirophanta*, *Molpadiodemas*, *Ellipinion*, and *Deima* (n = 2). Several additional samples were attempted but were of poor quality and were not taken. Parasitic gastropods of the family Eulimidae were targeted, and nine individuals were collected (with corresponding host tissue), all associated with *Oneirophanta* hosts. Gastropods were preserved in EtOH and host tissue was either preserved on EtOH, RNALater, or frozen at -80 °C.

Trawl samples taken

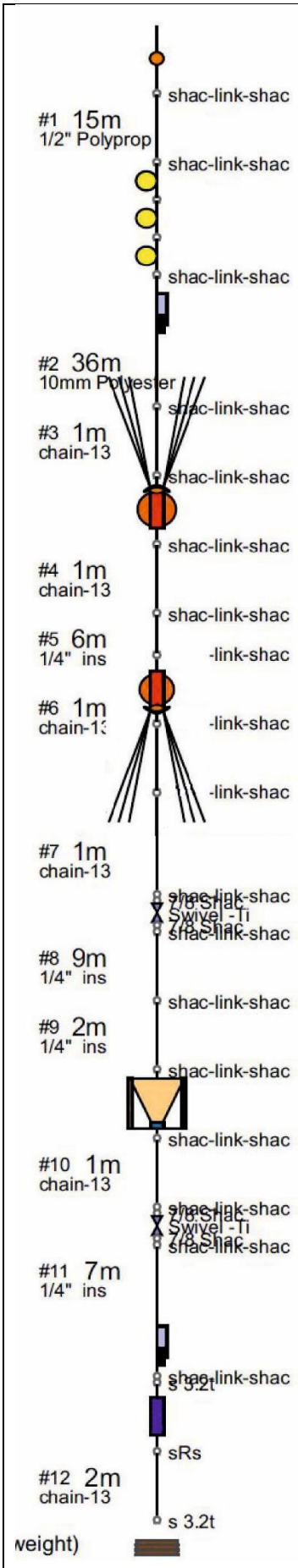
Station	Sample number	Preservation	Storage	Organism/ sample	Additional Information
033	019	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_018 (Oneirophanta); indiivdual dissected out in single falcon tube (host tissue attached)
033	020	EtOH	falcon tube	holothurian	DY103_033_020 (Oneirophanta); tissue feet, body wall
033	021	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_020 (Oneirophanta); no host tissue attached, probiscus dessicated before preservation
033	136	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_135 (Oneirophanta); indiivdual dissected out in single falcon tube (host tissue attached)
033	138	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_137 (Oneirophanta); indiivdual dissected out in single falcon tube (host tissue attached)
033	144	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_143 (Oneirophanta); indiivdual dissected out in single falcon tube (host tissue attached); host in bad shape, but eulimid intact
037	208	-80C, RNALater	box 1	holothurian, microbiome	Oneirophanta host (-80C), Anterior gut (-80C, RNALater), Posterior gut (-80C, RNALater)
037	209	NS			Molpadiodemas: gut busted, didn't take sample
037	211	-80C, RNALater	box 1	holothurian, microbiome	Molpadiodemas: host (-80C), Mid gut (-80C, RNALater), gut busted in anterior portion. Took mid gut from intact section
037	212	-80C, RNALater	box 1	holothurian, microbiome	Ellipinion: host (-80C, RNALater), nondescript gut location (-80C, RNALater), gut busted. Took gut sample from nondescript section
037	213	NS			Amporima: gut busted, didn't take sample
037	231	NS			Molpadiodemas: gut busted, didn't take sample
037	258	-80C	box 1	holothurian	DY103_033_258 (Oneirophanta); body wall
037	259	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_258 (Oneirophanta); indiivdual dissected out in single falcon tube (host tissue attached)
037	260	-80C	box 1	holothurian	DY103_033_260 (Oneirophanta); body wall
037	261	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_260 (Oneirophanta); indiivdual dissected out in single falcon tube (host tissue attached)
037	262	-80C	box 1	holothurian	DY103_033_262 (Oneirophanta); body wall
037	263	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_262(Oneirophanta); indiivdual dissected out in single falcon tube (host tissue attached)
037	264	-80C	box 1	holothurian	DY103_033_264 (Oneirophanta); body wall
037	265	EtOH	falcon tube	gastropod	Eulimid associated with DY103_033_264 (Oneirophanta); indiivdual dissected out in single falcon tube (host tissue attached)
037	268	-80C, RNALater	box 1	holothurian, microbiome	Deima host (-80C), Anterior gut (-80C, RNALater), Posterior gut (-80C, RNALater) very good sample
037	269	-80C, RNALater	box 1	holothurian, microbiome	Deima host (-80C), Anterior gut (-80C, RNALater), Posterior gut (-80C, RNALater) very good sample

16. Whittard Canyon mooring

Brian Bett, Corinne Pebody

As the final action of the cruise, a current meter and sediment trap mooring was deployed, as station DY103-041, in Whittard Canyon, in connection with the NERC Climate Linked Atlantic Sector Science (CLASS) project's sustained observations and marine protected area studies in that region. Recovery of this mooring is expected to take place during either the next PAP-SO cruise (2020) or a dedicated CLASS Whittard Canyon cruise (2020). The NOC lead for the mooring is Mike Clare (Marine Geoscience), and for CLASS activities in Whittard Canyon, Veerle Huvenne (Marine Geoscience).

Prior to deploying the mooring, two short lines of multibeam echo sounding (EM122) were undertaken to confirm the intended location (48° 37.573´ N 010° 00.234´ W). The mooring was streamed aft of the ship and towed to the nominal location, being let go within a few metres of the nominal position. The mooring descended rapidly to the seafloor (c. 140 m $min.^{-1}$) and its position was then triangulated by acoustic ranging from three locations on a 500 m radius from the nominal position. The resultant estimated position of the mooring at the seabed was 48° 37.569´ N 010° 00.224´ W was order of 15 m from the target site.



Triangulated position (via Olex system):

48° 37.569´ N 010° 00.224´ W

(Depth 1577 m, based on EM122 using last sound velocity profile from PAP area)

The mooring comprised:

a pick-up float,

15 m polyprop,

three 17” glass spheres,

a microcat (SBE37),

36 m polyprop,

1 m chain,

75 kHz upward-looking ADCP,

1 m chain,

6 m wire,

600 kHz downward-looking ADCP,

1 m chain,

1 m chain,

9 m wire,

2 m wire,

McLane sediment trap; 21 bottles, each open for 21 days (first bottle opens 12:00 UTC 09/07/19, last bottle closes 12:00 UTC 22/09/20), standard trap preservative (PAP deep water with: 5 g L^{-1} salt, NaCl; 0.25 g L^{-1} Borax; 2% solution of formaldehyde final concentration)

1 m chain,

7 m wire,

a microcat (SBE37),

acoustic release (s/n 1468, **ARM 09B9, REL 0955**),

2 m chain,

1000 kg anchor weight.

16. Social media

It is important to make our research at the PAP-SO open and accessible, and to show our collaborators and grant committees where their funding is being spent. This was partially achieved through social media updates via our blog posts (https://papobservatory.wordpress.com/), Tweets (@PAP_observatory) and instagram posts (pap_observatory) which took place throughout the cruise. Our most popular tweet was the time-lapse video of the PAP1 buoy and sensor frame recovery. Thank you so much to those who blogged, they are being read! (Table 1).

PAP2020 Blogging

Homeward bound 	Sue Hartman
Microbial genomics at sea: developing new approaches for ecological monitoring 	Rob Young
Long-term ocean observations: an international challenge 	Andy Gates
A beginners' guide to work aboard a research vessel 	Toby Mortimer

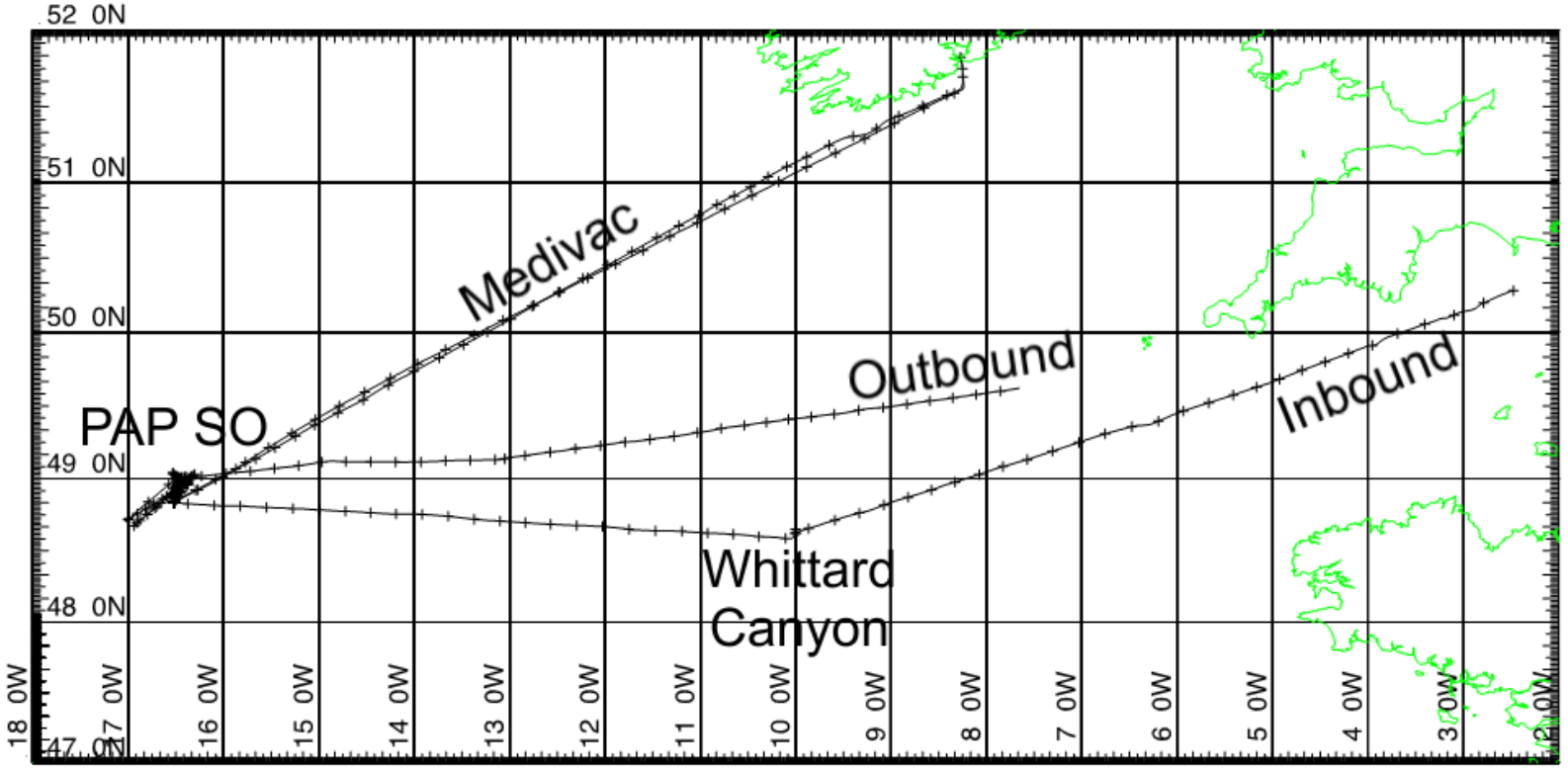
ICOS inter-comparison on DY103 	Hannelore
Eclectic cruising at the PAP-SO 	Corinne Pebody
Sampling for marine fungi at the PAP 	Kim Bird
Our eye in the abyss 	Phil Smith
Preparation, preparation, preparation 	Helen Oldridge
Maintaining the CTD 	Tim Powell
From shallow to deep 	Vanessa Fernandez

Coddicles shipboard chronicles 	Cordelia Roberts
DY103 	Sue Hartman

18. Acknowledgements

We thank all the crew of the RRS *Discovery* and the NMF technicians who kept us working to deliver our sometimes rather challenging science programme. The catering was exceptional this year and we were well looked after. This cruise was a contribution to the Climate Linked Atlantic Section Science (CLASS) project supported by the UK Natural Environment Research Council (grant number NE/R015953/1). We would also like to thank the Partnership for Observation of the Global Ocean (POGO) for funding and facilitating the participation of POGO Shipboard Training Fellow Vanessa Fernández Rodríguez. Many thanks to Ed Mawji and Pete Brown who helped us set up the chemistry labs on-board.

19. General cruise track chart



General track chart for RRS *Discovery* cruise 103

20. Station list

Metadata notes:
Station, Unique deployment identifier "DY", RRS *Discovery* IV, "103" consecutive cruise number, "-xxx" consecutive deployment number during cruise. Note that recoveries of moored systems retain the number of the initial deployment; Gear, Abbreviated name of deployed equipment; "Start", Date, DD/MM/YY format date beginning of sample or data acquisition; Time, HH:MM format UTC time beginning of sample or data acquisition; Latitude, dd, WGS84 latitude degrees beginning of sample or data acquisition; mm.mmm N, WGS84 latitude minutes beginning of sample or data acquisition; Longitude, ddd, WGS84 longitude degrees beginning of sample or data acquisition; mm.mmm W, WGS84 longitude minutes beginning of sample or data acquisition; Depth (Z m), Minimum water depth of sample or data acquisition; "End", Date, DD/MM/YY format date end of sample or data acquisition; Time, HH:MM format UTC time end of sample or data acquisition; Latitude, dd, WGS84 latitude degrees end of sample or data acquisition; mm.mmm N, WGS84 latitude minutes end of sample or data acquisition; Longitude, ddd, WGS84 longitude degrees end of sample or data acquisition; mm.mmm W, WGS84 longitude minutes end of sample or data acquisition; Depth (Z m), Maximum water depth of sample or data acquisition; Sounding (S m), Typical water depth of seafloor during sample or data acquisition; Comment 1, General comment on sample or data acquisition; Comment 2, General comment on sample or data acquisition - only applied when "End" metadata are given.

Gear notes:

ATRAPx	Amphipod trap, "DEMAR" type, four near-bottom, double parlour traps, plus barrel 'letter box' trap at c. 15 mab; times given are estimated arrivals / departures from seabed
BSNAP	"Bathysnap", time-lapse camera system [new Kongsberg camera and flash, Oceanlab Oceanback]; plus larval traps and colonisation substrates; times given are estimated arrivals / departures from seabed
CTD	Conductivity, temperature, depth etc. instrument, time and position refer to start and end of cast, depths refer to min. and max. of profile
MgCxx+y	Bowers & Connelly Megacorer fitted with xx 10 cm tubes and y 5 cm tubes, time, position, and depth refer to point of bottom contact by the gear (and are based on gear-mounted USBL beacon data)
OTSB14a	Semi-balloon otter trawl, 14 m head rope, (slight variant on standard pattern?), times, positions, and depths are estimates of trawl at the seabed
HyBIS	Hydraulic Benthic Interactive Sampler, For 'rescue' missions times refer to descent and near-seafloor operations, positions refer to general extent. For seafloor photography missions, times refer to seabed photography phase, positions refer to general extent (refer to charts for detail)
PAP1	ODAS buoy and instrument frame
PAP3	Sediment trap array; plus larval traps and colonisation substrates
WP2	Zooplankton net
WCM	Whittard Canyon mooring: 2 x ADCP + 1 x sediment trap

Station	Gear	Date	Time	Position (N W)		Z(m)	S(m)	Comments
DY077-084	BSNAP	25/04/17	16:03	49 00.387	016 23.866	4846	4846	Remains lost
JC165-013	PAP3	25/05/18	09:12	49 00.240	016 27.816	4844	4844	Deployed position in error
		30/06/19	08:54	49 01.326	016 29.823	4844		Recovery position corrected
JC165-058	PAP1	04/06/18	09:07	48 57.936	016 22.143	4836	4844	All sensors recorded
		25/06/19	09:24	49 00.240	016 27.816	4844		Buoy fouled with algae and barnacles
JC165-068	BSNAP	07/06/18	07:56	49 00.300	016 27.984	4842	4842	Recovered by HyBIS DY103-018
		01/07/19	05:00	49 00.256	016 28.004	4842		No photos recorded
DY103-001	CTD	23/06/19	14:15	49 08.272	013 03.024	0	2156	Cast 1, test cast, plus 2 releases
		23/06/19	15:21	49 08.270	013 03.020	1000		12 Bottles all OK
DY103-002	CTD	24/06/19	05:27	49 00.005	016 30.025	0	4845	Cast 2, release test, PAP3 water
		24/06/19	09:26	49 00.005	016 30.025	4836		sbe 317 imp 66262, 9475, 9469
DY103-003	MgC08+2	24/06/19	20:34	48 50.166	016 31.344	4845	4845	7/10 Fair cores
DY103-004	MgC08+2	25/06/19	01:08	48 50.100	016 30.948	4846	4846	10/10 Good cores
DY103-005	CTD	25/06/19	14:59	48 58.308	016 22.354	0	4845	Cast 3, PAP1 pre-dep. instrument cal.
		25/06/19	16:25	48 58.306	016 22.363	201		seaguard sn 1640, flntsub s/n 3050, star Oddis s6782, s7562, s7564, s7565, s7566
DY103-006	HyBIS	25/06/19	20:16	48 49.894	016 31.439	4845	4845	PAP Central line 4 (Hy44)
		25/06/19	22:41	48 50.487	016 31.468	4845		1430 images; 02:19 video (x2)
DY103-007	MgC08+2	28/06/19	23:01	48 50.286	016 30.936	4842	4842	10/10 Good cores
DY103-008	HyBIS	29/06/19	03:31	49 00.495	016 23.866	0	4846	BSNAP DY077-084 rescue attempt
		29/06/19	08:01	49 00.279	016 23.866	4840		No targets detected
DY103-009	PAP3	29/06/19	10:40	48 58.050	016 27.624	4842	4842	Trap 84 deployment
DY103-010	ATRAPx	29/06/19	15:25	48 56.606	016 29.084	4846	4846	Good catches
		01/07/19	10:07	48 56.606	016 29.084	4846		Soak time = 41.4 hours
DY103-011	CTD	29/06/19	16:17	48 56.570	016 29.170	0	4844	Cast 4, PAP1 post-dep. instrument cal.
		29/06/19	17:17	48 56.569	016 29.174	103		seaguard sn 2075, flntsub s/n 269, ODO 16503 and 10315
DY103-012	MgC08+2	29/06/19	20:04	48 50.184	016 31.152	4845	4845	10/10 Good cores
DY103-013	WP2	29/06/19	22:38	48 50.280	016 30.935	0	4844	Predominately *Themisto*
		29/06/19	23:35	48 50.281	016 30.935	200		?Slow hauling speed
DY103-014	MgC08+2	30/06/19	01:49	48 50.196	016 31.038	4844	4844	10/10 Good cores
DY103-015	CTD	30/06/19	13:00	49 02.294	016 31.811	0	4841	Cast 5
		30/06/19	17:00	49 02.300	016 31.810	4821		No leakers but issue with Niskin 19
DY103-016	MgC08+2	30/06/19	20:35	48 50.148	016 31.626	4841	4841	8/10 Good cores, 1 lost on deck
DY103-017	WP2	30/06/19	22:48	48 50.192	016 31.035	0	4842	Still mainly *Themisto*
		30/06/19	23:22	48 50.193	016 31.035	200		Good hauling speed
DY103-018	HyBIS	01/07/19	01:20	49 00.279	016 27.645	0	4845	BSNAP JC165-068 rescue mission
		01/07/19	05:00	49 00.256	016 28.004	4785		Successfully recovered mooring
DY103-019	CTD	01/07/19	13:22	48 56.605	016 29.398	0	4844	Cast 6, cal. dip
		01/07/19	13:47	48 56.605	016 29.399	105		mcat s/n 6915, 6904 and 6907
DY103-020	CTD	01/07/19	14:35	48 59.984	016 29.996	0	4842	Cast 7, bott.s 2 & 19 swapped (leak/misfire)
		01/07/19	17:56	48 59.984	016 29.999	4799		mcat s/n 7300 PAP3 post dep cal, OTEG instruments at 1 and 24
DY103-021	MgC09+1	01/07/19	21:16	48 50.202	016 30.912	4840	4840	9/10 Good cores
DY103-022	WP2	02/07/19	00:07	48 50.082	016 31.034	0	4842	Far fewer zplktn
		02/07/19	00:43	48 50.082	016 31.034	200		Squid at surface during hauling
DY103-023	MgC09+1	02/07/19	02:56	48 50.082	016 31.032	4844	4844	8/10 Fair cores
DY103-024	ATRAPx	02/07/19	09:13	48 56.631	016 29.098	4842	4842	Good catches
		03/07/19	17:00	48 56.631	016 29.098	4842		Soak time = 31.8 hours
DY103-025	CTD	02/07/19	09:58	48 59.998	016 30.061	0	4840	Cast 8, nutrient intercomparison
		02/07/19	16:48	48 59.990	016 30.020	4830		Long stops for OTEG sensors

Station	Gear	Date	Time	Position (N W)		Z(m)	S(m)	Comments
DY103-026	HyBIS	02/07/19	20:59	48 52.492	016 30.720	4839	4842	PAP trawl area (Hy47)
		03/07/19	03:58	48 54.566	016 30.720	4845		3881 images; 06:19 video (x2)
DY103-027	WP2	03/07/19	11:55	48 57.537	016 22.584	0	4842	Noon haul
		03/07/19	12:24	48 57.448	016 22.527	200		Far fewer zplktn
DY103-028	PAP1	03/07/19	14:43	48 57.936	016 22.143	0	4844	Systems operational once deployed
DY103-029	CTD	03/07/19	15:16	48 57.689	016 22.452	0	4845	Cast 9
		03/07/19	15:46	48 57.689	016 22.452	101		
DY103-030	HyBIS	03/07/19	23:06	48 49.886	016 31.124	4841	4842	PAP Central lines 8+11 (Hy48)
		04/07/19	04:03	48 50.542	016 31.124	4846		3037 images; 04:54 video (x2)
DY103-031	CTD	04/07/19	08:28	48 59.999	016 30.019	0	4840	Cast 10
		04/07/19	12:00	49 00.005	016 30.023	4828		Niskin 9 misfire
DY103-032	WP2	04/07/19	12:18	49 00.043	016 30.023	0	4840	Haul 5, noon
		04/07/19	12:48	49 00.007	016 30.042	200		Mostly copepods
DY103-033	OTSB14a	05/07/19	00:22	48 48.791	016 41.446	4838	4840	Fair, clean, catch
		05/07/19	02:40	48 52.805	016 34.343	4842		Dist. run = 11.37 km
DY103-034	CTD	05/07/19	10:01	48 57.690	016 23.977	0	4844	Cast 11
		05/07/19	11:16	48 57.691	016 23.980	102		
DY103-035	WP2	05/07/19	12:12	49 00.034	016 30.037	0	4844	Haul 6, noon, possible contamination
		05/07/19	12:38	49 00.034	016 30.038	200		niskins flushed during descent
DY103-036	CTD	05/07/19	13:02	49 00.001	016 29.996	0	4841	Cast 12
		05/07/19	16:27	49 00.001	016 29.996	4833		microcat cal.
DY103-037	OTSB14a	06/07/19	00:27	48 48.985	016 45.240	4837	4839	Fair, clean, catch
		06/07/19	02:48	48 52.109	016 37.262	4840		Dist. run = 11.30 km
DY103-038	BSNAP	06/07/19	10:46	49 00.198	016 26.605	4840	4840	Boomeranged
		06/07/19	14:25	48 59.938	016 26.603	4840		With LO3CAted 'traps'
DY103-039	BSNAP	06/07/19	15:10	49 00.214	016 26.615	4840	4840	With LO3CAted 'traps'
DY103-040	HyBIS	06/07/19	20:09	48 49.908	016 31.655	4841	4842	PAP Central lines 1+3 (Hy49)
		07/07/19	01:07	48 50.508	016 31.672	4845		2816 images; 04:35 video (x2)
DY103-041	WCM	08/07/19	06:22	48 37.569	010 00.224	1577	1577	2 x ADCP + sed. Trap