National Oceanography Centre

RESEARCH EXPEDITION REPORT

RRS *James Cook* Cruise 247

5-22 May 2023

Multidecadal Research at the Porcupine Abyssal Plain - Sustained Observatory

Andrew R Gates

2023

Cruise Report No. 76

Document Data Sheet

Author	Date
Andrew R Gates et al	2023

Title
RRS James Cook 247 / 5-22 May 2023 / UK / Multidecadal Research at the Porcupine Abyssal Plain - Sustained Observatory

Reference
Southampton, UK: National Oceanography Centre, Southampton, 199 pp. (National Oceanography Centre Cruise Report, No. 76)

Abstract
RRS *James Cook* Cruise 247 departed Southampton 5th May 2023, operated at L4, part of the Western Channel Observatory (6th May), Whittard Canyon (7th May) and the Porcupine Abyssal Plain Sustained Observatory (PAP-SO) area (8-19th May), arriving back in Southampton 22nd May 2022. The goal of the cruise was to continue time-series observations of the surface ocean, water column, and seafloor at PAP-SO, first studied by NOC (then the Institute of Oceanographic Sciences) in 1985. An additional goal was to service a mooring at Whittard Canyon. These activities are supported by the NERC national capability Climate Linked Atlantic Sector Science (CLASS) project. Other goals were to deploy a series of Met Office biogeochemistry Argo floats, test novel sensors in the water column and on seabed sediments and contribute to the EuroGO-SHIP and APERO programmes.

The Met Office Mobilis buoy was successfully recovered and a replacement deployed with a sensor frame at 30m. This was a top section turnaround with a full mooring replacement planned for next year. The sediment traps were successfully recovered and replace at both PAP and the Whittard canyon, samples and sensor data were retrieved and intial analysis presented. A series of water column observation and sampling operations were successfully carried out to full depth with a CTD instrument package. The CTD deployments included pre- and post-deployment calibrations of PAP1 and PAP3 sensors, continuation of water column time series data collection and trials for novel biogeochemistry microfluidic sensors. Transits between locations were used to compare underway sampling and sensor data with satellite observations for the region. Five Met Office Argo floats were deployed and one for the APERO programme.

The PAP benthic time series was continued with a seafloor sediment core sampling, amphipod traps and trawl samples, including some core sampling and multibeam mapping outside the main PAP benthic sampling area for consideration of future scientific requirements.

This cruise was a contribution to the CLASS project supported by the UK Natural Environment Research Council (grant number NE/R015953/1).

Keywords
Porcupine Abyssal Plain, Whittard Canyon, Ocean Observations, Integrated Carbon Observing System (ICOS), iFADO, Met Office, DEEPEND, Biogeochemistry, time series, EURO GO-SHIP, APERO

Issuing Organisation

National Oceanography Centre
European Way
Southampton
SO14 3ZH, UK

Email: publications@noc.ac.uk

(This page intentionally left blank)

Contents

1. Personnel

Ship's Personnel

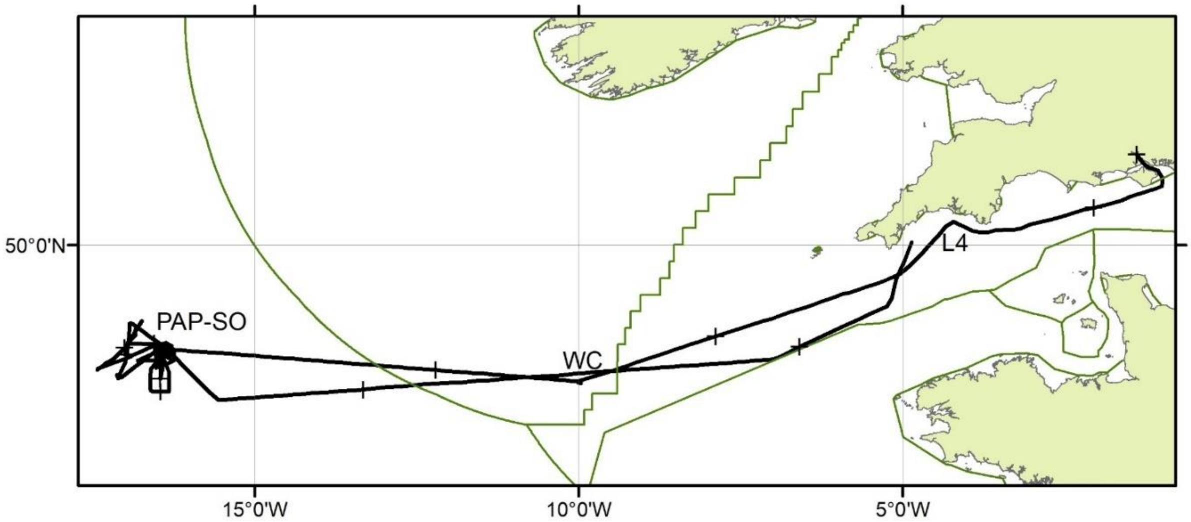
LEASK	JOHN ALAN	Captain
MACLEOD	IAIN	C/O
WILLIAMS	THOMAS JAY	2/O
BEAURAIN	BRYN PHILIP	3/O
SNEDDON	KEITH	C/E
MURREN	MICHAEL GERARD	2/E
LEE	JOHN EDWARD	3/E
PALMER	GEORGE WILLIAM	3/E
HAWKSWORTH	DAVID RONALD	ETO
McDOUGALL	PAULA ANNE	PCO
SQUIBB	MARK	CPOS
MCLENNAN	WILLIAM	CPOD
DUNCAN	STEVEN	POD
PARIS	RYAN	POS
MCKEOWN	ROBERT CHARLES	SG1A
ROSS	MARNIE SIOUX	SG1A
SMYTH	PETER	SG1A
WADLEY	CHRISTIAN NICOLAS	ERPO
CAINES	DARREN ALDOUS	H/Chef
LEIGH	MICHAEL WAYNE	Chef
PIPER	CARL	Stwd
WILLIAMS	DENZIL JOHN	A/Stwd

Scientific Personnel

GATES	ANDREW RUSSELL	PSO	NOC
HARTMAN	SUSAN	Scientist	NOC
BETT	BRIAN JAMES	Scientist	NOC
COOPER	ISABELLE	Student	University of Southampton
CURTIS	EMMA JULIET	Student	University of Southampton
FELTHAM	CHRISTOPHER NIGEL	Scientist	NOC
FLOHR	ANITA	Scientist	NOC
GOODWIN	LUCY	Student	University of Liverpool
HILDER	HANS	Scientist	NOC
READING	JETHRO	Scientist	University of Southampton
GAO	LOUISE	Student	University of Southampton
LICHTSCHLAG	ANNA	Scientist	NOC
LOVECCHIO	ELISA	Scientist	NOC
MAWJI	EDWARD	Scientist	NOC
OLUWAQBUSOLA	EMMANUEL TOPE	Scientist	University of Aberdeen
PICARD	THEO	Student	Université de Bretagne
WOODWARD	MALCOLM	Scientist	Plymouth Marine Laboratory
SUNNY	SNEHA	Student	University of Southampton
VALLS DOMEDEL	GEORGINA	Scientist	NOC
WARD	JUAN	SST	NOC
POWELL	TIMOTHY DAVID	Tech	NOC
BALLINGER	THOMAS JOSEPH	Tech	NOC
LEADBEATER	ANDREW JOHN	Tech	NOC
CHILDS	DAVID MATTHEW	Tech	NOC
PLATT	WILLIAM ROBERT	Tech	NOC
POOLE	BENJAMIN GEORGE	Tech	NOC
THOMAS	TINA MARIA	Tech	NOC

2. Itinerary

Mobilisation for RRS *James Cook* cruise 247 began on the 2nd May 2023. Scientists and technicians joined on 4th May. The RRS *James Cook* slipped moorings at NOC, Southampton at 1730 on Friday 5th May, making a first stop at 0800, Saturday 6th May for a shallow CTD at the L4 site off Plymouth, part of the CLASS funded Western Channel Observatory. The next stop was at Whittard Canyon in the Irish EEZ to turn around a CLASS mooring that has been operating since 2019. These operations were completed by 15:10 Sunday 7th May before departure toward the Porcupine Abyssal Plain Sustained Observatory (PAP-SO). The RRS *James Cook* arrived at PAP-SO 1700 on the 8th May. After several days of CTDs, coring and smaller moorings the ODAS mooring was recovered on the 11th May, temporarily replaced by a guard buoy, then the new buoy deployed on 12th May in favourable conditions. Coring continued by night and moorings, CTDs and Argo floats by day until the 16th May when attentions switched to scientific trawling. Two successful trawls were completed followed by a final day of activities before the ship turned to head back toward Southampton on Friday 19th May, briefly stopping near Falmouth on Sunday 21st May for an exercise with the fast response boat and arriving at NOC early on Monday 22nd May where demobilisation began immediately ahead of refit.



Cruise track 5-21st May 2023. PAP-SO: Porcupine Abyssal Plain Systained Observatory, WC: Whittard Canyon, L4: Part of Western Channel Observatory, +: midnight positions.

3. Cruise background and aims

Through international collaborations and advances in technology, multidisciplinary ocean observatories are increasingly capable of providing critical time-series monitoring of our oceans. The Porcupine Abyssal Plain Sustained Observatory (PAP-SO) open-ocean time-series site in the Northeast Atlantic (49.0 °N 16.5 °W, 4850 m water depth), is one of a small number of oceanic sites that has achieved full depth multidecadal monitoring. It has observed seafloor ecology since 1985, water column particle flux since 1992, and made surface ocean and atmosphere measurements since 2003. The UK National Oceanography Centre operates the observatory collaboratively with the UK Met Office. The observatory is serviced annually, providing the opportunity to carry out conventional ship-based observations, sensor comparison, sampling, and increasingly employs autonomous systems to expand and enhance the time series (Gates et al., 2021).

From the start the PAP-SO has been an international collaborative effort that has sought to understand long-term change in the ocean – from surface to seafloor. The initial aim was to study seasonality in the supply of detrital food to the deep-sea floor and its role in structuring the ecosystem. Today, observatory research is increasingly focused on the causes and consequences of multidecadal change, and monitors several essential ocean variables. The observatory also provides an excellent testbed for the development of new sensors and platforms. The increasing use of autonomous systems has expanded the spatial scale and temporal resolution of observations, including large-scale seafloor photography by autonomous vehicles, and underwater glider observations for example, to observe the spring phytoplankton bloom (Hartman et al., 2021).

Observations of multidecadal duration are essential for the detection of long-term change in the ocean and key to understanding our varying climate. Results from the PAP-SO demonstrate the importance of these long-term records of ocean variables and processes. For example, observatory data have revealed increased seasonal variability in seawater CO_2 and a decline in pH, driven by biological productivity. In the water column, long-term variability in particle flux to sequestration depth can be linked to the upper ocean phytoplankton community composition, specifically Rhizaria which, when abundant drive high flux. Rhizaria were found to be most abundance following high upper ocean temperatures months earlier (Lampitt et al., 2023). Close to the abyssal seafloor, sampling of scavenging crustacean populations since 1985 has shown a major change in the dominant species which may be linked to upper ocean climate as assessed by the Atlantic Multidecadal Variation – a 60-80-year cycle in sea surface temperature (Horton et al., 2020).

The aims of RRS *James Cook* Cruise 247 (JC247) were to study multidecadal change in the NE Atlantic by continuing long-term observations at PAP-SO and Whittard Canyon. Both sites are part of the Natural Environment Research Council's "Climate Linked Atlantic Sector Science" CLASS project (https://projects.noc.ac.uk/class-project/sustained-ocean-observations) that is managed by the National Oceanography Centre (NOC).

References:

Gates et al 2021, Oceanography, https://doi.org/10.5670/oceanog.2021.supplement.02-12.
Hartman et al 2021, Progress in Oceanography, https://doi.org/10.1016/j.pocean.2020.102508.
Horton et al 2020, Progress in Oceanography, https://doi.org/10.1016/j.pocean.2020.102318
Lampitt et al 2023, Frontiers in Earth Science, https://doi.org/10.3389/feart.2023.1176196
Macovei et al 2020, Progress in Oceanography, https://doi.org/10.1016/j.pocean.2019.102223

4. Objectives

The aims of the cruise were acheved by meeting the following objectives:

Whittard Canyon (Irish EEZ):

- Recovery of Whittard Canyon mooring (sediment trap, ADCPs and CTDs)
- CTD for testing release for new mooring
- Deployment of replacement sediment trap mooring in the Whittard Canyon

PAP-SO (High Seas):

- Recover and replace Met Office surface ocean ODAS buoy equipped with NOC biogeochemistry sensors
- Recover and replace sediment trap mooring
- Deploy and recover baited trap landers (amphipod trap)
- CTD water column profiles and sampling
- Zooplankton nets
- Sediment coring using Megacore
- Scientific trawling for time series
- Deploy 6 Argo floats
- Underway sampling of the surface water

Other objectives:

- Collect nutirents samples for the EuroGO-SHIP project
- Test microfluidic (lab on chip) sensors on underway systems and CTD
- Ex-situ sediment geochemistry sensor tests

5. Narrative

Thursday 4th May 2023 The science party arrive throughout the day, assist with mobilisation and begin to settle in to ship life. During mobilisation it becomes clear that there was a problem with the the rope delivered for the mooring. NMF team work with Met Office to splice but there are concerns that it is too short and the diameter is too large. Agree to measure the rope while winding on in the morning.

Friday 5th May 2023 Remaining scientists arrive early and we have a briefing with Paula the purser. The measurements shows the rope is too short. In consultation with NMF and the Met Office a final decision is made – we will sail and just complete a top section turnaround of the mooring. The large PAP winch and rope are removed from the ship and the guard buoy is loaded. The issues with the rope have delayed mobilisation so departure is pushed back until 17:30. We depart Southampton waved off by a few NOC staff still on site on Friday afternoon. We pass the Nab Tower, leaving the eastern Solent and heading for the L4 site off Plymouth for a first test CTD at Malcolm Woodward's request for the Euro GoShip programme.

Saturday 6th May 2023 We arrive near L4 and launch the CTD at 08:13, sampling to 50 m depth. The CTD team are pleased with the opportunity to get some samples early, test their analysers and it offers a good opportunity for those on their first cruise to learn their roles before the science begins at Whittard Canyon and PAP-SO. We continue onward to Whittard Canyon where weather conditions look favourable for mooring work.

Sunday 7th May 2023 Overnight the clocks are changed by one hour to UTC. The seas are calm and the wind light at sunrise as we approach Whittard Canyon. We plan to complete the mooring recovery, do a CTD to validate the MicroCAT CTD sensors and test the releases for the new mooring, and then deploy the new mooring. The mooring recovery goes to plan although the core liner inside is not as we expect. Nevertheless, some sediment is retained and the liner is stored upright in the controlled temperature lab. The CTD is completed and the new mooring is deployed without issue then triangulated before we depart Whittard Canyon for another year at 15:10.

Monday 8th May 2023 On transit to PAP our preparations continue. We prepare for Argo float deployments by running some self-tests on the systems, as guided by the Met Office. We arrive at PAP at 17:00 and approach the PAP1 ODAS buoy for a visual inspection. The buoy is sitting well in the water and looks good. We then complete a shallow CTD near the buoy before heading south to the PAP Central coring station for a night of megacore sampling.

Tuesday 9th May 2023 Overnight two cores are successfully taken but the wind is too strong for zooplankton nets. Samples are collected for PAP time series work and for Anna L to analyse in the lab. In the morning we do a deep CTD, followed by our first successful day-time plankton nets (the science bosun uses an additional line to stop the nets flying like a kite). We then deploy two Argo floats at the PAP deep CTD station. An amphipod trap deployment follows, the first with our new design trap, and some pilot whales are spotted on the port side shortly after. With strong winds overnight, for the comfort of everyone on board, the captain advises we take a longer route down to the coring site, so the swell is not on the beam.

Wednesday 10th May 2023 overnight the benthic team collect two megacore samples from PAP central and a zooplankton net. The day shift begins with a shallow CTD to validate the sensors on the PAP1 ODAS buoy followed by a deep CTD. We deploy two Biogeochemistry Argo floats after the CTD, one for the APERO programme and one Met Office float. We then deploy the PAP3 sediment trap mooring, beginning at 15:57 and dropping the anchor at 17:22. The mooring is triangulated successfully before heading to PAP central for a night of coring. We are expecting good weather for a mooring recovery tomorrow.

Thursday 11th May 2023 Two successful megacores overnight and we are on station with the PAP1 ODAS buoy astern by breakfast. At 09:30 we approach the buoy, hooking on shortly after. The buoy is lifted on to deck and secured by 10:00 The sensor frame is then recovered and the guard buoy off deck by 11:10. A smooth recovery of the buoy by all members of the team involved.

We spend some time assessing the state of the buoy and sensor frame to identify why we lost real-time data early in the last deployment. There appears to be water ingress to the umbilical above the sensor frame. There is some damage to parts of the frame with a sensor missing and one badly damaged.

We then move in to position to recover the amphipod trap after a 48-hour deployment. It takes about 2.5 hours to surface and is on deck at 17:45 with a modest catch.

Friday 12th May 2023 Overnight the benthic team collect two more megacore samples and one zooplankton net sample at the PAP central site. In the morning the sea is calm and the winds light, perfect for a PAP1 deployment. Most of the day is spent preparing the buoy for deployment by checking all sensors and brackets, attaching the umbilical, testing communications and last-minute checks. The system was switched on by the team at NOC and the buoy released at 1840 before steaming to the central coring site.

Saturday 13th May 2023 Two megacore deployments were completed overnight and we were on station for a Met Cal near the ODAS buoy at 0750. This is a rare opportunity to validate the ship's meteorological sensors near a met station (newly-deployed PAP1). A shallow CTD follows to validate sensors on the buoy deployed yesterday. We then sample with the WP2 plankton nets before recovering the sediment trap mooring PAP3. PAP3 is not where expected, surfacing approximately 1 nm from the reported position. PAP3 was not triangulated last year and we conclude that the position reported was likely the location where the deployment began, not where the anchor was dropped. The mooring is on deck by 1800 but a planned amphipod trap deployment is postponed to the morning after several long days of mooring work for the deck crew.

Sunday 14th May 2023 Overnight we completed 2 more megacore sampling stations at the PAP Central location arriving back near PAP1 to do a shallow CTD early in the morning. Deployed at 0645 this aims to sample at the same time as PAP1 sensors record data.

After completion of the shallow CTD the amphipod trap is deployed again with some minor modifications in case the new design entry has impacted catch size. This deployment is followed by a deep CTD with long stops which took most of the afternoon. When back on deck we took a transit across an apparent chlorophyll front noted from satellite data and seemingly showing different data from the buoy location to the deep CTDs. During this transit we ran the underway systems. This transit ended at our core sampling location for the night shift.

Monday 15th May 2023 Overnight we completed a WP-2 plankton net and after 6 nights coring at PAP central we changed locations to the N. plain site, now having sufficient samples for the macrofauna time series. The change of location was to provide some variability in the cores for Anna L's analysis. At N. Plain there has been a historic land slide and sediment structure is very different to PAP central. The sediment is more fluid and therefore more challenging to work with. The benthic team did a great job securing the sediments and Anna L. took cores to analyse with the pore waters from the drilled tubes and run the LOC sensors.

After breakfast we did a deep CTD with the MicroCATs from PAP-3 mooring and the new CO_2 sensor. We then set off on a long survey to measure underway data over fronts in the chlorophyll detected from satellite data analysed by Elisa. The survey route took us to the South Plain site for overnight coring. This site is a potential new site for biological monitoring at PAP-SO and we require some background environmental data to compare with the current PAP-central site.

Tuesday 16th May 2023 Two successful megacore samples were collected from the South Plain site. The majority of the night shift team are now able to return to day shift for trawl processing in 24 hours. We do an early shallow CTD near the PAP1 buoy for sensor validation, on completion we release the amphipod trap which resurfaces slowly, taking over two hours. It is soon spotted on the bridge and brought alongside. The catch is large in the upper 10 m "blue barrel" trap and in one of the bottom traps. When the amphipod trap is recovered we collect our final WP-2 net sample for midday zooplankton sampling. We then complete another deep CTD before deploying the two remaining Argo floats. Next we depart for the first trawl location overnight. The prevailing wind means that the trawl route must be north to south rather than the preferred east to west direction. The trawl is successfully deployed after dinner to fish overnight.

Wednesday 17th May 2023 The trawl comes on deck after breakfast to much anticipation but with a modest catch. Processing the catch is the day's work for most of the former night shift. The amphipod trap is deployed for a third time before further underway survey crosses fronts identified in satellite data take us to the night's trawling location. Two shallow CTDs are done in different areas of the chlorophyll fronts. Trawling tonight is in a similar heading to previously and is again deployed after dinner.

Thursday 18th May 2023 A moderate haul is brought on deck after breakfast despite some challenges with the main block on the A-frame overnight. The benthic team again spend the day working on the catch and all objectives from trawl sampling are met. The day is spent on a shallow CTD close to the PAP1 buoy for further sensor validation and a final deep CTD before travelling back to the South Plain site for a multibeam and sub-bottom profiler survey to expand our bathymetry data in an area mapped on DY130.

Friday 19th May 2023 On completion of the overnight mapping a final shallow CTD is carried out at 0630 to coincide with measurements from PAP1 before the recovery of the amphipod trap, with another good catch, being the final science activity at the PAP-SO for JC247. We depart PAP-SO with a route planned to cross some chlorophyll front features observed in satellite data that will be measured with the underway systems.

Saturday 20th – Monday 22nd May 2023 Transit continues with packing and cruise report writing the main activities for the science party. We stop near Falmouth on Sunday morning for some tests of the fast response boat and use the opportunity for a cruise photograph in beautiful weather. We depart Falmouth and continue transit to NOC, arriving early on Monday 22nd May where demobilisation began immediately ahead of the *James Cook* heading for refit.

Cruise photograph in calm seas off Falmouth

6. NMF Technical Report

Tim Powell (Senior Technical Officer), Thomas Ballinger, Dave Childs, Andy Leadbeater, Billy Platt, Ben Poole, Tina Thomas, Juan Ward.

6.1 Mooring Operations

Tim Powell - Lead Technician

Introduction

The initial plan for JC247 had been to carry out a full recovery and redeployment of the Whittard Canyon, PAP3 and PAP1 moorings and several short-term amphipod trap deployments. This plan was amended the day before sailing when it was discovered that the rope provided for PAP1 was too short meaning a full replacement would not be possible. The supplied rope was also of a larger diameter than originally specified with larger thimbles at each joint. This rope would likely not fit on the PAP winch in its entirety making deployment/recovery significantly more difficult.

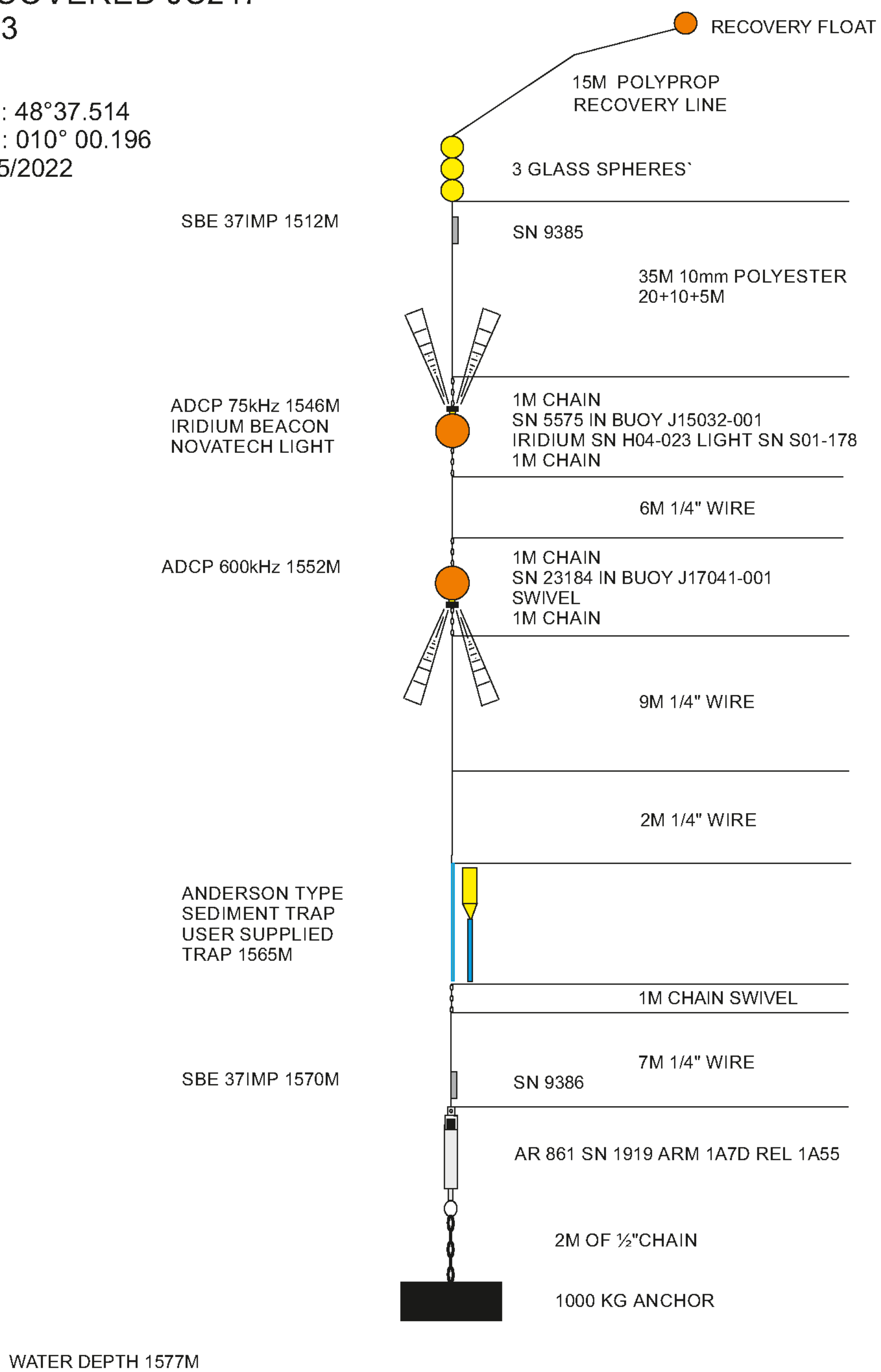
The PAP winch was quickly landed ashore giving enough deck space to proceed with a top end refurbishment of PAP1. An additional 5t deck winch was loaded along with the orange surface guard buoy required in order to carry out the new plan.

Whittard Canyon Mooring Recovery

The *James Cook* arrived on station at Whittard Canyon at 08:30 on 07/05/2023. The mooring was ranged and then released using an Ixsea TT801 deck unit connected to the ship fitted moorings transducer, both of which worked well throughout the cruise. The mooring took about 30 minutes to reach the surface and was recovered over the stern using the central 5t deck winch and moorings sheave suspended by the port pedestal crane. The mooring was onboard by 09:50.

WHITTARD CANYON
RECOVERED JC247
2023

LAT : 48°37.514
LON: 010° 00.196
03/05/2022



SENSORS & MOORINGS

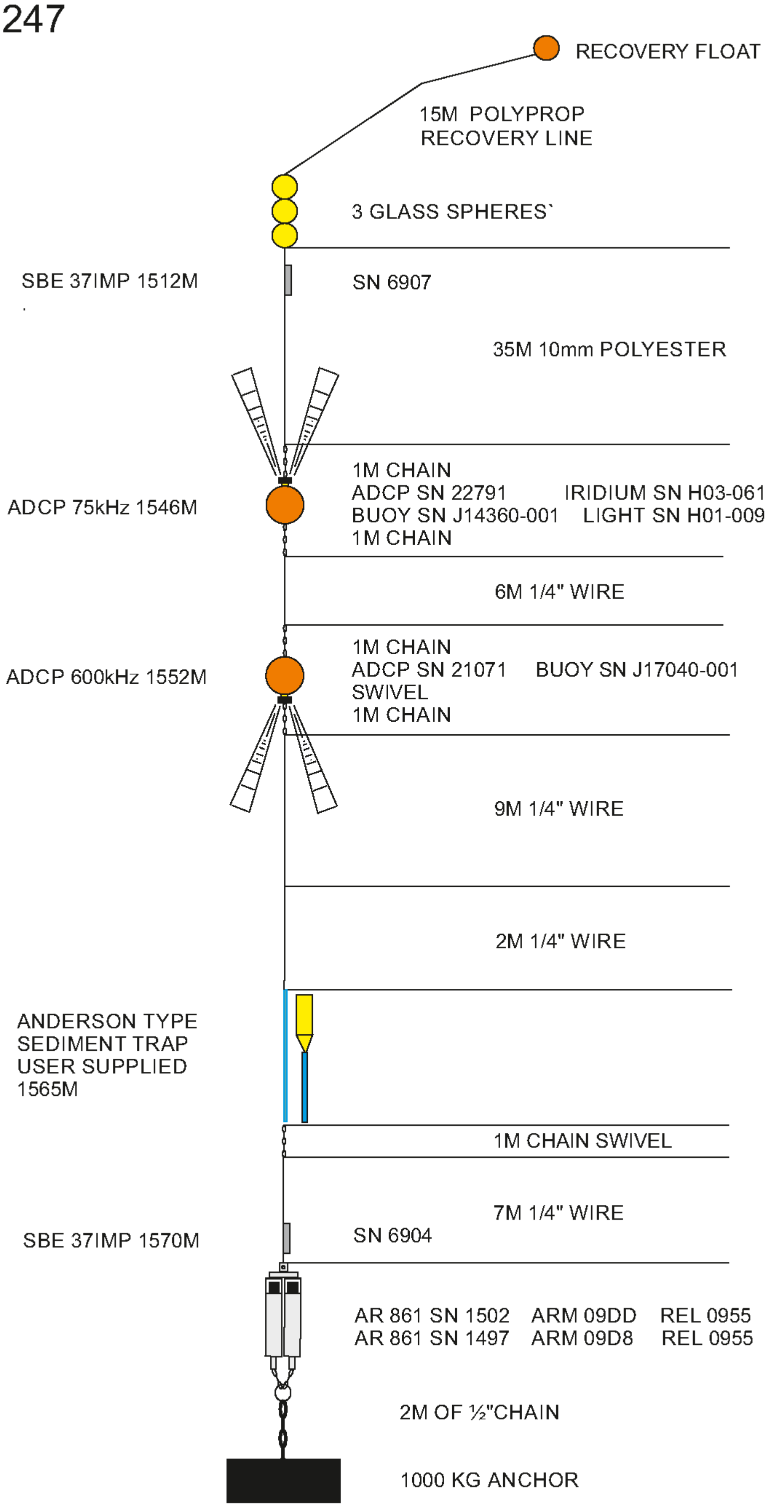
Whittard Canyon Mooring Deployment

Following a CTD at the Whittard Canyon site to test the acoustic releases the ship re-positioned ready for deployment. The recovery float, buoyant recovery line, glass spheres and first 35m of rope where deployed by hand from the red deck.

Due to the short distance between the two ADCP spheres, they were lifted simultaneously from the red deck using both pedestal cranes and released using SeaCatches. The Anderson type sediment trap was also hand lowered into the water before the starboard crane lifted the anchor to complete the deployment. The mooring was then trilaterated to calculate its ultimate position on the sea floor.

WHITTARD CANYON
DEPLOYED JC247
2023

STATION: JC247-003
DATE: 07/05/2023
LAT : 48° 37.529 N
LON: 010° 00.170 W
DEPTH: 1577m



PAP3 Mooring Deployment

Four AR861 releases were tested on a deep CTD cast, two for PAP 3, one for the amphipod trap and one spare, all gave good responses and released successfully.

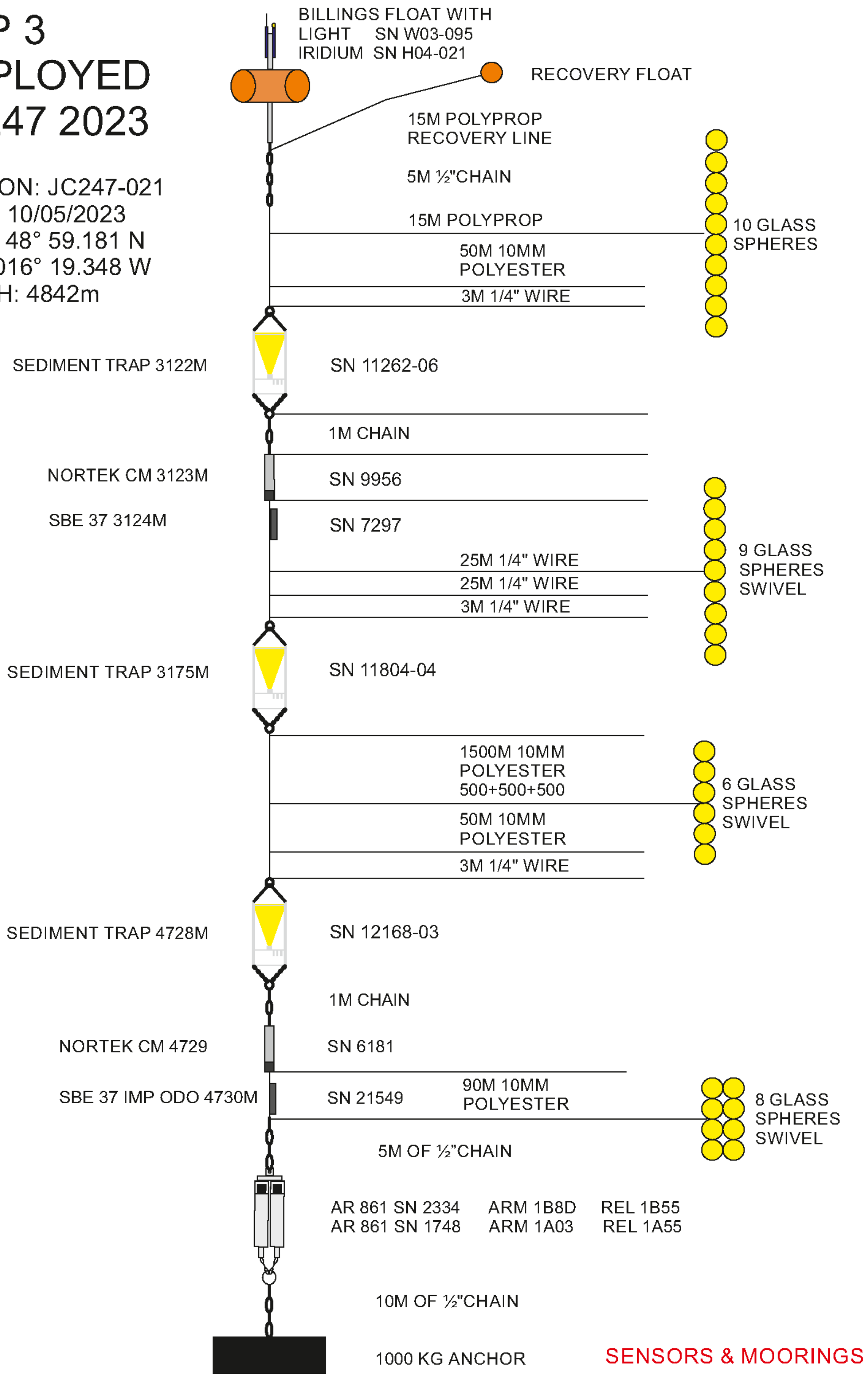
The mooring was prepared for deployment by winding the rope and wire onto the central 5t deck winch. Links and shackles were wrapped with canvas to help prevent snagging and damage to the rope or wire. The anchor was positioned on the red deck starboard side and the glass buoyancy, sediment traps and instruments were close at hand. The ship set up for deployment 2000 m meters from the desired anchor drop position and proceeded initially at 0.5 kts.

The billings float, glass buoyancy and first two sediment traps and instruments were deployed before the ships speed was increased to 1 kt whilst the 1500 m of polyester rope was payed out keeping sufficient tension on the rope. The final sediment trap, instruments and glass were then deployed followed by the anchor. In total the deployment took 1h25.

An attempt was made to trilaterate the mooring to determine its final position on the seabed, best practice is to pick three points 120 degrees apart at least the water depth away from the anchor drop location. As an exact position for PAP3 is not essential information, the decision was made to save time, and points much closer were chosen from which to range the mooring. This resulted in the range circles failing to intersect, as such an estimated anchor position is recorded on the deployment drawing.

PAP 3 DEPLOYED JC247 2023

STATION: JC247-021
DATE: 10/05/2023
LAT :   48° 59.181 N
LON: 016° 19.348 W
DEPTH: 4842m



PAP3 Mooring Recovery

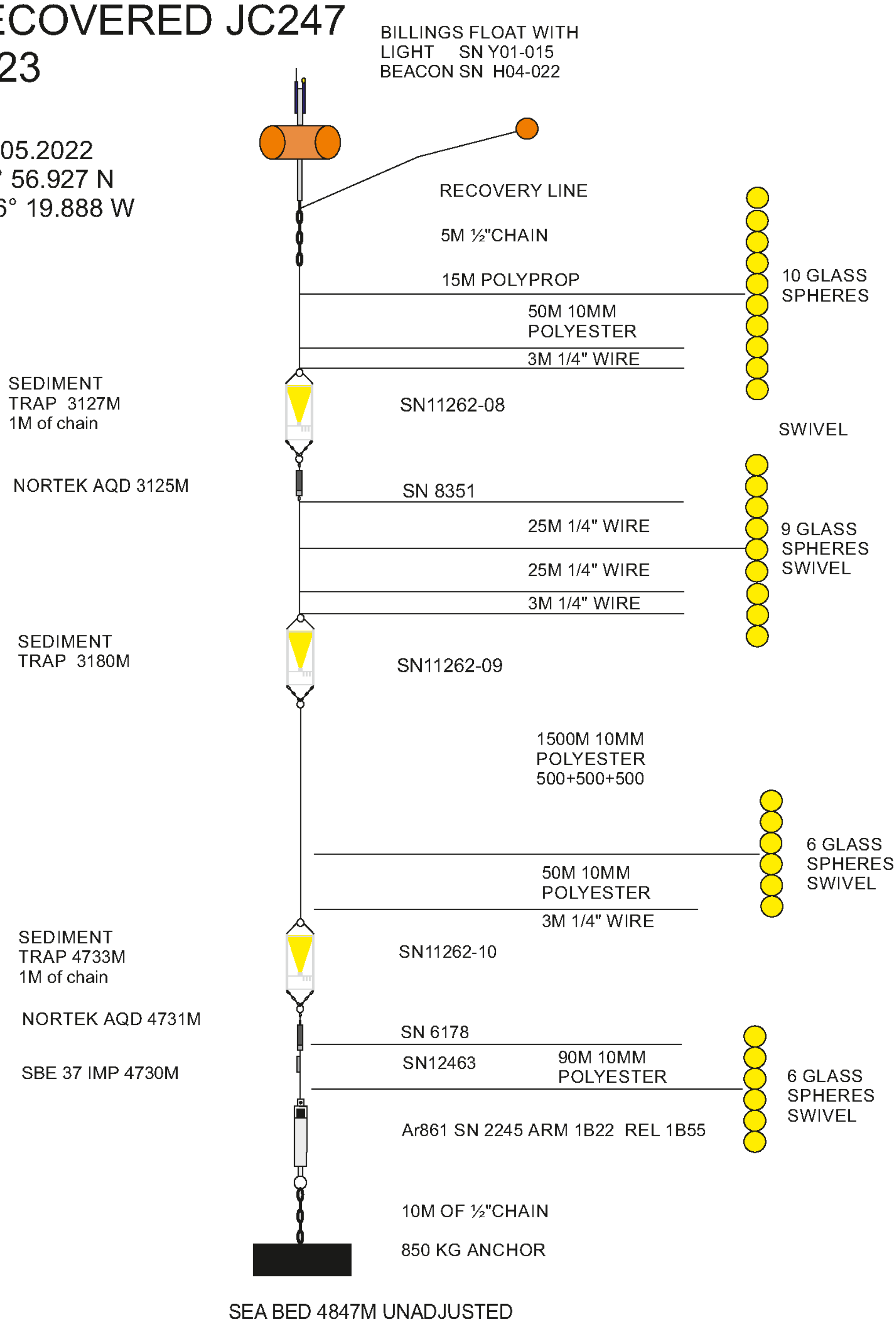
PAP3 was released from the seabed at 15:10 on the 13/05/2023 and took approximately an hour to fully surface. Upon surfacing the bridge were unable to visually locate the mooring, position information from the iridium beacon attached to the billings float indicated that the mooring was indeed on the surface but was roughly a mile and a half away. The ship repositioned and eventually the mooring was spotted and brought alongside ready for retrieval. The assumption is that the position recorded on the mooring diagram is that at which deployment of the mooring had started and not the final anchor resting position.

This incident highlights the need for secondary checks of deployment position including accurate trilateration to reduce the risk of mooring loss. There was some tangling of the ropes around the sediment traps upon recovery but this did not add significantly to the time taken to recover the mooring. Recovery took 1h30 from grappling the recovery float to the getting the full mooring back onboard.

Note – the position for JC231-004 (PAP3) has been revised in the Station List in this Cruise report to reflect a more accurate estimate of the seabed position for use in future scientific analysis.

PAP 3
RECOVERED JC247
2023

04.05.2022
48° 56.927 N
016° 19.888 W



SENSORS & MOORINGS

PAP1 Mooring Recovery

The recovery of PAP1 had been planned for 11/05/2023 due to the forecasted perfect weather conditions. The core warp was run through the large centre block on the A frame and attached to a length of plasma rope. On the end of this rope was a retrieval hook that was loosely fitted into the end of a telescopic carbon fibre pole.

Two further retrieval hooks were attached to ends of the wires from the two outboard 5t deck winches which ran via snatch blocks attached to the crane pedestals. The plan was to use these steadying lines to control the movement of the buoy once the main warp had lifted it clear of the water.

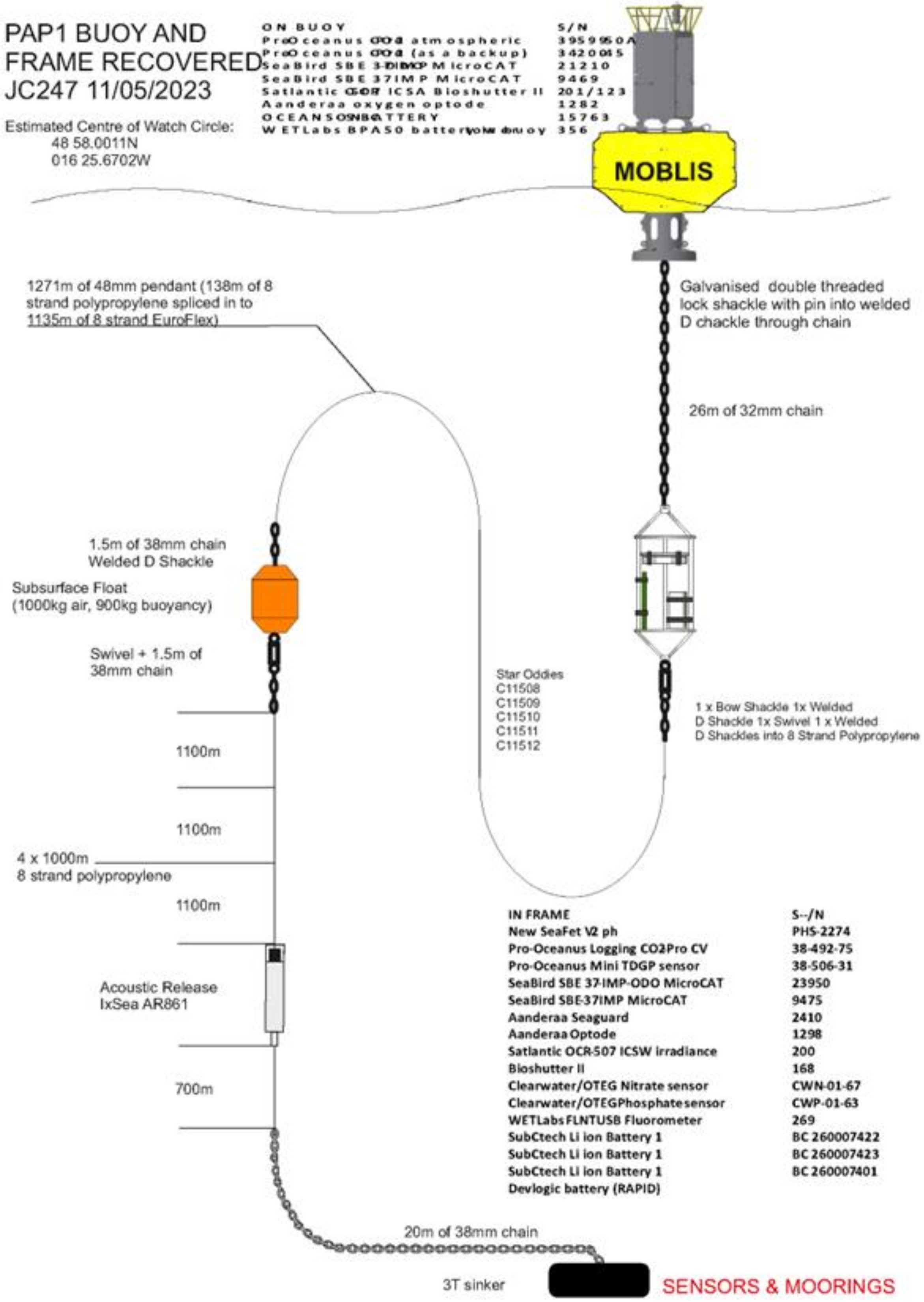
In practice this worked extremely well and the buoy was recovered to deck safely taking only 10 minutes from initial approach before the buoy was secured on deck.

The starboard Rexroth winch was then used to pull up sections of the chain before the frame was recovered to the red deck. The rest of the mooring was stoppered off, the frame was disconnected and moved clear and the guard buoy brought into position and attached.
The guard buoy was then lowered off the stern and released by SeaCatch before the ship slowly moved away.

Peak winch tension measured by the load cell exceeded 7 tonnes and averaged between 5-5.5 tonnes. It should be noted that the SeaCatch RH25 retrieval hook used has a safe working load limit of 10,080 lbs, 4.57 tonnes.

Following recovery of the buoy and frame it was noticed that many of the cable connections on the frame had come loose. Instrument brackets were also loose, which had resulted in the loss of some instrumentation. The umbilical cable connecting the frame and buoy also showed signs of damage, there was a large amount of slack cable above the frame where it had not been secured for several meters.

The 3m long large diameter hose above the frame was found not be secured and it appeared to have been free to move which may also have led to damage of the umbilical. The umbilical cable was cut close to the frame to enable separation of the frame and buoy, once cut water was found within the cable. Subsequent investigation by members of the technical party identified that there was no continuity found between the frame and buoy indicating a break in the cable. Further testing identified the break to be within 5m of the frame.



PAP1 BUOY AND
FRAME RECOVERED
JC247 11/05/2023
Estimated Centre of Watch Circle:
48 58.0011N
016 25.6702W
ON BUOY
S/N
ProOceanus CO2 atmospheric
3959950A
ProOceanus CO2 (as a backup)
3420045
SeaBird SBE 37-IMP-ODO MicroCAT
21210
SeaBird SBE 37IMP MicroCAT
9469
Satlantic OCR ICSA Bioshutter II
201/123
Aanderaa oxygen optode
1282
OCEANSONBATTERY
15763
WETLabs BPA50 battery on buoy
356
MOBLIS
1271m of 48mm pendant (138m of 8 strand polypropylene spliced in to 1135m of 8 strand EuroFlex)
Galvanised double threaded lock shackle with pin into welded D chackle through chain
26m of 32mm chain
1.5m of 38mm chain
Welded D Shackle
Subsurface Float
(1000kg air, 900kg buoyancy)
Swivel + 1.5m of 38mm chain
Star Oddies
C11508
C11509
C11510
C11511
C11512
1 x Bow Shackle 1x Welded D Shackle 1x Swivel 1 x Welded D Shackles into 8 Strand Polypropylene
1100m
1100m
4 x 1000m
8 strand polypropylene
1100m
Acoustic Release
IxSea AR861
700m
IN FRAME
S--/N
New SeaFet V2 ph
PHS-2274
Pro-Oceanus Logging CO2Pro CV
38-492-75
Pro-Oceanus Mini TDGP sensor
38-506-31
SeaBird SBE 37-IMP-ODO MicroCAT
23950
SeaBird SBE-37IMP MicroCAT
9475
Aanderaa Seaguard
2410
Aanderaa Optode
1298
Satlantic OCR-507 ICSW irradiance
200
Bioshutter II
168
Clearwater/OTEG Nitrate sensor
CWN-01-67
Clearwater/OTEGPhosphate sensor
CWP-01-63
WETLabs FLNTUSB Fluorometer
269
SubCtech Li ion Battery 1
BC 260007422
SubCtech Li ion Battery 1
BC 260007423
SubCtech Li ion Battery 1
BC 260007401
Devlogic battery (RAPID)
20m of 38mm chain
3T sinker
SENSORS & MOORINGS

PAP1 Mooring Preparation

Prior to sailing the majority of the instrumentation had been fitted to the frame and this had been connected to the buoy and tested. This had not been the case on previous cruises but was a very welcome improvement for JC247.

Once on board it was noticed that there was still significant additional work required both on the frame and buoy before deployment could occur.

The NMF onboard technical team worked closely with the scientific party over a number of days to inspect and secure all loose bracketry, nuts and bolts and instrumentation. Chafe protection was added to the cabling wherever possible in an attempt to increase the operating life of the system.

This work necessitated entry into the buoy keel and tower, in future it would be best if this preparatory work can be completed ashore as it would be safer than doing so on a moving vessel at sea. Cable conduits could be fitted to the buoy keel to make this process easier.

Work continued on the frame which was found to have many loose fixings, cabling not adequately secured and cable connectors loose. Once the connectors had been tightened they were wrapped with amalgamating tape in an effort to prevent them working loose over time.

Once the buoy had been positioned on the red deck the chain was laid out in a straight line running along the starboard side deck. As much slack as possible was removed from the chain before attaching the umbilical cable to it using all the available clamps spaced at 1.6 m intervals.

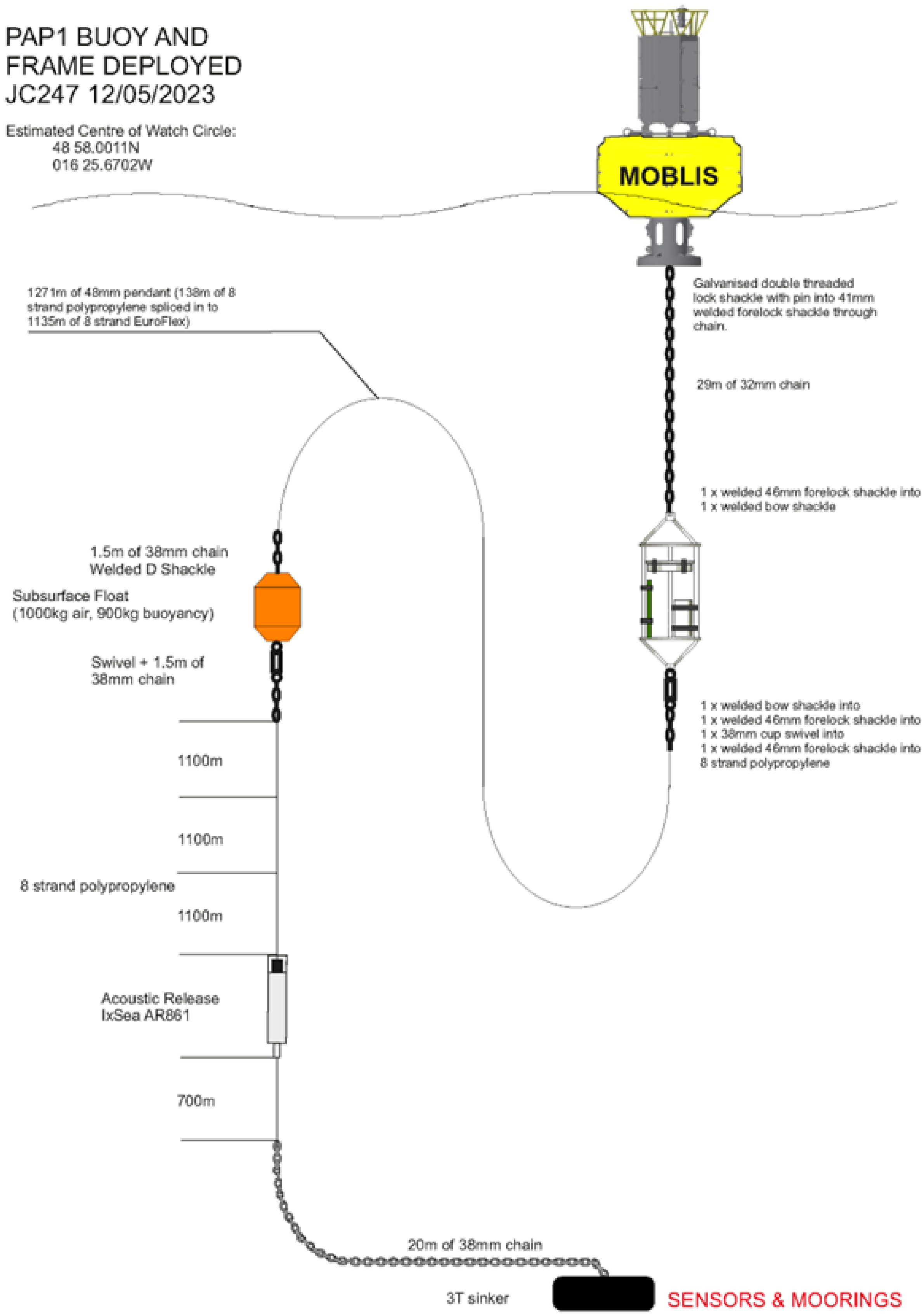
The chain was then routed through the new 3 m large diameter hose before being connected to the frame. The hose was secured by pinning it with m12 stainless steel threaded rod in an attempt to prevent it from riding up the chain and damaging the umbilical cable. The umbilical cable was secured to the outside of the hose hopefully avoiding the large amounts of slack found upon retrieval of the previous mooring. The umbilical cable was routed through the frame to the controller and secured by three sets of Stauff clamps to the central bar, heavy duty cable ties were used to further secure the cable. The moulded electrical termination was further waterproofed by abrading the outer surface and application of multiple layers of Scotchkote and amalgamating tape.

PAP1 Mooring Deployment

Redeployment of PAP1 occurred on 12/11/2023. The ship maneuvered to bring the guard buoy close to the port quarter where the pick-up line was grappled by the deck crew. The buoy was soon brought on deck, the rope stoppered off and the buoy disconnected and moved clear.

The frame was then lifted into position on the red deck, connected to the rope with a new 46 mm forelock shackle which was further secured by welding the shackle pin to prevent rotation.

The deployment procedure was essentially the reverse of the recovery with extra attention being paid to ensure the new umbilical cable was not damaged in the process.
Once again ideal weather conditions enabled the deployment to go smoothly, deployment in any kind of swell would be both dangerous and likely to result in damage of the frame, umbilical, buoy or even the ship.


PAP1 BUOY AND FRAME DEPLOYED JC247 12/05/2023
Estimated Centre of Watch Circle:
48 58.0011N
016 25.6702W
MOBLIS
Galvanised double threaded lock shackle with pin into 41mm welded forelock shackle through chain.
29m of 32mm chain
1 x welded 46mm forelock shackle into
1 x welded bow shackle
1 x welded bow shackle into
1 x welded 46mm forelock shackle into
1 x 38mm cup swivel into
1 x welded 46mm forelock shackle into
8 strand polypropylene
1271m of 48mm pendant (138m of 8 strand polypropylene spliced in to 1135m of 8 strand EuroFlex)
1.5m of 38mm chain
Welded D Shackle
Subsurface Float
(1000kg air, 900kg buoyancy)
Swivel + 1.5m of 38mm chain
1100m
1100m
8 strand polypropylene
1100m
Acoustic Release
IxSea AR861
700m
20m of 38mm chain
3T sinker
SENSORS & MOORINGS

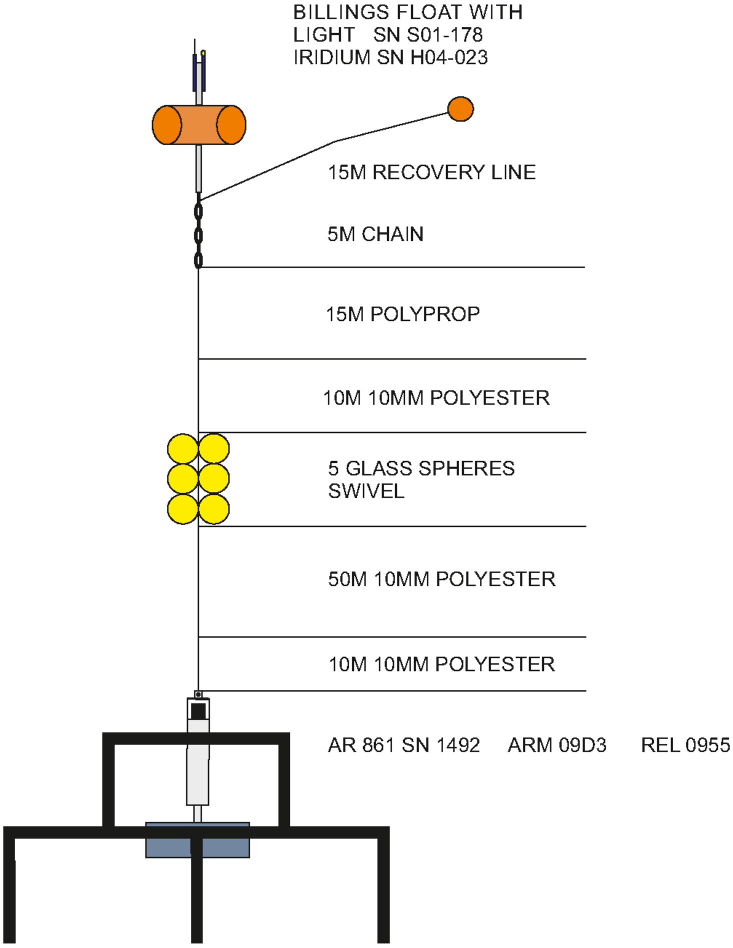
Amphipod Trap

Three successful deployments were made, each of approximately 48 hours duration. The amphipod trap was deployed top first from the red deck with the recovery float, billings and top 25 m of rope deployed by hand. The glass buoyancy package and final 60 m of rope were deployed using the central 5t deck winch with the line running through a hanging block suspended by the port pedestal crane. The trap itself was lifted off the red deck and into the water using the starboard pedestal crane and was released by using a Seacatch.

The trap was ranged down to the seabed, descent speeds were around 63m/min and ascent speeds were approximately 32m/min.

Despite the good weather throughout JC247, the amphipod trap was difficult to locate visually once on the surface. Position information provided by the iridium beacon was required to locate and retrieve the trap.

AMPHIPOD TRAP
DEPLOYED JC247
2023



SENSORS & MOORINGS

6.2 CTD operations

Thomas Ballinger

17 CTD casts were undertaken with an NMF 24-way Stainless Steel CTD frame with 24 of 20l Niskin water samplers. Dual SBE 43 dissolved oxygen sensors were used. The primary temperature, conductivity and dissolved oxygen sensors were fitted to the vane with the secondary sensors mounted on the Seabird 9 Plus. The shallowest cast was CTD001 at 50m, the deepest was CTD016 at 4827 m. The CTD was deployed on CTD wire storage drum 2.

The winch system Active Heave Compensation was used throughout JC247 to great effect. There was significant improvements in both package decent/ accent rates and the winch back tension. It should be standard practice for the AHC to be used for CTD operations.

There was a fouling event at max wire on CTD012 during which the primary sensors became noisy. This became more noticeable throughout the upcast, particularly in the oxygen data. Upon recovery both the primary and secondary sensors were flushed with bleach and triton-x solutions and then thoroughly flushed with MilliQ. The frame and optical sensors were also all cleaned as there were visible signs of fouling.

Between casts the whole CTD package was rinsed with fresh water with particular attention paid to the SBE 32 latch assembly. After each cast the primary and secondary sensors were flushed three times with MilliQ. Periodically the optical sensors were cleaned with MilliQ and Optic Prep wipes.

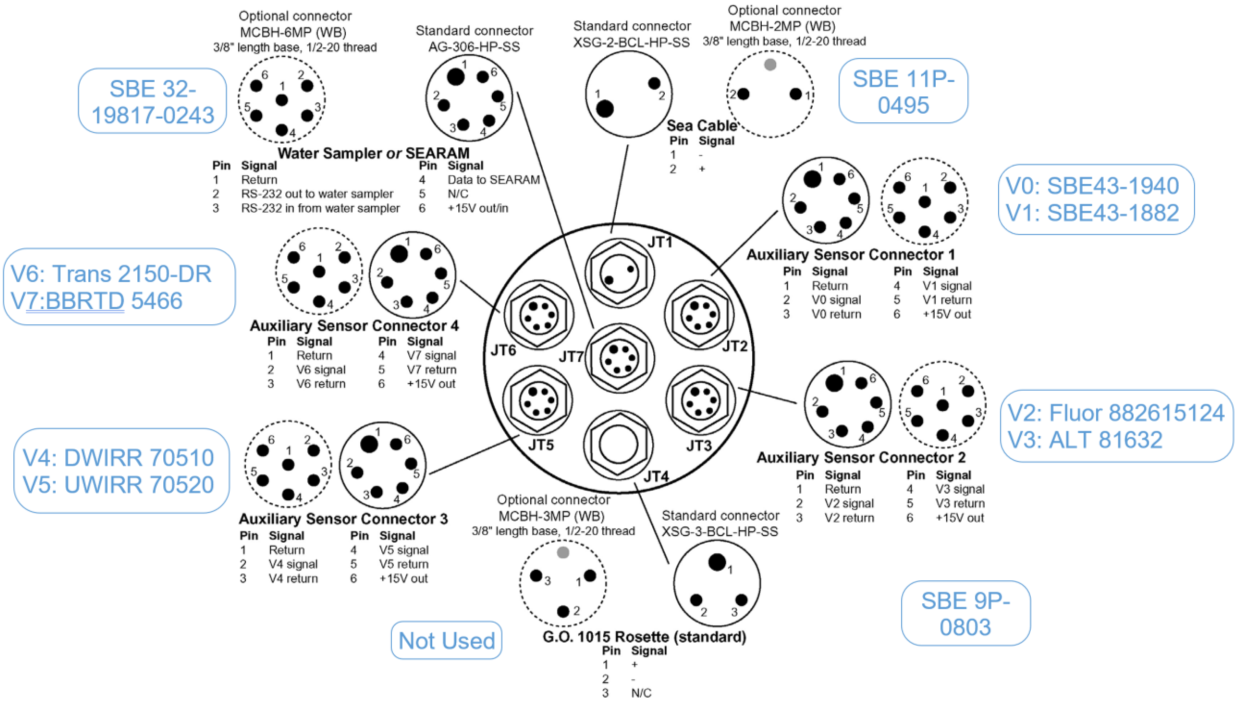
There were no major technical issues with the Stainless Steel CTD suite during JC247. A step down of 0.5% was noticed in beam transmission during cast 16, however it continued to record in its operational range. There were a number of Niskin misfires on bottle 9, this was due to the latch sticking, a jumper was added to the carousel to reduce the pressure on latch position 9. Bottle 5 occasionally had a slow leak from the bottom cap once the seal was opened, a new O-ring was fitted but leaking was noticed intermittently.

CTD Configuration

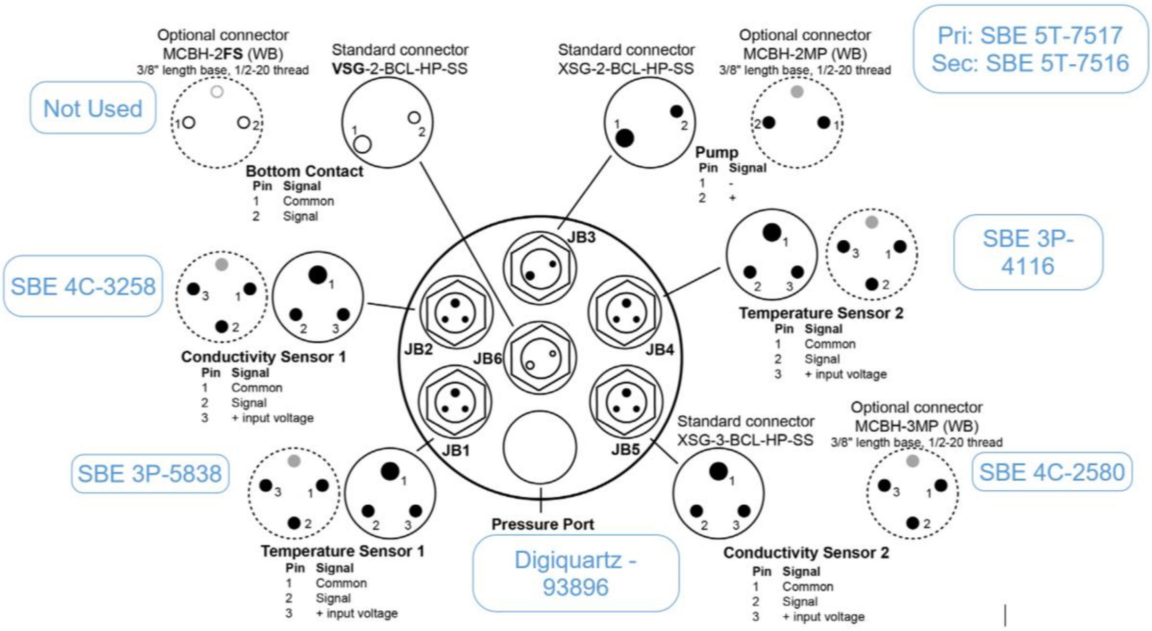
Stainless Steel CTD Instrument Package

Instrument / Sensor	Manufacturer/ Model	Serial Number	Channel	Casts Used
Primary CTD deck unit	SBE 11plus	11P-19817-0495	n/a	All casts
CTD Underwater Unit	SBE 9plus	09P-39607-0803	n/a	All casts
Stainless steel 24-way CTD frame	NOCS	SBE CTD8	n/a	All casts
Primary Temperature Sensor	SBE 3P	03P-5838	F0	All casts
Primary Conductivity Sensor	SBE 4C	04C-3258	F1	All casts
Digiquartz Pressure sensor	Paroscientific	93896	F2	All casts
Secondary Temperature Sensor	SBE 3P	03P-4116	F3	All casts
Secondary Conductivity Sensor	SBE 4C	04C-2580	F4	All casts
Primary Pump	SBE 5T	05T-7517	n/a	All casts
Secondary Pump	SBE 5T	05T-7516	n/a	All casts
24-way Carousel	SBE 32	32-19817-0243	n/a	All casts
Primary Dissolved Oxygen Sensor	SBE 43	43-1940	V0	All casts
Secondary Dissolved Oxygen Sensor	SBE 43	43-1882	V1	All casts
Fluorometer	Chelsea Aqua 3	88-2615-124	V2	All casts
Altimeter	Valeport VA500	81632	V3	All casts
Biospherical PAR DWIRR	Biospherical Insttruments	70510	V4	All casts
Biospherical PAR UWIRR	Biospherical Instruments	70520	V5	All casts
Transmissometer	WetLabs C-Star	CST-2150DR	V6	All casts
BBRTD	WetLabs ECO-AFL	5466	V7	All casts
20L Water Samplers	Ocean Test Equipment	Set A	n/a	All casts
Titanium EM CTD Swivel	MDS V2_2	1253-2	n/a	All casts
CO2 Sensor	CONTROS HydroB 20s	CO2-1019-006	n/a	Casts 008-012
CO2 Battery Housing	CONTROS HydroB 20s	20C-001	n/a	Casts 008-012
CO2 Pump	CONTROS HydroB 20s	05T-10112	n/a	Casts 008-012

SBE 9plus CTD Top End Cap Configuration



SBE 9plus CTD Bottom End Cap Configuration



Seasave Configurations & Instrument Calibrations

PSA file: C:\Users\sandm\Documents\Cruises\JC247\Data\Seasave Setup Files\JC247_0803_SS_nmea.psa
Date: 05/20/2023
Instrument configuration file: C:\Users\sandm\Documents\Cruises\JC247\Data\Seasave Setup Files\JC247_0803_SS_nmea.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-5838
Calibrated on : 21-Jun-22
G : 4.34201005e-003
H : 6.69357507e-004
I : 2.68285907e-005
J : 2.15005389e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-3258
Calibrated on : 23-Jun-22
G : -1.06618831e+001
H : 1.36169803e+000
I : -1.76754051e-004
J : 8.92351086e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 93896
Calibrated on : 12 November 2020
C1 : -8.331332e+004
C2 : -3.281962e-001
C3 : 2.216060e-002
D1 : 2.906000e-002
D2 : 0.000000e+000
T1 : 3.005232e+001
T2 : -3.843669e-004
T3 : 4.436390e-006
T4 : 0.000000e+000
T5 : 0.000000e+000
Slope : 1.00005000
Offset : -2.68480
AD590M : 1.289250e-002
AD590B : -8.106440e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-4116
Calibrated on : 15-Feb-22
G : 4.41813352e-003
H : 6.83200218e-004
I : 2.41440471e-005
J : 2.01915192e-006
F0 : 1000.000
Slope : 1.00000000

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

Serial number : 70520
Calibrated on : 13 August 2021
M : 1.00000000
B : 0.00000000
Calibration constant : 15384620000.00000000
Conversion units : umol photons/m^2/sec
Multiplier : 1.00000000
Offset : -0.06666738

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

Serial number : CST-2150DR
Calibrated on : 17 Septl 2021
M : 21.5314
B : -0.1313
Path length : 0.250

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

Serial number : 5466
Calibrated on : 28 April 2022
ScaleFactor : 0.003481
Dark output : 0.066000

Scan length : 41

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

Data Acquisition:
Archive data: NO
Delay archiving: NO
Data archive: C:\Users\sandm\Documents\Cruises\JC247\Data\CTD Raw Data\JC247_001.hex
Timeout (seconds) at startup: 60
Timeout (seconds) between scans: 20

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

Water Sampler Data:
Water Sampler Type: SBE Carousel
Number of bottles: 36
Port: COM5
Enable remote firing: NO
Firing sequence: User input
Tone for bottle fire confirmation uses PC sound card.

Header information:
Header Choice = Prompt for Header Information
prompt 0 = Ship: RRS James Cook
prompt 1 = Cruise: JC247
prompt 2 = Cast:
prompt 3 = Station:
prompt 4 = Julian Day:
prompt 5 = Date:
prompt 6 = Time (UTC):

Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-2580
Calibrated on : 25-Jan-22
G : -1.04651671e+001
H : 1.53673829e+000
I : 1.17991776e-003
J : 2.33292989e-006
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-1940
Calibrated on : 08-JUL-2021
Equation : Sea-Bird
Soc : 5.34300e-001
Offset : -4.97900e-001
A : -3.50440e-003
B : 1.75520e-004
C : -2.46610e-006
E : 3.60000e-002
Tau20 : 1.45000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Oxygen, SBE 43, 2

Serial number : 43-1882
Calibrated on : 06-Jul-22
Equation : Sea-Bird
Soc : 4.98000e-001
Offset : -4.97200e-001
A : -5.21160e-003
B : 1.98590e-004
C : -2.49030e-006
E : 3.60000e-002
Tau20 : 1.51000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

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

Serial number : 88-2615-124
Calibrated on : 11 October 2021
VB : 0.186400
V1 : 1.890430
Vacetone : 0.906790
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

9) A/D voltage 3, Altimeter

Serial number : 81632
Calibrated on : 9 June 2022
Scale factor : 15.000
Offset : 0.000

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

Serial number : 70510
Calibrated on : 13 August 2021
M : 1.00000000

prompt 7 = Latitude:
prompt 8 = Longitude:
prompt 9 = Depth (uncorrected m):
prompt 10 = Principal Scientist: Andrew Gates
prompt 11 = Operator: TB

TCP/IP - port numbers:
Data acquisition:
Data port: 49163
Status port: 49165
Command port: 49164
Remote bottle firing:
Command port: 49167
Status port: 49168
Remote data publishing:
Converted data port: 49161
Raw data port: 49160

Miscellaneous data for calculations
Depth, Average Sound Velocity, and TEOS-10
Latitude when NMEA is not available: 52.000000
Longitude when NMEA is not available: 0.000000
Average Sound Velocity
Minimum pressure [db]: 20.000000
Minimum salinity [psu]: 20.000000
Pressure window size [db]: 20.000000
Time window size [s]: 60.000000
Descent and Acceleration
Window size [s]: 2.000000
Plume Anomaly
Theta-B: 0.000000
Salinity-B 0.000000
Theta-Z / Salinity-Z 0.000000
Reference pressure [db] 0.000000
Oxygen
Window size [s]: 2.000000
Apply hysteresis correction: 0
Apply Tau correction: 1
Potential Temperature Anomaly
A0: 0.000000
A1: 0.000000
A1 Multiplier: Salinity

Serial Data Output:
Output data to serial port: NO

Mark Variables:
No variables are selected.

Shared File Output:
Output data to shared file: NO

TCP/IP Output:
Raw data:
Output raw data to socket: NO
XML wrapper and settings: NO
Seconds between raw data updates: 0.000000
Converted data:
Output converted data to socket: NO
XML format: NO

SBE 11plus Deck Unit Alarms
Enable minimum pressure alarm: NO
Enable maximum pressure alarm: NO
Enable altimeter alarm: NO

SBE 14 Remote Display
Enable SBE 14 Remote Display: NO

PC Alarms
Enable minimum pressure alarm: NO
Enable maximum pressure alarm: NO
Enable altimeter alarm: NO
Enable bottom contact alarm: NO
Alarm uses PC sound card.

B : 0.00000000 Calibration constant : 16666670000.00000000 Conversion units : umol photons/m^2/sec Multiplier : 1.00000000 Offset : -0.06110141	-- Options: Prompt to save program setup changes: YES Automatically save program setup changes on exit: NO Confirm instrument configuration change: YES Confirm display setup changes: YES Confirm output file overwrite: YES Check scan length: YES Compare serial numbers: YES Maximized plot may cover Seasave: NO

Technical Report

Stainless Steel CTD Wire CTD2

All stainless steel casts were carried out using wire CTD2, which was terminated using the potting method. The CTD wire was electrically tested prior to sailing and had an insulation resistance of > 999 MΩ at 250V.

The mechanical termination was load tested as per the standard CTD load test of 5 minutes at 0.5T, 1.0T, 1.5T and 10 minutes at 2.0T. The mechanical termination did not slip under load. The mechanical termination was checked periodically throughout the cruise with no movement observed.

AUTOSAL

A Guildline 8400B, s/n 71126 was installed in the Electronics Workshop as the main Autosal for salinity analysis. The bath temperature was set to 21°C with the lab ambient temperature ranging between 18°C – 19°C. The salinometer was standardised prior to the start of analysis.

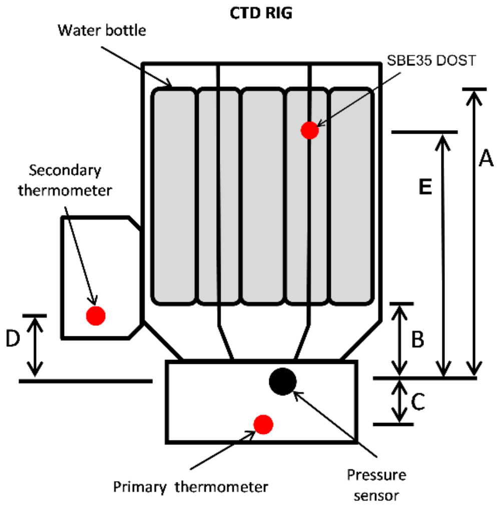
The Autosal was standardised using IAPSO Standard Seawater batch P164 (K15 = 0.9985, 2 x K15 = 1.99970). Once standardised the Autosal was not adjusted for the duration of sampling. A standard was analysed after each crate of samples to monitor and record drift. Standard deviation was set to 0.00002. The electronic standby value after the standardisation was stable at 6005 – 6006.

In total four crates were analysed by Sensors and Moorings, 3 CTD crates and 1 underway crate.

CONTROS CO2

A contros Hydro C CO2 sensor was fitted vertically to the CTD on casts CTD008 - CTD012. At the request of the manufacturer casts 008 and 009 had a maximum decent/ accent rate of 30m/min to minimise the risk of the head flooding as seen on DY116. This was only to mitigate the possibility of sensor failure, data collected while profile was unusable as the response rate of the sensor is too slow. The accent/ decent rates increased to the normal working speed of 60m/min for the remainder of casts with the CO2 sensor. No increase in the sensor head humidity was recorded, normal operating speeds can resume with the Contros installed on the CTD.

Stainless Steel CTD Frame Geometry



ID	Vertical distance from pressure sensor (m positive-up)
A	1.3 (Top of water samplers)
B	0.2 (Bottom of water samplers)
C	-0.075 (Secondary T mounted on 9p)
D	0.085 (Primary T mounted on Vane)
E	Not fitted

Sea-Bird Data Processing

The table below lists the Sea-Bird processing routines run by Sensors and Moorings Technicians.

Note this is only the modules that were run by NMF, not by scientific staff.

Module	Run?	Comments
Configure	N	
Data Conversion	Y	**As per BODC guidelines Version1.0 October 2010 (Oxygen Concentration umol/l and umol/kg, Latitude and Longitude (degrees), Scan Count, Time and Pressure Temperature)**
Bottle Summary	Y	**As per BODC guidelines Version1.0 October 2010, with above variables added (except not averaging Scan Count and Time)**
Mark Scan	N	
Align CTD	Y	As per BODC guidelines Version1.0 October 2010 **(dissolved oxygen advanced 6 seconds)** (appended file name)
Buoyancy	N	
Cell Thermal Mass	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Derive	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Bin Average	Y	As per BODC guidelines Version1.0 October 2010 **(1 metre depth bins)** (appended file name)
Filter	N	As per BODC guidelines Version1.0 October 2010 (appended file name)
Loop Edit	N	As per BODC guidelines Version1.0 October 2010 (appended file name)
Wild Edit	N	**Not applicable.**
Window Filter	N	
ASCII In	N	
ASCII Out	N	
Section	N	
Split	N	
Strip	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Translate	N	
Sea Plot	N	
SeaCalc II	N	

Software Used

- SeaBird SeaTerm 1.59
- SeaBird SeaSave 7.26.7.121
- SeaBird SBE Data Processing 7.26.6.28
- CONTROS Detect

6.3 Instrumentation Report

Dave Childs

Introduction

A range of different instruments are used across the Whittard Canyon, PAP1 and PAP3 moorings including Sea-Bird SBE 37 Microcat CTD's, Nortek Aquadopp Current Meters, Teledyne ADCP's and McLANE Sediment Traps. In addition to these instruments, a user supplied Anderson Sediment Trap was also used.

All instrumentation was serviced and tested back at NOC prior to being loaded for JC247 and had new battery packs installed where required.

All Ixsea releases were serviced, and bench tested at NOC prior to the cruise, but in order to verify their operation at depth all of the releases were attached to the CTD frame and then tested using the TT801 Deck Unit and the ship fitted transducer on the drop keel. No issues were observed or noted using this setup, however improved performance was noted on deeper CTD casts or mooring locations when the drop keel was lowered.

Whittard Canyon Mooring

For the Whittard Canyon Mooring 2023 deployment the following instrumentation was used:

Instrument	Serial Number
Sea-Bird SBE 37	6904
Sea-Bird SBE 37	6907
Teledyne 600 kHz ADCP	21071
Teledyne 75 kHz ADCP	22791
Novatech Light	H01-009
Novatech Iridium	H03-061
Ixsea Release	1497
Ixsea Release	1502
Anderson Sediment Trap	N/A

Both ADCP's were programmed in the lab prior to being fitted into the deepwater syntactic buoyancy and an audio check was performed to make sure the instruments were logging before being deployed.

The following configuration settings were applied to the ADCP's, assuming a 400 day deployment. This was to allow for a full year's deployment plus some additional time to cover any possible delays in the turnaround next year.

SN: 22791 (75 kHz)	SN: 21071 (600 kHz)
CR1 CQ255 CF11101 EA0 EB0 ED0 ES35 EX11111 EZ1111111 WA50 WB1 WD111100000 WF704 WN37 WP20 WS1600 WV175 TE00:30:00.00 TP00:05.00 CK CS ; ;Instrument = Workhorse Long Ranger ;Frequency = 76800 ;Water Profile = YES ;Bottom Track = NO ;High Res. Modes = NO ;High Rate Pinging = NO ;Shallow Bottom Mode= NO ;Wave Gauge = NO ;Lowered ADCP = NO ;Beam angle = 20 ;Temperature = 5.00 ;Deployment hours = 8760.00 ;Battery packs = 4 ;Automatic TP = NO ;Memory size [MB] = 256 ;Saved Screen = 2 ; ;Consequences generated by PlanADCP version 2.04: ;First cell range = 24.45 m ;Last cell range = 600.45 m ;Max range = 600.12 m ;Standard deviation = 1.69 cm/s ;Ensemble size = 894 bytes ;Storage required = 14.94 MB (15662880 bytes) ;Power usage = 2956.87 Wh ;Battery usage = 6.6 ; ; WARNINGS AND CAUTIONS: ; Advanced settings have been changed.	[BREAK Wakeup A] WorkHorse Broadband ADCP Version 50.40 Teledyne RD Instruments (c) 1996-2010 All Rights Reserved. >CR1 [Parameters set to FACTORY defaults] >CF11101 >EA0 >EB0 >ED15500 >ES35 >EX11111 >EZ1111101 >WA50 >WB0 >WD111100000 >WF88 >WN30 >WP10 >WS100 >WV175 >TE00:01:30.00 >TP00:05.00 >TF23/05/06 12:30:00 >CK [Parameters saved as USER defaults] >The command CS is not allowed in this command file. It has been ignored. >The following commands are generated by this program: >CF? CF = 11101 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec) >CF11101 >RN JC247 >cs

For the Sea-Bird SBE 37 Microcats, the following settings were used. Each instrument was programmed using Sea-Bird SeaTerm Version 2 software.

SN: 6904	SN: 6907
S>#13DS SBE37-IM 3.0b SERIAL NO. 6904 06 May 2023 12:51:48 vMain = 6.82, vLith = 2.93 samplenumber = 0, free = 559240 not logging, waiting to start at 07 May 2023 12:00:00 sample interval = 1800 seconds data format = converted engineering do not transmit sample number pump installed = yes, minimum conductivity frequency = 3123.6 PC baud rate = 9600 <Executed/> S>	S>#12DS SBE37-IM 3.0b SERIAL NO. 6907 06 May 2023 12:17:50 vMain = 6.94, vLith = 2.77 samplenumber = 0, free = 559240 not logging, waiting to start at 07 May 2023 12:00:00 sample interval = 1800 seconds data format = converted engineering do not transmit sample number pump installed = yes, minimum conductivity frequency = 3098.8 PC baud rate = 9600 <Executed/> S>

For the sediment trap on the Whittard Canyon mooring the decision was made to use an Anderson Sediment Trap, this was assembled on board the cruise rather than being set up at NOC. Due to the lack of a working electronics timer unit, the trap was deployed without one, with the view of the trap being used just to collect sediment.

For the Whittard Canyon mooring recovery, each instrument was cleaned and washed in fresh water, dried and then stopped before the data was downloaded.

- Sea-Bird SBE 37 SN: 9385, Logging data upon recovery.
- Sea-Bird SBE 37 SN: 9386, Logging data upon recovery.
- TRDI 75 kHz ADCP SN: 5575 Logging data upon recovery.
- TRDI 600 kHz ADCP SN: 23184 Logging data upon recovery.
- Anderson Sediment Trap: Recovered with sediment collected.

The Anderson sediment trap timer had released 4 disks, however these remained mixed with sediment within the top funnel section of the trap and had not dropped through to the collection tube as expected.

PAP1

Four Sea-Bird SBE 37 IMP's were used on the PAP1 Mooring, with each instrument having a unique inductive ID number. These instruments were set up at NOCS prior to the cruise and fitted to the sensor frame and buoy as required.

SN: 6909

```
S>#36ds
SBE37-IM 3.0b  SERIAL NO. 6909  24 Apr 2023 13:32:42
vMain =  6.97, vLith =  2.74
samplenumber = 0, free = 559240
not logging, stop command
sample interval = 10 seconds
data format = converted engineering alternate
transmit sample number
pump installed = yes, minimum conductivity frequency = 3024.4
PC baud rate = 9600
<Executed/>
S>#36sampleinterval=900
<Executed/>
S>#36startdatetime=04242023140000
<start dateTime = 24 Apr 2023 14:00:00/>
<Executed/>
S>#36ts
06909,  -0.0015,  17.3344,   -0.135, 13:35:51, 24-04-2023, 0
<Executed/>
S>#36sl
06909,  -0.0015,  17.3344,   -0.135, 13:35:51, 24-04-2023, 0
<Executed/>
S>#36ds
  S>pwron

sending wake up tone, wait 4 seconds
S>#36getcd
<ConfigurationData DeviceType = 'SBE37-IM' SerialNumber =
'03706909'>
   <PressureInstalled>yes</PressureInstalled>
   <PumpInstalled>yes</PumpInstalled>
   <MinCondFreq>3024.4</MinCondFreq>
   <SampleDataFormat>converted engineering
alternate</SampleDataFormat>
   <OutputTime>yes</OutputTime>
   <TxSampleNumber>yes</TxSampleNumber>
   <SampleInterval>900</SampleInterval>
   <PCBaudRate>9600</PCBaudRate>
</ConfigurationData>
<Executed/>
S>#36startlater
<!--start logging at = 24 Apr 2023 14:00:00, sample interval =
900 seconds-->
<Executed/>
```

SN: 24126

```
S>#47ds
SBE37IMP-ODO v6.1.1  SERIAL NO. 24126  24 Apr 2023 05:46:17
vMain = 13.67, vLith =  2.75
samplenumber = 0, free = 399457
not logging, never started
sample interval = 600 seconds
data format = converted engineering
output temperature, Celsius
output conductivity, S/m
output pressure, Decibar
output oxygen, ml/L
output sample number
minimum conductivity frequency = 3074.0
adaptive pump control disabled, pump on time 7.0 * 5.5 = 38.5 sec
RS232 baud rate = 9600
<Executed/>
S>#47datetime=04242023134800
<Executed/>
S>#47sampleinterval=1800
<Executed/>
S>#47ds
SBE37IMP-ODO v6.1.1  SERIAL NO. 24126  24 Apr 2023 13:48:18
vMain = 13.73, vLith =  2.75
samplenumber = 0, free = 399457
not logging, never started
sample interval = 1800 seconds
data format = converted engineering
output temperature, Celsius
output conductivity, S/m
output pressure, Decibar
output oxygen, ml/L
output sample number
minimum conductivity frequency = 3074.0
adaptive pump control disabled, pump on time 7.0 * 5.5 = 38.5 sec
RS232 baud rate = 9600
<Executed/>
S>#47getcd
<ConfigurationData DeviceType='SBE37IMP-ODO'
SerialNumber='03724126'>
   <PressureInstalled>yes</PressureInstalled>
   <SampleDataFormat>converted
engineering</SampleDataFormat>
   <TemperatureUnits>Celsius</TemperatureUnits>
   <ConductivityUnits>S/m</ConductivityUnits>
   <PressureUnits>Decibar</PressureUnits>
   <OxygenUnits>ml/L</OxygenUnits>
   <OutputTemperature>yes</OutputTemperature>
   <OutputConductivity>yes</OutputConductivity>
   <OutputPressure>yes</OutputPressure>
   <OutputOxygen>yes</OutputOxygen>
   <OutputSalinity>no</OutputSalinity>
   <OutputSV>no</OutputSV>
   <OutputSC>no</OutputSC>
   <SCCoeff>0.0200</SCCoeff>
   <OutputTime>yes</OutputTime>
   <TxSampleNumber>yes</TxSampleNumber>
   <SampleInterval>1800</SampleInterval>
   <MinCondFreq>3074.0</MinCondFreq>
   <AdaptivePumpControl>no</AdaptivePumpControl>
   <nTau>7.0</nTau>
   <PumpOnTime>38.5</PumpOnTime>
   <RS232BaudRate>9600</RS232BaudRate>
   <LegacyMode>no</LegacyMode>
   <CompatibleMode>no</CompatibleMode>
</ConfigurationData>
<Executed/>
S>#47ts
24126,  18.3756,  0.00007,   -0.188,  6.425, 24 Apr 2023, 13:48:55
<Executed/>
S>#47sl
24126,  18.3756,  0.00007,   -0.188,  6.425, 24 Apr 2023, 13:48:55
<Executed/>
S>#47startdatetime=04242023140000
```

	<start dateTime = 24 Apr 2023 14:00:00/> <Executed/> S>start#47startlater <!--start logging at = 24 Apr 2023 14:00:00, sample interval = 1800 seconds--> <Executed/> S> S>pwron sending wake up tone, wait 4 seconds S>#36ds SBE37-IM 3.0b SERIAL NO. 6909 25 Apr 2023 12:00:42 vMain = 6.96, vLith = 2.75 samplenumber = 89, free = 559151 logging sample interval = 900 seconds data format = converted engineering alternate transmit sample number pump installed = yes, minimum conductivity frequency = 3024.4 PC baud rate = 9600 <Executed/> S>#36sl 06909, -0.0015, 14.6302, -0.022, 12:00:01, 25-04-2023, 89 <Executed/> S>#36stop <logging stopped/> <Executed/> S>#36outputformat=1 <Executed/> S>#36sl 06909, 14.6302, -0.00015, -0.022, 25 Apr 2023, 12:00:01, 89 <Executed/> S>#36txsamplenum=N <Executed/> S>#36sl 06909, 14.6302, -0.00015, -0.022, 25 Apr 2023, 12:00:01 <Executed/> S>#47sl 24126, 14.8455, 0.00007, -0.366, 6.783, 25 Apr 2023, 12:00:01, 45 <Executed/> S>#47txsamplenum=N <Error type='NOT ALLOWED' msg='Cmd not recognized'/> <Executed/> S>#47stop <!--logging stopped--> <Executed/> S>#47txsamplenum=N <Executed/> S>#47sl 24126, 14.8455, 0.00007, -0.366, 6.783, 25 Apr 2023, 12:00:01 <Executed/> S>#47startdatetime=04252023123000 <start dateTime = 25 Apr 2023 12:30:00/> <Executed/> S>#startlater S>#47startlater <!--start logging at = 25 Apr 2023 12:30:00, sample interval = 1800 seconds--> <Executed/>

A SBE SeaFET instrument was recovered from the PAP1 mooring that failed to communicate when the scientific party tried to download the data. An initial inspection showed the instrument was in good condition and didn't have any signs of water ingress or flooding.

Each end cap from the instrument was carefully removed, after which it was found that one of the internal desiccant bags had been punctured and had spilled its contents into the housing and had spread to the o-rings fitted to the end caps.

With such debris around the o-rings a perfect seal would have been hard to achieve, however the instrument didn't flood and I think this was extremely lucky.

SBE SeaFET with desiccant around o-ring.

SBE SeaFET with desiccant inside housing.

With the instrument cleaned and all traces of desiccant removed a visual inspection of the internal electronics took place, however no damage or signs of water ingress could be found, so the end caps were re-fitted.

Several attempts with different comms and power leads were tried, along with different laptops running the Sea-Bird software but unfortunately despite our best efforts the instrument remained unresponsive and the decision was made that it would have to be returned to Sea-Bird for evaluation.

For the PAP1 recovered instruments, each instrument was cleaned and washed in fresh water, dried and then stopped before the data was downloaded. Both sets of SBE 37's had suffered from heavy marine fouling.

- SBE 37 SN: 9475 #46 was still logging data, 35612 samples. It was noted this instrument had a -15s time difference to GMT
- SBE 37 SN: 23950 was flooded at some point during deployment, no data recovered
- SBE 37 SN: 21210 #12 was still logging data, 17853 samples. It was noted this instrument had an +08 second time difference to GMT
- SBE 37 SN: 9469 #33 was still logging data, 38152 samples. It was noted this instrument had an -03 second time difference to GMT

A visual inspection of the recovered instruments showed that on the instruments mounted in the PAP1 Frame, some of the sensor guard securing screws had worked lose, with some missing completely.

All data was saved locally to the moorings laptops and then uploaded to the network drive and made available for the scientific party.

Unfortunately, SBE 37 ODO SN: 23960 had flooded during the deployment and it was not possible to recover any data from the instrument. Having secured the instrument in a well-ventilated area the screws on the end cap were slowly undone a quarter of a turn at a time until the instrument had finished venting, once all internal pressure had escaped the end cap was removed, as well as the internal battery pack.

Flooded SBE 37 ODO SN: 23950.

Flooded SBE 37 ODO SN: 23950 Battery Pack.

It was noted that the internal pump housing and ODO sensor had worked loose during the deployment, and this was the likely cause of the flooding. This can been seen in the photos below.

.


Flooded SBE 37 ODO SN: 23950 Loose sensor.


Flooded SBE 37 ODO SN: 23950 Loose pump housing.

PAP3

For the PAP3 recovered instruments, each instrument was cleaned and washed in fresh water, dried and then stopped before the data was downloaded.

- SBE 37 SN: 12463 was still logging data, 17981 samples. It was noted this instrument had a -06 second time difference to GMT
- Nortek CM SN: 6178 was still logging data. It was noted this instrument had a -36 second time difference to GMT
- Nortek CM SN: 8351 was still logging data. It was noted this instrument had a -41 second time difference to GMT

All three sediment traps were secured on deck once the mooring recovery had been completed. All sample bottles were removed by the technical party and safely stowed in fridges in the lab. Once all of the samples had been removed the instruments log files were downloaded.

- SN: ML11262-08 - 17 events completed, recovered early, still logging – battery voltage normal
- SN: ML11262-09 -17 events completed, recovered early, still logging – battery voltage normal
- SN: ML11262-10 - 17 events completed, recovered early, still logging – battery voltage normal

ML11262-09 Event Log

PAP 2022/23
JC231 TRAP A

SCHEDULE

Event 01 of 22 @ 05/08/2022 12:00:00
Event 02 of 22 @ 05/22/2022 12:00:00
Event 03 of 22 @ 06/05/2022 12:00:00
Event 04 of 22 @ 06/26/2022 12:00:00
Event 05 of 22 @ 07/17/2022 12:00:00
Event 06 of 22 @ 08/07/2022 12:00:00
Event 07 of 22 @ 08/28/2022 12:00:00
Event 08 of 22 @ 09/18/2022 12:00:00
Event 09 of 22 @ 10/09/2022 12:00:00
Event 10 of 22 @ 10/30/2022 12:00:00
Event 11 of 22 @ 11/20/2022 12:00:00
Event 12 of 22 @ 12/11/2022 12:00:00
Event 13 of 22 @ 01/08/2023 12:00:00
Event 14 of 22 @ 02/05/2023 12:00:00
Event 15 of 22 @ 03/05/2023 12:00:00
Event 16 of 22 @ 04/02/2023 12:00:00
Event 17 of 22 @ 04/30/2023 12:00:00
Event 18 of 22 @ 05/21/2023 12:00:00
Event 19 of 22 @ 06/11/2023 12:00:00
Event 20 of 22 @ 07/02/2023 12:00:00
Event 21 of 22 @ 07/23/2023 12:00:00
Event 22 of 22 @ 08/13/2023 12:00:00

DEPLOYMENT DATA

Event 01

Scheduled start time: 05/08/2022 12:00:00
Event start time: 05/08/2022 12:00:00
Event stop time: 05/08/2022 12:00:29

Aligned Battery Temperature Tilt
Heading
Start: Y 19.8 3øC 0ø 0ø
Stop: Y 19.5 3øC 0ø 0ø

Event 02

Scheduled start time: 05/22/2022 12:00:00
Event start time: 05/22/2022 12:00:00
Event stop time: 05/22/2022 12:00:29

Aligned Battery Temperature Tilt
Heading
Start: Y 19.3 3øC 0ø 0ø
Stop: Y 19.1 4øC 0ø 0ø

Event 03

Scheduled start time: 06/05/2022 12:00:00
Event start time: 06/05/2022 12:00:00
Event stop time: 06/05/2022 12:00:29

Aligned Battery Temperature Tilt
Heading
Start: Y 19.1 3øC 0ø 0ø
Stop: Y 18.8 3øC 0ø 0ø

Event 04

Scheduled start time: 06/26/2022 12:00:00
Event start time: 06/26/2022 12:00:00
Event stop time: 06/26/2022 12:00:29

Aligned Battery Temperature Tilt
Heading
Start: Y 18.5 3øC 0ø 0ø
Stop: Y 18.3 3øC 0ø 0ø

Event 05

Scheduled start time: 07/17/2022 12:00:00
Event start time: 07/17/2022 12:00:00
Event stop time: 07/17/2022 12:00:29

Aligned Battery Temperature Tilt
Heading

ML11262-08 Event Log

PAP 2022/23
JC231 TRPA B

SCHEDULE

Event 01 of 22 @ 05/08/2022 12:00:00
Event 02 of 22 @ 05/22/2022 12:00:00
Event 03 of 22 @ 06/05/2022 12:00:00
Event 04 of 22 @ 06/26/2022 12:00:00
Event 05 of 22 @ 07/17/2022 12:00:00
Event 06 of 22 @ 08/07/2022 12:00:00
Event 07 of 22 @ 08/28/2022 12:00:00
Event 08 of 22 @ 09/18/2022 12:00:00
Event 09 of 22 @ 10/09/2022 12:00:00
Event 10 of 22 @ 10/30/2022 12:00:00
Event 11 of 22 @ 11/20/2022 12:00:00
Event 12 of 22 @ 12/11/2022 12:00:00
Event 13 of 22 @ 01/08/2023 12:00:00
Event 14 of 22 @ 02/05/2023 12:00:00
Event 15 of 22 @ 03/05/2023 12:00:00
Event 16 of 22 @ 04/02/2023 12:00:00
Event 17 of 22 @ 04/30/2023 12:00:00
Event 18 of 22 @ 05/21/2023 12:00:00
Event 19 of 22 @ 06/11/2023 12:00:00
Event 20 of 22 @ 07/02/2023 12:00:00
Event 21 of 22 @ 07/23/2023 12:00:00
Event 22 of 22 @ 08/13/2023 12:00:00

DEPLOYMENT DATA

Event 01

Scheduled start time: 05/08/2022 12:00:00
Event start time: 05/08/2022 12:00:00
Event stop time: 05/08/2022 12:00:27

Aligned Battery Temperature Tilt
Heading
Start: Y 19.0 3øC 1ø 206ø
Stop: Y 18.7 3øC 1ø 207ø

Event 02

Scheduled start time: 05/22/2022 12:00:00
Event start time: 05/22/2022 12:00:00
Event stop time: 05/22/2022 12:00:27

Aligned Battery Temperature Tilt
Heading
Start: Y 18.5 3øC 1ø 226ø
Stop: Y 18.1 3øC 1ø 231ø

Event 03

Scheduled start time: 06/05/2022 12:00:00
Event start time: 06/05/2022 12:00:00
Event stop time: 06/05/2022 12:00:27

Aligned Battery Temperature Tilt
Heading
Start: Y 18.2 3øC 1ø 158ø
Stop: Y 17.8 3øC 1ø 155ø

Event 04

Scheduled start time: 06/26/2022 12:00:00
Event start time: 06/26/2022 12:00:00
Event stop time: 06/26/2022 12:00:27

Aligned Battery Temperature Tilt
Heading
Start: Y 17.4 3øC 1ø 84ø
Stop: Y 17.3 3øC 1ø 93ø

Event 05

Scheduled start time: 07/17/2022 12:00:00
Event start time: 07/17/2022 12:00:00
Event stop time: 07/17/2022 12:00:27

Aligned Battery Temperature Tilt
Heading

ML11262-10 Event Log

PAP 2022/23
JC231 TRAP C

SCHEDULE

Event 01 of 22 @ 05/08/2022 12:00:00
Event 02 of 22 @ 05/22/2022 12:00:00
Event 03 of 22 @ 06/05/2022 12:00:00
Event 04 of 22 @ 06/26/2022 12:00:00
Event 05 of 22 @ 07/17/2022 12:00:00
Event 06 of 22 @ 08/07/2022 12:00:00
Event 07 of 22 @ 08/28/2022 12:00:00
Event 08 of 22 @ 09/18/2022 12:00:00
Event 09 of 22 @ 10/09/2022 12:00:00
Event 10 of 22 @ 10/30/2022 12:00:00
Event 11 of 22 @ 11/20/2022 12:00:00
Event 12 of 22 @ 12/11/2022 12:00:00
Event 13 of 22 @ 01/08/2023 12:00:00
Event 14 of 22 @ 02/05/2023 12:00:00
Event 15 of 22 @ 03/05/2023 12:00:00
Event 16 of 22 @ 04/02/2023 12:00:00
Event 17 of 22 @ 04/30/2023 12:00:00
Event 18 of 22 @ 05/21/2023 12:00:00
Event 19 of 22 @ 06/11/2023 12:00:00
Event 20 of 22 @ 07/02/2023 12:00:00
Event 21 of 22 @ 07/23/2023 12:00:00
Event 22 of 22 @ 08/13/2023 12:00:00

DEPLOYMENT DATA

Event 01

Scheduled start time: 05/08/2022 12:00:00
Event start time: 05/08/2022 12:00:00
Event stop time: 05/08/2022 12:00:27

Aligned Battery Temperature Tilt
Heading
Start: Y 19.4 3øC 1ø 358ø
Stop: Y 18.9 3øC 1ø 7ø

Event 02

Scheduled start time: 05/22/2022 12:00:00
Event start time: 05/22/2022 12:00:00
Event stop time: 05/22/2022 12:00:27

Aligned Battery Temperature Tilt
Heading
Start: Y 18.9 3øC 1ø 3ø
Stop: Y 18.6 3øC 1ø 359ø

Event 03

Scheduled start time: 06/05/2022 12:00:00
Event start time: 06/05/2022 12:00:00
Event stop time: 06/05/2022 12:00:27

Aligned Battery Temperature Tilt
Heading
Start: Y 18.6 3øC 1ø 24ø
Stop: Y 18.1 3øC 1ø 27ø

Event 04

Scheduled start time: 06/26/2022 12:00:00
Event start time: 06/26/2022 12:00:00
Event stop time: 06/26/2022 12:00:27

Aligned Battery Temperature Tilt
Heading
Start: Y 18.0 3øC 2ø 336ø
Stop: Y 17.7 3øC 2ø 335ø

Event 05

Scheduled start time: 07/17/2022 12:00:00
Event start time: 07/17/2022 12:00:00
Event stop time: 07/17/2022 12:00:27

Aligned Battery Temperature Tilt
Heading

Start: Y 18.2 3øC 0ø 0ø
Stop: Y 17.7 4øC 0ø 0ø

Event 06

Scheduled start time: 08/07/2022 12:00:00
Event start time: 08/07/2022 12:00:00
Event stop time: 08/07/2022 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y 17.9 3øC 0ø 0ø
Stop: Y 17.6 3øC 0ø 0ø

Event 07

Scheduled start time: 08/28/2022 12:00:00
Event start time: 08/28/2022 12:00:00
Event stop time: 08/28/2022 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y 17.9 3øC 0ø 0ø
Stop: Y 17.5 3øC 0ø 0ø

Event 08

Scheduled start time: 09/18/2022 12:00:00
Event start time: 09/18/2022 12:00:00
Event stop time: 09/18/2022 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y 17.7 3øC 0ø 0ø
Stop: Y 17.2 3øC 0ø 0ø

Event 09

Scheduled start time: 10/09/2022 12:00:00
Event start time: 10/09/2022 12:00:00
Event stop time: 10/09/2022 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y 17.4 3øC 0ø 0ø
Stop: Y 17.0 3øC 0ø 0ø

Event 10

Scheduled start time: 10/30/2022 12:00:00
Event start time: 10/30/2022 12:00:00
Event stop time: 10/30/2022 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y 17.3 3øC 0ø 0ø
Stop: Y 16.9 3øC 0ø 0ø

Event 11

Scheduled start time: 11/20/2022 12:00:00
Event start time: 11/20/2022 12:00:00
Event stop time: 11/20/2022 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y 16.9 3øC 0ø 0ø
Stop: Y 16.6 3øC 0ø 0ø

Event 12

Scheduled start time: 12/11/2022 12:00:00
Event start time: 12/11/2022 12:00:00
Event stop time: 12/11/2022 12:00:29

Aligned Battery Temperature Tilt Heading
Start: Y 16.8 3øC 0ø 0ø
Stop: Y 16.2 3øC 0ø 0ø

Event 13

Scheduled start time: 01/08/2023 12:00:00
Event start time: 01/08/2023 12:00:00
Event stop time: 01/08/2023 12:00:29

Start: Y 17.1 3øC 1ø 46ø
Stop: Y 16.9 3øC 1ø 52ø

Event 06

Scheduled start time: 08/07/2022 12:00:00
Event start time: 08/07/2022 12:00:00
Event stop time: 08/07/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 17.1 3øC 2ø 116ø
Stop: Y 16.5 3øC 1ø 124ø

Event 07

Scheduled start time: 08/28/2022 12:00:00
Event start time: 08/28/2022 12:00:00
Event stop time: 08/28/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.8 3øC 1ø 37ø
Stop: Y 16.3 3øC 1ø 37ø

Event 08

Scheduled start time: 09/18/2022 12:00:00
Event start time: 09/18/2022 12:00:00
Event stop time: 09/18/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.6 3øC 1ø 261ø
Stop: Y 16.2 3øC 1ø 260ø

Event 09

Scheduled start time: 10/09/2022 12:00:00
Event start time: 10/09/2022 12:00:00
Event stop time: 10/09/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.4 3øC 1ø 230ø
Stop: Y 16.0 3øC 1ø 231ø

Event 10

Scheduled start time: 10/30/2022 12:00:00
Event start time: 10/30/2022 12:00:00
Event stop time: 10/30/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.4 3øC 1ø 214ø
Stop: Y 15.9 3øC 1ø 216ø

Event 11

Scheduled start time: 11/20/2022 12:00:00
Event start time: 11/20/2022 12:00:00
Event stop time: 11/20/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.1 3øC 2ø 129ø
Stop: Y 15.6 3øC 1ø 140ø

Event 12

Scheduled start time: 12/11/2022 12:00:00
Event start time: 12/11/2022 12:00:00
Event stop time: 12/11/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 15.9 3øC 1ø 338ø
Stop: Y 15.4 3øC 1ø 342ø

Event 13

Scheduled start time: 01/08/2023 12:00:00
Event start time: 01/08/2023 12:00:00
Event stop time: 01/08/2023 12:00:27

Start: Y 17.6 3øC 3ø 303ø
Stop: Y 17.2 3øC 3ø 309ø

Event 06

Scheduled start time: 08/07/2022 12:00:00
Event start time: 08/07/2022 12:00:00
Event stop time: 08/07/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 17.3 3øC 4ø 343ø
Stop: Y 17.1 3øC 4ø 355ø

Event 07

Scheduled start time: 08/28/2022 12:00:00
Event start time: 08/28/2022 12:00:00
Event stop time: 08/28/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 17.3 3øC 1ø 141ø
Stop: Y 16.9 3øC 1ø 137ø

Event 08

Scheduled start time: 09/18/2022 12:00:00
Event start time: 09/18/2022 12:00:00
Event stop time: 09/18/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 17.1 3øC 1ø 316ø
Stop: Y 16.7 3øC 1ø 319ø

Event 09

Scheduled start time: 10/09/2022 12:00:00
Event start time: 10/09/2022 12:00:00
Event stop time: 10/09/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.9 3øC 2ø 66ø
Stop: Y 16.5 3øC 1ø 66ø

Event 10

Scheduled start time: 10/30/2022 12:00:00
Event start time: 10/30/2022 12:00:00
Event stop time: 10/30/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.8 3øC 1ø 54ø
Stop: Y 16.2 3øC 1ø 45ø

Event 11

Scheduled start time: 11/20/2022 12:00:00
Event start time: 11/20/2022 12:00:00
Event stop time: 11/20/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.5 3øC 4ø 356ø
Stop: Y 16.1 3øC 3ø 357ø

Event 12

Scheduled start time: 12/11/2022 12:00:00
Event start time: 12/11/2022 12:00:00
Event stop time: 12/11/2022 12:00:27

Aligned Battery Temperature Tilt Heading
Start: Y 16.3 3øC 1ø 212ø
Stop: Y 15.8 3øC 1ø 214ø

Event 13

Scheduled start time: 01/08/2023 12:00:00
Event start time: 01/08/2023 12:00:00
Event stop time: 01/08/2023 12:00:27

Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt
Heading	Heading	Heading
Start: Y 16.5 3øC 0ø 0ø	Start: Y 15.6 3øC 1ø 1ø	Start: Y 16.0 3øC 1ø 174ø
Stop: Y 16.1 3øC 0ø 0ø	Stop: Y 15.1 3øC 1ø 11ø	Stop: Y 15.5 3øC 1ø 163ø
Event 14	Event 14	Event 14
Scheduled start time: 02/05/2023 12:00:00	Scheduled start time: 02/05/2023 12:00:00	Scheduled start time: 02/05/2023 12:00:00
Event start time: 02/05/2023 12:00:00	Event start time: 02/05/2023 12:00:00	Event start time: 02/05/2023 12:00:00
Event stop time: 02/05/2023 12:00:29	Event stop time: 02/05/2023 12:00:27	Event stop time: 02/05/2023 12:00:27
Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt
Heading	Heading	Heading
Start: Y 16.5 3øC 0ø 0ø	Start: Y 15.3 3øC 1ø 234ø	Start: Y 15.8 3øC 2ø 60ø
Stop: Y 16.1 3øC 0ø 0ø	Stop: Y 14.8 3øC 1ø 247ø	Stop: Y 15.4 3øC 1ø 62ø
Event 15	Event 15	Event 15
Scheduled start time: 03/05/2023 12:00:00	Scheduled start time: 03/05/2023 12:00:00	Scheduled start time: 03/05/2023 12:00:00
Event start time: 03/05/2023 12:00:00	Event start time: 03/05/2023 12:00:00	Event start time: 03/05/2023 12:00:00
Event stop time: 03/05/2023 12:00:29	Event stop time: 03/05/2023 12:00:27	Event stop time: 03/05/2023 12:00:27
Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt
Heading	Heading	Heading
Start: Y 16.5 3øC 0ø 0ø	Start: Y 15.4 3øC 1ø 277ø	Start: Y 15.8 3øC 1ø 262ø
Stop: Y 16.1 3øC 0ø 0ø	Stop: Y 15.1 3øC 1ø 284ø	Stop: Y 15.3 3øC 1ø 261ø
Event 16	Event 16	Event 16
Scheduled start time: 04/02/2023 12:00:00	Scheduled start time: 04/02/2023 12:00:00	Scheduled start time: 04/02/2023 12:00:00
Event start time: 04/02/2023 12:00:00	Event start time: 04/02/2023 12:00:00	Event start time: 04/02/2023 12:00:00
Event stop time: 04/02/2023 12:00:29	Event stop time: 04/02/2023 12:00:27	Event stop time: 04/02/2023 12:00:27
Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt
Heading	Heading	Heading
Start: Y 16.4 3øC 0ø 0ø	Start: Y 15.5 3øC 1ø 341ø	Start: Y 15.8 3øC 1ø 259ø
Stop: Y 15.8 3øC 0ø 0ø	Stop: Y 14.8 3øC 1ø 338ø	Stop: Y 15.3 3øC 1ø 258ø
Event 17	Event 17	Event 17
Scheduled start time: 04/30/2023 12:00:00	Scheduled start time: 04/30/2023 12:00:00	Scheduled start time: 04/30/2023 12:00:00
Event start time: 04/30/2023 12:00:00	Event start time: 04/30/2023 12:00:00	Event start time: 04/30/2023 12:00:00
Event stop time: 04/30/2023 12:00:29	Event stop time: 04/30/2023 12:00:27	Event stop time: 04/30/2023 12:00:27
Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt	Aligned Battery Temperature Tilt
Heading	Heading	Heading
Start: Y 16.0 3øC 0ø 0ø	Start: Y 15.1 3øC 1ø 194ø	Start: Y 15.6 3øC 1ø 219ø
Stop: Y 15.6 3øC 0ø 0ø	Stop: Y 14.5 3øC 1ø 193ø	Stop: Y 15.0 3øC 1ø 217ø
Schedule was not completed.	Schedule was not completed.	Schedule was not completed.

All data was saved locally to the moorings laptops and then uploaded to the network drive and made available for the scientific party.


PAP 3 Mooring – Recovered Sediment Trap.


PAP 3 Mooring – Recovered Sediment Trap Sample Bottles.

For the PAP 3 mooring deployment the following instruments were used:

Instrument	Serial Number
Sea-Bird SBE 37	7297
Sea-Bird SBE 37 ODO	21549
Nortek CM	6181
Nortek CM	9956
Sediment Trap	11262-06
Sediment Trap	11804-04
Sediment Trap	12168-03
Novatech Light	W03-095
Novatech Iridium	H04-021
Ixsea Release	1748
Ixsea Release	2334

All three sediment traps were serviced and had new batteries fitted prior to the cruise at NOC. Once serviced sample bottles were fitted and filled. A fresh set on batteries were then installed allowing each trap to be programmed with its deployment schedule.

Two Nortek current meters were used on the mooring, each being set up with the following settings:

SN: 6181	SN: 9956
Deployment : 6181 Current time : 08/05/2023 15:49:40 Start at : 08/05/2023 18:00:00 Comment: PAP3 JC247 -- Measurement interval (s) : 1800 Average interval (s) : 30 Blanking distance (m) : 0.50 Measurement load (%) : 9 Power level : HIGH Diagnostics interval(min) : 720:00 Diagnostics samples : 20 Compass upd. rate (s) : 10 Coordinate System : ENU Speed of sound (m/s) : MEASURED Salinity (ppt) : 35 Analog input 1 : NONE Analog input 2 : NONE Analog input power out : DISABLED Raw magnetometer out : OFF File wrapping : OFF TellTale : OFF AcousticModem : OFF Serial output : OFF Baud rate : 9600 -- Assumed duration (days) : 400.0 Battery utilization (%) : 50.0 Battery level (V) : 13.7 Recorder size (MB) : 9 Recorder free space (MB) : 8.973 Memory required (MB) : 1.4 Vertical vel. prec (cm/s) : 1.4 Horizon. vel. prec (cm/s) : 0.9 -- Instrument ID : AQD 6181 Head ID : A6L 3818 Firmware version : 3.37 -- Aquadopp Deep Water Version 1.40.16 Copyright (C) Nortek AS ==============================	Deployment : 9956 Current time : 08/05/2023 15:54:18 Start at : 08/05/2023 18:00:00 Comment: PAP3 JC247 -- Measurement interval (s) : 1800 Average interval (s) : 30 Blanking distance (m) : 0.50 Measurement load (%) : 9 Power level : HIGH Diagnostics interval(min) : 720:00 Diagnostics samples : 20 Compass upd. rate (s) : 10 Coordinate System : ENU Speed of sound (m/s) : MEASURED Salinity (ppt) : 35 Analog input 1 : NONE Analog input 2 : NONE Analog input power out : DISABLED Raw magnetometer out : OFF File wrapping : OFF TellTale : OFF AcousticModem : OFF Serial output : OFF Baud rate : 9600 -- Assumed duration (days) : 400.0 Battery utilization (%) : 50.0 Battery level (V) : 13.6 Recorder size (MB) : 9 Recorder free space (MB) : 8.973 Memory required (MB) : 1.4 Vertical vel. prec (cm/s) : 1.4 Horizon. vel. prec (cm/s) : 0.9 -- Instrument ID : AQD 9956 Head ID : A6L 5837 Firmware version : 3.37 -- Aquadopp Deep Water Version 1.40.16 Copyright (C) Nortek AS ==============================

Salinometry

Both the Underway and CTD salinity samples were processed using the onboard Salinometer, a Guildline Autosal 8400B, SN: 71126. This was set up at the start of the cruise in the Electronics Workshop. The Autosal was standardised using IAPSO Standard Seawater batch P164 (K15=0.99985, 2xK15=1.99970, 34.994 PSU).

The NMF Labview Autosal program was checked to ensure correct read/write access and function of the standardisation .ini file. A standard was run as a sample before and after each crate of samples as a control.

A data file from the analysis software was produced for each crate as an Excel spreadsheet and saved in the cruise folder. All raw double conductivity measurements were also logged manually on paper log-sheets. These log-sheets were also scanned to pdf format and saved to the cruise folder.

Software Used

Sea-Bird SeaTerm 1.59
Sea-Bird SBE Data Processing 7.26.6.28
TRDI BBTalk
TRDI WinSC

6.4 Ship Scientific Systems

Juan Ward

Cruise Overview

Ship Scientific Systems (SSS) is responsible for operating and managing the Ship's scientific information technology infrastructure, data acquisition, compilation and delivery, and the suite of ship-fitted instruments and sensors in support of the Marine Facilities Programme (MFP)

The work sites were Whittard Canyon and the Porcupine Abyssal Plain.

The main objectives for SSS in the service of the science party on this cruise were:

1. Acquire underway data and metadata, including sea-surface, meteorological, position and attitude, depth, sound velocity and multibeam swath.
2. Provide services for recording metadata and events and monitoring data streams.
3. Support and acquire tracking data for the Megacorer deployment.
4. Facilitate near-real time transfer of conductivity temperature depth (CTD) data to the UK Met Office.
5. Collect underway samples and run salinity analyses to calibrate thermosalinograph.
6. Provide basic IT support.

All times in this report are in UTC.

Summary

A summary of the progress made against objectives is shown below.

5 Objectives, 5 completed, 0 partially completed, 0 not completed.

Target	Outcomes	Objective met?
Acquire underway data and metadata, including sea-surface, meteorological, position and attitude, depth, sound velocity and multibeam swath.	Underway data collected into NetCDF and ASCII files. Multibeam as Kongsberg proprietary formats. SVP Probe attached to deep CTD casts and profile used to for sound correcting multibeam and USBL.	Yes
Provide services for recording metadata and events and monitoring data streams.	Event Logger and RVDAS Metadata and Logger running.	Yes
Support and acquire tracking data for the Megacorer deployment.	Sonardyne Ranger2 USBL system used to track corer deployments.	Yes
Facilitate transfer of near-real time CTD data to the UK Met Office.	PML’s CTD2MET service was run and the NMF team ran required Seabird processing. Data was confirmed received by Met Office.	Yes
Collect underway samples and run salinity analyses to calibrate thermosalinograph.	Approximately two samples collected per day.	Yes
Provide basic IT support.	Recovered a scientist’s PC that failed to boot and restored Office applications. Assisted with various minor issues involving printers. Chased the satcoms provider during a brief period below guaranteed service.	Yes

Scientific computer systems

Underway data acquisition

Data from the suite of ship-fitted scientific instrumentation was aggregated onto a network drive on the ship's file server. This was available throughout the voyage in read-only mode to permit scientists to work with the data as it was acquired. A Public network folder was also available for scientists to share files.
A copy of these two drives are written to the end-of-cruise disks that are provided to the Principal Scientist and the designated data centre.
The designated data centre for this cruise is: **British Oceanographic Data Centre**

> *List of logged ship-fitted scientific systems:*
>
> /Cruise_Reports/*[Keywords]*_Ship_fitted_information_sheet.docx

The data acquisition systems used on this cruise are detailed in the table below. The data and data description documents are filed per system in the *Data* and *Documentation* directories respectively within Ship Systems folder on the cruise data disk.

Data acquisition systems used on this cruise.

Data acquisition system	Usage	Data products	Directory system name
Ifremer TechSAS	Continuous	NetCDF ASCII pseudo-NMEA	/TechSAS/
NMF RVDAS	Continuous	ASCII Raw NMEA SeaDataNet NetCDF (Testing)	/RVDAS/
Kongsberg SIS (EM122)	Continuous.	Kongsberg .all	/Acoustics/EM-122/
Kongsberg SIS (EM710)	Unused.	Kongsberg .all	/Acoustics/EM-710/
Kongsberg SBP	Unused.	None	/Acoustics/SBP-120/
Kongsberg EA640	Continuous	None, redirected to Techsas/RVDAS RAM	/Acoustics/EA-640/
Kongsberg EK60/80	Unused.		/Acoustics/EK-60/
UHDAS (ADCPs)	Continuous	ASCII raw, RBIN, GBIN, CODAS files	/Acoustics/ADCP/
VMDAS (ADCPs)	Unused.		/Acoustics/ADCP/
Sonardyne Ranger2	Discrete.	None, redirected to Techsas/RVDAS RAM	/Acoustics/USBL/

Data description documents per system:
`/Cruise_Reports/Ship_Systems/Documentation`

Data directories per system:
`/Cruise_Reports/`*[Keywords]*`_Ship_fitted_information_sheet.docx`

Significant acquisition events and gaps

On this cruise, the NMF Event Logger was used with CSV records of events saved to the cruise data directory.

Path and pattern to event log CSV files:
`/Cruise_Reports/EventLogs/[logType]/[logName].csv`

Summary of main events

Date	Time start*	Time end*	Event
05/05/2023	16:30		Depart NOC Southampton
06/05/2023	08:00	08:40	EuroGoShip CTD, Plymouth
07/05/2023	08:30	15:10	Working in Whittard Canyon
08/05/2023	17:00		Working in PAP
11/05/2023	09:45		Recovered 2022 ODAS Buoy
12/05/2023	18:40		Deployed 2023 ODAS Buoy
13/05/2023	07:45	09:30	Met calibration
22/05/2023			
22/05/2023			Arrive NOC Southampton

Summary of data gaps

Date	Time start	Time end	Event
12/05/2023	?		WaMoS Wave Radar failed. Azimuth bearing fault on Furuno radar antenna. No further wave data was collected.

Internet provision

Satellite communications were provided with both the VSat and Fleet Broadband systems. The ship operated with bandwidth controls to prioritise business use.

Instrumentation

Coordinate reference

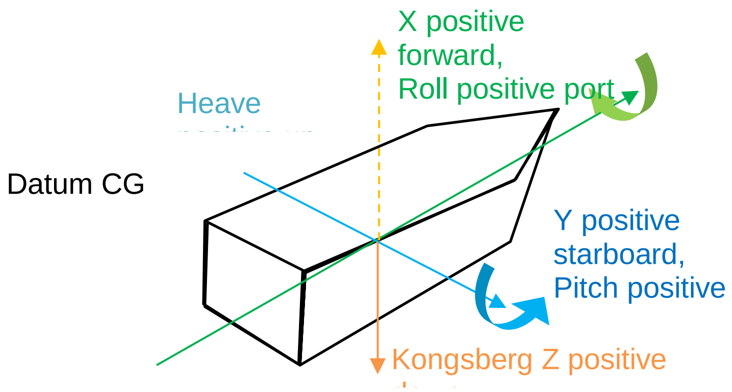
> *Path to ship survey files:*
> `Provided on request.`

Origin (RRS James Cook)

The common coordinate reference was defined by the Blom Maritime survey (2006) as:

1. The reference plane is parallel with the main deck abeam (transversely) and with the baseline (keel) fore- and aft-ways (longitudinally).
2. Datum (X = 0, Y = 0, Z = 0) is centre topside of the Applanix motion reference unit (MRU) chassis.

Multibeam



Conventions used for position and attitude. On the Discovery, the Datum is the CRP at the CG. On the Cook the Datum is on the centre, topside of the Applanix MRU.

The Kongsberg axes reference conventions are as follows:

1. X positive forward,
2. Y positive starboard,
3. Z positive downward.

The rotational sense for the multibeam systems and Seapath is set to follow the convention of Applanix PosMV (the primary scientific position and attitude system).

Primary scientific position and attitude system

The translations and rotations provided by this system (Applanix PosMV) have the following convention:

1. Roll positive port up,
2. Pitch positive bow up,
3. Heading true positive to starboard,
4. Heave positive up.

Position, attitude and time

System	Navigation (Position, attitude, time)		
Statement of Capability	/Ship_Systems/Documentation/GPS_and_Attitude		
Data product(s)	NetCDF: /Ship_Systems/Data/TechSAS/NetCDF/ Raw NMEA: /Ship_Systems/Data/RAM/ CSV: /Ship_Systems/Data/RAM/CSV		
Data description	/Ship_Systems/Documentation/TechSAS /Ship_Systems/Documentation/RVDAS		
Other documentation	/Ship_Systems/Documentation/GPS_and_Attitude		
Component	Purpose	Outputs	Headline Specifications
Applanix PosMV	Primary GPS and attitude.	Serial NMEA to acquisition systems and multibeam	Positional accuracy within 2 m.
Kongsberg Seapath 330	Secondary GPS and attitude.	Serial and UDP NMEA to acquisition systems and multibeam	Positional accuracy within 1 m.
Oceaneering CNav 3050	Correction service for primary and secondary GPS and dynamic positioning.	RTCM to primary and secondary GPS	Positional accuracy within 0.15 m.
Fugro Seastar / MarineStar	Correction service for primary and secondary GPS and dynamic positioning.	Corrections to primary and secondary GPS	Positional accuracy within 0.15 m.
Meinberg NTP Clock	Provide network time	NTP protocol over the local network.	

Significant position, attitude or time events or losses

Date	Time start*	Time end*	Event

Ocean and atmosphere monitoring systems

SURFMET

System	SURFMET (Surface water and atmospheric monitoring)	
Statement of Capability	/Ship_Systems/Documentation/Surfmet	
Data product(s)	NetCDF: /Ship_Systems/Data/TechSAS/NetCDF/ Raw NMEA: /Ship_Systems/Data/RAM/ CSV: /Ship_Systems/Data/RAM/CSV	
Data description	/Ship_Systems/Documentation/TechSAS /Ship_Systems/Documentation/RVDAS	
Other documentation	/Ship_Systems/Documentation/Surfmet	
Calibration info	See Ship Fitted Sensor sheet for calibration info for each sensor.	
Component	**Purpose**	**Outputs**
Inlet temperature probe (SBE38)	Measure temperature of water at hull inlet.	Serial to Interface Box.
Drop keel temperature probe (SBE38)	Measure temperature of water in drop keel space.	Serial to Interface Box.
Thermosalinograph (SBE45)	Measure temp. and conductivity at sampling board. Salinity is calculated.	Serial to Interface Box.
Interface Box (SBE90402)	Signals management.	Serial to Moxa.
Debubbler	Reduces bubbles through instruments.	None.
Transmissometer (CST)	Measure of transmittance.	Analogue to NUDAM.
Fluorometer (WS3S)	Measure of fluorescence.	Analogue to NUDAM.
Air temperature and humidity probe (HMP45A, HMP155)	Temperature and humidity at met. platform.	Analogue to NUDAM.
Ambient light sensors (PAR, SKE510; TIR, CMP6)	Ambient light at met. platform.	Analogue to NUDAM.
Barometer (PTB110, PTB210)	Atmospheric pressure at met. platform.	Analogue to NUDAM.
Anemometer (Windsonic)	Wind speed and direction at met. platform.	Serial to Moxa.
NUDAM	A/D converter.	Serial NMEA to Moxa.
Moxa	Serial to UDP converter.	UDP NMEA to Surfmet VM.
Surfmet Virtual Machine	Data management.	UDP NMEA to TechSAS, RVDAS.

Component	Calibrated product steps
SBE38: Temperature (°C)	No calibration to apply because the residuals are below uncertainty.
SBE45: Temperature (°C)	No calibration to apply because the residuals are below uncertainty.
SBE45: Conductivity (S m^{-1})	No calibration to apply because the residuals are below uncertainty.
CST: Transmission (%)	$\mathrm{Product} = (\mathrm{Data} - V_{\mathrm{dark}})/(V_{\mathrm{ref}} - V_{\mathrm{dark}})$. Here product has units % and data, V_{dark} and V_{ref} have units V.
WS3S: Fluorescence (µg L^{-1})	$\mathrm{Product} = \mathrm{Coefficient} \times (\mathrm{Data} - \mathrm{Offset})$. Here product has units µg L^{-1}, coefficient has units µg L^{-1} V^{-1}, and data and offset have units V.
HMP45A / HMP155: Temperature (°C)	No calibration to apply because the residuals are below uncertainty.
HMP45A / HMP155: Relative humidity (%)	No calibration to apply because the residuals are below uncertainty.
PTB110 / PTB210: Pressure (hPa)	No calibration to apply because the residuals are below uncertainty.
SKE510: PAR (W m^{-2})	$\mathrm{Product} = \mathrm{Data} \times \left(\frac{10^6}{\mathrm{Coefficient}}\right)$. Here product has units W m^2, data has units 10^{-5} V, the 10^6 scalar has units µV V^{-1}, and coefficient has units µV m^2 W^{-1}.
CMP6: TIR (W m^{-2})	$\mathrm{Product} = \mathrm{Data} \times \left(\frac{10^6}{\mathrm{Coefficient}}\right)$. Here product has units W m^2, data has units 10^{-5} V, the 10^6 scalar has units µV V^{-1}, and coefficient has units µV m^2 W^{-1}.
Windsonic: Wind speed (m s^{-1})	No calibration to apply.
Windsonic: Wind direction (m s^{-1})	No calibration to apply.

Note that while the residuals (difference of reference and measured) are below uncertainty and the output is considered calibrated for the SBE38, SBE45, HMP45A, HMP155, PTB110 and PTB210 instruments, a regression could still be made between the reference and measured data (see the calibration certificate) if desired. Follow the steps below:

1. Calculate $y = Bx + A$ from calibration data, where x is reference data.
2. $\mathrm{Product} = (\mathrm{Data} - A)/B$.

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 their recorded data have calibrations applied or not.

Surface water sampling board maintenance

Date	Time start*	Time end*	Event	Trans high (V)	Trans low (V)	Fluoro (V)	Salinity (PSU)

The system was cleaned prior to the cruise.

Wave radar

System	WAMOS Wave Radar	
Statement of Capability	/Ship_Systems/Documentation/Wamos	
Data product(s)	NetCDF: /Ship_Systems/Data/TechSAS/NetCDF/ Raw NMEA: /Ship_Systems/Data/RAM/ CSV: /Ship_Systems/Data/RAM/CSV Raw: /Ship_Systems/Data/Wamos/	
Data description	/Ship_Systems/Documentation/TechSAS /Ship_Systems/Documentation/RVDAS	
Other documentation	/Ship_Systems/Documentation/Wamos	
Statement of Capability	/Ship_Systems/Documentation/Wamos	
Component	**Purpose**	**Outputs**
Rutter OceanWaves WAMOS	Measure wave height, direction, period and spectra.	Summary statistics in NMEA to TechSAS and RVDAS. Spectra files.
RsAqua Rex2 Wave Height Sensor	Measure wave height at bow to provide calibration reference dataset.	Wave height NMEA, UDP to TechSAS, RVDAS.
Furuno Radar	Measures radar reflection on sea surface.	Radar data to WAMOS.

The wave radar magnetron requires annual replacement. Following replacement, WAMOS needs to collect wave data within 5 km of another wave height sensor over the full range of sea-states in order to derive wave height calibration coefficients for the new magnetron. This reference dataset can be derived by examining the ship's track for wave buoys and downloading their data, or by using the onboard RsAqua Wave Height sensor fitted on the ship's bow.

Summary of data gaps

Date	Time start	Time end	Event
12/05/2023			WaMoS Wave Radar failed. Azimuth bearing fault on Furuno radar antenna. No further wave data was collected.

Hydroacoustic Systems

System	Acoustics	
Statement of Capability	/Ship_Systems/Documentation/Acoustics	
Data product(s)	Raw: /Ship_Systems/Data/Acoustics NetCDF (EA640, EM122cb): /Ship_Systems/Data/TechSAS NMEA (EA640, EM122cb): /Ship_Systems/Data/RVDAS CSV: /Ship_Systems/Data/RAM/CSV	
Data description	/Ship_Systems/Documentation/Acoustics	
Other documentation	/Ship_Systems/Documentation/Acoustics	
Component	**Purpose**	**Operation and Outputs**
10/12 kHz Single beam (Kongsberg EA-640)	Primary depth sounder	Continuous, free running NMEA over serial, raw files
12 kHz Multibeam (Kongsberg EM-122)	Full-ocean-depth multibeam swath.	Continuous, free running Binary swath, centre-beam NMEA, *.all files, optional water column data
70 kHz Multibeam (Kongsberg EM-710)	Coastal/shallow multibeam swath.	Unused Binary swath, centre-beam NMEA, *.all files.
Sub-bottom Profiler (Kongsberg SBP-120)	Multi-frequency echogram to provide along-track sub-bottom imagery.	Unused BMP, raw files, optional water column data.
Drop keel sound velocity sensor	Provide sound velocity at transducer depth	Continuous, free running Value over serial to Kongsberg SIS.
Sound velocity profilers (Valeport Midas, Lockheed XBT)	Direct measurement of sound velocity in water column.	Discrete ASCII pressure vs sound velocity files. Manually loaded into Kongsberg SIS or Sonardyne Ranger2.
75 kHz ADCP (Teledyne OS75)	Along-track ocean current profiler	Continuous, free running (via UHDAS)
150 kHz ADCP (Teledyne OS150)	Along-track ocean current profiler	Continuous, free running (via UHDAS)
USBL (Sonardyne Ranger2)	Underwater positioning system to track deployed packages or vehicles.	Discrete NMEA over serial
CARIS	Post-processing	Unused CARIS Project file. CARIS Vessel files
MB-System	Post-processing	Unused XYZ, SegY files

Marine Mammal Protection

NMF policy is to follow JNCC guidelines for marine mammal observations before operating any equipment which causes significant acoustic disturbance in the water column. Such equipment includes the deep-water multibeam and sub-bottom profiler. For these systems, an MMO procedure is followed, which, in summary, involves a 60-minute bridge observation with a ramped start 45 minutes into the observation, if no mammals are observed.

> *Path to Marine Mammal Observations logs:*
> `/Ship_Systems/Cruise_Reports/EventLogs/scilogs/MMO.csv`

> *Path to Marine Mammal Observations, acoustic event logs:*
> `/Ship_Systems/Cruise_Reports/EventLogs/scilogs/Acoustic_Events.csv`

A member of the scientific party was responsible for carrying out and recording MMO activities (See section 21).

Sound velocity profiles

Sound velocity profiles were measured directly with a Midas SVP, derived from CTD or calculated from the WOA13 model using Ifremer DORIS.

> *Path of sound velocity profile data on the cruise datastore:*
> `/Ship_Systems/Data/Acoustics/Sound_Velocity`

Details of when sound velocity profiles were taken and applied are shown in the table below:

Sound velocity profiles.

Datetime	Method	Location (Lat/Lon)	Filename	Datetime SVP applied to SIS / Ranger2
07/07/2023 10:46	Midas SVP		20230507_thinned_ext.asvp	08/05/2023 10:07
09/05/2023 07:22	Midas SVP		20230509_thinned_ext.asvp	09/05/2023 13:17
10/05/2023 10:49	Midas SVP		20230510_thinned_ext.asvp	10/05/2023 18:50

Equipment-specific comments

ADCPs

> *Path of ADCP data on the cruise datastore:*
> `/Ship_Systems/Data/Acoustics/ADCP`

Attribute	Value
Acquisition software	UHDAS
Frequencies used	75 kHz, 150 kHz
Running mode	Free-running (untriggered)

EM-122 Configuration and Surveys

> *Path of Multibeam data on the cruise datastore:*
> `/Ship_Systems/Data/Acoustics/EM-122`

> *Path of EM122 CARIS Vessel Configuration File:*
> `/Ship_Systems/Data/Acoustics/EM-122/CARIS_Processed/VesselConfig`

<table>
<tr><th>Attribute</th><th>Value</th></tr>
<tr><td>Number of surveys</td><td>(Run continuously)</td></tr>
<tr><td>Date of patch test</td><td>Not undertaken.</td></tr>
<tr><td>Offsets and rotations</td><td>
<table>
<tr><th>Item</th><th>X (m, + Forward)</th><th>Y (m, + Starboard)</th><th>Z (m, + Down)</th></tr>
<tr><td>Tx transducer</td><td>19.205</td><td>1.830</td><td>6.934</td></tr>
<tr><td>Rx transducer</td><td>14.094</td><td>0.950</td><td>6.932</td></tr>
</table>
<table>
<tr><th>Item</th><th>Roll (deg)</th><th>Pitch (deg)</th><th>Yaw (deg)</th></tr>
<tr><td>Tx transducer</td><td>-0.35</td><td>-0.1</td><td>0.19</td></tr>
<tr><td>Rx transducer</td><td>-0.06</td><td>0.1</td><td>0.15</td></tr>
</table>
</td></tr>
<tr><td>Post-processing undertaken</td><td>None.</td></tr>
</table>

USBL Configuration and deployments

> *Path of USBL data on the cruise datastore:*
> `/Ship_Systems/Data/RAM/`*[Keywords]*`_RANGER2USBL_YYYY_MM_DD.nmea`

Attribute	Value
Number of deployments	Every Megacore deployment
Datetime of last CASIUS	15/02/2023
Starboard HPT7000 Head 1DRMS	0.34% of depth (63.2% of positions within 16.2m at 4700m)
Port Head 1DRMS	0.50% of depth (63.2% of positions within 23.5m at 4700m)

Deployment information:

Deployment name	Head used	Beacon(s) used	Datetime Start	Datetime End	SVP Used (Filename)

Geophysics systems

None used.

Other systems

Cable Logging and Monitoring

Winch activity is monitored and logged using the CLAM system.

7. PAP1 Recovered - Scientific Report

Anita Flohr, Susan Hartman, Ed Mawji, Hans Hilder, Elisa Loveccio

7.1 Sensors

Recovery of JC231 PAP1 buoy and frame (station JC231-036) was on 11/05/2023 at 10:51. Pictures available on cruise drive: Z:\JC247\PELAGIC\PAP1-MOORING

The Mobilis buoy was again covered in goose barnacles, though the fouling looked less than the previous year as all sensors were easy to identify. Most sensors were retrieved with the exception of 1 missing Met Office sensor (air temperature and humidity) from the buoy. At 1m, in the buoy keel, the tubing and pumps were all in place, with some minor damage to the copper on one of the pumps. Full datasets were retrieved both Seabird MicroCATs at 1m depth by NMF sensors and moorings (Dave Childs) onboard. Near real time (NRT) data will be available for other 1m sensors, with surface CO_2 readings running until November (see timeline table). This was around the time that the air temperature and humidity sensor stopped (6^{th} Nov). The NRT 1m CO_2 sensor stopped on the 28th of June (despite various power cycles eg:7^{th} May).

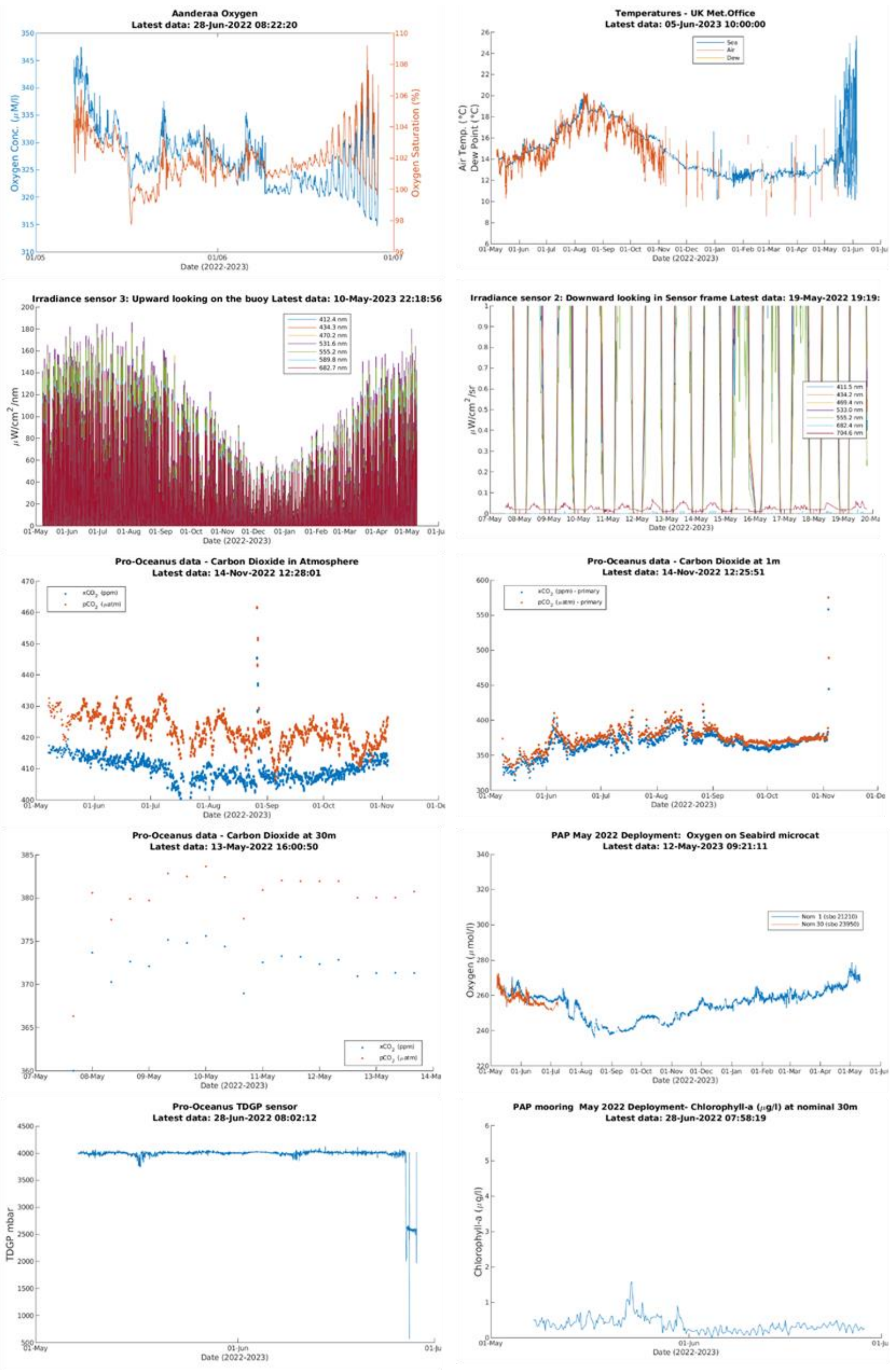
NRT data had stopped 52 days after deployment for the 30m frame sensors. Most sensors were retrieved from the 30m sensor frame but the Aanderra Seaguard was missing (no NRT data from 23rd July indicating battery loss, and likely instrument loss around this time). The Zebratech wiper was very loose but the Turner fluorometer was still in the clamp. The 30m ODO microcat appears to have had a shock and the housing was wobbly, which has not been seen before. No data was retrieved from this instrument. The 30m seabird microcat continued to log data, and had a full year of data - as did the older Wetlabs fluorometer (SN269). Both instruments had their own internal batteries, so internal records were retrievable. Some of the other 30m instruments relied on the hub to log data (eg: OCR and the separate Aanderra optode) so we had not expected to retrieve data onboard. However, we had expected sensors and samplers with internal loggers, and external power supplies (eg: SubCtech batteries), to keep on logging.

The timeline below gives a timeline for all sensors, with data stop times, and issues encountered:

Date	JC231 PAP1 deployment timeline
6-May-22	Hub 30V supply switched on
7-May-22	PAP-1 deployed JC231
7-May-22	Buoy CO2 sensors switched on remotely
9-May-22	Buoy CO2_B switched off to power cycle as no messages received from sensor
9-May-22	Buoy CO2_B switched on - still no messages from sensor
10-May-22	CW3 switched off as no data received
10-May-22	CW1 switched off as no data received
13-May-22	Frame CO2 starts drawing ~600mA excess current, last NRT data
13-May-22	Frame CO2 turned off as it was drawing excessive current
13-May-22	Buoy CO2_B switched off to power cycle - still no messages received from sensor
14-May-22	Buoy CO2_B switched on - still no messages from sensor
15-May-22	Frame CO2 turned on
27-Jun-22	5 and 10 m Star Oddi sensors depth change (1m)
23-May-22	Buoy CO2 send all samples - no averaging

23-May-22	Buoy CO2_B switched off to save power - still no messages
28-Jun-22	buoy FLNTUSB sampling interval changes from 4 hrs to a few sec
17-May-22	change in depth for all the Star Oddies
16-May-22	Frame CO2 turned off as it was drawing excessive current and not sending data
28-Jun-22	Frame controller lost power from buoy according to controller log
28-Jun-22	Hub 30V supply switched off
19-May-22	Last data from frame OCR SN200
6-Jul-22	Last NRT data from buoy FLNTUSB SN269 * full year on sensor
28-Jun-22	Last readable message from frame controller. Spurious RS232 data begins
28-Jun-22	Last RS232 data from frame hub, last 30m data (eg: CO2, GTD), last 1m NRT CO2
23-Jul-22	Last Seaguard data - internal battery ran out?
18-May-22	Supply to buoy FLNTUSB sn 7381 switched on
28-Jun-22	Supply to buoy FLNTUSB switched off. 30m CW-PO4, GTD and Optode stops
22-Sep-22	Frame controller battery ran out, 30m frame stops (eg: NRT SeaFET and SN269)
4-Nov-22	Atmospheric CO2 internal gas temp/humidity sensor failed - no more valid data
6-Nov-22	Met Office air temp and humidity sensors stop. On JC247 sensor was missing
16-Dec-22	Buoy accelerometers enabled
17-Jan-23	Buoy accelerometers disabled
11-May-23	PAP-1 recovered. 1-year FLNSUB SN269, 3 microcats (not 30m ODO)

NRT data plots as published on the PAP website are shown below – some additional data available from the hub (and from the actual sensors) as detailed in the Timeline table.

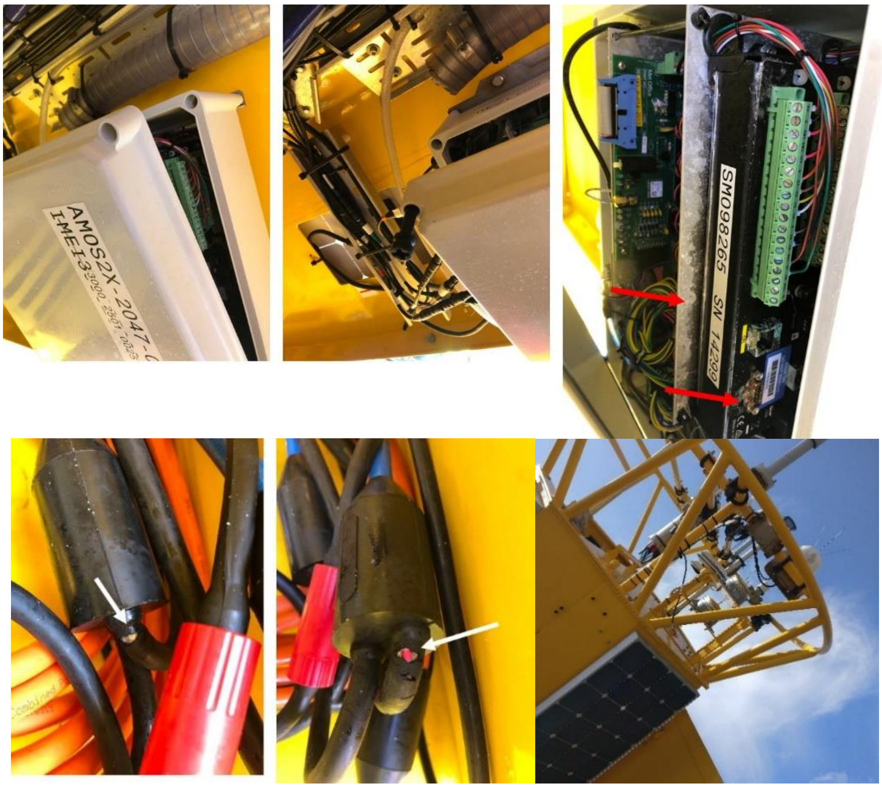


The new rechargeable SubCtech batteries were in perfect condition, with full charge, seemingly having not been used. The potentially self-logging sensors had no data (eg: Clearwater, SeaFET pH and OTE pH) suggesting the hub did not switch to the external battery power source. If this is the case, then perhaps in future the default could be to use the external batteries as the primary power source. This will need to be investigated back at NOC.

The Star Oddi data from between the buoy and frame is interesting in itself but may also help to identify shocks received to the buoy and frame. The Star Oddi data shows jumps to shallower depths on the 17th May. There are significant changes in depth for all of the star oddies (apart from the 5m one) at this time. The 10m-20m star oddies experience a 2-3m jump, but the 25m one jumps up by ~5m and down by ~7m. We theorized onboard that there may have been a collision or run in with fishing equipment. The timing corresponded with loss of NRT CO_2 and OCR data at 30m. There was another significant (1m) jump, to a shallower depth, in both the 5m and 10m Star oddi sensors on the 27^{th} June. This corresponds with the time that the 1m fluorometer experienced issues and with loss of telemetered data.

The following section shows photos of the retrieved sensors with comments on visual inspections and the data obtained.

7.2 buoy mast and tower



Visual inspection of the buoy tower showed the electrical box cover came loose during the deployment, signs of water/humidity on electronic boards; cables worn. On the top of the buoy the CO_2 air inlet box, and Xeos tracker were in place (the bracket was reused for the deployment on JC247). The Satlantic-OCR-507 ICSA + bioshutter II (SN: 201/122) were in place. A Met Office sensor was missing (see dangling cable in lower left photo above).

Data: Met Office NRT data available, although air temp and humidity NRT stopped 6 Nov 2022 18:00 (missing sensor). OCR NRT data until end of July.

7.3 Keel

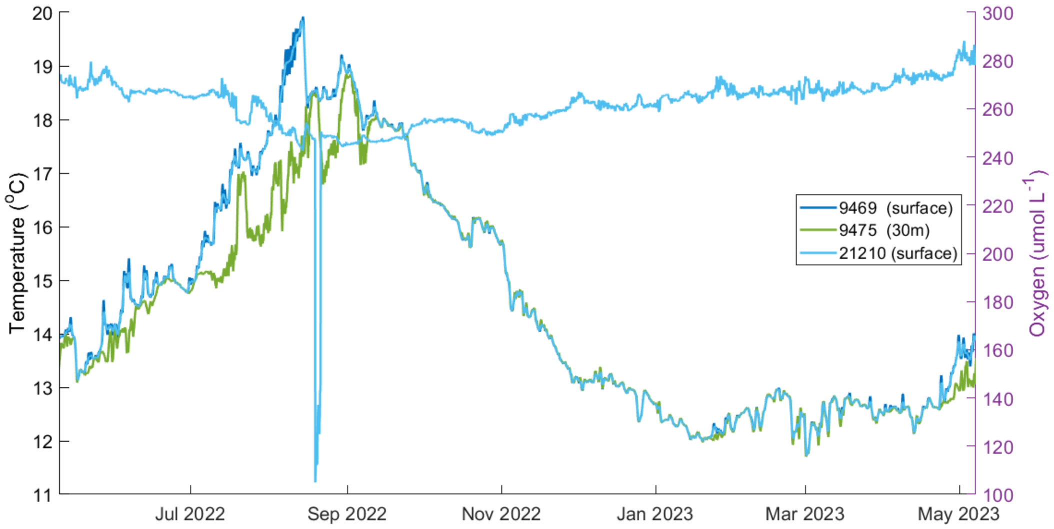
Visual inspection of both buoy CO_2 sensors: The Pro-Oceanus CO2-Pro atmospheric option – SN: 39-599-50A and Pro-Oceanus CO2-Pro – SN: 34-200-45. Tubing survived between both pumps and sensors (also along to the atmospheric box), however the copper was very worn on the pump SN 8727



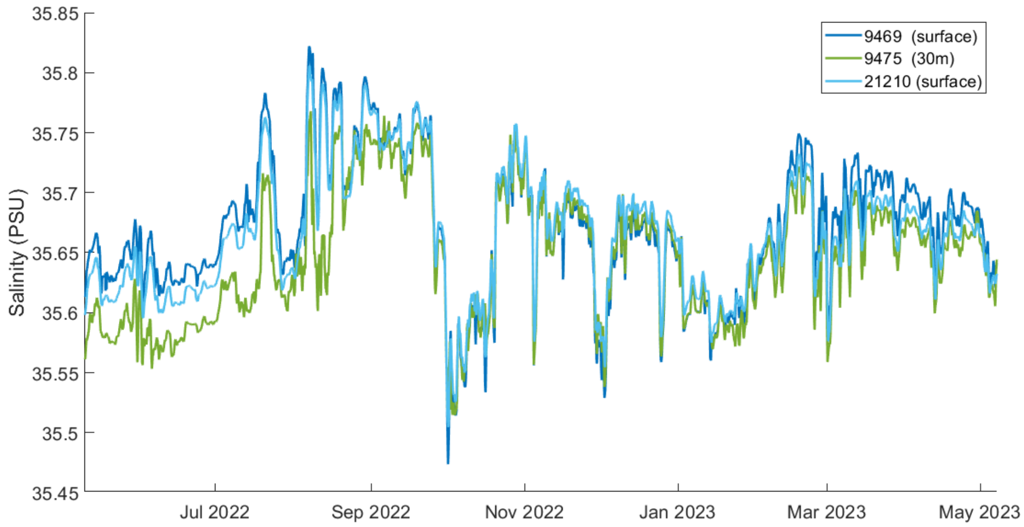
Data recovery: CO_2 39-599-50A and 34-200-45 may need to be downloaded ashore. We attempted to connect to the instruments. We got just 5 data points from the back-up sensor at 1m, although from NRT we expected no data since deployment despite power cycling (power switched off 9th May 2022). We couldn't connect to the Atmospheric sensor (CO2 39-599-50A) at sea, although NRT data suggested good CO_2 data until November. The CO2 39-599-50A Atmos sensor failed on 4 Nov 2022 after 181 days and it is hoped that the data can be retrieved at Pro-oceanus.

Visual inspection of the SeaBird SBE 37IMP-ODO- MicroCAT – SN: 21210 and SeaBird SBE 37IMP-MicroCAT – SN: 9469 showed that both units were covered in goose barnacles, as were all sensors in the keel of the buoy.


Seabird data from the buoy: NRT was apparently OK but we had very intermittent inductive comms. A full data internal data set was retrieved from both Seabird sensors by Dave Childs onboard.



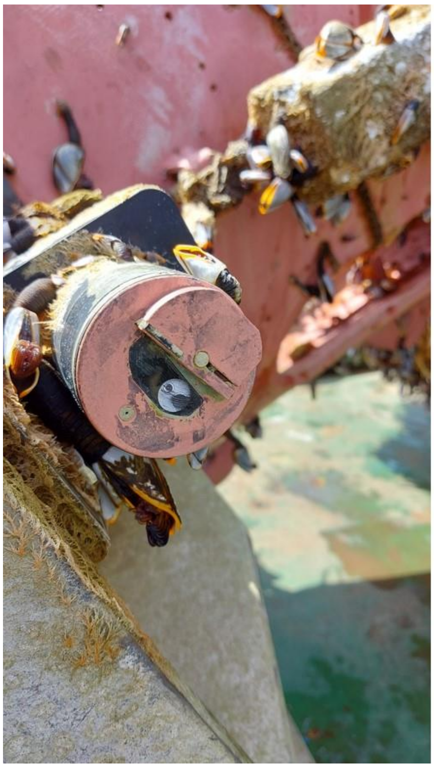
Full year of Seabird temperature (1m and 30m) and O_2 data (1m) - note upper line is 1m oxygen



Full year of Seabird Salinity (1m and 30m) data

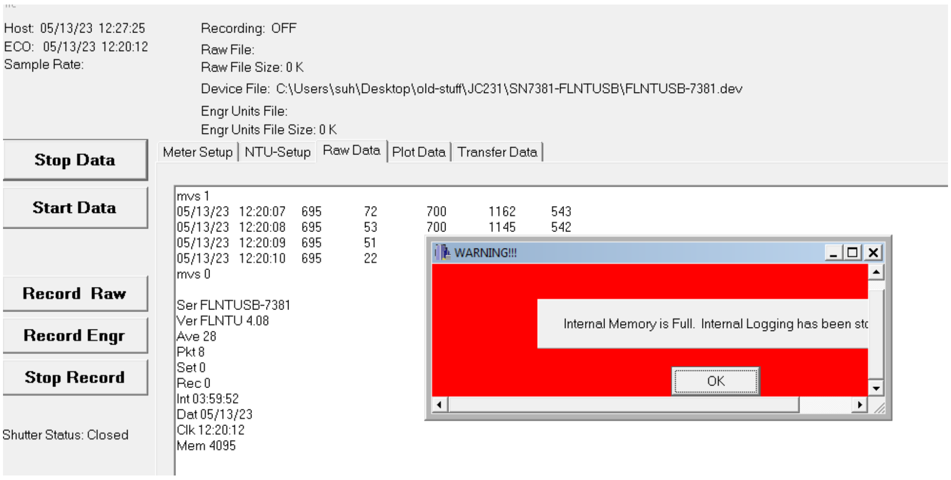
The Aanderaa oxygen optode – SN: 1282 was mounted at the base of the CO_2 sensors and the measurement window looked relatively clean. Only NRT data will be available, as it doesn't self-log.

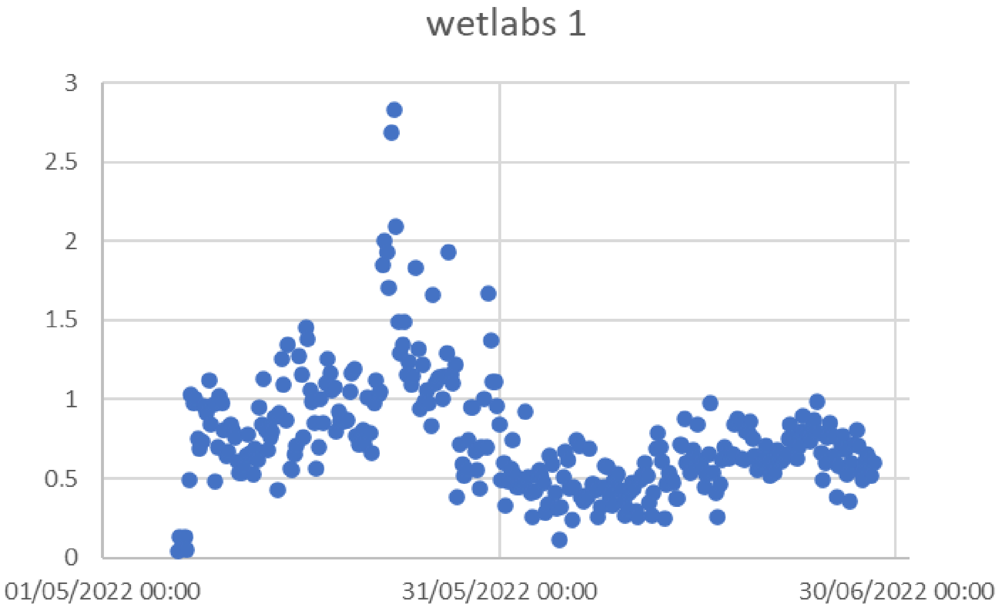
The copper shutter on Wetlabs FLNTUSB Fluorometer – SN: 7381 was stuck open, but it was relatively clean.



Data recovery: The NRT data had looked OK on this new sensor - but it missed a few messages between 18 - 21st May. On JC247 we could connect to the instrument and found it had recorded data internally for a month. However, the file was very large and the internal memory was full. It had been set up correctly, at 4 hourly intervals (in 8 pkt data) but went to continuous sampling from 28th June 14:36. Then there were erratic measurements (~35 per hour, although still in PKT 8), as had been the case on the previous deployment. The manufacturer calibration (from March 2022): Chl=0.0073x(output-48) was applied to the data.

Note that this was a new Wetlabs instrument.

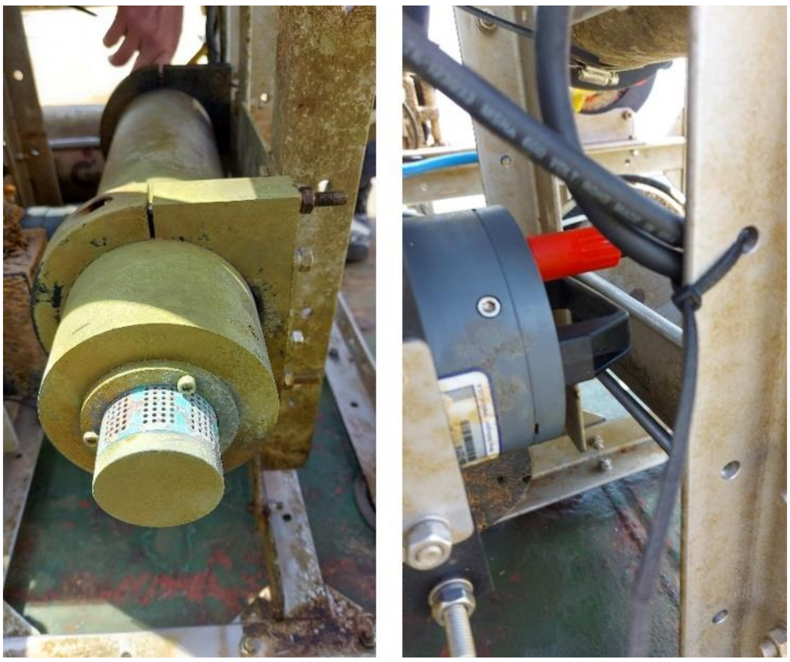




1m Chlorophyll fluorescence data in ug/l - 4 hourly readings until 28th June 2022

7.4 Sensor frame

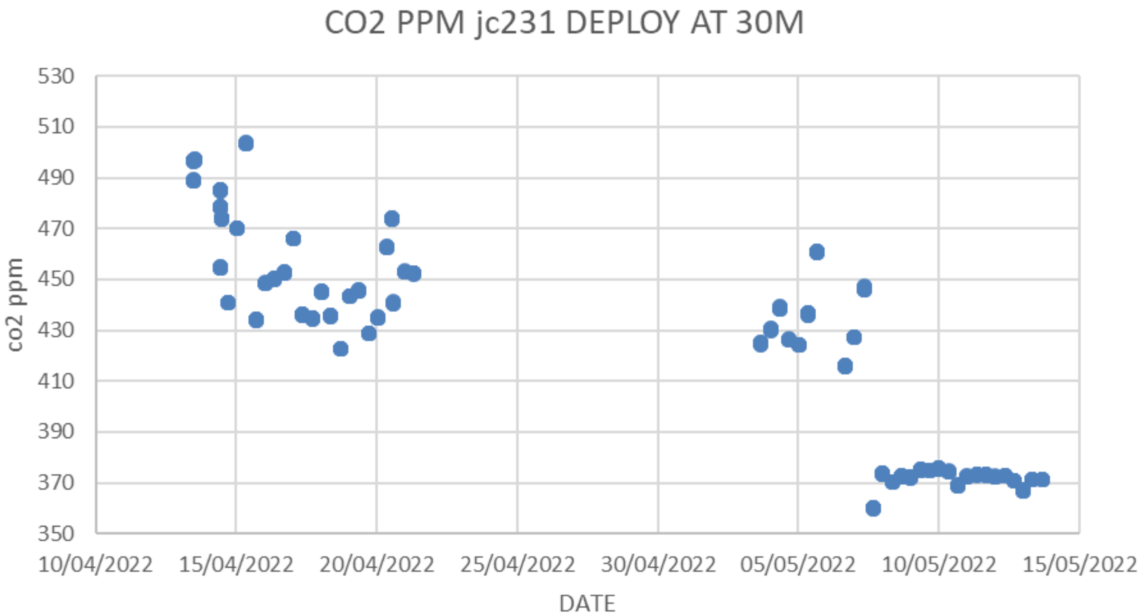
The SeaFET V2 pH – SN: PHS-2274 – was still in place and the copper guard looked in good condition. On recovery the copper was replaced with the flow through cover, which was filled with seawater. Data recovery: On JC247 we couldn't connect onboard, using the software and cables. Dave Childs opened the instrument and found salt crystals on the o-ring, suggesting it may have flooded if left longer. The desiccant bag was pierced by the end connector bolts on the inside of the instrument, which is a design fault. As we were not able to connect to the instrument to retrieve data, we returned this (new) instrument to seabird to see if it had logged internally. NRT data available to 22nd September. Seabird were able to download the data to 11/5/23 but cannot service the instrument due to international FET supply issues.



SeaFET V2 pH – SN: PHS-2274

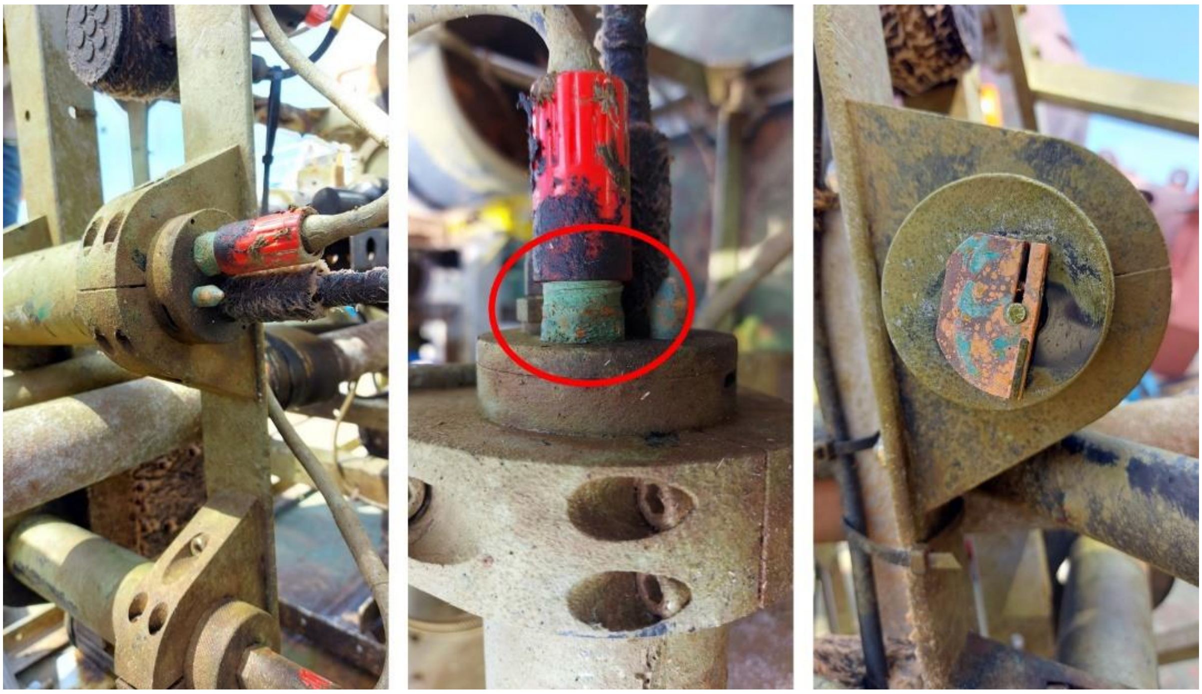
Pro-Oceanus CO2-Pro CV- SN: 38-492-75 had loose Subcon locking sleeves (2x). The pump looked ok (didn't come loose) and there was clean copper at the inlet - all pump tubing remains in place (below). Data recovery: NRT data for a month (13th April to 13th May 2022). No data since 16:00 13th May and then drawing high current. Data suspect after 7th May 2022.

Pro-Oceanus CO2-Pro CV- SN: 38-492-75

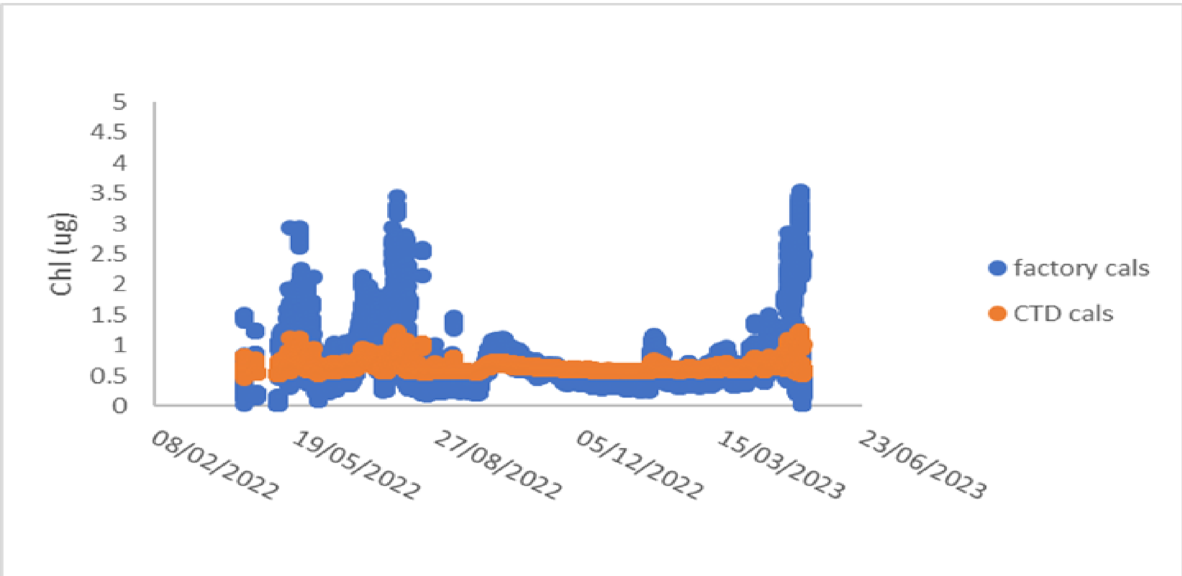


Downloaded pCO2 data at 30m (see also NRT data)

WETLabs FLNTUSB Fluorometer – SN:269 (below) also had a loose Subcon locking sleeve (1x). Data recovery: On JC247 we retrieved a full data set from FLNTSUB 269 (815k of data). All set up OK and 18537 records. Data from 11th March. Ran from deployment 2022 to data download on 13th May 2023. Apply cal sheet from Oct 2021: chl=0.0128 x (output-60). Corinne applied a cal after the cruise but this is still being looked at so the factory calibration may be the best available.



WETLabs FLNTUSB Fluorometer – SN:269



Downloaded FLNSUB SN269 Chl-fluorescence, 1 year of data

Aanderaa 4330 oxygen optode – SN: 1298 – was still in place. There will only be NRT data (to 28th June 2022), from this sensor as it does not self-log.

Aanderaa 4330 oxygen optode – SN: 1298

The Satlantic OCR-507 ICSW irradiance, with bio-shutter, SN: 200 had been deployed without copper, due to a last-minute substitution on JC231. It should have been an OC1. The housing looked very clean (may have been rubbed clean by umbilical?). Data recovery: NRT only (see NRT data plots), not stored at the hub. No NRT data since 19:20 on 19th May.

The Satlantic OCR-507 ICSW irradiance, with bio-shutter, SN: 200

The Aanderaa SeaGuard was deployed with the Turner fluorometer + optode – SN: 2410. Visual inspection: Seaguard and optode 2410 missing, Turner fluorometer was still present but the zebratech wiper brush was stuck “on”, loose zebratech battery case. Only NRT data because the seaguard logger was lost at sea (so no further O_2 and Turner fluorometer data from 23rd July 2022). Note the large diurnal bio-fouling signal with the O_2 data (on the NRT data plots). This was also seen on the last deployment (and maybe because there is no ‘umbrella’ effect from a current meter – so a non-working DCM was deployed on JC247).

Turner fluorometer + optode – SN: 2410

On the frame the SeaBird SBE 37IMP- ODO- MicroCAT – SN: 23950 and SeaBird SBE 37IMP- MicroCAT – SN: 9475 (below) looked OK until removed. The ODO head was loose. There was full data recovery from the SBE but at sea we could not connect with the ODO (perhaps it has recorded internally – we will find out once it has been returned to seabird, delivery back at NOC expected 26th Sept 2023.

SeaBird SBE 37IMP- ODO- MicroCAT – SN: 23950 and SeaBird SBE 37IMP- MicroCAT – SN: 9475

The Pro-Oceanus Mini TDGP – SN: 38-506-31 (below) was present and clean and all connections ok, but it had flooded. Only NRT data was available. The sensor was talking OK but giving erratic pressure values (~4000 mbar) since deployment. Clearwater suggested that the system had received power input (>16V) on the frame though we have not established how this could have happened.

Pro-Oceanus Mini TDGP – SN: 38-506-31

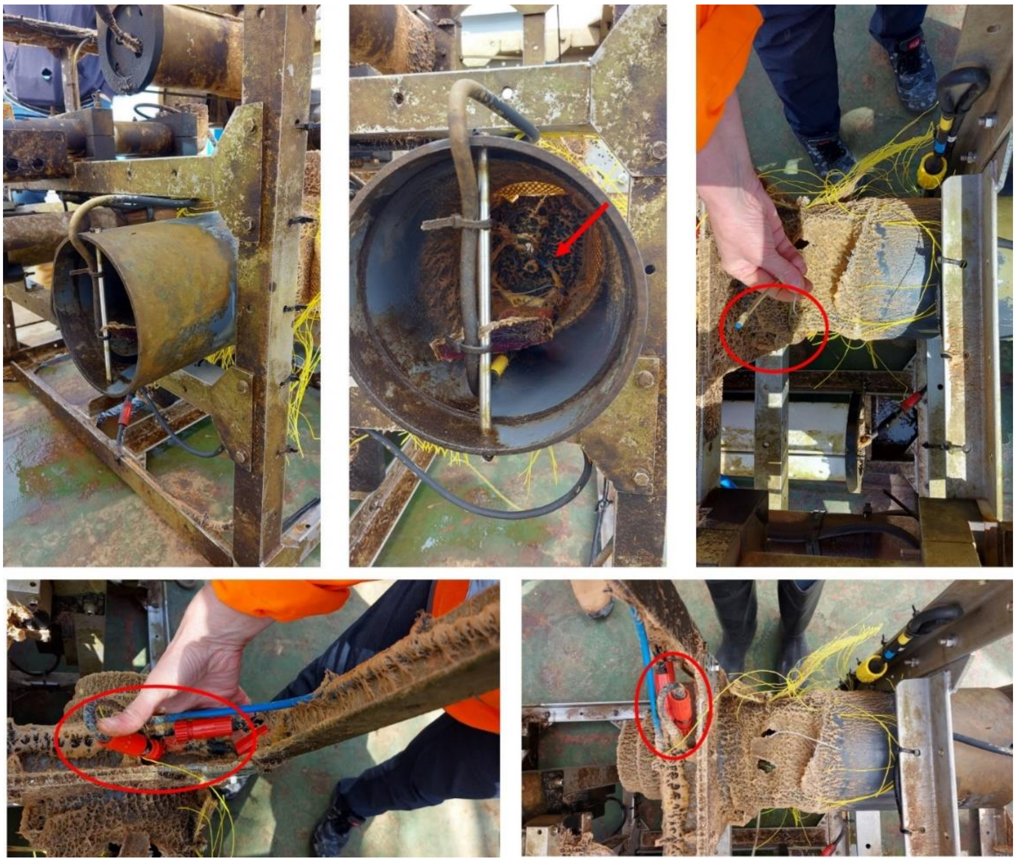
Clearwater Nitrate – SN: CWN-01-67 had biofouling on inlet / inlet growth. Data recovery: No data since deployment but drew a high current and was switched off 10th May 2022. When recovered it was clear that the CW-N had not started.

Clearwater Nitrate – SN: CWN-01-67

Clearwater Phosphate – SN: CWP-01-63 was also fouled at the inlet. Data recovery: No sensible data recovered – worked for a month giving some NRT data until 28th June 2022, but output negative values. Clearwater later said the pump had failed and have serviced the sensor free of charge.

Clearwater Phosphate – SN: CWP-01-63

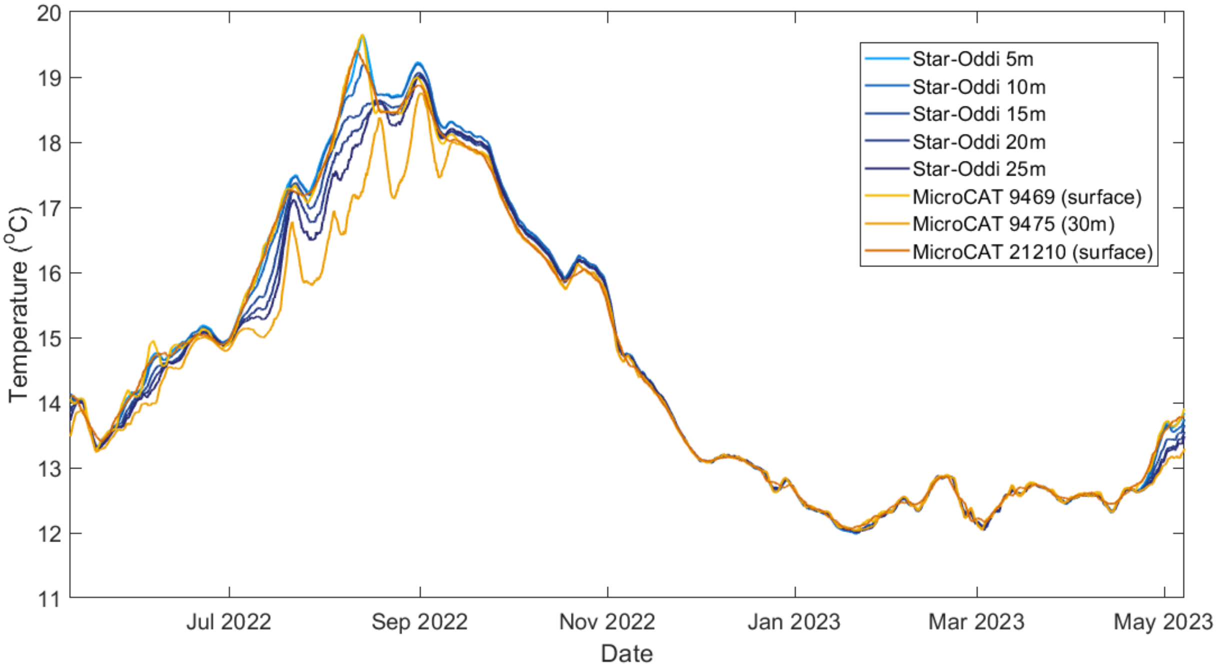
The OTE pH sampler – SN: 38 (below) had nothing left of the bags. The netting was frayed and the connectors were broken. There was no NRT data since deployment and the sensor was drawing a high current. It was switched off 10th May 2022.



OTE pH sampler – SN: 38

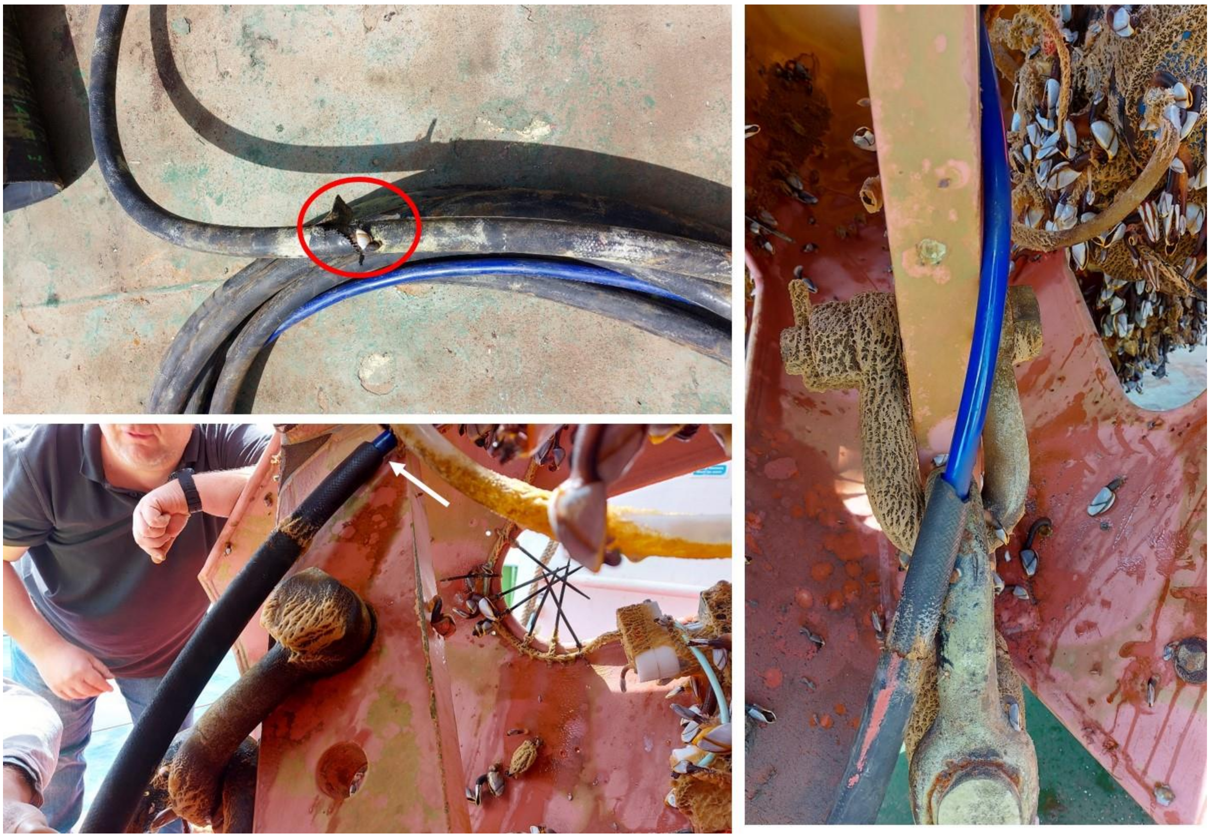
The Star Oddi DST Centris were a new batch, 2000 m rated. 88% of the battery had been used. All sensors were validated on CTD Cast7, 13th May 2023 to 100 m and depth corrections were made.

Star oddi SN	Approx. depth	Notes
C11512	25m	Actually ~28bar vals 2meas >cal On CTD7 27>cal range
C11511	20m	Deployment: 17>unit cal, 2>val range On ctd 659>cal, 218>unit
C11510	15m	actually ~25m, goose barnacle inside holder On CTD 1206 measurements
C11509	10m	Reads 5-7m, 811>cal, 17>unit val On ctd 722>cal, 606>unit
C11508	5m	Reads 3m, 2231 meas >cal range, 17>unit val On CTD 27>cal range, 648>unit val



Star oddi and Seabird 2022-2023 Temperature data

The PAP1 umbilical cable failed 28 Jun 2022 after 52 days



Photos of the umbilical at the keel

Photos of umbilical at the frame

8. PAP1 – deployment

The PAP1 mooring top section was deployed at 1800 12th May 2023 and the buoy parted from the rest of the mooring at on 31st August 2023. The buoy and frame preparations were largely done ashore at NOC by OTEG and NMF with support from Campbell Ocean Data, including all sensor testing. Some chemistry validation was done ashore by OBG with additional validation on JC247 after deployment. This involved shallow casts around 200 m from the buoy to take samples corresponding to the timings of the sensors.

One of the old buoy controllers (sn 02) was fitted on the buoy tower, and a new OTEG frame controller (sn 03) on the frame. A different type of cable was used for the umbilical connecting the buoy and frame controllers. The cable was a length of Nexans 4-core CTD cable with a yellow outer sheath and Kevlar armouring.

Five OceanSonics battery housings (3 blue, 2 old grey) were fitted in the frame. New instruments this year included the Clearwater NO3 sampler (a new SN one arrived on the day of sailing), Clearwater pH 'sampler' and a standalone LISST-HOLO camera (set up by Will Major, from Sari Giering's ANTICS group). A Vaisala GMP343 atmospheric CO_2 sensor was fitted inside the buoy tower along with a Vaisala PTU300 sensor providing air pressure and humidity readings.

8.1 Significant changes for 2023

Inductive communications. With only 4 electrical cores available in this year's umbilical cable it was not possible to operate inductive communications between the buoy and the frame. Instead the buoy controller had a separate inductive cable to communicate with the two MicroCATs on the buoy keel, and the frame controller employed a similar arrangement via an inductive coupler to communicate with the two MicroCATs on the frame.

UV lamp to combat biofouling. An AML UV lamp was fitted close to the Aanderaa optode in the buoy keel in an attempt to reduce biofouling on the optode foil. The lamp was powered and switched by the buoy controller with the capability to vary its duty cycle remotely. The buoy controller also records the lamp running hours as the lifetime of the UV LED is limited. The optode was configured to sample for 65 seconds every 30 minutes, and the UV lamp was switched on for 15 minutes once sampling was completed giving a 50% duty cycle for the lamp.

Atmospheric CO_2 measurements. This year two Pro-Oceanus CO_2-Pro atmospheric sensors were fitted side-by-side in the buoy keel with their two air intake boxes also being fitted side-by-side at the top of the buoy mast. A Vaisala GMP343 atmospheric CO_2 sensor was fitted inside the buoy tower along with a Vaisala PTU300 sensor providing air pressure and humidity measurements which are used to correct the CO_2 measurements. These two Vaisala sensors were fitted inside a plastic box mounted under the upper 'deck' inside the tower to protect them from seawater.

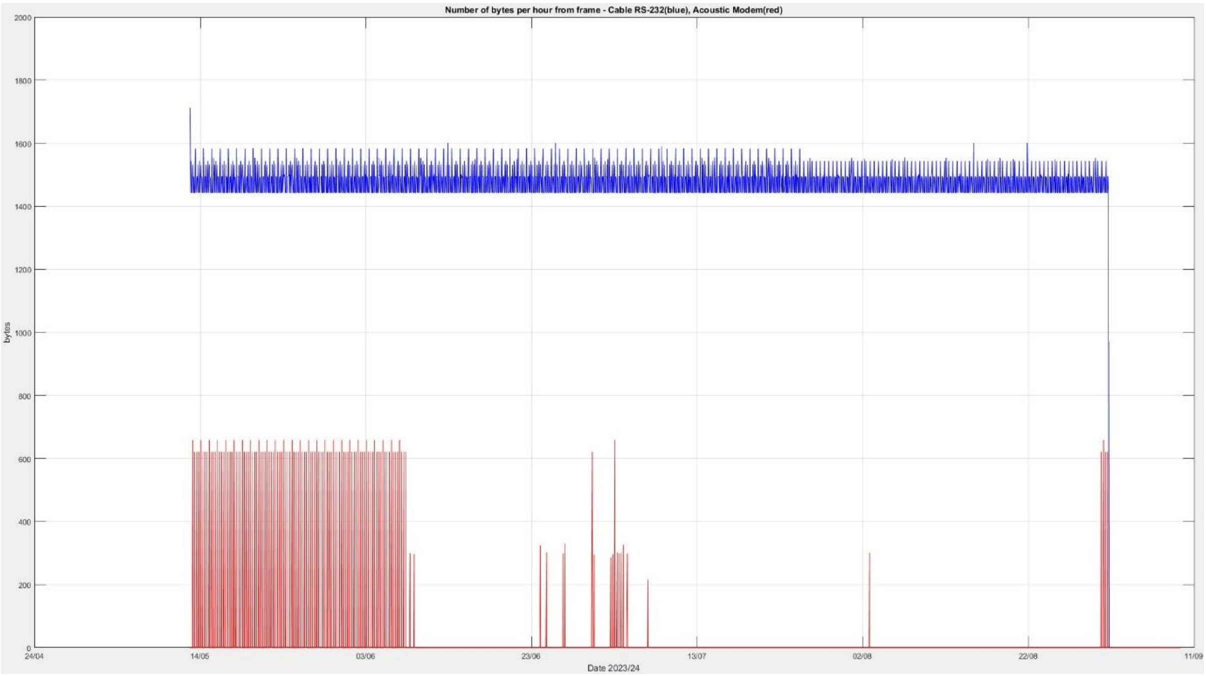
The buoy controller switches power to the Vaisala CO_2 sensor for 30 minutes once per hour, with a CO_2 measurement being made at the end of this period so that the sensor has had time to warm up.

Acoustic modem communications. A pair of LinkQuest UWM1000 acoustic modems were fitted to test the effectiveness of sending data from the frame to the buoy. These modems were purchased for PAP in 2014, together with a battery housing that was fitted in the frame to provide power for the 'bottom' modem.

The buoy controller switches power to the ‘surface’ modem, commands it to synchronise with the bottom modem, and then waits for data to arrive.

The bottom modem in the frame is always powered and is controlled by a controller on loan from the RAPID project which is mounted in a develogic housing together with alkaline batteries. For this deployment the acoustic modem system in the frame was not connected to the frame controller. The RAPID controller is configured to wake up every hour and measure battery voltages and internal temperature, and it also switches on a compass/pitch/roll sensor for 90 seconds. Every 6 hours it sends the accumulated data to the modem for transmission to the buoy. This equates to around 620 bytes every 6 hours.

The buoy modem was switched on shortly after deployment and synchronised with the frame modem at the first attempt. As the plot below shows in red, the system worked flawlessly for the next 26 days before it started struggling and then only worked sporadically until a day before the mooring parted.



New email commands for buoy and frame controllers. Several new email commands were added to the code to allow some degree of remote control over the frame sensors, Vaisala sensors, UV lamp and acoustic modem.

Aanderaa oxygen optodes. This year the three oxygen optodes were configured to output raw internal measurements as well as the computed oxygen values to provide the option of offline reprocessing. The buoy and frame controller code was modified to handle these additional parameters, as was the near real time data processing code.

The acoustic modem, and a fish tagger from Dalhousie were under trial. The frame ODO was new. On the buoy we had planned for a surface wetlab fluorometer (but it didn’t arrive in time). Also, on the buoy was a new UV light (from AML) to remove biofouling on the optode. It is recognized best practice to use these (see OOI cookbook, 2023) – however this is a trial as the UV light is power hungry. All other sensors had been for calibration, largely following retrieval on JC231 (the Seaguard was an old model but new to us this year).

The mooring was deployed on 12/05/2023, top end only - so the PAP1 watch circle remains as before. On the day of deployment all locking sleeves were covered with amalgamation tape (although it wasn't possible to do this for the frame hub connectors, which are very close together). Checks were made to secure all nuts, bolts, jubilee clips and cable ties on all instruments and harnesses (on the buoy and frame). The buoy power was switched off ashore and the umbilical laid out with the chain before being reconnected through to the OTEG hub. Jon Campbell switched the power back on from ashore. We had a last-minute check list (eg: all 3 CO_2 pumps, sensor covers, switching on the LISST-Holo). We needed to communicate with OTE and COD ashore to ensure all of the data was logging (successful after turning the ship through 180 degrees). We had confirmation from Jon Campbell, and from Jake Ludgate in OTE, that data was coming through. Only then could we proceed to PAP1 buoy deployment.

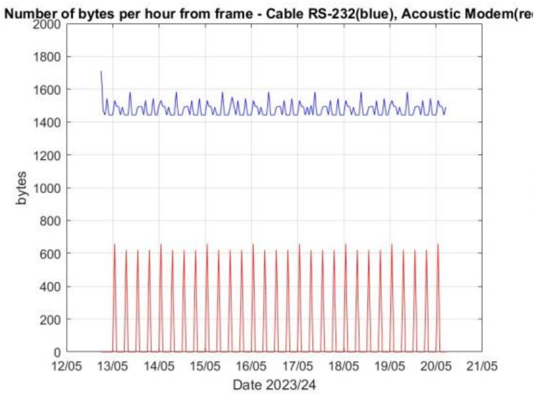
The NRT data are coming in and representative plots are shown below. This will be available on our new PAP-SO website. The table below is useful for tracking the IMS barcodes and SNs used, also for the timings of the sensor data. In the following section are photographs of each sensor before deployment, and some extra notes – especially on the umbilical as this is a perceived point of NRT comms failure on previous occasions. Ideally this should be replaced with something more robust and a swivel joint. Some effective looking solutions were found onboard by the NMF team, in a bid to protect the umbilical for as long as possible and photographs are again shown in this section.

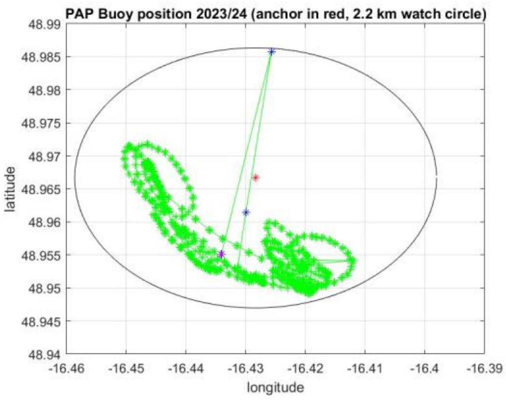
8.2 PAP1 sensor list for 2023

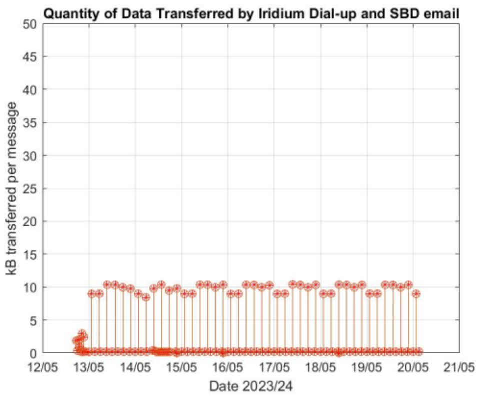
Buoy	Measurement details	Serial number	IMS number
Old Telemetry Unit/Buoy Controller		2	-
Pro-Oceanus CO2-Pro with atmospheric option	On 20 min then 12-hour sample @00:22 and zero	42-060-50A	260007774
Pro-Oceanus CO2-Pro Atmospheric (as a backup)	On 20 min then 6 hour @01:55 and 12 hour zero	41-824-50A	260006877
SeaBird SBE 37IMP-ODO MicroCAT	30 min @00	16503	260005135
SeaBird SBE 37IMP MicroCAT	15 min @00	6911	250005889
Satlantic OCR-507 ICSA (buoy)	On 1Hz, 2 mins, every 30 min @16 (30 sec mean)	226	250007461
Bioshutter II		230	250007461
Aanderaa oxygen optode with AML UV	30 min @08, every 15 sec for 65sec.	1279	250008127
AML UV light to reduce biofouling	15 min after optode	830328	
Vaisala GMP343 CO2 sensor	Ea. Hour 32min @22 and 52 past	J0350007	250008092
Vaisala PTU300 sensor	Ea. Hour for 5 min @14 past (sample at 18 past)	H4540002	250007970
LinkQuest UWM1000 Acoustic modem		15763	250008946
Xeos Beacon - Buoy tracker		1125	
Sensor frame			
New Frame Controller		3	-
Pro-Oceanus Logging CO2-Pro CV	On 20 min, then 8 hourly at 00, zero 12 hourly	33-146-45	250007965
Pro-Oceanus GTD-Pro sensor – gas tension	Every 30 min 02 and 32	33-152-16	250008089
SeaBird SBE 37-IMP-ODO MicroCAT T/S/O2	Ea.30 mins at 00 and 30	24126	260007405
SeaBird SBE-37IMP MicroCAT T/S	Ea.15 min at 00,15,30,45	6909	250005887
WETLabs FLNTUSB Chl Fluorometer	Ea. 4 hours at 00	7923	260007809
Satlantic SUNA-V2 Nitrate sensor	Hourly at 20 past	698	260001450

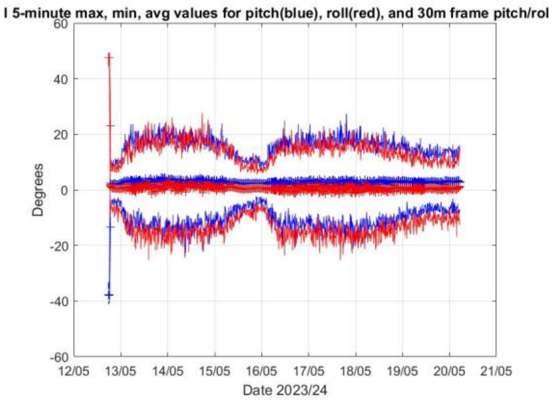
Clearwater Nitrate sensor	Switch on @00:35, ea. 12 hours (sample 15 mins later)	CWN-01-52	260008155
Satlantic OCR-507 R10W radiance (looking down)	Ea. 30min @16 and 46, 1Hz 2.5min (nrt mean ea. 30 sec)	113	250009593
Bioshutter II for OCR	For OCR	231	260006286
Aanderaa Seaguard logger (current meter not functioning)	Every hour at 00	91	260008111
Aanderaa 4330 oxygen Optode	Ea. 30 min at 15 and 45, ea. 15sec for 65sec	1299	250008134
Turner Cyclops chl Fluorometer in Seaguard	On seaguard	21102209	
ZebraTech Wiper for Cyclops	With Seaguard Cyclops		
Aanderaa oxygen optode	On seaguard	1281	250008128
CW LoC pH sensor - new one	Switch on @02:35, ea. 6 hours (sample 15 mins later)	CWpH-01-112	260008285
LinkQuest UWM1000 Acoustic modem	See Jon Campbell	15762	250008945
Old RAPID Lander controller to test AModem	See Jon Campbell	2032	260001732
LISST-HOLO camera and battery	See Will Major		
Battery housings in frame 2023		**Serial number**	**IMS number**
OceanSonics OS200 (blue)		2341, 42, 43	
OceanSonics old grey plastic		2303 (and 2306)	260002867
LinkQuest 21V alkaline UBH2047-800		15735	250008947
develogic controller housing for Acoustic modem		2032	260001732
WETLabs BPA50		356	260004507
Star oddis 8969, 8930, 8967, 8928,	12 hourly		5,10,15,20m

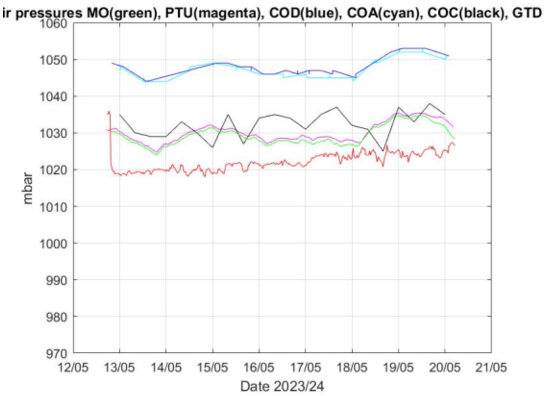
The following plots are an overview of data from PAP1 – NRT data up to 20/05/2023:

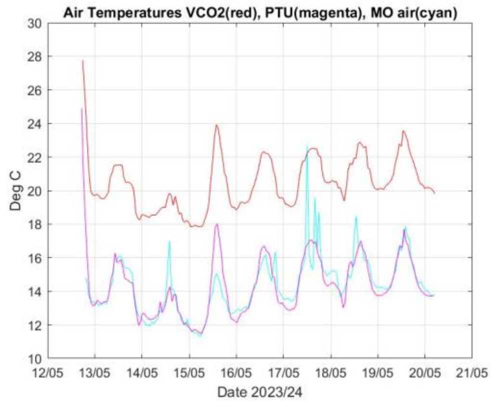


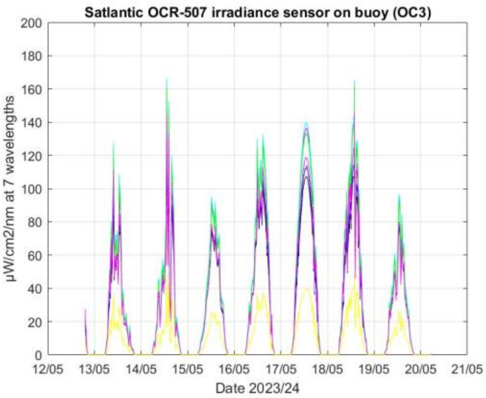


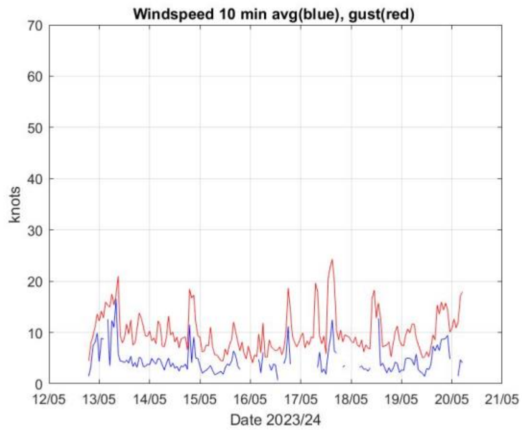

Quantity of Data Transferred by Iridium Dial-up and SBD email
kB transferred per message
Date 2023/24

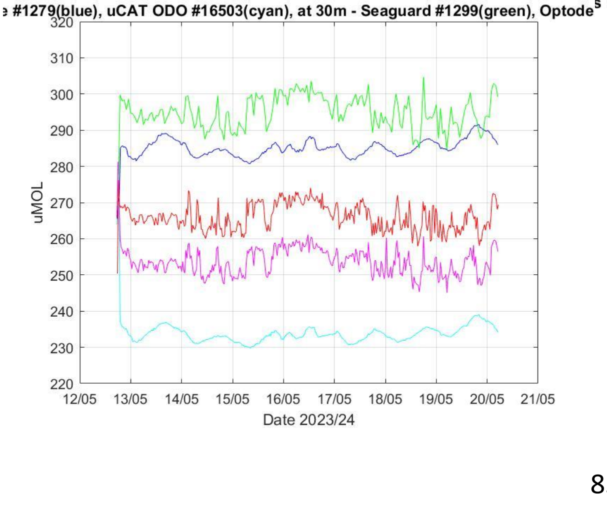

l 5-minute max, min, avg values for pitch(blue), roll(red), and 30m frame pitch/rol
Degrees
Date 2023/24

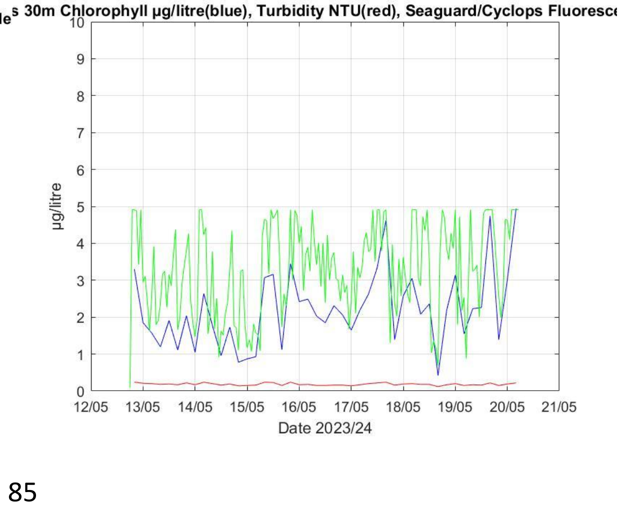

ir pressures MO(green), PTU(magenta), COD(blue), COA(cyan), COC(black), GTD
mbar
Date 2023/24

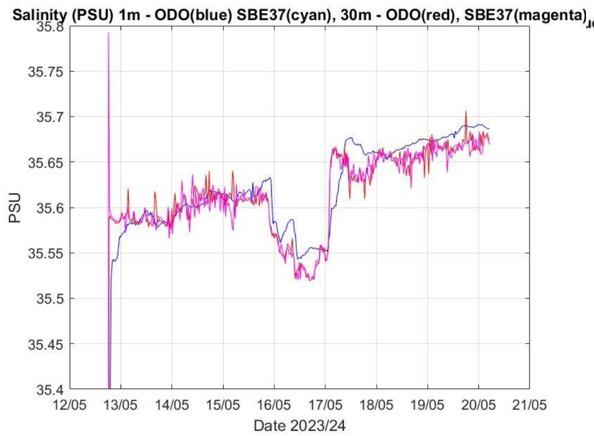

Air Temperatures VCO2(red), PTU(magenta), MO air(cyan)
Deg C
Date 2023/24

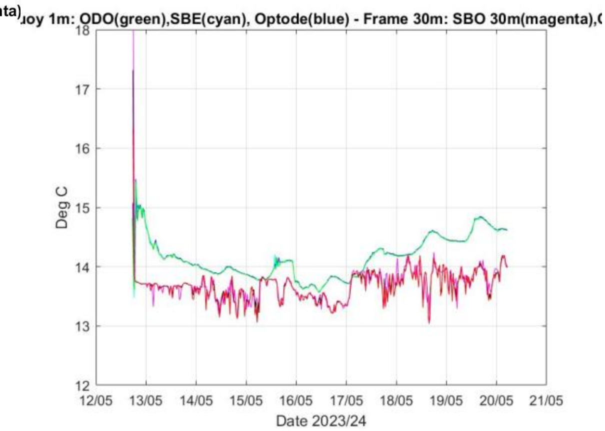

Satlantic OCR-507 irradiance sensor on buoy (OC3)
µW/cm2/nm at 7 wavelengths
Date 2023/24

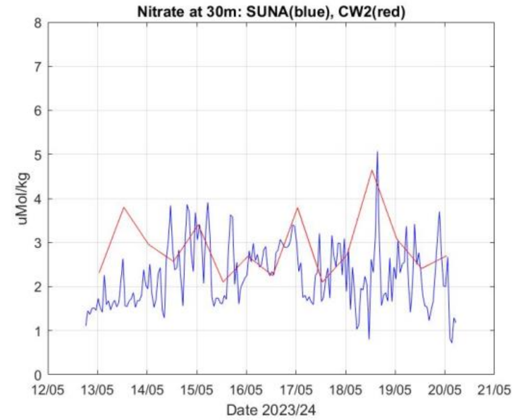

Windspeed 10 min avg(blue), gust(red)
knots
Date 2023/24

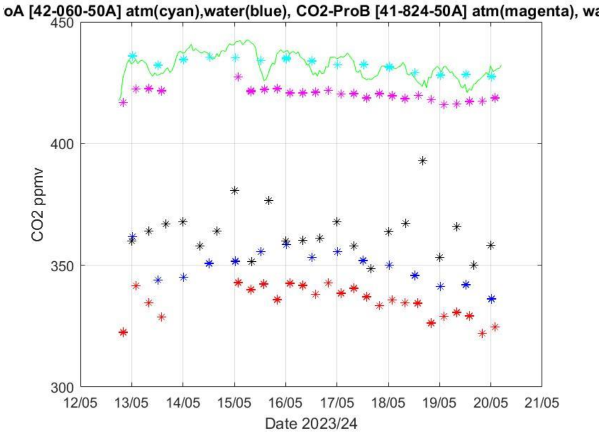

e #1279(blue), uCAT ODO #16503(cyan), at 30m - Seaguard #1299(green), Optode
uMOL
Date 2023/24

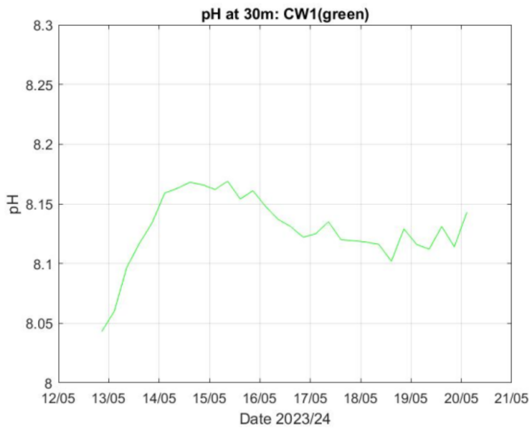

s 30m Chlorophyll µg/litre(blue), Turbidity NTU(red), Seaguard/Cyclops Fluoresc
µg/litre
Date 2023/24

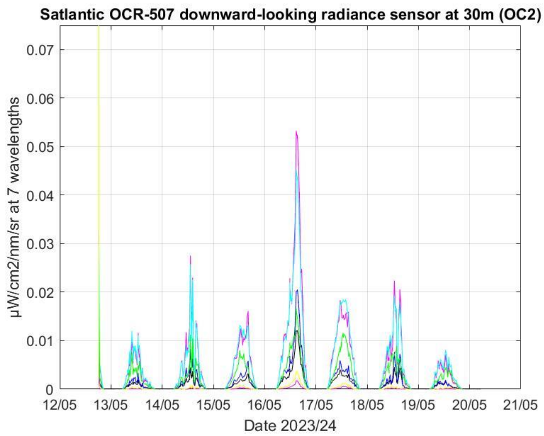

Salinity (PSU) 1m - ODO(blue) SBE37(cyan), 30m - ODO(red), SBE37(magenta)
PSU
Date 2023/24


uoy 1m: ODO(green),SBE(cyan), Optode(blue) - Frame 30m: SBO 30m(magenta),(
Deg C
Date 2023/24


Nitrate at 30m: SUNA(blue), CW2(red)
uMol/kg
Date 2023/24


oA [42-060-50A] atm(cyan),water(blue), CO2-ProB [41-824-50A] atm(magenta), wa
CO2 ppmv
Date 2023/24


pH at 30m: CW1(green)
pH
Date 2023/24


Satlantic OCR-507 downward-looking radiance sensor at 30m (OC2)
µW/cm2/nm/sr at 7 wavelengths
Date 2023/24

8.3 Buoy tower

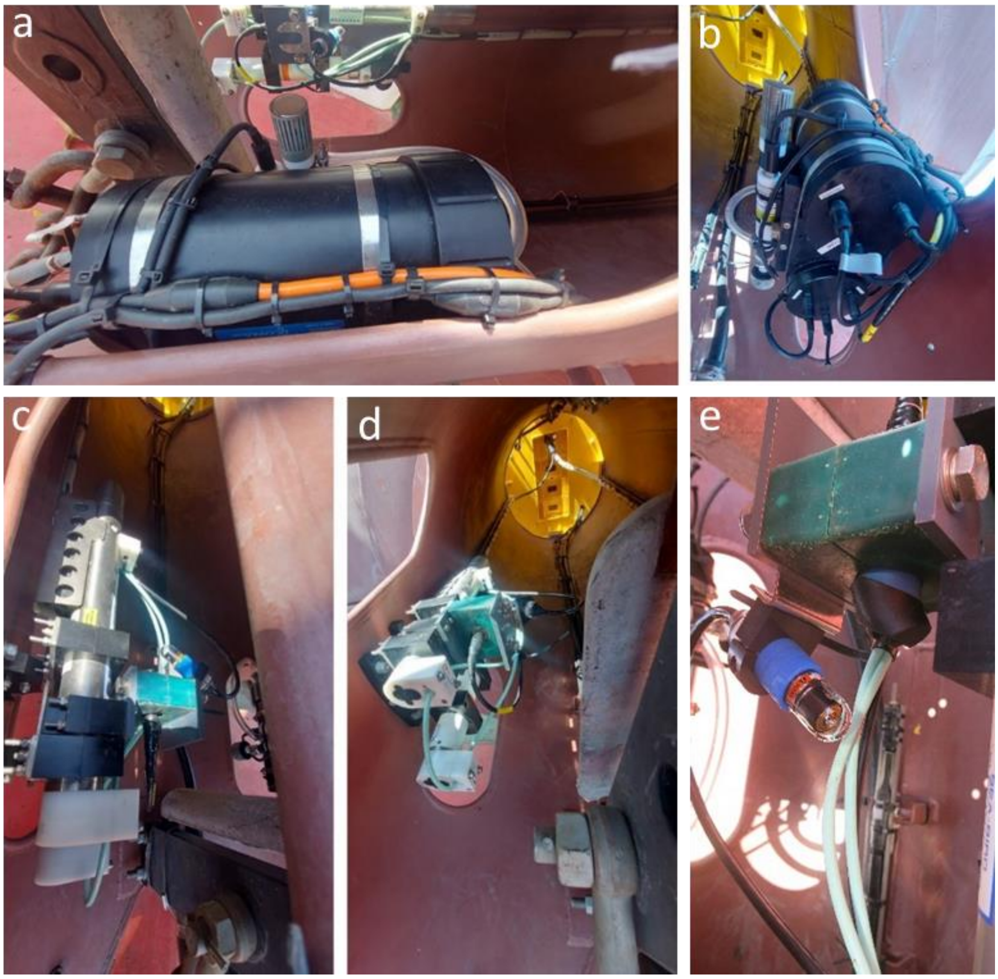
Photo of Met Office sensors, tracker, OCR and 2 Pro-CO2 atmospheric gas inlet boxes.

A bracket was taken from the retrieved buoy for the Xeos Beacon - Buoy tracker (SN: 1125) seen to the right of this photo. The Satlantic OCR-507 ICSA - SN: 226 (Bioshutter II – SN: 230) was mounted on the buoy back at NOC – the copper shutter is visible in the centre of this photo. The atmospheric air inlet boxes were fitted back at NOC (these are the 2 grey boxes in this photo). It is the first time that we have had a full atmospheric CO_2 sensor back up. Vaisala GMP343 CO2 sensor- SN: J0350007 and PTU300 sensor – SN: H4540002 are in the buoy tower – also for the first time at the PAP-SO. The old Telemetry Unit/Buoy Controller – SN: 2 – was used for the JC247 deployment.

Cables inside the tower JC247 deployment

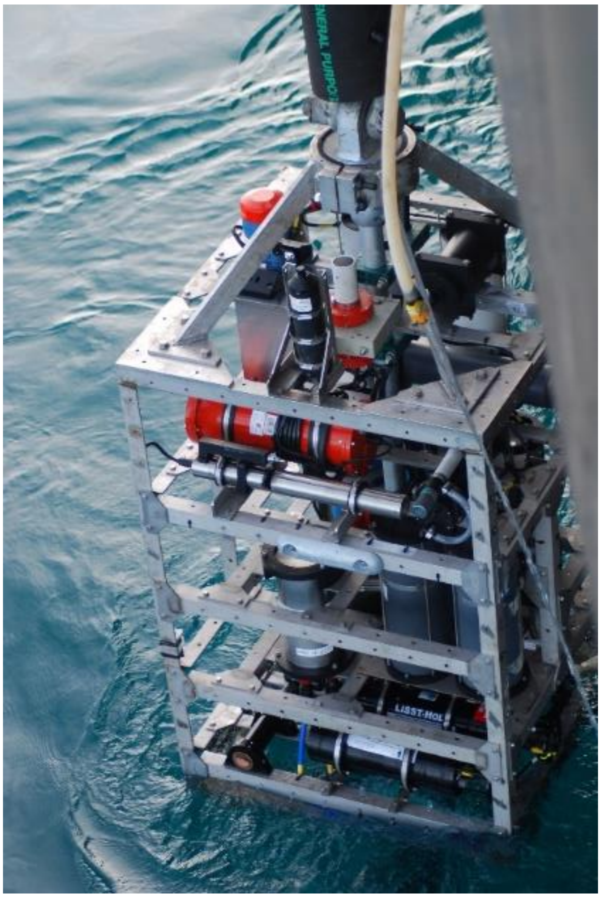
8.4 Buoy keel

The Pro-Oceanus CO2-Pro with atmospheric option – SN: 42-060-50A (a & b below) was positioned on the buoy keel at NOC – with new pumps and copper. A second Pro-Oceanus CO2-Pro Atmospheric was used as a backup (SN: 41-824-50A). Both copper variations are visible in the 2nd photo. The SeaBird SBE 37IMP-ODO MicroCAT – SN: 16503 and SeaBird SBE 37IMP MicroCAT – SN: 6911 (c & d below) were mounted on the opposite side of the keel. The new AML UV light (to protect the Aanderaa oxygen optode – SN: 1279) is just visible on the photo too, as is the caballing up to the MO buoy tower that was secured by NMF on JC247. The AML UV light is used to reduce biofouling – SN: 830328 (e below)



a & b: Pro-Oceanus CO2-Pro with atmospheric option – SN: 42-060-50A, c & d: SeaBird SBE 37IMP-ODO MicroCAT – SN: 16503 and SeaBird SBE 37IMP MicroCAT – SN: 6911, e: AML UV light

8.4 Sensor frame



The PAP1 sensor frame deployment during JC247

A LinkQuest UWM1000 Acoustic modem – SN: 15763 is being tested this year.

The New OTEG Frame Controller – SN: 3 is in use to control the frame sensor. It was set up by Jake Ludgate and Daisy Tong ashore.


The Pro-Oceanus Logging CO2-Pro CV – SN: 33-146-45 is used to measure CO_2 at 30m depth. It has a pump with the old-style copper and thick tubing (Set up by Jon Campbell at NOC).


The Pro-Oceanus GTD-Pro sensor – SN: 33-152-16 is used to measure the gas tension. SeaBird SBE 37-IMP-ODO (T, S, O2) MicroCAT – SN: 24126 and SeaBird SBE-37IMP MicroCAT – SN: 6909 were set up together on the frame. Unlike previous years we did not do a pre-calibration of these (or the other sensors) at sea.


The WETLabs FLNTUSB Fluorometer –SN: 7923 was set to be outward looking on the frame (30-degree cone of reference). The blue plug was applied at NOC to activate this sensor. An old Aanderaa Seaguard – SN: 91 was found for this deployment – and has been back to Aanderra for a new screen and for calibration of the Aanderaa Optode – SN: 1299. The new Turner Cyclops Fluorometer on the Seaguard - SN: 21102209 is protected from fouling by a brush wiper (driven by a ZebraTech motor). The Seaguard has a current meter fitted but it has not been activated – last year we saw diurnal variation in the oxygen that may have been from the rain down of particles, it is hoped that the current meter will go some way to protect from that. An additional Aanderaa oxygen optode – SN: 1281 was fitted to the frame.

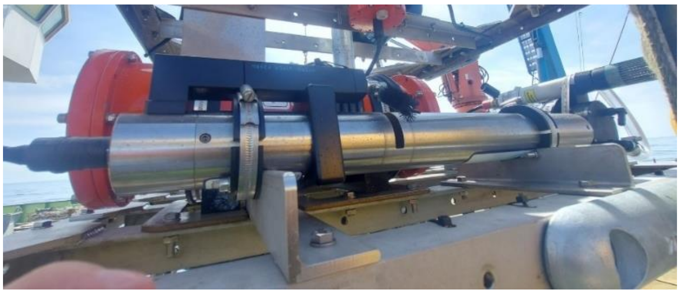
The wetlabs fluorometer on JC247

The 30m Seaguard – with bracket, optode and fluorometer

The zebratech wiper and motor for the cyclops fluorometer

Standalone Aanderra optode

Nitrate measurements will be made using two instruments. The solid state SUNA UV detection sensor had worked well on the DY130 deployment and has been redeployed this year after calibration at Seabird. It is a Satlantic SUNA-V2 Nitrate sensor – SN: 698, and the measurement window is protected through periodic brushing.



Suna nitrate with brush visible half way along, brush movement checked onboard

A Clearwater Nitrate sampler – SN: CWN-01-52 was acquired for the deployment. On the day that we left NOC this instrument had been replaced (SN 64). A subsample of the standard was provided by the company and measured onboard. We requested a 10 µmol/l standard, which actually measures closer to 12 µmol/l.

We also bought a CW LoC pH sensor - SN: CWpH-01-112 in the last capital round as pH (along with nutrients) is required by ICOS. Both instruments are wet chemistry LoC. They were mounted together on the frame and the seawater bags removed before deployment (these were to prevent the unit pumping dry and having air bubbles).

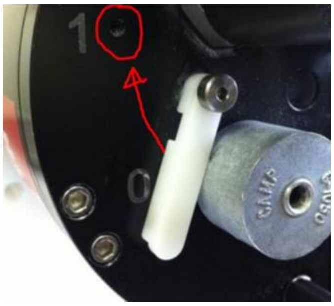
Clearwater nitrate and pH LoC 'samplers'

A Satlantic OCR-507 R10W radiance (looking down) – SN: 113 and Bioshutter II- SN: 231 were also mounted on the frame (unfortunately we do not have an upward looking OCR available). These instruments are now quite old and although it is useful to see how the light environment varies through the year we would probably prefer to use a more modern scanning radiometer in future.

A LinkQuest UWM1000 Acoustic modem – SN: 15762 and Old RAPID Lander controller was fitted to test Acoustic Modem – SN: 2032.

On previous PAP cruises including JC231 a LISST-HOLO camera had provided useful plankton data so we asked the ANTICS team if we could deploy one in 2023. Will Major and Sari Giering provided a stand-alone V1 Lisst Holo, with its own battery, that we have attached to the 30m frame. Instructions to switch this on were provided and this was done just before deployment.



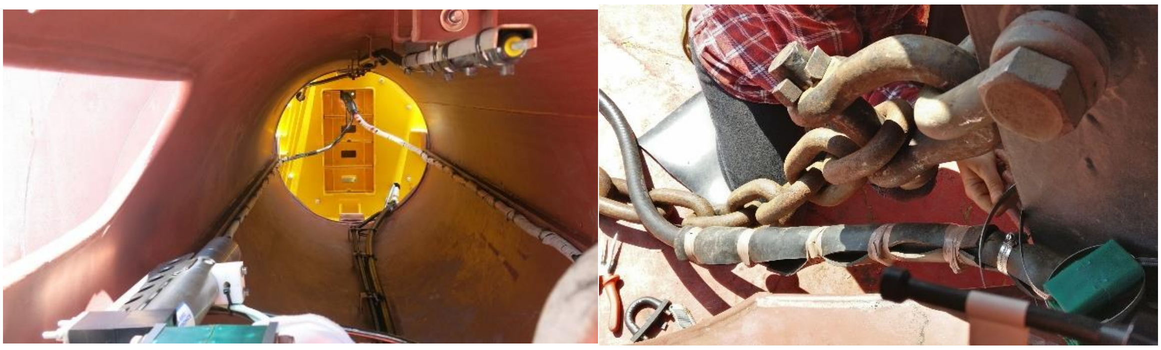
Lisst holo switch

Lisst-holo and battery JC247

DST Centri Star Oddis were attached to the chain links just before deployment. They had been set up by Corinne ashore on 20th May, to measure every 12 hours. They were provided in cases that just needed securing (using cable ties and tape as a marked for retrieval) to the brackets that hold the umbilical to the chain. They were added at approximate depths below the buoy as follows – SN8969 (5m, planned for 50m if on full turn around), SN8930 10m, SN8967 (15m, planned for 100m), SN8928 (20m).

Initial set up and an example of star oddi attached on JC247

8.5 Umbilical cable



Shows umbilical tidied away in the buoy tower onboard and at the base of the keel

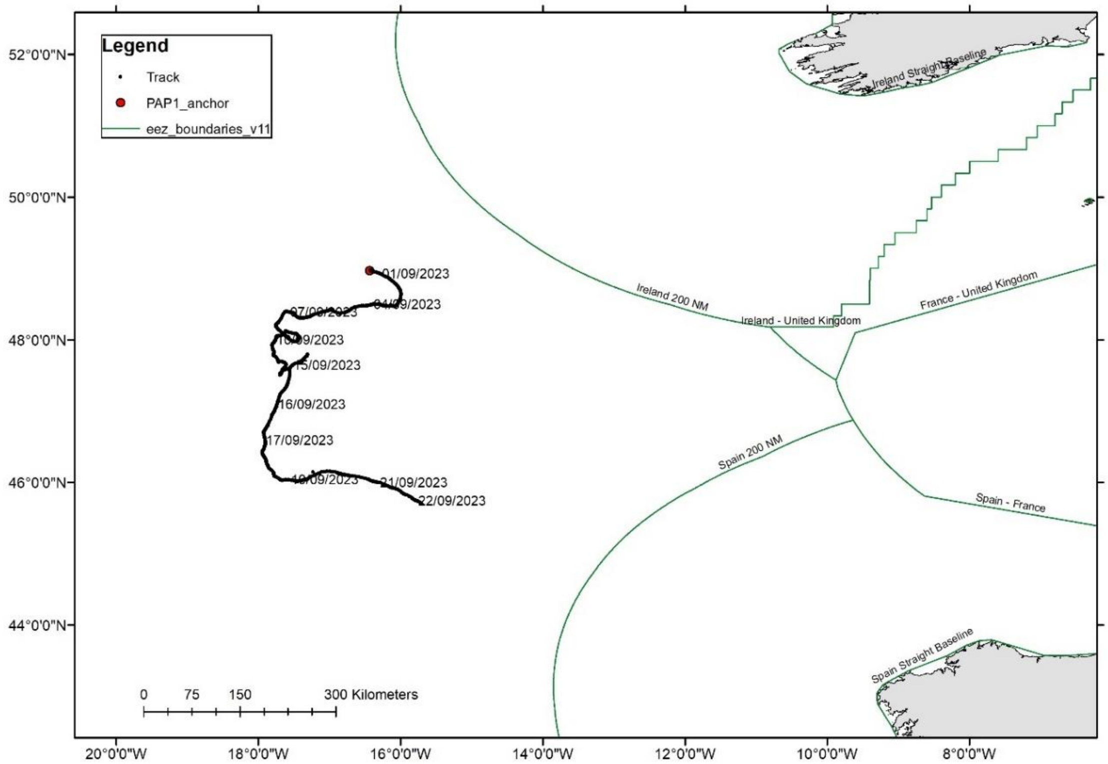
All tubing and cables up to the top of the Met Office buoy tower were secured onboard before deployment and the umbilical cable was protected (by NMF's Billy and Tina) using a green clamp, rubber sheeting and jubilee clips at the base of the buoy.

Pictures show how the chain cover was held in place by a bolt through the chain next to the frame shackle. The umbilical was attached to this and the coating lengthened using reinforced plastic tube that was covered with tape.

Photos show the umbilical and chain laid out on deck the morning of the deployment, with the green bracket, tubing (with black tape covering) inside the frame

8.6 Mooring loss 31st August 2023

The Mobilis buoy went adrift on 31st August 2023. The buoy was recovered by the RRS *James Cook* 22nd September 2023 at the end of JC251. The buoy drifted generally south during this period and was recovered 370 km from its anchor. The sensor frame hangs under the buoy on a chain which is shackled to a steel cross bar in the bottom of the keel. Upon recovery this bar was found to be missing along with everything beneath it. The engineering data (e.g. pitch and roll of the buoy) supports an interpretation that one side of the cross bar broke free approximately 10 days before it became fully detached. Nothing below the keel of the buoy was recovered. The remainder of the mooring (including the sensor frame) is assumed to be hanging beneath the midwater float and should be recovered on the next PAP cruise.



Track of the PAP1 buoy after it became detached from the mooring on 31st August 2023

9. CTD profiles and water sampling

Sue Hartman, Hans Hilder, Theo Picard, Anita Flohr, Ed Mawji,
Elisa Lovecchio & Malcolm Woodward

Samples were taken on all 17 CTD casts for various reasons, including: validation of sensors on the CTD frame; validation of mooring microcats and Star Oddis attached to the CTD frame; validation of ARGO floats (deployed in pairs, on 3 occasions immediately after the CTD casts). Additional sensors tested on the CTD casts included BORAbox (a standalone LoC carbonate chemisty sensor package typically deployed on industry remotely operated vehicles) at the start of JC247, then the Contros (CO_2) sensor mid-JC247. Full depth CTD samples and profiles will also be used for deep water mass analysis and comparison year to year, as they are always taken at same PAP CTD site (49°N, 16.5°W). The deeper casts were also used for mooring release tests. For the surface casts we generally returned to be as near to PAP1 as possible, though other casts were completed during underway surveys to compare with satellite data. The bottle depths were selected for interesting features and at some depths there were ‘long stops’ (especially for the slower response sensors that were being tested).

The first samples taken each time were for dissolved oxygen (analysed onboard) and included bottle temperature to identify any misfires. The second sample was for DIC and TA, sampled into 250ml bottles, preserved with HgCl2 for Vindta analysis ashore. Then Inorganic nutrients were taken for PAP - with additional Niskins fired specifically for the Euro Go-SHIP nutrient storage experiment. On some casts additional DOC samples were filtered and collected directly from the Niskins. In all cases non-nitrile gloves were used. The pelagic team then took salinity samples on most casts, for analysis by NMF. The 5L carboys were then filled (sometimes in duplicate) for all of the chlorophyll related variables. Most of the Chlorophyll (and SFC) samples were filtered, extracted in acetone and analysed onboard (Black Trilogy). PIC, POC and BSi analysis will be carried out at NOC. The HPLC analysis will be at SHOM, France (EU project MINKE). SHOM is the Service hydrographique et océanographique de la marine (French Naval Hydrographic and Oceanographic Service).

HPLC samples for SHOM (2L filtered)

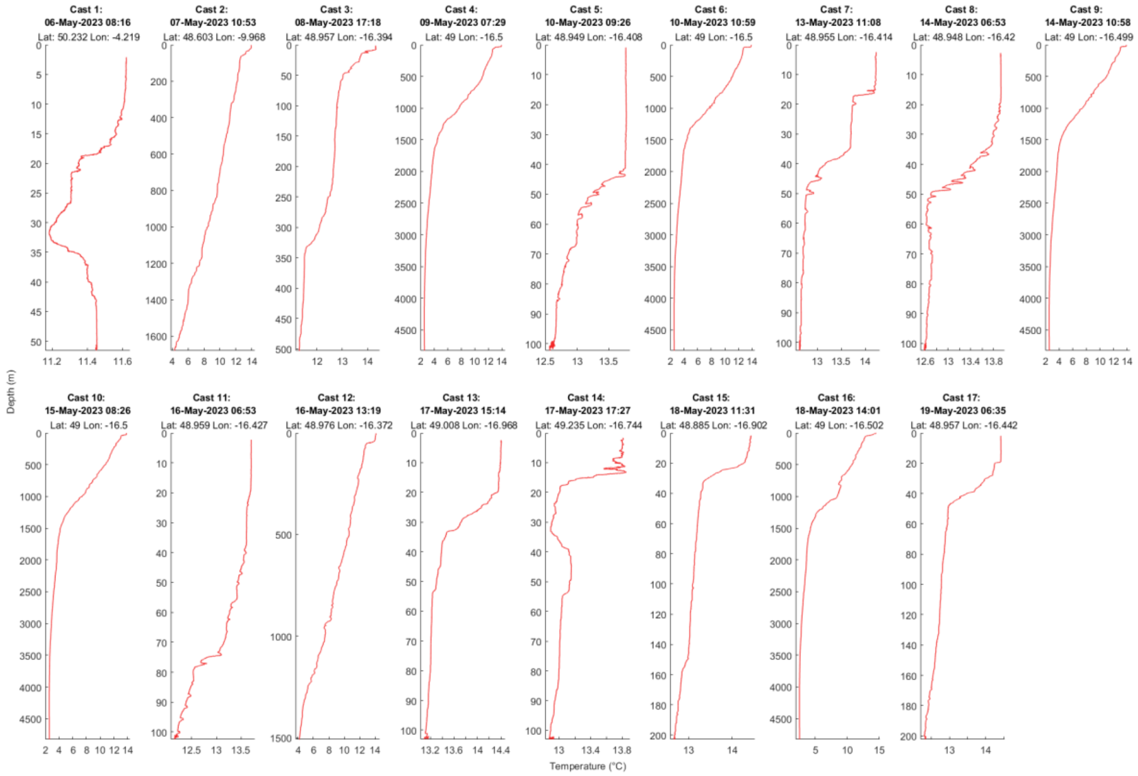
Date	Cast	Lat,lon	Niskin	Depth (m)
6/5/23	CTD1	50° 13.9, 4° 13.15	N19	5
7/5/23	CTD2	48° 36.2, 9° 58.1	N19 N22	25 5
10/5/23	CTD5	48° 56.934, 16° 24.474	N1 N6 N10 N20	100 60 30 5
14/5/23	CTD8	48° 56.868, 16° 25.198	N1 N6 N11 N15 N20	100 40 30 20 5
15/5/23	CTD10	49°, 16° 30	N23	5

9.1 Table of CTD depths and notes

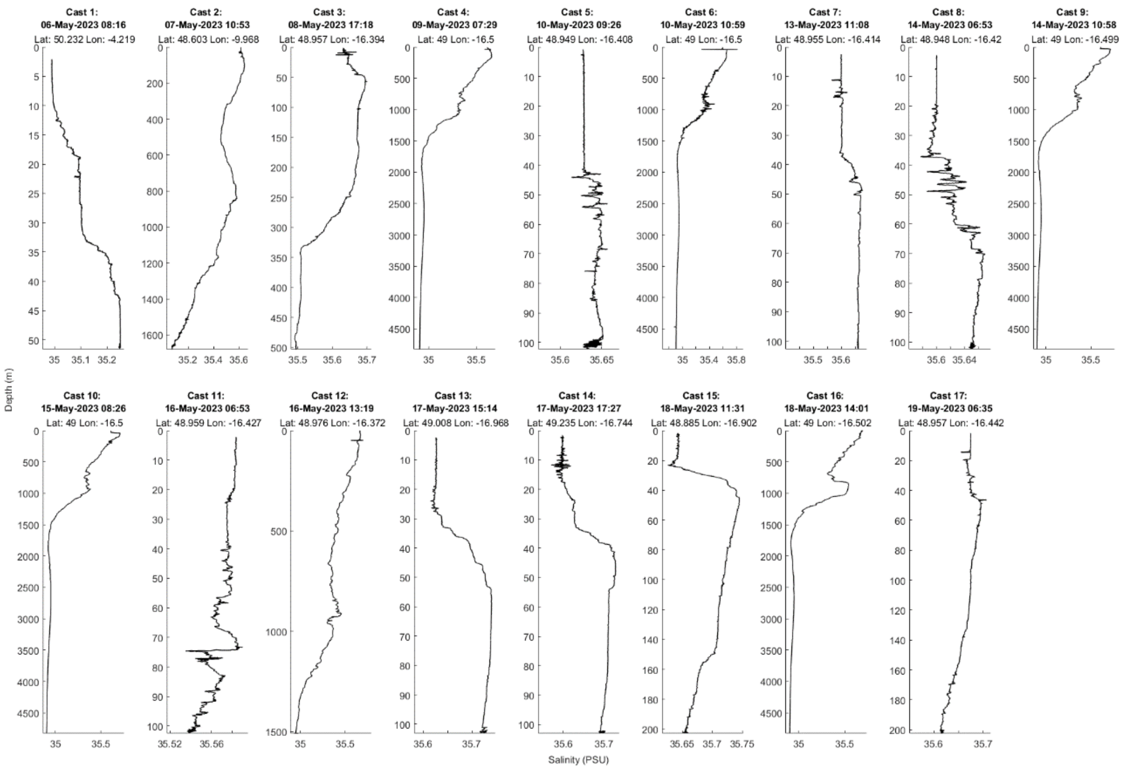
CTD cast, station no. and name	Depth (m)	Notes
1 (1) L4	50, 25, 10, 5	Coastal for Go-Ship. Missfire N17
2 (2) WC	1678, 1200, 800, 350, 200, 55, 25, 5	Release tests. Missfire N17
3 (4) PAP1	500,400,300,200,150,100,80, 60,50,40,30,25,5	BoraBox on. Remove N16 and N17
4 (8) PAP CTD	4825,4000,3000,2500,1900,1 500,1000,900,775,600,500,40 0,300,200,100,50,30,25,20,5	BoraBox 20min stops, for APEX SN10066+10068 N9 likely a missfire
5 (17) PAP1	100,60,30,25,5	No long stops. Val. BGC float deployed after.
6 (18) PAP CTD	4824,4500,3500,2000,1800,1 200,775,550,425,350,250,90, 30,22,10,5	BoraBox on. N9 missfire. Val. APERO and Navis
7 (31) PAP1	100,75,30,19,5	N9 likely a misfire (possibly N5 too although nutrient looks OK). Long stops, post cal star oddi c11508-12
8 (37) PAP1	100,80,40,30,5	Contros, BoraBox, long stops. Timed to PAP1. N9 missfire
9 (38) PAP CTD	4825,4700,4200,3200,2750, 2100,1800,1700,950,740,450, 325,175,85,55,35,30,17,5	Contros, long stops, SBE 9385,86 (WC), 9475 30m, 12463 PAP3
10 (42) PAP CTD	4826,4400,4100,3100,2200, 1840,1800,1100,925,800,735, 625,525,375,275,125,70,40, 30, 25,5	Contros (regular speed), BoraBox TA, long stops
11 (46) PAP1	100, 55, 3, 30,25,5	Contros, BoraBoxTA, long stops, N12 possible leaks
12 (48) PAP CTD	1500,1100,913,800,730,500,2 50,35,30,5	Go-Ship, use 2° sensors. 5 min stops. SBE PAP1 buoy 9469, 21210
13 (54) CTD1W	100,30,20,12,5	Survey 1 for chl:sat, Possible misfires N5 and N15 (check temperature?)
14 (55) CTD2N	100,50,30,12,5	Turb.spike at 50m sampled, Possible N5 missfire (although nutrients look OK), N11 nutrients look OK – check temp. for misfire?
15 (57) CTD3 survey	200,100,50,30,19,5	For chl:satellite survey. Light to 175m, N 7 possible leaks (looks ok on nutrients)
16 (58) PAP CTD	4827,4500,4000,3500,2500, 1500,925,800,750,600, 450,250,100,30,17,5	Jellies on the CTD frame. Last deep cast, collect bulk water for NOC
17 (59) PAP1	200,100,50,30,15,5	Last cal check PAP1 mooring. Light to 60m

9.3 Example profiles

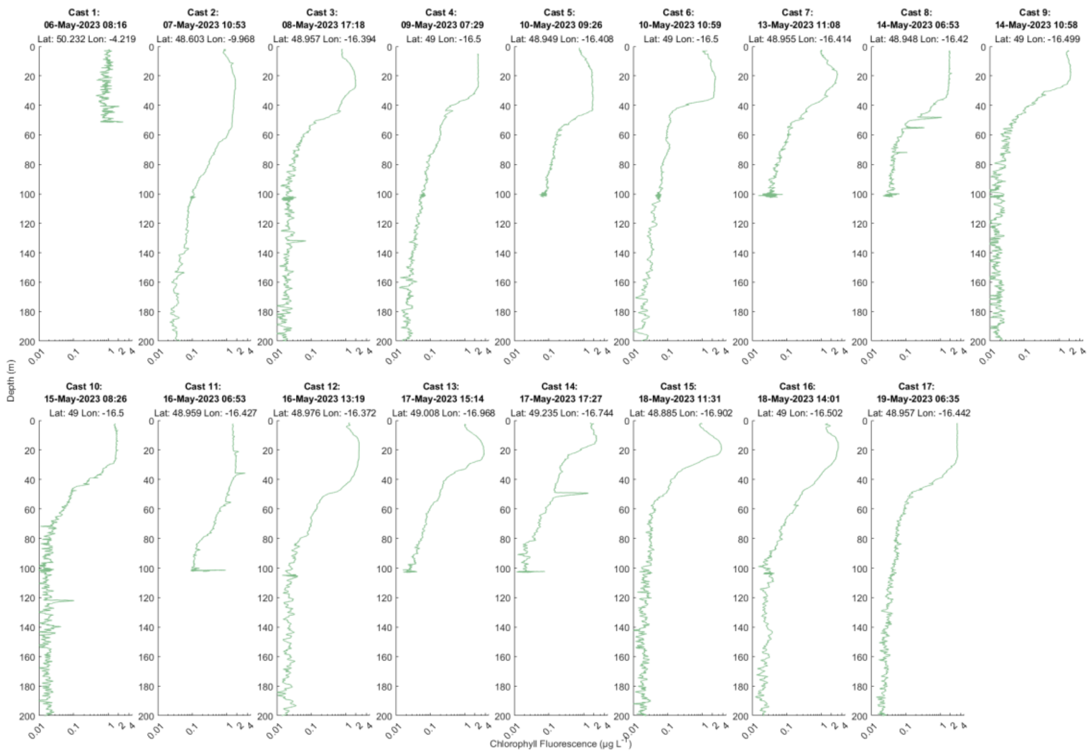
Hans Hilder



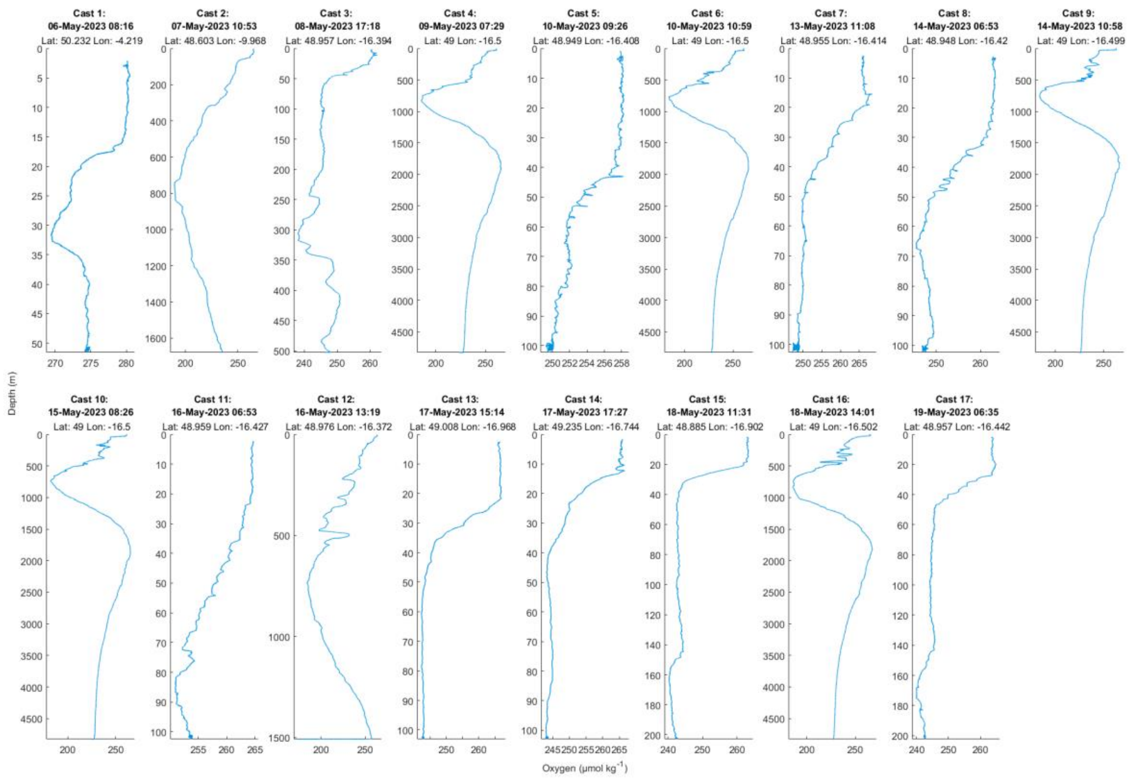
Temperature profiles for the 17 CTD casts on JC247. Note different scales on y axis (depth).



Salinity profiles for the 17 CTD casts on JC247. Note different scales on y axis (depth).



Chlorophyll fluorescence profiles for the 17 CTD casts on JC247. Note scale on y axis is always 200 m.



Oxygen profiles for the 17 CTD casts on JC247. Note different depth scales on y axis.

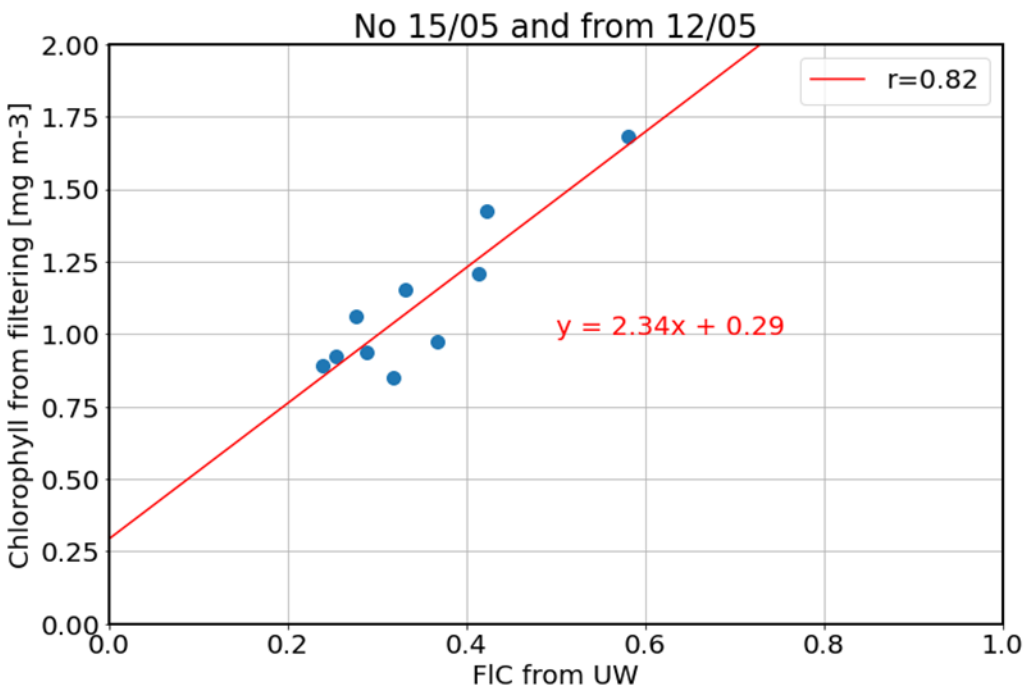
9.4 Filtering report

Chris Feltham, Theo Picard, Corinne Pebody (ashore)

This filtering report includes CTD samples from the Niskin bottles and underway water samples. Sea water is filtered, to collect particles of several size fractions (10; 5; 0.7; 0.2), for POC, PIC, silicate Chl-a. We used a set of 6 vertical towers bottles to let the water cross the filter by gravitation. We accelerated the filtering process using a pump under gentle pressure (< 20 kPa).

Chlorophyll a is extracted with 90% HPLC grade acetone and measured using a turner benchtop fluorometer. The benchtop fluorometer was then calibrated at NOC against chlorophyll (spinach) standards by Corinne Pebody and drift corrected. Calculated Data for chlorophyll a, and size fractioned chlorophyll from CTD and chlorophyll a from underway samples are submitted to BODC.

The graph below shows the regression curve for the chlorophyll concentration of the samples taken from 9th to 15th May 23 during the JC247 cruise. This equation is used to correct the TSG Fluorescence Induction Curve (FIC) readings. Note The r^2 value is relatively close the 1.



Protocols

Size fractionated samples

1. Collect CTD water from 3-6 depths in plastic bottles (either use dark brown plastic bottles or place clear bottles in black plastic bag when filled);
2. Measure out 500 ml from each depth (if filtration takes a long time for shallow depths, reduce filtered volume to 200 ml. Make sure that this is noted on the spread sheets);
3. Place 25 mm 0.2 µm polycarbonate filters on filtration tower using forceps;
4. Filter under gravity (if it takes a long time under gravity, filter under gentle pressure (max -20kPa);
5. Once finished filtering, place Chl filters into glass vials;
6. Add 6 ml of 90 % acetone using a bottle top dispenser;
7. Label glass vial;
8. Repeat steps 2 to 7 and filter 500 ml under gravity with a 25 mm 5 µm polycarbonate filter;
9. Repeat steps 2 to 7 and filter 500 ml under gravity with a 47 mm 10 µm polycarbonate filter;

POC

1. Collect CTD water from your chosen Niskin bottles, using plastic bottles (either use dark brown plastic bottles or place clear bottles in black plastic bag when filled);
2. Gently mix the water samples, turning the bottles upside down in a circular motion 3 times;
3. Measure out 1L from each of the selected depths.
4. Place one of the pre-combusted 25mm diameter Whatman GFF filters on the filtration tower using acetone cleaned forceps, to avoid contamination of the filter;
5. Filter the samples under gentle pressure (max-20KPa);
6. Once the sample has finished filtering, rinse the filtration cup with roughly 10ml of filtered sea water. This should remove excess salt residue;
7. Place the POC GFF filters into petri slides and label them with the following; Cruise number, Station number, CTD number, Niskin number, POC and Date;
8. Place the petri slides in a drying oven overnight at 40 ˚C, with the lid slightly askew as to facilitate the drying process.
9. The next day remove the petri slides and replace the lids securely. Then tape the lids shut and place in a plastic sample bag to avoid the mixing of samples.

PIC

1. Collect CTD water from your chosen Niskin bottles, using plastic bottles (either dark brown plastic bottles or place clear bottles in black plastic bag when filled);
2. Gently mix the water samples, turning the bottles upside down in a circular motion 3 times;
3. Measure out 500ml from each of the selected depths.
4. Place a 25mm diameter polycarbonate filter on the filtration tower, using forceps;
5. Filter the samples under gentle pressure (max-20KPa);
6. Once the samples has finished filtering, rinse the filtration cup with roughly 10ml of filtered sea water. This should remove excess salt residue;
7. Place the filters into 50ml centrifuge tubes and label them with the following; Cruise number, Station number, CTD number, Niskin number, PIC and Date;
8. Place the centrifuge tubes into a drying oven at 40 ˚C overnight, with the lids slightly loose as to facilitate the drying process.
9. The next day remove the centrifuge tubes and re secure their lids. Then place them into a plastic sample bag to avoid the mixing of the samples.

Lugols

1. Carefully measure out 100ml of the CTD water from your chosen Niskin bottle and pour into dark brown 100 ml glass bottles;
2. Add 1 ml of lugol (lugol should make up 1 % of sample volume)
3. Label the bottles (labels should contain: Cruise number, Station number, CTD number, Niskin number)
4. Store in cold room or fridge

HPLC

1. Collect CTD water from your preselected depths, using plastic bottles (either use dark brown plastic bottles or place clear bottles in black plastic bag when filled);
2. Mix sample gently. Slowly turn the bottle upside down in a circular motion 3 times;
3. Measure out 2 L samples from each depth;
4. Place 25 mm diameter Whatman GFF (effective pore size 0.7 µm) filters on filtration tower using forceps;
5. Filter under gentle pressure (max –20 kPa);
6. Once finished filtering, gently fold the filters in half using forceps. Make sure the filter is touching itself when folded as to create a semi-circular shape;
7. Store the filters in individual aluminium foil packets. Label foil packets with a cryopen (label foils before putting the filter in to avoid damaging the filter). Cruise number, Station number, CTD number, Niskin number, HPLC, Date;
8. Place immediately in liquid nitrogen to flash freeze then place in -80 ˚C freezer. (If no liquid nitrogen available, then place straight into -80 ˚C freezer;

A total of 521 samples have been produced including 402 chlorophyll measurements. We also prepared 50 samples for POC, 11 for PIC, 10 for Silicate, 14 for HPLC and 34 for Lugols. Those will be analyzed later at SHOM. A summary table below:

Date	Cruise code	Gear code	Station number	Cast no	Site	Niskin	Depth (m)						Filt Vol (ml)				Notes
								Chl-A GFF (x2)	Chl 10um (x2)	Chl 5um (x2)	Chl 0.2um (x2)	POC	PIC	bSiO2	HPLC	Lugols	
06/05/2023	JC247	CTD	JC247_01	1	PLM	19	25								2000	100	
07/05/2023	JC247	CTD	JC247_02	2	WC	13	200	500				1000	500	500			
07/05/2023	JC247	CTD	JC247_02	2	WC	16	55	500				1000	500	500			
07/05/2023	JC247	CTD	JC247_02	2	WC	19	25	500	500	500	500	1000	500	500	2000		We did POC twice, forgot to rinse with filtered sea water the first time -- 0,2um took too much time we reduced volume (see logs).
07/05/2023	JC247	CTD	JC247_02	2	WC	22	5	500	500	500	500	1000	500	500	2000		
08/05/2023	JC247	CTD	JC247_04	3	PAP-1	1	500					1000		500		100	
08/05/2023	JC247	CTD	JC247_04	3	PAP-1	4	200	500				1000	500	500		100	
08/05/2023	JC247	CTD	JC247_04	3	PAP-1	9	100	500	500	500	200	1000	500				
08/05/2023	JC247	CTD	JC247_04	3	PAP-1	14	50	500	500	500	200	1000	500	500			
08/05/2023	JC247	CTD	JC247_04	3	PAP-1	20	30	500	500	500	200	1000	500	500		100	
08/05/2023	JC247	CTD	JC247_04	3	PAP-1	21	25	500								100	
08/05/2023	JC247	CTD	JC247_04	3	PAP-1	23	5	500	500	500	200	1000	500			100	

09/05/2023	JC247	CTD	JC247_08	4	PAP	10	775					1000	500	500			
09/05/2023	JC247	CTD	JC247_08	4	PAP	14	200	500				1000	500	500			
09/05/2023	JC247	CTD	JC247_08	4	PAP	15	100	500	500	500	200	1000					No more 0.8um filters for PIC and Silicate
09/05/2023	JC247	CTD	JC247_08	4	PAP	18	50	500									
09/05/2023	JC247	CTD	JC247_08	4	PAP	19	30	500	500	500	200	1000					
09/05/2023	JC247	CTD	JC247_08	4	PAP	21	25	500				1000					
09/05/2023	JC247	CTD	JC247_08	4	PAP	23	5	500	500	500	200	1000					
10/05/2023	JC247	CTD	JC247_17	5	PAP	1	100	500	300	300	200				2000	100	Not enough water, we use 300ml for 10um and 5um
10/05/2023	JC247	CTD	JC247_17	5	PAP	6	60	500	300	300	200				2000	100	
10/05/2023	JC247	CTD	JC247_17	5	PAP	10	30	500	300	300	200				2000	100	
10/05/2023	JC247	CTD	JC247_17	5	PAP	20	5	500	300	300	200				2000	100	
10/05/2023	JC247	CTD	JC247_18	6	PAP	7	1800					1000					
10/05/2023	JC247	CTD	JC247_18	6	PAP	11	775					1000					
10/05/2023	JC247	CTD	JC247_18	6	PAP	12	550					1000					
10/05/2023	JC247	CTD	JC247_18	6	PAP	15	250	500				1000				100	
10/05/2023	JC247	CTD	JC247_18	6	PAP	19	30	500				1000				100	
10/05/2023	JC247	CTD	JC247_18	6	PAP	23	5	500				1000				100	
13/05/2023	JC247	CTD	JC247_31	7	PAP	1	100	500				1000					
13/05/2023	JC247	CTD	JC247_31	7	PAP	10	30	500				1000					
13/05/2023	JC247	CTD	JC247_31	7	PAP	13	19	500				1000					
13/05/2023	JC247	CTD	JC247_31	7	PAP	19	5	500				1000					
14/05/2023	JC247	CTD	JC247_36	8	PAP	1	100	500	500	500	500	1000			2000	100	Too long with 500
14/05/2023	JC247	CTD	JC247_36	8	PAP	11	40	500	500	500	500	1000			2000	100	

14/05/2023	JC247	CTD	JC247_36	8	PAP	15	30	500	500	500	390 / 385	1000			2000	100	ml and 0.2 um, we removed some water at the end
14/05/2023	JC247	CTD	JC247_36	8	PAP	21	5	500	500	500	210 / 235	1000			2000	100	
15/05/2023	JC247	CTD	JC247_38	9	PAP	15	175	500	500	500	200					100	
15/05/2023	JC247	CTD	JC247_38	9	PAP	19	35	500	500	500	200					100	
15/05/2023	JC247	CTD	JC247_38	9	PAP	20	30	500	500	500	200					100	
15/05/2023	JC247	CTD	JC247_38	9	PAP	22	17	500	500	500	200					100	
15/05/2023	JC247	CTD	JC247_38	9	PAP	24	5	500	500	500	200					100	
15/05/2023	JC247	CTD	JC247_42	10	PAP	12	625					1000					
15/05/2023	JC247	CTD	JC247_42	10	PAP	15	275	500				1000					
15/05/2023	JC247	CTD	JC247_42	10	PAP	18	70	500				1000					
15/05/2023	JC247	CTD	JC247_42	10	PAP	20	30	500	500	500	200	1000					
15/05/2023	JC247	CTD	JC247_42	10	PAP	22	25	500				1000					
16/05/2023	JC247	CTD	JC247_42	10	PAP	23	5	500	500	500	200	1000					
16/05/2023	JC247	CTD	JC247_46	11	PAP	1	100	500				1000					
16/05/2023	JC247	CTD	JC247_46	11	PAP	5	55	500				1000					
16/05/2023	JC247	CTD	JC247_46	11	PAP	8	37	500				1000					
16/05/2023	JC247	CTD	JC247_46	11	PAP	12	30	500	500	500	200	1000			2000	100	
16/05/2023	JC247	CTD	JC247_46	11	PAP	16	25	500	500	500	200	1000			2000	100	
16/05/2023	JC247	CTD	JC247_46	11	PAP	20	5	500	500	500	200	1000			2000	100	
16/05/2023	JC247	CTD	JC247_48	12	PAP	20	35	500	500	500	200						
16/05/2023	JC247	CTD	JC247_48	12	PAP	22	30	500	500	500	200					100	
16/05/2023	JC247	CTD	JC247_48	12	PAP	24	5	500	500	500	173/182					100	

17/05/2023	JC247	CTD	JC247_48	13	PAP	1	100	500									
17/05/2023	JC247	CTD	JC247_48	13	PAP	4	30	500									
17/05/2023	JC247	CTD	JC247_48	13	PAP	11	20	500	500	500	195/200					100	
17/05/2023	JC247	CTD	JC247_48	13	PAP	16	12	500									
17/05/2023	JC247	CTD	JC247_48	13	PAP	20	5	500	500	500	168/177					100	
17/05/2023	JC247	CTD	JC247_55	14	PAP	1	100	500								100	
17/05/2023	JC247	CTD	JC247_55	14	PAP	5	50	500								100	
17/05/2023	JC247	CTD	JC247_55	14	PAP	9	30	500								100	
17/05/2023	JC247	CTD	JC247_55	14	PAP	13	12	500	500	500	200					100	
17/05/2023	JC247	CTD	JC247_55	14	PAP	17	5	500	500	500	200					100	
18/05/2023	JC247	CTD	JC247_57	15	PAP	1	200	500				1000					
18/05/2023	JC247	CTD	JC247_57	15	PAP	4	100	500									
18/05/2023	JC247	CTD	JC247_57	15	PAP	7	50	500				1000					
18/05/2023	JC247	CTD	JC247_57	15	PAP	11	30	500	500	500	200	1000					
18/05/2023	JC247	CTD	JC247_57	15	PAP	15	19	500	500	500	200						
18/05/2023	JC247	CTD	JC247_57	15	PAP	20	5	500	500	500	200						
18/05/2023	JC247	CTD	JC247_58	16	PAP	16	450					1000					
18/05/2023	JC247	CTD	JC247_58	16	PAP	19	30	500				1000					
18/05/2023	JC247	CTD	JC247_58	16	PAP	21	17	500									
18/05/2023	JC247	CTD	JC247_58	16	PAP	24	5	500									
19/05/2023	JC247	CTD	JC247_59	17	PAP	4	100					1000					
19/05/2023	JC247	CTD	JC247_59	17	PAP	7	50	500	500	500	190/179						
19/05/2023	JC247	CTD	JC247_59	17	PAP	10	30	500				1000					
19/05/2023	JC247	CTD	JC247_59	17	PAP	16	5	500	500	500	188/169	1000					

9.5. Filtered underway samples

Cruise code	Gear Code	Date	time	Nominal Depth (m)
JC247	uw 1	07/05/2023	06:58:00	5
JC247	uway	07/05/2023	14:13:00	5
JC247	uw 3	08/05/2023	06:21:00	5
JC247	uw 4	09/05/2023	20:32:00	5
JC247	uw 5	09/05/2023	07:02:00	5
JC247	uw 8	11/05/2023	01:25:00	5
JC247	uw 9	11/05/2023	07:34:00	5
JC247	uw 10	12/05/2023	00:10:00	5
JC247	uw 11	12/05/2023	06:50:00	5
JC247	uw 12	13/05/2023	02:04:00	5
JC247	uw 13	13/05/2023	07:10:00	5
JC247	uw 14	14/05/2023	01:00	5
JC247	uw 15	14/05/2023	07:06	5
JC247	uw 16	15/05/2023	01:49:00	5
JC247	uw 17	15/05/2023	03:57:00	5
JC247	uw 18	15/05/2023	07:38:00	5
JC247	uw 19	15/05/2023	15:28:00	5
JC247	uw 20	15/05/2023	17:30:00	5
JC247	uw 21	15/05/2023	19:01:00	5
JC247	uw 22	16/05/2023	00:02:00	5
JC247	uw 23	16/05/2023	03:21:00	5
JC247	uw 24	16/05/2023	21:22:00	5
JC247	uw 25	17/05/2023	06:59:00	5

9.5 CTD Deck sampling logs

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	L4 PML
Comments	Malc. Coastal site for Goship nutrient comparison and Practice stn. for PAP. Mixing ~18 and 34m. Note N2 and N3 mixed, N17 leaks

Cruise number	JC247
Station ID	1
Cast number	1
Sea floor depth (m)	50
Cast depth (m)	50
Event number	

Date (UTC)	06/05/2023
Time in (UTC)	08:15
Time out (UTC)	08:32
Latitude	50° 13.9
Longitude	04° 13.15
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 10-	5 L carboy					HPLC	Comments
																CHL	PIC	POC	Bsi SFC	Lugol		
1	50													x								1. leave for Malc
3	50													x								1. leave for Malc
2	50													x								1. leave for Malc
4	50													x	200	x						4
5	50													x								5
6	50													x								6
7	25													x	201	x						7
8	25													x								8
9	25													x								9
10	25													x								10
11	25													x								11
12	25													x								12
13	10													x	202	x						13
14	10													x								14
15	10													x								15
16	10													x								16
17	10													x								17. sl. Leaking
18	10													x								18
19	5													x	203	xx	x	x	xx	x	x	19
20	5		a046	a048	11.7									x								20
21	5		a050		11.8	517								x								21
22	5													x								22
23	5													x								23
24	5													x								24
Sampling																						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	WC
Comments	release test (x3), sound profiler, USBL fitted

Cruise number	JC247
Station ID	2
Cast number	2
Sea floor depth (m)	1698
Cast depth (m)	1678
Event number	

Date (UTC)	07/05/2023
Time in (UTC)	10:51
Time out (UTC)	12:30
Latitude	48° 36.2
Longitude	09° 58.1
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 20-	5 L carboy					HPLC	Comments
																CHL	PIC	POC	Bsi SFC	Lugol		
1	1678		A29		5.4	97								x	500							1
2	1678													x								2
3	1678													x								3
4	1200		A24	A06	8	205								x	501							4
5	1200													x								5
6	1200													x								6
7	800		A12		9.9	896	98							x	502	x						7
8	800													x								8
9	800													x								9
10	350		A02		11.7									x								10
11	350													x								11
12	350													x								12
13	200		A30	A08	12.3	90S									503	xx	x	x	x			13
14	200													x								14
15	200													x								15
16	55		A10		12.7	48S								x	504	xx	x	x	x			16
17	55				12.7									x								17. sl. Leaking
18	55													x								18
19	25		A22		13.3	46									505	xx	x	x	x			19. SFC
20	25													x								20
21	25													x								21
22	5		A18		13.9	222								x	506	xx	x	x	x			22. SFC
23	5					475								x								23
24	5					1248								x								24
Sampling			EM		EL	AF	AF							MW	SH	CF, TP						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP1 in sight
Comments	BORA box fitted, so remove N16 and N17 (TA and pH). DCM @25m.

Cruise number	JC247	Date (UTC)	08/05/2023
Station ID	4	Time in (UTC)	17:17
Cast number	3	Time out (UTC)	18:36
Sea floor depth (m)	4810	Latitude	48° 57.394
Cast depth (m)	500	Longitude	09° 23.651

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcol	SALTS Crate	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1	500		29	24	11.6	20								x	507			x				1
2	400		6		11.7									x								2
3	300		12		12.2	256								x								3
4*	200		2		12.7	174								x	508	x	x	x	x			4
5	200													x								5
6	200																					6. For Go-Ship
7	200																					7. For Go-Ship
8	150		30		12.8	230								x	509							8
9	100		18		12.9	539								x	510	x		x				9
10	100													x								10
11	80		22		13	19t								x								11
12	80													x								12
13	60		10		13									x								13
14	50		8		13.1	20t								x								14.SFC
15	50													x								15
16																						16. removed for borabox
17																						17
18	40		17		13.1									x								18
19*	30					59									511							19
20	30		28		13.3	215								x		x	x	x	x	x		20. sFC
21	25		19		13.3	221								x		x						21
22	25													x								22
23	5		4	13	14	483	99	103						x	512	x		x		x		23. SFC
24	5													x								24
Sampling			EM, EL	EM, EL	HH	AF	AF	AF						MW	SH	CF, TP						
Notes	*=long stop for BoraBox (10 mins)																					

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP1 in sight ~1mile
Comments	BORA box. Val cast for Apex Argo 10066 and 10068. Long stops (*)

Cruise number	JC247	Date (UTC)	09/05/2023
Station ID	8	Time in (UTC)	07:26
Cast number	4	Time out (UTC)	12:43
Sea floor depth (m)	4840	Latitude	49° 0
Cast depth (m)	4825	Longitude	16° 30

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcol	SALTS Crate	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1*	4825		829	824	5.8	425	538				xx			x								1
2	4000		6		5.9									x	513							2
3	3000		12		6.1	289					xx			x								3
4	2500		2		6.4									x	514							4
5*	1900		30	18	6.6	233	116				xx			x								5
6	1500		22		7.1									x	515							6
7	1000		10		9	117					xx			x								7
8	900		8		9.4									x	516							8
9*	775		17		11.2	540	89?				xx			x								9. Odd: N9 and N10 same temp? Likely is 600m
10	600		28		11.2									x	517		x	x	x			10
11	500		19		11.5	114					xx			x								11
12	400		4		11.8									x	518							12
13	300		13		12.2									x								13
14	200		25		12.7	n21					xx			x		x	x	x	x			14
15	100		9		12.9									x	519	x	x	x	x	x		15.sfc
16																						16. removed for borabox
17																						17
18	50		15		13.3	b02					xx			x	520	x						18
19*	30		21		13.9	x134					xx			x	521	x	x	x	x	x		19. sfc
20	30					502					xx			x								20
21	25		11		14									x	522	x	x	x	x	x		21
22	20		23		14	609					xx			x								22
23	5		16		14						xx			x	523	x	x	x	x	x		23. SFC
24	5		14		13.9	471								x								24
Sampling			EM, EL		HH	AF	AF				AF			MW	SH	CF, TP						
Notes	light to ~100m DWRR. * is long stop (20 mins) for BoraBox																					

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP1 in sight ~200m
Comments	BORA box but no long stops

Cruise number	JC247
Station ID	17
Cast number	5
Sea floor depth (m)	4811
Cast depth (m)	100
Event number	

Date (UTC)	10/05/2023
Time in (UTC)	09:25
Time out (UTC)	09:47
Latitude	48° 56.934
Longitude	16° 24.474
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 38-	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1	100		29	24	12.8	265			x	x				x	932	x				x	x	1.SFC
2	100																					2
3	100																					3
4	100																					4
5	100																					5
6	60		6		13.2	477								x	933	x				x	x	6. SFC
7	60																					7
8	60																					8
9	60																					9
10	30		2	12*	13.9	925	100S		x	x				x	934	x				x	x	10. sfc
11	30					835			x													11
12	30																					12
13	30																					13
14	30																					14
15	25		30		13.9	85s								x	935							15
16																						16. removed for borabox
17																						17
18	25																					18
19	25																					19
20	5		18	10	13.9	232	97s		x	x				x	936							20. sfc
21	5					21			x													21
22	5																					22
23	5																					23
24	5																					24
Sampling			EM	EM	EL	AF	AF		AF	AF				MW	SH	CF/TP						
Notes	light to ~100m DWRR																					

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP CTD
Comments	BORA box but no long stops. Val cast for 2 BGC (MO Navis and APERO), SVP

Cruise number	JC247
Station ID	18
Cast number	6
Sea floor depth (m)	4836
Cast depth (m)	4824
Event number	

Date (UTC)	10/05/2023
Time in (UTC)	10:57
Time out (UTC)	14:17
Latitude	49° 0
Longitude	16° 30
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 38-	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1	4824		51		3.7	24s	37s							x	937							1
2	4824																					2.For Goship
3	4824																					3.For Goship
4	4500		53		3.8	31s								x	938							4
5	3500		32		4.2	22s								x								5
6	2000		34		4.9	25s								x								6
7	1800		44		5.4	34s								x	939			x				7
8	1200		5		6.7	36s								x								8
9	950													x								9. MISSFIRE
10	775		54	49	9.6	30s	26s							x	940							10
11	775					40s								x				x				11
12	550		39		11	27s								x				x				12
13	425		40	38	11.6	29s								x	941							13
14	350		7		12	39s								x								14
15	250		46		12.6	33s								x	942	x		x				15.sfc
16														x								16. removed for borabox
17														x								17
18	90		55		13	28s								x								18
19	30		52	43	13.9	32s	23s							x	943	x		x		x		19. SFC
20	30					35s								x								20
21	22		36		13.9	38s								x								21
22	10		35		14	98s								x								22
23	5		41		14	81s								x	944	x		x		x		23. SFC
24	5		48			82s	88s							x								24
Sampling			EL	EL	HH	AF	AF							MW	SH	CF/TP						
Notes	light to ~120m DWRR. Noisy primary sal (tube issues). **Many bubbles in base of O2 bottles especially ~N13**																					

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP1 near
Comments	reduced BORA box. PAP1 long stops*. Star oddi post JC231 cal

Cruise number	JC247
Station ID	31
Cast number	7
Sea floor depth (m)	4807
Cast depth (m)	100
Event number	

Date (UTC)	13/05/2023
Time in (UTC)	11:07
Time out (UTC)	12:45
Latitude	48° 57.275
Longitude	16° 24.851
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	δ^{13}C DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1*	100		12	29	13	94									38-945	x		x				1
2	100					160																2
3	100																					3
4	100																					4
5	75		18		13																	5.Missfire (leak at base), nutrien look OK
6	75		10		13										946							6
7	75																					7
8	75																					8
9*	30		2		14	21s																9. MissFire odd temp
10	30				13.7	182	60s								947	x		x				10
11	30		26		13.7																	11
12	30																					12
13*	19		30	24	13.8	84s									948	x		x				13.@DCM
14	19					x011																14
15	19																					15
16	19																					16
17																						17. Removed for BoraBox
18	19																					18
19*	5		8	6	14.1	x									949	x		x				19. SFC
20	5					567	1131															20
21	5																					21
22	5																					22
23	5																					23. SFC
24	5																					24
Sampling			EM	EM	EL	AF	AF							MW	HH	CF/TP						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP1 <200m away
Comments	BORA box, CONTROS on slow and 3 long stops.

Cruise number	JC247
Station ID	37
Cast number	8
Sea floor depth (m)	4810
Cast depth (m)	100
Event number	

Date (UTC)	14/05/2023
Time in (UTC)	06:48
Time out (UTC)	08:32
Latitude	48° 56.868
Longitude	16° 30
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	δ^{13}C DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 38-	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1*	100		22		12.9	248						x		x	950	x		x		x	x	1
2	100					535								x								2
3	100													x								3
4	100													x								4
5	100													x								5
6	80		14		12.9							x		x								6
7	80													x								7
8	80													x								8
9																						9. MISSFIRE
10	80													x								10
11	40			15	13.5							x		x		x		x		x	x	11.sfc
12	40													x								12
13	40													x								13
14	40													x								14
15*	30			2	10	13.7	667	58				x		x	951	x		x		x	x	15.sfc
16	30													x								16
17																						17. removed for borabox
18	30													x								18
19	30													x								19
20*	5			30	24	13.8	488		x	x		x		x	952							20
21	5					13.8	x133		x					x		x		x		x	x	21.sfc
22	5													x								22
23	5													x								23
24	5													x								24
Sampling			EM	EM	EL, HH	AF	AF					EM		MW	SH	CF/TP						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP CTD	Cruise number	JC247	Date (UTC)	14/05/2023
Comments	BORA box, CONTROS on slow stand alone and 3 long stops for 4x microcats	Station ID	38	Time in (UTC)	10:56
		Cast number	9	Time out (UTC)	17:58
		Sea floor depth (m)	4842	Latitude	48° 59.998
		Cast depth (m)	4825	Longitude	16° 29.947
		Event number		Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 38-	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1*	4825		22	14	6.4	210b	2						x		953							1
2	4700		30		6.2								x									2
3	4200		26		6.2								x									3
4	3200		4	8	6.4								x									4
5	2750		6		6.9								x									5
6	2100		23		6.9								x									6
7	1800		17		6.9								x									7
8																						8.remove for microcats
9																						9. remove for microcats
10	1700		28		7.1								x									10
11	950		19		9.3								x									11.sfc
12*	740		4	13	10.1	3s	534						x		954							12
13	450		25		11.5								x									13
14	325		9		12								x									14
15	175		15		12.7								x			x				x		15.sfc
16	85		21		13.1								x									16
17																						17. removed for borabox
18	55		11		13.1								x									18
19	35		12		13.2								x			x				x		19.sfc
20	30		16		13.5	73							x			x				x		20
21	30		29		13.5	295							x									21.sfc
22	17		3	1	13.8								x			x				x		22.sfc
23*	5		20		13.8	91							x		955							23
24	5					14n	171						x			x				x		24.sfc
Sampling			EM	EM	EL,HH	AF	AF						MW, HH		SH				CF/TP			
Notes	downwell light to 160m																					

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP CTD	Cruise number	JC247	Date (UTC)	15/05/2023
Comments	BORA box, CONTROS full speed and stand alone with 3 long stops	Station ID	42	Time in (UTC)	08:23
		Cast number	10	Time out (UTC)	13:25
		Sea floor depth (m)	4836	Latitude	49° 0
		Cast depth (m)	4826	Longitude	16° 30
		Event number		Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 43-	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1*	4826		18	2	6	252	235						x		1052							1
2	4400		24		6	516	596						x									2
3	4100		22		6								x									3
4	3100		14		6.3								x									4
5	2200		30		6.6	239							x									5
6	1840		26		6.8								x									6
7	1800		8		6.9								x									7
8	1100		6		8.5	x072							x									8
9	925		23		9.4	528							x		1053							9
10	800		17		10	292							x									10
11	735		28		10.3								x									11
12*	625		19		10.8	560							x					x				12
13	525		4		11.4	121							x									13
14	375		13		12								x									14
15	275		25		12.4								x			x		x				15
16	125		9		12.9	6							x		1054							16
17																						17. removed for borabox
18	70		15	21	13.1	x							x			x		x		x		18
19	40		11		13.5								x									19
20	30		12		13.7	298							x		1055	x		x		x		20. sfc
21	30		16		13.7	x124	78						x									21
22	25		29		13.8	x							x			x		x				22
23*	5		3		13.9	x							x			x		x		x		23.sfc
24	5		1		13.9	x	44						x		1056							24
Sampling			EM	EM	EL, HH	AF	AF						HH,		SH				CF, TP			
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP1
Comments	BORA box, CONTROS full speed and stand alone with 3 long stops

Cruise number	JC247
Station ID	46
Cast number	11
Sea floor depth (m)	4810
Cast depth (m)	100
Event number	

Date (UTC)	16/05/2023
Time in (UTC)	06:50
Time out (UTC)	08:09
Latitude	49° 57.522
Longitude	16° 25.608
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 43-	5 L carboy					HPLC	Comments
																CHL	PIC	POC	Bsi SFC	Lugol		
1*	100		10	18	12.4	x							x		1057	x		x		x		1
2	100																					2
3	100																					3
4	100																					4
5	55		2		13.3	451							x		1058	x		x		x		5
6	55																					6
7	55																					7
8	37		24		13.6	17b							x			x		x		x		8
9	37																					9
10	37																					10
11	37																					11
12*	30		22		13.6	138							x		1059	x		x		x	x	12. sfc (tap drips)
13	30					140	482															13
14	30																					14
15	30																					15
16	25		14		13.6	q03							x			x		x		x	x	16. sfc
17																						17. removed for borabox
18	25																					18
19	25																					19
20*	5		30	26	13.7	8							x			x		x		x	x	20. sfc
21	5					74	x															21
22	5																					22
23	5																					23
24	5																					24
Sampling			EM	EM	EL	AF	AF						HH		SH	CF, TP						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP CTD
Comments	(No BORA box or CONTROS). 2 microcats from PAP1. last 2 ARGO validation cast. **Don't use primary sensors for this cast**

Cruise number	JC247
Station ID	48
Cast number	12
Sea floor depth (m)	4812
Cast depth (m)	1500
Event number	

Date (UTC)	16/05/2023
Time in (UTC)	13:17
Time out (UTC)	14:49
Latitude	48° 58.579
Longitude	16° 22.322
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 43-	5 L carboy					HPLC	Comments
																CHL	PIC	POC	Bsi SFC	Lugol		
1*	1500		18	10	5.6	1711							x		1060							1
2	1500												x									2
3	1100		2	24	7.6	251							x									3
4	1100												x									4
5	913		22		8.8	x							x									5
6	913												x									6
7	800		14		9.1	60							x									7
8	800												x									8
9	800												x									9
10*	730		30		9.7	17b							x		1061							10
11	730					112b							x									11
12	500					48b							x									12
13	500		26		11.1	x							x									13
14	500													x								14. GO-SHIP
15	500													x								15. GO-SHIP
16	250		29		12	1128							x									16
17																						17. Still removed, for microcats
18	250												x									18
19	250												x									19
20	35		3		13.8	x							x			x				x		20. sfc
21*	30		1		14.1	8							x		1062							21
22	30					17s	16s						x			x				x		22.sfc
23	5		6	20	14.1	11s	19						x		1063							23
24	5					5s							x			x				x		24.sfc
Sampling			EL	EL	HH	AF	AF						HH	HH and EM	SH	CF, TP						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	CTD1 W
Comments	to capture high chl satelite area, west of PAP (chl and nutrients only)

Cruise number	JC247	Date (UTC)	17/05/2023
Station ID	54	Time in (UTC)	15:12
Cast number	13	Time out (UTC)	15:32
Sea floor depth (m)	4812	Latitude	49° 00.499
Cast depth (m)	100	Longitude	16° 58.058
Event number		Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 43-	5 L carboy					HPLC	Comments
																CHL	PIC	POC	Bsi SFC	Lugol		
1	100												x			x						1
2	100																					2
3	100																					3
4	100																					4
5	30												x									5.missfire
6	30												x			x				x		6
7	30																					7
8	30																					8
9	30																					9
10	30																					10
11	20												x			x				x		11.sfc,
12	20																					12
13	20																					13
14	20																					14
15	12												x			x				x		15.odd nutrients?
16	12																					16
17	12																					17
18	12																					18
19	12																					19
20	5												x			x				x		20. sfc
21	5																					21
22	5																			x		22.sfc
23	5																					23
24	5																			x		24.sfc
Sampling													HH, EL			EL, HH						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	CTD2 N
Comments	to capture lower chl satelitte area, northwest of PAP (chl and nutrients only). Turbidity spike @50m so take sieve

Cruise number	JC247	Date (UTC)	17/05/2023
Station ID	55	Time in (UTC)	17:26
Cast number	14	Time out (UTC)	17:47
Sea floor depth (m)	4812	Latitude	49° 24.126
Cast depth (m)	100	Longitude	16° 44.644
Event number		Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 43-	5 L carboy					HPLC	Comments
																CHL	PIC	POC	Bsi SFC	Lugol		
1	100												x			x				x		1
2	100																					2.sieve
3	100																					3
4	100																					4
5	50																					5.missfire? Looks OK nutrients
6	50												x			x				x		6
7	50																					7. sieve
8	50																					8
9	30												x			x				x		9
10	30																					10. sieve
11	30																					11 odd nutrients, may missfire?
12	30														1066							12
13	12												x			x				x		13
14	12																					14
15	12																					15
16	12																					16
17	5												x			x				x		17
18	5														1067							18
19	5																					19
20	5												x			x				x		20. sfc
21	5																					21
22	5																			x		22.sfc
23	5																					23
24	5																			x		24.sfc
Sampling													EL, HH		SH	EL, HH						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	CTD3 of survey
Comments	Back to high chl part of survey. Light to 175m as near midday. Chl/nutr and ID DCM only

Cruise number	JC247
Station ID	57
Cast number	15
Sea floor depth (m)	4799
Cast depth (m)	200
Event number	

Date (UTC)	18/05/2023
Time in (UTC)	11:30
Time out (UTC)	11:57
Latitude	48° 53.106
Longitude	16° 54.103
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 43-	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1	200												1			x		x				1
2	200																					2
3	200																					3
4	100												2			x						4
5	100																					5
6	100																					6
7	50												3			x		x				7. leak? But nutrients OK
8	50																					8
9	50																					9
10	50																					10
11	30												4			x		x				11.sfc
12	30																					12
13	30																					13
14	30																					14
15	19												5			x						15.sfc
16	19																					16
17	19																					17
18	19																					18
19	19																					19
20	5												6			x						20. sfc
21	5																					21
22	5																					22.sfc
23	5																					23
24	5																					24
Sampling													El, HH			EL, HH						
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	PAP CTD
Comments	Bulk water collect. No long stop deep cast.Light to 140m. Jellyfish on the frame

Cruise number	JC247
Station ID	58
Cast number	16
Sea floor depth (m)	4799
Cast depth (m)	4827
Event number	

Date (UTC)	18/05/2023
Time in (UTC)	13:58
Time out (UTC)	17:19
Latitude	49° 0.012
Longitude	16° 30.106
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS Crate 43-	5 L carboy CHL	PIC	POC	Bsi SFC	Lugol	HPLC	Comments
1	4827		18	22	3.6	13s							x		1-070							1
2	4500		10		3.7								x									2
3	4000		2		3.7								x									3
4	3500		24		3.9								x		1071							4
5	3500												x									5
6	3500												x									6
7	3500												x									7
8	2500		30		4.4								x									8
9	1500												x									9.missfire
10	925		14		9	14s							x		1072							10
11	925												x									11
12	800		26		8.9								x									12
13	750		8		9.3	p37							x		1073							13
14	750					15s							x									14
15	600		23		10.2								x									15
16	450		17		11.1								x					x				16
17	250		28		12								x									17
18	100		19		12.7								x									18
19	30		4		13.8	7s							x		1074	x		x				19
20	30					20s							x									20
21	17		13		14.2								x			x						21
22	17												x									22
23	5		25	9	14.6	266							x		1075							23
24	5					325	241						x			x						24
Sampling			EM	EM	EL, HH	AF	AF						HH, EM		SH	CF, TP						jelly noted on CTD
Notes																						

CTD deck sampling log

(List parameters sampling from CTD in header and tick relevant box if bottle sampled)

SITE	Near PAP1
Comments	Last cal check. DWR 60m and full mix chl to 30m

Cruise number	JC247
Station ID	59
Cast number	17
Sea floor depth (m)	4810
Cast depth (m)	200
Event number	

Date (UTC)	19/05/2023
Time in (UTC)	06:33
Time out (UTC)	07:06
Latitude	48° 57.402
Longitude	16° 26.543
Stainless steel cast	

Niskin No	Depth (m)	Bottle No.	O_2 bottle Rep 1	O_2 bottle Rep 2	O_2 Temp.	DIC/TA Rep 1	DIC/TA. Rep 2	DIC/TA. Rep 3	pH Rep 1	pH Rep 2	$\delta^{13}C$ DIC x2	DOC PAP	Nutrients PAP	Nutrients Malcolm	SALTS no	5 L carboy					HPLC	Comments
																CHL	PIC	POC	Bsi SFC	Lugol		
1	200		a21	11	12.4								x									1
2	200																					2
3	200																					3
4	100		12		12.9								x					x				4
5	100																					5
6	100																					6
7	50		16		13.3								x			x						7
8	50																					8
9	50																					9
10	30		29		14.3	x							x			x		x				10. sfc, hplc plan but ins sample
11	30					x																11.s
12	30																					12
13	15		3		14.3								x									13
14	15																					14
15	15																					15
16	5		1	14	14.4	x							x			x		x				16.sfc, hplc plan but ins. sample
17	5		6			181	23															17
18	5																					18
19	5																					19
20	5																					20. sfc
21	5																					21
22	5																					22.sfc
23	5																					23
24	5																					24
Sampling			EM	EM	EL, HH	AF	AF						HH			CF, TP, EL, HH						
Notes																						

10. Nutrient analysis

Malcolm Woodward, (PLYMOUTH MARINE LABORATORY, UK)

10.1 Objectives

Following discussions there was a collaboration agreed to enable PML to join the NOC PAP JC247 cruise team to carry out all the at-sea nutrient analytical work for the PAP cruise, which in turn allowed value-added research to go ahead which was a sampling programme for the long-term nutrient preservation investigations as part of the recently funded EU EuroGO-SHIP Infrastructure project (https://eurogo-ship.eu).

EuroGO-SHIP is an EU funded project that aims to improve the quality and integration of ship-based hydrographic data between nations. Within the aims of the nutrient package we are investigating the best practice for long term nutrient storage if analysis at sea is not possible. It is always the preferred practice to analyse samples fresh at sea, but sometimes this is not possible. Freezing has become the standard method used currently and a number of studies have supported this, however pasteurization has been recommended but no long-term comparisons have been carried out to date. Other chemical preservation techniques have been used in the past, but in modern times these methods should be avoided for environmental and health and safety reasons. The aim of this research will be to recommend to the EU community, and wider, the best practice for nutrient sample storage.

Nutrient analysis for Nitrate, Nitrite, Silicate, Phosphate and Ammonium was carried out at all the occupied CTD stations during the JC247 PAP cruise. The first sampling station was adjacent to the site of the Western Channel Observatory L4 data buoy (www.westernchannelobservatory.org.uk), this was a CTD to take the first coastal water sample for the EuroGO-SHIP project. The first deep CTD was at the Whittard Canyon with the remainder of the cruise 16 CTD's being either for shallow or deep water column sampling at the PAP site. A number of nutrient sensors were deployed either on the CTD or in underway mode in the ships laboratories and surface underway non-toxic water samples were regularly taken and analysed to compare and calibrate between the bench nutrient analyser and the nutrient sensors.

Three further sampling depths were taken for the EuroGO-SHIP project during CTD's at the PAP site where sufficient individual samples in HDPE (high density polyethylene) and glass were taken to carry out repeat triplicate analysis over the coming 12 months back in the laboratory in Plymouth.

10.2 Sampling and analytical methodology:

Sampling procedures

Acid clean 60m ml HDPE Nalgene bottles were used for all the underway and CTD nutrient sampling, these were aged, acid washed and cleaned initially, and stored with a 10% acid solution between sampling. Water column depth profile samples were taken from a CTD with a standard steel cable fitted with 20 litre OTE CTD bottles on a Stainless Steel CTD/Rosette system and sub-samples were taken from the bottles into the Nalgene nutrient bottles once the CTD was back on deck. The sample bottle was washed 3 times before taking the final sample, and capping tightly. These were then taken immediately to the nutrient analyser in the laboratory and analysis conducted as soon as possible after sampling. Nutrient free (Semperguard) gloves were used and other clean handling protocols were adopted as close to those according to the GO-SHIP nutrient manual protocols (Becker et al, 2020).

Underway water samples for nutrient analysis were taken from the underway non-toxic ships water supply and were stored in the dark at 4C until analysis which was as soon as practical. Various surface transects were sampled as detailed, investigating transects into and out of phytoplankton blooms with higher fluorescence as identified by satellite remote sensing.

Pore waters were taken using Rhizon samplers and the resulting sample was diluted accordingly to enable the nutrient analysis.

Analytical methods

The micro-molar segmented flow colorimetric auto-analyser used was the PML 5- channel (nitrate, nitrite, phosphate, ammonium and silicate) SEAL analytical AAIII system with high-resolution colorimeters and using classical proven analytical techniques. The analytical chemical methodologies used were according to Brewer and Riley (1965) for nitrate, Grasshoff (1976) for nitrite, Mantoura and Woodward (1983) for ammonium, and Kirkwood (1989) for silicate and phosphate.

The instrument was calibrated with calibrated home-produced nutrient stock standards and then daily quality control samples were analysed using Nutrient Reference Materials from SCOR/Jamstec and KANSO Technos, Japan. Specifically batches CH, and BU were used during the cruise.

References:

Becker S., Woodward, E.M.S., et al. 2020. GO-SHIP Repeat Hydrography Nutrient Manual: The precise and accurate determination of dissolved inorganic nutrients in seawater, using continuous flow analysis methods. Front. Mar. Sci.7: 581780. doi: 10.3389/fmars.2020.581790.

Brewer P.G. and Riley J.P., 1965. The automatic determination of nitrate in seawater. Deep Sea Research, 12, 765-72.

Grasshoff, K., 1976. Methods of seawater analysis. Verlag Chemie, Weinheim and New York, 317pp.

Mantoura, R.F.C, and Woodward, E.M.S., 1983. Ammonium Analysis.

Kirkwood D., 1989. Simultaneous determination of selected nutrients in seawater. ICES CM 1989/C:29.

10.3 Samples analysed

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

Date	CTD	Station	CTD Bottles analysed
06/05/23	CTD_001	001	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1
07/05/23	CTD_002	002	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1
08/05/23	CTD_003	004	24,23,22,21,20,19,18, 15,14,13,12,11,10,9,8,7,6,5,4,3,2,1
09/05/23	CTD_004	008	24,23,22,21,20,19,18, 15,14,13,12,11,10,9,8,7,6,5,4,3,2,1
10/05/23	CTD_005	017	24,23,22,21,20,19,18, 15,14,13,12,11,10,9,8,7,6,5,4,3,2,1
10/05/23	CTD_006	018	24,23,22,21,20,19,18, 15,14,13,12,11,10,8,7,6,5,4,3,2,1
13/05/23	CTD_007	031	24,23,22,21,20,19,18, 16, 15,14,13,12,11,10, 9,8,7,6,5,4,3,2,1
14/05/23	CTD_008	036	24,23,22,21,20,19,18, 16, 15,14,13,12,11,10, 9,8,7,6,5,4,3,2,1
14/05/23	CTD_009	038	24,23,22,21,20,19,18, 16, 15,14,13,12,11,10,7,6,5,4,3,2,1
15/05/23	CTD_010	042	24,23,22,21,20,19,18, 16, 15,14,13,12,11,10, 9,8,7,6,5,4,3,2,1
16/05/23	CTD_011	046	20, 16, 12, 8, 5, 1
16/05/23	CTD_012	048	24,23,22,21,20,19,18, 16, 15,14,13,12,11,10, 9,8,7,6,5,4,3,2,1
17/05/23	CTD_013	054	20, 15, 11, 6, 54, 1
17/05/23	CTD_014	055	17, 13, 9, 6, 5, 1
18/05/23	CTD_015	057	20, 15, 11, 7, 4, 1
18/05/23	CTD_016	058	24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1
19/05/23	CTD_017	060	16, 13, 10, 7, 4, 1

Nutrient Samples Analysed for Pore waters (for Anna Lichtschlag):

1	10th May 2023	7-BW, 7-1, 7-2, 7-3, 7-4, 7-5, 7-6, 7-7, 7-8, 7-9, 7-10, 7-12, 7-14, 7-16, 7-18, 7-20, 7-22, 7024, 7-26, 7-28, 7-20, 7-32, 7-34, 7-36
2	15th May 2023	35-BW, 35-1, 35-2, 35-3, 35-4, 35-5, 35-6, 35-7, 35-8, 35-9, 35-10, 35-11, 35-12, 35-14, 35-16, 35-18&20, 35-22, 35-24, 35-26, 35-28, 35-30, 35-32, 35-34
3	18th May 2023	41-1, 41-2, 41-3, 41-4, 41-5, 41-6, 41-7, 41-8, 41-9, 41-10, 41-12, 41-14, 41-16. 41-18, 41-20, 41-22, 41-24, 41-26, 41-28, 41-30, 41-32

Samples analysed and preserved for freezing and pasteurizing for EuroGO-SHIP project:

1	EuroGO-SHIP (EG) station 1.	6th May 2023	Sub samples taken from CTD Bottles 1and 2 from CTD JC247-001 (50m)
2	EuroGo-SHIP (EG2) station 2	8th May 2023	CTD Bottles 6 and 7 sampled from CTD JC247-003 (200m)
3	EuroGo-SHIP (EG3) station 3	10th May 2023	CTD Bottles 2 and 3 sampled from CTD JC247-006 (4824m)
4	EuroGo-SHIP (EG4) station 4	16th May 2023	CTD Bottles 14 and 15 sampled from CTD JC247-012 (500m)

Nutrient Samples Analysed from surface underway supply (Anita Flohr):

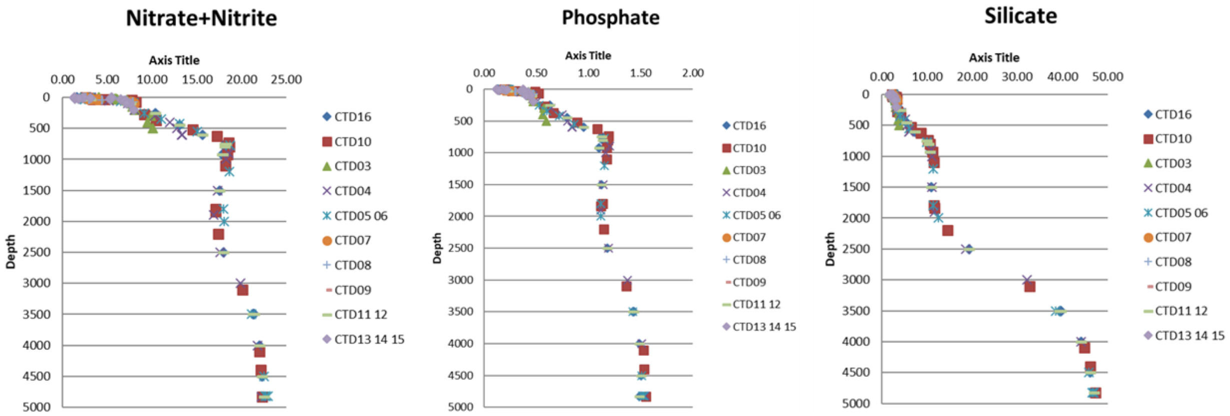
Sample	Time	Date
UWAY 1	0657	7.5.23
UWAY 2	1434	7.5.23
UWAY 3	0621	8.5.23
UWAY 4	0754	8.5.23
UWAY 5	1227	9.5.25
UWAY 6	2032	9.5.23
UWAY 7	0702	10.5.23
UWAY 8	0734	11.5.23
UWAY 9	0650	12.5.23
UWAY 10	1220	13.5.23
UWAY 11	0800	14.5.23
UWAY12	1934	14.5.23
UWAY13	1957	14.5.23
UWAY14	2022	14.5.23
UWAY15	2042	14.5.23
UWAY16	2104	14.5.23
UWAY17	2124	14.5.23
UWAY18	2145	14.5.23
UWAY19	2205	14.5.23
UWAY20	2226	14.5.23
UWAY21	2246	14.5.23
UWAY22	2307	14.5.23
UWAY23	2351	14.5.23
UWAY24	0738	15.5.23
UWAY25	1528	15.5.23
UWAY26	1609	15.5.23
UWAY27	1629	15.5.23
UWAY28	1650	15.5.23
UWAY29	1710	15.5.23
UWAY30	1730	15.5.23
UWAY31	1843	15.5.23
UWAY32	1914	15.5.23
UWAY33	1935	15.5.23
UWAY34	1352	17.5.23
UWAY35	1423	17.5.23
UWAY36	1445	17.5.23
UWAY37	1515	17.5.23
UWAY38	1536	17.5.23
UWAY39	1556	17.5.23
UWAY40	1618	17.5.23

Sample	Time	Date
UWAY41	1638	17.5.23
UWAY42	1658	17.5.23
UWAY43	1719	17.5.23
UWAY44	0722	18.5.23
UWAY45	0918	18.5.23
UWAY46	0948	18.5.23
UWAY47	1018	18.5.23
UWAY48	1031	18.5.23
UWAY49	1102	18.5.23
UWAY50	1121	18.5.23
UWAY51	1202	18.5.23
UWAY52	1222	18.5.23
UWAY53	1243	18.5.23
UWAY54	1303	18.5.23
UWAY55	1325	18.5.23
UWAY56	1201	19.5.23
UWAY57	1313	19.5.23
UWAY58	1438	19.5.23
UWAY59	1549	19.5.23
UWAY60	1631	19.5.23
UWAY61	1722	19.5.23
UWAY62	1943	19.5.23
UWAY63	2039	19.5.23
UWAY64	0509	20.5.23
UWAY65	0932	20.5.23
UWAY66	0803	20.5.23
UWAY67	0945	20.5.23
UWAY68	1018	20.5.23
UWAY69	1039	20.5.23
UWAY70	1121	20.5.23
UWAY71	1202	20.5.23
UWAY72	1244	20.5.23
UWAY73	1314	20.5.23
UWAY74	1356	20.5.23
UWAY75	1426	20.5.23
UWAY76	1507	20.5.23
UWAY77	1559	20.5.23
UWAY78	1722	20.5.23
UWAY79	1833	20.5.23
UWAY80	1925	20.5.23

Sample	Time	Date
UWAY81	2017	20.5.23
UWAY82	2118	20.5.23
UWAY83	2241	20.5.23
UWAY84	2343	20.5.23
UWAY85	0008	21.5.23
UWAY86	0515	21.5.23
2uM standard NO3		20.5.23
0.4uM PO4 standard		20.5.23
4.2uM standard		20.5.23

10.4 Cruise Summary, Preliminary results

The 5-channel nutrient autoanalyser worked generally well throughout the cruise, except for one autosampler failure and an initial Phosphate channel flowcell issue that was replaced. KANSO Certified nutrient reference materials (mainly batches BU and CH) were run with every analysis to check the auto-analyser integrity and analytical continuity from one day to the next, these results demonstrating very good overall analytical performance from the results of the analysis of these reference materials for Nitrate, Nitrite Silicate and Phosphate concentrations.



Preliminary nutrient plots are shown above for the 3 main nutrients for the PAP station over the whole cruise for the whole depth profile and all CTD's. Good inter profile continuity can be seen at depth.

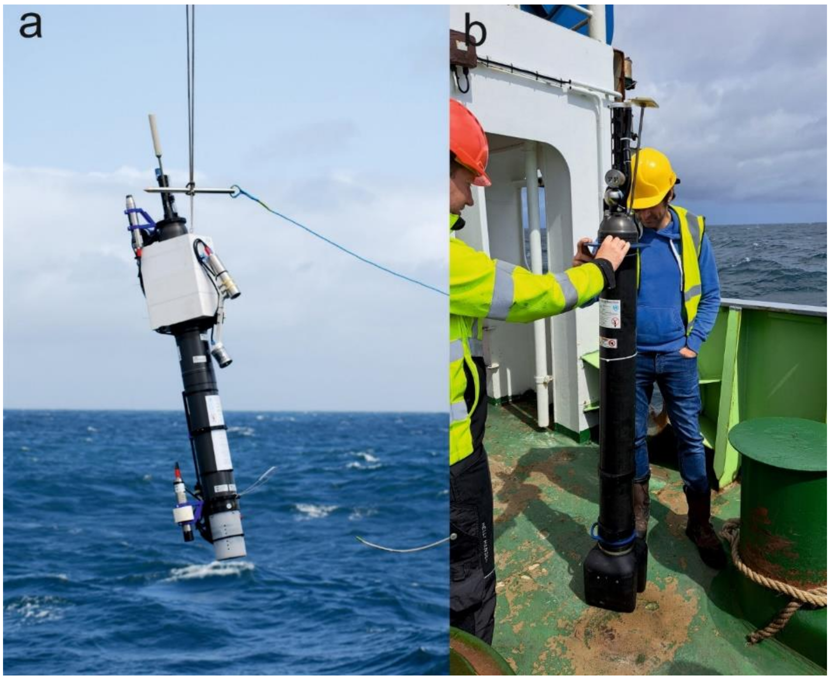
Thanks to the officers, crew, engineers, NMF technical team and catering staff of the RRS James Cook for a safe and enjoyable voyage. Also very many thanks to the invaluable help given by Anita, Ed and Hans in collecting the litres of water required for the EuroGO-SHIP nutrients project.

11. Argo Floats

Andrew Gates, Ed Mawji, Théo Picard & Anita Flohr

We deployed the following floats during JC247 to begin a collaboration with the APERO programme and to continue collaboration with the Met Office at PAP-SO.

Station number	Date	time	Deployment position	Name	Serial number	WMO_ID	Type	Validation CTD
JC247-010	09/05/2023	13:32	48° 59.683 N 016° 30.053 W	Apex	10066	3902494	Standard APEX	JC247-008
JC247-011	09/05/2023	13:36	48° 59.683 N 016° 30.053 W	Apex	10068	7901093	Engineering APEX	JC247-008
JC247-019	10/05/2023	14:38	49° 00.002 N 016° 30.050 W	NAVIS	F1242	4903670	BGC	JC247-018
JC247-020	10/05/2023	14:40	49° 00.002 N 016° 30.050 W	APERO		4903740	BGC NKE CTS-5	JC247-018
JC247-049	16/05/2023	14:47	48° 58.578 N 016° 22.323 W	Apex	10067	6990519	Standard APEX	JC247-048
JC247-050	16/05/2023	14:49	48° 58.578 N 016° 22.323 W	Apex	10069	5907048	Engineering APEX	JC247-048



Examples of Argo float deployment at the PAP-SO. Left, APERO BGC float. Right, NAVIS BGC float.

11.1 APEX Floats

Before deployment of the Apex floats we carried out the following diagnostic checks:

- Check for shipping damage
- Run 'Self-test' - details provided

Self-test requires connectors provided and communication with the float via a terminal programme. We used HyperTerminal. 'Self-test' must be run outside on deck to ensure satellite communications are working. The test takes at least 30 minutes.

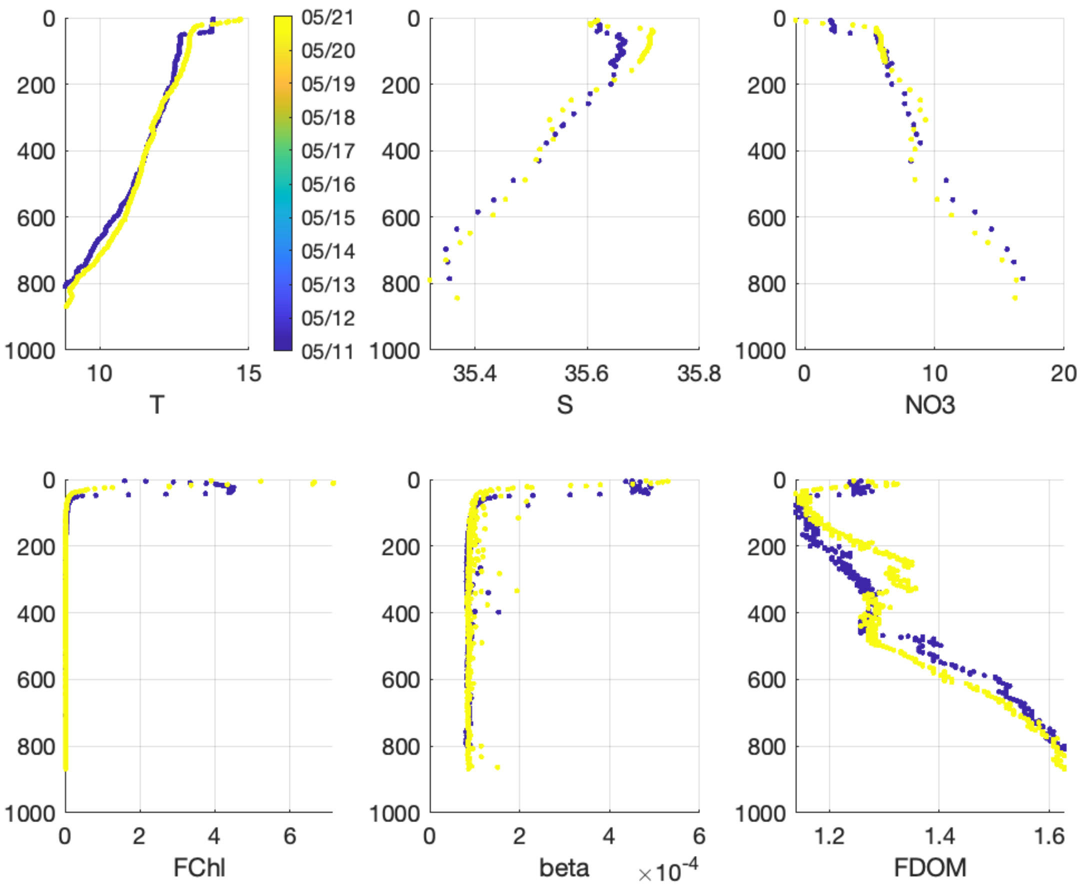
Floats 10068 and 10069 immediately passed the self-tests but Floats 10066 and 10067 failed. The failures were likely because of a poor satellite connection. We moved further from the hangar onto the port side. Advice from Teledyne was to run a different test ('*modem_test*') which would only test the connection and therefore be quicker. After several attempts both floats passed the tests and were ready for deployment.

The standard and engineering APEX floats were deployed as pairs near the beginning and end of the cruise.

11.2 NAVIS Float

The Met Office Navis float F1242 was previously deployed in 2022 on JC231 (Hartman., 2022) but the nitrate sensor failed so it was recovered before the end of that cruise. The float had been repaired in time for JC247 and was deployed. The temperature and salinity data from the NAVIS float are available at: ARGO Float 4903670 - Argo Fleet Monitoring (euro-argo.eu).

At the time of writing this cruise report Nathan Briggs at NOC is providing updates on Navis float data. Example plots are shown below:



First two profiles from the Met Office NAVIS BGC Argo float.

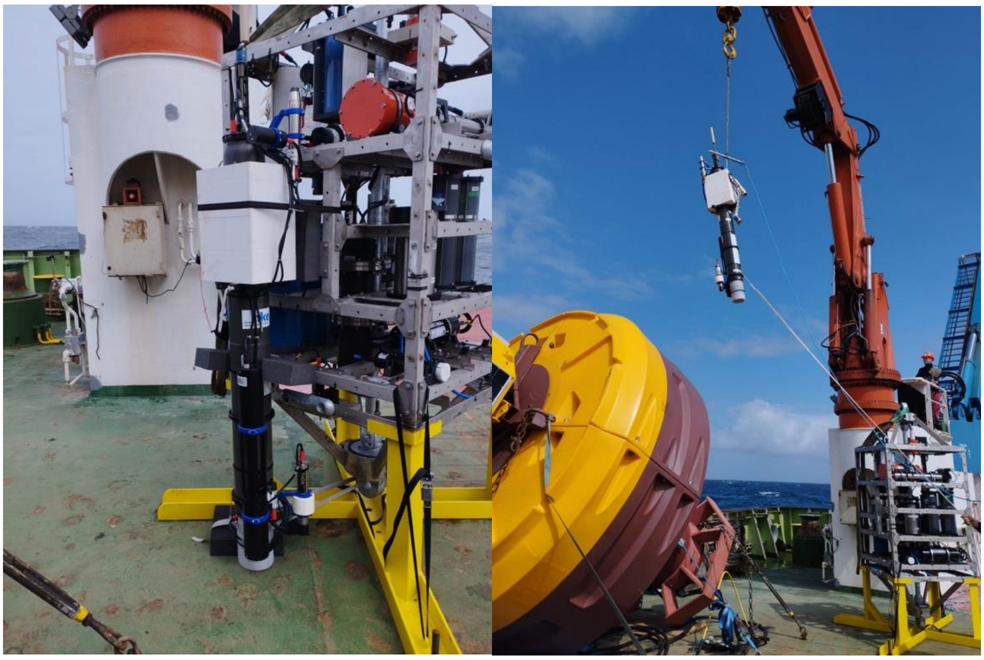
11.3 APERO Float

The APERO programme provided a BGC Argo float to be deployed at PAP ahead of their cruises to the area later in the summer. It was deployed as a pair with the BGC NAVIS float (F1242) at the regular deep CTD site (49 N 16.5 W). The float is a 5-parameter BGC NKE CTS-5, with no pH but enhanced with extra sensors: a particle camera, transmissometer, and two hyperspectral radiometers. Théo Picard coordinated the deployment with Antoine by communication 24 hours in advance. Both floats were deployed after a deep CTD.

The BCG float was set up one day before the deployment. With the help of the aft crane and

3 techs we vertically fixed the float on the PAP-1 sensor frame using two straps (one on the top white part of the float, the other at the bottom). Once secure, the BCG float was ready for a first test. The central magnet was removed for 30 min, activating the pump and inflating the balloon. After 30 min, a sound signal indicated that the float is operational and ready to be launched.

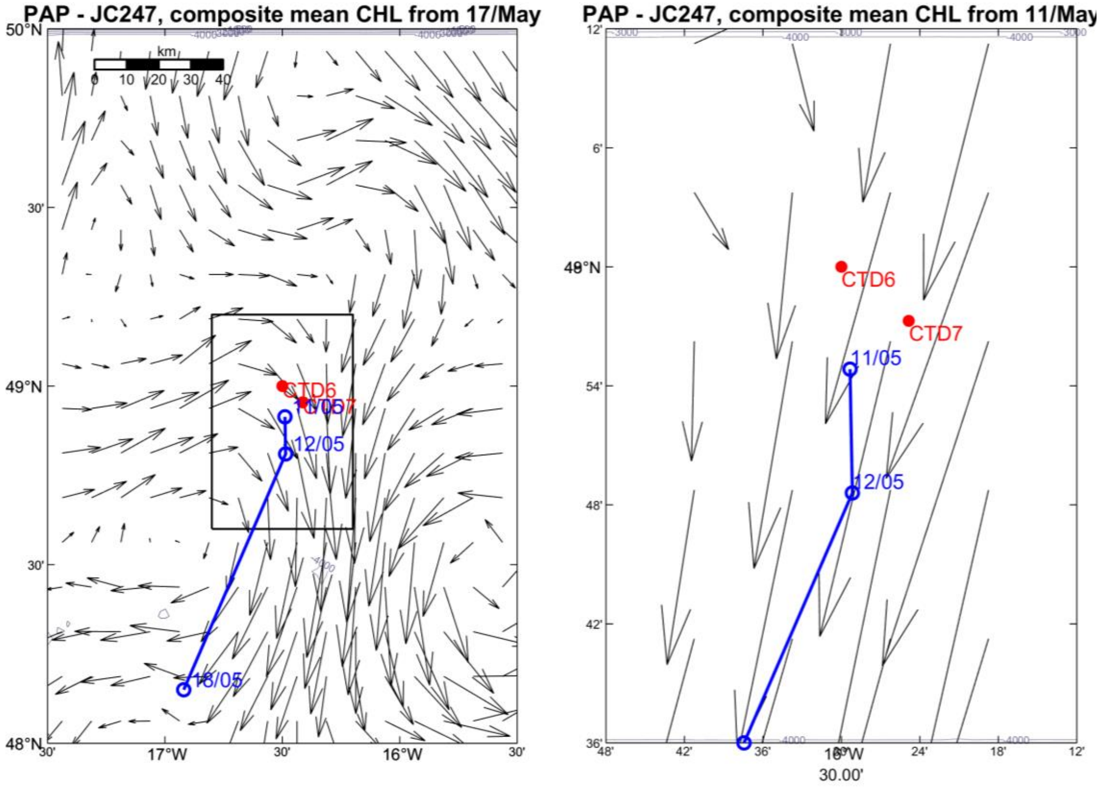
The same protocol was carried out the next day, 30 min before the deployment. The magnet was removed at 14:20 and after the float sound signal, the float was lifted using the aft crane. To avoid damaging the instruments at the top, we didn't use the hook but a rope attached with a metal bar (see picture). Once in the water, the metal bar can be removed by pulling the rope, detaching the float from the upper line. The Argo float was deployed at 14:40. The operator in charge was Tim. The sea state was moderate.



APERO BGC argo float fixed (left) and deployed (right)

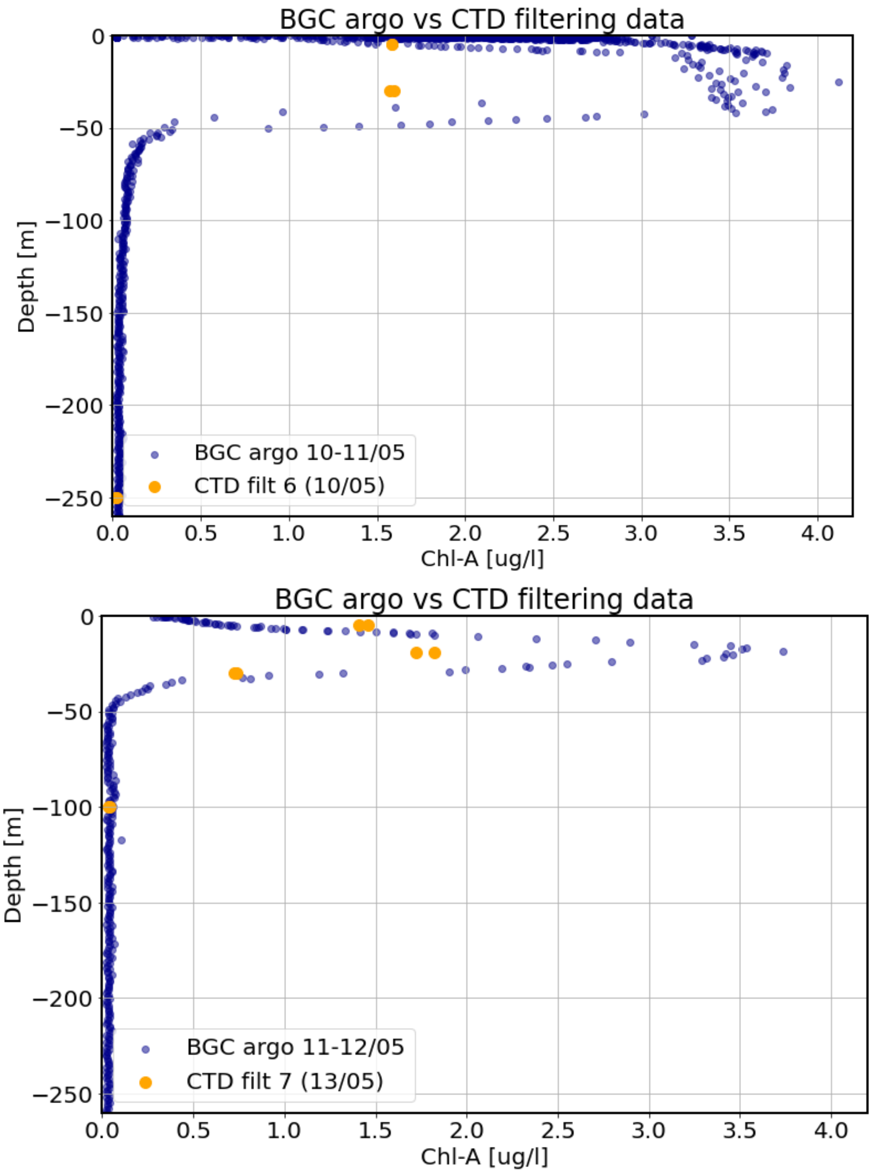
First profiles and comparison with CTD

The first profile of the BGC ARGO float was provided the day after its deployment (10/05/2023 from 18:00 to 11/05/2023 – 8:00) followed by another one the next day (from 11/05/2023 18:00 to 12/05/2023 - 11:00). The figures below show the profile location with the CTD 6 (10/05/2023) and 7 (13/05/2023). The float provided a third profile the 18/05/2023 but the float drifted significantly toward the south making comparison with CTDs difficult. But the trajectory seems coherent with the surface velocity.



In blue argo profiles locations, in red CTD locations. The background is the geostrophic velocity from SSH for the 11 and 17 May 2023

The figure below compares the first Chl profiles obtained with the CTD filtering data (cast no 6 and 7).



Chlorophyll concentration measured by the BGC argo vs CTD

Data for the APERO float are available at:
http://oao2022.imev-mer.fr/bioargo/lovuse036c/lovuse036c.html

References:

Hartman, Susan. 2022 Time-series studies at the Porcupine Abyssal Plain Sustained Observatory. Southampton, National Oceanography Centre, 201pp. (National Oceanography Centre Research Expedition Report, 77)

12. Underway measurements

12.1 Objective

On JC247 we used continuous underway pCO_2 measurements along with Lab-on-chip (LOC) nutrient sensors (nitrate and phosphate) and discrete sampling (TA, DIC, nutrients and chl a) to investigate the drivers of spatial (small and large scale) variability of surface pCO_2. In transit between locations (e.g.between PAP-1 and trawl sites) several more targeted underway surveys were completed. Surveys 1-4 focused on small scale variability of eddy structures and associated changes in chlorophyll, plankton community, pCO_2 and nutrient distribution around the PAP area. Survey 5 was focused on the larger scale variability, aimed to cross the centre of an eddy close to PAP and crossing two blooms on the shelf, one of which (bloom 1) had been crossed on the way out to PAP. Secondly, we used continuous underway pCO_2 measurements to validate the performance of recovered and deployed pCO_2 sensors at the PAP1 mooring site.

12.2 Continuous measurements

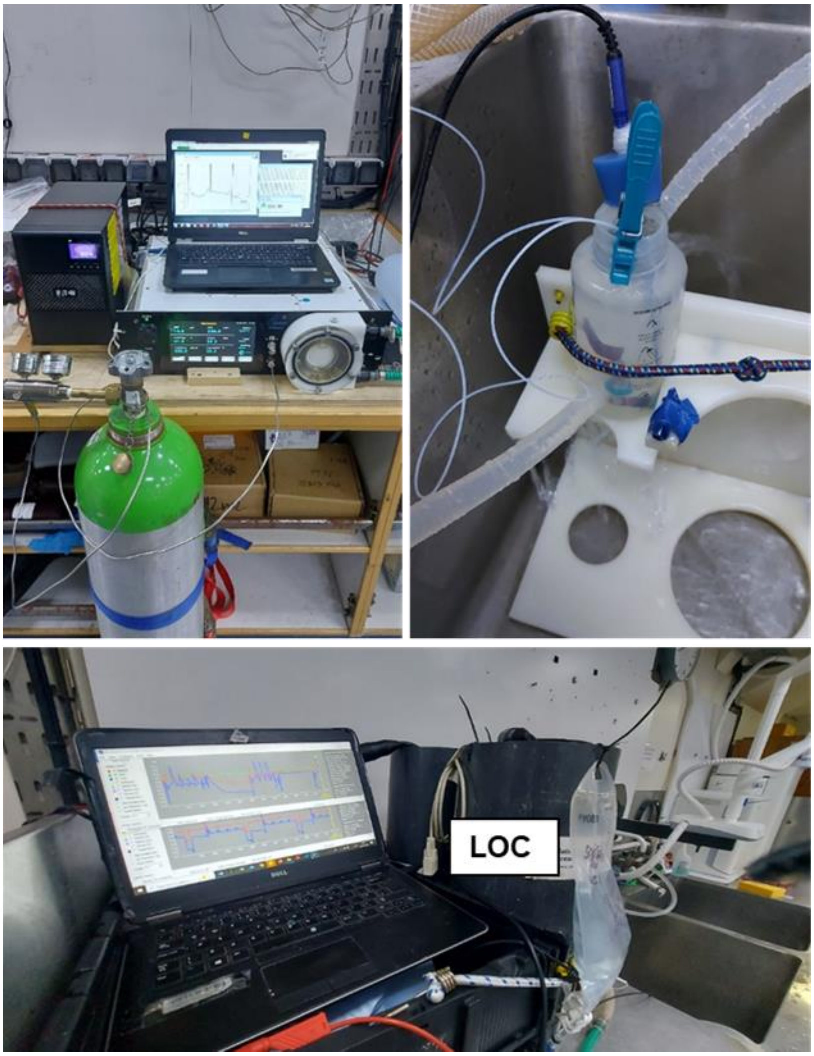
Underway pCO_2

Anita Flohr, Elisa Lovecchio, Sue Hartman

A SubCtech OceanPack MK2 Flow-Through Analyzer (SN: CO2-DLZEGAMK2-19-0-1803-01) was connected to the underway seawater supply in the deck lab for continuous xCO_2 measurements (below). The system was powered via an uninterruptible power supply to eliminate problems thought to occur in response to power spikes/drops that caused system to reset on DY116. No resets were detected during JC247.

The system was installed on 05/05/2023 and connected to the non-toxic seawater supply from ~18:30 UTC at ~12 L/min (Table below). The system was switched off on 21/05/2023 at 07:30 UTC. The water temperature was measured and logged at the analysers' outflow at 1 min intervals (Tinytag TGP-4204 PT1000, resolution: 0.01°C). The system was connected to a single standard gas (provided by ICOS, Ref: UK_FOS_PAP_CAL1 D928590 i20210093, 403.081±0.014 ppm) via stainless steel tubing. The measurement cycle included running a calibration (zero CO_2, span 1) twice a day and running the reference gas once a day (Table, below).

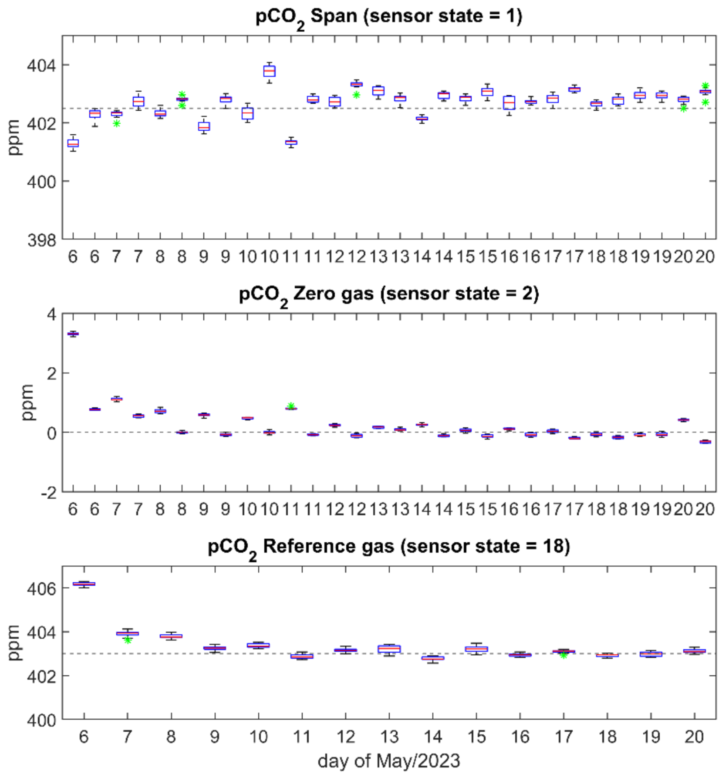
The data was streamed and logged to a laptop at 1 min intervals (using OceanView Software, SubCtech). Additionally, the data was logged and merged with the ship's TechSAS system. The data shown in this section are preliminary.



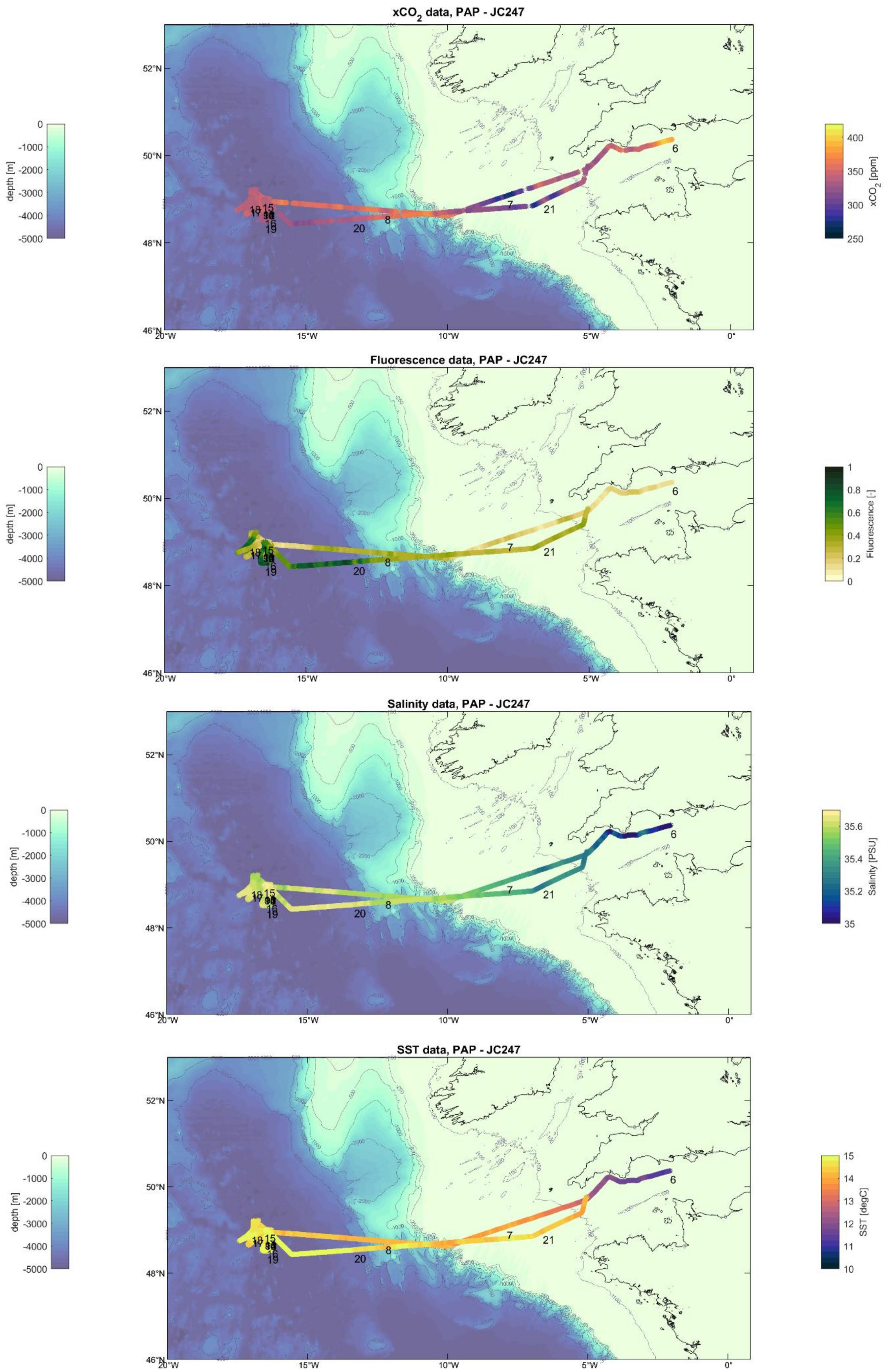
SubCtech connected to the non-toxic seawater supply in the deck lab on JC247, temperature sensor at outflow of SubCtech which was used for underway sampling of NO3 and PO3 by LOC sensors

SubCtech measurement cycle on JC247

Phase	Mode	Sensor state	Hrs	Phase end UTC
1	operate	5	07:30:00	21:32
2	zero CO2	2	00:15:00	21:47
3	span 1	1	00:15:00	22:02
4	operate	5	07:45:00	05:47
5	ref gas	18	00:15:00	06:02
6	operate	5	07:30:00	13:32
7	zero CO2	2	00:15:00	13:47
8	span1	1	00:15:00	14:02



Results of zero and reference gas measurements (raw data). Shown are boxplots of a) zero gas measurements and b) reference gas measurements during the calibration sequence and c) reference gas measurements between calibration sequences (green=outliers, dashed line = certified value of reference gas of 403.08 ppm. Please also refer to table 1 for explanation of measurement schedule.



Raw data of a) xCO2, b) fluorescence, c) sea surface salinity and d) seas surface temperature along the cruise track (raw data). Numbers on the maps represent day of May 2023

Underway NO3 and PO4 - Lab-on-chip

Anita Flohr, Malcolm Woodward, Anna Lichtschlag

Lab on chip (LOC) sensors for continuous measurements of dissolved phosphate (PO4, SN 110) and nitrate (NO3, SN 132) were attached to the underway water supply during surveys 1-5 (Section 13.3). Surveys 1-4 were focused on small scale variability of eddy structures and associated changes in chlorophyll, plankton community, pCO2 and nutrient distribution around the PAP area. Survey 5 was focused on the larger scale variability, aimed to cross the centre of an eddy close to PAP and crossing two blooms on the shelf, one of which (bloom 1) had been crossed on the way out to PAP.

The measurement cycle of the LOC sensors involved the measurement of an internal blank and internal standards (~20µM NO3, ~7.1 µM PO4). Both sensors had 2 sample inlets, one was used for an external reference (prepared by Malcolm Woodward) and the second line was used for the sample measurement. Discrete nutrient samples were taken (from the underway water outflow at the SubCtech) and timed to corresponded with the time of sample withdraw of LOC NO3 sample (state 19). These discrete samples were analysed on board and used as an additional check on LOC sensors performance and for correction. The LOC sensors internal standards were analysed to verify their stability over time and will be used to correct the NO3 and PO4 results. Types of samples and sampling times were recorded using the ship's event logger (Seciton 12.4).

List of underway surveys during JC247

		LOC NO3 (internal std: 20 µM)	**LOC PO4 (internal std: 7.8 µM)**
Survey 1 038	14/05/2023 1930-2400	Line 1 = sample Line 2 = ref = 2.1 µM (1.3 µM)	Not attached
Survey 2 043	15/05/2023 1345-1935	Line 1 = sample Line 2 = ref = 2.1 µM (1.3 µM)	Line 1 = ref = seawater Line 2 = sample
Survey 3 053	17/05/2023 1300-1800	Line 1 = sample Line 2 = ref = 4.7 µM	LOC not stable
Survey 4	18/05/2023 0900-1400	Line 1 = sample Line 2 = ref = 4.7 µM	Line 1 = ref = seawater Line 2 = sample
Survey 5	19/05-22/05/2023	Line 1 = sample Line 2 = ref = 2 µM NO3	Line 1 = ref = 0.4 µM Line 2 = sample

12.3 Discrete water sampling

Anita Flohr

Discrete water samples were collected for analyses of dissolved inorganic carbon (DIC) concentration and total alkalinity (TA). When close to the PAP1 mooring the underway sampling was timed to correspond with measurement times of the buoy and frame sensors (Table below). For crossing the shelf 2 samples / day for referencing the SubCtech. TA/DIC samples were collected in 250 mL borosilicate glass bottles following Dickson et al. (2007); after a 1% by-volume headspace was created the sample was poisoned by addition of 50 µL of saturated mercuric chloride solution and made air-tight by sealing with greased (Apiezon L) ground-glass stoppers and storing in the dark at room temperature. Samples will be analyzed at the National Oceanography Centre, Southampton, UK.

Sampling schedule of PAP1 sensors

PAP1 sensor list for JC231 May2022	Serial number	Battery housing	Timing can be altered remotely?	Possible sampling times
BUOY				
Pro-Oceanus CO2-Pro with atmospheric option	39-599-50A	none	NO	Every 6 hours at 00:22, 06:22, 12:22, 18:22
Pro-Oceanus CO2-Pro (as a backup)	34-200-45	none	NO	Every 12 hours at 01:55, 13:55
SeaBird SBE 37IMP-ODO MicroCAT	21210	internal	NO	Every 30 mins at 00 and 30
SeaBird SBE 37IMP MicroCAT	6917	internal	NO	Every 15 minutes at 00, 15, 30, 45
Satlantic OCR-507 ICSA with Bioshutter II	201/122 (123?)	none	YES	Every 30 mins at 17 and 47, sampling at 1Hz for 2 mins
Aanderaa oxygen optode	1282	none	YES	Every 30 mins at 14 and 44, sampling every 15 sec for 65secs

PAP1 sensor list for JC247 May2023	Serial number	NRT Header	Battery?	Timing can be altered remotely?	Possible sampling times (GMT)
BUOY					
Pro-Oceanus CO2-Pro with atmospheric option	42-060-50A	**COA/COB**	none	NO	Every 12 hours at 00:22, 12:22 (switches on 20 min before these times). AZPC every 12 hrs
Pro-Oceanus CO2-Pro with atmospheric option (backup)	41-824-50A	**COD/COE**	none	NO	Every 6 hours at 01:55, 07:55, 13:55, 19:55 (switches on 20 min before these times). AZPC every 12 hrs
SeaBird SBE 37IMP-ODO MicroCAT		**SBO**	internal	NO	Every 30 mins at 00 and 30
SeaBird SBE 37IMP MicroCAT		**SBE**	internal	NO	Every 15 minutes at 00, 15, 30, 45
Satlantic OCR-507 ICSA with Bioshutter II	226/230	**OC3**	none	YES	Every 30 mins at 16 and 46, sampling at 1Hz for 2.5 mins NRT avg vals every 30 sec.
Aanderaa oxygen optode with UV lamp	1279	**OX2**	none	YES	Every 30 mins at 08 and 38, sampling every 15 sec for 65secs. UV switched on after optode sampling for 15 mins.
Vaisala GMP343 atmospheric CO2		**VCO**	none	YES	On every hour for 32 mins at 22 past, sample at 52 mins past
Vaisala PTU 300 air pressure, temp, humidity		**PTU**	none	YES	On every hour for 5 mins at 14 past, sample at 18 past
WETLabs FLNTUSB Fluorometer	new	no NRT	internal	NO	Every 4 hours at 00 past

In addition, samples for analyses of dissolved nutrient concentration (Section 10), salinity (Section 6.4) and chlorophyll a (Chl a) concentration, Lugol (Section 9.4) were taken normally twice a day from the outlet water flow of the underway system. Nutrients, salinity and the majority of the chl a samples were measured onboard. Types of samples and sampling times were recorded using the ship's event logger (Section 12.4).

Acknowledgements

Many thanks to Joshua Pedder and Juan Ward (NMF) for setting up the data merger for the underway pCO2 and the ship's TechSAS data. Many thanks to Emma Curtis from the benthic science team for taking the night-time underway chl a samples.

References

Dickson, A. G., Sabine, C. L., and Christian, J. R.: Guide to Best Practices for Ocean CO2 Measurements. PICES Special Publication 3, 191 pp., 2007.

12.4 pCO2 Event Log

Excerpt of JC247 underway pCO2 event log. Includes discrete sampling (TA/DIC, nuts, LOC NO3 and PO4, Chla, Lugol) from the outflow of underway pCO2 system.

Time	Event	Comment	Latitude (N)	Longitude (E)	Ground Speed (knot)	Multibeam Depth (m)
05/05/2023 14:03	SubCTech	SubCTech runs on tap water	50.89177	-1.39511	0.2	NaN
05/05/2023 14:37	Ext temp sensor	Ext temp sensor configured, currently measures air temp	50.89176	-1.39489	0	NaN
05/05/2023 18:30	Underway seawater	Underway seawater supply switched on, SubCtech and ext temp sensor run on seawater	50.73475	-1.06647	12.6	25.2
06/05/2023 07:07		log started	50.18525	-4.0688	9.9	59.39
06/05/2023 17:47	Sampling	TA/DIC - bottles 282, A23	49.43665	-6.2331	9.5	110.14
07/05/2023 06:57	Sampling	UW1_nut, UW1_Chla, 2 x TA/DIC (517, no ID)	48.70205	-9.62101	11	171.31
07/05/2023 12:15	CTD 002	TA, DIC sampled from N22, 23, 24 (all at 5m); time is approximate	48.60334	-9.96834	0.2	1678.96
07/05/2023 14:13	Sampling	UW2_Chla	48.62956	-10.0035	1.6	1472.02
07/05/2023 14:34	Sampling	UW2_nut	48.62391	-9.99697	1.3	1533.16
08/05/2023 05:48	LOC NO3	LOC NO3 (SN 132) samples from UW, port 1 in UW seawater, port 2 in CTD water ~20 µMol (Malcolm nuts)	48.81345	-13.6107	10.6	NaN
08/05/2023 06:21	Sampling	UW3_nuts, UW3_Chla, 2xTA/DIC btls 472, no ID	48.82144	-13.7495	10.3	NaN
08/05/2023 06:58	LOC NO3	LOC NO3 (SN 123) port 2 = seawater	48.82906	-13.9062	10.2	4525.78
08/05/2023 07:54	LOC NO3	port 1 = UW, UW4_nut	48.84102	-14.1381	9.6	NaN
08/05/2023 08:38	LOC NO3	stopped LOC	48.85052	-14.319	10.1	4585.17
08/05/2023 08:40	LOC NO3	started LOC NO3 (SN132), port 2 in 2µMol reference (Malcom), port 1 in UW	48.85095	-14.3273	9.9	NaN
08/05/2023 19:03	sampling	2x TA, DIC while at station (CTD003)	48.91724	-16.4373	8.7	4825.58
08/05/2023 20:06	Bottle 205	TSG sample	48.83438	-16.5199	0.2	4832.38
09/05/2023 12:27	sampling	UW5_nuts, 2 x d13C_DIC, 2 x TA/DIC (590, no ID) at station (CTD004)	49.00002	-16.5001	0.5	4820.78
09/05/2023 20:32	Sampling	UW6_nuts, UW4_Chla, 2 x TA/DIC (270, no ID) during transit	48.87921	-16.347	6.1	NaN
10/05/2023 07:02	Sampling	UW5_Chla, UW7_nuts, 2x TA/DIC (050, no ID) on station (Megagcorer, stn 016)	48.84069	-16.5204	0.5	4826.38
10/05/2023 07:12	Sampling	3 x d13C_DIC on station (megacorer, stn 016)	48.84067	-16.5203	0.7	4827.86
10/05/2023 15:16	Sampling	2 x DIC, TA (87S, 95S) at station (CTD006)	48.99398	-16.3906	9.6	4831.7
10/05/2023 21:30	SubCTech	sink for underwater draining was filled to the top with water due to a blocked sink outlet, temp sensor record of previous 30 mins will be crap, temp record from 21:45 should be fine	48.83393	-16.5175	0.3	4830.01
11/05/2023 01:25	Sampling	UW8_Chla; night sample (Emma)	48.83695	-16.5173	0.3	4825.77
11/05/2023 07:34	Sampling	UW9_Chla, UW8_nuts, 2 TA/DIC (001,032), 3 x d13C-DIC very close to PAP1 buoy, day of PAP1 recovery	48.95384	-16.4212	0.3	4832.71
11/05/2023 12:00	flow rate	flow rate at analyser outflow at ~13 L/min	48.95843	-16.43	0.5	4828.38

12/05/2023 00:10	Sampling	UW10_Chla (night sample)	48.83554	-16.5223	1	4835.93
12/05/2023 06:50	Sampling	UW11_Chla, UW9_nuts, 2 x TA/DIC (X137,027), 3 x d13C_DIC at station	48.95535	-16.4221	0.1	4833.07
13/05/2023 02:04	Sampling	UW12_Chla (night sample)	48.83382	-16.5199	0.2	NaN
13/05/2023 07:10	Sampling	UW13_Chla at station close to PAP1	48.94984	-16.4092	0.3	NaN
13/05/2023 12:20	Sampling	UW10_nuts, 2 x TA, DIC (N15, 090) at PAP1 to coincide with surface pCO2 sensor sampling at 12:20	48.95459	-16.4142	0.3	NaN
14/05/2023 01:00	Sampling	UW14_Chla (night sample)	48.83529	-16.516	0.5	NaN
14/05/2023 07:06	Sampling	UW15_Chla	48.9477	-16.42	0.7	NaN
14/05/2023 08:00	Sampling	UW11_nuts, 3 x TA/DIC (no ID, 40, 141) on station (CTD008) close to PAP1 (=calibration cast)/ UW sampling corresponds with pCO2 sensor samling on buoy and frame	48.9477	-16.42	0.3	NaN
14/05/2023 10:00	flow rate	flow rate at anlayser outflow ~14 L/min	48.9846	-16.3846	9	NaN
14/05/2023 19:00	Sampling UW survey JC247-038	start of UW survey round about that time	49.00011	-16.317	9.6	NaN
14/05/2023 19:34	Sampling UW survey JC247-038	UW12_nuts	48.95969	-16.3506	10.8	NaN
14/05/2023 19:57	Sampling UW survey JC247-038	UW13_nuts	48.92476	-16.4398	10.9	NaN
14/05/2023 20:22	Sampling UW survey JC247-038	UW14_nuts	48.8915	-16.4718	10.1	NaN
14/05/2023 20:42	Sampling UW survey JC247-038	UW15_nuts, corresponds with time LOC NO3 draws sample	48.87475	-16.3844	10.8	NaN
14/05/2023 21:04	Sampling UW survey JC247-038	UW16_nuts, corresponds with time LOC NO3 draws sample	48.85675	-16.2893	10.2	NaN
14/05/2023 21:24	Sampling UW survey JC247-038	UW17_nuts, corresponds with time LOC NO3 draws sample	48.83034	-16.273	10.6	NaN
14/05/2023 21:45	Sampling UW survey JC247-038	UW18_nuts, corresponds with time LOC NO3 draws sample	48.80508	-16.3581	10.5	NaN
14/05/2023 22:05	Sampling UW survey JC247-038	UW19_nuts, corresponds with time LOC NO3 draws sample	48.7782	-16.4389	10.7	NaN
14/05/2023 22:26	Sampling UW survey JC247-038	UW20_nuts, corresponds with time LOC NO3 draws sample	48.78265	-16.5066	10.3	NaN
14/05/2023 22:46	Sampling UW survey JC247-038	UW21_nuts, corresponds with time LOC NO3 draws sample	48.83786	-16.5171	10.1	NaN
14/05/2023 23:07	Sampling UW survey JC247-038	UW22_nuts, corresponds with time LOC NO3 draws sample	48.89662	-16.5298	10.4	NaN
14/05/2023 23:27	Sampling UW survey JC247-038	stopped and restarted sensor due to negative values	48.95299	-16.5423	10.6	4985.69
14/05/2023 23:56	Sampling UW survey JC247-038	UW23_nuts, corresponds with time LOC NO3 draws sample	49.01036	-16.5536	0.2	4828.67
14/05/2023 23:58	Sampling UW survey JC247-038	UW survey stopped, arrived at megacorer station	49.01036	-16.5536	0.2	4743.91
15/05/2023 00:38	SubCtech	Computer shut down at ~00:38 - no data until ~07:20; at station (Megacorer) for that period	49.01066	-16.5536	0.2	4830.73
15/05/2023 01:49	Sampling	UW16_chla (night sample)	49.01066	-16.5536	0.2	NaN

15/05/2023 03:57	Sampling	UW17 Chla (night sample)	49.01067	-16.5536	0.5	NaN
15/05/2023 07:20	SubCtech	Computer and data log back on	49	-16.5	0.2	NaN
15/05/2023 07:38	Sampling	UW18_Chla, UW24_nuts, 2xTA/DIC (no IDs) while at station	49	-16.5	0.2	NaN
15/05/2023 13:40	Sampling UW survey JC247-043	start of survey, NO3 and PO4 LOC sensors attached to underway	49.00186	-16.4922	9.7	NaN
15/05/2023 15:28	Sampling UW survey JC247-043	UW25_nuts, UW19_Chla, UW1_Lugol	48.92872	-16.5007	10.4	NaN
15/05/2023 16:09	Sampling UW survey JC247-043	UW26_nuts, corresponds with state 19 of LOC NO3 when sample is being withdrawn	48.87988	-16.6697	10.9	NaN
15/05/2023 16:29	Sampling UW survey JC247-043	UW27_nuts, corresponds with state 19 of LOC NO3 when sample is being withdrawn	48.8556	-16.7512	10.8	NaN
15/05/2023 16:50	Sampling UW survey JC247-043	UW28_nuts, corresponds with state 19 of LOC NO3 when sample is being withdrawn	48.83008	-16.8021	7.1	NaN
15/05/2023 17:10	Sampling UW survey JC247-043	UW29_nuts, corresponds with state 19 of LOC NO3 when sample is being withdrawn	48.83442	-16.7159	10.9	NaN
15/05/2023 17:30	Sampling UW survey JC247-043	UW30_nuts, corresponds with state 19 of LOC NO3 when sample is being withdrawn	48.83583	-16.6239	10.6	NaN
15/05/2023 18:43	Sampling UW survey JC247-043	UW31_nuts, corresponds with state 19 of LOC NO3 when sample is being withdrawn	48.74526	-16.4529	8.7	NaN
15/05/2023 19:01	Sampling UW survey JC247-043	UW21_Chla, UW2_Lugol	48.70042	-16.4538	8.8	NaN
15/05/2023 19:14	Sampling UW survey JC247-043	UW32_nuts, corresponds with state 19 of LOC NO3 when sample is being withdrawn	48.66808	-16.4555	9.1	NaN
15/05/2023 19:35	Sampling UW survey JC247-043	end of survey, arrived at station	48.65836	-16.4584	0.4	NaN
16/05/2023 00:02	Sampling	UW22_Chla (night sample)	48.64998	-16.4583	0.1	NaN
16/05/2023 03:21	Sampling	UW23_Chla (night sample)	48.64999	-16.4583	0	NaN
16/05/2023 08:02	Sampling	2 x TA/DIC (501, X090) corresponds with PAP1 sensor sampling, on stn CTD11	48.95871	-16.4268	0.2	NaN
16/05/2023 21:22	Sampling	UW24_Chla (night sample)	49.02331	-16.9533	3.8	4834.2
17/05/2023 06:59	Sampling	UW25_Chla	48.68525	-17.1193	1.6	4762.24
17/05/2023 13:00	Sampling UW survey JC247 - 053	approx start of UW survey, LOC NO3 SN:132 attached to the underway, later LOC PO4 too but not stable	49.0013	-16.4361	10.4	NaN
17/05/2023 13:52	Sampling UW survey JC247 - 053	UW34_nuts corresponds with LOC NO3 sample withdraw	49.00296	-16.6669	10.5	NaN
17/05/2023 14:13	Sampling UW survey JC247 - 053	UW35_nuts corresponds with LOC NO3 sample withdraw	49.00476	-16.7592	10.5	NaN
17/05/2023 14:45	Sampling UW survey JC247 - 053	UW36_nuts corresponds with LOC NO3 sample withdraw	49.00813	-16.8963	10	NaN
17/05/2023 15:15	Sampling UW survey JC247 - 053	UW37_nuts corresponds with LOC NO3 sample withdraw	49.00831	-16.9677	0.1	NaN
17/05/2023 15:36	Sampling UW survey JC247 - 053	UW38_nuts corresponds with LOC NO3 sample withdraw, on station	49.0083	-16.9677	0	NaN
17/05/2023 15:56	Sampling UW survey JC247 - 053	UW39_nuts corresponds with LOC NO3 sample withdraw	49.04486	-16.9315	10.9	NaN

17/05/2023 16:18	Sampling UW survey JC247 - 053	UW40_nuts corresponds with LOC NO3 sample withdraw	49.09851	-16.8725	10.5	NaN
17/05/2023 16:38	Sampling UW survey JC247 - 053	UW41_nuts corresponds with LOC NO3 sample withdraw	49.14874	-16.8229	10.8	NaN
17/05/2023 16:58	Sampling UW survey JC247 - 053	UW42_nuts corresponds with LOC NO3 sample withdraw	49.20135	-16.7767	11	NaN
17/05/2023 17:19	Sampling UW survey JC247 - 053	UW43_nuts corresponds with LOC NO3 sample withdraw, on station	49.23516	-16.7442	0.2	NaN
17/05/2023 19:00	Sampling UW survey JC247 - 053	approx end of survey, arrived at trawling station	49.19162	-16.7887	4.2	NaN
18/05/2023 07:20	Sampling	UW26_Chla, UW44_nuts	48.77669	-17.362	3	4725.98
18/05/2023 08:02	Sampling	2 TA/DIC (043,186)	48.75836	-17.4018	2.7	4551.8
18/05/2023 08:45	Sampling UW survey_4	LOC NO3 (132) and PO4 (110) start measuring UW water (deploy)	48.74101	-17.4363	0.4	4438.05
18/05/2023 09:00	Sampling UW survey_4	approx time of start of survey 4	48.74101	-17.4362	0.2	4438.35
18/05/2023 09:18	Sampling UW survey_4	UW45_nuts corresponds with state 19 (sample withdraw) on LOC NO3 sensor	48.76391	-17.3879	10.4	4720.02
18/05/2023 09:48	Sampling UW survey_4	UW46_nuts corresponds with state 19 (sample withdraw) on LOC NO3 sensor	48.79504	-17.2621	10.8	4635.13
18/05/2023 10:18	Sampling UW survey_4	UW47_nuts corresponds with state 19 (sample withdraw) on LOC NO3 sensor	48.8243	-17.1365	10.8	4714.19
18/05/2023 10:31	Sampling UW survey_4	UW48_nuts corresponds with state 21 on LOC NO3 sensor	48.83631	-17.0821	10.5	4768.55
18/05/2023 11:02	Sampling UW survey_4	UW49_nuts corresponds with state 21 on LOC NO3 sensor	48.86641	-16.9523	10.6	4836.12
18/05/2023 11:21	Sampling UW survey_4	UW50_nuts corresponds with state 19 (sample withdraw) on LOC NO3 sensor	48.88501	-16.9015	0.7	4835.8
18/05/2023 12:02	Sampling UW survey_4	UW51_nuts corresponds with state 19 (sample withdraw) on LOC NO3 sensor on station CTD 13	48.88511	-16.9017	0.4	4839
18/05/2023 12:22	Sampling UW survey_4	UW52_nuts corresponds with state 19 (sample withdraw) on LOC NO3 sensor	48.90498	-16.8441	10.4	4838.48
18/05/2023 12:43	Sampling UW survey_4	UW53_nuts corresponds with state 17 on LOC NO3 sensor	48.92824	-16.7606	10.3	4832.04
18/05/2023 13:03	Sampling UW survey_4	UW54_nuts corresponds with state 19 on LOC NO3 sensor	48.95074	-16.6814	10.4	4831.06
18/05/2023 13:25	Sampling UW survey_4	UW56_nuts corresponds with state 19 (sample withdraw) on LOC NO3 sensor	48.97532	-16.5942	10.3	4833.92
18/05/2023 13:54	Sampling UW survey_4	end, arrived at CTD 14	49.0002	-16.5017	0.6	4837.77
18/05/2023 15:03	Sampling	2 x TA/DIC (44S, 290) while on station CTD14 deep	49.00022	-16.5017	0.4	4848.59
18/05/2023 15:34	Sampling UW survey_4	LOC NO3 and PO4 switched off	49.00023	-16.5017	0.2	4826.4
19/05/2023 07:00	Sampling	2 x TA/DIC (X130,006) while on station (CTD17) close to PAP1	48.95671	-16.4424	0.2	NaN
19/05/2023 12:00	Sampling UW survey_5	approx start of survey 5	48.97385	-16.3998	11.5	NaN
19/05/2023 12:01	UW survey 5	UW56_nuts,LOC NO3 state 19	48.9717	-16.3964	11.3	NaN
19/05/2023 13:13	UW survey 5	UW57_nuts, LOC NO3 state 19	48.8122	-16.1538	11	4727.79
19/05/2023 14:38	UW survey 5	UW58_nuts,LOC NO3 state 19	48.6275	-15.8706	10.9	4713.99
19/05/2023 15:49	UW survey 5	UW59_nuts, LOC NO3 state 19	48.47547	-15.6348	10.8	4831.93
19/05/2023 16:31	uw survey 5	UW60_nuts, LOC NO3 state 19	48.43608	-15.4593	12.4	4822.01
19/05/2023 17:22	uw survey 5	UW61_nuts, LOC NO3 state 19; UW28_Chla, UWx_Lugol, 2 x TA/DIC (56S, 19S)	48.44837	-15.207	12	4826.71

19/05/2023 19:43	uw survey 5	UW62_nuts, LOC NO3 state 24	48.48129	-14.5401	10.7	4698.49
19/05/2023 20:39	uw survey 5	UW63_nuts, LOC NO3 state 19	48.49273	-14.2747	10.6	4513.64
19/05/2023 21:09	uw survey 5	LOC NO3 and PO4 switched off	48.50129	-14.1373	11.4	4512.64
20/05/2023 05:59	uw survey 5	UW64_nuts, LOC sensors are not yet ready	48.62575	-11.626	11.7	3214.95
20/05/2023 06:00	uw survey 5	LOC NO3 and PO4 switched on, standards from Malcom from around 7 UTC	48.62603	-11.6214	10.5	3229.01
20/05/2023 07:32	uw survey 5	UW65_nuts LOC NO3 sensor state 17, 2 x TA/DIC (514, 41)	48.64874	-11.1869	11.6	2297.02
20/05/2023 08:03	uw survey 5	UW66_nuts, LOC NO3 sensor state 3	48.65523	-11.0411	11.3	1349.1
20/05/2023 09:05	uw survey 5	UW67_nuts LOC NO3 sensor state 19, 2 x TA/DIC (224,515)	48.66841	-10.7439	11.3	1744
20/05/2023 10:18	uw survey 5	UW68_nuts LOC NO3 sensor state 19	48.68034	-10.3963	11.5	690.4
20/05/2023 10:39	uw survey 5	UW69_nuts LOC NO3 sensor state 19	48.68614	-10.2972	10.2	394.26
20/05/2023 11:21	uw survey 5	UW70_nuts LOC NO3 sensor state 19	48.69766	-10.1018	10.5	633.72
20/05/2023 12:02	uw survey 5	UW71_nuts LOC NO3 sensor state 19, 2 x TA/DIC (603,463)	48.71041	-9.92096	10.5	234.9
20/05/2023 12:44	uw survey 5	UW72_nuts LOC NO3 sensor state 19	48.72018	-9.7287	11.2	351.71
20/05/2023 13:14	uw survey 5	UW73_nuts LOC NO3 sensor state 19	48.72495	-9.59076	10.5	165.51
20/05/2023 13:56	uw survey 5	UW74_nuts LOC NO3 sensor state 19	48.73209	-9.39619	11.3	166.96
20/05/2023 14:26	uw survey 5	UW75_nuts LOC NO3 sensor state 19	48.7414	-9.25384	11.8	160.13
20/05/2023 15:07	uw survey 5	UW76_nuts LOC NO3 sensor state 19, 2 x TA/DIC (245, 245)	48.75211	-9.0547	11.5	149.28
20/05/2023 15:59	uw survey 5	UW77_nuts LOC NO3 sensor state 19	48.76343	-8.79411	12.4	312.91
20/05/2023 17:22	uw survey 5	UW78_nuts LOC NO3 sensor state 19, 2 x TA/DIC (775,430)	48.782	-8.3722	12.3	158.71
20/05/2023 18:33	uw survey 5	UW79_nuts LOC NO3 sensor state 19	48.79944	-8.01231	12	148.1
20/05/2023 19:25	uw survey 5	UW80_nuts LOC NO3 sensor state 19	48.8084	-7.75715	11.6	NaN
20/05/2023 20:17	uw survey 5	UW81_nuts LOC NO3 sensor state 19	48.82404	-7.5158	10.5	NaN
20/05/2023 21:18	uw survey 5	UW82_nuts LOC NO3 sensor state 19	48.83853	-7.24819	10.8	NaN
20/05/2023 22:41	uw survey 5	UW83_nuts LOC NO3 sensor state 19, UWxx_Chla, UWxx_Lugol, 2 x TA/DIC (562, 470)	48.87551	-6.90153	10.1	NaN
20/05/2023 23:43	uw survey 5	UW84_nuts LOC NO3 sensor state 19	48.95169	-6.66414	10.6	NaN
21/05/2023 00:08	uw survey 5	UW85_nuts, LOC sensor state 19	48.9858	-6.56663	10.5	NaN
21/05/2023 00:28	uw survey 5	LOC sensors switched off	49.0119	-6.48697	10.7	NaN
21/05/2023 05:15	uw survey 5	UW86_nuts, UWxx_Chla, UWxx_Lugol, TA/DIC (2x no ID)	49.39946	-5.213	12	NaN
21/05/2023 07:13	uw survey 5	SubCTech logging switched off	49.77084	-5.02968	12.4	NaN
21/05/2023 07:27	SubCtech	tap water flush for 5 mins	49.81325	-4.99892	12	NaN

13. Satellite data and chlorophyll fronts

Elisa Lovecchio and Anita Flohr

We used a variety of satellite data to understand the regional and local flow and bloom conditions in which the cruise data were collected and design survey pathways aimed at crossing fronts between different blooming conditions. Satellite data was downloaded from NEODAAS and the CMEMS Copernicus portal. A full list of the products used is provided in the table below.

Product	Variables	Time resolution	Spatial resolution	doi / link
Copernicus DUACS Global Ocean Gridded L 4 Sea Surface Heights and Derived Variables NRT	- Sea surface height (SSH) [m] - Zonal (u) and meridional (v) geostrophic currents [m s^{-1}]	Daily	0.25° × 0.25°	https://doi.org/ 10.48670/moi-00149
Copernicus Sentinel-3 OLCI a&b	Chlorophyll [mg m^{-3}]	Daily	300m, 1.2km	https://sentinels. copernicus.eu/
VIIRS	Chlorophyll [mg m^{-3}]	Daily		

13.1 Shelf bloom on transit to PAP

In transit to Whittard canyon the cruise crossed a large bloom on the north-west European shelf between 6˚W - 8˚W and 48˚N - 50˚N during late 06/May and the first half of 07/May (figure below). At the location of the bloom, flow conditions were characterized by sluggish circulation, especially in contrast with the intense eddying field found in the Channel and off the shelf. According to satellite data, chlorophyll was lowest along the slope of the north-west European shelf, which was crossed by the cruise during the second half of 07/May. The underway pCO2 showed a minimum in correspondence with the shelf chlorophyll bloom.

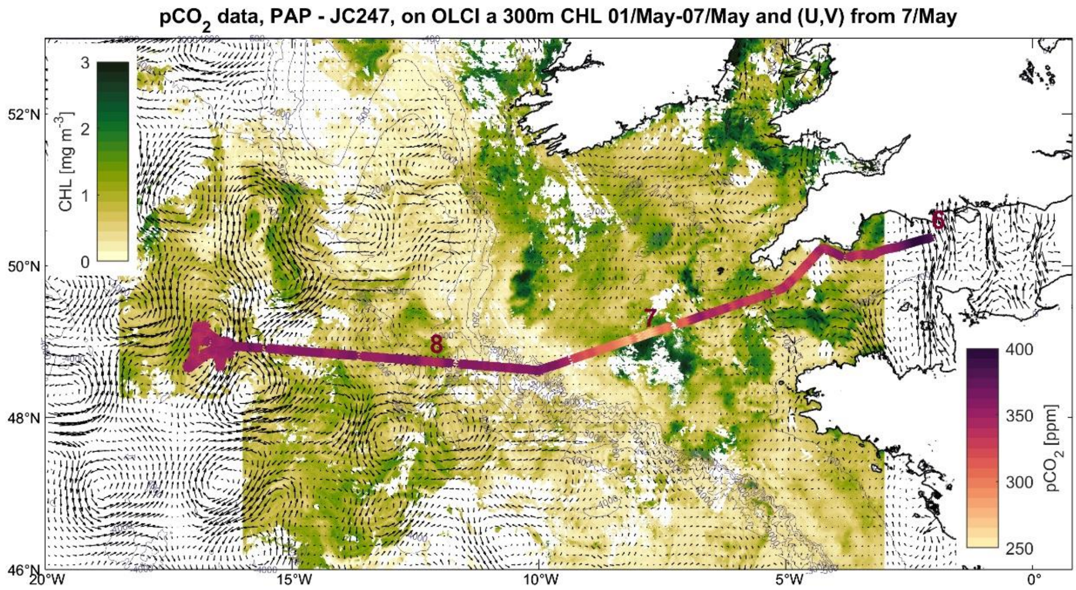


Figure 13-1. Cruise track from 06/May to 17/May over satellite chlorophyll (Sentinel-3 OLCI-a) and surface geostrophic currents (DUACS). The cruise track is coloured by pCO_2 from underway ship measurements. Numbers indicate the location of the first measurement on each day of May for the first three days of sampling (06-08/May).

13.2 Bloom and flow conditions at PAP

While at PAP (9-19/May) flow conditions were characterised by high currents (~0.1 m s^{-1}, according to LADCP data), mostly directed southward (figure below). Altimetry data indicates that PAP was located at the boundary between an anticyclonic and a cyclonic loop which convey water from the north to south.

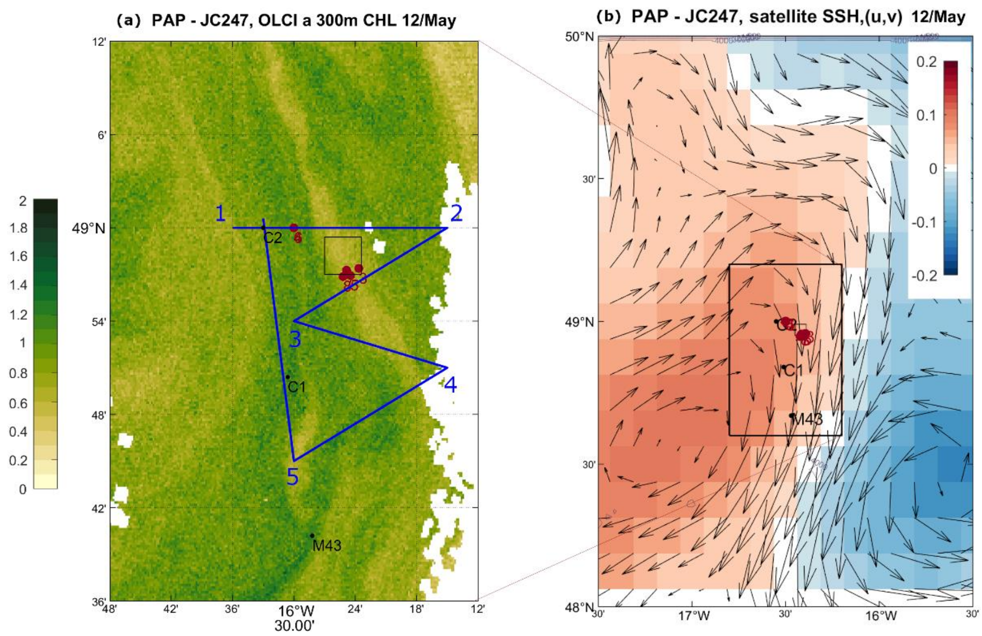


Figure 13-2. a) Chlorophyll [mg m^{-3}] around PAP on Friday 12/May with locations of the CTD casts in dark red, PAP mooring range delimited by a black square, sediment cast locations indicated in black and the designed path of the ship survey along chlorophyll fronts (carried on during Sunday 14/May but planned using the 12/May map) as a blue line; (b) Zoom-out on SSH and geostrophic currents on 12/May, the black square indicates the spatial extension of subplot (a).

During the first week at PAP, clear-sky high-resolution satellite images are available for 08 and 11-12 May (and to a lesser extent 09/May) thanks to good weather conditions. Satellite data for this period (Figure 13-2 and Figure 13-3) indicate that the bloom was comparably less intense (half-as-high chlorophyll concentrations) than the one that the ship crossed on the north-west European shelf during 06-07/May. Due to the flow being conveyed and stretched by the currents between the two eddies, the region around PAP was characterized by several small-scale fronts characterised by lower and higher chlorophyll concentrations. These fronts have a lateral extent of about 2- 10 km and they appear to be very dynamic, moving southward with the flow and also, to a certain extent, in the eastward direction. A comparison of chlorophyll images for 08, 11 and 12 May shows these fronts alternating in time at the CTD measurement locations.

13.3 Surveys across chlorophyll fronts

We used the available satellite images to design surveys aimed at sampling across chlorophyll fronts and gradients. The first survey was carried on during Sunday 14th May (Station 39), between 18:00 and midnight, taking advantage of the time available between CTD cast 8 at 16.42˚W 48.94˚N and the midnight deep sediment core at C2 (Figure 13-2a, survey approximate path as a blue line). As 13/May was characterized by complete cloud cover, we used images from 12/May to design the path across chlorophyll fronts (Figure 13-2a). Satellite images from the 14th of May downloaded in the following days also feature too much cloud cover to be able to identify the small-scale fronts that the survey aimed to target (Figure 13-4a). Nevertheless, the collected data indicates that we crossed some of the target fronts, which are visible in the data as high-chlorophyll and low-pCO_2 regions of a lateral extent of only a few km.

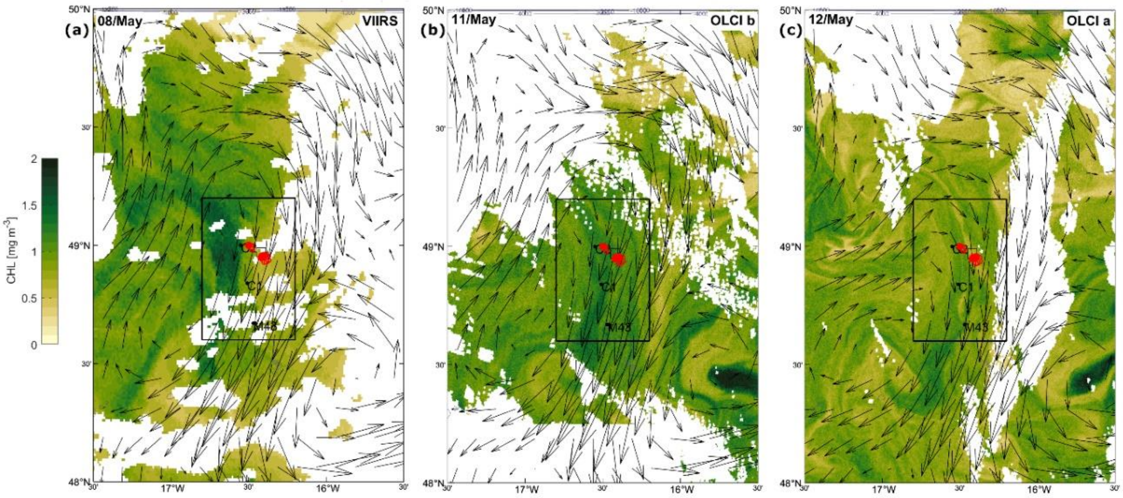


Figure 13-3. Bloom conditions from the available satellite products for chlorophyll (VIIRS-NOAA and Sentinel-3 OLCI-a and OLCI-b) and geostrophic currents from DUACS on 08/May, 11/May and 12/May. The black square delimiting the measurements' region corresponds to the spatial extent of Figure 2a, for comparison; red dots indicate CTD locations. PAP is located at the perimeter of an anticyclonic loop that bounds a smaller cyclonic eddy with a chlorophyll-rich core, clearly visible south-east of the measurement region. Currents are mostly directed southwards and are channelled between the two loops.

Additional surveys were carried on during the second week at PAP. One survey was carried on 15th May (Station 43), between 14:00 and 20:00. Due to the extensive cloud cover, the path was designed using chlorophyll satellite images built as a composite mean of all the available products for the 14th May, the most recent data available (Figure 13-3). Cloud cover spanned the entire region around PAP during the 15th, hence no better satellite images were available successively for the day of the survey. The 15/May survey aimed at spanning the full width of the black square region located around PAP, crossing both the centre of the black square characterized by small scale fronts and the flow convergence and exploring the high-chlorophyll region located west of PAP, likely associated to the anticyclonic circulation. The survey ended at the coring site planned for that night.

Underway surveys completed on JC237

UW Survey	Time frame	Path [lon,lat]	UW data	CTD cast data
Station 39 (Figure 13-2 a)	14/May 18:16-23:47	1=[-16.6,49] 2=[-16.25,49] 3=[-16.5,48.9] 4=[-16.25,48.85] 5=[-16.5,48.75] 6=[-16.55,49.01]	Temperature Salinity Fluoroescence ADCP currents pCO2 LoC Nutrients Discrete samples	None
Station 43 (Figure 13-4a)	15/May 13:45-19:30	Start= [-16.5,49] WP1= [-16.25,49] WP2= [-16.83, 48.83] WP3= [-16.46,48.83] CS1= [-16.46,48.658]	As above	None
Station 53 (Figure 13-4b)	17/May 13:00 – 19:00	Start= [-16.41,49] CTD13= [-16.97,49] CTD14= [-16.745,49.4]	As above	chlorophyll, POC, nutrients, lugol, zooplankton(CTD14)
Underway Survey 4. No Station number (Figure 13-4c)	18/May 08:45 – 16:00	Start = [48.75,-17.40] CTD15= [-16.90, 48.89] CTD16= [-16.50, 49.00]	As above	chlorophyll, POC, nutrients

On 17/May we carried on an additional survey with the purpose to compare the bloom conditions in two very distinct regions according to the satellite data: one located in the high-chlorophyll region of the anticyclone located south-west of PAP (target 1) and the second located in the low-chlorophyll region of the cyclone located north of PAP (target 2). We did 2 shallow CTD measurements (100 m depth) in the two target sites respectively, collecting samples for chlorophyll, nutrients, phytoplankton species. The survey was initially drawn based on satellite images from 16/May (Figure 4b) available on the 17/May morning. This was compared with satellite images from 17/May (Figure 13-4c) which confirmed the location of the fronts, reassuring us that we did sample in two regions with distinct blooming conditions. The satellite images from 17/May also confirmed that the survey crossed a variety of sharp fronts: one between CTD1 and CTD2 and some additional fronts along the path, including a very low chlorophyll front located close to the Start point.

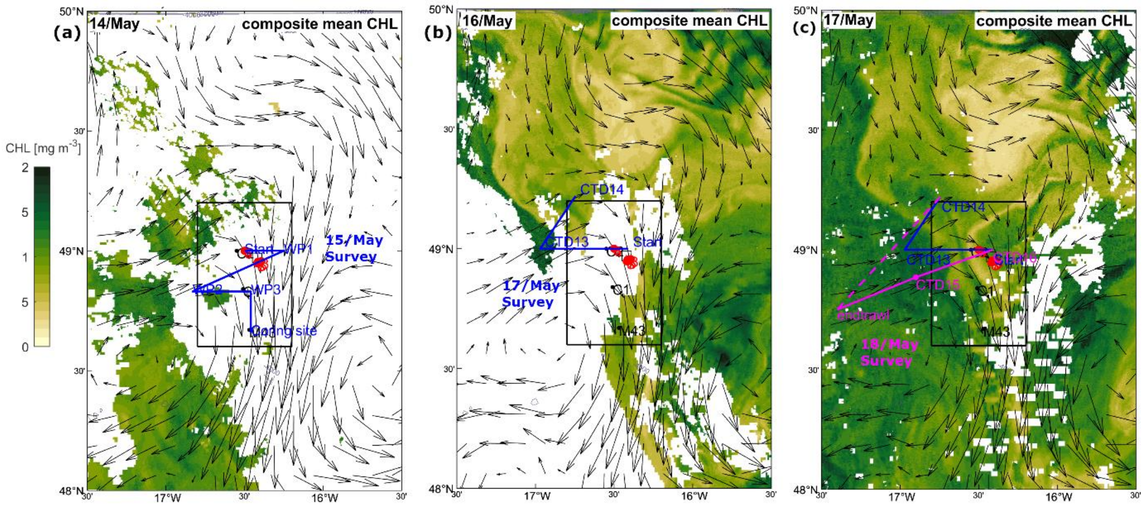


Figure 13-4. Bloom conditions visualized from composite images calculated as a mean of all the available satellite images for the day and geostrophic currents from DUACS for (a) 14/May used to draw the 15/May survey; (b) 16/May used to draw the 17/May survey and (c) 17/May used to draw the 18/May survey. The black square corresponds to the spatial extent of Figure 2a, for comparison; red dots indicate CTD locations. Blue lines indicate the paths of the planned surveys carried on (a) 15/May and (b) 17/May. The magenta line indicates the path of the survey planned for 18/May (with the dashed part indicating the approximate path of the night trawling between 17-18/May).

The 18/May survey started from the end-position of the 17-18/May overnight trawl. This survey also crossed the chlorophyll front between the south-western high-chlorophyll anticyclone and the lower chlorophyll region located around PAP-CTD, north of the mooring site (Figure 13-4c), with a path that is similar to the 17/May survey, although run across in the opposite direction. The 17/May and 18/May surveys hence constitute a couple of surveys addressing the same question, each survey including a couple of CTD casts collected on opposite sides of the chlorophyll front. On 18/May, we stopped along the way back to PAP-CTD for shallow cast up to 100 m on the 3rd CTD of the survey (CTD cast 15), while a deep cast was performed at PAP-CTD, as part of the measurement series collected at the location during the survey. This included measurements at the same depths of the shallow CTD for comparison. According to the 17/May satellite image, the PAP-CTD site is still surrounded by a variety of small-scale fronts (as it was during the first week at PAP), since it is still located between the two “wheels” of the south-western anticyclone and the south-eastern cyclone that convey the flow southwards across the PAP site. No lugol samples were collected during the 18/May survey due to the limited availability of the reagent and the need to collect additional samples on the way back from PAP across the shelf bloom.

Nevertheless, additional lugol samples were collected at the PAP-CTD site (eg: CTD 10, on the 15th May) and in the proximity of the buoy at PAP1 on eg: 16th May (CTD 11) [see chl section of the report]. As these two sites are often hit by the southward flowing sub-mesoscale fronts squeezed between the eddies, these measurements also contribute to building a picture of the variability of plankton and chlorophyll across the fronts of the bloom. Likewise, the PAP1 Wetlab fluorometer from 30m depth, and CO2 data from 1m and 30m, can be compared with the survey data.

13.4 Cyclonic eddy and shelf bloom on return from PAP

The last underwater survey was carried on the way back from PAP from 19/May. This survey had the purpose to cross two features of interest: the chlorophyll-rich cyclonic eddy located south-east of PAP, and the bloom on the north-west European shelf. The path across the cyclonic eddy draws two semi-transects that cross the eddy from the edge to the core (48.43˚N,15.58˚W) and out again eastwards. The shelf bloom on 17/May looks weaker than when we crossed it about 10 days before (6-7/May). Nevertheless, we aimed at crossing two portions of the remaining bloom: Bloom1=[48.85 ˚N,7 ˚W] and Bloom2=[49.4 ˚N,5.2˚W]. On top of the full set of underway measurements, lugol samples were collected while crossing the shelf bloom.

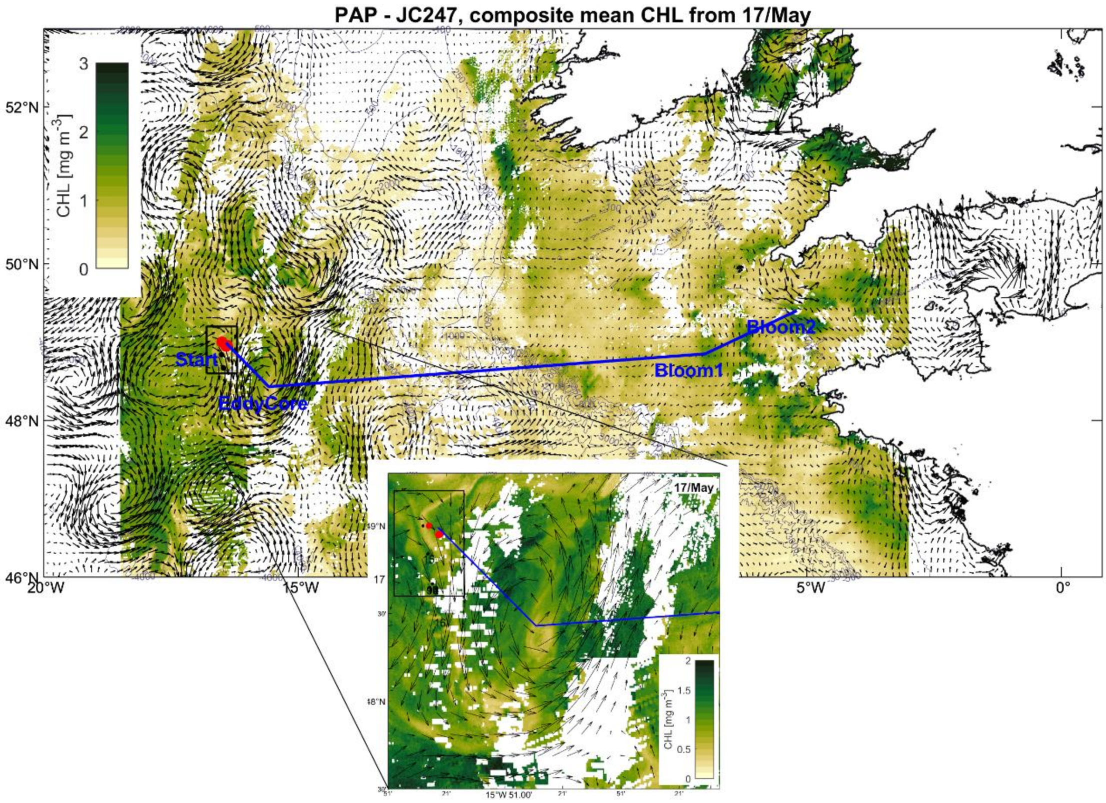


Figure 13-5. Underway survey planned on return transit from PAP (19-21/May) overlaid on the 17/May (the last cloud-free images available from satellite) chlorophyll images on the same colour scale as Figure 13-1 for comparison. The insert is a zoom-in around the cyclonic eddy showing the high-chlorophyll ring and low chlorophyll core captured on 17/May; note that the insert is plotted on a different colour scale with the purpose to better highlight the small-scale chlorophyll gradients.

Acknowledgements:

The authors thank the NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) for supplying data for this study'

14. PAP3 – Sediment traps

Christopher Feltam, Hans Hilder, Corinne Pebody (ashore)

The PAP3 mooring has 3 sediment traps, two around 3000m (A and B) with a current meter and trap C at ~4700m, a current meter and a Seabird MicroCAT. PAP3 was deployed on the 4th May 2022, during JC231 (station JC231-004). It was recovered on 13th May 2023, on JC247. The position was out by a few miles and has been corrected to 48° 57.563, 16° 20.967 in the station list. Note that on recovery the third trap was upside down and the microcat was hanging on by a single point attachment. Thanks to Dave and Tim for recovery of the mooring and then removal of the cups (adding parafilm and lids to each cup). All of the traps had stopped at cup 17 (although the amount of liquid ranged from half to full on this cup).

Note – the position for JC231-004 (PAP3) has been revised in the Station List in this Cruise report to reflect a more accurate estimate of the seabed position for use in future scientific analysis.

Note attachment of MicroCAT CTD sensor and orientation of lower trap on recovery.

The cups were lined up and photographed by Hans. Then the pH was checked (all at 7.0). 1 ml buffered formalin was added. Cup 15 on Trap A had a large Amphipod (which was removed and preserved in ethanol). Photos of the bottles and the logsheets below.

Deployment No:LXXXIX

Cruise deployed: JC231 | Date: 4/5/22 | BY: Corinne Pebody Christopher Feltham, Nick Rundle

Start & end times: ~14:50

Site: PAP | Station #: 884 | Sounding: 4847m

Position: 48° 57.563 16° 20.967 | Cruise recovered: JC247 | Date: 13/5/23 | BY:

Start & end times: 15:09 released, 18:00 on deck.

Current Meters: | Acoustic release: | Microcat:

All short sample @ No (17): Trap A= Trap B= Trap C=

- Trap 3 upside down @ Rec
- Microcat attach @ 1 point
- All stop @ cup 17.

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
Trap A 3000M								
LXXXIX-A-1	08/05/22	05/08/22	125	126	132	14		7.0 - 7.5
LXXXIX-A-2	22/05/22	05/22/22	139	140	146	14		7.0
LXXXIX-A-3	05/06/22	06/05/22	153	154	163.5	21		7.0
LXXXIX-A-4	26/06/22	06/26/22	174	175	184.5	21		
LXXXIX-A-5	17/07/22	07/17/22	195	196	205.5	21		
LXXXIX-A-6	07/08/22	08/07/22	216	217	226.5	21		
LXXXIX-A-7	28/08/22	08/28/22	237	238	247.5	21		
LXXXIX-A-8	18/09/22	09/18/22	258	259	268.5	21	FLUFF	
LXXXIX-A-9	09/10/22	10/09/22	279	280	289.5	21		
LXXXIX-A-10	30/10/22	10/30/22	300	301	310.5	21		
LXXXIX-A-11	20/11/22	11/20/22	321	322	331.5	21		
LXXXIX-A-12	11/12/22	12/11/22	342	343	356	28		
LXXXIX-A-13	08/01/23	01/08/23	5	6	19	28		
LXXXIX-A-14	05/02/23	02/05/23	33	34	47	28		
LXXXIX-A-15	05/03/23	03/05/23	61	62	75	28		
LXXXIX-A-16	02/04/23	04/02/23	89	90	103	28		
LXXXIX-A-17	30/04/23	04/30/23	117	118	127.5	21		
LXXXIX-A-18*	21/05/23	05/21/23	138	139	148.5	21	~ EMPTY	
LXXXIX-A-19	11/06/23	06/11/23	159	160	169.5	21	~ EMPTY	
LXXXIX-A-20	02/07/23	07/02/23	180	181	190.5	21	~ EMPTY	
LXXXIX-A-21	23/07/23	07/23/23	201	202	211.5	21	~ EMPTY	
FVIinal move to ope	13/08/23	08/13/23	222					

Site: PAP

eployment No LXXXIX

Cruise deployed: JC231

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments (mm)	pH
Trap B 3000M								
LXXXIX-B-1	08/05/22	05/08/22	125	126	132	14	18	
LXXXIX-B-2	22/05/22	05/22/22	139	140	146	14	12 (BLACK SPECKS)	
LXXXIX-B-3	05/06/22	06/05/22	153	154	163.5	21	13 (BLACK SPECKS)	
LXXXIX-B-4	26/06/22	06/26/22	174	175	184.5	21	6 (FLUFF)	
LXXXIX-B-5	17/07/22	07/17/22	195	196	205.5	21		
LXXXIX-B-6	07/08/22	08/07/22	216	217	226.5	21		
LXXXIX-B-7	28/08/22	08/28/22	237	238	247.5	21		
LXXXIX-B-8	18/09/22	09/18/22	258	259	268.5	21		
LXXXIX-B-9	09/10/22	10/09/22	279	280	289.5	21		
LXXXIX-B-10	30/10/22	10/30/22	300	301	310.5	21		
LXXXIX-B-11	20/11/22	11/20/22	321	322	331.5	21	<1	
LXXXIX-B-12	11/12/22	12/11/22	342	343	356	28	<1	
LXXXIX-B-13	08/01/23	01/08/23	5	6	19	28	<1	
LXXXIX-B-14	05/02/23	02/05/23	33	34	47	28	<1	
LXXXIX-B-15	05/03/23	03/05/23	61	62	75	28	<1	
LXXXIX-B-16	02/04/23	04/02/23	89	90	103	28		
LXXXIX-B-17	30/04/23	04/30/23	117	118	127.5	21		
LXXXIX-B-18* A-18	21/05/23	05/21/23	138	139	148.5	21	~	
LXXXIX-B-19	11/06/23	06/11/23	159	160	169.5	21	~	
LXXXIX-B-20	02/07/23	07/02/23	180	181	190.5	21	~	
LXXXIX-B-21	23/07/23	07/23/23	201	202	211.5	21	~	
FVIinal move to ope	13/08/23	08/13/23						

ARCHVIIVE B

BLACK LIDS

DUPLICATE A-18

* A-18, WITH BLACK LID, MEASURED IN PLACE OF B-18. NO B-18 LABELLED, YET NO OTHER SAMPLE BOTTLE GROUPS HAVE BLACK LID

Site: PAP

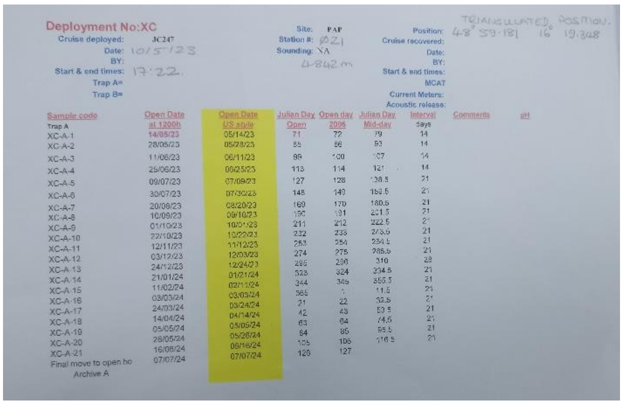
Deployment No:LXXXIX

Cruise deployed: JC231

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments (mm)	pH
Trap C 100MAB								
LXXXIX-C-1	08/05/22	05/08/22	125	126	132	14	23	
LXXXIX-C-2	22/05/22	05/22/22	139	140	146	14	18	
LXXXIX-C-3	05/06/22	06/05/22	153	154	163.5	21	10	
LXXXIX-C-4	26/06/22	06/26/22	174	175	184.5	21	3	
LXXXIX-C-5	17/07/22	07/17/22	195	196	205.5	21	2	
LXXXIX-C-6	07/08/22	08/07/22	216	217	226.5	21	3	
LXXXIX-C-7	28/08/22	08/28/22	237	238	247.5	21	7 (FLUFF)	
LXXXIX-C-8	18/09/22	09/18/22	258	259	268.5	21	1	
LXXXIX-C-9	09/10/22	10/09/22	279	280	289.5	21	Ø	
LXXXIX-C-10	30/10/22	10/30/22	300	301	310.5	21	<1	
LXXXIX-C-11	20/11/22	11/20/22	321	322	331.5	21	Ø	
LXXXIX-C-12	11/12/22	12/11/22	342	343	356	28	Ø	
LXXXIX-C-13	08/01/23	01/08/23	370	371	384	28	Ø	
LXXXIX-C-14	05/02/23	02/05/23	398	399	47	28	Ø	
LXXXIX-C-15	05/03/23	03/05/23	61	62	75	28	Ø	
LXXXIX-C-16	02/04/23	04/02/23	89	90	103	28	<1 (SHORT SAMPLED, [illegible])	
LXXXIX-C-17	30/04/23	04/30/23	117	118	127.5	21	~	
LXXXIX-C-18	21/05/23	05/21/23	138	139	148.5	21	~	
LXXXIX-C-19	11/06/23	06/11/23	159	160	169.5	21	~	
LXXXIX-C-20	02/07/23	07/02/23	180	181	190.5	21	~	
LXXXIX-C-21	23/07/23	07/23/23	201	202	211.5	21		
FVIinal move to ope	13/08/23	08/13/23	222	223	222			

The microcat (SN 12463) data was retrieved by Sensors and Moorings (Dave Childs) and the instrument was calibrated on CTD cast9. Nortek (61780, 835101) and sediment trap data were also secured by NMF.

On JC247 the PAP3 deployment was 17:22 on the 10th May 2023, station JC247-021. The triangulated position was 48° 59.181N, 16° 19.348W. The traps are due to open on 28th May 2023. On JC247 a 2nd microcat (ODO) has been added at depth. A logsheet of the trap timings is shown below.



Deployment No:XC

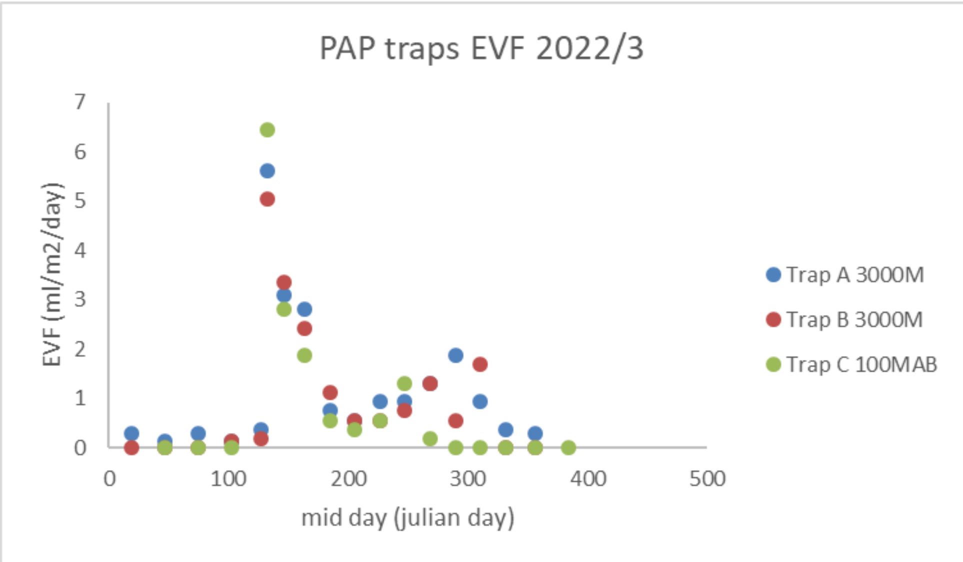
Cruise deployed: JC247
Date: 10/5/23
BY:
Start & end times: 17:22
Trap A=
Trap B=

Site: PAP
Station #: 021
Sounding: NA 4842m

Position: TRIANGULATED POSITION. 48° 59.181 16° 19.348
Cruise recovered:
Date:
BY:
Start & end times:
MCAT
Current Meters:
Acoustic release:

Sample code	Open Date at 1200h	Open Date US style	Julian Day Open	Open day 2006	Julian Day Mid-day	Interval days	Comments	pH
Trap A								
XC-A-1	14/05/23	05/14/23	71	72	79	14		
XC-A-2	28/05/23	05/28/23	85	86	93	14		
XC-A-3	11/06/23	06/11/23	99	100	107	14		
XC-A-4	25/06/23	06/25/23	113	114	121	14		
XC-A-5	09/07/23	07/09/23	127	128	138.5	21		
XC-A-6	30/07/23	07/30/23	148	149	159.5	21		
XC-A-7	20/08/23	08/20/23	169	170	180.5	21		
XC-A-8	10/09/23	09/10/23	190	191	201.5	21		
XC-A-9	01/10/23	10/01/23	211	212	222.5	21		
XC-A-10	22/10/23	10/22/23	232	233	243.5	21		
XC-A-11	12/11/23	11/12/23	253	254	264.5	21		
XC-A-12	03/12/23	12/03/23	274	275	285.5	21		
XC-A-13	24/12/23	12/24/23	295	296	310	28		
XC-A-14	21/01/24	01/21/24	323	324	334.5	21		
XC-A-15	11/02/24	02/11/24	344	345	355.5	21		
XC-A-16	03/03/24	03/03/24	365	1	11.5	21		
XC-A-17	24/03/24	03/24/24	21	22	32.5	21		
XC-A-18	14/04/24	04/14/24	42	43	53.5	21		
XC-A-19	05/05/24	05/05/24	63	64	74.5	21		
XC-A-20	26/05/24	05/26/24	84	85	95.5	21		
XC-A-21	16/06/24	06/16/24	105	106	116.5	21		
Final move to open ho Archive A	07/07/24	07/07/24	126	127				

Initial results suggest that export has not yet started this year. This is low and late, we will review the trap recovery files and current meter data to identify any methodological cause. Because of the cruise timing it was impossible to recover the traps with an intact last sample, consequently the last reliable bottle stopped sampling on 13/04/2023.

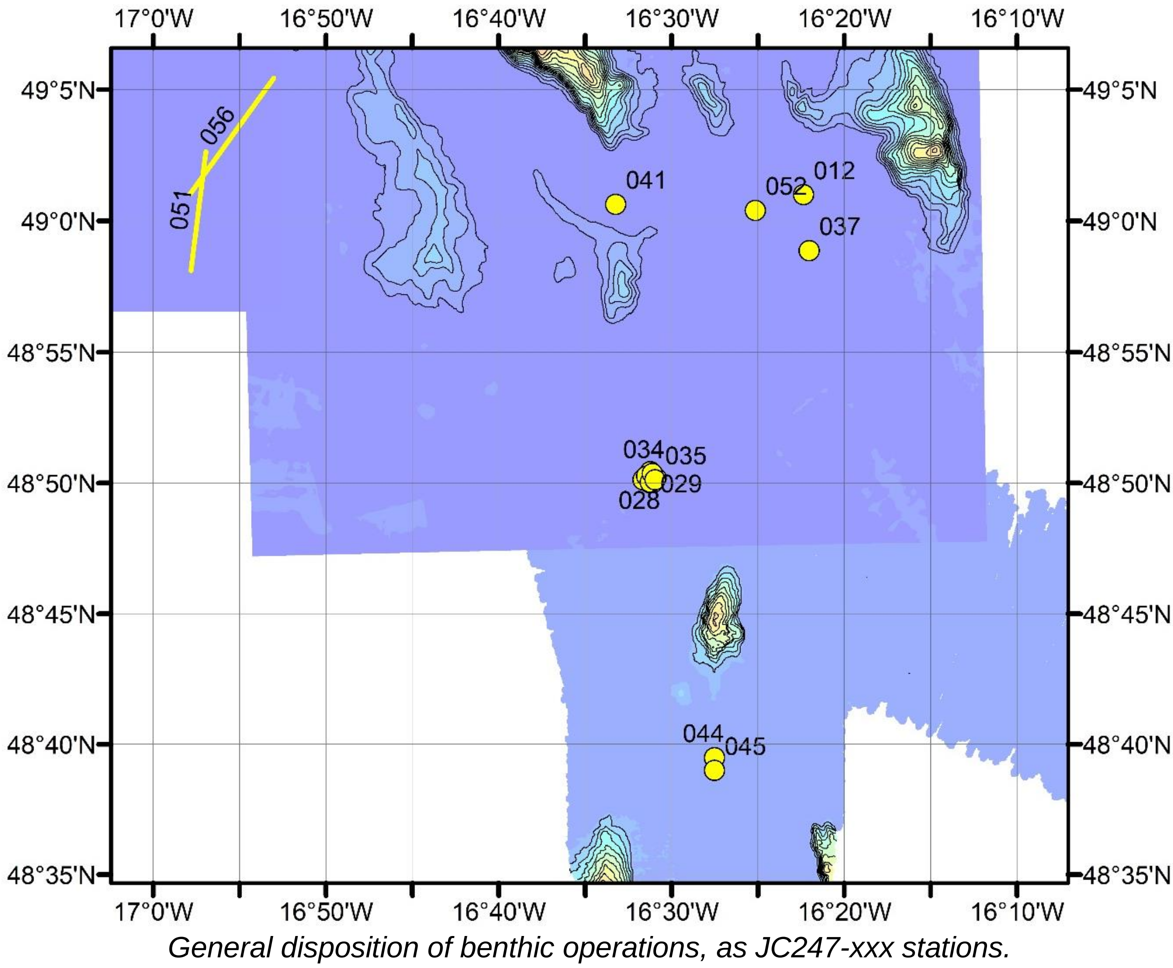


15. Benthic systems and sampling

Brian Bett, Isabelle J. Cooper, Emma J. Curtis, Lucy Goodwin, Jethro Reading, Louise Gao, Emmanuel Tope Oluwaqbusola, Sneha Sunny, Georgina Valls Domedel, Andrew Gates

The benthic group aboard RRS *James Cook* cruise 247 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 2023 cruise included: (i) a replicated set of seabed samples collected by Megacore from the PAP central location for macrobenthos studies, (ii) duplicate otter trawl samples for megabenthos studies; and (iii) duplicate amphipod trap sample sets. Additional requests for sample and specimen material were to be accommodated where possible.

Overall, benthic operations were very successful, meeting the primary objectives of the cruise and providing additional samples and specimens, essentially meeting all requests.



General disposition of benthic operations, as JC247-xxx stations.

15.1 Megacore

Coring operations at the PAP Central site were based on randomly selected points (ArcMAP 10.8 native function) within a 500 m radius buffer (geodesic; ArcMAP 10.8 native function) of the nominal centre of the "central coring area", 48° 50.22´ N 016° 31.27´ W. The NMF Megacore (ex-Deepseas) was rigged (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. Uniformly eight "large" (100 mm ID) coring units were deployed throughout, as identified in the Station List in the conventional manner (MgC08). Additional coring sites were occupied in the “North Plain” area and the prospective new study location “South area” (as illustrated below and detailed in the station list).

PAP Central cores were of familiar uniform profile, with a sharp discontinuity at c. 32-34 cm to a cream clay. North Plain cores were of the expected relatively uniform unconsolidated material for their full length. South area cores were of distinctly different profile to PAP Central, having a sharp colour discontinuity at 18 cm, representing the base of a c. 1 cm thick darkened band.

Core processing protocols:

Macrobenthos (MAC) - core top-water drained, extruded, and a single 0-5 cm section collected and preserved in toto in absolute ethanol. Destination NOC, Ocean BioGeosciences (Tammy Horton).

Organics (ORG) – core top-water drained, extruded, and sectioned into 0-2, 2-4, 4-6 cm horizons, with filtered sea water and ethanol wash of cutting ring and slicing plate (metal) between sections. Sections trimmed of edges in contact with plastics and placed into ethanol cleaned tin foil lined petri dish. The three petri dishes placed in a bag and stored frozen at -80°C. Destination NOC, Ocean BioGeosciences (Brian Bett).

Particle size analysis (PSA) – core top-water drained, extruded, and sectioned into 0-2, 2-4, 4-6 cm horizons. Each section placed in a plastic bag and the three sections placed in a bucket and stored cool. Destination NOC, Ocean BioGeosciences (Brian Bett).

Porosity (POR) – core top-water drained, syringe subcore (50 or 24 ml) inserted, core extruded and subcore dug out. Subcore extruded to target volume (50 or 24 ml), sample with retained in syringe and double bagged, then sored frozen at -20°C. Destination NOC, Ocean BioGeosciences (Brian Bett).

Geochemistry (GEO) – see separate sediment geochemistry section. Designation NOC, Ocean BioGeosciences (Anna Lichtschlag).

BOSCORF (BOS) – core top-water drained, packing material added at sediment surface, stored cool in constant temperature laboratory. Destination NOC, BOSCORF (Suzanne Maclachlan).

Metabolites (MET) – typically sample recovered from core used for other purposes, with recovery from the 5-7 cm horizon (5-10 for stn. 007; 0-5 cm for stn. 041), placed in 500 mL bottle and stored frozen at -80°C. Destination University of Aberdeen (UoA; Emmanuel Oluwabusola).

Biochemistry (BIO) – core top-water carefully siphoned off to keep surface flocculent material intact. Phytodetritus / flocculent material pipetted fluff off into muffled foil lined petri dish. Core then sectioned in 5 mm intervals down to 20 mm, Section edges (i.e., in contact with plastics) trimmed off and discarded, remainder placed in muffled foil lined petri dish. Slicing equipment rinsed with filtered seawater and then absolute ethanol between sections. Labelled petri-dishes placed in alabelled ziplock bag, and then stored frozen at -80°C. Destination University of Liverpool (UoL; Lucy Goodwin).

Porewater iron (PWI) – core top-water drained, extruded, and sliced at 5 cm depth intervals (0-5, 5-10, etc.), ensuring minimum contact with potential contaminants. Sections retained in labelled bags and stored frozen at -20°C. Destination University of Southampton (UoS; Izzy Cooper).

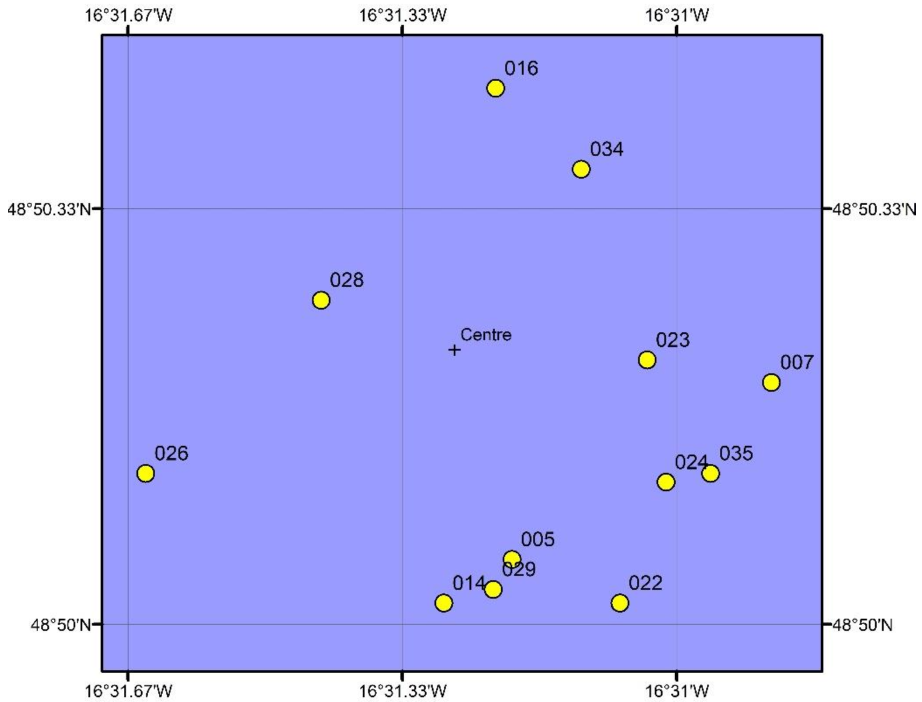
Summary tabulation of Megacore deployments and sample retention.

Station	Location	MAC NOC	ORG NOC	PSA NOC	POR NOC	GEO NOC	BOS NOC	MET UoA	BIO UoL	PWI UoS
JC247-005	Centre	6								
JC247-007	Centre	7				1		1		
JC247-014	Centre	5						1	2	
JC247-016	Centre	7				1				
JC247-022	Centre	6						1	2	
JC247-023	Centre	4				1		1		2
JC247-024	Centre	6							2	
JC247-026	Centre	7				1				
JC247-028	Centre	6						1	2	
JC247-029	Centre	5				1				
JC247-034	Centre	6							2	
JC247-035	Centre	7				1		1		
JC247-041	N. Plain					3		1		
JC247-044	South area		2	2	2				2	
JC247-045	South area		2	2	2	1	1			

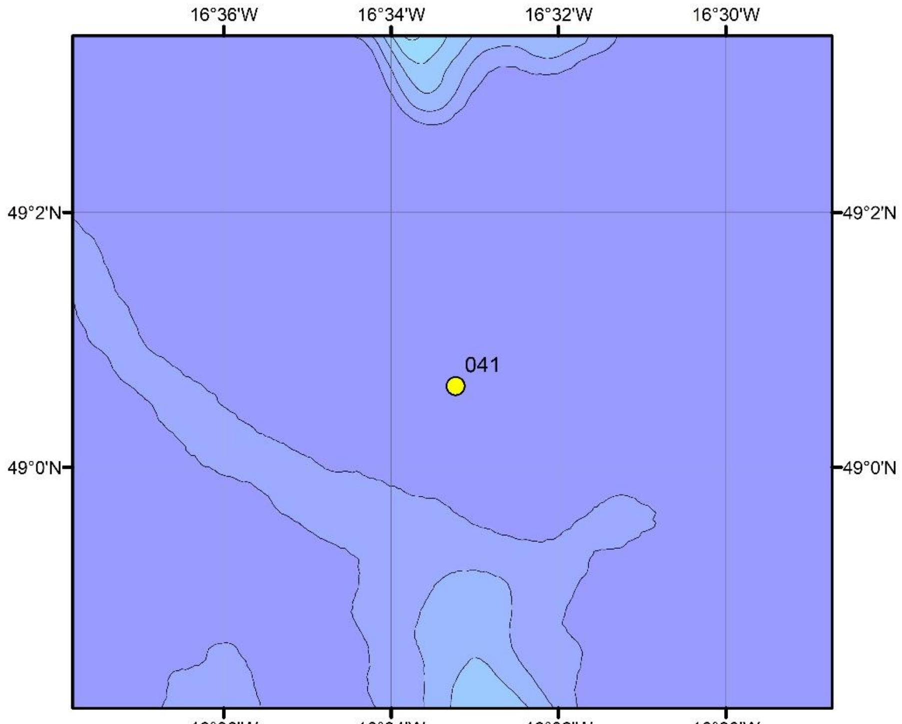
Sample type and institution abbreviations as per text above. Locations: Centre, “PAP Central”; N. Plain, “North Plain” AESA project fine grid area; South area; prospective new study area to the south of current operating areas.
Additional notes: biochemistry

Two cores were taken from six different stations and subsampled for biogeochemical analyses. These were processed on the extruder with the movable platform for stability and to reducing mixing of surface sediment into the water. The cores were pushed down the extruder to remove all but the last few centimetres of water, and the remaining water was carefully siphoned off as not to disturb the sediment surface. The fresh detritus from the surface of the sediment was pipetted off and placed into a pre-labelled petri-dish lined with sterile foil. The sediment was then sliced at 5 mm intervals down to 20 mm. All samples were sliced with a stainless-steel slicing plate and all edges that touched plastic were sliced off and discarded to avoid any impact on lipids. All samples were placed into pre-labelled petri-dishes lined with sterile foil and frozen in a -80°C freezer. Between samples, all equipment was rinsed with filtered seawater and with 100% ethanol immediately before use again.

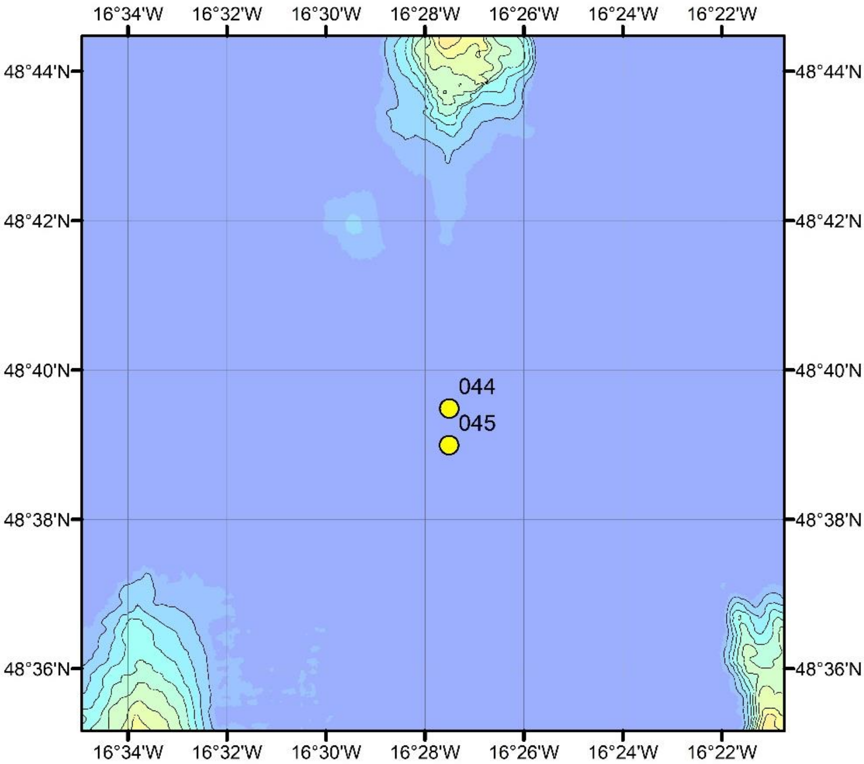
Additional notes: porewater iron
Two sediment cores were taken for analyses of particulate iron mineralogy in porewaters. Cores were sliced at 5 cm intervals down to 40 cm below the sediment-water interface, using a modified sampling procedure to minimise potential contamination with sources of metals. Each slice was then bagged, sealed and frozen. Separation, filtration, and pre-concentration of porewaters will be carried out at the National Oceanography Centre, Southampton. Samples will then be freeze-dried, with the aim of using ^{57}Fe Synchrotron Mössbauer Source Spectroscopy to define iron mineralogy and examine reactive iron-carbon stabilisation.



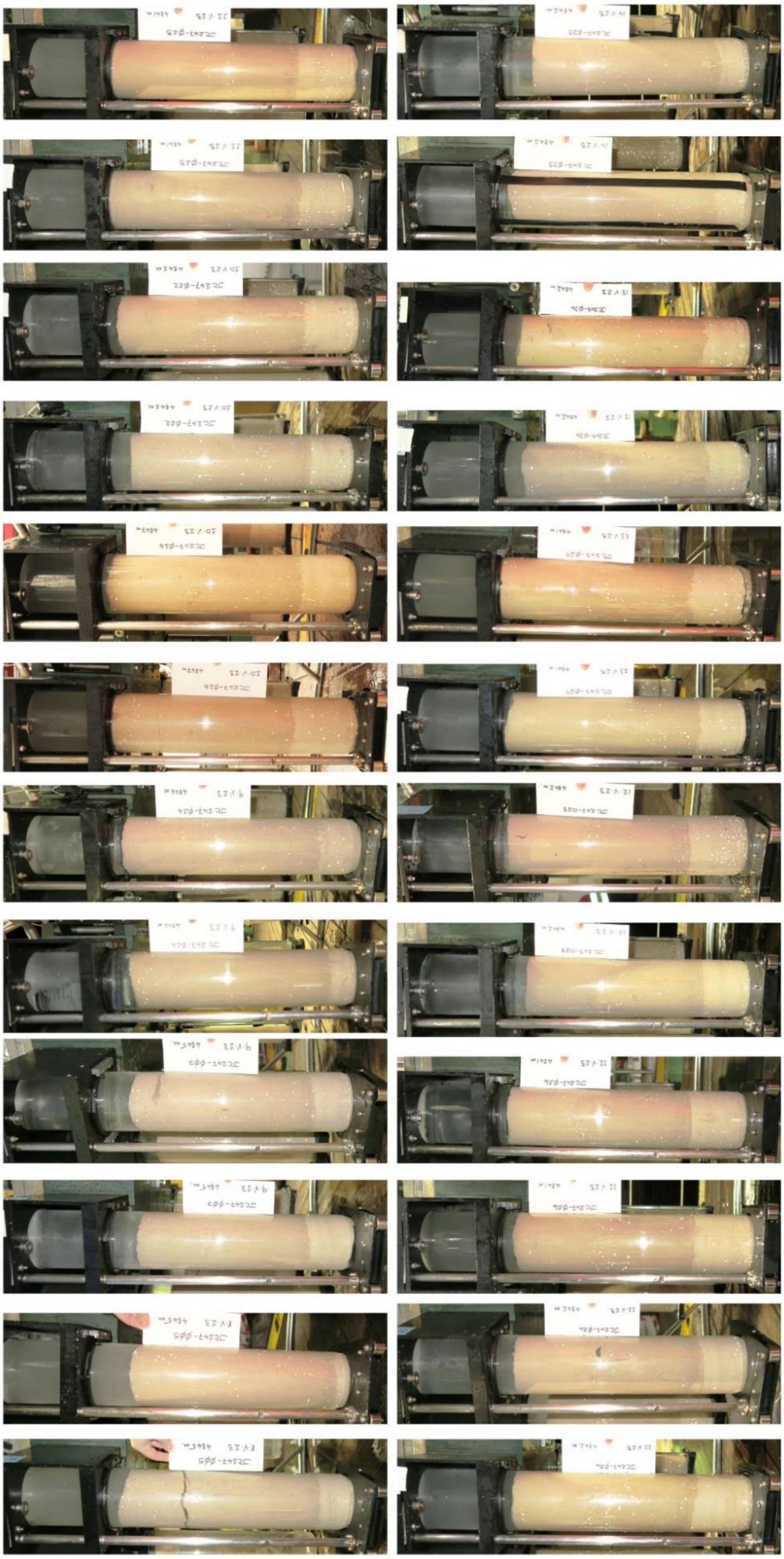
Megacore deployments, as JC247-xxx stations, in the "PAP Central" area.



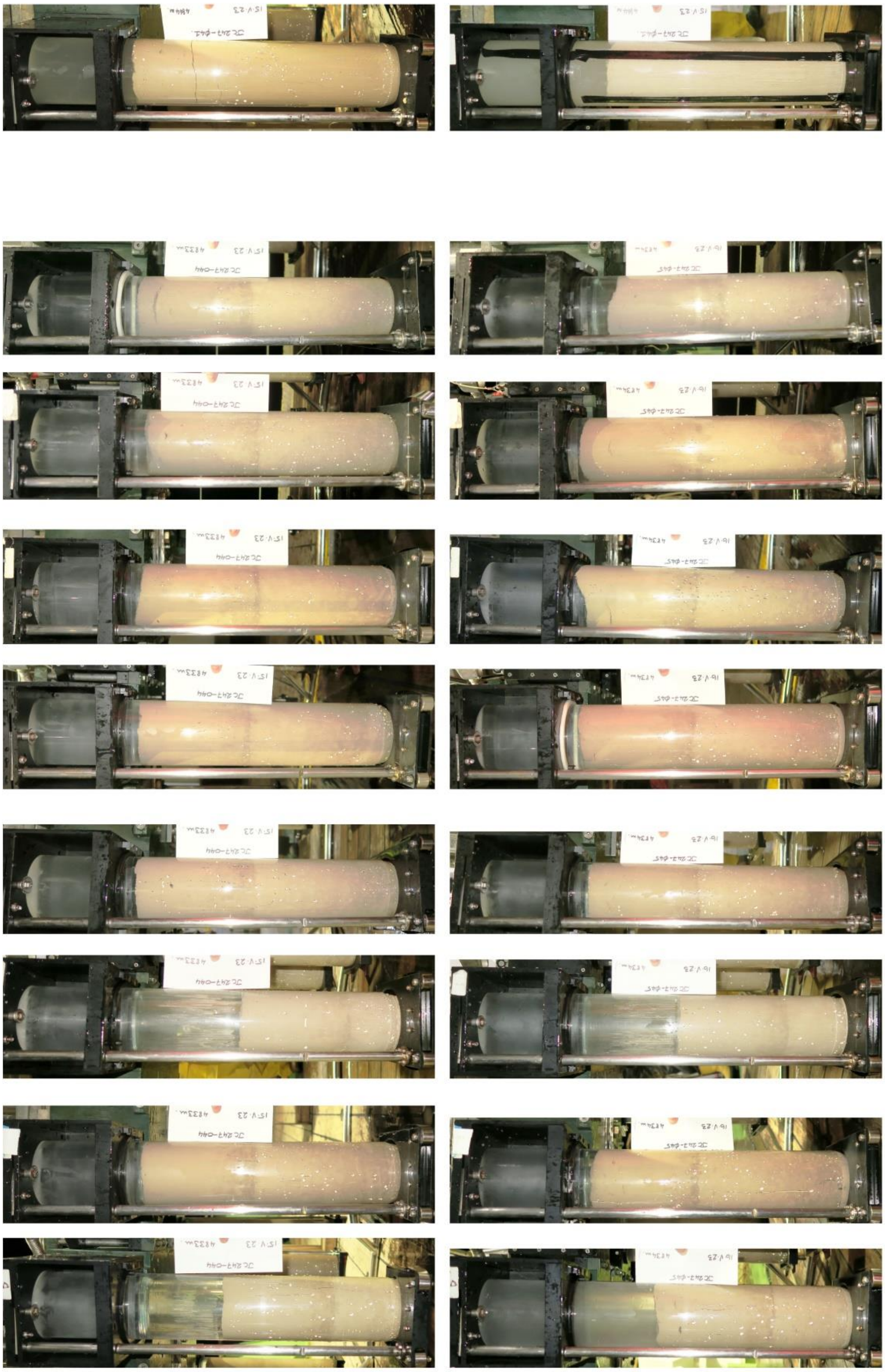
Megacore deployment, as JC247-xxx station, in the "North Plain" area.



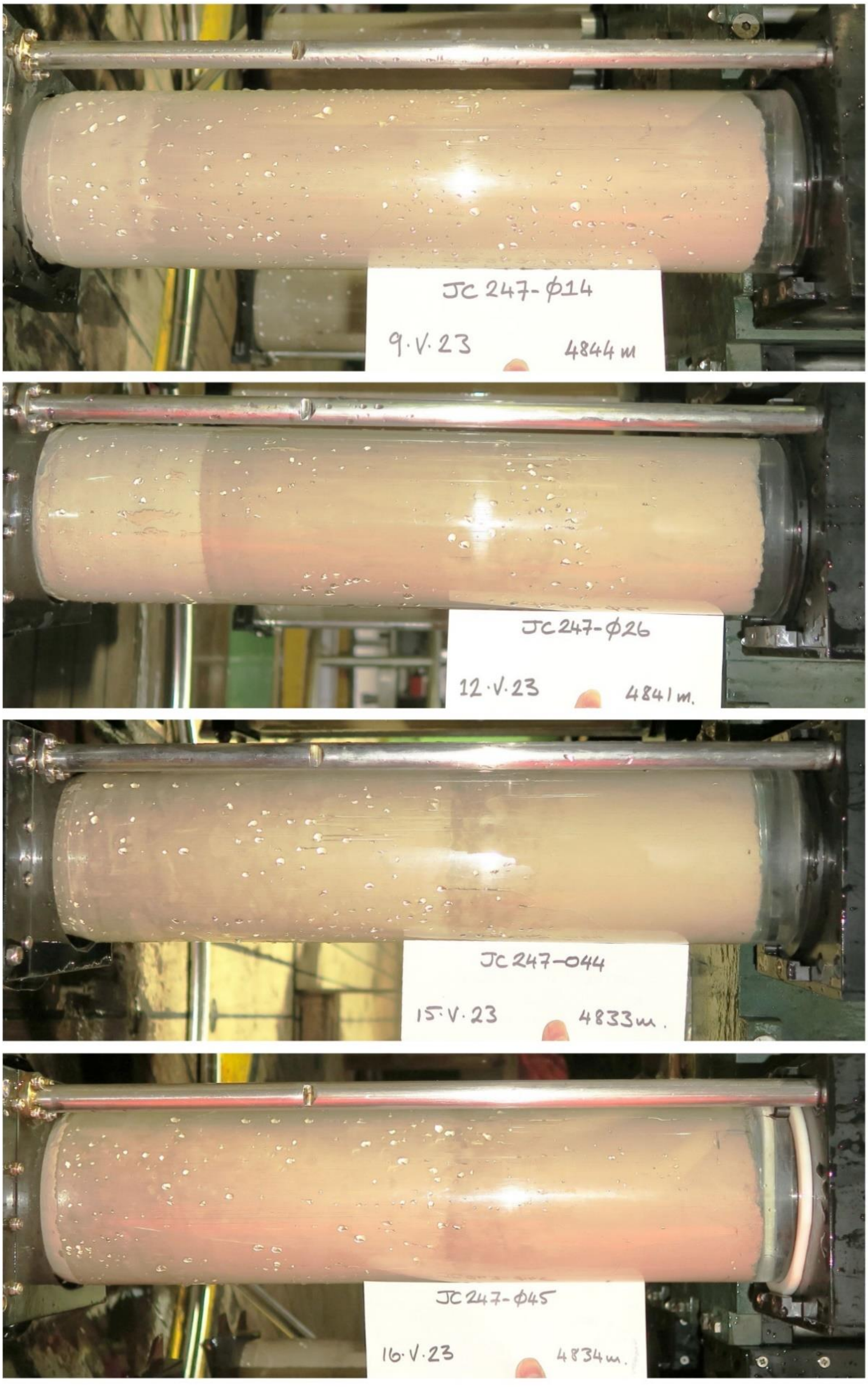
Megacore deployments, as JC247-xxx station, in the "South area".



Megacore profile photographs from the “PAP Central” area.



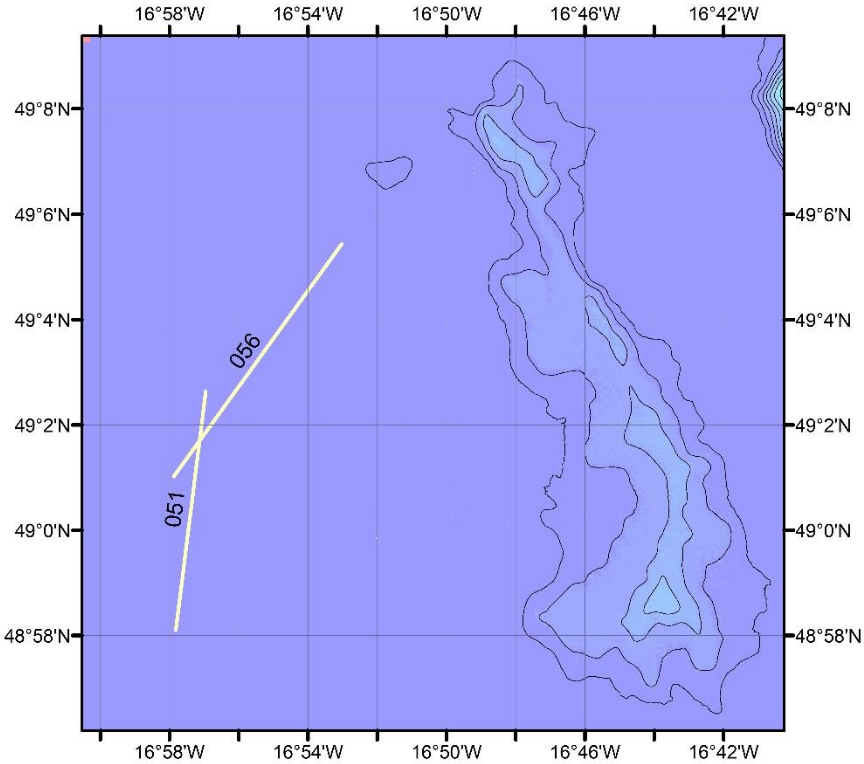
Megacore profile photographs from the "North Plain" (top line) and the "South area" (remainder).



Comparison of Megacore profiles from "PAP central" (top two) and the "South area" (bottom two).

15.2 Otter trawl

The NMF-supplied OTSB14 (semi-balloon otter trawl, 14 m headrope) was rigged and fished in conventional fashion. Note, this net appears to be a slight variant on the original pattern, having a 'conventional' codend closure (i.e., with sewn in rings on the outer netting) but having the 'non-standard' and lazy decky attachment (strangling rings, i.e., not a sewn in netting strop). No particular problems were encountered during launch, fishing, or recovery phases of the operations. However, to greater or lesser degrees the streaming phases of the tows were influenced by ship's heading changes in response to wire angle at the block. As has always been the case, the block is not suited to long-wire towing being narrow- and shallow-throated. The catches, and the gear generally, were very clean at recovery, suggesting that the net was only ever in light contact with the seafloor. Given other things being equal, ship's speed and / or current / counter-current variations between JC231 and JC247 may be worthy of further investigation (also noting N-S versus E-W trawl headings).



Estimated bottom tracks of otter trawls, as JC247-xxx station.

<u>General catch comments</u>

JC247-051 had a modest catch with little to no sediment present, with only two grey boxes being used to collect the animals from the trawl. Plastic rubbish (bags mainly) was also collected from the trawl.

JC247-056 had a larger catch but again little to no sediment caught with the animals. More plastic, some fabric, and a broken gravy jug were also collected in the trawl.
Most of the smaller organisms (Elpidiidae spp. and *Iosactis vagabunda*) were very damaged on collection, along with many of the collected *Psychropotes longicauda* (holes in main body).

There were fewer burrowing organisms than previous years' trawl catches (*Iosactis vagabunda*, *Molpadia blakei*) and no *Parasicyonis biotrans*, *Benthodytes lingua* nor *Benthothuria* spp. were collected this year. More fishes than usual were collected this year (macrourids, synaphobranchids, mid-water *Cyclothone* spp.).

Unless otherwise indicated biological specimen material was preserved in absolute ethanol, with the exception of some Scyphozoa and some fish.

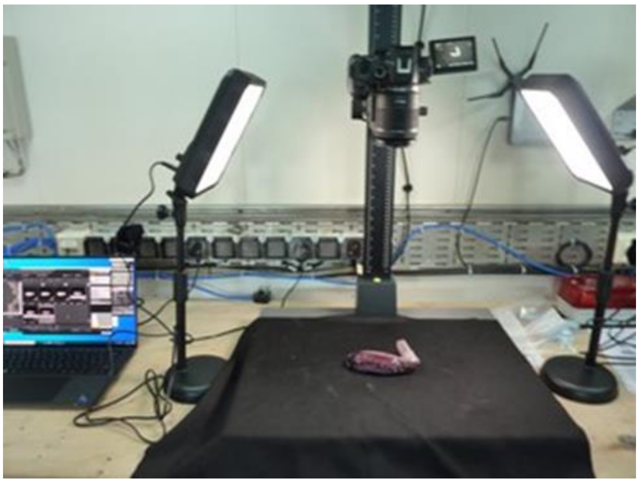
Trash collected from trawl. Left: JC247-051; Right: JC247-056.

<u>Trawl subsamples selection protocol</u>

Trawl catches were washed and sorted by morphospecies. Specimens within each morphospecies were arranged by size and specimens were selected with the aim to cover each size range. Targeted groups were holothurians: *Amperima rosea*, *Deima validum*, *Oneirophanta mutabilis mutabilis*, *Paroriza prouhoi*, *Molpadiodemas villosus*, *Pyschoprotes longicauda*, and *Pseudostichopus aemulatus*; asteroids: *Styracaster* spp., *Hyphalaster inermis*, and *Dytaster grandis grandis*; anemones: *Iosactis vagabunda*, *Amphianthius bathybium*, *Actinauge abyssorum* and *Englandactis commensalis*; crustaceans and octopuses. Provided there were enough of each morphospecies, 10-15 specimens from each size group of each target species were selected to be subsamples. If fewer were present, at least once specimen of each morphospecies was left unsampled for the Discovery Collections. Each specimen was given a label and an assigned specimen ID (e.g., 001). Subsamples removed from specimens were given a unique ID also (e.g., 001_01). It should be noted that specimen IDs were restarted for each trawl catch (e.g., JC247-051, 001; JC247-056, 001).

<u>Photography and morphometrics</u>

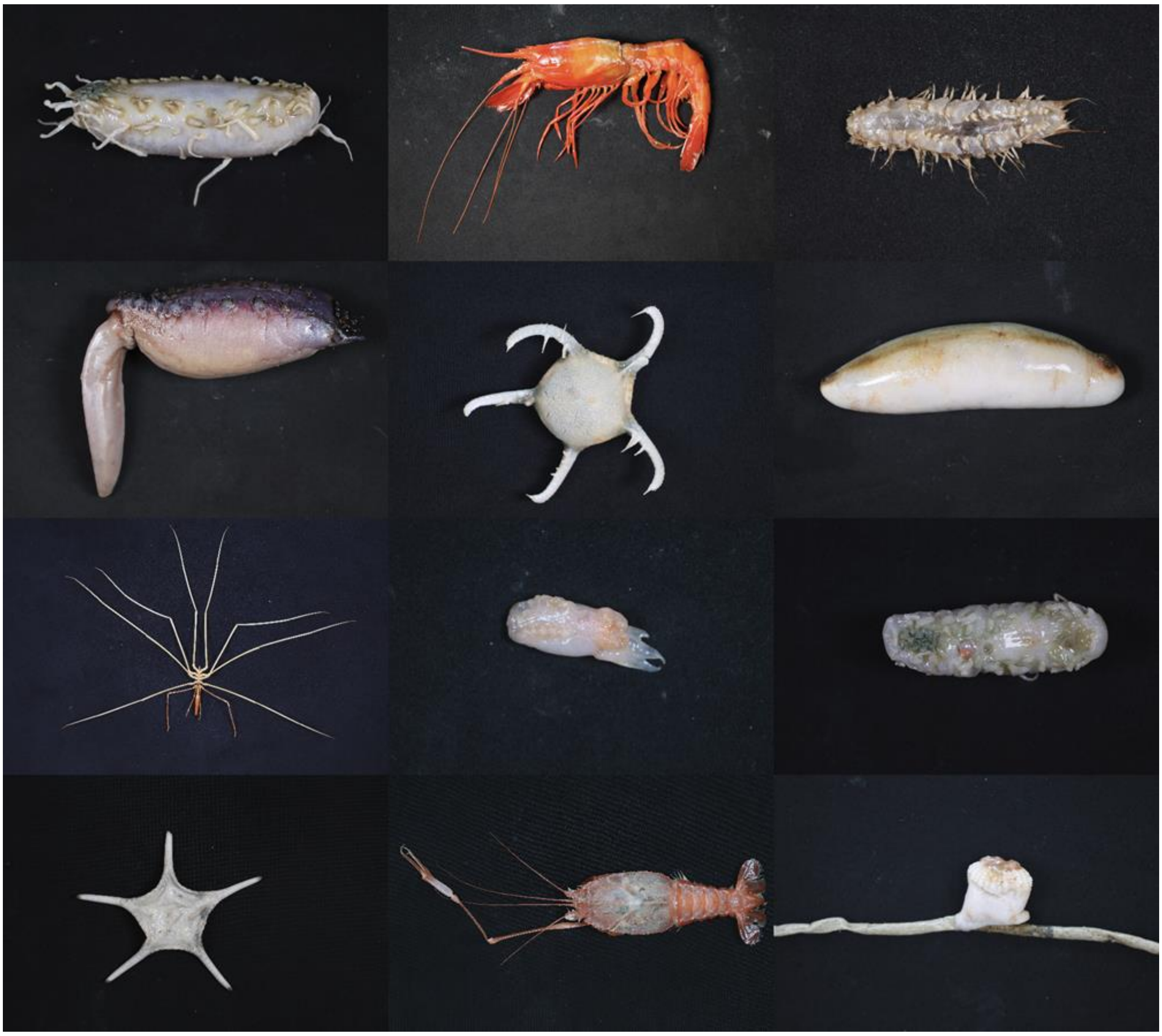
After specimen selection, photographs of individuals were taken from, dorsal, ventral, and lateral profiles, using a DSLR camera and the imaging setup displayed.



Imaging setup used to photograph specimens. Includes DSLR camera attached to copy stand; two standing lights with adjustable warmness and brightness; a laptop wirelessly connected to the camera for viewing and shooting images; a black cloth for imaging the specimens on, and a ruler for providing scale in images.

Images were taken with and without a ruler to provide scale and to provide correct white balance in photos respectively. For *Psychropotes longicauda*, care was taken to photograph the tube feet, head frills, and dorsal papillae.

After photographing, specimens were measured for their standard morphometrics and some additional morphometrics (types recorded alongside measurement), including volume displacement using plastic measuring cylinders filled with filtered seawater. In total, 184 specimens were weighed with a motion compensated balance and measured for their standard morphometrics, belonging to 22 morphotypes. Of these specimens, 176 were photographed, and 160 specimens from 14 morphotypes were measured for volume.



Example specimens from JC247-051 and JC247-056.

Morphological analysis of *Psychropotes longicauda*

From station JC247-056, *Psychropotes* specimens were morphologically analysed for tube feet count. Specimens having same length were sorted, cleaned using sea water and their anterior tube feet, mid-ventral tube feet, ventro-lateral tube feet, and dorsal papillae counted. After analyses they were preserved in ethanol for return to the Discovery Collections.

Morphological analysis of Psychropotes longicauda

Specimen number	Sole length (mm)	Mid-ventral tube feet	Ventro-lateral tube feet	Anterior tube feet	Dorsal papillae
1	135	15 pairs	12 pairs	23 pairs	4
2	135	14 pairs	8 pairs	22 pairs	4
3	135	16 pairs	9 pairs	23 pairs	3

Trawl subsample dissection protocol

Once all other trawl subsampling had been completed, the selected specimens were dissected for subsamples for stable isotope analyses. From each specimen, a sample of body wall (holothurians and anemones), tube feet (asteroids), muscle tissue (crustaceans and fishes) or arm (octopuses) was taken and placed into labelled cryovials. From larger, intact holothurians, gut contents and longitudinal muscle samples were collected as well. These subsamples were all frozen at -80°C for processing at the University of Liverpool. Some gonads or small pieces of tissue were taken from various specimens for DNA metabarcoding. These were placed in RNAlater and refrigerated for 12 hours before being frozen at -80°C. Subsamples were also taken for Rachel Jeffrey's RNA analyses from 3 x *Molpadiodemas villosus*, 3 x *Psychroprotes longicauda* and 3 x *Oneirophanta mutabilis mutabilis*. The body wall, longitudinal muscle, Polian vesicle, a gonad, the cloaca, and hind gut contents were taken and placed in cryovials. These were flash-frozen in liquid nitrogen and then placed in the -80°C freezer. The rest of each specimen was placed in perforated plastic bags with labels, and then preserved in buckets of ethanol for the Discovery Collections.

On following pages: Details of trawl subsamples taken during JC247

Station no.	Specimen no.	Subsample no.	Morphotype	Subsample	Wet weight (g)	Photo no.s	Issued to	Preservation	Measured dim. 1 (mm)	dim. type 1	Measured dim. 2 (mm)	dim. type 2	Measured dim. 3 (mm)	dim. type 3	Measured dim. 4 (mm)	dim. type 4	Measured dim. 5 (mm)	dim. type 5	Volume (ml)	Note
051	001		P. longicauda		209.8	080-088			152	len.	155	tail	41	dep.	40	wid.			199	
051	001-01	1	P. longicauda	BW	209.8	080-088	L	-80	152	len.	155	tail	41	dep.	40	wid.			199	
051	001-02	2	P. longicauda	BW	209.8	080-088	L/N	-80	152	len.	155	tail	41	dep.	40	wid.			199	
051	002		P. aemulatus		213	089-094			183	len.	45	wid.	36	dep.					199	
051	002-01	1	P. aemulatus	BW	213	089-094	L	-80	183	len.	45	wid.	36	dep.					199	
051	002-02	2	P. aemulatus	Gonad	213	089-094	L/N	-80	183	len.	45	wid.	36	dep.					199	
051	003		P. longicauda		460.8	95														[39]
051	004		O. mutabilis		37.4	096-101			84	len.	27	wid.	27	dep.					46	
051	004-01	1	O. mutabilis	BW	37.4	096-101	L	-80	84	len.	27	wid.	27	dep.					46	
051	004-02	2	O. mutabilis	Gonad	37.4	096-101	L/N	-80	84	len.	27	wid.	27	dep.					46	
051	005		P. longicauda		629	102-110			249	len.	58	wid.	35	dep.	234	tail			480	
051	005-01	1	P. longicauda	Longit. muscle	629	102-110	R	-80	249	len.	58	wid.	35	dep.	234	tail			480	
051	005-02	2	P. longicauda	BW	629	102-110	R	-80	249	len.	58	wid.	35	dep.	234	tail			480	
051	005-03	3	P. longicauda	Gonad	629	102-110	R	-80	249	len.	58	wid.	35	dep.	234	tail			480	
051	005-04	4	P. longicauda	Cloaca	629	102-110	R	-80	249	len.	58	wid.	35	dep.	234	tail			480	
051	005-05	5	P. longicauda	Hind gut cont.	629	102-110	R	-80	249	len.	58	wid.	35	dep.	234	tail			480	[26]
051	005-06	6	P. longicauda	Polian vesicle	629	102-110	R	-80	249	len.	58	wid.	35	dep.	234	tail			480	
051	005-07	7	P. longicauda	Gonad	629	102-110	L/N	-80	249	len.	58	wid.	35	dep.	234	tail			480	
051	005-08	8	P. longicauda	BW	629	102-110	L	-80	249	len.	58	wid.	35	dep.	234	tail			480	
051	006		P. aemulatus		175	111-116			182	len.	38	wid.	38	dep.					160	
051	006-01	1	P. aemulatus	BW	175	111-116	L	-80	182	len.	38	wid.	38	dep.					160	
051	006-02	2	P. aemulatus	Gonad	175	111-116	L/N	-80	182	len.	38	wid.	38	dep.					160	
051	007		P. longicauda		490.6	117-125			209	len.	43	dep.	47	wid.	167	tail			420	
051	007-01	1	P. longicauda	Gonad	490.6	117-125	R	-80	209	len.	43	dep.	47	wid.	167	tail			420	
051	007-02	2	P. longicauda	Polian vesicle	490.6	117-125	R	-80	209	len.	43	dep.	47	wid.	167	tail			420	
051	007-03	3	P. longicauda	Cloaca	490.6	117-125	R	-80	209	len.	43	dep.	47	wid.	167	tail			420	
051	007-04	4	P. longicauda	Longit. muscle	490.6	117-125	R	-80	209	len.	43	dep.	47	wid.	167	tail			420	
051	007-05	5	P. longicauda	BW	490.6	117-125	R	-80	209	len.	43	dep.	47	wid.	167	tail			420	
051	007-06	6	P. longicauda	Hind gut cont.	490.6	117-125	R	-80	209	len.	43	dep.	47	wid.	167	tail			420	
051	007-07	7	P. longicauda	BW	490.6	117-125	L	-80	209	len.	43	dep.	47	wid.	167	tail			420	
051	007-08	8	P. longicauda	Gonad	490.6	117-125	L/N	-80	209	len.	43	dep.	47	wid.	167	tail			420	
051	008		P. aemulatus		116	126-132			156	len.	40	dep.	40	wid.	20	head wid.	10	head dep.	110	
051	008-01	1	P. aemulatus	BW	116	126-132	L	-80	156	len.	40	dep.	40	wid.	20	head wid.	10	head dep.	110	
051	008-02	2	P. aemulatus	Gonad	116	126-132	L/N	-80	156	len.	40	dep.	40	wid.	20	head wid.	10	head dep.	110	
051	009		P. longicauda		644	133-141			250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]
051	009-01	1	P. longicauda	Longit. muscle	644	133-141	R	-80	250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]
051	009-02	2	P. longicauda	BW	644	133-141	R	-80	250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]
051	009-03	3	P. longicauda	Gonad	644	133-141	R	-80	250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]
051	009-04	4	P. longicauda	Polian vesicle	644	133-141	R	-80	250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]
051	009-05	5	P. longicauda	Cloaca	644	133-141	R	-80	250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]
051	009-06	6	P. longicauda	Hind gut cont.	644	133-141	R	-80	250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]
051	009-07	7	P. longicauda	BW	644	133-141	L	-80	250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]

051	009-08	8	P. longicauda	Gonad	644	133-141	L/N	-80	250	len.	71	wid.	22	dep.	192	tail		head dep.	600	[31]
051	010		O. mutabilis		43.8	142-147			81	len.	29	wid.	26	dep.	20	head wid.	16	head dep.	35	
051	010-01	1	O. mutabilis	BW	43.8	142-147	L	-80	81	len.	29	wid.	26	dep.	20	head wid.	16	head dep.	35	
051	010-02	2	O. mutabilis	Gonad	43.8	142-147	L/N	-80	81	len.	29	wid.	26	dep.	20	head wid.	16	head dep.	35	
051	011		P. longicauda		607.5	148-157			212	len.	71	wid.	73	dep.	150	tail			560	[15]
051	011-01	1	P. longicauda	BW	607.5	148-157	L	-80	212	len.	71	wid.	73	dep.	150	tail			560	[15]
051	011-02	2	P. longicauda	Longit. muscle	607.5	148-157	L	-80	212	len.	71	wid.	73	dep.	150	tail			560	[15]
051	011-03	3	P. longicauda	Fore gut cont.	607.5	148-157	L	-80	212	len.	71	wid.	73	dep.	150	tail			560	[15]
051	011-04	4	P. longicauda	Mid gut cont.	607.5	148-157	L	-80	212	len.	71	wid.	73	dep.	150	tail			560	[15]
051	011-05	5	P. longicauda	Hind gut cont.	607.5	148-157	L	-80	212	len.	71	wid.	73	dep.	150	tail			560	[15]
051	012		O. mutabilis		44.4	158-163			85	len.	32	wid.	26	dep.	21	head wid.	17	head dep.	40	
051	012-01	1	O. mutabilis	BW	44.4	158-163	L	-80	85	len.	32	wid.	26	dep.	21	head wid.	17	head dep.	40	
051	012-02	2	O. mutabilis	Gonad	44.4	158-163	L/N	-80	85	len.	32	wid.	26	dep.	21	head wid.	17	head dep.	40	
051	013		P. longicauda		666.5	164-170			296	len.	29	dep.	49	wid.	252	tail			580	[37]
051	013-01	1	P. longicauda	BW	666.5	164-170	L	-80	296	len.	29	dep.	49	wid.	252	tail			580	[37]
051	013-02	2	P. longicauda	Longit. muscle	666.5	164-170	L	-80	296	len.	29	dep.	49	wid.	252	tail			580	[37]
051	014		O. mutabilis		41	171-177			72	len.	36	wid.	31	dep.	13	head wid.	15	head dep.	35	
051	014-01	1	O. mutabilis	BW	41	171-177	L	-80	72	len.	36	wid.	31	dep.	13	head wid.	15	head dep.	35	
051	015		P. longicauda		407.8	178-189			175	len.	53	dep.	52	wid.	125	tail			350	
051	015-01	1	P. longicauda	BW	407.8	178-189	L	-80	175	len.	53	dep.	52	wid.	125	tail			350	
051	015-02	2	P. longicauda	Longit. muscle	407.8	178-189	L	-80	175	len.	53	dep.	52	wid.	125	tail			350	
051	015-03	3	P. longicauda	Fore gut cont.	407.8	178-189	L	-80	175	len.	53	dep.	52	wid.	125	tail			350	
051	015-04	4	P. longicauda	Mid gut cont.	407.8	178-189	L	-80	175	len.	53	dep.	52	wid.	125	tail			350	
051	015-05	5	P. longicauda	Hind gut cont.	407.8	178-189	L	-80	175	len.	53	dep.	52	wid.	125	tail			350	
051	016		O. mutabilis		63.8	190-198			91	len.	34	wid.	31	dep.	20	head wid.	14	head dep.	60	
051	016-01	1	O. mutabilis	BW	63.8	190-198	L	-80	91	len.	34	wid.	31	dep.	20	head wid.	14	head dep.	60	
051	016-02	2	O. mutabilis	Fore gut cont.	63.8	190-198	L	-80	91	len.	34	wid.	31	dep.	20	head wid.	14	head dep.	60	
051	016-03	3	O. mutabilis	Mid gut cont.	63.8	190-198	L	-80	91	len.	34	wid.	31	dep.	20	head wid.	14	head dep.	60	
051	016-04	4	O. mutabilis	Hind gut cont.	63.8	190-198	L	-80	91	len.	34	wid.	31	dep.	20	head wid.	14	head dep.	60	
051	017		P. longicauda		148.6	199-205			145	len.	46	dep.	46	wid.	106	tail			120	[37]
051	017-01	1	P. longicauda	BW	148.6	199-205	L	-80	145	len.	46	dep.	46	wid.	106	tail			120	[37]
051	018		O. mutabilis		32.8	206-212			75	len.	25	wid.	22	dep.	18	head wid.	15	head dep.	25	
051	018-01	1	O. mutabilis	BW	32.8	206-212	L	-80	75	len.	25	wid.	22	dep.	18	head wid.	15	head dep.	25	
051	019		P. longicauda		477.6	213-220			202	len.	67	dep.	68	wid.	90	tail			340	[15]
051	019-01	1	P. longicauda	BW	477.6	213-220	L	-80	202	len.	67	dep.	68	wid.	90	tail			340	[15]
051	019-02	2	P. longicauda	Hind gut cont.	477.6	213-220	L	-80	202	len.	67	dep.	68	wid.	90	tail			340	[15]
051	019-03	3	P. longicauda	Mid gut cont.	477.6	213-220	L	-80	202	len.	67	dep.	68	wid.	90	tail			340	[15]
051	019-04	4	P. longicauda	Fore gut cont.	477.6	213-220	L	-80	202	len.	67	dep.	68	wid.	90	tail			340	[15]
051	020		C. monstrosus		74.2	221-227			210	len.	75	carapace								
051	020-01	1	C. monstrosus	Muscle	74.2	221-227	L	-80	210	len.	75	carapace								
051	021		P. longicauda		196.2	228-239			155	len.	43	dep.	46	wid.	133	tail			170	[27]
051	021-01	1	P. longicauda	BW	196.2	228-239	L	-80	155	len.	43	dep.	46	wid.	133	tail			170	[27]
051	021-02	2	P. longicauda	Longit. muscle	196.2	228-239	L	-80	155	len.	43	dep.	46	wid.	133	tail			170	[27]
051	022		O. mutabilis		81.2	240-248			98	len.	38	wid.	38	dep.	16	head wid.	16	head dep.	65	
051	022-01	1	O. mutabilis	BW	81.2	240-248	L	-80	98	len.	38	wid.	38	dep.	16	head wid.	16	head dep.	65	
051	022-02	2	O. mutabilis	Fore gut cont.	81.2	240-248	L	-80	98	len.	38	wid.	38	dep.	16	head wid.	16	head dep.	65	
051	022-03	3	O. mutabilis	Mid gut cont.	81.2	240-248	L	-80	98	len.	38	wid.	38	dep.	16	head wid.	16	head dep.	65	
051	022-04	4	O. mutabilis	Hind gut cont.	81.2	240-248	L	-80	98	len.	38	wid.	38	dep.	16	head wid.	16	head dep.	65	
051	023		P. longicauda		199	249-259			148	len.	50	wid.	42	dep.	146	tail			170	
051	023-01	1	P. longicauda	BW	199	249-259	L	-80	148	len.	50	wid.	42	dep.	146	tail			170	
051	023-02	2	P. longicauda	Longit. muscle	199	249-259	L	-80	148	len.	50	wid.	42	dep.	146	tail			170	
051	024		Grimpoteuthis		18	260-269			68	arm len.	102	full body								

051	024-01	1	Grimpoteuthis	Arm	18	260-269	L	-80	68	arm len.	102	full body								
051	024-02	2	Grimpoteuthis	Arm subs.	18	260-269	L/N	-80	68	arm len.	102	full body								
051	025		P. longicauda		131.6	270-277			146	len.	42	wid.	36	dep.	71	tail			120	[21]
051	025-01	1	P. longicauda	BW	131.6	270-277	L	-80	146	len.	42	wid.	36	dep.	71	tail			120	[21]
051	025-02	2	P. longicauda	Longit. muscle	131.6	270-277	L	-80	146	len.	42	wid.	36	dep.	71	tail			120	[21]
051	026		P. aemulatus		35.6	278-285			107	len.	31	wid.	14	dep.					15	
051	026-01	1	P. aemulatus	BW	35.6	278-285	L	-80	107	len.	31	wid.	14	dep.					15	
051	027		P. longicauda		455.6	286-297			194	len.	56	wid.	57	dep.	132	tail			420	
051	027-01	1	P. longicauda	BW	455.6	286-297	L	-80	194	len.	56	wid.	57	dep.	132	tail			420	
051	027-02	2	P. longicauda	Longit. muscle	455.6	286-297	L	-80	194	len.	56	wid.	57	dep.	132	tail			420	
051	028		O. mutabilis		56.4	298-306			94	len.	31	wid.	30	dep.	28	head wid.	20	head dep.	50	
051	028-01	1	O. mutabilis	BW	56.4	298-306	L	-80	94	len.	31	wid.	30	dep.	28	head wid.	20	head dep.	50	
051	029		P. longicauda		114.8	307-316			147	len.	31	wid.	31	dep.	124	tail			105	
051	029-01	1	P. longicauda	BW	114.8	307-316	L	-80	147	len.	31	wid.	31	dep.	124	tail			105	
051	030		O. mutabilis		20.4	317-325			60	len.	25	wid.	23	dep.	11	head wid.	9	head dep.	20	
051	030-01	1	O. mutabilis	BW	20.4	317-325	L	-80	60	len.	25	wid.	23	dep.	11	head wid.	9	head dep.	20	
051	031		P. longicauda		388.4	326-332			170	len.	55	wid.	39	dep.	140	tail			330	
051	031-01	1	P. longicauda	BW	388.4	326-332	L	-80	170	len.	55	wid.	39	dep.	140	tail			330	
051	031-02	2	P. longicauda	Longit. muscle	388.4	326-332	L	-80	170	len.	55	wid.	39	dep.	140	tail			330	
051	032		Grimpoteuthis		145.2	333-338			134	arm len.	195	full body								
051	032-01	1	Grimpoteuthis	Arm	145.2	333-338	L	-80	134	arm len.	195	full body								
051	032-02	2	Grimpoteuthis	Arm subs.	145.2	333-338	L/N	-80	134	arm len.	195	full body								
051	033		P. longicauda		433.2	339-345			203	len.	57	wid.	45	dep.	158	tail			390	
051	033-01	1	P. longicauda	BW	433.2	339-345	L	-80	203	len.	57	wid.	45	dep.	158	tail			390	[30]
051	034		O. mutabilis		141.8	349-358			118	len.	43	wid.	43	dep.	21	head wid.	24	head dep.	130	
051	034-01	1	O. mutabilis	BW	141.8	349-358	R	-80	118	len.	43	wid.	43	dep.	21	head wid.	24	head dep.	130	
051	034-02	2	O. mutabilis	BW	141.8	349-358	L	-80	118	len.	43	wid.	43	dep.	21	head wid.	24	head dep.	130	
051	034-03	3	O. mutabilis	Longit. muscle	141.8	349-358	R	-80	118	len.	43	wid.	43	dep.	21	head wid.	24	head dep.	130	
051	034-04	4	O. mutabilis	Gonad	141.8	349-358	R	-80	118	len.	43	wid.	43	dep.	21	head wid.	24	head dep.	130	
051	034-05	5	O. mutabilis	Cloaca	141.8	349-358	R	-80	118	len.	43	wid.	43	dep.	21	head wid.	24	head dep.	130	
051	034-06	6	O. mutabilis	Hind gut cont.	141.8	349-358	R	-80	118	len.	43	wid.	43	dep.	21	head wid.	24	head dep.	130	
051	034-07	7	O. mutabilis	Polian vesicle	141.8	349-358	R	-80	118	len.	43	wid.	43	dep.	21	head wid.	24	head dep.	130	
051	035		H. inermis		10	359-362			51	R	33	d (NB)	7	dep.	20	r			20	
051	035-01	1	H. inermis	Tube feet	10	359-362	L	-80	51	R	33	d (NB)	7	dep.	20	r			20	
051	036		M. villosus		156.8	365-371			139	len.	39	wid.	40	dep.	23	head wid.	26	head dep.	145	
051	036-01	1	M. villosus	BW	156.8	365-371	L	-80	139	len.	39	wid.	40	dep.	23	head wid.	26	head dep.	145	
051	036-02	2	M. villosus	BW	156.8	365-371	R	-80	139	len.	39	wid.	40	dep.	23	head wid.	26	head dep.	145	
051	036-03	3	M. villosus	Longit. muscle	156.8	365-371	R	-80	139	len.	39	wid.	40	dep.	23	head wid.	26	head dep.	145	
051	036-04	4	M. villosus	Gonad	156.8	365-371	R	-80	139	len.	39	wid.	40	dep.	23	head wid.	26	head dep.	145	
051	036-05	5	M. villosus	Cloaca	156.8	365-371	R	-80	139	len.	39	wid.	40	dep.	23	head wid.	26	head dep.	145	
051	036-06	6	M. villosus	Hind gut cont.	156.8	365-371	R	-80	139	len.	39	wid.	40	dep.	23	head wid.	26	head dep.	145	
051	037		P. longicauda		13.8	372-379			60	len.	15	wid.	14	dep.	24	tail			10	[06]
051	037-01	1	P. longicauda	BW	13.8	372-379	L	-80	60	len.	15	wid.	14	dep.	24	tail			10	[06]
051	038		M. villosus		180	383-389			148	len.	41	wid.	41	dep.	23	head wid.	25	head dep.	162	
051	038-01	1	M. villosus	Longit. muscle	180	383-389	L	-80	148	len.	41	wid.	41	dep.	23	head wid.	25	head dep.	162	
051	038-02	2	M. villosus	BW	180	383-389	L	-80	148	len.	41	wid.	41	dep.	23	head wid.	25	head dep.	162	
051	039		Elpidiidae		3.6	390-395			29	len.	17	wid.	10	dep.					5	
051	039-01	1	Elpidiidae	BW	3.6	390-395	L	-80	29	len.	17	wid.	10	dep.					5	
051	040		A. abyssorum		14.2	396-401			23	D1	23	D2	43	ht.					15	
051	040-01	1	A. abyssorum	BW	14.2	396-401	L	-80	23	D1	23	D2	43	ht.					15	
051	041		M. villosus		32	411-417			88	len.	25	wid.	23	dep.	21	head wid.	18	head dep.	30	
051	041-01	1	M. villosus	BW	32	411-417	L	-80	88	len.	25	wid.	23	dep.	21	head wid.	18	head dep.	30	

051	041-02	2	M. villosus	Longit. muscle	32	411-417	L	-80	88	len.	25	wid.	23	dep.	21	head wid.	18	head dep.	30	
051	041-03	3	M. villosus	BW	32	411-417	L/N	-80	88	len.	25	wid.	23	dep.	21	head wid.	18	head dep.	30	
051	042		A. abyssorum		18.6	418-425			34	D1	16	D2	44	ht.					20	
051	042-01	1	A. abyssorum	BW	18.6	418-425	L	-80	34	D1	16	D2	44	ht.					20	
051	042-02	2	A. abyssorum	BW	18.6	418-425	L/N	-80	34	D1	16	D2	44	ht.					20	
051	043		M. villosus		42.8	426-432			94	len.	26	wid.	26	dep.	15	head wid.	16	head dep.	38	[18]
051	043-01	1	M. villosus	BW	42.8	426-432	L	-80	94	len.	26	wid.	26	dep.	15	head wid.	16	head dep.	38	[18]
051	043-02	2	M. villosus	Longit. muscle	42.8	426-432	L	-80	94	len.	26	wid.	26	dep.	15	head wid.	16	head dep.	38	[18]
051	043-03	3	M. villosus	BW	42.8	426-432	L/N	-80	94	len.	26	wid.	26	dep.	15	head wid.	16	head dep.	38	[18]
051	044		Elpidiidae		4.6	433-438			31	len.	17	wid.	17	dep.					5	[18]
051	044-01	1	Elpidiidae	BW	4.6	433-438	L	-80	31	len.	17	wid.	17	dep.					5	[18]
051	044-02	2	Elpidiidae	BW	4.6	433-438	L/N	-80	31	len.	17	wid.	17	dep.					5	[18]
051	045		A. abyssorum		13.6	439-445			34	D1	10	D2	43	ht.					13	
051	045-01	1	A. abyssorum	BW	13.6	439-445	L	-80	34	D1	10	D2	43	ht.					13	
051	045-02	2	A. abyssorum	BW	13.6	439-445	L/N	-80	34	D1	10	D2	43	ht.					13	
051	046		Grimpoteuthis		14	446-449			72	arm len.	97	full body								
051	046-01	1	Grimpoteuthis	Arm	14	446-449	L	-80	72	arm len.	97	full body								
051	046-02	2	Grimpoteuthis	Arm subs.	14	446-449	L/N	-80	72	arm len.	97	full body								
051	047		M. villosus		39.8	450-454			95	len.	24	wid.	28	dep.	18	head wid.	19	head dep.	40	
051	047-01	1	M. villosus	BW	39.8	450-454	L	-80	95	len.	24	wid.	28	dep.	18	head wid.	19	head dep.	40	
051	047-02	2	M. villosus	Longit. muscle	39.8	450-454	L	-80	95	len.	24	wid.	28	dep.	18	head wid.	19	head dep.	40	
051	048		A. abyssorum		10.8	455-464			29	D1	11	D2	38	ht.					10	
051	048-01	1	A. abyssorum	BW	10.8	455-464	L	-80	29	D1	11	D2	38	ht.					10	
051	049		Elpidiidae		7.6	465-473			39	len.	30	wid.	15	dep.					10	
051	049-01	1	Elpidiidae	BW	7.6	465-473	L	-80	39	len.	30	wid.	15	dep.					10	
051	050		A. bathybium		13	474-482			22	D1	18	D2	30	ht.					10	
051	050-01	1	A. bathybium	BW	13	474-482	L	-80	22	D1	18	D2	30	ht.					10	
051	051		Elpidiidae		8.6	483-488			44	len.	30	wid.	14	dep.					10	[18]
051	051-01	1	Elpidiidae	BW	8.6	483-488	L	-80	44	len.	30	wid.	14	dep.					10	[18]
051	052		A. abyssorum		7.2	489-495			20	D1	10	D2	29	ht.					8	
051	052-01	1	A. abyssorum	BW	7.2	489-495	L	-80	20	D1	10	D2	29	ht.					8	
051	053		H. inermis		20.6	496-499			54	R	47	d (NB)	11	dep.	25	r			17	
051	053-01	1	H. inermis	Tube feet	20.6	496-499	L	-80	54	R	47	d (NB)	11	dep.	25	r			17	
051	054		M. villosus		76.6	500-508			114	len.	29	wid.	32	dep.	20	head wid.	21	head dep.	67	
051	054-01	1	M. villosus	BW	76.6	500-508	L	-80	114	len.	29	wid.	32	dep.	20	head wid.	21	head dep.	67	
051	055		Elpidiidae		6.4	509-515			55	len.	9	wid.	19	dep.					5	[12]
051	055-01	1	Elpidiidae	BW	6.4	509-515	L	-80	55	len.	9	wid.	19	dep.					5	[12]
051	056		M. villosus		36.6	516-521			89	len.	24	wid.	26	dep.	18	head wid.	19	head dep.	30	
051	057		P. longicauda		57.2	522-529			113	len.	27	wid.	17	dep.	78	tail			55	
051	057-01	1	P. longicauda	BW	57.2	522-529	L	-80	113	len.	27	wid.	17	dep.	78	tail			55	
051	058		A. abyssorum		3.8	530-534			18	D1	7	D2	31	ht.					5	
051	058-01	1	A. abyssorum	BW	3.8	530-534	L	-80	18	D1	7	D2	31	ht.					5	
051	059		M. villosus		13.4	537-541			69	len.	19	wid.	17	dep.	14	head wid.	13	head dep.	12	
051	059-01	1	M. villosus	BW	13.4	537-541	L	-80	69	len.	19	wid.	17	dep.	14	head wid.	13	head dep.	12	
051	060		M. villosus		22.6	546-552			80	len.	22	wid.	19	dep.	14	head wid.	14	head dep.	20	
051	060-01	1	M. villosus	BW	22.6	546-552	L	-80	80	len.	22	wid.	19	dep.	14	head wid.	14	head dep.	20	
051	061		Styracaster		17.2	560-564			46	R	45	d (NB)	11	dep.	20	r			15	
051	061-01	1	Styracaster	Tube feet	17.2	560-564	L	-80	46	R	45	d (NB)	11	dep.	20	r			15	
051	062		Elpidiidae		1.8	565-569			24	len.	16	wid.	7	dep.					2	
051	062-01	1	Elpidiidae	BW	1.8	565-569	L	-80	24	len.	16	wid.	7	dep.					2	
051	063		A. abyssorum		6.4	570-576			20	D1	13	D2	31	ht.					5	
051	063-01	1	A. abyssorum	BW	6.4	570-576	L	-80	20	D1	13	D2	31	ht.					5	

051	064		M. villosus		216	577-582			160	len.	42	wid.	45	dep.	29	head wid.	26	head dep.	185	[18]
051	064-01	1	M. villosus	BW	216	577-582	L	-80	160	len.	42	wid.	45	dep.	29	head wid.	26	head dep.	185	[18]
051	065		Elpidiidae		9.4	583-590			45	len.	12	wid.	24	dep.					5	
051	065-01	1	Elpidiidae	BW	9.4	583-590	L	-80	45	len.	12	wid.	24	dep.					5	
051	066		P. prouhoi		683.5	591-598			288	len.	69	wid.	69	dep.	39	head wid.	36	head dep.	640	[16]
051	066-01	1	P. prouhoi	BW	683.5	591-598	L	-80	288	len.	69	wid.	69	dep.	39	head wid.	36	head dep.	640	[16]
051	066-02	2	P. prouhoi	BW	683.5	591-598	L/N	-80	288	len.	69	wid.	69	dep.	39	head wid.	36	head dep.	640	[16]
051	066b-01	b1	P. prouhoi	E. com. BW	683.5	591-598	L	-80	288	len.	69	wid.	69	dep.	39	head wid.	36	head dep.	640	[33]
051	066b-02	b2	P. prouhoi	E. com. BW	683.5	591-598	L/N	-80	288	len.	69	wid.	69	dep.	39	head wid.	36	head dep.	640	[33]
051	067		M. villosus		1.6	602-608			34	len.	9	wid.	8	dep.	7	head wid.	6	head dep.	5	
051	067-01	1	M. villosus	BW	1.6	602-608	L	-80	34	len.	9	wid.	8	dep.	7	head wid.	6	head dep.	5	
051	067-02	2	M. villosus	Gut contents	1.6	602-608	L	-80	34	len.	9	wid.	8	dep.	7	head wid.	6	head dep.	5	
051	068		Elpidiidae		8.2	621-625			40	len.	32	wid.	8	dep.					20	
051	068-01	1	Elpidiidae	BW	8.2	621-625	L	-80	40	len.	32	wid.	8	dep.					20	
051	069		Cirrata mt1		222.4	609-620			336	arm len.	410	full body								
051	070		M. villosus		64.4	626-630			112	len.	39	wid.	39	dep.	21	head wid.	19	head dep.	10	
051	070-01	1	M. villosus	BW	64.4	626-630	L	-80	112	len.	39	wid.	39	dep.	21	head wid.	19	head dep.	10	
051	071		A. bathybium		5	631-640			21	D1	14	D2	19	ht.					10	
051	071-01	1	A. bathybium	BW	5	631-640	L	-80	21	D1	14	D2	19	ht.					10	
051	072		Elpidiidae		2.8	641-646			26	len.	17	wid.	11	dep.					5	
051	072-01	1	Elpidiidae	BW	2.8	641-646	L	-80	26	len.	17	wid.	11	dep.					5	
051	073		A. abyssorum		4	647-652			18	D1	9	D2	28	ht.					10	
051	073-01	1	A. abyssorum	BW	4	647-652	L	-80	18	D1	9	D2	28	ht.					10	
051	074		Elpidiidae		3.8	653-657			35	len.	23	wid.	8	dep.					5	[13]
051	074-01	1	Elpidiidae	BW	3.8	653-657	L	-80	35	len.	23	wid.	8	dep.					5	[13]
051	075		O. mutabilis		14.2	658-662			67	len.	28	wid.	6	dep.	21	head wid.	12	head dep.	18	[25]
051	076		M. villosus		5	662-669			45	len.	17	wid.	9	dep.	14	head wid.	8	head dep.	22	
051	076-01	1	M. villosus	BW	5	662-669	L	-80	45	len.	17	wid.	9	dep.	14	head wid.	8	head dep.	22	
051	077		Elpidiidae		2.8	670-678			31	len.	18	wid.	12	dep.					5	
051	077-01	1	Elpidiidae	BW	2.8	670-678	L	-80	31	len.	18	wid.	12	dep.					5	
051	078		Styracaster		4.2	679-683			41	R	36	d (NB)	15	r	4	dep.			5	
051	078-01	1	Styracaster	Tube feet	4.2	679-683	L	-80	41	R	36	d (NB)	15	r	4	dep.			5	
051	079		P. longicauda		351.6	-			184	len.	-	-	-	-	143	tail			-	[02]
051	079-01	1	P. longicauda	BW	351.6	-	L	-80	184	len.	-	-	-	-	143	tail			-	[02]
051	080		M. villosus		189	690-694			167	len.	43	wid.	46	dep.	27	head wid.	27	head dep.	170	
051	080-01	1	M. villosus	BW	189	690-694	L	-80	167	len.	43	wid.	46	dep.	27	head wid.	27	head dep.	170	
051	080-02	2	M. villosus	Longit. muscle	189	690-694	L	-80	167	len.	43	wid.	46	dep.	27	head wid.	27	head dep.	170	
051	081		A. bathybium		5.8	695-701			23	D1	11	D2	25	ht.					2	
051	081-01	1	A. bathybium	BW	5.8	695-701	L	-80	23	D1	11	D2	25	ht.					2	
051	082		H. inermis		28.8	702-706			62	R	57	d (NB)	21	r	18	dep.			40	
051	082-01	1	H. inermis	Tube feet	28.8	702-706	L	-80	62	R	57	d (NB)	21	r	18	dep.			40	
051	083		Elpidiidae		2.4	707-711			34	len.	12	wid.	9	dep.					5	
051	083-01	1	Elpidiidae	BW	2.4	707-711	L	-80	34	len.	12	wid.	9	dep.					5	
051	084		A. abyssorum		3	717-722			22	D1	11	D2	21	ht.					3	
051	084-01	1	A. abyssorum	BW	3	717-722	L	-80	22	D1	11	D2	21	ht.					3	
051	085		M. villosus		194	723-729			162	len.	42	wid.	45	dep.	25	head wid.	25	head dep.	180	
051	085-01	1	M. villosus	BW	194	723-729	L	-80	162	len.	42	wid.	45	dep.	25	head wid.	25	head dep.	180	
051	085-02	2	M. villosus	Longit. muscle	194	723-729	L	-80	162	len.	42	wid.	45	dep.	25	head wid.	25	head dep.	180	
051	086		Elpidiidae		6.4	730-736			44	len.	19	wid.	12	dep.					10	
051	086-01	1	Elpidiidae	BW	6.4	730-736	L	-80	44	len.	19	wid.	12	dep.					10	
051	087		A. bathybium		4.4	737-743			20	D1	13	D2	19	ht.					10	
051	087-01	1	A. bathybium	BW	4.4	737-743	L	-80	20	D1	13	D2	19	ht.					10	

051	088		Elpidiidae		1.8	744-750			27	len.	6	wid.	9	dep.					10	
051	088-01	1	Elpidiidae	BW	1.8	744-750	L	-80	27	len.	6	wid.	9	dep.					10	
051	089		H. inermis		24.2	751-753			61	R	64	d (NB)	23	r	7	dep.			40	
051	089-01	1	H. inermis	Tube feet	24.2	751-753	L	-80	61	R	64	d (NB)	23	r	7	dep.			40	
051	090		P. prouhoi		143.2	754-758			183	len.	38	wid.	32	dep.	22	head wid.	21	head dep.	140	[03]
051	090-01	1	P. prouhoi	BW	143.2	754-758	L	-80	183	len.	38	wid.	32	dep.	22	head wid.	21	head dep.	140	[03]
051	090-02	2	P. prouhoi	BW	143.2	754-758	L/N	-80	183	len.	38	wid.	32	dep.	22	head wid.	21	head dep.	140	[03]
051	090b-01	b1	P. prouhoi	E. com. BW	143.2	754-758	L	-80	183	len.	38	wid.	32	dep.	22	head wid.	21	head dep.	140	[32]
051	091		M. villosus		76.8	759-766			124	len.	25	wid.	37	dep.	21	head wid.	19	head dep.	80	
051	091-01	1	M. villosus	BW	76.8	759-766	L	-80	124	len.	25	wid.	37	dep.	21	head wid.	19	head dep.	80	
051	091-02	2	M. villosus	Longit. muscle	76.8	759-766	L	-80	124	len.	25	wid.	37	dep.	21	head wid.	19	head dep.	80	
051	092		Elpidiidae		1.8	767-775			31	len.	9	wid.	13	dep.					3	
051	092-01	1	Elpidiidae	BW	1.8	767-775	L	-80	31	len.	9	wid.	13	dep.					3	
051	093		A. bathybium		3.8	782-787			20	D1	11	D2	19	ht.					4	
051	093-01	1	A. bathybium	BW	3.8	782-787	L	-80	20	D1	11	D2	19	ht.					4	
051	094		Elpidiidae		3.6	788-794			51	len.	10	wid.	17	ht.					5	
051	094-01	1	Elpidiidae	BW	3.6	788-794	L	-80	51	len.	10	wid.	17	ht.					5	
051	095		M. villosus		154.4	776-781			149	len.	35	wid.	39	dep.	23	head wid.	22	head dep.	100	
051	095-01	1	M. villosus	BW	154.4	776-781	L	-80	149	len.	35	wid.	39	dep.	23	head wid.	22	head dep.	100	
051	096		Elpidiidae		2.2	796-803			50	len.	5	wid.	9	dep.					5	
051	096-01	1	Elpidiidae	BW	2.2	796-803	L	-80	50	len.	5	wid.	9	dep.					5	
051	097		Cirrata mt2		57.6	804-813			188	arm len.	218	full body								
051	097-01	1	Cirrata mt2	Arm	57.6	804-813	L	-80	188	arm len.	218	full body								
051	097-02	2	Cirrata mt2	Arm subs.	57.6	804-813	L/N	-80	188	arm len.	218	full body								
051	098		A. bathybium		4	814-821			22	D1	18	D2	21	ht.					5	
051	098-01	1	A. bathybium	BW	4	814-821	L	-80	22	D1	18	D2	21	ht.					5	
051	099		I. vagabunda		0.8	822-826			7	D1	10	D2	18	ht.					2	
051	099-01	1	I. vagabunda	BW	0.8	822-826	L	-80	7	D1	10	D2	18	ht.					2	
051	100		A. bathybium		3.8	827-832			20	D1	12	D2	21	ht.					4	
051	100-01	1	A. bathybium	Body	3.8	827-832	L	-80	20	D1	12	D2	21	ht.					4	
051	101		I. vagabunda		0.4	833-836			7	D1	4	D2	23	ht.					2	
051	101-01	1	I. vagabunda	BW	0.4	833-836	L	-80	7	D1	4	D2	23	ht.					2	
051	101-02	2	I. vagabunda	BW	0.4	833-836	L/N	-80	7	D1	4	D2	23	ht.					2	
051	102		A. bathybium		3.6	837-842			20	D1	10	D2	18	ht.					4	
051	102-01	1	A. bathybium	BW	3.6	837-842	L	-80	20	D1	10	D2	18	ht.					4	
051	103		Elpidiidae		3.6	843-848			54	len.	10	wid.	16	dep.					3	
051	103-01	1	Elpidiidae	BW	3.6	843-848	L	-80	54	len.	10	wid.	16	dep.					3	
051	104		A. abyssorum		4.4	849-854			20	D1	9	D2	24	ht.					5	
051	104-01	1	A. abyssorum	BW	4.4	849-854	L	-80	20	D1	9	D2	24	ht.					5	
051	105		M. villosus		93	855-860			31	len.	26	wid.	38	dep.	22	head wid.	24	head dep.	85	[17]
051	105-01	1	M. villosus	BW	93	855-860	L	-80	31	len.	26	wid.	38	dep.	22	head wid.	24	head dep.	85	[17]
051	106		A. bathybium		2.4	861-865			17	D1	13	D2	14	ht.					3	
051	106-01	1	A. bathybium	BW	2.4	861-865	L	-80	17	D1	13	D2	14	ht.					3	
051	107		M. villosus		89.2	866-872			117	len.	32	wid.	34	dep.	21	head wid.	22	head dep.	80	
051	107-01	1	M. villosus	BW	89.2	866-872	L	-80	117	len.	32	wid.	34	dep.	21	head wid.	22	head dep.	80	
051	108		P. longicauda		285.2		E	EtOH	156	len.										
051	109		P. longicauda		376.6		E	EtOH	177	len.										
056	001		M. villosus		13.6	923-929			68	len.	17	wid.	18	dep.	13	head wid.	12	head dep.	15	
056	001-01	1	M. villosus	BW	13.6	923-929	L	-80	68	len.	17	wid.	18	dep.	13	head wid.	12	head dep.	15	[35]
056	001-02	2	M. villosus	BW	13.6	923-929	L/N	-80	68	len.	17	wid.	18	dep.	13	head wid.	12	head dep.	15	[35]
056	002		P. aemulatus		47.4	930-937			116	len.	21	wid.	18	dep.	16	head wid.	21	head dep.	50	
056	002-01	1	P. aemulatus	BW	47.4	930-937	L	-80	116	len.	21	wid.	18	dep.	16	head wid.	21	head dep.	50	

056	002-02	2	P. aemulatus	BW	47.4	930-937	L/N	-80	116	len.	21	wid.	18	dep.	16	head wid.	21	head dep.	50	
056	003		M. villosus		17	945-950			76	len.	20	wid.	19	dep.	7	head wid.	11	head dep.	15	
056	003-01	1	M. villosus	BW	17	945-950	L	-80	76	len.	20	wid.	19	dep.	7	head wid.	11	head dep.	15	[35]
056	003-01	2	M. villosus	BW	17	945-950	L/N	-80	76	len.	20	wid.	19	dep.	7	head wid.	11	head dep.	15	[35]
056	004		O. mutabilis		69.2	951-956			105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	004-01	1	O. mutabilis	BW	69.2	951-956	R	-80	105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	004-01	2	O. mutabilis	Longit. muscle	69.2	951-956	R	-80	105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	004-03	3	O. mutabilis	Gonad	69.2	951-956	R	-80	105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	004-04	4	O. mutabilis	Polian vesicle	69.2	951-956	R	-80	105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	004-05	5	O. mutabilis	Cloaca	69.2	951-956	R	-80	105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	004-06	6	O. mutabilis	Hind gut cont.	69.2	951-956	R	-80	105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	004-07	7	O. mutabilis	BW	69.2	951-956	L	-80	105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	004-08	8	O. mutabilis	Gonad	69.2	951-956	L/N	-80	105	len.	37	wid.	28	dep.	18	head wid.	15	head dep.	70	
056	005		M. villosus		18.6	957-963			73	len.	20	wid.	22	dep.	19	head wid.	13	head dep.	18	
056	005-01	1	M. villosus	BW	18.6	957-963	L	-80	73	len.	20	wid.	22	dep.	19	head wid.	13	head dep.	18	[35]
056	005-02	2	M. villosus	BW	18.6	957-963	L/N	-80	73	len.	20	wid.	22	dep.	19	head wid.	13	head dep.	18	[35]
056	006		D. validum		66.4	964-973			86	len.	18	wid.	18	dep.	14	head wid.	13	head dep.	15	
056	006-01	1	D. validum	BW	66.4	964-973	L	-80	86	len.	18	wid.	18	dep.	14	head wid.	13	head dep.	15	
056	006-02	2	D. validum	Gonad	66.4	964-973	L/N	-80	86	len.	18	wid.	18	dep.	14	head wid.	13	head dep.	15	
056	007		M. villosus		14.2	974-980			72	len.	18	wid.	18	dep.	14	head wid.	13	head dep.	15	
056	007-01	1	M. villosus	BW	14.2	974-980	L	-80	72	len.	18	wid.	18	dep.	14	head wid.	13	head dep.	15	
056	007-02	2	M. villosus	Longit. muscle	14.2	974-980	L	-80	72	len.	18	wid.	18	dep.	14	head wid.	13	head dep.	15	
056	008		D. validum		19.2	981-988			53	len.	24	wid.	22	dep.	14	head wid.	13	head dep.	15	
056	008-01	1	D. validum	BW	19.2	981-988	L	-80	53	len.	24	wid.	22	dep.	14	head wid.	13	head dep.	15	
056	008-02	2	D. validum	Gonad	19.2	981-988	L/N	-80	53	len.	24	wid.	22	dep.	14	head wid.	13	head dep.	15	
056	009		M. villosus		1.6	989-993			25	len.	10	wid.	7	dep.	8	head wid.	7	head dep.	5	
056	009-01	1	M. villosus	BW	1.6	989-993	L		25	len.	10	wid.	7	dep.	8	head wid.	7	head dep.	5	
056	010		M. villosus		71.6	994-1001			111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	010-01	1	M. villosus	BW	71.6	994-1001	R	-80	111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	010-02	2	M. villosus	Longit. muscle	71.6	994-1001	R	-80	111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	010-03	3	M. villosus	Gonad	71.6	994-1001	R	-80	111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	010-04	4	M. villosus	VOID, no PV	71.6	994-1001	R	-80	111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	010-05	5	M. villosus	Cloaca	71.6	994-1001	R	-80	111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	010-06	6	M. villosus	Hind gut cont.	71.6	994-1001	R	-80	111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	010-07	7	M. villosus	BW	71.6	994-1001	L	-80	111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	010-08	8	M. villosus	Gonad	71.6	994-1001	L/N	-80	111	len.	32	wid.	33	dep.	15	head wid.	15	head dep.	65	
056	011		O. mutabilis		23	1002-1008			68	len.	21	wid.	21	dep.	18	head wid.	16	head dep.	18	[29]
056	011-01	1	O. mutabilis	BW	23	1002-1008	L	-80	68	len.	21	wid.	21	dep.	18	head wid.	16	head dep.	18	[29]
056	012		P. longicauda		68.8	1009-1017			101	len.	28	wid.	34	dep.	68	tail			60	[34]
056	012-01	1	P. longicauda	BW	68.8	1009-1017	L	-80	101	len.	28	wid.	34	dep.	68	tail			60	[34]
056	012-02	2	P. longicauda	Longit. muscle	68.8	1009-1017	L	-80	101	len.	28	wid.	34	dep.	68	tail			60	[34]
056	013		Elpidiidae		5.4	1018-1027			37	len.	13	wid.	13	dep.					5	
056	013-01	1	Elpidiidae	BW	5.4	1018-1027	L	-80	37	len.	13	wid.	13	dep.					5	
056	013-02	2	Elpidiidae	BW	5.4	1018-1027	L/N	-80	37	len.	13	wid.	13	dep.					5	
056	014		M. villosus		45.6	1028-1033			104	len.	26	wid.	27	dep.	14	head wid.	14	head dep.	45	
056	014-01	1	M. villosus	BW	45.6	1028-1033	L	-80	104	len.	26	wid.	27	dep.	14	head wid.	14	head dep.	45	[35]
056	014-02	2	M. villosus	Longit. muscle	45.6	1028-1033	L	-80	104	len.	26	wid.	27	dep.	14	head wid.	14	head dep.	45	[35]
056	014-03	3	M. villosus	BW	45.6	1028-1033	L/N	-80	104	len.	26	wid.	27	dep.	14	head wid.	14	head dep.	45	[35]
056	015		Elpidiidae		11.2	1034-1041			44	len.	18	wid.	19	dep.						[40]
056	015-01	1	Elpidiidae	BW	11.2	1034-1041	L	-80	44	len.	18	wid.	19	dep.						[40]
056	015-02	2	Elpidiidae	BW	11.2	1034-1041	L/N	-80	44	len.	18	wid.	19	dep.						[40]
056	016		M. villosus		68.8	1042-1046			102	len.	31	wid.	33	dep.	12	head wid.	13	head dep.	65	

056	016-01	1	M. villosus	BW	68.8	1042-1046	L	-80	102	len.	31	wid.	33	dep.	12	head wid.	13	head dep.	65	
056	016-02	2	M. villosus	Longit. muscle	68.8	1042-1046	L	-80	102	len.	31	wid.	33	dep.	12	head wid.	13	head dep.	65	
056	017		Elpidiidae		3.8	1050-1057			38	len.	12	wid.	12	dep.					5	
056	017-01	1	Elpidiidae	BW	3.8	1050-1057	L	-80	38	len.	12	wid.	12	dep.					5	
056	017-02	2	Elpidiidae	Gut Contents	3.8	1050-1057	L	-80	38	len.	12	wid.	12	dep.					5	
056	018		M. blakei		77.8	1058-1066			85	len.	33	wid.	35	dep.	23	head wid.	20	head dep.	70	
056	019		Elpidiidae		5.4	1067-1073			35	len.	14	wid.	15	dep.					12	
056	019-01	1	Elpidiidae	BW	5.4	1067-1073	L	-80	35	len.	14	wid.	15	dep.					12	
056	020		O. mutabilis		93.2	1074-1081			96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	020-01	1	O. mutabilis	Longit. muscle	93.2	1074-1081	R	-80	96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	020-02	2	O. mutabilis	BW	93.2	1074-1081	R	-80	96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	020-03	3	O. mutabilis	Gonad	93.2	1074-1081	R	-80	96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	020-04	4	O. mutabilis	Cloaca	93.2	1074-1081	R	-80	96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	020-05	5	O. mutabilis	Hind gut cont.	93.2	1074-1081	R	-80	96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	020-06	6	O. mutabilis	Polian vesicle	93.2	1074-1081	R	-80	96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	020-07	7	O. mutabilis	BW	93.2	1074-1081	L	-80	96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	020-08	8	O. mutabilis	Gonad	93.2	1074-1081	L/N	-80	96	len.	38	wid.	37	dep.	21	head wid.	20	head dep.	85	
056	021		Elpidiidae		4.2	1082-1087			49	len.	12	wid.	17	dep.					5	
056	021-01	1	Elpidiidae	BW	4.2	1082-1087	L	-80	49	len.	12	wid.	17	dep.					5	
056	022		O. mutabilis		38.8	1088-1092			74	len.										
056	022-01	1	O. mutabilis	BW	38.8	1088-1092	L	-80	74	len.										[05]
056	022-02	2	O. mutabilis	BW	38.8	1088-1092	L/N	-80	74	len.										[05]
056	022-03	3	O. mutabilis	Hind gut cont.	38.8	1088-1092	L	-80	74	len.										[05]
056	022-04	4	O. mutabilis	Mid gut cont.	38.8	1088-1092	L	-80	74	len.										[05]
056	022-05	5	O. mutabilis	Fore gut cont.	38.8	1088-1092	L	-80	74	len.										[05]
056	023		O. mutabilis		74.4	1094-1099			84	len.	36	wid.	35	dep.	18	head wid.	18	head dep.	70	[11]
056	024		M. villosus		179	1100-1104			146	len.										[11]
056	025		O. mutabilis		84.2	1105-1111			97	len.	35	wid.	34	dep.	24	head wid.	17	head dep.	80	[11]
056	026		P. longicauda		363.6	1112-1115			160	len.	114	tail								[22]
056	027		O. mutabilis		92.6	1116-1121			99	len.	37	wid.	37	dep.	20	head wid.	19	head dep.	85	[11]
056	028		M. villosus		182.6	1122-1127			145	len.	41	wid.	41	dep.	23	head wid.	22	head dep.	165	[11]
056	029		O. mutabilis		106.6	1128-1133			101	len.	38	wid.	37	dep.	23	head wid.	18	head dep.	100	[11]
056	030		M. villosus		192.4	1134-1140			137	len.	45	wid.	47	dep.	20	head wid.	23	head dep.	180	[11]
056	031		P. longicauda		380	1141-1150			165	len.	55	wid.	55	dep.	129	tail			330	[11]
056	032		O. mutabilis		69.8	1151-1155			96	len.										
056	032-01	1	O. mutabilis	BW	69.8	1151-1155	L	-80	96	len.										
056	032-02	2	O. mutabilis	BW	69.8	1151-1155	L/N	-80	96	len.										
056	032-03	3	O. mutabilis	Fore gut cont.	69.8	1151-1155	L	-80	96	len.										
056	032-04	4	O. mutabilis	Mid gut cont.	69.8	1151-1155	L	-80	96	len.										
056	032-05	5	O. mutabilis	Hind gut cont.	69.8	1151-1155	L	-80	96	len.										
056	033		P. longicauda		37.6	1156-1160			89	len.										[38]
056	033-01	1	P. longicauda	BW	37.6	1156-1160	L	-80	89	len.										[38]
056	033-02	2	P. longicauda	Longit. muscle	37.6	1156-1160	L	-80	89	len.										[38]
056	034		M. villosus		62.6				104	len.										
056	034-01	1	M. villosus	BW	62.6		L	-80	104	len.										
056	034-02	2	M. villosus	BW	62.6		L/N	-80	104	len.										
056	035		O. mutabilis		89.6				94	len.										[10]
056	035-01	1	O. mutabilis	BW	89.6		L	-80	94	len.										[10]
056	036		P. longicauda		67.6	1161-1167			113	len.	27	wid.	20	dep.	150	tail			165	
056	036-01	1	P. longicauda	BW	67.6	1161-1167	L	-80	113	len.	27	wid.	20	dep.	150	tail			165	
056	036-02	2	P. longicauda	Longit. muscle	67.6	1161-1167	L	-80	113	len.	27	wid.	20	dep.	150	tail			165	
056	037		D. validum		135.4	1168-1173			134	len.	41	wid.	36	dep.	28	head wid.	24	head dep.	125	

056	037-01	1	D. validum	BW	135.4	1168-1173	L	-80	134	len.	41	wid.	36	dep.	28	head wid.	24	head dep.	125	
056	038		O. mutabilis		43				89	len.										
056	038-02	1	O. mutabilis	BW	43		L	-80	89	len.										
056	039		P. longicauda		182.6	1174-1185			142	len.	42	wid.	35	dep.	88	tail			160	[04]
056	039-01	1	P. longicauda	BW	182.6	1174-1185	L	-80	142	len.	42	wid.	35	dep.	88	tail			160	[04]
056	040		D. porcupina		20	1186-1189			11	D1	9	D2								[01]
056	041		O. mutabilis		8.2				42	len.										[19]
056	041-01	1	O. mutabilis	BW	8.2		L	-80	42	len.										[19]
056	042		Laetmonice		1.8	1190-1192			49	len.										
056	043		O. mutabilis		37.6	1193-1201			68	len.	36	wid.	30	dep.	21	head wid.	16	head dep.	30	
056	043-01	1	O. mutabilis	BW	37.6	1193-1201	L	-80	68	len.	36	wid.	30	dep.	21	head wid.	16	head dep.	30	
056	044		P. longicauda		647.5	1202-1212			220	len.	59	wid.	41	dep.	174	tail			390	[20]
056	044-01	1	P. longicauda	BW	647.5	1202-1212	L	-80	220	len.	59	wid.	41	dep.	174	tail			390	[20]
056	045		P. aemulatus		134	1225-1231			165	len.	31	wid.	42	dep.	24	head wid.	24	head dep.	120	[24]
056	045-01	1	P. aemulatus	BW	134	1225-1231	L	-80	165	len.	31	wid.	42	dep.	24	head wid.	24	head dep.	120	[24]
056	045b-01	b1	P. aemulatus	E. com. BW	134	1225-1231	L	-80	165	len.	31	wid.	42	dep.	24	head wid.	24	head dep.	120	[28]
056	045b-02	b2	P. aemulatus	E. com. BW	134	1225-1231	L/N	-80	165	len.	31	wid.	42	dep.	24	head wid.	24	head dep.	120	[28]
056	046		O. mutabilis		133	1232-1237			125	len.	41	wid.	37	dep.	25	head wid.	22	head dep.	120	
056	046-01	1	O. mutabilis	BW	133	1232-1237	L	-80	125	len.	41	wid.	37	dep.	25	head wid.	22	head dep.	120	
056	047		Elpidiidae		1.8	1238-1249			36	len.	11	wid.	8	dep.					3	[36]
056	047-01	1	Elpidiidae	BW	1.8	1238-1249	L	-80	36	len.	11	wid.	8	dep.					3	[36]
056	048		A. abyssorum		5.8	1250-1262			21	D1	9	D2	33	ht.					6	
056	048-01	1	A. abyssorum	BW	5.8	1250-1262	L	-80	21	D1	9	D2	33	ht.					6	
056	049		Pycnogonid		0.6				105	leg len.										
056	050		A. abyssorum		7.4				22	D1	12	D2	29	ht.					20	
056	050-01	1	A. abyssorum	BW	7.4		L	-80	22	D1	12	D2	29	ht.					20	
056	051		P. longicauda		14				56	len.										[23]
056	051-01	1	P. longicauda	BW	14		L	-80	56	len.										[23]
056	052		A. abyssorum		4	1263-1270			16	D1	7	D2	28	ht.					5	
056	052-01	1	A. abyssorum	BW	4	1263-1270	L	-80	16	D1	7	D2	28	ht.					5	
056	053		M. villosus		243.8	1271-1276			173	len.	43	wid.	47	dep.	24	head wid.	21	head dep.	220	
056	053-01	1	M. villosus	BW	243.8	1271-1276	L	-80	173	len.	43	wid.	47	dep.	24	head wid.	21	head dep.	220	
056	053-02	2	M. villosus	BW	243.8	1271-1276	R	-80	173	len.	43	wid.	47	dep.	24	head wid.	21	head dep.	220	
056	053-03	3	M. villosus	Longit. muscle	243.8	1271-1276	R	-80	173	len.	43	wid.	47	dep.	24	head wid.	21	head dep.	220	
056	053-04	4	M. villosus	Gonad	243.8	1271-1276	R	-80	173	len.	43	wid.	47	dep.	24	head wid.	21	head dep.	220	
056	053-05	5	M. villosus	VOID, no PV	243.8	1271-1276	R		173	len.	43	wid.	47	dep.	24	head wid.	21	head dep.	220	
056	053-06	6	M. villosus	Hind gut cont.	243.8	1271-1276	R	-80	173	len.	43	wid.	47	dep.	24	head wid.	21	head dep.	220	
056	053-07	7	M. villosus	Cloaca	243.8	1271-1276	R	-80	173	len.	43	wid.	47	dep.	24	head wid.	21	head dep.	220	
056	054		P. aemulatus		189.2	1277-1284			193	len.	33	wid.	36	dep.	23	head wid.	16	head dep.	168	
056	054-01	1	P. aemulatus	BW	189.2	1277-1284	L	-80	193	len.	33	wid.	36	dep.	23	head wid.	16	head dep.	168	
056	055		P. longicauda		163	1285-1299			133	len.	36	wid.	35	dep.	113	tail			140	
056	055-01	1	P. longicauda	BW	163	1285-1299	L	-80	133	len.	36	wid.	35	dep.	113	tail			140	
056	056		A. abyssorum		11.2	1300-1306			27	D1	14	D2	40	ht.					15	
056	056-01	1	A. abyssorum	BW	11.2	1300-1306	L	-80	27	D1	14	D2	40	ht.					15	
056	057		Englandactis		1	1307-1309			17	D										[14]
056	057-01	1	Englandactis	BW	1	1307-1309	L	-80	17	D										
056	057-02	2	Englandactis	BW	1	1307-1309	L/N	-80	17	D										
056	058		Pycnogonid		0.4				81	leg len.										
056	059		A. abyssorum		3.2	1310-1315			8	D1	17	D2	25	ht.					5	
056	059-01	1	A. abyssorum	BW	3.2	1310-1315	L	-80	8	D1	17	D2	25	ht.					5	
056	060		Englandactis		0.6				12	D										[14]
056	060-01	1	Englandactis	BW	0.6		L	-80	12	D										

056	060-02	2	Englandactis	BW	0.6		L/N	-80	12	D										
056	061		P. prouhoi		168	1316-1323			186	len.	35	wid.	34	dep.	20	head wid.	19	head dep.	140	
056	061-01	1	P. prouhoi	BW	168	1316-1323	L	-80	186	len.	35	wid.	34	dep.	20	head wid.	19	head dep.	140	
056	062		A. bathybium		1.4	1324-1329			13	D1	9	D2	17	ht.					3	
056	062-01	1	A. bathybium	BW	1.4	1324-1329	L	-80	13	D1	9	D2	17	ht.					3	
056	062-02	2	A. bathybium	BW	1.4	1324-1329	L/N	-80	13	D1	9	D2	17	ht.					3	
056	063		P. longicauda		243.8	1330-1338			160	len.	49	wid.	35	dep.	115	tail			200	[07]
056	063-01	1	P. longicauda	BW	243.8	1330-1338	L	-80	160	len.	49	wid.	35	dep.	115	tail			200	[07]
056	064		M. blakei		32	1339-1345			72	len.	34	wid.	33	dep.	15	head wid.	17	head dep.	25	[18]
056	065		P. prouhoi		123	1346-1352			157	len.	32	wid.	32	dep.	22	head wid.	21	head dep.	103	
056	065-01	1	P. prouhoi	BW	123	1346-1352	L	-80	157	len.	32	wid.	32	dep.	22	head wid.	21	head dep.	103	
056	066		Styracaster		4.8	1358-1360			35	R	35	d (NB)	6	dep.	19	r			5	
056	066-01	1	Styracaster	Tube feet	4.8	1358-1360	L	-80	35	R	35	d (NB)	6	dep.	19	r			5	
056	067		I. vagabunda		0.4	1361-1367			8	D1	4	D2	17	ht.					4	
056	067-01	1	I. vagabunda	BW	0.4	1361-1367	L	-80	8	D1	4	D2	17	ht.					4	
056	067-02	2	I. vagabunda	BW	0.4	1361-1367	L/N	-80	8	D1	4	D2	17	ht.					4	
056	068		H. inermis		10.2	1368-1371			41	R	38	d (NB)	6	dep.	12	r			10	
056	069		I. vagabunda		0.6	1378-1380			6	D1	5	D2	23	ht.					5	
056	069-01	1	I. vagabunda	BW	0.6	1378-1380	L	-80	6	D1	5	D2	23	ht.					5	
056	069-02	2	I. vagabunda	BW	0.6	1378-1380	L/N	-80	6	D1	5	D2	23	ht.					5	
056	070		H. inermis		10.6	1381-1385			54	R	54	d (NB)	6	dep.	17	r			20	
056	070-01	1	H. inermis	Tube feet	10.6	1381-1385	L	-80	54	R	54	d (NB)	6	dep.	17	r			20	
056	071		I. vagabunda		0.6	1391-1395			6	D1	4	D2	20	ht.					4	
056	071-01	1	I. vagabunda	BW	0.6	1391-1395	L	-80	6	D1	4	D2	20	ht.					4	
056	072		Styracaster		5	1396-1401			36	R	38	d (NB)	4	dep.	12	r			10	
056	073		I. vagabunda		0.4															[09]
056	073-01	1	I. vagabunda	BW	0.4		L													[09]
056	074		D. grandis		17	1402-1405			42	R	62	d (NB)	7	dep.	16	r			25	
056	075		H. inermis		17.2	1406-1409			47	R	52	d (NB)	19	dep.	17	r			8	
056	075-01	1	H. inermis	Tube feet	17.2	1406-1409	L	-80	47	R	52	d (NB)	19	dep.	17	r			8	
056	075-02	2	H. inermis	Tube feet	17.2	1406-1409	L/N	-80	47	R	52	d (NB)	19	dep.	17	r			8	
056	076		I. vagabunda		0.8	1421-1423			7	D1	6	D2	24	ht.					3	
056	076-01	1	I. vagabunda	BW	0.8	1421-1423	L	-80	7	D1	6	D2	24	ht.					3	
056	077		H. inermis		21.4	1424-1427			55	R	74	d (NB)	14	dep.	19	r			20	
056	077-01	1	H. inermis	Tube feet	21.4	1424-1427	L	-80	55	R	74	d (NB)	14	dep.	19	r			20	
056	077-02	2	H. inermis	Tube feet	21.4	1424-1427	L/N	-80	55	R	74	d (NB)	14	dep.	19	r			20	
056	078		I. vagabunda		0.4	1428-1430														[08]
056	078-01	1	I. vagabunda	Tube feet	0.4	1428-1430	L	-80												[08]
056	079		Styracaster		6.2	1431-1435			42	R	56	d (NB)	5	dep.	13	r			10	
056	079-01	1	Styracaster	Tube feet	6.2	1431-1435	L	-80	42	R	56	d (NB)	5	dep.	13	r			10	
056	079-02	2	Styracaster	Tube feet	6.2	1431-1435	L/N	-80	42	R	56	d (NB)	5	dep.	13	r			10	
056	080		I. vagabunda		0.6	1436-1439			7	D1	5	D2	23	ht.					3	
056	080-01	1	I. vagabunda	Tube feet	0.6	1436-1439	L	-80	7	D1	5	D2	23	ht.					3	

Report on the fishes

Both OTSB14 deployments returned good catches of fish, including both demersal species at target depth and incidental pelagic species. The second haul contained a good number of large abyssal fishes, mainly *Coryphaenoides armatus* and *Histiobranchus bathybius*. Highlights among the incidental catch included a *Trachipterus* dealfish, large specimens of the bathypelagic eels *Eurypharynx* and *Saccopharynx*, the dragonfish *Borostomias elucens*, and a small oneirodid anglerfish, most likely the pugnose dreamer *Lophodolos acanthognathus*. A large parasitic copepod was found on the *Eurypharynx* specimen.

Most small and medium fishes were preserved in ethanol onboard, with the exception of the *Saccopharynx* and *Trachipterus* specimens, which were preserved together in formalin in the hopes of retaining colours and the structure of the gelatinous eel. Voucher specimens of *C. armatus* and *H. bathybius* from each trawl, alongside the sole ophidiid caught, were also preserved in ethanol or formalin, as were two large unidentified macrourids. All preserved fish will be returned to the Discovery Collections.

Certain small pelagic fish (*Cyclothone*, *Argyropelecus hemigymnus*, and two myctophids) were frozen for later dissection and stable isotope analysis as part of the NERC-funded project ‘Constraining respiration rates of mesopelagic fishes’. Otoliths from three specimens of *Bathylagus euryops* were subsampled onboard, with muscle tissue and otoliths taken. Alongside these, *C. armatus* and *H. bathybius* (10 and 4 individuals respectively) were subsampled onboard after weights, pre-anal, and total lengths were recorded for each specimen. For *C. armatus*, otoliths, eye lenses, and muscles were removed for SIA, while intestines were removed whole and preserved in formalin for taxonomic identification of parasites. As the otoliths in *H. bathybius* are considerably smaller than those of *C. armatus*, whole heads were removed and frozen for that species, alongside muscle samples. Muscle samples from both species were also taken and preserved at -80°C for compound-specific SIA as a part of Lucy Goodwin’s PhD project. After dissection, these fish were discarded.

Example demersal fishes: top *Coryphaenoides armatus*, bottom *Histiobranchus bathybius.*

Example pelagic fishes: top left *Trachipterus arcticus*, top right *Borostomias elucens*, bottom left *Saccopharynx* sp., bottom right *Lophodolos acanthognathus.*

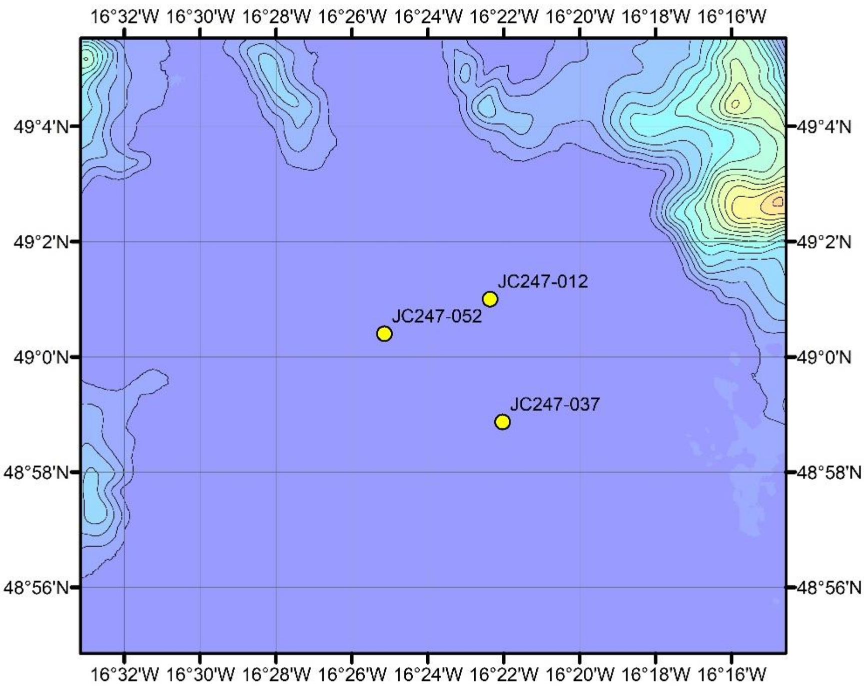
Samples collected for metabolite studies

STATION	Specimen number	Tentative identification	Comment
JC247-051	038	*Molpadiodemas villosus*	Dissected onboard
JC247-051	064	*Molpadiodemas villosus*	Dissected onboard
JC247-051	080	*Molpadiodemas villosus*	Dissected onboard
JC247-051	085	*Molpadiodemas villosus*	Dissected onboard
JC247-051	091	*Molpadiodemas villosus*	Dissected onboard
JC247-051	095	*Molpadiodemas villosus*	Dissected onboard
JC247-051	108	*Psychropotes*	1 whole specimen
JC247-051	109	*Psychropotes*	1 whole specimen
JC247-056	023	*Oneirophanta mutabilis*	1 whole specimen
JC247-056	024	*Molpadiodemas villosus*	1 whole specimen
JC247-056	025	*Oneirophanta mutabilis*	1 whole specimen
JC247-056	026	*Psychropotes*	1 whole specimen
JC247-056	027	*Oneirophanta mutabilis*	1 whole specimen
JC247-056	028	*Molpadiodemas villosus*	1 whole specimen
JC247-056	029	*Oneirophanta mutabilis*	1 whole specimen
JC247-056	030	*Molpadiodemas villosus*	1 whole specimen
JC247-056	031	*Psychropotes*	1 whole specimen

15.3 Amphipod trap

The new amphipod trap (carrying four cylindrical traps with a single 50 mm opening and sieve like-mesh in both the front and back opening) was deployed for the first time and in the conventional manner on three occasions during the cruise with an additional 'blue barrel' trap attached at about 15 mab on the mooring. All traps were baited with 'standard British mackerel'. The mooring was of conventional form: lazy float – 15 m polyprop- Billings dan buoy – 15 m polyprop – 6-ball main buoyancy pack – 50 m braid – IXSEA MORS B2S type release. Mooring descent rate was estimated at 62 m min-1, and ascend rate at 36 m min-1. Below is a photo of the new amphipod design and a map showcasing the different deployment locations.

New design amphipod trap.



Amphipod trap mooring deployment locations.

Summary tabulation of amphipod trap deployments:

Stn number	Start time		Position (DD MM.MMM N/W)				End time		Depth (m)	Soak time
JC247-012	09/05/2023	16:10	49	01.001	016	22.359	11/05/2023	14:42	4845	46.5 hours
JC247-037	14/05/2023	10:40	48	58.869	016	22.032	16/05/2023	09:15	4844	46.5 hours
JC247-052	17/05/2023	14:00	49	00.401	016	25.144	19/05/2023	08:38	4843	42.5 hours

Sample processing: Nitrile gloves were used to avoid biological contamination of the samples. Amphipods were removed from the trap by gently washing the trap cylinder 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 500 mL or 1500 mL UN certified plastic bottles (one bottle per trap). Each bottle was labelled with Station number, position of the trap (i.e., TOP1, TOP2, BOTTOM1, BOTTOM2, BLUE BARREL), date, and preservation method (100%ETOH).

First deployment: The catch for the blue barrel was small, including only two big specimens and a few medium sized and smaller specimens although the level of consumption of the bait was high. In the traditional amphipod traps, most amphipods comprised small individuals. The trap that caught the most amphipods was the BOTTOM1 trap, followed by the BOTTOM2 trap. However, in both instances the mackerel retained most of its flesh and the catch was inferior to those obtained in previous years. 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.

Trap modifications: The smaller size of the specimens collected in the traditional traps and the small catch initially suggested a flaw of design caused by the single narrower opening. To test

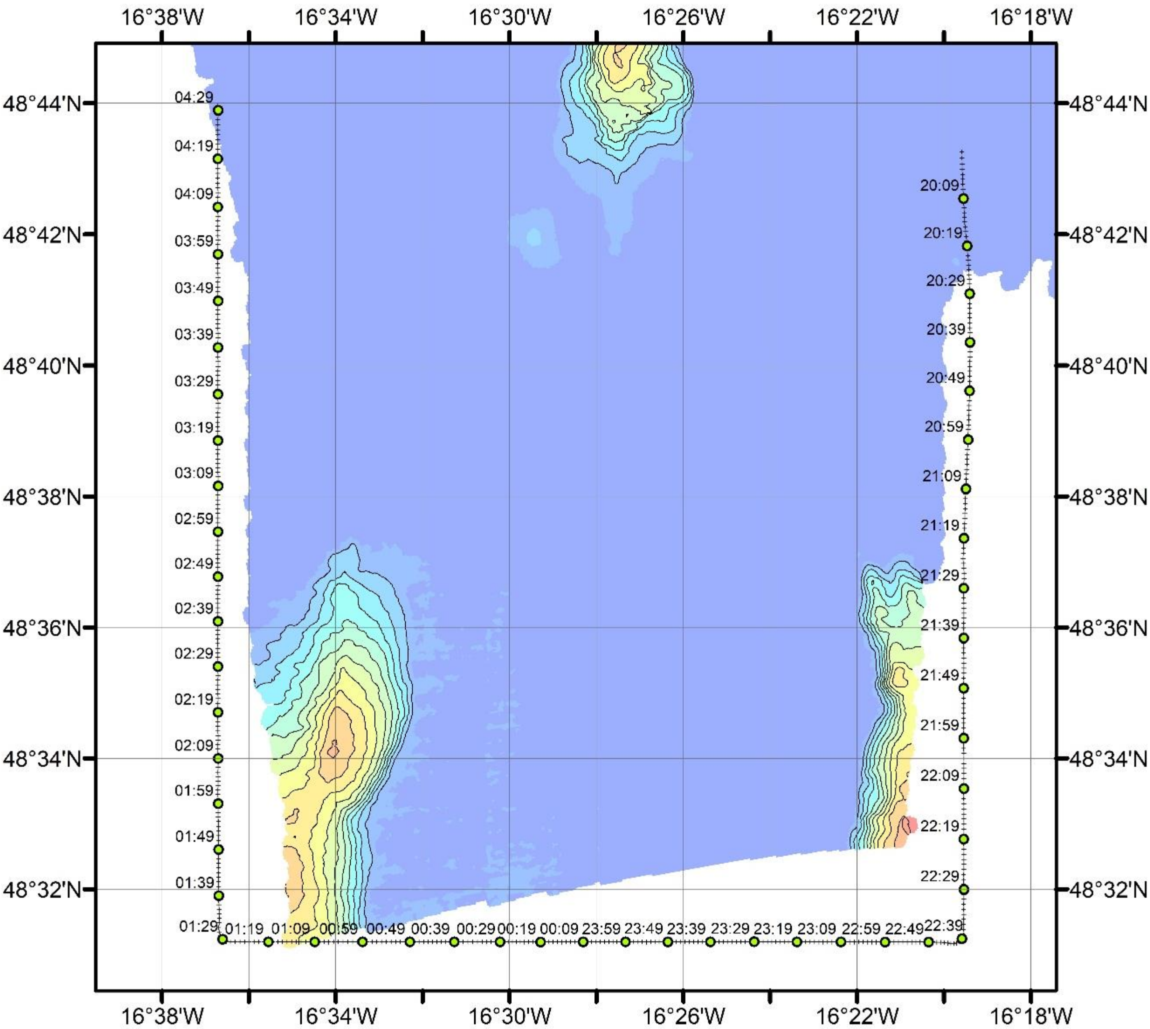
if the lid design was having an impact on the catches, two 50 mm holes were drilled on either side of the original opening for one bottom and one top trap. In addition, a mesh was attached to the mackerel to prevent the specimens from feeding on the mackerel and then leaving the trap – as it might have happened on the first deployment on the blue barrel.
Second and third deployments: a more successful catch was obtained on both the second and third deployments (JC247-037 and JC247-052). As per usual, the blue barrel was the trap that collected the biggest specimens. Within the bottom traps, the one that caught the most specimens in both instances was the trap BOTTOM2 (the one with the unmodified opening). The top traps had a lower success rate, with the TOP1 trap having only caught 5 specimens in total on the second deployment.

Photos from the catch obtained on JC247-037.

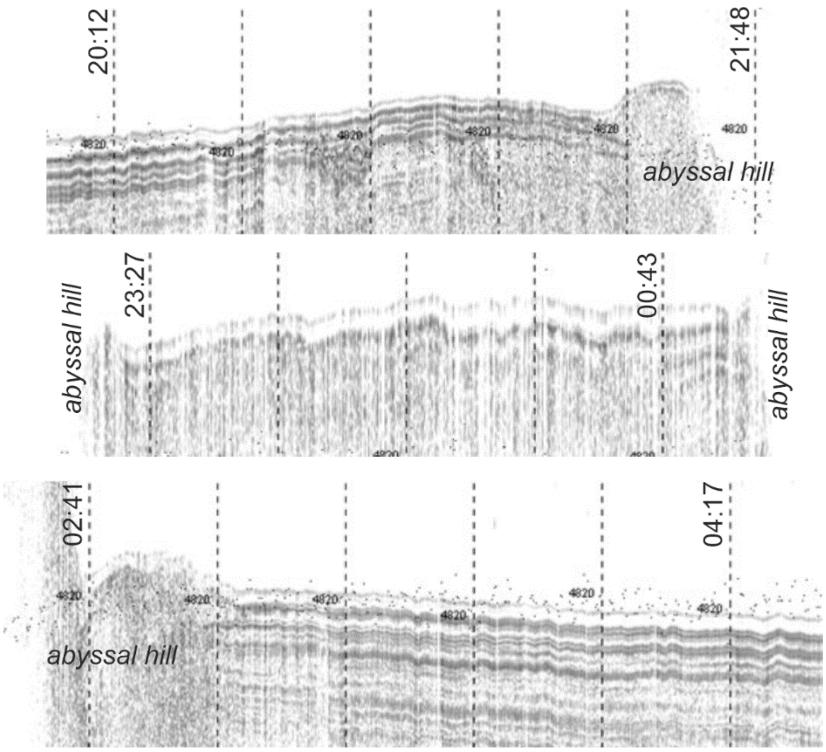
Subsampling of *Paralicella caperesca*: in addition to the usual amphipod trap processing, a total of 60 specimens were selected from the “BOTTOM2” trap on the second and third deployments (30 per deployment). To try to ensure appropriate specimen identifications (since the selection was carried out in situ and not using a microscope) only big specimens were selected. The subsampling consisted in the extraction of a pereopod. The extracted pereopods were preserved with absolute ethanol inside a cryotube and the specimens were contained within cryotubes without any preservatives. Both sets of samples were preserved in the -80°C freezer. This subsampling was carried out to aid with genetic sequencing of the species.

15.4 “South area” extension MBES (EM122) and SBP27 survey

Three survey lines were run around the periphery of the MBES data collected during RRS *Discovery* cruise 130: 18.V.23 20:00 – 19.V.23 04:30, MBES survey lines 0095-0097. The sub-bottom profiler was run during the survey, this was only effective over the abyssal plain stretches of the lines but did indicate the presence of landslide deposits on the northern peripheries of both southern abyssal hills.



MBES and SBP survey lines in “South area” (showing existing bathymetry from DY130).



Simple screen grabs of SBP output for the three survey lines (0095, 0096, 0097).

16. Sediment geochemistry

Anna Lichtschlag

The key objective of the sediment geochemistry work was to test the performance of the sediment nitrate and phosphate Lab-on-Chip sensors that are currently developed for the 'Hadal sensors' project. These sensors differ from the standard NOC Lab-on-Chip nutrient sensors in that they have several sample inlets (i.e. 4 inlets for nitrate and 2 inlets for phosphate); in addition, they are programmed with a slower sampling intake rate to carefully extract the porewater from the sediment.

To test the sensors for sediments, replicate sediment cores were collected with the megacorer (Section 15.1). One core was treated in the traditional way, i.e. porewater was extracted with Rhizones (1 cm interval in the upper 10 cm; 2 cm intervals below) and subsequently measured with a nutrient analyser (Section 10). The second core was transported to the deck lab and the porewater geochemistry was measured directly in the core by inserting a bespoke porewater filtration system from the top of the megacorer directly into the sediment (Figure 16.1). The filtration system consisted of a Lab-on-Chip suitable tubing inserted into a thin metal pipe and terminating into a 1 cm long cut-off Rhizone filter glued to the end of the pipe. 4 of these "filtration pipes", each 1 cm lower than the previous one, were inserted into the sediment so that a 4 cm interval could be measured within one measuring cycle. After the cycle, the same depth intervals were repeated or the filtration system was manually moved further down into the sediment. Initial results for porewater Lab-on-Chip measurements compared to the traditional results are displayed in Figure 16.2.

To put the nutrient data in context, samples for additional geochemical and geophysical parameters were collected. For porewater cation analyses ca. 1 mL of porewaters were acidified with 10 µL of trace metal clean concentrated HNO_3 in acid-cleaned plastic vials and for total alkalinity analysis 2.2 mL of porewater was stored headspace-free in glass vials and poisoned with $HgCl_2$. Additional cores from 3 stations were collected for solid phase analyses (Table 16.1). For this, sediments were sliced in 1 cm interval in the upper 10 cm and 2 cm intervals below and either 5 or 10 cm^3 were transferred to plastic vial and stored a 4°C for porosity and grain size analyses or frozen at -20°C in plastic bags for organic carbon analyses. In addition, 1 sediment core (St JC247-045) was capped with polystyrene at both ends and stored at 4°C for the British Ocean Sediment Core Research Facility BOSCORF.

Table 16.1: Sediment cores used for geochemistry.

Station	Date	Depth (m)	Measurements
JC247-007	09/05/2023	4845	Traditional porewater extraction (nutrients, cations, total alkalinity)
JC247-016	10/05/2023	4847	Porewater Lab-on-Chip trial
JC247-023	11/05/2023	4841	1 x Lab-on-Chip nitrate measurements
JC247-029	13/05/2023	4841	1 x Lab-on-Chip phosphate measurements
JC247-035	14/05/2023	4842	1 x porewater extraction to check variability (nutrients)
JC247-041	15/05/2023	4844	1 x porewater (nutrients) 1 x solid phase 1 x Lab-on-Chip (not working)
JC247-045	16/05/2023	4834	1 x Solid phase (porosity, grain size, Corg) 1 x BOSCORF

Figure 16.1. Left: Porewater extraction with Rhizones; Right: Lab- on-Chip porewater setup.

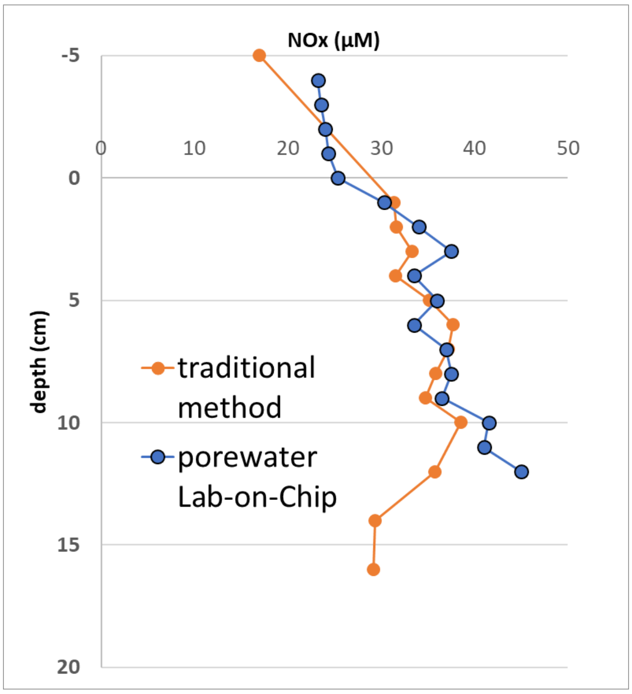


Figure 16.2. Comparison of traditional porewater nitrate analysis (orange) to Lab-on-Chip porewater results (blue).

17. Zooplankton Nets

Chris Feltham, Louise Gao, Corinne Pebody (ashore)

Zooplankton samples were collected at PAP-SO during the day and night using a 200 µm mesh WP2 net. For sample collection, the WP2 net was deployed to a depth of 200 m and vertically hauled back to the surface at a speed of 15-20 m/min. Net deployment occurred from the P frame on the rear starboard side of the ship, with the frame placed as close to the deck as possible. The wire suspending the WP2 net was supported by the deck crew, who used a guide rope to maintain the zooplankton net position; so as not to become tangled. Weighted chains were attached to the cod end of the net to hold it in place.

Samples collected from the cod end were sieved through a 200 µm sieve to reduce the volume of water in the sample. The samples were stored in 250 ml plastic bottles and preserved with 10% borax buffered formalin (225 ml sample and 25 ml of borax buffered formalin). The bottles were labelled and refrigerated. A total of six zooplankton samples were taken: 3 day and 3 night.

Sieved 200 µm mesh WP2 night sample, which included large salps (Station: 025 - 11/05/23).

Sieved 200 µm mesh WP2 night sample which contained amphipods (Station: 040 - 15/05/23).

Deployment of the 200 µm mesh WP2 night net from the P frame on the rear starboard side of the ship (Station: 025 - 11/05/23).

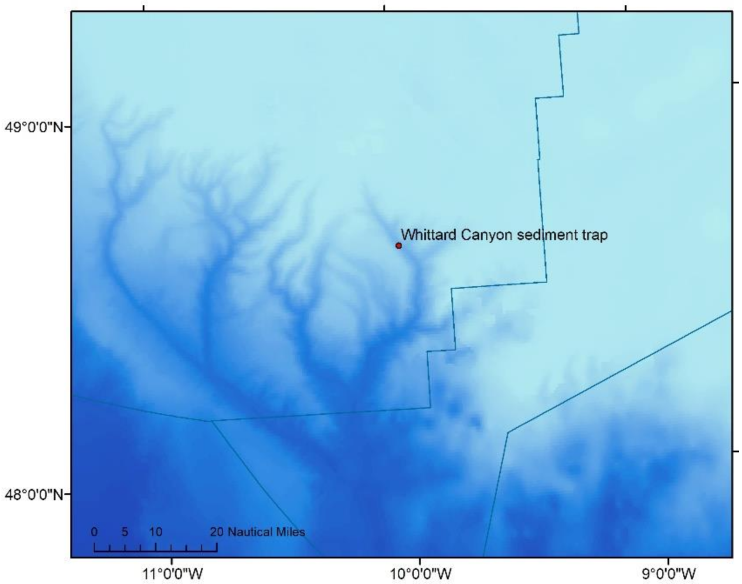
JC247 Zooplankton net sampling log

JC247-006 **Net #01**	Night sample	200 µm mesh WP2 net. Tow depth = 200 m Deployment aborted due to very strong winds – 09/05/23				**Seafloor** **depth**
JC247-009 **Net #02**	Day sample	200 µm mesh WP2 net. Tow depth = 200 m Very windy - Preserved in a 250 ml bottle with formalin				
Deployment		09/05/23	13:02	49°00.000'N	016°29.998'W	4841 m
At 200 m		09/05/23	13:16			4841 m
Recovery		09/05/23	13:26	48°59.869'N	016°29.919'W	4841 m
JC247-015 **Net #03**	Night sample	200 µm mesh WP2 net. Tow depth = 200 m Windy - Preserved in a 250 ml bottle with formalin				
Deployment		10/05/23	2:23	48°50.018'N	016°31.287'W	4841 m
At 200 m		10/05/23	2:33			4841 m
Recovery		10/05/23	2:51	48°50.017'N	016°31.286'W	4841 m
JC247-025 **Net #04**	Night sample	200 µm mesh WP2 net. Tow depth = 200 m Weak wind - Preserved in a 250 ml bottle with formalin. Large salps were found in the sample.				
Deployment		11/05/23	23:30	48°50.126'N	016°31.030'W	4841 m
At 200 m		11/05/23	23:37			4841 m
Recovery		11/05/23	23:51	48°50.126'N	016°31.030'W	4841 m
JC247-032 **Net #05**	Day sample	200 µm mesh WP2 net. Tow depth = 200 m No sample retained due to loss of tap on cod end of the net during deployment – 13/05/23				
JC247-033 **Net #06**	Day sample	200 µm mesh WP2 net. Tow depth = 200 m Preserved in a 250 ml bottle with formalin				
Deployment		13/05/23	13:23	48°57.225'N	016°24.851'W	4843 m
At 200 m		13/05/23	13:31			4843 m
Recovery		13/05/23	13:37	48°57.224'N	016°24.849'W	4843 m
JC247-040 **Net #07**	Night sample	200 µm mesh WP2 net. Tow depth = 200 m Weak wind - Preserved in a 250 ml bottle with formalin				
Deployment		15/05/23	00:02	49°00.624'N	016°33.217'W	4846 m
At 200 m		15/05/23	00:07			4846 m
Recovery		15/05/23	00:27	49°00.640'N	016°33.216'W	4846 m
JC247-047 **Net #08**	Day sample	200 µm mesh WP2 net. Tow depth = 200 m Preserved in a 250 ml bottle with formalin				
Deployment		16/05/23	12:37	48°58.569'N	016°22.344'W	4844 m
At 200 m		16/05/23	12:50			4842 m
Recovery		16/05/23	13:00	48°58.579'N	016°22.323'W	

18. Whittard Canyon

Brian Bett, Andrew Gates & Mike Clare (ashore)

The Whittard Canyon is another CLASS fixed point observations site. JC237 visited the site in 2022. The mooring in the canyon has been maintained on PAP cruises since 2019. It monitors turbidity currents in the canyon.



Location of the Whittard Canyon mooring in the eastern branch of the canyon system

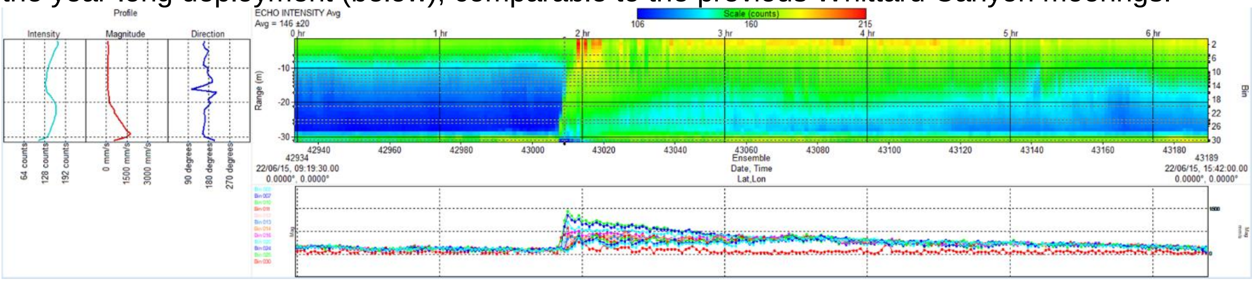
The Whittard Canyon sediment trap JC231-002 was released at 08:51 on 7th May 2023. It was spotted on the surface from the bridge at 09:05, grappled and on deck by 09:51. The mooring was tangled on recovery (below).

Recovery of the Anderson trap to deck and appearance of sediment that spilled from the trap during processing.

The recovered Anderson trap was placed horizontally on deck before it could be processed.

On opening the trap there was a narrow white tube instead of the expected transparent core liner. The core liner did contain some sediment which could not be examined. It was stored upright in the controlled temperature lab for the remainder of the cruise. Anoxic sediment spilled the funnel from the Anderson trap when it was opened to remove the core liner. A sample of the material retained in the funnel was transferred to a bucket and stored in the controlled temperature lab for the remainder of the cruise.

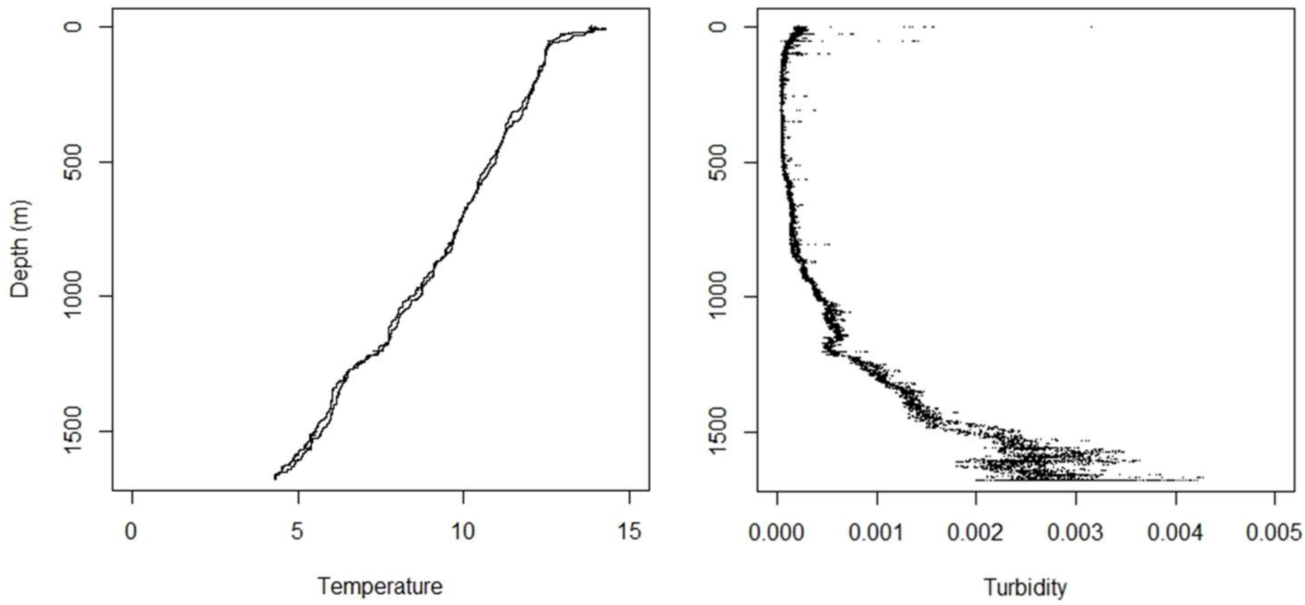
Initial analysis of the ADCP data by Mike Clare at NOC revealed 5 turbidity currents during the year-long deployment (below), comparable to the previous Whittard Canyon moorings.



Initial analysis of first turbidity current detected by the Whittard Canyon Mooring

A CTD cast (JC247-002) was completed at the Whittard Canyon site to test the releases for the new mooring (Below). The new mooring was set up with an Anderson trap with the correct core liner but no intervalometer. It was deployed without incident (JC247-003), the anchor dropped at 13:40 and triangulation was completed at 15:05. The RRS *James Cook* then departed for PAP-SO.

Station number	Latitude	Longitude	Depth (m)
JC231-002	48° 37.514 N	010° 00.196 W	1584
JC247-003	48° 37.529 N	010° 00.170 W	1577



Example CTD profiles from JC247-002 at Whittard Canyon (CTD-2).

19. Met Cals

Sue Hartman, Andrew Gates

Mags Yelland (ashore) requested information on the ships met sensors due to high noise to signal ratio. The aim was to do the calibration when the ship was near to the PAP1 buoy, soon after deployment, to make comparisons with the met and wave data from the mooring. So a comparison of the ship and mooring wave data required getting data from both at the same time.

Additionally the aim was to try to get a handle on the distortion (acceleration/deceleration) of the air flow to the anemometer on the foremast. This distortion biases the measured wind speed, and the bias depends on (a) the angle of the ship to the wind and b) the speed of the ship relative to the wind speed. This required the ship to go round in circles - but NOT round the buoy itself since this would interfere with the wind speed measurement on the buoy when the ship is upwind of it.

One Met Cal was done on JC247 and assigned a single station number JC247-030, completing 3 circles at 0, 4, and 8 knts.

For the 0 knot circle, previously we found that the best way to do it was to use the DP system, putting a marker on the position of the ship's anemometer on the bow, and getting the ship to rotate about the anemometer. It was suggested that a steady rate of change of heading would be better than a hexagon for example, so they would prefer a smooth circle rather than stepped changes in heading. A complete geographical circle was NOT necessary when the ship is steaming round. We just needed a full range of relative wind directions at a steady rate of change of heading (and ship speed if possible) so a spiral that is fine. For the circles at 4 or 8 knots, a steady ship speed preferred, as well as a steady heading, (realising the ship speed might vary a bit with the wind and waves). The size of the circle/spiral does not matter.

20. BORAbox

Anita Flohr, Anna Lichtschlag, Andy Gates (at sea)
S. Fowell, A. Schaap, J. Ludgate, S. Monk, C. Sands, C. Cardwell (at NOC)

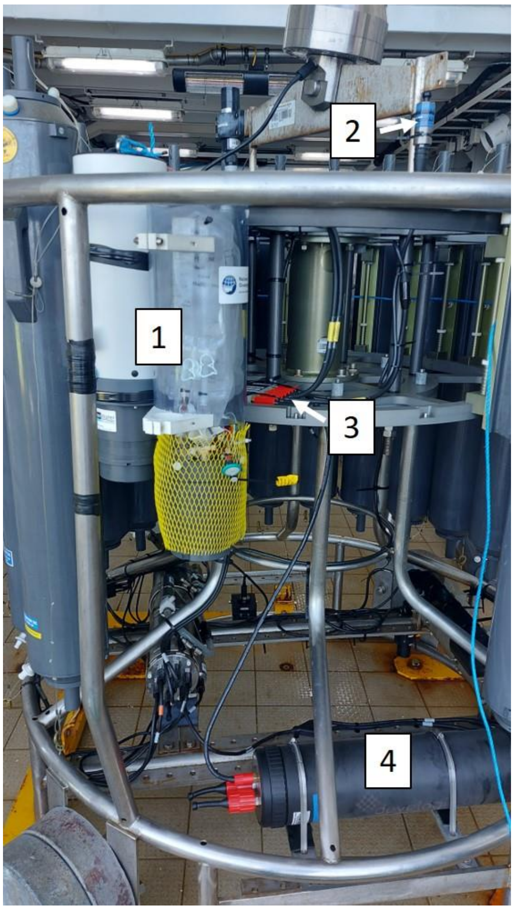
20.1. Objective

BORA (Blue Ocean Research Alliance) is an alliance, between NOC and Subsea7 that was established in 2021. The aim of BORA is to add scientific value to offshore industry operations. The BORAbox is a sensor package designed for the integration into remotely operated vehicles run by Subsea7. The BORAbox measures pH and total alkalinity (TA) (Schaap et al., 2021; Yin et al, 2021) and several BORAboxes are already in operation on the Subsea7 fleet during their routine operations, accessing areas of the ocean and depths where these measurements are extremely sparse.

To assess sensor handling, integration and operation, the BORAbox was deployed by personnel that is experienced with the use of autonomous sensors but not specifically with the BORAbox sensors. More specifically, the aim was to test whether some of the issues with sensor performance that occurred during recent Subsea7 deployments could be reproduced (e.g. pH=0, strong variability in TA) and to investigate potential points of failure. The information gathered will help simplifying sensor handling, diagnostics and maintenance.

20.2 Deployments

The BORAbox set up consisted of the 2 sensors (pH, TA) (SN: CWpH-01-110, TA30), a pressure sensor, the hub and a battery pack (Fig. 1). The BORAbox was mounted on the CTD frame from cast 3 (Table 1). During cast 3 and 4, no pH was recorded. Correspondence with the team at NOC showed that the pH sensor was not enabled on the hub, so wasn't initiated by the pressure sensor. It was suggested to swap the cables, i.e. pH would be powered instead of TA, to verify that this was the reason for the pH sensor not talking. Cables were swapped during cast 5 and 6, pH came on and produced mostly 0 values but sensible values towards the end of cast 6. The pH sensor was then taken off the frame for further tests in the lab, the TA stayed on the frame until cast 11. Benchtop tests with the pH sensor, including extensive flushing to remove potential trapped air bubbles, still resulted in pH = 0 values. Raw sensor file outputs suggested valves were working fine. Bubbles in the system might still be the most likely cause. This will be further investigated back at NOC.



BORAbox mounted to the CTD frame. 1 – BORAbox sensors, 2 – pressure sensor, 3 – hub, 4 – battery pack

The TA sensor performed well at shallow depths, reflected in very good sensor performance during shallow casts (casts 7, 8 and 11) and at the beginning of deep casts (e.g. 4, 9 and 10). What might have caused predominantly -1.#QO outputs at greater depths needs to be investigated back at NOC. The discrete TA/DIC samples collected from the CTD cast (Section 9) will be analysed back at NOC and will be used to check data quality of the BORAbox TA and pH results.

Acknowledgements

A huge thanks to Tom Ballinger (NMF) for mounting the BORAbox to the CTD frame and assistance throughout the cruise.

References

Schaap, A, et al.: Quantification of a subsea CO2 release with lab-on-chip sensors measuring benthic gradients, International Journal of Greenhouse Gas Control, 110, 103427, https://doi.org/10.1016/j.ijggc.2021.103427, 2021.

Yin, T, et al. 2021 A Novel Lab-on-Chip Spectrophotometric pH Sensor for Autonomous In Situ Seawater Measurements to 6000 m Depth on Stationary and Moving Observing Platforms, Environmental Science & Technology, 55, 14968-14978, 10.1021/acs.est.1c03517,

List of BORAbox deployments during JC247

Date	Time (UTC)	CTD cast	speed	Max depth (m)	TA on CTD frame	pH on CTD frame	TA data	pH data	Comment
06/05/2023		1		50	-	-			
07/05/2023		2		1625	-	-			
08/05/2023	1717-1836	3		500	✓	✓	✓	-	first deployment of BORAbox TA: one value towards the end of the cast, mainly -1.#QO pH: no data
09/05/2023	0730-1300	4		4825	✓	✓	✓	-	TA: 22 measurements (14 TA values) values seem reasonable, remaining measurements come out as -1.#QO pH: no data
10/05/2023		5		100	✓	✓	-	✓	Cables swapped, i.e. pH with power, TA without power, no TA data pH data files: HE data looks fine CH0 ~3.9 V, slight peak maybe CH1 ~3.4V, small peak maybe (file 2 very short, so ignored) HE0: 10 good pump strokes, 8 timeouts (TBC), 5 good (till end) - mirrored in HE1 CH0: ~4V to start, when stuck ~4.5V, lower peaks seen once jam unsticks.
10/05/2023	1100-1445	6		4824	✓	-	-	-	pH sensor taken off the CTD frame to prevent potential damage when deployed while unpowered
13/05/2023	1107-1245	7		100	✓		✓	-	TA: 5 measurements (5 TA values), sensor performance very good
14/05/2023	0650-0830	8		100	✓	-	✓	-	TA: 5 measurements (5 TA values), sensor performance very good
14/05/2023	1056-1800	9		4700	✓	-	✓	-	TA: 29 measurements (14 TA values), TA values start off nicely then gradually go down to unrealistic values of ~1400 umol/kg, followed by -1.#QO
14/05/2023	1630-1730	lab			✓	-	✓	-	Connected to pH via mains and USB, flushed 4x with seawater and then ran seawater sample pH data files: HE0: 5 good measurement cycles, no sign of sticking CH0: very low ~0.6 V --> suggests bubble in system

15/05/2023	0900- 1400	10		4820	✓	-	✓	-	TA: 23 measurements (10 TA values), TA starts off nicely, then start to get noisy, range 2167-2474 umol/kg, remaining measurements come out as -1.#QO
16/05/2023	0730- 0830	11		100	✓	-	✓	-	TA: 4 measurements (4 TA values), sensor performance very good, TA taken off the frame after cast 11
16/05/2023	1100- 1230	lab			-	-			pH tested on benchtop, flushed etc but did produce 0 values
17/05/2023	0700- 1500	lab			-	-			TA tested, low voltage and very noisy signal, tried several flushes with Decon, MilliQ and seawater but didn't help

21. Marine Mammal Observation Report

Dr Anita Flohr

This report summarises the relevant project details and mitigation measures for research cruise JC247 on board RRS *James Cook*.

Reference	Cruise JC247 (SME 22/1696)
Operator	National Oceanography Centre, European Way, Southampton, SO14 3ZH, United Kingdom
Project details	The scientific cruise JC247 on RRS James Cook (05/05-22/05/2023) to the Northeast Atlantic Ocean was a continuation of a long-term time-series of observations at the Porcupine Abyssal Plain Sustained Observatory (PAP-SO).
Chief Scientist	Dr Andrew Gates, National Oceanography Centre, Southampton, Email: arg3@noc.ac.uk; Tel: +44 (0)23 8059 6363
MMO	Dr Anita Flohr, Scientist, National Oceanography Centre, Southampton, Email: aflohr@noc.ac.uk, Tel: +44 (0)2380 599346 JNCC MMO training attended: 12th February 2019 non-dedicated MMO Juan Ward, National Marine Facilities Engineering Manager, Ship Scientific Systems, National Oceanography Centre Email: juan.ward@noc.ac.uk,Tel: +44 (0)23 8059 6844
Mitigation	At-sea mitigation measures (SME 22/1696) The JNCC guidelines (JNCC, 2017) recommend that for multibeam echosounders, side-scan sonar, and sub-bottom profilers, if several different types of equipment are to be started up consecutively or interchanged during the cruise • only one pre-start search of the mitigation zone is required, only if there are no gaps of greater than 10 minutes in the data acquisition. • If there is a gap of more than 10 minutes in the data acquisition, this should be treated as a new start-up. *Swath Bathymetry:* • At water depths >200 m, 60 minutes of observation focusing on the mitigation zone (500 m from the acoustic source) should be undertaken. • If marine mammals are observed during the search, start-up should be delayed at least 20 minutes from the time of the last detection within the mitigation zone, or the vessel manoeuvred away. • A soft-start (as defined in Appendix 1) should be enacted if the equipment allows. • Any observations of marine mammals should be recorded on the forms provided by JNCC – an MMO is only necessary before and during the start-up of equipment, and not for the whole time it is running. *Sub-bottom Profiling (SME 17/471):* Same as for Swath Bathymetry but in addition: • If water depth is <200 m, 30 minutes of observation focusing on the mitigation zone (500 m from the acoustic source) should be undertaken. *Post-sea requirements:* • Provide feedback to MEA regarding what mitigation measures were taken.
Sources	Single (Simrad EA640) and Multibeam (Simrad EM122) Echosounder (Kongsberg Maritime, at 12 kHz at up to -50 dB)

	Sub-bottom profiler (Simrad SBP120, Kongsberg Maritime, 2-9 kHz at -30 to 0 dB) ADCP (Teledyne RD Instruments, at 75 and 150 kHz with a dynamic range of 80 dB)
Summary	MMO watch-out was not required on JC247. The multibeam was started at berth (i.e. at <200m water depth). At sea, the single and multibeam were switched off occasionally, e.g. for mooring interrogation, release tests and triangulation but gaps in the data acquisition were <10 minutes (please see attached event logger). The sub-bottom profiler was started at sea at water depths >4500m for an EM122 and SBP120 survey (18/5/2023 20:00 UTC to 19/5/2023 04:30 UTC), which was unfortunately not captured on the event logger.
Annex	Annex 1: MMO Certificate_AFlohr Annex 2: Eventlogger_Acoustic events_JC247 Annex 3: MEMP_JC247_AF

22. Outreach

The following articles were posted on the NOC blog page:

4th May 2023	RRS James Cook Sails to the Porcupine Abyssal Plain	Andrew Gates
5th May 2023	Prepration for JC247	Corinne Pebody
10th May 2023	Measuring CO2 uptake at PAP-SO	Sue Hartman / Anita Flohr
15th May 2023	Sea experience: exploring the abyssal plain for new antimicrobial agents	Emmanuel Tope Oluwabusola
16th May 2023	Early career scientists and first experiences at sea	Hans Hilder
17th May 2023	Nutrient analysis at sea: EuroGO-SHIP and PAP	Malcolm Woodward
18th May 2023	JC247 and APERO collaboration	Théo Picard
19th May 2023	Expanding the reach of our ocean observations	Anita Flohr
20th May 2023	PAP-SO cruise: First time at sea	Sneha Sunny
20th May 2023	Eat, sleep, core – repeat!	Izzy Cooper
20th May 2023	Sampling scavenging amphipods	Georgina Valls Domedel

Blog posts were circulated on NOC and PAP-SO twitter feeds.

EuroGO-SHIP also published an article about Malcom Woodward's work on JC247: "RRS James Cook, PAP and EuroGO-SHIP": https://eurogo-ship.eu/jc247-rrs-james-cook-pap-and-eurogo-ship-cruise/

23. References

Becker S, Aoyama M, Woodward EMS, Bakker K, Coverly S, Mahaffey C and Tanhua T (2020) GO-SHIP Repeat Hydrography Nutrient Manual: The Precise and Accurate Determination of Dissolved Inorganic Nutrients in Seawater, Using Continuous Flow Analysis Methods. Front. Mar. Sci. 7:581790. https://doi.org/10.3389/fmars.2020.581790

Brewer P.G. and Riley J.P., 1965. The automatic determination of nitrate in seawater. Deep Sea Research, 12, 765-72.

Gates, A.R., S.E. Hartman, J. Campbell, C. Cardwell, J.M. Durden, A. Flohr, T. Horton, S. Lankester, R.S. Lampitt, C. Miskin-Hymas, C. Pebody, N. Rundle, A. Serpell-Stevens, and B.J. Bett. 2021. Porcupine Abyssal Plain Sustained Observatory monitors the atmosphere to the seafloor on multidecadal timescales. P. 29 in Frontiers in Ocean Observing: Documenting Ecosystems, Understanding Environmental Changes, Forecasting Hazards. E.S. Kappel, S.K. Juniper, S. Seeyave, E. Smith, and M. Visbeck, eds, A Supplement t o *Oceanography* 34(4) https://doi.org/10.5670/oceanog.2021.supplement.02-12.

Grasshoff, K., 1976. Methods of seawater analysis. Verlag Chemie, Weinheim and New York, 317pp.

Hartman, S.E., B.J. Bett, J.M. Durden, S.A. Henson, M. Iveren, R.M. Jeffreys, T. Horton, R. Lampitt, and A.R. Gates. 2021. Enduring science: Three decades of observing the Northeast Atlantic from the Porcupine Abyssal Plain Sustained Observatory (PAP-SO). Progress in Oceanography 191:201508, https://doi.org/10.1016/j.pocean.2020.102508.

Hartman, Susan. 2022 Time-series studies at the Porcupine Abyssal Plain Sustained Observatory. Southampton, National Oceanography Centre, 201pp. (National Oceanography Centre Research Expedition Report, 77).

Horton, T., Thurston, M. H., Vlierboom, R., Gutteridge, Z., Pebody, C. A., Gates, A. R., & Bett, B. J. (2020). Are abyssal scavenging amphipod assemblages linked to climate cycles? Progress in Oceanography, 184, 102318. https://doi.org/https://doi.org/10.1016/j.pocean.2020.102318

Lampitt, R. S., Briggs, N., Cael, B. B., Espinola, B., Hélaouët, P., Henson, S. A., Norrbin, F., Pebody, C. A., & Smeed, D. (2023). Deep ocean particle flux in the Northeast Atlantic over the past 30 years: carbon sequestration is controlled by ecosystem structure in the upper ocean [Original Research]. Frontiers in Earth Science, 11. https://doi.org/10.3389/feart.2023.1176196

Macovei, V. A., Hartman, S. E., Schuster, U., Torres-Valdés, S., Moore, C. M., & Sanders, R. J. (2020). Impact of physical and biological processes on temporal variations of the ocean carbon sink in the mid-latitude North Atlantic (2002–2016). Progress in Oceanography, 180, 102223. https://doi.org/https://doi.org/10.1016/j.pocean.2019.102223

Mantoura, R.F.C, and Woodward, E.M.S., 1983. Ammonium Analysis.

Kirkwood D., 1989. Simultaneous determination of selected nutrients in seawater. ICES CM 1989/C:29.

Schaap, A., Koopmans, D., Holtappels, M., Dewar, M., Arundell, M., Papadimitriou, S., Hanz, R., Monk, S., Mowlem, M., & Loucaides, S. (2021). Quantification of a subsea CO2 release with lab-on-chip sensors measuring benthic gradients. International Journal of Greenhouse Gas Control, 110, 103427. https://doi.org/https://doi.org/10.1016/j.ijggc.2021.103427

Yin, T., et al. (2021). A Novel Lab-on-Chip Spectrophotometric pH Sensor for Autonomous In Situ Seawater Measurements to 6000 m Depth on Stationary and Moving Observing Platforms. Environmental Science & Technology, 55(21), 14968-14978. https://doi.org/10.1021/acs.est.1c03517

24. Station list

GEAR	Description
ATRAPx	Amphipod trap, "DEMAR" type, four near-bottom, double parlour traps, plus barrel 'letter box' trap at c. 15 mab
CTD	Conductivity, temperature, depth etc. instrument
MgCxx+y	Bowers & Connelly Megacorer fitted with xx 10 cm tubes and y 5 cm tubes
OTSB14a	Semi-balloon otter trawl, 14 m head rope, (slight variant on standard pattern?)
PAP1	ODAS buoy and instrument frame
PAP3	Sediment trap array
WP2	Zooplankton net (200 um mesh)
WCM	Whittard Cayon mooring type 1 (Parflux sediment trap, 2 microcats, 2 ADCPs)
WCM(A)	Whittard Cayon mooring type 2 (Anderson sediment trap, 2 microcats, 2 ADCPs)
APEX	Teledyne design standard Argo float
NAVIS	Seabird design BGC Argo float
APERO	BGC NKE CTS-5 Argo float
METCAL	Inter-calibration of PAP1 ODAS buoy and ship's meteorological data
WT	Wire test
UWS	Survey using underway sensors to monitor surface ocean varaibles

Station	Gear	Date	Time (UTC)	Latitude	Longitude	Depth (m)	Sounding (m)	Comment
JC231-002	WCM(A)	03/05/22	09:12	48 37.514	010 00.196	1584	1584	Anderson trap, 2 microcat, 2 ADCP
		07/05/23	08:51	48 37.514	010 00.196	1584		Tangled at recovery
JC231-004	PAP3	04/05/22	14:50	48 57.563	016 20.967	4847	4847	Original position revised
		13/05/23	15:09	48 57.563	016 20.967	4847		Low sample volumes
JC231-036	PAP1	07/05/22	10:51	48 57.689	016 26.260	4848	4848	Recovered without incident
		11/05/23	10:20	48 57.383	016 25.692	4848		Issues with data retention on several sensors
JC247-001	CTD	06/05/23	08:15	50 13.900	004 13.148	5	58	Test CTD at L4 off Plymouth
		06/05/23	08:32	50 13.901	004 13.151	50		6 bottles at 4 depths: 5, 10, 25, 50 m
JC247-002	CTD	07/05/23	10:51	48 36.200	009 58.100	0	1688	Wire test WCM(A) releases
		07/05/23	12:25	48 36.200	009 58.099	1678		24 bottles at 8 depths
JC247-003	WCM(A)	07/05/23	13:58	48 37.529	010 00.170	1577	1577	Triangulated position
JC247-004	CTD	08/05/23	17:17	48 57.394	016 23.652	0	4844	2 bottles removed for BORAbox
		08/05/23	18:36	48 57.394	016 23.651	500		22 bottles at 13 depths
JC247-005	MgC08	08/05/23	21:45	48 50.052	016 31.200	4845	4845	6 x MAC samples
JC247-006	WP2	09/05/23	00:25	48 50.058	016 31.192	0	4845	Aborted for gear safety
JC247-007	MgC08	09/05/23	03:14	48 50.194	016 30.885	4845	4845	7 x MAC, 1 x Anna
JC247-008	CTD	09/05/23	07:26	49 00.000	016 30.000	0	4846	Wire test PAP3 releases
		09/05/23	12:43	49 00.001	016 29.999	4823		22 bottles at 20 depths
JC247-009	WP2	09/05/23	13:02	49 00.000	016 29.998	0	4848	Zplktn sample retained
		09/05/23	13:26	48 59.869	016 29.919	200		
JC247-010	APEX	09/05/23	13:32	48 59.683	016 30.053	0	4845	Apex Float 10066
JC247-011	APEX	09/05/23	13:36	48 59.683	016 30.053	0	4845	Apex Float 10068
JC247-012	ATRAP	09/05/23	16:10	49 01.001	016 22.359	4845	4845	Descent rate 63 m min-1
		11/05/23	14:42	49 01.001	016 22.359	4845		Soak time = 46.5 hours
JC247-013	WT	09/05/23	15:25	48 01.000	016 22.371		4845	LISST battery housing test
JC247-014	MgC08	09/05/23	23:51	48 50.017	016 31.283	4844	4844	5 x MAC, 2 x Lucy
JC247-015	WP2	10/05/23	02:33	48 50.018	016 31.287	0	4841	Zplktn sample retained
		10/05/23	02:51	48 50.017	016 31.286	200		
JC247-016	MgC08	10/05/23	05:31	48 50.430	016 31.220	4847	4847	7 x MAC, 1 x Anna
JC247-017	CTD	10/05/23	09:25	48 56.934	016 24.474	0	4841	Shallow CTD 700 m from PAP1
		10/05/23	09:47	48 56.934	016 24.474	100		22 bottles at 5 depths
JC247-018	CTD	10/05/23	10:57	49 00.000	016 30.001	0	4841	Deep CTD & float validation
		10/05/23	14:17	48 59.999	016 29.999	4824		22 bottles at 17 depths
JC247-019	NAVIS	10/05/23	14:38	49 00.002	016 30.050	0	4842	NAVIS float F1242
JC247-020	APERO	10/05/23	14:40	48 00.002	016 30.050	0	4842	APERO float BGC NKE CTS-5
JC247-021	PAP3	10/05/23	17:22	48 59.181	016 19.348	4842	4842	Triangulated position
JC247-022	MgC08	10/05/23	22:45	48 50.017	016 31.069	4841	4841	6 x MAC, 2 x Lucy
JC247-023	MgC08	11/05/23	02:53	48 50.212	016 31.036	4841	4841	4 x MAC, 2 x Izzy, 1 x Anna
JC247-024	MgC08	11/05/23	21:08	48 50.114	016 31.013	4842	4842	6 x MAC, 2 x Lucy
JC247-025	WP2	11/05/23	23:37	48 50.126	016 31.030	0	4841	Zplktn sample retained
		11/05/23	23:51	48 50.126	016 31.030	200		
JC247-026	MgC08	12/05/23	02:10	48 50.121	016 31.645	4841	4841	7 x MAC, 1 x Anna
JC247-027	PAP1	12/05/23	18:40	48 57.689	016 26.260	4848	4848	Deployed without incident
JC247-028	MgC08	12/05/23	22:05	48 50.260	016 31.432	4842	4842	6 x MAC, 2 x Lucy

Station	Gear	Date	Time (UTC)	Latitude		Longitude		Depth (m)	Sounding (m)	Comment
JC247-029	MgC08	13/05/23	02:03	48	50.028	016	31.223	4841	4841	5 x MAC, 1 x Anna
JC247-030	METCAL	13/05/23	08:05	48	56.991	016	24.550	0	4844	3 circles at 0, 4, and 8 knts
		13/05/23	09:17	48	58.152	016	24.504	0		
JC247-031	CTD	13/05/23	11:07	48	57.275	016	24.850	0	4841	Shallow CTD at PAP1
		13/05/23	12:42	48	57.275	016	24.851	100		23 bottles at 5 depths
JC247-032	WP2	13/05/23	12:58	48	57.275	016	24.849	0	4841	No sample retained
		13/05/23	13:17	48	57.224	016	24.849	200		
JC247-033	WP2	13/05/23	13:23	48	57.225	016	24.851	0	4841	Zplktn sample retained
		13/05/23	13:37	48	57.224	016	24.849	200		
JC247-034	MgC08	13/05/23	21:00	48	50.365	016	31.116	4842	4842	6 x MAC, 2 x Lucy
JC247-035	MgC08	14/05/23	01:12	48	50.121	016	30.959	4842	4842	7 x MAC, 1 x Anna
JC247-036	CTD	14/05/23	06:48	48	56.863	016	25.198	0	4842	Shallow CTD 150 m from PAP1
		14/05/23	08:32	48	56.842	016	25.222	100		23 bottles at 5 depths
JC247-037	ATRAP	14/05/23	10:40	48	58.869	016	22.032	4844	4844	Descent rate 62 m min-1
		16/05/23	09:15	48	58.869	016	22.032	4844		Soak time = 46.5 hours
JC247-038	CTD	14/05/23	10:56	48	59.998	016	29.947	0	4842	Deep CTD, slow descent, long stops
		14/05/23	17:58	48	59.996	016	29.947	4836		21 bottles at 20 depths
JC247-039	UWS	14/05/23	18:16	48	59.998	016	29.460	0	4844	Underway survey
		14/05/23	23:47	49	00.527	016	33.195	0		
JC247-040	WP2	15/05/23	00:07	49	00.624	016	33.217	0	4846	Zplktn sample retained
		15/05/23	00:27	49	00.640	016	33.216	200		
JC247-041	MgC08	15/05/23	02:21	49	00.636	016	33.228	4844	4844	3 x Anna, 1 x Emman
JC247-042	CTD	15/05/23	08:23	49	00.000	016	30.000	4842	4842	Deep CTD
		15/05/23	13:23	49	00.000	016	30.000	4836		23 bottles at 21 depths
JC247-043	UWS	15/05/23	13:45	49	00.063	016	27.300	4841	4844	Underway survey
		15/05/23	19:30	48	39.500	016	27.500	4833		
JC247-044	MgC08	15/05/23	21:12	48	39.485	016	27.508	4833	4833	2 x Lucy, 2 x Org, 2 x PSA, 2 x poro
JC247-045	Mgc08	16/05/23	01:28	48	38.994	016	27.510	4834	4834	2 x Org, 2 x PSA, 2 x poro, 1 Anna, 1 BOSCORF
JC247-046	CTD	16/05/23	06:30	48	57.522	016	25.608	0	4844	Shallow CTD
		16/05/23	08:09	48	57.522	016	25.608	100		23 bottles at 6 depths
JC247-047	WP2	16/05/23	12:37	48	58.569	016	22.344	0	4842	Zooplankton sample retained
		16/05/23	13:00	48	58.579	016	22.323	200		
JC247-048	CTD	16/05/23	13:17	48	58.579	016	22.322	0	4846	Cal dip for MicroCAT to 1500 m
		16/05/23	14:49	48	58.579	016	22.324	1500		23 bottles at 10 depths
JC247-049	APEX	16/05/23	14:47	48	58.578	016	22.323	0	4840	Apex Float 10067
JC247-050	APEX	16/05/23	14:49	48	58.578	016	22.323	0	4840	Apex Float 10069
JC247-051	OTSB14a	16/05/23	22:52	49	02.637	016	56.952	4844	4845	Small, clean catch
		17/05/23	00:34	48	58.106	016	57.815	4846		Dist. Run = 8.464 km
JC247-052	ATRAP	17/05/23	14:00	49	00.401	016	25.144	4843	4843	descent rate = 63 m min-1
		19/05/23	08:38	49	00.401	016	25.144	4843		Soak time = 42.5 hours
JC247-053	UWS	17/05/23	13:00	49	00.089	016	27.400	0	4838	Underway survey
		17/05/23	18:00	49	14.127	016	44.643	0		end at trawl site
JC247-054	CTD	17/05/23	15:12	49	00.499	016	58.060	0	4846	Shallow CTD
		17/05/23	15:32	49	00.498	016	58.058	100		24 bottles at 5 depths
JC247-055	CTD	17/05/23	17:26	49	14.126	016	44.644	0	4844	Shallow CTD

Station	Gear	Date	Time (UTC)	Latitude		Longitude		Depth (m)	Sounding (m)	Comment
		17/05/23	17:47	49	14.120	016	44.645	100		24 bottles at 5 depths
JC247-056	OTSB14a	17/05/23	22:51	49	05.435	016	53.023	4843	4846	Moderate, clean catch
		18/05/23	01:00	49	01.021	016	57.875	4848		Dist. Run = 10.075 km
JC247-057	CTD	18/05/23	11:30	48	53.106	016	54.103	0	4842	Shallow CTD
		18/05/23	11:57	48	53.106	016	54.103	200		24 bottles at 6 depths
JC247-058	CTD	18/05/23	13:58	49	00.012	016	30.104	0	4842	Deep CTD
		18/05/23	17:19	49	00.014	016	30.103	4827		24 bottles at 16 depths
JC247-059	CTD	19/05/23	06:33	48	57.402	016	26.543	0	4844	Shallow CTD
		19/05/23	07:06	48	57.403	016	26.543	200		24 bottles at 6 depths

25. Acknowledgements

We thank all the crew of the RRS *James Cook* and the NMF technicians who enabled us to deliver our science programme. The catering was exceptional, and we were well looked after. We acknowledge the Met Office for supply of the Mobilis buoy, and 5 ARGO floats deployed. The 6th Argo float was provided by the French APERO programme.

This cruise and Theo Picard's fellowship were funded by Climate Linked Atlantic Section Science (CLASS) project supported by the UK Natural Environment Research Council (grant number NE/R015953/1). Additional support came from iFADO and MINKE and the surface water data are a contribution to ICOS. Malcolm Woodward's participation was funded by the Euro GO-SHIP programme.

With thank NEODAAS for satellite data throughout JC231. Thanks to the NOC OBG and OTE colleagues (ashore and at sea) and to Campbell Ocean data (COD) for initial PAP1 setup ashore and assistance from a distance.

National Oceanography Centre, European Way, Southampton, SO14 3ZH
United Kingdom +44 (0)23 8059 6666

Joseph Proudman Building, 6 Brownlow Street, Liverpool,
L3 5DA United Kingdom +44 (0)151 795 4800

National Oceanography Centre is a company limited by guarantee, set up
under the law of England and Wales, company number 11444362.

National Oceanography Centre is registered as a charity in England and Wales,
charity number 1185265, and in Scotland, charity number SC049896.

NOC.AC.UK