National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre

Cruise Report No. 43

RRS *Discovery* Cruise DY032

20 JUN - 07 JUL 2015

Cruise to the Porcupine Abyssal Plain sustained observatory

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2017

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DOCUMENT DATA SHEET

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ABSTRACT

The Porcupine Abyssal Plain Observatory is a sustained, multidisciplinary observatory in the North Atlantic coordinated by the National Oceanography Centre, Southampton. For over 20 years the observatory has provided key time-series datasets for analysing the effect of climate change on the open ocean and deep-sea ecosystems. As is normally the case during cruises which are needed to refurbish the observatory, a wide range of other activities were carried out during the cruise.

The main mooring Ocean Data Acquisition System (ODAS) buoy had ceased transmitting data in March 2015, so a high priority was to recover the buoy and its stored data and this was successfully achieved. In addition, we recovered a set of sediment traps which had been collecting sinking material in the lower part of the water column for the previous 12 months and deployed a new set.

These are the autonomous systems, but as is usually the case with our trips to PAP, we carried out various other activities and in this case we investigated the degradation of particles as they sink. Our colleagues from MIO in France carry out sophisticated interrogation using radiolabelling.

The Bathysnap time-lapse camera system which had been taking photos of the seabed at 4800m was recovered to give an assessment of the behaviour of the benthic animals and how the seabed appearance changes in response to deposition of material. A new module was deployed.

Temporal variability of the water column and seabed fauna - a task which is difficult or impossible to do autonomously was assessed using nets and cores.

KEYWORDS

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Contents

1 Personnel

1.1 Scientific personnel

	Family Name	Given Names	Rank or Rating
1	Lampitt	Richard Stephen	PSO
2	Campbell	Jonathan Michael	Technician
3	Pebody	Corinne Anne	Scientist
4	Pabortsava	Katsiaryna	Scientist
5	Bett	Brian James	Scientist
6	Morris	Andrew	Scientist
7	Tamburini	Christian	Scientist
8	Riou	Virginie	Scientist
9	Garel	Marc	Scientist
10	Milligan	Rosanna	Scientist
11	Grange	Laura	Scientist
12	Young	Rob	Scientist
13	Baker	Chelsey	Scientist
14	Belcher	Anna	Scientist
15	Stefanoudis	Paris	Scientist
16	Charcos Llorens	Miguel	Scientist
17	Cavan	Emma	Scientist
18	Guasco	Sophie	Scientist
19	Duret	Manon	Scientist
20	Marsh	Lisa	Scientist
21	Provost	Paul	Technician
22	Whittle	Steve	Technician
23	Rundle	Nick	Technician
24	Phipps	Ritchie	Technician
25	Nemeth	Zoltan	Technician
26	Henson	Andy	Technician
27	Richardson	William	Technician
28	Bhairy	Nagib	Scientist
29	Clark	Joanne	Scientist

1.2 Ships Personnel

	Family Name	Given Names	Rank or Rating
1	Cox	Joanna Louise	Master
2	Gwinnell	James Marcus	C/O
3	Laidlow	Vanessa Ruth	2/O
4	Hoxby	Sean	3/O
5	Stoop	Marinus Johannes	C/E
6	Uttley	Christopher Paul	2/E
7	Nicholson	Gavin	3/E
8	Hamilton	John Angus	3/E
9	Brooks	Felix Robert Arthur	ETO
10	Rogers	Mark Alan	J/ETO
11	Lucas	Paul Derrick	PCO
12	Allison	Philip	CPOD
13	Smith	Stephen John	CPOS
14	McLennan	William	POD
15	Moore	Mark Stephen	SG1A
16	Lapsley	Craig James	SG1A
17	Crabb	Gary	SG1A
18	Lafferty	Raoul John	SG1A
19	Williams	Emlyn Gordon	ERPO
20	Ashfield	Mark James	H/Chef
21	Whalen	Amy Kerry	Chef
22	Orsborn	Jeffrey Alan	Stwd

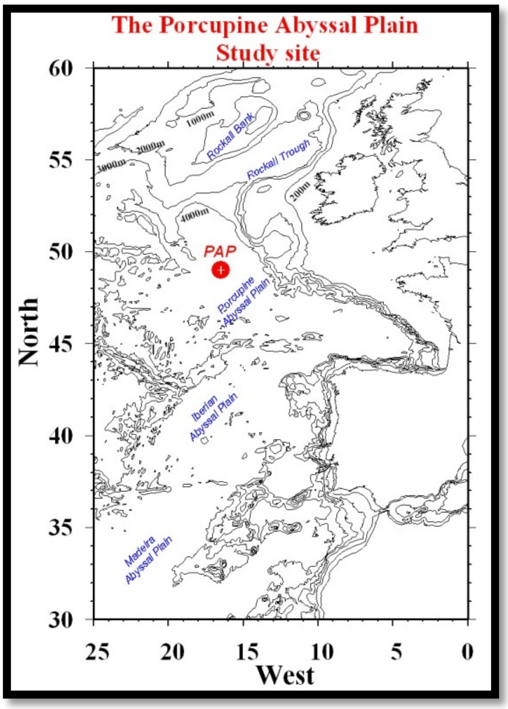
2 Itinerary

Discovery slipped moorings from Liverpool West Alexandra dock at 09:00 am on Saturday 20th June. Two Warsilla engineers sailed to fix propulsion problems that threatened to adversely affect the ship's ability to recover the PAP#1 mooring, the primary objective of the cruise. These adjustments were successful and the engineers were taken off by boat transfer in exchange for two additional scientists off Falmouth at midnight.

The consequence of the engineering adjustments was that *Discovery* did not reach the PAP site until 23/06/15 and sampling began at 00:32 on 24/06/15 with the MIO CTD. Winches were working well although some wires had been enthusiastically greased. The weather though not preventing work altogether had a serious affect in the order in which work was carried out. Days of higher wind a swell delayed deployment of PAP 1 and overside work was reviewed on a daily basis to optimise opportunity for all. Despite this samples and experiments were successful. The second otter trawl was curtailed due to wind and wave action causing drift that would have taken the trawl towards an undersea cable, but the first trawl was extremely successful with much plentiful material in all benthic groups.

The *Discovery* left the site at 21:04 on 04/07/15 and came alongside at Southampton NOC at 16:30 on 07/07/15, the evening before expected.

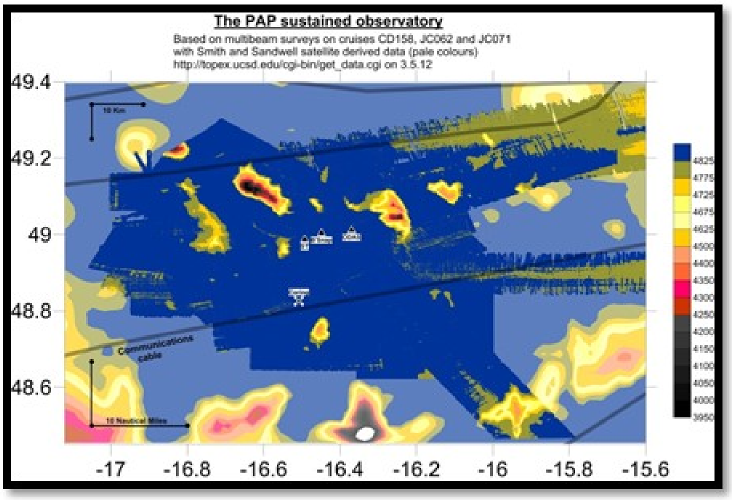
3 Background



The Porcupine Abyssal Plain Observatory is a sustained, multidisciplinary observatory in the North Atlantic coordinated by the National Oceanography Centre, Southampton. For over 20 years the observatory has provided key time-series datasets for analysing the effect of climate change on the open ocean and deep-sea ecosystems.

More information on PAP can be found in NOC's website at: http://noc.ac.uk/pap where the most current data can be found:http://noc.ac.uk/pap/data

PAP is one of the 23 fixed-point open ocean observatories included in the Europe-funded project FixO3, coordinated by Professor Richard Lampitt at NOC: http://www.fixo3.eu/



The 4-year project started in September 2013 with the aim to integrate the open ocean observatories operated by European organizations and is a collaboration of 29 partners from 10 different countries.

The PAP sustained observatory is about 300NM southwest of Ireland. Since 1989, this environmental study site in the Northeast Atlantic has become a major focus for international and interdisciplinary scientific research and monitoring including water column biogeochemistry, physics and seafloor biology. The first autonomous equipment included the sub-surface sediment trap mooring and the Bathysnap seafloor time-lapse camera system (both since 1989). Since 2002, a full depth multidisciplinary mooring has been in place with sensors taking a diverse set of biogeochemical and physical measurements of the upper 1000m of the water column. In 2010, collaboration between the Natural Environment research Council (NERC) and the UK Met Office led to the first atmospheric measurements at the site and this has continued since then to great effect.

The main mooring Ocean Data Acquisition System (ODAS) buoy ceased transmitting data in March, so a high priority was to recover the buoy and its stored data. In addition, we planned to recover a set of sediment traps which have been collecting sinking material in the lower part of the water column for the past 12 months and to deploy a new set. The Bathysnap time-lapse camera system which has been taking photos of the seabed at 4800m was to be recovered as well to give an assessment of the behaviour of the benthic animals and how the seabed appearance changes in response to deposition of material. A new one was to be deployed ready for recovery next year.

These are the autonomous systems, but as is usually the case with our trips to PAP, we planned to make observations on the temporal variability of the water column and seabed fauna - a task which is difficult or impossible to do autonomously. Furthermore we planned on this occasion to investigate the degradation of particles as they sink. Our colleagues from MIO carry out sophisticated interrogation using radiolabelling

4 Ship Systems

Zoltan Nemeth

The new RRS *Discovery* is broadly similar to the RRS *James Cook* and has a similar arrangement of instruments and sensors. This document provides a brief overview of what's on board; where it is; what it does; what its inputs and outputs are; and gives an indication of where to get more information. Datasheets for all instruments are provided on the Cruise disc.

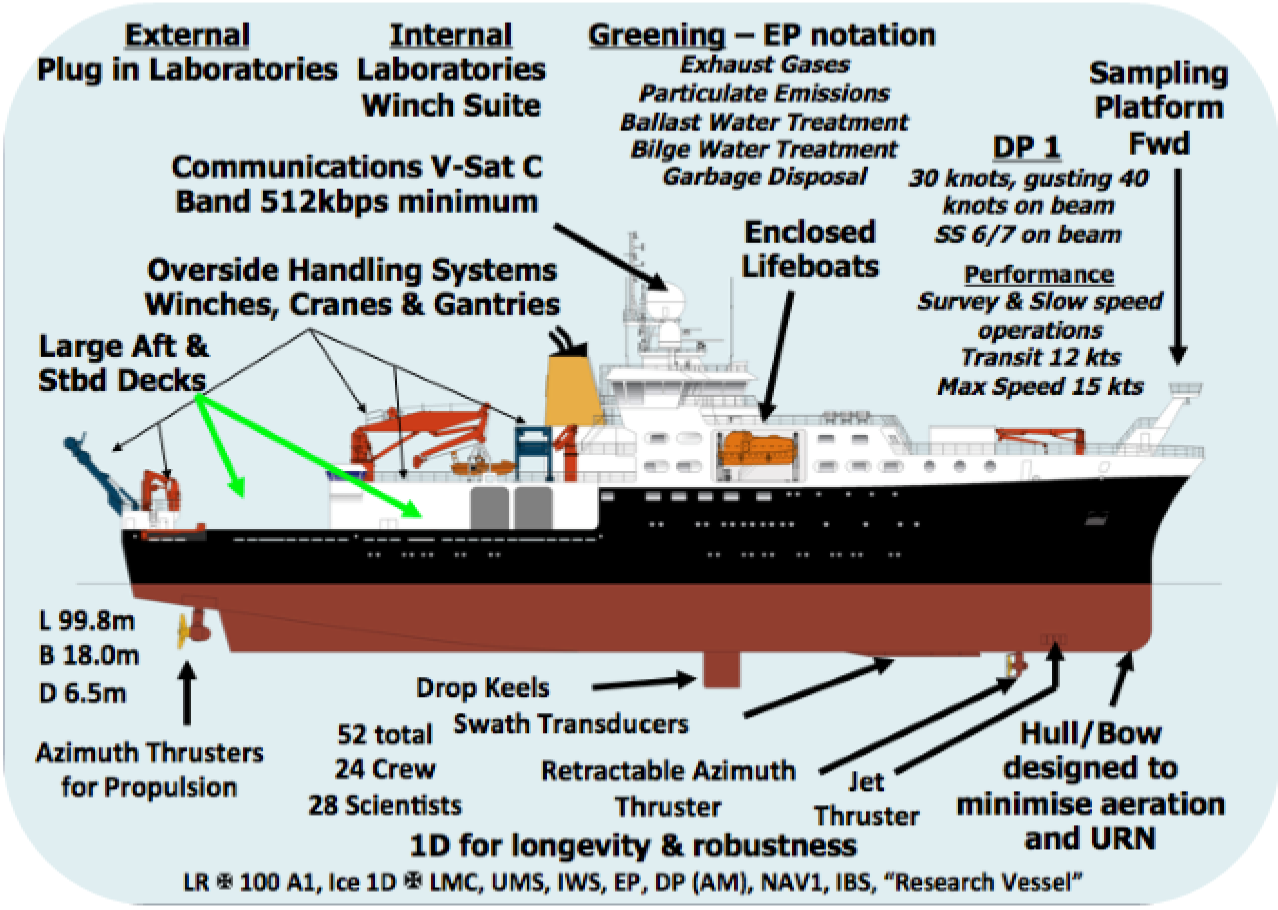


Fig 1. RRS *Discovery* in 2013

Full details of the shipboard systems are in appendix 4.

5 Mooring activities

Paul Provost, Steve Whittle, Nick Rundle, Ritchie Phipps, Andy Henson & William Richardson

The main mooring objectives of this cruise are as follows:

1) Replace the PAP 1 telemetry ODAS buoy subsurface frame but not the mooring beneath it.
2) Recover the PAP 3 sediment trap mooring deployed 2014
3) Deploy the PAP 3 sediment trap mooring.

All of the deck operations were performed successfully and as planned.

5.1 Dates and positions of mooring events:

PAP 1 ODAS buoy recovered

24th June 2015

49°00.30' N,

16°20.30'W

PAP 1 ODAS buoy deployed

1st July 2015

49°00.60' N,

16°20.20'W

PAP 3 mooring recovered

28th June 2015

48°59.10' N,

16°25.20'W

PAP 3 mooring deployed

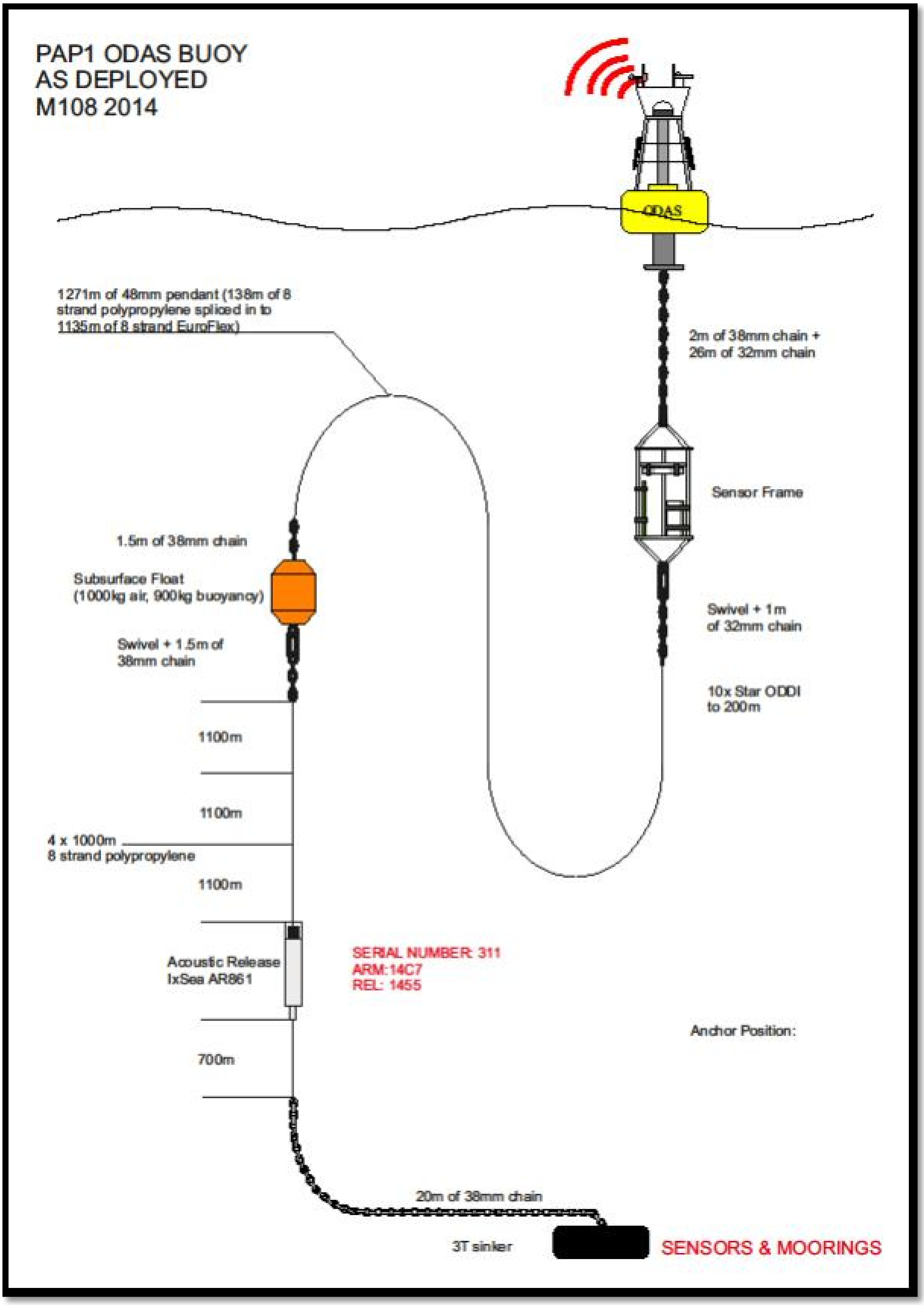
28th June 2015

49°01.50' N,

16°21.80'W

5.2 PAP#1 ODAS mooring

Mooring schematics Recovery and deployment of the PAP#1 ODAS buoy was completed using the aft gantry and a Lebus 5T deck winch mounted to starboard and the double barrel winch to steady the keel. During the time when the ODAS buoy was on deck having the keel changed and the instrument frame was replaced, the mooring was buoyed off using a 2 ton suitcase anchor pendant buoy.



The design of the mooring recovered and deployed are identical.

5.3 PAP#3 Sediment trap mooring

The PAP#3 moorings were recovered and deployed using the NMFSS double barrel capstan which and inline reeling winch system which was load-tested prior to commencement of operations. The moorings were recovered “top first”, and were deployed "top first, anchor-last", allowing the buoyancy to stream away from the vessel during deployment. Vessel speed varied between 0.5 and 1.5 knots during the mooring deployments.

5.3.1 PAP#3 Recovery

Upon recovery of the PAP#3 sediment trap mooring all instrumentation was washed in fresh water then dried before being opened or connected to a PC for downloading. Two Aanderaa RCM 11 current meters and one SeaBird SBE37 CTD in addition to the four Mclane Sediment Traps were successfully recovered.

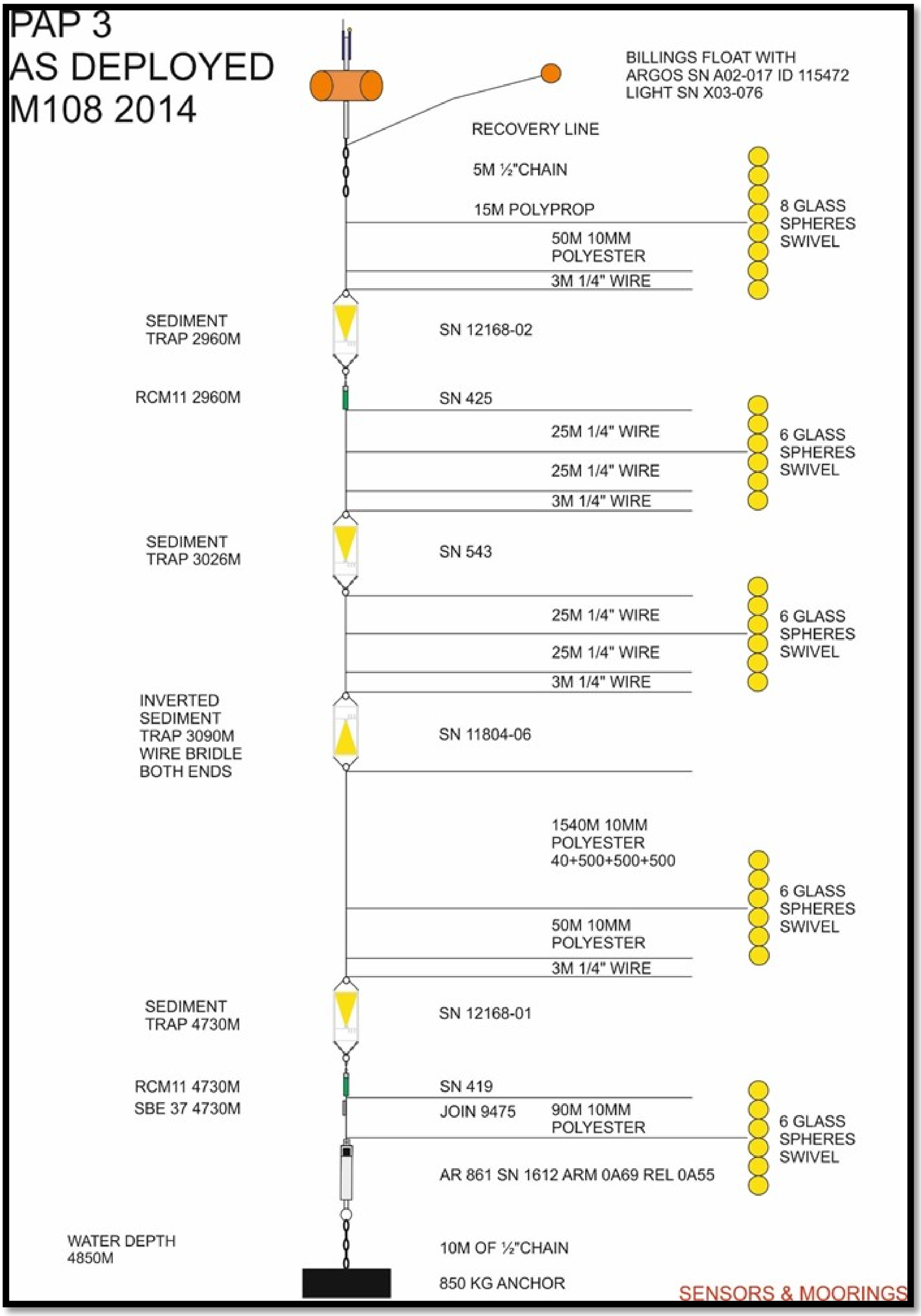
The SBE 37 was logging on recovery and provided a full data set for the deployment period.

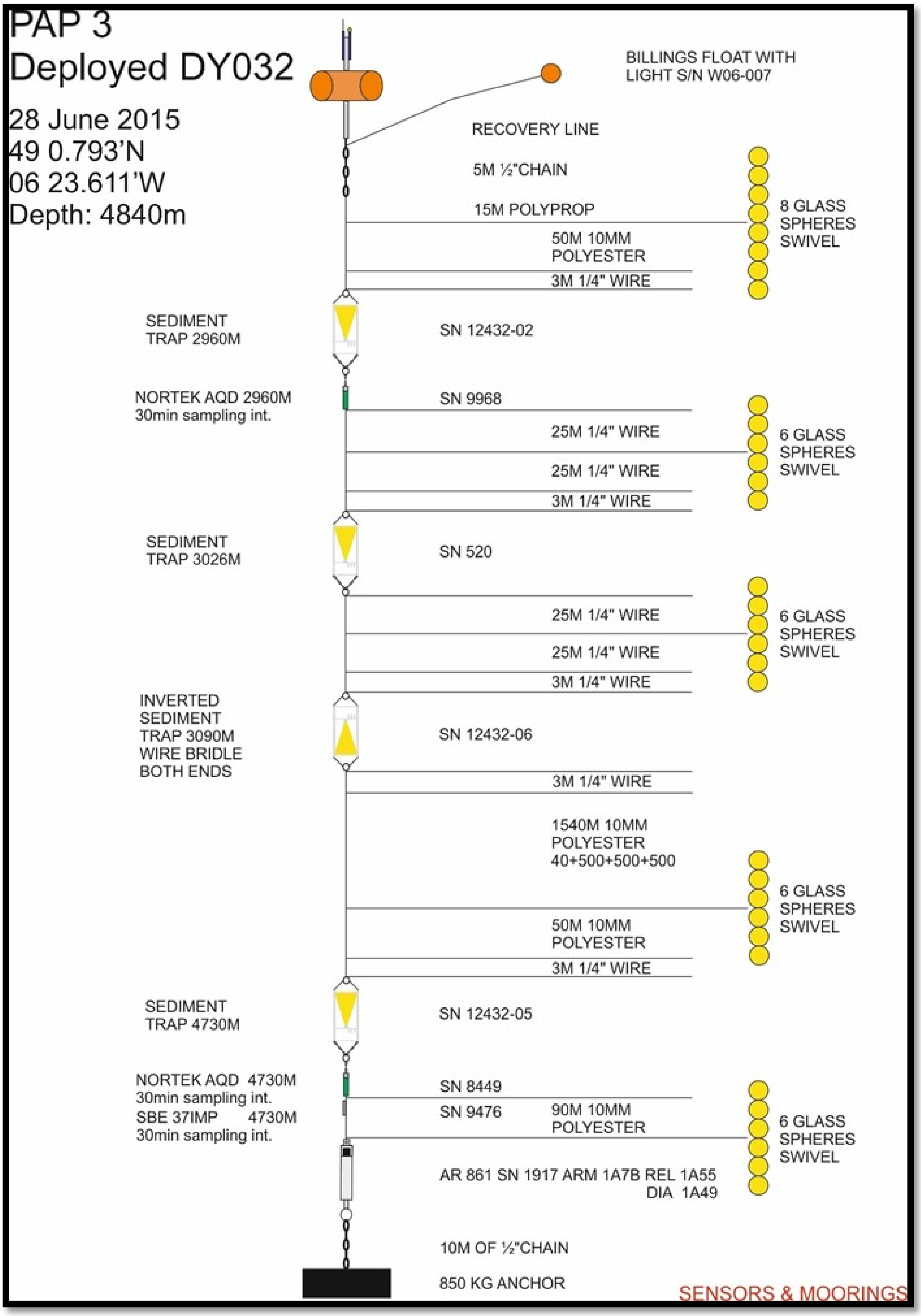
Both Aanderaa RCM 11 current meters were not logging on recovery. The data record stopped approximately two months before recovery due to battery failure.

5.3.2 PAP#3 Deployment

Sediment trap programming was completed by the scientific party, all hardware rigging and battery fitting was completed by the technical party. New cells were fitted to each of the sediment traps after they had been setup but prior to programming.

The sampling frequency for the Nortek acoustic current meters was set to 30 minute intervals and the SeaBird SBE37 CTD sampling frequency was set to a 15 minute sampling interval.


PAP 3
AS DEPLOYED
M108 2014
BILLINGS FLOAT WITH
ARGOS SN A02-017 ID 115472
LIGHT SN X03-076
RECOVERY LINE
5M ½"CHAIN
15M POLYPROP
8 GLASS
SPHERES
SWIVEL
50M 10MM
POLYESTER
3M 1/4" WIRE
SEDIMENT
TRAP 2960M
SN 12168-02
RCM11 2960M
SN 425
25M 1/4" WIRE
6 GLASS
SPHERES
SWIVEL
25M 1/4" WIRE
3M 1/4" WIRE
SEDIMENT
TRAP 3026M
SN 543
25M 1/4" WIRE
6 GLASS
SPHERES
SWIVEL
25M 1/4" WIRE
3M 1/4" WIRE
INVERTED
SEDIMENT
TRAP 3090M
WIRE BRIDLE
BOTH ENDS
SN 11804-06
1540M 10MM
POLYESTER
40+500+500+500
6 GLASS
SPHERES
SWIVEL
50M 10MM
POLYESTER
3M 1/4" WIRE
SEDIMENT
TRAP 4730M
SN 12168-01
RCM11 4730M
SBE 37 4730M
SN 419
JOIN 9475
90M 10MM
POLYESTER
6 GLASS
SPHERES
SWIVEL
AR 861 SN 1612 ARM 0A69 REL 0A55
WATER DEPTH
4850M
10M OF ½"CHAIN
850 KG ANCHOR
SENSORS & MOORINGS



PAP 3
Deployed DY032
28 June 2015
49 0.793'N
06 23.611'W
Depth: 4840m
BILLINGS FLOAT WITH LIGHT S/N W06-007
RECOVERY LINE
5M ½"CHAIN
15M POLYPROP
8 GLASS SPHERES SWIVEL
50M 10MM POLYESTER
3M 1/4" WIRE
SEDIMENT TRAP 2960M
SN 12432-02
NORTEK AQD 2960M
30min sampling int.
SN 9968
25M 1/4" WIRE
6 GLASS SPHERES SWIVEL
25M 1/4" WIRE
3M 1/4" WIRE
SEDIMENT TRAP 3026M
SN 520
25M 1/4" WIRE
6 GLASS SPHERES SWIVEL
25M 1/4" WIRE
3M 1/4" WIRE
INVERTED SEDIMENT TRAP 3090M WIRE BRIDLE BOTH ENDS
SN 12432-06
3M 1/4" WIRE
1540M 10MM POLYESTER
40+500+500+500
6 GLASS SPHERES SWIVEL
50M 10MM POLYESTER
3M 1/4" WIRE
SEDIMENT TRAP 4730M
SN 12432-05
NORTEK AQD 4730M
30min sampling int.
SBE 37IMP 4730M
30min sampling int.
SN 8449
SN 9476
90M 10MM POLYESTER
6 GLASS SPHERES SWIVEL
AR 861 SN 1917 ARM 1A7B REL 1A55
DIA 1A49
10M OF ½"CHAIN
850 KG ANCHOR
SENSORS & MOORINGS

6 PAP#1 Observatory

Corinne Pebody, Katsia Pabortsava, Andrew Morris, Jon Campbell and Miguel Charcos Llorens

6.1 General Description

The PAP telemetry system comprises a buoy telemetry electronics unit and a data concentrator hub in the sensor frame. Schematic drawings of these two units as configured for the latest deployment are shown in Figure 4 and Figure 5. Data are typically transmitted via the Iridium satellite system every 4 hours and are automatically displayed on the EuroSITES website: http://www.eurosites.info/pap/data.php. Short status messages are typically sent via the Iridium SBD (Short Burst Data) email system every 4 hours. The SBD email system is also used to send commands to the buoy to change sampling intervals, disable/enable sensors and to vary other settings. The frequency of the data transmission and SBD emails can be changed remotely using an SBD command.

The buoy also houses an entirely separate system provided by the UK Met Office which has its own Iridium telemetry system and a suite of meteorological sensors measuring wind velocity, wave spectra and atmospheric temperature, pressure and humidity. Data from these sensors are telemetered to the Met Office every hour.

The previous PAP Observatory system was deployed on July 2014 on cruise M108. The system deployed last year has been recording data internally on the sensors for the entire year. These data were transmitted remotely for 8 months before we started noticing problems with the iridium communications. More details of the recovered system are in the corresponding section below.

The goal of this cruise is to recover the data from the sensors of the frame and the buoy as well as the telemetry and data hub electronics. Then, deploy the new set of electronics and sensors that will be deployed for a year in 2015-2016. The PAP1 mooring rope will be re-used as well as the buoy and the Met Office equipment. The keel of the buoy will be replaced. All the science sensors will be replaced including the Star-Oddis on the chain and frame.

In this document, we describe the systems that were deployed in 2015 and the status of the system that was recovered from the deployment in 2014. Section 6.2 describes the observatory including the changes to the telemetry and data hub systems. Section 6.4 is devoted to the calibration and configuration of the deployed sensors. Section 6.6 includes an analysis of the status of the recovered telemetry and data hub systems. Finally, section 6.7 includes a description and post-deployment calibration of the sensors that were deployed in 2014 and recovered during this cruise.

6.2 Deployed PAP#1 Description

6.2.1 Design modifications

6.2.1.1 Software Updates

A duplicate of the current system was used after the successful deployment of previous year. The differences between the two electronics are minimal. Most of the changes happened from a software point of view in an attempt to include acoustic modem communications between the buoy and the data hub as a backup for the cable communication in the event of a failure of the cable. Various reasons lead to the decision of not installing the acoustic modem on the system. Firstly, we found a problem with the system that seems to be strengthening when the acoustic modem is connected. This could potentially compromise the rest of the system and it was decided that it needs to be further analysis before proceeding with the deployment of the acoustic mode. When the system was recovered, we verified that the cable connecting the buoy and the frame did not suffer any damage. We used a polyurethane sheathed cable to carry a 30V power supply, RS-232 communications and inductive communications between the buoy and the Data Hub. Additional protection is provided by fitting the cable inside steel-reinforced hydraulic hosing and this hosing is clamped to the mooring chain with plastic clamps (see Figure 2). A few metres of large diameter hydraulic hose was also placed over the mooring chain immediately above the sensor frame, to prevent the chain collapsing and striking the frame in severe weather (see Figure 3). This year system will use the same setup and therefore the chances of failure of the cable are small based on the previous year deployment. The balance between these two factors indicates that there are lesser risks by not including the acoustic modem on the deployed system. Because the libraries including on the software did not have any impact on the rest of the system and it includes other improvements defined in the development wiki page of the project (http://twiki.noc.soton.ac.uk/twiki/bin/view/PAP/PapTechDevelopment). The version that was deployed is a pre-released v1.0.

6.2.1.2 Data Hub and Telemetry systems

The previous Data Hub and telemetry system demonstrated being a good solution for a year deployment at PAP. We purchased a new housing from Develogic identical to the one that was recovered during this cruise, featuring a glass-reinforced plastic tube with titanium end caps and four large, 16-way Subconn connectors to carry signals to the sensors and the buoy. The housing also incorporates a substantial battery pack which could be used to power the hub in the event that the cable to the buoy was damaged. Since the acoustic modem was not deployed during this cruise, we decided that it was not necessary the additional power on the hub and the batteries were not included on the housing.

We used the same printed circuit boards (PCB) that were designed by Jon Campbell for the 2014 deployment and manufactured to fit in the Develogic housing. This board carries a Persistor CF2 microcomputer, two 8-channel UART (Universal Asynchronous Receiver transmitter) devices providing 16 serial communication ports and switched power supplies for some of the sensors. A small compass, pitch and roll board is mounted on the main PCB, along with temperature and humidity sensors. The electronics also include a triaxial accelerometer. However, we suspect that the accelerometer readings could be one of reasons of the failure this year. Therefore, we decided to remove the functionality from the software at the buoy and the accelerometer cannot be controlled during this deployment. This will avoid conflicts between the accelerometer and GPS readings which are very demanding on the memory card access. The decision was also supported by the fact that the data of the accelerometer has currently not being used and there are no scientific reasons to take the risk of failure.

The system was carefully tested at NOC by Miguel Charcos Llorens. The setup was similar to the one deployed. A few systems had to be tested again on board due mainly to some modifications to the test harnesses during the cruise. For instance, the ISUS sensor required a different connector for the voltage provided by the data hub. In addition, the cable between the data hub and telemetry system was not tested before getting on board. Another major change was the fact that we decided to have two batteries for the CO2 sensor on the frame. Since this also required a change on the harness, we used the harness that we recovered from the frame. A new harness was also made for the phosphate sensor since the acoustic modem was not going to be deployed. These last minute changes indicate that a better effort need to be done in future deployments since the changes on the harnesses may have a major impact on the performance of the observatory.

Other minor modifications on board included re-configuration of the Seaguard. Also, sensors that needed to be on the CTD needed to be reconfigured. Check lists for pre-deployment configurations will also be a major asset to decrease the risks during deployment preparation.

Figure 2: Buoy-to-Hub cable inside hydraulic hose clamped to mooring chain

Figure 3: Sensor frame being deployed showing large hydraulic hose over mooring chain

6.2.1.3 Sensor frame

Other modifications of the observatory include the clamps of the sensors. Nick Rundle created a CAD model of the frame system to optimise the solutions to clamp the sensors on the frame. These models will be used in future developments of the frame, saving time and decreasing the risk of failure. The sensor frame design proved to be effective for the past two previous deployments and thus, we used the same design. The OceanSonic batteries were re-fitted and used again for this deployment. The ZPS plankton sampler was not mounted because we could not recover the pump. We replaced the SUNA sensor with the ISUS sensor with the required cable and software modifications.

6.3 Deployment and initial performance

The PAP1 deployment commenced at 10:00 on 1st July 2015 and proceeded smoothly until 12:00. Data telemetered to NOC from the buoy were accessed via FTP using the ship's Internet connection and indicated that all the sensors were functioning. Once the frame was in the water, email commands were sent to switch on the Data Hub, the Satlantic OCR irradiance sensors, the CO2 and Sensor Lab pH sensor on the keel and the GTD sensor in the frame. The sampling regimes of these sensors may be altered by sending further email commands. The default sampling regime is shown in Table 1: Sensors fitted on buoy and sensor frame for July 2015 deployment.

Table 1: Sensors fitted on buoy and sensor frame for July 2015 deployment

PAP April 2015 sensor configuration	**Serial number**	**Sample interval**	**Minutes past the hour**	**Power source**
ON BUOY		Highlighted are remotely adjustable		
Pro-Oceanus CO2-Pro	29-097-45	12 hrs	19	Buoy
SeaBird SBE-37IMP IDO MicroCAT	13397	30 mins	0	Internal batteries
Satlantic OCR-507 ICSA (buoy)	226	30 mins	17	Buoy
Satlantic SeaFET pH	257	30 mins	27	Pro-Oceanus 266Ah battery housing
Sensor Lab SP101-Sm pH sensor	on loan	3 hrs	26	Buoy
IN SENSOR FRAME				
SeaBird SBE-37IMP-ODO MicroCAT	10535	30 mins	0	Internal batteries
SeaBird SBE-37IMP MicroCAT	6904	15 mins	0	Internal batteries
WETLabs FLNTUSB Fluorometer	3050	4 hrs	0	Internal batteries
Satlantic ISUS Nitrate sensor	59	1 hr	20	Satlantic 102Ah battery pack
Satlantic SeaFET pH sensor	63	30 mins	23	OceanSonics 200Ah battery housing
Aanderaa Seaguard	1614	1 hr	30	Internal batteries

Aanderaa 4330 optode in Seaguard	2001			
Turner Cyclops Fluorometer in Seaguard	2103960			
ZebraTech Wiper for Cyclops		6 hrs	0	Internal batteries
Satlantic OCR-507 ICSW irradiance	287	30 mins	17	Buoy via Data Hub
Satlantic OCR-507 R10W radiance	113	30 mins	17	Buoy via Data Hub
Pro-Oceanus Logging CO2-Pro	33-146-45	12 hrs	59	Two OceanSonics 200Ah battery housings
Pro-Oceanus GTD-Pro	26-049-09	6 hrs	56	Buoy via Data Hub
Data Hub in Develogic battery housing				Buoy
Star-Oddi DST TILT	H454	1Hz bursts		Internal batteries

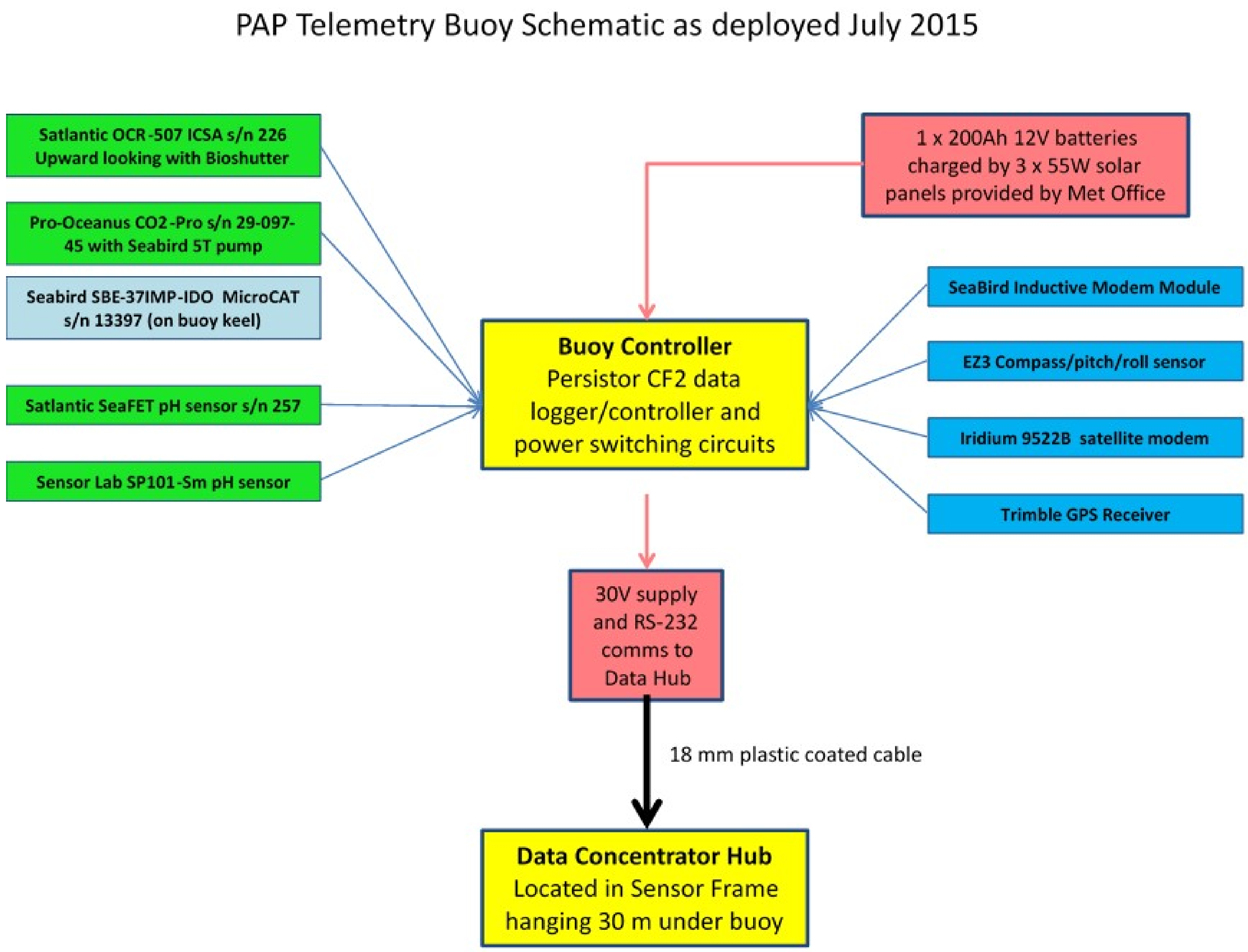


Figure 4: PAP Telemetry Buoy Schematic as Deployed in 2015

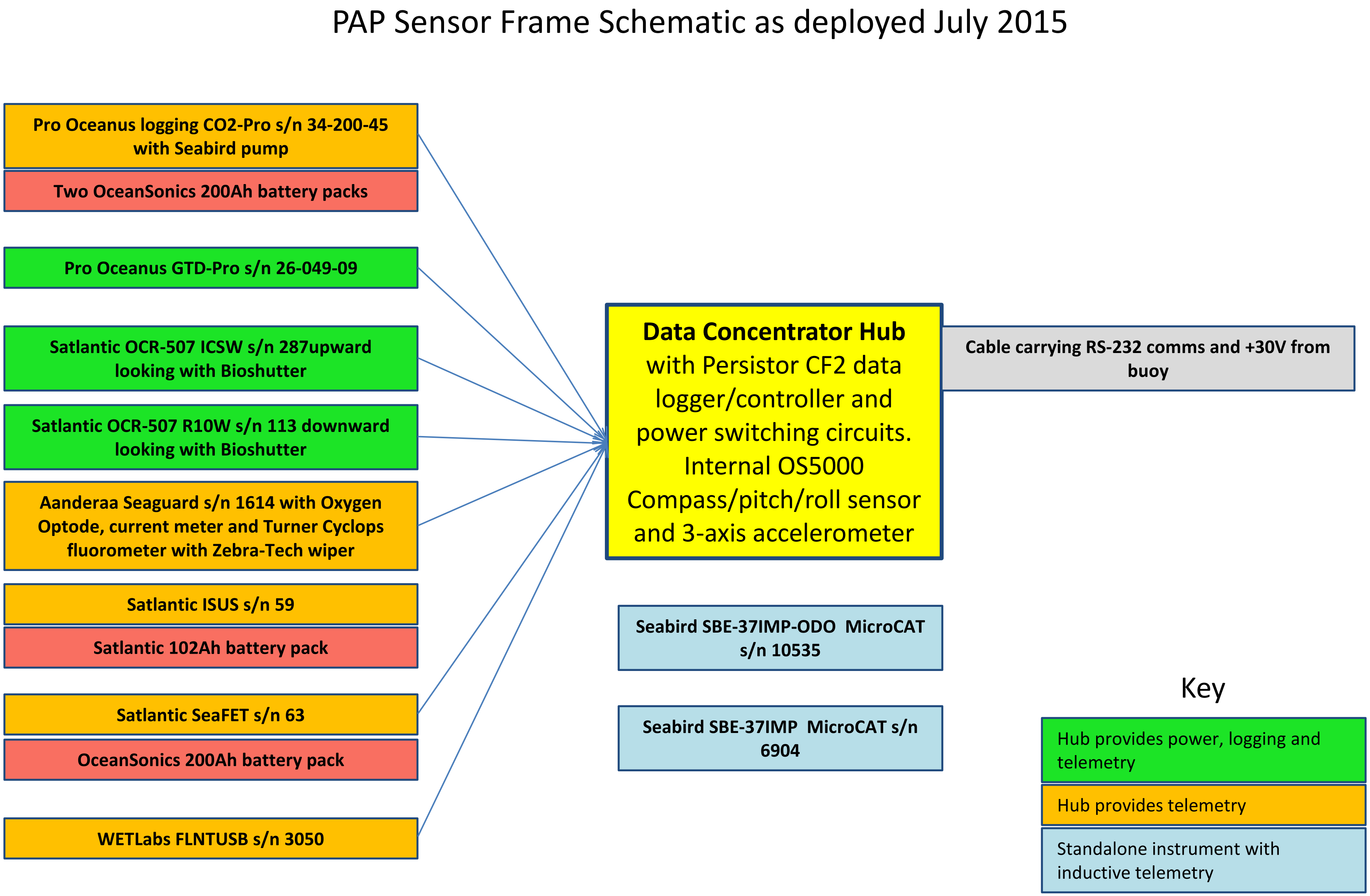


Figure 5: PAP Frame Schematic as Deployed in 2015

6.4 PAP#1 CTD rosette calibration samples

Corinne Pebody

There were two CTDs prior to deployment to PAP1, one shallow and one deep. Water samples were collected in order to provide comparison for PAP 1 instrumentation to be deployed. A second shallow and deep pair were taken after PAP 1 recovery to provide comparisons for recovered instruments.

Depth (m)	DIC	Oxygen	Chlorophyll	Nutrients	Salts	POC	Ammonium
5	DYO32-020, DYO32-076	DY032-020, DY032-076	DYO32-020, DYO32-076	DYO32-020, DYO32-076	DYO32-020, DYO32-076	DYO32-076	DYO32-020, DYO32-076
10	DYO32-020, DYO32-021, DYO32-076	DY032-020, DY032-021, DY032-076	DYO32-020, DYO32-021, DYO32-076	DYO32-020, DYO32-021, DYO32-076	DYO32-020, DYO32-021, DYO32-076	DYO32-020, DYO32-021, DYO32-076	DYO32-020, DYO32-021, DYO32-076
15	DYO32-076	DY032-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076
20	DYO32-020	DY032-020	DYO32-020	DYO32-020	DYO32-020	DYO32-020	DYO32-020
25	DYO32-076	DY032-021, DY032-076, DY032-105	DYO32-021, DYO32-076	DYO32-076	DYO32-076, DYO32-021	DYO32-076	DYO32-021, DYO32-076, DY032-105
30	DYO32-020,DYO32-076	DY032-020, DY032-076	DYO32-020, DYO32-076	DYO32-020, DYO32-076	DYO32-020, DYO32-076	DYO32-076	DYO32-020, DYO32-076
35	DYO32-076	DY032-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076
40	DYO32-020	DY032-020	DYO32-020	DYO32-020	DYO32-020	DYO32-020	DYO32-020
45	DYO32-076	DY032-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076
50	DYO32-020, DYO32-021	DY032-020, DY032-021	DYO32-020, DYO32-021	DYO32-020, DYO32-021	DYO32-020, DYO32-021	DYO32-020, DYO32-021	DYO32-020, DYO32-021
55	DYO32-076	DY032-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076
60	DYO32-020	DY032-020, DY032-105	DYO32-020	DYO32-020	DYO32-020	DYO32-020	DYO32-020, DY032-105
70	DYO32-076	DY032-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076	DYO32-076
80	DYO32-020, DYO32-076	DY032-020, DY032-076, DY032-105	DYO32-020, DYO32-076	DYO32-020, DYO32-076	DYO32-020, DYO32-076	DYO32-020, DYO32-076	DYO32-020, DYO32-076, DY032-105
100	DYO32-020, DYO32-021, DYO32-076,	DY032-020, DY032-021, DY032-076,	DYO32-020, DYO32-021, DYO32-076,	DYO32-020, DYO32-021, DYO32-076,	DYO32-020, DYO32-021, DYO32-076,	DYO32-020, DYO32-021, DYO32-076,	DYO32-020, DYO32-021, DYO32-076,
150	DYO32-020, DYO32-021	DY032-020, DY032-021, DY032-105	DYO32-020, DYO32-021	DYO32-020, DYO32-021	DYO32-020, DYO32-021	DYO32-020, DYO32-021	DYO32-020, DYO32-021, DY032-105
200	DYO32-020	DY032-020	DYO32-020	DYO32-020	DYO32-020	DYO32-020	DYO32-020

250	DYO32-021	DY032-021, DY032-105	DYO32-021	DYO32-021	DYO32-021	DYO32-021	DYO32-021, DY032-105
400	DYO32-021	DY032-021	N/A	DYO32-021	DYO32-021	DYO32-021	DYO32-021
600	DYO32-021	DY032-021, DY032-105		DYO32-021	DYO32-021	DYO32-021	DYO32-021, DY032-105
855	DYO32-021	DY032-021	N/A	DYO32-021	DYO32-021	DYO32-021	DYO32-021
1120	DYO32-021	DY032-021, DY032-105	N/A	DYO32-021	DYO32-021	DYO32-021	DYO32-021
2000	DYO32-021	DY032-021, DY032-105	N/A	DYO32-021	DYO32-021	DYO32-021	DYO32-021
2300	DYO32-021	DY032-021	N/A	DYO32-021	DYO32-021	DYO32-021	DYO32-021
3333	DYO32-021	DY032-021, DY032-105	N/A	DYO32-021	DYO32-021	DYO32-021	DYO32-021
4000	DYO32-021	DY032-021, DY032-105	N/A	DYO32-021	DYO32-021	DYO32-021	DYO32-021
4815	DYO32-021	DY032-105	N/A	DYO32-021	DYO32-021	DYO32-021	DYO32-021

6.5 PAP#1 Deployed Sensors

6.5.1 Aanderaa Seaguard

s/n1614

The Seaguard platform (SN 1130) is equipped with the following sensor nodes:

- Aanderaa 4339 oxygen optode (SN 2001)
- Turner Cyclops fluorometer (SN 2103960)
- DCS current meter (SN 685)

6.5.1.1 Bench Calibration

The RCM Seaguard with Oxygen optode and fluorometer have been procured and prepared for deployment as part of the PAP1 sensor frame. Initial set-up and preliminary checks in the lab and whilst on board showed the Seaguard to be in proper working order and correctly communicating with the central Hub of PAP1.

6.5.1.2 Pre-Deployment Calibration on a CTD Frame

Figure 6 Pre-deployment calibration CTD with Seaguard in place of one of the 20 l Niskin bottles, please note the Turner Cyclops fluorometer mounted on the top bar facing out of the CTD rosette.

The Seaguard was deployed on CTD cast 020 (see Figure 6) in order to calibrate the oxygen optode and fluorometer against the CTD sensors. The CTD cast went down to 200 m. Waters were collected by Niskin and later analysed through Winkler titration for Oxygen to calibrate the Aanderaa optode. The Turner Cyclops fluorometer was calibrated against the Wetlab sensor which was mounted on the base of the CTD. The results from the fluorometer are at Section 6.5.3. The RCM was not tested.

The oxygen data from the Seaguard was corrected for pressure and salinity using the equations provided in the optode manual and the pressure and salinity readings from the CTD's SBE9+, the temperature data was taken from the optode as it was closest to the sensing membrane.

The pressure and salinity corrected oxygen data was then compared to the levels read from Winkler. The result of this comparison is the calibration presented in Figure 7.

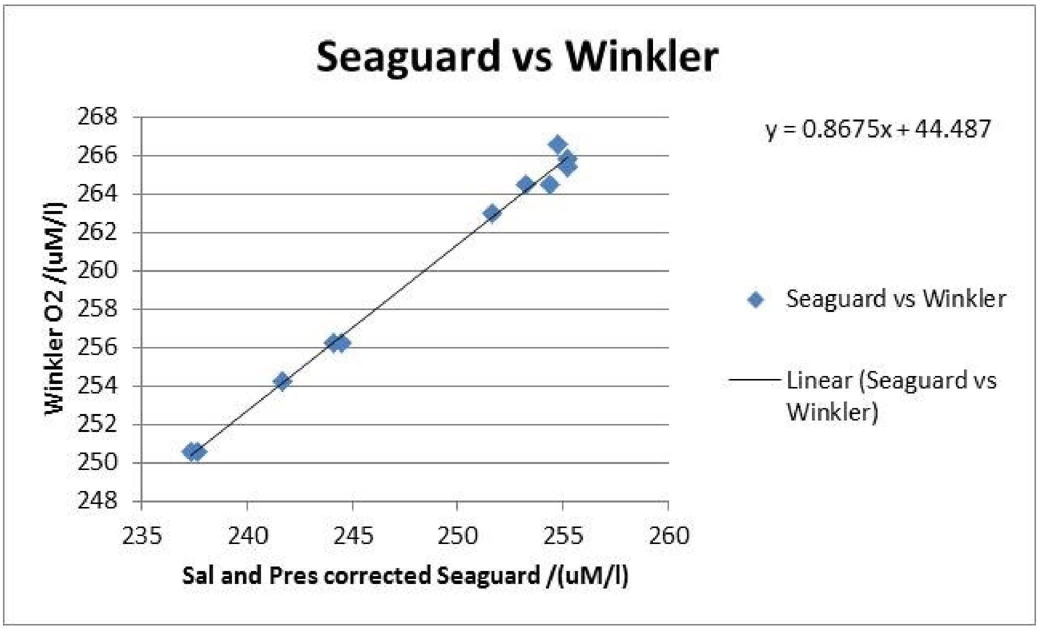


Figure 7 Corrected Seaguard vs Winkler.

Whilst the calibration dip did not span a large oxygen concentration the relationship appears to be linear across the range that is sampled. The result is also within Aanderaa's accuracy specification of 5%. It is therefore likely that this correction is suitable for the PAP deployment (NB correction only valid after first applying pressure and salinity corrections to Seaguard data).

6.5.1.3 Deployment on the PAP sensor Frame

The Seaguard was set-up and secured in its pressure housing. The unit was then integrated into the sensor frame (see Figure 8). The unit was armed to start operating before deployment to ensure correct communication to the Hub, 12.30 27/06/2015. The scheduling for deployment was to perform a measurement every hour on the half hour, so as to spread inputs to the Hub.

The Cyclops Turner fluorometer was mounted in the ZebraTech wiper and set to activate every 6 hrs, it was started at 14.00 28/06/2015. Having the wiper activate on the hour meant that there was the minimum chance that a wipe could happen at the same time as a measurement by the fluorometer, although the wiper time would have to drift well beyond specification for this to be a problem.

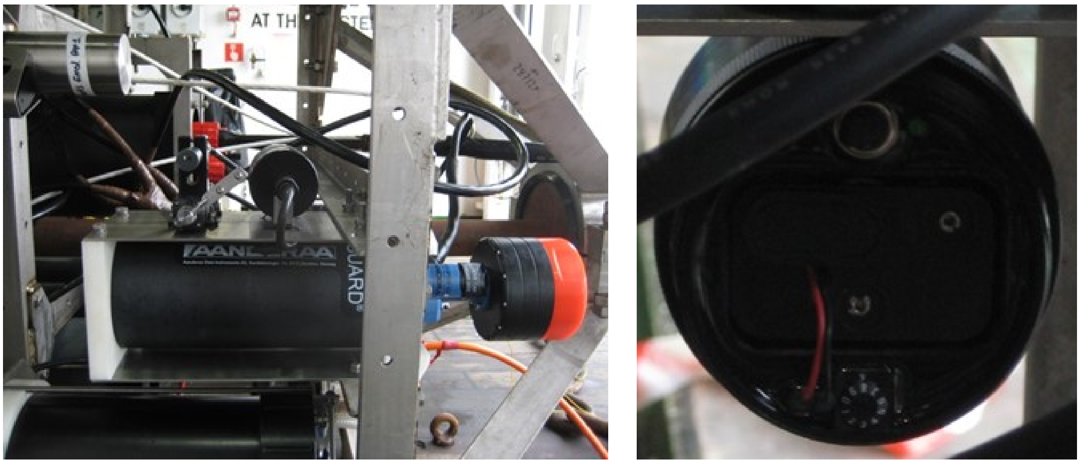


Figure 8 Left, Seaguard mounted in PAP1 sensor frame before full integration of all sensors and harnessing. Right, image of ZebraTech wiper (taken before turning on) with back cover off showing position of timer.

Extra heat shrink was also added to one of the cable arms from the Seaguard that linked with the Hub in attempt to better protect it from flexing while deployed (see Figure 9).

Figure 9 Image of the cable arm from Seaguard with additional heat shrink.

6.5.2 ISUS Nitrate Sensor (S/N: 59)

6.5.2.1 Bench Calibration

The ISUS nitrate sensor was calibrated in the lab at NOC (15.05.2014) and on board of RRS *Discovery* (21.06.2015) by Katsiaryna Pabortsava using one point calibration method, involving a set of nitrate calibration standards of 5, 10, 20, and 40µM concentrations prepared using a nitrate standard stock of 1000 µM and ultra-pure deionised water (Milli-Q DIW). The in-lab calibration agreed well with the manufacturer's calibration (Figure 10). The Milli-Q DIW sample for both in-lab and on-board bench calibration was in the range of the Satlantic's specifications of 0±2 µM for Milli-Q DIW.

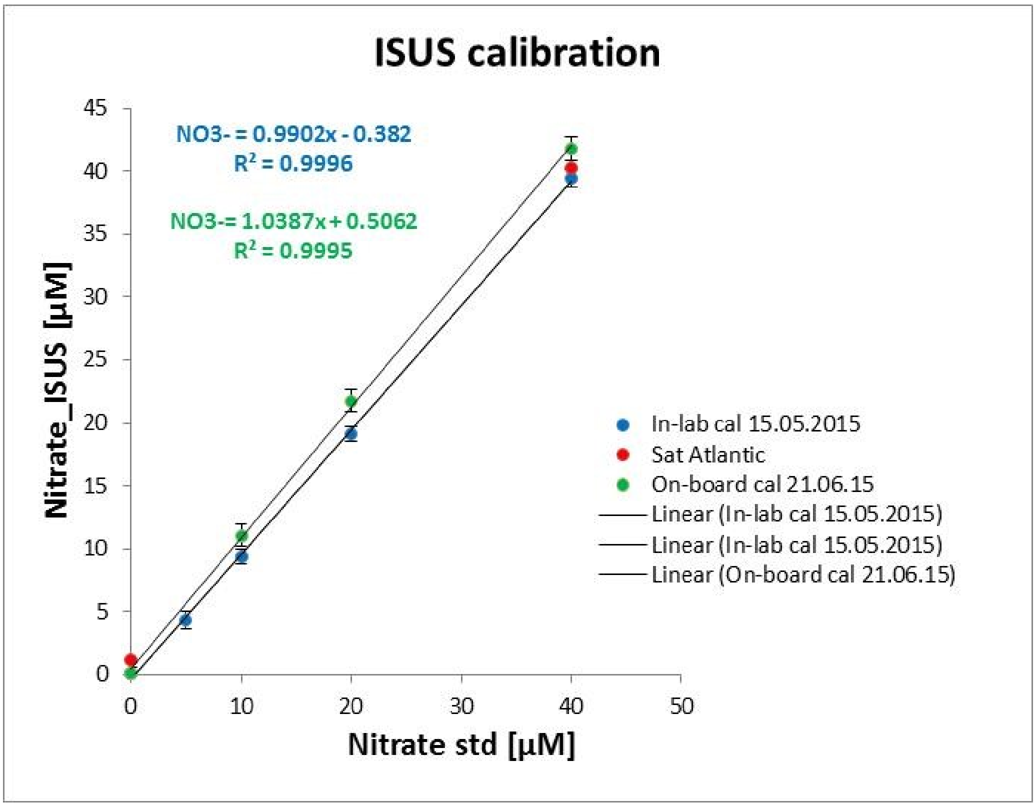


Figure 10: ISUS Nitrate sensor calibration

6.5.2.2 Pre-Deployment Calibration on a CTD Frame

The pre-deployment calibration of the ISUS sensor took place on 25.06.2015 during CTD DY032_020 deployment to 200 m depth. The connection with the sensor was established through ISUSCom 2.1.6 ware downloaded on a 64-bit PC. The sensor was mounted horizontally onto the CTD rosette frame and connected to Seabird CTD by Jon Campbell and Paul Provost. The ISUS was set to sample in a CONTINUOUS mode recording EACHEVENT of sampling to its internal memory. Upon recovery the ISUS data were downloaded. The ISUS measurements will be calibrated against Total Oxidised Nitrogen measurements (TON=NO_3^- +NO_2^-) from the Niskin bottles sampled at 10 discrete depths (5, 10, 20, 30, 40, 50, 60, 80, 100, 150 and 200 m).

6.5.2.3 Deployment on the PAP#1 sensor Frame

The ISUS sensor was mounted horizontally (sensor slot vertical) onto the sensor frame deployed at 30 m depth. The sensor is usually powered from a 102Ah battery pack, but can be powered from the Hub via email command. The copper coated guard with 100µm filter was used to protect the probe tip over the duration of the sensor deployment. The ISUS was synchronised with the PC time (GMT) and configured to sample in a SCHEDULED based operation logging the data DAILY into ASCII file. The sampling interval was set to 1 hour with 20 min offset past the hour and 10 sec of logging. This would produce 1 Dark Frame + 5 Light Frames. This configuration gives >500 days of battery duration and >3000 days of lamp duration. The sensor configuration is shown in Figure 11 and Figure 12.

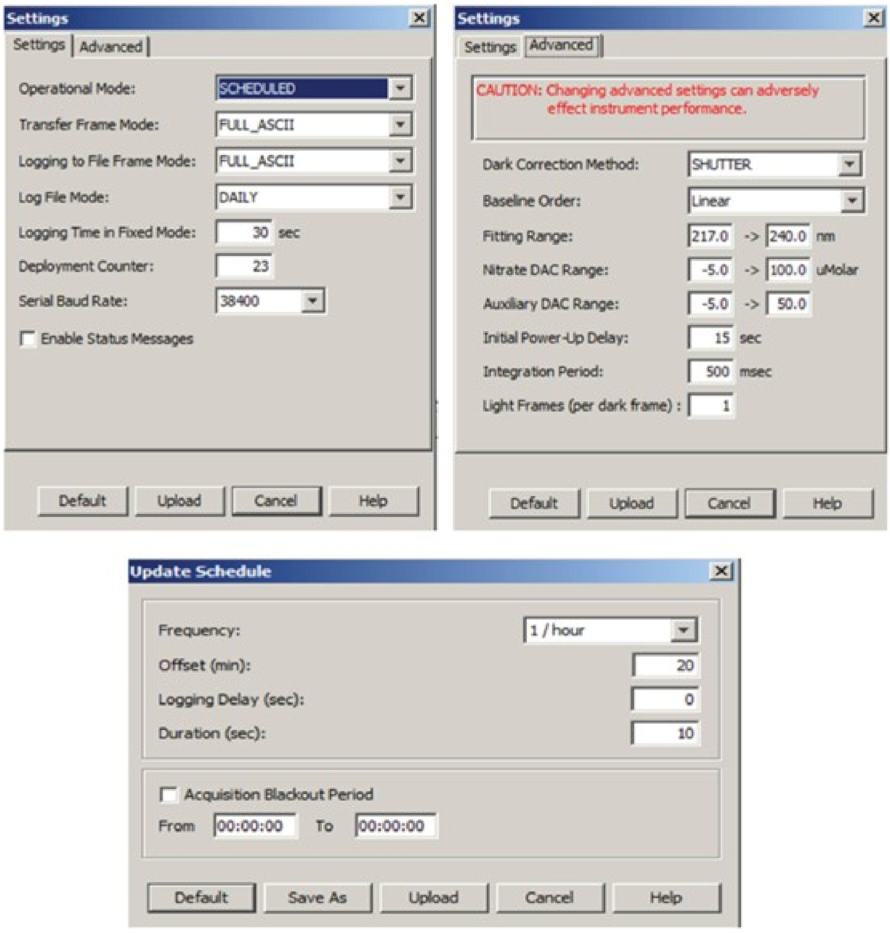


Figure 11: The ISUS configuration for the deployment on the PAP sensor frame.

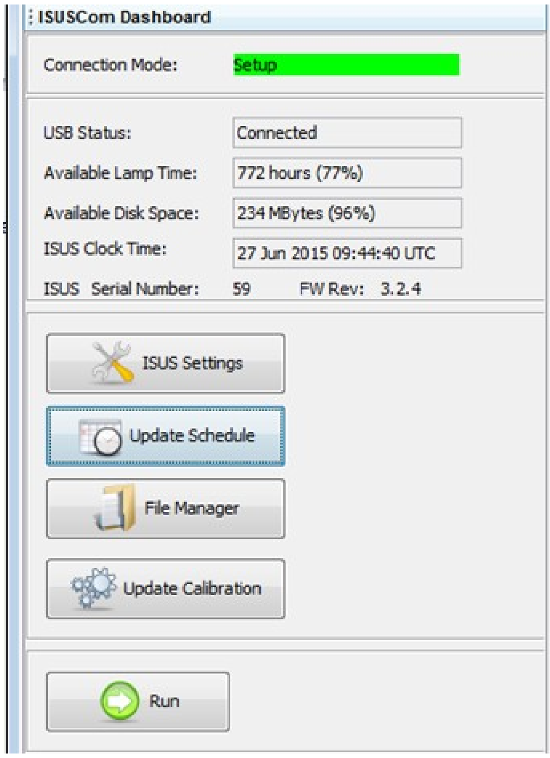


Figure 12: ISUS properties at deployment

Although the ISUS sensor was working normally on deck immediately before the deployment, no messages from it were received after the deployment. An email command was sent to the data hub to switch on the back-up power supply and messages from the ISUS commenced again. It seems likely that the brand new Satlantic battery housing powering the ISUS failed as soon as it entered the water.

6.5.3 WETLabs Fluorometer

ECO-FLNTUSB (S/N: 3050)

After the calibration the instrument was set up for the mooring deployment. The ECO will produce a set of 8 measurements every 4 hours, Since it was deployed the ECO is performing as expected. ECO-FLNTUSB (S/N: 3050)

The calibration was factor is

True chlorophyll = 0.3425 x flnt usb +0.0911 with an r^2 of 0.9932

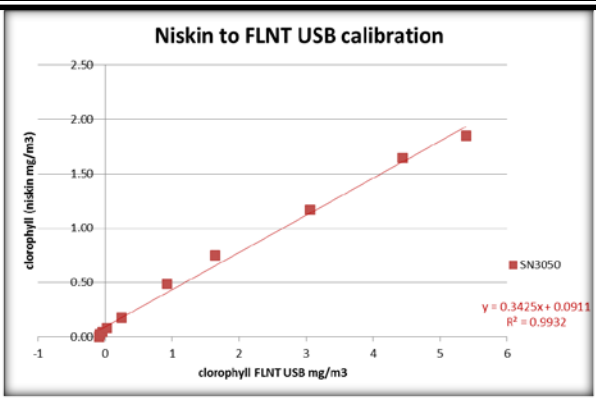


Figure 1 chlorophyll calibration flnt usb vs niskin samples

Figure 2 wetlabs position on frame

The initial position on the frame would have resulted in the 30° cone being partly obscured by the frame itself. Sea systems moved the unit to be nearer the edge to avoid this metal work, but the result is that the window is very near the edge of the frame.

6.5.4 Star-Oddi sensors

6.5.4.1 Pre-Deployment Calibration on a CTD Frame

Star ODDI (SO) DST CTD (S/N: S6782, S6784, S6788, S6792, S7724, S7725, S7727, 7728, S7729) and DST tilt (H453, H454, H457) sensors were deployed on CTD cast CTD020 and calibrated against the Seabird 9+ CTD . The recovery of PAP1 in 2015 was of the buoy and sensor frame only. The line down to the acoustic release is not scheduled for recovery until 2016 and so not all of the Star-Oddis deployed last year were planned for retrieval. Of the seven Star-Oddis expected for recovery this year two had been lost and a further one no longer communicated, a summary is provided in Table 2.

.

Table 2: Summary of Star-Oddi status upon PAP1 recovery

StarOddie	Type	Deployment depth /m	Position	Interval type	Interval	Status
6789	DST CTD	5	Below buoy	Fixed	30 min	Recovered, data collected
6790	DST CTD	10	Below buoy	Fixed	30 min	Recovered, no communication
5777	DST CTD	15	Below buoy	Fixed	30 min	Not recovered
H453	DST tilt	15	Below buoy	Multiple Interval	Tilt: 1 s x 60 measurements; Temperature: 30 min x 48 measurements	Recovered, data collected
5771	DST CTD	20	Below buoy	Fixed	30 min	Not recovered
5774	DST CTD	25	Below buoy	Fixed	30 min	Recovered, data collected
H454	DST tilt	30	Sensor frame	Multiple Interval	Tilt: 1 s x 60 measurements; Temperature: 30 min x 48 measurements	Recovered, data collected
7561	DST CTD	50	Below frame	Fixed	30 min	Not scheduled for recovery
7562	DST CTD	75	Below frame	Fixed	30 min	Not scheduled for recovery
7563	DST CTD	100	Below frame	Fixed	30 min	Not scheduled for recovery
7564	DST CTD	150	Below frame	Fixed	30 min	Not scheduled for recovery
7565	DST CTD	250	Below frame	Fixed	30 min	Not scheduled for recovery
7566	DST CTD	400	Below frame	Fixed	30 min	Not scheduled for recovery
H457*	DST tilt	1000	Sub-surface buoy	Fixed interval	45 min	Not scheduled for recovery

*rated to 3000 m

Through testing on board DY032 H453 was also lost, although the data from the deployment had already been recovered.

Figure 13 is an image of the five recovered Star-Oddis after removing any fixings (e.g. mounting block, cable ties or tape) that bound them to the cable hose or to the frame. H454 was the only one of the five recovered units that was in a mounting block as it was also the only one mounted on the frame. The remaining retrieved Star-Oddis had all been secured to the cable hose running alongside the chain and held in place by cable ties and amalgamated tape around the middle of each unit (leaving the tip and base of each unit to sense the ocean). All these four units show signs of what is presumed wear from friction at the sites that rested against the hose, principally at the base.

Figure 13 Image of the five recovered Star-Oddis; all have been removed from the fixings that bound them to the hose/frame.

Table 3: Calibration results of Star-Oddis

Star ODDI	Correlation	R^2	CTD-SO
6782	1.0146x – 13.056	0.9983	**ΔP/bar**
	0.9781x + 0.2607	0.999	**ΔT/°C**
6784	1.0024x + 0.9355	0.9983	**ΔP/bar**
	0.9819x + 0.194	0.9996	**ΔT/°C**
6788	0.9886x – 3.238	0.9983	**ΔP/bar**
	0.9864x + 0.1319	0.9996	**ΔT/°C**
6792	1.0117x + 0.65	0.9995	**ΔP/bar**
	0.992x + 0.0768	0.9997	**ΔT/°C**
7724	0.9958x + 0.2094	0.9984	**ΔP/bar**
	0.9929x + 0.0757	0.9999	**ΔT/°C**
7725	0.8523x + 0.9569	0.9764	**ΔP/bar**
	0.9737x + 0.3025	0.9988	**ΔT/°C**
7727	0.8164x + 1.1649	0.9626	**ΔP/bar**
	0.9948x + 0.0427	0.9998	**ΔT/°C**
7728	1.034x - 0.071	0.9982	**ΔP/bar**
	0.9947x + 0.0441	0.9995	**ΔT/°C**
7729	0.9039x + 0.6301	0.9894	**ΔP/bar**
	0.9822x + 0.2029	0.9991	**ΔT/°C**

Table 3: Calibration results of Star- shows the calibration of the Star-Oddis against the CTD values. The salinity values are all close to 35 psu and it was not possible to find a correlation. For pressure and temperature we plotted the Star-Oddis values versus the values from the CTD. The linear correlations are shown on the table with its R^2 values of the fit.

6.5.4.2 Star Oddi Deployment on PAP#1

For the DST CTD type Star-Oddis that were located on the chain direct replacements were made with units that had greater battery capacity. The DST tilt that had been fixed to the frame was re-used once more as a newer replacement was not available.

Table 4 Summary of Star-Oddis deployed at PAP1 following re-deployment of frame and buoy

StarOddie	Type	Deployment depth /m	Position	Interval type	Interval	Date memory will be full (and battery life at that time)
6788	DST CTD	5	Below buoy	Fixed	30 min	20/06/2020 (10.6%)
6782	DST CTD	10	Below buoy	Fixed	30 min	20/06/2020 (11.9%)
7728	DST CTD	15	Below buoy	Fixed	30 min	20/06/2020 (12%)
6792	DST CTD	20	Below buoy	Fixed	30 min	20/06/2020 (11.8%)
6784	DST CTD	25	Below buoy	Fixed	30 min	20/06/2020 (11.9%)
H454	DST tilt	30	Frame	Multiple Interval	Tilt: 1 s x 60 measurements; Temperature: 30 min x 48 measurements	09/11/2016 (68.2%)
7561	DST CTD	50	Below frame	Fixed	30 min	Deployed last year
7562	DST CTD	75	Below frame	Fixed	30 min	Deployed last year
7563	DST CTD	100	Below frame	Fixed	30 min	Deployed last year
7564	DST CTD	150	Below frame	Fixed	30 min	Deployed last year
7565	DST CTD	250	Below frame	Fixed	30 min	Deployed last year
7566	DST CTD	400	Below frame	Fixed	30 min	Deployed last year
H457*	DST tilt	1000	Sub-surface buoy	Fixed interval	45 min	Deployed last year

*rated to 3000 m

All units being deployed this year were set to start at 00:00 30th June 2015. As mentioned H454 was re-used and replaced on to the frame in the block holder, Figure 14. The remaining Star-Oddis being deployed were spaced 5 m apart from the bottom of the water line in accordance with the information in Table 4. The Star-Oddis on the hose were always placed on one of the brackets used to keep the hose and chain together. Last year it was found a number of these brackets had split in the middle so the Star-Oddis were placed to one side and next to one of the bolts that stand proud of the bracket. The bolt of the bracket should protect the Star-Oddis as the chain and hose slip over the deck on deployment and recovery.

Once again the Star-Oddis on the hose were at first secured with cable ties, wrapped in self-amalgamating tape and finally electrical tape, Figure 15. The tip and base of each Star-Oddi was kept free to allow full operation.

Figure 14 H454 being secured to cross bar of sensor frame before PAP1 deployment.

Figure 15 Star-Oddi secured on bracket along cable hose.

6.5.5 MicroCATs

A Sea-Bird SBE 37-ODO (s/n 13397) was attached to the buoy keel and set to sample temperature, pressure, conductivity and oxygen concentration every 30 minutes. It was assigned an inductive ID of 23. Sea-Bird sensors SBE 37-ODO (s/n 10535, ID 14) and SBE 37-IMP (s/n 6904, ID 36) were attached to the frame. The SBE 37-ODO was set to sample temperature, pressure, conductivity and oxygen concentration every 30 minutes, while the 37-IMP samples temperature, pressure and conductivity every 15 minutes. SBE 37-ODO (s/n 13397) was purchased in March 2015 and the SBE 37-ODO (s/n 10535) was serviced and recalibrated by Sea-Bird in the same month. SBE 37-IMP (s/n 6904) was recalibrated by Sea-Bird in January 2014.

6.5.6 Pro-Oceanus dissolved gas sensors

An old CO2-Pro CO2 sensor (s/n 29-097-45) was attached to the buoy keel and is powered and controlled by the buoy Telemetry Unit. It was serviced in 2015. This sensor was powered from the buoy and was switched on every 12 hours (at 11:20 and 23:30). The start time, warm-up minutes, equilibration minutes and sampling minutes can all be varied by email command and for this deployment a total on time of 37 minutes was used. A Sea-Bird pump pushes water through the sensor head and is powered directly from the buoy during the equilibration and sampling phases.

This sensor is not configurable and performs an Auto Zero Point Calibrations (AZPC) every time it is powered on.

A self-logging CO2-Pro (s/n 34-200-45) was attached to the sensor frame and was configured to sample every 12 hours at midnight and noon. The real time clock battery was fully charged shortly before deployment. This sensor is powered by two, 150Ah OceanSonics battery connected in parallel, which each had one layer of cells removed to provide a voltage of approximately 14.4V. The ascarite CO2 absorbent in this sensor was replaced at NOC shortly before the cruise. The real time clock battery was fully charged shortly before deployment and the sensor was configured to record every 12 hours producing 4 samples per record and performing an AZPC every 4 sampling sessions.

A GTD-Pro gas tension sensor (s/n 26-049-09) was also attached to the sensor frame and is powered and recorded by the Data Hub . This allows the sampling time and duration to be controlled by email command, and for this deployment the sensor sampled for 6 minutes every 6 hours. The data during the first few days is not showing reasonable pressures but we should wait to see if it stabilises. This sensor gave normal readings of pressure while on deck but increasingly high and unfeasible readings as soon as it entered the water, indicating some kind of malfunction.

6.5.7 pH sensors

The set of pH sensors at PAP1 deployment include a Sensor Lab SP101-Sm pH sensor on loan from Melchor González Dávila at ULPGC on Gran Canaria along with two Satlantic SeaFET pH sensors (s/n 63 and 257). The SP101 was calibrated before being received by NOC and checked and serviced in Southampton before the cruise began by Melchor. The SeaFET pH sensors were bench calibrated by Katsiaryna Pabortsava before the cruise.

6.5.7.1 SeaFET Bench Calibration

The SeaFET pH sensors (S/N 063 and 257) were tested in the lab at NOC and on-board RRS *Discovery* using TRIS buffer #26 solution of a known pH. The sensors were sampling in the CONTINUOUS mode whilst calibration. The sensors were allowed to warm up for approximately 2 hours before the readings were logged. Temperature was recorded at the start and end of the calibration test to calculate the pH of the TRIS buffer solution (Equation provided by the manufacturer). The results of the calibration test are summarised in Table 5.

Table 5: Results of the pre-deployment bench calibration of SeaFETs 063 and 257 against Tris buffer #26 solution

Date	S/N	T [°C]	pH internal	pH external	pH Tris#26
19.05.2015	63	20.1	8.211±0.013	8.270±0.022	8.24
19.05.2015	257	20.1	8.217±0.016	8.240±0.016	8.24
20.06.2015	63	22.0	8.177±0.002	8.129±0.007	8.188
20.06.2015	257	21.9	8.223±0.005	8.223±0.030	8.191

6.5.7.2 Deployment on PAP1 frame and buoy

The Sensor Lab SP101-Sm pH sensor was attached to the buoy keel. The SensLab pH sensor is powered through the buoy and takes a reading each time it is powered. It is set along with a Satlantic SeaFET pH sensor (s/n 257). A second SeaFET (s/n 63) is fitted in the sensor frame at 30m, and both SeaFETs are powered from dedicated battery packs in separate housings. The SeaFET sensors can also be powered from the hub or from an internal small battery pack. They were set up to sample in periodic mode with a sampling interval of 30 min (see post-deployment note below), producing 3 Frames per burst (output of 3 samples, each is an average of 10 readings) and creating a DAILY log ASCII file (Figure 16). SeaFET s/n 63 in the sensor frame was configured to sample at 23 minutes past the hour (1380 sec offset) while s/n 257 on the buoy samples at 27 minutes past the hour (1680 sec offset).

After deployment it became apparent that SeaFET s/n 257 on the buoy is only sampling once per hour suggesting that a mistake was made in the configuration of this sensor. Note that this sampling regime cannot be changed remotely.

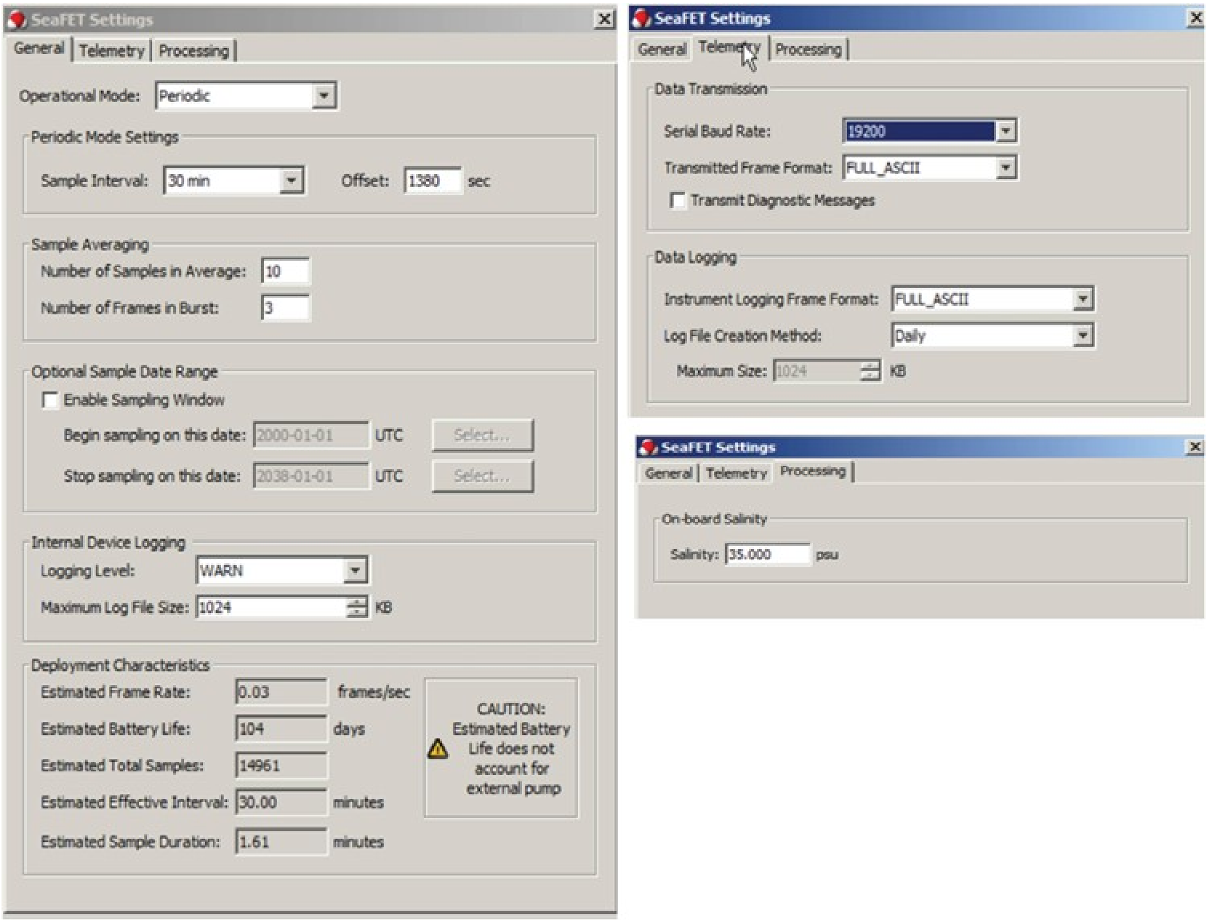


Figure 16: SeaFET 063 and 257 pH sensors configuration for the deployments on the frame and the buoy.

6.5.8 WETLabs Cycle phosphate sensor

(s/n CYCL-P-164)

The WETlabs CYCLE phosphate sensor was deployed on the PAP sensor frame at 30m. The sensor was calibrated in the lab at NOC and calibration was attempted on board, but dilutions were variable.

The cycle was set up on the morning of deployment because it was not clear that it would continue to operate if power was interrupted. As the hub communications and power are delivered through the same connection we still had to interrupt the power supply whilst plugs were changed over. The communication after the first sampling event confirmed that this interruption was not a problem. There are several issues to review the cycle. It needs to be vertical when sampling so must be horizontal on the sensor frame prior to deployment. Priming on land is achieved by drawing the three solutions through thin diameter tubing under a gentle vacuum. Once the sensor is on the frame, there is no access to any internal tubing. The tubes are then left for several days so could develop bubbles. The instrument doesn’t prime until in position at 30m it should then be at a pressure which should help the reagents to be drawn through.

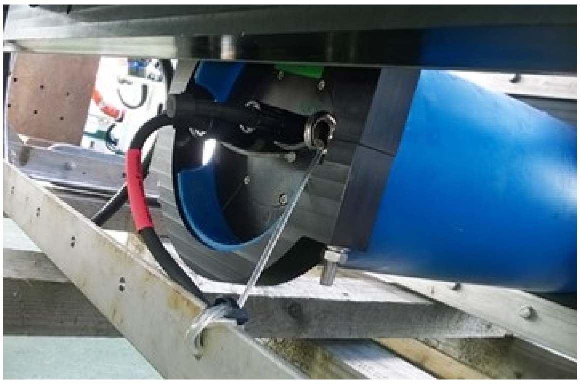


Figure 17 cycle on the frame prior to deployment

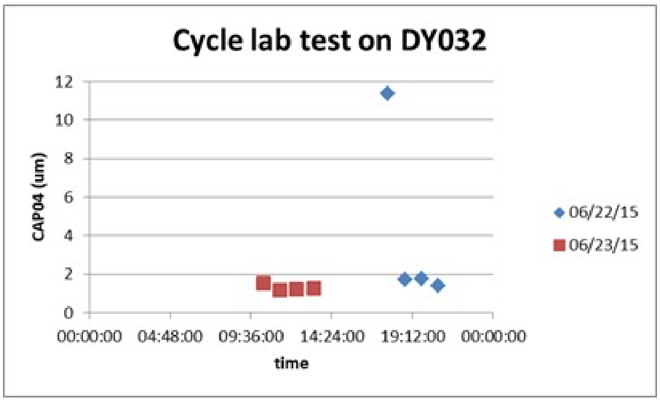


Figure 18 cycle bench tests prior to deployment

Due to time constraints bench tests were carried out to check the instrument was working correctly but solutions were not exact. The bench test at NOC will make for better calibrations. The high point on the 23rd is due to addition of unmixed sample to prevent tubes sucking dry.

6.5.9 Satlantic OCR-507 Irradiance sensors

A Satlantic OCR-507 ICSA irradiance sensor (s/n 226) was fitted to the buoy mast and is controlled by the Telemetry Unit. The Data Hub controls an OCR-507 ICSW upward-looking irradiance sensor (s/n 287) and an OCR-507 R10W downward-looking radiance sensor (s/n 113) which were both purchased in February 2015. All 3 sensors were commanded to sample every 30 minutes at the same time so that their data are coincident. The sampling intervals can be changed remotely using SBD commands.

6.6 PAP#1 Recovered Data Hub and Telemetry Systems

The buoy and sensor frame were recovered without difficulty on the morning of 24th June 2015. The mooring rope was disconnected from the bottom of the sensor frame and attached to a large buoy which was then released. This allowed the vessel to continue with other work until the system was finally re-attached to the mooring and deployed on 1st July.
In comparison to previous years the system was relatively unscathed after 11.3 months of deployment. On the buoy keel the only damage of note was the connector on the Satlantic SeaFET sensor which had corroded so badly that it was necessary to cut the cable in order to remove the sensor. This sensor had stopped recording data on 2 May 2015.
The main cable between the buoy and the sensor frame was still intact (the first time this has happened), although the protective hydraulic hosing over the cable was badly damaged in a few places, particularly immediately above the frame (see Figure 20). During the recovery operation the cable appeared to be quite tightly stretched on the upper section of chain, but a significant amount of slack cable was visible immediately above the section of large diameter

hydraulic hose (see Figure 19). An electrical continuity check of the cable cores showed that one of the small-diameter ones was open circuit but all the others were normal, suggesting that if the buoy controller had continued to function, the link to the data hub would have been maintained.
The sensor frame itself was undamaged and all the sensor clamps were still tight. The main damage to sensors in the frame was the loss of the ZPS pump which photos subsequently confirmed had not been properly secured to the instrument body. The upward-looking Satlantic OCR irradiance sensor had lost its copper Bioshutter plate but scratch marks around the top of the sensor suggest that this may have been caused by the departure of the ZPS pump which was in close proximity.

Figure 19: Bight in main cable above the sensor frame

Figure 20: Damage to cable protective hosing at top of sensor frame

The previous PAP Observatory system was deployed on 15th July 2014 on Meteor cruise M108. The system was fully operational after deployment and functioned flawlessly for the first 3 months.

6.6.1 Inductive Telemetry

The inductive communications with the Sea-Bird MicroCAT sensors in the frame then became intermittent and failed entirely after mid-November. Communications with the MicroCAT on the buoy keel continued to work normally and when recovered it was discovered that the splice connecting the inductive wire to the main buoy-to-frame cable had failed where it enters the sensor frame. Rather than use one of the normal conductors in the main cable, the inductive communications was carried by the thin stainless steel tube carrying (unused) optical fibres down the centre of the cable. An electrical continuity check after recovery showed that apart from the failure of the splice, this tube had parted somewhere else in the cable indicating that the inductive communications would have failed even if the splice had remained intact.

The new system uses one of the electrical cores in the main cable to carry the inductive telemetry signals.

6.6.2 Iridium Satellite Communications

The Iridium telemetry system which has proven very reliable on previous deployments experienced a number of problems during the 2014/15 deployment. In the 229 days before the buoy controller failed only 65% of dial-up data transfer attempts were successful, necessitating repeated re-tries. Fortunately the system is robust enough to cope with this and all data were eventually transferred. Figure 21 shows the number of bytes transferred per day throughout the deployment.

Examining the log files from the buoy controller shows that there were various modes of failure that caused data transfer sessions to fail. These included 'loss of carrier' where the link to the satellites was broken, failure to receive an acknowledgement message from the server at NOC , and most puzzling of all, failure of the Iridium modem to communicate with the buoy controller. This last fault was especially evident between 11th to 17th January and suggests that there may be an intermittent fault in the Iridium modem itself.

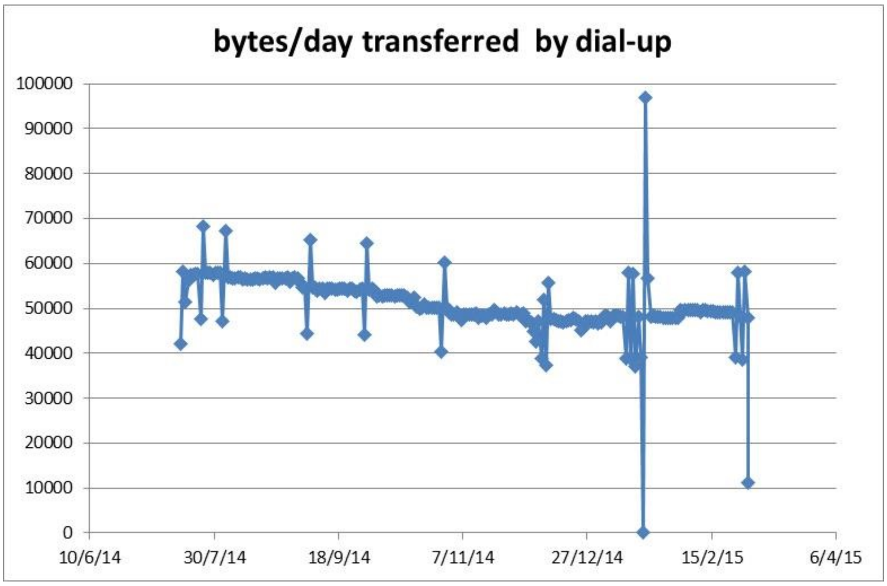


Figure 21: Data bytes per day transferred by Iridium dial-up

6.6.3 Buoy Controller Failure

By far the most serious problem experienced during the deployment was the failure of the buoy controller which controls all the telemetry sub systems including the data hub in the sensor frame. On the 1st March 2015 (7.5 months into the deployment) the buoy controller commenced its hourly, 4-minute compass and accelerometer sampling period at 11:10 and then ceased recording any information on its flash memory card. Dial-up messages also ceased although the buoy controller program continued to run and to send email status messages. On 9th March after 8 days with no data from the buoy, an email command was sent to restart the buoy controller program. This command was interpreted correctly and the program restarted, only to be stopped in its tracks because it was still unable to access the memory card. Once in this state the program stopped and all further communication with the buoy was impossible. In addition the data hub was switched off as part of the restart process, meaning that no further data from the OCR or GTD sensors were recorded.

After recovery, the telemetry unit was powered up and started normally. Initial suspicions that the CompactFlash memory card had become corrupted proved unfounded and no errors were found on the card.

This episode raises 3 questions:

- What prevented the program from accessing the memory card?
- Why didn't the BIOSReset() command (which performs a full hardware reset) cure the problem?
- What can be done to ensure this failure doesn't recur?

The only clue to answer the first question is that the program apparently failed during one of its most demanding tasks, i.e. simultaneous sampling of the compass, GPS and accelerometer data. The accelerometer sampling runs at 25Hz and uses the SPI bus to load values directly into memory where they are buffered and then written to the memory card in 1kB blocks. It could be that while servicing interrupts from the compass and GPS messages, and servicing the SPI bus data and writing data from all 3 sources to the memory card, some kind of low level conflict occurred that corrupted some part of the memory card control software. This corruption was such that it could only be cleared by a full power cycle of the entire electronics. The fact that it took 7.5 months for this problem to appear indicates that it will be hard to replicate or indeed confirm that this is what happened.

The third question is easier to answer. A watchdog timer circuit could be incorporated into the buoy controller electronics such that if the program fails to reset a counter every 5 minutes (say), then the 5V supply to the Persistor is power cycled to force a complete system reset. This should prevent the controller program from getting stuck in a 'hung' state.

6.7 PAP#1 Recovered Sensors

6.7.1 Satlantic SeaFET sensors

The SeaFET sensors (S/N 105 and 111) deployed during ME108 in July 2014 were successfully recovered on 24.06.2015. The sensor slot of the SeaFET-111 was covered in biofilm; the surface of the connector was also corroded right below the pins. These however did not affect the functioning of the SeaFET-111. The data was successfully downloaded from the internal memory of both instruments. The SeaFET-105 was recording data from

11.07.2014 till 24.06.2015, while the SeaFET-111 stopped logging the data on 02.05.2015. This might be related to the aforementioned corrosion of the connector. The raw data from both sensors are shown in Figure 22.

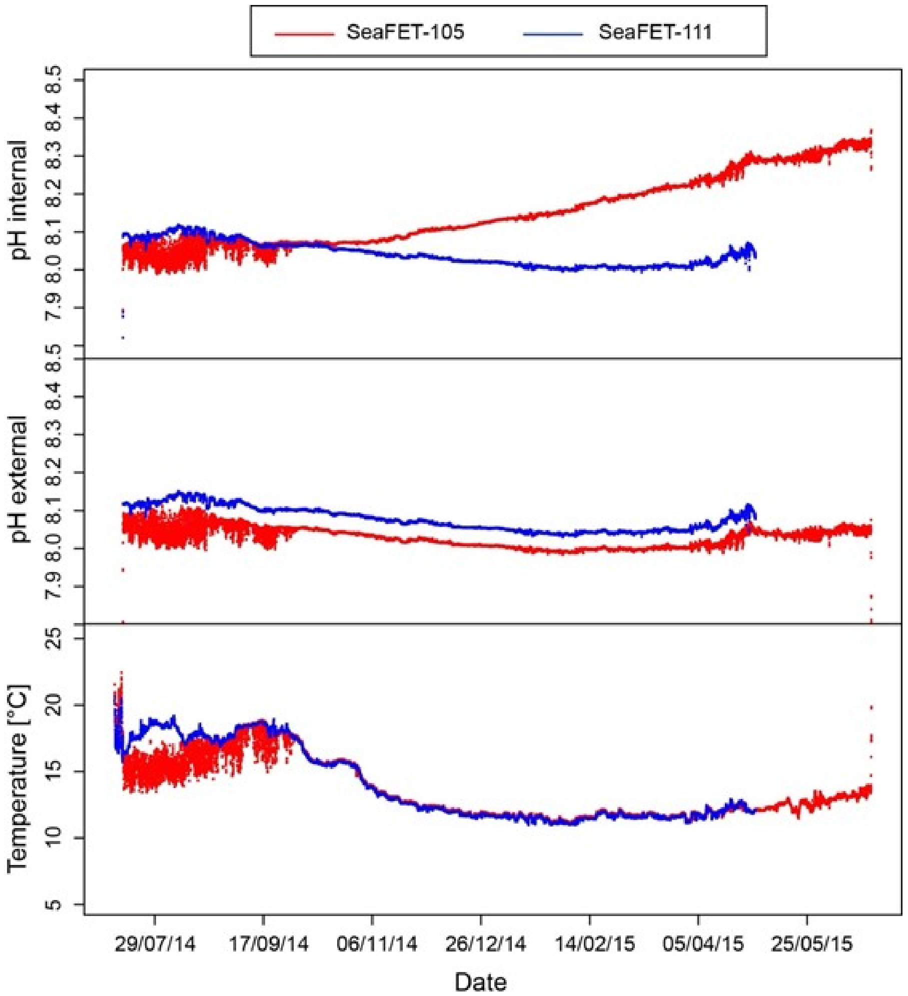


Figure 22: Uncorrected data from SeaFET S/N 105 and 111 pH sensors deployed during 2014-2015.

The performance of the SeaFET S/N 105 and 111 pH sensors was tested using Tris Buffer #26 solution. Note, the buffer solution was opened on 20.06.2015, which could bias the outcome of the calibration. The results are summarised in

Table 6: Post-deployment check of the SeaFET 105 and 111 pH sensors against Tris buffer #26 solution. A proper check with the fresh buffer solution and cleaned sensors will be conducted in the laboratory at NOCS.

Table 6: Post-deployment check of the SeaFET 105 and 111 pH sensors against Tris buffer #26 solution

Date	S/N	T[°C]	pH internal	pH external	Tris#26
27.06.2015	105	21.0	8.478±0.0005	8.170±0.0029	8.22
27.06.2015	111	21.1	8.161±0.0087	8.199±0.0246	8.217

6.7.2 Nitrate SUNA sensor

The SUNA sensor (S/N 391) deployed during ME108 in July 2014 was recovered on 24.06.2015. Upon recovery, the sensor failed to respond to communication and consumed a lot of current, suggesting a short circuit within the instrument. The data could not be recovered from the SUNA's internal. Instead, the data was retrieved from the hub. Figure 23: Nitrate concentration recorded by the SUNA sensor shows that the SUNA stopped logging the data on 08/03/2015.

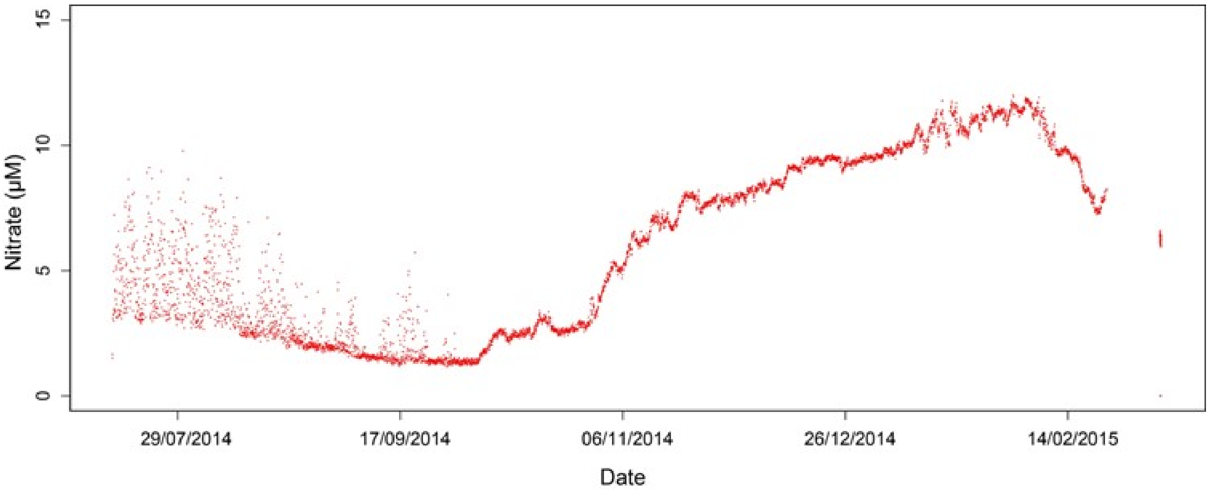


Figure 23: Nitrate concentration recorded by the SUNA sensor

6.7.3 Wet Labs flnt usb fluorimeter

The wetlabs was recovered downloaded and dipped to 100m for post deployment calibration.

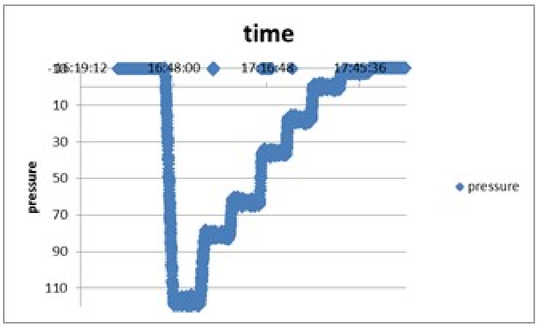


Figure 24 depth profile of sn 269 post deployment calibration

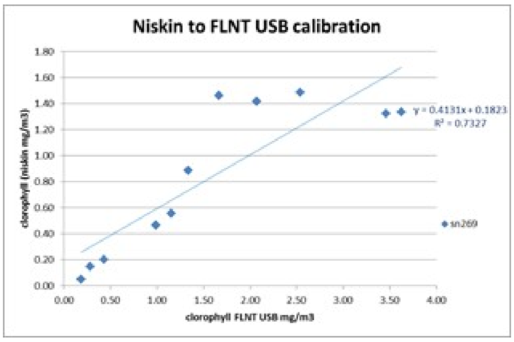


Figure 25 chlorophyll profile of sn 269 post deployment calibration

The calibration ctd consisted of 10 depths held for 7 minutes prior to firing Niskin bottles so that the instruments could equilibrate to a good degree. The depth profile shows that the instrument failed to register the 10 stops. This made it very hard to match the chlorophyll measured by the instrument to those sampled by Niskin. This may be why the r^2 for the correction equation is so poor. True chlorophyll = 0.4131 x measured chlorophyll + 0.1823.

6.7.4 Pro-Oceanus CO2-Pro

6.7.4.1 s/n 34-201-45 at the buoy keel

This sensor was powered from the buoy and was switched on every 12 hours (at 11:20 and 23:30). The start time, warm-up minutes, equilibration minutes and sampling minutes can all be varied by email command and for this deployment a total on time of 37 minutes was used. A Sea-Bird pump pushes water through the sensor head and is powered directly from the buoy during the equilibration and sampling phases.

Due to a configuration error the sensor was not configured to perform Auto Zero Point Calibrations (AZPC) and hence a gradually increasing zero offset error would be expected.

In addition, the log files of status messages from the sensor shows that it was reporting excessive humidity (>90%) for the entire deployment, although the actual humidity sensor readings reported in the data messages were normal, ranging from 10-20%. Guidance will be sought from Pro-Oceanus on this issue.

Fig. 4 shows a plot of the data logged by the buoy controller during the deployment up to 1st March when the buoy controller failed.

6.7.4.2 s/n 33-146-45 on the frame

This sensor ran autonomously and was powered from two OceanSonics battery housings each containing around 150Ah of lithium cells. The real-time clock battery was fully charged shortly before deployment and the sensor was configured to record every 12 hours producing 4 samples per record.

The sensor ran successfully throughout the deployment and was still running when recovered on 24th June 2015. Figure 26 shows the data from this sensor plotted over the data from the buoy CO2 sensor. Careful examination of the internally recorded data showed that around 9% of the values were corrupted by missing or extra characters, and these values have been excluded from the plotted data.

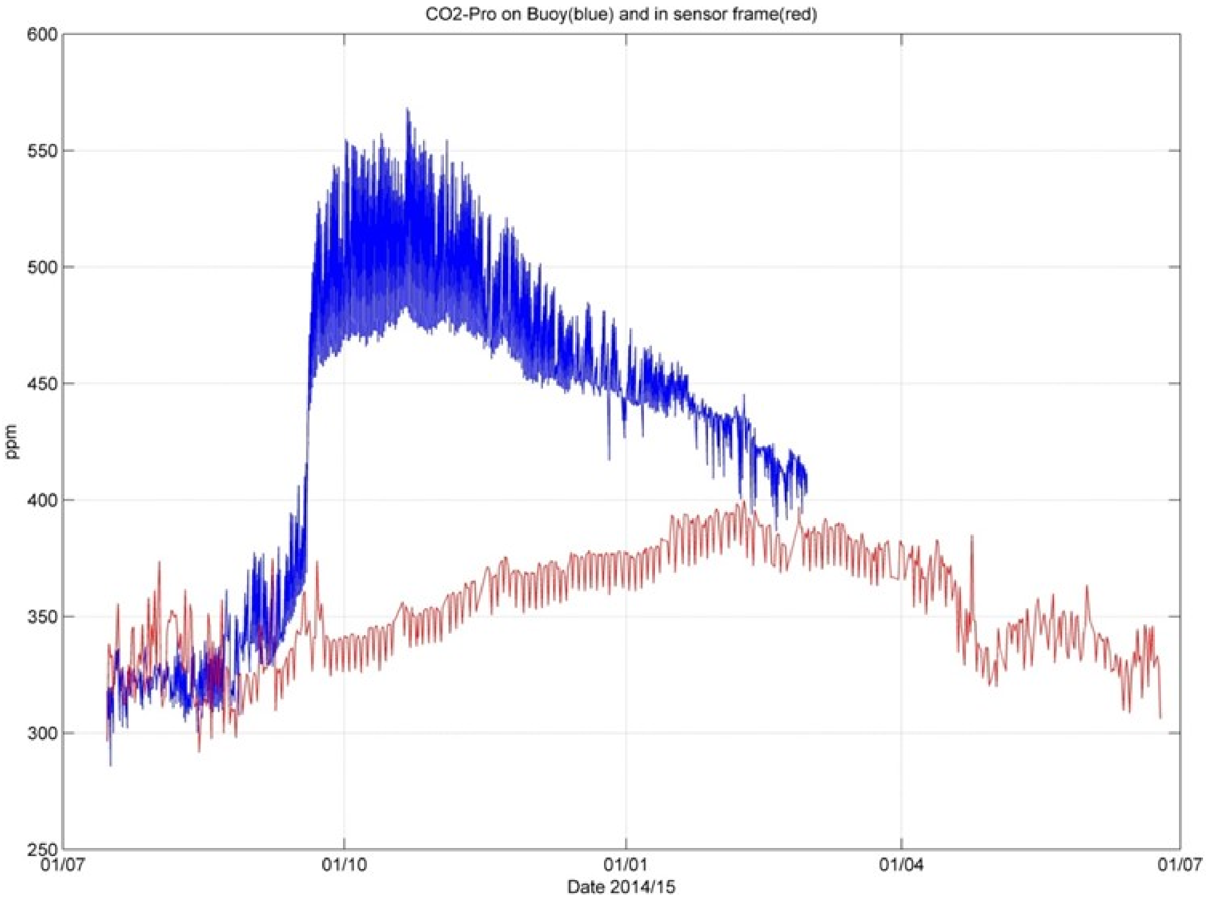


Figure 26: Uncorrected CO2 concentration data from the sensors on the buoy and the sensor frame at 30m

6.7.5 Pro-Oceanus GTD-Pro

6.7.5.1 s/n 29-099-15 on the frame

This sensor measures total dissolved gas pressure and was powered and controlled from the data hub. This allows the sampling time and duration to be controlled by email command, and for this deployment the sensor sampled for 6 minutes every 6 hours. Figure 27 shows the total dissolved gas pressure this sensor and the internal gas pressure from CO2-Pro in the sensor frame.

The GTD-Pro stopped producing data when the buoy controller finally shut down on 19th March, removing the power supply to the data hub.

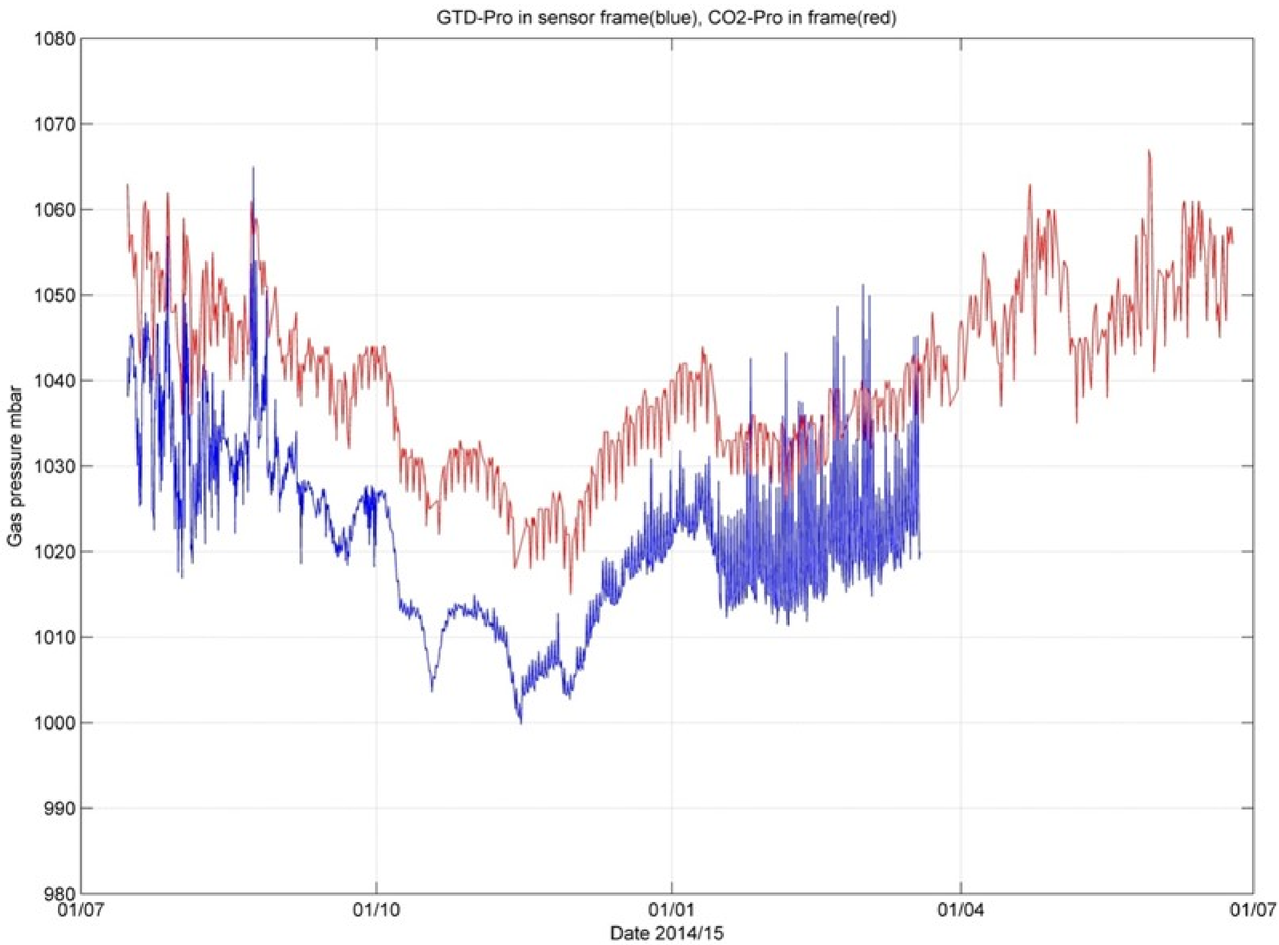


Figure 27: Total dissolved gas pressure from Pro-Oceanus GTD-Pro and internal gas pressure from CO2-Pro in frame

6.7.6 Sea-Bird SBE 37 MicroCATs

A Sea-Bird SBE 37-IDO (s/n 9030) was attached to the buoy keel and set to sample temperature, pressure, conductivity and oxygen concentration every 30 minutes.

A Sea-Bird SBE 37-ODO (s/n 10315) and an SBE 37-IMP (s/n 6915) were attached to the sensor frame. The SBE 37-ODO was set to sample temperature, pressure, conductivity and oxygen concentration every 30 minutes, while the 37-IMP sampled temperature, pressure and conductivity every 15 minutes.

- SBE 37-ODO (s/n 10315) was a new sensor purchased in January 2013.
- SBE 37-IDO (s/n 9030) and SBE 37-IMP (s/n 6915) were both serviced and recalibrated by Sea-Bird in January 2014.

These sensors functioned normally during the deployment but the oxygen sensor in s/n 10315 failed on 30th January 2015. Figure 28 shows the oxygen concentration measurements plotted together with readings from the Aanderaa optode in the Seaguard (corrected for temperature and salinity).

The 3 MicroCATs were attached to a 100m CTD on 1st July 2015 for a post-recovery calibration.

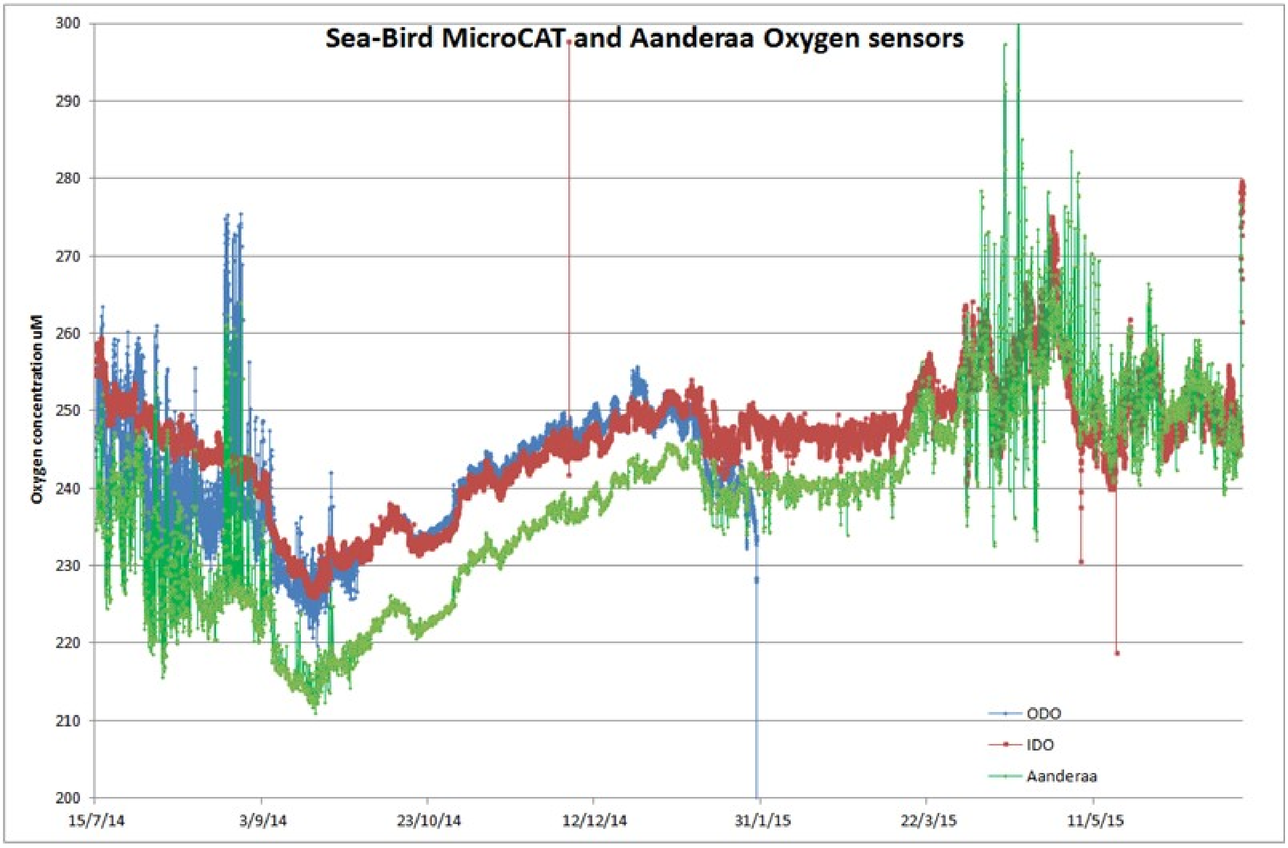


Figure 28: Oxygen concentration measurements from Sea-Bird and Aanderaa sensors

6.7.7 Satlantic OCR-507 Irradiance Sensors

A Satlantic OCR-507 ICSA irradiance sensor (s/n 201) was fitted to the buoy mast and is controlled by the Telemetry Unit. The Data Hub controlled an OCR-507 ICSW upward-looking irradiance sensor (s/n 200) and an OCR-507 R10W downward-looking radiance sensor (s/n 095). All 3 sensors were commanded to sample every 30 minutes at the same time so that their data are coincident. Sensor operation was suspended during hours of darkness according to a monthly look-up table in the buoy controller.

These sensors functioned normally until the buoy controller failed on 1st March.

On recovery the upward-looking irradiance sensor in the frame was found to have lost its copper Bioshutter and was badly fouled (see Figure 29). The top of the sensor housing also had some evidence of abrasion suggesting that the loss of the Bioshutter may have been caused by the departure of the ZPS pump unit which was located nearby in the frame and probably fell off early in the deployment. The window of the downward-looking radiance sensor was also slightly fouled despite the presence of its Bioshutter.

Figure 29: Upward-looking irradiance sensor s/n 200

6.7.8 Zooplankton Sampler

The ZPS consists of a pump which draws water across a mesh window then through the pump itself, also a motor which winds on the mesh windows and cover gauze from two passive reels. The McLane Labs ZPS s/n ML12860-01 was recovered from the PAP frame. The ZPS was deployed with new cables and a new intake dome in the 2015 deployment. However, the pump was detached from the frame. At some point during these repairs the clamp was taken off the motor’s housing and not put back on. This caused the sampler to fail during deployment.

The logger allows 50 samples at user defined intervals over a year's deployment. The wound on mesh is bathed in a hyper saline formalin preservative for subsequent sample retrieval. The logger also records engineering data for example voltage levels and pumping rates and volumes.

Figure 1 image from ZPS manual showing retaining clamp

Figure 2 ZPS mounted on frame, clamp missing (photo Jon Campbell ME108)

The full details of the pumping and winding events are in the ZPS appendix, but essentially the first 8 events were successful. The sampler was then put into sleep mode until event 9 on 01/04/15. Between these dates the pump broke off the housing. The winder continued to wind but with no water flow across the mesh pocket. The sampler will be returned to McLane for repair.

Event 01 of 50 @ 07/20/14 00:00:00 Event 02 of 50 @ 07/20/14 06:00:00 Event 03 of 50 @ 07/20/14 12:00:00 Event 04 of 50 @ 07/20/14 18:00:00 Event 05 of 50 @ 07/26/14 00:00:00 Event 06 of 50 @ 07/26/14 06:00:00 Event 07 of 50 @ 07/26/14 **12:00:00** **Event 08 of 50 @ 07/26/14 18:00:00** **Event 09 of 50 @ 04/01/15** 00:00:00 Event 10 of 50 @ 04/07/15 00:00:00 Event 11 of 50 @ 04/14/15 00:00:00 Event 12 of 50 @ 04/14/15	06:00:00 Event 13 of 50 @ 04/14/15 12:00:00 Event 14 of 50 @ 04/14/15 18:00:00 Event 15 of 50 @ 04/15/15 00:00:00 Event 16 of 50 @ 04/21/15 00:00:00 Event 17 of 50 @ 04/28/15 00:00:00 Event 18 of 50 @ 04/28/15 06:00:00 Event 19 of 50 @ 04/28/15 12:00:00 Event 20 of 50 @ 04/28/15 18:00:00 Event 21 of 50 @ 04/29/15 00:00:00 Event 22 of 50 @ 05/05/15 00:00:00 Event 23 of 50 @ 05/12/15 *plus other events up to 50.*

7 PAP#3 Sediment Trap Mooring

Corinne Pebody

7.1 PAP#3 Recovery

The PAP#3 sediment trap mooring was recovered on 28th June 2015. Traps A, B, C and D were recovered successfully, although trap C was delayed a little by a tangle with the microcat which should have been deeper than the trap but was recovered first. It was apparent that although there had been some relatively flux in summer 2014, there was only a small amount of flux from spring and early summer 2015.

On recovery, the bottles were removed and lids screwed on before removing to the general-purpose lab.

The bottles were photographed (see Figures below), the pH checked and the height of the flux measured. Then 1ml of formalin was added before the bottles, the lids replaced and samples stored in the chill room.

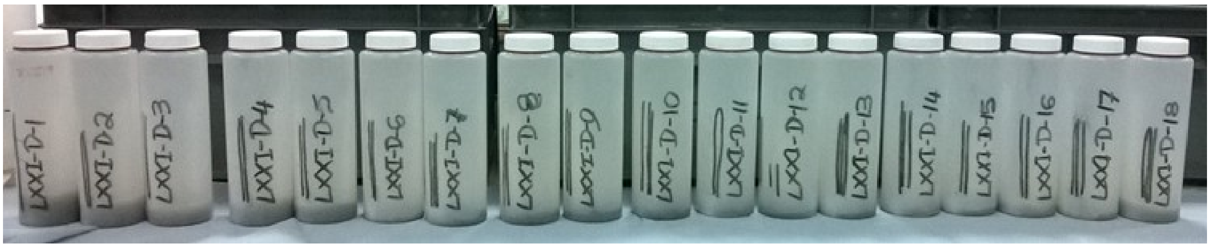


Figure 30 Bottles from 3000m 2014 – 2015 with very little flux so far in 2015 suggesting that the bloom may be late this year.

Figure 31 Bottles from 100mab showing the same picture as 3000m but perhaps with more flux more recently

Figure 32 Bottles 3000m 13 way trap. Note bottle 6, is dark and anoxic because it was open for too long and lost all the preservative.

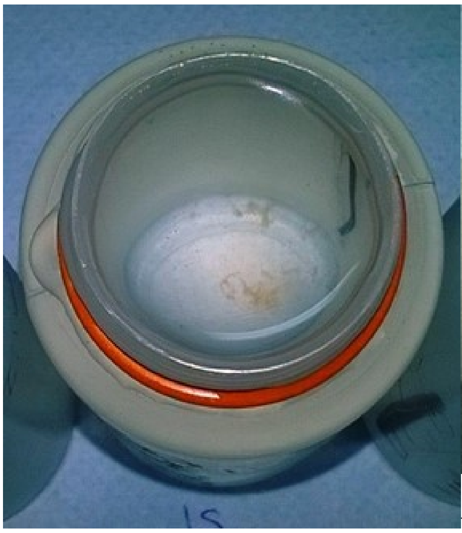


Figure 33 Particles floated in but became less buoyant after capture

Figure 34 Small jelly

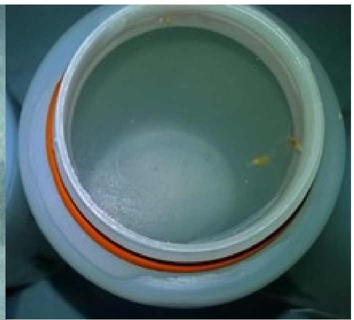


Figure 35 Swimmers even like our inverted traps!

Both traps A (3000m) and C (100mab) show similar flux profiles, but unusually trap C showed higher levels than trap A for the last two events. This suggests that the bloom may not be as late as initially thought.

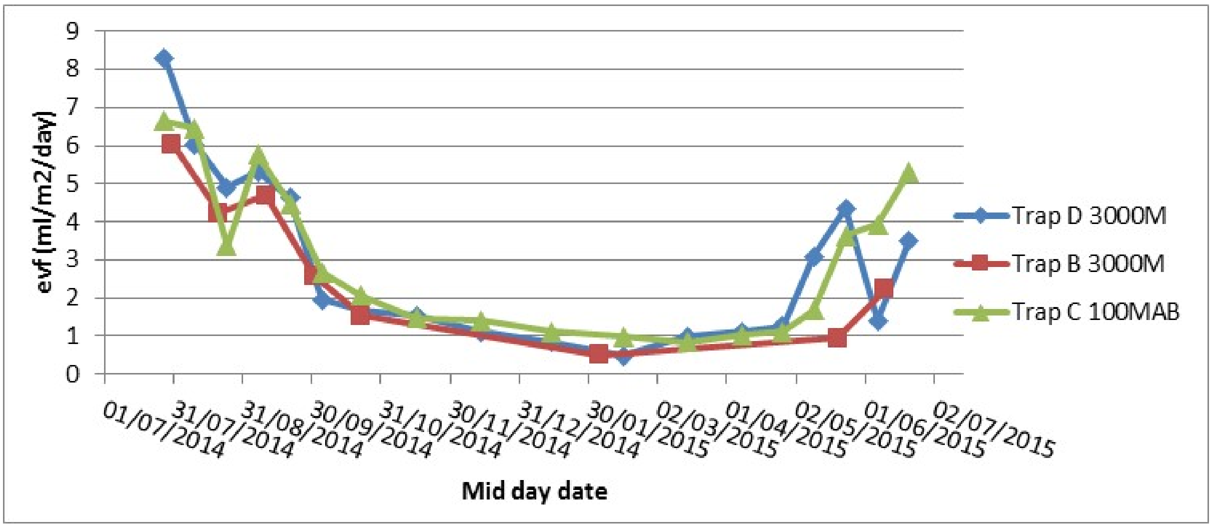


Figure 36 Estimated volume flux 2014/15

Recovery logs are included as an appendix

7.2 PAP#3 Deployment

Deployment of PAP#3 was on 28/06/15. This was apparently successful. This included trap (D), deployed inverted with hypo saline preservative sediment trap preservative. The traps collected in 2014 showed signs of dilution through mixing (lowered pH), so the degree of hyposalinity was increased to attempt to avoid further dilution. There may be also be an advantage to only filling the bottle half full. This will be considered prior to the next deployment. When the bottles are removed there is a very small amount of preservative which is lost. There is a tiny gap between the top of the bottle and the rotation plate of the trap. 1 ml or so is still lost even when the bottle is removed extremely carefully and the preservative is domed over the top of the bottle. But this 1ml may be critical as this is where our samples are most likely to be. Introducing a significant air gap would avoid any potential loss through this route.

Deployment logs are included as an appendix.

8 Zooplankton Net Sampling

Corinne Pebody

The WP2, 200µm net was weighted with approximately 8kg of weight, the bridles were wire, but the strings at the side permitted only a small amount of weight. The net was checked for twists and that the tap was closed, then the net was lowered over the side using the Rozler (Rexroth) winch over the starboard side. Maximum depth was 200 metres where the deployment was paused for a minute to allow the net to hang straight before the being brought up at approx. 10 metres per minute.

On recovery the net was hosed down from the outside with seawater and the cod end emptied into a white bucket. Hosing was repeated and time allowed for zooplankton to settle into the bottom of the cod end. Samples were then either, transferred to 2 litre bottles and preserved by adding borax buffered formalin to an approximate concentration of 5%. Alternatively the sample was sieved through a series of meshes, 2mm, 1mm, and 200µm and transferred to cryo vials and stored in the -80°C freezer.

After the first recovery a blue tap was missing from the cod end. The second net was used for the rest of the cruise, but this tap handle needed replacing on return to NOC (see photo below).

There was a spawning event on the midnight net, 30/06/15 – 01/07/15. The first net was full of spawn. A large and active shoal of garfish had been sighted on the surface around the net as it was deployed. There was a full and very bright moon. The first net was full of eggs, the second contained a few and the third and fourth none. This underlines the patchiness of zooplankton and export of the top 200m at the PAP site.

Future work:

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

MIO will run samples through ZooScanner to analyse size and species composition.

Rob Young will use sieved frozen samples as part of an eDNA project.

Figure 37 Spawn in sieve from dy032-79. Eggs had reached half way up sides of sieve.

Figure 38 Tap handle

Station ID						
DY032-011	noon sample	preserved in formalin 2litre bottles				Water depth
net shot		24/06/15	13:38	49 01.77 N	16 24.56 W	ucm
at surface		24/06/15	13:54			ucm
DY032-012	noon sample	Rejected poor sample volume. Tap part open?				
net shot		24/06/15	14:01	49 01.77 N	16 24.56 W	ucm
at surface		24/06/15	14:21			ucm
DY032-013	noon sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm>63 µm			frozen at - 80°C	
net shot		24/06/15	14:26	49 01.77 N	16 24.56 W	ucm
at surface		24/06/15				ucm
DY032-035	midnight sample	preserved in formalin 2 litre bottles				
net shot		26/06/15	23:10	48 51.85 N	16 31.85 W	
at surface		26/06/15	23:35	48 51.59 N	16 32.06 W	
DY032-036	midnight sample	preserved in formalin 2 litre bottles for MIO				
net shot		26/06/15	23:38	48 51.60 N	16 31.06 W	4844 ucm
at surface		26/06/15	23:47	48 51.55 N	16 32.10 W	
DY032-037	midnight sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm			frozen at - 80°C	
net shot		27/06/15	00:05	48 51.41 N	16 32.14 W	
at surface		27/06/15	00:29	48 51.21 N	16 32.29 W	ucm
DY032-038	midnight sample	For Rob Young			frozen at - 80°C	Water depth
net shot		27/06/15	00:33	48 51.18 N	16 32.32 W	
at surface		27/06/15	01:03	48 50.88 N	16 32.53 W	
DY032-056	midnight sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm			frozen at - 80°C	
net shot		29/06/15	00:05	48 55.330 N	16 28.226 W	4836 ucm
at surface		26/06/15	00:30	48 55.053 N	16 28.560 W	4836 ucm
DY032-057	midnight sample	preserved in formalin 2 litre bottles				
net shot		29/06/15	00:38	48 54.9672 N	16 28.6167 W	4836 ucm
at surface		26/06/15	01:02	48 54.869 N	16 28.843 W	4836 ucm
DY032-058	midnight sample	preserved in formalin 2 litre bottles for MIO				
net shot		29/06/15	01:06	48 54.8475 N	16 28.89522 W	4834 ucm
at surface		26/06/15	01:27	48 54.752 N	16 28.29.123 W	4837 ucm
DY032-059	midnight sample	For Rob Young			frozen at - 80°C	Water depth

net shot		29/06/15	01:31	48 54.73728 N	16 29.16354 W	4836 ucm
at surface		26/06/15	01:53	48 54.640 N	16 29.398 W	4840 ucm
DY032-063	noon sample	preserved in formalin 2 litre				
net shot		29/06/15	12:58	48 49.82568 N	16 31.18368 W	4836 ucm
at surface		29/06/15	13:20	48 49.6012 N	16 31.2431 W	
DY032-064	noon sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm			frozen at - 80°C	
net shot		29/06/15	13.25	48 49.5533 N	16 31.2164 W	4844 ucm
at surface		26/06/15	13:44	48 49.364 N	16 31.174 W	
DY032-065	noon sample	preserved in formalin 3 x 200 ml bottles for MIO				
net shot		29/06/15	13.49	48 49.183 N	16 31.228 W	4838 ucm
at surface		29/06/15	14:07			
DY032-079	midnight sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm			frozen at - 80°C	
net shot		30/06/15	23:52	49 4.31874 N	16 15.89718 W	4628 ucm
at surface		01/07/15	00:20	49 4.19544 N	16 15.97350 W	4262 ucm
DY032-080	midnight sample	preserved in formalin 2 litre bottles				
net shot		01/07/15	00:29	49 4.17144 N	16 15.98466 W	4283 ucm
at surface		01/07/15	00:52	49 3.99042 N	16 16.05660 W	4520 ucm
DY032-081	midnight sample	preserved in formalin 2 litre bottles for MIO				
net shot		01/07/15	00:54	49 3.997134 N	16 16.06404 W	4930 ucm
at surface		01/07/15	01:20	49 3.80700 N	16 16.12152 W	4425 ucm
DY032-082	midnight sample	For Rob Young			frozen at - 80°C	Water depth
net shot		01/07/15	01:23	49 3.77502 N	16 16.13112 W	4535 ucm
at surface		01/07/15	01:46	49 3.5889 N	16 16.18188 W	4543 ucm

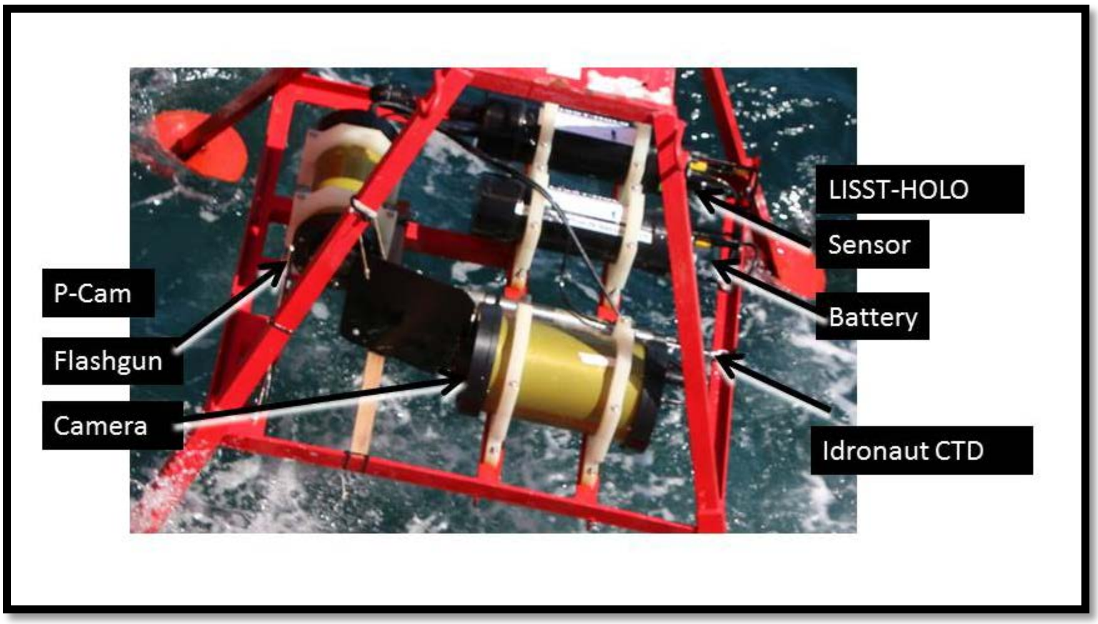
9 In situ particle characterisation

Particles responsible for downward flux were sampled optically and physically during the cruise. Optical profiles were taken using simultaneously the P-Cam and LISST-HOLO attached to the “Red Camera Frame”. In addition (See section 11.2) the MIO CTD was equipped with an Underwater Vision Profiler (UVP), a deep Laser In Situ Scattering Transmissometer (Deep-LISST) and a Deep Laser Optical Plankton Counter (Deep-LOPC). Particles were sampled using the Marine Snow Catcher (MSC).

9.1 The Red Camera Frame

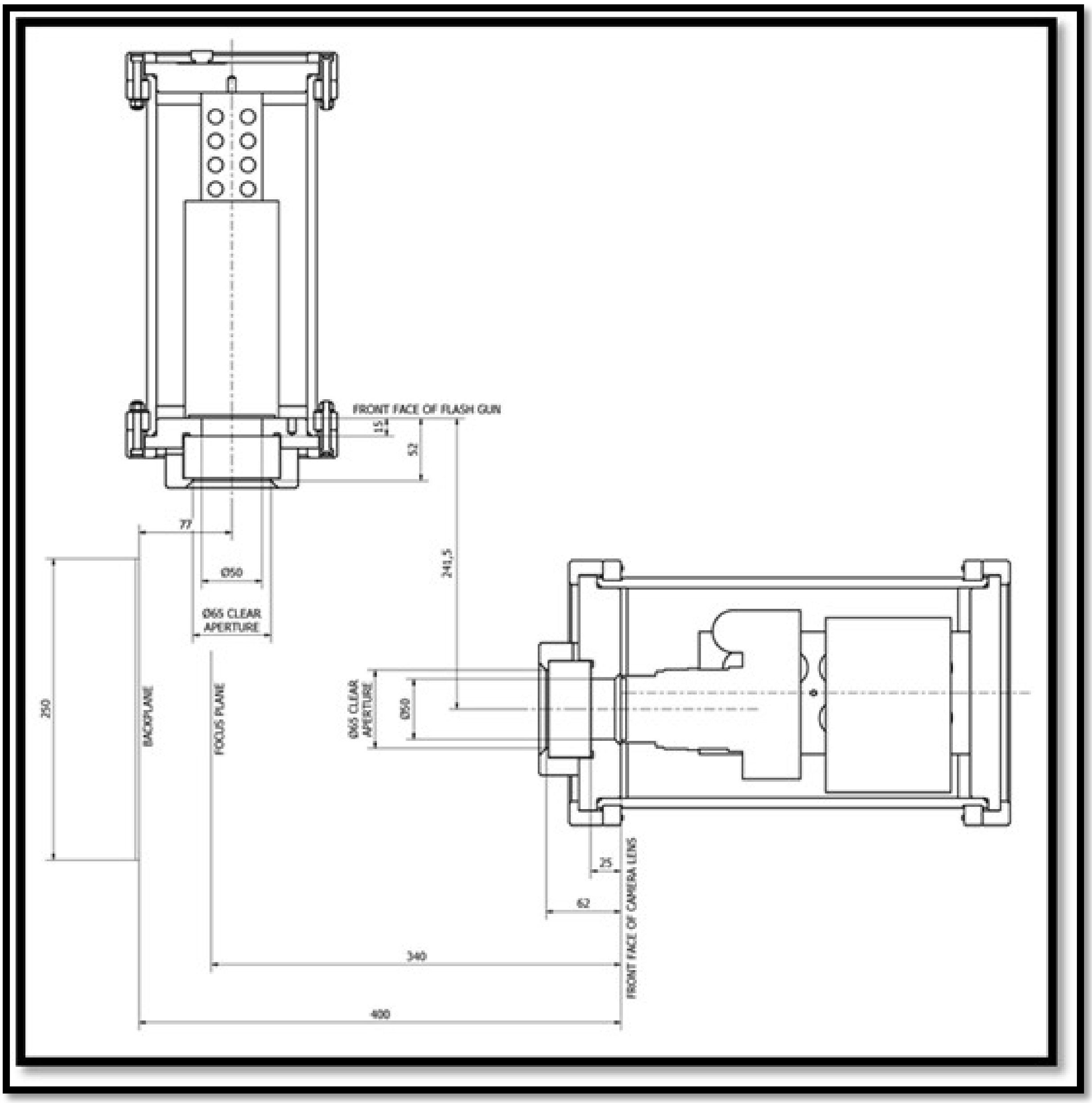
Richard Lampitt

The Red Camera Frame comprises three independent self-recording sensors; A standard camera system (P-Cam) photographing under dark ground illumination 7 litres of water every 5 seconds, a Holographic system (LISST-HOLO) imaging 1.8mls of water every 5 seconds and a CTD (Idronaut) sampling once per second. The system was lowered to 250m depth and raised at approximately 0.2m/sec giving one exposure of P-Cam and LISST-HOLO every



meter.

9.1.1 P-Cam description



- This comprised:
  - Canon EOS 6D digital SLR camera
  - Canon Speedlite 600EX-RT flash gun
  - Quantum Turbo 3 battery pack
  - Hahnel Giga T Pro II remote timer
  - Lens: 50mm

The camera was in general started in the Main Lab with a 15 minute delay in order to install the camera in the pressure case and fix it to the frame on deck. The camera settings were:

Frame interval: 5 sec
Apperture: f32

ISO: Variable. See table
Shutter speed: 1/180 sec
Flash energy: 35mm focal length

	P-Cam deployments on Red Camera Frame								
	DATE	JDAY	STN NO	TIME (GMT)	LAT (N)	LONG (W)	ISO	Flash	# of continuous 5 second exposures
1	24/06/2015	175	008	06:40	49 02.47	16 25.22	10,000	1/16	181
2	24/06/2015	175	015	20:55	49 01.90	16 24.61	10,000	1/16	>446
3	25/06/2015	176	019	15:40	48 50.39	16 31.31	10,000	1/16	383
4	27/06/2015	178	043	21:07	49 04.43	16 15.77	10,000	1/16	>444
5	01/07/2015	182	086	16:10	48 59.08	16 17.72	10,000	1/16	629
6	02/07/2015	183	093	16:46	48 40.9	17 03.5	10,000	1/16	585
7	02/07/2015	183	095	22:13	48 41.07	17 03.96	10,000	1/16	No images
8	03/07/2015	184	097	09:55	49 01.53	16 25.36	10,000	1/16	641
9	03/07/2015	184	106	21:01	49 00.59	16 26.22	10,000	1/16	>89
10	03/07/2015	184	107	22:08	49 00.5	16 26.23	640	full	52
11	03/07/2015	184	108	23:54	49 00.5	16 26.23	2,000	1/8	237
12	04/07/2015	185	113	13:53	48 56.15	16 10.37	5,000	1/8	>222
13	04/07/2015	185	114	14:30	48 56.15	16 10.37	10,000	1/8	>447
			Equivalent light exposures			Uncertain			
			Flash output	ISO					
			1/16	10,000					
			1/8	5,000					
			1/4	2,500					
			1/2	1,250					
			Full	625					

9.1.2 P-Cam data processing

Images were batch processed using "Image J" software after increasing the Virtual memory of the laptop to 20GB. Processing lasted about 1 hour. The processing sequence used was:

1: File/Import/Image Sequence
2: Image/ Type/ 8 bit
3: Image / Adjust/ Threshold……………. Set to 35
4: Process / Binary / Make Binary
5: Analyse / Set Scale ………………….. 32.15 pixels/mm
6: Analyse / Analyse particles

Summary data were immediately exported to Excel for visualisation. The full data set with characteristics of each particle will be carried out after the cruise.

9.1.3 LISST-HOLO Preparation

On initial preparation of the LISST-HOLO no communication was achieved with the instrument. Last use of the instrument, RRS *James Clark Ross* 304, was via a ship's network connection (rather than instrument's router), and it was thought likely that the instrument's IP address had been changed for that purpose. E-mail from Jeremy Robst (BAS IT) confirmed that the IP address had been changed to 10.104.2.34. Communication was achieved via the router by setting laptop LAN settings to IP address 10.104.2.100, and subnet mask to 255.255.255.0.

Instrument set-up then proceeded as follows:

- Power set to always on (for lab operations)
- Comment set to "DY032"
- Deployment number set to 1
- Image number set to 1
- Storage maintenance set to "at next boot"
- Instrument rebooted
- Time zone set to UTC
- Time set to match ship's GPS time
- All internal images deleted
- Programme 1 start condition set to magnetic switch
- Programme 1 sampling set to fixed rate 5-seconds
- Programme 1 stop condition set to magnetic switch
- Programme 1 selected and applied
- IP address reset to original 192.168.0.150
- Power set to sleep mode
- Instrument to sleep
- Instrument restarted and communications confirmed to be good via the router in original configuration

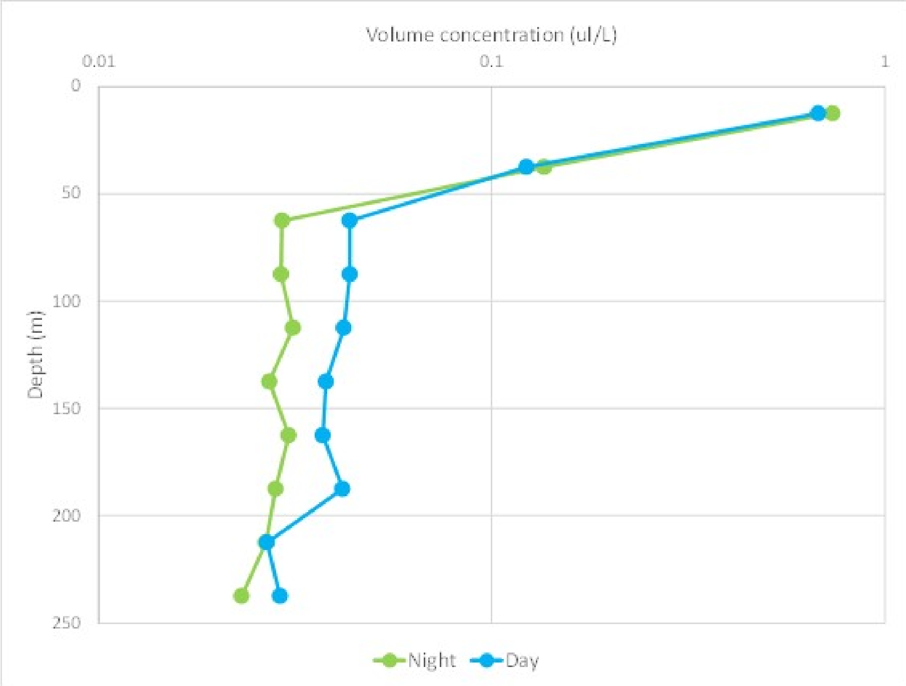
A new battery pack was fitted note this UK-made pack is oversize and was fitted without retaining plate. Instrument test start in lab, confirmed images were being recorded on EMM, those images were deleted and the instrument mounted on the 'red camera frame' (as per previous FS *Meteor* cruise) ready for deployment.

Thirteen deployments were successfully completed, returning a total of 5577 underwater holograms. All holograms were processed on board. Brief inspection of the resultant data (see below) suggested a broad similarity with results from the previous PAP cruise (FS *Meteor* 108).

9.1.4 LISST-HOLO Deployments

Stn DY032-	Date 2015	Time start	Locale	Descents	Holograms	EMM	Processed
008	24/06	06:40	49 02.5 16 25.2	3 x 250m	1216	yes	yes
015	24/06	20:55	49 01.9 16 24.6	1 x 250m	384	yes	yes
019	25/06	15:40	48 50.4 16 31.3	1 x 250m	448	yes	yes
043	27/06	21:07	49 04.4 16 15.8	1 x 250m	359	yes	yes
086	01/07	16:10	48 59.1 16 17.7	2 x 250m	708	yes	yes
093	02/07	16:46	48 40.9 17 03.5	2 x 250m	587	yes	yes
095	02/07	22:13	48 41.1 17 04.0	2 x 250m	704	yes	yes
097	03/07	09:55	49 01.5 16 25.4	2 x 250m	820	yes	yes
106	03/07	21:01	49 00.6 16 26.2	1 x 250m	448	yes	yes
107	03/07	22:08	49 00.5 16 26.2	2 x 100m	246	yes	yes

108	03/07	23:54	49 00.5 16 26.2	1 x 250m	354	yes	yes
113	04/07	13:53	48 56.2 16 10.4	1 x 100m	192	yes	yes
114	04/07	14:30	48 56.2 16 10.4	1 x 250m	400	yes	yes



Particle concentration with depth (all deployments combined; day = 06-18:00 hours).

9.2 Marine Snow Catcher

Marine Snow Catchers (MSC) are used to collect organic sinking particles of different settling velocities for a range of experiments and for calculating particulate organic carbon (POC) export and flux to the interior oceans.

6 MSCs were packed onto the ship, 2 large (~300 L) and 4 small (~95 L). However, only 3 of the small MSCs were operational during this cruise. The base of the other small MSC was broken from a previous cruise and due to their design the large MSCs are not reliable in any kind of sea state other than flat calm. Appropriate adjustments to the large MSCs could make them operable in moving waters. Additionally the deck frames made for the large MSCs are inadequate for the job intended, to make working with the large MSCs safe, and caused problems and risks than we would have had without them.

9.2.1 Deployments of MSCs

Table 1. *Stations and details of all MSC deployments*

Station	Date	Lat (N)	Long (W)	Time (GMT)	Person	Depth (m)
2	24/06/2015	49)02.47	16)25.22	02:10	Anna	28
3	24/06/2015	49)02.47	16)25.22	02:35	Anna	128
4	24/06/2015	49)02.47	16)25.22	04:00	NA	28
5	24/06/2015	49)02.47	16)25.22	04:35	Katsia	28
6	24/06/2015	49)02.47	16)25.22	05:00	Manon	28
7	24/06/2015	49)02.47	16)25.22	05:40	MIO	28
13	24/06/2015	49)02.50	16)24.61	15:35	Manon	28
25	26/06/2015	48)50.28	16)31.91	11:50	NA	150
26	26/06/2015	48)50.21	16)32.14	12:10	NA	70
27	26/06/2015	48)50.13	16)32.37	12:40	NA	70
28	26/06/2015	48)50.09	16)32.46	12:55	NA	70
30	26/06/2015	48)50.06	16)32.58	14:30	MIO	70
31	26/06/2015	48)50.06	16)32.58	14:35	Anna	70
32	26/06/2015	48)50.06	16)32.58	15:20	Katsia	150
33	26/06/2015	48)50.02	16)31.8	17:20	Manon	70
49	28/06/2015	49)01.25	16)25.04	11:50	Anna	110
51	28/06/2015	48)59.56	16)25.98	14:30	Manon	500
67	29/06/2015	48)49.3	16)31.3	16:40	Anna	70
68	29/06/2015	48)49.6	16)31.3	17:05	Manon	70
69	29/06/2015	48)49.7	16)31.2	17:30	Katsia	500
73	30/06/2015	49)03.70	16)16.17	14:30	MIO	500
74	30/06/2015	49)03.54	16)16.04	15:15	Manon	500
75	30/06/2015	49)03.30	16)15.84	18:55	Katsia	10
77	30/06/2015	49)03.8	16)15.8	19:55	Anna	40
88	02/07/2015	48)40.9	17)03.5	10:00	Anna	200
89	02/07/2015	48)40.9	17)03.5	10:25	Manon	128
90	02/07/2015	48)40.9	17)03.5	10:40	MIO	128
98	03/07/2015	49)01.51	16)25.36	12:05	Katsia	1000
99	03/07/2015	49)01.27	16)25.45	12:40	MIO	70
101	03/07/2015	49)01.10	16)25.46	13:30	Katsia	10
104	03/07/2015	49)01.6	16)25.7	16:15	MIO	28
110	04/07/2015	48)56.16	16)10.35	13:00	Anna	30
111	04/07/2015	48)56.16	16)10.35	13:15	Anna	60
112	04/07/2015	48)56.16	16)10.35	13:00	Anna	100

Table 1 lists all stations and depths of the MSCs deployed on this cruise. In total there were 33 deployments, with 28 being successful. Station 4 was the one attempt to use the large MSC, however this failed as the O-ring burst out of the base twice whilst trying to lower onto the deck frame. The MSCs were deployed off the port winch and aft starboard crane. All other MSC deployments were mechanically successful. However at stations 25 – 28 deployments were moved to the general-purpose wire on the parallelogram and they fired early due to the plastic coating on the wire allowing the release to slip down. From then on we only deployed the original winch as the release did not slip down the un-coated wire. We also checked the temperature of the water as soon as it was onboard so we knew which depth the water was collected at. MSCs were left to settle strapped to the bulwark. The deepest ever MSC deployment occurred during this cruise at 1000 m!!

9.2.2 Sampling of MSCs

Four different groups were sampling the MSCs for different purposes, but with a common goal; to understand more about remineralisation processes of organic particles. Specifically the teams and their projects were:

1. MIO – analyzing the effect of mineral ballast remineralisation on sinking organic particles
2. Manon – identifying differences in nitrogen cycle actors between particle-attached and free-living communities
3. Anna/Chelsey – calculating POC export and flux to depth, identifying type of particle, calculating sinking rates of fast sinking particles and taking oxygen profiles through particles
4. Katsia – looking for microplastics in the particles at similar depths to the SAPS deployments

Fig.1. Anna setting up a small MSC for deployment

10 Microplastics

Katsia Pabortsava and Emma Cavan

Large volume *in situ* Stand Alone Pumps (SAPs) and Marine Snow Catchers (MSC) were used to estimate the distribution of microplastics in the water column at the PAP site. This work was conducted by Katsia Pabortsava. Sediment core samples from the megacore were collected by Emma Cavan to investigate the abundance of microplastics in the deep marine sediments at PAP. The SAPs and MSC samples will also be analysed for particulate organic carbon (POC) and particulate aragonite.

10.1 Marine Snow Catchers for Microplastics

In total 7 MSC deployments at 6 different depths (10-1000 m) were performed to collect seawater for the analysis of microplastics and POC (Table 1). Once recovered, the MSC was left to stand on deck for 2 hours to separate fast and slow-sinking/suspended particle fractions. Seawater containing slow-sinking/suspended particles was collected into 2x5 L plastic carboys. The top part of the MSC was then drained and removed. The fast sinking particles were collected into a tray mounted at the base of the MSC. The overlaying seawater containing fast-sinking particles was then siphoned into 5 L carboy. Sample processing and filtration was conducted under laminar flow hood in the clean laboratory on board of the ship. First, particles were carefully picked with a glass pipette from the sample tray, filtered onto ashed (450°C for 12 hrs) 25 mm GF/F filter (0.7 µm pore size), and stored at -20°C. The remaining quarter of the tray sample was collected into acid-clean 20 ml glass vials (usually 3-4 vials) and spiked with 100 µL concentrated (37%) borax-buffered formaldehyde preservative to stop microbial degradation. Sample vials were stored at 4°C until analysis in the land laboratory. One litre of seawater containing slow-sinking/suspended and fast-sinking (siphoned) particles was filtered onto ashed 25 mm GF/F filter (0.7 µm pore size) and stored at -20°C. Duplicate samples for both parameters were taken. Finally, 1 L of seawater containing slow-sinking/suspended and fast-sinking (siphoned) particle fractions was preserved in 5 % (v/v %) borax-buffered formaldehyde solution.

Table 1: Marine Snow Catcher deployed for the microplastics collection

DATE	ST NO	Time	LAT [N]	LON [W]	DEPTH [m]
24/06/2015	005	04:35	49.041	16.420	28
26/06/2015	032	15:20	48.834	16.543	150
28/06/2015	054	18:20	48.983	16.418	500
29/06/2015	068	17:05	48.832	16.520	70
30/06/2015	075	15:52	49.060	16.263	10
03/07/2015	98	12:05	49.020	16.424	1000
03/07/2015	101	13:30	49.020	16.424	10

10.2 *In situ* Stand Alone Pumps (SAPs) for Microplastics

The SAPs were deployed at 4 discrete depths (Figure 1; Table 2) collecting particles on the 10% HCl-washed 53µm (prefilter) and 1µm (main filter) Nitex nylon meshes. The SAPs were set to pump for 90 min with a delay time of 90 min, filtering between 1244 L and 2008 L of seawater (Table 3). Each SAP was equipped with a SeaBird Temperature-Depth sensor, recording the data every 10 min. Upon recovery, the Nitex meshes were carefully removed from filter holders, folded into triangles and stored at -20°C until analysis in the land laboratory. Some unused 53 µm and

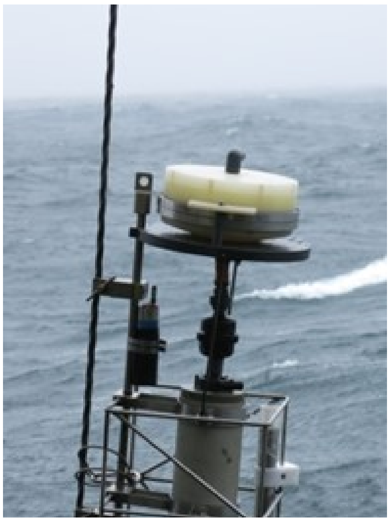


Figure 1: In situ Stand Alone Pump being deployed

1 µm Nitex meshes, rinsed with Milli-Q water only and with 10% HCl and Milli-Q were would be used as blanks. The filter loading and sample processing was conducted under the laminar flow hood in the clean laboratory on board of the ship.

Table 2: Summary of the SAPs deployments

DATE	St NO	LAT [N]	LON [W]	Depth [m]	SAP S/N	Volume filtered (L)	Size fraction
27.06.2015	40	49.0747	16.2639	990.3	03-04	1902	>53µm, 53-1µm
27.06.2015	40	49.0747	16.2639	490.7	02-002	1993	>53µm, 53-1µm
27.06.2015	40	49.0747	16.2639	144.1	03-03	1307	>53µm, 53-1µm
27.06.2015	40	49.0747	16.2639	65.0	03-01	1735	>53µm, 53-1µm
29.06.2015	62	48.83230	16.51965	495.1	03-04	2000	>53µm, 53-1µm
29.06.2015	62	48.83230	16.51965	149.8	03-03	1397	>53µm, 53-1µm
29.06.2015	62	48.83230	16.51965	70.4	03-01	2007	>53µm, 53-1µm
29.06.2015	62	48.83230	16.51965	10.3	02-002	1244	>53µm, 53-1µm
02.07.2012	91	48.0010	17.0367	504.5	03-04	1926	>53µm, 53-1µm
02.07.2012	91	48.0010	17.0367	150.8	03-03	1400	>53µm, 53-1µm
02.07.2012	91	48.0010	17.0367	70.9	03-01	2008	>53µm, 53-1µm
02.07.2012	91	48.0010	17.0367	10.5	02-002	1255	>53µm, 53-1µm

10.3 Sediment cores for microplastics

Sediment cores were collected from the megacore to quantify the amount of microplastics present in deep sea sediments at 4850 m.

10.3.1 Sediment cores collected

Generally the megacore deployments were successful with 6-8 successful cores taken per megacore. At one station (55) at the coring time-series site the megacore was deployed solely for microplastics, where 8 successful cores were collected. At the hill site one megacore was deployed where ~ 50 % of the cores were sampled for microplastics (station 83). In total 21 samples were collected and 8 control samples.

10.3.2 Sampling the megacore

Once on deck the cores were removed from the megacore one by one, which generally took ~ 30 minutes. The core designated for microplastics was immediately covered with foil to prevent any airborne microplastics contaminating the mud. The surface water was siphoned through a 250 µm sieve and the sediment remaining on the sieve collected in a glass sampling jar (250 ml). Next the top 1 cm was sliced off using a metal cutter and added to the sampling jar. Plastics are only likely to be found on the surface since plastic is a modern product. This means it was easy to take a control sample by removing the next 5 cm of mud and discarding and collecting the next 1 cm of mud and placing in a separate sampling jar. Therefore where the core depth is 0 cm on the table is the sample from the surface and where it is 6 cm this is the control deeper in the core (see Fig. 2).

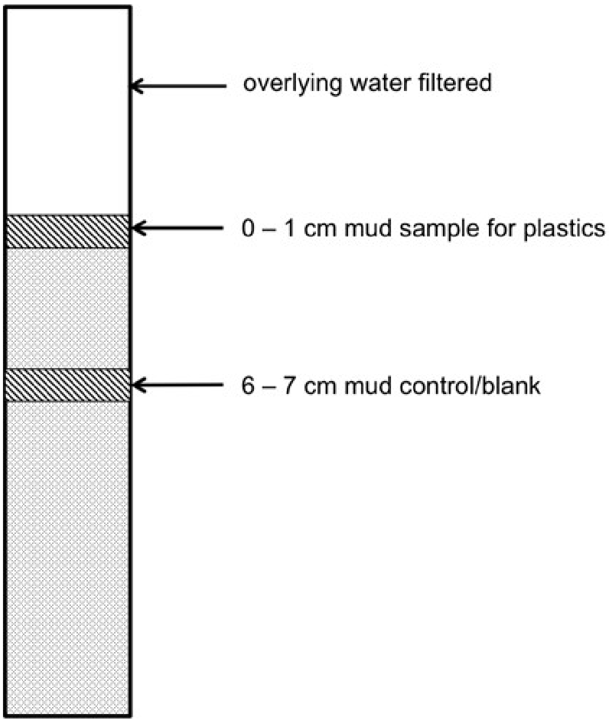


Figure 2: Diagram (not to scale) of how a core was sampled

Once the sample was collected the jars were covered in foil and weighed, then dried at 60 °C and weighed again. The dry mud samples will be taken back to NOCS where most of the sediment will be removed to leave only the most buoyant/least dense particles, including the plastics, before analysis on an FT-IR. At the plain sites the sediment was fine mud whereas at the hill site it was slightly coarser with a greaser range in grain sizes.

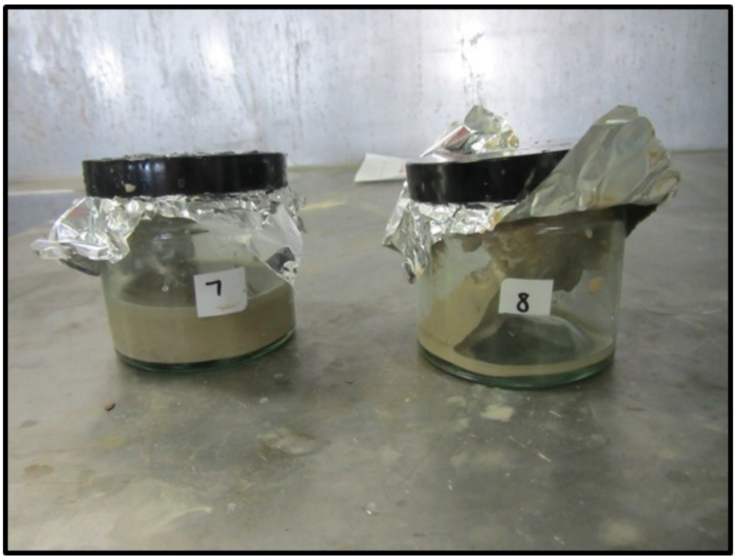


Figure 3: Mud samples collected from station 23. Jar 7 is a surface sample with the overlying water and jar 8 is the control from 6 cm deep before drying

We also catalogued the litter from the deep trawl, which is described in the cruise report written by the benthic team. There was even an oil drum in the trawl!

11 Mineral ballasts effects on carbon mineralization by prokaryotes

MIO team on board *Nagib Bhairy, Marc Garel, Manon, Sophie Guasco, Virginie Riou, Christian Tamburini.*

Other staff involved in the data analyses*: Léo Berline, François Carlotti, Christos Panagiotopoulos, Stéphanie Jacquet, Bernard Quéguiner, Karine Leblanc (MIO, Marseille, France), Luc Beaufort (CEREGE, Aix-en-Provence, France), Chiara Santinelli (CNR, Pisa, Italy) and Frédéric Le Moigne (Géomar, Kiel, Germany).*

11.1 General Objectives

Our main aim during this cruise was to estimate the role of prokaryotes into the degradation of the organic matter and regeneration of mineral ballasts in the mesopelagic waters of the Porcupine Abyssal Plain site (PAP site).
For such an aim, we have used special high-pressure (HP) systems using a common unit, the high-pressure bottles (HPBs). In one case, HPBs were fitted on a Sea-Bird Carousel with Niskin bottles (called thereafter HPSS for High Pressure Serial Sampler) in order to measure *in situ* prokaryotic activities. In the second case, HPBs were used to simulate the pressure that particle-attached microbes experience when they fall through the water column.

Hence 4 tasks can be differentiated:
- Task 1 – Distribution and characterization of particles in the mesopelagic waters
- Task 2 – Diversity and activity of prokaryotes through the water column
- Task 3 – Characterization of the organic and mineral composition of particles
- Task 4 – SINking PArticles Simulation experiment

Two sets of samples have been obtained:
- seawater samples: samples obtained with Niskin or high-pressure bottles (HPBs) (Figure 1)
- marine snow catcher samples: three fractions were sampled (suspended particles, slow sinking particles and fast sinking particles).

11.2 Task 1 – Distribution and characterization of particles in the mesopelagic

The MIO's Sea-Bird Carousel was equipped with several optical devices to estimate the quality and quantity of the particles throughout the water column (see figure 1):
- The deep Laser In Situ Scattering Transmissometer (Deep-LISST, Sequoia®) instrument obtains in-situ measurements of particle size distribution, optical transmission, and the optical volume scattering function (VSF) at depths down to 3,000 meters.

- The deep Laser Optical Plankton Counter (LOPC-6000): the LOPC offers advanced data collection features not found on conventional optical particle counters.
- The Underwater Visio Profiler or UVP is designed to study large (>100 µm) particles and zooplankton simultaneously and to quantify them in a known volume of water. The UVP system makes use of computerised optical technology with custom lighting to acquire digital images of zooplankton *in situ* down to depths of 6000m.

On the Sea-Bird CTD, other sensors were fitted: PAR cosinus, fluorimeter, transmissiometer and oxygen sensor.

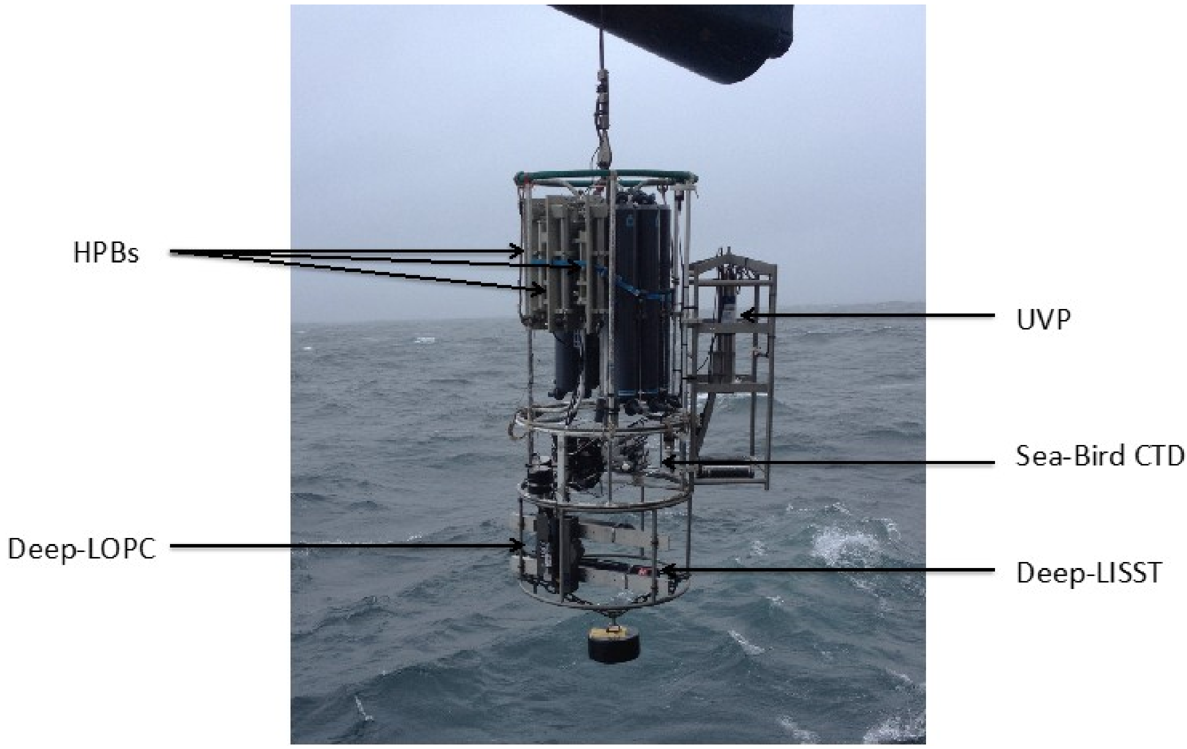
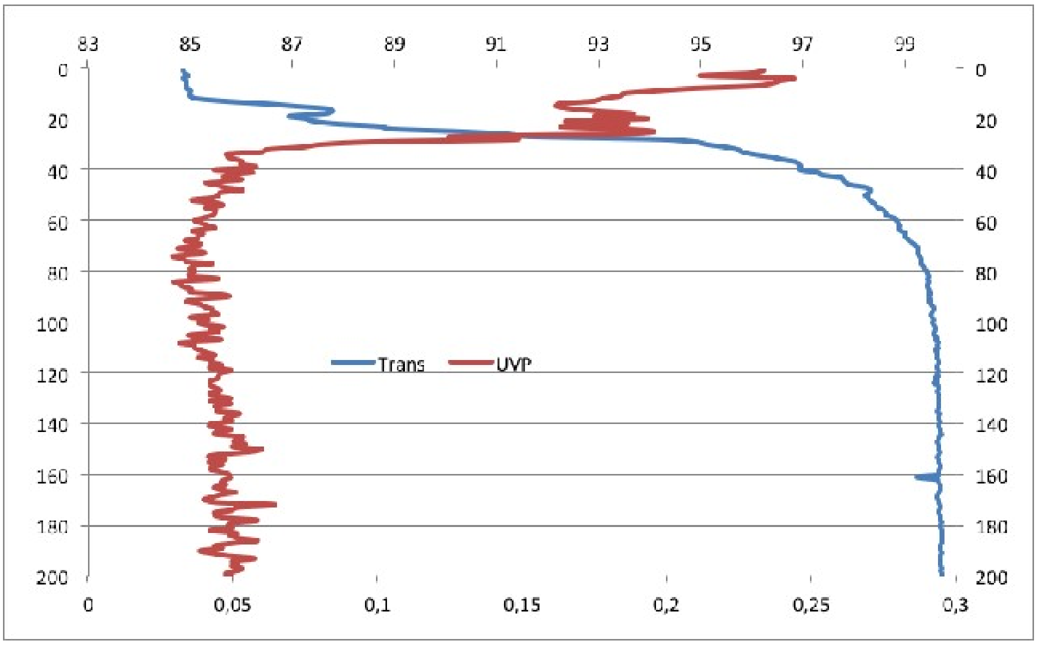


Figure 1: *The MIO's CTD carousel with the Underwater Vision Profiler (UVP), the deep Laser In Situ Scattering Transmissometer (Deep-LISST) and the deep Laser Optical Plankton Counter (Deep-LOPC). Note that during this cast, three high pressure bottles (HPBs) were fitted on the carousel to obtain un-decompressed seawater samples.*

Sixteen casts have been performed using the MIO's carousel (see Table below).

Table 1: MIO CTD's casts performed during the DY032 cruise on board the RRS Discovery.

CTD	STN	Depth	DATE	JDAY	TIME (GMT)	LAT (N)	LONG (W)	LISST	LOPC	UVP
1	001	1000m	24/06/2015	175	00:32	49 01.67	16 24.90	none	Data 0200 à 2001	OK
2	014	4700m	24/06/2015	175	15:55	49 02.50	16 24.61	none	0202 à 0226	OK
3	018	1000m	25/06/2015	176	09:40	48 50.47	16 31.32	none	none	OK
4	024	1000m	26/06/2015	177	10:00	48 50.40	16 31.55	none	none	OK
5	041	1000m	27/06/2015	178	15:54	49 04.44	16 15.68	L1781551	0227 à 0238	OK
6	042	1200m	27/06/2015	178	19:00	49 04.6	16 15.5	L1781858	0239 à 0250	OK
7	044	1000m	27/06/2015	178	22:00	49 04.42	16 15.83	L1782202	0251 à 0260	OK
8	047	1000m	28/06/2015	179	09:30	49 00.77	16 23.73	L1790933	0261 à 0268	OK
9	060	1000m	29/06/2015	180	02:56	48 54.38	16 29.39	L1800257	0269 à 0275	OK
10	066	500m	29/06/2015	180	15:20	48 49.15	16 31.24	L1801522	0276 à 0281	OK
11	072	4000m	30/06/2015	181	11:05	49 04.4	16 15.83	none	0282 à 0300	OK
12	078	4000m	30/06/2015	181	20:36	49 04.62	16 15.83	none	0301 à 0319	OK
13	085	1000m	01/07/2015	182	14:10	48 59.14	16 17.10	L1821414	0320 à 0328	OK
14	092	1000m	02/07/2015	183	15:00	48 40.93	17 03.54	L1831459	0329 à 0337	OK
15	094	1000m	02/07/2015	183	20:27	48 40.9	17 03.5	L1832030	0338 à 0345	OK
16	096	1000m	03/07/2015	184	07:27	48 58.7	16 30.8	L1840740	0346 à 0354	OK



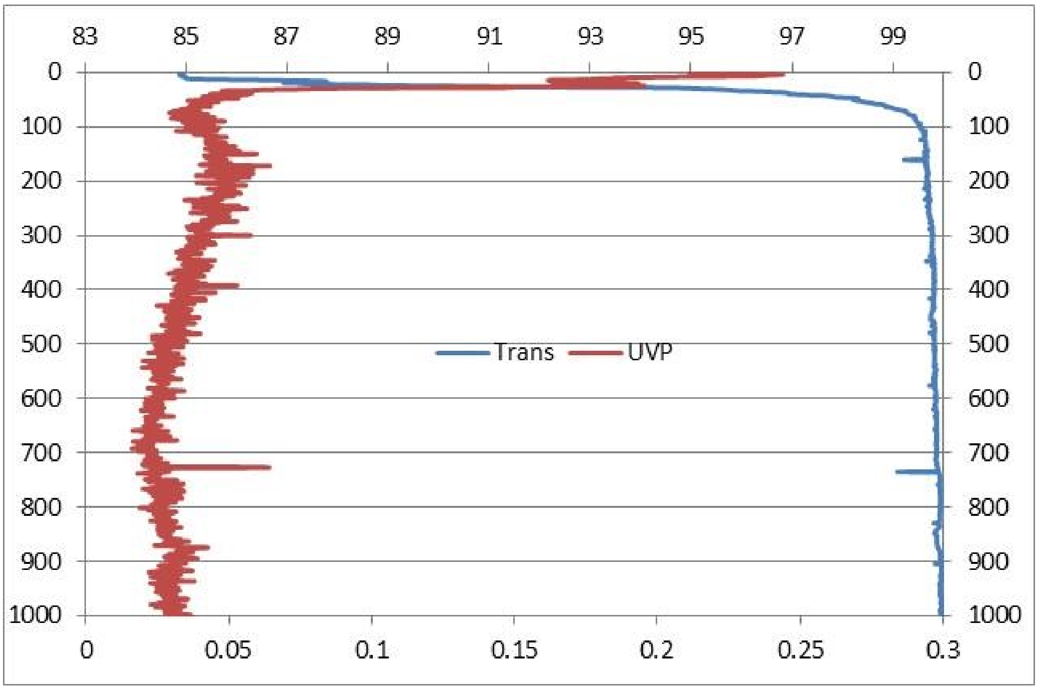


Figure 2: *Example of profiles obtained with the deep-UVP and the transmissiometer between 0-200m depth (top graph) and between 0-1000m depth (lower graph). Station 001, June 24th 2015.*

11.3 Task 2 – Diversity and activity of prokaryotes through the water column

In each sample obtained with Niskin bottles or with the MSC, we have sampled to measure:

- Prokaryotic heterotrophic production using ^{3}H-Leucine (PHP). During the DY032 cruise, 13 depths between 10 and 1000m depth have been sampled for PHP measurements with Niskin bottles. PHP measurements have been performed also at 28, 70, 128, 500m depth using the marine snow catcher according 3 fractions: suspended, slow sinking and fast sinking particles. Moreover, we have performed PHP measurement at 128, 500 and 1000 m-depth under *in situ* pressure and temperature conditions using HPBs. More than 300 samples have to be counted with a scintillation counter at land since the scintillation counter on board the RRS *Discovery* failed.
- Ectoenzymatic activities (EEA) using fluorescent compounds as well as MCA-Leucine, MUF-P, MUF-□-Glucopyranoside, MUF-N-AcetylGlucosamine, MUF-palmitate have been measured on board to collect data on aminopeptidase, phosphatase, chitinase and lipase activities, respectively. All these ectoenzymatic activities were performed using time and concentration kinetics directly on board the ship using a Varioskan multiwell plate spectrofluorimeter.
- Prokaryotic abundance and diversity: 28, 70, 128, 500 m depths have been sampled both with Niskin bottles or with MSC. 1000 and 4000m depth were sampled with Niskin bottles. Flow cytometry analyses will be used to evaluate the prokaryotic

abundance, while DNA/RNA extraction will be performed to identify total prokaryotic and 'active' communities.

Particulate Barium and Dissolved Barium analyses will be performed by Stéphanie Jacquet to test Barium as a proxy of mineralization processes. Samples were taken between 10 and 1200m depth.

In collaboration with Manon Duret and Phyllis Lam (NOC, UK) (cf. Manon Duret's cruise report), we have performed an experiment to evaluate the effect of hydrostatic pressure on N-mineralization processes (ammonification, chemolithoautrophy, remineralisation and assimilation of Urea). Two HPBs were used to achieve 1000m-depth samples maintaining all the time the temperature and pressure conditions (10 MPa). A decompressed counterpart has been performed using sample carried out at 1000m depth. Incubations were maintained during 72 h under in situ pressure and temperature conditions and sub-sampling were performed after 24 h maintaining the in situ pressure conditions.

In collaboration with Rob Young (NOC, UK), we have performed an experiment to evaluate the pressure effect on genomics and transcriptomics of prokaryotes at 4000m depth. Two HPBs have been used to sample, retrieve and incubate at 40 MPa (and at 2.6°C) seawater during 36 and 72h. At the end of incubation, filtrations have been performed using 0.2 □m sterivex filter, incubated overnight with RNA later and freeze at -80°C for further analyses (see Rob Young's report).

During this DY032, we have attempted to validate a new protocol to measure oxygen consumption directly into the high-pressure bottles (HPBs). We have achieved data only at 128, 500 and 1000 m depth. Unfortunately, our new design of sapphire window within our new HPBs failed and it was not possible to continue.

11.4 Task 3 – Characterization of organic and mineral composition of particles

In order to assess the impact of mineral ballasts (biogenic silica, calcite and atmospheric dust deposition) on organic carbon degradation by prokaryotes, we took subsamples of the same Niskin samples and MSC fractions used for prokaryotic activity/diversity characterization described in Task 2, for the analysis of their chemical composition.
The organic carbon composition will be described in terms of Total, Particulate and Dissolved Organic Carbon (TOC, DOC, POC), as well as total carbohydrates contents, to be related with the enzymatic activities analysed in Task 2.
Samples for particulate silicium (both biogenic and lithogenic), calcium (as a proxy of calcite) and aluminium (as a proxy of atmospheric dust deposition) were recovered in parallel for the characterization of the different particle fractions mineral content.
In addition, samples were taken for microscopic observations in order to identify/quantify the different mineralizing plankton species. Acid lugols was used to preserve biogenic silica-

producing species (e.g. diatoms, silicoflagellates, etc….), while calcite-producing species (e.g. coccolithophorids, foraminifera) will be analysed using scanning electron microscopy, also attempting to evaluate calcite biovolumes in each sample. This information will be supplemented by flow cytometric analyses of the phytoplankton community abundance.

11.5 Task 4 – SINking PArticles Simulation Experiment

In order to assess the effect of pressure during the descent through the water column at the PAP site on calcite and organic carbon degradation, we have performed a SINking PArticles Simulation (SINPAS) experiment, using natural prokaryotic assemblages from 105 m-depth obtained at the PAP site inoculated with aggregates made of an axenic culture of *Emiliania huxleyi*.

Pellets of *Emiliania huxleyi* have been added to reach a final POC concentration of around 50 □M, to 7-Liters of GFF-filtered 105m-depth seawater collected at the PAP site on June 28th 2015. These particles with surface "free-living" prokaryotes have been incubated during 6 days in 6 HPBs. Pressure has been increased within 3 HPBs (HP incubations) in order to simulate particle sinking at 150 $m.d^{-1}$ (for further details see Tamburini et al., 2009) while 3 other bottles were maintained at atmospheric pressure condition (0.1 MPa). Temperature decrease was simultaneously controlled to simulate the decrease of temperature between 100 and 1000m-depth.

12 Microbial controls on the remineralisation of POM

Manon T. Duret

12.1 Objectives and aims:

About half of anthropogenic atmospheric CO_2 is currently absorbed in global oceans, and a large portion due to surface primary production that converts CO_2 into organic matter. For this carbon to effectively stay sequestered, it needs to be transported away from the surface into the deep primarily *via* the ocean's biological pump – the sinking of particulate organic matter into the ocean interior. However, about 90% of these sinking particles are subjected to remineralisation that releases nutrients and CO_2 in the twilight zone water column (or "mesopelagic": ~100-1000m) by microorganisms. Therefore, microorganisms play a central role in determining the efficiency of the biological pump, and in the biogeochemical cycling of carbon and nutrients.

Nitrogen is often a biolimiting nutrient for phytoplankton in large parts of global ocean. It is thus beneficial to the biological pump for nitrogen to be remineralised sooner from dead organic matter to stimulate further phytoplankton growth. Despite such importance of microorganisms in linking organic and inorganic forms of N and C, questions remain regarding their phylogeny, the exact pathways leading to the remineralisation of organic matter, and the relative contribution of free-living and particle-attached communities.

The objective of this project is to investigate the pathways, activities and community structures of microorganisms responsible in the remineralisation of sinking and suspended particulate organic matter in the twilight zone, with a focus on nitrogen.

12.2 Sample collection:

All samples were collected from 70, 130, 500 and 1000m, to focus on particle maxima and the mesopelagic zone of the productive PAP site.

$^{15}N/^{13}C$ incubations:

In order to investigate microbial remineralisation of particulate organic matter, incubation experiments were carried out at 10˚C for 48hours using sub-samples from both the upper and lower parts of the Marine Snow Catcher (MSC; please see Emma Cavan's cruise report): suspended particles (MSC U), and fast- (and slow-) sinking particles (MSC B). 1-L subsamples were collected from each MSC portion from 70, 130 and 500m, focusing on the mesopelagic zone and particle maxima. Four ^{15}N-/^{13}C- stable isotope labelled tracers were used in parallel incubation experiments for each MSC portion and depth:

A. ^{15}N-ammonium and ^{13}C-bicarbonate (targeting nitrification and chemolithoautotrophy);
B. $^{15}N/^{13}C$-urea (targeting remineralisation/assimilation);
C. $^{15}N/^{13}C$-algae (targeting remineralisation);
D. ^{15}N-amino acids and ^{13}C-bicarbonate (remineralisation/assimilation and chemolithoautotrophy).

Dissolved organic nitrogen (30mL, immediately frozen at -20˚C), nutrients (12mL, -20˚C), ammonium (10mL, analysed on board by Chelsey Baker – please see CB's cruise report) and 100mL-subsamples preserved with paraformaldehyde (final concentration 1%) were collected at T0. At each time point (0, 12, 24 and 48hours), each labelled 1L-incubation experiment was sub-sampled for N and C isotopes (12mL, fixed with 100µL of saturated mercuric chloride solution and kept at room temperature), dissolved organic nitrogen, nutrients and ammonium. At 0, 24 and 48hours, additional 100mL-subsamples were preserved with paraformaldehyde and filtered onto 0.2µm pore-size polycarbonate membrane filters for analyses with fluorescence *in situ* hybridisation, to survey any change in microbial community structure throughout the incubation. Flow cytometry (1.5mL fixed with 1% paraformaldehyde) sub-samples were also collected to investigate microbial abundance.
At 48hours, the remaining incubated volume was filtered onto 0.22µm Sterivex filters, treated with RNAlater and deep-frozen for later metatranscriptomics and/or RT(q)PCR analyses on shore, in order to study transcriptional responses of N-remineralisation pathways.

In order to investigate any pressure effects on N-cycling processes, in collaboration with the MIO team (please see Christian Tamburini's cruise report) high-pressure incubations were carried out using a 1000m-depth water sample from high-pressure bottles (10MPa) on the CTD- rosette. Two parallel experiments were set up:

A. ^{15}N-Ammonium and ^{13}C-bicarbonate (targeting nitrification and chemolithoautotrophy);

B. $^{15}N/^{13}C$-Urea (targeting remineralisation/assimilation).

In parallel, control incubation experiments were carried out at atmospheric pressure (0.1MPa). Pressure and temperature controlled incubations on synthetic particles were used to simulate particle sinking process (SINPAS, please see Christian Tamburini's cruise report). Labelled ^{15}N- ammonium was added with ^{13}C-bicarbonate, to investigate the particle-associated nitrification process.

12.3 Nucleic acids sampling:

Nucleic acids samples (DNA/RNA) were collected from the MSC U and MSC B, as well as from the CTD-rosette for later (RT)qPCR and metatranscriptomics analyses, to uncover the phylogenetic and functional diversity and expression of microbial communities in various particle size- fractions (fast-/slow- sinking and suspended particles, as well as bulk water) involved the N- remineralisation processes. The collected samples were treated with RNAlater and frozen at -80°C.

12.4 Protein sampling:

Proteins as the final products of gene expression indicate cellular priorities, taking into account both transcriptional and post-transcriptional control mechanisms that regulate adaptive responses. Therefore, samples from CTD-rosette and SAPS (please see Katsia Pabortsava's cruise report) were collected for metaproteomics – the identification of all proteins expressed at a given time within an ecosystem that would enable the reconstruction of microbial processes and metabolic pathways that are central to the functioning of the ecosystem. Samples collected were treated with RNAlater and frozen at -80°C.

12.5 Samples list:

Instrument	Event n°	Latitude	Longitude	Date	Time (GMT)	Main sample	Side parameters
CTD	1	49 01.67	16 24.90	24/06/2015	00:32	DNA/RNA	Nutrients, ammonium
MSC	6	49 02.47	16 25.22	24/06/2015	05:00	$^{15}N/^{13}C$ incubation	Nutrients, ammonium, DON, isotopes
MSC	13	49 02.50	16 24.61	24/06/2015	15:10	DNA/RNA	Nutrients, ammonium
CTD	24	48 50.40	16 31.55	26/06/2015	10:00	DNA/RNA	Nutrients, ammonium
MSC	27	48 50.13	16 32.37	26/06/2015	12:40	$^{15}N/^{13}C$ incubation	Nutrients, ammonium, DON, isotopes
CTD	41	49 04.44	16 15.68	27/06/2015	15:54	Protein	Nutrients, ammonium
CTD	42	49 04.6	16 15.5	27/06/2015	19:00	Protein	Nutrients, ammonium
CTD	44	49 04.42	16 15.83	27/06/2015	22:00	Protein	Nutrients, ammonium
CTD	47	49 00.77	16 23.73	28/06/2015	09:30	DNA/RNA	Nutrients, ammonium
MSC	51	48 59.56	16 25.98	28/06/2015	14:15	$^{15}N/^{13}C$ incubation	Nutrients, ammonium, DON, isotopes
MSC	67	48 49.3	16 31.3	29/06/2015	16:40	DNA/RNA	Nutrients, ammonium
SAPS	70	48 50.0	16 31.2	29/06/2015	19:31	Protein	Nutrients, ammonium
MSC	74	49 03.54	16 16.04	30/06/2015	14:55	DNA/RNA	Nutrients, ammonium
CTD	85	49 04.42	16 15.85	01/07/2015	14:10	DNA/RNA	Nutrients, ammonium
MSC	90	49 01.1	16 08.8	02/07/2015	10:40	DNA/RNA	Nutrients, ammonium
CTD	92	49 01.1	16 08.8	02/07/2015	15:00		Nutrients, ammonium, DON, isotopes
CTD	94	49 01.1	16 08.8	02/07/2015	20:00	$^{15}N/^{13}C$ incubation	Nutrients, ammonium, DON, isotopes
CTD	96	48 58.7	16 30.8	03/07/2015	07:27	$^{15}N/^{13}C$ incubation	Nutrients, ammonium, DON, isotopes
SAPS	109	49 00.3	16 26.2	04/07/2015	08:34	Protein	Nutrients, ammonium
SAPS	115	48 56.15	16 10.37	04/07/2015	15:18	Protein	Nutrients, ammonium

13 Ammonium measurement

Chelsey Baker

Ammonium, the most labile form of nitrogen, is mainly produced through the remineralisation of organic nitrogen in the mesopelagic zone of the ocean. Ammonium is cycled quickly throughout the ocean and is readily assimilated by bacteria soon after production. Therefore, the concentration of ammonium can vary significantly on short timescales. Through the measurement of ammonium insight, into the nitrogen cycle and bacterial activity in the mesopelagic zone, can be gained.

Ammonium was measured using the SOES standard operating procedure. In summary, 10ml of water is sampled into an acid-washed vial and 800 µl of OPA working reagent is added immediately. The OPA working reagent is light-sensitive and is stored in the dark; a daily calibration is carried out to account for the diminishing fluorescence over time. Samples are incubated in the dark for 3-4 hours and subsequently measured using a Turner Trilogy fluorometer fitted with an ammonium/CDOM module. The raw fluorescence (RFU) is measured three times per sample to produce an average. The regression equation from the daily calibration is used to calculate the ammonium concentration.

The calibration standards in the SOP are 0, 10, 50, 100, 200, 500, 1000, 2000 nmol L^{-1}, however due to an issue with the standards the concentrations were 0, 1000, 5000, 10000 and 20000 nmol L^{-1} which were continued throughout the cruise for continuity. Overall, the calibration issue made little difference to the ammonium results as the method was only as sensitive as the 0 nmol L^{-1} value (from 4000 m unfiltered water) which had ~20 000 RFU. Originally MilliQ was used for the standards but was not appropriate due to high fluorescence of ~80 000 RFU. To improve the sensitivity of the method UV treated DI water could be used. Onboard the most appropriate solution we had was to use unfiltered 4000 m water (as filtering exploded the bacteria causing higher ammonium levels and subsequently high RFU).

Background fluorescence and the matrix effects of the sample water can be corrected for. The background fluorescence (the natural sample fluorescence and any fluorescence of the OPA working reagent) is corrected for by taking a 10ml sample, incubating for 3-4 hours, then adding 800 µl of OPA working reagent and measuring the RFU immediately (<30 seconds). The RFU is then subtracted from every sample measurement. Matrix effects are the interactions of the sample water with the OPA working reagent aside from fluorescence produced by ammonium. The matrix effects are measured by spiking 3 samples with NH_4^+ equivalent to the standard concentrations. The spiked sample RFU (which has already been corrected for the background fluorescence) is plotted against the spiked concentration. Using the regression equation, the corrected RFU at 0 nmol L^{-1} can be determined. This procedure is carried out for several common depths throughout the water column. The percentage of fluorescence due to matrix effects can be calculated and samples at these depths can be corrected. Ideally the matrix effects would be measured daily but the sampling and processing is very labour intensive.

Sampling was undertaken on CTD casts and marine snow catcher sample incubations - information regarding the latter can be found in Manon Duret's report. When sampling vinyl (or non-nitrile) gloves were used and a no smoking policy was employed around the sampling area. Sampling ranged from depths of 4000 m to 5 m but generally the method was only sensitive enough to detect ammonium at shallower depths within the mesopelagic zone (as shown in Figure 1) or where local phenomena occurred. Table 1 includes all the CTD casts and the sampling depths that were undertaken as well as the marine snow catcher samples and subsequent incubations.

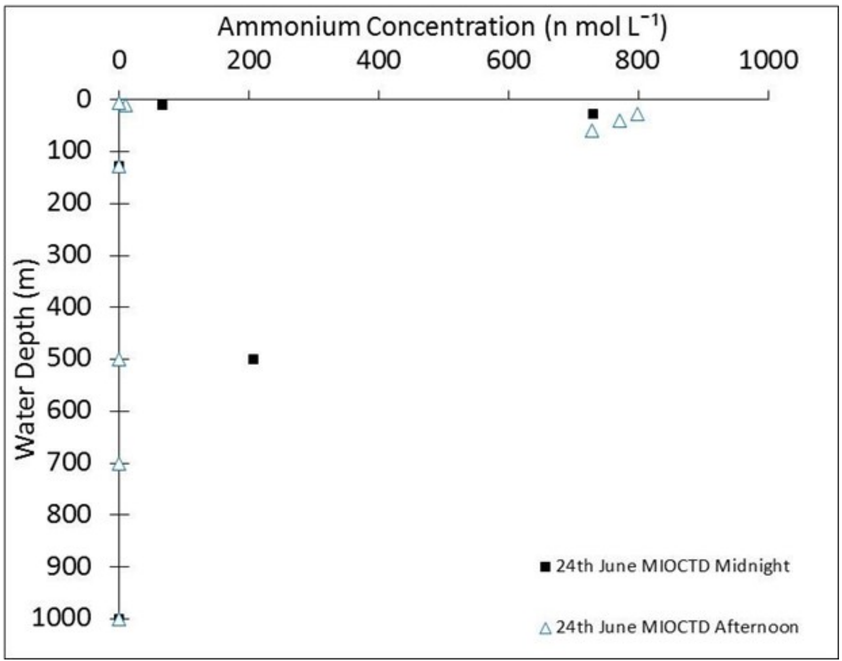


Figure 1 - Ammonium concentration (nmol L^{-1}) at midnight on the

24.06.15 (black squares) and at 16:00 on the 24.06.15 (blue triangles). The plot demonstrates the fast turnover of ammonium at 0 and 500 m whilst concentrations remained high at the mixed layer depth (28 m).

Ammonium concentrations at the PAP site are highest around the mixed layer depth where productivity is greatest, very low in the surface waters and depleted/ undetectable in the lower mesopelagic and deep ocean. Some elevated ammonium concentrations were observed in the lower mesopelagic on occasion where local phenomena may have occurred. Overall, the ammonium measurements at the PAP site on the DY032 cruise were successful and demonstrated interesting dynamics in the surface ocean.

Table 1 - Summary of the NOC and MIO CTD casts with sampling depths and the marine snow catcher (MSC) sampling depths and subsequent incubations.

Depth (m)	Ammonium NOC CTD	Ammonium MIO CTD	Ammonium MSC Incubations (T0,T12,T24,T48)
5	DYO32-020, DYO32-076	DY032-014, DY032-066, DY032-085, DY032-092	
10	DYO32-020, DYO32-021, DYO32-076	DY032-001, DY032-014, DY032-018, DY032-42, DY032-066	
15	DYO32-076		
20	DYO32-020		
25	DYO32-021, DYO32-076, DY032-105		
28		DY032-001, DY032-014, DY032-042, DY032-044, DY032-066, DY032-092	DY032-006, DY032-013
30	DYO32-020, DYO32-076	DY032-085	
35	DYO32-076		
40	DYO32-020	DY032-014,	
45	DYO32-076		
50	DYO32-020, DYO32-021	DY032-066	
55	DYO32-076		
60	DYO32-020, DY032-105	DY032-014	
70	DYO32-076	DY032-024, DY032-042, DY032-047, DY032-066, DY032-085, DY032-092	DY032-033, DY032-067
80	DYO32-020, DYO32-076, DY032-105		

100	DYO32-020, DYO32-021, DYO32-076,		
105		DY032-047	
128		DY032-001, DY032-014, DY032-024, DY032-042, DY032-047, DY032-066, DY032-085	
150	DYO32-020, DYO32-021, DY032-105		
180		DY032-044	
200	DYO32-020	DY032-041	
250	DYO32-021, DY032-105	DY032-066	
300		DY032-041	
400	DYO32-021		
500		DY032-001, DY032-014, DY032-024, DY032-041, DY032-044, DY032-047, DY032-066, DY032-085	DY032-051, DY032-074
600	DYO32-021, DY032-105		
700		DY032-014	
800		DY032-041	
855	DYO32-021		
1000		DY032-001, DY032-014, DY032-018, DY032-024, DY032-044, DY032-047, DY032-085	DY032-094
1120	DYO32-021		
2000	DYO32-021		
2300	DYO32-021		
3333	DYO32-021		
4000	DYO32-021	DY032-014	
4815	DYO32-021		

14 Sinking Particle Flux and Particle Respiration Rates

Anna Belcher and Chelsey Baker

14.1 Objectives and Aims

The aim of the cruise was to investigate particle flux and measure rates of microbial respiration on sinking particles collected at a number of depths at the PAP site. Marine snow catchers (MSC) were utilised to collect marine snow particles from the water column and examine the size, composition and abundance of material at different depths and make estimates of particle flux. As such it was aimed to use the MSC to:

1) Measure any variation in the particle flux (in terms of magnitude, particle size and composition) with depth
2) Measure the sinking velocities of particles to investigate any relationship with particle size
3) Collect water from the MSC to measure the particulate organic carbon (POC), particulate inorganic carbon (PIC), biogenic silica (BSi), and chlorophyll (Chl) in the slow sinking and suspended carbon pool
4) Investigate degradation of sinking particles, and any variation of this with depth, through measurement of oxygen gradients and calculation of respiration rates

14.2 Methods

14.2.1 Sample collection

95 litres of water were collected in each marine snow catcher (a PVC closing water bottle designed to minimise turbulence), deployed at a range of depths below the chlorophyll maximum at base of the mixed layer (determined from the most recent CTD profile). As soon as the MSCs were on deck, an initial two litre sample was taken from the bottom tap on the MSC. The MSCs were then left upright for two hours to allow the marine snow particles to sink to the bottom. One litre of the initial sample (Time zero - T_0 sample) was filtered immediately for POC and total chlorophyll and represents the homogenous water column. The remaining litre was left to stand for two hours before also being filtered for POC (T_2 sample).

After standing for two hours, a 3L sample was taken from the top section of the MSC (the suspended fraction) before draining the remaining water. The bottom section of the MSC containing 7 litres of water and settled particles was then removed. A 4L sample was siphoned out of the base section (representing the slow sinking pool), before removing the particle collector tray from the base and storing in a 10°C temperature controlled laboratory. Water samples collected from both the top and the base sections of the MSC were filtered for POC, PIC, POC, BSi, Chl (size fractionated) and SEM analysis.

14.2.2 Particle handling

Particles that had settled to the base (the fast sinking pool) of the bottom chamber were removed using a wide-bore pipette and 1 split (1/4 of the collector tray) was photographed using a Leica DM-IRB inverted microscope and Canon EOS 1100D camera. In addition to this 2 splits of fast sinking material were collected on GF/F filters for analysis of POC content. 1/4 were collected in well plates for measurements of sinking velocity and particle respiration. Sinking velocity measurements were carried out on 5-15 particles from each MSC using a flow chamber containing water collected from snow catcher deployment event 002 maintained at a temperature of 10 °C. Each particle was carefully placed in a 10cm high Plexiglas tube (5cm diameter), on a net extended across middle of the tube. Flow was supplied from below the net, adjusted using a needle valve, resulting in a uniform flow field across the upper chamber. The flow was adjusted so that the particle is suspended one particle diameter above the net. At this point the sinking velocity is balanced by the upward flow velocity, and can be calculated by dividing the flow rate by the area of the flow chamber. Three measurements of the sinking velocity were made for each particle and the x, y, and z dimensions measured using a horizontal dissection microscope with a calibrated ocular.

For a number of fast sinking particles, the oxygen gradients at the particle-water interface were measured using a Clark-type oxygen microelectrode with a guard cathode mounted in a micromanipulator. Sensors were calibrated at 0% and 100% oxygen. The microsensor had a tip diameter of 10 µm, with a 90% response time of <1s and stirring sensitivity of < 0.3%. The electrode current was read by a picoammeter (Unisense). Particles were placed on the net of the flow chamber, and after measuring the sinking velocity, the flow rate was reduced slightly so the particle was stable. The microsensor was then slowly brought down towards the particle surface in steps of 50-200 µm. Where possible two repeat profiles were taken per particle. Measured oxygen gradients will be analysed using a diffusion-reaction model to calculate oxygen uptake rates and calculate respiration rates.

In addition phytodetrital aggregates were made in roller tanks using water collected from 12 m from CTD event 01. The roller tanks were incubated in the dark at 10 °C for 10 days, after which particles were allowed to settle, and removed using a pipette, for analysis in the flow chamber. Measurements of size, sinking velocity and respiration rate were made.

14.2.3 **Filter Sample Preparation, Preservation and Analysis:**

POC: 1L was filtered through a 25mm diameter, ashed GF/F filter, rinsed with milliQ water, placed in a Petri dish, air dried and stored at room temperature for later analysis.

PIC: 500ml was filtered through a 0.8µm pore size, 25mm diameter, nucleopore polycarbonate membrane filter, rinsed with pH adjusted milliQ water, stored in a centrifuge tube, air dried and stored at room temperature for later analysis.

BSi: 500ml was filtered through a 0.8µm pore size, 25mm diameter, nucleopore polycarbonate membrane filter, rinsed with pH adjusted milliQ water, stored in a centrifuge tube, air dried and stored at room temperature for later analysis.

Total Chlorophyll: 200ml was filtered through a 0.8µm pore size, 25mm diameter, MPF300 filter, rinsed with milliQ water, placed in an eppendorf tube and stored at -20°C for later analysis.

Chl >10 µm: 200ml was filtered through a 10µm pore size, 25mm diameter nucleopore polycarbonate membrane filter, rinsed with milliQ water, placed in an eppendorf tube and stored at -20°C for later analysis.

SEM: 500ml was filtered through a 0.8µm pore size, 25mm diameter, nucleopore polycarbonate membrane filter, rinsed with pH adjusted milliQ water, placed in a Petri dish, air dried and stored at room temperature for later analysis.

14.3 Preliminary Results

A total of 10 marine snow catcher deployments were made to support this study (Table 1). Note that, only the fast sinking particles were analysed for MSC deployments 110,111,112, to 30, 60 and 100 m depth. These particles were put on GF/F filters for measurement of POC.

Table 1: Details of MSC deployments during DY032 utilised for this study.

Date	Time (GMT)	Event Number	Station	Latitude (°N)	Longitude (°W)	Depth (m)
24/06/2015	02:10	002	PAP	49 02.47	16 25.22	28
24/06/2015	02:35	003	PAP	49 02.47	16 25.22	128
26/06/2015	14:45	031	PAP	48 50.06	16 32.58	70
28/06/2015	11:50	049	PAP	49 01.25	16 25.04	110
28/06/2015	17:50	053	PAP	48 59.00	16 25.10	500
30/06/2015	18:45	077	PAP	49 03.80	16 15.80	40
02/07/2015	10:00	088	PAP	48 40.90	17 03.50	200
04/07/2015	13:00	110	PAP	48 56.15	16 10.37	30
04/07/2015	13:20	111	PAP	48 56.15	16 10.37	60
04/07/2015	13:30	112	PAP	48 56.15	16 10.37	100

MSC's were deployed at different depths to investigate changes in sinking material in the upper mesopelagic. Visual inspection of sinking particles collected suggests a general decease in abundance with depth, as expected considering remineralisation and bacterial degradation processes. Sinking particles mostly comprised of phytodetrital aggregates (Figure 1) with some small faecal pellets and occasional faecal pellet aggregates.

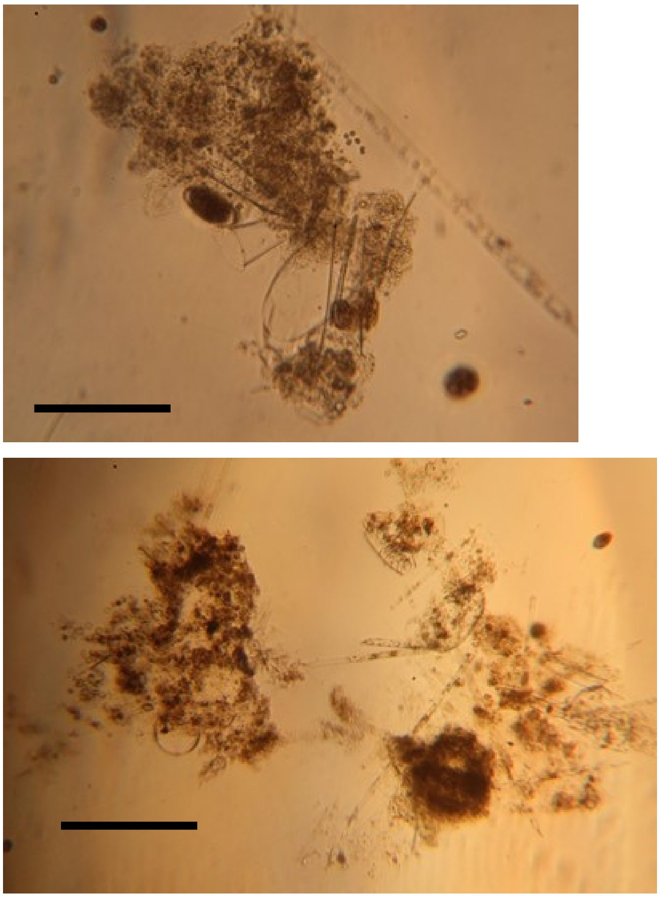


Figure 1: Examples of particles recovered in marine snow catcher, A: Phytodetrital Aggregate from roller tanks, B: Phytodetrital Aggregate from marine snow catcher. Scale bar = 0.5mm

Measured sinking velocities ranged from to 4 m/day to 936 m/day, with an average velocity of 50m/day, with the range reflecting the variation in particle composition, size and density.

A total of 158 oxygen profiles were measured across the diffusive boundary layer of fast sinking particles collected in MSCs, an example of which is shown in Figure 2. These data will be analysed to calculate respiration rates for individual particles and assess any variation in particle associated microbial respiration with depth through the mesopelagic.

Further results will be worked up following laboratory analysis of sample filters (POC, PIC, BSi, Chl and SEM) obtained from filtration of slow sinking and suspended water fractions from the MSCs. An estimate of the fast sinking POC flux will be made based on microscope photographs and volume calculations of particles (Alldredge et al., 1998). These will be compared to chemical measurements of POC made on a fraction of the fast sinking material.

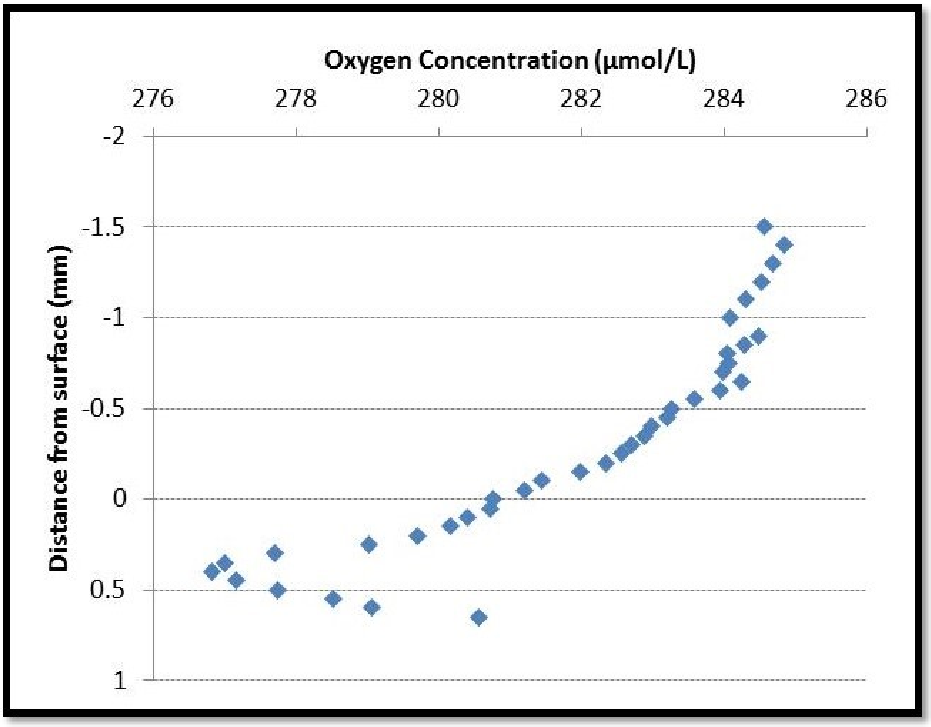


Figure 2: Example of the oxygen gradient measured across a sinking marine phytodetrital aggregate collected at 40m using a marine snow catcher. Negative values indicate vertical distance above the aggregate.

Data from the MSC will be compared with other data collected from the cruise, such as CTD data, and information on biological community structure from zooplankton net tows, to explain any variations and trends in particle size, composition and flux over the course of the cruise.

15 Benthic Studies

Brian Bett, Paris Stefanoudis, Laura Grange, Jo Clarke, Zan Milligan

The primary objective of the benthic team was to continue long-term time-series observations of the benthos at the Porcupine Abyssal Plain Sustained Observatory site. The main aims were to (i) obtain replicate macrobenthos samples from the PAP Central area, (ii) continue investigations of dropstone-attached foraminifera, (iii) collect material for study of ^{236}U and ^{210}Pb tracers, (iv) opportunistic collection of material for 'micro-plastics' study, (v) opportunistic collection of material eDNA studies, (vi) recovery of deployed Bathysnap (Stn ME108/782), (vii) deployment of Bathysnap system with AWI sediment oxygen profiler instrument attached, and (viii) re-commence trawling as part of time-series observations,

In summary:

I. Six replicate macrobenthos samples were obtained from the PAP Central area
II. Two sets of dropstone-attached foraminifera samples were obtained from abyssal hill site "H4"
III. Four sets of ^{236}U were obtained from the PAP Central area
IV. Samples for microplastics were obtained
V. Samples for eDNA were obtained

VI. Bathysnap (Stn ME108/782) was successfully recovered and returned 1000+ good seafloor photographs
VII. Bathysnap with AWI profiler was successfully deployed as Stn DY032-103
VIII. One successful trawl, demersal fish and megabenthos, Stn DY032-116

15.1 Seabed coring

15.1.1 Box core

An NMFSS USNEL-type spade box corer (0.25m^2) was deployed once during the cruise. It was rigged and operated in standard fashion, with penetration limiters fitted. The single deployment was carried out at site "H4" (a hill site from RRS *James Cook* cruise 062) at ship's position 49° 04.426´ N 016° 15.815´ W, at estimated water depth 4290m (from consideration of wire out and EM122 multibeam echosounder), with bottom contact at 02:39 28.VI.2015. Top water drained from the core on recovery, however, the core surface was complete and in good condition.

Foraminifera on Dropstones (Box core): Only dropstones at the surface of the core were taken into account. Prior to removal from the core each stone was photographed in order to note the surface of the stone above the sediment line. A total of 70 picked stones were placed in small labelled containers of variable size and fixed in 10% buffered formalin. Subsequently, the top sediment layer (0–3 cm) was sieved and all remaining stones were stored in a labelled container and fixed in 10% buffered formalin.

15.1.2 Megacorer

An NMFSS Bowers & Connelly Megacorer, with standard ballast load and fitted with 10 x 10 cm ID core tubes was used throughout the cruise. The corer was operated with a Sonardyne 6G USBL beacon (with pressure transducer) attached to the frame.

15.1.2.1 PAP Central ("Times series location") coring

Coring sites selected by 'random points' function in ArcMap, based on a 500m radius around nominal centre of coring area (48° 50.219' N 16° 31.266' W).

Stn DY032-	Date 2015	Site	Lat. dd mm.mmm N	Long. ddd mm.mmm W	Depth (m corr.)	Cores returned
016	25/6	PAPC01	48 50.170	016 31.610	4855	6/10
017	25/6	PAPC02	48 50.479	016 31.276	4854	6/10
022	26/6	PAPC03	48 50.211	016 31.285	4855	7/10
023	26/6	PAPC04	48 50.452	016 31.472	4856	6/10
039	27/6	PAPC05	48 50.222	016 31.103	4855	1/10
061	29/6	PAPC05	48 50.208	016 31.116	4853	9/10
071	29/6	PAPC06	48 49.996	016 31.248	4853	8/10

Positions and depths given here are for the USBL beacon at bottom contact

15.1.2.2 Other deployments

Stn DY032-	Date 2015	Site	Lat. dd mm.mmm N	Long. ddd mm.mmm W	Depth (m corr.)	Cores returned
034	26/6	Emma1	48 52.093	016 31.366	4855	0/10
055	28/6	Emma2	48 55.427	016 27.952	4854	8/10
083	1/7	Hill H4	49 04.372	016 15.872	4274	10/10

Positions and depths given here are for the USBL beacon at bottom contact

15.1.3 Megacorer Sampling protocols

Macrofauna: Three to six large tubes (10 cm ID) from each deployment at PAP Central were sliced for macrobenthos. The core was sliced into 5 layers: 0−1, 1−3, 3−5, 5−10 and 10−15 cm sediment horizons. The first three layers were each placed in a 500 ml labelled container and the next two layers in two 500 ml labelled containers respectively, due to large amount of sediment. Water in the top of each core was syringed and added to the 0−1 cm horizon sample. All slicing material (cutting guide, slicing plate, funnel and knife) were washed into the sample containers with filtered seawater (mesh: 250 µm). Samples were fixed in 10% formalin.

^{236}Uranium: One large tube (10 cm ID) from four deployments at PAP Central was sliced for stable isotope analyses. The core was sliced into 5 layers: 0−1, 1−3, 3−5, 5−10 and 10−15 cm sediment horizons. All layers were each placed in plastic bags. Samples were kept in a cold room (6°C).

Microplastics: detailed elsewhere in this report

eDNA: detailed elsewhere in this report

Foraminifera on Dropstones (Megacorer): In total six large tubes (10 cm ID) from one deployment were used for collecting benthic foraminifera attached on ice-rafted dropstones. Only stones residing at the surface of the core were taken into account. Prior to collection from the core each stone was photographed in order to note the surface of the stone above the sediment line. A total of 16 picked stones were placed in 14 small labelled containers of variable size and fixed in 10% buffered formalin.

15.1.4 Megacorer deployments

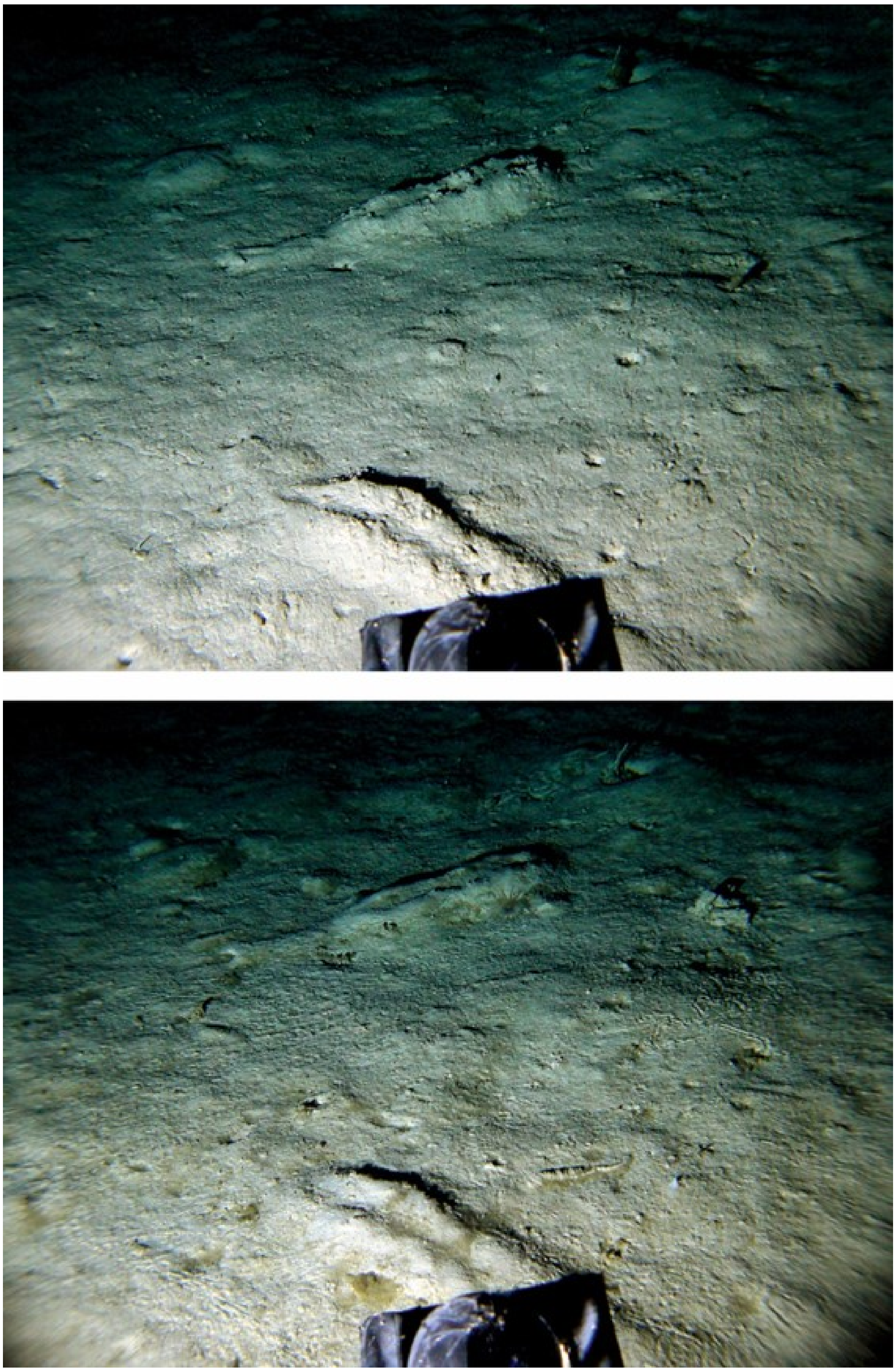
DY032-016 (PAPC01); 6/10 tubes returned fired and with samples (good core lengths 35−40 cm, some were full); 3 large tubes were sampled for macrobenthos. 1 large tube was sampled for Uranium, 1 large tube for microplastics and 1 for eDNA.
DY032-016 (PAPC02); 6/10 tubes returned fired and with samples (good core lengths 33−36 cm, but several were cracked); 3 large tubes were sampled for macrobenthos. 1 large tube was sampled for Uranium, 1 large tube for microplastics and 1 large tube for eDNA.
DY032-022 (PAPC03); 7/10 tubes returned fired and with samples (good core lengths 36−39 cm, but several were cracked); 4 large tubes were sampled for macrobenthos. 1 large tube was sampled for Uranium, 1 large tube for microplastics and 1 large tube for eDNA.

DY032-023 (PAPC04); 6/10 tubes returned fired and with samples (good core lengths 38−39 cm, but some were cracked); 3 large tubes were sampled for macrobenthos. 1 large tube was sampled for Uranium, 1 large tube for microplastics and 1 large tube for eDNA.
DY032-034 (N of PAP central); 0/10 tubes returned fired.
DY032-039 (PAPC05); 1/10 tubes returned fired and was used for microplastics.
DY032-045 (H4); the sediment interface was undisturbed. A total of 70 picked stones were placed in small labelled containers of variable size and fixed in 10% buffered formalin. Subsequently, the top layer (0−3 cm) was sieved and all remaining stones were stored in a labelled container and fixed in 10% buffered formalin.
DY032-055(N of PAP central); 8/10 tubes returned fired and with samples. All 8 large tube were used for microplastics.
DY032-061 (PAPC05); 9/10 tubes returned fired and with samples (good core lengths 35−52 cm, some were full); 6 large tubes were sampled for macrobenthos. 1 large tube was sampled for microplastics and 1 large tube for eDNA. One tube was lost when attempting to recover from the Megacore frame.
DY032-071 (PAPC06); 8/10 tubes returned fired and with samples (good core lengths 34−40cm, one had a split); 6 large tubes were sampled for macrobenthos. 1 large tube was sampled for microplastics and 1 large tube for eDNA.
DY032-083 (H4); 10/10 tubes returned fired and with samples (core lengths 21−24 cm, all in very good condition); 6 large tubes were sampled for microplastics and another 6 for foraminifera on dropstones (i.e. two were used for dual purposes).

15.2 Bathysnap

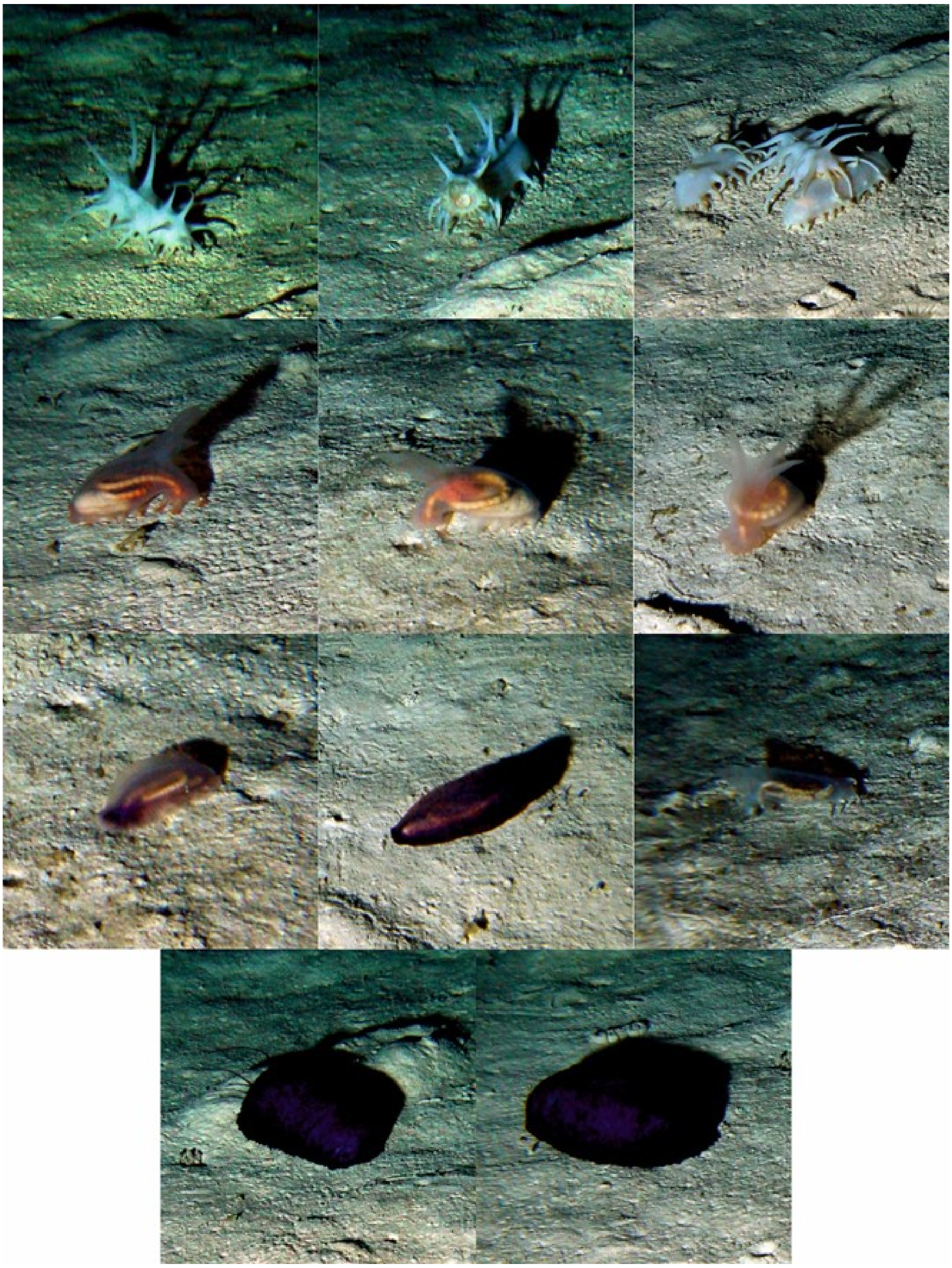
15.2.1 Recovery of ME108/782

The system originally deployed during FS *Meteor* cruise 108 on 17.VII.2014 as Stn ME108/782, was released and successfully recovered on 28.VI.2015. The recovered components seemed to be in generally good condition, although the dan buoy mast has suffered further corrosion and should be scrapped. The camera had recorded 1038 seabed images, the first at 13:39 17.VII.2014, the last at 06:08 28.VI.2015, with only a single black frame (? flash failure) (camera time was 00:05:07 slow to GPS UTC on recovery).

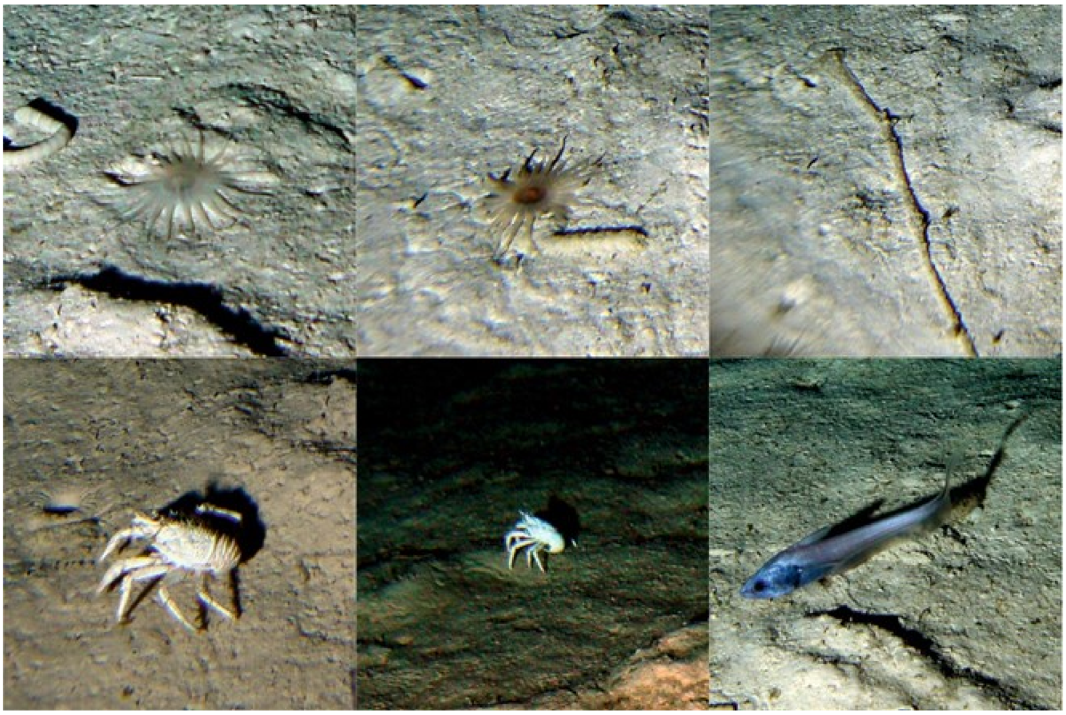


The first at 13:39 17.VII.2014, the last at 06:08 28.VI.2015 of Bathysnap Stn ME108/782.

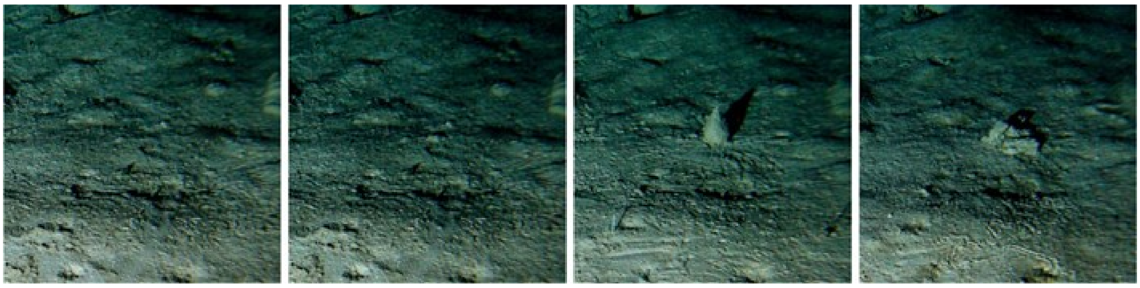
Quick assessment of the recovered images suggested a similar status for the megabenthos as the previous PAP cruise (FS *Meteor* 108), a moderate abundance of large holothurian, and a moderate abundance of large *Amperima*, consistent with the community being in a state intermediate to ‘*Amperima*-boom’ and ‘*Amperima*-bust’. Activity noted during the brief review included (i) echiuran spoke trace formation, (ii) ‘wandering’ by a number of *Iosactis* specimens, and (iii) the formation and collapse of a steep conical mound (potentially the “Rayed mound” morphotype of the current PAP species guide).



Example megabenthos from Bathysnap Stn ME108/782



Example megabenthos and demersal fish from Bathysnap Stn ME108/782



"Rayed mound" formation: left to right, (i) 16/11/14 21:54 not apparent; (ii) 17/11/14 05:54 initiated; (iii) 31/03/15 14:09 fully formed; (iv) 28/06/15 06:18 collapsed (last frame)

15.2.2 Deployment of DY032-103

The recovered Bathysnap frame, camera, flash and battery were redeployed with an NMFSS acoustic release (IXSEA AR861 s/n 315; ARM 14CB, REL. 1455) and mooring (see further below). Camera set-up for redeployment was as follows: Camera memory confirmed empty.

- Shutter speed 1/40
- Aperture F5.6
- Focus 3.0m
- Image size 12Mb
- Rec mode normal
- Colour mode normal
- ISO 200
- Metering mode multi
- White balance flash
- Flash level +/- zero
- Red eye off
- Contrast normal
- Sharpness normal
- Steady shot off
- Flash always on
- Camera time set to GPS / UTC
- Camera memory confirmed empty
- Timer values rest
- Timer interval set to 8-hour
- Timer settings updated
- Disconnect and camera off initiated

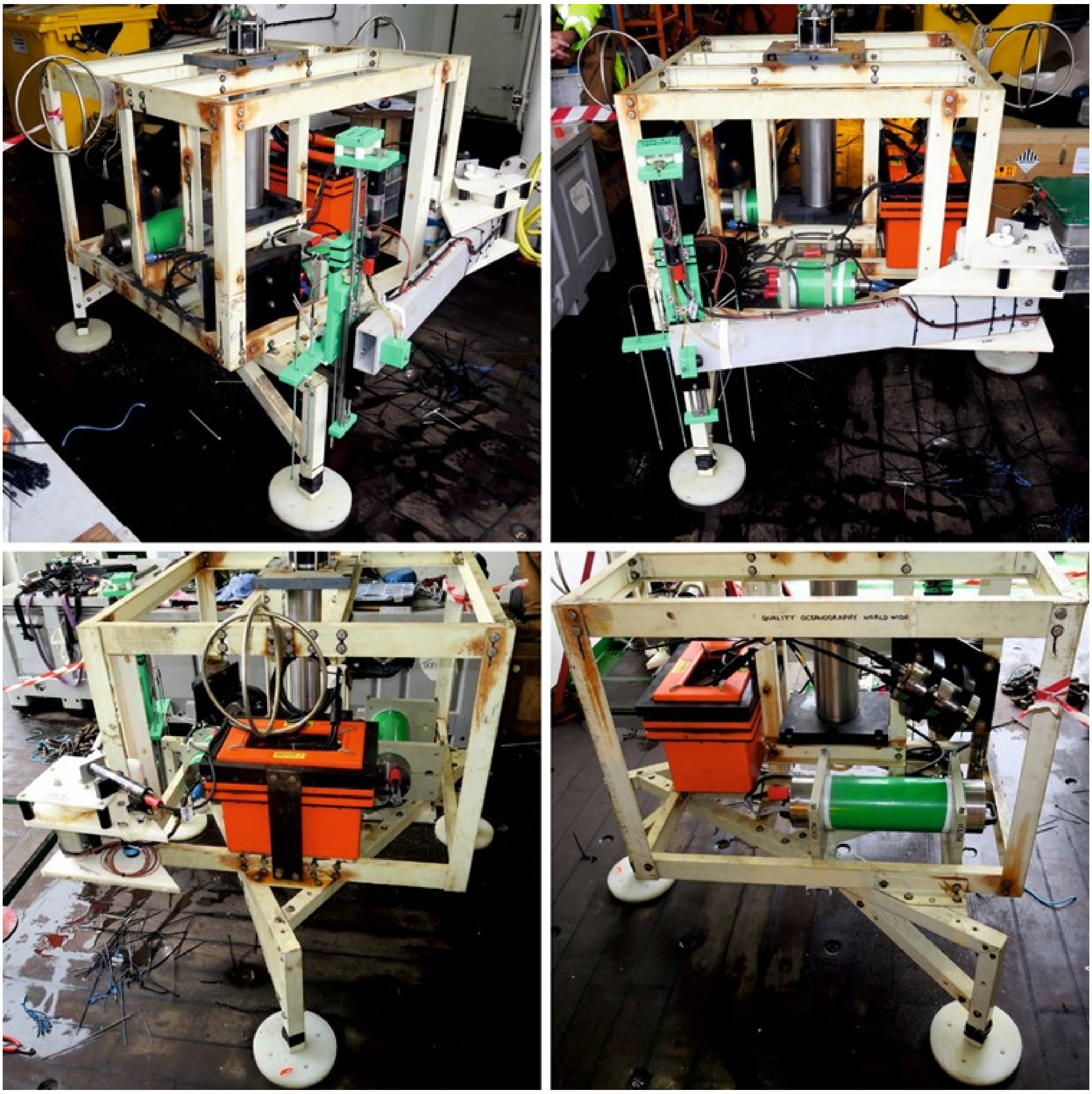
In addition, the Bathysnap frame was fitted with a sediment oxygen profiler from the HGF-MPG Group for Deep-Sea Ecology and Technology Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany (AWI), as part of the FixO3 TNA programme.

Components were attached to the frame as illustrated below, briefly, the arm was attached to an upright of the main frame, the battery and electronics pressure cases were attached to the top of the base frame using NMFSS clamps made onboard, optode and temperature sensors were simply cable-tied to the fame at convenient points. The tips of the four oxygen sensor probes were positioned to be approximately 10cm above the estimated sediment surface level. In addition, the outboard end of the profiler arm was temporarily secured to the main frame via a bungy cord and NMFSS supplied ‘fizz-link’, the fizz link will part c. 24-hours after deployment (i.e. after landing and before the first programmed movement of the arm).

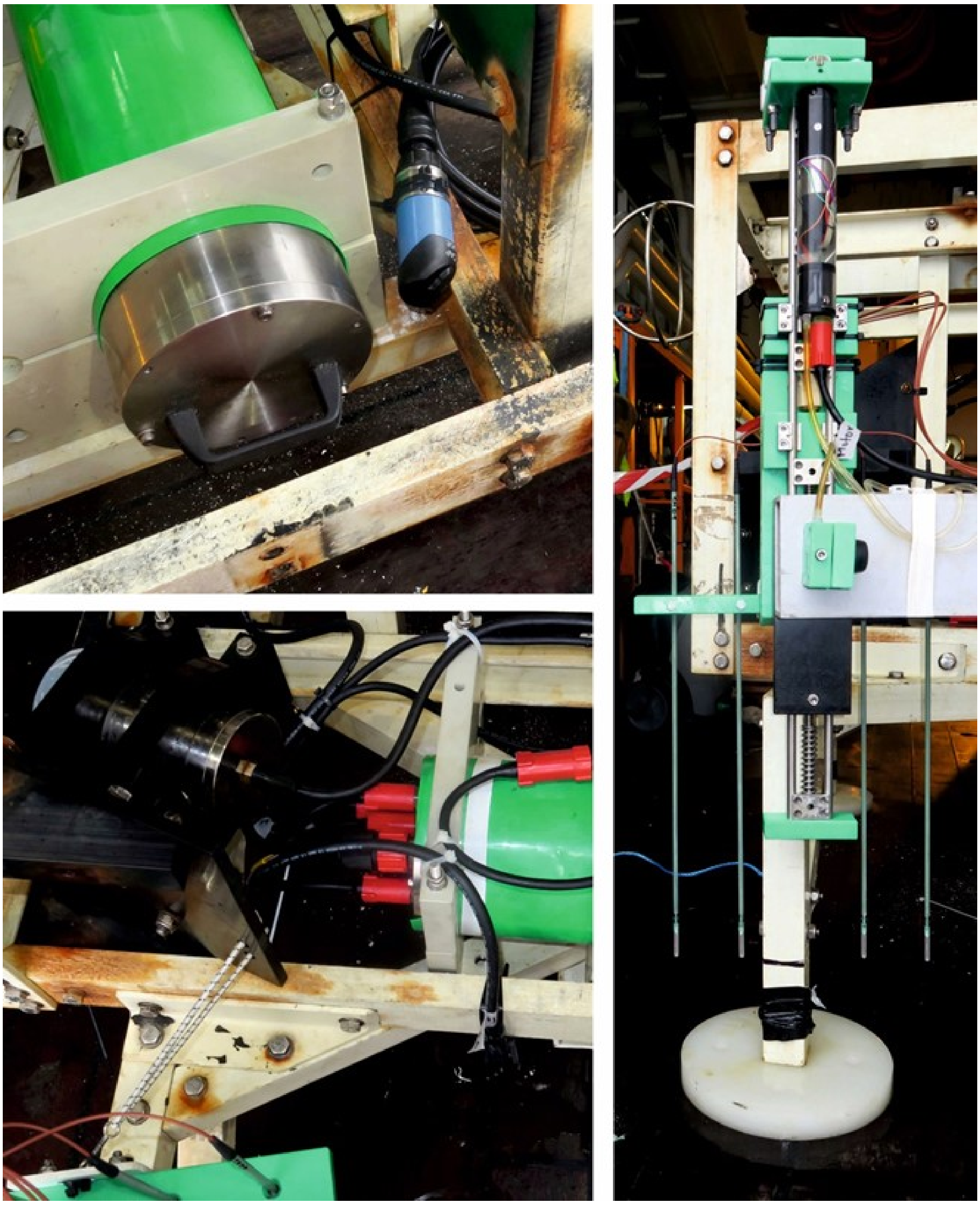
When fully constructed the profiler instrument was powered up (13:10 3.VII.2015), z-motor action was observed shortly thereafter. Sensor tip caps were removed and calibration then proceeded with the tip of each sensor being immersed in turn in a dithionite solution (made up with surface seawater) for 90 seconds, the temperature probe was similarly immersed for 90 seconds. Caps were then replaced on the sensor tips.

An attempt was made to obtain a wet weight for the fully rigged frame with ballast in place by shallow deployment attached to a load cell. Given the prevailing sea state this was something of a guestimate. An additional 22kg (one large glass sphere) of buoyancy was added to the standard Bathysnap mooring. All mooring components were supplied by NMFSS.

Immediately prior to launch the cap on the optode and the caps on the sensor tips were removed. For as long as visible from the deck, the sediment oxygen probes appeared to be intact.



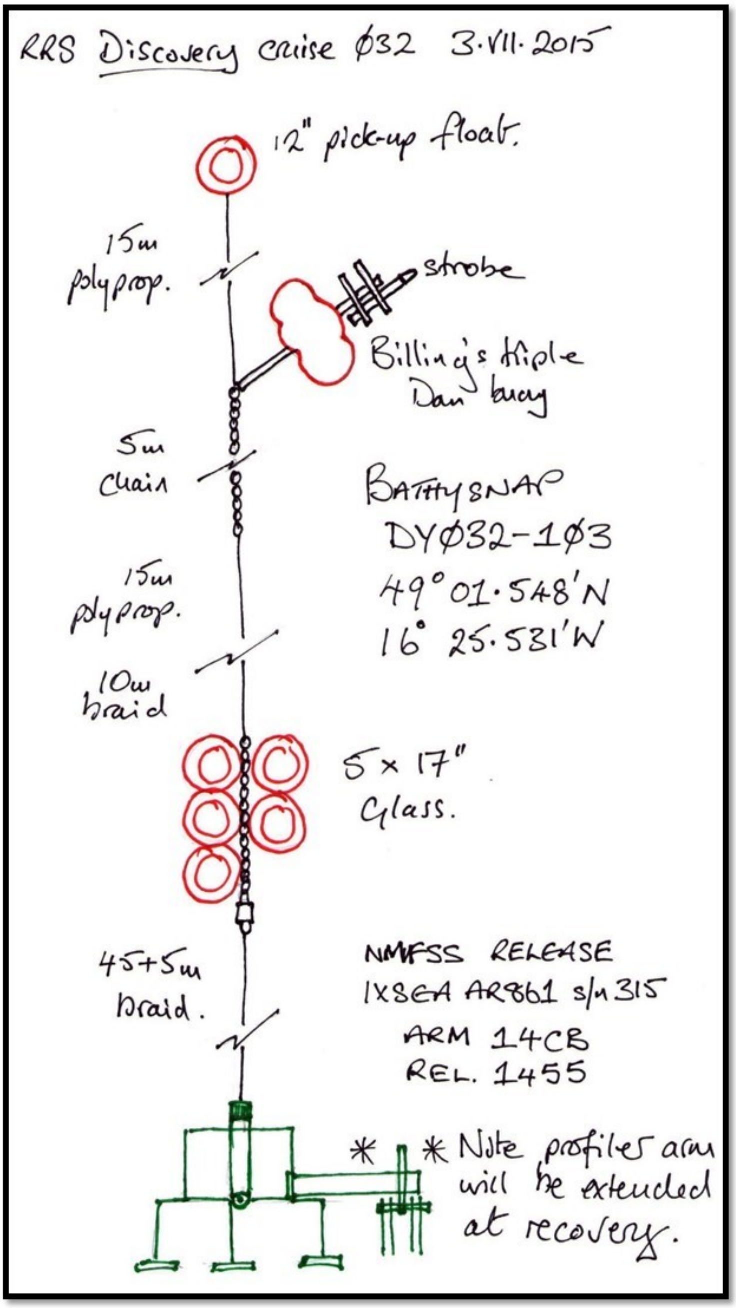
Fully rigged Bathysnap system with AWI oxygen profiler, as deployed as Stn DY032-103.



Sensor mounting: (top left) optode, adjacent to battery pack; (bottom left) temperature probe, adjacent to electronics case, note also detail of fizz-link and bungy cord; (right) sediment oxygen probes. (As deployed as Stn DY032-103.)

Bathysnap mooring ready to deploy at Stn DY032-103.

Bathysnap deployment (Stn DY032-103).



Mooring sketch and recovery details for Stn DY032-103.

15.3 Otter trawl

The otter trawl (OTSB14) net and rigging were supplied by NMFSS, the NOC deepseas group supplied the trawl doors, an acoustic monitor and waterfall display system, and NMFSS the 'Chunter fish'. The latter group of acoustic systems (monitor, waterfall and fish) were essential redundant. They were likely beset by a variety of problems, none of which could be fully tested during the cruise. The documented battery requirement for the monitor ("8 x 3.6V SAFT lithium D-cells") proved to be erroneous, the instrument is designed to carry 16 x C-cells. During the cruise it was powered with 16 x standard alkaline 1.5V cells. The monitor was fitted to a deep-cast CTD for calibration purposes, however, useful signals were not detected on the waterfall (note this same arrangement did prove successful on RRS *James Cook* cruise 085). Prior to deployment on Stn DY032-087 the cabling route from the fish to the main lab was checked and improved. Useful signals were then detectable initially during the trawl deployment, however, these became undetectable with c. 4000mwo, and consequently of no practical use. Note also that it proved impossible to set-up the EA640 echo-sounder to serve as a back-up pinger monitor – it is suggested that Kongsberg be contacted for appropriate settings for simple 10kHz pinger monitoring operations.

One successful trawl, returning a good catch of demersal fish and megabenthos, was undertaken as Stn. DY032-087. A second trawl was attempted as Stn. DY032-116, but was quickly aborted after the ship was unable to hold an appropriate course, with the wind normal to a strong surface current.

Metadata details for the successful trawl are estimated as:

Trawl landing position	48° 52.18´ N 016° 32.45´ W
Trawl end position	48° 49.73´ N 016° 39.31´ W
Sounding fished	4850m
Track length fished	5.15 nm (9.54 km)
Seabed area fished	8.1 Ha

15.3.1 Observations from Trawl

DY032-087

15.3.1.1 Invertebrate Benthos

Catch composition was dominated by characteristic PAP fauna. The top five taxa in terms of biovolume were: *Psychropotes*, *Pseudostichopus*, *Oneirophanta*, Actinaria spp. (mainly *Iosactis vagabunda*?) and Asteroidea spp. (mainly Asteroid sp 4 (*Styracaster* sp.?)). Where possible, the catch was sorted into class, and the most abundant and easily identified taxa, e.g. *Psychropotes*, was separated aboard. The smallest size fraction of the catch was bulk preserved as 'miscellaneous invertebrates'. Voucher specimen photographs were also taken. All material was preserved in 10% Borax buffered formalin (3.8% formaldehyde) for return to the *Discovery Collections* (contact Tammy Horton), at NOC.

15.3.1.2 Stable Isotope studies

Several of the most abundant taxa were sampled for stable isotope analysis (i.e. *Psychropotes longicauda*, *Pseudostichopus* sp. (*aemulatus*?), *Oneirophanta mutabilis*, *Amperima rosea*, *Hypalaster inermis, Iosactis, Paroriza* and, *Laetmonice*). Where possible, six to eighteen individuals of each species were preserved in 10% Borax buffered formalin, -20°C and -80°C to test for the effects of preservation method on stable isotope ratios. Specimens were individually bagged and/ or labelled, and where size differences between individuals were observed efforts were made to take a representative sample across size classes. Larger, more abundant taxa and/or those species more easily identified, e.g. *Psychropotes longicauda*, were also weighed wet (±0.1g). Where more than six individuals were available specimens will also be processed over different time periods (T0; 1-3 months, T6; 6 months, T12; 12 months and T12+; 12+ months). Individuals for all treatments were sampled whole. Please note it was not possible to sample specimens from all species in the above list. Efforts were made to wet weigh individuals and/ or sample for stable isotope analysis, where sample numbers were large enough to result a in representative sample across all three preservation treatments. (Material intended for Rachel Jeffreys, University of Liverpool).

15.3.1.3 Clinker and artefacts

Two large grey tubs full of clinker were recorded [not weighed]. Several artefacts were also noted [not weighed], including plastic items, broken glass, a beer bottle, and a large oil drum. The latter was caught in the net forward of the cod end, and most likely influenced the efficiency with which the net fished during deployment.

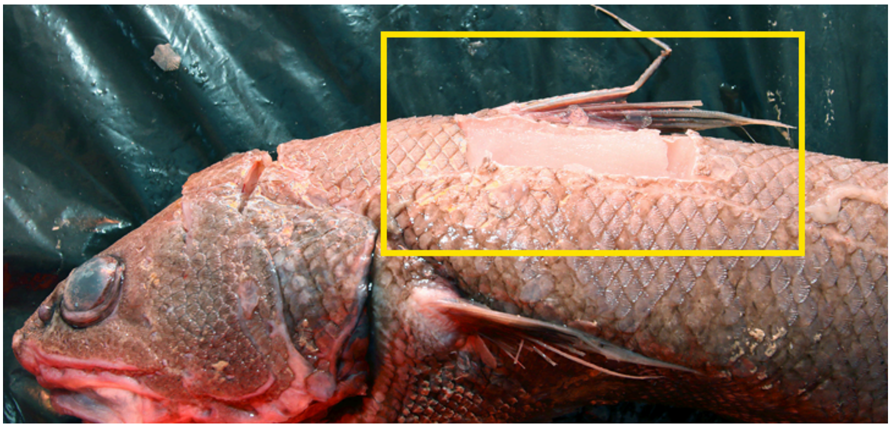

Artefacts from trawl DY032-087

15.3.1.4 Fish Samples

A total of 23 demersal fish were collected from trawl DY032-087. Each individual was identified to species level where possible, and any specimens that could not be definitively identified on board were preserved whole in 10% borax-buffered formalin for later identification on shore and were not processed further to avoid damaging the specimens. Individuals whose species identity was considered certain were discarded at sea following processing and dissection. High-resolution photographs were taken of all fish specimens and of the gonad tissues prior to preservation to aid in analysis. Any pelagic fish recovered in the trawls were preserved in 10% borax-buffered formalin, but were not processed on board the ship.

Total, standard, pre-anal fin and head lengths were recorded (as appropriate) to the nearest millimetre for each demersal fish. Total, viscera, liver and gonad wet weights were measured using a calibrated POLS heave-compensated balance (P-15/S-182) and recorded to the nearest 0.1 grams. The sex of each individual was recorded where possible.

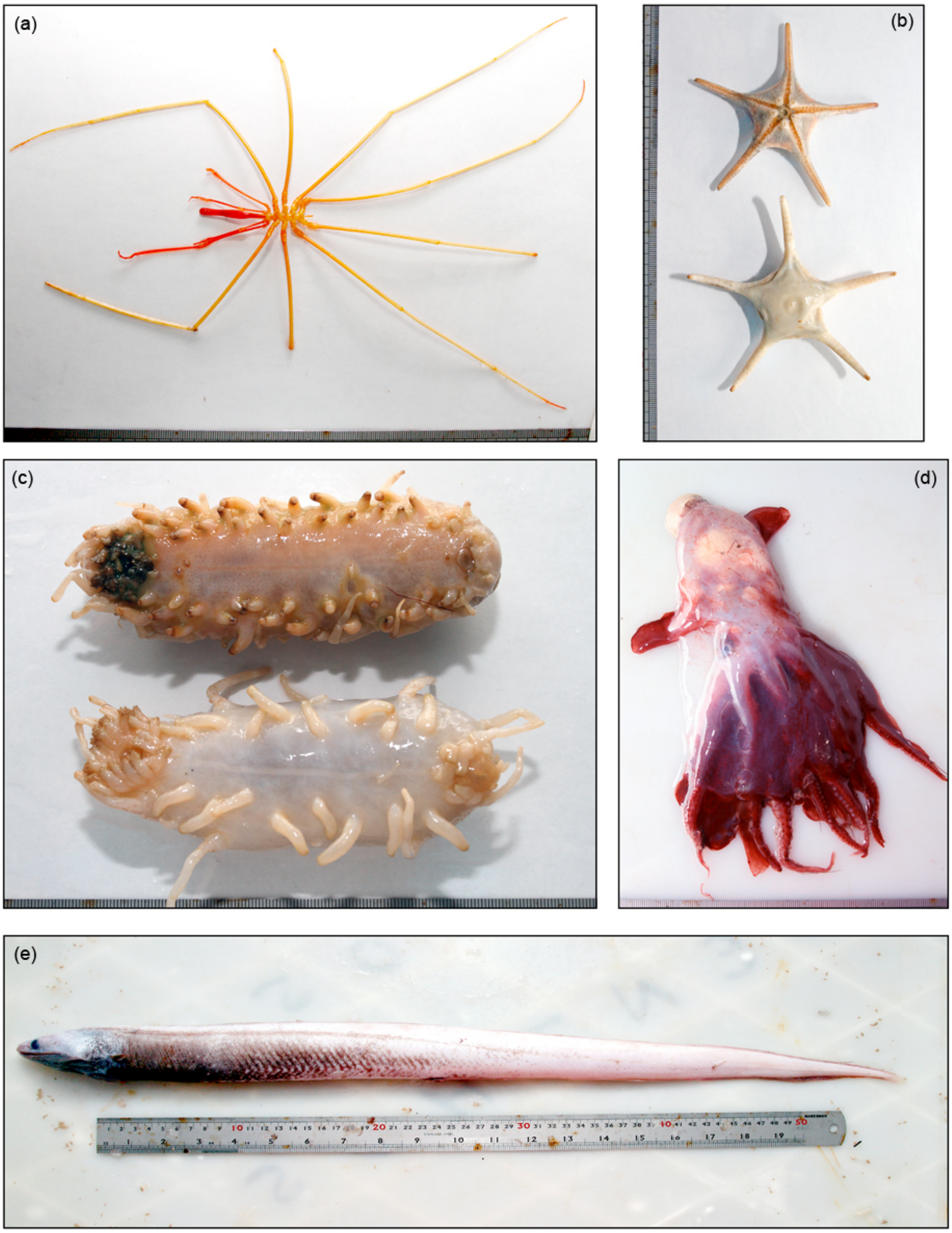
The gonads from each identified fish were preserved in 10% borax-buffered formalin solution for future histological analysis. The sagittal otoliths were removed from macrourid and anguillid specimens wherever possible and stored dry in individual plastic bags. Muscle tissue samples for stable isotope analysis (SIA) were taken from macrourids from the dorsal anterior musculature on the left side of the individual (see photograph below). The SIA samples were placed in individual plastic bags and stored at -20 °C within 12 hours of the trawl being recovered onto deck. Some *Coryphaenoides armatus* specimens were observed to have large ectoparasites embedded inside the gill cover. The parasites were collected and stored in 10% borax-buffered formalin.



Samples for SIA were collected from the anterior dorsal musculature on the left side (box).

Following the cruise, the fish specimens and samples will be transferred to NOC for temporary storage in the *Discovery Collections* before being transferred to the University of Glasgow. The muscle samples taken for SIA will remain at NOC for processing and analysis.

15.3.1.5 Specimen Photographs
High-quality photographs were taken of exemplary, fresh type-specimens from all fish and invertebrate megafauna taxa captured by the trawl prior to preservation and storage. These images will form part of a photographic guide to the abyssal megafauna of the PAP site to aid in the identification of these animals in future surveys.



Example specimen photographs taken from trawl DY032-087: (a) Colossendeis colossea; (b) Asteroidea; (c) Oneirophanta mutabilis; (d) Cephalopoda; (e) Histiobranchus bathybius

15.4 Molecular Ecology

Rob Young

Samples were collected from the megacore, plankton nets, and CTD for high-pressure amendment studies. All megacore samples were sectioned by 1cm intervals up to 5cm and 5cm intervals up to 20cm. Plankton net samples were separated by sieving through 2mm, 1mm and 200um mesh sizes. Samples were frozen at -80C for genetic processing. Three samples were filtered (7-9L) from DY032-078 and preserved in RNALater. Treatments and controls were filtered at 37.5 hrs. and 72 hrs, also preserved in RNALater and stored at -80C. The table below summarizes samples taken or attempted during the cruise along with replicates preserved for additional non-genetic analyses in the case of plankton nets.

STN NO	LAT (N)	LONG (W)	Sampler	Sampled	COMMENTS
016	48 50.16	16 31.53	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
017	48 50.5	16 31.2	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
022	48 50.20	16 31.26	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
023	48 50.45	16 31.43	Megacorer	Y	shift in core; only sampled to about 8cm; frozen at -80C
034	48 52.2	16 31.0	Megacorer	N	MC on bottom 20:47 - failed (only one core)
035	48 51.82	16 31.85	Zoop net	N	to 200m; morphological replicate sample
036	48 51.596	16 31.06	Zoop net	N	to 200m; morphological replicate sample
037	48 51.41	16 32.14	Zoop net	N	to 200m; morphological replicate sample
038	48 51.184	16 32.318	Zoop net	Y	to 200m; genetics
039	48 50.22	16 31.03	Megacorer	N	failed twice, one core out of 2 dips.
056	48 55.32	16 28.24	Zoop net	N	to 200m; morphological replicate sample

057	48 54.97	16 28.99	Zoop net	N	to 200m; morphological replicate sample
058	48 54.87	16 28.85	Zoop net	N	to 200m; morphological replicate sample
059	48 54.74	16 29.15	Zoop net	Y	to 200m; genetics
061	48 50.2	16 31.0	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
071	48 49.98	16 31.18	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
072	49 04.4	16 15.83	CTD (MIO)	N	CTD to 4000m; bottles failed
078	49 04.62	16 15.83	CTD (MIO)	Y	CTD to 4000m; 2 out of 4 bottles failed, 2 treatments plus 3 replicates from in situ samples
079	49 04.32	16 15.97	Zoop net	N	to 200m; morphological replicate sample
080	49 04.17	16 15.99	Zoop net	N	to 200m; morphological replicate sample
081	49 03.97	16 16.06	Zoop net	N	to 200m; morphological replicate sample
082	49 03.78	16 16.13	Zoop net	Y	to 200m; genetics
083	49 04.42	16 15.85	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C

16 Data Management

Lisa Marsh

Data management involved event logging throughout the cruise, CTD sample logging on deck and throughout the following analysis procedures, collating sampling information (from all deployments of CTDs, cores, trawls, nets, Marine Snowcatchers and camera frames) towards the end of the cruise, and capturing mooring deployment sensor serial numbers and calibration details.

At the outset, it was agreed to keep event-logging as simple as possible, as such, sequential station numbers starting from 001 were assigned to each science event throughout the cruise. A science event was defined as any instrument deployment over the side, or any mooring recovery or deployment. Each station number was confirmed with the Bridge, and the time (GMT) and science event were noted on the Main Lab whiteboard. Every morning, copies of the Bridge log sheets were collected, station numbers from the Bridge were cross-checked with those on the whiteboard, and positional information from the Bridge was transferred to the Master Event Log spreadsheet, along with any additional comments about each science event. The spreadsheet was updated regularly throughout each day.

Whilst the station number is the primary key for all event metadata, different teams also used an additional event-naming convention (for example, the MIO team numbered all their CTD deployments from 01 onwards) . However, the station number in the Master Event Log remains the key identifier for all positional/temporal information.

CTD sampling was conducted using well-established protocols which identified which Niskin would be sampled for which component (dissolved oxygen, DIC, ammonium, nutrients, POC, chlorophyll, salinity), in what order the sampling would happen, and which bottle/vial number the Niskin was sampled into. The results of any subsequent analyses at sea (in the case of dissolved oxygen, chlorophyll and salinity, for example) was followed through on the sampling log sheets so that there was clear traceability from station number and Niskin bottle (to give lat/long and depth) to the final analysis result. This system worked well, and limited confusion round the CTD during sampling. At the end of the cruise, all individual log sheets were collected and combined into one master CTD sampling spreadsheet to capture all relevant metadata.

17 Appendices

17.1 Appendix 1 SAPs log

<!-- Settings applied at 09:14:38 on 07/01/15 --> Autonomous mode Sync to host clock Reset sample counter Reset power consumption Data dir to new dir: DY32DEP1 Instrument units to uM Setting cal deployment volume to 250.0 Setting reagent 1 deployment volume to 250.0 Setting reagent 2 deployment volume to 250.0 Priming to start at 17:00:00 on 07/01/15 (466.4) minutes from now Sampling to start at 17:30:00 on 07/01/15 (496.4) minutes from now Number of samples = 1000 Sample interval = 8:00:00 Calibration frequency = 6	<!-- Results recorded at 09:15:22 on 07/01/15 --> Awake PO4>$WKM 0 PO4>$WKM 0 0 PO4>$CLK 07/01/15 09:14:44 PO4>$CLK 07/01/15 09:14:38 07/01/15 09:14:38 PO4>$VOL 157.320 6.900 7.680 7.680 PO4>$VOL 0.00 0.00 0.00 0.00 /S 0.000 0.000 0.000 0.000 PO4>$CNT 4 PO4>$CNT 0 /S 0 PO4>$ONT 1:54:20 PO4>$ONT 0 /S 0:00:00 PO4>$DSD DY032DP3 PO4>$DSD DY32DEP1 DY32DEP1 PO4>$EUF uM PO4>$EUF 0 uM PO4>$DCA 250.000 250.000 250.000 PO4>$DCA 250.00 250.00 250.00 /S 250.000 250.000 250.000 PO4>$SUD 07/01/15 17:00:00 /P 07/01/15 17:00:00 P PO4>$CSF 6 1 PO4>$CSF 6 6 0 PO4>$INT 1:00:00 PO4>$INT 28800 8:00:00 PO4>$IDT

	120 PO4>$NOS 4 4 PO4>$NOS 1000 1000 1000 PO4>$SUD none PO4>$SUD 07/01/15 17:30:00 07/01/15 17:30:00 PO4>$SLP Sleeping for 27922 secs

17.2 Appendix 2: ZPS recovery log

Enter ^C now to wake up ... [^C]

Configuration: ZPS-30G CF2 V2_00 of Apr 11 2012

McLane Research Laboratories, USA

ZooPlankton Sampler

ML12860-01

Main Menu

Fri Jul 3 12:28:27 2015

Belt is NOT aligned

<1> Set Time <5> Create Schedule

<2> Diagnostics <6> Deploy System

<3> Manual Operation <7> Offload Data

<4> Sleep <8> Contact McLane

Selection [] ? 7

Configuration: ZPS-30G CF2 V2_00 of Apr 11 2012

Offload/Display Data File

Fri Jul 3 12:28:31 2015

<1> Display all data

<2> Display summary data

<3> Display pump data

<4> EEPROM backup cache

<M> Main Menu

Selection [] ? 2

To copy the instrument data file to a disk file, initiate your communication program's file logging command now and then press any key to start the transfer. The instrument data file will remain resident and is not erased by this offload procedure.

Configuration: ZPS-30G
Software version: ZPS-2_00.c
Compiled: Apr 11 2012 09:37:53
Electronics S/N: ML12860-01
Data recording start time: 07/15/14 08:13:51
Data recording stop time: 07/03/15 10:49:08

HEADER

SAMPLE PARAMETERS

Initial flow rate: 20 liters/minute
Minimum flow rate: 10 liters/minute
Sample volume: 100 liters
Time limit: 9 minutes
Back flush volume: 5 liters
Back flush interval: 720 minutes
Sample delay: 5 minutes

SCHEDULE

Event 01 of 50 @ 07/20/14 00:00:00
Event 02 of 50 @ 07/20/14 06:00:00
Event 03 of 50 @ 07/20/14 12:00:00
Event 04 of 50 @ 07/20/14 18:00:00
Event 05 of 50 @ 07/26/14 00:00:00
Event 06 of 50 @ 07/26/14 06:00:00
Event 07 of 50 @ 07/26/14 12:00:00
Event 08 of 50 @ 07/26/14 18:00:00
Event 09 of 50 @ 04/01/15 00:00:00
Event 10 of 50 @ 04/07/15 00:00:00
Event 11 of 50 @ 04/14/15 00:00:00
Event 12 of 50 @ 04/14/15 06:00:00
Event 13 of 50 @ 04/14/15 12:00:00
Event 14 of 50 @ 04/14/15 18:00:00
Event 15 of 50 @ 04/15/15 00:00:00
Event 16 of 50 @ 04/21/15 00:00:00
Event 17 of 50 @ 04/28/15 00:00:00
Event 18 of 50 @ 04/28/15 06:00:00
Event 19 of 50 @ 04/28/15 12:00:00
Event 20 of 50 @ 04/28/15 18:00:00

Event 21 of 50 @ 04/29/15 00:00:00
Event 22 of 50 @ 05/05/15 00:00:00
Event 23 of 50 @ 05/12/15 00:00:00
Event 24 of 50 @ 05/12/15 06:00:00
Event 25 of 50 @ 05/12/15 12:00:00
Event 26 of 50 @ 05/12/15 18:00:00
Event 27 of 50 @ 05/13/15 00:00:00
Event 28 of 50 @ 05/19/15 00:00:00
Event 29 of 50 @ 05/26/15 00:00:00
Event 30 of 50 @ 05/26/15 06:00:00
Event 31 of 50 @ 05/26/15 12:00:00
Event 32 of 50 @ 05/26/15 18:00:00
Event 33 of 50 @ 05/27/15 00:00:00
Event 34 of 50 @ 06/02/15 00:00:00
Event 35 of 50 @ 06/09/15 00:00:00
Event 36 of 50 @ 06/09/15 06:00:00
Event 37 of 50 @ 06/09/15 12:00:00
Event 38 of 50 @ 06/09/15 18:00:00
Event 39 of 50 @ 06/10/15 00:00:00
Event 40 of 50 @ 06/16/15 00:00:00
Event 41 of 50 @ 06/23/15 00:00:00
Event 42 of 50 @ 06/23/15 06:00:00
Event 43 of 50 @ 06/23/15 12:00:00
Event 44 of 50 @ 06/23/15 18:00:00
Event 45 of 50 @ 06/24/15 00:00:00
Event 46 of 50 @ 06/30/15 00:00:00
Event 47 of 50 @ 07/07/15 00:00:00
Event 48 of 50 @ 07/07/15 06:00:00
Event 49 of 50 @ 07/07/15 12:00:00
Event 50 of 50 @ 07/07/15 18:00:00

DEPLOYMENT DATA

1 07/20/14 00:00:02 36.7 Vb 15 °C
Intake flush 5.00 L 16 sec 35.1 Vbl Volume reached
Sample 101.93 L 327 sec 35.1 Vbl Volume reached
07/20/14 00:11:05 36.9 Vb 19 °C
Sample successfully sealed
2 07/20/14 06:00:02 36.4 Vb 15 °C
Intake flush 5.00 L 16 sec 35.0 Vbl Volume reached
Sample 102.45 L 331 sec 34.9 Vbl Volume reached
07/20/14 06:11:04 36.7 Vb 19 °C
Sample successfully sealed
3 07/20/14 12:00:02 36.3 Vb 16 °C

Intake flush 5.00 L 16 sec 34.8 Vbl Volume reached
Sample 102.33 L 330 sec 34.8 Vbl Volume reached
07/20/14 12:11:04 36.5 Vb 20 °C
Sample successfully sealed
4 07/20/14 18:00:02 36.2 Vb 14 °C
Intake flush 5.00 L 16 sec 34.6 Vbl Volume reached
Sample 102.32 L 329 sec 34.7 Vbl Volume reached
07/20/14 18:11:05 36.4 Vb 18 °C
Sample successfully sealed
5 07/26/14 00:00:02 36.0 Vb 15 °C
Intake flush 5.00 L 16 sec 34.4 Vbl Volume reached
Sample 102.33 L 329 sec 34.5 Vbl Volume reached
07/26/14 00:11:04 36.3 Vb 19 °C
Sample successfully sealed
6 07/26/14 06:00:02 35.9 Vb 14 °C
Intake flush 5.00 L 17 sec 34.3 Vbl Volume reached
Sample 102.32 L 329 sec 34.4 Vbl Volume reached
07/26/14 06:11:04 36.1 Vb 19 °C
Sample successfully sealed
7 07/26/14 12:00:02 35.8 Vb 15 °C
Intake flush 5.00 L 16 sec 34.2 Vbl Volume reached
Sample 102.32 L 329 sec 34.3 Vbl Volume reached
07/26/14 12:11:03 36.0 Vb 19 °C
Sample successfully sealed
8 07/26/14 18:00:02 35.7 Vb 15 °C
Intake flush 5.00 L 16 sec 34.1 Vbl Volume reached
Sample 102.19 L 328 sec 34.2 Vbl Volume reached
07/26/14 18:11:03 35.9 Vb 19 °C
Sample successfully sealed

9 04/01/15 00:00:02 34.9 Vb 11 °C
Intake flush -0.08 L 1 sec 34.5 Vbl Pump would not start
Sample -0.13 L 3 sec 33.7 Vbl Pump would not start
04/01/15 00:05:56 34.6 Vb 12 °C
Sample successfully sealed
10 04/07/15 00:00:02 34.9 Vb 12 °C
Intake flush -0.08 L 1 sec 34.5 Vbl Pump would not start
Sample -0.13 L 3 sec 33.8 Vbl Pump would not start
04/07/15 00:05:56 34.6 Vb 12 °C
Sample successfully sealed
11 04/14/15 00:00:02 34.9 Vb 12 °C
Intake flush -0.08 L 2 sec 34.5 Vbl Pump would not start
Sample -0.13 L 3 sec 33.8 Vbl Pump would not start

04/14/15 00:05:56 34.5 Vb   12 °C
Sample successfully sealed
12 04/14/15 06:00:02 34.9 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.5 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.0 Vbl Pump would not start
04/14/15 06:05:57 34.6 Vb   12 °C
Sample successfully sealed
13 04/14/15 12:00:02 34.9 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.0 Vbl Pump would not start
04/14/15 12:05:56 34.6 Vb   12 °C
Sample successfully sealed
14 04/14/15 18:00:02 34.9 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.0 Vbl Pump would not start
04/14/15 18:05:56 34.6 Vb   12 °C
Sample successfully sealed
15 04/15/15 00:00:02 34.9 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.1 Vbl Pump would not start
04/15/15 00:05:56 34.6 Vb   12 °C
Sample successfully sealed
16 04/21/15 00:00:02 34.9 Vb   13 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 33.9 Vbl Pump would not start
04/21/15 00:05:56 34.5 Vb   13 °C
Sample successfully sealed
17 04/28/15 00:00:02 34.8 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   4 sec 33.9 Vbl Pump would not start
04/28/15 00:05:56 34.5 Vb   12 °C
Sample successfully sealed
18 04/28/15 06:00:02 34.9 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   4 sec 34.0 Vbl Pump would not start
04/28/15 06:05:56 34.5 Vb   12 °C
Sample successfully sealed
19 04/28/15 12:00:02 34.9 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   4 sec 34.0 Vbl Pump would not start
04/28/15 12:05:55 34.5 Vb   12 °C
Sample successfully sealed
20 04/28/15 18:00:02 34.9 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start

Sample -0.13 L 4 sec 34.0 Vbl Pump would not start
04/28/15 18:05:55 34.6 Vb 12 °C
Sample successfully sealed
21 04/29/15 00:00:02 34.9 Vb 12 °C
Intake flush -0.08 L 2 sec 34.4 Vbl Pump would not start
Sample -0.13 L 4 sec 34.0 Vbl Pump would not start
04/29/15 00:05:55 34.6 Vb 12 °C
Sample successfully sealed
22 05/05/15 00:00:02 34.8 Vb 12 °C
Intake flush -0.08 L 1 sec 34.4 Vbl Pump would not start
Sample -0.13 L 4 sec 33.9 Vbl Pump would not start
05/05/15 00:05:55 34.5 Vb 12 °C
Sample successfully sealed
23 05/12/15 00:00:02 34.8 Vb 12 °C
Intake flush -0.08 L 2 sec 34.4 Vbl Pump would not start
Sample -0.13 L 4 sec 33.9 Vbl Pump would not start
05/12/15 00:05:55 34.5 Vb 12 °C
Sample successfully sealed
24 05/12/15 06:00:02 34.9 Vb 12 °C
Intake flush -0.08 L 2 sec 34.4 Vbl Pump would not start
Sample -0.13 L 4 sec 34.1 Vbl Pump would not start
05/12/15 06:05:54 34.5 Vb 12 °C
Sample successfully sealed
25 05/12/15 12:00:03 34.9 Vb 12 °C
Intake flush -0.08 L 2 sec 34.4 Vbl Pump would not start
Sample -0.13 L 4 sec 34.1 Vbl Pump would not start
05/12/15 12:05:54 34.5 Vb 12 °C
Sample successfully sealed
26 05/12/15 18:00:03 34.9 Vb 12 °C

Intake flush -0.08 L 2 sec 34.4 Vbl Pump would not start
Sample -0.13 L 4 sec 34.1 Vbl Pump would not start
05/12/15 18:05:54 34.5 Vb 13 °C
Sample successfully sealed
27 05/13/15 00:00:03 34.9 Vb 13 °C
Intake flush -0.08 L 2 sec 34.4 Vbl Pump would not start
Sample -0.13 L 4 sec 34.1 Vbl Pump would not start
05/13/15 00:05:54 34.5 Vb 13 °C
Sample successfully sealed
28 05/19/15 00:00:03 34.8 Vb 12 °C
Intake flush -0.08 L 2 sec 34.4 Vbl Pump would not start
Sample -0.13 L 4 sec 33.9 Vbl Pump would not start
05/19/15 00:05:55 34.4 Vb 12 °C
Sample successfully sealed

29 05/26/15 00:00:03 34.8 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   4 sec 33.9 Vbl Pump would not start
05/26/15 00:05:53 34.4 Vb   13 °C
Sample successfully sealed
30 05/26/15 06:00:03 34.8 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   4 sec 34.0 Vbl Pump would not start
05/26/15 06:05:54 34.5 Vb   13 °C
Sample successfully sealed
31 05/26/15 12:00:03 34.8 Vb   12 °C
Intake flush   -0.08 L   1 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   4 sec 34.1 Vbl Pump would not start
05/26/15 12:05:54 34.5 Vb   13 °C
Sample successfully sealed
32 05/26/15 18:00:03 34.8 Vb   12 °C
Intake flush   -0.08 L   1 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   4 sec 34.1 Vbl Pump would not start
05/26/15 18:05:55 34.5 Vb   13 °C
Sample successfully sealed
33 05/27/15 00:00:03 34.8 Vb   12 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.1 Vbl Pump would not start
05/27/15 00:05:54 34.5 Vb   12 °C
Sample successfully sealed
34 06/02/15 00:00:03 34.8 Vb   13 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 33.9 Vbl Pump would not start
06/02/15 00:05:54 34.4 Vb   13 °C
Sample successfully sealed
35 06/09/15 00:00:03 34.8 Vb   13 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 33.9 Vbl Pump would not start
06/09/15 00:05:54 34.4 Vb   13 °C
Sample successfully sealed
36 06/09/15 06:00:03 34.8 Vb   13 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.0 Vbl Pump would not start
06/09/15 06:05:54 34.5 Vb   13 °C
Sample successfully sealed
37 06/09/15 12:00:03 34.8 Vb   13 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.1 Vbl Pump would not start
06/09/15 12:05:54 34.5 Vb   13 °C

Sample successfully sealed
38 06/09/15 18:00:03 34.8 Vb   13 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.1 Vbl Pump would not start
06/09/15 18:05:54 34.5 Vb   14 °C
Sample successfully sealed
39 06/10/15 00:00:03 34.8 Vb   13 °C
Intake flush   -0.08 L   2 sec 34.3 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.1 Vbl Pump would not start
06/10/15 00:05:54 34.5 Vb   13 °C
Sample successfully sealed
40 06/16/15 00:00:03 34.8 Vb   13 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 33.9 Vbl Pump would not start
06/16/15 00:05:53 34.4 Vb   14 °C
Sample successfully sealed
41 06/23/15 00:00:03 34.8 Vb   14 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 33.9 Vbl Pump would not start
06/23/15 00:05:54 34.4 Vb   14 °C
Sample successfully sealed
42 06/23/15 06:00:02 34.8 Vb   14 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.0 Vbl Pump would not start
06/23/15 06:05:52 34.4 Vb   14 °C
Sample successfully sealed
43 06/23/15 12:00:02 34.8 Vb   14 °C
Intake flush   -0.08 L   1 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.0 Vbl Pump would not start
06/23/15 12:05:52 34.5 Vb   14 °C
Sample successfully sealed
44 06/23/15 18:00:02 34.8 Vb   14 °C
Intake flush   -0.08 L   2 sec 34.4 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.1 Vbl Pump would not start
06/23/15 18:05:52 34.5 Vb   14 °C
Sample successfully sealed
45 06/24/15 00:00:02 34.8 Vb   14 °C
Intake flush   -0.08 L   2 sec 34.3 Vbl Pump would not start
Sample   -0.13 L   3 sec 34.1 Vbl Pump would not start
06/24/15 00:05:52 34.5 Vb   14 °C
Sample successfully sealed
46 06/30/15 00:00:02 35.0 Vb   21 °C
Intake flush   -0.08 L   2 sec 33.8 Vbl Pump would not start
Sample   -0.13 L   3 sec 33.9 Vbl Pump would not start

07/03/15 10:49:08 34.4 Vb 21 °C
Sample successfully sealed
Schedule was not completed.
End of instrument data file.
Terminate file logging operation now.
Press any key to continue.

Configuration: ZPS-30G CF2 V2_00 of Apr 11 2012

Offload/Display Data File

Fri Jul 3 12:29:53 2015
<1> Display all data
<2> Display summary data
<3> Display pump data
<4> EEPROM backup cache
<M> Main Menu
Selection [] ? 3

To copy the instrument data file to a disk file, initiate your communication program's file logging command now and then press any key to start the transfer. The instrument data file will remain resident and is not erased by this offload procedure.

Configuration: ZPS-30G
Software version: ZPS-2_00.c
Compiled: Apr 11 2012 09:37:53
Electronics S/N: ML12860-01
Data recording start time: 07/15/14 08:13:51
Data recording stop time: 07/03/15 10:49:08
HEADER

PUMPING DATA

Sample interval: 1 minute

event	L/min	Liters	Vbat
1	20.02	19.23	35.4
1	20.02	38.44	35.4
1	20.02	57.64	35.4
1	20.02	76.84	35.3
1	20.02	96.04	35.2
2	20.02	19.23	35.2
2	19.96	38.43	35.1
2	19.96	57.64	35.1
2	19.96	76.84	35.0
2	20.02	96.04	35.1

3	20.02	19.23	34.9
3	20.02	38.43	35.0
3	20.02	57.64	35.0
3	20.02	76.84	34.9
3	20.02	96.04	34.8
4	19.96	19.23	34.9
4	19.91	38.43	34.8
4	20.02	57.64	34.8
4	20.07	76.84	34.7
4	19.96	96.04	34.8
5	20.07	19.23	34.8
5	20.02	38.43	34.7
5	19.96	57.63	34.6
5	19.96	76.83	34.6
5	19.96	96.03	34.6
6	20.07	19.22	34.6
6	20.02	38.43	34.6
6	19.96	57.63	34.6
6	20.02	76.83	34.5
6	20.02	96.04	34.5
7	19.96	19.22	34.5
7	19.96	38.43	34.5
7	20.02	57.63	34.5
7	19.96	76.83	34.3
7	19.96	96.03	34.3
8	20.02	19.22	34.4
8	20.02	38.43	34.3
8	20.02	57.63	34.4
8	19.96	76.83	34.2
8	19.96	96.03	34.2

End of instrument data file.
Terminate file logging operation now.
Press any key to continue.

Main Menu

Fri Jul 3 12:31:06 2015
Belt is NOT aligned
<1> Set Time <5> Create Schedule
<2> Diagnostics <6> Deploy System
<3> Manual Operation <7> Offload Data
<4> Sleep <8> Contact McLane
Selection [] ? 1

```
Clock reads 07/03/15 12:31:20
Format is mm/dd/[yyyy or yy] hh:mm:ss
Enter correct time [07/03/2015 12:31:20] ?
Clock reads 07/03/15 12:31:20.  Change [N] ?
________________________________________________________________
Configuration: ZPS-30G           CF2 V2_00 of Apr 11 2012
        McLane Research Laboratories, USA
            ZooPlankton Sampler
              ML12860-01
        _________________________________
              Main Menu
        _________________________________
          Fri Jul  3 12:31:21 2015
            Belt is NOT aligned
      <1> Set Time         <5> Create Schedule
      <2> Diagnostics      <6> Deploy System
      <3> Manual Operation  <7> Offload Data
      <4> Sleep            <8> Contact McLane
        Selection [] ? 4
07/03/15 12:31:43 Suspending ...
```

17.3 Appendix 3: Datalogging & Data Storage

Datalogging software and storage is provided on a platform common to both *RRS* vessels (*RRS Discovery* and *RRS James Cook*), and managed by NERC's NMFSS Ship Scientific Systems group.

17.3.1 TechSAS

TechSAS is an integrated technical and scientific sensors acquisition system and is the primary datalogger on both vessels. The system allows monitoring and accurate time-stamping of each individual instrument with a graphical output

TechSAS saves data in the self describing NetCDF (Network Common Data Format) format that can be easily read via MatLab or using freely available NetCDF libraries. TechSAS also broadcasts the logged data across the ship's network in UDP pseudo-NMEA0183 (i.e.: "NMEA-like") packets. Separate NetCDF documentation is available that explains the logged variables.

17.3.2 RVS Level C

Level-C is a data management programme, written in C for its Sun SPARC environment. The Level-C system logs the TechSAS UDP packets in the Level-C binary format as flat files (colloquially known as "streams").

Level-C has a number of little programmes inside it that allow the flat files to be viewed, edited, and exported rapidly in a range of formats, e.g.: CSV; ASCII text file, at custom intervals and averaging periods.

Another feature is the display of meteorological, depth, and navigation data (as with the SSDS software running on the wall-mounted HP touchscreens around the ship).
The NMFSS Science Systems Technician can generate reports from the Level-C system.

17.3.3 CLAM 2014

Cable Loging And Monitoring System.
CLAM is mainly a monitoring system used to display a range of dynamic parameters, four of which are legally required for the ship to operate winches at sea. The use of winches is critical to oceangraphic field work, so the ship can't really sail without it.
The software is owned by NMFSS' Ship Scientific Systems group; and maintained by Ship Systems Technicians. It's designed to be fitted to both the RRS James Cook and the RRS *Discovery*, and potentially the BAS ships.
The Cable Logging And Monitoring system was devised to satisfy requirements set by the arrangements made between NMFSS and Lloyd's Register to allow winches to be used at a Factor of Risk of up to 2:1, as opposed to the usual 5:1. The agreement specifies that four dynamic values from the winches must be continually logged and monitored (i.e.: displayed) during oceanographic winch operations. Those values are:
Cable Tension (due to load on the cable)
Cable Out (i.e.: length of deployed cable)
Back Tension
Angular Velocity In addition to these four values, CLAM displays sea depth, and the vessel's Angle of Heel (how far it's leaning in either direction due to a combination of roll, weight distribution, and wind) from the POS MV MRU.

17.3.4 Attitude & Positioning Instruments

The new *RRS Discovery* has some of the same sensors as the *RRS James Cook*, and some new ones.

17.3.4.1 Applanix POS MV V4 (Primary Science GNSS and Attitude Sensor)

A combined GNSS receiver and attitude (i.e.: gyrocompass, and conventional motion) sensor that provides data about: attitude; heave; position; and velocity. The GNSS aspect is for use with Multibeam Echosounder systems.
The POSMV is logged to the TechSAS Datalogger. The datalogger produces two files for its configured file period (usually 24hrs).
These files are:

- POSMVPOS.POS - NetCDF File Containing Positional Data (Heading, Latitude, Longitude)
- POSMVATT.ATT - NetCDF File Containing Attitude data (Roll, Pitch, Heave)

Please note that the position output is the position of the ship's common reference point (the cross on the top of the POSMV MRU in the gravity room).

17.3.4.2 Kongsberg Seapath DPS330 (Secondary Science GNSS and Attitude Sensor)

This is a secondary Science GNSS and attitude sensor. The position output is the position of the ship's common reference point (the cross on the top of the POSMV MRU in the Gravity Meter Room).

17.3.4.3 iXBlue PhINS (Photonic Inertial Navigation System)

A surface inertial navigation system that uses a FOG (Fibre-Optic Gyro) to output accurate position, attitude, and velocity data.

17.3.4.4 CNav 3050 GPS, GLONASS, Galileo GNSS

GNSS and RTCM Satellite Corrections Receiver. The position output is the position of the antenna. This GPS is not referenced to any other systems. It is primarily used to provide RTCM differential corrections to the other GPS systems. Please note that the position output is the position of the antenna. This GPS is not referenced to any other systems.

17.3.5 Hydroacoustics

RRS Discovery has both vessel-mounted and smaller deployable transponders.

17.3.5.1 Kongsberg-Simrad

Simrad, now part of Kongsberg, is the supplier of the heavy artillery of echosounders.

17.3.5.2 EM122 Deep Water Multibeam Echosounder

This 12kHz echosounder is rated to 11,000m, but probably up to 8,000m for good quality data. The EM122 it is viewed and operated via SIS (Seafloor Information Service).

17.3.5.3 EM710 Shallow Water Multibeam Echosounder

This 70-100kHz echosounder is rated to 2,000m, but in reality you might consider switching to the EM122 between 600-1500 metres. Within this range, the EM710 gives a broader swathe, with less detail, so which one you use depends on what data you need to generate.

17.3.5.4 SBP120 Sub-Bottom Profiler

The SBP120 is a 6kHz-8kHz extension to the EM122 Deep Water Echosounding Profiler (the receiver part).

17.3.5.5 EA640 Single-beam Echosounder

The EA640 is a special version of the EA600 commissioned for the *RRS Discovery*, pretty much identical to the EA600 and can operate at either 12kHz or 10kHz as required. The performance of each varies with output power (e.g.: 1kW or 2kW) and pulse lengths. They both have a wide bandwidth that overlaps, and can be run at the same time.

17.3.5.6 EK60 Multi-Frequency Echosounder (“Fish Finder”)

The EK60 has 18, 38, 70, 120, 200, and 333 kHz transducers fitted to the starboard drop keel. Equipment to calibrate the system is carried onboard.
Specifications Ek60_brochure_english_reduced.pdf
Location dy###_data_disc/cruise_reports/instrument_data_sheets/

17.3.5.7 Kongsberg-Simrad SU16 Synchronisation Unit (K-Sync)

Running several acoustic systems simultaneously on ships with several acoustic instruments can cause interference between the systems, which may reduce the data quality. This unit and associated software lets you synchronise the pings of different acoustic equipment, (providing

that they operate at different frequencies!). This system lets the SST control the timing of the instruments and by controlling the triggering of each instrument's transmission.
Specifications Operator Manual.pdf
Location dy###_data_disc/cruise_reports/instrument_data_sheets/k-sync/

17.3.6 Sonardyne Transponder Beacons & Software

There are two hull-mounted transponders on the *RRS Discovery*. The Starboard side USBL is a 7000 directional bis head for improved performance in deeper water; the Port side USBL is a 5000 standard head. The USBL transponder spars are extensible & retractable and project more or less vertically down from the aft half of the hull between the Drop Keels and the Propellers. The software used is ***Ranger 2***.
Inputs Vertical Reference Units (VRUs), Gyro Compass; DGPS (Surface Positioning); GPS (Time Synchronisation). Transponders (1km-depth Wide-band Sub-Mini – WSM), and 3km-depth DP Transponder
Outputs it logs data itself into a file that can be taken away; can also output a data string to TechSAS (in this case, you only get the position of one beacon at a time in the water, you can put this info into the Level-C system and plot some data from it; it outputs to the OLEX 3D-seafloor mapping software that provides a visual display). It can also output DP telegram format data.

17.3.6.1 Teledyne-RDI Ocean Surveyor ADCP

The ADCP transducers are located in the hull, in blisters, in a forward-aft configuration approximately 6m below the water line. There are two systems that operate at two frequencies: 75 kHz; and 150kHz. Both the heads have a rotation relative to the ship's centre line of -45°. The software used for configuring and datalogging with the ADCP is called ***VmDAS*** (Vessel Mounted Data AcquisitionSystem). ***VmDAS*** gets data from the ship's attitude sensor and uses that to convert ship velocities into earth co-ordinates.
VmDAS can be configured either by loading or editing a command file; or by changing settings on the interface. Users should be aware that it's possible to simultaneously load and use a command file, and adjust settings using the interface, which can lead to command conflicts, in which case the interface overrides the command file. Data is logged to local hard-disc, and then create a back-up on the server. Set-up file is editable when starting the ***VmDAS*** software.

17.3.6.2 75KHz Vessel Mounted ADCP (VMADCP)

Inputs: GPS; Gyrocompass; *iXSea* PhINS so it can calculate accurate speed and direction of currents.
Range: 520-650m (Long-range/Low quality); 310-430m (Short range/High quality)

17.3.6.3 150 kHz Vessel Mounted ADCP (VMADCP)

Inputs: the same as for the 75kHz
Range: 325-350m or 375-400m (Long Range/Low Quality); 200-250m or 220-275m (Short Range/High Quality)

17.3.7 Sound Velocity Sensors

Discovery has a hull-mounted *AML Micro X Probe*, and a portable *Valeport Midas SV* Profiler. The Valeport uses *DataLogExpress* datalogger software and have a maximum depth of 5000m.
The *Kongsberg SIS* software has a new application called **MDM** for bringing the saved profiles in.

17.3.8 MetOcean

RRS Discovery has the same MetOcean instruments and sensors as the *RRS James Cook.*

17.3.8.1 OceanWaves WaMoS II Wave Radar

WaMoS is an X-Band nautical RADAR with a range of 100m to 4km. It can only generate data in above a minimum wind speed of $3ms^{-1}$. It detects open wave spectra. Sea state is calculated from detected backscatter of µwave "sea clutter" in real time. The system can detects wavelengths from 15 m – 600 m and covers periods from 4 sec-20 seconds. At coastal sites, WaMoS II can only measure the spatial wave field beyond the wave breaking zone. There is a WaMoS computer in the Met Lab, where it stores processed radar images. Data is logged in WaMoS's own format. Summary wave information is available in one of the ASCII files generated and also available in NetCDF format.

17.3.8.1.1 *NMFSS SurfMet (Surface Water System and Meteorological Monitoring* System)

SurfMet comprises two sets of scientific instruments: Meteorological; and Surface Water Sampling, along with ADCs and a PC hosting SurfMet data conversion software that passes data to the Data Systems for event logging.

17.3.9 Meteorological Instruments (Met)

The Meteorological part of the system comprises a range of instruments located near the forward mast about 10 metres above sea level.

The instrument called the...	**...measures...**	**...in...**	**...to calculate...**
Vaisala HMP155 Temperature & Humidity Sensor	Thermal radiation and water vapour	Sunlight; Air	Ambient air temperature and Relative humidity
Gill Windsonic Anemometer	Ultrasonic sound waves via ultrasound transceivers	Air	Wind speed and direction
Vaisala BaroCap PTB110 Barometric Pressure sensor	Change in electrical resistance via a deflectable diaphragm strain gauge within a pressure transducer	Air	Air pressure
Kipp & Zonen CM6B Pyranometer	Electromagnetic radiation flux density by converting solar radiation into heat, and thence into a voltage	Sunlight	Total Irradiance (Solar energy)
Skye Instruments SKE510 PAR (Photosynthetic Active	Electromagnetic radiation flux density by converting solar	Sunlight	Total Irradiance (Solar energy) within a fixed

Radiation) Pyranometer	radiation into heat, and thence into a voltage, passed through a bandpass filter		range of wavelengths for photosynthesis

17.3.9.1 Surface Water Sampling Instruments (SWS)

The Surface Water part of the SurfMet system collects seawater (known as “non-toxic" or "underway" water) from the upper 5.3 metres of the ocean, and passes it through the following instruments:

The instrument called the...	**...measures...**	**...in...**	**...to calculate...**
SeaBird 45 Thermosalinograph	Temperature and conductivity	Seawater	Salinity
SeaBird 38 Digital Oceanographic Thermometer	Change in resistance via a thermistor	Seawater	Temperature
WetLabs WetStar WS3S Fluorometer	Reflected light frequency difference between beams of light passed through water	Seawater	Marine floral density
WetLabs WetStar CST Transmissometer	Photon quanta (received light)	Seawater	Particulate density

TSG flow is approx 1.6 litres per minute whilst fluorometer and transmissometer flow is approx **20** l/min. Flow to instruments is degassed using a debubbler (outlet) with **10** l/min inflow; waste flow is usually around **8-10** l/min (adjusted to maintain balance, but at a low rate to keep the TSG flow rate to around 1.6 l/min).

17.3.9.2 DartCom HRPT L-Band Polar Orbiter Weather Satellite Imaging System

The DartCom system comprises a 1.2m Parabolic Dish enclosed in a Radome. It receives signals from satellites that take images of cloud coverage. These images can be used to see the type of atmospheric and weather conditions nearby.

17.3.10 Data Displays

Software for displaying useful science-related information is provided around the ship.

17.3.10.1 NMFSS-SSS SSDS (Ship Scientific Display Screens)

These touchscreens located around the ship display a range of data from scientific and non-scientific systems: Gyro information; GPS information from CNAV; sensor information from SurfMet; Depth from EA640; and winch information. Waypoints to stations can also be entered on the ETA tab, and propagated around the network to the other screens.

17.3.10.2 OLEX 3D Seafloor Hydrographic Mapping and Visualisation Software

OLEX is a 3-D seafloor map visualisation software that has a shared seafloor data files, and installed on a dedicated PC. OLEX receives data from navigation, depth, multibeam, and ship positioning systems (it can also position data from USBL). Olex provides rapid visualisation of multibeam data, as well as showing where in the world the ship is.

17.3.11 NetCDF File Descriptions

2013.01.??	1.0	File copied from RRS James Cook v1.17	JS
2015.01.27	1.1	CLAM errors and other errors corrected	JM
2015.04.??	1.2	V2 of Skipper Log Module	JS
2015.05.17	1.3	Tidying up	JM
2015.05.30	1.4	Corrected	ZN
2015.06.05	1.5	Commented	ZN

Fig 39. The official netCDF logo

17.3.12 Overview of TechSAS data logging

This document describes how the variables logged by the National Marine Facilities Sea System's TechSAS data logging system are recorded and processed on RRS *Discovery*. There is a similar set-up on RRS James Cook, but the NetCDF filenames are different; a similar document is available for RRS James Cook.

The following list of variables is arranged by the name of NetCDF files in which each variable occurs, with the RVS Level-C stream name afterwards in round brackets. The NetCDF filename includes the name of the subdirectory of the main NetCDF directory before the forward slash. The name in round brackets is the variable name from the RVS Level-C data file. The units are given in square brackets. The filenames are arranged alphabetically, with all upper case letters coming before lower case letters.

The **time** variable in the NetCDF files is the number of days since 30th December 1899 00:00:00 UTC. The **Time** variable in the RVS Level-C files when they are presented in an ASCII format varies depending upon the program used to generate the ASCII file, but is commonly YY DDD HH:MM:SS where YY is the last two digits of the year, DDD is the Julian day of the year and the remainder is the UTC time.

Variables in the Level-C files have a status flag associated with them. The value of these status flags indicates the following:

Flag	Meaning
60	Accept
55	Correct
50	Good (default)
45	Uncorrected
40	Interpolated
35	Restart
30	Suspect
20	Reject
10	Test
0	Not written

17.3.12.1 AIRSEAII/YYYYMMDD-hhmmss-AirSeaII-S84_DY1.AirSeaII (gravity)

This file contains data from the Micro-g Lacoste gravity meter.

- **grav_av (grav_av) [counter units]** is the filtered gravity value.
- **springt (springt) [counter units]** is the spring tension.
- **beam (beam) [volt × 750000]** is the beam position.
- **vc (vc) [see manual]** VCC data field.
- **al (al) [see manual]** AL data field.
- **ax (ax) [see manual]** AX data field.
- **ve (ve) [see manual]** VE data field.
- **ax2 (ax2) [see manual]** AX2 data field.
- **xac2 (xac2) [see manual]** XACC2 data field.
- **lac2 (lac2) [see manual]** LACC2 data field.
- **xac (xac) [Gal]** Cross acceleration.
- **lac (lac) [Gal]** Longitudinal acceleration.
- **eotcor (eotcor) [milliGal]** Eotvos correction.
- **lat (lat) [degree]** is the latitude that the gravity value was taken at.
- **lon (lon) [degree]** is the longitude that the gravity value was taken at.
- **heading (heading) [degree]** is the course made good from the GPS data.
- **velocity (vel) [knot]** is the vessel's velocity from the GPS data.
- **time (Time) []**

17.3.12.2 CLAM/YYYYMMDD-hhmmss-CLAM-CLAM_DY1.CLAM (winch)

The CLAM system records data from the ship's permanently fitted winches.

- **cabltype (cabltype) []** is the type of cable in operation.
  The cable types are shown below:

Numeric Value	Cable Type
0	No winch selected
1	CTD1
2	CTD2
3	Deep Core
4	Deep Tow
5	Trawl
6	General Purpose

- **cablout (cableout) [metre]** is the length of cable deployed.
- **rate (rate) [metres per second]** is the rate of cable deployment. A positive rate indicates that the cable is being paid out (veered) and a negative rate indicates that the cable is being hauled in.
- **tension (tension) [tonne]** is the cable tension.
- **btension (btension) [tonne]** is the cable back tension.
- **angle (angle) [degree]** is the heel (roll) angle of the vessel. A positive angle indicates that the port side of the vessel is above the starboard side.
- **time (Time) []**

17.3.12.3 EA600/YYYYMMDD-hhmmss-EA600-EA640_DY1.EA600 (ea640)

The EA640 echosounder outputs the depth that it measures from the sea bed to the ship's waterline, (i.e.: compensating for the depth of the sensor below the waterline). The compensation factor is set in the software. The sensor is mounted on the drop keel. The sonar user should modify the compensation factor when the drop keel is moved. The depth is output in various units, all of which are logged to the NetCDF file. Only the depth in metres is recorded in the RVS data files. No compensation is made for the current tidal height. No information about the sound velocity correction applied is contained in the file and the cruise report should be consulted for further information.

- **depthft (not logged) [feet]**
- **depthm (depth) [metre]**
- **depthF (not logged) [fathom]**
- **time (Time) []**

17.3.12.4 SURFMETv2/YYYYMMDD-hhmmss-Light-DY-SM_DY1.SURFMETv2 (surfmet)

- **pres (press) [hectopascal]** is the atmospheric pressure. The voltage measured by the NuDAM ADC is converted to hPa in the SurfMet program by the equation:
  $pres = 800 + (52 \times voltage)$
  where voltage is the measured voltage in volts.

- **ppar (ppar) [volt × 10^{-5}]** is the voltage measured by the NuDAM ADC in millivolts multiplied in the SurfMet software by 100, from the Photosynthetically Active Radiation (PAR) sensor on the port side of the ship's meteorological platform. To convert this value to a light intensity, it should be divided by the calibration factor specified on each sensor's data sheet, paying attention to the fact that the calibration factor typically has units of microvolt per watt per metre squared and this value has units of $\times 10^{-5}$ volts.
- **spar (spar) [volt × 10^{-5}]** is the voltage measured by the NuDAM ADC in millivolts multiplied in the SurfMet software by 100, from the PAR sensor on the starboard side of the ship's meteorological platform. To convert this value to a light intensity, it should be divided by the calibration factor specified on each sensor's data sheet.
- **ptir (ptir) [volt × 10^{-5}]** is the voltage measured by the NuDAM ADC in millivolts multiplied in the SurfMet software by 100, from the Total Irradiance (TIR) sensor on the port side of the ship's meteorological platform. To convert this value to a light intensity, it should be divided by the calibration factor specified on each sensor's data sheet.
- A typical maximum value for a TIR in a TechSAS or Level-C file is 1108.7. This is 1108.7×10^{-5} V. From the data sheet for this TIR the calibration to be applied is 11.94 μVolts/W/m^2. So the actual TIR light intensity is 0.011087 / 0.00001194 = 928.5 W/m^2.
- **stir (stir) [volt × 10^{-5}]** is the voltage measured by the NuDAM ADC in millivolts multiplied in the SurfMet software by 100, from the TIR sensor on the starboard side of the ship's meteorological platform. To convert this value to a light intensity, it should be divided by the calibration factor specified on each sensor's data sheet.
- **time (Time) []**

17.3.12.5 SURFMETv2/YYYYMMDD-hhmmss-MET-DY-SM_DY1.SURFMETv2 (surfmet)

- **speed (speed) [metre per second]** is the relative wind velocity. The wind speed and direction are at the height of the anemometer on the met platform, approximately 19.7 metres above the sea surface depending upon the trim of the ship. The sensor outputs a voltage between 0 and 5 volts corresponding to 0 and 50 ms^{-1}. These voltages are measured by a NuDAM ADC. The SurfMet software converts this voltage to a speed using the equation:
  $speed = (50/5) \times voltage$
- **direct (direct) [degree]** is the relative wind direction with 0° being at the bow. The sensor outputs a voltage between 0 and 5 volts corresponding to 0 and 360°. The SurfMet software converts this voltage to a direction using the equation:
  $direct = (360/5) \times voltage$
- **airtemp (airtemp) [degree Celsius]** is the air temperature. The sensor outputs a voltage between 0 and 1 volt, corresponding to -40°C to +60°C. This voltage is

measured by a NuDAM ADC and is converted to a temperature in the SurfMet software using the equation:
airtemp = (100×*voltage*) – 40
where *voltage* is the measured voltage in volts.

- **humid (humidity) [percent]** is the relative humidity of the air. The sensor outputs a voltage between 0 and 1 volt, corresponding to 0% and 100% relative humidity respectively. The voltage is measured by a NuDAM ADC and is converted to relative humidity in the SurfMet software using the equation:
  humid = 100 × *voltage*
  where *voltage* is the measured voltage in volts.
- **time (Time) []**

17.3.12.6 TSG/YYYYMMDD-hhmmss-SBE45-SBE45_DY1.TSG (sbe45)

The Sea-Bird Electronics SBE45 Thermosalinograph's (TSG) data is logged directly by the TechSAS data acquisition system. TechSAS rebroadcasts the data and it is logged for a second time in the SurfMet data files.

- **temp_h (temp_h) [degree Celsius]** is the water temperature measured in the SBE45 housing. The SBE45 contains its own calibration coefficients and outputs over RS232 the calibrated temperature.
- **cond (cond) [siemen per metre]** is the conductivity measured by the SBE45. It is the calibrated conductivity output via RS232.
- **salin (salin) []** is the water salinity calculated by SBE45. It is measured using the Practical Salinity Scale and hence is unit less.
- **sndspeed (sndspeed) [metre per second]** is the velocity of sound in the sampled water calculated by the SBE45 using the Chen-Millero equation.
- **temp_r (temp_r) [degree Celsius]** is the water temperature measured by the SBE38 remote thermometer at the raw water inlet to the ship. The SBE38 contains its own calibration coefficients and outputs over RS232 the calibrated temperature.
- **time (Time) []**

17.3.12.7 SURFMETv2/YYYYMMDD-hhmmss-Surf-DY-SM_DY1.SURFMETv2 (surfmet)

- **temp_h (temp_h) [degree Celsius]** is the SBE45 housing water temperature.
- **temp_m (temp_r) [degree Celsius]** is the SBE38 remote temperature at the ship's raw water inlet.
- **cond (cond) [siemen per metre]** is the conductivity measured by the SBE45 The unit corrected before DY032 set sail.
- **fluo (fluo) [volt]** is the voltage measured by the NuDAM Analogue to Digital Converter (ADC) from the Wet Labs WS3S Fluorimeter. Each fluorimeter's data sheet should be consulted for the equation and calibration factors to convert from voltage to chlorophyll concentration.

- **trans (trans) [volt]** is the raw voltage measured by the NuDAM ADC from the Wet Labs C-Star Transmissometer. Each transmissometer's data sheet should be consulted for the equation and calibration factors to convert from voltage to transmittance.
- **time (Time) []**

17.3.12.8 WINCH/YYYYMMDD-hhmmss-logskippervdvbw-SkipLog.winch (log_dysk)

The skipper log measures the ship's velocity through the water and over the sea bed. The winch part of the filename should be ignored, these datafiles and streams give the vessel's velocity.

There was initially some confusion about the direction of port and starboard motion. The direction that was given a positive value changed in the two versions of the data described below. The following text should be carefully consulted to check the sign of the lateral motion.

There have been two versions of this module. The following version was run until 07:26 UT on 26th November 2014.

17.3.13 Version 1 of The Skipper Log Module

The TechSAS Skipper Log recording module splits the motion along one axis into two components along that axis. The component along one direction of the axis has a positive value and the component along the other direction has a negative value. Each component has a value of zero when the other is non-zero. These two components can therefore be summed to give a more traditional variable that is positive when the vessel is moving in one direction along this axis and negative when moving in the other direction. Example data showing these two components of motion in a fore and aft direction is given in **Error! Reference source not found.**.

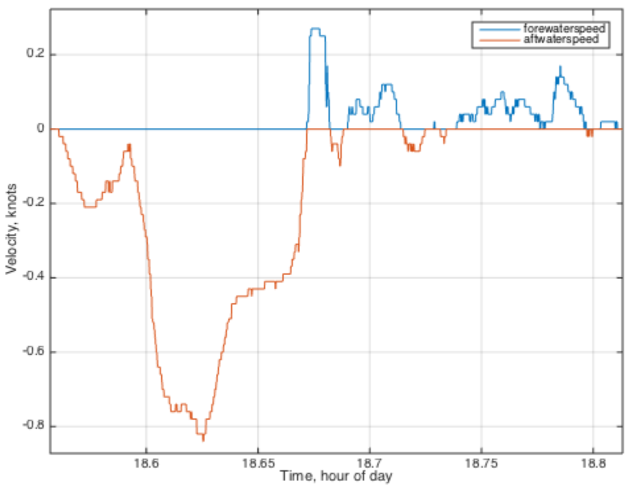


Fig 40. Example of Skipper Log fore and aft velocities

The direction of the port and starboard motion was not checked when this module was written. The port and starboard terms were confused and the variable names are confusing for motion in a lateral direction. The following wording should be checked carefully for the correct values in the port and starboard direction.

- **starboardbottomspeed (speedfa) [knot]** is the speed of the vessel over the sea bed in a starboard direction. If the vessel is moving to starboard then the sign of the value will be negative and the magnitude will be the velocity in the starboard direction. If the vessel is moving to port then this value will be zero. If the log does not have a good fix on the sea bed then this value will be inaccurate.
- **starboardwaterspeed (not logged) [knot]** is the speed of the vessel through the water in a starboard direction. If the vessel is moving to starboard then the sign of the value will be negative and the magnitude will be the velocity in the starboard direction. If the vessel is moving to port then this value will be zero.
- **aftbottomspeed (speedps) [knot]** is the speed of the vessel over the sea bed in an aft direction. If the vessel is moving backwards then the sign of the value will be negative and the magnitude will be the velocity in the aft direction. If the vessel is moving forwards then this value will be zero. If the log does not have a good fix on the sea bed then this value will be inaccurate.
- **portwaterspeed (not logged) [knot]** is the speed of the vessel through the water in a port direction. If the vessel is moving to port then the sign of the value will be positive and the magnitude will be the velocity in the port direction. If the vessel is moving to starboard then this value will be zero.
- **forebottomspeed (not logged) [knot]** is the speed of the vessel over the sea bed in a forwards direction. If the vessel is moving forwards then the sign of the value will be positive and the magnitude will be the velocity in the forwards direction. If the vessel is moving backwards then this value will be zero. If the log does not have a good fix on the sea bed then this value will be inaccurate.
- **aftwaterspeed (not logged) [knot]** is the speed of the vessel through the water in an aft direction. If the vessel is moving backwards then the sign of the value will be negative and the magnitude will be the velocity in the aft direction. If the vessel is moving forwards then this value will be zero.
- **forewaterspeed (not logged) [knot]** is the speed of the vessel through the water in an forwards direction. If the vessel is moving forwards then the sign of the value will be positive and the magnitude will be the velocity in the forwards direction. If the vessel is moving backwards then this value will be zero.
- **portbottomspeed (not logged) [knot]** is the speed of the vessel over the sea bed in a port direction. If the vessel is moving to port then the sign of the value will be positive and the magnitude will be the velocity in the port direction. If the vessel is moving to starboard then this value will be zero. If the log does not have a good fix on the sea bed then this value will be inaccurate.
- **time (Time) []**

17.3.14 Version 2 of The Skipper Log Module

The module was revised and the following version was run from 07:26 UT 26th November 2014:

In the revised module, the motion along an axis is again split into two components along each axis. The component along one direction is the inverse of the component along the other direction. Example data showing these two components of motion in a fore and aft direction is given in Figure 3.

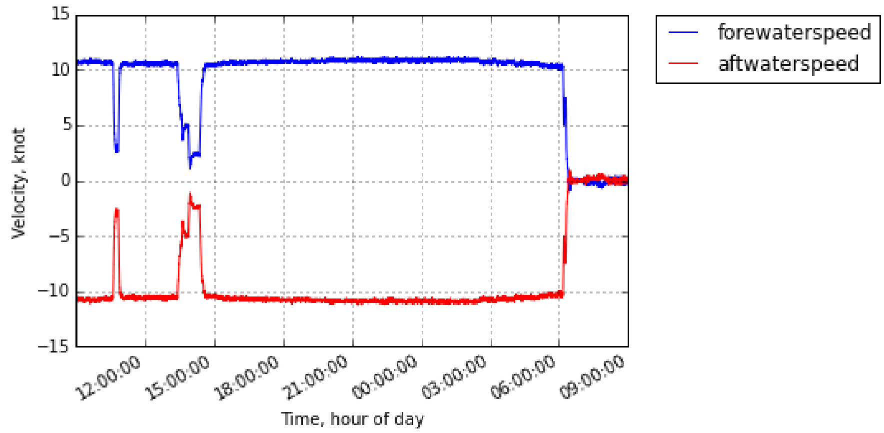


Fig 3. Example Skipper Log fore and aft velocities from version two

A bug occurred in this version of the module and the sign of the values of port and starboard lateral motion has been inverted.

- **starboardbottomspeed (not logged) [knot]** is the speed of the vessel over the sea bed in a starboard direction. If the vessel is moving to starboard then the sign of the value will be negative in the NetCDF and the magnitude will be the velocity in the starboard direction. If the log does not have a good fix on the sea bed then this value will be inaccurate.
- **starboardwaterspeed (speedps) [knot]** is the speed of the vessel through the water in a starboard direction. If the vessel is moving to starboard then the sign of the value will be negative in the NetCDF and positive in the Level-C and the magnitude will be the velocity in the starboard direction.
- **aftbottomspeed (not logged) [knot]** is the speed of the vessel over the sea bed in an aft direction. If the vessel is moving backwards then the sign of the value will be positive and the magnitude will be the velocity in the aft direction. If the log does not have a good fix on the sea bed then this value will be inaccurate.
- **portwaterspeed (not logged) [knot]** is the speed of the vessel through the water in a port direction. If the vessel is moving to port then the sign of the value will be negative in the NetCDF and the magnitude will be the velocity in the port direction.

- **forebottomspeed (not logged) [knot]** is the speed of the vessel over the sea bed in a forwards direction. If the vessel is moving forwards then the sign of the value will be positive and the magnitude will be the velocity in the forwards direction. If the log does not have a good fix on the sea bed then this value will be inaccurate.
- **aftwaterspeed (not logged) [knot]** is the speed of the vessel through the water in an aft direction. If the vessel is moving backwards then the sign of the value will be positive and the magnitude will be the velocity in the aft direction.
- **forewaterspeed (speedfa) [knot]** is the speed of the vessel through the water in an forwards direction. If the vessel is moving forwards then the sign of the value will be positive and the magnitude will be the velocity in the forwards direction.
- **portbottomspeed (not logged) [knot]** is the speed of the vessel over the sea bed in a port direction. If the vessel is moving to port then the sign of the value will be negative in the NetCDF and the magnitude will be the velocity in the port direction. If the log does not have a good fix on the sea bed then this value will be inaccurate.
- **time (Time) []**

17.3.14.1 GPS/YYYYMMDD-hhmmss-cnav-CNAV.GPS (gps_cnav)

This data file contains data from the CNAV GPS unit, which outputs a position of the CNAV GPS antenna on the main mast.

- **measureTS (measureT) []** is the time stamp applied to the data by the GPS unit.
- **lat (lat) [degree]** is the latitude of the CNAV GPS antenna in the format described above.
- **long (lon) [degree]** is the longitude of the CNAV GPS antenna in the format described above.
- **alt (not logged) [metre]** is the height of the CNAV GPS antenna above the reference ellipsoid.
- **prec (not logged) []** is the horizontal position precision code. It is defined by the following table:
-

prec	HDOP
0	HDOP < 0.3
1	0.3≤HDOP<1.0
2	1.0≤HDOP<3.0
3	3.0≤HDOP<10.0
4	10.0≤HDOP<30.0
5	30.0≤HDOP<100
6	100≤HDOP<300
7	300≤HDOP<1000
8	1000≤HDOP<3000
9	3000≤HDOP

- **mode (prec) []** is the mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix.

- **not logged (pdop) []** this is a null value that is only logged in the RVS data file.
- **gndcourse (cmg) [degree true]** is the course made good, or course over the ground.
- **gndspeed (smg) [knot]** is the speed over the ground, or speed made good.
- **time (Time) []**

17.3.14.2 GYR/YYYYMMDD-hhmmss-gyro-GYRO1_DY1.gyr (gyropmv)

- **heading (heading) [degree true]** is the true heading of the ship in degrees from the POSMV Motion Reference Unit (MRU).
- **time (Time) []**

17.3.14.3 GYR/YYYYMMDD-hhmmss-gyro-SGYRO_DY1.gyr (gyro_s)

- **heading (heading) [degree true]** is the true heading of the ship in degrees from the ship's gyro compass.
- **time (Time) []**

17.3.14.4 GPS/YYYYMMDD-hhmmss-position-Applanix_GPS_DY1.gps (posmvpos)

This data file contains data from the POSMV GPS unit, which outputs the position of the ship's common reference point.

- **measureTS (measureT) []** is the time stamp applied to the data by the GPS unit.
- **lat (lat) [degree]** is the latitude of the surveyed reference point (the cross on the top of the POSMV MRU).
- **long (lon) [degree]** is the longitude of the surveyed reference point.
- **alt (alt) [metre]** is the height of the surveyed reference point above the reference ellipsoid.
- **prec (prec) []** is the horizontal position precision code. It is defined by the following table:

prec	HDOP
0	HDOP < 0.3
1	$0.3 \le HDOP < 1.0$
2	$1.0 \le HDOP < 3.0$
3	$3.0 \le HDOP < 10.0$
4	$10.0 \le HDOP < 30.0$
5	$30.0 \le HDOP < 100$
6	$100 \le HDOP < 300$
7	$300 \le HDOP < 1000$
8	$1000 \le HDOP < 3000$
9	$3000 \le HDOP$

- **mode (mode) []** is the mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix.
- **gndcourse (cmg) [degree true]** is the course made good, or course over the ground.

- **gndspeed (smg) [knot]** is the speed over the ground, or speed made good.
- **time (Time) []**

GPS/YYYYMMDD-hhmmss-position-Seapath330_DY1.gps (spathpos)

This data file contains data from the Seapath 330 GPS unit. Prior to 26th September 2014 the NetCDF file for this data was called YYYYMMDD-hhmmss-position-Seapath200_DY1.gps and prior to 24th September 2014 the Level-C stream was called sb-pos.

- **measureTS (not logged) []** is the time stamp applied to the data by the GPS unit.
- **lat (lat) [degree]** is the latitude of the surveyed reference point (the cross on the top of the POSMV MRU).
- **long (lon) [degree]** is the longitude of the surveyed reference point.
- **alt (not logged) [metre]** is the height of the surveyed reference point above the reference ellipsoid.
- **prec (not logged) []** is the horizontal position precision code. It is defined by the following table:

prec	**HDOP**
0	HDOP < 0.3
1	0.3≤HDOP<1.0
2	1.0≤HDOP<3.0
3	3.0≤HDOP<10.0
4	10.0≤HDOP<30.0
5	30.0≤HDOP<100
6	100≤HDOP<300
7	300≤HDOP<1000
8	1000≤HDOP<3000
9	3000≤HDOP

- **mode (not logged) []** is the mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix.
- **gndcourse (not logged) [degree true]** is the course made good, or course over the ground.
- **gndspeed (not logged) [knot]** is the speed over the ground, or speed made good.
- **time (Time) []**

17.3.14.5 GPS/YYYYMMDD-hhmmss-position-usbl_DY1.gps (usblpos)

This data file contains the positions of beacons being tracked by the Ranger 2 USBL software. It is generated from the NMEA GGA stream output by the Sonardyne USBL position and uses a GPS data logging module to record the data and so there are additional fields logged that do not contain any meaningful data. The name of the beacon being tracked is not logged and so if multiple beacons are being tracked the data from all of the beacons will be logged with no way of telling which beacon the position logged refers to.

- **measureTS (measureT) []** is the time stamp applied to the data by the GPS unit.
- **lat (lat) [degree]** is the latitude of the object being tracked.
- **long (lon) [degree]** is the longitude of the object being tracked.
- **alt (alt) [metre]** is the depth below the water surface of the object being tracked.
- **prec (prec) []** contains no meaningful data.
- **mode (mode) []** contains no meaningful data and is always 2.
- **gndcourse (cmg) [degree true]** contains no meaningful data.
- **gndspeed (smg) [knot]** contains no meaningful data.
- **time (Time) []**

17.3.14.6 GPS/YYYYMMDD-hhmmss-satelliteinfo-Applanix_GPS_DY1.gps (not logged)

Additional information from the Applanix POSMV regarding the GPS position fix quality.

- **nbseen (not logged) []** is the number of satellites that can theoretically be seen from the current position.
- **nbused (not logged) []** is the number of satellites actually used to compute the position.
- **HDOP (not logged) []** is the GPS horizontal dilution of precision.
- **VDOP (not logged) []** is the GPS vertical dilution of precision.
- **PDOP (not logged) []** is the GPS positional dilution of precision.
- **time (not logged) []**

17.3.14.7 GPS/YYYYMMDD-hhmmss-satelliteinfo-Seapath330_DY1.gps (not logged)

Additional information from the Seapath 3300 regarding the GPS position fix quality, but not logged in RVS Level-C.

- **nbseen (not logged) []** is the number of satellites that can theoretically be seen from the current position.
- **nbused (not logged) []** is the number of satellites actually used to compute the position.
- **HDOP (not logged) []** is the GPS horizontal dilution of precision.
- **VDOP (not logged) []** is the GPS vertical dilution of precision.
- **PDOP (not logged) []** is the GPS positional dilution of precision.
- **time (not logged) []**

17.3.14.8 GPS/YYYYMMDD-hhmmss-satelliteinfo-CNAV.gps (not logged)

Additional information from the CNAV regarding the GPS position fix quality.

- **nbseen (not logged) []** is the number of satellites that can theoretically be seen from the current position.
- **nbused (not logged) []** is the number of satellites actually used to compute the position.
- **HDOP (not logged) []** is the GPS horizontal dilution of precision.
- **VDOP (not logged) []** is the GPS vertical dilution of precision.
- **PDOP (not logged) []** is the GPS positional dilution of precision.
- **time (not logged) []**

17.3.14.9 GPS/YYYYMMDD-hhmmss-satelliteinfo-usbl_DY1.gps (not logged)

Additional information from the Ranger 2 USBL software regarding the GPS position fix quality. Most of this data does not contain meaningful value and is generated because a GPS logging module is used to log the USBL NMEA GGA ouput.

- **nbseen (not logged) []** contains no meaningful data.
- **nbused (not logged) []** contains no meaningful data and is always 12.
- **HDOP (not logged) []** is the semi-major axis value for the fix of the beacon's position in metres.
- **VDOP (not logged) []** contains no meaningful data.
- **PDOP (not logged) []** contains no meaningful data.
- **time (not logged) []**

17.3.14.10 WAMOS/YYYYMMDD-hhmmss-wamos-WaMoS. wamos (not logged by Level-C)

This data file contains data from the OceanWaveS GmbH Wamos wave radar.

- **xhs (not logged) [metre]** is the significant wave height.
- **tm2 (not logged) [second]** is the mean wave period.
- **pdir (not logged) [degree true]** is the peak wave direction that the waves are coming from.
- **tp (not logged) [second]** is the peak wave period.
- **lp (not logged) [metre]** is the peak wavelength.
- **dp1 (not logged) [degree true]** is the direction that the swell system is coming from.
- **tp1 (not logged) [second]** is the swell period.
- **lp1 (not logged) [metre]** is the swell wavelength.
- **dp2 (not logged) [degree true]** is the direction that the second swell system is coming from.
- **tp2 (not logged) [second]** is the period of the second swell system.
- **lp2 (not logged) [metre]** is the wavelength of the second swell system.
- **currd (not logged) [degree true]** is the direction that the current is coming from.
- **currs (not logged) [metre per second]** is the velocity of the current.
- **datetime (not logged) [time]** is the date and time (in days since 00:00:00 on 1st January 1970) when the configuration was last changed .

- **hmax (not logged) [metre]** is the maximum wave height.
- **iq (not logged) []** is the internal quality index of the measurement.
- **time (Time) []**

17.3.14.11 DEPTH/YYYYMMDD-hhmmss-sb_depth-EM120_DY1.depth (em120cb)

This data file contains the depths logged by the centre beam of the EM122 multi-beam echosounder. The data has been corrected for sound velocity and the cruise report should be consulted for details of the corrections applied. The depths have not been corrected for tidal height.

- **snd (depth) [metre]** is the depth measured by the EM122 multi-beam sonar from the sea bed to the sea surface. No compensation is made for the current tidal height.
- **freq (not logged) [kilohertz]** is the sound frequency used to make the depth measurement. -1 indicates that the frequency was not included in the telegram from the echo sounder.
- **time (not logged) []**
- ATT/YYYYMMDD-hhmmss-shipattitude-Applanix_TSS_DY1.att (posmvtss)
- This data file contains data from the Applanix POSMV system's Motion Reference Unit (MRU). Prior to 26th October 2014 this file was called YYYYMMDD-hhmmss-shipattitude-Aplanix_TSS_JC1.att.
- **measureTS (not logged) []** is the time stamp applied to the data by the POSMV.
- **head (heading) [degree]** is the true bearing that the bow of the vessel is pointing at.
- **roll (roll) [degree]** is the roll angle of the vessel. A positive angle indicates that the port side of the vessel is above the starboard side.
- **pitch (pitch) [degree]** is the pitch of the ship. A bow up rotation gives a positive pitch value.
- **heave (heave) [metre]** is the vertical variation in height of the reference point on top of the POSMV MRU. Positive values indicate the reference point has risen above its stationary position. Please see the POSMV documentation for details of the filtering applied to the MRU data to calculate this value.
- **mode (not logged) []** is a quality indicator of the heading data. 0 indicates that the calculation of the heading was performed without any GPS aid, 1 indicates the heading calculation was aided by the GPS and 2 that it was aided by GPS and GAMS.
- **time (Time) []**

Prior to 26th September 2014 there was a bug in the Level-C configuration and the following data was recorded in the Level-C posmvtss stream:

Level-C Variable	Data Recorded
heading	heading
roll	roll
pitch	gite (angle of heel)
heave	pitch

17.3.14.12 ATT/YYYYMMDD-hhmmss-shipattitude_aux-Applanix_TSS_DY1.att (posmvtss)

This data file contains data from the Applanix POSMV system's Motion Reference Unit (MRU). Prior to 26th September 2014 this file was called YYYYMMDD-hhmmss-shipattitude_aux-Aplanix_TSS_DY1.att.

- **acX (not logged) []** is not valid data.
- **acY (not logged) []** is not valid data.
- **acZ (not logged) []** is not valid data.
- **hunc (acc_hdg) [degree]** is the heading uncertainty determined by the POSMV MRU.
- **runc (acc_roll) [degree]** is the roll uncertainty determined by the POSMV MRU.
- **punc (acc_ptch) [degree]** is the pitch uncertainty determined by the POSMV MRU.
- **time (Time) []**

17.3.14.13 Not Logged by TechSAS (relmov)

This RVS Level-C post processed file contains details of the motion of the vessel and is used by other Level-C post-processing streams. This file is generated from a gyro and log. The cruise documentation should be consulted to find which log and gyro source were used.

- **not logged (vn) [knot]** is the north component of the vessel's velocity.
- **not logged (ve) [knot]** is the east component of the vessel's velocity.
- **not logged (pfa) [knot]** is the vessel's speed in the fore direction.
- **not logged (pps) [knot]** is the vessel's speed in the port direction.
- **not logged (pgyro) [degree true]** is the vessel's average heading.
- **time (Time) []**

17.3.14.14 Not logged by TechSAS (bestnav)

This RVS Level-C post processed file was written when satellite positioning was in its infancy and there could be long periods of time between fixes. The program bestnav reads position fixes from up to three RVS data files along with the ship's motion as calculated by relmov and generates a series of positions at time intervals of the navigation window. The cruise report should be consulted to find the source of the three position fixes used.

The basis for the program's calculations is a series of position fixes. The input fix files are given in order and a timeout given for each file. Fixes will be taken from the first file until a data gap longer than that file's timeout is encountered. Fixes will then be taken from the second file until either the first file resumes or the second file also times out. In the latter case the third file will be used.

The gaps in the series of fixes are next filled using dead-reckoning based on the ship's motion relative to the water. When the end of each gap is reached the position obtained by dead-reckoning is compared with the fix position and the difference between the positions attributed to drift, caused either by wind or water currents.

The drift in position is used to calculate an average drift velocity during the fix gap whose magnitude is compared with the known drift and maximum allowable drift entered on the menu. If the drift is greater than the limit then the fix is assumed to be in error and processing is halted. If this occurs the user should either correct (or delete) the fix or increase the allowed drift and re-run the program.

If an acceptable drift velocity is found this is added to the dead reckoned positions. This completes the calculation of the ship's track. For each navigation window a position is interpolated from the calculated track and a record written to the output fixes file. Each record also contains the calculated velocity represented as north and east components and as speed made good and course made good.

The average heading of the ship is calculated along with a cumulative distance since the start of the file. If the output file contains a variable stream this will be set to 1, 2 or 3 to indicate which of the fix files the current fix was taken from. The status of the calculated values will either be good, if there was a fix at the time of the output record, or interp otherwise.

- **not logged (lat) [degree]** is the vessel’s calculated latitude.
- **not logged (lon) [degree]** is the vessel’s calculated longitude.
- **not logged (vn) [knot]** is the north component of the vessel’s velocity.
- **not logged (ve) [knot]** is the east component of the vessel’s velocity.
- **not logged (cmg) [degree]** is the vessel’s course made good.
- **not logged (smg) [knot]** is the vessel’s speed made good.
- **not logged (dist_run) [nautical miles]** is the distance that the vessel has run since the start of this bestnav file. Bestnav can also output this value in km. The BODC documentation produced for each cruise should be consulted for the units for cruises after December 2012.
- **not logged (heading) [degree]** is the vessel’s heading.
- **time (Time) []**

17.3.14.15 Not logged by TechSAS (bestdrf)

The drift velocities calculated by the bestnav program are also written to the bestdrf file. This contains either one record per navigation window (if there is more than one fix in the window) or one record per fix. The file contains the north and east calculated drift velocities as well as the known and limit drift speeds entered on the menu.

- **not logged (vn) [knot]** is the north component of the vessel’s drift.
- **not logged (ve) [knot]** is the east component of the vessel’s drift.
- **not logged (kvn) [knot]** is the known north velocity entered in the relmov menu.
- **not logged (kve) [knot]** is the known east velocity entered in the relmov menu.
- **time (Time) []**

17.3.14.16 Not logged by TechSAS (prodep)

The prodep post-processing file takes echo sounder depths that have been logged with a fixed sound velocity of 1500 ms-1 and corrects them for typical sound velocities for that geographical area using Carter's tables by the Hydrographic Office.

- **not logged (uncdepth) [metre]** is the uncorrected depth.
- **not logged (cordepth) [metre]** is the corrected depth.
- **not logged (cartarea) []** is the number of the Carter area used for the correction.
- **time (Time) []**

17.3.14.17 Not logged by TechSAS (pro_wind)

The Level-C windcalc post-processing program takes the bestnav and SurfMet Level-C files and calculates the absolute wind speed and direction.

- **not logged (abswpsd) [knot]** is the absolute wind speed at the height of the anemometer.
- **not logged (abswdir) [degree true]** is the absolute wind direction.
- **time (Time) []**

18 Station list

DATE	JDAY	STN NO	TIME (GMT)	LAT (N)	LONG (W)	SCIENCE EVENT	COMMENTS
24/06/2015	175	001	00:32	49 01.67	16 24.90	CTD (MIO)	Marseilles team CTD deployment
24/06/2015	175	002	02:07	49 02.47	16 25.22	MSC dep.	Marine Snow Catcher (MSC) deployment between 02:10-04:10, 28m depth
24/06/2015	175	003	02:30	49 02.47	16 25.22	MSC dep.	MSC deployment between 02:35-04:35, 128m depth
24/06/2015	175	004	03:29	49 02.47	16 25.22	MSC dep.	MSC FAILED deployment
24/06/2015	175	005	04:35	49 02.47	16 25.22	MSC dep.	MSC deployment between 04:35-06:35 (28m?)
24/06/2015	175	006	05:00	49 02.47	16 25.22	MSC dep.	MSC deployment
24/06/2015	175	007	05:35	49 02.47	16 25.22	MSC dep.	MSC deployment
24/06/2015	175	008	06:40	49 02.47	16 25.22	RCF dep.	Red Camera Frame deployed
24/06/2015	175	009	10:00	49 00.3	16 20.3	PAP1 rec.	PAP1 ODAS buoy and frame recovery 10:00-11:12 frame on deck
24/06/2015	175	010	13:26	49 01.77	16 24.56	Zoop net	Zooplankton net 13:26-13:55
24/06/2015	175	011	14:00	49 01.77	16 24.56	Zoop net	Zooplankton net 14:00-14:17
24/06/2015	175	012	14:23	49 01.57	16 24.56	Zoop net	Zooplankton net 14:23-14:39
24/06/2015	175	013	15:10	49 02.50	16 24.61	MSC dep.	MSC (28m) 15:10-15:14
24/06/2015	175	014	15:55	49 02.50	16 24.61	CTD (MIO)	CTD (MIO) to 4700 m water, depth 4809m on dep.
24/06/2015	175	015	20:55	49 01.90	16 24.61	RCF dep.	Red Camera Frame deployed 20:55-21:28
25/06/2015	176	016	01:27	48 50.16	16 31.53	Megacorer	Megacorer on seabed
25/06/2015	176	017	06:03	48 50.5	16 31.2	Megacorer	Megacorer on seabed
25/06/2015	176	018	09:40	48 50.47	16 31.32	CTD (MIO)	CTD (MIO) to 1000m
25/06/2015	176	019	15:40	48 50.39	16 31.31	RCF dep.	Red Camera Frame deployed 15:40-16:22
25/06/2015	176	020	16:52	48 50.39	16 31.31	CTD (NOC)	CTD (NOC) deployment -shallow calibration dip ahead of PAP1 deployment
25/06/2015	176	021	19:16	48 50.2	16 31.3	CTD (NOC)	CTD (NOC) deployment - deep dip to 4815m max depth in WD=4864m
26/06/2015	177	022	02:55	48 50.20	16 31.26	Megacorer	
26/06/2015	177	023	07:20	48 50.45	16 31.43	Megacorer	

26/06/2015	177	024	10:00	48 50.40	16 31.55	CTD (MIO)	
26/06/2015	177	025	11:47	48 50.28	16 31.91	MSC dep.	Nominally to 150m, fired early? Rust in sample.
26/06/2015	177	026	12:10	48 50.21	16 32.14	MSC dep.	Redeployed at stn 028
26/06/2015	177	027	12:40	48 50.13	16 32.37	MSC dep.	
26/06/2015	177	028	12:55	48 50.09	16 32.46	MSc dep.	MSC failed- fired early?
26/06/2015	177	029	13:10	48 50.06	16 32.58	Jellycam	
26/06/2015	177	030	14:27	48 50.06	16 32.58	MSC dep.	MSC deployment
26/06/2015	177	031	14:45	48 50.06	16 32.58	MSC dep.	MSC deployment
26/06/2015	177	032	15:20	48 50.06	16 32.58	MSC dep.	MSC deployment
26/06/2015	177	033	17:20	48 50.02	16 31.8	MSC dep.	MSC deployment
26/06/2015	177	034	18:31	48 52.2	16 31.0	Megacorer dep.	MC on bottom 20:47 - failed (only one core)
26/06/2015	177	035	23:10	48 51.82	16 31.85	Zoop net	
26/06/2015	177	036	23:38	48 51.596	16 31.06	Zoop net	
27/06/2015	178	037	00:05	48 51.41	16 32.14	Zoop net	
27/06/2015	178	038	00:33	48 51.184	16 32.318	Zoop net	
27/06/2015	178	039	03:41	48 50.22	16 31.03	Megacorer	Megacorer on seabed- almost failed twice, one core out of 2 dips.
27/06/2015	178	040	09:53	48 49.98	16 31.18	SAPS	SAPS x 4 deployment at 70m, 150m, 500m, 1000m
27/06/2015	178	041	15:54	49 04.44	16 15.68	CTD (MIO)	CTD to 1000m
27/06/2015	178	042	19:00	49 04.6	16 15.5	CTD (MIO)	
27/06/2015	178	043	21:07	49 04.43	16 15.77	RCF	Red Camera Frame
27/06/2015	178	044	22:00	49 04.42	16 15.83	CTD (MIO)	
28/06/2015	179	045	02:36	49 04.42	16 15.83	BC	Box Corer- successful
28/06/2015	179	046	06:00	49 01.5	16 21.8	PAP3 dep.	PAP3 sediment trap mooring deployment 06:00-8:30
28/06/2015	179	047	09:30	49 00.77	16 23.73	CTD (MIO)	CTD to 1000m
28/06/2015	179	048	11:15	49 01.42	16 25.04	JellyCam	
28/06/2015	179	049	11:50	49 01.25	16 25.04	MSC dep.	MSC deployment
28/06/2015	179	050	13:10	49 00.78	16 26.11	Bathysnap rec.	Bathysnap back on deck

28/06/2015	179	051	14:15	48 59.56	16 25.98	MSC dep.	MSC deployment
28/06/2015	179	052	16:45	48 59.1	16 25.2	PAP3 rec.	PAP3 sediment trap mooring recovery 15:00 to 16:45
28/06/2015	179	053	17:30	48 59.0	16 25.1	MSC dep.	MSC 500m
28/06/2015	179	054	18:20	48 59.0	16 25.1	MSC dep.	MSC 500m
28/06/2015	179	055	21:35	48 55.5	16 27.5	Megacorer	Megacorer on seabed- successful 8/10 tubes filled.
29/06/2015	180	056	00:05	48 55.32	16 28.24	Zoop net	to 200m
29/06/2015	180	057	00:38	48 54.97	16 28.99	Zoop net	to 200m
29/06/2015	180	058	01:06	48 54.87	16 28.85	Zoop net	to 200m
29/06/2015	180	059	01:31	48 54.74	16 29.15	Zoop net	to 200m
29/06/2015	180	060	02:56	48 54.38	16 29.39	CTD (MIO)	
29/06/2015	180	061	07:05	48 50.2	16 31.0	Megacorer	Megacorer on seabed
29/06/2015	180	062	09:49	48 49.98	16 31.18	SAPS dep.	SAPS x 4 deployment at 10m, 70m, 150m, 500m?
29/06/2015	180	063	12:58	48 49.82	16 31.18	Zoop net	To 200m
29/06/2015	180	064	13:35	48 49.52	16 31.20	Zoop net	To 200m
29/06/2015	180	065	13:49	48 49.52	16 31.20	Zoop net	To 200m
29/06/2015	180	066	15:20	48 49.15	16 31.24	CTD (MIO)	To 500m
29/06/2015	180	067	16:40	48 49.3	16 31.3	MSC dep.	MSC 70m
29/06/2015	180	068	17:05	48 49.6	16 31.3	MSC dep.	MSC 70m
29/06/2015	180	069	17:30	48 49.7	16 31.2	MSC dep.	MSC 500m
29/06/2015	180	070	19:31	48 50.0	16 31.2	SAPS	SAPS x 4 deployment at
29/06/2015	180	071	23:55	48 49.98	16 31.18	Megacorer	Megacorer on seabed 4879m WD
30/06/2015	181	072	11:05	49 04.4	16 15.83	CTD(MIO)	CTD to 4000m
30/06/2015	181	073	14:16	49 03.70	16 16.17	MSC dep.	MSC
30/06/2015	181	074	14:55	49 03.54	16 16.04	MSC dep.	MSC
30/06/2015	181	075	15:52	49 03.30	16 15.84	MSC dep.	MSC
30/06/2015	181	076	16:40	49 03.6	16 15.8	NOC CTD	CTD-shallow (100m) calibration dip
30/06/2015	181	077	18:44	49 03.8	16 15.8	MSC dep.	MSC
30/06/2015	181	078	20:36	49 04.62	16 15.83	CTD (MIO)	CTD to 4000m
30/06/2015	181	079	23:52	49 04.32	16 15.97	Zoop net	
01/07/2015	182	080	00:29	49 04.17	16 15.99	Zoop net	

01/07/2015	182	081	00:43	49 03.97	16 16.06	Zoop net	
01/07/2015	182	082	01:23	49 03.78	16 16.13	Zoop net	
01/07/2015	182	083	04:10	49 04.42	16 15.85	Megacorer	MgC 10/10! V.g. Time on seabed: 04:10
01/07/2015	182	084	11:47	49 00.6	16 20.2	PAP1 dep.	PAP1 mooring deployment 10:00-12:00
01/07/2015	182	085	14:10	48 59.14	16 17.10	CTD (MIO)	CTD to 1000m
01/07/2015	182	086	16:10	48 59.08	16 17.72	RCF dep.	Red Camera Frame deployment
01/07/2015	182	087	18:36	49 00.9	16 09.4	Trawl	OTSB14 Trawl outboard - transit not point! Details in Bridge log sheet
02/07/2015	183	088	10:00	48 40.9	17 03.5	MSC dep.	Marine Snowcatcher to 200m
02/07/2015	183	089	10:25	48 40.9	17 03.5	MSC dep.	Marine Snowcatcher to 128m
02/07/2015	183	090	10:40	48 40.9	17 03.5	MSC dep.	Marine Snowcatcher to 128m
02/07/2015	183	091	11:30	48 40.9	17 03.5	SAPS dep.	SAPS at 500m, 150m, 70m, 10m
02/07/2015	183	092	15:00	48 40.93	17 03.54	CTD (MIO)	CTD to 1000m
02/07/2015	183	093	16:46	48 40.9	17 03.5	RCF dep.	Red Camera Frame deployment
02/07/2015	183	094	20:27	48 40.9	17 03.5	CTD (MIO)	CTD to 1000m
02/07/2015	183	095	22:13	48 41.07	17 03.96	RCF dep.	Red Camera Frame deployment
03/07/2015	184	096	07:27	48 58.7	16 30.8	CTD (MIO)	CTD to 1000m
03/07/2015	184	097	09:55	49 01.53	16 25.36	RCF dep.	Red Camera Frame deployment
03/07/2015	184	098	11:35	49 01.51	16 25.36	MSC dep.	Marine Snowcatcher to 1000m
03/07/2015	184	099	12:38	49 01.27	16 25.45	MSC dep.	Marine Snowcatcher to 70m
03/07/2015	184	100	12:55	49 01.19	16 25.46	JellyCam	JellyCam deployment
03/07/2015	184	101	13:27	49 01.10	16 25.46	MSC dep.	Marine Snowcatcher to 10m
03/07/2015	184	102	14:30	49 01.05	16 25.44	Bathysnap test	Wet weigh Bathysnap + AWI profiler
03/07/2015	184	103	15:35	49 01.51	16 25.44	Bathysnap dep.	Bathysnap + AWI profiler deployment
03/07/2015	184	104	16:11	49 01.6	16 25.7	MSC dep.	Marine Snowcatcher to
03/07/2015	184	105	16:40	49 01.6	16 25.7	NOC CTD	NOC CTD to 4000m
03/07/2015	184	106	21:01	49 00.59	16 26.22	RCF dep.	Red Camera Frame deployment
03/07/2015	184	107	22:08	49 00.5	16 26.23	RCF dep.	Red Camera Frame deployment
03/07/2015	184	108	23:54	49 00.5	16 26.23	RCF dep.	Red Camera Frame deployment
04/07/2015	185	109	08:34	49 00.3	16 26.2	SAPS dep.	SAPS at 1000, 500, 130,70m

04/07/2015	185	110	13:00	48 56.15	16 10.37	MSC dep.	Marine Snowcatcher to 30m
04/07/2015	185	111	13:16	48 56.15	16 10.37	MSC dep.	Marine Snowcatcher to 60m
04/07/2015	185	112	13:29	48 56.15	16 10.37	MSC dep.	Marine Snowcatcher to 100m
04/07/2015	185	113	13:53	48 56.15	16 10.37	RCF dep.	Red Camera Frame deployment
04/07/2015	185	114	14:30	48 56.15	16 10.37	RCF dep.	Red Camera Frame deployment
04/07/2015	185	115	15:18	48 56.15	16 10.37	SAPS dep.	
04/07/2015	185	116	19:47	49 02.5	16 13.2	Trawl	Trawl deployment stopped at 21:04 due to weather/swell/cable on seabed