National
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NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre

Cruise Report No. 45

RRS *Discovery* Cruise DY050

18 APR - 08 MAY 2016

Cruise to the Porcupine Abyssal Plain
sustained observatory

Principal Scientist
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2017

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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.

More information on PAP can be found in NOC's website at: http://projects.noc.ac.uk/pap/ where the most current data can be found: http://projects.noc.ac.uk/pap/pap-april-2017
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/

This 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.

KEYWORDS

ISSUING ORGANISATION

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Contents

1 Cruise Personnel

1.1 Scientific Personnel

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1.2 Ships Personnel

	Surname	First Name	Rank
1	Gatti	Antonio	Captain
2	Voaden	Evelyn	Chief Officer
3	Williams	Tom	2nd Mate
4	O'Brien	Matthew	3rd Mate
5	Cook	Stuart	Chief Petty Officer, Deck
6	Gregory	Nathan	Chief Petty Officer, Science
7	Moore	Mark	Petty Officer, Deck
8	Crabb	Gary	Seaman Grade 1A
9	Cantlie	Ian	Seaman Grade 1A
10	Edwards	Barry	Seaman Grade 1A
11	Macneil	Seamus	Seaman Grade 1A
12	Bills	James	Chief Engineer
13	Uttley	Chris	2nd Engineer
14	Franklin	Nicholas	3rd Engineer (Fwd)
15	Hamilton	Angus	3rd Engineer (Aft)
16	Lawes	Duncan	Engine Room Petty Officer
17	Brazier	Tom	Electro-Technical Officer
18	Lynch	Peter C.	Cadet
19	Watterson	Ian	Purser
20	Lynch	Peter A.	Head Chef
21	Waterhouse	Jacqui	Chef
22	Dooherty	Tom	Steward
23	Mason	Kevin	Assistant Steward

2 Narrative

18.04.2016 – We departed Southampton at 09:00hrs and headed towards Sandown Bay on the east coast of the Isle of Wight for DP trials. These took approximately 16 hours but finally, at 04:00hrs, after dropping the engineer off, we turned west and sailed towards the PAP site.

19.04.2016 – We continued to sail west, towards the PAP1 mooring site. There was a science briefing in the morning, where the different cruise operations were discussed, and further discussion were held afterwards by the benthic team, and those interested in sampling the CTD. The first station was planned for the following morning, nominally a test CTD, but it would also be used to calibrate the PAP1 sensors.

20.04.2016 – At 08:00 we stopped for our first station, a CTD test to check the firing of the Niskin bottles and the sensors on the frame. It was also decided to use this dip as a calibration cast for the PAP1 mooring instruments. As we had lost so much on day 1, this would at least save us a bit of time in the future. During the cast there was an issue with some of the temperature sensors but this was traced back to incorrect cabling. All the Niskins fired correctly and on inspection of the PAP1 mooring instruments there was enough data to use to calibrate. After the cast we continued to steam towards PAP1.

21.04.2016 – A problem with the ODAS buoy battery was confirmed during the morning. Despite all the best efforts of Rob Craft and Miguel Charcos-Llorens, there didn't appear to be an easy way to fix the issue. Communications back to base were unable to shed light on the issue and the decision was made to feed power from the NAV light on the buoy. This was deemed a risky solution but the only one that could easily be completed on board the ship. Communications with the NOC continued to make sure the new system was tested thoroughly.

We also arrived at the PAP site. The first station was a CTD and the wire jumped off the sheath. This resulted in us switching to steaming to the coring stations and we began with a couple of megacores. The first of these was completed successfully, the second was not so successful.

22.04.2016 – After completing the coring work we steamed back to attempt to collect PAP1. Unfortunately the swell was too much for us to collect PAP1 so instead we headed to the bathysnap location. This was released and then ascended at a rate of 30m/min. It was spotted quickly at the surface and was then collected with ease. Steaming off, we readied ourselves for a CTD, marine

snow catchers SAPs, and a PELAGRA deployment before heading off to the next coring location. The first core was highly successful.

23.04.2016 – The second core of the night was not so successful, but it still returned 6 out of 10 cores intact. Overnight it had become apparent that one PELAGRA had surfaced early so after the coring was finished we headed to the last know location. After a brief search Henry spotted the PELAGRA and we moved in to collect it at about 10:00hrs. However it sank again before we were able to collect it. It resurfaced 5 minutes later and we tried again. This time it sank and after nearly 2 hours it hadn't resurfaced so we moved off to the safe sampling site. On arrival the winch broke down and so did the crane so there was period where we were unable to do any over the side work. The winch was quickly fixed and we started a deep SAPs deployment. The crane was fixed later in the afternoon but it still gave us time to complete a red camera frame dip and three marine snow catcher deployments. After this we moved off to the next coring location. The first core was unsuccessful so it was repeated. This time it was successful, and included a nice amphipod.

24.04.2016 – This morning there was enthusiasm and excitement as we had planned to deploy the new PAP3 and then recover the old PAP3 in one day. Initially though, during the final preparations, there was just enough time for a CTD to 500m and 4 marine snow catcher deployments. After that PAP3 was successfully deployed. An hour or so later, the old PAP 3 was released. It took a little bit of steaming to find it as the old position was slightly incorrect, but it was found and recovered. Then we steamed off to recover the two PELAGRAs which had both come to the surface again. They were spotted and collected with relative ease which allowed us to head off to the coring sight earlier than expected.

25.04.2016 – After one megacore we steamed to PAP1. The sea state was extremely calm which made this a perfect day to recover the ODAS buoy. It was hooked on and recovered by midday, the mooring team working very effectively and efficiently to bring the buoy on board quickly, but safely. It had a lot of biofouling on it, as expected. Samples of barnacles were collected by Brian and Sue and Miguel started looking at the sensors on the frame. Then there was a quick turnaround so that we could deploy the amphipod trap and move the new PAP1 ODAS buoy into position on the aft deck, ready for deployment at a later date. When this was completed we set to doing a SAPs deployment to 1,000m as well as the red camera frame and marine snow catchers. Finally, once everything was out of the water we deployed three PELAGRAs and then steamed off for the next set of megacores.

26.04.2016 – Both megacores were a success, with only a few core tubes not firing. After steaming back to the sampling site, we set about deploying the SAPs again, this time to a shallow depth. Next we attempted a deep deployment of the CTD, down to 3,000m. However at approximately 250m

there was a cable error and we lost communication with the CTD. It had to be hauled back up and a re-termination was done. During this time we deployed the marine snow catchers and the red camera frame. This time the red camera frame was on P-frame, not off the aft starboard quarter, which allowed us to do a very high resolution deployment. The frame was slowly lowered, stopping for ever increasing time intervals every 10m or so. Towards the end of this period we released the amphipod trap which unfortunately has a slower than expected ascent rate. It was finally on the surface at 20:30 and was collected and recovered by 21:30, just in time to deploy another PELAGRA. Once that was over the side we steamed back to the coring site.

27.04.2016 – We arrived at the coring site later than expected, but there was still time to get two cores completed before steaming back to the sampling site. The cores were deployed with 10 large tubes this time, instead of 8 large and 2 small, which had been the case on all the previous deployments. They both came up with 5 or 6 tubes out of 10 complete. Once finished we steamed back to the sampling site and proceeded with a deep SAPs deployment to 2,250m. At the same time we completed a couple of marine snow catcher deployments, the red camera frame for a normal deployment and for the first time this cruise, a plankton net was also deployed. After a 1,500m CTD we steamed off to recover the PELAGRAs that we deployed 2 days ago. We recovered two of them with ease, however the third one refused to communicate. We waited at the location of the second PELAGRA in the hope that the third one would have surfaced nearby. We stayed until it was totally dark but could not locate it so we started steaming back to the core site. On route we had a fantastic piece of luck. The errant PELAGRA was spotted directly in front of us. Its light shining in the dark. So we stopped and collected this one and headed off again, a little late but at least we had all three PELAGRA.

28.04.2016 – Once at the core site we completed a net and then deployed the megacore before heading back to PAP1. Today was deployment day. The deployment was completed with relative ease, the syntactic float being retrieved, the sensor cage connected to the mooring line and then that and the ODAS buoy being released. It was confirmed that the data was being sent back to base and everyone was pleased that the main objective of the cruise was complete. There wasn't a lot of time to rest though. We steamed back to the sampling site and did a couple of nets as well as a deep (3,000m) CTD to test a nitrate sensor which had never been that deep before. There was just enough time for a couple of marine snow catchers before we needed to start steaming to the start of the trawl run. This was 18nm away from a central point, roughly south by south-east. The trawl was then towed behind the ship, slowly being lowered until it hit the seafloor.

29.04.2016 – The trawl was slowly brought back to the surface again. The whole process takes from 12 to 16 hours. Near the end of the trawl on the bottom there was a large spike in the tension on the

wire, the trawl hit something. On recovery it was obvious that the trawl had become tangled and the trawl doors were wrapped around each other. The trawl recovery was a slow process because of this but finally, after an hour or so it was brought on deck. The net was full of mud but a number of animals had been brought to the top. These were easily collected but then it was a long slow process sieving the huge volume of abyssal mud. After the trawl was on deck we headed back to the sampling site where we completed a full depth CTD to push the nitrate sensor even deeper. Marine snow catchers and a red camera frame deployment were also completed before the ship turned north east to go and recover the PELAGRA we deployed two days ago. It was about this time that we received some bad news. The ODAS buoy had stopped communicating. We would monitor this over the next 12 hours or so. PELAGRA was found quickly and on route to the sampling site we stopped for a couple of nets.

30.04.2016 – The nets were followed by 5 red camera frame deployments in a row. Then we steamed off to get back to the sampling site by 08:00hrs, ready to deploy 4 of the 5 PELAGRA. The fifth was due to be deployed by it stopped communicating just as it was going to be deployed. During the course of the day we completed a shallow SAPs deployment as well as 3 marine snow catchers, 2 red camera frames, 2 nets and a shallow CTD to calibrate the old PAP1 mooring sensors. During the course of the day we got further information from the ODAS buoy. It turned out it was not just a communication error. It looked like the batteries failed shortly after deployment. There was communication with base to try to confirm our suspicions. Discussions continued on what the best course of action was but due to the weather closing in we would be unable to recover the buoy within the next few days. For the time being science would continue as normal. So this meant steaming off to the start of the next trawl run. This was started at approximately 18:00. However this did not go to plan either. After 2,000m of cable had been paid out, several alarms came on and cut the power to the winches. The alarms were from systems not even being used so there was a problem with the communication system of the winches somewhere. This continued for the next hour or so until a decision was made to stop the trawl. It took a few hours to get all the cable back in. So instead we headed off to do our last megacore using the general purpose wire.

01.05.2016 – Before reaching the megacore site we stopped to complete a couple more plankton nets and then continued to the final planned core site. Unfortunately the winch alarms started again after about 1,500m and so the decision was made to cancel this core as well. It took a long time to recover the cable. We steamed back to the sampling site whilst the ships engineers looked at what they thought was causing the problems. Once this was complete a test of the system was done using some lump weights. In the mean time we continued to deploy marine snow catchers and the red camera frame from the aft deck on the Romica winch. Once the winch issues were resolved we deployed the SAPs followed by a CTD.

02.05.2016 – During the course of the night we had to stop all operations due to the weather, the wind and swell had picked up and the ship couldn't hold position on DP. This meant we were unable to complete a megacore. Operations started again at around midday when we deployed the amphipod trap for the second time this cruise. We were also able to have a deep SAPs deployment and a deep CTD deployment with prolonged stops. As the wind was still quite strong we could no longer do two deployments at the same time so the marine snow catcher and red camera frame deployments had to fit in and around the SAPs and CTD. Finally a couple of nets were completed at around midnight before steaming off to the final megacore location.

03.05.2016 – RP12 was finally completed after 2 failed attempts and then we steamed back to the safe sampling site. We were still only able to do one deployment at a time so over the course of the morning we completed another deep SAPs. At midday we released the amphipod trap and did a few marine snow catcher deployments while we waited the expected 2 and a half hours for the amphipod trap to ascend. At around 16:30 it was clear that the trap had reached the surface but we couldn't see it. We had to steam around and get ranges from it to try and track it down. After 4 hours we eventually did and brought it on board. Then we headed off to track down the PELAGRAs. Two of the four deployed had given us positions. The swell was still quite high and the wind was quite strong. The first recovery was completed successfully just before midnight.

04.05.2016 – The second PELAGRA was recovered two hours later. Spotting them in the haze and the swell had not been easy. We had given up on the other two when one of the suddenly signalled to say it was at the surface. We turned around again and steamed off to collect it. It was eventually brought on board at 05:00hrs, at this time the wind and swell had died down a lot and visibility was very good. The fourth PELAGRA (P8) still had not given us a position so we turned and steamed back to the safe sampling site. Once back on site we completed another SAPs, three marine snow catchers and a red camera frame deployment before steaming off to the start of the trawl run. The trawl deployment went unhindered.

05.05.2016 – Over night the trawl had continued and shortly after breakfast it was ready to be brought on deck. The catch was good, although some human artefacts had also affected the quality of some of it. There were two barrels, beer cans and more clinker. In amongst this though were numerous holothurians, pycnogonids, fish and cnidarians. After the trawl there was a meeting to discuss the issue with the ODAS buoy. The forecast was that the weather was improving and so we were gathered to discuss what we could do to track the buoy. It had previously been identified that we might be able to get the tracking beacon on the buoy working by attaching a battery to the buoy somewhere and running a cable up to it. Exactly how this would be done was unclear at the time.

Following in depth discussions it was decided that the operation was too risky. The most we would get out of it would be 100 days of positional data, but the risk of damaging the buoy and/or the sensor frame was too high as the weather conditions were not going to be good enough to complete the task with minimal risk. We instead turned our attentions to completing the last day of science before heading home. A final deep CTD was completed with prolonged stops again, 3 marine snow catchers, 1 red camera frame and a final megacore (Station number 124 for the cruise) were completed. The ship was then turned for home.

06.05.2016 – The process of packing up was started, cruise reports started to be written and the cruise summary report and post-cruise assessment were written.

07.05.2016 – We had the post-cruise wash up meeting. There were only a few items to discuss, the issues with the winches and cranes that we had had during the cruise as well as a few domestic issues but there were no real problems other than these.

08.05.2016 – DY050 arrived in Southampton.

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3 Cruise Events Log

Table 1: Full cruise events log for DY050

Event No.	Date	Jday	Station	Latitude (N)	Longitude (W)	Uncorr. Sea Floor Depth (m)	Time IN (UTC)	Time Bottom (UTC)	Time OUT (UTC)	Activity	Comments
1	20.04.2016	111	DY050-001	49° 36.102	8° 21.633	139	08:25	08:36	09:35	CTD001	CTD test, calibration of PAP1 sensors
2	21.04.2016	112	DY050-002	48° 50.055	16° 31.312	4807	19:30	21:26	23:16	MgC08+2	Site RP01
3	22.04.2016	113	DY050-003	48° 50.387	16° 31.174	4810	00:17	02:14	04:10	MgC08+2	Site RP02
4	22.04.2016	113	N/A	49° 01.641	16° 24.150	4810	N/A	N/A	13:11	Bathysnap (2015)	Recovery of Bathysnap (Station DY032-103)
5	22.04.2016	113	DY050-004	49° 00.375	16° 23.848	4813	14:03	14:43	18:40	CTD002	Full depth, testing of releases, dodgy fluorescence
6	22.04.2016	113	DY050-005	49° 00.375	16° 23.848	4813	14:37		14:50	MSC001	20m

7	22.04.2016	113	DY050-006	49° 00.375	16° 23.848	4813	15:05		15:10	MSC002	20m, leaking, O-ring caught
8	22.04.2016	113	DY050-007	49° 00.375	16° 23.848	4813	15:20		15:45	MSC003	120m
9	22.04.2016	113	DY050-008	49° 00.375	16° 23.848	4812	48:50	N/A	N/A	PELAGRA	P2 deployed (200m) *recovered on the 24.04.2016
10	22.04.2016	113	DY050-009	49° 00.457	16° 23.540	4812	19:07	N/A	N/A	PELAGRA	P7 deployed (200m) *recovered on the 24.04.2016
11	22.04.2016	113	DY050-010	49° 00.457	16° 23.540	4811	19:52		21:38	SAPs001	3 deployed, maximum depth 150m
12	23.04.2016	114	DY050-011	48° 50.255	16° 31.084	4808	23:55	01:43	04:00	MgC08+2	Site RP03
13	23.04.2016	114	DY050-012	48° 50.016	16° 31.086	4809	04:35	06:26	08:16	MgC08+2	Site RP04
14	23.04.2016	114	DY050-013	49° 00.318	16° 23.846	4811	14:13	13:35	18:51	SAPs002	4 deployed, maximum depth 2,000m. 1 flooded and 1 had battery issues.
15	23.04.2016	114	DY050-014	49° 00.338	16° 23.808	4812	17:46	18:15	18:57	RCF001	300m
16	23.04.2016	114	DY050-015	49° 00.338	16° 23.808	4812	19:08		19:20	MSC004	60m

17	23.04.2016	114	DY050-016	49° 00.338	16° 23.808	4812	19:25		19:45	MSC005	160m
18	23.04.2016	114	DY050-017	49° 00.338	16° 23.808	4812	19:49		20:00	MSC006	80m
19	23.04.2016	114	DY050-018	48° 50.277	16° 31.270	4809	21:57	23:44	01:30	MgC08+2	Site RP05
20	24.01.2016	115	DY050-019	48° 50.296	16° 31.262	4810	01:50	03:42	05:45	MgC08+2	Site RP05 (repeated)
21	24.01.2016	115	DY050-020	49° 00.488	16° 27.184	4810	08:15	08:30	10:28	CTD003	500m, 30 minute stops
22	24.01.2016	115	DY050-021	49° 00.488	16° 27.184	4810	08:58		09:08	MSC007	80m
23	24.04.2016	115	DY050-022	49° 00.488	16° 27.184	4810	09:16		09:35	MSC008	180m
24	24.04.2016	115	DY050-023	49° 00.488	16° 27.184	4810	09:39		09:48	MSC009	Failed to close
25	24.04.2016	115	DY050-024	49° 00.488	16° 27.184	4810	09:50		10:00	MSC010	80m
26	24.04.2016	115	DY050-025	49° 00.443	16° 29.539	4810	13:31	N/A	N/A	PAP3 (2016)	PAP3 mooring deployed
27	24.04.2016	115	N/A	49° 01.460	16° 22.210	4811	N/A	N/A	18:36	PAP3 (2015)	Recovery of PAP3 (Station DY032-046)
28	24.04.2016	115	N/A	49° 00.350	16° 13.470	4811	N/A	N/A	19:35	PELAGRA	P7, recovery of DY050-010
29	24.01.2016	115	N/A	49° 02.310	16° 05.450	4811	N/A	N/A	20:27	PELAGRA	P2, recovery of DY050-009

30	25.04.2016	116	DY050-026	48° 50.171	16° 31.526	4807	23:04	00:51	02:45	MgC08+2	RP06
31	25.04.2016	116	N/A	49° 02.431	16° 17.875	4837	N/A	N/A	10:59	PAP1 (2015)	Recovery of DY032-084
32	25.04.2016	116	DY050-027	49° 00.789	16° 23.850	4812	13:52	N/A	N/A	ATRAP	Recovered on 26.04.2016
33	25.04.2016	116	DY050-028	49° 00.417	16° 23.864	4812	14:48		18:14	SAPs003	Maximum depth 1,000m
34	25.04.2016	116	DY050-029	49° 00.417	16° 23.864	4812	15:37		16:55	RCF002	300m
35	25.04.2016	116	DY050-030	49° 00.417	16° 23.864	4812	17:09		17:17	MSC011	60m
36	25.04.2016	116	DY050-031	49° 00.417	16° 23.864	4812	17:26		17:40	MSC012	160m
37	25.04.2016	116	DY050-032	49° 00.417	16° 23.864	4812	17:51		18:00	MSC013	80m
38	25.04.2016	116	DY050-033	49° 00.417	16° 23.864	4812	19:09	N/A	N/A	PELAGRA	P2 deployed *recovered on 27.04.2016
39	25.04.2016	116	DY050-034	49° 00.417	16° 23.864	4812	19:38	N/A	N/A	PELAGRA	P6 deployed *recovered on 27.04.2016
40	25.04.2016	116	DY050-035	49° 00.697	16° 23.853	4811	20:10	N/A	N/A	PELAGRA	P8 deployed *recovered on 27.04.2016

41	25.04.2016	116	DY050-036	48° 50.270	16° 30.999	4807	21:56	23:43	01:35	MgC08+2	RP07
42	26.04.2016	117	DY050-037	48° 50.477	16° 31.344	4810	02:07	03:56	05:45	MgC08+2	RP08
43	26.04.2016	117	DY050-038	49° 00.325	16° 23.855	4811	08:28		10:58	SAPs004	Maximum depth 150m
44	26.04.2016	117	DY050-039	49° 00.324	16° 23.852	4811	11:43		12:18	CTD004	Cable error at ~250m, pulled back in, re-termination
45	26.04.2016	117	DY050-040	49° 00.344	16° 23.860	4811	13:20		13:30	MSC014	60m
46	26.04.2016	117	DY050-041	49° 00.344	16° 23.860	4811	13:37		13:52	MSC015	Leaking, so redeployed
47	26.04.2016	117	DY050-042	49° 00.344	16° 23.860	4811	13:37		17:23	RCF003	300m, stopping at intervals on descent.
48	26.04.2016	117	DY050-043	49° 00.344	16° 23.860	4811	14:00		14:20	MSC016	160m
49	26.04.2016	117	DY050-044	49° 00.344	16° 23.860	4811	14:24		14:35	MSC017	60m, tap open so lost ~5 litres
50	26.04.2016	117	N/A	49° 01.300	16° 21.700	4810	N/A	N/A	21:28	ATRAP	Recovery of station DY050-027
51	26.04.2016	117	DY050-045	49° 01.400	16° 21.200	4810	21:35	N/A	N/A	PELAGRA	P7 deployed 400m *recovered on 29.04.2016

52	27.04.2016	118	DY050-046	48° 50.075	16° 31.223	4807	23:36	01:22	03:15	MgC10	RP09
53	27.04.2016	118	DY050-047	48° 50.263	16° 31.622	4810	03:43	05:37	07:25	MgC10	RP10
54	27.04.2016	118	DY050-048	49° 00.327	16° 23.842	4811	09:29		13:20	SAPs005	Maximum depth 2,250m
55	27.04.2016	118	DY050-049	49° 00.327	16° 23.842	4811	09:56		10:03	MSC018	60m
56	27.04.2016	118	DY050-050	49° 00.327	16° 23.842	4811	10:14		10:27	MSC019	160m
57	27.04.2016	118	DY050-051	49° 00.327	16° 23.842	4811	10:30	11:15	12:01	RCF004	300m
58	27.04.2016	118	DY050-052	49° 00.327	16° 23.842	4811	12:09		12:51	WP2NET001	200m
59	27.04.2016	118	DY050-053	49° 00.327	16° 23.842	4811	12:53		13:30	WP2NET002	200m
60	27.04.2016	118	DY050-054	49° 00.327	16° 23.842	4811	14:05		16:49	CTD005	1500m
61	27.04.2016	118	N/A	49° 15.950	16° 10.890	4808	N/A	N/A	19:17	PELAGRA	P8, recovery of DY050-035
62	27.04.2016	118	N/A	49° 11.100	15° 59.300	4779	N/A	N/A	20:50	PELAGRA	P6, recovery of DY050-034
63	27.04.2016	118	N/A	49° 09.300	16° 04.000	4810	N/A	N/A	22:24	PELAGRA	P2, recovery of DY050-033

64	28.04.2016	119	DY050-055	48° 50.250	16° 31.200	4807	01:41		02:07	WP2NET003	200m
65	28.04.2016	119	DY050-056	48° 50.281	16° 31.139	4807	02:27	04:56	05:43	MgC10	RP11
66	28.04.2016	119	DY050-057	49° 02.830	16° 18.070	4709	10:26	N/A	N/A	PAP1	Deployment of PAP1 mooring
67	28.04.2016	119	DY050-058	49° 00.314	16° 23.817	4810	11:30		12:16	WP2NET004	200m
68	28.04.2016	119	DY050-059	49° 00.314	16° 23.817	4810	12:17		13:07	WP2NET005	200m
69	28.04.2016	119	DY050-060	49° 00.314	16° 23.817	4810	12:22	13:25	15:44	CTD006	3,000m
70	28.04.2016	119	DY050-061	49° 00.314	16° 23.817	4810	15:04		15:11	MSC020	60m
71	28.04.2016	119	DY050-062	49° 00.314	16° 23.817	4810	15:18		15:27	MSC021	60m
72	28.04.2016	119	DY050-063	48° 58.800	16° 05.600		18:51		11:01*	OTSB14	*recovered on 29.04.2016
73	29.04.2016	120	DY050-064	49° 00.321	16° 23.847	4846*	14:00	15:55	18:38	CTD007	4,827m *corrected water depth
74	29.04.2016	120	DY050-065	49° 00.321	16° 23.847	4846*	14:22		14:37	MSC022	90m *corrected water depth
75	29.04.2016	120	DY050-066	49° 00.321	16° 23.847	4846*	14:48		15:15	MSC023	160m *corrected water depth

76	29.04.2016	120	DY050-067	49° 00.321	16° 23.847	4844*	16:05		18:16	RCF005	300m *corrected water depth
77	29.04.2016	120	DY050-068	49° 00.321	16° 23.847	4844*	18:24		18:35	MSC024	60m *corrected water depth
78	29.04.2016	120	N/A	49° 16.108	15° 55.597	4798	N/A	N/A	21:56	PELAGRA	P7, recovery of DY050-045
79	29.04.2016	120	DY050-069	49° 10.600	16° 05.400	4804	23:17		23:54	WP2NET006	200m
80	30.04.2016	121	DY050-070	49° 10.600	16° 05.400	4804	00:00		00:35	WP2NET007	200m
81	30.04.2016	121	DY050-071	49° 10.600	16° 05.400	4804	01:01	01:28	01:55	RCF006	300m
82	30.04.2016	121	DY050-072	49° 10.600	16° 05.400	4804	02:13	02:38	03:05	RCF007	300m
83	30.04.2016	121	DY050-073	49° 10.600	16° 05.400	4804	03:17	03:40	04:06	RCF008	300m
84	30.04.2016	121	DY050-074	49° 10.600	16° 05.400	4804	04:18	04:42	05:04	RCF009	300m
85	30.04.2016	121	DY050-075	49° 10.600	16° 05.400	4804	05:14	05:39	06:03	RCF010	300m
86	30.04.2016	121	DY050-076	49° 00.567	16° 23.232	4810	08:13	N/A	N/A	PELAGRA	P2 deployed *recovered on 04.05.2016

87	30.04.2016	121	DY050-077	49° 00.567	16° 23.232	4810	08:16	N/A	N/A	PELAGRA	P4 deployed *recovered on 03.05.2016
88	30.04.2016	121	DY050-078	49° 00.567	16° 23.232	4810	08:19	N/A	N/A	PELAGRA	P6 deployed *recovered on 04.05.2016
89	30.04.2016	121	DY050-079	49° 00.567	16° 23.232	4810	08:27	N/A	N/A	PELAGRA	P8 deployed *not recovered
90	30.04.2016	121	DY050-080	49° 00.324	16° 23.805	4810	09:30		10:59	RCF011	300m, holo-cam only
91	30.04.2016	121	DY050-081	49° 00.324	16° 23.805	4810	09:58		12:23	SAPs006	
92	30.04.2016	121	DY050-082	49° 00.324	16° 23.805	4810	11:09		11:21	MSC025	90m
93	30.04.2016	121	DY050-083	49° 00.324	16° 23.805	4810	11:30		11:50	MSC026	160m
94	30.04.2016	121	DY050-084	49° 00.324	16° 23.805	4810	12:00		12:10	MSC027	60m
95	30.04.2016	121	DY050-085	49° 00.324	16° 23.805	4810	12:16		13:28	WP2NET008	200m
96	30.04.2016	121	DY050-086	49° 00.324	16° 23.805	4810	13:02	13:16	13:42	CTD008	200m
97	30.04.2016	121	DY050-087	49° 00.324	16° 23.805	4810	13:31		14:15	WP2NET009	200m

98	30.04.2016	121	DY050-088	49° 00.324	16° 23.805	4810	14:31		16:04	RCF012	300m
99	30.04.2016	121	DY050-089	49° 00.689	16° 04.154		18:16		23:27	OTSB14	ABORTED mid water, winch issues
100	01.05.2016	122	DY050-090	48° 53.260	16° 28.200		00:24		01:10	WP2NET010	200m
101	01.05.2016	122	DY050-091	48° 53.260	16° 28.200		01:14		02:01	WP2NET011	200m
102	01.05.2016	122	DY050-092	48° 50.192	16° 31.210	4807	03:42		09:20	MgC10	ABORTED mid water, winch issues
103	01.05.2016	122	DY050-093	49° 00.331	16° 23.812	4809	11:14		11:24	MSC028	50m
104	01.05.2016	122	DY050-094	49° 00.331	16° 23.812	4809	11:33		11:52	MSC029	150m
105	01.05.2016	122	DY050-095	49° 00.331	16° 23.812	4809	12:00		12:08	MSC030	40m
106	01.05.2016	122	DY050-096	49° 00.331	16° 23.812	4809	12:20		14:03	RCF013	300m
107	01.05.2016	122	DY050-097	49° 00.331	16° 23.812	4809	14:11		15:57	RCF014	300m
108	01.05.2016	122	DY050-098	49° 00.331	16° 23.812	4809	16:03		18:19	SAPs007	70m
109	01.05.2016	122	DY050-099	49° 00.331	16° 23.812	4809	19:13	19:20	20:04	CTD009	100m
110	02.05.2016	123	DY050-100	49° 00.205	16° 23.851	4810	11:59			ATRAP	

111	02.05.2016	123	DY050-101	49° 00.708	16° 23.848	4810	12:20		15:18	SAPs008	1,000m
112	02.05.2016	123	DY050-102	49° 00.708	16° 23.848	4810	15:26		15:33	MSC031	30m
113	02.05.2016	123	DY050-103	49° 00.708	16° 23.848	4810	15:43		17:23	RCF015	300m
114	02.05.2016	123	DY050-104	49° 00.708	16° 23.848	4810	17:47	19:39	23:20	CTD010	4,800m
115	02.05.2016	123	DY050-105	49° 00.708	16° 23.848	4810	23:54		00:36	WP2NET012	200m
116	03.05.2016	124	DY050-106	49° 00.708	16° 23.848	4810	00:39		01:20	WP2NET013	200m
117	03.05.2016	124	DY050-107	48° 50.210	16° 31.222	4806	03:10		04:59	MgC10	RP12
118	03.05.2016	124	DY050-108	49° 00.323	16° 23.812	4810	09:00		11:32	SAPs009	500m
119	03.05.2016	124	DY050-109	49° 00.323	16° 23.812	4810	10:48		11:03	MSC032	160m
120	03.05.2016	124	DY050-110	49° 00.323	16° 23.812	4810	11:13		11:20	MSC033	Failed
121	03.05.2016	124	DY050-111	49° 00.323	16° 23.812	4810	14:35		14:44	MSC034	60m
122	03.05.2016	124	DY050-112	49° 00.323	16° 23.812	4810	14:53		14:55	MSC035	30m
123	03.05.2016	124	N/A	49° 06.300	16° 19.900	4805	N/A		20.29	ATRAP	Recovery of DY050-100

124	03.05.2016	124	N/A	49° 26.521	15° 56.673		N/A	N/A	23.42	PELAGRA	P4, recovery of DY050-077
125	04.05.2016	125	N/A	49° 29.255	15° 53.370		N/A	N/A	01:53	PELAGRA	P2, recovery of DY050-076
126	04.05.2016	125	N/A	49° 38.390	15° 41.599		N/A	N/A	05:06	PELAGRA	P6, recovery of DY050-078
127	04.05.2016	125	DY050-113	49° 00.299	16° 23.597	4811	11:05		13:18	SAPs010	
128	04.05.2016	125	DY050-114	49° 00.299	16° 23.597	4811			13:40	MSC036	30m
129	04.05.2016	125	DY050-115	49° 00.299	16° 23.597	4811			14:00	MSC037	60m
130	04.05.2016	125	DY050-116	49° 00.299	16° 23.597	4811			14:30	MSC038	160m
131	04.05.2016	125	DY050-117	49° 00.299	16° 23.597	4811	14:37		16:23	RCF016	300m
132	04.05.2016	125	DY050-118	49° 48.275	16° 03.188	4697	18:34		08:50	OTSB14	
133	05.05.2016	126	DY050-119	49° 00.319	16° 23.821	4808	11:25	12:16	15:13	CTD011	2,500m
134	05.05.2016	126	DY050-120	49° 00.319	16° 23.821	4808	12:43		13:03	MSC039	150m
135	05.05.2016	126	DY050-121	49° 00.319	16° 23.821	4808	13:11		13:37	MSC040	300m
136	05.05.2016	126	DY050-122	49° 00.319	16° 23.821	4808	13:43		13:51	MSC041	50m

137	05.05.2016	126	DY050-123	49° 00.319	16° 23.821	4808	14:07		15:58	RCF017	300m
138	05.05.2016	126	DY050-124	48° 50.165	16° 31.362	4805	17:33			MgC10	RP13

4 Scientific Systems Cruise Report

By Zoltan Nemeth

4.1 Overview

PAP - Porcupine Abyssal Plain cruise.

The Porcupine Abyssal Plain (PAP) Observatory is a sustained, multidisciplinary observatory in the North Atlantic coordinated by the National Oceanography Centre, Southampton. For over 25 years the observatory has provided key time-series datasets for analysing the effect of climate change on the open ocean and deep-sea ecosystems. Historically the term ‘abyss’ characterizes the dark, apparently bottomless ocean under extreme static pressure far beyond coastal and shelf areas. Today this ancient definition remains still rather unfocused in earth sciences. Geographers, marine biologists, and geologists use abyss for deep-sea regions with water depths exceeding 1000 or 4000 m. In physical oceanography a widely accepted definition of the abyss denotes the water column that ranges from the base of the main thermocline down to the seabed.

4.1.1 Itinerary & Maps

Figure 1: Map of North Atlantic showing the position of the PAP site in relation to the UK.

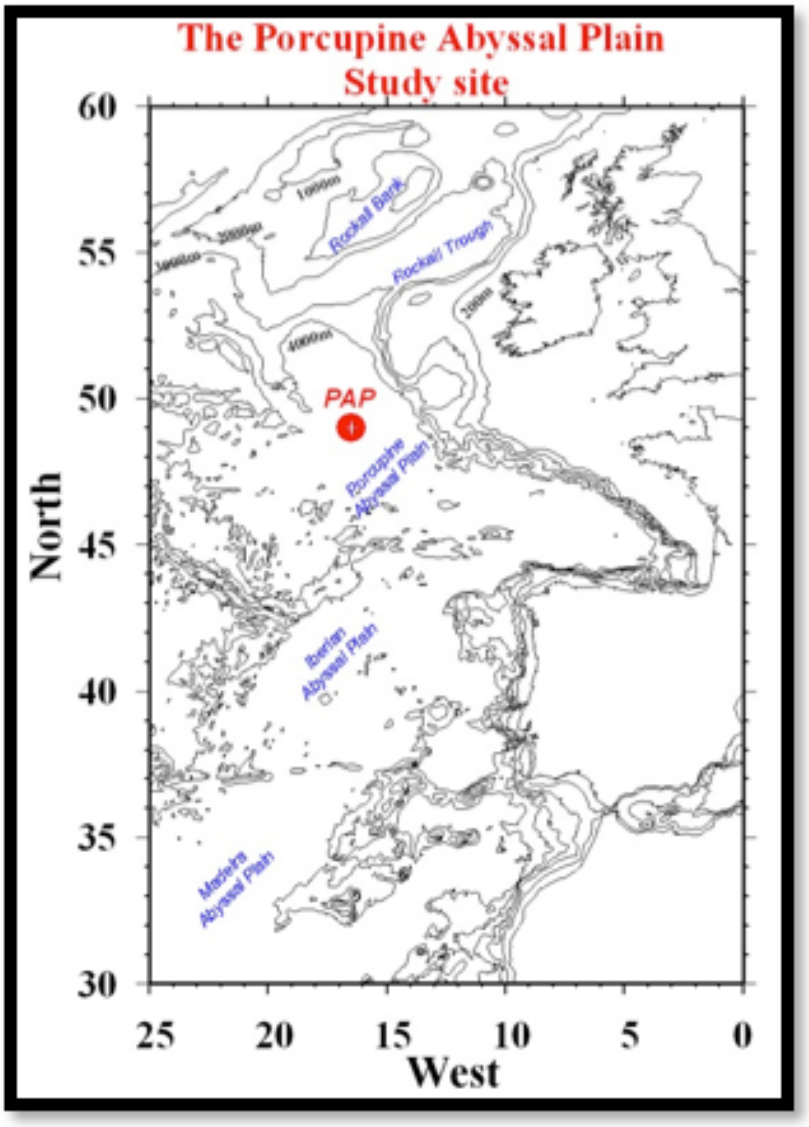


Table 2: Summary of events for DY050.

Event	Date:YYYYMMDD/Day:hhhh	Summary	Lat. & Lon.
Start Date:	20160415/Fri:	Mobilisation	
Sail Date:	20160418/Mon:0800UTC	Departed from Empress Dock, Southampton at 09.00BST	53° 26.79' N, 003° 00.81' W
Transit:	20160418/Mon	Transit to PAP	
Station:001	20160420/Wed	CTD001 (100m) Test	49° 36.10' N, 008° 21.63' W
Station:002-003	20160421/Thu	CTD002(aborted), MgC 1	49° 01.18' N, 016° 08.46' W
Station:004-011	20160422/Fri	Bsnap, CTD002, MSC01-03, PELAGRA (P2,P7 dep.), SAPS1, MgC 2	49° 01.65' N, 016° 25.51' W
Station:012-018	20160423/Sat	MgC 3-4, SAPS2, RCF 1, MSC04-06	48° 50.00' N, 016° 31.14' W
Station:019-029	20160424/Sun	PAP3 rec., CTD003, MSC 7-9, MgC 5, PELAGRA (P7, P2 rec.)	48° 50.28' N, 016° 31.33' W
Station:030-041	20160425/Mon	MgC 6-7, MSC 10-12, SAPS 2, A-Trap 1,RFC2, PELAGRA (P2;P6;P8 dep.)	48° 50.18' N, 016° 31.58' W
Station:042-052	20160426/Tue	CTD004(aborted) MSC 14-17, A-TRAP rec., RCF 3, SAPS 3, PELAGRA(), MgC 8-9	48° 50.45' N, 016° 31.39' W
Station:053-063	20160427/Wed	ZooP 1-2, MgC 10, CTD005, RCF 4, SAPS 4, MSC 18-19, PELAGRA (P8;P6;P2 rec.)	48° 50.23' N, 016° 31.68' W
Station:064-072	20160428/Thu	MgC 11, MSC 20-21, CTD006, Zoop 4-5, TRAWL 1	48° 50.26' N, 016° 31.19' W
Station:073-080	20160429/Fri	RCF 5, MSC 22-23, ZooP 6-7, CTD007	48° 53.01' N, 016° 31.06' W
Station:081-099	20160430/Sat	SAPS 6, MSC 25-27, RCF 11-12, OTSB14 Trawl 2 (aborted), Zoop 8-9, PELAGRA (P2;P4;P6;P8 dep.)	49° 00.57' N, 016° 23.24' W
Station:100-109	20160501/Sun	MgC12 (aborted), Zoop 10-11, MSC 28-30, RCF 13-14, SAPS 7,	48° 54.56' N, 016° 26.55' W

		CTD009, GENP winchtest	
Station:110-114	20160502/Mon	A-Trap dep., SAPS 8, MSC 31, RCF 15, CTD010	49° 00.61' N, 016° 23.56' W
Station:115-124	20160503/Tue	ZooP 12-13, MgC 12, SAPS 9, MSC 32-35, A-Trap rec., PELAGRA (P4 rec.)	48° 50.19' N, 016° 31.22' W
Station:125-132	20160504/Wed	PELAGRA (P2;P6 rec.), SAPS 10, MSC 36-38, RCF 6, Trawl 3	49° 29.22' N, 015° 53.40' W
Station:133-	20160505/Thu	MSC 39-41, RCF 7, MgC 13	48° 53.07' N, 016° 30.63' W
Transit:	20160506/Fri:2120UTC	Set off to Southampton	
Dock Date:	20160508/Sun:1100	Berthed in Southampton Alongside NOC	
End Date:		Preparation to DY051.	

4.1.2 Abbrevations

- *MSC – Marine Snow Catcher. The marine snow catcher (MSC) is essentially a large (95 L) water bottle. It is deployed open to the desired depth, often in the upper 500 m of the water column, and closed via a mechanical messenger/release system. Once closed it is brought immediately back to deck and left to stand full of water for 2 hours. During this time organic particles in the MSC sink towards the base. Particles will have different sinking times depending on their size, shape and density. Particles sat on the base of the MSC will be the fastest sinking particles, which have reached the bottom in 2 hours. Slightly higher up in the base will be slowly sinking particles, which are often smaller than the fast sinking particles. Finally in the top of the MSC are suspended particles with neutral buoyancy therefore they do not sink. Collecting fresh particles in this manner is useful for a whole suite of experimental analyses to further aid our understanding of the biological carbon pump.*
- *BSnap – Bathysnap. Bathysnap is a free-fall mooring / lander equipped with a digital still camera (Imenco) operated in time-lapse mode, capable of long-term (1-year+) full ocean depth (6000m) operations.*
- *OTSB14 Trawl - Hydraulic winches bolted to the deck matrix will be used for the deployment and recovery of the OTSB trawl system. The trawl net is deployed over the stern and controlled via the trawl doors, which are connected to the outboard winches. The doors and pennants fitted to the winches are then deployed simultaneously using the winches. The inboard ends of the*

pennant wires are then connected to the main winch trawl wire via the stern gantry main sheave block. This is then payed out to the seabed. Recovery is the opposite of deployment with the end of the net connected to another winch situated in the centre of the deck. This allows the 'full' net to be recovered and sat on deck. All winches and wires are tested and certified. When deploying and recovering the stern rails are removed. Therefore safety harnesses to be worn during deployment and recovery. Trawling for megafauna (large animals) on the abyssal plain is a lengthy process. The net we use is a modified Louisiana shrimp net, which is small enough to catch most of the animals we are interested in without being too big to handle. This net is attached to a staggering 12 km of cable, and takes about 4 hours to reach the seafloor. Once we think it's got to the seabed, we let it fish for about 2-3 hours before recovering it back to the ship. Providing everything goes smoothly, the whole process takes about 12 hours from start to finish, and until we get the net back on board, we have absolutely no idea if we're going to catch anything at all...

- *ZooP – Zooplankton Net – This system uses a WP2 net, 200 µm mesh size. Each vertical haul was lowered as quickly as the lightness of the net allowed down to 200m then brought up at 10metres/ minute. Samples were either preserved in formalin or sieved and frozen at -80°C.*
- *PAP1 - The PAP telemetry system comprises a buoy telemetry electronics unit and a data concentrator hub in the sensor frame. Data are transmitted via the Iridium satellite system every 4 hours (typically) and are automatically displayed on the EuroSITES website: http://www.eurosites.info/pap/data.php Short status messages are also sent via the Iridium SBD (Short Burst Data) email system every 4 hours (typically). 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 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.*
- *RCF – Red Camera Frame (Holocam) Scientists love to see what they're studying and the Red Camera Frame records both holographic image and traditional optical images. A typical deployment will take over ???? images from depths down to 150m. These pictures illuminate the plankton and the particles in the water column, allowing us to study critical pathways for carbon export from the surface to deeper waters.*
- *SAPS – Stand-alone Pumps Top filter 50µ (micron), bottom filter 1µ, A stand alone pump is used to filter sea water at various depths and collects any particles on the special filers. Deployment of SAP's is usually done on the stbd gantry using one of the ships' main warps. A weight (approx 100kg) is connected to the main warp via a swivel. This is then deployed using the stbd gantry and winch. At a certain depth the winch is stopped and the gantry is recovered so that the main*

warp is vertical and near the stbd gunnel. Using the rexroth winch, pennant and via a stbd gantry sheaveblock a SAPS (70kg) is lifted and clamped to the main warp. A safety line is then fitted around main warp and saps. The pennant is uncoupled from SAPS, gantry moved outboard and main warp is lowered. Recovery is the opposite of deployment.

- *MgC – Mega Corer (Bowers and Connelly) The Mega corer is deployed from the starboard deck using the general purpose winch and wire and the starboard gantry/P-frame. It can take up to twelve 0.5m long sediment cores, at 100mm diameter.*
- *PELAGRA - PELAGRA sediment traps are neutrally buoyant sediment traps. They are deployed as free-drifting instruments that are carefully ballasted to maintain neutral buoyancy at some pre-determined depth between 50 and 1000 m. They are built around APEX profiling floats that have the facility to adjust their buoyancy to counteract minor changes in ocean temperature and in situ density that may otherwise conspire to move the traps away from the ideal drift depth. Each PELAGRA carries four sediment collection pots that can be opened and closed at predetermined times. Deployments typically last from one to three days. At the end of the mission an abort weight is released that makes the traps positively buoyant and they return to the surface. Once at the surface, position is obtained via GPS and that is then transmitted to the Internet via the Iridium satellite telephone service.*

4.2 Deployed Equipment

The equipment deployed for is as follows:

- Networking:
  - Servers**,** Computers**,** Displays, Printers**,,** Network Infrastructure
  - A public network drive for scientists, updated via Syncback
- Datasystems:
  - IFREMer TechSAS logged data and converted it to **NetCDF** format
  - **NetCDF Format** given in: **dy050_netcdf_file_descriptions.docx**
  - **Logged Instruments** given in: **dy050_instrument_logging.docx**
  - Data was also logged to NERC/RVS Level-C format, also described in: **dy050_netcdf_file_descriptions.doc**
  - NERC software: Level-C; SurfMet Python; CLAM 2016; SSDS3
  - Olex
- Hydroacoustics
  - Kongsberg echosounders (EM122, EM710, EA640, SBP120)
- Telecommunications
  - GPS & DGPS (POS MV, PhINS; KB Seapath 330; CNAV 3050)

- OceanWaves WaMoS II Wave Radar
- DartCom Polar Ingester
- NESSCo V-Sat; Thrane & Thrane Sailor 500 Fleet BroadBand

- Instrumentation
  - SWS Underway & Met Platform instrumentation

4.2.1 Requested Services

- 150 kHz hull mounted ADCP system
- SBP120 system
- EM122, EM710 multi-beam echosounders
- Wave Radar
- Meteorology monitoring package
- Pumped sea water sampling system
- Sea surface monitoring system
- Ship scientific computing systems

4.2.2 Data Acquisition Performance

All times given are in UTC.

4.2.3 Ship Scientific Datasystems

Data was logged and converted into NetCDF file format by the TechSAS datalogger.
The format of the NetCDF files is given in the file **dy032_netcdf_file_descriptions.docx**.
The instruments logged are given in **dy032_ship_instrumentation_overview.docx**.
Data was additionally logged in the RVS Level-C format, which is also described in **dy032_netcdf_file_descriptions.docx**.

NetCDF data available in **/scientific_systems/TechSAS/NetCDF/**
ASCII data available in **/scientific_systems/Level-C/raw_data/dy050/**

4.2.4 TechSAS

TechSAS started by 2016.04.18 05:00:10 and running until the NOC. Gaps in data streams:

gyro_s:
time gap : 16 109 08:40:11 to 16 109 08:44:56 (4.8 mins)
time gap : 16 111 18:32:21 to 16 111 19:38:42 (66.3 mins)
time gap : 16 114 03:27:17 to 16 114 06:42:20 (3.3 hrs)

time gap : 16 129 06:35:23 to 16 129 06:48:54 (13.5 mins)

ea640: (longer than 5 minutes)
time gap : 16 111 21:06:49 to 16 111 21:19:19 (12.5 mins)
time gap : 16 113 15:51:24 to 16 113 16:19:17 (27.9 mins)
time gap : 16 117 16:50:21 to 16 117 17:09:45 (19.4 mins)
time gap : 16 119 15:53:40 to 16 119 16:00:33 (6.9 mins)
time gap : 16 124 13:29:28 to 16 124 18:57:45 (5.5 hrs)

em120cb: (longer than 5 minutes)
time gap : 16 113 08:29:13 to 16 113 08:50:55 (21.7 mins)
time gap : 16 113 09:04:51 to 16 113 12:12:40 (3.1 hrs)
time gap : 16 113 15:50:44 to 16 113 16:19:53 (29.1 mins)
time gap : 16 116 15:46:03 to 16 116 15:59:25 (13.4 mins)
time gap : 16 117 15:52:37 to 16 117 16:01:51 (9.2 mins)
time gap : 16 117 16:49:44 to 16 117 20:35:05 (3.8 hrs)
time gap : 16 118 11:04:44 to 16 118 11:14:17 (9.6 mins)
time gap : 16 119 15:05:13 to 16 119 15:10:28 (5.2 mins)
time gap : 16 119 15:19:27 to 16 119 15:21:34 (2.1 mins)
time gap : 16 119 20:22:40 to 16 119 20:38:55 (16.2 mins)
time gap : 16 124 12:59:31 to 16 124 13:04:19 (4.8 mins)
time gap : 16 124 13:28:50 to 16 124 20:14:01 (6.8 hrs)
time gap : 16 126 08:30:53 to 16 126 08:35:52 (5.0 mins)

spathpos:
time gap : 16 112 17:09:20 to 16 112 17:28:28 (19.1 mins)

4.2.5 Position & Attitude

The main GNSS and attitude measurement system, Applanix POS MV was run throughout the cruise. POSMV position and attitude was used by the EM (echosounders) System.

4.2.6 Kongsberg Seapath 330

The Seapath is the vessel's primary GPS, it outputs the position of the ship's common reference point in the gravity meter room. Seapath position and attitude was used by the EM (echosounders) System. Data ailable in **/scientific_systems/TechSAS/NetCDF/GPS/**

4.2.7 Applanix POSMV

The POSMV is the secondary scientific GPS, and is used on the SSDS displays around the vessel. A TechSAS data logging module for the iXSea PHINS and Seapath 330 is under development. Data available in **/scientific_systems/TechSAS/NetCDF/GPS/**

4.2.8 PhINS

PhINS supplies the ADCP OS75 and OS150 with position and attitude data. Lost ascii log between 2016.04.25 13:54:58 – 2016.04.26 11:09:20. Data is available in **/scientific_systems/Attitude_and_Position/phins_ph-832/**

4.3 Instrumentation

4.3.1 SurfMet

Following changes to the serial connections, SurfMet ran without any problems.
dy032_surfmet_sensor_information.docx for details of the sensors used and the calibrations that need to be applied. Calibration sheets are included in the directory **\scientific_systems\MetOcean\SurfMet_metocean_system\SurfMet_calibration_sheets\fitted**
Data is available in NetCDF format in /scientific_systems/TechSAS/NetCDF/SURFMETV2/

4.3.2 SurfMet: Surface Water System

The system cleaned on 2016.04.17 13:30 and rinse with freshwater.
The non-toxic water supply was ON from 2016.04.18 11:15 to 2016.05.07 17:15
The transmissometer optic cleaned on jd129 08:10-09:10
The fluorimeter cleaned on jd129 08:10-09:10
The whole system cleaned after end of the cruise on jd129 2016.05.08 08:10-09:10

4.3.3 SurfMet: Met Platform System

Light sensors glass covers cleaned during the ports of call at Southampton and 01/05/2016 12:00.

4.3.4 SurfMet: PYTHON

No issues.

4.3.5 WaMoS II Wave Radar

Logged locally. When data is logged, a summary of its output is given in the **PARA*.ems** files also in NetCDF format. The water depth set to fix rate 500m.

4.3.6 Gravity Meter

Not installed on the ship for this cruise.

4.4 Hydroacoustics

Generally worked well. Raw data is available in **\scientific_systems\Hydroacoustics**
During the Mooring release and tests all sounders switched off.

4.4.1 Kongsberg EA640

10kHz run at most of the times with uncorrected 1500m/s Sound Velocity. The History function is used to store echograms on bitmap format. Data is available in **\scientific_systems\Hydroacoustic\EA640\history**. The raw data recorded on this cruise is in **\scientific_systems\Hydroacoustic\EA640\raw**

4.4.3 Kongsberg EM710

Not requested, but during the transit from Southampton to PAP it is tested, some data logged. Data is available in **\scientific_systems\Hydroacoustic\EM710**. No problems.

Table 3: Summary of Kongsberg EM710 data

startdate	start JD	start time	sounder	survey name	draught	motion	motion Z pos	water line	Cell size	Total LogTime h:m:s	Lines
2016.04.18	109	07:58	EM710	Em710-dy050 soton to drift	6.6	Pos MV	7.841	1.34	1.1	16:28:49	11
2016.05.06	126	05:36	EM710	dy050 em710 posmv cdrift to soton	6.6	Pos MV	7.841	1.34	1.5		

4.4.4 Kongsberg EM122

When the ship was in DP mode in station, most of the time I started a new line, also started a new line when the ship was in transit between two station. Data is available in **\scientific_systems\Hydroacoustic\EM122**. No problems.

Table 4: Summary of Kongsberg EM122 data

startdate	start JD	start time	sounder	survey name	draught	motion	motion Z pos	water line	Cell size	Total LogTime h:m:s	Lines
2016.04.18	109	08:20	EM122	Em122-dy050 soton to ridge	6.6	Pos MV	7.841	1.34	6.0	58:22:34	28
2016.04.20	111	22:20	EM122	Dy050 em122 great sole bank to pap	6.6	Pos MV	7.841	1.34	6.0	77:18:32	39
2016.04.24	115	07:45	EM122	Dy050 em122 PAP	6.6	Pos MV	7.841	1.34	50.0	67:03:03	41
2016.04.27	118	11:17	EM122	Dy050 em122 posmv pap cs200m	6.6	Pos MV	7.841	1.34	200	203:40:18	106
2016.05.06	127	08:09	EM122	dy032 em122 posmv over cdrift csize200m	6.6	Pos MV	7.841	1.34	200	47:11:05	18

4.4.5 Kongsberg SBP120

Requested, just a short test recorded on 5th of May, 2016. Data is available in **\scientific_systems\Hydroacoustic\SBP120**.

4.4.6 Kongsberg EK60

Not requested. A short test run on 6th of May, 2016

4.4.7 Sound Velocity Profiles

SVP was taken at several stations. Data is available in **\scientific_systems\Hydroacoustics\Sound_Velocity_Profiles**.

Table 5: Summary of Sound Velocity Profiles

Date	St	cast number	time in water	time at bottom	pos at bottom	time on deck	max depth (m)	Water depth (m)	SVP
16111	001	CTD001	08:30	08:39	49°36.10N, 008°21.63W	09:33	100	138	22356SVP
16113	004	CTD002	14:08	15:43	49°00.33N, 016°23.83W	18:38	4790	4827	From CTD
15118	060	CTD005	14:05	14:50	49°00.35N, 016°23.85W	16:49	1500	4843	From CTD
15119	069	CTD006	12:20	13:25	49°00.31N, 016°23.82W	15:40	3000	4840	22563SVP+CTD
15123	114	CTD010	17:47	19:39	49°00.71N, 016°23.85W	23:25	4800	4838	From CTD
15126	133	CTD011	11:25	12:16	49°00.32N, 016°23.82W	15:13	2500	4840	22563SVP+CTD

4.4.8 Teledyne RDI Ocean Surveyor ADCPs

Ocean Surveyor 75kHz

During the transit between Southampton to PAP, until the edge of deep water running in Bottom Tracking mode and after the continental drift to back to Southampton. Data is available in **\scientific_systems\Hydroacoustics\OS75kHz**.

Table 6: Summary of Ocean Survey 75kHz data

Date	starttime	enddate	endtime	Os75 mode	Os75 file number	Remarks
2016.04.18	13:51:29	2016.04.19	08:33:33	Bt	0	Binsize: 16m, No. Bins: 60, Pings/Ens: 29, Time/Ping 00:01:50
2016.04.19	08:36:25	2016.04.20	10:20:28	Bt	1	Pings/Ens: 29
2106.04.20	09:36:08	2016.04.20	23:00:10	Bt	2	Pings/Ens: 29
2016.04.20	23:01:05	2016.04.21	10:49:05	nobt	3	Pings/Ens: 40
2016.04.21	10:49:20	2016.04.22	08:29:20	nobt	4	Pings/Ens: 40
2016.04.22	08:51:19	2016.04.22	09:39:19	nobt	5	Pings/Ens: 40
2016.04.22	12:17:38	2016.04.22	15:49:38	nobt	6	Pings/Ens: 40
2016.04.22	16:20:25	2016.04.23	17:38:25	nobt	7	Pings/Ens: 40
2016.04.23	17:38:51	2016.04.24	20:06:51	nobt	8	Pings/Ens: 40
2106.04.24	20:07:13	2016.04.25	17:07:13	nobt	9	Pings/Ens: 40
2016.04.25	17:07:40	2016.04.26	19:01:40	nobt	10	Pings/Ens: 40
2016.04.26	19:02:02	2016.04.27	07:52:02	nobt	11	Pings/Ens: 40

2016.04.27	19:42:37	2016.04.29	12:38:37	nobt	12	Pings/Ens: 40
2016.04.29	12:38:53	2016.04.30	16:58:53	nobt	13	Pings/Ens: 40
2016.04.30	16:59:13	2016.05.01	18:05:13	nobt	14	Pings/Ens: 40
2016.05.01	18:05:30	2016.05.03	07:03:30	nobt	15	Pings/Ens: 40
2016.05.03	07:03:55	2016.05.04	07:51:55	nobt	16	Pings/Ens: 40
2016.05.04	07:53:10	2016.05.05	07:01:10	nobt	17	Pings/Ens: 40
2016.05.05	07:01:56	2016.05.06	06:19:56	nobt	18	Pings/Ens: 40
2016.05.06	06:20:13	2016.05.06	13:44:13	nobt	19	Pings/Ens: 40
2016.05.06	13:45:06	2016.05.07	06:49:07	bt	20	Pings/Ens: 28
2016.05.07	06:49:28	2016.05.08	06:59:28	bt	21	Pings/Ens: 29

Ocean Surveyor 150kHz.

During the transit between Southampton to PAP, until the edge of deep water running in Bottom Tracking mode. Data is available in **\scientific_systems\Hydroacoustics\OS150kHz**.

Table 7: Summary of Ocean Survey 150kHz data

date	starttime	enddate	endtime	os150 mode	os150 file number	remarks
2016.04.18	13:09:50	2016.04.19	07:49:52	bt	1	Binsize: 8m, No. Bins: 60, Pings/Ens: 46, Time/Ping 00:01:00
2016.04.19	07:50:10	2016.04.20	09:34:13	bt	2	Pings/Ens: 46
2016.04.20	09:36:06	2016.04.20	23:00:09	bt	3	Pings/Ens: 42
2016.04.20	23:01:02	2016.04.21	10:49:02	nobt	4	Pings/Ens: 60
2016.04.21	10:49:18	2016.04.22	08:29:18	nobt	5	Pings/Ens: 60
2016.04.22	08:51:26	2016.04.22	09:37:26	nobt	6	Pings/Ens: 60
2016.04.22	12:17:34	2016.04.22	15:49:35	nobt	7	Pings/Ens: 57
2016.04.22	16:20:30	2016.04.23	17:38:30	nobt	8	Pings/Ens: 60
2016.04.23	17:38:46	2016.04.24	20:06:46	nobt	9	Pings/Ens: 60
2016.04.24	20:07:19	2016.04.25	17:07:19	nobt	10	Pings/Ens: 60
2016.04.25	17:07:32	2016.04.26	19:01:32	nobt	11	Pings/Ens: 60
2016.04.26	19:01:53	2016.04.27	19:41:53	nobt	12	Pings/Ens: 60
2016.04.27	19:42:26	2016.04.29	12:38:26	nobt	13	Pings/Ens: 60
2016.04.29	12:38:40	2016.04.30	16:58:40	nobt	14	Pings/Ens: 60
2016.04.30	16:58:58	2016.05.01	18:04:58	nobt	15	Pings/Ens: 60
2016.05.01	18:05:15	2016.05.03	07:03:15	nobt	16	Pings/Ens: 60
2016.05.03	07:04:38	2016.05.04	07:52:38	nobt	17	Pings/Ens: 60

2016.05.04	07:52:52	2016.05.05	07:00:52	nobt	18	Pings/Ens: 60
2016.05.05	07:01:36	2016.05.06	06:19:36	nobt	19	Pings/Ens: 60
2016.05.06	06:19:52	2016.05.06	13:43:52	nobt	20	Pings/Ens: 60
2016.05.06	13:44:43	2016.05.07	06:48:45	bt	21	Pings/Ens: 42
2016.05.07	06:49:03	2016.05.08	06:59:05	bt	22	Pings/Ens: 46
2016,07.08	07:00:55	2016.05.08	Xx:xx:xx	bt sync	23	Pings/Ens: 27

4.4.9 Sonardyne USBL

Data logged. The MF-DIR WMT 6G beacon (acoustic address 2004, s/n: 290249-001) was fixed to the MegaCorer frame, and logged data downwards. Data is available in **\scientific_systems\TechSAS\NetCDF\GPS**.

4.4.10 CLAM – Cable Logging And Management System

No problem. Data is available in **\specific_equipment\CLAM**.

4.5 Third Party Equipment

4.5.1 NMFSS Sensors & Moorings: CTD, LADCP, Salinometer

Nick RUNDLE has provided a CTD cruise report in the following location in the Data Disc **\specific_equipment\CTD\documents**.

4.5.2 DartCom Live PCO2

Used, and looked after by me on this cruise. Standard Cylinder 1 (250ppm was empty). 2016.04.23 the blocked equilibrator pipe cleaned.

5 PAP Mooring Instrumentation

By Rob McLachlan

5.1 SeaBird 37

5 SBE 37's were sent out for the cruise:

SN 10315 (ODO)
SN 9030 (ODO)
SN 6915
SN 9469
SN 9475

The first shallow calibration dip was carried out on 20th April 2016. Three SBE's were dipped at this time – SN's 10315, 9030 and 6915, all for PAP1. They were set up to sample at 10 seconds starting at 08:00. Once the cast had finished and the data looked at, SN 9030 showed no pressure readings. Initial investigations showed that the instrument recognizes that the sensor is installed and that were no error codes associated with the pressure sensor.

We hope to try this instrument on another cast at some point. It has been removed from service.

The next cast was deep, approximately 4800m. Two SBE's went down on this one, SN's 9469 and 9475, one for PAP3, the other spare. Both were set up to sample at 10 seconds starting at 07:00 on the 22nd April 2016. Both were recovered with good data.

We will use SN 6975 on PAP3 and SN 9469 will replace SN 9030 (bad pressure) on PAP1.

SN 6975 has been set up to sample at 1800 second intervals starting at 10:00 on the 24th April 2016. SN 6975 has also been set up to sample at 1800 second intervals. The ID has been changed to 01 so that it is easier to integrate in to the PAP1 telemetry system.

The SBE's recovered from PAP3 (SN 9976) and PAP1 keel (SN 13397) both worked well with full data.

5.2 Norteks

Both Norteks, SN's 8420 and 9969, have been set up to sample every 1800 seconds starting at 09:00 on the 24th April 2016. Before deployment a compass calibration was carried out and the internal memory cleared.

Both recovered Norteks, SN's 9968 and 8449, had worked well with good data.

5.3 Sediment traps

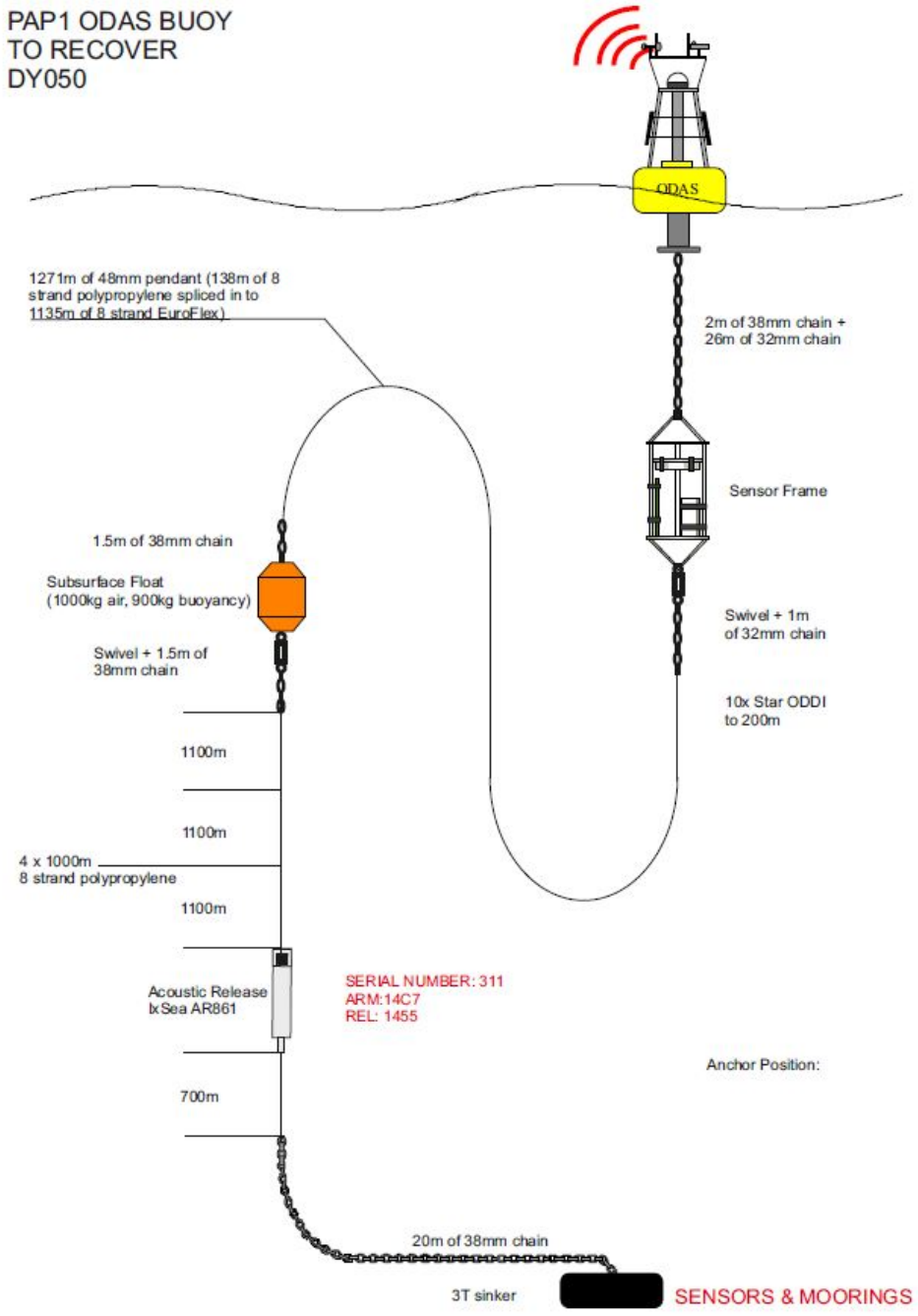
Four traps were sent out for the deployment, three 21 way and one 13 way. The battery pack sent out for the 13 way was dead. A replacement was quickly built. To conserve battery power the motor was removed and the rotor turned by hand to fill the bottles. Three of the four recovered traps all worked well, the inverted trap worked but appeared to have little if any matter in the bottles.

5.4 Acoustic releases

All of the acoustic releases worked as expected with good acoustics throughout.
The drop keel mounted unit was used with limited success. My recommendation is that a comprehensive testing procedure is drafted and carried out to prove the system.

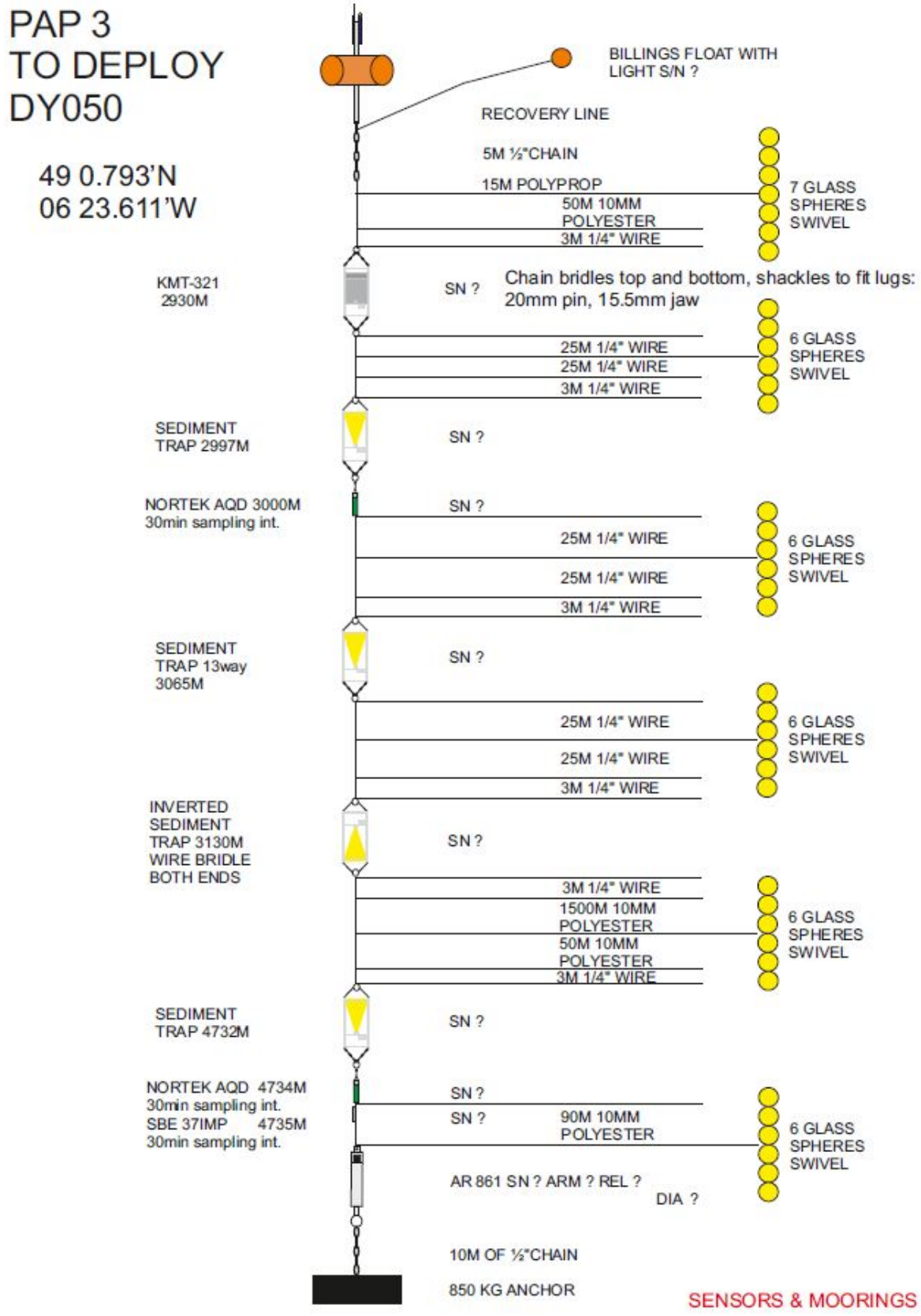
5.5 PAP1 Mooring Schematic

Figure 2: Diagram of the full PAP1 mooring. Only the top sensor frame and ODAS buoy is recovered and swapped.



5.6 PAP3 Mooring Schematic

Figure 3: Diagram of the full PAP3 mooring to be deployed.



6 PAP1 Observatory

By Miguel Charcos Llorens , Katsia Pabortsava, Andrew Morris, Susan Hartman and Corinne Pebody

6.1 General Description

The PAP0003 system comprises a buoy telemetry electronics unit and a frame data concentrator hub. Sensors in the frame and buoy connect to PAP003 and their data is sent using Iridium to our server at NOC. The telemetry communication is intended to provide remote quasi-real time data. Schematic drawings of these two units as configured for the latest deployment are shown in **Error! Reference source not found.** and **Error! Reference source not found.**. The buoy also hosts an entirely separate system provided by the UK Met Office which has its own Iridium telemetry unit and a suite of meteorological sensors measuring wind velocity, wave spectra and atmospheric temperature, pressure and humidity.

The goal during this cruise is to recover the data from the sensors of the frame and the buoy as well as the PAP0003 system that were deployed on July 2015. Then, deploy the new set of electronics and sensors that will be taking data for a year between 2016 and 2017. The PAP1 mooring rope will be re-used but the Met Office is providing a newly refurbished buoy (including flotation, mast, power system and keel) with new equipment. The frame of the PAP0003 system hosting the sensors at 30m was refurbished and new clamps were provided by NMF. The clamps in the buoy and the frame were reused from last recovery of the system that was deployed in 2014-2015. All science sensors were replaced with serviced and calibrated sensors except for the Star-Oddis on the chain.

The previous PAP1 Observatory system was deployed on July 1st 2015 on cruise DY032. The recovery and results of PAP1 were highly successful. The system deployed last year has been recording data internally on the sensors for the entire duration of the deployment. It has also been the most complete deployment of PAP1 providing real-time data along the entire 10 months mission except for some sensors that failed mostly due to large biofouling as we will explain in detail in the section about recovery.

Unfortunately, this year the power system provided by Met Office in the buoy failed to provide the necessary power to the PAP0003 and Met Office systems and therefore there is no real time data in the current deployment. As we will explain later in this document, only self-logging sensors with autonomous power are recording data. For this reason, we will emphasize in the sensor deployment section 6.4 the details about the power that is supplied to each of the sensors. In fact, the issue with the buoy batteries has a high impact in the 2016-2017 operations. A mission for repairing the system

is recommended in the shortest possible term in order to provide a successful science operation and for safety reasons. More details are explained in the power incident section 6.2.

In section 6.2 we describe the power incident, the consequences for the PAP1 observatory and recommendations to mitigate the consequences. Then, section 6.3 describes the systems that were deployed in 2016. It describes the deployed PAP1 observatory including the changes to the telemetry and data hub systems as well as the status after the power issues. Section 6.4 is devoted to the calibration and configuration of the deployed sensors. Section 6.5 includes an analysis of the status of the PAP0003 system that was recovered from the deployment in 2015. Finally, section 6.6 includes a description and post-deployment calibration of the sensors that were deployed in 2014 and recovered during this cruise.

6.2 Power Incident

6.2.1 Power System Description

The PAP buoy has 6 batteries of 12V and 180Ah that are charged by 6 solar panels. There are 2 sets of 3 solar panels providing up to 55W and 70W to the batteries. The typical efficiency of the solar panels is about 15-20%. The power system is separated in two independent subsystems of 3 batteries and 3 solar panels that bring power to the Met office and PAP0003 systems through two independent loops. The configuration between the set of batteries is unknown and we do not know what type of solar panels power which set of batteries. We assume for the subsequence diagrams a particular configuration for the sake of clarity.

Concerning the PAP0003 system, some sensors are powered internally or with external batteries providing a way to be functioning autonomously without depending in the power of the buoy. When the power is functional, we usually power them from the buoy since these batteries are charged by the solar panels. The Met Office sensors work with the batteries from inside the buoy. Figure 4 shows a block diagram of the main components powering the PAP0003 and MetOffice systems. Notice that the components inside the buoyancy were not accessible with the on-board equipment because we did not have the lifting equipment to disassemble the buoy.

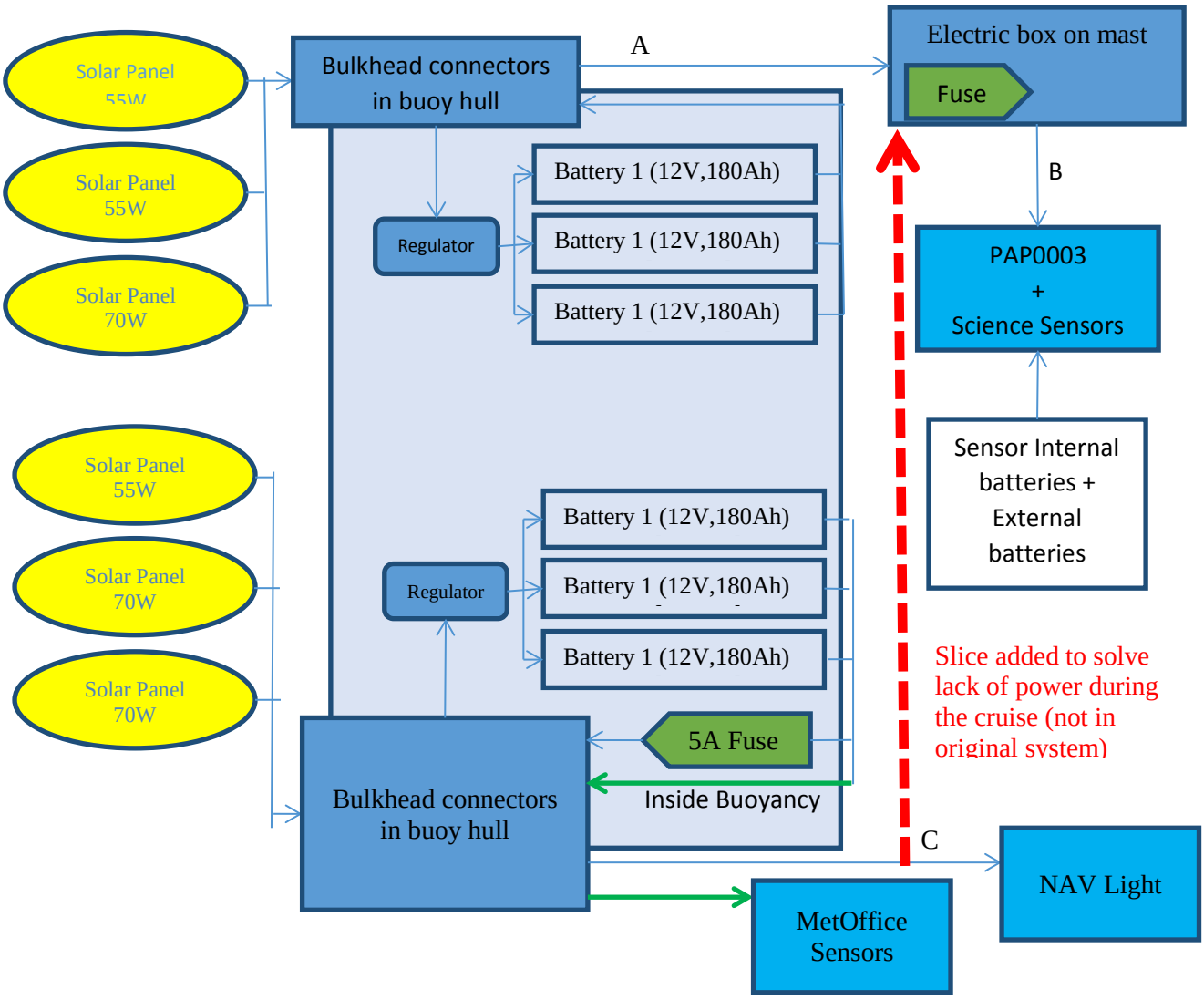


Figure 4: Block diagram of the power provided to PAP0003 and MetOffice systems. The points A, B and C are referenced in the text. The red line represents the slice that was performed to provide power to the PAP0003 as a solution.

In normal operations, PAP0003 data are transmitted via the Iridium satellite system every 4 or 6 hours and are automatically displayed on the PAP website: http://www.noc.ac.uk/pap/. 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. Data from the Met office sensors are telemetered to the Met Office every hour. Both Iridium communication systems are powered directly from the buoy batteries.

6.2.2 Incident Description

During the cruise we discovered a lack of power from the battery set that powers the PAP0003 system at point A. Our assessment indicated that there was not a problem with the connections between the outside of the flotation and the electrical box where the cable to the telemetry system is connected at any of points A or B. The conclusion of this assessment was that the buoy needed to be disassembled in order to fix the problem with the battery set. We decided not to follow that path because of the lack of equipment, the limitations of resources and time as well as the high risk involved in this solution. Instead, we spliced the cable providing power to the NAV light at point C where we measured full power (>12V). The risk involved in that solution was that we could potentially blow up a 5A fuse. Our calculations show that the sensors and telemetry systems usually provide up to 2A and there is a large safety margin. In addition, according to the information from the Met Office, this solution would not compromise their system that does not rely on the same fuse except if the batteries were drained.

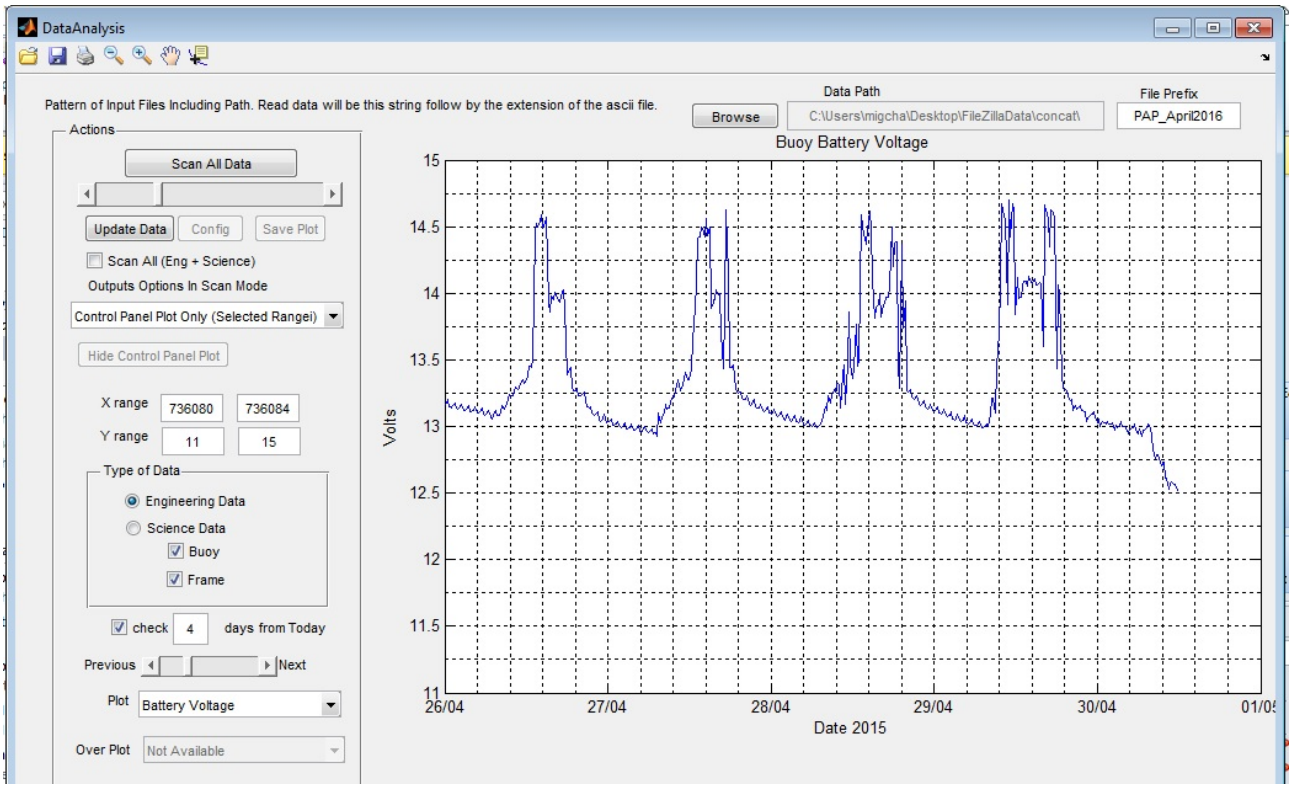


Figure 5: Voltage from buoy power system as measured from the input of the telemetry system of PAP0003

PAP0003 was tested on deck with the power new setup to confirm the expectations of the performance of the system. The system functioned normally with 30min interval Iridium modem communications (dialup + SBD emails) and all sensors that could be tested dry were powered from the buoy. No result from this test indicated a potential failure from the system and no flag was raised

stopping the deployment. In fact, the system worked fine for a day after deployment until it suddenly stopped communicating on April 29th around 12:30. Our latest data show a sudden drop in the voltage from the batteries at the time when they should be charging from the solar panels (Figure 5). At about 13:00, the Met Office also stopped receiving data. The most likely explanations would be either the batteries were drained or there is a problem with system inside the buoyancy similar to the one for the PAP0003 set. In order to identify the source of the failure, it will be necessary to disassemble the buoy and asses the system inside the buoyancy. It is likely that the same problem caused the failure in the second set of batteries. In fact, since the Met Office sensors stopped working, according to the information we gathered in our communications to the Met Office, the batteries are likely drained. It is unlikely that PAP0003 suddenly drained the batteries. A short circuit would probably blow the 5A fuse before that happens. In addition, the system was running wet for an entire day and no power hungry sensors were expected to run at the time of the failure. It will not be possible any final conclusion until we recover an asses the system carefully since a combination of various problems may have added to the failure of the power. Another possibility is that the cables connecting the two battery pods to the Met Office electronics pod have been damaged when assembling the buoy.

6.2.3 Consequences and Recommendations

The current situation of the observatory is that there is not rechargeable power from the buoy into the Met Office sensors or PAP0003. Therefore, no positioning system, communications or lights are left in the buoy. The weather conditions and equipment did not allow any recovery, swap or fix in PAP1 and the observatory was left with no facility to monitor its condition or position. It was recommended not to deploy the old buoy due to its conditions and the recovery of the entire mooring was not an option. We considered the option of adding the Oceansonics batteries at the keel of the buoy and use the CO2 harness to bring the power up to the telemetry system in order to have the position of the buoy remotely. Although this was a plausible technical solution the operation was risky. In fact, the chances of damaging the current system in the actual weather were non-negligible. The operation would likely require working on the buoy on deck while attached to the sea bed which would compromised the security of the personnel. The consequence for the science sampling is that the following sensors will not be functional:

- Buoy:
    - Pro-Oceanus CO2
    - pH senslab
    - OCR
- Frame:
    - GTD
    - OCRs

The rest of the sensors will probably survive a year deployment since they are powered as follow:

- Buoy:
    - SeaFET: Pro-Oceanus battery 15V, 268 Ah + Internal battery
    - SBO Microcat: Internal lithium batteries
- Frame:
    - Pro-Oceanus CO2: 2 Oceansonics batteries of 14.4V 2x168Ah=336Ah
    - SeaFET: Oceansonics batteries of 18V 168Ah + interal batteries
    - SUNA: 2xSatlantic batteries 14V 2x102Ah = 204Ah
    - 2 SBE MicroCats: Internal lithium batteries
    - Wetlabs FLNTUSB: internal batteries
    - Wetlabs P-cycle: External battery pack

The impact to the sampling of the sensors will be detailed in section 6.4 for each of the sensors. This section will estimate the lifetime of operation for each of the science sensors. The recovery of the buoy in the near term must be a priority. The information from the Met Office is that the refurbishing of the old buoy at NOC will take about 3 months and the cost would be around £17000.

Another recommendation is that integration testing prior to the cruise must be a priority in future deployments since it could mitigate this type of failures. Identifying these type of problems early in the process can save large unexpected costs and provide reliable systems and successful missions. This early integration if planned ahead could be performed with no extra cost since the work time of each group would not change but just moved earlier in the schedule. In the contrary, it would help the coordination of the different groups and save development costs.

This experience also shows the importance of having a technical lead coordinating the efforts from the different teams involved in this project. Having an engineer with decision power to coordinate the groups and oversee the developments would help smoothing the schedule plans and integration of the systems.

6.3 Deployed Observatory Description

6.3.1 Technical Configurations

The previously deployed PAP0003 system demonstrated being a good solution for the two previous years of deployment at PAP. This year, we deployed the same system that was recovered in 2015. 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 new Persistor CF2 microcomputers, 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, the accelerometer and the compass were often causing the data hub to fail when schedule. Because it is not critical to have these data the attitude system of the data hub was turned off providing more reliability to the system. The deployed version will be tagged as v1.1. See http://twiki.noc.soton.ac.uk/twiki/bin/view/PAP/PapTechDevelopment for more information about the content of this version release.

Figure 6: Ocean Sonics batteries for CO2 and SeaFET sensors

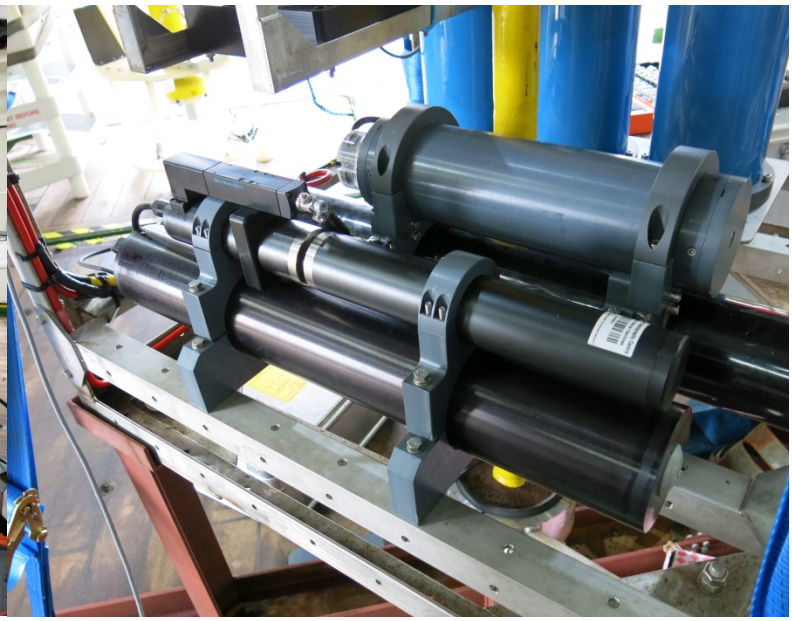


Figure 7: SeaFET, SUNA and Satlantic batteries

There were upgrades providing power and remote control of 3 more sensors: the Aanderaa Seaguard, the WetLabs fluorometer and the WetLabs Phosphate Cycle-P. They allow these sensors to last for a longer deployment since they were previously dependent only of their internal batteries or a separate pack for the Cycle-P. Three new Oceansonics battery housings were purchased to replace the one that were deployed (see Figure 6). The batteries were received the week before the cruise with the wrong electronics configuration. Fortunately, we were able to receive the necessary components to change the electronic boards of the batteries for the new configuration. The connectors of the new battery housings were also different compared to those deployed in 2015. We managed to get the wright connectors to modify the harness to fit the battery specifications.

Figure 8: Frame and buoy before 2016 deployment

Two complete PAP0003 systems are now available that can be swapped every year. Battery packs will need to be replaced and sensors serviced between the recovery and a new deployment. The harnesses were made in house to fit the new configuration of the sensors in the frame. These were carefully tested at NOC by Miguel Charcos Llorens for each of the sensors. The setup was similar to the one deployed.

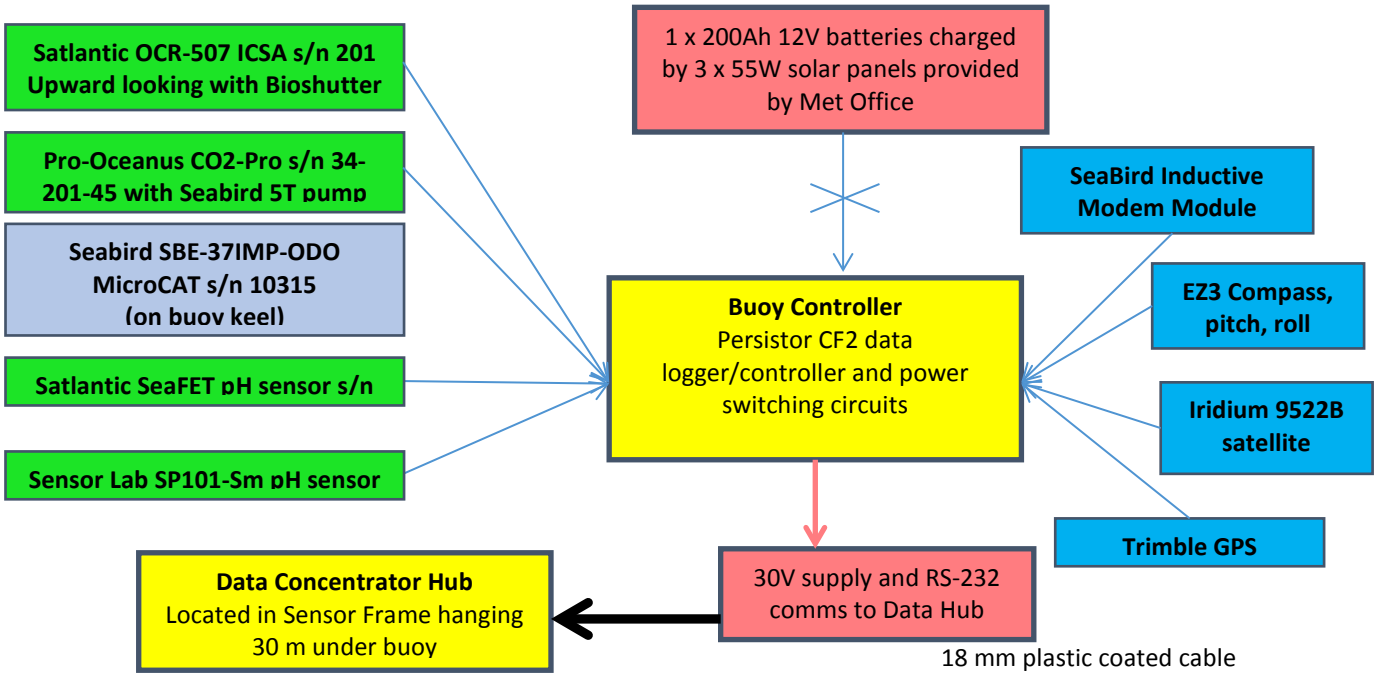


Figure 9: PAP Telemetry Buoy Schematic as Deployed in 2015

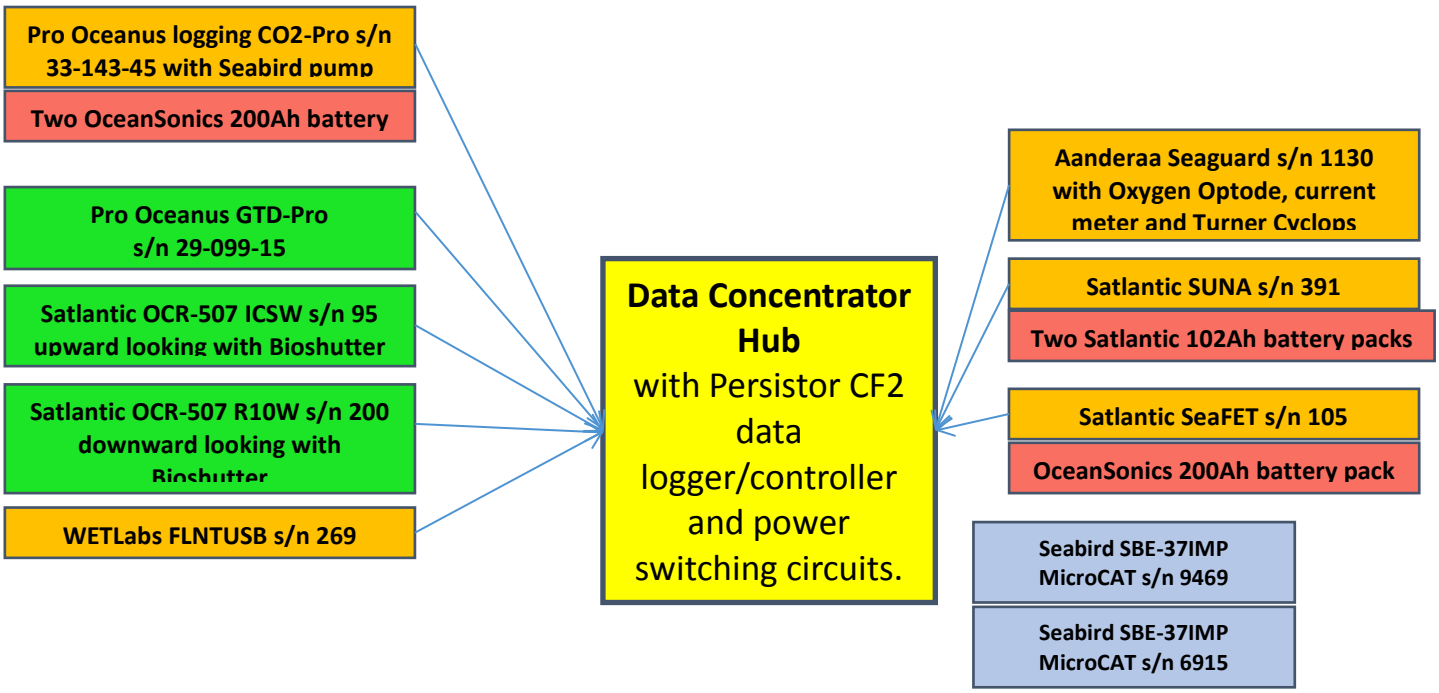


Figure 10: PAP Frame Schematic as Deployed in 2015

A few systems had to be tested again on board due mainly to some modifications before the cruise. The major modification was the data logger of one of the CO2 sensors that arrived the last week before the cruise (see description of the CO2 sensor). We also added an extra Satlantic battery to the SUNA nitrate sensor to provide more autonomous life time. We kept two Ocean Sonics batteries for the CO2 sensor. These two decisions for the battery configuration will be especially useful this year since the power from the buoy will not be available. We used the SUNA sensor instead of the ISUS sensor for nitrate measurements. One of the oxygen MicroCats had to be replaced by a regular SBE sensor as explained in the section 6.4.4.

Figure 9 and Figure 10 show the configuration of these sensors within the buoy and frame of the PAP0003 system. The configuration of the sensors is shown in Table 8.

6.3.2 Deployment and initial performance

The PAP1 deployment started at 9:00 on 28th April 2016 and proceeded smoothly until 10:30. 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. 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. Because of the failure of the power from the buoy the communication from PAP0003 lasted until 29th April at 12:30. The observatory is currently in autonomous configuration using the batteries of sensors and frame to take samples. Data are logged internally for the sensors that have this capability.

Sensor	Serial Number	Intervals (hours)	Minutes after hour
BUOY			
Pro-Oceanus CO2-Pro	34-201-45	12	19
SeaBird SBE-37-ODO-IMP MicroCAT	10315	0.5	0
Satlantic OCR-507 ICSA (buoy) with bioshutter	201	0.5	17
Satlantic SeaFET pH	111	0.5	27
Sensor Lab SP101-Sm pH sensor	Loan	3	26
FRAME			
SeaBird SBE-37IMP MicroCAT	9469	0.5	0
SeaBird SBE-37IMP MicroCAT	6915	0.5	0
WETLabs FLNTUSB Fluorometer	269	4	0
Satlantic SUNA Nitrate sensor	391	1	20
Satlantic SeaFET pH sensor	105	0.5	23
Aanderaa 4430H Seaguard	1130	1	30
Aanderaa 4330 optode in Seaguard	1339	1	30
Turner Cyclops Fluorometer in Seaguard (4808 Chlorophyll??)	2102108	1	30
ZebraTech Wiper for Cyclops	NA	6	0
Satlantic OCR-507 ICSW irradiance	200	0.5	17

with Bioshutter			
Satlantic OCR-507 R10W radiance with bioshutter	95	0.5	17
Pro-Oceanus Logging CO2-Pro	33-146-45	12	59
Pro-Oceanus GTD-Pro	29-099-15	6	56
WETLabs CYCL-P Phosphate Analyser	177 (Loan)	6	40

Table 8: Sensors fitted on buoy and sensor frame for April 2016 deployment

6.4 Deployed PAP1 Sensors

6.4.1 Aanderaa Seaguard s/n1130

A RCM Seaguard with Oxygen optode (Aanderaa 4330, S/N 1339) and fluorometer (Turner cyclops, S/N 2102108) was prepared for deployment as part of the PAP1 sensor frame. The Seaguard and its devices were serviced between the recovery in 2015 and the current deployment. 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.

6.4.1.1 Pre-Deployment Calibration on a CTD Frame

Figure 11: 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 placed on CTD cast 001, which went to a depth of 100 m (see Figure 11). Waters

were collected by Niskin and later analysed through Winkler titration for Oxygen to calibrate the Aanderaa optode. The Turner Cyclops fluorometer was also calibrated against water samples that were analysed by a lab based Turner Triology unit. 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 SBE911+, 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 12.

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).

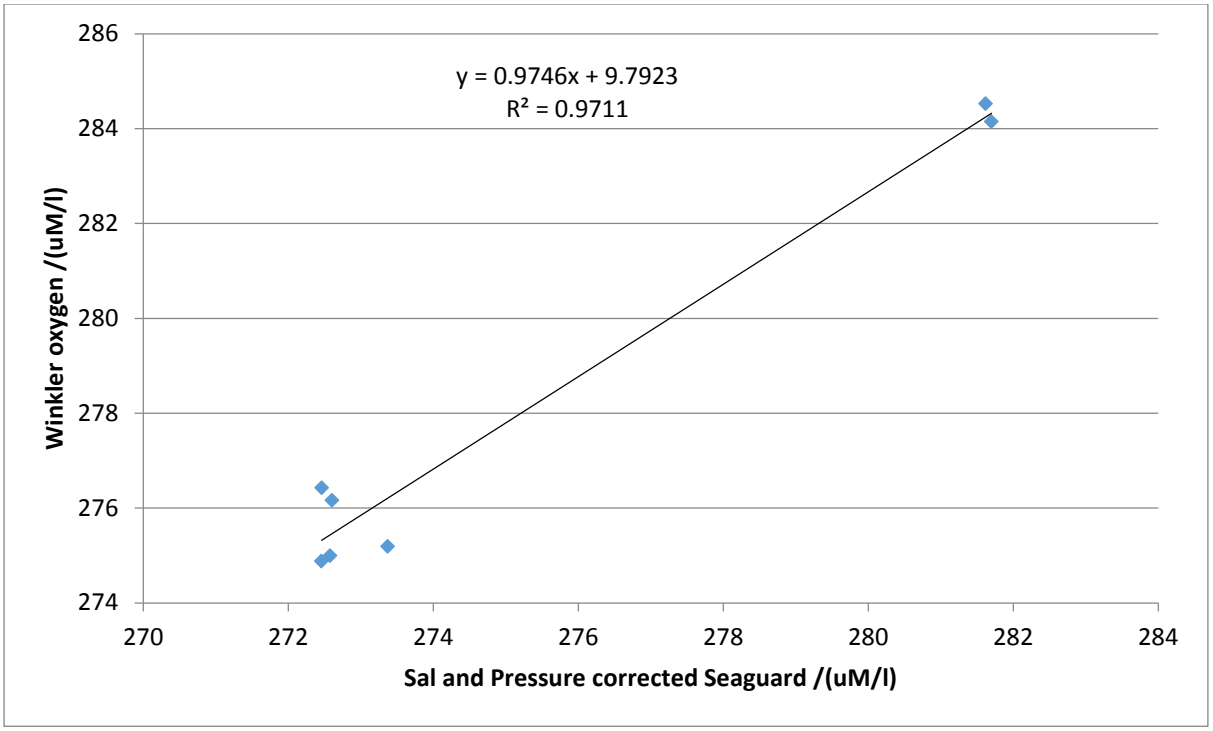


Figure 12: Corrected Seaguard vs Winkler.

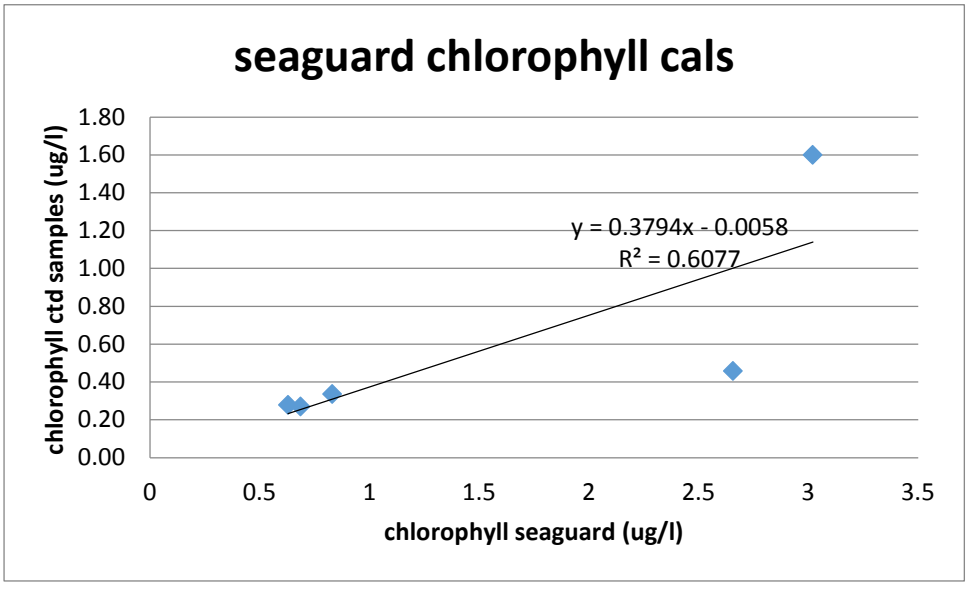


Figure 13: Chlorophyll Seaguard (turner fluorimeter) calibration.

Figure 13 illustrates the comparison of chlorophyll measurements between the Seaguard mounted Turner fluorometer and the bottle samples collected on the same CTD and analysed on board.

Unfortunately the CTD fluorometer was not working for the first two CTD casts so where we have concerns that there is a large difference between the Seaguard and the wet chemistry; it cannot be helped by the CTD data. The best next step would be to use the post deployment calibration dip to correct the output retrospectively.

6.4.1.2 Seaguard and ZebraTech wiper mounting on frame

The Seaguard was set-up and secured in its pressure housing. The unit was then integrated into the sensor frame (see Figure 14). The unit was armed to start operating before deployment to ensure correct communication to the Hub, 12.30 23/04/2016. The scheduling for deployment was to perform a measurement every hour on the half hour, so as to spread inputs to the Hub. The integration between the data hub and the sensor was successfully tested and data from the sensor was received by the RUDICS server. These tests were to complement the tests performed at NOC with the addition of being integrated with other sensors in a set up that is closer to deployment.

Figure 14: Seaguard mounted in PAP1 sensor frame before full integration of all sensors and harnessing.

Figure 15: Image of ZebraTech wiper (taken before turning on) with back cover off showing position of timer

The Cyclops Turner fluorometer was mounted in the ZebraTech wiper (see Figure 15) and set to activate every 6 hrs, it was started at 19:52 26/04/2016. Having the wiper activate near 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. Extra tubing was added to the cable arms from the Seaguard in an attempt to better protect it from flexing while deployed (see Figure 14).

6.4.2 SUNA Nitrate Sensor (S/N: 391)

6.4.2.1 In lab-calibration

The SUNA nitrate sensor was calibrated in the lab at NOC (12.03.2016) using one point calibration method with a set of nitrate calibration standards (5.9 µM, 11.8 µM, 29.5 µM). The standards were prepared using a nitrate standard stock of 5900 µM and ultra-pure deionised water (Milli-Q DIW). The exact concentrations of the calibration solutions will be determined using a Nutrient AutoAnalyser at the National Oceanography Centre Southampton. The in-lab and Satlantic calibration curves are presented in Figure 16.

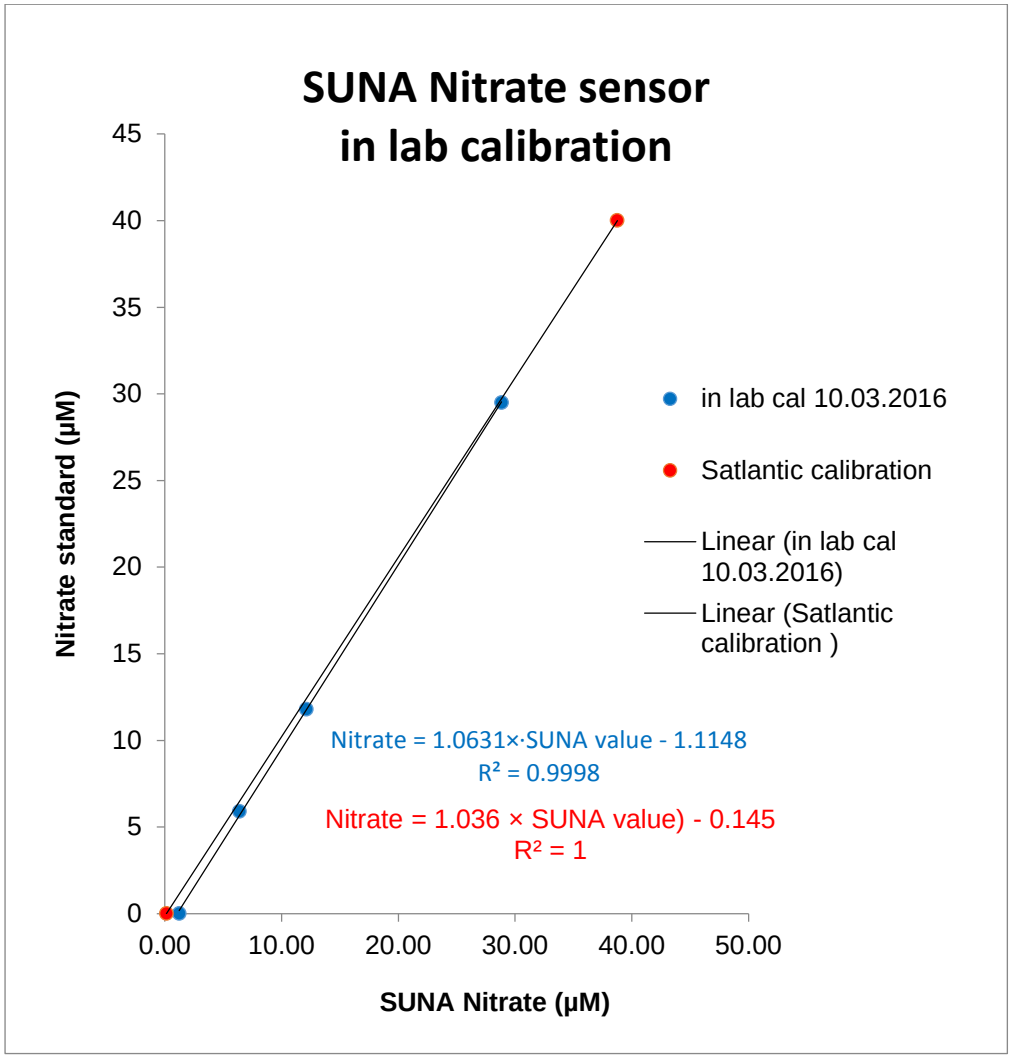


Figure 16: In-lab calibration of the SUNA nitrate sensor

6.4.2.2 Pre-deployment calibration on a CTD

The pre-deployment calibration of the SUNA sensor took place on 20.04.2016 during CTD DY050_001 deployment to 100 m depth. The connection with the sensor was established through SUNACom 3.0.6 software downloaded on a 64-bit PC. The sensor was mounted horizontally onto the CTD rosette frame and powered to a battery pack. The SUNA was set to sample in a PERIODIC mode recording EACHEVENT of sampling to its internal memory. Upon recovery, raw data and log files were downloaded. The SUNA nitrate values will be corrected against Total Oxidised Nitrogen measurements (TON=NO_3^- +NO_2^-) from the Niskin bottles sampled at 10 discrete depths (5, 10, 15, 20, 25, 30, 40, 50, 60, 80, and 100 m).

After CTD deployment, the instrument drift was checked using DIW. **NB: 'Sampling Fresh Water' was checked in 'Advanced' options of the SUNACom set up menu).** The measured nitrate concentrations drifted to an average of 2.64 µM, which is higher than the allowed range of ±2.0 µM for DIW. The calibration of the instrument was therefore updated using 'Update Calibration' option in the SUNACom main menu. The concentrations in DI water after recalibration were -0.34 µM on average. We suggest subtracting the drift value from the measured nitrate concentration during CTD deployment DY050-001.

6.4.2.3 Deployment on the PAP sensor frame

On the sensor frame deployed at 30 m, the SUNA Nitrate sensor was configured to sample in a periodic mode/frame based operation. The sampling interval was set to 1 hour with 1200 sec (20 min) offset past the hour. Within the sampling interval, the acquisition duration was given by the number of frames. For this deployment, the chosen 1 frame operation outputs 1 dark frame then 1 light frame which is the average of 10 samples. This gives an estimated frame rate of 0.1587 frames per second (6.3 sec/frame). The integrated wiper was enabled.

6.4.3 WETLabs Fluorometer

The Wetlabs fluorimeter was tested on the bench and found to working well. It was then deployed on CTD 1 to 100m to calibrate the chlorophyll reading prior to deployment. The CTD fluorometer was not working on either ctd 1 or 2, as we are unable to compare the measurements against the CTD. This is unfortunate as the r2 is only 0.69. One of the higher values in Figure 17 is probably incorrect but we cannot be sure which one. The calibration generated by this dip can be used for initial correction, but the post deployment calibration should be applied once this instrument is recovered and re calibrated.

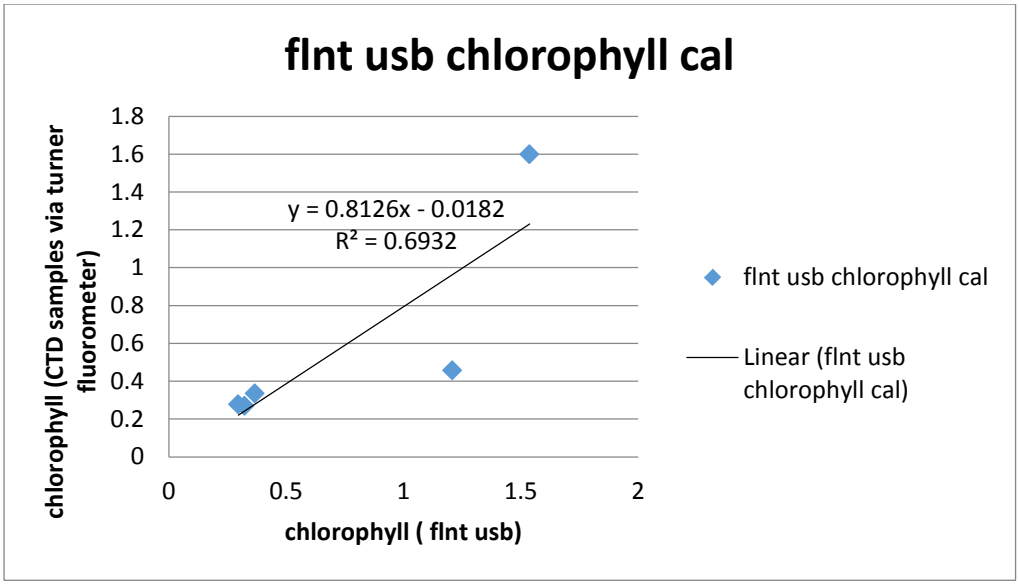


Figure 17: Chlorophyll calibration measurements on CTD cast

6.4.4 Sea-Bird SBE 37 MicroCATs

The SBE sensors s/n 10315, 9030 and 6915 were attached to the CTD and calibrated down to 100m with sampling intervals of 10s. All the SBE sensors were serviced prior to the cruise. The result showed that the SBE 37-ODO s/n 9030 sensor did not measure pressure and we decided to replace it with the SBE 37-IMP s/n 9469 MicroCAT. Because the latest does not provide oxygen measurements the configuration of the sensors on the frame was changed compared to the initial plans.

A Sea-Bird SBE 37-ODO (s/n 10315) 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 01. The initial plan was to clamp the SBE 37-ODO s/n 9030 on the keel and SBE 37-ODO s/n 10315 to the frame. By replacing the SBE 37-ODO s/n 9030 with SBE 37-IMP s/n 9469 the keel would be left with no oxygen measurements. Since the Aanderaa optode provides oxygen measurements in the frame we decided to swap them and install the SBE 37-IMP s/n 9469 and 6915 on the frame.

6.4.5 Pro-Oceanus dissolved gas sensors

6.4.5.1 CO2 sensor on the buoy

A non-logging CO2-Pro CO2 sensor (s/n 34-201-45) was attached to the buoy keel and is powered and controlled by the buoy Telemetry Unit. It was serviced in 2015 after its recovery on July. This sensor was supposed to be powered from the buoy and is planned to switched on every 12 hours (at 11:20 and 23:30). However, because of the lack of power from the buoy it will not be sampling.

The expected configuration was as follow. 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 would be powered on.

6.4.5.2 CO2 sensor on the frame

A self-logging CO2-Pro (s/n 33-146-45) was attached to the sensor frame and was configured to sample every 12 hours at midnight and noon producing 4 samples per record and performing an AZPC every 4 sampling sessions. The real time clock battery was fully charged shortly before deployment. This sensor is powered by two, 168Ah OceanSonics battery connected in parallel to provide a voltage of approximately 14.4V and 336Ah. The average power consumption during warmup for the CO2-Pro CV is 9 W, 643 mA at 14 VDC. The warming time in the context of PAP is less than 5min. After warmup, the sensor power consumption is ~3 W, 214 mA at 12 VDC. The sampling time is less than 5min for 4 samples. The internal controller requires ~30 μA of current during sleep, 263mAh for a year which is negligible in the battery lifetime calculation. Thus, the consumption during a year for 2 times a day sampling is 365*2*(5*0.643+5*0.214) = 3128Ah. The consumption increases of about 25% with the pump according to the values from the sensor manual. The consumption for a year would be 10160Ah. According to the manual, a battery of 268Ah would allow 833 days of sampling. The values of the consumption are all from the manual and we believe that they are inconsistent.

The ascarite CO2 absorbent in this sensor was replaced when serviced after the recovery of the sensor on July. The data logger of this sensor was changed shortly before the cruise by a new data logger provided by Pro-Oceanus. The previous data logger did not allow changing the sampling time. The Pro-Oceanus sensors with the tubular interface are slower at depth. By the time the sensor warms up and takes a zero, there was not enough time left in the 20 minute sampling cycle to fully equilibrate. This created lower values during the samples with automatic zeroing due to the lack of complete equilibration. The new logger can be configured to a range of sampling times. However, it was not able to wake up the MAX3244 component on the electronics of the data hub. This conclusion was reached after performing tests on board with various configurations. The sensor was communicating with the data hub only if it was previously woken up with a character from the PC within 30 seconds. The component also connects to the OCRs, the GTD and the Cycle-P sensor that did not have any trouble communicating with the data hub. In fact, the previous logger of the CO2 sensor did not seem to have any problem when tested at NOC. These results points out to a problem of incompatibility between the MAX3244 and the new data logger that needs to be investigated further. In the current

context, this issue lacks of importance since the data hub is not functional due to the lack of power from the Buoy. The CO2 sensor will be recording data internally.

6.4.5.3 GTD sensor on the frame

A GTD-Pro gas tension sensor (s/n 29-099-15) was also attached to the sensor frame and is only powered and recorded by the Data Hub. Therefore, it will not be sampling data due to the lack of power.

The expected configuration was as follow. The sampling time and duration is controlled by email command and was for this deployment the sensor sampled for 6 minutes every 6 hours. This sensor gave normal readings of pressure while on deck and the first day of deployment before the power shut down.

6.4.6 pH SensLab 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 105 and 111). The SP101 was calibrated before being received by NOC and checked and serviced in Southampton before the cruise began by Melchor. However, it is also powered through the telemetry system from the batteries of the buoy. Therefore, it will not be operational during this deployment.

6.4.7 SeaFET pH sensors (s/n 105 and 111)

6.4.7.1 In-lab calibration

The SeaFET pH sensors (S/N 105 and 111) were calibrated in the lab at NOC and on-board *RRS Discovery* using a set of Certified Reference Materials (CRMs) of known pH values (Batch 128, 146, and 151). The sensors were sampling in the CONTINUOUS mode during calibration. The sensors were warmed up for approximately 2 hours (to stabilise internal temperature of the sensor) before the steady readings were logged. Temperature was recorded with a thermometer at the beginning and end of the calibration test and the pH of CRM was calculated using CO2Sys_v2.1 macro. The results of the calibration test are summarised in Table 9. The offsets between the aim CRM values and pH measured by the SeaFETs 105 and 111 are shown in Figure 19.

Test	SeaFET S/N	pH internal	pH external	Temperature (°C)	CRM pH
Pre-deployment calibration 10.02.2016					
CRM Batch 140	105	7.864±0.001	7.932±0.001	20.1	7.929
CRM Batch 128	105	7.956±0.001	8.085±0.001	20.3	7.999
CRM Batch 140	111	7.859±0.008	7.936±0.009	20.4	7.929
CRM Batch 128	111	7.955±0.008	8.105±0.009	20.6	7.995
On-board pre-deployment calibration 19.04.2016					
CRM Batch 128	105	7.862±0.001	7.9812±0.002	21.6	7.98
CRM Batch 146	105	7.922±0.001	8.088±0.002	21.1	7.963
CRM Batch 151	105	7.865±0.0004	8.059±0.001	21.2	7.915
CRM Batch 128	111	7.950±0.006	8.039±0.008	20.1	8.002
CRM Batch 146	111	7.986±0.002	8.141±0.004	20.3	7.975
CRM Batch 151	111	7.928±0.001	8.111±0.001	20.5	7.963
On-board post -deployment calibration 1 25.05.2016					
CRM Batch 128	63	8.256±0.007	7.639±0.007	22.7	7.964
CRM Batch 146	63	8.468±0.012	7.862±0.041	22.8	7.938
CRM Batch 151	63	8.499±0.002	7.898±0.025	22.9	7.890
CRM Batch 128	257	7.772±0.014	7.724±0.016	22.9	7.961
CRM Batch 146	257	7.878±0.010	7.888±0.010	22.7	7.939
CRM Batch 151	257	7.854±0.011	7.881±0.013	23.1	7.887

On-board post -deployment calibration 2 28.05.2016					
CRM Batch 128	63	8.540±0.014	7.917±0.001	22.3	7.970
CRM Batch 146	63	8.619±0.001	8.007±0.001	22.6	7.940
CRM Batch 151	63	8.571±0.002	7.963±0.002	22.3	7.899
CRM Batch 128	63	8.061±0.054	8.083±0.060	22.5	7.967
CRM Batch 146	63	7.929±0.013	7.991±0.013	22.8	7.938
CRM Batch 151	63	7.859±0.012	7.938±0.010	22.7	7.893

Table 9: Summary of pre- and post-deployment calibration tests for Satlantic SeaFET pH sensors

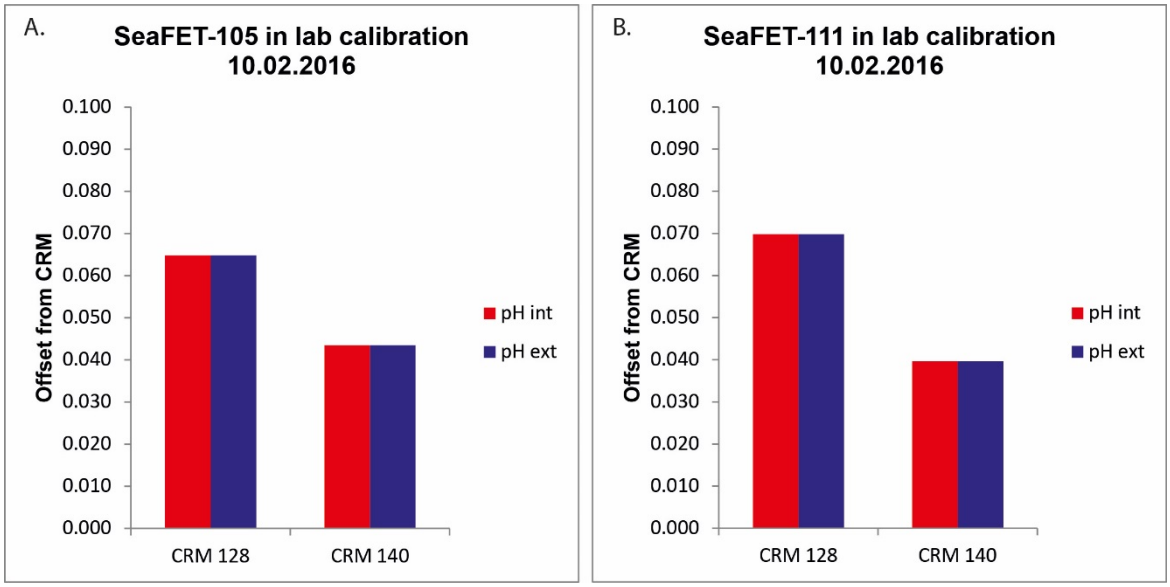


Figure 18: Results of the calibration tests for (A) SeaFET-105 and (B) SeaFET-111 pH sensors conducted in the land laboratory. The columns show the difference between the pH of certified reference materials (CRMs) and the values measured by internal (red) and external (blue) pH sensors of the SeaFETs.

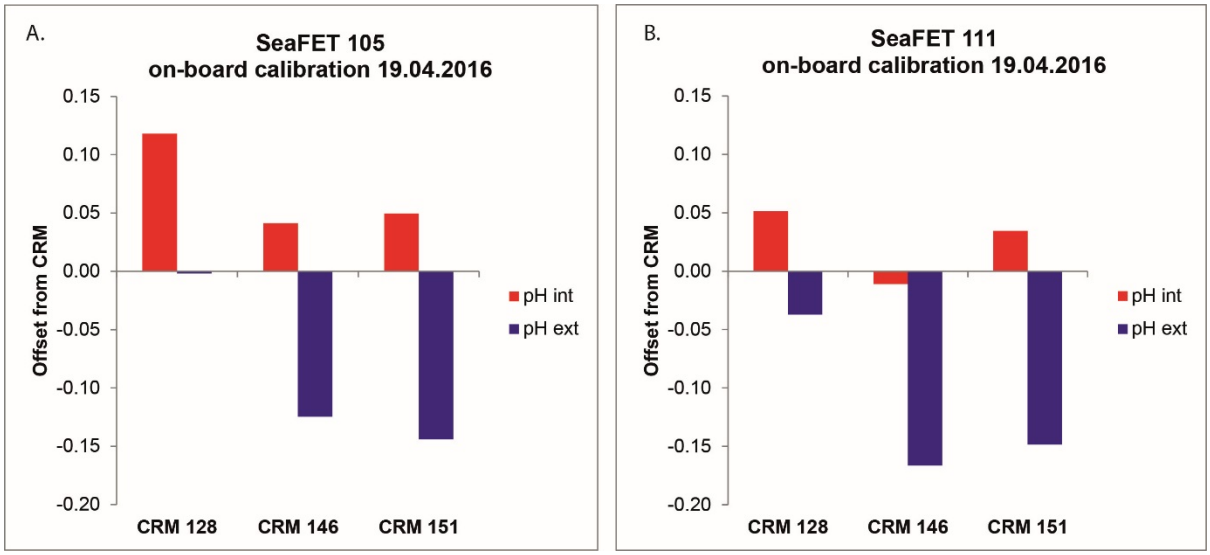


Figure 19: Results of the pre-deployment calibration tests for (A) SeaFET-105 and (B) SeaFET-111 pH sensors. The columns show the difference between the pH of CRMs and the values measured by internal (red) and external (blue) pH sensors of the SeaFETs.

6.4.7.2 Deployment of SeaFETs on the sensor frame and the buoy.

The SeaFET sensors are programmed to take samples every 30min. They are connected to internal batteries and external batteries. At the frame, the SeaFET 105 is connected to an Ocean Sonics battery with 150Ah and at the buoy the SeaFET 111 is also powered by a Pro-Oceanus 268Ah.

The internal battery compartment holds 12 Alkaline D-Cell batteries. A distinctive characteristic of the SeaFET is that it requires an uninterrupted and isolated source of power to keep the sensing element conditioned and the battery pack is split into two packs, the main pack with 8 batteries (12V) and the isolated pack with 4 batteries (6V). The 'Main battery pack' and the external batteries are used to power the instrument control electronics when the instrument is in active mode. Because the power consumption of the isolated battery power is 10uA in operation and 1.1mA in standby, the isolated battery will last more than 15/0.0011 = 13636h = 568d and thus the consumption for keeping the elements conditioned is not a limitation.

The main circuit consumes 340-400mW in operation and 70uA in standby. The consumption in standby of a year deployment is $70x10^{-6}x24*365$ = 600mAh which is negligible in this context. Assuming that the sensor stays on 15min for each sample, it would be in sampling mode half of the time in a day. The batteries provide 14V-18V which correspond in the worst case scenario to a consumption in sampling mode of 400/18-400/14 = 22mA-29mA. The consumption for an entire year would be 22*(24/2)*365 = 96Ah to 29*(24/2)*365 = 127Ah and therefore, our external batteries should provide power for a year deployment.

On the frame, SeaFET was set up to sample in periodic mode with a sampling interval of 30 min and 1380 sec offset (23 min past the hour), producing 3 Frames per burst (output of 3 samples, each is an average of 10 readings) and creating a DAILY log ASCII file (Figure 20). On the buoy, SeaFET was set up to sample in PERIODIC mode with a sampling interval of 30 min and 1620 sec offset (27 min past the hour), producing 3 Frames per burst (output of 3 samples, each is an average of 10 readings) and creating a DAILY log ASCII file. Note that the sampling regimes cannot be changed remotely.

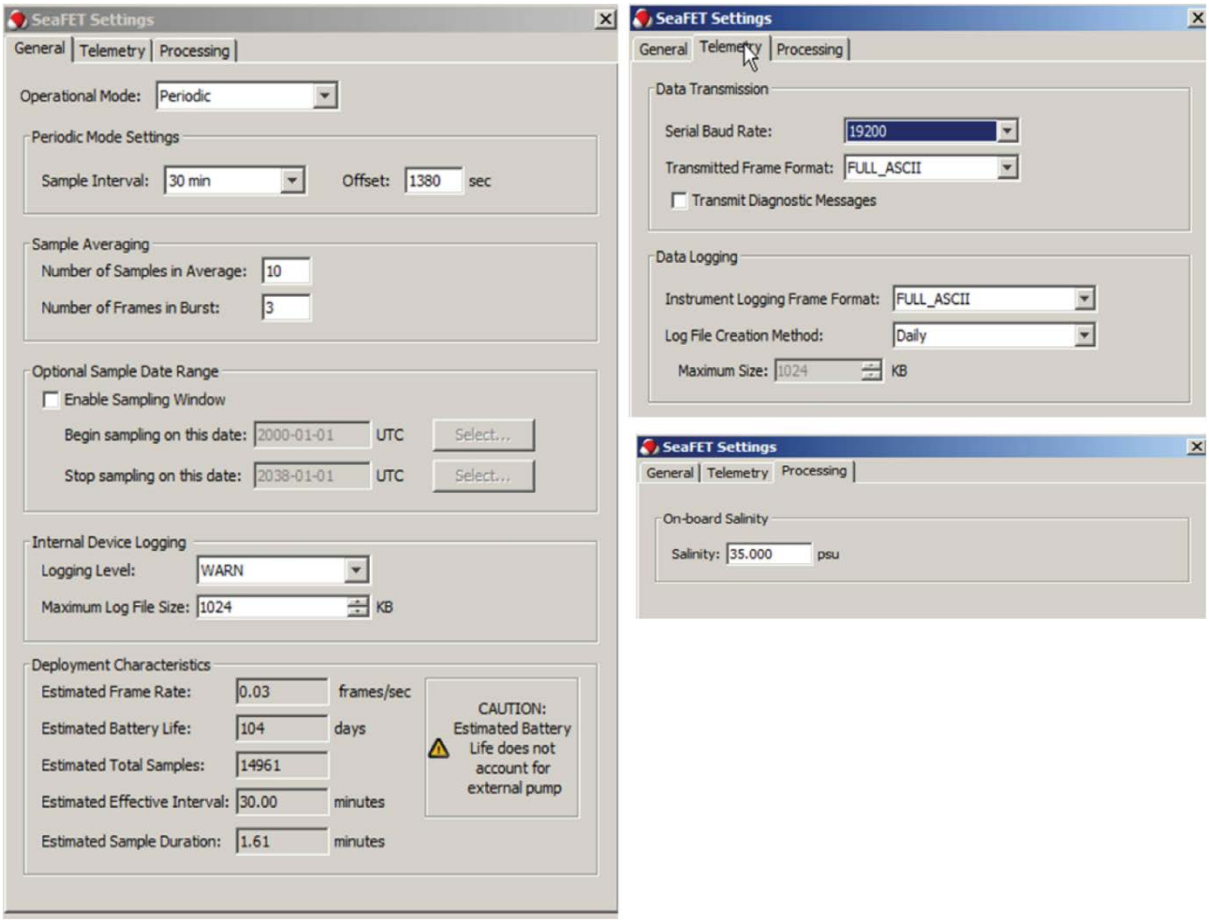


Figure 20: SeaFET 105 pH sensor configuration for the deployments on the frame.

6.4.8 WETLabs Cycle phosphate sensor (s/n CYCL-P-177)

The WETlabs CYCLE phosphate sensor was deployed on the PAP sensor frame at 30m. The sensor was calibrated in the lab at NOC. Because of the failure during the previous deployment, the company loaned one of their sensors to be installed during the current deployment.

The cycle was set up the day before deployment after testing a few days earlier that the sensor would continue to operate if power was interrupted. There are several issues to review the cycle. It needs to be vertical when sampling but 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.

The cycle was programmed on deck using a small power source because using a mains type power supply on deck is problematic. The instrument communicated for programming and the deployment report below was normal, but the cycle failed to output any data late on 28/04/16 when the first sample was due to be telemetered back. It is not clear whether it is still working and self logging but not communicating or whether it is not working. It was communicating well on the tests made on the frame when still on deck and was sampling and outputting correctly until it entered the water.

Figure 21: Set-up of the WETLabs Cycle phosphate sensor

```
<!-- Settings applied at 18:40:55 on 04/27/16 -->
Asynchronous Slave mode
   Output initiated by external control
Sync to host clock
Reset sample counter
Reset power consumption
Data dir to existing dir: DY050DEP - NOT RECOMMENDED
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 18:45:00 on 04/28/16
   (1444.6) minutes from now
Sampling to start at 19:15:00 on 04/28/16
   (1474.6) minutes from now
Number of samples = 300000
Sample interval = 6:00:00
Calibration frequency = 6

<!-- Results recorded at 18:41:04 on 04/27/16 -->

Awake
PO4>$WKM
2
```

```
PO4>$WKM 2
2
PO4>$CLK
04/27/16        18:41:00
PO4>$CLK 04/27/16    18:40:55
04/27/16        18:40:55
PO4>$VOL
117.124 6.900 7.718 7.560
PO4>$VOL 0.00 0.00 0.00 0.00 /S
0.000 0.000 0.000 0.000
PO4>$CNT
3
PO4>$CNT 0 /S
0
PO4>$ONT
1:27:04
PO4>$ONT 0 /S
0:00:00
PO4>$DSD
DY050DEP
PO4>$DSD DY050DEP
DY050DEP
PO4>$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 04/28/16    18:45:00 /P
04/28/16        18:45:00        P
PO4>$CSF
6 0
PO4>$CSF 6
6 0
```

PO4>$INT
1:00:00
PO4>$INT 21600
6:00:00
PO4>$IDT
120
PO4>$NOS
3 3
PO4>$NOS 300000
-27680 -27680
PO4>$SUD

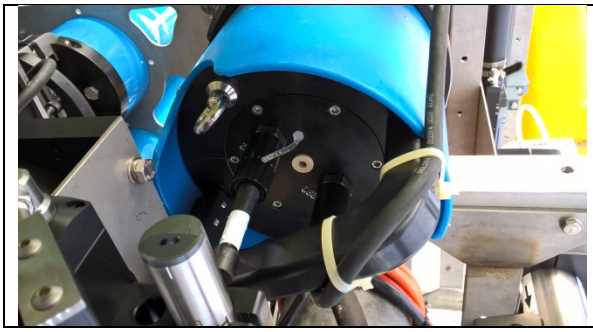


Figure 22: The Cycle with cables attached correctly, the exhaust tubes and intakes are free

6.4.9 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 controls an OCR-507 ICSW upward-looking irradiance sensor (s/n 200) and an OCR-507 R10W downward-looking radiance sensor (s/n 95). 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. All sensors were serviced before the deployment and they are paired with a bioshutter to avoid biofouling. They will not be working since they should be powered from the batteries of the buoy through the telemetry or data hub systems.

6.5 PAP1 Recovered Data Hub and Telemetry Systems

The recovered PAP Observatory system was deployed on 1st July 2015 on *RRS Discovery* cruise DY050 and the PAP0003 system was fully operational until its recovery. The buoy and sensor frame

were recovered without difficulty on the morning of 25th April 2016. 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 28th April.

Sensor	Performance	Recommendations and Actions
Telemetry	Worked and communicate for entire deployment.	Test system at NOC. Copy data from drive.
Pro-Oceanus CO2-Pro	Failed to collect data during deployment since 2016/03/03 but sensor worked when connected to PC after recovery. Extreme biofouling of sensor and pump.	Check harness. Assess if servicing is needed. Need new pump and its copper guard.
SeaBird SBE-37-ODO-IMP MicroCAT	Worked along deployment.	Assess need of servicing.
Satlantic OCR-507 ICSA (buoy) with bioshutter	Sensor sampled successfully to the end of deployment. Copper protection was absent.	Copy data from telemetry system. Asses if servicing is needed
Satlantic SeaFET pH	The sensor was sampling data for the entire deployment but the internal-external measurement diverged when checked in lab probably due to extreme biofouling. Data was uploaded from sensor.	Servicing.
Sensor Lab SP101-Sm pH sensor	It failed intermittently through winter. On 2016/01/13 failed to take sensible pH data but was still sending good MicroCAT data. Found extreme biofouling on keel explaining the failure.	Extract data. Return to Melchor

Table 10: Summary of status of sensors in the buoy

In comparison to previous years the system was extremely biofouled after 10 months of deployment, especially at the buoy (see Figure 23). This caused sensors to fail working properly or not at all. On the other hand, the orange cable, the protective hydraulic hosing over the cable and the sensors did not show any obvious damage (see Figure 24).

The operation observations and commands were logged in the wiki at http://twiki.noc.soton.ac.uk/twiki/bin/view/PAP/Papdep2015OpNotes. Table 10 shows the performance and the status of the data extraction for the sensors that are located on the buoy. The sensors located at the frame are shown in Table 11.

Sensor	Performance	Recommendations and Actions
SeaBird SBE-37IMP MicroCAT	Real time data stopped around mid-March due to problem of frame-buoy inductive link. Data was stored internally and uploaded from sensor.	Check inductive link. Service sensor.
SeaBird SBE-37IMP MicroCAT	Real time data stopped around mid-March due to problem of frame-buoy inductive link. Data was stored internally and uploaded from sensor.	Check inductive link. Service sensor.
WETLabs FLNTUSB Fluorometer	Sampling successfully to the end of the deployment. Data was uploaded from sensor.	Assess servicing
Satlantic ISUS Nitrate sensor	External battery failed intermittently. The sensor sampled for the entire deployment although the level raised considerably at the end of 2016 probably due to biofouling. Data was uploaded from sensor.	Servicing but not urgent since it will be replaced by SUNA.
Satlantic SeaFET pH sensor	Data started to scatter on March 2015. Some biofouling but probably mainly due to need of calibration.	Servicing.
Aanderaa 4430H	Sensors sampled data along the	Asses if servicing is

Seaguard	entire deployment. Data diverged at the end of the deployment due to biofouling on the sensors. Wiper was not working when recovered. Data was uploaded from sensor.	needed. Paint work to fix scratches.
Satlantic OCR-507 ICSW irradiance with Bioshutter	Sensor sampled successfully to the end of deployment. Data was lower than usual for a period of time may be due to biofouling. Copper protection was absent.	Asses if servicing is needed.
Satlantic OCR-507 R10W radiance with bioshutter	Failed on 2016/10/29 likely due to failure of harness.	Asses if servicing is needed
Pro-Oceanus Logging CO2-Pro	2016/01/8 sensor started to misbehave and stopped sampling a few days later. It shows assembling failures after recovery. Data was extracted from SD card inside. In addition, there was a problem with the logger as explained in the deployment section.	Servicing and discussions with company about improving assembling design. Need new pump and its copper guard.
Pro-Oceanus GTD-Pro	Showed signs of failure just after deployment on 2016/07/01 but it was working normally after recovery which indicates that we turned it off too soon	Servicing since it is an old sensor and the increase of values was probably due to need of inspection.
WETLabs CYCL-P Phosphate Analyser	Stopped working soon after deployment probably due to blocking of out tube. Data was uploaded from sensor.	Assess if servicing is needed.

Table 11: Summary of status of sensors in the frame

Figure 23: Picture of buoy keel after the recovery from deployment 2015-2016

Figure 24: Orange cable near the frame-chain connection

The PAP0003 system has proven very reliable during the entire deployment. There was no failure of the communication Figure 25 shows the efficiency of the data transfer. The power of the system was also very successful except for some shutdowns of the data hub unit at the end of the deployment. As mentioned earlier, the orange cable was intact after the recovery and even the hose was not damage. The tubing around the cable was sliced near the chain (see Figure 24).

There was a recurrent restart of the data hub at the end of the deployment when the OCR started to take measurements. This problem went away after a command was sent to stop the OCR sampling.

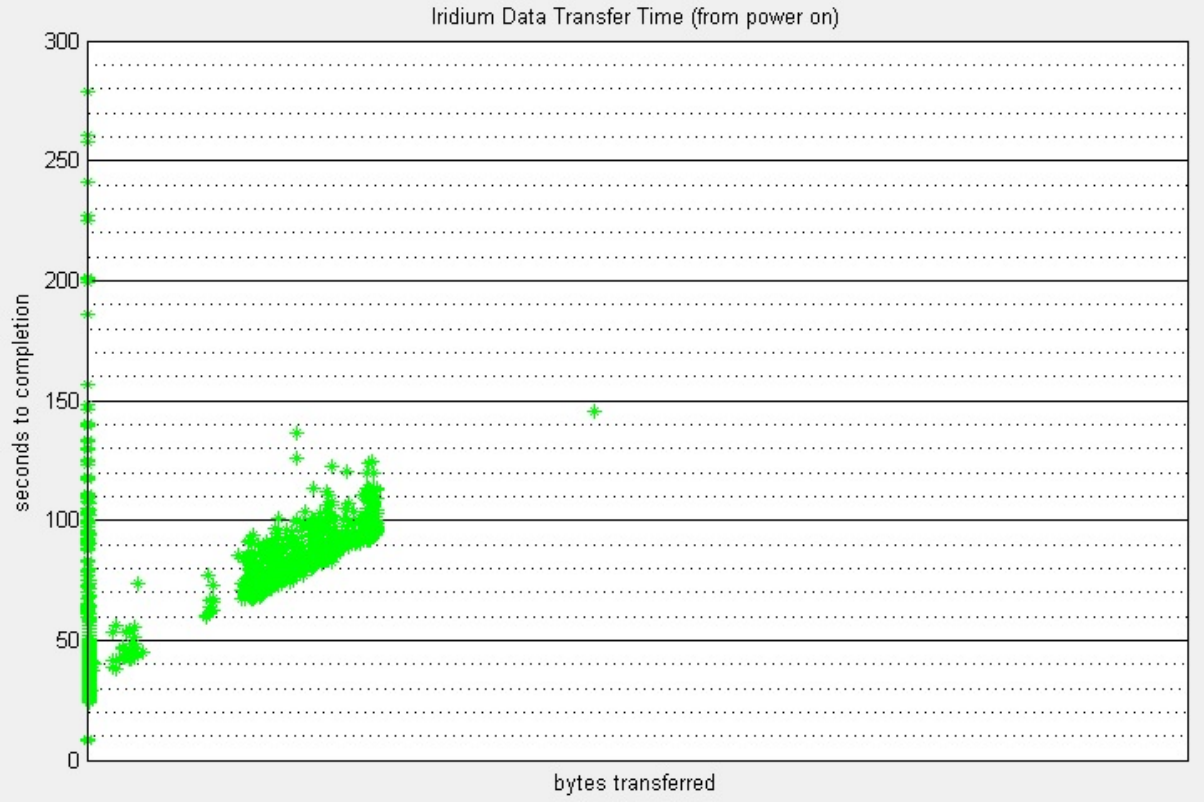


Figure 25: Time versus Data bytes transferred by Iridium dial-up

6.6 PAP1 Recovered Sensors

6.6.1 Satlantic SeaFET sensors (s/n 063 and 257)

The SeaFET sensors S/N 063 (frame) and 257 (buoy) deployed during DY032 in June 2015 were successfully recovered on 25.04.2016. The sensor slot of both instruments was covered with biofilm (Figure 27).

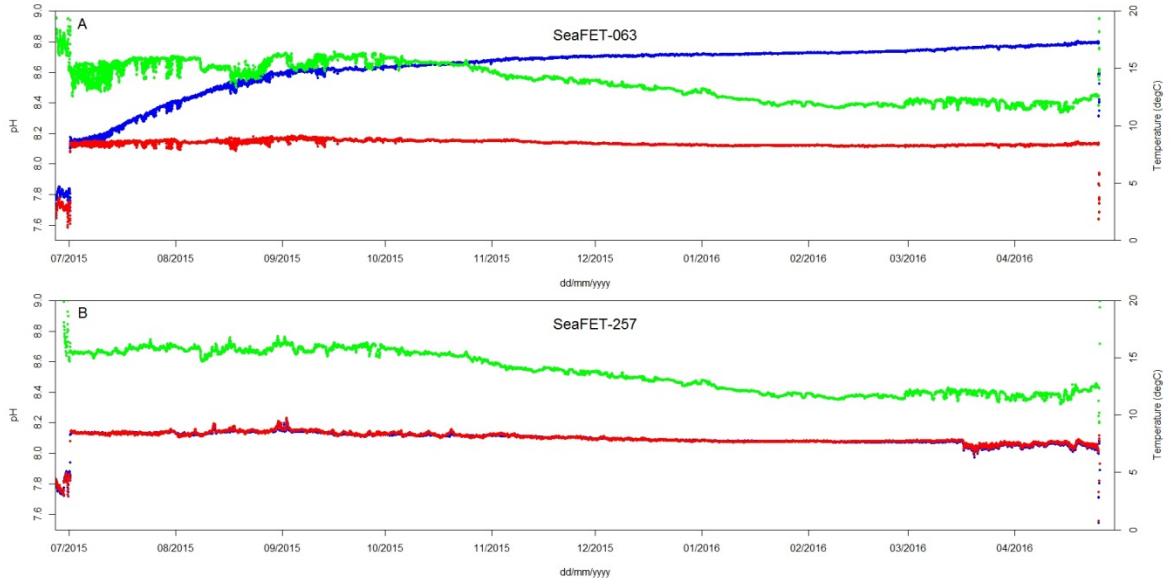


Figure 26: pH and temperature data collected by (A) SeaFET-063 (B) and SeaFET-257. The pH value measured by internal and external sensors are in red and blue, respectively. Temperature values are shown in green.

Figure 27: Biofouling on the ensor probe of SeaFET 257

The data collected over a year of deployment was successfully downloaded from the internal memory of both instruments. The SeaFET-063 was recording data from 22.05.2015 till 25.04.2015, while the SeaFET-257 was recording from 19.05.2015 to 25.04.2016.

Upon recovery, the performance of the sensors was tested using the same set of CRMs as for SeaFETs deployed during DY050 and following the procedure described in Section 6.4.7. The results of post-deployment calibration are summarised in **Error! Reference source not found.**. The offset between the measured pH and CRM values are shown in Figure 28 (A, C). Due to a relatively large offset observed for both SeaFETs, a repeated test with CRMs was conducted (see Table 9 and Figure 28 (B, D).

The uncorrected data collected by SeaFETs is shown in

Figure 26.

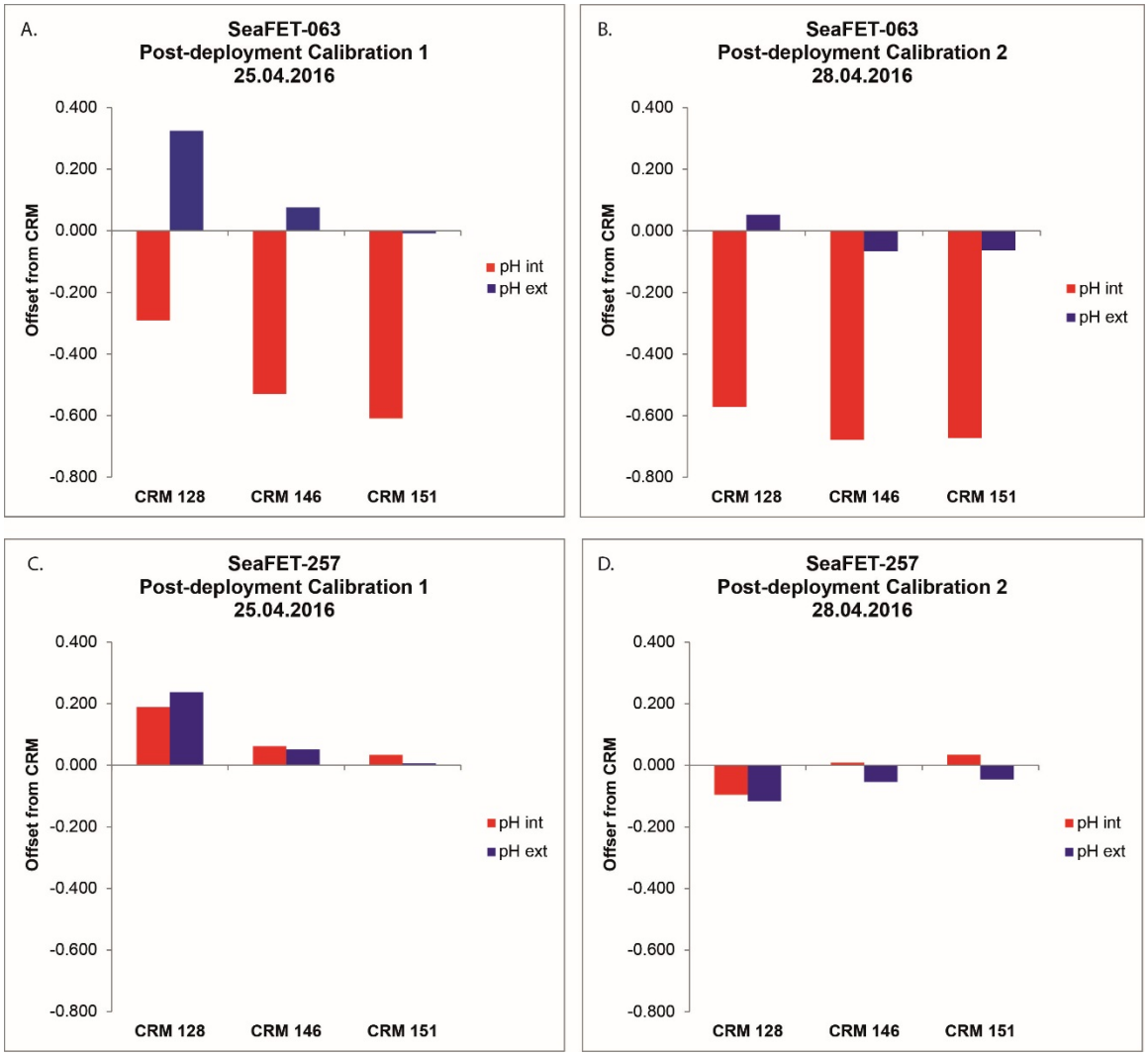


Figure 28: Results of the post-deployment calibration tests for (A,B) SeaFET 063 and (B, C) SeaFET 257. The columns show the difference between the pH of CRMs and the values measured by internal (red) and external (blue) pH sensors of the SeaFETs.

6.6.2 Nitrate ISUS sensor (s/n 059)

ISUS nitrate sensor deployed on a frame in June 2015 during DY032 cruise was successfully recovered on 25.04.2016. The data from internal memory of the instrument was downloaded immediately. ISUS was recording data from 20.06.2015 to 24.04.2016. The copper guard of ISUS corroded significantly over the deployment period (Figure 30), which might have affected the performance of the sensor.

A post-deployment calibration test was performed on 27.04. 2016 using DIW, low nutrient sea water (LNSW), and a set of nitrate standards (0.6 µM, 2.5 µM, 5 µM, 11 µM) prepared from 5900 µM nitrate stock solution. The exact concentrations of these standards will be determined using Nutrient AutoAnalyser at National Oceanography Centre Southampton. The initial calibration test revealed a lot of noise in the nitrate data and a large offset in nitrate concentrations (3.41±1.88µM) measured in DIW and LNSW samples. The real-time data observed along the year (see Figure 29) also showed a shift of the concentration data consistent with the first calibration.

For the second calibration run (29.04.2016), the sensor probe was cleaned with DIW and a tissue, and the test in DIW was performed again. The offset however persisted, indicating an overall drift in the accuracy of the sensor. The calibration update procedure was then conducted using DIW and 'Update Calibration' option in the ISUSCom main menu. DIW sample and nitrate standards (5.9 µM, 11.8 µM, 23.5 µM) were subsequently tested (Figure 31).

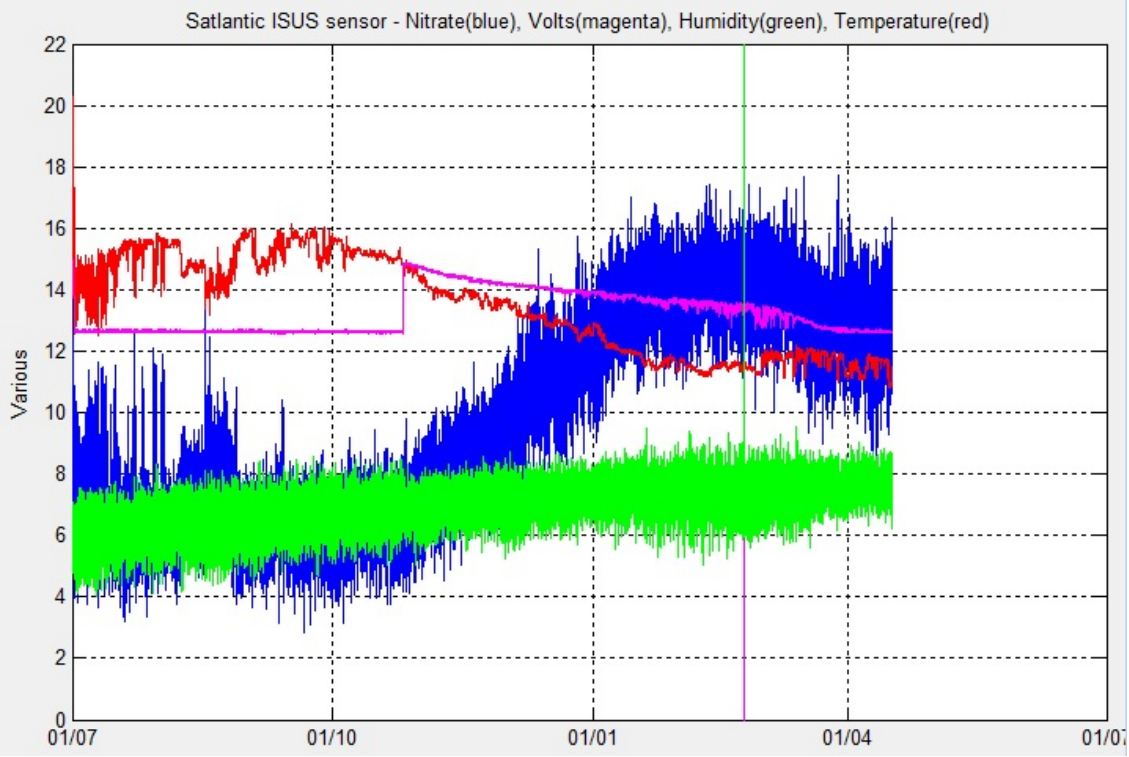


Figure 29: ISUS real time data during deployment 2015-2016

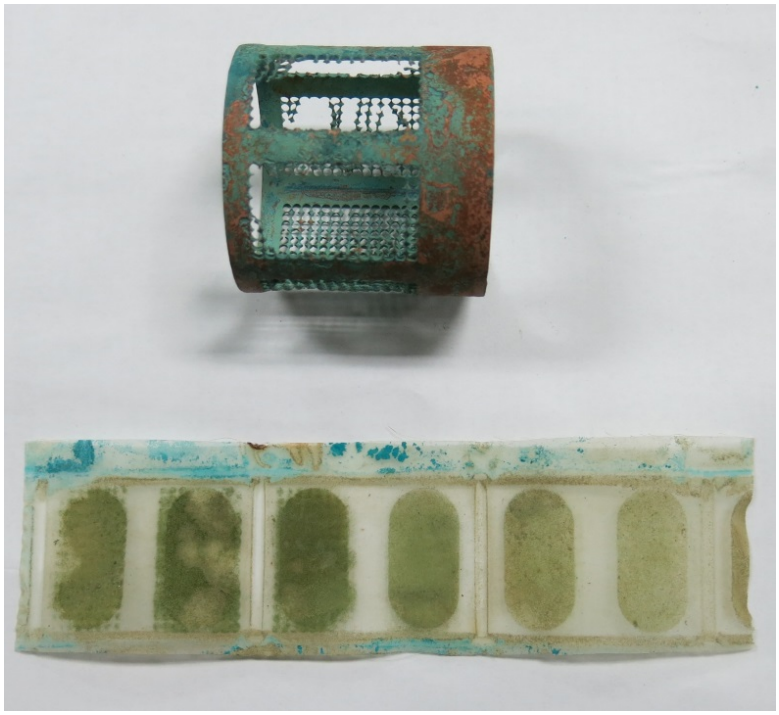


Figure 25: Corroded copper guard of ISUS nitrate sensor

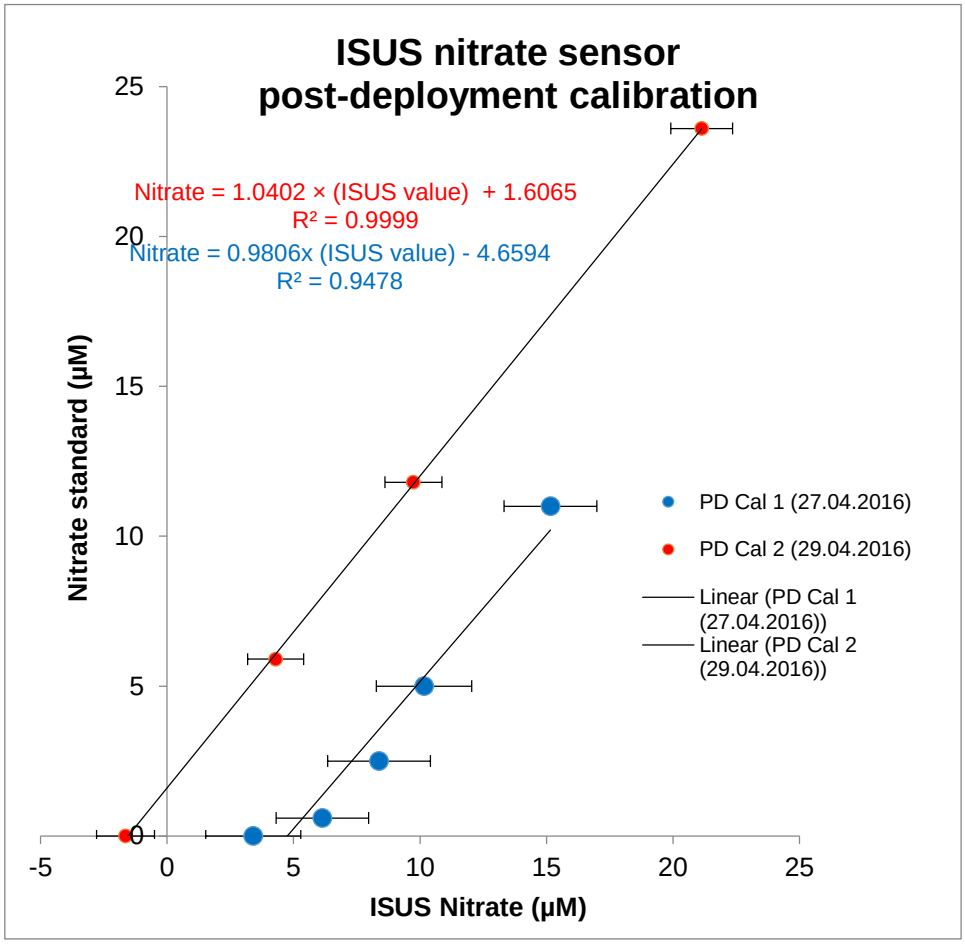


Figure 31: ISUS nitrate sensor post-deployment calibration results

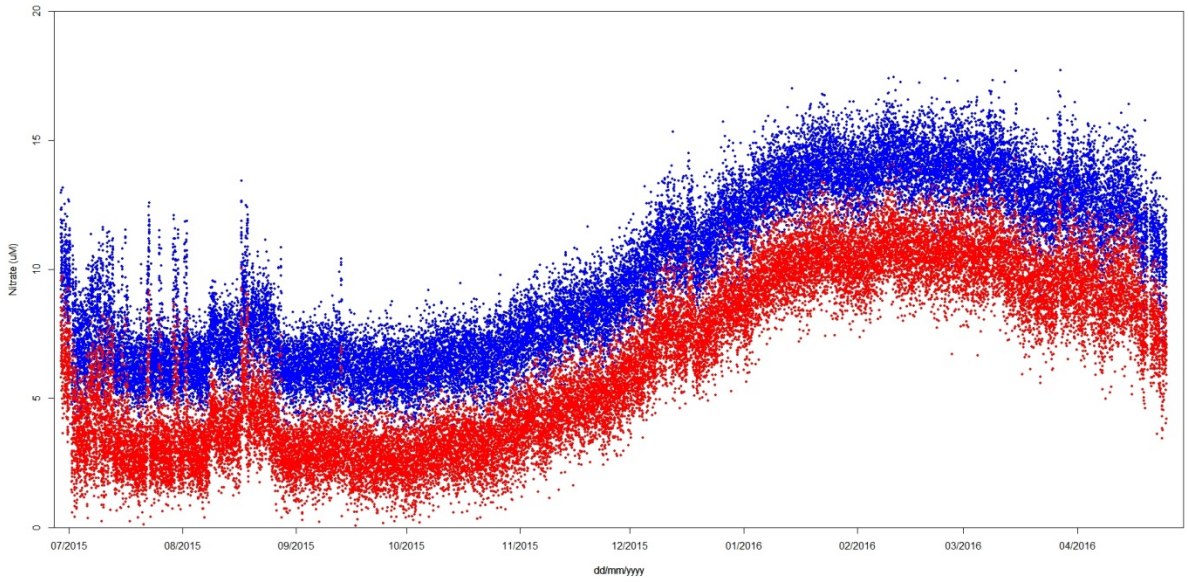


Figure 32: Uncorrected (blue) and corrected (red) nitrate data collected with ISUS sensor.

Although the average nitrate value for DIW (-1.67±1.15) was within the Satlantic recommended value of 0±2 µM, we note a persistent large standard error regardless the calibration update. The cause of this problem will be investigated with the Satlantic team.

The nitrate concentrations measurements that we recovered from the ISUS are shown in Figure 32. The uncorrected values are shown in blue. In red are nitrate values corrected for an average offset of 3.41±1.88µM determined during post-calibration tests. Note, that it is unknown at which point during the deployment this offset developed.

6.6.3 Pro-Oceanus CO2-Pro s/n 29-097-45 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. Figure shows the data during the deployment period. The sensor stopped sending data at the beginning of March. When recovered we did not see any sign of damage and it was operational when connected to the PC. This indicates a failure of the harness that connects the sensor to the telemetry unit. The sensor was covered with biofouling as shown by Figure 23. However, this is unlikely to stop the sensor providing data and we would expect at least non-sense data received through PAP0003. A first assessment of the cable indicates a possible failure in the

junction between the pump and the sensor. It is recommended a more careful assessment of the location of the harness failure to provide more information for future deployments.

6.6.3.1 Pro-Oceanus logging CO2-Pro s/n 34-200-45 at the frame

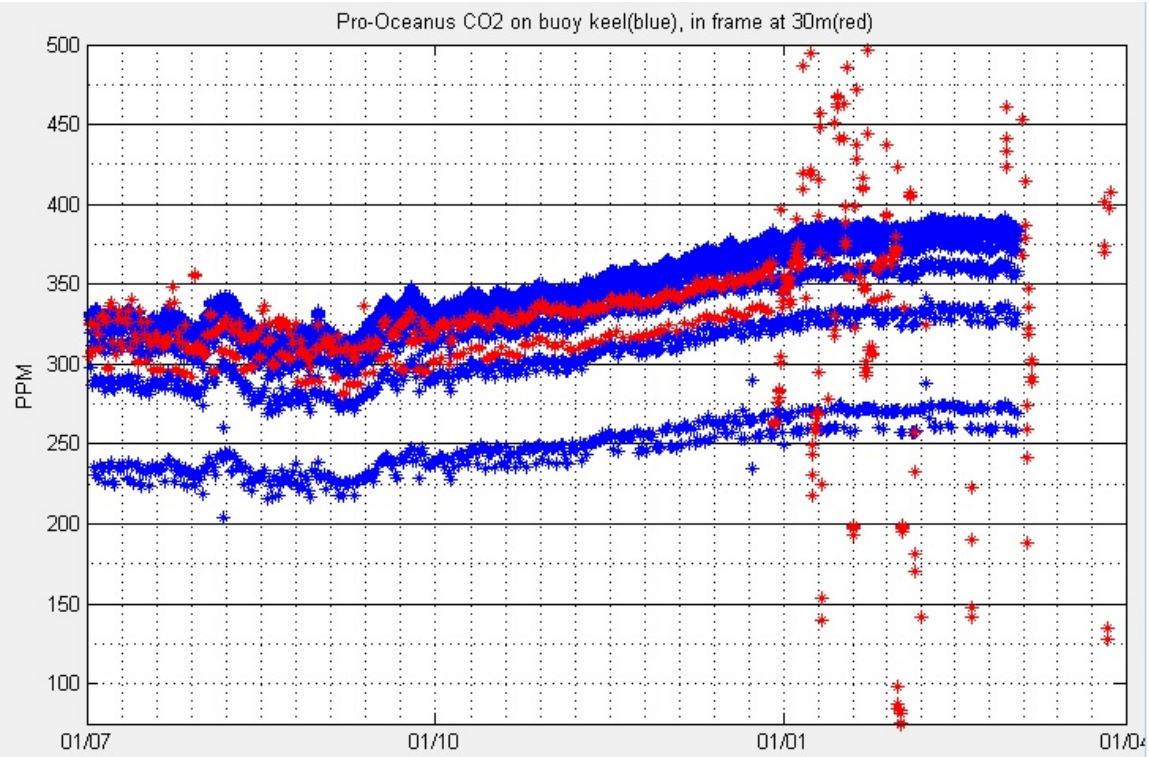


Figure 33: Uncorrected CO2 concentration data from the sensors on the buoy (blue) and the sensor frame at 30m (red)

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 until the end of December (see Figure 33). At that time the data started to diverge and it stopped sending any data at the beginning of March with intermittent stops. After recovery, we discovered that the electronics inside was loose which explains the failure during the deployment.

6.6.3.2 Pro-Oceanus GTD-Pro s/n 33-152-16 at the frame

A GTD-Pro gas tension sensor (s/n 33-152-16) 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 have waited to see if it stabilise.

This sensor gave normal readings of pressure while on deck. The increasingly high and unfeasible readings as soon as it entered the water made us believe that there was some kind of malfunction. The sensor was turned off after reaching to the conclusion that it was leaking. However, after recovery the sensor does not have any indication of water inside the tube and it is sampling data and communicating to the PC. The sensor would probably be sampling if we have not have send the command but the samples would probably not be reasonable. The sensor should be sent for inspection to the company, especially considering that we use an old sensor that was in the shelves for a long time.

6.6.4 Sea-Bird SBE 37 MicroCATs

Three Microcats were recovered from the 2015-2016 deployment. The 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. Sea-Bird sensors SBE 37-ODO (s/n 10535) and SBE 37-IMP (s/n 6904) 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. On March 2015, the SBE 37-ODO (s/n 13397) sensor was purchased and the SBE 37-ODO (s/n 10535) was serviced and recalibrated by Sea-Bird.

The sensors on the frame stopped the inductive communications with the telemetry system on mid-March 2016 indicating a problem with the inductive cable. In fact, the sensor on the buoy continued to send the data and therefore the problem and all three sensors recorded the data internally until they were recovered. The sensors recorded for 302 days since they were started on 2015/06/28 and recorded 14502 samples at the buoy and 14725 samples (ODO) and 29490 samples (ODE). The problem with the real time data was likely to come from a failure of the harness.

The data from the buoy is consistent with the values from the SensLab for temperature and conductivity. The values of oxygen are also consistent with the Seaguard measurements although the latest was biofouled and showed large scattering. The results from the MicroCAT on the buoy are surprising considering the large amount of biofouling. However, all these sensors were probably affected in same degree by biofouling.

6.6.5 Satlantic OCR-507 Radiance and 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 controlled an OCR-507 ICSW upward-looking irradiance sensor (s/n 287) and an OCR-507 R10W downward-looking radiance sensor (s/n 113). 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. The irradiance sensors on the buoy and frame were covered of biofouling and have lost their copper Bioshutter (see Figure 35). The radiance sensor in the frame (see Figure 34) looked physically fine.

Figure 34: Upward-looking irradiance sensor s/n 113

Figure 35: Upward-looking irradiance sensor s/n 287

The irradiance sensors in the frame and the buoy sampled and sent the data via iridium through the telemetry unit for the entire deployment. However, the looking downwards radiance sensor in the frame failed to send data in 29th October 2015. The cable seems to fail at the level of the sensor-bioshutter junction and the meter indicates a connection between pins 4, 5 and 6 which are the serial pins. In fact, the assessment was performed a week after recovery and the harness may have dried in between. Other wires probably started short-circuiting explaining why the data hub re-started at the time when OCRs were scheduled to turn on.

6.6.6 Wet Labs flnt usb fluorimeter

On recovery the instrument has some biofouling but the optical window was successfully kept clean by the copper shutter

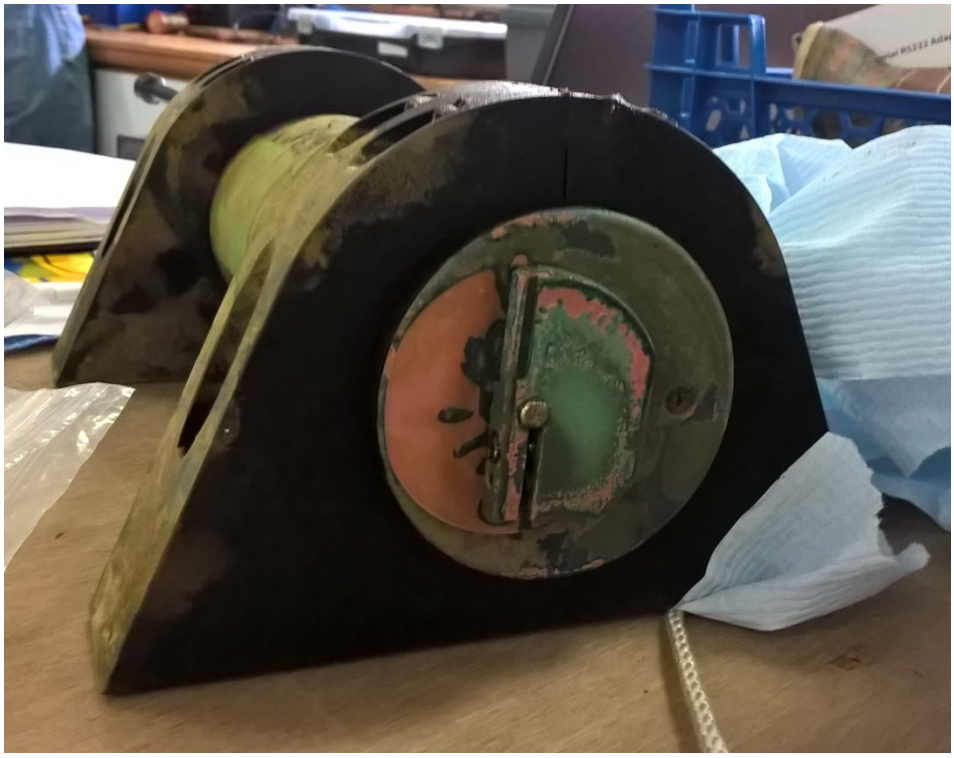


Figure 36: wetlabs s/n 3050 effective copper wiper

The recovered wetlabs fluorimeter was cleaned down with fresh water and deployed on a calibration cast to 200m.

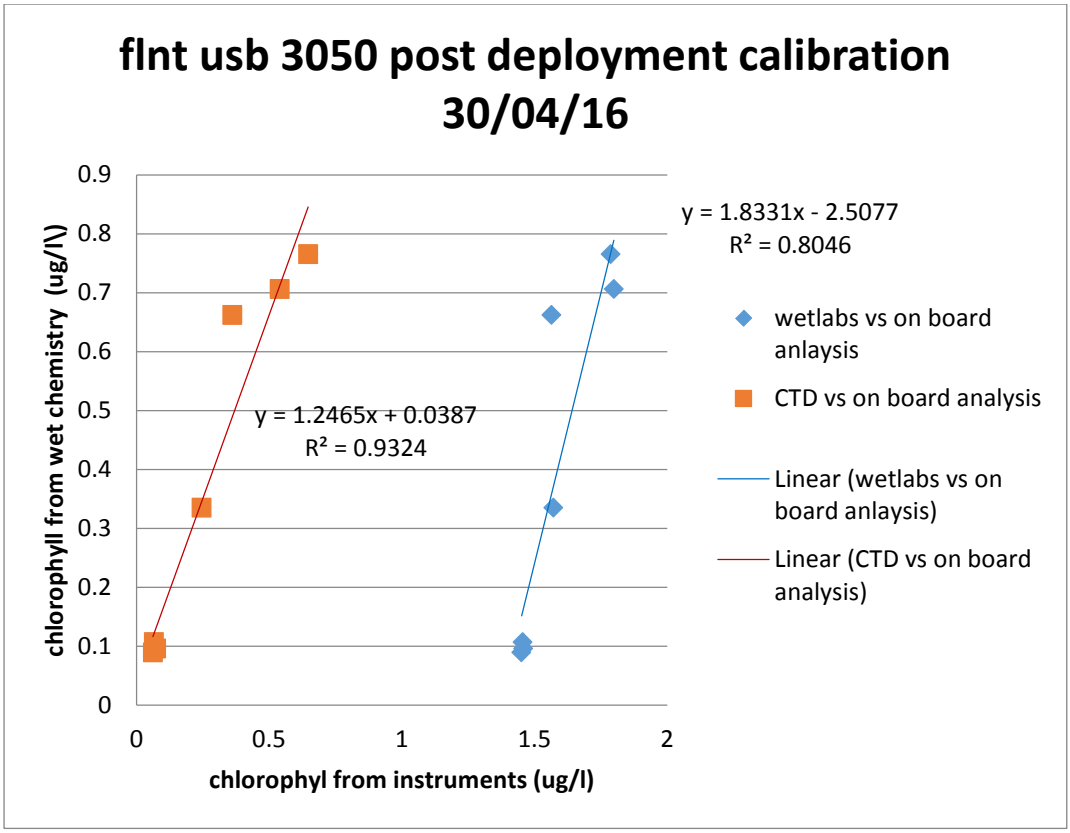


Figure 37: wetlabs s/n 3050 chlorophyll calibration

The post deployment calibration was reasonably successful with an r2 of 0.8. This calibration can be retrospectively applied to the data generated since deployment in June 2015.

6.6.7 Recovery of Seaguard s/n 1614

6.6.7.1 Recovery Status

A RCM Seaguard with oxygen optode (Aanderaa 4330, S/N 2001) and fluorometer (Turner cyclops, S/N 2103960) were part of the sensor frame of the PAP1 that was recovered in 25/04/2016.
Data had been continuously received from the Seaguard since deployment, only occasionally lost through a separate issue with shore side servers, but all data is also stored locally to the sensor so full data sets were available upon recovery.

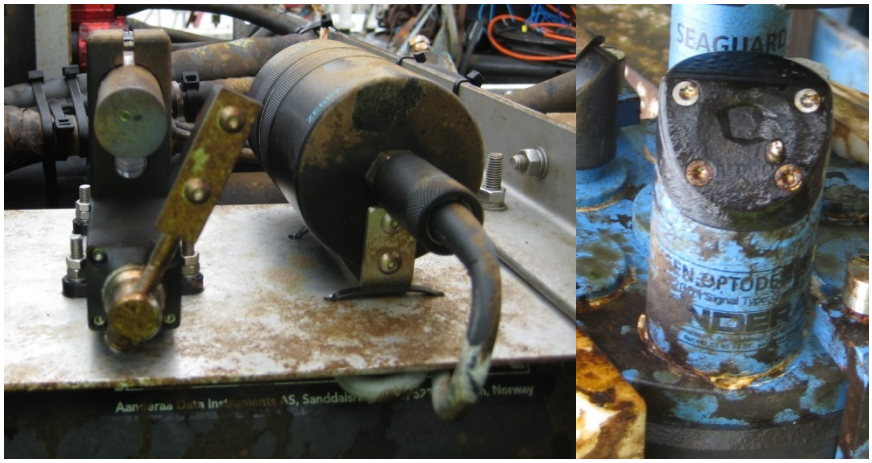


Figure 38: Image of flurometer and optode post deployment. Biofouling covers nearly all surfaces equally, including the sensing surfaces.

First impressions upon recovery were that the Seaguard had fared well. Biofouling was noticeable across all surfaces but did not appear to be debilitating. A partial success was the fluorometer sensing window that was serviced on deployment by a ZebraTech wiper (set to activate every 6 hrs). It appears that the operation failed at some point as there was slight biofouling on the surface of the fluorometer, **Error! Reference source not found.**. Manually passing the wiper across the fluorometer completely cleared the biofouling, indicating it had been out of operation for probably a few weeks. Another site of concern was the optode window that had biofouling across the membrane, Figure 38.

The sacrificial anode had performed its role and was noticeably corroded but approximately 50 % of its bulk remained. Its integrity is severely impaired and now crumbles easily. Some corrosion was noted around the G-clamps used to keep the instrument sealed within its pressure casing. The corrosion appear to match wear scratches in paintwork had occurred and around the bolts of the G-clamps.

Once removed from the PAP1 sensor frame the Seaguard was washed down with plain cold water and wiped with blue roll to remove as much of the growth on the unit as possible. Care was taken around the optode and fluorometer sensor windows, using kimwipes and MilliQ - and no scrubbing.

The Seaguard was still powered when removed from its pressure housing; no water ingress beyond the o-ring seal was noticed. Recording was halted and the two alkaline batteries reported a voltage of 6.9 V (7.6 V is considered the lowest level to be used by the instrument).

With the spare capacity of the SD card it is likely if future deployments employed lithium batteries for the Seaguard an increase in the sampling rate could be easily accommodated by the SD card.

An operational check was conducted with the Seaguard and it took readings at the expected intervals, without checking the accuracy of the readings the Seaguard appeared in good health.

Full data sets from Seaguard deployment

Figure 39 is the deployed data from the fluorometer and Figure 40 the deployment data from the oxygen optode. Both data sets do not have the pre-deployment calibrations applied.

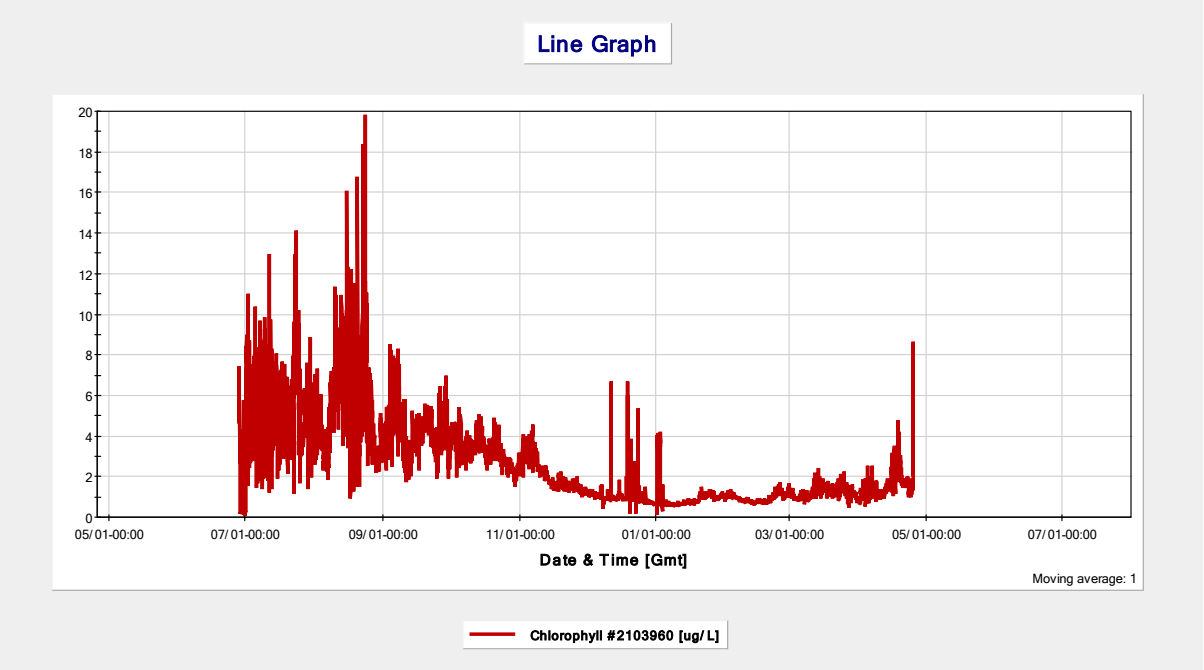


Figure 39: Screenshot of chlorophyll data collected by fluorometer during deployment, please note this data does not have pre-deployment calibrations applied.

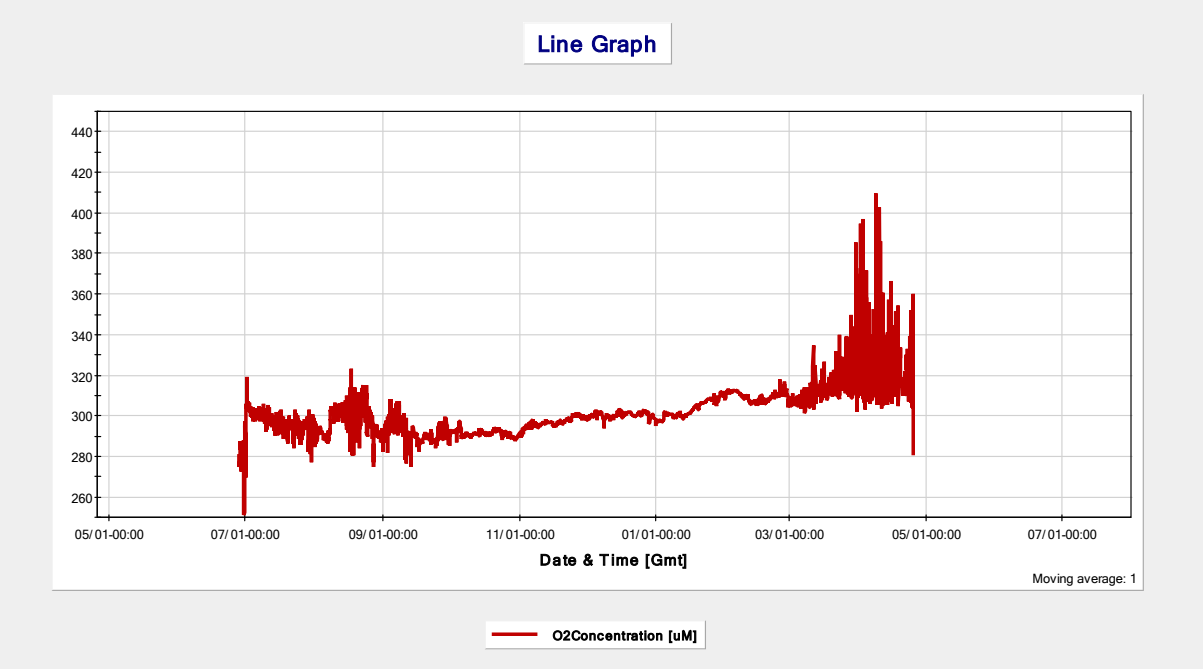


Figure 40: Screenshot of oxygen data collected by optode during deployment, please note this data assumes zero salinity and sea level pressure and does not have pre-deployment calibrations applied.

6.6.7.2 Post deployment calibration check of Seaguard

The deployment batteries were replaced and the Seaguard was mounted on a CTD frame for a cast to 200 m. Waters were collected by Niskin and later analysed through Winkler titration. The fluorometer was compared with chlorophyll readings, also analysed on board from the collected waters.

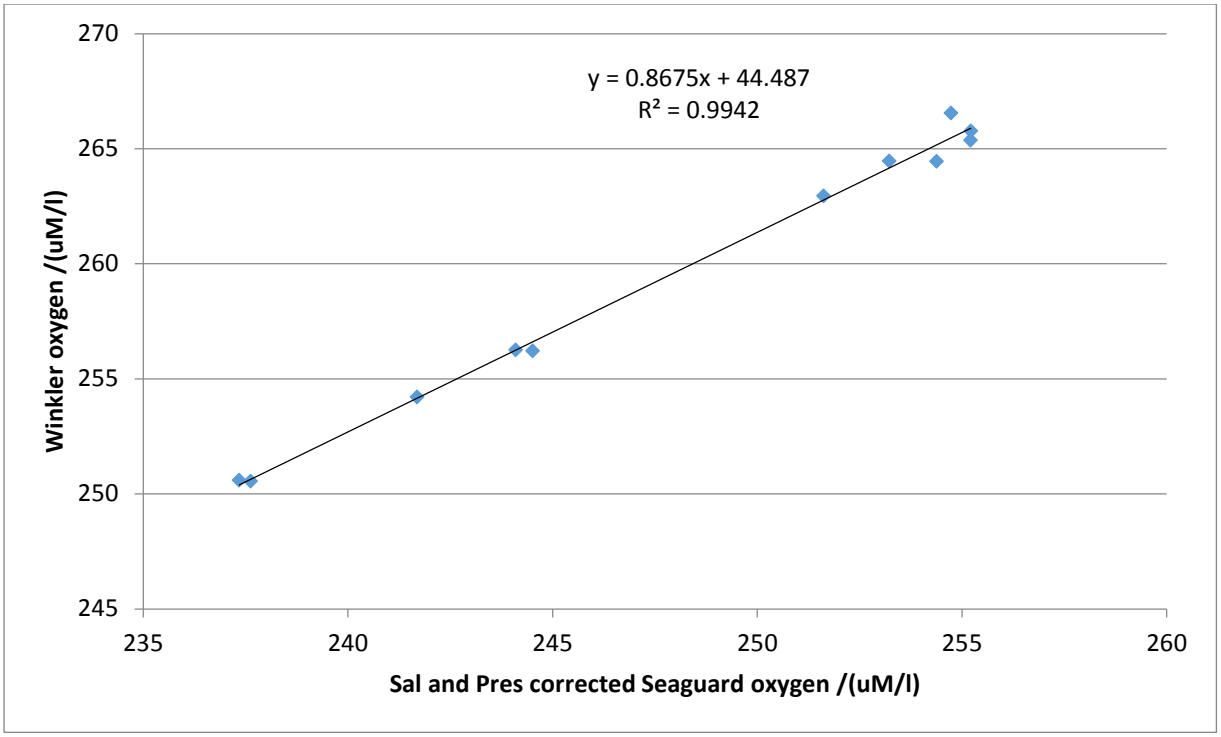


Figure 41: Seaguard pre-deployment calibration from 2015.

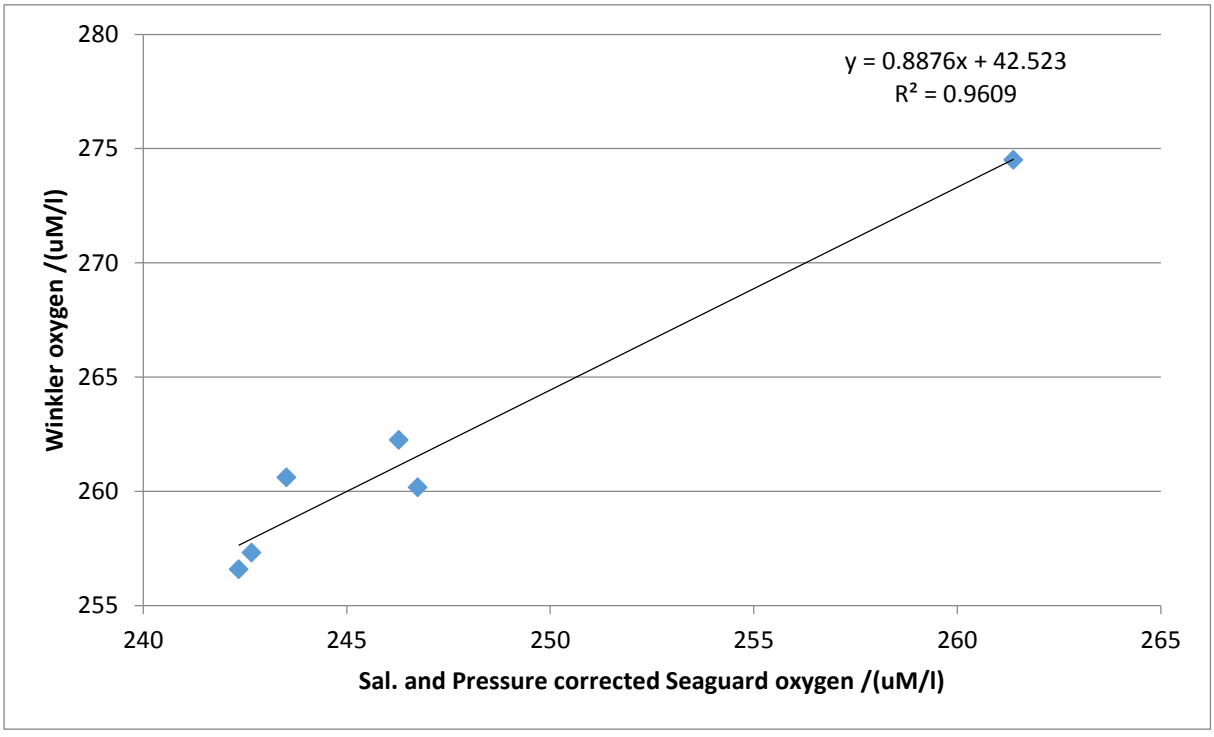


Figure 42: Seaguard post deployment calibration from 2016.

The Seaguard was cleaned post deployment, removing any biofouling. Therefore if biofouling has been the cause of drift whilst on deployment it is not directly revealed in the post calibration cast. The resulting difference between the two calibrations is equivalent to ≈ 2.8 µM/l at 250 µM/l.

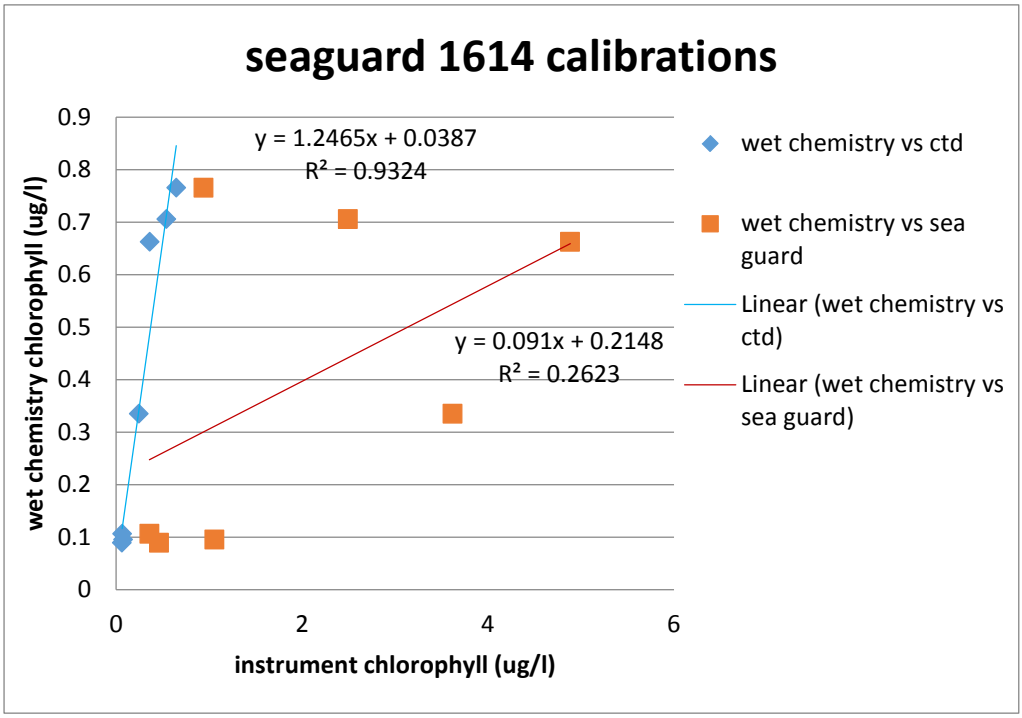


Figure 43: chlorophyll calibrations for turner fluorimeter

Chlorophyll samples were collected on the CTD cast and analysed on board using a Turner bench top fluorimeter courtesy of Alex Poulton. Whilst the comparison in Figure 43 with the fluorimeter on the CTD was close there was a greater difference with the Seaguard fluorimeter reflected in the r2 of 0.263. This can now be applied to correct data collected over 2015/16.

6.6.8 Wetlabs CYCLE phosphate sensor sn 164

We learned from the previous year deployment that the reason of failing taking measurements was likely to be related to the compression of the outlet tubes (see recovery section for more details). Therefore, we decided to cut the tubes instead of tying them to the frame.

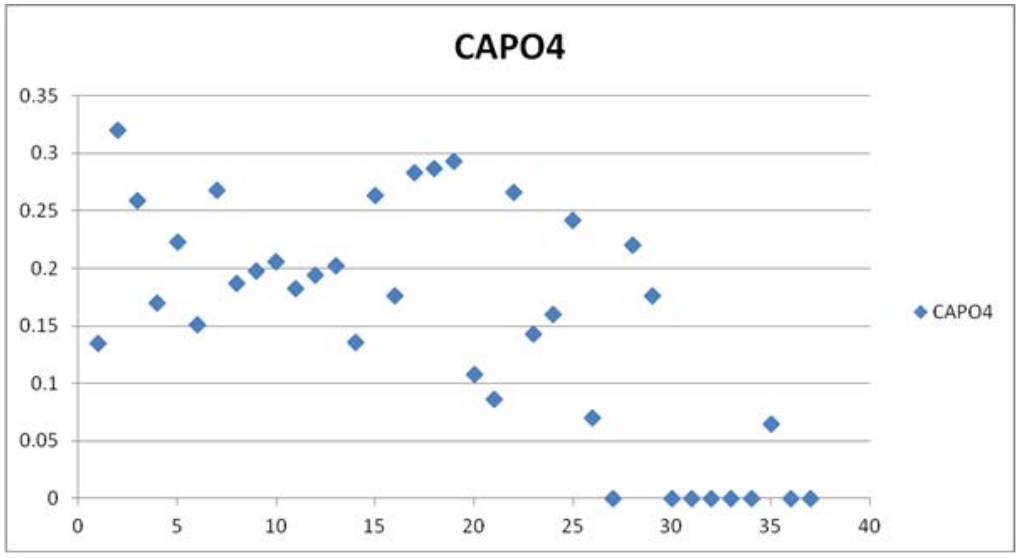


Figure 44: Measured phosphate (umol/l) from the cycle, which gave data for approximately three weeks after deployment then read zero

The deployment totalled 74 files which translates on the summary file to 37 readings, each file 1640001-16400025 looks OK, but after this there is a 'low power fault' on every file (aside from 16400026, 16400028, 16400029 and 16400058). This is thought to be due to the drain from trying to push the chemicals throught the over tight exhaust tube.

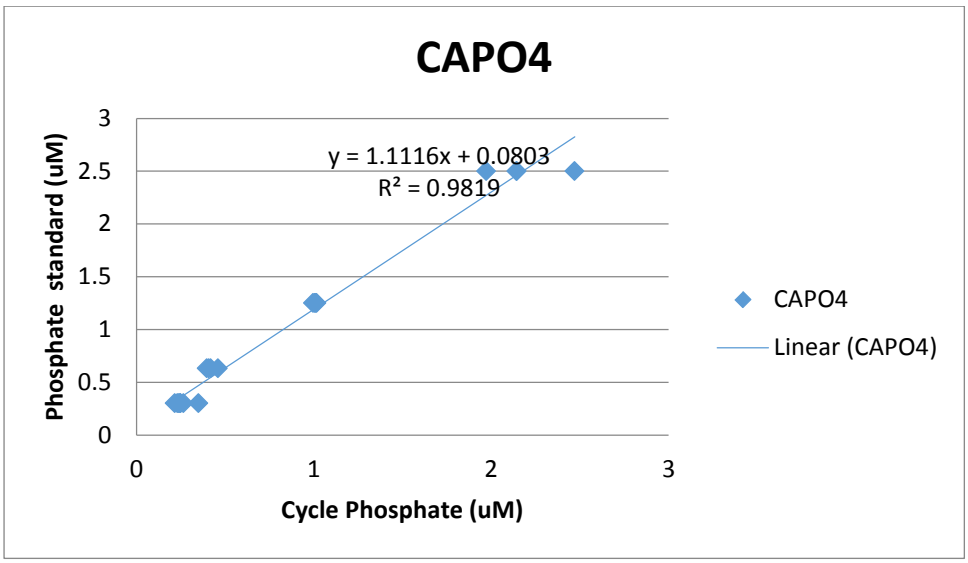


Figure 45: Measured phosphate standards on the Cycle

The recovered cycle was bench calibrated using a Phosphate standard. After each set of readings the standard was approximately halved in concentration. Exact concentration will be confirmed by running sub samples of the serial dilutions at NOC. The uncorrected standards were plotted against

the cycles reading below and showed a good level of accuracy from the instrument. This suggests there has been no lasting damage from the problem with the waste tube.

6.6.9 Star-Oddi sensors: Recovery and Re-deployment

6.6.9.1 Recovery of Staroddis from PAP1

The recovery of PAP1 in 2016 was of the buoy and sensor frame only. The line down to the acoustic release is not scheduled for recovery until 2017 (was originally planned for 2016 but has now been deferred) and so not all of the Staroddis that have been deployed were recovered. Of the six Staroddis expected for recovery this year all returned although one no longer communicated, a summary is provided in Table 12.

Table 12: Summary of Star-Oddi status upon PAP1 recovery

Staroddi	Type	Deployment depth /m	Position	Interval type	Interval	Status
6788	DST CTD	5	Below buoy	Fixed	30 min	Recovered, data collected
6782	DST CTD	10	Below buoy	Fixed	30 min	Recovered, data collected
7728	DST CTD	15	Below buoy	Fixed	30 min	Recovered, data collected
6792	DST CTD	20	Below buoy	Fixed	30 min	Recovered but loss of communication
6784	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

Please note that the sum of the measurements made by H454 does not equal 24 hrs, this is so the one minutes burst of tilt measurements do not occur at the same time of day.

Figure 46 is an image of the six recovered StarOddis 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 six recovered units that was in a mounting block as it was also the only one mounted on the frame. The remaining retrieved Staroddis had all been secured to the cable hose running alongside the chain and held in place by cable ties and amalgamated tape near a raised bolt on the bracket (leaving the tip and base of each unit to sense the ocean).

Figure 46: Image of the five recovered Staroddis; all have been removed from the fixings that bound them to the hose/frame and have been cleaned of any biofouling.

6.6.9.2 2015-2016 Deployment Data

The recovered data was treated with the pre-deployment calibration coefficients found from last year's preparation. Initial inspection suggests the results are sensible. Taking temperature as an example all units closely agree in colder months where the surface layers of the ocean are well mixed and in warmer months the temperature recorded separates in accordance to how deep the StarOddi was mounted (deeper units recorded colder temperatures).

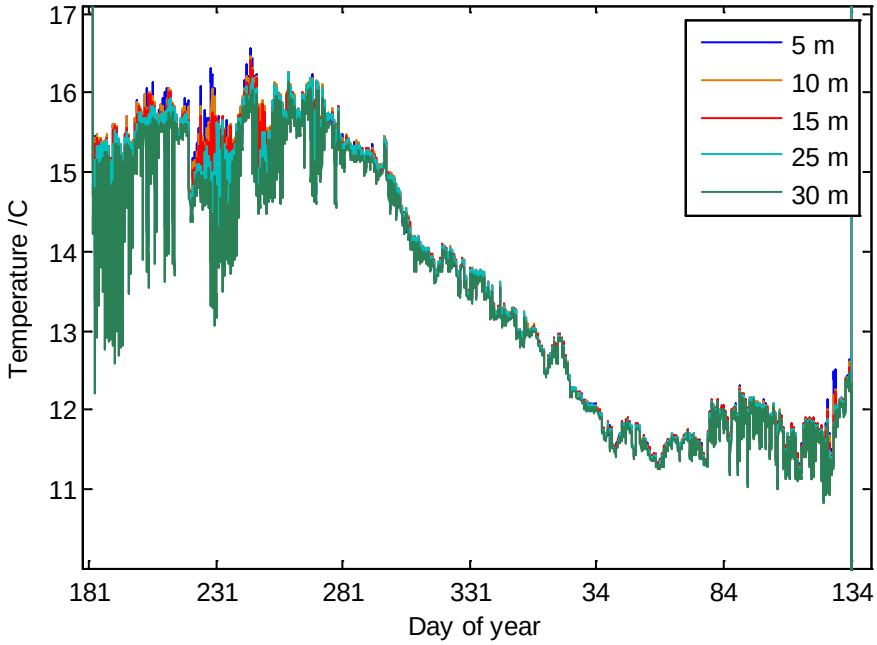


Figure 47: Complete temperature data set of StarOddis mounted at various depths.

When recovering the units it was noticeable how much more biofouling there was closer to the surface (Figure 48).

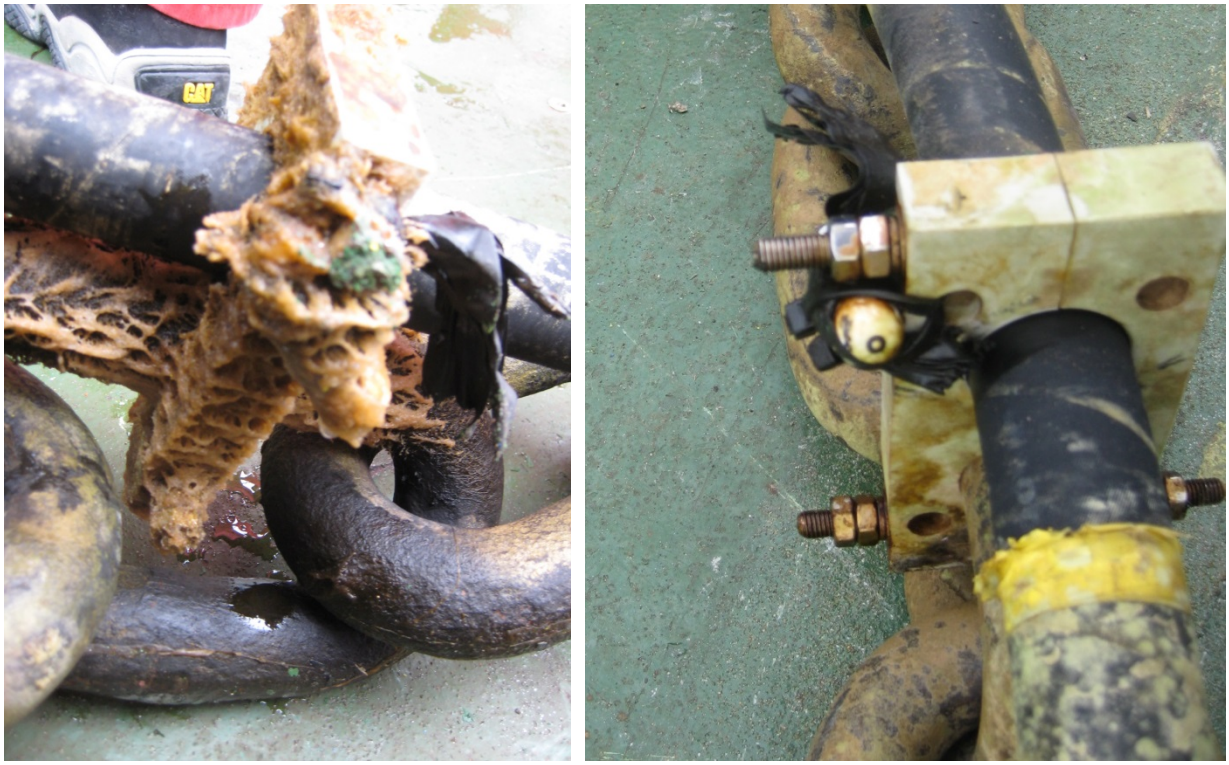


Figure 48: (left) Staroddi at 5 m depth (right) Staroddi at 25 m depth.

It is likely that this has affected the output from the StarOddis such as shown in the pressure data (Figure 49).

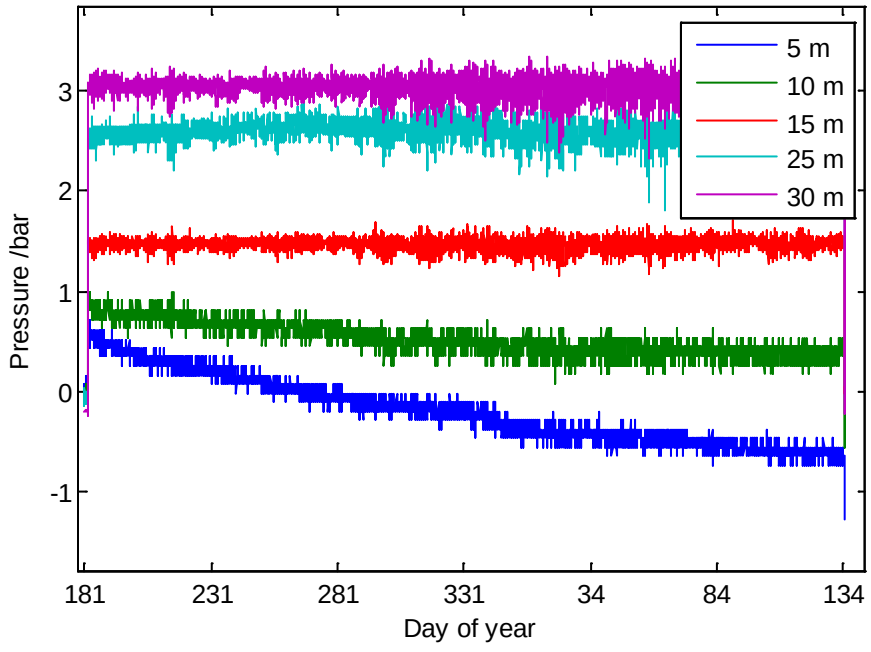


Figure 49: Complete pressure data set of StarOddis mounted at depths.

The pressure data in Figure 49 shows drift in sensor output, which appears worse depending on how close to the surface the StarOddi was placed. Since the StarOddis nearer the surface experienced greater levels of biofouling this drift could be attributed to that cause.

6.6.9.3 Post-deployment calibration

The StarOddis recovered that were not re-deployed or were no longer communicating underwent a post-deployment calibration. All biofouling had to be removed to download data and restart running, as a consequence the post-deployment calibration cannot be used to understand the effect biofouling may have had on readings taken.

Table 13: Pre-deployment and post-deployment calibration comparison

StarOddie	**Pre-deployment calibration 2015**	**Post-deployment calibration 2016**	**Test value (2015-2016)**
S6782			
Temperature	1.000x+0.03529	0.9838x+0.2083	-0.011 °C (@ 10 °C)
Pressure	0.97849x+12.9	0.9863x+13.46	-0.580 bar (@ 2.5 bar)
S6784			
Temperature	1.005x-0.02085	0.9879x+0.1709	-0.021 °C (@ 10 °C)
Pressure	0.9975x-0.8931	0.9945x-0.8756	-0.01 bar (@ 2.5 bar)
S7728			
Temperature	0.9929x+0.1279	0.9907x+0.1239	+0.026 °C (@ 10 °C)
Pressure	0.9781x-0.01775	0.9781x+0.01375	-0.032 bar (@ 2.5 bar)

The largest change was in the pressure measurement of S6782. This change closely matches the drift of the sensor from the deployment data.

Note that salinity has not been compared as there was not enough of a variation in the shallow CTD casts to enable a calibration.

6.6.9.4 Deployment of Staroddis from PAP1

For the DST CTD type Staroddis that were located on the chain direct replacements were made with units that had greater battery capacity, an exception being S6788 which was immediately redeployed. The DST tilt that had been fixed to the frame was also re-used as a newer replacement was not available.

Table 14: Summary of Staroddis deployed at PAP1 following re-deployment of frame and buoy

Staroddi	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	28/12/2019 Mem. 73% Batt. 45%
7724	DST CTD	10	Below buoy	Fixed	30 min	28/12/2019 Mem. 73% Batt. 45%
7725	DST CTD	15	Below buoy	Fixed	30 min	28/12/2019 Mem. 73% Batt. 45%
7727	DST CTD	20	Below buoy	Fixed	30 min	28/12/2019 Mem. 73% Batt. 45%
7729	DST CTD	25	Below buoy	Fixed	30 min	28/12/2019 Mem. 73% Batt. 45%
H454	DST tilt	30	Frame	Multiple Interval	Tilt: 1 s x 60 measurements; Temperature: 30 min x 48 measurements	09/09/2017 Mem. 100% Batt. 57.7%
7561	DST CTD	50	Below frame	Fixed	30 min	Deployed 2014
7562	DST CTD	75	Below frame	Fixed	30 min	Deployed 2014
7563	DST CTD	100	Below frame	Fixed	30 min	Deployed 2014
7564	DST CTD	150	Below frame	Fixed	30 min	Deployed 2014
7565	DST CTD	250	Below frame	Fixed	30 min	Deployed 2014

7566	DST CTD	400	Below frame	Fixed	30 min	Deployed 2014
H457*	DST tilt	1000	Sub-surface buoy	Fixed interval	45 min	Deployed 2014

*rated to 3000 m

All units being deployed this year were set to start at 12:00 28th April 2016.

As mentioned H454 was re-used and replaced on to the frame in the block holder, Figure 50. The orientation of H454 was modified to what it was last year. This year the z-axis of the tilt sensor is aligned to the vertical line of the frame when deployed – this is in line with the guidelines set out by the manufacturer.

Figure 50: H454 being secured to cross bar of sensor frame before PAP1 deployment.

The remaining StarOddis being deployed were spaced 5 m apart from the bottom of the water line in accordance with the information in Table 14. The StarOddis on the hose were always placed on one of the brackets used to keep the hose and chain together. In the past a number of these brackets had split in the middle so the Staroddis 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 Staroddis as the chain and hose slip over the deck on deployment and recovery. This methodology has proven successful with all units mounted in this way returning after deployment with no obvious physical damage.

Once again the Staroddis on the hose were first wrapped in self-amalgamating tape then secured with cable ties and further tape. Finally electrical tape was used to highlight there placement for care

during deployment and easier identification upon recovery, Figure 51. The tip and base of each Staroddi was kept free to allow full operation.

Figure 51: Staroddi secured on bracket along cable hose at 15 m mark.

7 PAP3 Mooring

7.1 Sediment Traps

By Corinne Pebody

The 2016/17 PAP#3 sediment trap moorings were deployed and the 2015/6 traps recovered on 24th April 2016. Traps A, B, C and D were recovered successfully. On recovery, the bottles were removed and lids screwed on before removing to the general purpose lab. The bottles were photographed (see Figures 52, 53 and 54) and the pH checked. Then 1ml of formalin was added before the bottles, an extra layer of parafilm was added then the lids replaced and samples stored in the chill room.

Figure 52: Bottles from 3000m 2015 – 2016 with bottle 14 showing the spring bloom has started to export material already.

Figure 53: Bottles from 100mab showing the export has reached the seabed.

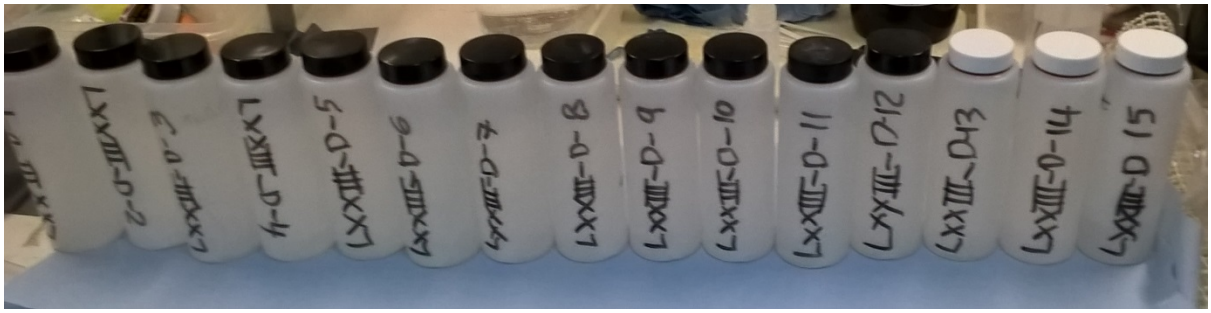


Figure 54: Bottles from the 3000m inverted trap. The bottles were empty except for 14 which had a medusa.

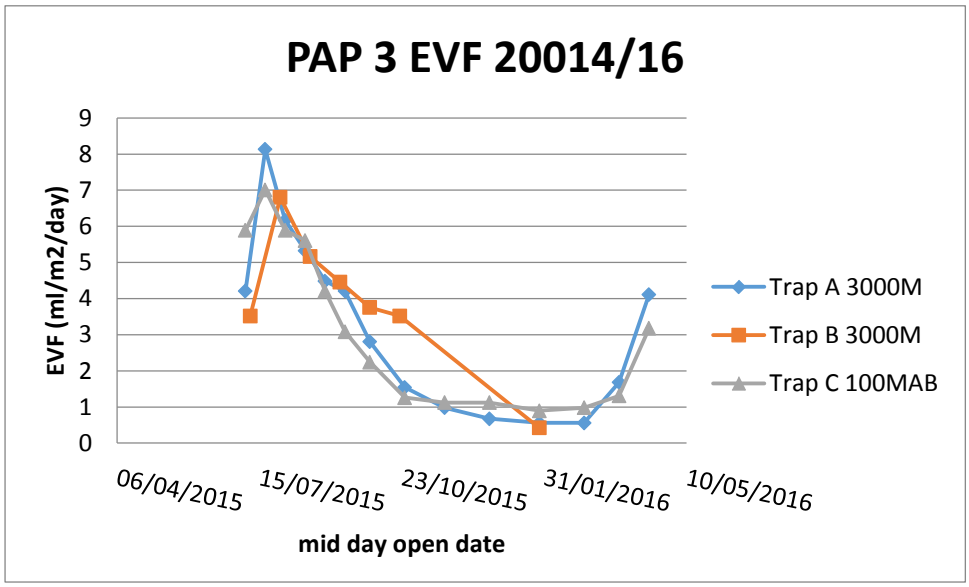


Figure 55: Estimated volume flux 2015/16

The bottles were measured to estimate volume flux (a quick bit reasonable measure of the particle flux) over the deployment year. Figure 55 illustrates the summer bloom of 2015, the drop off over winter and the 2016 bloom. This was suspected before the cruise as the instruments at PAP 1 were showing a spikey fall in nitrate and a similarly spikey increase in chlorophyll.

7.2 BioOptical Platform

By Christian Konrad, Clara Flintrop, Morten Iversen

7.2.1 Using the BioOptical Platform (BOP) to study long-term aggregate dynamics as part of the PAP3 Mooring

We developed a new method to follow aggregate dynamics throughout a whole year by combining in situ optics with gel traps. The BioOptical Platform (BOP) uses an optical system to determine size-distribution, abundance and size-specific sinking velocities of settling particles every day throughout a whole year. Additionally, it collects the settling particles in a viscous gel over different time intervals throughout the year. The BOP system is based on a modified sediment trap (Fa. KUM GmbH) where we have replaced the collection funnel with a polycarbonate cylinder to avoid that the settling particles are sliding down the sides of the funnel, which would change the physical structure. The polycarbonate cylinder has an inner diameter of 35 mm and functions as a settling column and allows us to measure the settling velocities and sizes of the particles without interference from ocean currents (Figure 1). This is done with a camera system that is placed at the lower part of the settling column. The camera system consists of an industrial camera (Fa. Basler), a fixed focal length lens (Fa. Edmund Optics) and the system electronics consisting of single board computer including a SSD hard disc and custom made power and time management circuitry. The images are illuminated by a custom made visible light source providing backlight. The whole camera system is powered by a Li-Ion battery (24V, 1670Wh, Fa. SubCTech GmbH) (2). The camera system makes 5 min of recordings every day. Once the particles have settled through the settling column they are collected in cups filled with a viscous gel that preserves their size and physical structure. The gel cups are placed on two rotation tables capable of carrying 40 gel cups (Figure 56).

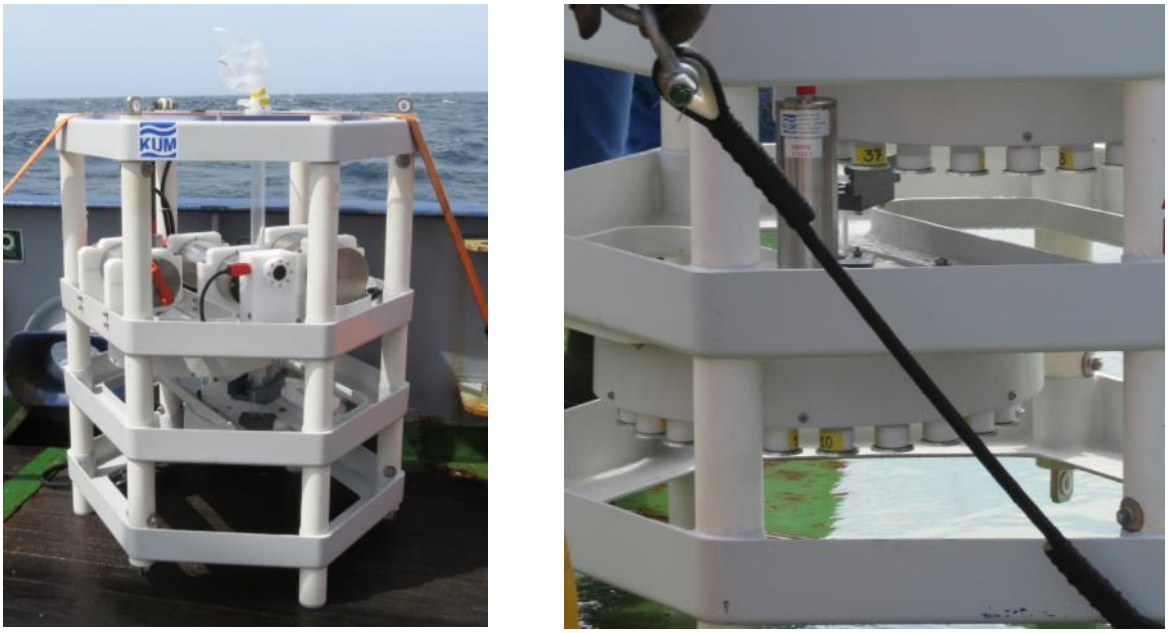


Figure 56: The BOP system with the polycarbonate settling column (left image) and the two rotation tables (right image).

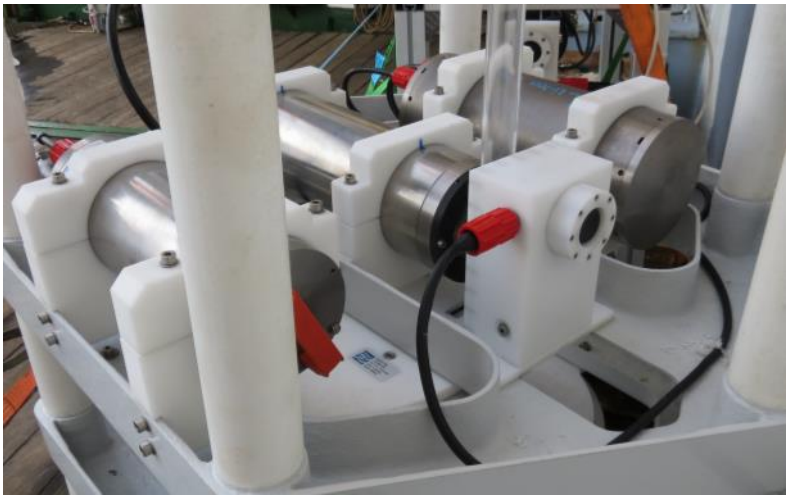


Figure 57: Camera System on BOP with the camera housing (for camera, lens and system electronics), the VIS light source and the Li-Ion battery

7.2.2 System configuration, measurements and deployment

The geometrical configuration of the camera system enables daily recordings of shadow images of the particles within the settling column throughout a whole year. It is programmed to take one image per second for five minutes every day throughout one year (Table 5).

The system was deployed at as part of the PAP3 mooring at 2930m. See the final position and layout of the mooring is given in the PAP3 report. During the deployment of the trap the top polycarbonate plate got damaged and due to that the measurement might be influenced by this event.

Table 15: Programming of the BOP system. Periodical measurements of the camera system for 5 minutes every day and changing of 40 gel cups in the sediment trap every 3 / 15.5 days alternately.

Date [YYYY-MM-DD]	Time [HH:MM:SS]	Remarks
2016-04-21	12:00:00	Camera: auto start, 1 image per second for 5 minutes, auto shutdown, THIS PROCEDURE WILL BE REPEATED EVERY DAY WITHOUT END DATE
2016-04-26	00:01:00	Trap: Next bottom bottle
2016-05-12	00:01:00	Trap: Next bottom bottle
2016-05-15	00:01:00	Trap: Next bottom bottle
2016-05-18	00:01:00	Trap: Next bottom bottle
2016-05-26	00:01:00	Trap: Next bottom bottle
2016-05-29	00:01:00	Trap: Next bottom bottle
2016-06-01	00:01:00	Trap: Next bottom bottle
2016-06-12	00:01:00	Trap: Next bottom bottle
2016-06-15	00:01:00	Trap: Next bottom bottle
2016-06-23	00:01:00	Trap: Next bottom bottle
2016-06-26	00:01:00	Trap: Next bottom bottle
2016-06-29	00:01:00	Trap: Next bottom bottle
2016-07-10	00:01:00	Trap: Next bottom bottle
2016-07-13	00:01:00	Trap: Next bottom bottle
2016-07-21	00:01:00	Trap: Next bottom bottle
2016-07-24	00:01:00	Trap: Next bottom bottle
2016-07-27	00:01:00	Trap: Next bottom bottle
2016-08-07	00:01:00	Trap: Next bottom bottle
2016-08-10	00:01:00	Trap: Next bottom bottle
2016-08-28	00:01:00	Trap: Next bottom bottle
2016-08-31	00:01:00	Trap: Next bottom bottle
2016-08-31	00:02:00	Trap: Next top bottle
2016-09-18	00:02:00	Trap: Next top bottle
2016-09-21	00:02:00	Trap: Next top bottle
2016-10-09	00:02:00	Trap: Next top bottle
2016-10-12	00:02:00	Trap: Next top bottle
2016-10-30	00:02:00	Trap: Next top bottle

2016-11-02	00:02:00	Trap: Next top bottle
2016-11-27	00:02:00	Trap: Next top bottle
2016-11-30	00:02:00	Trap: Next top bottle
2016-12-25	00:02:00	Trap: Next top bottle
2016-12-28	00:02:00	Trap: Next top bottle
2017-01-22	00:02:00	Trap: Next top bottle
2017-01-25	00:02:00	Trap: Next top bottle
2017-02-26	00:02:00	Trap: Next top bottle
2017-03-01	00:02:00	Trap: Next top bottle
2017-04-02	00:02:00	Trap: Next top bottle
2017-04-05	00:02:00	Trap: Next top bottle
2017-04-23	00:02:00	Trap: Next top bottle
2017-04-26	00:02:00	Trap: Next top bottle
2017-05-17	00:01:00	Trap: Last bottle out; System open

7.3 Larval Traps

By Mark Stinchcombe

A number of larval traps were supplied by Luciana Génio, Marina Cunha, Ana Hilário and Clara Rodrigues from the Universidade de Aveiro, Nikoleta Bellou from the Hellenic Centre for Marine Research and Craig Young from the Oregan Institute of Marine Biology. They were attached to the PAP3 mooring and deployed with it. These were in the form of 4 settlement traps which were attached to the uprights of one of the sediment traps on PAP3 and colonisation and settlement traps which were attached to the rope of PAP3 above the anchor.

The settlement traps consisted of PVC pipe which contained 50ml centrifuge tubes with fixative inside. To ensure the fixative stayed inside the tube until the traps were in position, they were sealed with parafilm pulled taught with an elastic band connected to a galvanic release. After 2f hours the galvanic release would let go of the parafilm which would come clear of the tube.

The colonisation traps were a wide diameter plastic pipe with large holes in it. Within were cages containing different substrates. They were bone, wood and oyster shells. These were placed in different orders in the two traps. One of these traps also had a repeat of the settlement traps attached to the top. These traps were attached to the rope of PAP3 using clamps which were made onboard (Figure 58).

Figure 58: Colonisation traps with smaller larval settlement traps being attached to the PAP3 rope.

8 Zooplankton Net Sampling

By Corinne Pebody

The WP2, 200µm net was deployed to 200m in a series of paired vertical hauls. Prior to each haul, the net was checked for twists and that the tap was closed, then the net was lowered over the side using either the Rozler (Rexroth) winch over the starboard side or the Romica with the crane over the aft starboard side. There were strong currents running on some occasions and the rope was put over the roller when using the Rexroth to keep the net clear of the ship (thanks Stuart and Barry). This also seemed to improve the vertical line of the net, except for the last deployment where even the addition of extra weight failed to keep the angle to less than 30 degrees. 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.

Figure 59: Deployed Net

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.

8.1 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

Figure 60: Pteropod and Salp (?) dominated nets 12 and 13.

Table 16: Summary of zooplankton net deployments.

Station ID						
DY050-052 NET #1	noon sample	preserved in formalin 2litre bottles				Water depth
net shot		27/04/16	12:09			ucm
at surface		27/04/16	12:47			ucm
DY050-053 NET #2	noon sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm>63 µm Nb due to oil leak and orders from bridge, net hauled up at 60m a minute to get away			frozen at - 80°C	

		from azipods. Part way up we were allowed to go back to 102m/min.				
net shot		27/04/16	12:53	49 02.00 N	16 15.00 W	4810
at surface		27/04/16	13:26			ucm
DY050-055 NET #3	midnight sample	preserved in formalin 2 litre bottles				
net shot		28/04/16	01:49	48 50.2462 N	16 31.2201 W	4806
at surface		28/04/16	02:09			
DY050-058 NET #4	noon sample	preserved in formalin 2litre bottles				Water depth
net shot		28/04/16	11:30	49 0.31416 N	16 23.81724 W	4810
at surface		28/04/16	12:13			ucm
DY050-059 NET #5	noon sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm>63 µm			frozen at - 80°C	
net shot		28/04/16	12:17	49 0.31434 N	16 23.81766 W	4809
at surface		28/04/16	13:07			ucm
DY050-069 NET #6	midnight sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm>63 µm			frozen at - 80°C	Water depth
net shot		29/04/16	23:39	49 10.5208 N	16 5.58828 W	4806
at surface		29/04/16	23:53			Ucm
DY050-070 NET #7	midnight sample	preserved in formalin 2 litre bottles				
net shot		29/04/16	23:59	49 10.64322 N	16 5.4234 W	4804
at surface		30/04/16	00:32			Ucm
DY050-085 NET #8	noon sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm>63 µm			frozen at - 80°C	Water depth
net shot		30/04/16	12:17	49 0.32508 N	16 23.8056 W	4809
at surface		30/04/16	12:26			ucm
DY050-087	noon sample	preserved in formalin 2 litre bottles				

NET #9						
net shot		30/04/16	13:31	49 0.32466 N	16 23.80554 W	4809
at surface		30/04/16				ucm
DY050-90 NET #10	midnight sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm>63 µm			frozen at - 80°C	Water depth
net shot		01/05/16	00:25	48 53.26968 N	16 28.18164 W	4808
at surface		01/05/16	01:09			Ucm
DY050-91 NET #11	midnight sample	preserved in formalin 2 litre bottles				
net shot		01/05/16	01:14	48 53.269610 N	16 28.18170 W	4807
at surface		01/05/16	02:04			Ucm
DY050-105 NET #12	midnight sample	Sieved into >2mm; ,<2mm; >1mm; <1mm>200µm; <200µm>63 µm			frozen at - 80°C	Water depth
net shot		02/05/16	23:53	49 0.70930 N	16 23.84860 W	4811
at surface		03/05/16	00:33			Ucm
DY050-106 NET #13	midnight sample	preserved in formalin 2 litre bottles				
net shot		03/05/16	00:40	49 0.70974 N	16 23.84784 W	4811
at surface		03/05/16	01:??			Ucm

Thank you to Brian, Ben, Owain, Stuart, Barry, Seamus and Ian.

9 Marine Snow Catchers

By Anna Belcher, Clara Flintrop, Christian Konrad, Morten Iversen

We used the MSC to determine the sinking particle flux, particle composition, size-specific settling velocity of in situ collected particles, and bacterial colonization of marine particles.

9.1 Objectives and Aims

The aim of the cruise was to investigate temporal changes in sinking particle flux over the duration of the cruise at the PAP site, with the hope to capture the spring bloom. 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. We further used the collected marine snow to determine bacterial colonization processes via laboratory incubations. As such it was aimed to use the MSC to:

1) Measure any variation in the sinking particles (in terms of magnitude, particle size and composition) with depth and over the course of the cruise
2) Measure the sinking velocities of particles to calculate particle fluxes
3) Collect water from the MSC to measure the particulate organic carbon (POC) and size fractionated chlorophyll (Chl) in the slow sinking and suspended carbon pool
4) Determine how bacteria colonize marine aggregates and how different motility strategies influence the colonization efficiency.

9.2 Methods

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). A RBR Concerto CTD with fluorescence and turbidity sensors was attached to each MSC to record the vertical profile during deployment. 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 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 1.5L 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 1.5L 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 and Chl (size fractionated).

Particles that had settled to the base (the fast sinking pool) of the bottom chamber and collected in the collector try were photographed with a Canon EOS DSLR camera and a 105 mm macro lens. These images enable us to determine the sizes, types, and abundance of the particles collected in each of the four compartments in the collector tray and will make it possible to relate different particle types and

abundance to the POC measurements done for two of the compartments for each deployment. Following this sinking velocity measurements were carried out on 5-15 particles from a number of MSC. Sinking velocity measurements were conducted using a flow chamber containing water collected from MSC 004 (stn 15) which was filtered (GF/F) and maintained at a temperature of 12 °C. Each particle was carefully placed in a 10 cm high Plexiglas tube (5 cm 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 of the particle measured using a horizontal dissection microscope with a calibrated ocular.

Two splits were taken from each marine snow catcher and put on ashed GF/F filters for measurement of POC. High resolution microscope photos were taken of particles in one split, and one final split frozen for future analysis. All particles were collected from one collector tray compartment and placed in an Utermöhl chamber for investigations of the individual aggregates using an inverted microscope. We used magnifications ranging between 100x and 400x in a brightfield and phase contrast microscope. Pictures were taken of aggregates and wherever interesting grazing behaviour occurred, a video recording was. Special attention was devoted to grazing activity in marine snow by ciliates and nanoflagellates to answer questions such as where and at which components of the aggregates have the highest abundance of grazers? How does this correlate with the compactness and the content of the aggregate? How does grazing activity differ between aggregates collected from different depths? Some of the particles were stained with Alcian Blue to qualitatively assess TEP content within aggregates. The microscopic investigations of the particles will be used to determine changes in the settling particles both vertically and over time during the cruise period.

9.2.1 Filter Sample Preparation, Preservation and Analysis

9.2.1.1 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.

9.2.1.2 Total Chlorophyll

200 ml 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.

9.2.1.3 Chl >20 µm

200ml was filtered through a 20µm 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.

9.3 Preliminary Results

A total of 41 marine snow catcher deployments were made to support this study (Table 17).

Table 17: Details of MSC deployments during DY050 utilised for this study.

Date	Time on deck (GMT)	MSC #	Station #	Latitude (°N)	Longitude (°W)	Depth (m)	Notes
22/04/16	14:50	001	5	49° 00.375	16° 23.848	20	Contaminated with ship's rust
22/04/16	15:10	002	6	49° 00.375	16° 23.848	20	Leaked – no usable sample
22/04/16	15:45	003	7	49° 00.375	16° 23.848	120	Leaked a little, but stopped once secured on deck
23/04/16	19:20	004	15	49° 00.338	16° 23.808	60	
23/04/16	19:45	005	16	49° 00.338	16° 23.808	160	
23/04/16	20:00	006	17	49° 00.338	16° 23.808	80	
24/04/16	09:10	007	21	49° 00.488	16° 27.184	80	Deployed without tray for particles for CF

24/04/16	09:35	008	22	49° 00.488	16° 27.184	180	
24/04/16		009	23	49° 00.488	16° 27.184		MSC didn't fire
24/04/16	10:00	010	24	49° 00.488	16° 27.184	80	
25/04/16	17:20	011	30	49° 00.417	16° 23.864	60	
25/04/16	17:40	012	31	49° 00.417	16° 23.864	80	
25/04/16	18:00	013	32	49° 00.417	16° 23.864	160	
26/04/16	13:30	014	40	49° 00.344	16° 23.860	60	Deployed without tray for particles for CF
26/04/16		015	41	49° 00.344	16° 23.860	160	Leaking so redeployed (MSC017)
26/04/16	14:20	016	43	49° 00.344	16° 23.860	160	
26/04/16	14:35	017	44	49° 00.344	16° 23.860	60	
27/04/16	10:02	18	49	49° 00.327	16° 23.842	60	
27/04/16	10:27	19	50	49° 00.327	16° 23.842	160	
28/04/16	15:15	20	61	49° 00.314	16° 23.817	60	Deployed without tray for particles for CF
28/04/16	15:27	21	62	49° 00.314	16° 23.817	60	
29/04/16	14:40	22	65	49° 00.321	16° 23.847	90	*benthic trawl had just come up and lots of mud being washed into water. But mostly on port side, MSC deployed off starboard side
29/04/16	15:15	23	66	49° 00.321	16° 23.847	160	Dripping a little on deck
29/04/16	18:35	24	68	49° 00.321	16° 23.847	60	
30/04/16	11:25	25	82	49° 00.324	16° 23.805	90	
30/04/16	11:55	26	83	49° 00.324	16° 23.805	160	
30/04/16	12:10	27	84	49° 00.324	16° 23.805	60	
01/05/16	11:25	28	93	49° 00.331	16° 23.812	60	
01/05/16	11:55	29	94	49° 00.331	16° 23.812	160	
01/05/16	12:10	30	95	49° 00.331	16° 23.812	30	
02/05/16	15:35	31	102	49 00.708	16 23.848	30	Deployed without tray for particles for CF
03/05/16	11:07	32	109	49 00.323	16 23.812	160	
03/05/16		33	110	49 00.323	16 23.812	60	Knocked against ship as

							came aboard and started to leak, so aborted
03/05/16	14:45	34	111	49 00.323	16 23.812	60	
03/05/16	14:55	35	112	49 00.323	16 23.812	30	
04/05/16	13:40	36	114	49 00.299	16 23.597	30	
04/05/16	14:00	37	115	49 00.299	16 23.597	60	
04/05/16	14:30	38	116	49 00.299	16 23.597	160	
05/05/16	13:03	39	120	49 00.319	16 23.821	150	
05/05/16	13:37	40	121	49 00.319	16 23.821	300	
05/05/16	13:51	41	122	49 00.319	16 23.821	50	

The RBR CTD showed a change in the mixed layer depth over the course of the cruise as well as in the magnitude and depth of the chlorophyll maximum. The chlorophyll maximum shallowed from 50 to 30m, becoming a more defined peak (Figure 61). The RBR CTD has not been fully calibrated for temperature, salinity, fluorescence and turbidity and hence data should be considered relative but not absolute.

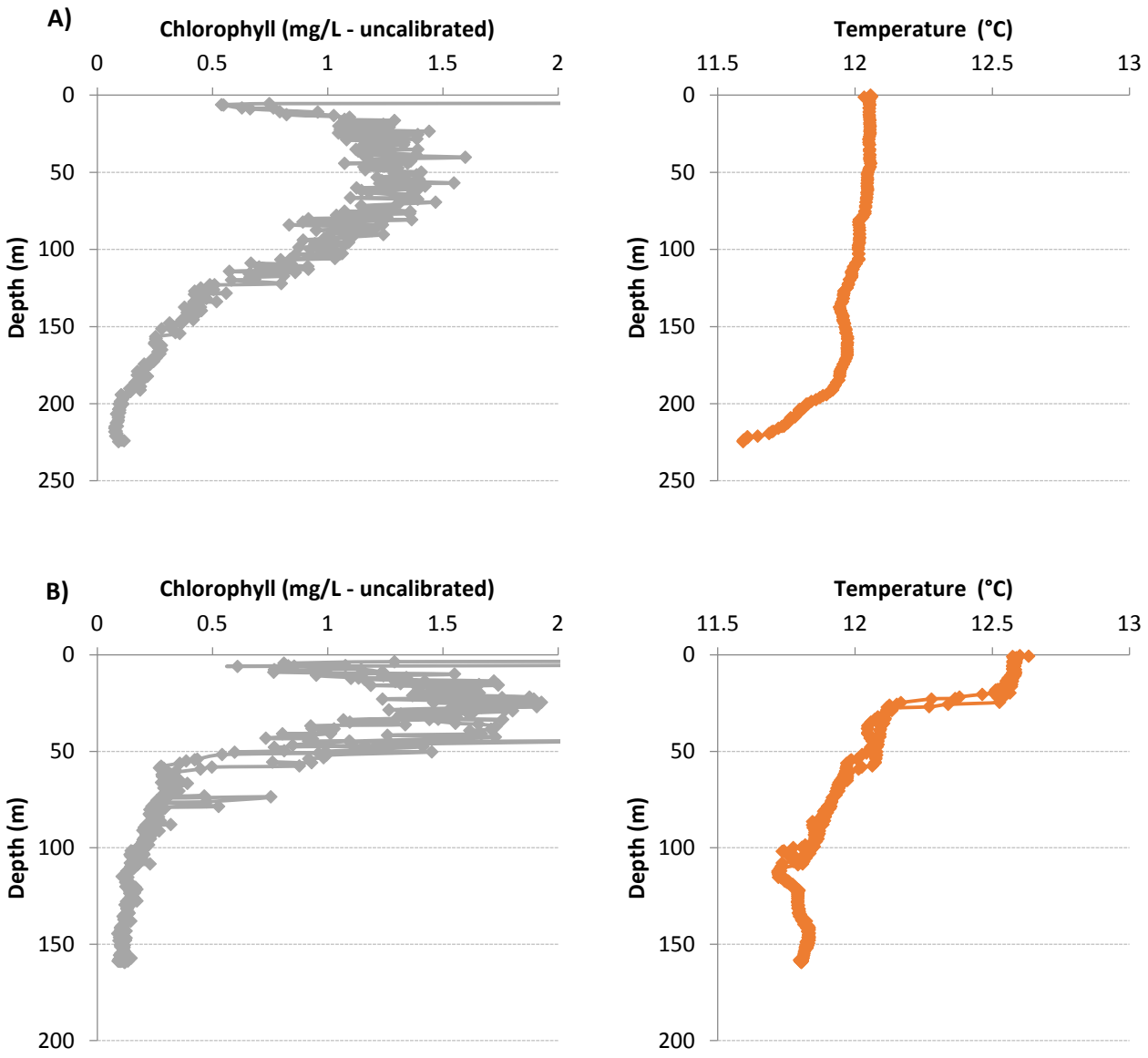


Figure 61: Example profiles of chlorophyll and temperature from the RBR attached to the marine snow catcher. A) for MSC 3, B) for MSC 28

Further results will be worked up following laboratory analysis of sample filters (POC, Chl) obtained from filtration of slow sinking and suspended water fractions from the MSCs. These data will be accompanied by measurements from the CTD as well as PELAGRA trap samples, SAPS samples and holocam and PELAGRA Cam profiles to support investigation of changing export flux over the spring bloom at the PAP site.

The microscopic investigations of the particles collected with the MSC showed that there was a shift in the particles types at the 1st of May. Before this period we had mainly collected compact and dense particles consisting of small phytoplankton – too small to identify with 400x magnification, though some indications of the presence of coccolithophores were observed. After the 1st of May we observed

a shift toward a higher presence of mucous aggregates. We stained those aggregates with Alcian Blue and found that large proportions of the particles contained polysaccharides that were stained by Alcian Blue (Figure 62).

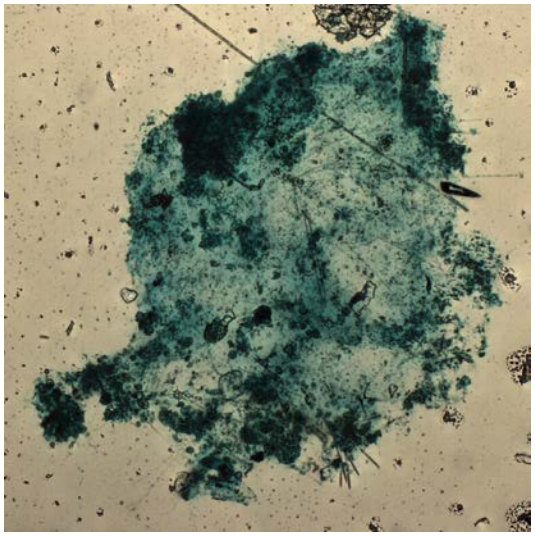


Figure 62: Alcian Blue stained aggregate. The blue-green colour is due to the Alcian blue staining and suggests the presence of polysaccharides within the aggregate. This aggregate with photographed on an inverted microscope at a 100x magnification. The total width of the image is 1.14 mm and diameter of the aggregate is around 1 mm.

9.4 Marine snow catcher maintenance issues

One MSC (MSC Tom) was se 0rviced before the first deployment as the pole through the plunger in the base was not secure and slipped up and down preventing the MSC from sealing. The inner pole was secured to the plunger with a pin and no further problems occurred (Figure 2). There was a problem of contamination of the first samples (MSC 001-003) which may have been due to material trapped inside the MSC or material falling in when the MSC made contact with the side of the ship. The MSCs were thoroughly hosed again before redeployment and no further contamination issues occurred. Following the initial deployment, MSCs Tom and Jerry were leaking from the base. This problem was rectified by tightening the nuts on the clasps that secure the base to the top. Additionally the MSC bases were marked with tape to help line up the top and the base of the MSC for the most water tight fit. MSC Tom has continued to drip slightly from the base and may need some additional silicon applied to the pole at the base of the plunger where the fix was made.

MSC Tom in particular has a very tight fitting top plunger making it difficult to attach the base and the top. This problem was exacerbated by the o-rings falling out or becoming misaligned when trying to clasp the base to the top. **Thicker and/or flat o-rings that would sit more securely in the groove**

are recommended to be purchased for future deployments. The problem of the tight plunger can be solved by rigging the snow catchers upright (either manually or using the crane), however the use of the crane eats into valuable ship time. The option to sand back part of the plunger was not carried out on board for fear of causing further damage and preventing the snow catcher from sealing. However, this should be investigated further to create a more permanent solution.

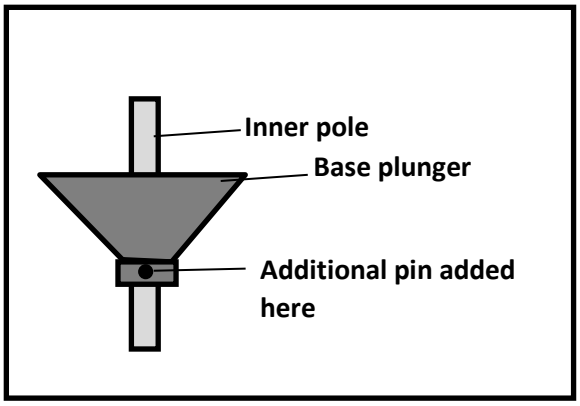


Figure 63: Schematic to highlight fix that was carried out on MSC Tom.

10 Microplastics sampling

By Katsia Pabortsava

10.1 Sampling microplastics with large volume in situ pumps (SAPs).

Microplastics and biogenic particles in the water column were collected with large-volume stand-alone *in situ* pumps (SAPs; Figure 64A). Over the course of the cruse, SAP 03-06 was flooded and fell out of action, while SAP 03-07 had an internal fault, the nature of which could not be identified and fixed. During the last SAPs deployment on 04.05.2016 we also discovered a leak in SAP 03-03. Nevertheless, the instrument still pumped a substantial volume of water.

The SAPs were deployed at 2-3 discrete depths (Table 18) collecting particles onto acid-washed (10% HCl) 53 µm (pre-filter) and 1 µm (main filter) NITEX© nylon meshes. Filter loading, sample preparation, and processing were always carried out under the laminar flow hood in a clean laboratory on board of the ship. The SAPs were set to pump for 90 min, filtering up to 2000 L of seawater (Table 18). Each SAP was equipped with a SeaBird Temperature-Depth sensor, recording the data every 10 min. Upon recovery, NITEX© meshes were carefully removed from filter holders. Particles collected onto a 53 µm mesh were immediately rinsed into a beaker with exactly 1 L of artificial sea water (ASW; 35 g NaCl per 1 L of ultra-pure water) and split into 4 sub-samples using Folsom splitter (Fig. 64B, C, D). Splits designated for POC analysis were filtered onto pre-ashed (450°C for 24 hrs) 25 mm Whatman GF/F filters (0.8 µm nominal pore size). Splits for microplastic analysis were filtered onto 25 mm Whatman cyclopore polycarbonate filter (0.4 µm nominal pore size). All filters were stored frozen at -20°C until analysis. For POC and microplastic sample blanks, 100 ml of ASW was filtered through unused GFF and polycarbonate filters. The microplastic contamination level during sample processing was accessed by keeping polycarbonate filters exposed in the laminar flow hood for the duration of particle rinse-off and splitting. The remaining particle-ASW splits were spiked with 12.5 mL of concentrated formalin (5% v/v final concentration) buffered with 5g/L di-sodium tetraborate and stored at 4°C until analysis. One micron mesh with particles was carefully folded, wrapped into aluminium foil, and frozen at -20°C until processing and analysis in the land laboratory. For blanks, unused acid-washed 53 µm and 1 µm NITEX© meshes were processed in exactly the same way as the samples.

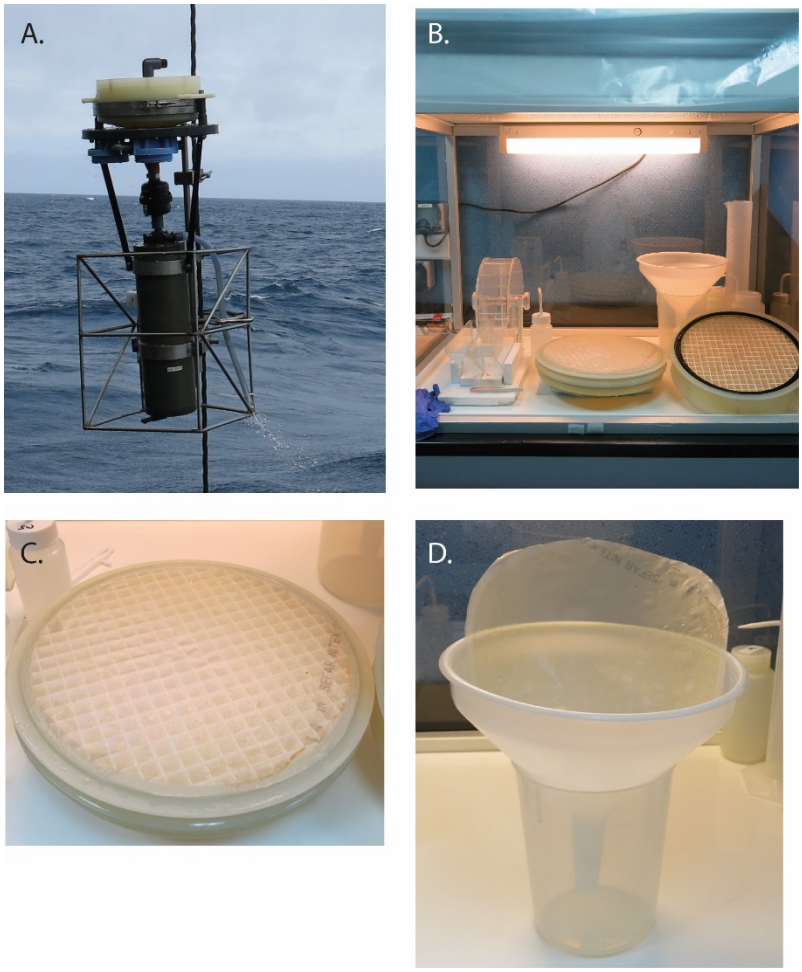


Figure 64: A. Large volume *in situ* Stand Alone Pump (SAP) used to collect microplastics and marine particles; B. SAPs sample processing under the laminar flow hood; C. NITEX© pre-filter (53 µm) with collected particles; D. Set-up for rinsing particles off the NITEX© mesh.

Table 18: SAPs deployment log during DY050 cruise

Date	Station #	Latitude ºN	Longitude ºW	SAPS S/N	Depth (m)	Volume pumped (L)	Remarks
22.04.2016	DY050-10	49.008	16.392	03-03	10	1174	
22.04.2016	DY050-10	49.008	16.392	03-06	70	781	
22.04.2016	DY050-10	49.008	16.392	03-06	150	1178	
23.04.2016	DY050-13	49.005	16.397	03-04	250	1027	
23.04.2016	**DY050-13**	**49.005**	**16.397**	**03-06**	**500**	**85**	**leaked**
23.04.2016	DY050-13	49.005	16.397	03-03	1000	1924	
23.04.2016	**DY050-13**	**49.005**	**16.397**	**03-07**	**2000**		**failed**
25.04.2016	DY050-28	49.007	16.398	03-04	1000	1785	
25.04.2016	DY050-28	49.007	16.398	03-03	500	1985	
26.04.2016	**DY050-38**	**49.005**	**16.398**	**03-07**	**150**	**62**	**failed**
26.04.2016	DY050-38	49.005	16.398	03-04	70	766	
26.04.2016	DY050-38	49.005	16.398	03-03	10	1902	
27.04.2016	DY050-48	49.005	16.397	03-03	250	1421	
27.04.2016	DY050-48	49.005	16.397	03-04	500	1649	
27.04.2016	**DY050-48**	**49.005**	**16.397**	**03-07**	**2000**	**1**	**failed**
30.04.2016	DY050-81	49.005	16.397	03-03	150	2002	
30.04.2016	DY050-81	49.005	16.397	03-04	10	896	
01.05.2016	DY050-97	49.006	16.397	03-03	70	455	
01.05.2016	DY050-97	49.006	16.397	03-04	10	779	
02.05.2016	DY050-101	49.012	16.397	03-04	1000	783	
02.05.2016	DY050-101	49.012	16.397	03-03	250	973	
03.05.2016	DY050-108	49.005	16.386	03-03	500	1056	
03.05.2016	DY050-108	49.005	16.386	03-04	250	1054	
04.05.2016	**DY050-113**	**49.005**	**16.393**	**03-03**	**150**	**691**	**leaked**
04.05.2016	DY050-113	49.005	16.393	03-04	70	834	

10.2 Microplastics collection with megacorer

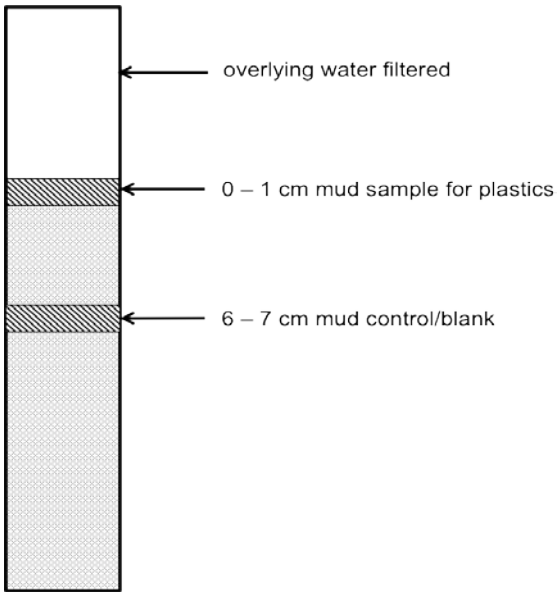


Figure 65: Diagram of microplastic sampling of a sediment core (not to scale; figure credits: E. Cavan)

Sediment core samples were collected by Brian Bett's benthic team to investigate the abundance of microplastics in the deep marine sediments at PAP. Upon recovery, the cores were removed from the megacorer one by one. The core designated for microplastics was immediately covered with foil to prevent any airborne microplastics contamination. The surface water was siphoned through a 250 µm sieve and the sediment remaining on the sieve was collected in a pre-weighed, ashed, acid-clean, glass sampling jar (250 ml). 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 sediments since plastic is a modern product. Hence, for control sample, the next 5 cm of mud sample was discarded and the following 1 cm of mud was collected into a separate jar. The sampling procedure is described in section 16. The layer of foil was placed between the jar and lid. The wet sample was then weighted wet and dried at 50°C in the oven. The weight of a dry sample was also determined. All core samples will be analysed for microplastics in the land laboratory.

Table 19: Log of cores samples for microplastics

Core ID	Site	Date	Latitude (ºN)	Longitude (ºW)	Depth (m)	Thickness	Wet weight (g)
MgC08+2	RP02	22.04.2016	48.840	16.520	4810	0-1 cm	657.5
MgC08+2	RP03	23.04/2016	48.838	16.518	4808	0-1 cm	826
MgC08+2	RP03	23.04/2016	48.838	16.518	4808	6-7 cm	958
MgC08+2	RP07	26.04.2016	48.838	16.517	4807	0-1 cm	705
MgC08+2	RP07	26.04.2016	48.838	16.517	4807	6-7 cm	606.5
MgC10	RP09	27.04.2016	48.835	16.520	4807	0-1 cm	734.5
MgC10	RP09	27.04.2016	48.835	16.520	4807	6-7 cm	621.5
MgC10	RP11	28.04.2016	48.838	16.519	4807	0-1 cm	566.8
MgC10	RP11	28.04.2016	48.838	16.519	4807	6-7 cm	591.4
MgC10	RP13	05.05.2016	48.836	16.522	4805	0-1 cm	746.5
MgC10	RP13	05.05.2016	48.836	16.522	4805	6-7 cm	862.5

11 PELAGRA Cruise Report

By Kevin Saw and Robin Brown

The purpose of including the PELAGRA sediment traps on DY050 was to carry out engineering trials in preparation for the COMICS science program scheduled for 2017 and 2018.
Following various issues experienced on the previous cruise (JC087, 2013), the traps have undergone a number of modifications:

- The sample pot rotation carousel has been upgraded from the original four-roller system to a full complement slew-ring type ball race arrangement utilising acetal balls. This has also allowed the drive motor to be re-mounted with its axis tangential to the worm wheel which removes the need for the original bevel gear arrangement.
- The 1000 m emergency abort releases have been redesigned to replace the original disc springs with a conventional coil spring to improve reliability.
- The LED flashing light beacons have been modified to replace the original rubber pressure switch membrane with a waspaloy metal foil membrane.
- Four polypropylene feet have been added to the base ring to enable moving the traps with a pallet truck and lifting the attached weights clear of the deck without the need for the existing wooden deck stands.

All five existing traps (P2, P4, P6, P7 and P8) were present for the cruise. P4 and P7 were rigged with particle cameras as described in the cruise report for JC087. All traps were re-weighed and re-ballasted prior to the cruise.

Apart from testing the mechanical alterations, it was intended that data from these deployments could be used to confirm ballasting calculations and any adjustments needed and to gain a better understanding of the coefficients for compressibility and thermal expansion. To help with the latter it was hoped that successful (i.e. stable) deployments could be achieved for each trap at two distinct depths, e.g. around 200 m and 600 m.

11.1 Deployment 1

Initially, for least risk, it was decided to deploy one of each trap type (i.e. one ‘standard’ trap and one camera trap with gels, P2 and P7 respectively) to check accuracy of ballasting. Both traps were set up for 200 m deployments with ballast added as calculated by the ballast spreadsheets with no adjustments. In situ temperature and salinity data were obtained from the CTD cast made at station DY050-004.

P2 (standard trap)

Station:	DY050-008
Target depth:	200 m
Target temp:	11.86°C
In situ density:	1027.924 kg m^{-3}
Added ballast:	4123 g
Deployment time:	22.04.16 18:50
Deployment posn:	49° 00.375’ N
	16° 23.848’ W

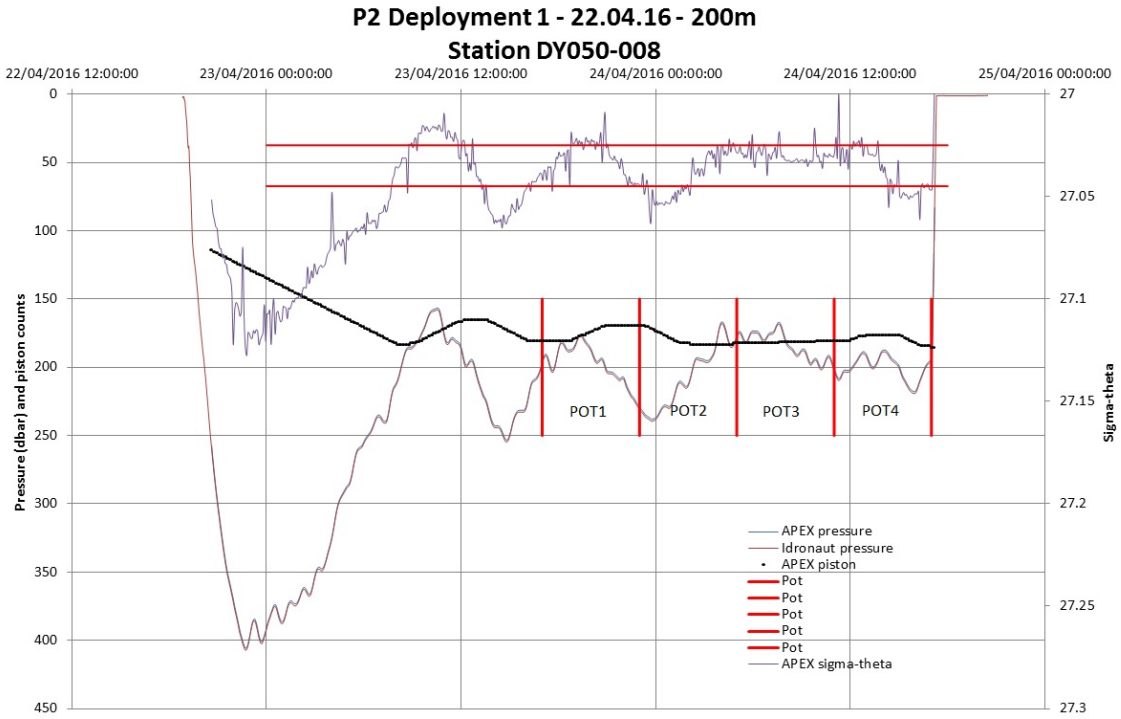


Figure 66: P2, deployment 1

As is evident from the above plot, P2 was over-ballasted and descended to 400 m before recovering to the intended 200 m. It then underwent a number of oscillations before stabilising (as evidenced by stable sigma-theta) around 03:00 on 24 April. The APEX buoyancy engine needed to increase displacement by about 60 counts to achieve this suggesting that the trap was over-ballasted by c. 60 g. The depressor weight was released at 100 m as expected.

On recovery, all four sample pots had collected particles, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing.

P7 (camera trap)

Station:	DY050-009
Target depth:	200 m
Target temp:	11.86°C
In situ density:	1027.924 kg m^{-3}
Added ballast:	4123 g
Deployment time:	22.04.16 18:50
Deployment posn:	49° 00.375’ N
	16° 23.848’ W

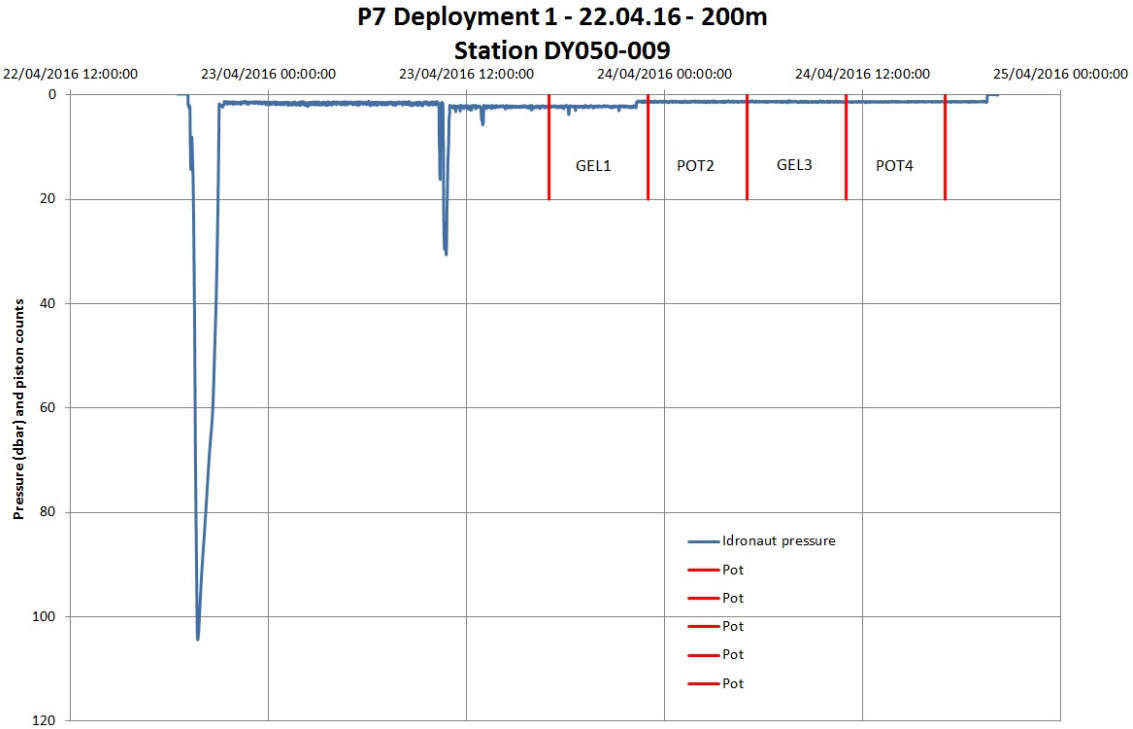


Figure 67: P7, deployment 1

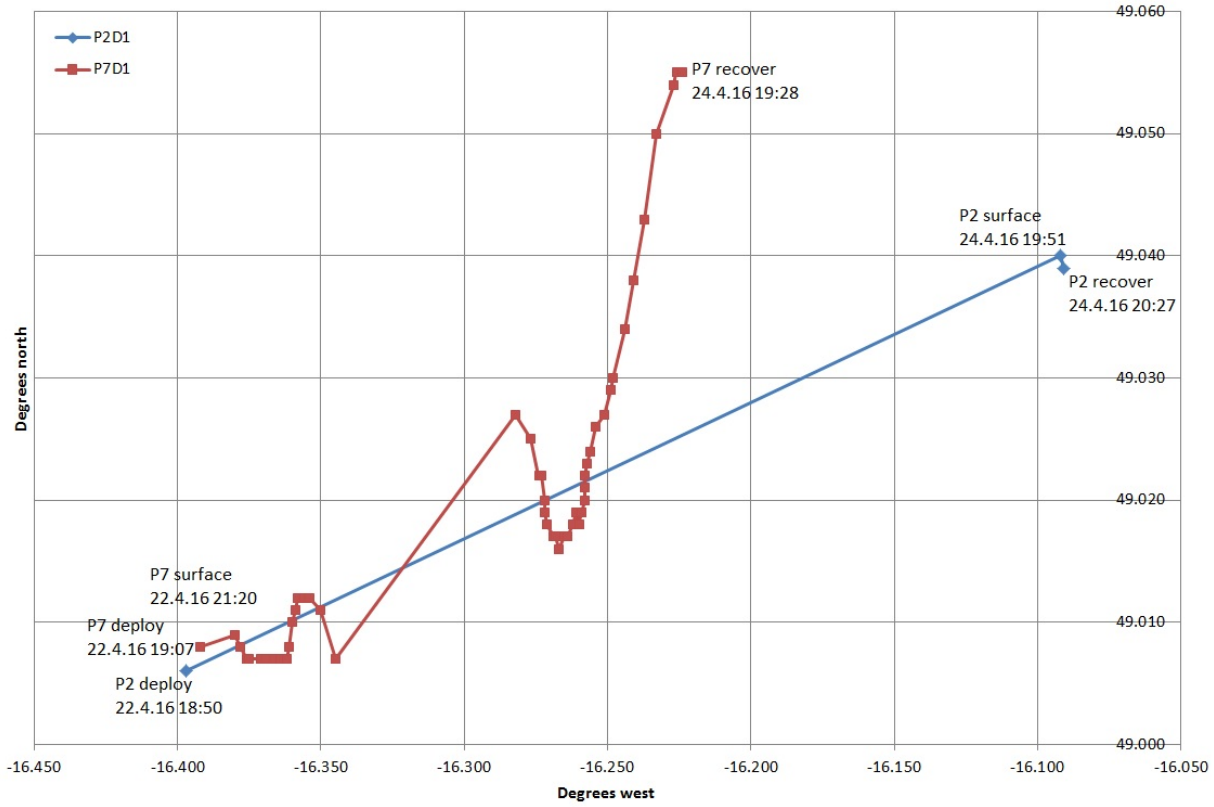
P7 was under-ballasted. The APEX buoyancy engine attempted to correct for this but had no chance of doing so before the trap reached the surface and went into recovery mode. No quantitative assessment can be made from this deployment of the degree of ballast error.

The depressor weight was released at 100 m as expected.

On recovery, although no particles had been collected, swimmers were found in the pots indicating that they had been open, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing. As the ship

approached P7 for recovery the LED flash beacon was not working (although it appeared to be working prior to the close approach). After investigation it was concluded that the switch plunger was a bit too tight. This was rectified and the light functioned normally for later deployments.

Figure 68: Deployment 1 drift plot (including surface drift for P7)



11.2 Deployment 2

For deployment 2, it was decided to carry out a deployment of all three ‘standard’ traps to 200 m again. Due to the findings from P2 deployment 1, a -50 g adjustment was made to the calculated ballast for all three traps based on the assumption that being similar in construction, P6 and P8 would be similarly over-ballasted. Temperature and salinity data recorded during deployment 1 was used as it differed somewhat from the original CTD data recorded at station 004.

P2 (standard trap)

Station:	DY050-033
Target depth:	200 m
Target temp:	11.547°C
In situ density:	1027.912 kg m^{-3}
Added ballast:	4111- 50 = 4061 g
Deployment time:	25.04.16 19:00
Deployment posn:	49° 00.417’ N
	16° 23.864’ W

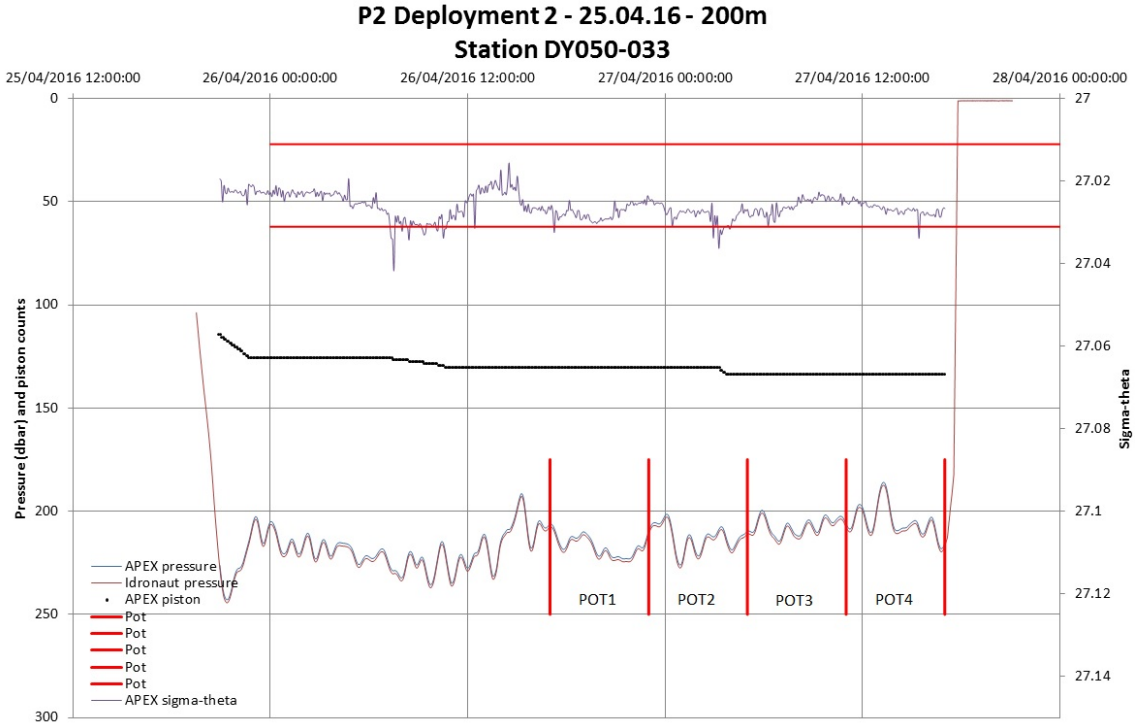


Figure 69: P2, deployment 2

Here, P2 is ballasted about as well as can be expected. The initial stable period was achieved with just 9 counts adjustment of the APEX buoyancy engine. The trap was fully stable well before the first sample collection period.

The depressor weight was released at 100 m as expected.

On recovery, all four sample pots had collected particles, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing.

P6 (standard trap)

Station:	DY050-034
Target depth:	200 m
Target temp:	11.547°C
In situ density:	1027.912 kg m^{-3}
Added ballast:	4123 – 50 = 4073 g
Deployment time:	25.04.16 19:30
Deployment posn:	49° 00.417’ N
	16° 23.864’ W

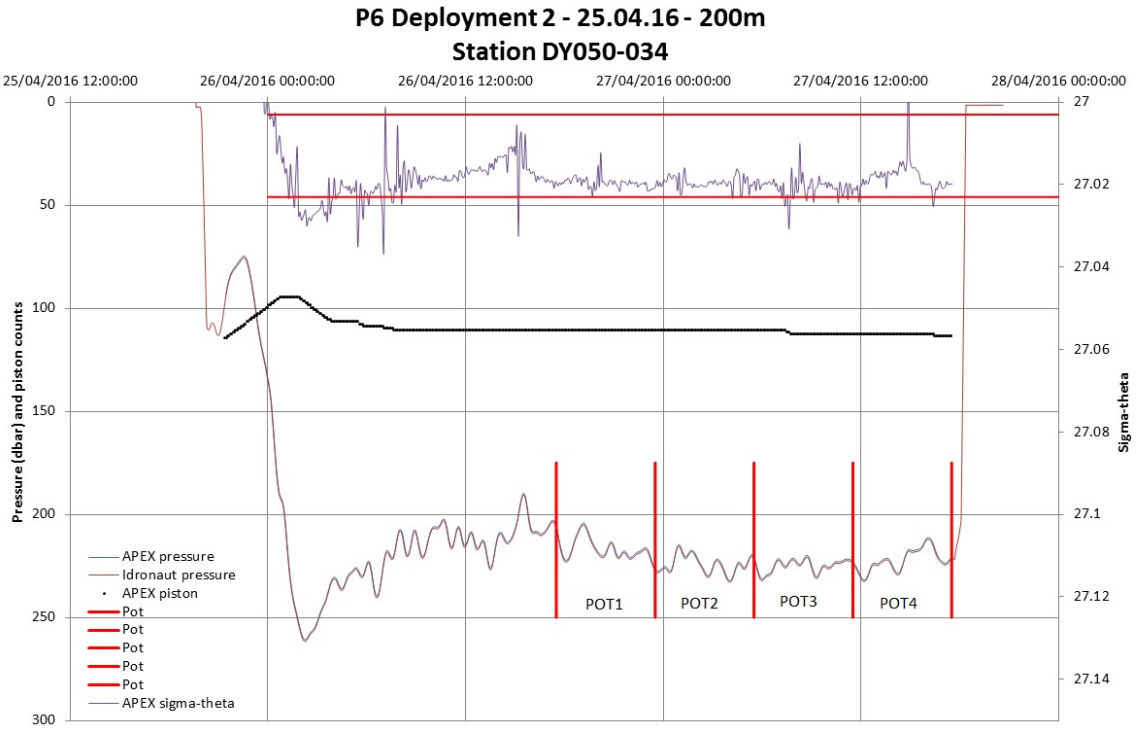


Figure 70: P6, deployment 2

Here, P6 is ballasted almost perfectly. Despite an initial adjustment in response to the trap ascending just after the depressor weight released and the slight over-depth situation caused by that, stability was achieved with just 4 counts adjustment of the APEX buoyancy engine. The trap was fully stable well before the first sample collection period.

The -50 g ballast adjustment was correct for this trap.

The depressor weight was released at 100 m as expected.

On recovery, all four sample pots had collected particles, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing.

P8 (standard trap)

Station:	DY050-035
Target depth:	200 m
Target temp:	11.547°C
In situ density:	1027.912 kg m^{-3}
Added ballast:	4053 – 50 = 4003 g
Deployment time:	25.04.16 20:00
Deployment posn:	49° 00.697’ N
	16° 23.853’ W

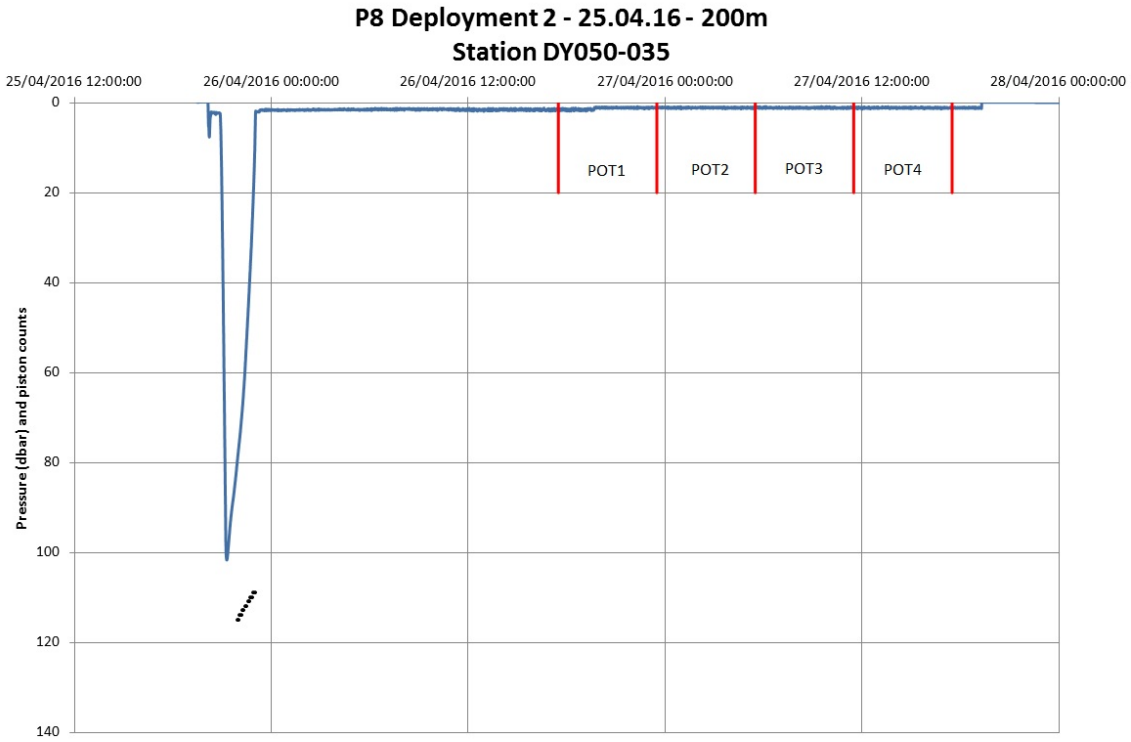


Figure 71: P8, deployment 2

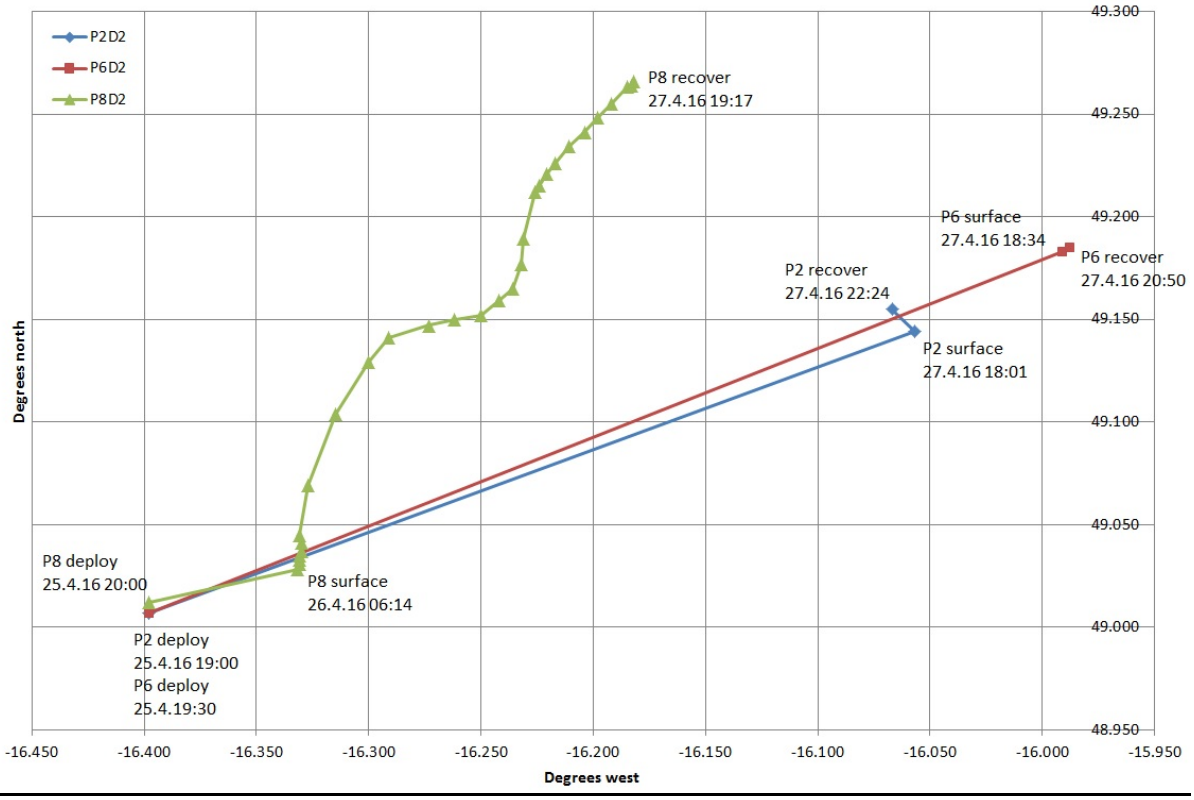
P8 was under-ballasted and returned to the surface after the depressor weight had released at 100 m and quicker than the APEX could adjust to compensate. The APEX aborted and entered recovery

mode. Nothing quantitative can be learned from this deployment regarding ballasting error except that making the -50 g adjustment as for P2 and P6 was not correct for this trap.

The depressor weight was released at 100 m as expected.

On recovery, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing.

Figure 72: Deployment 2 drift plot (including surface drift for P8)



11.3 Deployment 3

Deployment 3 was intended to test ballasting of P7 following the failed deployment in deployment 1. In an attempt to prevent re-surfacing due to under-ballasting again, it was decided to deploy deep. The trap was ballasted as per the calculations for 400 m but the APEX float was set to a depth of 800 m. The hope was that the trap would initially descend to 400 m and then the APEX would pump it down as deep as the buoyancy engine allowed, which was thought to be around 800 m. This way it was hoped that equilibrium would be reached at 800 m or some lesser depth so that an informed judgement could be made for ballasting of future shallower deployments. In order to prevent rapid

descent that may carry the risk of descending to 1000 m or more and thus aborting, the APEX float was set to a piston adjust period of 15 minutes instead of the usual 5 minutes.

P7 (camera trap)

Station:	DY050-045
Target depth:	400 m (ballast), 800 m (APEX)
Target temp:	11.23°C (400 m), 8.94°C(800 m)
In situ density:	1028.923 kg m^{-3} (400 m), 1031.022 kg m^{-3} (800 m)
Added ballast:	4784 g
Deployment time:	26.04.16 20:30
Deployment posn:	49° 01.380’ N
	16° 21.180’ W

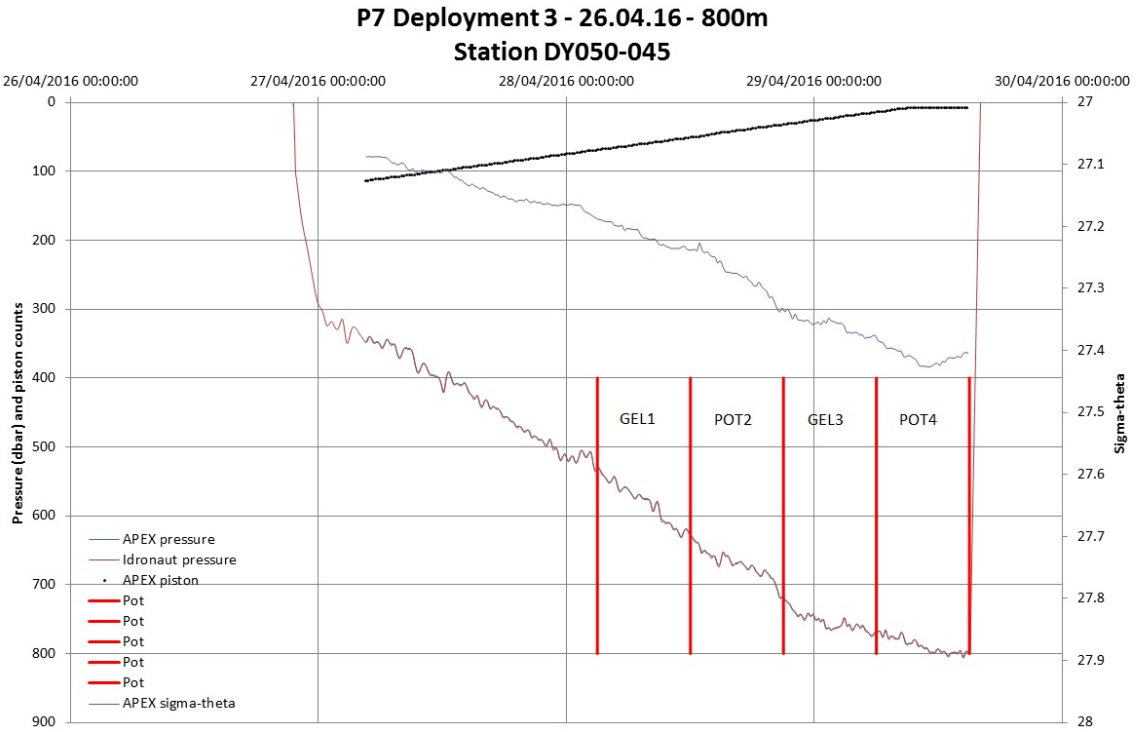


Figure 72: P7, deployment 3

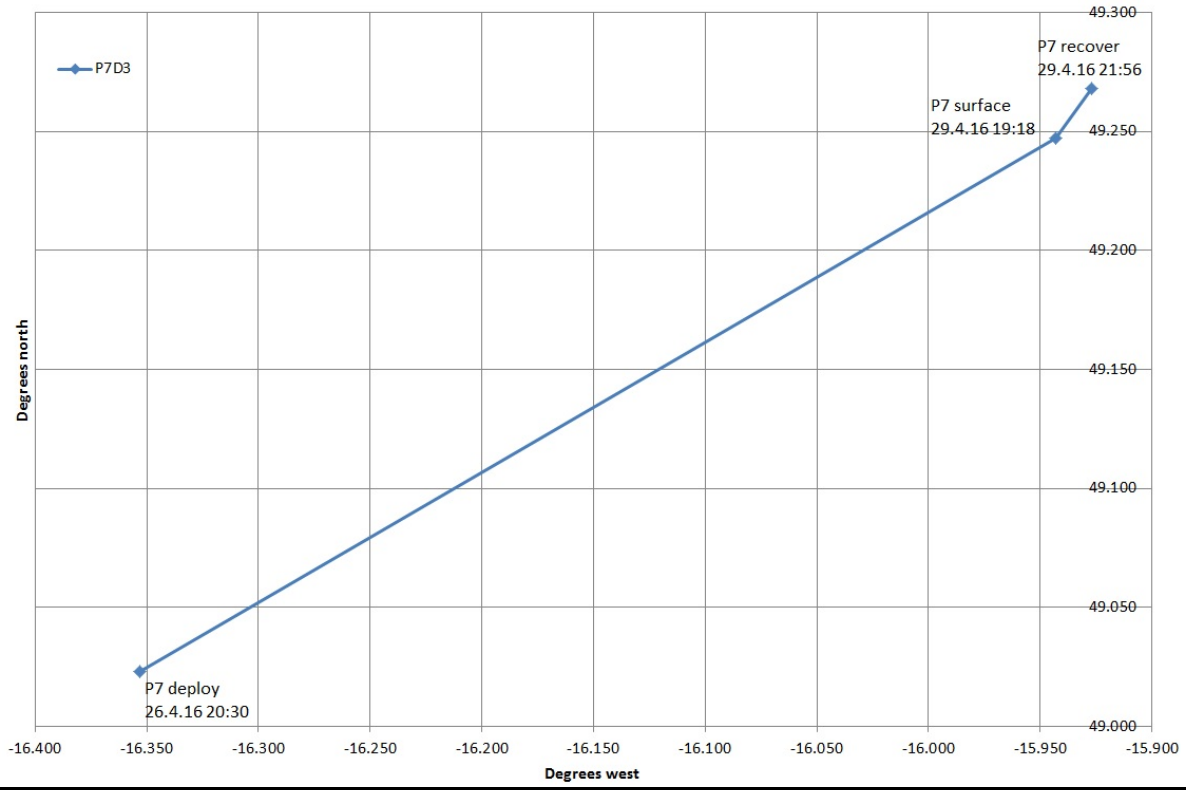
As can be seen, P7 did just about achieve equilibrium at 800 m with the APEX buoyancy engine at its minimum adjustment of 9 counts but only for the final 4 hours. It also appears to have begun to equilibrate at about 350 m just before the APEX began adjusting. Changing the piston adjust period to 15 minutes was unnecessary as the trap wouldn’t have descended deeper than 800 m and, had the adjustments been quicker, it is clear that equilibrium would have been achieved much sooner.

Based on this result, a further deployment would be made using the as-calculated ballast but for 600 m depth.

The depressor weight was released at 100 m as expected.

On recovery, all four sample pots had collected particles, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing.

Figure 73: Deployment 3 drift plot



11.4 Deployment 4

Deployment 4 was intended as a deep (600 m) deployment of all five traps. This would complement the successful shallow deployments of P2 and P6 and obtain equilibrium data for P4, P7 and P8 without the risk of premature surfacing.

In the event, P7 suffered a malfunction during mission prelude that caused its air bladder to not inflate so it wasn't deployed. Subsequent investigations revealed a 'modem registration' failure also. The causes of this will be investigated on our return to NOC.

P2 (standard trap)

Station:	DY050-076
Target depth:	600 m
Target temp:	10.30°C
In situ density:	1029.914 kg m^{-3}
Added ballast:	4172 g
Deployment time:	30.04.16 08:13
Deployment posn:	49° 00.540' N
	16° 23.220' W

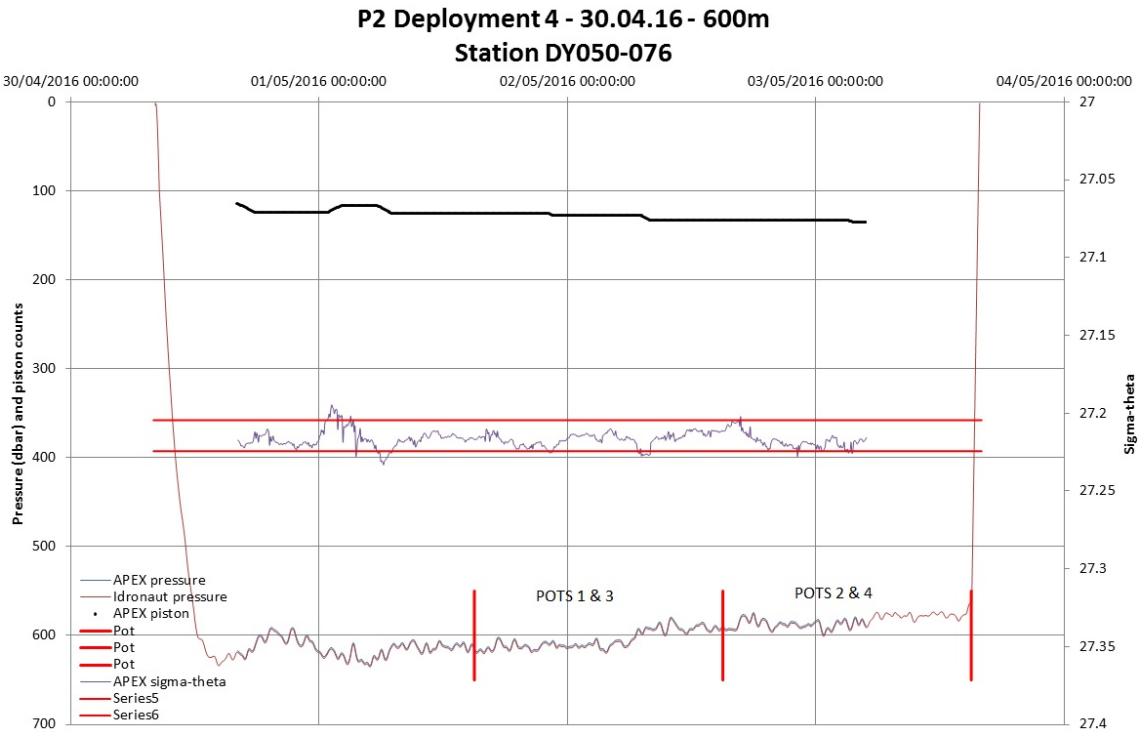


Figure 74: P2, deployment 4

P2 was correctly ballasted using the previous adjustment from the calculated value of -50 g. Initial equilibrium was achieved with an adjustment of just 10 piston counts and the maximum adjustment throughout the mission was 21 counts.

For this deployment two pot cams were fitted with pots 1 & 3 and 2 & 4 opening in pairs.

The depressor weight was released at 100 m as expected.

On recovery, all four sample pots had collected particles, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing.

P4 (camera trap)

Station:	DY050-077
Target temp:	10.30°C
In situ density:	1029.914 kg m^{-3}
Added ballast:	4830 g
Deployment time:	30.04.16 08:16
Deployment posn:	49° 00.540’ N
	16° 23.220’ W

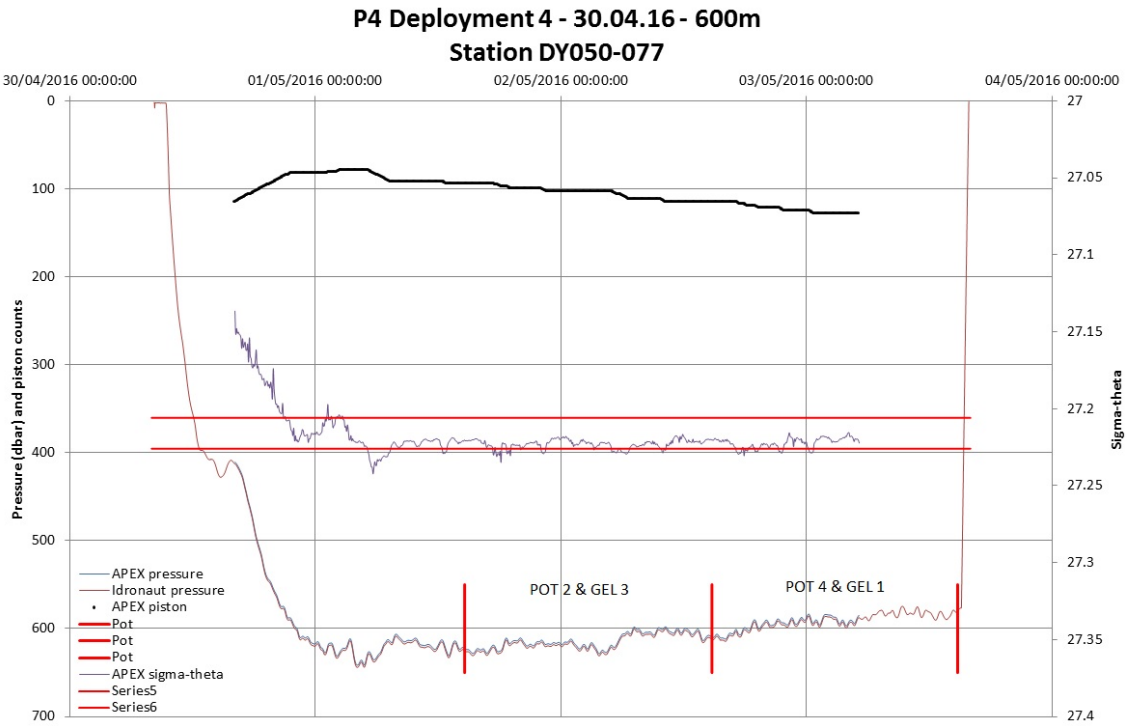


Figure 75: P4, deployment 4

P4 was slightly under-ballasted with a piston adjustment of 23 counts needed to reach initial equilibrium at just over 600 m. With no other data to go on, P4 was ballasted as calculated with no adjustments.

Two adjacent cams were fitted in order for one gel pot and one standard formalin pot to open simultaneously for subsequent comparison of particles. Positioning of the cams was such that pot 2 (labelled wrongly as 1 on the trap funnel) opened with gel 3 and pot 4 (wrongly labelled as 3 on the trap funnel) opened with gel 1.

The depressor weight was released at 100 m as expected.

On recovery, all four sample pots had collected particles, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing.

P6 (standard trap)

Station:	DY050-078
Target depth:	600 m
Target temp:	10.30°C
In situ density:	1029.914 kg m^{-3}
Added ballast:	4185 g
Deployment time:	30.04.16 08:19
Deployment posn:	49° 00.540’ N
	16° 23.220’ W

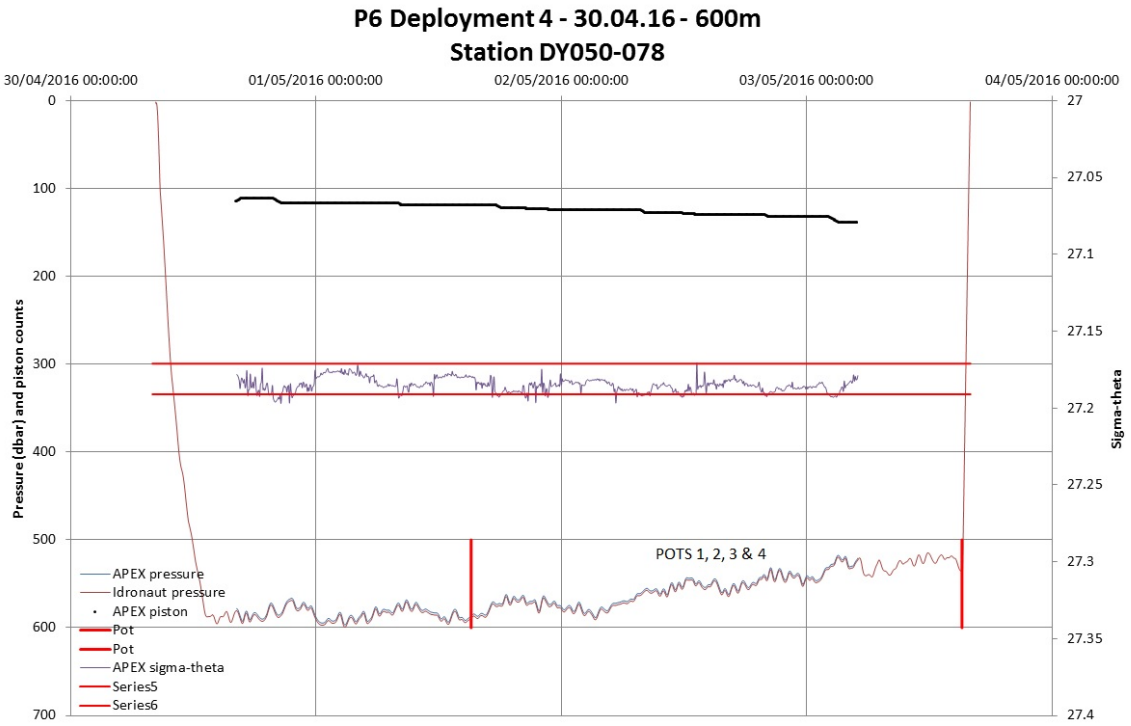


Figure 76: P6, deployment 4

P6 was ballasted perfectly with just 3 piston counts needed to reach its initial equilibrium period. Further adjustments were made but only in response to changing sigma-theta values as expected. Ballasting was made with a -50 g adjustment on the calculated value as in the previous deployment.

All four cams were fitted such that all four pots opened simultaneously for one single aggregated sample.

The depressor weight was released at 100 m as expected.

On recovery, all four sample pots had collected particles, the carousel was positioned as expected and the burn wire released at the expected time, all indicating proper function of the timer and the new carousel bearing.

P7 (camera trap)

P7 was not deployed as the air bladder failed to inflate during mission prelude and a ‘modem registration’ error was encountered. This will be investigated when back at NOC.

P8 (standard trap)

Station: DY050-079

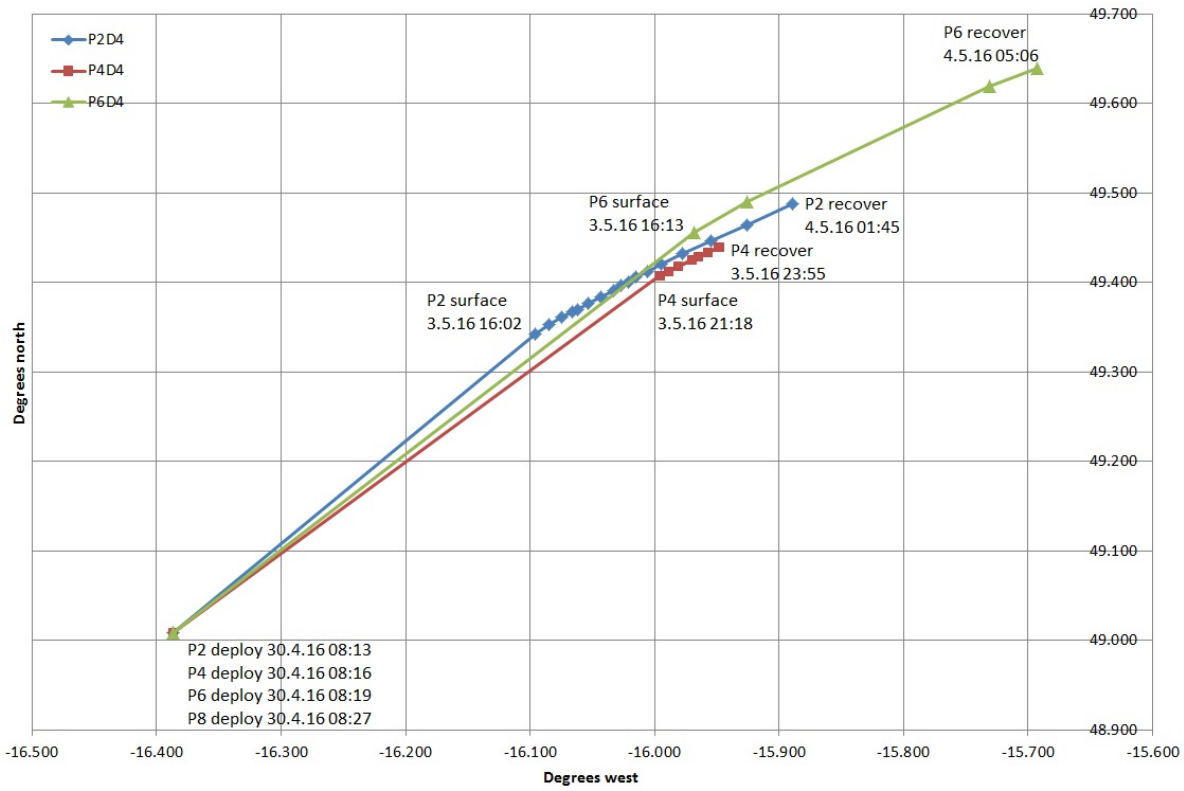
Target depth: 200 m

Target temp:	10.30°C
In situ density:	1029.914 kg m^{-3}
Added ballast:	4053 – 50 = 4003 g
Deployment time:	30.04.16 08:27
Deployment posn:	49° 00.540’ N
	16° 23.220’ W

P8 was set up and deployed in the same manner as P2, P4 and P6 but appears to have failed to surface. No Iridium transmissions have been received to date (6.5.16 11:05). All setup records have been checked and all appear to be in order so it is not clear what has gone wrong with this deployment. A search was carried out in the vicinity of the expected position assuming it had surfaced at the programmed time and followed the other traps’ course but nothing was found. Possible scenarios include:

- Trap descended too deep and the emergency abort weight failed to release at 1000 m. *(All releases have been refurbished and fully tested at NOC).*
- Trap is on the surface but the APEX telemetry has failed. *(Telemetry on P8 has worked up until now and P8 did successfully telemeter its position whilst on deck during mission prelude).*
- Trap is on the surface and APEX telemetry is working but messages are not being received on the Iridium server at NOC. *(All other traps have been able to log in and upload/download successfully. The modem at NOC has been power cycled to rule out any problem with that).*
- The timer and/or burnwire have failed in some way so the end-of-mission weight hasn’t released. This may cause the trap to be neutrally buoyant at some depth below the surface and so telemetry is impossible. *(This is a possibility. If this is the case, the burnwire may eventually corrode through and the trap may yet surface and communicate – this may take several weeks or months).*
- Something may have flooded; APEX float, Idronaut logger, buoyancy hoop. *(This is always a possibility).*

Figure 77: Deployment 4 drift plot (including surface drift)



12 PELAGRA Cam

By Morten Iversen, Christian Konrad, Kev Saw, Clara Flintrop, Richard Lampitt

Deployment of the PELAGRA Cam on the RCF and on the PELAGRAs

12.1 Introduction

We deployed the PELAGRA Cam in the upper water column to determine the abundance and size-distribution of particles larger than ~100 µm. We deployed the PELAGRA Cam both as a profiling system to capture an image of the particles in the upper 300 m of the water column at five seconds intervals and as neutrally buoyant systems on the PELAGRA sediment traps. The PELAGRA Cam was time to take ten images with two seconds intervals every 30 minutes while on the PELAGRA sediment traps. While it is difficult to determine if a particle is settling or suspended from the images obtained with the profiling system, the PELAGRA sediment trap deployments offers the opportunity to determine settling velocity of the particles in situ, as well as estimating the proportion of settling versus suspended particles. Further, due to the high resolution of illumination of the PELAGRA cams,

it is possible to determine particle types and colours and thereby quantify abundance and size-distribution of different particle types (e.g. marine snow versus zooplankton faecal pellets). We can even determine size-specific settling velocities of the different particles types from the deployments on the neutrally buoyant PELAGRA sediment traps.

12.2 Methods

The PELAGRA Cam consisted of a Canon EOS 6D digital SLR camera equipped with a 50 mm macro lens and a Canon Speedlite 600EX RT flash gun. The camera and the flash gun were places perpendicular to each other provide illumination from the right side of the captured images (see Figure 78). We used a Hahnel Giga T Pro II remote timer to capture an image every five seconds. The camera was put in manual mode and the settings were adjusted to have an ISO of 2500, a shutter speed of 1/160 seconds, an aperture of f/32, and the lens focus was put to 1.5 feet. The flash was also in manual mode and put for straight flash direction and a flash output of 1/8.

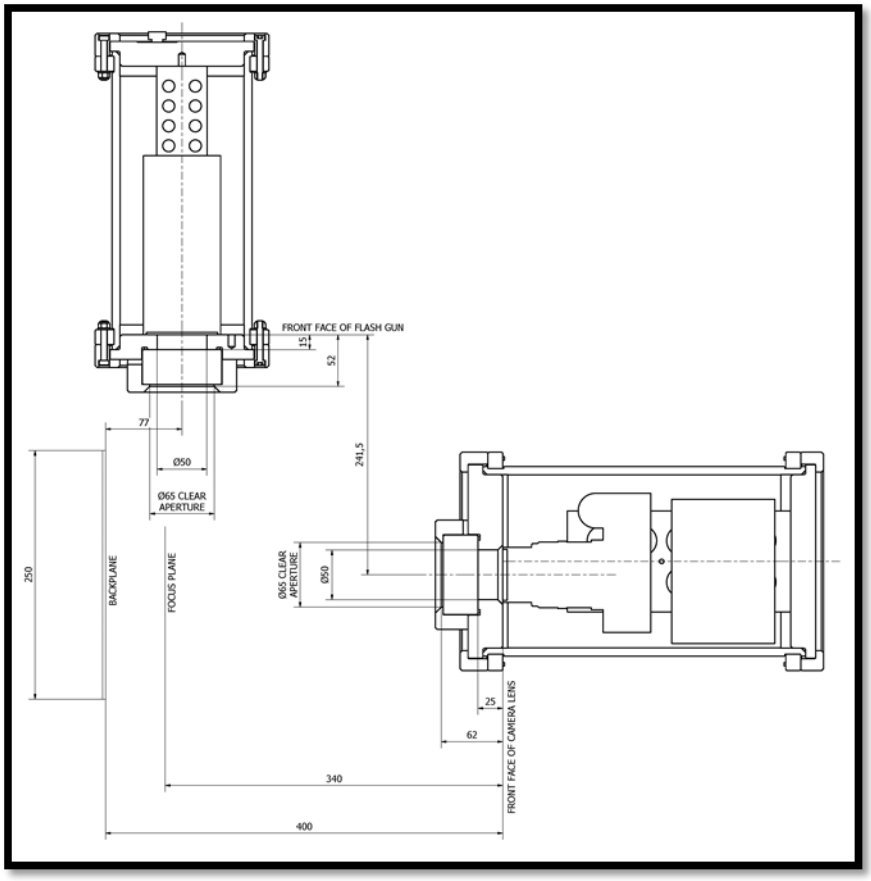


Figure 78: Overview figure of the PELAGRA Cam configuration. The pressure housing in the lower right part of the image contained the camera and the upper left pressure housing contained the flash gun.

We were able to capture individual particles through the water column in a water volume of 2.15 L for each captured image. The pixel size of the images changed depending on whether the particles were in the front of back of the field of depth. We determined a pixel size of 33 µm per pixel in the front of the depth of field (as seen from the camera) and a pixel size of 61 µm per pixel at the back of the depth of field. This suggested an average pixel size of 54 µm per pixel. The field of view for each image was 157 mm width, 101 mm height, and 135 mm depth. The width and height of the images were determined by the cropping of each image to compensate for uneven flash illumination and might change when we do the final image processing.

12.3 The Red Camera Frame (RCF)

The PELAGRA Cam deployments were done as vertical profiles on the Red Camera Frame (RCF) in combination with the LISST HOLO (Holocam) and an Idronaut CTD (Figure 79). The Holocam captured images every five seconds, which was the same frequency as the PELAGRA Cam. The Idronaut CTD was programmed to obtain depth, temperature, and conductivity (salinity) every 125 ms. We made 16 vertical profiles with the RCF from the surface to 300 m depth (see Table 20).

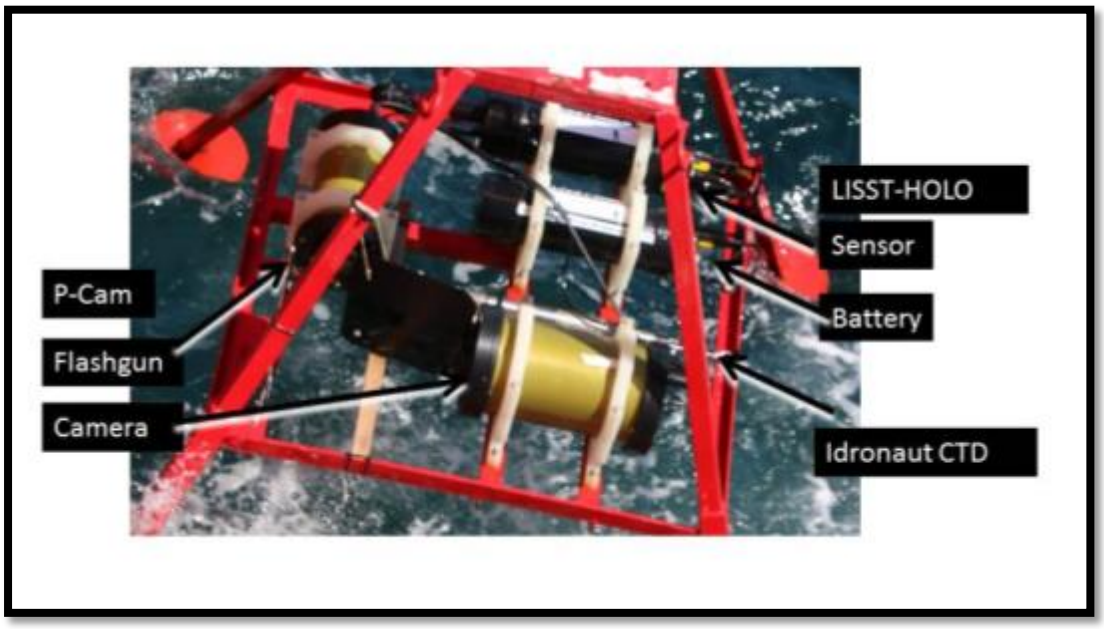


Figure 79: The Red Camera Frame (RCF) with the PELAGRA Cam, the Idronaut CTD, and the LISST HOLO (Holocam). Image provided by Richard Lampitt.

Table 20: Overview of deployments of the Red Camera Frame (RCF). Station No is the ship's station number, RCF No. is the deployment number of the RCF.

Station No.:	RCF No.:	Date	Maximum wire out (m)	No of Images taken	Latitude N	Longitude W
DY050-014	RCF_001	2016-04-23	300	287	49°00,33'	16°23,81'
DY050-029	RCF_002	2016-04-25	300	914	49°00,42'	16°23,86'
DY050-042	RCF_003	2016-04-26	300	450	49°00,33'	16°23,86'
DY050-051	RCF_004	2016-04-27	300	933	49°00,33'	16°23,84'
DY050-067	RCF_005	2016-04-29	300	1403	49°00,32'	16°23,85'
DY050-071	RCF_006	2016-04-30	300	647	49°10,82'	16°05,29'
DY050-072	RCF_007	2016-04-30	300	625	49°10,82'	16°05,29'
DY050-073	RCF_008	2016-04-30	300	592	49°10,82'	16°05,29'
DY050-074	RCF_009	2016-04-30	300	560	49°10,82'	16°05,29'
DY050-075	RCF_010	2016-04-30	300	588	49°10,82'	16°05,29'
DY050-088	RCF_012	2016-04-30	300	1082	49°00,21'	16°23,45'
DY050-096	RCF_013	2016-05-01	300	1214	49°00,33'	16°23,81'
DY050-097	RCF_014	2016-05-01	300	1263	49°00,33'	16°23,81'
DY050-103	RCF_015	2016-05-02	300	1180	49°00,71'	16°23,85'
DY050-117	RCF_016	2016-05-04	300	1249	49°00,30'	16°23,59'
DY050-125	RCF_017	2016-05-05	300	1243	49°48.28'	16°03,19'
total count of images				14230		

12.4 PELAGRA Cam and gel traps on the PELAGRAs

We deployed the PELAGRA Cam on the PELAGRAs three times (Figure 80); on P7 deployment 1, P7 deployment 3, and P4 deployment 4. The first deployment (P7 deployment 1) was under-ballasted and never made it to depth (see cruise report on the PELAGRAs, Section 11). Additionally the horse shoe connected for the flash on the camera had slipped out during mounting of the camera in the pressure housing and no illumination was provided for the images. The second deployment (P7 deployment 3) provided well illuminated images with particles in focus. However, since the PELAGRA did not reach its target depth until at the end of the deployment period (see Cruise Report for PELAGRAs), all image sequences were obtained while the PELAGRA was descending. This means that we cannot use the images to determine size-specific settling velocities, but the images are very useful for determinations of particle size-distribution and abundance through the upper 800 m of the water column. The last deployment (P4 deployment 4) was successful both in terms of the PELAGRA reaching its target depth within a few hours and in terms of focus and illumination of the images and we have several image sequences that provide settling velocities of the captured particles.

Figure 80: PELAGRA with the PELAGRA Cam mounted (the two green pressure housings). The left side pressure housing is for the camera and the right side pressure housing is for the flash gun.

12.4.1 Preliminary results

We still need to quantify the particle sizes and abundance via image processing of the captured particles. From the first qualitative observations of the images we observed a change in the marine snow particles on the 1st of May. The profiles made before the 1st of May showed mainly small and

compact particles (Figure 81, left panel) while the particles captured from the 1st of May and onward suggested that the particles were more loosely structured and contained high amounts of gel-like substances (Figure 81, right panel). We could confirm this observation from the microscopic observations of the individual particles collected with the Marine Snow Catcher. This seemed to coincide with indications of increasing abundances of pteropods in the vertical hauls of zooplankton nets, suggesting that the gel-like substances in the marine snow aggregates could be caused by mucous feeding structures produced by pteropods.

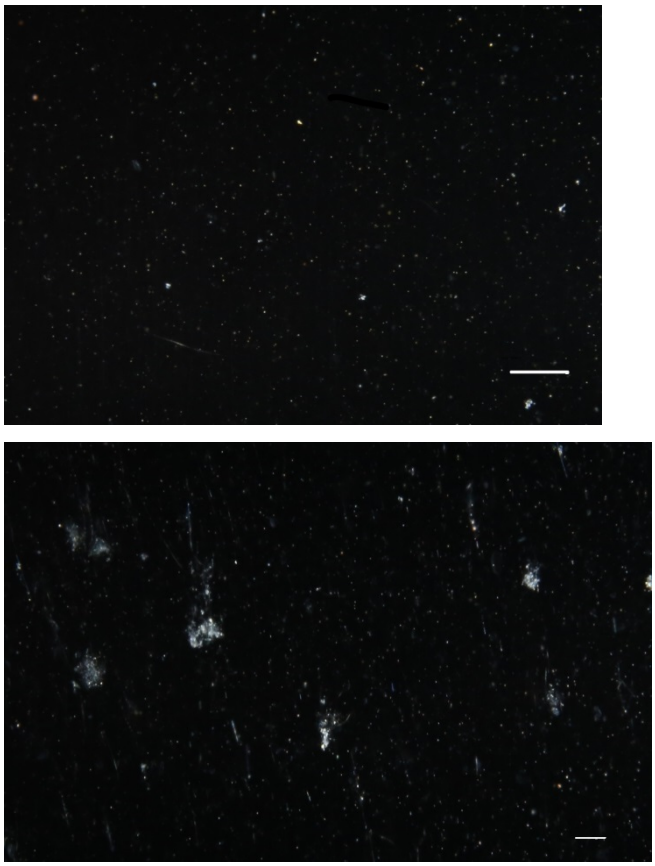


Figure 81: Examples of particles captured in the upper 50 m of the water from the 30th of April 2016 (left panel) and from the 5th of May 2016 (right panel). The white line in the lower right corner of both images is a scale bar showing 5 mm.

13 Holographic imaging of particles

We deployed a LISST-Holo (Sequoia Scientific, Inc.) holographic imager. The system was run on the same "Red Camera Frame" as the pelagic particle camera operated by Morten Iversen *et al* (Section 12). The system uses a laser and 1600 x 1200 pixel image sensor to image a small volume of water 1.86 cm^3 at full frame (*see also* region of interest). The system was run over 17 deployments of varying length including 4 night-time deployments. All deployments were run over the full operational depth of the instrument, 300 m depth (Table 21). This system was frequently operated before or after the marine snow catcher. The instrument was oriented such that there was unobstructed flow in the viewed volume in both the upward and downward casts. The system was deployed by running the Romica winch wire through a block on the starboard aft crane over the starboard side. Winch wire speed was generally between 3-5 rpm on the winch, equating to <10 m s^{-1} in water vertical speed. The only exception was DY050-042, where stops every 10 m depth of between 2-8 min. were added, with longer stops at deeper depths. The holographic system was set at its maximum image capture rate of 1 image every 5 s. The viewed volume can be sub-sampled as needed to generate size-volume distributions of particles from ~25-2500 µm in equivalent spherical diameter. The software Holo Batch v3.0 was used to process the images into the size distribution data with the "LISST-100x RANDOM type C" size class output. A reduced region of interest (ROI) was used to avoid an apparent errant object in the optical path, where the right ~20% of the image was removed. As an additional adjustment to avoid errant particle detection, we only considered the volume from 5 to 45 mm in the 0 to 50 mm optical path length, avoiding volume adjacent to the windows.

Figure 82: Red camera frame with the LISST-Holo instrument (foremost housing), battery housing (backmost black housing), as well as the macro camera and flash (green housings).

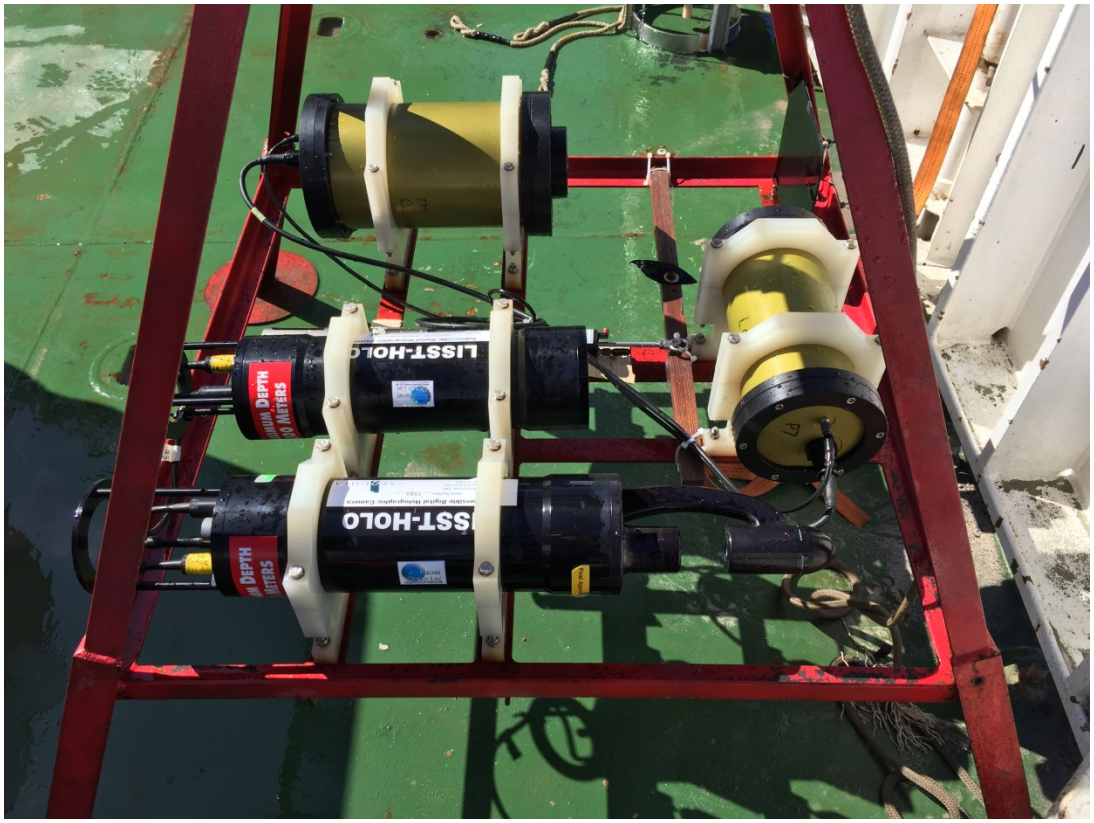


Figure 83: Screen grabs of the Holo Batch settings, including the adjusted ROI area.

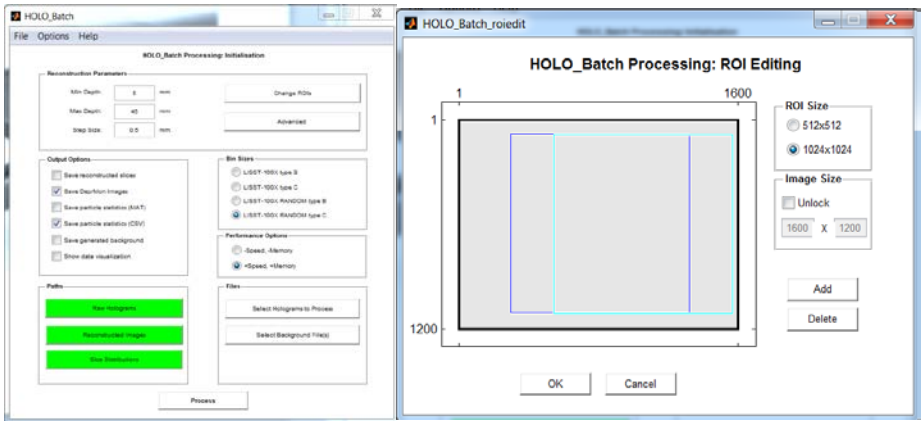


Table 21: Station log of LISST-Holo deployments.

Station	In water times (instrument clock)					Useful holograms (count)	Maximum wire out (m)	Comments
	Year	Month	Day	Start time	End time			
DY050-014	2016	4	23	17:46:39	18:56:16	577	300	
DY050-029	2016	4	25	15:39:26	16:54:21	624	300	
DY050-042	2016	4	26	13:37:56	17:22:38	1858	300	Longer time at deeper depths
DY050-051	2016	4	27	10:40:06	11:57:38	637	300	
DY050-067	2016	4	29	16:07:14	18:16:07	1048	300	Mud being washed overboard
DY050-071	2016	4	30	01:01:31	01:55:06	438	300	
DY050-072	2016	4	30	02:14:20	03:05:12	425	300	
DY050-073	2016	4	30	03:18:05	04:06:34	407	300	
DY050-074	2016	4	30	04:18:55	05:04:14	384	300	
DY050-075	2016	4	30	05:15:52	06:03:35	400	300	
DY050-080	2016	4	30	09:30:12	10:58:34	723	300	No macro camera on Red Camera Frame
DY050-088	2016	4	30	14:33:41	16:02:40	736	300	
DY050-096	2016	5	1	12:20:51	14:00:49	832	300	
DY050-097	2016	5	1	14:11:38	15:56:41	863	300	
DY050-103	2016	5	2	15:45:40	17:22:23	800	300	After weather hold
DY050-117	2016	5	4	14:38:53	16:22:04	842	300	
DY050-123	2016	5	5	14:08:54	15:52:00	1012	300	
Total count of useful images						12606		

14 CTD sampling

By Sue Hartman, Corinne Pebody, Andrew Morris

CTD casts on DY050 were primarily for testing sensors and releases. The first cast was shallow and was used for pre deployment validation of the wetlabs and Cyclops fluorometer on the Aanderra Seaguard, to be deployed at PAP1. Unfortunately there was a problem with the CTD fluorometer cable so we do not have this measurement for comparison. The sensors were tested against each other and also the extracted chlorophyll samples. The star oddis, optode, SUNA nitrate and PAP1 microcats were also tested at CTD001.

CTD002 was the first deep station and was used to test the PAP3 microcats and releases. The post deployment validation check of PAP1 sensors was CTD008, with the testing of microcats on CTD009. The PAP3 microcat was tested on CTD010.

Table 22: A summary of sensors (additional to the CTD sensors) attached to the rosette

CTD Cast	Sensor type	Serial number
001	**Pre deployment sensors:**	
	Suna nitrate	698
	Seaguard Turner fluorometer	2102108
	Seaguard optode	1339
	Wetlab fluorometer FLNTSUB	269
	Oxygen microcat 37imp odo (for buoy PAP1)	10315
	Microcat 37im (for 30m PAP1)	6915
	Oxygen microcat 37 imp ido (pressure sensor fail)	9030
002	**Pre deployment sensors:** PAP 3 microcats & releases	
	Microcat sbe37-im	09469
	Microcat sbe77-im	09475
008	**Post deployment sensors:**	
	Seaguard Turner fluorometer	2103960
	Seaguard optode 44330	2001
	Wetlab fluorometer FLNTSUB	3050
009	**Post deployment sensors:**	
	Oxygen microcat odo (from buoy PAP1)	13397
	Oxygen microcat odo (from frame PAP1)	10535
	Microcat (from buoy PAP1)	6904
	Pre deployment sensors:	

	Oxygen microcat 37 imp ido (pressure sensor fail)	9030
010	**Post deployment sensors:** PAP3 microcat 37-imp-66262	 9476

In total we had 11 CTD stations (with no bottle samples from CTD004). The station positions are shown in Table 23 (which shows that the first shallow CTD station was not near the PAP site area). In retrospect the pre deployment calibration should have been repeated on a later cast, once the CTD sensors were working properly.

Table 23: CTD station positions, seabed and cast depth

Station	Latitude (N)	Longitude (W)	Seabed depth (m)	Cast depth (m)
CTD001	49 36.102	08 21.633	138	100
CTD002	49 0.33	16 23.82	4812	4790
CTD003	49 0.488	16 27.184	4811	500
CTD004	49 0.32	16 23.85	4811	N/A
CTD005	49 0.347	16 23.846	4811	1500
CTD006	49 0.314	16 23.817	4809	3000
CTD007	49 0.321	16 23.847	4849	4828
CTD008	49 0.325	16 23.8	4810	200
CTD009	49 0.334	16 23.813	4810	100
CTD010	49 0.708	16 23.85	4810	4800
CTD011	49 0.319	16 23.82	4808	2500

Aside from sensor validation the stations were used to collect water for analysis, to validate the CTD sensors and to test NOC sensors that are in development (for T, S and nitrate). On each occasion samples were taken in the following order: Dissolved oxygen, Dissolved Inorganic Carbon (DIC), inorganic nutrients, salinity and associated parameters from the top 200m. The associated parameters from the surface samples were chlorophyll, size fractionated chlorophyll, PIC, POC and biogenic silica. These surface samples were filtered and frozen as appropriate for analysis ashore. Occasionally Lugols samples were also taken (from CTD001,002, 003 and 005), for analysis at NOC.

Table 24: Summary of the CTD log sheets showing the depth sampled for DIC, nutrients and oxygen, then depths sampled for surface parameters such as chlorophyll.

depth (m)	CTD stations with DIC, oxygen and	CTD stations with surface parameters		depth (m)	CTD stations with DIC, oxygen and

	nutrients	Eg: Chlorophyll			nutrients
10	2,3,5,6,7,8,9,10,11	2,3,5,6,7,8,9,10,11		900	6,7,10
20	1,2,5,6,7,9,10,11	1,2,5,6,7,8,9,10,11		1000	2,5,6,7,10
30	2,3,5,6,7,8,9,10,11	2,3,5,6,7,8,9,10,11		1200	7
50	2,8,10,11	1,8,10,11		1500	5,7,10
60	1,2,3,5,6,7,8,9	5,6,7,8,9		1600	11
70	1	1		2000	2,6,7,10
80	2,3,5,6,7,8,9,10,11	2,3,5,6,7,8,9,11		2500	11
100	1,2,3,5,6,7,8,9,10,11	1,3,5,6,7,8,9,10,11		3000	2,6,7,10
150	8,11	11		3500	10
200	2,6,8,10	2,10		4000	2,7,10
250	3,5	3		4300	10
300	10			4700	2
400	2,6,7			4760	2
500	2,3,5,6,7,10	3		4790	2,7
600	2,6,7,10			4800	7
750	2,5,6,7,10,11			4828	7

DIC samples were preserved with mercuric chloride and will be analysed on Vindta24 at NOC for Dissolved Inorganic Carbon (DIC) and Total Alkalinity (TA). Duplicates were taken from each station (usually 2). Nutrient samples were collected in centrifuge tubes and frozen for analysis of inorganic nutrients (NO_2+NO_3, phosphate and silicate) using the Quattro auto-analyser at NOC. Sufficient sample was taken for duplicate analysis.

Generally 2-3 salinity bottle samples were taken from each cast, for analysis on-board at the end of DY050. Chlorophyll samples were filtered and frozen for analysis in batches on DY050. The oxygen bottle samples were fixed on deck, returned to the deck laboratory and analysis was started within 2 to 7 hours of collection.

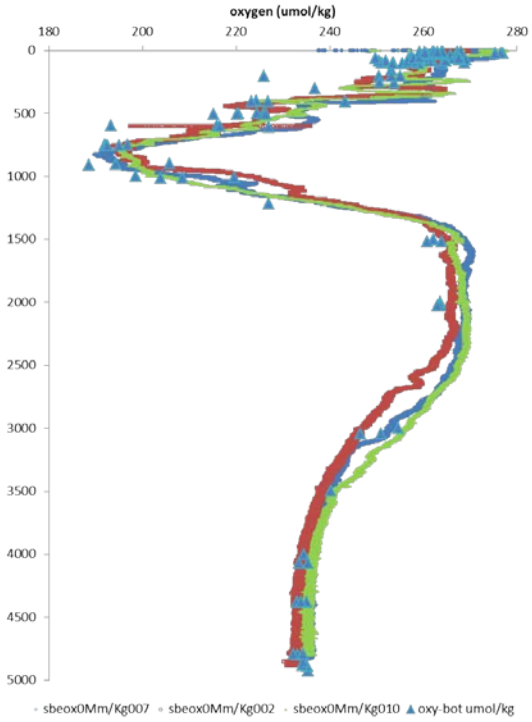
14.1 Oxygen analysis on-board

By Sue Hartman

In total 140 samples were analysed for dissolved oxygen using a modified Winkler technique. An amperometric end point method was used, following the titration using an electrode to a set end point. Thiosulphate titrant was delivered using a Titrino 794. The method was standardised using 5ml additions of 0.01N OSIL iodate (3 bottles were used during DY050). The normality of the thiosulphate ranged from 0.0992-0.0996 (a constant 0.0995 was used to calculate each cast).

Duplicate samples were taken on each cast (between 2 and 4 each time). The average duplicate difference was 0.38 umol/l. The CTD temperature was used for the fixing temperature to account for any changes in bottle volume (as the probe that was used initially was not thought to be reliable enough). Density from the CTD processed files was then used to convert to umol/kg units so the oxygen bottle data could be compared with the CTD sensors (Figure 84).

Figure 84: Oxygen data from the three deep casts (CTD002, 007 and 010) with associated bottle oxygen data.



As seen in Figure 84 the bottle oxygen agreed reasonably well on the deep casts. Figure 2 however shows that there is a potentially high offset between bottle oxygen and CTD seabird oxygen measurements in the shallow water (Figure 85). This was reasonably linear and could be used to correct the sensor data to the bottle samples.

Figure 85: The offset between bottle data (minus CTD oxygen data) for the three deep stations, CTD002 (in red), 007 (in blue) and 010 (in green) was linear with depth, with larger offsets in shallow water.

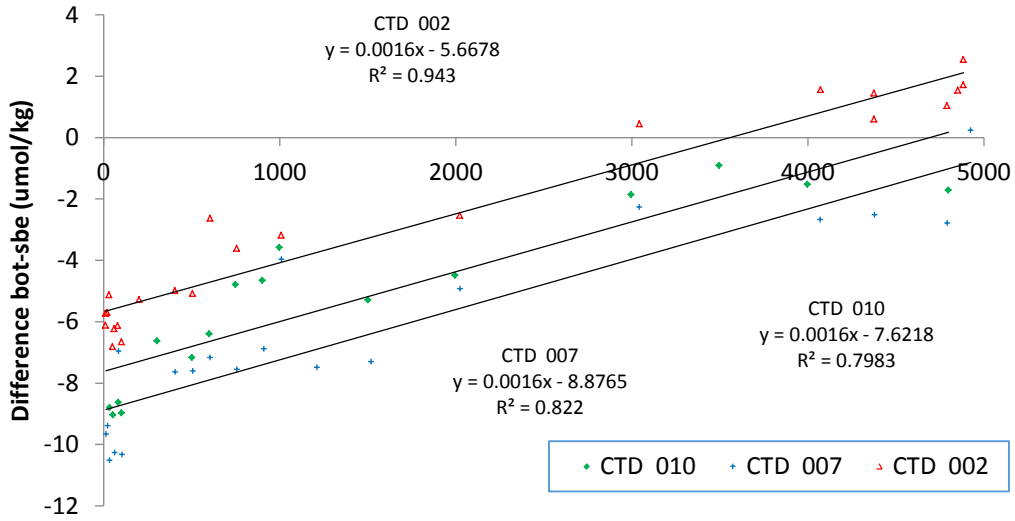
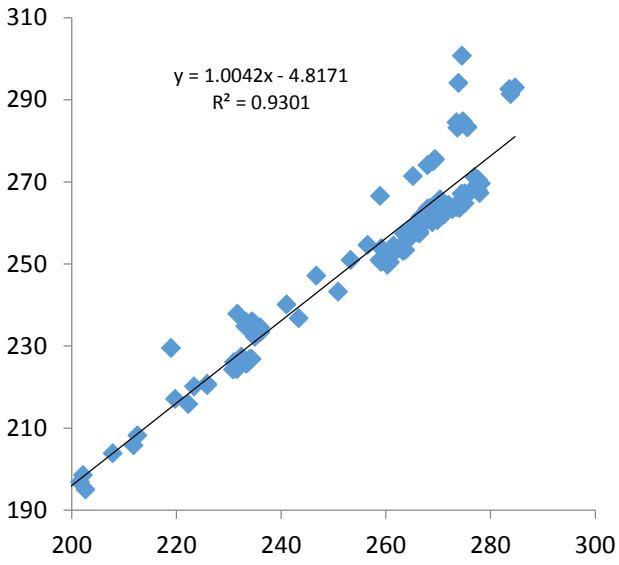
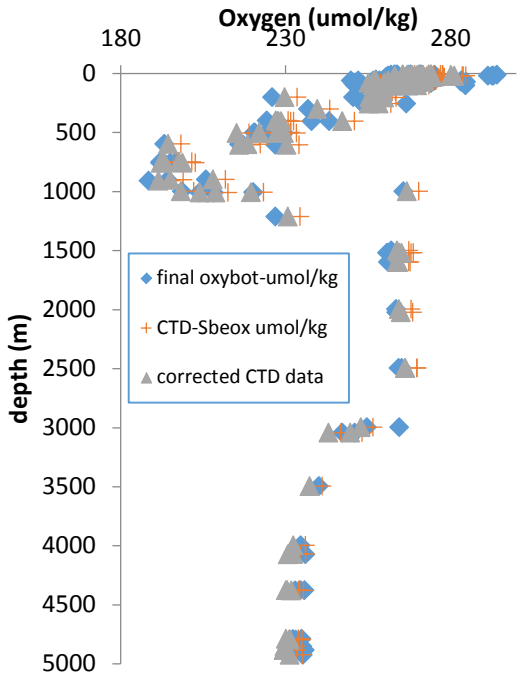


Figure 86: Tthe overall relationship between the bottle and CTD oxygen data



This equation can be applied to the CTD oxygen data however this will not improve data agreement at depth (Figure 87). The final merged bottle oxygen data are available in a file called: 'All-Final-Oxy-data-DY050'.

Figure 87: Corrected CTD oxygen data (in grey) along with the bottle data (blue) and uncorrected CTD oxygen data (red crosses).



15 Underway sampling

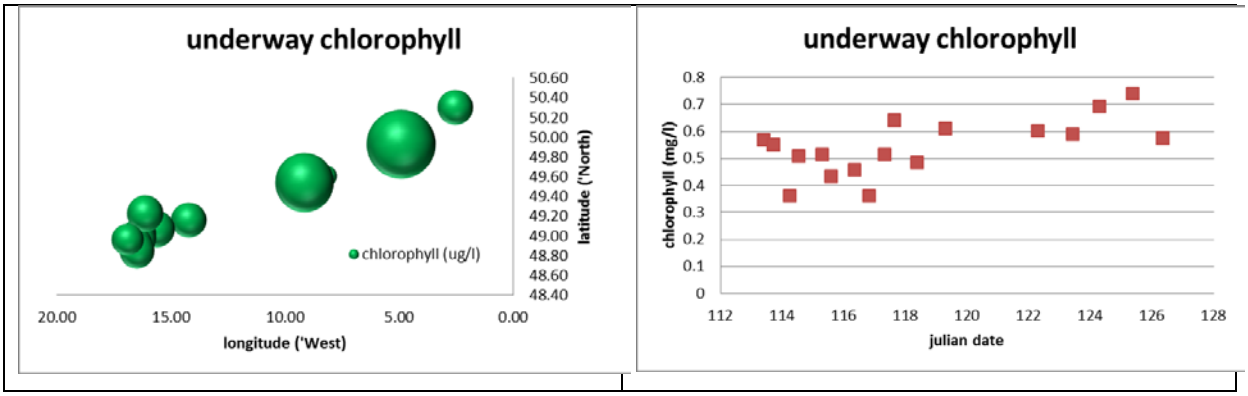
By Sue Hartman

Bottle samples were taken from the non-toxic supply seawater at the sampling point next to the thermo-salino-graph (TSG) on the main deck, one deck down from the CTD sampling. Samples were taken 1-2 times a day for DIC, salinity and chlorophyll. 250ml aliquots of the chlorophyll samples were immediately filtered onto GF/F filters and frozen for analysis on-board. Likewise salinity analysis was done on-board, at the end of DY050.

The DIC samples were preserved for analysis on Vindta 24 at NOC. These samples will be analysed for DIC and TA and calculations made of pCO_2 for comparison with the PML underway pCO_2 system. At the start of DY050 the PML system was found to have only two of the three calibrant gases. The system was also initially blocked at the equilibrator but was soon fixed. The dataset will be assessed and made available via PML.

Chlorophyll concentration was greatest in the western English Channel, but once at the PAP observatory site, the chlorophyll concentration increased throughout the cruise. The drop at the end may be due to poor weather that blew through.

Figure 88: Location and quantity of chlorophyll from the underway sampling.



16 Benthic Biology

By Brian Bett, Henry Ruhl, Andrew Gates, Rob Young, Claire Laguionie-Marchais , Lenka Nealova, Noelie Benoist, Simone Pfeifer and Marla Spencer

16.1 Megacorer

The NOC-OBE Bowers & Connelly megacorer was used on 14 occasions at 13 stations during the cruise for collection of sediment for biological analysis (Table 25). If sufficient cores were available samples were also collected to analyse for microplastics. The deployment at RP-05 was repeated because the first attempt at that station only recovered one good sample. The first 9 deployments used 8 large core tubes and 2 small (MgC-08+2). On subsequent deployments 10 large tubes were used (MgC-10).

16.1.1 On deck

Once megacorer was recovered to deck the cores were examined for overlying water clarity, disturbance and cracks in the core and notable layers or patches in the sediment. The length of core

sediment retention was measured and example core profiles were photographed. They were then removed from the megacorer and allocated to analysis type randomly.

16.1.2 Lab processing

Once the cores were removed from the megacorer they were processed by three teams of two with assistance from others if available. One person held the core in position while the other sliced the sediment. Details of slicing procedures to acquire the necessary sediment horizons are detailed in Table 26 and summarised below.

16.1.3 Macrofauna

Macrofauna samples were the priority for the megacorer deployments. A minimum of four large tubes per deployment were allocated to macrofauna. If fewer than four were available macrofauna samples were not taken. If four were available the remaining cores were allocated to other analyses with any additional cores allocated to macrofauna.

To process the cores the overlaying top water was siphoned into a 250 µm sieve and then transferred into the bottle for 0-1 cm sediment layer (syringes were used when necessary to extract the small volume of remaining water). Slicing rings were used to measure the following horizons: 0.0 – 1.0 cm (if the top layer was not flat, the lower part of a slope was used to define the 0-1 cm layer), 1.0 – 3.0 cm, 3.0 – 5.0 cm, 5.0 – 10.0 cm, 10.0 – 15.0 cm. Each layer was cut with slicing plate, which was then rinsed (the upper side on the current layer and the downside side used as the top side for the next slice). The top three layers were usually transferred into the bottle with the help of funnel, the 5cm thick layers were sliced with knife and then put directly into the bottle. Rings, funnels and knives were rinsed into appropriate bottle in filtered seawater.

The 0-1, 1-3 and 3-5 cm were put in 500 ml UN bottles and 1500 ml UN bottles were used for the 5-10 and 10-15 cm layers. Each bottle was labelled on the cap and one side and a paper label was placed inside the bottle. Samples were preserved in 4% formaldehyde (½ 8% formaldehyde with borax (5 g l^{-1}) ½ sediment/filtered seawater). If the sample filled more than half the volume of a bottle, the overlying water was passed through a 250 µm mesh sieve and the material washed back into the bottle to ensure the correct formaldehyde concentration.

16.1.4 eDNA & Phosphlipids

One large core was used for eDNA. All slicing equipment was sterilised in bleach prior to sample processing and washed with Milli-Q between each slice. Nitrile gloves were worn at all stages (new pair for each core). The overlying water was discarded and the following horizons were sliced: 0.0-

1.0 cm, 1.0-2.0 cm, 2.0-3.0 cm, 3.0-4.0 cm, 4.0-5.0, 10.0-15.0 and 15.0-20.0. For each 1 cm slice samples of sediment were placed in 3 small sterile aliquots for DNA (stored at -80°C), 3 small aliquots for RNA Later (-80°C after 4°C for few hours) and the remainder of slice in a 50 ml Falcon tube at -80°C for phospholipids analysis. For the 5.0-10.0, 10.0-15.0 and 15.0-20.0 cm slices sediment was placed in 50 ml Falcon tubes at stored at -80°C using spatula. In all cases sediment near the edge of the core was discarded. New sterile spatulas were used for each slice. In between the slices, the slicing plate was rinsed with Milli-Q. More details in section 17.

16.1.5 Biomarkers

One large core was used as a replicate for biomarkers. The top water was discarded. Before slicing and between slices the equipment was rinsed with milli-Q water. Four sections were taken at 0.5 cm horizons to 2 cm. Sediment in contact with the core tube was removed using a knife rinsed in Milli-Q water and the remaining material preserved in muffled foil (preserving as much as possible the integrity of the slice) held inside labelled petri dishes, placed inside a single labelled bag per sample and frozen at -80°C straight away. Nitrile gloves were worn at all stages

16.1.6 Quantitative protozoan meiofauna (Foraminifera):

A small core was used. Before processing and between slices the slicing equipment was washed with filtered seawater. The top 1cm of overlaying sea water was passed through 250 µm sieve and added to the 0-0.5 cm sample. The samples were then sliced at 0.5 cm intervals to 2 cm then at 1 cm interval from 2-3 cm. The sediment was preserved in 4% formaldehyde (½ 8% formaldehyde with borax (5 g l^{-1}) ½ sediment/filtered seawater) and placed into 500 ml UN bottles (blue lids, one for each slice).

Metazoan meiofauna: A small core was used. Before processing and between slices the slicing equipment was washed with filtered seawater. The top five cm of sediment and 2 cm of sieved top water were retained in 1.5 l plastic bottles and preserved in 4% formaldehyde (½ 8% formaldehyde with borax (5 g l^{-1}) ½ sediment/filtered seawater).

Microplastics: As soon as the sample was removed from the megacorer, the large core allocated for microplastics analysis was covered with aluminium foil (instead of a rubber bung, to avoid plastic contamination). Before processing and between slices the slicing equipment was washed with filtered seawater. Two 1 cm slices were retained: the 0-1 cm (including the overlaying water) and the 6-7 cm. Each sliced was placed in a glass jar with a plastic top covered in foil to avoid plastic contamination from the cap. The overlying water was filtered with a 250 µm mesh sieve and added to the 0-1 cm jar. For both slices, as little as possible water was added to the samples. Samples were provided to Katsia Pabortsava who then dried them at 60°C on board *RRS Discovery*.

Labelling

All samples were labelled with Cruise ID (DY050), Station number, Date of the megacorer at the bottom, core letter (for macrofauna only), sediment horizon, analysis type and type of preservative. The outside of every container was labelled (top and side if possible) and a paper label was placed inside the container.

Table 25: Summary of megacorer samples collected at the PAP central coring station during DY050

Station	Site	Sampler	Latitude (N)	Longitude (W)	Depth (m) (USBL)	Macrofauna	eDNA/Phospholipids	Biomarkers	Metazoan Meiofauna	Foraminifera	Microplastics
DY050-002	RP-01	MgC-08+2	48° 50.055'	016° 31.312'	4850	5	1	1	1	1	
DY050-003	RP-02	MgC-08+2	48° 50.387'	016° 31.174'	4850		1	1			1
DY050-011	RP-03	MgC-08+2	48° 50.255'	016° 31.084'	4849	5		1	1	1	1
DY050-012	RP-04	MgC-08+2	48° 50.016'	016° 31.086'	4850	5				1	
DY050-018	RP-05	MgC-08+2	48° 50.277'	016° 31.270'	4849			1			
DY050-019	RP-05 repeat	MgC-08+2	48° 50.296'	016° 31.262'	4851	4	1		1	1	

DY050-026	RP-06	MgC-08+2	48° 50.171'	016° 31.526'	4849	4	1		1	1	
DY050-36	RP-07	MgC-08+2	48° 50.270'	016° 30.999'	4849	4	1		1	1	1
DY050-37	RP-08	MgC-08+2	48° 50.477'	016° 31.344'	4850	4		1	1	1	
DY050-46	RP-09	MgC-10	48° 50.075'	016° 31.223'	4849	4	1				1
DY050-47	RP-10	MgC-10	48° 50.263'	016° 31.622'	4851	4					
DY050-56	RP-11	MgC-10	48° 50.281'	016° 31.139'	4850	7					1
DY050-107	RP-12	MgC-10	48° 50.210'	016° 31.222'	4848	5					
DY050-124	RP-13	MgC-10	48° 50.183'	016° 31.377'	4850	5					1
				TOTAL REPLICATES		12	6	5	6	7	6
				Total cores		56	6	5	6	7	6

Table 26: Summary of the megacore processing protocols

	Large core (10 cm diameter)				**Small core (7 cm diameter)**	
	eDNA & phospholipids	**Microplastic**	**Macrofauna**	**Biomarkers**	**Foraminifera**	**Metazoan meiofauna**
Number of core per megacore	1	1	At least 4	1	1	1
Preservation	RNA Later, -80°C	dried	4% buffered formaldehyde	frozen -80°C	4% buffered formaldehyde	4% buffered formaldehyde
Surface water	Discard	300 micron sieve + added to first layer	300 micron sieve + added to first layer	In sample	300 micron sieve + added to first layer	Top 1 cm retained and added to first layer
	0-1	0-1	0--1	0-0.5	0-0.5	0-5
				0.5-1	0.5-1	
	1-2		1-3	1-1.5	1-1.5	
				1.5-2	1.5-2	
	2-3				2-3	
	3-4		3-5			
	4-5					
	5-10		5-10			
		6-7				
	10-15		10-15			
	15-20					

16.2 Trawls

16.2.1 DY050-063 OTSB14

When the trawl came on deck there was a large amount of mud in the net. In front of the mud there was a clean selection of specimens which were removed before attempting to deal with the mud. These specimens were cleaned in filtered seawater and brought to the 5°C chill room for further sorting. Once these specimens were removed the haul was initially hosed with the fire hose. The mud was then spilled on deck and shovelled in to grey crates for washing through the sieving table. Thick gloves were used during the washing to avoid injury with glass and clinker. Clinker was put aside and photograph for the records as were any waste found in the trawl.

Specimens were regularly transferred to the 5°C chiller room for further sorting. Owing to the length of time required to process the mud on deck the specimens were broadly sorted in the chill room (one broad category, one container Table 27) and added to preservative as batches were available. A category of unedified taxa was added as some specimens were too damaged to be quickly identified.

Crustaceans were preserved in 100 % ethanol, while other taxa were preserved in 4% formaldehyde (½ 8% formaldehyde with borax (5 g l^{-1}) ½ sediment/filtered seawater). All samples were labelled with Cruise ID (DY050), Station number, Date of the trawl, taxa and type of preservative. The outside of every container was labelled (top and side if possible) and a paper label was placed inside the container.

Noelie Benoist took photos, measurements, volume and weight for 47 specimens (see section Specimen Measurements by Noelie, Table 28 and 29). These animals are in separate bags within the main preservation container for future identification. Rob Young took tissue samples for DNA from most of the specimens examined by Noelie. (Further details of RY and NB's work elsewhere).

The catch comprised fairly typical haul of megabenthic invertebrates from PAP. Holothurians such as *Psychropotes* sp., actiniarians and asteroids (*Styracaster* sp.) were the most abundant. The specimens were preserved and the catch is stored in 20 containers labelled with the station number and listed in Table 27.

Figure 89: DY050-063 OTSB14, the trawl as it came on deck. Note the large quantity of mud

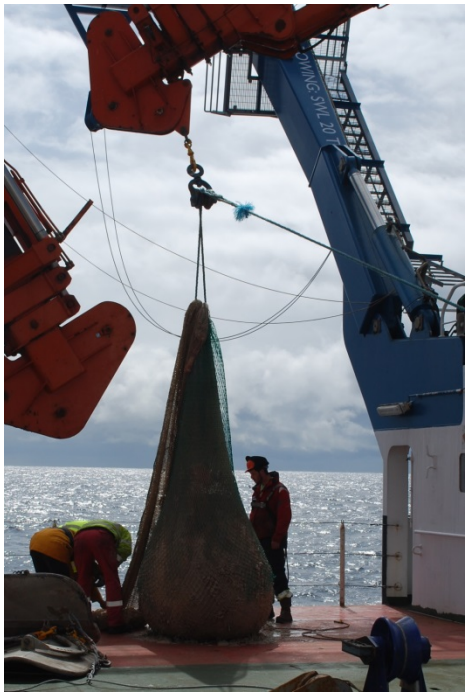
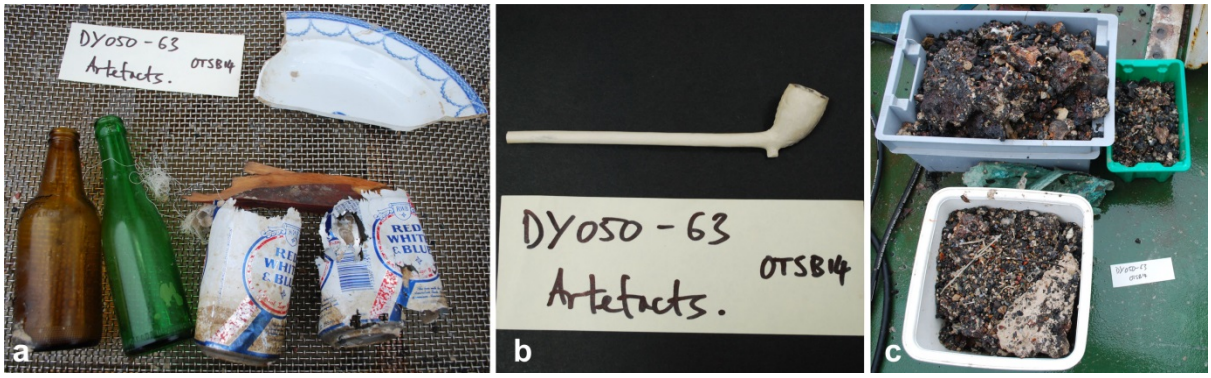


Figure 90: Example images of the catch from DY050-063 a) holothurians, b) arthropods, molluscs and asteroids c) fishes

Figure 91: Example artefacts from the otter trawl DY050-063. a) Left, litter including cans, bottles, broken plate, fishing line, b) clay pipe, c) clinker and other hard substrate



16.2.2 DY050-118 OTSB14

The second successful trawl arrived on deck with considerably less mud in the net. The catch contained two large barrels/drums (Figure 92), one painted white and blue and labelled "FLOATING" (Figure 94). The trawl was opened and specimens were spilled in to grey crates and washed with filtered seawater at the sieving table while wearing thick gloves to avoid injury with broken glass, rusty metal and clinker. Specimens were transferred to the 5°C chiller room for further sorting. Clinker, litter and artefacts were put aside and photographed. The catch comprised a fairly typical haul of megabenthic invertebrates from PAP. Holothurians (*Psychropotes* sp.), actiniarians and asteroids (resembling *Styracaster* sp.) were the most abundant. Several macrourid fish were also caught, the two largest of which were discarded at sea.

In the chill room, the samples were quickly sorted to the broad groups based on the main taxa present (see table 27) then separated into different containers. For crustaceans, 100% ethanol was added in the chill room. Other taxa were preserved in 4% formaldehyde outside on the back deck (½ 8% formaldehyde with borax (5 g l^{-1}) ½ sediment/filtered seawater). There were 25 containers in total (Table 27).

All samples were labelled with Cruise ID (DY050), Station number, Date of the trawl, taxa and type of preservative (Table XX). The outside of every container was labelled (top and side if possible) and a paper label was placed inside the container.

Noelie Benoist took photos, measurements, volume and weight for 42 specimens. These animals were placed in separate bags within the main preservation container for identification by *Discovery* Collections (see section 16.3 by Noelie Benoist, Table 28 and 29). Rob Young took gut contents of two broad morphologies of holothurian. These dissected specimens were preserved in formaldehyde for identification (see section 17 by Rob Young).

Figure 92: Otter Trawl arriving on deck, note the drums in the catch

Figure 93: examples of the catch from DY050-118, a) & b) mixed catch direct from emptying the net, c) specimens examined by Noelie Benoist & d) two large macrourids.

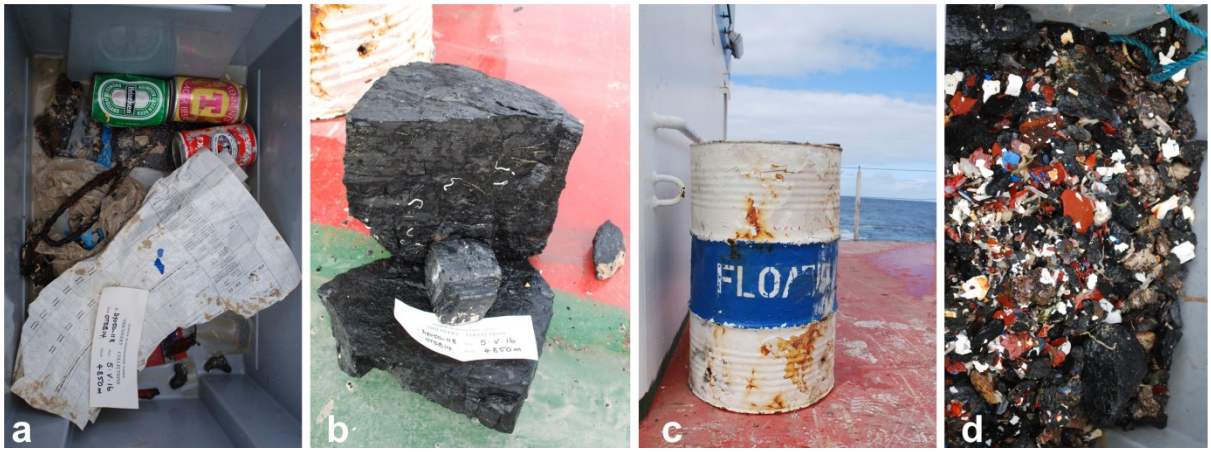


Figure 94: Examples of litter from DY050-118, a) Drinks cans, glass, lifting strop, plastic wrapping and a (Dutch?) shipping manifest, b) coal, c) one of two large drums, this one was marked "Floating" and d) clinker and chipped paint (blue and white presumably from the drum).

Table 27: Samples retain from trawls DY050-063 and DY050-118

Station number	Container label	Container type	Preservation	Notes
DY050-063	Paroriza	Blue barrel	Formaldehyde	Not only *Paroriza*
DY050-063	Deima/Oneirophanta	Blue barrel	Formaldehyde	
DY050-063	Mixed holothurians	Blue barrel	Formaldehyde	
DY050-063	Psychropotes	Blue barrel	Formaldehyde	
DY050-063	Asteroids	Large white bucket	Formaldehyde	
DY050-063	Fish	Large white bucket	Formaldehyde	
DY050-063	Actiniaria	Large white bucket	Formaldehyde	
DY050-063	Others	1500 ml UN - red lid	Formaldehyde	
DY050-063	"Mixed Noelie stuff"	1500 ml UN - red lid	Formaldehyde	
DY050-063	"Noelie unknown"	1500 ml UN - red lid	Formaldehyde	
DY050-063	Mixed arthropods	1500 ml UN - red lid	Formaldehyde	
DY050-063	Ophiuroidea	1500 ml UN -	Formaldehyde	

		red lid		
DY050-063	Molluscs	1500 ml UN - red lid	Formaldehyde	
DY050-063	Sipuncula	1500 ml UN - red lid	Formaldehyde	
DY050-063	Tubes	1500 ml UN - red lid	Formaldehyde	
DY050-063	Polychaeta Laetmonice sp.	500 ml UN - red lid	Ethanol	ID by Lenka Nealova.
DY050-063	Munida/Munidopsis	Small white bucket	Ethanol	
DY050-063	Pycnogonida	1500 ml UN - red lid	Ethanol	
DY050-063	Cirripedia (barnacles)	1500 ml UN - red lid	Ethanol	Took time to get preserved
DY050-063	Cirripedia	500 ml UN - blue lid	Ethanol	Preserved almost straight away in ethanol
DY050-118	Holothurian smooth	Blue barrel	Formaldehyde	*Pseudostichopus*?
DY050-118	Fish	Blue barrel	Formaldehyde	2 large grenadiers discarded
DY050-118	Psychropotes	Blue barrel	Formaldehyde	
DY050-118	Psychropotes	Blue barrel	Formaldehyde	
DY050-118	Deima/Oneirophanta	Blue barrel	Formaldehyde	spikey holothurians
DY050-118	Psychropotes	Large white bucket	Formaldehyde	
DY050-118	Mixed holothurians	Small white bucket	Formaldehyde	
DY050-118	Actiniaria	Small white bucket	Formaldehyde	
DY050-118	Asteroids	Small white bucket	Formaldehyde	
DY050-118	Jelly/blobby	Small white bucket	Formaldehyde	
DY050-118	Encrusting polychaete	500 ml UN	Formaldehyde	A small number of serpulids removed

				from a drum
DY050-118	Mixed to be sorted	500 ml UN	Formaldehyde	last minute extras (mostly crustactean appendages)
DY050-118	Porifera spicules	500 ml UN	Formaldehyde	
DY050-118	Scale worms/Polychaete	500 ml UN	Formaldehyde	
DY050-118	Polychaete Eunice morph	500 ml UN	Formaldehyde	
DY050-118	Unidentified taxa	500 ml UN	Formaldehyde	
DY050-118	Transparent	500 ml UN	Formaldehyde	mid water?
DY050-118	Jellyfish	1500 ml UN - red lid	Formaldehyde	
DY050-118	Gastropod	1500 ml UN - red lid	Formaldehyde	
DY050-118	Cephalopod	1500 ml UN - red lid	Formaldehyde	Dumbo octopods
DY050-118	Mixed Animalia	Large white bucket	Formaldehyde	Noelie's samples
DY050-118	Munida/Munidopsis	1500 ml UN - red lid	Ethanol	
DY050-118	Cirripedia	1500 ml UN - red lid	Ethanol	
DY050-118	Pycnogonida	1500 ml UN - red lid	Ethanol	
DY050-118	Mixed crustaceans	Small white bucket	Ethanol	

16.3 Trawl specimen measurement

By Noelie M.A. Benoist

Body measurement data – body length, fresh wet weight, and volume – were obtained from trawled benthic megafauna specimen during *RRS Discovery* DY050 cruise.

16.3.1 Specimen measurement

A subset of the benthic megafauna collected from the OTSB14, spanning various shapes (e.g. vermiform, star-shaped, with appendages, etc.) and sizes within taxa (i.e. at least one 'small' and one 'big' of a kind when possible), were sampled for individual body measurement (Figure 95, Table 28 and 29). Only those complete and intact specimens (i.e. not punctured, including all 'legs' / appendages) were selected.

16.3.2 Photography

Each individual was photographed in their *in situ* position (i.e. as if they were observed using a downward-orientated camera (e.g. the tail of squat lobsters remained underneath their body, shrimps and anemones were sited to view their dorsal side and oral disc, respectively), in a tray next to a ruler, using a Fine Pix F550EXR FUJIFILM camera (photograph dimension: 4608 x 3456 pixels, focal length: 4 mm, max aperture: 3.6), Nikon D800 camera (photograph dimension: 7360 x 4912 pixels, focal length: 24 mm, max aperture: 3.6), Canon PowerShot SX100 IS camera (photograph dimension: 3264 x 2448 pixels, focal length: 6 mm, max aperture: 2.9).

16.3.3 Body weight measurement

Excess of water was quickly absorbed with tissue, and fresh body wet weight (fwwt, g) of each specimen was measured using a Marine Scale S/V-182 (Program ver.3.58). Note the body weight of the fish specimen (i.e. DY050-118-noe_89) wasn't recorded.

16.3.4 Body volume measurement

Each specimen was placed in a measuring cylinder containing sea water permitting measurement of their body volume (ml) (i.e. volume including individual – initial volume without individual). Note the body volume of the fish specimen (i.e. DY050-63-noe_43 and angler fish DY050-118-noe_89) weren't recorded.

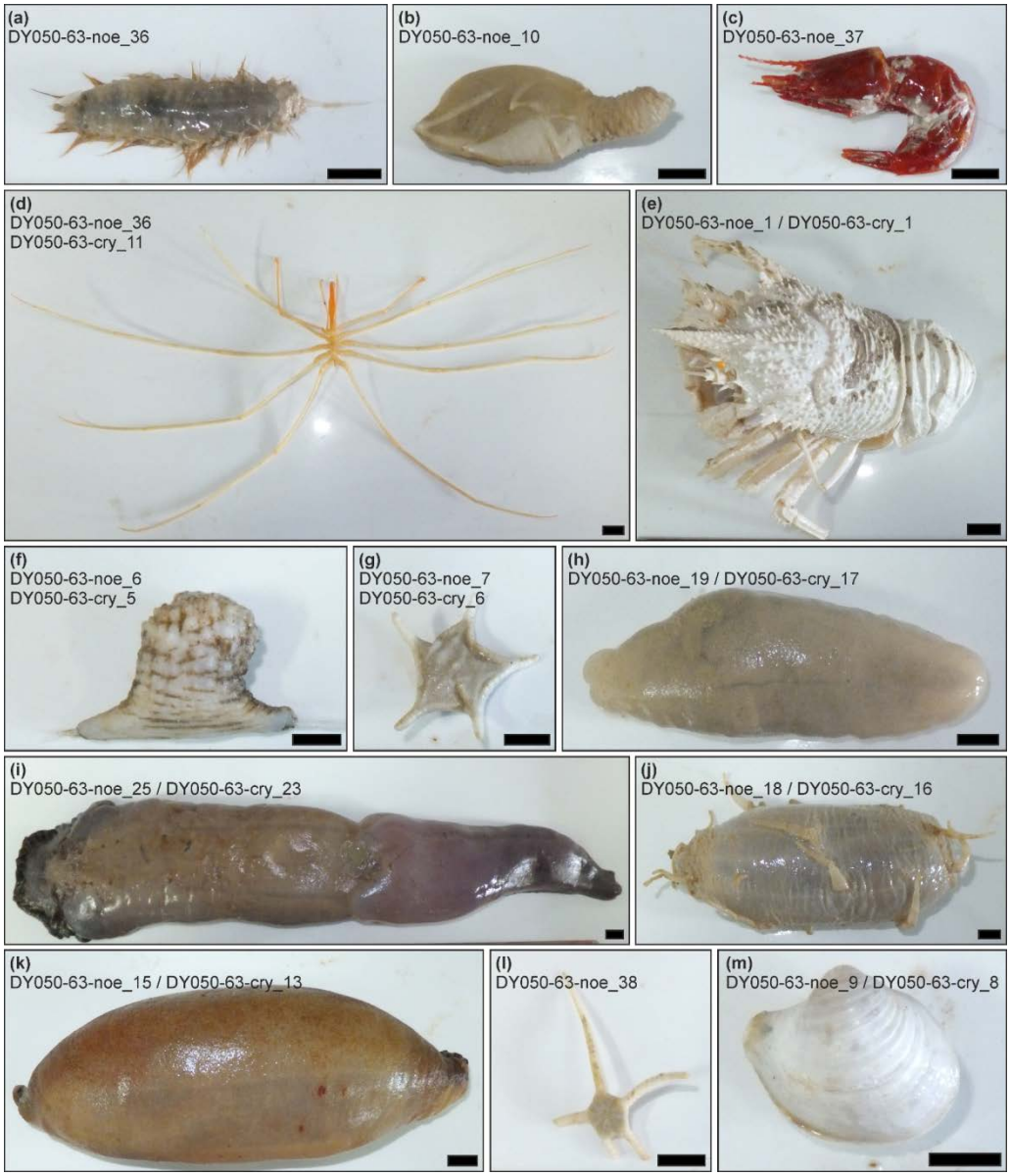


Figure 95. Photo example of the trawled benthic megafauna collected in the Porcupine Abyssal Plain (PAP) during *RRS Discovery* DY050-063. (a) ?*Laetmonice sp.*; (b) Cirripedia; (c) Caridea; (d) ?*Colossendeis colosea*; (e) ?*Munidopsis spp.*; (f) Anthozoa; (g) ?*Styracaster sp.*; (h) Holothurian_c; (i) *Psychropotes sp.*; (j) ?*Oneirophanta mutabilis*; (k) Holothurian_a; (l) Ophiuroidea; (m) Bivalvia. Individuals with label ending with 'noe_*X*' were those used for body measurement and 'cry_*X*' for DNA sample (Table 28 and 29). Scale bars represent 1 cm.

Table 28: Subset of the trawled benthic megafauna collected in the Porcupine Abyssal Plain (PAP) during *RRS Discovery* DY050-063. (a) Individual body measurements of forty-six specimen: fresh wet weight (fwwt, g) and volume (ml), (b) samples collected for DNA by Rob Young.

Table 28 1/2			**(a) Body measurement**			**(b) DNA sampling**
Station Number	**Taxa**	**Comment**	**Sample label**	**Weight (fwwt, g)**	**Volume (ml)**	**Sample label**
DY050-063	*?Munidopsis spp.*	with eggs	DY050-63-noe_1	54.8	60.0	DY050-63-cry_1
DY050-063	*?Munidopsis spp.*		DY050-63-noe_2	27.2	20.0	DY050-63-cry_2
DY050-063	anthozoa		DY050-63-noe_3	8.0	6.0	DY050-63-cry_3
DY050-063	anthozoa		DY050-63-noe_4	3.0	2.0	DY050-63-cry_4
DY050-063	*?Munidopsis spp.*		DY050-63-noe_5	4.1	2.0	DY050-63-cry_9
DY050-063	*?Actinauge abyssorum*	attached to sponge glass	DY050-63-noe_6	7.8	8.0	DY050-63-cry_5
DY050-063	*?Styracaster sp.*		DY050-63-noe_7	2.2	2.0	DY050-63-cry_6
DY050-063	*?Styracaster sp.*		DY050-63-noe_8	15.8	10.0	DY050-63-cry_7
DY050-063	bivalve		DY050-63-noe_9	4.4	20.0	DY050-63-cry_8
DY050-063	cirripedia		DY050-63-noe_10	4.2	6.0	n/a
DY050-063	cirripedia		DY050-63-noe_11	7.2	6.0	n/a
DY050-063	*?Colossendeis colosea*		DY050-63-noe_12	1.0	0.5	DY050-63-cry_10
DY050-063	*?Colossendeis colosea*		DY050-63-noe_13	1.8	2.0	DY050-63-cry_11
DY050-063	*Psychropotes sp.*		DY050-63-noe_14	407.4	375.0	DY050-63-cry_12
DY050-063	holothurian_a		DY050-63-noe_15	247.2	225.0	DY050-63-cry_13
DY050-	holothurian_a		DY050-63-noe_16	311.0	275.0	DY050-

063						63-cry_14
DY050-063	*?Oneirophanta mutabilis*		DY050-63-noe_17	98.8	80.0	DY050-63-cry_15
DY050-063	*?Oneirophanta mutabilis*		DY050-63-noe_18	107.2	100.0	DY050-63-cry_16
DY050-063	holothurian_c		DY050-63-noe_19	47.0	32.0	DY050-63-cry_17
DY050-063	*?Oneirophanta mutabilis*		DY050-63-noe_20	31.2	28.0	DY050-63-cry_18
DY050-063	holothurian_c		DY050-63-noe_21	20.8	20.0	DY050-63-cry_19
DY050-063	*?Oneirophanta mutabilis*		DY050-63-noe_22	55.2	38.0	DY050-63-cry_20
DY050-063	holothurian_a		DY050-63-noe_23	106.0	40.0	DY050-63-cry_21
DY050-063	holothurian_a		DY050-63-noe_24	46.2	44.0	DY050-63-cry_22
DY050-063	*Psychropotes sp.*	punctured?	DY050-63-noe_25	417.4	400.0	DY050-63-cry_23
DY050-063	holothurian_a		DY050-63-noe_26	37.2	32.0	DY050-63-cry_24
DY050-063	holothurian_c		DY050-63-noe_27	23.6	22.0	DY050-63-cry_25
DY050-063	holothurian_a		DY050-63-noe_28	15.0	14.0	DY050-63-cry_26
DY050-063	holothurian_a		DY050-63-noe_29	6.6	8.0	DY050-63-cry_27
DY050-063	holothurian_a		DY050-63-noe_30	4.2	4.0	DY050-63-cry_28
DY050-063	anthozoa		DY050-63-noe_31	26.4	20.0	n/a
DY050-063	*?Styracaster sp.*		DY050-63-noe_32	5.0	2.0	n/a
DY050-063	*?Laetmonice sp.*		DY050-63-noe_33	1.8	2.0	n/a
DY050-	shrimp		DY050-63-noe_34	6.6	6.0	n/a

063						
DY050-063	shrimp		DY050-63-noe_35	4.8	14.0	n/a
DY050-063	*?Laetmonice sp.*		DY050-63-noe_36	2.0	1.0	n/a
DY050-063	shrimp		DY050-63-noe_37	3.2	4.0	n/a
DY050-063	opiuroid		DY050-63-noe_38	0.4	1.0	n/a
DY050-063	indeterminate		DY050-63-noe_39	6.0	40.0	n/a
DY050-063	*?Styracaster sp.*		DY050-63-noe_40	4.8	4.0	n/a
DY050-063	shrimp		DY050-63-noe_41	2.2	2.0	n/a
DY050-063	anthozoa	*?Parasicyonis biotrans*	DY050-63-noe_42	162.6	150.0	n/a
DY050-063	fish_a		DY050-63-noe_43	11.0		n/a
DY050-063	*Psychropotes sp.*	smashed	DY050-63-noe_44	17.6	16.0	n/a
DY050-063	indeterminate		DY050-63-noe_45	1.0	1.0	n/a
DY050-063	holothurian_a		DY050-63-noe_46	418.2	400.0	n/a

Table 29. Subset of the trawled benthic megafauna collected in the Porcupine Abyssal Plain (PAP) during *RRS Discovery* DY050-118. (a) Individual body measurements of forty-six specimen: fresh wet weight (fwwt, g) and volume (ml), (b) samples collected for DNA by Rob Young

Table 29 2/2			**(a) Body measurement**			**(b) DNA sampling**
Station Number	**Taxa**	**Comment**	**Sample label**	**Weight (fwwt, g)**	**Volume (ml)**	**Sample label**

DY050-118	holothurian_d		DY050-118-noe_48	60.0	55.0	n/a
DY050-118	?Oneirophanta mutabilis		DY050-118-noe_49	103.0	100.0	n/a
DY050-118	Psychropotes sp.		DY050-118-noe_50	515.2	450.0	n/a
DY050-118	shrimp		DY050-118-noe_51	7.6	5.0	n/a
DY050-118	isopod		DY050-118-noe_52	5.2	5.0	n/a
DY050-118	fish_b		DY050-118-noe_53	584.3	570.0	n/a
DY050-118	jelly fish		DY050-118-noe_54	42.8	40.0	n/a
DY050-118	?Oneirophanta mutabilis		DY050-118-noe_55	54.6	53.0	n/a
DY050-118	?Colossendeis colosea		DY050-118-noe_56	1.8	5.0	n/a
DY050-118	?Colossendeis colosea		DY050-118-noe_57	1.4	1.0	n/a
DY050-118	?Styracaster sp.		DY050-118-noe_58	1.6	5.0	n/a
DY050-118	Paroriza sp.		DY050-118-noe_59	434.0	400.0	n/a
DY050-118	Paroriza sp.		DY050-118-noe_60	217.6	175.0	n/a
DY050-118	anthozoa	?Actinauge abyssorum	DY050-118-noe_61	8.0	5.0	n/a
DY050-118	anthozoa	attached to plastic sachet	DY050-118-noe_62	8.2	7.0	n/a
DY050-118	anthozoa	?Parasicyonis biotrans	DY050-118-noe_63	142.4	110.0	n/a
DY050-118	?Colossendeis colosea		DY050-118-noe_64	2.8	2.0	n/a
DY050-118	Psychropotes sp.	?punctured tail	DY050-118-noe_65	281.2	250.0	n/a

DY050-118	holothurian_d		DY050-118-noe_66	69.6	60.0	n/a
DY050-118	arthropoda		DY050-118-noe_67	11.4	5.0	n/a
DY050-118	?Dytaster grandis grandis		DY050-118-noe_68	64.4	50.0	n/a
DY050-118	Psychropotes sp.		DY050-118-noe_69	361.2	320.0	n/a
DY050-118	anthozoa	?Actinauge abyssorum	DY050-118-noe_70	2.0	1.0	n/a
DY050-118	anthozoa	?Actinauge abyssorum	DY050-118-noe_71	8.2	20.0	n/a
DY050-118	anthozoa		DY050-118-noe_72	2.0	1.0	n/a
DY050-118	anthozoa		DY050-118-noe_73	8.6	9.0	n/a
DY050-118	?Laetmonice sp.		DY050-118-noe_74	1.4	1.0	n/a
DY050-118	?Oneirophanta mutabilis		DY050-118-noe_75	25.6	25.0	n/a
DY050-118	Psychropotes sp.		DY050-118-noe_76	312.0	275.0	n/a
DY050-118	Psychropotes sp.		DY050-118-noe_77	136.0	100.0	n/a
DY050-118	Psychropotes sp.		DY050-118-noe_78	25.2	30.0	n/a
DY050-118	?Peniagone sp.		DY050-118-noe_79	63.4	60.0	n/a
DY050-118	indeterminate		DY050-118-noe_80	0.8	1.0	n/a
DY050-118	jelly fish		DY050-118-noe_81	52.8	50.0	n/a
DY050-118	?Dytaster grandis grandis		DY050-118-noe_82	54.2	50.0	n/a
DY050-118	?Dytaster grandis grandis		DY050-118-noe_83	13.6	13.0	n/a

DY050-118	cirripedia		DY050-118-noe_84	6.4	5.0	n/a
DY050-118	gastropoda		DY050-118-noe_85	8.2	7.0	n/a
DY050-118	anthozoa	attached to red soft plastic	DY050-118-noe_86	2.4	12.0	n/a
DY050-118	anthozoa		DY050-118-noe_87	2.4	2.0	n/a
DY050-118	anthozoa		DY050-118-noe_88	0.8	1.0	n/a
DY050-118	angler fish		DY050-118-noe_89			n/a

16.4 Amphipod Traps

By Marla Spencer

16.4.1 Sample processing

Each trap was photographed with the Station ID and Sample ID number and then subsequently removed from the frame and taken to the cold room (~10°C) for processing. Each trap was marked with location (e.g. Top 1, Top 2, Bottom 1, or Bottom 2), this was to ensure that we kept everything straight. Gloves were used at all times. All amphipods were removed from the trap using Ethanol into labelled 0.5L UN certified plastic bottles and kept in the refrigerator at 4° C. To remove the amphipods, the net and remains of fishes are removed first and placed in a bucket labelled with the trap ID. The fish is then carefully examined and rinsed in ethanol to ensure that all amphipods are taken from the bait. The net is then carefully rinsed with ethanol and any amphipod placed on the 0.5L UN bottle. Then the first funnel of the trap is carefully removed and rinsed with ethanol, putting every individual within the 0.5L UN bottle. The rest of the trap (the cylinder and second funnel) are then rinsed. Individuals trapped between the funnel edge and the cylinder trap were removed using tweezers or spraying ethanol with a syringes on them. At the end, all individuals are placed in the 0.5L UN bottle. The trap is then washed in filtered seawater and reassembled for future use.

16.4.2 Deployment 1: Station DY050_027 25/04/2016

The (double parlour acrylic) Amphipod traps were loaded with one standard mackerel (~0.5 kg each). One mackerel was attached to the base of the trap (nearest the mesh bottom) securely with cable ties. The traps were then reassembled, checked that they were fastened securely, and then placed onto the frame (securely holding all four traps).The pins were placed through the handle locking it onto the frame. The frame was deployed at 13:52 (GMT) on 25/04/2016 with an estimated time of arrival to the seabed (~97 minutes later) at 14:24 (GMT) and was released on 26/04/2016 at ~16:45, travelling at ~15-20 m per min^{-1}. The estimated soak time was approximately 26 hours. Once it had arrived to the surface, it was recovered on deck at approximately 20:30 GMT.

Table 30: DY050_027 amphipod trap deployment data

Deployment 1_Date	Station number/sample ID	Deployment Latitude	Deployment Longitude	Deployment shot time_GMT	Release date time_GMT	Recovery date time_GMT	Depth (m)	Bait used	Preservation method	Container
25/4/16	DY050-027_TOP1	49° 0.379	16° 23.850	13:52 (25/04/16)	16:45 (26/04/16)	20:30 (26/04/16)	4850	1 x Mackerel	(95%) ETOH	500ml UN blue lid
25/4/16	DY050-027_TOP2	49° 0.379	16° 3.850	13:52 (25/04/16)	16:45 (26/04/16)	20:30 (26/04/16)	4850	1 x Mackerel	(95%) ETOH	500ml UN blue lid
25/4/16	DY050-027_BOTTOM 1	49° 0.379	16° 23.850	13:52 (25/04/16)	16:45 (26/04/16)	20:30 (26/04/16)	4850	1 x Mackerel	(95%) ETOH	500ml UN blue lid
25/4/16	DY050-027_BOTTOM 2	49° 0.379	16° 23.850	13:52 (25/04/16)	16:45 (26/04/16)	20:30 (26/04/16)	4850	1 x Mackerel	(95%) ETOH	500ml UN blue lid

16.4.3 Deployment 2: Station DY050_100 02/05/2016

The (double parlour acrylic) Amphipod traps were loaded with two standard mackerel (~0.5 kg each). One mackerel was defrosted the morning of the deployment, the second mackerel was in a sealed container and remained in the refrigerator for 6 days (~144 hours). Both mackerel were attached to the base of the trap (nearest the mesh bottom) securely with cable ties. The traps were then reassembled, checked that they were fastened securely, and then placed on the frame. The frame was deployed at 12:00 (GMT) on 02/05/2016 with an estimated time of arrival to the seabed (~97 minutes later) at 13:37 (GMT), and then it was released on 03/05/2016 at ~13:52. With the additional buoyancy sphere the rate of travel to the surface had increased, from previous deployment to ~35 m per min^{-1}. The estimated soak time was approximately 24 hours. There were strong winds, ~30 knots and subsequent surface currents meaning that the frame had blown off course by ~4 miles. After searching for 4 hours, the trap was recovered on deck at approximately 21:00 03/05/2016 GMT. Each trap was photographed (e.g. Figure 96) with the Station ID and Sample ID number and then subsequently removed from the frame and taken to the cold room

(~10°C) for processing. Each trap was marked with location (e.g. Top 1, Top 2, Bottom 1, or Bottom 2), this was to ensure that we kept everything straight. All amphipods were removed from the trap using Ethanol into labelled 0.5L and 1.5 L UN certified plastic bottles and kept in the refrigerator at 4° C.

Table 31: DY050_100 amphipod trap deployment data

Deployment 2_Date	Station number/Sample ID	Deployment Latitude	Deployment Longitude	Deployment shot time_GMT	Release date time_GMT	Recovery date time_GMT	Depth (m)	Bait used*	Preservation method	Container
02/05/2016	DY050-100_TOP1	49° 0.647	16° 23.769	12:00 (02/05/16)	16:15 (03/05/16)	21:00 (03/05/16)	4850	2 x Mackerel	(95%) Ethanol	500 ml UN blue
02/05/2016	DY050-100_TOP2	49° 0.647	16° 23.769	12:00 (02/05/16)	16:15 (03/05/16)	21:00 (03/05/16)	4850	2 x Mackerel	(95%) Ethanol	500 ml UN blue
02/05/2016	DY050-100_BOTTOM 1	49° 0.647	16° 23.769	12:00 (02/05/16)	16:15 (03/05/16)	21:00 (03/05/16)	4850	2 x Mackerel	(95%) Ethanol	1500 ml UN red
02/05/2016	DY050-100_BOTTOM 2	49° 0.647	16° 23.769	12:00 (02/05/16)	16:15 (03/05/16)	21:00 (03/05/16)	4850	2 x Mackerel	(95%) Ethanol	500 ml UN blue

*1 x out freezer 144hours, 1 X 24 hours

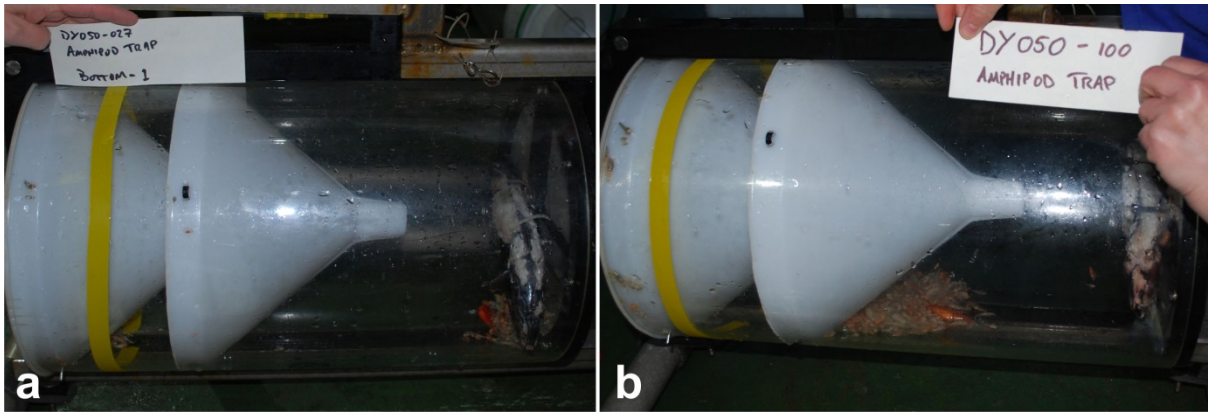


Figure 96: Images of the traps with greatest catch from deployment a) DY050-027 and b) DY050-100.

17 Molecular Ecology

By C. R. Young

Genetic samples were collected from the megacore, trawl, and CTD.

17.1 Megacore

All megacore samples were sectioned by 1cm intervals up to 5cm, and by 5cm intervals up to 20cm when possible. Spatulas, slicer, and rings were sterilized between cores. A different, sterile, spatula was used for each slice. Slicer and ring was rinsed in Milli-Q water between slices. Three replicate DNA and RNA samples were taken from each slice and archived in 2ml tubes. The bulk of the slices were stored in 50ml falcon tubes and frozen at -80C. Replicate DNA samples were immediately frozen at -80C, and RNA samples were preserved in RNALater, left in the cold room (10-12C) for 24 hours, and then frozen at -80C.

17.2 CTD

Three CTD samples were filtered (1.3L) from the CTD cast, preserved in RNALater, left in the cold room for 24 hrs., then stored at -80C. In addition, one negative control was filtered from the MilliQ water supply (1.3 L) and processed in the same manner.

17.3 Trawl

Tissue samples were taken from select taxa collected from the trawl, and samples were preserved in EtOH. Due to recovery issues with DY050-063 (twisted leader lines and a larger than usual amount of sediment in the net), samples were exposed to ambient sea temperatures for an extended period of time, and time to processing of tissue samples once on deck was considerably longer than optimal. Recovery was scheduled for 8am, however the last tissue sample that I took was processed around 3:30 pm. Table 32 summarizes samples taken or attempted during the cruise. Samples taken during DY050-118 included 10 holothurians from two different species.

Figure 97: Holothurians samples from DY050-118. Body wall tissue and gut along with contents were dissected and stored at -80°C

STN NO	LAT (N)	LONG (W)	SCIENCE EVENT	Sampled	COMMENTS
002	48 50.055	16 31.342	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm; frozen at -80C
003	48 50.387	16 31.174	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
004	49 0.375	16 23.848	CTD	Y	CTD to 4800m; Sampled depths: 4300m, 4700m, 4760m, 4790m (all 1.3L)
018	48 50.277	16 31.270	Megacorer	N	failed deployment
019	48 50.296	16 31.262	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
026	48 50.171	16 31.526	Megacorer	Y	0-3cm by 1cm; slippage in core, 0-2cm OK, 2-3cm questionable; frozen at -80C
036	48 50.270	16 30.999	Megacorer	Y	*0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
046	48 50.075	16 31.223	Megacorer	Y	0-5cm by 1cm, 5-10cm, 10-15cm, 15-20cm; frozen at -80C
063	48 58.800	16 05.600	Otter Trawl	Y	See trawl sample list for details; tissue in EtOH; 28 samples taken: munidopsis, anemones, asteroids, bivalve, pyncogonids, holothurians. Rest of sample individually bagged and preserved in formalin, labels cry-1 to cry-28.
118	48 48.275	16 03.188	Otter Trawl	Y	10 individuals from two holothurian taxa (5 each) were sampled. Body wall and gut + contents were dissected out and stored at -80C. Remainder of sample preserved in formalin, labels cry-29 to cry-38.

Table 32: Samples taken for Molecular Ecology during DY050. * Standard sample taken, some core slippage after/at 3-4cm but not much, Some MilliQ water transfer to the core that changed consistency of sediment

Figure 98: Winston, the DY050 curlew