National Oceanography Centre

RESEARCH CRUISE REPORT

RRS Discovery cruise DY180

22 May 2024 – 27 June 2024

Spring BIO-Carbon cruise

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Abstract
The purpose of the BIO-Carbon programme is to reduce uncertainties in the biological contribution to ocean carbon storage. DY180 was the first in a 2 cruise fieldwork programme; JC269 is the second and will take place in the same region September-October 2024. This spring cruise was intended to capture the peak and subsequent export of the phytoplankton spring bloom in the central Iceland Basin. Three projects participated in the cruise: CHALKY (led by Alex Poulton), IDAPro (led by Mark Moore) and PARTITRICS (led by Steph Henson). CHALKY aims to examine the production and fate of CaCO3 from key pelagic calcifiers (coccolithophores) during their highest CaCO3-production in the North Atlantic. IDAPro aims to deliver new process understanding of the drivers of oceanic primary production with the aim of reducing uncertainty in projected productivity changes in the future Ocean. PARTITRICS aims to generate new mechanistic understanding of key processes that influence the rate and depth of interior respiration.

The cruise consisted of a “super-station” which we revisited 5 times during the cruise, and 5 “roaming stations” which were within 1 day’s steam (or less) of the super-station. We interspersed super and roaming stations over the duration of the cruise. Each station comprised a series of observations of water column properties, phytoplankton, zooplankton, sinking particles, respiration and experimental work. At the first super-station we deployed 4 gliders and 3 floats; thereafter the exact location of the super-station varied as we followed the floats in a semi-Lagrangian fashion. Towards the end of the cruise, we recovered 1 ALR and rendezvoused with another, both of which had been launched from Iceland.

Keywords
Biological carbon pump, primary production, ocean carbon sink, calcification

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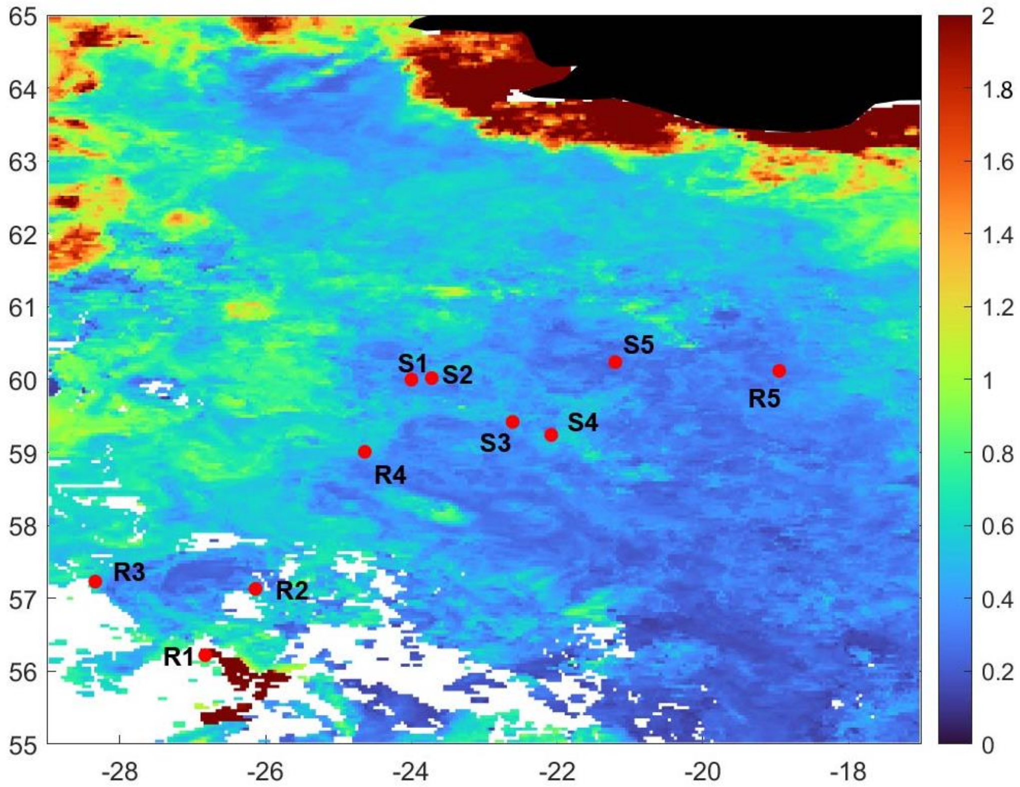
Itinerary

4 super-stations of approx. 3 days duration were completed in full, and one super-station (S2) was started but abandoned due to poor weather after ~ 16 hours. 5 roaming stations of approx. 1 day duration were completed.



Map of the super-stations and roaming stations overlaid on the median Sentinel-3 satellite chlorophyll concentration (mg m^{-3}) for 23 May – 23 June 2024.

Narrative

Tuesday 21st May
Sailing delayed by 1 day as one NMF technician was taken ill. It would have been very difficult to complete the cruise programme with only 3 techs, so luckily Jason was able to join with short notice.

Wednesday 22nd May
After a very busy mobilisation, with many visiting scientists on board to help us set up the multitude of user-supplied equipment, we set sail at 07:30. Heading past the Needles and westward through the English Channel in calm seas.

Thursday 23rd May
Little bit lumpy this morning, calming down in the afternoon. Mini-science meetings to cover underway sampling and CTD sampling were held, as was a crew briefing.

Friday 24th May
A beautiful sunny morning (perhaps our last for a while!) as we head out towards international waters. We're hoping to do a test station tomorrow, but that will be determined by the weather. Further mini-science meetings were held through the day.

Saturday 25th May
Rather lumpy overnight, but everything has been well lashed down. The test station planned for today was postponed until tomorrow due to weather conditions, but the weather looks fair for the coming week.

Sunday 26th May
Some science at last at a test station! We stopped at 08:00 and deployed the stainless CTD to 1000m, which a few scientists chose to sample as a test. This was followed by a TM CTD, with all bottles fired at 1000m to pre-soak. All 5 MSCs were tested, with the new Umi and Yuki designs both working well, however one of the old MSCs was leaking and can't be used for this cruise. The TM fish was deployed in its new position of starboard, just aft of the deck winch used to deploy MSCs, Bongos, optics etc. etc. Any possible interference between the TM fish and operations over the starboard stern needs to be closely watched. The deployment and recovery of the optics rig were also successfully tested, and we set off for the super-station site about 18:00. Very foggy all day.

Monday 27th May
Overnight, we were delayed arriving on station by about 2 hours due to a slight navigational error…. We started the super-station (S1) with a stainless CTD to 1000m ("respiration, deep") for the respiration team. Some scrolling problems on the way up which slowed everything down. This was followed by a stainless CTD to 450m to collect water primarily for the Drift-SPIRE array and experiments. The respiration team followed up with 2 MSCs. The Drift-SPIRE array was deployed successfully and will be recovered in ~ 2.5 days. 3 MSCs were then deployed by the fluxes team, with one of the old MSCs leaking on recovery and so being redeployed. Then followed 2x Bongo nets. The second round of flux MSCs were cancelled by the team because they were having trouble filtering the material sufficiently quickly. A successful ISMI deployment to 450m followed, then an RCF to 600m and finally 2 Mammoth nets.

Tuesday 28th May
As the Mammoth nets ran back-to-back with TM and stainless CTDs, there was a bit of shenanigans with switching wires around which resulted in ~ 1 hour delay, so this should be factored in to future super-station plans. The day kicked off with a TM CTD to 1000m and a "respiration, shallow" CTD to

120m. Four MSCs were then deployed by the fluxes team, with a second round previously planned for later in the day being cancelled because of the same filtering issues as yesterday. The 3 Jumbo BGC-Argo floats from LOV were then deployed very smoothly; we look forward to getting the first data tomorrow lunch-time. The "optics&general" stainless CTD to 1000m followed. A backlog is forming on the filter rigs, so we may have to rearrange events for the next super-station to prevent a repeat. All 3 of the Strathclyde optics rigs were deployed successfully while the 4 gliders were prepared for deployment. All 4 gliders were then successfully deployed in a line upstream of the super-station site. After repositioning, an ISMI was deployed to 750m depth. Overnight, a set of turbulence profiles were completed, followed by 2 RCFs, 2 Bongos, and 2 MSCs for the respiration team.

Wednesday 29th May
The last day of super-station 1 kicked off with Mammoth net deployments, and then a mammoth set of turbulence profiles. Another stainless CTD to 1000m for ETS & Omics, then the TM fish was recovered to avoid interference with the Drift-SPIRE recovery this evening. Another RCF was completed to 600m, and an ISMI at 1000m. We then relocated to the location of the drifting array which was ~ 15nm south of us. A quick CTD to 700m (sensors only), as we'd observed a curious peak in backscatter in all instruments and platforms and were wondering if it was present at the site of the array – but it wasn't (so the feature is obviously very localised). The array was then successfully recovered, with the DriftCam sinking cylinder containing lots of fecal pellets and aggregates (and one unfortunate copepod). The TM fish was redeployed and then we started steaming to the south-southwest for our first roaming station.

Thursday 30th May
On (rather lumpy) passage to the south-southwest to reach our first roaming station, the location of which was chosen more-or-less at random as we've had continual cloud cover and so no satellite data! We plan to stop wherever we are at midnight to commence the roaming station. News came through that one of the gliders and one of the floats that we deployed at the super-station are misbehaving so we will attempt to recover them when we return to the super-station site.

Friday 31st May
The first roaming station got underway at midnight at 56.45N, 27.06W with a pair of Bongos, followed by a TM CTD and a "respiration, shallow" CTD. Then followed several MSCs, an RCF profile, and turbulence profiles. The "optics & general" CTD, Bongos and Mammoth nets were completed before we commenced steaming back towards our super-station site. As hoped, high concentrations of coccolithophores were found in the CTD and MSC samples at the roaming site.

Saturday 1st June
Heading back towards the super-station, aiming for the last known location of the floats. The misbehaving glider is looking in better health, so we don't need to recover it urgently – although we may still be asked to recover it at the end of the cruise. The misbehaving float now seems to be recording data on the downcast, but not on the upcast; the LOV group would nevertheless like us to recover the float.

Sunday 2nd June
Back for our second round of the super-station (60.02N, 23.72W), in considerably choppier seas than before – although at least the sun has come out at last! The second deployment of the Drift-SPIRE array had to be postponed until the last day of the super-station as it's having some technical problems. The day kicked off with 2 stainless CTDs to 1000m ("general" and "respiration, deep"), followed by turbulence profiles. During the MSC deployments by the respiration team, the wind and sea state picked up considerably. We decided to abandon this round of the super-station and head

south again for another roaming station instead, hoping the weather will be workable there.

Monday 3rd June
We stopped to begin our second round of the roaming station, R2, at 10:00 at 57.12N, 26.25W in much calmer seas. We started with a round of shallow MSCs for CHALKY and followed up with a stainless CTD to 1000m ("optics & general"). A suite of optics rig deployments, a pair of Bongo nets (one of which came loose from the cod end, but team zooplankton decided not to repeat as they already had plenty of material), and 2 Mammoth deployments. As we were ahead of schedule and had clear skies and distinctly chalky water, we squeezed in an extra set of optics rig deployments before the RCF and turbulence profiles.

Tuesday 4th June
R2 continued overnight with a pair of Bongos, a TM CTD to 1000m, and a stainless CTD to 120m ("respiration, shallow"). We then set off for our super-station location again, but soon had to make a turn towards Reykjavik for a helicopter medi-vac, expecting to arrive on Wednesday morning.

Wednesday 5th June
The medi-vac was completed by helicopter about 07:30 this morning and we began steaming back towards our super-station site with the hope of recovering the errant float before nightfall. As the seas were calm, recovery of the float was undertaken using the rescue boat which hooked the float and brought it alongside before it was winched up on the P-frame at ~ 19:30. We then made our way towards our super-station 3 location for a ~ 01:00 arrival. Far too much excitement for one day.

Thursday 6th June
We reached our super-station 3 site at 59.44N, 22.64W at around midnight, deployed the TM fish and steamed around for an hour to collect water. This was followed by 2 back-to-back stainless CTDs: "RESPIRE & general" and "respiration, deep". A pair of MSCs for the respiration team followed, and then the 2nd deployment of the Drift-SPIRE array. Then the RCF was deployed, followed by a pair of Bongos and 3 shallow MSCs for the fluxes team. An ISMI deployment to 1001m (and 1!) followed and then turbulence profiles. The night was rounded off with a pair of Mammoth deployments.

Friday 7th June
Overnight, super-station 3 continued with a TM CTD to 1000m, followed by a stainless CTD to 120m ("respiration, shallow"). MSCs for the fluxes team (deep deployments) followed, and then a bonus CTD (stainless to 1000m) as we had the time, followed by a suite of optics rig deployments and then an ISMI to 750m. After a RCF deployment, we steamed for about 1 hour in the direction of the floats and drifting array (which is whizzing off to the southeast rather faster than we'd like). The day was rounded off with turbulence profiles and a pair of Bongos. The weather picked up a little through the day, but remained workable.

Saturday 8th June
Although the weather stayed fairly fresh overnight, science was able to continue with a RCF deployment, stainless CTD to 1000m ("ETS & Omics") and MSCs for the respiration team. Umi, the new new MSC, was still misfiring so the techs came up with a fix which was tested (and seemed to work) after the Mammoth deployments. A stainless CTD to 1000m ("Optics & general") followed, and then a series optics rig deployments, and finally an ISMI to 450m. We then set off in chase of the Drift-SPIRE array which was ~ 27 nm to the east. After recovery in heavy rain, the TM fish was redeployed and we set off for our 3rd roaming station.

Sunday 9th June

A day on passage towards our 3rd roaming station, R3, under overcast skies. We are aiming in the direction of 57N, 29W to the southwest of the super-station, and will see how far we can get by midnight tonight. ALR4 was deployed from Vestmannaeyjar Island around 16:00.

Monday 10th June

We are at our 3rd roaming station, R3, at 57.23N, 28.34W – still overcast. The station began with a pair of Bongos, followed by a TM CTD to 1000m, and then a stainless CTD to 120m ("respiration, shallow"). A series of MSCs followed (with Umi still playing up), then RCF and turbulence profiles. After a pair of Bongos, we deployed the stainless CTD to 1000m ("optics & general"), then the suite of optics rigs, and finally a Mammoth to complete R3. We then set off back towards the super-station site, relocating to near the floats.

Tuesday 11th June

We are en route back to our 4th super-station, S4, heading towards the gliders. We arrived around dinner time and targeted 3 of the gliders for CTD calibration casts (sensors only, no bottles).

Wednesday 12th June

We arrived back at S4 around 01:00, after steaming around to collect water with the TM Fish. We started with a stainless CTD to 1000m ("RESPIRE & general") – and realised that the current speed was > 1m/s. So we relocated back to the position of the 2nd glider cal CTD where current speeds were ~ 0.1 m/s. The next stainless CTD to 1000m ("respiration, deep") then took place at the new S4 site (59.24N, 22.08W), followed by MSCs for the respiration team, and then deployment of the Drift-SPIRE array. A RCF deployment followed, but the planned Bongos were cancelled as it was too windy. A further round of MSCs (shallow, for the fluxes team) were undertaken, and then an ISMI to 120m. The wind had died off considerably, and so we deployed the Bongos that had been cancelled earlier. Turbulence profiles followed, we relocated to near the position of the array (~5 km away) and the day was then rounded off with Mammoth deployments.

Thursday 13th June

The TM Fish was recovered, then the TM CTD was deployed to 1000m, followed by the stainless CTD to 1000m ("respiration, shallow"). Unfortunately, due to illness the respiration Winklers couldn't be taken. A series of deep MSCs for the fluxes team followed, and then a suite of optics rigs. An ISMI to 750m followed, and then RCF, turbulence profiles and a pair of Bongos rounded off day 2 of super-station 4. During the day, we moved in the direction of the Drift-SPIRE array whenever operations allowed.

Friday 14th June

Overnight, another RCF was completed, followed by a stainless CTD to 1000m ("ETS & Omics"), MSCs for the respiration team and a pair of Mammoths. A stainless CTD to 1000m ("optics & general") followed, and then optics rigs, before the Drift-SPIRE array was recovered. The TM Fish underwent some repairs after it had got tangled with the Bongos a couple of days previously and was then redeployed. We then set off for our 4th roaming station.

Saturday 15th June

To identify a position for our 4th roaming station, a different approach was taken – we headed to a central location (58.1N, 26.3W), with the intention of undertaking a survey in a butterfly pattern around the area to identify a likely region of high coccolithophore abundance. However, on arrival it was found that there was little sign of a coccolithophore bloom on the basis of the underway data and the colour of the water. So we instead headed towards the location of a bloom observed in the underway data during passage earlier in the day. Around 20:00 we entered a patch of very chalky waters. After surveying it, a location was chosen for R4.

Sunday 16th June
R4 started with some steaming around for TM Fish sampling, followed by a titanium CTD to 1000m, then stainless CTD to 120m. However, as the CTD was on the way down, the chlorophyll signature was clearly different (and lower) than on the previous titanium CTD. So the decision was made not to fire any bottles and instead to relocate into the higher chlorophyll waters again. The stainless CTD to 120m ("respiration, shallow") was then followed by MSCs for CHALKY and a RCF. Turbulence profiles followed and then some further Bongos and a stainless CTD to 1000m ("optics & general"). The station was rounded off with a suite of optics rigs and a Mammoth. We then steamed back to our 5th (and final!) super-station site.

Monday 17th June
Unexpectedly bad weather during the night delayed our arrival at super-station S5. As we approached our proposed site, current speeds were found to be high so we steamed north for a few km on the basis of satellite images received the previous day and found a patch with much lower current speeds (probably the centre of an upwelling eddy). Waters were again chalky. We started S5 with a stainless CTD to 1000m ("RESPIRE & general"), followed by MSCs for the respiration team, and then another stainless CTD to 1000m ("respiration, deep"). The Drift-SPIRE array was then deployed with traps at 120m and 250m only, followed by RCF, and a series of shallow MSCs for the fluxes team. A pair of Bongos followed, and then an ISMI to 1005m! The night was rounded off with Mammoth deployments. During the day we moved the ship close to the drifting array whenever operations allowed.

Tuesday 18th June
We began day 2 of S5 by steaming around for TM Fish sampling, followed by a titanium CTD to 1000m. There followed a stainless CTD which we sent to 500m as 2 of the gliders (345 and 405) were very close by, although bottles were only fired in the top 120m for the usual "respiration, shallow" cast. A series of deep MSCs for the fluxes team followed, and then the faulty Jumbo Argo float was set up on the back deck to undertake some tests (although it's not expected that we'll redeploy it). The tethered and IOP rigs followed (although not the profiling rig as it was a little too lumpy), and then the ISMI to 250m. An RCF followed, then turbulence profiles and finally a pair of Bongos.

Wednesday 19th June
The night continued with an RCF before the weather picked up and stopped science for a few hours. We then continued with a stainless CTD to 1000m ("ETS & Omics") and a pair of MSCs for the respiration team. Weather then stopped play again for the rest of the day.

Thursday 20th June
During the night we relocated to the drifting array which had drifted about 20nm east, and began recovery at first light in marginal seas. The array was successfully recovered though (and both traps worked), and we then moved back towards the S5 site. We restarted the station with turbulence profiles, followed by a stainless CTD cast to 1000m ("Optics & general"). Then followed a suite of optics rigs, and finally a Mammoth to complete S5. We then began steaming towards the last surfacing position of our "main" float for roaming station, R5.

Friday 21st June
We started our final roaming station around midnight and began the programme with a Bongo. As the current turned out to be unexpectedly strong, only a single Bongo (rather than the usual pair) was completed. Then followed a titanium CTD to 1000m, a stainless CTD to 120m ("respiration, shallow"), MSCs for CHALKY, a RCF profile and turbulence profiles. We then did another pair of Bongos (without any scary moments this time), deployed the NOC ASBAN BGC-Argo float, and then

deployed a stainless CTD to 1000m ("optics & general"). A suite of optics rigs followed, and finally a Mammoth deployment to finish R5. We then completed a glider cal CTD casts (398, Churchill) with no bottles, only sensors, followed by IOP rig deployment, then another glider cal CTD (397, Nelson), another IOP rig deployment, and then RCF with the UVP6 from the CTD frame attached (in place of the CPICS).

Saturday 22nd June
The day started with news of an emergency recovery of ALR6 (the profiling ALR) as pretty much everything had stopped working. A Bongo to collect animals for experiments went in first, and then the ALR recovery proceeded very smoothly. As ALR4 was also close by, we did a calibration CTD (stainless, to 1000m, with a limited set of samples collected), followed by optics rigs. Finally, we moved to the location of gliders 345 and 405 (Cabot and Doombar) which were only a couple of hundred meters from each other and did a sensors only (no bottles) stainless CTD to 1000m. Just in time as the weather began to pick up considerably. And that was all folks!

Sunday 23rd June
On passage back towards Scotland with the science party finishing experiments, analysing samples and starting to pack boxes although the weather stayed rather lumpy.

Monday 24th June
Approaching the Scottish mainland with still lumpy weather, the ship stopped for several hours to test the DP and then we called in at Loch Eriboll to see a bit of land and sleep in calm seas!

Tuesday 25th June
Left Loch Eriboll in the morning to make our way towards Aberdeen harbour with packing in full swing.

Wednesday 26th June
Arrived in Aberdeen harbour at ~ 09:30.

DY180 Event Log

Event number	Deployment type & number	Date	Time (UTC)	Station	Latitude	Longitude	Notes
001	CTD001S	26/05	08:20	Test	59.19169	-22.4127	Stainless, to 1000m, limited sampling
002	CTD002T	26/05	11:28	Test	59.18383	-22.4764	Titanium, to 1000m, all bottles fired at 1000m
003	MSC001	26/05	13:44	Test	59.17264	-22.5228	To 30m (Umi)
004	MSC002	26/05	14:07	Test	59.17142	-22.5239	To 30m (Yuki)
005	MSC003	26/05	14:30	Test	59.1699	-22.5252	To 30m (silver)
006	MSC004	26/05	14:48	Test	59.16868	-22.5263	To 30m (red)
007	MSC005	26/05	15:08	Test	59.16849	-22.5381	To 30m (blue) – failed. Condemned.
008	TM fish out	26/05	15:48	Test	59.1605	-22.5324	
009	Turbulence001	26/05	16:34	Test	59.15192	-22.5249	Two profiles to ~ 180m
010	Turbulence001	26/05	16:48	Test	59.15089	-22.5229	
011	Optics rig (tethered)	26/05	17:07	Test	59.1495	-22.5188	
012	CTD003S	27/05	04:12	S1	59.99981	-23.9995	Stainless, to 1000m, “respiration deep”
013	CTD004S	27/05	07:40	S1	60.00016	-24.0004	Stainless, to 450m, RESPIRE water collection
014	MSC006	27/05	08:39	S1	60.00016	-24.0004	Umi for respiration team, 120m
015	MSC007	27/05	09:04	S1	60.00015	-24.0004	Yuki for respiration team, 55m
016	Array001	27/05	11:25	S1	60.00001	-24.0001	Drift-SPIRE array deployment, fully deployed at 13:03
017	MSC008	27/05	13:17	S1	59.98576	-23.9642	MSC fluxes, Umi to 110m
018	MSC009	27/05	13:52	S1	59.98342	-23.9515	MSC fluxes – silver came up leaking so re-deploying
019	MSC010	27/05	14:05	S1	59.98151	-23.9448	MSC fluxes, Yuki to 55m
020	MSC011	27/05	14:31	S1	59.98297	-23.9374	MSC fluxes – silver MSC to 55m
021	Bongo001	27/05	14:56	S1	59.97997	-23.9364	Bongo to 200m
022	Bongo002	27/05	15:18	S1	59.97831	-23.9284	Bongo to 50m
023	ISMI001	27/05	18:04	S1	60.00227	-23.9945	To 450m
024	RCF001	27/05	20:14	S1	60.00018	-24.0002	To 600m
025	Mammoth001	27/05	21:45	S1	60.00019	-24.0002	To 500m
026	Mammoth002	27/05	23:36	S1	60.00018	-24.0002	

027	CTD005T	28/05	02:59	S1	60.00018	-24.0002	Titanium, to 1000m
028	CTD006S	28/05	05:19	S1	60.00019	-24.0002	Stainless, to 120m, “respiration, shallow”
029	MSC012	28/05	06:15	S1	60.00017	-24.0002	Fluxes, Umi to 250m
030	MSC013	28/05	06:47	S1	60.00018	-24.0002	Fluxes, silver to 250m
031	MSC014	28/05	07:16	S1	60.00017	-24.0002	Fluxes, Yuki to 450m
032	MS015	28/05	07:54	S1	60.00018	-24.0002	Fluxes, Red, to 120m
033	Float001	28/05	09:38	S1	59.99922	-23.999	
034	Float002	28/05	09:45	S1	59.99788	-23.9968	
035	Float003	28/05	09:53	S1	59.9921	-23.9884	
036	CTD007S	28/05	11:10	S1	60.0002	-24.0003	Stainless, to 1000m, “optics & general”
037	IOP001	28/05	12:48	S1	60.00019	-24.0004	IOPs to 120m
038	OpticsP001	28/05	13:33	S1	59.99983	-23.9997	Profiling optics rig
039	OpticsT001	28/05	14:02	S1	59.99986	-23.9997	Tethered optics rig
040	Glider001	28/05	15:43	S1	59.93475	-23.9597	Glider 397
041	Glider002	28/05	17:00	S1	59.94676	-23.9674	Glider 405
042	Glider003	28/05	17:51	S1	59.96021	-23.9741	Glider 398
043	Glider004	28/05	18:39	S1	59.97413	-23.9819	Glider 345
044	ISMI002	28/05	19:28	S1	59.99932	-23.9989	To 750m
045	Turbulence002	28/05	21:31	S1	60.00021	-24.0002	
046	RCF002	28/05	23:42	S1	59.99977	-23.9998	
047	RCF003	29/05	00:29	S1	59.99979	-23.9998	
048	Bongo003	29/05	01:04	S1	59.99979	-23.9998	
049	Bongo004	29/05	01:30	S1	59.99979	-23.9998	
050	MSC016	29/05	02:29	S1	59.99979	-23.9998	Yuki to 120m, for respiration
051	MSC017	29/05	02:48	S1	59.99981	-23.9998	Umi to 55m, for respiration
052	Mammoth003	29/05	04:20	S1	59.99981	-23.9997	To 550m
053	Mammoth004	29/05	06:11	S1	59.99983	-23.9997	05:58 Aborted due to twisted net; 06:11 redeployed to 550m
054	Turbulence003	29/05	08:41	S1	59.99994	-23.9998	
055	CTD008S	29/05	12:07	S1	59.9999	-23.9996	Stainless, to 1000m, “ETS & omics”
056	RCF004	29/05	14:00	S1	59.99991	-23.9996	
057	ISMI003	29/05	16:00	S1	59.99991	-23.9996	To 1000m

058	CTD009S	29/05	19:48	S1	59.73712	-23.9052	At location of drifting array; Quick CTD to 700m, sensors only
059	Array001	29/05	20:53	S1	59.7332	-23.9254	Drift-SPIRE array; fully recovered at 22:01
060	TM fish out	29/05	22:27	S1	59.72748	-23.9864	TM fish redeployed for passage
061	Bongo005	30/05	23:54	R1	56.21601	-26.8302	
062	Bongo006	31/05	00:20	R1	56.21602	-26.8302	
063	CTD010T	31/05	01:28	R1	56.21603	-26.8302	Titanium, to 1000m
064	CTD011S	31/05	03:31	R1	56.21602	-26.8302	Stainless, to 120m, “respiration, shallow”
065	MSC018	31/05	05:06	R1	56.21604	-26.8302	Yuki, to 15m, for CHALKY
066	MSC019	31/05	05:20	R1	56.21602	-26.8302	Umi, to 55m, for CHALKY
067	MSC020	31/05	05:42	R1	56.21604	-26.8302	Red, to 55m, for CHALKY
068	MSC021	31/05	06:01	R1	56.21604	-26.8302	Silver, to 55m, for CHALKY
069	RCF005	31/05	06:47	R1	56.21603	-26.8302	
070	Turbulence004	31/05	08:18	R1	56.21584	-26.8306	
071	CTD012S	31/05	10:45	R1	56.21608	-26.8301	Stainless, to 1000m, “optics & general”
072	IOP002	31/05	12:26	R1	56.21608	-26.8301	
073	OpticsT002	31/05	13:01	R1	56.21601	-26.8302	Tethered optics rig
074	OpticsP002	31/05	13:20	R1	56.21527	-26.8309	Profiling optics rig
075	Bongo007	31/05	14:23	R1	56.215	-26.8299	
076	Bongo008	31/05	14:43	R1	56.21502	-26.83	
077	Mammoth005	31/05	15:37	R1	56.21503	-26.83	To 550m
078	Mammoth006	31/05	17:09	R1	56.21502	-26.83	
079	CTD013S	02/06	01:17	S2	60.01929	-23.7195	Stainless, to 1000m, “general”
080	CTD014S	02/06	03:55	S2	60.01922	-23.7194	Stainless, to 1000m, “respiration, deep”
081	Turbulence005	02/06	05:58	S2	60.01915	-23.7193	
082	MSC022	02/06	08:44	S2	60.01924	-23.72	Yuki, 65m, didn’t close, respiration
083	MSC023	02/06	09:00	S2	60.01918	-23.72	Yuki, 65m, didn’t close again, respiration
084	MSC024	02/06	09:13	S2	60.01812	-23.7196	Umi, 65m, respiration
085	MSC025	02/06	09:32	S2	60.01751	-23.7194	Silver, 120m, respiration
086	MSC026	03/06	09:59	R2	57.12447	-26.1376	Umi, 55m, CHALKY
087	MSC027	03/06	10:11	R2	57.12452	-26.1376	Yuki, 15m, CHALKY
088	MSC028	03/06	10:30	R2	57.12489	-26.1376	Silver, 55m, CHALKY

089	CTD015S	03/06	10:50	R2	57.12564	-26.1376	Stainless, to 1000m, "optics & general"
090	IOP003	03/06	12:23	R2	57.12694	-26.138	
091	OpticsT003	03/06	12:45	R2	57.12695	-26.1384	
092	OpticsP003	03/06	13:17	R2	57.12872	-26.1435	
093	Bongo009	03/06	13:37	R2	57.12816	-26.1416	
094	Bongo010	03/06	13:59	R2	57.1273	-26.1485	One net came unmoored, but plenty of material in the other net.
095	Mammoth007	03/06	15:56	R2	57.12758	-26.1577	To 600m
096	Mammoth008	03/06	17:29	R2	57.12166	-26.184	
097	OpticsT004	03/06	18:52	R2	57.11618	-26.2126	Bonus optics because the sun came out (briefly!)
098	IOP004	03/06	19:07	R2	57.11564	-26.218	
099	RCF006	03/06	19:53	R2	57.11114	-26.218	
100	Turbulence006	03/06	21:04	R2	57.11199	-26.2284	
101	Bongo011	03/06	23:05	R2	57.12453	-26.2534	
102	Bongo012	03/06	23:25	R2	57.12492	-26.2594	
103	CTD016T	04/06	01:32	R2	57.1178	-26.2574	Titanium, to 1000m
104	CTD017S	04/06	03:55	R2	57.11454	-26.2812	Stainless, to 120m, "respiration, shallow"
105	TM Fish	05/06	23:30	S3	59.46964	-22.5676	TM fish deployed
106	CTD018S	06/06	01:14	S3	59.43984	-22.6396	Stainless, to 1000m, "RESPIRE & general"
107	CTD019S	06/06	03:58	S3	59.43715	-22.6379	Stainless, to 1000m, "respiration, deep"
108	MSC029	06/06	06:44	S3	59.43778	-22.6371	Yuki, 65m, respiration
109	MSC030	06/06	06:57	S3	59.43595	-22.6392	Silver, 120m, respiration
110	Array002	06/06	08:01	S3	59.43584	-22.6399	Drift-SPIRE array deployment, fully deployed at 09:11
111	RCF007	06/06	10:49	S3	59.43944	-22.6497	
112	Bongo013	06/06	11:47	S3	59.43681	-22.6561	
113	Bongo014	06/06	12:06	S3	59.43587	-22.6584	
114	MSC031	06/06	12:27	S3	59.43512	-22.6602	Yuki, 65m, misfired
115	MSC032	06/06	12:40	S3	59.43468	-22.6613	Umi, 65m, fluxes
116	MSC033	06/06	12:57	S3	59.43405	-22.6628	Silver, 65m, pin not removed
117	MSC034	06/06	13:19	S3	59.43356	-22.664	Silver, 65m, leaky
118	MSC035	06/06	13:31	S3	59.43343	-22.6643	Red, 120m, fluxes
119	MSC036	06/06	13:49	S3	59.43323	-22.6648	Umi, 250m, fluxes

120	ISMI004	06/06	14:26	S3	59.43278	-22.6659	To 1001m
121	Turbulence007	06/06	18:25	S3	59.41918	-22.6444	
122	Mammoth009	06/06	21:38	S3	59.42951	-22.637	
123	Mammoth010	06/06	23:34	S3	59.41526	-22.6188	
124	CTD020T	07/06	02:32	S3	59.4266	-22.6265	Titanium, to 1000m
125	CTD021S	07/06	04:42	S3	59.43156	-22.625	Stainless, to 120m, “respiration, shallow”
126	MSC037	07/06	08:14	S3	59.43881	-22.6477	Umi, 250m, fluxes
127	MSC038	07/06	08:41	S3	59.43872	-22.6479	Red, 250m, fluxes
128	MSC039	07/06	09:05	S3	59.43885	-22.6463	Yuki, 450m, fluxes
129	MSC040	07/06	09:47	S3	59.4391	-22.6436	Silver, 750m, fluxes
130	CTD022S	07/06	11:11	S3	59.44079	-22.629	Stainless, to 1000m, bonus CTD
131	IOP005	07/06	12:38	S3	59.43532	-22.6143	
132	OpticsT005	07/06	13:05	S3	59.43186	-22.6063	Tethered optics rig
133	ISMI005	07/06	13:56	S3	59.43493	-22.615	To 750m
134	RCF008	07/06	18:05	S3	59.40284	-22.5653	
135	Turbulence008	07/06	21:07	S3	59.36283	-22.4858	
136	Bongo015	07/06	23:01	S3	59.37492	-22.4852	
137	Bongo016	07/06	23:20	S3	59.37025	-22.4799	
138	RCF009	08/06	00:27	S3	59.36723	-22.4848	
139	CTD023S	08/06	02:05	S3	59.36755	-22.4838	Stainless, to 1000m, “ETS & Omics”
140	MSC041	08/06	03:54	S3	59.36612	-22.4875	Yuki, to 65m, respiration
141	MSC042	08/06	04:12	S3	59.36711	-22.4855	Silver, to 120m, respiration
142	MSC043	08/06	04:28	S3	59.36744	-22.4848	Red, to 65m, fluxes
143	MSC044	08/06	04:43	S3	59.36712	-22.4853	Umi, test, base closing on deployment
144	Mammoth011	08/06	06:05	S3	59.36588	-22.487	
145	Mammoth012	08/06	07:39	S3	59.36516	-22.4871	
146	MSC045	08/06	09:21	S3	59.35508	-22.4756	Test of closure mechanism on Umi, then sent to 450m, fluxes
147	CTD024S	08/06	11:01	S3	59.35051	-22.4729	Stainless, to 1000m, “Optics & general”
148	IOP006	08/06	12:33	S3	59.34523	-22.4631	
149	OpticsT006	08/06	13:06	S3	59.34506	-22.4661	Tethered optics rig
150	OpticsP004	08/06	13:23	S3	59.34651	-22.4701	Profiling optics rig

151	ISMI006	08/06	13:56	S3	59.34549	-22.4719	To 450m
152	Array002	08/06	19:55	S3	59.4122	-21.5399	Drift-SPIRE array; fully recovered at 21:03
153	TM Fish out	08/06	21:15	S3	59.42774	-21.4845	TM Fish deployed for passage
154	Bongo017	10/06	00:01	R3	57.2301	-28.3399	
155	Bongo018	10/06	00:28	R3	57.23073	-28.3414	
156	CTD025T	10/06	01:32	R3	57.23084	-28.3424	Titanium, to 1000m
157	CTD026S	10/06	03:31	R3	57.23148	-28.3433	Stainless, to 120m, “respiration, shallow”
158	MSC046	10/06	04:55	R3	57.23188	-28.3438	Yuki, 15m, CHALKY, leaking
159	MSC047	10/06	05:09	R3	57.2322	-28.3443	Silver, 55m, CHALKY
160	MSC048	10/06	05:20	R3	57.23242	-28.3447	Umi, 100m, CHALKY, base not closed
161	MSC049	10/06	05:45	R3	57.23267	-28.345	Yuki, 15m, CHALKY
162	RCF010	10/06	06:02	R3	57.23234	-28.3445	
163	Turbulence009	10/06	07:55	R3	57.22962	-28.3495	
164	Bongo019	10/06	09:49	R3	57.2139	-28.3814	
165	Bongo020	10/06	10:06	R3	57.21354	-28.3825	
166	CTD027S	10/06	11:11	R3	57.21014	-28.3903	
167	IOP007	10/06	12:31	R3	57.20963	-28.3913	
168	OpticsT007	10/06	12:58	R3	57.20938	-28.3907	
169	OpticsP005	10/06	13:21	R3	57.20894	-28.3855	
170	Mammoth013	10/06	14:38	R3	57.20982	-28.3845	
171	Mammoth014	10/06	16:02	R3	57.21314	-28.3868	
172	CTD028S	11/06	16:53	S4	59.039	-22.4553	Stainless, to 1000m, glider cal for 345 (Cabot), sensors only, no bottles fired
173	CTD029S	11/06	19:41	S4	59.23023	-22.0932	Stainless, to 1000m, glider cal for 398 (Churchill), sensors only, no bottles fired
174	CTD030S	11/06	22:02	S4a	59.18469	-22.3873	Stainless, to 1000m, glider cal for 397 (Nelson), sensors only, no bottles fired
175	CTD031S	12/06	01:14	S4a	59.18699	-22.3884	Stainless, to 1000m, “RESPIRE & general”. Relocated S4 back to position of CTD029S because weaker currents there.
176	CTD032S	12/06	04:17	S4	59.24316	-22.0786	Stainless, to 1000m, “respiration, deep”
177	MSC050	12/06	06:38	S4	59.24462	-22.0796	Yuki, 55m, respiration

178	MSC051	12/06	06:52	S4	59.24457	-22.08	Silver, 120m, leaking, redeployed
179	MSC052	12/06	07:09	S4	59.24452	-22.0803	Silver, 120m, respiration
180	Array003	12/06	08:20	S4	59.24527	-22.0765	Drift-SPIRE array deployment (traps at 120 & 450m), fully deployed at 09:32
181	RCF011	12/06	10:06	S4	59.23358	-22.0715	
182	MSC053	12/06	11:58	S4	59.23271	-22.0832	Fluxes, Yuki, to 55m
183	MSC054	12/06	12:10	S4	59.23246	-22.0842	Fluxes, Umi test dip, to 55m
184	MSC055	12/06	12:28	S4	59.23208	-22.0857	Fluxes, Silver, to 250m
185	MSC056	12/06	13:06	S4	59.23104	-22.0896	Fluxes, Red, to 250m, leaky base
186	ISMI007	12/06	13:58	S4	59.23526	-22.0868	To 120m
187	Bongo021	12/06	17:58	S4	59.22268	-22.0587	
188	Bongo022	12/06	18:22	S4	59.21881	-22.0539	
189	Turbulence010	12/06	18:48	S4	59.21422	-22.0478	
190	Mammoth015	12/06	21:30	S4	59.25693	-22	
191	Mammoth016	12/06	23:16	S4	59.25704	-22.0009	
192	CTD033T	13/06	02:15	S4	59.28147	-21.9664	Titanium, to 1000m
193	CTD034S	13/06	04:22	S4	59.28471	-21.9512	Stainless, to 120m, “respiration, shallow”
194	MSC057	13/06	08:01	S4	59.30764	-21.9054	Fluxes, Silver, to 450m
195	MSC058	13/06	08:44	S4	59.30309	-21.9125	Fluxes, Red, to 120m
196	MSC059	13/06	09:01	S4	59.30469	-21.9108	Fluxes, Yuki, to 750m
197	IOP008	13/06	12:59	S4	59.33205	-21.8606	
198	OpticsT008	13/06	13:30	S4	59.33357	-21.8608	
199	ISMI008	13/06	14:13	S4	59.3364	-21.858	To 750m
200	RCF012	13/06	18:44	S4	59.35799	-21.8417	
201	Turbulence011	13/06	20:19	S4	59.3732	-21.8226	
202	Bongo023	13/06	22:53	S4	59.3802	-21.8273	
203	Bongo024	13/06	23:12	S4	59.38293	-21.8251	
204	RCF013	14/06	00:26	S4	59.39924	-21.8106	
205	CTD035S	14/06	02:08	S4	59.41707	-21.807	Stainless, to 1000m, “ETS & Omics”
206	MSC060	14/06	04:05	S4	59.42529	-21.7981	Respiration, Yuki, to 55m
207	MSC061	14/06	04:19	S4	59.42574	-21.7983	Respiration, Silver, to 120m
208	Mammoth017	14/06	05:59	S4	59.43941	-21.785	

209	Mammoth018	14/06	07:23	S4	59.45171	-21.7918	
210	CTD036S	14/06	11:05	S4	59.48767	-21.8007	
211	IOP009	14/06	12:46	S4	59.50326	-21.7851	
212	OpticsT009	14/06	13:16	S4	59.50634	-21.7829	Tethered optics rig
213	OpticsP006	14/06	13:33	S4	59.50874	-21.7747	Profiling optics rig
214	Array003	14/06	15:20	S4	59.52948	-21.786	Drift-SPIRE array; fully recovered at 16:36
215	TM Fish	14/06	17:21	S4	59.54597	-21.7542	TM Fish deployed
216	Bongo025	16/06	01:10	R4	58.99212	-24.6729	
217	Bongo026	16/06	01:33	R4	58.99187	-24.6724	
218	CTD037T	16/06	02:26	R4	58.99137	-24.6712	
219	CTD038S	16/06	04:22	R4	58.98127	-24.6766	Stainless, to 120m, no bottles fired. Repositioned to centre of CHALKY patch again.
220	CTD039S	16/06	05:22	R4	59.01376	-24.6681	Stainless, to 120m, “respiration, shallow”
221	MSC062	16/06	06:14	R4	59.01343	-24.6674	CHALKY, Yuki, to 55m
222	MSC063	16/06	06:24	R4	59.01343	-24.6674	CHALKY, Silver, to 55m
223	RCF014	16/06	06:48	R4	59.01343	-24.6675	
224	Turbulence012	16/06	08:18	R4	59.01184	-24.6645	
225	Bongo027	16/06	10:02	R4	59.01746	-24.6531	
226	Bongo028	16/06	10:20	R4	59.01643	-24.6537	
227	CTD040S	16/06	11:03	R4	59.01396	-24.6565	Stainless, to 1000m, “Optics & general”
228	IOP010	16/06	12:29	R4	59.01115	-24.6492	
229	OpticsT010	16/06	13:07	R4	59.01042	-24.646	Tethered optics rig
230	OpticsP007	16/06	13:34	R4	59.01445	-24.6395	Profiling optics rig
231	Mammoth019	16/06	14:16	R4	59.01315	-24.6412	
232	Mammoth020	16/06	15:48	R4	59.01335	-24.642	
233	CTD041S	17/06	07:38	S5	60.23638	-21.2035	Stainless, to 1000m, “RESPIRE & general”
234	MSC064	17/06	08:59	S5	60.23655	-21.2025	Respiration, Silver, to 120m
235	MSC065	17/06	09:17	S5	60.23678	-21.2012	Respiration, Yuki, to 55m. Leaking.
236	MSC066	17/06	09:35	S5	60.23716	-21.199	Respiration, Red, to 55m.
237	CTD042S	17/06	10:05	S5	60.23761	-21.1966	Stainless, to 1000m, “respiration, deep”
238	Array004	17/06	11:37	S5	60.23903	-21.1887	Drift-SPIRE deployment (traps at 120m and 250m); fully deployed at 12:42

239	RCF015	17/06	13:11	S5	60.24321	-21.1895	
240	MSC067	17/06	14:04	S5	60.24333	-21.1889	Yuki, to 55m, Fluxes team
241	MSC068	17/06	14:18	S5	60.24354	-21.1881	Umi, to 120m, Fluxes team
242	MSC069	17/06	14:40	S5	60.24405	-21.1859	Silver, to 250m, Fluxes team
243	MSC070	17/06	15:15	S5	60.2427	-21.1822	Red, to 120m, Fluxes team
244	Bongo029	17/06	16:02	S5	60.24203	-21.1791	
245	Bongo030	17/06	16:22	S5	60.24176	-21.1801	
246	ISMI009	17/06	17:01	S5	60.23955	-21.1784	To 1005m!
247	Mammoth021	17/06	22:13	S5	60.23736	-21.1391	
248	Mammoth022	17/06	23:54	S5	60.24007	-21.1316	
249	CTD043T	18/06	04:19	S5	60.25205	-21.0843	Titanium, to 1000m
250	CTD044S	18/06	06:04	S5	60.25954	-21.081	Stainless, to 500m for glider cal, bottles only fired in top 120m, “respiration, shallow”
251	MSC071	18/06	08:00	S5	60.26593	-21.0875	Yuki, to 15m, CHALKY
252	MSC072	18/06	08:16	S5	60.26704	-21.0894	Red, to 450m, fluxes
253	MSC073	18/06	08:57	S5	60.27165	-21.0973	Silver, to 750m, fluxes
254	IOP011	18/06	12:22	S5	60.28246	-21.1228	
255	OpticsT011	18/06	12:47	S5	60.2857	-21.1273	Tethered optics rig
256	ISMI010	18/06	13:28	S5	60.28208	-21.1287	To 250m
257	RCF016	18/06	18:00	S5	60.29231	-21.2202	
258	Turbulence013	18/06	19:26	S5	60.2913	-21.2438	
259	Bongo031	18/06	22:51	S5	60.26929	-21.2195	
260	Bongo032	18/06	23:09	S5	60.2695	-21.2214	
261	RCF017	19/06	00:14	S5	60.27017	-21.2179	
262	CTD045S	19/06	04:33	S5	60.26925	-21.2126	Stainless, to 1000m, “ETS & Omics”
263	MSC074	19/06	06:01	S5	60.26838	-21.2083	Red, to 55m, respiration
264	MSC075	19/06	06:16	S5	60.26794	-21.2072	Silver, to 120m, respiration
265	Array004	20/06	04:55	S5	60.26794	-21.2072	Drift-SPIRE array; fully recovered at 06:07
266	TM Fish	20/06	08:47	S5	60.24321	-21.1895	TM Fish deployed
267	Turbulence014	20/06	09:08	S5	60.24333	-21.1889	
268	CTD046S	20/06	11:20	S5	60.24354	-21.1881	Stainless, to 1000m, “Optics & general”
269	IOP012	20/06	12:40	S5	60.24405	-21.1859	

270	OpticsT012	20/06	13:07	S5	60.2427	-21.1822	
271	Mammoth023	20/06	13:34	S5	60.21557	-21.0607	
272	Mammoth024	20/06	14:59	S5	60.21702	-21.0321	
273	Bongo033	20/06	23:57	R5	60.12031	-18.9531	Second Bongo not completed due to weather/current conditions
274	CTD047T	21/06	01:23	R5	60.12128	-18.9495	
275	CTD048S	21/06	03:27	R5	60.12021	-18.9386	
276	MSC076	21/06	04:56	R5	60.1185	-18.9274	Yuki, to 15m, CHALKY
277	MSC077	21/06	05:07	R5	60.11858	-18.9276	Silver, to 55m, CHALKY
278	RCF018	21/06	05:38	R5	60.12009	-18.9309	
279	Turbulence015	21/06	07:02	R5	60.11941	-18.9481	
280	Bongo034	21/06	08:58	R5	60.12108	-18.9494	
281	Bongo035	21/06	09:19	R5	60.12364	-18.9458	
282	Float004	21/06	10:26	R5	60.13307	-18.9342	ASBAN-UK BGC float
283	CTD049S	21/06	11:03	R5	60.12502	-18.945	Stainless, to 1000m, “optics & general”
284	IOP013	21/06	12:25	R5	60.1295	-18.9283	
285	OpticsP008	21/06	12:54	R5	60.13529	-18.9184	
286	OpticsT013	21/06	13:26	R5	60.13846	-18.905	
287	Mammoth025	21/06	14:03	R5	60.13356	-18.9112	
288	Mammoth026	21/06	15:38	R5	60.13564	-18.9029	
289	CTD050S	21/06	18:50	CAL1	60.12388	-18.7098	Stainless, to 1000m, glider cal for 398 (Churchill), sensors only, no bottles fired
290	IOP014	21/06	19:53	CAL1	60.1237	-18.7068	
291	CTD051S	21/06	21:22	CAL2	60.20461	-18.6789	Stainless, to 1000m, glider cal for 397 (Nelson), sensors only, no bottles fired
292	IOP015	21/06	22:24	CAL2	60.20483	-18.6792	
293	RCF019	21/06	23:13	CAL2	60.20139	-18.6676	With UVP6 from CTD frame attached in place of CPICS
294	Bongo036	22/06	05:56	ALR	60.17072	-20.0031	To collect zooplankton for experiments
295	ALR6	22/06	06:45	ALR	60.16968	-19.9951	Faulty ALR6 recovered
296	CTD052S	22/06	08:26	ALR	60.18192	-20.0388	Calibration CTD for ALR4
297	IOP016	22/06	09:49	ALR	60.18197	-20.0389	
298	OpticsT014	22/06	10:31	ALR	60.17704	-20.0294	Tethered optics rig

299	CTD053S	22/06	11:43	CAL	60.18023	-20.1108	Stainless, to 1000m, glider cal for 345 and 405 (Cabot and Doombar), sensors only, no bottles fired
300	TM Fish	22/06	13:03	CAL	60.18395	-20.1032	TM Fish deployed

NMF CTD technical report

B. Platt and P.Henderson (NOC)

CTD

Two CTD systems were prepared. A Stainless-steel (SS) frame fitted with 24 x 20ltr OTE water samplers and an MDS swivel fitted above it.
A Titanium (Ti) frame with 24 x 10L water samplers was deployed using the containerised Lebus 22mm trace-metal-free winch system. Casts were numbered sequentially with a suffix of S (stainless) or T (Titanium) to denote which CTD system had been used.

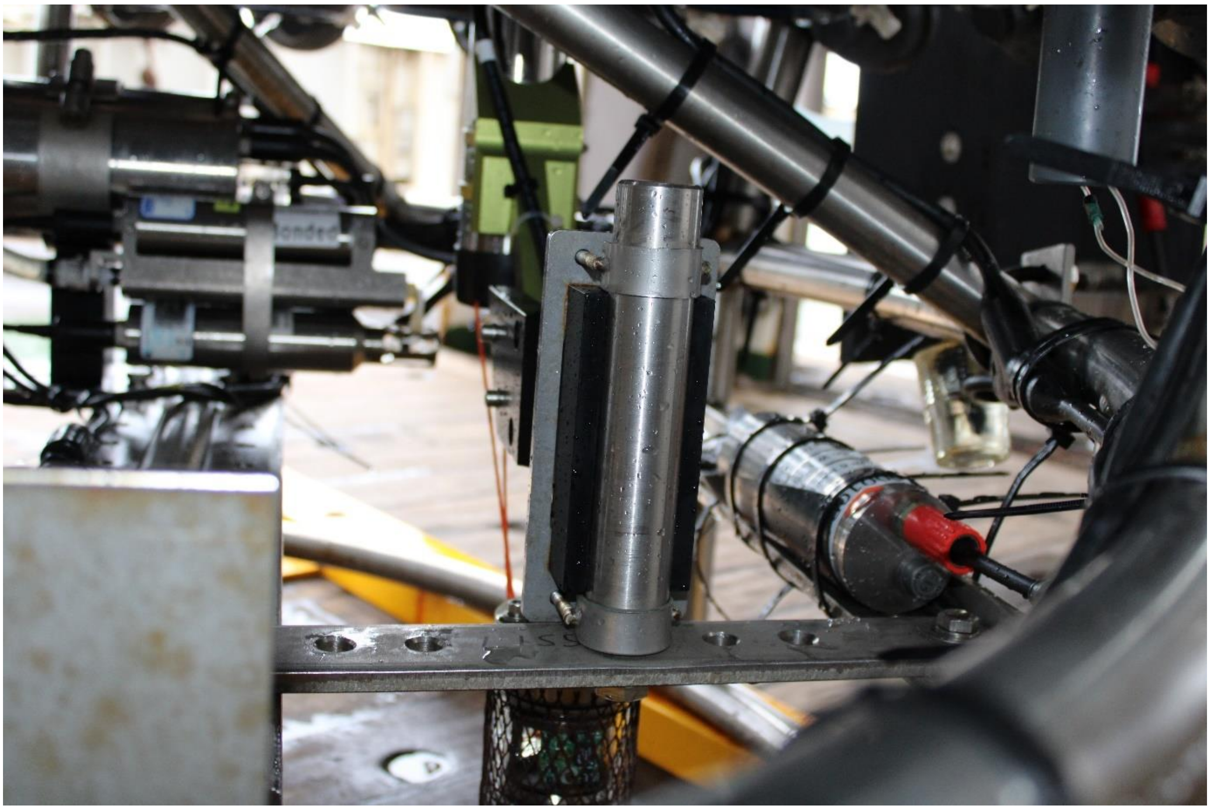
CTD wire 2 was terminated at the start of the trip using the potted termination method and used for all the SS casts. Insulation and resistance tests were carried out prior to terminating and were as expected. The termination was re-torqued through the cruise and not found to have moved.

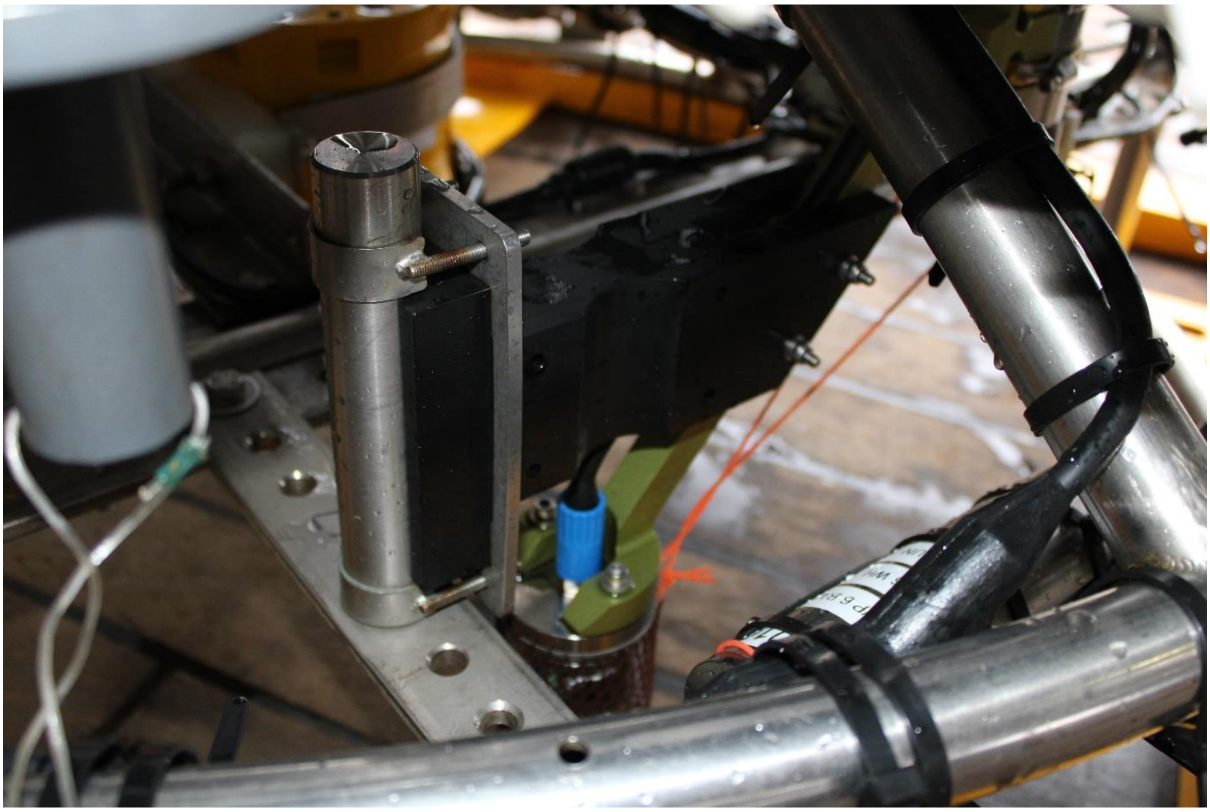
Several instruments were swapped-out during the cruise due to suspicious reading. This included both the oxygen sensors on the Titanium frame and the transmissometer on the Stainless Steel frame.
After cast 027S all of the sampling taps were removed from the 20L water samplers for cleaning. They were soaked in a <10% HCl solution and rinsed with MilliQ water to remove the signs of growth and general dirt that had built up on them.
There were several instances of the 20L bottles failing to release from the SBE 32 latch assembly. This was removed, cleaned, soaked in hot soapy water and re-installed. After this only bottle 4 continued to occasionally not release from the latch assembly. It was clear after all failed bottle closures that the software and electronics had worked but the side-load on the latch assembly was too much to allow it to release. An extension to the lanyard of bottle 4 was made and there were no more issues with bottles not closing.
The blue O-rings in the bottom on the water samplers that make the water-tight seal would sometimes be observed to be hanging out of their groove upon cocking the bottles and thus would not be able to seal. Before many deployments they had to be re-seated which required two people, one to hold the bottom cap down and one to re-seat the O-ring. There is a large danger of trapped fingers if the bottom cap snaps shut as the springs are very tight.

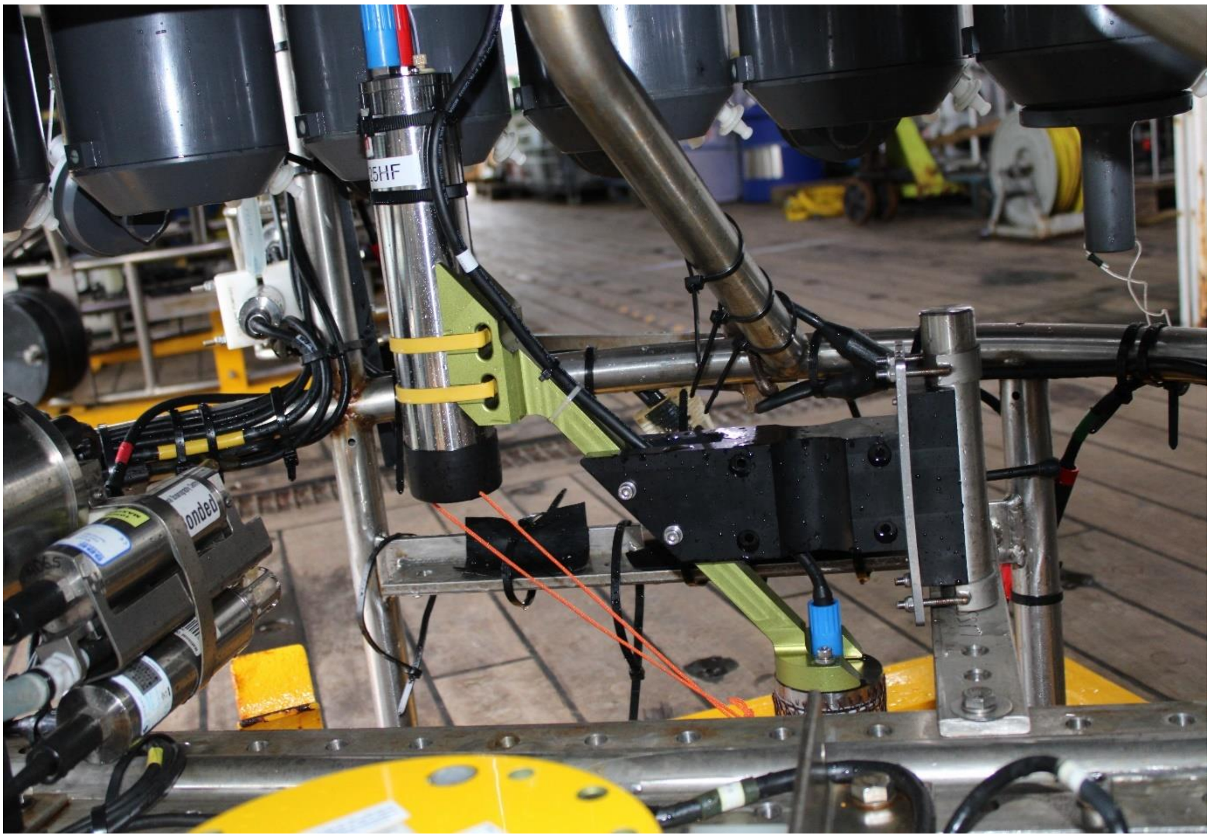
User-supplied equipment

Two pieces of user-supplied equipment were attached to the SS CTD. A UVP6 (Hydroptic Under Water Vision Profiler) mounted on the lower section of the frame and what became known as the 'Optics Octopus' mounted on the vane. The Optics Octopus consisted of an ECO Triplet, Eco FL3, RBR Tridente and SBE 50 pressure sensor. These were present for all SS CTD casts and shown in pictures below.

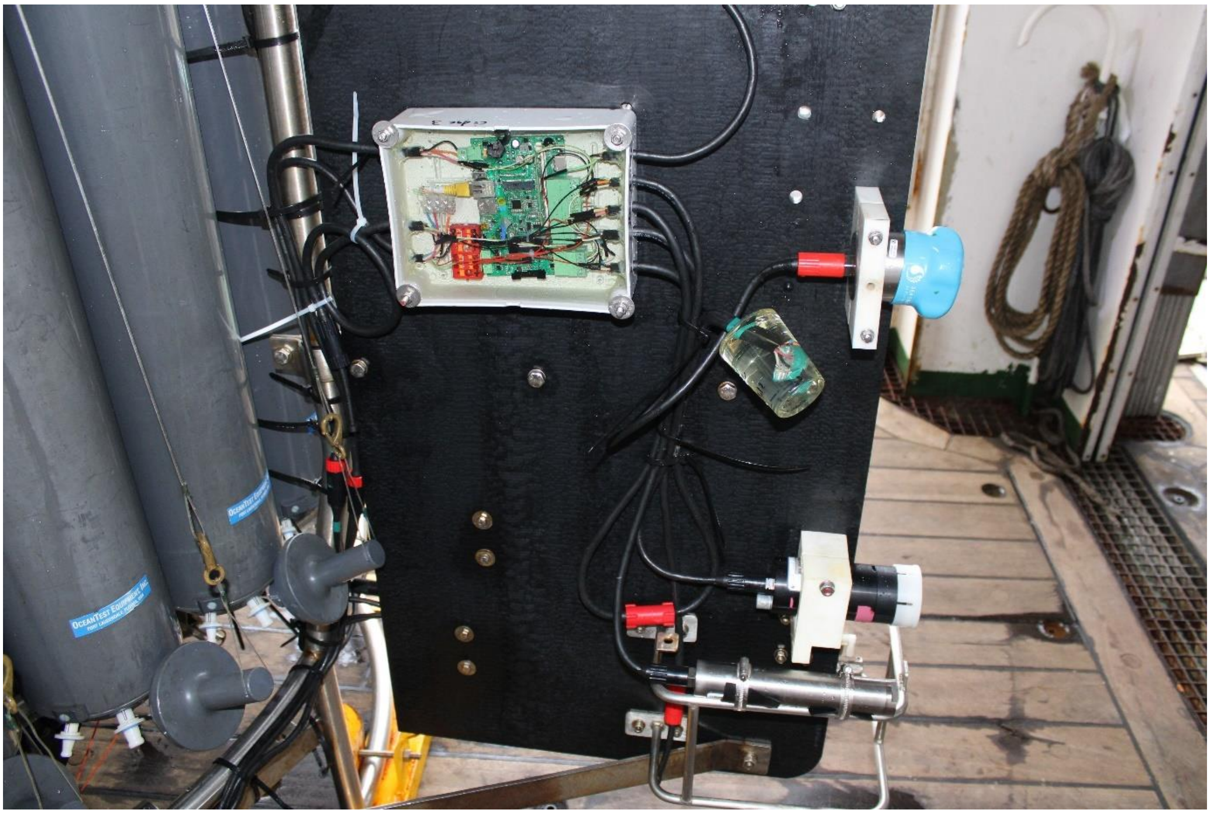
UPV6

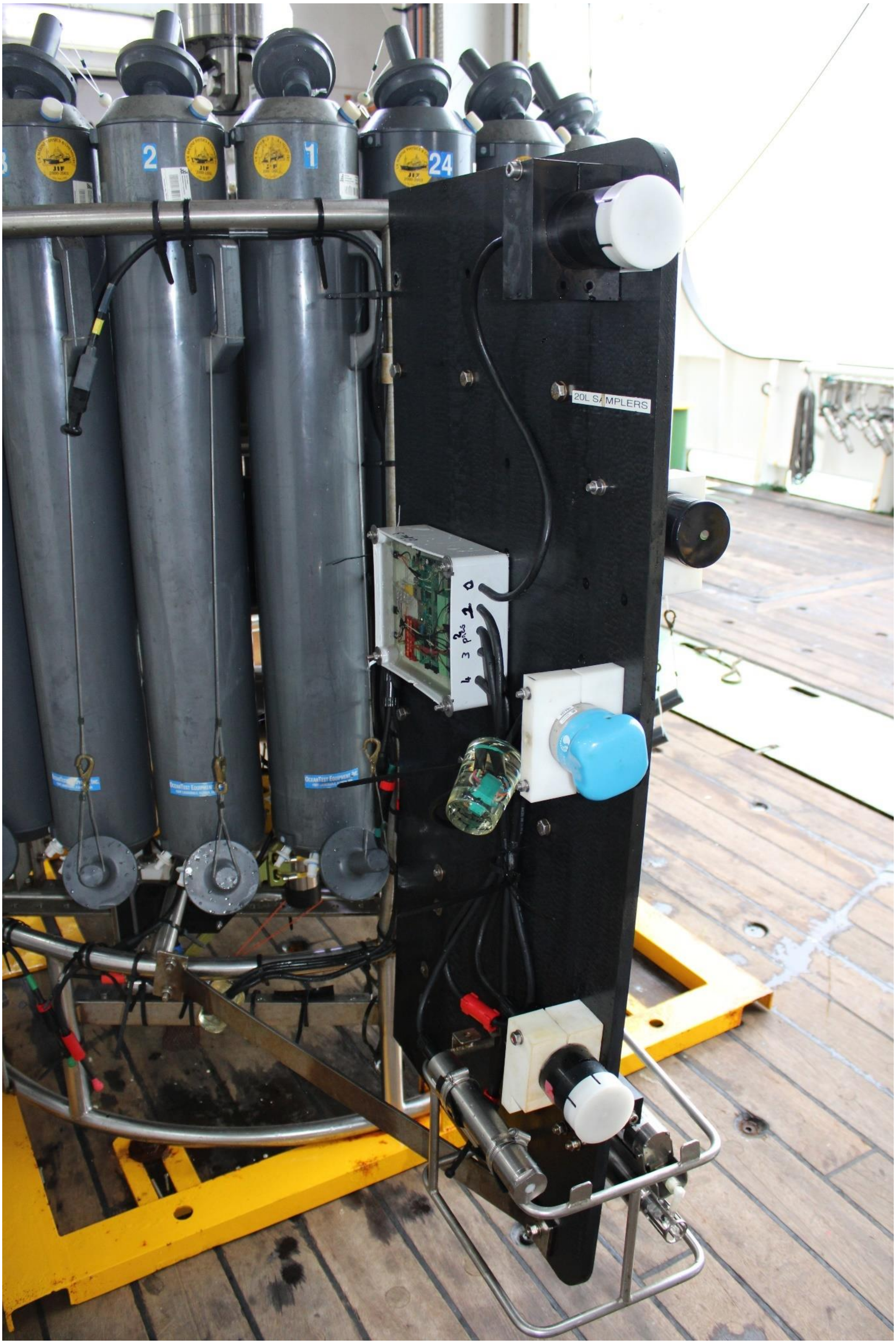






Optics 'Octopus'




20L SAMPLERS

LADCP

Two 300KHz ADCP's were mounted on the SS CTD frame. The down-looking, main, located at the bottom centre of the frame and the up-facing slave on an out-rigger sub-frame on the side of the CTD frame opposite the vane. They were configured with agreement from the science team and deployed on every SS cast.

The slave instrument failed to launch on casts 021S and 023S. The connections were all taken apart, the connectors cleaned with Electronic Cleaning Solution and washed out with MilliQ to remove any possible build-up of salt. Some tarnishing was observed on the pins of the connector on the ADCP. Several deck tests were done whereby the slave was launched with the master script file to test the instrument. We were unable to get the slave to fail to start and record. The slave script file was edited to enable the serial output so that it could be confirmed when starting deployments that it was running. There were no further occurrences of this problem.

LADCP script files

Down-looking main

```
CR1
RN MAST_
WM15
TC2
LP1
TB 00:00:02.80
TE 00:00:01.30
TP 00:00.00
LN25
LS0800
LF0
LW1
LV400
SM1
SA011
SB0
SW5500
SI0
EZ0011101
EX00100
CF11111
CD001000000
CK
CS
```

Up-looking Slave

```
CR1
RN SLAV_
WM15
LP1
TP 00:00.00
TE 00:00:00.00
LN25
LS0800
LF0
WB1
LW1
LV400
SM2
SA011
SB0
EZ0011101
EX00100
CF11111
CD001000000
CK
CS
```

Setup of Titanium 24-way CTD frame DY180

Checked By: Billy Platt / Paul Henderson	DATE: 09 June 2024

Instrument / Sensor	Manufacturer/ Model	Serial Number	Channel	Casts Used
Titanium 24-way CTD frame	NOCS	SBE TITA1	n/a	All titanium casts
Primary CTD deck unit	SBE 11plus	11P-24680-0588	n/a	All titanium casts
CTD Underwater Unit	SBE 9plus	09P-24680-0637	n/a	All titanium casts
24-way Carousel	SBE 32	32-24680-0346	n/a	All titanium casts
Primary Temperature Sensor	SBE 3P	03P-4816	F0	All titanium casts
Primary Conductivity Sensor	SBE 4C	04C-2165	F1	All titanium casts
Digiquartz Pressure sensor	Paroscientific	79501	F2	All titanium casts
Secondary Temperature Sensor	SBE 3P	03P-5494	F3	All titanium casts
Secondary Conductivity Sensor	SBE 4C	04C-3873	F4	All titanium casts
Primary Pump	SBE 5T	05T-3090	n/a	All titanium casts
Secondary Pump	SBE 5T	05T-6320	n/a	All titanium casts
Primary Dissolved Oxygen Sensor	SBE 43	43-0363	V0	Titanium cast 002T
Primary Dissolved Oxygen Sensor	SBE 43	43-0619	V0	Titanium casts 005T-
Secondary Dissolved Oxygen Sensor	SBE 43	43-0709	V1	Titanium casts 002T-016T
Secondary Dissolved Oxygen Sensor	SBE 43	43-0862	V1	Titanium casts 020T -
Fluorometer	CTG Aquatracka MKIII	88-2050-095	V2	All casts
Transmissometer	WETLabs C-Star	CST-1797TR	V3	All casts
Altimeter	Valeport VA500	81630	V4	All casts
BBRTD	WETLabs	1055	V5	All casts
PAR Up-looking DWIRR	Satlantic	2356	V6	All casts
pH	AMT Deep pH	348	V7	All casts
10L TMF Water Samplers	Ocean Test Equipment (Set T)	---	n/a	All casts

SHIP: RRS DISCOVERY	CRUISE: DY180

FORWARDING INSTRUCTIONS / ADDITIONAL INFORMATION:

Setup of Stainless Steel 24-way CTD frame DY180

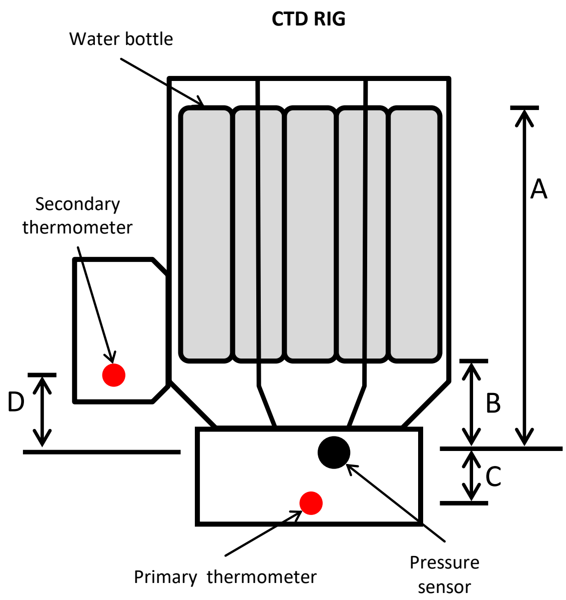
User supplied equipment: UVP6
Optics 'Octopus'

Checked By: Billy Platt / Paul Henderson	DATE: 09 June 2024

Instrument / Sensor	Manufacturer/ Model	Serial Number	Channel	Casts Used
Stainless steel 24-way CTD frame	NOCS	SBE CTD6	n/a	All stainless steel casts
Primary CTD deck unit	SBE 11plus	11P-24680-0588	n/a	All stainless steel casts
CTD Underwater Unit	SBE 9plus	09P-34173-0758	n/a	All stainless steel casts
24-way Carousel	SBE 32	32-60380-0805	n/a	All stainless steel casts
Primary Temperature Sensor	SBE 3P	03P-4593	F0	All stainless steel casts
Primary Conductivity Sensor	SBE 4C	04C-4065	F1	All stainless steel casts
Digiquartz Pressure sensor	Paroscientific	90074	F2	All stainless steel casts
Secondary Temperature Sensor	SBE 3P	03P-4712	F3	All stainless steel casts
Secondary Conductivity Sensor	SBE 4C	04C-4138	F4	All stainless steel casts
Primary Pump	SBE 5T	05T-3088	n/a	All stainless steel casts
Secondary Pump	SBE 5T	05T-3086	n/a	All stainless steel casts
Primary Dissolved Oxygen Sensor	SBE 43	43-1882	V0	All stainless steel casts
Secondary Dissolved Oxygen Sensor	SBE 43	43-2722	V1	All stainless steel casts
Fluorometer	CTG Aquatracka MKIII	088244	V2	All stainless steel casts
Transmissometer	WETLabs C-Star	CST-2150DR	V3	Stainless steel casts 001S-009S
Transmissometer	WETLabs C-Star	CST-1837TR	V3	Stainless steel

				casts 011S -
Altimeter	Valeport VA500	81629	V4	All stainless steel casts
BBRTD	WETLabs	758R	V5	All stainless steel casts
PAR Down-looking UWIRR	Satlantic	2348	V6	All stainless steel casts
PAR Up-looking DWIRR	Satlantic	2349	V7	All stainless steel casts
LADCP Down-looking (Master)	TRDI WHM 300KHz	24465	n/a	All stainless steel casts
LADCP Up-looking (Slave)	TRDI WHM 300KHz	24466	n/a	All stainless steel casts
LADCP battery pack	NOCS	WH006T	n/a	
LADCP battery pack	NOCS	WH008T	n/a	
20L Water Samplers	Ocean Test Equipment	---	n/a	All stainless steel casts
Titanium EM CTD Swivel	MDS ST6003-2E2-Ti	1246-2	n/a	All stainless steel casts

Rig geometry:



ID	Vertical distance from pressure sensor (m)
A	1.50 (Top of water samplers)
B	0.30 s/s system (Bottom of water samplers)
C*	0.10 (Primary Temperature mounted on 9plus)
D*	0.10 (Secondary Temperature mounted on the vane)
*NOTE: C & D may be minimal	

Salinity

An Autosal was setup in the Salinity room which was set at 18 degrees Celsius. The Autosal was set at 21 degrees and remained stable after it was standardised.
Salinity samples were taken from all 'general' SS CTD casts, four per cast, by either the CTD technicians or the science party. Once taken they were stored in the Salinity lab for 48hours before being processed by the NMF CTD technicians. The data from the salinity analysis was cross-compared with the CTD data from the bottle files and found to match well with the exception of four bottles. It is unknown where the issue with these bottles lies but suspected to be a labelling or log sheet error.

Initial Stainless steel configuration setup, casts 1-9

PSA file: C:\Users\sandm\Documents\Cruises\DY180\Data\Seasave Setup Files\DY180_SS_0758_nmea.psa

Date: 06/15/2024

Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY180\Data\Seasave Setup Files\DY180_SS_0758_CST1837_nmea.xmlcon

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

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

1) Frequency 0, Temperature

   Serial number : 03P-4593
   Calibrated on : 19 October 2023
   G             : 4.35395452e-003
   H             : 6.44499059e-004
   I             : 2.17255941e-005
   J             : 1.74681447e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-4065
```

Calibrated on : 24 October 2023
G : -9.85030327e+000
H : 1.48531990e+000
I : -1.73591946e-003
J : 2.15487780e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 90074
Calibrated on : 23 September 2022
C1 : -6.571123e+004
C2 : 2.050504e-001
C3 : 1.612220e-002
D1 : 2.883800e-002
D2 : 0.000000e+000
T1 : 2.986693e+001
T2 : -2.678465e-004
T3 : 3.986390e-006
T4 : 7.472100e-010
T5 : 0.000000e+000
Slope : 1.00012000
Offset : 0.01710
AD590M : 1.283700e-002
AD590B : -8.642460e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-4712
Calibrated on : 20 October 2023
G : 4.40425129e-003
H : 6.33609252e-004
I : 1.93045577e-005
J : 1.19439714e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-4138
Calibrated on : 24 October 2023
G : -9.82151347e+000
H : 1.44576150e+000
I : 5.24326300e-005
J : 9.34357467e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008

Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-1882
Calibrated on : 21 November 2023
Equation : Sea-Bird
Soc : 5.06600e-001
Offset : -4.90200e-001
A : -5.11770e-003
B : 1.99190e-004
C : -2.32590e-006
E : 3.60000e-002
Tau20 : 1.41000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

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

Serial number : 2722
Calibrated on : 22 June 2023
Equation : Sea-Bird
Soc : 5.67000e-001
Offset : -4.98300e-001
A : -4.57120e-003
B : 1.63170e-004
C : -2.72700e-006
E : 3.60000e-002
Tau20 : 1.26000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

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

Serial number : 088244
Calibrated on : 29 November 2022
VB : 0.358220
V1 : 2.123120
Vacetone : 0.550570
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

9) A/D voltage 3, Transmissometer, WET Labs C-Star

Serial number : CST-1837TR
Calibrated on : 17 October 2022
M : 21.8133
B : -0.1592
Path length : 0.250

10) A/D voltage 4, Altimeter

Serial number : 81629
Calibrated on : N/A
Scale factor : 15.000
Offset : 0.000

11) A/D voltage 5, OBS, WET Labs, ECO-BB

Serial number : 758R
Calibrated on : 21 September 2023
ScaleFactor : 0.003461
Dark output : 0.073000

12) A/D voltage 6, PAR/Irradiance, Biospherical/Licor

Serial number : 2359
Calibrated on : 19 February
M : 0.80861200
B : 1.05340900
Calibration constant : 735889322.20000005
Conversion units : umol photons/m^2/sec
Multiplier : 1.00000000
Offset : 0.00000000

13) A/D voltage 7, PAR/Irradiance, Biospherical/Licor, 2

Serial number : 2348
Calibrated on : 19 February 2023
M : 0.80753400
B : 1.05899300
Calibration constant : 735889322.20000005
Conversion units : umol photons/m^2/sec
Multiplier : 1.00000000
Offset : 0.00000000

Scan length : 45

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

Data Acquisition:
Archive data: YES

Delay archiving: NO
Data archive: C:\Users\sandm\Documents\Cruises\DY180\Data\Raw Data\DY180_CTD036S.hex
Timeout (seconds) at startup: 60
Timeout (seconds) between scans: 10

Instrument port configuration:
Port = COM1
Baud rate = 19200
Parity = N
Data bits = 8
Stop bits = 1

Water Sampler Data:
Water Sampler Type: SBE Carousel
Number of bottles: 32
Port: COM5
Enable remote firing: NO
Firing sequence: User input
Tone for bottle fire confirmation uses PC sound card.

Header information:
Header Choice = Prompt for Header Information
prompt 0 = Ship / Cruise: RRS DISCOVERY / DY180
prompt 1 = Event:
prompt 2 = Cast:
prompt 3 = Station:
prompt 4 = Julian Day:
prompt 5 = Date:
prompt 6 = Time (UTC):
prompt 7 = Latitude:
prompt 8 = Longitude:
prompt 9 = Depth (uncorrected m)
prompt 10 = Principal Scientist: Steph Henson
prompt 11 = Operator:

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

Miscellaneous data for calculations
Depth, Average Sound Velocity, and TEOS-10
Latitude when NMEA is not available: 57.00000000

```
    Longitude when NMEA is not available: 0.00000000
  Average Sound Velocity
    Minimum pressure [db]:             20.00000000
    Minimum salinity [psu]:            20.00000000
    Pressure window size [db]:         20.00000000
    Time window size [s]:              60.00000000
  Descent and Acceleration
    Window size [s]:                   2.00000000
  Plume Anomaly
    Theta-B:                           0.00000000
    Salinity-B                         0.00000000
    Theta-Z / Salinity-Z               0.00000000
    Reference pressure [db]            0.00000000
  Oxygen
    Window size [s]:                   2.00000000
    Apply hysteresis correction:       1
    Apply Tau correction:              1
  Potential Temperature Anomaly
    A0:                                0.00000000
    A1:                                0.00000000
    A1 Multiplier:                     Salinity
--------------------------------------------
Serial Data Output:
  Output data to serial port: NO
--------------------------------------------
Mark Variables:
  Variables:
  Digits   Variable Name [units]
  ------   --------------------
  0      Scan Count
  4      Depth [salt water, m]
  7      Conductivity [S/m]
  5      Salinity, Practical [PSU]
--------------------------------------------
Shared File Output:
  Output data to shared file: NO
--------------------------------------------
TCP/IP Output:
  Raw data:
    Output raw data to socket:         NO
    XML wrapper and settings:          NO
    Seconds between raw data updates:     0.00000000
  Converted data:
    Output converted data to socket:      NO
    XML format:                        NO
--------------------------------------------
SBE 11plus Deck Unit Alarms
  Enable minimum pressure alarm:   NO
  Enable maximum pressure alarm:   NO
  Enable altimeter alarm:          NO
--------------------------------------------
```

SBE 14 Remote Display
  Enable SBE 14 Remote Display: NO

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

Options:
  Prompt to save program setup changes: YES
  Automatically save program setup changes on exit: NO
  Confirm instrument configuration change: YES
  Confirm display setup changes: YES
  Confirm output file overwrite: YES
  Check scan length: NO
  Compare serial numbers: NO
  Maximized plot may cover Seasave: NO

Stainless steel configuration casts 11-

PSA file: C:\Users\sandm\Documents\Cruises\DY180\Data\Seasave Setup Files\DY180_SS_0758_nmea.psa

Date: 06/15/2024

Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY180\Data\Seasave Setup Files\DY180_SS_0758_CST1837_nmea.xmlcon

Configuration report for SBE 911plus/917plus CTD

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

1) Frequency 0, Temperature

  Serial number : 03P-4593
  Calibrated on : 19 October 2023
  G   : 4.35395452e-003
  H   : 6.44499059e-004
  I   : 2.17255941e-005

J : 1.74681447e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-4065
Calibrated on : 24 October 2023
G : -9.85030327e+000
H : 1.48531990e+000
I : -1.73591946e-003
J : 2.15487780e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 90074
Calibrated on : 23 September 2022
C1 : -6.571123e+004
C2 : 2.050504e-001
C3 : 1.612220e-002
D1 : 2.883800e-002
D2 : 0.000000e+000
T1 : 2.986693e+001
T2 : -2.678465e-004
T3 : 3.986390e-006
T4 : 7.472100e-010
T5 : 0.000000e+000
Slope : 1.00012000
Offset : 0.01710
AD590M : 1.283700e-002
AD590B : -8.642460e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-4712
Calibrated on : 20 October 2023
G : 4.40425129e-003
H : 6.33609252e-004
I : 1.93045577e-005
J : 1.19439714e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-4138
Calibrated on : 24 October 2023
G : -9.82151347e+000
H : 1.44576150e+000
I : 5.24326300e-005
J : 9.34357467e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-1882
Calibrated on : 21 November 2023
Equation : Sea-Bird
Soc : 5.06600e-001
Offset : -4.90200e-001
A : -5.11770e-003
B : 1.99190e-004
C : -2.32590e-006
E : 3.60000e-002
Tau20 : 1.41000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

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

Serial number : 2722
Calibrated on : 22 June 2023
Equation : Sea-Bird
Soc : 5.67000e-001
Offset : -4.98300e-001
A : -4.57120e-003
B : 1.63170e-004
C : -2.72700e-006
E : 3.60000e-002
Tau20 : 1.26000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

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

Serial number : 088244
Calibrated on : 29 November 2022

VB : 0.358220
V1 : 2.123120
Vacetone : 0.550570
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

9) A/D voltage 3, Transmissometer, WET Labs C-Star

Serial number : CST-1837TR
Calibrated on : 17 October 2022
M : 21.8133
B : -0.1592
Path length : 0.250

10) A/D voltage 4, Altimeter

Serial number : 81629
Calibrated on : N/A
Scale factor : 15.000
Offset : 0.000

11) A/D voltage 5, OBS, WET Labs, ECO-BB

Serial number : 758R
Calibrated on : 21 September 2023
ScaleFactor : 0.003461
Dark output : 0.073000

12) A/D voltage 6, PAR/Irradiance, Biospherical/Licor

Serial number : 2359
Calibrated on : 19 February
M : 0.80861200
B : 1.05340900
Calibration constant : 735889322.20000005
Conversion units : umol photons/m^2/sec
Multiplier : 1.00000000
Offset : 0.00000000

13) A/D voltage 7, PAR/Irradiance, Biospherical/Licor, 2

Serial number : 2348
Calibrated on : 19 February 2023
M : 0.80753400
B : 1.05899300
Calibration constant : 735889322.20000005
Conversion units : umol photons/m^2/sec
Multiplier : 1.00000000
Offset : 0.00000000

Scan length : 45

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

Data Acquisition:
  Archive data: YES
  Delay archiving: NO
  Data archive: C:\Users\sandm\Documents\Cruises\DY180\Data\Raw Data\DY180_CTD036S.hex
  Timeout (seconds) at startup: 60
  Timeout (seconds) between scans: 10

Instrument port configuration:
  Port = COM1
  Baud rate = 19200
  Parity = N
  Data bits = 8
  Stop bits = 1

Water Sampler Data:
  Water Sampler Type: SBE Carousel
  Number of bottles: 32
  Port: COM5
  Enable remote firing: NO
  Firing sequence: User input
  Tone for bottle fire confirmation uses PC sound card.

Header information:
  Header Choice = Prompt for Header Information
    prompt 0 = Ship / Cruise: RRS DISCOVERY / DY180
    prompt 1 = Event:
    prompt 2 = Cast:
    prompt 3 = Station:
    prompt 4 = Julian Day:
    prompt 5 = Date:
    prompt 6 = Time (UTC):
    prompt 7 = Latitude:
    prompt 8 = Longitude:
    prompt 9 = Depth (uncorrected m)
    prompt 10 = Principal Scientist: Steph Henson
    prompt 11 = Operator:

TCP/IP - port numbers:
  Data acquisition:
    Data port: 49163
    Status port: 49165
    Command port: 49164
  Remote bottle firing:
    Command port: 49167

    Status port: 49168
  Remote data publishing:
    Converted data port: 49161
    Raw data port: 49160

Miscellaneous data for calculations
  Depth, Average Sound Velocity, and TEOS-10
    Latitude when NMEA is not available: 57.00000000
    Longitude when NMEA is not available: 0.00000000
  Average Sound Velocity
    Minimum pressure [db]:   20.00000000
    Minimum salinity [psu]:   20.00000000
    Pressure window size [db]:   20.00000000
    Time window size [s]:   60.00000000
  Descent and Acceleration
    Window size [s]:   2.00000000
  Plume Anomaly
    Theta-B: 0.00000000
    Salinity-B   0.00000000
    Theta-Z / Salinity-Z   0.00000000
    Reference pressure [db]   0.00000000
  Oxygen
    Window size [s]:   2.00000000
    Apply hysteresis correction: 1
    Apply Tau correction: 1
  Potential Temperature Anomaly
    A0:   0.00000000
    A1:   0.00000000
    A1 Multiplier: Salinity

Serial Data Output:
  Output data to serial port: NO

Mark Variables:
  Variables:
  Digits   Variable Name [units]
  ------   ---------------------
  0   Scan Count
  4   Depth [salt water, m]
  7   Conductivity [S/m]
  5   Salinity, Practical [PSU]

Shared File Output:
  Output data to shared file: NO

TCP/IP Output:
  Raw data:
    Output raw data to socket: NO
    XML wrapper and settings: NO
    Seconds between raw data updates: 0.00000000
  Converted data:

Output converted data to socket: NO
XML format: NO

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

SBE 14 Remote Display
Enable SBE 14 Remote Display: NO

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

Options:
Prompt to save program setup changes: YES
Automatically save program setup changes on exit: NO
Confirm instrument configuration change: YES
Confirm display setup changes: YES
Confirm output file overwrite: YES
Check scan length: NO
Compare serial numbers: NO
Maximized plot may cover Seasave: NO

Titanium CTD configuration

PSA file: C:\Users\sandm\Documents\Cruises\DY180\Data\Seasave Setup Files\DY180_Ti_0637_nmea.psa

Date: 06/15/2024

Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY180\Data\Seasave Setup Files\DY180_Ti_0637_nmea.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : Yes

NMEA device connected to : PC
Surface PAR voltage added : No
Scan time added : Yes

1) Frequency 0, Temperature

Serial number : 03P-4593
Calibrated on : 06 December 2023
G : 4.30506041e-003
H : 6.34434624e-004
I : 2.18750259e-005
J : 2.06352477e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-2165
Calibrated on : 25 May 2023
G : -9.76363454e+000
H : 1.34247498e+000
I : -2.18490618e-003
J : 2.18392826e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 79501
Calibrated on : 11 January 2023
C1 : -6.052595e+004
C2 : -1.619787e+000
C3 : 1.743190e-002
D1 : 2.819600e-002
D2 : 0.000000e+000
T1 : 3.011561e+001
T2 : -5.788717e-004
T3 : 3.417040e-006
T4 : 4.126500e-009
T5 : 0.000000e+000
Slope : 0.99991000
Offset : -1.54590
AD590M : 1.293660e-002
AD590B : -9.522570e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-5494

Calibrated on : 6 December 2023
G : 4.32405672e-003
H : 6.25703216e-004
I : 1.92390345e-005
J : 1.43555581e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-3873
Calibrated on : 25 May 2023
G : -1.01907700e+001
H : 1.35671221e+000
I : -8.74487206e-004
J : 1.41175722e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-0619
Calibrated on : 21 November2023
Equation : Sea-Bird
Soc : 5.70300e-001
Offset : -4.94800e-001
A : -4.47190e-003
B : 1.86320e-004
C : -2.76280e-006
E : 3.60000e-002
Tau20 : 1.64000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

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

Serial number : 0862
Calibrated on : 16 May 2023
Equation : Sea-Bird
Soc : 4.93600e-001
Offset : -4.88500e-001
A : -4.13620e-003
B : 1.63210e-004
C : -2.82180e-006
E : 3.60000e-002

Tau20 : 1.05000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

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

Serial number : 088244
Calibrated on : 29 November 2022
VB : 0.338130
V1 : 2.070150
Vacetone : 0.647630
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

9) A/D voltage 3, Transmissometer, WET Labs C-Star

Serial number : CST-1797TR
Calibrated on : 18 April 2022
M : 21.4291
B : -0.1307
Path length : 0.250

10) A/D voltage 4, Altimeter

Serial number : 81630
Calibrated on : N/A
Scale factor : 15.000
Offset : 0.000

11) A/D voltage 5, OBS, WET Labs, ECO-BB

Serial number : 1055
Calibrated on : 19 July 2022
ScaleFactor : 0.003302
Dark output : 0.058000

12) A/D voltage 6, PAR/Irradiance, Biospherical/Licor

Serial number : 2356
Calibrated on : 7 March 2023
M : 0.80621000
B : 1.04544900
Calibration constant : 735889322.20000005
Conversion units : umol photons/m^2/sec
Multiplier : 1.00000000
Offset : 0.00000000

13) A/D voltage 7, pH

Serial number : 348
Calibrated on : 17 April 2024
pH slope : 5.9439
pH offset : 2.3987

Scan length : 45

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

Data Acquisition:
Archive data: YES
Delay archiving: NO
Data archive: C:\Users\sandm\Documents\Cruises\DY180\Data\Raw Data\DY180_CTD033T.hex
Timeout (seconds) at startup: 60
Timeout (seconds) between scans: 10

Instrument port configuration:
Port = COM1
Baud rate = 19200
Parity = N
Data bits = 8
Stop bits = 1

Water Sampler Data:
Water Sampler Type: SBE Carousel
Number of bottles: 32
Port: COM5
Enable remote firing: NO
Firing sequence: User input
Tone for bottle fire confirmation uses PC sound card.

Header information:
Header Choice = Prompt for Header Information
prompt 0 = Ship / Cruise: RRS DISCOVERY / DY180
prompt 1 = Event:
prompt 2 = Cast:
prompt 3 = Station:
prompt 4 = Julian Day:
prompt 5 = Date:
prompt 6 = Time (UTC):
prompt 7 = Latitude:
prompt 8 = Longitude:
prompt 9 = Depth (uncorrected m)
prompt 10 = Principal Scientist: Steph Henson
prompt 11 = Operator:

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

Miscellaneous data for calculations
  Depth, Average Sound Velocity, and TEOS-10
    Latitude when NMEA is not available: 57.0000
    Longitude when NMEA is not available: 0.0000
  Average Sound Velocity
    Minimum pressure [db]: 20.0000
    Minimum salinity [psu]: 20.0000
    Pressure window size [db]: 20.0000
    Time window size [s]: 60.0000
  Descent and Acceleration
    Window size [s]: 2.0000
  Plume Anomaly
    Theta-B: 0.0000
    Salinity-B 0.0000
    Theta-Z / Salinity-Z 0.0000
    Reference pressure [db] 0.0000
  Oxygen
    Window size [s]: 2.0000
    Apply hysteresis correction: 1
    Apply Tau correction: 1
  Potential Temperature Anomaly
    A0: 0.0000
    A1: 0.0000
    A1 Multiplier: Salinity

Serial Data Output:
  Output data to serial port: NO

Mark Variables:
  Variables:
  Digits Variable Name [units]
  ------ ---------------------
  0 Scan Count
  4 Depth [salt water, m]
  7 Conductivity [S/m]
  5 Salinity, Practical [PSU]

Shared File Output:
  Output data to shared file: NO

TCP/IP Output:
  Raw data:
    Output raw data to socket: NO
    XML wrapper and settings: NO
    Seconds between raw data updates: 0.0000
  Converted data:
    Output converted data to socket: NO
    XML format: NO

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

SBE 14 Remote Display
  Enable SBE 14 Remote Display: NO

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

Options:
  Prompt to save program setup changes: YES
  Automatically save program setup changes on exit: NO
  Confirm instrument configuration change: YES
  Confirm display setup changes: YES
  Confirm output file overwrite: YES
  Check scan length: NO
  Compare serial numbers: NO
  Maximized plot may cover Seasave: NO

NMF Ship Scientific Systems

Daniel Phillips (NOC)

Cruise Overview

Ship Scientific Systems (SSS) is responsible for operating and managing the Ship's scientific information technology infrastructure, data acquisition, compilation and delivery, and the suite of ship-fitted instruments and sensors in support of the Marine Facilities Programme (MFP).
The work site was the Icelandic Basin.
The main objectives for SSS in the service of the science party on this cruise were:

1. Acquire underway data and metadata, including sea-surface, meteorological, sub-surface currents position and attitude and depth.
2. Acquire qualitative Ek-80 acoustics surveys of superstation and roaming station sites.
3. Provide services for recording metadata and events and monitoring data streams.
4. Trial and commission NMF pCO_2 system.
5. Provide basic IT support.

All times in this report are in UTC.

Summary

A summary of the progress made against objectives is shown below.
[X] Objectives, [X] completed, [X] partially completed, [X] not completed.

Target	Outcomes	Objective met?
Acquire underway data and metadata, including sea-surface, meteorological, sub-surface currents position and attitude and depth.	Completed	Yes
Acquire qualitative Ek-80 acoustics surveys of superstation and roaming station sites	Completed	Yes
Provide services for recording metadata and events and monitoring data streams.	Completed	Yes
Trial and commission NMF pCO_2 system.	Completed	Yes
Provide basic IT support	Completed	Yes

Scientific computer systems

Underway data acquisition

Data from the suite of ship-fitted scientific instrumentation was aggregated onto a network drive on the ship's file server. This was available throughout the voyage in read-only mode to permit scientists to work with the data as it was acquired. A Public network folder was also available for scientists to share files.
A copy of these two drives are written to the end-of-cruise disks that are provided to the Principal Scientist and the designated data centre.
The designated data centre for this cruise is: **British Oceanographic Data Centre**.
The data acquisition systems used on this cruise are detailed in the table below. The data and data description documents are filed per system in the *Data* and *Documentation* directories respectively within Ship Systems folder on the cruise data disk.

Data acquisition systems used on this cruise.

Data acquisition system	Usage	Data products	Directory system name
Ifremer TechSAS	Continuous	NetCDF ASCII pseudo-NMEA	/TechSAS/
NMF RVDAS	Continuous	ASCII Raw NMEA	/RVDAS/
Kongsberg EA640	Continuous	None, redirected to Techsas/RVDAS RAM	/Acoustics/EA-640/
Kongsberg EK80	Discrete		/Acoustics/EK-60/
UHDAS (ADCPs)	Continuous	ASCII raw, RBIN, GBIN, CODAS files	/Acoustics/ADCP/

Significant acquisition events and gaps

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

Path and pattern to event log CSV files:
/Ship_Systems/Documents/Eventlog/[logName]/*.csv

Summary of main events

Date	Time start*	Time end*	Event
2024-05-19	08:15		DY180 acquisition started.
2024-05-22	06:40		Departed from Southampton, UK.
2024-05-22	11:10		Non-toxic seawater supply started.
2024-05-22	15:00		Non-toxic seawater supply stopped.
2024-06-26	08:00		Arrived in Aberdeen, UK.
2024-06-26	08:30		DY180 acquisition ended.

Summary of data gaps

Date	Time start	Time end	Event
2024-05-30	16:00	n/a	Failure of 75 kHz ADCP transducer. No data is available after this date.

Instrumentation

Coordinate reference

Path to ship survey files:
/Ship_Systems/Documentation/Vessel_Survey

Origin (RRS Discovery)

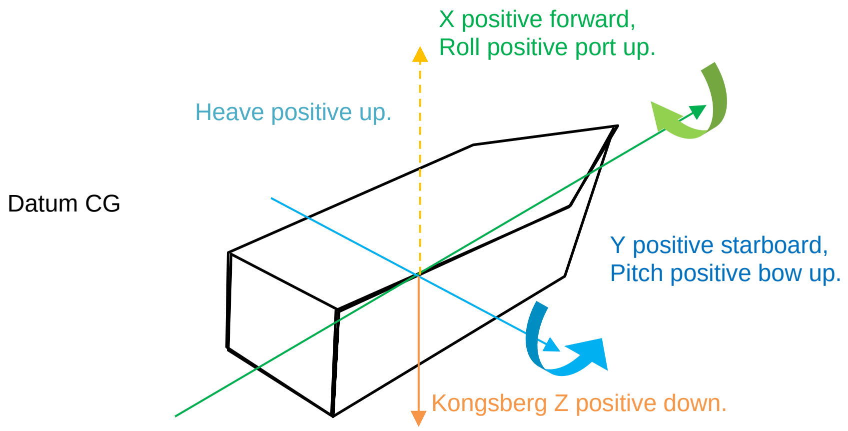
All coordinates, unless otherwise specified, use the following convention: Central reference point (0,0,0) at Frame 44, centreline, main deck with sense (X+ fwd, Y+ stbd, Z+ down). This CRP is at (32.4m, 0m, -7.4m) with respect to the ship's absolute stern, centreline, baseline.

The ship's survey (Parker Maritime, 2013) defines two systems of reference point using two different central reference points (CRPs):

1. (0,0,0) at Frame 0 (aft-most frame, 6m forward from stern), centreline (centre of keel), baseline (ship's bottom-most longitudinal).
2. (0,0,0) at ship's centre of gravity (CG), Frame 44 (26.4m forward from Frame 0 at 0.6m framespacing), centreline (centre of keel), main deck (7.4m up from baseline).

The survey coordinate sense is X is positive forward, Y positive starboard, and Z positive down. The coordinate order in the survey is (Y,X,Z), but unless otherwise noted, all coordinates are given elsewhere as (X,Y,Z).
For all scientific purposes, unless otherwise stated, the coordinate system is referenced using the second system, with the CRP at the CG.

Multibeam



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

The Kongsberg axes reference conventions are as follows:

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

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

Primary scientific position and attitude system

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

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

Position, attitude and time

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

Significant position, attitude or time events or losses

Date	Time start*	Time end*	Event
n/a	n/a	n/a	n/a

Ocean and atmosphere monitoring systems

SURFMET

System	SURFMET (Surface water and atmospheric monitoring)	
Data product(s)	NetCDF: /Ship_Systems/Data/TechSAS/NetCDF/ Raw NMEA: /Ship_Systems/Data/RVDAS/	
Data description	/Ship_Systems/Documentation/TechSAS	
Other documentation	/Ship_Systems/Documentation/Surfmet	
Calibration info	See Ship Fitted Sensor sheet for calibration info for each sensor.	
Component	Purpose	Outputs
Inlet temperature probe (SBE38)	Measure temperature of water at hull inlet.	Serial to Interface Box.
Drop keel temperature probe (SBE38)	Measure temperature of water in drop keel space.	Serial to Interface Box.
Thermosalinograph (SBE45)	Measure temp. and conductivity at sampling board. Salinity is calculated.	Serial to Interface Box.
Interface Box (SBE90402)	Signals management.	Serial to Moxa.
Debubbler	Reduces bubbles through instruments.	None.
Transmissometer (CST)	Measure of transmittance.	Analogue to NUDAM.
Fluorometer (WS3S)	Measure of fluorescence.	Analogue to NUDAM.

Air temperature and humidity probe (HMP45A, HMP155)	Temperature and humidity at met. platform.	Analogue to NUDAM.
Ambient light sensors (PAR, SKE510; TIR, CMP6)	Ambient light at met. platform.	Analogue to NUDAM.
Barometer (PTB110, PTB210)	Atmospheric pressure at met. platform.	Analogue to NUDAM.
Anemometer (Windsonic)	Wind speed and direction at met. platform.	Serial to Moxa.
NUDAM	A/D converter.	Serial NMEA to Moxa.
Moxa	Serial to UDP converter.	UDP NMEA to Surfmet VM.
Surfmet Virtual Machine	Data management.	UDP NMEA to TechSAS, RVDAS.

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

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

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

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port, and whilst alongside. Please see the separate information sheet for details of the sensors used and whether their recorded data have calibrations applied or not.

Surface water sampling board maintenance

Date	Time start*	Time end*	Event	Fluoro (V)
2024-05-28	13:26	14:27	Cleaning	Before: 0.10 After: 0.08
2024-06-05	10:08	11:05	Cleaning	Before: 0.08 After: 0.07
2024-06-14	15:01	16:06	Cleaning	Before: 0.09 After: 0.09
2024-06-23	14:46	16:05	Cleaning	Before: 0.09 After: 0.09

The system was cleaned prior to the cruise.

Wave radar

System	WAMOS Wave Radar	
Data product(s)	NetCDF: /Ship_Systems/Data/TechSAS/NetCDF/ Raw NMEA: /Ship_Systems/Data/RVDAS/	
Data description	/Ship_Systems/Documentation/TechSAS	
Other documentation	/Ship_Systems/Documentation/Wamos	
Component	Purpose	Outputs
Rutter OceanWaves WAMOS	Measure wave height, direction, period and spectra.	Summary statistics in NMEA to TechSAS and RVDAS. Spectra files.
Furuno Radar	Measures radar reflection on sea surface.	Radar data to WAMOS.

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

Summary of data gaps

Date	Time start	Time end	Event
n/a	n/a	n/a	n/a

pCO_2 system

System	pCO_2 system	
Data product(s)	Raw: /Ship_Systems/Data/pCO2/Raw/	
Data description	/Ship_Systems/Documentation/pCO2/Data description	
Calibration certificates	/Ship_Systems/Documentation/pCO2/Certificates	
Other documentation	/Ship_Systems/Documentation/pCO2	
Component	Purpose	Outputs
Model 8060 General Oceanics' pCO_2 system	Measure CO_2 in seawater and atmosphere.	Raw measurements in ACSII files.

The pCO_2 system measured gas standards roughly every 18 hours. The LICOR span was not changed throughout the cruise.

Summary of data gaps

Date	Time start	Time end	Event
n/a	n/a	n/a	n/a

Hydroacoustic Systems

System	Acoustics	
Statement of Capability	/Ship_Systems/Documentation/Acoustics	
Data product(s)	Raw: /Ship_Systems/Data/Acoustics NetCDF (EA640, EM122cb): /Ship_Systems/Data/TechSAS NMEA (EA640, EM122cb): /Ship_Systems/Data/RVDAS	
Data description	/Ship_Systems/Documentation/Acoustics	
Other documentation	/Ship_Systems/Documentation/Acoustics	
Component	Purpose	Operation and Outputs
10/12 kHz Single beam (Kongsberg EA-640)	Primary depth sounder	Continuous, free running NMEA over serial, raw files
75 kHz ADCP (Teledyne OS75)	Along-track ocean current profiler	Continuous, free running (via UHDAS) **No data after 2024-05-30.**
150 kHz ADCP (Teledyne OS150)	Along-track ocean current profiler	Continuous, free running (via UHDAS)

Equipment-specific comments

ADCPs

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

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

At 16:00 UTC on 2024-05-30, the 75 kHz transducer failed. Any 75 kHz transducer data after this time should be ignored.

Other systems

Cable Logging and Monitoring

Winch activity is monitored and logged using the CLAM system.

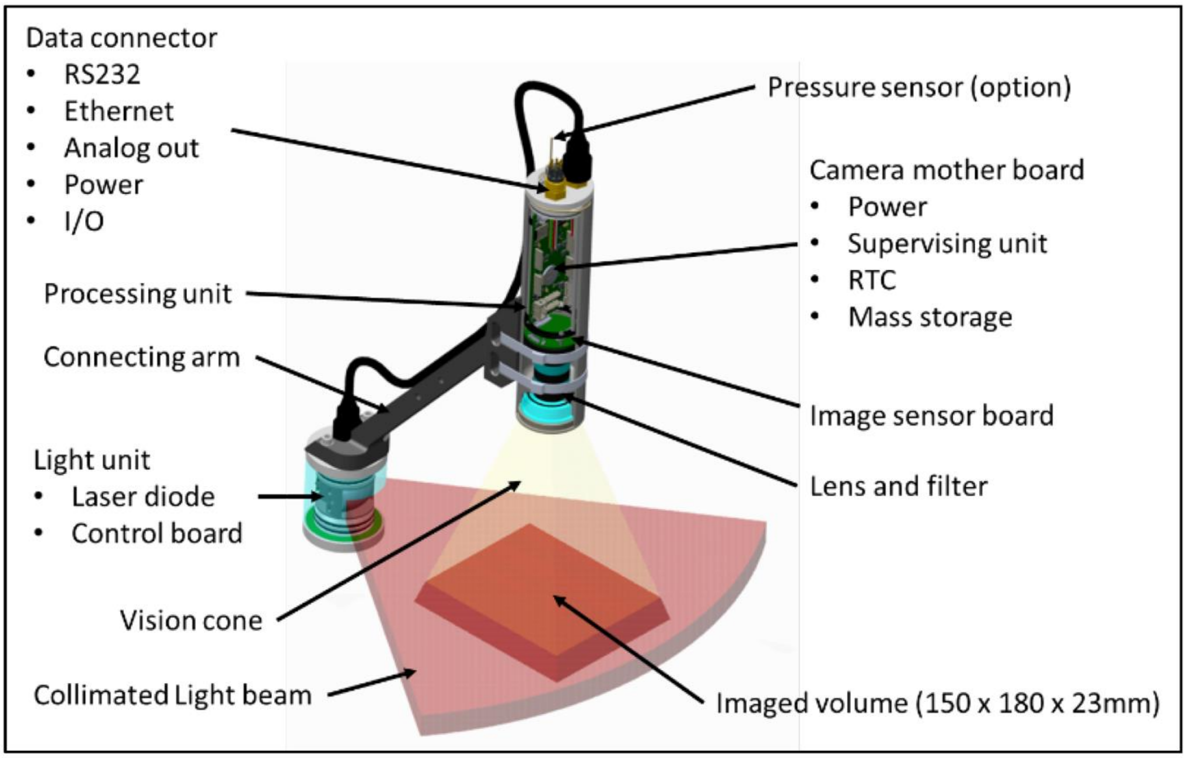
UVP6 on CTD frame

Filipa Carvalho (NOC)

Description

The Underwater Vision Profiler (UVP), developed under a CNRS patent, is an imaging sensor designed to count and size large particles (>80 µm) in situ within a known volume of water. The UVP6 captures images of larger aggregates and zooplankton (>700 µm) for later classification with the EcoTaxa/EcoPart web application. The high-frequency version (HF) can operate at higher speeds (>1 m/s) than the UVP6 Low Power (LP), making it suitable for fast-speed platforms such as CTDs and AUVs.

The UVP6 consists of a main camera containing a motherboard with a supervising processor, a mezzanine image processor unit, an image sensor board, a lens and a passband filter centred on 630nm wavelength and an optional pressure sensor necessary when the hosting vector cannot provide the pressure information to the UVP6. The light unit contains a controlling board, a laser diode and lenses. It is attached at a fixed distance of the camera using a connecting arm.



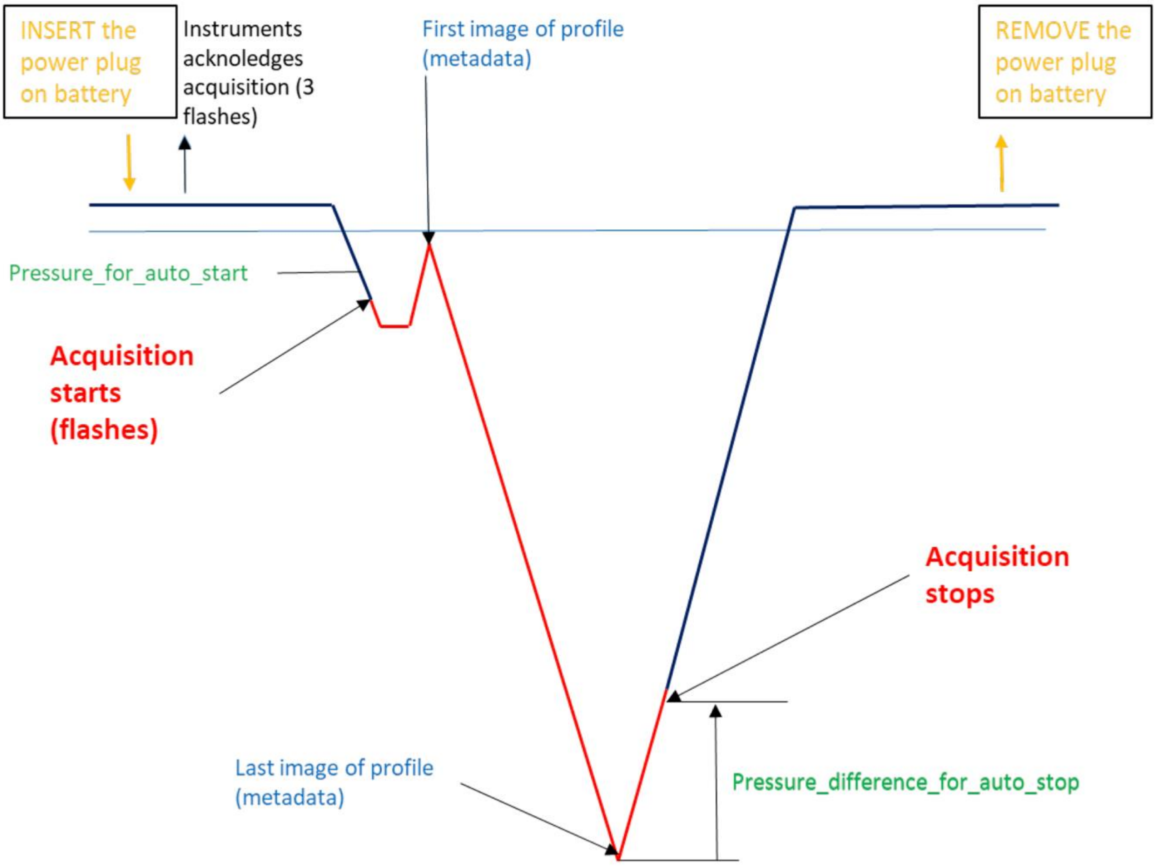
Schematic of UVP6

During DY180, a UVP6-HF was rented from LOV. The shipment came with the UVP6, 2 batteries, comms cable, 2 Y-cables, PC with UVPapp2 installed, a CTD mounting frame.

UVP6 was set in CTD mode during DY180, i.e. it is pressure activated. It was debated whether to use AUTO mode, given we had interest in sampling on the upcast as well as the downcast. AUTO mode is generally recommended for profiling when there is interest in more than just the downcast, but the manual start and stop (or time delay set) was less convenient as likely more data on deck would be collected, increasing data download times. This also has more settings to deal with and conveniently, CTD mode has already all the highest resolution settings possible by default. On top of that, the conveniency of automatic pressure activation, determined the mode selected. The CTD mode is set to stop at a given pressure difference from the deepest pressure. To collect data on the upcast as well, the ‘stop’ acquisition was bypassed by setting the ‘Pressure difference for auto stop’ to 3000. This meant that the UVP would stop recording 3000 dbar/m from the deepest depth. Given that the

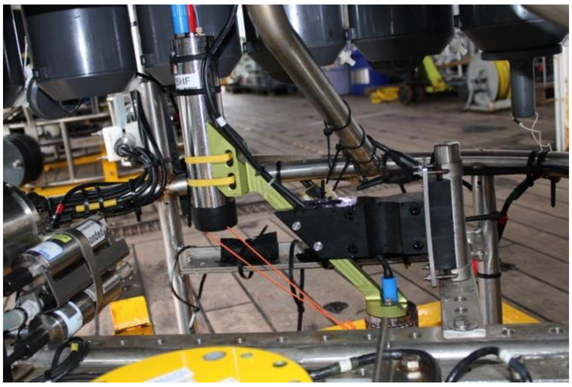
max CTD depth on DY180 was ~1000dbar, the UVP was still recording when the CTD package was brought on board. It was then disconnected from the battery as soon as it was safe to do so.
CTD mode only allows 4 settings to be modified as it is already optimised for high frequency acquisition:

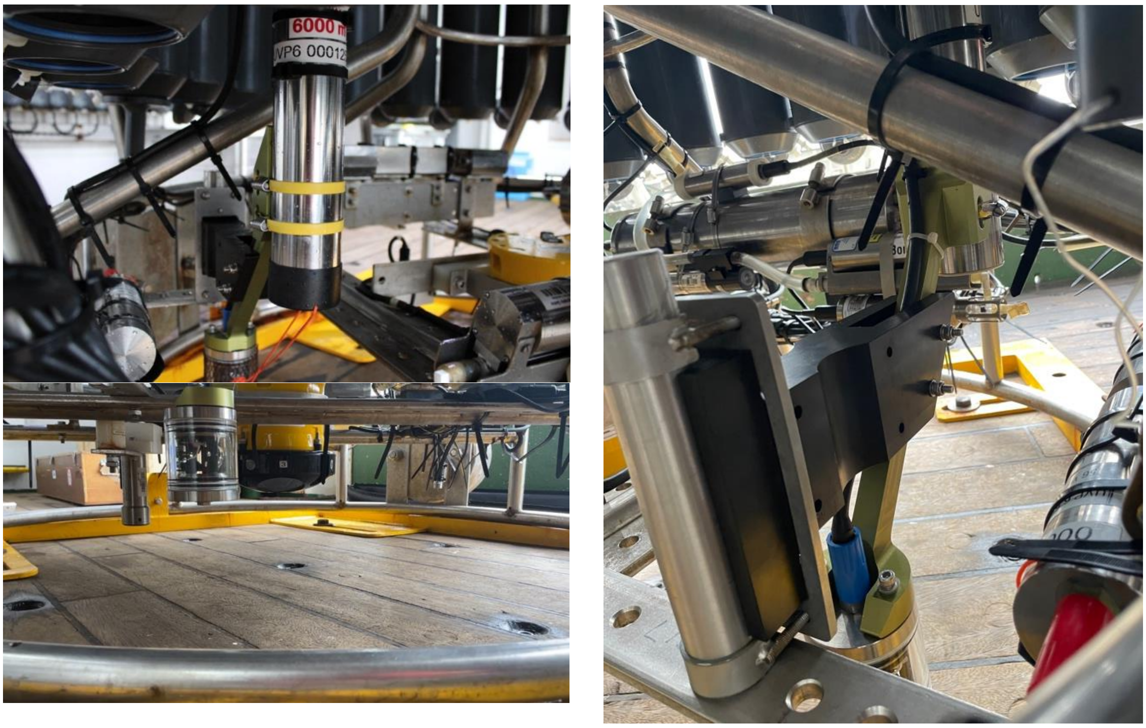
- Pressure offset : 0.5
- Pressure for auto start : 5
- Pressure difference for auto stop : 3000
- Gain for analog out: 1000



Setup on the CTD rosette

The CTD kit supplied by LOV did not fit our non-standard CTD rosette – our frame is slightly thicker than a standard SBE rosette. So, NMF techs created a special bracket to accommodate the slightly thinner fit.





UVP6 and external battery fitted onto the CTD rosette using a custom made adapter for the CTD kit supplied by LOV

Setup on the Red Camera Frame

At the end of the cruise, the UVP6 was removed from the CTD and fitted on the Red Camera Frame to provide a cross-calibration with the UVP5 (RCF019, Event 293). Red Camera Frame was fitted with:

- LISST Holo 2
- RBR Concerto with CTD, RBRTrident and RBRCoda
- UVP5
- UVP6
- Seabird ECO triplet

Red Camera Frame with both UVP5 (as standard) and UVP6 for cross-sensor calibration and validation

Sequence of operations

In the beginning of the cruise, Hans Hilder (not sailing) performed the first checks after getting the instrument from LOV:

- Check items against packing list
- Instrument connection to Power (AC or battery) and UVPapp
- Instrument programming (in CTD mode)
- Time synchronisation
- Delete data
- Autocheck

Before (or after) every CTD cast, the external battery was plugged in (or unplugged).
Second battery supplied was charged and ready to replace the battery in use. Batteries were swapped at the end of each superstation.
Every 2 days or so, data was downloaded from the UVP6 by plugging in the comms cable and the battery. Only sequences collecting during the CTD casts were imported into the current project (uvp6_sn000125hf_20240526_dy180).
After downloading a few sequences, and a few times during the cruise, data was processed using the UVPapp:

- Download sequences (this took ~15-20 mins per cast).
- Manage sequences and creating samples. Three samples were created for each sequence, i.e. for every cast:
    - CTDXXXX – up and downcast in a single sample
    - CTDXXXX_10s – integrating data in 10s bins
    - CTDXXXX_d – only downcast in the sample – the UVP is in the bottom of the rosette, so we expect the data to be of good quality in the downcast only
- Fill in sample metadata – compiled in a xlsx file (*DY180_UVP6_log.xlsx*) using the bridge and PSO event log.
- Once samples were created, next step was processing the data and the images.
- Export to ODV did not work, with the exported file not being recognised by ODV
- View vignettes and export results (plots).
- Once on land, data will be loaded in EcoPart FTP and imported to EcoPart and EcoTaxa for image classification

Data

Common required metadata filled in the sample creation:
UVP SERIAL NUMBER: 000125HF/009VE2
UVP6 PROJECT NAME: BIO-Carbon Cruise 1
OPERATOR: Filipa Carvalho
SHIP: RRS Discovery
CRUISE: DY180

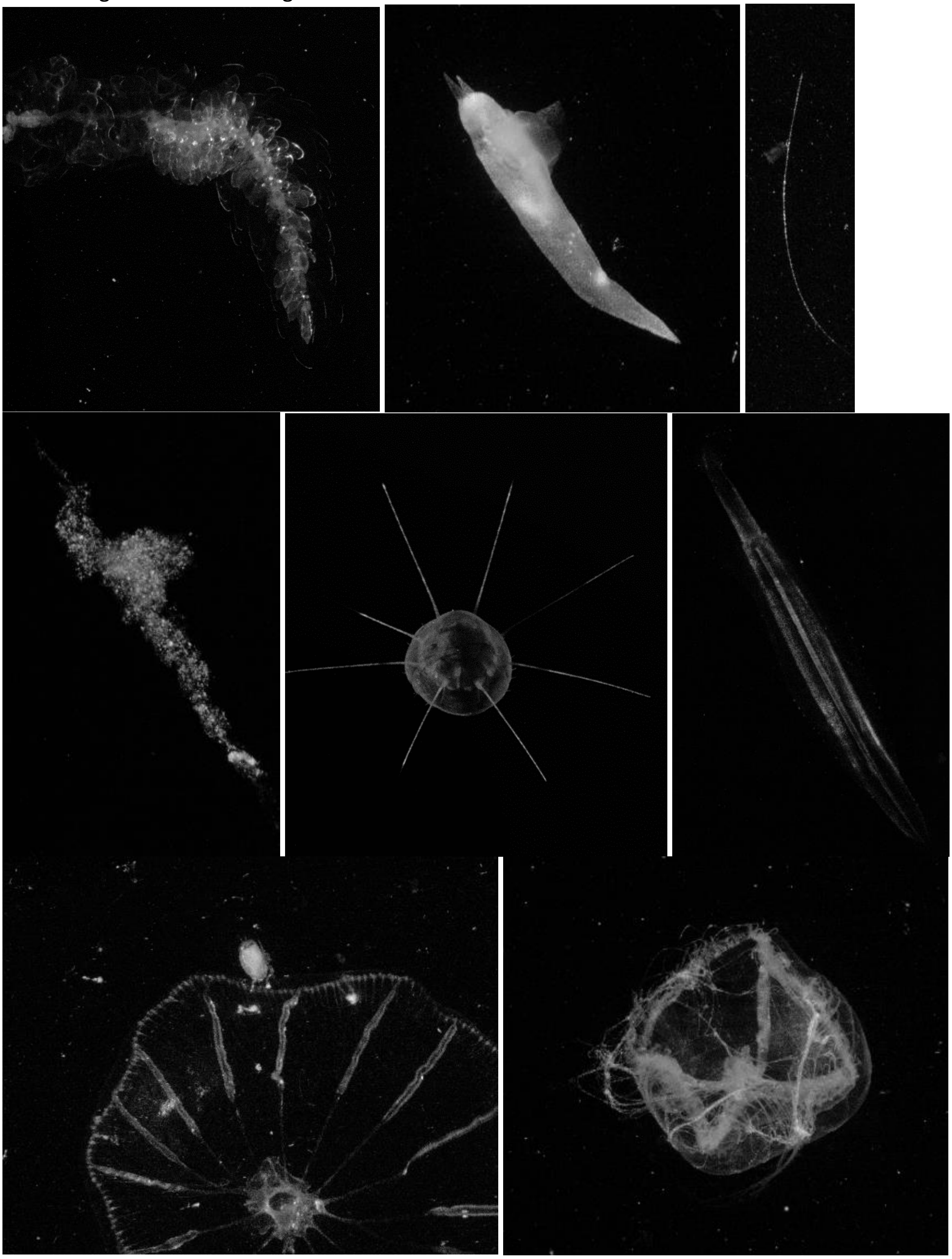
Details of all the casts where UVP data was collected during DY180. This included 43 CTD casts and 1 Red Camera Frame profile.

Event	SampleID	cast depth (m)	STATION	time in	raw sequence	first image	end of downcast	last image
1	dy180_CTD001S	1000	S1	26/05/2024 08:20	20240526-075539	3099	46924	96473
12	dy180_CTD003S	1000	S1	27/05/2024 04:12	20240527-041033	2909		112900
13	dy180_CTD004S	450	S1	27/05/2024 07:24	20240527-070127	1767	13128	54401
28	dy180_CTD00	120	S1	28/05/20	2024052	3306	7581	31208

	6S			24 05:19	8-051220			
36	dy180_CTD007S	1000	S1	28/05/2024 11:10	20240528-110026	9651	31996	75205
55	dy180_CTD008S	1000	S1	29/05/2024 12:07	20240529-1200413	2501	23512	65007
58	dy180_CTD009S	700	S1*	29/05/2024 19:48	20240529-194529	3135	20447	40299
64	dy180_CTD011S	120	R1	31/05/2024 03:31	20240531-030629	2703	7868	30012
71	dy180_CTD012S	1000	R1	31/05/2024 10:45	20240531-104312	2355	25686	84010
79	dy180_CTD013S	1000	S2	02/06/2024 01:17	20240602-010033	3826	27575	76802
80	dy180_CTD014S	1000	S2	02/06/2024 03:55	20240602-034956	2439	24061	70026
89	dy180_CTD015S	1000	R2	03/06/2024 10:50	20240603-102524	2935	26550	78203
104	dy180_CTD017S	120	R2	04/06/2024 03:55	20240604-034542	2500	7574	29540
106	dy180_CTD018S	1000	S3	06/06/2024 01:14	20240606-010519	3331	26301	70502
107	dy180_CTD019S	1000	S3	06/06/2024 03:58	20240606-035429	2005	22974	56814
125	dy180_CTD021S	120	S3	07/06/2024 04:42	20240607-043510	2534	9003	29828
130	dy180_CTD022S	1000	S3	07/06/2024 11:11	20240607-110724	1570	26264	51453
139	dy180_CTD023S	1000	S3	08/06/2024 02:05	20240608-015459	2187	23336	61849
147	dy180_CTD024S	1000	S3	08/06/2024 11:01	20240608-105757	3165	26417	74121
157	dy180_CTD026S	120	R3	10/06/2024 03:31	20240610-031624	1853	6948	26736
166	dy180_CTD027S	1000	R3	10/06/2024 11:11	20240610-110328	1876	26124	66891
172	dy180_CTD028S	1000	S4	11/06/2024 16:53	20240611-155352	2162	23849	46500
173	dy180_CTD029S	1000	S4	11/06/2024 19:41	20240611-193620	3070	26013	50701
174	dy180_CTD030S	1000	S4a	11/06/2024 22:02	20240611-215425	2500	25041	47034
175	dy180_CTD031S	1000	S4a	12/06/2024 01:14	20240612-010913	2727	24466	66963
176	dy180_CTD032S	1000	S4	12/06/2024 04:17	20240612-040852	2027	22478	61500
193	dy180_CTD034S	1000	S4	13/06/2024 04:22	20240613-040309	2127	7981	30470
205	dy180_CTD035S	1000	S4	14/06/2024 02:08	20240614-012750	2022	23006	61422

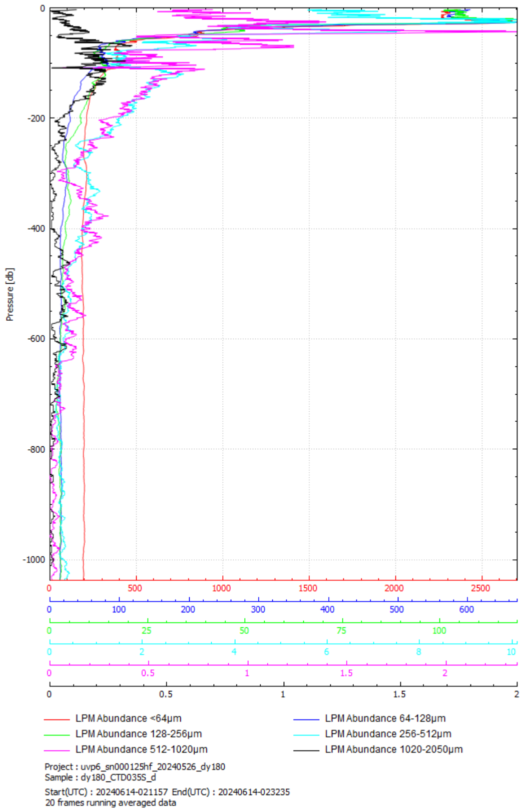
210	dy180_CTD036S	1000	S4	14/06/2024 11:05	20240614-110033	1940	22592	64929
219	dy180_CTD038S	120	R4	16/06/2024 04:22	20240616-041010	2299	7952	16082
220	dy180_CTD039S	120	R4	16/06/2024 05:22	20240616-045311	1567	7861	30261
227	dy180_CTD040S	1000	R4	16/06/2024 11:03	20240616-105218	1714	22357	63755
233	dy180_CTD041S	1000	S5	17/06/2024 07:38	20240617-072732	1317	19751	64605
237	dy180_CTD042S	1000	S5	17/06/2024 10:05	20240617-100238	2109	23750	62239
250	dy180_CTD044S	500	S5	18/06/2024 06:04	20240618-055542	2780	16127	44818
262	dy180_CTD045S	1000	S5	19/06/2024 04:33	20240619-042451	1591	24834	60404
268	dy180_CTD046S	1000	S5	20/06/2024 11:20	20240620-111146	2393	24810	65785
275	dy180_CTD048S	500	R5	21/06/2024 03:27	20240621-032133	2119	14515	40662
283	dy180_CTD049S	1000	R5	21/06/2024 11:03	20240621-105216	2269	24787	68721
289	dy180_CTD050S	1000	CAL1	21/06/2024 18:50	20240621-182744	2121	27353	53717
291	dy180_CTD051S	1000	CAL2	21/06/2024 21:22	20240621-210829	7105	28637	51014
293	dy180_RCF019	600	CAL2	21/06/2024 05:38	20240621-230846	3326	24586	37243
296	dy180_CTD052S	1000	ALR	22/06/2024 08:26	20240622-080623	2009	24630	71310
299	dy180_CTD053S	1000	CAL	22/06/2024 11:43	20240622-080623	1976	25082	52956

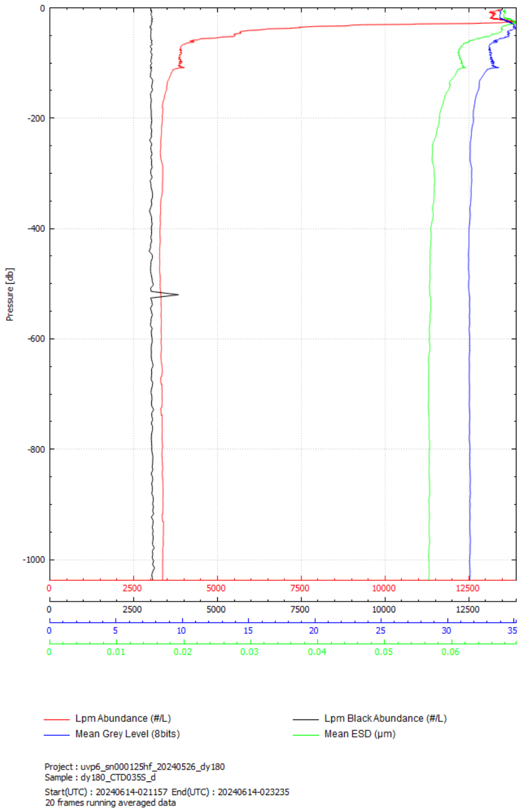
Some images collected during the cruise:



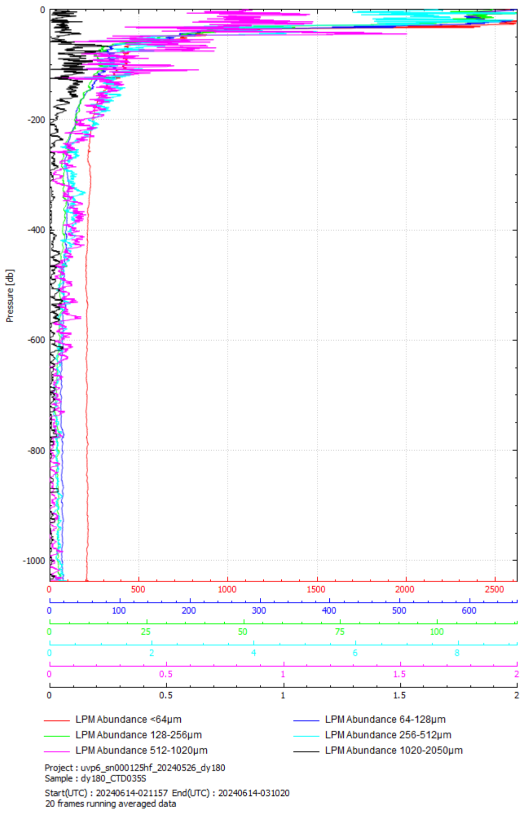
Example of automated output after processing:

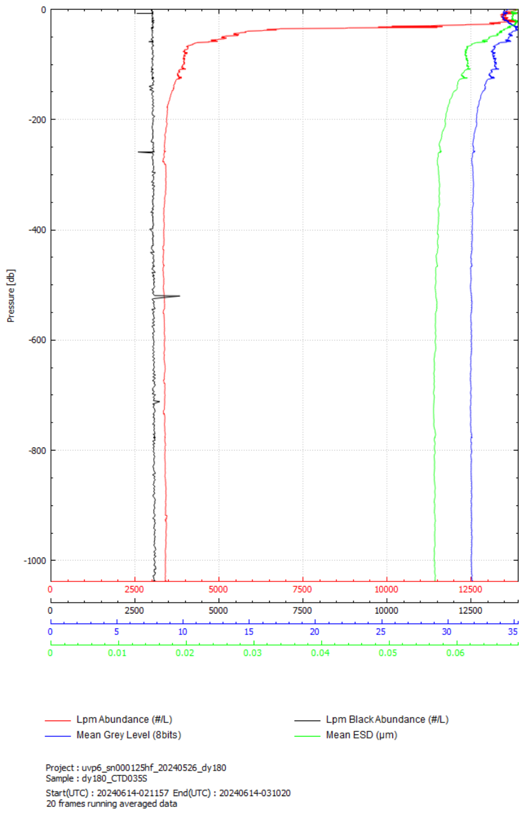
- Downcast only:





- Upcast and downcast together – signal diluted





LOV Optics Cidre package on CTD frame (aka the octopus)

Nathan Briggs (NOC)

Cidre package overview

On DY180, the Cidre package consisted of a rechargeable lithium ion battery, a controller, a pressure sensor, and up to three optical backscattering and/or fluorescence sensors. The main purpose of the Cidre package is to replicate the three-channel optical scattering and fluorescence sensors on the floats of project partner Herve Claustre's REFINE project. REFINE floats measure optical backscattering at 700 nm and two channels of chlorophyll fluorescence with excitation wavelengths of 435 nm and 490 nm. In combination with routine CTD package measurements (temperature, salinity, and optical beam attenuation), this allows us to replicate the full suite of measurements used by REFINE to further develop float-based proxies for plankton community structure. The primary Cidre optical sensor was a Seabird ECO FL2BB sensor. In addition, the Cidre carried an equivalent "Tridente" sensor from RBR, in order to compare the two sensors, as well as a three-channel Seabird ECO Chlorophyll fluorometer.

Cidre Optical sensors and related sensors

Name	**Model**	**Serial number**	**Parameters**
Cidre main sensor	Seabird Scientific ECO triplet FLBBFLRT2K	FLBBFLRT2K-7339	Chl Fluorescence (435 nm excitation) Chl Fluorescence (490 nm excitation) Optical backscattering (700 nm)
Cidre RBR Comparison sensor	RBR Tridente	P-0024038 23478	Chl Fluorescence (435 nm excitation) Chl Fluorescence (490 nm excitation) Optical backscattering (700 nm)
Cidre "Bonus" triple excitation fluorometer	Seabird Scientific ECO 3X1M RT2K	3X1MRT2K-5818	Chl Fluorescence (440 nm) Chl Fluorescence (490 nm) Chl Fluorescence (532 nm)
CTD standard backscattering sensor	Seabird Scientific ECO BBRTD	BBRTD-758	Optical backscattering (700 nm)
CTD standard transmissometer	Seabird Scientific C-Star	CST-1837TR	Optical beam attenuation

Plankton Community Sampling for LOV

In order to continue development of a float-based bacterio- and phytoplankton community proxy (building on Rembauville et al., 2017), the REFINE project requested a standard suite of plankton community structure samples at three depths during each noontime "optics and general" CTD casts. This included filtered samples for microscopy, preserved samples for microscopy and flow cytometry, POC, PIC, and HPLCs. While the filtration was done on all nine noon "optics" casts, unfortunately, preserved samples for microscopy were only collected on the first cast, and no preserved samples were collected for flow cytometry (green columns in table below). On the other hand, related plankton community measurements were made at ≥4 depths on these casts (red columns in table below).

List of number of depths of plankton community bottle samples taken from the during noontime "Optics and General" CTDs. Green columns show standard REFINE measurements. Red columns show related plankton community measurements.

CTD	St	HPLC	Filters for micro-scopy	POC/PIC	Lugols for micro-scopy	Flow cyto-metry (on board)	Cyto-sense/ SEM	Flow-CAM

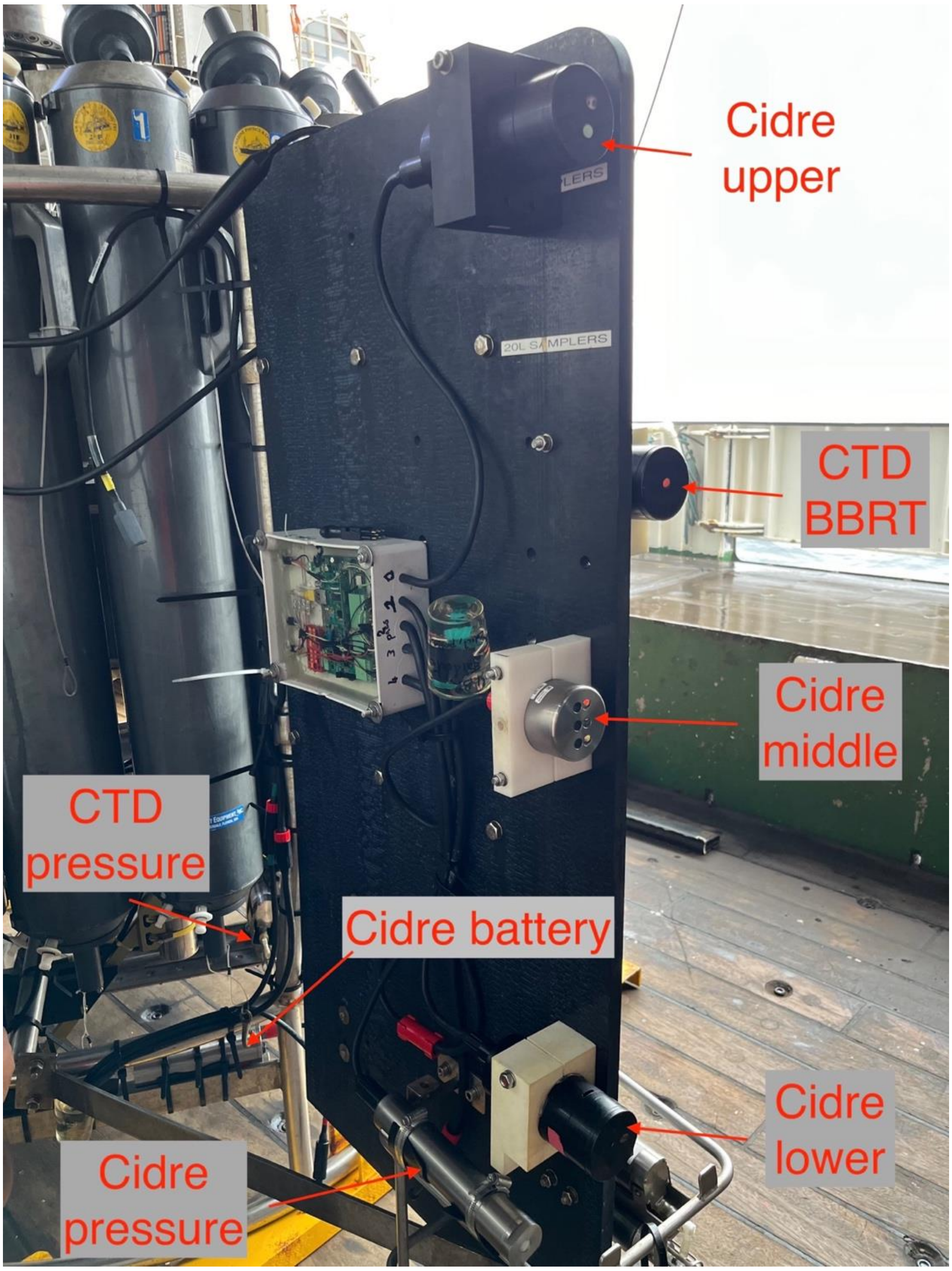
007	S1	11	3	12	3	12	7	4
012	R1	11	3	12		12	7	4
015	R2	11	3	12		12	7	4
024	S3	10	3	12		12	7	4
027	R3	11	3	12		12	7	4
036	S4	10	3	11		11	7	4
040	R4	10	3	11		11	7	4
046	S5	11	3	12		12	7	4
049	R5	11	3	12		12	7	4

Physical arrangement of Cidre package on DY180 stainless steel CTD

The Cidre package was mounted on the fin of the Discovery's stainless steel CTD package, with all sensors facing horizontally into undisturbed water, as shown below. LED illumination cones were oriented horizontally where possible to minimize interference between the different sensors. Vertical positions are given in the table below. During the first six stainless steel CTD profiles, the positions of the different Cidre were swapped around to test the effects of different configurations on the quality of the data. While some unusual sensor noise and apparent sensor drift was observed, there was no clear difference in performance with the different arrangements tested, so all three optical sensors were left connected for the remainder of the cruise.

Vertical distance between Cidre sensors and CTD pressure sensor

Sensor name/position	Sensor height above CTD pressure sensor
Cidre Optics Upper	+112 cm
CTD BBRT	+85 cm
Cidre Optics Middle	+67 cm
Cidre Optics Lower	+29 cm
Cidre pressure sesnsor	+20 cm



Labelled photograph of Cidre package mounted on DY180 Stainless Steel CTD package.

List of Cidre Sensors and their positions on each stainless steel CTD.

CTD	Upper	Middle	Lower	BBRT	REFINE bottle samples?
001	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
003		S3-Tridente	S0-FL2BB		
004		S3-Tridente	S0-FL2BB		
006	S0-FL3	S3-Tridente	S1-FL2BB	Opposite	
007	S0-FL3	S3-Tridente	S1-FL2BB	Opposite	Yes
008	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
009	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
011	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	

012	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	Yes
013	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
014	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
015	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	Yes
017	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
018	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
019	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
021	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
022	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
023	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
024	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	Yes
026	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
027	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	?
028	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
029	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
030	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
031	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
032	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
034	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
032	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
034	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
035	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
036	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
037	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
038	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
039	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
040	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	Yes
041	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
042	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
044	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
045	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
046	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	Yes
048	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
049	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	Yes
050	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
051	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
052	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	
053	S0-FL2BB	S3-Tridente	S1-FL3	Opposite	

Sensor performance

Pressure sensor

Unfortunately, the Cidre pressure sensor stopped working after the sixth profile. Also, unfortunately, the Cidre clock appeared to change on every profile. Therefore, data from the CTD was aligned in time with the Cidre using a semi-automated procedure, and then CTD pressure data was interpolated to the Cidre sampling times. The semi-automated alignment procedure involved automated detection of initial jumps in parameters when the CTD entered the water. Timing was adjusted manually for only four profiles (ctds 015, 022, 046, and 048).

Optical sensors

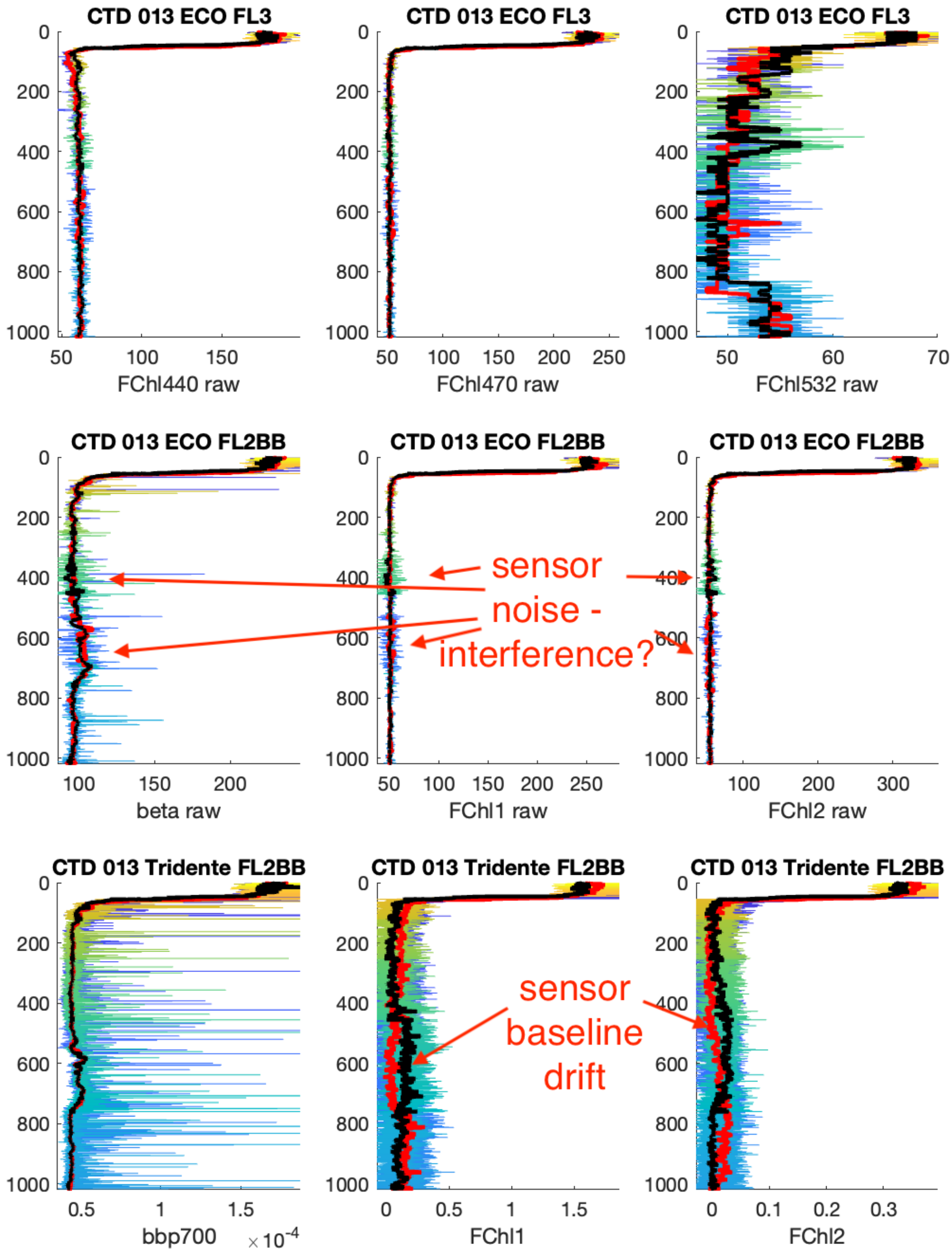
The three optical sensors performed consistently throughout the cruise, albeit with some unexplained noise and baseline drift in some parameters (e.g. see figure below). It is not known which, if any, of the observed issues derived from the sensors themselves, vs. the Cidre logger.

Main sensor – Seabird ECO FLBBFLRT2K-7339

The main sensor was set to sample at 1Hz (via internal averaging of raw samples). It performed overall very well, with good signal-to-noise ratio and very consistent performance on both up and downcast. This sensor did, however, suffer from occasional pulses of elevated noise that seemed possibly consistent with either optical or electronic interference, however, we were not able to eliminate this noise problem, even when switching around sensor location and removing both the ship's BBRT and the "Bonus" three-excitation wavelength fluorometer.

RBR Tridente Comparison Sensor - P-0024038 23478

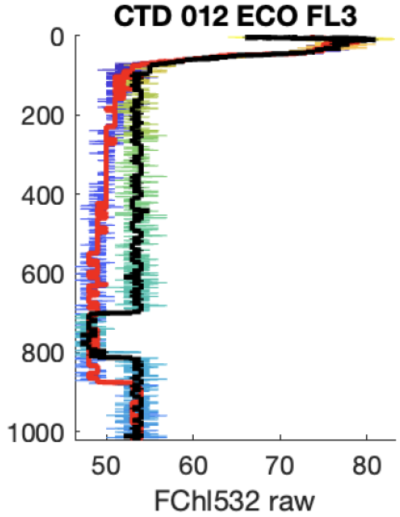
The RBR sensor output was set to sample at 8 Hz, and does not perform any internal averaging of ~30 ms samples. Consequently, as expected, it was "noisier" than the main sensor. The backscattering channel appeared to perform very well, with the "noise" dominated by positive spikes that are likely due to large particles. We plan to extract particle size distribution and compare to the UVP6. The fluorescence channels had lower overall signal-to-noise ratio, and the noise primarily appeared to be inherent sensor noise. Unfortunately, in contrast to the stable ECO fluorometers, the Tridente fluorescence sensor baselines also appeared to drift slowly up and down at depth, with a period of ~800 m, and with peaks and troughs not matching between down and upcast and also not matching between fluorescence channels. The amplitude of these fluctuations could be 0.14 mg Chl m^{-3}, which is uncomfortably high relative to the expected signal in much of the ocean.



Raw sensor output from example Cidre backscattering and fluorescence cast (CTD013s). Raw data is shown colored by time (blue to yellow) and median-filtered data is shown as thicker red (downcast) and black (upcast) lines.

Triple excitation fluorometer - ECO 3X1MRT2K-5818

This fluorometer's 470 nm excitation (standard) Chl fluorescene channel performed well, with some sign of the occasional increased noise suffered by the main sensor, but less in magnitude. The 440 nm channel also looked good, except a consistent, unexpected dip on the downcast, just below the surface layer. The 532 nm channel had a very low signal-to-noise ratio, some apparently random fluctuations at depth, and also a consistent positive jump of ~5 counts at ~800 m that reversed (equivalent negative jump), usually at a slightly different depth, on the upcast. On a single profile (CTD012s; below), this jump was clearly reversed again on the upcast at 700 m. The shape of this profile (diverging at depth and converging at surface, suggests that this jump may represent a switch between two states of sensor performance, one subject to a pressure dependency.



Anomalous 532 nm excitation fluorescence profile.

BGC-Argo Floats

Nathan Briggs (NOC)

Float overview

Four BGC Argo floats were deployed on DY180, one of which was recovered before the end of the cruise. Three floats from the REFINE project were deployed together near the beginning of the cruise. A calibration CTD was taken immediately after deployment. These floats carried an array of "standard" BGC Argo sensors in addition to the UVP6 particle imaging camera, a C-Rover transmissometer arranged as an "optical sediment trap", and (for the Phyto float only), hyperspectral radiometers. Two of these (Flux1 and Flux2) performed well. The Phyto float, however, had persistent problems with the beam transmissometer and the fluorescence and backscattering sensor, both of which repeatedly stopped recording data partway through each profile. A cable issue was suspected, so this float was recovered on 18 June. Float Flux1 was initially deployed with an incorrect setup file and therefore did not record nitrate data. This problem was fixed on 23 June. REFINE floats were set to profile every three days for the duration of the cruise (with flux floats alternating noon and midnight). They were then switched to profiling every 10 days at the end of the cruise. The REFINE floats were chosen as a semi-Lagrangian reference point and used to set the initial location for the majority of the DY180 superstations as well as targets for gliders to follow. The only exception was superstation 5, which targeted an eddy and, in exchange, Roaming station 5 occurred at the float location. When floats were together at the beginning of the cruise, all were followed as a whole. As the floats separated and the Phyto float was recovered, float Flux1 became the primary reference location.

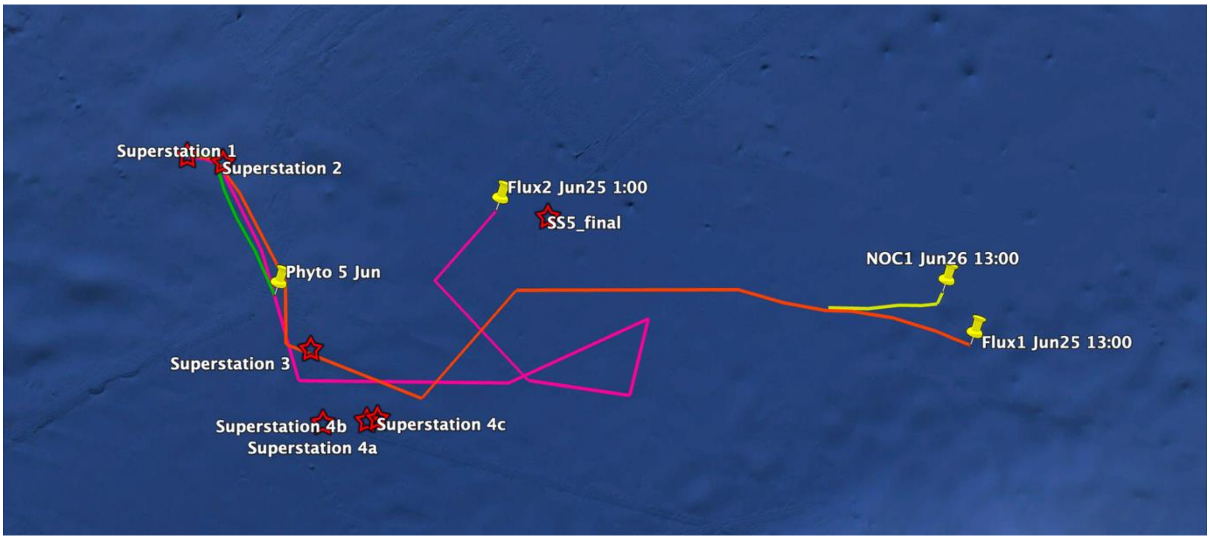
One ASBAN-UK (full BGC Argo) float ("NOC1") was deployed near the end of the cruise, near the location of float Flux1. After a few profiles at 1 day intervals, float NOC1 was set to profile every 2.5 days, at the end of the cruise, and gliders switched to following this float as the primary semi-Lagrangian reference point.

Float deployment details

WMO number	Name	Deploy date	Lat	Lon	Project	Calibration CTD
1902695	Phyto	28/05	59.99922	-23.999	REFINE	CTD007S
4903659	Flux1	28/05	59.99788	-23.9968	REFINE	CTD007S
6990636	Flux2	28/05	59.9921	-23.9884	REFINE	CTD007S
3901581	NOC1	21/06	60.13307	-18.9342	ASBAN-UK	CTD049S

Float sensor details

WMO number	Parameters
1902695	Temperature, Salinity, Oxygen, FChl 435nm, FChl 470nm, b_{bp} 700, c_p (optical sediment trap), particle size/class (UVP6), hyperspectral downwelling irradiance, hyperspectral upwelling radiance
4903659	Temperature, Salinity, Oxygen, FChl 435nm, FChl 470nm, b_{bp} 700, c_p (optical sediment trap), particle size/class (UVP6), nitrate, pH, Downwelling Irradiance (380 nm, 412 nm, 490 nm, PAR)
6990636	Temperature, Salinity, Oxygen, FDOM, FChl 470nm, b_{bp} 700, c_p (optical sediment trap), particle size/class (UVP6), nitrate, Downwelling Irradiance (380 nm, 412 nm, 490 nm, PAR)
3901581	Temperature, Salinity, Oxygen, FDOM, FChl 470nm, b_{bp} 700, nitrate, pH, Downwelling Irradiance (380 nm, 412 nm, 490 nm, PAR)



Float tracks and final positions during DY180 relative to the superstations

Float data

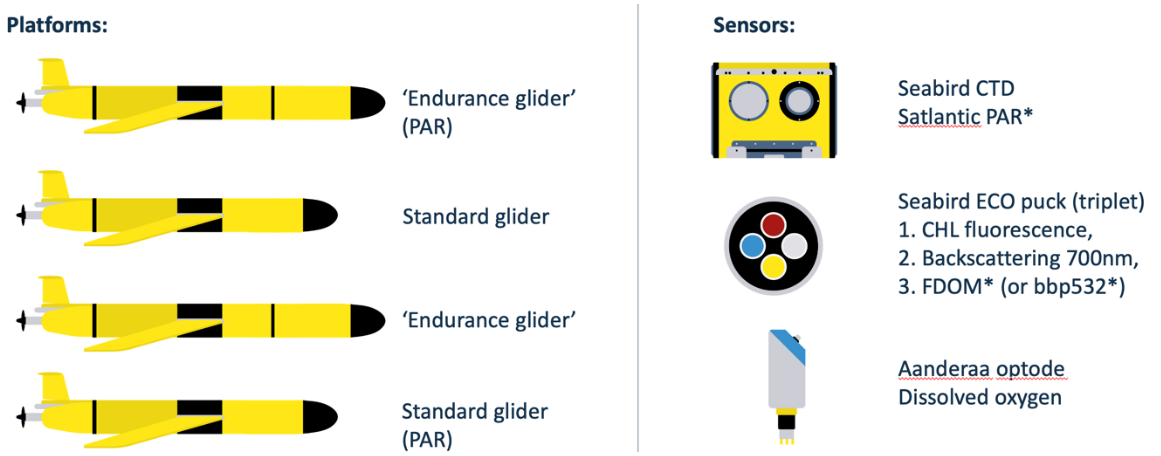
Float data can all be found in near real time in the Argo database, and fleetmonitoring.euro-argo.eu.

Glider deployments

Personnel in the field: Filipa Carvalho (BIO-Carbon glider lead), Nathan Briggs, Stephanie Henson, Mark Moore
Ground Support: Flavien Petit, Hans Hilder, Elisa Lovecchio
Glider pilots (MARS): Alex Cerra (lead), James Burris, Trishna Saeharaseelan, Steve Woodward, Ben Allsup.

Mission description and objectives

Glider operations on DY180 consisted of the deployment of 4 G2.5 Slocum gliders from MARS, National Oceanography Centre (NOC) in support of 2 BIO-Carbon projects, PARTITRICS (PI: Henson), IDAPro (PI: Mark Moore):



'Endurance gliders': extended battery, all profiles, high-resolution for entire deployment)

The fieldwork is coordinated among the 3 projects, and data from autonomous platforms will be combined, curated, and calibrated to deliver a unified science-ready dataset, that the individual projects can then use to answer their specific science questions.
The autonomy mission of the BIO-Carbon programme is setup in a semi-Lagrangian framework, by tasking gliders to follow drifting BGC-Argo floats, allowing us to collect a timeseries where advection is a smaller issue that when setting up Eularian missions (i.e. sampling in the same spot over time).
The high-resolution capabilities of the gliders allow us to resolve diel cycles – something floats can't do due to >1 day between surfacings. They will also allow us to understand and quantify spatial variability in ocean physics and biogeochemistry by comparing the data collected when platforms are surfacing around the same time, but in different places from each other.

Glider sensor packages

Gliders were fitted with a custom made Wetlabs Environmental Characterization (ECO) Triplet puck Eco Puck, measuring backscatter at 532 and 700 nm together with the standard chlorophyll fluorescence. A standalone 'Octopus' system with several ECOpucks and RBR trident (from our LOV project partners) was fitted on the CTD rosette during the cruise to provide good calibrations between the gliders, cruise CTD and in situ POC samples.

The following tables summarise the serial numbers, last calibration date, measured variables and additional notes for each sensor on each glider.

Sensor package details, including serial numbers, last calibration date, measured variables and additional notes for each sensor on each glider

	SL-397 (Nelson)	**SL-398 (Churchill)**	**SL-405 (Doombar)**	**SL-345 (Cabot)**
	Endurance glider w/PAR	Standard glider w/PAR	Endurance glider	Standard glider
CTD (Conductivity, Temperature, Depth)	Seabird pumped CTD (SBE GPCTD) Sampling Freq: ~ 1Hz			
	SciBay 1087 S/N: 9099 Cal date: 09/08/2023	SciBay 1088 S/N: 9100 Cal date: 09/02/2024	SciBay 1117 S/N: 9140 Cal date: 13/08/2023	SciBay 1097 S/N: 9110 Cal date: 01/02/2024
Bio-optics (chlorophyll fluorescence, optical backscatter, FDOM)	Seabird/Wetlabs ECO Puck Sampling Freq: ~ 0.3Hz			
	FLBB2 SN: 1611 Cal date: 12/21/2018	FLBBCDSLC SN: 3289 Cal date: 26/01/2024	FLBBCDSLC SN: 3352 Cal date: 13/12/2018	FLBBCDSLC SN: 3325 Cal date: 13/12/2018
Oxygen optode (dissolved oxygen)	Aanderaa Optode 4831 Sampling Freq: Up to 1 Hz			
	SN: 144 Cal date: 06/11/2020	SN: 286 Cal date: 04/10/2020	SN: 143 Cal date: 06/11/2020	SN: 119 Cal date: 04/10/2020
PAR (Photosynthetic Active Radiation)	Seabird/Satlantic PAR Sampling Freq: ~ 1Hz		N/A	N/A
	SN: 459 Cal date: 23/10/2019	SN: 461 Cal date: ?		

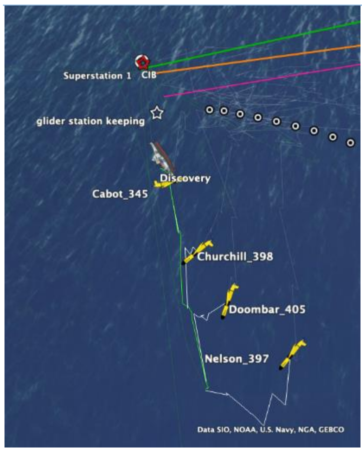
Four gliders deployed during DY180, Cabot (unit-345), Nelson (unit-397), Churchill (unit-398) and Doombar (unit-405).

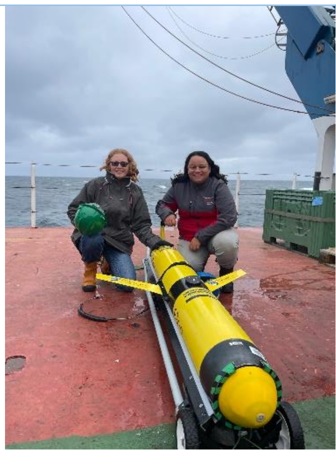
Deployment details

Gliders were deployed on May 28th, 2024. A few hours ahead of the deployment all 4 gliders were placed on the back deck for functional checks by the MARS pilot Alex Cerra. Alex requested that gliders were deployed about a mile apart from each other, so the ship steamed 4.5 nautical miles away from the superstation and we deployed the gliders every mile as we slowly made our way back to Superstation 1.

Glider deployment characteristics.

Glider	Nelson (unit-397)	Doombar (unit-405)	Churchill (unit-398)	Cabot (unit-345)
Date	28/05/2024	28/05/2024	28/05/2024	28/05/2024
Time	15:43 UTC	17:00 UTC	17:51 UTC	18:39 UTC
Lat	59.93475 N	59. 94676 N	59.96021 N	59.97413 N
Lon	23.9597 W	23.9674 W	23.9741 W	23.9819 W
Event number	040	041	042	043





Staggered deployment locations, starting with 397, 405, 398 and finally 345. Gliders were then tasked to head North towards the glider station-keeping waypoint, located ~1.5km South of Superstation 1.

Glider-to-glider and glider-to-ship calibration and validation

One ‘targeted’ calibration cast per glider was conducted at the end of the cruise in coordination with the MARS piloting team, where gliders were tasked to station keep at the same vertex a few hours before the cast, initially performing shallow dives. When the ship’s CTD (sensors only) was ready to be deployed, glider was sent on a deep (1000 m) dive.

Detail of the ‘targeted’ calibration casts between the Slocum gliders and the ship's CTD - sensors only, no bottles fired

	Calibration 1	**Calibration 2**	**Calibration 3**
Date	21/06/2024	21/06/2024	22/06/2024
Time	18:50	21:22	11:43
Latitude	60.12388	60.1237	60.18023
Longitude	-18.7098	-18.7068	-20.1108
Event number	289	291	299
CTD cast	CTD050S	CTD051S	CTD053S
Gliders involved	Churchill (unit-398)	Nelson (unit-397)	Cabot (unit-345) & Doombar (unit-405)

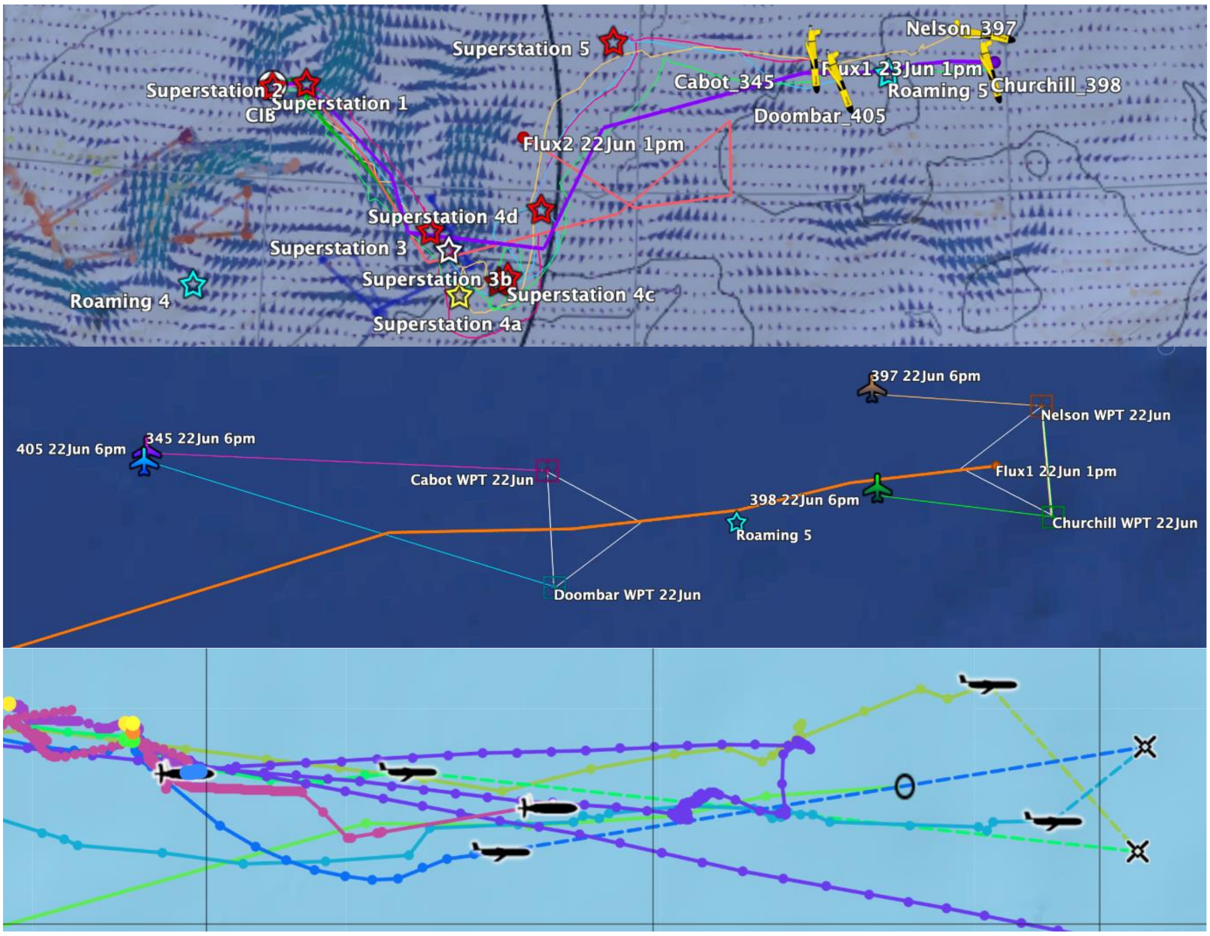
During the cruise, we took the opportunity to collect concurrent ship-glider casts without the coordination with MARS, instead we went to the last glider surfacing and did a CTD cast with sensors only.

Detail of the ‘opportunistic’ calibration casts between the Slocum gliders and the ship's CTD (sensors only, no bottles fired), i.e. cast at gliders last surfacing without coordination with MARS

	Calibration 1	**Calibration 2**	**Calibration 3**
Date	11/06/2024	11/06/2024	11/06/2024
Time	16:53	19:41	22:02
Latitude	59.039	59.23023	59.18699
Longitude	-22.4553	-22.0932	-22.3873
Event number	172	173	174
CTD cast	CTD028S	CTD029S	CTD030S
Gliders involved	Cabot (unit-345)	Churchill (unit-398)	Nelson (unit-397)

Daily piloting during the cruise

Communication during the cruise was done successfully via WhatsApp and new waypoints provided via e-mail. Piloting was mostly by Alex Cerra (lead), James Burris and Trishna Saeharaseelan, with support from Steve Woodward and Ben Allsup.



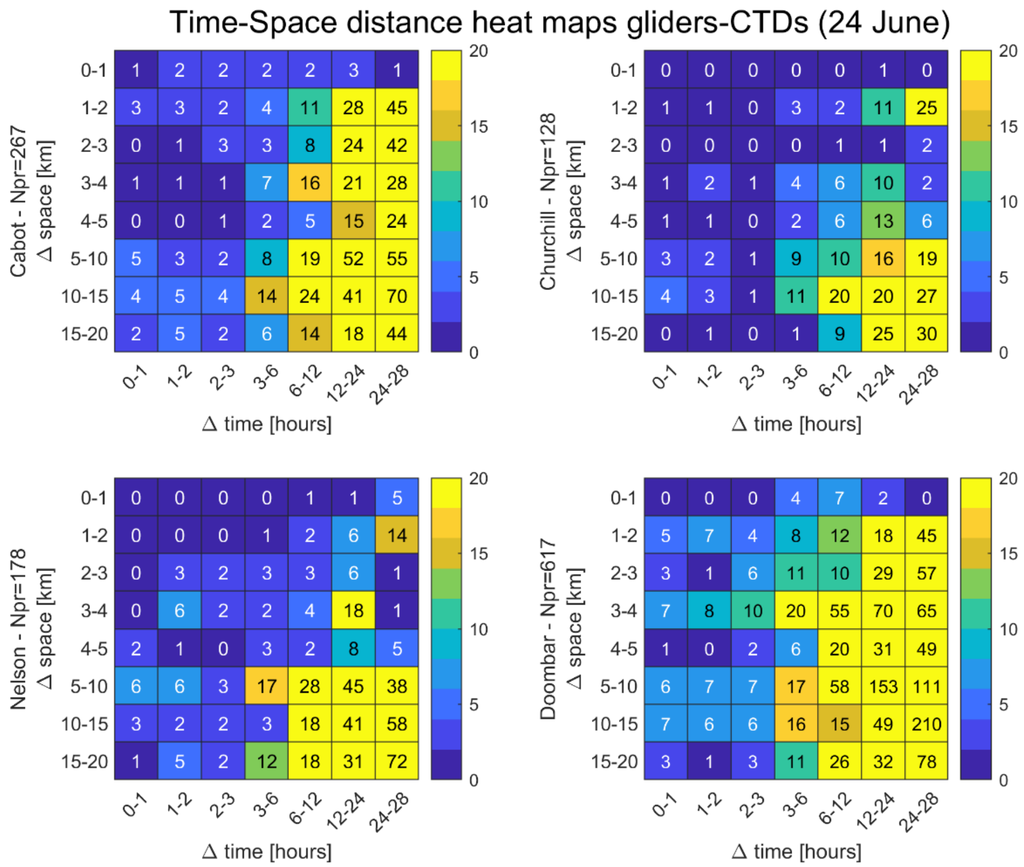
(top) Screenshot of Google Earth interface to track all assets and stations during the cruise. Glider tracks in different colours. (middle) Example of daily WPT planning sent to MARS. (bottom) C2 campaign website to track all assets in NRT, including gliders (and current waypoints), ALRs, Discovery and floats.

Flavien Petit and Hans Hilder at NOC were providing semi-daily updates on float/glider surfacing locations with their depth averaged currents and satellite imagery, respectively. These data and images were crucial to the daily planning of waypoints, given that gliders were, consistently, in currents higher than they can handle (>25 cm/s), especially in the second half of the cruise.

Ship-to-glider matchups:

Elisa Lovecchio at NOC provided a preliminary analysis on glider-to-glider as well as ship-to-ship matchups to help plan waypoints to maximise our ability to end up with a well intercalibrated platform independent dataset.

Doombar, profiling only to 500m, was a faster glider and therefore was picked to follow the RESPIRE array (deployed for 3 days at each superstation), which meant it was sampling closer to the ship's position than the other gliders and ended up with the most matchups overall, but also the closest ones in time and space. In the end, the strong current resulted in only co-sampling during RESPIRE02.

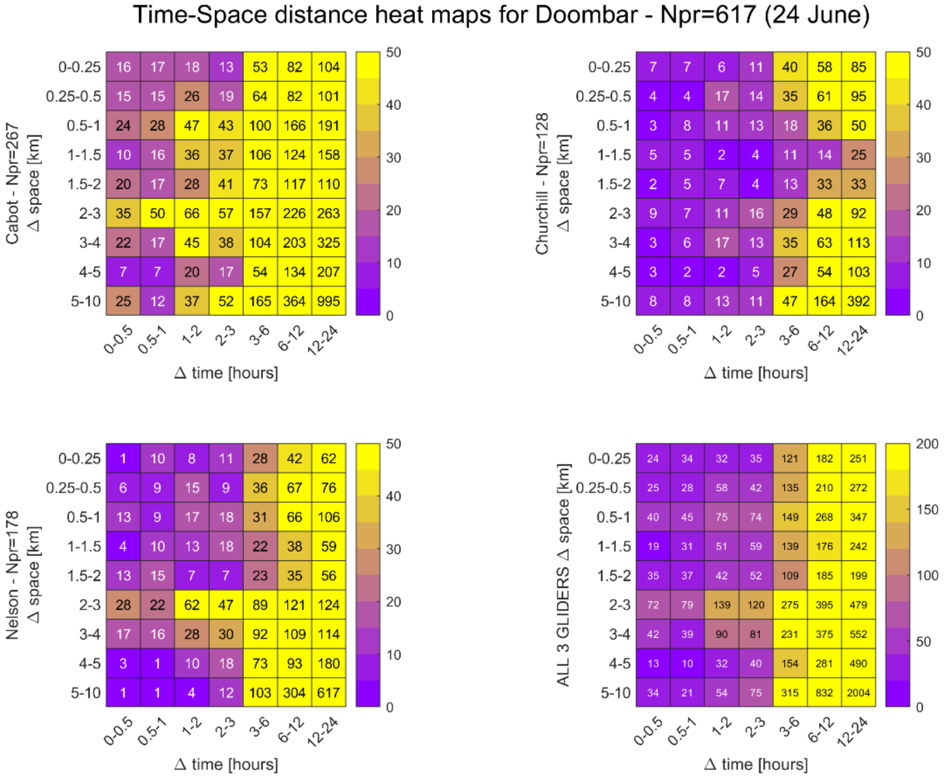


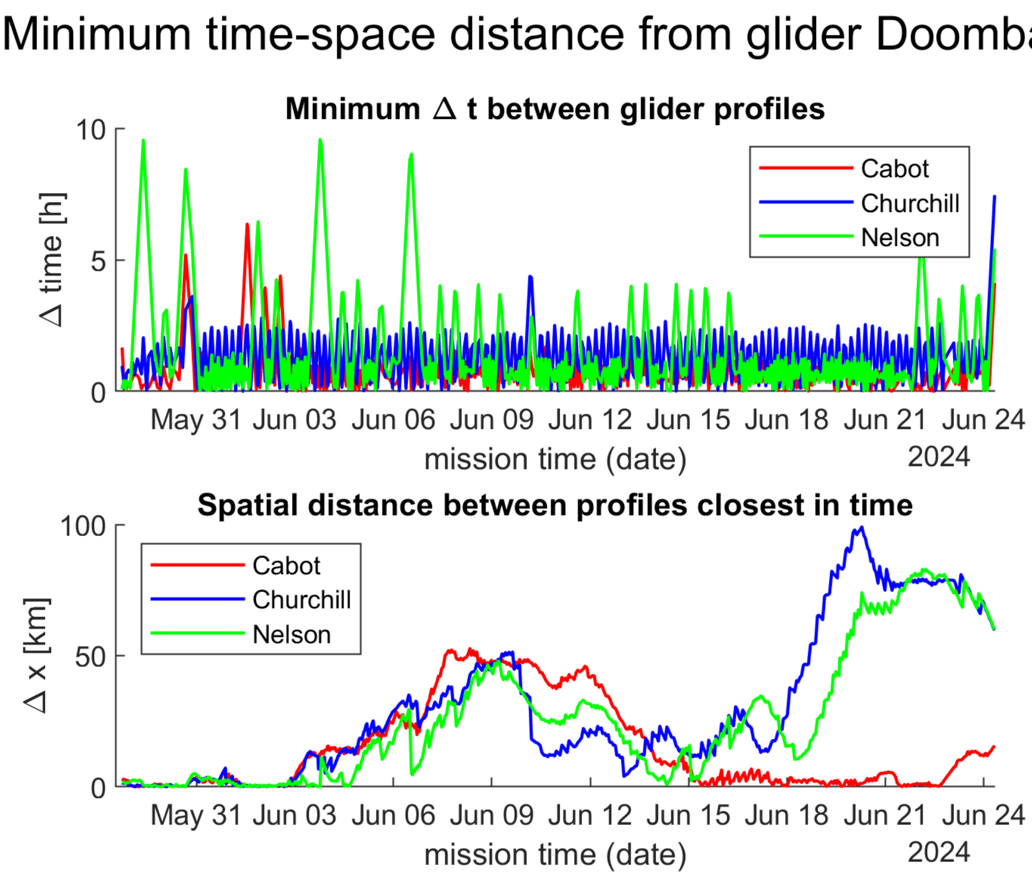
Heat maps of number of profile matchups against the ship's CTD casts.

Glider to glider matchups

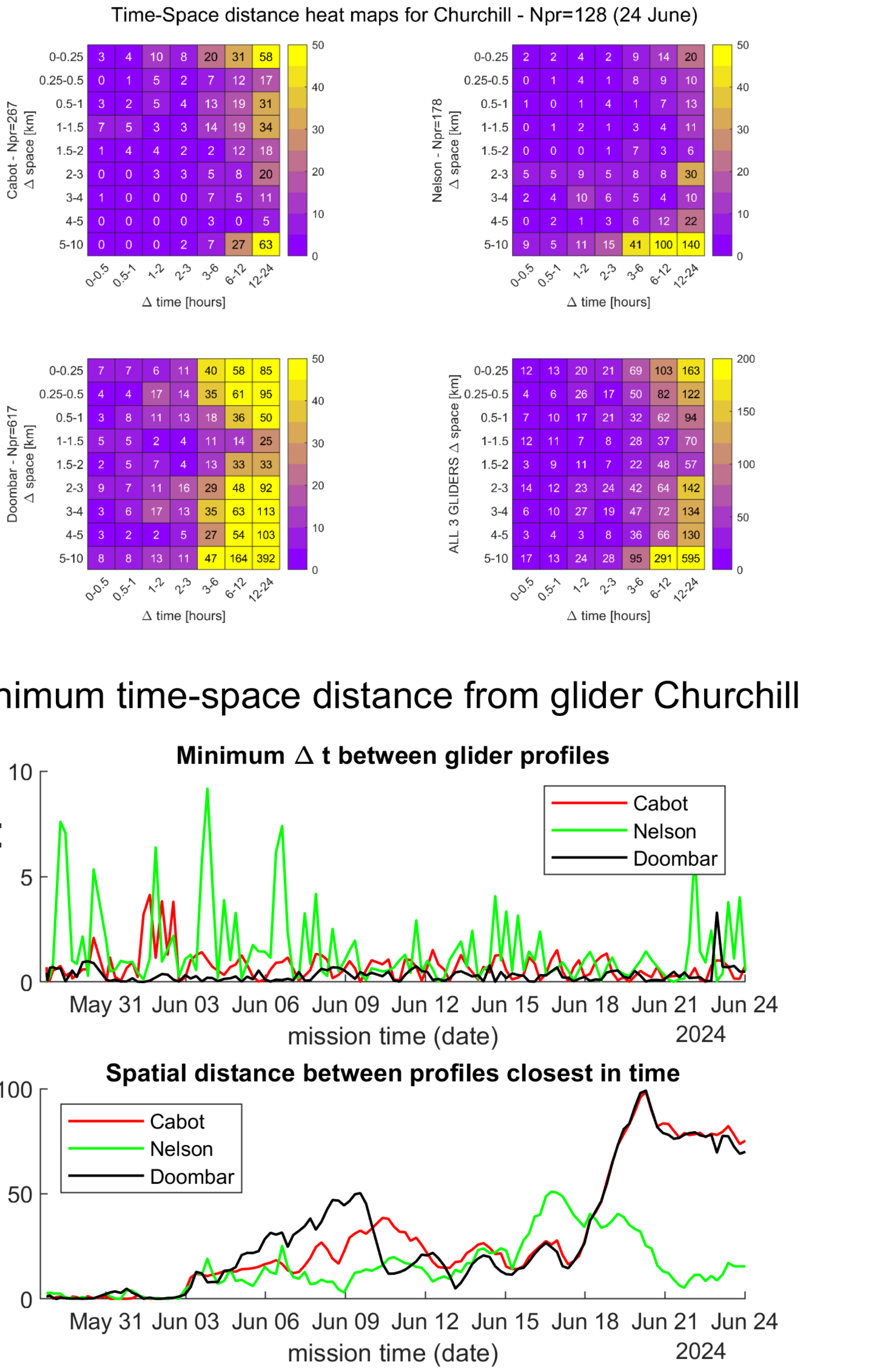
In order to maximise glider to glider intercalibrations, we purposefully created station-keeping opportunities or waypoint sharing, so multiple gliders would sample the same water masses (short distance) concurrently:

- Superstation 1: as soon as the gliders were deployed (28 May), all 4 gliders were tasked to station-keep at 59 59.22'N, 23 59.4'W for 2 days.
- Superstation 2: on 1 Jun, all gliders station keep at 60 01.0 N; 023 46.964W for 1 day
- Best buddies, Doombar and Cabot hung out and flew together from Jun 15-22.

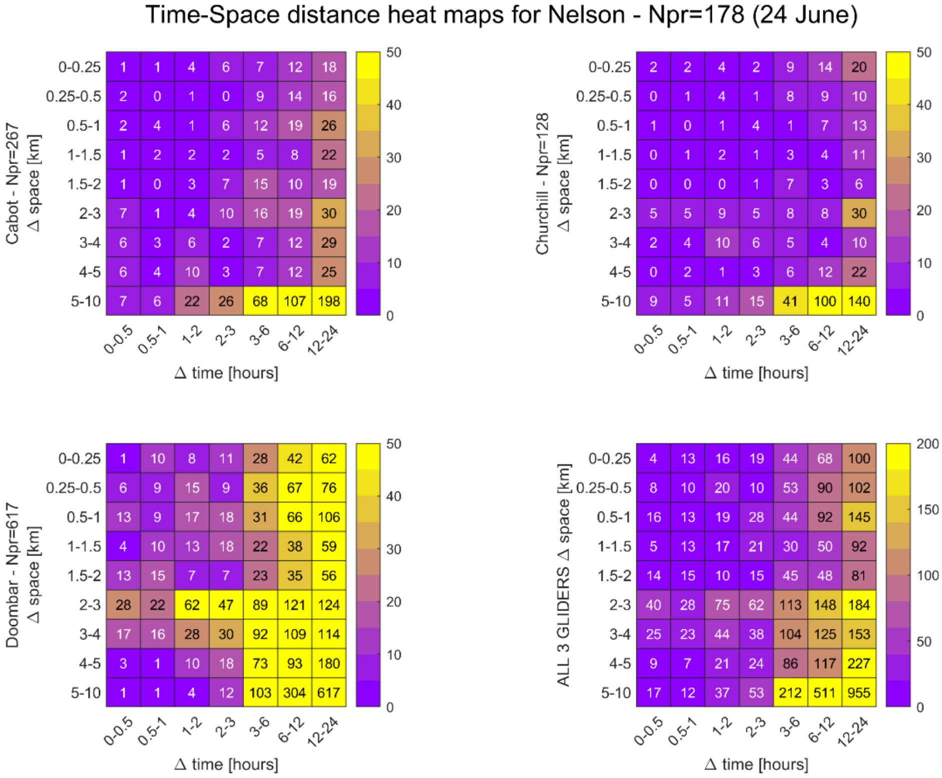


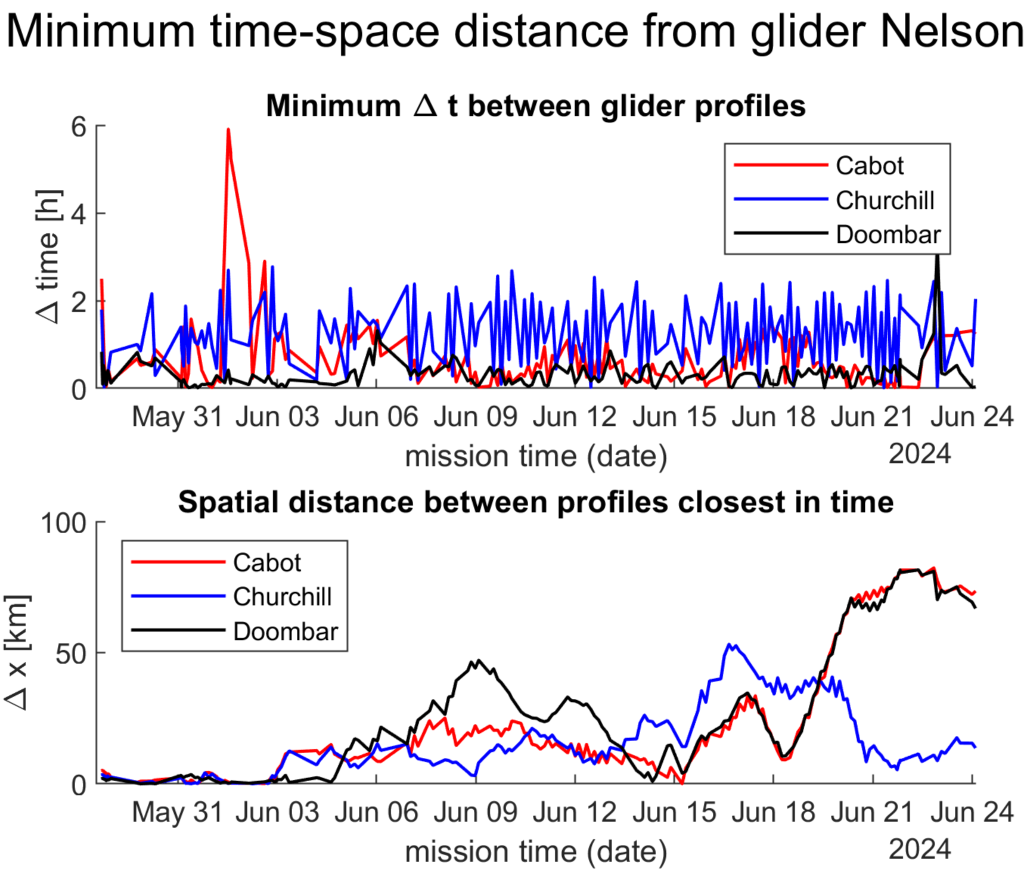


Doombar (unit-405) vs other 3 gliders. (top) Heat maps of number of casts matchups. (bottom) Distance in time and space between profiles closest in time.

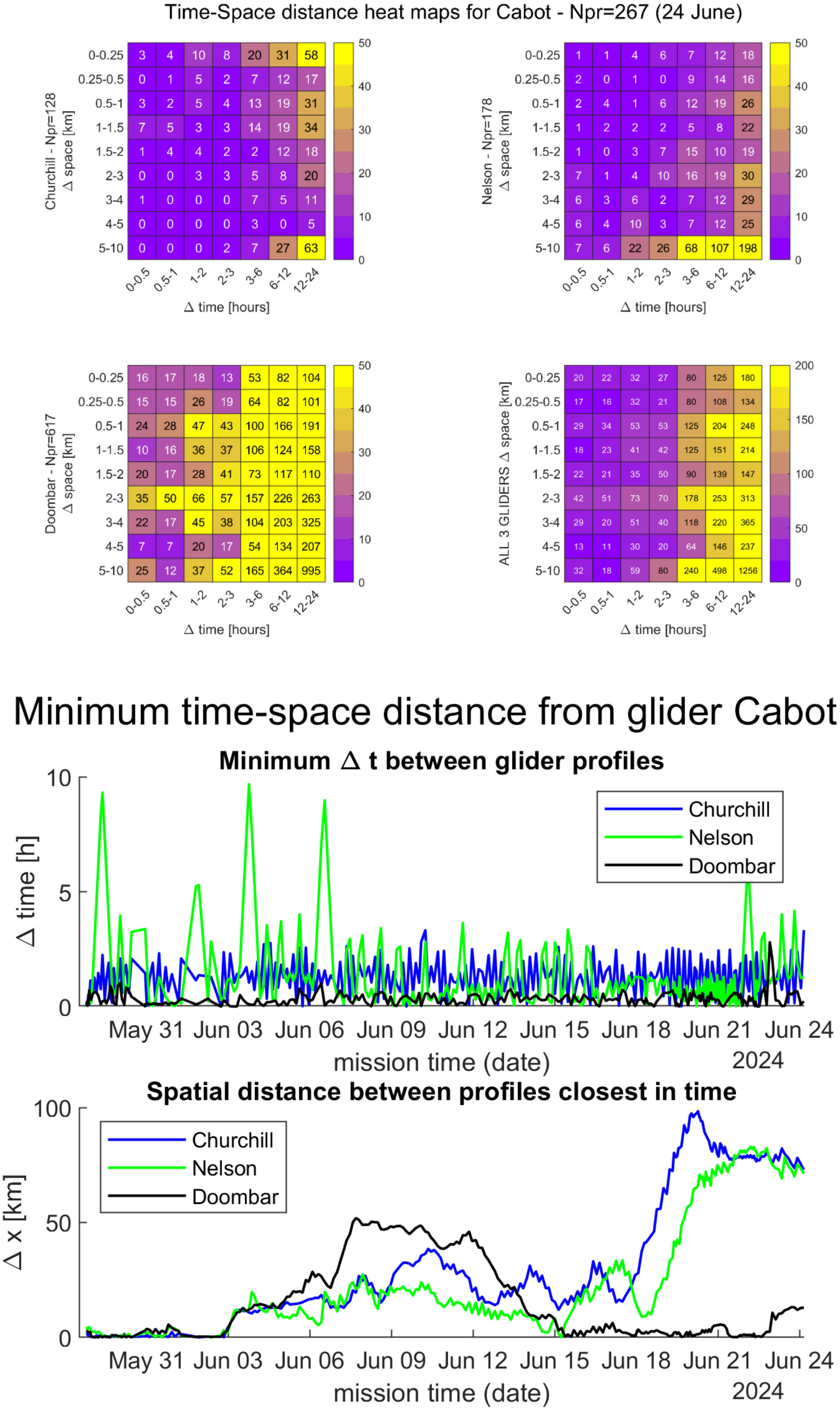


Churchill (unit-398) vs other 3 gliders. (top) Heat maps of number of casts matchups. (bottom) Distance in time and space between profiles closest in time.





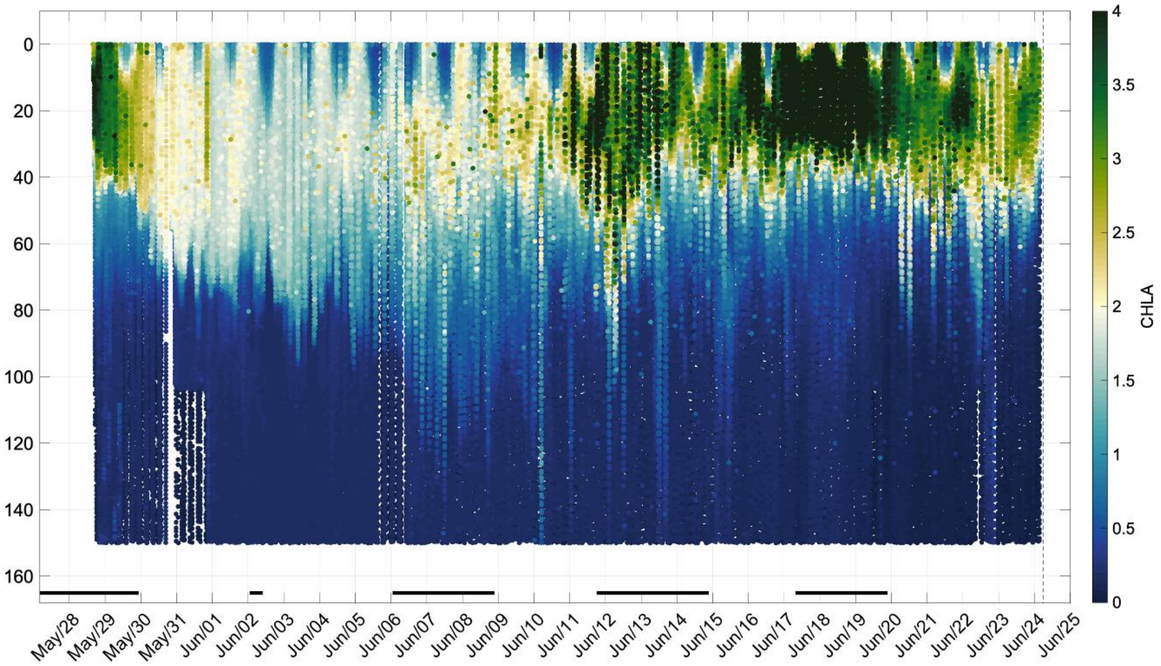
Nelson (unit-397) vs other 3 gliders. (top) Heat maps of number of casts matchups. (bottom) Distance in time and space between profiles closest in time.



Cabot (unit-345) vs other 3 gliders. (top) Heat maps of number of casts matchups. (bottom) Distance in time and space between profiles closest in time.

Preliminary NRT Data (uncalibrated)

Data was provided by BODC via ERDDAP (https://platforms.bodc.ac.uk/deployment-catalogue/, under BIO-Carbon Campaign). Data was downloaded for each glider and a kmz created and exported (bio_carbon_import_gliders.m) to facilitate waypoint planning.



Upper 150m of uncalibrated chlorophyll fluorescence from NRT data (all 4 gliders combined).

General Filtering / CTD sampling

Alex Poulton, Ben Gustafson (Heriot-Watt University), Mark Moore (University of Southampton), Kyle Mayers (NORCE), Heather Bouman (University of Oxford)

CTD Sampling – Titanium CTD

For each Titanium CTD cast, seawater samples were collected from 5 depths from the upper 60 m for rate measurements (see NPP and CP section by Poulton) and to filter for chlorophyll-*a* (total), Particulate Inorganic Carbon (PIC) and Scanning Electron Microscopy (SEM). Samples were collected from 15, 30 and 55m for DNA and RNA filtration through Sterivex filters.

CTD Sampling – 'Optics & General' Stainless steel CTD

For each 'Optics' Stainless steel CTD cast, seawater was collected from 12 standard depths from the surface to 1 km. Standard depths were: near surface (depth varies with sea state), 5 m, 10 m, 15 m, 20 m, 30 m, 55 m, 120 m, 250 m, 450 m, 750 m and 1000 m. Seawater was collected for measurements of: chlorophyll-a (total), phytoplankton pigments (High-Performance-Liquid-Chromatography), particulate organic carbon and nitrogen (POC, PN), particulate organic phosphorus (POP), particulate inorganic carbon (PIC), and biogenic silica (BSi). From the upper 4 to 6 depths, further measurements were collected for assessment of plankton community, including size-fractionated chlorophyll-*a* (0.2-2, 2-5, 5-20, >20 µm), Scanning Electron Microscopy (SEM), CytoSense, and Cellulose Nitrate filters (LOV-Beaufort). Triplicate filters were collected for PIC (Bigelow) and HPLC (NASA) from the surface depth, as well as replicate filters from 5 to 7 depths for PIC measurements at the University of Ghent (Neukermans). Finally, filters were also collected from the surface for Particle Absorption (PABS, Bouman).

Further details of sample collection and analysis planned:

Particulate Organic Carbon and Nitrogen (POC, PN)

For POC/PN, 1 L was filtered onto pre-ashed (400°C, 12 h) Whatman GF/F filters, stored individually in pre-ashed tinfoil and frozen (-80°C) for analysis. A 500ml aliquot of the filtrate was collected and refiltered using the same protocol to proved a measure of the DOC filter blank for a subset of samples. All samples will be analysed on return to NOC (Major).

Particulate Phosphorus (PP)

For POP, 1 L was filtered onto pre-ashed and Milli-Q rinsed Whatman GF/F filters, placed in clean Eppendorf tubes and frozen (-80oC) for analysis via NOC (Mawji).

Particulate Inorganic carbon (PIC)

For PIC, 0.5 L was filtered onto 0.4 µm polycarbonate filters, rinsed with pH-adjusted MilliQ (trace ammonia solution), placed in 15-mL Falcon tubes and oven dried (50°C) overnight. PIC measurements will be carried out by ICP-OES at the University of Maine (Poulton, Mitchell) or at the University of Ghent (Neukermans, Poulton).

Particulate Biogenic Silica (BSi)

For BSi, 0.5 L was filtered onto 0.4 µm polycarbonate filters, placed in 15-mL Falcon tubes and oven dried (50oC) overnight. BSi measurements will be carried out by NOC (Mawji).

High Performance Liquid Chromatography (HPLC)

For HPLC, 1 to 2 L (2 L for deep samples) was filtered onto Whatman GF/F filters, placed in 2 mL Cryotubes, flash frozen in liquid Nitrogen and stored at -80°C before analysis by NASA (Moore, Bouman).

Chlorophyll-*a* (total and size-fractionated)

Measurements of total and size-fractionated chlorophyll-*a* were made onboard DY180. For total chlorophyll-*a*, 100 to 250 mL (depending on biomass levels) was filtered onto Fisherbrand MF300 glass fibre filters, with filters placed in 20 mL glass vials and chlorophyll-*a* extracted in 6 mL of 90% acetone (HPLC grade) for 18 to 24 hours at 4°C in a dark fridge. Chlorophyll-a fluorescence was subsequently measured onboard using a Turner Designs Trilogy fluorometer set up with a nonacidification module (after Welschmeyer, 1994). The fluorometer was calibrated against a pure chlorophyll-a extract prior to the cruise and a solid standard was used at the start of each set of measurements to check for instrument drift.

For size-fractionated chlorophyll-*a*, 200 to 250 mL was sequentially filtered through a set of 47 mm dia. polycarbonate filters in a tower system, filters included 20 µm, 5 µm, 2 µm and 0.2 µm. Filters were placed in 20 mL glass vials and chlorophyll-*a* extracted as above for total chlorophyll-*a* measurements.

Scanning Electron Microscopy (SEM)

For SEM, 100 to 500 mL (depending on biomass levels) was filtered onto 0.4 µm Whatman polycarbonate filters, rinsed with pH-adjusted MilliQ (trace ammonia solution) to remove saltwater and prevent salt crystals, placed in Petri-slides and dried overnight at 50°C before being stored at room temperature for later analysis at Heriot-Watt (Poulton). Filters will be analysed for coccolithophore and diatom abundance and species identification.

Cellulose Nitrate (CN)

For CN, 100 to 500 mL (depending on coccolithophore abundances) was filtered onto 47 mm dia. 0.2 mm cellulose nitrate filters, rinsed with pH-adjusted MilliQ (trace ammonia solution), placed in Petri-slides and dried overnight at 50oC before being stored at room temperature for later analysis at CNRS (Beaufort, Poulton). Filters will be analysed for coccolith calcite mass.

Particle Absorption (PABS)

Between 0.125 and 2 L of seawater were filtered through 25 mm diameter Whatman glass fiber GF/F filters. The filters were placed in a plastic petri dish, taped closed, and flash frozen in liquid nitrogen before being stored in the -80°C freezer. The *in vivo* light absorption spectrum of phytoplankton and non-algal particles will be measured using a UV-Vis spectrophotometer back in Oxford.

CytoSense

49.5 mL samples of seawater were collected from the ship's underway system. Samples were fixed with glutaraldehyde to give a final concentration of 0.25%. The samples were left in the fridge for 3 hours to allow the preservative to penetrate the cells before being transferred to the -80°C freezer for analysis in Southampton at a later date.

Sterivex filtration for DNA/RNA

For analysis of DNA/RNA, 5L of water from 15, 30 and 55m depth were filtered through 0.2 µm Sterivex cartridge filters using a peristaltic pump set to 100 rpm. Filters were preserved in DNA/RNA shield using a luer lock syringe, sealed with caps or Parafilm, flash frozen in liquid nitrogen and stored at -80°C. The DNA and RNA will be extracted from these filters and shared between project participants (NORCE, NOCS and Imperial College London) as well as project partners in Canada. The current planned activity with these filters is metabarcoding for eukaryotic communities using the 18s V9 rDNA marker. A proposal is currently in preparation for further activities using these samples and Sterivex filters collected from marine snow catchers.

Single cell transcriptomics, bacterial and virus isolation

Samples were taken from 15m on the Titanium CTD for single cell transcriptomics (SCT) at project collaborator the Weizmann Institute. Water from 15m from the trace metal CTD was taken and filtered through 20-µm 47mm filters with the filtrate collected. Of the filtrate 1.5-2L was concentrated on 3-µm polycarbonate filters by filtering with vacuum pressure ≤200 mmHg and regularly clearing the filter using a 1mL pipette and tip. Once the volume of water on the filter was ~100 mL the concentrate was pipetted off into 50 mL falcon tubes. Falcon tubes were centrifuged for 3 minutes at 2599g and the supernatant (~47mL volume) was discarded. The remaining volume was pipetted into cryotubes, with 4% or 1% (final concentration) formalin added. Tubes were left at 4°C for 16 hours before 10% (final concentration) glycerol was added and incubated at 4°C for 1 hour. Finally, tubes were transferred to -80°C with no liquid nitrogen fixation.

For bacterial and virus isolation, 50 mL of the 20-µm filtrate generated above was filtered through 47mm GF/F filters with the filtrate collected. Using a filter pipette tip, 0.7 mL of filtrate was transferred into sterile tubes pre-filled with 0.3 mL 50% autoclaved glycerol. Tubes were well mixed and fixed in liquid nitrogen before being transferred to -80^{o}C. For virus isolation, 13 mL of the GF/F filtrate was placed into 15 mL falcon tubes, parafilmed and kept at 4^{o}C. All samples will be returned to collaborators at the Weizmann Institute for analysis.

DIC, TA and pH sampling

On-board: Stephanie Day (UEA), Glen Tarran (PML), Alex Poulton & Ben Gustafson (Heriot Watt)
Shore-side: Gareth Lee & Dorothee Bakker (UEA)

Sampling from the CTD Rosette for DIC, TA and pH

Water samples for the determination of DIC and TA were drawn from the 20 L Niskin bottles on the stainless steel CTD rosette and collected in 250 mL and 500 mL glass bottles. Tygon tubing was used to collect the sample and bubbles removed prior to sampling. The bottles were rinsed and overflowed to avoid gas exchange with the air. The 500mL samples were filtered into corresponding 250mL bottles post sampling. A CTD was sampled at each roaming and superstation except superstation 2 due to bad weather. Niskin 1,5,7,9,11,13,15,19 and 21 were sampled with two replicates on niskin 7,9,11,15 and 21.

The highlighted niskin bottles included replicates

Depth	5m	10m	20m	30m	55m	120m	250m	450m	1000m
Niskin bottle sampled	21	19	15	13	11	9	7	5	1

Leaking/misfired Niskins were not sampled, these were recorded on the comments section of the sampling sheet. All optics/ general CTD casts were sampled (midday day 2/3 superstation, midday roaming station). This totaled to 11 CTD cast including one test CTD. On two occasions pH was also sampled from the CTD which coincided with deployment or co-location of gliders, ALRs and floats. These occasions were at superstation 1 on the 28/5/24 and cal station sampled on 22/6/24. In total approximately 336 CTD samples were taken; 168 filtered, 168 unfiltered.
The 500ml samples were filtered using methodology from Bockmon and Dickson (2014). A peristaltic pump and tygon tubing enclosed a Pall Life Sciences 47 mm Polycarbonate In-Line Filter Holder (1119) with a 0.45 µm Durapore Membrane Filter to reduce gas exchange with the atmosphere. Filter papers were changed when flow became restricted. The 500mL sample was filtered into 250mL bottles. A headspace of 2.5mL was created using a Pasteur pipette and the samples were poisoned with a saturated mercuric chloride solution (50 µL per 250 mL sample). The stoppers were greased, inserted, bottles covered with an elastic band and cable tied to maintain positive pressure. The fixed sampled were repacked into boxes and their location recorded on the sampling sheet.
When pH was sampled, similar methodology was used collecting both a 250mL and 100mL sample from the CTD. The 250mL sample was filtered using the same filtration rig into 100mL bottles post sampling. A headspace of 1mL was created in the bottles before adding saturated mercuric chloride (10 µL per 100 mL sample). Samples were greased, enclosed in an elastic band and cable tied.
The table below contains the workflow post sampling for single sampling event. When pH was also sampled the order of events remained the same however, the time taken doubled. Total sampling time averaged at 3 hours 30 minutes for each CTD event.

Workflow post sampling for single sampling event

Time taken	Event
30 minutes	Sampling from CTD
1 hour	Fixing of unfiltered samples
1 hour	Filtration of filtered samples
1 hour	Fixing of filtered samples

<u>Stations sampled</u>

The superstation was visited 4 times throughout the cruise and 5 roaming stations. The station names, event number and deployment code are summarized below. DIC/TA were sampled on every occasion, the two highlighted rows denote when pH was also collected.

CTDs sampled

Date	Station	Event number	Deployment code
26/5/24	Test	1	CTD001S
28/5/24	S1	36	CTD007S
31/5/24	R1	71	CTD012S
3/6/24	R2	89	CTD015S
8/6/24	S3	147	CTD024S
10/6/24	R3	166	CTD27S
14/6/24	S4	210	CTD036S
16/6/24	R4	227	CTD040S
20/6/24	S5	268	CTD046S
21/6/24	R5	283	
22/6/24	cal	297	CTD052S

Continuous and underway pH measurements

Underway pH measurements were taken from the Discovery clean seawater laboratory with an ANB pH sensor (https://www.anbsensors.com/)

ANB pH sensor

The S series pH sensor is based on patented electrochemical technology to provide a calibration free sensor. The biggest reason why electrochemical based pH sensors require frequent recalibration is reference electrode drift, where the reference to which the pH is measured against is not stable and moves with time, making the measurements inaccurate until the sensor is recalibrated. ANB's technology contain an innovative reference tracker, which follows any drift in the reference and accounts for it in-situ, removing the need to manually recalibrate. The S series is made from robust materials and is all solid state, making it ideally suited for the extreme environments found in the world oceans. The key element of the S series is its sensing transducer, which is where ANB's innovative sensing chemistry is found. It contains a series of solid-state carbon impregnated electrodes from which the electrochemical measurements are conducted. The onboard computer on the sensor analyses the electrochemical measurement and the temperature of the solution and combines these factors to produce a pH, with no compensation for depth required. The outputs of the sensor are time, pH temperature and health. The output of the health is key to end user experience as it provides a qualifier on the accuracy of the pH response and gives an indication of maintenance required in real time. Maintenance is a simple abrasion over the surface of the transducer, with the supplied abrasion block. The process replenishes the transducer interface, and after the abrasion has completed, the sensor is ready for deployment, with no recalibration necessary. The lifetime of the sensor is dependent on the number of measurements it records, and therefore depends on the measurement profile set by the end user. The transducer provides about 15,000 measurements before maintenance is required. A continuous measurement cycle will give about 5 days before re-abrasion is required.

The ANB pH sensor was set up for underway sampling in the Discovery clean seawater laboratory from 30th May to 23rd June 2024. The setup consisted of submerging the ANB pH sensor in the outflow. The pH sensor was set to measure continuously, meaning a pH measurement every ~23 seconds. Regular abrasion of the sensor was completed every 3-4 days and logged.

Two 100mL discrete subsamples for pH was taken once daily at 10am throughout underway sampling to be cross referenced with the pH measurements. On each occasion one filtered and one unfiltered sample was collected, fixed and stored. There were several occasions when the pH fluctuated largely which will require further inspection.

A summary of the times fluctuations in pH were observed and a cleaning record.

Date	Time	Observation
31/5/24	8:53	Cleaning
6/6/24	15:19	Cleaning
7/6/24	16:11	pH changed from ~8 to ~10 with no location change so cleaned and checked flow
9/6/24	18:10	pH fluctuating all day between 11 and 8 have changed water source to sample pipe used for discrete samples to compare
10/6/24	10:34	Sample tube discovered fallen out of bucket. Could have occurred anytime since 22:00 on 9/6
11/6/24	8:54	Cleaning
13/6/24	22:13	pH averaged 1.97 since 22:00. Stopped recording, cleaned and restarted
14/6/24	18:05	Had been switched off by a tech for cleaning but not restarted since 15:00. Restarted recording
19/6/24	11:07	Cleaning
22/6/24	19:56	pH dropped to 2.87 for a short time
22/6/24	22:00	pH 11.53 – left running overnight to see if evened out
23/6/24	10:54	Cleaning
23/6/24	13:30	Probe shutdown for final cleaning and packing

The data will be processed, and quality controlled back at UEA and the final data-set will be available.

Underway DIC and TA sampling and fixing

During transit between super and roaming stations, underway sampling occurred on a 4 hourly basis. When possible, samples were collected by Stephanie Day except for the 2am and 6am samples. All unfiltered samples were fixed immediately. The 2am and 6am samples were filtered and fixed with the 10am underway the following day. During this time, they were stored in cool boxes to help maintain temperature however the delay in fixing needs to be considered during analysis.
Samples were drawn from the non-toxic surface water supply in the Discovery clean seawater laboratory unless otherwise stated on the sample sheets. Parallel sampling was undertaken for nutrients, flow cytometry, flow camera, cytosense, Psi cam, CDOM, chlorophyll, PIC, Bsi, SEM, POC, HPLC and PABS from the underway tap in the General Purpose laboratory. For DIC and TA sampling, a 500mL and 250mL sample were taken and treated identically to the CTD samples. The 500mL samples were filtered into 250mL bottles. The 250mL samples were rinsed and overflowed, headspace created, poisoned with mercuric chloride and secured with an elastic band and cable tie.
Approximately 122 underway samples were collected; 61 filtered and 61 unfiltered.

Sample processing

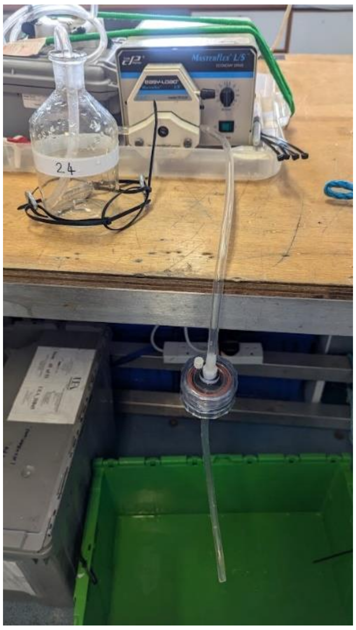
All collected samples will be transported back to UEA for analysis and data processing. For access to sampling sheets containing detailed sample naming, underway timing and comments please contact either Stephanie Day or Dorothee Bakker.

Future recommendations

DY180 was the first time this research group collected both filtered and unfiltered samples. When using the filtration rig I recommend a set up similar to shown below. The pump should be above the sample collection bottle to use gravity to promote the removal of bubbles. When degassing the system, work sequentially from the inlet to outlet.

Methodology for using the filtration unit:

1. Put on vinyl gloves
2. Remove the white filter cap to stop pressure build up
3. Insert the inlet tubing slowly into the 500mL sample bottle and turn on the peristaltic pump slowly (flow around 0.8).
4. Hold the 500mL bottle below the pump to encourage bubbles to migrate through the system. Ensure the tubing touched the bottom of the bottle. Once all bubbles have reached the pump secure 500mL bottle.
5. Gently increase the pump speed to encourage any trapped bubble to leave the pump covering. Reduce flow back to 0.8
6. Cover the tubing outlet with a thumb until water flows exclusively out of the filter hole. Gently rotate the filter to remove any trapped air bubbles.
7. Replace the white filter cap and tighten whilst simultaneously removing the outlet covering.
8. Hold the bottom tubing vertically upwards to remove any trapped bubbles and rinse 250mL bottle twice.
9. Place the tubing outlet at the bottle of the 250mL collection bottle. The flow speed can now be increased.
10. Fill the 250mL bottle overflowing until the 500mL sample is depleted. Gently remove the tubing whilst the flow continues creating a meniscus and stopper the bottle. Turn off the pump.



Filtration set up

Repeat this protocol between samples. The time taken to de-gas the system will rinse it with the new sample before collection. Regardless, try to filter samples sequentially to reduce contamination.

BOCKMON, E. & DICKSON, A. 2014. A seawater filtration method suitable for total dissolved inorganic carbon and pH analyses. *Limnology and oceanography, methods,* 12**,** 191-195.

Abundance and Composition of Microbial Plankton Communities by Flow Cytometry

Glen Tarran (PML)

Objective

To determine the distribution, abundance and community structure of nano- and picophytoplankton and heterotrophic bacteria from CTD casts and from incubation experiments by flow cytometry.

Vertical profiles of phytoplankton and bacteria community structure and abundance from CTD rosette sampler casts

Phytoplankton

Fresh seawater samples were collected in clean 125 mL polycarbonate bottles from a stainless steel framed Seabird CTD system containing a 24 bottle rosette of 20 L Niskin bottles from 120 m to the surface. Seawater samples were also provided in 15 mL cryovials from the trace metal-free Niskin bottles from the titanium frame CTD casts. Samples were stored in a refrigerator and analysed within 2 hours of collection. Fresh samples were measured using a Becton Dickinson FACSCalibur flow cytometer which characterised and enumerated pico- and nanoeukaryote phytoplankton and prokaryote phytoplankton, based on their light scattering and autofluorescence properties. Data were saved in listmode format and analysed during the cruise. The table below summarises the CTD casts sampled and analysed during the cruise.

Heterotrophic bacteria

Samples for bacteria enumeration were collected in clean 125 mL polycarbonate bottles using a stainless steel-framed Seabird CTD system containing a 24 bottle rosette of 20 L Niskin bottles from 1000 m to the surface on various CTD casts. Seawater samples were also provided in 15 mL cryovials from the trace metal-free Niskin bottles from the titanium frame CTD casts from 1000 m to 15 m below the surface. 0.5 mL samples were fixed with glutaraldehyde solution (Sigma-Aldrich, 50%, Grade 1. 0.5% final concentration, minimum of 30 mins at 4°C) within half an hour of surfacing. Samples (see below) were stained for 1 h at room temperature in the dark with the DNA stain SYBR Green I (Thermo-Fisher) in order to separate particles in suspension based on DNA content and light scattering properties. This enabled bacteria to be discriminated from other particles and enumerated. Samples were analysed flow cytometrically, within 3 hours of surfacing. Stained samples were measured using a Becton Dickinson FACSCalibur flow cytometer. Data were saved in listmode format and analysed during the cruise.

CTD casts sampled for phytoplankton and heterotrophic bacteria community structure & abundance. Depths below 120 m are bacteria only. CTD frame: S – stainless steel, T – titanium. CTD type: R – respire, RS – respiration shallow, RD - respiration deep, TM – trace metal-free, O – optics, EO – ETS/Omics

DATE	EVENT	STN	CTD	CTD frame	CTD type	TIME on deck (GMT)	LAT N	LON E	DEPTHS/*NISKIN BOTTLES (in italics)*
26-May	Test	1	1	S	Test	09:58	59.19	-22.41	3 5 10 15 20 30 55 120 *24 22 20 18 16 14 12 10*
27-May	S1	12	3	S	RD	06:06	60.00	-24.00	30 55 120 250 450 750 1000 *24 22 20 16 13 8 3*
27-May	S1	13	4	S	R	08:21	60.00	-24.00	2 5 10 15 20 30 50 *17 16 15 14 13 12 10*
28-May	S1	27	5	T	TM	04:19	60.00	-24.00	15 20 25 30 55 75 120 250 450 750 1000 *24 20 15 12 9 6 5 4 3 2 1*

28-May	S1	28	6	S	RS	05:53	60.00	-24.00	3 5 10 17 20 30 55 120 *24 20 18 16 14 10 6 3*
28-May	S1	36	7	S	O	12:28	60.00	-24.00	3 5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 12 10 8 6 4 2*
29-May	S1	55	8	S	EO	13:12	60.00	-24.00	5 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 11 8 4*
31-May	R1	63	10	T	TM	02:45	56.22	-26.83	15 20 25 30 55 75 120 250 450 750 1000 24 18 15 12 9 6 5 4 3 2 1
31-May	R1	64	11	S	RS	04:02	56.22	-26.83	5 8 14 24 29 40 55 120 *24 20 18 16 14 10 6 3*
31-May	R1	71	12	S	O	12:13	56.22	-26.83	3 5 10 15 20 30 55 120 250 450 750 1000 24 22 20 18 16 14 12 10 8 6 4 2
02-Jun	S2	79	13	S	R	02:34	60.02	-23.72	5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 13 10 8 6 4 2*
02-Jun	S2	80	14	S	RD	05:07	60.02	-23.72	30 55 120 250 450 750 1000 *24 22 20 16 13 8 3*
03-Jun	R2	89	15	S	O	12:10	57.13	-26.14	3 5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 12 10 8 6 4 2*
04-Jun	R2	103	16	T	TM	02:54	57.12	-26.26	15 20 25 30 55 75 120 250 450 750 1000 *24 18 15 12 9 6 5 4 3 2 1*
04-Jun	R2	104	17	S	RS	04:26	57.11	-26.28	3 5 10 17 20 30 55 120 *24 20 18 16 14 10 6 3*
06-Jun	S3	106	18	S	R	02:25	59.44	-22.64	5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 13 10 8 6 4 2*
06-Jun	S3	107	19	S	RD	04:54	59.44	-22.64	30 55 120 250 450 750 1000 *24 22 20 16 13 8 3*
07-Jun	S3	124	20	T	TM	03:48	59.43	-22.63	15 20 25 30 55 75 120 250 450 750 1000 *24 18 15 12 9 6 5 4 3 2 1*
07-Jun	S3	125	21	S	RS	05:18	59.43	-22.63	3 7 15 20 25 37 55 120 *24 20 18 16 14 10 6 3*
07-Jun	S3	130	22	S	O	12:08	59.44	-22.63	4 40 120 *9 6 3*
08-Jun	S3	139	23	S	EO	03:08	59.37	-22.48	5 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 11 8 1*
08-Jun	S3	147	24	S	O	12:17	59.35	-22.47	3 5 10 15 20 30 55 120 250 450 750 1000 *2 3 6 8 10 12 14 16 18 20 22 24*
10-Jun	R3	156	25	T	TM	02:53	57.23	-28.34	15 20 25 30 55 75 120 250 450 750 1000 *24 18 15 12 9 6 5 4 3 2 1*
10-Jun	R3	157	26	S	RS	04:00	57.23	-28.34	3 7 15 25 30 45 55 120 *24 20 18 16 14 10 6 3*
10-Jun	R3	166	27	S	O	12:19	57.21	-28.39	3 5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 12 10 8 6 3 2*
12-Jun	S4	175	31	S	R	02:22	59.19	-22.39	5 10 15 20 30 55 120 250 450 750 1000 *24 23 21 20 18 16 13 10 7 4 2*
12-Jun	S4	176	32	S	RD	05:19	59.24	-22.08	30 55 120 250 450 750 1000 *24 22 20 16 13 8 3*
13-Jun	S4	191	33	T	TM	05:19	59.28	-21.97	15 20 25 30 55 75 120 250 450 750 1000 *24 18 15 12 9 6 5 4 3 2 1*
13-Jun	S4	192	34	S	RS	04:56	59.28	-21.95	3 8 14 20 26 40 55 120 *24 20 18 16 14 10 6 3*
14-Jun	S4	205	35	S	EO	03:12	59.42	-21.81	5 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 11 8 4*
14-Jun	S4	210	36	S	O	12:10	59.49	-21.80	3 5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 12 10 8 6 3 2*
16-Jun	R4	218	37	T	TM	03:39	58.99	-24.67	13 20 25 30 55 75 120 250 450 750 1000 *24 18 15 12 9 6 5 4 3 2 1*
16-Jun	R4	220	39	S	RS	05:56	59.01	-24.67	3 6 10 15 20 30 55 120 *24 20 18 16 14 10 6 3*
16-Jun	R4	227	40	S	O	12:17	59.01	-24.66	3 5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 12 10 8 6 3 2*
17-Jun	S5	233	41	S	R	08:44	60.24	-21.20	5 10 15 20 30 55 120 250 450 750 1000 *24 23 21 20 18 16 13 10 7 4 1*

17-Jun	S5	237	42	S	RD	11:10	60.24	-21.20	30 55 120 250 450 750 1000 *24 22 20 16 13 8 3*
18-Jun	S5	249	43	T	TM	05:25	60.25	-21.08	15 20 25 30 55 75 120 250 450 750 1000 *24 18 15 12 9 6 5 4 3 2 1*
18-Jun	S5	250	44	S	RS	06:50	60.26	-21.08	3 6 10 15 20 30 55 120 *24 20 18 16 14 10 6 3*
19-Jun	S5	262	45	S	EO	05:36	60.27	-21.21	5 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 11 8 4*
20-Jun	S5	268	46	S	O	12:28	60.22	-21.08	3 5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 12 10 8 6 3 2*
21-Jun	R5	274	47	T	TM	02:32	60.12	-18.95	15 20 25 30 55 75 120 250 450 750 *24 18 15 12 9 6 5 4 3 2*
21-Jun	R5	275	48	S	RS	04:10	60.12	-18.94	5 9 16 23 29 45 55 120 *24 20 18 16 14 9 6 3*
21-Jun	R5	283	49	S	O	12:12	60.13	-18.99	3 5 10 15 20 30 55 120 250 450 750 1000 *24 22 20 18 16 14 12 10 8 6 4 2*

Underway sampling

Samples were collected at 4 hour intervals from the uncontaminated seawater supply in the general purpose lab between 02:00 and 22:00 on days when the ship was transiting between the Central Iceland Basin superstation and 'Roaming' stations where the focus was on coccolithophores. 1.8 mL samples were collected into 2 mL cryovials containing 50% glutaraldehyde and were left to fix in a fridge until they were analysed the following day. Samples were analysed as per phytoplankton and bacteria community structure samples in the previous section.

Respiration incubation experiments

Live 5 mL samples, collected in 15 mL centrifuge tubes were provided by Marta Cecchetto of Heriot-Watt University and Carol Robinson of the University of East Anglia respectively to test the efficiency of 0.1-0.8, 0.8-2 and 2-20 µm filtration at the beginning of their ETS respiration experiments (shallow and deep CTDs). Samples were also provided to test filtration efficiency in ETS experiments in water from ETS/Omics CTDs by enumeration of bacteria passing through GF/F filters (nominal particle retention >0.7 µm).
Bacteria were also enumerated daily in respiration experiments to assess bottle effects where the incubation period was 96 hours. Samples were treated and analysed as per bacteria community structure samples in previous sections. See relevant sections in this cruise report for details of incubation experiments.

Marine snow catchers (MSC)

Samples were provided by Elena Garcia Martin and Chelsey Baker of National Oceanography Centre, Southampton and Cordelia Roberts of Imperial College London for bacteria and algae enumeration in suspended, slow sinking and fast sinking MSC fractions for respiration experiments at superstations and for the CHALKY project at roaming stations. Samples were treated and analysed as per phytoplankton and bacteria community structure samples in previous sections. See relevant sections in this cruise report for details of MSCs.

Trace metal addition bioassay incubation experiments

Live samples, collected in 15 mL centrifuge tubes were provided by Mark Moore of the University of Southampton to measure the effects of trace metal treatments on the growth, cell size (light scatter) and pigment fluorescence of phytoplankton during 5 day bioassay incubation experiments, as well as to test for bottle effects. Samples were treated and analysed as per phytoplankton community structure samples in previous sections. See relevant section in this cruise report for details of bioassay incubation experiments.

Drift-Spire

1.8 mL samples were collected into 2 mL cryovials and preserved with 50% glutaraldehyde on completion of Drift-Spire deployments at superstations by Filipa Carvalho and Nathan Briggs of National Oceanography Centre, Southampton. The samples were left overnight in a fridge before being analysed for algae and bacteria the next morning. Samples were analysed as per phytoplankton and bacteria community structure samples in previous sections. See relevant section in this cruise report for details of Drift-Spire deployments.

***In situ* microbial incubator (ISMI)**

A protocol was developed onboard to stain bacteria with the redox dye redox sensor green (RSG) to assess their metabolic activity for Chie Amano and Marilena Heitger of the University of Vienna. Successful development of the protocol will enable them to flow cytometrically cell-sort samples from their ISMI deployments at the superstations to determine metabolically active components of the microbial community by molecular techniques, back in Vienna. See relevant section in this cruise report for details of ISMI deployments.

Dilution grazing experiments

A series of dilution experiments was conducted during the cruise by Kyle Mayers of the Norwegian Research Centre (NORCE), Mark Moore of the University of Southampton and Alex Poulton of Heriot Watt University. Samples were analysed for algae and bacteria by flow cytometry as per phytoplankton and bacteria community structure samples in previous sections. 100% undiluted seawater samples were analysed for 2 minutes and 20% samples for 6 minutes. All samples were analysed on high flow rate (approx. 385 µL min^{-1}). See relevant section in this cruise report for details of dilution grazing experiments.

Copepod grazing experiments

Samples provided by the zooplankton group were analysed at T0 and after 24 hours to enumerate algae from copepod grazing experiments involving dominant copepod taxa (*Oithona* and *Calanus*) that had been isolated from bongo net samples. See relevant section in this cruise report for details of copepod grazing experiments.

FlowCam analysis

Ben Gustafson (Heriot-Watt University)

Sample collection

Seawater was collected for analysis from the CTD, dilution experiments, and underway seawater system. From the CTD, water was collected from the 5, 15, 30, and 55 meter Niskin bottles from the 'Optics and general' CTD casts. From the dilution experiments, water was collected from the whole seawater (WSW) carboys at T0, and WSW and WSW +Fe after 24 hours. Finally, samples were also collected from the ship's seawater system while underway every 4 hours with the underway sampling team.

Sample analysis

Samples were run using the FlowCam 8100 and VisualSpreadsheet 6 software. Samples were run using a 10x objective to visualize particles between 4 and 100 µm. At first, 5 mL samples were run, but given the lack of larger particles, 10 mL samples were run between 3/6/24 and 14/6/24. On 15/6/24, it was switched back to running 5 mL samples. Similarly, samples were pre-filtered at the start of the cruise using 100 µm cell strainers, to prevent flow cell clogs. But, after a lack of large particles in general, the pre-filter process was stopped on 3/6/24 and did not resume for the remainder of the cruise. Samples will be sorted using VisualSpreadsheet to get phytoplankton community assemblage metrics such as carbon biomass and cell count of each community group.

Titanium CTD sampling

Te Liu and Mark Moore (University of Southampton)

Iron (Fe) and other trace metals (TM) including manganese, cobalt, zinc, nickel, cadmium and copper are essential micronutrients for phytoplankton growth, thus can be co-limiting net primary production in the ocean. A key question arose by the project of IDAPro is if nutrient limitation would terminate the "spring bloom" in the subpolar North Atlantic. Addressing this, total dissolvable, dissolved and particulate trace metal samples were collected in the upper water (< 1000 m) through the main "spring bloom" period (late May to the end of June) to examine the TM supply, consumption and recycling in the subpolar North Atlantic. Our new results will provide a semi-time series of TM distribution in the subpolar North Atlantic and fill the gap of linkage between TM dynamics and ecosystem evolution.

Seawater Collection

A Ti rosette frame equipped with 24 trace metal clean 10L Teflon-coated OTE (Ocean Test Equipment) bottles was used for trace metal sample collection (Ti-CTD). The Ti-CTD was also equipped with the full package of sensors including temperature, conductivity, pressure, depth, turbidity and oxygen (Seabird Electronics). When deploying the Ti-CTD, it was attached to Kevlar coated conducting wire and operated by the ship trace metal clean winch system. At the test station, all bottles were fired at 1000 m and no samples collected. The seawater was left in the bottle for 24 hours. At other stations, bottles were fired at depth of 1000 m, 750 m, 450 m, 250 m, 120 m, 75 m, 55 m, 30 m, 25 m, 20 m, 15 m. After recovery, the tap on each OTE bottle was covered by clean vinyl gloves to minimize the risk of contamination and all 24 bottles were immediately transferred into a class 1000 clean air shipboard laboratory, where sampling was to occur.

Unfiltered samples were collected first at each station. This includes samples for total dissolvable trace metals (TdTMs), inorganic nutrient, alkaline fuel cell, physiology, DNA/RNA, chlorophyll a and size-fractionated chlorophyll a. After unfiltered sample collection was finished, the OTE bottles were gently shaken to homogenize seawaters for filtered water and particle collection. Specifically, samples for dissolved trace metals (dTMs) and dissolved Fe isotopes (dFe isotopes) were collected through 0.45/0.2 µm filter cartridge (Sartobran-300, Satorius^{TM}) under a low pressure of filtered compressed air (~0.7 bar) through a 0.2 µm PTFE filter capsule (Millex-FG 50, Millipore) into acid-clean low-density polyethylene (LDPE) bottles (125 ml and 1 L, respectively). Sample details are shown below.

Additionally, samples for TdTMs, dTMs and inorganic nutrients in surface seawater (~3-4 m) were collected every 4 hours along the entire cruise track. These sample collections were managed by a trace metal clean "towfish" system. Surface waters were directly pumped to the clean lab via a Teflon diaphragm pump (Almatec A-15) connected by acid-washed braided PVC pump tubing, ultimately collected into acid clean LDPE bottles. Samples for dTMs were collected through 0.8/0.2 µm polyethersulfone membrane filter capsule (Sartobran, Sartorius). Total dissolvable trace metals and inorganic nutrients were collected unfiltered. In total, 47 surface water samples were collected from 30/05/2024 to 23/06/2024.

Sampling bottles were always rinsed three times by targeted seawater before being filled up. All LDPE bottles for TdTM, dTM and dFe isotopes were acid cleaned at the home lab in the University of Southampton. All TdTMs and dTMs samples were acidified to pH ~1.7 onboard by ultra-pure grade hydrochloric acid (ROMIL, HCl, UpA) in a laminar flow bench built in the clean lab. Dissolved Fe isotope samples will be acidified once they are returned to the University of Southampton. Samples of TdTMs, dTMs and dFe isotopes were stored in dark at room temperature.

Particle Collection

Suspended particles were collected onto the 0.45 µm Supor® polyethersulfone (PES) membrane disc filter (25 mm, Pall). These filters were acid cleaned following three steps of cleaning by 10% HCl, 0.1

M HCl and Milli Q water. Prior to use, clean filters were rinsed with MilliQ water and placed in acid cleaned Millipore Swinnex filter holders for sampling. The filter holders were connected to the OTE bottles using lure lock fittings and acid cleaned Bev-a-line tubing (Cole Parmer). The volume of filtered water was collected and recorded for each filter. Water volumes were variable depending on water depths, however, broadly 1-6 L seawater would pass through each filter within 2 hours. Once the filtration was done, filters were transferred to the laminar flow bench. An all-polypropylene syringe was attached to the top of the filter holder, residual seawater was forced through the filter using air. This ensures there is no spillage and loss of particulate material from surface of filter when filter holder is opened, and will remove as much seawater as possible in order to reduce the residual seasalt matrix for analytical simplicity after the sample is digested. Subsequently, filters were gently rinsed with ~15 ml Milli Q water and stored in the petri dishes. Filters were always handled using a clean plastic tweezer. All particle samples were stored in a -20°C freezer and shipped frozen back to University of Southampton.

Ti-CTD sampling locations of TDTMs, dTMs and dFe isotopes on the cruise

No.	Station	CTD No.	Date	Time	Latitude	Longitude	Note
0	Test station	CTD002T	26/05/2024	11:28	59.184	-22.476	No sampling
1	Superstation 1	CTD005T	28/05/2024	02:57	60.000	-24.000	
2	Roaming station 1	CTD010T	31/05/2024	01:28	56.216	-26.830	
x	Superstation 2						Not happened due to bad weather
3	Roaming station 2	CTD016T	04/06/2024	01:34	57.118	-26.257	
4	Superstation 3	CTD020T	07/06/2024	02:34	59.427	-22.626	
5	Roaming station 3	CTD025T	10/06/2024	01:34	57.231	-28.342	
6	Superstation 4	CTD033T	13/06/2024	02:15	59.281	-21.966	
7	Roaming station 4	CTD037T	16/06/2024	02:26	58.991	-24.671	
8	Superstation 5	CTD043T	18/06/2024	04:19	60.252	-21.084	
9	Roaming station 5	CTD047T	21/06/2024	01:23	60.121	-18.949	

Underway sampling from "towfish". TdTMs and inorganic nutrients were unfiltered and dTMs were 0.2 µm filtered.

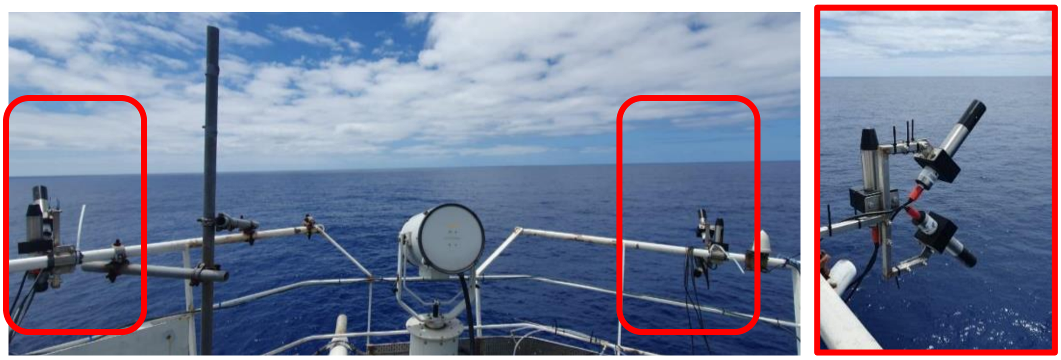
Date	**Samling time (GMT)**	**FISH No.**	**Parameters**
30/05	06:15	001	TDTMs, dTMs, inorganic nutrients
30/05	11:02	002	TDTMs, dTMs, inorganic nutrients
30/05	14:02	003	TDTMs, dTMs, inorganic nutrients
30/05	17:59	004	TDTMs, dTMs, inorganic nutrients
30/05	21:57	005	TDTMs, dTMs, inorganic nutrients
01/06	09:58	006	TDTMs, dTMs, inorganic nutrients
01/06	13:58	007	TDTMs, dTMs, inorganic nutrients
01/06	18:03	008	TDTMs, dTMs, inorganic nutrients
01/06	21:56	009	TDTMs, dTMs, inorganic nutrients

Date	Samling time (GMT)	FISH No.	Parameters
02/06	14:00	010	TDTMs, dTMs, inorganic nutrients
02/06	17:57	011	TDTMs, dTMs, inorganic nutrients
02/06	21:50	012	TDTMs, dTMs, inorganic nutrients
03/06	02:22	013	TDTMs, dTMs, inorganic nutrients
03/06	09:54	014	TDTMs, dTMs, inorganic nutrients
04/06	13:55	015	TDTMs, dTMs, inorganic nutrients
04/06	18:10	016	TDTMs, dTMs, inorganic nutrients
04/06	21:56	017	TDTMs, dTMs, inorganic nutrients
05/06	02:08	018	TDTMs, dTMs, inorganic nutrients
05/06	10:17	019	TDTMs, dTMs, inorganic nutrients
05/06	13:55	020	TDTMs, dTMs, inorganic nutrients
05/06	17:58	021	TDTMs, dTMs, inorganic nutrients
09/06	02:20	022	TDTMs, dTMs, inorganic nutrients
09/06	06:05	023	TDTMs, dTMs, inorganic nutrients
09/06	09:57	024	TDTMs, dTMs, inorganic nutrients
09/06	13:53	025	TDTMs, dTMs, inorganic nutrients
09/06	17:52	026	TDTMs, dTMs, inorganic nutrients
09/06	22:08	027	TDTMs, dTMs, inorganic nutrients
10/06	21:55	028	TDTMs, dTMs, inorganic nutrients
11/06	02:30	029	TDTMs, dTMs, inorganic nutrients
11/06	06:25	030	TDTMs, dTMs, inorganic nutrients
11/06	10:15	031	TDTMs, dTMs, inorganic nutrients
11/06	14:00	032	TDTMs, dTMs
14/06	21:57	033	TDTMs, dTMs, inorganic nutrients
15/06	09:55	034	TDTMs, dTMs, inorganic nutrients
15/06	14:01	035	TDTMs, dTMs, inorganic nutrients
15/06	17:59	036	TDTMs, dTMs, inorganic nutrients
15/06	21:55	037	TDTMs, dTMs, inorganic nutrients
16/06	17:56	038	TDTMs, dTMs, inorganic nutrients
16/06	21:56	039	TDTMs, dTMs, inorganic nutrients
17/06	06:45	040	TDTMs, dTMs, inorganic nutrients
20/06	17:56	041	TDTMs, dTMs, inorganic nutrients
20/06	21:37	042	TDTMs, dTMs, inorganic nutrients
22/06	13:48	043	TDTMs, dTMs, inorganic nutrients
22/06	17:55	044	TDTMs, dTMs, inorganic nutrients
22/06	21:54	045	TDTMs, dTMs, inorganic nutrients
23/06	04:04	046	TDTMs, dTMs, inorganic nutrients

Date	Samling time (GMT)	FISH No.	Parameters
23/06	06:30	047	TDTMs, dTMs, inorganic nutrients

Radiometry on meteorological mast

Mark Moore (University of Southampton) on behalf of Tiera-Brandy Robinson (GEOMAR)



TriOS hyperspectral radiometers and irradiance meters on top of the mast at the bow of Discovery.

Objectives:

Satellite radiometric data are used to determine many large scale ocean colour properties. However, measurements are hampered by interference from the atmosphere the signal must pass through. Radiometers installed on ships therefore bypass atmospheric interference and can give high resolution in-situ ocean colour data. This can be used both to improve satellite derived ocean colour measurements and to investigate small time and spatial scale changes. Furthermore, radiometers can measure the passive fluorescence of phytoplankton in the ocean as opposed to most onboard sensors which measure active fluorescence, helping to bridge the gap between onboard in situ sampling and satellite data.

Methods:

Automated continuous above-water hyperspectral radiometric quantities were recorded during the majority of the cruise track of DY180. Two identical radiometer setups were installed. Each with one TriOS RAMSES-ACC hyperspectral cosine irradiance meter to measure incoming solar irradiance Es (λ), and two TriOS RAMSES-ARC hyperspectral radiance meters to measure total sea surface leaving radiance Lsfc (θsfc, Φ, λ) and sky-leaving radiance Lsky (θsky, Φ, λ). The radiometers were installed on the foremast of RRS Discovery shortly after leaving port and required no adjustment during the cruise. The foremast has a height of 5.65 m, putting the radiometers at a relative height of 17.5 m above the sea surface. Lsky and Lsfc, radiance meters were placed at 45° and 135° zenith angles respectively. 50 m cables were connected to each radiometer and ran from the foremast down to a computer in the meteorological lab. Hyperspectral measurements were collected at 1-minute intervals over a spectral range of λ = 320 – 950 nm. Remote sensing reflectance (Rrs) and water leaving radiance (Lw) can be calculated from the radiometric measurements via the following equation and will be used to investigate changes in fluorescence line height (normalized to Chl a) over the cruise track.

$R_{rs} = L_w/E_s = L_{sfc}-(\rho_{(air-sea)}*L_{sky})/E_s$

The two sets of radiometers (1 ACC and 2 ARC each) were placed at opposing relative azimuth angles (45° and 315°) in order to ensure that at least one set would always have minimal effect from a solar azimuth angles <90°. In addition to the application of sun glint correction, data will be optimized for each timepoint so that the sensor set with the best solar azimuth angles is used. Data processing will be completed as proposed in literature (Garaba and Zielinski, 2013). Raw data are available on the DY180 drive at \DY180\Radiometers (GEOMAR).

References:

Garaba, S., and Zielinski, O. (2013). Methods in reducing surface reflected glint for shipborne above-water remote sensing. Journal of the European Optical Society-Rapid publications 8.

Strathclyde University Optics

David McKee (Strathclyde University)

Aim: To develop a bio-optical model for coccolithophore blooms in the North Atlantic that can be applied to data collected on autonomous sampling platforms and used to establish links to satellite remote sensing products. To further use the bio-optical model to improve retrieval of PIC and Chl from satellite remote sensing reflectance spectra.

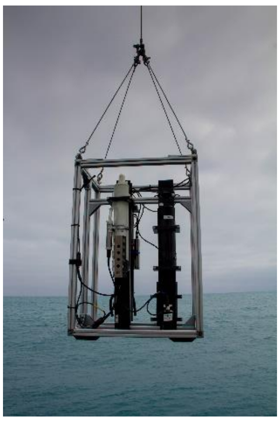
Approach: The bio-optical model will be developed from measurements of IOPs collected in situ (Strathclyde) and from the underway system (Bigelow). This will be supplemented by measurements of total non-water absorption and CDOM absorption measured using the PSICAM (Point Source Integrating Cavity Absorption Meter) and the liquid waveguide (LWCC) system. Links to remote sensing will be established using in situ radiometric observations from an above surface downwards irradiance sensor (Es), a floating upwards radiance sensor (Lu) and a set of upwards and downward scalar and planar irradiance sensors (Ed, Eod, Eu, Eou) on a profiling platform. This combination will provide sufficient information to robustly prove appropriate scattering correction approaches for in situ IOP measurements and generally quality control the optical data. Material specific IOPs will be established using chemically partitioned IOPs from the underway system and associated biogeochemical sample analyses (PIC, Chl, POC).

In Situ Measurements Completed: In situ optical measurements were collected at a total of 16 stations. IOPs were measured at all stations, but weather conditions limited deployment of radiometry systems, particularly the profiling radiometers. Lesson learned – need to add additional weight to the profiling frames in order to improve in water stability. Table below shows the distribution of in situ optical measurements and associated CTDs.

In situ optical measurements metadata.

Date and Time	ST	Type	SS CTD	CTD Event	IOPs	IOP Event	Floating	Floating Event	Profilir
28/05/2024 12:48	1	SS1	5	36	1	37	1	39	1
31/05/2024 12:26	2	RS1	9	71	2	72	2	73	2
03/06/2024 12:23	3	RS2	12	89	3	90	3	91	3
03/06/2024 19:07	4	EX1	NaN	NaN	4	98	4	97	NaN
07/06/2024 12:38	5	SS2	17	130	5	131	5	132	NaN
08/06/2024 12:33	6	SS2	19	147	6	148	6	148	6
10/06/2024 12:31	7	RS3	21	166	7	167	7	168	7
13/06/2024 12:59	8	SS3	27	193	8	197	8	198	NaN
14/06/2024 12:46	9	SS3	29	210	9	211	9	212	9
16/06/2024 12:29	10	RS4	32	227	10	228	10	229	10
18/06/2024 12:22	11	SS4	NaN	NaN	11	254	11	255	NaN
20/06/2024 12:40	12	SS4	38	268	12	269	12	270	NaN
21/06/2024 12:25	13	RS5	40	283	13	284	13	286	13
21/06/2024 19:53	14	GCAL1	41	289	14	290	NaN	NaN	NaN
21/06/2024 22:24	15	GCAL2	42	291	15	292	NaN	NaN	NaN
22/06/2024 09:49	16	ALRCAL	43	296	16	297	16	298	NaN

In Situ IOP Measurements: The IOP profiling package consists of a WETLabs AC9+ nine wavelength absorption and attenuation meter, a WETLabs BB9 nine wavelength backscattering meter, a Seabird SBE19Plus V2 CTD, a WETLabs BBFL2 backscattering, chlorophyll fluorescence and CDOM fluorescence sensor and a WETPak lead acid rechargeable battery pack. Photos show the IOP profiling package being deployed on DY180. The BB9 was calibrated at Harbor Branch labs immediately prior to the cruise and the AC9+ was regularly calibrated

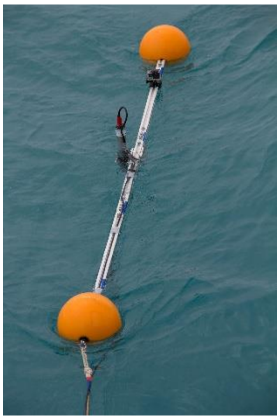


Profiling IOP package

using Milli-Q water throughout the cruise. All IOP data is post-processed to apply calibrations, temperature and salinity corrections, absorption and scattering corrections (where appropriate) and split into down and up casts between near surface waters and 120m, with an additional short time series recorded near the surface on up casts. Vertical casts are median averaged into 1m bins while the near surface time series are represented in the figure below as spectral medians.

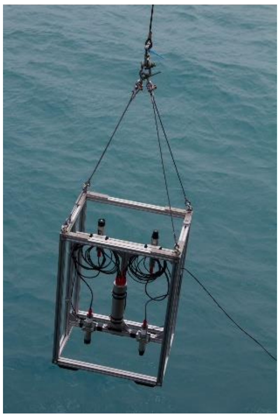
Post cruise analysis will include comparisons with flow through and PSICAM IOP measurements, with the latter providing an opportunity to refine scattering corrections for both the absorption and attenuaiton data using the Monte Carlo scattering corrections previously developed at Strathclyde.

In Situ Radiometry Measurements: Trios RAMSES hyperspectral sensors were used to measure in situ light fields. A planar irradiance sensor was mounted on top of the large deck crane to provide downwards surface irradiance with minimal obscuration from the rest of the superstructure. A radiance meter was mounted on a floating platform to provide upwards radiance immediately below the sea surface. This was deployed ~30m behind the stern of the ship, with the vessel moving forwards at ~0.4 knots in order to facilitate easy clearance away from the vessel. This provides optimal radiance vlues that are minimally affected by any ship shadow effects.



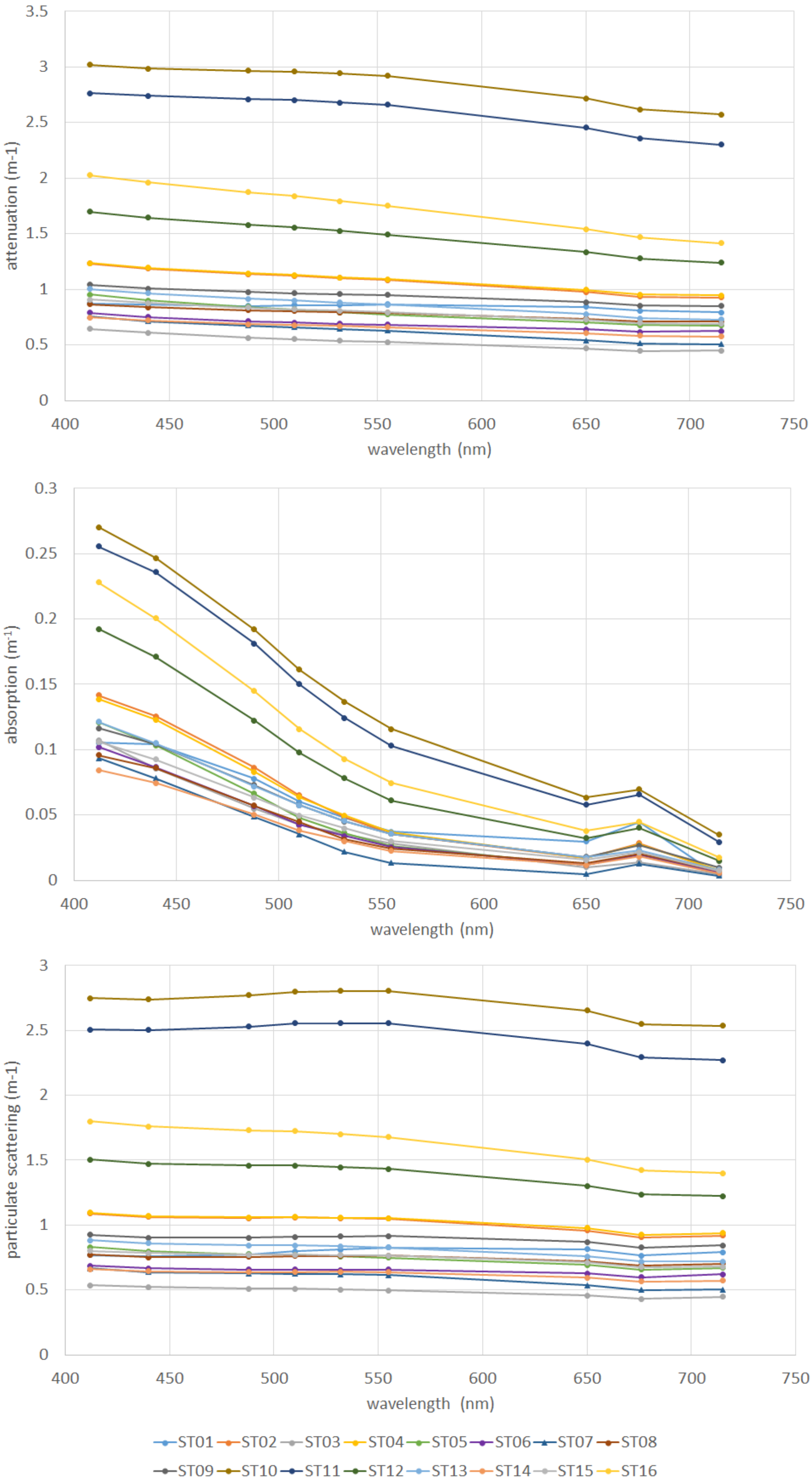
Profiling IOP package

In contrast, the profiling radiometer package, which was deployed over the starboard side using the deck winch and a block on the crane arm at maximum extension, remains susceptible to ship shadow effects. Care was taken to try to minimise this by orienting the ship to maximise free illumination of the starboard, but weather conditions often precluded this in practise, with additional concerns about the trailing electrical cable potentially being caught on the propellor.

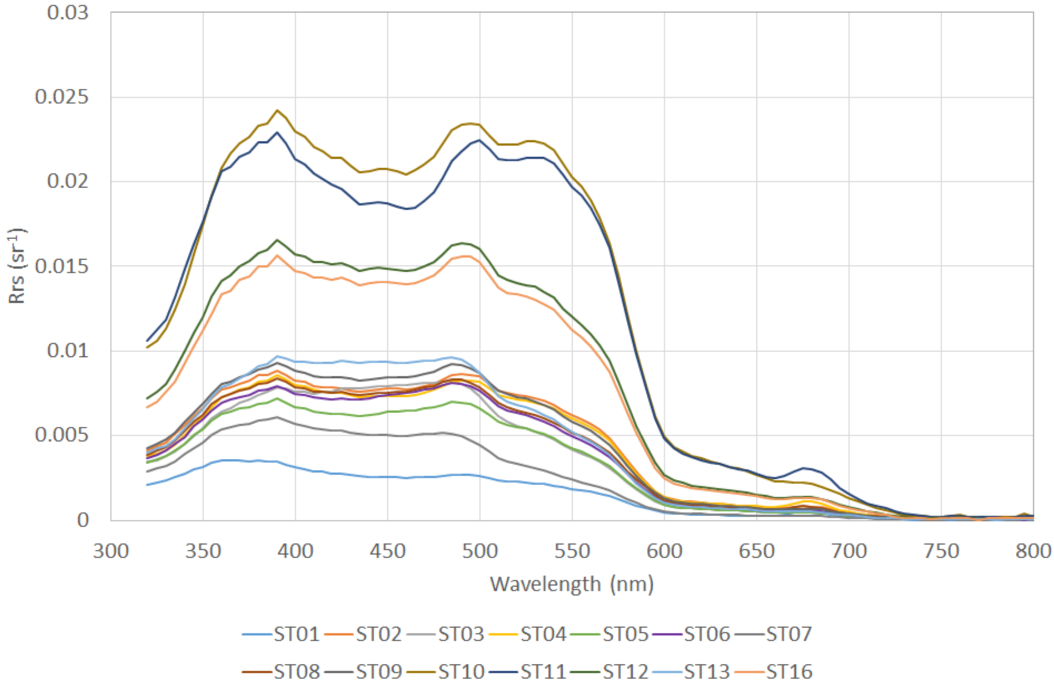


Profiling radiometry package

Figure below shows surface remote sensing reflectance spectra derived from Es and Lu data for DY180 optical stations. Spectral distributions show a number of recurring features which are related to the presence of varying concentrations of coccolithophores dominating the optical properties of the brighter waters. Station 1 is probably the least influenced by coccolithophores and was collected at the first superstation. All others were influenced to some extent by coccolithophores. This means there are a good number of samples to test a coccolithophore bio-optical model / remote sensing reflectance algorithm, but there are fewer data to represent other scenarios occurring in the North Atlantic at this time.



Near surface in situ non-water absorption, non-water attenuation and particulate backscattering *measurements for optical stations occupied during DY180.*



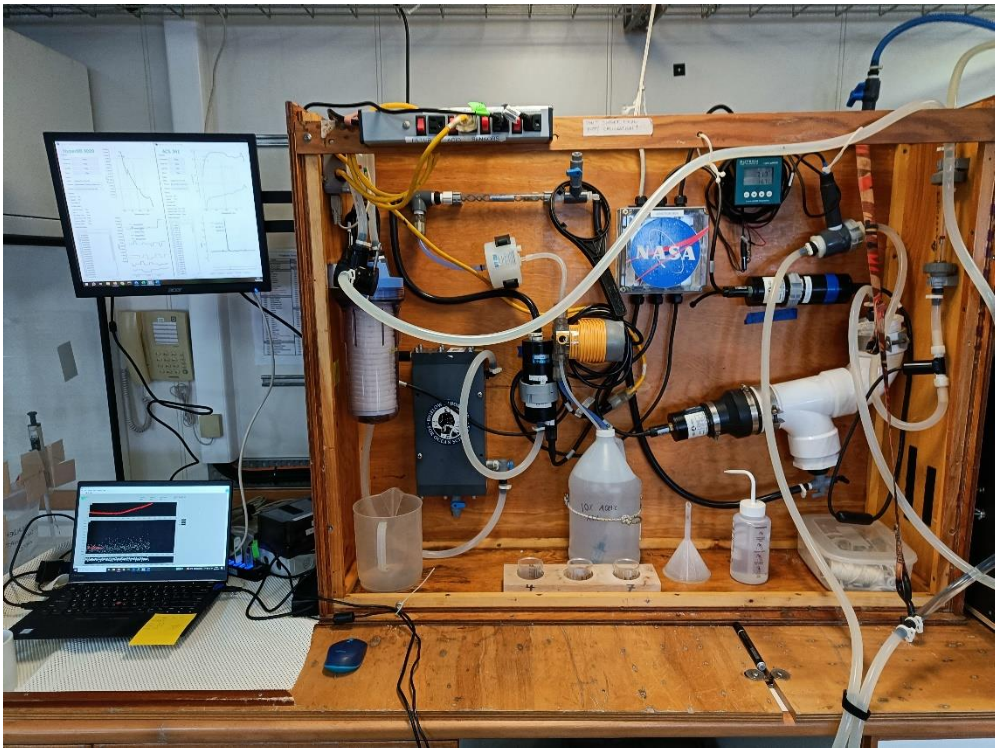
Surface remote sensing reflectance spectra.

Bigelow Underway Optics

Farley Miller (Bigelow)

GNATS Flow-Through

We installed a surface water flow-through system based on the system developed and used in the Gulf of Maine Atlantic Time Series (GNATS, Balch et al 2012). This system receives surface water from the ships seawater supply and passes it through several instruments (detailed below). On a cycle of roughly 20 minutes, 10% acetic acid is introduced into the flow at a sufficient rate to bring the pH below 6.0 units. After enough points (~100) have been recorded at this low pH, the acid pump shuts off and raw seawater is restored. This “acid cycling” allows us to calculate the absorbance, backscattering, transmittance, and polarized transmittance of the total raw seawater and the acidified water. The difference between these should be partial absorbance. Once a day we also took reading on just the dissolved portion by passing the water through a 0.2um filter.



Half of the flow-through system with acid pump. The Hyper-BB sat on the floor, and the ACS was in the forward sink.


The PSICAM and LWCC setup next to the two LISST sensors and logging computer.


The ACS sitting in its aquarium in the sink.

Instruments

The UW system has 9 instruments plumbed in series.

- **Temperature-Salinity -** SeaBird T-sal unit
- **Chlorophyll Fluorescence -** WetLabs WetSTAR chlorophyll Fluorometer
- **WetLabs VSF -**Backscattering at 100, 125, and 150 degrees at three wavelengths.

- **Sequoia Hyper-BB -** Backscattering between 430 and 700nm.
- **pH probe -** pH is measured to control the acid cycling.
- **WetLabs Flow meter -** A flow meter records flow rate through the system.
- **WetLabs ACS -** Simultaneously measures absorbance and scattering. This unit is housed upright in an aquarium to prevent air from being introduced and to keep the instrument at ambient temperatures.
- **Sequoia LISST Tau and prototype LISST PIC -** Griet Neukermans of U Ghent brought us two LISST sensors to test side by side. The LISST Tau is a laser transmissometer. The LISST PIC is a prototype polarized transmissometer to measure the birefringence of coccolithophores in-situ.

The prototype PIC sensor was shown by Griet to be very sensitive to temperature changes, especially at lower temperatures. Their solution was to wrap the unit in heat tape that was turned on when the seawater was below 15C. This heater ran for the duration of the cruise, except during calibration and cleaning.

Logging Software

The Hyper-BB, ACS, and GPS are logged independently using Inlinino, a python-based freeware developed at the optics group at UMaine. The two LISST sensors logged in two iterations on Sequoia's proprietary software. The rest feed into a LabView program that logs the data (including another GPS feed) and controls the acid cycling.

Filtered Seawater Readings

At least once per day, the seawater inlet was routed through a 0.2um filter to remove all particles. This data was recorded for ~1 hour to get a non-particle reading in all instruments.

System Maintenance & Calibration

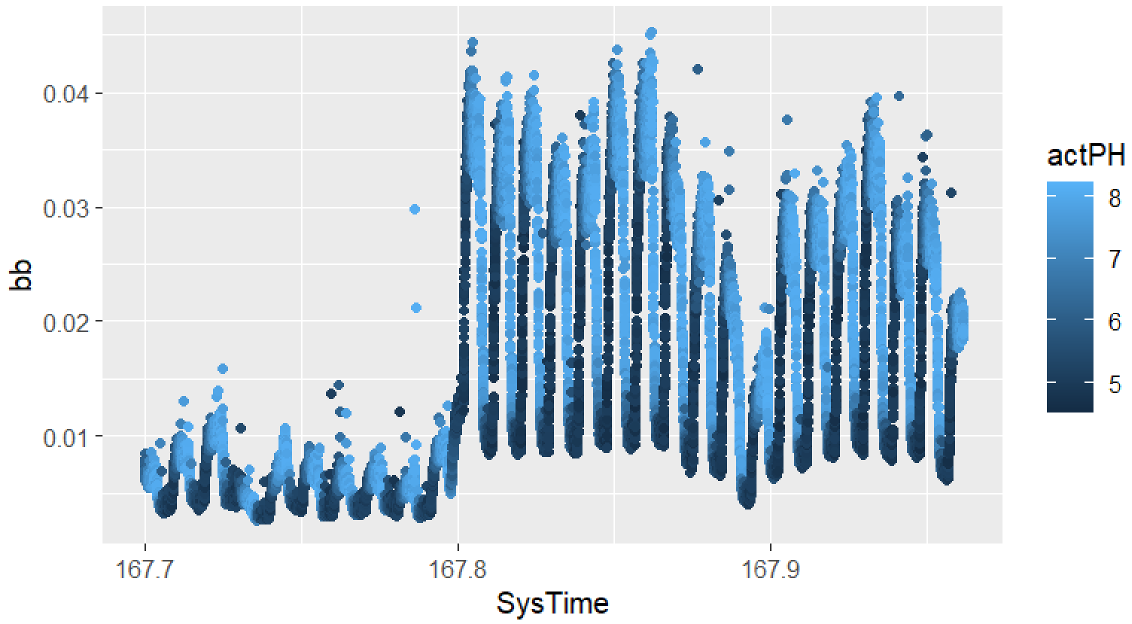
Every day the system was checked over for bubbles or leaks, and the acetic acid jug was topped up.
Every 5-8 days the system was shut down for calibration and cleaning. The first calibration was a "dirty milli-Q" where > 20L of milli-Q water was pumped through the system. Once readings had stabilized, data was logged for 5-10 minutes. After this the system was dismantled and all the instruments were cleaned. After reassembly, more MQ water was pumped through and a "clean MQ" calibration was taken for all the instruments. After this, the daily filtered seawater readings were taken as normal.

Future Modifications

A second de-bubbler for the ACS would be very helpful to remove any bubbles that form mid-system. Perhaps a second pH probe to record the pH of the acidified water before and after it enters the instruments.

Preliminary Results

Because we could get near real time data from the flow-through system, we used it during our roaming days and stations to track and find high scattering regions. Using a combination of flow-through data, sparse satellite images, and flow-cytometry we could determine if we had passed through an area of high coccolithophores on our outward roaming day. We then used this information to plan our return trip. Below is some hastily plotted backscattering data. The pH cycling is apparent as the sine wave pattern (the pH is not accurately aligned, however). The larger the backscattering (bb) the more particles and dissolved colors are in the water, and the larger the sine wave height, the more particles (presumably calcium carbonate) are being dissolved by the acid. We observed this peak on June 15th.



Discrete Optics Sampling

At least once daily, and at three or more depths for the “optics” CTDs, we took discrete water samples and analyzed them through two optical instruments.

PSICAM

The Point Source Integrating Cavity Absorption Meter (PSICAM) was developed by Rudiger Röttgers et al. (2005) and sold by Sunstone Scientific (Vero Beach, California). This unit is essentially a spherical spectrometer cell with highly reflective walls and a spherical light diffuser suspended in the middle of the integrating sphere. This allows us to measure absorption to a very fine degree with almost no interference from scattering.

Liquid Waveguide Capillary Cell

Coupled with the PSICAM, we brought a LWCC both for discrete CDOM measurements and to calibrate the reflectivity of the PSICAM. For most of the trip we had very low, unusable readings in the LWCC, even with extensive cleaning and flushing. Then all of a sudden at the end of June something fixed itself and the readings were much clearer.

At the beginning we had an integration time of over 2 seconds. At the end it was closer to 90 milliseconds, which is much more what I had experienced in the lab when testing the cell. The only explanation was that some contamination or particle was stuck in the cell for the duration. Our CDOM readings with the PSICAM were an excellent, if laborious, backup.

Single Turnover Active Fluorometry of Enclosed Samples (STAFES)

Mark Moore (University of Southampton), Alex Poulton (Heriot Watt)

Active chlorophyll fluorescence analysis, specifically Single Turnover Active Fluorometry (STAF), can provide a useful non-destructive and rapid index of the physiological status of phytoplankton. STAF can be used to measure a suite of parameters pertaining to the photosynthetic physiology of the entire phytoplankton community, most commonly an estimate of the photosystem II photochemical efficiency (Fv/Fm) which can provide a proxy of the overall photosynthetic 'health' of the community, alongside other variables which can be used to derive photosynthetic electron transport rates using a 'Fluorescence Light Curve' (FLC) sampling protocol. The STAFES technique measures in real time and at high sensitivity.

Instruments summary:
Three LabSTAF instruments were used during DY172.

Serial number	Location on ship	Use
19-0105-003	Chem lab	Continuous FLC
21-1345-003	Chem lab	Discrete FLC
20-0787-003	Chem lab	Discrete FLC

Calibration:
All instruments were calibrated prior to the cruise, calibration files are available on the DY180 shared drive (\DY180\ActiveFluorometry\STAFES).

Software:
Instruments were run on RunSTAF v9.1.18. The software version used is available on the DY180 shared drive (\DY180\ActiveFluorometry\STAFES\RunSTAF v9.1.18).

Continuous FLC measurements:
Instrument 19-0105-001 was used to run continuous fluorescence light curves (FLC) using the same protocol throughout the cruise. The instrument was run in AutoFLC mode, with dynamic FLC and AutoHigh activated which results in the light levels of light steps automatically adjusting during each FLC. The FLC protocol included a low light time of 200s at 20 umol quanta m^{-2} s^{-1} and a dark step of 40s, 10 light levels of 80s each and a final dark step of 60s. A dual waveband measurement (DWM) was automatically run prior to each FLC. Photochemical excitation profiles (PEP) were also run prior to FLCs at the beginning of the cruise and intermittently throughout, but some problems with the instrument hanging up during this phase of the protocol resulted in this function being turned off for some periods. The value of Seq/Saq (number of acquisitions to be averaged) was set to 32. Blanks were run with MQ water every two days, with and 0.2 um filtrates run on occasion. Raw data files can be found at \DY180\ActiveFluorometry\UW_STAFES.

Discrete FLC measurements:
Instruments 21-1345-003 and 20-0787-003 was used to run fluorescence light curves (FLC) on discrete samples from CTD casts (surface samples from the 'Optics' CTD) and nutrient addition experiments ('ExL' experiments). A similar FLC setup to the continuous FLC protocol used on instrument 19-0105-001 was used (10 light steps and 1 dark step, DWM and PEP). Raw files can be found at DY180\ActiveFluorometry\STAFES under separate folders for each instrument.

Resources (LabSTAF instrument):
More information about the instrument and approach can be found in the instrument handbook,

available on the Ocean Best Practice Repository: https://repository.oceanbestpractices.org/handle/11329/1531.4
The latest version of the instrument software, required to open raw files, can be downloaded at https://1drv.ms/u/s!AkUtV8PHZSmVvJ9wFOm-fSR1FbwYGQ?e=
A zenodo repository of continuous FLC data from previous cruises can be accessed on: https://zenodo.org/communities/staf_underway?q=&l=list&p=1&s=10&sort=newest

FastOcean FRRf measurements:
In addition to the STAFES measurements, single turnover active chlorophyll fluorescence measurements were also made using a Chelsea Technologies Group (CTG) FastOceanTM fluorometer on sub-samples from the nutrient addition experiments (see Section on nutrient amendment experiments).
The instrument (SN 15-0093-002) was set up with a saturating sequence of 100 flashlets (at 2µs pitch) and a relaxation sequence of 20 flashlets (at 60 µs pitch), with 110 sequence repeats at a sequence interval of 100ms. Data was downloaded daily and analysed with 'FastPro8' software to derive fluorescence parameters (see above). Raw data and a scan of the completed log book is available on the ships drive at the location 'Z:\DY180\ActiveFluorometry\FRRf_3_Data'. Processed data are available on the ships drive within the data files for the nutrient addition experiments at location: 'Z:\DY180\Nutrient Addition Experiments'.

Photosynthesis Irradiance Experiments

Heather Bouman (University of Oxford)

Objectives:

Seawater samples were collected to determine the photosynthetic response of phytoplankton assemblages for Central Basin (Superstation) and Roaming stations and one nutrient addition bioassay experiment. These data will be used to obtain information on the photosynthetic efficiency of the natural phytoplankton community and provide estimates of daily primary production for each station using chlorophyll profiles, inherent optical properties and irradiance data.

Sampling:

For each stainless steel CTD cast (CTDs), seawater was collected from the surface (approximately 5m). Additionally, seawater was collected from the trace-metal fish for Long Term (6 day) Experiments (LTE) to monitor the growth response of natural assemblages to trace metal. Seawater was also collected to determine chlorophyll-a concentrations from the same Niskin or experimental bottle in order to normalise carbon uptake rates to pigment biomass

PI experiments were conducted in a custom-built incubator holding 10 60ml polycarbonate bottles. Samples were maintained at ambient temperatures (+/- 1˚C) throughout the incubation period using the ship's flow through system. Each of the 60ml polycarbonate bottles was rinsed three times with sample water then filled with 50 ml of sample in a low-light environment. 100 µl of ^{14}C stock sodium bicarbonate solution is added to each of the 15 bottles (10 µCi added per bottle). The bottles were placed into the incubator and neutral density filters were spaced between bottles to obtain a gradient of light levels. A single dark bottle was also placed in the incubator to measure ^{14}C incorporation in the dark.

The stock containing the ^{14}C sodium bicarbonate solution is stored in the refrigerator until the next experiment is conducted. 100µl of spiked sample was pipetted into a scintillation vial containing 100µl of PEA. 4 ml of scintillation cocktail (Ultima Gold) were added, the cap is replaced and the solution is mixed well. Counts obtained from these vials were provided by the shipboard liquid scintillation counter in disintegrations per minute (DPM).

At the end of the incubation period, samples were filtered through GF/F filters at a vacuum pressure of 200 mm Hg. Filters are removed from the towers and carefully placed in order in a dessicator in the fumehood containing ~ 200 ml of concentrated hydrochloric fuming acid (HCl). After fuming the filters were placed individually into numbered plastic scintillation vials. Scintillation cocktail was added to each vial and were counted in the scintillation counter onboard the ship. The light intensity inside of the incubator was measured using a LI-COR LI-250A light meter.

Samples Collected:

A detailed list of samples collected may be found in the table below.

Sample analysis:

The biomass-normalised primary production, P^B, at each light level will be calculated from the formula:

$$P^B = ((DPM_{light} - DPM_{dark}) \times 12000 \times ALK \times 1.05) / ((DPM_{add} \times 500) \times N \times Chl),$$

where DPM_{light} is the counts in the light bottle, DPM_{dark} is the counts in the dark bottle, ALK is the carbonate alkalinity (Meq), 12000 converts Meq to µg C, 1.05 is the isotope discrimination factor, DPM_{add} is the counts from the flask inoculated with 100 µl of ^{14}C stock solution, 500 converts counts to total counts for the DPM_{add} flask, N is the duration of the incubation in hours and Chl is the chlorophyll concentration in µg l^{-1}. The units for P^B is mg C (mg Chl)$^{-1}$ h^{-1}.

List of water samples collected for photosynthesis-irradiance incubations.

Date collected	**CTD/EXPT**	**Station**
28/05/2024	CTD-07S	SS1
31/05/2024	CTD-12S	R1
03/06/2024	CTD-15S	R2
07/06/2024	CTD-22S	SS3_D2
08/06/2024	CTD-24S	SS3_D3
10/06/2024	CTD-27S	R3
14/06/2024	CTD-36S	S4
16/06/2024	CTD-40S	R4
20/06/2024	CTD-46S	S5
21/06/2024	CTD-49S	R5
	EXP	LTE_Control
	EXP	LTE_FE+

Net primary production and calcite production

Alex Poulton (Heriot-Watt University)

Upper ocean rates of net primary production (NPP) and calcite production (CP) were measured from pre-dawn (0200-0600 local time) trace-metal free (titanium) CTD casts at nine stations. Water samples (0.5-1.5 L) were collected from 3 depths and incubated at five light levels (60, 40, 20, 10, and 5% of surface irradiance) representative of the upper ocean (<40 m). As the trace-metal free CTD did not sample shallower than 15 m, water samples for the 60, 40 and 20% surface irradiance were collected from 15 m and incubated at representative light doses (see below). Uptake of ^{14}C into particulates measured primary production and calcite production using the Micro-diffusion Technique (see Poulton et al., 2014).

Rates of PP were measured over long-term (24 h; 'Net primary production', NPP) incubations in a temperature controlled (10 ± 1°C) laboratory incubator (PHCBI, model MIR-254-PE) with a white LED light panel and a mixture of misty blue and neutral density light filters (Lee Filters™) to recreate the required light doses (after Poulton et al., 2019). Each incubation depth was supplied with a daily (18 h; 0400-2200) light dose equivalent to the average light dose for June at that light depth, as determined from MODIS satellite PAR data. Light doses were: 24 E m^{-2} d^{-1} (60% surface irradiance), 14 E m^{-2} d^{-1} (40%), 8 mol quanta m^{-2} d^{-1} (20%), 3 E m^{-2} d^{-1} (10%) and 2 mol quanta m^{-2} d^{-1} (5%).

Sampling stations for NPP and CP

Sampling details				
Date	**Event No.**	**CTD No.**	**Niskin bottles sampled**	**Site**
28/05/24	27	C005T	24, 18, 15	Superstation 1
31/05/24	63	C010T	24, 18, 15	Roam 1
04/06/24	103	C016T	24, 18, 15	Roam 2
07/06/24	124	C020T	24, 18, 15	Superstation 3
10/06/24	156	C025T	24, 18, 15	Roam 3
13/06/24	191	C033T	24, 18, 15	Superstation 4
16/06/24	218	C037T	24, 18, 15	Roam 4
18/06/24	249	C043T	24, 18, 15	Superstation 5
21/06/24	274	C047T	24, 18, 15	Roam 5

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Nutrient amendment incubation experiments

Mark Moore & Te Liu (University of Southampton), Kyle Mayers (NORCE), Alex Poulton (Heriot Watt), Glen Tarren (PML), Ed Mawji (NOC)

A series of multi-element factorial elemental addition experiments were performed during DY180 (see below) to investigate how spatial and temporal changes in nutrient (Fe and Mn) availability and an inhibitor of diatom silicification (Ge) influenced phytoplankton physiology, growth, community structure and macro-nutrient drawdown. Experiments were run using similar methods to those employed previously in a number of settings including the temperate / sub-polar North Atlantic (Moore et al. 2006; Ryan-Keogh et al. 2013). Long-term experiments (denoted 'ExL') were run over a 5 day period and were designed to assess changes in community physiology, structure and nutrient drawdown in response to changes in nutrient (and inhibitor) additions (see table below).

Strict controls were required to avoid the contamination of incubation bottles, sampled seawater water and nutrient spikes. All incubation bottles had been previously passed through a vigorous cleaning process involving a Decon and strong (1 M) HCl wash followed by Milli-Q rinsing and storage with 0.024 M HCl prior to sailing. The trace metal spikes (Fe and Mn) were prepared from high purity salts prior to sailing. Seawater was collected using a trace metal clean 'tow-fish' through acid-cleaned tubing when the ship was sailing at a minimum of four knots. Bottle filling and all manipulation steps including spiking and sub-sampling were performed in a purpose built, Class-100 clean air container.

Water for the experiments was collected and transferred unfiltered into 4.5 L polycarbonate bottles (Nalgene). Incubation bottles were filled in a random order, 50 % at a time, with triplicate samples for initial (T_{zero}) measurements collected at the beginning, middle and end of the filling process. Filling bottles half-way and then topping up in random order ensured a relatively homogenous water collection representative of the surface conditions encountered during the sampling period. The time between the primary initial and final initial sample for the experiments was between 18-27 minutes, corresponding to distances travelled during water collection being <8 km.

In addition to an unamended control, separate bottles were amended with 2 nM Fe in all experiments and with either 2 nM Mn in a factorial design, or using a modified dilution method (see details below). Treatments consisting of Ge and GeFe additions were also included in all experiments. All experimental conditions were conducted as biological triplicates. Following nutrient amendment, all bottles were parafilm-sealed before transfer into a temperature controlled incubation container set to approximately local sea surface temperature (incubator temperature ranged from 10.41 – 11.51 °C across the cruise). The bottles were incubated on shelves surrounded by light banks with ~200 µmol photons m^{2} s^{1} irradiance flux and set to a day/night cycle of 16 and 8 h, respectively. Preliminary processed data are available within the directory: '*DY180\Nutrient Addition Experiments*' within the spreadsheets 'All_ExS' and 'All_ExL'.

Further method and (sub-)sampling details:

As outlined above, all incubation setups, subsampling, and incubation breakdowns took place under trace-metal clean SOPs, with unfiltered seawater from the trace-metal clean tow-fish fed into the clean-lab container on the Mezzanine Deck of the *RRS Discovery*.

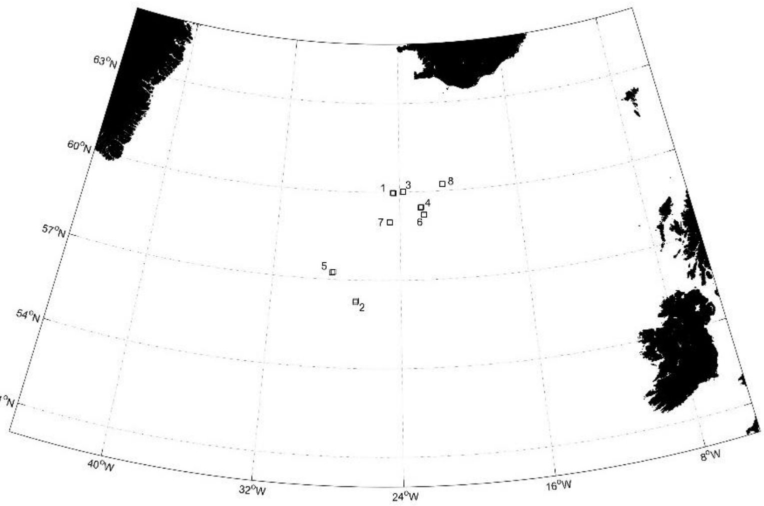
Nutrient stocks used: iron (20µM $FeCl_2$), manganese (20µM $MnCl_2$), alongside a 20 mM GeO_2 stock. All stocks were trace-metal clean and made up so that nutrients could be added at 100µL for every 1L of seawater (i.e. 400 µL for every 4L large bottle), with Ge added at a level expected to be in a ratio of around 0.05-0.1 relative to the ambient Si concentration. Once spiked, bottles were fastened and sealed with clean parafilm, before being placed in the incubation container under a 16-8hr light-dark cycle (off at 20:00 UTC and on at 04:00 UTC) at set temperatures of 11-12°C (achieved temperatures of 10.41-11.51°C adjusted upwards once mid-cruise to continue approximating SST). At the end of each incubation experiment, bottles were acid-washed, rinsed, and prepped ready for the next round of incubations. If not run sequentially (i.e. setup immediately following the breakdown of a prior run), bottles were washed and stored overnight with dilute acid inside.

The 4.5L acid-cleaned polycarbonate bottles were labelled as follows: 1-3 were kept as controls (no nutrient additions), 4-6 Fe addition, 7-9 Mn addition (experiments ExL01-ExL06), or a 20% filtered seawater dilution (ExL07 and ExL08), 10-12 Fe+Mn addition (experiments ExL01-ExL06), or a 20% filtered seawater dilution +Fe (ExL07 and ExL08). Mn was added to test for potential (co-)limitation by this other trace-metal nutrient (Browning et al. 2017; Wyatt et al. 2023). The bottles were subsampled after 1 day (T_1) and 3 days (T_2) for Chl-a, FRRf, AFC and macronutrients and after 5 days (T_3) for Chl-a, FRRf, AFC, macronutrients, SEM, HPLC and cytosense (the latter within a subset of experiments / treatments). Long incubation experiments were staggered (typically two running simultaneously) to allow setup on all 'super-stations' and the majority of roaming stations.

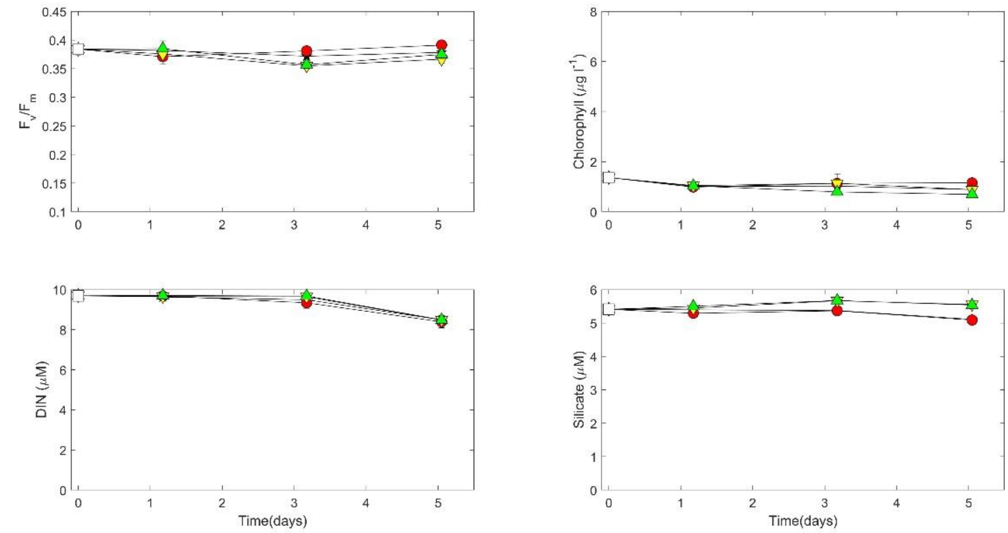
Preliminary results:
Results from the Control, Fe, Ge and FeGe treatments from two representative experiments are shown below. During the early stages of the cruise (example from ExL03 shown), there was no evidence of Fe stress either within the extant in-situ community or developing during the experiment. In contrast, by the latter stages of the cruise (around mid-June onwards, example from ExL07 shown), there were clear physiological responses to Fe addition observable after 24hrs, with subsequent increased biomass accumulation and macronutrient drawdown with Fe addition. A clear response to Ge addition was also observed in the majority of experiments, with the Ge addition appearing to completely supress Si uptake and correspondingly cause decreases in dissolved inorganic nitrogen (DIN) uptake and chlorophyll accumulation presumably due to a suppression of diatom growth.

Average Tzero location, start and end dates of nutrient addition experiments. Details available in the DY180 cruise folder under '\DY180\Nutrient Addition Experiments' scanned logbook is available within the same folder.

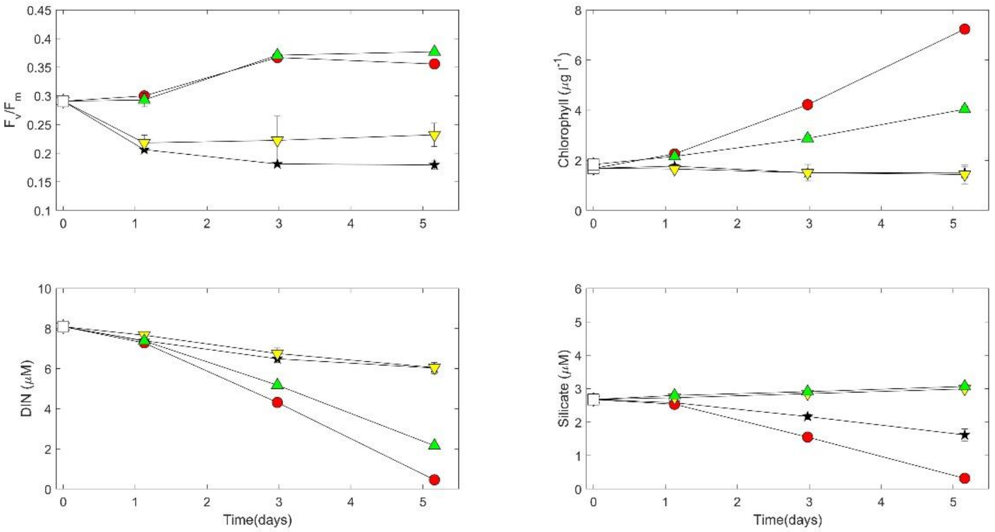
Experiment id	**Latitude (oN)**	**Longitude (oW)**	**Sampling method**	**Start date**	**End date**
ExL-01	59.973	24.428	Trace clean fish	27/05/24	01/06/24
ExL-02	56.27.6	26.781	Trace clean fish	30/05/24	05/06/24
ExL-03	60.015	23.75	Trace clean fish	02/06/24	07/06/24
ExL-04	59.465	22.589	Trace clean fish	06/06/24	11/06/24
ExL-05	57.245	28.276	Trace clean fish	09/06/24	15/06/24
ExL-06	59.214	22.397	Trace clean fish	12/06/24	17/06/24
ExL-07	58.975	24.668	Trace clean fish	16/06/24	21/06/24
ExL-08	60.224	21.056	Trace clean fish	18/06/24	23/06/24



Locations of all ExL experiments. The locations corresponding to each of the triplicate Tzero measurements are plotted. Details available in the DY180 cruise folder under '\DY180\Nutrient Addition Experiments'



Result from ExL03, started at S02. Treatments are Control (black diamonds), Fe addition (red circles), Ge addition (yellow circles), FeGe addition (green circles). A small suppression of Si uptake with Ge addition was observed, with few other responses.



Result from ExL08, started at S05. Treatments are Control (black diamonds), Fe addition (red circles), Ge addition (yellow circles), FeGe addition (green circles).Suppression of Si uptake with Ge addition was observed, with clear physiological, biomass and nutrient drawdown responses to Fe addition.

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Dilution experiments for microzooplankton grazing and viral lysis rates

Kyle Mayers (NORCE), Alex Poulton & Ben Gustafson (Heriot Watt), Mark Moore & Te Liu (University of Southampton), Glen Tarran (PML), Ed Mawji (NOC), Kathryn Cook and Franki Perry (University of Exeter)

Experimental set-up

Phytoplankton population dynamics are determined by a variety of factors, particularly mortality agents. The 2 most dominant forms of mortality within marine phytoplankton communities are grazing by microzooplankton (Schmoker et al., 2013) and viral lysis (Suttle, 2005). The fate of carbon fixed by phytoplankton differs whether they succumb to grazing or viral infection. Typically, grazing leads to material being respired and entering the food web, being passed to higher trophic levels. In contrast, viral lysis leads to the release of cellular contents and the remineralisation within the upper euphotic zone. Understanding the rates and prevalence of these processes is essential for ocean carbon dynamics. In the Biocarbon project CHALKY, we are particularly interested in the dynamics of the bloom forming coccolithophore *Emiliania huxleyi*, and the fate of the inorganic calcium carbonate coccoliths they produce. In IdaPro we are interested in how phytoplankton dynamics vary over time and particularly with changing iron stress.

Paired dilution experiments (Landry, 1995, Evans et al., 2003) were set-up to determine the rates of phytoplankton growth, microzooplankton predation and viral lysis. This technique involves incubations of 100% whole seawater (WSW) and dilutions of 20% WSW with 80% filtered seawater (FSW) through 0.45 µm cartridge filters, and 80% ultrafiltered seawater (UFSW) through 10 or 30 kDa filters. Filter sizes are chosen to allow most large algal viruses to pass through 0.45 µm (Chaudri et al., 2021) but remove all viruses through 10-30 kDa filters. The WSW was taken from pre-dawn trace metal CTD casts and passed through 200-µm mesh to remove larger mesozooplankton prior to experimentation.

Water for FSW and UFSW was taken in a variety of ways depending on the station, since making enough virus free UFSW took up to 8 hours to produce. From superstations, water was taken on station ~12 hours before the experiment began from the trace metal fish, filtered through 0.45 µm cartridge filters, and then through a 10 kDa Vivaflow tangenital flow filtration (TFF) system. At the roaming stations, water was taken from the trace metal fish as we came onto station (approximately 30 minutes before) to ensure filtered water had similar characteristics to the WSW and FSW used for the dilution experiment. Water was also filtered through 0.45 µm cartridge filters, but then passed through a 30 kDa Sartoslice TFF system which had a higher filtration area and faster production time of TFF water. In total, 9 dilution experiments were conducted.

Dilution experiment	Station	Dates	Coordinates	TM CTD event #
ExD01	Superstation 01	28.05.2024-29.05.2024	60.000181°N 24.000216°W	27
ExD02	Roaming station 01	31.05.2024-01.06.2024	56.216026°N 26.830218°W	63
ExD03	Roaming station 02	04.06.2024-05.06.2024	57.117801°N 26.257362°W	103
ExD04	Superstation 03	07.06.2024-08.06.2024	59.426596°N 22.62653°W	124
ExD05	Roaming station 03	10.06.2024-11.06.2024	57.230841°N 28.342404°W	156
ExD06	Superstation 04	13.06.2024-15.06.2024	59.281466°N 21.966373°W	191

ExD07	Roaming station 04	16.06.2024-17.06.2024	58.991374°N 24.67123°W	218
ExD08	Superstation 05	18.06.2024-19.06.2024	60.252047°N 21.084322°W	249
ExD09	Roaming station 05	21.06.2024-22.06.2024	60.121279°N 18.949453°W	274

Dilution experiment set-up and handling was undertaken in trace metal clean laboratories and using standard clean practices to reduce contamination of trace metals from external sources. WSW was gently siphoned from niskin bottles into 10L carboys, and to 10L carboys containing 80% FSW or UFSW to make dilutions. FSW was generated from pressurised niskin bottles and passed through a 0.45-µm cartridge filter. Six replicate 1.1L bottles for the 3 treatments (100% WSW, 80% FSW and 80% UFSW) were gently filled from carboys and to 3 bottles in each treatment 100 µL of 20 µM FeCl stock (final addition 2 nM Fe) was added. Bottles were then parafilm-sealed and incubated in a temperature-controlled container set to ambient sea surface temperature (range 10.41-11.51°C across the cruise). Light panels provided irradiance at 200 µmol photon m^2 s^{-1} on a 16:8 light/dark cycle. Experiments were incubated for 24 hours with the motion of the ship providing agitation of bottles throughout. In one experiment, ExD06 bottles were incubated for 48 hours, with sub-samples taken at 24 hours. The bottles were then parafilm-sealed and incubated for a further 24 hours.

<u>Sampling information</u>

Samples were taken at T0 and T24 for all experiments, and at T48 for ExD06. For all treatments at T0, sub-samples were taken for chlorophyll-*a*, flow cytometry, nutrients and fast repetition rate fluorometry. Also, at T0, samples were taken from 100% WSW and 80% FSW treatments for DNA analysis and size fractionated chlorophyll or particulate inorganic carbon (PIC). Low initial volume of UFSW meant that not enough water was available for T0 samples from this treatment, but the 80% FSW will be used to determine the changes after 24 hours. Samples for PIC were only taken during ExD07 and ExD08 when high *E. huxleyi* abundance was observed in the water (>5000 cells mL^{-1}). Size fractionated chlorophyll-*a* was taken at all experiments aside from ExD01, ExD02, ExD07 and ExD08. From the 100% WSW bottles at T0 and T24, 100 mL was fixed in 1% acidified Lugol's iodine for microzooplankton abundance onshore by the University of Exeter, and 40 mL was run live onboard using a FlowCam 8100.

For chlorophyll-*a*, 100 mL was filtered onto MF300 filter paper, extracted for 18-24 hours in 90% acetone and read on a Turner Fluorometer (Poulton et al., 2014). Acetone blanks and a solid standard were measured during each series of chlorophyll measurements taken. For size fractionated chlorophyll-*a*, 200-250mL of sample was sequentially filtered through 20, 5, 2 and 0.2 µm filters at T0. For T24, we determined the 3 pore sizes with the greatest concentration at T0 (typically 20, 5 and 2-µm). Filters were extracted as above.

Flow cytometry was run live onboard for phytoplankton counts by Glen Tarran (PML). Samples were enumerated using a FACSCalibur flow cytometer which differentiated phytoplankton groups into pico- and nanoeukaryotes, *Synechococcus* and *E.huxleyi* based on their light and autofluorescence properties (see cruise report on flow cytometry). To enumerate heterotrophic bacteria and viruses, 1 mL samples were fixed onboard with 50% glutaraldehyde (10 µL), kept at 4°C for 30 minutes – 2 hours and then flash frozen in liquid nitrogen (Larsen et al., 2004). These samples were transferred to -80°C and will be sent to University of Exeter to be analysed by Susan Kimmance.

Microzooplankton and diatoms were enumerated using a FlowCam (v8100) using a 10x objective lens. Images were collected in auto image mode using 10 mL of sample volume at a flow rate of 0.5 mL $minute^{-1}$. The images will be classified using EcoTaxa at Heriot-Watt University. Lugols iodine fixed samples from T0, T24 and T48 100% WSW bottles will be returned to University of Exeter and analysed on a FlowCam 8400 to also enumerate microzooplankton and diatoms from a larger

concentrated volume.
Filters (0.4 µm) and filtrate were collected for quantitative PCR of *E. huxleyi* and the Emiliania huxleyi virus (EhV) in all dilution samples (Mayers et al., 2021; Pagarete et al., 2009, Nejstgaard et al., 2008). Between 125 – 500 mL of water was filtered onto an 0.4 µm polycarbonate filter to allow free viruses to pass through, but cells to be retained. For the filtrate, 5-10 mL was filtered through a syringe filter of 0.4 µm and 0.5 mL subsampled for virus quantification. All filters and filtrate for DNA analysis was immediately frozen at -20°C. The samples will be returned to NORCE in Bergen, Norway where the DNA will be extracted, and digital droplet PCR (ddPCR) will be used to quantify the copy number of *E. huxleyi* from filters and EhV in filters and filtrate from dilution experiments. This analysis will allow us to quantify rate specific measurements of *E. huxleyi* at high specificity and allow differentiation of intracellular viral production (from filters) versus free viruses released by cell lysis (from filtrate).
Nutrient samples were taken at T0, T24 and T48 from all experiments. For analytical procedures, please see the nutrient section of the cruise report. Concentrations of nitrite, nitrate, phosphate and silicate were measured.
Particulate inorganic carbon (PIC) samples were taken from T0 and T24 dilution experiments ExD07 and ExD08, when the abundance of *E. huxleyi* was high in the water. This was to ensure that a signal could be detected in diluted (20% WSW) treatments. Water was subsampled and 300-500 mL was filtered through 0.4 µm polycarbonate filters, rinsed with pH buffered MilliQ and then placed in an oven with the caps removed at 50°C overnight. PIC will be quantified at Bigelow Laboratory after the cruise.

Recommendations for future sampling
Due to issues with shipment arrivals of TFF filters, we had to use two different systems onboard DY180. This is not ideal, as the two systems had different pore sizes (10 kDa and 30kDa) and could influence comparison between experiments. Both however will remove viruses, but it should be considered during sample analysis. The same system was used for all Superstations and a different system for all roaming stations. Ideally, one TFF system would be used during the cruise, and a system which has a higher processing rate. The Vivaflow took ~8 hours to generate enough lysate for incubations, and sometimes not enough sample was left for all T0 measurements to be taken. The water filtered should be as close to that used for incubations and a more rapid generation time could help with this.

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Mesozooplankton biomass and metabolism

Kathryn Cook (University of Exeter), Vicky Fowler (BAS), Franki Perry (University of Exeter), Eloïse Savineau (University of Southampton), Ben Gustafson (Heriot Watt), Kyle Mayers (NORCE), Glen Tarran (PML)

Overview

A series of net sampling operations were carried out to address the objectives of BIOCARBON projects:

CoccolitHophore controls on ocean ALKalinitY (CHALKY)

- Assess grazing losses of coccolithophores, and other phytoplankton, to mesozooplankton.
- Collect faecal pellets produced by mesozooplankton for Scanning Electron Microscopy (SEM) analysis of their composition.
- Determine mesozooplankton species composition and biomass, including $CaCO_3$-biomass of pelagic calcifiers (e.g. pteropods, foraminifera).

Integrating Drivers of Atlantic Productivity (IDAPro)

- Determine the community composition, biomass and size structure of mesozooplankton collected via net sampling (0-200m, 100µm mesh).
- Measure mesozooplankton grazing.
- Measure the C:N:Si:P:Fe stoichiometry of selected zooplankton species.

PARTIcle Transformation and Respiration Influence on ocean Carbon Storage (PARTITRICS)

- Quantify the vertical distribution of mesozooplankton biomass and rates of growth and respiration through the epi- and mesopelagic during day and night.
- Quantify how particle concentration influences zooplankton feeding, and rates of particle fragmentation and faecal pellet production.

We collected samples to allow us to describe the taxonomic composition, biomass and abundance of the mesozooplankton community in the epipelagic and mesopelagic depth layers. Size fractionated samples and specimens were frozen to determine the metabolic performance and trophic interactions through measurement of Electron Transport System (ETS) activity, Amino-acyl-t-RNA-synthetases (AARS) activity, elemental (CHN) analysis, and biomarker analysis. Live specimens were incubated to establish respiration, feeding and faecal pellet production rates, including faecal pellet composition, of dominant copepod species.

Mammoth net

The Hydro-Bios Mammoth net had nine 100µm nets that open and close sequentially. These opening/closing preset depths were consistent across all deployments and divided the sampled water column into intervals: 500-438, 438-375, 375-313, 313-250, 250-188, 188-125, 125-63, 63-33 and 33-5m.

The Mammoth net was deployed from the mid-ships P-frame. The trawl warp was fed through the main winch. The side wires, which were combined to form a single bridle, were hauled using a Rexroth winch. The trawl warp was inboard of the anti-pendulum roller attached to a swivel on the main net, whilst the side wires for the cod-end rosette were out-board. The anti-pendulum roller was bent inwards to create a gap between the cod-end rosette and the main net body. Steady lines were used on the cod-end rosette and the net frame to control the system going outboard. Once over the side, the net was spun around so the safety bar could be disengaged prior to deployment. Retrieval was the reverse.

The Mammoth net was deployed to a depth of 550m or 600m wire out at a rate up to 0.5 m/s, usually 0.3 m/s, dependent on the swell and time constraints, and retrieved at 0.3 m/s. The

Mammoth net was run in self-logging mode, with a trigger depth for the instrument to turn on set at 520m. On occasions when the wire angle was greater than usual, extra wire was paid out to ensure the Mammoth net reached the trigger depth.

Once onboard, the nets were washed down with seawater to ensure the whole sample was collected in the cod-end. Each Mammoth station consisted of 2 consecutive deployments. For the first deployment, the contents of each cod-end were concentrated onto a 63 µm mesh before being washed into a 250 mL Nalgene bottle with filtered seawater and preserved using 25 mL borax buffered formaldehyde (4% final concentration) for later analysis using a FlowCam Macro. For the second deployment, the contents of each cod-end were size fractionated using a filter stack (100µm, 200µm, 500µm, 1000µm, 2000µm). Each size fraction was filtered onto a 47mm pre-combusted GF/F filter and frozen at -80ºC for ETS/AARS activity measurements.

Day/night pairs of Mammoth samples were taken at each Superstation, and daytime only Mammoth samples were taken at each Roaming Station.

Mammoth net deployments during DY180

Stn.	**Mammoth No.**	**Event**	**Date/Time (UTC)**	**Samples preserved?**	**Comments**
SS1	MN1	25	27/05/2024 21:45	Formaldehyde	
SS1	MN2	26	27/05/2024 23:36	Size fractionated & frozen	
SS1	MN3	52	29/05/2024 04:20	Formaldehyde	
SS1	MN4	53	29/05/2024 06:11	Size fractionated & frozen	
RS1	MN5	77	31/05/2024 15:37	Formaldehyde	
RS1	MN6	78	31/05/2024 17:09	Size fractionated & frozen	Copepods picked from Net 4 for respiration
RS2	MN7	95	03/06/2024 15:56	Formaldehyde	Copepods picked from Net 4 for respiration
RS2	MN8	96	03/06/2024 17:29	Size fractionated & frozen	
SS3	MN9	122	06/06/2024 21:38	Formaldehyde	
SS3	MN10	123	06/06/2024 23:24	Size fractionated & frozen	
SS3	MN11	144	08/06/2024 06:05	Formaldehyde	Net 1 not washed down before cod-end removed. Some of net 8 lost removing cod-end
SS3	MN12	145	08/06/2024 07:39	Size fractionated & frozen	
RS3	MN13	170	10/06/2024 14:38	Formaldehyde	Copepods picked from Net 4 for respiration
RS3	MN14	171	10/06/2024 16:02	Size fractionated & frozen	
SS4	MN15	190	12/06/2024 21:30	Formaldehyde	
SS4	MN16	191	12/06/2024 23:16	Size fractionated & frozen	
SS4	MN17	208	14/06/2024 05:59	Formaldehyde	
SS4	MN18	209	14/06/2024 07:23	Size fractionated & frozen	
RS4	MN19	231	16/06/2024 14:16	Formaldehyde	Copepods picked from Net 4 for respiration
RS4	MN20	232	16/06/2024 15:48	Size fractionated & frozen	
SS5	MN21	247	17/06/2024 22:13	Formaldehyde	
SS5	MN22	248	17/06/2024 23:54	Size fractionated & frozen	
SS5	MN23	271	20/06/2024 13:34	Formaldehyde	

SS5	MN24	272	20/06/2024 14:59	Size fractionated & frozen	
RS5	MN26	287	21/06/2024 14:03	Formaldehyde	Copepods picked from Net 4 for respiration
RS5	MN27	288	21/06/2024 15:38	Size fractionated & frozen	

Bongo net

A motion compensated Bongo net (53 cm diameter rings, 100µm mesh, non-filtering cod-ends) was deployed from the aft starboard using the NMF winch and starboard aft crane, which held the block. The net was moved gradually from the deck to vertical by hauling on the winch. Once suspended and clear of the deck, the net was moved outboard by the crane and the wire paid out to start the deployment. The net was deployed and retrieved at approx. 0.5 m/sec.

Each Bongo station consisted of 2 consecutive deployments. The first deployment, to 200m, was preserved using 4% borax buffered formaldehyde for later analysis using a FlowCam Macro, and ethanol for later enumeration of pelagic calcifiers (e.g. pteropods, foraminifera). The second deployment, to 50m, was immediately transferred to the controlled temperature laboratory which was set to 8 °C and used to collect live animals for grazing, respiration, and egg/faecal pellet production incubations as well as specimens for ETS/AARS and biochemical measurements (CHN, lipids, biomarkers, molecular, stoichiometry).

Day/night pairs of Bongo net samples were taken at each Superstation and Roaming Station.

Bongo net deployments during DY180

Stn.	Bongo No.	Event	Date/Time (UTC)	Depth (m)	Samples preserved?	Comments
SS1	BN1	21	27/05/2024 14:56	200	Formaldehyde & ethanol	
SS1	BN2	22	27/05/2024 15:18	50	Picking	
SS1	BN3	48	29/05/2024 01:04	200	Formaldehyde & ethanol	
SS1	BN4	49	29/05/2024 01:30	50	Picking	
RS1	BN5	61	30/05/2024 23:54	200	Formaldehyde & ethanol	
RS1	BN6	62	31/05/2024 00:20	50	Picking	
RS1	BN7	75	31/05/2024 14:23	200	Formaldehyde & ethanol	
RS1	BN8	76	31/05/2024 14:43	50	Picking	
RS2	BN9	93	03/06/2024 13:37	200	Formaldehyde & ethanol	Large angle on wire so deployed to 210m wire
RS2	BN10	94	03/06/2024 13:59	50	Picking	One codend lost tap and jubilee clip so only one sample
RS2	BN11	101	03/06/2024 23:05	200	Formaldehyde & ethanol	
RS2	BN12	102	03/06/2024 23:25	50	Picking	
SS3	BN13	112	06/06/2024 11:47	200	Formaldehyde & ethanol	
SS3	BN14	113	06/06/2024 12:06	50	Picking	

SS3	BN15	136	07/06/2024 23:01	200	Formaldehyde & ethanol	
SS3	BN16	137	07/06/2024 23:20	50	Picking	
RS3	BN17	154	10/06/2024 00:01	200	Formaldehyde & ethanol	
RS3	BN18	155	10/06/2024 00:28	50	Picking	
RS3	BN19	164	10/06/2024 09:49	200	Formaldehyde & ethanol	
RS3	BN20	165	10/06/2024 10:06	50	Picking	No egg production expt (very few females)
SS4	BN21	187	12/06/2024 17:58	200	Formaldehyde & ethanol	Collided with TM tow fish
SS4	BN22	188	12/06/2024 18:22	50	Picking	
SS4	BN23	202	13/06/2024 22:53	200	Formaldehyde & ethanol	
SS4	BN24	203	13/06/2024 23:12	50	Picking	
RS4	BN25	216	16/06/2024 01:10	200	Formaldehyde & ethanol	
RS4	BN26	217	16/06/2024 01:33	50	Picking	
RS4	BN27	225	16/06/2024 10:02	200	Formaldehyde & ethanol	
RS4	BN28	226	16/06/2024 10:20	50	Picking	
SS5	BN29	244	17/06/2024 16:02	200	Formaldehyde & ethanol	
SS5	BN30	245	17/06/2024 16:22	50	Picking	
SS5	BN31	259	18/06/2024 22:51	200	Formaldehyde & ethanol	
SS5	BN32	260	18/06/2024 23:09	50	Picking	
RS5	BN33	273	20/06/2024 23:57	200	Formaldehyde & ethanol	Strong current took net under ship
RS5	BN34	280	21/06/2024 08:58	200	Formaldehyde & ethanol	
RS5	BN35	281	21/06/2024 09:19	200	Picking	No egg production expt (very few females)
	BN36	294	22/06/2024 05:56	50	Picking	Radiotracer experiment only (Mark Moore)

CTD water samples
10L of water was collected at 450, 250, and 120m from each ‘Respire & General’ SS CTD, and at 450, 250, 120, 55, 15, and 5m from each ‘Optics & General’ SS CTD for lipid analysis. As much of the 10L as possible was filtered onto a 47mm GF/F filter which was frozen at -80ºC.

Up to 40L of water was collected at 55m or shallower at each station for use in grazing and egg production incubations.

CTD water sampled for lipids and mesozooplankton experiments during DY180

Stn.	CTD No.	Event	Date/Time (UTC)	Bottle No.	Depth (m)	Analysis	Volume filtered (L)	Comments
SS1	SS3	13	27/05/2024 07:24	2	450	Lipids	10.0	
				5	250	Lipids	10.0	
				8	120	Lipids	10.0	
				10	50	Experiment		
				11	50	Experiment		
SS1	SS5	36	28/05/2024 11:10	5	450	Lipids	14.0	
				7	250	Lipids	10.0	
				9	120	Lipids	10.0	
				11	55	Lipids	7.0	
				17	15	Lipids	5.5	
				21	5	Lipids	3.0	
RS1	SS8	64	31/05/2024 03:31	4	55	Experiment		
				7	40	Experiment		
RS1	SS9	71	31/05/2024 10:45	5	450	Lipids	11.0	
				7	250	Lipids	10.5	
				9	120	Lipids	10.5	
				11	55	Lipids	10.0	
				17	15	Lipids	7.5	
				21	5	Lipids	6.5	
RS2	SS12	89	03/06/2024 12:10	5	450	Lipids	9.8	
				7	250	Lipids	9.8	
				9	120	Lipids	10.0	
				11	55	Lipids	7.5	
				17	15	Lipids	7.5	
				21	5	Lipids	5.5	
				11	55	Experiment		
				12	55	Experiment		
SS3	SS14	106	06/06/2024 01:14	5	450	Lipids	9.8	
				8	250	Lipids	9.8	
				11	120	Lipids	10.0	
				14	55	Experiment		
				15	55	Experiment		
SS3	SS19	147	08/06/2024 11:01	5	450	Lipids	10.5	
				7	250	Lipids	11.0	
				9	120	Lipids	10.0	
				11	55	Lipids	10.5	
				17	15	Lipids	10.0	Visible copepods

				21	5	Lipids	8.5	
RS3	SS21	166	10/06/2024 11:11	5	450	Lipids	10.0	
				7	250	Lipids	12.0	
				9	120	Lipids	10.5	
				11	55	Lipids	11.5	
				17	15	Lipids	10.0	Visible copepods
				21	5	Lipids	11.5	
				11	30	Experiment		
				13	55	Experiment		
SS4	SS25	175	12/06/2024 01:14	6	450	Lipids	10.5	
				9	250	Lipids	10.4	
				12	120	Lipids	11.0	
				14	55	Experiment		
				15	55	Experiment		
SS4	SS29	210	14/06/2024 11:05	5	450	Lipids	10.8	
				7	250	Lipids	11.5	
				9	120	Lipids	10.6	
				11	55	Lipids	10.8	
				17	15	Lipids	8.0	
				21	5	Lipids	6.0	
RS4	SS32	227	16/06/2024 11:03	5	450	Lipids	10.5	
				7	250	Lipids	10.8	
				9	120	Lipids	10.6	
				11	55	Lipids	11.0	Visible amphipod
				17	15	Lipids	5.0	
				21	5	Lipids	5.0	
				11	55	Experiment		
				12	55	Experiment		
				13	30	Experiment		
				15	20	Experiment		
SS5	SS33	233	17/06/2024 07:38	5	450			Bottle misfired
				9	250	Lipids		Volume written on sample bag
				12	120	Lipids		Volume written on sample bag
				14	55	Experiment		
				15	55	Experiment		
SS5	SS37	268	20/06/2024 11:20	5	450	Lipids	11.0	
				7	250	Lipids	10.5	
				9	120	Lipids	11.0	
				11	55	Lipids	10.7	
				17	15	Lipids	7.0	

				20	5	Lipids	6.0	
RS5	SS40	283	21/06/2024 11:03	5	450	Lipids	10.0	
				7	250	Lipids	10.8	
				9	120	Lipids	10.6	
				11	55	Lipids	10.0	Visible copepods
				17	15	Lipids	10.0	
				20	5	Lipids	10.0	
				11	55	Experiment		
				13	30	Experiment		

Bulk faecal pellet & egg production incubations

Several hundred *Calanus* spp. stages C5 and C6F were collected from each station and incubated in a 350µm mesh bottomed container floating in a bucket of unscreened seawater from the same station. After 24 hours, the water was gently siphoned through a fine mesh to collect the faecal pellets and eggs. Subsamples of faecal pellets were taken for later SEM analysis, *Oithona* spp. grazing experiments, and for molecular quantification of *Emiliania huxleyi* virus, and at Roaming Station 04 for viral infectivity assays. Subsamples of 1000 eggs were filtered onto pre-combusted 25mm GF/F filters and stored frozen at -80ºC for subsequent CHN analysis.

Copepod grazing experiments

Experimental animals (*Calanus* spp. stages C5 and C6F, *Oithona* spp.) were sorted using a dissection microscope. Experimental water was collected via the CTD and was immediately transferred into HDPE carboys using wide-bore silicone tubing. Copepod grazing rates were examined using particle-removal experiments (Mayor et al., 2006). In brief, glass incubation bottles were filled with 200µm screened seawater. Experimental animals were carefully introduced into triplicate bottles and incubated alongside triplicate control bottles on a plankton wheel rotating at 1 rpm for 24 hr. Microplankton (100 mL, preserved with 1% acidified Lugol's iodine), flow cytometry (1.8mL, preserved with 50% glutaraldehyde) and chlorophyll samples were collected from the initial water and each of the incubated bottles. The incubated animals were transferred into tin cups for CHN analysis and stored frozen at -80ºC.

An additional one-off grazing experiment was carried out with the particle-associated copepod *Oithona* spp. offered faecal pellets produced by *Calanus* spp. to quantify their functional response and rates of faecal pellet fragmentation. In brief, glass incubation bottles were filled with 0.2µm filtered seawater and 0, 5 20 or 50 faecal pellets. Experimental animals were carefully introduced into triplicate bottles and incubated alongside triplicate control bottles on a plankton wheel rotating at 1 rpm for 24 hr. All bottles were then preserved with 1% Lugol's for later analysis.

Copepod grazing experiments conducting during DY180

Stn	Expt	Date start	Time start	Date end	Time end	Event (animals)	Event (water)	Species/ stage	n	Bottle (mL)	Lugol's	Chl	Flow cyt	CHN	Comments
SS1	GRZ1	27/05/24	18:15	28/05/24	18:50	22	13	Calanus C5	1	1000	Y		Y	Y	
			18:15		18:50			Calanus C6F	1	1000	Y		Y	Y	
			19:00		18:50			Oithona	20	200	Y		Y		
RS1	GRZ2	31/05/24	18:20	01/06/24	18:20	76	64	Calanus C5	1	1000	Y	Y	Y	Y	No pre-filter of water
								Calanus C6F	1	1000	Y	Y	Y	Y	
								Oithona	20	200	Y		Y		
RS2	GRZ3	03/06/24	18:25	04/06/24	18:30	94	89	Calanus C5	1	1000	Y	Y	Y	Y	
								Calanus C6F	1	1000	Y	Y	Y	Y	
		03/06/24	18:09	04/06/24	18:15			Oithona	20	200	Y		Y		
SS3	GRZ4	06/06/24	13:45	07/06/24	13:45	113	106	Calanus C5	5	1000	Y	Y	Y	Y	
								Calanus C6F	5	1000	Y	Y	Y	Y	
		06/06/24	14:31	07/06/24	14:30			Oithona	20	200	Y		Y		
SS3	GRZ5	10/06/24	03:00	11/06/24	03:00	155	0.2µm FSW + faecal pellets	Oithona	20	200	Y				0, 5, 20, 50 FP
RS3	GRZ6	10/06/24	14:15	11/06/24	14:30	165	166	Calanus C5	5	1000	Y	Y	Y	Y	
								Calanus C6F	5	1000	Y	Y	Y	Y	
								Oithona	20	200	Y		Y		Plankton wheel stopped ~1hr

SS4	GRZ7	12/06/24	19:50	13/06/24	18:10	188	175	Calanus C5	5	1000	Y	Y	Y	Y	Plankton wheel stopped ~ 2hr
								Calanus C6F	5	1000	Y	Y	Y	Y	
		12/06/24	20:25	13/06/24	18:10			Oithona	20	200	Y		Y		
RS4	GRZ8	16/06/24	14:45	17/06/24	14:40	217	227	Calanus C5	5	1000	Y	Y	Y	Y	
								Calanus C6F	5	1000	Y	Y	Y	Y	
								Oithona	20	200	Y		Y		
SS5	GRZ9	17/06/24	18:30	18/06/24	18:30	245	233	Calanus C5	5	1000	Y	Y	Y	Y	
								Calanus C6F	5	1000	Y	Y	Y	Y	
								Oithona	20	200	Y		Y		
RS5	GRZ10	21/06/24	13:30	22/06/24	13:20	281	283	Calanus C5	5	1000	Y	Y	Y	Y	
								Oithona	20	200	Y		Y		

Copepod egg production experiments conducting during DY180

Stn	**Expt**	**Date start**	**Time start**	**Date end**	**Time end**	**Event (animals)**	**Event (water)**	**Species**	**n**	**Comments**
SS1	EP1	27/05/24	18:11	18/05/24	18:15	22	13	Calanus	20	Female and egg samples not matched up
RS1	EP2	31/05/24	18:20	01/06/24	18:20	76	64	Calanus	20	Female 7 lost
RS2	EP3	03/06/24	19:00	04/06/24	18:30	94	89	Calanus	20	Female 12 lost
SS3	EP4	06/06/24	14:30	07/06/24	13:45	113	106	Calanus	20	Female 12 eggs lost; Female 20 lost
SS4	EP5	12/06/24	20:06	13/06/24	18:10	188	175	Calanus	19	
RS4	EP6	16/06/24	14:45	17/06/24	14:40	217	227	Calanus	18	
SS5	EP7	17/06/24	18:00	18/06/24	18:30	245	233	Calanus	18	

Copepod respiration experiments

Copepod respiration experiments were carried out at four superstations and five roaming stations, using PreSens loligo micro respirometers. At superstations copepods were taken from both shallow (50-0 m) day and night bongo net samples, while at roaming stations copepods were selected from the shallow bongos (50-0 m) and Net 4 (313-250 m) of the Mammoth net samples, where possible, and at roaming station 5 copepods were selected from the deep bongo (0-200m). At superstations 1-3, *Calanus* spp. were selected for respiration with *Calanus* spp. and *Oithona* spp. being selected at superstations 3-5. At roaming stations *Calanus* spp. were targeted.

The micro respirometer uses a 24 well plate populated with PreSens glass SensorVials of 2 ml and 4 ml, fitted with optode sensors at their base. The plate sits on a Sensor Dish Reader (SDR) connected to a laptop set up to read the oxygen levels in each well every 5 minutes. Prior to use SensorVials were hydrated with temperature equilibrated 0.2 µm filtered underway sea water, this was then replaced, vials filled and bubbles removed before experiments.

At superstation 1, 40 *Calanus* spp. were selected and placed individually straight into 4 ml vials to begin respiration experiments within 2.5 hours of the net being retrieved. At superstations 3-5, approximately 40 *Calanus* spp. were selected from both shallow bongo nets. Twenty *Calanus* spp. were placed individually into 4 ml SensorVials and respiration experiments took place straight away. The remaining individuals were transferred to plastic bottles containing filtered sea water and left in the dark to starve for a minimum of 4 hours. Following this starvation period individuals were placed in SensorVials and experiments conducted. At superstations 3 and 4 *Oithona* spp. were also collected to carry out a respiration trial. At these stations varying numbers of individuals (from 1 to 25) were placed in 2 ml vials to aid in optimising future *Oithona* spp. respiration experiments. Following these trials five *Oithona* spp. was deemed to be the minimum number of individuals required in a 2 ml vial. At superstation 5 ,100 *Oithona* spp. were selected from both the day and night bongo net samples and transferred into 0.2 µm filtered seawater for a minimum of 6 hours before being placed into 2 ml SensorVials for respiration experiments. Where possible, at roaming stations 2-5, approximately 30 *Calanus* spp. were also collected from Net 4 of the Mammoth net. At roaming stations 2 and 3 respiration experiments on individuals taken from the Mammoth net took place immediately after copepods were picked, whilst at roaming stations 3-5 copepods were placed in starvation bottles for a minimum of 6 hours before being transferred to SensorVials. Once populated, SensorVials were mounted on SDR readers in LMS incubators set to the average temperature from 0-50m or 250-300m (for those taken from the mammoth net) taken from a previous CTD. Respiration experiments were run for a minimum of 6 hours.

Following completion of experiments, *Calanus* spp. were removed from each SensorVial and photographed individually using an integrated Leica microscope camera (Camera: IC90E, Microscope: Leica M80) on a rimmed petri dish, before being prepared for CHN analysis through being placed in a tin capsule and stored frozen at -80 ºC. Photographs were taken of a selection of *Oithona* spp. following respiration experiments to allow a representative size estimate to be made. At superstation 5 each SensorVial containing *Oithona* spp. was filtered onto a separate pre-ashed 25mm GF/F filter and stored frozen at -80ºC for subsequent CHN analysis.

Copepod biochemistry

Samples of copepods for biomarker analysis were picked from individual Bongo net samples. Replicates of 5 or 10 *Calanus* spp. stages C5 and C6F were transferred into glass vials for ETS/AARS, lipids and biomarker analyses and stored frozen. Replicates of 50 *Oithona* spp. were transferred onto 25mm GF/F filters for ETS/AARS measurements and stored frozen. Replicates of 5 *Calanus* spp. stages C5 and C6F were transferred into tin cups for CHN analysis and stored frozen. All frozen material was stored at -80 °C. Replicates of 5 *Calanus* spp. stages C5 and C6F and 10 *Oithona* spp.

were transferred into glass vials containing RNA/DNA Shield for molecular analysis of gut contents and kept refrigerated.

Pteropod and foraminifera samples were collected for particulate inorganic carbon (PIC) analysis. All of the pteropods and foraminifera were collected by swirling the Bongo net samples until the foraminifera and pteropods fell out of suspension and collected in the center of the bucket. The pteropods and foraminifera were filtered onto 47 mm diameter 5µm filters and frozen to be stored for analysis.

Copepod respiration experiments carried out during DY180.

Stn.	Net No.	Event	Event Date/ Time (UTC)	Depth (m)	Species	Number	Starved/ Unstarved	Respiration Start	Respiration End
SS1	BN2	22	27/05/2024 15:18	0-50	Calanus	40	Unstarved	27/05/2024 17:48	28/05/2024 01:51
SS1	BN4	49	29/05/2024 01:30	0-50	Calanus	40	Unstarved	29/05/2024 03:39	29/05/2024 11:39
RS1	BN8	76	31/05/2024 14:43	0-50	Calanus	20	Unstarved	31/05/2024 16:40	31/05/2024 22:58
RS1	MN6	78	31/05/2024 17:09	250-313	Calanus	20	Unstarved	31/05/2024 19:36	01/06/2024 01:58
RS2	BN10	94	03/06/2024 13:59	0-50	Calanus	20	Unstarved	03/06/2024 15:36	03/06/2024 21:56
RS2	MN7	95	03/06/2024 15:56	250-313	Calanus	15	Unstarved	03/06/2024 18:22	04/06/2024 01:01
SS3	BN14	113	06/06/2024 12:06	0-50	Calanus	20	Unstarved	06/06/2024 13:09	06/06/2024 19:30
					Calanus	20	Starved	06/06/2024 18:30	07/06/2024 01:00
					Oithona	108	Unstarved	06/06/2024 14:58	06/06/2024 21:48
SS3	BN16	137	07/06/2024 23:20	0-50	Calanus	20	Unstarved	08/06/2024 00:20	08/06/2024 07:40
					Calanus	20	Starved	08/06/2024 09:32	08/06/2024 18:12
RS3	BN18	155	10/06/2024 00:28	0-50	Calanus	20	Starved	10/06/2024 11:09	10/06/2024 19:42
RS3	BN20	165	10/06/2024 10:06	0-50	Calanus	20	Starved	10/06/2024 19:42	11/06/2024 02:54
RS3	MN13	170	10/06/2024 14:38	250-313	Calanus	20	Starved	10/06/2024 22:35	11/06/2024 07:07
SS4	BN22	188	12/06/2024 18:22	0-50	Calanus	20	Unstarved	12/06/2024 19:30	13/06/2024 02:15
					Calanus	20	Starved	13/06/2024 01:30	13/06/2024 08:05
SS4	BN24	203	13/06/2024 23:12	0-50	Calanus	20	Unstarved	14/06/2024 00:07	14/06/2024 07:59
					Calanus	20	Starved	14/06/2024 07:59	14/06/2024 14:41
					Oithona	225	Starved	14/06/2024 09:40	14/06/2024 18:03
RS4	BN28	226	16/06/2024	0-50	Calanus	20	Unstarved	16/06/2024 11:22	16/06/2024 18:47

			10:20		Calanus	20	Starved	16/06/2024 18:48	17/06/2024 02:00
RS4	MN19	231	16/06/2024 14:16	250-313	Calanus	20	Starved	16/06/2024 18:51	17/06/2024 02:30
SS5	BN30	245	17/06/2024 16:22	0-50	Calanus	20	Unstarved	17/06/2024 17:17	18/06/2024 00:20
					Calanus	20	Starved	18/06/2024 00:13	18/06/2024 07:55
					Oithona	200	Starved	18/06/2024 00:40	18/06/2024 07:55
SS5	BN32	260	18/06/2024 23:09	0-50	Calanus	20	Unstarved	19/06/2024 00:10	19/06/2024 06:44
					Calanus	20	Starved	19/06/2024 08:05	19/06/2024 14:03
					Oithona	200	Starved	19/06/2024 07:35	19/06/2024 14:15
RS5	BN35	281	21/06/2024 09:19	0-200	Calanus	20	Unstarved	21/06/2024 10:15	21/06/2024 16:05
					Calanus	20	Starved	21/06/2024 16:20	21/06/2024 22:05
RS5	MN26	287	21/06/2024 14:03	250-313	Calanus	20	Starved	21/06/2024 22:35	22/06/2024 05:09

Copepod biochemistry samples taken from Bongo net deployments during DY180

Stn.	Bongo No.	Event	Species	Stage	ETS		Lipids		Biomarkers		Molecular		CHN		Stoichiometry	PIC	SEM
					n	reps	n	reps	n	reps	n	reps	n	reps	n		
SS1	BN2	22	Calanus	C5	10	3	5	3	10	3	5	3	5	3			
			Calanus	C6F	10	3	5	3	10	3	5	3	5	3	20		
			Oithona		50	3					10	3					
SS1	BN4	49	Calanus	C5	10	3											
			Calanus	C6F	10	3											
			Oithona		50	3											
RS1	BN6	62	Calanus	C5	10	3											
			Calanus	C6F	10	3											
			Oithona		50	3											
RS1	BN8	76	Calanus	C5	10	3	5	3	10	3	5	3	5	3			

			Calanus	C6F	10	3	5	3	10	3	5	3	5	3			
			Oithona		50	3											
			Pteropods													Y	
RS2	BN10	94	Calanus	C5	10	3	5	3	10	3	5	3	5	3			
			Calanus	C6F	10	3	5	3	10	3	5	3	5	3			
			Oithona		50	3											
			Pteropods													Y	
			Foraminifera														
RS2	BN12	102	Calanus	C5	10	3											
			Calanus	C6F	10	3									20		
			Oithona		50	3											
			Calanus	Faecal pellets (FP)													Y
SS3	BN14	113	Calanus	C5	10	3	5	3	10	3	5	3	5	3			
			Calanus	C6F	10	3	5	3	10	3	5	3	5	3			
			Oithona		50	3					10	3					
			Pteropods													Y	
			Foraminifera													Y	
SS3	BN16	137	Calanus	C5	10	3											
			Calanus	C6F	10	3									20		
			Oithona		50	3											
			Calanus	Eggs									1000	1			
RS3	BN18	155	Calanus	C5	10	3											
			Calanus	C6F	10	3											
			Oithona		50	3											
			Calanus	Eggs									1000	1			
			Calanus	FP													Y
RS3	BN20	165	Calanus	C5	10	3	5	3	10	3	5	3	5	3			
			Calanus	C6F	10	3	5	3			5	3	5	3	20		

			Oithona		50	3											
			Pteropods														
			Foraminifera														
SS4	BN22	188	Calanus	C5	10	3	5	3	10	3	5	3	5	3			
			Calanus	C6F	10	3	5	3	10	3	5	3	5	3			
			Oithona		50	3					10	3					
			Pteropods													Y	
			Foraminifera													Y	
SS4	BN24	203	Calanus	C5	10	3											
			Calanus	C6F	10	3									20		
			Oithona		50	3											
			Calanus	Eggs									700	1			
			Calanus	FP													Y
RS4	BN26	217	Calanus	C5	10	3	5	3	10	3	5	3	5	3			
			Calanus	C6F	10	3	5	3	10	3	5	3	5	3			
			Oithona		50	3					10	3					
			Pteropods													Y	
			Foraminifera													Y	
RS4	BN28	226	Calanus	C5	10	3											
			Calanus	C6F	10	3											
			Oithona		50	3											
			Calanus	FP													Y
SS5	BN30	245	Calanus	C5	10	3	5	3	10	3	5	3	5	3			
			Calanus	C6F	10	3	5	3	10	3	5	3	5	3			
			Oithona		50	3					10	3					
			Calanus	Eggs									1000	1			
			Calanus	FP													Y
			Pteropods													Y	
			Foraminifera													Y	
SS5	BN32	260	Calanus	C5	10	3											

			Calanus	C6F	10	3									20		
			Oithona		50	3											
			Calanus	FP													Y
RS5	BN35	281	Calanus	C5	10	3	5	3	10	3	5	3	5	3			
			Calanus	C6F	10	3							5	3			
			Oithona		50	3											
			Calanus	FP													Y
			Pteropods													Y	
			Foraminifera													Y	
			Calanus	C6F											20		
	BN36	294	Pteropods													Y	
			Foraminifera													Y	

Microbial respiration

Carol Robinson (UEA), Marta Cecchetto (Heriot Watt), Natalia Osma (University of Antofagasta) and Igor Fernández-Urruzola (Millennium Institute of Oceanography)

The Respiration team onboard: L-R Marta Cecchetto, Carol Robinson, Marilena Heitger, Chie Amano, Elena Garcia-Martin

The work of the microbial respiration team contributes to addressing 4 hypotheses within the BIOCARBON CHALKY and PARTITRICS projects:

CHALKY

H4 Plankton community respiration is enhanced in 'white waters' due to bacterial consumption of lysed material, and/or a high respiratory cost for zooplankton ingesting a $CaCO_3$-rich diet

H5 Recycling of coccolithophore $CaCO_3$ in the upper ocean, combined with enhanced plankton community respiration and low export of $CaCO_3$, cause seasonal reductions in the air-sea CO_2-influx

PARTITRICS

H3 Microbial respiration by particle-attached microbes predominantly varies with particle type and pressure, and microbial respiration by free-living microbes varies with pressure, temperature and oxygen concentration

H4 The relative influence of microbial respiration, zooplankton activity and particle characteristics on the depth at which particulate organic carbon is respired changes seasonally

Specific Objectives

1. Determine plankton community respiration from consumption of dissolved oxygen (CR_{O2}) within the epipelagic depths dominated by coccolithophores
2. Determine microbial respiration from consumption of dissolved oxygen (CR_{O2}) at the mesopelagic depths at which the ISMI (In Situ Microbial Incubator) is deployed to compare with respiration derived by the Redox Sensor Green fluorescence method undertaken by Chie Amano and Marilena Heitger (University of Vienna)
3. Determine plankton respiration (surface to 1000m) within the size fractions 0.1-0.8 µm (bacterioplankton), 0.8-2.0 µm, 2-20 µm (nanoplankton, including coccolithophores) and >20 µm (microplankton including microzooplankton) from both the classical electron transport system (ETS) method and using an enzyme kinetic model (EKM) incorporating pyridine nucleotide concentrations
4. Determine plankton community respiration (<200 µm, surface to 1000m) from the classical electron transport system (ETS) method to compare with the current global database of ETS measurements
5. Determine the relationship between plankton respiration derived from dissolved oxygen consumption (CR_{O2}) and that derived from the activity of the ETS

Methods

Plankton community respiration derived from the decrease in dissolved oxygen concentration (CR_{O2})

CR_{O2} was determined as the decrease in dissolved oxygen concentration of a water sample incubated in the dark (Robinson et al., 2002; Serret et al., 2015). Water samples were collected into 10L carboys from up to eight depths from the early morning CTD casts (01:00 to 04:00 UTC) between the surface and 1000m. Ten gravimetrically calibrated ~55 ml glass bottles were filled with water from each depth. Five bottles were 'fixed' at the start of the incubation ("zero time samples") with 0.75 ml of manganese sulphate ($MnSO_4$) and 0.75 ml of a solution of sodium iodide and sodium hydroxide (NaI/NaOH). The other five bottles were placed underwater in temperature-controlled incubators ("dark incubated samples"). We aimed to have the incubation temperatures within ±0.5 °C of the in situ temperature. Bottles were removed from the incubators after the incubation (24 hours) and fixed with $MnSO_4$ and NaI/NaOH. Dissolved oxygen concentration was measured by automated Winkler titration using a Metrohm 765 titrator to a photometric end point (Carritt & Carpenter, 1966; Williams and Jenkinson, 1982). Plankton community respiration was calculated as the difference in oxygen concentration between the means of the "zero" and "dark" measurements and reported with an associated standard error.

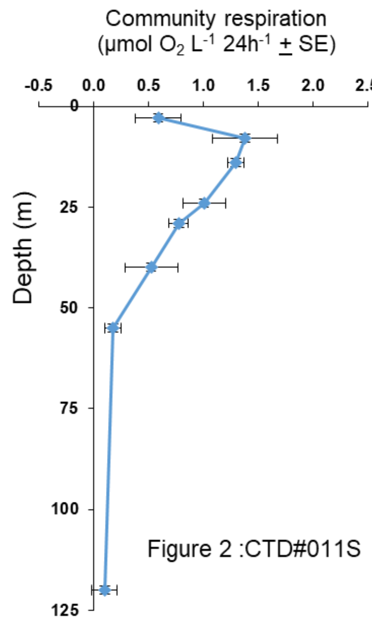
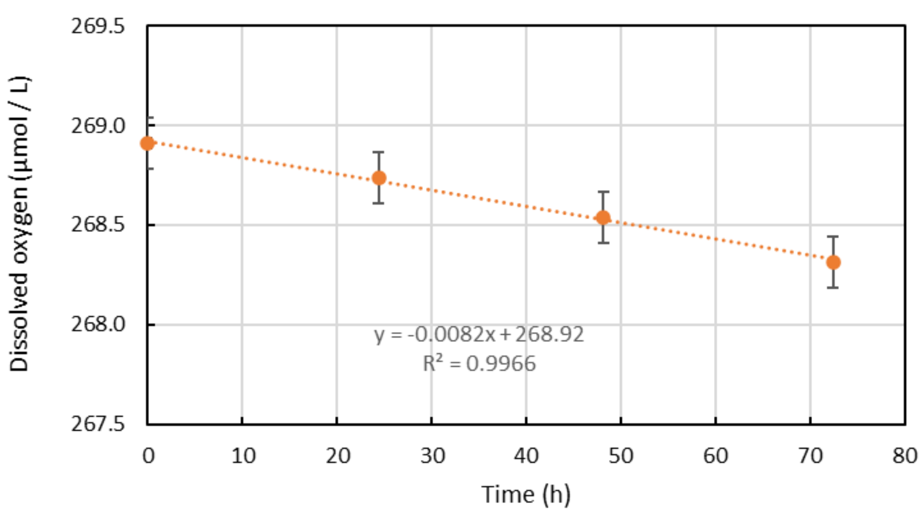


Figure 2 :CTD#011S

At depths greater than 120m, time series experiments were undertaken with respiration measured at time points of 24, 48, 72 and 96 hours. Samples were analysed at each time point by Glen Tarren (PML) for the abundance of high nucleic acid and low nucleic acid containing heterotrophic bacteria.

Figure 3 CTD 019S 250m



Sampling times, locations and Niskin bottles sampled for plankton community respiration are given in the table below.

Community and size fractionated respiration measured with the classical electron transport system (ETS) method

Water samples were collected from the early morning CTD casts into 20 L carboys from Niskin bottles closed at the same depths as the CR_{O2} samples described above. Between 10-40 L of seawater, depending on the depth, were filtered through 4 polycarbonate filters (20 µm, 2.0 µm, 0.8 µm and 0.1 µm), allowing the estimation of the contribution of each size class of the plankton community to the total respiration. The filters were snap-frozen in liquid nitrogen (-196 ^{o}C) and stored at -80 ^{o}C. At the 'superstation' a full depth ETS profile (0-1000m) was also collected using the traditional GFF filters with no size fractionation. Samples were collected for flow cytometric analysis (Glen Tarren, PML) to assess the community within each size class and to determine the abundance of heterotrophic bacteria which were not captured on the GFF or the 0.1 µm filters. Samples will be transported back to UEA for subsequent kinetic analyses of the electron transport system activity (ETS) following the Kenner and Ahmed (1975) protocol.

Filtering from the early morning CTDs

See table below for a list of samples collected.

Community and size fractionated respiration derived from pyridine nucleotide concentrations and an enzyme kinetic model (EKM)

The same procedure as that described for the classical ETS method was followed for water collection and sample processing. These filters will be analysed at UEA for the intracellular concentration of pyridine nucleotides (Wagner and Scott, 1994, as modified by Osma et al., 2016) in order to apply a kinetic model that uses the potential respiratory activity (ETS), kinetic enzymatic constants and the concentration of intracellular substrates to estimate actual respiration rates.

Acknowledgements

Many thanks to everyone who helped carry our samples from the CTD to the constant temperature (CT) room, to the other users of the CT room who allowed us to turn the lighting red while we filled all the oxygen bottles and to the sample collectors, filterers and analysers of particulate organic carbon who will enable us to derive carbon specific respiration rates. Special thanks to Reuben Forrester, Elena Garcia Martin and Cordelia Roberts who helped build and tame the ETS filtration system variously known as Pearl (when working) and Ursula (when being temperamental). Many thanks to Glen Tarran whose flow cytometric analysis will help constrain the uncertainty on the time series and size fractionation experiments. Huge thanks to the Principal Scientist and Biocarbon project Principal Investigators for keeping us on track and to the excellent technical team and ship's staff for deploying

the CTDs safely and efficiently.

References

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CTD samples collected for plankton community respiration derived from oxygen consumption

DATE	TIME (UTC)	CTD CAST	STATION	LAT (+ve N)	LON (+ve E)	NISKINS SAMPLED	PARAMETERS
27/05/2024	04:40	003S	S1	59.1897	-22.423	24, 22, 20	24h oxygen consumption
27/05/2024	04:40	003S	S1	59.1897	-22.423	16, 13, 8, 3	96h time series
28/05/2024	05:20	006S	S1	60.0001	-24.0002	24,20,18,16,14, 10, 6, 3	24h oxygen consumption
31/05/2024	03:27	011S	R1	56.2160	-26.8302	24,20,18,16,14, 10,6,3	24h oxygen consumption
02/06/2024	04:23	014S	S2	60.1923	-23.7194	24,22,20	24h oxygen consumption
02/06/2024	04:23	014S	S2	60.1923	-23.7194	16,13, 8, 3	96h time series
04/06/2024	04:02	017S	R2	57.114	-26.2818	24,20,18,16,14, 10,6,3	24h oxygen consumption
06/06/2024	04:22	019S	S3	59.4338	-22.6406	24,22,20	24h oxygen consumption
06/06/2024	04:22	019S	S3	59.4338	-22.6406	16, 13	96h time series
07/06/2024	04:54	021S	S3	59.4316	-22.6249	24,20,18,16,14, 10,6,3	24h oxygen consumption
08/06/2024	02:05	023S	S3	59.36755	-22.4838	5, 1	96h time series
10/06/2024	03:40	026S	R3	57.2313	-28.3431	24,20,18,16,14, 10,6,3	24h oxygen consumption
12/06/2024	04:42	032S	S4	59.2447	-22.0781	24, 22, 20	24h oxygen consumption
12/06/2024	04:42	032S	S4	59.2447	-22.0781	16,13	96h time series
16/06/2024	04:22	039S	R4	58.98127	-24.6766	24, 20, 18, 16, 14, 10, 6, 3	24h oxygen consumption
17/06/2024	05:51	042S	S5	60.23761	-21.1966	24, 22, 20	24h oxygen consumption
17/06/2024	05:51	042S	S5	60.23761	-21.1966	16, 6	96h time series
18/06/2024	06:04	044S	S5	60.25954	-21.081	24, 20, 18, 16, 14, 10, 6, 3	24h oxygen consumption
21/06/2024	03:27	048S	R5	60.12021	-18.9386	24, 20, 18, 16, 14, 10, 6, 3	24h oxygen consumption

CTD samples collected for ETS / EKM analysis

DATE	TIME (UTC)	CTD CAST	STATION	LAT (+VE N)	LON (+VE E)	NISKINS SAMPLED	FILTER SIZE (µm)	DEPTH (m)	ETS/EKM
27/05/2024	04:40	003S	S1	59.1897	-22.423	23, 21, 19, 18, 17, 15, 14, 12, 11, 10, 9, 7, 6, 5, 4, 2, 1	20, 2.0, 0.8, 0.1	30, 55, 120, 250, 450, 750, 1000	ETS/EKM

28/05/2024	05:20	006S	S1	60.0001	-24.0002	24, 23, 22, 21,19, 17, 15, 14, 13, 12, 11, 10, 9, 8,7, 5, 4, 2, 1	20, 2.0, 0.8, 0.1	3, 5, 10, 17, 20, 30, 55, 120	ETS/EKM
29/05/2024	12:07	008S	S1	59.9999	-23.9996	24, 22, 20, 18, 16, 14, 13, 11, 10, 8, 7, 5, 4	GF/F	5, 20, 30, 55, 120, 250, 450, 750, 1000	ETS
31/05/2024	03:27	011S	R1	56.2160	-26.8302	23, 22, 19, 17, 15, 13, 12, 9, 8, 5, 2, 1	20, 2.0, 0.8, 0.1	3, 8, 14, 24, 29, 40, 55, 120	ETS/EKM
02/06/2024	04:23	014S	S2	60.1923	-23.7194	23, 21, 19, 18, 17, 15, 14, 12, 11, 10, 9, 7, 6, 5, 4, 2, 1	20, 2.0, 0.8, 0.1	30, 55, 120, 250, 450, 750, 1000	ETS/EKM
04/06/2024	04:02	017S	R2	57.114	-26.2818	23, 22, 19, 17, 15, 13, 13, 12, 9, 8, 5, 2	20, 2.0, 0.8, 0.1	3, 6, 10, 17, 20, 30, 55, 120	ETS/EKM
06/06/2024	04:22	019S	S3	59.4338	-22.6406	23, 21, 19, 18, 15, 12, 10, 7, 5, 1	20, 2.0, 0.8, 0.1	30, 55, 120, 250, 450, 750, 1000	ETS/EKM
07/06/2024	04:54	021S	S3	59.4316	-22.6249	23, 22, 19, 17, 15, 13, 13, 12, 9, 8, 5, 2	20, 2.0, 0.8, 0.1	3, 7, 15, 20, 25, 37, 55, 120	ETS/EKM
08/06/2024	02:05	023S	S3	59.36755	-22.4838	24, 22, 20, 18, 16, 14, 13, 11, 10, 8, 7, 3, 1	GF/F	5, 20, 30, 55, 120, 250, 450, 750, 1000	ETS
10/06/2024	03:40	026S	R3	57.2313	-28.3431	23, 22, 19, 17, 15, 13, 12, 9, 8, 5, 2	20, 2.0, 0.8, 0.1	3, 7, 15, 25, 30, 45, 55, 120	ETS/EKM
12/06/2024	04:42	032S	S4	59.2447	-22.0781	23, 21, 19, 18, 15, 12, 10, 7, 5, 1	20, 2.0, 0.8, 0.1	30, 55, 120, 250, 450, 750, 1000	ETS/EKM
13/06/2024	4:22	034S	S4	59.28471	-21.9512	23, 22, 19, 17, 15, 13, 12, 9, 8, 5, 2	20, 2.0, 0.8, 0.1	3, 8, 14, 20, 26, 40, 55, 120	ETS/EKM
14/06/2024	2:08	035S	S4	59.41707	-21.807	24, 22, 20, 18, 16, 14, 13, 11, 10, 8, 7, 4, 3	GF/F	5, 20, 30, 55, 120, 250, 450, 750, 1000	ETS
16/06/2024	06:14	039S	R4	59.01376	-24.6681	23, 22, 19, 17, 15, 13, 12, 9, 8, 5, 2	20, 2.0, 0.8, 0.1	3, 6, 10, 15, 20, 30, 55, 120	ETS/EKM

17/06/2024	10:05	042S	S5	60.23761	-21.1966	23, 21, 19, 18, 15, 12, 10, 7, 5, 1	20, 2.0, 0.8, 0.1	30, 55, 120, 250, 450, 750, 1000	ETS/EKM
18/06/2024	06:04	044S	S5	60.25954	-21.081	23, 22, 19, 17, 15, 13, 12, 9, 8, 5, 2	20, 2.0, 0.8, 0.1	3, 6, 10, 15, 20, 30, 55, 120	ETS/EKM
19/06/2025	04:33	044S	S5	60.26925	-21.2126	24, 22, 20, 18, 16, 14, 13, 11, 10, 8, 7, 4, 3	GF/F	5, 20, 30, 55, 120, 250, 450, 750, 1000	ETS
21/06/2024	03:27	048S	R5	60.12021	-18.9386	23, 22, 19, 17, 15, 13, 12, 9, 8, 5, 2	20, 2.0, 0.8, 0.1	5, 9, 16, 23, 29, 45, 55, 120	ETS/EKM

Drift-SPIRE array deployments

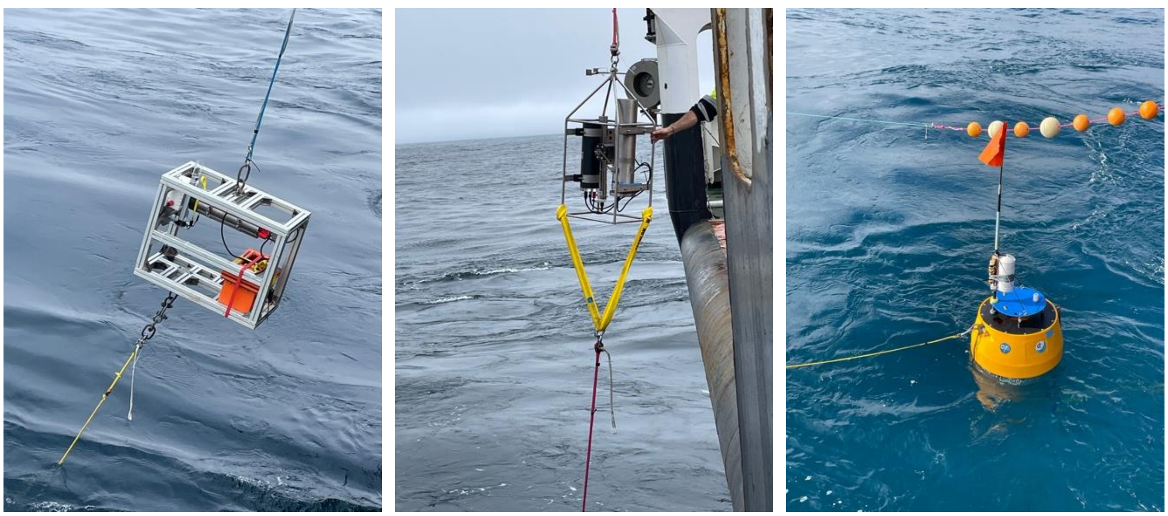
Filipa Carvalho, Nathan Briggs, Will Major (NOC)
Shore-side: Matthiew Bressac (RESPIRE, Partner at LOV), Morten Iverson (Drift-CAM, Partner at AWI)

Description

The Drift-SPIRE array consists of 3 RESPIRE (REspiration of Sinking Particles In the subsuRface ocEan particle interceptors) traps and a Drift-CAM, mounted at different depths on a free-drifting surface-tethered array for an average duration of 2.5 days.

The full drifting array was designed and supplied by our project partner, Matthieu Bressac from LOV (France). The three traps were deployed at nominal depths of 120m, 250m and 450m, the last one conditioned by the maximum operational depth of the controllers. The drift-CAM was placed 10m below the shallowest RESPIRE at around 130m. a Seabird39 microcat, measuring temperature, conductivity and pressure was fitted in each of the RESPIRE frames to provide the actual depth that the traps were during the deployment. Though the actual depths differed from the conceptual design, 124-126m, 269m and 420-424m, this document will continue to refer to the nominal depths.

The surface buoy, also supplied by LOV, was fitted with a flashlight, an AIS and an iridium beacon, communicating its GPS position every 30 mins.



Left: Drift-CAM; middle: RESPIRE trap; right: surface buoy with light, flag and GPS tracker and AIS.

The main goal of deploying the RESPIRE traps during BIO-Carbon was to collect in situ rates of bacterial remineralisation on sinking particles in the mesopelagic zone. RESPIRE traps are composed by a titanium cylinder equipped with an indented rotating sphere (IRS) which collects sequentially the sinking particles during the first period of the deployment (collection period), and deposit them into a virtually closed incubation chamber (<0.6 mm gap between IRS and trap cylinder walls), where an oxygen optode (Aanderaa 4831 series) measures dissolved oxygen concentration and temperature. The rotation of the sphere is programmed to stop after a given amount of time ("end of the collection") and marks the beginning of the "incubation time". A "delay period" is also set to allow the traps to be deployed and settle at the right depth before the collection period starts. Oxygen concentration is measured during the whole deployment (delay, collection and incubation) and the rate of its decrease during the incubation period is a metric of particle remineralisation related to particle-attached bacteria.

Process of emptying the RESPIRE trap (top), splitting the sample (middle left), particles accumulated in the chamber after 2.5 days at sea (middle right), removing the particles from the bottom plate (bottom left) and zoom in on 120m trap particle from the 4th RESPIRE deployment (during SS5).

Deployments during D180

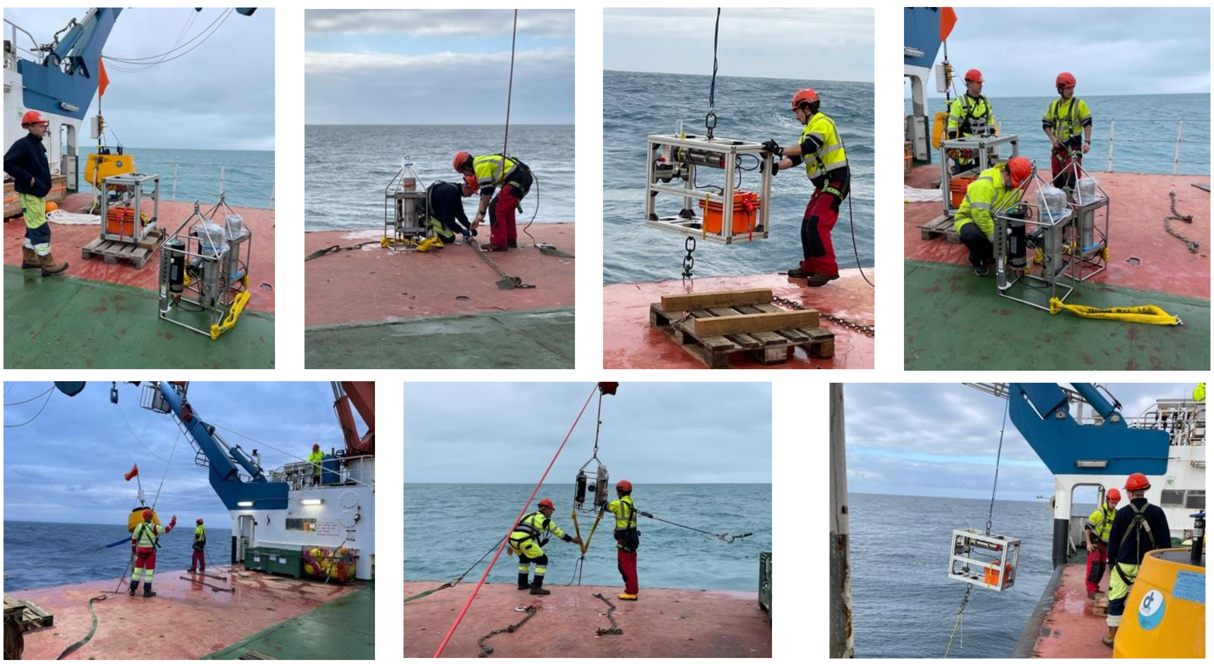
Before the first deployment

- The RESPIREs came pre-mounted from Matthieu at LOV (O-rings, sphere + shaft, baffle).
- Trap, motor and belt (linking the motor and the shaft) were fitted in the frame
- Optode and O-rings on the base plate were fitted (no lubrication). Optode cap was removed.

- Traps were fitted onto the frame using the provided brackets (using pieces of rubber to avoid metal-metal contact).
- Batteries were plugged inside the controller and controller also fitted onto the frame.
- Cables were connected between the controller, optode and motor.
- Incubation chamber was filled will Milli-Q water 2 days before the deployment in order to pre-condition the foil of the optode.

Mooring line & RESPIRE instruments preparation

- MicroCats were clamped to the metal frame
- RESPIRE traps were gently filled with seawater collected at the deployment depth from the RESPIRE CTD, keeping a bag covering the trap at all times
- RESPIRE controllers were pre-programmed
- Once the RESPIRE is pre-programmed, the green led was flashing (controller). In the new controller, a red light was also on (solid).
- RESPIREs were kept in the hangar until deployment



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

Deployment/recovery procedure

- Both the deployments and recoveries took between 1-2 hours
- During deployment and recovery, the array was lifted or lowered slower than ~0.2 m/s
- All shackles were secured with a cable tie.
- Array deployment started by deploying the weight (surface buoy at the end)
- For each trap, the bottom was secured to the line using 2 yellow webbing slings
- Bag was kept on the trap until the last minute, right before the frames were lowered towards the water – same thing during recovery, bags were placed on the traps as soon as they were lifted to deck height
- Traps were kept s as vertical as possible during deployment/recovery
- The logbook (logbook_RESPIRE_PARTITRICS.xlsx) was filled after the deployment/recovery

- We were not able to turn the Iridium beacon off, so it reported its position even while on deck in between deployments. AIS and flashlight were turned on for deployment, and charged in between deployments

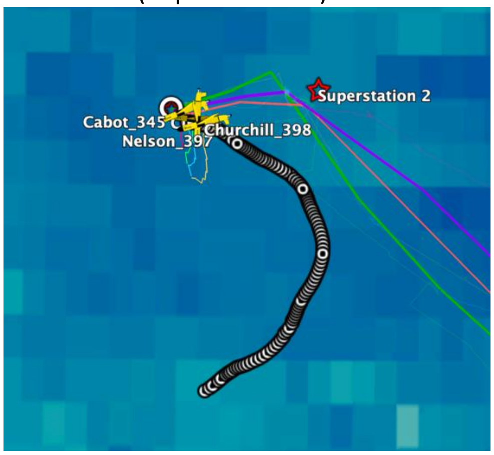
RESPIRE deployment/recovery details during DY180

	deployment_ID	Event 016 RESPIRE001			Event 110 RESPIRE002			Event 180 RESPIRE003			Event 238 RESPIRE003		
RESPIRE	depth_m	120	250	450	120	250	450	120	250	450	120	250	450
	trap_ID	R3	R2	R1	R2	R3	R1	R1	R3	R2	R1	R2	N/A
	controller_ID	C_R_2	C_R_1	C_R_5	C_R_1	C_R_3	C_R_5	C_R_5	C_R_3	C_R_1	C_R_5	C_R_1	N/A
	motor_ID	M_R_1	M_R_3	M_R_2	M_R_3	M_R_1	M_R_2	M_R_2	M_R_1	M_R_3	M_R_2	M_R_3	N/A
	optode_SN	278	787	881	787	278	881	881	278	787	881	787	N/A
	MicroCat_SN	7291	7292	9382	7292	9382	7291	7291	N/A	7292	TBC	TBC	N/A
INITIAL SEAWATER	Event	013	013	013	106	106	106	175	175	175	233	233	N/A
	CTD_ID	CTD004S	CTD004S	CTD004S	CTD018S	CTD018S	CTD018S	CTD031S	CTD031S	CTD031S	CTD041S	CTD041S	N/A
MISSION PARAMETERS	start_trigger_UTC	27/05/2024 08:36:00	27/05/2024 08:33:00	27/05/2024 08:18:00	06/06/2024 08:01:00	06/06/2024 07:01:00	06/06/2024 06:56:00	12/06/2024 06:59:00	12/06/2024 05:55:00	12/06/2024 07:30:00	17/06/2024 10:55:00	17/06/2024 11:04:00	N/A
	battery_V	11.15	11.15	11.61	11.6	11.6	11.46	11.32	11.17	11.25	11.38	11.42	N/A
	start_delay_h	4	4	4	3	4	4	0	0	0	0	0	N/A
	collection_duration_h	32	32	32	24	24	24	28	28	28	27	27	N/A
	mission_duration_h	96	96	96	96	96	96	96	96	96	96	96	N/A
	rotation_speed	170	170	170	170	170	170	170	170	170	170	170	N/A
	rotation_time_s	60	60	60	60	60	60	60	60	60	60	60	N/A
	rotation_interval_min	10	10	10	10	10	10	10	10	10	10	10	N/A
	O2_sampling_min	5	2	5	2	5	5	2	2	2	2	2	N/A
DEPLOYMENT	date_UTC	2024-05-27 13:03:00			2024-06-06 09:11:21			2024-06-12 09:32:15			2024-06-17 11:37:00		
	lat_N	59.988422			59.439427			59.238827			60.23903		
	lon_E	-23.968429			-22.649149			-22.069033			-21.1887		
RECOVERY	date_UTC	2024-05-29 22:01:13			2024-06-08 21:03:05			2024-06-14 16:36:02			2024-06-20 04:55:00		
	lat_N	59.727939			59.426351			59.544667			60.26794		
	lon_E	-23.983381			-21.495848			PS138_20			-21.2072		
	COMMENTS	No file was logged			No file was logged	No file was logged			Optode didn't work on deck, so it wasn't deployed				Not deployed

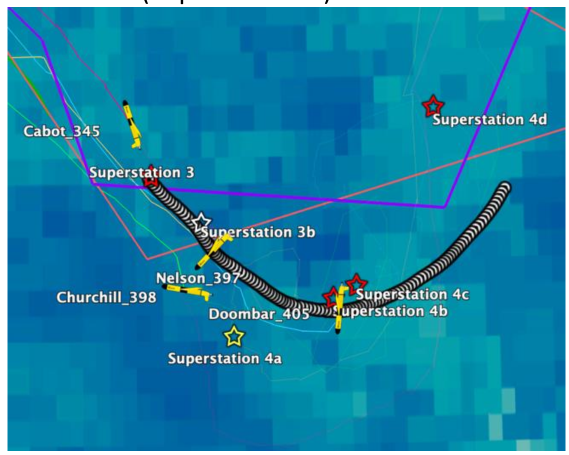
For all missions, controllers were setup in the hangar prior to deployment and mission was started in the lab before frames were moved outside.
Generally, mission was setup as follows:

- IRS rotation frequency: 10 mins
- IRS rotation time: 60 (deployments 001-002) and 50 secs (deployments 003-005)
- dO2 Sampling period: 2-5 mins
- Delay: 4 hours (0 for last 2 deployments due to controllers not logging)
- Collection:
    - 32h initially
    - 24 hours (decreased due to enough concentration of particles and short deployment duration constraints)
    - 28h (increased when troubleshooting why the controllers weren't logging, to account for 0h delay).
- Incubation: ~24 hours

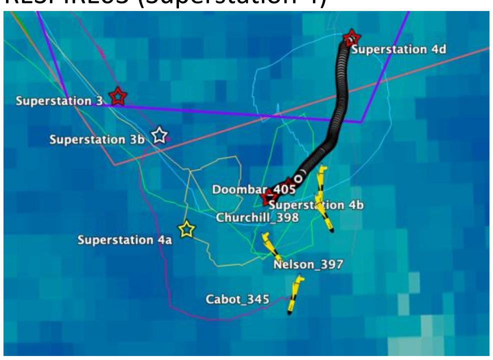
RESPIRE01 (Superstation 1)



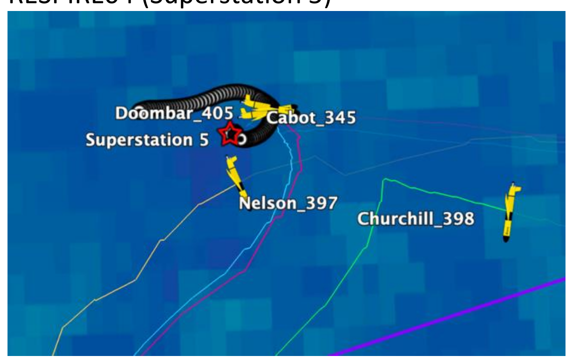
RESPIRE02 (Superstation 3)



RESPIRE03 (Superstation 4)



RESPIRE04 (Superstation 5)



Snapshots of the different RESPIRE deployments and the location of the gliders mid way through the 2.5 day deployment.

Incubation chamber water sampling

Water in the incubation chamber totals 1.6L. Water was siphoned from the top section of the trap on deck using silicone tubbing. Water was then drained from the incubation chamber onto a 3L darkened Nalgene bottle by removing the screw from the bottom. Bottom plate was then removed from the trap itself and brought inside for particle sampling. Bottom plate was separated from the trap and particles were picked and photos were taken for qualitative characterisation. Once done, particles were put back in the carboy, contents homogenised using a magnetic stirrer and samples were then taken for:

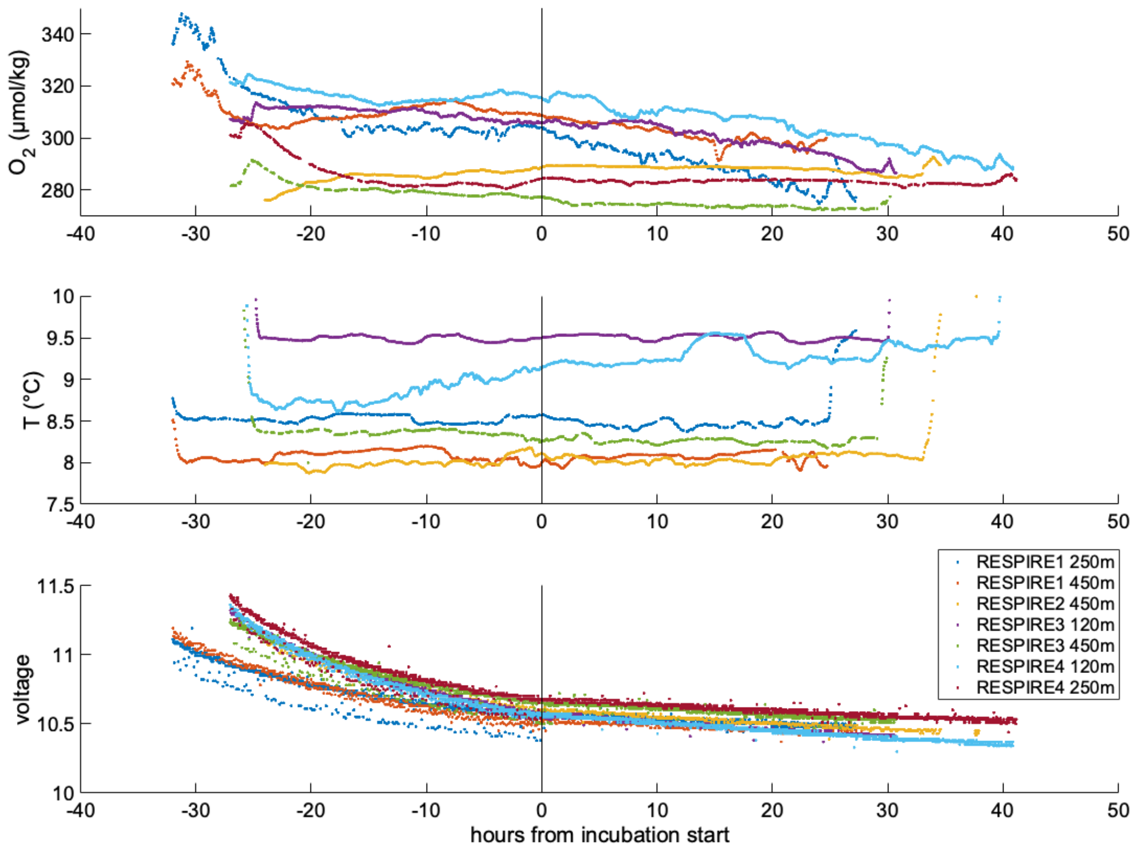
- POC, PIC, BSi, HPLC, chl, HPLC, lipids,
- Nutrients, DOC
- algae and bacteria flowcytometry (Glen Tarran, PML)
- Particle imaging (Elena Garcia-Martin),
- RSG (Chie Amano, U. Vienna)
- Genomics (Cordelia Roberts, Imperial College London)
- Metabarcoding

Swimmers found in the base, sample and filters were removed and frozen at -20C.

During the processing after the first deployment, we used the particle splitter, but it was a convoluted process that, given the rolling ship, didn't result in equally split samples. Instead, during the following deployments, we used the magnetic stirrer and plate and sampled directly from the 3L Nalgene using a 40ml electric pipette (Thanks Elena!!).

Preliminary Results

Communication with the controllers was done using Arduino software for Mac. Data was printed directly from the controller and preliminary results from all deployments are shown below.



RESPIRE data collected during the 4 deployments. Top: raw oxygen concentration reported by the optodes; top middle: Battery voltage as an indication of the sphere rotation; bottom middle: Temperature reported by the optode/controller.

Issues encountered during DY180

No log file after recovery

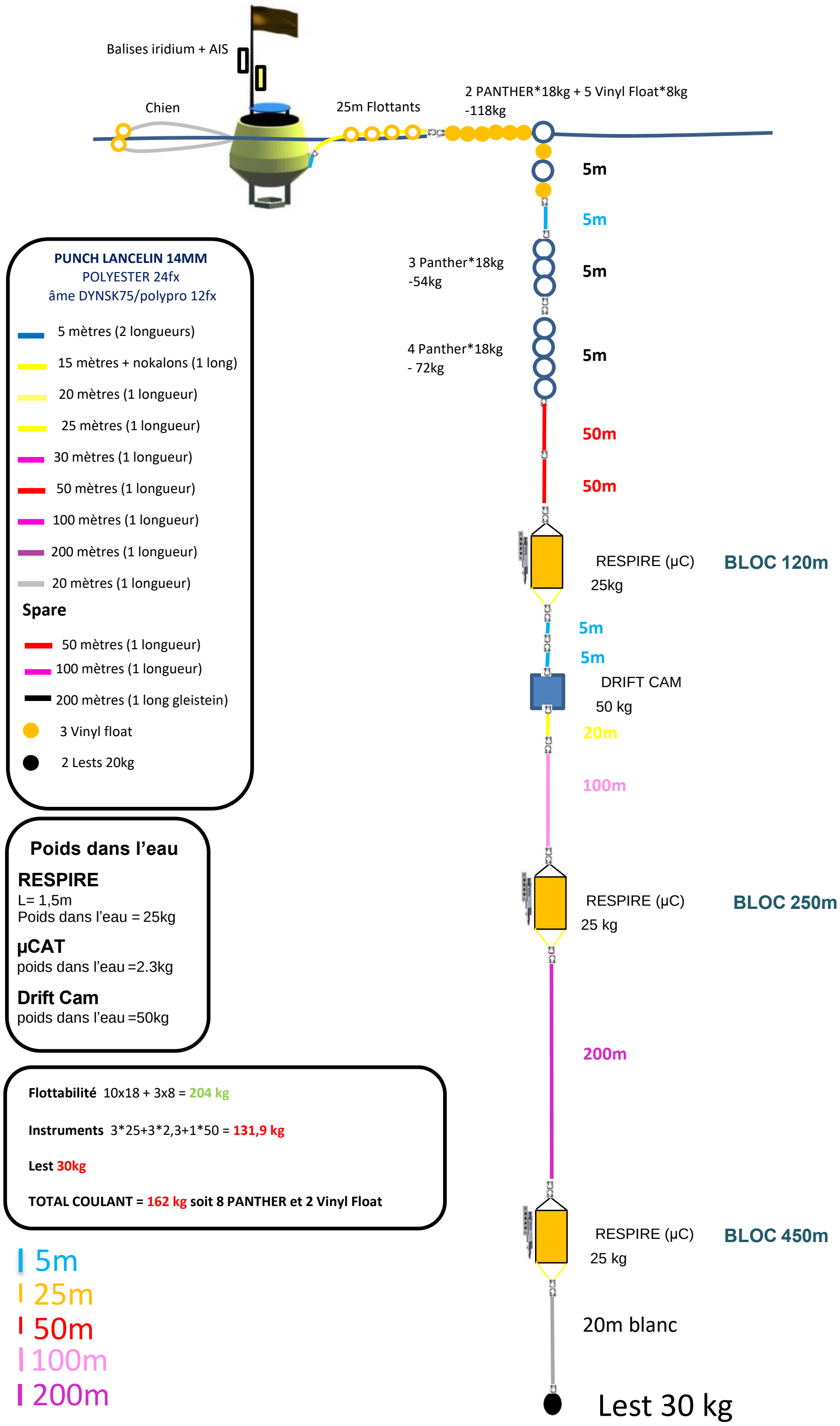
On the first deployment, no log file containing data was found for the 120 m trap. However, the voltage drop between deployment and recovery was similar to the other traps, and there was plenty of material in the trap, indicating that the mission did run. An attempt was made to troubleshoot after the deployment, opening up the controller to check for signs of a leak, and testing different sequences of unplugging the oxygen sensor during a test mission. We were not able to replicate the problem, but we replaced the pressure housing of the controller that did not record, and secured the SD card with tape.

On the second deployment, the same issue occurred, this time with both the original faulty controller and also a second controller (with newer software). Again, material was collected, but no file was recorded. Again, after extensive troubleshooting, we were not able to find the source of the problem. However, we changed the deployment sequence on the third and fourth RESPIRE deployments in order to better track the problem. We eliminated the “start delay” period, instead starting the mission on deck just prior to deployment. This means that the collection sphere already started rotating on deck and during deployment, putting particles into the incubation chamber. However, this also meant we could confirm whether the controller was writing data to a file before deployment. On the third deployment, we discovered that the oxygen sensor associated with the consistently faulty controller was not communicating with the controller. This appeared to be a new error, but maybe related. We could not get this sensor to communicate with any controller so this trap was eliminated from deployments 3 and 4. The other change made was that data from deployments 3 and 4 were downloaded sooner (after sample collection but before filtration) and data were also downloaded without plugging in the optode and without connecting the controller to external power or charging. The two remaining traps did properly record data on deployments 3 and 4.

100 file limit

One other issue encountered was that RESPIRE log files are automatically created with names ending in sequential numbers (01 to 99). After file 99 has been created, no new files can be created. Luckily this problem was identified on deck, and files were deleted by removing the SD card and connecting it to a PC (not mac, in order to avoid extra files that macs create). Files were deleted from the SD card via the PC and this fixed the problem.

Drift-SPIRE array design



Cell-specific respiration and extracellular enzymatic activity of prokaryotes

Chie Amano & Marilena Heitger (University of Vienna)

Objectives

Despite the major insights obtained from studies on microbial activity in the surface ocean, knowledge on the microbial processing of organic matter in the dark ocean is still in its infancy due to the lack of data (Aristegui et al. 2009; Herndl and Reinthaler 2013). Recent studies showed effects of high hydrostatic pressure on prokaryotic productivity in the dark ocean (Tamburini et al. 2013; Amano et al. 2022), indicating a potential alternation in their respiratory rates. Here, we aim to isolate the effect of pressure on the prokaryotic respiration and enzymatic activity and identify active microbial taxa respiring at in situ depths.

Methods and sample processing

In situ microbial incubator (ISMI)

ISMI is a device which allows autonomously collecting and incubating seawater at depth, injection of substrate and fixation of the samples after a preprogramed incubation time. To determine prokaryotic respiration rates at in situ hydrostatic pressure conditions, RedoxSensor Green (RSG, ThermoFisher scientific; final conc. of 1 µM,) was placed into the duplicate ISMI incubation bottles. All the bottles in contact with the samples were acid-washed (0.2 N HCl) and rinsed with MQ water or 0.2 µm filtered seawater collected at the same depths of the ISMI deployment at the previous station. Prior to deployment of the ISMI, sampling schedule was programed with the software (N-Com communicator ver. 3.01, Nichiyu Giken Co Ltd) to incubate seawater samples with RSG for 2 h and thereafter mix with Glycerol-TE (final conc. of 5% Glycerol). After recovering the ISMI on board, the samples were immediately collected into Griner tubes and flash-frozen in liquid nitrogen. The samples will be kept at -80°C until the further analysis at the home lab using Flowcytometry (FACSAria) and fluorescence microscopy for cell specific respiration measurements following Munson-McGee et al. (2022).

Benchtop pressure vessels

To determine the effect of depressurization on prokaryotic respiration and extracellular enzymatic activity (EEA), seawater collected from Niskin bottles was re-pressurized with the benchtop pressure vessels and incubated with RSG and fluorogenic substrate analogues. Benchtop pressure vessels are ~150mL-size metal pressure chambers that can increase hydrostatic pressure up to 100 MPa (equivalent to 10000 m). Seawater taken from Niskin bottles at the same station as ISMI was incubated in the benchtop pressure vessels at in situ pressure conditions with either RSG (1µM final conc.) or fluorogenic substrate analogues (MCA-Leucine, MUF-Phosphate, MUF-b-D-glucopyranoside). After the incubation time (2 hours for RSG, 9 hours for fluorogenic enzyme substrates) and releasing the pressure, the samples were transferred into cryovials or cuvettes for RSG and EEA measurements, respectively. For RSG analysis, samples were flash frozen in liquid nitrogen after adding Glycerol-TE. For EEA, fluorescence was measured in the Turner Trilogy fluorometer equipped with the Ammonium module (Excitation: 350/80nm, Emission: 410-450 nm), immediately after substrate amendment and then every 3-4 hours until the end of the incubation time. The raw fluorescence was subsequently converted to (hydrolyzed) substrate concentration by using a calibration curve with seawater blanks and standards (MUF and MCA, respectively) with known substrate concentrations.

For both ISMI and benchtop pressure vessels, seawater taken from the Niskin bottles was incubated under atmospheric pressure in temperature regulated spaces as on-deck controls (in situ temperature

±2°C). After the incubation, the samples were treated as described above and will be further analyzed at the home lab.

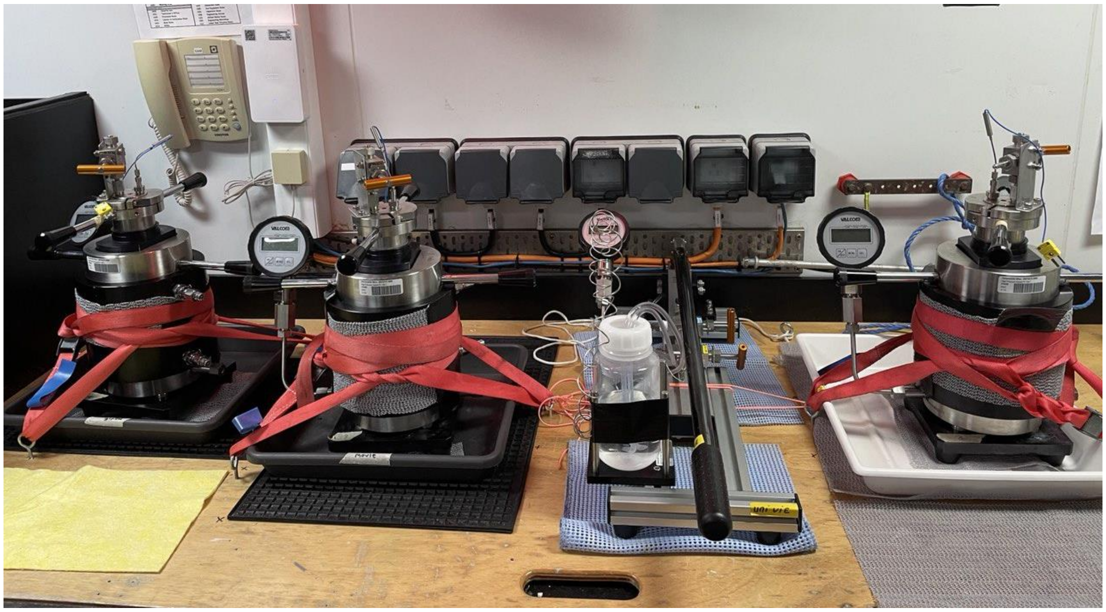
Prokaryotic cell specific respiration on particles

Particle-enriched seawater samples collected from Marine snow catcher (fast, slow, suspended fractions) and RESPIRE were incubated with RSG (1µM final conc.) for 2 h in the dark at in situ temperature ± 2°C under atmospheric pressure conditions. After adding of Glycerol-TE, samples were shock-frozen and kept at -80°C. Further analysis will be done in the home lab.

Metagenome and -transcriptome (Omics)

To perform metagenomic and metatranscriptmic analysis, 10-20L seawater collected from Niskin bottles at 120, 250, 450, 750, 1000 m at superstations was filtered onto Sterivex filters (0.22µm). Filtration was performed in the controlled temperature room (CT room, 8-9°C) to avoid increase of temperature in samples. Sterivex filters were shock-frozen in the liquid N2 and kept at -80°C. DNA/RNA extraction and further analysis will be performed in the home lab.

ISMI being deployed to 1000 m at S5



Setup of the benchtop pressure vessels in the CT room (hand pump in the middle)

Sampling locations during the DY180 cruise

St	Event	Deployment	Sampler	Depth_m	ISMI-RSG	Benchtop-RSG	Benchtop-EEA	On-deck control RSG|EEA	Particle-RSG	Kinetics RSG|EEA	Omics
S1	12	CTD003S	Niskin	1000		x		x			
S1	12	CTD003S	Niskin	750		x		x			
S1	12	CTD003S	Niskin	450		x		x			
S1	23	ISMI001	ISMI	450	x						
S1	27	CTD005T	Niskin	1000			x	x			
S1	27	CTD005T	Niskin	750			x	x			
S1	27	CTD005T	Niskin	450			x	x			
S1	44	ISMI002	ISMI	750	x						
S1	55	CTD008S	Niskin	1000							x
S1	55	CTD008S	Niskin	750							x
S1	55	CTD008S	Niskin	450							x
S1	55	CTD008S	Niskin	250							x
S1	55	CTD008S	Niskin	120							x
S1	57	ISMI003	ISMI	1000	x						
S2	80	CTD014S	Niskin	1000		x		x			
S2	80	CTD014S	Niskin	750		x		x			
S2	80	CTD014S	Niskin	450		x		x			
S3	107	CTD019S	Niskin	1000		x		x			
S3	107	CTD019S	Niskin	750		x		x			
S3	107	CTD019S	Niskin	450		x		x			
S3	120	ISMI004	ISMI	1001	x						
S3	124	CTD020T	Niskin	1000			x	x			
S3	124	CTD020T	Niskin	750			x	x			

S3	124	CTD020T	Niskin	450			x	x			
S3	133	ISMI005	ISMI	750	x						
S3	139	CTD023S	Niskin	1000							x
S3	139	CTD023S	Niskin	750							x
S3	139	CTD023S	Niskin	450							x
S3	139	CTD023S	Niskin	250							x
S3	139	CTD023S	Niskin	120							x
S3	151	ISMI006	ISMI	450	x						
R3	166	CTD027S	Niskin	1000			x	x			
R3	166	CTD027S	Niskin	450			x	x			
S4	176	CTD032S	Niskin	120			x	x			
S4	176	CTD032S	Niskin	750				x			
S4	179	MSC052	MSC	120					x		
S4	186	ISMI007	ISMI	120	x						
S4	194	MSC057	MSC	450					x		
S4	199	ISMI008	ISMI	750	x						
S4	205	CTD035S	Niskin	1000							x
S4	205	CTD035S	Niskin	750							x
S4	205	CTD035S	Niskin	450							x
S4	205	CTD035S	Niskin	250							x
S4	205	CTD035S	Niskin	120							x
S4	210	CTD036S	Niskin	1000			x	x		x	
S4	210	CTD036S	Niskin	450			x	x		x	
S4	180, 214	Array003	RESPIRE	120					x		
S4	180, 214	Array003	RESPIRE	120					x		
R4	227	CTD040S	Niskin	450						x	
S5	237	CTD042S	Niskin	1000				x			
S5	237	CTD042S	Niskin	250				x			
S5	240-243	MSC067-070	MSC	750					x		
S5	240-243	MSC067-070	MSC	450					x		
S5	240-243	MSC067-070	MSC	250					x		
S5	240-243	MSC067-070	MSC	120					x		
S5	246	ISMI009	ISMI	1005	x						
S5	256	ISMI010	ISMI	250	x						
S5	262	CTD045S	Niskin	1000							x
S5	262	CTD045S	Niskin	750							x
S5	262	CTD045S	Niskin	450							x
S5	262	CTD045S	Niskin	250							x
S5	262	CTD045S	Niskin	120							x
S5	238, 265	Array004	RESPIRE	120					x		

S5	238, 265	Array004	RESPIRE	120					x		
S5	268	CTD046S	Niskin	1000			x	x			
S5	268	CTD046S	Niskin	450			x	x			

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Herndl, G., and T. Reinthaler. 2013. Microbial control of the dark end of the biological pump. **6:** 718-724. doi:10.1038/NGEO1921

Munson-McGee, J. H., M. R. Lindsay, E. Sintes, J. M. Brown, T. D'Angelo, J. Brown, L. C. Lubelczyk, P. Tomko, D. Emerson, B. N. Orcutt, N. J. Poulton, G. J. Herndl, and R. Stepanauskas. 2022. Decoupling of respiration rates and abundance in marine prokaryoplankton. Nature. doi:10.1038/s41586-022-05505-3

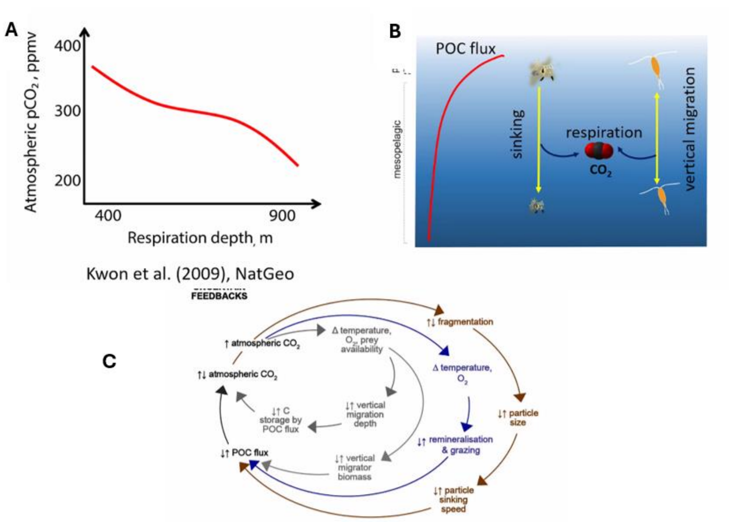
Tamburini, C., M. Boutrif, M. Garel, R. R. Colwell, and J. W. Deming. 2013. Prokaryotic responses to hydrostatic pressure in the ocean – a review. Environ. Microbiol. **15:** 1262–1274. doi:10.1111/1462-2920.12084

Respiration of sinking particles collected from the Marine Snow Catcher

Cordelia Roberts (Imperial College London) & E. Elena García-Martín (NOC)

Scientific Motivation

Organic carbon fixed in surface waters during photosynthesis sink as carbon rich particles to the deep ocean, facilitating the transfer and storage of carbon in deep waters. These particles can include aggregates and faecal pellets. Particles could act as hotspots for microbial activity and organic remineralisation. Remineralisation of particles along the water column as a result of respiration by microorganisms, exerts a strong control over atmospheric CO_2. Respiration by heterotrophic microorganisms, in part, is responsible for the observed decreasing concentrations of particulate organic carbon (POC) with increasing depth. Therefore, understanding the magnitude and variability of microbial respiration is crucial in determining the efficiency of how carbon is stored now in our oceans. Yet, respiration remains a poorly constrained variable within models meaning there is significant uncertainty in climatic feedbacks.



A) Influence of respiration on atmospheric CO_2 taken from Kwon et al, (2009), B) Observed flux of particulate organic carbon (POC) with depth, C) Uncertainty in climate feedbacks taken from Henson et al, (2022).

Furthermore, despite the heterogeneity of particle types found within the ocean (aggregates, faecal pellets, carcasses, gels), there is limited knowledge on how particle type influences remineralisation rates in the ocean. This means, our understanding of the contribution of different particle types in transporting carbon to depth is limited and not well parameterised within models.

Aims:

1. To quantify particle attached respiration rates in three sinking particle fractions (suspended, slow and fast sinking particles) at two depths 20 and 80 meters below the mixed layer depth (typically 55 or 65 m and 120 m).
2. To quantify how particle attached respiration is influenced by particle type including aggregates vs faecal pellets.

3. To characterise and image particles and associated planktonic communities across the two depths using FlowCam and PlanktoScope.

Marine Snow Catcher deployments
Four Marine Snow Catchers (MSC) were used during the DY180 cruise. The Marine Snow Catchers collect ~100 L of water at a specific depth but the working and closing mechanisms differ between them. More details of the different working procedures of the MSC are available in Baker et al. cruise report section.

Marine Snow Catchers; fraction taps are indicated.

In total, 22 MSCs were deployed for respiration experiments (18 good ones, 4 misfires) across 2 depths below the mixed layer depth and samples were collected to quantify rates of microbial respiration across different particle fractions including suspended, slow sinking and fast sinking particles and to characterize those particles. MSC deployments were usually conducted in the morning (2am – 8am). Once deployed MSCs were recovered to deck and secured to the vessel, MSCs were left to settle on deck for two hours. This started from the time the messenger was deployed, to allow the particle fractions to segregate by their sinking rates. Seawater from three fractions were collected: suspended (SUS), which corresponds to the water sample plus particles collected from the middle tap; slow-sinking (SS), which corresponds to water sample plus particles collected from the lower tap and above the fast-sinking tray; and fast-sinking (FS), which corresponds to the water sample plus particles that reached the particle tray at the bottom of the MSC. The SUS fraction was sampled first, followed by the SS and FS. SUS and SS samples were collected in opaque plastic bottles, whilst the FS trays were covered with a lid and opaque black bag to prevent light exposure to samples and all samples were transported directly to the controlled-temperature lab. Bottles were rinsed three times with seawater from the MSC before collecting the samples. In addition, between 100-200 mL of seawater was sampled from the suspended fraction and filtered through a 0.2 µm filter to obtain filtered seawater (FSW) to use it as control samples for the respiration measurements (see below). The temperature-controlled lab was set at 7.4 ºC and special care was taken to prevent the exposure of the samples to light, therefore, the subsampling for the different variables was done under red light conditions. We collected samples for particle respiration, bacterio-, pico- and nanoplankton community characterization (flow cytometry, see Tarran report) and microbial community characterization (via FlowCam and PlanktoScope). In addition, we collected several samples for molecular analyses (16S and 18S metabarcoding).

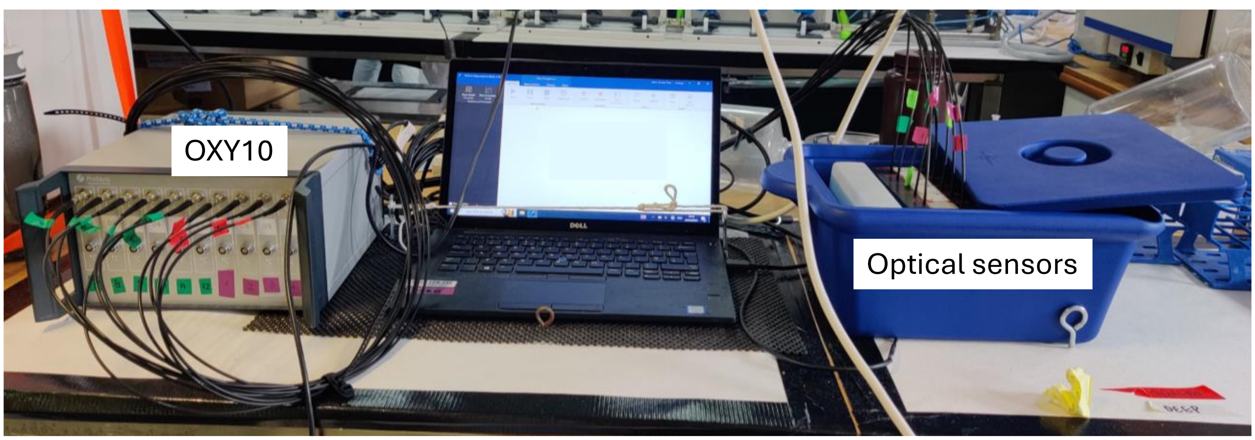
Sampling and analytical methodology
Particles respiration by optical oxygen sensors
Changes in dissolved oxygen concentration were measured using Fibox4 OXY10 SMA and PSt3 spots (PreSense, Germany) mounted with silicone glue inside 25 mL glass vials, and PreSens Measurement

Studio 2. The ten sensors of the OXY10 were two-point calibrated with air-saturated and anoxic waters. The anoxic water was obtained by dissolving small quantities of sodium sulphite anhydrous in MilliQ water. For SUS and SS fractions, 2-3 x 25 mL optode vials were filled from the 1 L bottle for each respective fraction until a convex meniscus formed and no bubbles were observed within the vial chamber. The FS material was collected from the tray. When particle numbers allowed, aggregate and faecal pellets were picked using a combination of a calibrated P1000 and 5mL Fisherbrand pipette and put into petri dishes separately for aggregates and faecal pellets before further processing. Aggregates or faecal pellets were added to separate optode vials and topped up with SUS seawater fraction. When the segregation and selection of aggregates and faecal pellets were not possible a FS sample was collected directly from the tray.

Two additional vials were filled in the same manner with FSW and MilliQ water. These vials were used as background for abiotic changes in oxygen concentration associated with any temperature changes vials may experience during the incubation period.

Once all vials were filled, they were left to acclimate for 15-30 minutes in cooled incubators (LMS Model 80) at the temperatures of the respective depths in which particles were sampled from, before reading the "Tzero" measurement. Dissolved oxygen concentrations were read simultaneously in ten vials at 10-12 time points for 2-4 minutes over each 36-48 hours incubation period. The Fibox4 sensors were automatically corrected for salinity. Salinity was determined with the conductivity sensors mounted on the CTD, deployed 2-3 hours before the MSC deployments.

At the end of the experimental incubations, vials with FS fraction particles (aggregates and faecal pellets), were filtered onto pre-combusted glass fibre filters (pore size 0.7 µm) for particulate organic carbon (POC) content. The POC content for the SUS and SS fractions were collected from the subsequent MSCs deployed for POC fluxes (see Baker et al. cruise report).



Optode setup.

Flow Cytometry (AFC)

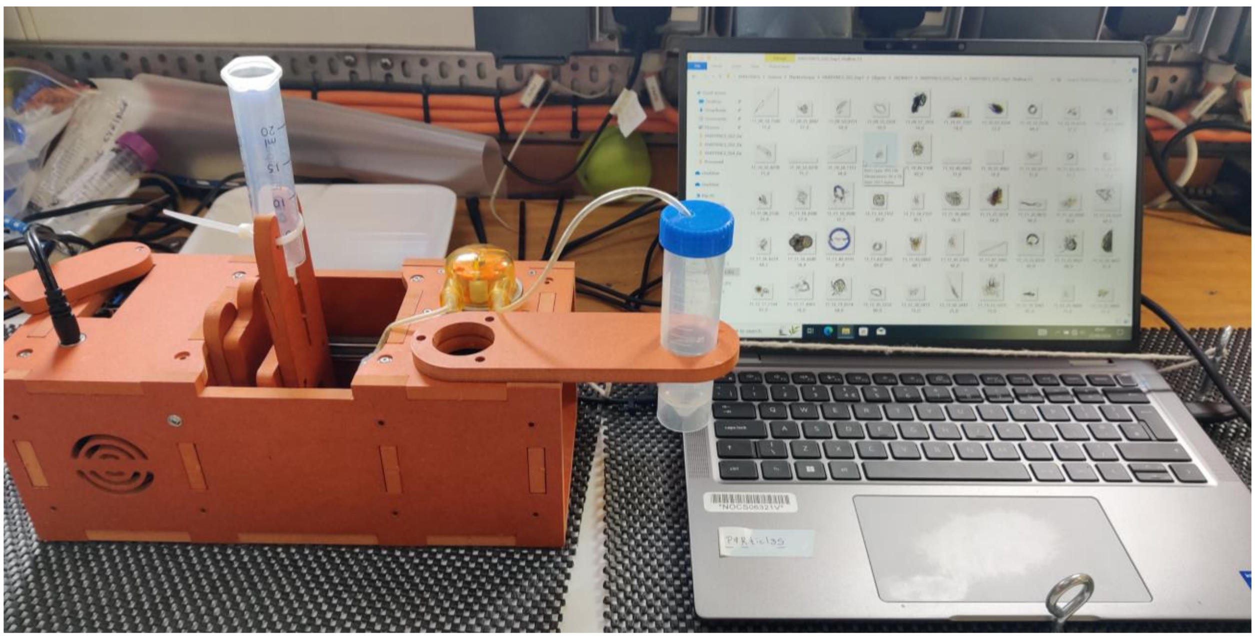
For flow cytometry, 8-10 mL of seawater was subsampled from each fraction bottle (SUS, SS, FS, respectively) and depth (55 or 65 and 120 m, respectively) and collected in 15 mL Falcon tubes. Samples were fixed with glutaraldehyde for cytometry counts of bacterio-, pico- and nanoplankton cells (see Tarran report for further details of the analysis).

Imaging of the particles via PlanktoScope and FlowCam

250 mL of subsampled SUS and SS sampled was concentrated into 5-10 mL using an 18 µm filter mesh. The concentrated sample was transferred into a 15 mL tube and stored in the cool room (4 °C) until further processing with the PlanktoScope.

The PlanktoScope is a compact, benchtop modular digital microscope which allows for high-throughput

quantitative imaging of water samples. Briefly, samples are transferred to the syringe, and a peristaltic pump allows the sample to flow through a flow cell at a predefined rate. Images of the sample are taken at a specified time instances. After imaging, microscope images are segmented into the respective individual objects which make up the image and are available for viewing or uploading onto the online identification platform EcoTaxa for further classification of plankton/particles/organism objects.
The details of the imaging acquisition are:
Number of images: 200 or 400
Pumped Volume: 0.0005 mL
Delay to stabilize image: 0.7 s
Flow cell: 200 µm
Total imaged Volume: 0.5 or 1.01 mL (200 or 400 images, respectively)
Total pumped volume: 1 or 2 mL (200 or 400 images, respectively).



PlanktoScope and example objects from the fast sinking fraction.

For FlowCam analyses, 250 mL each for SUS and SS fractions were concentrated into 50 mL and 1 mL of acetic Lugol solution (final concentration 2 %) added to preserve the samples. For FS fractions, 12 mL of fast sinking material, aggregates or faecal pellets were collected and 0.3 mL acetic Lugol solution (final concentration ~2-3 %) was added. Samples were stored at 4 ºC in amber glass bottles, for analysis on return to land.
The FlowCam is a high-throughput automated flow imaging microscope. Briefly, a sample is drawn through an optical flow cell and a high-speed camera records images of the flow cell across the optical field of view and particles/objects are automatically segmented as they flow through the flow-cell (further details in Gustavson and Poulton report).
Particulate Organic Carbon (POC)
On the days that respiration MSC deployments coincided with flux MSC, the characterization of POC was determined from the MSC corresponding to the fluxes and assumed constant between the respiration and fluxes deployments. For respiration MSC deployments which did not coincide with a flux MSC, POC for the SUS and SS fractions was sampled directly from the respiration MSC.

Briefly, for SUS and SS fractions ~1 L was filtered onto pre-combusted 25 mm glass fibre filters (pore size 0.7 µm). For FS fractions, POC was sampled directly from the oxygen consumption incubation vials. The duplicate/triplicate vials were pooled together for each sample type (e.g. fast sinking, aggregates or faecal pellets, sample volume 75 mL). Filters were stored in pre-combusted aluminium foil packets at – 80 °C.

Opportunistic samples
In specific MSC (see table below), seawater for 16S and 18S metabarcoding was collected from each MSC fraction (SUS, SS, FS – not split between aggregates and faecal pellets) and filtered using 0.2 µm Sterviex filters. After filtering the sample, Sterivex filter chambers were flooded with DNA/RNA shield as a preservative, lure lock caps were added, and filters were flash frozen using liquid nitrogen and stored at – 80 °C. These samples will be analysed in the future and extra funding is being requested for the analysis.

Problems encountered
Several challenges were encountered during the cruise regarding equipment failure and scientific problems. The four MSC had different efficiencies, being the new models not as reliable as the old models. Overall, the new MSC models were not firing at the desired depth in rough weather conditions and had more misfires. Detailed information about the different problems can be found in Baker et al. cruise report. To assure that the water was collected at the desired depth, we decided to collect extra nutrient samples or chlorophyll samples from the respiration MSC and compare the results to the nutrients and chlorophyll-a concentration measured from the CTD casts on the early morning.
In addition, the temperature and stability of the LMS cooled incubators were ± 1 °C, and influenced the oxygen incubations and readings. The desired incubation temperatures were between 8.7-9.7 °C. The incubators managed to sustain those temperatures during the day, when the temperature inside the laboratory was lower, but the temperature of the incubators increased at night because of the higher temperatures inside the laboratory. For future cruises working in cold waters, we would recommend keeping the door of the laboratory open for several hours during the night to cool down the temperature inside the laboratory.
One of the biggest challenges encountered was the unexpected bad health conditions of one of the team members, who needed a medivac. With one person less in the team, we needed to make several adjustments:

a) sampling time-points during the optode incubations were reduced to allow the member of the team to have at least four-hour rest during the night period, and
b) the segregation of fast sinking particles into aggregates and faecal pellets were not possible with only one person, and therefore the FS fraction was incubated all together.

Acknowledgements
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Deployments of Marine Snow Catchers for respiration work.

Date	St	Event	MSC	Bridge log MSC	Latitude	Longitude	MSC type / Name	Depth (m)	Time deployed	Time fired	Notes / Comments/Weather
27/05/2024	SS1	14	6	6	60.000155	-24.000414	Umi	120	08:41	08:46	Sampling time: 10:46
27/05/2024	SS1	15	7	7	60.000149	-24.000404	Yuki	55	09:04	09:07	Sampling time: 11:07; hairline leak in base, added marine grade sealant
29/05/2024	SS1	50	16	16	59.99978	-23.999779	Yuki	120	02:29	02:34	Sampling time: 04:34; windy dark
29/05/2024	SS1	51	17	17	59.999809	-23.999762	Umi	55	02:48	02:51	Sampling time: 04:51; windy, dark
02/06/2024	SS2	82	22	22	60.019241	-23.720027	Yuki	65	08:44	08:46	Not fired; extremely windy
02/06/2024	SS2	83	23	23	60.018735	-23.719852	Yuki	65	09:01	09:04	Misfired; extremely windy
02/06/2024	SS2	84	24	24	60.018117	-23.719592	Umi	65	09:15	09:16	Sampling time: 11:16; extremely windy
02/06/2024	SS2	85	25	25	60.017508	-23.719389	Silver	120	09:32	09:36	Sampling time: 11:36; extremely windy
06/06/2024	SS3	108	29	29	59.437783	-22.637074	Yuki	65	06:42	06:47	Sampling time: 8:47
06/06/2024	SS3	109	30	30	59.435945	-22.638358	Silver	120	06:57	07:01	Sampling time: 09:01
08/06/2024	SS3	140	40	41	59.366118	-22.48754	Yuki	65	03:55	03:58	Sampling time: 05:58
08/06/2024	SS3	141	41	42	59.367112	-22.485458	Silver	120	04:15	04:19	Sampling time: 06:19
12/06/2024	SS4	177	50	50	59.244622	-22.07958	Yuki	55	06:37	06:43	RAINY! Sampling time: 06:44
12/06/2024	SS4	178	51	51	59.244565	-22.079951	Silver	120	06:53	06:57	Misfire. Leaking between top and base
12/06/2024	SS4	179	52	52	59.244519	-22.080311	Silver	120	07:09	07:14	Still chucking it down! Sampling time: 09:14
14/06/2024	SS4	206	60*	60	59.425292	-21.798125	Yuki	55	04:05	04:08	Windy and darkish; sampling time: 06:08
14/06/2024	SS4	207	61*	61	59.425741	-21.798332	Silver	120	04:18	04:25	Windy; sampling time: 06:25
17/06/2024	SS5	234	64	64	60.236553	-21.202533	Silver	120	09:02	09:06	Sampling time: 11:06
17/06/2024	SS5	235	65	65	60.236784	-21.201184	Yuki	55			Misfire. Leaking between top and base
17/06/2024	SS5	236	66	66	60.237161	-21.199043	Red	55	09:35	09:38	Sampling time: 11:38
19/06/2024	SS5	263	74*	74	60.268375	-21.208286	Red	55	05:59	06:03	Sampling time: 08:03 - windy and bumpy
19/06/2024	SS5	264	75*	74	60.267941	-21.20724	Silver	120	06:14	06:21	Sampling time: 08:21 - very windy on recovery and extremely windy (40kts) when separating top and base.

The * indicates no samples were collected for molecular work

Marine Snow Catchers

Chelsey Baker, Will Major, E. Elena García-Martín, Filipa Carvalho, Simon Jones (NOC), Cordelia Roberts (Imperial College London), Alex Poulton, Ben Gustafson (Heriot Watt), Kyle Mayers (NORCE), Glen Tarran (PML), Chie Amano and Marilena Heitger (University of Vienna).

Overview

Marine snow catchers (MSCs) were deployed during the cruise in order to collect a sinking particle flux profile at each Superstation (NOC), collect material for particle respiration rates at the Superstations (NOC + Imperial College London) and to determine what was sinking in and exported out of the mixed layer at the Roaming stations (Heriot Watt University, NORCE and PML).

MSCs were deployed from the starboard side winch and once at depth a messenger (double weight for new MSCs) was sent down the wire to fire the MSC. The MSC was returned to deck, secured, and a 5L time zero (Tzero) sample was taken. The MSCs were then allowed to settle for 2 hours to allow for the particles to sink down into the base. In order to standardize measurements across the old and new MSCs the sampling strategy was changed slightly. A 5L suspended sample was taken from the middle tap of the snowcatchers as only one of the old snowcatchers had a top tap. The slow sinking fraction was then sampled (5L) from the lower tap on all MSCs (which are at the same height above the tray +/- 1cm) instead of the previous method of siphoning from the base. The MSCs were then drained by opening the middle tap fully and half opening the bottom tap. As the MSC drained (~20 minutes) the bottom tap was gradually opened more but kept at a medium flow. Once the MSCs were drained the tops were lifted off the old MSCs using the crane and with the support from two members of the crew. The base was unclipped for the new MSCs and excess water above the tray was siphoned off. On some roaming station MSCs the siphoned based was also sampled to allow for a comparison between the fractions. The lid was put on the tray and carefully moved to the lab where it was decanted into a carboy using a funnel. Carboys were kept in the dark at 4 °C until filtered. MSCs were hosed down with fresh water after deployments and the new MSCs mechanisms were rinsed with MilliQ.

Sample Preparation

Particulate organic carbon and nitrogen (POC/N)

Samples were filtered onto pre-combusted (24 hrs at 400°C) glass fibre filters (GF/F; pore size 0.7 µm, 25 mm diameter, Whatman) that were stored in individual foil wrappers. Typically, 1L was filtered for the Tzero, top and base samples and 250 mL was filtered from the tray. Replicates (POC 1 and POC 2) were taken for POC/N to ensure no data points were lost. The filters were rinsed with MilliQ water and were not allowed to dry to avoid cell lysis (following Chavez et al., 2021). One set of triple volume filtration was undertaken (0.5L, 1L and 2L) to aid in determining a blank and filtrate from the CTD was also filtered as an alternative approach. Filters were returned to their foil wrappers, placed in plastic bags for each MSC deployment and stored at -80 °C. Samples will be freeze dried and analysed onshore.

Particulate Inorganic Carbon (PIC)

Samples were filtered onto polycarbonate filters (0.4 µm pore size, 25 mm, Whatman) and briefly rinsed with pH-adjusted MilliQ water (pH 8.5; 180 µL 25% ammonium in 1L MilliQ) to remove any salt. Typically, 500 mL was filtered for the Tzero, top and base fractions and between 100-250mL depending on the size of the snowcatcher tray. Filters were placed into 15 mL blue capped Falcon tubes and dried overnight at 50 °C for analysis onshore.

Biogenic Silica (BSi)

Samples were filtered onto polycarbonate filters (0.4 µm pore size, 25 mm, Whatman) and briefly rinsed with pH-adjusted MilliQ water (pH 8.5; 180 µL 25% ammonium in 1L MilliQ) to remove any salt. Typically, 500 mL was filtered for the Tzero, top and base fractions and between 100-250mL depending on the size of the snowcatcher tray. Filters were placed into 15 mL purple capped Falcon tubes and dried overnight at 50 °C for analysis onshore by collaborators in the US.

Scanning Electron Microscopy (SEM)

Samples were filtered onto polycarbonate filters (0.4 µm pore size, 25 mm, Whatman) and briefly rinsed with pH-adjusted MilliQ water (pH 8.5; 180 µL 25% ammonium in 1L MilliQ) to remove any salt. Typically, between 100-250mL was filtered from the snowcatcher tray. Filters were placed into petri slides and dried overnight at 50 °C for analysis onshore.

Chlorophyll a

Samples were filtered onto MF300 GF/F filters (nominal pore-size 0.7 µm, 25 mm diameter, Whatman), placed into glass vials filled with 6 mL acetone (90%) for pigments to extract for 18-24 hours. Fluorescence was analysed on board as described elsewhere in the cruise report (see General Filtering cruise report).

Nutrients

From mid-way through the cruise nutrient samples were taken from the Tzero sample of all MSCs to aid in confirming whether they fired at the intended depth. A 15 mL subsample was collected in a Falcon tube and stored in the fridge until analysed by Ed Mawji (see nutrients cruise report).

Particle Respiration

Changes in dissolved oxygen concentration were measured on the suspended, slow and fast sinking fractions and particles (see *García-Martín* and Roberts cruise report).

Imaging

Particles from the respiration MSCs were imaged using the PlanktoScope (see *García-Martín* and Roberts cruise report) and the FlowCam (see Gustafson and Poulton cruise report).

Flow Cytometry

A 15 mL subsample from each MSC fraction was collected at the Roaming stations in a Falcon tube and run in the flow cytometer within two hours of sample collection (see Tarran cruise report).

Cell Specific Respiration

A 15mL subsample was provided from all MSC fractions for cell specific prokaryotic respiration. The samples were incubated with RedoxSensor Green (RSG, ThermoFisher scientific), which is a marker for changes in electron transport chain function that can fluorescently stain respiratory active cells. Detailed information can be found in the cruise report by the Vienna group.

Quantitative Molecular Biology

From all MSC fractions at most roaming stations, 35 – 500 mL of sample was filtered onto 0.4 µm polycarbonate filters, and immediately placed at -20ºC for later DNA analysis. Filters will be returned to NORCE for DNA extraction. Following this, the samples will be analysed using quantitative PCR techniques targeting *Emiliania huxleyi* and its virus (Emiliania huxleyi virus) to determine the relative copy numbers of these targets in different particle fractions.

Deployment Strategies and Samples Collected

Superstation Deployments (PARTITRICS)

Fluxes

MSCs were deployed in two sessions (day 1 and 2) in order to collect one particle flux profile per station. The standard depths were 55m, 120m, 250m, 450m and 750m to match the CTD, RESPIRE, DriftCam and ISMI sampling. POC/N, PIC, BSi and Chlorophyll-a samples were filtered from the snowcatchers and subsamples were taken for nutrients and RSG for a few of the deep MSCs.

Respiration

MSCs were deployed early in the morning of day 1 and 3 of the superstation typically at 55m (65m in some instances due to a deeper mixed layer depth) and 120m. Eighteen experiments were set up and 54 samples collected (see García-Martín and Roberts cruise report). Often chlorophyll-a and nutrient subsamples were collected from the Tzero or suspended sample to ensure that MSCs had fired at the correct depth.

Roaming Station Deployments (CHALKY)

At each roaming station the MSCs were deployed at 15m and 55m to determine what was sinking out of and exported from the mixed layer. From the 15m snowcatcher duplicate PIC samples and chlorophyll samples were collected from each fraction and SEM was sampled from the tray along with subsamples for flow cytometry, DNA and nutrients. Filtered samples were collected for POC/N, PIC, BSi, Chlorophyll a and DNA from the 55m MSC. Subsamples for flow cytometry and nutrients were also collected from the 55m snowcatcher.

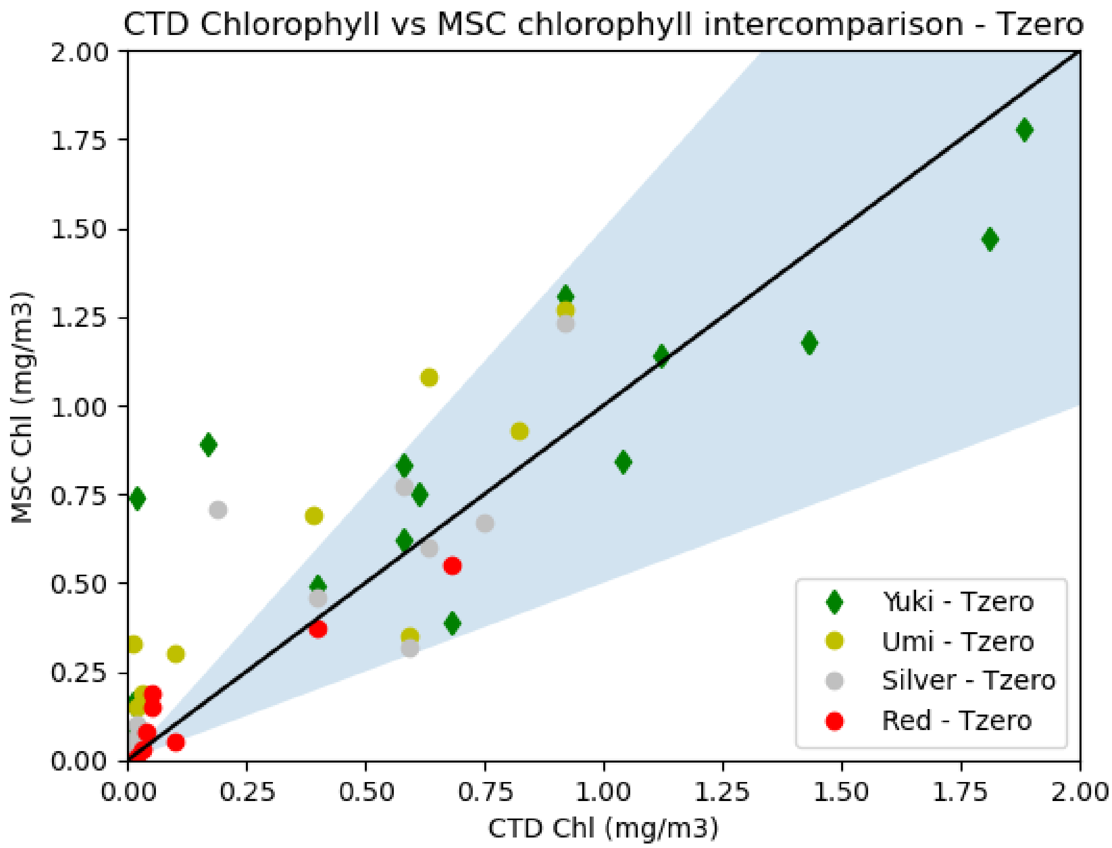
Snowcatcher Issues

At the test station all five MSCs were deployed. The blue snowcatcher (old design) did not form a seal between the top and base and as it had been deemed as unusable on a previous cruise (DY111) it was not deployed again. There were three different designs of snowcatchers on board:

1. Old design (red and silver) – 95L MSCs that have been used on many cruises (e.g. Giering et al. 2017; Baker et al 2017; Riley et al. 2012).
2. 1st iteration of new MSC design (Yuki) – ~100L MSC that has a new design which is self-contained with a frame and does not require the winch to separate the top and base. It also has a different opening design and a different firing mechanism. Yuki has been deployed previously on two other cruises (JC231 and DY157) but it was yet to be determined whether data from the new design was comparable to the old MSC design.
3. 2nd iteration of new MSC design (Umi) – 95L MSC that had only previously been tested in a tank. This has a different opening mechanism to Yuki but a similar firing mechanism.

The four MSCs used on the cruise and their respective names.

As a 4-5 depth flux profile was required for each superstation, it was important to confirm whether the data from the new design MSC was comparable to the old MSC data. To do this we undertook paired deployments of one old and one new MSC at the same depth and compared the results of the chlorophyll concentrations. This approach highlighted an issue with the new MSCs, and particularly with Umi, misfiring shallow in the water column as demonstrated by very high chlorophyll values compared to the paired MSC and the CTD chlorophyll data at the same depth (see below). From mid-way in the cruise nutrient samples were collected from each MSC to ensure they hadn't misfired and to allow us to have a better understanding of where in the water column they had fired.
The overall success rates of the four MSCs, in terms of mechanical success and firing depth success, is detailed in the table below. It is possible that the Umi success rate should be lower but chlorophyll concentration samples were not collected from the respiration MSCs at the beginning of the cruise.



CTD chlorophyll concentrations at similar dates/depths to MSC deployments plotted against MSC chlorophyll for the Tzero sample for each snowcatcher deployment. The black line is the 1:1 line and the blue shading indicates 50% deviation from the 1:1 line. Data points that plot above the blue shading are generally considered to have misfired, with a few exceptions where the CTD and MSC deployments were far away in space/time or where there was an indication of lots of submesoscale variability (i.e. different upper ocean nutrient profiles in back to back CTD casts).

Mechanical and firing depth success rates for the MSC deployments

MSC	Number of deployments	Number of mechanical misfires	Mechanical failure rate (%)	Number of depth misfires	Deployment success rate (%)	Notes
Yuki	25	5	20	3	68	

Umi	15	2	13	6	47	Should be much higher for mechanical failures with base likely closing on impact with the water
Silver	24	4	17	0	83	
Red	12	2	17	0	83	A couple of deployments likely did not flush properly

Umi and Yuki may have been misfiring in the upper mixed layer due to the cocking arm being lifted upon deployment, particularly for Umi. Modifications were made to Umi which included adding a small weight to the cocking arm and cable ties were added to keep the firing wire from catching. The wire was also shortened to ensure the cocking arm could lift high enough for the base to fully fire. Some tests were done after these modifications and this seemed to fix the issue.

Yuki had issues of the base not falling correctly into place when firing which led to a seal not being formed and water leaking rapidly from the base upon recovery. Some modifications which included added an extra washer one side of the base plate and filing down the bolts which held the plate in place seemed to improve Yuki's performance.

From the nutrient data it became apparent that Umi and Yuki were still often not firing at the right depth but firing somewhere between the mixed layer and the intended depth. We suspect this may be due to the winch wire not being straight when deploying in fast currents which may lead to the firing mechanism being pressed by the wire and therefore the MSC firing early.

Based on the MSC deployments on the cruise the following modifications have been suggested for Umi but may apply to Yuki too:

- Larger hole to allow for the same shackle to be used on new and old MSCs
- The firing slot the wire sits in is too tight to the wire for the new MSCs, widening this out may prevent misfires in choppy conditions.
- Increase the length between the cocking arm and the pivot in the wire in the firing mechanism.
- Consider a less fragile release mechanism for the lid release.
- Further weight to the cocking arm to withstand rough weather/ deployment conditions.

Notes for future users

The red MSC does not flush particularly well and so when setting up the mechanism on the wire is important to ensure that the wire and the firing wire are as taut as possible to keep the plunger high upon deployment.

For the new MSCs ensure the cocking arm sits as far down as possible upon deployment to reduce the chance of it misfiring on impact with the water.

Acknowledgments

We would like to thank the crew of the RRS Discovery for help and support with the MSC deployments, especially in challenging conditions, with special thanks to John and Ryan. We would also like to thank the NMF techs for their support with deployments and troubleshooting the MSC issues, with special thanks to Simon and Billy.

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Red Camera Frame particle size distributions

Will Major, Nathan Briggs, Filipa Carvalho (NOC)

Objectives

Particle size, shape and type are key controls on downward carbon transport through the mesopelagic. We aimed to use particle imaging with the Red Camera Frame (RCF) to investigate the impact of particle dynamics and size distributions on carbon export depth. Particle parameters will be used in conjunction with turbulence measurements and respiration experiments to better understand particle aggregation, fragmentation, and depth of organic carbon remineralisation.

Methods

The RCF housed seven devices for the duration of the cruise: Underwater Vision Profiler 5 (UVP5), LISST-Holo2, Continuous Particle Imaging and Classification System (CPICS), weeHoloCam, ECOTriplet, RBR Concerto and CamHUB. Data from simultaneous deployments of these devices intercalibrated together provide particle information on the entire size spectrum of marine particles. We collected data across 19 deployments of the RCF including 12 deployments at Superstation and 6 deployments at Roaming stations (deployment summary included below).

Deployment

All devices are powered on prior to connecting to the ship's wire. The power cycle of UVP5 is triggered by pressure and so the RCF is dipped to 20 metres for 90 seconds, before RCF is brought to the surface and profiles at 0.5 m/s to 600 metres depth (limited by LISST-Holo2 and RBR Concerto). On two occasions, descent speed was 0.25 m/s for the first 100 metres of the profile to test whether CPICS' performance was improved, however, little difference was made. Earlier deployments included a fast ascent speed, however, upcast UVP5 data were important to compare with float data so 0.5 m/s throughout the deployment was used instead from RCF8 onwards.

UVP5

Underwater Video Profiler 5 (UVP5, Hydroptic); Pressure rated to 3000m, continuously records images in the sample volume (field view of 22 x 18 cm). All images are recorded in the internal memory that can store up to 100 profiles. Fully charged internal battery lasts up to 7 hours with recording mode. The system automatically detects particles in focus, crop the in-focus particles (vignettes) and save the vignettes. UVP5 took images successfully across 15 profiles. 4 profiles were missed during Superstation 5 and Roaming 5 because the memory on the camera was full.

LISST-Holo2

LISST-Holo2 (Sequoia Scientific, Inc.) is a standalone instrument which carries an internal battery that lasts up to 20 hours. An issue with the device at the beginning of the cruise meant that the first 6 profiles of the RCF did not include LISST-Holo2 images. It was found that the internal battery was not working. LISST-Holo2 was powered by its external battery for the remainder of the cruise. Holographic images of particles that go through its sample volume (1.86 cm^3) were taken at 10 Hz and saved in the internal memory. Each hologram is 1600 x 1200 pixel with 4.5 µm and we can resolve particles larger than 25 µm. Sampling started when LISST HOLO2 was below 5 m and sampling was manually stopped when RCF was recovered on the deck, or at 595 metres depth (if the RCF made it to that depth – stronger currents sometimes meant the angle of the ship's wire was not perpendicular to the water). We used the default setting for image names such as 000-0001 – using timestamps is not possible because the DateTime on LISST-Holo2 resets with each power cycle. Each deployment captured 15,000-30,000 holograms, depending on whether 595 metres was reached. We transferred holograms after each deployment to clear the internal memory for next deployment, except for the last two deployments when there was not time.

CPICS

Continuous Plankton Imaging and Classification (Coastal Ocean Vision) continuously record images in the sample volume (330 mm^3 with field view of 15 x 11 mm). It automatically detects particles in focus, crops the in-focus particles (region of interest, ROI) and saves the cropped images. We decided to save ROIs only, but full frame images were saved for several deployments for a record on how well the camera performs this task. Start and end of recording was controlled by CPICS viewer that requires communication between CPICS and laptop via ethernet cable before and after deployment. We had a new model of CPICS for this cruise and it was only switched on for the first time at Superstation 3.

ECOTRIPLET3

The 1000-m rated standalone Wetlabs Environmental Characterization Optics (ECO) Triplet Fluorometer and Backscattering Sensor measures backscatter at 2 wavelengths (532nm and 700 nm) and chlorophyll fluorescence. This instrument does not have a pressure sensor. Data transfer was carried out via the CamHUB system for the first 5 deployments, but once LISST-Holo2 needed to be powered by its external battery, this meant that HUB could no longer be powered. After the LISST-Holo2 was fixed, data was downloaded straight from the instrument. Batteries were replaced with fresh packs before the cruise and no replacement was required during the cruise.

RBR concerto

RBR concerto measures multiple biological and physical variables (pressure, temperature, conductivity, turbidity and fluorescence). Since CPICS and ECOTRIPLET do not have pressure sensors, measurements of pressure by RBR concerto is important. However, RBR Concerto could not be powered once LISST-Holo2 was powered by its external battery, so only 5 profiles of data were gathered. Pressure from LISST-Holo2 or UVP5 can be used instead.

WeeHoloCam

WeeHoloCam was on loan from Thangavel Thevar from the University of Aberdeen. Instructions were provided on how to setup and deploy the device, but data remained on the device and was not downloaded. 5 profiles of weeHoloCam data were taken, with two alongside the LISST-Holo2 to allow a comparison. Two separate external batteries were used to power the device. The first battery pack was damaged because of the use of an improper cable dummy during a deployment leading to some corrosion. The damaged connector on the first battery pack was cleaned but the second battery was used instead thereafter.

List of RCF deployments

DateTime	Station	Event	RCF	Profile dep	Latitude	Longitude	Day/Night	Descent s	Ascent spe	Operator	UVP	LISST-Holo	weeHoloC	ECOTriplet	RBR	CPICS	Connected	In water	20m dip	Post-dip s	Profile bas	Surface	Comments
2024-05-27T20:54:40.000Z	S1	24	1	600	60.00018	-24.0002	D	0.5	0.8	Will	Y	N	Y	Y	Y	N		20:15	20:16	20:20:00	20:39:05	20:52:20	No CPICS
2024-05-29T00:23:31.000Z	S1	46	2	600	59.99979	-23.9998	N	0.5	0.9	Nathan	Y	N	Y	Y	Y	N				23:47:30	00:08:26	00:21:04	Covers left
2024-05-29T00:53:25.000Z	S1	47	3	350	59.99979	-23.9998	N	0.5	0.9	Nathan	Y	N	N	Y	Y	N		00:29:10	00:30:29	00:33:11	00:44:57	00:51:55	
2024-05-29T14:44:48.000Z	S1	56	4	600	59.99991	-23.9996	D	0.5		Will	Y	N	N	Y	Y	N	13:57	14:00	14:03	14:04	14:24	14:44	weeHoloC
2024-05-31T07:24:34.000Z	R1	69	5	600	56.21604	-26.8302	D	0.5	1	Filipa	Y	N	N	Y	Y	N	06:45	06:47:27	06:48:21	06:51:02	07:12:30	07:23:45	
2024-06-03T20:36:58.000Z	R2	99	6	600	57.1121	-26.2283	D	0.5		Nathan	Y	N	Y	Y	N	N		19:53:30	19:54:14	19:56:59	20:18:29	20:35:28	
2024-06-06T11:25:53.000Z	S3	111	7	600	59.43782	-22.6537	D	0.5		Will	Y	Y	Y	Y	N	Y	10:46	10:48	10:49	10:52	11:11:00	11:24:43	No hub or
2024-06-07T18:56:12.000Z	S3	134	8	600	59.40066	-22.5648	D	0.5		Will	Y	Y	N	Y	N	Y	18:03	18:08:20	18:06:26	18:08:24	18:32:08	18:55:05	to 100m at
2024-06-08T01:04:14.000Z	S3	138	9	600	59.36767	-22.4834	N	0.5		Nathan	Y	Y	Y	Y	N	N		00:26:59	00:27:50	00:30:32	00:50:26	01:02:45	
2024-06-10T06:41:15.000Z	R3	162	10	600	57.23308	-28.3457	D	0.5		Nathan	Y	Y	N	Y	N	Y		06:02:57	06:03:34	06:05:55	06:26:02	06:39	weeHoloca
2024-06-12T10:53:01.000Z	S4	181	11	600	59.2327	-22.076	D	0.5		Will	Y	Y	N	Y	N	Y	10:03	10:05	10:06	10:08	10:31	10:51	0.25 m/s f
2024-06-13T19:25:31.000Z	S4	200	12	600	59.36105	-21.8506	D	0.5		Nathan	Y	Y	N	Y	N	Y		18:43:03	18:44:27	18:46:45	19:06:00	19:24:29	
2024-06-14T01:03:59.000Z	S4	204	13	600	59.40235	-21.8079	N	0.5		Nathan	Y	Y	N	Y	N	Y		00:27:05	00:28	00:30:50	00:51:40	01:02:46	
2024-06-16T07:34:26.000Z	R4	223	14	600	59.01251	-24.6658	D	0.5		Will	Y	Y	N	Y	N	Y	06:46	06:48	06:49	06:52	07:12	07:32	uvp lights
2024-06-17T13:11:07.000Z	S5	239	15	600	60.24321	-21.1895	D	0.5		Will	N	Y	N	Y	N	Y	13:10	13:11	13:13	13:15	13:35	13:56	uvp lights
2024-06-18T18:00:42.000Z	S5	257	16	600	60.29231	-21.2202	D	0.5		Will	N	Y	N	Y	N	Y	17:58	18:01	18:02	18:05	18:26	18:46	uvp lights
2024-06-19T00:14:33.000Z	S5	261	17	600	60.27017	-21.2179		0.5		Filipa	N	Y	N	Y	N	Y	00:12:40	00:15:13	00:16:37	00:19:43	00:40:10	01:01	MICROCAT
2024-06-21T05:38:17.000Z	R5	278	18	600	60.12009	-18.9309		0.5		Will	N	Y	N	Y	N	Y	05:21	05:38	NA	NA	05:58	06:17	UVP5 mem
2024-06-21T23:13:34.000Z	R6	293	19	600	60.20139	-18.6676		0.5		Nathan	Y	Y	N	Y	N	N				23:18	23:39	00:00	UVP6 inclu

Transparent Exopolymer Particles (TEP) sampling

Chelsey Baker (NOC)

Transparent exopolymer particles (TEP) can play a role in the aggregation and sedimentation of detritus out of the upper ocean (Alldredge et al., 1993). TEP are sticky polysaccharides and may enhance the success of particle collisions (Engel, 2000). TEP is measured using a semi-quantitative spectrophotometric method which uses Alcian Blue to stain polysaccharides that TEP consists of (Bittar et al., 2018; Passow & Alldredge, 1995). Alcian Blue has been shown to precipitate out of solution over time (> 30 days; Bittar et al., 2018) and so a calibration at the beginning and the end of the cruise was undertaken to account for any changes in the strength of the stain.

Transparent exopolymer particles (TEP) were sampled at 5 depths from the CTD (general and optics) at the Superstations and Roaming stations between the 26th May 2024 and the 21st June 2024 during the BIO-Carbon cruise DY180 aboard the RRS Discovery as part of the PARTITRICS project.

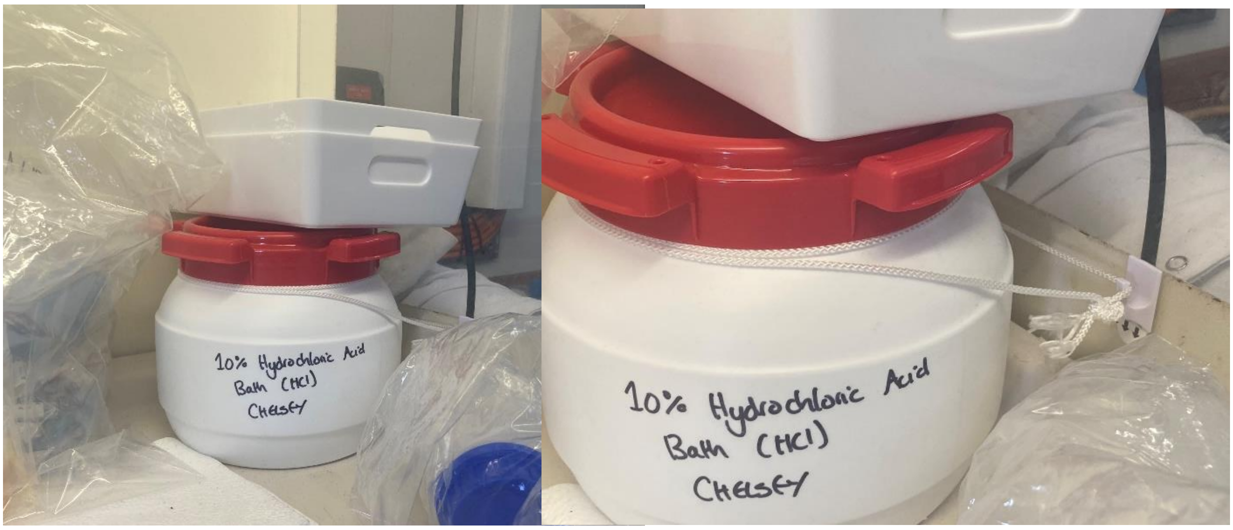
Sample Collection

Approximately 1L was sampled from Niskin bottles on the CTD using a tube into a seawater rinsed carboy. At Roaming station 3 there was *Phaeocystis* in the water which is known to produce TEP and so two extra depths were sampled to get a higher resolution depth profile. At Superstation 5 there was a bonus 15m Marine Snow Catcher in chalky waters with lots of sinking *E. Hux.* and TEP was also measured on the snow catcher fractions. Samples were typically stored in the dark at 4 °C until the sample was ready to be filtered (always within 8 hours of sampling).

Sample Preparation

TEP is measured by filtering seawater under a very gentle vacuum (< 110 mmHg/ 0.14 BAR) and staining with a pre-filtered (0.2 µm) Alcian Blue working solution.

Typically, 45-100 mL of gently mixed seawater were filtered under low vacuum (always < 110 mmHg/0.14 BAR) through a 0.4 µm 25 mm polycarbonate filter (Whatman). 2-3 10% HCL acid-cleaned glass filtration holders were used (cleaned between filtration sessions in an acid bath secured in the fume hood; see images below).



Before the filter dried 0.5 mL of Alcian Blue stain was added, filtered out and rinsed with MilliQ. Filter blanks were made by filtering 0.5 mL of Alcian Blue stain and rinsing with MilliQ. The collected samples were often visibly darker than the 6 blanks. For each depth 3-5 replicates were filtered to quantify the variability arising from the filtering procedure and TEP heterogeneity within the seawater. Filters were placed in 15 mL centrifuge tubes and frozen at -20 °C and will be analysed onshore.

TEP filtering set up in front of the size-fractionated filtration rig. The rig was setup and taken down for each filtration session. Near the end of the cruise one of the glass filtration cups would no longer form a seal and so only two cups were used.

Filtering Issues

As filtering began for TEP for the Roaming 1 station it became clear that the pump was not working correctly and that the vacuum was much stronger than the reading was indicating. Filtering also went very quickly on Superstation 1 and so it seems likely that the pump was broken then.

The pump was switched and filtering recommenced on Roaming station 1 and the filtering proceeded at the expected rate and the blanks (7-9) were much lower than the Test station, Superstation 1 and for Blanks 1-6 on the Roaming 1 station. It was unclear whether the pump would have affected the pre-sampling calibration on the cruise as the Xanthan Gum should not be sucked through the filter but the blanks were much higher than the sampling blanks possibly because the process is different. The calibration was re-done the day after Roaming station 1 (1st June).

A post-sampling calibration was undertaken on the 23rd of June 2024 to account for any changes in the strength of the stain.

Acknowledgements

Thank you to Cordelia Roberts for sampling the CTD for TEP when I was unavailable.

Sampling details for TEP

Event ID	CTDNumber	Date	Ship Station	Latitude	Longitude	Niskin Bottle	Depth (m)	TEP Carboy	Notes/Comments
1	CTD001S	26/05/2024	Test	59 11.50 N	22 24.76	16	20	1	Broken pump
1	CTD001S	26/05/2024	Test	59 11.50 N	22 24.76	12	55	2	
1	CTD001S	26/05/2024	Test	59 11.50 N	22 24.76	10	120	3	
36	CTD005S	28/05/2024	Superstation 1	60.000201	-24.000319	20	10	1	Broken Pump
36	CTD005S	28/05/2024	Superstation 1	60.000201	-24.000319	14	30	2	
36	CTD005S	28/05/2024	Superstation 1	60.000201	-24.000319	12	55	3	
36	CTD005S	28/05/2024	Superstation 1	60.000201	-24.000319	10	120	4	
36	CTD005S	28/05/2024	Superstation 1	60.000201	-24.000319	8	250	5	
71	CTD012S	31/05/2024	Roaming 1	56.216086	-26.830094	20	10	1	Changed pump and then filtered with correct vacuum pressure (except blanks 1-6)
71	CTD012S	31/05/2024	Roaming 1	56.216086	-26.830094	14	30	2	
71	CTD012S	31/05/2024	Roaming 1	56.216086	-26.830094	12	55	3	
71	CTD012S	31/05/2024	Roaming 1	56.216086	-26.830094	10	120	4	
71	CTD012S	31/05/2024	Roaming 1	56.216086	-26.830094	8	250	5	
89	CTD015S	03/06/2024	Roaming 2	57.125642	-	20	10	1	Correct vacuum pressure

					26.137596				
89	CTD015S	03/06/2024	Roaming 2	57.125642	-26.137596	14	30	2	
89	CTD015S	03/06/2024	Roaming 2	57.125642	-26.137596	12	55	3	
89	CTD015S	03/06/2024	Roaming 2	57.125642	-26.137596	10	120	4	
89	CTD015S	03/06/2024	Roaming 2	57.125642	-26.137596	8	250	5	
147	CTD024S	08/06/2024	Superstation 3	59.350511	-22.472926	20	10	1	
147	CTD024S	08/06/2024	Superstation 3	59.350511	-22.472926	14	30	2	
147	CTD024S	08/06/2024	Superstation 3	59.350511	-22.472926	12	55	3	
147	CTD024S	08/06/2024	Superstation 3	59.350511	-22.472926	10	120	4	
147	CTD024S	08/06/2024	Superstation 3	59.350511	-22.472926	8	250	5	
166	CTD027S	10/06/2024	Roaming 3	57.210143	-28.390329	20	10	1	phaeocystis at station, the most TEP so far
166	CTD027S	10/06/2024	Roaming 3	57.210143	-28.390329	18	15	2	
166	CTD027S	10/06/2024	Roaming 3	57.210143	-28.390329	16	20	3	
166	CTD027S	10/06/2024	Roaming 3	57.210143	-28.390329	14	30	4	
166	CTD027S	10/06/2024	Roaming 3	57.210143	-28.390329	12	55	5	
166	CTD027S	10/06/2024	Roaming 3	57.210143	-28.390329	10	120	6	
166	CTD027S	10/06/2024	Roaming 3	57.210143	-	8	250	7	

					28.390329				
210	CTD036S	14/06/2024	Superstation 4	59.495235	-21.804866	20	10	1	lots of diatoms but no nutrient limitation yet (double check)
210	CTD036S	14/06/2024	Superstation 4	59.495235	-21.804866	14	30	2	
210	CTD036S	14/06/2024	Superstation 4	59.495235	-21.804866	12	55	3	
210	CTD036S	14/06/2024	Superstation 4	59.495235	-21.804866	10	120	4	
210	CTD036S	14/06/2024	Superstation 4	59.495235	-21.804866	8	250	5	
227	CTD040S	16/06/2024	Roaming 4	59.011527	-24.650197	20	10	1	lots of coccos, viruses?
227	CTD040S	16/06/2024	Roaming 4	59.011527	-24.650197	14	30	2	
227	CTD040S	16/06/2024	Roaming 4	59.011527	-24.650197	12	55	3	
227	CTD040S	16/06/2024	Roaming 4	59.011527	-24.650197	10	120	4	
227	CTD040S	16/06/2024	Roaming 4	59.011527	-24.650197	8	250	5	
251	MSC71	18/06/2024	Superstation 5	60.265927	-21.087477	Tzero	15	N/A	e hux in the tray, possibly infected with viruses (flow cytometry)
251	MSC71	18/06/2024	Superstation 5	60.265927	-21.087477	Top	15	N/A	
251	MSC71	18/06/2024	Superstation 5	60.265927	-21.087477	Base	15	N/A	
251	MSC71	18/06/2024	Superstation 5	60.265927	-21.087477	Tray	15	N/A	
268	CTD046S	20/06/2024	Superstation	60.218907	-	20	10	1	chalky

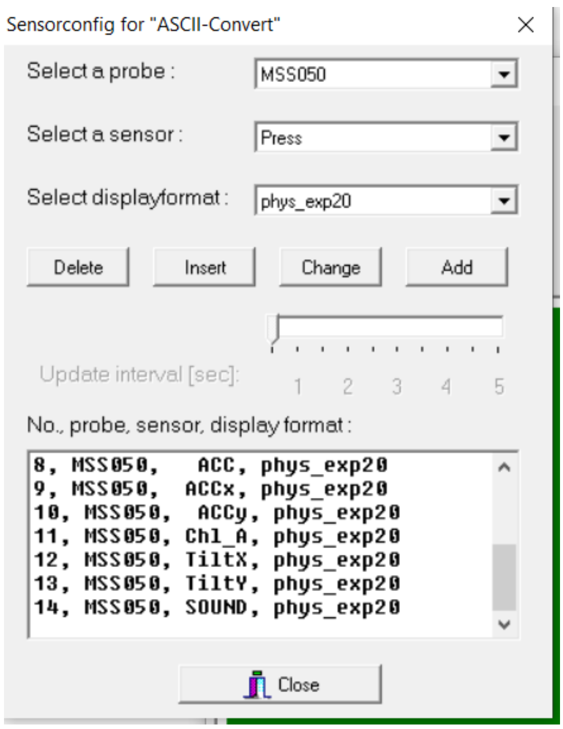
			5		21.079711				
268	CTD046S	20/06/2024	Superstation 5	60.218907	-21.079711	14	30	2	
268	CTD046S	20/06/2024	Superstation 5	60.218907	-21.079711	12	55	3	
268	CTD046S	20/06/2024	Superstation 5	60.218907	-21.079711	10	120	4	
268	CTD046S	20/06/2024	Superstation 5	60.218907	-21.079711	8	250	5	
283	CTD049S	21/06/2024	Roaming 5	60.125017	-18.944951	20	10	1	
283	CTD049S	21/06/2024	Roaming 5	60.125017	-18.944951	14	30	2	
283	CTD049S	21/06/2024	Roaming 5	60.125017	-18.944951	12	55	3	
283	CTD049S	21/06/2024	Roaming 5	60.125017	-18.944951	10	120	4	
283	CTD049S	21/06/2024	Roaming 5	60.125017	-18.944951	8	250	5	

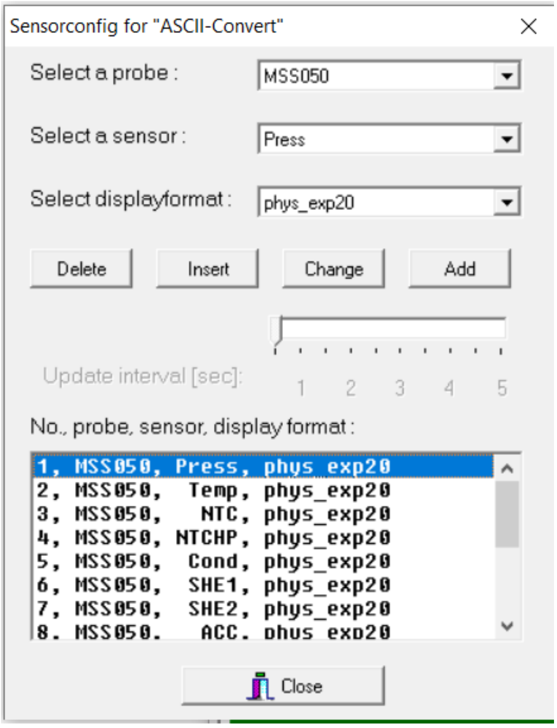
Microstructure Profiler

Chelsey Baker, Filipa Carvalho, Nathan Briggs, Will Major, Billy Platt, Jason Scott, Paul Henderson, Simon Jones (NOC)

Microstructure profiles were undertaken from the 26th May to the 21st June on the DY180 BIO-Carbon cruise to measure small-scale turbulence along with temperature and salinity. The MSS050 profiler was used. Typically, 10 profiles were undertaken down to 200m, with two ~2 hour profiling sessions at each Superstation and one ~2 hour profiling session at each Roaming station. In total 141 profiles were collected (not including 1 bench test and 2 test profiles) throughout the cruise. The turbulence profiler was deployed from the port quarter with two technicians and one scientist outside and one scientist inside monitoring the depth and sinking speed of the profiler, with communications via radio. As standard practice the cable was spooled out sufficiently quickly to avoid any tension in the cable but not so fast as to leave excessive cable at the surface or to overshoot excessively at the stop depth. Cable was spooled down straight from the drum, not over the winch arm. The ship was kept moving relative to the water at ~0.2-0.4 kt. The two shear sensors on MSS50 were 98 and 99. The pod thruster on the port side was turned off during deployments. The profiler generally sank at ~0.6 m s^{-1} – the sinking speed was timed during deployments using the changes in pressure over a 15 second period, with 10m covered in 15 seconds for 0.6 m s^{-1}.
As the SSDA_228 processing software is no longer available a combination of various MATLAB processing scripts were used. The processing stages included:

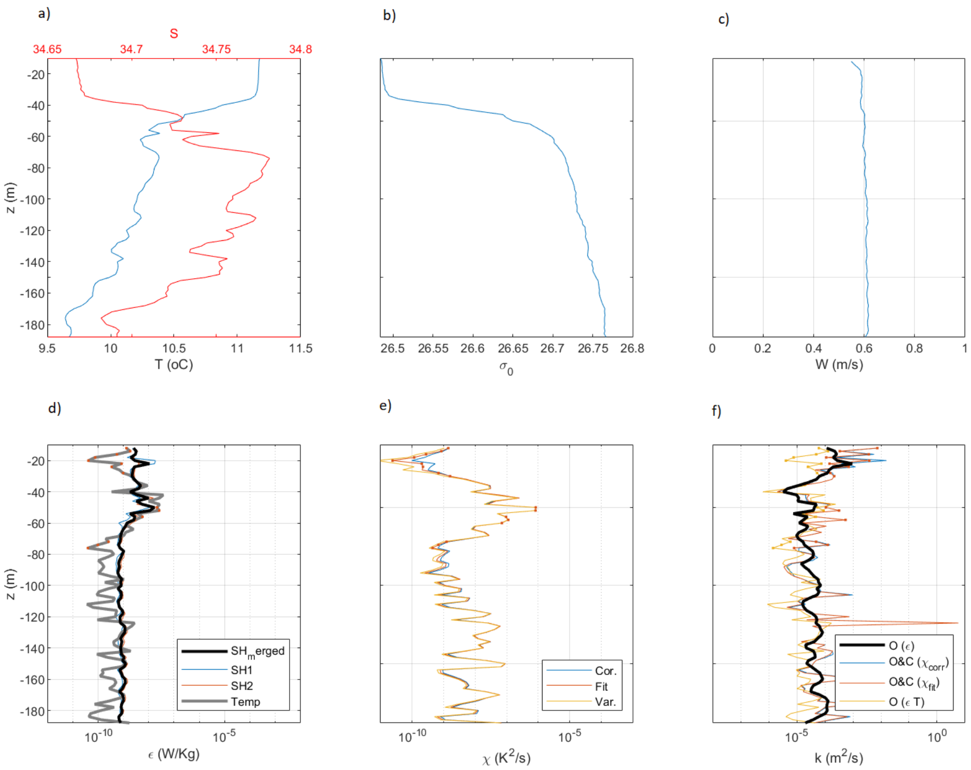
1) Converting the .MRD files to a .TOB (ASCII) file using the SSDA software. To do this the following steps were followed:
    a. Open the SSDA_228 software on the NMF laptop
    b. Go to 'Options' and select 'Export Datafile'
    c. Select probe MSS050
    d. Ensure the sensors are configured as below with phys_exp20





   e. Select 'Close'
   f. Select a file to convert e.g. 'DY180_MSS17_6.MRD' and press 'Open'
   g. Ensure dataset rate says 'everyone' or '1' and press 'Ok, Show'
   h. Choose a file name to save it as e.g. 'DY180_MSS17_6.TOB' and press 'Save'
   i. The software should show % of conversion at the bottom and a box saying 'ASCII-Convert completed' should appear.
   j. The .MRD and .TOB raw data files can then be copied and stored on the cruise folder on the science public drive.

2) The .MRD and .TOB files were renamed to be in numerically ascending order and then read into a MATLAB script originally written by Marcus Dengler (GEOMAR) and adapted for cruise DY111 data by Adrian Martin (NOC). The scripts did not work very well for the Iceland Basin as the mixed layer was continually cut off from the profiles and there was a bug in the code that could not be identified which was hindering processing and plotting of the data.
3) Bieito Fernández-Castro (University of Southampton) kindly sent through some further processing scripts that used the pre-processed .mat files from the GEOMAR scripts and further processed and plotted the data (example below).



a) Temperature and salinity profiles, b) surface-reference potential density, c) sinking speed of the profiler in m/s, d) turbulent kinetic energy calculated from the shear sensors and from temperature (as in Fernandez-Castro et al. 2024), e) thermal variance and f) vertical diffusivity from the shear sensors and derived from thermal variance.

Turbulence profiles collected during DY180

MSS #	Event#	Filename	Renamed to	Date	Time	Lat	Lon	Echo depth	Depth	Temp	SST	Sea state	Wind	W-direction	Max out
0001	-1	test on deck	0001.MRD	22/05/2024	10:28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0002	9	DY180 test 1.MRD	0002.MRD	26/05/2024	16:34	59.151923	-22.524929	N/A	100	N/A	N/A	N/A	3.2	238	N/A
0003	10	DY180 test 2.MRD	0003.MRD	26/05/2024	16:48	59.150889	-22.522884	N/A	100	N/A	N/A	N/A	2.8	180.3	N/A
0004	45	DY180 MSS4_1.MRD	0004.MRD	28/05/2024	21:30	60	-24		200				12.04	61.8	
0004	45	DY180 MSS4_2.MRD	0005.MRD	28/05/2024		60	-24		200						
0004	45	DY180 MSS4_3.MRD	0006.MRD	28/05/2024		60	-24		200						
0004	45	DY180 MSS4_4.MRD	0007.MRD	28/05/2024		60	-24		200						
0004	45	DY180 MSS4_5.MRD	0008.MRD	28/05/2024		60	-24		200						
0004	45	DY180 MSS4_6.MRD	0009.MRD	28/05/2024		60	-24		200						
0004	45	DY180 MSS4_7.MRD	0010.MRD	28/05/2024		60	-24		200						
0004	45	DY180 MSS4_8.MRD	0011.MRD	28/05/2024		60	-24		200						
0004	45	DY180 MSS4_9.MRD	0012.MRD	28/05/2024		60	-24		200						
0004	45	DY180 MSS4_10.MRD	0013.MRD	28/05/2024	23:03	60	-24		200				11.87	62.3	
0005	54	DY180 MSS5_01	0014.MRD	29/05/2024	08:41				200				8.57	344.2	
0005	54	DY180 MSS5_02	0015.MRD	29/05/2024					200						
0005	54	DY180 MSS5_03	0016.MRD	29/05/2024					200						
0005	54	DY180 MSS5_04	0017.MRD	29/05/2024					200						
0005	54	DY180 MSS5_05	0018.MRD	29/05/2024					200						
0005	54	DY180 MSS5_06	0019.MRD	29/05/2024				2217	200						
0005	54	DY180 MSS5_07	0020.MRD	29/05/2024				2217	200						
0005	54	DY180 MSS5_08	0021.MRD	29/05/2024	10:19			2217	200				9.31	340.7	
0005	54	DY180 MSS5_09	0022.MRD	29/05/2024		60.0.25	24.0.87	2216	175				8.38	342.3	

0005	54	DY180 MSS5_10	0023.MRD	29/05/2024	10:31	60.0.27	24.0.948	2215	203				10.58	326.7	
0006	70	DY180 MSS6_1	0024.MRD	31/05/2024	08:30	56.2158	-26.8306		200	9.4	9.9		13	175.7	
0006	70	DY180 MSS6_2	0025.MRD	31/05/2024					200						
0006	70	DY180 MSS6_3	0026.MRD	31/05/2024					200						
0006	70	DY180 MSS6_4	0027.MRD	31/05/2024					200						
0006	70	DY180 MSS6_5	0028.MRD	31/05/2024					200						
0006	70	DY180 MSS6_6	0029.MRD	31/05/2024					200						
0006	70	DY180 MSS6_7	0030.MRD	31/05/2024					200						
0006	70	DY180 MSS6_8	0031.MRD	31/05/2024					200						
0006	70	DY180 MSS6_9	0032.MRD	31/05/2024					200						
0006	70	DY180 MSS6_10	0033.MRD	31/05/2024	10:00	56.209	-26.8399		200						
0007	81	DY180 MSS7_1	0034.MRD	02/06/2024	06:00	60.019	-23.719		200	8.66	9.44		28.7	254.7	
0007	81	DY180 MSS7_2	0035.MRD	02/06/2024					200						
0007	81	DY180 MSS7_3	0036.MRD	02/06/2024					200						
0007	81	DY180 MSS7_4	0037.MRD	02/06/2024					200						
0007	81	DY180 MSS7_5	0038.MRD	02/06/2024					200						
0007	81	DY180 MSS7_6	0039.MRD	02/06/2024					182						
0007	81	DY180 MSS7_7	0040.MRD	02/06/2024					200						
0007	81	DY180 MSS7_8	0041.MRD	02/06/2024					200						
0007	81	DY180 MSS7_9	0042.MRD	02/06/2024					200						
0007	81	DY180 MSS7_10	0043.MRD	02/06/2024	07:44	60.0168	-23.7418		200	8.54	9.46				
0008	100	DY180_MSS8_1	0044.MRD	03/06/2024	21:04	57.129758	-26.257708		200	10.36	35.15		24.6	331 (rel), 311 (true)	
0008	100	DY180_MSS8_2	0045.MRD	03/06/2024					200						
0008	100	DY180_MSS8_3	0046.MRD	03/06/2024					200						
0008	100	DY180_MSS8_4	0047.MRD	03/06/2024					200						
0008	100	DY180_MSS8_5	0048.MRD	03/06/2024					200						
0008	100	DY180_MSS8_6	0049.MRD	03/06/2024					200						
0008	100	DY180_MSS8_7	0050.MRD	03/06/2024					200						
0008	100	DY180_MSS8_8	0051.MRD	03/06/2024					200						

0008	100	DY180_MSS8_9	0052.MRD	03/06/2024					200						
0008	100	DY180_MSS8_10	0053.MRD	03/06/2024					200						
0009	121	DY180_MSS9_1	0054.MRD	06/06/2024	18:26	59.419175	-22.63748	2543	187	8.34	10.16	4	15	15	187
0009	121	DY180_MSS9_2	0055.MRD	06/06/2024					200						213
0009	121	DY180_MSS9_3	0056.MRD	06/06/2024					200						
0009	121	DY180_MSS9_4	0057.MRD	06/06/2024					200						
0009	121	DY180_MSS9_5	0058.MRD	06/06/2024					200						
0009	121	DY180_MSS9_6	0059.MRD	06/06/2024					200						
0009	121	DY180_MSS9_7	0060.MRD	06/06/2024					200						
0009	121	DY180_MSS9_8	0061.MRD	06/06/2024					200						
0009	121	DY180_MSS9_9	0062.MRD	06/06/2024					200						
0009	121	DY180_MSS9_10	0063.MRD	06/06/2024	20:09	59.430111	-22.63748	2531	200	8.31	10.06	4	11.8	2.0 (rel), 344(true)	
0010	135	DY180_MSS10_1	0064.MRD	07/06/2024	21:05	59.37111	-22.48667	2621	200	7.94	9.79	5	14.7	345 re;, 320 true	
0010	135	DY180_MSS10_2	0065.MRD	07/06/2024											
0010	135	DY180_MSS10_3	0066.MRD	07/06/2024											
0010	135	DY180_MSS10_4	0067.MRD	07/06/2024											
0010	135	DY180_MSS10_5	0068.MRD	07/06/2024											
0010	135	DY180_MSS10_6	0069.MRD	07/06/2024											
0010	135	DY180_MSS10_7	0070.MRD	07/06/2024											
0010	135	DY180_MSS10_8	0071.MRD	07/06/2024											
0010	135	DY180_MSS10_9	0072.MRD	07/06/2024											
0010	135	DY180_MSS10_10	0073.MRD	07/06/2024	22:48	59.374648	-22.48696	2618	200	8.2	9.77	5	18.3	343 (rel), 328 (true)	
	163	DY180_MSS11_1	0074.MRD	09/06/2024	07:58	57.229623	-28.349466	2709	200	9.97	11.01	3	6.4	250 (rel), 128 (true	200
	163	DY180_MSS11_2	0075.MRD	09/06/2024											187
	163	DY180_MSS11_3	0076.MRD	09/06/2024											208
	163	DY180_MSS11_4	0077.MRD	09/06/2024											206
	163	DY180_MSS11_5	0078.MRD	09/06/2024											196
	163	DY180_MSS11_6	0079.MRD	09/06/2024											

	163	DY180_MSS11_7	0080.MRD	09/06/2024											
	163	DY180_MSS11_8	0081.MRD	09/06/2024											195
	163	DY180_MSS11_9	0082.MRD	09/06/2024											
	163	DY180_MSS11_10	0083.MRD	09/06/2024	09:39	57.214396	-28.380467	2709	200	10.51	11.01	3	7.9	10 (rel), 164 (true)	200
0012	189	DY180_MSS12_1	0084.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_2	0085.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_3	0086.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_4	0087.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_5	0088.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_6	0089.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_7	0090.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_8	0091.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_9	0092.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0012	189	DY180_MSS12_10	0093.MRD	12/06/2024	18:48	59.21422	-22.047829	24164	200	10.55	11.05	4	14.8	0 (rel), 198 (true)	200
0013	201	DY180_MSS13_1	0094.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_2	0095.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_3	0096.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_4	0097.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_5	0098.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_6	0099.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_7	0100.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_8	0101.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_9	0102.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
0013	201	DY180_MSS13_10	0103.MRD	13/06/2024	20:19	59.3732	-21.8226	2822	200	8.97	10.46	4	17	320	200
014	224	DY180_MSS14_1	0104.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	195
014	224	DY180_MSS14_2	0105.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200
014	224	DY180_MSS14_3	0106.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200
014	224	DY180_MSS14_4	0107.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200
014	224	DY180_MSS14_5	0108.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200

014	224	DY180_MSS14_6	0109.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200
014	224	DY180_MSS14_7	0110.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200
014	224	DY180_MSS14_8	0111.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200
014	224	DY180_MSS14_9	0112.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200
014	224	DY180_MSS14_10	0113.MRD	16/06/2024	08:18	59.01184	-24.664455	2750	200	9.07	10.61	3	9.4	359	200
015	258	DY180_MSS15_1	0114.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_2	0115.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_3	0116.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_4	0117.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_5	0118.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_6	0119.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_7	0120.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_8	0121.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_9	0122.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
015	258	DY180_MSS15_10	0123.MRD	18/06/2024	19:26	60.29129	-21.2402		200	10.58	10.73		18.7	205.4	200
016	267	DY180_MSS16_1	0124.MRD	20/06/2024	09:15	60.219997	-21.069431	2729	200	10.78	10.87	6	24.4	315	208
016	267	DY180_MSS16_2	0125.MRD	20/06/2024	09:25	60.219997	-21.069431	2729	200	10.78	10.87	5	24.4	315	185
016	267	DY180_MSS16_3	0126.MRD	20/06/2024	09:35	60.219997	-21.069431	2729	200	10.78	10.87	6	24.4	315	220
016	267	DY180_MSS16_4	0127.MRD	20/06/2024	09:46	60.219997	-21.069431	2729	200	10.78	10.87	6	24.4	315	191
016	267	DY180_MSS16_5	0128.MRD	20/06/2024	09:58	60.219997	-21.069431	2729	200	10.78	10.87	5	24.4	315	205
016	267	DY180_MSS16_6	0129.MRD	20/06/2024	10:09	60.219997	-21.069431	2729	200	10.78	10.87		24.4	315	
016	267	DY180_MSS16_7	0130.MRD	20/06/2024	10:18	60.219997	-21.069431	2729	200	10.78	10.87		24.4	315	
016	267	DY180_MSS16_8	0131.MRD	20/06/2024	10:30	60.219997	-21.069431	2729	200	10.78	10.87		24.4	315	
016	267	DY180_MSS16_9	0132.MRD	20/06/2024	10:41	60.219997	-21.069431	2729	200	10.78	10.87		24.4	315	
016	267	DY180_MSS16_10	0133.MRD	20/06/2024	10:51	60.219997	-21.069431	2729	200	10.78	10.87		24.4	315	

017	279	DY180_MSS17_1	0134.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_2	0135.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_3	0136.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_4	0137.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_5	0138.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_6	0139.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_7	0140.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_8	0141.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_9	0142.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	
017	279	DY180_MSS17_10	0143.MRD	21/06/2024	07:02	60.1194	-18.9481	2636	200	10.4	11.17		12	191.7	