National Oceanography Centre

Cruise Report No. 68

RRS *Discovery* Cruise DY096
28 November – 14 December 2018
Punta Arenas, Chile – Punta Arenas, Chile

CUSTARD: Carbon Uptake and Seasonal Traits in Antarctic Remineralisation Depth

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2018

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ABSTRACT

The CUSTARD project examines how seasonal changes in nutrient availability for phytoplankton, at a key junction of the global ocean circulation, influence how long carbon is trapped in the ocean rather than escaping to the atmosphere as carbon dioxide.

If we want to understand the role of the Southern Ocean in regulating global climate we need to understand both how much carbon is used to make phytoplankton at the ocean surface and how deep this material penetrates into the ocean interior; the 'remineralisation depth'. The objective of CUSTARD is to make new observations of the remineralisation depth and its controls in an important, yet remote, region of the Southern Ocean, using a combination of gliders, a mooring, sophisticated new sensors and a process cruise. The observations will be combined with modelling to determine the key processes regulating carbon uptake in the Southern Ocean.

DY096 marked the start of one year of observations by CUSTARD. Cruise objectives included the deployment of a surface mooring and two gliders to make observations throughout the year until they would be retrieved on a cruise at the start of 2020. Immediately prior to the recovery cruise a process cruise is planned. For DY096 the surface mooring was provided and deployed by a team from WHOI as part of the NSF Ocean Observatories Initiative. The mooring had also been adapted by WHOI to integrate novel NOC lab-on-a-chip nitrate and silicate sensors. Another aim was to recover the surface mooring already at the site, now into its third year after recovery was not possible in 2017, and the lower parts of two subsurface moorings, all parts of the original OOI array. These deployments and recoveries were the priorities together with the collection of observations to calibrate the sensors on mooring and gliders. If further iron and optical particulate data could be obtained it would also be very useful to inform planning for the 2019 process cruise.

Weather, swell and a ship issue restricted time on site to 102 hours of which conditions were suitable to deploy/recover equipment over the side for just 61 hours, out of a 16 day cruise. Nevertheless, all of the priorities were achieved. It was also possible to collect some limited samples for iron concentrations but not to collect any standalone optical particulate observations.

CUSTARD (NE/K015613/1) is part of the NERC Role of the Southern Ocean in the Earth System (RoSES) programme.

KEYWORDS

Carbon, Southern Ocean, biological carbon pump, mode water, phytoplankton, glider, mooring, OOI, lab-on-a-chip, iron, nutrients, diatoms, export, transfer efficiency, CUSTARD, RoSES

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List of Personnel

Scientific Personnel

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Wright, Alan	University of Southampton

Technical Personnel

Leadbeater, Andrew (Senior Technician)	National Oceanography Centre
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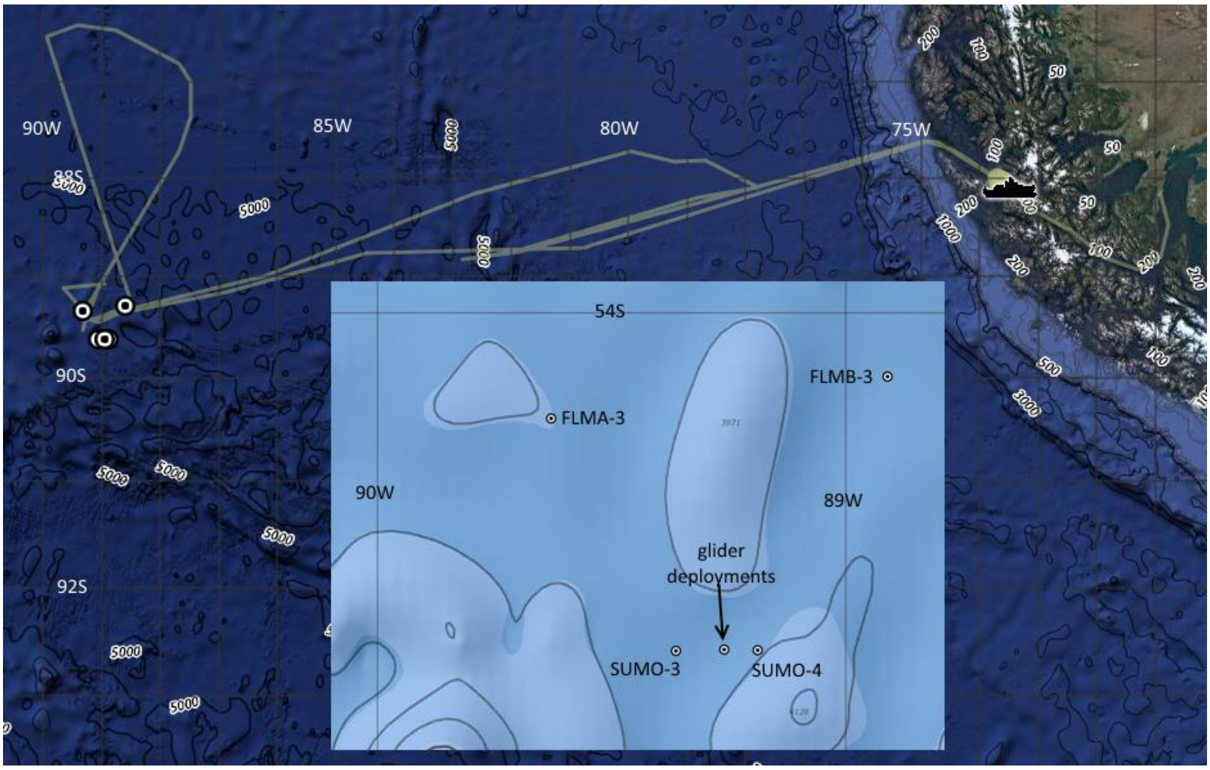
Nemeth, Zoltan	National Oceanography Centre
Shah, Hatim	National Oceanography Centre
Short, Jon (mob only)	National Oceanography Centre

White, David	National Oceanography Centre
Whittle, Stephen	National Oceanography Centre

Ship's Personnel

Gatti, Antonio	Master
Mackay, Stewart	C/O
Leggett, Colin	2/O
Lawrence, Ben	3/O
Bills, Jim	C/E
Kemp, Chris	2/E
Evans, Daniel	3/E
Murren, Michael	3/E
Fisher, Charles	ETO
Watterson, Ian	Purser
MacDonald, John	CPOS
Maclean, Andrew	CPOD
Spencer, Robert	POD
Dwyer, Andy	SG1A
Lapsley, Craig	SG1A
Harvey, Nathan	SG1A
Gilfillan, Craig	SG1A
Williams, Emlyn	ERPO
Ashfield, Mark	H/Chef
Leigh, Michael	Chef
Ray, Charlotte	Stwd
Williams, Denzil	A/Stwd

Itinerary



Map showing site of DY096 activity. Marked are positions of mooring deployed (SUMO-4), moorings recovered (SUMO-3, FLMA-3, FLMB-3) and glider deployments. Deviations of ship tracks were due to engine issue and weather. See Narrative for details.

Objectives

The CUSTARD project will examine how seasonal changes in nutrient availability for phytoplankton, at a key junction of the global ocean circulation, influence how long carbon is trapped in the ocean rather than escape to the atmosphere as carbon dioxide.

If we want to understand the role of the Southern Ocean in regulating global climate we need to understand both how much carbon is used to make phytoplankton at the ocean surface and how deep this material penetrates into the ocean interior; the ‘remineralisation depth’. The objective of CUSTARD is to make new observations of the remineralisation depth and its controls in an important, yet remote, region of the Southern Ocean, using a combination of gliders, a mooring, sophisticated new sensors and a process cruise. The observations will be combined with modelling to determine the key processes regulating carbon uptake in the Southern Ocean.

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Weather, swell and a ship issue restricted time on site to 102 hours of which conditions were suitable to deploy/recover equipment over the side for just 61 hours, out of a 16 day cruise. Nevertheless, all of the priorities were achieved. It was also possible to collect some limited samples for iron concentrations but not to collect any standalone optical particulate observations.

Narrative

Saturday 24th November

Sunny with brisk wind, punctuated by a squall in afternoon. All but one UK science team arrived 0200. WHOI team have been in Punta Arenas for a week, building mooring in warehouse on dock. NMF team arrived 20th. Setting up. Steel CTD frame was irreparably damaged in transit so titanium one to be used.

Sunday 25th November

Sunny with variable wind and occasional heavy showers. Setting up of labs and equipment continued.

Monday 26th November

Sunny with winds a little lighter but still variable. Good visibility to a snowy peak southwest down the Strait. WHOI equipment craned on board in morning, including the buoy. WHOI team now on board so we are at full complement for the cruise.

Tuesday 27th November

A beautiful sunny day with light winds. Vessel familiarisation after breakfast punctuated by a team photo in front of Discovery. Continued setting up. Meeting to discuss sampling, given the complexities of now having to use TM clean rosette for all sampling. Also discussed underway and OTE-Flo sampling, and watch allocations. Dave White took the gliders down to the shore end of dock with Filipa and Pablo to do compass checks. Visited by a party from the Almirante Maximiano, a Brazilian Antarctic vessel which pulled up on the opposite side of the dock yesterday. A group was invited back to the Almirante Maximiano for a tour and refreshments. Discovery plaque given to the officer on duty.

Wednesday 28th November

Sunny and calm. Sailed at 0600 with pilot departing shortly after. Antony Birchill gave tutorial on use of TM lab to those who will be sampling from CTD. Safety drill at 1030. Passed through the narrows of the Magellan Strait. Humpbacks, sealions and albatrosses in foreground, snowy, pointy mountains behind. Antony set up and installed NOC nitrate and silicate sensors on sensor cage of NSF mooring with assistance of Sheri and Alan.

Thursday 29th November

Left the Strait around midnight into stiff conditions. Weather abated a little and came off the shelf just after breakfast. Quite sunny, around Force 5 for rest of day. First daily meeting at 0830. Science team briefing at 1030. Talk on project to crew by Principal Scientist at 1400.

Friday 30th November

Entered international waters at 0430. Swath bathymetry turned on at 0600 with Principal Scientist on bridge watching for marine mammals in vicinity during start-up. Underway sampling for FRRF started at 0600 too and Pablo sampled for DIC and oxygen. Plan had been to lower mooring releases on CTD frame to test them soon after leaving Chilean waters. Stopped to appraise conditions for deployment at 0700. Although OK to deploy, concerns at conditions for recovery in 2 hours time given the rising swell. Deployment postponed. Swell rising and forecast for tomorrow worse so release test now not expected before we are due on site. However, decision made by Captain at 1845, while at 53^{o} 50.5S 82^{o} 52.5W, to return to Magellan Strait. Electrical issue with engines that requires more sheltered environment for work to proceed.

Saturday 1st December

Underway sampling ceased just after midnight and data streams stopped at 0200 ahead of re-entering Chilean waters. Weather caught up with us and decision was made at 1046 to heave to until it passed before continuing to the Strait. Engineers resolved issue with engine and can now head back towards OOI site, rather than back to Strait, when the weather abates.

Sunday 2nd December

Wind and then swell subsided gradually subsided. Turned back towards OOI site. Underway sampling resumed on crossing out of Chilean waters. Principal Scientist on bridge watched for marine mammals while swath bathymetry system was fired up again.

Monday 3rd December

Light wind, reduced swell and blue skies. Halted at 1300 at 53^{o} 57.6' S 86^{o} 05.2' W to drop mooring releases to 1500m on CTD frame for testing. Using TM frame as stainless steel one had been badly damaged in transit to Punta Arenas. Test successful. Resumed course for OOI site.

Tuesday 4th December

Freshening wind and increased swell delayed arrival but still on site (54^{o} 27.85' S 89^{o} 01.7'W) just after 0300. Subsequent day was under almost cloudless blue skies until departure. Cold and fresh breeze. Dipped as many OTE-Flo bottles as possible before 0400 at which point mooring deployment began. Near Surface Instrument Frame containing NOC nitrate and silicate sensors overboard at 0548. Buoy in the water at 0652. Anchor released at 1410, deliberately 400m beyond target position of 54^{o} 24.408' S 89^{o} 12.144' W, to allow anchor to sink into correct position. Moved out of watch circle of mooring to 54^{o} S 24.3' 89^{o} 16.8' W, a position equidistant between anchor point of both moorings to allow later CTD cast to be used as calibration for both moorings and gliders. Deployed both MARS gliders successfully, the first (Doombar, 405 at 1439) with the WHOI launch trolley and the second (Churchill, 398, at 1330) with the MARS release system. Immediately followed by CTD to 1000m to collect calibration data. Ecopuck fitted to Titanium frame CTD vane for this comparison but unfortunately not turned on before deployment and no data collected. Water samples collected at depths to match sensors on SUMO-4 mooring that had just been deployed. Following CTD cast, ship repositioned to 54^{o} 24.61' S 89^{o} 22.18' W, 750m north of old mooring (SUMO-3) to allow WiFi contact. While WHOI team tried to download files from mooring, opportunistic OTE-Flo sampling from 20m was carried out. Three bottles collected before decision made by Captain to move off. Only a fraction of files were downloaded from buoy before departure. On departing site, visual inspection was made of the old SUMO-3 buoy. It seemed in good condition: turbine blades were still intact (though only one was known to be working), little biofouling above the water line and photovoltaic cells apparently intact. Headed due north to put distance between ourselves and bad weather approaching form west. Sweepstake set up for first silicate and nitrate values from buoy sensors.

Wednesday 5th December

Made good time overnight. Hove to at 0830 having reached 52^{o}S. Force 8 reducing to force 7 over the day. Swell not presently a major issue but rising. Underway sampling continuing. First sample from nitrate and silicate sensors on buoy; 7000µM and 4.96µM respectively. Silicate OK but nitrate clearly still settling in. Mark wins sweepstake for first silicate value. Nitrate winner delayed until tomorrow. Swath bathymetry turned off at 1700 as vessel stationary and system acquiring a lot of noise in swell.

Thursday 6th December

Grey, force 6, reasonable swell. Foggy with ~500m visibility for much of the day. Mooring data show 9m max height waves at the site in our absence. Prediction was for 12m. Both higher than the 7m we experienced en route on Saturday 1st December. Sheri plotted historical wave heights from the mooring. The maximum was 20m in July 2017. Slowly tracking round outside of weather system to head back towards site. Underway sampling continuing. Swath bathymetry restarted at 0900 with PSO on bridge watching for marine mammals during start-up. Second sample from nitrate and silicate sensors on buoy; 19.6□M and 5.86□M respectively which both seem sensible. Antony wins the sweepstake on the nitrate value. Safety meeting at 1030. No issues from DY096 but useful information on impact of Polar Code for cruise scheduled for next year as it is due to touch 60^{o}S. Antony connected spare lab-on-chip nitrate sensor to the underway, collecting a sample every ~20mins. At 1705 (51^{o} 30'S 89^{o} 57' W) decision made that weather and swell allow return to the site.

Friday 7th December

Lower visibility to start but brightening with even some blue sky appearing. Force 7 throughout, give or take a point, and swell persistent. Xmas decorations up. At 1010 (54^{o} 15.1' S 88^{o} 27.7'W) we changed direction to westward in order to approach site after travelling SSE over night to minimise rolling with swell. At 1411 stopped to hold position roughly equidistant between buoys at 54^{o} 23.8' S 89^{o} 02.1' W.

Collecting ship met data for direct comparison/calibration of surface moorings' met data. WHOI recommendation was for at least 6 hours on position. Since deployment, the Doombar (405) glider has been experiencing difficulties in communicating. In addition to reliability this raises a concern over greater energy usage if it keeps trying and failing to make contact. As a year's deployment is already pushing the battery limit this problem needs to be rectified or else the glider needs to be recovered. Decision made to deploy the spare glider Pancake (404) but not to recover Doombar yet. All three would be left in until tomorrow at least in order to allow further remote work from NOC on Doombar before a decision is made on whether to recover Doombar or Pancake. Pancake does not have a pumped CTD and so would be second choice to Doombar (with a pumped CTD) should Doombar start behaving. At 1800 swell conditions assessed as too risky for glider deployment. It might be possible to get Pancake in but if it then exhibited problems it would be impossible to get it back in without a significant risk of damage. Resumed collection of met data for buoy comparison holding same position.

Saturday 8th December

Swell and wind (Force 7) as yesterday. No wire activity overnight and swell too great in morning. Ship moved to first triangulation point using dynamic positioning for anchor survey (Tri Lat 2 - 0900 - 54° 25.150' S, 89° 12.425' W) also allowing WiFi download of data from buoy to do met comparison. After acoustic sounding of anchor, moved off towards second triangulation station (Tri Lat 1 - 1045 - 54° 23.944' S, 89° 13.180' W) and then third (Tri Lat 3 - 1142 - 54° 25.040' S, 89° 11.014'). Calculated anchor position was 54° 24.4301' S 89° 12.3622' W in 4589 m water depth. Forecast suggesting conditions may start to improve late afternoon so DP used to move towards original glider release point to be ready should they do so. At location and holding position.

Sunday 9th December

Swell and wind gradually dropping throughout day. Conditions finally workable around breakfast. Replacement glider (Pancake 404) deployed at 0736 (1036 GMT). Location 54° 24.62 S 89° 16.66 W to match that of original glider deployments, equidistant between two surface moorings. Followed immediately by CTD to 1000m at same location for calibration. Moved off to south to rendezvous with Doombar (405) glider which has not been uploading files. Successful recovery. Meeting to discuss whether conditions allow surface mooring recovery involving Captain, NMF techs, WHOI team, CPO Deck and PSO. Decision to go ahead with option to leave buoy adrift overnight if conditions don't allow its recovery at end. Moved to position 1nm downwind (54° 24.32 S 89° 23.04 W) at 1340 (1640 GMT) and fired releases. Flotation balls at surface within 45mins and grappled onto line. On board and hauling in of mooring began at 1515 (1815 GMT). Wire cut with c250m remaining below buoy at 1955 (2255 GMT). Buoy hooked on and lifted onto deck at 2044 (2344 GMT). NSIF and remaining wire on board by 2147 (0047 GMT). All secured. Returned to site of glider deployments for full depth (4510m) CTD. Began 2328 (0228 GMT)

Monday 10th December

CTD back on deck 0244 (0544 GMT). Day cold and grey with occasional fluctuations into sun and rain. Swell low by local standards and forecast good for day so decision made to go for both subsurface moorings. On site (54° 07.07' S 89° 38.98' W) for subsurface Flanking Mooring A (FLMA-3) at 0534 (0834 GMT). After acoustically triggering release at 0708 (1008 GMT), syntactic float on surface in just over 10 mins, and all on deck by 1243 (1543 GMT). On site (54° 03.87' S 89° 57.04' W) to recover subsurface Flanking Mooring B (FLMB-3) at 1455 (1755 GMT). Mooring all on deck by 2107 (0007 GMT). Moved to be near gliders and new surface buoy (SUMO-4).

Tuesday 11th December

On site (54° 25.38' S 89° 15.06' W) by 0027 (0327 GMT). Filipa had predicted glider progression sufficiently well to be within 1.5km of Churchill (398) and 1km of Pancake (404). Site 4.5km from SUMO-4. OTE-Flo deployed using the 3 bottles that we had managed to prepare sufficiently with previous dips. Bottles using full depth of Kevlar rope as our last chance of a profile, firing bottles by messenger at 200m, 100m and 20m. Immediately followed by a CTD to 1000m with Ecopuck attached. On deck by 0352. Sampling from rosette bottles continued as we started east, beginning return to Punta Arenas. Six right angle turns done at start of route at 0512, 0518, 0536, 0542, 0620, 0624 (0812, 0818, 0836, 0842, 0920, 0924 GMT) to provide information for deep water calibration of ship-mounted ADCP. Day, cold and grey with wind and swell starting to pick up. WHOI team spent much of it cleaning biofouling from moorings. In transit.

Wednesday 12th December

Grey, cold, force 4-5 and rain. A day of packing and paperwork. Underway sampling and swath bathymetry stopped at 0952 (1252 GMT) ahead of crossing into Chilean waters.

Thursday 13th December

Entered Strait around 0400 (0700 GMT). Light winds, partially blue sky. Spent day sailing up Strait. Much of snow on mountains has gone in our absence. Packing. Team photo on deck just before lunch. More packing. Waited just offshore of Punta Arenas overnight

Friday 14th December

Pilot on board first thing and docked alongside just before breakfast. Demob.

DY096 Event Log

Event	Bridge notes	Activity #	Date	Day of year	Time UTC	Time ship	Lat (°S)	Lon (°W)	Notes
	Swath bathymetry recordings started. Marine Mammal Observations started.		30/11/18	334	09:00	06:00	53 32.8	80 38.5	Left Chilean waters
001	On station for SUMO-4 mooring release test	CTD1	3/12/18	337	16:02	13:02	53 57.6	86 05.2	Labelled as CTD as data collected. No bottles.
001	CTD with releases deployed	CTD1	3/12/18	337	16:22	13:22	53 57.63	86 05.29	
001	CTD at 1500m; held now for 20mins	CTD1	3/12/18	337	16:59	13:59	53 57.63	86 05.29	
001	CTD frame on deck	CTD1	3/12/18	337	17:52	14:52	53 58.09	86 07.93	
001	Left station	CTD1	3/12/18	337	18:06	15:06	53 58.15	86 08.18	
002	On station for OTE-Flo	OTEFLO1	4/12/18	338	06:06	03:06	54 27.8	89 01.7	
002	OTE-Flo deployment commenced	OTEFLO1	4/12/18	338	06:10	03:10	54 27.81	89 01.69	
002	OTE-Flo recovered to deck	OTEFLO1	4/12/18	338	06:56	03:56	54 27.81	89 01.69	
003	NSIF over side	BUOY1	4/12/18	338	08:48	05:48	54 27.81	89 01.69	Deployment of SUMO-4
003	Surface buoy in water. Speed 0.5kn	BUOY1	4/12/18	338	09:52	06:52	54 27.81	89 01.71	
003	ADCP in water	BUOY1	4/12/18	338	11:13	08:13	54 27.40	89 02.99	

003	Increase speed. 1.0 kn over ground	BUOY1	4/12/18	338	11:33	08:33	54 27.28	89 03.35	
003	Connected nylon rope	BUOY1	4/12/18	338	12:50	09:50	54 26.66	89 05.24	
003	Begin paying out Colmega rope	BUOY1	4/12/18	338	14:05	11:05	54 25.98	89 07.33	
003	Anchor weight released	BUOY1	4/12/18	338	17:10	14:10	54 24.28	89 12.52	
003	Off station	BUOY1	4/12/18	338	17:15	14:15	54 24.38	89 16.92	
	On station for glider release		4/12/18	338	17:46	14:46	54 24.3	89 16.8	
004	Glider 1 deployed	GLIDER1	4/12/18	338	17:58	14:58	54 24.39	89 16.92	
005	Glider 2 deployed	GLIDER2	4/12/18	338	18:30	15:30	54 24.49	89 16.71	
006	CTD deployed to 1000m	CTD2	4/12/18	338	19:44	16:44	54 24.48	89 16.78	
006	CTD recovered	CTD2	4/12/18	338	21:00	18:00	54 24.3	89 16.8	
007	OTE-Flos deployed	OTEFLO2	4/12/18	338	21:40	18:40	54 24.61	89 22.18	
007	OTE-Flo's recovered	OTEFLO2	4/12/18	338	22:05	19:05	54 24.61	89 22.18	
008	On station for buoy met comparison	BUOY2	7/12/18	341	17:17	14:17	54 26.11	89 15.09	
009	Station Tri Lat 2 for anchor survey	BUOY3	8/12/18	342	11:59	08:59	54 25.14	89 12.44	
009	Off station Tri Lat 2 hdg for Tri Lat 1	BUOY3	8/12/18	342	12:05	09:05	54 25.16	89 12.43	
009	Station Tri Lat 1 for anchor survey	BUOY3	8/12/18	342	13:46	10:46	54 23.95	89 13.17	

009	Off station Tri Lat 1 hdg for Tri Lat 3	BUOY3	8/12/18	342	13:50	10:50	54 20.35	89 13.17	
009	Station Tri Lat 3 for anchor survey	BUOY3	8/12/18	342	14:37	11:37	54 24.04	89 10.98	
009	Anchor survey complete	BUOY3	8/12/18	342	14:42	11:42	54 24.05	89 10.96	
010	Glider deployed	GLIDER3	9/12/18	343	10:36	07:36	54 24.62	89 16.66	Pancake 404
011	CTD deployed to 1000m	CTD3	9/12/18	343	12:13	09:13	54 24.62	89 16.66	
011	CTD on deck	CTD3	9/12/18	343	13:34	10:34	54 24.62	89 16.67	
	Off station		9/12/18	343	13:58	10:58	54 25.35	89 17.51	
012	Glider recovered	GLIDER4	9/12/18	343	15:08	12:08	54 33.00	89 19.07	Doombar 405
	Off station		9/12/18	343	15:16	12:16	54 33.04	89 18.99	
013	On station for mooring recovery 1m upwind	BUOY4	9/12/18	343	16:40	13:40	54 24.32	89 23.04	Recovery of SUMO-3
013	Hydrophone deployed	BUOY4	9/12/18	343	16:50	13:50	54 24.31	89 23.04	
013	Confirmed release	BUOY4	9/12/18	343	16:51	13:51	54 24.31	89 23.04	
013	Flotation on surface	BUOY4	9/12/18	343	17:40	14:40	54 24.49	89 20.82	
013	Hydrophone recovered	BUOY4	9/12/18	343	17:56	14:56	54 24.50	89 20.88	
013	Flotation grapnelled	BUOY4	9/12/18	343	18:05	15:05	54 24.48	89 20.71	
013	Flotation on deck	BUOY4	9/12/18	343	18:15	15:15	54 24.48	89 20.66	

013	Releases on deck	BUOY4	9/12/18	343	18:18	15:15	54 24.48	89 20.61	
013	ADCP recovered	BUOY4	9/12/18	343	22:16	19:16	54 22.4	89 15.6	
013	Wire cut c250m wire remaining under buoy	BUOY4	9/12/18	343	22:55	19:55	54 22.1	89 15.6	
013	Buoy hooked on	BUOY4	9/12/18	343	23:21	20:21	54 22.14	89 15.93	
013	Buoy on deck	BUOY4	9/12/18	343	23:44	20:44	54 21.87	89 16.42	
013	End of wire on deck	BUOY4	10/12/18	344	00:47	21:47	54 20.54	89 18.35	
	Off station		10/12/18	344	01:14	22:14	54 20.32	89 18.35	
	On station for CTD		10/12/18	344	02:01	23:01	54 24.58	89 16.77	
014	CTD deployed to full depth 4510m	CTD4	10/12/18	344	02:28	23:28	54 24.58	89 16.77	
014	CTD on deck	CTD4	10/12/18	344	05:44	02:44	54 24.58	89 16.78	
	Off station		10/12/18	344	06:05	03:05	54 24.57	89 16.78	
015	On station for flanking mooring A	BUOY5	10/12/18	344	08:34	05:34	54 07.07	89 38.98	Recovery of FLMA-3
015	Deploy release transducer	BUOY5	10/12/18	344	10:08	07:08	54 06.54	89 38.64	
015	Top float on surface	BUOY5	10/12/18	344	10:19	07:19	54 06.56	89 38.62	
015	Float hooked on	BUOY5	10/12/18	344	12:19	09:19	54 06.58	89 38.61	
015	Float on deck	BUOY5	10/12/18	344	12:25	09:25	54 06.59	89 38.60	

015	Controller cage on deck	BUOY5	10/12/18	344	13:31	10:31	54 07.58	89 36.66	
015	First set glass floats on deck	BUOY5	10/12/18	344	13:41	10:41	54 07.62	89 36.19	
015	Second set glass floats on deck	BUOY5	10/12/18	344	14:34	11:34	54 07.62	89 34.09	
015	Recovery complete	BUOY5	10/12/18	344	15:43	12:43	54 07.69	89 31.03	
016	On station for flanking mooring B	BUOY6	10/12/18	344	17:55	14:55	54 03.87	88 57.04	Recovery of FLMB-3
016	Confirmed release	BUOY6	10/12/18	344	18:00	15:00	54 03.87	88 57.04	
016	Syntactic buoy on deck	BUOY6	10/12/18	344	20:10	17:10	54 04.88	88 56.05	
016	Glass floats on deck	BUOY6	11/12/18	345	00:03	21:03	54 04.12	89 00.13	
016	Mooring all on deck	BUOY6	11/12/18	345	00:07	21:07	54 04.12	89 00.28	
	Off station		11/12/18	345	00:53	21:53	54 04.54	89 01.66	
	On station		11/12/18	345	03:27	00:27	54 25.38	89 15.06	
017	OTE-Flo deployed	OTEFLO3	11/12/18	345	04:07	01:07	54 25.38	89 15.06	
017	OTE-Flo recovered	OTEFLO3	11/12/18	345	04:51	01:51	54 25.38	89 15.06	
018	CTD deployed to 1000m	CTD5	11/12/18	345	05:38	02:58	54 25.38	89 15.06	
018	CTD recovered	CTD5	11/12/18	345	06:52	03:52	54 25.38	89 15.06	
	Swath and underway systems off ahead of Chilean waters. MMO stopped.		12/12/18	346	12:52	09:52	53 36.5	80 11.07	

OOI Mooring Activities

(Sheri White, Jim Ryder, Kris Newhall, Steve Caldwell, Jennifer Batryn, Nico Llanos (WHOI), Andy Leadbeater, Steve Whittle (NMF)

Background & Summary

The Ocean Observatories Initiative (OOI) is a US National Science Foundation (NSF) funded program to build and deploy infrastructure to enable long-term observations in the ocean. This 25-year program consists of mooring arrays and vehicles deployed in Coastal, Regional and Global regions, and collected data are delivered in near real-time to the public via a Cyberinfrastructure (http://oceanobservatories.org/).

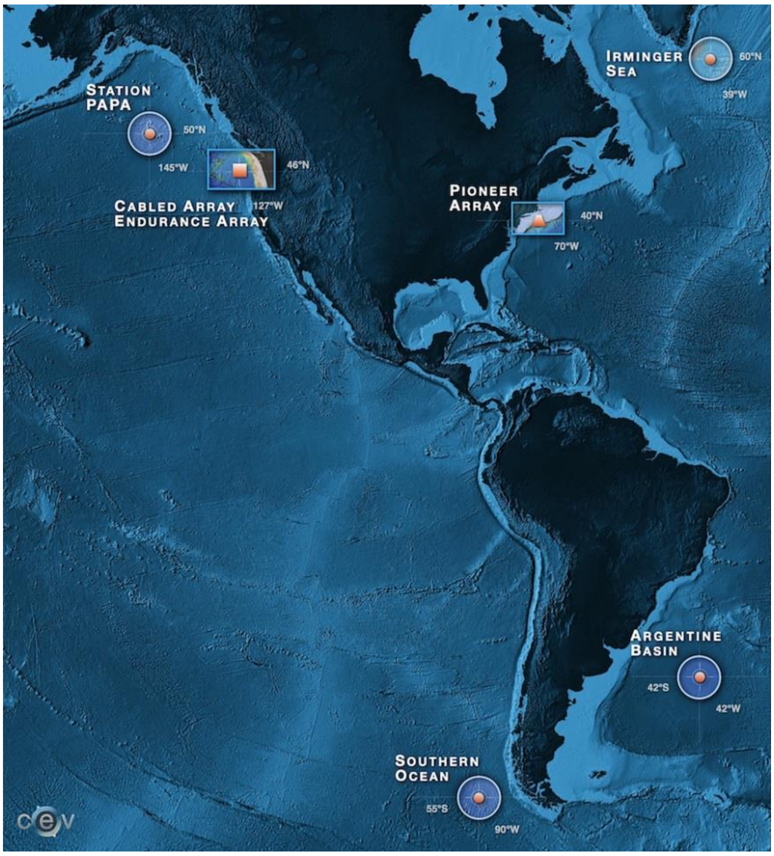

Figure 1 – Ocean Observatories Initiative (OOI) Array Map

The OOI Global Southern Ocean array is located southwest of Chile near 55° S, 90° W. It originally comprised four moorings set in water depths of approximately 4800 m, and a combination of Open Ocean and Profiling Gliders. The array was first deployed in March 2015 aboard R/V *Atlantis* (AT 26-30), and then replaced with new moorings and gliders in December 2015 and November-December 2016 on the R/V *Nathaniel B. Palmer* (NPB15-11 and NBP 16-10, respectively). In 2017, guided by the National Academy of Sciences' 2015 report "Sea Change: Decadal Survey of Ocean Sciences 2015-2025", the NSF elected to discontinue the Operations and Management of the OOI Southern Ocean Array due to budget reductions. The November-December 2017 cruise on the R/V *Nathaniel B. Palmer*

(NPB17-09) was supposed to recover all assets. However, due to difficult weather conditions, the Surface Mooring and bottom halves of both Flanking Moorings could not be covered in 2017 and remained in place collecting data. An agreement between NSF and NERC meant that the surface mooring would be replaced on DY096, as part of the NERC CUSTARD project. DY096 would also recover the current surface mooring and lower parts of Flanking Moorings.

During the DY096 cruise, we successfully deployed a new OOI Surface Mooring outfitted with 2 NOC sensors and an additional pCO2 air-sea instrument. This OOI Surface Mooring with NOC sensors will be deployed for one year, then recovered on the CUSTARD DY112 cruise in 2020. We also successfully recovered the other moorings.

Mobilisation

Loading of the RRS *Discovery* at Pratt Pier occurred on 25-26 November 2018. The Ball Van and Rigging Van were positioned on the starboard side of the main deck, just forward of the A-frame. The Lebus winch traction head was positioned on the centerline just aft of the Lebus spooler, which was just aft of the hangar. The Lebus power pack was positioned port of the Lebus spooler, and Ropak boxes with synthetic rope components was just aft of that. Additional components (e.g., the ADCP and inductive instruments) were located in the hangar. The GS01SUMO-00004 Surface Buoy and NSIF were positioned under the A-frame and staged for deployment.

Adapter plates were required to mount the Lebus and the air tuggers to the deck. US ships have a 1 ft x 1 ft bolt pattern, whereas the UK ships have a 1 m x 1 m bolt pattern.

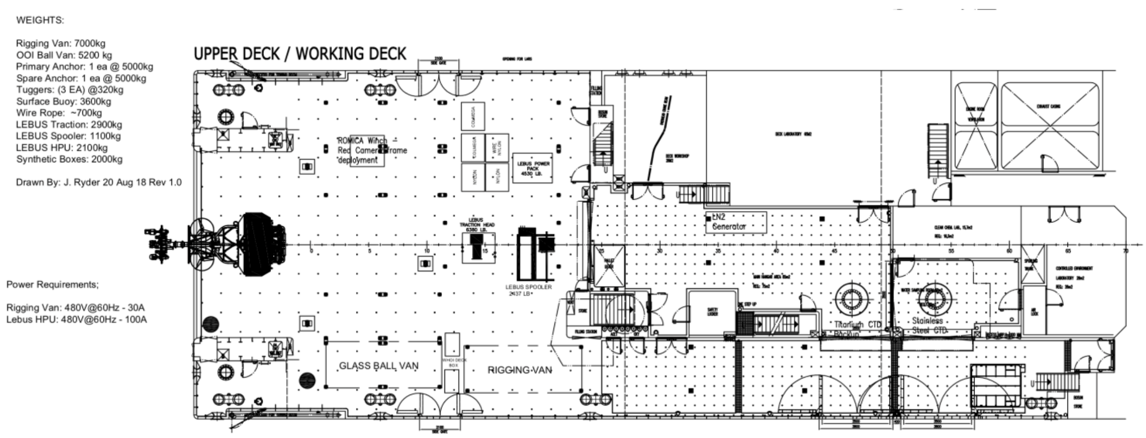

Figure 2 – Planned Deck Layout

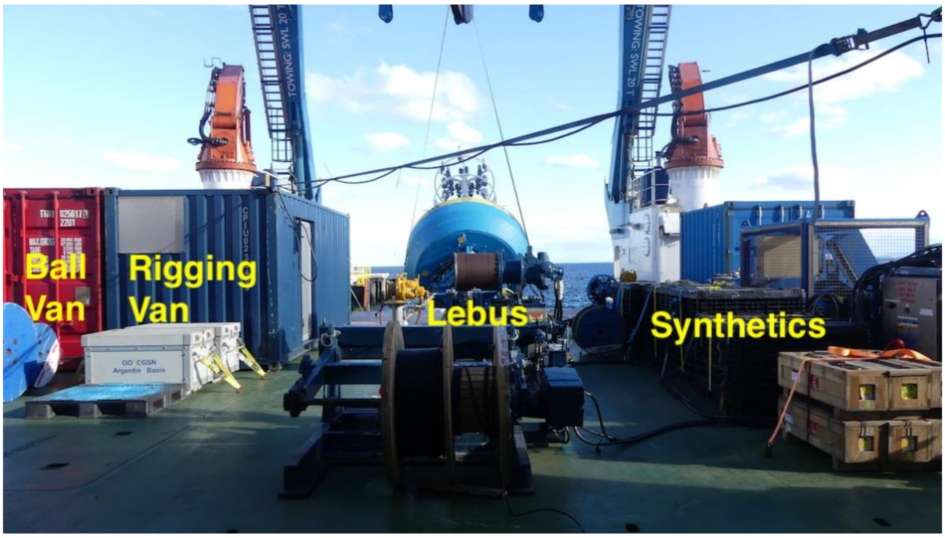

Figure 3 – Actual Deck Layout

WHOI personnel and equipment occupied the Deck Laboratory (on the port side of the ship) and the Controlled Environment Lab (forward of the hangar).

Figure 4 – OOI Telemetry positioning on aft Boat Deck rail

Three types of OOI-specific telemetry were installed on the ship to communicate with the Surface Mooring (WiFi and FreeWave) and with shore if needed (FleetBroadBand – FBB). These were mounted to the aft rail of the Boat Deck, above the hangar door. The cables were run from the antenna, down the through a stairwell to the hanger, and then through the hangar workshop into the Deck Lab via mouse holes.

Global Surface Mooring GS01SUMO-00004

Deployment

The GS01SUMO-00004 (SUMO-4) Global Surface Mooring was integrated and tested at the Woods Hole Oceanographic Institution (WHOI) and then packed and shipped to Punta Arenas, Chile on 23 August 2018. Southern Ocean mobilization began on 16 November 2018 in Punta Arenas, Chile. All shipped gear, and gear remaining in Punta Arenas from 2017 was unpacked, and the mooring was re-integrated and tested, and assembled per standard procedures.

The GS01SUMO-00004 mooring was deployed on the morning of 4 December 2018.

Prior to the deployment, the 9/16" trawl wire was reeved through the center block on the A-framed and shackled to a 4 foot red sling which was rigged to the lifting bail of the buoy. Roughly 90 metres of the 486.3 metre shot was faked out on deck. This allowed personnel to attach 4 sets of instrumentation to the wire (at 20 m, 40 m, 60 m, and 80 m). A 12 foot sling was rigged through the frame of the NSIF and was shackled to the port hydraulic winch on the A-frame. A yellow slip line was also rigged to the frame and passed through the chaulk of the port quarter bulwark. The hydraulic winch hauled in, lifting the NSIF off the deck. The A-frame boomed out allowing the NSIF frame and EM chain transfer to the port quarter. Once clear of the stern, the winch lowered the frame allowing the frame to rest off the stern. The yellow slip line took up the slack and was made fast to a cleat. The sling was then removed from the NSIF.

Four slip lines were used to control the buoy while deploying, 2 each yellow (65 ft) and 2 each blue (80 ft). The trawl wire hauled in lifting the buoy off the deck. A-frame was boomed out while the winch paid out keeping the load level (**Figure 5**). The NSIF was eased into the water using the yellow (65 ft) slip line. The yellow slip lines were cleared first. As the buoy settled in the water the peck & hale was released and the blue slip lines were cleared. The 90 metres of wire rope was deployed hand over hand. Once deployed, the wire rope was placed into the red German snatch block which was attached to the aft port crane.

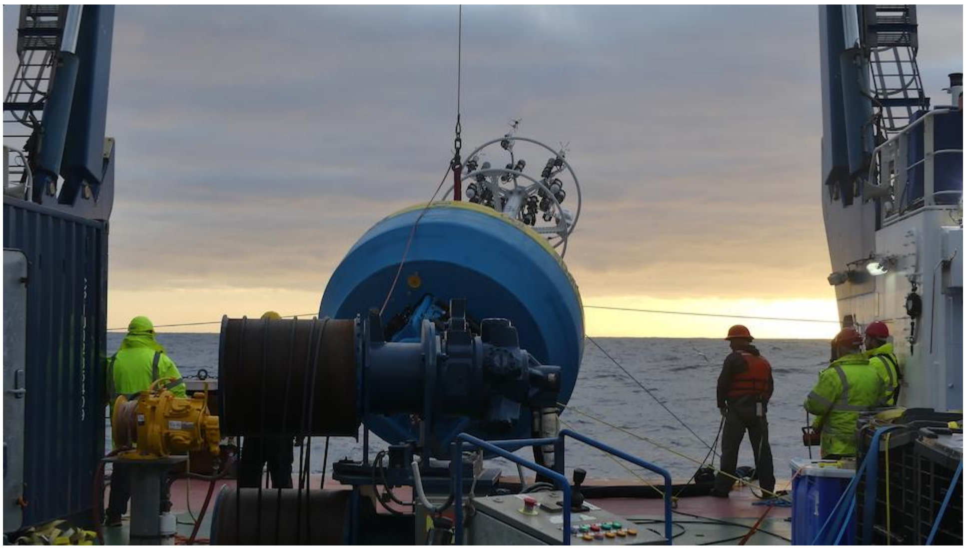

Figure 5 – GS01SUMO-00004 Buoy Deployment.

The Lebus winch had five turns wrapped around the heads. As the winch paid out the wire instrumentation was clamped onto the wire at designated depths. With 8 wraps remaining on the 486.3 metre reel the Lebus was stopped and a yale grip was placed on the high tension side of the winch and then stopped off to a deck cleat. The remaining wire rope was spooled off the reel and was walked forward. The empty reel was removed from the spooler and the 1/2" Amsteel blue winch leader was installed. A yale was attached about 1 metre from the end of the bottom termination. The yale grip was shackled to the winch leader and remaining wire rope was wound onto winch leader reel. Once tension was applied to the spooler, the stopper line was eased off and cleared from the yale grip. The yale grip was removed and payout continued. When the lower termination passed through the low tension gate, it was passed around the heads of the winch with 2 deck personnel.

Once the lower termination passed through the snatch block, the stopper line was snapped into the yale grip and took the load. The Lebus winch was slacked and cleared from the yale grip. The wire rope shot was removed from the snatched block. The ADCP cage was bolted to the lower termination of the 486.3 m shot. The winch leader was replaced with the 1000 m shot. The 1000 m shot was passed through both gates of the capstan and bolted to the bottom of the ADCP cage. The spooler paid out the wire slowly to wind the capstan heads with five wraps. The 1000 m shot was placed in the snatched block. The crane boomed up raising the ADCP off the deck then swung aft while the Lebus paid out, lowering the ADCP into the water (**Figure 6**, left). The wire continued to pay out while stopping to attach instruments at designated depths (**Figure 6**, right).

Figure 6 – Deployment of ADCP cage (left), and attaching instruments to the wire rope (right).

With roughly 8 wraps remaining on the reel, the Lebus was stopped and the yale grip was placed on the high tension side and stopped off. The remaining wire rope was removed and walked forward. The 300 metre shot of 3/8" wire rope replaced the empty spool. The 3/8" and 7/16" shots were shackled together with a 7/8 link between them. A canvas wrap was placed around the terminations and the winch then wound the remaining 1000 metre shot on top of the 3/8 wire rope. The winch took the load and the stopper line was removed. The winch then continued to pay out wire. At the end of the 300 metres with 8 wraps remaining the yale grip was placed on the high tension side of the capstan heads. The stopper line was attached and winch was slacked.

The remaining 300 metre shot was shackled to the top of 100 metres of 3/8" wire to nylon special termination. An additional two wraps were added to the capstan heads in order to prevent the wire from slipping on the heads. The stopper line was eased off and cleared along with yale grip being removed. A mooring tech was positioned behind the low tension of the capstan providing back tension as the winch paid out the remaining 300 metres and the 100 metres of 3/8" wire rope. When the wire to nylon termination boot was near the low tension of the gate the winch stopped and a yale grip placed on the high tension side of the capstan. The remaining wire on the heads was removed. The stopper line slowly eased out the wire until the yale grip was near the stern. Another yale grip was placed on the wire near the aft side of the winch. The other stopper line was attached to the yale grip and then made fast. The stopper line attached near the stern was eased off and cleared, also removing the yale grip. This process was used until the wire/nylon termination neared the capstan heads. When the boot was clear of the winch, the 90 metres of plymkraft overbraid nylon was wrapped around the capstan heads with six turns (**Figure 7**, left). Once the winch had the load, the payout continued for the 7/8" nylon and of 1" Colmega line (**Figure 7**, right). With roughly 10 m of Colmega to be slipped out the yale grip was placed on the Colmega and stopped off with the stopper line. The winch tag line was placed in the spooler and was shackled to the end of the Colmega. The spooler hauled in the remaining slack of the Colmega and took tension off the mooring. The stopper line was eased and cleared and the yale grip was removed. The winch paid out until there was one metre left of Colmega on deck by the stern. The stopper line was attached to the link of the Colmega and stopped off. The Lebus winch line was removed. The first set of balls was dragged to the stern and was shackled to the link from the Colmega. The Lebus winch leader was shackled to a link in the shot of chain and then took tension. The stopper line was eased and cleared. The Lebus paid out until there were two ball's left at the stern. The stopper was snapped into the link and made fast. This was the sequence of paying out the 16 sets of 4 glass balls (**Figure 8**, left). The 5 m shot of trawler chain was shackled to the last set of balls. The winch leader was shackled to a link in that shot and then hauled in to take the tension of the mooring. The stopper line was cleared and the winch paid out the 5 m shot leaving 1 m left at the stern. The stopper line was shackled to another link of the 5 m shot and made fast. The mooring was towed for roughly an hour.

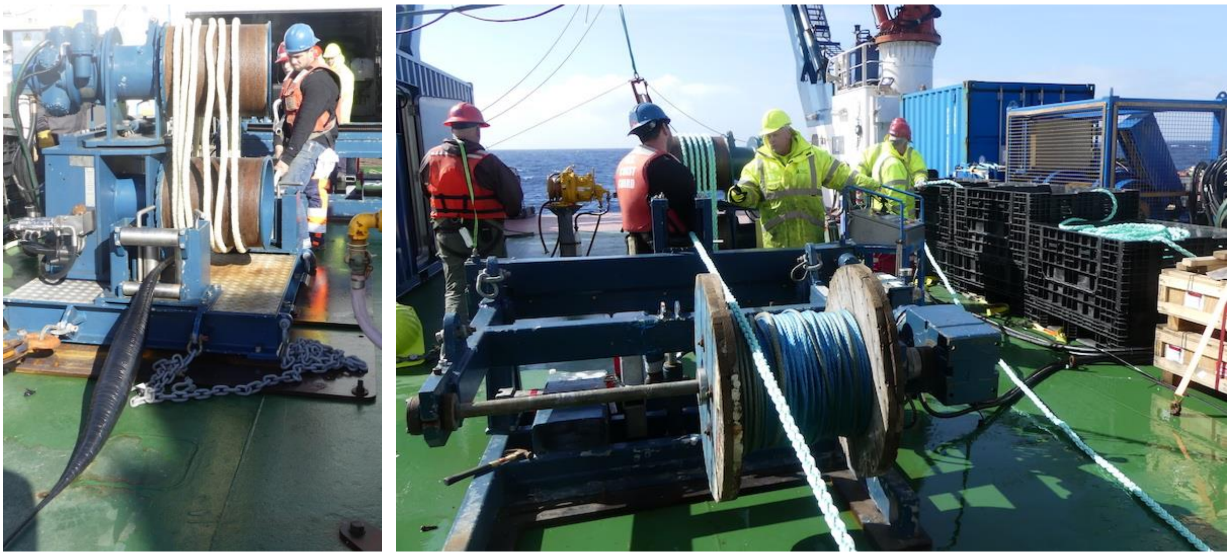

Figure 7 – Wire to rope transition (left) and Colmega (right) passing through the Lebus winch

The dualed Edge Tech releases were shackled to the bottom of the 5 m shot. A 5 m shot of chain was shackled to the master link. The winch tag line was shackled into a link near the bottom of the shot. The port crane lifted the releases off the deck and aft while the winch paid out lowering the releases over the stern. The stopper line was shackled into the 5 m shot and made fast and the winch leader was removed.

A 50 ft ¾" nystron slip line placed through the 7/8" link which was shackled to the 20 m shot 1" samson nystron. The two ends of the slip line were bowline to the winch leader. The slip line and the 20 m shot of nystron were wound on the winch. The 5 m ½" chain from the releases was shackled to the 20 m shot of nystron. The 5 m shot was shackled to the 11,000 lb anchor. The chain lashing on the anchor was removed, and an expendable back stay was rigged on the anchor to secure it. With 200 metres to the drop site, the winch paid out slowly. When the end of 20 m shot of 1" nystron was near the 1/2" chain from the anchor, the winch stopped so the connection could be made between the two. Payout continued until anchor had the load. The ¾" slip line was removed from the winch leader and was slowly slipped out through the 7/8" link. The port crane hooked into the tip plate bridle and took up the slack. As the ship approached the launch site, the backstay was removed; the crane boomed up allowing the tip plate to raise enough to let the anchor slip into the water (**Figure 8**, right).

The surveyed location of the deployed GS01SUMO-00004 mooring is **54° 24.4301' S, 89° 12.3622' W** in a water depth of 4589 m.

Figure 8 – Glass balls (left) and anchor (right) deployment

Instrument configuration and sampling

The Surface Mooring sampling strategy and instrument configuration are driven by the OOI Sampling Strategy document (1102-00200), and the CGSN Global Surface Mooring Sampling and Configuration Plan (3103-00022). Details are summarized in the table below.

Table 1 – Surface Mooring Instrument Power and Comms Schedule

Platform	Instrument Identifier	Power Schedule		Comms Schedule		Comments
		Interval (min)	Duration (min)	Interval (min)	Duration (min)	
SURFACE BUOY						
meteorology_bulk (2)	METBK	On continuous		On continuous		Continuous sampling, heater on port 07
flux_direct_covariance	FDCHP	60 min	25 min	60 min	30 min	Turn on 2 min before the hour, only processed flux data sent
wave_spectra_surface	WAVSS	60 min	30 min	60 min	30 min	Samples for 20 minutes, outputs processed data
nutrient_Nitrate	NUTNR	15 min	3 min	15 min	3 min	SUNA instrument
attenuation_absorption_optical	OPTAA	60 min	2 min	60 min	2 min	
Fluorometre_three_wavelength	FLORT	15 min	3 min	15 min	3 min	
spectral_irradiance	SPKIR	15 min	3 min	15 min	3 min	
oxygen_dissolved_stable	DOSTA	15 min	3 min	15 min	3 min	
pCO2_air-sea (2)	PCO2A	60 min	55 min	60 min	55 min	Starts 25 mins after top of the hour
Motion Pack	MOPAK	60 min	20 min	60 min	20 min	Engineering sensor
Hydrogen sensor (2)	H2	60 min	5 min	60 min	5 min	Engineering sensor

Platform	Instrument Identifier	Power Schedule		Comms Schedule		Comments
		Interval (min)	Duration (min)	Interval (min)	Duration (min)	
NSIF						
CTD_bottom_pumped	CTDBP	15 min	3 min	15 min	3 min	
oxygen_dissolved_stable	DOSTA	15 min	3 min	15 min	3 min	
Fluorometre_three_wavelength	FLORT	15 min	3 min	15 min	3 min	
spectral_irradiance	SPKIR	15 min	3 min	15 min	3 min	
Velocity_point_mean	VELPT	15 min	7 min	15 min	7 min	
pCO2_water	PCO2W	120 min	14 min	120 min	14 min	Samples on even hours
nutrient_Nitrate	NUTNR	15 min	3 min	15 min	3 min	SUNA instrument
attenuation_absorption_optical	OPTAA	60 min	2 min	60 min	2 min	
MOORING WIRE						
CTD_Mooring (10)	CTDMO	N/A	N/A	7.5 min	N/A	20, 60, 100, 180, 250, 350, 500, 750, 1000, 1500 metres
pH_stable (2)	PHSEN	N/A	N/A	60 min	N/A	20, 100 metres
CTD_bottom_pumped (3)	CTDBP	N/A	N/A	120 min	N/A	40, 80, 130 metres Samples on even hours
oxygen_dissolved_stable (3)	DOSTA	N/A	N/A	120 min	N/A	40, 80, 130 metres Samples on even hours
Fluorometre_two_wavelength (3)	FLORD	N/A	N/A	120 min	N/A	40, 80, 130 metres Samples on even hours
pCO2_water (3)	PCO2W	N/A	N/A	120 min	N/A	Samples on even hours

Platform	Instrument Identifier	Power Schedule		Comms Schedule		Comments
		Interval (min)	Duration (min)	Interval (min)	Duration (min)	
velocity_profile	ADCPS	N/A	N/A	180 min	N/A	Samples every 3 hours starting at zero. (0, 3, 6... hours)

The NOC nitrate and silicate sensors were set up with three default sampling configurations:

1x per day @ 00:00

2x per day @ 00:00, and 12:00

4x per day @ 00:00, 06:00, 12:00, and 18:00

The NOC nitrate sensor is powered on for 20 minutes and the silicate sensor is powered on for 1 hour and 45 minutes. The NOC CUSTARD team will monitor the data from these sensors and request changes to the schedule as needed to optimize data collection. The instruments have sufficient reagent to collect 2 samples every day for ~400 days.

A UV-light is installed for bio-fouling mitigation for the DOSTA instrument on the NSIF. The UV-light is connected to NSIF DCL27, which also powers the NOC instruments. The UV-light is turned on every 6 hours for 105 minutes (similar to the NOC silicate sensor). This totals 7 hours per day – approximately a 30% duty cycle. The UV-light will at times be on during DOSTA sampling, but based on prior testing and confirmation from the vendor, it will not affect the dissolved oxygen measurement.

All data telemetreed to shore is accessible by the public via the internet at the OOI Data Portal (https://ooinet.oceanobservatories.org/) and the OOI Raw Data Repository (https://rawdata.oceanobservatories.org/files/). Data from the NOC sensors is embargoed for one year and accessible only by the CUSTARD team at NOC via a secured section of the OOI Raw Data Repository. After one year, the data will be made available to the public via both the OOI Raw Data Repository and the OOI Data Portal.

Global Surface Mooring GS01SUMO-00003

Recovery

The GS01SUMO-000003 (SUMO-3) mooring was recovered in the afternoon of 9 December 2018.

Before recovery operations began, the RRS *Discovery* was positioned roughly 1 nm upwind of the surveyed anchor position. The portable transducer was lowered into the water and one of the dualed acoustic releases was enabled, ranged to confirm, then released at 16:42 UTC. The backup flotation surfaced in a large cluster within one hour after being released. The Lebus winch leader was reeved through the port quarter crane 2.5-ton block, around the starboard quarter then walked forward along the starboard bulwark and secured.

The ship made its approach keeping the cluster on the starboard side. The cluster eventually was hooked on the starboard side by a 5-ton Titanium pickup hook after the balls were held by grapnel to keep them close. The ship made forward headway letting the balls drift aft and away from the stern. The Lebus winch hauled in, while adjusting the crane block height, until the cluster was on deck (**Figure 9**, left).

A six-foot sling was choked around the cluster and then shackled to the mid-ship air tugger winch leader. The tugger hauled in, bringing the balls farther forward while the deck stopper line was shackled to the ½" trawler chain section above the balls. The stopper was tied off and the Lebus winch leader removed.

The winch leader was shackled into the 5-metre shot of ½" trawler chain above the releases, which were still hanging from the stern. The winch payed in, pulling the releases onto the stern. The leader was removed from the chain and shackled to the endlink connected to the thimble of the Colmega. The connection between the releases and the Colmega was removed and the leader hauled in. Once there were sufficient wraps of synthetics around the leader reel (3-4), a Yale grip was placed on the Colmega on the high-tension side of the winch. A deck stopper line was secured to the Yale grip eye and tied off to a deck cleat, the winch payed out thus taking the load from the winch; this enabled for the winch leader reel and Colmega to be removed from the spooler. The 3-4 wraps of Colmega were then placed in an empty Ropak plastic box. The winch was hauled in which took the load from the stopper line and continued hauling in until the remaining Colmega and Nylon were recovered (Error! Reference source not found.**,** right).

After all of the synthetics were recovered there was a mechanical boot transition to 3/8" wire rope. The urethane boot was wound around the Lebus heads, making sure that it didn't get fouled on the capstan heads. An empty reel was secured to the spooler. Using a steel wire grab as a stopper, the load was transferred to the deck stopper line. At approximately 1 m from the boot, the 3/8" wire rope was then cut allowing the remaining 100 m and 300 m shots to be recovered on the empty reel.

An empty reel was switched out in order to recover the next 1000 m shot of 7/16" wire rope and clamped inductive instrumentation. At the top of this shot, the Acoustic Doppler Current Profiler (ADCP) was recovered by continuing to haul in with the Lebus as well as extending the height of the port quarter crane. Once the ADCP was on deck, a Yale grip was secured below the lower termination of the 485.5

m shot of 7/16” wire (**Figure 10**) and made fast to the deck cleat. The ADCP was disconnected from both sides of the mooring wire rope.

Figure 9 – SUMO-3 glass balls (left) and synthetic rope (right) being hauled in.

Figure 10 – SUMO-3 ADCP recovery

Another empty reel was placed on the spooler and approximately half of the 485.5 m shot of wire rope was recovered, along with clamped instrumentation. A Yale grip was secured to the wire and a slip line was passed through the eye and made fast to a deck cleat. The wire rope section leading to the buoy was cut at the 180 m depth mark, thus releasing the surface buoy and leaving the remaining section of mooring riser free, setting up for a buoy-first recovery. Due to the top-heaviness of the buoy, having a portion of the mooring riser hanging below the buoy is suggested to keep it upright and stable.

The deck was prepared for the buoy recovery. The Lebus winch leader was reeved through the 2.5-ton block secured to the port quarter crane and brought around to the starboard bulwark then shackled to a long 5-ton recovery hook pennant (Note: a specialized pennant length of approximately 12-metres was made and used for the buoy recovery). The ship repositioned allowing the buoy to come along the starboard side. When the buoy was hooked, the ship moved slow ahead allowing the buoy to come astern. When the buoy was center line, the Lebus winch hauled in bringing the buoy closer to the ship's stern. Once the end of the 5-ton pennant was on deck it was disconnected then shackled into the ship's core (trawl) wire which was reeved through the A-frame center line block.

When the buoy was lifted out of the water it turned, allowing the masthead to face forward; two tugger leaders were attached to the port and starboard buoy tag line bales with a third tugger secured to the masthead, preventing the buoy from swinging further. The A-frame was brought in bringing the buoy on board (**Figure 11**, left) and yellow aircraft straps were used to secure it on deck. Once secured, a 6-foot sling was choked around a cleaned section of the EM chain and secured to the Lebus winch leader. As the Lebus hauled in, the EM chain was brought forward, adjacent to the buoy foam, and until the Near Surface Instrument Frame (NSIF) broke the water's surface. Using the port 5-ton A-frame tugger winch and a 5-ton recovery pennant, the NSIF was brought on deck. Using the deck mounted port tugger winch, the NSIF was brought as far forward as possible to allow enough room to secure a Yale grip to the remaining 7/16" wire rope still in the water. A deck stopper was secured to the Yale grip and the wire rope was cut, thus freeing the NSIF. The Lebus winch leader was secured to the Yale grip and the stopper removed. The remaining wire rope and inductive instrumentation were recovered (**Figure 11**, right). The recovery was completed at 00:46 UTC 10 December 2018.

Global Flanking Moorings GS03FLMA-00003, GS03FLMB-00003

The top portions of the GS03FLMA-000003 (FLMA-3) and GS03FLMB-00003 (FLMB-3) moorings were recovered in 2017. The bottom portions were recovered on 10 December 2018.

FLMA-3 Recovery

The GS03FLMA-00003 mooring was recovered the morning of 10 December 2018.

The RRS *Discovery* was positioned 0.75 miles south of mooring position (wind was from the west). The release was enabled then released when the bridge was ready (10:11 UTC). The top float surfaced within 8 minutes and the cluster of glass balls surfaced ~45 minutes after the initial release. The Lebus winch leader was run through the traveling block held up by the port crane, around the starboard quarter, to mid-ship. The ship approached the 62-inch sphere by sidling up to it using dynamic positioning. The 5-ton pickup pennant was hooked into the side bail of the sphere. The ship moved ahead allowing the sphere to come astern. Deck personnel were positioned along the starboard rail tending the winch leader.

Figure 11 – Recovery of the SUMO-3 surface buoy (left), and removal of instrumentation clamped on the wire rope (right).

Once the top float was centered astern of the ship, recovery began. The Lebus winch began to haul up the sphere. Deck personnel hooked two tugger lines on opposing sides of the sphere, securing the sphere from swinging. The sphere was lowered into the stand and secured with ratchet straps. A Yale grip was attached to the top of the 1000 metre IM shot and the stopper line attached to the Yale grip and made fast. The IM fitting was removed from the sphere. The Lebus winch leader was reeved through the snatch block and shackled to the Yale grip. The winch hauled in and the stopper line and Yale grip were cleared. The port side crane was hooked to the snatch block and boomed up raising the block off the deck. The Lebus winch hauled in. A Yale grip was placed on the high tension side of the Lebus heads after having 5 wraps on the spectra spool and made fast with the stopper. The 1000 metre IM shot was recovered removing instruments at designated depths. As the controller cage cleared the stern, the stopper line was hooked into the shot of chain below the cage and the cage was removed. The Lebus winch leader now on the spooler was shackled to the 1000 metre shot and took up the slack and the stopper line was removed. The 1000 metre IM, three (3) 1000 metre shots, adjustable shots and glass balls were recovered.

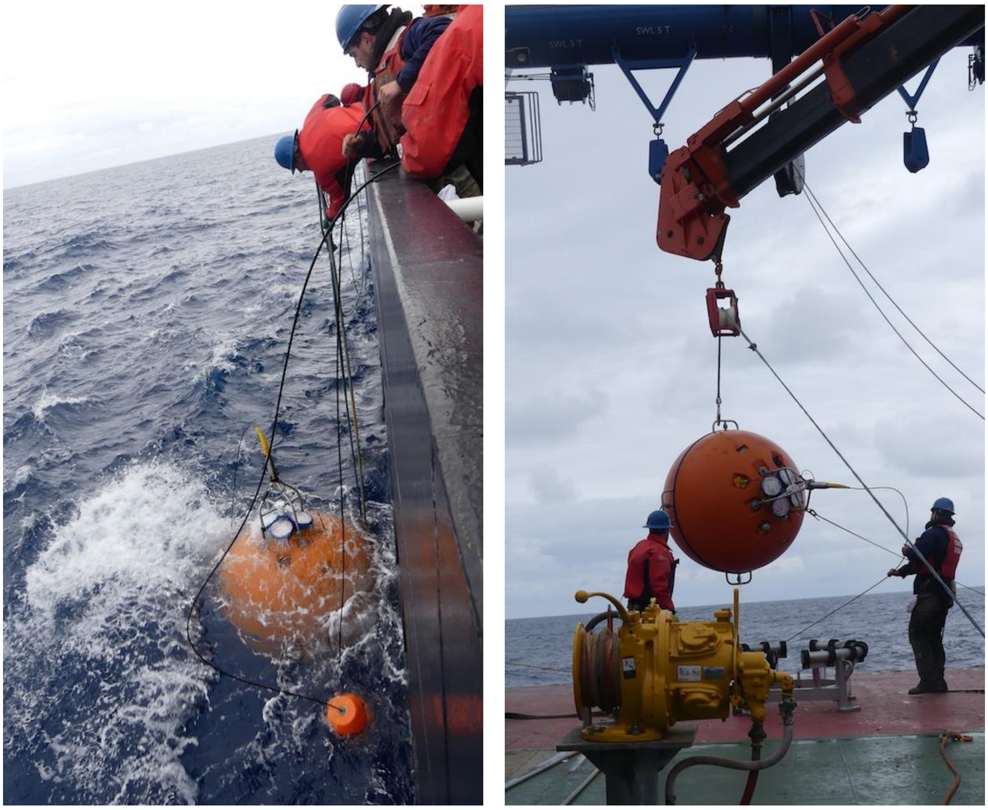

Figure 12 – Hooking the FLMA-3 62" sphere (left) and bringing it on deck (right).

On Flanking Mooring A, the middle 1000-metre shot was hooked over the 2nd cluster of glass balls, and the last 1000-metre shot was "wuzzled" in the bottom cluster of glass balls (**Figure 13**). Hauling continued while tape and tie-wraps were applied, securing the 3 different leads of wire rope.

The dual releases were recovered using the forward air tugger reeved through the snatch block. The recovery was completed at 15:42 UTC.

Figure 13 – Wire rope drapped over the 2nd set of balls, and wuzzled in the last cluster.

FLMB-3 Recovery

The GS03FLMB-00003 mooring was recovered the evening of 10 December 2018.

Due to a typo in the anchor position given to the bridge, the ship was set up ~1 nm upwind from the anchor. The acoustic release was fired at 17:57 UTC. Once the discrepancy in the position was determined, the sphere was spotted on the surface, and the glass balls apeared ~45 min after the release was fired. The ship initially positioned to recover the glass balls first. The ship sidled up to the cluster of balls and they were initially grappled. However, the balls came free before they could be hooked, and the sphere moved around the starboard quarter to the aft of the ship. The ship was forced to move away and reappoach the mooring. Due to the layout of the mooring in the water, the bridge decided to shift to a sphere-first recovery. As for FLMA-3, the ship sidled up to the sphere. Due to the high freeboard of the RRS *Discovery*, the full length of the pole was needed to reach the side bales of the sphere. The increasingly choppy seas, made hooking the sphere by the side bales difficult, so it was instead hooked at the top weldment.

Once the sphere was hooked and the mooring was trailing aft, the recovery proceeded as described for FLMA-3 above. No wuzzles or looped wire shots were experienced with FLMB-3. The recovery was completed at 00:46 UTC (11 December 2018).

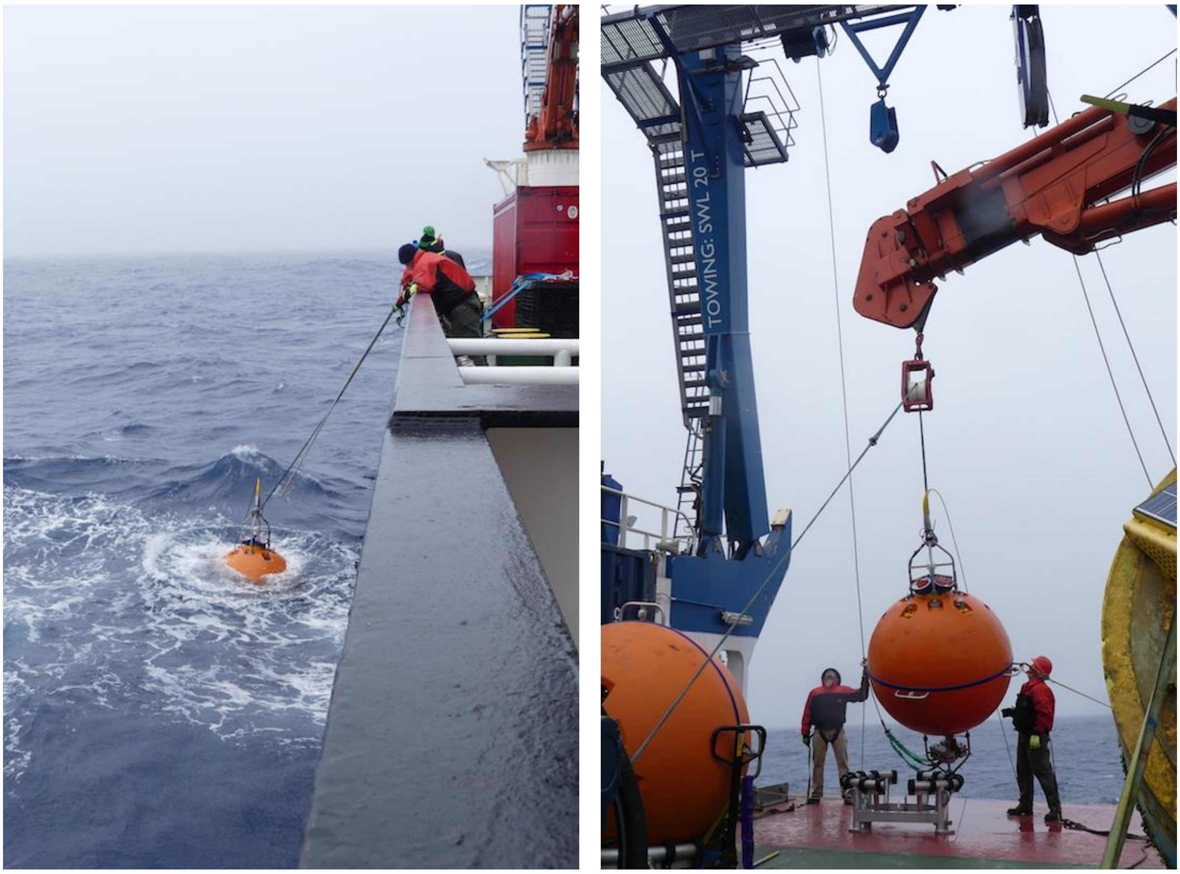

Figure 14 – Hooking the FLMB-3 62" sphere, and using the starboard A-frame winch to level it.

Seasonal study of nitrate and silicate concentration using Lab-on-Chip platforms

Antony Birchill (NOC)

In order to observe the seasonal cycle of nitrate and silicic acid (hereafter silicate) at the OOI mooring site (54° 24.408' S, 89° 12.144' W), two Lab-on-Chip (LoC) platforms were to be deployed for a 12 month period. The LoC platforms were set up to provide daily measurements, with the possibility to increase this to two or four measurements per day during periods of rapid change in nutrient concentration (e.g. phytoplankton blooms). This sampling approach will provide a unique dataset, being the first to observe a complete seasonal cycle in this remote and hostile region of the ocean. In addition, a second LoC nitrate platform was deployed on the clean underway system, situated at approx. 5m, to provide measurements at 20 minute intervals.

Lab-on-Chip Platforms

The LoC platforms were developed in the Ocean Technology and Engineering group at the National Oceanography Centre Southampton (e.g Clinton-Bailey et al., 2017, Beaton et al., 2012). They are capable of measuring nano-molar nutrient concentrations, which is a requirement of marine nutrient measurements, whilst also using little power and reagents (approx. 1 mL for a calibrated measurement). Both nitrate and silicate platforms are spectrophotometric instruments, the nitrate platform utilising the Griess assay and the silicate platform utilising the molybdenum blue assay. The Griess test is the most widely used technique for the determination of nitrate (Griess, 1879, Shinn, 1941, Patey et al., 2008). 'Molybdenum blue' is the most widely used technique for the determination of silicate (Patey et al., 2008, Murphy and Riley, 1962, Grasshoff et al., 2009, Strickland and Parsons, 1972).

Deployment Details

The deployment details for LoC platforms are summarised in Table 2. Two LoC platforms were integrated into the SUMO-4 mooring at a depth of 12 m on the NSIF frame as part of a wider sensor array. Standard concentrations were decided prior to the research cruise based on previously reported values for the region. Sub-samples of blank and standard solutions were collected and frozen for analysis using traditional gas-segmented flow techniques at National Oceanography Centre Southampton. All times reported by the platforms deployed are GMT.

Table 2- Details of Lab-on-Chip platform deployments during cruise DY096. Nitrate platform has only one on-board standard.

Sensor Type (SN)	Deployment	Deployment Date	Measurement Frequency	Standard 1 (µM)	Standard 2 (µM)
Nitrate (N112)	SUMO-4 Mooring	4/12/2018	Daily	20	n/a
Nitrate (N133)	Underway	6/12/2018	19 mins	20	n/a
Silicate (Si5)	SUMO-4 Mooring	4/12/2018	Daily	5	10

Preliminary Data

The preliminary data from the mooring are displayed in Table 3.1. The concentrations reported by the nitrate and silicate platforms were within the range expected for this region. Following the deployment, the platforms were powered on at midnight, with the nitrate sensor taking 17 minutes to perform a complete analytical cycle and the silicate platform taking 94 minutes to complete an analytical cycle. The first measurement of nitrate should be disregarded as an anomaly.

*Table 3.1- Preliminary concentrations reported by Lab-on-Chip platforms deployed on the OOI SUMO-4 mooring.*outlier*

Date	Nitrate (µM)	Silicate (µM)
5/12/2018	7094*	5.0
6/12/2018	19.6	5.9
7/12/2018	20.3	5.6
8/12/2018	19.5	5.0

The preliminary data from the underway nitrate sensor are displayed in Table 3.2. The concentration of nitrate values reported is within the range expected and similar to those reported by N112 deployed on the SUMO-4 mooring at 12 m depth. The mean concentration of nitrate from the underway is 20.4 ± 2.9 µM (± 1 S.D), after suspected outliers are removed.

*Table 3.2- Preliminary concentrations reported by Lab-on-Chip platform deployed on the clean underway system. *suspected outliers.*

Sensor Timestamp	**Nitrate (µM)**
06/12/2018 22:36	21.95
06/12/2018 22:55	20.972
06/12/2018 23:15	20.829
06/12/2018 23:34	20.116
06/12/2018 23:54	20.507
07/12/2018 00:13	20.403
07/12/2018 00:33	20.418
07/12/2018 00:53	20.379
07/12/2018 01:12	20.679
07/12/2018 01:32	20.912
07/12/2018 01:51	20.261
07/12/2018 02:11	20.83
07/12/2018 02:30	20.62
07/12/2018 02:50	20.535
07/12/2018 03:09	20.599
07/12/2018 03:29	20.576
07/12/2018 03:48	20.473
07/12/2018 04:08	20.564
07/12/2018 04:28	20.61
07/12/2018 04:47	20.531
07/12/2018 05:07	40.189*
07/12/2018 05:26	19.966
07/12/2018 05:46	10.573
07/12/2018 06:05	20.262
07/12/2018 06:25	19.921
07/12/2018 06:44	20.235
07/12/2018 07:04	20.289
07/12/2018 07:24	20.325
07/12/2018 07:43	20.264
07/12/2018 08:03	20.284
07/12/2018 08:22	20.429
07/12/2018 08:42	20.79
07/12/2018 09:01	20.494
07/12/2018 09:21	20.645
07/12/2018 09:40	20.607
07/12/2018 10:00	20.568
07/12/2018 10:20	19.972
07/12/2018 10:39	20.255
07/12/2018 10:59	20.202
07/12/2018 11:18	20.325
07/12/2018 11:38	20.357
07/12/2018 11:57	20.463
07/12/2018 12:17	20.42
07/12/2018 12:37	20.843
07/12/2018 12:56	20.849
07/12/2018 13:16	21.018
07/12/2018 13:35	20.961
07/12/2018 13:55	20.296
07/12/2018 14:14	-512.82*
07/12/2018 14:34	20.247
07/12/2018 14:54	20.543
07/12/2018 15:13	20.727
07/12/2018 15:33	20.413
07/12/2018 15:52	20.518
07/12/2018 16:12	20.345
07/12/2018 16:31	20.428
07/12/2018 16:51	20.549
07/12/2018 17:10	20.436

07/12/2018 17:30	20.795	08/12/2018 03:56	20.324
07/12/2018 17:50	20.617	08/12/2018 04:16	20.597
07/12/2018 18:09	20.57	08/12/2018 04:35	20.724
07/12/2018 18:29	20.415	08/12/2018 04:55	20.656
07/12/2018 18:48	19.77	08/12/2018 05:14	18.3
07/12/2018 19:08	20.145	08/12/2018 05:34	19.845
07/12/2018 19:27	20.365	08/12/2018 05:54	20.443
07/12/2018 19:47	20.446	08/12/2018 06:13	17.504
07/12/2018 20:07	20.164	08/12/2018 06:33	20.352
07/12/2018 20:26	20.508	08/12/2018 06:52	20.195
07/12/2018 20:46	20.366	08/12/2018 07:12	20.422
07/12/2018 21:05	20.497	08/12/2018 07:31	20.552
07/12/2018 21:25	20.463	08/12/2018 07:51	20.549
07/12/2018 21:44	20.584	08/12/2018 08:10	20.625
07/12/2018 22:04	20.372	08/12/2018 08:30	15.68
07/12/2018 22:24	18.673	08/12/2018 08:50	20.21
07/12/2018 22:43	20.586	08/12/2018 09:09	20.591
07/12/2018 23:03	20.462	08/12/2018 09:29	20.524
07/12/2018 23:22	15.966	08/12/2018 09:48	19.512
07/12/2018 23:42	20.442	08/12/2018 10:08	20.217
08/12/2018 00:01	20.497	08/12/2018 10:27	20.585
08/12/2018 00:21	20.44	08/12/2018 10:47	20.605
08/12/2018 00:40	20.586	08/12/2018 11:07	20.617
08/12/2018 01:00	20.403	08/12/2018 11:26	20.603
08/12/2018 01:20	20.585	08/12/2018 11:46	20.825
08/12/2018 01:39	20.189	08/12/2018 12:05	20.534
08/12/2018 01:59	20.723	08/12/2018 12:25	20.604
08/12/2018 02:18	20.499	08/12/2018 12:44	20.525
08/12/2018 02:38	20.435	08/12/2018 13:04	20.68
08/12/2018 02:57	20.583	08/12/2018 13:24	20.728
08/12/2018 03:17	20.593	08/12/2018 13:43	20.5
08/12/2018 03:37	20.816	08/12/2018 14:03	20.689

08/12/2018 14:22	20.608	09/12/2018 00:49	20.105
08/12/2018 14:42	20.486	09/12/2018 01:08	20.143
08/12/2018 15:01	20.613	09/12/2018 01:28	20.312
08/12/2018 15:21	20.502	09/12/2018 01:48	20.405
08/12/2018 15:41	20.563	09/12/2018 02:07	20.44
08/12/2018 16:00	20.604	09/12/2018 02:27	20.524
08/12/2018 16:20	15.064	09/12/2018 02:46	20.514
08/12/2018 16:39	18.041	09/12/2018 03:06	21.224
08/12/2018 16:59	20.12	09/12/2018 03:25	20.629
08/12/2018 17:19	20.414	09/12/2018 03:45	17.185
08/12/2018 17:38	20.522	09/12/2018 04:05	19.918
08/12/2018 17:58	20.587	09/12/2018 04:24	20.478
08/12/2018 18:17	20.657	09/12/2018 04:44	20.461
08/12/2018 18:37	20.93	09/12/2018 05:03	20.368
08/12/2018 18:56	20.583	09/12/2018 05:23	19.798
08/12/2018 19:16	20.765	09/12/2018 05:43	19.772
08/12/2018 19:36	20.5	09/12/2018 06:02	20.822
08/12/2018 19:55	20.47	09/12/2018 06:22	20.587
08/12/2018 20:15	20.496	09/12/2018 06:41	9.856*
08/12/2018 20:34	12.168	09/12/2018 07:01	18.827
08/12/2018 20:54	20.219	09/12/2018 07:20	19.648
08/12/2018 21:13	20.452	09/12/2018 07:40	20.084
08/12/2018 21:33	20.548	09/12/2018 08:00	20.083
08/12/2018 21:53	20.483	09/12/2018 08:19	20.079
08/12/2018 22:12	20.466	09/12/2018 08:39	20.43
08/12/2018 22:32	20.426	09/12/2018 08:58	20.446
08/12/2018 22:51	20.411	09/12/2018 09:18	20.105
08/12/2018 23:11	20.349	09/12/2018 09:38	20.445
08/12/2018 23:30	20.503	09/12/2018 09:57	20.506
08/12/2018 23:50	20.286	09/12/2018 10:17	20.519
09/12/2018 00:10	19.899	09/12/2018 10:36	20.676
09/12/2018 00:29	19.588	09/12/2018 10:56	20.617

09/12/2018 11:15	-64.155*	09/12/2018 21:42	20.445
09/12/2018 11:35	20.341	09/12/2018 22:02	20.873
09/12/2018 11:55	19.688	09/12/2018 22:21	20.58
09/12/2018 12:14	19.419	09/12/2018 22:41	20.447
09/12/2018 12:34	17.484	09/12/2018 23:00	20.395
09/12/2018 12:53	20.162	09/12/2018 23:20	-28.556*
09/12/2018 13:13	19.049	09/12/2018 23:40	19.073
09/12/2018 13:33	19.685	09/12/2018 23:59	-5.603*
09/12/2018 13:52	17.625	10/12/2018 00:19	-17.784*
09/12/2018 14:12	18.887	10/12/2018 00:38	16.141
09/12/2018 14:31	20.098	10/12/2018 00:58	19.405
09/12/2018 14:51	20.293	10/12/2018 01:18	35.943*
09/12/2018 15:10	20.306	10/12/2018 01:37	29.61
09/12/2018 15:30	20.496	10/12/2018 01:57	20.387
09/12/2018 15:50	20.485	10/12/2018 02:16	20.514
09/12/2018 16:09	20.432	10/12/2018 02:36	19.904
09/12/2018 16:29	20.619	10/12/2018 02:55	21.149
09/12/2018 16:48	21.184	10/12/2018 03:15	20.823
09/12/2018 17:08	20.736	10/12/2018 03:35	20.828
09/12/2018 17:28	20.77	10/12/2018 03:54	20.693
09/12/2018 17:47	20.725	10/12/2018 04:14	20.657
09/12/2018 18:07	20.766	10/12/2018 04:33	20.714
09/12/2018 18:26	20.564	10/12/2018 04:53	20.889
09/12/2018 18:46	20.542	10/12/2018 05:13	20.847
09/12/2018 19:05	20.751	10/12/2018 05:32	21.398
09/12/2018 19:25	20.83	10/12/2018 05:52	18.016
09/12/2018 19:45	20.801	10/12/2018 06:11	22.082
09/12/2018 20:04	16.627	10/12/2018 06:31	19.687
09/12/2018 20:24	19.976	10/12/2018 06:51	18.792
09/12/2018 20:43	20.242	10/12/2018 07:10	21.053
09/12/2018 21:03	20.449	10/12/2018 07:30	20.017
09/12/2018 21:23	20.631	10/12/2018 07:49	19.739

10/12/2018 08:09	19.834	10/12/2018 18:36	20.453
10/12/2018 08:29	19.676	10/12/2018 18:56	20.531
10/12/2018 08:48	20.048	10/12/2018 19:15	23.694
10/12/2018 09:08	19.609	10/12/2018 19:35	35.492
10/12/2018 09:27	20.399	10/12/2018 19:54	22.393
10/12/2018 09:47	20.266	10/12/2018 20:14	41.727
10/12/2018 10:06	20.102	10/12/2018 20:34	21.379
10/12/2018 10:26	17.004	10/12/2018 20:53	21.347
10/12/2018 10:46	19.605	10/12/2018 21:13	21.777
10/12/2018 11:05	19.947	10/12/2018 21:32	-7.587*
10/12/2018 11:25	20.187	10/12/2018 21:52	10.363
10/12/2018 11:44	20.74	10/12/2018 22:12	15.484
10/12/2018 12:04	20.215	10/12/2018 22:31	23.053
10/12/2018 12:24	20.248	10/12/2018 22:51	20.537
10/12/2018 12:43	20.297	10/12/2018 23:10	23.978
10/12/2018 13:03	20.226	10/12/2018 23:30	15.564
10/12/2018 13:22	20.229	10/12/2018 23:50	18.721
10/12/2018 13:42	20.488	11/12/2018 00:09	20.147
10/12/2018 14:02	20.302	11/12/2018 00:29	18.577
10/12/2018 14:21	19.933	11/12/2018 00:48	18.44
10/12/2018 14:41	20.353	11/12/2018 01:08	-127.924*
10/12/2018 15:00	20.12	11/12/2018 01:28	19.945
10/12/2018 15:20	20.173	11/12/2018 01:47	19.28
10/12/2018 15:40	20.117	11/12/2018 02:07	20.41
10/12/2018 15:59	28.576	11/12/2018 02:26	20.021
10/12/2018 16:19	19.824	11/12/2018 02:46	20.533
10/12/2018 16:38	20.464	11/12/2018 03:06	20.151
10/12/2018 16:58	20.746	11/12/2018 03:25	20.336
10/12/2018 17:18	20.583	11/12/2018 03:45	20.44
10/12/2018 17:37	20.685	11/12/2018 04:04	20.581
10/12/2018 17:57	20.742	11/12/2018 04:24	20.383
10/12/2018 18:16	20.561	11/12/2018 04:44	20.337

11/12/2018 05:03	20.589	11/12/2018 13:52	20.682
11/12/2018 05:23	20.523	11/12/2018 14:12	20.768
11/12/2018 05:42	20.575	11/12/2018 14:32	20.931
11/12/2018 06:02	20.363	11/12/2018 14:51	20.728
11/12/2018 06:22	20.755	11/12/2018 15:11	20.718
11/12/2018 06:41	20.717	11/12/2018 15:30	20.983
11/12/2018 07:01	20.744	11/12/2018 15:50	20.737
11/12/2018 07:20	21.024	11/12/2018 16:10	20.795
11/12/2018 07:40	21.141	11/12/2018 16:29	20.734
11/12/2018 08:00	21.106	11/12/2018 16:49	20.948
11/12/2018 08:19	20.948	11/12/2018 17:08	20.911
11/12/2018 08:39	22.956	11/12/2018 17:28	20.953
11/12/2018 08:58	20.652	11/12/2018 17:48	20.82
11/12/2018 09:18	20.805	11/12/2018 18:07	51.402*
11/12/2018 09:38	20.677	11/12/2018 18:27	19.413
11/12/2018 09:57	21.04	11/12/2018 18:47	20.627
11/12/2018 10:17	20.65	11/12/2018 19:06	21.045
11/12/2018 10:36	21.296	11/12/2018 19:26	20.822
11/12/2018 10:56	23.338	11/12/2018 19:45	20.834
11/12/2018 11:16	18.461	11/12/2018 20:05	21.564
11/12/2018 11:35	20.568	11/12/2018 20:25	20.948
11/12/2018 11:55	19.107	11/12/2018 20:44	20.724
11/12/2018 12:14	20.487	11/12/2018 21:04	20.664
11/12/2018 12:34	20.369	11/12/2018 21:23	20.772
11/12/2018 12:54	1.413*	11/12/2018 21:43	20.636
11/12/2018 13:13	20.729	11/12/2018 22:03	21.078
11/12/2018 13:33	20.672		

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Slocum glider deployments

(Dave White, MARS)

Summary

To deploy 2 Slocum gliders with the BBFLSv9 twin backscatter WetLab puck, Aanderaa optode and Seabird CTD at the CUSTARD site (55°S 90°W OOI mooring site). Recovery is planned for December 2019 on DY111.

Mobilisation

Functional check carried out on board RRS Discovery in Punta Arenas (53S 70W) on all three gliders with no failures.

The compass check showed all three gliders to have a compass curve within the limits required for navigation, i.e. no variation greater than 10 degrees, as they had been when calibrated at NOC (50°N 1°W). It was carried out on an area of open ground near the port entrance.

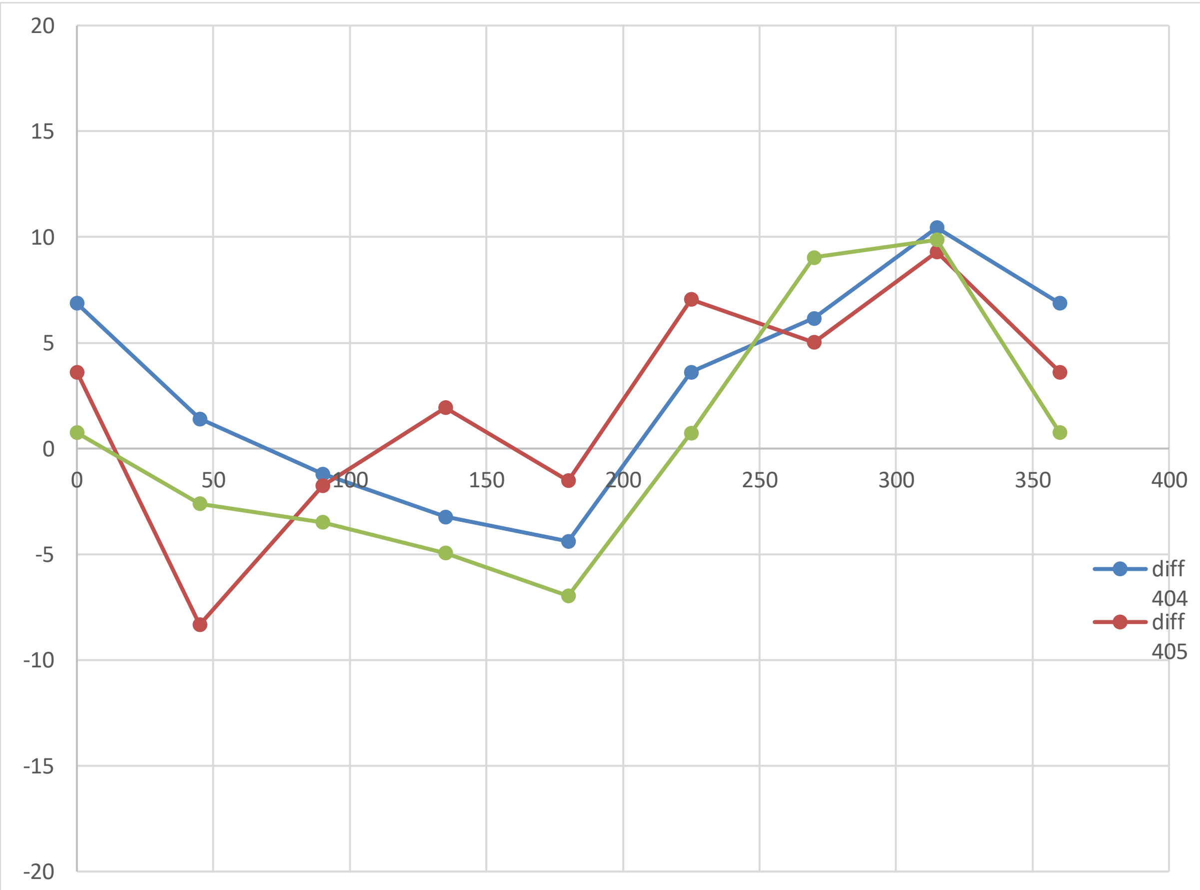


Figure 15: glider compass check

Deployment details

TIME UTC	DATE	GLIDER	LATITUDE	LONGITUDE	EVENT	CTD CALIBRATION CAST
18:31	4/12/18	Unit_398 Churchill	54º 24.5'S	89º 16.75'W	004	CTD2: event 006

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	EVENT	CTD CALIBRATION CAST
17:51	4/12/18	Unit_405 Doombar	54º 24.5'S	89º 16.75'W	005	CTD2: event 006
15:09	9/12/18	RECOVERY	54º 32.873'S	89º 19.066'W	012	NONE

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	EVENT	CTD CALIBRATION CAST
10:30	9/12/18	Unit_404 Pancake	54º 24.62'W	89º 16.667'W	010	CTD3: event 011

At launch, unit_405 took a long time before the Iridium would call in to the primary dockserver. It had called in from the deck the previous day, and when in port, but not on the day of launch. When it eventually did, in the water, it subsequently called in again without any more delay than the other glider, both before and after diving.

First dive to 30m was successful. First dive to 990m at the same spot also. Unit_398 commenced its deep dive at 19:48UTC on 4th starting from 54º 24.501'S 89º 17.274'W. Unit_405 commenced its first deep dive at 19:27UTC on 4th starting from 54º 24.307'S 89º 17.697'W

Both gliders then switched to the low power mission, custard.mi. They stayed underwater for 12 hours on the first dives, recording science on one half yo per dive. Power consumption was 3.1Ah/day for unit_398 and 3.2Ah/day for unit_405. As low power mode was implemented this reduced to 2.1Ah/day. The realistic target for 1 year operation had previously been estimated at 2.4Ah/day, further details on consumption are at the end of this section.

Unit_404 commenced its first deep dive at 12:00UTC on 9th starting from 54° 24.620'W 89° 16.667'W

During CTD work, all the gliders were put onto single dives, all sensors sampling on both climb and dive. At times this was hampered by the length of time underwater, and the issues all gliders had calling in during periods of rough weather (wave height 5m and over). Up until the time the RRS *Discovery* departed the work area on 10th the gliders were sampling intensively. After this, sampling went back to low power cycles and Freewave was disabled.

Faults

After a few days it was noted that unit_405 was significantly worse at file transfer than unit_398. This had resulted in no engineering (sbd) files being successfully uploaded. The decision was taken to deploy the spare, unit_404 and to recover unit_405 at the first suitable weather window.

Unit_404 showed its battery Voltage (m_battery_inst) was dipping lower at inflection compared to the other two gliders, to 9.3V. Comparison with previous data showed that this behaviour had occurred throughout its previous deployment. In addition, during the time of comparison, unit_404 was pumping more ballast oil as the autoballast slowly converged. It was not deemed to be so far out of the ordinary to warrant recovery.

Glider details

All three gliders are fitted with an extended energy bay containing an extra 3S pitch pack. This gives a nominal 1140Ah with no de-rating either for normal or cold water operation. The conventional wisdom is to de-rate the pack by 2% for conventional glider operations, plus 2% for each year of the battery's age, plus 15% for 0C (cold water) operation; "normal" capacity is measured at 20C. The real world lies between the two on an undefined, non-linear sliding scale.

The normal target end-point is 20% of cold water capacity, but in this case it will be rather less.

"Doombar" unit_405	Sensors	Serial Number
	Aanderaa Optode	Type 4831 S/N: 285 Cal Date: October 2018
	Wet Labs Triple Puck	Type BBFLSv9 S/N: 1612 Cal Date: July 2018
	SeaBird GPCTD	S/N: 9109 Cal Date: 30 Aug 2017

"Churchill" unit_398	Sensors	Serial Number
	Aanderaa Optode	Type 4831 S/N: 119 Cal Date: October 2018
	Wet Labs Triple Puck	Type BBFLSv9 S/N: 1609 Cal Date: July 2018
	SeaBird GPCTD	S/N: 9105 Cal Date: 19 Jul 2018

"Pancake" unit_404	Sensors	Serial Number
	Aanderaa Optode	Type 4831 S/N: 210 Cal Date: October 2018
	Wet Labs Triple Puck	Type BBFLSv9 S/N: 1610 Cal Date: July 2018
	SeaBird CT (unpumped)	S/N: 0049 Cal Date: 11 May 2017

Deployment and recovery methods

Unit_405 was deployed first, using the WHOI rig. This comprises an extended Slocum glider cart with a float-activated release mechanism, and is a standard Teledyne Webb design. A strap holds the glider in and is released when the cart is submerged. The design requires a significant weight to be attached to the nose. We found a 3/4" shackle is insufficient. The cart tilted and took a long while to release, having to be lowered well under the water.

Unit 398 was deployed using the NOC bridle. This is more fiddly to set up and requires a certain amount of skill and practice, but the issues from earlier cruises of the bar floating have been remedied. The safety pin took a little effort to remove as it was out of reach, but the seacatch worked perfectly, first pull. The glider rolled as the bridle was pulled then floated free.

Unit_404 was deployed using the WHOI rig. A much larger shackle was attached to the cart's nose and it stayed upright, the glider peeling away as planned.

All gliders were deployed from the P-frame mid-ships in a sea state 3-4 with a 2-3 metre swell running, more like 3-4m for unit_404. Wind was F5-6. The problem with this was that the ship had some difficulty in moving away from the glider, as pointed out in the original SoP. The convenience of the midships deployment, especially with a crowded after deck, is counterbalanced by the inability to release the glider very far from the ship, unlike the alternative position of the aft crane. The down side of that, apart from ship movement in heavy swell, is that the crane has not got the fine controllability of the midships winches. Recovery of unit_405 was using the detachable nose cone as per usual. The line tended to drift around the Glider in this case, and the grapnel could only be cast when the glider was close to the ship. This was not a problem.

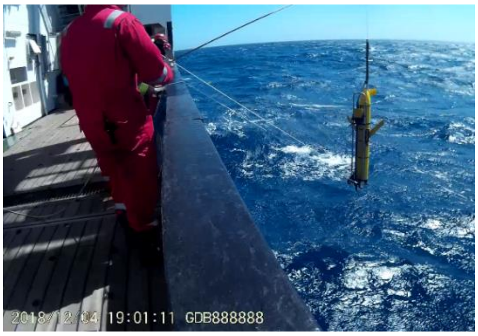
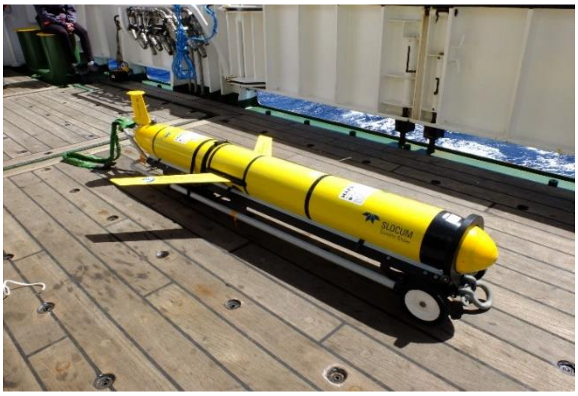


Figure 16: glider deployment



Power consumption and endurance

At the end of the ship's time on site the gliders will spend two more days in full sampling mode. This takes 2.3-2.4 times the energy consumption of the low power mode, so approximately one week's deployment lost for these two days. Using the projected coulomb_amphr_total for each glider, estimated 20% and 0% dates for cold water are shown below.

Glider	Ah on 12th Dec	2.1Ah 20% date	2.1Ah 0% date	2.4ah 20% date	2.4Ah 0% date
398	31.6	18 Oct 2019	26 Jan 2020	9 Sep 2019	19 Nov 2019
404	20.13	23 Oct 2019	7 Jan 2020	14 Sep 2019	24 Nov 2019

This shows that even with the best possible power consumption, we are only just going to get the gliders through to the recovery cruise in early December 2019, and losing more than the planned two extra days to high density sampling could result in the gliders running out of power and being left to drift before the arrival of the ship. Failing to keep consumption continuously to the very low levels achieved shortly after deployment will have a similar effect.

The planned science cruise is 23 November 2019 to 3 January 2020, so allowing for bad weather on site and any delays getting there, recovery is planned with no more than 10% remaining if it occurs as one of the first actions of the ship, on or around 15th December. Always assuming nothing changes in the meantime.

Glider science mission

At sea: Filipa Carvalho (NOC)

On land: Stephanie Henson, Nathan Briggs (NOC)

When Doombar (405) and Churchill (398) were deployed, they were tasked to head to the southern WPT (54^{o} 30'S 89^{o} 18'W). They both struggled to come back to the northern site, which is why Churchill was not present for the 2nd and 3rd calibration casts (CTD003-004).

Pancake was deployed right before CTD003. Gliders were tasked to keep station at 54°25.1 S and 89°14.933 W.

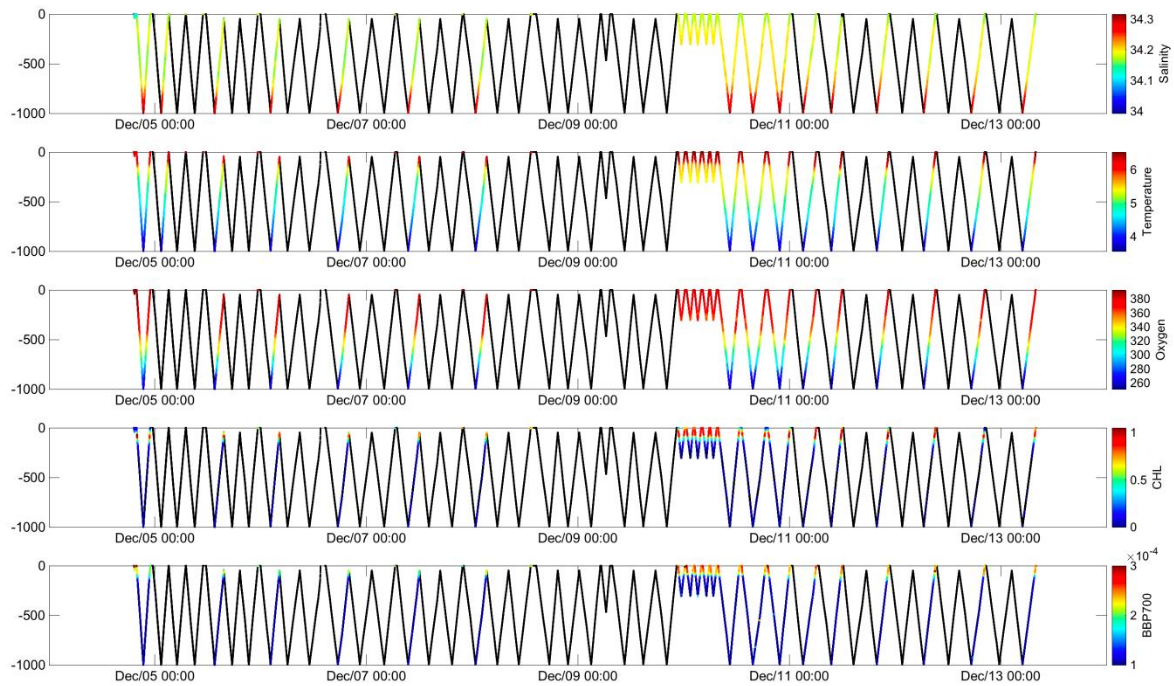


Figure 17: Sampling scheme for Churchill (unit 398) since deployment. Black line indicates glider dives. Colour indicates when respective variable was sampled. Glider has been alternating between (1) 3 yo's per segment, sampling in the last upcast ("low power mode"), (2) double dives, sampling on the last upcast, (3) single dives sampling both casts (for calibration purposes – CTDs occurred during this period), and (4) single dives, sampling in the upcast.

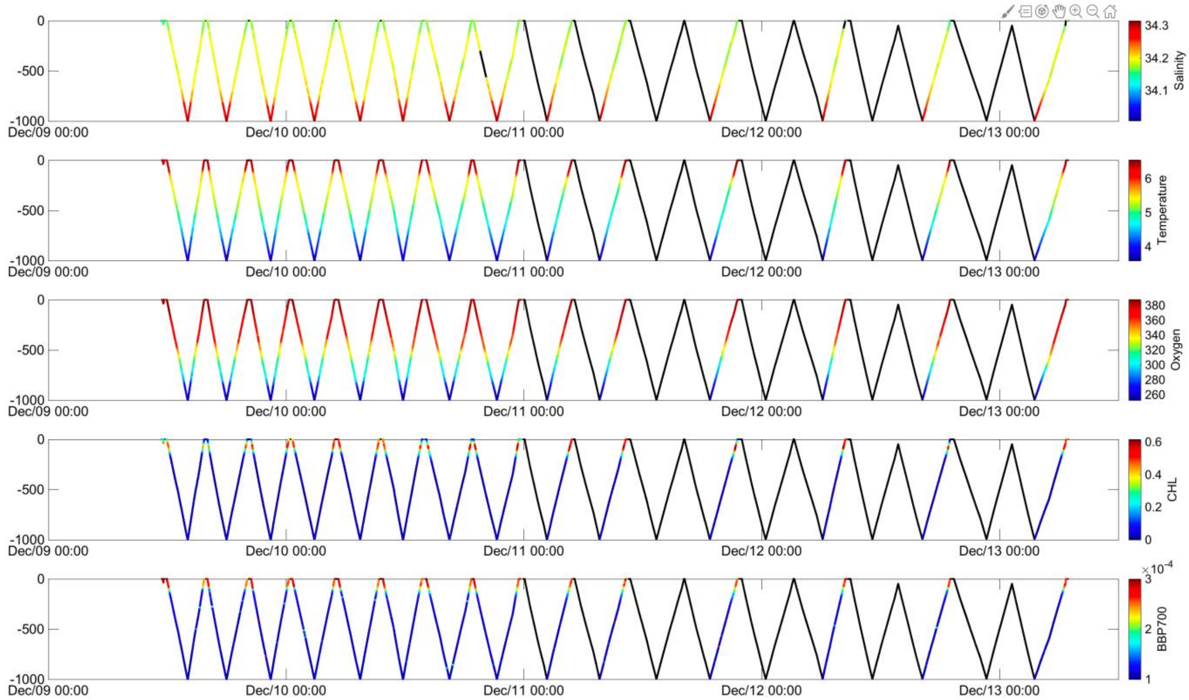


Figure 18: Sampling scheme for Pancake (unit 404). Later deployment for Pancake as it was the backup glider. Same flight details as Churchill.

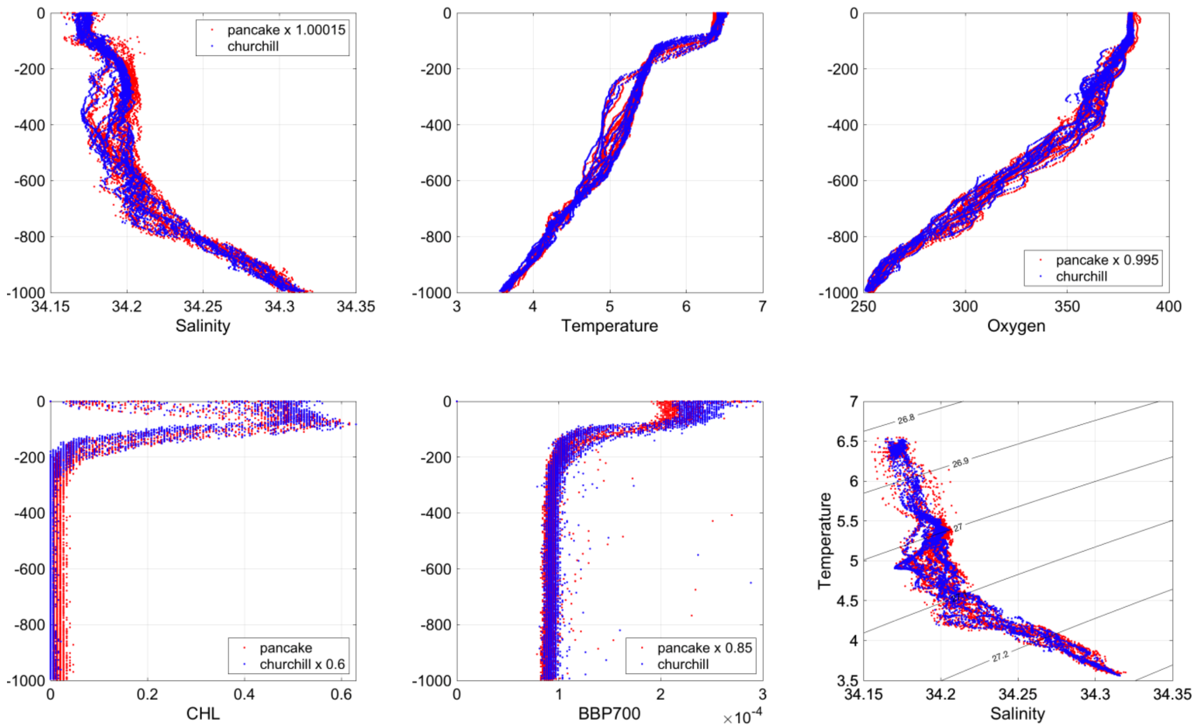


Figure 19: Depth profiles of Salinity, Temperature, Oxygen, Chlorophyll (CHL) and Backscattering at 700nm (BBP700) as well as a TS diagram. Colours indicate glider (Pancake in red and Churchill in blue). Scale shown was just illustrative, as no inter-calibrations have been done.

Glider calibration casts

Table 4: Timing, location and details of CTD calibration casts as well as timing and location of the closest surfacing for the 3 gliders. Gliders not deployed at the timing of the CTD cast show no data. Gliders which were too far (>10km) from the CTD location are highlighted in red.

CTD	Event (CTD)	6 (002)	11 (003)	14 (004)	18 (005)
	Date	04 Dec 2018	09 Dec 2018	10 Dec 2018	12 Dec 2018
	Time UTC	19:44	12:13	02:28	05:38
	Latitude	54° 24.48'S	54° 24.62'S	54° 24.48'S	54° 25.38'S
	Longitude	89° 16.78'W	89° 16.66'W	89° 16.77'W	89° 15.06'W
	Notes		Ecopuck	Full depth	Ecopuck
unit_398 (Churchill)	Closest surfacing UTC	23:30	07:27	02:15	08:03
	Latitude	54° 26.91'S	54° 32.08'S	54° 30.43'S	54° 26.30'S
	Longitude	89° 19.05'W	89° 22.57'W	89° 17.82'W	89° 16.21'W
unit_405 (Doombar)	Closest surfacing UTC	19:27	12:46	-	-
	Latitude	54° 24.31'S	54° 32.47'S	-	-
	Longitude	89° 18.70'W	89° 18.96'W	-	-
unit_404 (Pancake)	Closest surfacing UTC	-	11:43	00:20	05:02
	Latitude	-	54° 24.44'S	54° 25.74'S	54° 24.07'S
	Longitude	-	89° 16.61'W	89° 15.84'W	89° 15.02'W

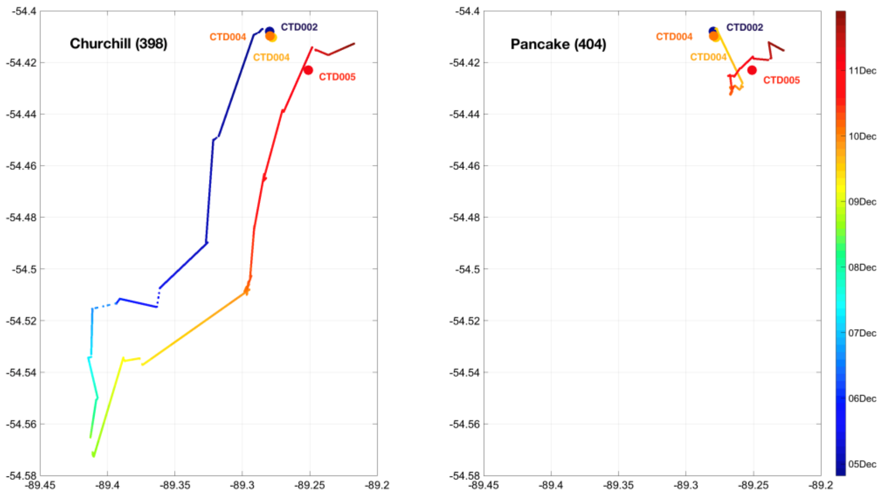


Figure 20: Location of CTD calibration casts (large dots) and glider tracks. Colour indicates time, so large dots close to the track with the same colour indicate that glider was nearby when cast happened.

ECO Triplet Fluorometer and Backscattering Sensor

Filipa Carvalho (NOC)

Introduction

A 1000m rated standalone Wetlabs Environmental Characterization Optics (ECO) Triplet Fluorometer and Backscattering Sensor, measuring backscatter at 2 wavelengths (532nm and 700 nm) and chlorophyll fluorescence was used during DY096. This sensor is the same one found on both Slocum gliders used as part of the GOCART project and as part of CUSTARD, and it will be used to improve calibrations between optical backscatter and chlorophyll fluorescence with in situ POC and chlorophyll concentrations data, respectively.

This ECO triplet was deployed on the CTD rosette on profiles to a maximum of 1000 m. This instrument does not have a pressure sensor, so it relies on the time variable that is then matched to the Seabird CTD (on the rosette). Two brackets using 17mm bolts were used to secure the instrument to the CTD rosette vane. The sensor was placed horizontally, facing outwards.

Callibrations

S/N: BB2FLWB-1633

Date: 9/15/2017

CHL (µg/l)= Scale Factor x (Output-Dark counts)

$\beta(\theta_c)$ $m^{-1}sr^{-1}$ = Scale Factor x (Output-Dark counts)

Table 5: Factory supplied parameters used to convert raw data into chlorophyll fluorescence and backscatter concentrations

	ECO Chlorophyll Fluorometer	**Scattering meter at 700 nm**	**Scattering meter at 532 nm**
Scale Factor (SF)	0.0305 µg/l/count	3.004E-06 $(m^{-1}sr^{-1})$/counts	6.974E-06 $(m^{-1}sr^{-1})$/counts
Maximum output	4130	N/A	N/A
Dark Counts	53 counts	52 counts	53 counts
Resolution	1.2 counts	1.3 counts 3.94E-06 $(m^{-1}sr^{-1})$	1.3 counts 8.77E-06 $(m^{-1}sr^{-1})$
Ambient temperature during characterization	21.5 °C	N/A	N/A

Standard Operating Procedures

Prior to the deployment of the CTD rosette, the sensor needs to be turned on. A computer with EcoView123 software is required as well as a USB to serial cable (and Windows drivers!).

Before deployment

Bring PC, comms cable and blue power plug

1. Launch EcoView123 software
2. Compare PC clock with ship's clock – if necessary, adjust PC clock (see below)
3. Remove dummy plugs from sensor
4. Attach blue power plug and comms cable
5. Attach comms cable to PC using USB to serial connector
6. Select COM port (yellow buttons top right) – COM Port 3 on RICS laptop. If different computer, check 'Device Manager'
7. Select Device File (BB2FLWB-1633.dev) from the ECO puck folder
8. Press Stop Data in EcoView123
9. Click Set Date, Set Time and/or Get Date/Time/Setup until correct time appears in top left of window
10. On Meter Setup tab, change settings to:
    a. Avg/Data Rate 1
    b. Number of Samples 0
    c. Number of Cycles N/A
    d. Cycle Interval N/A
    e. After each change click the relevant button 'Set …..' to update settings. These settings will run the sensor continuously at 1 Hz frequency until switched off again.
11. Press Turn Logging On
12. Press Store To Flash (yellow Setup not stored message in top right should disappear)
13. When ready to deploy, press Start Data
14. Disconnect comms cable and attach dummy plug
15. Take sensor cap off

Items 11 and 12 are sometimes interchangeable. If the suggested order doesn't work, try step 12 before step 11. During COMICS 2, logging was left ON. This allows the sensor to start recording data (and logging) from the time it is powered on – easy to leave it all setup for an early morning CTD! To stop data acquisition just power off the sensor. When plugging the sensor to a PC, all the data should be there.

Note that step 10a represents a change from the configuration on COMICS I (DY086). This change, made on 27 May of dy090, increases the sampling frequency from ~1 Hz to ~10 Hz. The purpose was to increase the precision of particle size estimates made from high frequency variability in backscattering measurements.

After deployment:

Bring PC, comms cable, dummy plug, bottle of water to rinse instrument and sensor cap

1. Connect comms cable to PC
2. Select COM port and device file, if necessary
3. Press Stop Data
4. Click Turn Logging Off
5. On Transfer Data tab, click Receive Data and save file
6. Open transferred file with text editor to verify data transfer
7. Press Erase Memory
8. Disconnect comms cable. Disconnect blue power plug.
9. Replace dummy plugs, rinse the instrument and place sensor cap.

Adjust Time

To adjust the time to the ship's time server:

1. Right click on the time on the left right corner of the Windows screen
2. Scroll down to 'Additional date, time and regional settings
3. In the 'Date and Time' menu, select 'Set the time and date'
4. On the 'Internet Time' tab, select 'Change settings'
5. Click 'Synchronize with an 'internet time server'
6. For DY096, the ship's server was 192.168.63.222 (need to be hardwired to the network)

Data and operations during DY096

Like DY090, when the sensor was removed from its box at the beginning of DY096 there were signs of corrosion on the copper plate where the sensors are. It is unclear what caused it as the instrument was washed with Milli-Q water and carefully dried before packing after COMICS 1. When plugged in, the ECO triplet did not turn on as usual. After careful inspection, the connectors were found to be very dirty, showed signs of dryness and the rubber "skin" was starting to detach from the pins. Dougal, one of the NMF techs on board, cleaned the connectors, cut the rubber parts that were starting to detach and put grease on them.

Because CTD operations were done with the Trace Metal Clean rosette (titanium frame and clean Niskin bottles), 4 holes were drilled on the vane to accommodate the sensor brackets. The copper plate was temporarily removed from the sensor to prevent metal contamination to the trace metal clean niskin bottles. The plate comes off easily by removing 3 small screws.

The first CTD was to 1500m, so the ECO triplet was not mounted due to its depth rating. On the second CTD (to 1000m), the ECO triplet was mounted but not turned on. For the third CTD to 1000m (a glider calibration cast right after unit 404 (Pancake) was deployed (unit 398 – Churchill – was about 10 km away)), the ECO triplet was mounted and sampling. A final CTD with Ecopuck fitted was done about 1.5km from Churchill, 1 km from Pancake and 4.5 km from the surface mooring.

The ECO triplet was on the following CTD profiles:

GMT time	Event (CTD)	Latitude	Longitude	Deployment Notes
11-Dec-2018	011 (03)	54 24.62 S	89 16.66 W	CTD to 1000m – Glider calibration (Pancake);
12-Dec-2018	018 (05)	54 25.38 S	89 15.06 W	CTD to 1000m – Glider calibration (Pancake and Churchill)

Data analysis

Depths were assigned to the dataset by matching timestamps on the ECO puck and the CTD. Datasets from the ECO triplet and CTD were merged and matlab files (.mat) were created using dy096_read_ECO.m. For each ECO triplet data entry each file contains a matching CTD pressure, CTD temperature, CTD salinity, CTD fluorescence and CTD turbidity. Examples are shown for CTD deployments (Figures 21 and 22). The three variables measured by the ECO puck (backscatter at 532nm and 700nm and chlorophyll fluorescence) show reasonable numbers.

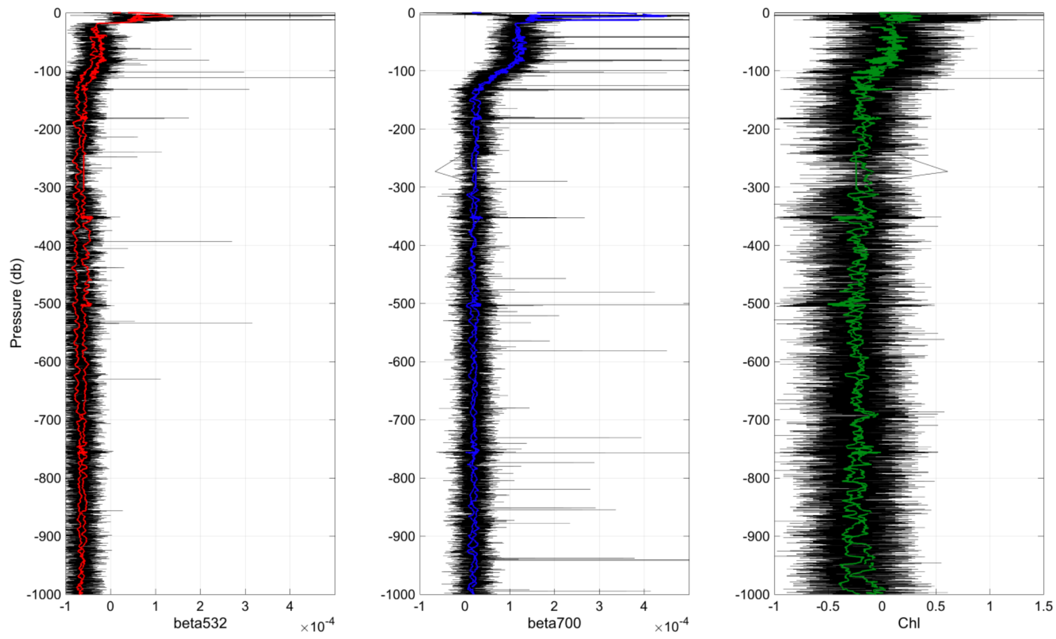


Figure 21: Depth profiles of data collected using the ECO triplet (EcoPuck_003_201812091347.mat) on CTD003 (event 11). Black lines are unaveraged. Solid thick lines for beta532 (red), beta700 (blue) and chlorophyll (green) are smoothed using a 11-point (1 s, or 0.2 m) running median followed by a 51-point (5 s, or 1 m) running mean.

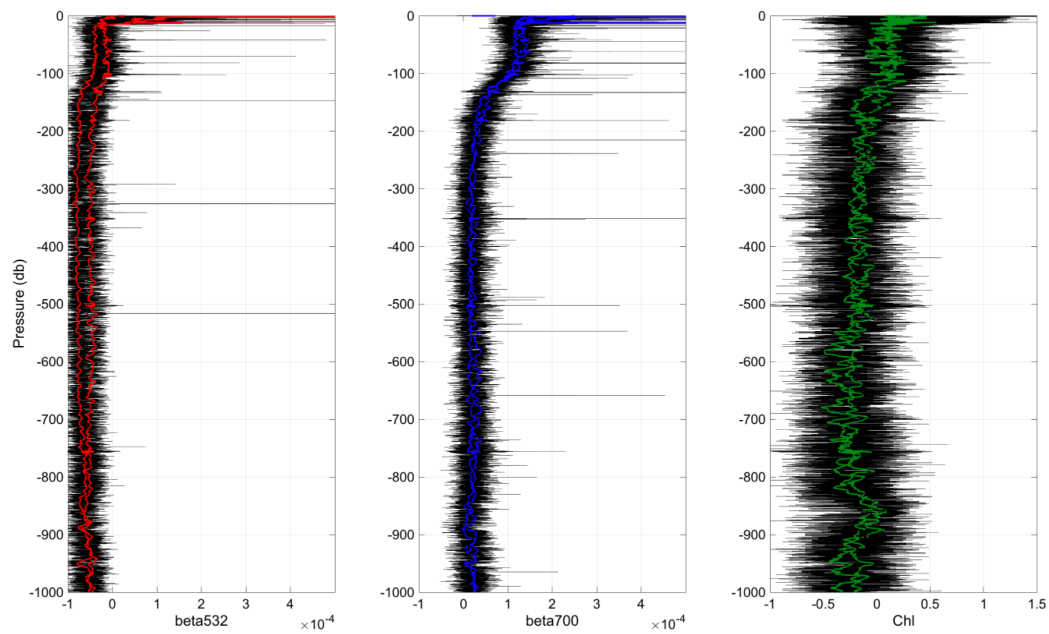


Figure 22: Depth profiles of data collected using the ECO triplet (EcoPuck_005_201812110703.mat) on CTD005 (event 18). Black lines are unaveraged. Solid thick lines for beta532 (red), beta700 (blue) and chlorophyll (green) are smoothed using a 11-point (1 s, or 0.2 m) running median followed by a 51-point (5 s, or 1 m) running mean. Raw profiles are very noisy due to lack of internal averaging, but backscattering spikes due to large particles are very well resolved.

Issues during DY096 deployment

An error related to the baud rate showed up while downloading data from the ECO triplet after CTD003 (event 11). This message showed up as an informative error only and the only option was to press okay. The download continued as usual. While downloading the data (it takes almost an hour for the entire cast to downloaded), the sensor started sampling data and as logging was on, it continued to record. This caused the download to be longer and resulted in a bigger file, but completed successfully eventually. Because of this, it was decided to transfer the file again once the download was completed. There are therefore 2 files for CTD003. I checked the file as suggested in the SOP, and the last entry corresponded to the time the second data acquisition had stopped.

However, when plotting the data, it looks like the file had some sort of corruption, or the sensor stopped recording for a few minutes during the deployment (Figure 23). It is not certain if this is related to the battery, connectors not being fully waterproof after being trimmed or data was corrupted during download.

After downloading ECO triplet data successfully for CTD 005 (event 18), a plot of the data showed similar missing data in the middle of the deployment. As the data were still stored in the ECO triplet, data were downloaded again and there were no missing data on the file. Careful testing should therefore be done before deploying the ECO triplet again (Figure 24) to determine cause.

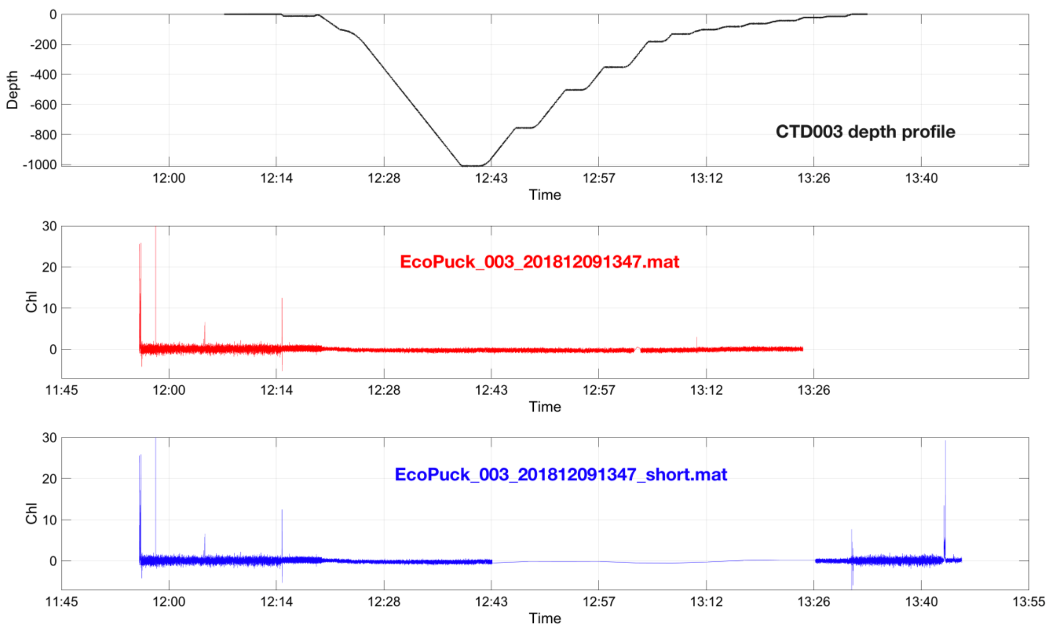


Figure 23: Example data (chlorophyll in this case, but it applies to all channels) showing the missing data from both files after CTD003. Top plot shows depth profile. Middle profile (EcoPuck_003_201812091347.mat) has data for most of the deployment.

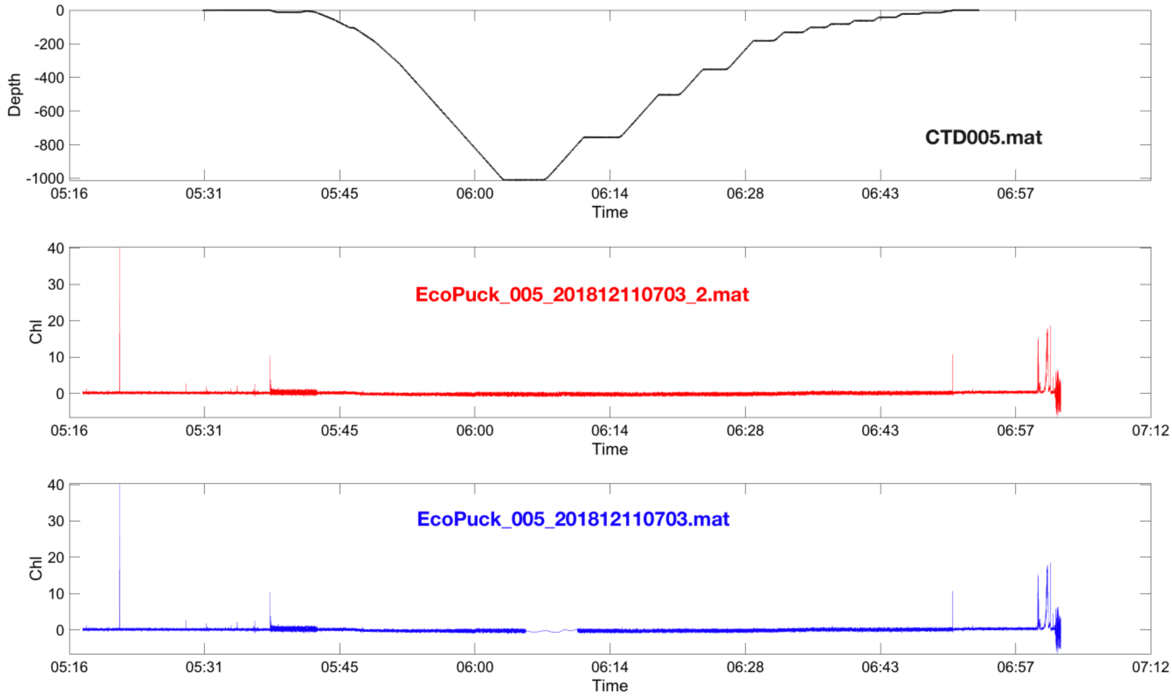


Figure 24: Example data (chlorophyll in this case, but it applies to all channels) showing the missing data from only one of the files after CTD005. Top plot shows depth profile. Middle profile (EcoPuck_005_201812110703.mat) has data for all of the deployment.

Testing was done to try to understand what caused the corrupted files. If the issues were due to low battery during the CTD casts, battery would have been insufficient for the ensuing several hours of bench testing. Plus, if battery was the issue, further tries at transferring the data would have not made it possible to successfully download the complete dataset. So, narrowing it down, it seems like the issue could be connectivity during file transfer.

A 2-hour long test data acquisition was done on the lab bench with the computer connected. After stopping the instrument, data were then transferred as usual and plotted in matlab. On this first test run there were about 10 minutes of missing data in the middle of the dataset. There was no indication of a failed transfer. Another try at transferring the data yielded incomplete status (highlighted in red) after a few seconds. It was not possible to transfer again this dataset as an incomplete status would appear seconds after starting the transfer. The ECO triplet showed the date 1 January of a year some time past. Time was set to local (PC) time, data were then erased and the ECO triplet was powered down – this sort of suggests a reset of some kind.

Suspecting connectivity issues, drivers for the Serial cable were downloaded and reinstalled on the PC. Energy settings were set for the PC not to sleep (ever!) while on battery power nor when charging. The PC was restarted and a new test was done. On this test, transfer was completed successfully and all data were sent. Another test run was carried out and another successful transfer was completed.

A final test run was done where the same dataset was transferred twice; the first time (Figure 25, top) allowing the computer go to sleep in the middle of the file transfer and a second time with the transfer preventing the computer from going to sleep by plugging it to a power source (Figure 25, bottom). The former gave rise to the issue but the second didn't.

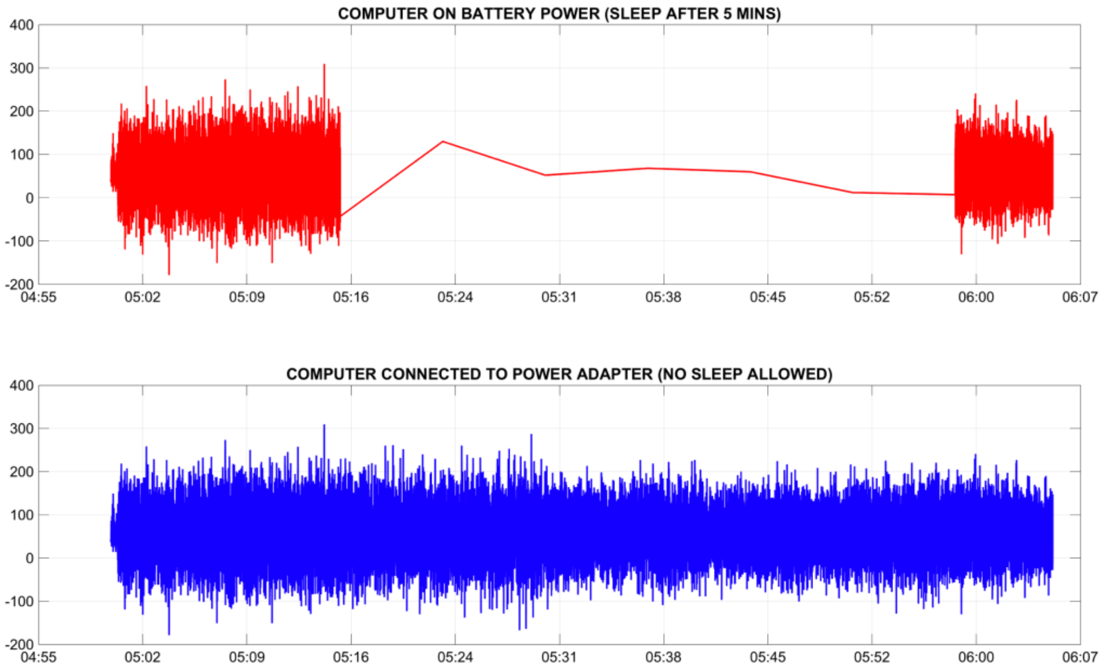


Figure 25: Data transfer for the same file with: (top) computer on battery power and energy setting to let computer sleep after 5 minutes; (bottom) computer connected to a power source, without going to sleep during the transfer

So, it is therefore <u>imperative</u> to transfer data with either the (1) computer connected to a power source (usually the default setting is to not let the computer sleep if connected to a power adapter) or (2) if on battery power, set the computer settings to make sure the PC does not go to sleep while transferring the file.

Water sampling for nutrient and inorganic carbon system analysis

Antony Birchill (NOC), Pablo Trucco Pignata (University of Southampton)

Underway sampling

To provide detailed information of the biogeochemistry of surface waters sampling of the underway system was conducted every 6 hours. Samples were collected for the determination of macronutrients, salinity and dissolved inorganic carbon. Macronutrient samples were collected unfiltered and frozen. Dissolved inorganic carbon samples were taken and preserved according to the protocols specified in the best practices manual SOP 1 (Dickson et al., 2007).. Both macronutrient and dissolved inorganic carbon samples were stored on-board Discovery for future analysis at the National Oceanography Centre Southampton. Salinity samples were collected for analysis on-board as described elsewhere in report. A total of 38 nutrient and salinity samples were collected and 32 dissolved inorganic carbon samples. The total sampling procedure was timed on three occasions. It took between 210-260 s to collect all three samples.

CTD sampling

Profiles of dissolved inorganic carbon and total Alkalinity

To calibrate the pCO_2 and pH sensors deployed on the Ocean Observation Initiative SUMO-04 mooring and more generally to understand the vertical distribution of dissolved inorganic carbon (DIC) and total alkalinity (TA), discrete samples were taken at different depths from CTD casts. DIC and TA samples were taken and preserved according to the protocols specified in the best practices manual SOP 1 (Dickson et al., 2007). A total of 40 DIC and TA were sampled to be analysed in laboratory conditions.

Nutrients

Seawater samples for macronutrient analyses were collected unfiltered into sterile 50 mL centrifuge tubes and frozen (-20 °C) onboard the RRS *Discovery* for future analyses at the National Oceanography Centre. The samples will be analysed using standard gas-segmented flow spectrophotometric techniques (Hydes et al., 2010).

HYDES, D., et al.. 2010. Determination of Dissolved Nutrients (N, P, SI) in Seawater With High Precision and Inter-Comparability Using Gas-Segmented Continuous Flow Analysers.

CTD #	Event	Date	Jday	Lat °S	Lon °W	Start (UTC)	End (UTC)	Depth (m)	Samples
1	001	3/12	337	53° 58’	86° 05’	1622	1752	1500	None
2	006	4/12	338	54° 25’	89° 17’	1944	2100	1000	S,O_2,nut,DIC, TA, Chl, HPLC,POC, PON, BSi
3	011	9/12	343	54° 25’	89° 17’	1213	1334	1000	As CTD002
4	014	10/12	344	54° 25’	89° 17’	0228	0544	4510	As CTD002 plus PFe
5	018	11/12	345	54° 25’	89° 17’	0538	0652	1000	As CTD002

Dissolved oxygen

Pablo Trucco Pignata (University of Southampton)

Instrumentation

Discrete seawater samples were collected from the CTD hydrocasts for calibrating the CTD oxygen sensors and those deployed in gliders and on the mooring. Dissolved Oxygen (DO) was determined by automated Winkler titration with potentiometric end-point (Williams and Jenkinson 1982) using a Metrohm 916 Ti-Touch controller and 2 Metrohm Dosino 800 units for dispensing Thiosulphate and Iodate solutions. A Metrohm Pt-Titrode electrode was used for detecting the potentiometric end-point of the titration. The titration sequence and data acquisition were controlled by Metrohm Tiamo software.

Sampling

Seawater samples for dissolved oxygen concentration were directly collected from the Niskin bottles in the clean laboratory to avoid their contamination. Seawater was siphoned into 100 ml borosilicate glass bottles (nominal volume, actual volume was determined gravimetrically prior to the cruise), using silicone tubing and overflowing 2 times the bottle volume, and samples were immediately fixed. Oxygen in the samples was fixed with Manganese Sulphate and Alkaline Iodide solutions dispensed from calibrated pipettes. The fixing temperature was recorded on a hand-held thermometer. Immediately after fixing, the samples were stored until analysis. Titrations for dissolved oxygen determination were made within the following 12 h. The concentration of thiosulphate was calibrated prior to starting oxygen analyses as well as blank determination. Oxygen saturation was calculated from the equations for solubility in seawater of Benson and Krause (1984).

Calibration results

A single Thiosulphate solution was prepared and calibrated against a 0.1667 M KIO_3 standard (OSIL). The concentration of the Thiosulphate solution did not vary significantly during the cruise with a mean of 0.1103 ± 0.0004 M (Figure 26, n=13). The mean value calculated for each day of analysis was used for the respective sample calculation. For the oxygen concentrations encountered during DY096, the thiosulphate concentration uncertainty of ±0.0004 M, equates to a 95% confidence interval (2 standard deviation) of approximately 0.9 µmol/L (analytical uncertainty). Replicate samples from the same Niskin bottle varied in difference between 0.09-1.37 µmol/L (average 0.51 µmol/L; n=2 on 4 levels for every CTD cast, equivalent to ±0.19 % saturation with respect to atmospheric equilibrium). Also the oxygen sensor of the CTD showed a positive correlation with oxygen measured by Winkler (Figure 27, n=60). A depth comparation between CTD oxygen measurement and Winkler determination showed an average offset of 16.035 ± 1.074 µmol/L (Figure 28)

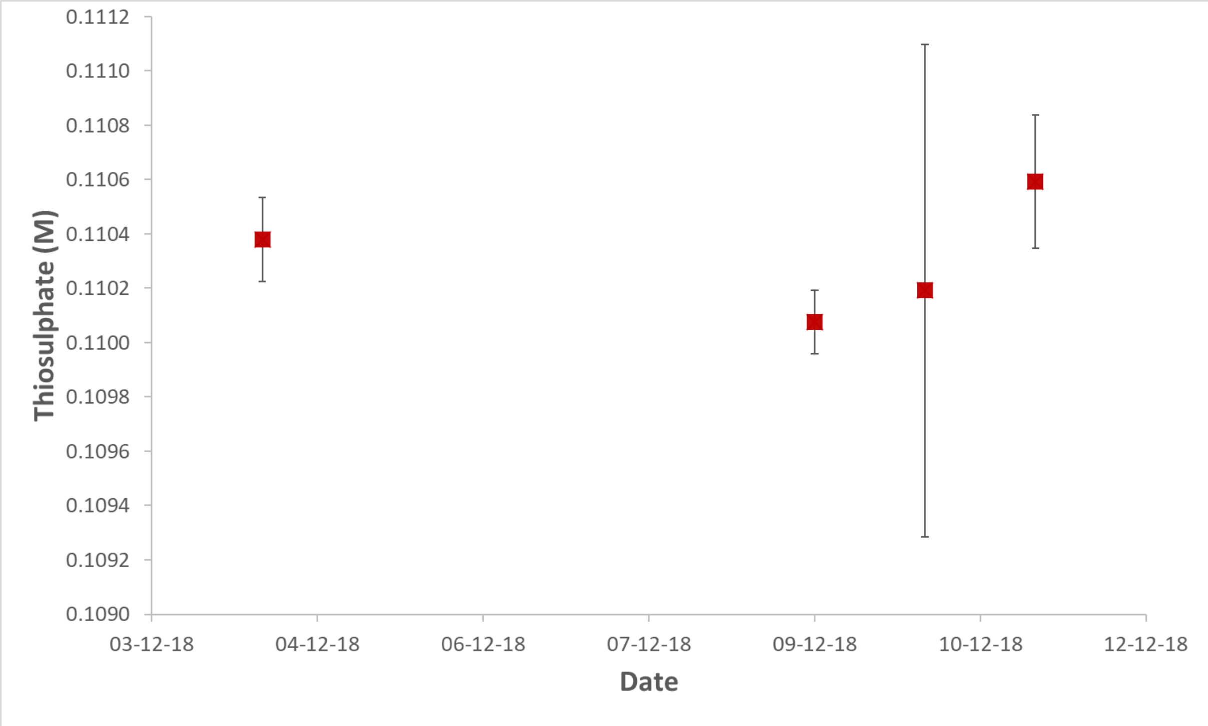


Figure 26. Thiosulphate concentration against date of measurement.

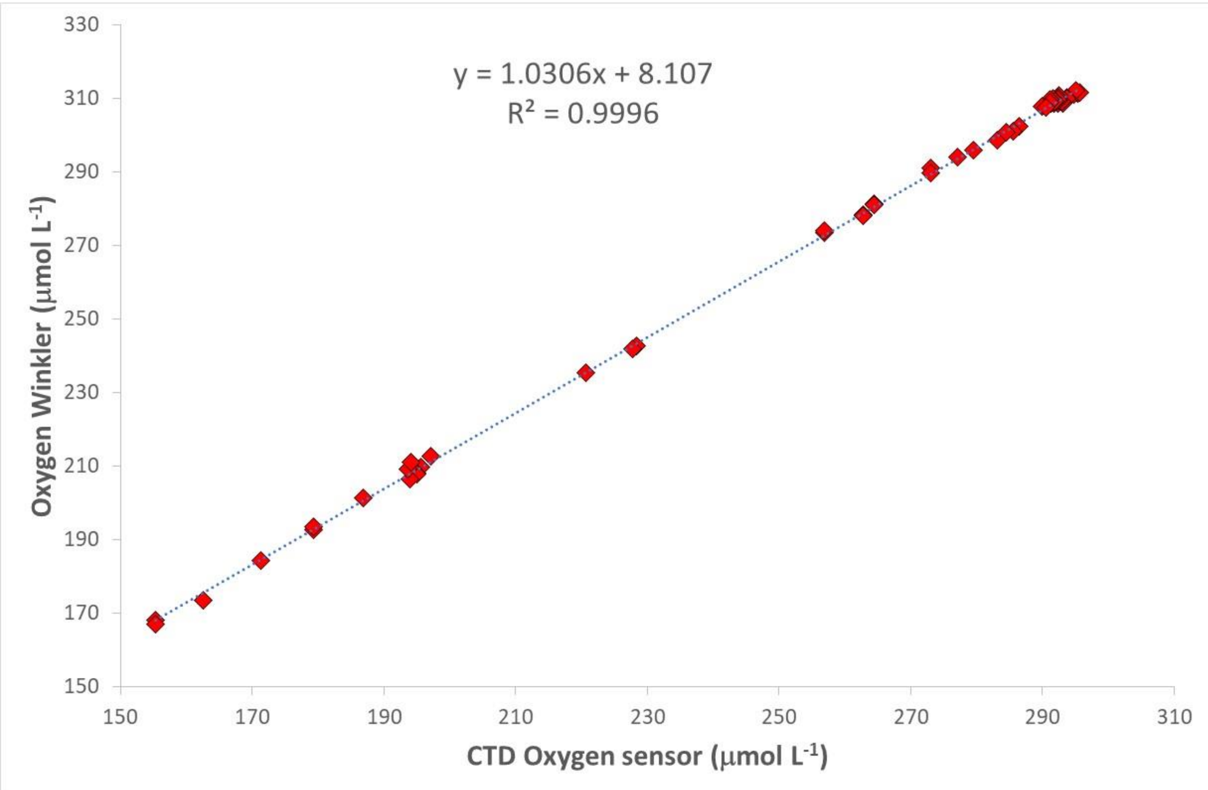


Figure 27. CTD oxygen measurement against oxygen concentration determined by Winkler

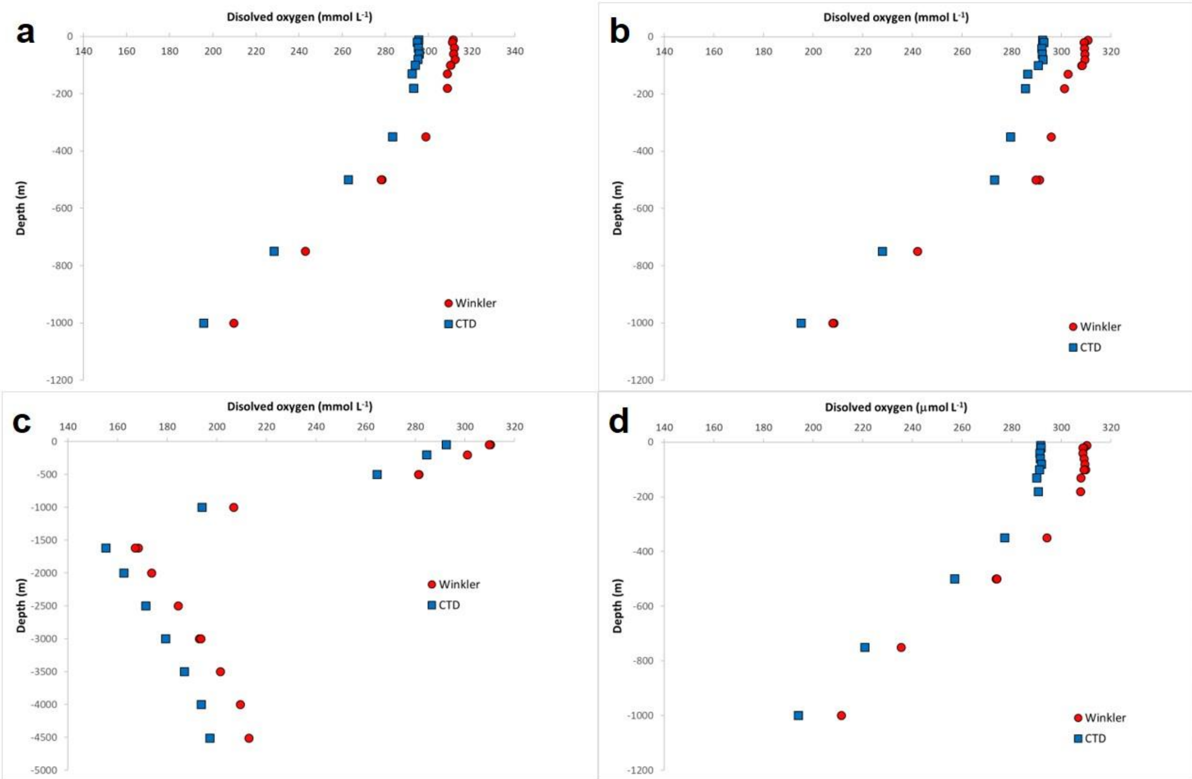


Figure 28. Profile comparation between CTD measurements and Winkler oxygen determination. a) Cast 002, b) Cast 003, c) Cast004, d) Cast 005.

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Upper ocean pelagic sampling of phytoplankton processes: chlorophyll, POC/N, BSi, HPLC, PABS, Lugols and active chlorophyll fluorescence

Mark Moore, Alan Wright, Angela Bahamondes Dominguez, Eleanor Haigh (University of Southampton)

Introduction

The physiology and composition of upper ocean plankton communities has a strong influence on the magnitude and nature of sinking organic and inorganic material. As part of the CUSTARD project, work package 2 is addressing the linkages between surface phytoplankton iron stress and community structure and the subsequent stoichiometric composition and export of material out of the upper ocean.

To examine relationships between surface plankton elemental stoichiometry, community structure, community iron status and bio-optical properties, a series of samples and measurements were collected on DY096 to assess: levels of phytoplankton biomass (chlorophyll-*a*), community composition (preserved and filtered water samples for microscopy, diagnostic pigments via High-Performance-Liquid-Chromatography), particulate absorption spectra (PABS), biomineral standing stocks (biogenic silica) and total particulate organic carbon and nitrogen standing stocks. Measurements were collected on CTD casts over the top 1000m or in one case over full ocean depth. Additionally, the physiological state of near surface phytoplankton communities was assessed using a number of single turnover active chlorophyll techniques applied to water collected from the ship's underway sampling system alongside underway chlorophyll measurements.

CTD Sampling

For each stainless steel CTD cast (CTDs), seawater was typically collected from 12 depths from the near surface down to ~1000 m to filter for pigments (chlorophyll-a via fluorometric analysis, accessory pigments via High-Performance-Liquid-Chromatography), particulate organic carbon (POC), particulate organic nitrogen (PON) and biogenic silica ($bSiO_2$). Additionally, seawater was collected and processed for evaluation of phytoplankton community structure determined by microscopy from preserved (acidic Lugol's solution) samples. Sampling and protocols typically followed those employed previously and described in detail elsewhere (see e.g. Moore et al. 2007a&b; Poulton et al. 2006, 2013).

An overall list of samples collected is provided here:

Table 6

Date Julian Day	Site	Event	CTD cast	Niskin Bottle	Nominal Depth (m)	Variables Filtered
04/12/18 338	OOI	6	2	1, 2, 3, 5, 6, 8, 11, 12	1000, 750, 500, 350, 180, 130, 100, 80, 60, 40, 20, 12	Chl-a, POC/N, BSi, HPLC, PABS
09/12/18 343	OOI	10	3	1, 2, 3, 5, 6, 8, 11, 12	1000, 750, 500, 350, 180, 130, 100, 80, 60, 40, 20, 12	Chl-a, POC/N, BSi, HPLC, PABS, Lugols
10/12/18 344	OOI	14	4	1, 2, 3, 5, 6, 8, 11, 12	4510, 4000, 3500, 2500, 2000, 1620, 1000, 500, 200, 50, 12	Chl-a, POC/N, BSi, HPLC, PABS
11/12/18 345	OOI	18	5	1, 2, 3, 5, 6, 8, 11, 12	1000, 750, 500, 350, 180, 130, 100, 80, 60, 40, 20, 12	Chl-a, POC/N, BSi, HPLC, PABS, Lugols

Particulate Organic Carbon and Nitrogen (POC/N)

POC/N samples were collected from the CTD. For POC/N, 1000 mL of seawater was filtered onto pre-ashed (400°C, 12 h) Whatman GF/F filters. These were then placed in clean Eppendorf tubes, and dried overnight (50°C) for storage prior to analyses back at NOCS.

Particulate Silica (bSiO$_2$)

Particulate silica (bSiO$_2$) water samples were collected from the CTD. For bSiO$_2$, 500-1000 mL of seawater was filtered onto Whatman 0.8 µm polycarbonate filters. After filtration, the filters were placed into plastic 50 mL centrifuge tubes, then dried overnight (50°C) for storage prior to analyses back at NOCS.

High Performance Liquid Chromatography (HPLC)

For phytoplankton pigment analysis (chlorophylls, carotenoids), 500-1000 mL of seawater was filtered onto Whatman GF/F filters for later extraction and analysis of pigments by HPLC. After filtration, HPLC filters were placed into nunc™ CryoTube™ vials or similar and stored at -80°C prior to later analyses back at NOCS.

Preserved phytoplankton (acidic Lugol's solution)

Water samples (100 mL) were preserved in acidic Lugol's solution (2% final solution) for later enumeration and identification of phytoplankton species by inverted light microscopy. Samples were stored in brown 100 mL medicine bottles containing acidic Lugol's solution.

Chlorophyll analysis

In order to provide an index of overall phytoplankton biomass, water samples for the determination of chlorophyll-*a* concentrations were collected from:

i) CTD deployments
ii) Underway sampling
iii) Surface iron limitation experiments

Further details specific to different sampling types can be found in the corresponding sections of the cruise report, but briefly:

i) CTD samples: The titanium frame CTD was used to collect samples at 12 different depths (See Table 6). 100 mL of seawater was filtered onto Whatman glass fibre GF/F filters for total chlorophyll-a concentration.
ii) For the Underway samples, water was collected off the ship's underway system at a nominal depth of 5 m and a volume of 100 mL filtered onto GF/F filters.
iii) For the limitation experiments, 100 mL was filtered from sub-samples of each experimental bottle at each timepoint (see below)

In all cases, chlorophyll-*a* was extracted in 6 mL of 90 % acetone over >24 hours at 4°C in a fridge in the dark. Measurements of chlorophyll-*a* were subsequently made on board using a Turner Designs Trilogy fluorometer set up with a non-acidification kit (after Welschmeyer, 1994). The fluorometer was calibrated against a pure chlorophyll-a extract. A Turner solid standard (Part No. 8000-952) was used at the start of each set of readings as well as an acetone blank sample to monitor for instrument drift. Both of these readings are subsequently used in the calculations to determine chlorophyll-a concentrations (see Equation 1).

Chlorophyll-a concentrations in mg m^{-3} were calculated as:

$$Chl\ a = Dilution * (R)adj * (F - blank) * \left(\frac{v}{V}\right) \qquad \text{Equation (1)}$$

Dilution = 1 (unless required for an over-range sample)

(R) adj = response factor adjusted for the shift in the solid standard

F = sample fluorescence

blank = acetone blank reading

v = acetone extracted volume (6 mL)

V = filtered sample volume in mL

A total of 120 underway chlorophyll samples were also collected approximately every 2 hours when in international waters.

Surface ocean Fe and Mn (co-)limitation experiments

In order to determine whether the surface phytoplankton communities were iron (Fe) limited (and potential Fe and Mn co-limited) during the period on site, while simultaneously confirming that the trace metal clean sampling/handling processes were effective, a surface community iron limitation experiment was performed using protocols similar to those employed previously (Moore et al. 2007a&b, Nielsdottir et al. 2012). Briefly, 12 sub-samples were collected from OTE-Flo bottles (see Trace Metal Sampling report section by Birchill) fired in the surface mixed layer (20m nominal depth) on 04/12/18 (JD338) and dispensed into acid-washed 2000ml polycarbonate bottles. Of these, 3 bottles were left as un-amended controls and 3 were amended with Fe additions (100 µl of 40 µM $FeCl_3$ in 10% HCL), 3 were amended with Mn additions (100 µl of 40 µM $MnCl_3$ in 10% HCL) and 3 amended with both Fe and Mn, all to a final concentration of 2nM. Triplicate bottles were initiated for each treatment, with samples within the triplicates collected from separate OTE-Flo bottles (see Table 7). The samples were incubated on deck using a surface flow through incubator shaded with one layer of 'Blue Lagoon' optical filter (Lee Filters™). Subsequently subsamples were collected for active chlorophyll fluorescence measurements and chlorophyll (100ml) taken at 2 days, 4 days and 8 days after the start of the experiment. Additional samples for trace metal analysis (total dissolvable), POC/PON and bSi were collected at the final sampling point on day 8. Initial results were somewhat ambiguous, with increases in the apparent photochemical efficiency of photosystem II (Fv/Fm) observed across all treatments over the first two timepoints, with some indication of a subsequent drop in Fv/Fm in the non-Fe amended treatments and correspondingly higher chlorophyll within the Fe amended treatments for the final timepoint, noting that the third bottle in each of the non-Fe amended triplicates was higher, potentially indicating contamination occurred during sampling with OTE-Flo bottle #7 (see Table 7 and cruise report section by Birchill).

Table 7: bottles sampled for incubation experiment

OTE-Flo Bottle for sample	5	6	7*
Treatment bottles	C1, Fe1, Mn1, FeMn1	C2, Fe2, Mn2, FeMn2	C3, Fe3, Mn3, FeMn3

* subsequent to set up of this experiment, OTE-Flo bottle 7 was found to have a leak towards the top which prevented pressurisation and hence may have potentially led to leakage and contamination during sampling.

Active chlorophyll fluorescence measurements

Chlorophyll fluorescence, using techniques such as Fast Repetition Rate fluorometry (FRRf), can provide a useful non-destructive and rapid index of the physiological status of phytoplankton (e.g. Moore et al. 2007). Instruments such as FRR fluorometers are capable of measuring a suite of parameters pertaining to the photosynthetic physiology of the entire phytoplankton community, most commonly including the photosynthetic energy transfer efficiency (Fv/Fm) which can provide a proxy of the overall photosynthetic 'health' of the community. The FRRf technique measures in real time, in situ and at high sensitivity.

A variety of active chlorophyll fluorometers were employed during DY096.

Underway sampling

Four separate active chlorophyll fluorometers were employed during underway sampling. Two Chelsea Technologies Group (CTG) 'Single turnover active fluorescence (STAF)' systems based on CTG 'FastBallast' fluorometers (Kolber et al. 1998), with serial numbers 16-0550-011 and 16-0550-18 respectively were connected in series to the ship's non-toxic underway supply within the main lab in order to assess and monitor the physiological state of Photosystem II (PSII) within the surface phytoplankton population of the study area. Additionally, two Chelsea Technologies Group (CTG) FastOcean^{TM} FRR fluorometers, with serial numbers 14-9727-004, and 14 -9615-002 were connected into the underway system within the general-purpose laboratory. Water for all systems was collected by pumping from a flow-through reservoir set up in the 'General Purpose' lab.

'FastBallast' fluorometers

Both STAF FastBallast systems typically employed the following settings:

PMT eht = 560V initially with auto-ranging on

1st. pulse – Saturation Pulse (SP) duration = 120µs

2nd. pulse Relaxation Pulse (RP) duration = 120µs

Start Gap -Shortest gap (between SP and RP) = 80µs

End Gap -Longest gap (between SP and RP) = 8000µs

Gap Steps = 12

Sequence interval = 100ms

Sequences per acquisition = 6

Acquisitions per super-acquisition = 4

Group time = 30s

The following LED combinations were used for the routine underway measurements:

FastBallast 16-0550-18 = 460nm @ 2.3 intensity

FastBallast 16-0550-11 = 460nm @ 1.3 intensity, and 440nm @ 1.3 intensity.

The gain was set using the instrument's auto-ranging mode. Data from this instrument when used underway was automatically archived onto a laptop and intermittently backed up. Data quality for these developmental systems will be assessed in detail following the cruise.

A series of MilliQ and Filtered Sea Water Blanks were collected. (Table 8, Table 9, Table 10)

Date	Julian Day	Instrument	Gain	Fm
5/12/18	339	16-0550-11	560V	1.165
5/12/18	339	16-0550-11	400V	1.188
5/12/18	339	16-0550-18	560V	0.07014
5/12/18	339	16-0550-18	400V	??

Table 8

Date	Julian Day	Instrument	Gain	LED(s)	File
12/12/18	346	16-0550-18	560	440, 460	MBQ_G560_L440460

12/12/18	346	16-0550-18	560	460	MBQ_G560_L460
12/12/18	346	16-0550-11	560	440, 460	MBQ_G560_L440460_SN11
12/12/18	346	16-0550-11	560	460	MBQ_G560_L460_SN11

Table 9 MilliQ Blanks collected JD346

Date	Julian Day	Instrument	Gain	LED(s)	File
12/12/18	346	16-0550-18	560	460	FSWB_G560_L460
12/12/18	346	16-0550-18	560	440, 460	FSWB_G560_L440460
12/12/18	346	16-0550-11	560	460	FSWB_G560_L460_SN11
12/12/18	346	16-0550-11	560	440,460	FSWB_G560_L440460_SN11

Table 10 Filtered Sea Water Blanks (0.2μm filtered) collected JD346

It should be noted that SN11 used the '3D printed' top, and SN18 used a precision machined aluminium top, therefore the relative magnitude of the blanks for each instrument should be compared.

Duration of sampling

Both FastBallast instruments were run between the following times with the following LED configurations (Table 11)

instrument	Date	Julian day	Start time	Julian day	End time	Led(s)	intensity
18	30/11/18	334	1105	335	0250	460nm	2.3
11	30/11/18	334	1133	335	0250	460nm, 440nm	1.3
18	30/11/18	334	1731	335	2255	460nm	2.3
11	2/12/18	336	1711	338	2255	460nm, 440nm	1.3
18		339	0032	339	1458	460nm	2.3
11		339	0100	339	1458	460nm, 440nm	1.3

18		339	1818	342	0951	460nm	2.3
11		339	1843	342	0951	460nm, 440nm	1.3
18		342	1055	345	1100	460nm	2.3
11		342	1039	345	1100	460nm, 440nm	1.3

Table 11

Discrete samples.

The following discrete sampling was carried out, with a run time of 60s in order to collect data with the multiple LED sets available. Files were saved using the S_day_instrument_varient syntax. Samples were collected by shutting down the pump from the underway system sub-sampling resevoir.

instrument	Gain	LED (s)	Intensity	file
16-0550-018.	560	460	2.3	S_339_18_A
16-0550-018.	560	440	2.3	S_339_18_B
16-0550-018.	560	490, 460	2.3, 2.3	S_339_18_C
16-0550-018.	560	560,460	2.3, 2.3	S_339_18_D
16-0550-018.	560	490, 560	2.3,2.3	S_339_18_E
16-0550-018.	560	440, 460	1.3, 1.3	S_339_18_F
16-0550-011	560	460	2.3	S_339_11_A
16-0550-011	560	440	2.3	S_339_11_B
16-0550-011	560	425	2.3	S_339_11_C
16-0550-011	560	410	2.3	S_339_11_D
16-0550-011	560	410, 425	2.3,2.3	S_339_11_E
16-0550-011	560	460, 440	1.3,1.3	S_339_11_F

Table 12.1 Discrete sampling carried out on 5/12/18 Julian day 339 @ 1729 GMT

instrument	Gain	LED (s)	Intensity	file
16-0550-018.	560	460	2.3	S_342_18_A
16-0550-018.	560	440	2.3	S_342_18_B

16-0550-018.	560	490, 460	2.3, 2.3	S_342_18_C
16-0550-018.	560	560,460	2.3, 2.3	S_342_18_D
16-0550-018.	560	490, 560	2.3,2.3	S_342_18_E
16-0550-018.	560	440, 460	1.3, 1.3	S_342_18_F
16-0550-011	560	460	2.3	S_342_11_A
16-0550-011	560	440	2.3	S_342_11_B
16-0550-011	560	425	2.3	S_342_11_C
16-0550-011	560	410	2.3	S_342_11_D
16-0550-011	560	410, 425	2.3,2.3	S_342_11_E
16-0550-011	560	460, 440	1.3,1.3	S_342_11_F

Table 12.2 Discrete sampling carried out on 8/12/18 Julian day 342 @ 1012 GMT

instrument	Gain	LED (s)	Intensity	file
16-0550-018.	560	460	2.3	S_345_18_A
16-0550-018.	560	440	2.3	S_345_18_B
16-0550-018.	560	490, 460	2.3, 2.3	S_345_18_C
16-0550-018.	560	560,460	2.3, 2.3	S_345_18_D
16-0550-018.	560	490, 560	2.3,2.3	S_345_18_E
16-0550-018.	560	440, 460	1.3, 1.3	S_345_18_F
16-0550-011	560	460	2.3	S_345_11_A
16-0550-011	560	440	2.3	S_345_11_B
16-0550-011	560	425	2.3	S_345_11_C
16-0550-011	560	410	2.3	S_345_11_D
16-0550-011	560	410, 425	2.3,2.3	S_345_11_E
16-0550-011	560	460, 440	1.3,1.3	S_345_11_F

Table 12.3 Discrete sampling carried out on 11/12/18 Julian day 345 @1100GMT

The instrument was controlled by 'RunSTAF' software (development version) and was stored on an external data logger and backed up every 1-4 days throughout the cruise. The Instrument optics were cleaned periodically and before the protocol was set to run again, blank measurements were performed to calibrate the results. Data will then be analysed using custom software in a Matlab^{TM} environment.

FastOcean^{TM} FRR fluorometers

The FastOcean instrument serial number 14-9727-004 was set up with the following settings:

Gain = 560. See notes in Table 13

Saturation phase = 100 flashlets

Relaxation phase = 40 flashlets

Acquisition pitch = 0

Sequence repetition = 56

Sequence interval = 100ms

The following LED combination was used.

1. 450nm with an intensity of 1.3
2. 530 nm with 0 intensity
3. 624 nm with 0 intensity

Samples were manually exchanged every two hours, with the following start and stop times.

Date (Start)	Julian Day (Start)	Time (Start)	Julian Day (Stop)	Time (Stop)	Notes
30/11/18	334	0900	335	0250	
2/12/18	336	1716	339	1458	
5/12/18	339	1715	342	0951	
8/12/18	342	1102	343	0255	1, Gain changed to 540. 2, File 342_1458 to be discarded
9/12/18	343	0255	345	0200	

Table 13

The instrument settings were controlled by the FastPro software and were stored on an external data logger using the file syntax; Julian Day_time, e.g. 334_0900

Data were backed up every 1-4 days throughout the cruise. The Instrument optics were cleaned periodically and before the protocol was set to run again, blank measurements were performed to calibrate the results. Data will then be analysed using custom software in a Matlab™ environment.

The FastOcean instrument serial number 14-9615-002 was set up to run continuous fluorescence light curves (FLCs), with a white LED providing actinic light (0-1800 umol photons m^{-2} s^{-1}), and a cycle time of 28 minutes. The following settings, were typical;

Gain = auto-ranging

Saturation phase = 100 flashlets, with a pitch of 2μs

Relaxation phase = 40 flashlets, with a pitch of 60μs

Acquisition pitch = 7s

Loop time 21s

Gap steps = 12

Sequence repetition = 48

Sequence interval = 100ms

LED settings, intensity and protocol

Protocol ‘A’ has the 450nm LED at intensity 0.7, with all other turned off (Table 14)

Protocol ‘B’ has the 450nm LED at intensity 0.7 and the 530nm Led at intensity 0.5, with all others turned off.

Protocol ‘C’ has the 450nm LED at intensity 0.7 and the 624nm Led at intensity 0.8, with all others turned off.

Protocol ‘D’ has all the LED’s at the same time, but this was not used beyond the first day of sampling.

LED wavelength	intensity	Protocol ‘A’	Protocol ‘B’	Protocol ‘C’
450nm	0.7	*	*	*
530nm	0.5		*	

624nm	0.8			*

Table 14

Duration of Measurements.

Date (Start)	Julian Day (Start)	Time (Start)	Julian Day (Stop)	Time (Stop)	Notes
30/11/18	334	1100	334	1115	
30/11/18	334	1149	335	0250	
1/12/18	335	1713	338	2255	Sample exchange time extended from 30 seconds to 60 seconds upon re-start
5/12/18	339	0030	339	1458	Stopped to clean
5/12/18	339	1904	342	0951	Change protocol
8/12/18	342	1012	342	1458	Run FLC long 6 minutes light steps x8
8/12/18	342	1500	345	1100	

Table 15

The gain was set using the instrument's auto-ranging mode. Data were stored on an external data logger and were downloaded for backup every 1-4 days throughout the cruise. The instrument's optics were cleaned whilst the download operation was being carried out. Data will be analysed using the instrument manufacturers software post – cruise, then files will be combined for archiving.

Blanks.

A series of MiliQ and Filtered (0.2 um) Sea Water (FSW) blanks were sampled as follows;

Date	Julian Day	Gain	File (MQ)
6/12/18	340	583	E01T01MilliQ
8/12/18	342	495	E01T02MilliQ

Table 16.1

Date	Julian Day	Gain	File (MQ)	File (FSW)
12/12/18	346	450	MQB_G450	FSWB_G450
12/12/18	346	500	MQB_G500	FSWB_G500
12/12/18	346	550-	MQB_G550	FSWB_G550

Table 16.2

References:

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Trace metal sampling

Antony Birchill (NOC)

Marine primary production drives carbon fixation in the ocean and is the base of the marine food web, it is therefore an important component of the Earth system (Falkowski and Raven, 2007). Iron (Fe) based proteins are required for numerous vital cellular processes (e.g. photosynthesis, respiration, nitrogen fixation), and Fe is therefore an essential nutrient for the growth of marine microbes (Twining and Baines, 2013, Tortell et al., 1996). The low availability of trace metals such as iron, and others such as manganese, can limit the growth of marine microbes (Moore et al., 2013). On DY096 we collected seawater and suspended particulate samples for trace metal analyses.

Water and suspended particulate sampling

Water column samples were collected using OTE-Flo bottles (10 L OTE bottles with external springs for trace metal work, mounted onto a 250m Kevlar wire fired using a messenger). All sample processing was conducted in a trace metal clean laboratory using clean handling techniques. Unfiltered water samples were collected for biological iron and manganese addition experiments, macronutrient analyses (frozen for future analyses) and total dissolvable metal analyses (acidified on-board for future analyses). Filtered samples were collected by passing water over 0.45 µm polyethersulpone membrane, the filtrate was collected to analysed dissolved trace metals (acidified on-board for future analyses) and the filter retained for particulate trace metal analyses (frozen for future analyses). Collected samples will be sent to Dr. Angela Milne and Prof. Simon Ussher at the University of Plymouth for analysis.

Due to bad weather and other operational activities taking priority, only 3 OTE-Flo deployments were conducted. The first OTE-Flo deployment was intended to soak the bottles to ensure that they were ‘trace metal clean’ for future deployments. Only 3 bottles successfully fired out of 6 deployed. Of these 3, one was later found to not be air tight when pressurised, which is needed to collect filtered samples. In addition, a deep (4500 m) profile of unfiltered water samples was collected from OTE-Niskin bottles deployed on a titanium frame and stainless steel conducting wire.

A summary of trace metal sampling is displayed in Table 17.

Table 17- Trace metal sampling on DY096.

Deployment Type	Date	Dissolved trace metals	Total dissolvable trace metals	Particulate Trace Metals	Nutrient addition Experiments
OTE-Flo	4/12/18	0	0	0	0
OTE-Flo	4/12/18	1	1		3
OTE-Niskin	10/12/18	0	12	0	0
OTE-Flo	11/12/18	2	3	2	0

Future improvements to trace metal sampling

In the clean sampling laboratory, there is a metal bar that runs in front of the sink, this is rusting and presents a contamination risk. Ideally this should be changed to a plastic material. The cupboard hinges are rusting and ideally should be replaced. The cladding on the ceiling is peeling off in places. The lighting system to indicate when the inner door whether open or closed does not work.

As part of the CUSTARD program a follow-on cruise to this location is scheduled for Dec 2019- Jan 2020. Trace metal work will be central to the scientific aims of this cruise. Therefore, it is essential that the Kevlar conducting wire is available for reliable OTE-Niskin bottle sampling and to allow full-ocean depth profiling.

References

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Satellite data

Filipa Carvalho (NOC)

Introduction

Satellite data were provided as a bulletin by the NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) on a daily basis.

Data provided included weekly composites and daily images (when coverage was available) of ocean colour, sea surface temperature (SST) and mean sea level anomaly (MSLA) in netcdf format and a png (low resolution thumbnail).

The following datasets were available:

- From VIIRS, MODIS and OLCI:
    - Chlorophyll daily (chlor_a)
    - Chlorophyll weekly (chlor_a).
- From VIIRS and MODIS
    - PAR
- From VIIRS
    - SPMI (suspended inorganic particulate matter)
- From MW+IR and MUR:
    - sea surface temperature daily
- MSLA product distributed by CMEMS.
    - Msla and geostrophic currents

Data availability during the cruise

Data was downloaded daily via FTP from:

ftp://neodaas7:quooKahpu9uch4Ahcahx@ftp.rsg.pml.ac.uk/mmmdd

where ‘mmm’ is the month (the first 3 letters) and ‘dd’ is the day (2 digits).

Data were plotted daily. PNGs were generated daily and available in the public drive from November 27th to December 10th. Data could be found on Public/DY096/satellite/. Plots are available for daily (currents, SST, SPMI, Chl) and weekly (SPMI, Chl) products. Plots for a larger area are also available as well as the composites created for the week-long stay at the mooring site (also in this report).

Matlab routines

Importing data

Several functions were written to import the netcdf files to a struct variable in Matlab:

- *satchlL2nc2struct.m*: for all ocean colour satellites
- *satmslanc2struct.m*: for mean sea level anomaly data (MSLA)
- *satmursstnc2struc.m*: for Sea Surface Temperature (SST) from MUR
- *satmwirsstnc2struct.m*: for SST from MWIR

PNG images were generated in Matlab using the following routines:

- *CUSTARD_satellite_image2png_standard.m*: creates png images of geostrophic currents (overlaid on top of bathymetry), total chlorophyll from all 3 satellites, MSLA, SST all with curly geostrophic current vectors overlaid on top of the pcolor map.
- *CUSTARD_stations.m*: adds mooring location
- *CUSTARD_satellite_averages.m*: plots shown in this section of the report

Satellite imagery for the three main stations

Figure 29: Mean Geostrophic Currents from Mean Sea Level Anomaly (MLSA)

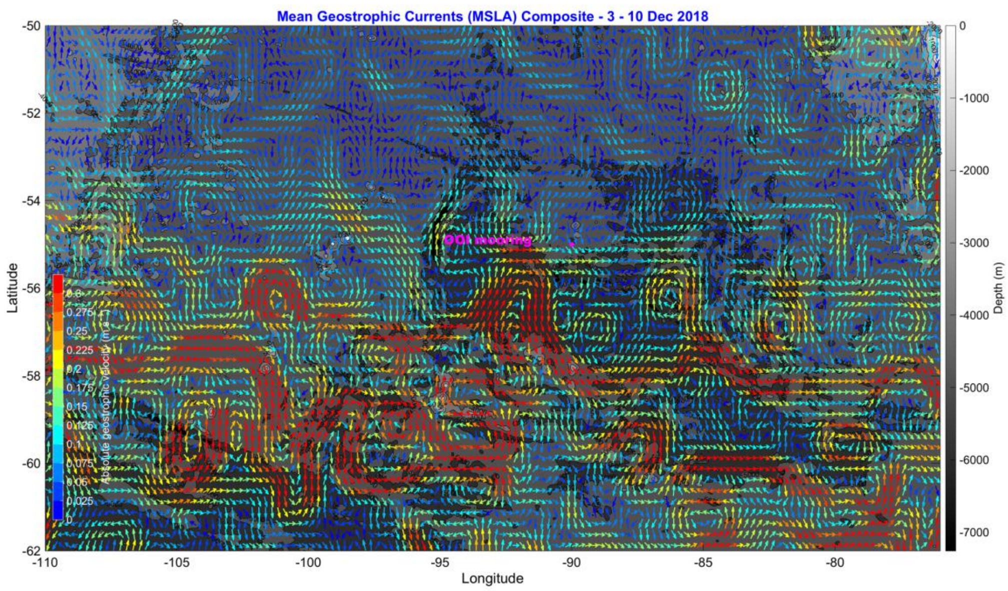


Figure 30: Sea Surface Temperature (SST) from MWIR with mean geostrophic currents overlaid

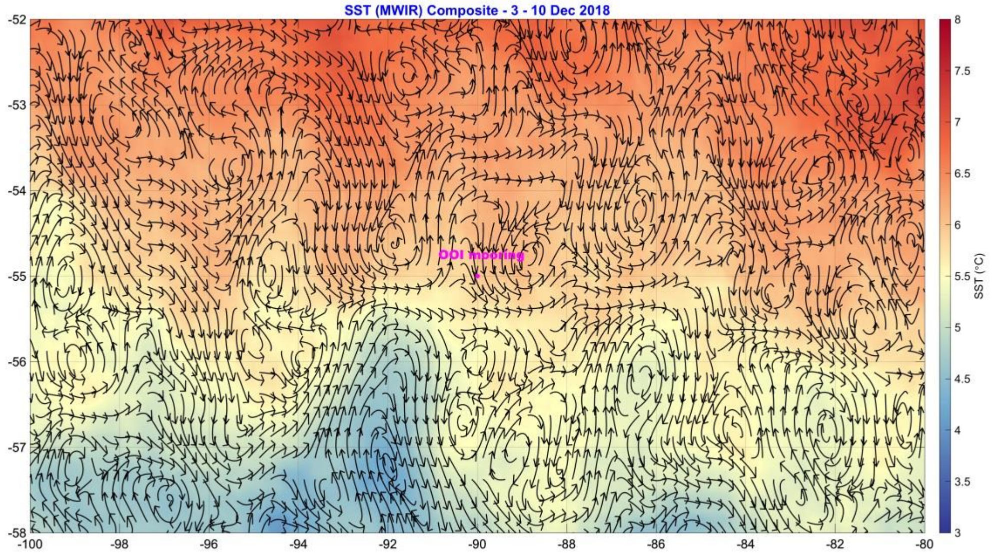


Figure 31: Total Chlorophyll from VIIRS

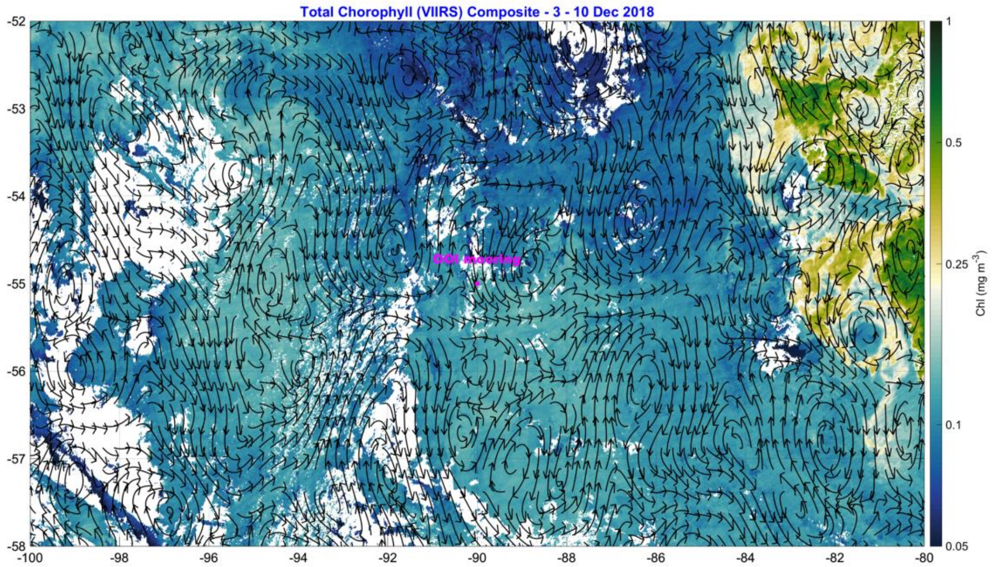
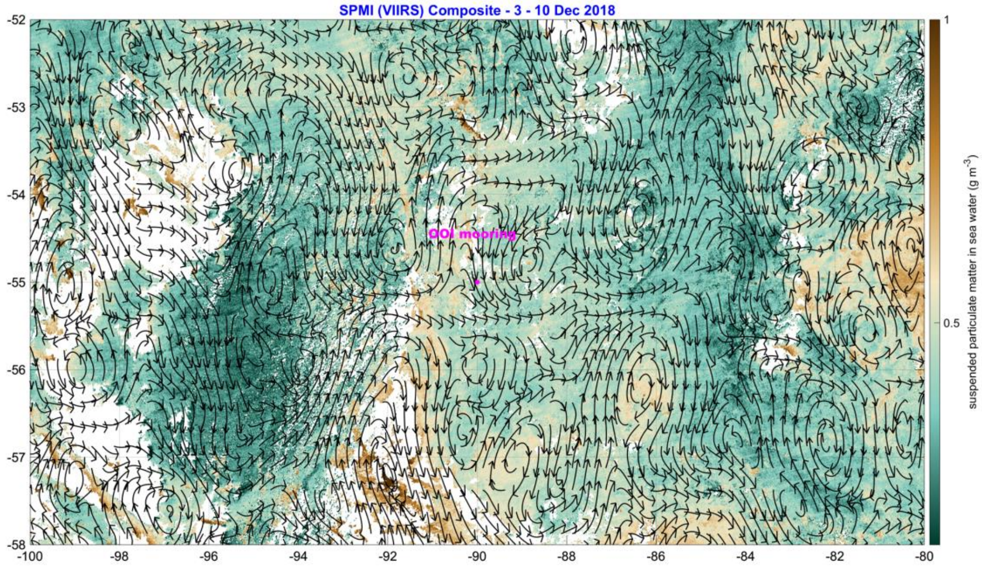


Figure 32: Total Suspended Particulate Matter (SPMI) from VIIRS



Overall, the current field didn't change much while we were on site. Currents around the mooring site were predominately towards the South, also seen by the gliders struggling to make it to the Northern Waypoint. Surface water was 6-6.5°C, also seen by the gliders, CTD and underway data. Chlorophyll was overall low at the mooring site, with concentrations yet to be confirmed by the in situ samples.

NMF Sensors and Moorings: CTD, OTE C-Free Water Samplers, SBE39 & Salinometry

Dougal Mountifield (NMF)

Summary

5 CTD casts were undertaken with an NMF 24-way titanium CTD frame with 10l OTE TMF water samplers. 12 water sampler bottles were used (#1 through #12). Cast CTD001 was for in-situ testing of 3 WHOI EdgeTech acoustic releases, with no bottles fitted for this cast. For subsequent casts, the bottles were mounted in even positions on the rosette to balance the frame and hence only even rosette positions are in the data files. To map from bottle number to carousel position, multiply the bottle number by two. All instrument serial numbers were checked and all channels of the 9plus underwater unit checked prior to completing the Sensor Information Sheets for DY096. Primary T, C & DO sensors and associated pump were mounted within the frame attached to the 9plus underwater unit. Secondary T & C sensors and associated pump were mounted on the vane. No LADCPs or FRR instruments were fitted to the CTD package.2 CTG 2π hemispherical PAR sensors with titanium housings were available for use. The calibrations for DWIRR and UWIRR were entered in the con file, but as all casts were deeper than the 500m pressure rating of the instruments, they were not fitted. The deepest cast was to 4,510m (CTD004). The shallowest was to 1,000m.

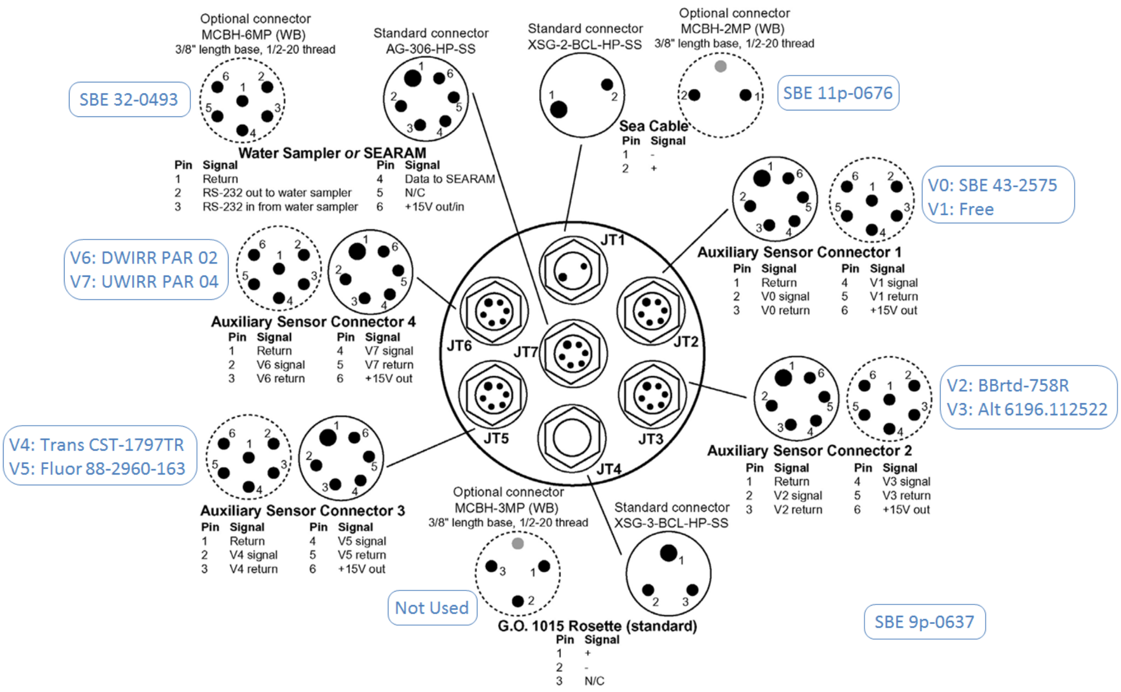
Titanium CTD Configuration

Instrument Package

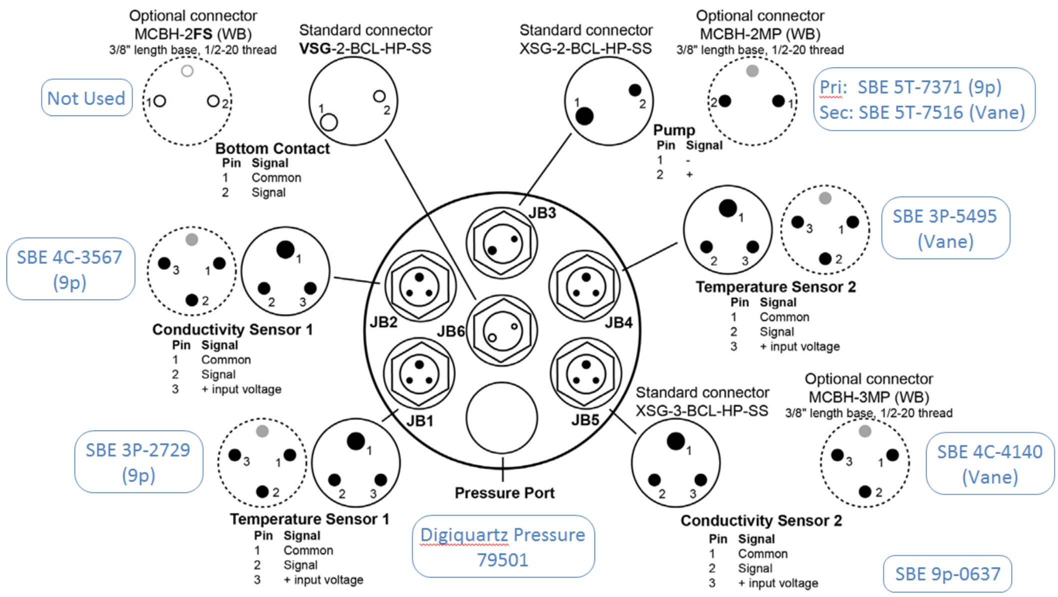
The following sensors were installed on the CTD frame:

CTD Underwater Unit	SBE 9plus	09p-0637
Primary Temperature Sensor	SBE 3P	3p-2729
Primary Conductivity Sensor	SBE 4C	4c-3567
Digiquartz Pressure sensor	Paroscientific	79501
Secondary Temperature Sensor	SBE 3P	3p-5495
Secondary Conductivity Sensor	SBE 4C	4c-4140
Primary Pump	SBE 5T	05-7371
Secondary Pump	SBE 5T	05-7516
Primary Dissolved Oxygen Sensor	SBE 43	43-2575
Altimeter	Tritech	6196.112522
Back Scattering Sensor	WETLabs BBrtd	758R
Transmissometer	WET Labs C-Star	1797TR
Fluorometer	CTG Aquatracka MKIII	88-2960-163
PAR Down-looking UWIRR	CTG 2PI PAR (Ti)	04
PAR Up-looking DWIRR	CTG 2PI PAR (Ti)	02

SBE 9plus CTD Top End Cap Configuration



SBE 9plus CTD Bottom End Cap Configuration



Seasave Configuration & Instrument Calibrations

The Seasave Instrument Configuration file used for all casts was DY096_0637_TI.xmlcon

```
Date: 11/28/2018
Instrument configuration file:
C:\Users\sandm\Documents\Cruises\DY096\Data\Seasave Setup
Files\DY096_0637_TI.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-2729
   Calibrated on : 23-AUG-2017
   G             : 4.35488024e-003
   H             : 6.41092983e-004
   I             : 2.28108724e-005
   J             : 2.13673442e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-3567
   Calibrated on : 28-APR-2017
```

G : -1.04226833e+001
H : 1.25432334e+000
I : -1.77315110e-003
J : 1.74324168e-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 : 16-SEP-2016
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 : 0.99978000
Offset : -1.84490
AD590M : 1.293660e-002
AD590B : -9.522570e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-5495
Calibrated on : 28-APR-2017
G : 4.38175515e-003
H : 6.30130857e-004
I : 1.97447367e-005
J : 1.46941938e-006
F0 : 1000.000

```
   Slope          : 1.00000000
   Offset         : 0.0000

5) Frequency 4, Conductivity, 2

   Serial number : 04C-4140
   Calibrated on : 28-APR-2017
   G             : -9.84050514e+000
   H             : 1.48515255e+000
   I             : -2.32402328e-003
   J             : 2.60869645e-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 : 43-2575
   Calibrated on : 24-AUG-2017
   Equation      : Sea-Bird
   Soc           : 4.36700e-001
   Offset        : -4.65800e-001
   A             : -4.36310e-003
   B             : 2.56280e-004
   C             : -3.68010e-006
   E             : 3.60000e-002
   Tau20         : 1.34000e+000
   D1            : 1.92634e-004
   D2            : -4.64803e-002
   H1            : -3.30000e-002
   H2            : 5.00000e+003
   H3            : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, OBS, WET Labs, ECO-BB
```

```
   Serial number : 758R
   Calibrated on : 16-AUG-2016
   ScaleFactor   : 0.004068
   Dark output   : 0.051000
```

9) A/D voltage 3, Altimeter

```
   Serial number : 6196-112522
   Calibrated on : 19-JUL-2013
   Scale factor  : 15.000
   Offset        : 0.000
```

10) A/D voltage 4, Transmissometer, WET Labs C-Star

```
    Serial number : CST-1797TR
    Calibrated on : 26-AUG-2016
    M             : 20.8712
    B             : -0.1273
    Path length   : 0.250
```

11) A/D voltage 5, Fluorometer, Chelsea Aqua 3

```
    Serial number : 88-2960-163
    Calibrated on : 16-AUG-2018
    VB            : 0.237930
    V1            : 2.021270
    Vacetone      : 0.441380
    Scale factor  : 1.000000
    Slope         : 1.000000
    Offset        : 0.000000
```

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

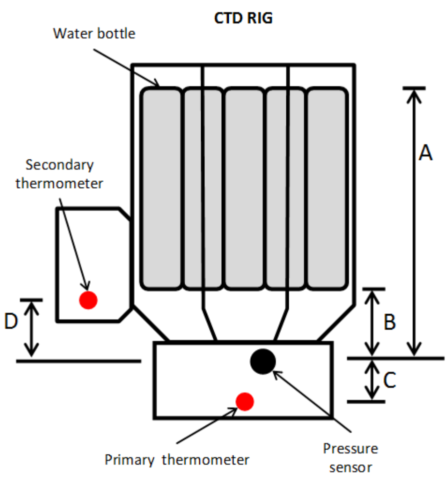
```
    Serial number        : 02
    Calibrated on        : 25-MAY-2016
    M                    : 0.47920900
```

```
    B                        : 1.05661800
    Calibration constant : 21740000000.00000000
    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         : 04
    Calibrated on         : 8-FEB-2017
    M                     : 0.44188100
    B                     : 1.59626600
    Calibration constant : 21740000000.00000000
    Conversion units      : umol photons/m^2/sec
    Multiplier            : 1.00000000
    Offset                : 0.00000000
Scan length                    : 45
```

Titanium CTD Frame Geometry



ID	Vertical distance from pressure sensor (m)
A	-1.18 Ti frame with 10L TMF samplers Above pressure sensor
B	-0.31 Ti frame with 10L TMF samplers Above pressure sensor
C**	0.07 Mounted on 9plus Below pressure sensor
D	-0.10 Mounted of vane Above pressure sensor

CTD Operations

The Titanium CTD was operated out of the Water Sampling Annex at the forward end of the hangar. It was deployed on the 11.43mm conducting CTD wire (CTD1 storage drum) using the starboard P-Frame.

Narrative

In order to maintain the cleanliness of the TMF water samplers, they were stored in the clean chemistry lab between casts. The following protocol was observed:

Pre-deployment

- CTD moved from water sampling annex to deck using beam hoist.
- CTD termination and sea-cable connected and slack taken up as required
- Winch joystick disabled
- Both rosette adapter plates wiped down with blue-roll
- Bottles transferred from clean chemistry lab to rosette one at a time maintaining the lobby air lock
- Bottles secured on frame with safety line
- 11p powered up, and logging started on Seasave
- Bottles cocked and protective gloves removed from taps
- Winch joystick enabled
- CTD deployed using tag-lines

Post-deployment

- CTD recovered using tag-lines
- CTD landed on deck, and pendulum roller luffed out slightly to remove tension from CTD wire
- Winch joystick disabled
- Logging stopped on Seasave and 11p powered down
- Safety line removed from bottles. The taps were not protected with gloves on recovery
- Bottles transferred from CTD rosette to clean chemistry lab one at a time maintaining the lobby air lock
- Seacable and CTD termination disconnected, and termination secured to the side of the annex door
- CTD moved from deck to water sampling annex using beam hoist

Once moved to the annex, the TC sensor ducts were flushed with milli-Q and drained three times before installation of caps on the temperature duct inlet and pump exhaust of both sensor pairs. The carousel latch mechanisms were then rinsed with milli-Q to prevent salt-crystals forming. Also the optical faces of the back-scatter, fluorescence and beam transmission instruments were rinsed with milli-Q. Occasionally the whole CTD package was rinsed with fresh water. The TC-ducts were not cleaned during the cruise with dilute bleach or Triton-X solutions. No drift or shift was observed in the differences between the Temperature or Conductivity sensor pairs.

The CTD was only worked within altimeter range on one cast (CT004). The normal range of 10m from bottom for maximum wire out was used. Both EA640 and EM122 centre beam indicated a water depth of ~4630m. The EM122 did not have a local full depth speed of sound profile. Carter's tables indicated an estimated depth of 4600m. An initial call for winch wire out of 4500m was made. Altimeter contact (100m range) was established with ~4410m of wire of wire out. This was monitored as the winch driver continued to veer to 4500m. A good stable minimum altimeter range of 20m was observed. The winch was then veered another 10m to place the CTD 10m above bottom. Shortly after the veer was started, altimeter contact was lost. All CTD instrumentation was monitored very closely as the max wire out of 4510m was approached. No good altimeter return was obtained during the bottle firing interval at 4510m. Shortly after the haul to 4000m was commenced, the altimeter obtained good returns at ~20m above bottom.

After a protracted period of poor weather, the sea state produced marginal operating conditions for CTD003 (Julian day 343) and it is expected that data quality is significantly reduced due to vessel and package motion.

The science party sampled TMF water samplers for salinity samples in the clean chemistry lab.

Technical Issues & Instrument Changes

There were no major technical issues with the CTD suite during the cruise. However, the WETLabs C-Star Transmissometer s/n CST-1797TR exhibited poor stability and was replaced with a spare instrument s/n CST-1837TR on Julian Day 344 between casts 003t and 004t. Notably the deck air reading (V_{air} 4.9096V) taken at the start of the cruise was significantly (~100mV) higher than the manufacturers calibration (V_{air} 4.812V).

Deck dark and air voltage readings were taken for CST-1837TR with clean lenses. V_{dark} was 0.0073V and V_{air} was 4.8022V. The instrument was allowed to warm up for ~30 mins prior to taking the deck voltage readings. A new con file was created with the calibration for CST-1837TR

(DY096_0637_TI_new_trans.xmlcon), and dark and air readings confirmed in Seasave as 0% and 102% beam transmission respectively. The deck air reading was approximately 30mV higher than the calibration sheet value (V_{air} 4.789V).

```
10) A/D voltage 4, Transmissometer, WET Labs C-Star

    Serial number : CST-1837TR
    Calibrated on : 08-NOV-2017
    M             : 21.2420
    B             : -0.1551
    Path length   : 0.250
```

3 full sets of instruments were available for use on-board.

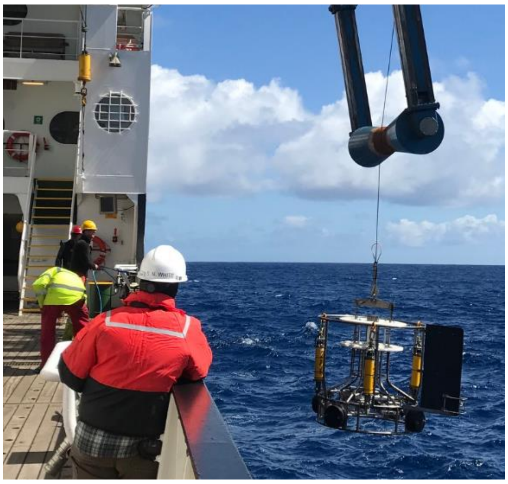
Cast Summary

Cast	**Station**	**Date**	**Julian Day**	**Max Wire Out/m**	**Notes**
001t	RELEASE_TEST	3/12/18	337	1500	3 x WHOI EdgeTech Acoustic Releases No Bottles fitted to CTD frame.
002t	OOI	4/12/18	338	1000	TMF Niskins #1-#12 fitted in even rosette positions. Odd Positions not fired.
003t	OOI	9/12/18	343	1000	TMF Niskins #1-#12 fitted in even rosette positions. Odd Positions not fired. Marginal operating conditions.

004t	OOI	10/12/18	344	4510	TMF Niskins #1-#12 fitted in even rosette positions. Odd Positions not fired.
005t	OOI	11/12/18	345	1000	TMF Niskins #1-#12 fitted in even rosette positions. Odd Positions not fired.

Total Veer	**9,010**	**metres**
Total Haul	**9,010**	**metres**
Total Wire Distance	**18,020**	**metres**
Max Wire Out	**4,510**	**Metres**

Note: Station ID for casts 002-004 is letters OOI (Ocean Observatories Initiative), not numerals



On the transit to station for CTD001t, the user input header form was set up for the cast. However, this was not updated once on station. Hence the user input header form for cast CTD001t has the incorrect Time, Latitude, Longitude and Depth (uncorr m). Please refer to the NMEA position and time in the header and the CTD log-sheet for water depth for this deployment.

Data Processing

Standard Sea-Bird processing of the raw data was completed using Sea-Bird Data Processing software. The full BODC "Recommended steps for basic processing of SBE-911 CTD data." Version 1.0 October 2010 were followed for all casts. This reference document can be found in the BODC Documents folder.

The processing order used was:

- Data Conversion (including sound speed)
  DY096_CTDxxxt.cnv & DY096_CTDxxxt.ros
- Data Conversion of raw frequency and voltages
  DY096_CTDxxxt_RAW.cnv
- Bottle Summary to create .btl file -2.5 to +2.5 seconds around bottle closure event
  DY096_CTDxxxt.btl
- Bottle Summary to create _oxy.btl file with averaged oxygen concentration included
  DY096_CTDxxxt_oxy.btl
- Seaplot Pressure vs Time to confirm no spikes (wild edit did not need to be used)
  DY096_CTDxxxt_Pressure_Time_Series.jpg
- Filter 0.15s on pressure only
  DY096_CTDxxxt_FilterP.cnv
- Seaplot Pressure vs Time on filtered pressure
  DY096_CTDxxxt_FilterP_Pressure_Time_Series.jpg
- AlignCTD 6s on oxygen channels only
  DY096_CTDxxxt_FilterP_AlignDO.cnv
- Seaplot Primary Oxygen Profile, up and down cast, to confirm alignment
  DY096_CTDxxxt_FilterP_AlignDO_Oxygen_Profile.jpg
- CellTM
  DY096_CTDxxxt_FilterP_AlignDO_CellTM.cnv
- Loop Edit velocity limit=0 with remove surface soak
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit.cnv
- Seaplot Pressure vs Time on loop-edited pressure
  DY096_CTDxxxt_ FilterP_AlignDO_CellTM_LoopEdit_Pressure_Time_Series.jpg
- Derive depth salt-water, salinities, oxygen (umol/l) and density (sigma-theta)
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive.cnv
- Strip original variables that have been re-calculated with derive
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip.cnv

- Seaplot Depth Saltwater vs Time from stripped derived file
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_Derived_DSW_Time_Series.jpg
- Seaplot Primary Oxygen Saturation and Concentration from stripped derived file
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_Oxygen_Profile.jpg
- Bin Average in depth down cast only 5m bins
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_5mBins.cnv
- Bin Average in depth, down-cast only 25m bins
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_25mBins.cnv
- Bin Average in time down and upcast 0.5s (2Hz)
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_2Hz.cnv
- ASCII out to create .asc files
  DY096_CTDxxxt_RAW_24Hz.asc
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_24Hz.asc
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_2Hz.asc
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_5mBins.asc
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_25mBins.asc
  DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_25mBins_SV.asc

Separate header files were output at each stage of processing to provide processing meta-data including parameters applied, software versions and processing order.

Data Conversion and ASCII out was run on each cast to extract uncalibrated raw frequencies (F_0-F_5) and voltages (V_0-V_7) for all sensor channels. These files are named in the form:

DY096_CTDxxxt_RAW.cnv and DY096_CTDxxxt_RAW_24Hz.asc

Sound speed (Delgrosso algorithm for deep water) tabulated with Depth Saltwater (metres) in 25m bins was output with ASCII out as separate files for uploading to the EM122 swath system. These files are named in the form:

DY096_CTDxxxt_FilterP_AlignDO_CellTM_LoopEdit_Derive_Strip_25mBins_SV.asc

OTE C-Free Water Samplers

12 OTE 10l C-Free Water Samplers were supplied. Only 9 of these (#2, #5, #6, #7, #8, #9, #10, #11, #12) had suitable mounting blocks (TMF mount) to rack in the clean chemistry lab. The other 3 bottles (#1, #3, #4) had mounting blocks to suit the pinned recess of the aluminium rosette adapter plates fitted to the stainless steel CTD frame (conventional mount).

One of the pin-mount bottles suffered both cams exploding during cocking. The cams split cleanly in half. It is likely that these were already damaged as no other problems were encountered. The damaged cams were glued together with PVC cement as emergency spares, as there was only one spare unit in the spares kit.

One bottle had a boilie bar that was not square to the pressure release valve face. This caused one boilie to run along the bar and release. It was not possible to place the boilie in a stable position. The boilie bar was jacked out with fox-wedges and the hole depths measured. One hole was too shallow and was drilled 3mm deeper. The boilie bar was then pressed back in. An improvement was seen in the stability of the boilie in the cocked position, but the bar is still not quite square. We suspect that there is a burr in the hole that is preventing the bar from being pressed home.

Three C-Free deployments were completed:

- A string of 9 bottles to fill bottles for 24hr soaking to condition them. The deepest bottle was placed 40m above the SAPs ballast weight, no SBE 39plus was fitted due to limited time. The bottles were clamped to the rope with 20m separations. During the installation of the messenger below the 7th bottle (#10), the whole push rod lifted releasing the (closing) cocking string. When attempting to re-install the cocking string on the pin, the messenger was accidentally released triggering the whole string. 6 bottles were in the water (#2,5,6,7,8,9) and the top bottle (#9) would have been at 15m depth due to the rail height (estimate 5m above waterline). Hence bottle depths would have been 15m (#9), 35m (#8), 55m (#7), 75m (#6), 95m (#5) and 105m (#2). The deployment was aborted and the bottles recovered. The 7th bottle (#10) was removed from the rope without going in the water. Upon recovery, bottle #2 did not fully close at the top, #8 had a leaking tap.

- Three separate deployments of one bottle each time to 20m depth (bottles #5, #6 and #7) for incubation experiment. Again the bottle was clamped on the rope with 40m separation from the SAPs ballast weight. Again the SBE 39plus was not used due to time constraints. There were no problems with deployment or recovery and all closed well.

- A string of 3 bottles to 20m, 100m and 200m target depths (bottles #5, #6 and #7). For this final deployment, the SBE 39plus was fitted 20m above the SAP ballast weight. The bottom bottle was clamped to the rope 20m above the SBE 39 plus, then separations of 100m and 80m for the second and third bottles. Finally a further 20m of rope was paid out. No problems were encountered with deployment or recovery. After this deployment, the bottles were gas pressurised in the clean chemistry lab for the first time. Bottle #7 would not seal. The top ball valve has excessive play causing it to move away from the inner 'o'-ring seal when pressurised. A review of the SBE 39plus data indicated that the whole string was deployed 10m too deep. It is possible that there was a mark missing from the rope, as all the separations are correct. Hence actual deployment depths are 30m (#7), 110m (#6) and 210m (#5).

To control cleanliness, all bottles were prepared and cocked by scientists working in the clean chemistry lab.

Sea-Bird SBE 39plus Temperature & Pressure Loggers

Four Sea-Bird SBE 39plus Temperature and Pressure Loggers were available for use (S/N's: 8511-8514)

S/N 8511 was allocated to record the deployment depth of the OTE C-free Water Samplers, by clamping to the 6mm diameter 250m length Dyneema rope 20m above the ballast weight. The rope diameter was built up to suit the clamp ID of 10mm using Scotch 23 and Scotch 33 tape.

S/N 8512 was allocated deployed on the Red Camera Frame. However, due to time constraints, the Red Camera Frame was not deployed.

S/N's 8513 & 8514 were not used.

A set of 4 off 3V Lithium batteries was installed in S/N 8511 and 8512 during passage at the start of the cruise.

The sample interval was set to 1 sec.

The serial sync mode was disabled as this was not used.

The real-time output was enabled to confirm logging pre and post-deployment.

The instruments were configured to record temperature and pressure.

Due to time constraints, the SBE39plus was only used on the last OTE C-free deployment.

After configuration, terminal captures were obtained of each instruments response to the DS (Display Settings) and DC (Display Calibrations) and saved as files in each instrument folder for reference.

Data was downloaded using Sea-term V2 to obtain the raw .xml, converted .cnv and ASCII .asc data files. Sea-term V2 was configured to create the files with pressure converted to depth salt water. The deployment latitude was manually entered the depth conversion.

Sea-Bird SBE 39plus Deployment Summary

Only a single SBE 39plus deployment was completed with the OTE C-Free Water Samplers.

The SBE 39plus was clamped to the dyneema rope 20m above the SAP ballast weight. Three OTE C-free samplers were clamped to the rope:

20m (two marks) above SBE 39plus (target depth 200m)

120m (twelve marks) above SBE 39plus (target depth 100m)

200m (20 marks above the SBE 39plus (target depth 20m)

The separations between the bottles in the SBE 39plus data-file are correct. However, the maximum depth in the SBE39plus record was 230m. This implies that the bottles were triggered 10m deeper than target (210, 110 and 30m). We suspect that there may be a mark missing on the rope as 5 people were counting marks and in all other respects the deployment was as planned.

The RED Camera Frame was not deployed.

Salinometry

After each CTD cast, The OTE TMF 10l water sampler bottles were transferred from the CTD rosette to the clean chemistry lab. 48 discrete salinity samples were taken from the OTE TMF bottles by the scientists in the clean chemistry lab. One sample was taken from each of the 12 TMF bottles for casts CTD002t – CTD005t. A total of 2 crates (#14 and #15) of salinity samples were taken from the CTD (24 bottles per crate). The CTD samples were taken using salinity sample bottles 356-403.

In addition 39 samples were taken from the underway pumped system by the vessel TSG. These samples were also taken by the science party using 2 crates (#TSG 012 and #TSG004). The TSG samples were taken using salinity sample bottles 224-227 and 097-111.

All samples were analysed on Guildline Autosal 8400B S/N 68426 by Dougal Mountifield (NMF). During commissioning the stirrer of this unit would not start. The unit was withdrawn from its housing and the stirrer was rotated by hand. The shaft bushing was initially marginally less free than usual, but quickly freed up, and subsequently worked smoothly. The machine was operated at 21°C bath temperature with an ambient temperature range of 19.1°C – 19.8°C, yielding an elevation of 1-2°C above ambient.

Guildline Autosal 8400B S/N 65764 was also commissioned and was available as a spare unit. This unit has an air-leak in the pickup tube which requires attention.

The Autosal was standardised using IAPSO Standard Seawater batch P161 (K15=0.99987, 2xK15=1.99974, 34.995 PSU). The salinometers were installed and powered up on 22 November and an initial standardisation check was completed on 23 November. The main salinometer was standardised on 12 December prior to analysing the first crate. During standardisation the PC software was observed to be jumping values (missing a bit). This was traced to a faulty BCD interface ribbon. Once resolved, the machine was trimmed to a zero offset with the standardisation pot. The machine was not re-standardised during the cruise, and exhibited excellent stability.

The cell was flushed 3 times, with the 4th fill being the first sample measurement. The software standard deviation limit was set at 0.00002 in double conductivity ratio. A measurement period of ~10 seconds is used for each averaged measurement. This is then repeated a further 2 times with the cell flushed and filled with new sample each time. Finally the three measurements (4th, 5th and 6th cell fill) are averaged for the analysed value. If the standard deviation any of the measurements exceeds the limit, it is rejected and another measurement is taken with a further cell flush. The three double conductivity ratio values (10 sec averages), and the average of the averages are recorded in the data file. The machine offset in double conductivity ratio at standardisation is then corrected for before the salinity is calculated and recorded in the file.

The convention used was to name CTD samples as ‘CTD’ and underway TSG as ‘TSG’ with the bottle number of the salinity sample bottle for each sample. The standard that was run as a control at the start and end of each crate were named ‘STD’ with bottle number 999 for clarity. The offset between this value and the P161 label value must be applied to all the salinity values in the data file in post-processing.

A data file from the analysis software was supplied for each crate as a tab separated text file that can be opened as an Excel spreadsheet. All measurements were also logged manually as double conductivity ratio on paper log-sheets. These log-sheets were also supplied along with scans in pdf format.

A data file from the analysis software was supplied for each crate as an Excel spreadsheet. All measurements were also logged manually on paper log-sheets. These log-sheets were also supplied along with scans in pdf format.

Software Used

All software was updated to the latest versions during DY096 mobilisation.

Sea-Bird SeaTerm V2 2.7.0.108 (SBE 39plus operation and data upload)

Sea-Bird Seasave 7.26.7.110 (SBE 9/11plus data acquisition)

Sea-Bird SBE Data Processing 7.26.7.118 (SBE 9/11plus data processing)

Notepad ++ 7.6 (Datafile and Header viewing)

Moxa PComm Terminal Emulator 2.10 (Serial port testing)

Scientific Ship Systems

Zoltan Nemeth, Hatim Shah (NMF)

Surface, meteorology and labs

Surfmet and Thermosalinograph (SBE45, SBE38)

Non Toxic ON: 2018.11.30 09:00UTC the non toxic was switched off later before we crossed the international border again (ship turned back to engine service) at: 2018.12.01 03:00UTC.

Non Toxic ON again: 2018.12.02 JD336 18:00UTC.

Non Toxic OFF end of the cruise (crossing international border): 2018.12.12 JD 346 12:52UTC.

Data Gaps:

Surfmet:

time gap : 18 333 08:47:20 to 18 333 08:47:52 (32 s)

time gap : 18 333 08:51:31 to 18 333 08:52:10 (39 s)

time gap : 18 333 13:56:22 to 18 333 13:58:40 (2.3 mins)

time gap : 18 333 14:34:18 to 18 333 14:34:56 (38 s)

time gap : 18 338 03:30:13 to 18 338 04:53:32 (83.3 mins)

time gap : 18 339 03:30:08 to 18 339 03:34:20 (4.2 mins)

time gap : 18 343 10:09:48 to 18 343 10:10:42 (54 s)

time gap : 18 343 10:16:12 to 18 343 10:16:44 (32 s)

time gap : 18 343 10:30:16 to 18 343 10:31:42 (86 s)

Data available

Calibration Sheets in: Ship_Fitted_Scientific_System/Surfmet/Surfmet: This directory should contain the current datasheet for each of the Surfmet sensors used on this cruise and also for any other instruments used by the Science Systems Technician, e.g. SVP.

Data in: \Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\SURFMETV3 in NetCDF

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\TSG (SBE45, SBE38 NetCDF)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\SURF1(pseudo NMEA format.)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\SBE45(SBE45, SBE38 Pseudo NMEA format)

\Ship_Fitted_Scientific_Systems\RVDAS\DY096_NMF_SURFMET_yyyy_mm_dd.nmea.txt timestamped RAW NMEA Format

\Ship_Fitted_Scientific_Systems\RVDAS\DY096_SBE45_TSG_yyyy_mm_dd.nmea.txt timestamped RAW NMEA Format

Data description document in:

Cruise_Documentation\Data_Description_Documents\Surfmet

Data Description_v2_1DY.docx and pdf version.

Cruise_Documentation\Data_Description_Documents\SBE45

Data Description.docx

Ocean Waves WaMoS II

Testing started before we left the berth in Punta Arenas. Data recording started after we crossed the international border 2018/12/02.

Field #	Description	Format	Unit	Chars.
1	Header	$PWAM	n/a	5
2	Significant wave height	9999.9	m	6
3	Tm2 period	9999.9	s	6
4	Peak direction	9999.9	deg	6
5	Peak period	9999.9	s	6
6	Peak wave length	9999.9	m	6
7	1st peak direction	9999.9	deg	6
8	1st peak period	9999.9	s	6
9	1st peak wave length	9999.9	m	6
10	2nd peak direction	9999.9	deg	6
11	2nd peak period	9999.9	s	6
12	2nd peak wave length	9999.9	m	6
13	Current direction	9999.9	deg	6
14	Current speed	9999.9	m/s	6
15	Timestamp	yyyy-MM-dd hh:mm:ss	n/a	19

Total length of sentence including separating commas 121

Example:

$PWAM,0005.3,0006.9,0015.0,0008.1,0101.0,0006.0,0008.0,0100.0,-009.0,-009.0,-009.0,0119.0,
0001.3,2000-12-05 17:20:00*3A

The numbers in the fields are separated by commas and have this order, for instance:

Hs: 5.3 m

TM2: 6.9 s

PDir: 15 deg

TP: 8.1 s

LP: 101 m

DP1: 6 deg

TP1: 8.0 s

LP1: 100 m

DP2: -9 deg

TP2: -9.0 s

LP2: -9 m

Current Dir: 119 deg

Current Speed: 1.3 m/s

Data in:

\Ship_Fitted_Scientific_Systems\WaMoS\WAMOSDATA

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\WAVERADAR (NetCDF format)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\WAMOS (Pseudo NMEA format)

Data description document in: \Cruise_Documentation\Data_Description_Documents\???

Equipment Documentation in: \Equipment_Documentation\WaMoS \WaMoSII_geninfo_2010.pdf

Live PCO2

Tested.

Acoustics and deployed instruments

Kongsberg EA640 10&12kHz single beam

System run during cruise:	✓
Drop keel transducer cleaned pre-cruise:	×
Drop keel transducer cleaned post-cruise:	×
System fully serviceable:	✓

Both the 10 kHz and 12 kHz were used. 1500m/s used for sound speed.

12kHz used on passive mode, 10kHz used on active mode.

The data collection stopped during mooring release tests and triangulation.

Gaps in data (due to acoustic silence, triangulation and bad weather)

time gap : 18 330 23:37:33 to 18 331 00:01:16 (23.7 mins)

time gap : 18 331 19:39:20 to 18 332 08:32:22 (12.9 hrs)

time gap : 18 337 17:10:23 to 18 337 17:24:25 (14.0 mins)

time gap : 18 342 11:38:27 to 18 342 14:43:58 (3.1 hrs)

time gap : 18 343 16:45:56 to 18 343 17:05:54 (20.0 mins)

time gap : 18 344 10:02:04 to 18 344 10:14:07 (12.1 mins)

time gap : 18 344 17:41:45 to 18 344 18:00:47 (19.0 mins)

Data available:

Calibration Sheets SVP and SV in: Ship_Fitted_Scientific_System/Surfmet/Surfmet: This directory should contain the current datasheet for each of the Surfmet sensors used on this cruise and also for any other instruments used by the Science Systems Technician, eg. Micro-X SV sensor or Midas SVP.

Data in:

\Ship_Fitted_Scientific_Systems\Acoustics\EA640 (xyz and raw Kongsberg Format: Version="17.2.0.0" FileFormatVersion="1.21")

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\EA600 (EA640 WaterDepth)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\EA600 (ASCII Pseudo NMEA Depth)

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_EA640_DEPTH_yyyy_mm_dd.nmea.txt (Timestamped RAW NMEA – Talker ID SD = 10kHz, II=12kHz)

2018/12/03 00:00:10.046,$SDDBS,14174.68,f,4320.44,M,2362.45,F*39

$SDDPT,4313.27,7.17*66

$IIDBS,0.00,f,0.00,M,0.00,F*26

$IIDBT

2018/12/03 00:00:10.174,,-22.61,f,-6.89,M,-3.77,F*3F

$IIDPT,-6.89,6.89*6D

Data description document in:

\Cruise_Documentation\Data_Description_Documents\EA640 Data Description.docx

Equipment Documentation in:

\Equipment_Documentation\Acoustics\ Kongsberg_EA640_10khz_&_12kHz_data_sheet_lr.pdf

Kongsberg EM122 deep water multi beam (12kHz)

System run during cruise:	✓
PC filters cleaned post-cruise:	✓
BIST tests passed and saved:	✓
SV sensor cleaned pre-cruise:	✓
SV sensor cleaned post-cruise:	×
System fully serviceable:	✓

System was BIST tested before departure, no fault found. Ping test was unsatisfied because of the shallow berth, but later was OK. Data collected after we crossed the international border and no marine mammals were closer than 500m to the ship.

Data Processed with MB-System v5.5.2315

sensor	surveyname	start	end	lines	GPS	MRU	cellsize	remarks
EM122	DY096-001	2018/11/30 09:14:17	2018/12/01 04:50:35	39	PosMV	PosMV	150m	First survey
EM122	Dy096-002	2018/12/02 17:04:40	2018/12/04 20:02:04	107	PosMV	PosMV	150m	

EM122	DY096-003	2018/12/04 20:25:42	2018/12/05 19:48:33	49	PosMV	PosMV	150m	
EM122	DY096-004	2018/12/06 12:08:36	2018/12/12 12:54:26	287	PosMV	PosMV	150m	Last survey

SVP profiles

Date	SurveyName	LineNo	Source
2018/12/03 20:32	DY096-002	61	CTD001
2018/12/10 07:24	DY096-004	179	CTD004

Gaps in EM122 data (due to acoustic silence, triangulation and bad weather)
time gap : 18 337 17:10:35 to 18 337 17:25:25 (14.8 mins)
time gap : 18 339 19:48:15 to 18 339 19:58:59 (10.7 mins)
time gap : 18 342 01:13:59 to 18 342 01:27:56 (13.9 mins)
time gap : 18 342 02:36:16 to 18 342 02:53:23 (17.1 mins)
time gap : 18 342 04:39:41 to 18 342 04:55:06 (15.4 mins)
time gap : 18 342 06:02:04 to 18 342 06:20:51 (18.8 mins)
time gap : 18 342 11:37:35 to 18 342 14:44:55 (3.1 hrs)
time gap : 18 342 17:07:43 to 18 342 17:20:01 (12.3 mins)
time gap : 18 342 19:30:30 to 18 342 19:42:23 (11.9 mins)
time gap : 18 342 20:04:39 to 18 342 20:16:56 (12.3 mins)
time gap : 18 342 20:53:10 to 18 342 21:04:31 (11.3 mins)
time gap : 18 343 16:44:47 to 18 343 17:07:48 (23.0 mins)
time gap : 18 344 10:00:23 to 18 344 10:14:35 (14.2 mins)
time gap : 18 344 17:41:08 to 18 344 18:01:27 (20.3 mins)

Data available:

Calibration Sheets SVP and SV in: Ship_Fitted_Scientific_System/Surfmet/Surfmet: This directory should contain the current datasheet for each of the Surfmet sensors used on this cruise and also for any other instruments used by the Science Systems Technician, eg. Micro-X SV sensor or Midas SVP.

Data in:

\Ship_Fitted_Scientific_Systems\Acoustics\EM122.

\Ship_Fitted_Scientific_Systems\Acoustics\MB-System_Processed_Multibeam_Data

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\DEPTH (NetCDF CentreBeam Depth)

Y:\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\EM1_1 (ASCII Pseudo NMEA CentreBeam Depth)

Data description document in:

Y:\Cruise_Documentation\Data_Description_Documents\ EM122 Data Description.docx.

Equipment Documentation in:

\Equipment_Documentation\Acoustics\ Kongsberg_EM122_12kHz_product_specification.pdf

Kongsberg EM710 shallow water multi beam (60-100kHz)

System run during cruise:	✗
PC filters cleaned post-cruise:	✓
BIST tests passed and saved:	✓
SV sensor cleaned pre-cruise:	✓
SV sensor cleaned post-cruise:	✗
System fully serviceable:	✓

Tested, but no data logged.

Kongsberg SBP120 sub-bottom profiler

System run during cruise:	✓
PC filters cleaned post-cruise:	✓
BIST tests passed and saved:	✓
System fully serviceable:	✓

Not used.

Kongsberg EK60 fish finder

System run during cruise:	✓
System fully serviceable:	✓

Data collection started at 2018.12.02@17:11UTC the echograms in surface mode range set accordingly.

Software crashed:

2018.12.07 around 09UTC restarted at 11:40UTC.

Raw data file name prefix: DY091R_

70kHz and 120kHz running in passive mod avoid to interfere with 75kHz and 150kHz ADCP's.

Channel	Mode	Pulse duration(µs)	Sample Interval(µs)	Bandwith(Hz)	Power (W)	Depth(m)
GPT 18kHz ES18-11	Active	1024	256	1574	1400	6.6
GPT 38kHz ES38B	Active	1024	256	2425	1000	6.6
GPT 70kHz ES70-7C	Passive	1024	256	2859	750	6.6
GPT 120kHz ES120-7C	Passive	1024	256	3026	250	6.6
GPT 200kHz ES200-7C	Active	1024	256	3088	150	6.6
GPT 333kHz ES333-7C	Active	1024	256	3112	50	6.6

Configuration saved: DY096-config

RAW Data in:
\Ship_Fitted_Scientific_Systems\Acoustics\EK60
Equipment Documentation in:
\Equipment_Documentation\Acoustics\ Kongsberg_SIMRAD_EK60_brochure_english_reduced.pdf

Kongsberg K-Sync

System run during cruise:	✓
System fully serviceable:	✓

Ksync used for EA640, *EM710*, EM122, ADCP75, ADCP150, EK60 and SBP120.

Unit: 192.168.10.53; System Sound Speed: 1500m/s; Current Config File: DY096; 1 group

Echo Sounder	Trigger Mode	Special Trigger Settings
EA640	Calculated	Maximize Pinging
EM122	Calculated	Maximize Pinging
EM710 Disabled	N/A	N/A
SBP120	External Input	EM122 dependant
OS150	Fixed (3000ms)	Maximize Pinging
OS75	Fixed (3000ms)	Maximize Pinging
EK60	Fixed (3000ms)	Maximize Pinging

Equipment Documentation in:

\Equipment_Documentation\Acoustics\ K-Sync_Unit_Datasheet.pdf

Sound velocity profiler

System run during cruise:	✓
System fully serviceable:	✓

Midas SVP sn. 22356. Remaining battery voltage within functional parameters.
Main: 11.916V, Lithium: 3.020
Midas SVP sn. 41603. Remaining battery voltage within functional parameters.
Main: 11.674V, Lithium: 3.030

75kHz and 150kHz hull-mounted ADCP

We used the DY090 setup paramaters both ADCP's triggered with K-Sync. Because of the deep water system ran with Narrowband on No Bottom Tracking Mode.

OS150

Data Structure BB/WH/OS
Ensemble Length 1268 bytes
Data Types 0000 0080 0100 0200 0300 0400 3000 30E0 2000
Firmware Version 23.19

System Frequency 153.6 kHz
Convex
Sensor Configuration #1
Transducer Head Attached TRUE
Orientation DOWN
Beam Angle 30 Degrees
Transducer Unknown

Real Data

False Target(WA) 255 counts
Band Width (WB) 0
Cor. Thres. (WC) 0 counts
Err Thres. (WE) 1000 mm/s
Blank (WF) 4.00 m
Min PGood (WG) 0
Ref Layer (WL) 1, 1 first bin, last bin
Mode (WM) 10
Bins (WN) 48
Pings/Ens (WP) 38
Bin Size (WS) 8.00 m

Head Align (EA) -45.11 degrees
Head Bias (EB) 0.00 degrees
Coord Xform (EX) 11111 Earth Coordinates Using Tilts, 3 Beam Solutions, and Bin Mapping
Sens Source (EZ) 1011101 cdhprst
Sens Avail 0000001 cdhprst

Time/Ping (TP) 00:01.00

Hardware 4 Beams

Lag 11 elements Code Reps. 0 Lag Length 0.74 m Xmt Length 8.00 m 1st Bin 11.96 m

OS75
Data Structure BB/WH/OS Ensemble Length 1208 bytes Data Types 0000 0080 0100 0200 0300 0400 3000 30E0 2000 Firmware Version 23.19 System Frequency 76.8 kHz Convex Sensor Configuration #1 Transducer Head Attached TRUE Orientation DOWN Beam Angle 30 Degrees Transducer Unknown Real Data False Target(WA) 255 counts Band Width (WB) 0 Cor. Thres. (WC) 0 counts Err Thres. (WE) 1000 mm/s Blank (WF) 8.00 m Min PGood (WG) 0 Ref Layer (WL) 1, 1 first bin, last bin Mode (WM) 10 Bins (WN) 45 Pings/Ens (WP) 38 Bin Size (WS) 16.00 m Head Align (EA) -45.53 degrees Head Bias (EB) 0.00 degrees

Coord Xform (EX) 11111 Earth Coordinates Using Tilts, 3 Beam Solutions, and Bin Mapping

Sens Source (EZ) 1011101 cdhprst

Sens Avail 0000001 cdhprst

Time/Ping (TP) 00:01.50

Hardware 4 Beams

Lag 21 elements

Code Reps. 0

Lag Length 1.42 m

Xmt Length 16.00 m

1st Bin 23.94 m

freq	first_ensemble	last_ensemble	ensemble_total	binsize	1st_bin	no._bins	ping/ens	time/ping	average_ens_interval	mode	remark
OS76.8	2018/30/11 08:49:03	2018/12/01 04:49:05	601	16	-23.98	45	15	00:01.5	02:00.0	NB_NOBT	Vessel turned back at 2018/11/30 21:40
OS76.8	2018/02/12 17:07:00	2018/12/03 12:39:02	587	16	-23.94	45	38	00:01.5	02:00.0	NB_NOBT	-
OS76.8	2018/03/12 12:39:43	2018/12/03 17:09:44	136	16	-23.95	45	39	00:01.5	02:00.0	NB_NOBT	Data Collection Stopped (Acoustic Releaser Tests)
OS76.8	2018/03/12 17:26:54	2018/12/04 12:14:56	565	16	-23.94	45	40	00:01.5	02:00.0	NB_NOBT	-
OS76.8	2018/04/12 12:15:18	2018/12/05 11:57:24	712	16	-23.97	45	36	00:01.5	02:00.0	NB_NOBT	-
OS76.8	2018/05/12 11:57:46	2018/12/06 12:23:47	734	16	-23.95	45	38	00:01.5	02:00.0	NB_NOBT	-
OS76.8	2018/06/12 12:24:08	2018/12/07 11:46:10	702	16	-23.96	45	35	00:01.5	02:00.0	NB_NOBT	-
OS76.8	2018/07/12 11:47:46	2018/12/08 11:35:47	626	16	-23.94	45	35	00:01.5	02:17.1	NB_NOBT	Data Collection Stopped (Triangulation)
OS76.8	2018/08/12 14:46:22	2018/12/09 11:52:24	634	16	-23.99	45	36	00:01.5	02:00.0	NB_NOBT	-
OS76.8	2018/09/12 11:54:01	2018/12/09 16:44:01	146	16	-23.97	45	35	00:01.5	02:00.0	NB_NOBT	Data Collection Stopped (mooring operation)
OS76.8	2018/09/12 17:08:30	2018/12/10 10:00:31	507	16	-24	45	34	00:01.5	02:00.0	NB_NOBT	Data Collection Stopped (mooring operation)
OS76.8	2018/10/12 18:02:53	2018/12/11 11:50:54	535	16	-23.99	45	35	00:01.5	02:00.0	NB_NOBT	-
OS76.8	2018/11/12 11:51:24	2018/12/12 12:53:26	752	16	-23.95	45	35	00:01.5	02:00.0	NB_NOBT	Data Collection OFF

freq	first_ensemble	last_ensemble	ensemble_total	binsize	1st_bin	no._bins	ping/ens	time/ping	average_ens_interval	mode	remark
OS153.6	2018/11/30 08:48:52	2018/12/01 04:48:55	601	8	-11.93	48	15	00:01.0	02:00.0	NB_NOBT	Vessel turned back at 2018/11/30 21:40
OS153.6	2018/12/02 17:06:40	2018/12/03/12:40:41	588	8	-11.96	48	38	00:01.0	02:00.0	NB_NOBT	-
OS153.6	2018/12/03 12:40:56	2018/12/03 17:11:17	136	8	-11.93	48	39	00:01.0	02:00.2	NB_NOBT	Data Collection Stopped (Acoustic Releaser Tests)
OS153.6	2018/12/03 17:26:17	2018/12/04 12:14:17	565	8	-11.93	48	38	00:01.0	02:00.0	NB_NOBT	-
OS153.6	2018/12/04 12:14:42	2018/12/05 11:56:43	712	8	-11.98	48	36	00:01.0	02:00.0	NB_NOBT	-
OS153.6	2018/12/05 11:57:06	2018/12/06 12:23:07	734	8	-11.95	48	37	00:01.0	02:00.0	NB_NOBT	-
OS153.6	2018/12/06 12:23:30	2018/12/07 11:45:30	702	8	-12	48	36	00:01.0	02:00.0	NB_NOBT	-
OS153.6	2018/12/06 11:47:11	2018/12/08 11:37:14	716	8	-11.98	48	34	00:01.0	02:00.0	NB_NOBT	Data Collection Stopped (triangulation)
OS153.6	2018/12/07 14:45:42	2018/12/09 11:51:44	634	8	-11.94	48	36	00:01.0	02:00.0	NB_NOBT	-
OS153.6	2018/12/09 11:53:42	2018/12/09 16:43:42	146	8	-11.95	48	35	00:01.0	02:00.0	NB_NOBT	Data Collection Stopped (mooring operation)
OS153.6	2018/12/09 17:07:51	2018/12/10 09:59:54	507	8	-11.94	48	34	00:01.0	02:00.0	NB_NOBT	Data Collection Stopped (mooring operation)
OS153.6	2018/12/10 18:02:17	2018/12/11 11:50:19	535	8	-11.93	48	34	00:01.0	02:00.0	NB_NOBT	-
OS153.6	2018/12/11 11:50:46	2018/12/12 12:52:46	752	8	-11.98	48	35	00:01.0	02:00.0	NB_NOBT	Data collection OFF

RAW Data in:

\Ship_Fitted_Scientific_Systems\Acoustics\OS75kHz

\Ship_Fitted_Scientific_Systems\Acoustics\OS150kHz

Equipment Documentation in:

\Equipment_Documentation\Acoustics\ RDI_Ocean_Surveyor_75_&_150kHz_VMADCP.pdf

Drop-Keel Rugged Transducer (Acoustic Release)

Not used.

Sonardyne USBL

System run during cruise:	✓
Beacons charged post-cruise:	✓
System fully serviceable:	✓

The starboard head wires were reconnected to the spare USBL PC, ready for USBL Casius calibration.

Skipper Log

System run during cruise:	✓
System fully serviceable:	✓

Ran through the cruise.

RAW Data in:

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\NC (NetCDF format)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\SKIPL (Pseudo NMEA format)

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_SHIPS_SKIPPERLOG_yyyy_mm_dd.nmea.txt

Equipment Documentation in:

\Equipment_Documentation\Acoustics\

Data description document in:

\Cruise_Documentation\Data_Description_Documents\ Skipper Log Data Description.docx

Dartcom

Tested. No issues.

GPS & Attitude Systems

System run during cruise:	✓
System fully serviceable:	-
DGNSS Corrections to Applanix Posmv	CNAV ✓
DGNSS Corrections to Seapath 330	Fugro ×*

Position and attitude

GPS and attitude measurement systems were run throughout the cruise.

The ***Applanix POSMV*** system is the vessel's primary GPS system, outputting the position of the ship's common reference point in the gravity meter room. The POSMV is available to be sent to all systems and is repeated around the vessel. The position fixes attitude and gyro data are logged to the Techsas system. This was also the navigation source for the EK60, indicated by the TalkerID 'GP'.

The ***Kongsberg Seapath 300*** system is the vessel's secondary GPS system. It provides an input to the Gravity meter due to the POSMV not having vessel course available in its RMC NMEA message. Position fixes and attitude data are logged to the Techsas system.

The ***CNav 3050*** GPS system is a differential correction service. It provides the Applanix POSMV system with RTCM DGPS corrections (greater than 1m accuracy). The position fixes data are logged to the Techsas system.

The **Fugro Seastar 9205** GPS system is a differential correction service. It provides the Seapath system with RTCM DGPS corrections and is also logged to the Techsas system.

Applanix PosMV

No issues.

RAW Data in:

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\GPS (NetCDF format)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\sppos (Pseudo NMEA format)

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_POSMV_POS_yyyy_mm_dd.nmea.txt

Data description document in:

\Cruise_Documentation\Data_Description_Documents\ Posmv Data Description.docx

Equipment Documentation in:

\Equipment_Documentation\GPS_And_Attitude\ POS MV V5 Installation and Operation Guide Rev 8.pdf

Seapath 330

The Fugro G2 correction problems was resolved with a new firmware install, but the correction only available when we are using the AORE satellite.

RAW Data in:

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\GPS (NetCDF format)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\spatt (Pseudo NMEA format)

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_SEAPATH_POS_yyyy_mm_dd.nmea.txt

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_SEAPATH_ATT_yyyy_mm_dd.nmea.txt

Data description document in:

\Cruise_Documentation\Data_Description_Documents\ Seapath 330 Data Description.docx

Equipment Documentation in:

\Equipment_Documentation\GPS_And_Attitude\ Kongsberg_Seapath_330_march14.pdf

PHINS

In used to feed to ADCP's with heading data.

RAW Data in:

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\ATT (NetCDF format)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\pashr (Pseudo NMEA format)

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_PHINS_ATT_yyyy_mm_dd.nmea.txt

Data description document in:

\Cruise_Documentation\Data_Description_Documents\ Phins Attitude Data Description.docx

Equipment Documentation in:

\Equipment_Documentation\GPS_And_Attitude\ ixblue-ps-phins-06-2014-web.pdf

C-NAV

No Science related issues. This system provide the correction to the Applanix PosMV GPS.

RAW Data in:

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\GPS (NetCDF format)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\CNAVJ (Pseudo NMEA format)

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_CNAV_GPS_yyyy_mm_dd.nmea.txt

Data description document in:

\Cruise_Documentation\Data_Description_Documents\ CNAV 3050 Data Description_v2_DY.docx

Equipment Documentation in:

\Equipment_Documentation\GPS_And_Attitude\ C&CTechnologiesCNav3050Brochure.pdf

Fugro/Seastar

No issues.

RAW Data in:

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\GPS (NetCDF format)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\FUGRO (Pseudo NMEA format)

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_FUGRO_GPS_yyyy_mm_dd.nmea.txt

Data description document in:

\Cruise_Documentation\Data_Description_Documents\ FUGRO-Seastar Data Description.docx

Equipment Documentation in:

\Equipment_Documentation\GPS_And_Attitude\ 9205_GNSS_User_Guide.pdf

Gravity

AIR Sea gravity meter

Not onboard.

Winches

CLAM

System run during cruise:	✓
System fully serviceable:	✓

Winch operators mentioned about a delay on the display (think this is not a recent issue). They have been asked to keep a log/note of issues.

RAW Data in:

\Ship_Fitted_Scientific_Systems\CLAM\Logs (comma delimited CSV ASCII format)

\Ship_Fitted_Scientific_Systems\CLAM\Settings\CLAM DY096 Settings 2018-11-29-124309.txt

\Ship_Fitted_Scientific_Systems\TechSAS\NetCDF\CLAM (NetCDF format)

Y:\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\winch (Pseudo NMEA format)

\Ship_Fitted_Scientific_Systems\RVDAS\ DY096_NMF_WINCH_yyyy_mm_dd.nmea.txt

Data description document in:

\Cruise_Documentation\Data_Description_Documents\ CLAM Data Description.docx

Computers, network and communications

XBT PC

System run during cruise:	✗
System fully serviceable:	✓

No XBTs were deployed during the cruise.

Techsas

System run during cruise:	✓
System fully serviceable:	✓

Dual Techsas logging running on this cruise.

Data Collection Stopped: 2012/12/12 13:56UTC

The GPS module GSA parser corrected during the ports of call.

RAW Data in:

\Ship_Fitted_Scientific_Systems\TechSAS\ (NetCDF format)

\Ship_Fitted_Scientific_Systems\TechSAS\NMEA\ (Pseudo NMEA format)

Data description document in:

\Cruise_Documentation\Data_Description_Documents\

RVDAS (RAW data logger)

RVDAS ran without problems. New RVDAS version installed during the mobilization.

Gaps in Data:

From 2018/12/06 10:36 to 2018/12/09 12:14.

Enterprise & Discovery1

System run during cruise:	✓
System fully serviceable:	✓

No problem. LevelC ran on both machine.

CARIS

Tested.

VSAT

System run during cruise:	✓
System fully serviceable:	✓

All good, only problems were when the satellite was blocked by the ship's mast and we were almost out of the beam footprint.

FBB

System run during cruise:	✓
System fully serviceable:	✓

No issues.

Network

System run during cruise:	✓
System fully serviceable:	✓

No issues.

GPS & Serial Feeds

System run during cruise:	✓
System fully serviceable:	✓

GPGGA, GPRMC,GPZDA, GPHDT nmea messages were set up for scientific use in the main lab CTD PC and in the DeckLAB mooring PC.

AMS

Run without problem.

Intranet

System run during cruise:	✓
System fully serviceable:	✓

South Pacific Passageweather map added to the system.Weather map and access to the untangle certificate were its main use.

CTD2MET

System run during cruise:	✗
System fully serviceable:	✓

CTD2MET setup and sent data to metoffice CTD003, CTD004 and CTD005.

QNAPS

System run during cruise:	✓
System fully serviceable:	✓

No issues. Firmware upgraded during the ports of call, I is resolved the external disk issues, currently 4 disk connected over USB3 for backup.

Blackbox Display

System run during cruise:	✓
Cruise-specific TX names removed:	
System fully serviceable:	✓

Setup one additional console station in the Decklab.

Vessel Mounted ADCP

Filipa Carvalho (NOC)

Introduction

Two Teledyne RDI vessel-mounted Acoustic Doppler Current Profilers (ADCPs) were operated on RRS Discovery throughout the DY096 cruise to measure the horizontal velocity field. The two instruments, a 75 kHz and a 150 kHz Ocean Surveyor VMADCP, have different depth ranges and resolutions. The 150 kHz provides good vertical resolution, but the signal is more rapidly attenuated and it will only penetrate typically to depths up to 400 m. The 75 kHz instrument does not provide as good vertical resolution, but it penetrates deeper in the water column, to depths around 800 m.

Transducers are fitted to the hull of the RRS Discovery at a depth of 6.6 m. Beam 3 (Y-axis) is rotated -45 degrees (anticlockwise) relative to the ships central line, i.e. the mounting angle of the transducers is -45 degrees. This needs to be considered during post-processing to remove the ship's velocity from the data.

VMADCP file types

Files produced have names of the form *OStt_DY096nnn_mmmmmm.ext*, where *tt* is either the 75 kHz instrument or the 150 kHz, *nnn* is the file sequence number, *mmmmmm* is the number of the segment file within the sequence and ext is the extension. On this cruise, just like DY090, no NB, BT nor NoBT was added to the file name to facilitate batch processing in date order (no option of putting BT at the end), where NB is narrowband and BT is bottom track on. VMDAS automatically increments the file segment number every time data collection was stopped and restarted (Table 18, Table 19).

Files produced have the following extensions:

- *.ENR files: the binary raw data files (beam coordinates).
- *.ENS files: binary ADCP data after being screened for RSSI and correlation, with navigation data included.
- *.ENX files: ADCP single ping and navigation data after having been bin-mapped, transformed to Earth coordinates and screened for error velocity and false targets.
- *.STA files: binary files of short-term average ADCP data (120 sec, user-specified in VmDas).
- *.LTA files: binary files of long-term average ADCP data (600 sec, user-specified in VmDas).
- *.N1R files: ASCII text files of raw NMEA navigation data from the NMEA1 stream.
- *.NMS files: binary files of navigation data after screening.
- *.VMO files: ASCII text files specifying the option settings used for the data collection.
- *.LOG files: ASCII text files logging all output and error

Raw files were automatically synchronized to the dynas1 science network (smb://dynas1.discovery.local/current_cruise/Ship_Fitted_Scientific_Systems/Acoustics/OS*tt*kHxz/, where *tt* is 75 or 150) and manually resynced to Filipa's computer. A folder per each set of files and for each instrument was created (same number, e.g. vmdas_data_os75_001 included all the files 001 from instrument os75)

Real-time data acquisition

Data was acquired from the instrument using the RDI VMDAS software, version 1.48, installed in a computer in the computer room. Software carried out preliminary screening and transformation of the data, from beam to earth coordinates. A default configuration file was set to facilitate interchange depth ranges, bottom track to water track and whether the information was synced with the other acoustic instruments (K-sync unit).

During the cruise, both instruments were managed using the K-sync unit. Data collection was typically stopped and restarted to generate a new file segment number on a daily basis, thus facilitating the incremental processing in both instruments.

Unfortunately, due to lack of diplomatic clearance to sample in Chilean waters, no bottom track data were collected.

DY096 OS75 setup

All command files used with K-sync:

- DY096_OS75_NB_BT_with_sync_16m
  - Used to calibrate the instrument (misalignment angle calculation)
  - narrowband single-ping profile mode (NP), 100 (NN) 8 meter bins (NS), 8 meter blanking distance (NF)
- DY096_OS75_NB_NO_BT_with_sync_16m
  - narrowband single-ping profile mode (NP), 45 (NN) 8 meter bins (NS), 8 meter blanking distance (NF)

DY096 OS150 setup

All command files used with K-sync:

- DY096_OS150_NB_BT_with_sync_8m
  - Used to calibrate the instrument (misalignment angle calculation)

- narrowband single-ping profile mode (NP), 96 (NN) 8-meter bins (NS), 4 meter blanking distance (NF)

- DY096_OS150_NB_NO_BT_with_sync_8m
  - narrowband single-ping profile mode (NP), 45 (NN) 8-meter bins (NS), 8 meter blanking distance (NF)

Common to all configuration files:

- NMEA Ship Position (GGA) Source: NMEA1
- NMEA Ship Speed (VTG) Source: NMEA1
- Transform: Heading/tilt source: PRDID; NMEA2
- Custom NMEA from C:\\RDI\VmDas
- ADCP misalignment correction: -45 degrees

Table 18: Data collection log for instrument OS75 kHz.

First ensemble	Last ensemble	ens total	Bin size	1st_bin	No. bins	ping / ens	time/ ping	Ave ens interval	Mode (NoBT, NB)	remark
30/Nov 08:49:03	01/Dec 04:49:05	601	16	-23.98	45	15	00:01.5	02:00.0	Yes	Vessel turned back at 2018/11/30 21:40
02/Dec 17:07:00	03/Dec 12:39:02	587	16	-23.94	45	38	00:01.5	02:00.0	Yes	-
03/Dec 12:39:43	03/Dec 17:09:44	136	16	-23.95	45	39	00:01.5	02:00.0	Yes	Stopped (Acoustic Releaser Tests)
03/Dec 17:26:54	04/Dec 12:14:56	565	16	-23.94	45	40	00:01.5	02:00.0	Yes	-
04/Dec 12:15:18	05/Dec 11:57:24	712	16	-23.97	45	36	00:01.5	02:00.0	Yes	-
05/Dec 11:57:46	06/Dec 12:23:47	734	16	-23.95	45	38	00:01.5	02:00.0	Yes	-

06/Dec 12:24:08	07/Dec 11:46:10	702	16	-23.96	45	35	00:01.5	02:00.0	Yes	-
07/Dec 11:47:46	08/Dec 11:35:47	626	16	-23.94	45	35	00:01.5	02:17.1	Yes	Sampling stopped (Triangulation)
08/Dec 14:46:22	09/Dec 11:52:24	634	16	-23.99	45	36	00:01.5	02:00.0	Yes	-
09/Dec 11:54:01	09/Dec 16:44:01	146	16	-23.97	45	35	00:01.5	02:00.0	Yes	Sampling stopped (mooring operation)
09/Dec 17:08:30	10/Dec 10:00:31	507	16	-24	45	34	00:01.5	02:00.0	Yes	Sampling stopped (mooring operation)
10/Dec 18:02:53	11/Dec 11:50:54	535	16	-23.99	45	35	00:01.5	02:00.0	Yes	-
11/Dec 11:51:24	12/Dec 12:53:26	752	16	-23.95	45	35	00:01.5	02:00.0	Yes	OFF

Table 19: Data collection log for instrument OS150 kHz.

First ensemble	**Last ensemble**	**ens total**	**Bin size**	**1st_bin**	**No. bins**	**ping/ens**	**time/ping**	**Ave ens interval**	**Mode (NoBT, NB)**	**Remark**
Nov/30 08:48:52	Dec/01 04:48:55	601	8	-11.93	48	15	00:01.0	02:00.0	Yes	Vessel turned back at 2018/11/30 21:40
Dec/02 17:06:40	Dec/01 12:40:41	588	8	-11.96	48	38	00:01.0	02:00.0	Yes	-
Dec/03 12:40:56	Dec/03 17:11:17	136	8	-11.93	48	39	00:01.0	02:00.2	Yes	Stopped (Acoustic

										Releaser Tests)
Dec/03 17:26:17	Dec/04 12:14:17	565	8	-11.93	48	38	00:01.0	02:00.0	Yes	-
Dec/04 12:14:42	Dec/05 11:56:43	712	8	-11.98	48	36	00:01.0	02:00.0	Yes	-
Dec/05 11:57:06	Dec/06 12:23:07	734	8	-11.95	48	37	00:01.0	02:00.0	Yes	-
Dec/06 12:23:30	Dec/07 11:45:30	702	8	-12	48	36	00:01.0	02:00.0	Yes	-
Dec/06 11:47:11	Dec/08 11:37:14	716	8	-11.98	48	34	00:01.0	02:00.0	Yes	Sampling stopped (triangulation)
Dec/07 14:45:42	Dec/09 11:51:44	634	8	-11.94	48	36	00:01.0	02:00.0	Yes	-
Dec/09 11:53:42	Dec/09 16:43:42	146	8	-11.95	48	35	00:01.0	02:00.0	Yes	Sampling stopped (mooring operation)
Dec/09 17:07:51	Dec/10 09:59:54	507	8	-11.94	48	34	00:01.0	02:00.0	Yes	Sampling stopped (mooring operation)
Dec/10 18:02:17	Dec/11 11:50:19	535	8	-11.93	48	34	00:01.0	02:00.0	Yes	-
Dec/11 11:50:46	Dec/12 12:52:46	752	8	-11.98	48	35	00:01.0	02:00.0	Yes	OFF

Data post-processing

Onboard post-processing was done using the new Python version of CODAS (Common Ocean Data Access System) suite of software provided by the University of Hawaii. The four main steps that characterizes the CODAS VMADCP processing:

i) Removal of the ship velocity;

ii) Correction of the gyro heading with GPS-derived heading;

iii) Estimate the heading misalignment from either bottom track (BT) or water-track (WT) data;

iv) Manual inspection/editing of bad data.

VMADCP Processing using Python CODAS

A few steps that help the VMADCP processing:

If issues with topography arise, it is likely that the link to the topography data is broken:

```
> ln -s ~/adcpcode/topog topog
```

Create a codaspy_proc_dy096 folder on:

```
> cd ../Data/VMADCP/
> mkdir codaspy_proc_dy096
```

Create a fake_uhdas_data directory:

```
> cd codaspy_proc_dy096/
> mkdir fake_uhdas_data
```

Create a vmdas_data_os*_00*. This should indicate the OS (instrument, os75 or os150) and file number

```
> mkdir vmdas_data_os75_001
```

Copy files from the raw data folder to this new subfolder, isolating one filename at a time (it includes multiple filetypes with the same name)

```
> cp vmdas_data_os75/OS075_DY096_ Sync_2018*_001_0*.* vmdas_data_os75_001/
> ls vmdas_data_os75_001
```

Inside the codaspy_proc_dy096 folder, navigate to adcp_pyproc/ and create an enrproc_os*_00* folder. Inside create a config folder

```
> cd adcp_pyproc/
> mkdir enrproc_os75_001
> mkdir enrproc_os75_001/config
> cd enrproc_os75_001/
```

Then create an info file for the LTA datatype. Check the text file info using more command

```
> vmdas_info.py --logfile lta_info.txt os ../../vmdas_data_os75_001/*LTA
> more lta_info.txt
```

Do the same thing for the ENR files

```
> vmdas_info.py --logfile enr_info.txt os ../../vmdas_data_os75_001/*ENR
> more enr_info.txt
```

Go to the config directory and create the following files reform_defs.py and vmdas2uhdas.py by using the GUI window.

cd config

```
> pythonw `which reform_vmdas.py` ../../..
```

In the GUI window:

Vmdas source: where your data is, e.g. …/VMADCP/codaspy_proc_dy096/ vmdas_data_os75_001
Uhdas dir: …/ VMADCP/codaspy_proc_dy096/fake_uhdas_data
Ship ID: zzz
Instrument: os75
Cruise name: dy096_os75_001
Filename: variable definitions: reform_defs.py

Filename for translation: vmdas2uhdas.py

Make config files

```
> python vmdas2uhdas.py
```

Go to …/VMADCP/codaspy_proc_dy096/ adcp_pyproc/enrproc_os75_001/config (you should be there)

```
> pythonw `which proc_starter.py` reform_defs.py
```

In the GUI window:

Transducer angle: -45

Transducer depth: n6

Position: N1R, gps

Heading: N1R, hdg

Make config file

Run the treeadcp.py to create the folders inside enrproc_* folder

```
> cd ..
> adcptree.py os75nb --datatype uhdas --cruisename dy096_os75_001
```

Create the q_py.cnt file OR copy from another folder of the same instrument and edit the cruise name – easier to copy and edit the different file name. Make sure to remove the ping_headcorr line from the q_py.cnt file)

```
> ``vim q_py.cnt``
```

If we are re-running the same dataset again and we are happy with gpin data, delete that line from the q_py.cnt file or if we want to rerun everything again, need to delete the gbin subdirectory (~/codaspy_proc_dy096/fake_uhdas_data/dy090_os75_001/gbin

To run quick_adcp, go to the os75nb folder and:

```
> cd os75nb
> quick_adcp.py --cntfile q_py.cnt --auto
```

Calibration

The calibration values are created in the first round of processing. They are located at dy090NNNnbenx/cal/watertrk/adcpcal.out and dy096NNNnbenx/cal/botmtrk/btcaluv.out. For this cruise we did not have a bottom-track cal file as we did not collect bottom-track data.

A water-track cal file looks like this:

```
 ADCP watertrack calibration
##
 Time range 330.61 to 344.31
   Calculation done at Wed Dec 12 22:13:44 2018
   delta-u min = -100.00, max = 100.00
   delta-v min = -100.00, max = 100.00
   clip_amp = 0.04,  clip_ph =  3.0
   clip_dt =   60,  clip_var = 0.050
Number of edited points:  23 out of  26
   amp   = 1.0241  + -0.0009 (t - 341.0)
   phase =   1.57  + 0.0556 (t - 341.0)
            median     mean      std
amplitude   1.0230   1.0241   0.0124
phase       1.5920   1.5687   0.6465
nav - pc    9.0000  11.0870   9.7650
var         0.0120   0.0147   0.0096
min var     0.0070   0.0103   0.0076
delta-u     1.7800   0.8943   3.6102
delta-v     1.4000   0.6643   3.2501
```

For the second stage of the processing we require calibration files collected during water-track mode. Check cal water track data (~/codaspy_proc_dy096/adcp_pyproc/enrproc_os75/ os75nb/cal/watertrk folder). Apply corrections if necessary.

The following step reprocesses the data by applying amplitude and/or phase corrections.

```
> quick_adcp.py --steps2rerun rotate:navsteps:calib --rotate_amplitude 1.024 --rotate_angle 1.6
```

For the os75 kHz instrument, data were corrected using amplitude=1.024 and angle/phase=1.6.

After the second round of processing, the adcpcal.out is as follows:

```
 ADCP watertrack calibration
##
 Time range 330.61 to 344.31
   Calculation done at Wed Dec 12 22:30:06 2018
   delta-u min = -100.00, max = 100.00
   delta-v min = -100.00, max = 100.00
   clip_amp = 0.04,  clip_ph =  3.0
   clip_dt =   60,  clip_var = 0.050
Number of edited points:  23 out of  26
   amp    = 1.0003  + -0.0008 (t - 341.0)
   phase =   -0.02  + 0.0573 (t - 341.0)
            median     mean      std
amplitude   1.0000   1.0003   0.0121
phase      -0.0070  -0.0248   0.6487
nav - pc    6.0000   6.3043   5.8187
var         0.0070   0.0075   0.0060
min var     0.0050   0.0056   0.0046
delta-u     1.7800   0.8517   3.6246
delta-v     1.4000   0.6717   3.2354
```

For the os150 kHz instrument, the calibrations applied were amplitude=1.01 and angle/phase=1.2. Results of the corrections can be found on Table 20.

Table 20: Before and after cal correction (~/cal/watertrk/acdpcal.out files)

1st run of processing	**After 2nd run (after applying cal correction)**
ADCP watertrack calibration ## Time range 330.61 to 344.31 Calculation done at Wed Dec 12 23:27:39 2018 delta-u min = -100.00, max = 100.00 delta-v min = -100.00, max = 100.00 clip_amp = 0.04, clip_ph = 3.0 clip_dt = 60, clip_var = 0.050 Number of edited points: 24 out of 26 amp = 1.0050 + -0.0009 (t - 341.1) phase = -0.15 + 0.0218 (t - 341.1) median mean std amplitude 1.0010 1.0050 0.0121 phase 0.0190 -0.1518 0.7911 nav - pc 7.5000 7.2500 7.2547 var 0.0065 0.0075 0.0058 min var 0.0040 0.0055 0.0043 delta-u 1.5150 0.9050 3.5802 delta-v 1.1250 0.6288 3.5439	ADCP watertrack calibration ## Time range 330.61 to 344.31 Calculation done at Wed Dec 12 23:20:06 2018 delta-u min = -100.00, max = 100.00 delta-v min = -100.00, max = 100.00 clip_amp = 0.04, clip_ph = 3.0 clip_dt = 60, clip_var = 0.050 Number of edited points: 23 out of 26 amp = 1.0138 + -0.0006 (t - 341.2) phase = 1.03 + 0.0316 (t - 341.2) median mean std amplitude 1.0110 1.0138 0.0108 phase 1.2170 1.0293 0.8022 nav - pc 8.0000 9.0435 7.5587 var 0.0110 0.0098 0.0073 min var 0.0050 0.0070 0.0058 delta-u 1.2400 0.8183 3.6348 delta-v 1.4700 0.6222 3.6224

Output plot

Using the shortcuts setup during codas installation, running ‘dv’ is supposed to show a GUI with maps. During Dy096, I could not make ‘dv’ work. The following error would appear:

```
(mini27) 253-153:enrproc_os75 filcar$ dv
/Users/filcar/miniconda2/envs/mini27/lib/python2.7/site-packages/pycurrents/adcpgui/dataview.py:253: wxPyDeprecationWarning: Using
 deprecated class PySimpleApp.
  wxapp = wx.PySimpleApp()

 CODAS ERROR:   UNABLE_TO_OPEN                  ACCESSING:   BLOCK_DIR_FILE
 FROM FUNCTION: open_block_dir                  IN DATABASE: 1

 CODAS ERROR:   UNABLE_TO_OPEN                  ACCESSING:   BLOCK_DIR_FILE
 FROM FUNCTION: DBOPEN                          IN DATABASE: 1
Traceback (most recent call last):
  File "/Users/filcar/miniconda2/envs/mini27/bin/dataviewer.py", line 31, in <module>
    gg = main(arglist)
  File "/Users/filcar/miniconda2/envs/mini27/lib/python2.7/site-packages/pycurrents/adcpgui/dataviewer.py", line 268, in main
    startdday=options.startdday)
  File "/Users/filcar/miniconda2/envs/mini27/lib/python2.7/site-packages/pycurrents/adcpgui/dataview.py", line 272, in __init__
    self.init()
  File "/Users/filcar/miniconda2/envs/mini27/lib/python2.7/site-packages/pycurrents/adcpgui/dataview.py", line 277, in init
    CD = self.get_CD(p)
  File "/Users/filcar/miniconda2/envs/mini27/lib/python2.7/site-packages/pycurrents/adcpgui/dataview.py", line 350, in get_CD
    return CData(**param)
  File "/Users/filcar/miniconda2/envs/mini27/lib/python2.7/site-packages/pycurrents/adcpgui/cplotter.py", line 75, in __init__
    data = get_txy(self.dbpathname)
  File "/Users/filcar/miniconda2/envs/mini27/lib/python2.7/site-packages/pycurrents/codas/tools.py", line 290, in get_txy
    db = DB(dbname, yearbase=yearbase)
  File "_codas.pyx", line 485, in _codas.DB.__init__
IOError: Can't open database /Users/filcar/OneDrive - NERC/Research/Projects/2018_CUSTARD/Cruise_1/Data/VMADCP/codaspy_proc_dy096/
adcp_pyproc/enrproc_os75/os75nb/adcpdb/aship
(mini27) 253-153:enrproc_os75 filcar$
```

Outreach

Eleanor Haigh (University of Southampton)

Blog

The cruise was documented through a blog, found at https://roses.ac.uk/catergory/custard/2018-cruise. Posts were made every other day describing the progress of the cruise, from leaving port to the deployment of the mooring and gliders. Contributions came from members of NOCS, WHOI, and NMF, all with varying levels of experience, providing an insight into not only scientific activity on board but also more personal thoughts on the project and day-to-day life on the cruise. This produced an informative and accessible account of the cruise, made available to a wider public audience that might otherwise have not been engaged in the activities of the cruise and the CUSTARD project.

Twitter

The RoSES project twitter account (@RoSES_ocean) was utilised to publish live updates on cruise activity, and promote blog posts. On average there were 19 likes and re-tweets for each post on the cruise, the highest rate of interaction seen for all tweets on the RoSES account over the past year, with most interactions coming from academics across various UK research institutions.

The University of Southampton's School of Ocean and Earth Science's twitter account (@OceanEarthUoS) was also used to highlight the travel and research opportunities available to undergraduate students through documenting Eleanor's experience on board. On average there were 5 likes and re-tweets per post with most interaction from academics at the university, and levels of interaction on some tweets being the highest seen on the account for the past three months. Material generated by this takeover will also be used by the university marketing team in promoting the Oceanography degree at Southampton.

All tweets posted on the ROSeS and University account regarding the cruise can be found under the hashtag #CUSTARDcruise, at https://twitter.com/hashtag/CUSTARDcruise?src=hash.

Acknowledgements

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More generally, we would like to thank Mike Webb (NERC), Jess Surma (NERC), Natalie Powney (NERC) and Colin Day (NERC) for their work in bringing the collaboration with NSF, to make use of the OOI mooring, to fruition. This was a cornerstone of the CUSTARD fieldwork and we are extremely grateful for their patience, perseverance and support in bringing this about.