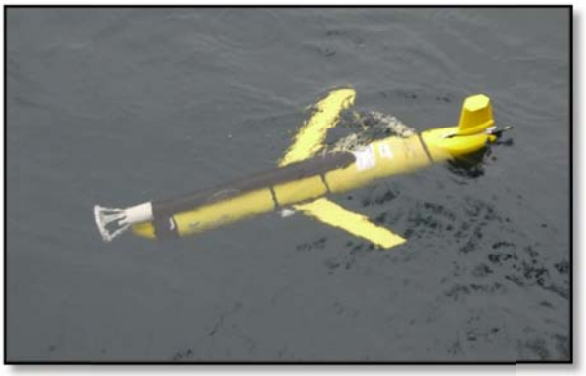
DY018 Cruise Report

RRS *Discovery*

9th November – 3rd December 2014



PS: Jonathan Sharples
University of Liverpool

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1. General Information

Jonathan Sharples (University of Liverpool)

Cruise Personnel

Master: Joanna Cox

Cruise science personnel:

1. PSO: Jonathan Sharples (Principal Scientist), University of Liverpool
2. Clare Davis, University of Liverpool
3. Hanna Shuster, University of Liverpool and University of Southampton
4. Maeve Lohan, University of Plymouth
5. Anthony Birchill, University of Plymouth
6. Amber Annett, Edinburgh University
7. Dagmara Rusiecka, University of Southampton
8. Malcolm Woodward, Plymouth Marine Laboratory
9. Andy Rees, Plymouth Marine Laboratory
10. Darren Clark, Plymouth Marine Laboratory
11. Sari Giering, University of Aberdeen
12. Seona Wells, University of Aberdeen
13. Jo Hopkins, National Oceanography Centre
14. Chris Balfour, National Oceanography Centre
15. Alex Poulton, National Oceanography Centre
16. Kyle Mayers, National Oceanography Centre
17. Sharon McNeill, Scottish Association for Marine Science
18. Enma Elena Garcia Martin, University of East Anglia
19. Isabel (Chata) Seguro, University of East Anglia
20. Matthew Bone, University of East Anglia
21. Clare Ostle, University of East Anglia
22. Alison Webb, University of East Anglia
23. Lou Darroch, British Oceanographic Data Centre, Liverpool

NMF Technical and Engineering:

1. Ben Poole (Senior technician)
2. Zoltan Nemeth (Computer tech)
3. Dougal Mountifield
4. Tom Roberts
5. Sam Ward (glider tech)
6. Billy Platt

Scientific background.

Cruise DY018 was the autumn/winter cruise associated with the NERC/Defra-funded Shelf Sea Biogeochemistry research programme. The overall goals of this work are to determine how much carbon the NW European shelf exports to the deep ocean, and how the shelf biogeochemical system is able to sustain this export. There is both pelagic and benthic work associated with this research programme, being carried out on a series of cruises through 2014 and 2015. A second component to this work involves assessing the role of the shelf in supplying iron to the open ocean.
The work on DY018 was largely focused on pelagic biogeochemical processes on the Celtic Sea shelf and the adjacent shelf slope, deliberately targeting the time of year when the surface mixed layer is deepening convectively towards winter. There were 5 main objectives for the cruise:

i. Carry out 2 process stations, one on the shelf and one at the shelf edge, to measure biogeochemical rates through the water column.
ii. Carry out 2 transects of stations over the shelf slope to the shelf edge, measuring biogeochemical states and also iron chemistry.
iii. Carry out a broader survey of biogeochemical states and iron chemistry across the wider shelf.
iv. Service an array of moored instrumentation in the central Celtic Sea.
v. Deploy both long-term and short-term gliders in the Celtic Sea and at the shelf edge. The short-term gliders were recovered before the end of the cruise.

The cruise has highly successful, largely as a result of remarkably good weather considering the expectations for the time of year. Process stations were carried out in the central Celtic Sea and at the shelf edge, each lasting about 3 days. Work on these stations typically comprised CTDs for water sample collection and autotrophic and bacterial rate measurements; use of the Marine Snowcatcher and Standalone Pumps for particle characterisation and remineralisation rates; WP2 zooplankton net hauls for biomass, species and grazing rates; and cores for very-near-bed water sampling and ammonia release experiments. Two cross-slope transects, each consisting of 7 stations between depths of 2500m and 200m, were carried out to measure iron chemistry and radium. A line of CTD stations was run from the shelf edge, through the central Celtic Sea mooring site and up into the Celtic Deep. Measurements at these stations were made for basic iron chemistry and biogeochemical states. An array or moorings in the central Celtic Sea was recovered and redeployed. A separate wirewalker mooring was deployed at the start of the cruise, recovered/redeployed partway through the cruise (because it had come adrift from its bottom anchor) and recovered towards the end of the cruise. A total of 5 gliders were deployed, Two were recovered towards the end of the cruise, as planned. One of the long-term gliders running along a line over the shelf slope appears to have been lost already.

Cruise narrative.

Date	Time	Activity/event	Weather (Wind directions are FROM)
9th Nov	0830	Sailed from Falmouth Lifeboat tests Muster drill	
10th Nov	0430 0501 0900 1024 1220 1355 1625 2201 2229 2250 2330	On station CCS. **Event 1**: CTD (steel) fully sampled. **Event 2**: CTD (steel) for radium water. **Event 3**: wirewalker test over stern. **Event 4:** CTD (steel), sampled for nutrients, organics, DIC/TA. **Event 5:** zooplankton net **Event 6:** zooplankton net **Event 7:** zooplankton net **Event 8:** zooplankton net **Event 9:** zooplankton net **Event 10:** zooplankton net **Event 11:** CTD (titanium) for bottle soaking **Event 12:** NIOZ box corer **Event 13:** zooplankton net **Event 14:** zooplankton net **Event 15:** zooplankton net **Event 16:** zooplankton net **Event 17:** zooplankton net **Event 18:** zooplankton net **Event 19:** box core **Event 20:** box core **Event 21:** box core **Event 22:** box core Surfmet meteorology largely garbage (giving 10 knots of wind instead of 40, and very noisy).	S'ly 35-40 knots Moderate/rough sea SW'ly 15 knots Moderate sea
11th Nov	 0908 1024 1205 1403 1524 2124 2317	 **Event 23:** CTD (steel) for radium water **Event 24:** CTD (titanium) for Fe **Event 25:** CTD (steel) nutrients, DIC/TA etc **Event 26:** CTD (steel) for radium water **Event 27:** OMG glider deployment **Event 28:** Wirewalker deployment **Event 29:** CTD (steel) zooplankton **Event 30:** MSC (misfire) **Event 31:** SAPS (25 m) **Event 32:** SAPS (80 m)	 SE'ly 5-10 knots Slight sea and swell SW'ly 5 – 10 knots Squally showers pm
12th Nov		**Events 33-38:** zooplankton nets	SW'ly 20 knots

	0508 0905 1024 1224 1545	**Event 39:** CTD (steel) fully sampled **Event 40:** CTD (steel) for radium water. **Event 41**: CTD (titanium) **Event 42:** CTD (steel) nutrients, DIC/TA etc. **Events 43-46**: zooplankton nets **Event 47:** Glider deployment (Seaglider with nitrate sensor). **Events 48-50:** MSC (misfires) STATION CCS FINISHED Ship lost internet and phone communications.	Moderate sea and swell SW'ly 25 – 30 knots Rough sea, moderate swell S'ly 30 knots Rough Sea, moderate swell.
13th Nov	 0800 0809 1115 1129 1304 1453 1500 1655 1730 1833 2109 2243	 On station **O1** **Event 51:** CTD (steel) nutrients, DIC/TA etc. **Event 52:** trace metal fish deployed On station **O2** **Event 53:** CTD (steel), radium water. **Event 54:** CTD (steel) **Event 55:** CTD (steel), radium water. Seaglider reported as not working and stuck on the surface. On station **O3** **Event 56:** CTD (steel) – misfired (CTD hit ship) **Event 57:** CTD (steel) On station **O4** **Event 58:** CTD (steel) **Event 59:** CTD (steel)	Very rough, 50 knots S'ly over night. SW'ly 15 knots, moderate sea and moderate swell. SW'ly 30-35 knots, rough sea, moderate swell. SE'ly 10-15 knots, rain.
14th Nov	0009 0224 1302	**Event 60:** CTD (steel) On station **O5** **Event 61:** CTD (steel) On station **CS2** **Event 62:** CTD (steel) aborted Waves 7 – 8 metres. Heavy rolling. Heave to, CS2. **Event 63:** CTD (steel) on CS2 Steam to 48° 24.2' N, 09° 32.6' W, then to deep water along course 240°T to depth of 2500 metres.	 SW'ly 20 knots, moderate sea and swell.

		Station **Fe01**	
	1846	**Event 64:** CTD (steel) for radium	
	2212	**Event 65:** CTD (titanium)	
15th Nov	0017	**Event 66:** CTD (steel) for radium	
		Steam to depth of 2,000 metres	
			SW'ly 20 knots, moderate sea and swell.
		Station **Fe02**	
	0327	**Event 67:** CTD (steel) for radium	
	0604	**Event 68:** CTD (titanium)	
			W'ly 15-20 knots
		Steam to 1,500 metres	
	0920	**Event 69:** CTD (steel) to 100m for experiment water.	W'ly 10-15 knots
	1200-1315	**Events 70 & 71:** Glider deployments (2): deep Slocum gliders for the cross-slope transect (deployed until Feb/March).	N'ly 15 knots
		Wirewalker reported as drifting.	
			NW'ly 25-30 knots
		Events 72-74: Marine snowcatcher tests.	
		Station **Fe03**	
	1812	**Event 75:** CTD (steel), radium water (500m)	
	1933	**Event 76:** CTD (titanium)	
	2202	**Event 77:** CTD (steel), radium water (1500m)	
16th Nov		Steam to 1000m	
		Station **Fe04**	
	0128	**Event 78:** CTD (steel) for radium.	
	0439	**Event 79:** CTD (steel) for radium	
		Work stopped due to difficult sea state	
	0610	**Event 80:** CTD (titanium)	NW'ly 25-30 knots
		Steam to 750m	
		Station **Fe05**	
	1107	**Event 81:** CTD (steel) for radium.	
	1245	**Event 82:** CTD (titanium)	
	1421	**Event 83:** CTD (steel) for radium	
		Steam to 500m	
		Station **Fe06**	
		Event 84: zooplankton nets	
		Event 85: zooplankton nets	
	1722	**Event 86:** CTD (steel)	

	1838	**Event 87:** CTD (titanium)	
		Steam to 250m	
		Station **Fe07**	
	2230	**Event 88:** CTD (titanium)	
	2328	**Event 89:** CTD (steel) for radium	
		Steam to CS2	
17th Nov		On station **CS2** for process work	
	0600	**Event 90:** zooplankton nets	
		Event 91: zooplankton nets	
		Event 92 zooplankton nets	
		Event 93: zooplankton nets	
		Event 94: zooplankton nets	N'ly 10-15 knots
	0900	**Event 95:** T chain deployment	Slight sea and swell
	1213	**Event 96:** CTD (steel)	
		Events 97 – 100: zooplankton nets	
	1537	**Event 101:** CTD (steel)	
		Events 102-108: zooplankton nets	
		Events 109-114: NIOZ box corer	
18th Nov	0506	**Event 115:** Pre-dawn CTD (steel)	
	0758	**Event 116:** CTD (steel) for radium	
	0905	**Event 117:** CTD (titanium)	
	0957	**Event 118:** CTD (steel) for radium	SE'ly 20-25 knots,
	1200	**Event 119:** CTD (steel) noon profile	moderate sea, slight
	1320	**Event 120:** Glider deployment (shallow Slocum)	swell.
	1603	**Event 121:** SAPS deployment (2 at 120 metres depth)	SE'ly 30-35 knots,
		Event 122: Snowcatcher (large), misfire.	rough sea, moderate
	1845	**Event 123:** Snowcatcher (large), near-surface.	swell.
	1920	**Event 124:** SAPS (2) at 15 metres	
		Event 125: Snowcatcher (large), misfire.	
		Event 126: Snowcatcher (small), near-surface.	
		Event 127: Snowcatcher (large), 100 m.	
		Event 128: Snowcatcher (small), 100 m.	
19th Nov	0600	**Events 129-133:** zooplankton nets (1 misfire)	
	0950	**Event 134:** CTD (titanium)	SW'ly 15 knots, slight sea, moderate swell.
	1030	Muster drill	
	1205	**Event 135:** CTD (steel)	
	1347	**Event 136:** CTD (steel) for zooplankton	
		Events 137-142: zooplankton nets	S'ly 5-10 knots, slight sea, moderate swell.
	1600	T chain recovered	
		Events 143-146: MSC (large) 15 metres (3 misfires)	

		Event 147: MSC (small) 15 metres **Event 148:** MSC (large) 105 metres **Event 149:** MSC (small) 105 metres	
20th Nov	0201	**Event 150:** Super pre-dawn CTD (steel) Steam to CCS for mooring work Arrive CCS Trace metal fish recovered	E'ly 25 knots, moderate sea and swell.
	0923	**Event 151:** CTD (steel) for mooring calibration	
	1200	Mooring recoveries begin.	
	1254	**Event 152:** In-line ADCPs recovered.	
	1420	**Event 153:** ADCP bedframe recovered.	
	1627	**Event 154:** T-logger mooring recovered.	
	1700	All recoveries successful.	
21st Nov	0800	Mooring deployments begin.	
	0833	**Event 155:** CTD (steel) for release tests.	
	1059	**Event 156:** T-logger mooring deployed.	
	1138	**Event 157:** Bedframe ADCPs deployed. Move off to search for wirewalker.	S'ly 20 knots, moderate sea and swell.
		Wire walker recovered intact and still profiling. Move off to search for glider.	
	1615	Glider recovered.	
	1813	**Event 158:** CTD (steel) for mooring calibration and zooplankton water. **Events 159-161:** zooplankton nets.	
22nd Nov	0455	**Event 162:** Pre-dawn CTD (steel).	
	0645	**Event 163:** CTD (steel) for radium.	NW'ly 15-20 knots, Slight sea and swell.
	0755	**Event 164:** CTD (steel) for radium.	
	0918	**Event 165:** Glider redeployed	
	1043	**Event 166:** ADCP in-line mooring deployed	
	1123	**Event 167:** wirewalker redeployed Arrive 2500m (deep E-W trench)	NW'ly 20-25 knots,
	1930	Station **Fe08**	moderate sea and
	2006	**Event 168:** CTD (titanium) – cast aborted due to blocked sensor ducts.	swell.
	2038	**Event 169:** CTD (titanium) Steam to 200m, **Fe09**	
23rd Nov	0011	**Event 170:** CTD (steel) radium to 2000m	
	0242	**Event 171:** CTD (titanium)	

	0449 0608 0801 1009 1200 1915 2105 2300	**Event 172:** CTD (steel) radium to 200m **Event 173:** CTD (steel) radium to 800m Steam to 1500m **Fe10** **Event 174:** CTD (titanium) **Event 175:** CTD (steel) radium to 500m Steam to 1000m **Fe11** **Events 176-180:** zooplankton nets **Event 181:** CTD (titanium) **Event 182:** CTD (steel) for radium Steam to 700m **Fe12** **Event 183:** CTD (titanium) (aborted after collision with side of ship)	N'ly 20 knots, slight sea, moderate swell. NE'ly 5-10 knots, calm sea and slight swell.
24th Nov	0005 0153 0440 0550 0755 0848 1316 1402	**Event 184:** CTD (titanium) **Event 185:** CTD (steel) for radium Steam to 500m **Fe13** **Event 186:** CTD (titanium) **Event 187:** CTD (steel) for radium Steam to 48° 29.5' N, 09° 48.5' W **Fe14** **Event 188:** CTD (titanium) **Event 189:** CTD (steel) for radium Steam to CS2 **Events 190-194:** zooplankton nets **Event 195:** CTD (steel) near-surface with cameras **Event 196:** CTD (steel) **Event 197:** Marine Snowcatcher (large) 15m **Event 198:** Marine Snowcatcher (small) 15m **Event 199:** Marine Snowcatcher (large) 15m **Event 200:** Marine Snowcatcher (small) 15m Steam to CCS	E'ly <5knots, calm sea, slight swell.
25th Nov	 0502 1206 1535 1716	On station CCS **Event 201:** CTD (steel) pre-dawn experiments **Event 202:** CTD (steel) **Events 203-211:** zooplankton nets **Event 212:** CTD (steel) **Event 213:** Marine Snowcatcher (large) 15m **Event 214:** Marine Snowcatcher (small) 15m **Event 215:** SAPS at 20 and 100 metres. **Event 216:** Marine Snowcatcher (large) 100m **Event 217:** Marine Snowcatcher (small) 100m **Events 218-223:** zooplankton nets	NE'ly 5-8 knots, calm sea, slight swell. Scientists spotted sunbathing. NE'ly <5 knots, calm, slight swell.

26th Nov	0756 1215	**Event 224:** CTD (steel) by wirewalker mooring. Move to recover wirewalker. Wirewalker recovered. Move to recover OMG glider. Glider recovered. Move to recover Seaglider. Seaglider recovered. **Event 225:** CTD (steel) noon profile with wirewalker instruments attached. **Events 226-227:** Marine snowcatcher, 15m **Events 228-230:** zooplankton nets. **Events 231-232:** Marine snowcatcher, 100m.	NE'ly <5 knots.
27th Nov	0815 1127 1424 1704 1807	**Event 233:** CTD (titanium) at J08 **Event 234:** CTD (titanium) at J07 (Jones Bank) **Event 235:** CTD (titanium) at J06 **Event 236:** CTD (titanium) at J05 **Event 237:** CTD (steel) for radium at J05	SE'ly 25-30 knots, moderate sea, slight swell. ESE'ly 40 knots, rough sea, moderate swell.
28th Nov	0800 1135 1444 1954	Station J04 aborted – initially delayed because of fishing boat, then cancelled because of TM winch problems. **Event 238:** CTD (steel) at J03 **Event 239:** CTD (steel) at J02 **Events 240-241:** zooplankton nets at J02. J01 skipped due to time constraints. **Event 242:** CTD (titanium) at site A **Events 243-245:** NIOZ box corer **Events 246-250:** zooplankton nets **Events 251-252:** NIOZ box corer	E'ly 25-30 knots, rough sea, moderate swell.
29th Nov	 1405	Steam for CCS **Event 253:** CTD (titanium) at station CCS **Event 254:** Marine snowcatcher (large) 100m **Event 255:** Marine snowcatcher (small) 15m **Event 256:** Marine snowcatcher (large) 100m **Event 257:** Marine snowcatcher (small) 100m **Events 258-259:** zooplankton nets	NE'ly 5-10 knots, calm sea, moderate swell.
30th Nov	0958 1130	**Event 260:** CTD (titanium) – no sample bottles attached, just pure T/S data. Steam for E1	N'ly 5-10 knots, calm sea, slight swell.
1st Dec	0600	Arrive E1	

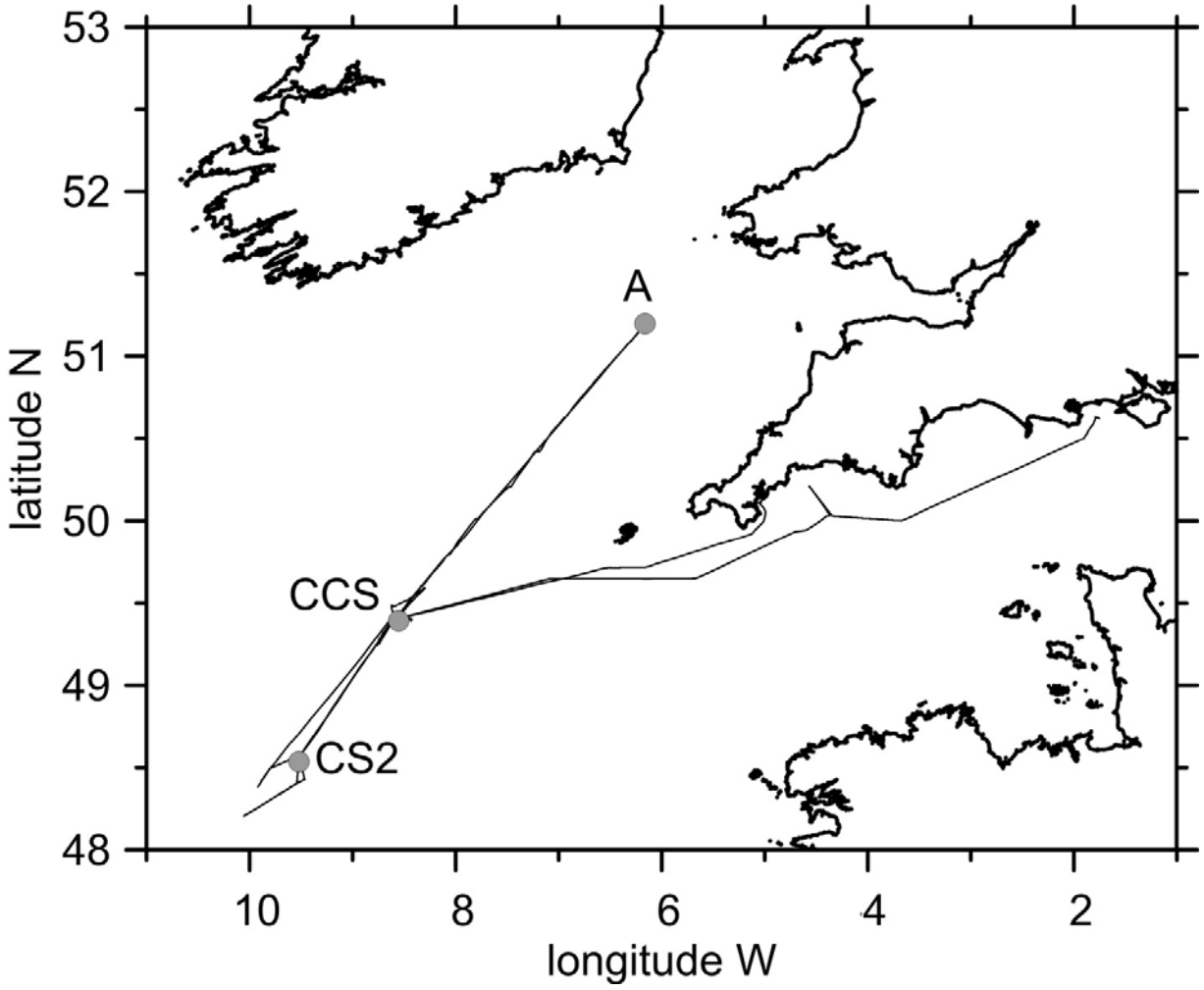
	0630 0800	**Event 261:** CTD (titanium) at E1 **Events 262-267:** NIOZ box cores at E1, transferred to Steve Widdicombe PML. **Event 268:** zooplankton net. Steam for Christchurch Bay and Southampton.	N'ly 15-20 knots, calm sea, slight swell. NE'ly 5-10 knots, calm sea, no swell.
2nd Dec	0840 1230 1700	Begin run in towards Christchurch Bay, collecting surface water samples. Steam to meet pilot. Alongside Empress Dock.	N'ly 25-30 knots, rough sea, no swell.

Station Positions:

Note: positions are nominal. Refer to logs of individual events to get more precise information.

Station ID	Latitude N	Longitude W	Depth	Comments
CCS	49° 24'	8° 36'	150m	Main mooring site.
CS2	48° 34.26'	9° 30.58'	203m	Shelf edge station.
O1	49° 16.0'	8° 45.0'	152m	Transect between CCS and CS2
O2	49° 07.7'	8° 54.3'	157m	"
O3	49° 00.0'	9° 02.7'	155m	"
O4	48° 51.2'	9° 12.0'	166m	"
O5	48° 43.1'	9° 21.1'	170m	"
Fe01	48 12.35	10 3.24	2422m	Iron transect 1
Fe02	48 14.37	9 57.92	2001m	"
Fe03	48 20.45	9 42.25	1480m	"
Fe04	48 22.21	9 37.71	934m	"
Fe05	48 22.69	9 36.49	727m	"
Fe06	48 24.53	9 31.56	469m	"
Fe07	48 25.71	9 28.03	247m	"
Fe08	48 23.11	9 55.06	2597m	Iron transect 2
Fe09	48 23.97	9 54.06	1954m	"
Fe10	48 24.61	9 53.37	1555m	"
Fe11	48 25.33	9 52.72	922m	"
Fe12	48 25.77	9 52.26	705m	"
Fe13	48 26.24	9 51.78	485m	"
Fe14	48 29.49	9 48.51	250m	"
J1	51° 01.5'	6° 23.75'	Not sampled	Transect between site A and CCS
J2	50° 49.7'	6° 40.0'	103m	"
J3	50° 37.5'	6° 56.5'	111m	"
J4	50° 25.2'	7° 13.7'	Not sampled	"
J5	50° 12.7'	7° 30.0'	115m	"
J6	50° 00.8'	7° 46.6'	118m	"
J7	49° 48.5'	8° 03.0'	91m	"
J8	49° 36.3'	8° 19.8'	145m	"
A	51° 12.8'	6° 7.8'	111m	Benthic workpackage site A

Cruise track



2. Underway navigation, sea surface hydrography and meteorology

Louise Darroch (BODC)[1], Jo Hopkins[2]
[1]Author, [2]Dataset PI

Background and objectives

The underway navigation, sea surface hydrography and meteorology were processed on board DY018 by Louise Darroch (British Oceanographic Data Centre (BODC)) on behalf of Jo Hopkins at the National Oceanography Centre, Liverpool (NOC). The underway data will contribute to WP1.

Instrument description

Navigation

The following navigational sensors were used for processing positions, ship heading and sea floor depth (Table 1.1). The POS MV GPS unit was one of the primary GPS sources for science. It was capable of differential GPS (DGPS) and was accurate to 0.5 m. The system was not prone to drop outs and was considered an ideal substitute for the UKORS *bestnav* navigational stream which faulty during the cruise. The POS MV system also comprises an Inertial Measurement Unit (IMU) which was accurate to 0.010° with a 4 m baseline. The gyro heading was filtered and was preferred to the ship gyro which may be prone to oscillations. The Kongsberg Simrad EM122 swath bathymetry sensor was located on the port drop keel approximately 6.5 m below seawater (when retracted). The central beam was the preferred source of sea floor depth because it was corrected for local sound velocity during the cruise using sound velocity probes (SVP) mounted on the stainless steel CTD frame and was not prone to heavy noise.

Meteorology

The suite of ship-fitted meteorological sensors formed part of the ship's scientific *surfmet* system. The sensors were mounted on the meteorology platform which was located on the ship's foremast at the bow of the ship. According to the ship's plans, the foremast was approximately 17.4 m above typical sea level (16.2 m above the maximum loading mark - 7 m draft mark) and approximately 38 m in front of the nearest ship superstructure. Table 1.2 describes the current suite of sensors. Figure 1.1 shows the orientation of sensors on the platform. The met platform had two sonic anemometers. The starboard-side was used for science while the port-side anemometer was used by the MET office. The scientific anemometer orientation was 0^{o} on the bow.

Sea surface hydrography

The suite of ship-fitted sea surface hydrography sensors formed part of the ship's scientific *surfmet* system (Table 1.2). The sea surface hydrography suite of sensors were plumbed, in-line, to the clean seawater pumped system. The Sea-Bird SBE 38 temperature sensor (SST) was located close to the seawater intake towards the hull of the ship where it was less likely to suffer from any interior heating effects. The remaining sensors were located in the clean seawater laboratory on the main deck, directly above the intake pipe (estimated to be ~ 5 m). The depth of the seawater intake was estimated to be approximately 6 m below sea level. In the clean laboratory, the flow of seawater through the system was initially down-regulated to 16-18 L/min using a flow meter and de-bubbled using an Instrument Laboratory, Vortex VDB-1H de-bubbler. The flow was then further regulated to approximately 1500 ml/min using a floating ball flow meter prior to the first sensor, the fluorometer. This was followed in-line by the transmissometer and finally the thermosalinograph (TSG) before the water was wasted to the drain.

Data processing

Output from the *surfmet* sensors were initially logged by a designated PC. Some of the sensor's firmware, connection modules and PC software manipulated the output (Figure 1.2). All the sensors used (including the *surfmet* sensors) were then registered by the TECHSAS logging system and broadcast to NetCDF, pseudo-TECHSAS ascii and UKORS format in the *raw_data* area of the level-C logging system. At the time of the cruise, the Skipper DL 850 Doppler speed log was faulty and processing to *bestnav*, *prodep* or *prowind* in the Level-C logging system was not possible. Consequently, underway data were extracted from the pseudo-TECHSAS ascii files (at 1 Hz resolution). The meteorological, fluorescence and transmittance sensors were not recorded in pseudo-TECHSAS ascii format and were instead extracted from the level-C *raw_data*, *surfmet* stream which had been converted to ascii.

Navigation

Daily pseudo-TECHSAS ascii files were copied to the local PC where they were reformatted and appended using the following matlab scripts:

uw_nav – reformatted daily 1 Hz POS MV positional files *(#Applanix_GPS_DY1.aplnx*) to ascii (*DY018_NAV_#_raw.txt*).

uw_swath - reformatted daily 1 Hz swath files *(#EM120_DY1.EM1_1*) to ascii (*DY018_SWATH_#_raw.txt*).

uw_gyro - reformatted daily 1 Hz POS MV gyro files *(#-GYRO1_DY1.GYRO1*) to ascii (*DY018_GYRO1_#_raw.txt*).

uw_append – appended daily 1 Hz ascii files to master ascii files (*DY018_NAV_master_raw.txt, DY018_SWATH_master_raw.txt* and *DY018_GYRO1_master_raw.txt*)

The swath bathymetry was filtered of noise and averaged as follows:

uw_swclean – filtered the swath bathymetry (*DY018_SWATH_master_raw.txt*). Output: *DY018_SWATH_master_filt.txt.*

uw_swavg – averaged the filtered 1 Hz data (*DY018_SWATH_master_filt.txt*) over 30 second intervals (*DY018_SWATH_master_30secav.txt*).

Swath bathymetry

The swath bathymetry was filtered of noise twice by applying a moving average window of 60 seconds and removing all data outside 2 standard deviations of that average.

Ship velocity and distance run

Ship velocities and distance run will be derived after the cruise.

Sea surface temperature and TSG

Sea surface temperature (SST) and SBE 45 TSG channels were duplicated in both the *sbe45* and *surfmet* streams, however, the *sbe45* stream was considered the best source for this data as it is unlikely to be delayed in time. Therefore, daily pseudo-TECHSAS ascii files were copied to the local PC where they were reformatted, appended and cleaned using the following matlab scripts:

uw_tsg - reformatted daily 1 Hz TSG files *(#SBE45_DY1.SBE45*) to ascii (*DY018_TSG_#_raw.txt*).

uw_append – appended daily 1 Hz ascii files to a master ascii file (*DY018_TSG_master_raw.txt*)

uw_tsgclean – applied moving average filters to the TSG data (*temph, cond* and *salin*). Flagged suspect data ~ day 318. Output: *DY018_TSG_master_filt.txt*

TSG temperature, conductivity and salinity
All channels were filtered of noise once by applying a moving average window of 60 seconds and removing all data outside 3 standard deviations of that average. This was particularly necessary for salinity. However this did not remove regular tailed spikes that were present in all the channels.

Meteorology, fluorescence and transmittance
The level-C, *surfmet.txt* ascii file was copied to the local PC where it was reformatted, cleaned and calibrated as follows:

uw_surf – reformatted the 1 Hz *surfmet.txt* file to ascii (*DY018_SURF_master_raw.txt*)
uw_sfclean – removed drop outs in the *surfmet* stream and flagged suspect data. Applied moving average filters to air temperature, relative wind speed and fluorescence.
uw_surfcal – applied manufacturer calibrations to fluorescence, transmittance and light.

Relative wind speed
Relative wind speed was filtered of noise once by applying a moving average window of 60 seconds and removing all data outside 1 standard deviation of that average.

Air temperature
Air temperature was filtered of noise once by applying a moving average window of 60 seconds and removing all data outside 1 standard deviation of that average.

Fluorescence
Fluorescence was filtered of noise once by applying a moving average window of 60 seconds and removing all data outside 3 standard deviations of that average.

True wind speed and direction
Wind speed and direction will be corrected for ship movement after the cruise. Data may also be obtained from the MET office anemometer if it is deemed that the anemometer was faulty.

Manufacturer calibrations applied by uw_surfcal
The fluorescence voltage channel (*fluo*) was converted to engineering units (*chla*) using the following calibration:

$$Chl\,a\ [\mu g l^{-1}] = SF\left(fluo - CWO\right)$$

where SF = 4.8 µg/L/V and CWO = 0.053 V.

The transmissometer voltage channel (*trans*) was converted to beam transmission (*beamtrans*) and beam attenuation (*atten*) as follows:

$$trans\,[\mathrm{V}] = trans \geq Vdark$$

$$beamtrans\,[\%] = \left(\frac{trans - Vdark}{Vref - Vdark}\right) \times 100$$

$$atten\ [\mathrm{m}^{-1}] = \left(-\frac{1}{pathlength}\right) \ln\left(\frac{beamtrans}{100}\right)$$

where Vdark = 0.059 V, Vref = 4.662 V and pathlength = 0.25 m.

The raw light channels (*ppar, spar, ptir, stir*) were initially converted to volts and calibrated as follows:

$$[\text{voltage}] = raw \times 10^{-5}$$

$$[\text{W m}^{-2}] = \left(\text{voltage} \times 10^{6}\right) / x$$

where *raw* is the raw light channel, *voltage* is the output in volts and *x* is the calibration scale factor. Scale factors were as follows for each sensor:

spar = 10.36 µV/W m^{-2} (s/n 28556, starboard, 04/07/2013)
ppar = 11.03 µV/W m^{-2} (s/n 28559, port, 04/07/2013)
stir = 11.94 µV/W m^{-2} (s/n 047462, starboard, 29/05/2013)
ptir = 10.67 µV/W m^{-2} (s/n 047463, port, 29/05/2013)

Field calibration
Salinity and SST will be calibrated against underway discrete salinity samples and CTD temperature after the cruise.

Data quality notes
The anemometer was considered faulty for the duration of the cruise. Relative wind speed appeared to be reading lower than expected and relative wind direction contained sporadic negative readings.
The port-side PAR sensor readings were noisy in comparison to the starboard sensor through the cruise. It was thought the sensor had a loose connection.

There was a large offset between the port and starboard TIR sensors after calibration with manufacturer coefficients. This did not appear to be due to shading effects. Both sensors were sent for calibration at the same time meaning that the time between calibrations was not a factor. It was not clear which sensor was reading correctly.

The transmissometer was affected by trapped bubbles in the detector chamber throughout the cruise. This severely degraded the data. The ship-fitted technicians were aware of the problem and may solve the issue by using wider or longer tubing leading into the sensor, or introducing a de-bubbler. The data were considered unusable for DY018.

Data from the SBE45 MicroTSG contained regular tailed spikes. Presumably this was caused by bubbles trapped in the system. These channels will be manually de-spiked after the cruise.

Table 1.1. Navigation sensors used for processing

Manufacturer	Model	Function/Data types	Comments
Applanix	POSMV 320 V5	DGPS and IMU 7	General use gyro. Secondary *bestnav* positional source.
Kongsberg	EM122	Deep Water Multi-Beam echo sounder	Port drop keel

Table 1.2. Surfmet sensors used for processing

Make	Model	Sensor	Serial number	Location (e.g Port)	Last calibration date	Comments (e.g accuracy)
WETLabs	WETStar		WS3S-247		12/06/2013	

WETLabs	CSTAR		CST-1141PR		19/07/2013	25 cm pathlength, 660 nm
Sea-Bird	SBE45		4548881-0232		18/10/2013	
Sea-Bird	SBE38		3854115-0476		11/01/2014	
Skye	SKE 510		28556	Starboard	04/07/2013	
Skye	SKE 510		28559	Port	04/07/2013	
Kipp & Zonen	CM 6B		047463	Port	29/05/2013	
Kipp & Zonen	CM 6B		047462	Starboard	29/05/2013	
Gill	Windsonic	Option 3	250004845 (071123)	Starboard	No calibration required	Suspect readings
Vaisala	PTB110		J0710001		03/03/2013	
Vaisala	HMP155		K0950056		28/02/2014	

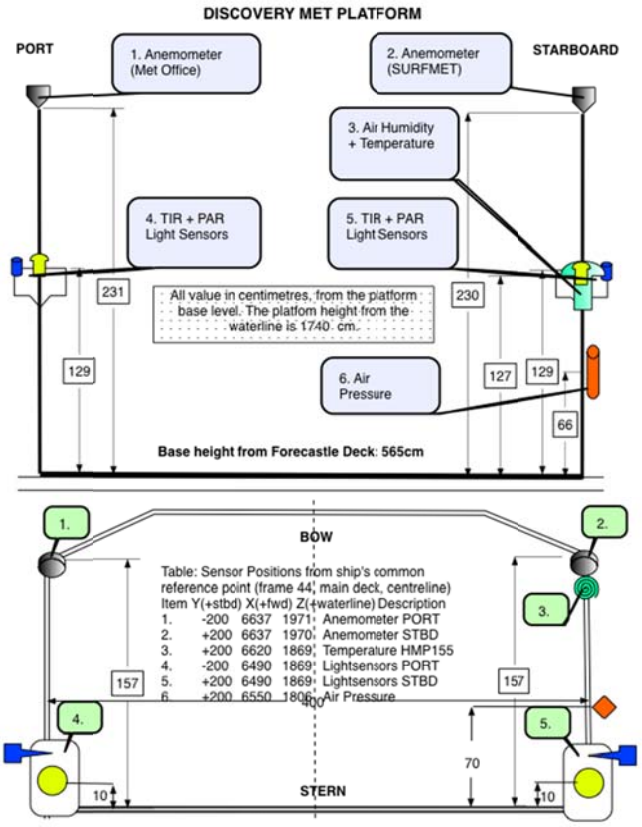


Figure 1.1. Schematic of Discovery met platform layout

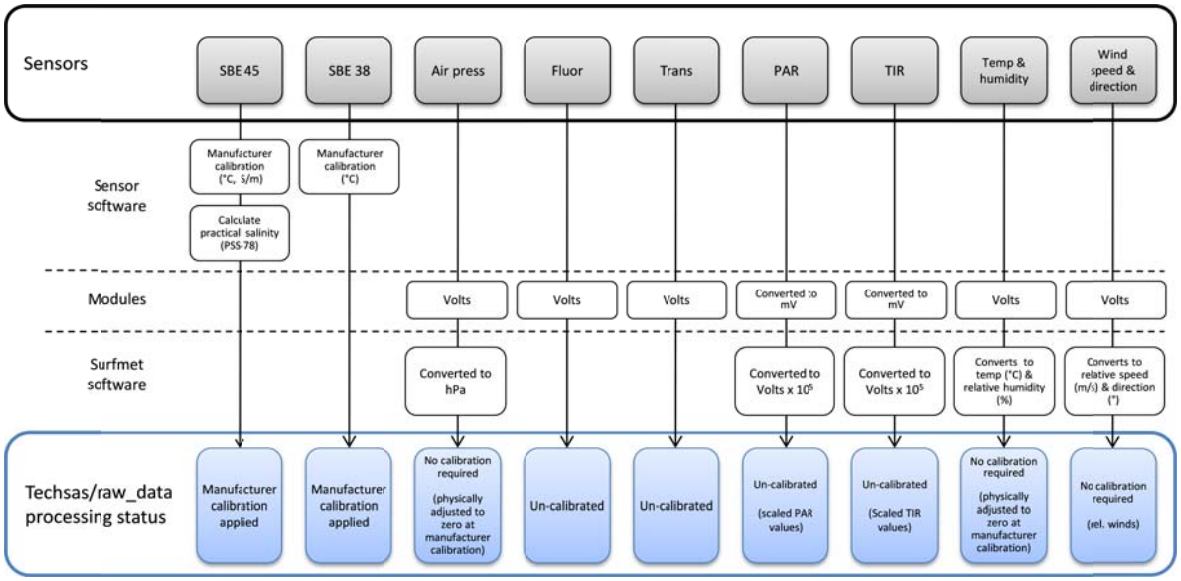


Figure 1.2. Surfmet data processing. Diagrams shows the processing route from sensor to *raw_data* in the level-C logging system.

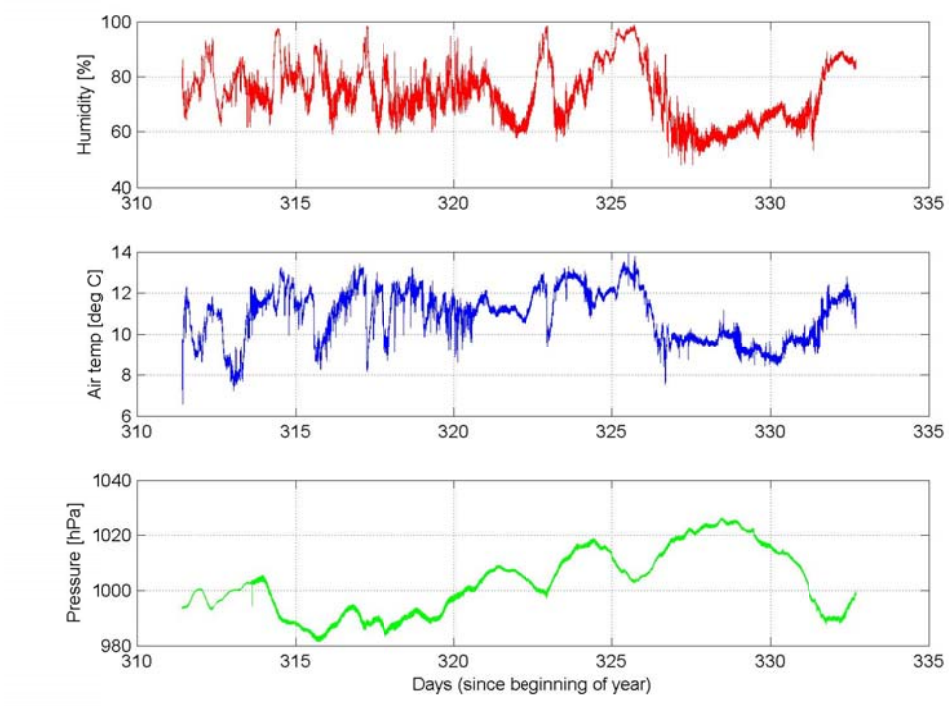


Figure 1.3. Swath bathymetry averaged to 30 seconds (top), sea surface temperature (tempr, middle), TSG housing temperature (temph, middle) and salinity (bottom).

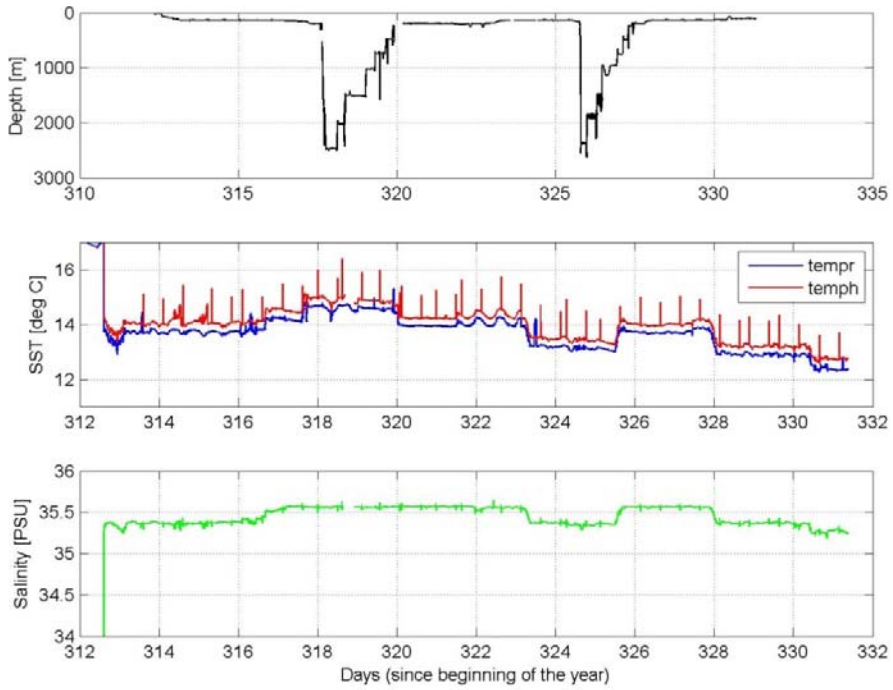


Figure 1.4. Relative humidity (top), air temperature(middle) and air pressure (bottom).

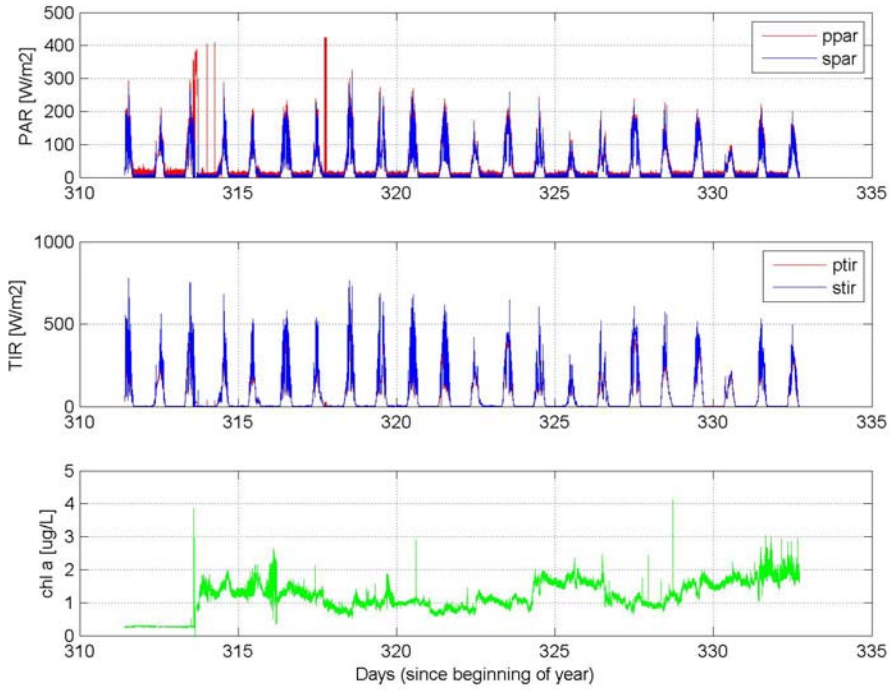


Figure 1.5. PAR (top), TIR (middle) and chlorophyll a (bottom)

3. CTD Processing

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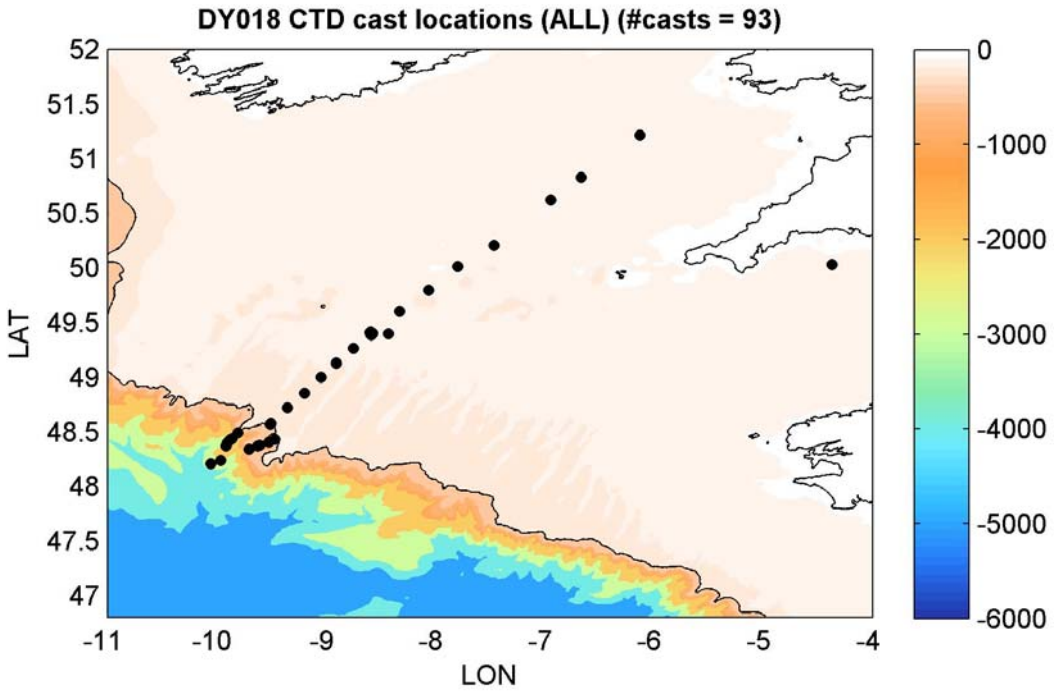
A total of 66 casts with the stainless steel frame and 27 casts with the titanium CTD frame were completed. See technical reports for sensor serial numbers and channels.

Map of CTD cast locations



Raw data files:

The following raw data files were generated for the stainless CTD:

DY018_CTD001.bl (a record of bottle firing locations)
DY018_CTD001.hdr (header file)
DY018_CTD001.hex (raw data file)
DY018_CTD001.con (configuration file)

Where _CTD001 is the cast number (not STNNBR)

Files generated by the titanium CTD frame have a suffix 'T', e.g DY018_CTD004T.bl etc

The following casts were aborted and are not processed further: 24, 62T, 72T, 91T

SBEDataProcessing steps

The following processing routines were run in the SBEDataProcessing software (Seasave Version 7.23.2):

1. **DatCnv:** A conversion routine to read in the raw CTD data file (.hex) containing data in engineering units output by the CTD hardware. Calibrations as appropriate though the instrument configuration file (.CON) are applied.

   Data Setup options were set to the following:

   Process scans to end of file: yes
   Scans to skip: 0
   Output format: ascii
   Convert data from: upcast & downcast
   Create file types: both bottle and data
   Source of scan range data: bottle log .BL file
   Scan range offset: -2.5 seconds for stainless, -1 second for titanium
   Scan range duration: 5 seconds for stainless, 1 second for titanium
   Merge separate header file: No
   Apply oxygen hysteresis correction: yes (2 second window)
   Apply oxygen Tau correction: yes

   Selected output variables:

   - Time [seconds]
   - Pressure [db]
   - Temperature [ITS-90, °C] and Temperature 2 [ITS-90, °C], referring to primary and secondary sensors)
   - Conductivity and Conductivity 2 [S/m]
   - Salinity and salinity 2 [PSU, PSS-78]
   - Oxygen raw, SBE 43 [V]
   - Oxygen, SBE 43 [µmol/l]
   - Beam attenuation [1/m]
   - Fluorescence [µg/l]
   - PAR/irradiance, downwelling [W m^2] *[stainless steel frame only]*
   - Turbidity [m^{-1} sr^{-1}]
   - Altimeter [m]
   - Voltage channel 2: Downwelling Irradiance sensor (DWIRR) *[stainless steel frame only]*
   - Voltage channel 4: Altimeter
   - Voltage channel 5: Light scattering Wetlabs BBRTD
   - Voltage channel 6: Transmissometer
   - Voltage channel 7: Fluorometer

2. **Bottle Summary** was run to create a .BTL file containing the average, standard deviation, min and max values at bottle firings. .ROS files were placed in the same directory as the .bl files during this routine to ensure that bottle rosette position was captured in the .btl file.

   Output saved to DY018_CTD001.btl (DY018_CTD004T.btl)

3. **Wild Edit:** Removal of pressure spikes

   Standard deviations for pass 1: 2
   Standard deviations for pass 2: 20

Scans per black: 100
Keep data within this distance of the mean: 0
Exclude scans marked as bad: yes

4. **Filter:** Run on the pressure channel to smooth out high frequency data
   Low pass filter time B: 0.15 seconds
5. **AlignCTD:** Based on examination of different casts a 3 second advance was chosen for alignment of the oxygen sensor on the stainless steel CTD and 4 seconds for the titanium casts. This alignment is a function of the temperature and the state of the oxygen sensor membrane. The colder (deeper) the water the greater the advance needed. The above alignments were chosen as a compromise between results in deep (cold) and shallow (warmer) waters.

6. **CellTM:** Removes the effect of thermal inertia on the conductivity cells. Alpha = 0.03 (thermal anomaly amplitude) and 1/beta = 7 (thermal anomaly time constant) for both cells.

   Output of steps 1-6 above saved in DY018_CTD001.cnv (24 Hz resolution) (DY018_CTD004T.cnv)

7. **Derive:** Variables selected are
   Salinity and Salinty 2 [PSU, PSS-78]
   Oxygen SBE43 [µmol/l]
   Oxygen Tau correction: yes (2 second window)

   Output saved to DY0018_CTD001_derive.cnv (24 Hz resolution) (DY018_CTD004T_derive.cnv)

8. **BinAverage:** Average into 2Hz (0.5 seconds),
   Exclude bad scans: yes
   Scans to skip over: 0
   Casts to process: Up and down

9. **Strip:** Remove salinity and oxygen channels from the 2 Hz file that were originally created by DatCnv, but then later regenerated by Derive.

   Output saved to DY018_CTD001_derive_2Hz.cnv (DY018_CTD004T_derive_2Hz.cnv)

Matlab processing steps

The following processing steps were performed in MATLAB:

(1) Create a .mat file of meta data extracted from the cruise Event Log with the following variables:

CRUISECODE e.g. DY018
STNNBR (as per BODC data management guidance for the Shelf Sea Biogeochemistry programme)
DATE and TIME of the cast at the bottom of the profile
LAT and LON when the CTD was at the bottom of the profile
DEPTH (nominal water depth in metres from echo sounder)
CAST (CTD cast number, e.g. 001)

File created: DY018_metadata.mat

(2) Extract data from 2Hz averaged files (e.g. DY018_CTD001_derive_2Hz.cnv), merge with metadata and save into a matlab structure for each cast. Each file (DY018_CTD001_derive_2Hz.mat) contains the following un-calibrated channels.

CTD001 =

CRUISE: 'DY018'
CAST: 1
STNNBR: 1
DATE: '10/11/2014'
TIME: '05:12'
LAT: 49.4013
LON: -8.5802
DEPTH: 151 [m]
CTDtime: [6706x1 double] [seconds]
CTDpres: [6706x1 double] [db]
CTDtemp1: [6706x1 double] [°C]
CTDtemp2: [6706x1 double] [°C]
CTDcond1: [6706x1 double] [S/m]
CTDcond2: [6706x1 double] [S/m]
CTDoxy_raw: [6706x1 double] [V]
CTDatt: [6706x1 double] [1/m]
CTDfluor: [6706x1 double] [µg/l]
CTDpar: [6706x1 double] [Wm^2] [STAINLESS ONLY]
CTDturb: [6706x1 double] [m^{-1} s^{-1}]
CTDalt: [6706x1 double] [m]
CTDpar_dn_raw: [6706x1 double] [V] [STAINLESS ONLY]
CTDalt_raw: [6706x1 double] [V]
CTDturb_raw: [6706x1 double] [V]
CTDatt_raw: [6706x1 double] [V]
CTDfluor_raw: [6706x1 double] [V]
CTDsal1: [6706x1 double] [PSU]
CTDsal2: [6706x1 double] [PSU]
CTDoxy_umoll: [6706x1 double] [µmol/l]
CTDflag: [6706x1 double]

(3) Extract data from 24Hz files (e.g. DY018_CTD001_derive.cnv), merge with metadata and save into a matlab structure for each cast. Each file (DY008_001_derive.mat) contains the following un-calibrated channels.

CTD001 =

CRUISE: 'DY018'
CAST: 1
STNNBR: 1
DATE: '10/11/2014'
TIME: '05:12'

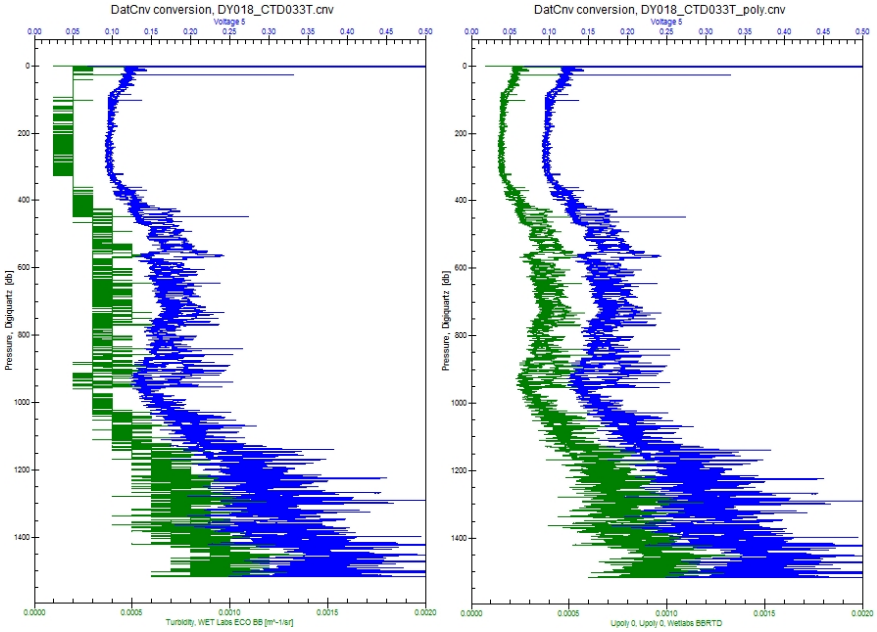
LAT: 49.4013
LON: -8.5802
DEPTH: 151 [m]
CTDtime: [80468x1 double] [seconds]
CTDpres: [80468x1 double] [db]
CTDtemp1: [80468x1 double] [°C]
CTDtemp2: [80468x1 double] [°C]
CTDcond1: [80468x1 double] [S/m]
CTDcond2: [80468x1 double] [S/m]
CTDsal1_1: [80468x1 double] [PSU]
CTDsal2_1: [80468x1 double] [PSU]
CTDoxy_raw: [80468x1 double] [V]
CTD_oxy_umoll_1: [80468x1 double] [µmol/l]
CTDatt: [80468x1 double] [1/m]
CTDfluor: [80468x1 double] [µg/l]
CTDpar: [80468x1 double] [Wm^2] [STAINLESS ONLY]
CTDturb: [80468x1 double] [m^{-1} s^{-1}]
CTDalt: [80468x1 double] [m]
CTDpar_dn_raw: [80468x1 double] [V] [STAINLESS ONLY]
CTDalt_raw: [80468x1 double] [V]
CTDturb_raw: [80468x1 double] [V]
CTDatt_raw: [80468x1 double] [V]
CTDfluor_raw: [80468x1 double] [V]
CTDsal1: [80468x1 double] [PSU]
CTDsal2: [80468x1 double] [PSU]
CTDoxy_umoll: [80468x1 double] [µmol/l]
CTDflag: [80468x1 double]

Note that '_1' for the first instances of salinity and oxygen in this file are variables before re-derivation in the SeaBird Processing routines.

Inspection of the turbidity channel (CTDturb) and comparison to the original raw voltage (CTDturb_raw) revealed a potential bug in the SeaBird DatCnv conversion module. Somewhere in the module values are being discretized. This is demonstrated below (left) where the raw voltage channel (blue) is compared to the SeaBird DatCnv output (green). Direct conversion using the scale factor (SF) and dark counts (DC) supplied in the manufacturer's calibration appears to rectify this problem (right plot). We therefore replace the original turbidity channel in the .cnv files with a corrected version using:

CTDturb = CTDturb_raw .* SF - (SF x DC);

This appears to reinstate the original resolution.



(4) Manual identification of the surface soak (while waiting for pumps to turn on) and the end of the downcast using the 2Hz files. Times to crop were saved to DY018_stainless_castcrop_times.mat and DY018_titanium_castcrop_times.mat

CAST: [14x6 char]
STNNBR: [14x1 double]
CTDstart: [14x1 double] [seconds]
CTDstop: [14x1 double] [seconds]

This was then used to crop both the 2Hz and 24Hz files and output (i.e. just the downcast recordings) saved to DY018_CTD001_derive_2Hz_cropped.mat and DY018_CTD001_derive_cropped.mat respectively.

(5) De-spiking of downcast 24 Hz data. The salinity, conductivity, temperature, oxygen, attenuation, turbidity and fluorescence channels were all de-spiked. The worst spikes were identified using an automated routine (similar to WildEdit) where the data was scanned twice and points falling outside a threshold of *nstd* x standard deviations from the mean within a set window size were removed (turned into NaNs).

Window size (#scans) and number of standard deviations from the mean (nstd) used for each channel.

Channel	*Pass 1 window*	*Pass 1 nstd*	*Pass 2 window*	*Pass 2 nstd*
Temperature, conductivity, fluorescence	100	3	200	3
Salinity, turbidity	200	2	200	3
Oxygen	100	2	200	3

Auto-despiking saved to DY018_CTD001_derived_cropped_autospike.mat

Manual de-spiking was then performed to remove larger sections of bad data or any remaining isolated spikes in each channel.

Large 'spikes' were regularly observed in the CT sensors lasting a few seconds, predominantly in the thermocline. This is a persistent problem in shallow water with strong property gradients (e.g. see for example D352, D376); particularly where a large CTD package carrying large volume bottles is used. The spikes coincide with a decrease in the decent rate of the CTD package and are therefore likely associated with inefficient flushing of water around the sensors. It is caused by the pitch and roll of the boat, so is accentuated in rough weather. As the decent rate of the CTD package slows on the downcast 'old' water (from above and therefore typically warmer) is pushed back passed the sensors. As the decent rate increases again 'new' water is flushed past the sensors. A similar problem can occur if the veer rate on the CTD winch varies (as was the case on CD173).

The largest and most significant warm anomalies identified in the primary CT sensors were removed from all variables (incl. turbidity, oxygen, chlorophyll and attenuation since these sensors would also be sampling 'old' water during these periods). This was at times up to 5 m of the profile. Anomalies identified in the secondary sensors were only removed from the secondary temperature, salinity and conductivity channels. The impact of smaller scale anomalies that were not removed is mostly minimised during the averaging processes, but care should be taken when interpreting smaller scale features, particularly through the thermocline. The casts are more than good enough for looking at large scale trends and anomalies but should probably not be used for Thorpe scale analysis and interpretation of fine scale structures. To achieve this in a shelf sea environment free fall profiling techniques are more suitable.

Individual, isolated spikes within each channel were only removed (NaN'd) from that particular variable.

Output saved to DY018_CTD001_derived_cropped_autospike_manualspike.mat

Additional channels added into this file:

Vectors of 0's and 1's indicating data that has been NaN'd (=1). Outputs depend on channels loaded and viewed so each column may have variable meaning and is saved for processing archive purposes only.

Pindex: [18900x3 double]
Sindex: [18900x3 double]
Aindex: [18900x4 double]

(6) Average 24Hz (cropped and de-spiked data) into 1 db bins and then interpolate (linearly) across any missing points.

Files for each cast were created: DY018_001_1db_dn.mat

(7) Application of calibrations to salinity, chlorophyll and oxygen in 1db downcasts. Calibrated files saved to DY018_001_1db_dn_calib.mat.

Sigma theta (σ_θ) (relative to 0 pressure) is also calculated at this stage using the matlab function sw_pden-1000 from the SEAWATER toolkit.

CTD001 =

CRUISE: 'DY018'
CAST: 1
STNNBR: 1
DATE: '10/11/2014'
TIME: '05:12'
LAT: 49.4013
LON: -8.5802
DEPTH: 151
pres: [140x1 double] [db]
time: [140x1 double] [seconds]
temp1: [140x1 double] [°C]
temp2: [140x1 double] [°C]
sal1: [140x1 double] [PSU] - calibrated
sal2: [140x1 double] [PSU] - calibrated
cond1: [140x1 double] [S/m] – not calibrated
cond2: [140x1 double] [S/m] – not calibrated
oxy_umoll: [140x1 double] [µmol/l] – calibrated
fluor: [140x1 double] [µg/l] – calibrated
par: [140x1 double] [Wm^2]
turb: [140x1 double] [m^{-1} s^{-1}]
att: [140x1 double] [1/m]
sigma_theta: [140x1 double]

The calibrations were also applied to the 24 Hz data (cropped and de-spiked) and output to .mat files DY018_001_derive_cropped_autospike_manualspike_calib.mat containing the same variables as above.

(8) Application of salinity, chlorophyll and oxygen calibrations to bottle firing data. A new file, DY018_stainless_btl_calib.mat/ DY018_titanium_btl_calib.mat, with variables CTDsal1_cal, CTDsal2_cal, CTDoxy_umoll_cal and CTDfluor_cal was created.

Notes:
The primary conductivity sensor and oxygen sensor were blocked during cast 81 (stainless) and therefore removed.

From Event 183 onwards the vane on the titanium frame was removed

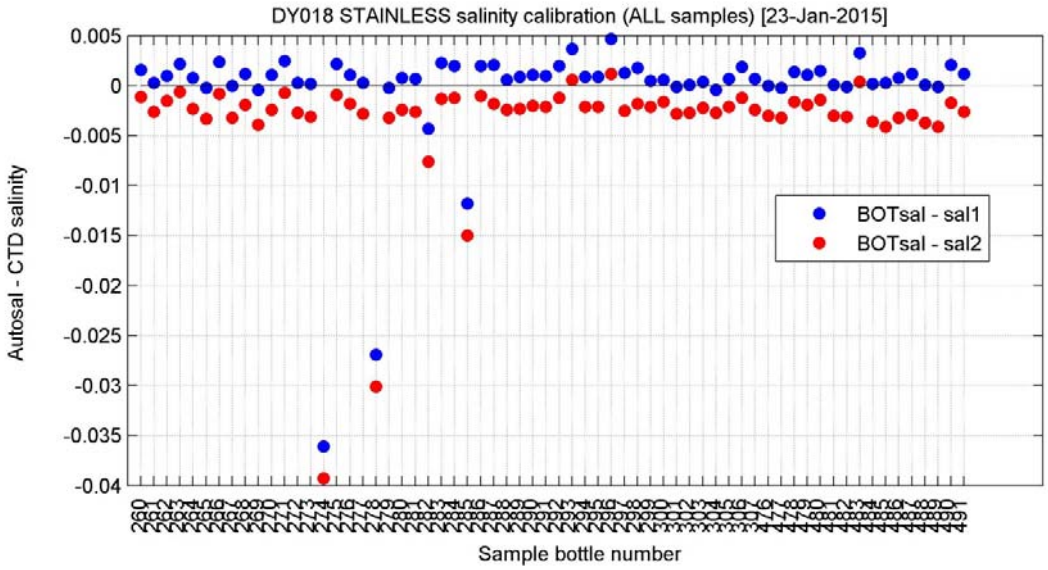
Calibrations

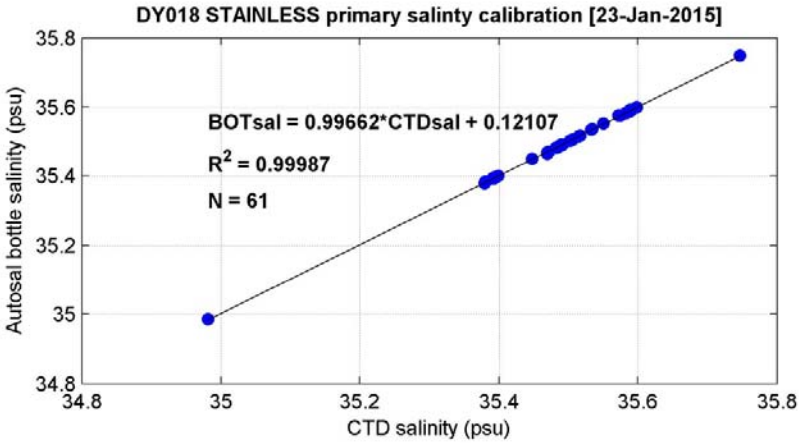
Salinity

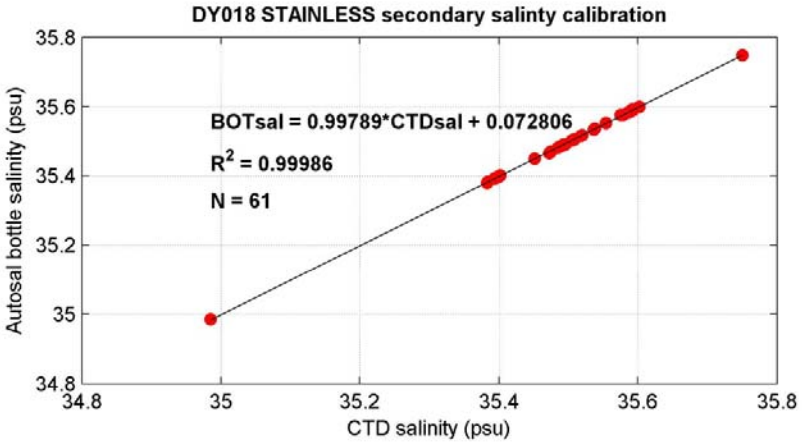
5 samples (bottle #s CTD222, CTD215, CTD235, CTD221 and CTD225) were removed because it was unclear which cast and niskin bottle the sample was taken from.

Stainless CTD

64 salinity samples were taken and analysed on a Guildline Autosal salinometer. Using all samples the mean and standard deviation of residuals from the primary and secondary sensors were -0.00025937 ± 0.0060541 and -0.0034422 ± 0.006066 respectively. After removal of outliers (3 bottles) where the difference between Autosal and CTD values was greater than 1.5 standard deviations the mean ± standard deviations for the primary and secondary sensors was reduced to 0.0009541± 0.0012369 and -0.0022279 ±0.0012792 respectively.

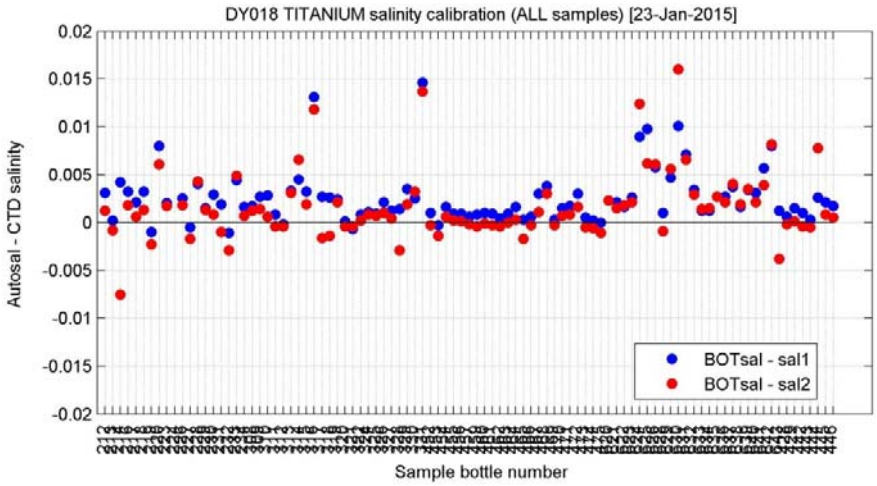


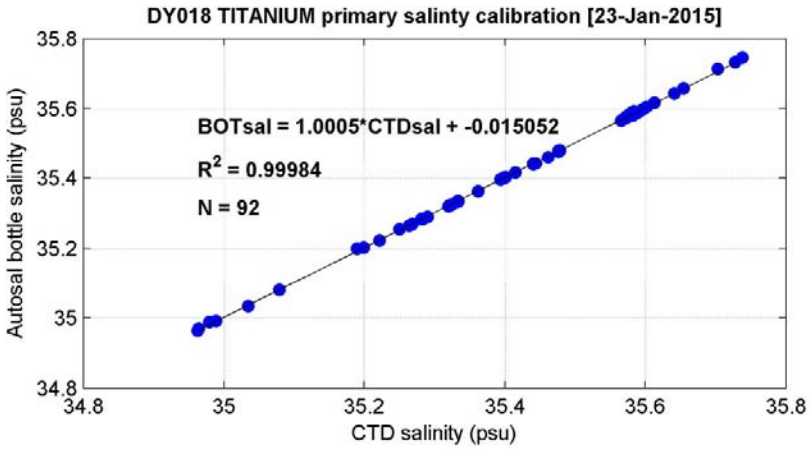


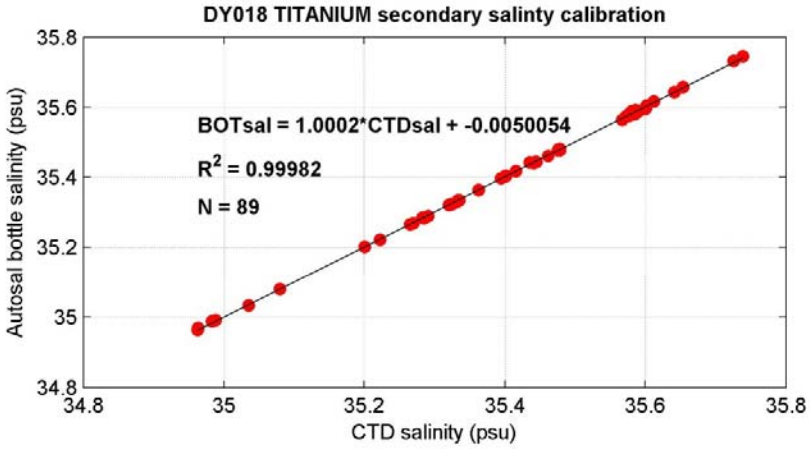


Titanium CTD

95 salinity samples were taken and analysed on a Guildline Autosal salinometer. Using all samples the mean and standard deviation of residuals from the primary and secondary sensors were 0.0042011 ± 0.016468and 0.00328 ± 0.016545 respectively. After removal of outliers where the difference between Autosal and CTD values was greater than 0.5 standard deviations the mean ± standard deviations for the primary and secondary sensors was reduced to 0.0022891± 0.0022131 and - 0.001191± 0.00236 respectively.

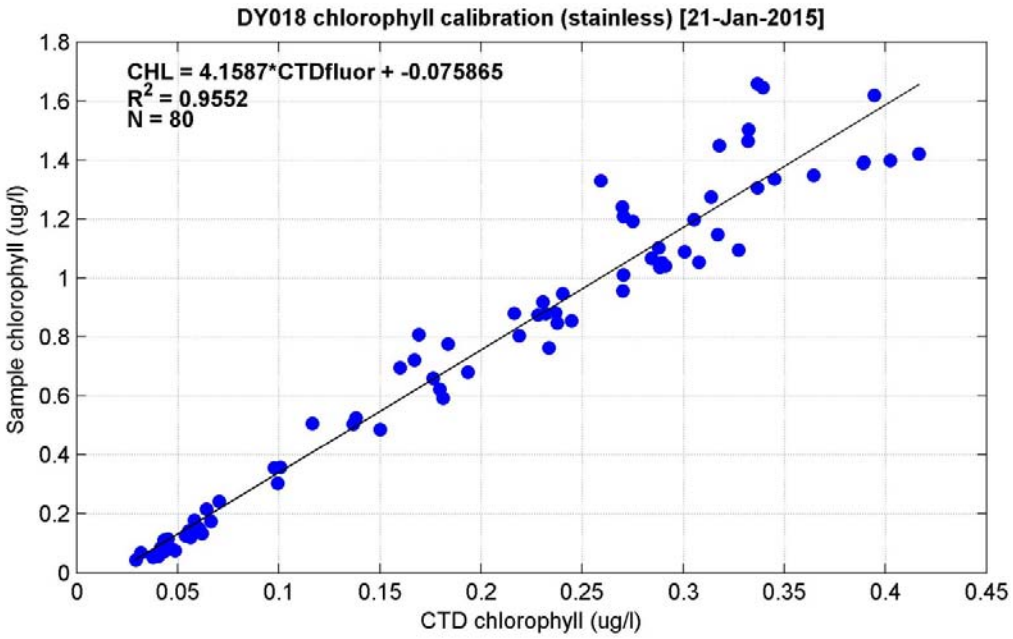


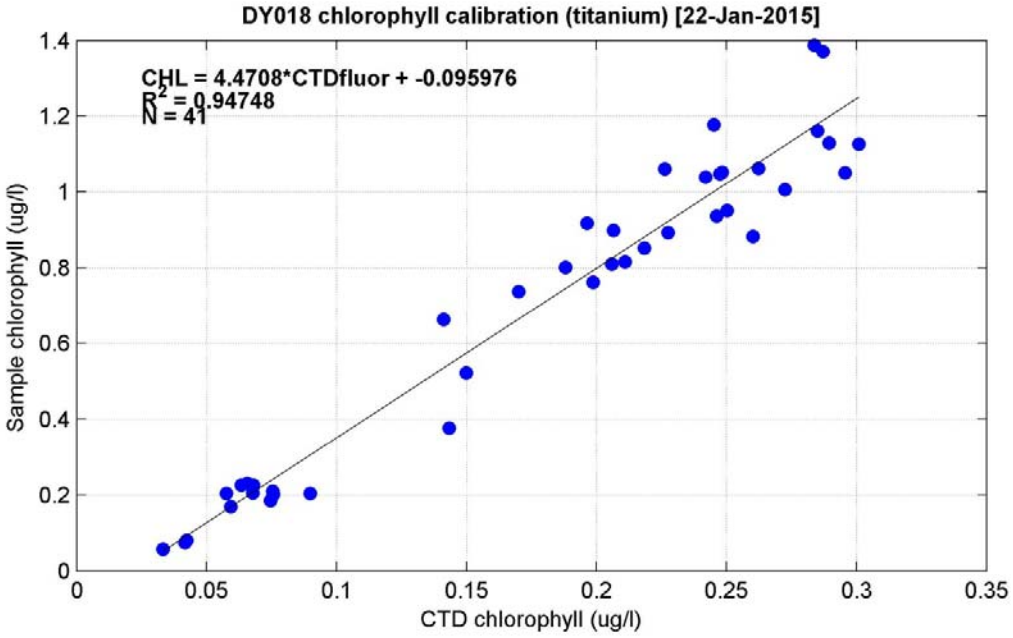




Chlorophyll

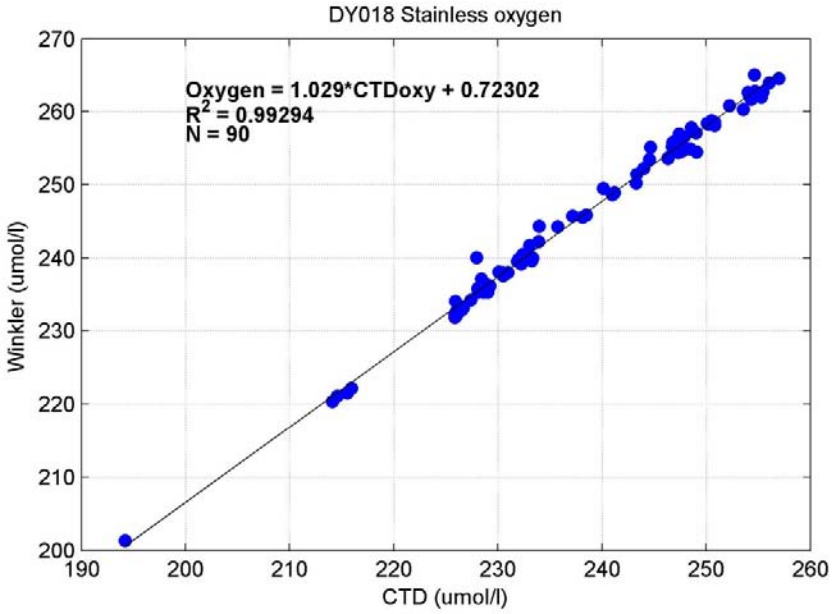
After removal of samples taken during daylight in the surface 30 m, the following calibrations were applied to the stainless and titanium fluorometers.

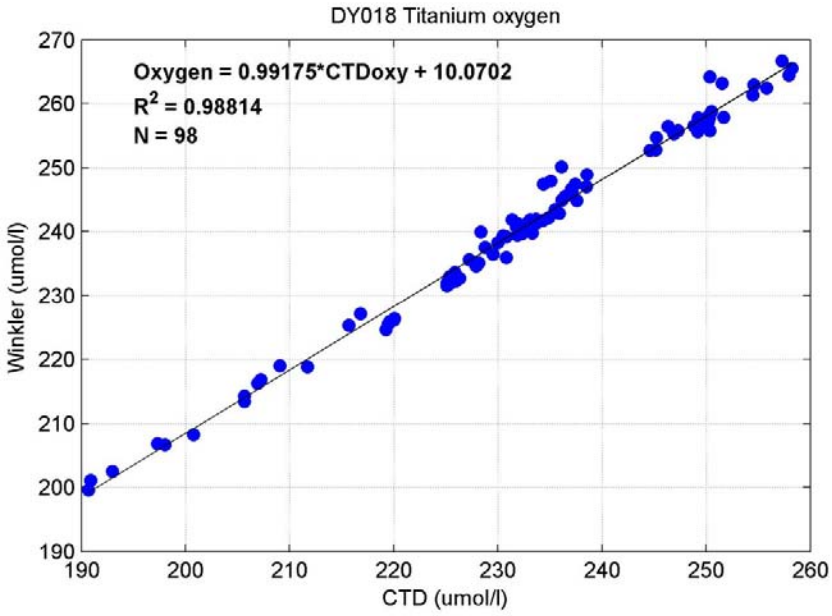




Oxygen

After eliminating any samples that differed from the CTD oxygen sensor by more than 15 umol/l the following calibrations were applied.





Turbidity – no samples were taken for calibration on this cruise

Emails between Seabird and Dougal Mountifield regarding ECO-BB module conversion
Urgent: Wetlabs BB con file module SBE Data Processing problem
Date: Wed, 19 Nov 2014 08:28:13 +0000
From: Dougal Mountifield
To: SeaBird

Hi,

I am currently at sea on RRS Discovery. We are deploying 2 CTD packages which both have Wetlabs BBrtd instruments installed as a 0-5V analog channel on a SBE 9+ underwater unit. We are using the Wetlabs BB module in the con file.
9+ When acquiring the data in Seasave the data from the instrument looks fine, however after data conversion in SBE data processing, and plotting in Seaplot, the profile from the BB is quantised resulting in very poor resolution. The voltage channel is fine (V5). If the BB module in the con file is replaced with a user poly (as used prior to the introduction of the Wetlabs con file module) the result is fine. Have you seen this problem before? Is it possible that the RS-232 digital version of the Wetlabs BB module is applied in error with a 9+ instead of the 0-5V analog version?

Please see the attached graphs, one with V5 and Wetlabs BB module and one with
V5 and user poly. Also attached is the cast specific con file with the BB module selected and the associated instrument calibration sheet from Wetlabs.
We don't have sufficient network bandwidth to send the data file. We are using v.7.23.2, but have also tried some older versions with the same result.

Urgent assistance would be appreciated.

Dougal Mountifield
National Marine Facilities - Sea Systems Sensors & Moorings Group National Oceanography Centre, Southampton UK.
Aboard RRS Discovery.

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From: Stephanie Jaeger [mailto:sjaeger@seabird.com]
Sent: 19 November 2014 21:54
To: dm1@noc.ac.uk
Cc: techsupport@seabird.com; Benson, Jeffrey Ray; Hopkins, Joanne
Subject: RE: Urgent: Wetlabs BB con file module SBE Data Processing problem

Hi Dougal,

Thanks for bringing this to our attention. We haven't noted this issue before, and I will check with the software engineer to clarify the conversion formula that is currently used for the parameter "Turbidity Meter, WET Labs, ECO-BB" in the .xmlcon file. Has the data in the plot that you sent been processed at all beyond the data conversion step?

In the meantime, it sounds like you have found a workaround while on the cruise, using the user polynomial function. It should be a simple conversion step:

Turbidity = ?(?c) = (Output – Dark Output) * Scale Factor

When possible, it will be helpful to have the raw data, if you could send a copy of a HEX file? It could also work if you would like to send a short section of the cast (such as 100 m), as an example.

Let us know if you have any further questions on this.

Regards,

Stephanie

Stephanie Jaeger, M.Sc.
Technical Support
Sea-Bird Electronics

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From: Stephanie Jaeger [sjaeger@seabird.com]
Sent: 12/10/2014 9:25 AM
To: dougal.mountifield@noc.ac.uk;
dm1@noc.ac.uk
Cc: daves@wetlabs.com; jeh200@noc.ac.uk; jrbn@noc.ac.uk
Subject: RE: Urgent: Wetlabs BB con file module SBE Data Processing problem [
ref:_00D7096pT._50070vbxjt:ref]

Hi Dougal,

Thanks for the update. We were able to reproduce the issue that you mentioned. The software engineer found that the converted ECO-BB output is reported to a fixed precision. The user polynomial function reports a fixed number of significant figures, rather than a fixed precision, so it will provide the same resolution as raw data, regardless of the mean data level.

I'm checking in with Wetlabs directly about your question, in order to get further feedback about the best output to use, given the limits on data resolution for the ECO-BB.

Regards,
Stephanie

****

From: Stephanie Jaeger [sjaeger@seabird.com]
Sent: 18/12/2014 19:54
To: dougal.mountifield@noc.ac.uk;
dm1@noc.ac.uk
Cc: daves@wetlabs.com; jeh200@noc.ac.uk; jrbn@noc.ac.uk
Subject: RE: Urgent: Wetlabs BB con file module SBE Data Processing problem [
ref:_00D7096pT._50070vbxjt:ref]

Hi Dougal,

I'm following up regarding your question on this processing the ECO-BB data. I did check in with Wetlabs, and they confirmed that the raw resolution (given in voltage on the A/D channel) should match the resolution of the converted engineering output. So, the output should show up as it does with the User Polynomial function, as you mentioned.

Also, we noted that the units of the output variable should be in "scattering" rather than "turbidity." So, the variable will be fixed to be named "OBS Meter, WET Labs, ECO-BB" rather than turbidity.

We have reported this to the software engineer, and he'll work to resolve this in a future version of SBE Data Processing.

Thank you for letting us know about this, and let me know if you have further questions.
Regards,
Stephanie

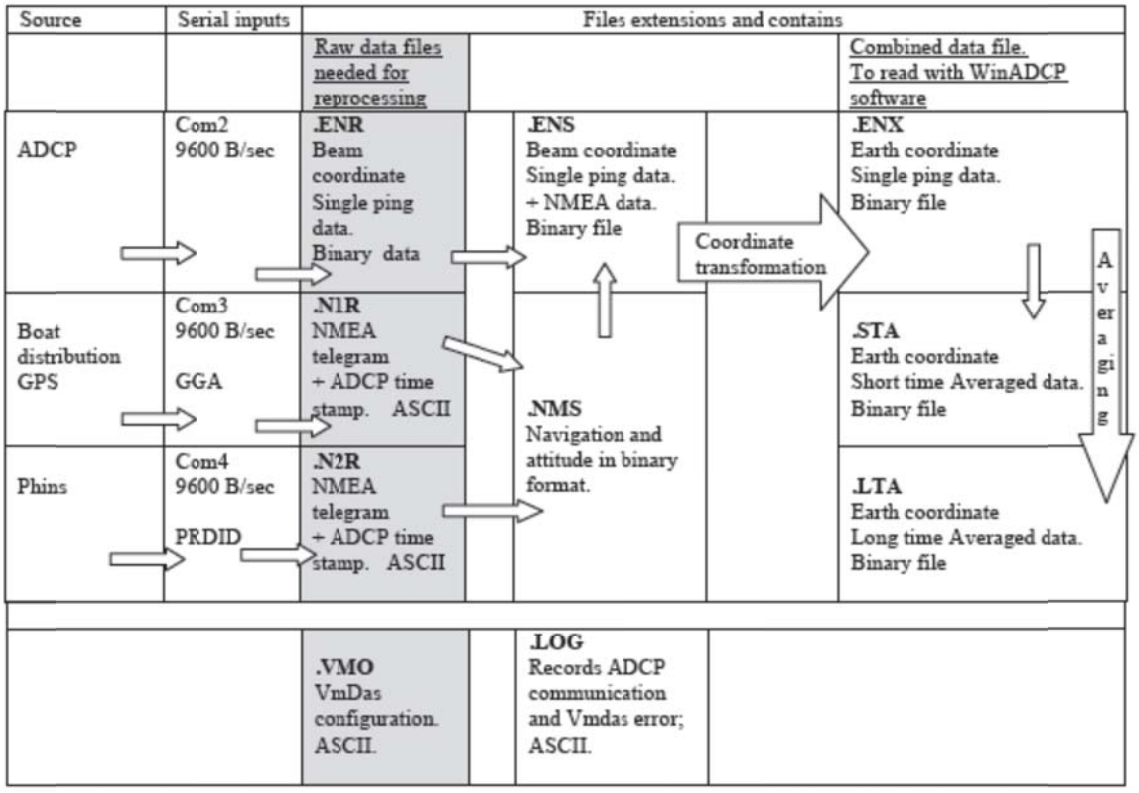
4. Vessel Mounted ADCP (VMADCP)

Jo Hopkins, National Oceanography Centre, Liverpool

The RRS Discovery is fitted with RD Instruments 75 kHz and 150 kHz Ocean Surveyor ADCPs. The following table, taken from the Dock Side and Sea Acceptance Test report (June 3-5, 2013), details the serial numbers, computer operating systems and software versions installed.

SYSTEM / SHIP INFORMATION		
Vessel Length	99.70 m	
Vessel Weight		
System Frequency	**150 Khz**	**75 kHz**
XDCR Serial Number	SN 648108	SN 640594
Chassis Serial Number	SN 28550	SN 28548
Cable Length	20+30 m	20+30 m
ADCP Electronics Rack or Table mounted	Rack	Rack
Transducer Mounting Angle (Bow, 45 starboard …)	-45	-45°
Transducer Mounting Type (Acoustic Window, Flush, Keel, Gondola …)	Hull + windows	Hull + windows
PC System type		
Operating System	Windows 7 64 bits	Windows 7 64 bits
Computer Ram	6 GB	6 GB
Comports available on Computer	COM2, COM 3, COM 4, COM5	COM2, COM 3, COM 4, COM5
Network Card	Yes	Yes
Hard Drive Space		230 GB
RDI Programs Installed	VMDAS 1.46, BBTalk 3.08, WinADCP 1.14	VMDAS 1.46, BBTalk 3.08, WinADCP 1.14

The instruments are mounted 6.6 m below the ships waterline and beam 3 (Y-axis) is rotated -45° (anti-clockwise) relative to the ships centreline. A nominal rotation of -45° (misalignment angle) is therefore necessary to remove the ships velocity from the data. Fine tuning of this misalignment is performed in the Matlab post-processing routines.
The VmDas computer setup and file structure recorded by each OS ADCP was as shown in the schematic below.



There are two navigation (NAV) feeds into the VMDas software. NMEA1 stream is from the Applainix PosMV GPS and contains navigation (heading) information. This is written to the .N1R files. NMEA2 stream is from the IXSEA PHINS and contains both navigation (heading) and attitude (pitch and roll) information.

N1R contents (from PosMV)
$INZDA : Date and time information
$INGGA : Time, position and fix related to the GPS receiver (PosMV)
$INVTG : Track made good and Ground speed (relative to the ground)
$INRMC : Date, time, position speed and tracks made good, magnetic variation
$GPGST : GPS pseudorange noise statistics
$PADCP : Time stamp from the VmDas software every time the ADCP pings

N2R contents (from PHINS)
$PRDID : Ships heading, pitch and roll from PHINS
$PADCP : Time stamp from the VmDas software every time the ADCP pings

The Matlab post processing uses the $PRDID string in the .N2R files and the binary .ENX file from VMDAS that contains single ping, bin mapped, earth coordinate data (transformed within the software using the heading and tilt sources specified).

DY018 OS150 setup
A number of OS150 command files and user options were used during DY018. When 'free running' (without using k-sync to control the timing of the ADCPs pings – requiring a command file being sent), the main ADCP user options selected were as follows:

Number of bins: 96
Bin Size: 4 m
Blanking distance: 4 m
Transducer depth: 6.6 m
Processing mode: low resolution (long range, narrow band)
Bottom track: on (range 800 m)
Ensemble time: as fast as possible

Max file size: 10 mb
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
All data screening unchecked
Do NOT set a backup location

These options are saved to *DY018 OS150 BTon NB nosync.ini*

Command file for use with k-sync: *DY018 OS150 Narrowband and Bottom track with sync.txt.* Note that the additional settings (ADCP options and within k-sync) necessary to make this stable were not determined (see problems section).

DY018 OS75 setup
A number of OS75 command files and user options were used during DY018. When 'free running' (without using k-sync to control the timing of the ADCPs pings – requiring a command file being sent), the main ADCP user options selected were as follows:

Number of bins: 60
Bin Size: 16 m
Blanking distance: 8 m
Transducer depth: 6.6 m
Processing mode: low resolution (long range, narrow band)
Bottom track: on (range 1200 m)
Ensemble time: as fast as possible

Max file size: 10 mb
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
All data screening unchecked
Do NOT set a backup location

These options are saved to *DY018 OS75 BTon NB nosync.ini*

Command file for use with k-sync: *DY018 OS75 Narrowband bottom track sync.txt.* Note that the additional settings (ADCP options and within k-sync) necessary to make this stable were not determined (see problems section).

Post-processing in Matlab

A suite of Matlab routines was used to perform data screening and transformation into absolute velocities in Earth coordinates. The routines were first obtained from IfM Kiel by Mark Inall and adapted for use on the RRS James Clark Ross by Deb Shoosmith in 2005. Since then numerous bug fixes and refinements have been added by various users, the most recent by Sam Jones on DY017. In short the following processing takes place:

1. RDI binary file with extension ENX (single-ping ADCP ship referenced data from VMDAS) and extension N2R (ascii NMEA output from PHINS saved by VMDAS) read into MATLAB environment. NB: The N2R file consists of ADCP single ping time stamps ($PADCP string) and pitch, roll and heading information ($PRDID string).
2. Ensembles with no ADCP data removed
3. Ensembles with bad or missing PHINS heading data identified and adjusted GYRO heading substituted
4. Attitude information time-merged with single ping data
5. Heading data used to rotate single ping ADCP velocities from vessel centreline reference to True North reference
6. Transducer mis-alignment error corrected for (derived from the mis-alignment determination)
7. Ship velocity derived from PHINS positional information
8. Further data screening performed:
   -Max heading change between pings (10 degrees per ping)
   -Max ship velocity change between pings (>2ms^{-1}pingrate^{-1})
   -Error velocity greater than twice Stdev of error velocities of single ping profile
9. All data averaged into 300-second super-ensembles
10. Determine absolute water velocities from either bottom track derived ship velocity or PHINS GPS derived ship velocity, dependent on depth.

The final post processing output is saved to **OS150_DY01800x_000000_zz_abs.mat** where *"zz"* is the number of the last file in the concatenation. Two structures are saved in this .mat file.

Data to be banked by BODC are contained within the structure OS75_abs (n.b. both 150 kHz and 75 kHz data are saved in structures called 'OS75' but it does contain the correct information). Underlined variables are those to be banked.

OS75_abs =

ref: [1x1 struct]
<u>vel: [96x2x3094 double] : Absolute velocity in m/s (zonal, meridional)</u>

nav: [1x1 struct]
depth: [96x3094 double] : bin depths (m) of velocity profiles

OS75_abs.nav =

txy1: [3x3094 double] : array of time (Julian day), longitude and latitude
txy2: [3x3094 double]

Output
It was not possible to create one long concatenated file for the entire cruise due to changes in configurations, data drop outs and file sizes. The following 5 min average data files have therefore been created.

OS150

PART 1 - files: 2 -4 and 8-24
Dates: 9/11/14 13:44 to 20/11/14 21:28
Misalignment angle = 0.3438°
Scaling factor = 1.002389
Saved to **OS150_DY01800x_000000_24_abs.mat**

PART 2 - files: 25 - 47
Dates 20/11/14 21:28 to 01/12/14 15:19
Misalignment angle = 0.4267°
Scaling factor = 1.005849
Saved to **OS150_DY01800x_000000_47_abs.mat**

PART 3 – files 6-7
Dates: 11/11/14 09:22 to 13/11/14 07:13
Misalignment angle = 0.3438°
Scaling factor = 1.002389
Saved to **OS150_DY01800x_000000_7_abs.mat**

OS75

PART 1 - files: 2-13 and 16-26
Dates: 09/11/14 13:46 to 20/11/14 21:27
Misalignment angle = 0.7766°
Scaling factor = 1.008561
Saved to **OS75_DY01800x_000000_26_abs.mat**

PART 2 - files: 27-28 and 31-44
Dates: 20/11/14 21:27 to 30/11/14 19:36
Misalignment angle = 0.6952°
Scaling factor = 1.009811
Saved to **OS75_DY01800x_000000_44_abs.mat**

Problems encountered

ENX files not being written

During DY018 the VmDas software at times stopped producing .ENX files in advance of a file being closed. The reason for this remains unknown. In most instances the raw .ENR files (beam coordinate, single ping) continued to be written and the reprocessing utility in VmDas was used to re-make the earth coordinate transformed .ENX files necessary for the Matlab post processing. On a few occasions however the .ENR files also stopped being written and data recovery was not possible.

Files successfully recovered using the post-processing utility:

OS150 files 11, 15, 22, 26, 38, 40

OS75 files 16, 20, 21, 23, 45

K-sync

Attempting to run the ADCPs using k-sync, a system that controls the timings of pings from acoustic instrumentation on board so that they do not interfere with each other was problematic. Although command files with the necessary synchronisation command (CX 1,1) were successfully sent the k-sync system would often switch from an *active* to a *standby* mode. Since the k-sync system initialises each ADCP ping this meant that no data was collected during these standby periods. Two different setups were tried but both proved unstable so for most of the cruise the ADCPS were left to free-run to avoid large data gaps. This however degraded the quality of a lot of the other acoustic systems on board.

1) ADCP options: 'ping as fast as possible' and k-sync runtime settings: Trigger mode calculated (active period=1.204 seconds for 150 kHz)
2) ADCP options: Ensemble time 2 seconds for 150 kHz (3 seconds for 75 kHz) and k-sync runtime settings: Tigger mode fixed period (2 and 3 seconds for 150 kHz and 75 kHz respectively).

If k-sync cannot make the ADCP ping within 3 x active period (e.g. 3 x 1.204 seconds) then it will fall into standby mode. <u>The necessary settings for these systems to work reliably need to be determined for future cruises.</u>

Log of files opened and closed during the cruise

OS150

DATE	TIME	FILENAME	OPEN/ CLOSED	Comments	Setup	Sync Y/N	Bottom Track	# bins
09/11/14	08:56	OS150_DY018001	open	At mouth of Fal Estuary during lifeboat drills	DY018_OS150_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	96
09/11/14	13:44		closed					
09/11/14	13:44	OS150_DY018002	open	Moving off coast towards CCS site	DY018_OS150_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	96
10/11/14	07:04		closed	Arrival on site at CCS (just after 1st CTD cast)				
10/11/14	07:05	OS150_DY018003	open	Start of process station at CCS	DY018_OS150_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	96
10/11/14	19:30		closed					

10/11/14	19:30	OS150_DY018004	open		DY018_OS150_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	96
11/11/14	08:53		closed					
11/11/14	09:11	OS150_DY018005	open	Test as PHINS attitude sensor was dropping in and out around 09:00	DY018_OS150_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	96
11/11/14	09:12		closed					
11/11/14	09:22	OS150_DY018006	open	Successful use of k-sync and initialised from command file. Sent to winadcp. #bins reduced to 60 for better viewing in Winadcp. Gap in ship gyro 06:31:59 to 10:37:40 (4.1 hrs)	DY018_OS150_BTon_BB_ADCP_align_-45_sync_winadcp.ini Command file: OS150-DY018_BTON_sync_shelf.txt	Y	ON	60
12/11/14	08:07		Closed					
12/11/14	08:28	OS150_DY018007	open	File 06 suspicious noise and nav/attitude/gyro drop outs when in sync so run without sync. Bins reduced to 60 for Winadcp.	DY018_OS150_BTon_BB_ADCP_align_-45_nosync_shelf_winadcp.ini	N	ON	60
13/11/14	07:13		closed					
13/11/14	07:16	OS150_DY018008	open	Start of first transect CCS-shelf edge (Winadcp option turned on)	DY018_OS150_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	96
14/11/14	08:17		closed					
14/11/14	08:17	OS150_DY018009	open	At CS2 shelf edge station waiting for the swell to die down	DY018_OS150_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	96
14/11/14	08:23		closed	Closed to attempt a restart in k-sync - unsuccessful				
14/11/14	08:41	OS150_DY018010	open	Spent some time trying to run with k-sync but failed to maintain an	DY018_OS150_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	96

				active sync so instead OS150 restarted without sync				
14/11/14	18:25		closed	Query over whether there were lots of data drop outs				
14/11/14	18:27	OS150_DY018011	open	Turned bottom track OFF. At start of first deep cast (2500m) for Iron transect	DY018_OS150_BToff_BB_ADCP_align_-45_nosync.ini	N	OFF	96
15/11/14	08:16		closed					
15/11/14	08:17	OS150_DY018012	open		DY018_OS150_BToff_BB_ADCP_align_-45_nosync.ini	N	OFF	96
15/11/14	11:05		closed					
15/11/14	11:13	OS150_DY018013	open	Start of tests of newly created command files. Worked with 1st attempt	\corrected_command_files\ DY018 OS150 Narrorowband NO Bottom track with sync.txt	Y	OFF	96
15/11/14	18:56		Closed					
15/11/14	18:56	OS150_DY018014	open		DY018 OS150 Narrorowband NO Bottom track with sync.txt	Y	OFF	96
15/11/14	20:42		closed					
15/11/14	20:48	OS150_DY018015	open	BT back on and increased to 800 m. External heading and sensor ticked and EZ10222010 in file	DY018 OS150 BTon NB nosync.ini	N	ON	96
16/11/14	09:18		closed					
16/11/14	09:18	OS150_DY018016	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
16/11/14	17:14		closed					
16/11/14	17:18	OS150_DY018017	open	Changed EZ to EZ10222010. Group 2 in sync. Out of sync when back from dinner at 18:00 and ADCP had stopped pinging.	DY018 OS150 Narrowband and Bottom track with sync.txt (.ini with same name)	Y	ON	96
16/11/14	18:03		closed					
16/11/14	18:07	OS150_DY018018	open	EM122 stopped at 21:42	DY018 OS150 BTon NB nosync.ini	N	ON	96
17/11/14	08:06		Closed					

17/11/14	08:07	OS150_DY018019	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
17/11/14	10:40		closed					
17/11/14	10:42	OS150_DY018020	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
17/11/14	20:25		closed					
17/11/14	20:25	OS150_DY018021	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
18/11/14	09:34		closed					
18/11/14	09:35	OS150_DY018022	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
18/11/14	19:03		closed	ENX stopped at 17:20				
18/11/14	19:04	OS150_DY018023	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
19/11/14			closed					
19/11/14	18:49	OS150_DY018024	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
20/11/14	21:28		closed					
20/11/14	21:28	OS150_DY018025	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
21/11/14	20:13		closed					
21/11/14	20:13	OS150_DY018026	open	PHINS crashed just before dinner (approx. 16:00)	DY018 OS150 BTon NB nosync.ini	N	ON	96
22/11/14	18:20		closed					
22/11/14	18:20	OS150_DY018027	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
23/11/14	20:45		closed	PHINS stopped at approx. 16:00				
23/11/14	20:46	OS150_DY018028	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
23/11/14	21:28		closed	Problem with altimeter on CTD so OS150 stopped to check for interference				
23/11/14	21:36	OS150_DY018029	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
24/11/14	00:21		closed	Problem with CTD altimeter				
		Files 30-32		Turned on/off by Dougal	DY018 OS150 BTon NB nosync.ini	N	ON	96
24/11/14	01:59	OS150_	open		DY018 OS150 BTon NB nosync.ini	N	ON	96

		DY018033						
25/11/14	08:17		closed					
25/11/14	08:18	OS150_DY018034	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
25/11/14	17:18		closed					
25/11/14	17:27	OS150_DY018035	open	Trials with k-sync	DY018 OS150 Narrowband and Bottom track with sync.txt k-sync will active the pinging of the ADCP. EZ10222010 – ping as fast as possible selected in ADCP user options Screen shot of k-sync saved. The active period calculated by k-sync is 1.204 seconds. If k-sync can not make the ADCP ping within 3 x active period (=3x1.204) then it will go into standby mode and the ADCP will stop pinging. Drops out at 17:43 and ENR files stops then too.	Y	ON	96
25/11/14	18:06		closed					
25/11/14	18:10	OS150_DY018036	open	Crashed at 04:52 (into standby). Restarted at 06:51	DY018 OS150 Narrowband and Bottom track with sync.txt EZ10222010, but set ensemble time to 2 seconds (rather than ping as fast as possible). K-sync settings changed to 'fixed period' of 2 seconds. The active period is then 2 seconds.	Y	ON	96
26/11/14	07:52		closed					
26/11/14	07:52	OS150_DY018037	open	Standby at 08:10	DY018 OS150 Narrowband and Bottom track with sync.txt 2 second pings	Y	ON	96
26/11/14	08:10		closed					
26/11/14	08:11	OS150_DY018038	open		DY018 OS150 Narrowband and Bottom track with sync.txt	Y	ON	96
26/11/14	08:20		closed					
26/11/14	08:22	OS150_DY018039	Open	Back to free running – k-sync not stable enough to be left	DY018 OS150 BTon NB nosync.ini	N	ON	96
26/11/14	12:36		closed					
26/11/14	12:52	OS150_DY018040	Open	Accidently shut down VmDas	DY018 OS150 BTon NB nosync.ini	N	ON	96
26/11/14	15:42		closed					
26/11/14	15:44	OS150_DY018041	Open		DY018 OS150 BTon NB nosync.ini	N	ON	96
27/11/14	12:05		closed					
27/11/14	12:05	OS150_DY0180	open		DY018 OS150 BTon NB nosync.ini	N	ON	96

		42						
28/11/14	07:50		closed					
28/11/14	07:51	OS150_DY018043	open	In sync for SBP120 test	DY018 OS150 Narrowband and Bottom track with sync.txt	Y	ON	96
28/11/14	09:03		closed					
28/11/14	09:04	OS150_DY018044	open	Back to free running. PHINS froze 28/11/14 22:54 to 29/11/14 00:02	DY018 OS150 BTon NB nosync.ini	N	ON	96
29/11/14	08:20		closed					
29/11/14	08:20	OS150_DY018045	open	Accidently cut/paste .ENX into another folder. It was then moved back.	DY018 OS150 BTon NB nosync.ini	N	ON	96
29/11/14	20:49		closed					
30/11/14	20:50	OS150_DY018046	open		DY018 OS150 BTon NB nosync.ini	N	ON	96
30/11/14	19:34		closed					
30/11/14	19:34	OS150_DY018047	open	PHINS down 05:36-05:37	DY018 OS150 BTon NB nosync.ini	N	ON	96
1/12/14	15:19		closed					

OS75

DATE	TIME	FILENAME	OPEN/ CLOSED	Comments	Setup	Sync Y/N	Bottom Track	# bins
09/11/14	09:04	OS75_DY018001	Open	Leaving Falmouth – lifeboat drills	DY018_OS75_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	60
09/11/14	13:45		Closed					
09/11/14	13:46	OS75_DY018002	open	En-route to CCS	DY018_OS75_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	60
10/11/14	07:09		closed	On site at CCS just after 1st cast				
10/11/14	07:16	OS75_DY018003	open	Start of process station at CCS. Using sync. Cut out at approx. 07:19:55 then restarted (re-sync'd) at 07:41.	Command file: DY018 OS75 Broadband shallow water bottom track with sync.txt	Y	ON	60

				08:37 and 12:09 cut out and then restarted				
10/11/14	13:50		closed					
10/11/14	13:52	OS75_ DY018 004	open	First attempt to launch Winadcp but failed because path to Winadcp.exe was incorrect	DY018_OS75_BTon_BB_ADCP_align_-45_sync_winadcp.ini Command file: DY018 OS75 Broadband shallow water bottom track with sync.txt	Y	ON	60
10/11/14	13:59		closed					
10/11/14	14:01	OS75_ DY018 005	open	Path to Winadcp corrected. Stalled at 14:23 with k-sync so gap in data	DY018_OS75_BTon_BB_ADCP_align_-45_sync_winadcp.ini	Y	ON	60
10/11/14	15:11		closed					
10/11/14	15:22	OS75_ DY018 006	open	Reduced number of bins to 13 and bottom track to 200 m	DY018_OS75_BTon_BB_ADCP_align_-45_sync_winadcp_reducedbin.ini Command: DY018 OS75 Broadband shallow water bottom track with sync winadcp.txt	Y	ON	13
10/11/14	18:56		closed	Too unstable with k-sync. Stopped after a crash at 17:54.				
10/11/14	19:00	OS75_ DY018 007	open	Not stable enough with k-sync to be left over night	DY018_OS75_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	60
12/11/14	08:15		closed					
12/11/14	08:19	OS75_ DY018 008	open		DY018_OS75_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	60
13/11/14	07:20		closed					
13/11/14	07:23	OS75_ DY018 009	open	Sending to Winadcp. Start of CCS to shelf transect	DY018_OS75_BTon_BB_ADCP_align_-45_nosync.ini	N	ON	60
14/11/14	08:44		closed	At Shelf edge CS2 station				
14/11/14	08:48	OS75_	open	At CS2 shelf	DY018_OS75_BTon_BB_ADCP_alig	N	ON	60

		DY018 010		edge station	n_-45_nosync.ini			
14/11/14	18:34		closed	At start of first deep cast for Iron transect (2500m)				
14/11/14	18:37	OS75_ DY018 011	open	Turned bottom track off	DY018_OS75_BToff_BB_ADCP_align_-45_nosync.ini	N	OFF	60
14/11/14	21:57		closed					
14/11/14	21:58	OS75_ DY018 012	open	VMDAS tuned off and then back on in an attempt to improve penetration (as suggested by DY017 report)	DY018_OS75_BToff_BB_ADCP_align_-45_nosync.ini	N	OFF	60
15/11/14	08:13		closed	Stopped to check that water tracking is ok				
15/11/14	08:14	OS75_ DY018 013	open	Penetration down to about 500 m – improved once 150 kHz was sync'd perhaps?	DY018_OS75_BToff_BB_ADCP_align_-45_nosync.ini	N	OFF	60
15/11/15	12:33		closed					
15/11/14	12:37	OS75_ DY018 014	open	Keeps dropping out of sync	\corrected_command_files\ DY018 OS75 Narrowband NO bottom track sync.txt .ini file with same name saved	Y	OFF	60
15/11/14	12:39		closed					
15/11/14	12:40	OS75_ DY018 015	open	Keeps dropping out of sync		Y	OFF	60
15/11/14	12:41		closed					
15/11/14	12:42	OS75_ DY018 016	open	Put OS75 in Group 3 of ksync (OS150 in Group 2). Keeps dropping out of sync		Y	OFF	60
15/11/14	14:14		closed	Keeps dropping out of sync				

				(going into standby) butadcp file appear to keep running.				
15/11/14	14:18	OS75_DY018017	open	Command file did not contain sync command (CX 1,1) – corrected!	\corrected_command_files\ DY018 OS75 Narrowband NO bottom track sync.txt .ini file with same name saved	Y	OFF	60
15/11/14	19:43		closed	Closed for checking				
15/11/14	19:43	OS75_DY018018	open		DY018 OS75 Narrowband NO bottom track sync.txt	Y	OFF	60
15/11/14	20:31		closed	Suspect that file may not be good				
15/11/14	20:38	OS75_DY018019	open	BTon – increased to 1200 m. N.b. external heading nd tilt sensor are NOT set in the VMDAS ADCP options and the EZ command does not appear in the startup logging text. PHINS or just the interface was frozen and restarted at 03:50 16/11/14	DY018 OS75 BTon NB nosync.ini	N	ON	60
16/11/14	09:14		closed					
16/11/14	09:15	OS75_DY018020	opened		DY018 OS75 BTon NB nosync.ini	N	ON	60
16/11/14	14:08		Closed	Stopped because ENX file time stamp of 10:02 was behind				

				ENR timestamp of 14:08				
16/11/14	14:09	OS75_ DY018 021	opened	EM122 stopped at 21:42	DY018 OS75 BTon NB nosync.ini	N	ON	60
17/11/14	08:05		closed	ENX stopped 23:04				
17/11/14	08:06	OS75_ DY018 022	open		DY018 OS75 BTon NB nosync.ini	N	ON	60
17/11/14	20:23		closed					
17/11/14	20:24	OS75_ DY018 023	Open		DY018 OS75 BTon NB nosync.ini	N	ON	60
18/11/14	09:36		closed	ENX stopped at 03:49				
18/11/14	09:37	OS75_ DY018 024	open		DY018 OS75 BTon NB nosync.ini	N	ON	60
18/11/14	19:05		closed					
18/11/14	19:05	OS75_ DY018 025	open		DY018 OS75 BTon NB nosync.ini	N	ON	60
19/11/14	18:50		closed					
19/11/14	18:51	OS75_ DY018 026	open		DY018 OS75 BTon NB nosync.ini	N	ON	60
20/11/14	21:27		closed					
20/11/14	21:27	OS75_ DY018 027	open		DY018 OS75 BTon NB nosync.ini	N	ON	60
21/11/14	20:12		closed					
21/11/14	20:12	OS75_ DY018 028	open	PHINS crashed	DY018 OS75 BTon NB nosync.ini	N	ON	60
22/11/14	18:13		closed					
22/11/14	18:13	OS75_ DY018 029	open	Error – can't open nAV serial port. VMDAS closed and reopened. A file 30 was also created.	DY018 OS75 BTon NB nosync.ini	N	ON	60
			closed	VMDAS closed				
22/11/14	18:18	OS75_ DY018 031	open	PHINS stopped at approx. 16:00	DY018 OS75 BTon NB nosync.ini	N	ON	60
23/11/14	20:44		closed					
23/11/14	20:44	OS75_	open		DY018 OS75 BTon NB nosync.ini	N	ON	60

		DY018 032						
24/11/14	00:31		closed	Problem with CTD altimeter				
		File 33 turned on/off by Dougal						
24/11/14	01:59	OS75_ DY018 034	open		DY018 OS75 BTon NB nosync.ini	N	ON	60
25/11/14	08:16		closed					
25/11/14	08:17	OS75_ DY018 035	open		DY018 OS75 BTon NB nosync.ini	N	ON	60
25/11/14	19:46		closed					
25/11/14	19:51	OS75_ DY018 036	open	Crashed 00:09:28 26/11/14 Restarted from k-sync at 06:51	DY018 OS75 Narrowband bottom track sync.txt EZ changed to EZ10222010 and resaved Ensemble time set to 3 seconds (rather than ping as quickly as possible) DY018 OS75 Narrowband bottom track sync.ini. Fixed period of 3 seconds in k-sync, active period = 3 seconds	Y	ON	60
26/11/14	07:54		closed					
26/11/14	07:54	OS75_ DY018 037	open	k-sync into standby 08:14	DY018 OS75 Narrowband bottom track sync.txt 3 second pings	Y	ON	60
26/11/14	08:15		closed					
26/11/14	08:19	OS75_ DY018 038	open	Back to free-running since k-sync is unstable and cannot be left	DY018 OS75 BTon NB nosync.ini External heading and tilt sensor ticked in ADCP options. Ping as fast as possible. EZ10222010	N	ON	60
26/11/14	12:37		closed					
26/11/14	12:53	OS75_ DY018 039	Open		DY018 OS75 BTon NB nosync.ini EZ10222010	N	ON	60
27/11/14	12:06		closed					
27/11/14	12:07	OS75_ DY018 040	open		DY018 OS75 BTon NB nosync.ini EZ10222010	N	ON	60
28/11/14	07:53		closed					
28/11/14	07:54	OS75_ DY018 041	open	Test of sub-bottom profiler (SBP120). In sync. 3 second	DY018 Os75 Narrowband bottom track sync.txt	Y	ON	60

				pings				
28/11/14	09:05		closed					
28/11/14	09:06	OS75_DY018042	open	Back to free-running. PHINS froze 28/11/14 22:55 to 29/11/14 00:52	DY018 OS75 BTon NB nosync.ini EZ10222010	N	ON	60
29/11/14	08:17		closed					
29/11/14	08:18	OS75_DY018043	open		DY018 OS75 BTon NB nosync.ini EZ10222010	N	ON	60
30/11/14	10:29		closed					
30/11/14	10:29	OS75_DY018044	open		DY018 OS75 BTon NB nosync.ini EZ10222010	N	ON	60
30/11/14	19:36		closed					
30/11/14	19:36	OS75_DY018045	open	PHINS down 05:36-05:37	DY018 OS75 BTon NB nosync.ini EZ10222010	N	ON	60
1/12/14	15:18		closed					

5. Salinity sample analysis

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(Jo Hopkins[2] (NOC))
[1]Author, [2]Dataset PI, [3]Technical contact

Background and objectives
Discrete salinity samples were collected by all of the above on behalf of Jo Hopkins at the National Oceanography Centre, Liverpool (NOC). Samples were analysed on board by Dougal Mountifield (NMF-SS). Samples were collected from CTD casts in order to calibrate CTD sensors on the stainless steel and titanium CTD packages for WP1 and WP3. Samples were also collected underway to calibrate the Sea-Bird MicroTSG SBE45 sensor as part of WP1.

Sampling strategy
Discrete samples were collected from 16 casts carried out with the stainless steel CTD package and 22 casts with the titanium package (Table 5.1). Samples were also collected 3-6 times a day from the non-toxic, pumped seawater supply (Table 5.2). A total of 81 underway samples were collected. The seawater intake pipe was located approximately 6 m below sea level.

Methods
Discrete salinity samples were collected directly from CTD bottles and the non-toxic, pumped seawater supply using 200 ml glass medicine bottles with plastic lids and low density polyethylene (LDPE) plastic inserts to prevent evaporation and salt formation inside the lid. All bottles were rinsed 2-3 times with sample prior to water collection. Samples were then equilibrated to laboratory temperature (20.3-20.5 ˚C) for at least 24 hours prior to analysis. Each sample was analysed in triplicate on a Guildline 8400B Autosal salinometer (s/n 71126) by the NMF-SS technician on board. Briefly, samples were analysed as double conductivity ratio and converted to practical salinity using the UNESCO 1983 algorithm. The water bath temperature for analysis was set to 24 ˚C (~3.5 ˚C above ambient). The salinometer was standardised to IAPSO 35 PSU standard seawater (batch P155) at the beginning of the cruise. Subsequently, a standard was run before and after every 24 bottles analysed and the overall correction in drift was applied to those samples. The software was configured with a standard deviation limit of 0.00002 in double conductivity ratio. For full details of the salinity analysis, please refer to the Sensors and Moorings cruise report.

Data quality notes
The variation in measured standard value due to bath temperature fluctuation was always more significant than the machine offset from standard. (NMF-SS observation).

Table 5.1. Discrete salinity samples withdrawn from CTD casts

STNNBR	SITE	GEAR	CONTACT	COMMENTS	NMFID
001	CCS	Stainless steel CTD	Poulton	Pre-dawn	CTD001
004	CCS	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD003
024	CCS	Titanium CTD	Lohan	Calibration	CTD006
039	CCS	Stainless steel CTD	Poulton	Pre-dawn	CTD010
041	CCS	Titanium CTD	Lohan	Calibration	CTD012
042	CCS	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD013
051	Transect O1	Stainless steel CTD	Woodward		CTD014
054	Transect O2	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD016
057	Transect O3	Stainless steel CTD	Woodward	Repeat of event 056	CTD019
061	Transect O5	Stainless steel CTD	Woodward	Big ship roll during deployment	CTD023
063	CS2	Stainless steel CTD	Hopkins	Water structure check. Minimal sampling	CTD025
064	Fe01	Stainless steel CTD	Amber	Radium (2500 m)	CTD026
065	Fe01	Titanium CTD	Lohan	2500 m. No LADCP	CTD027
068	Fe02	Titanium CTD	Lohan	2000 m	CTD030
076	Fe03	Titanium CTD	Lohan	1500 m	CTD033
088	Fe07	Titanium CTD	Lohan	250 m	CTD043
096	CS2	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD045
115	CS2	Stainless steel CTD	Poulton	Pre-dawn	CTD047
117	CS2	Titanium CTD	Lohan	Calibration	CTD049
119	CS2	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD051
134	CS2	Titanium CTD	Lohan	Calibration	CTD052
135	CS2	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD053
151	CCS	Stainless steel CTD	Hopkins	Mooring calibration	CTD056
169	Fe08	Titanium CTD	Lohan	2500 m	CTD063
171	Fe09	Titanium CTD	Lohan	2000 m (replaced 2 niskin bottles)	CTD065
174	Fe10	Titanium CTD	Lohan	1500 m	CTD068
181	Fe11	Titanium CTD	Lohan	1000 m	CTD070
184	Fe12	Titanium CTD	Lohan	700 m (Altimeter issues start on Ti casts)	CTD073
186	Fe13	Titanium CTD	Lohan	500 m	CTD075

188	Fe14	Titanium CTD	Lohan	250 m	CTD077
225	CCS_glider	Stainless steel CTD	Woodward	Shelf-wide programme/calibration (Glider cal and wirewalker sensor cal)	CTD085
233	J08	Titanium CTD	Lohan		CTD086
234	J07	Titanium CTD	Lohan		CTD087
235	J06	Titanium CTD	Lohan		CTD088
236	J05	Titanium CTD	Lohan		CTD089
242	Benthic A	Titanium CTD	Lohan		CTD093
253	CCS	Titanium CTD	Lohan	Shelf-wide programme/calibration/iron CTD	CTD094
261	E1	Titanium CTD	Lohan		CTD096

Table 5.2. Discrete salinity samples withdrawn from the non-toxic, pumped, seawater supply.

DATE (UTC)	TIME (UTC)	CRATE	SAMPNO	COMMENTS
10/11/2014	15:37	TSG01	25	
	19:34		26	
11/11/2014	07:35		27	
	11:22		28	
	16:58		29	
	19:53		30	
12/11/2014	04:35		31	
	08:37		32	
	10:04		33	
	14:00		34	
	18:00		35	
	22:00		36	
13/11/2014	08:00		37	
	12:00		38	
	16:00		39	
	20:00		40	
14/11/2014	07:32		41	
	11:30		42	
	15:30		43	
	19:30		44	
	23:30		45	
15/11/2014	07:31		46	

	11:37		47	
	15:36		48	
	19:31	TSG02	49	new crate
	23:30		50	
16/11/2014	07:30		51	
	11:37		52	
	15:30		53	
	19:30		54	
	23:30		55	
17/11/2014	07:15		56	
	11:15		57	
	15:15		58	
	19:15		59	
18/11/2014	00:16		60	
	06:25		61	
	10:37		62	
	14:56		63	
	18:42		64	
	23:00		65	
19/11/2014	07:25		66	
	11:25		67	
	14:54		68	
	18:55		69	
	22:52		70	suspect time
20/11/2014	03:59		71	
	07:40		72	
	11:24	901	1	new crate
	16:17		2	
	20:16		3	
	23:20		4	
21/11/2014	07:34		5	
	12:19		6	
	20:06		7	
22/11/2014	00:24		8	
	07:23		9	
	11:50		10	

	17:20		11	
	21:10		12	
23/11/2014	07:36		13	
	11:42		14	
	17:35		15	
	23:38		16	
24/11/2014	07:35		17	
	14:46		18	
	20:40		19	
25/11/2014	07:30		20	
	14:22		21	
	20:38		22	
26/11/2014	07:30		23	
	13:30		24	
	20:43	22	548	new crate (CTD crate)
27/11/2014	07:26		549	
	14:04		550	
	20:05		551	
28/11/2014	07:32		552	
	13:37		553	
	19:35		554	
29/11/2014	07:35		555	
	13:34		556	

6. NMF-SS Sensors & Moorings Cruise Report

Billy Platt & Dougal Mountifield, NMF Sea Systems, NOC.

CTD System Configurations

Titanium Frame

The first water sampling arrangement was a 24-way titanium frame system (s/n SBE CTD TITA1), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-77801-1182
Sea-Bird 3P temperature sensor, s/n 03P-5700, Frequency 0 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-4138, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 129735, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P-5785, Frequency 3 (secondary)
Sea-Bird 4C conductivity sensor, s/n 04C-4143, Frequency 4 (secondary)
Sea-Bird 5T submersible pump, s/n 05T-3088, (primary)
Sea-Bird 5T submersible pump, s/n 05T-3090, (secondary)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-60380-0805
Sea-Bird 11plus deck unit, s/n 11P-34173-0676 (main)
Sea-Bird 11plus deck unit, s/n 11P-24680-0589 (spare)

The auxiliary input initial sensor configuration was as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-2055 (V0)
WETLabs light scattering sensor, s/n BBRTD-758R (V4)
Benthos PSA-916T altimeter, s/n 62679 (V5)
Chelsea Aquatracka MKIII fluorometer, s/n 088244 (V6)
Chelsea Alphatracka MKII transmissometer, s/n 161049 (V7)

Also fitted to the titanium frame system;

TRDI/WHM300kHz Downward looking LADCP, s/n 13400 (T)
NOCS LADCP battery pressure case, s/n WH009T

Sea-Bird 9*plus* configuration file DY018_tita_1182_NMEA.xmlcon was used for the initial titanium frame CTD casts.

Stainless Steel Frame

The second water sampling arrangement was the Zubkov 24-way stainless steel frame system (s/n 75313), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-46253-0869
Sea-Bird 3P temperature sensor, s/n 03P-4782, Frequency 0 (primary)

Sea-Bird 4C conductivity sensor, s/n 04C-2231, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 100898, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P-5495, Frequency 3 (secondary)
Sea-Bird 4C conductivity sensor, s/n 04C-3874, Frequency 4 (secondary)
Sea-Bird 5T submersible pump, s/n 05T-3085, (primary)
Sea-Bird 5T submersible pump, s/n 05T-3086, (secondary)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-19817-0243
Sea-Bird 11plus deck unit, s/n 11P-34173-0676 (main)
Sea-Bird 11plus deck unit, s/n 11P-24680-0589 (spare)

The auxiliary input initial sensor configuration was as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-1624 (V0)
Biospherical QCP Cosine PAR irradiance sensor, DWIRR, s/n 70510 (V2)
Biospherical QCP Cosine PAR irradiance sensor, UWIRR, s/n 70520 (V3)
Benthos PSAA-916T altimeter, s/n 59493 (V4)
WETLabs light scattering sensor, s/n BBRTD-1055 (V5)
Chelsea Alphatracka MKII transmissometer, s/n 161048 (V6)
Chelsea Aquatracka MKIII fluorometer, s/n 88-2615-124 (V7)

Also fitted to the stainless steel frame system;

TRDI/WHM300kHz Downward looking LADCP, s/n 15288
NOCS LADCP battery pressure case, s/n WH010T

Sea-Bird 9*plus* configuration file DY018_stainless_0869_NMEA.xmlcon was used for all stainless steel frame CTD casts.

Total number of casts between the two systems - 96

Total number of casts with the titanium frame - 30
Total number of casts with the stainless steel frame – 66

Casts deeper than 2000m - 2 titanium frame, 1 S/S frame.
Deepest casts - 2452m titanium frame, 2430m S/S frame.

TITANIUM CTD

On cruise DY017 water sampler no. 13 had small leak through upper left lanyard guide, replaced with no. 26. Bottle 26 was used in place of bottle 13 for the duration of DY018.

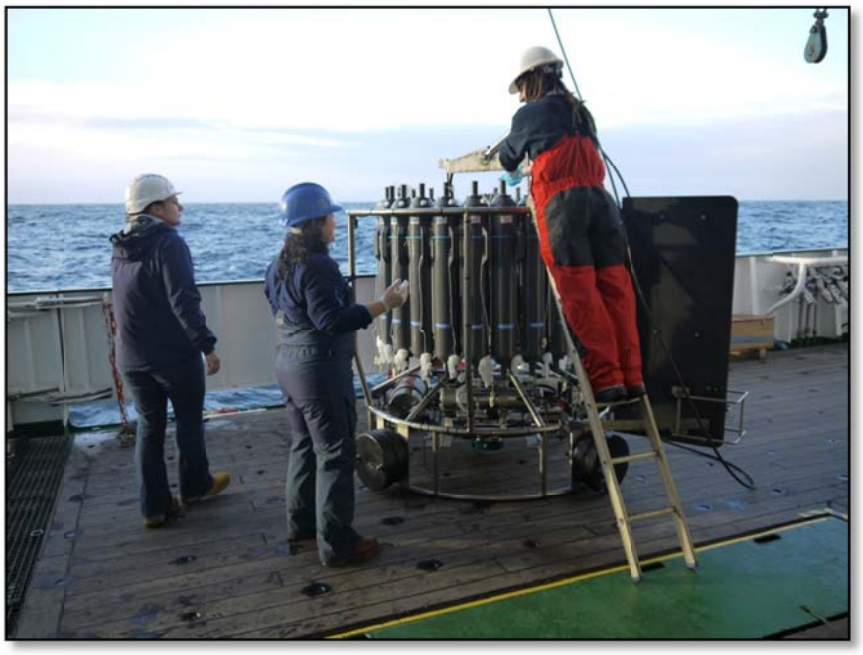
Water sampler no.23 had small leak through the mounting block, removed after cast 012T. The leak was repaired and the bottle was put back on the frame for its soak on cast 027T. During the casts in-between no replacement bottle was fitted.

The titanium package struck the ship lightly during cast 063T. No damage was initially noticed. Prior to cast 065T it was noticed that the mounting block on bottles 13 and 16 were broken, presumably from

the impact with the ship previously. Bottle 13 was replaced with bottle 12 and bottle 16 was replaced with bottle 25 for the rest of the cruise.

Cast 072T was aborted after the package struck the ship hard during deployment. As the ship rolled to port the tail fin of CTD package came into contact with the ship. This resulted in the fin T-C guard cage around the secondary temperature and conductivity sensors being broken and the ducting between the two sensors also being broken. The ducting was repaired, sensors inspected and the package re-deployed as cast 073T. Prior to the next titanium cast, 075T, the secondary temperature and conductivity sensors were removed from the fin and fitted on the 9plus unit next to the primary pair. The fin was then removed for the remainder of the cruise.

All samplers have now been repaired.



STAINLESS STEEL CTD

Often, some of the bottles did not release properly when fired and returned to the surface in the 'cocked' position. Upon inspection it was clear that the solenoid had fired, and the latch partially released, but the lever on the SBE 32 was binding preventing release of the bottle lanyard. It was noted that bottle 21 was particularly bad for this. The SBE 32 was removed, dismantled, thoroughly cleaned and replaced after washing with hot soapy water (Triton-X solution). Although there was some improvement, the problem later returned. It was also noted that this problem often occurred when it had been raining.

Prior to deployment, with the CTD frame on deck, it was often covered in rainwater rushing off the hangar roof top every time the ship listed to starboard. Upon multiple inspections, cleans and rinses it was found that paint, rust and debris was fouling the SBE 32 latches. This is thought to have contributed to the misfires along with slightly worn release arms. Note that this unit is due for routine service post-

cruise. After CTD cast 070 the spare titanium SBE32 unit (s/n: 32-71442-0940) was installed and subsequently there were no more misfires. It should be noted that subsequently there were also no more rainy days washing debris into the replacement unit.

LADCPs

The Teledyne RDI 300kHz LADCPs on both CTD frames were configured in a downlooking configuration. During deployment the BBtalk session was logged to a file of the form DY018_xxxm.txt, where xxx was the cast number. For titanium casts a T suffix was used for the cast number. Prior to deployment the baud rate was changed to 9600 (CB411), the clock checked (TS?) and the recorder space checked (RS?) Subsequently the pre-deployment tests (PA, PT200 and PC2) were run. To confirm which frame the deck cable was connected to, sometimes PS0 was sent to confirm instrument serial number. Finally the following command file was sent:

PS0
CR1
CF11101
EA00000
EB00000
ED00000
ES35
EX11111
EZ0011101
WM15
LW1
LD111100000

LF0500
LN016
LP00001
LS1000
LV250
SM1
SA001
SW05000
TE00:00:01.00
TP00:00.00
CK
CS

Upon recovery, the instrument was stopped pinging by sending a break, the baud rate changed to 115,200 (CB811), the number of deployments checked (RA?), then the data downloaded using Recover Recorder in BBtalk. The RDI file was then re-named in a similar form to the log file (DY018_XXX.000), data backed up to the network and the data file checked in WinADCP. After each cast the echo intensity balance was checked between the four beams to identify deteriorating beams.

There were no problems with the LADCPs during the cruise apart from some comms issues with the titanium unit. This is likely to be an intermittent problem with the instrument bulkhead connector, the star cable or battery pack as the same deck cable was used for both frames and no problems were experienced with the LADCP on the stainless frame.

On the final titanium cast, the instrument redeployed itself several times in the water, acquiring little useful additional data after the main file. Hence the LADCP data file for cast 096T is truncated. During the cruise the deck cable marked for instrument s/n 5414 failed with an intermittent comms problem that deteriorated to the point that it was unuseable. This cable requires assessment and repair post-cruise.

WINCH AND DEPLOYMENT SYSTEMS

Due to issues with the RRS Discovery CTD Winch Suite, the stainless CTD frame was deployed using the Deep Tow winch and 17.3mm armoured wire from the P-frame location. An Evergrip mechanical termination was applied during the previous cruise and an electrical splice made. The splice uses 2 of the 3 power cores with the 3rd core bonded to armour (vessel EARTH). The termination and splice stayed in good condition for the duration of the cruise.

Note that this wire was also used for NIOZ box-coring. The electrical tail was protected with hose pipe and taped to the mechanical termination for coring. The winch operator had to move the pendulum roller away briefly during recovery to clear the protected electrical tail bundle.

The P-frame geometry on the new RRS Discovery is excellent for working CTD packages. The roller extension was used on all deployments to very effectively control pendulum. This is a significant improvement on the CTD deployment arrangement on the RRS James Cook.

The trace-metal sampling titanium CTD package was deployed using the new Rolls Royce ODIM containerized winch system with 15.25mm Cortland Polyester jacketed, vectran strength member, 4 core conducting metal-free cable. Note that the rated working load of this cable that the manufacturer recommends to prevent damage to the 18AWG copper conductors is a very low at 1.32T. In practice this is often exceeded when any vessel motion is present.

The titanium CTD was worked with the bull-horn beam and the plastic deployment block. There are two issues with this arrangement. Firstly, as there is no pendulum roller arrangement, the pendulum at the water line is approx 10m which affords very little control of the package in any seaway or any slight vessel motion. Secondly, the outboard extension of the bullhorn beam is very limited. These issues conspire to make it highly likely that the package strikes the side of the vessel when being deployed or recovered.

During the cruise the titanium CTD struck the ships' side on many occasions, with the exception of a couple of occasions, these were luckily light glancing contact. Even during these light contacts, bottle mounts were fractured and the heaviest impact destroyed the fin T-C guard cage, which could be argued to be minor damage/loss. However, it is only a matter of time until significant damage is incurred and as such the bullhorn beam should be modified as a matter of urgency.

Suggested modifications would be to increase the outboard travel by approx 2m and to fit a pendulum arm and roller as per the P-frame. As it stands it is my opinion that this deployment location is totally unsuitable for CTD work in anything but calm conditions.

SALINOMETRY

A Guildline 8400B, s/n 71126, was installed in the Salinometer Room as the main instrument for salinity analysis. A second Guildline 8400B, s/n 71185, was installed in the Salinometer Room as a spare instrument.

The Ambient temperature control in the dedicated Salinometer room was particularly good with temperatures ranging from 20.3 to 20.5ºC throughout analysis. The Autosal bath temperature was set to 24ºC (~3.5 ºC above ambient).

The machine was standardised at the beginning of the cruise and the Rs Pot set to 598, yielding a standby value of 5094. The standby value varied between 5093/5094 and 5094/5095 throughout analysis. At the start of each day of analysis, the standardisation procedure was run to obtain machine offset from standard, but the pot was not adjusted throughout the cruise. A standard was run as a sample before and after each crate of 24 samples. All standards were described as STD with a bottle number of 999. As the Autosal was well trimmed and stable, the variation in measured standard value due to bath temperature fluctuation was always more significant than the machine offset from standard.

IAPSO 35 PSU standard seawater batch P155 was used throughout analysis. The label K15 ratio was 0.99981, yielding a double conductivity ratio of 1.99962. The salinity of the standard was 34.993.

Standards were always flushed 5 times prior to measurement, samples were flushed 4-5 times depending on the volume of sample available in the bottle. After flushing, 10-15 seconds was allowed

for the bath to stabilize before switching the machine from standby to read. The software subsequently waits 5 seconds before taking a 10 second average for each of the three discrete measurements which are averaged themselves for the final double conductivity measurement. The software was configured with a standard deviation limit of 0.00002 in double conductivity ratio. This limit yields 0.4 mPSU for one, 0.8 mPSU for two and 1.2 mPSU for three standard deviations. This is acceptable for a stable machine operating in a stable environment.

164 CTD and 81 underway TSG samples were analysed along with 8 samples from the large Marine Snowcatcher to identify triggering 'misfires'. A small number of samples from the TSG had visible organic matter in (mashed by the seawater pumps) which created standard deviations larger than the limit (~0.00003 – 0.00007 in double conductivity ratio). These samples were identified on the rough Autosal logsheets for clarity.

STAND ALONE PUMPS

The Challenger Stand Alone Pumps that were available for use on the cruise were:

S/N: 02-002 – Fitted with older style dot matrix display board – used for Clare Davis's filters with NMF-SS double filter pancake housing. The battery pack wiring on this unit was found to be intermittent during mobilisation. The battery packs were completely dismantled and all suspect wiring replaced. The unit performed well throughout the cruise. On the first 2 deployments the flow-meter ran backwards as it was installed in the incorrect orientation. This was rectified and subsequent deployments measured flow in the correct direction.

S/N: 02-004 – Fitted with original segmented LCD display board. Not used due to no double filter pancake housing being available and unserviceable pump. A single filter pancake housing was supplied with this unit in error. The pump on this unit is damaged beyond repair. The shaft locating insert in the magnetic window has failed resulting in damage to the impellor, shaft and surface of the magnetic window. The only salvageable part is the pump housing.

S/N: 03-01 – Fitted with older style dot matrix display board – used for Maeve Lohan's filters with double pancake filter housing. One NMF-SS double filter housing used with standard long stand-off pillars. One Liverpool double filter housing used with additional pair of 5mm spacers made on board to accommodate thicker mid section of double housing. Last deployment used for Clare Davis' filters.

S/N: 03-03 – Fitted with new SAP controller board – not used due to no double filter pancake housing being available. A single filter pancake housing was supplied with this unit in error.

Liverpool unit S/N: P-002 – Fitted with Oceanlab touchscreen style controller with single battery pack. Not used, but top-up charged and floated for cruise duration.

The SAPs were deployed on 4mm wire with plastic coating from the forward Rexroth winch on the Bull-horn beam. A 100kg plastic coated lead SAPs ballast weight was used. Nominal separation from the lower SAP and the ballast was ~15m. Delay times varied from 0.3 to 0.5 hours and pump times fixed at 1hr. When SAPs were turned around for redeployment, they could not be charged. However, with the exception of one unit on one deployment, they pumped for the full hour on the second deployment and batteries were not deeply discharged.

All units (including the Liverpool unit) were boost charged at 20V at the packs (20.7V at the charger), trickle charged at 18.3V at the packs (19V at the charger) and floated at 17.3V at the packs (18V at the charger). At the end of the cruise the batteries were fully charged and isolated prior to sealing pressure housings for packing.

TURNAROUND OF NOC, LIVERPOOL IN-LINE ADCP MOORING AT SITE 1 (CCS)

The three 600kHz Teledyne RDI Sentinel moored ADCPs on this mooring were serviced, downloaded and redeployed by NMF-SS Sensors & Moorings technicians.

Top Buoy: s/n 7301 Up-looking with battery pack s/n: 27843 - shallow 200m (white/blue) plastic housing (Bangor supplied) 15m target depth.

Mid Frame: S/N 3725 Down-looking with battery pack s/n: 3095 - deep 6000m (yellow) housing (NMF-SS supplied) 27m target depth.

Bottom Buoy: S/N 4015 Up-looking with battery pack s/n: 3096 - deep (red) housing (NMF-SS supplied). 45m target depth.

All three instruments are configured with one internal battery pack and two additional packs in an external battery housing, thus all have three battery packs each. All three units are fitted with 2 off 2Gb Pretech PCMCIA flash cards.

Upon recovery, all instruments and battery packs were removed from the buoys and frame. The instruments were stopped logging by sending a break in BBtalk and RA? confirmed 2 deployments on each instrument in two files (one on each card). Instrument real-time clocks were confirmed to be accurate within a couple of minutes. All instruments, battery packs and cables were washed with freshwater and stubborn marine growth removed with scotchbrite pads.

All data was downloaded, but PC Inspector File Recovery software supplied by Chris Balfour of NOC, Liverpool had to be used to recover data from the second (top) card of all three instruments, which was indicated to be corrupt by windows. Thanks to Chris Balfour for his assistance with this problem. It is suspected that these cards may have been erased whilst mounted in a laptop, rather than by using re ErAsE in the instrument. All data was checked ok in WinADCP. The files recovered were:

7301:
Bottom card - CAN3_000.000 (2,013,664 kB)
Top card - CAN3_000.001 (330,448 kB)

3725: CAN
Bottom card – CAN1_000.000 (2,013,664 kB)
Top card – CAN1_000.001 (335,152 kB)

4015: CAN
Bottom card – CAN2_000.000 (2,013,664 kB)
Top card – CAN2_000.001 (332,616 kB)

All battery packs were measured post-recovery at 37.7-37.9V. All packs were replaced with new packs and all voltages confirmed at 44.8-44.9V. Most of the face-seal o-rings were replaced. Test writes were run on all cards, both individually and as pairs with the command file that was used for redeployment, followed by power-down and test-reads with the card mounted in a laptop. All test files were checked in WinADCP. After final installation in the instruments, the cards were erased with re ErAsE. The instrument real-time clocks were set to within 1 second. All instruments passed all relevant pre-deployment tests including successful beam rub tests on all four beams.

The observed pressure data in the recovered data-files led us to take a closer look at the instrument pressure data whilst servicing the instruments. S/N 7301 has a 0kPa pressure on deck which is correct. S/N 4015 had a positive 10kPa offset in deck pressure. S/N 3725 had a very noisy pressure channel on deck varying from ~ -6 to -48 kPa. All copper pressure port fittings were removed and cleaned prior to re-installation before re-deployment.

All cables, connectors and bulkhead connectors were cleaned with Milli-Q and once dry, lubricated with silicone spray prior to installation.

The instruments were configured to acquire 5 minute bursts of 300 pings at ~1 ping / second, followed by 20 minutes sleep. The data written was approx 286kB per burst. This should yield a full bottom card and ~0.5Gb on the top card after the planned deployment time of 155 days. No co-ordinate transformations are applied, with data in along beam co-ordinates only. 40 bins of 0.1m were used for a range of ~4m.

The command file was provided by Jo Hopkins but was modified to start pinging immediately:

CR1
CB411
CF11101
EA0
EB0
ED500
ES35
EX00000
EZ1111101
WA50
WB0
WD111100000
WF88
WM5
WN40
WP1
WS10
WZ10
TB00:20:00.00
TC300
TE00:00:01.00
TP00:01.00

CK
CS

All instruments were audibly confirmed to be pinging both immediately after the command file was sent and also after installation in buoys/frame prior to deployment.

Appendix A: Configuration files

Titanium CTD frame
Date: 30/11/2014

Instrument configuration file: C:\Program Files\Sea-Bird\SeasaveV7\DY018\Documents\CTD setup files\DY018_tita_1182_NMEA.xmlcon

Configuration report for SBE 911plus/917plus CTD

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

1) Frequency 0, Temperature

Serial number : 03P-5700
Calibrated on : 11 April 2014
G : 4.34159706e-003
H : 6.28508868e-004
I : 1.87468534e-005
J : 1.17132278e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-4138
Calibrated on : 27 February 2014
G : -9.83474601e+000
H : 1.45187267e+000
I : -1.86002512e-003

J : 2.21735389e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 129735
Calibrated on : 12 March 2014
C1 : -6.064446e+004
C2 : 6.966022e-001
C3 : 1.971200e-002
D1 : 2.882500e-002
D2 : 0.000000e+000
T1 : 3.029590e+001
T2 : -6.713679e-005
T3 : 4.165400e-006
T4 : 0.000000e+000
T5 : 0.000000e+000
Slope : 1.00000000
Offset : 0.00000
AD590M : 1.279181e-002
AD590B : -8.821250e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-5785
Calibrated on : 6 May 2014
G : 4.33666977e-003
H : 6.27870652e-004
I : 1.95435025e-005
J : 1.44731780e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-4143
Calibrated on : 25 February 2014
G : -9.80210332e+000
H : 1.32372648e+000
I : -5.61268048e-004
J : 1.06763091e-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 : 43-2055
Calibrated on : 2 May 2014
Equation : Sea-Bird
Soc : 3.65900e-001
Offset : -7.06100e-001
A : -2.57000e-003
B : 1.30080e-004
C : -2.23610e-006
E : 3.60000e-002
Tau20 : 1.46000e+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, Free

9) A/D voltage 3, Free

10) A/D voltage 4, Altimeter

Serial number : 62679
Calibrated on : 27 March 2014
Scale factor : 15.000
Offset : 0.000

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

Serial number : BBRTD-758R
Calibrated on : 3 June 2013
ScaleFactor : 0.002903
Dark output : 0.043100

12) A/D voltage 6, Transmissometer, Chelsea/Seatech

Serial number : 161049
Calibrated on : 20 October 2010
M : 23.9408
B : -0.3507
Path length : 0.250

13) A/D voltage 7, Fluorometer, Chelsea Aqua 3

Serial number : 088244
Calibrated on : 6 August 2014
VB : 0.236800
V1 : 2.151000
Vacetone : 0.305900
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

Scan length : 45

Stainless CTD frame
Date: 30/11/2014

Instrument configuration file: C:\Program Files\Sea-Bird\SeasaveV7\DY018\Documents\CTD setup files\DY018_stainless_0869_NMEA.xmlcon

Configuration report for SBE 911plus/917plus CTD

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

1) Frequency 0, Temperature

Serial number : 03P-4782
Calibrated on : 2 July 2013
G : 4.34988979e-003
H : 6.36411045e-004
I : 2.08372334e-005
J : 1.75345425e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 04C-2231
Calibrated on : 2 July 2013
G : -1.07805493e+001
H : 1.69843332e+000
I : -3.58275165e-003
J : 3.82993434e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 100898
Calibrated on : 6 January 2012
C1 : -4.405863e+004
C2 : -6.206030e-002
C3 : 1.337540e-002
D1 : 3.669100e-002
D2 : 0.000000e+000
T1 : 2.990734e+001
T2 : -3.493620e-004
T3 : 4.061200e-006
T4 : 3.043880e-009
T5 : 0.000000e+000
Slope : 0.99995000
Offset : -1.59900
AD590M : 1.288520e-002
AD590B : -8.271930e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-5495
Calibrated on : 18 October 2013
G : 4.38224202e-003
H : 6.31062233e-004
I : 2.03280217e-005
J : 1.58958907e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-3874
Calibrated on : 24 October 2013
G : -1.05028427e+001
H : 1.38920147e+000

I : -1.01866557e-003
J : 1.39949777e-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 : 43-1624
Calibrated on : 17 May 2013
Equation : Sea-Bird
Soc : 5.26900e-001
Offset : -5.08100e-001
A : -3.06370e-003
B : 1.92500e-004
C : -2.78720e-006
E : 3.60000e-002
Tau20 : 1.43000e+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, PAR/Irradiance, Biospherical/Licor

Serial number : 70510
Calibrated on : 1 March 2013
M : 1.00000000
B : 0.00000000
Calibration constant : 12531000000.00000000
Multiplier : 1.00000000
Offset : -0.08126488

9) A/D voltage 3, PAR/Irradiance, Biospherical/Licor, 2

Serial number : 70520
Calibrated on : 3 February 2014
M : 1.00000000
B : 0.00000000
Calibration constant : 17574692442.90000200
Multiplier : 1.00000000
Offset : -0.05835960

10) A/D voltage 4, Altimeter

Serial number : 59493
Calibrated on : 29 November 2012
Scale factor : 15.000
Offset : 0.000

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

Serial number : BBRTD-1055
Calibrated on : 13 March 2013
ScaleFactor : 0.002365
Dark output : 0.061000

12) A/D voltage 6, Transmissometer, Chelsea/Seatech

Serial number : 161048
Calibrated on : 24 July 2012
M : 23.5922
B : -0.1151
Path length : 0.250

13) A/D voltage 7, Fluorometer, Chelsea Aqua 3

Serial number : 88-2615-124
Calibrated on : 19 October 2012
VB : 0.277300
V1 : 1.956300
Vacetone : 0.356100
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000
Scan length : 45

7. Mooring deployments and servicing

Chris Balfour and Jo Hopkins, NOC Liverpool.

The table below summarises the deployment and recovery times and positions of the long-term moorings at Site 1 (also referred to as CCS and/or Candyfloss site). Further times and positions relevant to the mooring deployments and recoveries can be found in the cruise Event Logs. Details of senor serial numbers, depth etc can be found in reports provided by Chris Balfour, Dougal Mountifield and the NMFSS mooring team.

Summary of long-term mooring deployment and recovery positions and dates/times

	Mooring	**Date**	**Time**	**Latitude**	**Longitude**	**Depth (m)**
Recoveries		*Recovery start time*				
Site 1 (Candyfloss)	Temperature chain	20/11/14	16:27	49° 24.189 N	8° 36.013 W	150
	In-line ADCP mooring	20/11/14	12:54	49° 24.2277 N	8° 35.93394 W	150
	ADCP bedframe	20/11/14	14:20	49° 23.999 N	8° 36.186 W	150
Deployments		*Recovery end time (anchor/frame dropped)*				
Site 1 (Candyfloss)	Temperature chain	21/11/14	10:59	49° 23.959 N	8° 36.152 W	149
	In-line ADCP mooring	22/11/14	10:43	49° 24.111 N	8° 36.077 W	149
	ADCP bedframe	21/11/14	11:38	49° 23.9423 N	8° 35.8629 W	150

Moorings and instrumentation (all times GMT)

Deployments

Mooring Site 1 - (49.40, -8.60) Candyfloss - NOCL Bedframe Deployed on 21/11/2014 at 11:38, GPS 49° 23.942'N, 8° 35.863'W, depth 150m Extra buoyancy of ~50KG was added to this frame during a previous cruise to ensure a margin of at least this amount of positive buoyancy with the upper instrumentation assembly of the frame.	
Instrument	**Details**
RS485 + DQ pressure, pumped CTD, SN4736	The CTD clock was reset and logging was set to start at 09:10 on 21/11/14. The CTD cell was located 67cm above seabed and configured for a 300s logging interval. A horizontal mounting orientation was used.
*Flowquest 150 kHz underwater current profiler (ADCP), SN015963	The FlowQuest real time clock was reset and a delayed start was set for 12:00 on 18/11/14. The top of the FlowQuest sensor array was 97cm above the deck. An extra external battery case with two internal packs was connected to double the endurance of the FlowQuest to ensure that data is recorded until the next scheduled

	recovery of the NOCL bedframe during April 2015.
*600 kHz RDI (turbulence mode) ADCP, SN12239 fitted to a gimbal. 2GB of memory was installed and the pressure sensor port was blanked.	The top of the ADCP sensor array was 96cm above the deck. Beam 2 pointed towards the FlowQuest. The instrument clock was reset on 08/11/14 and logging was set to commence at 00:00 on 01/01/15. The next recovery is scheduled for April and battery conservation is essential. This was a significantly delayed start until early 2015 to allow for the battery endurance of the ADCP and record measurements over the more scientifically interesting January to April 2015 winter to spring transition.
NOCL ballast jettison acoustic release 1	SN72863, RX 13.5, TX 12.0, Release A
NOCL ballast jettison acoustic release 2	SN70358, RX 11.0, TX 12.0, Release A

* Script file/parameters available upon request

Mooring Site 1 (cont) - (49.40, -8.60) Candyfloss - Long term T chain 2

The instruments were put into a sink of salt water for logging comparisons at 06:00 on 21/11/14 and then removed from the sink of salt water at 08:20 on 21/11/14. The instruments were then subsequently deployed on 21/11/2014 at 10:59 at a GPS location of 49° 23.959'N, 8° 36.152'W at a nominal depth 150m.

Depth	Type	Param	SN	Details
-10	SBE 16+	RS232+ DQ pressure pumped CTD	4848	Clock reset and logging set for 06:00 on 21/11/14 – new batts
-15	RBR Solo		76789	Clock reset and logging set for 06:00 on 20/11/14 – new batt
-20	Starmon mini	T	3893	Clock reset and logging set for 06:00 on 20/11/14 – 86% batt
-25	RBR Solo		76790	Clock reset and logging set for 06:00 on 20/11/14 – new batt
-30	SBE 37	RS232 + press (unpump) CTD	2506	Clock reset and logging set for 06:00 on 21/11/14
-35	Starmon mini	T	3894	Clock reset and logging set for 06:00 on 20/11/14 – 86% batt
-37	RBR Solo		76791	Clock reset and logging set for 06:00 on 20/11/14 – new batt
-40	Starmon	T	3896	Clock reset and logging set for

	mini			06:00 on 20/11/14 – 86% batt
-42	RBR Solo		76792	Clock reset and logging set for 06:00 on 20/11/14 – new batt
-45	SBE 16+	RS232 + DQ pressure - Pumped CTD	5310	Clock reset and logging set for 06:00 on 21/11/14 – new batts
-47	DST	Substituted Star Oddi DST SN 3613 as the logger is mounted on a chain	3613	Clock reset and logging set for 09:45 on 21/11/14 – 43% bat
-49	SBE 37	RS232+pressure (pumped) - V2 CTD	7460	Clock reset and logging set for 06:00 on 21/11/14
-54	Starmon mini	T	3897	Clock reset and logging set for 06:00 on 20/11/14 – 86% batt
-59	Starmon mini	T	3899	Clock reset and logging set for 06:00 on 20/11/14 – 86% batt
-64	Starmon mini	T	3901	Clock reset and logging set for 06:00 on 20/11/14 – 86% batt
-69	SBE 37	IM + No pressure CT	2081	Clock reset and logging set for 06:00 on 21/11/14
-74	RBR Solo		76794	Clock reset and logging set for 06:00 on 20/11/14 – new batt
-79	Starmon mini	T	3903	Clock reset and logging set for 06:00 on 20/11/14 – 86% batt
-89	Starmon mini	T	3905	Clock reset and logging set for 06:00 on 20/11/14 – 86% batt
-99	SBE 37	RS232 + press (pumped) V2 CTD	7458	Clock reset and logging set for 06:00 on 21/11/14
-109	RBR Solo		76795	Clock reset and logging set for 06:00 on 20/11/14 – new batt
-120	RBR Solo		76796	Clock reset and logging set for 06:00 on 20/11/14 – new batt
-129	SBE 16+	RS485 + DQ pressure pumped CTD	4737	Clock reset and logging set for 06:00 on 21/11/14 – new batts

Instrument Recoveries

Mooring Site 1 (cont) - (49.40, -8.60) Candyfloss - Long term T chain 1

This mooring was deployed on during DY026 on 22/08/2014 at 13:58, the instrument logging interval was set to 300s. The mooring recovery occurred during DY018 and was completed by 17:05 on 20/11/14 at a GPS of 49° 24.384'N, 8° 34.903'W from a water column depth of 150m. The instruments were the put into a sink of salt water for logging comparisons at 16:45 on 20/11/14. Following this the instruments were subsequently removed from the sink of salt water at 18:20 on 20/11/14. Initial tests show a full data return from all of the instruments.

Depth	Type	Param	SN	Details
-10	SBE 16+	RS485+ DQ pressure pumped CTD	4597	Clock drift was GMT +27s
-15	Star Oddi	CT	5753	54% batt

	DST			
-20	Starmon mini	T	3578	82% batt
-25	Star Oddi DST	CT	5768	52% batt
-30	SBE 37	RS232 + press (unpump) CTD	4998	Clock drift GMT +23s
-35	Starmon mini	T	3584	82% batt
-37	Star Oddi DST	TP	3278	35% batt
-40	Starmon mini	T	3580	82% batt
-42	Star Oddi DST	TP	3654	41% batt
-45	SBE 16+	RS232 + DQ pressure Pumped CTD	5309	Clock drift GMT +25s
-47	Star Oddi DST	TP	3653	39% batt
-49	SBE 37	RS232+pressure (pumped) V2 CTD	7459	Clock drift GMT +6s
-54	Starmon mini	T	3890	86% batt
-59	Starmon mini	T	3881	82% batt
-64	Starmon mini	T	3891	86% batt
-69	SBE 37	IM + No pressure CT	2010	Clock drift GMT +42s
-74	Star Oddi DST	TP	3661	36% batt
-79	Starmon mini	T	3582	82% batt
-89	Starmon mini	T	3583	82% batt
-99	SBE 37	RS232 + press (pumped) CTD	4550	Clock drift GMT +35s
-109	Star Oddi DST	TP	5284	67% batt
-120	Star Oddi DST	TP	5264	67% batt
-129	SBE 16+	RS485 + DQ pressure pumped CTD	4738	Clock drift GMT +26s

<u>Mooring Site 1 - (49.40, -8.60) Candyfloss - NOCL Bedframe</u>

The frame was originally deployed on 22/08/14 during DY026 at 08:30 and recovered on 20/11/14 during DY018 at 14:20. The recovery occurred at a GPS location of 49° 23.999'N, 8° 36.186'W. The water depth was 150m. Extra buoyancy of ~50KG was previously added to this frame and an extra

ballast weight of ~75kg was also added.	
Instrument	**Details**
RS485 + DQ pressure, pumped CTD, SN4596	Clock reset and logging set for 08:10 on 22/08/14. The CTD was mounted horizontally at 68cm above the deck and set for a 300s logging interval. The measured clock drift was GMT +19s on 22/11/14 after the frame recovery and a full data return from the CTD occurred.
*Flowquest 150 kHz underwater current profiler (ADCP), SN11043	The FlowQuest memory was cleared on 12/08/14 and the clock reset, with a delayed start set for 06:00 on 22/08/14. The top of the sensor array was 97cm above the deck. The measured clock drift was GMT –213s after the recovery and initial checks showed that a full data return was achieved.
*600 kHz RDI (turbulence mode) ADCP, SN5807 fitted to a gimbal. 2GB of memory was installed and the pressure sensor port was blanked.	The top of the ADCP sensor array was mounted 99cm above the deck of the ship. Beam 1 pointed towards the frame spooler. The ADCP clock was originally reset to 11:42 on 20/08/14 and logging set for 06:00 on 22/08/14. A clock drift of GMT +7s was observed when the instrument was shut down at 08:34 on 24/11/14, following the recovery. The full internally recorded data set of ~1.21GB was downloaded and tested. Initial indications show a full data return.
NOCL Spoolerbuoy™ acoustic release previously installed for a frame and ballast recovery attempt and not used during DY018.	SN69676, RX 11.5, TX 12.0, Release C **This acoustic seemed to provide a range of 300m once prior to the recovery before becoming unresponsive after the recovery. Visual inspection showed signs of limited seawater ingress and a suspected small amount of positive pressure was vented when the vacuum port was temporarily opened. The internal steel banding and mastic seal seemed intact.**
NOCL ballast jettison acoustic release 1	SN72378, RX 10.5, TX 12.0, Release A **This acoustic was also unresponsive when the recovery was attempted. Visual inspection after the frame recovery showed seawater ingress, although not flooding. There was no noticeable pressure build up when the vacuum port was temporarily vented. The internal steel banding was broken cleanly, without corrosion indicating some kind of impact or shock may have occurred to this acoustic transponder.**
NOCL ballast jettison acoustic release 2	SN70356, RX 10.5, TX 12.0, Release D **This acoustic worked correctly and jettisoned the ballast to allow the frame to be recovered. On inspection after recovery, although the acoustic was working, the metal banding around the glass sphere was broken. This seems to be as a result of corrosion plus possible mechanical shock.**

* Script file/parameters available upon request

Towed Temperature and Fluorometer (T-F) Chain Deployment

Deployment overview

Stratification was shown in the water column with a CTD profile prior to the T-F deployment at the intended survey location close to the Celtic Sea shelf edge. This meant that the towed T-F chain was useful for studying the properties of the water column with a potentially higher temporal resolution and possibly spatial resolution than that achievable by the ship's CTD.

The towed T-F chain temperature and Seabird Microcat CT/CTD instruments had a delayed start set for 06:00 on Monday 17/11/14. The WetLabs Eco Fluorometers did not have a delayed start capability and these self-recording fluorometers were manually started at approximately 24:00 on 16/11/14. All of the instruments used were set to sample at 30 second intervals.

A 200m long 10mm diameter stainless steel wire with hard eyes on each end and copper ferrules every 2.5m was used to deploy the instruments. The ferrules on the deployment line were marked with coloured tape to indicate where to place the instruments to achieve the desired measurement depths. A swivel coupling and a 380Kg spherical lead weight (wrecking ball) were used to tension the lower end of the line and encourage the mooring assembly to adopt a vertical profile underwater. The towed T-F deployment occurred over the stern of RRS Discovery using a deck winch and a block with a wide channel plastic lined sheave, which was coupled to the ship's aft A-frame.

Deployment summary

At 06:00 on 17/11/14 the towed T-F chain instruments were placed into a sink of salt water in the main lab on RRS Discovery for measurement comparison. At 07:45 the instruments were removed to prepare for the deployment. The T-F chain deployment occurred between 09:05 and 09:45 on 17/11/14. Unfortunately a problem was encountered with the ferrule marking on the towed line. As the instruments were placed in position on the stainless line in reverse order (deepest instrument first) for deployment, an offset appeared to occur, with the final instruments located at higher positions along the line than expected. After a brief discussion with the onboard deployment team it was decided to correct the positions in the water column that the instruments were located by counting the ferrules between the instruments when the instruments were progressively recovered. This information, relative to a sea surface target marker on the line, would be used to calculate the deployed instrumentation depths. The deployment occurred at 09:43 on Monday 17th November at a GPS location of 48° 35.250N, 9° 30.580W. The Celtic Sea based shelf edge survey area used for the deployment was 205m in depth.

Recovery summary

The recovery was completed by 17:07 on Monday 19th November at 48° 33.769N, 9° 30.16W. During the recovery operations 5 of the 10 fluorometers and 3 off the 5 Seabird Microcat CT/CTD sensors were missing. There was no evidence of the lost instruments or their mounting clamps on the recovered towed line. It is assumed that the clamps for the lost instruments had worked loose during the deployment leading to the equipment loss that occurred. The recovered instruments were placed into a sink of salt water for measurement comparison at 17:30 on 19/11/14 and removed at 19:00 on 19/11/14.

A list of the lost and recovered instruments is provided in the table below. All of the Seabird Microcats CT/CTD sensors used had un-pumped conductivity cells.

Towed T-F Chain Instrument Depths and Details		
Depth (m)	**Instrument Type**	**Inst Number**
7.5	FLB 775 + DST3604 T only	1
10	FLB 776/ DST 3613 T only	2
17.5	Microcat 4966 RS232 + pressure	3
20	FLB 777/ DST 3608 T only	4
25	FLB 778/ DST 3619 T only	5
XX	FLB 779/ DST 3270T+P (100m,0.05m) – LOST!	6
40	Starmon Mini 2849 T	7
XX	FLB 780/ DST 3271 T+ P (100m,0.05m) – LOST!	8
XX	FLB 907/ DST 3655 T+P (240m,0.1m) – LOST!	9
60	Starmon Mini 2842 T	10
XX	FLB 937/ DST 5269 T+P (100m,0.05m) – LOST!	11
XX	Microcat SN 5793 - RS232 + pressure – LOST!	12
82.5	Starmon Mini 2841 T	13
90	FLB 938/DST 5270 T+P (1400m,0.5m)	14
95	RBR Solo 76797 T	15
97.5	RBR Solo 76798 T	16
105	RBR Solo 76799 T	17
XX	FLB 1712/ DST 5269 T+P (1400m,0.5) – LOST!	18
120	RBR Solo 76800 T	19
130	Microcat 2991 - RS485 No pressure	20
132.5	RBR Solo 76801 T	21
135	Starmon Mini 2840 T (no measurements recorded)!	22
140	RBR Solo 76802 T	23
142.5	Starmon Mini 2838 T	24
145	Starmon Mini 2836 T	25
147.5	Starmon Mini 2837 T	26
150	RBR Solo 76803 T	27
157.5	RBR Solo 76804 T	28
165	RBR Solo 76805 T	29
XX	Microcat 5433 - RS232 with pressure – LOST!	30
177.5	RBR Solo 76806 T	31
185	RBR Solo 76807 T	32
XX	Microcat 5790 RS232 with pressure – LOST!	33

Key:

FLB	WetLabs internally recording Eco Chlorophyll-a fluorometer.
DST	Star Oddi Dst Centi internally recording Temperature/T+ Pressure logger.
Starmon Mini	Star Oddi internally recording temperature logger.
RBR Solo	Internally recording temperature logger.
Microcat	Seabird SBE37 internally recording CT/CTD sensor.

Wire Walker System Deployments and Recoveries

Overview

The Wirewalker is a wave-powered autonomous profiler. It uses the surface wave field to power continual vertical profiling. Internally powered and recording instrumentation attached to the Wirewalker collects a two-dimensional depth-time record. Briefly, the mooring itself includes a surface buoy, a wire suspended from the buoy, a weight at the end of the wire, and the profiler attached to the wire via a cam mechanism. A mooring diagram is included below. The wire and weight follow the surface motion of the buoy. The wave-induced motion of the water is reduced with increasing depth, and the relative motion between the wire and the water is used to propel the profiler. The cam engages the wire as it descends and releases it as it ascends, pulling the profiler downwards. At the bottom of the wire, the wirewalker hits a mechanical stop that causes the cam to remain open and the profiler free floats to the surface. At the top of the wire, the cam is reset and the wirewalker is ratcheted downwards again.

Preparation of the wirewalker in the lab

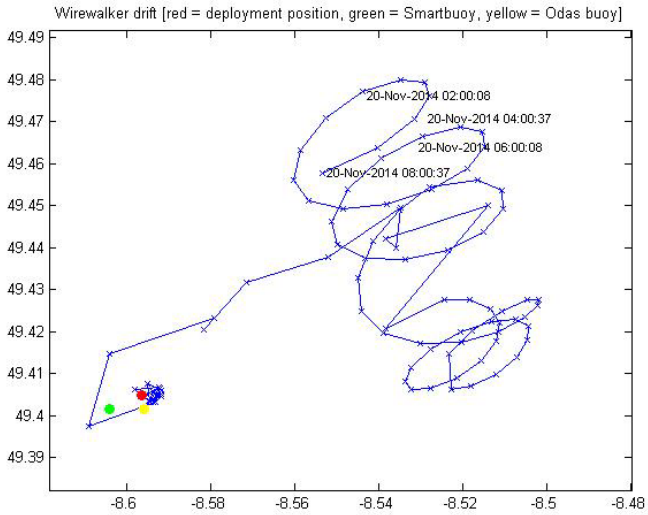
Two short term deployments took place during the cruise

Deployment 1

Deployed: 11/11/14 16:31, 49° 24.294 N, 8° 35.790 W

Recovered: 21/11/14 13:49, 49° 28.614, 8° 36.54 W

The WireWalker with the intended 100m long underwater profiling wire was deployed at 16:31 on 11/11/14 at a GPS location of 49° 24.294'N, 8° 35.790'W with a water depth of 150m. After approximately 3 days into the deployment the Iridium surface buoy indicated that the buoy had drifted off station by several km, indicating a problem with the mooring. The WireWalker was recovered at 13:49 on 21/11/14 at a GPS location of 49° 28.614'N, 8° 36.54'W. An inspection showed that the mooring rope between the subsurface weight and the seabed anchor clump had been frayed and worn until it had snapped due to suspected entanglement with the clump. The RBR CTD and Triplet measurements recorded during this deployment were retrieved successfully.



Instrumentation:

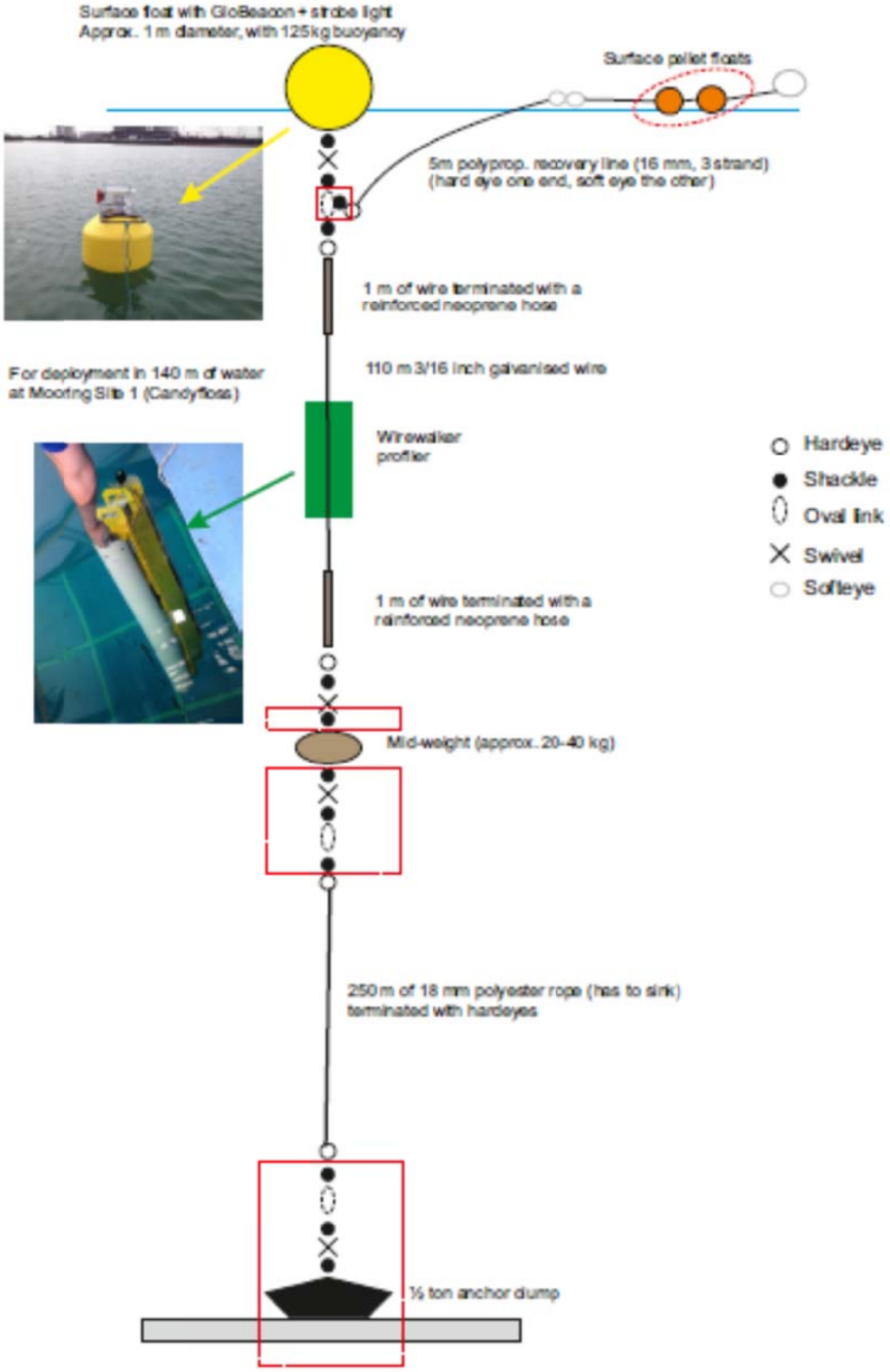
- RBR Concerto Fast SN 060048 sampling at 6 Hz (Temperature, Conductivity and Pressure)
- Wetlabs Triplet SN 2560 sampling at 4 Hz (Chlorophyll-a, Phycoerythrin and CDOM fluorescence)
- DH-4 Logger SN 119

Deployment 2

Deployed: 22/11/14 11:23, 49° 24.281 N, 8° 36.035 W
Recovered: 26/11/14 09:23, 49° 24.111N, 8° 35.896 W
The WireWalker with the 100m long underwater profiling wire was deployed for a second time at 11:23 on 22/11/14 at a GPS location of 49° 24.281'N, 8° 36.035'W, with a water depth of 150m. A 10m length of chain was added between the underwater rope and the anchor clump to discourage entanglement. The WireWalker was recovered at 09:23 on 26/11/14 and had held station during the second deployment. On recovery the 10m long section of chain had wrapped around the anchor clump. A full RBR CTD and WetLabs triplet data return was achieved.
Instrumentation

- RBR Concerto Fast SN 060048 sampling at 6 Hz (Temperature, Conductivity and Pressure)
- Wetlabs Triplet SN 2560 sampling at 4 Hz (Chlorophyll-a, Phycoerythrin and CDOM fluorescence)
- DH-4 Logger SN 096

Mooring diagram



Ballasting Test:
This was a wirewalker buoyancy test from the stern of RRS Discovery using a 10m long underwater profiling guide line, the subsurface 40kg weight and the surface buoy. The test occurred between 10:24 and 10:36 at a GPS location of 49° 23.9069'N, 8° 34.592'W on 10/11/14, with a water depth of 148.5m. Analysis of the pressure record of the RBR CTD confirmed that the ballasting was suitable for this work area and the profiler was operating correctly. The triplet measurements were also retrieved successfully from this test deployment.

WireWalker Instrumentation calibration CTD cast 085, event 225:
The RBR CTD, triplet and DH4 logger were attached to the ship's stainless steel CTD system to provide co-located, calibrated CTD and fluorometer reference readings to a depth of 127m between 12:22 and 13:08 on 26/11/14 at a GPS location of 49° 23.656'N, 8° 25.879'W. This CTD cast was intended to be as close to the WireWalker deployment location as practicable. A full data return was achieved from the RBR CTD and the triplet, via a DH4 data logger for this deployment.

8. Gliders

Sam Ward (NOCS, MARS Gliders, NMFSS)
If any information is required about the gliders deployed during DY018 then please email nocs_mars_gliders@noc.ac.uk .

DY018 Glider Aims and Objectives

SSB Slocum Deployments:

- To deploy one 200m (shallow) Slocum: Unit_424 'OMG3' with the Microrider turbulence probe for the duration of DY018
- To deploy two 1000m (deep) Slocums: Unit_304 'Ammonite' and Unit_330 'Bellamite' until April 2015
- To deploy one 200m (shallow) Slocum: Unit_345 'Cabot' until April 2015

Sensors on Gliders Seaglider Deployment:

- To deploy one 1000m (deep) Seaglider: SG534 'Denebola' with the LoC Nitrate sensor for the duration of DY018

DY018 Glider Activity Tables in Chronological Order

Deployed:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
15:24	11/11/14	SLOCUM Unit_424 'OMG3' 200m MICRORIDER	49° 23.9942 N	08° 37.4881 W	27	26

Deployed:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
15:45	12/11/14	SEAGLIDER 534 'DENEBOLA' 1000m LoC SENSOR	49° 23.9985 N	08° 37.4935 W	47	42

Deployed:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
12:27	15/11/14	SLOCUM Unit_304 'AMMONITE' 1000m	48° 20.500 N	09° 41.500 W	70	69

Deployed:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
13:06	15/11/14	SLOCUM Unit_330 'BELLAMITE' 1000m	48° 20.400 N	09° 42.000 W	71	69

Deployed:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
13:19	18/11/14	SLOCUM UNIT_345 'CABOT' 200m	48° 34.400 N	09° 31.500 W	120	119

Recovered:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
16:10	21/11/14	SEAGLIDER 534 'DENEBOLA' 1000m LoC SENSOR	49° 35.4889 N	08° 17.905 W	47	164

Deployed:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
09:18	22/11/14	SEAGLIDER 534 'DENEBOLA' 1000m LoC SENSOR	49° 23.498 N	08° 35.359 W	165	164

Recovered:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
10:36	26/11/14	SLOCUM Unit_424 'OMG3' 200m MICRORIDER	49° 23.830 N	08° 27.135 W	27	225

Deployed:

TIME	DATE	GLIDER	LATITUDE	LONGITUDE	CAST	CTD CALIBRATION CAST
11:28	26/11/14	SEAGLIDER 534 'DENEBOLA' 1000m LoC SENSOR	49° 23.685 N	08° 25.827W	165	225

Glider Sensors and Serial Numbers

'Ammonite' Unit_304	Sensors	Serial Number
	Aanderaa Optode	Type 4831 S/N: 119 Cal Date: 19th Dec 2012
	Wet Labs Triple Puck	Type 700nm S/N: 2882 Cal Date: 11th Mar 2014
	Micron Pressure Sensor	Pressure Tx (Micron) S/N: 80344
	SeaBird CT sail	S/N: 0157 Cal Date: 30th Jan 2014

'Bellamite' Unit_330	Sensors	Serial Number
	Aanderaa Optode	Type 4831 S/N 104 Cal Date: 16th Jan 2014?
	Wet Labs Triple Puck	Type 700nm S/N: 2799 Cal Date: 17th March 2014
	Micron Pressure Sensor	Pressure Tx (Micron) S/N: 61200 Cal Date: 26th sep 2005
	SeaBird CT Sail	S/N: 0049 Cal Date: 14th Feb 2014

'Cabot' Unit_345	Sensors	Serial Number
	Aanderaa Optode	Type 4831 S/N: 122 Cal Date: 16th Jan 2014
	Wet Labs Triple Puck	Type 700nm S/N: 2810 Cal Date: 22nd March 2014
	Micron Pressure Sensor	Pressure Tx (Micron) S/N: 94363 Cal Date: 11th Jan 2013
	SeaBird CT Sail	S/N: 9034 Cal Date: 05 March 2014

'OMG3' Unit_434	Sensors	Serial Number
	Aanderaa Optode:	Type 4831 S/N: 268 Cal Date: 23rd sep 2013
	Wet Labs Triple Puck	N/A Not Installed
	Micron Pressure Sensor	Pressure Tx (Micron) S/N: 96124 Cal Date: 17th June 2013
	SeaBird CT Sail	S/N: 221
	Microrider	Micro Rider: S/N: 105 Cal Date: 12/12/2013 S1 = M1071, 0.0931, 600 Bar. Horizontal so there for will be measuring vertical. S2 = M1071, 0.0729, 600 Bar. Vertical so there for will be measuring horizontal. T1 = T838 2K0hm

'Denebola' SG534	Sensors	Serial Number
	Aanderaa Optode	S/N: 465
	Wet Labs Triple Puck	N/A Not Installed
	SeaBird CT Sail	S/N: 0156
	NOC LoC	2 x Nitrate sensors in a single housing with external oil bladder and no battery

Deployment Water Density and Temperature Data

CTD cast 26:

Depth (m)	Density	Temperature (°c)
6	26.62	14
90	26.82	13.14
180	27.02	12.1

Glider Buoyancy Modifications and Issues

Prior to the glider deployments the following buoyancy modifications were made based on the above density and temperature data.

'OMG3' Unit_424 (Cast 27)

Three bullet weights were removed (30g in Seawater) from 'Coprolite' Unit_304 (the spare deep glider) and added to 'OMG3' Unit_424. This brought 'OMG3' Unit_424's buoyancy up to around 130g for its deployment.

'Denebola' SG534 (Cast 47):

Based on the density and temperature data taken from CTD Cast 26, 136g of lead was removed from 'Denebola' SG534.

On its first deployment 'Denebola' SG534 only achieved one dive due to the vehicle being to buoyant and it was unable to break through the water's surface layer.

'Denebola' SG534 (Cast 165):
Based on the buoyancy data taken from 'Denebola' SG534's dive data on its first deployment, the 136g of lead was added back on to the vehicle.
'Denebola' SG534's dive data on its second deployment suggests that the 136g of buoyancy removed prior to its first deployment (Cast 47) was adequate and that the vehicle should have been able to dive sufficiently. It is unknown why the vehicle couldn't dive on its first deployment and this issue will be looked into by the MARS glider team after DY018 to rectify this issue ready for the NOC LoC Nitrate sensors next deployment in 2015. The issue could have been caused by trapped air within the gliders fairing or issues with the NOC LoC Nitrate sensor itself? Until further investigation is undertaken it remains unknown as to why 'Denebola' SG534 wouldn't dive on its first deployment.
During Cast 47 ('Denebola' SG534's second deployment) when the NOC LoC Nitrate sensor was turned on during one of the dives the gliders 10 volts battery dropped very low to around 8.7 volts. It is thought this was caused by the one of the two Nitrate sensors and again this problem will be investigated by OTE and the MARS glider team after DY018 to insure that the Seaglider and Nitrate sensor are operating sufficiently for any deployments in 2015.

Deployments, Recoveries and Future Recommendations

Deployments

The first two deployments ('OMG3' Unit_424 Cast 27 and 'Denebola' SG534 Cast 47) were done using the forward auxiliary winch from the P frame using the Slocom deployment rig and the rigid rope deployment rig. A buoyancy test was undertaken prior to 'Denebola' SG534 Cast 47 to insure that the vehicle was floating on the surface in the correct position in the water (which it was). Once it was deployed 'Denebola' SG534 was drawn under the starboard hull (vessels waist) due to the negative effect the ship has to the water when the vessel is moving. This could have led to the Seaglider being sucked into the ships propeller which could of caused destruction of the vehicle and also damage to the ship itself.

Deployment Recommendations

The captain and crew recommended that the next deployments be conducted from the starboard aft quarter using the pedestal crane. Deployments: Cast 70 'Ammonite' Unit_304, Cast 71 'Bellamite' Unit_330, Cast 120 'Cabot' Unit_345 and Cast 165 'Denebola' SG534 were all undertaken from this position and the ships positive thrust pushed the gliders away safely using the vessels propulsion.

Recoveries

'OMG3' Unit_424' and 'Denebola' SG534 was recovered using the forward auxiliary winch from the P frame starboard side of the vessel. 'OMG3' Unit_424' was recovered using the new plastic grapnel to pull inboard the Slocum recovery line once the recovery nose drogue had been blown. 'Denebola' SG534's ruder was noosed using the carbon fibre recovery pole and aluminium hoop. The recovery line was tied to an eye on the bulwark and a boss hook was attached which enabled the glider to be pulled out of the water safely at double the speed.

Acknowledgments

- Thank you to the MARS Glider team back at base for all of their support during DY018.
- Thank you to the Captain and crew of the RRS Discovery for providing excellent support for all of the glider operations.

- Thank you to Ben Pool and Tom Roberts for always giving a helping hand during glider deployments and recoveries.
- Thank you to the principle investigator Jonathan Sharples for be extremely flexible with deployment and recovery times
- Thank you to Billy Platt and Dougal Mountifield for supply the pre deployment buoyancy data.
- Thank you to Zoltan Nemeth for fixing the ships communications which were crucial to the glider operations.
- Thank you to Maeve Lohan for fixing the external pump fitting on the nitrate sensor which fell off just as SG534 was being deployed.

9. Dissolved Inorganic Nutrients

Malcolm Woodward, PLYMOUTH MARINE LABORATORY, UK

OBJECTIVES:

To investigate the spatial and temporal variations of the micromolar nutrient species; Nitrate, Nitrite, Silicate, Ammonium and Phosphate during the DY018 research voyage in the Celtic Sea, Shelf Edge, and Off Shelf sea areas off the West of the UK. Including specific 'Iron' transects (WP3) for a series of stations in from 2500m deep in the Atlantic up onto the Shelf.
To carry out nutrient analysis from zooplankton and benthic experiments where required as part of the SSB programme (Giering and Bone), plus other samples for snow-catcher depth confirmations etc. Please see individual cruise reports for these colleagues as to their individual sampling protocols.

SAMPLING and ANALYTICAL METHODOLOGY:

Sample preparation and procedure

There was absolutely minimal storage of the CTD water column samples except for the time waiting to be analysed in the laboratory. These samples were always run at lab temperature and were not filtered. 60m ml HDPE Nalgene bottles were used for all the nutrient sampling, these were aged, acid washed and cleaned initially, and stored with a 10% acid solution between sampling. Samples were taken from the Sea-Bird CTD systems on-board the RRS Discovery, both Stainless Steel and Titanium units. The sample bottle was washed 3 times before taking final sample, and capping tightly. This was then taken immediately to the analyzer in the lab, and analysis conducted as soon as possible after sampling. Nutrient free gloves (Duratouch) were used and other clean handling protocols were adopted as close to those according to the GO-SHIP protocols, (2010) as possible.

Sample Analysis

The micro-molar segmented flow auto-analyser used was the PML 5 channel (nitrate, nitrite, phosphate, silicate and ammonium) Bran and Luebbe AAIII system, using classical proven analytical techniques. The instrument was calibrated with home produced nutrient standards and then compared regularly against Nutrient Reference Materials, from KANSO Technos, Japan. The results from this also being part of a global nutrient programme (the INSS, International Nutrient Scale System) to improve nutrient analysis data quality world-wide.
The analytical chemical methodologies used were according to Brewer and Riley (1965) for nitrate, Grasshoff (1976) for nitrite, Kirkwood (1989) for phosphate and silicate, and Mantoura and Woodward (1983) for ammonium.

References:

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Water samples were taken from the 24 x 10 litre Stainless Steel CTD/Rosette system (SeaBird). Clean handling techniques were employed to avoid any contamination of the samples, particularly for the ammonium samples. Gloves used were Dura-Touch to minimise nutrient contamination. Samples were kept tightly closed until just before analysis for the ammonium, this to avoid any contamination from external sources.

CTD Samples Analysed by AAIII Micromolar analysis:

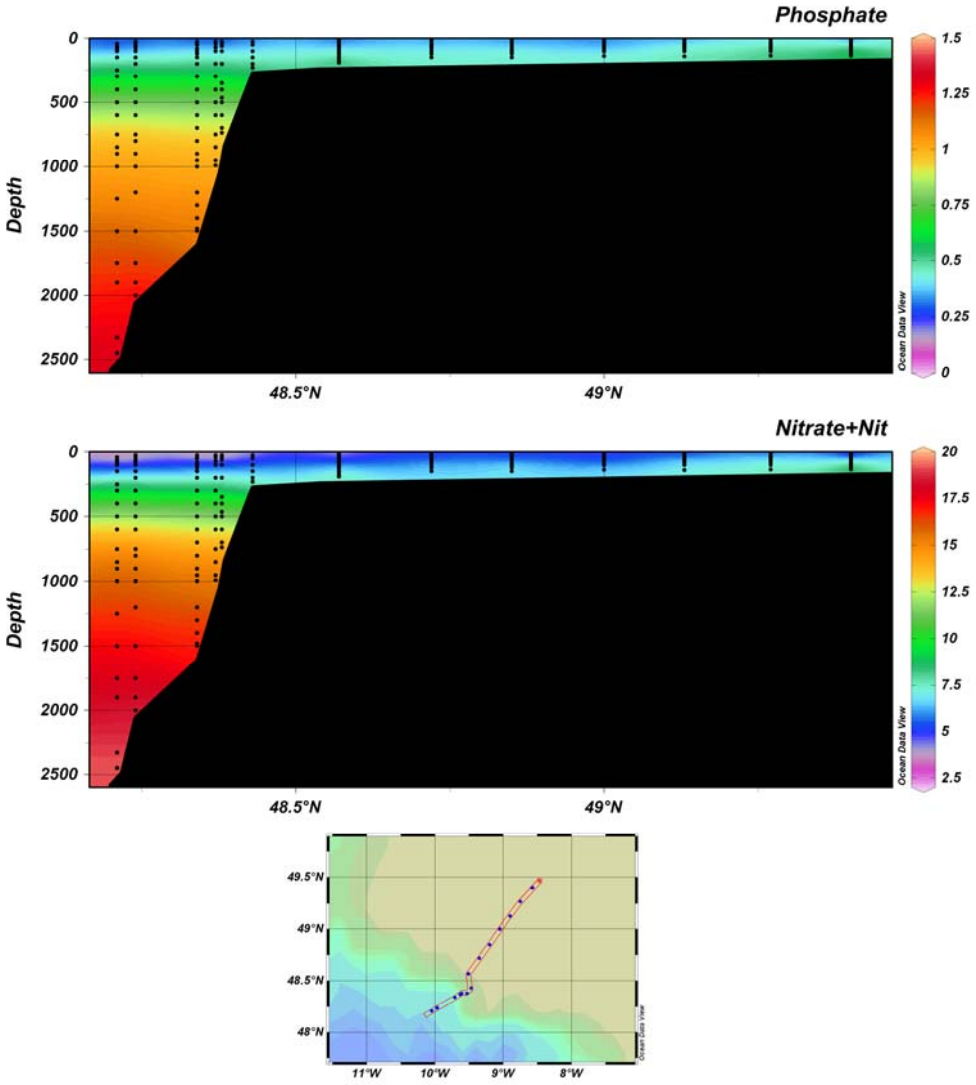
Date	CTD	Event	Position	CTD bottle analysed
10/11/14	CTD_001	001	49^{0}24.095'N 8^{0}34.841'W	Bottles 2,4,6,9,12,14,16,18,20,24(depths: 136,100,83,67,42,28,15,15,10,5,5m)
10/11/14	CTD_003	004	49^{0}23.906'N 8^{0}34.592'W	Bottles 7,8,10,12,14,16,18,20,24(depths: 130,100,85,70,60,50,40,25,m)
11/11/14	CTD_006	024	49^{0}23.90'N 8^{0}34.72'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19)Depths:134,134,130,120,120,100,90,70,60,55,40,30,25,25m
11/11/14	CTD_007	025	49^{0}23.90'N 8^{0}34.72'W	Bottles 2,4,6,8,10,12,15,16,18,20,24 (depths: 130, 100, 85,70,60,50,45,40,25,10,5m
12/11/14	CTD_010	039	49^{0}23.928'N 8^{0}34.595'W	Bottles 2,4,6,8,10,12,14,16,18,20,24 (depths: 130, 111, 82,58,45,36,28,24,18,14,8m
12/11/14	CTD_012	041	49^{0}23.965'N 8^{0}34.478'W	Bottles1,2,3,4,5,6,7,8,9,15,16,17,18,19,20,21,22,23 (depths135,135,135,130,130,120,120,100,90,90,70,60,50,40,30,25,25,25m
12/11/14	CTD_013	042	49^{0}23.964'N 8^{0}34.441'W	Bottles 2,4,6,8,10,12,14,16,18,20,24 (depths: 130, 100, 80,70,65,59,49,41,30,10,5m
13/11/14	CTD_014	051	49^{0}16.009'N 8^{0}44.986'W	Bottles 2,4,6,8,10,12,14,18,21,24 (depths: 136, 100, 80,70,60,55,50,40,30,10,5m
13/11/14	CTD_016	054	49^{0}07.700'N 8^{0}54.289'W	Bottles 2,3,5,7,10,11,13,15,17,19,21,24 (depths: 140, 100, 80,70,65,61,55,50,40,30,10,5m
13/11/14	CTD_019	057	49^{0}00.04'N 9^{0}02.754'W	Bottles 2,4,6,7,10,12,14,16,18,20,22,24 (depths: 139, 102, 86,77,71,67,61,51,40,30,10,5m
13/11/14	CTD_021	059	48^{0}51.234'N 9^{0}11.934'W	Bottles 2,4,6,8,10,12,14,16,18,20,22,24 (depths: 149, 120,100,95,90,85,80,60,40,20,5m
14/11/14	CTD_023	061	48^{0}43.106'N 9^{0}21.085'W	Bottles 1,3,6,7,9,11,13,16,17,19,21,24 (depths: 150, 121, 100, 80,70,65,60,55,50,40,20,5m
14/11/14	CTD_27	065	48^{0}12.383'N 10^{0}03.265'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,24(depths:2450,2448,2330,1900,1750,1500,1250,1000,900,850,750,600,500,400,300,250,150,100,90,75,60,40,40m
15/11/14	CTD_030	068	48^{0}14.370'N 09^{0}57.977'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24(depths:2000,2000,1900,1750,1750,1500,1200,1000,1000,900,800,750,600,500,400,300,200,150,100,75,60,40,25,25m
15/11/14	CTD_033	076	48^{0}20.398'N 09^{0}42.41'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24(depths:1597,1498,1481,1400,1300,1200,1000,950,900,800,700,600,500,400,300,200,150,100,80,50,30,25,25m
16/11/14	CTD_037	080	48^{0}22.208'N 09^{0}37.05'W	Bottles2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24(depths:990,990,990,950,950,950,850,850,750,750,600,500,500,400,300,200,100,100,70,40,25,25,25
16/11/14	CTD_039	082	48^{0}22.690'N	Bottles1,2,3,4,5,6,12,13,14,15,16,17(depths:736,73

			09^{0}36.491'W	6,700,600,500,400,200,100,60,40,25,25m
16/11/14	CTD_042	087	48^{0}24.529'N 09^{0}31.558'W	Bottles1,2,3,4,12,13,14,15(depths:465,465,400,350,200,100,40,25m
16/11/14	CTD_043	088	48^{0}25.714'N 09^{0}28.026'W	Bottles2,4,6,14,16,18(depths:230,200,150,100,50,25m
17/11/14	CTD_045	096	48^{0}34.251'N 9^{0}30.581'W	Bottles 2,4,6,8,9,12,15,16,18,20,24 (depths: 190,150,100,80,70,60,50,40,20,10,5m
18/11/14	CTD_047	115	48^{0}34.264'N 9^{0}30.31'W	Bottles 1,3,6,8,10,13,15,16,19,21,24 (depths: 190,155,105,85,77,66,40,30,20,10,5m
18/11/14	CTD_049	117	48^{0}34.277'N 9^{0}30.661'W	Bottles 1,2,3,4,5,13,14,15,16,17 (depths: 192,192,185,175,150,100,80,60,25,25m
18/11/14	CTD_051	119	48^{0}34.276'N 9^{0}30.661'W	Bottles 2,4,6,8,10,12,14,16,18,20,22,24(depths: 190,150,130,120,110,100,80,60,40,20,10,5m
19/11/14	CTD_052	134	48^{0}34.267'N 9^{0}30.570'W	Bottles 1,2,3,4,5,12,13,14,15,16,(depths: 190,190,185,175,150,100,80,60,40,25m
19/11/14	CTD_053	135	48^{0}34.267'N 9^{0}30.571'W	Bottles 2,4,6,8,10,12,14,16,18,20,22,24 (depths: 180,150,120,100,85,75,55,40,30,20,10,5m
20/11/14	CTD_055	150	48^{0}34.410'N 9^{0}30.378'W	Bottles 2,4,6,8,10,12,14,16,18,20,22,24 (depths: 190,150,120,100,80,75,70,60,40,20,10,5m
22/11/14	CTD_059	162	49^{0}23.261'N 8^{0}35.230'W	Bottles 1,4,6,8,10,13,15,17,19,20,24 (depths: 136,100,80,70,60,42,35,28,20,10,5m
22/11/14	CTD_063	169	48^{0}23.108'N 09^{0}55.056'W	Bottles1,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24(depths:2332,2250,2000,1750,1500,1300,1200,1000,900,800,700,600,500,400,300,250,200,150,100,75,50,25m
23/11/14	CTD_065	171	48^{0}23.971'N 09^{0}54.062'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,23,24(depths:1847,1800,1700,1600,1500,1250,1000,900,800,700,600,500,500,400,300,250,200,150,100,80,60,40,25m
23/11/14	CTD_068	174	48^{0}24.614'N 09^{0}53.370'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24(depths:1492,1488,1450,1300,1200,1000,900,800,800,700,600,500,400,350,350,300,250,200,200,150,100,50,25,25m
23/11/14	CTD_070	181	48^{0}25.326'N 09^{0}52.728'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16(depths:935,935,800,700,600,500,400,300,200,150,150,100,65,40,25,25m
24/11/14	CTD_073	184	48^{0}25.771'N 09^{0}52.261'W	Bottles1,2,3,4,5,6,13,14,15,16,17,18(depths:510,510,450,400,300,200,200,150,100,50,25,25m
24/11/14	CTD_075	186	48^{0}26.244'N 09^{0}51.781'W	Bottles1,2,3,4,5,6,13,14,15,17,18(depths:480,50,400,350,300,200,150,100,90,25,25m
24/11/14	CTD_077	188	48^{0}29.488'N 09^{0}48.186'W	Bottles1,2,3,4,5,6(depths:240,200,150,125,80,25m
25/11/14	CTD_081	201	49^{0}24.068'N 08^{0}35.020'W	Bottles1,4,5,8,10,13,15,17,19,21,24(depths:135,100,75,60,52,50,40,30,20,10,5m
25/11/14	CTD_082	202	49^{0}23.951'N 08^{0}34.916'W	Bottles2,4,6,8,10,12,14,16,18,20,22,24(depths:131,100,80,70,65,60,55,50,40,20,10,5m

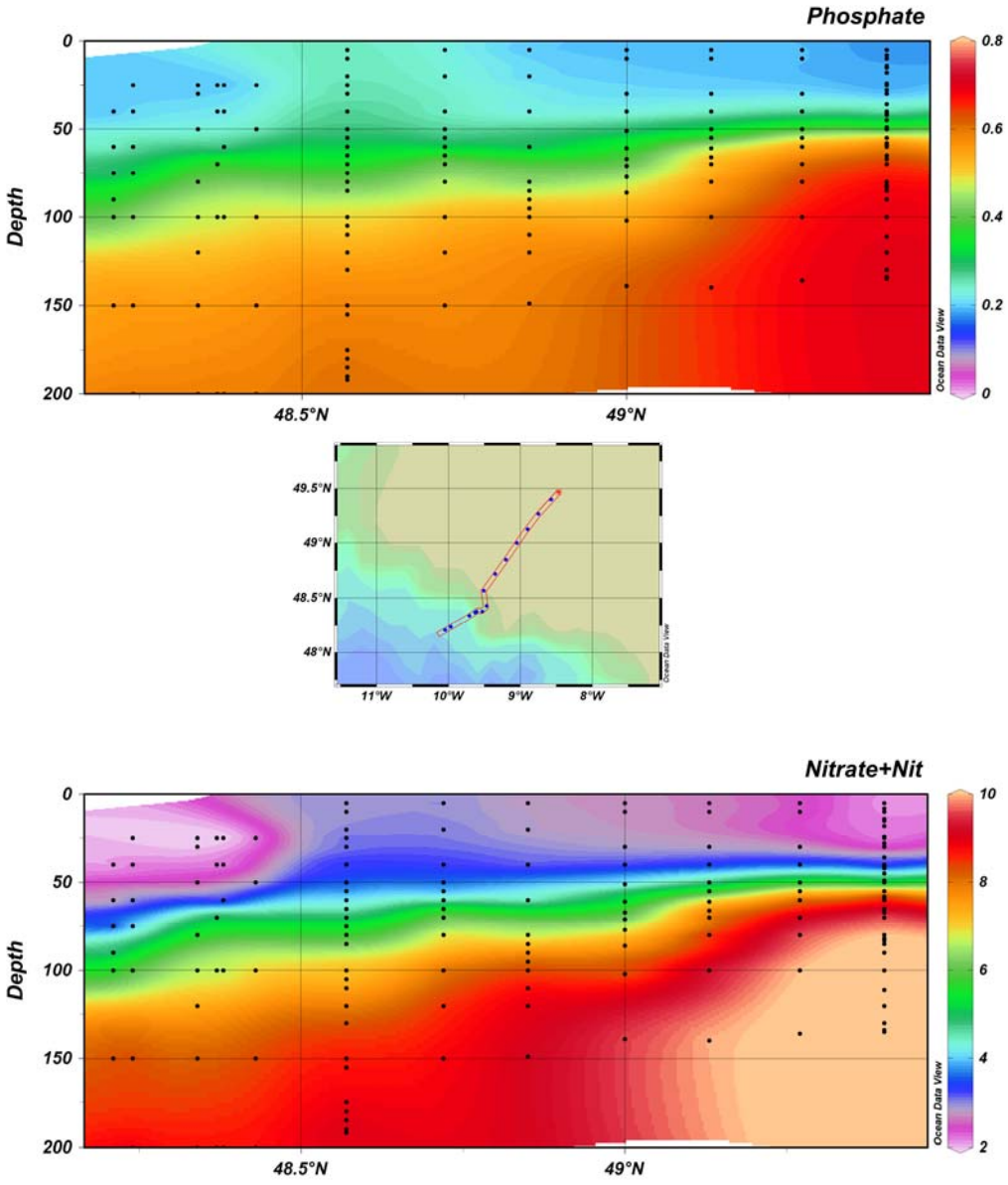
26/11/14	CTD_085	225	49^{0}23.656'N 08^{0}25.874'W	Bottles2,4,6,7,8,10,12,14,16,18,20,22,24(depths:127,100,80,70,65,60,55,50,40,20,10,5m
27/11/14	CTD_086	233	49^{0}36.314'N 08^{0}19.798'W	Bottles1,2,3,4,5,6,13,14,15,16,17,18(depths:130,120,110,90,80,80,80,60,60,40,25,25m
27/11/14	CTD_087	234	49^{0}47.671'N 08^{0}03.779'W	Bottles1,2,3,4,5,6,13,14,15,16,17,18(depths:75,75,75,70,70,65,65,65,50,45,25,25m
27/11/14	CTD_088	235	50^{0}00.79'N 07^{0}47.732'W	Bottles1,2,3,4,5,6,13,14,15,16,17,18(depths:100,100,90,80,80,70,60,48,48,40,25,25m
27/11/14	CTD_089	236	50^{0}12.479'N 07^{0}27.773'W	Bottles1,2,3,4,5,6,13,14,15,16,17,18(depths:99,99,99,85,85,80,80,60,60,40,25,25m
28/11/14	CTD_091	238	50^{0}37.501'N 06^{0}56.556'W	Bottles2,4,7,10,12,14,16,18,20,22,24(depths:86,70,65,60,55,50,45,40,20,10,5m
28/11/14	CTD_092	239	50^{0}49.79'N 06^{0}40.028'W	Bottles2,4,10,12,14,16,18,20,22,24(depths:86,70,60,55,50,45,40,20,10,5m
28/11/14	CTD_093	242	50^{0}49.79'N 06^{0}40.028'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24(depths:1492,1488,1450,1300,1200,1000,900,800,800,700,600,500,400,350,350,300,250,200,200,150,100,50,25,25m
29/11/14	CTD_094	253	49^{0}24.25'N 08^{0}35.121'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,23,24(depths:135,135,135,135,120,110,100,100,90,80,80,80,75,70,65,60,55,50,45,40,25,25,25m
01/12/14	CTD_096	261	50^{0}02.048'N 04^{0}22.257'W	Bottles1,2,3,4,5,6,7,8,9,10,11,12(depths:68,68,60,60,50,50,40,40,30,30,25,25m

Preliminary Results

The first 'Iron' transect results are presented below. This shows the Nitrate and Phosphate for the sampling transects from the deep (2500m) Atlantic Waters up onto the Continental Shelf. This shows the nutrient rich deeper Atlantic waters at the base of the Shelf.



A more detailed upper 200m profile shows the area of nutrient enrichment pushing upwards towards the surface waters between about 48^0.5 and 48^0.7 North.



Cruise Summary

Science

The 5-channel autoanalyser worked very well throughout the cruise.

KANSO nutrient reference materials (Batch BT) were run regularly to check analyser integrity and analytical continuity from one day to the next. Very good continuity in sensitivity for all 5 channels was found, demonstrating excellent analytical performance.

Thanks:

To the officers and engineers of RRS Discovery, the NMF technicians and crew who made things work for us and kept them working, and of course Mark and the catering team for excellent food. It is good to have chefs who produce quality right through the cruise rather than resort to deep fat frying everything that some chefs have done on past cruises!

10. Dissolved inorganic carbon and total alkalinity

Louise Darroch (BODC)[1], Jo Hopkins (NOC), (Sue Hartman (NOC)[2] and Caroline Kimivae (NOC))
[1]Author, [2]Dataset PI

Background and objectives

Dissolved inorganic carbon (DIC) and total alkalinity (TA) discrete samples were collected by Louise Darroch and Jo Hopkins (cruise participants) on behalf of Sue Hartman and Caroline Kimivae at the National Oceanography Centre, Southampton (NOC). Samples were collected from CTD casts as part of WP1 in order to characterise the water column of the study area and to calibrate the sensors on deployed gliders and the CEFAS Smart buoy. CTD samples were collected as part of the Shelf Wide monitoring programme and work package 1. CTD samples collected on iron transects were collected as part of work package 3.

Sampling strategy

Discrete samples were collected from 21 CTD casts carried out with the titanium CTD package and 22 CTD casts carried out with the stainless steel (Table 1). Samples were withdrawn from 5 to 12 depths, spanning the entire water column.

Methods

Samples were collected in 250 ml glass stoppard bottles. Samples were withdrawn from CTD niskin bottles and the non-toxic, pumped seawater supply using silicone tubing. The tubing was inserted into the base of bottle and slowly filled (and over-filled) from the bottom to avoid and remove air bubbles. Samples were immediately poisoned by removing 2.5 ml volume and adding 50 µl saturated mercuric chloride solution. The samples were then stored in the dark at room temperature for analysis back at NOC.

Data quality notes

No issues were found during sample collection.

Table 1. Discrete DIC and TA samples withdrawn from the CTD

STNNBR	SITE	GEAR	CONTACT	COMMENTS	NMFID
001	CCS	Stainless steel CTD	Poulton	Pre-dawn	CTD001
004	CCS	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD003
025	CCS	Stainless steel CTD	Woodaward	Shelf-wide programme/calibration	CTD007
039	CCS	Stainless steel CTD	Poulton	Pre-dawn	CTD010
042	CCS	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD013
051	Transect O1	Stainless steel CTD	Woodward		CTD014
054	Transect O2	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD016
057	Transect O3	Stainless steel CTD	Woodward	Repeat of event 056	CTD019
059	Transect O4	Stainless steel CTD	Woodward		CTD021
061	Transect O5	Stainless steel	Woodward	Big ship roll during deployment	CTD023

		CTD			
063	CS2	Stainless steel CTD	Hopkins	Water structure check. Minimal sampling	CTD025
065	Fe01	Titanium CTD	Lohan	2500 m. No LADCP	CTD027
068	Fe02	Titanium CTD	Lohan	2000 m	CTD030
076	Fe03	Titanium CTD	Lohan	1500 m	CTD033
080	Fe04	Titanium CTD	Lohan	1000 m	CTD037
082	Fe05	Titanium CTD	Lohan	750 m	CTD039
087	Fe06	Titanium CTD	Lohan	500 m	CTD042
088	Fe07	Titanium CTD	Lohan	250 m	CTD043
096	CS2	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD045
115	CS2	Stainless steel CTD	Poulton	Pre-dawn	CTD047
119	CS2	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD051
135	CS2	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD053
150	CS2	Stainless steel CTD	Poulton	Pre-dawn	CTD055
162	CCS	Stainless steel CTD	Poulton	Pre-dawn	CTD059
169	Fe08	Titanium CTD	Lohan	2500 m	CTD063
171	Fe09	Titanium CTD	Lohan	2000 m (replaced 2 niskin bottles)	CTD065
174	Fe10	Titanium CTD	Lohan	1500 m	CTD068
181	Fe11	Titanium CTD	Lohan	1000 m	CTD070
184	Fe12	Titanium CTD	Lohan	700 m (Altimeter issues start on Ti casts)	CTD073
186	Fe13	Titanium CTD	Lohan	500 m	CTD075
188	Fe14	Titanium CTD	Lohan	250 m	CTD077
201	CCS	Stainless steel CTD	Poulton	Pre-dawn	CTD081
202	CCS	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD082
225	CCS_glider	Stainless steel CTD	Woodward	Shelf-wide programme/calibration (Glider cal and wirewalker sensor cal)	CTD085
233	J08	Titanium CTD	Lohan		CTD086
234	J07	Titanium CTD	Lohan		CTD087
235	J06	Titanium CTD	Lohan		CTD088
236	J05	Titanium CTD	Lohan		CTD089
238	J03	Stainless steel CTD	Woodward	Shelf-wide programme/calibration	CTD091
239	J02	Stainless steel CTD	Woodward		CTD092
242	Benthic A	Titanium CTD	Lohan		CTD093
253	CCS	Titanium CTD	Lohan	Shelf-wide programme/calibration/iron CTD	CTD094
261	E1	Titanium CTD	Lohan		CTD096

11. Dissolved and Particulate Organic Matter

Clare Davis, University of Liverpool. Contact: davis@liverpool.ac.uk

Dissolved organic nutrients: Samples were collected from between 6 and 9 depths from the CTD and underway system and were filtered through 47 mm GF/F (combusted, Whatman, nominal pore size 0.7 µm) and stored in acid-cleaned 175 mL HDPE bottles at -20°C for later laboratory analysis to determine dissolved organic carbon (DOC), organic nitrogen (DON) and organic phosphorus (DOP) concentrations.

Dissolved free and total hydrolysable amino acids: Samples were collected from between 6 and 9 depths from the CTD and underway system and were filtered through 47 mm GF/F (combusted, Whatman, nominal pore size 0.7 µm) and stored in 20 mL muffled glass vials at -80°C for later laboratory analysis.

Coloured Dissolved Organic Matter (CDOM): Samples were collected from between 6 and 9 depths from the CTD and underway system. Samples were filtered through 47 mm GF/F (combusted, Whatman, nominal pore size 0.7 µm) and then through 0.2 µm Durapore filters. Samples were kept in the dark and analysed on board using a Shimadzu UV-1650PC spectrophotometer and a Horiba Fluoromax-4 spectrofluorometer. Data will later be processed using PARAFAC by Nealy Carr (Sensors on Gliders student) to determine the source and composition of CDOM.

Particulate organic carbon, particulate organic nitrogen and particulate phosphorus: Samples were collected from between 6 and 9 depths from the CTD and marine snow catcher. For particulate carbon and nitrogen (PC/PN), 2L was filtered onto 25 mm GF/F (combusted, Whatman, nominal pore size 0.7µm) on a plastic filter rig under <12 kPa vacuum pressure. For particulate phosphorus (PP), 1L was filtered onto 25 mm GF/F (combusted and HCl acid washed, Whatman, nominal pore size 0.7µm) on a plastic filter rig under <12 kPa vacuum pressure. All filters were stored at -80°C for laboratory analysis.

Particulate lipids, pigments and particulate amino acids: Samples were collected from between 6 and 9 depths from the CTD and marine snow catcher. For both lipids and amino acids, 2L was filtered onto 47 mm GF/F (combusted, Whatman, nominal pore size 0.7µm) on a 3-port glass filter rig under <12 kPa vacuum pressure. Filters were stored at -80°C for later laboratory analysis.

δ^{15}N of particulate nitrogen and nitrate: Samples were collected from between 6 and 9 depths from the CTD and underway system (dissolved only). Samples for the δ^{15}N and δ^{18}O of nitrate were filtered through 47 mm GF/F (combusted, Whatman, nominal pore size 0.7 µm) and stored in 60 mL HDPE bottles (HCl acid washed) and stored at -20 °C for later analysis. Samples for δ^{15}N-particulate nitrogen were collected by filtering 2L onto 25 mm GF/F (combusted, Whatman, nominal pore size 0.7 µm) and stored at -80°C for later analysis.

Stand Alone Pump System (SAPS): The SAPS was deployed six times to collect samples for PC/PN, PP, particulate lipids and particulate amino acids from two fractions: particles >53 µm and particles between 0.7 – 53 µm. Each time the SAPs were deployed at similar depths to the marine snow catcher deployments made at similar times. The SAPs was programmed to pump for 1 hour once at that depth. Upon recovery, the 53 µm mesh fraction was washed onto a 47 mm GF/F (combusted, Whatman, nominal pore size 0.7µm) which was stored at -80°C for later analysis. Below the mesh were two 27.3 cm diameter GF/Fs (combusted, Whatman, nominal pore size 0.7 µm) one was the sample GF/F and the second was stored as the blank GF/F, both were stored whole at -80 °C for later analysis.

CTD Samples: Table 1 summarises the samples taken from the CTD for particulate carbon and nitrogen (PCPN), particulate phosphorus (PP), particulate lipids (LIPIDS), particulate amino acids (P-AA), dissolved and particulate $\delta^{15}N$ (d15N), and dissolved organic nutrients (DOC, DON, DOP), dissolved amino acids (dAA) and coloured dissolved organic matter (CDOM).

Table 1: Summary of sample collection from the CTDs.

EVENT	ROS NO	PCPN	PP	LIPIDS	P-AA	PIGMENTS	P-d15N	DOM	D-AA	D-15N	CDOM
1	2	X	X	X	X	X	X	X	X	X	X
1	4	X	X	X	X	X	X	X	X	X	X
1	6	X	X	X	X	X	X	X	X	X	X
1	9	X	X	X	X	X	X	X	X	X	X
1	12	X	X	X	X	X	X	X	X	X	X
1	14	X	X	X	X	X	X	X	X	X	X
1	16	X	X	X	X	X	X	X	X	X	X
1	24	X	X	X	X	X	X	X	X	X	X
4	7							X	X	X	X
4	10							X	X	X	X
4	14							X	X	X	X
4	18							X	X	X	X
4	20							X	X	X	X
25	2							X	X	X	X
25	8							X	X	X	X
25	12							X	X	X	X
25	16							X	X	X	X
25	18							X	X	X	X
25	24							X	X	X	X
42	2							X	X	X	X
42	8							X	X	X	X
42	12							X	X	X	X
42	16							X	X	X	X
42	18							X	X	X	X
42	24							X	X	X	X
51	4							X	X	X	X
51	10							X	X	X	X
51	12							X	X	X	X
51	14							X	X	X	X
51	18							X	X	X	X
51	22							X	X	X	X
54	2							X	X	X	X
54	5							X	X	X	X
54	10							X	X	X	X

54	15							X	X	X	X
54	19							X	X	X	X
54	21							X	X	X	X
57	2							X	X	X	X
57	4							X	X	X	X
57	10							X	X	X	X
57	12							X	X	X	X
57	18							X	X	X	X
57	21							X	X	X	X
59	2							X	X	X	X
59	6							X	X	X	X
59	10							X	X	X	X
59	14							X	X	X	X
59	18							X	X	X	X
59	21							X	X	X	X
61	1							X	X	X	X
61	6							X	X	X	X
61	9							X	X	X	X
61	13							X	X	X	X
61	17							X	X	X	X
61	21							X	X	X	X
65	1							X	X	X	X
65	6							X	X	X	X
65	10							X	X	X	X
65	13							X	X	X	X
65	14							X	X	X	X
65	15							X	X	X	X
65	16							X	X	X	X
65	18							X	X	X	X
65	24							X	X	X	X
68	1							X	X	X	X
68	6							X	X	X	X
68	9							X	X	X	X
68	12							X	X	X	X
68	13							X	X	X	X
68	15							X	X	X	X
68	16							X	X	X	X
68	17							X	X	X	X
68	19							X	X	X	X
68	24							X	X	X	X
76	1							X	X	X	X

76	7							X	X	X	X
76	9							X	X	X	X
76	12							X	X	X	X
76	14							X	X	X	X
76	15							X	X	X	X
76	16							X	X	X	X
76	19							X	X	X	X
76	24							X	X	X	X
80	2							X	X	X	X
80	6							X	X	X	X
80	9							X	X	X	X
80	13							X	X	X	X
80	15							X	X	X	X
80	16							X	X	X	X
80	17							X	X	X	X
80	18							X	X	X	X
80	24							X	X	X	X
82	1							X	X	X	X
82	4							X	X	X	X
82	5							X	X	X	X
82	6							X	X	X	X
82	12							X	X	X	X
82	13							X	X	X	X
87	1							X	X	X	X
87	4							X	X	X	X
87	12							X	X	X	X
87	13							X	X	X	X
87	15							X	X	X	X
88	1							X	X	X	X
88	4							X	X	X	X
88	6							X	X	X	X
88	14							X	X	X	X
88	18							X	X	X	X
96	2							X	X	X	X
96	6							X	X	X	X
96	12							X	X	X	X
96	16							X	X	X	X
96	18							X	X	X	X
96	24							X	X	X	X
115	1	X	X	X	X	X	X	X	X	X	X
115	8	X	X	X	X	X	X	X	X	X	X

115	10	X	X	X	X	X	X	X	X	X	X
115	13	X	X	X	X	X	X	X	X	X	X
115	21	X	X	X	X	X	X	X	X	X	X
119	2							X	X	X	X
119	4							X	X	X	X
119	8							X	X	X	X
119	14							X	X	X	X
119	18							X	X	X	X
119	22							X	X	X	X
135	2							X	X	X	X
135	6							X	X	X	X
135	8							X	X	X	X
135	16							X	X	X	X
135	20							X	X	X	X
135	24							X	X	X	X
150	2	X	X	X	X	X	X	X	X	X	X
150	8	X	X	X	X	X	X	X	X	X	X
150	12	X	X	X	X	X	X	X	X	X	X
150	14	X	X	X	X	X	X	X	X	X	X
150	18	X	X	X	X	X	X	X	X	X	X
150	24	X	X	X	X	X	X	X	X	X	X
162	1	X	X	X	X	X		X			
162	8	X	X	X	X	X		X			
162	13	X	X	X	X	X		X			
162	17	X	X	X	X	X		X			
162	19	X	X	X	X	X		X			
162	24	X	X	X	X	X		X			
169	1							X	X	X	X
169	5							X	X	X	X
169	9							X	X	X	X
169	15							X	X	X	X
169	16							X	X	X	X
169	17							X	X	X	X
169	18							X	X	X	X
169	21							X	X	X	X
169	24							X	X	X	X
171	1							X	X	X	X
171	4							X	X	X	X
171	7							X	X	X	X
171	12							X	X	X	X
171	14							X	X	X	X

171	15							X	X	X	X
171	18							X	X	X	X
171	20							X	X	X	X
171	24							X	X	X	X
174	1							X	X	X	X
174	4							X	X	X	X
174	6							X	X	X	X
174	12							X	X	X	X
174	13							X	X	X	X
174	16							X	X	X	X
174	19							X	X	X	X
174	21							X	X	X	X
174	24							X	X	X	X
181	1							X	X	X	X
181	3							X	X	X	X
181	7							X	X	X	X
181	8							X	X	X	X
181	9							X	X	X	X
181	12							X	X	X	X
181	15							X	X	X	X
184	1							X	X	X	X
184	5							X	X	X	X
184	6							X	X	X	X
184	13							X	X	X	X
184	15							X	X	X	X
184	16							X	X	X	X
186	1							X	X	X	X
186	3							X	X	X	X
186	5							X	X	X	X
186	14							X	X	X	X
186	15							X	X	X	X
186	18							X	X	X	X
188	1							X	X	X	X
188	2							X	X	X	X
188	3							X	X	X	X
188	4							X	X	X	X
188	5							X	X	X	X
188	6							X	X	X	X
201	1	X	X	X	X	X		X			
201	8	X	X	X	X	X		X			
201	10	X	X	X	X	X		X			

201	13	X	X	X	X	X		X			
201	17	X	X	X	X	X		X			
201	24	X	X	X	X	X		X			
202	2							X			
202	12							X			
202	14							X			
202	16							X			
202	20							X			
202	24							X			
225	2							X			
225	8							X			
225	12							X			
225	14							X			
225	18							X			
225	22							X			
233	1							X	X	X	X
233	6							X	X	X	X
233	14							X	X	X	X
233	16							X	X	X	X
233	17							X	X	X	X
234	3							X	X	X	X
234	4							X	X	X	X
234	15							X	X	X	X
234	18							X	X	X	X
235	1							X	X	X	X
235	4							X	X	X	X
235	6							X	X	X	X
235	15							X	X	X	X
235	16							X	X	X	X
235	17							X	X	X	X
236	1							X	X	X	X
236	6							X	X	X	X
236	14							X	X	X	X
236	16							X	X	X	X
236	17							X	X	X	X
238	2							X	X	X	X
238	10							X	X	X	X
238	14							X	X	X	X
238	18							X	X	X	X
238	22							X	X	X	X
239	2							X	X	X	X

239	4							X	X	X	X
239	10							X	X	X	X
239	14							X	X	X	X
239	18							X	X	X	X
242								X	X	X	X
242								X	X	X	X
242								X	X	X	X
242								X	X	X	X
242								X	X	X	X
253								X			
253								X			
253								X			
253								X			
253								X			

Marine snow catcher: For the snow catchers, the filtering protocols were as stated above with the exception that for the fast sinking fraction (F3) the total tray contents were filtered rather than a volumetric measure.

Table 2: Summary of sample collection from the marine snow catcher.

EVENT	FRACTION	PCPN	PP	LIPIDS	P-AA	PIGMENTS
123	F1	X	X	X	X	X
123	F2	X	X	X	X	X
123	F3	X	X	X	X	X
126	F1	X	X			
126	F2	X	X			
126	F3	X	X			
127	F1	X	X	X	X	X
127	F2	X	X	X	X	X
127	F3	X	X	X	X	X
197	F1	X				
197	F3	X				
199	F1	X				
199	F3	X				
213	F1	X	X	X	X	X
213	F2	X	X	X	X	X
213	F3	X	X	X	X	X
214	F1	X				
214	F2	X				
214	F3	X				
216	F1	X	X	X	X	X

216	F2	X	X	X	X	X
216	F3	X	X	X	X	X
217	F1	X				
217	F2	X				
217	F3	X				
254	F1	X				
254	F3	X				
256	F1	X				
256	F3	X				

Stand alone pump system (SAPS) deployments: SAPS protocols as stated above.

Table 3: Summary of SAPS deployments and volume filtered.

EVENT	DEPTH (m)	VOLUME (L)
31	15	336
32	80	159
120	120	366
124	15	776
215	100	375
215	20	572

12. Phytoplankton: community composition and biogeochemical rate (C-P-Si) measurements

Alex Poulton (NOC), Kyle Mayers (NOC/UoS), Allison Webb (UEA)

Rationale: As part of the pelagic component of the Shelf Sea Biogeochemistry (SSB) research programme we collected samples for phytoplankton enumeration and made biogeochemical rate measurements from six CTD profiles at the two process sites (Central Celtic Sea, Shelf Edge) sampled during DY018. Rate measurements included short term (6 h) measurements of carbon fixation and phosphorus uptake, and the production of dissolved organic carbon (DOC) and phosphorus (DOP), as well as long term (24 h) measurements of calcite production, silica uptake and size-fractionated (0.2-2 µm, 20-20 µm, >20 µm) primary production. Combined these measurements will allow us to examine biogeochemical interactions between carbon (C), phosphorus (P) and silica (Si) uptake (and recycling) by autumnal phytoplankton communities, as well as examine growth dynamics of coccolithophores and diatoms in shelf sea environments. An identical suite of samples and measurements will be collected on the 2015 SSB cruises allowing seasonal changes in these processes to be fully examined. The underlying goal of this work is to address the hypothesis that 'autotroph community structure and resource (nutrients, light) availability influence the stoichiometry of organic matter through increasing C:N:P:Si ratios under resource limited conditions'.

Methods:

1. General water sampling

Water samples were collected from pre-dawn (5 am) CTD casts from six light depths (60%, 40%, 20%, 10%, 5% and 1% of surface irradiance) in the water column. Light depths were determined based on the assumption that the base of the upper mixed layer represented the 1% light level (i.e. the depth of the euphotic zone). Water samples for chlorophyll-*a* analysis, phytoplankton enumeration (acidic Lugol's preservation) and all rate measurements (see section 4) were collected in dark brown opaque bottles. Water samples for biogenic silica ($bSiO_2$) and coccolithophore enumeration were collected in clear polycarbonate bottles.

2. Chlorophyll-a and biogenic silica ($bSiO_2$)

Water samples for total chlorophyll-*a* (chl-*a*) analysis were collected from all CTD casts while samples for size-fractionated chl-*a* were only collected from the pre-dawn casts. Samples for total chl-*a* were collected by filtering 200-250 ml sea water samples through 25 mm diameter Fisherbrand MF300 filters (effective pore size 0.7 µm). Samples for size-fractionated chl-*a* were collected by sequentially filtering 100-250 ml of seawater through 47 mm diameter 20 µm, 2 µm and 0.2 µm filters. Filters were extracted in 8 mL of 90% acetone for 18-20 h and the resulting chl-*a* fluorescence was measured on a Turner Trilogy fluorometer calibrated against a solid standard and a chl-*a* extract (Sigma).

Water samples for analysis of biogenic silica ($bSiO_2$) concentrations were only collected from pre-dawn CTD casts. Samples for $bSiO_2$ were collected by filtering 500 mL seawater samples through 25 mm 0.8 µm pore size Nucleopore filters, oven dried (50-60^{o}C, 10-12 h) and stored in 15 mL centrifuge tubes for later analysis following Poulton et al. (2006). Further samples for $bSiO_2$ determination were also collected in association with measurements of silica uptake where 500 mL bottles were incubated for 24 h alongside radio-labelled incubations (see rate measurements) and filtered at the end of the incubations. These samples will allow first-order estimates of $bSiO_2$ dissolution (following Krause et al. 2010).

3. Community composition

Samples for the determination of phytoplankton community composition were collected from pre-dawn CTD casts and two types of sample were collected: (a) acidic Lugol's preserved water samples (200 mL) for enumeration of diatoms, microzooplankton and small flagellates; and (b) cellulose nitrate filters for the enumeration of coccolithophores. For (a), water was added to brown glass bottles which had previously had 5 mL of acidic Lugol's solution added. In the case of (b), 1 L water samples were filtered through 25 mm 0.8 µm pore size Whatman cellulose nitrate filters under gentle pressure and with a backing filter (Fisherbrand MF300) to ensure an even spread of material across the filter. Cellulose nitrate filters were then oven dried (50-60^{o}C, 10-12 h) and stored in Millipore petri-slides until they were converted into permanent glass slides using Norland Adhesive no. 74 following Poulton et al. (2010). Lugol's samples will be sub-sampled (10-50 mL) and settled in Hydro-Bios settling chambers and examined under an inverted microscope at Plymouth Marine Laboratory (PML) by Claire Widdecombe. Slides prepared from cellulose nitrate filters will be examined under cross-polarised light to enumerate coccolithophore cells and detached coccoliths.

4. Rate measurements

Biogeochemical rate measurements were made at six process sites (Table 1) during DY018 using radioactive isotopes (^{14}C, ^{33}P, ^{32}Si) following methodology adapted from several references (Table 2). To summarise, carbon fixation (CFIX) and phosphorus uptake (PUP) were made on short term incubations (6 h), and the production of dissolved organic carbon (pDOC) and dissolved organic phosphorus (pDOP) were measured on filtrates from these incubations. Over 24 h, calcite production (CAL), size-fractionated primary production (SF-PP) and silica uptake (SIL) were also measured.

Table 1. Station details for biogeochemical rate measurements. CCS indicates the Central Celtic Sea site, CS2 indicates the Shelf Edge site. Rate measurement abbreviations are: CAL, daily calcite production; CFIX, short term (6 h) carbon-fixation; *p*DOC, production of dissolved organic carbon; PUP, short term (6 h) uptake of phosphorus; *p*DOP, production of dissolved organic phosphorus; SFPP, size-fractionated (>20 µm, 20-2 µm, 2-0.2 µm) primary production; SIF, daily uptake of silicic acid. All measurements were made at 6 light depths in the water column. ND indicates not determined.

Date	Site	Event number	CFIX	*p*DOC	PUP	*p*DOP	CAL	SF-PP	SIF
10/11/2014	CCS	001	x	ND	x	ND	x	x	ND
12/11/2014	CCS	039	x	x	x	x	x	x	x
18/11/2014	CS2	115	x	x	x	x	x	x	x
20/11/2014	CS2	150	x	x	x	x	x	x	x
22/11/2014	CCS	162	x	x	x	x	x	x	x
25/11/2014	CCS	201	x	x	x	x	x	x	x

Table 2. Methodological details of the rate measurements made on DY018.

Rate measurement	Incubation length	Methodological reference(s)	Synopsis
Carbon fixation (CFIX)	6 h (dawn + 6 h)	(1, 2)	^{14}C-labelled sodium bicarbonate addition; three light and one dark bottle.
DOC production (*p*DOC)	6 h (dawn + 6 h)	(3)	0.2 µm filtrate from CFIX light and dark bottles; 3 depths (60%, 20% and 1%) only; acidified to remove ^{14}C-DIC as ^{14}C-CO_2.
Phosphate uptake (PUP)	6 h (dawn + 6 h)	(4)	^{33}P-labelled orthophosphoric acid addition; three light and one dark bottle; P addition <5% of ambient concentrations.
DOP production (*p*DOP)	6 h (dawn + 6 h)	(4, 5)	0.2 µm filtrate from PUP light and dark bottles; three depths (60, 20 and 1%) only; 1 M NaOH addition to precipitate DIP and centrifuged.
Calcite production (CAL)	24 h (dawn-dawn)	(1)	^{14}C-labelled sodium bicarbonate addition; uses Micro-Diffusion Technique (Balch et al. 2000) to separate inorganic and organic particulate production; three light and one formalin-killed blank; measures coccolithophore calcite production (daily calcification) and community primary production.
Size-fractionated primary production (SF-PP)	24 h (dawn to dawn)	(2)	^{14}C-labelled sodium bicarbonate addition; sequential filtering through 20 µm, 2 µm and 0.2 µm filters.
Silica uptake (SIF)	24 h (dawn to dawn)	(6, 7)	^{32}Si-labelled silicic acid addition; duplicates only; hot NaOH digestion, neutralised with HCl.

Methodological references: (1) Poulton et al. (2014); (2) Poulton et al. (2006a); (3) Lopez-Sandoval et al. (2011); (4) Reynolds et al. (2014); (5) Karl and Tien (1992); (6) Poulton et al. (2006b); (7) Krause et al. (2010).

Incubations were carried out in an adapted refrigeration container (see Richier et al. 2014) where light depths in the water column were replicated through the use of LED light panels, grey light (neutral density) filters of varying optical density and a set day length of 9 h. Hence, the light levels (60%, 40%, 20%, 10%, 5% and 1% of incidental irradiance) had absolute light intensities which had been chosen to reflect the average light available at that percentage irradiance depth during November (pre-determined from 5 yrs of satellite PAR data). The absolute instantaneous light intensity for each light depth was checked using a 4 π light sensor (Biospherical Instruments). These absolute irradiance levels

for DY018 were: 5.4 mol photons m^{-2} d^{-1} (60% of average November incidental irradiance), 4.8 mol photons m^{-2} d^{-1} (40%), 2.3 mol photons m^{-2} d^{-1} (20%), 0.8 mol photons m^{-2} d^{-1} (10%), 0.5 mol photons m^{-2} d^{-1} (5%) and 0.2 mol photons m^{-2} d^{-1} (1%). Temperature of the refrigeration container was set at 13^{o}C which was ± 1^{o}C from mixed layer temperatures.

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13. Shelf-sea gross and net production estimates from triple oxygen isotopes and oxygen-argon ratios in relation with phytoplankton physiology.

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Objectives:

1. Infer spatial variations of net (*N*) and gross (*G*) O_2 production rates from O_2/Ar [*N* (O_2/Ar)] and triple oxygen isotopes [*G* (^{17}O)] in the Celtic Sea.
2. Derive 24 h in-situ production rates from diurnal changes at process stations.
3. Calculate seasonally integrated production estimates from cruise-to-cruise changes.
4. Compare *G* (^{17}O) with FRRF-based physiological turnover and CO_2 fixation rates.
5. Use statistical tools to relate *N* and *G* to production estimates based on ^{15}N- and ^{14}C-uptake, respiration rates, light availability, nutrient supply, community structure and other SSB consortium data products.

Introduction:

In order to increase the resolution of dynamic waters such as shelf seas, continuous underway measurement systems have been demonstrated a good choice.

Membrane inlet mass spectrometry is a technique invented by Hoch and Kok in 1963. This technique permits the sampling of dissolved gases from a liquid phase. The principle is a semipermeable membrane that allows dissolved gases pass through but not the liquid into the mass spectrometer flying tube. The advantages of the MIMS are several with the exception of the precision. These can be mounted onboard which permit the analysis of several dissolved gases of seawater in situ and continuously. Phytoplankton photosynthesis and respiration understandings can be achieve from the analysis of stable isotopes distribution of certain gases or to obtaining chemical exchange rates (Beckmann et al., 2009). This is also a very simple way to analyze volatile gases, do not require exhaustive preparation of material for sampling nor the use of chemicals, and data is recorded directly in the computer without the need of post analysis in the laboratory.

The dissolved O_2 in seawater gives an estimation of the NCP. Physical process such us variation in temperature and pressure, transport fluxes, diffusion and bubble injection also changes the amount of dissolved O_2 in seawater. Now is clear that we need a tracer that separates oxygen produced biologically from the one added or removed from physical processes. Argon does not react during photosynthesis or respiration and have similar solubility and diffusivity than O_2. Variation in O_2 concentration due to biological production can be separated from physical forces using the ΔO_2/Ar ratio.

Craig and Hayward (1987) were the first ones describing a technique for using ΔO_2 and Ar differences to determinate NCP. The equation that is now used is ΔO_2/Ar ratio, and is defined as follow in Eq. (1).

$$\Delta O_2/Ar = [c(O_2)/c(Ar)]/[(c_{sat}(O_2)/c_{sat}(Ar)]-1 \quad (1)$$

Were *c* is the dissolved gas concentration (mol m^{-3}) and c_{sat} is the saturation concentration at known temperature, pressure and salinity (Kaiser, 2005).

This technique was considered very sensitive (Hoch and Kok, 1963) but nowadays, even if modern MIMS have high sensitivity (Beckmann et al., 2009) these instruments lack the ultra-high precision of IRMS. Thus, in addition to the underway measurements, discrete samples were taken for calibration purposes and to measure the $^{17}O/^{16}O$ and $^{18}O/^{16}O$ isotope ratio analysis of dissolved oxygen. Triple oxygen isotope measurements combined with O_2/Ar data can be used to estimate the ratio of net

community production to gross production and the ratio of gas exchange to gross production. Again, in combination with suitable wind-speed gas-exchange parameterizations this can be used to estimate gross production over large regional scales at timescales of weeks to months.

Methodology:

Continuous measurements of dissolved N_2, O_2, and Ar were made by MIMS on board RRS Discovery. The ship's underway sampling system was used to pump water through a tubular Teflon AF membrane (*Random Technologies*). The membrane was connected to the vacuum of a quadrupole mass spectrometer (*Pfeiffer Vacuum* Prisma). The intake of the underway sampling system is located at the bow at a nominal depth of 5 m. The water from the underway sampling system passed through an open bottle at several litres per minute to remove macroscopic bubbles and to avoid pressure bursts. A flow of about 45 ml/min was continuously pumped from the bucket through the membrane, using a gear pump (*Micropump*). In order to reduce O_2/Ar variations due to temperature effects and water vapour pressure variations, the exchange chamber with the membrane was held at a constant temperature of 12ºC (3 to 10ºC below the sea surface temperature, to avoid temperature-induced supersaturation and subsequent bubble formation) The flight tube was in a thermally insulated box maintained at 50ºC.

In addition to the continuous underway measurements, I also analysed CTD samples with the MIMS in order to characterize the depth profile of the O_2/Ar ratio in regions of the Celtic Sea.

The O_2/Ar ratio measurements will be calibrated with discrete water samples taken from the same seawater outlet as used for the MIMS measurements. 200 cm^3 samples were drawn into pre-evacuated glass flasks poisoned with 7 mg $HgCl_2$ [*Quay et al.*, 1993]. These samples will be later analysed with an isotope ratio mass spectrometer (IRMS, *Thermo Finnigan*) for their dissolved O_2/Ar ratios and the oxygen triple isotope composition relative to air [*Hendricks et al.*, 2004]. Raw O_2/Ar ion current ratio measurements were made every 10 to 20 s and had a short-term stability of 0.05%.

O_2 concentrations were also measured continuously with an optode (*Aanderaa* model 3830, serial no. 241), readings at 10 s resolution. The measurements were taken from the open bottle connected to the underway sampling system used to measure the O_2/Ar ratios as well. This optode attached to the underway system and both the stain steel and titanium CTDs optode were calibrated by automatic Winkler titration of discrete water samples with photometric endpoint detection. Calibration of the underway water was made

every two days, which were taken in triplicate and shows an error between 2 - 0.02%. The highest error was assumed to be due to the change in the concentration of oxygen when the ship is in movement. Comparisons between Winkler samples from Niskin bottles fired at the surface and Winkler samples taken from the non-toxic supply at the same time of the surface firing agreed well. That means that the non-toxic underway sea water supply is working in good conditions and the Winkler method is measuring consistently during the cruise.

Winkler station on the left, MIMS in the middle.

Discrete samples:

The CTD profile has shown a stratified water column during all the cruise sampling, less pronounced in Celtic Deep station A. The mixed layer was between 35 – 70 meters deep and the euphotic zone was always deeper than the mix layer. No peaks of chlorophyll maximum or oxygen were found as expected for the winter season.

Discrete Winkler samples were taken from 4 - 6 Niskin bottles to calibrate the optode of the stain steel and titanium CTD. Samples were drawn carefully into borosilicate glass bottles and later analyzed by whole-bottle Winkler titration to a photometric endpoint. A thiosulphate solution of about 0.1961 mol L^{-1} was used, standardized with a KIO_3 solution of 0.1N. The relationship between Winkler samples and CTD optode was almost in all measurements between 0.99 - 1 = R^2, with a constant offset between CTD and Winkler measurements. Major errors are due to the movement of the ship, which directly affect the accuracy of the photometric method. For that reason, the titrations were done in calm weather days when possible. The data from the Winkler measurements was given to Jo Hopkins and she will use it to calibrate all oxygen measurements in every CTD.

The following samples were collected:

STNNBR	NMF ID	Date	Time	Latitude		Longitude		CTD Optode Calibration	$O^{16\,17\,18}$	O_2/Ar *
001	CTD001	10/11/2014	05:01	49	24.095	8	34.841	✓ / ✗		
024	CTD006	11/11/2014	10:44	49	23.901	8	34.722	✓		
025	CTD007	11/11/2014	12:05	49	23.900	8	34.722		✓	✓
042	CTD013	12/11/2014	12:34	49	23.964	8	34.441		✓	✓
051	CTD014	13/11/2014	08:09	49	16.009	8	44.986	✓	✓	✓
054	CTD016	13/11/2014	13:04	49	07.700	8	54.289	✓	✓	✓ / ✗
065	CTD027	14/11/2014	22:12	48	12.383	10	3.265	✓		
068	CTD030	15/11/2014	06:04	48	14.370	9	57.917			
076	CTD033	15/11/2014	19:33	48	20.398	9	42.410	✓		

082	CTD039	16/11/2014	12:45	48	22.690	9	36.499	✓		
087	CTD042	16/11/2014	18:38	48	24.529	9	31.558	✓		
096	CTD045	17/11/2014	12:13	48	34.250	9	30.581	✓	✓	
101	CTD046	17/11/2014	15:37	48	34.252	9	30.581		✓	
117	CTD049	18/11/2014	09:05	48	54.277	9	30.661	✓		
118	CTD050	18/11/2014	09:57	48	34.276	9	30.661		✓	
119	CTD051	18/11/2014	12:00	48	34.276	9	30.661	✓	✓	
134	CTD052	19/11/2014	09:50	48	34.267	9	30.570	✓		
135	CTD053	19/11/2014	12:05	48	34.267	9	30.571	✓	✓	
151	CTD056	20/11/2014	09:23	49	23.554	8	35.556		✓	
164	CTD061	22/11/2014	20:38	48	22.108	9	55.056	✓		
169	CTD063	23/11/2014	08:01	48	24.614	9	53.370	✓		
174	CTD068	23/11/2014	19:23	48	25.326	9	52.723	✓		
181	CTD070	23/11/2014	21:05	48	25.326	9	52.728	✓		
182	CTD071	24/11/2014	00:05	48	25.771	9	52.261	✓		
184	CTD073	24/11/2014	14:02	48	34.260	9	30.568	✓		
196	CTD080	24/11/2014	14:02	48	34.260	9	30.568	✓	✓	
201	CTD081	25/11/2014	05:02	49	24.068	8	35.020	✓		
202	CTD082	25/11/2014	12:06	49	23.951	8	34.916	✓	✓	
212	CTD083	25/11/2014	15:35	49	24.881	8	35.590	✓	✓	
224	CTD084	26/11/2014	07:56	49	24.343	8	35.748	✓	✓	
225	CTD085	26/11/2014	12:22	49	23.656	8	25.879	✓	✓	
233	CTD086	27/11/2014	08:17	49	36.314	8	19.798	✓	✓	
234	CTD08	27/11/20	11:2	49	47.671	8	03.779	✓	✓	

	7	14	0							
235	CTD088	27/11/2014	14:17	50	00.790	7	47.734	✓	✓	
236	CTD089	27/11/2014	17:04	50	12.479	7	27.773	✓	✓	
238	CTD091	28/11/2014	11:35	50	37.501	6	56.556	✓	✓	
239	CTD092	28/11/2014	14:44	50	49.700	6	40.028	✓	✓	
242	CTD093	28/11/2014	19:54	51	12.781	6	07.904	✓	✓	
253	CTD094	29/11/2014	14:05	49	24.254	8	35.119	✓	✓	
261	CTD096	01/12/2014	06:39	50	2.048	4	22.237	✓		

*Due to an unfixable problem in the MIMS, sampling was stopped from the 14th of November onwards. Exhaustive sampling of $O^{16,17,18}$ was carried during the rest of the cruise to palliate this issue. The use of both titanium and stain steel CTDs were necessary to get samples in every station and transects.

Acknowledgements:
I would like to thank scientists, crew, officers and engineers of RRS Discovery Cruise DY018 for the help and good environment during the entire cruise, especially to Jonathan who was very patient answering all my questions and to the iron group to allow me to participate in the “clean room parties”.

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Quay, P. D., S. Emerson, D. O. Wilbur, and C. Stump (1993), The □^{18}O of dissolved oxygen in the surface waters of the subarctic Pacific: A tracer of biological productivity, *J. Geophys. Res*., 98, 8447-8458.

14. Bacterial Production Measurements

Sharon McNeill, SAMS.

1.1 Introduction

Radiolabelled leucine methods were used to determine bacterial production in the Celtic Sea. Water column and marine snowcatcher samples were chosen to correspond to respiration studies. A full list of bacterial production samples taken and analysed on board are shown in Table 1.

1.2 Method

Leucine

Water samples were collected from the CTD in acid washed polycarbonate bottles then incubated for bacterial production.Aliquots of 10ul leucine working solution (0.01 MBq ml^{-1}) were pipetted into each 2ml sterile centrifuge tube then additions of 1.6ml sample added. For each depth two samples in duplicate were run for T0, T1, T2 and T3, and incubated in a coolbox in the RN container at above and below thermocline temperatures. Samples were fixed with 80ul of 20% paraformaldehyde (giving a final concentration of 1%). Samples were filtered with 25mm GFF and 0.2um polycarbonate filters presoaked in 1mM non labelled leucine in separate petri dishes, placed on the 25mm filter rig with the GFF as a backing filter. The sample pipetted into each filter holder and then deionised water used to rinse any remaining sample from each vial.Both samples at each timepoint were combined and filtered as one. The 0.2um polycarbonate filter was placed into a scintillation vial and dried overnight in the fumehood, 4ml Optiphase Hi-Safe II scintillant added and samples read in the scintillation counter after 24 hours. Marine snowcatcher samples were analysed on 3 fractions, suspended, slow and fast sinking using the method describe above. Marine snowcatcher fast fractions samples were taken from a quarter tray approx 40ml shared with respiration studies.

Calibration experiment- Leucine

Three replicate water column samples A, B and C were prepared into a 1litre polycarbonate bottle, 900ml of each filtered through a 0.2um filter vacuum cap with 100ml unfiltered making up the volume. Each replicate was sampled at T0, T8, T18, T24, T32, T42 and T48 for leucine, bacterial abundance counts for flow cytometer and dapi slide prep. Samples were incubated in a CT container with 20% light. Then processed as water column methods for leucine.

Table 1: Leucine sampling

Date	Event	Depth M	Niskin	Comments	Coordinates
10/11/14	01-CTD	5	23		Lat: 49 24.09552 N
		10	19		Long: 8 34.84128 W
		15	15		
		28	13		
		40	11		
		65	8		
12/11/14	039-CTD	8	23		Lat: 49 23.92536 N
		14	19		Long: 8 34.59354 W
		24	15		
		36	11		
		45	9		
		82	5		

13/11/14	051-CTD	5	24		Lat: 49 16.00866 N
		50	15		Long: 8 44.98764 W
		80	7		
		10	21	Calibration exp T0,T8,T18,T24,T32,T42,T48	
15/11/14	069-CTD	5	17		Lat: 48 20.45004 N
		70	9		Long: 9 42.25026 W
		100	1		
18/11/14	115-CTD	5	23		Lat: 48 34.26314 N
		10	20		Long: 9 30.63072 W
		30	16		
		40	14		
		65	12		
		105	6		
		105	5		
18/11/14	123-MSC	15		Suspended	Lat: 48 34.193 N
				Slow	Long: 9 30.620 W
				Fast	
	127-MSC	100-120		Suspended	Lat: 48 34.193 N
				Slow	Long: 9 30.620 W
				Fast	
20/11/14	150-CTD	5	23		Lat: 48 34.41024 N
		10	21		Long: 9 30.37644 W
		55	13		
		100	7		
22/11/14	162-CTD	5	23		Lat: 49 23.61354 N
		10	20		Long: 8 35.23014 W
		20	18		
		35	15		
		43	12		
		100	4		
24/11/14	197-MSC	15		Suspended	Lat: 48 34.39 N
				Fast	Long: 9 30.51 W
				Dilution 1:1 (Suspended:Fast)	
25/11/14	201-CTD	5	23		Lat: 49 24.06906 N
		10	20		Long: 8 35.01924 W
		30	16		
		40	14		
		50	12		
		100	3		
25/11/14	213-MSC	15		Suspended	Lat: 48 34.3159 W
				Slow	Long: 9 30.555 W
				Fast	
	216-MSC	100		Suspended	Lat: 49 24.94 N

				Slow	Long: 8 35.581 W
				Fast	
29/11/14	254-MSC	100		Suspended	Lat: 49 24.297 N
				Fast	Long: 8 34.964 W
				Dilution 1:1 (Suspended:Fast)	

15. DOM Degradation Experiments

Sharon McNeill, SAMS

1.1 Introduction

Dissolved organic matter degradation experiments were carried out to determine remineralization rates in the Celtic Sea. Water was collected at one station (Central Celtic Sea) at the start and near the end of the cruise, for comparison of changes due to seasonal mixing see Table 1.

1.2 Method

Water samples were filtered through pre-combusted (450 degree C for 6hrs) GF/F filters (pore size ~ 0.7µm) and transferred to 150ml amber bottles. A microbial culture was added by filtering water from the same depth through a GF/C filter (pore size ~1.2µm) and inoculated at 5% of the total volume. The degradation experiments were set up in duplicate for each depth, surface mixed layer, thermocline and ~100M (i.e. below thermocline). Bottles were then incubated in the dark either in the CT room or cold room at temperatures as similar to in situ as possible for a period of 80 days. During the incubation period 7 samples were collected (days 0,3,6,10,15,25 and 80) from amber bottles using an acid washed glass syringe with a 25mm pre-combusted GF/F filter. The syringe first rinsed with deionised water 3 times before collecting samples for dissolved organic carbon (DOC), total dissolved nitrogen (TDN), total dissolved phosphorous (TDP), inorganic nutrients, bacterial abundance, FISH, DOM fluorescence and amino acids. Inorganic nutrient samples were analysed on the ship, DOM fluorescence and amino acids by C Davis (Liverpool) and the rest of analysis to be completed at SAMS.

Table 1

Date	Event	Depth M	Niskin	Comments	Coordinates
12/11/14	042-CTD	10	21	Surface mixed layer	Lat: 49 23.96448 N
		59	13	Thermocline	Long: 8 34.44318 W
		100	5	Below thermocline	
25/11/14	202-CTD	10	22	Surface mixed layer	Lat: 49 23.95194 N
		60	11	Thermocline	Long: 8 34.91772 W
		100	3	Below thermocline	

16. Measurements of community and bacterial respiration

E. Elena García-Martín and Clare Ostle (University of East Anglia)

Background

Dissolved oxygen (O_2) in seawater is produced by photosynthesis and consumed by respiration and photochemical reactions in the surface waters. Community respiration (CR) represents the magnitude of biologically fixed carbon that is available for export to the deep ocean or for transference to upper levels of the marine food-web. Bacteria play an important role in this balance, although their contribution to community respiration has been difficult to characterize due to methodological difficulties to separate them from the rest of the plankton community. The possible biases that the separation could cause in the bacterial respiration rates could be minimised with the applicability of the in vivo INT reduction method (ivINT). This method allows size fraction without distorting the natural community as the size fraction is performed after the incubation. Moreover, the short incubation time needed (1-4h) reduces the likelihood of community structure changes and agrees with the incubation times for bacterial production determinations. It has been successfully applied to samples from the water column and in this cruise a modification of the method was applied to the marine snow.

The aims of this work were:

1. To determine the daily plankton community respiration with Winkler technique (CR_{O2}) and oxygen optode throughout the water column from CTD samples.
2. To determinate plankton community (CR_{INT}) and bacterial respiration (BR_{INT}) with the ivINT method at short incubation times from CTD samples.
3. To quantify community and bacterial respiration of the three fractions of the Marine Snow Catcher (suspended, slow sinking and fast sinking) above and below the thermocline with Winkler technique and ivINT method.
4. To log and quantify continuously the respiration of fast and suspended particles with oxygen optodes.

1. Sampling and analytical methodology of CTD samples.

Water samples (5-6 l) were collected from predawn CTD casts at each station from 3-5 depths in the euphotic zone and 1 depth in the aphotic zone (see Table 1 for specific details of the depths and stations) in 10-20 l carboys. The depth of the aphotic sampling was coincident with the depth of the deep deployment of the MSC, around 30-40 m below the thermocline.

Each carboy was subsampled for measuring community respiration by in vitro changes of dissolved oxygen concentration, community and bacterial respiration by the size-fractionated in vivo INT reduction capacity method and oxygen optodes (see below).

1.1-Community respiration by in vitro changes of dissolved oxygen concentration

CR_{O2} was measured by monitoring changes in oxygen concentrations after 24h dark bottle incubations. Dissolved oxygen concentration was measured by automated precision Winkler titration performed with a Metrohm 765 Titrino titrator, utilising a photometric end point (Carritt & Carpenter, 1966).

Ten gravimetrically calibrated 60 ml glass Winkler bottles were carefully filled with water from each depth. Water was allowed to overflow during the filling, and special care was taken to prevent air bubble formation in the silicone tube. Five bottles were fixed at start of the incubation (“zero”) with 0.5 ml of sulphate manganese and 0.5 ml of a solution of sodium iodine/sodium hydroxide. The other five bottles were placed in water temperature controlled incubators inside the CT room for 24 hours. The incubation temperatures were ±0.5 °C of the in situ temperature. Bottles were removed from the

incubators after the 24 hours and fixed as the "zero". All bottles were analysed within the next 24 hours. The concentrations of the thiosulphate used were ca. 0.138 N. Thiosulphate was calibrated every day before the analysis of the samples and the coefficient of variation of the calibration was <0.3%.
Community respiration was calculated from the difference in oxygen concentration between the means of the "zero" measurements and the replicate dark incubated samples.

1.2- *In vivo* community and bacterial respiration (CR_{INT} and BR_{INT}) by INT reduction method.
Four 200 ml dark glass bottles were filled with seawater from each 10 litre carboy from the CTD. One replicate was immediately fixed by adding formaldehyde (2% w/v final concentration) and used as a killed control. Twenty minutes later all four replicates were inoculated with a sterile solution of 7.9 mM 2-(ρ-iodophenyl)-3-(ρ-nitrophenyl)-5phenyl tetrazolium salt (INT) to give a final concentration of 0.8 mM. The solution was freshly prepared for each experiment using Milli-Q water. Samples were incubated in the same temperature controlled water bath as the dissolved oxygen bottles for 1-2 hours and then fixed by adding formaldehyde, as for the killed control. After 20 minutes, samples were sequentially filtered through 0.8 and onto 0.2 µm pore size polycarbonate filters, air-dried, and stored frozen in 1.5 ml cryovials at –20°C until further processing (laboratory at UEA). The CR_{INT} (i.e. the sum of respiration of the >0.8 µm and 0.2-0.8 µm fractions) and BR_{INT} (considered as the respiration of the 0.2-0.8 µm fraction) will be measured following Martínez-García et al. (2009).
A time-course experiment was carried out in order to know the optimal incubation time that these samples should be incubated.

Optimal incubation time test.
14 samples of 100 ml from the fast sinking particles from the CTD were collected and dispensed to glass bottles. Incubations were undertaken in the dark for 0, 0.5, 1, 2 and 4 hours at in situ temperature. Optimal incubation time was considered as the time period, prior to saturation of the formazan concentration, during which the relationship between concentration versus time remained linear.

1.3- Continuous monitoring of in vitro oxygen evolution.
Changes in oxygen concentration were measured continuously with three optode systems (YSI ProODO). Prior to each experiment, all the three sensors were air-calibrated simultaneously. Two glass optode chambers of 5 ml were filled from water samples collected from one depth sampled (see Table 1, for the sampling depth at each station). Water sample (120-150 ml) from the same depth was collected and filtered by 0.2 µm pore size polycarbonate filters. A third chamber of 5 ml was filled with filtered sea water and monitored continuously with a third optode sensor. The filtered water was used as a background for abiotic changes in oxygen concentration associated to any temperature changes that the samples could have experienced during the incubation inside the water bath. The chambers were sealed to the probes with parafilm. Incubation was performed at the in situ temperature conditions ±0.5 °C inside a dark water bath (Figure 1). After half an hour of acclimation, oxygen concentration was recorded every half a minute during 21-24 hours in a chart recorded.

Figure 1. YSI PrODO optodes deployment and the water bath used.

2.- Sampling and analytical methodology of MSC samples.

Two large MSC were deployed unsuccessfully at the CCS station during the evening of the 11th November. Several misfires and leaks occurred and no data are available from this station during the first part of the cruise. One of the MSC did not work after several tries and at the end only one large one was available (see Hanna Shuster's report for further details). This forced us to sample for carbon and nitrogen remineralization rates in consecutive days. Two depths were sampled at each station: 10-15 m and 100 m. The sampling was done after the sunset, avoiding any external light.

Water samples from the suspended, slow and fast sinking fractions were collected from the Marine Snow Catchers at 2 stations (Table 2). Water samples (2 - 6 l) of suspended material and slow sinking were collected in 2-10 l carboys and transported to the Controlled Temperature room of the RRS Discovery for subsequent subsampling and analysis of community and bacterial respiration, as outlined below. Special care was taken at all moments to prevent the exposure of the samples to light, the room was completely in darkness and two red lights were used while handling the samples (Figure 2). Suspended water was used to rinse all the Winkler bottles before collecting the water samples. The fast sinking material from two quarters of the tray was gently taken with a turkey baster and put into a 2 l bottle from where it was subsampled to the different methodologies. As the water volume was not enough for the different techniques, 1:1 dilutions (suspended: fast) were applied.

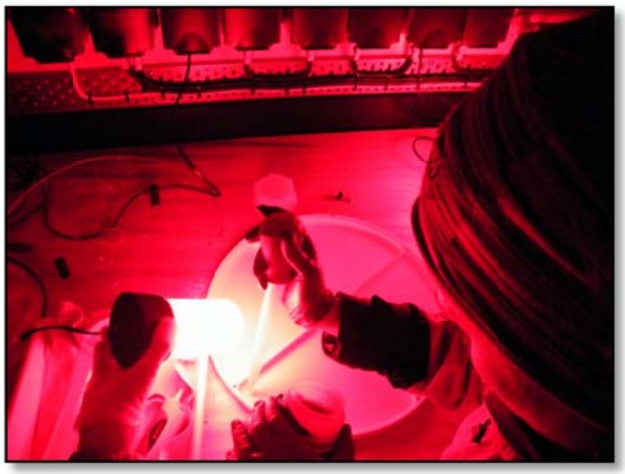

Figure 2. Sampling the fast sinking particles in the CT dark room.

2.1- Community respiration by in vitro changes of dissolved oxygen concentration

CR was measured by monitoring changes in oxygen concentrations after 24h dark bottle incubations as outlined before (section 1.1). Ten gravimetrically calibrated 60 ml glass Winkler bottles were carefully filled with water from the suspended and the other ten with slow sinking fraction of the two MSC. The sampling methodology differed for the fast sinking fraction. 30 ml sample of fast sinking particles were collected with a 10 ml precise pipette and siphoned into 10 gravimetrically calibrated 60 ml glass Winkler bottles. Then, all of them were topped up with suspended water (30-35 ml). Five replicate bottles of each fraction were fixed at the start of the incubation ("zero") and the other five bottles were placed in a water temperature controlled incubators inside the CT room for 24 hours. After 24 hours, the incubated samples were fixed as the "zero" ones. Respiration was estimated by changes in oxygen concentration as described above (see section 1.1 for further details).

2.2- *In vivo* community and bacterial respiration (CR_{INT} and BR_{INT}) by INT reduction assay.

Community and bacterial respiration was measured by the ivINT reduction method as outlined in section 1.2. For the Marine Snow catcher samples, four 100 ml dark glass bottles were filled with suspended and slow sinking seawater samples from the carboys collected. Four 50 ml dark glass bottles were filled with 20 ml of fast sinking sample and 20 ml of suspended one, maintaining the same dilution ratio as the Winkler technique. One replicate was immediately fixed by adding formaldehyde (2% w/v final concentration) and used as a killed control. Twenty minutes later all four replicates were inoculated with a sterile solution of 7.9 mM 2-(ρ-iodophenyl)-3-(ρ-nitrophenyl)-5phenyl tetrazolium salt (INT) to give a final concentration of 0.8 mM. The solution was freshly prepared for each experiment using Milli-Q water. Samples were incubated in the same temperature controlled water bath as the dissolved oxygen bottles for 1-2 hours and then fixed by adding formaldehyde, as for the killed control. After 20 minutes, samples were put inside an ultrasound bath for 30-60 seconds and then they were sequentially filtered through 0.8 and onto 0.2 μm pore size polycarbonate filters, air-dried, and stored frozen in 1.5 ml cryovials at –20°C until further processing (laboratory at UEA). The CR_{INT} (i.e. the sum of respiration of the >0.8 μm and 0.2-0.8 μm fractions) and BR_{INT} (considered as the respiration of the 0.2-0.8 μm fraction) will be measured following Martínez-García et al. (2009).

Dilution test.

A dilution test was applied in each main station in order to test if the dilution applied to the fast sinking particles affected the respiration rates measured with the Winkler and ivINT technique. Ten gravimetrically calibrated 60 ml glass Winkler bottles were carefully filled with suspended water, ten with fast sinking water and another ten with 30 ml of suspended water and 30 ml of fast sinking particles (dilution 1:1). Five replicate bottles of each treatment were fixed at start of the incubation ("zero") with 0.5 ml of sulphate manganese and 0.5 ml of a solution of sodium iodine/sodium hydroxide. The other five replicates bottles of each treatment were placed in water temperature controlled incubators inside the CT room for 24 hours. After 24 hours, all incubated replicates were fixed as the "zero" ones. Respiration was estimated with changes in oxygen concentration and ivINT reduction methods as described above.

2.3- Continuous monitoring of in vitro oxygen evolution.

There is no data from the continuous measurements of oxygen concentration for the MSC at the Shelf edge station. In the CCS station, suspended and slow sinking particles were recorded continuously. There was no fast sinking material left, so this fraction was not measured.

3.- Preliminary results.

8 vertical profiles of three-six depths were sampled for community and bacterial respiration rates (Winkler and ivINT method).

8 incubations for continuous oxygen consumption (ProODO YSI optodes) were run with water samples from the CTD.

4 MSC were sampled to calculate the carbon remineralization rates of the different fractions above and below the thermocline.

1 time-course experiment for the ivINT reduction capacity method was done with sample taken from the CTD.

2 dilution tests were performed in order to check if the dilution of the fast sinking particles with suspended water from the same depth affected the remineralization rates.

Respiration analyses with Winkler technique were all performed on board, but data will be processed on return.

4.- Problems encountered.

The fume hood in the deck lab some of the days didn't keep the flow constant and the alarm signal was beeping.

The MilliQ system in the deck lab had a leak and it was fixed temporally but nearly all days there was water running on the floor. The leak was not properly sealed any of the times.

The email system in the boat failed several times and there were days without connection. Emails sent did not go through and needed to be resent for a couple of times. There is the necessity of sending files to colleges to check the good quality of the data. A new and modern research cruise should have a better internet access.

The depth of the MSC could be subjected to error as the only way to measure the deployment was by measuring the metres of wire out. During stormy weather (as we experienced) the MSC were not deployed vertically but with a little angle between the wire and the sea surface. Some kind of sensor (salinity, pressure, etc) should be settled within the MSC for being sure of the depth sampled. The design of the MSC was modified during the cruise and some weight was put on the bottom of it to help to deploy it straight. Salinity and nutrients measurements were taken in the last cast of MSC to verify the depths sampled.

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We would like to acknowledge the crew of the RSS Discovery and the NMF people for their help and patience in the deployment of the Marne Snow Catcher. Equally importantly, the chief scientist Jonathan Sharples and our other scientific colleagues on board who generously assisted and supported our work throughout DY018.

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Table 1. List of collected water samples for measurements of respiration from CTD.

Gear code	Date	Time	Event Number	Latitude	Longitude	Nisking bottle	Depth (m)	Variable
CTD	10/11/2014	05:01	1	49 24.095 N	8 34.841 W	23	5	Winkler, ivINT, O_2 sensors
						19	10	Winkler, ivINT
						15	17	Winkler, ivINT
						13	28	Winkler, ivINT
						11	40	Winkler, ivINT
						8	65	Winkler, ivINT
CTD	12/11/2014	05:08	39	49 23.928 N	8 34.595 W	23	8	Winkler, ivINT, O_2 sensors
						19	14	Winkler, ivINT
						15	28	Winkler, ivINT
						11	36	Winkler, ivINT
						9	45	Winkler, ivINT
						5	82	Winkler, ivINT
CTD	13/11/2014	08:09	51	49 16.009 N	8 44.986 W	24	5	Winkler, ivINT, O_2 sensors
						15	50	Winkler, ivINT
						7	80	Winkler, ivINT
CTD	15/11/2014	09:19	69	48 20.45 N	9 42.248 W	17	5	Winkler, ivINT, O_2 sensors
						9	70	Winkler, ivINT
						1	100	Winkler, ivINT
CTD	18/11/2014	05:06	115	48 34.264 N	9 30.631 W	23	5	Winkler, ivINT, O_2 sensors
						20	10	Winkler, ivINT
						16	30	Winkler, ivINT
						15	40	Winkler, ivINT
						12	65	Winkler, ivINT
						5	100	Winkler, ivINT
CTD	20/11/2014	02:01	150	48 34.41 N	9 30.378 W	23	5	Winkler, ivINT
						22	10	Winkler, ivINT, O_2 sensors
						17	30	Winkler, ivINT
						15	40	Winkler, ivINT
						13	55	Winkler, ivINT
						7	100	Winkler, ivINT
CTD	22/11/2014	04:55	162	49 23.261 N	8 35.230 W	23	5	Winkler, ivINT, O_2 sensors
						20	10	Winkler, ivINT
						18	20	Winkler, ivINT
						15	35	Winkler, ivINT
						12 & 13	43	Winkler, ivINT
						4	100	Winkler, ivINT
CTD	25/11/2014	05:02	201	49 24.068 N	8 35.02 W	23	5	Winkler, ivINT
						20	10	Winkler, ivINT, O_2 sensors
						16	30	Winkler, ivINT
						14	40	Winkler, ivINT
						12	50	Winkler, ivINT
						3	100	Winkler, ivINT

Table 2. List of collected water samples for measurements of respiration from the Marine Snow Catchers.

Gear code	Date	Time	Event Number	Latitude	Longitude	Depth (m)	Variable
MSC large	12/11/2014	19:13	48	49 23.580 N	8 36.957 W		Misfire
	12/11/2014	19:24	49	49 23.580 N	8 36.957 W		Misfire
	12/11/2014	19:50	50	49 23.580 N	8 36.957 W		Misfire
	18/11/2014	19:00	123	48 34.105 N	9 30.459 W	15	Winkler, ivINT
	18/11/2014	21:43	127	48 34.092 N	9 30.311 W	115	Winkler, ivINT
	24/11/2014	16:00	197	48 34.304 N	9 30.559 W	15	dilution test ivINT
	24/11/2014	18:30	199	48 34.259 N	9 30.53 W	15	dilution test Winkler
	25/11/2014	16:18	213	49 24.904 N	8 35.592 W	15	Winkler, ivINT
	25/11/2014	18:57	216	49 25.17 N	8 35.497 W	100	Winkler, ivINT
	29/11/2014	16:05	254	49 24.297 N	8 34.964W	100	dilution test ivINT
	29/11/2014	18:40	256	49 24.316 N	8 34.996 W	100	dilution test Winkler

17. The determination of pelagic nitrogen regeneration and assimilation rates.

Darren Clark, PML.

Overview

Bacterial degradation of particulate and dissolved organic matter (P/DOM) simultaneously regenerates inorganic nutrients and renders the residual material of lower nutritional quality. Given sufficient time, the exposure of POM and DOM to a sufficiently broad range of microbes with their associated biochemical machinery renders organic material recalcitrant. This material represents a quantitatively significant form of carbon storage. The preferential regeneration and retention of nutrients such as nitrogen and phosphorous during this process, generically termed the microbial carbon pump, sustains productivity of the shelf sea region.

During this program of research, the nutrient recycling processes of NH_4^+ regeneration and nitrification were examined. The former is primarily associated with the bacterially mediated degradation of organic molecules; if the C:N ratio of organic matter utilised by bacterial cells exceeds the cells C:N (i.e. cellular N-requirements) the excess is released as NH_4^+. The latter is the two stage oxidation of NH_4^+ to NO_2^- to NO_3^-, facilitated by specific clades of bacteria and archaea. In combination, NH_4^+ regeneration and nitrification have the capacity to significantly influence the concentration and composition of the dissolved inorganic nitrogen (DIN) pool, which sustains autotrophic primary production.

The processes of inorganic nitrogen assimilation were also investigated. Primarily these are autotrophic processes although bacteria may also make a contribution to observed rates. Three forms of inorganic nitrogen were used for this study; NH_4^+, NO_2^-, NO_3^-.

The rates of N-regeneration and assimilation were derived using stable isotope techniques during both observational CTD casts and Marine Snow Catcher (MSC) deployments. The aim of this research was to understand variability in N-cycle processes by investigating how rates related to water column structure and particle loading.

Experiments

Marine Snow Catcher

Large Marine Snow Catcher (LMSC, 300 L volume) experiments: The regeneration of N associated with 3 particle fractions (suspended, slow and fast sinking) was determined during LMSC deployments at depths within the photic zone (approximately 15 meters) and at a depth in the lower mixed layer (approximately 100 meters). The rates of NH_4^+ regeneration, NH_4^+ oxidation and NO_2^- oxidation were measured on each fraction. Method details are provided below.

Observational casts

At observational stations water was collected at three depths (approximately 15, 50 and 100 meters). The regeneration and assimilation of each form of dissolved inorganic nitrogen (DIN; NH_4^+, NO_2^-, NO_3^-) was measured at each depth.

N-assimilation by N-fixing filaments

At a single station (collected JD327, used JD 329) filaments of nitrogen fixing cells were collected and a suit of measurements undertaken which included the assimilation rates of inorganic nitrogen.

Methods

The regeneration of inorganic nitrogen was investigated using ^{15}N dilution methods (Clark et al 2006, 2007). The LMSC was used to collected seawater from a specific depth. N-regeneration rates were determined in three particulate fractions (suspended particle (SP); slow sinking particle (SSP); fast sinking particle (FSP)). Following deployment and a 2 hour period of settling, 15L of SP seawater

was collected from the LMSC. 1.5L of this water was added to each of 3 2.2 L bottles containing either $^{15}NO_3^-$, $^{15}NO_2^-$ or $^{15}NH_4^+$. The ^{15}N addition was estimated to provide a 20% enrichment of the DIN pool, based on recently determined nutrient concentration profiles. A further 4.0L of water containing SSP was collected from the MSC directly into bottles containing ^{15}N. FSP were recovered in a tray from the LMSC, and in a constant temperature room under low intensity red light the particle tray was screened for magnetic particles. FSP were then transferred to 2.2L bottles containing ^{15}N. One third of the total FSP load (equating to the FSP content of approximately 100 L of seawater) was added to each of 3 bottles (each representing one process). SP water was used to dilute the FSP to a total volume of 1.5L. The 9 x 2.2 L bottles (3 processes, 3 particles fractions) were placed in a temperature controlled room for 30 minutes to ensure that the isotope was homogenously distributed. Following this period, bottles were used to fill 1.0L incubations bottles and placed in an incubator simulating appropriate light and temperature for a period of 24 hours. The remaining ^{15}N amended seawater was filtered using 47mm GF/F. The filter was retained to enable a measure of particulate carbon and nitrogen content. The filtrate was used to derive the pre-incubation DIN concentration and isotopic enrichment by synthesising indophenol from ammonium and sudan-1 from nitrite (nitrate is quantitatively reduced to nitrite prior to further analysis). Following the incubation period, samples were filtered using GF/F. The filter was retained to enable an estimation of the particulate carbon and nitrogen content of the incubated sample. The filtrate was used to generate post-incubation samples for DIN concentration and isotopic enrichment.

Indophenol was synthesised in samples by adding the first reagent (4.7 g phenol and 0.32 g sodium nitroprusside in 200 mL Milli Q water) in the proportion of 1 mL per 100 mL of sample volume, mixing the sample and leaving for 5 minutes. The second reagent (1.2 g sodium dichloro-isocyanurate and 2.8 g sodium hydroxide in 200 mL Milli Q) was then added in the proportion of 1 mL per 100 mL sample volume, mixed and left for 5 hours at room temperature for indophenol development. Indophenol was collected by solid-phase extraction (SPE) as described below. Sudan-1 was synthesised by adding the first reagent (0.8 g of aniline sulphate in 200 mL 3M HCl) to samples in the proportion 0.5 mL per 100 mL sample volume. Samples were mixed and left for 5 minutes to homogenise after which sample pH was verified to be < 2.0. Reagent 2 (24 g NaOH and 0.416 g 2-napthol in 200 mL Milli Q) was added in the proportion 0.5 mL per 100 mL sample volume. Samples were again mixed, left for 5 minutes before sample pH was verified to be approximately 8.0. Sudan-1, the development of which was complete after 30 minutes of incubation at room temperature, was collected by SPE as described below.

Deuterated internal standards were added to samples immediately prior to SPE collection. Deuterated indophenol and deuterated sudan-1 were synthesised according to methods described previously (Clark et al. 2006; 2007). Standard solutions in methanol were prepared (100 $ng \cdot \mu L^{-1}$) and the concentration verified against analytical standard solutions (Sigma-Aldrich). Appropriate volumes of deuterated internal standards (i.e. comparable to sample size) were added to samples following acidification by citric acid and prior to SPE collection.

Indophenol and sudan-1 were collected by SPE using 6 mL/500 mg C18 cartridges (Biotage, UK) which were prepared for sample collection by first rinsing with 5 mL methanol, followed by 5 mL Milli Q water and 5 mL 0.22 µm filtered seawater. Prior to sample collection seawater samples were acidified with 1 M citric acid to a pH of 5.5, before collection by SPE under low vacuum (120 mmHg) at a flow rate of approximately 1 mL per minute without drying. Samples were then rinsed with 5 mL 0.22 µm filtered seawater and 5 mL Milli Q water before being air dried under high vacuum (360 mmHg). Samples were stored frozen until further processing at the land based laboratory.

The assimilation of inorganic nitrogen was investigated using methods described in Clark et al 2011; 2014. Briefly, seawater collected from a specific depth was separately amended with separate ^{15}N solutions of NH_4^+, NO_2^-, NO_3^- to a final concentration equivalent to <10% of ambient. Volumes were incubated for 3-4 hours under appropriate temperature and light conditions before collection by filtration using 25mm GF/F. The concentration of particulate nitrogen and its natural abundance

of ^{15}N was derived from material collected by filtration from additional volumes of un-amended seawater. The concentration of particulate nitrogen and its enrichment with ^{15}N was determined by isotope ratio mass spectrometry from which the rates of nitrogen assimilation were derived.

Sampling events table.

Observational casts

Event	Date	Gear	Depth (m)	CTD bottle	Process
001	10/11/14	CTD (SS)	5	21	NH_4^+ assimilation
001	10/11/14	CTD (SS)	5	21	NO_2^- assimilation
001	10/11/14	CTD (SS)	5	21	NO_3^- assimilation
001	10/11/14	CTD (SS)	40	10	NH_4^+ assimilation
001	10/11/14	CTD (SS)	40	10	NO_2^- assimilation
001	10/11/14	CTD (SS)	40	10	NO_3^- assimilation
001	10/11/14	CTD (SS)	65	7	NH_4^+ assimilation
001	10/11/14	CTD (SS)	65	7	NO_2^- assimilation
001	10/11/14	CTD (SS)	65	7	NO_3^- assimilation
001	10/11/14	CTD (SS)	5	21	NH_4^+ regeneration
001	10/11/14	CTD (SS)	5	21	NO_2^- regeneration
001	10/11/14	CTD (SS)	5	21	NO_3^- regeneration
001	10/11/14	CTD (SS)	40	10	NH_4^+ regeneration
001	10/11/14	CTD (SS)	40	10	NO_2^- regeneration
001	10/11/14	CTD (SS)	40	10	NO_3^- regeneration
001	10/11/14	CTD (SS)	65	7	NH_4^+ regeneration
001	10/11/14	CTD (SS)	65	7	NO_2^- regeneration
001	10/11/14	CTD (SS)	65	7	NO_3^- regeneration
051	13/11/14	CTD (SS)	5	23	NH_4^+ assimilation
051	13/11/14	CTD (SS)	5	23	NO_2^- assimilation
051	13/11/14	CTD (SS)	5	23	NO_3^- assimilation
051	13/11/14	CTD (SS)	50	16	NH_4^+ assimilation
051	13/11/14	CTD (SS)	50	16	NO_2^- assimilation
051	13/11/14	CTD (SS)	50	16	NO_3^- assimilation
051	13/11/14	CTD (SS)	80	5	NH_4^+ assimilation
051	13/11/14	CTD (SS)	80	5	NO_2^- assimilation
051	13/11/14	CTD (SS)	80	5	NO_3^- assimilation
051	13/11/14	CTD (SS)	5	23	NH_4^+ regeneration
051	13/11/14	CTD (SS)	5	23	NO_2^- regeneration
051	13/11/14	CTD (SS)	5	23	NO_3^- regeneration
051	13/11/14	CTD (SS)	50	16	NH_4^+ regeneration
051	13/11/14	CTD (SS)	50	16	NO_2^- regeneration
051	13/11/14	CTD (SS)	50	16	NO_3^- regeneration
051	13/11/14	CTD (SS)	80	5	NH_4^+ regeneration
051	13/11/14	CTD (SS)	80	5	NO_2^- regeneration
051	13/11/14	CTD (SS)	80	5	NO_3^- regeneration
069	15/11/14	CTD (SS)	5	18	NH_4^+ assimilation
069	15/11/14	CTD (SS)	5	18	NO_2^- assimilation
069	15/11/14	CTD (SS)	5	18	NO_3^- assimilation
069	15/11/14	CTD (SS)	70	10	NH_4^+ assimilation
069	15/11/14	CTD (SS)	70	10	NO_2^- assimilation

069	15/11/14	CTD (SS)	70	10	NO_3^- assimilation
069	15/11/14	CTD (SS)	100	2	NH_4^+ assimilation
069	15/11/14	CTD (SS)	100	2	NO_2^- assimilation
069	15/11/14	CTD (SS)	100	2	NO_3^- assimilation
069	15/11/14	CTD (SS)	5	18	NH_4^+ regeneration
069	15/11/14	CTD (SS)	5	18	NO_2^- regeneration
069	15/11/14	CTD (SS)	5	18	NO_3^- regeneration
069	15/11/14	CTD (SS)	70	10	NH_4^+ regeneration
069	15/11/14	CTD (SS)	70	10	NO_2^- regeneration
069	15/11/14	CTD (SS)	70	10	NO_3^- regeneration
069	15/11/14	CTD (SS)	100	2	NH_4^+ regeneration
069	15/11/14	CTD (SS)	100	2	NO_2^- regeneration
069	15/11/14	CTD (SS)	100	2	NO_3^- regeneration
115	18/11/14	CTD (SS)	5	22	NH_4^+ assimilation
115	18/11/14	CTD (SS)	5	22	NO_2^- assimilation
115	18/11/14	CTD (SS)	5	22	NO_3^- assimilation
115	18/11/14	CTD (SS)	65	11	NH_4^+ assimilation
115	18/11/14	CTD (SS)	65	11	NO_2^- assimilation
115	18/11/14	CTD (SS)	65	11	NO_3^- assimilation
115	18/11/14	CTD (SS)	105	4	NH_4^+ assimilation
115	18/11/14	CTD (SS)	105	4	NO_2^- assimilation
115	18/11/14	CTD (SS)	105	4	NO_3^- assimilation
115	18/11/14	CTD (SS)	5	22	NH_4^+ regeneration
115	18/11/14	CTD (SS)	5	22	NO_2^- regeneration
115	18/11/14	CTD (SS)	5	22	NO_3^- regeneration
115	18/11/14	CTD (SS)	65	11	NH_4^+ regeneration
115	18/11/14	CTD (SS)	65	11	NO_2^- regeneration
115	18/11/14	CTD (SS)	65	11	NO_3^- regeneration
115	18/11/14	CTD (SS)	105	4	NH_4^+ regeneration
115	18/11/14	CTD (SS)	105	4	NO_2^- regeneration
115	18/11/14	CTD (SS)	105	4	NO_3^- regeneration
162	22/11/14	CTD (SS)	5	22	NH_4^+ assimilation
162	22/11/14	CTD (SS)	5	22	NO_2^- assimilation
162	22/11/14	CTD (SS)	5	22	NO_3^- assimilation
162	22/11/14	CTD (SS)	43	11	NH_4^+ assimilation
162	22/11/14	CTD (SS)	43	11	NO_2^- assimilation
162	22/11/14	CTD (SS)	43	11	NO_3^- assimilation
162	22/11/14	CTD (SS)	100	2	NH_4^+ assimilation
162	22/11/14	CTD (SS)	100	2	NO_2^- assimilation
162	22/11/14	CTD (SS)	100	2	NO_3^- assimilation
162	22/11/14	CTD (SS)	5	22	NH_4^+ regeneration
162	22/11/14	CTD (SS)	5	22	NO_2^- regeneration
162	22/11/14	CTD (SS)	5	22	NO_3^- regeneration
162	22/11/14	CTD (SS)	43	11	NH_4^+ regeneration
162	22/11/14	CTD (SS)	43	11	NO_2^- regeneration
162	22/11/14	CTD (SS)	43	11	NO_3^- regeneration
162	22/11/14	CTD (SS)	100	2	NH_4^+ regeneration
162	22/11/14	CTD (SS)	100	2	NO_2^- regeneration
162	22/11/14	CTD (SS)	100	2	NO_3^- regeneration

201	25/11/14	CTD (SS)	5	22	NH_4^+ assimilation
201	25/11/14	CTD (SS)	5	22	NO_2^- assimilation
201	25/11/14	CTD (SS)	5	22	NO_3^- assimilation
201	25/11/14	CTD (SS)	50	11	NH_4^+ assimilation
201	25/11/14	CTD (SS)	50	11	NO_2^- assimilation
201	25/11/14	CTD (SS)	50	11	NO_3^- assimilation
201	25/11/14	CTD (SS)	100	2	NH_4^+ assimilation
201	25/11/14	CTD (SS)	100	2	NO_2^- assimilation
201	25/11/14	CTD (SS)	100	2	NO_3^- assimilation
201	25/11/14	CTD (SS)	5	22	NH_4^+ regeneration
201	25/11/14	CTD (SS)	5	22	NO_2^- regeneration
201	25/11/14	CTD (SS)	5	22	NO_3^- regeneration
201	25/11/14	CTD (SS)	50	11	NH_4^+ regeneration
201	25/11/14	CTD (SS)	50	11	NO_2^- regeneration
201	25/11/14	CTD (SS)	50	11	NO_3^- regeneration
201	25/11/14	CTD (SS)	100	2	NH_4^+ regeneration
201	25/11/14	CTD (SS)	100	2	NO_2^- regeneration
201	25/11/14	CTD (SS)	100	2	NO_3^- regeneration

Marine Snow catcher deployments

Event	Date	Gear	Depth (m)	Process	Note
N/A	11/11/14	LMSC	N/A	N/A	Deployments failed
N/A	12/11/14	LMSC	N/A	N/A	Deployments failed
143-5	19/11/14	LMSC	15	N/A	Deployments failed
146	19/11/14	LMSC	15	NH_4^+ regeneration	
146	19/11/14	LMSC	15	NO_2^- regeneration	
146	19/11/14	LMSC	15	NO_3^- regeneration	
147	19/11/14	LMSC	100	NH_4^+ regeneration	Mis-fire (15 not 100m)
147	19/11/14	LMSC	100	NO_2^- regeneration	Mis-fire (15 not 100m)
147	19/11/14	LMSC	100	NO_3^- regeneration	Mis-fire (15 not 100m)
226	26/11/14	LMSC	15	NH_4^+ regeneration	
226	26/11/14	LMSC	15	NO_2^- regeneration	
226	26/11/14	LMSC	15	NO_3^- regeneration	
231	26/11/14	LMSC	100	NH_4^+ regeneration	
231	26/11/14	LMSC	100	NO_2^- regeneration	
231	26/11/14	LMSC	100	NO_3^- regeneration	

Marine Snow Catcher issues

- The units were is a poor state of service and could not be reliably deployed at the start of this cruise. Following extensive efforst by NMF staff, one of the units was salvaged for use. However, this limitation placed serious constraints on the work subsequently undertaken.

- The messenger assembly firing unit was unreliable – mis-fires occurred leading to uncertainty in the depth at which water was collected. Samples for salinity and inorganic nutrients were used to constrain this uncertainty.
- Concerns over safety for crew and science staff were raised in the deployment and use of the LMSC.

Status of samples and data availability.

No data is available during the cruise. The samples are stored at -20°C in the form of solid-phase extraction cartridges and GF/F filters to be analysed at the land-based laboratory. The former will be used for isotope dilution studies and the later for quantifying the carbon and nitrogen content of incubated samples and for assimilation rate determinations. Analysis will take approximately 6 weeks, after which a high quality data set is expected to be delivered.

References

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Clark, D. R, Miller, P, Woodward, M and Rees, A. (2011). Inorganic nitrogen assimilation and regeneration in the coastal upwelling region of the Iberian Peninsula. Limnol. Oceanogr., 56(5), 2011, 1689–1702

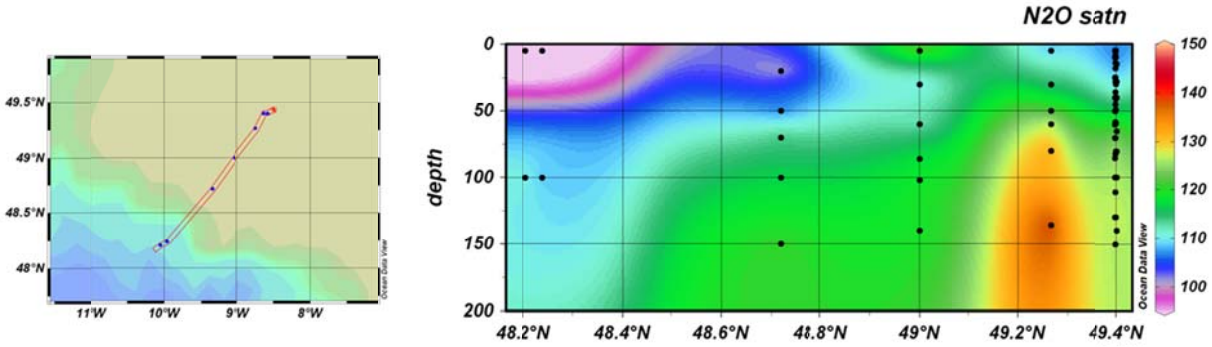
18. Nitrous Oxide & Methane

Andy Rees, Plymouth Marine Laboratory

Nitrous oxide and methane are biogenically produced trace gases whose atmospheric concentrations are increasing at a rate in the order of 0.7 ppbv y-1. Both gases are radiatively active, contributing approximately 6% and 15% of "greenhouse effect" respectively, whilst N_2O contributes to stratospheric ozone depletion and CH_4 limits tropospheric oxidation capacity.
The oceans are generally considered to be close to equilibrium relative to the atmosphere for both gases, however oceanic source/sink distributions are largely influenced by oxygen and nutrient status and regulatory processes are complicated and are currently not well understood. Shelf seas and ocean areas overlying sub-oxic waters and upwelling areas dominate the ocean source and saturations of up to 300% have been reported.

Aim:- To perform vertical profiles of N_2O and CH_4 concentration in order to assess variability in the source-sink strength and exchange of both gases across benthic-pelagic, pycnocline and ocean-atmosphere boundaries within the Celtic Sea.

Methods
Samples were collected from CTD bottles at stations identified below. 1 litre seawater samples were equilibrated with compressed air and headspace analysis performed onboard using flame ionisation detection-gas chromatography (FID-GC) and electron capture detection-gas chromatography (ECD-GC) for CH_4 and N_2O respectively[1,2,3]. Atmospheric concentrations were determined by the same methods using samples collected from the ships bow into a sealed Tedlar bag.
On the 15th November the ecd detector which is used for the determination of N_2O failed and was unuseable for the rest of the cruise. A sub-set of samples were collected, these will be analysed on return to PML using an alternative gc system.



N_2O saturation (%) relative to atmospheric equilibrium during DY018, November 2014

[1] *Upstill-Goddard R.C., A.P. Rees & N.J.P. Owens (1996) Simultaneous high-precision measurements of methane and nitrous oxide in water and seawater by single phase equilibration gas chromatography Deep-Sea Research I. Vol. 43, No. 10, PP. 1669-1682*

N_2O, CH_4 Sampling Date and position – DY018, November 2014. CH4 was analysed onboard. N_2O was analysed onboard until 15 November, and after samples were collected for later N_2O analysis where indicated by *

Day	Event	CTD No.	Lat (°N)	Long (°W)	Niskin	Depths Sampled
10	1	1	49.4011	8.5800	24,18,14,12,9,6,4,2	5,15,28,40,65,80,100,140
10	4	3	49.3985	8.5765	20,16,12,7,8	25,50,70,130,150
11	25	7	49.3983	8.5787	24,20,18,16,12,10,8,6,4,2	5,10,25,40,50,60,70,85,100,130
12	39	10	49.3988	8.5765	24,20,18,14,12,10,8,6,4,2	8,14,18,28,36,45,58,82,111,130
12	42	13	49.3998	8.6317	24,20,18,16,14,12,6,2	5,10,30,41,49,59,80,130
13	51	14	49.2667	8.7498	24,20,14,10,6,2	5,30,50,60,80,136
13	57	19	49.0000	9.0458	24,20,14,6,4,2	5,30,60,86,102,140
14	61	23	48.7185	9.3500	24,21,17,9,6,1	5,20,50,70,100,150
14	66	26	48.2060	10.0540	24,23,21,20,18,6	5,100,500,1000,2000,2430
15	67	29	48.2395	9.9653	24,23,21,20,1	5,100,1000,1500,2000
17	96	45	48.5708	9.5097	24,20,18,16,12,8,6,2	5,10,20,40,60,80,100,190
18*	115	47	48.5710	9.5105	24,21,19,15,13,10,8,6,3,1	5,10,20,40,65,75,85,105,155,190
18	119	51	48.5712	9.5110	24,18,12,8,2	5,40,100,120,190
19	135	53	48.5762	9.5095	24,20,16,10,6,2	5,20,60,80,120,190
22*	162	59	49.3935	8.5870	24,19,13,10,6,1	5,20,43,60,80,135
23	182	71	48.4222	9.8788	22,20,18,14,12,2	5,50,100,300,500,900
24	187	76	48.4373	9.8630	19,18,16,14,12,10	5,50,100,200,300,475
25	201	81	49.4000	8.5830	24,21,19,17,15,13,8,5,4,1	5,10,20,30,40,50,60,75,100,135
26	225	85	49.3943	8.4313	24,20,18,12,6,2	5,20,40,55,80,127
27		nontox	49.6052	8.3300	non-tox	6
27*	234	87	49.7945	8.0630	non-tox,18,15,1	6,25,50,75
27		nontox	50.0142	7.7827	non-tox	6

27*	236	89	50.2078	7.4630	non tox,18,15,6,1	6,25,60,80,100
28*	238	91	50.6250	6.9427	24,20,18,12,7,2	5,20,40,55,65,86
28*	239	92	50.8283	6.6670	24,20,4	5,20,70
28*	242	93	51.2130	6.1318	non-tox,22,19,14,9,4	6,25,40,65,80,95
29	253	94	49.4042	8.5853	non-tox,24,18,8,2	6,25,55,100,135
1/12*	261	96	50.0347	4.3707	Non-tox,12,8,6,4,2	6,25,40,50,60,67

19. Abundance and Composition of Microbial Plankton Communities by flow cytometry

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

Samples for enumeration of plankton, approx. <20 µm were collected CTD Niskin bottles into clean 125 mL polycarbonate bottles. Subsamples were then pipetted into 2 mL microcentrifuge tubes and fixed with glutaraldehyde (50%, TEM grade, 1% final concentration) within half an hour of surfacing. Table 1 summarises the CTD casts sampled and analysed during the cruise. Samples were left to fix in a refrigerator for between 1 – 12 h, and then stored at -80^{o}C. Samples will be analysed ashore as follows. For phytoplankton, samples will be thawed at room temperature and then analysed using a Becton Dickinson FACSort flow cytometer to characterise and enumerate *Synechococcus* sp. (cyanobacteria) and pico- and eucaryote phytoplankton, based on their light scattering and autofluorescence properties. Samples for bacteria and heterotrophic nanoflagellates will be thawed and then stained with the DNA stain SYBR Green I (Invitrogen) in order to separate particles in suspension based on DNA content and light scattering properties. All data will be saved in listmode format and the data analysed to enumerate the different plankton groups.

***Table 1*: CTD casts sampled for phytoplankton, heterotrophic bacteria and heterotrophic flagellate community structure & abundance**

Station	CTD	Event	Time in water	Lat (N)	Lon (W)	Depths sampled (m)
CCS	1	1	501	49° 24.07	08° 34.8	140,100,80,65,40,28,15,10,5
CCS	3	4	1220	49° 23.91	08° 34.59	5,25,40,50,60,70,85,100,130
CCS	7	25	1205	49° 23.90	08° 34.72	130,100,85,70,60,50,45,40,25,10,5
CCS	10	39	508	49° 23.93	08° 34.59	130,111,82,58,45,36,28,24,18,14,8
CCS	13	42	1224	49° 23.99	08° 37.9	130,100,80,65,59,49,41,30,10,5
1	14	51	809	49° 16.00	08° 44.99	136,100,80,70,60,50,40,30,10,5
3	19	57	1833	49° 0.0	09° 2.75	140,102,86,77,71,60,50,40,30,5
5	23	61	224	48° 43.11	09° 21.08	150,100,70,65,60,55,50,40,20,5
Fe03	31	69	919	48° 20.45	09° 42.25	5,70,100
CS2	45	96	1213	48° 34.25	09° 30.58	190,150,100,80,60,50,40,20,10,5
CS2	47	115	506	48° 34.26	09° 30.63	190,155,105,85,75,65,40,20,10,5
CS2	51	119	1200	48° 34.27	09° 30.66	190,130,110,100,80,60,40,20,10,5
CS2	53	135	1205	48° 34.57	09° 30.57	190,120,80,75,70,60,40,20,10,5
CS2	55	150	201	48° 34.41	09° 30.38	55,40,20,10,5
CCS	59	162	455	49° 23.61	08° 35.22	135,100,80,70,60,43,35,28,20,5
CCS	81	201	511	49° 24.00	08° 34.98	135,100,75,60,50,40,30,20,10,5
CCS	82	202	1217	49° 23.95	08° 34.92	131,100,80,60,55,50,40,20,10,5
CCS	85	225	1222	49° 23.66	08° 25.88	127,80,65,60,55,50,40,20,10,5
J03	91	238	1135	50° 37.5	06° 56.56	86,65,60,55,50,45,40,20,10,5
CCS	94	253	1405	49° 24.25	08° 35.12	135,100,55,25,6
E1	96	261	639	50° 2.08	04° 22.24	6,25,40,50,60,67

20. Zooplankton biomass and metabolic rates

SLC Giering, Seona Wells: University of Aberdeen

1. Scientific motivation

Zooplankton play a significant role in the biogeochemical cycle of the sea as they ingest particulate organic matter and transform it into (1) CO_2 via respiration, (2) N-rich dissolved matter via excretion, and (3) particulate matter via the production of biomass, eggs and C-rich faecal pellets. The N-rich excretion products are likely to remain in the dissolved phase, whereas the C-rich faecal pellets may sink to depth at rates of up to 2700 m per day (review by Turner 2002). This differential recycling, with N staying in the upper ocean and C being exported to depth, has been postulated to enhance decoupling of C and N in shelf regions.

During DY018, we collected mesozooplankton (here zooplankton larger than 63 µm) to assess their abundance, elemental composition and to carry out experiments measuring excretion, sloppy feeding and grazing for mixed zooplankton communities in different size fractions (63-200 µm, 200-500 µm, 500-5,000 µm). Due to the high abundance of large gelatinous zooplankton, we dedicated several experiments to measure excretion, defecation and grazing of salps and cnidaria.

2. Material & Methods

2.1. Abundance estimates

Samples for zooplankton biomass and elemental composition were sampled using WP2 nets of two different mesh sizes (63 µm and 200 µm). At each process station, WP2 nets fitted with non-filtering cod-ends and a closing mechanism were deployed: 4 during daytime and 4 during night-time to sample below and above the thermocline. Zooplankton of the size between 63-200 m were collected using a 63- m WP2 net hauled at 0.2 m/s. Zooplankton larger than 200 m were collected using a 200- m WP2 net hauled at 0.5 m/s. Collected zooplankton was size-fractioned into 63-200 m, 200-500 m, and >500 m. Each size fraction was split: half was preserve in borax-buffered formaldehyde for identification and counts and half was frozen at -80°C for POC/N/P analyses. Nets were fitted with a temperature and depth logger. Net samples for distribution and abundance will be complemented by vessel-mounted ADCP backscatter data. Samples for microzooplankton abundance and distribution (preserved with Lugol's iodine) were taken from 6 depth from each pre-dawn CTD by Alex Poulton.

2.2. Rate-series experiments

Vital rates experiments were aimed to measure different metabolic rates (excretion, sloppy feeding and grazing) of the same 'mixed community'. To do so, we transferred groups of zooplankton of one size class (63-200 m, 200-500 m and >500 m) in triplicates through sequential experiments determining rates. Zooplankton was first acclimated in unfiltered sea water for 3 hours. Animals were placed into filtered water and excretion of DOC, ammonium, and nutrients was measured over a period of 2 hours. Animals were then placed into unfiltered sea water to measure sloppy feeding release of DOC, ammonium, and nutrients. Last, animals were transferred into 1.2-L or 2.3-L bottles filled with unfiltered water and incubated for 24 hours to measure ingestion of microplankton. The order is chosen to combine acclimation phases with actual rate measurements. A similar experiment was carried out with gelatinous zooplankton. 1-30 Salps or cnidaria of similar size were incubated in filtered water and excretion of ammonium and nutrients was measured over a time frame of 5 h. Faecal pellets were collected, photographed, their sinking speed measured and frozen for later POC/N/P content analyses. The gelatinous zooplankton were then transferred into bottles with unfiltered water and incubated for 24 hours on a plankton wheel. Size-fractionated chlorophyll (0.2-2, 2-20, and >20 µm) was measured before and after the incubation to estimate grazing on phytoplankton. All equipment was acid-washed, bottles and carboys were rinsed three times with incubation water prior to filling, and gloves and hair nets were worn at all times.

2.3. Microzooplankton grazing

We carried out one dilution experiment to measure microzooplakton grazing (Landry & Hassett 1982). Water was collected from two depth, in the euphotic zone and below the thermocline, using Niskin bottles mounted on a CTD rosette. Water was either gently pre-screened with 200-µm mesh and transferred into carboys or filtered through an in-line filter cartridge (0.2 µm). Dilutions were made up in separate carboys as 100% unfiltered water and 30% unfiltered water + 70% filtered water. 1-L glass bottles were filled in replicates (5 replicates) and closed without any bubbles present. Bottles were placed on a plankton wheel (1 rpm) and incubated for 48 hours at in situ temperature and at the local photoperiod. Samples for time zero of Chlorophyll a (size fractionated: 0.2-2, 2-20, and >20 µm), microplankton and nutrients were taken in triplicates from the carboys. After the incubation period, samples for Chlorophyll a (size fractionated), microplankton counts (preserved using Lugol's iodine), ammonium and nutrients, coccolithophore counts and flow cytometry counts. All equipment was acid-washed, bottles and carboys were rinsed three times with incubation water prior to filling, and gloves and hair nets were worn at all times.

3. Sample summary

92 nets were deployed in total (Table 1). Daytime/night-time distribution was sampled six times, resulting in a total of 66 samples for biomass and 66 samples for elemental composition. Three zooplankton vital rates experiments, four gelatinous vital rates experiments and one dilution experiment were carried out. A total of 234 ammonium and nutrient samples were collected, and analysed on board. 96 DOC samples were collected, frozen and stored at -20°C degrees for on-shore analysis. From the grazing and dilution experiments, 380 samples for Chlorophyll a were taken and analysed on board. 47 samples for microplankton (preserved using Lugol's iodine) were taken from two zooplankton grazing experiments and the dilution experiment. Lugol's-preserved samples will be analysed on shore. 284 faecal pellets from salps and cnidaria were photographed and the sinking speed of 176 faecal pellet measured. 153 Faecal pellets were placed on filters and frozen for POC/N/P analysis; 55 faecal pellets were preserved for HPLC analysis, 35 for SEM, and 22 for lipid biomarkers.

Trichodesmium distribution

SLC Giering, Hanna Schuster, Seona Wells

1. Scientific motivation

The diazotrophic cyanobacterium *Trichodesmium* has been recognized to as a major player in the fixation of atmospheric nitrogen, and it thus contributes substantially to the nitrogen influx of the global marine ecosystem. It is commonly assumed that the distribution of *Trichodesmium* is roughly limited to waters with temperatures warmer than 20°C (review by Bergman et al. 2013). However, during DY018 we found large numbers of *Trichodesmium* colonies in the zooplankton net samples. We therefore dedicated several days to collect and process *Trichodesmium* colonies.

2. Methods:

Trichodesmium colonies were collected from 5 sites in the Celtic Sea using a WP2 net (either 63 or 200-µm mesh size). In a temperature-controlled lab (at sea surface temperature), *Trichodesmium* colonies were pipetted from the mesh sample into smaller beakers. Under a light microscope, 50 colonies were individually picked with soft tweezers and transferred into glass vials containing 15 mL 0.2-µm sea filtered water from 10 m depth at the respective station. Colonies were kept at sea surface temperature and the local photo period until usage.

Carbon fixation, phosphorous fixation and nitrogen assimilation rates were measured by Alex Poulton, Kyle Mayers and Darren Clark on board. Samples for particulates, biomarkers and DNA

were given to Clare Davis, Clare Ostle and Andy Rees, respectively. Samples were further taken for pigments (HPLC), cell counts and Chlorophyll a. To test how *Trichodesmium* preserves in formaldehyde, two samples were fixed in 4% formaldehyde.

We further carried out three incubations to see whether the copepod *Calanus* feeds on *Trichodesmium.* 10-15 *Calanus* were transferred into 500-mL bottles and incubated on a plankton wheel (1 rpm) in darkness at in situ temperature. Two experiments looked at grazing on *Trichodesmium* as sole food source. Treatments were (1) filtered water + *Calanus,* (2) filtered water + *Trichodesmium,* (3) filtered water + *Calanus + Trichodesmium*, and (4) unfiltered water + *Calanus* (feeding control); bottles were incubated for 24 h. One experiment looked at grazing behaviour in presence of *Trichodesmium.* Treatments were (1) unfiltered water, (2) unfiltered water + *Calanus*, and (3) unfiltered water + *Calanus + Trichodesmium*; bottles were incubated for 7 hours during night-time. Final Chlorophyll a concentrations and gut fluorescence was measured for all experiments.

Table Usage of *Trichodesmium* samples

	Station	C fix.	N ass.	P fix.	POC/N/P	Bio-marker	HPLC	Chl	DNA	Lugol's	Formaldehyde	Grazing
		Poulton, Mayers	Clark	Poulton, Mayers	Davis, Giering	Ostle	Poulton, Giering	Giering, Schuster, Wells	Rees	Poulton, Giering	Giering	Giering, Schuster, Wells
23/11	Fe10			x	x	x	x		x	x		
24/11	CS2	x	x							x		
25/11	CCS											x
26/11	CCS						x	x	x	x		x
28/11	Benthic A						x	x	x	x		
29/11	CCS				x		x	x	x	x	x	x
01/12	E1				x		x	x	x	x	x	

References:

Bergman B, G Sandh, S Lin, J Larsson & EJ Carpenter (2013) *Trichodesmium* – a widespread marine cyanobacterium with unusual nitrogen fixation properties. FEMS Microbiol Rev 37:286-302. doi:10.1111/j.1574-6976.2012.00352.x

Landry MR & RP Hassett (1982) Estimating the grazing impact of marine micro-zooplankton. Mar Biol 67:283–288

Turner JT (2002) Zooplankton fecal pellets, marine snow and sinking phytoplankton blooms, Aquat Microb Ecol, 27:57–102, doi:10.3354/ame027057

Station No.	Site	Net No.	Date	Day Night	Time	Net opened								Time	Net closed									Depth opened	Depth closed	Mesh size	Use
			(UTC)		(UTC)	Latitude				Longitude				(UTC)	Latitude				Longitude					(m)	(m)	(μm)	
005	CCS	1	10/11/2014	Day	14:01	49	°	23.905	N	8	°	34.584	W	14:18	49	°	23.905	N	8	°	34.584	W		130	50	63	Frozen / Formalin
006	CCS	2	10/11/2014	Day	14:21	49	°	23.905	N	8	°	34.584	W	14:30	49	°	23.905	N	8	°	34.584	W		50	0	63	Frozen / Formalin
007	CCS	3	10/11/2014	Day	14:39	49	°	23.905	N	8	°	34.584	W	14:48	49	°	23.905	N	8	°	34.584	W		50	0	63	-
008	CCS	4	10/11/2014	Day	14:55	49	°	23.905	N	8	°	34.584	W	15:10	49	°	23.905	N	8	°	34.584	W		130	50	200	Frozen / Formalin
009	CCS	5	10/11/2014	Day	15:16	49	°	23.905	N	8	°	34.584	W	15:20	49	°	23.905	N	8	°	34.584	W		50	0	200	Frozen / Formalin
010	CCS	6	10/11/2014	Day	15:25	49	°	23.905	N	8	°	34.584	W	15:29	49	°	23.905	N	8	°	34.584	W		50	0	200	-
013	CCS	7	10/11/2014	Night	20:24	49	°	23.972	N	8	°	34.314	W	20:40	49	°	23.972	N	8	°	34.314	W		130	50	63	Frozen / Formalin
014	CCS	8	10/11/2014	Night	20:44	49	°	23.881	N	8	°	34.163	W	20:47	49	°	23.881	N	8	°	34.163	W		50	0	63	Frozen / Formalin

015	CCS	9	10/11/2014	Night	20:48	49	°	23.847	N	8	°	34.076	W	21:08	49	°	23.847	N	8	°	34.076	W	50	0	63	-
016	CCS	10	10/11/2014	Night	21:10	49	°	23.819	N	8	°	33.911	W	21:17	49	°	23.819	N	8	°	33.911	W	130	50	200	Frozen / Formalin
017	CCS	11	10/11/2014	Night	21:19	49	°	23.777	N	8	°	33.849	W	21:24	49	°	23.777	N	8	°	33.849	W	50	0	200	Frozen / Formalin
018	CCS	12	10/11/2014	Night	21:26	49	°	23.744	N	8	°	33.812	W	21:31	49	°	23.744	N	8	°	33.812	W	50	0	200	-
033	CCS	13	12/11/2014	Night	01:11	49	°	23.945	N	8	°	34.276	W	01:20	49	°	23.945	N	8	°	34.276	W	40	0	63	VR1
034	CCS	14	12/11/2014	Night	01:24	49	°	23.871	N	8	°	34.276	W	01:30	49	°	23.871	N	8	°	34.276	W	40	0	63	VR1
035	CCS	15	12/11/2014	Night	03:11	49	°	23.781	N	8	°	34.206	W	03:25	49	°	23.781	N	8	°	34.206	W	130	50	200	Frozen / Formalin
036	CCS	16	12/11/2014	Night	03:28	49	°	23.759	N	8	°	34.184	W	03:38	49	°	23.759	N	8	°	34.184	W	50	0	200	Frozen / Formalin
037	CCS	17	12/11/2014	Night	03:41	49	°	23.723	N	8	°	34.149	W	03:54	49	°	23.723	N	8	°	34.149	W	130	50	63	Frozen / Formalin
038	CCS	18	12/11/2014	Night	03:57	49	°	23.67	N	8	°	34.104	W	04:10	49	°	23.67	N	8	°	34.104	W	50	0	63	Frozen / Formalin

043	CCS	19	12/11/2014	Day	13:31	49	°	23.966		8	°	34.443	W	13:50	49	°	23.966		8	°	34.443	W	130	50	63	Frozen / Formalin
044	CCS	20	12/11/2014	Day	13:52	49	°	23.95		8	°	34.542	W	14:00	49	°	23.95		8	°	34.542	W	50	0	63	Frozen / Formalin
045	CCS	21	12/11/2014	Day	14:08	49	°	23.922		8	°	34.603	W	14:18	49	°	23.922		8	°	34.603	W	130	50	200	Frozen / Formalin
046	CCS	22	12/11/2014	Day	14:20	49	°	23.89		8	°	34.644	W	14:25	49	°	23.89		8	°	34.644	W	50	0	200	Frozen / Formalin
084	Fe06	23	16/11/2014	Day	16:05	48	°	24.556	N	9	°	31.621	W	16:10	48	°	24.551	N	9	°	3.612	W	40	0	63	-
085	Fe06	24	16/11/2014	Day	16:16	48	°	24.543	N	9	°	31.590	W	16:22	48	°	24.532	N	9	°	31.563	W	40	0	63	-
090	CS2	25	17/11/14	Night	06:15	48	°	34.250	N	9	°	30.60	W	06:21	48	°	32.230	N	9	°	30.65	W	35	0	63	FP
091	CS2	26	17/11/14	Night	06:27	48	°	34.220	N	9	°	30.67	W	06:32	48	°	34.210	N	9	°	30.70	W	35	0	63	FP
092	CS2	27	17/11/14	Night	06:37	48	°	34.210	N	9	°	30.73	W	06:40	48	°	34.200	N	9	°	30.79	W	35	0	63	FP
093	CS2	28	17/11/14	Night	06:46	48	°	34.200	N	9	°	30.79	W	06:51	48	°	34.200	N	9	°	30.83	W	35	0	63	FP

094	CS2	29	17/11/14	Night	06:56	48	°	34.200	N	9	°	30.86	W	07:01	48	°	34.200	N	9	°	30.78	W	35	0	63	FP
097	CS2	30	17/11/2014	Day	14:06	48	°	34.250	N	9	°	30.580	W	14:16	48	°	34.250	N	9	°	30.580	W	150	55	63	Frozen / Formalin
098	CS2	31	17/11/2014	Day	14:27	48	°	34.250	N	9	°	30.580	W	14:35	48	°	34.250	N	9	°	30.580	W	55	0	63	Frozen / Formalin / GE1
099	CS2	32	17/11/2014	Day	14:44	48	°	34.250	N	9	°	30.580	W	14:49	48	°	34.250	N	9	°	30.580	W	150	55	200	Frozen / Formalin
100	CS2	33	17/11/2014	Day	14:58	48	°	34.250	N	9	°	30.580	W	15:03	48	°	34.250	N	9	°	30.580	W	55	0	200	Frozen / Formalin / GE1
102	CS2	34	17/11/2014	Night	18:20	48	°	24.245	N	9	°	30.624	W	18:32	48	°	34.235	N	9	°	30.738	W	150	55	63	Frozen / Formalin
103	CS2	35	17/11/2014	Night	18:41	48	°	24.240	N	9	°	30.810	W	18:47	48	°	34.243	N	9	°	30.870	W	55	0	63	Frozen / Formalin
104	CS2	36	17/11/2014	Night	18:55	48	°	34.248	N	9	°	30.920	W	19:02	48	°	34.250	N	9	°	31.026	W	55	0	63	VR2
105	CS2	37	17/11/2014	Night	19:11	48	°	34.258	N	9	°	31.036	W	19:15	48	°	34.262	N	9	°	31.090	W	150	55	200	Frozen / Formalin
106	CS2	38	17/11/2014	Night	19:24	48	°	34.266	N	9	°	31.137	W	19:28	48	°	34.270	N	9	°	31.171	W	55	0	200	Frozen / Formalin

107	CS2	39	17/11/2014	Night	19:32	48	°	34.272	N	9	°	31.191	W	19:35	48	°	34.274	N	9	°	31.220	W	-	-	200	-
108	CS2	40	17/11/2014	Night	19:37	48	°	34.278	N	9	°	31.261	W	19:42	48	°	34.278	N	9	°	31.224	W	55	0	200	VR2
129	CS2	41	19/11/2014	Night	06:06	48	°	34.227	N	9	°	30.588	W	06:21	48	°	34.120	N	9	°	30.588	W	150	55	63	Frozen / Formalin
130	CS2	42	19/11/2014	Night	06:25	48	°	34.120	N	9	°	30.588	W	06:30	48	°	34.120	N	9	°	30.588	W	-	-	63	-
131	CS2	43	19/11/2014	Night	06:52	48	°	33.961	N	9	°	30.873	W	07:00	48	°	33.915	N	9	°	30.935	W	55	0	63	Frozen / Formalin
132	CS2	44	19/11/2014	Night	07:11	48	°	33.866	N	9	°	31.001	W	07:15	48	°	33.840	N	9	°	31.032	W	150	55	200	Frozen / Formalin/ GE2
133	CS2	45	19/11/2014	Night	07:24	48	°	33.805	N	9	°	31.082	W	07:26	48	°	33.805	N	9	°	31.082	W	55	0	200	Frozen / Formalin/ GE2
137	CS2	46	19/11/2014	Day	15:37	48	°	34.214	N	9	°	30.501	W	15:49	48	°	34.157	N	9	°	30.451	W	150	55	63	Frozen / Formalin
138	CS2	47	19/11/2014	Day	15:59	48	°	34.073	N	9	°	30.363	W	16:06	48	°	34.028	N	9	°	30.326	W	55	0	63	Frozen / Formalin
139	CS2	48	19/11/2014	Day	16:08	48	°	34.028	N	9	°	30.326	W	16:12	48	°	33.955	N	9	°	30.289	W	-	-	63	-

140	CS2	49	19/11/2014	Day	16:16	48	°	33.955	N	9	°	30.289	W	16:20	48	°	33.955	N	9	°	30.289	W	20	0	63	-
141	CS2	50	19/11/2014	Day	16:29	48	°	33.890	N	9	°	30.232	W	16:33	48	°	33.855	N	9	°	30.211	W	150	55	200	Frozen / Formalin
142	CS2	51	19/11/2014	Day	16:43	48	°	33.810	N	9	°	30.181	W	16:48	48	°	33.768	N	9	°	30.154	W	55	0	200	Frozen / Formalin
159	CCS	52	21/11/2014	Night	18:56	49	°	23.900	N	8	°	35.074	W	19:09	49	°	23.900	N	8	°	35.074	W	140	0	63	MP
160	CCS	53	21/11/2014	Night	19:15	49	°	23.743	N	8	°	35.167	W	19:20	49	°	23.743	N	8	°	35.167	W	40	0	63	GE2 – prey
161	CCS	54	21/11/2014	Night	19:29	49	°	23.653	N	8	°	35.224	W	19:35	49	°	23.653	N	8	°	35.224	W	40	0	200	GE2 – prey
176	Fe10	55	23/11/2014	Day	12:17	48	°	25.338	N	9	°	52.766	W	12:35	48	°	25.362	N	9	°	52.868	W	150	0	63	MP
177	Fe10	56	23/11/2014	Day	12:40	48	°	25.367	N	9	°	52.893	W	12:45	48	°	25.367	N	9	°	52.893	W	40	0	63	-
178	Fe10	57	23/11/2014	Day	12:48	48	°	25.367	N	9	°	52.893	W	12:53	48	°	25.367	N	9	°	52.893	W	40	0	63	-
179	Fe10	58	23/11/2014	Day	13:00	48	°	25.414	N	9	°	52.992	W	13:04	48	°	25.414	N	9	°	52.992	W	25	0	63	Tricho

180	Fe10	59	23/11/2014	Day	13:06	48	°	25.443	N	9	°	52.036	W	13:14	48	°	25.443	N	9	°	52.036	W	25	0	63	Tricho
190	CS2	60	24/11/2014	Day	12:05	48	°	34.335	N	9	°	30.723	W	12:09	48	°	34.335	N	9	°	30.723	W	40	0	63	GE3
191	CS2	61	24/11/2014	Day	12:11	48	°	34.392	N	9	°	30.786	W	12:15	48	°	34.392	N	9	°	30.786	W	40	0	63	GE3
192	CS2	62	24/11/2014	Day	12:18	48	°	34.494	N	9	°	31.026	W	12:25	48	°	34.494	N	9	°	31.026	W	40	0	63	GE3
193	CS2	63	24/11/2014	Day	12:29	48	°	34.494	N	9	°	31.026	W	12:33	48	°	34.494	N	9	°	31.026	W	20	0	63	TER
194	CS2	64	24/11/2014	Day	12:35	48	°	34.529	N	9	°	31.111	W	12:40	48	°	34.529	N	9	°	31.111	W	20	0	63	TER
203	CCS	65	25/11/2014	Day	13:00	49	°	24.071	N	8	°	35.007	W	13:07	49	°	24.071	N	8	°	35.007	W	1	0	63	GE4
204	CCS	66	25/11/2014	Day	13:12	49	°	24.071	N	8	°	35.007	W	13:19	49	°	24.071	N	8	°	35.007	W	1	0	63	GE4
205	CCS	67	25/11/2014	Day	13:25	49	°	24.071	N	8	°	35.007	W	13:36	49	°	24.071	N	8	°	35.007	W	130	0	63	MP
206	CCS	68	25/11/2014	Day	13:43	49	°	24.095	N	8	°	35.043	W	13:51	49	°	24.133	N	8	°	35.100	W	130	60	63	-

207	CCS	69	25/11/2014	Day	14:02	49	°	24.171	N	8	°	35.154	W	14:15	49	°	24.186	N	8	°	35.179	W	60	0	63	Frozen / Formalin
208	CCS	70	25/11/2014	Day	14:22	49	°	24.331	N	8	°	35.340	W	14:26	49	°	24.362	N	8	°	35.372	W	130	60	200	Frozen / Formalin
209	CCS	71	25/11/2014	Day	14:35	49	°	24.433	N	8	°	35.451	W	14:39	49	°	24.480	N	8	°	35.502	W	60	0	200	Frozen / Formalin
210	CCS	72	25/11/2014	Day	14:47	49	°	24.546	N	8	°	35.572	W	14:57	49	°	24.619	N	8	°	35.653	W	130	60	63	Frozen / Formalin
211	CCS	73	25/11/2014	Day	15:00	49	°	24.546	N	8	°	35.572	W	15:10	49	°	24.619	N	8	°	35.653	W	40	0	63	GE4 – prey
218	CCS	74	25/11/2014	Night	20:55	49	°	24.881	N	8	°	35.594	W	21:05	49	°	24.881	N	8	°	35.594	W	130	60	63	Frozen / Formalin
219	CCS	75	25/11/2014	Night	21:18	49	°	24.880	N	8	°	35.595	W	21:28	49	°	24.880	N	8	°	35.594	W	60	0	63	Frozen / Formalin
220	CCS	76	25/11/2014	Night	21:33	49	°	24.880	N	8	°	35.594	W	21:39	49	°	24.880	N	8	°	35.594	W	40	0	63	TE1 – T
221	CCS	77	25/11/2014	Night	21:53	49	°	24.880	N	8	°	35.592	W	22:00	49	°	24.883	N	8	°	35.617	W	130	60	200	Frozen / Formalin
222	CCS	78	25/11/2014	Night	22:10	49	°	24.884	N	8	°	35.688	W	22:15	49	°	24.800	N	8	°	35.600	W	60	0	200	Frozen / Formalin

223	CCS	79	25/11/2014	Night	22:17	49	°	24.885	N	8	°	35.758	W	22:22	49	°	24.885	N	8	°	35.758	W	80	0	200	TE1 – C
228	CCS	80	26/11/2014	Night	18:55	49	°	24.436	N	8	°	34.962	W	19:10	49	°	24.436	N	8	°	34.962	W	40	0	63	VR3 / TE2 – T
229	CCS	81	26/11/2014	Night	19:12	49	°	24.498	N	8	°	34.777	W	19:18	49	°	24.498	N	8	°	34.777	W	40	0	200	VR3 / TE2 – T
230	CCS	82	26/11/2014	Night	19:20	49	°	24.525	N	8	°	34.704	W	19:35	49	°	24.525	N	8	°	34.704	W	70	0	200	VR3 / TE2 – T
240	J02	83	28/11/2014	Day	15:31	50	°	49.704	N	6	°	40.029	W	15:40	50	°	49.704	N	6	°	40.029	W	70	0	200	-
241	J02	84	28/11/2014	Day	15:45	50	°	49.768	N	6	°	40.168	W	15:55	50	°	49.768	N	6	°	40.168	W	70	0	200	-
246	Benthic A	85	28/11/2014	Night	21:56	51	°	12.809	N	6	°	7.863	W	21:58	51	°	12.82	N	6	°	7.853	W	100	70	200	Frozen / Formalin
247	Benthic A	86	28/11/2014	Night	22:00	51	°	12.866	N	6	°	7.814	W	22:13	51	°	12.886	N	6	°	7.794	W	70	0	200	Frozen / Formalin
248	Benthic A	87	28/11/2014	Night	22:17	51	°	12.903	N	6	°	7.776	W	22:20	51	°	12.95	N	6	°	7.765	W	70	0	200	TE2 – C/ Tricho
249	Benthic A	88	28/11/2014	Night	22:29	51	°	12.952	N	6	°	7.732	W	22:33	51	°	12.973	N	6	°	7.727	W	100	70	63	Frozen / Formalin

250	Benthic A	89	28/11/2014	Night	22:42	51	°	13.017	N	6	°	7.713	W	22:49	51	°	13.038	N	6	°	7.706	W	70	0	63	Frozen / Formalin
258	CCS	90	29/11/2014	Night	19:30	49	°	24.305	N	8	°	34.932	W	19:34	49	°	24.307	N	8	°	34.938	W	60	0	200	TE3 – C/T
259	CCS	91	29/11/2014	Night	19:38	49	°	24.307	N	8	°	34.941	W	19:45	49	°	24.307	N	8	°	34.923	W	60	0	200	TE3 – C/T
268	E1	92	01/12/2014	Day	12:10	50	°	2.049	N	4	°	22.239	W	12:19	50	°	2.045	N	4	°	22.226	W	25	0	200	Tricho

21. Marine Snowcatcher

Hanna Schuster, University of Liverpool & University of Southampton

1. Background

Marine Snow Catchers (MSCs) are designed to capture 3 different fractions of particles: suspended, slow and fast sinking particles. The measurement of aerobic respiration, bacterial production, organic carbon, chlorophyll and nitrogen assimilation of these particles provide essential data to understand the relationship between the benthos and overlaying water column. Further, the MSC can be used to estimate organic matter that is consumed in the water column during settling, transported from the shelf into the open ocean or may reach the sediment.

2. Material and Methods

MSCs are deployed with both ends open. At the desired depth a messenger is fired to close the plungers. After the MSC is shut, it is brought immediately to deck and left to settle for 2 h.
After 2 h the suspended and slow sinking fractions of the large MSCs are sampled by opening the corresponding taps. The tray with the fast sinking particles is removed and processed as soon as the MSCs have drained. The small MSC has no tap for the slow sinking fraction. Therefore, when using the small MSC, the suspended fraction is sampled first, then the top section is drained, the top part removed and the tray containing the fast sinking particles is removed before slow sinking fraction can be siphoned out from the base.

Two large and one small MSC were brought on the cruise DY018 to 1) deploy the large MSC consecutively to ensure a large sample of fast sinking particles from the same water body that would allow the parallel measurement of aerobic respiration (Elena Garcia), bacterial production (Sharon McNeill), organic carbon (Clare Davies) and nitrogen assimilation (Darren). 2) The small MSC was intended to sample for organic carbon to analyse the comparability of the different sized snow catchers, DNA and chlorophyll of suspended, slow sinking and fast sinking fraction. Any remaining particles from the fast sinking fraction of the small MSC were fixed in 4% borax buffered formaldehyde for future microscopy analysis. Before sampling of the fast sinking particles, the tray was photographed using an imaging rig build by Stephanie Wilson. Approximately 35 pictures were taken of each tray and will be processed at a later date using Image J. Using these pictures, the size of the particles and their particulate organic carbon content can be estimated. The pictures are further scanned for any faecal pellets to compare their proportion to other particle aggregates.

Chlorophyll

A 200 ml sample of the suspended and slow sinking fractions and 125 ml of the fast sinking particles were filtered on a GF/F filter (Whatman 25mm), washed with Milli Q and extracted for 24 h in aceton. Subsequently, the samples were measured on board on a Fluorometer to determine the chlorophyll concentration.

DNA

A 10ml sample of each fraction was filtered on a GF/F (Whatman 25mm) and rinsed with Milli Q. Samples were frozen on the filter at -80˚C for future analysis.

3. Deployments and limitations

Unfortunately, the both large MSCs misfired or leaked during the first deployments at CCS, so that no successful deployment was possible during our first stay at this station. In the following days it was possible to repair one of the large MSCs while the second could not be repaired in the time frame of the cruise. Thus, only one large MSC and the small MSC were deployed during this cruise and the sampling for aerobic respiration, bacterial production, organic carbon and nitrogen

assimilation took place at consecutive days. The small and large MSC were deployed 12 times each at two different stations: CCS and CS2 (24 deployments in total).

The cruise report of DY026 (August 2014, Emma Cavan) already has addressed a number of issues encountered during the deployment of the large MSCs. As reported previously, the large MSC were prone to leak when brought on deck. To avoid any leaks the top was fixed to the base with 4 additional ratchet straps which allowed for 12 successful deployments.
One of the most pressing issues was the safety concern owing to the size especially in high winds as well as the way of removing the top part of the MSC from its base. To address these concerns custom-made frames were made. Unfortunately, the frames were very tightly fitted around the MSC so that there was only a very small margin between lowering the MSC into the frame correctly or getting the MSC and potentially fingers and hands stuck between the MSC and the frames. To avoid the related safety issues the frames were not used for any further deployments. Owing to this the initial health and safety issues (lashing against the bulwark and using a step ladder to release the wire from the top of them, at 2.5 m tall, undoing the R-pin that holds top and base together) have to be addressed before taking the large MSC to sea again.

4. Preliminary results

Imaging

Differences between the two stations CCS (shelf) and CS2 (shelf edge) were particularly visible in the samples from the deep (105 m depth) deployments of the MSC.

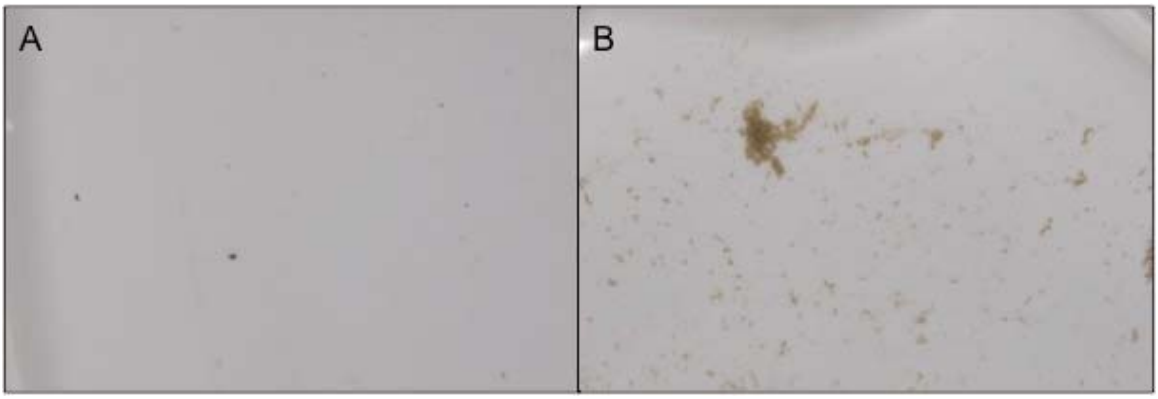

Figure 1: Fast sinking particles from the shelf edge station CS2 at 105m (A) in comparison to the particles at the shelf station CSS (B) .

Chlorophyll data

The preliminary analysis of the chlorophyll data there is significantly more chlorophyll in the fast sinking fraction than in the slow sinking and suspended fractions at both depth. However, the chlorophyll content in the slow sinking and suspended particles is higher in the shallow mixed layer (15 m) compared to the water body below the thermocline at 105m. This difference is less clear in the fast sinking fraction.

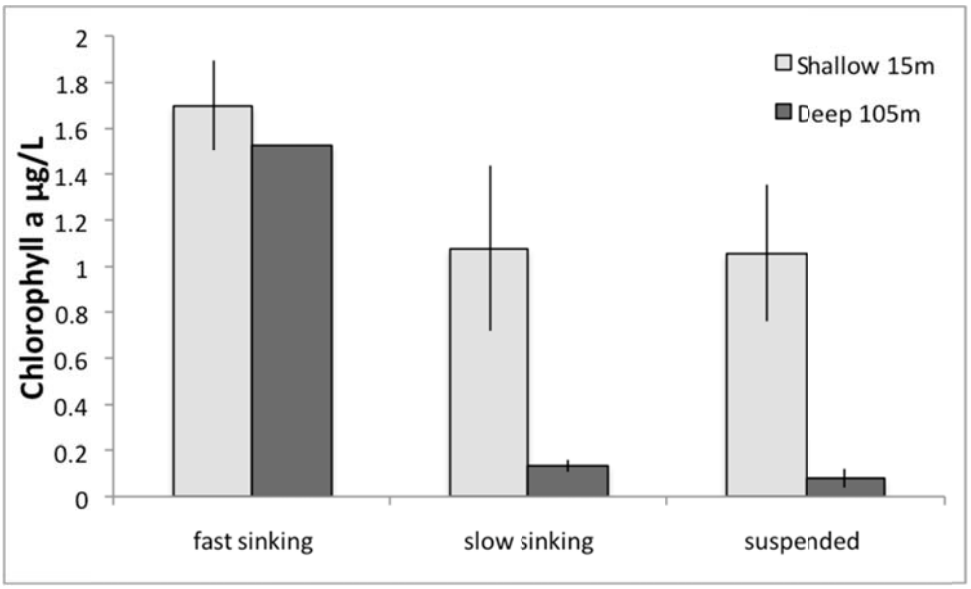

Figure 2: Preliminary data of chlorophyll samples. Comparison of fast, slow sinking and suspended particles of all deployments and stations between the mixed layer (15 m) and below the thermocline (105 m). Errorbars: standard deviation.

														SAMPLES								
CRUISE	EVENT	MSC NO	SITE	DATE	Time	DEPTH	LAT		LONG			Photos (Hanna small MSC fast sinking)	Formalin (Hanna small MSC fast sinking)	CN (Hanna small MSC, suspended high/low tap & slow sinking. Fast sinking(FS) when indicated)	DNA (Hanna small MSC all fractions, filtered on GF/F)	Respiration (Elena large MSC all fractions)	DOM (Clare small + large MSC all fractions)	Nitrogen Assimilation (Darren large MSC all fractions)	Bacterial Production (Sharon large MSC, fast sinking)	CONTACT for event	COMMENTS
DY018	123	Large1	CS2	18/11/2014	19:00	15	48	34.105	N	9	30.459	W					1/2 Tray	1/2 Tray		40ml from 1/4Tray	Elena/Clare/Sharon	
DY018	126	Small 1	CS2	18/11/2014	20:00	15	48	34.105	N	9	30.459	W	1 Tray	1/2 Tray	200ml	10ml		1/2 Tray			Hanna/Clare	
DY018	127	Large2	CS2	18/11/2014	21:43	105	48	34.092	N	9	30.311	W					1/2 Tray	1/2 Tray		40ml from 1/4Tray	Elena/Clare/Sharon	
DY018	128	Small 2	CS2	18/11/2014	23:00	105	48	34.061	N	9	30.229	W	1 Tray	2x 1/4 Tray	200ml	10ml		1/2 Tray			Hanna/Clare	
DY018	146	Large 3	CS2	19/11/2014	19:15	15	48	34.242	N	9	30.585	W							1 Tray		Darren	
DY018	147	Small 3	CS2	19/11/2014	20:00	15	48	34.270	N	9	30.582	W	1 Tray	2x 1/4 Tray	200ml/125ml FS	10ml					Hanna	
DY018	148	Large 4	CS2	19/11/2014	22:20	105	48	34.990	N	9	30.509	W							1 Tray		Darren	Fired to early (Salinity test)
DY018	149	Small 4	CS2	19/11/2014	23:00	105	48	34.270	N	9	30.582	W				10ml					Hanna	Base tipped during sampling
DY018	197	Large 5	CS2	24/11/2014	16:00	15	48	34.304	N	9	30.559	W					1/2 Tray	1/2 Tray		40ml from 1/4Tray	Elena/Sharon	
DY018	198	Small 5	CS2	24/11/2014	16:24	15	48	34.316	N	9	30.556	W	1 Tray	2x 1/4 Tray	200m/ 125ml FS	10ml					Hanna	
DY018	199	Large 6	CS2	24/11/2014	18:42	15	48	34.259	N	9	30.530	W					1/2 Tray	1/2 Tray		40ml from 1/4Tray	Elena/Sharon	
DY018	200	Small 6	CS2	24/11/2014	19:20	105	48	34.258	N	9	30.505	W									Hanna	Leaked not sampled
DY018	213	Large 7	CCS	25/11/2014	16:18	15	49	24.904	N	8	35.592	W					1/2 Tray	1/2 Tray		40ml from 1/4Tray	Elena/Clare/Sharon	
DY018	214	Small 7	CCS	25/11/2014	16:40	15	49	24.944	N	8	35.581	W	1 Tray	2x 1/4 Tray	200ml	10ml		1/2 Tray			Hanna/Clare	
DY018	216	Large 8	CCS	25/11/2014	18:57	15	49	25.170	N	8	35.497	W					1/2 Tray	1/2 Tray		40ml from 1/4Tray	Elena/Clare/Sharon	
DY018	217	Small 8	CCS	25/11/2014	19:27	105	49	25.100	N	8	35.482	W	1 Tray	2x 1/4 Tray	200ml	10ml		1/2 Tray			Hanna/Clare	
DY018	218	Large 9	CCS	26/11/2014	18:15	15	49	24.449	N	8	34.832	W							1 Tray		Darren	
DY018	219	Small 9	CCS	26/11/2014	18:28	15	49	24.457	N	8	34.888	W	1 Tray	2x 1/4 Tray	200ml/125ml FS	10ml					Hanna	
DY018	220	Large 10	CCS	26/11/2014	21:05	105	49	24.432	N	8	34.958	W							1 Tray		Darren	
DY018	221	Small 10	CCS	26/11/2014	21:30	105	49	24.429	N	8	34.804	W	1 Tray	2x 1/4 Tray	200ml/125ml FS	10ml					Hanna	
DY018	222	Large 11	CCS	29/11/2014	16:10	105	49	24.244	N	8	35.075	W					1/2 Tray	1/2 Tray		40ml from 1/4Tray	Elena/Sharon	
DY018	223	Small 11	CCS	29/11/2014	16:26	15	49	24.300	N	8	34.923	W	1 Tray	2x 1/4 Tray	200ml/125ml FS	10ml					Hanna	
DY018	224	Large 12	CCS	29/11/2014	18:47	105	49	24.316	N	8	34.997	W					1/2 Tray	1/2 Tray		40ml from 1/4Tray	Elena/Sharon	
DY018	225	Small 12	CCS	29/11/2014	19:16	15	49	24.306	N	8	35.016	W	1 Tray	2x 1/4 Tray	200ml/125 FS	10ml					Hanna	

22. Trace Metal Sampling

Maeve Lohan, Antony Birchill (University of Plymouth) and Dagmara Rusiecka (NOCS)

Sample logs for all Ti-CTD casts are available in Appendix X. Samples were collected for trace metal analysis in both the dissolved and particulate fractions using the dedicated trace metal 10 L OTE bottles mounted on a Ti-frame rosette system.

The trace metal samples collected will be analysed at different institutes for differing parameters:

Total dissolvable, dissolved Iron and soluble Iron – Antony Birchill at the University of Plymouth

Total dissolvable and dissolved Trace Metals (excluding iron) – Dagmara Rusiecka at IfM Geomar NOCS.

Fe (II)- Analysed on board ship - Antony Birchill, University of Plymouth

Iron Binding Ligands – Dagmara Rusiecka at IfM Geomar NOCS.

Particulate Material – Angela Milne and Antony Birchill at the University of Plymouth.

Two off-shelf iron transects were conducted each with 7 stations. The first off-shelf iron transect was down a canyon starting in water depth of 2500 m and stations were at 2500 m, 2000 m, 1500 m, 1000 m, 750 m, 500 m and 250 m (Fe 01-Fe07). In addition to the samples mentioned above, samples for Cr isotopes were collected for Rachel James (University of Southampton). The second off-shelf iron transect was along a ridge over the shelf at the same depths as previous transect (Fe 08-Fe 14). Samples for iron isotopes were also collected from the 2nd off shelf transect for Peter Statham (University of Southampton). Samples for macronutrients were taken from each bottle, salinity, oxygen and chlorophyll *a* samples were collected at selected depths for calibration. In addition samples for DOM and CDOM for Clare Davis (University of Liverpool) and Alkalinity for Eric Achterberg (University of Southampton) were collected at selected depths from all stations.
At the processes stations, CCS (3 profiles were collected, 2 on 12/11/14 and one on the 29/11/14), CS2 (2 profiles were collected on the 18/11/14 and 19/11/14), Site A (1 profile on the 28/11/14).
The J transect from CCS to Benthic Site A samples from J8-J5 (27/11/14) were collected using the Ti rosette. In addition to trace metal samples, samples were collected for macronutrients, oxygen, chlorophyll a, Methane and Oxygen isotopes. However, on the 28/11/14 the trace metal winch was not operational due to a cooling pump problem so we were unable to sample J5-J1.
Benthic Site A was sampled on the 28/11/14. In addition to trace metal samples, samples were collected for macronutrients, oxygen, chlorophyll a, Methane and Oxygen isotopes.
Finally station E1 was sampled on the 1/12/14.
Underway surface samples were collected by pumping surface seawater into a trace metal clean sampling laboratory using a Teflon diaphragm pump (Almatec A-15, Germany) connected by an acid-washed braided PVC tubing to a towed fish positioned at approximately 2 - 3m depth alongside the ship. Seawater samples were filtered in-line using a 0.2 µm Sartonbran membrane filter capsule (Sartorius). Surface seawater samples were collected at and in between stations when possible, a total of 6 surface samples were collected. There were issues with the deployment of the fish (see problems encountered when sampling).

Problems encountered when sampling:
With regards to the new clean sampling laboratory, overall the new facility has worked well and the close vicinity of the laboratory to the rosette system has aided efficient deployment and recovery of the clean OTE bottles. The general set-up in the laboratory is very good and being within the ship, as opposed to a container on the aft deck, has allowed work to continue even in bad weather. However, there have been some noticeable issues that have been raised during the course of the cruise. One problem relates to a lack of windows in either of the two outside doors that are used to enter the clean sampling laboratory. To maintain a clean environment in the inner laboratory, these

outer doors should not be opened at the same time as the inner door. This has resulted in shouting between the inner and outer doors to ensure that one in closed before the other is opened.
With regards to actual sampling, the clamps that are needed to keep the bottles closed while under pressure for sampling are difficult to attach, this is due to the positioning of the gas lines, the wall bracket that the bottles hang from and the closeness of the bottles. This results in clamping, and therefore sampling, taking longer. Overall it takes 45 minutes to clamp all 24 bottles. While this did not prevent any stations from being sampled it did add to the turnaround time of the OTE bottles which, when stations were close (1.5 h apart), it was not possible to be ready in time for the next station. Overall investment in Go-Flo samplers would be excellent as they would negate the use of clamps ensuring bottles could be turned around much faster. Go-Flo bottles are now routinely used on sampling rosettes and are easy to maintain.
Sampling for suspended particulate material (SPM) has been a particular challenge due to the drainage tray not being low enough and the bottles/clamps being too close together. Though alterations can and will be made to the filtration apparatus for future cruises, it would still not be possible to collect SPM from OTE bottles as has been done in the past on previous GEOTRACES cruises. The drainage tray also hinders sampling for samples collected using the cartridge filter. This drain needs to be lowered for the next SSB cruise.
It is not possible to empty the OTE bottles into the drainage trays without seawater ending up on the floor as the bottles are centred over the trays. The poor drainage in the laboratory floor (there is only one drain hole along the middle of the side wall) means that salt water often ends up behind the fridge and freezer until the ships role allows for cleaning up.
The positon of the trace metal fish is not working on the Discovery. When the fish was deployed the fish continually hit the side of the ship in bad weather and overall the fish is very close to the ship which brings into question the integrity of the samples. In addition, scientists on board complained about the noise of the fish hitting the side of the ship close to their cabins.

Total dissolvable, dissolved iron and soluble iron
(Antony Birchill, University of Plymouth)

Objectives: Iron (Fe) is an essential nutrient for primary productivity in the ocean. Due to its low solubility iron can be a limiting factor for the growth of phytoplankton in the open ocean as well as in coastal seas (de Baar et al., 1990; Hutchins and Bruland, 1998; Martin and Fitzwater, 1988). It has become evident that the atmosphere (Duce and Tindale, 1991), rivers (De Baar and de Jong, 2001), hydrothermal activity (Tagliabue et al., 2010 ; Klunder et al.,2011) and advection of shelf derived sediment to the open ocean (Bucciarelli et al., 2001; Lam and Bishop, 2008) are significant transport pathways for iron to the ocean. Fe fluxes from shelf seas to the open ocean are poorly constrained, although estimates indicate they could be 2-10 times higher than atmospheric inputs (Elrod et al. 2004) and thus potentially be a major contributor to the oceanic Fe cycle. Shelf edge biogeochemical processes that result in Fe export to the ocean are not well understood and key questions remain about the magnitude and significance of Fe fluxes from the shelf to the open ocean. We aim to investigate and quantify the supply and transport of iron and hence the fate of iron in the Celtic Sea and off-shelf region.

Sampling protocol: On recovery, the 10 L OTE bottles were transferred into a clean sampling laboratory where they were immediately sampled for oxygen, nutrients, salinity and total dissolvable iron before being pressurised to ~ 7 psi with 0.2 µm filtered air using an oil free compressor. After the collection of particulate samples (see section on Particulate Trace Metals), a Sartobran 300 (Sartorius) filter capsule (0.2 µm) was used to collect filtered seawater samples into clean LDPE sample bottles. Bottles and caps were rinsed 3 times with the filtered sample before being filled. In addition, at 6 depths these filtered samples were filtered once more through AcroPak 0.02 µm filters

for soluble iron. All samples, including underway samples, were acidified to 0.024 M (UpA HCl, Romil) and stored, double bagged, for shore based analysis.

Samples collected: Samples for total dissolvable and dissolved iron were collected at 22 stations as detailed below, a total of 740 samples were collected for analysis:

Station	Samples Collected Dissolvable + Dissolved +Soluble	Station	Samples Collected Dissolvable + Dissolved+ Soluble
CCS	32 + 32+18	Fe10	22 + 22+6
Fe01	23 + 23+6	Fe11	13 + 13+6
Fe02	20 + 20+6	Fe12	10 + 10+6
Fe03	22 + 22+6	Fe13	10 + 10+6
Fe04	13 + 13+6	Fe14	6 + 6+6
Fe05	10 + 10+6	J08	8 + 8+6
Fe06	7 + 7+6	J07	7 + 7+6
Fe07	6 + 6+6	J06	8 + 8+6
CS2	18 + 18+12	J05	6 + 6+6
Fe08	23 + 23+6	A	6 + 6+6
Fe09	22 + 22+6	E1	6+6+0

Sample analysis: Samples for dissolved iron will be analysed at the University of Plymouth after 2 months acidification, whereas samples for total dissolvable iron will be left for at least 6 months prior to analyses. Flow Injection with chemiluminescence detection (FI-CL) (Obata et al. 1993; de Jong 1998; Klunder et al. 2011) will be used for all sample analyses using Toyopearl AF-650-M resin for pre-concentration.

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Total dissolvable and dissolved trace metals
(Dagmara Rusiecka, National Oceanography Centre (NOCS) and IfM GEOMAR)

Objectives: Iron is well established as a limiting element for phytoplankton growth, however the role and cycling of other trace elements are less understood and there is a lack of data on the concentration and distribution of these elements in the global ocean. While elements such as cadmium, zinc and cobalt have a biological role, reflected in their nutrient like profiles, other trace elements can be used as tracers of inputs to the ocean, e.g. aluminium (Al) is an indicator of aerosol deposition (Tria et al., 2007), and manganese (Mn) can indicate sedimentary or hydrothermal inputs (Johnson et al., 1992; Middag et al., 2011). As with Fe, there is a paucity of data concerning the input, and cycling, of trace metals from shelf regions. The questions surrounding the magnitude and export of Fe from the shelf to the open ocean also apply to a suite of trace metals. We aim to investigate and quantify the supply and transport of selected trace metals in the Celtic Sea and off-shelf region.

Sampling protocol: Following recovery of the Ti-rosette, the OTE bottles were transferred into a clean sampling laboratory where they were immediately sampled for oxygen, nutrients, salinity and total dissolvable trace metals before being pressurised to approximately 7 psi with 0.2 µm filtered air using an oil free compressor. After the collection of particulate samples (see section on Particulate Trace Metals), a Sartobran 300 (Sartorius) filter capsule (0.2 µm) was used to collect filtered seawater samples into clean LDPE sample bottles. Bottles and caps were rinsed 3 times with the filtered sample before being filled. All samples, including those from the underway system, were acidified to 0.016 M (UpA HCl, Romil) and stored, double bagged, for shore based analysis.

Samples collected: Samples for total dissolvable and dissolved trace metals were collected at 22 stations as detailed below, a total of 585 samples were collected for analysis:

Station	Samples Collected Dissolvable + Dissolved	Station	Samples Collected Dissolvable + Dissolved
CCS	32 + 32	Fe10	22 + 22
Fe01	23 + 23	Fe11	13 + 13
Fe02	20 + 20	Fe12	10 + 10
Fe03	22 + 22	Fe13	10 + 10
Fe04	13 + 13	Fe14	6 + 6
Fe05	10 + 10	J08	8 + 8
Fe06	7 + 7	J07	7 + 7
Fe07	6 + 6	J06	8 + 8
CS2	18 + 18	J05	6 + 6
Fe08	23 + 23	A	6 + 6
Fe09	22 + 22	E1	6+ 6

Sample analysis: Samples will be analysed for a range of trace metals e.g. Mn, Co, Cd, Zn, Cu, Pb by inductively coupled mass spectrometry (ICP-MS) at IfM GEOMAR (Milne et al. 2010). For Al analysis, flow injection with fluorescence detection (Resing and Measures, 1994) will be used following the modified method of Brown and Bruland (2008). Dissolved samples will be analysed after 2 months acidification whereas dissolvable samples will be left for at least 6 months before analysis.

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Iron (II)

(Antony Birchill, University of Plymouth)

Objectives: In shelf sediments microbial oxidation of organic carbon delivered from primary productivity in the overlying shallow water column is the main driver of early diagenesis [23] which produces dFe. For cohesive sediments (~40% of the North Sea floor), Fe(II) is principally generated by dissimilatory reduction of Fe(III), and is subsequently transferred to the water column via diffusion and sediment resuspension. Sedimentary supply of dFe(II) has been reported in low oxygen shelf waters (Lohan & Bruland, 2008) and in more oxic European shelf waters (Ussher et al. 2007). While the benthic cruise is determining Fe(II) in the sediments, our goal was to determine how much Fe(II) is in the bottom water overlying these sediments. In addition Fe(II) is produced in the upper water column from photochemical processes and from biological production. As Fe(II) is a transient species this was determined onboard ship.

Sampling protocol: On recovery of the Ti-rosette, the OTE bottles were transferred into a clean sampling laboratory where they were immediately sampled for Fe(II) from 6 depths. 6 deoths were chosen due to the transient nature of Fe(II) and the analyses time. Samples for Fe(II) were collected first from the OTE bottles using tubing whereby the tube was placed into an acid cleaned LDPE bottle upside down and water allowed to overfill to reduce any oxygen entering the bottle. After the collection the samples were filtered in-line.

Samples collected: We were unable to analyse Fe(II) on the off-shelf transects due to a lack of personal on-board the ship. Therefore a total of 59 samples were collected from 7 stations as detailed below:

Station	Samples Collected
CCS	19
CS2	7
J08	6
J07	6
J06	6
J05	6
A	9

Sample analysis: Samples were analysed using flow injection with chemiluminescence detection (Fe-CL) according to procedures outlined in Ussher et al. (2007). Briefly, a 1L sample of seawater was collected from the cast prior to Fe(II) analyses which was stored in the dark was used to calibrated the Fe (II) system. The aged seawater sample was adjusted to pH 5.5 with ammonium acetate. Samples were filtered in-line using 0.2 µm luer lock filter.

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Iron Binding Ligands

(Dagmara Rusiecka, National Oceanography Centre (NOCS) and IfM GEOMAR)

Objectives: Understanding the biogeochemistry of Fe requires the ability to measure its oceanic chemical speciation. Fe is present in seawater as chelates with strong metal-binding organic ligands (Bruland & Lohan, 2004) which dramatically influences its' chemical behaviour. These ligands have a stabilising influence, preventing inorganic precipitation (e.g. Liu and Millero, 2002) and increasing the availability of metals for biological uptake. They are therefore an important component in understanding the cycling and distribution of Fe in any system. Ligand samples will therefore be collected at selected stations along the cruise.

Sampling protocol: On recovery of the Ti-rosette, the OTE bottles were transferred into a clean sampling laboratory where they were immediately sampled for oxygen, nutrients, salinity and total dissolvable elements before being pressurised to approximately 7 psi with 0.2 µm filtered air using an oil free compressor. After the collection of particulate samples (see section on Particulate Trace Metals), a Sartobran 300 (Sartorius) filter capsule (0.2 µm) was used to collect filtered seawater samples into clean LDPE sample bottles. Bottles and caps were rinsed 3 times with the filtered sample before being filled. All samples were double bagged and stored unacidified at -20^{o}C until analysis.

Samples collected:

A total of 119 speciation samples were collected at 20 stations as detailed below:

Station	Samples Collected	Station	Samples Collected
CCS	12	Fe10	5
Fe01	8	Fe11	6
Fe02	7	Fe12	4
Fe03	7	Fe13	5
Fe04	6	Fe14	3
Fe05	6	J08	4
Fe06	3	J07	0
Fe07	3	J06	4
CS2	10	J05	0
Fe08	6	A	3
Fe09	7	E1	3

Sample analysis: The concentrations and conditional stability of Fe ligands, Fe' (soluble inorganic Fe) and free aqueous Fe will be measured at NOCS/IfM GEOMAR by competitive ligand exchange cathodic stripping voltammetry (CLE-CSV) with the ligand TAC (Croot and Johansson, 2000).

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Particulate trace metals

(Angela Milne and Antony Birchill, University of Plymouth)

Objectives: Particulate trace metals may occur in several forms, including stable refractory phases or as coatings on surfaces that can be rapidly recycled. Particulate behaviour is metal specific with, for instance, the majority of particulate Fe occurring in refractory phases while Zn is primarily associated with more labile phases (Hurst & Bruland, 2005). Few studies have concurrently measured trace elements in both the dissolved and particulate phases. Furthermore, labile particulate trace metals which are biologically available could be considerably higher than the dissolved phase (Berger et al., 2008). Assessment of total biologically available trace elements may thus require the determination of both dissolved and labile particulate metal phases (Lam & Bishop, 2008). A step towards a quantitative description of the cycling of trace elements between the dissolved and particulate phases required for their realistic incorporation into biogeochemical ocean models is to measure the standing stock of the particulate fraction. To address this, particulate material will be filtered on selected water samples collected using the trace metal rosette.

Sampling protocol: Profiles were collected from varying depths through the whole water column using twenty-four 10 L OTE bottles mounted on a Ti rosette. On recovery, the OTE bottles were transferred into a clean sampling container where they were immediately sampled for nutrients and salinity before being pressurised to approximately 7 psi with 0.2 µm filtered air using an oil free compressor. Acid clean filter holders (Swinnex, Millipore) were attached to the Teflon taps of the OTE bottles using acid cleaned Bev-A-Line (Cole Parmer) tubing and luer lock fittings. Up to a maximum of 7 L of seawater from each depth was then filtered through acid washed 25 mm (0.2 µm) polyethersulfone filters (PES, Supor, Pall Gellman) housed in the clean filter holders. Following filtration, the filter holders were removed and placed in a laminar flow bench. Using an all polypropylene syringe attached to the top of the filter holder, residual seawater was forced through

the filter using air from within the flow hood. The filter holders were gently opened and the PES filter was folded in half using plastic tweezers, the filters were then placed in acid clean 2 mL LDPE vial and frozen at -20^{o}C until analysis.

Samples collected: A total of 108 samples were collected from 19 stations as detailed below:

Station	Samples Collected	Station	Samples Collected
CCS	14	Fe10	6
Fe01	7	Fe11	6
Fe02	7	Fe12	5
Fe03	8	Fe13	5
Fe04	10	Fe14	3
Fe05	3	J08	0
Fe06	3	J07	0
Fe07	3	J06	0
CS2	7	J05	5
Fe08	6	A	6
Fe09	7	E1	0

The filter housings of the SAPs were fitted with acid washed nylon mesh (10 µm) and 293 mm PES filters (0.8 µm, Pall Gelman) and deployed to varying depths in the water column. On recovery, the filter housings were placed in a laminar flow hood for removal of the nylon mesh and PES filters. A clean stainless steel blade was used to cut a quarter section from the nylon mesh which was rinsed with UHP water into a clean plastic jug. This water was then filtered over a 25 mm PES filter (0.2 µm, Supor, Pall Gellman) housed in a clean filter holder (Swinnex, Millipore) using an all polypropylene syringe attached to the top of the filter holder. Residual water was forced through the filter using air from within the flow hood, the filter was then folded in half and placed in acid clean 2 mL LDPE vial. The 293 mm PES filters were folded upon themselves and placed into clean zip-lock plastic bags. Both the 25 mm and 293 mm PES filters were frozen at -20^{o}C until analysis.

Samples collected: Samples were collected from 2 depths at the Shelf edge and the CCS site.

Sample analysis: Samples will be analysed for both labile and refractory particulate Fe, Mn, Al, Co, Zn, Cd, Ba, Ni, Cu, Ti and potentially other trace elements using ICP-MS at the University of Plymouth. For labile particulate trace elements the filter is subjected to a weak acid leach (25% acetic acid at pH 2) with a mild reducing agent (0.02 M hydroxylamine hydrochloride) and a heating step (20 min 90-95^{o}C). This approach is fully detailed in Berger et al. (2008). After the labile fraction has been determined the refractory trace elements will be determined following the method of Ohnemus and Lam (Deep Sea Research, in press). Briefly, the filters will be digested following a three step heating/dry-down process, firstly H_2SO_4 and H_2O_2 are used to digest the filter, followed by HNO_3, HCl and HF and finally HNO_3 and H_2O_2 to digest the particulate material. The final solution is dried down and the residue brought back into solution with 2 % HNO_3 for analysis by ICP-MS. The samples are then spiked with an internal reference material such as In for drift correction.

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23. Radium Sampling

Amber Annett, University of Edinburgh, UK

Objectives:

The primary objective of the radium (Ra) work done on research voyage DY018 is to use flux rates from Ra analysis to quantify off-shelf iron (Fe) fluxes from the Celtic Sea shelf to the open ocean. Radium is present in the ocean as four naturally-occurring radioactive isotopes: ^{223}Ra, ^{224}Ra, ^{226}Ra and ^{228}Ra. Radium is produced continuously in sediments from the decay of thorium (Th) and thus displayed elevated concentrations near the sediment-water interface. The four isotopes have different half-lives (11.4 d, 3.66 d, 1600 y and 5.75 y, respectively) spanning a range of time scales relevant to both vertical fluxes of (micro)nutrients out of sediments into the overlying water column, as well as horizontal advection. As Ra is not particle reactive, the decrease in concentration of each short-lived isotope away from the source (sediments) can be used in conjunction with its half-life to constrain flux rates, which will be coupled to trace metal results to assess the magnitude of any shelf source of Fe and other metals to offshore regions.

A secondary aim is to use the disequilibrium between dissolved ^{228}Ra and ^{228}Th to investigate particle export above the shelf. The shortest half-life in this system (^{228}Th) is ~1.9 y, thus this approach can integrate particle export over a similar period, although in the case of the Celtic Sea the annual overturning/mixing cycle will result in the Ra-Th disequilibrium reflecting an annually-integrated particle export flux.

Sampling Protocol:

Ra sampling requires very large volumes of water, as Ra activities are typically very low away from sediment sources. Samples of 60 – 200 L were collected from the stainless steel Sea-Bird CTD system on-board the RRS Discovery at both process stations and transect stations, and stored in 20 L collapsible plastic containers. These sample bottles were washed with 10% HCl prior to the cruise, and rinsed with Milli-Q between samples.

For surface water samples, water was collected using a Teflon diaphragm pump (Almatec A-15, Germany) connected by an acid-washed braided PVC tubing to a towed fish positioned at approximately 5 m depth alongside the ship. This system was set up for the trace metals group, and flowed continuously into the sink in the hangar container except when being sampled in the trace metal-clean container. 20 L bottles were filled in the sink from the continuous flow.

Each 20 L water sample was weighed using a beam scale, and stored on shelves outside the container in the hangar space. The samples were then passed through a column holding 20 g of MnO_2-coated acrylic fiber, which strongly binds Ra. The fibers were then rinsed with Milli-Q and loaded into a Ra Delayed Coincidence Counter (RaDeCC; Scientific Computer Instruments, USA) system purged with He gas, and decay of Ra was counted for 6-10 h to quantify ^{223}Ra and ^{224}Ra content. Following decay of these short-lived isotopes, the fibres will be re-analysed using the RaDeCC to determine the activity of the parent isotopes (^{227}Ac and ^{228}Th).

At each depth processed, a subsample was collected into acid-clean 125 mL LDPE bottles for analysis of the long-lived Ra isotopes by mass spectrometry at the University of Edinburgh.

Sampling issues:

Collecting such large-volume samples is labour intensive, and setting up the Ra work in the container in the hangar to minimise the distance between the rosette and sample processing was incredibly helpful.

Draining the sample bottles through the columns worked well in calm conditions, but as the ship rolled the drainage tubing tended to back up, resulting in back-pressure on the columns and slowing down the filtrations (the expected ~3 h usually took 6-8 hours). This could be helped somewhat with larger tubing, but ideally the tubing would not have to lie on the floor in front of the

container door (and thus not drain uphill half the time) – however this would probably require the tubing to either go across the main traffic area between the front and aft sections of the hangar (trip hazard), or to go around the rear of the container and back to the scupper (too far for effective draining).

The underway surface sampling (fish) system presented several issues, which are detailed in the trace-metal cruise report.

CTD Samples analysed:

Sample Name (Cruise-STNNBR-station-depth)	Volume (in L)
DY018-002-CCS-40	190.085
DY018-002-CCS-40-Filtered	120.1
DY018-004-CCS-130	96.26
DY018-023-CCS-134	105.94
DY018-023-CCS-120	94.96
DY018-023-CCS-100	102.35
DY018-023-CCS-90	94.145
DY018-026-CCS-70	132.16
DY018-026-CCS-50	126.82
DY018-026-CCS-25	144.295
DY018-040-CCS-08	169.89
DY018-040-CCS-08-Filtered	44.235
DY018-053-O2-141	96.94
DY018-053-O2-135	75.22
DY018-053-O2-100	99.39
DY018-------O2-5mFish	168.84
DY018-055-O2-50	160.37
DY018-055-O2-25	145.22
DY018-058-O4-151	90.44
DY018-058-O4-110	79.52
DY018-058-O4-080	97.365
DY018------O4-5mFish	140.68
DY018-060-O4-140	92.26
DY018-060-O4-60	97.06
DY018-060-O4-25	120.93
DY018-064-Fe01-2340	56.605
DY018-064-Fe01-2330	96.38
DY018-064-Fe01-2000	59.5
DY018-------Fe01-5mFish	148.925
DY018-066-Fe01-500	118.96
DY018-066-Fe01-250	116.59
DY018-067-Fe02-2000	91.28
DY018-067-Fe02-1900	90.35
DY018-067-Fe02-1500	92.29
DY018-------Fe02-5mFish	168.84
DY018-075-Fe03-500	151.71
DY018-075-Fe03-250	130.01
DY018------Fe03-5mFish	152.92
DY018-077-Fe03-1488	96.06
DY018-077Fe03-1400	96.37
DY018-077Fe03-1000	105.02

DY018-078-Fe04-990	94.36
DY018-078-Fe04-890	95.08
DY018-078-Fe04-750	93.46
DY018-079-Fe04-500	114.58
DY018-079-Fe04-250	112.35
DY018-------Fe04-5mFish	130.4
DY018-081-Fe05-725	75.26
DY018-081-Fe05-625	86.35
DY018-081-Fe05-500	97.73
DY018-083-Fe05-250	149.82
DY018-083-Fe05-100	150.36
DY018-------Fe05-5mFish	164.92
DY018-086-Fe06-465	91.59
DY018-086-Fe06-400	97.57
DY018-086-Fe06-250	113.51
DY018-------Fe06-5mFish	140.13
DY018-089-Fe07-230	75.54
DY018-089-Fe07-200	90.57
DY018-089-Fe07-100	92.27
DY018-------Fe07-5mFish	151.32
DY018-116-SE-190m	96.06
DY018-116-SE-175	118.69
DY018-116-SE-100	159.43
DY018-118-SE-80	98.69
DY018-118-SE-60	150.28
DY018-118-SE-25	131.83
DY018-163-CCS-135	96.83
DY018-163-CCS-75	73.9
DY018-163-CCS-62	97.79
DY018-163-CCS-55	111.485
DY018-164-CCS-40	111.945
DY018-164-CCS-25	107.01
DY018-164-CCS-5	108.98
DY018-170-Fe09-1838	58.03
DY018-170-Fe09-1600	58.12
DY018-170-Fe09-1300	76.13
DY018-170-Fe09-1000	77.04
DY018-170-Fe09-900	89.76
DY018-173-Fe09-800	56.92
DY018-173-Fe09-700	74.55
DY018-173-Fe09-600	74.44
DY018-173-Fe09-500	76.005
DY018-173-Fe09-400	76.22
DY018-172-Fe09-300	96.06
DY018-172-Fe09-200	92.88
DY018-172-Fe09-100	94.62
DY018-175-Fe10-500	94.55
DY018-182-Fe11-500	95.69
DY018-185-Fe12-500	95.77
DY018-187-Fe13-475	94.57
DY018-189-Fe14-240	73.28

DY018-237-J05-100m	57.29	
DY018-237-J05-85m	54.91	
DY018-237-J05-70m	56.91	
DY018-237-J05-50m	95.47	
DY018-237-J05-25m	94.25	
DY018-237-J05-5m	94.18	
	Total:	**10103 L**

Core water samples analysed:

To link water-column Ra isotope ratios with source ratios from sediments, samples were collected of the overlying water from the NIOZ corer deployed for Matthew Bone, following resuspension experiments. The first core water sample was processed by passing it over 2 g of acrylic fibre to remove large particles before collecting the Ra onto Mn fibre as for water column samples. The final two samples were filtered through 0.7 □m GF/F filters prior to processing to remove the suspended sediment.

Sample Name	Volume (in L)
DY018-019	9.18
DY018-244	3.39
DY018-245	2.97

Preliminary results:

Several casts at the CCS site were combined to give a water column profile showing higher activities of the short-lived Ra isotopes below the mixed layer, which reflects a sedimentary Ra source. In contrast, preliminary estimates of long-lived ^{226}Ra activities (determined from RaDeCC analysis, which involves significant uncertainty due to the relatively short counting times onboard) are much more consistent throughout the water column (Fig 1). Note that all data presented here are uncorrected for long-lived parent isotopes (^{228}Ra, ^{228}Th, ^{227}Ac) and interference from higher activity isotopes (^{224}Ra). Once the samples have been allowed to decay, repeated analyses are performed to make these corrections; all reported activities will be revised downwards due to these corrections.

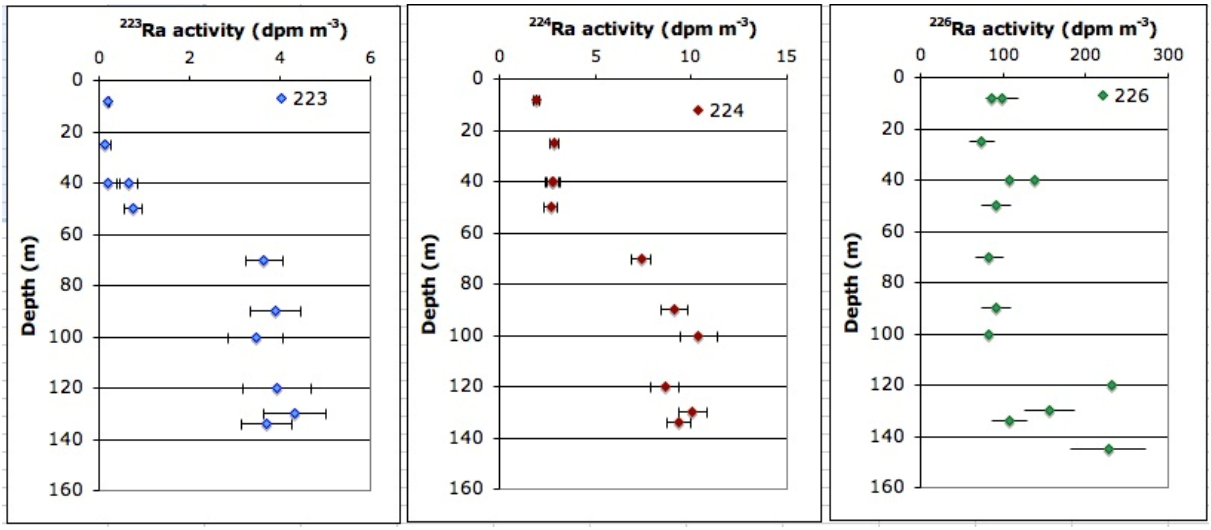

Figure 1: Short lived (blue, red) and long-lived (green) Ra activities (uncorrected) at station CCS from samples collected Nov 10-12th, 2014. The depth of the mixed layer was ~60m at this time.

Results from the first transect suggested a signal of off-shore transport at a depth above 1000m, therefore on the second Fe transect a high-resolution depth profile (every 100m) was

sampled at station Fe09 (~2000 m water depth) to better characterise this signal. The uncorrected ^{224}Ra activities show a strong signal centered at ~500 m, which was sampled at all other 2nd Fe transect stations to constrain horizontal off-shelf flux rates. ^{224}Ra activity at Fe09 is shown in Figure 2.

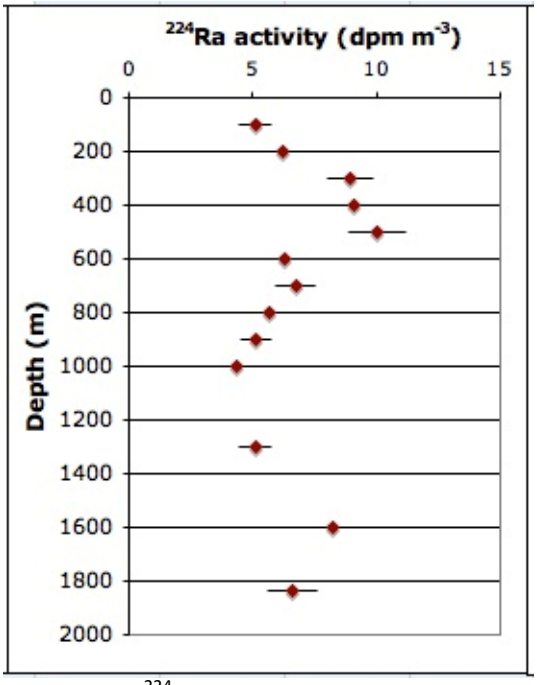

Figure 2: Vertical profile of uncorrected ^{224}Ra activity at station Fe09.

Acknowledgements
Thank you to the officers, engineers and crew of RRS Discovery. My heartfelt thanks to the many scientists who helped me with sampling, especially during the transects, and a special thank-you to the NMF technicians and crew for collecting over 10000 L of seawater at all hours of the day (and night).

24. Seabed coring and underway ammonia.

Matthew Bone, University of East Anglia.

09.11.14

The HPLC measuring a continuous trace of ammonium (NH_4^+) from the underway system was set up, and two runs were carried out from 16:57 – 19:36, and 20:46 – 22:59. These will be referred to as a 'time series'. Before each run, the equipment was purged with high concentrated acid, decontaminating it and then flushed with the working reagent and Milli Q to remove the traces of the acid and bring it back to a baseline. A calibration was also carried out before almost every single run.

A high resolution fluorescent scan of the ships Milli Q was carried out to check for contamination – data needs to be compared with other scans from other systems, but the initial conclusion was that the contamination of NH_4^+ was negligible.

10.11.14

Two time series runs of NH_4^+ were carried out:

10:33 – 15:19

16:12 – 19:26

A calibration was carried out before each run. Sediment coring began at 23.997N, 34.353W at a depth of 149m. Five cores were taken at the times: 18:19, 22:01, 22:29, 22:50, and 23:38.

The overlying water from the first core was decanted into 16 1l bottles for incubation experiments. For each row, there were three replicates:

Control	Bottom water
Control + inhibitor	Bottom water + inhibitor
Sample	Bottom water + sediment
Sample + inhibitor	Bottom water + sediment + inhibitor

Syringe cores of the sediment were taken and added to the bottles. A nitrification inhibitor was added to the appropriate samples. A sample of water was taken before the addition of sediment/inhibitor as well as immediately after. Subsequent samples were taken for analysis later throughout the following 72hours.

A litre of overlying water from the first sediment core was taken by Andy (PML) to look at the effect of NOx in 'true' bottom water and found that there was a significant decrease when compared to CTD bottom water, and was attributed towards denitrification.

The third and fourth core were for use with the FloWave – a resuspension device that simulates a tidal forcing, as well as turbulence and wave action upon the surface of the sediment core. Due to the nature of the sediment – sandy mud, a way to stop the water from leaking out of the core was trialled. This was carried out by applying a sealant designed for use in wet conditions around the base of the core. At first it looked like it was working. The plan was to work with Meave (PML) looking at a continuous trace of NH_4^+ as well as Fe_{II} throughout the FloWave experiment. Due to calibration errors on the Fe machine, there was a significant delay in carrying out the experiments. Four hours passed from the initial recovery of the core, to when all the conditions were ready to carry out the experiment. An Fe_{II} sample was taken from the overlying water before the experiment began and was found to have exceptionally high values. After starting the FloWave, it was soon realised that due to the time the core had been sitting around, a small volume of water has been leaking out the core and had led to the overall water volume to drop significantly – and thus lead to a change in the chemistry. The experiment was thus abandoned. The same fate also happened to the fourth core and was unusable for a FloWave experiment.

One litre of water was taken from the CTD at depths: 5m (12:30) and 130m (13.06) for analysis of TEP.

11.11.14
Three time series runs of NH_4^+ were carried out:
11:45 – 12:27
12:57 – 17:04
19:32 – 21:05
A calibration was carried out before each run.

12.11.14
Three time series runs of NH_4^+ were carried out:
01:15 – 05:27
12:04 – 16:56
17:21 – 06:22
A calibration was carried out before each run.

One litre of water was taken from the underway system at: 15:19 and then again at 18:44 for analysis of TEP.

13.11.14
A single time series run of NH_4^+ was carried out:
11:33 – 16:31
A calibration was carried out before the run. During the run, the ship began to discharge waste. The analysis showed a prominent peek in NH_4^+ from the under way system thirty minutes after the discharge had started under calm weather and sea conditions.
One litre of water was taken from the CTD at depths: 5m (23:20), 40m (23:14), 95m (23:00) and 149m (22:53) for analysis of TEP.

14.11.14
Four time series runs of NH_4^+ were carried out:
00:15 – 05:43
12:45 – 14:56
15:01 – 17:52
19:54 – 03:40
A calibration was carried out before the first and last run.
One litre of water was taken from the underway system at: 23:26 for analysis of TEP.

15.11.14
A single time series run of NH_4^+ was carried out:
12:10 – 23:27
A calibration was carried out before the run.
One litre of water was taken from the underway system at: 17:58 for analysis of TEP.

16.11.14
A single time series run of NH_4^+ was carried out:
00:25 – 05:04
A calibration was carried out before the run.
One litre of water was taken from the underway system and CTD (500m & 900m) at: 02:36, 02:29 and 02:15 respectively, for analysis of TEP.

17.11.14
A single time series run of NH_4^+ was carried out:
16:21 – 22:27

A calibration was carried out before the run.

18.11.14
Three time series runs of NH_4^+ were carried out:
02:38 – 14:34
17:50 – 22:27
22:27 – 04:55
No calibration was carried out during these runs.

19.11.14
An inter-calibration was carried out. The samples were analysed straight away using the discrete sampling mode to gauge the concentrations, but when it came about to performing a calibration using the continuous mode, it was found that the machine was contaminated. The samples were left aside for twelve hours whilst the machine, working reagent as well as standard was checked for contamination. It was determined there were contamination issues, the standards were not carried out until 8hours upon receiving them. The method that was set up with the HPLC was also designed for low nanomolar concentrations, and a fairer test needs to be applied when carrying out further intercalibrations on board.

Malcolm's STDs		**Matt's STDs**	
Malcolm	Matt	Malcolm	**Matt**
0.086	0.084	0.209	**0.067**
0.804	1.229	0.314	**0.312**
1.501	2.9	1.527	**1.736**
1.595	3.274	1.65	**1.866**
3.194	6.514	12.994	**15.973**

One litre of water was taken from the CTD: 5m, 10m, 40m, 80m, 100m and 190m for analysis of TEP.

20.11.14
Three time series runs of NH_4^+ were carried out:
03:36 – 04:12
04:19 – 08:28
18:50 – 01:30
A calibration was carried out prior to all the runs.

21.11.14
Two time series runs of NH_4^+ were carried out:
02:31 – 07:38
11:35 – 16:00
A calibration was carried out prior to all the runs.
23.11.14
A single time series run of NH_4^+ was carried out:
22:31 – 10:52
A calibration was carried out before the run.

24.11.14
A single time series run of NH_4^+ was carried out:

18:26 – 19:27
A calibration was carried out before the run.
The labs need lighting to suit working in dark conditions. Work was hindered because a scientist required darkness within the CT lab.

25.11.14
01:12 – 01:59 Calibration
03:19 – 04:19 Testing integrity of standards
16:25 – 17:04 Calibration
18:39 – 03:56 Testing integrity of standards
One litre of water was taken from the CTD 5m, 65m, and 100m for analysis of TEP.

26.11.14
20:41 – 22:02 Calibration
22:09 – 06:34 Testing integrity of standards

27.11.14
A single time series run of NH_4^+ was carried out for a 25hour period.
During a period of elevated wind stress and on station, the Dynamic Positioning of the ship was on causing large vibrations as the front two thrusters fired up to keep the ships position. Due to measuring continuously from the underway system, it was thought that it could be causing a significant effect upon the analysis of NH4+. This was discussed with the Watch Keeper and the Captain will be informed and will hopefully provide a log of the time the thrusters were operational.

28.11.14
5cores were taken from Benthic Site A (51.12781N, 6.7905W).
The first core drove too deep into the mud so was un-useable for any experiments. Microbiological samples were taken from the core.
The second core had a good ratio of mud to water . The micro-topography was broken up, small crevasses and a non-uniform terrain structure. A shrimp (species name) was found within the core and was observed on multiple occasions to be shifting the mud around using his arms nearest his face as well as flipper on occasions. The third core was perfectly flat, containing a small hole in which a worm was residing. Both the second and third cores were sampled for:

- 16l of water for incubation experiments (Core 2 and 3)
- Syringe cores for incubation experiments (Core
- 5ml vials of sediment for microbiological samples (Core 1, 2 and 4)
- 1l of water for NOx (Andy Rees) (Core 3)
- 60ml of water for Antony (Feii) (Core 3)

Cores 4 and 5 were scheduled for FloWave experiments, and it was planned that Fe_{ii} analysis would be carried out at regular 15minute intervals. A sample was taken from the overlying water (Core 3) and analysed, but the collaboration was abandoned due to analysis mistakes being made, and lack of rest within the Fe party.
Two FloWave experiments were undertaken on Cores 4 and 5. The first (Core 4) experiment started off well, but it was later found that the inline filter was blocked due to high sediment load water. It is not known when the filter became blocked, but from the profile on raw data received it can be estimated due to the signal change.
During the second experiment, the flow rate was reduced from 1ml/min to 0.8ml/min to compensate for the blocking of the inline filter. This worked perfectly; though the filter was changed an hour after the resuspension experiment had stopped to ensure it was not affecting the analysis.

The water was continuously analysed once the FloWave had stopped to see the changes in NH_4^+ after a resuspension event.
One litre of water was taken from the CTD 5m, 65m, and 100m for analysis of TEP.

29.11.14
Incubation samples were analysed.

30.11.
Incubation samples were analysed.