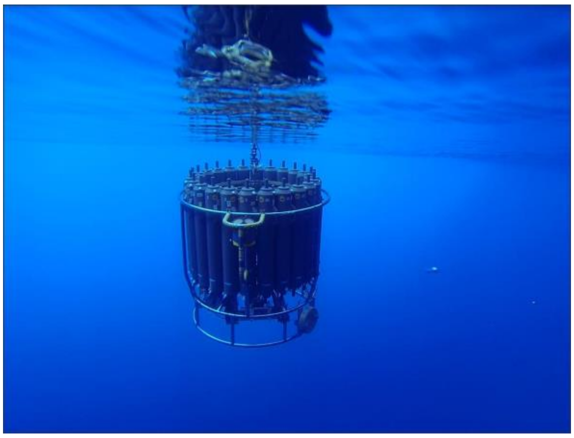
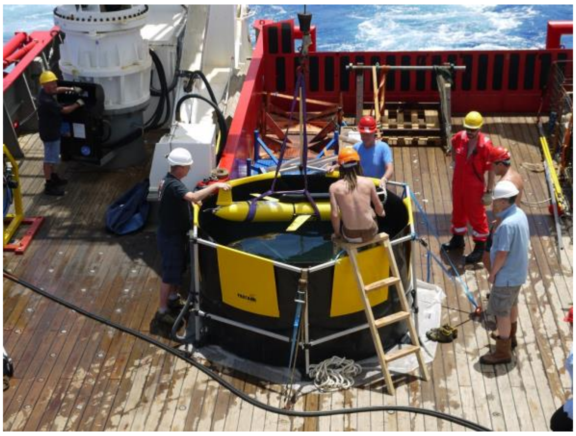
JR15-007 Cruise Report





RRS *James Clark Ross*
25th May – 10th July 2016

Port of Spain, Trinidad & Tobago, to Immingham, UK

RidgeMix NERC Responsive Mode Project

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The British Antarctic Survey in Cambridge provided vital practical support in getting the cruise scheduled and arranging for us all to get to Port of Spain; logistical support was provided by National Marine Facilities in Southampton (with thanks to Dan Comben).

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2. Project Summary

Increased amounts of mixing arising from the internal tide over ridges and seamounts has been recognised for some time, but the biogeochemical consequences of that mixing have not yet been quantified. The Ridgemix project takes as its key hypothesis that the mixing generated by the internal tide over steep ocean seabed topography, such as mid ocean ridges, plays an important role in the biogeochemistry of the ocean. In the subtropical North Atlantic work using noble gas tracers has identified the amounts of nutrient that must be supplied to the region, which is in agreement with the requirements of primary production, but the mechanisms responsible for supplying this nutrient are not understood. Our view in the Ridgemix project is that internal tide mixing over the mid-Atlantic ridge brings deep nutrients upward onto isopycnals that, downstream of the ridge, are accessed by deep winter mixing in the western subtropical Atlantic Ocean. Based on preliminary evidence from earlier research cruises on other projects we also think that the upward mixing of nutrients could have local effects on primary production and plankton community structure immediately above the ridge.

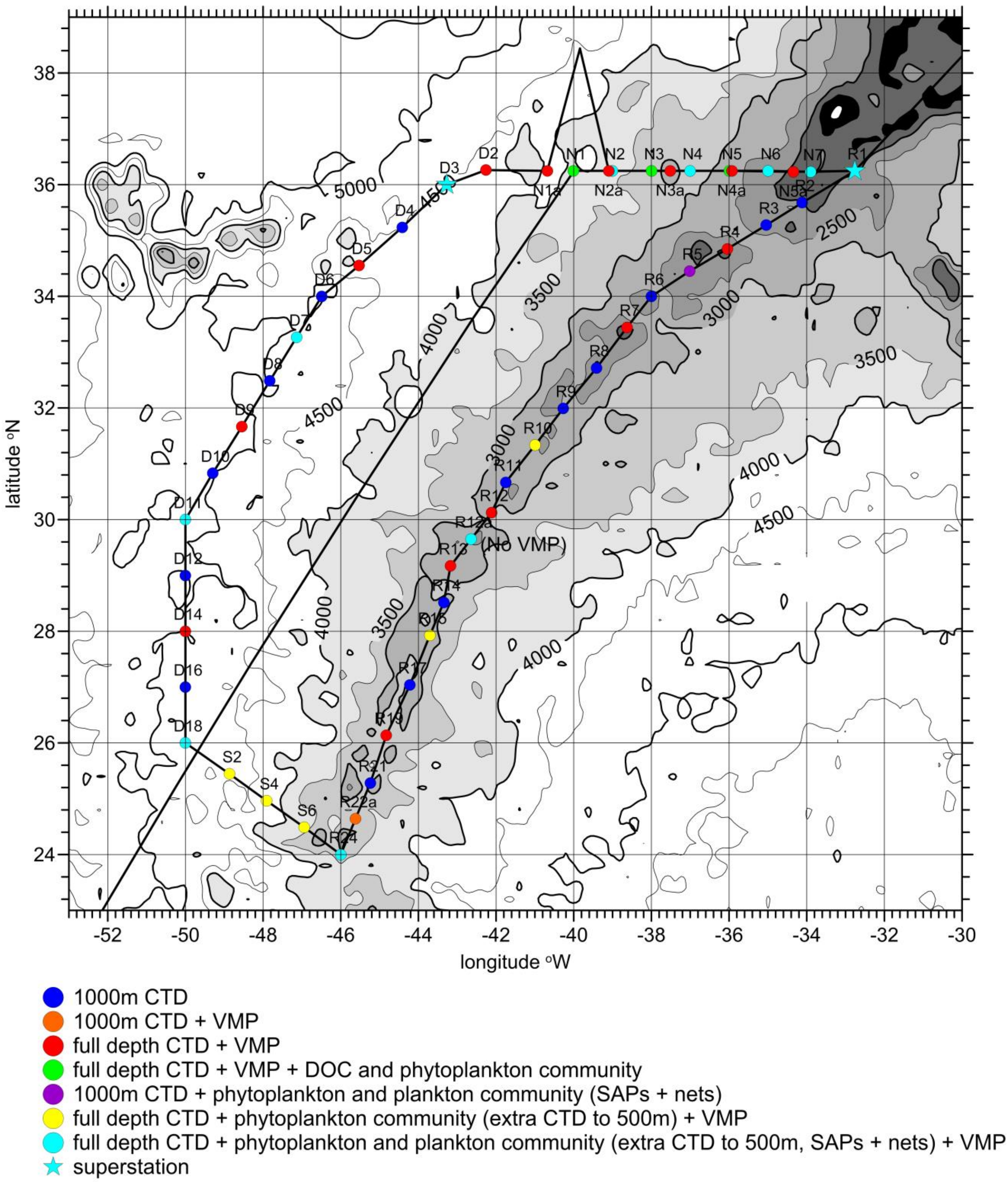
Our cruise track and sampling stations had the following aims:

(i) Quantify the internal mixing and vertical nutrient fluxes at spring and neap tides at sites above the ridge and in the deep water away from the ridge.
(ii) Quantify the general distribution of vertical turbulent mixing along the ridge, in the adjacent deep basin to the west, and across the slopes of the ridge.
(iii) Measure the distribution of nutrients on key isopycnals in water masses before, during and downstream of the mixing over the ridge.
(iv) At sites along the ridge and in the deep basin to the west, quantify the phytoplankton and zooplankton community structures with a particular focus on the deep chlorophyll maximum.

As well as the cruise sampling from the ship the following other activities were involved in the project:

(i) Two moorings were deployed on the mid-Atlantic ridge from AMT25 in October 2015. One mooring consisted of 4 ADCPs and numerous temperature and temperature/depth loggers through the whole water column. The second mooring consistent of a tethered, profiling APEX float (CTD plus SUNA nitrate sensor) working in the upper 1000 metres of the water column. Only the first of these moorings was successfully recovered. The APEX float mooring had clearly broken free and is viewed as lost.
(ii) Two ocean microstructure gliders were deployed during the cruise as part of the Ridgemix project, one in the deep basin to the west of the ridge and one over the ridge crest and both set to profile between the surface and 1000 metres. Neither deployment was successful. The basin glider failed 2 days after deployment, and stayed at the surface until we were able to retrieve it. The ridge glider worked well throughout its deployment, but failed to return and communicate just a few hours before planned recovery.
(iii) A 3rd ocean microstructure, with integrated ADCP, was included by NMF-MARS. This glider profiled in the upper 200 metres of ocean along a track crossing the flank of the ridge. This was successful.
(iv) A drifting wirewalker mooring, with CTD and turbulent microstructure profiling in the upper 200 metres, was deployed over the ridge crest. This was also successful.

3. Cruise Track and Sampling Stations.



Superstations

Nominal activities were:

(i) 2 profiles with the deep VMP6000 turbulence profiler.

(ii) 25 hours of profiling with the tethered VMP2000 microstructure profiler.

(iii) 2 CTDs, one to full depth and the 2nd to 500 metres.
(iv) Standalone pumps and zooplankton nets.

See Cruise Narrative for details.

4. Station Positions.

Station	Latitude ° ʻ		Longitude ° ʻ		Latitude decimal°	Longitude decimal°
N1	36	14.82	40	0.46	36.247	-40.008
N2	36	14.82	39	0.40	36.247	-39.007
N3	36	14.82	37	59.80	36.247	-37.997
N4	36	14.82	37	0.28	36.247	-37.005
N5	36	14.82	35	59.69	36.247	-35.995
N6	36	14.82	34	59.81	36.247	-34.997
N7	36	13.80	33	54.12	36.230	-33.902
R1	36	14.82	32	45.66	36.247	-32.761
R2	35	40.60	34	6.94	35.677	-34.116
R3	35	16.52	35	2.50	35.275	-35.042
R4	34	51.07	36	2.38	34.851	-36.040
R5	34	26.99	37	0.82	34.450	-37.014
R6	34	0.00	38	0.00	34.000	-38.000
R7	33	26.64	38	37.74	33.444	-38.629
R8	32	43.05	39	24.68	32.717	-39.411
R9	31	59.46	40	16.28	31.991	-40.271
R10	31	20.14	40	59.62	31.336	-40.994
R11	30	40.06	41	45.11	30.668	-41.752
R12	30	7.50	42	7.08	30.125	-42.118
R12a	29	38.88	42	38.70	29.648	-42.645
R13	29	10.20	43	10.32	29.170	-43.172
R14	28	31.04	43	20.80	28.517	-43.347
R15	27	55.62	43	42.35	27.927	-43.706
R17	27	2.27	44	13.10	27.038	-44.218
R19	26	8.22	44	49.62	26.137	-44.827
R21	25	16.81	45	14.42	25.280	-45.240
R22a	24	38.41	45	37.21	24.640	-45.620
R24	24	0.00	46	0.00	24.000	-46.000
S6	24	29.26	46	56.38	24.488	-46.940
S4	24	57.76	47	54.46	24.963	-47.908
S2	25	26.72	48	52.00	25.445	-48.867
D18	26	0.00	50	0.00	26.000	-50.000
D16	27	0.00	50	0.00	27.000	-50.000
D14	28	0.00	50	0.00	28.000	-50.000
D12	29	0.00	50	0.00	29.000	-50.000
D11	30	0.00	50	0.00	30.000	-50.000
D10	30	49.81	49	17.89	30.830	-49.298
D9	31	39.95	48	32.76	31.666	-48.546
D8	32	29.18	47	49.60	32.486	-47.827
D7	33	15.97	47	8.25	33.266	-47.137
D6	34	0.00	46	29.40	34.000	-46.490
D5	34	33.09	45	31.63	34.551	-45.527
D4	35	14.09	44	25.06	35.235	-44.418
D3	36	0.00	43	16.28	36.000	-43.271

D2	36	15.67	42	15.86	36.261	-42.264
N1a	36	14.82	40	40.80	36.247	-40.680
N2a	36	14.82	39	5.76	36.247	-39.096
N3a	36	14.82	37	30.72	36.247	-37.512
N4a	36	14.82	35	55.68	36.247	-35.928
N5a	36	13.80	34	20.64	36.230	-34.344
R1	36	14.82	32	45.66	36.247	-32.761

5. Cruise Narrative

Date	Time (ship/GMT)	Event	Weather	Notes
25/5/16	1600/2000	Leave Port of Spain	Calm sea, wind E'ly 15 knots	
26/5/16	0700/1100	Position: 12° 32.8'N, 60° 31.4'W	Slight swell, wind E'ly 13 knots	
27/5/16	0700/1000	Position: 15° 33.9'N, 58° 16.9'W	Slight swell, wind E'ly 12-15 knots	Ship time moved + 1 hr last night
28/5/16	0815/1115	Position: 18° 59.3'N, 55° 29.8'W	Slight swell, wind E'ly 15-17 knots	
29/5/16	0710/1010	Position: 22° 01.6'N, 52° 58.2'W	Slight swell, wind E'ly 10-14 knots	
30/5/16	0710/0910 0815/1015	Position: 22° 01.6'N, 52° 58.2'W CTD01	Calm, wind NE'ly 3 knots	Ship time moved +1 hr last night Test CTD to 3000 metres VMPs tested
31/5/16	0730/0930	Position: 27° 26.0'N, 48° 18.1'W	Calm, slight swell, wind NE'ly 5-8 knots	
1/6/16	0710/0910	Position: 30° 33.0'N, 45° 30.0'W	Moderate swell overnight. Calm, wind NE'ly 5-10 knots	
2/6/16	0730/0830	Position: 33° 38.0'N, 42° 33.9'W	Slight swell, wind SW'ly 10-12 knots	Ship time moved +1 hr last night
3/6/16	0330/0430 0413/0513 0600/0700 1330/1430	Arrive at N1 Position: 36° 14.8'N, 40° 00.5'W CTD02 in water, profile to 1000 metres Glider deployment and tests begin (OMG424) Station N2 VMP6000 deployed	 NW'ly 7-10 knots, slight swell.	 A few problems experienced getting the glider mission files to work. USBL problems – no communication from

	1408/1508 1820/1920 2356/0056	CTD03 full depth CTD at N2 (approx. 3600m) VMP recovered CTD04 to 1000m at N3	Wind NW'ly 20 knots Increasing swell.	VMP. Instrument failed at about 1000m.
4/6/16	0600/0700 0830/0930 1600/1700 2223/2323	OMG/ADCP glider deployment CTD05 full depth at N4 (approx. 3000m) CTD06 to 1000m at N5. CTD07, full depth, at N6	Wind NW'ly 25-28 knots. Moderate swell. Incrseasing swell, winds sometimes NW'ly 30 knots.	 VMP6000 not deployed due to worsening swell conditions. VMP6000 not deployed due to swell.
5/6/16	0829/0729 1500/1600 2030/2130 2216/2316	CTD08, full depth, at N7 Wirewalker tests at R1 Wirewalker deployed at: 36° 14.721 N, 32° 45.245 W. CTD09, full depth, at R1.	Wind W'ly 20-24 knots, moderate swell. Wind W'ly 15 knots, slight-moderate swell. Wind SW'ly 15-18 knots, slight-moderate swell.	VMP6000 not deployed due to swell.
6/6/16	0050/0150 0100/0200 – > 0430/0530 0615/0715	VMP6000 recovered Zooplankton nets (x6) VMP2000 25 hour station begins	 Wind SW'ly 30-35 knots, rough sea. Squally showers during afternoon/ evening.	This is the 2nd VMP6000 unit. It also failed, at about 1500m. Same problem as the 1st unit.

7/6/16	0700/0800	VMP2000 station finished. VMP recovered.	Wind NW'ly 25-30 knots, moderate swell, rough sea.	Overnight winds reached >40 knots.
	0815/0915	CTD10 to 1000m		
	1110/1210	All SAPs deployed.		
	1350/1450	SAPs recovered.	Wind NW'ly 18-22 knots. Swell decreasing.	
	1430/1530	Glider deployed.		
	1630/1730	VMP6000 test profile	NW'ly 12-17 knots.	
	1900	VMP6000 recovered, steam for R2.		
8/6/16	0130/0230	CTD11 to 1000m at R2	NW'ly 10-12 knots, calm sea, slight swell.	
	0755/0855	CTD12 to 1000m at R3		
	1455/1555	VMP6000 deployed at R4.	NW'ly 5-7 knots.	
	1515/1615	CTD13, full depth, at R4.		
	1715/1815	VMP6000 recovered.		
	1735/1835	VMP2000 profile.		
9/6/16	0100/0200	CTD14 to 300m (not sampled) at R5		
	0130/0230 -> 0600/0700	Zooplankton nets and SAPs		
	0610/0710	CTD15 to 1000m at R5	Wind SW'ly 20 knots, slight sea and swell.	
	1300/1400	CTD16 to 1000m at R6		
	1953/2053	VMP6000 deployed at R7 (depth about 1370 metres).		
	2015/2115	CTD17 to full depth at R7		

	2216/2316	VMP recovered		
10/6/16	0430/0530 1155/1255 1900/2000 1920/2020 2216/2315 2230/2360 2320/0020 ->	CTD18 to 1000m at R8 CTD19 to 1000m at R9 VMP6000 deployed at R10 CTD20 at R10, full depth VMP6000 recovered VMP6000 deployed at R10 SAPs and zooplankton nets at R10	Wind SW'ly 13 knots, calm sea.	VMP6000 still had sensor caps on. This time without sensor caps.
11/6/16	0420/0520 1020/1120 1515/1625 1530/1630 1720/1820 2145/2245	VMP6000 recovered during short break in SAPs and nets. CTD21 to 1000m at R11 VMP6000 deployed CTD22 at R12, full depth. VMP6000 recovered CTD23 at R12a to full depth.	SW'ly 14-16 knots, calm sea, slight swell.	Lost City vent site. Very shallow (850m) steep topography. CTD into convectively mixed plume?
12/6/16	0420/0520 0450/0550 0815/0915 1225/1325 1800/1900 1820/1920	VMP6000 deployed at R13 CTD24 at R13, full depth. VMP6000 recovered CTD25 at R14 to 1000m VMP6000 deployed at R15. CTD26 deployed at R15 for full depth	SW'ly 12-14 knots, calm sea, slight swell. S'ly 8 knots. Calm.	Broken Spur vent site. Deep (>3000m).

	2045/2145 2140/2240 2245/2345	profile. VMP6000 recovered SAPs deployment Zooplankton nets begin		
13/6/16	0040/0140 0200/0300 0830/0930 1615/1715 -> 2015/2115 2034/2134	SAPs recovered Nets end. CTD27 to 1000m at R17 3 attempts to deploy VMP6000 at R19. CTD28 at R19, to full depth.	SE'ly 8-10 knots, slight swell.	The Meteor is close by. VMP fails each time due to early weight release.
14/6/16	0515/0615 1154/1254 1325/1425 1530/1630 2006/2106 2052/2152 2140/2240 2238/2338	CTD29 at R21 to 1000m VMP deployed at R22a CTD30 at R22a to 1000m VMP recovered CTD31 at R24 to 500m. CTD32 at R24 to 500m SAPs deployment Nets begin	NW'ly 2 – 4 knots, calm sea, slight swell. Showers.	Gantry problems delayed CTD deployment. CTD31 is a dud.
15/6/16	0035/0135 0155/0255 0230/0330 0250/0350 0535/0635 1155/1255 1252/1352 1340/1440 1710/1810	SAPs recovered Nets end VMP6000 deployed CTD33 to full depth at R24 VMP6000 recovered CTD34 to 500m at S6 VMP6000 deployed to full depth CTD35 to full depth at S6 VMP6000 recovered	E'ly 8 – 10 knots, calm sea.	VMP6000 released weights about 200m too early.

	1130/1230	CTD36 to 500m at S4		
16/6/16	0043/0143 0120/0220 0520/0620 1128/1228 1217/1317 1250/1350 1630/1730 2308/0008	VMP6000 to full depth CTD37 to full depth at S4 VMP6000 recovered CTD38 to 500m at S2 VMP6000 deployed CTD39 to full depth at S2 VMP6000 recovered CTD40 to 500m at D18	SE'ly 8 – 10 knots, calm sea. Showers in the distance.	VMP6000 arrives at surface 1410 (ship time), so looks to have profiled only 1800m.
17/6/16	0000/0100 0024/0124 0230/0330 0350/0450 0413/0513 0440/0540 1015/1115 1600/1700 2312/0012 2330/0030	SAPs deployed Nets begin SAPs recovered Nets end VMP6000 deployed to full depth at D18 CTD41 to full depth D18 VMP6000 recovered CTD42 to 1000m at D16. VMP6000 deployed CTD43 to full depth at D14	SE'ly 1-5 knots, calm sea, slight swell. Showers.	
18/6/16	0315/0415 0925/1025 1658/1758 1718/1818 2202/2302 2255/2355 2332/0032	VMP6000 recovered CTD44 to 1000m at D12 VMP6000 deployed at D11 CTD45 to full depth at D11 CTD46 to 500m at D11 SAPs deployment Zooplankton nets start	S'ly 9 – 11 knots, calm sea, slight swell.	

19/6/16	0140/0240 0300/0400 0920/1020 1702/1802 1722/1822	SAPs recovered Nets end CTD47 to 1000m at D10 VMP6000 deployed at D9 CTD48 to full depth at D9	S'ly 11-13 knots, calm sea, slight swell.	
20/6/16	0335/0435 1212/1312 1235/1335 1619/1719 1652/1752 -> 1821/1921 1914/2014 2108/2208 2306/0006 2325/0025 2350/0050	CTD49 to 1000m at D8 VMP6000 deployed CTD50 full depth at D7 VMP6000 recovered Tethered VMP2000 tests VMP6000 deployed CTD51 to 500m VMP6000 recovered SAPs deployed Nets start	SE'ly 2 – 4 knots, calm sea, slight swell.	
21/6/16	0205/0305 0318/0418 0858/0958 1607/1707 1625/1725 2012/2112	SAPs recovered Nets end CTD52 to 1000m VMP6000 to full depth at D5 CTD53 to full depth at D5 VMP6000 recovered	N'ly 1-3 knots. Glassy sea.	
22/6/16	0339/0439 1205/1305 1228/1328 1625/1725	CTD54 to 1000m at D4 VMP6000 deployed at D3 CTD55 to full depth at D3 VMP2000 25 hour	E'ly 10-13 knots, calm sea, tiny swell.	VMP6000 fails to return on time. USBL shows it is sat on the seabed.

		station begins at D3		
23/6/16	0500/0600 -> 0615/0715 0615/0715 1245/1345 2008/2108 2044/2144 2340/0040	Break off from VMP2000 station to collect VMP6000 Recommence VMP2000 station D3 Bad buffers reported by VMP2000. Recovered for wire tests. VMP6000 deployed CTD56 at D3 to 500m VMP6000 recovered	E'ly 10 knots	VMP2000 fixed and tested. VMP6000 release tested.
24/6/16	0030/0130 0309/0409 0313/0413 0426/0526 1005/1105 1018/1118 1343/1443 2136/2236 2200/2300	SAPs deployed SAPs recovered Nets begin Nets end VMP6000 deployed at D2 CTD57 to full depth at D2 VMP6000 recovered VMP6000 deployed at N1a CTD58 to full depth at N1a	E'ly 12-15 knots, calm sea, overcast.	Britain votes for BREXIT. General air of despondency amongst the scientists.
25/6/16	0140/0240 1353/1453	VMP6000 recovered Heading off to find glider OMG3 Glider recovered at: 38.4403 N 39.8359 W	E'ly 14-18 knots, slight sea, overcast.	
26/6/16	0258/0358 0320/0420 0627/0727	VMP6000 deployed at N2a CTD59 to full depth at N2a VMP6000 recovered	E'ly 20-25 knots, slight-	

	1420/1520 1443/1543 1808/1908	VMP6000 deployed at N3a CTD60 to full depth at N3a VMP6000 recovered	moderate sea. E'ly 12-14 knots, slight o moderate sea.	VMP6000 failed to record data on this profile
27/6/16	0219/0319 0237/0337 0526/0626 1315/1415 1337/1437 1515/1615 1942/2042 1955/2055	VMP6000 deployed at N4a CTD61 to full depth at N4a VMP6000 recovered VMP6000 deployed at N5a CTD62 to full depth at N5a VMP6000 recovered Wirewalker fully recovered CTD63 to 200m	E'ly 10-15 knots, calm sea. Showers and overcast.	36.3076° N; 33.3775° W
28/6/16	0009/0109 0027/0127 0243/0343 0352/0452 0930/1030 1130/1230 1814/1914 1844/1944 1910/2010 2125/2225 2245/2345	VMP6000 deployed at R1 CTD64 to full depth at R1 VMP6000 recovered VMP2000 12.5 hour station begins at R1 Profiling stopped for wire re-termination – bad data in last 2 profiles between about 70 and 120 metres. Profiling restarts VMP2000 ends VMP6000 deployed at R1 CTD65 to full depth at R1 VMP6000 recovered CTD66 to 500m at R1	E'ly 12-14 knots, heavy showers early morning.	CTD64 not sampled. Moorings successfully contacted. Neap tides.

	2341/0041	SAPs deployment starts		
29/6/16	0017/0117 0234/0334 0559/0659 0650/0750 1847/1947	Nets begin SAPs recovered Nets end VMP2000 12.5 hour station begins at R1 VMP2000 12.5 hour station ends.	E'ly 12-15 knots, calm sea.	
30/6/16	0814/0914 0930/1030 1014/1114 1348/1448 1617/1717	Recovery of APEX float mooring begins. Recovery complete. Recovery of ADCP/logger mooring begins. Recovery complete OMG444 ADCP glider recovered	NE/ly 6-10 knots, calm sea.	APEX float and upper 1000m of line is missing. Only the release and lower buoyancy recovered. All instruments on ADCP/logger mooring recovered successfully.
1/7/16	0857/0957 1550/1650 1845/1945	CTD67 to full depth at mooring site SAPs deployed SAPs recovered Head to last known position of missing glider.		
2/7/16	0600 -> 1300	Search for missing glider (unsuccessful)	E'ly 7 – 9 knots, calm sea.	
3/7/16	0800	38° 28.8'N, 29° 45.5'W	SE'ly 3-5 knots. Very calm.	Heading for the UK.

6. CTD Processing

Carl Spingys, University of Liverpool.

A total of 67 CTD profiles were collected on the cruise JR15-007 distributed across four lines. The CTD processing was performed using the MEXEC software developed by Brian King (NOC).

6.1 Instrumentation

One stainless steel CTD frame was prepared with 24 20L Niskin Bottles, as well as the series of instruments listed in Table 1. All the instruments were mounted at the bottom and inside the CTD frame with the exception of the SBE 35 and PAR sensors, which were mounted on the perimeter of the CTD approximately 1 metre above the other instruments.

Parameter	Model	S/N	Notes
Temperature 1	SBE3	5766	Removed 19/6/16
Temperature 1	SBE3	4302	Added 19/6/16
Conductivity 1	SBE4	2289	Removed 19/6/16
Conductivity 1	SBE4	2875	Added 19/6/16
Temperature 2	SBE3	2705	
Conductivity 2	SBE4	2222	
Pressure	SBE9plus	0707	
Temperature Reference	SBE35	0024	
Transmission	WETLABS C-STAR	CST-846DR	
Fluorescence	AQUATRACKA MKIII	088-249	
PAR	Biospherical QCD-905L4S	7274	
Dissolved Oxygen	SBE43	0676	

Table 1: Instruments and serial numbers for all equipment deployed on the CTD frame during JR15-007

The primary temperature and conductivity sensors were swapped on 19/6/16 prior to CTD 49 due to a series of short periods when the primary temperature and conductivity records became offset relative to the secondary sensors (illustrated by blue/black offsets relative to the purple/red lines in Fig. 1). Unfortunately this change did not resolve the problem (Fig. 2) and the source of the fault has not been identified. It is recommended that only the secondary temperature and conductivity records are used.

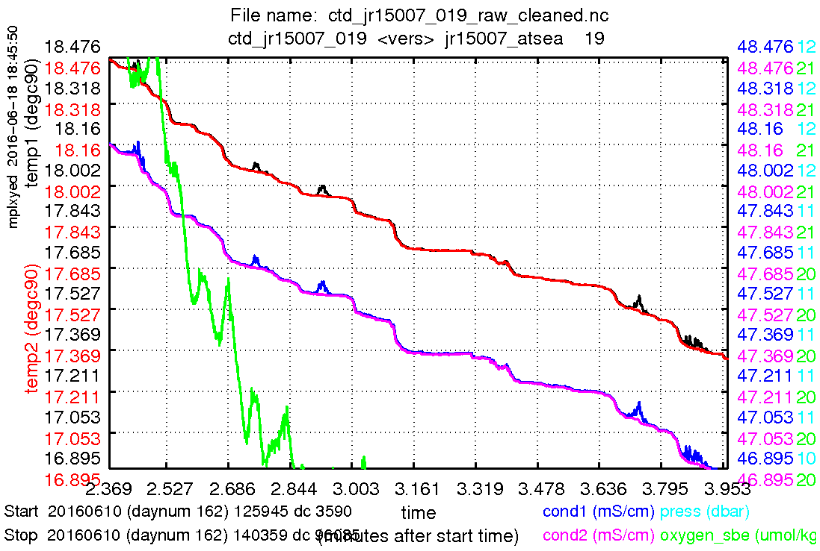


Figure 1: Temperature and conductivity time-series from CTD 19 showing periods of mismatch between the two sets of sensors.

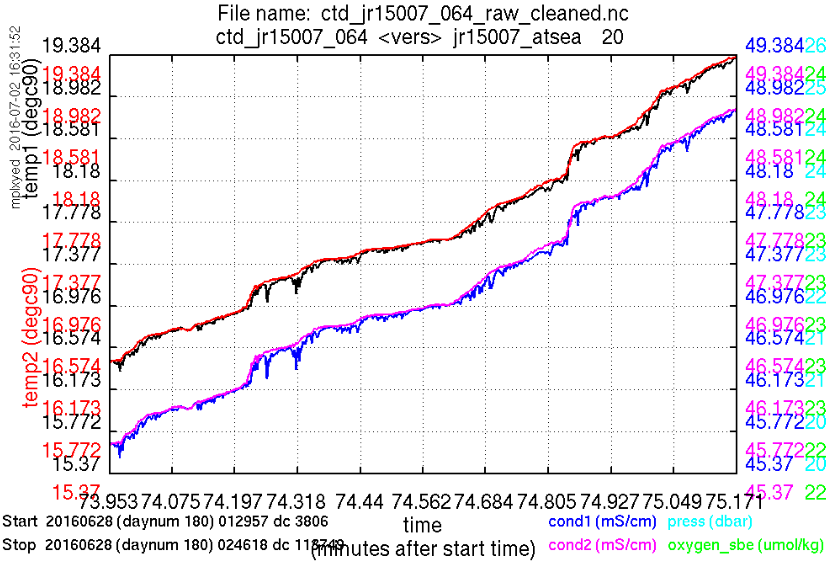


Figure 2: Temperature and conductivity time-series from CTD 64 showing the periods of mismatch still existing after changing the primary sensors

6.2 Processing

Modified from the cruise report for JR306 by Brian King et al.

The initial SeaBird data conversion, align, and cell thermal mass corrections (alpha = 0.03. tau = 7.0000 on both primary and secondary) were performed using SBE Data Processing, Version 7.22.2 software. The network data drive, legdata, was linked to ctd/ASCII FILES/jcrfs ctd and ctd linkscript was used to copy files to fola and set up additional symbolic links to filenames following mstar convention. At the beginning of processing empty sample files sam jr15007 nnn.nc for all casts nnn were generated using msam 01, as described in the comments at the beginning of msam 01b. For each cast the following m-files were then run, using wrapper script ctd all part1: mctd 01, mctd 02a, mctd 02b, mctd 03, mdcs 01, mdcs 02. The processes completed by these scripts include:

- read ASCII cnv data from ctd/ASCII FILES/ctd_jr15007_001.cnv
- convert variable names from SBE names to mexec names using data/templates/ctd/jr15007_renamelist.csv
- copy raw file to 24hz file
- average to 1hz
- calculate derived variables psal, potemp
- extract information from bottom of cast identified by maximum pressure.

Subsequently mdcs 03g was run to inspect the profiles and hand-select cast start and end times. The way oxygen time lag is handled in the SBE align algorithm, and the weak dependence of oxygen calculation on salinity, means that when air is ingested into the conductivity cell at the end of the cast, the oxygen becomes biased a few seconds earlier than the psal. Care should therefore be taken to select a cast end time for which all the important variables are free from bias.
The start, bottom and end data cycles are stored in files with names like dcs jr15007_001.nc. After selecting the limits for start and end, ctd all part2 was then run, executing mctd 04, mfir 01, mfir 02, mwin 01, mwin 03, mwin 04. The processes completed by these scripts include:

- Extract down and upcasts using scan numbers stored in dcs_jr15007_001, and average into 2 dbar files (2db and 2up)
- Read the data/ctd/ASCII FILES/ctd_jr15007_001.bl file and extract scan numbers corresponding to bottle firing events.
- Add time from CTD file, merging on scan number
- Add CTD upcast data (P,T1,T2,S1,S2, etc) corresponding to bottle firing events
- Paste these data into the master sample file data/ctd/sam_jr306_001.nc
- Load winch telemetry data from winch SCS file
- Add winch wireout data to the fir_jr306_001 file
- Paste winch wireout data into the master sample file

Processed data could then be examined using mctd checkplots to view sensor and up-down cast differences as well as compare nearby profiles, with particular attention paid to any drift in deep temperature or salinity (expected to be relatively stable) over time. The 24-Hz data were checked for spikes in either of the temperature or conductivity sensors using mctd rawshow and, if necessary, edited using mctd rawedit. A variety of extra steps is available after other processing has been carried out; these steps can be run in any order.

After navigation data processing has been completed the file data/nav/seapos/bst_jr15007_01 will be available. mdcs 04 will generate files dcs_jr15007_001 pos.nc which include position at start, bottom and end of profiles. mdcs 05 will then paste the position at the bottom of the cast into the header of all relevant files in data/ctd.

When a conductivity calibration is available, it is applied to the 24hz files using mctd condcal, as described below. A subset of scripts should now be rerun, specifically mctd 02b, mctd condcal with senscal = 1, mctd condcal with senscal = 2, mctd 03, mctd 04, mfir 03, mfir 04, msam updateall. This collection of calls can usefully be put in a script like smallscript.m Selection of data cycle start and end points is preserved by smallscript, as well as edits to the raw file made using mctd rawedit. Water depth and position data will also be preserved and do not need to be re-entered after conductivity calibration.

6.3 Calibrations

Temperature

Methods

SBE35 temperature data can be logged when a Niskin bottle is fired. If the SBE35 is set to 8 samples, it requires approximately 13 seconds to make a measurement, calculated as 8 * 1.1 seconds plus an overhead. Data are stored internally and must be downloaded at the CTD deck unit as a separate process from the CTD data transfer. The SBE35 data are then transferred as a collection of ASCII files. On JR15-007 these were found in data/ctd/ASCII FILES/SBE35.
msbe35 01 reads the data from a single station. The script works in data/ctd/SBE35/. The script requires a list of all available SBE35 data files, so on JR15-007 the list was called data/ctd/SBE35/lsbe.
msbe35 01 operates one station at a time. It reads all ascii files in the lsbe list file and extracts data cycles for the station, based on the start and end times with a 15-minute extra window in case the SBE35 clock timestamps are not perfectly accurate.

- msbe35 02 pastes the SBE35 data from one station into the master sample file. msam update all could be used to paste the data into the appended sample file sam_jr15007_all.
- ctd evaluate temp compares the SBE35 temperature measurements taken each time a bottle is fired with the coincident measurements by the two CTD temperature sensors.

Comparison and Calibration

Initial comparisons showed that the two CTD temperatures were in good agreement with little skew however the SBE35 was recording temperatures O(0.1°C) higher near the surface. These discrepancies were co-located with strong vertical temperature gradients, O(0.1°C/m). In order to minimise the effects of this gradient, the temperature calibration was performed only using values below 2000dB.

(a) (b)

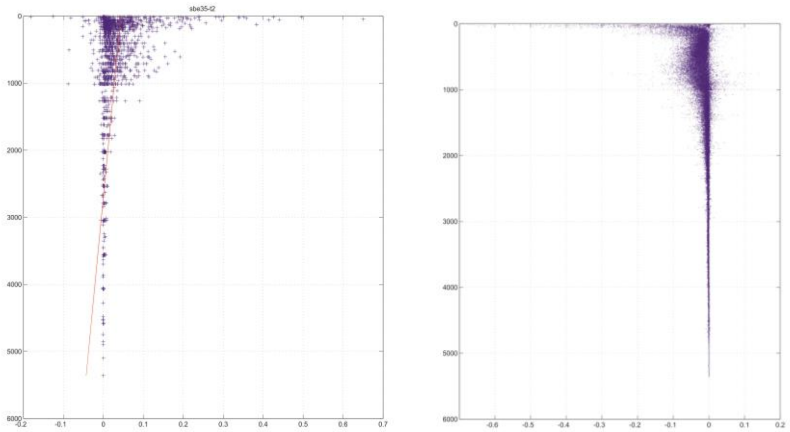


Figure 1: Vertical profiles of (a) the difference between the sbe35 recorded temperature and the temperature from the secondary temperature sensor (°C) and (b) the vertical temperature gradient (°Cm^{-1}) calculated from the 2dB downcast temperature.

This temperature choice lead to a calibration not varying in depth of:

- Primary 1: +0.00045
- Primary 2: +0.00205
- Secondary: +0.00114

These calibrations lead to a zero median below 2000dB with scatter up to approximately 0.01°C, although the scatter and median is still large near the surface.

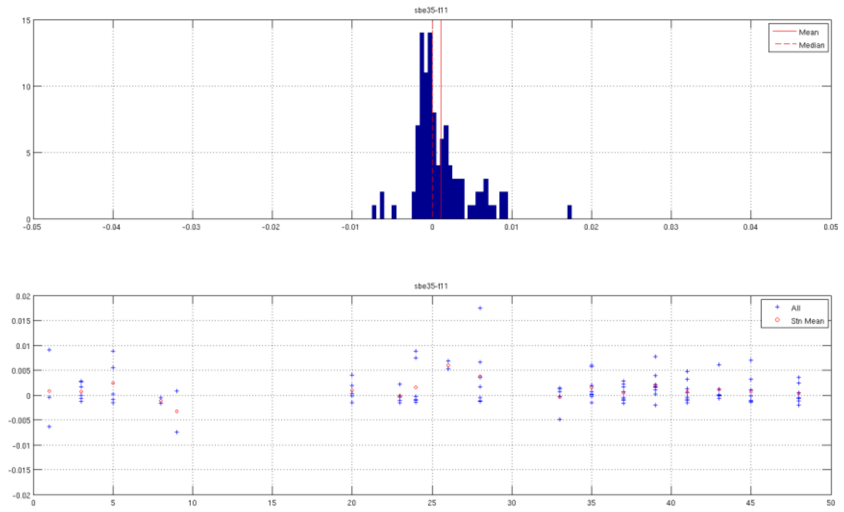


Figure 2: SBE35 minus the first primary temperature sensor after calibration for depths greater than 2000dB. (a) Histogram of temperature difference with the mean and median marked with red lines. (b) Temperature difference by station, with the station mean marked in red.

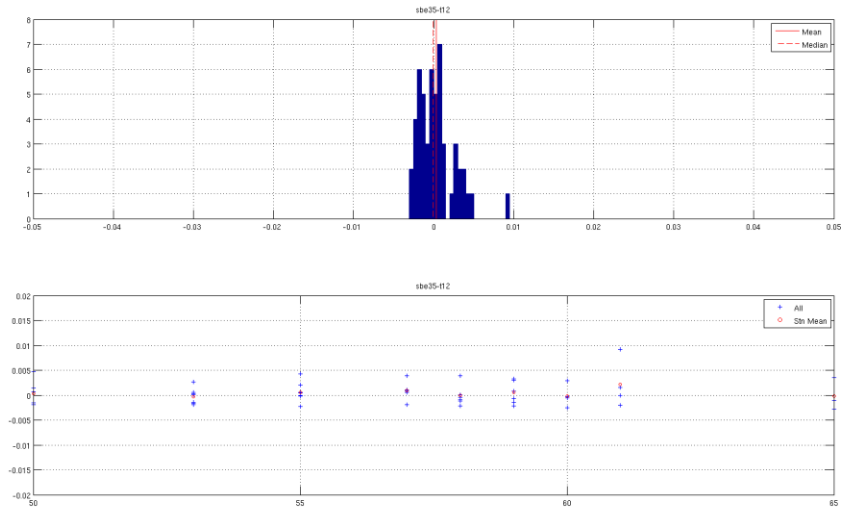


Figure 3: SBE35 minus the second primary temperature sensor after calibration for depths greater than 2000dB. (a) Histogram of temperature difference with the mean and median marked with red lines. (b) Temperature difference by station, with the station mean marked in red.

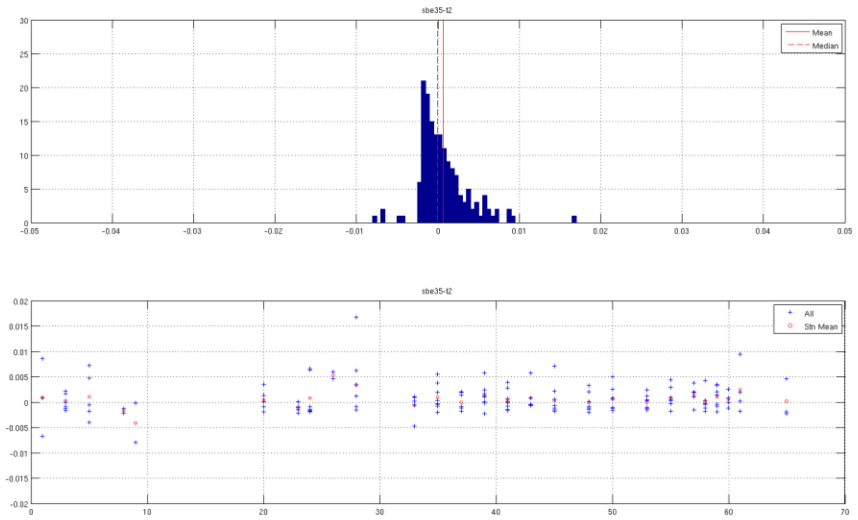


Figure 4: SBE35 minus the secondary temperature sensor after calibration for depths greater than 2000dB. (a) Histogram of temperature difference with the mean and median marked with red lines. (b) Temperature difference by station, with the station mean marked in red.

Salinity

Determination of bottle salinity

Salinity samples were taken from each CTD cast, the number of samples taken being dependent on the depth of the cast. All salinity samples were then run through a Guildline Autosal 8400B salinometer. The Guildline Autosal 8400B measures the conductivity of a water sample with very high precision, in a water bath of known temperature. The readout is given as twice the conductivity ratio between the sample and standard seawater with salinity 35 PSU at 20ºC, and 1 atmospheric pressure (known as the Vienna Standard). The instrument (S/N 68959) was standardised at the beginning of the cruise and set to a reading of 719. Once the instrument had been standardised, it was left like this for the duration of the cruise.
Ocean Scientific International Ltd (OSIL) standard seawater (batch number P157) was used to provide calibration readings at regular intervals: before each crate of 24 salt samples and after each crate so that corrections could be applied to the intermediate measurements. Measurements were taken from each sample/standard until three readings with a std dev <0.00002 were achieved. The mean reading was then taken as the accepted value. From these conductivity ratios, the practical salinity of the sample could be calculated using the equation of state from UNESCO (1978). The measurements were loaded into an Excel spreadsheet, where salinities were calculated. One spreadsheet was created per salinity crate.

It was important to keep the salinometer room at a constant temperature, which should be as close as possible to, but not exceed, the temperature of the salinometer's internal water bath. The water bath was set to a temperature of 24ºC and the room temperature was kept between approx. 21.5ºC and 24ºC. There were periods when the air conditioning could not maintain the temperature, and measurements were suspended until the temperature was stable for 24 hours. All crates of salinity samples were left in the salinometer room for at least 24 hours before being analysed, to give them time to acclimatise to the room temperature.

Salinometer problems

At the beginning of JR15007, Autosal s/n 63360 was standardised and running well, but problems were noted during initial crates – some values were recorded differently on the software to the Autosal LCD display. The Autosal display was stable, with software values jumping around. Initially it was thought that some samples were recorded 0.00020 high, but it was later established that others were 0.00020 low. The problem was isolated by running junk samples of various salinities - all Autosal values were correct but output to software was corrupted. The 4th digit after the decimal place was reading normally for values of 0, 1 and 6-9. All values of 2 were output to software as 4 and vice versa, all values of 3 were output as 5 and vice versa. This gives the result of some samples being +/- 0.00020. To confuse matters, at times correct and incorrect values are averaged out to give a final result which may be incorrect even where some readings do not have a corrupted digit in the appropriate position.

For example:

Autosal value	Software value	Averaged result
2.02319	2.02319	
2.02320	2.02340	2.02326
2.02318	2.02318	

As readout values change during the 10 second measurement window, some individual results were also corrupted. Several different software versions and laptops were tested, results were always the same. The ribbon cable between Autosal and integrator checked OK for continuity on all 50 pins, meaning that the problem lies almost certainly within the Autosal itself. Autosal s/n 68959 was standardised and run for the remainder of the cruise without issue (12/06/2016 onwards)

Processing Methods

Ctd evaluate sensors.m are used to examine the difference between the CTD cond1 and cond2 sensors, and the residuals with bottle salinity (after they appear in sam_jr15007_all.nc). The script performs comparisons in both salinity and conductivity space, and suggests adjustments of conductivity ratio or converted to equivalent salinity offsets to judge their importance. Plots are generated to reveal biases between sensors, and either pressure- or station-dependence of bottle minus sensor differences.

When a possible calibration adjustment has been identified for either or both sensors, ctd evaluate sensors.m can be edited to see the effect of that calibration without changing the data in any files. A new switch/case for the cruise name should be introduced, following previous examples. If sensors have been changed, subgroups of stations corresponding to sensor configurations can be declared, using, eg, k11, k12, k13 for sets of stations with the first, second, third, primary sensor. Indexes k21, k22, k23 would correspond to successive secondary sensors. Calibrations in ctd evaluate sensors.m can be tried until a satisfactory set of residuals is obtained for both sensors. This calibration adjustment can then be transferred to a switch/case in cond apply cal.m. A further switch is required for each sensor. The wrapper smallscript.m can then be run on a set of stations (see section on CTD processing). This will produce calibrated CTD profiles in all the derived files (24hz, 1hz, psal, 2db, 2up) and paste the adjusted CTD data into the sam bottle files. With the exception of the ctd_jr306_nnn raw.nc file, which still contains raw data, adjusted conductivity and associated adjusted salinity will occur in all derived files from the 24hz file onwards. To check that the adjustment was well chosen and has been applied correctly, ctd evaluate sensors.m should now be edited to have the trail adjustment removed, so there is no adjustment in that script. The set of residuals now correspond to the data in the sam_jr306_all.nc file, and should have zero median and no obvious vertical shape.

Comparison and Calibration

All three conductivity sensors deployed show a large amount of scatter near the surface, where there are also large vertical gradients in salinity. As the water collected by the Niskin bottle will have been taken from a range between a few tens centimetres above the sensor to over a metre it is likely that strong vertical gradients will bias the bottle samples relative to the CTD. In the upper 1500m the vertical gradient is typically O(0.01 °C m^{-1}) whilst the differences between the bottle and CTD salinity is typically in the range O(0.001 to 0.01). As a result we will, in a similar manner to the temperature, perform the calibration using data from deeper than 1500dB and assume the pressure dependant correction is linear throughout the water column. This has been applied by least-squares fitting an equation of the form:

$$o = m * P + c$$

where *o* is the offset to be applied to the salinity, *P* is the pressure and *m* and c are constants to be fitted (Fig. 7, 8 and 9). The constants derived are given in Table 2.

Table 2: The constants derived from linear fitting of the conductivity difference (in salinity equivalent units).

Sensor	m	c
First Primary	-2.5091e-7	1.9003e-3
Second Primary	-3.5512e-8	3.6565e-3
Secondary	-4.9835e-7	2.6667e-3

These result in vertical profiles where, for depths below 1500dB , the median is close to zero and there is little vertical structure (Figure. 10). There is still spread O(0.001) at depth and O(0.01) in the upper 1000dB, although this could be a result of the stronger vertical gradients near the surface.

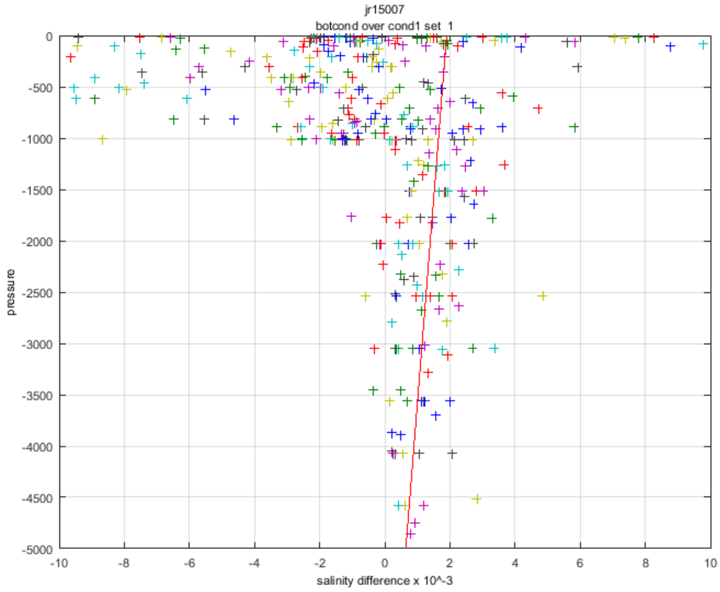


Figure 7: Vertical profile of the difference between the conductivity given from bottle samples and the first primary sensor. The conductivity difference has been scaled to an equivalent salinity difference. The linear fit used for calibration is show in red.

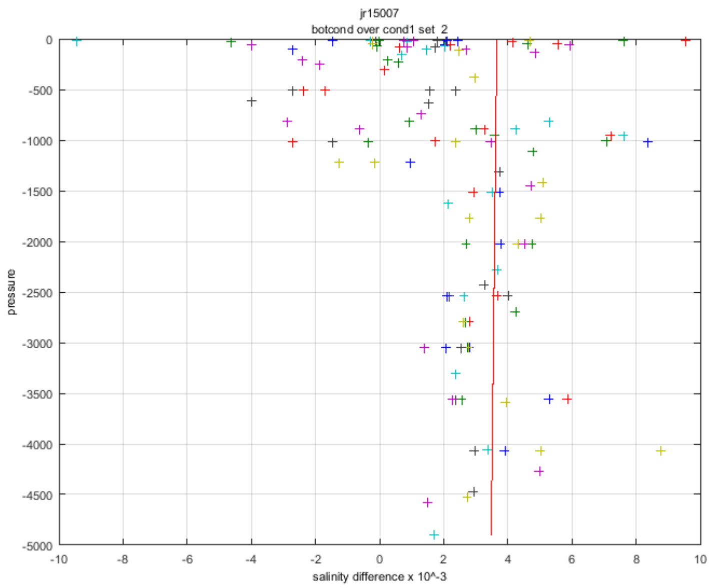


Figure 8: Vertical profile of the difference between the conductivity given from bottle samples and the first primary sensor. The conductivity difference has been scaled to an equivalent salinity difference. The linear fit used for calibration is show in red.

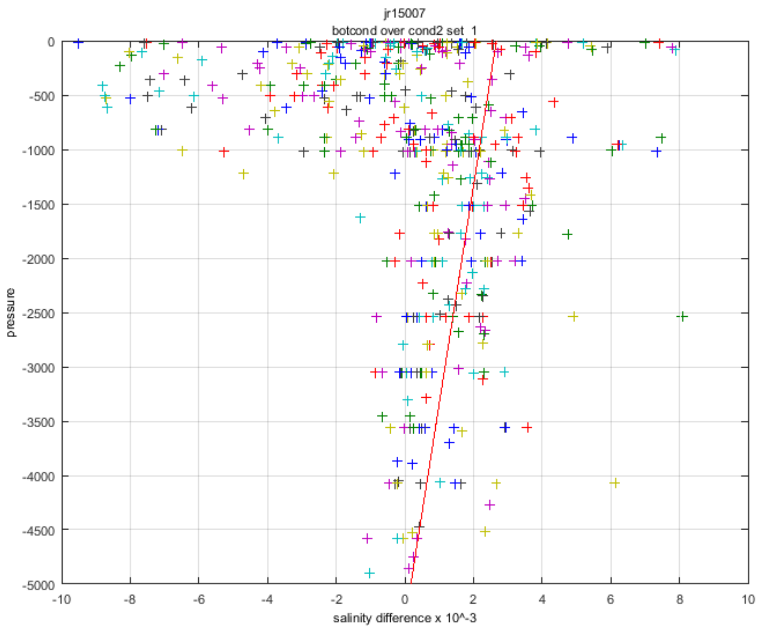


Figure 9: Vertical profile of the difference between the conductivity given from bottle samples and the first primary sensor. The conductivity difference has been scaled to an equivalent salinity difference. The linear fit used for calibration is show in red.

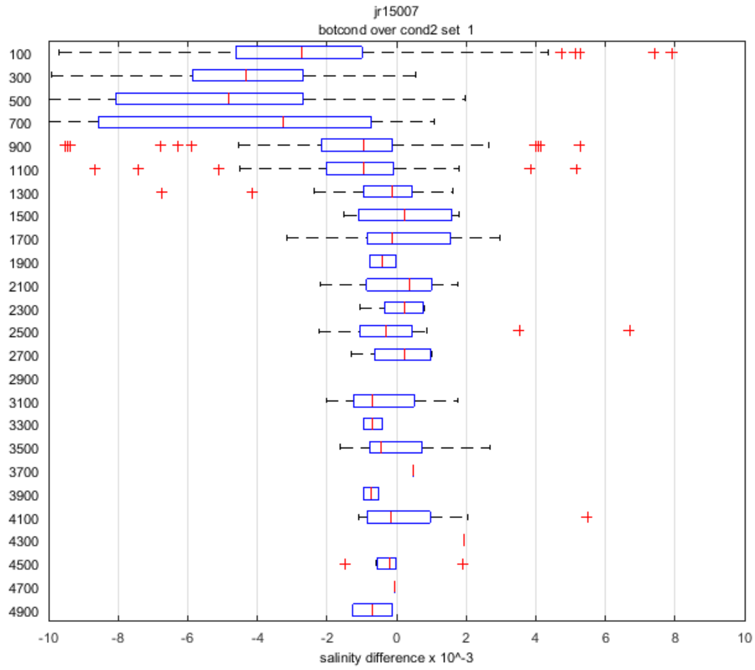


Figure 10: Series of box plots calculated in 200m bins post calibrations for the preferred sensor (secondary). The red lines indicate the median, the blue boxes the interquartile range and the black lines the full range. Data points more than 1.5 times the interquartile range away from q1 or q3 are excluded.

7. Microstructure profilers

Alex Forryan, Clément Vic (University of Southampton)

7.1. Overview

Three vertical microstructure profilers manufactured by Rockland Scientific International (one tethered VMP-2000 and two untethered VMP-6000) were used during the JR15-007 cruise. Both types of instruments measured profiles of temperature and velocity microstructure (i.e. on the length scales of dissipation of turbulent flows, typically a few millimetres to tens of centimetres), from which the rates of dissipation of turbulent kinetic energy (ε) and temperature variance (χ) are estimated using methodology based on Oakey (1982); and finescale temperature, salinity and pressure with a Seabird CTD mounted on each instrument. The RidgeMix microstructure program aims at contrasting different regimes of turbulent kinetic energy dissipation on and off the ridge. The kinetic energy dissipation on the ridge is suspected to be supported by the breaking of internal tides loccally generated. To this end, a series of deep casts were scheduled on the ridge (11 stations R01-R24, Figure 1) and off the ridge (10 stations D02-D18), as well as transects in the cross-ridge direction (3 stations in the south S02-S06 and 5 stations in the north N01-N05). Besides, three 25h stations (each one thus covering two semi-diurnal cycles) were scheduled to spot and characterize internal tides. Two of these stations were conducted at R01 (on the ridge, one during neap tide and one during spring tide) and one was conducted at D03 (off the ridge).

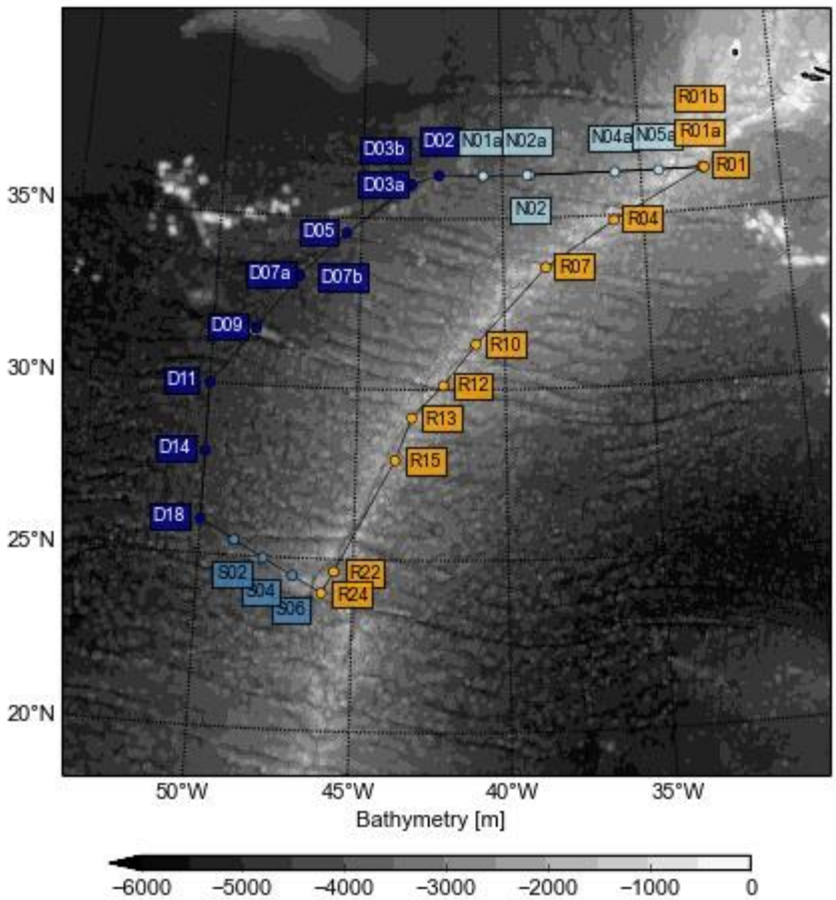


Figure 1: Bathymetry and VMP6000 stations. VMP2000 profiles were done on stations R01 and D03. (JR15-007)

7.2. VMP 6000 (free falling, non-tethered)
A total of 32 casts were conducted, 30 of which have good data. Table 1 gives general information on VMP6000 stations. In the following, we detail some important facts encountered during the cruise. Due to a rough sea while in the northern transect during the first passage (04-05/06), we were not able to deploy the VMP (no station N03-N05). We deployed the VMP at these stations during the second passage (N01a-N05a).

The first issue encountered with VMP6000 (N02,R01) was linked with a corruption of data by noise emitted by the LED (allowing to spot the beginning of data acquisition). As we did not have any spare LED, we used it only to make sure the VMP was turned on then we unscrewed it before deployment. Some casts were interrupted by a « fall rate release » or a « time out release » of the loads (R19, S06, D18). It occured that the fall rate was too slow (0.4 dbar/s at the beginning then rapidly decreasing down to 0.2 dbar/s). Paul worked this out appending a third load that allowed the instrument to fall at a rate of 0.7 dbar/s. An unexpected but interesting side effect of the increased fall rate is to reduce the noise due to vibrations. Practically, it also reduces the overall time of the cast and the instrument surfaced at the same time as the CTD, therefore improving the time efficiency of the stations.
VMP got stuck at the seafloor at station D03a. Logfile recorded "out of disk space" then "acquisition stop out of disk space". The instrument shut down and loads were released by the "fizz-link" corrosion.

Station (CTD)	**Latitude (N)**	**Longitude (W)**	**Date/Time (GMT)**	**Max Press. (dbar)**	**Data file name**	**Comments**
N2 (003)	36 14.865	39 00.399	03/06/16 14:31	3509	S003_001.P	sn016 Not good all micro data duff below 1000 m. Looks like an internal board problem.
R1 (010)	36 13.605	32 45.242	05/06/16 22:34	2245	S10_001.P	sn107 same as for sn016 except microT are both good this time.
R4 (013)	34 51.118	36 02.2709	08/06/16 15:47	1665	S13_001.P	sn107 T1 unresponsive replaced post dive with T383
R7 (017)	33 26.647	38 37.755	09/06/16 19:53	1268	S17_008.P	Weight release broken/replaced on deployment
R10 (020)	31 20.139	40 59.600	10/06/16 17:58	2570	R10_001.P	Probe guards left on – data not processed
R10 (020)	31 19.784	40 59.297	10/06/16 23:30	2467	R10_002.P	Slightly shallower – reprogrammed from above
R12 (022)	30 07.443	47 06.587	11/06/16 16:10	840	R12_002.P	Thermal vent site
R13	29 10.232	43 9.958	12/06/16	3079	R13_001.P	Thermal vent site 2 – data

(024)			05:04			noisy bad buffers. Swapping instruments for next dive. Used fix_bad_buffers to patch .P file.
R15 (026)	27 55.576	43 49.336	12/06/16 18:53	2300	R15_002.P	Using SN016 with micro sensors from SN107 micro C looks broken.
R19 (028)	26 8.755	44 50.120	13/06/16 18:00	N/A		Aborted early twice weight release issues
R22a (030)	24 38.325	45 37.180	14/06/16 12:54	3175	R22_001.P	MicroC not working. MicroT 2 biasing low below 10-10
R24 (033)	24 00.012	45 59.981	15/06/16 03:20	2262	R24_001.P	MicroC still not working – board problem ? MicroT now both fine
S6 (034)	24 29.262	46 56.367	15/06/16 13:45	2836	S6_001.P	Fall rate release – dive aborted early
S4 (036)	24 57.786	47 54.474	16/06/16 00:42	3742	S4_001.P	Flawless – wow.
S2 (038)	25 26.805	48 51.925	16/06/16 13:10	3966	S2_001.P	Battery tap-dance release slight bias in microT
D18 (041)	26 00.028	50 00.078	17/06/16 05:12	4718	D18_001.P	Sn107 Timeout release due to very very very slow drop rate
D14 (043)	27 59.925	50 00.263	18/06/16 00:11	4768	D14_001.P	Sn107 New three weight configuration – fall rate now near 0.7 db/s
D11 (045)	30 00.004	49 59.643	18/06/16 17:58	5063	D11_001.P	Sn107 bad buffers again. Used fix_bad_buffers to repair .P file. NB Wrong setup.cfg in .P file – patched to correct version.
D09 (048)	31 39.938	48 32.359	19/06/16 18:02	4523	D09_002.P	Sn107 bad buffers again. Used fix_bad_buffers to repair .P file. NB Wrong setup.cfg in .P file – patched to correct version.
D07a (050)	33 15.975	47 08.270	20/06/16 12:30	4623	D07_001.P	Sn107 bad buffers. Used fix_bad_buffers to epair .P file.
D07b (051)	33 15.606	47 08.544	20/06/16 20:07	4630	D07_002.P	Sn107 no bad buffers – wow! T2 looks a bit iffy – swapped T1 & T2 round.

D05 (053)	34 33.066	45 31.540	21/06/16 17:09	4135	D05_001.P	Sn107 bad buffers again. Used fix_bad_buffers to repair .P file. T1 iffy – will need swapping out. Wrong setup.cfg – patched to correct version
D03a (055)	35 59.999	43 16.266	22/06/16 13:05	4052	D03A_001.P	Sn107 'disk full acquisition stopped' combined with possible release mechanism failure. Surfaced 12hrs later released on chem-link. Only first 1800 m recorded.
D03b (056)	36 00.020	43 16.115	23/06/16 09:07	4023	D03B_003.P	Sn107 with sensors from Sn016. Used fix_bad_buffers to repair .P file.
D02 (57)	36 15.760	42 16.191	24/06/16 11:06	3840	D02_001.P	Sn107 no bad buffers – wow! microC replaced after last cast.
N01a (58)	36 14.848	40 40.840	24/06/16 22:38	4423	N1A_001.P	Sn107 No bad buffers – wow!
N02a (59)	36 14.889	39 05.740	26/06/16 03:57	3479	N2A_001.P	Sn107 No bad buffers.
N03a (60)	36 14.824	37 30.788	26/06/16 15:21	3440	N03A_001.P	Sn107 data file is blank – records nothing but zeros from about 13 mins into the dive.
N04a (61)	36 14.874	35 55.775	27/06/16 03:17	2580	N04A_001.P	Sn107 bad buffers again. Used fix_bad_buffers to repair .P file. T2 duff.
N05a (062)	36 13.805	34 20.699	27/06/16 14:14	1340	N05A_001.P	Sn107 T2 still duff. 1 bad buffer report
R01a (064)	36 34.791	32 45.737	28/06/16 01:12	2162	N01A_001.P	Sn107 T2 still duff. Bad buffers patched .P file.
R01b (065)	36 13.668	32 42.271	28/06/16 19:45	2180	R01B_001.P	Sn107 T2 still duff. Bad buffers patched .P file.

Table 1 : VMP6000 deployments

Table 2 gives the probe serial numbers used with the two VMP6000, serial numbers SN016 and SN107.

SN 016								
She1	She2	Temp1	Temp2	uCond	SBET	SBEC	Date	Comments

M396	M399	T383	T765	C98	35916	43490	29-05-2016	
M390	M395	T383	T617	C97			12-06-2016	Swapped from sn107
		T617	T383	C101			14-06-2016	
SN 107								
She1	She2	Temp1	Temp2	uCond	SBET	SBEC	Date	Comments
M390	M395	T377	T617	C97	32634	44245	29-05-2016	
		T383					08-06-2016	
M713	M722	T1165	T1166	C100			17-06-2016	New sensor set as sn016 is still live
		T1166	T1165				21-06-2016	swapped over after T2 looked dodgy
M395	T617	T617	T383	C101			23-06-2016	Swapped in sn016 sensors after hitting seabed station D03a
				C100			24-06-2016	
			T1168				26-06-2016	T2 swapped post N4a
		T1168	T617				27-06-2016	T1/T2 swapped round as T2 still not working post N5a

Table 2 : VMP6000 (serial numbers SN016 and SN107) probe serial numbers

7.3 VMP 2000 (tethered)

A total of 83 casts were conducted, 79 of which have good data. Table 3 gives general information on VMP2000 stations. The only type of issues encountered was a sudden increase number of bad buffers. It appeared to be linked with wire damage (too much tension, twisting, ...). Each time, NMF technicians droped out several tens of meters of wire and reterminated it. The overall time for this operation is 1.5h (taking VMP out of water, opening, reterminating, replugging the wire, tighting VMP, redeployment). This solved the problem for the following dozens of casts.

Station (CTD)	**Latitude (N)**	**Longitude (W)**	**Date/Time (GMT)**	**Casts**	**Max Pressure (dbar)**	**Comments**
R1 (009)	36 13.2	32 45.4	06/06/2016 07:00 – 07/06/2016 08:00	02 – 28	1769	25hr super station timeseries
R4 (013)	34 50.925	36 01.175	08/06/2016 18:40	1	1292	same location as vmp 6000
D7 (050)	35 15.522	47 08.196	10/06/2016 17:57	01 – 02	1296	same location as station D7 test dips prior to 25hr super station

D3 (055)	35 58.947	43 16.224	22/06/2016 17:24 – 23/06/2016 13:01	01 – 24	1749	25hr super station. First 12hr to 800m second to 1600m. Break to recover VMP6000 after first 12.5 hr. Bad buffers cast 20. Cast 21 aborted. Then bad buffers reported from cast 22 onwards. Station terminated early due to excessive bad buffers in cast 24
R1a (064)	36 14.871	32 46.019	28/06/2016 04:52 – 18:33	01 – 20	862	12 hr super station shallow casts. Bad buffers reterminated after cast 9 then clear.
R1b (065)	36 13.667	32 42.077	29/06/2016 07:49 – 19:10	01 – 09	1586	12 hr super station repeat deep casts. 6 badn buffers cast 3.

Table 3 : VMP2000 deployments

Table 4 gives the sensors serial numbers used with VMP2000.

She1	She2	Temp1	Temp2	SBET	SBEC	Date
M400	M540	T382	T858	5776	4169	29—05-2016

Table 4 : VMP2000 sensors serial numbers

7.4 Processing

All processing scripts used on this cruise were adaptations of those used in previous VMP cruises by the NOCS group. A summary of the processing steps is given below :

Function	**Description**
vmp_firstlook4 (upgraded by Alex to v4)	Produces a series of diagnostic plots for the raw un-calibrated VMP data (from XXX.P, produces XXX.mat) and calibrates data (XXX_cal.mat)
vmp_process_seabird3	Processes the VMP seabird data and applies various corrections (despike, filter, ...). Output is saved as a separate matlab file, XXX_dCTD.mat and XXX_uCTD.mat for VMP2000. (d : downcast, u: upcast)
vmp_process_micro4 (upgraded by Alex to v4)	Processes the VMP microstructure shear, temperature and conductivity. Microstructure temperature and conductivity are calibrated by regressing against the processed VMP seabird temperature and conductivity. Output is saved as a separate matlab file, XXX_micro.mat.

7.5. Early results

Figure 2 shows the kinetic energy dissipation measured by VMP6000. We are pleased to notice the sharp contrast between the *on ridge* regime where dissipation is rather strong (epsilon~1e-9-1e-8 W/kg, stations R01-R24) and the *off ridge* regime where dissipation is much lower (epsilon~1e-11-1e-10 W/kg, stations D02-D18).

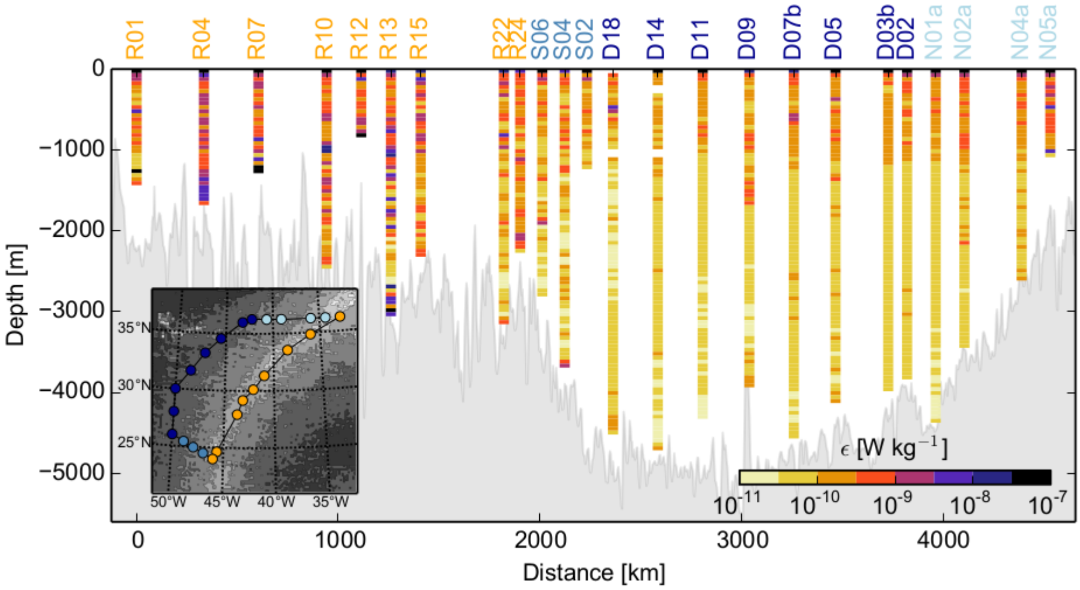


Figure 2: Kinetic energy dissipation from VMP6000 measurements. Stations in the top x-axis are reported in Figure 1.

8. Lowered Acoustic Doppler Current Profiler (LADCP)

Alex Forryan (University of Southampton)

8.1 Instrument and Configuration

For all CTD casts, two RDI 300kHz Workhorse LADCP units were fitted to the CTD frame one in a downward-looking orientation the other upward-looking. Each LADCP was configured to have 25 x 8 m bins, a 0 m blank-to-surface, one ping per ensemble, and two ensembles per burst in narrowband mode. Data were collected in beam coordinates. The LADCP command configuration files are included in Appendix 1.

Parameter	Description
WM15	water mode 15 (LADCP)
TC2	ensembles per burst
LP1	pings per ensemble
TB 00:00:02.80	time per burst
TE 00:00:01.30	time per ensemble
TP 00:00.00	time between pings
LN25	number of depth cells
LS0800	bin size [cm]
LF0	blank after transmit [cm]
LW1	narrow bandwidth LADCP mode
LV400	ambiguity velocity [cm/s]
SB0	disable hardware-break detection on Channel B (ICN118)
EZ0011101	Sensor source: - manual speed of sound (EC) - manual depth of transducer (ED = 0 [dm]) - measured heading (EH) - measured pitch (EP) - measured roll (ER) - manual salinity (ES = 35 [psu]) - measured temperature (ET)
EX00100	Coordinate transformation: - radial beam coordinates (2 bits) - use pitch/roll (not used for beam coords?) - no 3-beam solutions - no bin mapping
CF11101	Flow control: - automatic ensemble cycling (next ens when ready) - automatic ping cycling (ping when ready) - binary data output - disable serial output - enable data recorder

Table 1: JR15007 LADCP configuration parameters

8.2 LADCP Deployments

Stn.	CTD	Date	Time (GMT)	Lon. (oE)	Lat. (oN)	Max Press. (dbar)	RDI Master file	Comments
	1	30/May/2016	10:27	-49.8625	25.34	3048	JR294_001_m.000	test station
N1	2	03/Jun/2016	05:17	-39.9927	36.247	1152	JR294_002_m.000	Duff uplooker (broken beam 2)

N2	3	03/Jun/2016	15:12	-38.9922	36.252	3576	JR294_003_m.000	Uplooker replaced.
N3	4	04/Jun/2016	01:00	-36.0033	36.247	1160	JR294_004_m.000	
N4	5	04/Jun/2016	09:45	-36.995	36.2472	2800	JR294_005_m.000	
N6	6	04/Jun/2016	17:24	-34.0078	36.2417	1160	JR294_006_m.000	
N7	7	04/Jun/2016	23:47	-33.0037	36.2473	1960	JR294_007_m.000	
N8	8	05/Jun/2016	07:31	-32.099	36.2322	2288	JR294_008_m.000	
R1	9	05/Jun/2016	23:19	-31.237	36.221	2320	JR294_009_m.000	Super station start
R1	10	07/Jun/2016	09:18	-31.05	36.1143	1160	JR294_010_m.000	Super station end
R2	11	08/Jun/2016	02:32	-33.885	35.6768	1144	JR294_011_m.000	
R3	12	08/Jun/2016	08:59	-34.9578	35.2757	1152	JR294_012_m.000	
R4	13	08/Jun/2016	16:18	-35.9558	34.852	1728	JR294_013_m.000	
R5	15	09/Jun/2016	07:14	-36.9865	34.45	1152	JR294_015_m.000	
R5	16	09/Jun/2016	14:01	-37.9998	34	1144	JR294_016_m.000	
R6	17	09/Jun/2016	21:17	-37.3673	33.441	1336	JR294_017_m.000	
R7	18	10/Jun/2016	05:34	-38.5887	32.7167	1128	JR294_018_m.000	
R8	19	10/Jun/2016	13:00	-39.7278	31.992	1096	JR294_019_m.000	
R9	20	10/Jun/2016	20:29	-39.0013	31.3357	2632	JR294_020_m.000	
R10	21	11/Jun/2016	11:22	-40.2483	30.6675	1144	JR294_021_m.000	
R11	22	11/Jun/2016	16:37	-41.8822	30.125	992	JR294_022_m.000	
R12	23	11/Jun/2016	22:49	-41.3552	29.6478	2480	JR294_023_m.000	
R13	24	12/Jun/2016	05:52	-42.8275	29.1697	3064	JR294_024_m.000	
R14	25	12/Jun/2016	13:28	-42.654	28.5172	1120	JR294_025_m.000	
R15	26	12/Jun/2016	19:24	-42.2915	27.9302	2384	JR294_026_m.000	
R17	27	13/Jun/2016	09:34	-43.7815	27.0373	1120	JR294_027_m.000	
R19	28	13/Jun/2016	21:40	-43.1732	26.1368	3632	JR294_028_m.000	
R21	29	14/Jun/2016	06:22	-44.7595	25.2802	1112	JR294_029_m.000	
R22a	30	14/Jun/2016	14:31	-44.3797	24.6402	1104	JR294_030_m.000	Both units look suspect
R24	32	14/Jun/2016	21:15	-44.0003	24	648	JR294_032_m.000	shallow pre-SAPS
R24	33	15/Jun/2016	03:54	-44.004	24.0047	2640	JR294_033_m.000	
S6	34	15/Jun/2016	12:59	-45.0605	24.4877	656	JR294_034_m.000	

S6	35	15/Jun/2016	14:45	-45.0627	24.4928	3872	JR294_035_m.000	Up-looker data in downlooker detected (and vice versa)
S4	36	16/Jun/2016	00:36	-46.092	24.9632	648	JR294_036_m.000	
S4	37	16/Jun/2016	02:25	-46.0955	24.9693	3984	JR294_037_m.000	
S2	38	16/Jun/2016	12:31	-47.1345	25.4467	656	JR294_038_m.000	
S2	39	16/Jun/2016	13:53	-47.1407	25.4458	4440	JR294_039_m.000	
D18	40	17/Jun/2016	00:12	-49.9988	26.0003	648	JR294_040_m.000	
D18	41	17/Jun/2016	05:42	-49.9985	25.9958	4896	JR294_041_m.000	
D16	42	17/Jun/2016	17:06	-48.0007	26.9998	1136	JR294_042_m.000	
D14	43	18/Jun/2016	00:36	-48.0047	27.9965	4760	JR294_043_m.000	
D12	44	18/Jun/2016	10:30	-48.0002	29.0005	1136	JR294_044_m.000	
D11	45	18/Jun/2016	18:19	-48.0002	30	5256	JR294_045_m.000	
D11	46	18/Jun/2016	23:06	-48.0082	29.9982	648	JR294_046_m.000	
D10	47	19/Jun/2016	10:21	-48.6992	30.8305	1136	JR294_047_m.000	
D09	48	19/Jun/2016	18:25	-47.4542	31.6657	4648	JR294_048_m.000	
D08	49	20/Jun/2016	04:38	-46.1733	32.4867	1152	JR294_049_m.000	
D07	50	20/Jun/2016	13:39	-46.862	33.2718	4808	JR294_050_m.000	
D07	51	20/Jun/2016	22:11	-46.8577	33.2645	680	JR294_051_m.000	
D06	52	21/Jun/2016	10:04	-45.5095	34.0005	1160	JR294_052_m.000	
D05	53	21/Jun/2016	17:30	-44.47	34.5547	4576	JR294_053_m.000	
D04	54	22/Jun/2016	04:44	-43.582	35.2353	1168	JR294_054_m.000	
D03	55	22/Jun/2016	13:32	-42.7325	36.0047	4200	JR294_055_m.000	
D03	56	23/Jun/2016	21:47	-42.7375	36.0007	696	JR294_056_m.000	
D02	57	24/Jun/2016	11:22	-41.7387	36.2652	3992	JR294_057_m.000	
N1a	58	24/Jun/2016	23:04	-39.3247	36.2475	4392	JR294_058_m.000	
N2a	59	26/Jun/2016	04:23	-38.9078	36.2433	3504	JR294_059_m.000	
N3a	60	26/Jun/2016	15:55	-36.493	36.2505	3536	JR294_060_m.000	
N4a	61	27/Jun/2016	03:40	-34.0753	36.2435	2656	JR294_061_m.000	
N5a	62	27/Jun/2016	14:40	-33.6553	36.2353	1440	JR294_062_m.000	
R1a	64	28/Jun/2016	01:30	-31.2422	36.243	2232	JR294_064_m.000	
R1a	65	28/Jun/2016	20:12	-31.2902	36.2185	2400	JR294_065_m.000	
R1a	66	28/Jun/2016	23:47	-31.2898	36.226	672	JR294_066_m.000	
R1a	67	01/Jul/2016	10:02	-31.2228	36.244	2280	JR294_067_m.000	

Table 2: JR15007 LADCP deployments

8.3 Data Processing

RDI format binary files, recorded by the instrument, were downloaded after each cast and stored with the corresponding pre-deployment test log files. All data were processed using the latest version of the Lamont-Doherty Earth Observatory (ldeoIX) software which calculates velocities using an inverse method. This package was also used to monitor the health of the beams on the instrument.

Navigation data, for use in the processing, were extracted from the SCS data stream for the ship's primary GPS positional system the Seatex Seapath 320+ (seatex-gga.ACO). Data from the ship mounted ADCP was averaged in into station mean profiles for all casts. CTD data was extracted from the raw SeaBird .hex files, corrected for cell thermal mass, filtered to remove noise, and averaged into one second bins.

Parameters changed from the ldeoIX default values were set in the *set_cast_params.m* script and are given below:

Parameter Setting	Description
p.cut = 20;	Ignore data above 20 db
p.edit_mask_dn_bins = [1]; p.edit_mask_up_bins = [1];	Disregard data from 1st bin as blank-to-surface is set to zero

fname = ['Postimes/postime' stnstr];
postime = load(fname);
autocat = 1;
intlat = postime(4);
intlon = postime(6);
p.drot = magdev(intlat,intlon);
	Calculate magnetic deviation using matlab script magdev.m using lat. lon. from postime file constructed from CTD NMEA data.

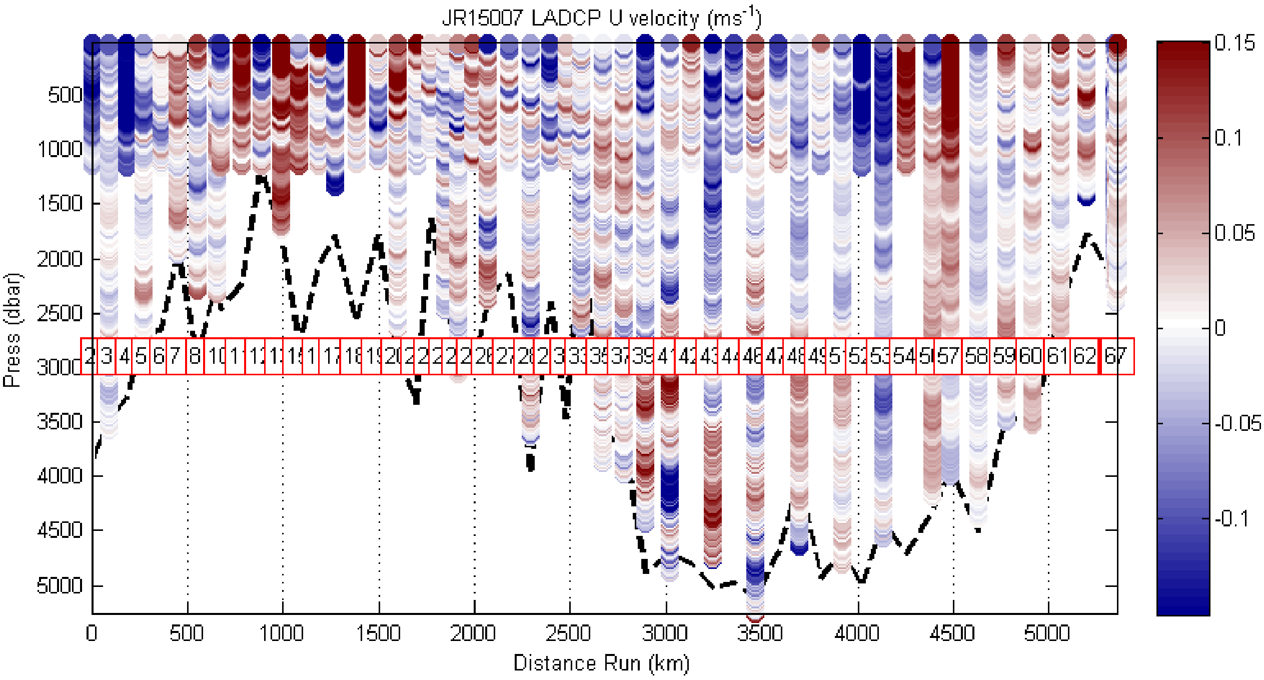
p.nav_error = 30	Allowable error in navigation (30 m)
p.navtime_av = 2/60/24	Average navigation data into 2 minute bins
ps.shear = 1	Calculate a shear solution
ps.std_weight = 1	Use super ensemble to weight data
ps.sadcpfac = 1	Give equal weight to vmadcp
ps.shear_stdf = 2	Average shear over two standard deviations
ps.dz = 8	8 m vertical resolution for profiles
ps.outlier = 1	Remove 1% of outlier data after solution

Table 3: Changes to ldeoIX parameters used on JR15007

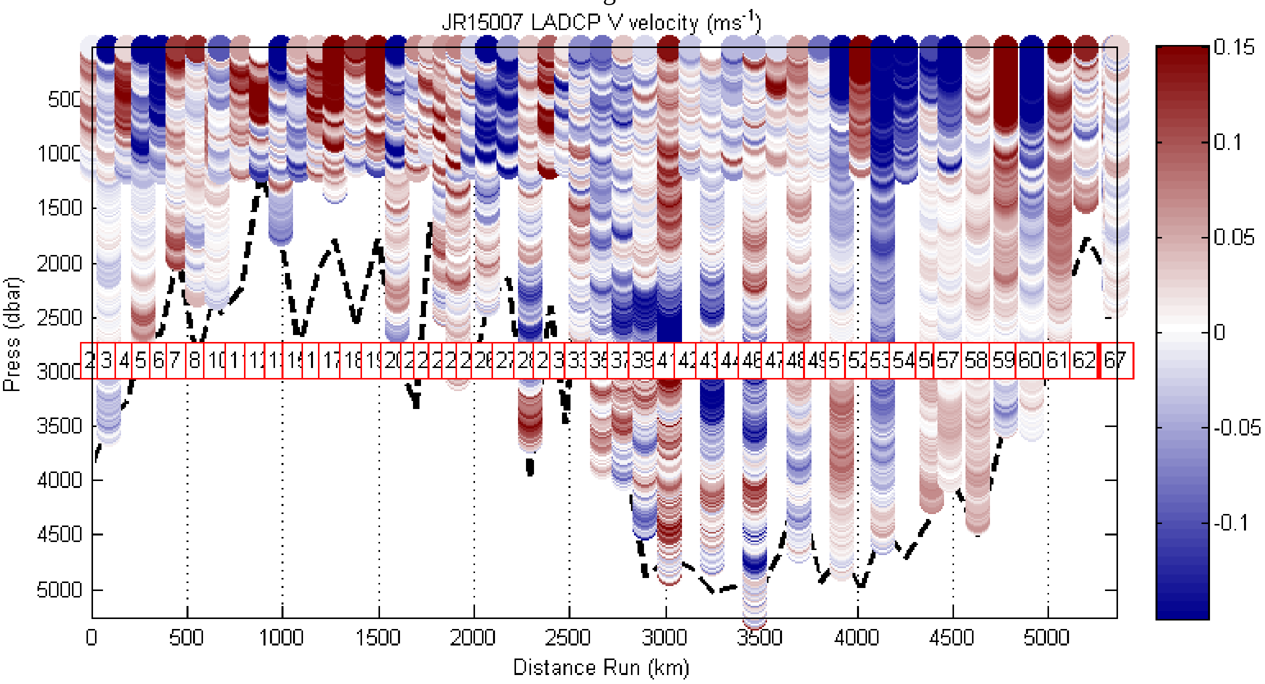
8.4 Results

Both LADCP units preformed well throughout the cruise. Calculated velocities appeared plausible and corresponded well with velocity estimates from the VMADCP.

Figure



Figure



Appendix 1 LADCP Command Files

Master

```
CR1
RN JR15007M
WM15
TC2
LP1
TB 00:00:02.80
TE 00:00:01.30
TP 00:00.00
LN25
LS0800
LF0
LW1
LV400
SM1
SA011
SB0
SW5500
SI0
EZ0011101
EX00100
CF11101
CK
CS
$l
```

Slave

```
CR1
RN JR15007S
WM15
LP1
TP 00:00.00
TE 00:00:00.00
LN25
LS0800
LF0
WB1
LW1
LV400
SM2
SA011
SB0
EZ0011101
EX00100
CF11101
CK
CS
$l
```

9. Vessel Mounted Acoustic Doppler Current Profiler (VMADCP)

Alex Forryan (University of Southampton)

9.1 Instrument and configuration

The ADCP mounted on the JCR is a 75 kHz RD Instruments Ocean Surveyor (OS75, model 71A- 1029-00, SN 2088), which can measure water velocity down to roughly 1000 m below the surface. However, in practice, usable measurements typically reach up to 800 m below the surface. The OS75 uses a phased array transducer that produces all four beams from a single aperture at specific angles. Because of the way that the beams are formed, horizontal velocities can be estimated independently from the speed of sound (this is not true for vertical velocities, which still require sound speed). The OS75 unit on the JCR (installed August 2005) is located in the transducer space in the hull, the typically assumed value for the transducer depth, used on JR15007, is 6.3 m.

Configuration of the VMADCP was set using one of the JCR standard VMADCP command files, included in Appendix 1, using the VmDas ADCP control software. The VMADCP was configured with a maximum depth of 800 m, 100 x 8 m bins, 8 m surface-blanking distance and, ping rate set independently from the SIMRAD Synchronization Unit (SSU), i.e. the OS75 was set to use its own internal ping rate. The misalignment angle was set to 60.08°.

Parameter	Description
CR1	Restore the ADCP to factory default settings
CB611	Set the data collection baud rate to 38400, no parity, 1 stop bit, 8 data bits
NP1	Switch on narrowband mode
NN100	When in narrowband mode, use 100 bins
NS0800	When in narrowband mode, use 8 m bins
NF0800	When in narrowband mode, use 8 m blanking depth
W*	Broadband options [not used on this cruise]
BP00	Disable bottom tracking
BX8000	Set maximum bottom search depth to 800 m (only used when bottom tracking is on)
WD111100000	Tells VmDas to output velocity, correlation, echo intensity, and percent good
TP000050	Allow half a second between bottom and water pings
TE00000100	Allow one second between ensembles (this is overridden by VmDas)
EZ1020001	Calculate the speed of sound, no depth sensor, external synchro heading sensor, no pitch or roll used, no salinity sensor, use internal transducer temperature sensor
EX00000	Tells VmDas to output beam coordinate data (rotations are done in software)
EA6008	Set transducer misalignment to 60.08°
ED00063	Set transducer depth (6.3 m on the JCR)
ES0	Set salinity (ppt) [salinity is zero in the transducer well]
CX0,0	Disable external trigger (e.g. from K-Sync or SSU)

Table 4: JR15007 VMADCP Parameter settings.

VmDas creates data files containing ship navigation data, raw instrument data, and other logging information. The nine different types of file produced by VmDas are:

- .VMO VmDas configuration file (ASCII)
- .LOG log of ADCP communication and VmDas error (ASCII)
- .ENR beam coordinate single-ping raw data (binary)
- .ENX Earth coordinate single-ping data (binary)
- .LTA Earth coordinate long-term averaged data (binary)
- .STA Earth coordinate short-term averaged data (binary)
- .NMS navigation and attitude data (binary)
- .N1R navigation data from the ship's Seatex GPS system (ASCII)

VmDas uses the same file naming convention for each file type: CRUISExxx_000nnn.aaa, where CRUISE is the cruise name (in this case, JR15007), "xxx" is the ensemble number, "nnn" the file sequence number, and "aaa" is the file format (e.g. N1R, LOG). A new set of files is created each time VmDas is started and the ensemble number incremented, a new file is also created if the file size goes above 10 Mb when the sequence number is incremented.

9.2 VMADCP File Summary

Date	Time (GMT)	Filename	Seq. No.	Comments
25/05/16	21:37:00	JR15007002	00 to 03	250 m max depth bottom track on (not used)
28/05/16	11:40:00	JR15007031	00 to 29	800 m max depth no bottom track. Test station
01/06/16	13:33:00	JR15007032	00 to 10	
03/06/16	01:33:00	JR15007033	00 to 07	Stations N1 – N3
04/06/16	02:07:00	JR15007034	00 to 07	Stations N4 – N6
05/06/16	02:35:00	JR15007035	00 to 07	Stations N7 – N8
06/06/16	03:10:00	JR15007036	00 to 13	Station R1
07/06/16	22:58:00	JR15007037	00 to 08	Stations R2 - R4
09/06/16	02:02:00	JR15007038	00 to 06	Stations R5 – R7
10/06/16	00:30:00	JR15007039	00 to 08	Stations R8 – R10
11/06/16	03:48:00	JR15007040	00 to 06	Stations R11 – R13
12/06/16	01:00:00	JR15007041	00 to 05	Stations R14 – R15
13/06/16	23:30:00	JR15007042	00 to 06	Stations R17 – R19
14/06/16	00:57:00	JR15007043	00 to 06	Stations R21 – R24
15/06/16	07:07:00	JR15007044	00 to 07	Stations S6 – S4
16/06/16	06:47:00	JR15007045	00 to 11	Stations S2 – D 16
17/06/16	21:14:00	JR15007046	00 to 09	Stations D14 – D11
19/06/16	05:56:00	JR15007047	00 to 05	Stations D10 – D09
19/09/16	23:15:00	JR15007048	00 to 09	Stations D08 – D07

21/06/16	05:20:00	JR15007049	00 to 04	Stations D06 – D05
21/06/16	21:36:00	JR15007050	00 to 07	Stations D04 – D03 (part)
23/06/16	09:02:00	JR15007051	00 to 06	Remainder of D03
24/06/16	06:20:00	JR15007052	00 to 07	Stations D02 – N1a
25/06/16	03:32:00	JR15007053	00 to 08	Station N2a
26/06/16	08:40:00	JR15007054	00 to 04	Station N3a
26/06/16	23:29:00	JR15007055	00 to 05	Stations N4a & N5a. Concatenated N1R files.
27/06/16	21:31:00	JR15007056	00 to 16	Station R1 (repeat) up to mooring recovery
30/06/16	00:20:00	JR15007057	00 to 09	Mooring recovery plus extra CTD

Table 5: VMADCP file emsembles recorded during JR15007

9.3 Data Processing

The data recorded by OS75 via VmDas software needs to be post-processed through a set of matlab scripts to quality check the data and to calibrate the ADCP misalignment angle and amplitude factors. A brief description of what the Matlab code does during post-processing is given below (for more detailed descriptions of each m-file, refer to cruise report JR235/236/239).

1. Read the selected .ENX files (Earth coordinate single-ping data; binary) and .N1R files (navigation data; ASCII) into Matlab.
2. Remove missing data and data with bad navigation.
3. Merge single-ping ADCP data with Seapath attitude data.
4. Correct for transducer misalignment and velocity scaling error.
5. Derive ship velocity from Seapath navigation data.
6. Perform quality control, such that only the four-beam solution is permitted. Quality control also screens data based on maximum heading change between pings, maximum velocity change between pings, and the error velocity.
7. Average the data into ensembles (120 seconds for JR15007).
8. Calculate transducer misalignment and velocity scaling error.
9. Discard velocities from depths deeper than 86% of the bottom-tracking depth (i.e. set to missing).
10. Determine water velocities (referred to as "absolute velocities") from either bottom-track ship velocity or Seapath GPS (usually the latter).
11. Plot eastward and northward velocities.

The final data is stored in Matlab format (*.mat). Below is a brief description of the output files:

Filename	Description
JR15007_cal_pts_wt.mat	Contains misalignment angle (phi) and amplitude scaling (scaling) statistics.
JR15007xxx_000nnnd_att.mat	Contains ship's attitude data
JR15007xxx_000nnn_raw.mat	Contains ensemble-averaged data and absolute velocities
JR15007xxx_000nnn_sgl_ping.mat	Contains single-ping data in a structured array

JR15007xxx_bad_nav.mat	Contains counts of bad navigation points
JR15007xxx_bad_heading.mat	Contains counts of bad heading points
JR15007000_000000_xxx_abs.mat	Contains absolute horizontal velocity (i.e. water velocity) navigation data and bin depths.

Table 6: Description of VMADCP processing output files for JR15007

Misalignment angle and amplitude factors were estimated using water track calibration over the duration of the cruise (approximately 30 days). The estimated values for both misalignment angle and amplitude factors appeared to be stable through time, consequently only a single value was used for each parameter during the processing (-0.894 misalignment ; 1.011 amplitude).

Parameters	Mean	Median	Standard Deviation
Misalignment angle	1.010656	1.010821	0.007754
Amplitude factor	-0.8935	-0.8938	0.4452

Table 7: Calibration parameters estimated using water track for JR15007

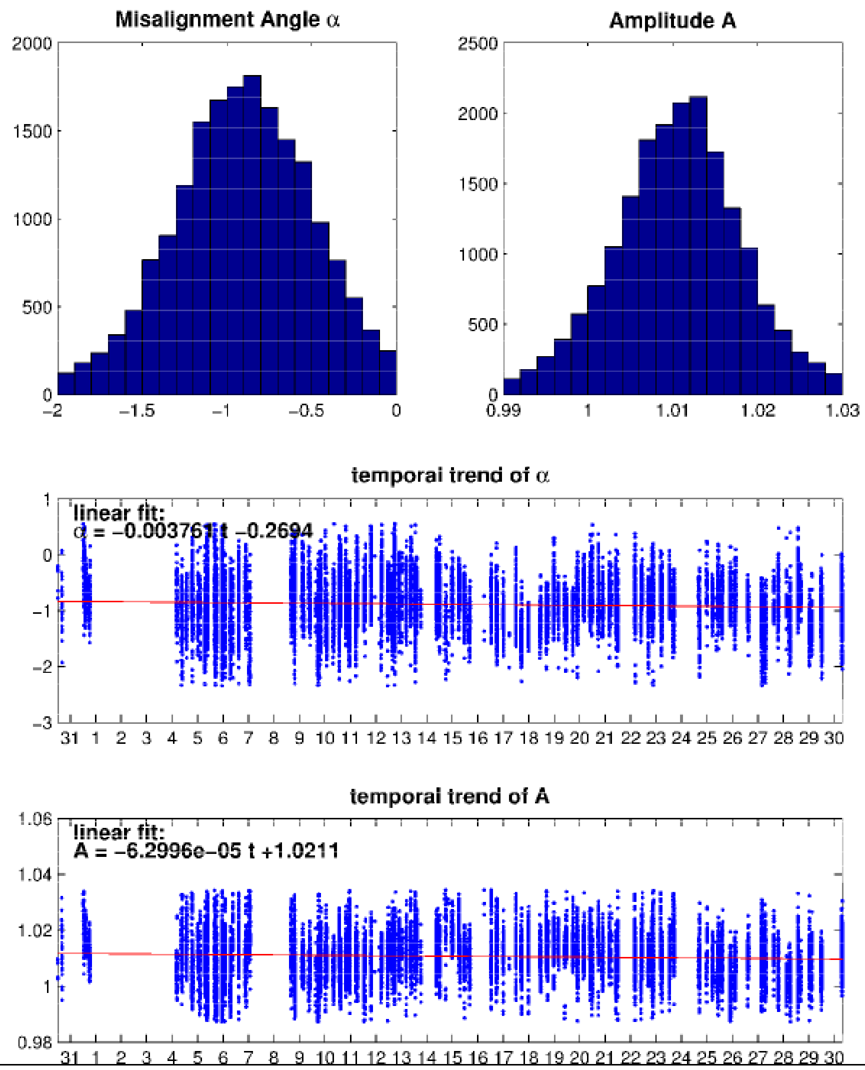
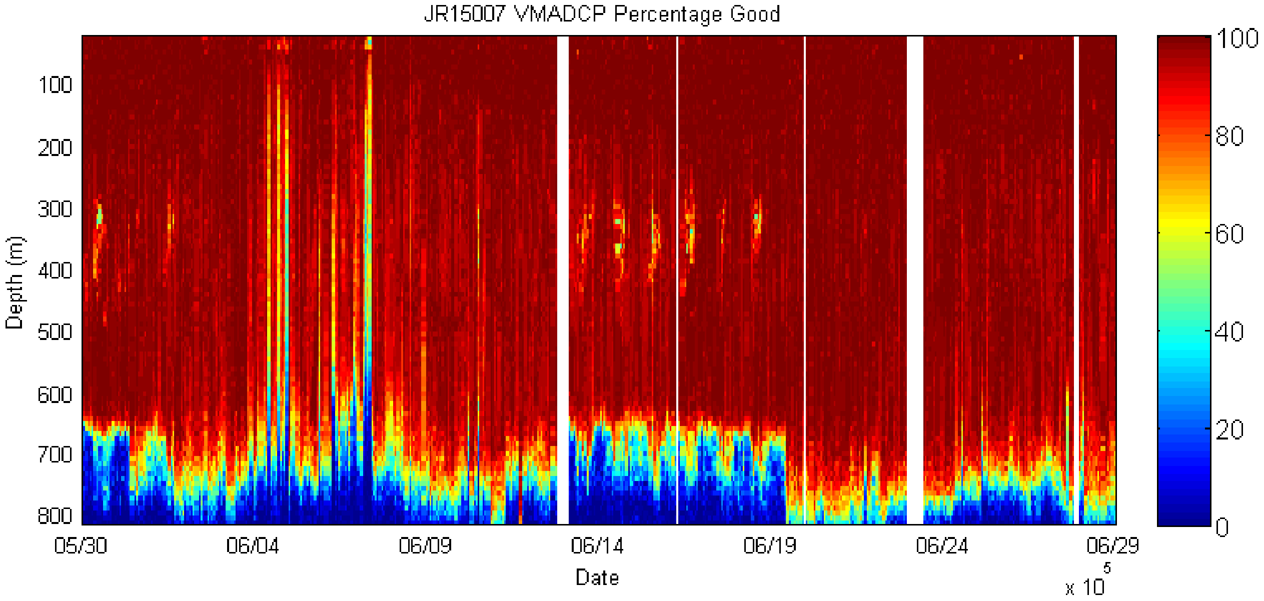


Figure 7: Statistics and temporal trend for VMADCP misalignment angle and amplitude factor estimated using water track calibration during JR15007.

9.4 Results

The VMADCP appeared to perform well throughout the cruise, with respectable percentage good values (mostly in excess of 80%) down to depths of approximately 700 m.

Figure



Periods longer than 10 minutes when no VMADCP was processed, due to quality issues, are detailed below.

Start Time (GMT)	End Time (GMT)	Duration (hrs)
12-Jun-2016 18:32:31	13-Jun-2016 03:36:29	9.07
22-Jun-2016 23:10:30	23-Jun-2016 09:04:29	9.90
27-Jun-2016 17:18:32	7-Jun-2016 21:32:30	4.23

Table 8: Periods of VMADCP dropout for JR15007

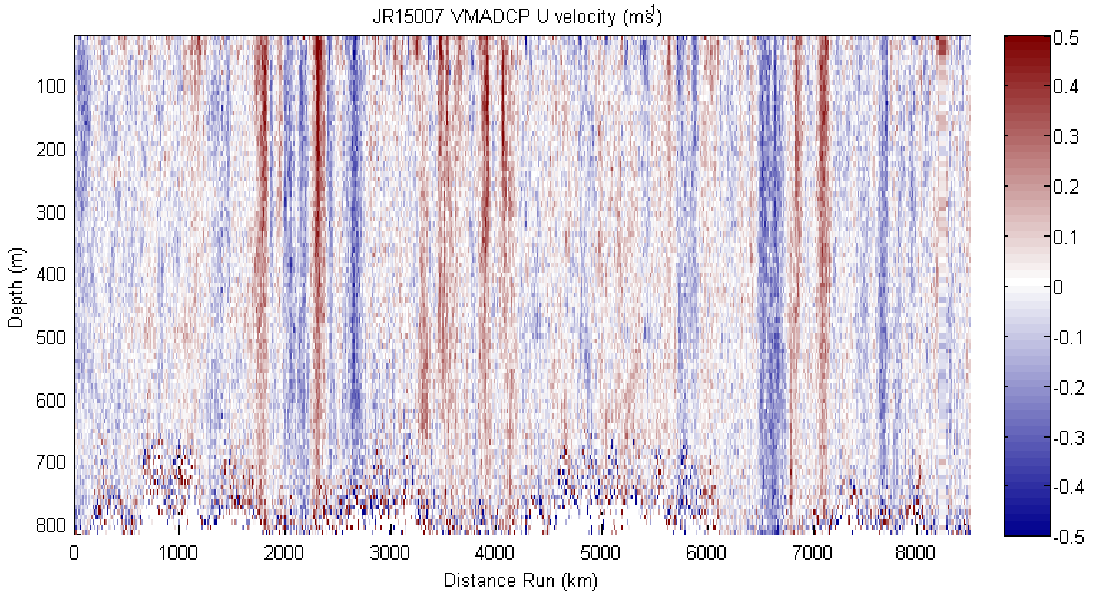


Figure 9: VMADCP U velocity (ms^{-1}) recorded during JR15007.

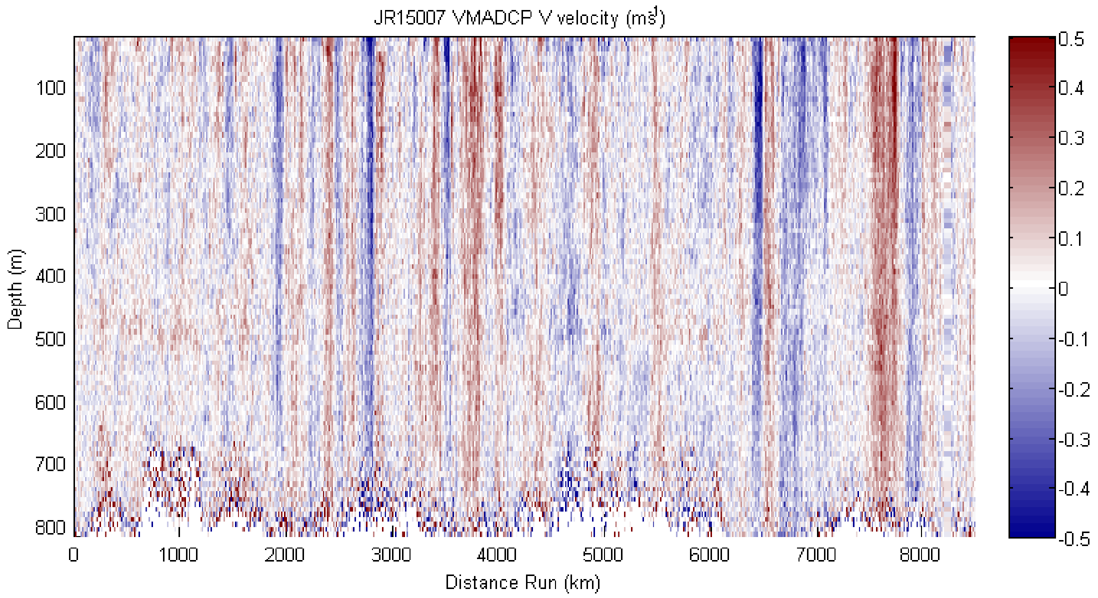


Figure 10: VMADCP V velocity (ms^{-1}) recorded during JR15007

Appendix VMADCP command file

```
;--------------------------------------------------------------------------
---\
; ADCP Command File for use with VmDas software.
;
; ADCP type:     75 Khz Ocean Surveyor
; Setup name:    default
; Setup type:    High resolution, short range profile(broadband)  500 m
;
; NOTE:  Any line beginning with a semicolon in the first
;        column is treated as a comment and is ignored by
;        the VmDas software.
;
; NOTE:  This file is best viewed with a fixed-point font (e.g. courier).
; Modified Last: 13January2006 (for JR141: routing through the SSU)
;--------------------------------------------------------------------------
--/

; Restore factory default settings in the ADCP
cr1

; set the data collection baud rate to 38400 bps,
; no parity, one stop bit, 8 data bits
; NOTE:  VmDas sends baud rate change command after all other commands in
; this file, so that it is not made permanent by a CK command.
cb611

; Set for broadband single-ping profile mode (WP), one hundred (WN) 8 meter
bins (WS),
; 8 meter blanking distance (WF), 390 cm/s ambiguity vel (WV)

; Switch off Narrowband NP0
NP1
nn100
ns800
nf0800

; Switch on Broadband  WP1

WP000
WN100
WS800
WF0800

WV390

; Enable single-ping bottom track (BP),
; Set maximum bottom search depth to 1000 meters (BX)
BP00
BX10000

; output velocity, correlation, echo intensity, percent good
WD111100000

; Two seconds between bottom and water pings
TP000050
```

```
; Three seconds between ensembles
; Since VmDas uses manual pinging, TE is ignored by the ADCP.
; You must set the time between ensemble in the VmDas Communication options
TE00000100

; Set to calculate speed-of-sound, no depth sensor, external synchro
heading
; sensor, no pitch or roll being used, no salinity sensor, use internal
transducer
; temperature sensor
EZ1020001

; Output beam data (rotations are done in software)
EX00000

; Set transducer misalignment (hundredths of degrees)
EA6008

; Set transducer depth (decimeters) [= 6.3m on JCR]
ED00063

; Set Salinity (ppt) [salinity in transducer well = 0]
ES0

; Set Trigger In/Out [ADCP run through SSU]
CX0,0

; save this setup to non-volatile memory in the ADCP
CK
```

10. Inorganic Nutrients

Robyn Tuerena (University of Liverpool)

Objectives:

The spatial variations in the micro-molar nutrient species nitrate, nitrite, phosphate, and silicate will be used to determine whether enhanced mixing over changes in topography affect their distributions on isopycnals through the water column.

The nutrient data will be used to produce diapycnal and advective nutrient fluxes within the thermocline, which combined with turbulence measurements, will be used to determine the downstream implications of nutrient mixing in supporting localised and gyre-wide productivity.

Sampling and methodology:

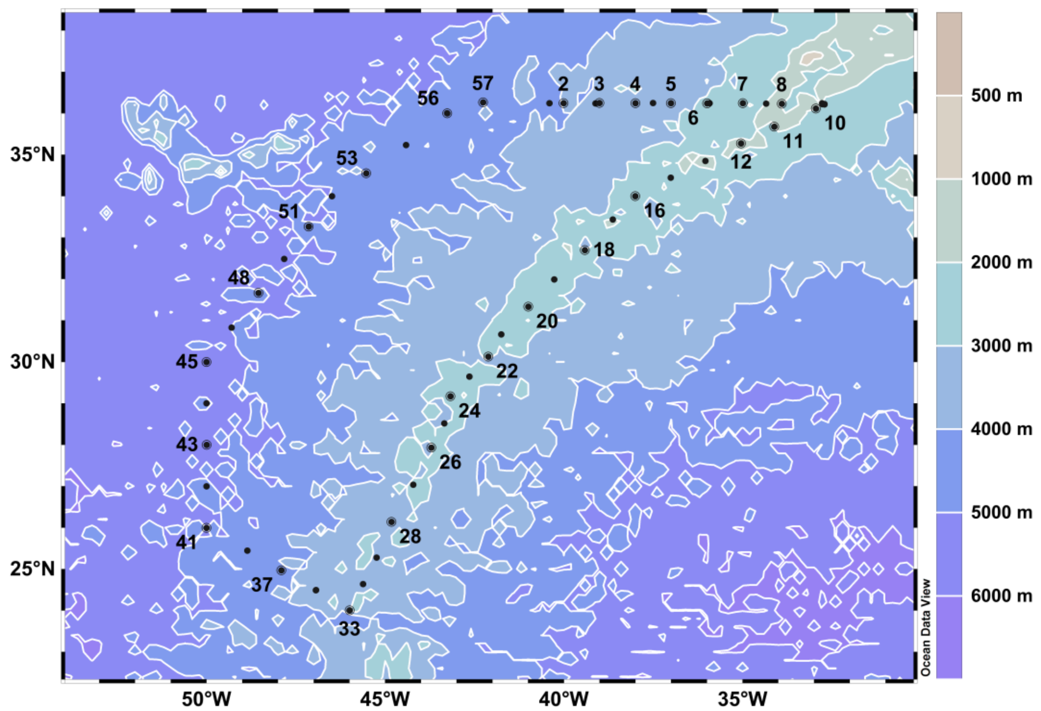
Micro-molar nutrient analysis was carried out using a 4 channel (nitrate (Brewer & Riley, 1965), nitrite (Grasshoff, K., 1976), phosphate, silicate (Kirkwood, D.S., 1989) Bran & Luebbe AAIII segmented flow, colourimetric, auto-analyser. Established, proven analytical protocols were used. Water samples were taken from a 24 x 20 litre bottle stainless steel framed CTD / Rosette system (Seabird), every depth was sampled from each CTD cast. These were sampled into clean (acid-washed) 60ml HDPE (Nalgene) sample bottles, which were rinsed x3 with sample seawater prior to filling.

References:

Brewer & Riley, 1965. The automatic determination of nitrate in seawater. *Deep Sea Research*, 12: 765-772

Grasshoff, K., 1976. Methods of sea-water analysis, *Verlag Chemie*, Weiheim: pp.317.

Kirkwood, D.S. 1989. Simultaneous determination of selected nutrients in sea-water, *ICES CM* 1989/C:29



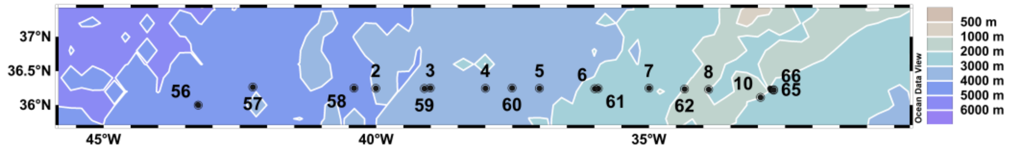


Figure 1. CTD locations through the Ridgemix cruise. Top panel: CTD sampling started at the Northwest corner and continued in a clockwise direction. Bottom panel: The northern transect was completed twice, once at the start of the transect (CTDs 2-10) and once at the end (CTDs 57-67).

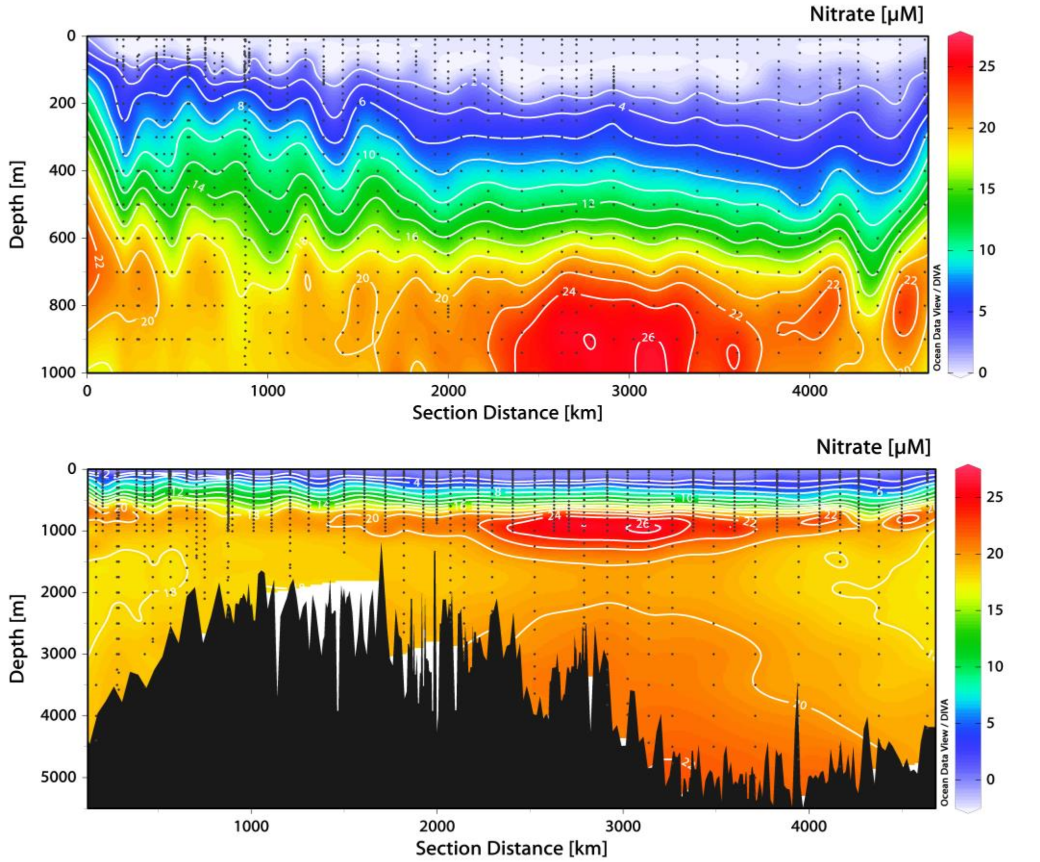


Figure 2. Nitrate concentrations (µmol L^{-1}) across the Ridgemix transect (a. 1000m, b.full water column).

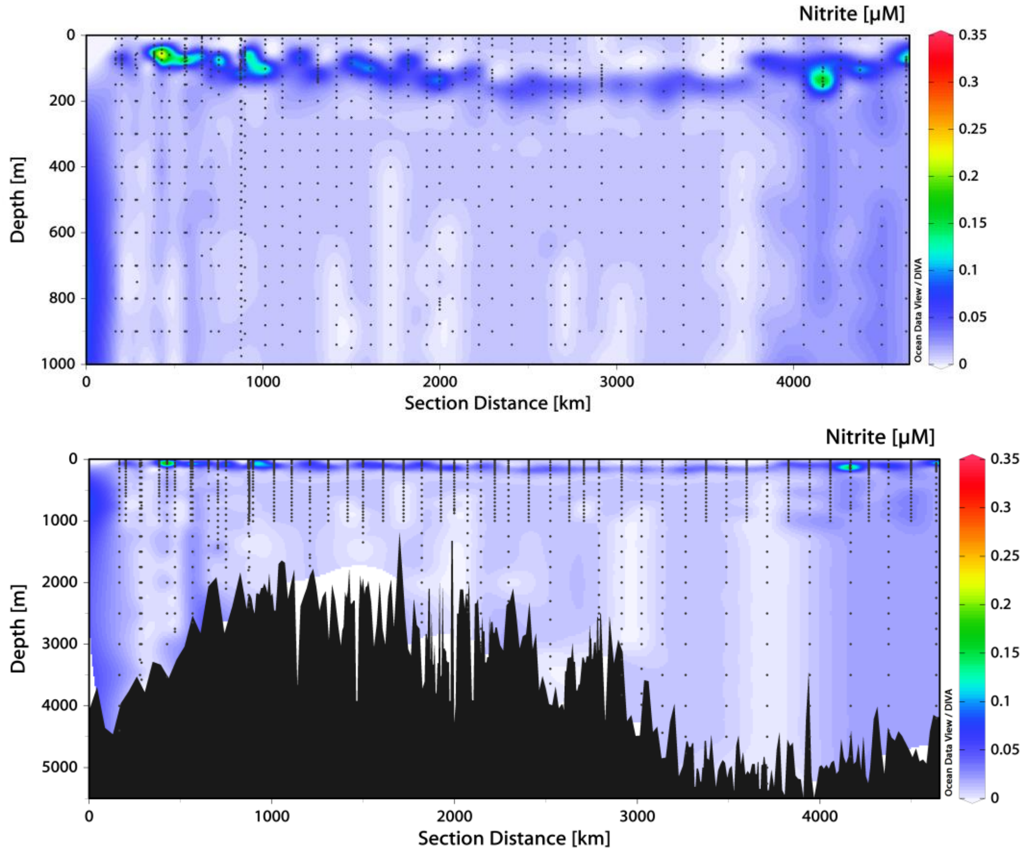


Figure 3. Nitrite concentrations (µmol L-1) across the Ridgemix transect (a. 1000m, b.full water column).

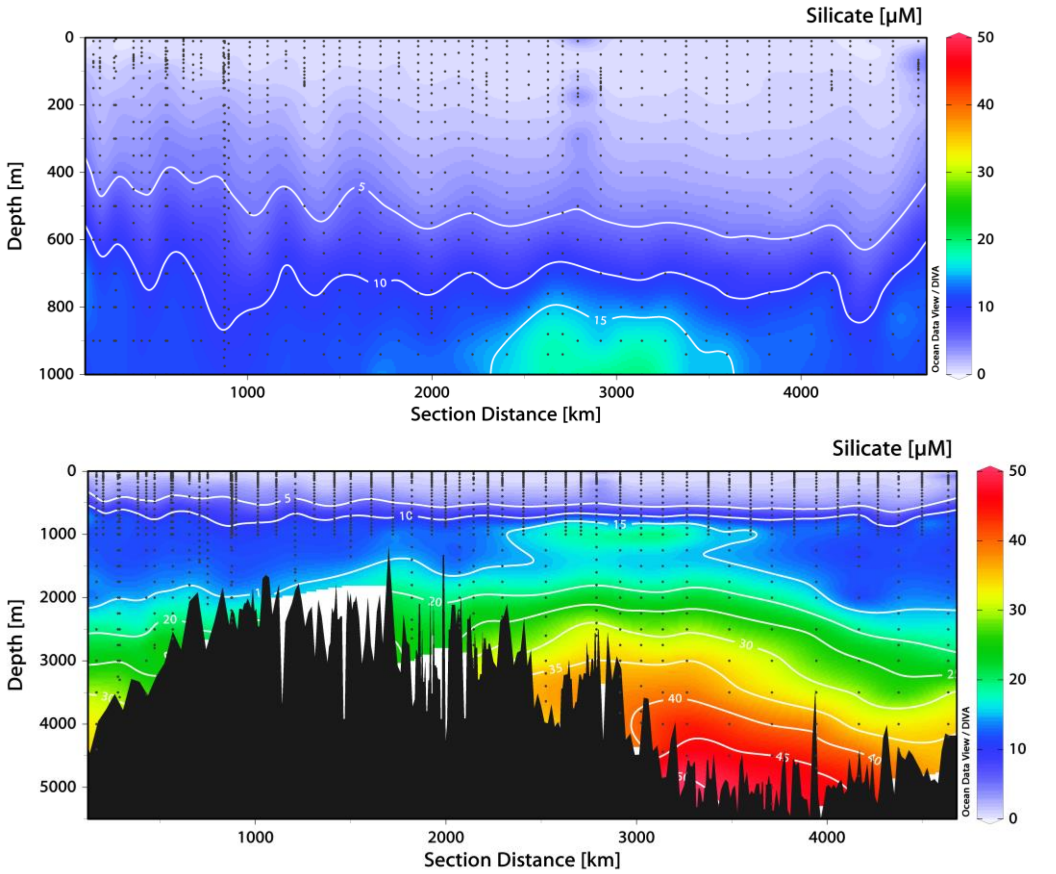


Figure 4. Silicate concentrations (µmol L^{-1}) across the Ridgemix transect (a. 1000m, b.full water column).

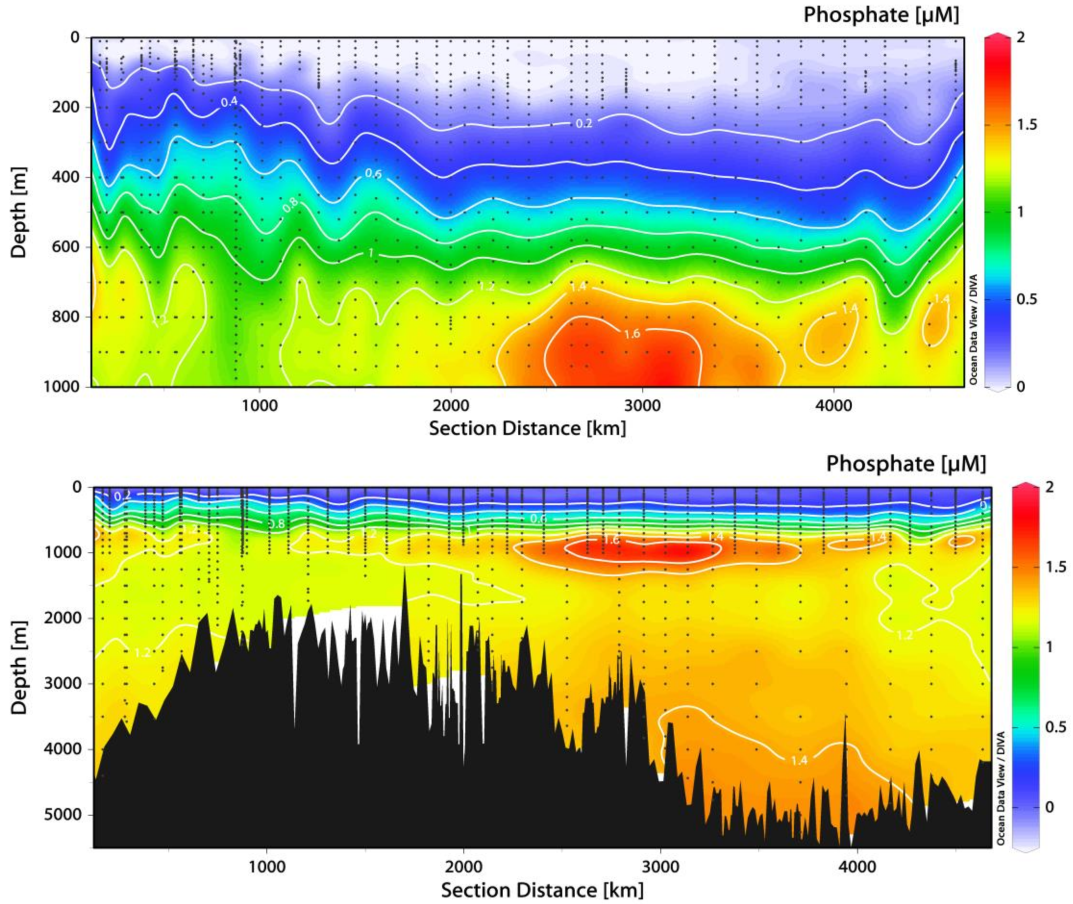


Figure 5. Phosphate concentrations (µmol L^{-1}) across the Ridgemix transect (a. 1000m, b.full water column).

11. Dissolved Organic Carbon (DOC)

Robyn Tuerena (University of Liverpool), Beth Francis (University of Bangor)

Objectives:

Enhanced diapycnal mixing over mid ocean ridges may provide a mechanism for the downward export of dissolved organic carbon (DOC) out of the mixed layer into the deep ocean. Deep ocean concentrations of DOC over the ridge will also be analysed close to vent sites to determine the importance of ridge vents on DOC concentrations in the deep ocean.

Sampling and Methodology

Samples were taken from each deep CTD cast (Type 3 or Dominic) (Table 1). DOC samples were collected after oxygen (either first, or second in order) around the CTD. DOC samples were collected straight from the valve, after triple rinsing with sea water, into 1 L HDPE bottles triple MilliQ rinsed

DOC analysis

In the main laboratory, for each water sample, a glass filtration rig holding 45 mm, 0.7 µm pore size GFFs was flushed through with sample water four times before 20 ml of water was collected into a pre-acidified (20 µl hydrochloric acid, 50% v/v HCl) 20 ml glass vial with a screw cap and septum. GFFs were changed every four to five samples. Following each CTD cast,, the rig was dismantled and placed in a 10% acid bath overnight. Prior to sampling, the rig was rinsed, reassembled and covered in muffled foil (350°C for 24 hours). Samples were stored upright in the 4°C fridge prior to analysis at the University of Liverpool.

DOC samples will be analysed on the TOC-V Shimadzu at the University of Liverpool, in a method similar to Pan et al., (2014).

References

Pan, X., Achterberg, E. P., Sanders, R., Poulton, A. J., Oliver, K. I. C., & Robinson, C. (2014). Dissolved organic carbon and apparent oxygen utilization in the Atlantic Ocean. *Deep Sea Research Part I: Oceanographic Research Papers*, *85*, 80–87. doi:10.1016/j.dsr.2013.12.003

Table 1. CTD and niskin numbers samples for dissolved organic carbon in the Ridgemix cruise.

CTD Number	DOC
1	1-4, 6-10, 12-16, 18, 21, 24
2	1-14, 16, 18, 20, 22, 24
3	1-13, 15-18, 20-23
4	1-3, 5, 7, 9, 12, 15, 19
5	1-14, 16, 18, 20-24
6	1-6, 8, 10, 12, 15, 21, 24
7	1-12, 14, 16, 18, 20, 22, 24
8	1,2, 4-18, 20, 22, 24
9	1-8, 14, 16, 18, 20-24
10	6, 10, 12, 15, 18, 20, 24
13	1-24
15	1-6, 8, 10, 12, 14, 18, 20, 24

17	1-12, 14, 16, 18, 20, 21, 24
20	1-10, 12, 14, 16, 17, 19-21, 24
22	1-24
23	1, 3, 5, 7, 9, 10,12, 14, 16, 20, 22, 24
24	1-16, 18-24
26	1-11, 13, 15, 17-20, 24
28	1-15, 17, 18, 20, 21, 23, 24
31	1, 3, 5, 7, 9, 11, 13, 16, 21
33	1-8, 10, 12, 14, 16, 18, 21, 24
35	1-24
37	1-24
39	1-24
41	1-24
43	1-19, 21, 24
45	1-12, 14, 16, 18, 20, 22, 24
48	1-24
50	1-24
53	1-12, 14-16, 18-22, 24
55	1-24
57	1-24
58	1-24
60	1-24
62	1-24
65	1-5, 7-24
67	1, 3, 5, 7, 9, 11, 12, 14, 16, 18, 21, 24

12. $\delta^{15}N$ and $\delta^{18}O$ of nitrate

Robyn Tuerena (University of Liverpool)

Objectives

To determine the sources and recycling of nitrate in the nitricline throughout the Ridgemix transect.

This will be carried out by the characterisation of the nitrate isotope signatures ($\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$) through the water column covering the full transect. The data will be used to determine how recycling processes change across the transect and the variation in preformed and remineralised nitrate within the nitricline. In addition the importance of nitrogen fixation will be determined to provide an extensive overview of the nutrient budget for the Ridgemix project.

Sampling and Methodology

Samples were collected throughout the transect, on every type 3 or Dominic CTD, only at depths where adequate nitrate concentrations were identified for isotopic analysis. Samples were collected into 1 L Nalgene bottles (rinsed x3 with Milli Q). Seawater was subsequently filtered through a glass filtration rig using precombusted 47 mm GF/F (0.7 µm) filters, and collected into HCl clean 125 ml Nalgene bottles, which were double bagged, then frozen until analysis at the University of Liverpool.

Isotopic analysis will be carried out using the Denitrifier Method (Sigman et al., 2001, Casciotti et al., 2002), by the conversion of nitrate to nitrous oxide using bacterial strain *P. aureofaciens* and analysis by isotope ratio mass spectrometry.

For any further information regarding analysis, please contact Robyn Tuerena (robynt@liv.ac.uk).

References

Casciotti, K. L., D. M. Sigman, M. G. Hastings, J. K. Bohlke, and A. Hilkert (2002), Measurement of the oxygen isotopic composition of nitrate in seawater and freshwater using the denitrifier method, Analytical Chemistry, 74(19), 4905-4912.

Sigman, D. M., K. L. Casciotti, M. Andreani, C. Barford, M. Galanter, and J. K. Bohlke (2001), A bacterial method for the nitrogen isotopic analysis of nitrate in seawater and freshwater, Analytical Chemistry, 73(17), 4145-4153.

Table 2. CTD and niskin numbers of samples taken along the Ridgemix transect.

CTD Number	Isotopes
1	
2	
3	1-13, 15-18, 20-22
4	1-3, 5, 7, 9, 12, 15, 19
5	1-14, 16, 18, 20-24
6	1-6, 8, 10, 12, 15, 21, 24
7	1-12, 14, 16, 18, 20, 22, 24
8	1,2, 4-18, 20, 22, 24
9	1-8, 14, 16, 18, 20-24
10	6, 10, 12, 15, 18, 20, 24

13	1-20
15	1-6, 8, 10, 12, 14, 18, 20, 24
17	1-12, 14, 16, 18, 20, 21, 24
20	1-10, 12, 14, 16, 17, 19-21, 24
22	1-24
23	1, 3, 5, 7, 9, 10,12, 14, 16, 20, 22, 24
24	1-16, 18-24
26	1-11, 13, 15, 17-20
28	1-15, 17, 18, 20, 21, 23, 24
31	
33	
35	1-21
37	1-21
39	1-21
41	1-21
43	1-19, 21
45	1-12, 14, 16, 18, 20
48	1-21
50	1-21
53	1-12, 14-16, 18-21
55	1-21
57	1-21
58	1-21
60	
62	
65	1-5, 7-21
67	

13. ^{226}Radium

Robyn Tuerena (University of Liverpool), Walter Geibert (Alfred Wegener Institute)

Objectives

^{226}Ra is an isotope which is naturally produced from the ^{228}U series with a half-life of 1600 years. The ^{226}Ra within the ocean is principally sourced from marine sediments and has a low particle reactivity which allows it to be used as a water mass tracer. Enhanced mixing over the Mid Atlantic Ridge may increase the concentrations of ^{226}Ra through the water column and could be used to assess the integrated effects of mixing on a particular body of water.

Sampling and Methodology

Samples were collected throughout the transect at the CTDs listed in Table 3, typically every CTD type 3 (or Dominic), and with coverage of the full water column. Approximately 100ml of seawater was collected into each 125ml Nalgene bottle (first rinsed x3 with sample). Following collection from the CTD, samples were acidified with 200ul of concentrated HCl and the bottles were closed, parafilmed, double bagged and stored at room temperature until analysis on land. From each CTD a triplicate sample was taken at a depth of 1000m to determine the reproducibility of sample analysis. A blank was also collected from each CTD using Milli-Q and processed as above with the seawater samples.

Samples will be analysed at the Alfred Wegener Institute.

For any further information regarding analysis, please contact Walter Geibert (walter.geibert@awi.de).

Table 3. CTD and niskin numbers of Ra-226 samples taken along the Ridgemix transect.

CTD Number	Isotopes
3	1-16, 18, 20, 22, 24, Blank
5	1-16, 18, 20, 22, 24, Blank
7	1-16, 18, 20, 22, 24, Blank
8	1-16, 18, 20, 22, 24, Blank
9	1-16, 18, 20, 22, 24, Blank
13	1-16, 18, 20, 22, 24, Blank
17	1-16, 18, 20, 22, 24, Blank
20	1-16, 18, 20, 22, 24, Blank
22	1-16, 18, 20, 22, 24, Blank
24	1-16, 18, 20, 22, 24, Blank
26	1-16, 18, 20, 22, 24, Blank
28	1-16, 18, 20, 22, 24, Blank
33	1-16, 18, 20, 22, 24, Blank
41	1-16, 18, 20, 22, 24, Blank
43	1-16, 18, 20, 22, 24, Blank
45	1-16, 18, 20, 22, 24, Blank
48	1-16, 18, 20, 22, 24, Blank
50	1-16, 18, 20, 22, 24, Blank
53	1-16, 18, 20, 22, 24, Blank
55	1-16, 18, 20, 22, 24, Blank

57	1-16, 18, 20, 22, 24, Blank
58	1-16, 18, 20, 22, 24, Blank

14. Zooplankton and enhanced alkaline phosphatase activity

Clare Davis (University of Liverpool)

Alkaline phosphatase activity assays

Alkaline phosphatase (AP) is an enzyme specific to the hydrolysis of phospho-monoester bonds. It is ubiquitous in the marine environment and plays a key role in alleviating phosphate (DIP) limitation in some regions of the surface ocean through enabling utilisation of dissolved organic phosphorus (DOP) by microbial populations to meet cellular phosphorus (P) quotas. In addition to this role in DIP deplete environments, there is increasing evidence that AP has a significant role in remineralisation of organic P (OP). This in turn has seen focus on AP activity (APA) and distribution extend from the surface waters, where it commonly is an indicator of DIP limitation, to deeper in the euphotic layer and below where it may have an enhanced role in remineralisation. The motivation behind the current study was to assess whether zooplankton potentially provide a source of AP and potentially contribute to OP remineralisation at depth.

Incubation experiment design

Stations where nets were deployed were named ZOO1, ZOO2, ZOO3 etc. and refer to individual experiments. Net samples were combined after collecting replicate samples from three net hauls using the 200 µm mesh from 200 m depth at a rate of approximately 0.17 ms^{-1}. Each haul took approximately 30 minutes. Samples were held in filtered seawater for a maximum of 90 minutes (first haul), the purpose of this being to effectively clean the zooplankton and allow separation between the healthy and dead animals.

For the experiment, zooplankton were then transferred based on volume to unfiltered seawater collected from the non-toxic underway supply at a zooplankton sample to unfiltered seawater ratio of 1:9 (i.e. 0.1 L in 0.9 L, or 0.9 L in 9 L). Experiments were conducted in triplicate (EXP1, EXP2, and EXP3; unfiltered seawater plus zooplankton) plus a control (CONTROL; unfiltered seawater). Experiments were incubated on-deck at ambient sea surface temperature (SST) in the dark for a maximum of 24 hours and sampled at regular time points throughout (e.g. 0 h, 3 h, 6 h, 9 h…).

Measuring enzyme activity

At each time point from each experiment/control (CONTROL, EXP1, EXP2, EXP3), 100 mL of pre-filtered (63 µm mesh) sample was transferred to a 125 mL polycarbonate bottle and spiked with the synthetic florigenic enzyme substrate methyumbelliferyl (MUFP) to a final saturating concentration of 10 µM. A fluorescent product was released upon hydrolysis of the synthetic substrate. During this secondary incubation, samples were incubated once more in the dark and at SST for up to 20 hours and the change in fluorescence in this second set of incubations was measured over time to derive a rate of AP activity. This was conducted at each time point. At the end of each experiment (EXP1, EXP2, EXP3), the remaining >63 µm sample was collected for later I.D. and dry weight analysis (resuspended in small volumes of filtered low nutrient seawater and filtered onto 0.7 µm GF/F, stored at -20 °C).

ZOO1 to ZOO6 were conducted in 10L polycarbonate carboys that were subsampled for secondary APA incubations. From ZOO7, experiments were conducted in replicate 1 L polycarbonate bottles. This was so that at each time point the whole sample/control could be sacrificed, allowing additional samples could be collected. Additional measurements included total chlorophyll (500 mL filtered onto 0.7 µm GF/F, stored at -20 °C), particulate phosphorus (400 mL filtered onto 0.7 µm GF/F, stored at -20 °C), and FCM (1.9 mL sample plus 20 µL glutaraldehyde, flash frozen in liquid nitrogen and stored at -80 °C).

Summary table of sampling

Experiment	Date	Latitude (°N)	Longitude (°W)	Comment
ZOO1	06/06/16	36. 227	32.754	
ZOO2	09/06/16	34.450	37.015	
ZOO3	11/06/16	31.331	40.994	
ZOO4	13/06/16	27.922	43.703	
ZOO5	15/06/16	24.000	46.000	
ZOO6	17/06/16	26.000	50.000	
ZOO7	19/06/16	29.998	49.992	
ZOO8	21/06/16	33.356	47.149	
ZOO9	30/06/16	36.224	32.707	

Thanks and praise
Thanks to everyone in the science party for their hard work and a great team effort. For this work, special thanks go to Jenny Jardine and Charli Smith for chlorophyll analysis. Thanks to Charli for her help collecting FCM samples. Thanks to the captain and crew of RRS James Clark Ross, in particular Johno, Kenny and Colin for their excellent zooplankton net deployments. Thanks to the NMF technicians Paul, Steve, Candice, Billy, Nick and Jez for their help with net set up, maintenance, winching and dedicated on-deck incubator care.

15. Plankton, particles and chlorophyll

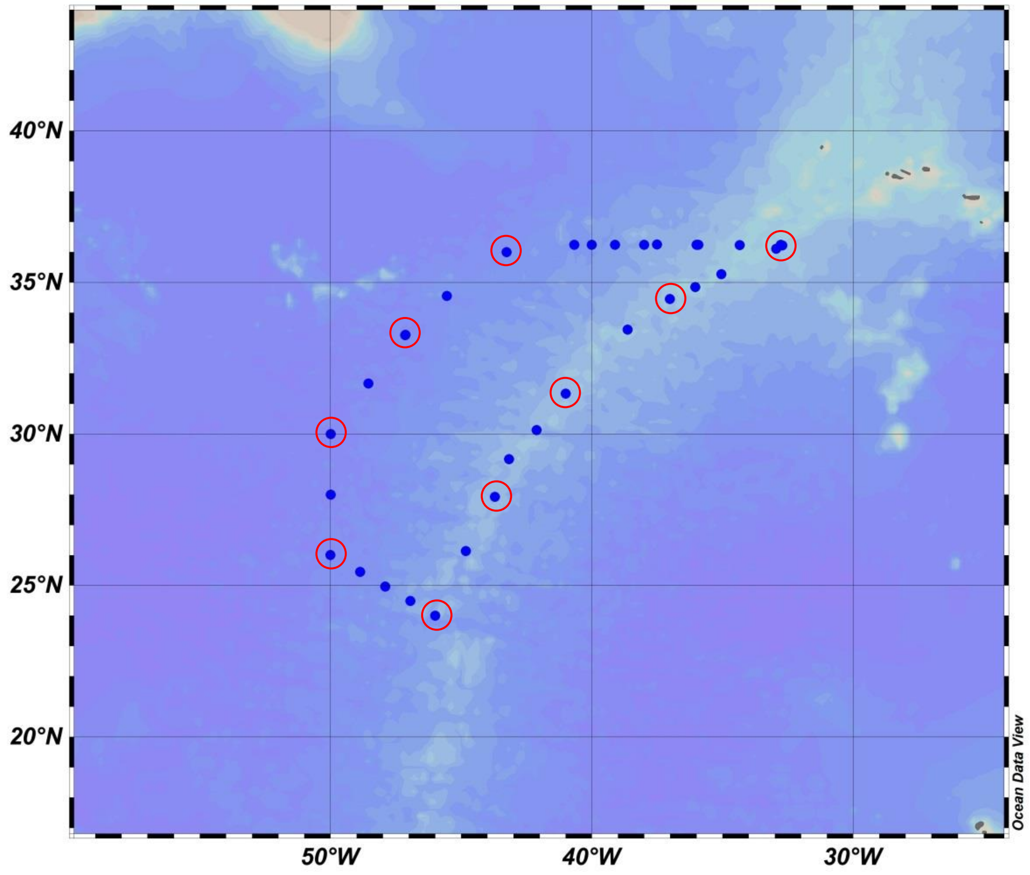
Charlotte Smith and Jennifer Jardine (University of Liverpool)

Objective:

The objective is to assess whether topography, specifically the Mid-Atlantic Ridge, influences the local productivity, community structure, particle quantity and quality in the above surface waters.

This was approached using a variety of techniques.

1. CTD casts were used to collect samples for picoplankton and bacteria community structure (flow cytometry), size-fractionated chlorophyll, particulate organic carbon (POC), and microscopy.
2. Stand-Alone Pumps (SAPs) were used to collect samples for lipid analysis and POC, PC, PN analysis.
3. Vertical tow zooplankton nets were used to collect zooplankton samples from the upper 200 m



Location of stations sampled: blue dots = CTD sampling; red circles = stations with SAPs and zooplankton nets.

Table 9 CTD Niskin bottles sampled

Station	CTD	Date	Time (GMT)	POC Niskin Numbers	FCM Niskin numbers	Size-Fractionated Chlorophyll Niskin Numbers	Microscopy Niskin Numbers
	1	30/05/2016	10:24	15-18,20-24	15-18,20-24	15-18,20-24	15,18,24
	2	03/06/2016	05:13	7-18, 20-24	11, 13, 15-18, 20-24	11, 13, 15-18, 20-24	11, 20, 24
	4	04/06/2016	00:56	7-21, 23, 24	11, 13-21, 23, 24	11, 13-21, 23, 24	11, 19, 24
	6	04/06/2016	17:21	6-24	10, 12, 14-24	10, 12, 14-24	10, 19, 24
Mooring Super-station	9	05/06/2015	23;16	1-4, 6, 14, 18, 20-24		18, 20-24	18, 23, 24
Mooring Super-station	10	07/06/2016	09:17	6 - 24	10, 12-24	10, 12-24	10, 18, 23, 24
	12	08/06/2016	08:56	9, 11, 13, 16, 19, 24	13, 16, 19, 21-24	13, 16, 19, 21, 22, 24	
	13	08/06/2016	16:15	14, 16, 18 - 24	18 – 24	18 – 24	
	15	09/06/2016	07:11	6-24	10, 12-24	10, 12-24	10, 15, 18, 20, 24
	17	09/06/2016	21:14	12-24	16, 18-24	16, 18-24	
	20	10/06/2016	20:35	1, 5, 7, 10, 14-24	16-24	16-24	16, 20, 21, 24
	22	11/06/2016	16:31	1, 3, 5, 7, 9, 11 – 24	15, 17-24	15, 17-24	15, 19, 24
	24	12/04/2016	05:48	1, 7, 11, 16, 18 – 24	18-24	18-24	18, 21, 24
	26	12/06/2016	19:20	11 – 24	13, 15-24	13, 15-24	13, 19, 24
	28	13/06/2016	21:35	1, 3, 4, 7, 11, 16 – 24	18 – 24	18 – 24	18, 21, 24
	32	24/06/2016	21:07	1 – 21	5, 7, 9 -21	5, 7, 9 – 21	5, 6, 13, 14, 21
	34	15/06/2016	12:55	1 – 20	5, 7 – 20	5, 7 – 20	5, 10, 12, 20
	36	16/06/2016	00:12	1 – 22	5, 7, 9 – 17, 19 – 22	5, 7, 9 – 17, 19 – 22	5, 10, 13, 16, 22

	38	16/06/2016	12:12	1 – 21	5, 7 – 14, 16-19, 21	5, 7 – 14, 16-19, 21	5, 9, 13, 17, 21
	40	17/06/2016	00:08	1 – 20	5 – 18, 20	5 – 18, 20	5, 6, 12, 20
	43	18/06/2016	00:34	6, 10, 12, 15 – 24	17 – 24	17 – 24	17, 20, 24
	46	18/06/2016	18:01	1 – 19	5 – 19	5 – 19	5, 6, 12, 19
	48	19/06/2016	18:22	9, 12, 15 – 24	18, 20 – 24	18, 20 – 24	18, 22, 24
	51	20/06/2016	22:07	1 – 22	5, 7 – 22	5, 7 – 22	5, 12, 15, 18, 22
	53	21/06/2016	17:26	8, 10, 12, 14, 17 – 24	19 – 24	19 – 24	19, 22, 24
	55	22/06/2016	13:29	2, 4, 8, 12, 14, 17 – 24	19 – 24	19 – 24	
Open Ocean Super-station	56	23/06/2016	21:41	1 – 23	5, 8 – 23	5, 8 – 23	5, 8, 13, 16, 19, 23
	58	24/06/2016	23:01	4, 6, 10, 12, 15 – 24	17, 19 – 24	17, 19 - 24	17, 21, 24
	59	26/06/2016	04:20	1, 3, 7, 9, 11, 13, 16 – 24	18 – 24	18 - 24	18, 22, 24
	60	26/06/2016	15:53	2, 4, 7, 9, 12 – 24	16, 18 – 24	16, 18 – 24	16, 22, 24
	61	27/06/2016	03:37	4, 8, 10, 13 – 24	15, 17 – 24	15, 17-24	15, 22, 24
	62	27/06/2016	14:37	1, 6, 8, 11, 13 – 24	17 – 24	17 – 24	17, 21, 24
	65	28/06/2016	20:10	1, 3, 5, 9, 12, 15			
Mooring Super-station	66	28/06/2016	23:45	1 – 21	5, 7 – 21	5, 7 - 21	5, 7, 12, 13, 21
Mooring Super-station	67	01/07/2016	09:59	1, 12, 17, 19 – 21, 24	16 – 24	16 – 24	

Methods

1. CTD Sample Collection and Analysis

Samples were taken from designated CTDs throughout the cruise (Figure 1, Table 1). Samples for flow cytometry, size-fractionated chlorophyll, POC and microscopy were collected from around the chlorophyll maximum and down to 300 m. Additional samples for POC were collected at 50 m intervals from 250 m down to 500 m, depending on CTD cast depth, sometimes additional intervals of 500 m down to 5000 m).

Flow cytometry samples were collected after nutrients (either first or forth in order) around the CTD, and chlorophyll, POC and microscopy samples were taken immediately after flow cytometry. Flow cytometry samples were collected straight from the valve, after triple rinsing with sea water, into 150 ml polycarbonate bottles triple Milli-Q rinsed. Size-fractionated chlorophyll samples were collected using tubing into 1 L brown bottles, triple rinsed with Milli-Q and seawater. POC (+microscopy) samples were collected immediately after the chlorophyll samples into 5 or 10 L plastic bottles after triple rinsing with seawater. Once a week POC bottles were acid cleaned overnight and triple rinsed with Milli-Q.

Flow Cytometry Analysis

In the fume hood 1.9 ml of each sample was pipetted into 2 ml cyrovials containing 20 µL of 50% Glutaraldehyde solution. The vials were inverted slowly ten times and left in the fridge for 1 hour. After one hour the samples were flash frozen in liquid nitrogen then stored in the -80°C freezer until transport back to the UK where they will be run through a flow cytometer in Plymouth Marine Laboratory.

Size-Fractionated Chlorophyll Analysis (Done by Jennifer Jardine)

In the chem. lab 250 ml to 1000 ml of seawater was filtered through the size-fractionated chlorophyll rig containing 47 mm polycarbonate filter papers of pore size 20 µm, 2 µm and 0.2 µm. The filter papers were folded, transferred to glass tubes and 5 ml of 90% acetone was added in the fume cupboard. Samples were stored in the fridge at 4°C for 24 hours. Samples were run through a Turner Trilogy Fluorometer and chlorophyll concentrations calculated from raw fluorescence units (RFU). Three blanks and two solid standards were run before each batch of samples. The fluorometer couvet was triple rinsed with acetone between samples.

POC Analysis

In the chem. lab 2-4 L of seawater was filtered through 25 mm 0.7 µm pore size GFFs. The volume filtered varied with the quantity of material in the water. 2 L was filtered for surface samples (down to ~250 m), 3 - 4 L was filtered between ~250 m and 500 m. Filter papers were placed onto squares of muffled foil (350°C for 24 hours) in plastic petri-dishes and placed in the oven (60°C, 12 hours). After 12 hours the petri-dishes were removed from the oven, taped up, placed in double zip-lock plastic bags and placed in the -20°C freezer in polystyrene boxes until transport back to the UK in dry ice. Samples will be acid fumed in a desiccator and analysed for PN, PC and POC using a Carlo Erbo elemental analyser.

Microscopy

In the chem. lab 2 L's of sea water was filtered through 45 mm polycarbonate filters of 10 µm pore size. The filter was transferred to an amber glass jar and 'fixed'/preserved in 2% Lugols solution. The jar was wrapped in foil and stored in the dark. In the UK species will be identified and enumerated.

Table 2 SAPs and zooplankton net sampling

Station	Related CTD	Latitude (Degrees, min)	Longitude (Degrees, min)	Date	Time of arrival at station (GMT)	SAPs Depths (m)	200 um Net (no. of tows)	63 um Net (no. of tows)

Mooring Site	009	36 13.282	32 45.775	5/06/2016	23:16		2	2
Mooring Site	010	36 06.854	32 57.002	7/06/2016	09:17	16, 61, 161, 500		
	014	34 27.004	37 00.798	9/6/2016	02:00	76, 176 ,500	2	2
	020	31 20.129	40 59.920	10/06/2016	20:25	86, 187, 503	2	2
	026	27 55.809	43 42.505	12/06/2016	19;20	131, 231, 500	2	2
	031	24 00.004	45 59.983	14/06/2016	21:07	151, 251, 500	2	2
	040	26 00.045	50 00.074	17/06/2016	00:08	160, 260, 500	2	2
	046	29 59.889	49 59.508	18/06/2016	22:56	141, 241, 500	2	2
	051	33 15.874	47 08.537	20/06/2016	22:07	91, 191, 500	2	2
Open Ocean Site	056	36 00.043	43 15.754	23/06/2016	21:41	15, 76, 176, 501	2	2
Mooring Site	066	36 13.559	32 42.610	28/06/2016	23:45	17, 102, 202, 501	4	2
Mooring Site	067	36 14.644	32 46.628	1/07/2016	09:59	15, 15, 102, 204, 510, 972		

2. SAPs Sample Collection and Analysis

The SAPs were deployed at 11 designated stations throughout the cruise (Figure 1, Table 2), all selected to give an on-ridge open ocean contrast. Samples were collected at night between 10 pm and 2 am.

The SAPs were set up with double filter housing, holding a 53 micron mesh over two stacked 0.7 µm, 293 mm GFFs. The lower GFF is the blank. The meshes were acid washed before mounting and the GFFs had been muffled at 450°C for >4 hours. The filter housing was attached to the SAPs and the depths chosen according the CTD profile. At all stations SAPs were placed at the deep chlorophyll maximum (DCM), DCM+100, and 500 m. At the three superstations an additional SAPs was placed in the surface at 15 m. At the final superstation an additional SAPs deployment was made with two SAPs at 15 m, the DCM, DCM+100, 500 m and 1000 m.

The SAPs were deployed off a 5 tonne deck winch mounted at the starboard waist. Once down to depth the SAPs pumped for 1 ½ hours. Back on deck the GFF filters were removed from the filter housing, folded and placed in the -80°C freezer. The 53 µm meshes were rinsed down onto 47 mm (0.7 µm) GFFs and placed in the -80°C freezer. Samples will be analysed back in the UK.

For lipid analysis, after freeze drying, sections of the filters will be cut up and the lipids extracted using dichloromethane with 10% methanol. Samples will be sonicated and centrifuged three times. Samples will be derivatised with bis-trimethylsilyltrifluoroacetamide (BSTFA, 25 µL, 60°C, 45 mins), the lipids identified and semi-quantified by running the samples through the Gas Chromatography-Mass Spectrometer and comparing to an internal standard (Cholestane). For POC analysis punched circles taken from the freeze-dried SAPs filters will be acid fumed in a desiccator and analysed for PN, PC and POC using a Carlo Erbo elemental analyser.

3. Zooplankton Nets Sample Collection and Analysis

Samples were taken at the same stations as SAPs immediately after the SAPs were back on deck (Figure 1, Table 2). Samples were collected between 11 pm and 5 am.

Two different sized nets, 200 µm and 63 µm, with 1 L non-filtering cod ends were used to collect samples. The two nets were deployed simultaneously over the side of the ship the 200 µm net from the aft deck winch and the 63 µm net from a 5 tonne deck winch mounted at the starboard waist. The 200 µm nets were hauled in vertically at a winch rate of ~10 m/min, and the 63 µm nets at ~9 m/min. The nets were each deployed twice to get duplicate samples. Each haul took approximately 30 minutes. At the last super station (the mooring site) an additional two 200 µm nets were lowered down to 500 m and hauled in at a winch rate of ~11.9 m/min. The 500 m hauls took approximately 40 minutes.

Once on deck the nets were rinsed down, the samples poured into white buckets and 900 ml fixed with 100 ml of 40% buffered formaldehyde. These samples were stored in black bags in the +4°C fridge until transport back to Liverpool. In the UK zooplankton will be identified and enumerated.

For further information regarding biological analysis, please contact Charlotte Smith, charlotte.smith@liverpool.ac.uk

16. Determination of oxygen concentrations

Eugenio Ruiz (University of Liverpool)

Methods

125 ml optically-clear glass oxygen bottles triple-rinsed with Milli-Q and stored full of Milli-Q. Each bottle is pre-calibrated for volume and has unique identifying number on shoulder and on stopper. Oxygen samples were drawn first from Niskin as soon as rosette was secured on deck. Tygon tubing was used to fill bottles from Niskin and bottle was overflowed for 20 seconds to ensure no bubbles. Temperature of each sample was taken immediately then sample was fixed with 1ml manganese sulphate (3M) and 1ml alkaline iodide and shaken vigorously for a 20 seconds prior to storage approximately 15 minutes later.

Samples were stored upright under water in a dark 60L container until the precipitate had settled. Samples were analysed after 4 hours and within 4 days of collection. Prior to analysis 1ml sulphuric acid (10N) was added to each sample to dissolve the precipitate.

Samples were analysed for dissolved oxygen concentration onboard using the modified Winkler method (Carpenter, 1965) and a PC-controlled potentiometric titration system (Metrohm Titrando 888). Reagent blanks were run using 0.025N potassium iodate (1 aliquots) and sodium thiosulphate titrant (~ 0.18 N). Each of these was performed in triplicate (at minimum) prior to analysis of samples each day. Lab temperature was monitored throughout analysis. Calculation of dissolved oxygen concentration was according to HOT protocol (website given below) and Grasshoff (1983). Samples were analysed to produce a dissolved oxygen concentration in µmol l^{-1}. "and these values were forwarded to the oxygen sensor calibration team for conversion to µmol kg^{-1} and further processing".

Samples were taken from 35 CTDs (Table 1). Mean reagent blank was 0.00174 ± 0.016 mL over the course of the cruise and mean thiosulphate normality was 0.3070 ± 0.0002 N. Oxygen concentrations measured ranged from 150 µmol O_2 l^{-1} to 300 µmol O_2 l^{-1}. Data will be submitted to BODC for conversion to mmol kg^{-1} and calibration of the oxygen sensor on the CTD.

Problems with the automated dispenser of Alkaline Iodide were found while fixing samples on CTD-25. These were solved and used normally for the rest of the CTD's.

Table 1. List of rosette casts which were sampled for dissolved oxygen.

Date	CTD no	Lat	Long	Depths
30-05-2016	1	25º 20.360	50º 8.305	6
3-06-2016	3	36º 15.1288	39º0.4695	6
4-06-2016	5	36º 14.8289	37º 0.2994	6
5-06-2016	7	36º 14.8489	34º 59.7794	6
5-06-2016	8	36º 13.8805	33º 54.1055	6
5-06-2016	9	36º 13.2600	32º 45.7785	6
8-06-2016	12	35º 16.5462	35º 2.5297	6
8-06-2016	13	34º 51.1254	36º 2.6525	6
9-06-2016	16	34º 0.0002	38º 0.0086	6
9-06-2016	17	33º 26.6289	38º 37.7586	6
10-06-2016	19	31º 59.5234	40º 16.3285	6
10-06-2016	20	31º 20.1385	40º 59.9239	6

11-06-2016	21	30º 40.0501	41º 45.1086	6
11-06-2016	22	30º 7.4988	42º 7.0667	6
12-06-2016	23	29º 38.866	42º 38.6917	6
12-06-2016	24	29º 10.181	43º 10.352	6
12-06-2016	25	28º 31.031	43º 20.7692	6
12-06-2016	26	27º 55.809	43º 42.505	6
13-06-2016	27	27º 2.249	44º 13.1167	6
13-06-2016	28	26º 8.212	44º 49.613	6
14-06-2016	30	24º 38.4094	45º 37.2211	6
15-06-2016	35	24º 29.5704	46º 56.2412	8
16-06-2016	39	25º 26.7470	48º 51.5558	6
17-06-2016	42	26º 59.9806	49º 59.9645	10
18-06-2016	44	29º 00.0369	49º 59.9954	10
19-06-2016	47	30º 49.8247	49º 18.0556	10
20-06-2016	50	33º 16.3088	47º 8.2801	10
21-06-2016	53	34º 33.2088	45º 31.800	10
22-06-2016	55	35º 58.9796	43º 16.1914	10
24-06-2016	57	36º 15.9203	42º 15.4514	10
25-06-2016	58	36º 14.8403	40º 40.5208	10
26-06-2016	59	36º 14.6731	39º 5.5109	10
27-06-2016	61	36º 14.6065	35º 55.470	10
27-06-2016	62	36º 14.1209	34º 26.6740	10
28-06-2016	65	36º 13.1104	32º 42.5914	14

REFERENCES:

Carpenter, J.H. (1965). The Chesapeake Bay Institute Technique for the Winkler oxygen method. Limnol. Oceanogr., 10, 141–143.

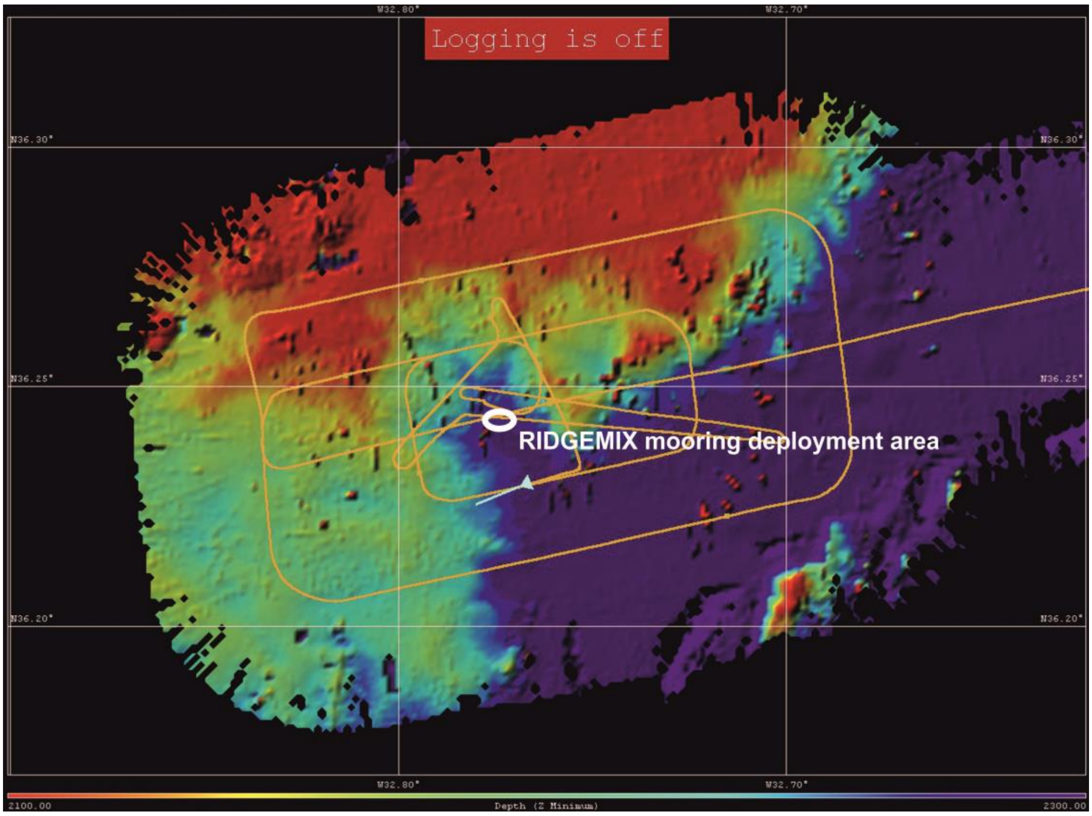
Grasshoff, K. Ehrhardt, M, and K. Kremling (1983). Methods of Seawater Analysis. Grasshoff, Ehrhardt and Kremling, eds. Verlag Chemie GmbH. 419 pp.

17. Moorings

17.1 Deployment (From RRS James Clark Ross, October 2015 during AMT25)

Paul Provost, Candice Cameron, Nick Rundle (Sensors & Moorings Group, National Marine Facilities Sea Systems)

Prior to the commencement of mooring operations the area of interest was surveyed using the hull mounted swath system to get an accurate topographical map of the seabed. From this map the mooring positions were assessed and determined.



The moorings were equipped with IXBlue Oceano 2500 acoustic releases (AR861), which were attached to the CTD frame on cast no.15, and a release test was performed at the expected deployment depth of 2200m. There are dual parallel releases on both moorings for redundancy. All moorings were deployed using the BAS direct-pull reeling winch system which was load-tested prior to commencement of operations. The moorings were deployed "top first, anchor-last", allowing the buoyancy to stream away from the vessel during deployment. Vessel speed varied between 0.5 and 1.5 knots during the mooring deployments.

Mooring deployment operations occurred on 26 September 2015 (Ridgemix 1 mooring) and 27 September 2015 (Ridgemix 2 mooring). All moorings were deployed from the aft deck of the RRS James Clark Ross by the National Marine Facilities team and the ship's crew.

The anchors for the instrumented moorings consisted of scrap eight-inch chain made up to the required dry weights.

The estimated final mooring anchor positions were determined from three independent ranging locations (triangulation) to the acoustic release. This required the ship to position itself approximately an ocean depth horizontally away from the likely location of the mooring. A transducer was deployed over the side of the ship and the slant range (distance) to the mooring was obtained. The calculated horizontal distance provided an estimate of the radius from the ship location within which the mooring was located. The cross-over of the range circles (the "cocked hat" method) provided an estimate of the location of the mooring. The estimated position given was the locus of the small area close to where the circles met.

There are inherent errors in the accuracy of the triangulation method which are a result of a number of factors such as variations in the speed of sound through the water column, the relative positions of the GPS beacons and the transducer and the drift of the ship while the observations were being taken.

RIDGEMIX 1

The target for the Ridgemix 1 mooring was 36°14.625’N, 032°46.546’W in approximately 2280m of water. The mooring consisted of 35 RBR Solo T self logging thermistors, 6 RBR Duo TD self logging instruments, 4 SeaBird SBE37SMP MicroCAT CTD sensors, two TRDI 75 kHz Longer Ranger ADCPs rated to 1500m, one TRDI 75 kHz Longer Ranger ADCP rated to 3000m, two Flowquest 75 kHz ADCPs rated to 1500m. In addition, a Xenon light and Iridium locator beacon was attached at the top of the mooring, with a further Iridium locator beacon attached to the uppermost ADCP syntactic float at approximately 300m depth

Instrument/equipment	Serial number	Time (GMT) in water	Predicted depth (m from surface)	Sampling interval (seconds)
RBR Duo TD	50753	10:08	24	15
Xenon Flasher	W10-030	10:08	-	-
Iridium beacon	IMEI: 300234062982050	10:08	-	-
RBR Solo T	76492	10:08	28	15
RBR Solo T	76493		33	15
RBR Solo T	76494	10:09	38	15
RBR Solo T	76495		43	15
RBR Solo T	76496		48	15
RBR Duo TD	50752		53	15
RBR Solo T	76497		63	15

RBR Solo T	76498	10:18	73	15
RBR Solo T	76499		83	15
RBR Solo T	76500		93	15
RBR Duo TD	50751	10:27	103	15
RBR Solo T	76501		113	15
RBR Solo T	76502		123	15
RBR Solo T	76503		133	15
RBR Solo T	76504	10:37	142	15
RBR Solo T	76505	10:39	152	15
RBR Solo T	76506	10:40	162	15
RBR Solo T	76507	10:43	172	15
RBR Solo T	76508	10:44	183	15
RBR Solo T	76509		193	15
RBR Duo TD	50750	10:50	205	15
RBR Solo T	76510	10:54	255	15
TRDI 75kHz LRADCP (up)	10583	11:10	305	3600
Iridium beacon	IMEI: 300234062988050	11:10	-	-
SBE37SMP CTD	9395	11:10	305	300
RBR Solo T	76511	11:10	308	15
TRDI 75kHz LRADCP (down)	10584	11:10	309	3600
SBE37SMP CTD	9396	11:10	311	300
RBR Solo T	76512		352	15
RBR Solo T	76513	11:46	402	15

RBR Solo T	76514		452	15
RBR Duo TD	57049	11:55	503	15
RBR Solo T	76515	11:59	603	15
RBR Solo T	76516	12:03	703	15
RBR Solo T	76517	12:11	803	15
RBR Solo T	76518	11:18	902	15
RBR Solo T	76519		1002	15
RBR Solo T	76520		1102	15
RBR Solo T	76521		1202	15
SBE37SMP CTD	9397	12:50	1300	300
Flowquest 75kHz ADCP (up)	11626	12:50	1302	3600
Flowquest 75kHz ADCP (down)	15951	12:50	1303	3600
RBR Solo T	72067	12:50	1304	15
RBR Duo TD	50748	13:00	1394	15
RBR Solo T	72068	13:09	1598	15
RBR Solo T	72069	13:15	1799	15
SBE37SMP CTD	9398	13:30	1901	300
TRDI 75kHz LRADCP (up)	20676	13:30	1901	3600
RBR Solo T	72070	13:37	2005	15
RBR Solo T	72071	14:43	2197	15
IXBlue AR861 release	1501	14:45	2208	-
IXBlue AR861 release	1918	14:45	2208	-

The mooring operation began at 10:08 GMT on 26 September 2015 with the deployment of the pickup float. The attachment of instruments, buoyancy, releases and chain continued until 13:45 GMT, after which time the mooring had been streamed and ship had travelled 5.1km.

The plastic jacket on the wire just beneath the first set of ADCPs at approximately 350m was damaged by friction due to the wire digging into itself on the drum. The areas where the plastic coating was damaged was wiped clean and wrapped in self amalgamating tape, to prevent water ingress through the jacket, followed by a top layer of PVC electrical tape, for added protection. The wire was continually monitored for further damage which may have occurred in deeper layers on the drum.

The Aft gantry suffered a hydraulic leak during the deployment, whilst this was repaired the deployment of the mooring was stopped and the ship slowed to prevent over-running the mooring target position. The repair to the gantry did not significantly affect the deployment time.

Once the mooring had been streamed, the ship towed the mooring a further 1.8km until the deployment position of 36°14.654'N, 032°46.862'W was reached at 14:45 GMT when the anchor was released. This was approximately 470 m beyond the target position to allow for fall-back. The anchor took 15 minutes to reach the seabed after it released and this was tracked by acoustic ranging on the releases. The estimated final mooring anchor position was 36°14.680'N, 032°46.670'W. The estimated mooring location was 211m in a direction of 299°T from the target location. The mooring fall back was approximately 290m.

Moored instrumentation
The recovery cruise for the moorings is planned to finish on 4 July 2016, this gives approximately 300 days for data collection. All instruments were programmed prior to deployment to maximise data resolution during the planned deployment time using the manufacturers provided software to make best use of the calculated battery power and memory capacity available. In all cases the battery power capacity was the limiting factor.

RBR Solo T
There were 35 RBR Solo T sensors deployed along the mooring at 5m intervals in the top 50m of the water column, 10m intervals in the top 50 to 200m of the water column, 50m intervals in the upper 200 to 500m of the water column, 100m intervals between 500 and 1400m and 200m intervals from 1400m to the seabed. All 35 instruments were set-up with identical parameters and were programmed to start at 10:00 on 26 September 2015 and to take measurements continuously every 15s thereafter. The loggers were clamped to the wire using two Jubilee clips with added PVC tape for protection.

RBR Duo TD
There were six RBR Duo TD sensors measuring temperature and pressure deployed along the mooring at intervals of 0m, 50m, 100m, 200m, 500m and 1400m from the top of the mooring. All six instruments were set-up with identical parameters and were programmed to start at 10:00 on 26 September 2015 and to take measurements continuously every 15s thereafter. The loggers were clamped to the wire using two specifically made clamps for the instrument and wire diameter.

Sea Bird SBE37SMP CTD
There were four SeaBird SBE37SMP MicroCAT CTD sensors deployed on the moorings positioned as close as possible to each ADCP to measure temperature, pressure and conductivity. All four

instruments were set-up with identical parameters and were programmed to start at 10:00 on 26 September 2015 and to take measurements continuously at five minute (300s) intervals thereafter. Three of the MicroCAT sensors were mounted within the syntactic floatation for the ADCPs, the fourth was clamped on the wire 1m below the ADCP transducer (s/n 9396).

SBE37SMP (s/n)	75kHz ADCP (s/n)	Relative distance of CTD from transducer face (m)
9395	10583	0
9396	10584	-1
9397	11626	-3
9397	15951	-4
9398	20676	0

TDRI 75kHz LRADCP

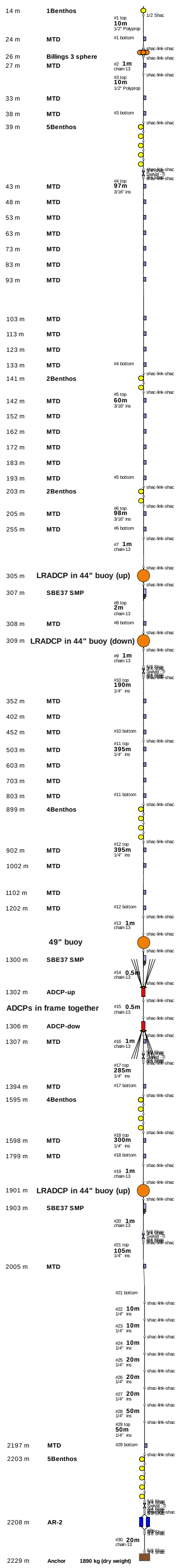
All three TRDI 75kHz ADCPs were set-up with identical parameters shown below and mounted in specially designed syntactic floatation:

Blank Distance:	704cm
Bin cell size:	800cm
Max working distance:	74 bins
Ensemble Interval:	3600s
Pings per ensemble:	50
Ping Interval:	72s
Radial ambiguity velocity:	175 cm/s
Standard deviation:	2.07cm/s
Start time:	18:00 on the 25 September 2015

Flowquest 75kHz ADCP

Both Flowquest 75kHz ADCPs were setup with identical parameters shown below and mounted side by side in a dual clamping frame:

Blank Distance:	380cm
Bin cell size:	800cm
Max working distance:	600m
Ensemble Interval:	3600s
Pings per ensemble:	150
Ping Interval:	20s
Start time:	09:20 on the 26 September 2015


14 m 1Benthos
24 m MTD
26 m Billings 3 sphere
27 m MTD
33 m MTD
38 m MTD
39 m 5Benthos
43 m MTD
48 m MTD
53 m MTD
63 m MTD
73 m MTD
83 m MTD
93 m MTD
103 m MTD
113 m MTD
123 m MTD
133 m MTD
141 m 2Benthos
142 m MTD
152 m MTD
162 m MTD
172 m MTD
183 m MTD
193 m MTD
203 m 2Benthos
205 m MTD
255 m MTD
305 m LRADCP in 44" buoy (up)
307 m SBE37 SMP
308 m MTD
309 m LRADCP in 44" buoy (down)
352 m MTD
402 m MTD
452 m MTD
503 m MTD
603 m MTD
703 m MTD
803 m MTD
899 m 4Benthos
902 m MTD
1002 m MTD
1102 m MTD
1202 m MTD
49" buoy
1300 m SBE37 SMP
1302 m ADCP-up
ADCPs in frame together
1306 m ADCP-dow
1307 m MTD
1394 m MTD
1595 m 4Benthos
1598 m MTD
1799 m MTD
1901 m LRADCP in 44" buoy (up)
1903 m SBE37 SMP
2005 m MTD
2197 m MTD
2203 m 5Benthos
2208 m AR-2
2229 m Anchor 1890 kg (dry weight)
#1 top 10m 1/2" Polyprop
#1 bottom
#2 1m chain-13
#3 top 10m 1/2" Polyprop
#3 bottom
#4 top 97m 3/16" ins
#4 bottom
#5 top 60m 3/16" ins
#5 bottom
#6 top 98m 3/16" ins
#6 bottom
#7 1m chain-13
#8 top 2m chain-13
#8 bottom
#9 1m chain-13
#10 top 190m 1/4" ins
#10 bottom
#11 top 395m 1/4" ins
#11 bottom
#12 top 395m 1/4" ins
#12 bottom
#13 1m chain-13
#14 0.5m chain-13
#15 0.5m chain-13
#16 1m chain-13
#17 top 285m 1/4" ins
#17 bottom
#18 top 300m 1/4" ins
#18 bottom
#19 1m chain-13
#20 1m chain-13
#21 top 105m 1/4" ins
#21 bottom
#22 10m 1/4" ins
#23 10m 1/4" ins
#24 10m 1/4" ins
#25 20m 1/4" ins
#26 20m 1/4" ins
#27 20m 1/4" ins
#28 50m 1/4" ins
#29 top 50m 1/4" ins
#29 bottom
#30 20m chain-13
1/2 Shac
shac-link-shac

RIDGEMIX 2

The target for the RIDGEMIX 2 mooring was 36°13.710'N, 32°46.307'W in approximately 2273m of water. The mooring consisted of a single Webb Research Apex float, which was programmed to profile in the upper 1000m of the water column whilst tethered to the mooring, with an integrated Satlantic Suna nitrate sensor and AADI Optode.

The Apex and Suna was programmed to perform one profile every three days. Prior to deployment the Apex float was switched on using the magnetic reed switch and the internal pump could be heard operating whilst the bladder was observed to inflate.

Instrument/equipment	Serial number	Time (GMT) in water	Predicted depth (m from surface)
Apex Float	7237	10:23	20 - 1135
Satlantic Suna	483		
IXBlue AR861 release	685	11:58	2218
IXBlue AR861 release	1468	11:58	2218

The mooring operation began at 09:53 GMT on 27 September 2015 with the deployment of the pickup float. The attachment of Apex float, buoyancy, releases and chain continued until 11:15 GMT.

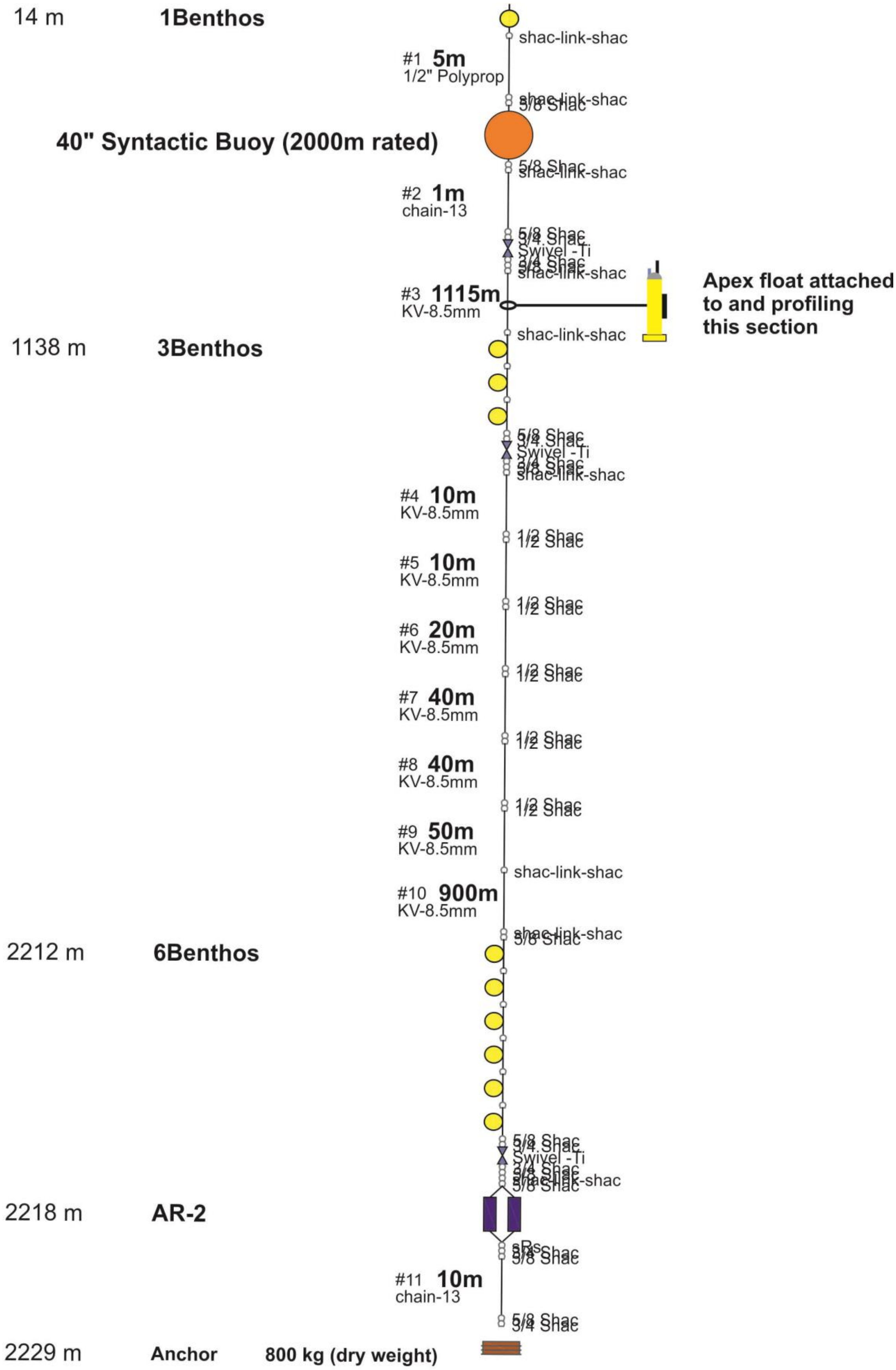
The float was attached to the mooring by a 1m length of 10mm neutrally buoyant Dynema rope. At one end this was attached to the Apex float using the deployment collar and at the other a 120mm eye was spiced in the rope tether that would allow it to freely move up and down the 1115m section of Dynema mooring rope. The float was attached to the mooring line once the 1115m rope had been paid out, whilst stopped off before the three glass spheres were installed. After which the remaining mooring deployment continued.

The Apex float was seen to float freely along the mooring line once it had been carefully lowered into the sea along the mooring line from the stern of the vessel. Once all of the mooring rope had been streamed after 90 minutes (travelling 3.9km), the ship towed the mooring a further 1.1km until the deployment position of 36°13.568'N 032°46.549'W was reached at 11:58 GMT at which point the anchor was released. This was approximately 450 m beyond the target position to allow for fall-back.

The anchor took 16 minutes to reach the seabed after it released and this was tracked by acoustic ranging on the releases.

The estimated final mooring anchor position was 36°13.632'N, 032°46.458'W. The estimated mooring location was 269m in a direction of 237°T from the target location. The mooring fall back was approximately 180m.


Apex float
Rope tether
Mooring line



14 m
1Benthos
shac-link-shac
#1 5m
1/2" Polyprop
shac-link-shac
5/8 Shac
40" Syntactic Buoy (2000m rated)
5/8 Shac
shac-link-shac
#2 1m
chain-13
5/8 Shac
3/4 Shac
Swivel -Ti
3/4 Shac
shac-link-shac
Apex float attached to and profiling this section
#3 1115m
KV-8.5mm
shac-link-shac
1138 m
3Benthos
5/8 Shac
3/4 Shac
Swivel -Ti
3/4 Shac
shac-link-shac
#4 10m
KV-8.5mm
1/2 Shac
1/2 Shac
#5 10m
KV-8.5mm
1/2 Shac
1/2 Shac
#6 20m
KV-8.5mm
1/2 Shac
1/2 Shac
#7 40m
KV-8.5mm
1/2 Shac
1/2 Shac
#8 40m
KV-8.5mm
1/2 Shac
1/2 Shac
#9 50m
KV-8.5mm
shac-link-shac
#10 900m
KV-8.5mm
shac-link-shac
5/8 Shac
2212 m
6Benthos
5/8 Shac
3/4 Shac
Swivel -Ti
3/4 Shac
shac-link-shac
5/8 Shac
2218 m
AR-2
5/8 Shac
#11 10m
chain-13
5/8 Shac
3/4 Shac
2229 m
Anchor
800 kg (dry weight)

17.2 Mooring Recoveries during JR15-007

Paul Provost, Nick Rundle, Billy Platt, Candice Cameron, Jez Evans (Sensors & Moorings Group, National Marine Facilities Sea Systems).

Refer to the RIDGEMIX Mooring Deployment Report (section 17.1 above) which details the moorings deployed on 26 September 2015 (Ridgemix 1 mooring) and 27 September 2015 (Ridgemix 2 mooring). All moorings were recovered from the aft deck of the RRS James Clark Ross by the National Marine Facilities team and the ship's crew.

Prior to the recoveries commencing the acoustic releases were ranged and using trigonometry the mooring position (from one slant range position) was calculated to confirm the moorings had not moved from their deployment positions. Using this method both moorings were in the expected position.

Prior to triggering the mooring acoustic releases the vessel stood-by 600m from the mooring position to allow a sufficient and a safe distance. Both mooring recoveries took place on 30 June 2016. Recovery operations began at 08:04 local time (GMT-2). Ridgemix mooring 2 was recovered first.

RIDGEMIX 1

The position of the Ridgemix 1 mooring was 36°14.680'N, 032°46.670'W in approximately 2280m of water. The mooring consisted of 35 RBR Solo T self logging thermistors, 6 RBR Duo TD self logging instruments, 4 SeaBird SBE37SMP MicroCAT CTD sensors, two TRDI 75 kHz Longer Ranger ADCPs rated to 1500m, one TRDI 75 kHz Longer Ranger ADCP rated to 3000m, two Flowquest 75 kHz ADCPs rated to 1500m. In addition, a Xenon light and Iridium locator beacon was attached at the top of the mooring, with a further Iridium locator beacon attached to the uppermost ADCP syntactic float at approximately 300m depth

The mooring recovery operation began at 10:13 local time (GMT-2) on 30 June 2016, the release command was sent at 10:16. A positive confirmation of release was confirmed and the top buoyancy (Billings floats) was seen at 10:18, less than 2 minutes after release. The acoustic releases continued to be interrogated and it was clear that they were rising as expected. The rate of rise of the releases was approximately 95 m/min. At 11:00 recovery of the mooring commenced once all the buoyancy was observed at the surface. The top recovery float was grappled at 11:06 and recovered to deck, and the line passed aft to be recovered from the stern. At 11:15 the vessel was positioned to allow hauling of the mooring wire.

Instrument/equipment	Serial number	Time (GMT) recovered to deck	Predicted depth (m from surface)	
RBR Duo TD	50753	13:19	24	
Xenon Flasher	W10-030	13:20	-	
Iridium beacon	IMEI: 300234062982050	13:20	-	
RBR Solo T	76492	13:20	28	
RBR Solo T	76493	13:22	33	
RBR Solo T	76494	13:23	38	
RBR Solo T	76495	13:25	43	
RBR Solo T	76496	13:27	48	
RBR Duo TD	50752	13:28	53	
RBR Solo T	76497	13:31	63	
RBR Solo T	76498	13:33	73	
RBR Solo T	76499	13:34	83	
RBR Solo T	76500	13:36	93	
RBR Duo TD	50751	13:36	103	
RBR Solo T	76501	13:37	113	
RBR Solo T	76502	13:39	123	
RBR Solo T	76503	13:43	133	
RBR Solo T	76504	13:43	142	
RBR Solo T	76505	13:42	152	
RBR Solo T	76506	13:49	162	
RBR Solo T	76507	13:50	172	
RBR Solo T	76508	13:51	183	
RBR Solo T	76509	13:52	193	
RBR Duo TD	50750	13:54	205	
RBR Solo T	76510	14:00	255	
TRDI 75kHz LRADCP (up)	10583	14:15	305	
Iridium beacon	IMEI: 300234062988050	14:15	-	

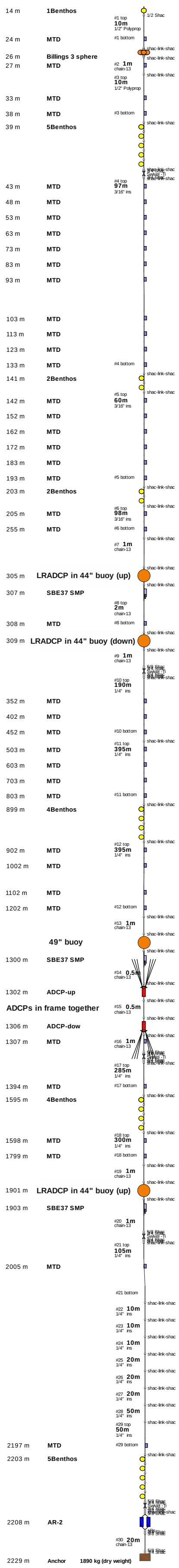
SBE37SMP CTD	9395	14:15	305	
RBR Solo T	76511	14:15	308	
TRDI 75kHz LRADCP (down)	10584	14:15	309	
SBE37SMP CTD	9396	14:15	311	
RBR Solo T	76512	14:25	352	
RBR Solo T	76513	14:27	402	
RBR Solo T	76514	14:30	452	
RBR Duo TD	57049	14:32	503	
RBR Solo T	76515	14:35	603	
RBR Solo T	76516	14:40	703	
RBR Solo T	76517	14:45	803	
RBR Solo T	76518	14:50	902	
RBR Solo T	76519	14:52	1002	
RBR Solo T	76520	14:55	1102	
RBR Solo T	76521	14:58	1202	
SBE37SMP CTD	9397	15:02	1300	
Flowquest 75kHz ADCP (up)	11626	15:02	1302	
Flowquest 75kHz ADCP (down)	15951	15:02	1303	
RBR Solo T	72067	15:02	1304	
RBR Duo TD	50748	15:15	1394	
RBR Solo T	72068	15:20	1598	
RBR Solo T	72069	15:29	1799	
SBE37SMP CTD	9398	15:32	1901	
TRDI 75kHz LRADCP (up)	20676	15:32	1901	
RBR Solo T	72070	15:41	2005	
RBR Solo T	72071	15:48	2197	
IXBlue AR861 release	1501	15:48	2208	
IXBlue AR861 release	1918	15:48	2208	

During recovery some of the buoyancy and instruments became tangled, this was due to the negatively buoyant wire hanging between buoyancy packages and getting caught on the numerous small temperature and CTD loggers. None of the tangles were serious and none of the instruments were damaged during the recovery. Care was taken when hauling in to allow the mooring to stream itself behind the vessel which removed some of the tangles prior to recovering to deck.

The ¼” wire that had its jacket damaged on deployment showed no signs of corrosion or increased deterioration as a result.

The mooring recovery operations were completed by 14:00 local time (GMT-2).

The instruments were downloaded and the data backed up. All instruments recorded except for RBR Solo T serial no. 76493, which appeared to start at the prescribed time and then fail with a few hours of deployment with the data suggesting an electronic failure of some kind. The two FlowQuest 75kHz ADCPs did not record for the full deployment duration due to battery life failure.


14 m 1Benthos
24 m MTD
26 m Billings 3 sphere
27 m MTD
33 m MTD
38 m MTD
39 m 5Benthos
43 m MTD
48 m MTD
53 m MTD
63 m MTD
73 m MTD
83 m MTD
93 m MTD
103 m MTD
113 m MTD
123 m MTD
133 m MTD
141 m 2Benthos
142 m MTD
152 m MTD
162 m MTD
172 m MTD
183 m MTD
193 m MTD
203 m 2Benthos
205 m MTD
255 m MTD
305 m LRADCP in 44" buoy (up)
307 m SBE37 SMP
308 m MTD
309 m LRADCP in 44" buoy (down)
352 m MTD
402 m MTD
452 m MTD
503 m MTD
603 m MTD
703 m MTD
803 m MTD
899 m 4Benthos
902 m MTD
1002 m MTD
1102 m MTD
1202 m MTD
49" buoy
1300 m SBE37 SMP
1302 m ADCP-up
ADCPs in frame together
1306 m ADCP-dow
1307 m MTD
1394 m MTD
1595 m 4Benthos
1598 m MTD
1799 m MTD
1901 m LRADCP in 44" buoy (up)
1903 m SBE37 SMP
2005 m MTD
2197 m MTD
2203 m 5Benthos
2208 m AR-2
2229 m Anchor 1890 kg (dry weight)

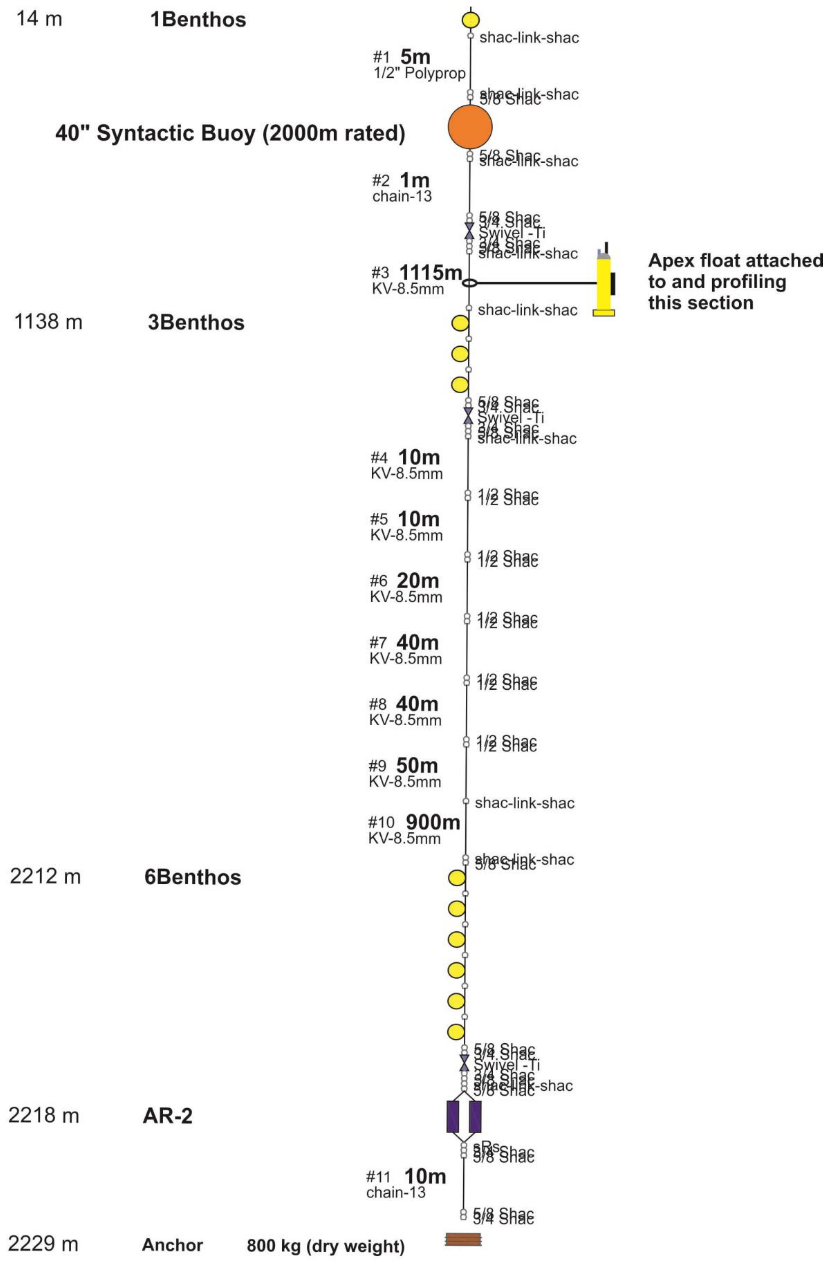
RIDGEMIX 2
The position for the RIDGEMIX 2 mooring was 36°13.632’N, 032°46.458’W in approximately 2273m of water. When deployed the mooring consisted of a single Webb Research Apex float, which was programmed to profile in the upper 1000m of the water column whilst tethered to the mooring, with an integrated Satlantic Suna nitrate sensor and AADI Optode.

The mooring recovery operation began at 08:04 local time (GMT-2) on 30 June 2016, the release command was sent at 08:13. A positive confirmation of release was confirmed however the top buoyancy was not seen in the first few minutes after release. The acoustic releases continued to be interrogated and it was clear that they were rising as expected. The rate of rise of the releases was approximately 90 m/min. The middle set of three spheres was seen at around 08:26 with the release spheres arriving at the surface at 08:40.

The top sphere and recovery line was missing so the vessel positioned to recover the mooring from the bottom end where the releases were located. At 08:53 the 6 spheres were grappled and secured to the mid-ships 10T crane. The spheres and releases were recovered to deck and the line passed aft to be recovered from the stern. At 08:58 the vessel was positioned to allow hauling of the mooring rope. The middle 3 spheres were recovered to deck at 09:28. The mooring line above the 3 spheres had parted 1m into the 1115m length. The stopper that had been placed on the rope to prevent the profiling apex float from hitting the buoyancy had chaffed through the line. A piece of soft plastic hose had been slid over the rope to prevent any damage to it. Unfortunately however this appeared to be the cause of the chaffing and ultimate failure of the rope. This resulted in the loss of the 40” Flotec syntactic buoy (inventory no. 250007734), the Apex profiling float and Suna nitrate sensor (NERC Asset no. 195211) and the 1115m of kelvar rope and 10” recovery sphere.






14 m
1Benthos
shac-link-shac
#1 5m
1/2" Polyprop
40" Syntactic Buoy (2000m rated)
#2 1m
chain-13
Swivel -Ti
#3 1115m
KV-8.5mm
Apex float attached to and profiling this section
1138 m
3Benthos
shac-link-shac
#4 10m
KV-8.5mm
1/2 Shac
#5 10m
KV-8.5mm
#6 20m
KV-8.5mm
#7 40m
KV-8.5mm
#8 40m
KV-8.5mm
#9 50m
KV-8.5mm
#10 900m
KV-8.5mm
2212 m
6Benthos
2218 m
AR-2
#11 10m
chain-13
2229 m
Anchor
800 kg (dry weight)

18. JR15007 WireWalker underwater profiler

Chris Balfour (National Oceanography Centre, Liverpool).

All times are GMT.

Measurement system scientific requirements

The 'wirewalker' is a wave and buoyancy driven underwater profiling measurement system that was added to original RidgeMix project suite of scientific instrumentation. This was a relatively late inclusion to the planned scientific sensing systems to be used during the RRS James Clark Ross (RRS JCR) based JR15007 scientific research cruise. The wirewalker was configured to provide high resolution measurements of chlorophyll-a concentration, conductivity, temperature and depth (CTD) and turbulent kinetic energy dissipation in the upper 200 metres of the water column. The MicroRider oceanic microstructure and turbulence sensor included a high speed accelerometer for determining the movement and position of the sensor and the host platform during the deployment. Wave energy and the profiler system buoyancy were used to provide repeated underwater profiles from close to the sea surface to an approximate depth of 200 metres. Measurements from this system were configured to occur with the profiler attached via a vertically suspended steel wire, sub-surface weight and couplings to the underside of a surface buoy. The entire mooring system was then deployed to drift around the mid-Atlantic underwater ridge survey area under the influence of wind, waves and underwater currents. The primary objective was to generate scientific measurements as the profiler drifted through regions of increased underwater mixing due to breaking internal tides. The mooring was originally deployed approximately 1km to the west of the main R1 mooring site of the JR15007 research cruise survey grid. This was intended to provide co-located, high resolution microstructure measurements in close proximity to a series of subsurface moorings. Within the RidgeMix programme this information will help to test the hypothesis that increased mixing transports nutrients from deeper waters, which are then advected along near surface isopycnals, to subsequently support open ocean biological production.

Sensors and mooring configuration

For the drifting mooring configuration a surface expression in the form of an approximately 1 metre diameter buoy was used. Positional tracking systems were installed on the buoy to monitor and record the location of the surface buoy and subsequently the attached underwater vertical profiling system. A beacon using the iridium satellite constellation with an integrated GPS receiver was the primary system for tracking the buoy position remotely in near real time. A backup positional indication was provided by the Argos satellite constellation using a marine mammal tracking tag fitted to the surface buoy. A further, shorter range, positional indication system was installed in the form of a VHF radio beacon. The surface buoy instrumentation included a high resolution GPS recording system that was used for tracking the buoy path during the deployment. Table 1 provides a list of the internally recording underwater profiler scientific sensor system basic specifications. The subsequent list in table 2 provides some details of the buoy mounted position indication and recording systems. A functional diagram of the mooring arrangement is provided in figure 1. The key features of the underwater profiling system are shown in the labelled picture in figure 2. The primary components mounted to the surface buoy are indicated in figure 3.

Table. 1 – Wire Walker underwater profiler instrumentation

Rockland Scientific International (RSI) MicroRider SN043	An internally recording underwater microstructure and turbulence sensor including two fast sampling temperature sensors, a microstructure conductivity

	sensor, high resolution pressure and two underwater velocity shear sensors.
RBR Concerto CTD SN060048	Fast sampling underwater conductivity, temperature and depth sensor (CTD), capable of a measurement rate of up to 6Hz.
WetLabs Eco fluorimeter SN777	A self-recording fluorimeter configured for a maximum measurement rate of up to 20Hz. A custom data recording system has been added to allow for several weeks of measurements to be recorded up to this maximal data rate.

Table. 2 – Surface buoy based instrumentation

Pacific Gyre Globeacon	An iridium beacon with integrated GPS receiver for surface buoy location tracking. A nominal position transmission update rate of 30 minutes was used.
Novatech Minibeacon 7500	A VHF radio beacon for locating the surface buoy with a typical range of 3-5 nautical miles.
Argos Tag	A Wildlife Computers SPOT-100 inline fin mount, 258A tag with a 90s transmission rate that was used for backup locational information.
Carmanah M650 light	A solar powered, rechargeable battery based light for night time buoy positon indication.
High resolution GPS recorder	This was a custom built GPS recording system in a bespoke pressure case. The battery powered system internally logged to memory GPS fix information at a nominal 1 second interval and had an operational endurance of several weeks.

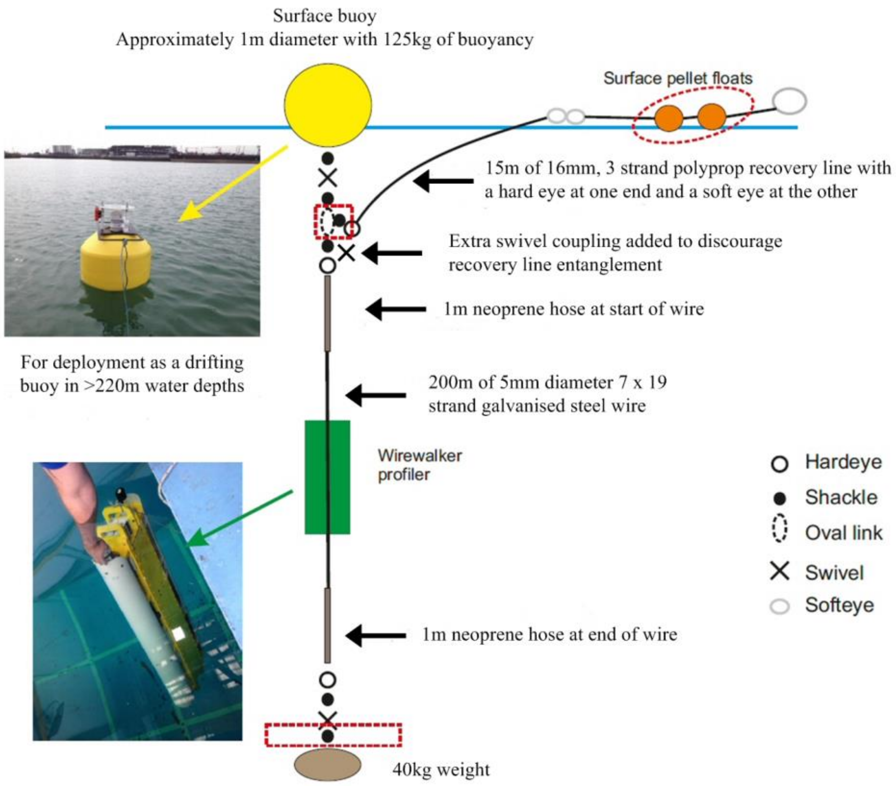


Figure 1 - Basic mooring layout of the wirewalker underwater profiling system

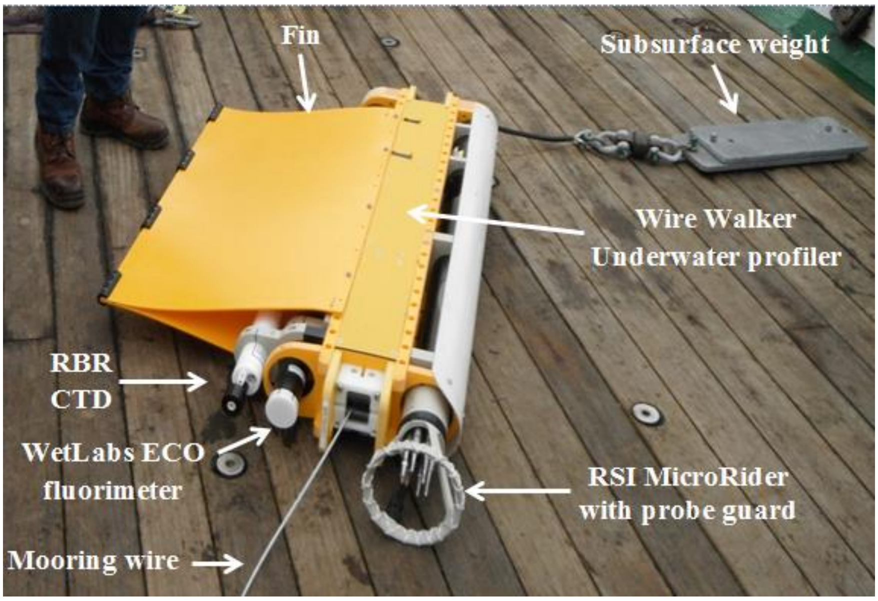


Figure 2 - Wirewalker underwater profiling system key features

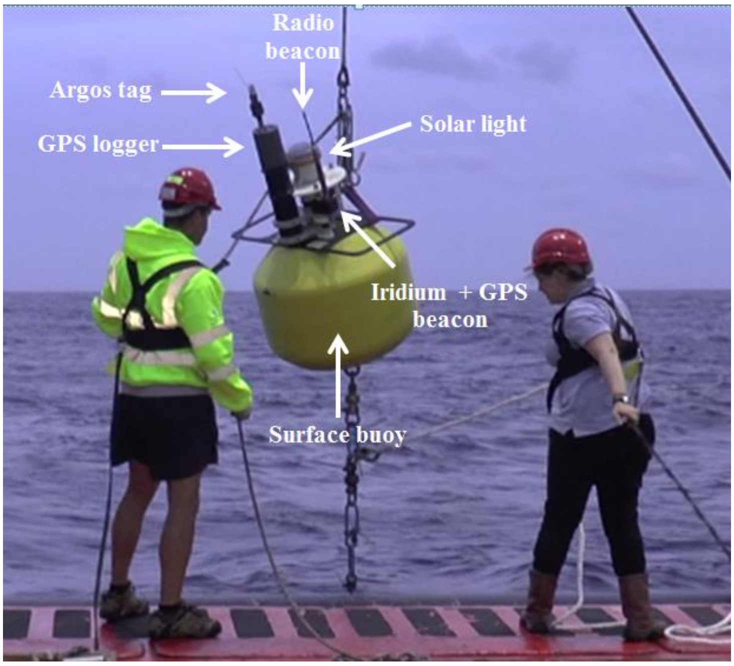


Figure 3 - Wirewalker mooring surface buoy key features

Pre-deployment configuration and testing
During the pre-deployment ballasting testing a 20m wire and the sub-surface weight were attached to the underside of a reserve surface buoy. The profiler was coupled to the wire and the buoy was then temporarily deployed from the starboard side of RRS JCR with a tether to the ship being used to keep the buoy on close proximity. A series of test profiles underwater to a depth of 20m were then generated to assess the local conditions and the ascent rate of the wirewalker system. The climb rate of the profiler during the 20 metre wire ballasting tests was trimmed to approximately 0.5m/s by altering the number of foam buoyancy blocks installed in the wirewalker mechanism compartment. Previous CTD casts to 200m and beyond had indicated a trend of higher density at increased depths than the original 20m test depth that was used for determining the initial ballasting setup. This is likely to increase the profiler ascent rate from depths deeper than the 20m ballasting tests, as a result of the increased buoyancy of the wirewalker in higher density seawater lower down below 20m in the underwater column. To compensate for the likely increased buoyancy due to higher depth profiles to 200m when the wirewalker was deployed, 2 buoyancy blocks were removed from the profiler mechanism compartment. The aim was to yield a target ascent rate of approximately 0.3m/s to 0.4m/s during the up-cast or rising phase of the underwater profiler operation, when scientific measurements occur up to a position close to the sea surface under the influence of the profiler buoyancy. This arrangement was deemed compatible with measuring fine scale changes in the water column temperature, pressure, microstructure conductivity, in addition to gathering underwater current rate of change of velocity or 'velocity shear' measurements. The modified ballasting setup for the JR15007 research cruise reduced the wirewalker mechanism compartment buoyancy block configuration to a total of 9. Originally the maximum of 11 buoyancy blocks in the wirewalker mechanism compartment were used for an early trial of the profiler prior to the JR15007 research cruise in lower density coastal waters. Two external foam blocks were fitted to the base of the profiler for the previous trials work in coastal waters. These remained in place during the ballasting tests and for the scientific deployment for the JR15007 research cruise.

Deployment of the wirewalker and mooring

The wirewalker mooring was deployed at 21:38 on Sunday 5th June 2016 at a GPS location 36° 14.743N, 32° 45.303W with a water depth of 2183 metres. The profiler, subsurface weight and 200m long line were deployed first over the stern of RRS JCR. After the full 200m long wire had been paid out from the stern of the ship using a deck based winch and a large, wide sheave block suspended from the ship's A-frame, the surface buoy, recovery line and pellet floats were deployed with RRS JCR progressively moving away from the mooring as the operations concluded. A sequence of pictures of the deployment of the sub-surface weight, mooring line, profiler and then surface buoy are shown in figures 4 and 5.

Post deployment sensor calibration CTD cast

The nearest post deployment calibration CTD using the RRS JCR over the side carousel was event number 24, CTD cast 9 at 23:58 GMT on Sunday 5th June. This calibration CTD occurred at a GPS location of 36° 13.261N, 32° 45.788W to a depth of 2300 metres. During this CTD profile an underwater temperature of 20°C with a salinity reading of 36.3 PSU occurred to a depth of approximately 50m, indicating well mixed waters to this depth. From 50m to 200m the temperature reduced to 14.5°C and the salinity reduced to 35.8 PSU. This corresponded to an approximate density near the sea surface of 1026 kg/m^3 increasing to a density of approximately 1027 kg/m^3 at a depth of 200m. This seemed to support the premise that, for increased profiler operating depths to 200m during the deployment, some additional buoyancy needed to be removed. Therefore a reduction in the profiler positive buoyancy that was made before the deployment was justified. This was to compensate for the increased buoyancy at higher depths due to an elevating level of density with depth from close to the sea surface to 200m below the sea surface.

Figure 4 – Deployment of the sub-surface weight, line and wirewalker

a Surface buoy deployment over the stern of the ship

b Deployed surface buoy and recovery line

Figure 5 – Deployment of the surface buoy and recovery line

A plot of the track of the surface buoy GPS position is shown in figure 6. The arrows added to the plot show the deployment location on Sunday 5th June and the subsequent recovery location on Monday 27th June. Some markers have been added to indicate the scale of the track of the wire walker track in km. Each of the black crosses represent the wirewalker mooring surface buoy reported GPS position via the iridium low earth orbit satellite constellation, at a predominantly 30 minute update rate.

Wirewalker mooring recovery

A selection of pictures of the Wirewalker mooring recovery operations are shown in fig 7. The mooring recovery operations were initiated using a grapnel from the aft starboard side of RRS JCR to snag the buoyant mooring recovery line. The link below the surface buoy was stopped off on the stern of the ship and the recovery line and surface buoy were de-coupled.

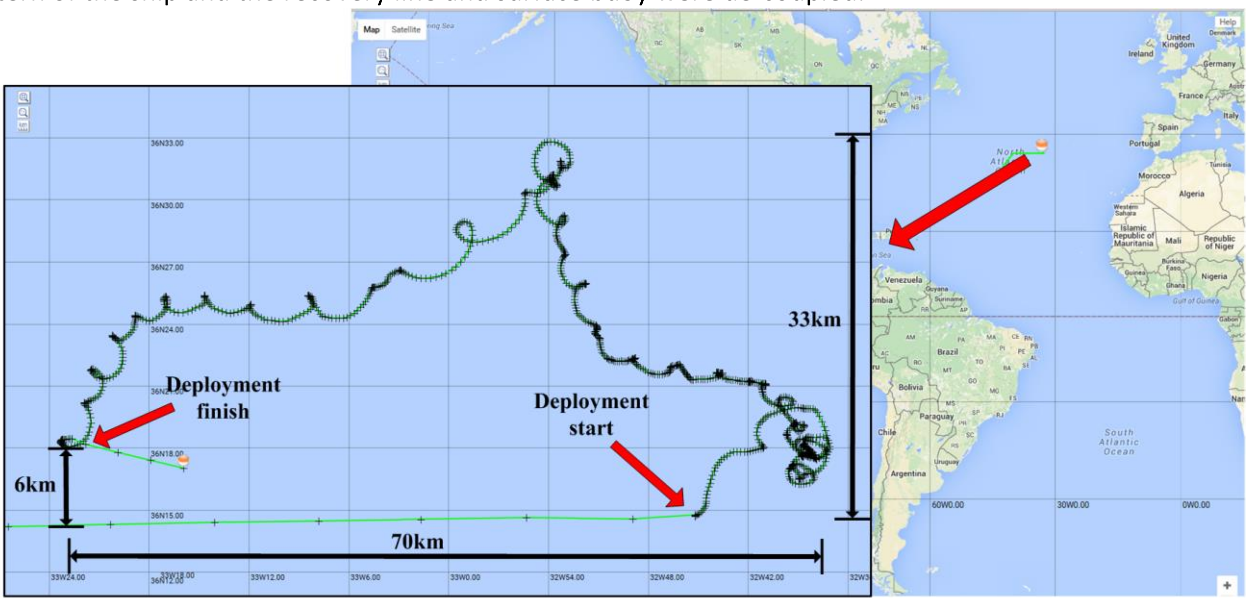
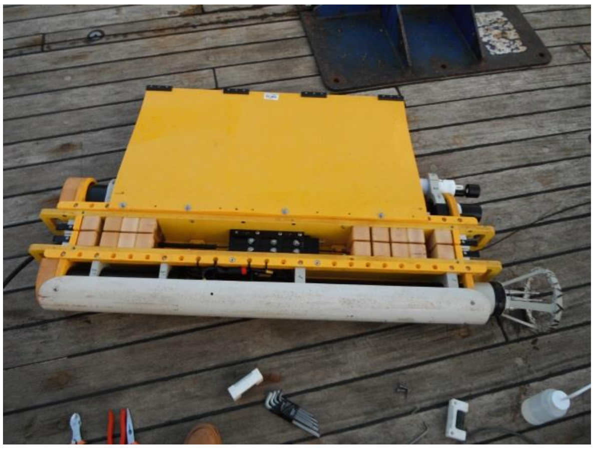


Figure 6 - Deployed wirewalker mooring surface buoy track

a subsurface weight, wire and wirewalker profiler recovery



b No significant biofouling or sedimentation was evident with the recovered profiler

c The recovered MicroRider probes were clean and free of contamination and the MicroRider was still running and recording data after the recovery

Figure 7 – Recovery of the Wirewalker and mooring

The mooring wire was then winched on-board and the profiler wave energy harvesting mechanism had disengaged and the Wirewalker profiler was resting on the lower mooring wire neoprene hose. The wide sheave block from the A frame at the stern of RRS JCR was moved inwards to allow the profiler and subsurface weight to be carefully landed on the stern of the ship. There was not any significant biofouling or sedimentation evident on or in the profiler and the fluorimeter and MicroRider were still running on battery power after the recovery. The galvanised steel mooring wire was intact without any significant corrosion or noticeable damage. There was not any significant wear and tear to the wirewalker wire guide and wave energy harvesting cam and tapered plate mechanism. The recovery was at a GPS location of 36° 18.4243N, 32° 23.0228W at 20:00 GMT on Monday 27th June 2016.

Post recovery CTD calibration CTD cast

Scheduling and limited daylight working hours dictated that a calibration CTD cast to 200m was undertaken in close proximity to the wirewalker mooring recovery location. The calibration CTD using the RRS JCR over the side carousel was event number 188, CTD cast 63 at 20:58 GMT on Monday 27th June. This calibration CTD occurred at a GPS location of 36° 18.462N, 33° 22.626W to a depth of 200 metres. During this CTD profile an underwater temperature of 21.6°C with a salinity reading of 36.3PSU occurred at a depth of approximately 10m, with a corresponding density of 1025.36kg/m^3. The thermocline was at approximately 30m depth indicating well mixed waters to this point. At an approximately 200m depth the temperature was 15.6°C with a salinity of 36.3PSU corresponding to a density of 1026.19 kg/m^3. Cruise scheduling also precluded a calibration profile for oceanic microstructure and turbulence in close proximity to the Wirewalker profiler before it was recovered.

Scientific Measurement data sets

During the deployment high speed data was recorded by the RBR CTD, the RSI MicroRider and the WetLabs Eco fluorimeter. Table 3 provides a brief review of these data. The typical vertical profiler ascent rate was 0.35m/s and > 3 profilers of wave driven descent and subsequent buoyant return ascents occurred per hour for approximately 22 days.

Table 3 – Wire Walker underwater profiler instrumentation data summary

Deployment from Sunday 5th June to Monday 27th of June 2016	
Sensor	**Summary of data return**
MicroRider	Data was recorded during the deployment and a full return was achieved.
CTD	Data recorded successfully at 6Hz and the 21.5 day memory capacity of the CTD at this sampling rate was reached.
Fluorimeter	A potential proprietary logger issue resulted in a lower than 20Hz sample rate. With careful recorded data processing a high resolution chlorophyll-a concentration record should be achievable.

A review of the performance of the buoy based instrumentation is provided in table 4. In general the buoy based instrumentation operated correctly. The GPS location of the wirewalker mooring buoy was reported at typically 30 minute intervals via near real time data transfer for the duration of the deployment using the iridium low earth orbit satellite constellation. The Argos marine mammal backup position tag reported several positional estimates per day. The VHF radio beacon at a frequency of 154.585MHz, with a transmission on time of 1 seconds and a gap between transmissions of 5 seconds, continued transmitting throughout the deployment. The solar powered night time buoy light was activated following the deployment after sunset on Sunday 5th June. After the recovery on Monday 27th June the buoy light was confirmed to be functioning correctly.

Table. 4 – Surface buoy based instrumentation post deployment review

Deployment from Sunday 5th June to Monday 27th of June 2016	
Pacific Gyre Globeacon	A nominal position transmission update rate of 30 minutes was sustained throughout the deployment, as required, using the iridium low earth orbit satellite constellation.
Novatech Minibeacon 7500	The VHF radio beacon was confirmed as functioning correctly after the mooring was deployed and when the mooring was recovered.
Argos Tag	A Wildlife Computers SPOT-100 inline fin mount, 258A tag with a 90s transmission rate for backup locational information worked correctly during the deployment.
Carmanah M650 light	A solar powered buoy light for night time buoy positon

	indication was confirmed to be working as expected following the deployment and after the recovery.
High resolution GPS recorder	A high resolution log of GPS positional fix information was recorded using a proprietary data recording system housed in a custom pressure case. Post processing of the GPS positional record should allow a higher resolution GPS positional log than that from the Pacific Gyre Globeacon to be extracted.

19. JR15-007 Glider operations cruise report

Stephen Woodward, Candice Cameron (MARS Gliders, NMF-SS, NOC Southampton)

Objectives

Glider operations on JR15-007 consisted of deployment and recovery of 3 Ocean Microstructure Gliders (OMGs)

1. 1000m Slocum glider 424 (OMG3) to hold station within 10km of station D1 (deep site)
2. 1000m Slocum glider 423 (OMG2) to hold station within 10km of station R1 (ridge site)
3. 200m Slocum glider 444 (Kelvin) to transit across the work area. This glider is also equipped with an upward facing ADCP

All glider deployments were carried out from the starboard deck crane, using rigid rope rigs. Recoveries were carried out using the midships 10T crane. Gliders were recovered by jettisoning the nose recovery device (the buoyant nose is detached using a burn wire, and drifts away from the vehicle whilst attached by a buoyant line which can be grappled from the deck).

Deployments/Recoveries

1. **Deep site**

Slocum glider SN_424 ('OMG3'). Deployed 03/06/2016 (36°14.82 N, 40°00.44 W). Recovered 25/06/2016 (38°26.42 N, 39°50.15 W)

2. **Ridge site**

Slocum glider SN_423 ('OMG2'). Deployed 07/06/2016 (36°06.86 N, 32°57.00 W)

3. **On-ridge transect**

Slocum glider SN_444 ('Kelvin'). Deployed 04/06/2016 (36°13.44 N, 37°01.21 W). Recovered 30/06/2016 (36°14.89 N, 32°53.73 W)

Sensor Packages

Slocum glider SN_424:	Seabird CT sensor S/N 0221	
	Aanderaa Oxygen optode S/N 210	
	Rockland Microrider S/N 105:	Shear probe 1 – S/N M1073
		Shear probe 2 – S/N M1074
		Thermistor 1 – S/N T838
		Thermistor 2 – S/N T699
Slocum glider SN_423:	Seabird CT sensor S/N 207	
	Aanderaa Oxygen optode S/N 272	
	Rockland Microrider S/N 106:	Shear probe 1 – S/N M1077
		Shear probe 2 – S/N M1075
		Thermistor 1 – S/N T839
		Thermistor 2 – S/N T698
Slocum glider SN_444:	Seabird CT sensor S/N 9154	
	Aanderaa Oxygen optode S/N 245	
	Wetlabs fluorometer S/N 3423	
	Rockland Microrider S/N 108:	Shear probe 1 – S/N M1078
		Shear probe 2 – S/N M1079
		Thermistor 1 – S/N T331

Thermistor 2 – S/N T837

Problems encountered

1) Slocum 424 suffered serious mechanical failure shortly after deployment. A pitch motor failure prevented the glider from attaining the correct pitch angle required for surfacing:

```
4.53  1 pitch_motor NOT MOVING FAST ENUF vel: 0.036994, limit: 0.037500
4.57  cx: 0.184, cxts: 4522 ; px: 0.175, pxts: 4277, dt = 245
4.61  DRIVER_ODDITY:pitch_motor:300:motor_safety_check(): Motor is not measured as moving
4.66  DRIVER_WARNING:pitch_motor:300:MOVE ERROR Error from motor safety check
```

After approximately 30 hours without comms, the abort weight dropped and contact was restored. Unable to dive, it drifted North for 22 days before recovery. Significant biofouling developed during this time, and on recovery several medium-sized fish could be seen swimming around the glider, presumably feeding on the goose barnacles and crabs. Damage to the microstructure probes seems consistent with this.

Post-recovery analysis showed that a corrupted autoexec.mi file during Iridium transfer was responsible for the fault, being cut short in the section responsible for loading battery position calibration factors:

```
# Battery Position
# max battpos = safety_max - deadzone
# x_max_battpos = f_safety_max_battpos - f_deadzone_width_battpos
 sensor: f_battpos_deadzone_width(inches)      0.2     # Sets x_ limit
           sensor: f_battpos_db_frac_dz(nodim)  0.5     # deadband as fraction of dead zone;
                                                        Recomended setting for improved servo
                                                        with memory - from 7.7 release
 sensor: f_battpos_nominal_vel(inches/sec)     0.15    # nominal speed for REV.A motor
                                                        # Specs linear relationship between sensor
                                                        units (inches) and the
                                                        # voltage we actually read out of the AD for
                                                        position
                                                        # battpos(inches) = _cal_m(inches/Volt) *
                                                        volts + _cal_b(inches
#UNCOMMENT THE CALIBRATION NUMBERS FOR THE GLIDER CONFIGURATION
```

sensor: f_battpos_safety_ma

2) Contact was lost with Slocum 423 on 04/06/2016, 10 hours before recovery. The glider accepted new .ma files reducing dive depth from 1000m to 200m and performed 3 dives before contact was lost. No errors or abnormalities were seen in the last surface dialogue:

```
GPS Location:  3613.516 N -3254.453 E measured     62.447 secs ago
sensor:c_autoballast_state(enum)=0            1e+308 secs ago
sensor:c_climb_bpump(X)=1000                1e+308 secs ago
  sensor:c_dive_bpump(X)=-1000                1e+308 secs ago
sensor:c_wpt_lat(lat)=3614.68              11664.9 secs ago
sensor:c_wpt_lon(lon)=-3252.457             11664.9 secs ago
sensor:m_battery(volts)=11.0973021064357       57.493 secs ago
sensor:m_coulomb_amphr(amp-hrs)=136.316696166992     5.626 secs ago
sensor:m_coulomb_amphr_total(amp-hrs)=143.025256651733      5.646 secs ago
sensor:m_final_water_vx(m/s)=-0.0703354036501221    3212.59 secs ago
sensor:m_final_water_vy(m/s)=0.0176584204581672    3212.63 secs ago
sensor:m_iridium_signal_strength(nodim)=2      30.192 secs ago
sensor:m_leakdetect_voltage(volts)=2.4965811965812     62.214 secs ago
sensor:m_leakdetect_voltage_forward(volts)=2.48675213675214     62.234 secs ago
sensor:m_lithium_battery_relative_charge(%)=79.6260318159924      5.904 secs ago
sensor:m_tot_num_inflections(nodim)=2436      209.725 secs ago
sensor:m_vacuum(inHg)=7.71532884615384        125.025 secs ago
sensor:m_water_vx(m/s)=-0.0682924412277227     132.651 secs ago
sensor:m_water_vy(m/s)=-0.0197514425348702     132.691 secs ago
sensor:u_use_current_correction(nodim)=0       1e+308 secs ago
sensor:x_last_wpt_lat(lat)=3614.82            165950 secs ago
  sensor:x_last_wpt_lon(lon)=-3245.66           165950 secs ago
```

Although this does not rule out problems such as a catastrophic leak or battery malfunction, there is no evidence for these. Whilst some traffic was noted in the area, the last surface dialogue finishes exactly as expected:

```
841944  4 00860175.mlg LOG FILE OPENED
Megabytes used     on CF file system = 369.031250
Megabytes available on CF file system = 1628.937500
841947    init_gps_input()
841947    behavior surface_3: SUBSTATE 7 ->10 : Waiting for final gps fix
surface_3: Waiting
```

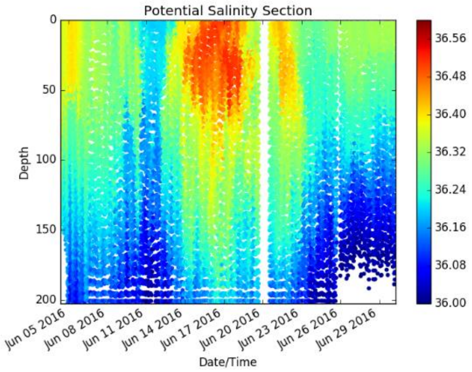
Unless fresh information comes to light at a later stage, it will be impossible to identify the cause of loss for glider 423. Argos and freewave radio systems were set up to monitor for transmissions whilst the ship remained in the vicinity of 423's last waypoint (36°14.68 N, 32°52.46 W) from 30/06/2016, 18:00 to 02/06/2016, 06:00 and during an expanding box search from the glider's last known location (36°13.52 N, 32°54.45 W) in the direction of the prevailing surface drift from 06:00 to 13:00 on 02/06/2016. No transmissions were received.

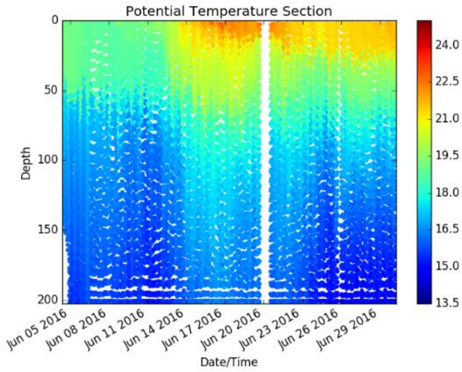
3) On recovery, the Rockland microstructure sensor on Slocum 444 was found to have come loose. Two cap head machine screws securing the sensor housing to the vehicle were discovered to have processed loose over the course of the deployment despite being securely fastened with

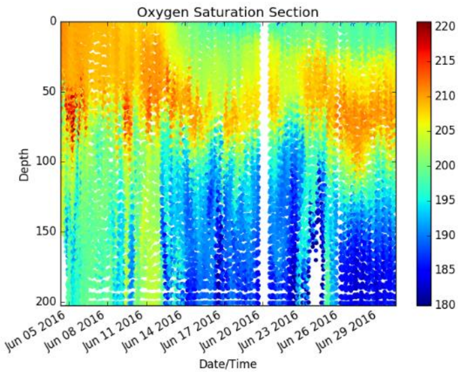
thread sealant. Initial analysis of microstructure profiles show increased noise in later dives. The sensor was able to rock from side to side, but remained securely fastened at the nose of the vehicle.

Data

Whilst decimated data from Slocum 423 prior to its loss are available, data from Slocum 444 will be the only full set produced. The microstructure sensor worked for the duration of the deployment, recording 525 profiles. ADCP profiles were collected in a variety of configurations to test performance of the sensor. The following plots are examples of raw decimated temperature, salinity and oxygen data from 444's deployment:







20. BAS ICT Summary

20.1 ICT Engineer

Andy England

20.2 SCS Logging system / Data logging

Newleg & ACQ started at 17:21 25th May 2016 (UTC)
SCS ACQ version : 4.5.1.1063

20.3 Systems

UNIX

Veeam replication of the JRLB OS disk caused three disconnections of the samba shares for the SCS server, after which the Veeam replication was set to only run when manual triggered to prevent impact to science.

Windows

No problems reported.

Network

No problems reported.

20.4 Event Log

25 May 2016

1. New leg started.
2. Gyro not logging, fixed by resetting the device.
3. Started ADCP at May 25 21:18 UTC, not tied to the KSync and on 250m Bottom Tracking.

27 May 2016

1. AME are running opportunistic Swath on behalf of Alex Tate (BAS).

28 May 2016

1. 11:35 UTC - The ADCP was logging with the incorrect cruise name. Stopped and reset to JR15007 and restarted.

30 May 2016

1. CDT PC not receiving NMEA string from SCS. CDT PC was rebooted and issue was resolved.
2. 15:23 UTC, ASVP for EM122 changed using data from CTD test cast.

12 June 2016

1. 18:56 UTC - During the Veeam JRLB OS backup replication the samba network share on JRLB was interrupted, requiring a restart of SCS acquisition and a restart of string compression.

16 June 2016

1. 12:20 (UTC) - Seatex experienced an out of memory error. Restarted both units.

19 June 2016

1. USBL GGA stream on the SCS not updated since 16-06-10 21:48:11. This was due to configuration changes made on the USBL PC to troubleshoot tracking issues. Tracked the relevant port down to the NCU unit port 5a. AME re-enabled the port in the software.

20 June 2016

1. USBL logging to SCS again.

23 June 2016

1. ADCP stopped logging, application was either closed or crashed at line 50, June 22, 23:12 UTC. Restarted on line 51 at 9:02 UTC.

25 June 2016

1. The Clam PC failed overnight. The spare clam PC setup.

27 June 2016

1. 17:22 UTC - Manually ran Veeam JRLB OS replication - this caused a short Samba outage and acquisition required stopping and starting. Restarted SCS compression.
2. The ADCP created a large number of N1R files, multiple files every minute between 19:51 UTC and 21:31 UTC when it was stopped and restarted triggering a new line.

28 June 2016

1. No data from the CLAM PC is being logged to the SCS, AME investigating whether this is due to a different copy of the software being used.

30 June 2016

1. The CLAM PC is now logging to the SCS again, this was due to a lose cable.

2 July 2016

1. 14:06 UTC EM122 turned off for the remainder of the cruise.

5 July 2016

1. SCS acquisition stopped and restarted at 17:57:40 UTC due to JRLB U: drive becoming unavailable. Stopped a second time at 18:04:35, restarted at 18:04:45 UTC due to SCS stopped writing to U: drive, and stopped a third time at 18:11:59 UTC and restarted at 18:12:46 UTC. Copied over old SCS data to JRLB and restarted compression of the SCS streams.
2. 18:42 UTC noticed the SCS had stopped logging to the JRLB U: again. Stopped SCS acquisition at 18:49:24 UTC, closed the software and restarted and then restarted acquisition at 18:50:11 UTC. Copied over old SCS data to JRLB and restarted compression of the SCS streams.

9 July 2016

1. 11:50 UTC – SCS stopped logging to JRLB due to U: drive being unavailable. No cause discovered, load on JRLB was low at the time. Acquisition stopped at 12:50:57 UTC and restarted at and restarted at 12:51:12. Compression of SCS streams restarted.
2. 13:18 UTC - ADCP shutdown. Prior to this it was noted that the NAV IO err was intermittently showing an error. Within the ADCP logs files this is connected to occurrences of "NMEA [Nav] serial buffer full: Storing 300 bytes without processing.".

10 July 2016

1. 12:00 UTC All logging stopped and data copied to externals disks for transfer to BAS Cambridge.