RRS Discovery

Cruise DY052

Glasgow to Glasgow

Extended Ellett Line

7th June 2016 > 24th June 2016

S. F. Gary and the DY052 Science Team

SAMS

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Summary

This report describes the events that occurred during DY052, a cruise on the RRS Discovery that sailed Glasgow to Glasgow from June 7 to June 24, 2016.

The main objective of the cruise was to occupy the annually repeated hydrographic section of the Extended Ellett Line (EEL). The EEL runs from the Sound of Mull via Rockall to Iceland. The EEL is is funded by NERC under the National Capability Program.

More information on the history and findings of the EEL can be found at http://prj.noc.ac.uk/ExtendedEllettLine/ . This was a successful cruise with all objectives fulfilled and minimal downtime. Calibrated, processed data from DY052 will be banked with the British Oceanographic Data Centre (BODC, http://www.bodc.ac.uk).

The main objectives for DY052 were:

1) Hydrographic stations

71 planned CTD stations + 1 test station. We achieved 89 CTD stations.

Specific measurements:

- CTD + other electronic instruments + LADCP
- Bottle salinity
- Bottle oxygen
- Bottle nutrients (Nitrate+Nitrite, Phosphate, Silicate)
- Bottle carbon (alkilinity, DIC)
- Bottle trace metals
- Bottle density

2) Underway measurements

- towed hydrophone for any transits greater than 30 minutes
- meterological and oceanographic underway measurements
- sail by the locations of the OSNAP moorings in Rockall Trough

3) Epibenthic sled tows at “Station M” (4 tows)

4) Argo float deployments (3 floats)

DY052 – Extended Ellett Line 2016
Cruise Report

1) Personnel

1.1) Scientific personnel

Stefan François Gary	SAMS, PS
Richard Edward Abell	SAMS
Timothy Brand	SAMS
James Anothony Cameron Coogan	SAMS
Elizabeth Anne Comer	University of Southampton
Winifred Martha Courtene-Jones	SAMS
Estelle Dumont	SAMS
Clare Beth Embling	Plymouth University
Stacey Louise Felgate	SAMS
Martin Stephen Foley	University of Glasgow
Emily Jane Hill	SAMS
David John Hughes	SAMS
Robert King	UK MetOffice
Ashlie Jane McIvor	SAMS
Emma Slater	BODC
Jonathan Paul Tinker	UK MetOffice
Leah Elizabeth Trigg	Plymouth University
Colin John Hutton	NMF
Jack McNeill	NMF
Jonathan Barry Short	NMF

Image credit Winnie Courtene-Jones

1.2) Ship’s personnel

Joanna Louise Cox	Master
Michael Patrick Hood	C/O
Declan Daniel Anderson Morrow	2/O
Colin James Leggett	3/O
Andrew Nicholas Lewtas	C/Eng
Geraldine Anne O'Sullivan	2/E
Ian Stuart Meldrum Collin	3/E
Edin Silajdzic	3/E
Felix Robert Arthur Brooks	ETO
Graham Bullimore	PCO
Samuel Nicholaidis	Cadet
Calum Nathan Deacy	Cadet
Stephen John Smith	CPOS
Thomas Gregory Lewis	CPOD
Robert George Spencer	POD
William Mclennan	SG1A
Raoul John Lafferty	SG1A
Craig James Lapsley	SG1A
John Michael Hopley	SG1A
Emlyn Gordon Williams	ERPO
Mark James Ashfield	H/Chef
Amy Kerry Whalen	Chef
Jeffrey Alan Orsborn	Stwd
Kevin John Mason	A/Stwd

2) Cruise narrative

(All times on ship's time, UK BST)

June 07, J159 08:15 muster stations and boat drill. 09:30 pilot arrived and underway shortly thereafter leaving Inchgreen, near Glasgow. Safety briefing for science party at 17:30 previous evening. A beautiful day, not as much sun as the last two astonishlingly beautiful weeks but still very nice. Weather forecast for the EEL region looks generally good giving us confidence that we can proceed to the sick glider's position in the Iceland Basin for recovery. Pumped sea surface underway system switched on at 15:30. Ongoing tests with the VMADCP and EK60 configuration.

June 08, J160 08:30 meeting between ship's team leaders and science team leaders. The first CTD test cast was at 09:30 and all went smoothly. After CTD recovery, there was a hydrophone toolbox talk for relevant parties. Then, the hydrophone was deployed for first time at 11:15. EA640 and EM122 switched off because they interfere with the hydrophone. Echo sounders will be turned on when needed for navigation and approaching stations for CTD operations, but off otherwise.

June 09, J161 Fire drill and science party muster at 15:30. Then fire hose training for science party. Hydrophone first recovery was after the drill in preparation for glider recovery. Glider recovered at about 19:00 then hydrophone redeployed and ship underway to first station near Iceland.

June 10, J162 Echosounders back on at noon and hydrophone recovery at 13:00 in preparation for first CTD cast on the Extended Ellett Line, CTD 002. Minor technical issues with bottle firing, but otherwise all well. CTD 003 through 005 proceeded without any glitches. Hyrdophone not in the water due to short steaming time between stations.

June 11, J163 Steady progress for CTD 006 through 011. Hydrophone deployed 5 times in between stations as steaming time is now more than 1 hour.

June 12, J164 Steady progress for CTD 012 through 016. Argo float deployed immediately after CTD 013. Hydrophone deployed 6 times. Slightly rougher seas than previous days, but not enough to interrupt work.

June 13, J165 Steady progress for CTD 017 through 022. Two Argo floats deployed directly after CTD 017. The carousel failed during CTD 018 so no bottles were fired on this cast. As this station is not one of the core Extended Ellett Line stations, the electrionic instruments recorded good data, and it was uncertain how long it would take to replace the carousel, this station was not repeated and we progressed to the next station. CTD 019, with a new carousel, went without incident and all the bottles closed as commanded.

June 14, J166 Completed CTD 023 through 031 and 6 hydrophone tows. Now working in over the Rockall Hatton Basin. Cloudy.

June 15, J167 Completed CTD 032 through 040 and 8 hydrophone tows. Still cloudy for most of the day but a break in the clouds was well-timed for nice views of Rockall.

June 16, J168	During the night, entered the Rockall Trough and made slight deviations to sail over OSNAP moorings WB1 and WB2 in between CTD 040, 041, and 042. Worked steadily through CTD 049 and 3 hydrophone tows. Sailed over Anton Dohrn Seamount.
June 17, J169	Early morning hydrophone tow and CTD 050. Starting at 8AM, back-to-back epibenthic sled tows at Station M. Both tows were sucessful. While the sled team rested at night, CTD 051 and 052 were done along with 3 hydrophone tows in transit.
June 18, J170	Second day of epibenthic sled tows. Two sucessful back-to-back tows. RRS James Cook came by to say hello. Extra CTD cast, 053, with all bottles fired at the bottom for microplastics sampling at Station M. Then, proceeded to next station on EEL with hydrophone in tow. Learned that an OSNAP glider needed assistance but it is 3 days' steam and expected heavy seas in the area until Wednesday (J174). As we are due in port on J177 morning, we cannot recover it.
June 19, J171	Working up the continental slope and across the Scottish Shelf for CTD 054 though 068. Tentative plans were made to use the remaining time of DY052 to go back to the shelf break and make a high resolution electronics-only section of the European Slope Current at the Ellett Line as well as traverse the Rockall Trough with hydrophone in tow and extra stations to the north of Anton Dohrn Seamount. Weather forecasts suggest that we will not be able to work last year's extra stations at 58N on the Rockall Hatton Plateau but the Rockall Trough area should be workable. Stations north of Anton Dohrn would help verify the latitudinal extent of the Rockall Trough hydrographic observations. Of course, the mention of extra stations caused the pumps to not turn on during the start of CTD 065. The cast was aborted, the SBE 9+ was replaced, and CTD 065-068 were completed.
June 20, J172	Finished the Extended Ellett Line with CTD 069 through 073 in the morning. Steam back out to the open ocean towing the hydrophone over moderate swell for electronics-only casts over the shelf break. Completed CTD 074 through 076 at the 200 m, 300 m, and 400 m isobaths despite the challenging conditions due to the swell.
June 21, J173	Continued with electronics-only CTD casts every 100 m of water depth for CTD 077 through 084. Then towed the hydrophone and operated the EK60 and ADCPs in the Rockall Trough, sailing over Anton Dohrn Seamount and then north, nearly to Rosemary Bank. Swell calmed down substantially over the course of the day.
June 22, J174	Worked extra CTD stations 085 to 087 north of Anton Dohrn Seamount, towing the hydrophone in between stations.
June23, J175	Completed the last of the CTD stations, 088 and 089, and steamed back to Glasgow with hydrophone in tow. Hydrophone recovered just before reaching the continental shelf. Cruise summary meeting at 1400 to discuss the Post Cruise Assessment. TechSAS, non-toxic, and all other instruments turned off at 21:00.
June24, J176	Continued compiling the cruise report, running the last samples, and cleaning labs. Docked at 16:30 at Ocean Terminal, Greenock.

3) Cruise track and station map

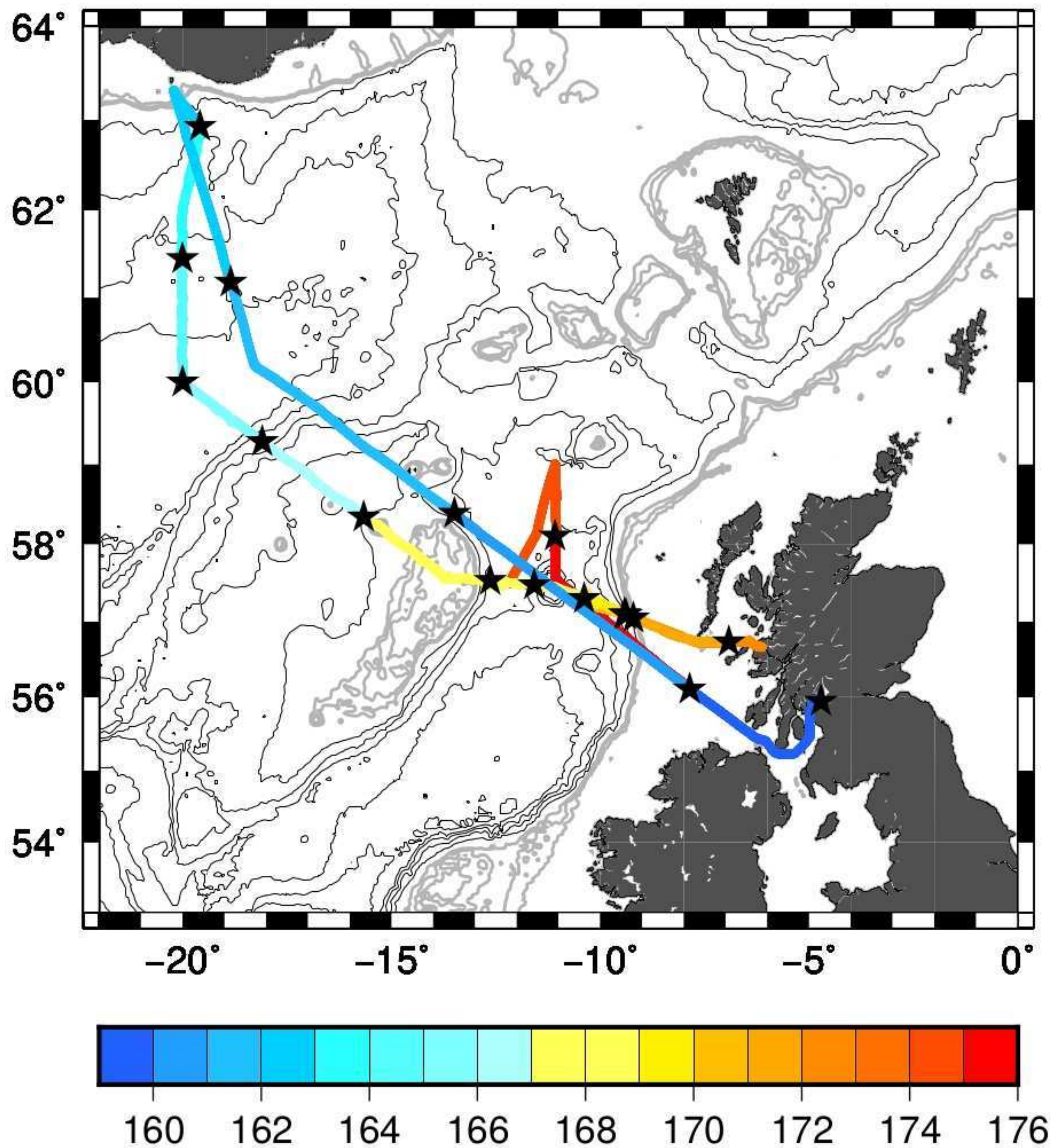


Figure 3.1: DY052 track shaded by Julian day. Black stars indicate the start of each day. Bathymetry is contoured at 500 m intervals at depths greater than 500 m in black and at 100 m intervals at depths shallower than 500 m in gray.

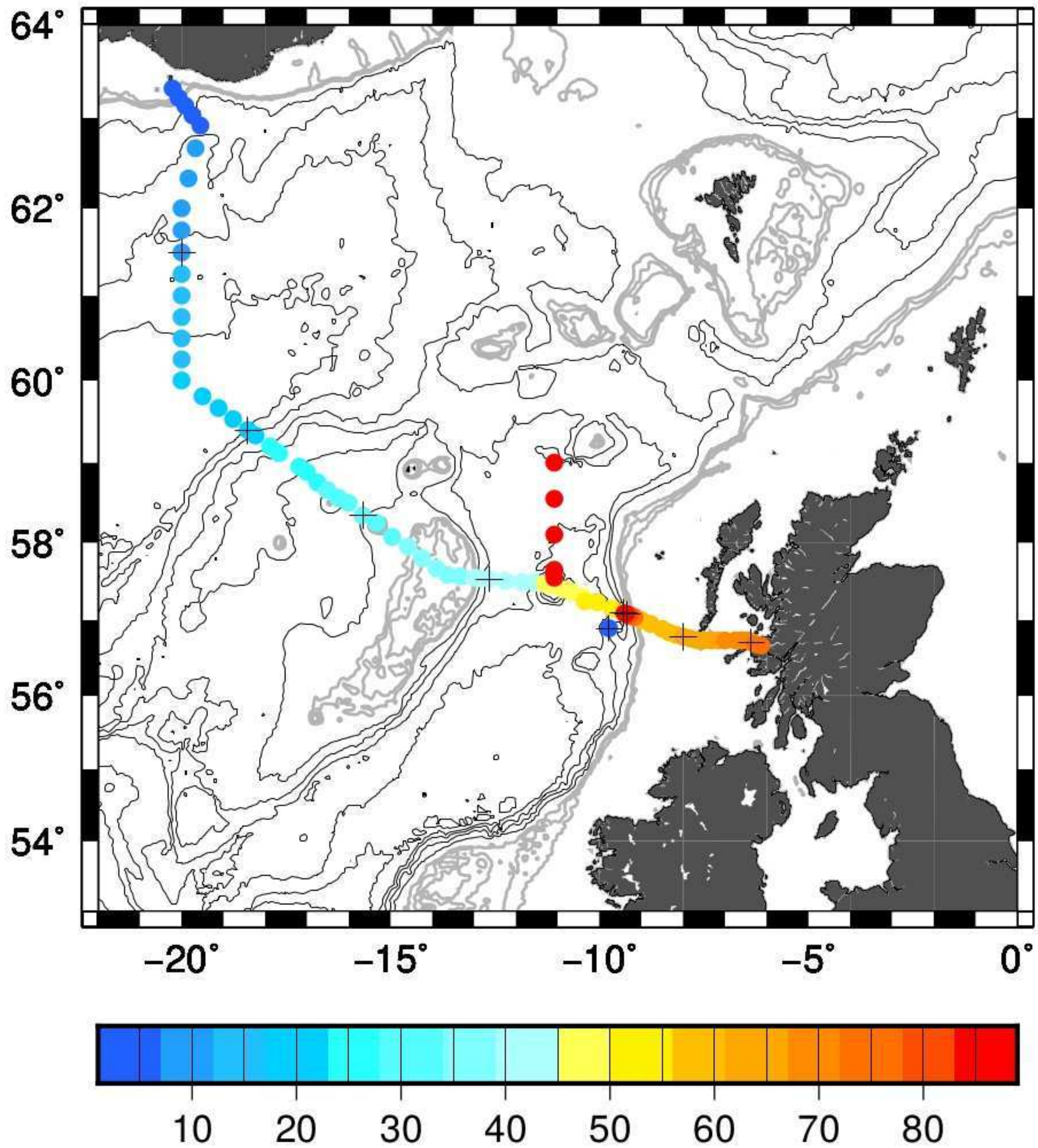


Figure 3.2: Map of all 89 CTD casts on DY052 shaded by station number. Every 10th cast is indicated by a thin plus sign. Bathymetry is the same as in Figure 3.1.

Table 3.1: CTD station list

The first column is the CTD station number, followed by the date, time at bottom, latitude, longitude and water depth. Water depth, cdep, was computed as described at the end of Section 5.2. The max. depth of the CTD and altimeter reading at the bottom of the casts, maxd and alt, respectively, are compared to cdep to determine the residual, res. Columns 14-20 list the max. wire out, max. pressure, number of depths, and number of sampled depths. Comments indicate the historical Extended Ellett Line station names for each station, if available. The E: series of stations are electronics-only casts at the shelf break on the EEL and the X series are stations north of Anton Dohrn.

stn	yy/mo/dd	hhmm	dg	min	lat	dg	min	lon	cdep	maxd	alt	res	wire	pres	nd	sal	oxy	nut	car	Comments
1	16/06/08	858	56	53.52	N	9	46.18	W	1912	501	-9	-999	500	507	9	9	9	0	1	Test
2	16/06/10	1338	63	19.11	N	20	13.01	W	133	124	9	-1	120	125	8	7	7	7	0	IB23S
3	16/06/10	1606	63	12.93	N	20	4.14	W	674	664	11	2	662	672	12	12	12	13	9	IB22S
4	16/06/10	1844	63	7.98	N	19	55	W	1041	1032	10	1	1029	1045	15	15	15	15	0	IB21S
5	16/06/10	2157	63	1.6	N	19	44.37	W	1304	1295	2	-6	1300	1312	17	17	17	17	0	
6	16/06/11	112	62	55.05	N	19	33.2	W	1398	1390	11	2	1385	1408	16	16	16	16	0	IB20S
7	16/06/11	457	62	40.09	N	19	40.1	W	1681	1672	6	-3	1668	1695	17	17	17	17	0	IB19S
8	16/06/11	922	62	20.09	N	19	50.12	W	1799	1791	5	-3	1787	1816	19	19	19	19	0	IB18S
9	16/06/11	1403	62	0.02	N	20	0.13	W	1801	1793	6	-2	1790	1819	18	18	18	18	0	IB17
10	16/06/11	1805	61	45.04	N	20	0.2	W	1791	1783	10	2	1780	1808	18	18	17	18	9	IB16A
11	16/06/11	2218	61	30.05	N	20	0.09	W	2212	2204	10	2	2206	2237	20	20	20	20	0	IB16
12	16/06/12	230	61	15.07	N	20	0.17	W	2369	2362	8	1	2358	2398	20	20	19	20	0	IB15
13	16/06/12	656	61	0.03	N	20	0.11	W	2397	2389	8	1	2382	2426	20	20	20	20	0	IB14
14	16/06/12	1124	60	45.01	N	19	59.99	W	2362	2354	9	2	2350	2390	21	21	20	21	0	IB13A
15	16/06/12	1557	60	30.05	N	20	0.09	W	2526	2519	11	3	2512	2558	21	21	21	21	0	IB13
16	16/06/12	2031	60	15.02	N	20	0.05	W	2641	2634	10	3	2627	2676	21	21	21	20	0	IB12A
17	16/06/13	104	60	0.01	N	20	0.15	W	2718	2711	9	2	2705	2755	22	22	22	21	0	IB12
18	16/06/13	554	59	48.53	N	19	30.04	W	2703	2696	9	2	2689	2740	0	0	0	0	0	IB11A
19	16/06/13	1110	59	40.02	N	19	7.02	W	2671	2664	7	0	2658	2707	21	21	21	22	0	IB11
20	16/06/13	1533	59	31.96	N	18	46.11	W	2715	2709	10	3	2702	2752	22	22	21	22	0	
21	16/06/13	1917	59	24.03	N	18	25.05	W	2396	2389	11	4	2390	2426	21	21	19	20	0	IB10
22	16/06/13	2222	59	20	N	18	14.02	W	1844	1837	8	1	1835	1862	18	18	17	18	6	IB09
23	16/06/14	145	59	12.05	N	17	53.05	W	1528	1520	10	2	1515	1540	17	17	16	17	0	IB08
24	16/06/14	416	59	7.01	N	17	40.05	W	980	971	10	1	968	982	15	15	15	16	0	IB07
25	16/06/14	729	58	56.97	N	17	11.11	W	890	882	10	1	880	892	13	13	13	13	0	IB06

26	16/06/14	948	58	52.99	N	17	0.15	W	1155	1147	6	-3	1145	1161	16	16	16	16	0	IB05
27	16/06/14	1243	58	45.41	N	16	45.12	W	1161	1152	8	0	1152	1166	16	16	15	16	0	
28	16/06/14	1534	58	39.62	N	16	30.79	W	1204	1195	9	0	1193	1210	15	15	16	15	0	IB04A
29	16/06/14	1827	58	33.93	N	16	15.09	W	1217	1209	9	1	1208	1224	16	16	16	16	0	
30	16/06/14	2107	58	29.98	N	16	0.17	W	1186	1178	10	2	1177	1192	16	16	15	16	6	IB04
31	16/06/15	11	58	20.51	N	15	39.96	W	1156	1148	8	0	1145	1162	15	15	14	15	0	
32	16/06/15	256	58	14.97	N	15	20.02	W	659	650	10	0	648	657	12	12	12	12	0	IB03
33	16/06/15	542	58	4.29	N	14	57.68	W	558	549	10	1	547	555	11	11	11	11	0	
34	16/06/15	827	57	56.94	N	14	34.95	W	442	433	9	0	430	437	10	10	10	10	0	IB02
35	16/06/15	1113	57	48.03	N	14	15.04	W	229	219	10	0	215	221	9	9	8	9	0	
36	16/06/15	1341	57	40.05	N	13	54.16	W	150	140	9	-1	137	142	7	7	7	7	0	IB01
37	16/06/15	1601	57	34.96	N	13	38.05	W	114	104	10	0	101	105	6	5	6	5	0	A
38	16/06/15	1756	57	34	N	13	19.99	W	179	169	10	0	166	171	8	8	8	8	0	B
39	16/06/15	2001	57	32.99	N	13	0.02	W	295	285	10	1	281	288	9	9	9	9	0	C
40	16/06/15	2149	57	32.51	N	12	52.1	W	1085	1077	9	1	1075	1090	15	15	15	15	0	D
41	16/06/16	46	57	31.88	N	12	38.13	W	1636	1628	11	3	1624	1650	18	18	18	18	0	E
42	16/06/16	416	57	30.48	N	12	15.18	W	1799	1792	8	1	1789	1816	18	18	18	18	10	F
43	16/06/16	802	57	29.49	N	11	51.08	W	1788	1781	9	2	1780	1805	18	19	19	19	0	G
44	16/06/16	1135	57	28.94	N	11	32.06	W	2011	2004	10	3	2001	2033	19	20	20	20	0	H
45	16/06/16	1421	57	28	N	11	19.07	W	751	742	9	0	741	751	13	14	14	14	0	I
46	16/06/16	1643	57	26.95	N	11	4.99	W	588	579	10	1	576	585	11	11	11	11	0	J
47	16/06/16	1842	57	23.97	N	10	52	W	786	777	10	1	776	786	13	13	13	13	0	K
48	16/06/16	2059	57	22	N	10	40.06	W	2104	2097	10	3	2096	2127	20	19	19	18	0	L
49	16/06/17	16	57	17.94	N	10	23.16	W	2205	2198	10	3	2195	2231	19	19	19	19	0	M
50	16/06/17	341	57	13.98	N	10	3.21	W	2099	2092	10	3	2093	2123	20	20	20	20	0	N
51	16/06/17	2351	57	5.99	N	9	25.05	W	1417	1409	10	2	1406	1427	16	16	16	16	0	P
52	16/06/18	243	57	8.94	N	9	41.9	W	1923	1916	8	1	1913	1942	18	18	18	18	10	O
53	16/06/18	1945	57	14.75	N	10	21.1	W	2234	2227	10	3	2224	2260	1	0	0	0	0	M
54	16/06/19	107	57	4.54	N	9	19.09	W	780	771	11	2	770	780	13	13	13	13	0	Q1
55	16/06/19	238	57	3.05	N	9	13.03	W	315	305	10	1	301	308	9	9	9	9	0	Q
56	16/06/19	406	57	0.1	N	8	59.98	W	135	125	10	0	122	126	6	6	6	6	6	R
57	16/06/19	530	56	57.09	N	8	46.99	W	130	120	9	-1	117	121	7	7	7	7	0	S
58	16/06/19	724	56	53	N	8	29.98	W	129	119	10	0	116	120	7	7	7	7	0	15G
59	16/06/19	841	56	50.27	N	8	20.01	W	133	123	10	0	120	124	6	6	6	6	0	T

60	16/06/19	953	56	48.52	N	8	10	W	128	118	9	0	115	119	7	7	7	7	0	14G
61	16/06/19	1113	56	47	N	8	0	W	123	113	9	-1	110	115	7	7	7	7	0	13G
62	16/06/19	1241	56	45.52	N	7	50.09	W	59	49	8	-2	46	49	4	4	4	4	0	12G
63	16/06/19	1353	56	44.02	N	7	40.13	W	63	53	10	1	50	53	4	4	4	5	0	11G
64	16/06/19	1508	56	44.07	N	7	29.95	W	221	211	10	0	208	214	8	8	8	8	6	10G
65	16/06/19	2035	56	44	N	7	19.96	W	157	148	11	1	145	149	7	0	7	7	0	9G
66	16/06/19	2154	56	44.01	N	7	9.9	W	173	163	9	0	161	165	8	0	8	8	0	8G
67	16/06/19	2322	56	43.98	N	6	59.92	W	137	127	10	0	125	128	6	4	6	6	0	7G
68	16/06/20	106	56	44	N	6	44.92	W	38	28	10	0	27	29	4	0	3	3	0	6G
69	16/06/20	221	56	44.01	N	6	35.9	W	78	68	10	0	67	69	5	0	5	5	0	5G
70	16/06/20	428	56	44.03	N	6	26.88	W	86	76	10	0	75	77	6	3	5	5	0	4G
71	16/06/20	626	56	42.57	N	6	21.9	W	70	60	10	0	58	60	4	0	4	4	0	3G
72	16/06/20	726	56	41	N	6	16.93	W	41	31	8	-2	30	31	3	0	3	3	0	2G
73	16/06/20	845	56	40.02	N	6	7.97	W	171	161	7	-2	160	163	7	8	8	8	0	1G
74	16/06/20	2229	57	2.33	N	9	9.75	W	203	193	12	2	190	195	0	0	0	0	0	E:0200m
75	16/06/21	4	57	2.78	N	9	12.55	W	299	289	9	0	283	292	0	0	0	0	0	E:0300m
76	16/06/21	124	57	3.17	N	9	14.44	W	401	392	10	0	386	396	0	0	0	0	0	E:0400m
77	16/06/21	254	57	3.48	N	9	15.89	W	509	500	10	1	496	505	0	0	0	0	0	E:0500m
78	16/06/21	415	57	3.82	N	9	17.08	W	598	589	10	0	585	596	0	0	0	0	0	E:0600m
79	16/06/21	534	57	4.12	N	9	18.28	W	720	711	11	2	707	719	0	0	0	0	0	E:0700m
80	16/06/21	651	57	4.37	N	9	19.03	W	804	795	9	0	792	804	0	0	0	0	0	E:0800m
81	16/06/21	812	57	4.45	N	9	19.84	W	922	914	10	2	910	924	0	0	0	0	0	E:0900m
82	16/06/21	939	57	4.59	N	9	20.61	W	1023	1015	9	0	1010	1027	0	0	0	0	0	E:1000m
83	16/06/21	1132	57	4.81	N	9	22.15	W	1206	1198	8	0	1195	1213	0	0	0	0	0	E:1200m
84	16/06/21	1349	57	5.24	N	9	24.2	W	1388	1380	10	2	1375	1397	0	0	0	0	0	E:1400m
85	16/06/22	1248	59	0.03	N	11	4.94	W	1951	1944	10	2	1940	1971	19	18	19	19	0	X1
86	16/06/22	1841	58	32.98	N	11	4.92	W	1836	1828	10	2	1825	1854	18	18	17	18	0	X2
87	16/06/22	2343	58	6.03	N	11	5	W	1964	1957	9	2	1953	1984	18	18	18	18	10	X3
88	16/06/23	436	57	39	N	11	4.9	W	1810	1802	10	2	1800	1827	19	18	18	18	0	X4
89	16/06/23	637	57	33.02	N	11	4.94	W	704	695	10	0	693	703	12	8	12	12	0	X5

4) NMF-SS CTD Sensors

J. Short, C. Hutton, E. Dumont

4.1) CTD system configurations

1) One CTD system was prepared. The initial water sampling arrangement was NMF frame 24-way stainless steel frame system (s/n CTD8), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-24680-0637
Sea-Bird 3P temperature sensor, s/n 03P-4381, Frequency 0 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-3054, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 79501, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P-4712, Frequency 3 (secondary)
Sea-Bird 4C conductivity sensor, s/n 04C-3529, Frequency 4 (secondary)
Sea-Bird 5T submersible pump, s/n 05T-6320, (primary)
Sea-Bird 5T submersible pump, s/n 05T-6916, (secondary)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-31240-0423
Sea-Bird 11plus deck unit, s/n 11P-24680-0589 (main)
Sea-Bird 11plus deck unit, s/n 11P-34173-0676 (back-up/spare)

2) The auxiliary input initial sensor configuration was as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-2575 (V0, primary)
Benthos PSAA-916T altimeter, s/n 59494 (V2)
WETLabs light scattering sensor, s/n BBRTD-758R (V3)
Biospherical QCP Cosine PAR Sensor (UWIRR), s/n 70510 (V4)
Biospherical QCP Cosine PAR Sensor (DWIRR), s/n 70520 (V5)
Chelsea Aquatracka MKIII fluorometer, s/n 088244 (V6)
WETLabs C-Star Transmissometer, s/n CST-1759TR (V7)

3) Additional instruments:

TRDI WorkHorse Monitor 300kHz LADCP, s/n 4275
NOCS LADCP battery pack, s/n WH005
SBE35 Deep Oceans Standards Thermometer, s/n 35-0037

4) Changes to instrument suite:

Carousel changed to Sea-Bird 32 Carousel 24 position pylon, s/n 32-60380-0805 prior to cast DY052_19.

LADCP s/n 4275 replaced with s/n 13400 prior to cast DY052_051.
LADCP s/n 13400 replaced with s/n 13399 prior to cast DY052_074.

Sea-Bird 9plus underwater unit, s/n 09P-24680-0637 replaced with Sea-Bird 9plus underwater unit, s/n 09P-39607-0803 prior to cast 65. Sea-Bird *9plus* configuration file DY052_0637_SS.xmlcon was used for CTD casts 001 through 064. DY052_0803_SS.xmlcon was used for CTD casts 065 through 089.

The spare water sampling equipment was the 24-way stainless steel frame system (s/n SBE CTD1), and the spare sensors were as follows:

Sea-Bird 9plus underwater unit, s/n 09P-39607-0803

Digiquartz temperature compensated pressure sensor, s/n 93896
Sea-Bird 9plus underwater unit, s/n 09P-34173-0758
Digiquartz temperature compensated pressure sensor, s/n 90074
Sea-Bird 3P temperature sensor, s/n 03P-4782
Sea-Bird 3P temperature sensor, s/n 03P-5660
Sea-Bird 3P temperature sensor, s/n 03P-5700
Sea-Bird 3P temperature sensor, s/n 03P-5785
Sea-Bird 4C conductivity sensor, s/n 04C-2571
Sea-Bird 4C conductivity sensor, s/n 04C-4138
Sea-Bird 4C conductivity sensor, s/n 04C-4139
Sea-Bird 4C conductivity sensor, s/n 04C-4140
Sea-Bird 5T submersible pump, s/n 05T-3085
Sea-Bird 5T submersible pump, s/n 05T-5301
Sea-Bird 5T submersible pump, s/n 05T-7371
Sea-Bird 5T submersible pump, s/n 05T-7514
Sea-Bird 32 Carousel 24 position pylon, s/n 32-34173-0493
Sea-Bird 32 Carousel 24 position pylon, s/n 32-60380-0805

5) The auxiliary spare sensors were as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-0619
Sea-Bird 43 dissolved oxygen sensor, s/n 43-0709
Sea-Bird 43 dissolved oxygen sensor, s/n 43-0363
Sea-Bird 43 dissolved oxygen sensor, s/n 43-2831
Benthos PSAA-916T altimeter, s/n 59493
Benthos PSAA-916T altimeter, s/n 62679
WETLabs light scattering sensor, s/n BBRTD-759R
WETLabs C-Star Transmissometer, s/n CST-1720TR
Chelsea Alphatracka MKII transmissometer, s/n 161-2642-002
Chelsea Aquatracka MKIII fluorometer, s/n 088195
Chelsea Aquatracka MKIII fluorometer, s/n 88-2050-095

6) Additional instruments:

TRDI WorkHorse Monitor 300kHz LADCP, s/n 10607
TRDI WorkHorse Monitor 300kHz LADCP, s/n 13399
TRDI WorkHorse Monitor 300kHz LADCP, s/n 13400
NOCS LADCP battery pack, s/n WH006T

Total number of casts – 089
Casts deeper than 2000m - 016
Deepest cast - 2710 m on CTD017

4.2) Technical detail report

S/S CTD

Communication errors with carousel noted on cast DY052_018 meaning no bottles were fired.
Pumps failed to start at the beginning of cast DY052_65. Deck testing and trouble shooting carried out on deck, no faults found with pumps, conductivity cells or cabling, hence underwater unit changed.

LADCP

LADCP instruments rotated for testing purposes as all units were recently received back from the manufacturer.

AUTOSAL

A Guildline 8400B, s/n 71185, was installed in the Salinometer Room as the main instrument for salinity analysis. A second Guildline 8400B, s/n 71126, was installed in the Salinometer Room as a spare instrument. The Autosal set point was 24C, and samples were processed according to WOCE cruise guidelines: The salinometer was standardized at the beginning of the first set of samples, and checked with an additional standard analysed prior to setting the RS. Once standardized the Autosal was not adjusted for the duration of sampling. Additional standards were analysed every 24 samples to monitor & record drift. These were labeled sequentially and increasing, beginning with number 9001. The standard deviation limit of the three Autosal readings that contribute to the final average value reported as an observation was set to 0.00002. Autosal readings were repeated until all readings for that sample were within the standard deviation limit.

A large drift was noted on 71185 on running of last set of samples (day 172) standby value settled at 5994 (from 5988 where it had been steady for the duration of the cruise preceding day172), further analysis carried out with instrument s/n 71126.

4.3) Configuration files

Stainless CTD frame:

Casts 001 - 065	**Casts 065 - 089**
-- Date: 06/23/2016 Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY052\Data\Seasave Setup Files\DY052_0637_SS.xmlcon Configuration report for SBE 911plus/917plus CTD -- Frequency channels suppressed : 0 Voltage words suppressed : 0 Computer interface : RS-232C	-- Date: 06/23/2016 Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY052\Data\Seasave Setup Files\DY052_0803_SS.xmlcon Configuration report for SBE 911plus/917plus CTD -- Frequency channels suppressed : 0 Voltage words suppressed : 0 Computer interface : RS-232C

Deck unit : SBE11plus Firmware Version >= 5.0	Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1	Scans to average : 1
NMEA position data added : Yes	NMEA position data added : Yes
NMEA depth data added : No	NMEA depth data added : No
NMEA time added : Yes	NMEA time added : Yes
NMEA device connected to : PC	NMEA device connected to : PC
Surface PAR voltage added : No	Surface PAR voltage added : No
Scan time added : Yes	Scan time added : Yes
1) Frequency 0, Temperature	1) Frequency 0, Temperature
Serial number : 3P-4381	Serial number : 3P-4381
Calibrated on : 21-Jul-15	Calibrated on : 21-Jul-15
G : 4.42359050e-003	G : 4.42359050e-003
H : 6.44917114e-004	H : 6.44917114e-004
I : 2.26674159e-005	I : 2.26674159e-005
J : 1.97655514e-006	J : 1.97655514e-006
F0 : 1000.000	F0 : 1000.000
Slope : 1.00000000	Slope : 1.00000000
Offset : 0.0000	Offset : 0.0000
2) Frequency 1, Conductivity	2) Frequency 1, Conductivity
Serial number : 4C-3054	Serial number : 4C-3054
Calibrated on : 16-Jun-15	Calibrated on : 16-Jun-15
G : -9.80759366e+000	G : -9.80759366e+000
H : 1.42268693e+000	H : 1.42268693e+000
I : -2.32442769e-004	I : -2.32442769e-004
J : 8.20502779e-005	J : 8.20502779e-005
CTcor : 3.2500e-006	CTcor : 3.2500e-006
CPcor : -9.57000000e-008	CPcor : -9.57000000e-008
Slope : 1.00000000	Slope : 1.00000000
Offset : 0.00000	Offset : 0.00000
3) Frequency 2, Pressure, Digiquartz with TC	3) Frequency 2, Pressure, Digiquartz with TC
Serial number : 79501	Serial number : 93896
Calibrated on : 06-Jan-15	Calibrated on : 09-Jul-14
C1 : -6.052595e+004	C1 : -8.331332e+004
C2 : -1.619787e+000	C2 : -3.281962e+000
C3 : 1.743190e-002	C3 : 2.216060e-002
D1 : 2.819600e-002	D1 : 2.906000e-002
D2 : 0.000000e+000	D2 : 0.000000e+000
T1 : 3.011561e+001	T1 : 3.005232e+001
T2 : -5.788717e-004	T2 : -3.843669e-004
T3 : 3.417040e-006	T3 : 4.436390e-006
T4 : 4.126500e-009	T4 : 0.000000e+000
T5 : 0.000000e+000	T5 : 0.000000e+000
Slope : 0.99985000	Slope : 1.00001000
Offset : -1.66130	Offset : -1.35810
AD590M : 1.293660e-002	AD590M : 1.289250e-002
AD590B : -9.522570e+000	AD590B : -8.106440e+000
4) Frequency 3, Temperature, 2	4) Frequency 3, Temperature, 2

Serial number : 3P-4712
Calibrated on : 21-Jul-15
G : 4.40403756e-003
H : 6.33214711e-004
I : 1.90723282e-005
J : 1.14981012e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 4C-3529
Calibrated on : 21-Jul-15
G : -9.91877058e+000
H : 1.57004159e+000
I : -2.20163146e-003
J : 2.65000201e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-2575
Calibrated on : 31-Jul-15
Equation : Sea-Bird
Soc : 4.41200e-001
Offset : -4.67000e-001
A : -4.32580e-003
B : 2.14910e-004
C : -2.87190e-006
E : 3.60000e-002
Tau20 : 1.00000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Turbidity Meter, WET Labs, ECO-BB

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

9) A/D voltage 3, Altimeter

Serial number : 59494
Calibrated on : 29 November 2012
Scale factor : 15.000

Serial number : 3P-4712
Calibrated on : 21-Jul-15
G : 4.40403756e-003
H : 6.33214711e-004
I : 1.90723282e-005
J : 1.14981012e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 4C-3529
Calibrated on : 21-Jul-15
G : -9.91877058e+000
H : 1.57004159e+000
I : -2.20163146e-003
J : 2.65000201e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

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

Serial number : 43-2575
Calibrated on : 31-Jul-15
Equation : Sea-Bird
Soc : 4.41200e-001
Offset : -4.67000e-001
A : -4.32580e-003
B : 2.14910e-004
C : -2.87190e-006
E : 3.60000e-002
Tau20 : 1.00000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Turbidity Meter, WET Labs, ECO-BB

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

9) A/D voltage 3, Altimeter

Serial number : 59494
Calibrated on : 29 November 2012
Scale factor : 15.000

Offset : 0.000 10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor Serial number : 70510 Calibrated on : 01-Jun-15 M : 1.00000000 B : 0.00000000 Calibration constant : 20161290300.00000000 Multiplier : 1.00000000 Offset : -0.05051050 11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2 Serial number : 70520 Calibrated on : 01-Jun-15 M : 1.00000000 B : 0.00000000 Calibration constant : 19531250000.00000000 Multiplier : 1.00000000 Offset : -0.05251338 12) A/D voltage 6, Transmissometer, WET Labs C-Star Serial number : 1759TR Calibrated on : 22-Dec-2015 M : 21.3083 B : -0.1705 Path length : 0.250 13) A/D voltage 7, Fluorometer, Chelsea Aqua 3 Serial number : 088-244 Calibrated on : 6 August 2014 VB : 0.236800 V1 : 2.151000 Vacetone : 0.305900 Scale factor : 1.000000 Slope : 1.000000 Offset : 0.000000 Scan length : 45	Offset : 0.000 10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor Serial number : 70510 Calibrated on : 01-Jun-15 M : 1.00000000 B : 0.00000000 Calibration constant : 20161290300.00000000 Multiplier : 1.00000000 Offset : -0.05051050 11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2 Serial number : 70520 Calibrated on : 01-Jun-15 M : 1.00000000 B : 0.00000000 Calibration constant : 19531250000.00000000 Multiplier : 1.00000000 Offset : -0.05251338 12) A/D voltage 6, Transmissometer, WET Labs C-Star Serial number : 1759TR Calibrated on : 22-Dec-2015 M : 21.3083 B : -0.1705 Path length : 0.250 13) A/D voltage 7, Fluorometer, Chelsea Aqua 3 Serial number : 088-244 Calibrated on : 6 August 2014 VB : 0.236800 V1 : 2.151000 Vacetone : 0.305900 Scale factor : 1.000000 Slope : 1.000000 Offset : 0.000000 Scan length : 45

LADCP script file:

```
; Append command to the log file: "C:\adcp\ladcp.log"
$lC:\Users\SANDM\Documents\DY052 ladcp data\log files\ladcp.log
;
$P ***********************************************************************
$P *******  LADCP Deployment downward looking ADCP.  DY052        **********
$P ***********************************************************************
; Send ADCP a BREAK
$B
```

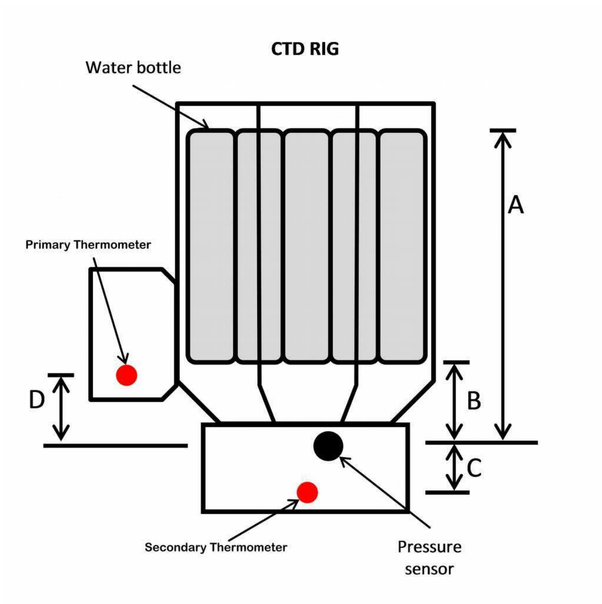
```
; Wait for command prompt (sent after each command)
$W62
;Set Baud rate to 9600,8,N,1
cb411
$w62
;**Start**
; Display real time clock setting
tt?
;Display unused Memory
rs?
$d5
$w62
;Display number of deployments
ra?
$d5
$w62
;Run predeployment tests
pa
pt200
pc2
$d5
a
$w62
; Set to factory defaults
CR1
$W62
; Save settings as User defaults
CK
$W62
; Name data file
RN DY052
$W62
;Set Profiling mode 15
WM15
$w62
TC2
; Set one ping per ensemble. Use WP if LADCP option is not enabled.
LP1
$W62
;Set time per burst to 2.8sec
TB 00:00:02.80
$w62
; Set zero second between pings
TP 00:00.00
$W62
;set time per ensemble to 1.3s
TE 00:00:01.30
$w62
; Set to record 25 bins. Use WN if LADCP option is not enabled.
LN25
$W62
;Set depth bin to 800cm
LS0800
$w62
;set blank after transmit to zero
LF0
$w62
;set narrow bandwidth
LW1
$w62
;set ambiguity velocity to 400cm/s (radial)
LV400
$w62
;set as master
SM1
$w62
```

```
;set  Synch Before/After Ping/Ensemble Bottom/Water/Both
SA011
$w62
;disable channel b break interrupts
SB0
$w62
;set synch delay (1/10 msec)
SW5500
$w62
;set synch interval to zero
SI0
$w62
;set Sensor Source (C;D;H;P;R;S;T)
EZ0011101
$w62
;set Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EX00100
$w62
;set Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CF11101
$w62
;save as user defaults
CK
$w62
CS
$d3
$l
$P *************************************************************************
$P ******* Please disconnect ADCP and Remember to rename log file!**********
$P *************************************************************************
```

4.4) CTD sensor geometry

Cruise	DY052
Technician	J. Short
Date	23 June 2016
CTD type	24-way s/s frame, 10L water samplers, SBE 9/11+

ID	**Vertical distance from pressure sensor (m)**
A	1.25
B	0.17
C**	0.17
D	0.07



**NOTE: C & D may be minimal.

Fitted Sensors***:

Manufacturer	Sensor/Instrument	Serial No.	Comments (Casts installed)	Calibration applied?**	Last calibration date
SBE 11plus V2	CTD deck unit	11P-24680-0589	All casts	Y	10 March 2004
SBE 9plus	*CTD Underwater Unit*	*09P-24680-0637 (Ti)*	*001 - 064*	*Y*	*6 January 2015*
NOCS	*Stainless steel 24-way frame*	*SBE CTD8*	*All casts*	*N/A*	*N/A*
Paroscientific	*Digiquartz Pressure sensor*	*79501*	*All casts*	*Y*	*6 January 2015*
SBE 3P	*Primary Temperature Sensor*	*3P-4381 (Ti)*	*All casts*	*Y*	*21 July 2015*
SBE 4C	*Primary Conductivity Sensor*	*4C-3054(Ti)*	*All casts*	*Y*	*16 June 2015*
SBE 5T	*Primary Pump*	*5T-6320*	*All casts*	*N/A*	*N/A*
SBE 3P	*Secondary Temperature Sensor*	*3P-4712(Ti)*	*All casts*	*Y*	*21 July 2015*
SBE 4C	*Secondary Conductivity Sensor*	*4C-3529 (Ti)*	*All casts*	*Y*	*21 July 2015*
SBE 5T	*Secondary Pump*	*5T-6916*	*All casts*	*N/A*	*N/A*
SBE 32	*24-way Carousel*	*32-31240-0423*	*All casts*	*001-018*	*N/A*
SBE 43	*Dissolved Oxygen Sensor*	*43-2575*	*All casts*	*Y*	*31 July 2015*
Benthos PSA-916T	*Altimeter*	*59494*	*All casts*	*Y*	*29 November 2012*
WETLabs BBRTD	*Light Scattering Sensor*	*BBRTD-758R*	*All casts*	*Y*	*3 June 2013*
WETLabs C-Star	*Transmissometer*	*CST-1759TR*	*All casts*	*Y*	*22 December 2015*
CTG Aquatracka MKIII	*Fluorometer*	*088244*	*All casts*	*Y*	*6 August 2014*
Biospherical QCP Cosine PAR	*Irradiance Sensor (DWIRR)*	*70520*	*All casts*	*Y*	*1 June 2015*
Biospherical QCP Cosine PAR	*Irradiance Sensor (UWIRR)*	*70510*	*All casts*	*Y*	*1 June 2015*
OTE	*10L Water Samplers*	*1 through 24*	*All casts*	*N/A*	*N/A*
TRDI Workhorse Monitor	*ADCP*	*4275*	*001-050*		
TRDI Workhorse Monitor	*ADCP*	*13400*	*051-73*		
TRDI Workhorse Monitor	*ADCP*	*13399*	*074-089*		
Deep Ocean Standards Thermometer	SBE 35	*35-0037*	*All casts*		

***Please include details of LADCP, CTD carousel and deck unit in addition to CTD and auxillary sensors.

** Were the manufacturer's calibrations applied during NMF-run Sea-Bird processing?

Spare Sensors***:

Manufacturer	Sensor/Instrument	Serial No.	Comments (Casts installed)	Calibration applied?**	Last calibration date
SBE 11plus	CTD deck unit	11P-34173-0676	N/A	Y	10 March 2004
SBE 9plus	*CTD Underwater Unit*	*09P-39607-0803(Ti)*	*065-089*	*Y*	*9 July 2014*
Paroscientific	*Digiquartz Pressure sensor*	*93896*	*065-089*	*Y*	*9 July 2014*
SBE 3P	*Temperature Sensor*	*3P-5660*	*N/A*	*Y*	*21 July 2015*
SBE 3P	*Temperature Sensor*	*3P-4782*	*N/A*	*Y*	*17 September 2015*
SBE 3P	*Temperature Sensor*	*3P-5700*	*N/A*	*Y*	*17 September 2015*
SBE 3P	*Temperature Sensor*	*3P-5785*	*N/A*	*Y*	*17 September 2015*
SBE 4C	*Conductivity Sensor*	*4C-4138*	*N/A*	*Y*	*17 September 2015*
SBE 4C	*Conductivity Sensor*	*4C-4139*	*N/A*	*Y*	*14 July 2015*
SBE 4C	*Conductivity Sensor*	*4C-4140*	*N/A*	*Y*	*21 July 2015*
SBE 4C	*Conductivity Sensor*	*4C-2571*	*N/A*	*Y*	*17 September 2015*
SBE 5T	*Pump*	*5T-3085*	*N/A*	*N/A*	*N/A*
SBE 5T	*Pump*	*5T-5301*	*N/A*	*N/A*	*N/A*
SBE 5T	*Pump*	*5T-7371*	*N/A*	*N/A*	*N/A*
SBE 5T	*Pump*	*5T-7514*	*N/A*	*N/A*	*N/A*
SBE 32	*24-way Carousel*	32-0493 *(Ti)*	*N/A*	*N/A*	*N/A*
SBE 32	*24-way Carousel*	32-60380-0805 *(Ti)*	*019-089*	*N/A*	*N/A*
SBE 43	*Dissolved Oxygen Sensor*	*43-0709*	*N/A*	*Y*	*21 August 2015*
SBE 43	*Dissolved Oxygen Sensor*	*43-0619*	*N/A*	*Y*	*9 September 2015*
WETLabs C-Star	*Transmissometer*	*CST-1720TR*	*N/A*	*Y*	*16 April 2015*
CTG MKII Alphatracka	*Transmissometer*	*161-2642-002*	*N/A*	*Y*	*3 September 2014*
CTG Aquatracka MKlll	*Fluorimeter*	*88-2050-095*	*N/A*	*Y*	*15 September 2014*
Guildline Autosal 8400B	*Salinometer*	*71126*	*Main*	*N/A*	*Service 19 January 2015 & Alignment 19 January 2015*
Guildline Autosal 8400B	*Salinometer*	*71185*	*Spare (used for last 6 salinity crates)*	*N/A*	*Service 20 January 2015 & Alignment 20 January 2015*
Benthos PSA-916T	*Altimeter*	*59493*	*N/A*	*Y*	*25 March 2013*
Benthos PSA-916T	*Altimeter*	*62679*	*N/A*	*Y*	*27 March 2014*
WETLabs BBRTD	*Light Scattering Sensor*	*BBRTD-759R*	*N/A*	*Y*	*3 June 2013*
OTE	*10L Water Samplers*	*1D through 24D*	*N/A*	*N/A*	*N/A*
Deep Ocean Standards Thermometer	*SBE 35*	*35-0037*	*N/A*		

Sea-Bird processing:

The table below lists the Sea-Bird processing routines run by NMF staff (if any). Note this is only the modules that were run by NMF, not by scientific staff.

Module	Run?	Comments
Configure	N	
Data Conversion	Y	As per BODC guidelines Version1.0 October 2010 (Beam Transmission, mS/cm Conductivity)
Bottle Summary	Y	As per BODC guidelines Version1.0 October 2010
Mark Scan	N	
Align CTD	Y	As per BODC guidelines Version1.0 October 2010 **(dissolved oxygen advanced 6 seconds)**
Buoyancy	N	
Cell Thermal Mass	Y	As per BODC guidelines Version1.0 October 2010
Derive	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Bin Average	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Filter	Y	As per BODC guidelines Version1.0 October 2010 (appended file name)
Loop Edit	N	Not applicable.
Wild Edit	N	No pressure spikes observed.
Window Filter	N	
ASCII In	N	
ASCII Out	Y	As per request from NMF Sea Systems for sound velocity profiles, periodic processing only.
Section	N	
Split	N	
Strip	Y	As per BODC guidelines Version1.0 October 2010
Translate	N	
Sea Plot	N	
SeaCalc II	N	

Field calibrations

The table below details any calibrations against independent (bottle) samples that were applied by NMF staff

Sensor serial no.	Coefficients

5) CTD data processing

Stefan Gary, Emma Slater, and Estelle Dumont

The CTD data processing on DY052 closely mirrored that of DY031. Updated extracts of the DY031 cruise report are included here for completeness and expanded to reflect this cruise.

The CTD used on DY052 had two independent sets of temperature, T, and conductivity, C, sensors, each with its own pump. The first pair of T and C sensors, T_1 and C_1, were mounted close to the bottom, outermost corner of the CTD “fin” within a small metal frame to protect the sensors from any bumps during deployment and recovery (Chapter 4). The second pair of sensors, T_2 and C_2, were mounted near the bottom of the CTD frame, under the Niskin bottles, and inside of the SeaBird 9+ underwater unit. We chose to report the results from the primary sensors because previous experience (see DY031 cruise report) has shown that fin-mounted sensors result in cleaner data that are less impacted by turbulent eddies spun off from the CTD frame and sensors attached to the frame. Furthermore, the CTD oxygen sensor was mounted on the same pump line as the primary temperature and conductivity sensors.

5.1) Sea-Bird processing

The first stage of processing of the CTD data was with the Sea-Bird Electronics SeaSave software package. Each step is outlined below.

Data Conversion - The Data Conversion tool converted the raw frequency and voltage data to engineering units as appropriate by applying the manufacturer's calibrations stored in the CON file and saved both downcast and upcast to an ASCII format file. This process can include the oxygen hysteresis correction using SBE parameters but we opted to do the oxygen hysteresis correction separately, described below. Two files are created during the data conversion step; the .cnv data file and the .ros rosette file.

It is essential that the output variables from Data Conversion include scan and pressure temperature, latitude and longitude:

name 0 = timeS: Time, Elapsed [seconds]
name 1 = depSM: Depth [salt water, m]
name 2 = prDM: Pressure, Digiquartz [db]
name 3 = t090C: Temperature [ITS-90, deg C]
name 4 = t190C: Temperature, 2 [ITS-90, deg C]
name 5 = c0mS/cm: Conductivity [mS/cm]
name 6 = c1mS/cm: Conductivity, 2 [mS/cm]
name 7 = sal00: Salinity, Practical [PSU]
name 8 = sal11: Salinity, Practical, 2 [PSU]
name 9 = sbeox0V: Oxygen raw, SBE 43 [V]
name 10 = sbeox0Mm/Kg: Oxygen, SBE 43 [umol/kg]
name 11 = sbeox0ML/L: Oxygen, SBE 43 [ml/l]
name 12 = CStarTr0: Beam Transmission, WET Labs C-Star [%]
name 13 = flC: Fluorescence, Chelsea Aqua 3 Chl Con [ug/l]
name 14 = turbWETbb0: Turbidity, WET Labs ECO BB [m^-1/sr]
name 15 = altM: Altimeter [m]
name 16 = scan: Scan Count
name 17 = ptempC: Pressure Temperature [deg C]
name 18 = pumps: Pump Status
name 19 = latitude: Latitude [deg]
name 20 = longitude: Longitude [deg]

name 21 = flag: 0.000e+00

Align - Next, the Align CTD option aligns the oxygen sensor in time relative to pressure and writes the output to a new file.

In the Sea-Bird processing suite, the CTD align function will shift the oxygen sensor output in time relative to the temperature and salinity sensors to account for the additional length of hose between the *T* and *S* sensors and the oxygen sensor. Each water sample in the CTD will pass through the *T* and *S* sensors first and then the oxygen sensor and then the pump. In addition to the impact of geometry, this correction also helps to address the response time of the oxygen sensor. As the response time of the sensor may change with temperature, the first 7 casts were all reprocessed with 2, 4, 6, 8, and 10 second shifts of the oxygen sensor time series as well as applying the default Sea-Bird oxygen hysteresis correction.

To evaluate the best time alignment of the oxygen sensor, the oxygen-pressure relationship for the up and down casts were separated based on the deepest pressure measurement and then independently bin averaged into 2 dbar bins. The absolute value of the oxygen difference (µmol/kg) between each corresponding upcast and downcast bin was computed and the median of these differences, over each cast, was used to evaluate the impact of the alignments. Three of the 7 casts exhibited the lowest median difference between up and down cast with a 6 second alignment with other casts exhibiting the lowest median differences at 2, 4, and 10 seconds.

Since the most casts agreed with a 6 second alignment time, we chose this value for the Sea-Bird oxygen alignment. 6 seconds also corresponds to the default value in the Sea-Bird software as well as our estimate, by eye, of which alignment produced the least deviations between the up and downcast plots. Finally, it is important to note that the metric used here to evaluate the alignment shift was not particularly sensitive – its variability from alignment time to alignment time was very small compared to its uncertainty in light of the variability within each cast.

Cell Thermal Mass - The next step is the Cell Thermal Mass correction for the conductivity because there is a time lag during which the conductivity cell is flushed, so its temperature is not precisely the same as the temperature measured by the temperature sensor. This last step creates a new file (**dy052_NNN_actm.cnv**). All the Sea-Bird data files were copied to the DY052 ship's public server, and copied to the MSTAR workstation using the shell script **ctd_linkscript**.

5.2) MSTAR processing

MSTAR uses some template files to define the variables in sample files (**sam_dy052_varlist.csv**) and CTD variable names (**ctd_dy052_renamelist.csv** and **ctd_dy052_renamelist_out**). These were edited at the start of the cruise.

At this stage, the CTD data are ready to be read into MSTAR for additional processing. The standard MSTAR CTD data processing suite was applied to the CTD data for each station. First an empty sample file was created with **msam_01**. The converted, aligned, and thermal mass corrected data from SeaSave in .cnv format were copied into MSTAR with **mctd_01** and the variables were renamed with **mctd_02a** and the oxygen hysteresis correction was applied (see below), along with creating a backup of the data, with **mctd_02b**.

The original 24 Hz data were averaged to 1 Hz and the salinity was computed from temperature, pressure and conductivity with **mctd_03**. The suite of **mdcs_01**, **mdcs_02**, and **mdcs_03g** were used to collect station position and time information from the TechSAS position data stream and put it in each station file as well as select the exact start and end of the cast. The .dcs files created for each cast store the cast start and stop independently of the rest of the cast data and can be used for other purposes, for example matching SBE35 timestamps with a particular cast.

Once the cast timing was determined, **mctd_04** was used to average the data to 2 dbar levels and the **mfir_01**, **mfir_02**, **mfir_03**, and **mfir_04** suite were used to collect bottle firing information in the .bl file created by SeaSave, extract data from the cast to represent the instrument measurements at the time of bottle firing, and paste this bottle-specific data to the sample file. The **mwin_01**, **mwin_02**, and **mwin_3** suite of scripts was used to collect wire out from the TechSAS winch data stream and paste this information into the sample file.

Once this first round of MSTAR processing was executed, the CTD data were ready for manual inspection and quality control. The script **mctd_checkplots** was used to check for large spikes, significant differences between primary and secondary sensors, deviations from the expected *T-S* relationship, and any potential station-to-station drifts in the sensors. Spikes observed via a graphical user interface in **mctd_rawedit** were changed to NaN. Throughout the cruise there was the manual removal of conductivity spikes due to the ingestion of particles into the conductivity cells of the primary and secondary sensors. Spikes were defined by an anomalously low conductivity value over just a few scans (usually 1-10 scans at 24 Hz), that was not reflected by a similar dip in temperature. With the spikes removed for a particular station, **mctd_02b**, **mctd_03**, **mctd_04**, **mfir_03**, and **mfir_04** were run again and the data (with spikes removed this time) were bin averaged and overwritten in the 24 Hz, 1 Hz, 2dbar, and sample files.

Casts 65-73 exhibited noisy oxygen data where the signals were amplified in both directions. These points were removed from the raw files. It was not known what the cause for this was and the cables were checked for loose connectivity. From cast 74 onwards this noise was not observed as prolifically. As stated below in Section 5.8, during cast 18 the CTD data acquisition was restarted at the bottom of the down cast. Large spikes in the oxygen signal were removed from the bottom of the downcast.

mctd_makelists was run to create ascii listings used in LADCP processing, and for providing key CTD variable to chemists. This step was very helpful as data were ready to be imported into ODV for quick plots to check, for example, the validity of the oxygen calibration on a nearly cast-by-cast basis.

Water depth for each station was determined by adding the range to the bottom, estimated as 10 m, to the pressure at the bottom of each cast as stored in the dcs_ file for each cast. To within a couple meters, every cast ended about 10 m off the bottom. The only exception to this was CTD001, which was a partial depth cast to about 500 m in 1912 m of water. The depth as recorded in the CTD001 log sheet is the reported value for the water depth in this case. The script **populate_station_depths** will read the **station_depths_dy052.txt** file and convert it to a .mat file. Then, **mdep_01.m** reads the .mat file containing water depth in the variable **bestdeps** and pastes this information into headers of all CTD files.

5.3) Oxygen hysteresis correction

To account for the hysteresis of the oxygen sensor, we need to do a trial and error modification of the parameters for the hysteresis correction. This analysis was done with CTD016 because it was one of the deepest stations (~2680 m) during the cruise and early in the cruise. The standard Sea-Bird correction parameters were applied to a subset of the other deep stations and also compared to the hysteresis correction determined here with good agreement.

The first step in the process was to save the results using the default Sea-Bird oxygen hysteresis correction (-0.033, 5000, 1450). Then **mctd_02b** and **mctd_03** were run without any hysteresis correction at all and the resulting 1 Hz file was also saved. When comparing no correction with the SBE default correction at the depths of Labrador Sea Water (~3-4 ºC), the SBE defaults help to reduce the gap between the upcast and the downcast from about 1.5 µmol/kg to about 1.0 µmol/kg. Furthermore, the hysteresis correction causes the value of the oxygen in the LSW to be shifted by about 3 µmol/kg, roughly 1.2% of the measurement value.

To get better agreement between the up and down casts in the deepest water, we used **plot_oxygen_profiles.m** to quantify the differences between the upcast and the downcast. Given the recommended range for the hysteresis correction parameters and trailing various combinations of parameters, we chose the values -0.02, 5000, and 2000 to get the up and downcast to within about 2 µmol/kg of each other below about 500 m and within about 0.3 µmol/kg in the depth range of Labrador Sea Water. These selected values are an improvement over uncorrected profiles as well as the default Sea-Bird hysteresis correction. Visual inspection with a range of deep oxygen casts showed that these parameters were valid for several casts. All oxygen sensor data were then reprocessed with the **mctd_02b**, **mctd_03**, **mctd_04**, **mfir_03**, and **mfir_04** pipeline.

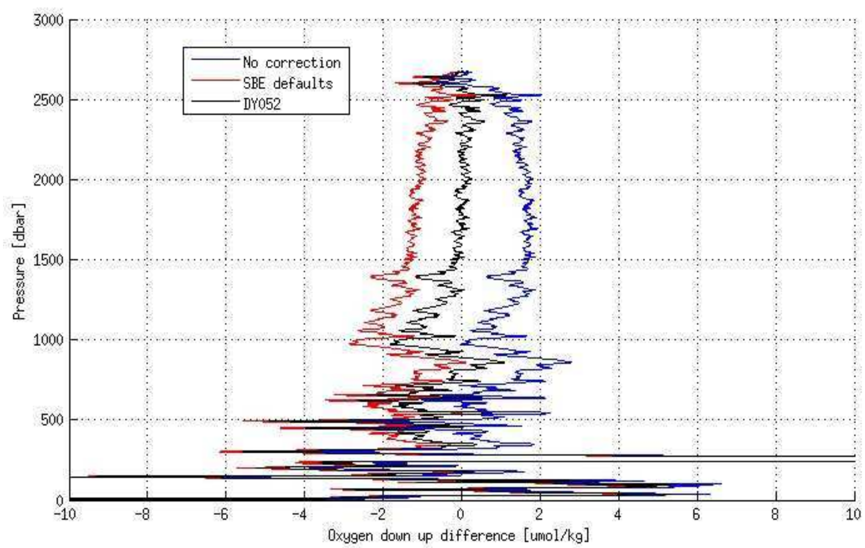


Figure 5.1: Difference between up and down cast oxygen on CTD016 for raw (blue), default Sea-Bird (red) and parameters for this cruise (black).

5.4) Oxygen sample files and CTD oxygen calibration

Once the bottle oxygen values had been measured they were written into spreadsheets for ingesting into MSTAR. The files provided by the oxygen team, one for each CTD cast, conformed to the naming convention **Oxy_StationNNN.csv**, with NNN replaced by the zero-padded station number. The headers for the columns in each text file were:

botnum,statnum,sampnum,tfixa,botoxya,Flag,tfixb,botoxyb,Flag
number,number,number,degC,umol/l,a,degC,umol/l,b

where the 'a' and 'b' values allow for 2 samples drawn from a single Niskin bottle.

These files were used by **oxy_linkscript** to create a symbolic link for each oxygen bottle file with a name expected by MSTAR: **oxy_dy052_NNN.csv**. Each text file was then read and copied into a cast-by-cast netcdf file with **moxy_01** whose output is **oxy_dy052_NNN.nc**. A subset of the data were manually checked for accurate data transcription. The next step is to paste the oxygen-only netcdf bottle file into the sample file for that station with the script **moxy_02**. As the laboratory analysis of oxygen results in concentrations of µmol/L, the draw temperature measured at the time of taking the oxygen sample and CTD salinity was used to compute the density of the sample and thus convert the µmol/L to µmol/kg in the script **msam_oxykg**. The result is written in the sample file for each cast into the variable botoxy. Oxygen data from the individual cast sample files were then pasted into the master sample file, **sam_dy052_all.nc**, which contains all the bottle data from the whole cruise, with **msam_updateall**.

The master sample file itself was created by first copying the sample file from the first cast, **sam_dy052_001.nc**, to sam_dy052_all.nc and then using **msam_append_dy052**. The master sample file was then used as the source data for generating diagnostic plots showing the relationship between bottle oxygen and ctd oxygen (**ctd_evaluate_oxygen**) (Figure 5.2) and residuals between bottle oxygen and CTD oxygen (Figure 5.3). All CTD data were grouped into one of two subsets: before and after cast 65. As noted in Chapter 4, when the pumps did not turn on at the deployment of cast 65, the cast was initially aborted, the SBE 9+ underwater unit was replaced, and the cast was restarted. As the oxygen sensor sends its output voltage through an analog, not digital, data acquisition port in the SBE9+, a change in the analog amplifier resulted in a different gain applied within the new SBE9+ relative to the previous SBE9+. The result was a shift in the magnitude of the oxygen measured by the CTD system (Figures 5.2 and 5.3). It's important to note in Figure 5.2 that casts 74-84 were run electronics only. Figure 5.3 shows that when accounting for the change in SBE9+ underwater unit, the oxygen sensor was stable in time. What appears as a possible temporal drift from casts 65-89 is really a temperature-based variation because the waters for CTD 065-073 were much shallower warmer than for CTD 084-089.

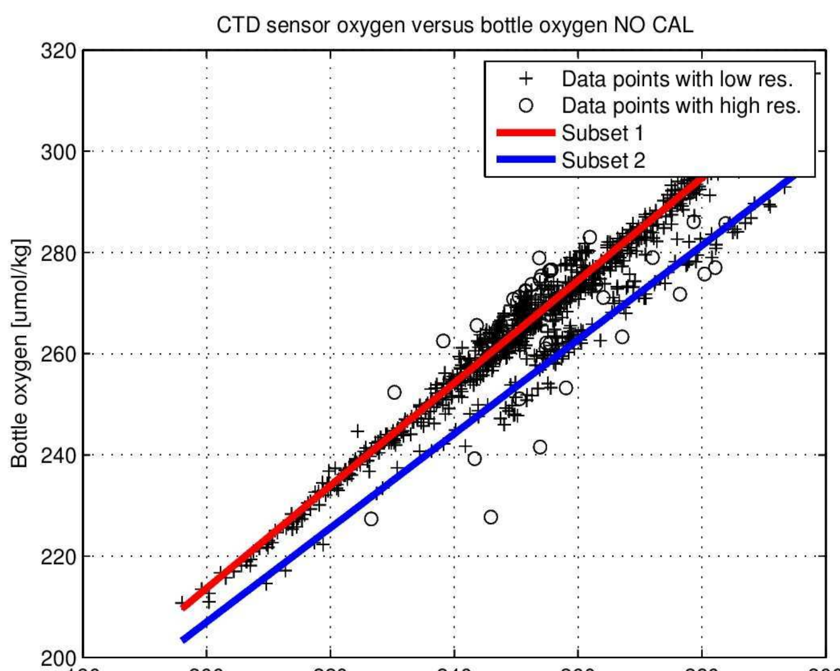


Figure 5.2: The relationship between bottle oxygen and CTD oxygen. Plus signs denote points that were used in determining the calibration and open circles are points that were excluded from the calibration because their respective residuals (Figure 5.3) lie outside 2 standard deviations of the mean. Subset 1 is the data before the change in the SBE9+ unit.

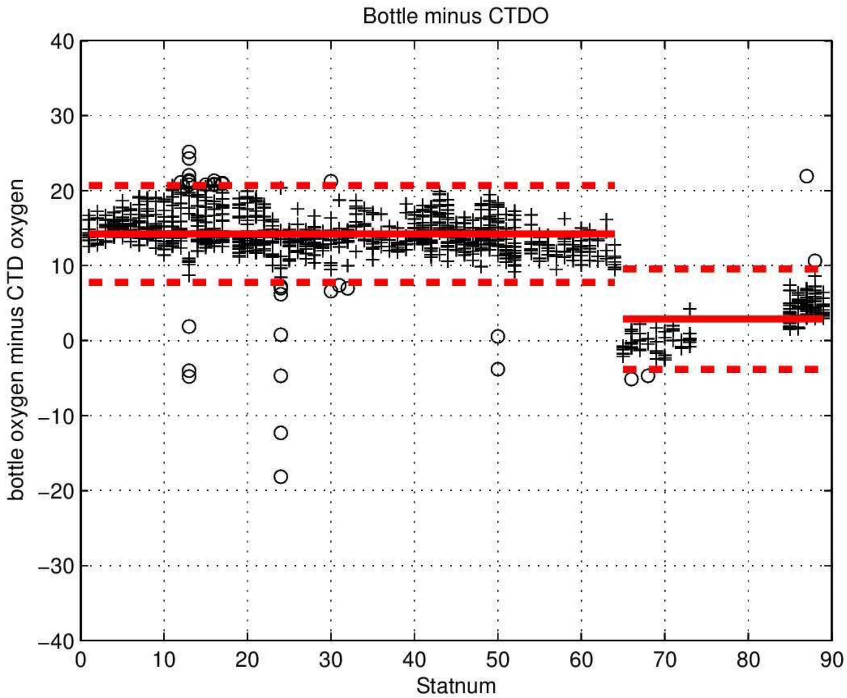


Figure 5.3: Residuals of bottle oxygen relative to CTD oxygen plotted with CTD cast number. Plus signs denote points that were used in determining the calibration and open circles are points that were excluded from the calibration because their respective residuals lie outside 2 standard deviations of the mean. The mean for each subset is shown with a solid red line and the 2 standard deviation envelope is shown with the dashed lines.

From the best fit lines in Figure 5.2, the slope and and intercept for CTD 001 – 064 were determined to be 1.01335 and 10.99686 µmol/kg, respectively. For CTD 065-089, the slope and intercept were 0.92960 and 21.07409 µmol/kg, respectively. After applying these slopes and intercepts to the CTD oxygen data, the residuals were plotted again in Figure 5.4 and it was found that a small pressure adjustment was needed. A piece-wise linear adjustment was determined by computing the average residuals in 3 zones: the upper 100 m (-0.97109 µmol/kg); from 900 m to 1100 m (0.19834 µmol/kg); and below 2500 m (5.72306 µmol/kg). These residuals, together with the corresponding pressures of 0 dbar, 1000 dbar, and 2655 dbar were used to create the red lines in Figure 5.4. A linearly interpolated adjustment, using these three points, was applied to all CTD oxygen data based on the pressure of each data point. The final result of the calibration and adjustment process is shown in Figures 5.5 and 5.6. After this process, the mean residual is 0.039 ± 2.7 µmol/kg. The variability reported here is one standard deviation of all residuals.

The oxygen calibration and adjustment was applied in **mctd_oxycal**, which is a wrapper script for **oxy_apply_cal** which stores the exact parameters of the calibration. These scripts were run in a loop over all CTD casts once the calibration was determined.

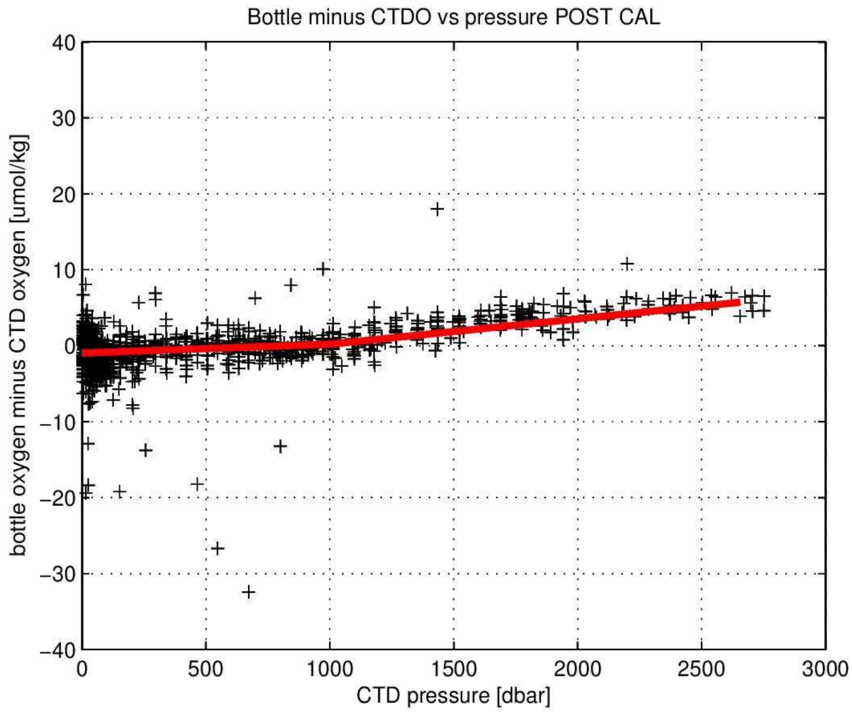


Figure 5.4: Residuals between bottle oxygen and CTD oxygen plotted with pressure after the calibration was applied but before the pressure adjustment was applied. The red line indicates the piecewise linear pressure-based adjustment that will be applied.

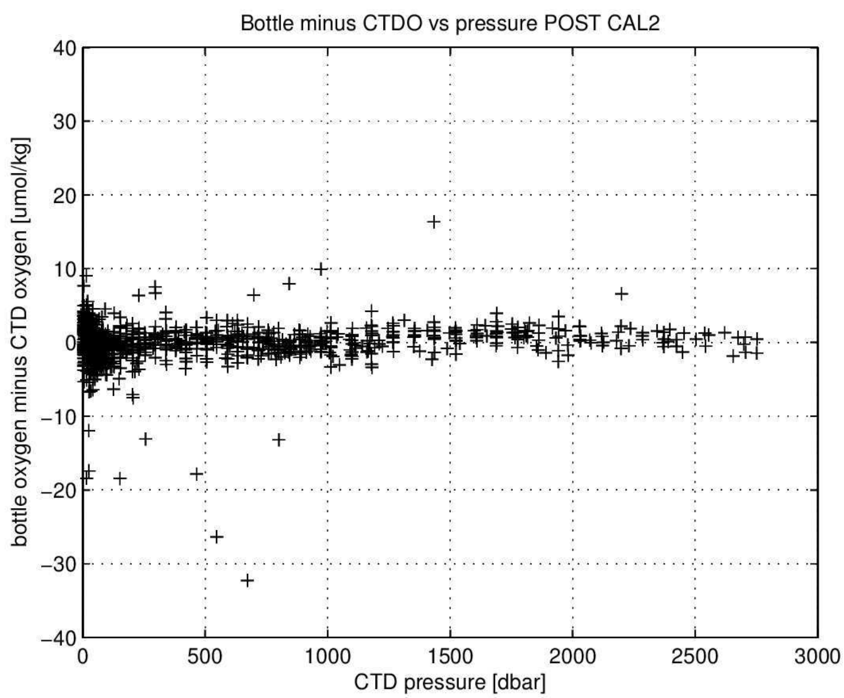


Figure 5.5: As in Figure 5.5 but after the pressure adjustment was applied.

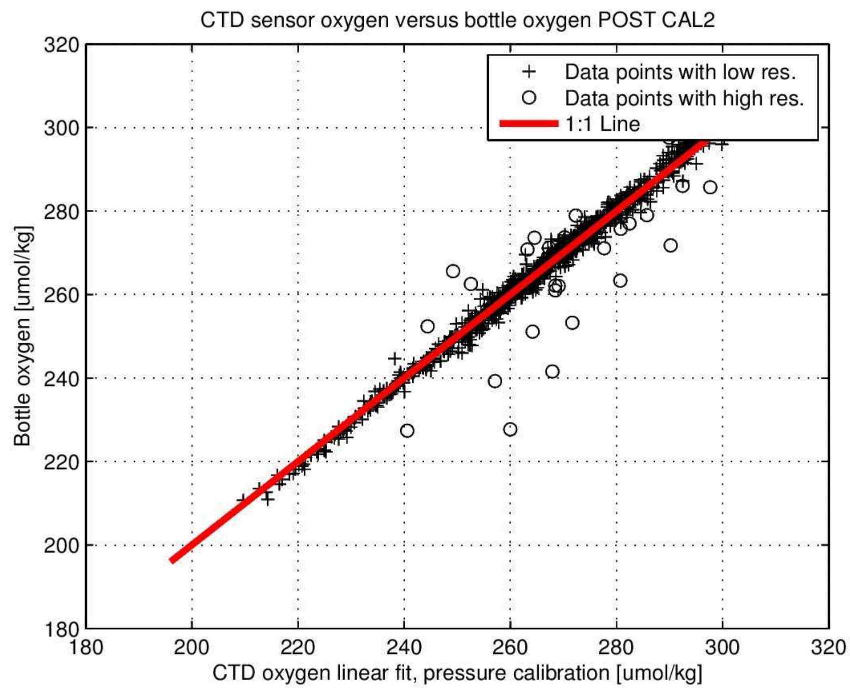


Figure 5.6: Relationship between bottle oxygen and CTD oxygen after both the calibration and the pressure adjustment were applied.

5.5) SBE35 temperature sensor data processing

There were three temperature measurements on each CTD cast; two SBE3P temperature sensors continuously recording temperature for the whole cast at 24 Hz and one SBE35 sensor that was triggered by the firing of each bottle. When triggered, the SBE35 was set to average over 9 measurement cycles and each measurement cycle is about 1.1 s, so SBE35 measurements at the bottle stops represent averages over approximately 10 s windows. The SBE35 did not collect data at other times.

In contrast to the real-time data acquisition of the SBE3P sensors, the SBE35 stores all of its data internally. After the cast, the sensor uploads its data via the CTD deck unit. The upload process is manually initiated by the CTD operator and due to the limited memory of the SBE35, data may be overwritten if not downloaded regularly. The SBE35 data are stored as a series of ASCII files, usually one for each cast, in cruise/data/ctd/BOTTLE_SBE35. As the data download process is manual, the following anomalies were noted:

CTD003 – 14 samples on the SBE35 but only 13 bottles fired. This is due to a test fire on deck before the cast.

CTD015 – SBE35 data pointer not reset to 1 from the previous cast. CAP ASCII file modified by hand to remove the data from the previous cast and reset the bottle numbers to be consistent with just cast 15.

CTD016 – Error during data download, only the first bottle was recorded.

CTD018 – No bottles fired due to carousel failure so no SBE35 data.

CTD025 – Error in saving data capture file resulting in some of the header information in the .asc file being copied into the data capture file. Manual edits to the capture file so it can be in the same format as the other data files but no data loss.

CTD028 - SBE35 data pointer not reset to 1 from the previous cast. CAP ASCII file modified by hand to remove the data from the previous cast and reset the bottle numbers to be consistent with just cast 28.

CTD032 – Only 13 data scans logged because bottles 8 and 9 fired too close together in time. Both bottles fired at the same depth.

CTD036 – Data pointer not reset after download after cast 35, so CTD035 data included in this file. Manually removed CTD035 data and reset the bottle numbers *after* this data was ingested in MSTAR. In the process, confirmed that manual edits are not necessary as MSTAR can detect duplicate data (see below). No data lost.

CTD037, 038 – data missing.

CTD045 – Data for this cast appended to CTD044 (data pointer not reset, no data lost). No manual changes made to original files since MSTAR edits out data duplication.

CTD047 – Only data from the deepest bottle was recorded (similar to CTD016).

CTD058 to 061 – Data not downloaded and overwritten by subsequent casts.

CTD067 – Data pointer not reset from previous cast. Manually removed previous casts data and renumbered the firing index.

CTD073 – Data point not reset from previous cast, no data lost. No manual changes made to original files since MSTAR edits out data duplication.

CTD074 to 084 no bottles fired so no SBE35 data.

MSTAR will ingest SBE35 data via the **msbe35_01** and **msbe35_02** pipeline where SBE35 data are read from the ASCII files and pasted into the sample file, respectively. The first step reads in all the SBE35 data from all casts and checks each SBE35 data time stamp with the cast start and stop times in the .dcs file so SBE35 data is automatically sorted by cast (please see MSTAR processing, above). Due to this functionality, occasionally forgetting to reset the SBE35 data pointer during the data download does not have an impact on how the data are ingested into the MSTAR database. A subset of the SBE35 data were manually inspected, including all casts where the data pointer was accidentally not reset and a handful of normal casts, to check that data were transcribed accurately and no anomalies were noted. Once SBE35 data are pasted on the sample files, the master sample file must be updated with **msam_updateall**.

5.6) Temperature sensor performance

Figures 5.7 and 5.8 show the differences between each temperature sensor for all bottle stops and bottle stops below 1000 dbar, respectively. All sensors performed reliably and no temporal drift was detected in any sensor relative to the others. The median differences between the primary and secondary SBE3P sensors and the SBE35 are -0.0009 ºC (SBE35 cooler) and +0.0012 ºC (SBE35 warmer), respectively. The median difference between the primary and secondary CTD sensors was 0.0021 ºC. As all three sensors are factory calibrated to an accuracy of 0.002 ºC and given the overall noise (on the order of at least 0.001 ºC) in the sensor-to-sensor comparisons, there is no firm basis for deciding whether either SBE3P sensor should be adjusted relative to the SBE35. Taking the SBE35 as the reference temperature measurement, both SBE3P sensors are within the 0.002 ºC accuracy limit for WOCE quality data.

Sensor mounting position does play a role in the observed temperature differences. In particular, the secondary SBE3P, T_2, was mounted immediately next to the SBE35 while the primary SBE3P, T_1, was mounted on the fin of the CTD. To minimize the impact of vertical gradients, the SBE35 itself was mounted horizontally, adjacent to the SBE9+ underwater unit in the bottom section of the CTD frame. In Figures XX and YY, the upper and lower quantiles for the distribution of temperature differences is tighter for SBE35 minus T_2 than SBE35 minus T_1, suggesting that the uncertainty in the temperature difference is smaller for sensors that are mounted more closely together. Furthermore, CTD053 with all bottles fired near the bottom at ~2200 m in the relatively homogeneous Labrador Sea Water, is a unique opportunity to repeatedly sample nearly uniform water. Consistent with the overall results, for CTD053, T_1 was 0.0009 ± 0.0002 °C warmer and T_2 was 0.0014 ± 0.0001 °C cooler than the SBE35. Since these median temperature differences, observed under nearly ideal conditions, are consistent with the median differences over the whole cruise, we conclude that the temperature sensors performed consistently.

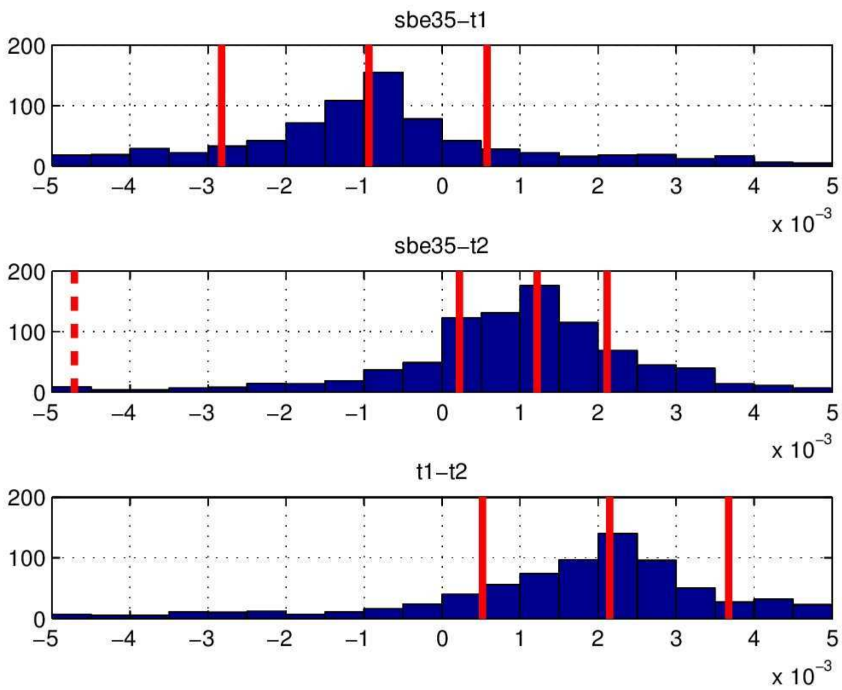


Figure 5.7: Temperature differences between each of the three sensors for all bottle stops. The histogram bin intervals are at 0.0005 °C, the precision of all three sensors. Solid red lines are the lower (25%), middle (50%, i.e. median), and upper (75%) quantiles of the differences between the sensors. Dashed red lines are the 5% and 95% quantiles.

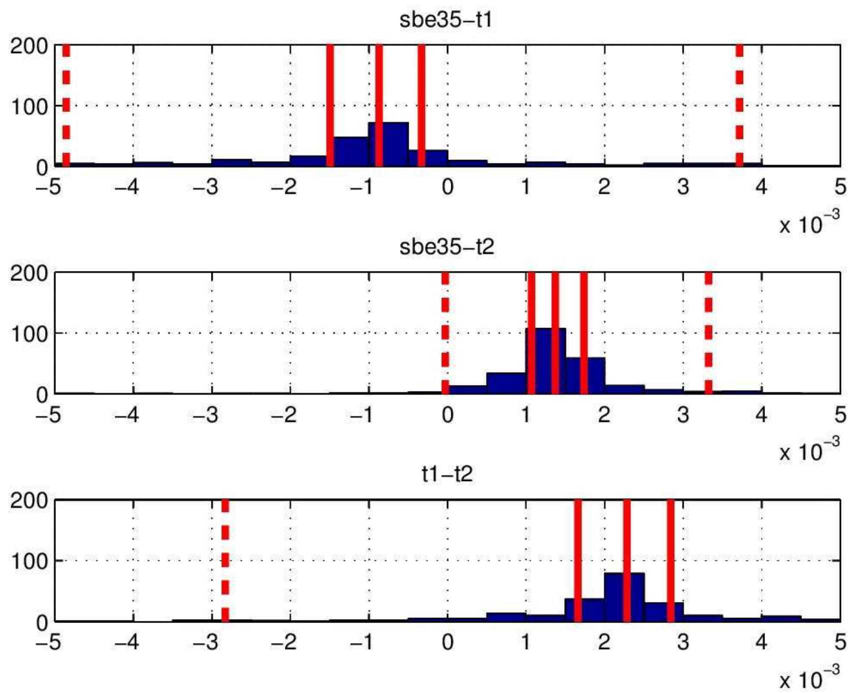


Figure 5.8: Same as Figure 5.7 except only for temperature data at bottle stops below 1000 dbar.

5.7) Conductivity calibration

The calibration of the CTD conductivity sensors was achieved by directly comparing conductivity from Niskin bottle salinity samples measured in the laboratory (Chapter 9) with a subset of data from the primary and secondary conductivity sensors, C_1 and C_2, respectively, taken at the time of bottle closure. The WOCE precision limit for salinity is 0.002 PSU, which, depending on temperature, translates to approximately 0.0015 to 0.0023 mS/cm in conductivity difference or the range from 0.99995 to 1.00005 in conductivity ratio. The calibration steps are similar for the primary and secondary conductivity sensors but both sensors were calibrated separately. The residuals between the bottle data and the primary and secondary sensors are compared to check for any possible temporal drifts or pressure effects on the conductivity calibration.

The conductivity sensors showed differences from around 0.004 PSU on the beginning casts to around 0.009 PSU towards the end of the cruise. The station-by-station correction determined by comparing the bottle conductivities with CTD conductivities will be detailed below and any calibrations were applied after spikes were removed during MSTAR processing (Section 5.2).

As with oxygen, the conductivity calibration is essentially two steps. The first step is a linear fit between bottle conductivity and C_1 and C_2. The second step is a correction based on the residuals from the first step (usually to correct for pressure effects or temporal drifts). We attempted applying different linear fits to subsets of the data, grouped by station. However, in the end, we chose to apply a single linear fit over all the data because of large temporal discontinuities in the salinity offsets that arose with different linear fits being applied over different subsets of the stations. Figures 5.9 and 5.10 show the initial, uncalibrated differences between CTD and bottle data for C_1 and C_2, respectively. In general, for both conductivity sensors, there does not seem to be a pressure effect. However, both conductivity sensors exhibit temporal drifts with the drift in C_1 being bigger than C_2.

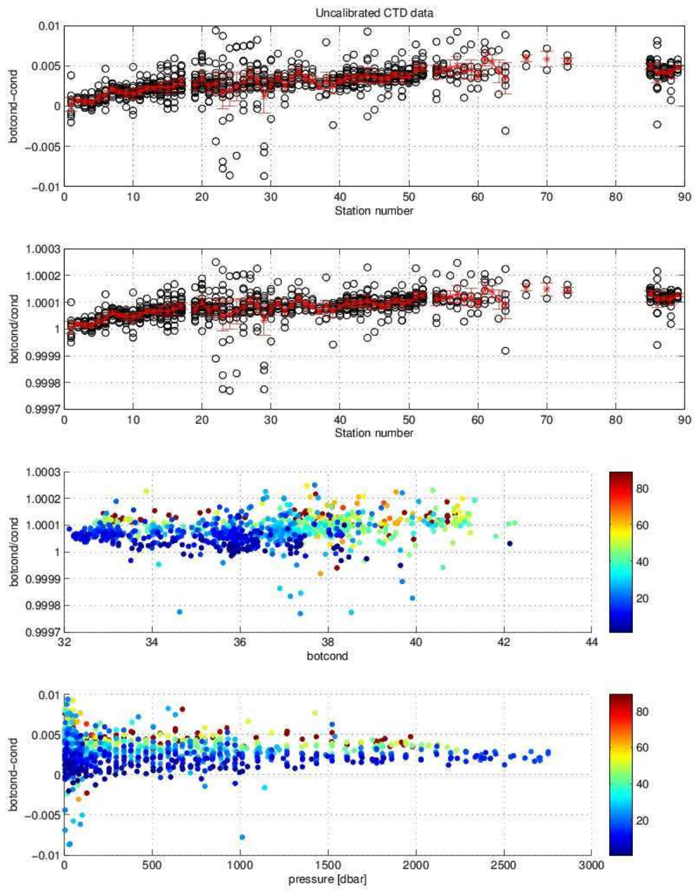


Figure 5.9: Uncalibrated CTD primary conductivity residuals and ratios compared to the corresponding bottle conductivities.

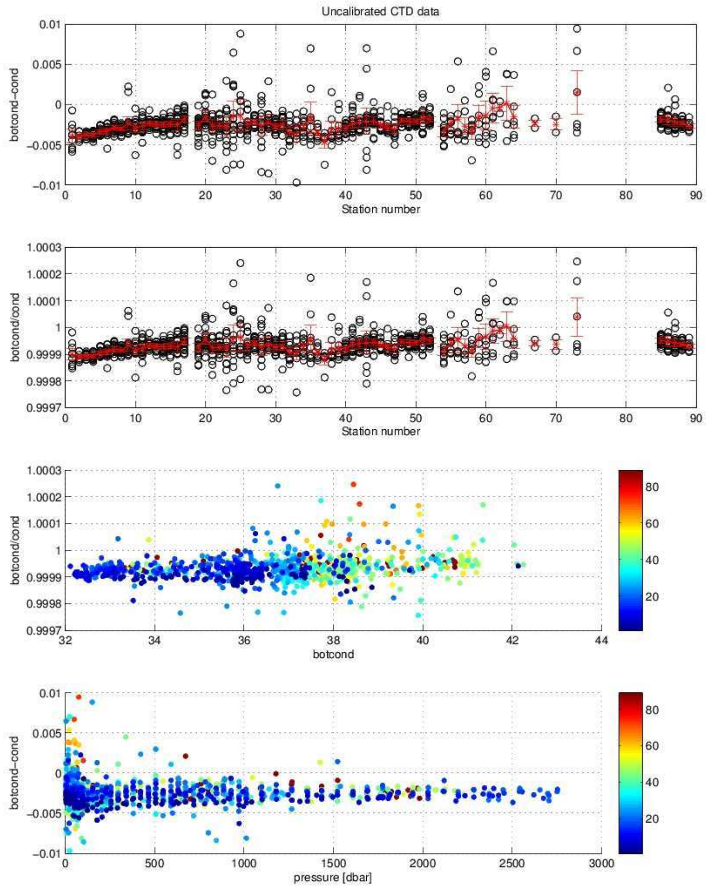


Figure 5.10: Same as Figure 5.9 except for the secondary CTD sensor.

Once a linear fit, using standard practice to force the intercept to zero, was applied, new residuals were computed and are displayed in Figures 5.11 and 5.12 for C_1 and C_2, respectively. These residuals are the basis for the station by station conductivity adjustment was applied to the data to compensate for the temporal drift. As shown in Figures 5.11 and 5.12, a parabolic fit does not sufficiently capture the range of the drift, so a piecewise linear adjustment was applied on a station-by-station basis instead. The final salinity residuals calculated from the calibrated conductivity data are shown in Figures 5.13 and 5.14. Table 5.1 summaries the parameters for the calibrations applied to the two sensors as well as the resulting estimates for the overall accuracy of the calibrations.

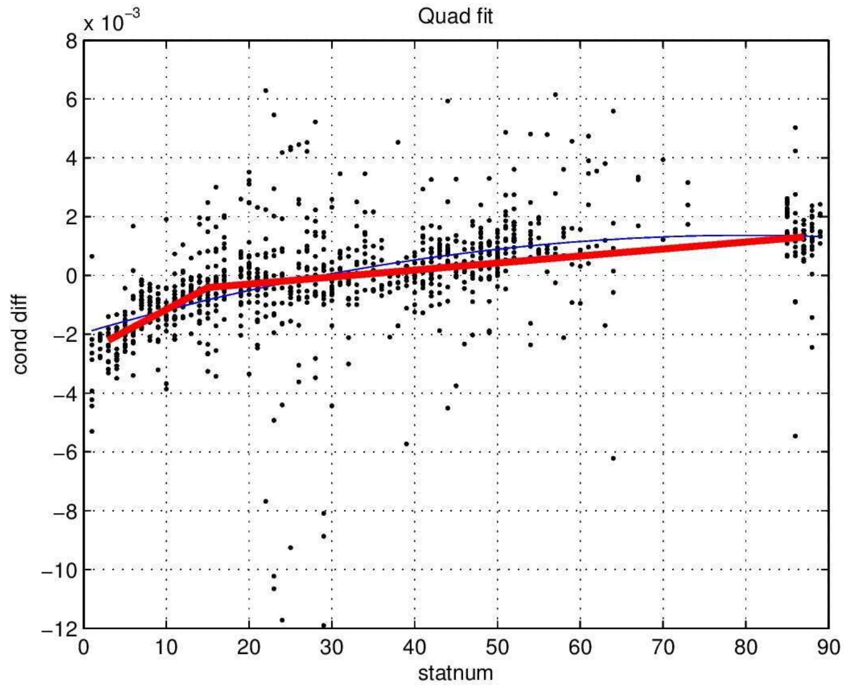


Figure 5.11: Conductivity residuals plotted with station number after the linear calibration fit was applied on the primary conductivity sensor. The piecewise linear adjustment is shown by the bold red line. A quadratic fit for the adjustment, which was not used, is shown with a blue line.

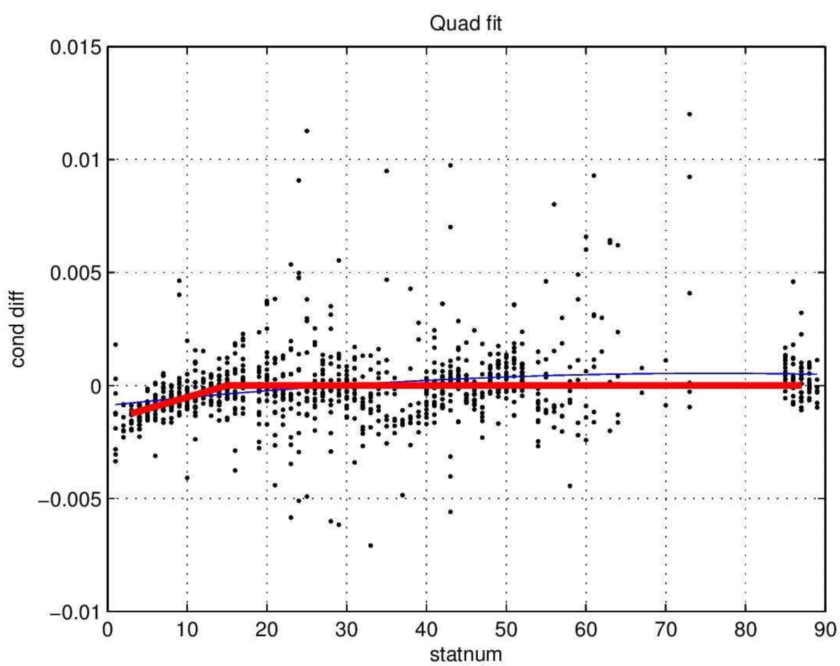


Figure 5.12: Same as Figure 5.11 except for the secondary conductivity sensor.

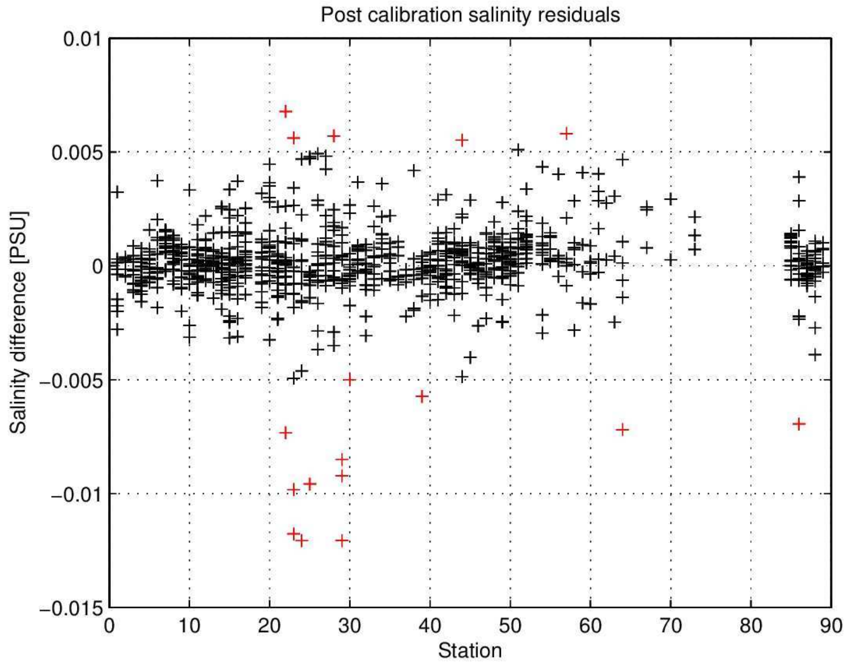


Figure 5.13: Salinity residuals between bottle salinity and CTD-derived salinity from the primary instruments after calibration slope and station-by-station adjustments were applied. Red plus signs are residuals outside of ± 3 standard deviations.

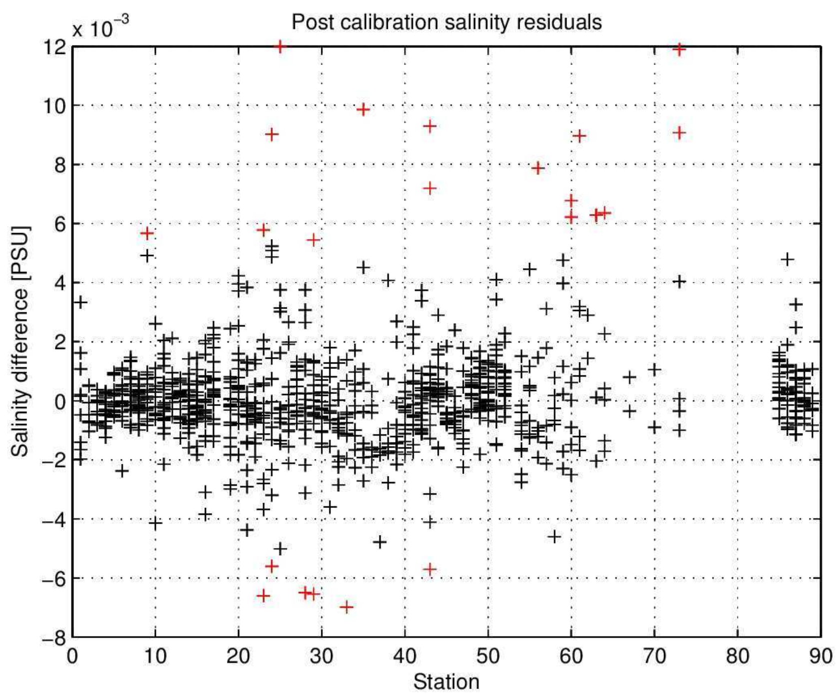


Figure 5.14: Same as Figure 5.13 except for the secondary conductivity sensor.

Table 5.1: Summary of parameters and performance of conductivity calibration. The symbol *C*' represents conductivity residuals, $C' = C_{bottle} - C_{CTD}$. All conductivities are in units of mS/cm and all salinity are in practical salinity units. The mean conducitivity residuals from stations 1-6, 10-20, and 85-89 were used to determine the endpoints of the red lines in Figures 5.11 and 5.12 – the linear conductivity adjustments that were applied to each sensor to account for the temporal drift of the sensors.

Calibration parameter	Primary Conductivity	Secondary Conductivity
mean(abs(*C*')) no calibration [mS/cm], removing ± 3 std residuals	0.0032 ± 0.0016	0.0027 ± 0.0012
Slope (intercept = 0)	1.0000832788	0.9999343064
mean(abs(*C*')) after slope applied	0.0013 ± 0.0014	0.0011 ± 0.0013
Mean *C*' stn 1:6	-0.0022095	-0.0012403
Mean *C*' stn 10:20	-0.0004107	0 (no adjustment applied)
Mean *C*' stn 85:89	0.0013027	0 (no adjustment applied)
mean(abs(*C*')) after adjustment applied	0.0010 ± 0.0013	0.0010 ± 0.0014
mean(abs(*S*')) [PSU]	0.0010 ± 0.0014	0.0011 ± 0.0014
mean(abs(*S*')) after removing ± 3 std	0.0009 ± 0.0009	0.0009 ± 0.0009
mean(abs(*S*')) after removing ± 3 std and below 1000 dbar.	0.0006 ± 0.0006	0.0006 ± 0.0006

The calibration slopes and temporal adjustments in Table 5.1 were applied to the data in MSTAR with the wrapper script **mctd_condcal**, which, in turn, calls **cond_apply_cal**, a script designed to hold the exact parameters of the conductivity calibration. The calibration was applied to the 24 Hz data for each station which then had to be reprocessed with **mctd_03**, **mctd_04**, **mfir_03**, and **mfir_04** to recreate the calibrated 1Hz, 2dbar, and sample files.

5.8) Cast anomalies

This section details some overall cast anomalies that had implications for one or more streams of the CTD data.

CTD002 – bottles had to be fired manually due to a PC setup error. Operator fired 9 bottles, but when the package came up on deck, only 8 bottles had closed. The same setup error resulted in the Seabird .bl file not being created so we had to turn to the operator logsheet and the SBE35 time stamps to figure out the bottle firing order.

On the logsheet for cast 2, the first two bottles were commanded to fire at the bottom with less than 1 minute spacing between them. Then, bottles were fired about every 2 to 4 minutes for the duration of the cast because no other bottles were fired at the same depth and the bottles were spaced pretty closely together (max spacing ~25 m). The SBE35 sampling timestamps were off by a couple minutes from the CTD logsheet probably due to a slight offset in the SBE35 clock. However, the spacing between SBE35 timestamps are all about 2 to 4 minutes. This means that the initial double fire at the deepest level was not registered by the SBE35. Assuming that the bottle closing carousel operated in sync with the SBE35, either the first or the second bottle did not fire and the rest of the bottles closed one after the other.

As all the samples will be logged in MSTAR based on cast number and (Niskin) bottle number, we don't need to make any special considerations for the labelling of samples. We do, however, need to reconstruct the Seabird .bl file so that MSTAR knows what scans to use when constructing sub-samples of the sensor data to compare to the bottle data for calibration.

To reconstruct the .bl file, the following information is required: bottle firing sequences, bottle positions, firing times, first scan and the last scan. It was not possible to use the SBE35 for the bottle firing times as the SBE35 internal clock is offset to the CTD. It could however be used as a guide. In order to assimilate the bottle firing times, plots were created of scan vs depth from the .cnv file. This is shown in Figure 5.15. Here we could see where the CTD had stopped in the water column to fire a bottle. Using the plot and zooming in we got the first scan number (when the scans settled at the firing depth).

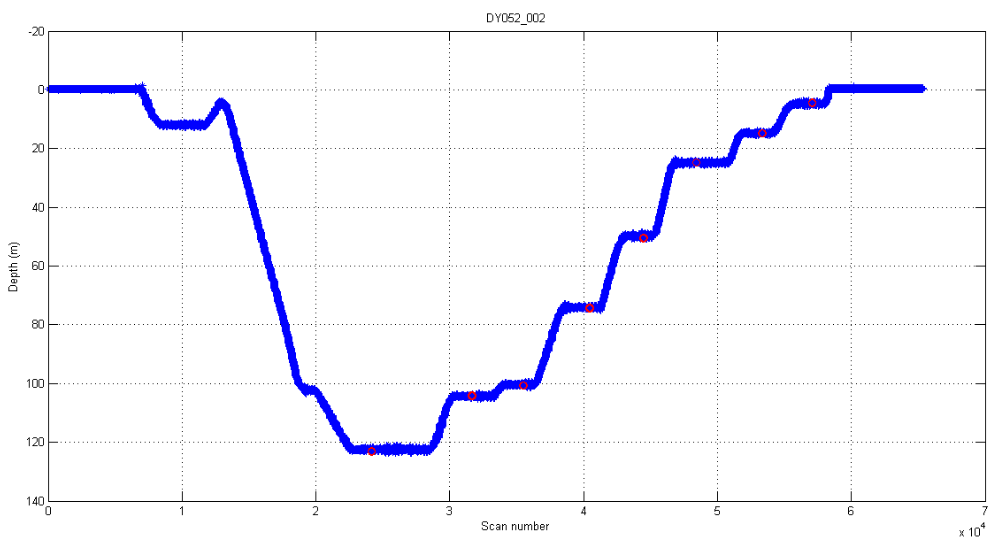


Figure 5.15: CTD depth versus data scan to identify when the bottles fired on CTD cast CTD002. Red circles indicate the scan numbers that were used to reconstruct the .bl file for CTD002 and indicate a best estimate for when the bottles were fired.

The normal firing procedure is to wait 30 seconds before firing a bottle at a desired depth, however when we calculated the first and last scan numbers, this seemed too short for the time the CTD stayed at these firing depths. We therefore assumed a minute was left before firing a bottle and this resulted in a more realistic scan number.

To calculate the scan number, we needed to know the frequency of the CTD output. The CTD is recording at 24Hz. Therefore to include a 60 second wait, 1440 (60 *24 =1440 scans) was added from the initial first scan from looking at Figure 5.15.

In order to obtain the last scan number, we looked at the other .bl files and this showed the number of scans from start to end that are averaged for each bottle and this was 36 scans (1.5 seconds). Therefore, after calculating the first scan (from looking at the plot and adding the waiting time) we added 36 to get a last scan number.

The first and last scan number was then added to Figure 5.15 in red. These scans fit nicely into the middle of where the CTD has stopped so we are confident this approach has worked. We then worked out the times of these firings and checked them against the operator log as a sanity check.

CTD018 **–** Carousel Failure, so no bottles were fired. CTD data acquisition was restarted at the bottom of the cast when computer and manual attempts to fire bottles failed, to no avail. The down and up casts were manually stitched together after the standard Sea-Bird processing (convert, align, cell thermal mass) but before the MSTAR processing steps. The carousel was replaced with a new unit and operated well on subsequent casts.

CTD021 - reported Niskin 11 was leaking slowly.

CTD029-031 – reported Niskin 09 was leaking slowly.

CTD053 – all bottles fired at bottom for micro-plastics study.

CTD062 – Pumps took 10 minutes to start.

CTD065 – Initially aborted as pumps failed to turn on. Sea-Bird 9plus unit replaced with S/N 0803 and cast redeployed. The sensors remained the same.

CTD071 – Pumps did not work on first attempt with possibility of air trapped in the system. CTD brought back on deck to re-flush with seawater. Second attempt 7 minutes to start.

6) Vessel Mounted ADCP

Liz Comer

6.1) Synchronisation

The processing method described here is very much the same as that in DY031 but some sections may be updated or edited. The Discovery has two VMADCPs; the 150 kHz and the 75 kHz. Both were switched on at the start of DY052. There are many acoustic instruments on the ship, such as the EM122 Deep Water Multibeam Echosounder, EM710 Shallow Water Multibeam Echosounder, SBP120 Sub-bottom Profiler, EA640 Single Beam Echosounder, EK60 Multi-frequency Echosounder ('fish-finder') and the Kongsberg SU16 Synchronisation Unit (K-Sync). The VMADCP's were triggered and running as normal with K-Sync.

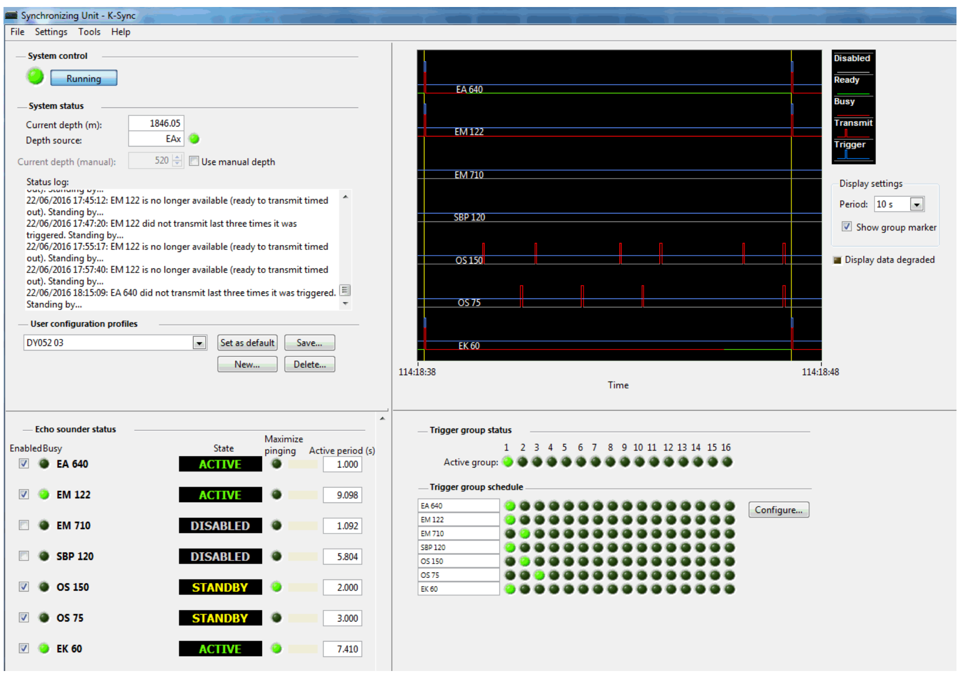


Figure 6.1: Screenshot of K-Sync setup.

6.2) Data summary

Whilst processing the OS75 data it was noticed that it produced significant amounts of poor quality bins and the instrument was not producing any data throughout the water column regularly. This is still to be fully investigated but likely to be caused by either bubbles near the mounted instrument or interference with other acoustic instruments. However, when on-station the OS75 produces reasonable data, with a good data quality. The percent good data images in Figures 6.2 and 6.3 show that the OS150 and OS75 are preforming at similar levels with better data quality over shallow regions and lower data quality in adverse weather conditions. The OS75 has a larger spread of percent good data which is seen in a visual inspection of the bottom images.

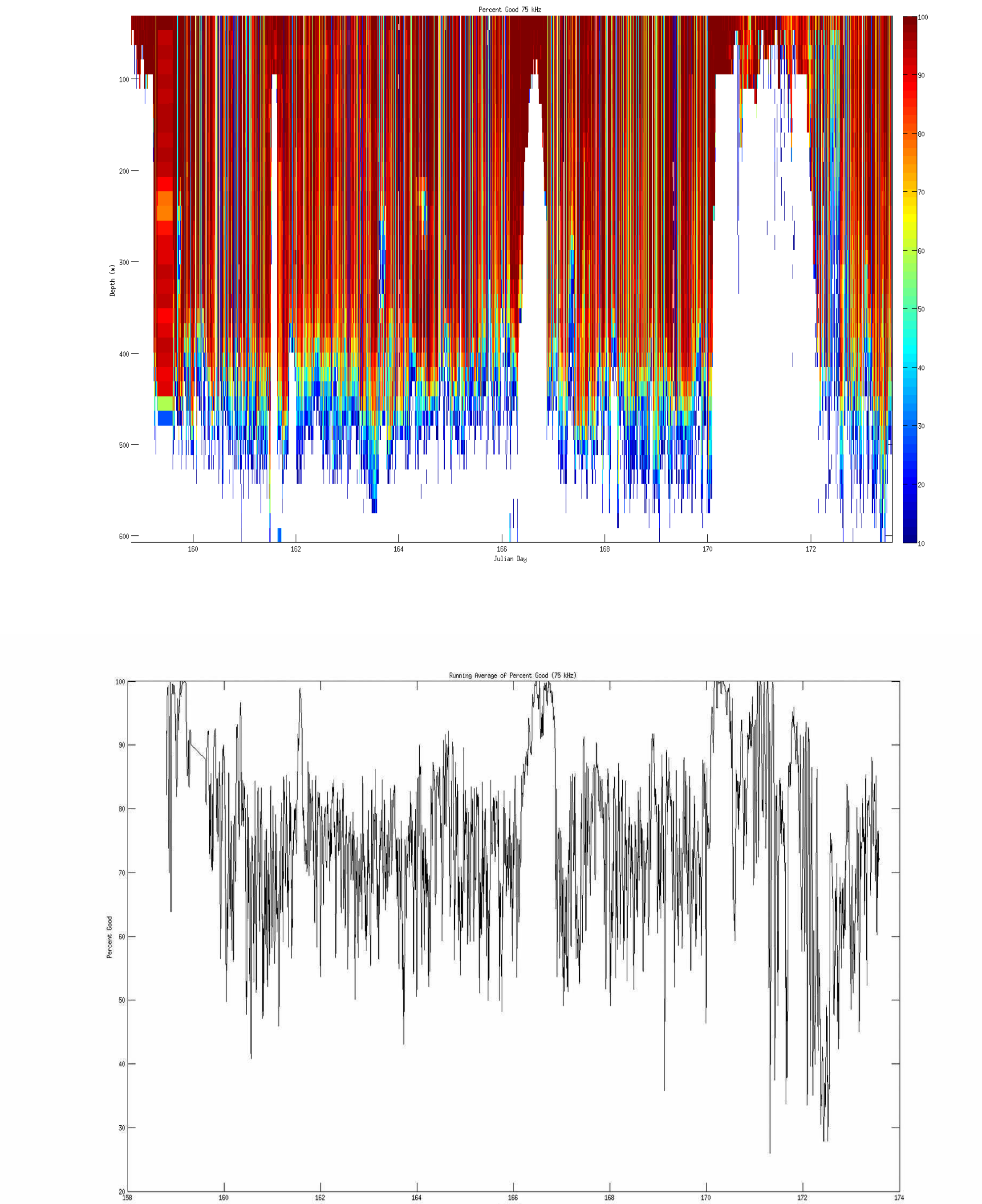
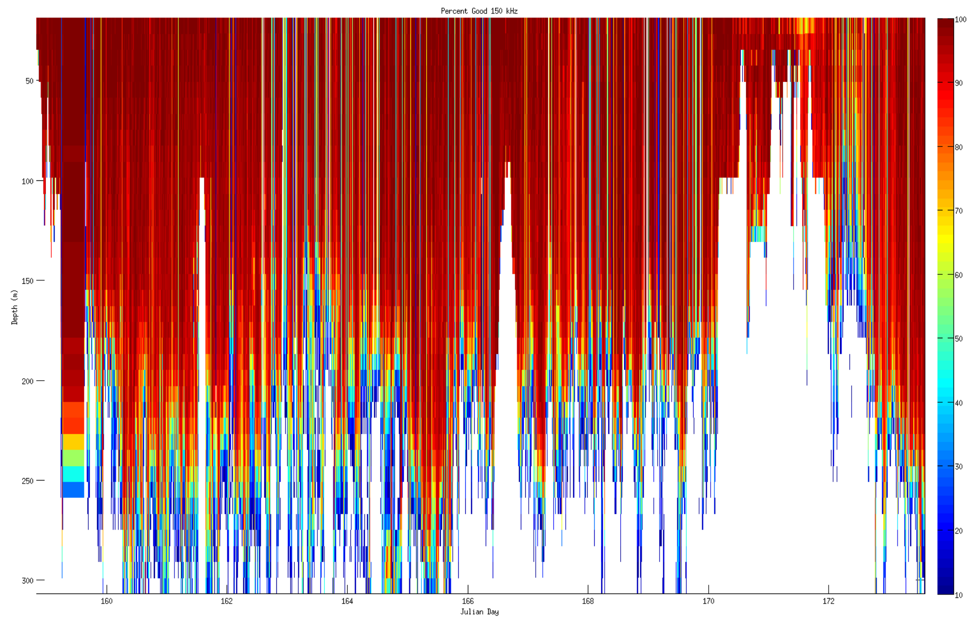


Figure 6.2: The top image shows a timeseries of the percent good data for the OS 75 kHz and the bottom shows its column-by-column average over time.



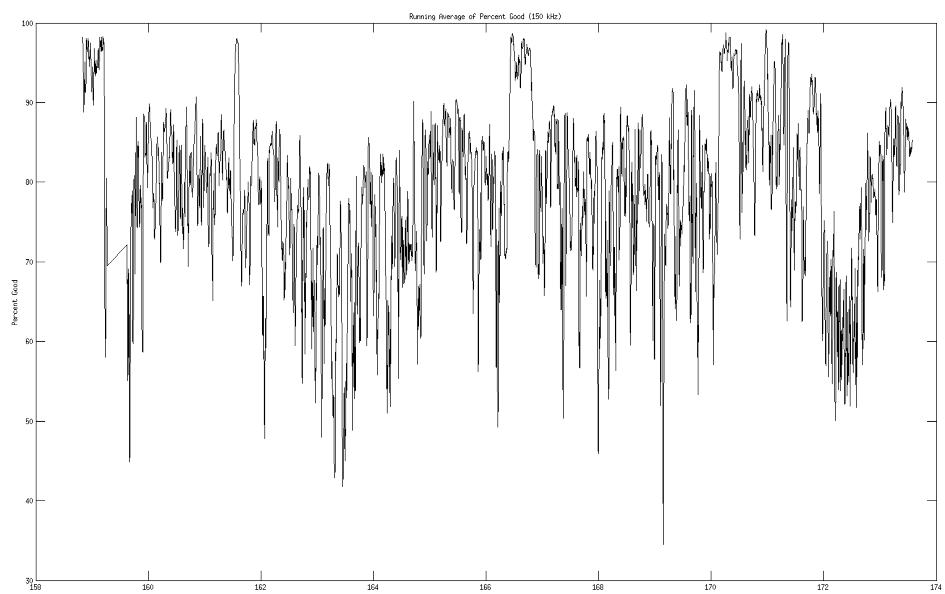


Figure 6.3: The top image shows a timeseries of the percent good data for the OS 150 kHz and the bottom shows its column-by-column average over time.

Multiple re-starting events at the beginning of the cruise, for both the instruments but more so in the OS 75 kHz, is due to the setup of the command file. Towards the end of the cruise it was noticed that the VMADCP automatically collects bottom tracking data when in shallow enough water, therefore, the bottom tracking command file did not need to be activated manually. All raw data has been kept from both instruments. The successfully processed files are given in the tables below. Any gaps in the record correspond to when raw data files were not successfully processed, usually due to short files during the testing of the instrument setup.

Table 6.1: Data file information for the 75 kHz VMADCP.

File no.	Start	End	Comments
01	7/6 19:03	8/6 07:37	BT on
36	8/6 14:24	8/6 14:49	BT on
37	8/6 14:50	8/6 15:52	
38	8/6 15:52	10/6 12:23	
39	10/6 12:24	10/6 15:00	BT on
40	10/6 15:00	11/6 14:04	
41	11/6 14:04	12/6 14:27	
42	12/6 14:27	13/6 13:57	
43	13/6 13:57	14/6 14:01	
44	14/6 14:01	15/6 12:06	
45	15/6 12:06	15/6 15:21	BT on
46	15/6 15:22	15/6 15:54	
47	15/6 15:54	15/6 18:47	BT on
48	15/6 18:48	16/6 13:59	
49	16/6 13:59	17/6 14:53	
50	17/6 14:53	18/6 00:15	
51	18/6 00:16	18/6 14:13	
52	18/6 14:13	19/6 14:23	
53	19/6 14:23	20/6 13:58	
54	20/6 13:58	21/6 14:09	
55	21/6 14:09	22/6 13:57	
56	22/6 13:57	23/6 14:38	
57	23/6 14:38	23/6 19:54	

Table 6.2: Data file information for the 150 kHz VMADCP.

File no.	Start	End	Comments
24	7/6 19:39	8/6 06:25	BT on
30	8/6 14:45	10/6 12:22	
31	10/6 12:23	10/6 14:59	BT on
32	10/6 15:00	11/6 14:04	
33	11/6 14.04	12/6 14:26	
34	12/6 14:26	13/6 13:57	
35	13/6 13:57	14/6 14:00	
36	14/8 14:01	15/6 12:05	
37	15/6 12:05	15/6 15:20	BT on
38	15/6 15:21	15/6 15:53	
39	15/6 15:53	15/6 18:46	BT on
40	15/6 18:47	16/6 13:58	
41	16/6 13:59	17/6 14:53	
42	17/6 14:53	18/6 14:12	
43	18/6 14:12	19/6 14:23	
44	19/6 14:23	20/6 13:58	
45	20/6 13:58	21/6 14:09	
46	21/6 14:09	22/6 13:57	
47	22/6 13:57	23/6 14:38	
48	23/6 14:38	23/6 19:53	

6.3) Processing

Data processing followed the usual paths:

Stage A: Initial Processing

i) Copy data from the ship server:

cd data
cd vmadcp
cd v150

Remove the directory and data with the largest sequential number. You need to do this because the linkscript also copies data that is still being collected, creating a new incomplete rawdataNNN directory, and if a directory is already present it does not get updated with new data. To copy the most up to date data (once the logging has been restarted) it is necessary to remove the directory with the largest sequential number before running vmadcp_linkscript*.

e.g. for file 128:
/bin/rm ./rawdata/*128*
/bin/rm -r rawdata128
/bin/rm -r dy052128nbenx

Now copy the new data files:

vmadcp_linkscript150

This script redistributes raw data from rawdata to rawdataNNN; rawdataNNN is automatically created if necessary (may need to edit movescript so that it parses the file names correctly). Now do the same for the os75:

cd data
cd vmadcp
cd v75
/bin/rm ./rawdata/*128*
/bin/rm -r rawdata128
/bin/rm -r dy031128nbenx
vmadcp_linkscript75

The following steps are repeated for each v150 and v75 data file.

ii) Create a new directory containing all the output files:

cd v150 (or v75)
adcptree.py dy052NNNnbenx --datatype enx

iii) Copy calibration files into the directory for each data file (there is a template file called q_py.cnt in data/v150 and data/v75):

cd dy052NNNnbenx
cp ../q_py.cnt .

Generally, only the dbname and datadir for each NNN need to be updated.

For information, an example q_py.cnt file is

```
# q_py.cnt is
## comments follow hash marks; this is a comment line
--yearbase 2016
--dbname dy052001nnx
--datadir /local/users/pstar/cruise/data/vmadcp/v75/rawdata001
#--datafile_glob "*.LTA"
--datafile_glob *.ENX
--instname os75
--instclass os
--datatype enx
--auto
--rotate_angle 0.0
--pingtype nb
--ducer_depth 5
#--verbose
# end of q_py.cnt
# end of q_py.cnt
```

At the start of the cruise check yearbase, dbname, os75 or os150 and datatype enx (glob ENX). dbname should be of form dy052NNNPTT where P is n for narrowband, b for broadband. In order to achieve the deepest measurements, the instrument should be operated in narrow unless there is a good reason to choose broad. TT is “nx” for ENX; “ns” for ENS; “nr” for ENR; “lt” for LTA; “st” for

STA. Standard processing is to process ENX. Traditionally, dbname must not exceed 11 chars. So if we use 9 for dy052NNNn, there are only two left to identify ENX, ENS, LTA, STA. Without calibration information the angle can be left as zero. The transducer depth was changed for this file in cruise DY052 to 7. It must be an integer.

iv). Process in CODAS (with no calibration)

quick_adcp.py --cntfile q_py.cnt

v) To access data in Matlab type in the command line:

>> **m_setup**
>> **codaspaths**
>> **cd edit**
>> **gautoedit**

The gautoedit utility allows you to view the data and do a quick check for quality. Note that the JDAY on the plots is our DOY minus 1. Alter the time step and tick the list of variables to plot on the figures (including using depth as x axis), then click the "show now" button in order to get plots up on the screen.

Gautoedit does allow you to clean up data but this was not done on DY052. See DY031 and JC086 cruise reports or CODAS documentation for more information.

Stage B: Finding and correcting the ADCP misalignment angle (the calibration)

i) Find the calibration information

The calibration information can come from BT (bottom track) or WT (water track) files. The latter are generated during sharp turns in the ship's track, especially coming on or off station.

Any calibration information produced can be found in the "cal" directories of the processing directories (eg dy052001nbenx/cal/*/*out). Note that a calibration is not always achieved, for example if the ship has made no manoeuvres while the ADCP is in water tracking mode, so there may be no *out file). Note also that additional calibration information maybe saved after flags are applied after the gautoedit process (not done on DY052). Tables 6.3 and 6.4 summarize the DY052 calibration information.

Table 6.3: Calibrations from bottom-tracking and water-tracking for v150.

File	Time (DoY)	BT/ WT	Amp Median	Mean	STD	Phase Median	Mean	STD
024	163.67-164.31	BT	0.9991	0.9990	0.0039	0.2628	0.2609	0.2291
027		BT	0.9991	0.9990	0.0039	0.2628	0.2609	0.2291
031	161.52-161.62	BT	0.9981	0.9994	0.0067	0.3461	0.5980	0.5760
037	166.51-166.24	BT	0.9970	0.9967	0.0022	0.1317	0.1505	0.2267
039	166.67-166.78	BT	0.9988	0.9993	0.0027	0.1189	0.0724	0.2313
Mean			0.9984			0.2245		

WT mean of all files 1.0007 1.0019 0.2968 0.2753

Table 6.4: Calibrations from bottom-tracking and water-tracking for OS75.

File	Time (DoY)	BT/ WT	Amp Median	Mean	STD	Phase Median	Mean	STD
001	158.80-159.24	BT	1.0151	1.0156	0.0035	0.7339	0.7572	0.2113
036	159.61-159.61	BT	1.0179	1.0179	0.0028	0.4561	0.4561	0.1566
039	161.52-161.62	BT	1.0148	1.0121	0.0086	0.8307	0.7586	0.7533
045	166.51-166.64	BT	1.0136	1.0146	0.0044	0.6542	0.6484	0.4104
047	166.67-166.78	BT	1.0144	1.0148	0.0032	0.6012	0.5379	0.2832
Mean			1.0152			0.6552		

WT mean of all files 1.0199 1.0209 0.6196 0.6077

ii) Select the most reasonable looking values of the amplitude and phase.

Reasonable might mean the values from a large file, or from BT rather than WT, or an average of all the median values produced. Once can take into account values from previous cruises on the same ship, as long as the ADCP has not been refitted since then. On DY052 we chose the mean of the BT median values (bottom row of Tables 6.3 and 6.4) which is consistent with the method from last year’s cruise (DY031). It is also useful to note that the BT median shows a similar value to the BT mean and is consistent from file to file.

iii) Apply the calibration

The calibration application is repeated for both ADCPs and for each data file. The calibration was applied by manually putting the amplitude and phase coefficients determined above into the control files ("q_pyrot.cnt"), one for each instrument. If required, different values for groups of files can be manually specified, in particular for cases where there are different EA values in the command files. An example q_pyrot.cnt with calibration coefficients contains:

```
# q_pyrot.cnt for OS 150 DY052
## comments follow hash marks; this is a comment line
--yearbase 2016
--rotate_angle 0.2245
--rotate_amp 0.9984
--steps2rerun rotate:navsteps:calib
--auto
# end of q_pyrot.cnt
```

Still in directory dy052NNNnbenx, apply the final calibration only once. Adjustments are cumulative so if this step is done twice the cal is applied twice.

quick_adcp.py --cntfile q_pyrot.cnt

Stage C: Merge VMADCP data into MSTAR

i) Still in directory dy052NNNnbenx open a Matlab window and type into its command line:

>> **mcod_01**

This step produces an empty output file os75_jr265NNNnnx.nc.

>> **mcod_02**

This step will grab water speed and ship speed from the VMADCP files and get all the variables onto an NxM grid.

ii) Append individual files using:

>> **mcod_mapend**

This script will append individual files to create a single cruise file ("_01"). This script expects the files to have the same bin number and bin depths. On DY052 we did this after every VMADCP file was processed. If this is done periodically, the new .nc file needs to be manually added to the ‘nc_files’ text file, which contains a list of all the processed ones.

iii) Create .mat files specific to each CTD stations

>> **mcod_03**
>> **mcod_stn_out(‘ctd’,nnn,75)**

In the above, nnn is the CTD cast number. This script will generate the .mat files in: ~/cruise/data/vmadcp/dy052_os75

iv) The final step is to make the data available for LADCP processing. Create symbolic links to the .mat files in /ladcp/ix/data/SADCP with the format 'os75_dy052_ctd_nnn.mat'. The VMADCP data will now be available for comparison with LADCP data and for providing a constraint on the processing. During LADCP processing, the .mat files are automatically picked up by the 'process_cast' script (Chapter 7).

7) Lowered ADCP data processing

Jonathan Tinker and Stefan Gary

This chapter builds on the LADCP processing carried out during DY031, the 2015 EEL cruise. As such, the LADCP section of the DY031 cruise report was the starting point for this section and is updated here to reflect the data pipeline during DY052.

7.1) Introduction and data processing

Data from the LADCP instrument was processed as soon as possible between stations to allow early detection of any problems with the ADCP workhorse. The final processing relied on the processed CTD casts, and the processed VMADCP (which also relied on the processed CTD casts), and so LADCP was at the end of the chain of processing.

Data quality was checked in WinADCP by the CTD operators (Colin Hutton, Estelle Dumont, and Jon Short) immediately after download from the LADCP. They copied the data files and the pre-deployment log text files from the LADCP PC onto the DY052/Public server. The instruments performed well and there were no problems. The LADCPs had just been recalibrated at the factory and so they were rotated out prior to casts 51 and 74 (Chapter 4).

Processing was via the Lamont-Doherty IX.8 software. The processing was performed in three steps, each with additional supplementary data to further constrain the LADCP results:

1) The data from the LADCP was processed in isolation, including bottom tracking from the LADCP
2) The pressure, temperature, salinity, and lon/lat data from the CTD was included in the processing
3) Data from the vessel mounted ADCP (VMADCP, or in the IX software, referred to as SADCP) was compared to the result from step 2.
4) Data from the VMADCP was included as a constraint, along with bottom tracking, GPS, and CTD data, in the LADCP processing.

At sea, a Linux link script was run followed by Matlab processing and as Matlab wrote the output file to the same directory each time (DL_BT), the files were then moved to DL_LADCP, DL_CTD, and DL_VM_ADCP_75 for steps 1, 2 and 3, respectively. Step 4 was performed ashore and during that step, all the processed data were written directly to the directory DL_BT_GPS_CTD_SADCP.

Bold text denotes commands to enter at the X-window/terminal prompt. ‘>>’ preceding bold text indicates commands to be entered in the Matlab window.

<u>*Step 1: Processing without any auxiliary data*</u>

a) Move to the appropriate location on the Unix system. The linkscript creates a new directory for that cast and creates a symbolic link with the filename structure that the processing expects.

cd ~/cruise/data/exec
lad_linkscript_ix_dy052

b) Open Matlab window, move to the processing directory, setup paths, and process the cast:

>> **m_setup**
>> **mcd ladcp**
>> **cd ix/data**
>> **ixpath**
>> **process_cast(nnn)**

c) Copy output files to the correct location

The previous step put the output into
~/cruise/data/ladcp/ix/data/DL_BT/processed
The output includes a number of ps files, and a .mat file of the format nnn.mat (where nnn is the zeropadded cast number i.e. 001). The .mat file includes a structure called dr which will not include the fields ctd_t, or u_sadcp. These data should be moved to ../../DL_LADCP/processed

mv ~/cruise/data/ladcp/ix/data/DL_BT/processed/nnn*
~/cruise/data/ladcp/ix/data/DL_LADCP/processed/nnn*

Step 2: Processing with CTD and GPS

a) Created Linux link files:

cd ~cruise/data/ladcp/ix/data/raw
ladctd_linkscript_ix

b) Process in Matlab using the same series of steps as in Step 1.

c) copy to the correct location

The .mat files will now have a ctd_t field, but still no u_sadcp field

mv ~/cruise/data/ladcp/ix/data/DL_BT/processed/nnn*
~/cruise/data/ladcp/ix/data/DL_CTD/processed/nnn*

Step 3: Processing compared to VMADCP

a) Created link files:

cd ~cruise/data/ladcp/ix/data/raw
ladvmadcp_linkscript_ix

b) Process in Matlab

c) copy to the correct location

The .mat files will now have both ctd_t field and u_sadcp fields

mv ~/cruise/data/ladcp/ix/data/DL_BT/processed/nnn*
~/cruise/data/ladcp/ix/data/DL_VM_ADCP_75/processed/nnn*

Step 4: Processing with all constraints, including VMADCP

Post cruise, it was found that the variable ps.sadcpfac was set to 0 in set_cast_params.m which effectively removed the VMADCP from processing the LADCP data but still loaded the VMADCP data for comparison with the LADCP. To rectify this omission, all LADCP data were processed again, this time including the VMADCP data by setting ps.sadcpfac = 1 in set_cast_params.m. All data processed at this level were written to DL_BT_GPS_CTD_SADCP/processed and the *.lad, *.mat, and *.ps files were retained. This final level of processing, including the VMADCP and other constraints, is the data submitted to BODC along with the raw data files.

For all processing ashore, the geomagnetic database was updated from IGRF11 (used at sea) to IGRF12 (http://www.ngdc.noaa.gov/IAGA/vmod/igrf.html). All LADCP profiles were visually inspected to check for consistency with the VMADCP constraint (at the top of the profile) and the bottom tracking constraint (at the bottom of the profile).

7.2) Preliminary quality checks

Some of the figures generated by the processing script are particularly useful to provide early indication of poor quality data, possible faults, and incorrect transfer of the raw data. Use the paper log file ("LADCP_QC_JT.xlsx") to note the following points, and then compare to the CTD logs where necessary. The following is a list of what was looked at in each of the figures generated by the Matlab processing.

Figure 1: Make sure that the bottom track velocities (bottom part of the plot on the left hand side) match those of the water track (plot on the left hand side). Also check if time and depth of the cast indicated in Figure 1 match with the corresponding logged data.

Figure 2: Check the performance of the four beams from the bottom-left plot. This figure also indicates the CTD heading direction. This can represent valuable information for the CTD operator, in case it is spinning excessively.

Figure 4: Compare profiles from down and up casts and check if they are both complete. If not, this could indicate a fault. This figure also indicates the depths of the cast, which can be checked against logged information.

Figure 11: This figure provides a list of processing errors and warnings.

For each cast, these figures (from the CTD processing) were assessed and logged in the log sheet "LADCP_QC_JT.xlsx": for figure 1, the profile was compared to the bottom track, the start and stop time was noted, and the max depth; figure 2, the number of spins (heading time-series) and beam performance (that they were similar to one another etc.); figure 4, that the top and bottom profile match (lower left panel), and the bottom depth (bottom at: - middle panel); figure 11, any other errors. The depths and times were then compared to the CTD logs.

Cast 068: did not process at the first stage (without CTD or VMADCP) as there was insufficient data.

Processing was completed for every cast at the second stage (with CTD).

For processing with the VMADCP data, the following anomalies were noted:
Cast 001: was not processed with the VMADCP, as there was no VMADCP data.
Cast 061, 062, 068, 070-072 did not have sufficient VMADCP data to create a constraint for the LADCP data.

Specific error messages from the LADCP processing:

Cast 002:	shifted ADCP timeseries by 122 seconds
Cast 005:	Battery voltage is low : 36.8 V
Cast 006:	Battery voltage is low : 34.8 V
Cast 007:	Battery voltage is low : 34.2 V
Cast 008:	Battery voltage is low : 32.9 V
Cast 037:	shifted ADCP timeseries by 17 seconds
Cast 060:	shifted ADCP timeseries by 37 seconds
Cast 061:	shifted ADCP timeseries by 45 seconds
Cast 062:	all SADCP values removed because of low weight
Cast 063:	all SADCP values removed because of low weight large V bottom track bias 0.11082
Cast 070:	all SADCP values removed because of low weight
Cast 071:	all SADCP values removed because of low weight

7.3) Initial results

Some Matlab functions and scripts were created to allow for an initial data analysis. These are found at:

cd /home/mstar/Desktop/DY052/LADCP/

The main script,

>> JT_plotting_LADCP_proc_comp

shows the LADCP data with each level of processing (Figure 7.1) and the effect each level of processing has (Figure 7.2). We found that the CTD and GPS data had an appreciable effect on the results. The VMADCP constraint also had an impact, but less so than the CTD.

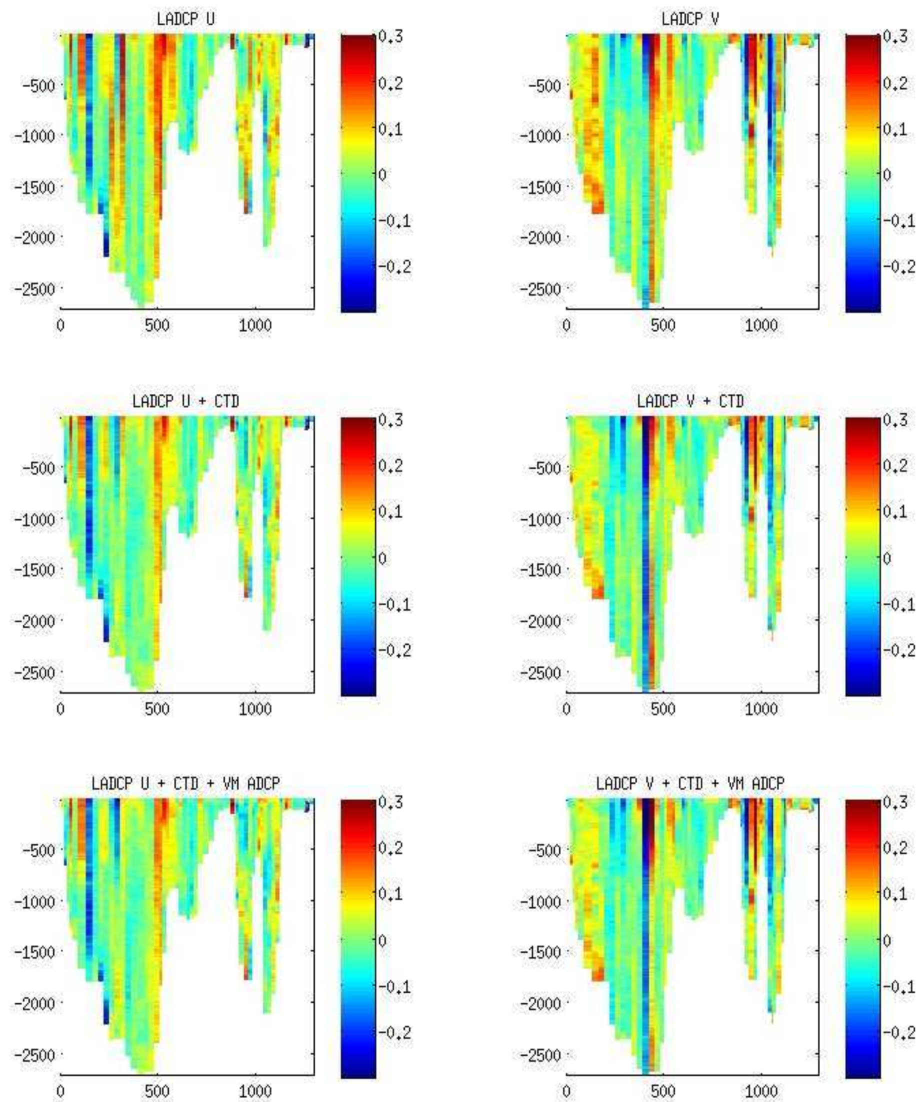


Figure 7.1: Lowered ADCP data with different stages of processing. Velocity shading is in units of m/s. The vertical axis is depth (m) and the horizontal axis is distance along the section starting in Iceland (km).

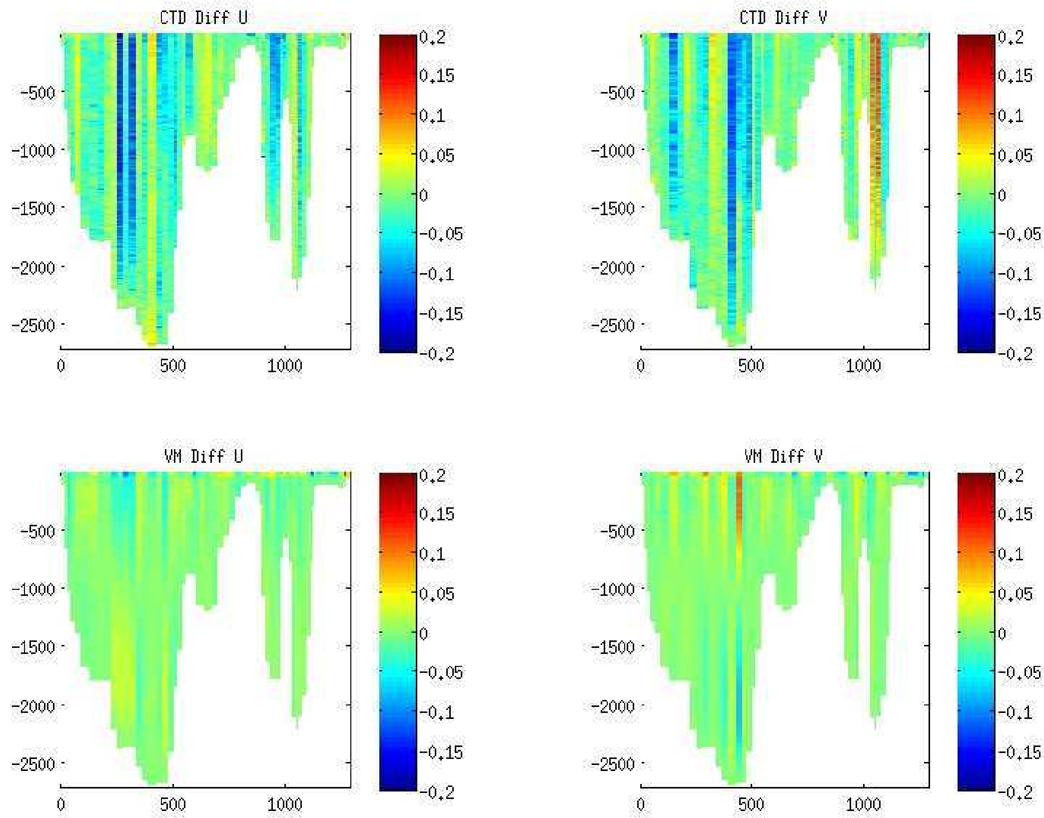


Figure 7.2: Effect of each stage of processing on LADCP. The top row is the differences between LADCP only and LADCP + CTD + GPS. The bottom row is the differences between LADCP + CTD + GPS and LADCP + CTD + GPS + VMADCP. Velocity shading is in units of m/s. The vertical axis is depth (m) and the horizontal axis is distance along the section starting in Iceland (km).

8) Underway data processing

Robert King

The underway observations include data-streams from navigation, echo sounding bathymetry, meteorological observations, and sea surface observations.

Much of the processing has followed the steps used during last year's Extended Ellett Line cruise (DY031) with some changes to account for changes in data-streams. Extracts of these notes are based on the previous Ellett line cruise DY031.

8.1) Daily processing

The daily processing for DY052 involved the following steps:

1) The techsas link script was run to create a directory of symbolic links to the netCDF files in the TechSAS stream.

~/mstar/dy052/data/exec/techsas_linkscript_dy052.sh

For the first two days (20160607-08) of DY052, an error in the server configuration meant that TechSAS netCDF files were spread across two folders. This script was hard-coded to copy the different dates from the appropriate network location. Also, for some early dates in the cruise duplicate files with time-stamps offset by 1-second were present. This may have been caused by data-streams being paused/restarted. The link script removes the unnecessary duplicates.

There was also an intermittent problem with some of the TechSAS netCDF files which required close inspection. Occasionally, the final (few) elements of the time variable would be set to zero (the fill value specified in the netCDF file) which would cause the underway and CTD processing to fall-over. A short script to identify the files was written and a work-around added to the linking script which removes the offending elements from all variables. See **techsas_linkscript_dy052_check_bad_data.sh** and **techsas_linkscript_dy052_bad_data.sh**. This was not automated further as the number of trailing zeroes varied and once was not the final value. It would be better in future to adapt MSTAR to deal with masked times in the netCDF files.

In total, for each date there were 18 unique files produced from the different streams:

CLAM-CLAM_DY1.CLAM
cnav-CNAV.GPS
EA600-EA640_DY1.EA600
gyro-GYRO1_DY1.gyr
gyro-SGYRO_DY1.gyr
Light-DY-SM_DY1.SURFMETv2
lgskippervdvbw-SkipLog.winch
MET-DY-SM_DY1.SURFMETv2
positon-Applanix_GPS_DY1.gps
position-Seapath330_DY1.gps
satelliteinfo-Applanix_GPS_DY1.gps
satelliteinfo-CNAV.gps
satelliteinfo-Seapath330_DY1.gps
SBE45-SBE45_DY1.TSG
shipattitude-Applanix_TSS_DY1.att
shipattitude_aux-Applanix_TSS_DY1.att
Surf-DY-SM_DY1.SURFMETv2

wamos-WaMoS.wamos

Note that the EM120 echo sounder was not logging in TechSAS.

2) To confirm that the linking script properly updated the available data-streams to process a full day, in MatLab run

```
>> mtlookd
# NumCycles StartDate StartJD StartTime EndJD EndTime EndDate DataStream
  1415366   16/06/05   157 09:00:01  to  174 02:09:38   16/06/22  CLAM-CLAM_DY1.CLAM
   138561   16/06/07   159 12:00:42  to  173 14:47:04   16/06/21  EA600-EA640_DY1.EA600
  1526145   16/06/05   157 09:00:01  to  174 02:09:40   16/06/22  Light-DY-SM_DY1.SURFMETv2
  1526145   16/06/05   157 09:00:01  to  174 02:09:40   16/06/22  MET-DY-SM_DY1.SURFMETv2
  1372783   16/06/05   157 09:00:01  to  174 02:09:40   16/06/22  SBE45-SBE45_DY1.TSG
  1526145   16/06/05   157 09:00:01  to  174 02:09:40   16/06/22  Surf-DY-SM_DY1.SURFMETv2
  1529700   16/06/05   157 09:00:01  to  174 02:09:39   16/06/22  cnav-CNAV.GPS
  1530481   16/06/05   157 09:00:00  to  174 02:09:40   16/06/22  gyro-GYRO1_DY1.gyr
  6969347   16/06/05   157 09:00:00  to  174 02:09:40   16/06/22  gyro-SGYRO_DY1.gyr
  3583650   16/06/05   157 09:00:00  to  174 02:09:41   16/06/22  logskippervdvbw-SkipLog.winch
  1444081   16/06/05   157 09:00:00  to  174 02:09:39   16/06/22  position-Applanix_GPS_DY1.gps
  1431040   16/06/05   157 09:00:00  to  174 02:09:39   16/06/22  position-Seapath330_DY1.gps
  1444081   16/06/05   157 09:00:00  to  174 02:09:39   16/06/22  satelliteinfo-Applanix_GPS_DY1.gps
  1529700   16/06/05   157 09:00:01  to  174 02:09:39   16/06/22  satelliteinfo-CNAV.gps
  1431040   16/06/05   157 09:00:00  to  174 02:09:40   16/06/22  satelliteinfo-Seapath330_DY1.gps
  1530479   16/06/05   157 09:00:00  to  174 02:09:38   16/06/22  shipattitude-Applanix_TSS_DY1.att
  1530481   16/06/05   157 09:00:00  to  174 02:09:39   16/06/22  shipattitude_aux-Applanix_TSS_DY1.att
     3303   16/06/08   160 15:48:01  to  174 02:03:59   16/06/22  wamos-WaMoS.wamos
```

3) To extract the appropriate 24 hours of data from each stream run **m_dy052_daily_processing(nnn)** where nnn is the Julian Day. This script calls the routine **mday_00_get_all** and **mday_00** for each data stream, skipping any streams not present for the current cruise. The output will be a series of daily files with the raw data from each stream (e.g., attposmv_dy052_d157_raw.nc) which will be stored in the following directories within /home/mstar/dy052/data/

/em120
/log_skip
/met/*
/nav/*
/sim
/tsg

The daily processing script does some further processing of specific streams:

mgyr_01 is used to remove any data cycles with non-monotonic times from the ship gyro data-stream (nav/gyros)

msim_01 is used to run a median clean and 5-minute averaging of the EA640 echo sounder data. The corresponding routine for the EM122 (mem120_01) was not run as the EM122 sounder was not logging during this cruise.

msim_plot is used to interactively remove spikes from the echo sounder derived depths. Additional files were saved to log which data were rejected. This script was edited to explicitly ignore EM122 for DY052. The script relies on a lower resolution bathymetry file being available in ~cruise/data/tracks/. This is used to provide a comparison for the echo sounder data.

mmet_01 is used to correct the units of wind speed stored in the netCDF header. Although the header originally reported the speed in knots, comparison against the on-boar live streams showed that the units were in fact m/s.

Finally, the script runs **mday_02_run_all** to append the daily file onto the cruise master file for each stream (e.g., nav/gyros/gyp_dy052_01.nc).

4) Once a TSG salt crate has been run through the AutoSal, calibration of the underway salinity can start.

Further details on individual streams is given below.

8.2) Navigation

As part of the routine daily processing six navigation streams were extracted from TechSAS (attposmv, cnav, gyropmv, gyros, posmvpos, seapos). Note that there is duplicated information among some of the streams. The posmvpos is the master position source. The master file pos_dy052_01.nc contains the full and final cruise archive. There was no editing of positional information, except for the removal of any non-monotonic times with the routine **mgyr_01**

Finally **mbest_all** was used to run a series of scripts to produce the master bestnav file (nav/posmvpos/bst_dy052_01.nc). This uses posmvpos for position, and merges on heading so that there is a complete file containing position, heading, course and speed made good, and distance run. The data are reduced to a 30-second time base and heading is properly vector averaged. This is the definitive cruise navigation file. In order to avoid the problem of housekeeping variables like distrun across daily files, the bestnav processing is rerun from the start of the cruise each time it is required. There is therefore only ever one bst_dy052_01.nc file.

8.3) Bathymetry

On DY052 the EA640 echo sounder was activated when not towing the hydrophone. The EM120 sounder observations were not recorded in TechSAS. Since the echo sounder was only in operation when not towing the hydrophone, most of the data will correspond to time spent stationary at CTD stations.

As part of the daily processing (m_dy052_daily_processing), the bathymetry data from EA640 was cleaned of gross errors. Only spikes widely discrepant with the lower resolution bathymetry from **cruise/data/tracks/n_atlantic.mat** were removed. Some ~50m spikes were left in place. The constant magnitude of the spikes suggests that these could be caused by interference from other instruments.

8.4) Surface atmosphere and ocean observations

The ‘met’ streams are divided into three TechSAS streams: met/surfmet, met/surflight, and met/surftsg. The SeaBird SBE45 thermosalinograph data (in surftsg) is also logged in separate data stream (in the directory cruise/data/tsg or mexec abbreviation M_TSG).

SurfMet

Ship speed, position and heading from the bst navigation file were merged onto the wind data in the surfmet stream.

The absolute wind speed is calculated and vector averaged with **mtruew_01.m**. As with bestnav processing, this is rerun for the entire cruise each time the data are updated. The output files from this processing are

data/met/surfmet/met_dy052_true.nc
data/met/surfmet/met_dy052_trueav.nc

The latter file is reduced to 1-minute averages, with correct vector averaging when required. In order to avoid ambiguity, variable units are explicit in whether wind directions are ‘towards’ or ‘from’ the direction in question.

As stated earlier, **mmet_01** is used to correct the units of wind speed stored in the netCDF header. Although the header originally reported the speed in knots, comparison against the on-board live streams showed that the units were in fact m/s.

SurfLight

PA irradiance and thermal-IR data are found in the surflight stream, which also contains surface pressure. These streams were ingested and stored, but no further processing was undertaken.

SurfTSG

The daily processing creates two sets of raw files and two concatenated cruise master files related to the underway thermosalinograph (TSG) stream:

data/met/surftsg/met_tsg_dy052_d???.nc
extracted from TechSAS data stream Surf-DYS-SM_DY1.SURFMETv2
including variables time, temp_h, temp_m, cond, fluo, trans

data/tsg/tsg_dy052_d???.nc
extracted from TechSAS data stream SBE45-SBE45_DY1.TSG
including variables time, temp_h, temp_r, cond, sndspeed, salin

It was found that the surftsg steam was not logging the temperatures (temp_h and temp_m) or conductivity (cond). The temperatures were logged as constant values while the conductivity variable contained data which did not correlate with the expected values. The cruise SST, Jack McNeil, explained that this was a known fault with the current set-up of the surftsg stream.

Although the temperature and conductivity were not logged in the surfmet stream, it does contain valid observations of the fluorescence and transmissance.

Thermosalinograph (TSG, SurfTSG)

The TSG stream, however, contains the logged temperatures, conductivity, and derived salinity. The salinity values were recalculated from the housing temperature and conductivity (using **mtsg_make_sal.m**) to confirm that the salinity values stored in the files was reliable and the conductivity units (S/m) as reported in the netCDF attributes.

We therefore use the TSG stream in the thermosalinograph calibration (unlike last year's cruise DY031 where the SurfTSG stream was used). Calibration used the followed steps:

1) Edit **mtsg_cleanup.m** to hardcode the times when the pumps were switched off, such as the stat and end of the cruise, and any periods of the maintenance. This routine will be run later as part of **mtsg_medav_clean_sal.m**.

2) Run **mcd('M_TSG')** to move to the TSG directory within MatLab.

3) Run **mtsg_findbad_dy052.m** to interactively remove spikes and bad data from the temp_h, cond and salin variables. The commands to select periods to be marked as bad are explained on running the routine. Note the use of 'n' to store the start and end of the bad data and move on to the next segment. The output file with bad times is appended every time this routine is run, so can be done throughout the cruise.

Input: data/tsg/tsg_dy052_01.nc

Output: data/tsg/bad_time_limits.mat

During the spike removal for DY052, a regular feature was noticed (see Figure 8.1): approximately every 12 hours, the housing temperature (temp_h) logged by the SBE45 would sharply increase by ~1.5K (over 1 minute) and decrease back to the background level over a period of ~10 minutes. On several occasions this was followed by a smaller magnitude signal (around 15 minutes later) with the same features. Although this feature was not observed in the remote temperature (temp_r), it was present in the conductivity and salinity. These data were therefore excluded from the final data-set using mtsg_findbad.

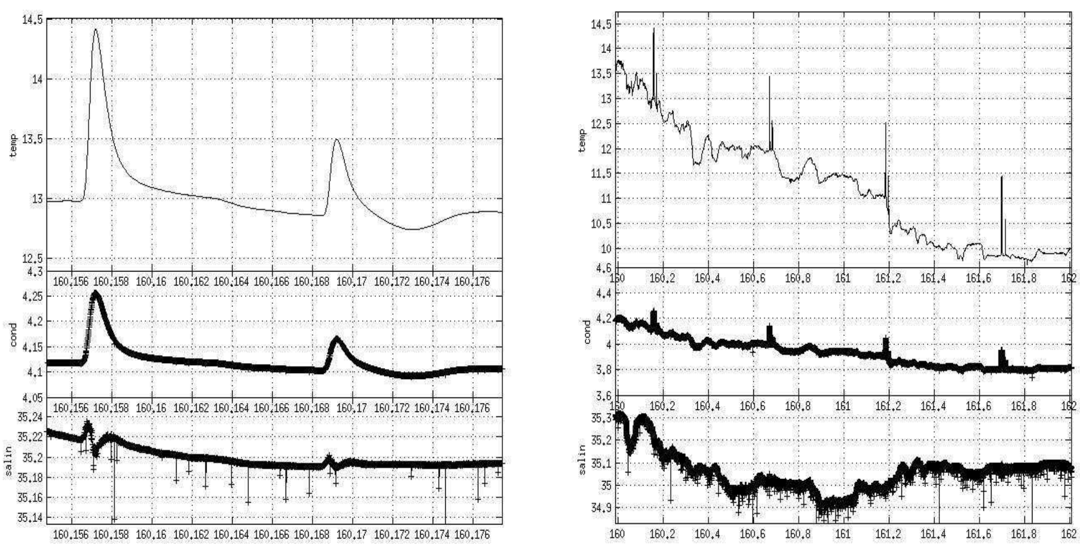


Figure 8.1: The remote temperature (top), conductivity (middle) and salinity reported by the TechSAS TSG stream. The left-hand plot shows a single occurrence of the possible discharge-related feature, while the right-hand plot shows the same feature reappearing on a ~12 hourly cycle. These data shown are prior to any spike removal or median averaging.

4) Run **mtsg_medav_clean_cal_dy052.m** to create 1-minute median-binned data and remove known bad data identified in the previous step (the times stored in bad_time_limits.mat).

Input: data/tsg/tsg_dy052_01.nc

Output: data/tsg/tsg_dy052_01_medav_clean.nc

5) Check for updates to the TSG salinity bottle samples, in data/ctd/BOTTLE_SAL/. When new crates have been processed run **cruise/data/exec/modsal_unix_dy052** (in a terminal) to convert the csv file from a Mac format to a unix compatible format (this just adds end-line characters), unless the csv file was created on linux. You may first need to create the CSV file from the AutoSal-produced spreadsheet using Excel or LibreCalc.

Also, to this file, add a sample number for each underway salinity sample using the format DDDHHMMSS (recorded in the underway logsheets) for TSG samples, and sample number 99#### for standards, where #### is the bottle number.
    Input: data/ctd/BOTTLE_SAL/tsg_dy052_nnn.csv
    Output: data/ctd/BOTTLE_SAL/tsg_dy052_nnn.csv_linux

6) Run **mtsg_01_dy052.m** to convert TSG salinity bottle samples from ASCII to netCDF. First the routine had to be updated with a cruise specific bath temperature. For DY052, the same settings were used as had been agreed for the CTD salt sample processing. This step can be run as each TSG crate has been processed.
    Input: data/ctd/BOTTLE_SAL/tsg_dy052_nnn.csv_linux
    Output: data/ctd/tsg_dy052_nnn.nc
    Output: data/ctd/tsg_dy052_all.nc

7) Run **mtsg_bottle_compare_dy052.m** to merge the clean 1-minute data onto bottle samples. This should first be run with the switch at the top of the script set to uncalibrated. Individual bottle residuals are plotted, as well as a smoothed time series of the residuals, (see Figure 8.2) which can then be used as a slowly-varying adjustment to the TSG salinity in the next step.

Input: data/ctd/tsg_dy052_01_medav_clean_cal.nc
Output: data/tsg/tsg_dy052_01_medav_clean_cal_botcompare.nc

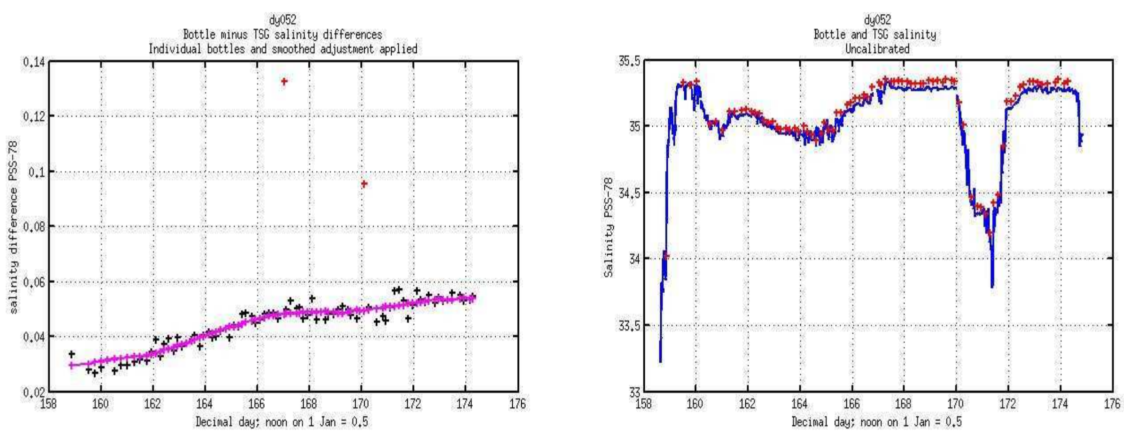


Figure 8.2: Left: Salinity difference (PSS-78) between underway bottle measurements and the SBE45 salinity measurement at each sample time (black crosses) and a smoothed fit (magenta line). The red crosses show data-points rejected from the smoothed fit. Right: Uncalibrated salinity from the SBE45 (blue line) along with the individual bottle samples (red crosses).

8) Run **mtsg_apply_salcal_dy052.m** to smooth the differences in botcompare, interpolates and adds them to the uncalibrated salinity data. You can run mtsg_bottle_compare_dy052.m after this to check the residuals are acceptable.

calls **mtsg_salcal_dy052.m**
    Input: data/met/surftsg/met_tsg_dy052_01_medav_clean.nc
    Input: data/met/surftsg/met_tsg_dy052_01_medav_clean_botcompare.nc
    Output: data/met/surftsg/met_tsg_dy052_medav_clean_cal.nc

9) Rerun **mtsg_bottle_compare_dy052.m** to merge the clean 1-minute data onto bottle samples. This should now be run with the switch at the top of the script set to

calibrated. Individual bottle residuals are plotted, as well as a smoothed time series of the residuals, (see Figure 8.3) which can then be used as a slowly-varying adjustment to the TSG salinity in the next step.

Input: data/ctd/tsg_dy052_all.nc
Input: data/tsg/tsg_dy052_01_medav_clean.nc
Output: data/tsg/tsg_dy052_01_medav_clean_botcompare.nc

10) Run **met_tsg_av_addnav_dy052.m** to merge with navigation data (lat and long) on variable time. Run **mbest_all.m** prior to this to update the best navigation file bst_dy052_01.nc.

Input: data/tsg/tsg_dy052_01_medav_clean_cal.nc
Input: data/nav/posmvpos/bst_dy052_01.nc
Output: data/tsg/tsg_dy052_medav_clean_cal_nav.nc (final file)

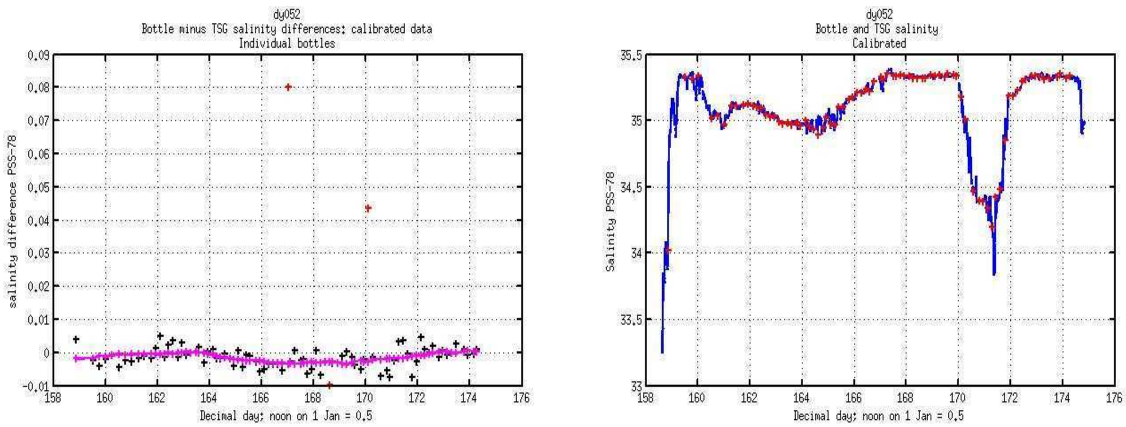


Figure 8.3: Left: Salinity difference (PSS-78) between underway bottle measurements and the calibrated SBE45 salinity measurement at each sample time (black crosses) and smoothed fit (magenta line). The red crosses show data-points rejected from the smoothed fit. Right: Calibrated salinity from the SBE45 (blue line) along with the individual bottle samples (red crosses).

9) Salinity samples and analysis

Estelle Dumont, Jon Short, Colin Hutton, and Stefan Gary

9.1) Bottle sampling

The 24 Niskin bottles on the CTD rosette were sampled for laboratory determination of conductivity in order to calibrate the CTD conductivity sensors. Salinity samples were drawn from each unique depth. When 2 bottles were fired at the same depth only one bottle was sampled. Salt bottle samples were collected after oxygen and carbon into glass bottles with plastic inserts and caps. Some bottles on the Scottish Shelf east of Barra were not sampled due to the strong salinity signals on the shelf and to reduce Autosal operator workload when arriving in port. For each sample, the bottle and cap was rinsed three times and then filled with sample. The neck, threads, and cap were carefully dried, to prevent salt crystals from forming around the opening, and the insert and cap were put on the bottle for storage. Filled salt bottles were placed in the Autosal lab and allowed a minimum of 24 hours to reach the ambient lab temperature before analysis on the Autosal. The salinity samplers were Liz Comer, Martin Foley, Dave Hughes, Rob King, Emma Slater, and Jon Tinker.

9.2) Autosal analysis

These samples were subsequently analysed on two Guildline Autosal salinometers (serial number 71185 and 71126) using NMF software in Labview for the automated reading of the digital output of the Autosal. The Autosals were standardized during mobilization and no adjustments to the resistance knob were made thereafter. Handwritten paper logs were kept of the Autosal readings as a backup but were not needed during the cruise. The Autosal water bath was maintained at 24˚C. The room temperature fluctuated slightly (between 20 and 22˚C) during the first two days of analysis, until the engineers fixed the temperature-control unit, leaving a more stable room temperature of approximately 20.5˚C for the remainder of the cruise. The first Autosal (S/N 71185) failed on the 29th June, and the last few crates were analysed on Autosal S/N 71126. The Autosal operators for DY052 were Jon Short, Colin Hutton and Estelle Dumont.

Over the course of the cruise, 41 crates of 24 bottles and 82 OSIL standard seawater bottles (SSW) were processed for the CTD discrete salinity sampling. An additional 4 crates of salt samples taken from the underway system were also analysed. On the first day seawater standards from batch P158 (K_{15} = 0.99970, 34.988 PSU) were used, then P159 (K_{15} = 0.99988, 34.995 PSU) for the rest of the cruise. A standard was run at the start and end of each crate to check for any drift of the salinometer. When several crates were run in sequence, only one new bottle of standard run between each crate. For the first two days, the same standard bottle was analysed at the start and end of each crates. However after some discussion this practice was discontinued and new standards were always used.

The Autosal standard seawater measurements appear to have been more variable in the first two days of operation than the rest of the cruise. After this, the nearly constant temperature in the Autosal laboratory resulted in good instrument stability. An offset for each cast was determined from the standard seawater reading offsets (Figures 9.1 and 9.2).

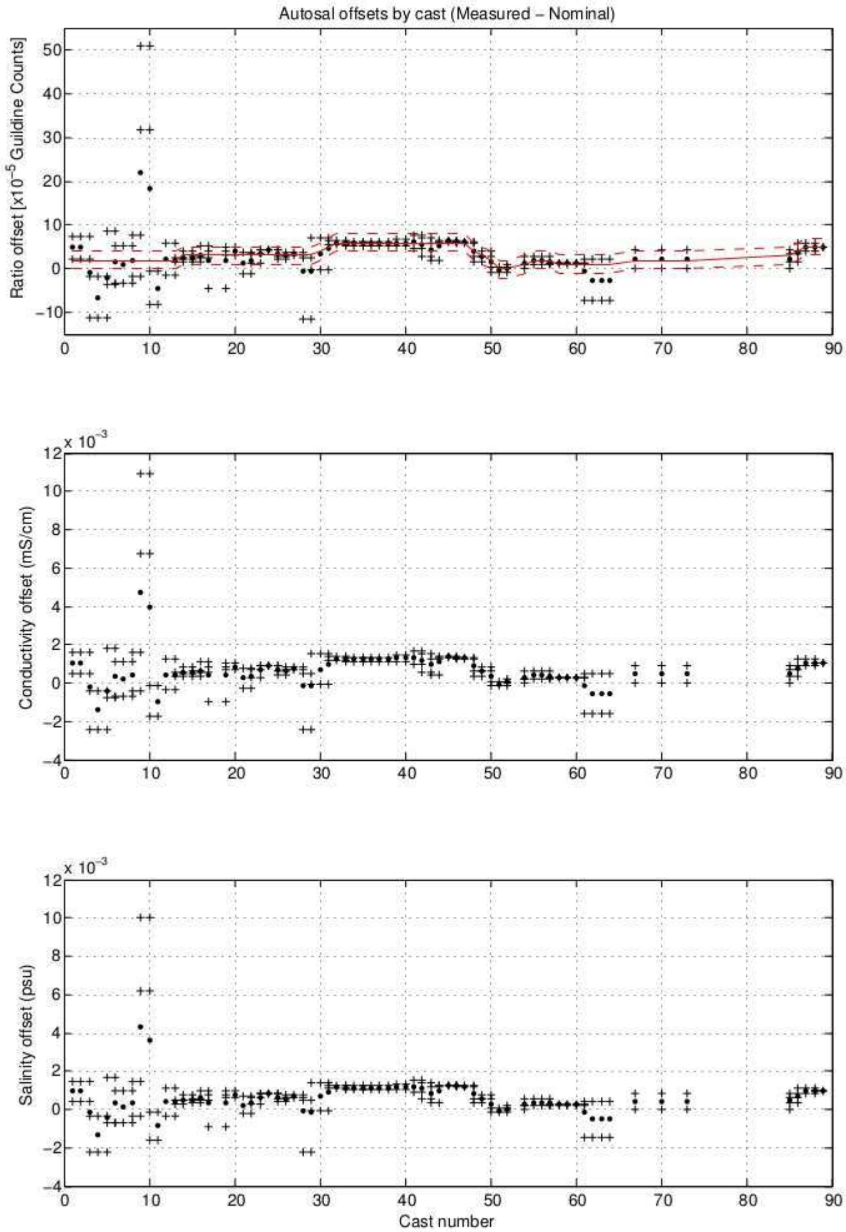


Figure 9.1: Autosal standards offset readings for each cast. Black + symbols are the measured – nominal values for each SSW observation in Guildline counts (Autosal display units, double the conductivity ratio) and the corresponding conductivity and salinity differences. Black dots indicate the average of the SSW measurements associated with each cast, an average of up to 4 measurements if a cast was split between two crates. The red line in the top panel is the offset adjustment applied to each cast when the salinity bottle data were read into MSTAR (see Table 9.1 and Section 9.3, below). The red dashed lines are plus or minus 0.00003 Guildline counts relative to the solid red line, a rough approximation to the uncertainty in the average of the SSW observations contributing to each data point. The standard deviation limit for the three Autosal readings that are averaged to create each bottle observation is 0.00002 (Chapter 4) and the RMS combination of the two such uncertainties results in 0.000028 Guildline counts.

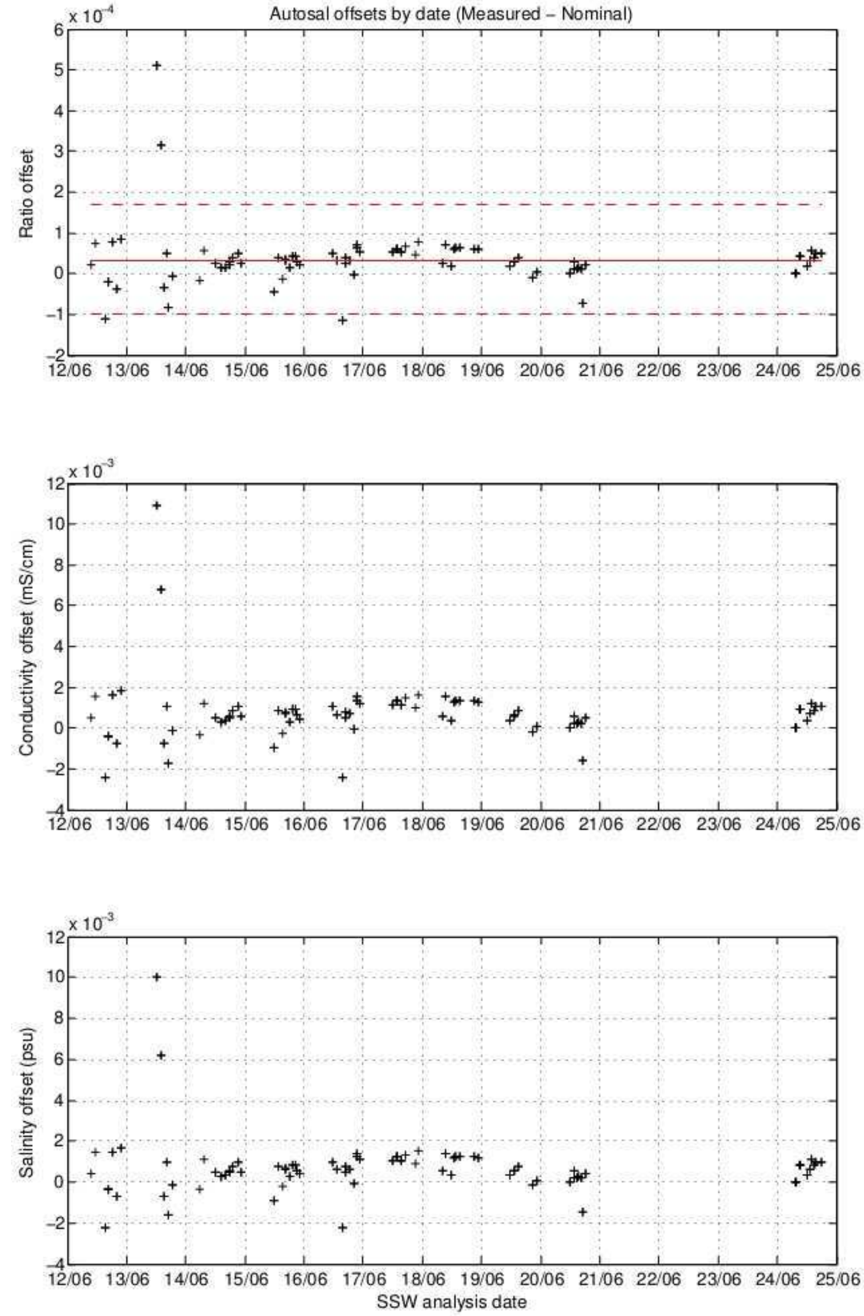


Figure 9.2: Similar to Figure 9.1 except the autosal standards are plotted by date of analysis rather than CTD cast number. The red line in the top panel is the mean conductivity ratio offset over the whole cruise and the dashed lines are plus or minus two standard deviations relative to the mean.

9.3) MSTAR processing

All the analysed bottle salinities were read into MSTAR via the **msal_01**, **msal_02**, **msam_updateall** pipeline. The first step in this process requires applying an adjustment to each bottle salinity based on the Autosal offsets determined from the observations of standard seawater. The purpose of this adjustment is to account for any long-term drift or temporal offset in the laboratory salinometer while also taking into account any errors in the standards. As such, offsets were applied to groups of casts and occasionally to single casts with no more than 0.00002 Guildline counts steps for each change (Table 9.1, next page). Offsets were informed by the average offset for each cast (black dots in Figure 9.1) but the final decision was made by examining the offsets by eye. All values were rounded to the nearest 10^{-5} Guildline count.

The exceptionally high standard run on a crate containing bottles form casts 9 and 10 was ignored. Note that two dots appear for this standard in Figure 9.2 because this was one of the standards run in the first two days, so the same standard seawater bottle was analysed twice. The four cases of exceptionally low standards run for casts 3-5, 10-11, 28-29, and 60-70 are most likely do to incomplete flushing of de-ionized water from the Autosal conductivity cell as all of these standards were run after a relatively long pause in analysis when the Autosal was stored with de-ionized water in the conductivity cell.

Once the adjustment was applied to each observation, the CISRO Seawater Toolbox, version 3.2, was used to compute the corresponding conductivity with **sw_sals**. Since the Autosal laboratory was maintained at nearly constant temperature and the Autosal lights were blinking continuously, the bath temperature of the Autosal was taken to be constant at 24 °C.

Table 9.1: Conductivity ratio offsets that were applied to all laboratory CTD bottle conductivity ratio observations on a cast-by-cast basis. Note that in Figures 9.1 and 9.2 the Autosal display is in general a bit higher than the nominal reading, so the adjustment is negative to bring the value back down towards the nominal value of the standard.

Start CTD	End CTD	Offset [Guildline counts = 2 x Cond. Ratio x10^{-5}]
1	13	-2
14	29	-3
30	30	-4
31	31	-5
32	47	-6
48	48	-4
49	49	-3
50	50	-2
51	52	0
54	54	-1
55	57	-2
58	64	-1
67	74	-2
85	85	-3
86	86	-4
87	89	-5

10) Dissolved inorganic nutrients

Tim Brand

10.1) Introduction

The basic water column dissolved nutrients, phosphate, silicate (reactive silica) and total oxidized nitrogen, TON, (nitrate+nitrite) were analyzed from 72 (out of a possible 73) CTD casts along the Extended Ellett line and 5 stations along a N-S transect approaching the Anton Dohrn seamount. Samples were drawn at every unique depth at which the Niskin bottles were closed.

10.2) Method

Samples were collected in 50ml acid pre-cleaned polythene vials directly from the CTD spigots without the use of a tube and using a single half-full rinse prior to collection. Samples were always analyzed within 24 hours of collection and stored in low light conditions at room temperature prior to analysis if analysis time exceeded 8 hours after collection time. Measurement was conducted using a Lachat *QuikChem 8500* flow injection autoanalyser (Hach Lange) using the manufacturers recommended methods: Orthophosphate, 31-115-01-1-G; Silicate, 31-114-27-1-A and Nitrate/Nitrite, 31-107-04-1-A. After analysis, the 50ml tubes were double rinsed with the ship's DI water and reused for subsequent CTD sample collection.

Samples were measured in triplicate to identify instrument precision. Individual stock standard solutions of nitrate, phosphate and silicate were prepared in deionised water immediately prior to the cruise from oven dried (60C) salts. A primary mixed working standard solution was prepared each day from the stock solutions using the ship's DI water and the calibration standard solutions were prepared by the instruments autodiluter facility using OSIL Low Nutrient Sea Water for dilution, (OSIL, http://www.osil.co.uk, Batch LNS 23 24, Salinity 35). Seven calibration standards and blank seawater were run at the start of each batch of samples (between 21 and 42 samples) followed by a drift standard run in triplicate at the end of the batch. Calibration drift determined was accounted for in the calculation of the sample result (arithmetic methodology assumes linear calibration drift correction from start to finish of sample batch).

A standard reference solution prepared from nutrient standard solutions supplied by OSIL containing 1 μMPO_4, 10 μMSiO_2 and 10 μMNO_3 was run at the start, during and end of the entire analysis to check accuracy of the dried salt derived standards.

10.3) Data quality assessment

Analytical precision was gathered by running each sample in triplicate and regularly yielded relative standard deviations (S.D.) of better than 2% for phosphate and nitrate and better than 5% for silicate. The method detection limit (MDL) of each nutrient was calculated as 3 x S.D. of 7 replicates of the blank low nutrient sea water. This yielded MDL's of PO4, 0.02uM, SiO2, 0.48uM, and NO3+NO2, 0.03uM. Accuracy, determined by analysing the independent OSIL reference standard solutions at the beginning and end of the cruise showed a 103.3+/- 1.8% recovery for phosphate, 97.9 +/- 3.3% recovery for silicate and a 101.7 +/- 1.1% recovery for nitrate+nitrite. Recovery percentages have not been factored into the final results.

11) Determination of dissolved oxygen concentrations by Winkler titration.

Richard Abell, James Coogan, Winnie Courtene-Jones and Ashlie McIvor.

11.1) Introduction

Dissolved oxygen concentrations were measured in 1111 seawater samples collected during DY052. Sampling and analysis were performed 24hrs a day from every CTD cast using Winkler photometric auto-titration. Methodologies followed those documented in GO-SHIP protocols (Langdon, 2010) and based on the standard methodologies of Carpenter 1965 adapted for large scale hydrographic studies (e.g. Culberson, 1991 and Dickson, 1995).

Prior to analytical session the titration was standardised using an OSIL 0.01N iodate standard. Precision of the analysis was estimated using duplicate measurements of samples collected from same the Niskin bottle (11% of samples collected, 1σ = 0.17%). 4% of the data was rejected either due to poor analysis or sampling issues.

11.2) Method

Seawater samples were drawn from Niskin bottles via a short length of silicon tubing without allowing air bubbles to enter the individually calibrated sampling bottles. Excess seawater (at least three times the bottle volume) was flushed through the sample bottle to both clean it and remove any air bubbles. Samples were fixed immediately upon addition of 1ml of 3M $MnCl_2$ and 1ml of 8M NaOH + 4M NaI. The temperature of the sample during fixing was recorded using a digital thermometer (±0.1°C) in a separate sample bottle. Reagents were dispensed below the surface of the sample so as not to introduce air bubbles and ensure all reacting species were contained within the sample. Ground glass lid stoppers were added tightly, again ensuring no air bubbles were trapped within the sample. Samples were shaken vigorously and transferred to a dark cool storage space in the lab. After half an hour samples were re-shaken and allowed to settle and equilibrate with lab temperature for at least 1 hour.

Before every analytical session the titrant (0.1M $Na_2S_2O_3$) was standardised using a commercially purchased OSIL 0.001667M KIO_3 standard. During the course of the analytical sessions the drift in titre concentration was small (~ 0.0002M). Reagent blanks were also measured during standardisation following the methodologies of Carpenter (1965) and subtracted during the titration calculation.

Prior to analysis 1 ml of 5M H_2SO_4 was added to samples followed by a Teflon coated magnetic stirrer. End points reached by the auto burette were recorded.

11.3) Summary of results

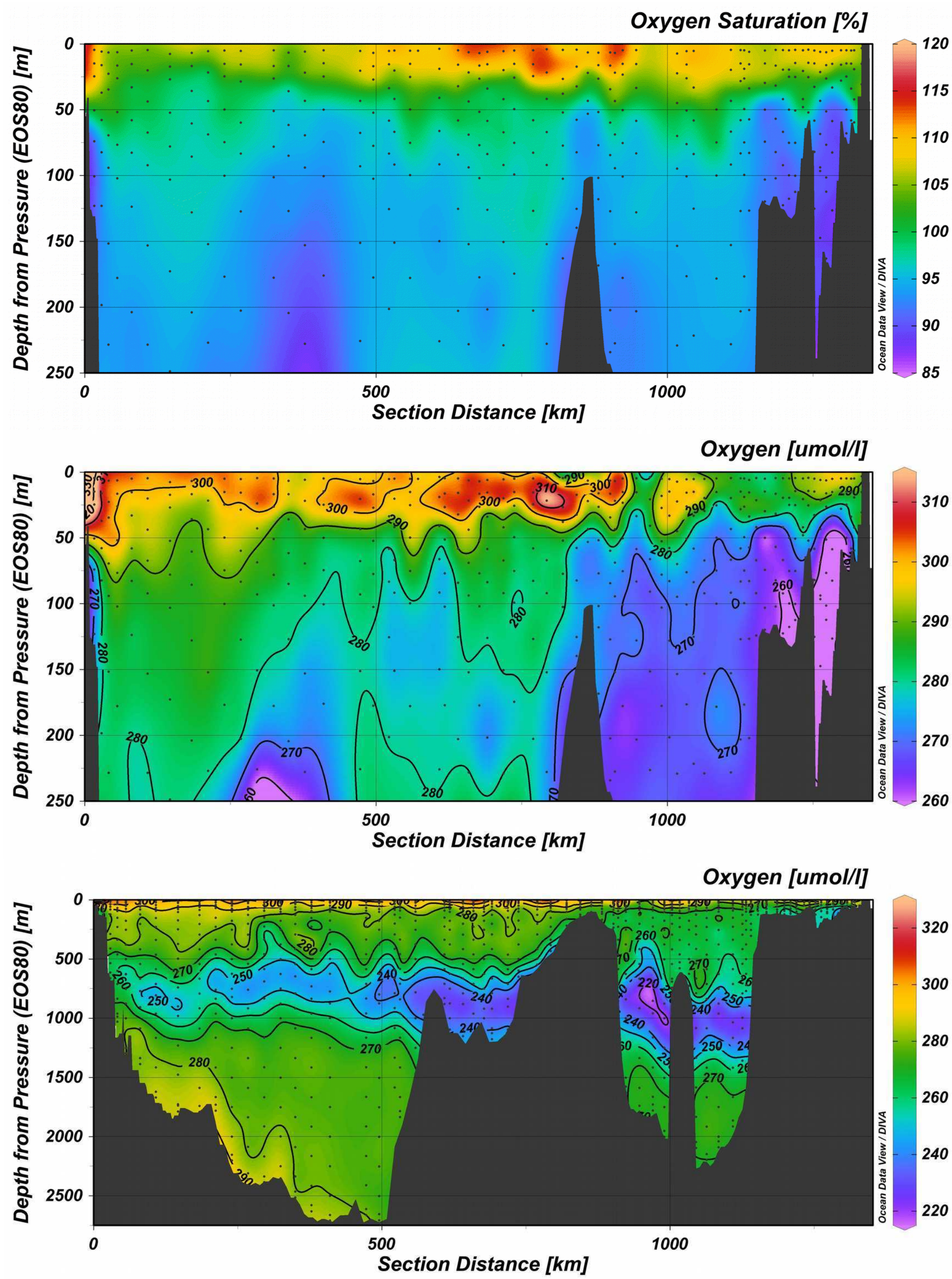


Figure 11.1: Dissolved Oxygen profiles measured during DY052 from Iceland (left) to Scotland (right) (Ocean Data View, R. Schlitzer, 2011). The top panel shows saturation highlighting the plankton blooms encountered, particularly strong above the Rockall Hatton Plateau. Middle panel shows oxygen concentration in the upper 250m and lower panel the full depth profile.

References

Carpenter, J.H. 1965. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. *Limnol.and Oceanogr.* 10:141-143.

Culbertson, C.H. 1991. Dissolved Oxgen. WHPO Publication 91-1.

Dickson, A.D. 1995. Determination of dissolved oxygen in sea water by Winkler titration. WOCE Operations Manual, Part 3.1.3 Operations & Methods, WHP Office Report WHPO 91 – 1.

Langdon. C. 2010. Determination of dissolved oxygen in seawater by Winkler titration using the amperometric technique. The GO-SHIP Repeat hydrography manual: A collection of expert reports and guidelines. IOCCP report No.14.

12) Carbon samples

Stacey Felgate

Water samples were collected from 8 initial EEL stations (IB22, 1B16A, 1B9, 1B4, F, O, R & 10G) and an additional 1 station in the Anton Dohrn deep (X3). At each of these stations, 6 samples were collected from depths representative of water mass features:

1. Bottom
2. Bottom – 50 m
3. Mid-way between bottom and OMZ
4. OMZ
5. Mid-way between OMZ and surface
6. 2nd from surface

Additional samples were taken at high priority stations (IB22, 1B16A, F, O & X3) in order to obtain a higher resolution, with 3-4 extra samples taken to provide a profile spaced as evenly as possible within the top 1200 m. Accepted bubble-free water sampling techniques were used in all cases. Samples were collected into 250 ml glass stoppered bottles. Once collected, samples were poisoned by removing 2.5 ml water and adding 0.050 ml Mercuric Chloride solution (7 g/100 ml). Bottles were sealed using PVC tape, and stored in a chilled room at 9 °C. Analysis will be conducted at the Scottish Association for Marine Science under the supervision of Dr Kirsty Crocket.

The carbon samples were taken to coincide with the trace metal samples (Chapter 13) and so the sampling scheme for the carbon samples is identical to that of Table 13.1.

It is of possible note that the paper used to stop the glass stoppered bottles from sealing pre-sampling in some cases became attached inside the bottle neck and was problematic to remove, potentially leading to some contamination of the samples. In particular, this affected the later sampling stations.

13) Trace Metal and Nd isotope sampling

Emily Hill

A total of 82 samples for rare earth element (REE) analysis and 7 samples for Nd analysis were collected along the EEL transect from 9 stations: IB22S, IB16, IB9, IB4, F, O, R, 10G and X3. The deepest sample from each station was sampled twice from a duplicate niskin bottle for reproducibility purposes. Stations and niskin bottles sampled for REEs and Nd isotopes are shown in Tables 1 and 2 respectively.

Table 13.1: CTD no and station names for REE samples

CTD no.	EEL station	niskins sampled
003	IB22S	1 2 3 4 5 6 7 8 10 12
010	IB16	1 2 5 7 8 9 13 14 17 18
022	IB9	1 2 3 5 8 11 18
030	IB4	1 2 3 4 5 9 16
042	F	1 2 3 4 6 8 10 11 13 15 18
052	O	4 5 6 7 8 10 12 14 15 17 21
056	R	1 2 3 4 5 6 8
064	10G	1 2 3 4 5 6 8
087	X3	1 2 3 4 7 9 12 13 15 17 18

Table 13.2: CTD no and station names for Nd samples

CTD no.	EEL station	niskins sampled
49	L	22
50	M	18
51	N	5 8 11
52	O	2 3

REE samples: 250ml bottles were used to collect seawater from the appropriate niskin. Once sampling was completed, seawater was filtered in a clean lab through 47µm polycarbonate filters and poured into 50ml spin tubes. The seawater was then acidified on board with 2ml/L of concentrated UpA hydrochloric acid. The samples were then placed into the fridge until disembarkation and will be analysed for REE composition at SAMS.

Nd samples: Seawater was filtered directly from the niskin using an AcroPak filter and 10L were collected in a cubitainer. Samples were then acidified with 20ml of 6M hydrochloric acid and placed into the fridge until disembarkation. Neodymium isotopic analysis will be carried out at the National Oceanographic Centre in Southampton.

14) Direct density samples

Emma Slater

Density samples were taken where bottles were also sampled for salinity, nutrients and carbon data. Aluminium bottles were used to sample the density. Replicate samples were taken from the deepest bottle to check measurement precision.

The sampling method consisted of:

1) Sample immediately after salinity.
2) Rinse bottle three times.
3) Fill to neck (allowing gap for thermal expansion of cold water) and cap bottle tightly by screw cap.
4) Soak in freshwater for a few seconds to wash away seawater on the bottle and cap.
5) Put bottle in the box upside down.
6) Store the box at room temperature.

The following CTD stations were sampled:

Cast	**Site**	**Niskin number**
CTD001	Shakedown	1 (duplicated)
CTD003	IB22S	1 (duplicated), 3, 4, 5, 6, 7, 8, 10, 12
CTD010	IB16A	1, 5, 7, 8, 9, 13, 14, 17, 18
CTD022	IB9	1 (duplicated), 3, 5, 8, 11, 18
CTD030	IB4	1 (duplicated), 3, 4, 5, 9, 16
CTD042	F	1 (duplicated), 3, 4, 6, 8, 10, 11, 13, 15, 18
CTD052	O	5 (duplicated), 6, 7, 9, 10, 12, 14, 15, 17, 21
CTD056	R	1 (duplicated), 3, 4, 5, 6, 7
CTD064	10G	1 (duplicated), 3, 4, 5, 6, 8
CTD087	X3	1 (duplicated), 3, 4, 7, 9, 12, 13, 15, 17, 18

A duplicate sample at the deepest depth on cast CTD010 was not taken in mistake. These bottles will then be sent to Hiroshi Uchida at JAMSTEC for direct analysis of density.

15) Epibenthic sled deployments

Dave Hughes

15.1) Introduction

SAMS biological sampling in the Rockall Trough dates from 1973. As David Ellett established his hydrographic survey line the late John Gage decided to use one of the Ellett stations – 'M' – as a regular benthic sampling station, located near the foot of Anton Dohrn seamount at 2,200 m depth. Over the period from 1973-1994 regular samples were obtained from Station M with the Woods Hole Oceanographic Institution (WHOI) pattern epibenthic sled. The historical samples span a time frame of >20 years, during which there have been noticeable changes in the surface phytoplankton productivity. Since the end of John Gage's sampling programme in 1994 the issue of climate change and its impacts has become one of the most important research themes in biological oceanography and long-term time series measurements have correspondingly grown in importance. Very few deep-sea benthic time series exist, and none extend back as far as the SAMS historical samples from Station'M'. The deep-sea benthic group at SAMS, now led by Dr Bhavani Narayanaswamy, therefore decided to carry out a community-level analysis of macrofaunal composition of the historical samples, and to initiate a renewed sampling programme at Station 'M' using the same gear and methods as originally used by Gage. The WHOI epibenthic sleds were refurbished at SAMS, Oban in late 2012 and deployed on the 2013 and 2015 EEL cruises (see *James Cook* 086 and *Discovery* 031 cruise reports). Possible changes in the macrobenthic community at Station 'M' are currently being investigated with analysis of the 2013 and 2015 samples to provide a >40 year time span record for this gear and position. Cruise DY052 has enabled a further set of sled tows to be carried out, extending the benthic time series to 2016.

15.2) Methods

Two of the original WHOI-pattern sleds, used by John Gage, were rigged as in 2013 and 2015 with identical net meshes of 0.5 mm for both main and extension nets (Figure 15.1). The sleds are fished with the door open and fishing stops when the door is closed by a timer mechanism. The door closure at the end of the tow prevents both over-washing of the trapped sample and incorporation of planktonic fauna during the recovery. As far as possible, deployment procedures followed the method used for the historical samples. Sled deployment, towing and recovery protocols are described in detail in the cruise report for *Discovery* 031.

Figure 15.1: Epibenthic sled

After washing on stacked 4 mm, 0.5 mm and 0.42 mm sieves (Figure 15.2) the retained material is placed in suitable sample buckets with 4% buffered formaldehyde in filtered seawater. The largest volume of material is retained on the 0.5 mm sieve and constituted between 3 and 6 litres of washed material per sled (Figure 15.3). This large volume is impractical to be processed as a unit so sub-sampling is carried out. This is achieved in the laboratory in an agitated water column which allows the fauna to settle out at random between eight segments in a collecting chamber. The same sub-sampler has been in use since 1974. Historically, final screening was carried out on a 0.42 mm and a 0.425 mm sieve (Figure 15.4) so the original sieves were employed for comparison with historical data.

Figure 15.2: Stacked sieves

Figure 15.3: Sample collected on 0.5 mm sieve.

Figure 15.4: Sample collected on 0.42 mm sieve.

15.3) Initial results

Four successful sled tows were carried out. In all cases the sled door-closing mechanism worked perfectly, retaining the benthic sample as intended. The only minor technical mishap was the detachment of one of the pair of towing bridles on the first sled tow, caused by an insufficiently-secured shackle. However, the sled was held firm by the second bridle and was recovered on board without difficulty.

On the first tow the collected sediment filled the extension net but did not extend into the main net contained within the sled frame. The following three tows were longer in duration and collected larger volumes of sediment, filling the extension net and up to approximately one-third of the main net. This represents approximately 200 litres of sediment per tow, requiring about six hours for sieving on deck, sample fixation and labelling.

The table below gives the ship's positions at the start and end of each sled tow. The starting position was recorded at the time at which the sled was considered to have reached the seabed (from length of wire paid out). The end coordinates were taken at the time of sled door closure, immediately before the beginning of haul-in.

Sled tow	**SAMS sample number**	**Position at start of tow**	**Position at end of tow**	**Tow duration (bottom time)**
1	ES_1693	57^0 20.018' N $10^0$22.082' W	57^0 20.791' N $10^0$21.603' W	49 mins
2	ES_1694	57^0 18.987' N $10^0$23.234' W	57^0 19.908' N $10^0$22.613' W	1 hr 30 mins
3	ES_1695	57^0 18.582' N $10^0$22.809' W	57^0 19.787' N $10^0$21.051' W	1 hr 33 mins
4	ES_1696	57^0 17.386' N $10^0$22.842' W	57^0 16.133' N $10^0$22.014' W	1 hr 20 mins

The epibenthic sled is not designed to collect larger benthic animals (megafauna), although some specimens are fortuitously caught up and recovered in the nets. Representative specimens of the species caught were frozen individually for laboratory analysis of microplastic particles in gut contents (see Section 16). The sieve residues will contain large numbers of benthic macrofauna, ranging in size from approximately 0.42 mm to >1 cm body length, consisting principally of various species of polychaete worms, bivalves, isopod and amphipod crustaceans, and other minor groups. On return to the laboratory these animals will be extracted from the sediment, identified and counted for comparison with the macrofauna recorded from Station 'M' in the 2013, 2015 and historical samples.

15.4) Conclusion

The 2016 epibenthic sled deployments proved highly successful and achieved the desired replicated sampling of Station 'M' to further extend the benthic time series. Analysis of these new samples will begin on return to SAMS and will require several months' work in the laboratory.

16) Sampling microplastics in the deep sea

Winnie Courtene-Jones

Microplastics are small pieces (most commonly fragments, fibres or beads) of plastics, less than 5mm in diameter. Microplastics occur in the environment from the fragmentation of larger items of plastic debris or are manufactured to be of small size for use as ‘scrubbers’ or as a precursor for other products. Due to the persistent nature of microplastics these accumulate in the environment, and have been identified in a range of marine ecosystems. The work carried out during this cruise compliments the deep sea epibenthic operations undertaken by the Scottish Association for Marine Science, and furthermore represents the first efforts to quantify microplastics in deep sea macro-invertebrates and in deep sea water.

16.1) Microplastics in deepsea fauna

Samples were collected using an epibenthic sled as described in Chapter 15. Sled sediment was processed by systematically washing small quantities through stacked sieves of mesh sizes 4mm, 500µm and 420µm. Once at this stage additional sample processing was carried out for those macrofauna retained on the 4mm sieve (Figure 16.1). Invertebrates were wrapped individually in aluminium foil and placed in pre-cleaned sealable containers separated to group level (e.g. gastropods, bivalves etc) as shown in Figure 16.2. These containers were labelled for each sled trawl and specimens were frozen in a -20°C freezer.

To mitigate against and control for contamination, samples of all ropes used on the epibethic sled, along with fibres from the net and net cover were taken. Additionally samples from ropes used on the winch and on the ship deck and surrounding areas were also taken. The water filter system fitted to the ship’s underway water intake was tested for efficiency by running the water through a 80µm mesh filter for 2 hours before sampling commenced and once all operations were completed. All containers were cleaned with 70% ethanol and wiped clean with non-shedding paper, followed by rinsing in deionised water. Before operations and between each sled haul, the ships deck was washed with a high pressure fire hose to remove any debris from the deck. Between processing sediment from each sled deployment sieves were washed thoroughly.

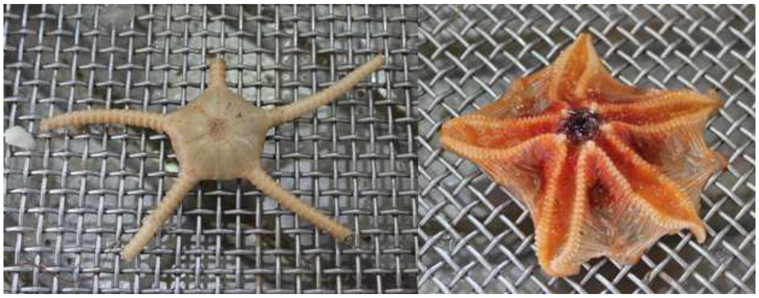


Figure 16.1: *Ophiomusium lymani* (left) and *Hymenaster* sp. (right) shown on a 4mm sieve.

Figure 16.2: Invertebrate specimens individually wrapped in aluminium foil in clean sealable container

16.2) Microplastics in deep sea water

Immediately after the final epibenthic sled was completed a CTD cast was deployed at position 57° 14.74 N, 10° 21.09 W. All 24 niskin bottles from the roseatte were fired at bottom depth of 2224 m. Once on deck, care was taken to remain downwind of the CTD to avoid contamination. Water filters were made by securing 80µm mesh gauze to a length of rubber tubing, all tubing and gauze was cleaned with deionised water and inspected under a microscope before use to ensure they were clean and free from contaminants.

Each niskin bottle spigot was cleaned using deionised water and immediately after the tube containing filter was fitted to the spigot. The air tap was opened to allow water flow and the spigot was fully opened. Water was allowed to flow through the mesh until each the bottle was completely empty (Figure 16.3). The rubber pipe was carefully removed, avoiding any contact with the mesh filter and placed on the next cleaned spigot. This was repeated for each of the 24 bottles; in total 240 litres of water was filtered. Once complete mesh were paced into sterile petri dishes, sealed with electrical tape and labelled.

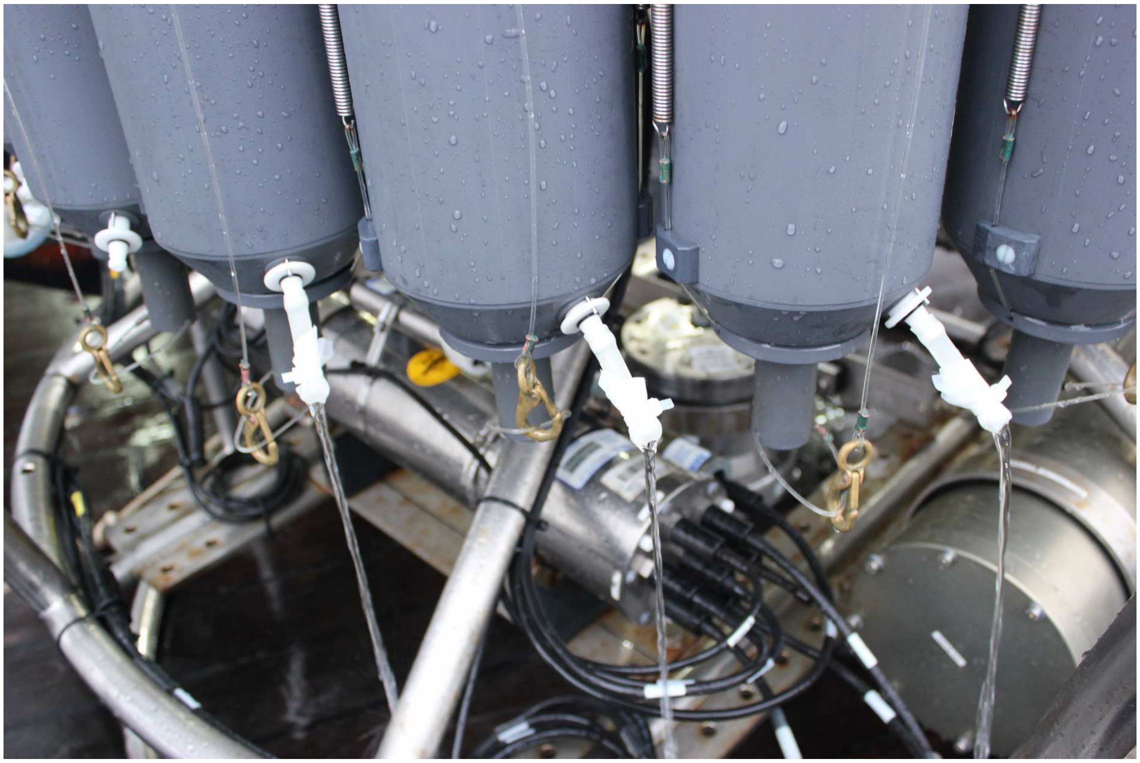


Figure 16.3: Rubber pipe with 80µm mesh gauze screen fitted to the niskin bottle spigot, allowing for water filtration directly from the CTD to analyse microplastics in deep sea water.

17) Hydrophone & EK60

Clare Embling and Leah Trigg

17.1) EK60

Deployment

The EK60 (ER60) was switched on and recording according to the schedule given in Table 17.1.

Table 17.1: EK60 logged data during DY052

Deployment start (UTC)	Deployment end (UTC)	Frequencies switched on & logged	Depth range (logged)
08/06/2016 19:57	12/06/2016 14:40	18, 38, & 70 kHz	200m
18/06/2016 14:34	19/06/2016 17:57	18 & 38 kHz	2000m
20/06/2016 23:13	23/06/2016 10:46	18 & 38 kHz	2000m

The 18 and 38 kHz frequencies were selected due to interest in the deep scattering layer (DSL), higher frequencies do not transmit deep enough to detect the DSL. The EK60 was uncalibrated during this cruise, and there is no evidence that it has ever been calibrated (this should be done if this is going to be used to produce useful data for analysis). The EK60 was synchronised with the other echosounders (ADCP, and depth sounders) using the synchronisation unit.

Initial results

We were primarily interested in the mesopelagic deep scattering layer, which was clearly visible in daylight hours (Figure 17.1). This showed clear internal waves in the deep scattering layer around Rosemary Bank and Anton Dohrn seamount (Figure 17.2).

Since no log was kept for when the echosounders were on or off, we didn't have a record of which EK60 transceivers were on or off, however the recorded EK60 files provided a record (though it wasn't always recording when switched on) by viewing them in EchoView (Figure 17.3).

The EK60 data was poor in high swell, which varied depending on the direction of travel (see Figure 17.4), and frequency (38kHz was generally worse than 18kHz).

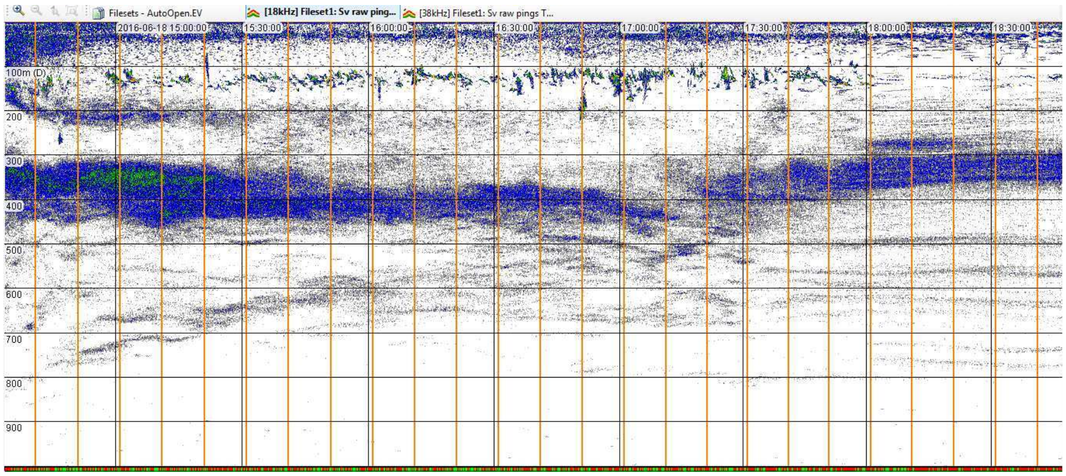


Figure 17.1: EK60 18kHz, 70 dB echogram for waters between Anton Dohrn and the shelf break (57° 17.500' N, 10° 21.009'W to 57° 14.755' N, 10° 21.009'W), colour scale: red = highest backscatter, yellow/green = moderate backscatter, blue = low backscatter. The mesopelagic deep scattering layer is between around 300-500m, and apparent fish schools just below 100m.

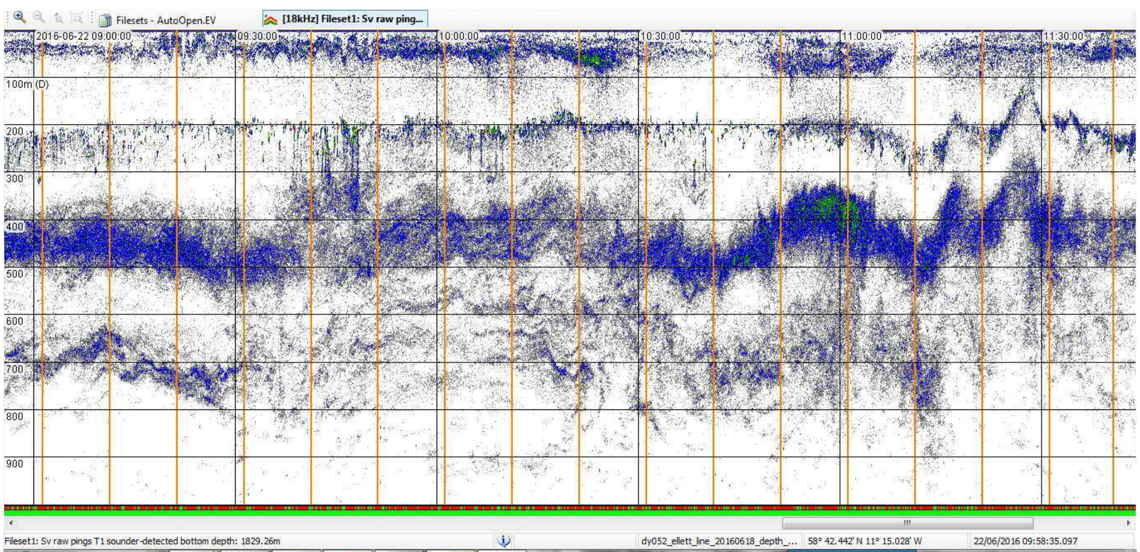


Figure 17.2: EK60 data for 18kHz at 70dB, on the approach to Rosemary Bank. Colour scale: red = highest backscatter, yellow/green = moderate backscatter, blue = low backscatter. Fish schools around 200m depth, and the deep scattering layer 400-500m, with clear internal waves in both layers.

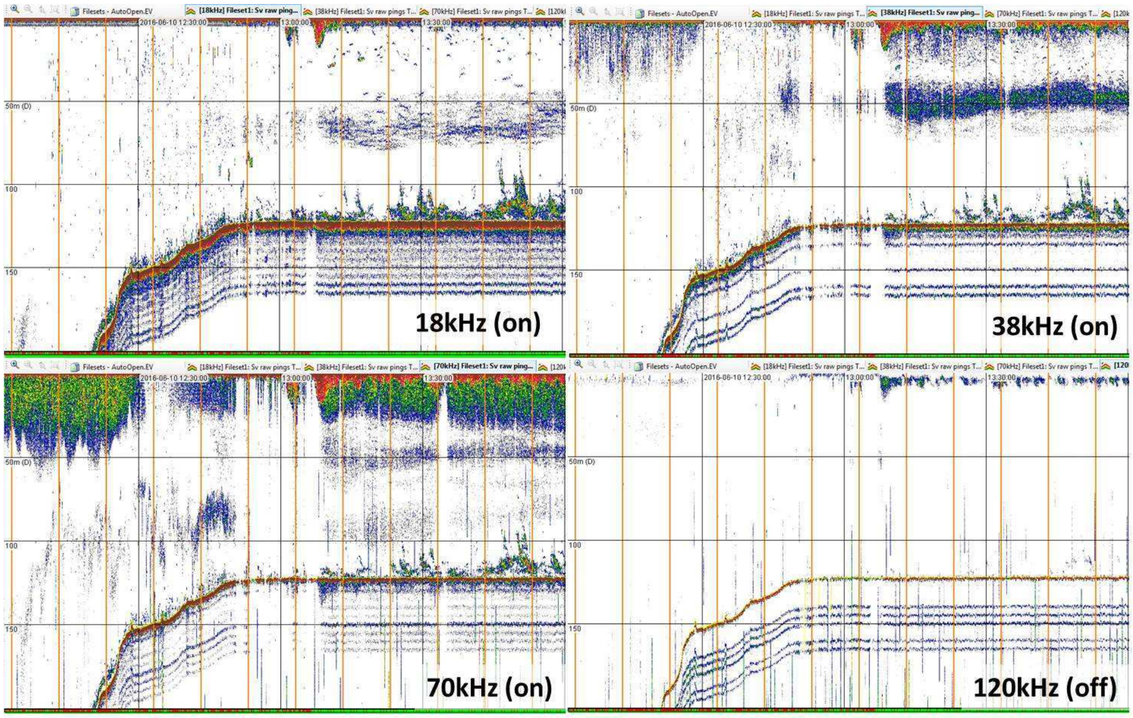


Figure 17.3: Example of EK60 data recorded at 4 different frequencies over the Icelandic Shelf (for the 200m data). There was no record of which frequencies were switched on but this suggests that the 18, 38 and 70kHz transceivers were switched on, while higher frequencies were switched off.

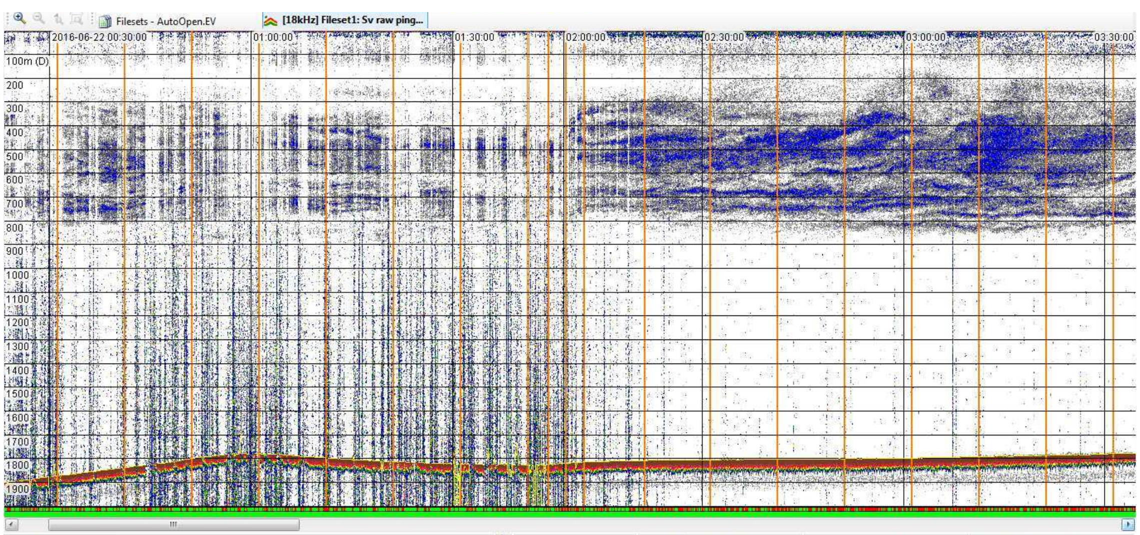


Figure 17.4: EK60 18kHz at 70dB, showing the effect of swell and direction on the return of signal to the receiver. The ship turned at the point where the EK60 return improved substantially.

Recommendations for future EK60/ADCP working simultaneously

The ER60 when reset would automatically switch to default settings, which was 200m (& set to operate at certain frequencies? Why was the 70kHz echosounder turned on?).

(1) Recommend that the default settings are set to the desired combination (in this case 2000m depth, and only on 18 and 38 kHz), and being logged to an appropriate folder for the cruise, and with an appropriate file name (in this case DY052 directory, and DY052 file name with the date and time stamp in the filename).
(2) Log every time any of the echosounders are turned on or off, since this wasn't recorded, so it wasn't known, making it difficult to determine interference from other devices (either for the EK60 data, the ADCP data, or the hydrophone).

17.2) Hydrophone

Specification & deployment

The hydrophone array is built by and on loan from Thom Gordon, Vanishing Point (www.vanishingpoint.org.uk). The array comprises of ~340m of tow cable, and a 5m long oil-filled (Isopar M) polyurethane tube streamer containing the hydrophone elements and pre-amplifiers, comprising:

(i) Two Magrec HP03 hydrophone/pre-amp units, each consisting of spherical hydrophone elements feeding broadband preamplifiers (Magrec HP/02). The preamps have a low cut filter set at 2kHz and the units have good frequency response between 2-150 kHz. The two elements are spaced 30cm apart.
(ii) Two Benthos AQ4 elements with matching Magrec HP02 preamplifiers. These have a low cut filter in the preamp set to -3dB at 100Hz. The elements are flat to 15kHz, and sensitivity is reasonable up to 30kHz. The two elements are spaced 3m apart.

The high frequency elements (HP03) were connected to a SAIL DAQ card (St Andrews Instrumentation Ltd), which was set via the PAMGUARD software to a gain of 24dB, and sampling rate of 500kHz. The medium frequency elements (AQ4) were connected via a Behringer Ultragain Pro Mic 2200 amplifier unit set to a gain of 20dB, and a Fireface 400 sound card, connected to a second computer running PAMGUARD, sampling at 48kHz.

All logging of the hydrophone data was carried out via PAMGUARD, with automatic recordings of all elements for 2 minutes every 15 minutes, continuous running of click detectors (to monitor for sperm whales from the medium frequency and beaked whales on the high frequency computers). The high frequency computer was connected to the NMEA GPS feed so that all data was GPS referenced. Listening stations were carried out every 15 minutes, where noise levels, sperm whale and dolphin sounds were scored on a loudness level from 0 to 5. Environmental data such as sea state and swell was recorded at least every hour. The data were stored in a SQLite database (Version 3.0.6). Deployment and retrieval times were logged.

For the majority of deployments the 10 and 12kHz bottom-detection echosounders (EM122 and EA640) were switched off during each tow since it was difficult to hear sounds over these specific echosounder pings (due to the long ping duration). Other echosounders that were on for the majority of the time during hydrophone deployment, and that can be detected by the hydrophone (but didn't interfere with listening or detecting whales) were: EK60 18kHz and 38kHz (and ~8-12th June the 70kHz EK60 echosounder was on, we aren't sure when it was turned off); ADCP 75kHz and 150 kHz.

The hydrophone was best deployed at speeds of 8 knots or greater, thrown to the side of the ship, out of the propeller wash. Lower speeds and the hydrophone would tend to be sucked into the propeller wash. The hydrophone was suspended when towed, as shown in Figure 17.5, to avoid chafing. Retrieval could be carried out at 8 knots (or higher). Deployment/retrieval took generally less than 10 minutes. It could be towed in most weather conditions (we were not restricted by weather during the whole survey).

Figure 17.5: Hydrophone deployment

Deployment dates and times are given in Table 17.2.

Initial results

Sperm whales were heard in highest densities in the Rockall Trough between Anton Dohrn Seamount and the shelf edge (Figure 17.6). Pilot whales were also heard on several occasions, along with dolphin whistles of unidentified species (Figure 17.6). Sightings of cetaceans included a fin whale and pilot whales close the shelf edge, beaked whales over Anton Dohrn, sperm whale blows in the Rockall Trough, and common dolphins over the Scottish Shelf (harbour porpoises and seals were also seen on the transit out from Glasgow in the Firth of Clyde). Feeding buzzes were heard most frequently in the Rockall Trough.

Table 17.2: Hydrophone deployment dates, times and locations of tows for DY052

Tow	Deployment start (UTC)	Start location	Deployment end (UTC)	End location
1	08/06/2016 10:15	59.909486N, 9.812368783W	09/06/2016 15:21	60.016971N, 17.72408W
2	09/06/2016 18:30	60.2432293N, 18.307422W	10/06/2016 12:36	63.27944N, 20.19403116W
3	11/06/2016 02:28	62.908538N, 19.5536695W	11/06/2016 03:53	62.697693N, 19.666148
4	11/06/2016 06:24	62.63822683N, 19.677538W	11/06/2016 08:23	62.3444773N, 19.8511788W
5	11/06/2016 10:52	62.320106N, 19.840990W	11/06/2016 12:40	62.0500553N, 19.9858898W
6	11/06/2016 15:35	61.958163N, 20.0068358W	11/06/2016 16:50	61.787148N, 20.016376W
7	11/06/2016 19:25	61.7284833N, 19.996575W	11/06/2016 21:00	61.5068452N, 20.0543002W
8	11/06/2016 23:50	61.4740752N, 20.001409W	12/06/2016 01:13	61.2617553N, 20.0145228W
9	12/06/2016 04:03	61.2284153N, 20.0038193W	12/06/2016 06:32	61.0207365N, 20.0252082W
10	12/06/2016 08:40	60.9885783N, 19.9945105W	12/06/2016 10:18	60.7536117N, 20.0266323W
11	12/06/2016 13:07	60.728479N, 20.0011095W	12/06/2016 14:26	60.5310748N, 20.012301W
12	12/06/2016 17:35	60.472649N, 20.0006965W	12/06/2016 19:05	60.26216N, 20.016863W
13	12/06/2016 22:10	60.2355786N, 19.9951076W	12/06/2016 23:35	60.017331N, 20.0007075W
14	13/06/2016 02:55	59.9787752N, 19.9545875W	13/06/2016 04:30	59.830212N, 19.5540903W
15	13/06/2016 07:40	58.8041403N, 19.4761653W	13/06/2016 09:05	59.6606223N, 19.1651018W
16	13/06/2016 12:55	59.6600111N, 19.097477W	13/06/2016 14:07	59.5191036N, 18.8130315W
17	13/06/2016 17:05	59.5202646N, 18.7304968W	13/06/2016 18:10	59.41316116N, 18.45244W
18	13/06/2016 23:39	59.315564N, 18.18604817W	14/06/2016 00:43	59.20298917N, 17.914186W
19	14/06/2016 05:15	59.096403N, 17.6212978W	14/06/2016 06:50	58.95738917N, 17.209390W
20	14/06/2016 10:54	58.8762345N, 16.9805848W	14/06/2016 11:44	58.7767955N, 16.8158258W
21	14/06/2016 13:52	58.7448531N, 16.7223595W	14/06/2016 14:32	58.6760283N, 16.5730163W
22	14/06/2016 16:38	58.6456885N, 16.4807238W	14/06/2016 17:20	58.580774N, 16.314874W
23	14/06/2016 22:10	58.4905478N, 15.9772622W	14/06/2016 23:27	58.3444608N, 15.6854245W
24	15/06/2016 01:12	58.3281035N, 15623214W	15/06/2016 02:15	58.2403023N, 15.3625168W
25	15/06/2016	58.2339468N,	15/06/2016	58.08091N,

	03:44	15.294005W	05:05	14.98620783W
26	15/06/2016 06:30	58.0601667N, 14.9280872W	15/06/2016 07:48	57.964145N, 14.6167625W
27	15/06/2016 09:17	57.9409608N, 14.5651178W	15/06/2016 10:40	57.779978N, 14.2816325W
28	15/06/2016 11:53	57.787626N, 14.214811W	15/06/2016 13:05	57.6734976N, 13.949283W
29	15/06/2016 14:15	57.654582N, 13.8808351W	15/06/2016 15:17	57.5551235N, 13.6841893W
30	15/06/2016 16:28	57.5747448N, 13.607319W	15/06/2016 17:14	57.5551946N, 13.3878293W
31	15/06/2016 18:28	57.565438N, 13.2961463W	15/06/2016 19:16	57.5466975N, 13.0679003W
32	16/06/2016 05:26	57.507057N, 12.219757W	16/06/2016 06:53	57.4745835N, 11.8695643W
33	16/06/2016 09:28	57.492637N, 11.8229017W	16/06/2016 10:33	57.4736415N, 11.5474093W
34	16/06/2016 22:20	57.360527N, 10.6386306W	16/06/2016 23:10	57.3016882N, 10.4162808W
35	17/06/2016 01:40	57.287414N, 10.3460687W	17/06/2016 02:37	57.23268217N, 10.086367W
36	17/06/2016 05:04	57.2345718N, 10.0863357W	17/06/2016 06:09	57.2494665N, 10.3996428W
37	17/06/2016 19:35	57.3368818N, 10.3461253W	17/06/2016 22:40	57.1104776N, 9.473409W
38	18/06/2016 00:55	57.10591517N, 9.4568512W	18/06/2016 01:41	57.135087N, 9.68108383W
39	18/06/2016 03:59	57.15109217N, 9.7329448W	18/06/2016 06:25	57.237797N, 10.4226367W
40	18/06/2016 20:47	57.2400888N, 10.313108W	19/06/2016 00:05	57.0857526N, 9.37001W
41	19/06/2016 06:00	56.9452637N, 8.74824317W	19/06/2016 06:58	56.8962548N, 8.5077205W
42	20/06/2016 12:05	56.7292728N, 6.868674W	20/06/2016 20:26	56.9663103N, 8.8243558W
43	21/06/2016 14:40	57.0918553N, 9.4289605W	22/06/2016 11:29	58.9577948N, 11.1043031W
44	22/06/2016 14:50	58.9675251N, 11.0820335W	22/06/2016 17:30	58.5723246N, 11.0517836W
45	22/06/2016 19:51	58.5338156N, 11.0811305W	22/06/2016 22:29	58.1391488N, 11.0524755W
46	23/06/2016 00:59	58.07435N, 11.08240683W	23/06/2016 03:44	57.65926167N, 11.079971W
47	23/06/2016 07:17	57.539857N, 11.06649467W	23/06/2016 13:58	58.8696855N, 9.5427556W

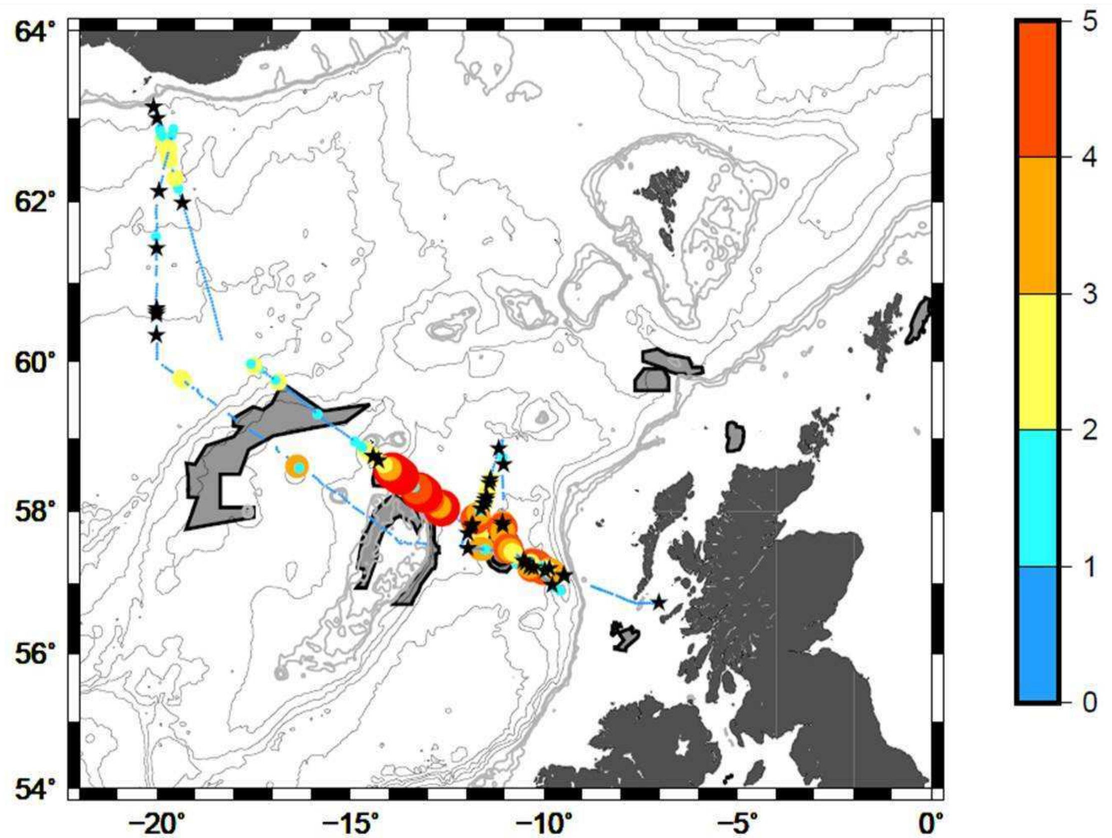


Figure 17.6 – Loudness of sperm whale clicks (coloured, sized dots), and locations of whistles (stars) from the towed hydrophone array. Size of sperm whale dots and colour indicates loudness of the clicks (a proxy for proximity to the ship) on a scale from 0 (absent) to 5 (very loud).

The noisiest location was in the shallow area close to Rockall, in this area the propeller noise reverberated a lot off the bottom making it difficult to hear animals. Also the EM122 and EA640 bottom echosounders were switched on which, combined with the propeller noise made it impossible to hear anything except for the ship.

Ship noise primarily comprised of the propeller noise, and some associated cavitation, quietest in deep water, and at slower speeds. There was also water noise suggesting that the hydrophone was quite close to the surface (the hydrophone could have benefitted from a little weight to bring it down in the water column a little). The medium frequency channel was quite crackly in rougher weather conditions, these were recorded as clicks in the click detector, and overloaded the buffer when the crackling was severe (resulting in a cut-out of the audio signal). The high frequency elements did not suffer from this problem, and the recordings are much cleaner (this is the data provided to BODC). Other occasional noises included propagation of noise from the needle drill (heard on the hydrophone), another ship (in shelf waters), and occasional ‘chirp’ sounds of unknown source.

Recommendations for future hydrophone deployment

- Deploy the hydrophone at a minimum of 8 knots, and throw to the side away from the propeller wash.
- Ensure that the echosounders with long ping durations are turned off during hydrophone steaming.
- Keep a clear record of which echosounders are on, and when.
- Request needle drill use avoided during hydrophone tows.
- Ensure any sightings of cetaceans are reported to the hydrophone team for recording and for species ID for any recorded vocalisations

18) Argo float deployment

Stefan Gary

Three Argo floats were deployed during DY052 according to the standard Argo float deployment instructions, i.e. plugs removed, lowered over back rail on a line through a hole in the plate, line removed from the float as it drifted away. All floats were in pressure activation mode. No anomalies in the deployment were noted. The last two floats were deployed at nearly the same location to test the RBR versus the standard version.

S/N:	7575, standard Apex
Time:	0828 UTC
Day:	164 (June 12)
Depth:	about 2400 m
Conditions:	calm
Position:	Just after CTD013, a.k.a. IB14
	60 deg 59.988 N
	20 deg 0.04434 W

S/N:	7576, standard Apex
Time:	0230 UTC
Day:	165 (June 13)
Depth:	about 2700 m
Conditions:	calm
Position:	Just after CTD017, a.k.a. IB12
	59 deg 59.900 min
	20 deg 00.314 min

S/N:	7626, RBR Apex
Time:	0244 UTC
Day:	165 (June 13)
Depth:	about 2700 m
Conditions:	calm
Position:	Just after CTD017, a.k.a. IB12
	59 deg 59.510 min
	19 deg 59.316 min

19) Seaglider recovery

Estelle Dumont

One Seaglider, SG550 ('Eltanin'), belonging to the MARS pool and operated by SAMS, was recovered during DY052.

The glider had been deployed in the Hebrides on the 11th February 2016, and was planned to travel along the Extended Ellett Line and back, with recovery planned in the Hebrides in August. She was equipped with a Seabird CT sail, Aanderaa oxygen optode, and a Wetlabs puck measuring fluorescence, C-DOM and backscatter. Eltanin successfully completed her journey to Iceland, however she suffered an early battery failure on the way back while traversing the Icelandic Basin. She was put into recovery by the SAMS pilot on the 29th May, and left to drift at the surface awaiting recovery during DY052. During this time she was set to regularly transmit her position (every 6 hours) to the primary basestation based at SAMS.

By the time Discovery set sail Eltanin had drifted slightly East of the Extended Ellett Line, North-West of the Hatton Bank, and it was decided to recover her on the passage leg to Iceland. The glider call interval was decreased to 3 hours then to one hour during the night prior to recovery on the 9th June 2016. As Discovery was approaching the glider the call interval was decreased to 10 minutes. She was spotted in the water from the bridge around 17:00 UTC, and the ship manoeuvred alongside. The pilot checked the internal pressure, humidity and battery levels prior to recovery, and deemed the glider safe to recover. After a few attempts, the crew managed to lasso a rope around the tail of the glider (under the rudder) using a telescopic pole and soft rope, while the SAMS team tried to help holding the glider still with another telescopic pole. The glider was lifted her on deck using the auxiliary winch on the starboard side.

Full recovery details:
SAMS Mission #18 - Recovery

Glider:	SG550 - Eltanin
Glider mission:	1 (for SAMS)
Project:	Extended Ellett Line #5
Date:	09-Jun-16 18:10 UTC
Location:	60° 12.3' N, 18° 16.9'W
Vessel:	RRS Discovery
Cruise:	DY052
Weather:	Wind force 3 / 4, sea state slight, rain
Pilot:	Estelle Dumont, Loic Houpert
Field team:	Estelle Dumont, Stefan Gary

Following the cruise, Eltanin will be returned to the MARS glider team for refurbishment and evaluation of the battery failure. At this stage, a fault in the battery pack manufacturing seems the most likely cause.

The full mission's raw data can be viewed at: vocal.sams.ac.uk/gliders, and is available from BODC. Delayed-mode data will be submitted to BODC within the next few months. The full glider technical mission report will also be finalised within the next few months and will be available from BODC and SAMS.

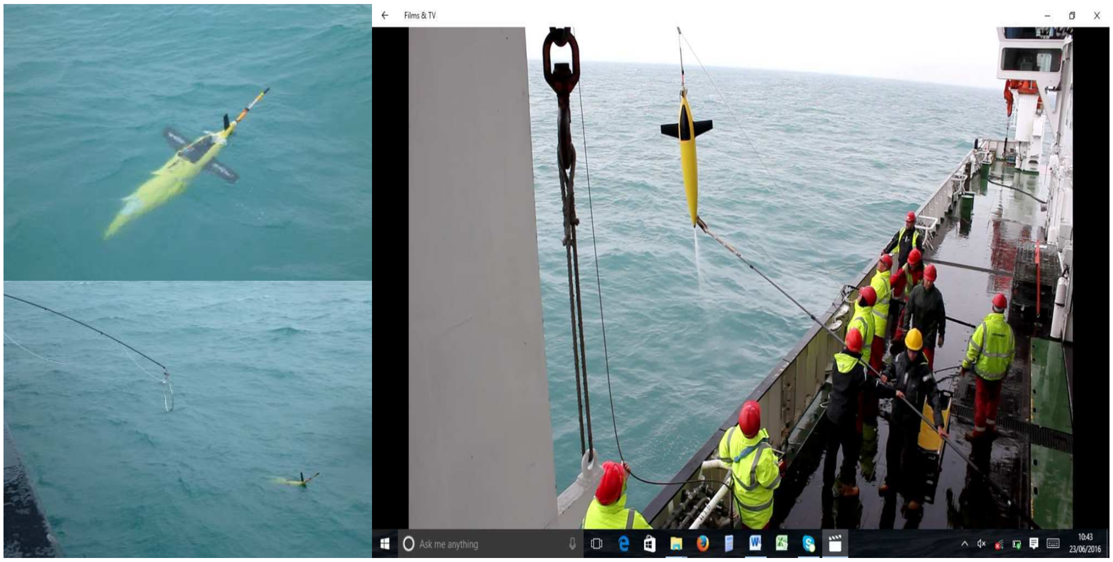


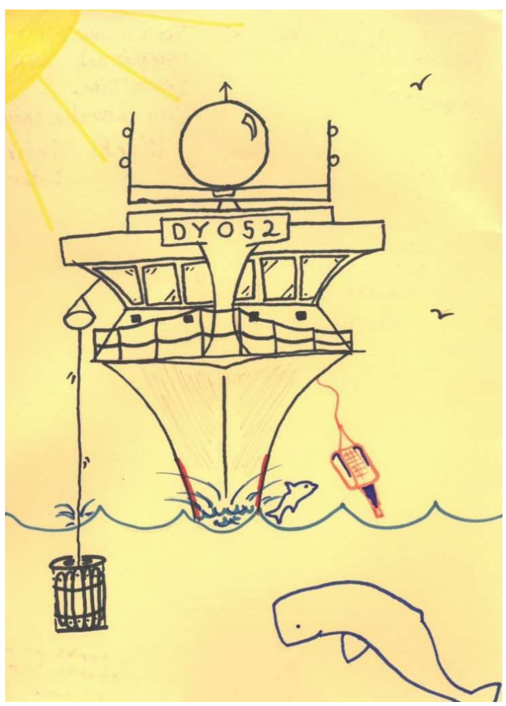
Figure 19.1: SG550 in the water; recovery hoop and lasso; SG550 being lifted on board.

20) Acknowledgements

DY052 was a very successful cruise thanks to excellent teamwork and good weather. We would like to thank the Master, Jo Cox, for her support during the trip. Also, many thanks are extended to the whole ship's crew. The skill and professionalism of the bridge officers, the engineers, the catering staff and the ABs was very much appreciated.

We would also like to thank the science party for their positive attitude and hard work. Special thanks are extended to the CTD/Autosal operators who sailed on DY052: Jon Short, Colin Hutton, and Estelle Dumont; whose experience, skills, and careful attention to detail helped keep things moving along smoothy.

Many thanks are extended to Laura Wedge, Krys Szczotka, Jade Garner, Sally Heath, Rolly Rogers (NMF) and Collin Griffiths (SAMS) for assistance with cruise planning; Stuart Cunningham, Loïc Houpert, Rich Dale (SAMS), Penny Holliday, and Brian King (NOC) for assistance with setting up and using the MSTAR software; and Thom Gordon for loaning the hydrophone.



National Marine Facilities

Ship Instrumentation Overview

RRS *Discovery*
IMO: **9588029**
MMSI: **235091165**
Call Sign: **2FGX5**

Cruise: DY052 (Ellet Line)

by Jack McNEILL

7th of June - 25th of June 2016

This document describes systems maintained by NERC Scientific Systems Technicians

Revision History

Date	Version	Description	Author
2015.03.12	1.0	First draught	JM
2015.06.04	1.1	Corrected	ZN
2016.06.17	1.2	Updated & Corrected	JM

Fig 1. RRS Discovery in 2013

Questions?

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Table of Contents

1 Introduction

The new *RRS Discovery* is broadly similar to the *RRS James Cook* and has a similar arrangement of instruments and sensors. This document provides a brief overview of what's on board; where it is; what it does; what its inputs and outputs are; and gives an indication of where to get more information. Datasheets for all instruments are provided on the Cruise disc.

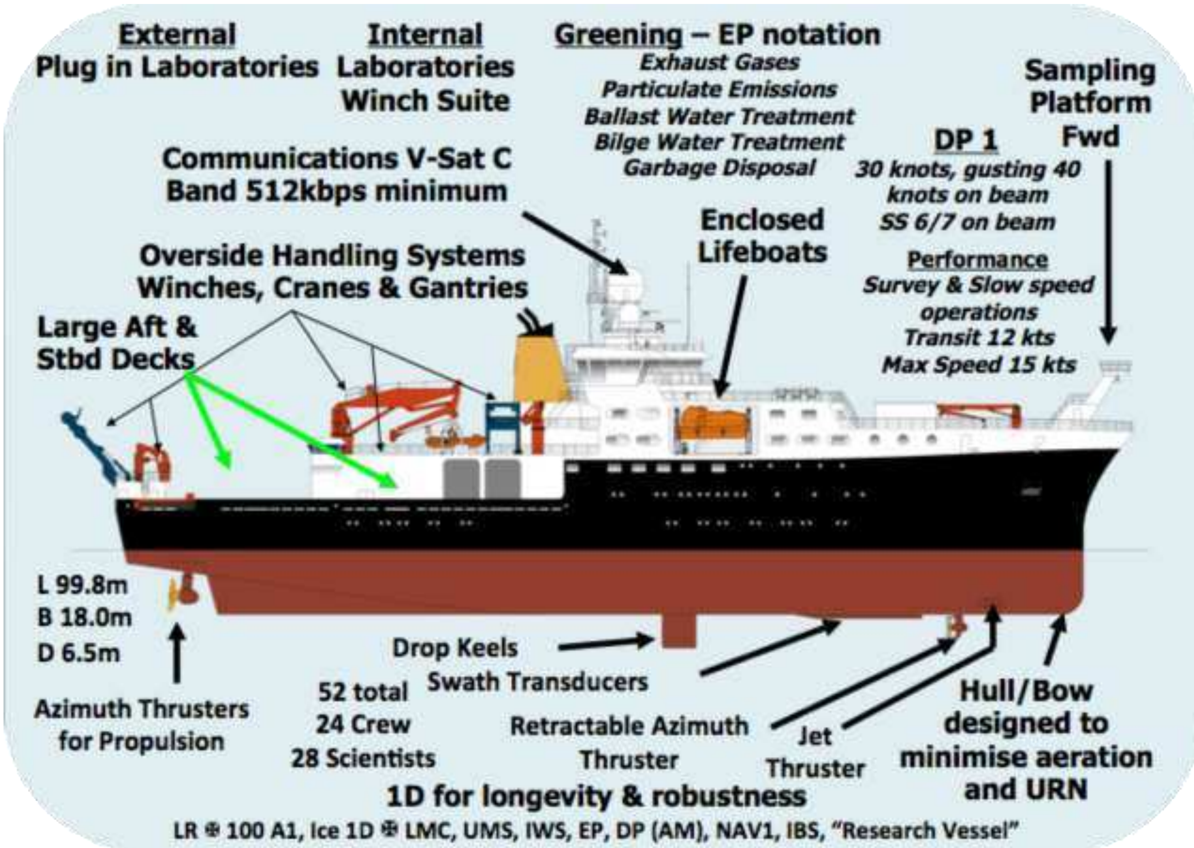

Fig 2. RRS Discovery in 2013

1.1 Datalogging & Data Storage

Datalogging software and storage is provided on a platform common to both *RRS* vessels (*RRS Discovery* and *RRS James Cook*), and managed by NERC's NMFSS Ship Scientific Systems group.

1.2 TechSAS

TechSAS is an integrated technical and scientific sensors acquisition system and is the primary datalogger on both vessels. The system allows monitoring and accurate time-stamping of each individual instrument with a graphical output

TechSAS saves data in the self-describing NetCDF (Network Common Data Format) format that can be easily read via MatLab or using freely available NetCDF libraries. TechSAS also broadcasts the logged data across the ship's network in UDP pseudo-NMEA0183 (i.e.: "NMEA-like") packets. Separate NetCDF documentation is available that explains the logged variables.

1.3 RVS Level C

Level-C is a data management programme, written in C for its Sun SPARC environment.

The Level-C system logs the TechSAS UDP packets in the Level-C binary format as flat files (colloquially known as "streams").

Level-C has a number of little programmes inside it that allow the flat files to be viewed, edited, and exported rapidly in a range of formats, e.g.: CSV; ASCII text file, at custom intervals and averaging periods.

Another feature is the display of meteorological, depth, and navigation data (as with the SSDS software running on the wall-mounted HP touchscreens around the ship).

The NMFSS Science Systems Technician can generate reports from the Level-C system.

2 Attitude & Positioning Instruments

The new *RRS Discovery* has some of the same sensors as the *RRS James Cook*, and some new ones.

2.1 Applanix POS MV V4 (Primary Science GNSS and Attitude Sensor)

A combined GNSS receiver and attitude (i.e.: gyrocompass, and conventional motion) sensor that provides data about: attitude; heave; position; and velocity. The GNSS aspect is for use with Multibeam Echosounder systems.
The POSMV is logged to the TechSAS Datalogger. The datalogger produces two files for its configured file period (usually 24hrs).
These files are:

- POSMVPOS.POS - NetCDF File Containing Positional Data (Heading, Latitude, Longitude)
- POSMVATT.ATT - NetCDF File Containing Attitude data (Roll, Pitch, Heave)

Please note that the position output is the position of the ship's common reference point (the cross on the top of the POSMV MRU in the gravity room).

2.2 Kongsberg Seapath DPS330 (Secondary Science GNSS and Attitude)

This is a secondary Science GNSS and attitude sensor. The position output is the position of the ship's common reference point (the cross on the top of the POSMV MRU in the Gravity Meter Room).

2.3 iXBlue PhINS (Photonic Inertial Navigation System)

A surface inertial navigation system that uses a FOG (Fibre-Optic Gyro) to output accurate position, attitude, and velocity data.

2.4 CNav 3050 GPS, GLONASS, Galileo GNSS

GNSS and RTCM Satellite Corrections Receiver. The position output is the position of the antenna. This GPS is not referenced to any other systems. It is primarily used to provide RTCM differential corrections to the other GPS systems. Please note that the position output is the position of the antenna. This GPS is not referenced to any other systems.

3 Hydroacoustics

RRS Discovery has both vessel-mounted and smaller deployable transponders.

3.1 Kongsberg-Simrad

Simrad, now part of Kongsberg, is the supplier of the heavy artillery of echosounders.

3.1.1 EM122 Deep Water Multibeam Echosounder

This 12kHz echosounder is rated to 11,000m, but probably up to 8,000m for good quality data. The EM122 it is viewed and operated via SIS (Seafloor Information Service).

3.1.2 EM710 Shallow Water Multibeam Echosounder

This 70-100kHz echosounder is rated to 2,000m, but in reality you might consider switching to the EM122 between 600-1500 metres. Within this range, the EM710 gives a broader swathe, with less detail, so which one you use depends on what data you need to generate.

3.1.3 SBP120 Sub-Bottom Profiler

The SBP120 is a 6kHz-8kHz extension to the EM122 Deep Water Echosounding Profiler (the receiver part).

3.1.4 EA640 Single-beam Echosounder

The EA640 is a special version of the EA600 commissioned for the *RRS Discovery*, pretty much identical to the EA600 and can operate at either 12kHz or 10kHz as required. The performance of each varies with output power (e.g.: 1kW or 2kW) and pulse lengths. They both have a wide bandwidth that overlaps, and can be run at the same time.

3.1.5 EK60 Multi-Frequency Echosounder (“Fish Finder”)

The EK60 has 18, 38, 70, 120, 200, and 333 kHz transducers fitted to the starboard drop keel. Equipment to calibrate the system is carried onboard.
Specifications Ek60_brochure_english_reduced.pdf
Location dy###_data_disc/cruise_reports/instrument_data_sheets/

3.1.6 Kongsberg-Simrad SU16 Synchronisation Unit (*K-Sync*)

Running several acoustic systems simultaneously on ships with several acoustic instruments can cause interference between the systems, which may reduce the data quality. This unit and associated software lets you synchronise the pings of different acoustic equipment, (providing that they operate at different frequencies!). This system lets the SST control the timing of the instruments and by controlling the triggering of each instrument's transmission.
Specifications Operator Manual.pdf
Location dy###_data_disc/cruise_reports/instrument_data_sheets/k-sync/

3.2 Sonardyne Transponder Beacons & Software

There are two hull-mounted transponders on the *RRS Discovery*. The Starboard side USBL is a 7000 directional bis head for improved performance in deeper water; the Port side USBL is a 5000 standard head. The USBL transponder spars are extensible & retractable and project more or less vertically down from the aft half of the hull between the Drop Keels and the Propellers. The software used is ***Ranger 2***.

Inputs Vertical Reference Units (VRUs), Gyro Compass; DGPS (Surface Positioning); GPS (Time Synchronisation). Transponders (1km-depth Wide-band Sub-Mini – WSM), and 3km-depth DP Transponder

Outputs it logs data itself into a file that can be taken away; can also output a data string to TechSAS (in this case, you only get the position of one beacon at a time in the water, you can put this info into the Level-C system and plot some data from it; it outputs to the OLEX 3D-seafloor mapping software that provides a visual display). It can also output DP telegram format data.

3.3 Teledyne-RDI *Ocean Surveyor* ADCP

The ADCP transducers are located in the hull, in blisters, in a forward-aft configuration approximately 6m below the water line. There are two systems that operate at two frequencies: 75 kHz; and 150kHz. Both the heads have a rotation relative to the ship's centre line of -45°. The software used for configuring and datalogging with the ADCP is called ***VmDAS*** (Vessel Mounted Data AcquisitionSystem). ***VmDAS*** gets data from the ship's attitude sensor and uses that to convert ship velocities into earth co-ordinates.

VmDAS can be configured either by loading or editing a command file; or by changing settings on the interface. Users should be aware that it's possible to simultaneously load and use a command file, and adjust settings using the interface, which can lead to command conflicts, in which case the interface overrides the command file. Data is logged to local hard-disc, and then create a back-up on the server. Set-up file is editable when starting the ***VmDAS*** software.

3.3.1 Teledyne Ocean Surveyor 75KHz Vessel Mounted ADCP (VMADCP)

Inputs: GPS; Gyrocompass; *iXSea* PhINS so it can calculate accurate speed and direction of currents. It is recommended that the EM710 is not used at the same time as the OS75

Range: 520-650m (Long-range/Low quality); 310-430m (Short range/High quality)

3.3.2 Teledyne Ocean Surveyor 150 kHz Vessel Mounted ADCP (VMADCP)

Inputs: the same as for the 75kHz

Range: 325-350m or 375-400m (Long Range/Low Quality); 200-250m or 220-275m (Short Range/High Quality)

3.4 Sound Velocity Sensors

Discovery has a hull-mounted *AML Micro X Probe*, and a portable *Valeport Midas SV* Profiler. The Valeport uses *DataLogExpress* datalogger software and have a maximum depth of 5000m.

The *Kongsberg SIS* software has a new application called **MDM** for bringing the saved profiles in.

4 MetOcean

RRS Discovery has the same MetOcean instruments and sensors as the *RRS James Cook, except the Temperature/humidity probe different on the RRS James Cook it's Vaisala HMP45A on the RRS Discovery it's HMP155*.

4.1 OceanWaves WaMoS II Wave Radar

WaMoS is an X-Band nautical RADAR with a range of 100m to 4km. It can only generate data in above a minimum wind speed of 3ms^{-1}. It detects open wave spectra. Sea state is calculated from detected backscatter of μwave "sea clutter" in real time. The system can detects wavelengths from 15 m – 600 m and covers periods from 4 sec-20 seconds. At coastal sites, WaMoS II can only measure the spatial wave field beyond the wave breaking zone. There is a WaMoS computer in the Met Lab, where it stores processed radar images. Data is logged in WaMoS's own format. Summary wave information is available in one of the ASCII files generated.

4.2 NMF SurfMet (Surface Water System and Meteorological Monitoring)

SurfMet comprises two sets of scientific instruments: Meteorological; and Surface Water Sampling, along with ADCs and a PC hosting SurfMet data conversion software that passes data to the Data Systems for event logging.

4.3 Meteorological Instruments (Met)

The Meteorological part of the system comprises a range of instruments located near the forward mast about 10 metres above sea level.

The instrument called the...	...measures...	...in...	...to calculate...
Vaisala HMP155 Temperature & Humidity Sensor	Thermal radiation and water vapour	Sunlight ; Air	Ambient air temperature and Relative humidity
Gill Windsonic Anemometer	Ultrasonic sound waves via ultrasound transceivers	Air	Wind speed and direction
Vaisala BaroCap PTB110 Barometric Pressure sensor	Change in electrical resistance via a deflectable diaphragm strain gauge within a pressure transducer	Air	Air pressure
Kipp & Zonen CM6B Pyranometer	Electromagnetic radiation flux density by converting solar radiation into heat, and thence into a voltage	Sunlight	Total Irradiance (Solar energy)
Skye Instruments SKE510 PAR (Photosynthetic Active Radiation) Pyranometer	Electromagnetic radiation flux density by converting solar radiation into heat, and thence into a voltage, passed through a bandpass filter	Sunlight	Total Irradiance (Solar energy) within a fixed range of wavelengths for photosynthesis

4.4 Surface Water Sampling Instruments (SWS)

The Surface Water part of the SurfMet system collects seawater (known as “non-toxic" or "underway" water) from the upper 5.3 metres of the ocean, and passes it through the following instruments:

The instrument called the...	...measures...	...in...	...to calculate...
SeaBird 45 Thermosalinograph	Temperature and conductivity	Seawater	Salinity
SeaBird 38 Digital Oceanographic Thermometer	Change in resistance via a thermistor	Seawater	Temperature
WetLabs WetStar WS3S Fluorometer	Reflected light frequency difference between beams of light passed through water	Seawater	Marine floral density via fluorescence
WetLabs WetStar CST Transmissometer	Photon quanta (received light)	Seawater	Particulate density

TSG flow is approx 1.6 litres per minute whilst fluorometer and transmissometer flow is approx **20** l/min. Flow to instruments is degassed using a debubbler (outlet) with **10** l/min inflow; waste flow is usually around **8-10** l/min (adjusted to maintain balance, but at a low rate to keep the TSG flow rate to around 1.6 l/min).

4.5 DartCom *HRPT L-Band Polar Orbiter* Weather Satellite Imaging System

The DartCom system comprises a 1.2m Parabolic Dish enclosed in a Radome. It receives signals from satellites that take images of cloud coverage. These images can be used to see the type of atmospheric and weather conditions nearby.

5 Data Displays

Software for displaying useful science-related information is provided around the ship.

5.1 *NMF/SE/SSS* SSDS (Ship Scientific Display Screens)

These touchscreens located around the ship display a range of data from scientific and non-scientific systems: Gyro information; GPS information from CNAV; sensor information from SurfMet; Depth from EA640; and winch information. Waypoints to stations can also be entered on the ETA tab, and propagated around the network to the other screens.

5.2 *OLEX* 3D Seafloor Hydrographic Mapping and Visualisation Software

OLEX is a 3-D seafloor map visualisation software that has a shared seafloor data files, and installed on a dedicated PC. OLEX receives data from navigation, depth, multibeam, and ship positioning systems (it can also position data from USBL). Olex provides rapid visualisation of multibeam data, as well as showing where in the world the ship is.

National Marine Facilities

BODC Ship-Fitted Instrument Logging

RRS *Discovery*
IMO: **9588029**
MMSI: **235091165**
Call Sign: **2FGX5**

Cruise: DY052 (Ellet Line)

by Jack McNeill

7th of June - 25th of June 2016

This document describes systems maintained by NERC Scientific Systems Technicians

Revision History

Date	Version	Description	Author
2015.05.05	1.0	First draught	JM
2015.05.15	1.1	Format changes & fixes	JM
2016.06.18	1.2	Template update	JM

Fig 1. RRS Discovery off the coast of Galicia in 2013

Questions?

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1 Ship-fitted instruments:

The following table lists the logging status of ship-fitted instrumentation and suites.

Manufacturer	Model	Function/data types	Logged?	Comments
Meinberg	M300 Lantime	GPS network time server (NTP)	N	Not logged but feeds times to other systems
Trimble/Applanix	POS MV v4	DGPS and attitude	Y	Secondary DGPS s/n 5421 IMU36 s/n 2236_423154
C-Nav	3050	DGPS and DGNSS	Y	Primary correction
Kongsberg Seatex	Seapath 330	DGPS and attitude	Y	Primary DGPS No attitude logged, only position
iXBlue	PhINS	Inertial Navigation System	Y	TechSAS logging module in development. Attitude input to the ADCPs s/n PH-832; logged raw data from 2016/06/13/23.04
Sonardyne	Ranger 2 USBL	USBL	N	n/a
Sperry Marine		Ship gyrocompasses x2	Y	"gyro_s" message in Level-C
Kongsberg Maritime	EA640	Single beam echo sounder (hull)	Y	s/n 420041 Software version 2.5.0.2f Logged via TechSAS & CLAM2014
Kongsberg Maritime	EM122	Multibeam echo sounder (deep)	N	s/n 123 SIS version 4.1.3
Kongsberg Maritime	EM710	Multibeam echo sounder (shallow)	N	s/n 211 SIS version 4.1.5
Kongsberg Maritime	SBP120	Sub-bottom profiler	N	n/a
Kongsberg Maritime	Simrad EK60	Scientific echo sounder (fisheries)	Y	n/a
Kongsberg Maritime	K-Sync	Acoustic Synchronisation Unit	N	See cruise report for systems synchronised version 1.7.0 SU version 1.5.1
NMFSS	CLAM2014	CLAM system winch log	Y	Constant hourly logging
NMFSS	SurfMet	Meteorology suite	Y	dy052_surfmet_sensor_information.docx for sensor details
NMFSS	SurfMet	Hydrography suite	Y	dy052_surfmet_sensor_information.docx for sensor details
OceanWaveS GmbH	WaMoS II	Wave Radar	Y	Logged locally and in TechSAS, not requested, so no large raw data files.
Teledyne RDI	Ocean Surveyor 75	VM-ADCP	Y	Deck unit s/n 1813 VMDas version 1.46.5 Inteference from EM710 affects data
Teledyne RDI	Ocean Surveyor 150	VM-ADCP	Y	Deck unit s/n 28550 VMDas version 1.46.5
Microg Lacoste	Air-Sea System II	Gravity	N	Not fitted

2 *Bestnav* hierarchal ordering:

The following table lists the order of navigational systems in the *bestnav* process for positional fix.

Rank	Order of positional fixes	Comment
1	Kongsberg Seapath 330	spathpos
2	Applanix POSMV v5	posmvpos
3	C&C Tech. C-Nav 3050	gps_cnav

Units of dist_run: nautical miles.

3 Relmov source:

The following table lists the navigational systems that are used in the *relmov* process for ship's motion.

Navigational source of ship's motion	Comments
Sperry Marine gyro	gyro_s
Skipper Speedlogger	log_dysk

4 RVS data processing:

The following table lists the RVS Level-C processing programs that were run.

Programme	Run?	Comments
bestnav	Y	Data from: • 16 159 15:42 on Discovery1 • 16 164 10:18 on Enterprise
*prodep***	N	Using Carter Table Corrections
protsg	N	
relmov	Y	Data from: • 16 159 15:42 on Discovery1 • 16 164 10:18 on Enterprise
satnav	N	
windcalc	Y	Data from: • 16 159 15:42 on Discovery1 • 16 164 10:18 on Enterprise

**Please state if sound velocity probes used for depth correction instead of *prodep*.

National Marine Facilities

SurfMet Sensor Information

RRS *Discovery*
IMO: **9588029**
MMSI: **235091165**
Call Sign: **2FGX5**

Cruise: DY052 (Ellet Line)

by Jack McNEILL

7th of June - 25th of June 2016

This document describes systems maintained by NERC Scientific Systems Technicians

Revision History

Date	Version	Description	Author
2015.03.12	1.0	First draught	JM
2015.06.04	1.1	Corrected	ZN
2016.06.17	1.2	Updated & Corrected	JM

Fig 1. RRS Discovery off the coast of Galicia in 2013

Questions?

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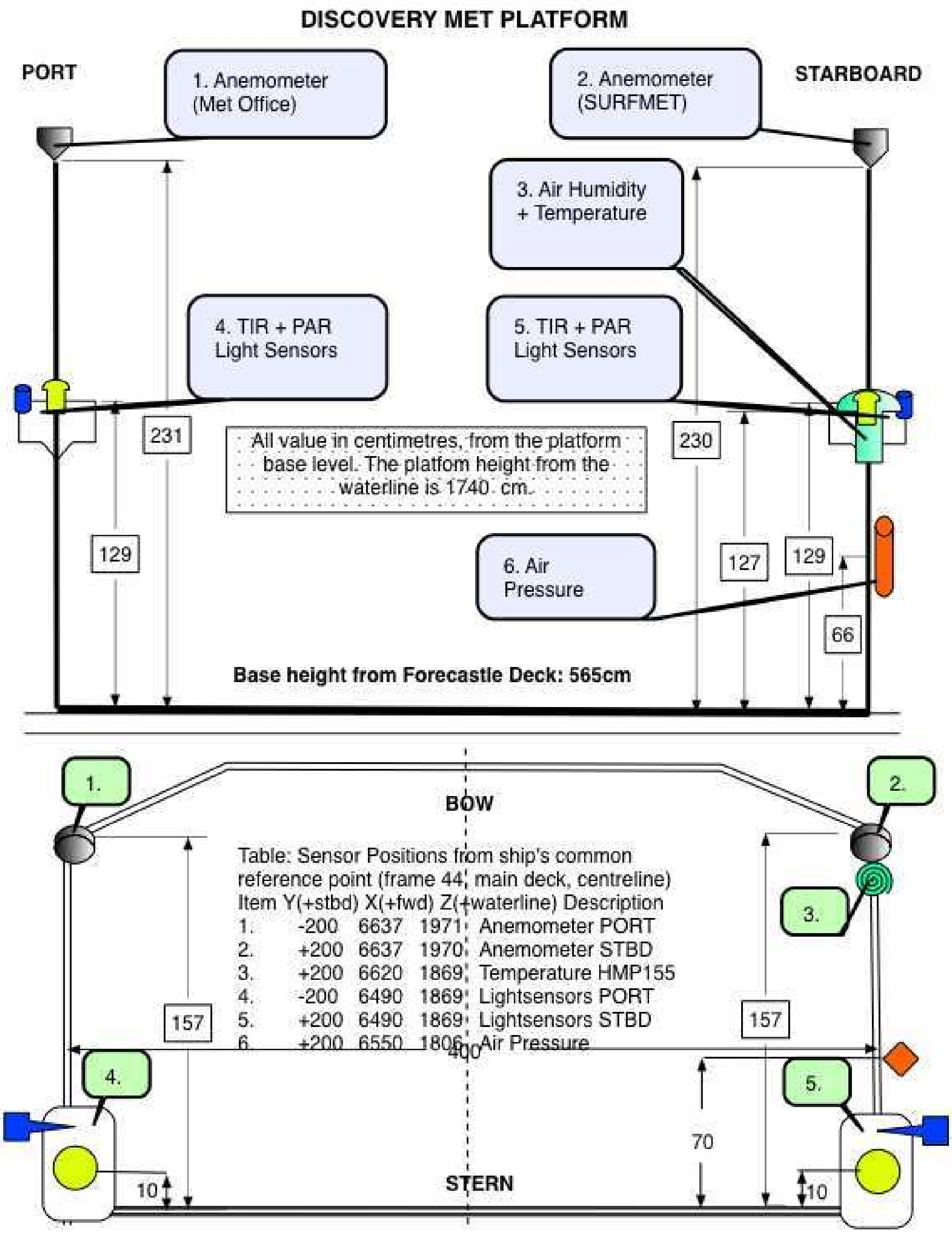

Fig 2. RRS Discovery Met Platform (Foremast)

Seawater System Parameter	Value
Pumped seawater flow rates (ml/min):	1500
Anemometer orientation on bow (deg):	0°
Seawater intake depth (m):	5.5

Fitted Sensors:

Manufacturer	Sensor	Serial No.	Comments (e.g. port)	Calibration applied?	Last calibration (DD/MM/YYYY)
Surface SV	AML Micro X-Series	10626/204242	Drop Keel SV		2015.09.30
Skye	PAR SKE510	28556	Starboard	No	2015.09.11 (2yr)
Skye	PAR SKE510	28561	Port	No	2015.04.30 (2yr)
Kipp & Zonen	TIR CM6B	962276	Starboard	No	2014.11.13 (2yr)
Kipp & Zonen	TIR CM6B	973134	Port Inv:240004209	No	2015.03.19 (2yr)
Gill	Windsonic Option 3	071121	Starboard Inv:250004845	No	N/A (tested 2015.09.28)
Vaisala	HMP155 Temp./Hum.	K0950057	Met Platform	No	2015.01.19
Vaisala	PTB110 Air Pressure	M1750058	Met Platform	No	2016.04.29
Vaisala	PTB110 Air Pressure	G0820001	Mast Battery Room	No	2016.01.21
Wet Labs	WS3S Fluorimeter	WS3S-246	Inv:240002938	No	2015.09.01
Wet Labs	CST Transmissometer	CST-1131PR	Inv:24000####	No	2016.04.13 (2yr)
Sea-Bird	SBE38 Temperature	3854115-0491		No	2015.06.25
Sea-Bird	SBE45 TSG	4548881-0231	Installed & freshwater-tested on 2015.10.05	No	2015.07.02 (1yr from 2015.10.05)

Spare Sensors on-board not fitted:

Manufacturer	Sensor	Serial No.	Comments (e.g. port)	Calibration applied?	Last calibration (DD/MM/YYYY)
Surface SV	AML Micro X-series	10156/204889			2015.09.17
Skye	PAR	28558			2015.09.11
Kipp & Zonen	TIR	962301			2015.08.25
Kipp & Zonen	TIR	973135			2015.08.25
Gill	Windsonic Option 3	71123	Inv.: 250004845	No	N/A (Tested 2015.03.10)
Vaisala	HMP155Temp./Hum.	K0950058			2015.01.16
Wet Labs	WS3S Fluorimeter	WS3S-117			2015.09.16
Wetlabs	CST Transmissometer	CST-1132PR			2014.09.29 (2yr)
Sea-bird	SBE38 Temperature	3854115-0488			2015.11.09
Sea-Bird	SBE38 Temperature	3853440-0416			2015.08.10
Sea-Bird	SBE45 TSG	4548881-0229			2015.08.13 (valid for 1y from 2015.10.20)
Valeport	Midas SVP	22356			2015.09.23 (2yr)
Valeport	Midas SVP	41603			2015.04.28 (2yr)

National Marine Facilities

Scientific Systems Technician Report

RRS *Discovery*
IMO: **9588029**
MMSI: **235091165**
Call Sign: **2FGX5**

Cruise: DY052 (Ellett Line)

by Jack McNEILL

8th of June - 24th of June 2016

This document describes systems maintained by NERC Scientific Systems Technicians

Revision History

Date	Version	Description	Author
2016.06.11	1.0	First draught	JM
2016.06.23	1.1	Final	JM

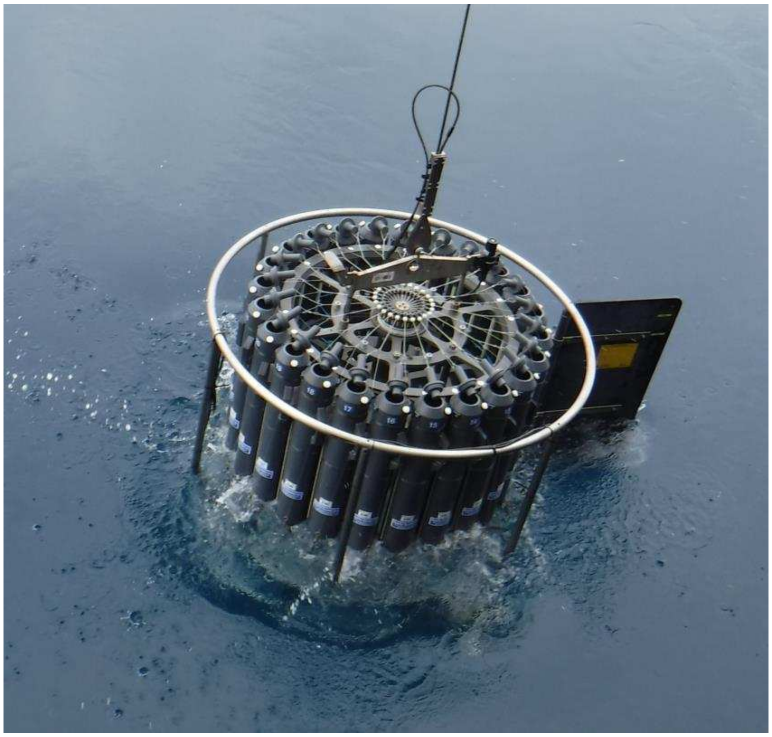

Fig 1. ***RRS Discovery*** **Ellet Line 2016, Port Glasgow to Vestermannaeyjar Islands, via Rockall**

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Table of Contents

1 Overview

The Ellet Line 2016, the previous Ellet Line was DY031 in 2015. The next two cruises are both OSNAP cruises with a stopover in Reykjavik.

1.1 Itinerary & Maps

Event	Date:YYYYMMDD/Day:hhhh	Summary	Lat. & Lon.
Start Date:	20160606/Mon:1400BST	Transit to Port Glasgow	12 hours by car
Sail Date:	20160607/Tue:0800UTC	Departed from PG at 07.00BST	55° 57.1'N 4° 47.2' W
Transit:	20160608/Wed	Vastermanaeyar Is. near Iceland	63° 18.9'N 20° 12.7' W
Station:	20160612/Sun	Due south along Ellet Line	62° 54.1'N 19° 34.8' W
Station:	20160615/Wed	Rockall Bank, Argo deployments	59° 57.7'N 19° 58.5' W
Station:	20160617/Fri	ESE towards Anton Doern seamt.	57° 34.4'N 13° 41.8' W
Station:	20160618/Tue	Rendezvous with RRS James Cook	
Station:	20160619/Sun	Glider pickup	57° 26.9'N 11° 03.2' W
Station:	20160620/Mon	Barra Islands	56° 43.4'N 7° 40.2' W
Station:	20160621/Tue	Isle of Coll & Ardnamurchan	56° 44.2'N 6° 26.6' W
Station:	20160622/Wed	Out again to Rockall-Hatton	57° 55.2'N 11° 04.7' W
Transit:	20160623/Thu:0900	Return to PG via Inner Hebrides	n/a
Dock Date:	20160624/Fri:1800	Moored alongside Port Glasgow	55° 57.1'N 4° 47.2' W
End Date:	20160625/Sat	Handover to ZN for DY053, DY054	

Weather Map

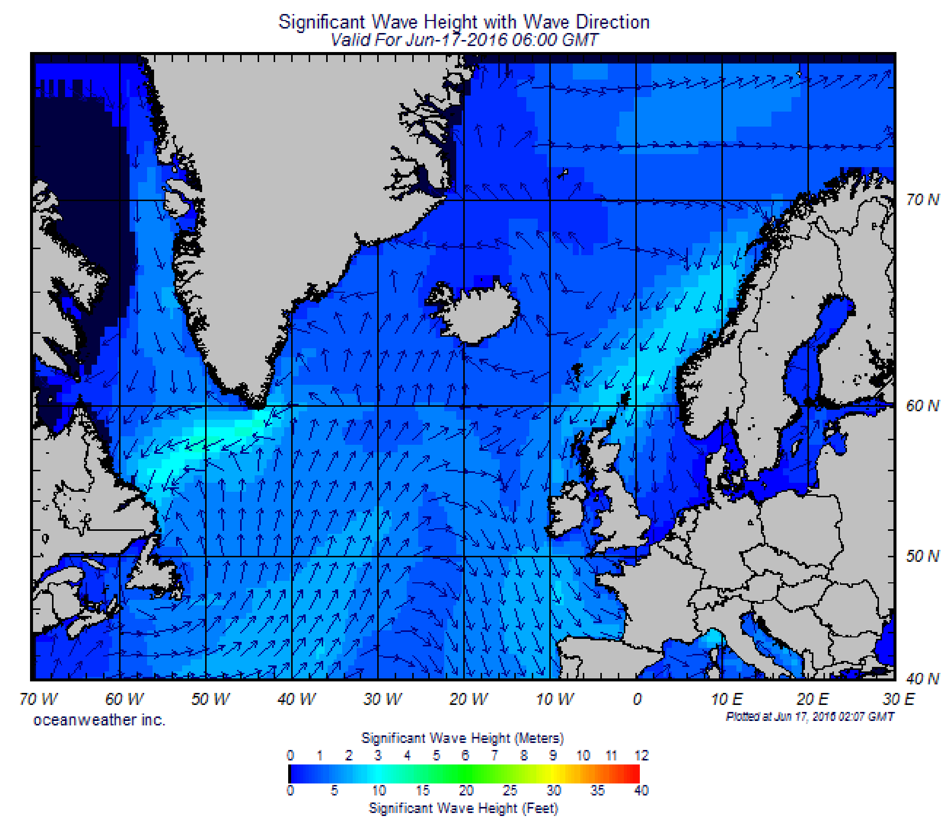

Fig 2. Mostly calm and clear,

Geographic Map

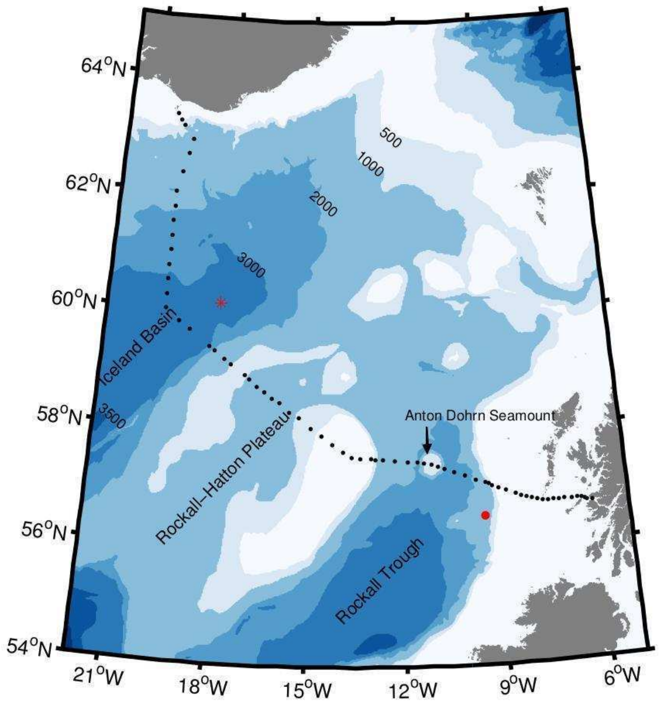

Fig 3. Port Glasgow to near Eyjafjallajökull in south-west Iceland via Rockall near Vestmannaeyjar Islands

1.2 Deployed Equipment

The equipment deployed for is as follows:

- Networking:
  - Servers**,** Computers**,** Displays, Printers, Network Infrastructure
  - A public network drive for scientists, updated via Syncback
- Datasystems:
  - IFREMer TechSAS logged data and converted it to **NetCDF** format
  - **NetCDF Format** given in: **dy052_netcdf_file_descriptions.docx**
  - **Logged Instruments** given in: **dy052_instrument_logging.docx**
  - Data was also logged to NERC/RVS Level-C format, also described in: **dy052_netcdf_file_descriptions.doc**
  - NERC software: Level-C; SurfMet Express; CLAM2016; SSDS3
  - Olex
- Hydroacoustics
  - Kongsberg echosounders (EM122, EM710, EA640, EK60)
  - Teledyne RDI (OS75, OS150)
- Telecommunications
  - GNSS & DGNSS (POS MV, PhINS; KB Seapath 330; CNAV 3050)
  - OceanWaves WaMoS II Wave Radar
  - DartCom Polar Ingester
  - NESSCo V-Sat; Thrane & Thrane Sailor 500 Fleet BroadBand
- Instrumentation
  - SurfMet MetOcean system: SWS Underway & Met Platform instrumentation

1.3 Personnel

Technicians

NERC Staff			
Senior Project Support (STO)	Jon	SHORT	jos@noc.ac.uk
Scientific Systems Technician	Jack	McNEILL	jmn@noc.ac.uk
Sensors & Moorings Technician	Colin	HUTTON	chut@noc.ac.uk
Guest Technicians			
SAMS Oceanographic Technician	Estelle	DUMONT	sa01ed@sams.ac.uk
Remote Technical Support			
Scientific Systems Technician	Martin	BRIDGER	mart@noc.ac.uk
Scientific Systems Technician	Zoltan	NEMETH	zome@noc.ac.uk
Scientific Systems Technician	Mark	MALTBY	mma@noc.ac.uk
Scientific Systems Technician	Lisa	SYMES	lisa.symes@noc.ac.uk
Teledyne RDI	Kevin	GRANGIER	kevin.grangier@teledyne.com
Teledyne RDI	Loïc	MICHEL	loic.michel@teledyne.com

Fig 4. Technicians and technical support

Crew

Deck		
Captain	Jo	COX
Chief Officer	Mike	HOOD
2nd Mate	Declan	MORROW
3rd Mate	Colin	LEGGETT
Chief Petty Officer, Deck	Greg	LEWIS
Chief Petty Officer, Science	Steve	SMITH
Petty Officer, Deck	Bob	SPENCER
Petty Officer, Science	Steve	SMITH
Seaman Grade 1A	Willie	McLENNAN
Seaman Grade 1A	Raoul	LAFFERTY
Seaman Grade 1A	John	HOPLEY
Seaman Grade 1A	Craig	LAPSLEY
Deck Cadet	Sam	NICHOLAIDIS
Engine		
Chief Engineer	Andy	LEWTAS
2nd Engineer	Geraldine	O'SULLIVAN
3rd Engineer (Fwd)	Ian	COLLIN
3rd Engineer (Aft)	Edin	SILAJDIC
Engine Room Petty Officer	Emlyn	WILLIAMS
Engine Cadet	Calum	DEACY
Auxiliary		
Electro-Technical Officer	Felix	BROOKS
Hotel		
Purser	Graham	BULLIMORE
Head Cook	Mark	ASHFIELD
Cook	Amy	WHALEN
Steward	Jeff	ORSBORN
Assistant Steward	Kevin	MASON

Fig 5. Crew list

Crew changes due on Saturday June 25th in Port Glasgow.

Scientists

Job Title	Hon.	Forename	SURNAME	Institution	E-Mail Address
PSO	Dr	Stefan	GARY	SAMS	sa01sg@sams.ac.uk
Cetacean Researcher	Dr	Clare	EMBLING	Plymouth	clare.embling@plymouth.ac.uk
Sr Marine Biogeochemist		Tim	BRAND	SAMS	sa01tb@sams.ac.uk
Sr Benthic Ecologist	Dr	David	HUGHES	SAMS	sa01dh@sams.ac.uk
Marine Chemist	Dr	Richard	ABELL	SAMS	sa01ra@sams.ac.uk
Met Office Scientist	Dr	Jon	TINKER	Met Office	jonathan.tinker@metoffice.gov.uk
Met Office Scientist	Dr	Rob	KING	Met Office	robert.r.king@metoffice.gov.uk
Data Scientist		Emma	SLATER	BODC	emmer@bodc.ac.uk
PhD Student		Liz	COMER	Southampton	ec10g10@soton.ac.uk
PhD Student		Leah	TRIGG	Plymouth	leah.trigg@plymouth.ac.uk
PhD Student		Winnie	COURTENE-JONES	SAMS	sa01wcj@sams.ac.uk
MSc Student		Martin	FOLEY	Glasgow	2039728f@student.gla.ac.uk
UG Student		Ashlie	McIVOR	UHI	13000201@uhi.ac.uk
UG Student		James	COOGAN	UHI	14003393@uhi.ac.uk
UG Student		Emily	HILL	UHI	emily.hill94@hotmail.co.uk
UG Student		Stacey	FELGATE	UHI	13002514@uhi.ac.uk

Fig 6. Scientist list

2 Requested Services

- Project Consumables: Stationery; Stationery Tools; Insulation Tape; Cables; Tags; Ties; Labels; Workshop Tools; Printer Ink.
- Telecoms, Network & Computing infrastructure: VSat; FBB; Exinda; Vigor; Cisco Switches & WAPS; BlackBox; DiscoFS; AMS; Squid; Desktop Computers; Printers.
- Datasystems: TechSAS; Level-C; CLAM; Olex; SSDS; VNC Nettops; Display PCs.
- Instruments: PySurfMet; PML's *Live* pCO_2;
- Hydroacoustics:
  - K-Sync
  - 150 kHz hull mounted ADCP system
  - 75 kHz hull mounted ADCP system
  - EM122 multi-beam echosounder for Sondes (CTDs)
  - EA640 single-bottom echosounder for Sondes (CTDs)
  - EK60 fish-finder echosounder (18kHz)
- SurfMet
  - Meteorology monitoring package
  - Pumped sea water sampling system
  - Sea surface monitoring system
- Ship scientific computer networking infrastructure

2.1 TechSAS & Hydracoustics

All acoustics, Wave Radar, TechSAS, Level-C (both Discovery1 & Enterprise), SWS (Underway), PCO2, POSMV software & PHINS logging, was turned off by 201606232100, as we approached the Irish EEZ on the return to Port Glasgow. This was done at the request of the PSO.

3 Data Acquisition Performance

All times given are in UTC.

3.1 Ship Scientific Datasystems

Data was logged and converted into NetCDF file format by the TechSAS datalogger.
The format of the NetCDF files is given in the file: **dy052_netcdf_file_descriptions.docx**
The instruments logged are given in **dy052_ship_instrumentation_overview.docx**.
Data was additionally logged in the RVS Level-C format, which is also described in: **dy052_netcdf_file_descriptions.docx**.

3.2 Position & Attitude

The main GNSS and attitude measurement system, Applanix POS MV was run throughout the cruise. Kongsberg Seapath 330 is not set up to log to TechSAS yet. iXBLue PhINS was logged from 2016.06.13:23.05 UTC.

3.2.1 Kongsberg Seapath 330

The Seapath is the vessel's primary GNSS, it outputs the position of the ship's common reference point in the gravity meter room. Seapath position and attitude was used by the EM122 (and by the EM710 when it was on). The system was turned off by the ETO on 2016.06.16:1520, and restarted on 2016.06.15:1842. Seapath Position and Heading was logged from 2016.06.8:13:28 in TechSAS.

3.2.2 Applanix POSMV

The POSMV is the secondary scientific GNSS, and is used on the SSDS displays around the vessel. TechSAS and Level-C only attitude data from the POSMV was logged from 2016.06.8:13:28 in TechSAS.
A TechSAS data logging module for the iXSea PHINS and Seapath 330 is under development.

3.2.3 C&C Technologies CNAV 3050

The POSMV is the tertiary scientific GNSS, and is located on the bridge. TechSAS and Level-C only attitude data from the CNAV was logged from 2016.06.8:13:28 in TechSAS.

3.2.4 PhINS

PhINS supplies the ADCP OS75 and OS150 with position and attitude data. iXBLue PhINS was logged from 2016.06.13:23.05 UTC.

3.3 Instrumentation

3.3.1 SurfMet & SBE45

Following changes to the serial connections, SurfMet ran without any malfunctions.
dy052_surfmet_sensor_information.docx for details of the sensors used and the calibrations that need to be applied.
Calibration sheets are included in the directory:
\Ship_Fitted_Scientific_Systems\MetOcean\SurfMet_metocean_system\SurfMet_calibration_sheets\fitted
Data is available in NetCDF in: **\Ship_Fitted_Scientific_Systems\TechSAS\SURFM**
The non-toxic water supply was active from before 2016.06.07:1536-1631.
TechSAS files are generated from 2016.06.07:09.00 to 2016.06.24:0?00. Data in Level-C starts from 2016.06.08:13:28.

3.3.1.1 SurfMet: Surface Water System & SBE45

The system operated normally throughout the cruise, in fact the flow rate was more stable than it has been in previous cruises.
SBE45 Thermosalinograph files now contain Conductivity, Temperature, and
There was some data loss on 2016.06.16:2000-2400 approximately; this is indicated by the slightly smaller file size in TechSAS around that time. NetCDF shows a restart time of 2016.06.15:18.54. Data in Level-C starts from 2016.06.08:13:28.

3.3.1.2 SurfMet: Met Platform System

No problems. The HMP155 temperature sensor (K0950056) on the Met Platform was replaced at the start of the cruise on 2016.06.06 (with K0950057).

3.3.1.3 SurfMet: PySurfMet.

The software operated normally throughout the cruise.

3.3.2 WaMoS II Wave Radar

Not requested, but logged locally, and in TechSAS. When data is logged, a summary of its output is given in the **PARA*.ems** files.

3.3.3 Gravity Meter

Not installed on the ship for this cruise.

3.4 Hydroacoustics

Generally worked well, apart from the OS75 VMADCP, which suffered from interference from an as yet unknown source (i.e.: apparently not from an echosounder at a similar frequency). Data is available in: **\Ship_Fitted_Scientific_Systems\Hydroacoustics**

3.4.1 Kongsberg EA640

10kHz and 12kHz both run in synch with K-Sync. Both transducers were turned off and on frequently to accommodate the 2kHz-250kHz passive hydrophone deployed off the back deck. Not normally logged, but logged mainly after June 11th and from the 13th.

3.4.2 Kongsberg EM710

Not requested, but some data logged, at the start of the cruise, and turned off long before reaching Iceland. This echosounder was not calibrated with an SVP dip, and was run purely to ensure the system is in good working order and to add data to the Olex map, and to provide depth for CTD Rosette deployments. Data logged from 2016.06.07:1559-1905 and 2008, and 2016.06.19:1409-2126. This was mainly to collect diagnostic data, but was turned off for periods to investigate possible interference with OS75 VMADCP. EM710 turned off again at 2016.06.21:1625 along with the SBP.

3.4.3 Kongsberg EM122

Not requested, but some data logged, at the start of the cruise, and turned off long before reaching Iceland. This echosounder was not calibrated with an SVP dip, and was run purely to ensure the system is in good working order and to add data to the Olex map, and to provide depth for CTD Rosette deployments.

3.4.4 Kongsberg SBP120

Not requested, tested briefly 2016.06.21:0132-1623, no usable data logged.

3.4.5 Kongsberg EK60

18kHz and 38kHz transducers were both run to collect data on the deep-scattering layer.
Data was logged from 2016.06.08:20.03 and restarted at 2016.06.11:1524; restarted again at 2016.06.15:1850 and from 2016.06.17:1959 and 2016.06.18:1434
38KHz was turned off on 2016.06.17:1959
Logged data is available in: **\Ship_Fitted_Scientific_Systems\Hydroacoustics\EK60**

3.4.6 Sound Velocity Profiles

Used manual setting of 1500m/s in the swathe. The opportunity to do an SVP dip was overtaken by other events, and there was no pressing science requirement to do this.

3.4.7 Teledyne RDI Ocean Surveyor ADCPs

ADCPs received GNSS data from the iXBLue PhINS system. There are no known faults on the VMADCPs or K-Sync, tests were done and passed at the start and end of the cruise.
Command files were applied according to details provided by e-mail and discussed prior to the cruise.
Data recorded from the OS75 before 2016.06.08:22.26 seems suboptimal, and may seem more optimal after this date and time, but there is no firm conclusion on this yet.
Data is available for the OS150 from 2016.06.08:14.17.

3.4.7.1 Ocean Surveyor 75kHz

No faults. The system operated normally throughout the cruise.
Data available at: **\Ship_Fitted_Scientific_Systems\Hydroacoustics \OS75kHz**
Data logged from 2016.06.07:20.00, for testing and tweaking the command file.
Data logged from 2016.06.08:22.00 with bottom tracking turned off in narrowband, 64 bins, 16m bin Size and 8m blanking distance, as requested by Dr Penny Holliday.
From the UHDAS processed data, it looks like when on DP, bubbles from the Aziprops contributed part of the interference seen. Another component of interference can be weather, this is evident in the latter few days of the cruise when the ship travelled WNW again.
On the morning of the 20th, there was a lot of noise being put into the water from many echosounders being turned on (not the SBP120) during that watch. There is no clear evidence of any interference from any other similar frequency source, such as EM710.

3.4.7.2 Ocean Surveyor 150kHz

No faults. The system operated normally throughout the cruise.
Data available at: **\Ship_Fitted_Scientific_Systems\Hydroacoustics\OS150kHz**
I used to 64 bins of 4m bin size, on narrowband mode; 8m blanking distance. The maximum number of bins is 128, the more you use, the slower the ping rate. There was no limited or no data in depths >1000m, which is to be expected.
Bottom tracking was turned on over near the coast of Iceland and Vastermannaeyjar, over Rockall Bank, and on the Hebridean shelf.

3.4.8 Sonardyne USBL

Not requested; no data logged.

3.5 Third Party Equipment

3.5.1 NMF/SE/Sensors & Moorings: CTD, LADCP, Salinometer

Jon Short has provided a CTD cruise report in the following location in the Data Disc:
\Specific_Equipment\CTD\documents