National
Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre

Cruise Report No. 34

RRS *Discovery* Cruise DY031

28 MAY – 18 JUN 2015
Southampton to Liverpool

The 40th Anniversary Extended Ellett Line

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2015

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ABSTRACT

Cruise DY031 was the 2015 annual occupation of the Extended Ellett Line, taking place 40 years after the start of the time series.

The Extended Ellett Line is a hydrographic section between Iceland and Scotland that is occupied annually by scientists from the National Oceanography Centre (NOC) and the Scottish Association for Marine Science (SAMS), UK. The measurement programme began as a seasonally-occupied hydrographic section in the Rockall Trough in 1975, building on early surface observations made underway from ocean weather ships. In 1996 the section was extended to Iceland, sampling three basins: the Rockall Trough, the Hatton-Rockall Basin and the Iceland Basin. These three basins form the main routes though which warm saline Atlantic water flows northwards into the Nordic Seas and Arctic Ocean. The section crosses the eastern North Atlantic subpolar gyre; as well as the net northward flow there is a large recirculation of the upper layers as part of the wind-driven gyre. During its passage through the region, the warm saline water is subjected to significant modification by exchange of heat and freshwater with the atmosphere. The two deep basins (Rockall Trough and Iceland Basin) contain southward flowing dense northern overflow waters, and Labrador Sea Water in the intermediate layers.

The specific objectives of cruise DY031 were:

To complete the annual Extended Ellett Line CTD section
To collect water samples for measuring biogeochemical properties including dissolved oxygen, nutrients, carbon and trace metals.
To collect underway measurements of surface currents, surface temperature and salinity, bathymetry, surface meteorology.
To complete epibenthic sled tows at a deep location in the central Rockall Trough.
To launch a seaglider for a related research programme (near Rockall) which will stay in UK or international waters.
To launch a second seaglider for a related research programme (near Iceland) which will operate in Iceland and Greenland waters.
To deploy 2 Met Office Argo floats along the CTD section

We successfully completed all of these objectives.

KEYWORDS

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Contents

1. Personnel

Scientific Personnel

Penny Holliday (PS)	NOC
Stefan Gary	SAMS
Geoff Stanley	Oxford University PhD student
Karen Wilson	SAMS
Hayley Mills	BODC
Eoghan Daly	NUI Galway undergraduate student
Tim Brand (lead)	SAMS
Richard Abell	SAMS
Caroline Kivimae	NOC
Lesley Salt	Roscoff
Nikki Clargo	NIOZ PhD student
Aikaterina Giamalaki	NOC PhD student
Caroline Mengeot	NOC MSc student
Emily Hill	SAMS undergraduate student
Natalia Serpetti	SAMS
Peter Lamont	SAMS
David Hughes	SAMS
Steph Allen	NOC PhD student
Paris Mudan	NOC MSc student
Jeff Benson	NMFSS Senior Technician
Zoltan Nemeth	NMFSS Scientific Systems Technician
Ian Murdoch	NMFSS Base engineering Technician
Rob Craft	NMFSS Sensors and Mooring Technician
Billy Platt	NMFSS Sensors and Mooring Technician

Figure 1. Scientific party on DY031 (sadly without Zoltan who was very busy elsewhere)

Ships Personnel

Antonio Gatti	Master
Jim Gwinnell	Chief Officer
Mike Hood	Second officer
Evelyn Voaden	Third officer
Richard Stoop	Chief engineer
Chris Uttley	Second engineer
Gavin Nicholson	Third engineer
Nick Franklin	Third engineer
Tom Brazier	ETO
Alan Rogers	J/ETO
Ian Watterson	Purser
Jon Hardy	Engine Cadet
Phil Allison	CPO-Deck
Mick Minnock	CPO-Science
Ian Cantlie	POD
Mark Moore	SG1A
Craig Lapsley	SG1A
Jarrod Welton	SG1A
Barry Edwards	SG1A
Brian Conteh	ERPO
Lloyd Sutton	Head Chef
Jacqui Waterhouse	Chef
Jane Bradbury	Steward
Dave Arkley	Assistant Steward

2. Cruise Narrative

Thursday 29 May 2015 - Day 148: Left NOC Southampton at 9am. Scientists given safety briefing at 8am. Sailed along south coast in good weather. VMADCPs (BT) and non-toxic started at 1100.

Friday 29 May 2015 - Day 149: Turned northwards past the Scilly Isles in early hours of the morning, moving into slightly lumpier seas. Non-toxic switched off for a few minutes at 1400 UTC to clean the transmissometer optics. Prior to the clean the readings had been extremely low (order 3V), afterwards they increased to a more normal ~4V.

Saturday 30 May 2015 - Day 150: Heading north through Irish Sea in better weather. Short detour into Firth of Clyde (Ayr) to meet small boat to retrieve CTD spares driven up from Southampton. Forecast looks grim for Sunday and Monday, possibly Tuesday too. Package collected from pilot boat at 14.10 UTC. Ships clocks moved back by an hour to UTC overnight into Sunday.

Sunday 31 May - Day 151: Steaming into heavy seas, high winds. Much seasickness all round. But heading towards IB23S as even stronger winds forecast for Scotland shelf seas

Monday 1 June - Day 152: 8.30am planning meetings started. Then at 9am a shakedown CTD station to 500m (CTD001). Training samplers, deck hands, winch handling, plus pressure testing CTD connectors. CTD section proper commenced with CTD002 at IB23S at 21.29.

Tuesday 2 June - Day 153: CTD section continuing. Winch electronic stopped unexpectedly at 1200m during CTD006. Re-started after 30 mins. Glider deployment (Knockando) in fine calm conditions at 12.30 after CTD006. Stayed slightly beyond deployment location for 30 mins while pilot in SAMS (Estelle Dumont) performed test dive. Moved off when glider reported as operating successfully.

Thursday 4 June - Day 155: CTD stopped at 500m on CTD012 at 14.30; water ingress in cable. Delay of 9.5 hours for re-termination and load test. Section recommenced with new cast CTD013 at same station position at 23.00.

Friday 5 June - Day 156: CTDs commenced with new termination. Winch has small scrolling issue but not affecting operations at the moment. Weather good - the delay last night might have worked in our favour regarding a low pressure system passing to the south and east of us, meaning we will catch only the edges of strong winds forecast over Rockall. Argo float deployed after CTD015 at 0937. CTD failed at again 1630 on Cast 16, at 1525m. Re-termination required again and lots of wire removed to find a dry stretch.

Saturday 6 June - Day 157: CTDs commenced with new termination (CTD18) at 02.00. Significant swell over night. New termination performing well, and winch scrolling issues resolved.

Sunday 7 June - Day 158: CTDs continue. Weather staying clear so progress is extremely good. PSO feels bold enough to plan for an extra station across the Hatton-Rockall Basin because we have plenty of time and a good weather forecast for the foreseeable future.

Monday 8 June - Day 159: CTDs continue. Second glider deployed successfully in the morning in calm conditions. Confirmation from base (SAMS) that glider is OK and we move off. World Ocean Day today. Went past Rockall in good weather in the afternoon, with clear views of the island and it's feathered inhabitants. Overnight we steamed back to near IB2 to start an extra section, stations X1 to X8. Wind picking up a little.

Tuesday 9 June - Day 160: Working CTD section X across Rockall-Hatton Basin. Wind around force 7 making steaming a little slow but CTDs continue. Steam back to Rockall and station A overnight. No carbon sampling on the X section, giving carbon team a rest and catch-up time. High resolution nutrient sampling at seafloor for silicate profile.

Wednesday 10 June - Day 161: Main Rockall Trough CTD section begun in earnest in the morning and with good views again of Rockall.

Thursday 11 June - Day 162: CTDs in the early hours, then 2 epibenthic sled tows starting at 9am. All went well. Return to station H to resume CTDs overnight.

Friday 12 June - Day 163: Back to M for the third and fourth epibenthic sled tows, starting at 8.30am. Again, CTDs overnight while benthic team rested. The combination of tows and CTDs works well in terms of time efficiency; CTD samplers and analysts able to more samples than would be possible with continuous CTDs.

Saturday 13 June - Day 164: CTDs in the morning, final tow in the afternoon. CTDs resume overnight

Sunday 14 June - Day 165: Beautiful sunny day. CTDs through the slope current and up onto the shelf; extra stations taken to best resolve the slope current.

Monday 15 June - Day 166: Finished shelf stations late afternoon. Last station was CTD085.

Tuesday 16 June - Day 167: Testing rescue boat off Oban in the morning, proceed to Liverpool. Underway carbonate samples from non-toxic carried on overnight.

Wednesday 17 June - Day 168: Clocks set to BST. Non-toxic turned off at 0820, alongside in Liverpool after lunch.

Thursday 18 June - Day 169: Demobilisation in the morning.

3. Cruise Track and Station Map

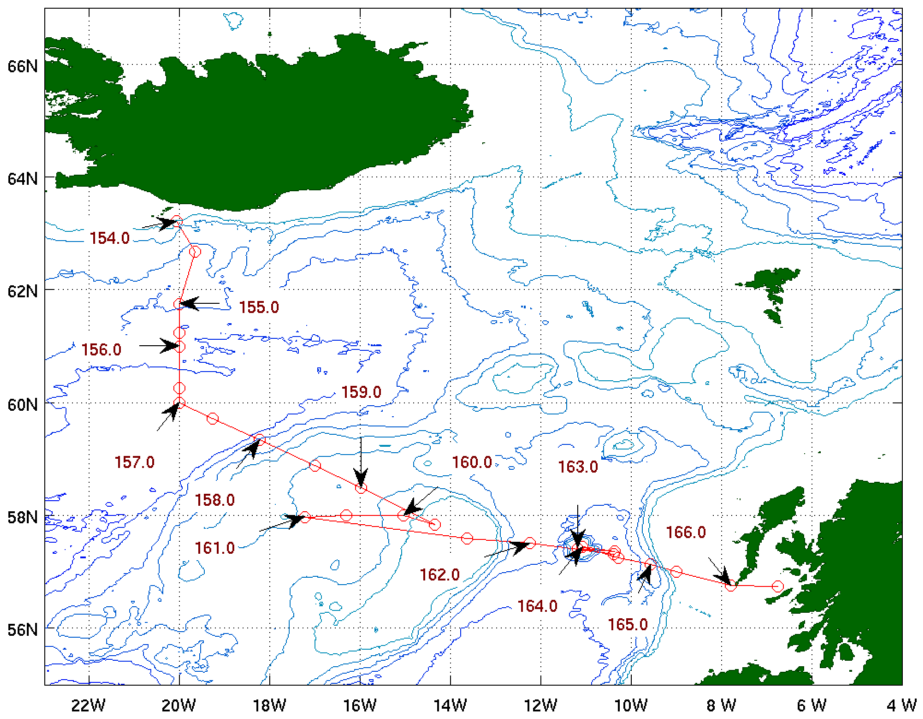

Figure 3.1. DY031 cruise track with JDay indicated (passage sections excluded)

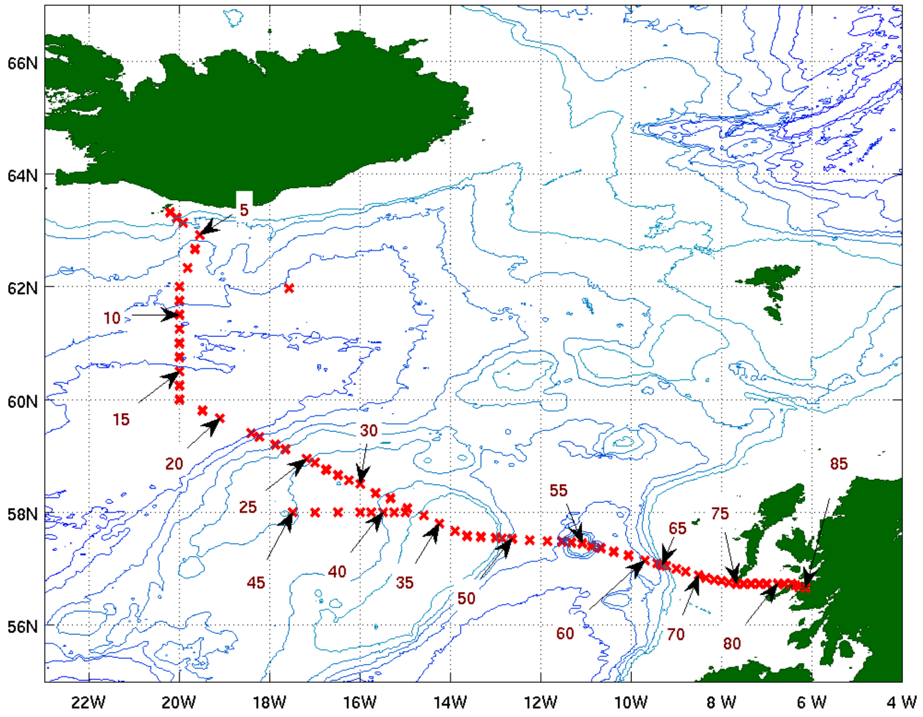

Figure 3.2 DY031 CTD station positions

Table 1: CTD Station list

stn	yy/mo/dd	hhmm	dg min lat	dg min lon	water depth (m)	alt (m)	max CTD depth	max wire out	max press	btls fired	sal	oxy	nut	DIC /TA	Comments	Stn code
1	15/06/2002	0936	61 58.44 N	17 34.60 W	2118	NaN	501	501	506	6	5	7	0	5	-	Test
2	15/06/2002	2139	63 18.96 N	20 12.84 W	130	6	122	120	123	6	6	5	7	6	EEL	IB23S
3	15/06/2003	0008	63 13.03 N	20 04.06 W	664	4	662	660	670	12	12	12	12	12	EEL	IB22S
4	15/06/2003	0312	63 08.05 N	19 54.96 W	1034	6	1030	1028	1043	14	15	13	14	14	EEL	IB21S
5	15/06/2003	0713	62 55.06 N	19 33.13 W	1397	8	1392	1384	1410	15	15	14	15	13	EEL	IB20S
6	15/06/2003	1051	62 40.10 N	19 40.01 W	1670	7	1670	1665	1693	19	19	18	19	14	EEL	IB19S
7	15/06/2003	1617	62 20.01 N	19 49.98 W	1786	5	1789	1786	1815	20	19	19	20	11	EEL	IB18S
8	15/06/2003	2045	62 00.00 N	19 59.94 W	1790	3	1794	1790	1820	18	18	18	18	12	EEL	IB17
9	15/06/2004	0046	61 45.01 N	19 59.97 W	1786	7	1785	1781	1811	16	16	17	17	12	EEL	IB16A
10	15/06/2004	0506	61 30.03 N	19 59.99 W	2203	11	2201	2197	2234	19	19	18	19	13	EEL	IB16
11	15/06/2004	0954	61 15.06 N	20 00.01 W	2358	9	2362	2357	2398	19	19	21	20	14	EEL	IB15
12	15/06/2004	1401	61 00.04 N	20 00.00 W	NaN	NaN	488	NaN	494	0	0	0	0	0	CTD fail	
13	15/06/2004	2358	61 00.00 N	20 00.02 W	2390	3	2393	2390	2430	20	20	22	21	14	EEL	IB14
14	15/06/2005	0354	60 45.02 N	20 00.05 W	2350	10	2351	2348	2387	20	20	22	20	19	EEL	IB13A
15	15/06/2005	0802	60 29.98 N	20 00.02 W	2517	6	2521	2517	2561	21	21	23	21	18	EEL	IB13
16	15/06/2005	1214	60 14.89 N	19 59.93 W	2630	5	2638	2638	2680	22	22	23	22	18	EEL	IB12A
17	15/06/2005	1617	59 59.86 N	20 00.00 W	NaN	NaN	1526	NaN	1546	0	0	0	0	0	CTD fail	
18	15/06/2006	0315	59 59.92 N	19 59.92 W	2705	7	2712	2728	2756	21	21	23	22	18	EEL	IB12
19	15/06/2006	0931	59 48.35 N	19 29.77 W	2695	5	2701	2718	2744	21	21	24	21	17	EEL	IB11A
20	15/06/2006	1350	59 39.94 N	19 06.87 W	2659	8	2662	2664	2705	23	23	24	23	20	EEL	IB11
21	15/06/2006	1920	59 24.07 N	18 24.98 W	2394	5	2397	2390	2434	19	19	0	20	19	EEL	IB10
22	15/06/2006	2249	59 20.05 N	18 14.07 W	1843	7	1844	1840	1870	17	18	20	18	16	EEL	IB9
23	15/06/2007	0223	59 12.01 N	17 52.96 W	1519	6	1519	1515	1539	17	17	18	17	17	EEL	IB8
24	15/06/2007	0519	59 06.99 N	17 39.95 W	972	6	971	966	983	13	13	15	14	13	EEL	IB7
25	15/06/2007	0900	58 56.92 N	17 11.02 W	891	5	891	887	902	13	13	15	13	13	EEL	IB6
26	15/06/2007	1125	58 52.98 N	17 00.00 W	1147	4	1150	1146	1164	16	15	17	15	13	EEL	IB5
27	15/06/2007	1424	58 45.39 N	16 44.93 W	1156	6	1153	1150	1167	16	16	18	16	0	EEL	IB4C
28	15/06/2007	1703	58 39.71 N	16 30.06 W	1199	6	1195	1192	1210	15	15	17	16	12	EEL	IB4B
29	15/06/2007	2010	58 34.00 N	16 14.88 W	1233	5	1213	1210	1228	15	15	17	15	0	EEL	IB4A
30	15/06/2007	2258	58 30.04 N	15 59.97 W	1185	3	1185	1183	1199	15	15	18	15	14	EEL	IB4
31	15/06/2008	0203	58 20.60 N	15 39.92 W	1154	6	1151	1148	1165	15	15	17	16	14	EEL	IB3A
32	15/06/2008	0436	58 14.97 N	15 19.88 W	656	6	651	648	658	11	11	13	11	11	EEL	IB3
33	15/06/2008	0722	58 04.30 N	14 57.57 W	560	5	555	553	561	10	10	12	10	8	EEL	IB2A
34	15/06/2008	0954	57 57.02 N	14 34.99 W	449	6	440	438	444	9	9	11	8	8	EEL	IB2
35	15/06/2008	1252	57 48.09 N	14 14.89 W	233	3	225	224	227	10	7	8	10	6	EEL	IB1A
36	15/06/2008	1508	57 40.00 N	13 53.91 W	154	3	145	144	146	9	6	8	9	6	EEL	IB1

stn	yy/mo/dd	hhmm	dg min lat	dg min lon	water depth (m)	alt (m)	max CTD depth	max wire out	max press	btls fired	sal	oxy	nut	DIC /TA	Comments	Stn code
37	15/06/2008	1702	57 34.93 N	13 37.95 W	118	3	108	108	109	9	9	8	10	6	EEL	A
38	15/06/2008	2311	58 00.02 N	14 59.90 W	568	4	560	559	566	13	10	12	13	0	X sectn	X1
39	15/06/2009	0118	58 00.04 N	15 14.91 W	641	4	634	632	641	14	11	13	15	0	X sectn	X2
40	15/06/2009	0339	58 00.07 N	15 29.96 W	887	4	884	879	894	16	13	15	16	0	X sectn	X3
41	15/06/2009	0635	58 00.03 N	15 44.98 W	1067	3	1064	1060	1077	18	15	17	18	0	X sectn	X4
42	15/06/2009	0943	58 00.08 N	15 59.98 W	1090	4	1087	1083	1100	19	16	18	19	0	X sectn	X5
43	15/06/2009	1348	58 00.05 N	16 29.95 W	1141	5	1136	1132	1150	19	16	18	19	0	X sectn	X6
44	15/06/2009	1754	57 59.99 N	17 00.01 W	1130	8	1119	1115	1132	19	16	18	20	0	X sectn	X7
45	15/06/2009	2214	58 00.03 N	17 29.91 W	732	5	723	720	731	16	12	6	15	0	X sectn	X8
46	15/06/2010	1148	57 35.01 N	13 38.04 W	118	5	108	107	109	6	6	8	6	3	EEL	A
47	15/06/2010	1335	57 34.04 N	13 19.93 W	183	7	169	169	171	7	7	9	7	7	EEL	B
48	15/06/2010	1533	57 33.05 N	12 59.87 W	302	8	290	289	293	9	9	11	9	8	EEL	C
49	15/06/2010	1713	57 32.53 N	12 51.95 W	1091	5	1091	1089	1105	15	15	17	16	14	EEL	D
50	15/06/2010	1954	57 32.01 N	12 37.99 W	1637	8	1629	1628	1651	15	15	17	16	14	EEL	E
51	15/06/2010	2321	57 30.52 N	12 14.95 W	1803	10	1791	1791	1816	18	18	21	18	16	EEL	F
52	15/06/2011	0238	57 29.49 N	11 50.90 W	1792	5	1785	1783	1809	18	18	21	19	16	EEL	G
53	15/06/2012	0206	57 28.97 N	11 31.94 W	2018	3	2013	2010	2042	20	20	21	19	17	EEL	H
54	15/06/2012	0442	57 27.98 N	11 19.00 W	756	NaN	748	750	756	12	12	14	12	12	EEL	I
55	15/06/2012	2335	57 26.97 N	11 05.02 W	592	NaN	584	585	591	16	10	12	11	10	EEL	J
56	15/06/2013	0123	57 23.99 N	10 52.03 W	791	NaN	780	780	789	13	13	15	13	12	EEL	K
57	15/06/2013	0336	57 22.03 N	10 39.94 W	2106	4	2115	2122	2145	19	0	21	19	16	EEL	L
58	15/06/2013	0647	57 17.98 N	10 23.04 W	2209	4	2204	2200	2236	20	20	22	20	17	EEL	M
59	15/06/2013	1004	57 14.00 N	10 03.03 W	2099	4	2097	2094	2127	20	20	22	19	17	EEL	N
60	15/06/2013	2216	57 08.97 N	9 41.97 W	1921	NaN	1917	1914	1943	18	16	19	16	17	EEL	O
61	15/06/2014	0122	57 05.99 N	9 25.04 W	1408	NaN	1415	1413	1433	15	15	17	16	13	EEL	P
62	15/06/2014	0340	57 05.00 N	9 20.99 W	997	6	1019	1017	1031	15	14	16	14	11	EEL	SC1
63	15/06/2014	0530	57 04.74 N	9 20.09 W	896	NaN	893	890	903	0	0	0	0	0	EEL	SC2
64	15/06/2014	0640	57 04.51 N	9 19.10 W	779	NaN	780	778	789	13	13	14	13	8	EEL	Q1
65	15/06/2014	0833	57 04.28 N	9 18.27 W	700	NaN	698	697	705	0	0	0	0	0	EEL	SC3
66	15/06/2014	0931	57 04.02 N	9 17.35 W	599	NaN	596	597	603	0	0	0	0	0	EEL	SC4
67	15/06/2014	1035	57 03.00 N	9 13.09 W	319	4	315	314	318	9	9	11	9	9	EEL	Q
68	15/06/2014	1209	56 59.99 N	9 00.05 W	134	NaN	124	123	125	6	6	8	6	6	EEL	R
69	15/06/2014	1339	56 56.97 N	8 46.93 W	129	NaN	119	118	120	6	6	7	6	6	EEL	S
70	15/06/2014	1526	56 53.01 N	8 29.95 W	130	8	120	120	121	7	0	8	6	6	EEL	15G
71	15/06/2014	1641	56 50.22 N	8 20.01 W	135	8	126	126	128	6	6	8	7	6	EEL	T
72	15/06/2014	1758	56 48.47 N	8 10.02 W	130	6	123	123	125	6	6	8	6	0	EEL	14G
73	15/06/2014	2025	56 46.99 N	8 00.05 W	124	8	113	113	114	6	6	8	6	6	EEL	13G
74	15/06/2014	2238	56 45.51 N	7 50.11 W	60	9	48	48	49	3	3	5	3	0	EEL	12G
75	15/06/2015	0043	56 44.00 N	7 40.02 W	65	4	60	59	60	5	4	6	5	0	EEL	11G
76	15/06/2015	0252	56 43.99 N	7 29.99 W	218	6	211	210	213	8	8	9	8	8	EEL	10G
77	15/06/2015	0507	56 44.03 N	7 20.05 W	161	5	155	154	156	8	0	10	8	6	EEL	9G

stn	yy/mo/dd	hhmm	dg min lat	dg min lon	water depth (m)	alt (m)	max CTD depth	max wire out	max press	btls fired	sal	oxy	nut	DIC /TA	Comm- ents	Stn code
78	15/06/2015	0717	56 44.00 N	7 09.98 W	176	4	170	169	172	8	0	10	8	0	EEL	8G
79	15/06/2015	0925	56 43.99 N	7 00.06 W	139	4	134	133	135	7	0	9	7	7	EEL	7G
80	15/06/2015	1135	56 44.01 N	6 45.05 W	38	4	35	34	36	4	0	6	4	0	EEL	6G
81	15/06/2015	1309	56 44.03 N	6 35.97 W	79	8	69	68	69	5	0	7	5	5	EEL	5G
82	15/06/2015	1440	56 44.06 N	6 26.95 W	92	8	86	85	87	4	0	6	4	0	EEL	4G
83	15/06/2015	1604	56 42.54 N	6 21.92 W	77	8	66	65	66	4	0	6	5	4	EEL	3G
84	15/06/2015	1750	56 41.00 N	6 17.00 W	40	9	31	30	31	2	0	4	2	0	EEL	2G
85	15/06/2015	1934	56 40.03 N	6 08.07 W	173	10	171	170	172	7	0	8	7	7	EEL	1G

4. NMF-SS sensors report

Jeff Benson, Rob Craft, Ian Murdoch, Billy Platt

4.1 CTD system configurations

One CTD system was prepared. The water sampling arrangement was a 24-way stainless steel frame system (s/n SBE CTD1), and the initial sensor configuration was as follows:

Sea-Bird 9plus underwater unit, s/n 09P-39607-0803
Sea-Bird 3P temperature sensor, s/n 03P-4116, Frequency 0 (primary)
Sea-Bird 4C conductivity sensor, s/n 04C-3529, Frequency 1 (primary)
Digiquartz temperature compensated pressure sensor, s/n 93896, Frequency 2
Sea-Bird 3P temperature sensor, s/n 03P-4381, Frequency 3 (secondary)
Sea-Bird 4C conductivity sensor, s/n 04C-4065, Frequency 4 (secondary)
Sea-Bird 5T submersible pump, s/n 05T-5247, (primary)
Sea-Bird 5T submersible pump, s/n 05T-6320, (secondary)
Sea-Bird 32 Carousel 24 position pylon, s/n 32-31240-0423
Sea-Bird 11plus deck unit, s/n 11P-34173-0676 (main)
Sea-Bird 11plus deck unit, s/n 11P-24680-0589 (back-up logging)

The auxiliary input initial sensor configuration was as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 43-0363 (V0)
WETLabs light scattering sensor, s/n BBRTD-1055 (V2)
Benthos PSA-916T altimeter, s/n 59493 (V3)
Chelsea Alphatracka MKII transmissometer, s/n 161048 (V4)
Chelsea Aquatracka MKIII fluorometer, s/n 88-2615-124 (V5)

Additional instruments:

TRDI Workhorse 300kHz Monitor LADCP, s/n 15288
NOCS LADCP battery pack pressure case, s/n WH009T

Sea-Bird 9plus configuration file DY031_ss_NMEA.xmlcon was used for the stainless steel frame CTD casts.

Total number of casts – 85 S/S frame.
Casts deeper than 2000m - 14 S/S frame.
Deepest cast - 2700m S/S frame.

4.2 Technical detail report

On CTD cast DY031_007, rosette position 1 ‘fired’ properly, but did not release the end-cap successfully. SBE 32 Carousel inspected for any problems; none found, and no further release failures occurred. Position 1 was duplicated whenever possible as sampling depths allowed.

During deployment DY031_012, the termination had a hard short circuit at 550m on the downcast. After the CTD was recovered to deck, the subsequent ‘megger’ test revealed resistance of less than 0.1 MOhm. The termination was removed, and ‘meggered’ to >999 MOhm. 30m of seacable was removed, ‘meggered’ to infinity again, and re-terminated. Following the load tests it was noted the termination now ‘meggered’ only to 30 MOhm. As this was deemed to be sufficient for operations (suspected ScotchKote not completely cured), CTD deployments were resumed. Subsequent ‘meggering’ revealed deterioration to 10 MOhm or less, and during DY031_017, another hard short circuit occurred at 1525m on the downcast. The same procedures as above were followed after recovery to deck, and seawater was observed in large quantities emerging from the seacable after 30m was removed. Sections of the seacable were then cut off at 100m intervals, with periods of 20 minutes in between removals to observe if any seawater had “wicked” up the centre conductor. Also noted was any oxidation or discolouration of the copper core. Approximately 567m in total of seacable was removed before the conductor was found to be clean, shiny and dry. The seacable was ‘meggered’ to >999 MOhms, re-terminated, periodically ‘meggered’ and checked for internal DC resistance. Final results were infinity and 75 Ohms respectively. The seacable was then checked after every deployment in deep water: ‘meggered’, torque adjustments & removal of twists from the seacable.

A small fish was sucked into secondary temperature and conductivity pair during deployment DY031_052, on downcast at approximately 1681m. The fish was removed once the CTD frame was on deck, and the sensors were flushed with Milli-Q.

LADCP:

No log file was recorded for cast DY031_027.

No data file was recorded for cast DY031_051.

LADCP battery pack was not taking a charge properly, and was swapped over for the spare battery pressure case, s/n WH010T, beginning with cast DY031_061.

Intermittent communications problems were noted prior to cast DY031_080, and the 25m comms lead was switched to the spare. No further communications issues were noted, and the suspect cable will be repaired.

The LADCP was not deployed for cast DY031_084 as per PSO instructions.

4.3 AUTOSAL

A Guildline 8400B, s/n 71126, was installed in the Salinometer Room as the main instrument for salinity analysis. A second Guildline 8400B, s/n 71185, was installed in the Salinometer Room as a spare instrument. The 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 decreasing, beginning with number 999. Standard deviation set to 0.00002.

4.4 Configuration files

Stainless CTD frame:

Date: 06/01/2015

```
Instrument configuration file: C:\Program Files\Sea-
Bird\SeasaveV7\DY031\DY031_ss_NMEA.xmlcon *

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

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

1) Frequency 0, Temperature

   Serial number : 03P-4116
   Calibrated on : 3 October 2014
   G            : 4.42599648e-003
   H            : 6.84468698e-004
   I            : 2.45010956e-005
   J            : 2.02814677e-006
   F0           : 1000.000
   Slope        : 1.00000000
   Offset       : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-3529
   Calibrated on : 8 July 2014
   G            : -9.91693851e+000
   H            : 1.56970936e+000
   I            : -2.17106254e-003
   J            : 2.66056853e-004
   CTcor        : 3.2500e-006
   CPcor        : -9.57000000e-008
   Slope        : 1.00000000
   Offset       : 0.00000
```

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 93896
Calibrated on : 9 July 2014
C1 : -8.331332e+004
C2 : -3.281962e-001
C3 : 2.216060e-002
D1 : 2.906000e-002
D2 : 0.000000e+000
T1 : 3.005232e+001
T2 : -3.843669e-004
T3 : 4.436390e-006
T4 : 0.000000e+000
T5 : 0.000000e+000
Slope : 1.00001000
Offset : -1.35810
AD590M : 1.289250e-002
AD590B : -8.106440e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-4381
Calibrated on : 3 July 2014
G : 4.42350675e-003
H : 6.44751744e-004
I : 2.25650461e-005
J : 1.95574043e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-4065
Calibrated on : 10 April 2014
G : -9.85383685e+000
H : 1.48716606e+000
I : -2.32226903e-003
J : 2.56674485e-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 : 43-0363
Calibrated on : 22 July 2014
Equation : Sea-Bird
Soc : 4.33000e-001

Offset : -5.02900e-001
A : -3.68140e-003
B : 1.85440e-004
C : -2.74870e-006
E : 3.60000e-002
Tau20 : 1.24000e+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-1055
Calibrated on : 13 March 2013
ScaleFactor : 0.002365
Dark output : 0.061000

9) A/D voltage 3, Altimeter

Serial number : 59493
Calibrated on : 25 March 2013
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, Fluorometer, Chelsea Aqua 3

Serial number : 88-2615-124
Calibrated on : 21 January 2015
VB : 0.463400
V1 : 2.044300
Vacetone : 0.474400
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

11) A/D voltage 5, Transmissometer, Chelsea/Seatech

Serial number : 161048
Calibrated on : 24 July 2012
M : 24.0022
B : -0.1613
Path length : 0.250

12) A/D voltage 6, Free

13) A/D voltage 7, Free

```
* - The configuration was changed after the file was opened.
Scan length              : 45
```

LADCP command file:

```
CR1
RN J302M
WM15
TC2
LP1
TB 00:00:02.80
TP 00:00.00
TE 00:00:01.30
LN25
LS0800
LF0
LW1
LV400
SM1
SA011
SB0
SW5500
SI0
EZ0011101
EX00100
CF11101
CK
CS
```

5. NMF-SS scientific systems

Zoltan Nemeth

Data was logged and converted into NetCDF file format by the TechSAS datalogger. Data was additionally logged in the RVS Level-C format.

TechSAS was started 201505261053.

5.1 Position & attitude

The main GNSS and attitude measurement system, Applanix POS MV was run throughout the cruise.

The Kongsberg Seapath 330 is the vessel’s primary GPS: it outputs the position of the ship’s common reference point in the gravity meter room. Seapath position and attitude was used by the EM System.

The Applanix POSMV is the secondary scientific GPS, and is used on the SSDS displays around the vessel. A TechSAS data logging module for the iXSea PHINS and Seapath 330 is under development.

PhINS supplies the ADCP OS75 and OS150 with position and attitude data. Connection for the PhINS was lost on occasion:

Lost Connections	from 2015.05.30 jd150 23:18 to 2015.05.31 jd151 07:33
	from 2015.06.12 jd163 20:06 to 21:08
	from 2015.06.15 jd166 04:43 to 05:59

5.2 SurfMet

Following changes to the serial connections, SurfMet ran without any problems.

The Surface Water System was cleaned on 201505272200 and rinsed with freshwater.
The non-toxic water supply was active from 201505281100 to 201506170730.
The transmissometer optic cleaned on jd149 201505291600-1605.
The fluorimeter cleaned on JD162 201506110710-0728.
The whole system cleaned after end of the cruise on JD168 20150617-0830.
We had some low flow rate issues, especially when the ship start/stop moving. I want to add an electric flowmeter/controller to the system, after the TSG outlet and logging the flow rate with TechSAS.

SurfMet: Met Platform System
Portboard TIR sensor (047463) swapped with a freshly calibrated sensor (973134) on 201505271600.

SurfMet: PC Express
20150529 jd149 17:00-18:39 spar, ppar, stir, ptir data invalid.
Met Platform Nudam6018 error.

5.3 Hydroacoustics

Generally worked well.

Kongsberg EA640 (Echosounder)
10kHz run at most of the times;
When the system run with fixed 1500m/s mode or if the new Sound Velocity Profile was not applied to the system (late night or very early morning) the offset between the EM122 middle beam depth and the EA640 depth was higher, so I decided to use the closest SVP profile in the system.

Kongsberg EM122 (Swath Bathymetry)
When the ship was in DP mode in station, I started a new line, also started a new line when the ship was in transit between two station, but because the science was 24/7 sometimes I was unable to start new lines. When we are moved a different area new sound velocity profile added to the system. Once I’m compared the CTD sensor extracted (Chen-Millero) profile with the Valeport SVP profile, I don’t found real difference between this two, so after the system applied profiles most of the times from the CTD sensor. SVP was taken at several stations (CTDs 01, 06, 10, 17, 18, 34, 42, 50, 53, 58, 61, 76).

5.4 Teledyne RDI Ocean Surveyor ADCPs

Ocean Surveyor 75kHz:
JD 153 20150603:0840 the beam4 failed. The transducer cable reattached and put it back it's solved the problem, but some reason the VMDAS was unable to run with K-sync. Later the two trigger cable swapped and it's revealed the faulty OS75 cable or BNC connector caused the problem. Tests in port at the end of the cruise also showed Beam4 failures.

Ocean Surveyor 150kHz:
On JD161 20150610 from 10:16 to 18:27 the system do not recorded ensembles for unknown reason. On 18:27 the VMDAS restarted, and the system was worked well again.

5.5. Others

CLAM – Cable Logging And Management System: No problems.

DartCom Live PCO2:
Used, and looked after me on this cruise.
JD149 201505291016 I got a low flow rate alarm in all three standard cylinders.
Empty cylinders are replaced with full one, except the 380pp, because the spare cylinder was also empty. On JD157 I found the Metlab flooded with water, I closed the tap. Probably the scupper not sealed properly, currently it is under investigation. On JD160 I open the seawater tap again, so far no more flooding occurred. During the refit the engineers want to cut the scupper, eliminate the problem. At the end of the cruise sometimes I got low equilibrator air flow alarms, I'm going to clean the pipe when we are in port. Otherwise the system worked well. The seawater flow closed on JD167 20150617 07:30, I let open the cylinders and let run the system, because the relatively short ports of call before the next scientific cruise DY032.

6. CTD data processing

Penny Holliday, Stefan Gary

6.1 Introduction and overview

The CTD used on DY031 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 near the bottom of the CTD frame, under the Niskin bottles, and on inside of the SeaBird 9+ underwater unit. The second pair of sensors, T_2 and C_2, 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.

Both sets of sensors performed reliably throughout the course of the cruise but it is the fin-mounted sensors, T_2 and C_2 which will be considered as the primary sensors for almost all casts. It is believed that the sensors on the fin will provide the cleanest data because there are fewer obstructions (CTD frame bars and other instruments) in the vicinity of the fin-mounted sensors. It has been shown, and observed on this cruise (Figure 6.1), that small eddies, similar to a von Karman vortex street, can be shed from the CTD frame. CTD frame elements are relatively close to the intake for the T_1 and C_1 sensors, on the order of ~10 cm. The 24 Hz sensor sampling rate is fast enough to resolve these eddies as they cross the path of the sensors, which appear as a periodic deviation between the two temperature and salinity sensors. These deviations are sometimes still clearly visible even when the data are smoothed to 1 Hz. During these deviations, temperature and salinity anomalies are in phase which means that T_2 and C_2 have the potential to measure slightly different water than that measured by T_1 and C_1 at each instant. Furthermore, since T_1 and C_1 stay in phase, the *T-S* relationship and density measured by T_1 and C_1 still remains very similar to the *T-S* relationship of T_2 and C_2. Therefore, both sets of sensors produce very similar results once the raw data have been averaged to 2 dbar.

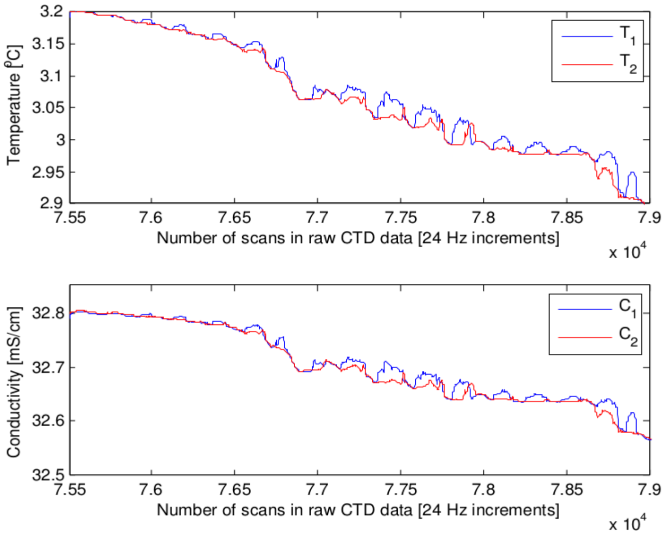

Figure 6.1: Example of periodic deviations between CTD frame mounted sensors T_1 and C_1 and fin-mounted sensors T_2 and C_2. These deviations are believed to be due to the CTD frame-mounted sensors measuring eddies shed from the CTD frame elements. This example is drawn from station 11, in the middle of the Iceland Basin.

The fin-mounted sensors, T_2 and C_2, are the primary sensors for the cruise dataset except for stations 42 and 52. On station 42, there was a substantial deviation in C_2 near the bottom of the downcast compared to C_1 as well as data from other nearby stations. Close inspection also revealed a synchronous, warm offset in T_2. This deviation resulted in a very clear outlier in a *T-S* diagram. Whatever was ingested into the fin-mounted sensors cleared through the system just before the bottom of the cast. During the upcast, no anomalous behaviour was observed for T_2 and C_2 compared to the other sensors or data from other casts. For station 52, a small fish became lodged in the intake port for the fin-mounted sensors near the bottom of the downcast. The fish impacted T_2 and C_2 for the rest of the cast until the CTD was recovered the fish was removed from the intake port. The fish was easily removed by hand from the intake port and data from subsequent stations appear unaffected.

Another anomalous CTD event to note was that on cast 60 the lanyard for bottle 15 was trapped in the bottle lid during closure. This bottle was not sampled. The CTD termination failed on two stations: 12 and 17. In both cases, the termination failed on the downcast, so there were no bottled fired. Both stations were reoccupied with casts 13 and 18. The failed casts' data was saved and the salinity and oxygen calibrations discussed below were applied to this data. However, since the cast was incomplete, the processing the 2 dbar averaged data was not possible because the downcast was not complete.

6.2 Seabird processing

The first stage of processing of the CTD data was with the SeaBird SeaSave software package. 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 hysterisis 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 = xmiss: Beam Transmission, Chelsea/Seatech/WET Labs CStar [%]
# 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
```

Next, the Align CTD option aligns the oxygen sensor in time relative to pressure and writes the output to a new file. 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 (**dy031_NNN_actm.cnv**). All the Seabird data files were copied to the DY031 ship's public server, and copied to workstation ERIU using the c-shell **ctd_linkscript**.

6.3 Initial mexec processing

MEXEC uses some template files to define the variables in sample files (**sam_dy031_varlist.csv**) and CTD variable names (**ctd_dy031_renamelist.csv** and **ctd_dy031_renamelist_out**). These were edited at the start of the cruise.

At this stage, the CTD data are ready to be read into MEXEC for additional processing. The standard MEXEC 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 MEXEC 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. 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 MEXEC 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. The sensors exhibited remarkable stability in time and with respect to their calibrations so the only manual intervention throughout the cruise, with the exception of the large deviations described previously for stations 42 and 52, 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 1-5 scans at 24 Hz), that was not reflected by a similar dip in temperature. These spikes were changed to NaN values via a graphical user interface in **mctd_rawedit**. 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.
mctd_makelists was run to create ascii listings used in LADCP processing, and for providing key CTD variable to chemists.

As header information for the CTD data files became available, the information in the files were updated through the following steps:

- **mdep_01.m** requires a matlab file (**station_depth_dy031.mat**) containing water depth in variable 'bestdeps'. On DY031 this information came from the LADCP data files where it existed. Where there was no LADCP the depth was left as NaN. mdep_01.m pastes this information into headers of all CTD files.

- **mdcs_04.m** takes the lat and lon from the navigation (**posmv_dy031_01**) at the time of start, bottom and end of each cast and pastes into **dcs_dy031_nnn_pos.nc**. **mdcs_05.m** pastes the lat and lon for the bottom of the cast into the headers of all CTD files. **msam_putpos.m** pastes the lat and lon into the header of the sam files.

6.4 Oxygen hysteresis adjustment

The oxygen sensor shows a time-dependent hysteresis, manifesting as a difference in the oxygen up cast and down cast values. At the first deep CTD stations on DY031 the size of this difference in deep, low stratification water (Labrador Sea Water, 1000-1800m) is 5 umol/kg.

We can adjust parameters in mctd_02b to reduce this difference. The approach is to make adjustments to the params and examine the difference it makes to the profile. Examples of params used by previous cruises/operators are recorded in mctd_02b and are a good starting point.

The process was:
i. make a back up copy of ctd_dy031_011_1hz.
ii. make adjustments to parameters in mctd_02b_dy031.m
iii. run mctd_02b (creates new 24hz file , then mctd_03 to make new 1hz)
iv. mload ctd_dy031_011_1hz_bak, save data as "d"
v. mload ctd_dy031_011_1hz, save data as "d2"
vi. plot(d.press, d.oxygen,'b'); hold on; plot(d2.press,d2.oxygen,'r');
vii. Repeat until you are satisfied that the upcast completely overlays the downcast in deep, well-mixed waters, and as much as the upper water column as possible.
viii. Delete the spare 1hz file and re-run the CTD processing from ctd_02b.m for all existing files - the new params will be used in all future files too.

```
mctd_02b
mctd_03
mctd_04
mfir_03
mfir_04
```

(easiest to use smallscript.m to do this)

6.5 Oxygen sample files and CTD oxygen calibration

Once the bottle oxygen values had been measured (see section 12) they were written into spreadsheets for ingesting into mexec sample files. The process followed was:

i. Prepare ascii files.
One per cast, on DY031 the filename must be in the form:

Oxy_StationNNN.csv

Headings in the text file must be:

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

ii. Make sure **/mnt/public** is actually mounted
iii. in /ctd/BOTTLE_OXY

oxy_linkscript

Copies the data from Public/oxygen_spreadsheets and creates a symbolic link with the filename that the next step requires
iv. Read the text file into an mstar file

moxy_01 (output is **oxy_dy031_nnn.nc)**

This script can successfully run but still fail to read the data in correctly - scroll up the screen and make sure that the numbers in the .nc file are correct.

v. Paste the bottle file into the master sample file for that station

moxy_02
Inputs: sam_dy031_NNN.nc and oxy_dy031_NNN.nc
Output: **sam_dy031_NNN.nc**

Again its worth checking here that the numbers are correct and in the right place.

vi. Calculate a new bottle oxygen in units that match the CTD data stream umol/kg. This uses the CTD salinity and the bottle oxygen fixing temperature.

msam_oxykg
Input: sam_dy031_NNN.nc
Output: **sam_dy031_NNN.nc** with variable botoxy

Once all the oxygen data were successfully read into the sample files, we appended all station sample files into a master file, **sam_dy031_all.nc,** using mpapend. This file was then examined using a simple script to generate diagnostic plots showing the relationship between bottle oxygen and ctd oxygen (**ctd_evaluate_oxygen**). From these plots we established that there was a simple linear correction that could be made to CTD oxygen, followed by a small pressure correction (Figures 6.2 and 6.3).

To establish a calibration of CTD oxygen, the process was:

i. calculate the bottle minus CTD residuals

ii. calculate the mean and standard deviation of the residuals.

iii. Excluding residuals larger than mean±1sd, derive the coefficients for y = mx + c, where y is calibrated CTDO, x is uncalibrated CTDO.

iv. Apply the calibration and determine the slope of the pressure correction.

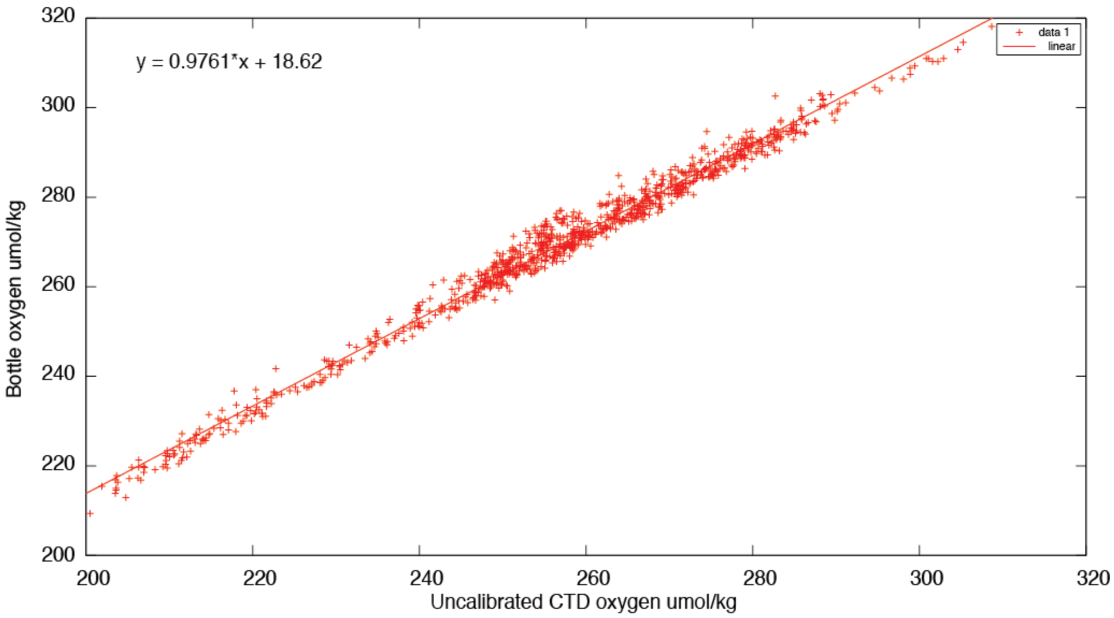

Figure 6.2 Uncalibrated CTD oxygen vs. bottle oxygen, with residuals larger than mean±1sd excluded.

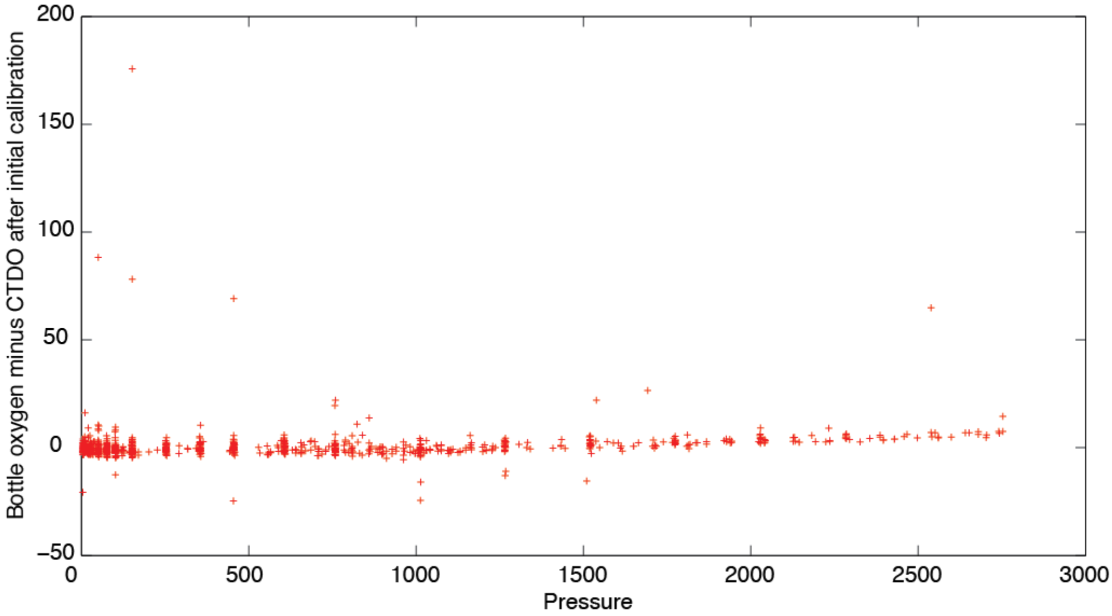

Figure 6.3 Bottle minus CTDO residuals (after initial fit applied) plotted against pressure.

To apply the calibration to all CTD data files, edit **oxy_apply_cal** which is called by **mctd_oxycal**. **mctd_oxycal** was run on all CTD stations, followed by the standard steps **mctd_04, mfir_03** and **mfir_04**.

6.6 Salinity bottle samples and conductivity calibration

In the case of the conductivity calibration, the conductivity observation for each bottle was subtracted from the conductivities measured by the primary and secondary conductivity sensors. The residuals between the bottle data and the primary and secondary sensors was plotted versus station number and pressure to check for any possible temporal drifts or pressure effects on the conductivity calibration. Neither a time nor pressure dependence was detected, possibly because the deepest cast on DY031 was less than 3000 m. However, there was a slight constant offset between the conductivity in both sets of CTD sensors and the bottle data. After removing all CTD minus bottle residuals that fell outside of a +/- 2 standard deviation envelope around the mean residual, the mean residuals were recomputed as 0.0008 mS/cm and 0.0018 mS/cm for the secondary and primary sensors, respectively. A similar average residual was derived for only data below 1000 m resulting in offsets of 0.0013 +/- 0.003 and 0.0021 +/- 0.008, which are not substantially different from the offsets computed from all data.

Since there was no pressure or temporal variation in the conductivity residuals, the conductivity calibration for both C_1 and C2 was decided to be simply a constant offset using the offsets derived from all residuals (shallow and deep). This offset was applied to the data in MEXEC 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**.

7. Vessel Mounted ADCP processing and calibration

Penny Holliday and Eoghan Daly

The *Discovery* has two VMADCPs; the 150 kHz and the 75 kHz. Both were switched on at the start of DY031. There are many acoustic instruments on the ship and their operation is coordinated through the k-sync system. Early on in the cruise the two VMADCPs were placed into different pinging groups in k-sync. The Teledyne OS interference sheet indicates that the GDS102 (shallow water navigational echo sounder) causes interference with the OS150, so we requested that the Bridge switch that off on day 153.

Early processing of the underway data indicated that there were no good water tracking data being recorded. We had been experiencing bad weather and that was considered a possible reason for the data drop out. However as the weather improved, the data did not. Adjusting k-sync did not improve the data, nor did switching off the GDS102. A pre-deployment check on the OS75 at 0830 on day 154 indicated that Beam 4 had failed. A subsequent check revealed the Beam passed all tests, but the only way to get good data was to allow it to run freely, outside of the k-sync framework. ZN was in contact with Teledyne, who suggested some alterations to the command files to correctly apply the misalignment angle (EA=4500) and to activate water pings. After these changes, both instruments began producing reasonable data, although inspection of the 75kHz data suggests that there was large amounts of poor quality bins.

All of these issues in the first few days led to multiple re-starting events and therefore a slightly confusing list of filenames. We copied and kept all raw data files produced from both instruments, but only kept the processed files which contained good and usable data. Those files are given in Tables 7.1 and 7.2.

Table 7.1 Data file information for the 150 kHz VMADCP. All files run within k-sync.

File no.	Start	End	Comments
69	4/6 18:16	5/6 08:54	
70	5/6 08:54	6/6 08:43	
71	6/6 08:43	7/6 08:49	
72	7/6 08:50	8/6 03:51	
73	8/6 03:56	9/6 08:46	BT on
74	9/6 08:56	10/6 08:51	BT on
75	10/6 08:57	10/6 10:17	BT on
76	10/8 18:31	11/6 08:46	
77	11/6 08:54	12/6 09:14	
78	12/6 09:23	13/6 08:48	BT on
79	13/6 08:56	14/6 08:11	BT on
80	14/6 08:20	15/6 08:50	BT on
81	15/6 08:57	16/6 09:16	BT on

Table 7.2 Data file information for the 75 kHz VMADCP. All files are instrument free-running (ie no k-sync).

File no.	Start	End	Comments
102	4/6 19:15	5/6 08:54	
103	5/6 08:59	6/6 08:39	
104	6/6 08:49	6/6 12:24	
120	6/6 12:37	7/6 08:47	
121	7/6 08:53	7/7 19:48	
128	8/6 04:09	9/6 08:49	
129	9/6 08:56	10/6 08:51	
131	10/6 08:59	11/6 08:49	BT on
133	11/6 08:57	12/6 09:17	BT on
134	12/6 09:19	13/6 08:52	BT on
135	13/6 08:52	14/6 08:16	BT on
137	14/6 08:27	15/6 08:47	BT on
138	15/6 08:57	16/6 09:12	BT on

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‘.***

eg for file 128:

```
> /bin/rm ./rawdata/*128*
and
> /bin/rm -r rawdata128
> /bin/rm -r dy031128nbenx
```

Now copy the new data files:

```
vmadcp_linkscript150
```

This 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 v75
```

```
> /bin/rm ./rawdata/*128*
```

and

```
> /bin/rm -r rawdata128
> /bin/rm -r dy031128nbenx
```

Now copy the new data files:

```
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 dy031NNNnbenx --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 dy031NNNnbenx
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 2015
--dbname dy031001nnx
--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 dy031NNNPTT where P is n for narrowband, b for broadband. 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. As far as I can tell, dbname must not exceed 11 chars. So if we use 9 for dy031NNNn, there are only two left to identify ENX, ENS, LTA, STA.

Without calibration information the angle can be left as zero
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
```

This 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 "show now" in order to get plots up on the screen.

Gautoedit does allow you to clean up data as follows. We didnt do this on DY031, but here we retain the information from JC086 in these notes.

Select day and step to view, then "show now". "show now" may have to be done twice to get the surface velocity plot. "show next" to step through the file. "Del bad times" sets "bad" flags for a section of time, or for a whole profile. "rzap" allows single bins to be flagged. Note that "list to disk" must be clicked each time for the flags to be saved.

Applying edits identified in gautoedit:
The gautoedit process in Matlab sets flags, but does not change the data.
To apply the flags and recalculate a calibration:

```
quick_adcp.py –-cntfile q_pyedit.cnt
```

N*ote two dashes before cntfile.*

Where q_pyedit.cnt contains

```
# q_pyedit.cnt is
## comments follow hash marks; this is a comment line

--yearbase 2015
--steps2rerun apply_edit:navsteps:calib:matfiles
--instname os75
--auto

# end of q_pyrot.cnt
```

Stage B. Finding the ADCP misalignment angle (the calibration).

i). Finding the calibration information

This can come from BT (bottom track) or WT (water track) files - the latter from 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 jc086001nbenx/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 applied after gautoedit process.

On DY031 we had the following information:

Table 7.3 Calibrations obtained from bottom-tracking and water-tracking for ***v150.***

		Amplitude			**Phase**		
File	**Time (DoY)**	**Median**	**Mean**	**sd**	**Median**	**Mean**	**sd**
073	158.25-159.1	1.0051	1.0059	0.0027	0.1636	0.1370	0.2015
074	159.88-160.37	1.0069	1.0068	0.0085	0.7253	0.5623	0.7197
075	160.38-160.43	1.0053	1.0054	0.0026	0.8762	0.8691	0.1999
078	164.42-165.37	1.0060	1.0072	0.0047	0.1499	0.1486	0.1766
081	165.38-165.55	1.0038	1.0043	0.0055	0.0344	0.0314	0.0720
Mean		**1.0054**			**0.3899**		
WT	mean of all files		1.0078	0.1589		0.1589	0.8386

Table 7.4 Calibrations obtained from bottom-tracking and water-tracking for ***v75****.*

		Amplitude			**Phase**		
File	**Time (DoY)**	**Median**	**Mean**	**sd**	**Median**	**Mean**	**sd**
131	160.38-161.29	1.0128	1.0132	0.0035	0.7357	1.0032	0.4623
133	161.96-162.29	1.0137	1.0141	0.0033	0.5877	0.6014	0.1578
134	162.93-163.09	1.0161	1.0178	0.0064	0.6936	0.6688	0.1661
137	164.36-165.37	1.0144	1.0148	0.0060	0.6308	0.6355	0.2263
138	165.38-165.57	1.0123	1.0165	0.0097	0.5045	0.5083	0.2002
Mean		**1.0139**			**0.6305**		
WT	mean of all files		1.0127	0.0207		0.3950	0.8237

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. You can take into account values from previous cruises on the same ship, as long as the ADCP has not been refitted since then. On DY031 we had no prior information; we chose to use the mean of all of the BT median values.

Put them into edit control files ("q_pyrot.cnt"), one for each v150 and v75, and if required, different values for file groups that have different EA values in the command files.

An example q_pyrot.cnt contains:

```
# q_pyrot.cnt is
## comments follow hash marks; this is a comment line
--yearbase 2015
--rotate_angle 0.3899
```

```
--rotate_amp 1.0054
--steps2rerun rotate:navsteps:calib
--auto
# end of q_pyrot.cnt
```

iii). Apply the calibration (repeat for both ADCPs and for each data file)

Still in directory /dy031NNNnbenx, apply the final calibration ONLY ONCE (adjustments are cumulative, so if this step is done twice, the cal is applied twice) when you have done the edits.

quick_adcp.py --cntfile q_pyrot.cnt
Note two dashes before cntfile..

Stage C. Get the data into MSTAR:

i). Still in directory /dy031NNNnbenx open Matlab window and type into command line:
>> **mcod_01**
Produces output file os75_jr265NNNnnx.nc, which has a collection of variables of dimensions Nx1 1xM NxM

>> **mcod_02**
Will calculate water speed and ship speed 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"). It does seem to depend on the files having the same bin number and bin depths.

On DY031 we did this once, at the end of the cruise and after calibration applied.
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 to re-process CTD stations:
>> **mcod_03**
>> **mcod_stn_out(‘ctd’,nnn,75)**
Where nnn is the CTD cast number. This will generate the .mat files in:
~/data/vmadcp/dy031_os75

iv). A final step is to make the data available for LADCP processing. We did not get to this point on DY031 but we include these final notes from previous cruises:
Create symbolic links to the .mat files in /ladcp/ix/data/SADCP with the format ‘os75_dy031_ctd_nnn.mat’.

These final steps make data available for comparison with LADCP data (the .mat files are automatically picked up by the ‘process_cast’ script).

8. Lowered ADCP data processing

Eoghan Daly and Penny Holliday

8.1 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. Data quality was checked in WinADCP by the NMF CTD operators, Robin and Billy, immediately after download from the LADCP. They copied the data files and the predeployment log txt files from the LADCP PC onto the DY031/Public server. The instrument performed well and there were no problems. The LADCP was not switched on for cast 84 because water depth was only 30m. All casts were processed, although it was noted that casts shallower than 100-200 m often seemed to have problems, usually characterised as giving a profile that was significantly deeper than the true water depth. We assume this was due to confusing reflections at the seabed, and recommend that those profiles not be used (Casts 35, 37, 46, 47, 68-75, 79-81, 83).

Processing was via the Lamont-Doherty IX path, as follows. Bold text denotes commands to enter at the X-window/terminal prompt. '>>' preceding bold text indicates commands to be entered in the Matlab window. Notes are in italics.

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 data
cd ladcp/ix/data/raw
```

```
lad_linkscript_ix
```

If the CTD data have been processed, run the following step to gain access to the CTD 1hz ascii data

```
cd ladcp/ix/data/CTD/1Hz
ladctd_linkscript_ix
```

The correct creation of the link can be checked by typing **ls -ltr**, *which will show its existence and which file it is linked to. This will also denote if the link is corrupted.*
A link can be deleted using **rm filename**. *This will not delete the original file.*

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)
```

The Matlab processing script produces and automatically saves .ps image files. These can be viewed by typing:

```
cd data
cd ladcp/ix/data/DL_GPS/processed
display filename
```

The processing steps described above can be performed before the CTD casts have been processed as far as 1hz files, to check the LADCP performance.

Once the CTD casts have been processed as 1hz files, the ‘process_cast’ script can be run again and the CTD files will automatically be read in. Check that the corresponding CTD links are in place by typing:

```
cd data
cd ladcp/ix/data/CTD
ls –ltr
```

Each cast should have a corresponding link in the format ‘ctd_dy031_056_1hz_txt’.

e) The ‘process_cast’ script can also be re-run after the vessel-mounted ADCP data has been processed, and these are added to the cast. Check that the corresponding .mat files have been generated in **/ladcp/ix/data/SADCP** in the format ‘os75_dy031_ctd_041.mat’.
Figures have been saved before and after re-processing. They can be found (respectively) in: **/ladcp/ix/data/DL/processed/no_VMADCP** and **/ladcp/ix/data/DL/processed**.

8.2 LADCP 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.

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.

9. Underway data processing

Geoff Stanley

9.1 Overview

A MATLAB script to read in most the underway data and produce various figures is found in cruise/gjs/MATLAB/underway_plotting.m. In particular this produces plots of underway salinity and temperature and density, wind speed and direction after vector averaging to half hourly data, air temperature and humidity, and bathymetric depth under the ship track. It also estimates from ship speed the times when the ship arrives and departs from CTD stations. It also produces two maps, one showing the ship track and one showing the CTD stations, with bathymetry contoured.

9.2 Daily processing

All underway data (which includes navigation, surface air and water, and bathymetry) can be processed on a daily basis as follows:

Step 1: Check that the system has automatically updated the links to the files on the network TechSAS server. The script cruise/data/exec/techsas_linkscript should be automatically run via a crontab. The way to check that this is indeed running OK is in MATLAB with:

```
>> mtlookd
316905   15/05/26   146 10:53:31  to  150 04:40:20   15/05/30  CLAM-CLAM_DY1.CLAM
92311   15/05/28   148 03:10:28  to  150 04:40:22   15/05/30  EA600-EA640_DY1.EA600
...[additional lines for the other streams removed]...
```

The first column is the number of data cycles, then the start date, the time series end date (which should be close to the current time, highlighted in red) and the name of the data stream. If the stream end time is not close to the current time (GMT), then the linking is not automated. Either fix the automation or run the link script manually.

Step 2: Run **m_dy031_daily_processing(nnn)** where nnn is the year-day number. This script calls **mday_00_get_all**, which itself which calls **mday_00** for each data stream, to extract the appropriate 24 hours worth of raw data from the TechSAS data stream given as an input variable; though TechSAS raw files are completed at 09:00 every day this may be run any time after midnight to get the previous day's data, piecing it together from two TechSAS files. **mday_00** will skip any data stream that does not actually exist for the present cruise or ship. The output is a series of daily files from each data stream, located in their individual data directories (e.g. sim_dy031_d155_raw.nc). After the initial step to acquire the raw data, the script further processes key data streams to edit (remove bad data) and average to appropriate time steps (the **"_01"** scripts, e.g. **msim_01**). Finally, the script runs **mday_02_run_all** which appends the daily file to create a master cruise file for each data stream (e.g. sim_dy031_01.nc). The list of daily files appended into the master files is given in the header information of that file. The daily files have been appended if *_01.nc files have been created and grow in size. Check that the sum of the sizes of the *_dnnn.nc files matches the size of the master file as a rough (but not absolute) check for missing or extra appended days. Also, check the time axis on each *_01.nc file to check that the daily files have been properly appended.

Step 3: Hand edit the data (particularly the TSG. Bathymetry, usually being a quick edit, was handled in Step 2 m_dy031_daily_processing. See below for more details on each stream.)
Step 4: Calibrate the underway salinity based on underway bottle data (see below).
If daily processing is run more than once for an individual day, the master file will have the day's data appended again and may need to be recreated from the beginning of the cruise. It may be useful for future cruises to run the appending steps in a separate script. Currently, the underway data for the thermosalinograph is hand edited in the master file (not day-by-day) but the bathymetry data is hand edited day-by-day. **mday_02_run_all** was configured to automatically append daily thermosalinograph and bathymetry data. Further details of the individual data streams are given in the following subsections.

Navigation: 'nav'

As part of the routine daily processing eight navigation streams were extracted from TECHSAS into mexec directories, as summarised in the following table. Note that there is duplicated information among some of the streams. The posmvpos is the master position source. The master file **pos_dy031_01.nc** contains the full and final cruise archive. Usually, there is no hand editing necessary for position information. The directory listed is where the files are stored, the directory abbreviation name can be passed as the argument to mcd in MATLAB to quickly switch to that directory, and the file root is the beginning characters of the file names for each respective stream.

Table 9.1: Navigation data streams.

Ship on which stream is present	Directory under cruise/data/	mexec short name	mexec directory abbreviation	mexec file root
James Cook	nav/ash	adu5pat	M_ASH	ash
James Cook	nav/attsea	attsea	M_ATTSEA	attsea
Discovery	nav/attposmv	attposmv	M_ATTPOSMV	attposmv
James Cook *Discovery*	nav/cnav	cnav	M_CNAV	cnav
James Cook	nav/dps116	dps116	M_DPS116	dps116
James Cook *Discovery*	nav/gyropmv	gyropmv	M_GYP	gyp
James Cook *Discovery*	nav/gyros	gyro_s	M_GYS	gys
James Cook *Discovery*	nav/posmvpos	posmvpos	M_POS	pos

James Cook *Discovery*	nav/seapath200 nav/seapos	seapos	M_SEA200	seapos

Synchro gyro & Ashtech ADU heading: Due to the availability of high-quality real-time heading from the Applanix posmv, the Ashtech ADU can be a low-priority navigation stream maintained in case needed at short notice. Standard processing includes scripts **mgyr_01, mash_01** and **mash_02** to clean up any duplicated times in the 5Hz gyro stream, and then an ashtech minus gyro comparison, which cleans up the ashtech data before producing a smoothed ashtech minus gyro time series.

Bestnav: **mbest_all.m** runs a series of scripts to produce the master bestnav file, data/nav/posmvpos/**bst_dy031_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_dy031_01.nc file.

Surface Atmosphere and Ocean: 'met'

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).

Table 9.2: Surface meteorology data streams.

Directory under cruise/data/	mexec short name	mexec directory abbreviation	mexec file root	variables
met/surfmet	surfmet	M_MET	met	speed direct airtemp humid
met/surflight	surflight	M_MET_LIGHT	met_light	pres ppar spar ptir stir
met/surftsg	surftsg	M_MET_TSG	met_tsg	temp_h temp_m cond fluo trans

tsg	SBE45	M_TSG	tsg	temp_h temp_r cond salin sndspeed

Meteorology: ‘met/surfmet’

Wind variables: Ship speed, position and heading from the bst navigation file are merged onto the wind data in the surfmet stream. The absolute wind speed is calculated and vector averaged in one multi-step script **mtruew_01.m**. As with bst 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_dy031_true.nc**
data/met/surfmet/**met_dy031_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. The result is a bit cumbersome, but should be unambiguous if the units are read carefully.

Wind over the stern: The standard test of whether the relative wind processing has been done correctly would be to observe no change in the calculated absolute wind when the ship changes direction or speed. This can be misleading, since the anemometer sited on the foremast under-reads speed by a significant margin when the wind is over the stern. Therefore if either the ‘before’ or ‘after’ wind direction is over the stern, there can be a significant change in the apparent true wind speed during such manoeuvres.

This test is shown in Figure 9.1. Even when using wind velocity data produced by mtruew_01.m, there nonetheless remains a very strong correlation between ship speed and wind speed: there are rapid changes of wind speed and direction when coming on and off station, the times of which are indicated by vertical dashed lines. Further analysis would be required to know whether this wind data is accurate.

Wind relative direction near 0/360: The age old problem of wind direction near the 0/360 boundary still remains. Since the anemometer is set up with 0/360 at the bow, the relative wind is very often around this heading. Even though the anemometer data are recorded at the data rate generated by the sensor (nominal 1 Hz), there is a problem with the raw data. In particular, when the wind is near 0/360, the TechSAS files will sometimes contain headings in between, e.g. in the range 150 to 210, reminiscent of when simple numerical averaging of heading was occurring. When these bad headings are used in correct calculation of true wind, bad data are the result.

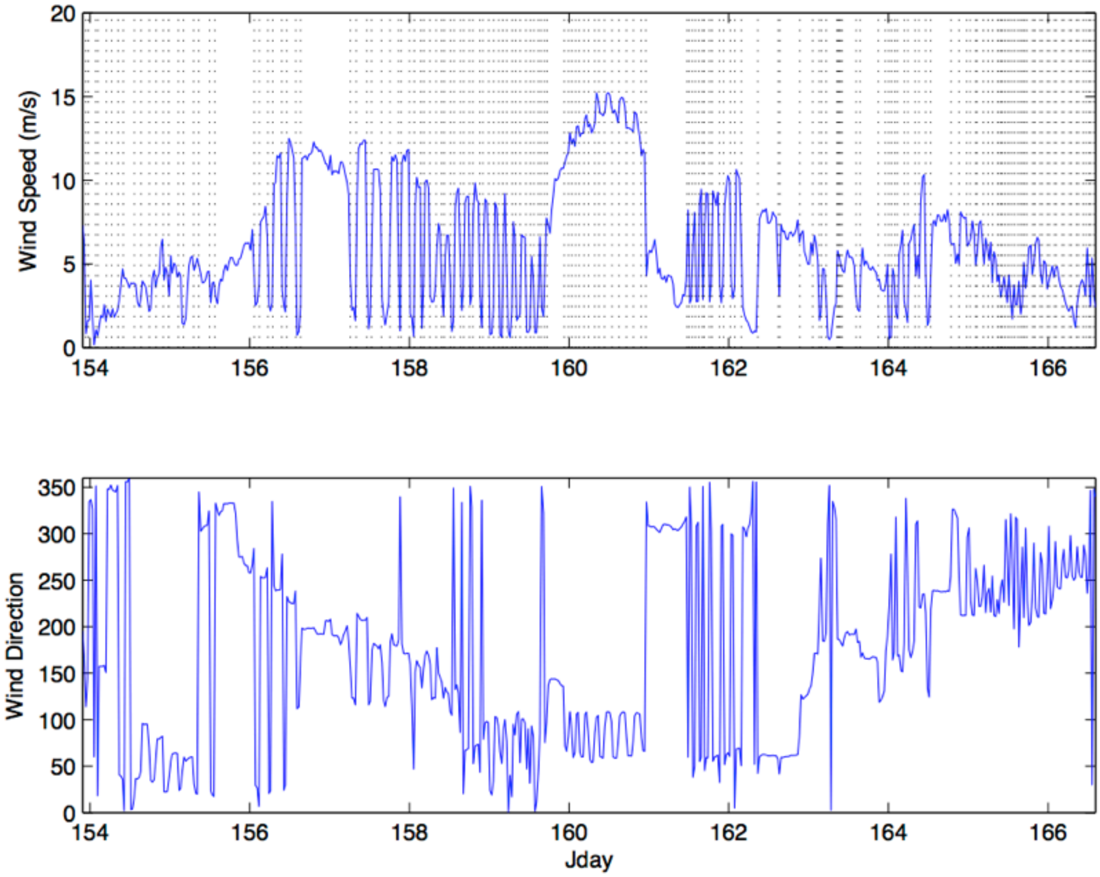

Figure 9.1: True wind speed and direction from met_dy031_trueav.nc, vector averaged to half hourly data. Dashed vertical lines indicate when the ship came on or off station.

Light: ‘met/surflight'

<u>Irradiance and surface pressure</u>: Downwelling PAR and TIR data are found in the surflight stream, which also contains barometer pressure. These streams were ingested and stored, but no further processing was undertaken.

Thermosalinograph: ‘met/surftsg’

At the start of the cruise a check was performed to ensure that the salinity calculated from ‘met/surftsg/met_tsg_dy031_dnnn_raw.nc’ cond and temp_h matched the salinity found in ‘tsg/tsg_dy031_dnnn_raw.nc’. Since the ‘met/surftsg’ file also contains the other pumped seawater variables, calibration work was carried out in the ‘met/surftsg’ directory. The ‘tsg’ files are uncalibrated and should not be used. Note that amongst the met data stream variables, salinity is the only one that is calibrated.

There are alternative names (temp_r and temp_m) for sea surface temperature measured close to the pipe intake, while the housing temperature (temp_h) is measured at the TSG itself; the latter is used with conductivity to calculate salinity. Since the exact sampling times for temp_r and temp_m differ, the time series are very slightly different, but for all practical purposes, temp_r and temp_m are identical. Since it takes time for water to flow through the pipes and reach the SBE45, temp_h should resemble temp_r but be smoother and lag (by 3-4 minutes on *Discovery*).

On the *James Cook* for JC086 and the *Discovery* for DY031, the wind speed is stored in TechSAS in m/s, whereas TechSAS states the variable units as knots. Therefore the script **mmet_01.m** is inserted in the daily processing to correct the units in the met/surfmet/met_dy031_dnnn_raw.nc file. On the *Discovery* for DY031, the underway conductivity in met_tsg is reported as mS/cm, but the numbers are actually S/m requiring another correction. The factor of ten conversion was applied within **mtsg_make_sal.m**, which is used to compute salinity and write it to met_tsg_dy031_01.nc. In general, variable names and reported units should be checked at the beginning of each cruise as the TechSAS variable metadata can be manually changed each time TechSAS is restarted.

9.3 Thermosalinograph salinity calibration

The daily processing creates two sets of daily raw files and two appended cruise master files (nnn is day number). They are:

data/tsg/**tsg_dy031_dnnn_raw.nc** and data/tsg/**tsg_dy031_01.nc**
Extracted from TechSAS data stream 'SBE45-SBE-45_DY1.TSG' (mstar shortname SBE45), variables are temp_h, cond, salin, snspeed, temp_r, time.
and

data/met/surftsg/**met_tsg_dy031_ddd_raw.nc** and data/met/surftsg/**met_tsg_dy031_01.nc**
Extracted from TechSAS data stream ‘Surf-DYS-SM_DY1.SURFMETv2', (mstar shortname Surftsg) variables are temp_h, temp_m, cond, fluor, trans, time.

The appended data from Surftsg can be further processed as follows. These steps can be performed at any time of the cruise, but need to be carried out at again at the end of the cruise since step (i) acts on the appended file which is incremented daily.

i) Run **mcd('M_MET_TSG')** then run **mtsg_make_sal.m** with MATLAB's present working directory the same directory as which contains the input file. mtsg_make_sal.m uses the sw_salt function to compute salinity from conductivity and (local, so housing) temperature, and was lifted from met_tsg_calcsalt.m for use on DY031.
Input: data/met/surftsg/met_tsg_dy031_01.nc
Output: data/met/surftsg/**met_tsg_dy031_01_sal.nc**

ii) Edit **mtsg_cleanup.m** (in mexec_processing_scripts) to hardcode any periods when the pumps were switched off, such as before the start of the cruise, short periods in the early part of the cruise, and after the end of the cruise.

iii) Run **mtsg_findbad.m** to graphically and manually edit temp_h, temp_r, cond and salin. Note the use of 'n' to store the start and end of bad data and move onto the next segment of bad data. This is a CRITICAL step.
Input: data/met/surftsg/met_tsg_dy031_01_sal.nc
Output: data/met/surftsg/**bad_time_lims.mat**

iv) Run **mtsg_medav_clean_cal.m** to generate 1-minute median bin average of data, and remove known bad data identified in mtsg_cleanup.m (which includes data stored in bad_time_lims.mat generated through mtsg_findbad.m).
Input: data/met/surftsg/met_tsg_dy031_01_sal.nc
Output: data/met/surftsg/**met_tsg_dy031_01_medav_clean.nc**

v) You can re-run mtsg_findbad and **m_tsg_medav_clean_cal.m** as many times as required to get a clean record. Limits of bad times are accumulated by sucessive uses of mtsg_findbad so may be worth making a back-up copy of bad_time_lims.mat.

vi) 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** (in a terminal) to convert the csv file from a Mac format to a unix compatible format (this just adds end-line characters).

Input: data/ctd/BOTTLE_SAL/tsg_dy031_nnn.csv
Output: data/ctd/BOTTLE_SAL/**tsg_dy031_nnn.csv_linux**

vii) Run **mtsg_01.**m to convert TSG salinity bottle samples from ASCII to NetCDF.

Input: data/ctd/BOTTLE_SAL/tsg_dy031_nnn.csv_linux

Output: data/ctd/**tsg_dy031_nnn.nc**	Data from crate nnn
Output: data/ctd/**tsg_dy031_all.nc**	Master appended bottle salts file

viii) Run **mtsg_bottle_compare.m** to merge the clean 1-minute data onto bottle samples. The script is set up to make it easy to switch between uncalibrated (variable salin) or calibrated (variable salin_cal) data by setting the case switch at the start of the .m file. Individual bottle residuals are plotted, as well as a smoothed time series of the residuals, which can then be used as a slowly-varying adjustment to the TSG salinity in the next step.

Input: data/ctd/tsg_dy031_all.nc
Input: data/met/surftsg/met_tsg_dy031_01_medav_clean.nc
Output: data/met/surftsg/**met_tsg_dy031_01_medav_clean_botcompare.nc**

Or:

Input: data/ctd/met_tsg_dy031_01_medav_clean_cal.nc
Output: data/met/surftsg/**met_tsg_dy031_01_medav_clean_cal_botcompare.nc**

vii) Run **mtsg_apply_salcal.m** to smooth the differences in botcompare, interpolates and adds them to the uncalibrated salinity data. You can run mtsg_bottle_compare_dy031.m after this to check the residuals are acceptable.

calls **mtsg_salcal.m**
Input: data/met/surftsg/met_tsg_dy031_01_medav_clean.nc
Input: data/met/surftsg/met_tsg_dy031_01_medav_clean_botcompare.nc
Output: data/met/surftsg/**met_tsg_dy031_medav_clean_cal.nc**

vii) Run **met_tsg_av_addnav.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_dy031_01.nc.

Input: data/met/surftsg/**met_tsg_dy031_01_medav_clean_cal.nc**
Input: data/nav/posmvpos/**bst_dy031_01.nc**
Output: data/met/surftsg/**met_tsg_dy031_medav_clean_cal_nav.nc** (final file)

9.4 Thermosalinograph data quality

The surface temperature and salinity were recorded throughout the cruise by the SeaBird 45 MicroTSG (thermosalinograph). For full details of the device, see data/dyfs/scientific_systems/MetOcean/SurfMet_metocean_system/SurfMet_sensor_manuals/SBE45.pdf in the cruise directory.

Times of high variance of the remote temperature were noticed early in the cruise. Figure 9.2 shows an example of this from JDay – 1 = 152.54 to 152.61 (a duration of 100 minutes). It is believed that air bubbles entered the pipe and raised the measured temperature, but they dissipated by the time the temperature was measured at the TSG and hence the housing temperature was not greatly affected. The pitch, roll, and heave of the ship during this time were mild, probably slightly below average. Wind speed was reasonably high between 10 and 20 m/s. The ship was steaming at about 10 knots. This issue was resolved by increasing the pump rate for the ship's non-toxic intake for the rest of the cruise.

A potentially similar, big section of bad data occurred from JDay = 158.01 to 159.79 when the remote temperature again exceeded the housing temperature, which should not be possible. This also occurred briefly from JDay = 166.93 to 166.94 and a few very brief moments later that day. The remote temperature signal looked similar to that in Figure 9.2 with rapid drops in temperature, but with more time near the high (> temp_h) asymptotic values.

Nonetheless flow control remained an issue, generally when the flow rate dropped too low. This has negatively affected the data to the point that much of it must be removed. Presently the *Discovery* has an analogue flow meter before the TSG and flow control is achieved by manual operation of a choke. When the ship changes speed the flow rate through the TSG is modified. During his waking hours the SST would do his best to adjust the flow rate at these times, particularly when coming on and off station. This simple solution still leaves some flow rate issues, especially in heavy waves when unpredictable ship motion also affects the flow rate.

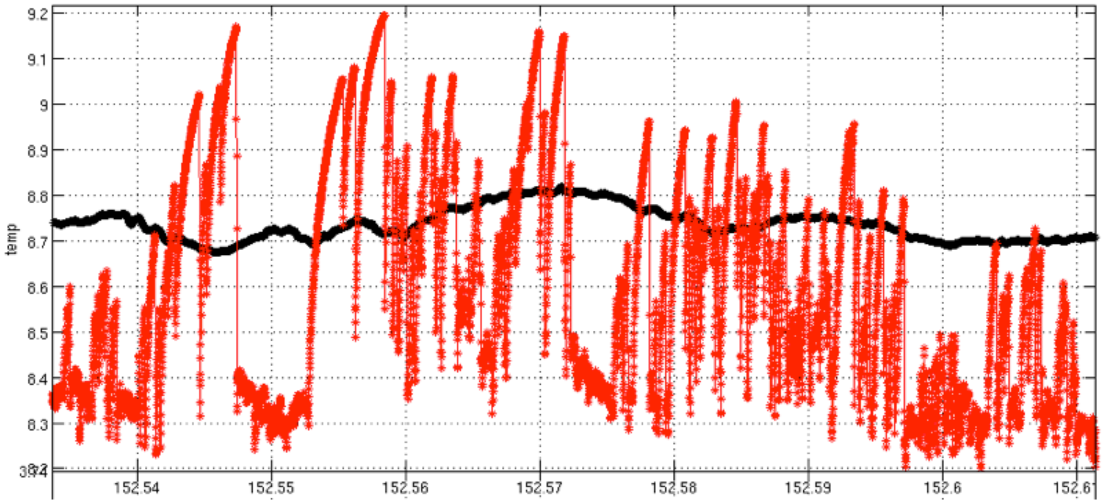

Figure 9.2: Remote and housing temperature (deg C) in red and black, respectively, recorded by the underway TSG. Time is on the horizontal axis and is enumerated as JDay – 1, i.e. noon on January 01, 2015 is recorded here as 0.5.

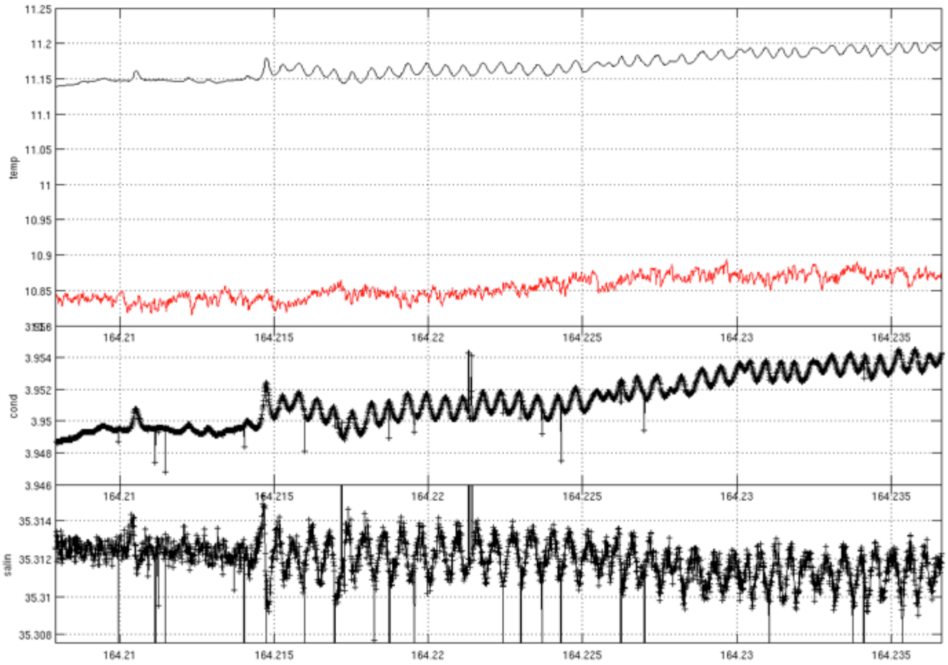

Figure 9.3: An example of TSG data fouling by flow rate fluctuations. Top panel is housing and remote temperature (deg C) in black and red respectively. Middle panel is conductivity (S/m). Bottom panel is salinity (psu-78). Time axis is as in Figure 9.2.

The influence of the flow rate on the TSG data is illustrated first in Figure 9.3. At 164.215 the housing temperature begins oscillating, and this lasts for 45 minutes until about 164.245 (not shown), while the remote temperature remains fairly steady, within the limits of its standard noise. Being a strong function of temperature, the conductivity replicates the oscillations of the housing temperature. Finally, the calculated salinity also oscillates, and with higher than standard variance (compare salinity variance before and after 164.215). The housing temperature spikes are believed to be caused when the flow rate dips too low and the seawater takes more time to reach the TSG and hence has warmed more by the ship's environment. We do not know precisely why the spikes appear as quite regular oscillations, but the initiation and conclusion of these events seems to correlate with changes in ship speed. Events like this occurred around 15 or so times per day starting around JDay-1 = 162. For days 164 and 165, 37% of the data was fouled.

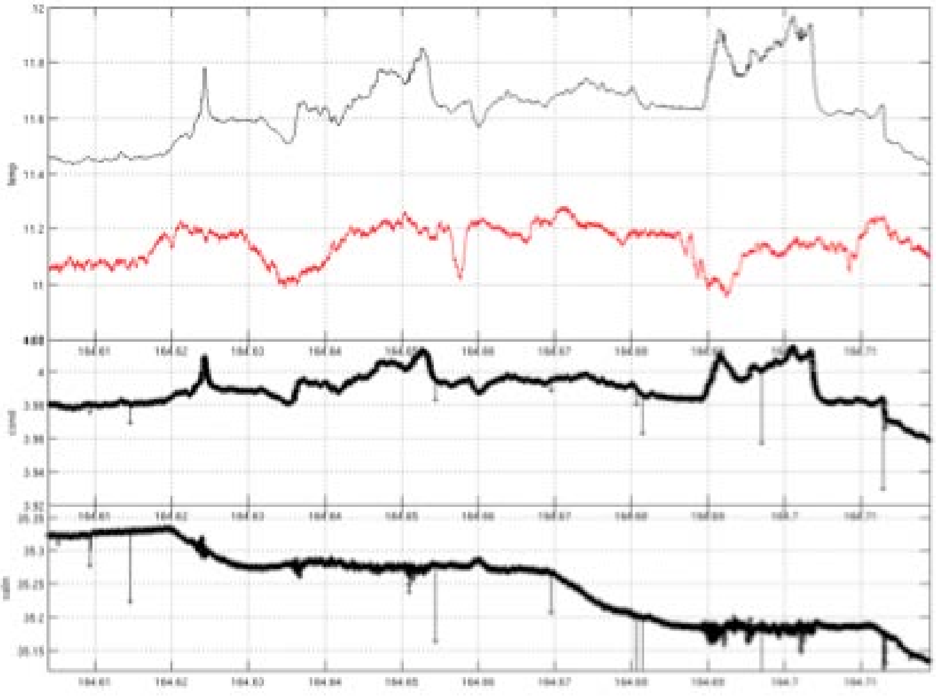

Figure 9.4: TSG data, with all properties as in Figure 11.3, albeit at a later time.

Another, more sinister, fouling of the underway salinity data is shown in Figure 9.4. First, the spikes in remote temperature are larger in absolute magnitude than in Figure 9.3. Second, there are instances (JDay – 1 = 164.69) when the housing and remote temperatures are actually changing in *opposite* directions, leading to fluctuations in salinity of up to 0.03 psu in either direction. In comparison, salinity fluctuations are about 0.001 psu in either direction when this system is functioning well. (The remote temperature is changing and the housing temperature can be seen to sometimes track this with a time delay that is in the normal operating range of 3-4 minutes.)

To resolve these issues, we recommend a digital flow control be installed either upstream or downstream of the TSG.

Water samples were taken approximately every four hours throughout the cruise and their conductivity measured with the onboard Autosal. As outlined above, the scripts mtsg_bottle_compare.m and mtsg_apply_salcal.m were used to calculate bottle salinity and then to calibrate the SBE45 salinity measurements. This is shown in Figure 9.5. Near the start of the cruise, roughly 0.05psu were added to the SBE45 salinity data, while by the end this amount increased to 0.075psu.

GJS processed the underway data and the times blocks flagged as bad data (using mtsg_findbad.m) are stored in ~/cruise/data/met/surftsg/bad_time_lims.mat. A human-readable record of these times is stored in ~/cruise/data/met/surftsg/bad_time_lims_min.txt. This document was automatically created by the script ~/cruise/gjs/MATLAB/bad_underway_times.m.

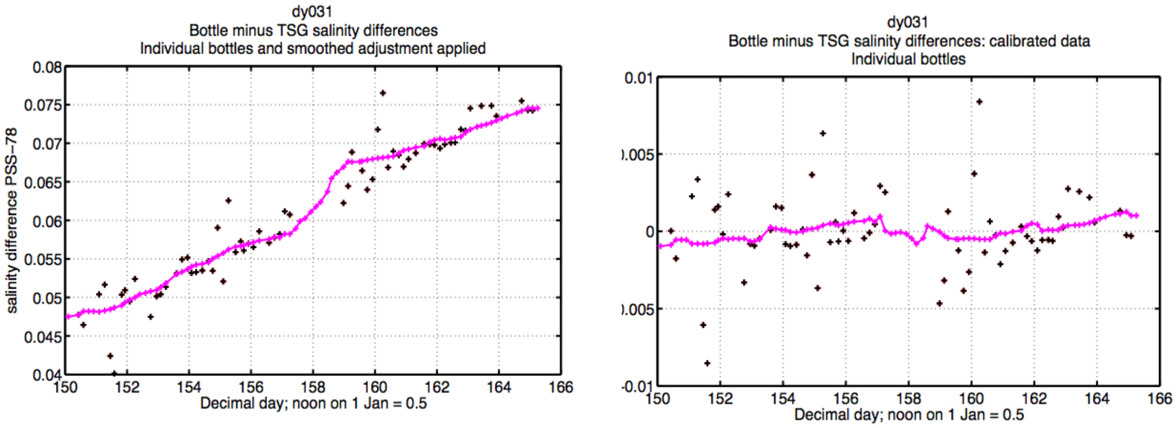

Figure 9.5: Left: difference (psu-78) between bottle measurements and the SBE45's measurements of salinity at each sample time (black symbols) and smoothed (pink line). Right: as left panel but after the SBE45 salinity has been calibrated by subtracting the smoothed differences from the left panel.

9.5 Bathymetry

The EA640 and EM122 generally performed well and produced fairly consistent results. Very little data was flagged as bad by GJS.

The EA640 data were read into mexec directory 'data/sim', and the EM122 data into the mexec directory 'data/em120'. The data were routinely processed within the script **m_dy031_daily_processing.m**. Daily files of raw data and smoothed data were preserved. The key stages are:

msim_01 and mem120_01 to read raw data for given day number and discard data outside the depth range 20m to 10000m, then take the median depth in 300 second bins to discard noise.
Input: data/sim/**sim_dy031_dnnn_raw.nc**
Output: data/sim/**sim_dy031_dnnn_smooth.nc**
Output: data/sim/**sim_dy031_dnnn_edited.nc**

The _edited.nc file is an exact copy of the _smooth.nc file, for later use in msimplot.m.

msim_02 cross-merges bathymetric data streams, bringing em120 data into the sim*.nc file.
Input: data/sim/**sim_dy031_dnnn_edited.nc**
Input: data/em120/**em120_dy031_dnnn_edited.nc**
Output: data/sim/**sim_dy031_dnnn_edited.nc**

msim_plot for graphical editing of the data for spike removal. This allows editing of both (sim and em120) data streams since they've already been merged.
Input: data/sim/**sim_dy031_dnnn_edited.nc**
Output: data/sim/**sim_dy031_dnnn_edited.nc** – selected values are changed to NaN
Output: data/sim/**mplxyed_<time>_sim_dy031_dnnn** – records of which values were selected by the user.

Note: it is not necessary to run mem120_plot.m since msim_02 cross-merged the data.
mday_02 to append edited daily files are appended into a single file:

Input: data/sim**sim_dy031_dnnn_edited.nc**
Output: data/sim**sim_dy031_01.nc**

On DY031 there were no manual stages at the end of the cruise to generate a master cruise file, since mday_02.m was modified to append the edited bathymetric data files rather than the raw ones.

10. Salinity bottle samples and analysis

Stefan Gary, Jeff Benson, Karen Wilson, Penny Holliday

Salinity samples from the CTD were collected using a 24 bottle rosette system containing 10 liter Niskin bottles. Salinity samples were drawn from each unique depth. When 2 bottles were fired at the same depth only one bottle was sampled. These samples were subsequently analyzed on a Guildline Autosal salinometer (serial number 71126) using NMF software in Labview for the automated reading of the digital output of the Autosal. 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 and the room at approximately 21˚C. The Autosal operators for DY031 were Jeff Benson, Stefan Gary, Karen Wilson, and Billy Platt.

Over the course of the cruise, 45 crates of 24 bottles and 66 OSIL seawater standards (all Batch 157) were processed. For each crate, a standard was run before and after the crate. The nearly constant temperature in the Autosal laboratory resulted in excellent instrument stability and very small corrections to the Autosal measurements. (Figure 10.1)

Once the Autosal analysis was complete, the .xls files created by the NMF software were modified to manually enter the station number and Niskin bottle number for each Autosal reading. The .xls files were then saved as .csv files and the line endings were converted to UNIX format with the mac2unix utility. The process followed on DY031 is given below.

A. Prepare the bottle salinity files

We need to edit the Autosal spreadsheets to give them a specific format, and to add the information to link the salinity samples with the CTD cast and niskin number.

i. Autosal spreadsheets can be found on the ship's server at
discofs/dy031/specific_equipment/CTD/Autosal data

The files will be named by crate number and the date they were analysed.
To work on them, drag and drop them onto the UKOSNAP laptop hard drive
/Documents/DY031/salinity_spreadsheets

ii. We need to produce one spreadsheet per CTD cast from the original spreadsheet. The original is saved as a new filename and edited as an .xls file.
For example "**DY031 CTD10 4 June 2015.xls**" may be saved twice as:
sal_dy031_001.xls and **sal_dy031_002.xls**
for stations 001 and 002.

iii. Remove any blank header lines; there must be exactly 10 header lines in the new .xls file.

iv. The first column should already include the CTD crate number (or cast number) and the salinity bottle number (ie the number written on the bottle in the crate).

For example ctd001_596
ctd001_597

v. A new last column (J) needs to be manually added to indicate the CTD station number and niskin bottle - this is the unique identifier for that sample and is called "**sampnum**". The format is **NNNnn** where NNN is cast number and nn is niskin number.

For example sampnum
00101
00102
00103

This information can be found on the CTD sampling logsheets.
SSW samples should be given sampnum starting at **999001** and increasing sequentially.

vi. The corrected spreadsheet needs to be save as an xls file, and also as a comma-delimited file (.csv).

B. Get the data files into the right place and format.
vii. The original autosal file, the new xls file and the new csv file should all be saved on the "ukosnap" laptop at:
Documents/DY031/salinity_spreadsheets/
then drag-and-dropped to
discofs/public/salinity_spreadsheets/

viii. On eriu, copy the csv files to
/local/users/pstar/cruise/data/ctd/BOTTLE_SAL

ix. The csv files are now in mac format and need to be converted to unix ascii (with correct end of line characters). Additionally, we need to create a single concatenated ascii file with all the station data in it. Both these steps are done in a simple c-shell script:
modsal_unix (run this in ctd/BOTTLE_SAL/)
input: sal_dy031_???.csv
output: sal_dy031_???.csv_linux
sal_dy031_01.csv (concatenated file with all stations)

C. Read the ascii data into mstar netcdf:

First "edit msal_01.m" to ensure the salinometer bath temperature is set to the correct temperature used on the cruise (24°C on DY031).

Next check the cruise-specific conductivity ratio offset to be applied to create a new adjusted salinity variable. The offset is derived from the SSW samples run through the salinometer.

At the start of the cruise this should be set to zero for all stations, and you will change this later on when you have evaluated the salinometer performance with the SSW data.

```
> matlab &
>> m_setup
```

>> msal_01.m reads the ascii file into matlab and saves as **sal_dy031_nnn.nc**.
>> msal_02.m pastes the bottle salinity into sam_dy031_nnn.nc.

D. Evaluate the Autosal performance using the SSW samples
Before using the salinity data to calibrate the CTD conductivity data, you need to see whether the bottle salinities need adjusting for the autosal offset.

First pick out all the information from the standards:

```
>> msal_get_standards.m
```

Output is text file **sal_dy031_standards**

```
>> msal_evaluate_standards.m
```

mevaluate_standards generates a plot of the adjustment indicated by the samples to the Guideline Ratio of the SSW batch. The script can be edited to account for more than one batch of SSW used during the cruise. The figure allows the user to look for drift in the salinometer over time and to decide on an appropriate offset to use in **msal_01.m**.

The performance of the salinometer on DY031 is shown in Figure 10.1. The red crosses indicate the uncorrected difference between the SSW batch ratio and the ratio measured by the Autosal. The black line indicates the suggested offset and the black crosses indicate the difference after than correction has been made.

E. Apply the SSW-derived adjustment to bottle salinities
Edit the cruise-specific case adjustments in **msal_01.m**, then
run **msal_01** and **msal_02** for all the affected stations.

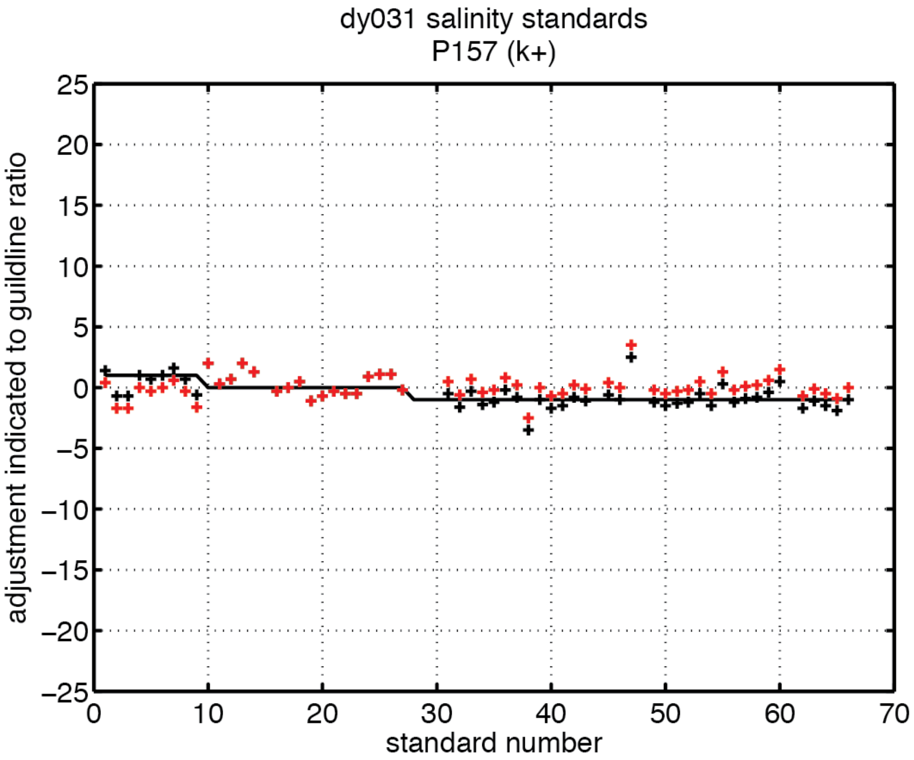

Figure 10.1, Salinometer performance as indicated by the standard seawater (SSW) bottles run at the start and end of crates of salinity samples. The variable plotted is the difference between the salinometer reading and the SSW ratio of the batch (listed on the bottle) (x10^{-5}) (black crosses); the red line indicates the correction applied to the bottle sample data and the red crosses give the difference with the correction applied.

11. Dissolved inorganic nutrients

Tim Brand

11.1 Introduction

The basic water column dissolved nutrients, phosphate, silicate (reactive silica) and total oxidized nitrogen, TON, (nitrate+nitrite) were analyzed from CTD casts along the Extended Ellett line and 8 stations along the OSNAP transect. A full list of stations for which nutrient samples were taken and analysed on board is shown in Table 1.

11.2 Method

Samples were collected in 50ml acid 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 a fridge 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, Batches LNS 23 and 24, Salinity 35). Five 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 which was also run 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 1mMPO_4, 10mMSiO_2 and 10mMNO_3 was run at the start and end of the entire analysis to check accuracy of the dried salt derived standards.

11.3 Data quality assessment

Analytical precision was gathered by running each sample in triplicate and regularly yielded relative S.D.'s 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*s.d of 7 replicates of the blank low nutrient sea water. This yielded MDL's of PO4, 0.03uM, SiO2, 0.28uM, and NO3+NO2, 0.06uM. Accuracy, determined by analysing the independent OSIL reference standard solutions at the beginning and end of the cruise showed a 0.52% error for phosphate, 0.76% error for silicate and a 2.08% error for nitrate+nitrite.

11.4. Reading nutrient data into mexec

The final nutrient data were available after the cruise, and were read into the mexec sample files through the usual route:

Ascii files (eg. nut_dy031_nnn.csv) were prepared, with header lines and a range of columns of data. The first columns in both sets should be: bottle number (bb), station number (nnn), sample number (nnnbb).
mnut_01 reads the ascii file into matlab and saves as **nut_dy031_nnn.nc**
mnut_02_sams pastes the bottle data into sam_dy031_nnn.nc

12. Determination of dissolved oxygen concentrations by Winkler titration.

Richard Abell and Caroline Kivimae

12.1 Introduction

Dissolved oxygen (DO) concentrations were measured in 1268 discrete seawater samples collected during DY031. Sampling and analysis were performed 24hrs a day using Winkler photometric auto-titration following 'Go-Ships' protocols (Langdon, 2010) based on the standard methodologies of Carpenter 1965 adapted for large scale hydrographic studies (eg Culberson, 1991 and Dickson, 1995).

Precision of the analysis was estimated using repeat measurements of samples collected from same Niskin bottle (6% of samples collected, 1σ = 0.19%) and by measuring separate Niskin bottles fired at the same depth (11% of samples 1σ = 0.18%). 2% of data were rejected due to poor analysis resulting in 1237 reported values.

12.2 Methodology

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 MnCl2 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 we 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 2 hours.

Before every analytical session the titrant (0.1M Na2S2O3) was standardised using both a commercially purchased OSIL 0.001667M KIO3 standard and an in-house gravimetrically prepared 0.009M KIO3 standard. During the course of the analytical sessions the drift in titre concentration was small (~ 0.0002M). Reagent blanks were also monitored prior to sample analysis and subtracted during the titration calculation (Figure 12.1).

Prior to analysis 1 ml of 5M H2SO4 was added to samples followed by a Teflon coated magnetic stirrer. End points reached by the auto burette were recorded.

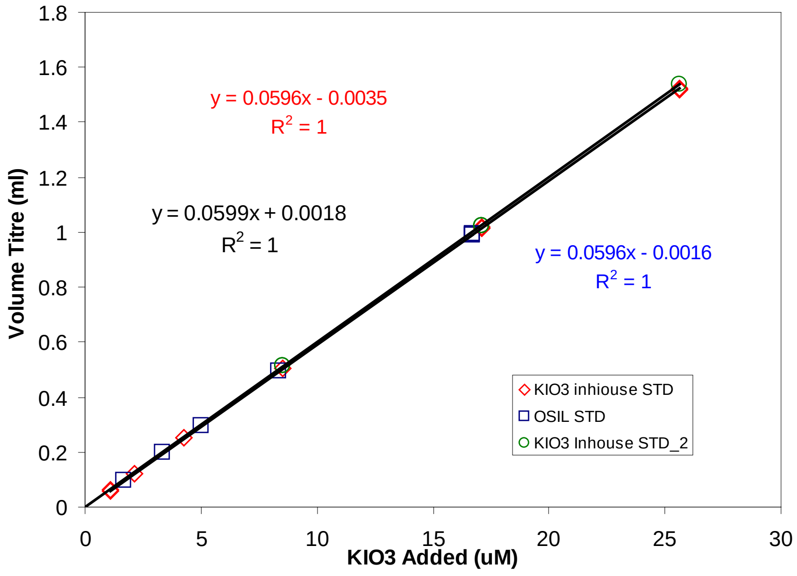

Figure 12.1. Results of addition method of blank calculation during DY031.

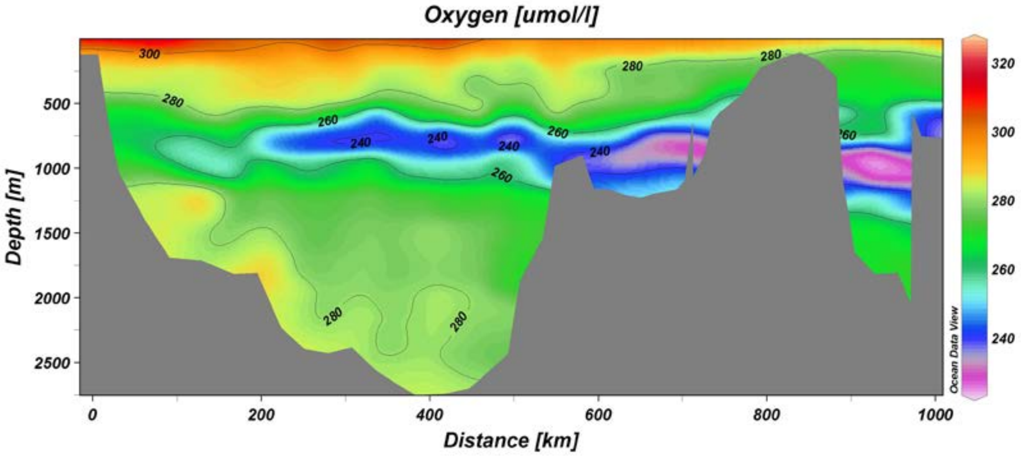

Figure 12.2: Summary of dissolved oxygen results measured during DY031

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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.

13. Dissolved inorganic carbon, total alkalinity

Nikki Clargo, Lesley Salt, Caroline Kivimae
Samplers: Aikaterina Giamalaki, Caroline Mengeot

13.1 Methodology

Sampling and analysis for carbonate system parameters broadly followed the standard operating procedures outlined by Dickson et al., 2007. Water samples of 0.25 L were collected from the CTD niskin bottles into Duran sample bottles with ground glass stoppers, using silicone tubing. Samples were collected from every station occupied except IB9, IB4C, IB4A, the X transect and on the Scottish shelf. On the Scottish shelf only every other station was sampled (13G, 10G, 9G, 7G, 5G, 3G, 1G). Samples were collected from the stainless steel CTD. In general one duplicate sample was collected on each station.

Stations sampled:	64	of which poisoned:	8
Number of depths sampled:	693	of which poisoned:	57
Duplicate depths:	46		
Underway samples:	90	of which poisoned:	29
CRM bottles used:	75		

CRM duplicates: 58

Sample analysis commenced immediately after collection and analysis of profiles was in all cases completed within 24 hours after sampling (most often within 12 hours). All analyses were performed on two VINDTA 3C (Versatile INstrument for the Determination of Total Alkalinity, designed and built by Dr. L. Mintrop, Marine Analytics and Data, Kiel, Germany), ♯11 and ♯24.

There were also underway samples collected from the ship's non-toxic system, for the majority of the cruise once every 4 hours. Any samples (both profiles and underway) collected after 20.00 on the 14th of June were poisoned with 50 µl 50% mercuric chloride solution and will be analyzed back at NOC.

The analysis and correction of the raw data is in progress. Final results will be available within one month.

13.2 Dissolved inorganic carbon (DIC)

Dissolved inorganic carbon (DIC) was determined by coulometric titration. An automated extraction line takes a 20 mL subsample which is subsequently purged of CO_2 in a stripping chamber containing ~1 mL of ~8.5% phosphoric acid (H_3PO_4). A stream of nitrogen carries the CO_2 gas into a coulometric titration cell via a condenser, to strip the gas flow of any water. The CO_2 reacts with the cathode solution in the cell to form hydroxyethylcarbamic acid, which is then titrated with hydroxide ions (OH^-) generated by the coulometer. The current of the coulometer is then integrated over the duration of the titration to obtain the total amount of carbon titrated. The power to the two coulometers were stabilized with a UPS.

13.3 Total alkalinity (TA)

Determinations of total alkalinity were performed by acid titration that combines aspects from both the commonly used 'closed cell' method and the 'open cell' method, following the VINDTAs standard settings. A single 10 L batch of acid of ~0.1M and salinity 35 was prepared to be used by both VINDTAs. Potential drift in acid strength due to HCl-gas loss to acid vessel headspace is not accounted for.

Certified reference material (CRM, Batch #145 and 146) obtained from Dr. Andrew Dickson at Scripps Institute of Oceanography (San Diego, California) was used for calibration purposes and quality control for both DIC and TA.

References

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to best practices

14. Net growth rates and community composition of marine phytoplankton

Stephanie Allen

14.1 Overview

The net growth rates of marine phytoplankton and their community composition were examined along the Ellett line using incubation experiments. An incubation crate was attached to the aft deck on a pallet, which had a lid coated in a blue film to give samples 20% PAR, representing the light received at the oceans surface.

For the incubation experiments nine 750ml bottles of seawater were collected from the CTD from a depth of 5-10m. Three of these bottles were filtered straight away representing time 0 hours, and the other six bottles were placed in the incubation crate so that three bottles could be sampled after 24 hours, and the other three could be sampled 48 hours after collection from the CTD. Water from the ships underway system was passed through the incubation crates, around the bottled samples to maintain them at their environmental temperature.

All samples were filtered for total chlorophyll-a, measured onboard using a flurometer, and for community composition. Filtration for community composition analysis was filtered on SEM and Cellulose Nitrate filters for examination back at the National Oceanographic Centre, Southampton. A log of all sampled stations can be found in Table 14.1 and a map of sampled locations can been seen in Figure 14.1 below.

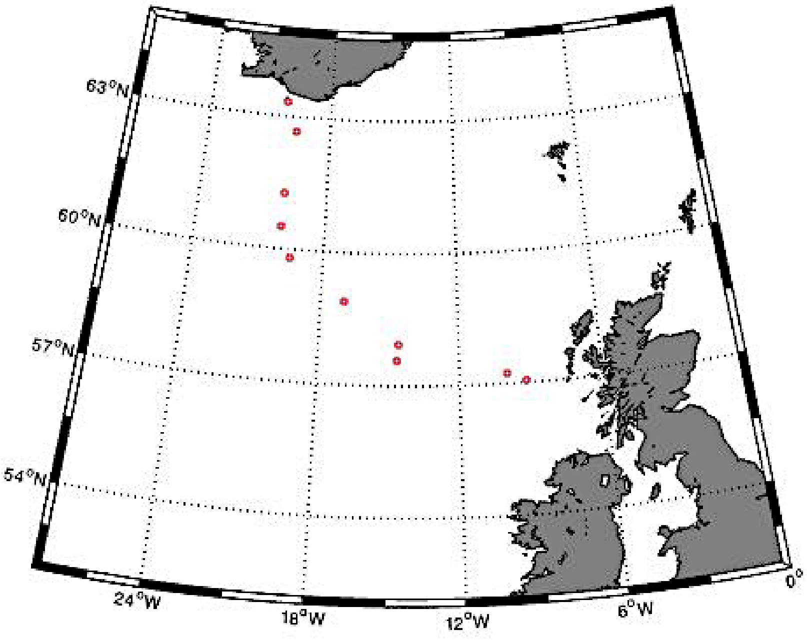

Figure 14.1: Map of sampled stations along the Extended Ellett Line for Total Chlorophyll-a and net growth experiments.

14.2 Filtering methods

Total Chlorophyll-a:
200-250ml of seawater is filtered through a 25mm diameter Whatman GF/F (effective pore size 0.7µm). When filtering is completed the filter is placed sampled side up in a numbered 20ml glass scintillation vial to which 6ml of 90% acetone (HPLC grade) is added using a bottle top dispenser. The vial is then placed in a tray and kept in a dark fridge (4˚C) for 20-24 hours. After this period, the vial is removed from the fridge but kept in a dark place. On the Trilogy fluorometer a reading is taken from the solid standard and a blank sample (consistently of 90% acetone). Next the sample from the vial that has been removed from the fridge can be measured and recorded in the logsheet. Once recorded the sample is deposed of in a wasted container. The fluorometer tubes and glass vials are washed with MilliQ in order to be used again.

Cellulose Nitrate:
300ml of seawater is filtered onto a Whatman Cellulose Nitrate Membrane Filter (0.8µm pore size), with a backing filter placed underneath. When filtering is completed the filter is place onto a Millipore petri slide that has been labeled with the following information in blue pen:

- Date
- Time
- CTD number
- Niskin bottle
- Depth
- Volume filtered
- 0, 24, or 48 hour sample
- Sample repeat 1, 2 or 3
- Cellulose nitrate label

With the lid slightly offset, the Millipore petri slide with the sample is placed in an oven to dry at 50-60˚C for 10-12 hours. After this period the slide is removed from the oven, the lid replace and boxed for further analysis back at the National Oceanography Centre.

Scanning Electron Microscope (SEM) samples:
The remaining seawater is measured, recorded and filtered onto a Millipore Isopore membrane filter (0.8µm pore size). When filtering is completed the filter is place onto a Millipore petri slide that has been labeled with the following information in red pen:

- Date
- Time
- CTD number
- Niskin bottle
- Depth
- Volume filtered
- 0, 24, or 48 hour sample
- Sample repeat 1, 2 or 3
- SEM label

With the lid slightly offset the Millipore petri slide with the sample is placed in an oven to dry at 50-60˚C for 10-12 hours. After this period the slide is removed from the oven, the lid replace and boxed for further analysis back at the National Oceanography Centre.

Record of sampled stations

Table 14.1: Record of all sampled stations

CTD	Date	EEL Number	Latitude	Longitude
CTD 002	02/06/15	IB23S	63 18.960 N	20 12.840 W
CTD 006	03/06/15		62 40.020 N	19 40.080 W
CTD 011	04/06/15	IB15	61 15.067 N	20 00.005 W
CTD 015	05/06/15	IB13	60 29.850 N	19 59.732 W
CTD 019	06/06/15	IB11A	59 48.500 N	19 30.000 W
CTD 026	07/06/15	IB5	58 53.000N	17 00.000W
CTD 034 *	08/06/15	IB2	57 57.000N	14 35.000W
CTD 046 *	10/06/15	A	57 35.000N	13 38.000W
CTD 059	13/06/15	N	57 14.000N	10 03.000W
CTD 067	14/06/15	Q	57 03.000N	09 13.000W

(* Sites were collected during the presence of a Coccolithophore bloom)

15. Total chlorophyll-a and size fractionated chlorophyll-a

Paris Mudan

Overview:
As part of a Masters project total chlorophyll-a and size-fractionated chlorophyll-a were collected for the CTD stations recorded in Table 15.2.

Fluorometric Total Chlorophyll-a Protocol:

1. Collect CTD water (250 ml) from 6-8 depths in dark brown plastic bottles;
2. Measure out 200 ml from each depth and filter under gentle pressure through a 25 mm diameter Whatman GF/F or Fisherbrand MF300 (effective pore size 0.7 mm);
3. Once finished filtering, remove filter and place sample-side up in a numbered 20-ml glass scintillation vial;
4. Add 6-ml of 90% acetone (HPLC grade) using bottle top dispenser;
5. Place vials in tray and keep in dark fridge (4°C) for 20-24 hours;
6. Remove vials shortly before measurement and keep in a dark between measurements;
7. Turn on Trilogy fluorometer (if not already on) and allow to warm up;
8. Take fluorescence readings from the solid standard to check for instrument drift (raised lip should be at the back of the fluorometer);
9. Fill fluorometer tube 1-2 cm from bottom with 90% acetone and take blank reading and then empty to waste;
10. Gently pour the extracted chlorophyll samples from each filter into the fluorometer tube, wipe sides of tube with tissue to remove condensation and measure;
11. Note the fluorescence reading, pour the acetone into a waste container and continue measuring the rest of the samples.
12. Dispose of filters and wash fluorometer tubes and glass vials with MilliQ and dry before using again.

Fluorometric Size-fractionated Chlorophyll-a Protocol

1. Collect CTD water (1000 ml) from 6-8 depths in dark brown plastic bottles;
2. Measure out 200 ml from each depth and filter under gentle pressure through a 25 mm diameter 0.2 mm polycarbonate filter;
3. Once finished filtering, remove filter and place sample-side up in a numbered 20-ml glass scintillation vial;
4. Repeat step 2. with 25 mm 2 mm polycarbonate filter and 25 mm 20 mm polycarbonate filter;
5. Add 6-ml of 90% acetone (HPLC grade) using bottle top dispenser;
6. Place vials in tray and keep in dark fridge (4°C) for 20-24 hours;

Table 15.2: CTDs sampled for total and size-fractionated Chlorophyll-a

Sampled CTD Stations			
002	016	032	052
003	019	034	053
004	020	035	056
006	021	036	058
007	023	037	059
008	025	046	061
010	026	047	067
011	027	048	068
013	028	049	069
015	030	050	070

16. Seaglider operations

Karen Wilson

16.1 Seaglider deployments

Two Seagliders were deployed during the cruise SG603 (Knockando) and SG606 (Laphroaig).

The first Seaglider (SG603) was deployed in deep water south of Iceland, immediately after the CTD had been recovered on deck at station IB19 (CTD station 6). Due to the forecast of bad weather in the days preceding the launch the pre-deployment self test was carried out on the 30th May before transit from UK waters. Encompassing the sea-level test, the internal pressure test and interactive self test, all sections of the test were completed satisfactorily.

SG603 was deployed on the 6th June at IB19 (see Table 16.1). Pre-launch checks were carried out satisfactorily before reaching station and confirmation of communications was received from the pilot via Iridium phone. The pilot gave clearance for launch once the ship CTD operations were completed. The weather conditions were clear and calm, offering no problems during the launch.

The starboard crane was used to lift the glider into the water and gave ample distance from the ship's side on release to allow the glider to drift away from the ship. The glider was secured to the crane by a soft rope around the rudder lifting point to a quick release hook. Although the glider had been previously ballasted in water fresher than the deployment site a quick ballast check was carried out before the release hook was opened and the glider was released. Once released the glider was in the correct orientation slightly off vertical with the water at rudder level.

The ship moved off to a safe distance and waited for the first dive to complete, once conformation of correct operation was received from the pilot via phone the ship continued on with the program.

The second glider (SG606) was deployed at IB2 using an identical method to the previous glider deployment detailed above. Again, there was favourable weather conditions and deployment proceeded without incident. Pre-deployment self test was carried out 2 days before the launch with both the field and pilot sections completed satisfactory.

16.2 Seaglider project details

SG603 was deployed in the deep waters off the Icelandic shelf as it was the most convenient location on the ship's program for the glider's transit to Greenland. The aim of this mission is to investigate the conditions and circulation patterns in Kangerdluggsuaq Trough. In particular, the goal is to measure the interaction of Atlantic water with the fjord water by use of the Seaglider's CTD and the depth averaged current. SG603 is due to be recovered off Iceland in November 2015.

SG606 was deployed close to the eastern end of the OSNAP glider line to relieve SG605 (Bowmore). The overarching goal of the Overturning in the Subpolar North Atlantic Programme (OSNAP) is to capture the meridional fluxes of mass, heat, and flux across the whole subpolar North Atlantic. A component of the OSNAP array is the continual occupation of the Rockall-Hatton Plateau by Seagliders, of which SG606 is the fourth since the start of the programme.

After completing 4 transects of the Rockall-Hatton Plateau, SG606 will be piloted east to the Scottish shelf and will be recovered by small boat off Tiree.

Table 16.1 DY031 glider deployments

Glider team	Launch Technician	Karen Wilson
	Pilot	Estelle Dumont
SG603 Knockando	Release position	60 40.1N, 19 40.0W
	Release time and date	03/06/2015 12:36 UTC
	Water depth	1670m
SG606 Laphroaig	Release position	57 57.0N 14 35.0W
	Release time and date	08/06/2015 10:27 UTC
	Water depth	440m

Progress of SAMS operated gliders and preliminary data can be viewed at:
http://velocity.sams.ac.uk/gliders/

The full glider mission report will also be finalized within 6 months of the end of the mission and will be available at: http://velocity.sams.ac.uk/gliders/mission_list.php

17. Benthic macrofauna

Peter Lamont and Natalia Serpetti

17.1 Introduction

SAMS sampling in the Rockall Trough dates from 1973. As Dave Ellett established his 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 years until 1994 twenty three samples were obtained from M with the WHOI-pattern epibenthic sled. Station 'M' was also sampled with the Agassiz trawl (x35), Bed-Hop Camera (x7), Barnett-Watson Multicorer (x10), USNEL spade boxcorer (x24), Megacorer (x3), and the rectangular midwater trawl (x6) for plankton. The historical samples span a time frame of >20 years and there have been noticeable changes in the surface productivity during this period possibly as a consequence of a changing climate. The epibenthic sleds were refurbished at SAMS, Oban in late 2012 and deployed in 2013 (see *James Cook* 086 cruise report). Possible changes in the macrobenthic community at Station M are currently being investigated with analysis of the 2013 samples to provide a new point over a 40 year time span record for this gear and position. Cruise DY 031 has enabled a further five, good quality sled tows to be carried out adding 2015 to the benthic time series.

17.2 Methods

Deployment/recovery

Two of the original WHOI-pattern sleds, used by John Gage, were rigged as in 2013 with identical net meshes of 0.5 mm for both main and extension nets. The sleds are fished with the door open and fishing stops when the door is closed by a timer mechanism. The sled door closing timing device worked without fail for the five deployments during this cruise. 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 historical samples. The main trawl winch on the *Discovery* had not been used much before this cruise but no problems were encountered.

The first sled had sediment extending about 30 cm into the main net while the last four were consistently 50 to 60 cm into the main net with the extension net full in every case. After washing on stacked 4 mm, 0.5 mm and 0.42 mm sieves the retained material is placed in suitable sample buckets with 4% buffered formaldehyde in filtered seawater. The largest size fraction is retained on the 0.5 mm sieve and constituted between 3 and 6 litres of washed material per sled. This large volume is impractical to be processed as a unit so subsampling 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 (Gage 1982). 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 so the original sieves were employed for comparison purposes with historical data.

The sleds were deployed according to a three step deployment procedure (Fig. 17.1). Based on the EEL 2013 experience of deployment time scale, a deployment events outline was prepared for the bridge and the winch (Table 17.1). This was useful to the bridge officers and winch operators and resulted in ~1 hour towing on the seabed for all the deployments.

Table 17.1. Sled deployment outline

Approx elapsed time	**cable out**	**veer/haul**	**Ship speed**	**Description**
start	0	veer slow & increasing	2 knts	speed THROUGH THE WATER to stream gear
30 min	500	stop	2 knts	attach pennant to main trawl warp
45 min	1000	veering 60 m/min	2 knts	winch speed increase to 60 m/min max
2hr	5000	stopped	1 knt	speed OVER THE GROUND
2 hr 15 min	5000	stopped	1 knt	assume gear on bottom - towing
2 hr 45 min	5000	stopped	1 knt	target position?
3 hr 15 min	5000	stopped	1 knt	door closure (pre-set on timer)
3 h 20 min	5000	start hauling	1 knt	gear assumed off bottom, slow winch
3 h 30 min	4000	hauling	1-1.5 knt	hauling increase to max 50 m/min
4 h 30 min - 5 hr	0	on deck		gear on deck

Shooting

Ship's speed is requested to be 2 – 2.5 knots (Fig. 17.1, light blue line). Check frequently that the ship's speed does not drop below 2 knots.

Winch speed very slow initially. After 250 m veered wire gradually increase veering rate to a traditional maximum of 60 m/min (Fig. 17.1, green line) after 1000 m of wire (Fig. 17.1, red line). *Discovery* winch rates are software controlled stepwise in units of 0.1 ms^{-1} so that a veering maximum of 1.0 ms^{-1} was selected.

A pennant wire is fitted to the sled to protect the end of the 15 km trawl wire from damage on the seabed. This pennant (~500 m) is housed on a deck winch with direct control and the wire led over a block at the end of the deck crane. The main trawl wire is routed through the A frame block and coupled to the inboard end of the pennant wire. A weak link of three tons was fitted inboard of the sled, above which is attached the sled safety strop linked to the rear of the sled. Inboard of the safety strop attachment is a swivel linking in turn to the pennant wire.

Fishing

Once the chosen wire length has been paid out i.e. 5,000 m for station ‘M’ (4,500 m + 500 m of the pennant wire, Fig. 17.1, red line) stop winch and reduce ship’s speed to 1 knot ideal with 1.5 knots MAXIMUM (sled and Agassiz, Fig. 17.1, light blue line). Allow 15 minutes for gear to settle on bottom. Towing is for one hour (normally) or until the sledge door is closed.

If there is a tension plotter, watch for any sudden increase in tension as for any towed gear (Fig. 17.1, blue line). Should the gear become fast (sudden tension increase) inform bridge immediately. Wire may be paid out to reduce tension while the ship speed relative to the bottom is reducing. Both sled and Agassiz are rigged with (usually) a 3 ton weak link between the towing strops and the safety strop. Inboard of the safety strop is rigged a swivel. This coupling arrangement was employed on DY 031.

Hauling

Maintain ship’s speed at 1 to 1.5 knots. Start hauling at dead slow until the gear is assumed to be off the bottom (probably 10 minutes). Gradually increase hauling speed to a maximum of 50 m/min (70 m/min Agassiz). At 200 m wire remaining, reduce speed to 50 m/min falling to 30 m/min at 100 m wire remaining. On DY031 when hauling a maximum rate of 0.8 m/s (=48 m/min) was employed.

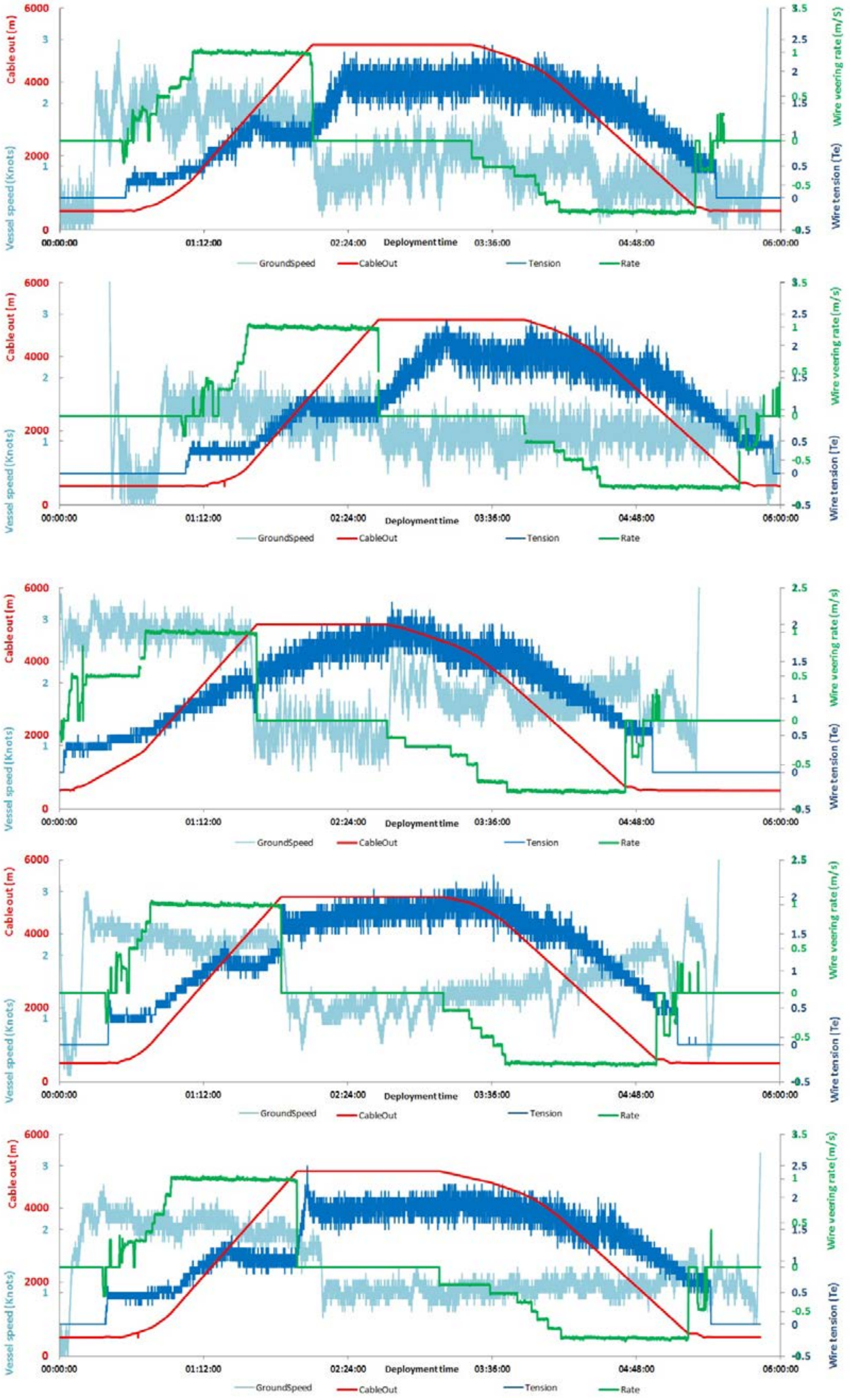

Fig. 17.1 Composite synchronous plots of vessel speed (knots, light blue line), wire out (m, red line), wire veering rate (m/s, green line) and the wire tension (Te, blue line)

Sample processing

Sled sediment was processed historically with an elutriation set-up involving a pair of smooth-sided, tapered, galvanised bins each fitted with 60 mm outlet and mounted in an adjustable wooden stand. Each bin overflowed into a sieve stack also mounted in an adjustable wooden stand. The seawater supply for this apparatus was via a thick, rubber hose of 2.5 cm internal diameter coupled to the ship's fire hose supply. A screen of 0.45 mm prevented surface plankton from contaminating the sample.

For DY 031 we attempted to duplicate the historical elutriation using a Storz 66 mm coupling with 25 mm internal diameter hose tail fitting, linking to the ship's fire hose system (Fig. 17.2). The hose led to a compressed disc type filter (Fig. 17.3) that can be dismantled and cleaned. A plastic water butt was tried with the bulk sediment at first but the residence time for the large fauna was unnecessarily long as they tended to collect at the bottom and were not easily washed out because of the corrugations in the moulding of the water butt. It was found to be much more efficient to process the sediment in the 20 litre buckets it had been collected in (Fig. 17.4). This reduced fauna residence time in the elutriation and all material could be removed from each bucket relatively quickly due to the smaller volume. When emptied, a typical sled catch from DY 031 filled the order of 24 x 20 litre buckets with each filled from a third to a half with sediment. This permitted the catch to be stored, either for less than 24 hours in a cold room, or, with about the same volume of 4% formaldehyde added to each bucket permitting washing some days later as was the case with ES1681. Large-scale sediment washing, flowing overboard, can disrupt shallow CTD readings so that a storage solution is a necessity. About 50 x 20 litre buckets were brought aboard DY 031 in anticipation of this eventuality.

Results

Fig. 17.2 Storz 66 mm firehose coupling with 2.5 cm hose tail connection for seawater.

Fig. 17.3 Washing water filter

Fig. 17.4 Elutriation from 20 litre collecting bucket into 4 mm, 0.5mm and 0.42 mm sieves.

Five sled deployments were obtained (ES_1677, ES_1678, ES_1679, ES_1680 and ES_1681 listed in Table 17.2, and plotted in Fig. 17.5). The samples were sieved on board through 3 sieves (Fig. 17.4) of 4 mm, 500 µm and 420 µm apertures.

Table 17.2. Sled deployments showing depth (m), sledge ID, date and geographical coordinates.

Sled ID.	**Date**	**Depth (m)**	**Start**		**End**	
			Lat	**Lon**	**Lat**	**Lon**
ES_1677	11-Jun-15	2200	57.31795	-10.3687	57.3076	-10.3943
ES_1678	11-Jun-15	2201	57.3127	-10.3743	57.30397	-10.3963
ES_1679	12-Jun-15	2185	57.34506	-10.3772	57.36309	-10.3693
ES_1680	12-Jun-15	2209	57.30995	-10.3927	57.33001	-10.4006
ES_1681	13-Jun-15	2213	57.30844	-10.3927	57.31965	-10.3726

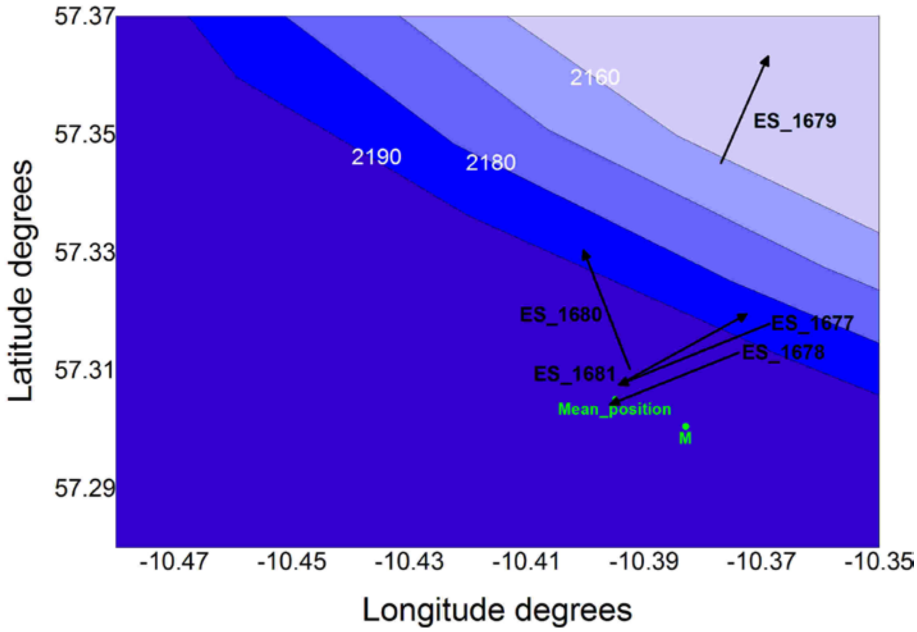

Fig. 17.5 Estimated tracks of the four sled deployments on DY031. Arrows indicate the direction of tow and length represents the estimated distance along the seabed.

Figure 17.6. A typical >4 mm catch from one sled haul in a 5 litre bucket. Dominated by echinoderms with some sponges and molluscs. Unusually a fragment of bladderwrack (Ascophyllum) is present.

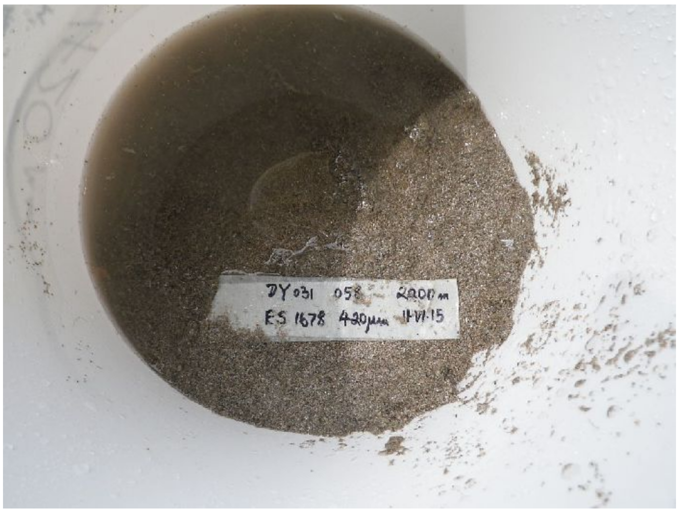

Figure 17.7. A typical volume (half litre) of <0.5>0.42 mm catch from a sled haul in a 5 litre bucket.

Figure 17.8. Three Ophiomusium lymani and three Hymenaster sp. are show here on the 4 mm sieve.

Comments

For the 2015 deployments a timeline guide, Table 17.1, was prepared based on historical and also 2013 deployments. This was useful to the bridge officers. The winch operators used the timeline as a target to match, sometimes to the minute. Overall the five sleds were very consistent in the volume of sediment recovered (Fig. 17.5).

The first, second and fifth tows run parallel and close together. The fourth is at right angles to these while the third, ES1679, is at 90 degrees to the slope and a little removed from the other four tracks. It is anticipated that the results from these five samples will elucidate any differences in patchiness across station ‘M’ as well as providing a more assured basis, when combined with 2013, to compare with historical sled data.

In case of future sledge deployments during the EEL cruise we would recommend deploying the first two sledges in day light (e.g. one in the morning and in the afternoon on the first day (approximately 5/6 hours per deployment) and to wash the sediment (washing sediment can take up to 5 hours) during the following deployments. When necessary to avoid contaminating outboard seawater for the CTD the buckets containing the mud can be stored, either for less than 24 hours in a cold room, or, with about the same volume of 4% formaldehyde added to each bucket and then mixed, permitting washing some days later.

References

Gage, J.D., 1982. *An aerated sedimentation column for subsampling large benthic samples from deep-sea sediments.* Deep-Sea Research, V2

18. Argo float deployments

Penny Holliday

Two Met Office Argo floats were deployed. They were supplied in pressure-activated mode for the cruise so it was a just a matter of deploying them with a rope from the starboard quarter as we headed off from a CTD station. The two floats were ballasted for the Iceland Basin and deployment details given in Table 18.1.

Table 18.1. Argo float deployments

Float Serial Number	**7207**	**7208**
Argos ID	142535	142536
WMO ID	6901176	6901177
Suggested Deployment Latitude	59.5N	60.5
Suggested Deployment Longitude	18.5W	20.0W
Deployment Date and Time	07/06/2015 00:00	05/06/2015 09:37
Deployment Latitude	59 20.036	60.49963
Deployment Longitude	18 9.737	-20.00004
Method (crane, rope, throw-over)	Rope	Rope
Package type (expendable box, no box)	No box	No box
Wind speed (in Beaufort scale)	12 knots	22 knots
CTD Cast	CTD022	CTD015

19. Trace metal Sampling

Emily Hill

The purpose of collecting samples aboard the 2015 Extended Ellett Line was to characterize water masses based on their trace metal concentration. These data will be used in conjunction with temperature, salinity, oxygen, nutrients and carbon in order to identify the water masses between Iceland and Scotland. These measurements will then be used to identify the Arctic component of the North Atlantic using previous datasets of trace metal investigations from the Arctic Ocean and surrounding waters.

Samples were taken at 6 stations along the cruise line at 6 depths. Two depths were sampled with duplicate niskin bottles for reproducibility purposes. The stations and sampling depths are shown in Table 19.1.

Table 19.1. Stations and depths sampled along the 2015 Ellett Line Cruise.
** denotes where duplicate samples were taken.*

Station	**Depths sampled (m)**
IB16A	1785, 1550, 750*, 350, 100, 5*
IB9	1843, 1500, 100*, 700, 350, 10*
IB4	983*, 800, 450, 150, 25, 10*
F	1790, 1500, 1000*, 600, 100, 5*
O	1916, 1500, 1060*, 600, 150, 5*
9G	154*, 100, 75, 50, 25, 5*

The approximate locations of sampled stations are shown in Figure 19.1.

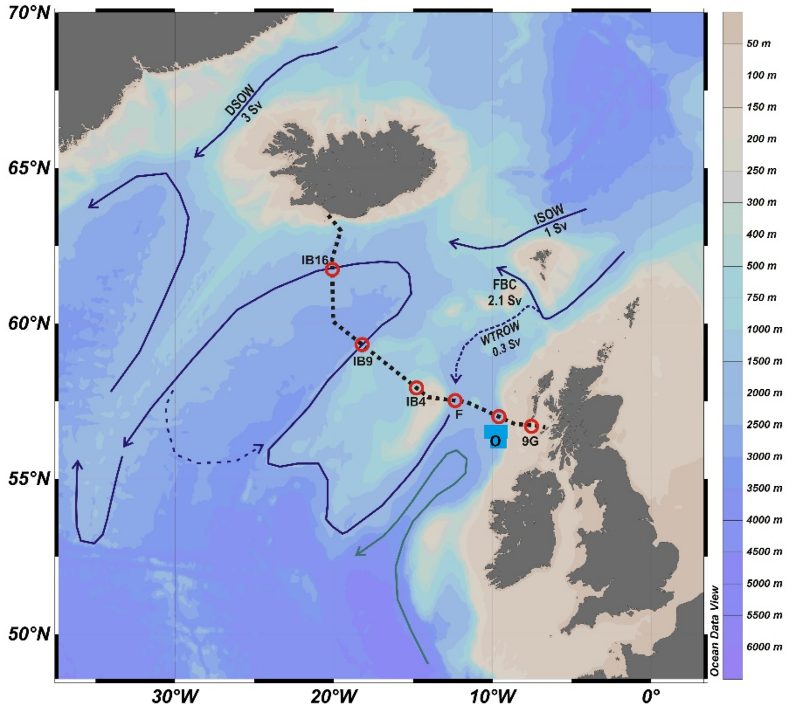

Figure 19.1. Locations of stations sampled for trace metals.

Samples were labelled with the station name followed by the niskin bottle number. For example at station IB9 and niskin bottle 2, the sample label should be IB92.
Once the CTD was back on deck, 1L bottles were used to collect seawater from the niskin. Once sampling was completed, seawater was filtered in a clean lab through polycarbonate filters and poured into 100ml bottles. The seawater was then acidified on board with 4ml/L of 7M UpA hydrochloric acid. The samples were then placed into the fridge until disembarkation. On return to SAMS, the samples will then be analysed by an ICP-MS for trace metal concentrations.

20. Benthic camera deployment

A Go-Pro camera with water-proof camera housing and battery-powered lights was attached to the CTD frame at selected stations to test whether this was a feasible approach to surveying the seafloor for benthic fauna.

The equipment was supplied by Kerry Howell (Plymouth University) and consisted of a single GoPro camera with a housing rated to 1500m, plus two lights depth rated to 1250m. The lights were battery-powered.

The camera and lights were deployed at CTD stations 25, 26, 28, 30, 43, 44, 46 and 47.

The equipment worked, but there were some problems. The batteries for the lights took a long time to charge and usually ran out of power before the end of the CTD cast. The lights were insufficient to illuminate the seabed if they were on a low setting or if only one was operating. One cast had very little data recorded because the memory card had not been erased beforehand. The main problem, however, was that the seafloor was not easily visible when the CTD was 5-10m off the bottom, not just because of insufficient light, but because there was so much biological material in the water.

We found that downloading data by inserting the SD card into a laptop was fast and efficient (as opposed to using the cable which was slow). Video files needed to be deleted on the camera, not via the laptop (too easy to forget to "empty trash" meaning data files not actually deleted).

21. Acknowledgements

This was a very successful and good humoured cruise with good weather and a lot achieved. We would like to thank the Master, Antonio Gatti, for his support during the trip. We would also like to thank all the ship’s crew for their professionalism and good humour. The skill of the bridge officers, the engineers, the catering staff and the ABs was very much appreciated.

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