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National Oceanography Centre

Cruise Report No. 35

RRS *James Clark Ross* Cruise 302

06 JUN - 21 JUL 2014

The 2015 RAGNARRoC, OSNAP and
Extended Ellett Line cruise report

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2015

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REFERENCE

Southampton, UK: National Oceanography Centre, Southampton, 76pp.
(National Oceanography Centre Cruise Report, No. 35)

ABSTRACT

Cruise JR302 was an NERC-NC funded cruise aiming to complete a full CTD section across the subpolar gyre, from Canada to Greenland to Scotland. The CTD section was located along the OSNAP track (www.ukosnap.org), providing a high quality and high resolution synoptic survey for the start of that programme. The objectives included a full suite of biogeochemistry measurements under the RAGNARRoC programmes.

Finally, the eastern part of the section included the 2014 occupation of the Extended Ellett Line (projects.noc.ac.uk/ExtendedEllettLine) between Scotland and Iceland. Additional sections were made around the Cape Farewell region with the objective of measuring transport and the movement of water away from the boundary currents.

Additional objectives included deploying eight Met Office Argo floats, and recovering one SAMS glider. Two new instruments were trialled by deploying them on the CTD frame; the IMP and RBR.

All objectives were successfully completed.

KEYWORDS

ISSUING ORGANISATION

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Ship's Personnel

1. Overview

1.1 Itinerary

St Johns, Newfoundland, Canada to Immingham, UK, 6 Jun - 21 Jul 2014

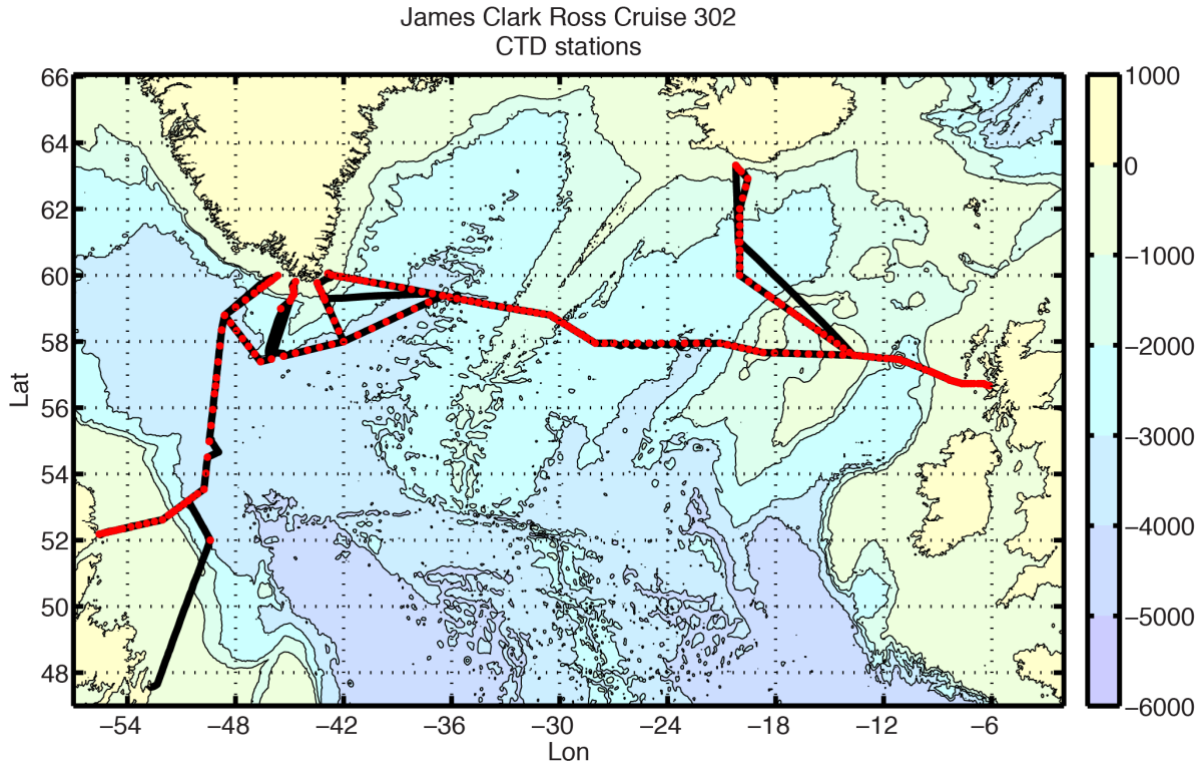


Figure 1.1.1 The JR302 station positions and track line

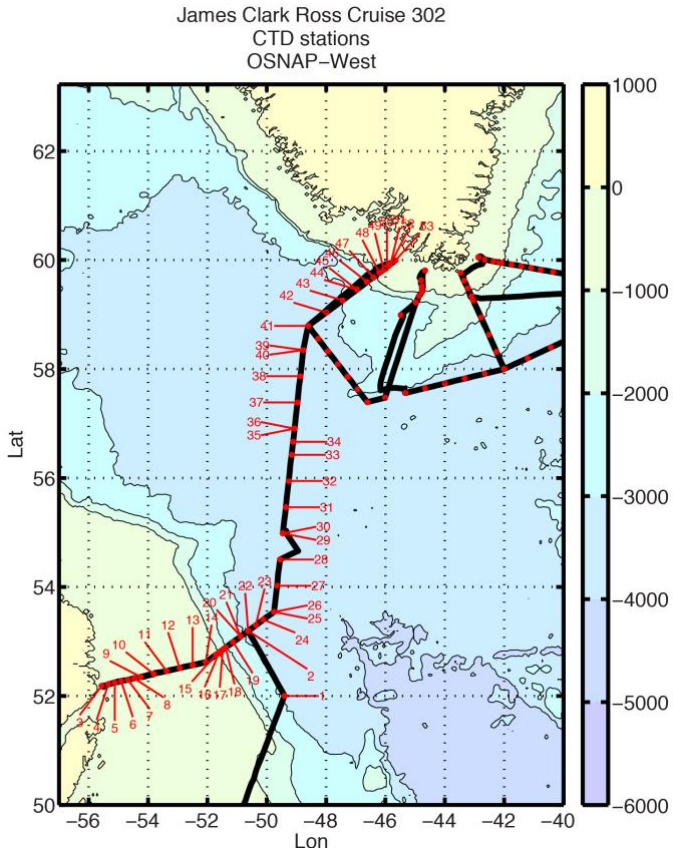


Figure 1.1.2. Station positions and numbers for the OSNAP West line

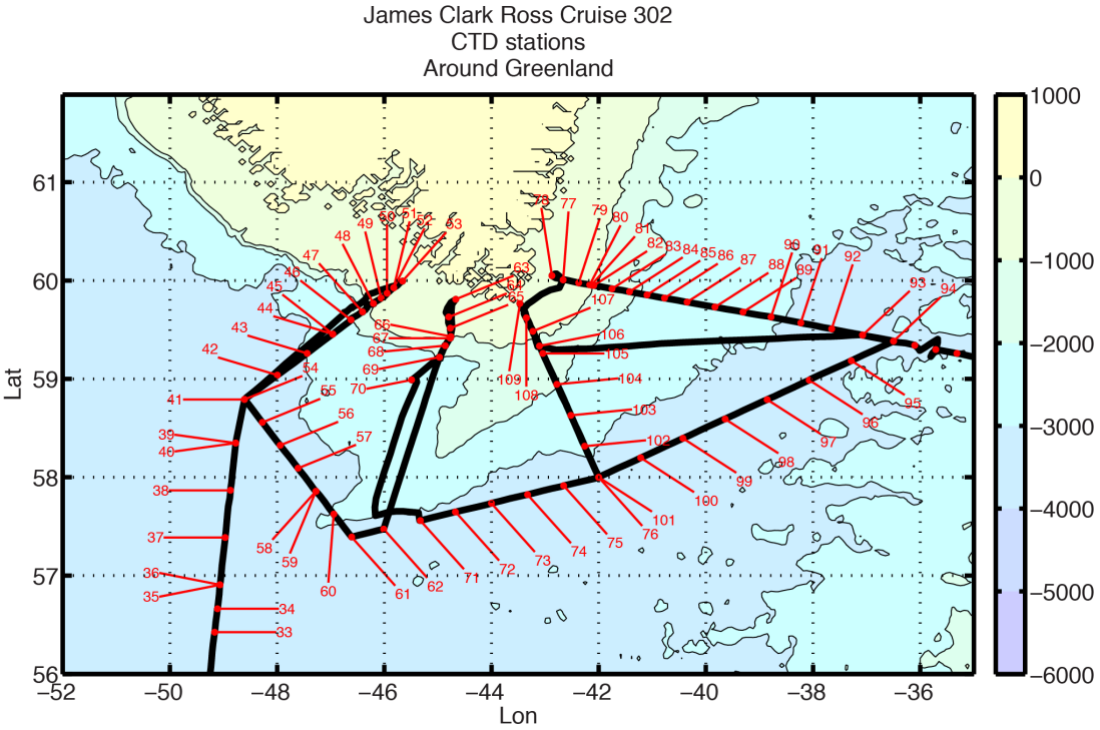


Figure 1.1.3 Station positions and numbers for stations around Greenland

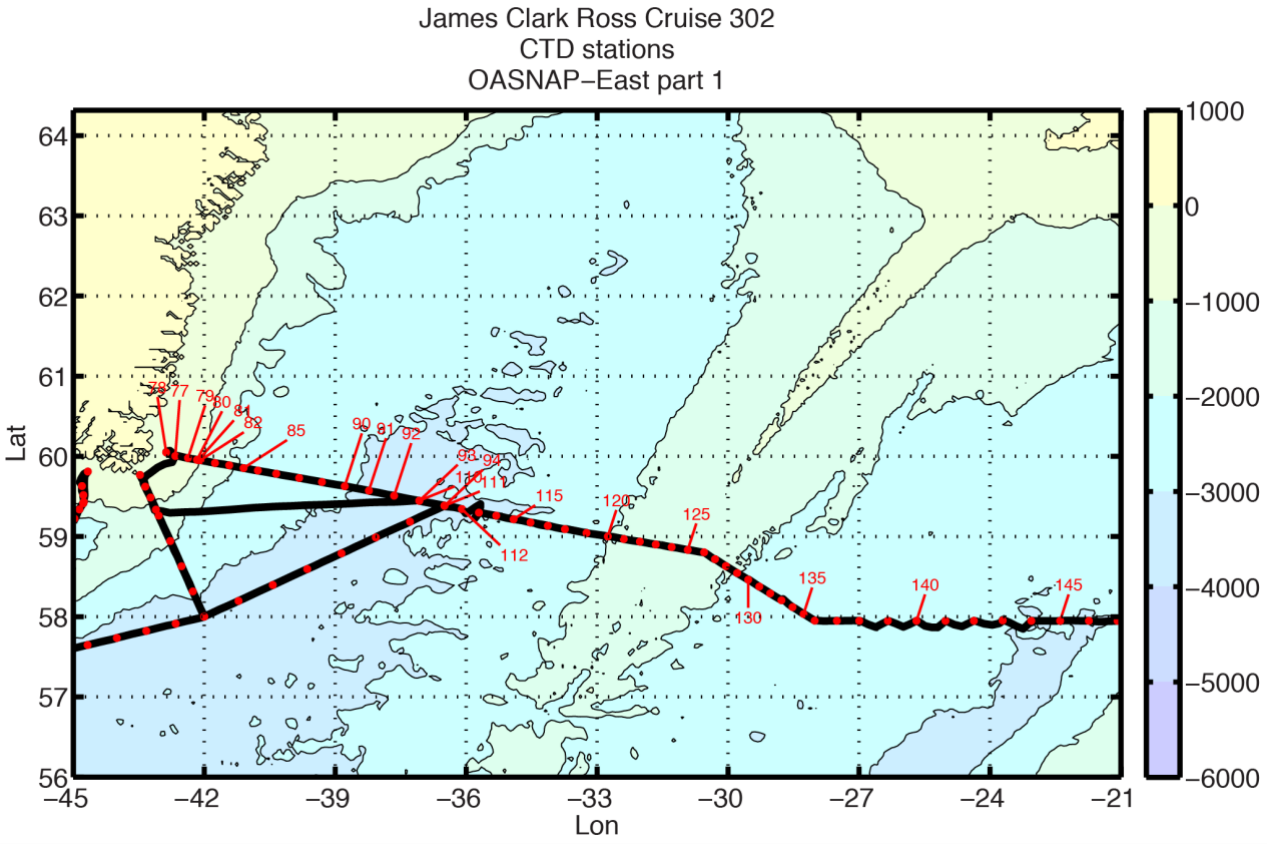


Figure 1.1.4 Station positions and numbers for OSNAP East (part 1).

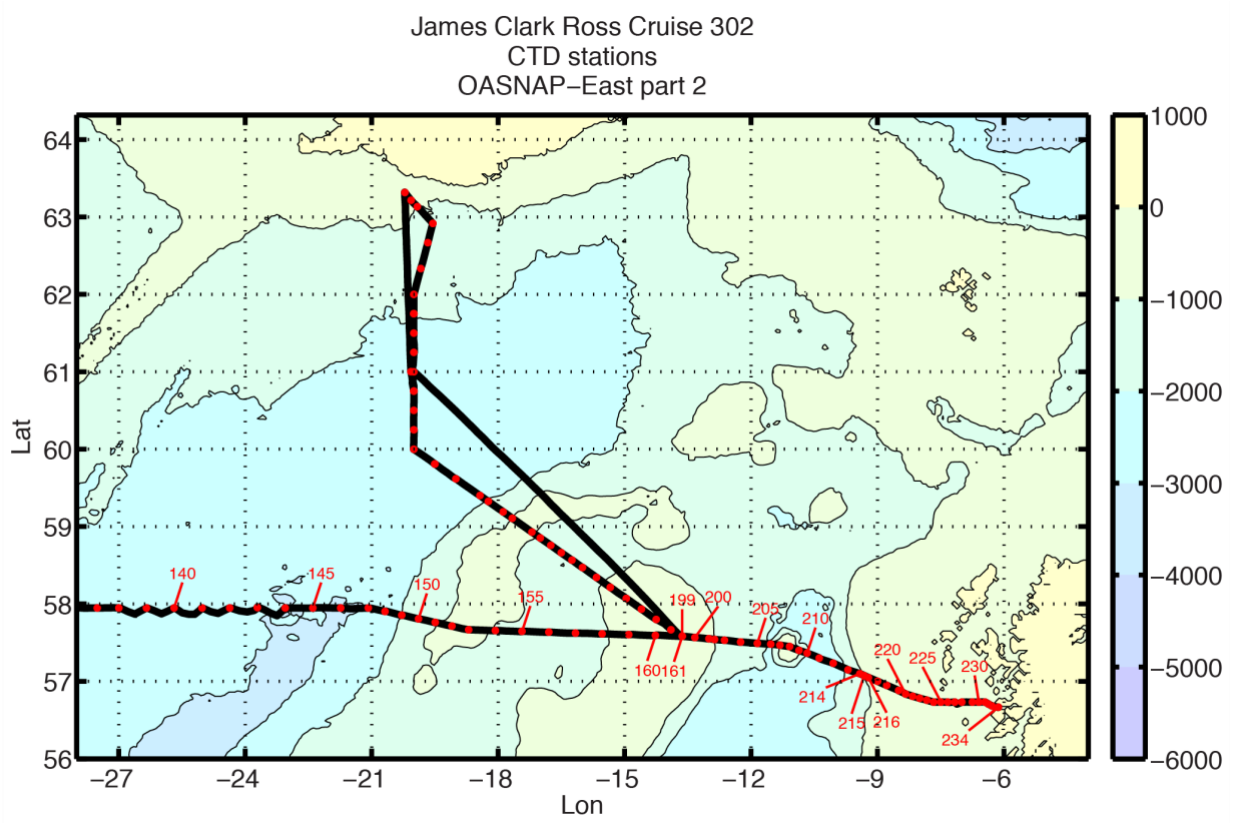


Figure 1.1.5 Station positions and numbers for OSNAP East (part 2).

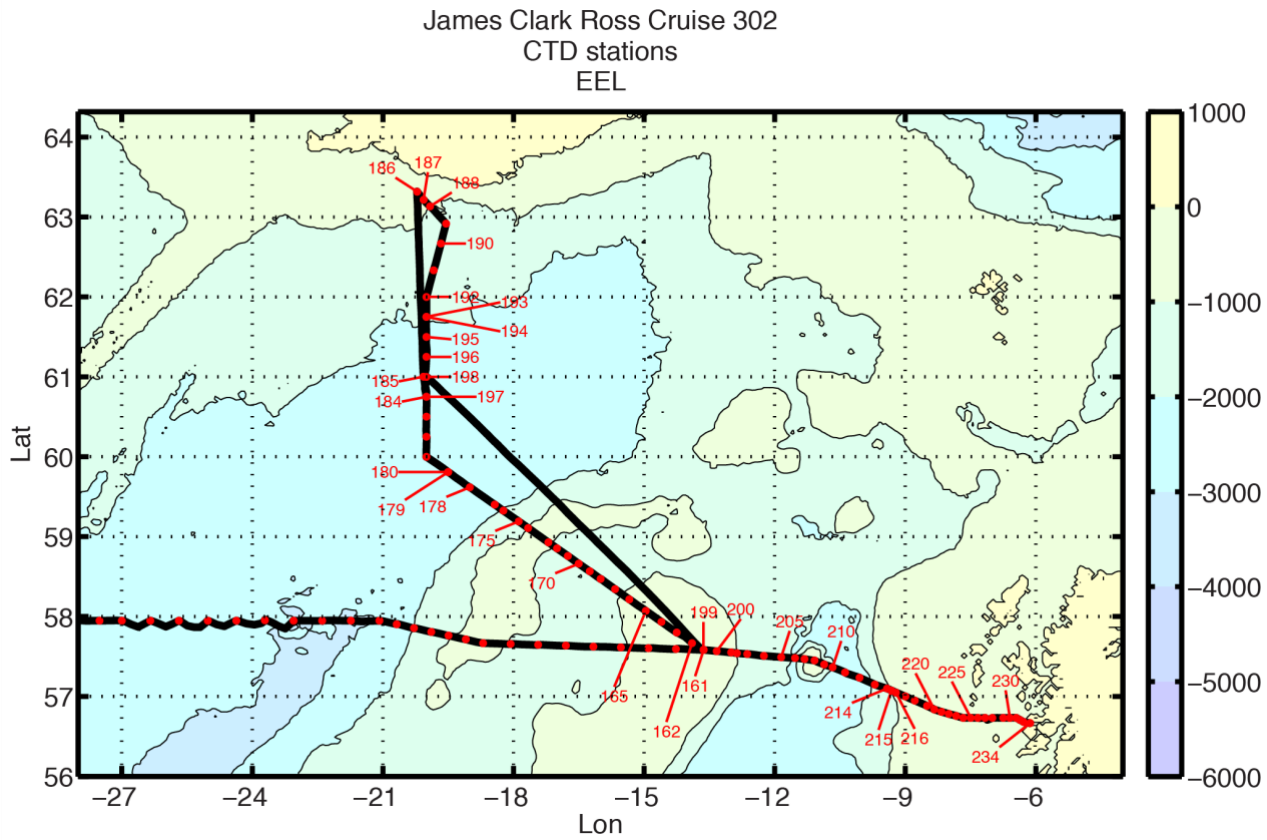


Figure 1.1.6 Station positions and numbers for Extended Ellett Line.

Table 1.1.1 JR302 CTD stations. cdep=corrected water depth (m); maxd = maximum depth of CTD (m), alt = height of bottom (m); res = cdep-maxd-alt; wire = max wireout (m); pres = max pressure (dbar); nd = number of bottles fired; sal/oxy/nut/car/cfc = number of bottles sampled for salinity/oxygen/nutrients/carbon/CFCs.

stn	yy/mo/dd	hhmm	dg	min	lat	dg	min	lon	cdep	maxd	alt	res	wire	pres	nd	sal	oxy	nut	car	cfc	Comments
001	14/06/08	0858	52	00.00	N	49	24.01	W	3022	2003	-9	-999	2000	2030	17	17	24	24	0	22	Test station 1
002	14/06/08	2157	53	11.70	N	50	37.61	W	3152	3029	-9	-999	3035	3078	22	22	24	24	10	0	Test station 2
003	14/06/09	2244	52	11.01	N	55	33.91	W	86	82	3	-1	79	83	6	6	6	7	6	5	OSNAP-W; shelf
004	14/06/10	0237	52	12.89	N	55	20.34	W	164	160	4	-0	156	161	8	8	8	8	8	10	OSNAP-W; shelf
005	14/06/10	0520	52	14.50	N	55	07.24	W	156	152	4	-0	150	153	8	8	7	8	8	6	OSNAP-W; shelf
006	14/06/10	0823	52	16.14	N	54	54.18	W	191	187	5	1	184	189	8	8	8	24	8	12	OSNAP-W; shelf
007	14/06/10	1039	52	17.77	N	54	41.04	W	195	190	5	1	187	192	8	8	10	24	8	6	OSNAP-W; shelf
008	14/06/10	1339	52	19.37	N	54	28.02	W	194	189	6	0	186	190	8	8	9	24	8	7	OSNAP-W; shelf
009	14/06/10	1545	52	20.98	N	54	14.89	W	260	254	5	-1	252	256	8	8	9	24	7	8	OSNAP-W; shelf
010	14/06/10	2010	52	24.24	N	53	48.67	W	358	354	4	-0	352	357	12	12	12	12	12	14	OSNAP-W; shelf
011	14/06/11	0004	52	27.42	N	53	22.44	W	192	187	6	1	184	189	8	8	8	8	7	0	OSNAP-W; shelf
012	14/06/11	0437	52	30.62	N	52	56.21	W	250	246	4	0	245	249	9	9	9	9	7	7	OSNAP-W; shelf
013	14/06/11	0840	52	33.89	N	52	29.76	W	254	248	6	-1	245	250	8	8	8	8	8	0	OSNAP-W; shelf
014	14/06/11	1238	52	37.09	N	52	03.41	W	296	293	3	0	289	296	8	8	10	10	6	8	OSNAP-W; shelf
015	14/06/11	1630	52	45.32	N	51	42.79	W	495	490	5	-0	488	495	12	4	12	12	12	0	OSNAP-W; shelf
016	14/06/11	1919	52	47.70	N	51	36.56	W	996	990	6	-0	988	1001	14	14	24	24	14	14	OSNAP-W; shelf
017	14/06/11	2213	52	50.93	N	51	28.97	W	1482	1477	4	-1	1474	1496	15	15	15	15	14	8	OSNAP-W
018	14/06/12	0105	52	53.32	N	51	23.01	W	2007	2000	5	-2	1997	2028	19	19	19	20	18	18	OSNAP-W
019	14/06/12	0724	52	59.36	N	51	08.17	W	2411	2401	9	-1	2395	2437	20	20	23	24	20	19	OSNAP-W
020	14/06/12	1044	53	05.48	N	50	52.85	W	2890	507	-9	-999	500	512	8	0	0	0	0	0	Shallow; CH4/N2O only
021	14/06/12	1242	53	05.48	N	50	52.85	W	2890	2884	6	-1	2880	2929	24	24	24	24	12	6	OSNAP-W
022	14/06/12	1706	53	11.67	N	50	37.57	W	3146	3147	5	6	3144	3200	24	24	24	24	14	23	Repeat of Test 2
023	14/06/12	2113	53	17.81	N	50	22.34	W	3295	3290	5	0	3284	3346	24	24	24	23	24	12	OSNAP-W
024	14/06/13	0355	53	24.02	N	50	07.11	W	3466	3456	10	-0	3446	3515	22	22	22	22	13	18	OSNAP-W
025	14/06/13	0805	53	32.51	N	49	45.19	W	3589	504	-9	-999	500	509	8	0	0	0	0	0	Shallow; CH4/N2O only
026	14/06/13	1010	53	32.51	N	49	45.19	W	3589	3577	12	-0	3572	3640	24	24	24	23	14	23	OSNAP-W
027	14/06/13	1624	54	01.33	N	49	39.19	W	3637	3627	9	-0	3622	3692	24	24	24	24	15	14	OSNAP-W
028	14/06/13	2221	54	30.19	N	49	33.37	W	3612	3602	10	-1	3595	3666	24	24	24	24	15	19	OSNAP-W
029	14/06/14	0748	54	59.03	N	49	27.58	W	3642	503	-9	-999	500	508	8	0	0	0	0	0	Shallow; CH4/N2O only
030	14/06/14	0944	54	59.03	N	49	27.58	W	3642	3631	10	-1	3625	3696	24	24	24	24	14	20	OSNAP-W
031	14/06/14	1554	55	27.81	N	49	21.55	W	3662	3651	10	-1	3644	3717	24	24	24	24	23	16	OSNAP-W
032	14/06/14	2153	55	56.70	N	49	15.73	W	3758	3748	9	-1	3747	3817	24	24	24	24	15	18	OSNAP-W
033	14/06/15	0406	56	25.50	N	49	09.87	W	3671	3659	11	-1	3653	3725	23	23	22	24	14	20	OSNAP-W
034	14/06/15	0836	56	39.82	N	49	06.73	W	3636	2705	-9	-999	2700	2748	1	0	24	24	0	24	CFC bottle blank; CFCs, O2 only
035	14/06/15	1146	56	54.38	N	49	03.91	W	3618	504	-9	-999	500	510	8	0	0	0	0	0	Shallow; CH4/N2O only
036	14/06/15	1344	56	54.38	N	49	03.91	W	3618	3609	8	-1	3605	3674	22	22	24	24	13	19	OSNAP-W
037	14/06/15	1930	57	23.21	N	48	58.04	W	3550	3538	11	-1	3532	3601	21	21	24	24	13	12	OSNAP-W
038	14/06/16	0118	57	52.04	N	48	52.15	W	3481	3469	12	-1	3465	3530	21	21	24	24	16	18	OSNAP-W
039	14/06/16	0631	58	20.87	N	48	46.35	W	3478	502	-9	-999	500	507	8	0	0	0	0	0	Shallow; CH4/N2O only
040	14/06/16	0831	58	20.89	N	48	46.25	W	3478	3468	10	-1	3477	3529	21	22	24	24	21	17	OSNAP-W
041	14/06/16	1406	58	47.51	N	48	36.40	W	3421	3411	10	-0	3418	3471	22	21	24	24	22	18	Offshore start of line A

042	14/06/16	1921	59 02.29 N	47 59.55 W	3184	3173	11	-0	3168	3227	20	20	24	24	20	17	OSNAP-W; Line A
043	14/06/17	0007	59 15.61 N	47 26.51 W	2953	2943	10	-0	2939	2992	20	21	20	24	19	15	OSNAP-W; Line A
044	14/06/17	0543	59 27.42 N	46 57.61 W	2428	502	-9	-999	500	508	8	0	0	0	0	0	Shallow; CH4/N2O only
045	14/06/17	0720	59 27.42 N	46 57.60 W	2428	2419	10	1	2420	2456	20	20	20	22	20	16	OSNAP-W; Line A
046	14/06/17	1155	59 36.03 N	46 37.46 W	2192	2180	11	-1	2178	2212	22	22	22	22	22	19	OSNAP-W; Line A
047	14/06/17	1619	59 40.85 N	46 24.35 W	1260	1248	11	-1	1244	1263	22	22	22	24	14	14	OSNAP-W; Line A
048	14/06/18	0032	59 46.02 N	46 12.20 W	431	421	8	-1	420	426	15	15	14	15	14	15	OSNAP-W; Line A
049	14/06/18	0343	59 49.38 N	46 03.56 W	151	141	10	0	140	143	9	9	9	9	9	8	OSNAP-W; Line A
050	14/06/18	0646	59 52.30 N	45 56.91 W	136	127	9	-0	125	128	9	9	9	9	9	7	OSNAP-W; Line A
051	14/06/18	1128	59 55.62 N	45 49.49 W	121	114	7	-0	112	115	13	0	0	0	0	0	No samples;taps open;rpt at 052
052	14/06/18	1215	59 55.62 N	45 49.51 W	121	115	6	0	115	116	14	0	11	13	11	8	OSNAP-W; Line A
053	14/06/18	1618	59 59.75 N	45 39.47 W	136	131	6	0	130	132	14	14	12	13	12	5	Inshore end of line A
054	14/06/19	1426	58 47.50 N	48 36.50 W	3395	3412	10	27	3427	3472	0	0	0	0	0	0	Start A-B arc; repeat of 041
055	14/06/19	1831	58 33.51 N	48 16.43 W	3454	3445	9	-1	3446	3506	22	22	22	23	0	0	A-B arc
056	14/06/19	2304	58 19.51 N	47 56.46 W	3386	3376	10	-0	3369	3435	22	22	22	22	14	0	A-B arc
057	14/06/20	0408	58 05.49 N	47 36.47 W	3272	3264	9	1	3268	3321	21	21	21	21	0	0	A-B arc
058	14/06/20	0808	57 51.53 N	47 16.53 W	3184	504	-9	-999	500	509	8	0	0	0	0	0	Shallow; CH4/N2O only
059	14/06/20	1015	57 51.53 N	47 16.53 W	3184	3175	8	-0	3172	3230	20	19	21	18	19	0	A-B arc
060	14/06/20	1435	57 37.51 N	46 56.61 W	2901	2893	8	-1	2895	2940	21	21	24	24	0	0	A-B arc
061	14/06/20	1858	57 23.56 N	46 36.59 W	3215	3206	8	-1	3205	3261	20	20	20	24	16	0	A-B arc
062	14/06/21	0011	57 28.37 N	46 00.70 W	3264	3242	21	-1	3260	3298	21	21	19	24	0	0	End A-B arc
063	14/06/21	1522	59 48.62 N	44 39.99 W	128	125	4	1	123	126	15	15	14	15	6	0	Inshore start of line B
064	14/06/21	1814	59 37.78 N	44 47.71 W	145	138	4	-3	135	139	15	15	11	15	0	0	Line B
065	14/06/21	1946	59 30.91 N	44 46.08 W	213	203	8	-2	200	205	17	17	12	24	0	0	Line B
066	14/06/21	2214	59 25.92 N	44 45.48 W	513	507	9	3	505	513	19	19	10	24	0	0	Line B
067	14/06/22	0021	59 24.87 N	44 46.29 W	1019	1008	10	-1	1004	1020	16	15	15	24	0	0	Line B
068	14/06/22	0242	59 20.38 N	44 51.73 W	1503	1488	11	-4	1483	1507	20	11	20	24	0	0	Line B
069	14/06/22	0536	59 13.30 N	44 58.23 W	2008	1998	10	-0	2017	2026	20	20	20	23	0	0	Deepest station on line B
070	14/06/22	0855	58 59.42 N	45 29.26 W	2417	503	-9	-999	500	508	8	0	0	0	0	0	Shallow; CH4/N2O only
071	14/06/23	0131	57 33.62 N	45 19.65 W	3129	3114	15	-0	3118	3166	20	20	19	24	19	0	Start B-C arc
072	14/06/23	0713	57 38.92 N	44 40.29 W	3186	3176	9	-1	3187	3231	22	22	22	24	0	0	B-C arc
073	14/06/23	1203	57 44.14 N	44 00.12 W	3336	3327	9	-0	3323	3385	22	22	24	24	22	0	B-C arc
074	14/06/23	1715	57 49.46 N	43 19.71 W	3339	3329	10	-0	3321	3387	22	22	23	24	0	0	B-C arc
075	14/06/23	2156	57 54.89 N	42 39.23 W	3272	3255	16	-0	3250	3311	20	20	23	23	7	0	B-C arc
076	14/06/24	0230	58 00.00 N	41 59.97 W	3177	3165	10	-1	3160	3219	22	22	22	24	0	0	End B-C arc
077	14/06/24	1921	60 00.37 N	42 39.77 W	200	191	10	2	190	193	16	15	13	15	11	0	OSNAP-E; Line D
078	14/06/24	2252	60 03.09 N	42 52.22 W	170	159	11	-0	155	160	11	11	11	11	11	0	Inshore start of line D
079	14/06/25	0204	59 58.61 N	42 22.29 W	203	194	10	0	192	196	11	11	11	11	10	0	OSNAP-E; Line D
080	14/06/25	0348	59 57.41 N	42 09.92 W	493	483	10	-0	478	488	10	10	10	10	10	0	OSNAP-E; Line D
081	14/06/25	0551	59 57.25 N	42 08.10 W	1035	1017	8	-11	1013	1029	12	12	12	12	0	0	OSNAP-E; Line D
082	14/06/25	0749	59 57.04 N	42 05.39 W	1486	1476	10	-0	1475	1495	15	15	15	15	15	0	OSNAP-E; Line D
083	14/06/25	1026	59 55.01 N	41 45.16 W	1813	1803	9	-1	1807	1829	21	21	19	21	20	0	OSNAP-E; Line D
084	14/06/25	1315	59 53.18 N	41 25.52 W	1901	1892	9	-0	1888	1919	22	22	22	22	15	0	OSNAP-E; Line D
085	14/06/25	1641	59 51.25 N	41 05.91 W	2087	2077	9	-1	2073	2107	22	22	22	22	18	0	OSNAP-E; Line D
086	14/06/25	1943	59 49.35 N	40 46.34 W	2565	2555	9	-1	2553	2596	21	21	21	24	0	0	OSNAP-E; Line D
087	14/06/26	0028	59 46.88 N	40 20.93 W	2570	2560	10	-0	2555	2600	20	20	20	23	14	0	OSNAP-E; Line D

088	14/06/26	0412	59 43.83 N	39 49.61 W	2726	2716	10	-0	2711	2760	19	19	19	24	0	0	OSNAP-E; Line D
089	14/06/26	0754	59 40.79 N	39 18.26 W	2845	2836	9	-0	2830	2882	21	20	20	20	14	0	OSNAP-E; Line D
090	14/06/26	1142	59 37.75 N	38 46.95 W	2950	2941	9	-0	2937	2990	23	22	23	20	0	0	OSNAP-E; Line D
091	14/06/26	1539	59 34.25 N	38 13.80 W	3052	3042	9	-0	3038	3094	20	20	20	20	18	0	OSNAP-E; Line D
092	14/06/26	1932	59 30.50 N	37 39.09 W	3107	3096	10	-1	3092	3149	20	20	21	20	0	0	OSNAP-E; Line D
093	14/06/26	2326	59 26.75 N	37 04.42 W	3121	3110	10	-0	3106	3163	20	20	20	20	0	0	OSNAP-E; Line D
094	14/06/27	0336	59 22.99 N	36 29.85 W	3137	3088	10	-38	3082	3141	20	20	18	24	16	0	Branch to C-D arc
095	14/06/27	0825	59 11.17 N	37 17.03 W	3139	3129	10	-0	3125	3182	19	19	19	19	0	0	C-D arc
096	14/06/27	1317	58 59.32 N	38 04.18 W	3127	3118	9	0	3114	3171	20	20	20	20	15	0	C-D arc
097	14/06/27	1802	58 47.45 N	38 51.32 W	3124	3114	10	-1	3109	3166	19	19	19	20	0	0	C-D arc
098	14/06/27	2241	58 35.58 N	39 38.50 W	3110	3099	10	-0	3096	3152	20	20	20	20	0	0	C-D arc
099	14/06/28	0337	58 23.73 N	40 25.63 W	3136	3124	11	-1	3121	3177	20	20	20	24	16	0	C-D arc
100	14/06/28	0827	58 11.86 N	41 12.84 W	3182	3172	10	-0	3175	3226	17	15	16	16	0	0	C-D arc
101	14/06/28	1317	58 00.00 N	42 00.04 W	3177	3168	9	0	3187	3222	20	19	20	20	16	0	Start line C; repeat of 076
102	14/06/28	1726	58 18.92 N	42 15.68 W	2913	2903	9	-1	2900	2951	21	21	22	22	0	0	Line C
103	14/06/28	2122	58 37.75 N	42 31.23 W	2456	2445	11	-1	2443	2483	20	19	18	18	18	0	Line C
104	14/06/29	0100	58 56.66 N	42 46.86 W	1922	1912	9	-1	1910	1939	17	17	17	17	0	0	Line C
105	14/06/29	0440	59 15.51 N	43 02.50 W	1505	1495	10	-0	1487	1514	15	15	15	15	12	0	Line C
106	14/06/29	0656	59 20.11 N	43 06.24 W	1007	997	10	0	997	1009	13	13	13	13	10	0	Line C
107	14/06/29	1008	59 29.10 N	43 13.78 W	502	496	5	-0	494	502	11	10	11	0	8	0	Line C
108	14/06/29	1312	59 37.28 N	43 21.01 W	175	169	5	-0	168	171	10	10	10	10	8	0	Line C
109	14/06/29	1629	59 46.03 N	43 28.15 W	145	149	5	9	148	151	9	9	18	18	8	0	Inshore end of line C
110	14/06/30	1516	59 26.78 N	37 04.52 W	3121	3111	9	-0	3108	3165	20	19	19	19	0	0	OSNAP-E; repeat of 093
111	14/06/30	1908	59 23.03 N	36 29.86 W	3099	3090	9	1	3082	3143	19	19	19	19	0	0	OSNAP-E; repeat of 094
112	14/06/30	2242	59 20.53 N	36 06.20 W	3093	3082	11	-1	3078	3134	20	20	20	20	0	0	OSNAP-E
113	14/07/01	0902	59 17.95 N	35 42.56 W	3100	3091	10	0	3085	3143	19	19	19	24	16	0	OSNAP-E
114	14/07/01	1300	59 15.50 N	35 18.86 W	2970	2960	9	-0	2949	3010	21	20	20	23	0	0	OSNAP-E
115	14/07/01	1650	59 12.89 N	34 54.99 W	2501	2491	9	-0	2486	2530	18	18	18	18	0	0	OSNAP-E
116	14/07/01	2004	59 10.47 N	34 31.52 W	2663	2653	9	-0	2650	2695	18	18	18	24	0	0	OSNAP-E
117	14/07/02	1411	59 07.98 N	34 07.79 W	2460	2451	9	-0	2444	2489	19	18	19	19	0	0	OSNAP-E
118	14/07/02	1754	59 05.52 N	33 44.27 W	2213	2203	10	0	2192	2235	18	18	19	19	0	0	OSNAP-E
119	14/07/02	2120	59 02.79 N	33 14.77 W	2196	2187	9	0	2178	2219	17	17	17	18	0	0	OSNAP-E
120	14/07/03	0042	59 00.10 N	32 45.48 W	2023	2014	9	-0	2003	2043	16	16	15	16	0	0	OSNAP-E
121	14/07/03	0339	58 58.17 N	32 23.39 W	1981	1970	10	-2	1963	1998	0	0	0	0	0	0	OSNAP-E
122	14/07/03	0618	58 56.11 N	32 01.41 W	1774	1765	9	1	1762	1790	16	16	16	16	0	0	OSNAP-E
123	14/07/03	0907	58 54.08 N	31 39.45 W	1463	1448	12	-3	1444	1467	0	0	0	0	0	0	OSNAP-E
124	14/07/03	1127	58 52.10 N	31 17.42 W	1426	1417	8	-1	1411	1435	15	15	13	14	0	0	OSNAP-E
125	14/07/03	1346	58 50.04 N	30 55.48 W	1315	1305	9	-2	1298	1321	0	0	0	0	0	0	OSNAP-E
126	14/07/03	1603	58 48.09 N	30 33.19 W	1521	1510	10	-0	1506	1530	15	14	15	15	0	0	OSNAP-E
127	14/07/03	1824	58 42.95 N	30 18.15 W	1360	1351	9	-0	1347	1368	4	0	0	0	0	0	OSNAP-E
128	14/07/03	2034	58 37.82 N	30 02.96 W	1808	1790	17	-1	1785	1814	15	15	15	15	0	0	OSNAP-E
129	14/07/03	2313	58 32.72 N	29 47.68 W	2197	2187	11	0	2185	2219	5	0	0	5	0	0	OSNAP-E
130	14/07/04	0152	58 27.66 N	29 32.35 W	2297	2286	10	-1	2280	2320	18	17	17	17	0	0	OSNAP-E
131	14/07/04	0449	58 22.54 N	29 17.21 W	2099	2089	10	0	2082	2119	7	0	0	6	0	0	OSNAP-E
132	14/07/04	0730	58 17.45 N	29 01.95 W	2109	2098	10	-0	2092	2129	17	16	14	19	0	0	OSNAP-E
133	14/07/04	1022	58 12.35 N	28 46.62 W	2222	2214	8	0	2208	2247	12	0	9	9	0	0	OSNAP-E

134	14/07/04	1346	58	07.22	N	28	31.31	W	2312	2305	8	0	2297	2339	18	18	18	18	15	0	OSNAP-E
135	14/07/04	1636	58	02.11	N	28	16.28	W	2330	2320	9	-1	2313	2355	10	10	10	10	0	0	OSNAP-E
136	14/07/04	1920	57	57.06	N	28	00.91	W	2513	2503	10	-0	2497	2542	19	19	18	18	5	0	OSNAP-E
137	14/07/04	2249	57	57.02	N	27	30.43	W	2299	2291	9	1	2282	2325	18	18	17	18	0	0	OSNAP-E
138	14/07/05	0231	57	56.98	N	26	59.90	W	2679	2671	8	-0	2660	2713	19	19	19	19	0	0	OSNAP-E
139	14/07/05	0712	57	56.99	N	26	20.46	W	2825	2816	9	-0	2808	2861	22	22	22	22	0	0	OSNAP-E
140	14/07/05	1141	57	57.00	N	25	41.06	W	2711	2712	9	9	2702	2755	19	19	19	19	0	0	OSNAP-E
141	14/07/05	1642	57	56.92	N	25	01.32	W	2741	2732	9	-1	2717	2775	19	19	19	19	0	0	OSNAP-E
142	14/07/05	2103	57	56.99	N	24	22.12	W	2843	2833	10	0	2832	2879	19	20	19	19	0	0	OSNAP-E
143	14/07/06	0136	57	57.18	N	23	42.59	W	2954	2946	8	0	2938	2995	20	21	21	21	0	0	OSNAP-E
144	14/07/06	0642	57	57.01	N	23	03.12	W	2990	2982	9	0	2975	3031	21	21	21	21	0	0	OSNAP-E
145	14/07/06	1118	57	56.98	N	22	23.71	W	2973	2964	9	0	2958	3013	22	22	22	22	0	0	OSNAP-E
146	14/07/06	1534	57	57.00	N	21	44.19	W	3012	3003	9	0	2996	3053	19	19	18	19	0	0	OSNAP-E
147	14/07/06	1934	57	57.05	N	21	04.78	W	2644	2634	10	0	2628	2676	20	20	20	19	0	0	OSNAP-E
148	14/07/06	2250	57	54.24	N	20	40.88	W	2138	2127	11	-0	2122	2158	17	17	17	17	0	0	OSNAP-E
149	14/07/07	0152	57	51.34	N	20	17.16	W	1911	1902	9	0	1896	1928	16	16	16	16	0	0	OSNAP-E
150	14/07/07	0442	57	48.50	N	19	53.33	W	1371	1361	10	-0	1357	1378	14	13	14	14	0	0	OSNAP-E
151	14/07/07	0709	57	45.69	N	19	29.53	W	986	976	10	0	973	988	13	13	13	13	0	0	OSNAP-E
152	14/07/07	0917	57	42.84	N	19	05.77	W	852	846	7	1	843	856	14	14	13	14	0	0	OSNAP-E
153	14/07/07	1121	57	40.03	N	18	42.00	W	711	706	5	0	703	714	12	10	12	12	0	0	OSNAP-E
154	14/07/07	1414	57	39.39	N	18	03.98	W	1057	1051	6	0	1047	1063	14	12	14	14	0	0	OSNAP-E
155	14/07/07	1713	57	38.80	N	17	25.92	W	1223	1216	6	-0	1213	1231	15	15	15	15	0	0	OSNAP-E
156	14/07/07	2011	57	38.13	N	16	47.92	W	1193	1183	10	0	1178	1198	15	15	15	15	0	0	OSNAP-E
157	14/07/07	2307	57	37.44	N	16	10.08	W	1171	1160	11	-0	1150	1174	14	14	14	14	0	0	OSNAP-E
158	14/07/08	0232	57	36.88	N	15	31.94	W	1055	1045	10	-0	1044	1057	12	12	12	12	0	0	OSNAP-E
159	14/07/08	0542	57	36.24	N	14	53.98	W	477	466	12	0	460	471	8	9	8	8	0	0	OSNAP-E
160	14/07/08	0834	57	35.61	N	14	15.96	W	195	185	10	1	182	187	6	6	6	12	0	0	OSNAP-E
161	14/07/08	1119	57	34.97	N	13	37.95	W	109	109	5	4	106	110	6	6	6	6	0	0	OSNAP-E/EEL junction
162	14/07/08	1304	57	40.03	N	13	53.92	W	146	144	5	3	141	146	7	7	7	7	0	0	EEL
163	14/07/08	1503	57	48.04	N	14	14.99	W	227	226	4	3	223	228	9	9	9	9	0	0	EEL
164	14/07/08	1709	57	56.03	N	14	35.98	W	446	442	4	0	438	446	10	10	10	10	0	0	EEL
165	14/07/08	1920	58	04.29	N	14	57.57	W	559	552	8	0	550	558	12	12	12	12	0	0	EEL
166	14/07/08	2140	58	12.96	N	15	20.12	W	633	624	10	1	620	631	11	11	11	11	0	0	EEL
167	14/07/09	0009	58	20.56	N	15	39.96	W	1157	1147	10	0	1143	1161	14	14	14	14	0	0	EEL
168	14/07/09	0324	58	28.20	N	16	00.00	W	1190	1182	8	-0	1175	1196	13	13	14	13	0	0	EEL
169	14/07/09	0546	58	33.97	N	16	14.96	W	1217	1206	10	-0	1201	1221	13	13	13	13	0	0	EEL
170	14/07/09	0815	58	39.68	N	16	30.04	W	1202	1191	11	-0	1188	1206	13	13	14	14	0	0	EEL
171	14/07/09	1026	58	45.43	N	16	45.02	W	1159	1153	7	1	1150	1167	15	11	15	15	0	0	EEL
172	14/07/09	1233	58	51.18	N	17	00.07	W	1154	1149	5	0	1146	1163	15	12	15	15	0	0	EEL
173	14/07/09	1429	58	55.73	N	17	11.96	W	913	908	5	0	905	919	13	12	12	13	0	0	EEL
174	14/07/09	1714	59	06.45	N	17	39.98	W	976	967	10	1	965	978	13	13	14	14	0	0	EEL
175	14/07/09	1914	59	11.45	N	17	52.89	W	1459	1448	11	-1	1447	1467	16	16	16	16	0	0	EEL
176	14/07/09	2205	59	19.50	N	18	14.06	W	1829	1819	11	0	1816	1844	17	17	17	17	0	0	EEL
177	14/07/10	0037	59	24.08	N	18	26.00	W	2423	2413	9	-0	2410	2450	19	19	19	19	0	0	EEL
178	14/07/10	0436	59	37.07	N	19	00.08	W	2685	2674	11	-1	2671	2716	19	19	0	19	0	0	EEL
179	14/07/10	0810	59	48.54	N	19	29.99	W	2703	751	-9	-999	750	760	8	0	0	0	0	0	EEL

180	14/07/10	0959	59	48.54	N	19	29.99	W	2703	2694	9	1	2690	2738	20	19	20	20	0	0	EEL
181	14/07/10	1350	60	00.01	N	20	00.17	W	2718	2710	9	1	2705	2753	20	19	19	19	0	0	EEL
182	14/07/10	1747	60	15.00	N	19	59.99	W	2643	2634	10	0	2631	2676	20	20	20	21	0	0	EEL
183	14/07/10	2127	60	30.02	N	19	59.96	W	2525	2514	11	-0	2510	2554	18	18	18	18	0	0	EEL
184	14/07/11	0056	60	45.00	N	19	59.99	W	2362	2352	10	0	2344	2389	18	17	18	19	0	0	EEL
185	14/07/11	0439	61	00.16	N	20	04.15	W	2389	2378	10	-1	2370	2415	18	18	17	18	0	0	EEL
186	14/07/11	1921	63	19.02	N	20	12.90	W	128	119	9	1	116	121	9	9	9	9	0	0	EEL
187	14/07/11	2046	63	12.96	N	20	04.02	W	669	660	10	1	655	667	11	11	11	11	0	0	EEL
188	14/07/11	2236	63	07.98	N	19	54.98	W	1037	1028	10	1	1024	1040	13	13	12	13	0	0	EEL
189	14/07/12	0124	62	55.01	N	19	33.08	W	1399	1389	10	-0	1388	1407	14	14	14	14	0	0	EEL
190	14/07/12	0431	62	40.04	N	19	40.07	W	1678	1668	10	0	1665	1691	15	14	15	15	0	0	EEL
191	14/07/12	0810	62	20.00	N	19	50.03	W	1794	1784	10	-0	1781	1809	15	15	15	15	0	0	EEL
192	14/07/12	1153	61	59.99	N	19	59.99	W	1797	1789	8	-0	1786	1814	18	18	17	18	0	0	EEL
193	14/07/12	1437	61	45.02	N	20	00.03	W	1794	802	-9	-999	800	811	1	0	0	0	0	0	EEL
194	14/07/12	1555	61	45.02	N	20	00.03	W	1794	1786	7	-1	1784	1811	17	17	17	17	0	0	EEL
195	14/07/12	1907	61	29.98	N	19	59.98	W	2216	2208	8	0	2205	2241	17	17	17	17	0	0	EEL
196	14/07/12	2233	61	14.96	N	20	00.04	W	2371	2362	9	-0	2357	2398	16	16	16	17	0	0	EEL
197	14/07/13	0329	60	45.02	N	19	59.94	W	2364	2353	10	-0	2350	2389	0	0	0	0	0	0	EEL
198	14/07/13	0854	60	59.99	N	20	00.00	W	2397	2387	10	0	2382	2424	18	18	18	18	0	0	EEL
199	14/07/14	1451	57	34.96	N	13	38.00	W	109	109	4	4	106	110	7	7	7	7	0	0	OSNAP-E/EEL junction; repeat 161
200	14/07/14	1630	57	34.02	N	13	19.97	W	179	170	10	0	167	171	8	8	8	8	0	0	OSNAP-E/EEL
201	14/07/14	1830	57	33.02	N	12	59.96	W	299	287	11	-1	285	290	9	9	9	9	0	0	OSNAP-E/EEL
202	14/07/14	1957	57	32.52	N	12	52.00	W	1100	1088	10	-1	1086	1101	13	13	13	13	0	0	OSNAP-E/EEL
203	14/07/14	2204	57	31.96	N	12	37.98	W	1641	1631	10	-0	1626	1653	15	15	15	15	0	0	OSNAP-E/EEL
204	14/07/15	0058	57	30.48	N	12	14.97	W	1799	1790	10	0	1787	1814	15	15	15	15	0	0	OSNAP-E/EEL
205	14/07/15	0402	57	29.52	N	11	51.00	W	1790	1779	10	-0	1778	1804	15	15	15	15	0	0	OSNAP-E/EEL
206	14/07/15	0649	57	28.99	N	11	31.97	W	2015	2006	9	0	2002	2034	15	15	15	15	0	0	OSNAP-E/EEL
207	14/07/15	0902	57	28.06	N	11	19.03	W	750	744	6	-0	742	752	11	9	11	11	0	0	OSNAP-E/EEL
208	14/07/15	1046	57	27.01	N	11	04.97	W	589	584	4	-0	582	590	11	11	11	11	0	0	OSNAP-E/EEL
209	14/07/15	1233	57	24.01	N	10	52.04	W	785	780	4	-1	778	789	12	12	12	12	0	0	OSNAP-E/EEL
210	14/07/15	1459	57	22.02	N	10	40.02	W	2105	2095	10	-0	2092	2125	17	17	17	17	0	0	OSNAP-E/EEL
211	14/07/15	1752	57	18.01	N	10	22.94	W	2208	2198	10	0	2195	2230	18	17	18	18	0	0	OSNAP-E/EEL
212	14/07/15	2058	57	14.05	N	10	03.05	W	2103	2093	9	-1	2090	2123	16	16	16	16	0	0	OSNAP-E/EEL
213	14/07/16	0004	57	08.95	N	9	41.99	W	1925	1916	9	0	1913	1943	17	17	17	20	0	0	OSNAP-E/EEL
214	14/07/16	0250	57	06.00	N	9	25.02	W	1419	1409	10	0	1405	1427	14	14	14	14	0	0	OSNAP-E/EEL
215	14/07/16	0454	57	04.50	N	9	19.02	W	778	767	10	-1	762	776	11	11	11	11	0	0	OSNAP-E/EEL
216	14/07/16	0625	57	03.03	N	9	13.01	W	312	304	10	3	302	307	7	7	7	7	0	0	OSNAP-E/EEL
217	14/07/16	0817	57	00.01	N	8	59.85	W	134	131	5	2	128	132	7	7	7	7	0	0	OSNAP-E/EEL
218	14/07/16	1013	56	57.00	N	8	46.93	W	127	124	5	2	121	125	7	6	7	7	0	0	OSNAP-E/EEL
219	14/07/16	1239	56	52.97	N	8	29.99	W	125	121	6	2	119	123	7	7	7	7	0	0	OSNAP-E/EEL
220	14/07/16	1429	56	50.22	N	8	19.98	W	128	127	5	4	122	128	7	7	7	7	0	0	OSNAP-E/EEL
221	14/07/16	1624	56	48.48	N	8	10.01	W	126	118	10	2	113	119	7	7	7	7	0	0	OSNAP-E/EEL
222	14/07/16	1805	56	46.98	N	8	00.00	W	121	114	9	2	110	115	7	7	4	7	0	0	OSNAP-E/EEL
223	14/07/16	1949	56	45.47	N	7	49.96	W	54	53	7	6	48	54	3	3	3	3	0	0	OSNAP-E/EEL
224	14/07/16	2141	56	43.94	N	7	40.05	W	60	58	6	4	53	58	4	4	4	4	0	0	OSNAP-E/EEL
225	14/07/16	2333	56	43.98	N	7	29.97	W	212	208	7	4	205	210	6	6	6	6	0	0	OSNAP-E/EEL

226	14/07/17	0129	56	43.96	N	7	19.99	W	155	148	9	3	146	150	5	5	6	5	0	0	OSNAP-E/EEL
227	14/07/17	0316	56	43.98	N	7	10.01	W	170	162	10	2	160	164	5	5	5	5	0	0	OSNAP-E/EEL
228	14/07/17	0521	56	43.97	N	7	00.04	W	134	128	10	5	126	130	5	5	5	5	0	0	OSNAP-E/EEL
229	14/07/17	0723	56	43.98	N	6	44.98	W	45	40	7	2	37	40	3	3	3	3	0	0	OSNAP-E/EEL
230	14/07/17	0857	56	43.97	N	6	35.91	W	78	75	5	3	73	76	5	5	5	5	0	0	OSNAP-E/EEL
231	14/07/17	1038	56	43.99	N	6	27.01	W	87	88	5	6	85	89	6	6	6	6	0	0	OSNAP-E/EEL
232	14/07/17	1208	56	42.47	N	6	22.00	W	72	72	5	5	70	73	5	5	5	5	0	0	OSNAP-E/EEL
233	14/07/17	1340	56	40.99	N	6	16.99	W	36	32	2	-2	30	32	4	3	3	3	0	0	OSNAP-E/EEL
234	14/07/17	1516	56	40.00	N	6	07.98	W	171	180	5	14	178	182	6	6	6	6	0	0	OSNAP-E/EEL final station

1.2 Objectives

Cruise JR302 was an NERC-NC funded cruise aiming to complete a full CTD section across the subpolar gyre, from Canada to Greenland to Scotland. The CTD section was located along the OSNAP track, providing a high quality and high resolution synoptic survey for the start of that programme. The objectives included a full suite of biogeochemistry measurements under the RAGNARRoC programmes. Finally, the eastern part of the section included the 2014 occupation of the Extended Ellett Line between Scotland and Iceland. Additional sections were made around the Cape Farewell region with the objective of measuring transport and the movement of water away from the boundary currents.

Additional objectives included deploying eight Met Office Argo floats, and recovering one SAMS glider. Two new instruments were trialled by deploying them on the CTD frame; the IMP and RBR.

Figure 1.2.1 The scientific personnel of JR302

2. Profile Measurements

2.1 CTD Sensors

Seth Thomas

SBE_Instrument Configuration SB_ConfigCTD_FileVersion="7.22.0.2"

Name SBE 911plus

Frequency Channels Suppressed	0
Voltage Words Suppressed	0
Computer Interface	0
!-- 1 == SBE11plus Firmware Version 5.0 --	
Deck Unit Version	0
Scans To Average	1
Surface Par Voltage Added	0
Scan Time Added	0
Nmea Position DataAdded	1
Nmea Depth Data Added	0
Nmea Time Added	0
Nmea Device ConnectedToPC	1

Sensor index="0" Sensor ID="55"
Temperature Sensor Sensor ID="55"

Serial Number	03P-4472
Calibration Date	30 August 2012
G	4.41398102e-003
H	6.42799011e-004
I	2.19747460e-005
J	1.88664616e-006
F	1000.000
Slope	1.00000000
Offset	0.0000

Sensor index="1" SensorID="3"
Conductivity Sensor SensorID="3"

Serial Number	2875
Calibration Date	19 March 2013
G	-1.01639718e+001
H	1.40355804e+000
I	8.86145233e-005
J	5.99096076e-005
CPcor	-9.57000000e-008
CTcor	3.2500e-006

Sensor index="2" SensorID="45"
Pressure Sensor SensorID="45"

Serial Number	89973
Calibration Date	22 August 2012
C	1-4.925971e+004
C2	-2.136250e-001
C3	9.435710e-003
D1	3.900400e-002
D2	0.000000e+000
T1	2.983458e+001
T2	-3.883229e-004

T3 3.262440e-006
T4 3.429810e-009
Slope 1.00010000
Offset -1.27140
T5 0.000000e+000
AD590M 1.277500e-002
AD590B -9.391460e+000

Sensor index="3" SensorID="55"
Temperature Sensor SensorID="55"
Serial Number 03P-2366
Calibration Date 30 August 2012
G 4.31974772e-003
H 6.44172106e-004
I 2.35210024e-005
J 2.26433319e-006
F 01000.000
Slope 1.00000000
Offset 0.0000

Sensor index="4" SensorID="3"
ConductivitySensor SensorID="3"
SerialNumber 04C-2289
CalibrationDate 21 August 2012
G -1.04066323e+001
H 1.38729309e+000
I -2.46034773e-003
J 2.40168672e-004
CPcor -9.57000000e-008
CTcor 3.2500e-006
Slope 1.00000000
Offset 0.00000

Sensor index="5" SensorID="71"
WET_LabsCStar SensorID="71"
SerialNumber CST-846DR
CalibrationDate 13 March 2013
M 21.6360
B -1.2938
PathLength 0.250

Sensor index="6" SensorID="5"
FluoroChelseaAqua3Sensor SensorID="5"
SerialNumber 088216
CalibrationDate 19 February 2013
VB 0.219400
V1 2.068800
Vacetone 0.228700
ScaleFactor 1.000000
Slope 1.000000
Offset 0.000000

Sensor index="7" SensorID="42"
PAR_BiosphericalLicorChelseaSensor SensorID="42"
SerialNumber 7235
CalibrationDate 24 April 2013

```
      M                 1.00000000
      B                 0.00000000
      CalibrationConstant                 33557046980.00000000
      Multiplier        1.00000000
      Offset            -0.04219064

    Sensor index="8" SensorID="0"
     AltimeterSensor SensorID="0"
      SerialNumber                        244740
      CalibrationDate                     16 May 2012
      ScaleFactor       15.000
      Offset            0.000

    Sensor index="9" SensorID="38"
     OxygenSensor SensorID="38"
      SerialNumber                        0676
      CalibrationDate                     28-Aug-12
      Soc               4.4589e-001
       offset           -0.4962
       A                -8.8979e-004
       B                 6.4609e-005
       C                -5.1722e-007
       D0                2.5826e+000
       D1               1.92634e-004
       D2               -4.64803e-002
       E                3.6000e-002
       Tau              20 1.1700
       H1               -3.3000e-002
       H2                5.0000e+003
       H3                1.4500e+003
```

2.2 CTD Data processing

Brian King, Damien Desbruyeres, Penny Holliday

CTD data processing followed the usual mexec path described in previous cruise reports, as follows.

2.2.1 Sea Bird Data processing

• Preparation at the start of the cruise

The first step is to select the SBE output variables. It is essential that the output variables include scan and pressure temperature. For example (JR302):

```
# 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

- Oxygen hysteresis correction: decide whether to use the SBE oxygen hysteresis correction using standard parameters, or whether to derive your own. Look at options in the SBE data conversion program: it is here that the hysteresis correction is applied and you can uncheck that option. Make sure that mstar script **moxy_02b** is edited to match your requirement.

• SBE Data Processing

On the CTD logging computer, the SBE Data Processing software was used for initial processing when the cast was finished, by running the following:

Data Conversion to convert the raw frequency and voltage data to engineering units as appropriate by applying the manufacturer's calibrations stored in the CON file and save both downcast and upcast to an ASCII format file. Can include hysteresis correction using SBE parameters.

Align CTD to align the oxygen sensor in time relative to pressure.

Cell Thermal Mass to correct the pressure and conductivity.

Output File: **JC86_NNN_actm.cnv**

2.2.2 MSTAR Data Processing

• Preparation at the start of the cruise

- Data are retrieved from the ship's data directories by the use of symbolic links in **ctd_linkscript**
- Edit **ctd_linkscript** to pick up the files using the symbolic links, check format of lines that extract information from SBE filenames to create the standard mstar names. The script only picks up data files not already copied to the ASCII_FILE directory.

Edit the list of variable names that you require for your sample file. This will vary from cruise to cruise depending on which samples are being collected. The list of variables is contained in the file **/data/templates/sam_jr302_varlist.csv.**

- Create a template csv file in which you will input information about bottle firing, ready for pasting into the master sample file later. It is useful to create a blank master file with all bottles set to flag 2 (No problems noted), to be edited after each cast when bottles are either not fired (flag 9), or dont trip correctly (flag 4) etc. File: **/data/ctd/ASCII_FILES/bot_jr302_001.csv**.

• **ctd_linkscript** was used to copy the data from the ship's network drive to the NOCS Sun workstation FOLA. The files are copied with their original names, then a symbolic link created for each one with the name in the format expected by standard mstar scripts.

• MatLab was opened and '**m_setup**' run to setup the environment for mexec processing.

The MSTAR processing was split into several phases. '**ctd_all_part1'** included the following:

• **msam_01** creates an empty sam file sam_jr302_NNN.nc (make sure that the list of variable contains the expected channels);

• **mctd_01** reads in 24Hz CTD data into ctd_jr302_NNN_raw.nc;

• **mctd_02a** renames SeaBird variable names in ctd_jr302_NNN_raw.nc ;

• **mctd_02b** carries out oxygen hysteresis correction using SBE default parameters or users preferred parameters (edit as appropriate, check it matches your decision for SEBE data processing). Creates ctd_jr302_NNN_24hz;

• **mctd_03** averages data to 1Hz (output to ctd_jr302_NNN_1hz.nc) and calculates derived variables (output to ctd_jr302_NNN_psal.nc);

• **mdcs_01** creates empty dcs file which will store information about start, bottom and end of good data in CTD file;

• **mdcs_02** populates dcs file with data to identify bottom of cast.

• **mdcs_03g** allows the user to decide which scan numbers mark the start of the downcast and the end of the upcast. This is a graphical interface. The start of the downcast was selected to be the lowest pressure after the CTD had soaked and been brought to the surface before descending. The end of the downcast was selected as the last scan for which there was good in-water oxygen, temperature, conductivity and salinity data (note that oxygen data becomes out-of-water before the other variables because the different sensor response times). Output to dcs_jr302_nnn.nc.

Phase 3 routines grouped under **'ctd_all_part2'** ran the following:

• **mctd_04** extract downcast data from psal file using index information from dcs file; sort, interpolate gaps and average to 2db (output to ctd_jr302_NNN_2db.nc);

• **mdcs_04** merge positions of start, bottom and end cast from navigation file into dcs file;

• **mfir_01** read in information from SeaBird .bl file and create netCDF fir file;

• **mfir_02** merge time from ctd file onto fir file using scan number (output to fir_jr302_NNN_time.nc);

• **mfir_03** merge CTD upcast data onto fir file;

• **mfir_04** paste CTD fir data into sam file and output to sam_jr302_NNN.nc;

• **mwin_01** creates win file which will hold winch data and extracts times from start and end of 1Hz ctd file;

• **mwin_03** merge winch wire out data onto fir file;

• **mwin_04** paste winch fir data into sam file;

At this point the data can be examined using some scripts to generate standard plots:

• **mctd_checkplots** and **mctd_rawshow** generate a series of plots of raw, 1hz and 2db data. mctd_checkplots allows a series of previous casts to be plotted also. The plots should be examined for data quality.

• **mctd_rawedit** is a graphical interface that allows the user to manually select bad data cycles in temp, cond and oxygen. Preserves original raw file as ctd_jr302_nnn_raw_original.nc and outputs new file ctd_jr302_nnn_raw_cleaned.nc. The cleaned file is linked by a new symbolic link called ctd_jr302_nnn_raw.nc so that following scripts work on the cleaned version if it exists.

The editing is done on the raw data file so that edits are preserved throughout all derived files. So after the edits are finished, the derived files need to be re-generated. This is done in steps mctd_02b, mctd_03, mctd_04, mfir_03, mfir_04. These scripts can be run manually or using **smallscript.m** (check and edit this first).

• **list_ctd_1hz(nnn)** generates and ascii listing of the 1hz file ready for use in the LADCP processing. Each file was saved in /data/ctd and a symbolic link created to it from the LADCP directory (/data/ladcp/ix/data/CTD/)

• **mbot_01.m** takes bottle firing quality flags manually set in bot_jr302_001.csv. Output: bot_jr302_nnn.nc.

• **mbot_02.m** pastes the bottle firing codes into sam__jr302_nnn.nc

As header information for the CTD data files becomes available, the information in the files can be updated through the following steps:

• **mdep_01.m** requires a matlab file (**station_depth_jr302.mat**) containing water depth in variable 'bestdeps'. On JR302 this information came from the LADCP data files where it existed, or from the bathymetry file (saved as ascii file **ctd_depths.csv**). Where there was neither LADCP or bathymetry data (one station) 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 (**pos_jr302_01**) at the time of start, bottom and end of each cast and pastes into **dcs_jr302_nnn_pos.nc**.

• **mdcs_05.m** pastes the lat and lon for the bottom of the cast into the headers of all CTD files.

2.3 CTD calibrations

Penny Holliday, Brian King, Damien Desbruyeres

2.3.1 Oxygen

When oxygen bottle data had been pasted into the CTD sample files, and the individual station sample files had been appended (sam_jr302_all), the data were used to examine the performance of the CTD oxygen sensor. First the relationship between the bottle oxygen and uncalibrated CTD oxygen was derived (bottle sample units were converted to umol/kg using the calibrated CTD salinity). The standard procedure is to define an initial correction to the data (linear or quadratic), then apply further temperature- and/or pressure-dependent corrections if the calibrated residuals suggest one is required. For JR302 data, a linear initial fit followed by a pressure correction was applied. The fit was used to define coefficients as follows:

CTD_oxycal = a*CTD_oxygen + b

where a = 1.0633 and b = 16.91. The subsequent pressure correction applied was a linear offset defined by interpolations between offset-pressure pairs (-1, 0), (0, 1000) and (4, 3800). These coefficients are specified in function oxy_apply_cal.m called by mctd_oxycal.m

In mstar:

• **mctd_oxycal:** used to apply these calibrations to the CTD files (**ctd_jr302_nnn_24hz**). After calibrations have been applied, subsequent steps need to be repeated (**mctd_03, mctd_04, mfir_03, mfir_04)** this was done by editing and running **smallscript.m**. All sam_jr302_nnn files were re-appended to create a new version of **sam_jr302_all.nc** that contained the calibrated CTD conductivity, salinity and oxygen.
The calibration was initially determined from the first 30 stations of the cruise and subsequently monitored against newer samples. The CTD oxygen sensor was remarkably stable and this calibration was used unchanged for the rest of the cruise. Variations in the oxygen bottle residuals were associated with new batches of reagents used in the titrations up to station 179. The offsets between batches of chemicals was order 2 umol/kg and this can be considered to be the level of uncertainty associated with the samples.
From station 180 onwards however, there is an issue with the bottle oxygen samples that led us to label them all as "suspect data" (coloured red in Fig. 2.3.1). Those samples were not used to correct the CTD sensor. Examination of the CTD temperature-oxygen relationship before and after station 180 has led us to conclude there was no observable drift in the sensor to the end of the cruise.

The mean of the oxygen residuals (good samples from stations 1-180, and excluding outliers) was -1.1 ± 2.5 umol/kg.

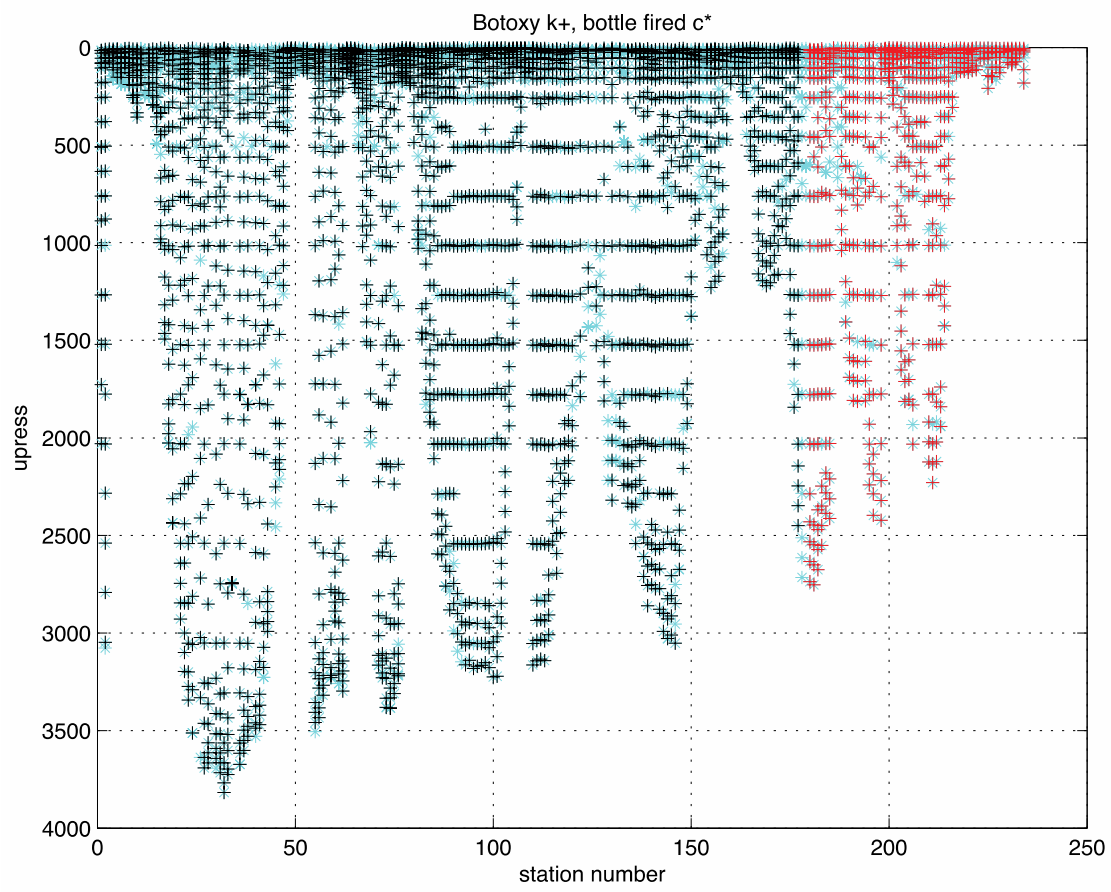


Figure 2.3.1 Distribution of bottles fired (cyan) and "good" oxygen samples (black). Samples from stations 180 onwards are shown as red.

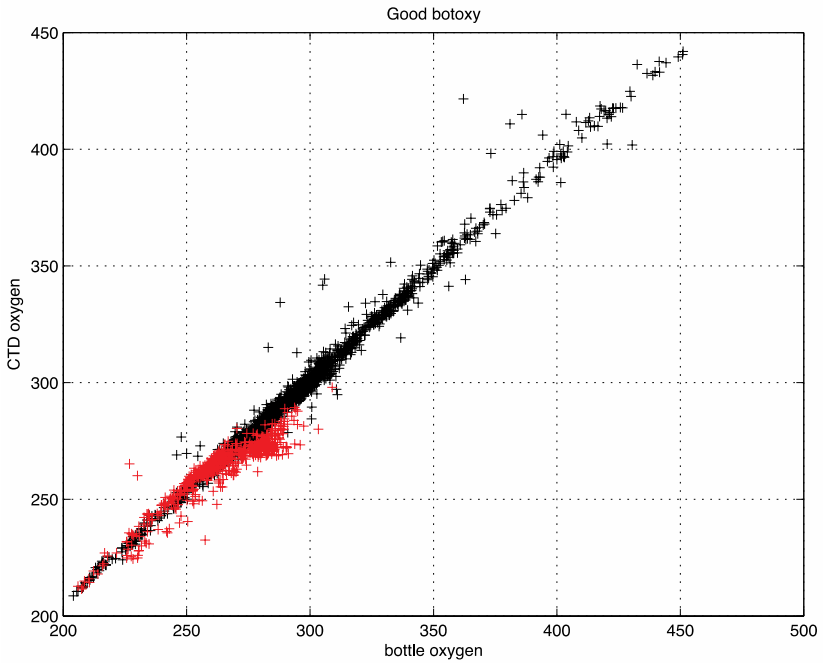


Figure 2.3.2 Calibrated CTD oxygen against bottle oxygen. Samples from stations 180 onwards are shown as red.

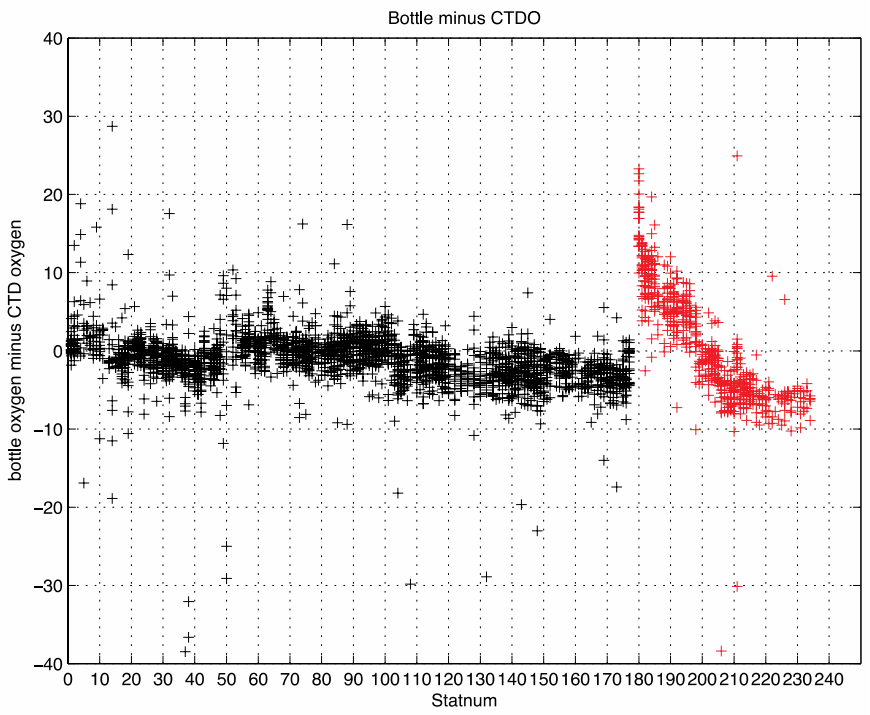


Figure 2.3.3 Calibrated oxygen residuals against station number. Samples from stations 180 onwards are shown as red.

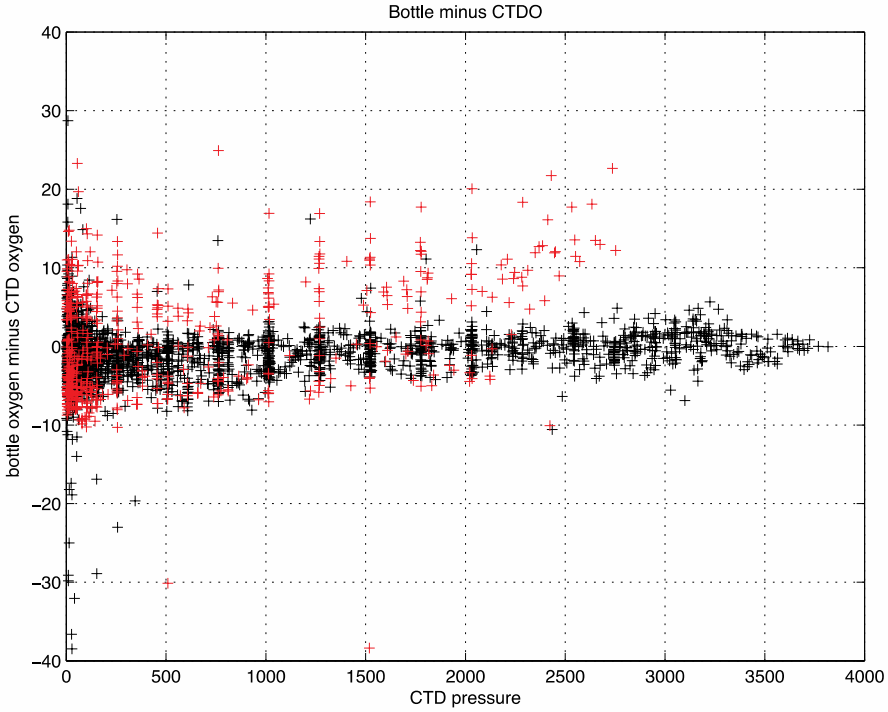


Figure 2.3.4 Calibrated oxygen residuals against pressure. Samples from stations 180 onwards are shown as red.

2.3.2 Salinity Calibration

CTD conductivity was calibrated with the water sample bottles (see section 3.1).

2.4 LADCP

2.4.1 Instrument technical details

A downward looking 300 kHz Workshorse LADCP was attached to the CTD frame for JR302. The configuration was 16x10m bins with data collected in beam co-ordinates and rotated to earth co-ordinates during processing. The LADCP was connected to a charger and by a serial cable to a BAS AME-supplied laptop in the Chem Lab for programming and testing prior to each data, and data download after each station, using BB-talk. Data downloaded after each station were copied to the network legdata drive, along with the pre-deployment logs.

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
```

2.4.2 Data Processing

Data from each station were processed on workstation FOLA using two software packages; the University of Hawaii software, and the Lamont-Doherty IX software.

2.4.3 IMP

John Wynar

The IMP mk 3 consists of a Raspberry Pi (RPi) micro computer, and separate clock and 3-axis tilt/magnetic field sensor boards. Communication with the device is achieved wirelessly. Initially, when these boards were connected together and 5V power applied from a Farnell PSU, communication could not be established. However, subsequent testing using a proprietary PSU was successful and the system functions validated. The boards were then assembled together with a dc/dc converter which would provide the 5V necessary to power the system, stepped down from the 50V (approximately) of the LADCP battery pack. With the long antenna fitted, wireless communication with the IMP was easily achieved even when fitted into its pressure case and

on the CTD frame. The pressure case was tested on the CTD frame to a depth of over 3000m without the IMP inside to ensure its water tight integrity.

Calibration of the IMP inside the pressure case was carried out in the lab as per the instructions and the data logged. As the IMP sensor board was to be kept to near horizontal when fitted, a line was drawn on the end cap to show the orientation of the boards when in the pressure case.

In actual operation, communication with the IMP was carried out using a laptop in the laboratory adjoining the CTD annexe. Logging (and other house-keeping tasks) was initiated and terminated using the Tera Term terminal software. Data were copied and backed up onto a network drive using WinSCP. Start and stop times were written onto a log sheet and referenced to the station number.

Problems only occurred on two occasions, the first after some 26 days of operation, when communication with the IMP could not be established. On the first occasion, power cycling the unit was attempted but without success. The next step was to remove the IMP from it's pressure case and investigate further. Bench testing did not reveal any fault so the system was re-assembled and fitted back into the CTD frame and operation continued. The system "hung up" again two days later. This time simple power cycling re-booted the IMP and communication re-established. It is possible that insufficient time was given on the first occasion between disconnecting and re-applying power for a re-boot to take effect.

The data collected from the IMP during the cruise will be sent to the designer, Andreas Thurnherr, for analysis.

2.5 RBR Concerto CTD

John Wynar

The instrument (S/N 065583) was attached to brackets fitted to a vertical stanchion on the CTD frame (constructed of stainless steel) with the plastic clamps provided (Figure 2.5.1). This gave a separation of about 50mm between the conductivity cell and the metalwork of the frame. This position was the best compromise which could be attained considering the aspects of (i) accessibility (to switch on logging), (ii) safety (to prevent accidental damage), (iii) free uncontaminated current flow through the cell, and (iv) proximity to the frame (affecting the cell's external field).

The unit was depth rated for 2000m, hence it was necessary to remove the instrument for CTD casts in excess of this. For the sake of convenience, it was also removed prior to the final shallow casts near to the Scottish coast. In any case, by then the instrument had logged over a hundred "dives" which was deemed sufficient for the purpose intended. The instrument's logging could be initiated without using a computer which made it very simple to use. The end cap was simply twisted to a point where two marks lined up, the starting of logging confirmed by a slight and short period of vibration coming from inside the unit. To disable logging, the end cap was twisted to come in line with a different mark, again confirmed by a period of vibration.

The instrument was downloaded several times using the Ruskin software when it was convenient to do so, for instance when it had to be removed for deeper stations. On the first occasion, logging was disabled (for no particular reason). However, it was unknown at that point that when logging was re-enabled this would mean that the memory would be erased. It might be beneficial in a future revision of the software to allow logging to be enabled without erasing the memory. Also on this occasion, the clock was corrected to GPS time (albeit it was only 1 second slow) and the battery voltage recorded as 11.81V as displayed in the Ruskin software. On successive occasions, the battery voltage was noted as not being less than 12.0V, the fifth and final value being 12.02V. (The author also suggests that a channel displaying the battery voltage during deployment would be useful.) After re-setting the onboard clock during the first download, the clock was found to be 5 seconds slow some 29 days later. Total memory used at this point was 45.14MB although there was no numerical display of the memory remaining. There was, however, a sliding bar giving a graphical representation of unused memory.

Figure 2.5.1. The RBR concerto CTD attached to the stainless steel frame.

3. Water Sample Measurements

3.1 Salinity

Team: Brian King, Penny Holliday, Stefan Gary, Damien Desbruyères, Jonathan Lawrence, Felicity Williams, John Wynar

Water samples from CTD casts and TSG underway measurements were analysed with a salinometer to retrieve accurate estimates of the conductivity ratio for further calibration of the CTD/TSG data. Crates of water samples and sea water standards (batch P156; K15 = 0.99984) were stored at the same temperature for at least 24 hours in the laboratory room before being analysed following the usual procedure of 3 rinsing – 3 reading – average for each sample and standards. One (sometimes two) standard seawater (SSW) samples were run before and after each crate of samples. All readings were numerically recorded and saved in Excel and csv files as "*sal_jr302_stationnumber*" before being merged together in "*sal_jr302_01.csv*".

The lab temperature fluctuated between about 20 and 23.5 °C. The same salinometer was used for most of the analysis (serial number 68959) and showed a satisfactory behaviour (light cycling, constant temperature, stability) during the whole cruise. A drift (probably electronically-related) in the standard conductivity ratio was however revealed from standard 25 to standard 100 (see Figure 3.1.1). This initiated the use of a secondary machine (serial number 63360), which was yet aborted after noticing an inconsistency between the machine reading and the software display (station 66/67). The drift disappeared at about station 100 and standard conductivity ratio stabilized around 1.99980, although some "short-term" spreading around this value continued to be observed (e.g. higher ratios for standards 170 to 180, lower ratios for standards 230 to 239).

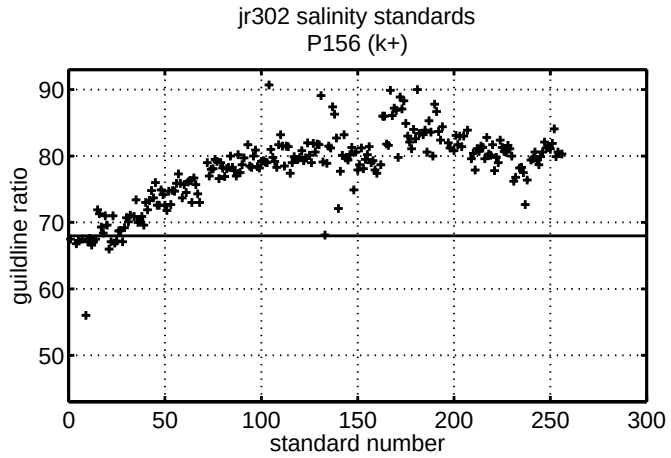


Figure 3.1.1. The difference between the salinometer-measured conductivity ratio and the label ratio of SSW samples (x10^{-5}).

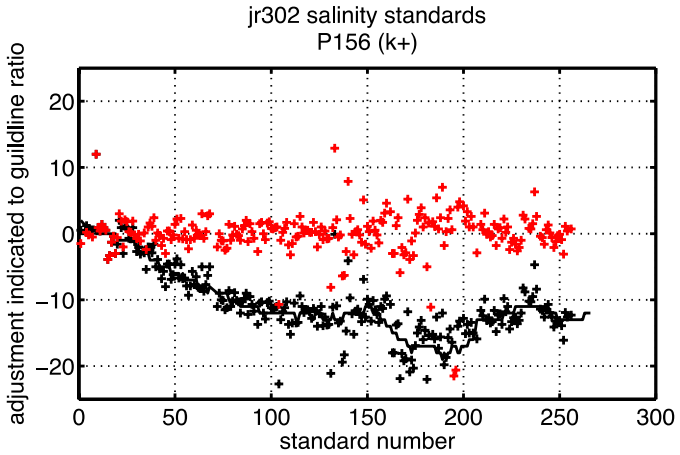


Figure 3.1.2. The offsets applied to all bottle conductivity ratios (derived from Figure 3.1.1, see also Table 3.1.1) (black) and the residuals after corrections applied.

By visually inspecting the temporal behaviour of the standard conductivity ratios, a correction was applied to sets of station samples. These offsets are given in the table below. The resulting calibrated bottle salinities were then used to adjust the CTD data.

Table 3.1.1 Offset applied to conductivity ratio, derived from SSW analysis

Station number	Offset applied to conductivity ratio (*10^{-5})
1 to 20	0
21 to 30	-1
31 to 32	-2
33 to 36	-3
37 to 40	-4
41 to 46	-5
47 to 54	-6
55 to 60	-7
61 to 63	-8
64 to 65	-9
66 to 67	0
67 to 74	-9
75 to 79	-10
80 to 90	-11

91 to 143	-12
144 to 150	-19
151 to 165	-15
166	-14
167	-15
168	-14
169	-15
170 to 177	-14
178 to 198	-13
199 to 204	-9
204 to 234	-13

3.2 Dissolved Oxygen

Team: Hannah Donald, Carolyn Graves, Mark Stinchcombe and Sinhue Torres-Valdes

All stations (except where no bottles were fired and one occasion when the night shift carried out a safety drill) occupied during JR302 were sampled for dissolved oxygen (DO). Sampling for DO was done just after CFCs and surfactants were sampled, or first when CFCs and surfactants were not sampled. Seawater was collected directly into pre-calibrated glass flasks using a Tygon® tube. Before the sample was drawn, bottles were flushed with seawater for several seconds (for about 3 times the volume of the bottle) and the temperature of the water was recorded simultaneously using a hand held thermometer. The fixing reagents (manganese chloride and sodium hydroxide/sodium iodide solutions) were then added. Care was taken to avoid bubbles inside the sampling tube and sampling bottle, and a water seal was used after the sample was fixed and stoppered. Samples were thoroughly mixed following the addition of the fixing reagents and were then kept in a dark plastic crate for 30-40 min to allow the precipitate to settle to <50% the volume of the bottle. Once the precipitate had settled all samples were thoroughly mixed for a second time in order to maximize the efficiency of the reaction. Analyses were carried out within 2-4 h of sample collection.

Methods

DO determinations were made following the Winkler method using a potentiometric Ω-Metrohm titration unit (916 Ti-Touch, with electronic burettes). Chemical reagents were previously prepared at NOCS following the procedures described by *Dickson* (1994). Recommendations given by *Dickson* (1994) and by *Holley and Hydes* (1994) were adopted.

Oxygen calibration

Titrations were carried out with a thiosulphate solution which was prepared at least 24 hours before use (50 g dissolved in 1 L of Milli-Q water). Its concentration was determined by the use of certified OSIL standards of known molarity (1.667 mmol L^{-1}). Typically, calibrations were carried out every 3-4 days to monitor potential changes in the concentration of the thiosulphate. Calculation of oxygen concentrations were facilitated by the use of an Excel spreadsheet set up with unique flask calibrated volumes and reagent dispenser volumes. When a new calibration was done, calculation sheets were updated with the latest numbers and oxygen concentrations determined with those results until a new calibration was completed. By examining the results of the calibrations carried out for a given batch of thiosulphate we determined that there was no significant drift in the concentration, and that the slight differences in the calibration results are likely due to instrument sensitivity and analytical noise. Hence, it was decided that an average of the calibrations done for a specific batch of thiosulphate was the best option to produce consistent results for oxygen concentration in samples as determined by plotting the difference between oxygen measurements against the CTD sensor data (residuals). Table **3.2.1** lists the calibrations carried out during JR302 separated by thiosulphate batch, showing the results of the blank and standard, as well as the averages for a given thiosulphate batch.

For every cast replicates were taken from randomly selected Niskin bottles to assess reproducibility of the analysis. Figure 3.2.1 shows the results of replicates (same Niskin bottle sampled twice) selected randomly in every cast. Overall (except values flagged as bad), reproducibility was between 0.3 and 1 umol L^{-1}.

Problems encountered

From CTD cast 180-200, a drift was noted in the residuals. Examination of CTD data suggested that the oxygen sensor was not responsible for this drift, and given that no chemical reagents or thiosulphate solution were changed during these measurements, we believe that the titration probe may be responsible for this drift for reasons we do not understand; all of a sudden the amount of thiosulphate added to titrate a sample at a specific depth increased relative to neighbouring stations at similar depths. The addition of thiosulphate was determined potentiometrically by the probe, and just as the problem appeared, it also disappeared. By the time this report was completed, this issue remained unresolved.

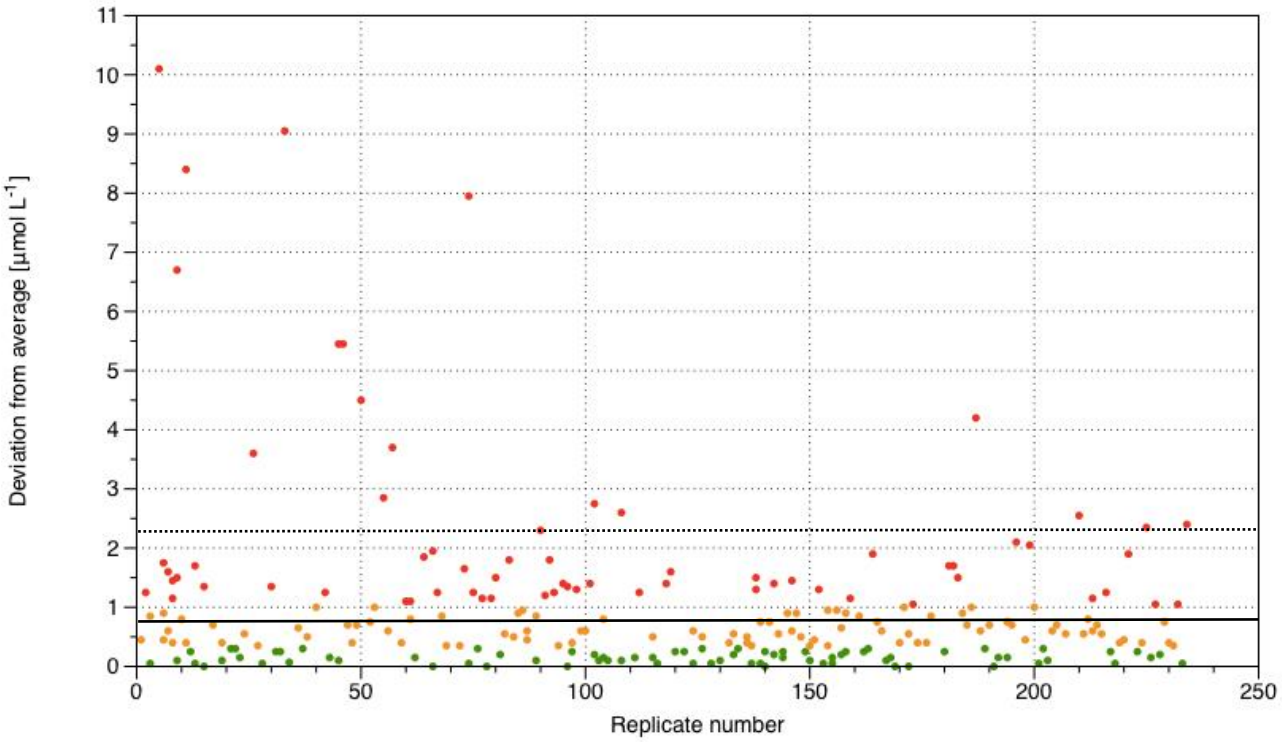


Figure 3.2.1. The absolute replicate difference for the oxygen bottles in each CTD cast (n=236). The mean (0.96 umol L^{-1}) and the standard deviation of –all values in the plot considered- are specified with solid and dash line respectively (± 1.4 umol L^{-1}). Green symbols show replicate values flagged as good (0 - 0.3 umol L^{-1}), yellow symbols show replicate values flagged as good (0.3 - 1.1 umol L^{-1}) and red symbols show remaining data, including values flagged as dubious or bad (1.1 umol L^{-1} and above).

References

Dickson, A.G. (1994) Determination of dissolved oxygen in seawater by Winkler titration. Technical report, WOCE operations manual, WOCE report 68/91 Revision 1 November 1994.

Holley, S.E. and Hydes, D.J. (1994) Procedures for the determination of dissolved oxygen in seawater. Technical report, James Rennell Centre for Ocean Circulation.

Table 3.2.1. JR302 Dissolved O_2 analysis calibrations; showing number of casts analysed with a given thiosulphate batch, dates on which calibrations were carried out, stations for which concentrations were originally calculated with a given calibration, mean blank titre volume (BLK) per calibration and per thiosulphate batch, standard titre volume (STD) per calibration and per thiosulphate batch, STD minus BLK, molarity of thiosulphate per calibration and per thiosulphate batch, standard deviation (stdev) of average molarity and stdev as percent of the mean molarity.

No. Casts		Date	Station No.	Blank	Blank AVERAGE	Standard	Standard AVERAGE	STD-BLK	Molarity	Average	Stdev	%
		04/06/2014	training	0.01190		0.51920		0.5073	0.199			
42	**001 - 042**	07/06/2014	CTD001-003	0.01326		0.51520		0.5019	0.2010			
		10/06/2014	CTD004-026	0.01335		0.51622		0.5029	0.2006			
		14/06/2014	CTD027-37	0.01320		0.51763		0.5044	0.2000			
		16/06/2014		0.01310		0.51532		0.5022	0.2008			
		16/06/2014	CTD040-42	0.01274	**0.01311**	0.51410	**0.51521**	0.5014	0.2012	0.2007	0.000468	0.23
33	**043 - 076**	17/06/2014	CTD043-62	0.01476		0.51210		0.4973	0.2028			
		21/06/2014	CTD063-76	0.01328	**0.01402**	0.51268	**0.51239**	0.4994	0.2020	0.2024	0.000593	0.29
37	**077 - 115**	24/06/2014	CTD077-96	0.01358		0.51524		0.5017	0.2011			
		27/06/2014	CTD097-111	0.01364		0.51870		0.5051	0.1997			
		30/06/2014	CTD112-115	0.01336	**0.01353**	0.51746	**0.51713**	0.5041	0.2001	0.2003	0.00070	0.35
62	**116 - 177**	01/07/2014	CTD116-130	0.01392		0.51700		0.5031	0.2005			
		04/07/2014	CTD132-177	0.01396		0.51570		0.5017	0.2010			
		10/07/2014		0.01296	**0.01361**	0.51626	**0.51632**	0.5033	0.2004	0.2006	0.000337	0.17
54	**180 - 234**	10/07/2014	CTD180-205	0.01438		0.51460		0.5002	0.2016			
		15/07/2014	CTD206-234	0.01330	**0.01384**	0.51516	**0.51488**	0.5019	0.2010	0.2013	0.000467	0.23

3.3 Total Dissolved and Dissolved Inorganic Nutrients

Team: Hannah Donald, Carolyn Graves, Mark Stinchcombe and Sinhue Torres-Valdes

Lab Set up

A 7-channel Seal Analytical AA3 autoanalyser was set up in the main lab of the JCR for the analysis of micro-molar concentrations of dissolved inorganic nutrients (silicate, phosphate, nitrate plus nitrite -hereafter nitrate-, nitrite and ammonium) and total nutrients (total dissolved phosphorus and total dissolved nitrogen). Two members of the team (CG and ST) arrived on the ship on the 28th May to start mobilisation. Flight cases with instrumentation were distributed within the lab and chemical reagents identified and stored in the respective ship's hazardous chemicals lockers. The two other members (HD and MS) arrived on the 30th when instrument installation began. Installation of the AA3 took two full days, involving; the fitting of new pump tubing and new cadmium columns, tubing connections between sampler-pumps-manifold-detectors, and a thorough cleaning with wash solutions as per Seal Analytical protocols. Simultaneously, chemical reagents (stock and working solutions) and standards (stock solutions and calibrants) were prepared. 'Stocks' are concentrated solutions from which working reagents/standards are prepared as required by solution stability or usage. Working standards were prepared in a saline solution (40 g NaCl in 1 L of Milli-Q water, here after artificial seawater or ASW), which was also used as a diluent for the analysis. Seal Analytical protocols used during JR302 were:

i) Silicate in seawater method No. G-177-96 Rev 10 (Multitest MT19).
ii) Phosphate in water and seawater method No. G-175-96 Rev. 13 (Multitest MT 18).
iii) Total dissolves phosphorus in seawater method No. MKA-0152-14 Rev. 0.
iv) Total dissolved nitrogen in seawater method No. G-218-98 Rev. 12 (Multitest MT23).
v) Nitrate and nitrite in seawater method No. G-172-96 Rev. 13 (Multitest MT19).
vi) Nitrite in seawater method No. G-062-92 Rev. 3.
vii) Ammonium in water and seawater No. G-327-05 Rev. 6.

Calibrants

Table 3.3.1 lists compounds used for the preparation of stock standard solutions, weight of compound dissolved in 1 L of Milli-Q water and the resulting molarity of the solution. Dilutions were then made from stock solutions to prepare a set of five standards to calibrate the analysis. Table 3.3.2 shows target concentrations -which are concentrations aimed for when preparing the standards- and actual concentrations –which have been obtained given the molarity of stock solutions and/or that result from the combination of related chemical species (e.g., TN, $NO_3^-+NO_2^-$, NO_2^-, NH_4^+).

Table 3.3.1. Compounds used to prepare stock standard solutions, weight dissolved in 1 L of Milli-Q water and Molarity of the solution.

Compound	Weight (g)	Molarity 1 L stock solution
Ammonium Sulphate	0.6919	**10.0118**
Potassium Nitrate	0.5066	**5.0107**
Sodium Nitrite	0.3449	**4.9989**
Potassium Di-hydrogen Phosphate	0.6811	**5.0049**
Sodium Metasilicate	1.4219	**5.0032**

Table 3.3.2. Set of calibration standards (*Std*) used for dissolved inorganic and total dissolved nutrient analysis. Concentration units are umol L^{-1}. Target concentrations are shown in bold characters. Actual concentrations as calculated from the molarity of the stock solution are shown in normal characters. Note that concentrations for $NO_3^-+NO_2^-$ are the sum of $NO_3^-+NO_2^-$ and NO_2^-, and concentrations for TN also include those of NH_4^+.

	$Si(OH)_4$		PO_4^{3-}/TP		TN		$NO_3^-+NO_2^-$		NO_2^-		NH_4^+	
Std 1	**1**	1.00	**0.25**	0.25	**1**	1.20	**1**	1.10	**0.1**	0.10	**0.1**	0.10
Std 2	**5**	5.00	**0.75**	0.75	**5**	6.51	**5**	5.51	**0.5**	0.50	**1.0**	1.00
Std 3	**10**	10.01	**1.50**	1.50	**10**	13.02	**10**	11.02	**1.0**	1.00	**2.0**	2.00
Std 4	**20**	20.01	**3.00**	3.00	**20**	25.54	**20**	22.04	**2.0**	2.00	**3.5**	3.50
Std 5	**30**	30.02	**5.00**	5.00	**30**	38.07	**30**	33.06	**3.0**	3.00	**5.0**	5.00

Although the range of calibrant concentrations is typically determined by minimum and maximum expected nutrient levels at any given location, for JR302 the range of calibrants for phosphate and ammonium were set to 5 umol L^{-1} despite the fact that maximum concentrations in the area of investigation were not expected to be greater than 1.5 umol L^{-1} and ~2 umol L^{-1} for phosphate and ammonium, respectively. In the case of phosphate the decision was taken following lab based tests of the TP channel (which uses the same calibrants as those for phosphate) and whose performance was not acceptable at calibration levels of ≤2.5 umol L^{-1}. Once on board JR302, a top standard level of 5 umol L^{-1} was found to properly reproduce peak shapes. In the case of ammonium, lab tests showed ammonium peak shapes were also not acceptable at ≤2.0 umol L^{-1}. Poor peak shape is observed at low concentrations because the resulting amplified instrument gain also amplifies the noise signal, rendering analytical results unreliable.

Unfortunately, less than two weeks into the cruise the TP channel stopped working. Attempts were made to fix it, but the work load did not allow for much time to be spent on this and it was then decided that samples from selected stations (upper 150 m of the water column where DOP occurs at detectable levels) would be collected and stored frozen for later analysis on land. At the same time, the ammonium channel was found to be performing well and reliably. Thus, from run 19 the calibrant range for phosphate and ammonium was changed as shown in Table 3.3.3. Additionally, the silicate range was increased to include the certified values (KANSO CRMs) for this variable, which were slightly higher than our original adopted range.

Table 3.3.3. Set of calibration standards (*Std*) used for dissolved inorganic and total dissolved nutrient analysis from run 19 (see text for further information). Concentrations in µmol L^{-1}.

	$Si(OH)_4$		PO_4^{3-}/TP		TN		$NO_3^-+NO_2^-$		NO_2^-		NH_4^+	
Std 1	**1**	1.00	**0.10**	0.25	**1**	1.20	**1**	1.10	**0.1**	0.10	**0.1**	0.10
Std 2	**5**	5.00	**0.50**	0.75	**5**	6.01	**5**	5.51	**0.5**	0.50	**0.5**	0.50
Std 3	**10**	10.01	**1.00**	1.50	**10**	12.02	**10**	11.02	**1.0**	1.00	**1.0**	1.00
Std 4	**20**	20.01	**2.00**	3.00	**20**	24.05	**20**	22.04	**2.0**	2.00	**2.0**	2.00
Std 5	**40**	40.03	**3.00**	5.00	**30**	36.07	**30**	33.06	**3.0**	3.00	**3.0**	3.01

Quality Controls (QCs)

Organic standards: Total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) are measured as nitrate and phosphate respectively following oxidation of the sample by exposure to UV radiation and a wet chemical oxidation with potassium persulphate. During JR302 five organic compounds containing phosphorus and/or nitrogen were used to test the efficiency of the oxidation. Table 3.3.4 lists the compounds used to prepare stock solutions and Table 3.3.5 lists the concentration of standards prepared, the average concentration measured during the cruise for each compound, the standard deviation of all measurements, and the percent oxidation efficiency. Time series of the recovery of nitrogen from each of the organic compounds used are shown in Figure 3.3.1.

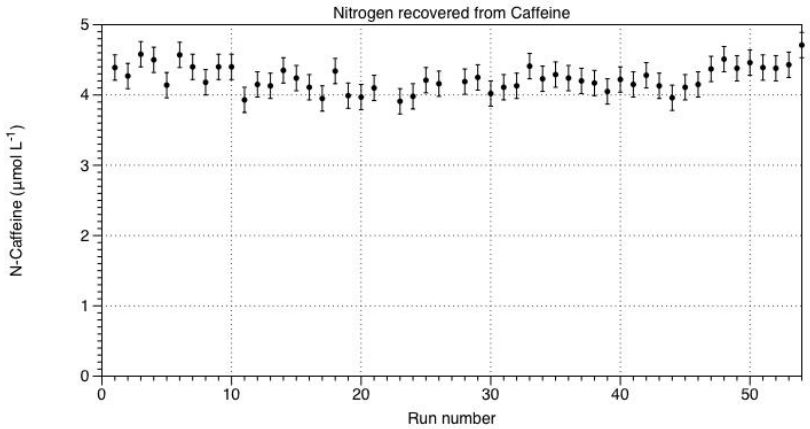
Table 3.3.4. Compounds used to prepare stock organic standard solutions to test oxidation efficiency of TDN and TDP, weight dissolved in 1 L of Milli-Q water and Molarity of the solution.

Compound	**Weight (g)**	**N molarity 1 L stock solution**
Caffeine (Caff)	0.1203	**2.4780**
Urea (Ur)	0.1547	**5.0509**
Adenosine triphosphate (ATP)	0.3030	**2.5033**
Guanosine monophosphate (GMP)	0.2065	**2.5106**
Adenosine monophosphate (AMP)	0.1895	**2.5685**

Table 3.3.5. Set of organic standards used to test the oxidation efficiency of the TDP and TDN channels. This table shows prepared concentration ([ ]), average concentration ([Av]) of total measurements (n) during JR302 and respective standard deviation of measurements, and average percent (%) oxidation efficiency. Concentration units are umol L^{-1}.

	N					P				
	[ ]	[Av]	Sd	n	%	[ ]	[Av]	sd	N	%
Caff	4.99	4.24	0.18	54	85.4	------				
Ur	5.05	4.09	0.91	54	81.0	------				
ATP	2.50	1.77	0.20	54	70.6	1.50	0.81	0.02	3	54.1
GMP	5.02	3.03	0.22	54	60.4	1.00	0.73	0.01	3	73.0
AMP	5.14	3.84	0.14	53	74.7	1.03	0.97	0.04	3	93.7

Certified Reference Materials (CRM) from Hansell's Lab (University of Florida, USA) from deep and surface Atlantic Ocean waters were also used to test the oxidation efficiency for TN. These CRMs are designed for the measurement of dissolved organic carbon and dissolved organic nitrogen via high temperature combustion and are fixed with small amounts of hydrochloric acid. In order to measure them with the colorimetric techniques employed here, we needed to neutralise their pH of ~3.00 to a pH of 7.0 using NaOH (20-50 uL of a 10.2 M solution). Although this introduced noise to these measurements, these CRMs provided an additional test for the oxidation efficiency of the method (not shown here).



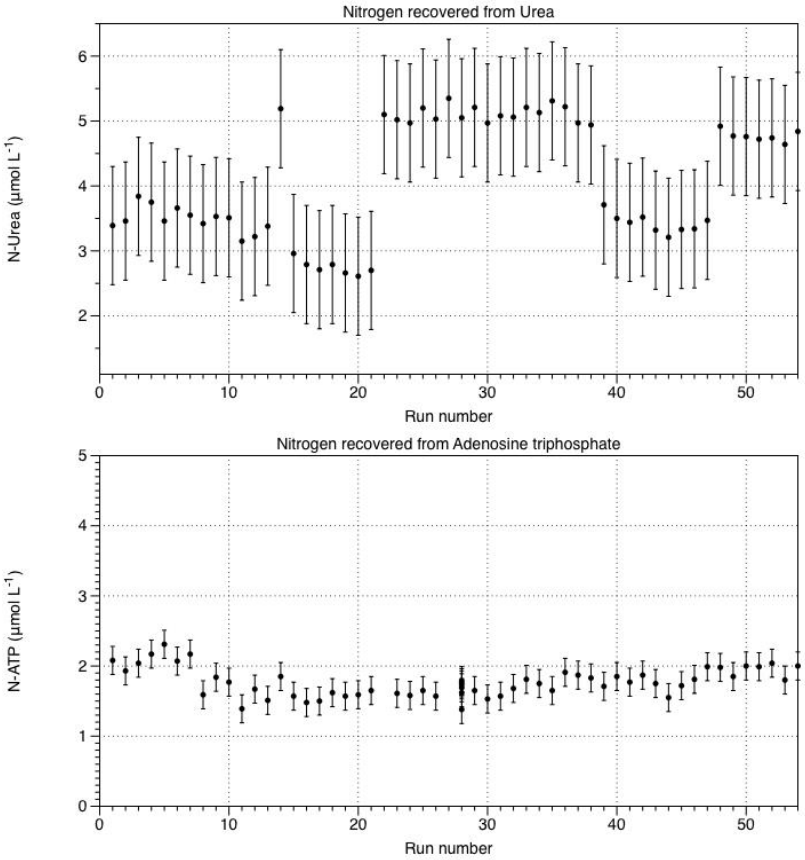
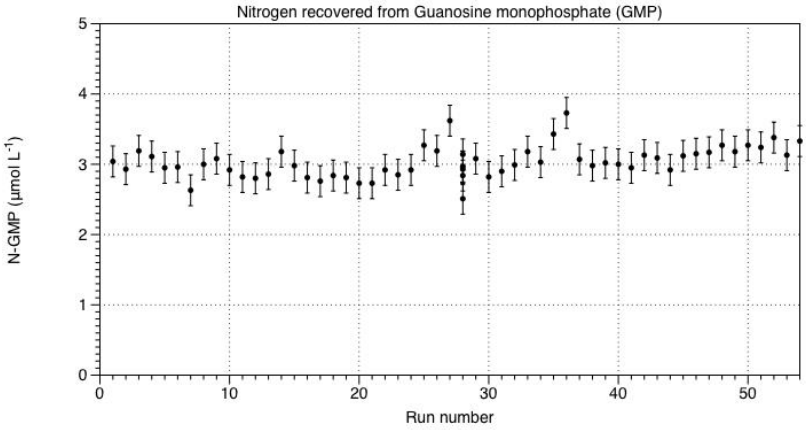


Figure 3.3.1a. Time series of the nitrogen recovered (TN autoanalyser channel) from the various organic compounds used to test the oxidation efficiency of the method (concentration plotted against run number; n=54). Error bars show the standard deviation of the global mean. The concentration of nitrogen of each organic compound was 5 umol L^{-1}, except ATP, which was 2.5 umol L^{-1}.



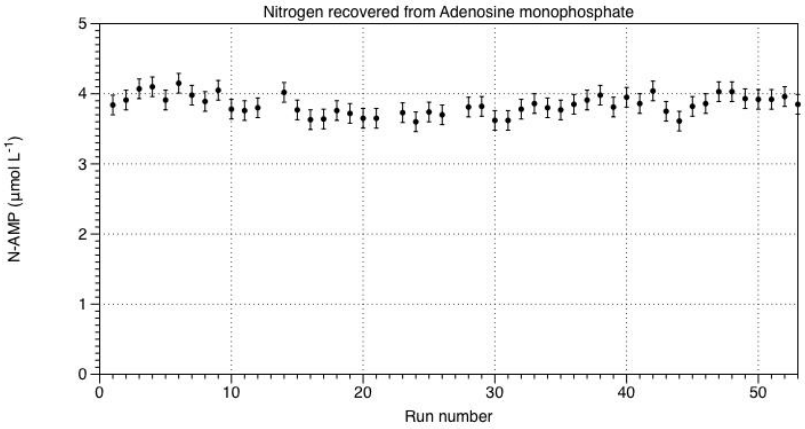


Figure 3.3.1b. Time series of the nitrogen recovered (TN autoanalyser channel) from the various organic compounds used to test the oxidation efficiency of the method (concentration plotted against run number; n=54). Error bars show the standard deviation of the global mean. The concentration of nitrogen of each organic compound was 5 umol L^{-1}, except ATP, which was 2.5 umol L^{-1}.

Inorganic nutrients: In order to test the accuracy and precision of the analyses, CRMs from The General Environmental Technos Co., Ltd., (KANSO) were measured in all but one run. During JR302 KANSO CRMs lot CA and lot BU were used; certified concentrations of both are shown in Table 3.3.6. Lot CA is water from Suruga Bay, Japan, collected at 270 m depth, 19ºN, 130ºE, salinity 34.376 (certified date 19/06/2013, production date 22/02/2013, expiry date 22/02/2019). Lot BU is from the Suruga Bay, Japan, collected at 397 m depth, 32ºN, 144ºE, salinity 34.538 (certified date 03/08/2012, production date 26/04/2011, expiry date 26/04/2017). Average results from the measurement of KANSO CRMs are also shown in Table 5. The methods employed here are able to reproduce the CRMs values for nitrate+nitrite and phosphate within the overall analytical uncertainty. However, our methods seem to underestimate nitrite and silicate by 0.017 mmol L^{-1} (Lot CA) and 0.016 mmol L^{-1} (Lot BU) and by 3.99 mmol L^{-1} (Lot CA) 2.69 mmol L^{-1} (Lot BU) for nitrite and silicate, respectively (see Table 5). Although no certified concentration is reported for TN, measurements of KANSO CRMs provided consistent values throughout the cruise (Lot CA 21.68±1.19 mmol L^{-1}; Lot BU 8.03±0.64 mmol L^{-1}).

Table 3.3.6. Certified concentrations (umol kg^{-1}) of KANSO CRMs used during JR302 and our results for each lot (also in umol kg^{-1}).

	Nitrate	**Nitrite**	**Silicate**	**Phosphate**
KANSO **CA**	19.56 ± 0.19	0.055 ± 0.0047	36.06 ± 0.30	1.419 ± 0.029
KANSO **BU**	3.88 ± 0.063	0.068 ± 0.0043	21.01 ± 0.68	0.372 ± 0.010
Measured CA	19.48 ± 054	0.038 ± 0.019	32.07 ± 0.45	1.47 ± 0.03
Measured BU	3.94 ± 0.21	0.052 ± 0.021	18.32 ± 0.62	0.36 ± 0.01

Cadmium column reduction efficiency: The reduction of the nitrate (NO_3^-) present in a sample or from the oxidation of TN in a sample, to nitrite (NO_2^-), is achieved by passing the sample through a column

filled with granular cadmium (cadmium column); cadmium is oxidised and nitrate is reduced. With use, the capacity of the cadmium column to reduce nitrate diminishes. The reduction efficiency was determined in every run by measuring nitrite and nitrate standards of similar concentrations (30 umol L^{-1}). The ratio of nitrate to nitrite expressed as a percentage provides an indication of the reduction efficiency of the cadmium column. For the analysis to produce reliable results, the oxidation efficiency needs to be >90%. When the efficiency is lower, the cadmium column is typically replaced. New cadmium columns are conditioned by flushing ammonium chloride through them for at least 10 hours; the time it takes to attain stable reduction efficiencies.

AA3 Test

Upon installation, the AA3 was tested by carrying out three analytical runs. For the first test, only standards (calibrants) were used to provide an indication of the linearity of calibration curves. This was followed by two runs with a full set of QCs standards and KANSO and Hansell's Lab CRMs to verify the system was working properly. Following the tests, every run was set up as shown in Table 3.3.7.

Analyses

Seawater was collected for the analysis of micro-molar concentrations of dissolved inorganic and total nutrients. Samples were collected directly into 15 mL plastic centrifuge tubes. These were rinsed with sample water at least three times before withdrawing the sample. Tubes were stored in a fridge at approximately 4°C until sampling for 2 or more stations was completed; analyses were thus carried out for typically 2-10 stations at a time depending on frequency of sampling and number of samples per cast. Analyses of individual CTD casts were thus done from just after sampling to within 10 h after sample collection. All unique sampling depths were sampled and analysed.

Observations

Prior to the cruise all labware was washed with 10% HCl and rinsed with MQ water. Once on board, all labware was rinsed several times before use. Following each run, each analytical channel was flushed with wash solutions and the autosampler with Milli-Q water following Seal Analytical cleaning protocols. At least once per week the system was thoroughly cleaned with sodium hydroxide (TP lines), ~10 % hydrochloric acid (ammonium), and sodium hypochlorite (nitrite, nitrate, TN, phosphate and silicate line). After turning the AA3 on, about 2 hours are required before obtain stable baselines are established and a run can be started (approximately 30 minutes of flushing the instrument with wash solutions (as per Seal Analytical protocols) and 1.5 h flushing channels with their respective chemical reagents).

Batches of ASW were prepared about twice per week, and the different chemical reagents were prepared from daily, to every 2 or 3 days.
Samples from sections around Cape Farewell affected by sea ice and glacier melt with salinity <34 were analysed separately using ASW of lower salinity (diluted by using 800 mL of normal ASW topped up to 1000 mL with Milli-Q water).

Performance of the Analyser

The performance of the autoanalyser was monitored by producing time series of standards, QCs, CRMs and cadmium column reduction efficiency, plotted against run/analysis number.
The precision of the method employed by each nutrient channel was determined by monitoring the variations of the complete set of standards, QCs and CRMs measured throughout the cruise. Accuracy of the analysis was determined via the measurement of KANSO CRMs.

Results of the measurement of standards; average concentration, analytical uncertainty (*sd*) and precision of the analysis at the different concentration levels, are summarised in Tables 3.3.8 and 3.3.9 and shown in Figure 3.3.2. Random samples were collected in duplicate in every cast to assess reproducibility. The average difference between duplicates (n=315) were < 0.03, 0.005, 0.2, 0.05, 0.003, and 0.013 umol L^{-1} for silicate, phosphate, TP, TN, nitrate+nitrite, nitrite, and ammonium, respectively. The limits of detection for the different variables, determined as twice the standard deviation of the

lowest concentration standard were 0.08, 0.02, 0.18, 0.15, 0.04 and 0.07 umol L^{-1} for silicate, phosphate, TP, TN, nitrate+nitrite, nitrite, and ammonium, respectively.

Problems

(i) TP channel: this channel stopped working after run 3 and we were not able to fix it. This channel has never worked properly since it was first installed at NOC back in January 2013. We tested it for three months between July-September 2013 following Seal Analytical advice, but were not able to make it work. The system was then sent back to Seal Analytical headquarters in Germany where it was further tested and the method modified and improved. We tested that new method a week before packing for JR302, but did not get it to work in the lab. We have been in contact with Seal Analytical and they are planning to send an engineer/technician to carry out further work on the TP channel once back at NOC.

(ii) Ammonium Channel: this channel stopped working from run 19 to 21; there was no signal from the channel despite the fact that the fluorometer and connections were working properly. Following some tests by MS, it was found that some batches of the main fluorescence reagent, ortho-phthalaldehyde (OPA), were most likely degraded and thus the reaction for florescent detection of ammonium was not occurring. Due to the OPA being a hazardous material that requires storage at less than 5ºC, this reagent was airfreighted just a few days prior to the team joining the ship. Unfortunately, the shipping company re-packed our boxes and did not label them properly. As a result, upon delivery to the ship there was confusion as to what boxes contained temperature-sensitive reagents and thus they were not stored in the fridge for about two days. This seems to have affected some of the OPA. Another problem found with this channel is that clogs tend to form within the manifold and within the fluorometer, possibly due to a combination of heat and reaction of residual chemical reagents mixed with washing/cleaning solutions. It was observed that clogging could be diminished by cleaning the system after switching off the heater and allowing it to cool down to room temperature. By station 216 the gain of the ammonium channel had increased from 3 or 4 (as initially) to over a hundred, rendering the measurements unreliable despite the preparation of several new OPA solutions. Thus, we were not able to measure ammonium from CTD cast 216 onwards.

(iii) Cadmium column on the nitrate+nitrite channel: For reasons we do not fully understand, any newly installed cadmium column on this channel seems lose its reduction efficiency from the start (see Figure 3.3.3). By experience using autoanalysers in previous cruises we know that the life span of a new cadmium column is approximately 2 to 3 weeks depending on number of samples analysed. However, on the AA3 the efficiency starts to decrease from the moment the column is installed. What is most puzzling is the fact that once the reduction efficiency decreased below 90%, the cadmium column was swapped to the TN channel, where it performed at 100% for far longer (1-1.5 weeks); this despite having being used for 3 or 4 days in the nitrate+nitrite. Also intriguing is the fact that the CRMs and QCs continue to produce reliable results. Thus, rather than using the nitrate to nitrite ratio of the reduction efficiency standards as a way of monitoring the performance of the cadmium column, we decided to replace any new column after 3-4 days and then switch it over to the TN channel where it performed well. When we first noticed this problem, CTD casts 30 and 31 (run 11), and casts 32 and 33 (run 12) had been affected. By measuring CRMs in every run we were able to detect when the reduction efficiency of the cadmium column affected the results. We were then able to correct affected stations using a correction factor determined from the ratio of the average results of KANSO CRMs of non-affected runs relative to those affected. By re-evaluating the data, we concluded this resulted in nitrate+nitrite (or TN) profiles consistent with neighbouring stations which were not affected by the problem. Table 3.3.10 lists stations that were affected by low reduction efficiency and correction factors employed.

Table 3.3.7. Calibration and QCs analysis template.

ID	Description	Comment
Primer	Initial peak identified by the AA3 software as the start of a run.	Followed by a null (or wash)

2 Drifts	Separate standard of constant concentration used by the software in combination with 'baseline' checks to correct for potential drifts of the baseline. The first drift is specified as a null since it may be affected by carry over and thus is not taken into account by the software.	Followed by a null
3 x STD 1	The first standard is specified as a null since it may be affected by carry over and thus is not taken into account by the software.	Followed by a null
3 x STD 2	As above.	Followed by a null
3 x STD 3	As above.	Followed by a null
3 x STD 4	As above.	Followed by a null
3 x STD 5	As above.	Followed by a null
2 Drifts	As for the drifts above.	Followed by 2 nulls
Baseline	Baseline check	Followed by 1 null
4 x 30 umol L^{-1} NO_2^- STD	The first is specified as a null	Cadmium column efficiency test
3 x 30 umol L^{-1} NO_3^- STD		Cadmium column efficiency test. Followed by a null
2 x GMP	The first is specified as a null	Followed by a null
2 x Ur	The first is specified as a null	Followed by a null
2 x AMP	The first is specified as a null	Followed by a null
2 x ATP	The first is specified as a null	Followed by a null
2 x Caff	The first is specified as a null	Followed by a null
2 x Hansell's Lab CRM surface	The first is specified as a null	Followed by a null
2 x Hansell's Lab CRM deep	The first is specified as a null	Followed by a null
2 x KANSO CRM	The first is specified as a null	Followed by a null
2 Drifts	The first is specified as a null	Followed by 2 nulls
Baseline	Baseline check	Followed by a null

Samples	Ordered from surface to deep samples to avoid cross contamination and grouped by CTD cast.	Samples from CTD casts were separated by Drifts and baselines as above.
Pairs of STD 1 to 5	To test consistency with standards specified as calibrants in the software.	Followed by Drifts and baseline check.
End of run		

Table 3.3.8a. Mean and variation of all calibration standards measured for initial standard concentrations (runs 1-18), and precision of the analysis at each concentration (umol L^{-1}). Note that TP was included in runs 1-3 only.

	Si(OH)4	Prec.	PO_4^{3-}	Prec.	TP	Prec.	TN	Prec.
Std 1	1.03±0.06	6.3	0.24± 0.02	7.4	0.29±0.01	4.6	1.30± 0.12	9.0
Std 2	5.07± 0.08	1.6	0.74± 0.01	1.7	0.73±0.02	2.7	6.52± 0.11	1.7
Std 3	10.03±0.21	2.1	1.51± 0.04	3.1	1.41±0.04	3.1	12.96±0.25	1.9
Std 4	20.15±0.21	1.0	3.09± 0.05	1.6	2.94±0.01	0.4	25.63±0.27	1.0
Std 5	29.90±0.17	0.6	4.95± 0.04	0.8	5.07±0.01	0.2	38.03±0.27	0.7

Table 3.3.8b. Mean and variation of all calibration standards measured for initial standard concentrations (runs 1-18), and precision of the analysis at each concentration (umol L^{-1}).

	NO3+NO2	Prec.	NO2	Prec.	NH4	Prec.
Std 1	0.98±0.10	10.4	0.09± 0.01	9.7	0.08 ± 0.03	32.4
Std 2	5.69±0.14	2.4	0.50± 0.01	2.3	1.00 ± 0.03	3.2
Std 3	11.34±0.24	2.1	1.00± 0.02	1.7	2.04 ± 0.05	2.3
Std 4	22.38±0.14	0.6	2.02± 0.02	1.0	3.56 ± 0.04	1.1
Std 5	32.69±0.19	0.6	2.99± 0.02	0.6	4.97 ± 0.04	0.8

Table 3.3.9a. Mean and variation of all calibration standards measured for second standard concentrations (runs 19-54), and precision of the analysis at each concentration (umol L^{-1}).

	Si(OH)4	Prec.	PO_4^{3-}	Prec.	TP	Prec.	TN	Prec.
Std 1	1.00±0.04	3.9	0.11 ± 0.01	8.7	*not analysed*		1.37± 0.09	6.6
Std 2	5.08±0.03	0.6	0.48 ± 0.01	1.9	*not analysed*		5.88±0.14	2.3
Std 3	10.13±0.07	0.7	0.98 ± 0.02	1.9	*not analysed*		11.83±0.20	1.4
Std 4	20.10±0.09	0.5	1.99 ± 0.02	1.1	*not analysed*		23.89±0.17	0.7
Std 5	39.94±0.12	0.3	3.02 ± 0.02	0.7	*not analysed*		36.25±0.23	0.6

Table 3.3.9b. Mean and variation of all calibration standards measured for second standard concentrations (runs 19-54), and precision of the analysis at each concentration (umol L^{-1}). Note that NH_4 was included in runs 22-52 only.

	NO3+NO2	Prec.	NO2	Prec.	NH4	Prec.

Std 1	1.06 ± 0.08	7.3	0.10±0.02	15.8	0.12± 0.03	28.0
Std 2	5.52 ± 0.12	2.2	0.50± 0.01	1.4	0.48± 0.02	5.0
Std 3	11.14 ± 0.20	1.8	1.00± 0.01	1.5	0.99± 0.02	2.3
Std 4	22.18 ± 0.14	0.6	2.00± 0.02	0.8	2.04± 0.03	1.3
Std 5	32.93 ± 0.17	0.5	3.00± 0.01	0.5	2.99± 0.02	0.6

Table 3.3.10. Correction factors used to correct data affected by low reduction efficiency of the cadmium column in the nitrate+nitrite channel and TN channel.

Channel	Run No	CTD casts	Correction factor
Nitrate+nitrite	11	30 to 31	1.067
Nitrate+nitrite	12	32 to 33	1.168
Nitrate+nitrite	47	170 to 180	1.09
Nitrate+nitrite	48	181 to 185	1.14
Nitrate+nitrite	49	186 to 191	1.12
Nitrate+nitrite	51	198 to 208	1.046
Nitrate+nitrite	52	209 to 215	1.043
Nitrate+nitrite	53	216 to 224	1.062
TN	14	37 to 40	1.089

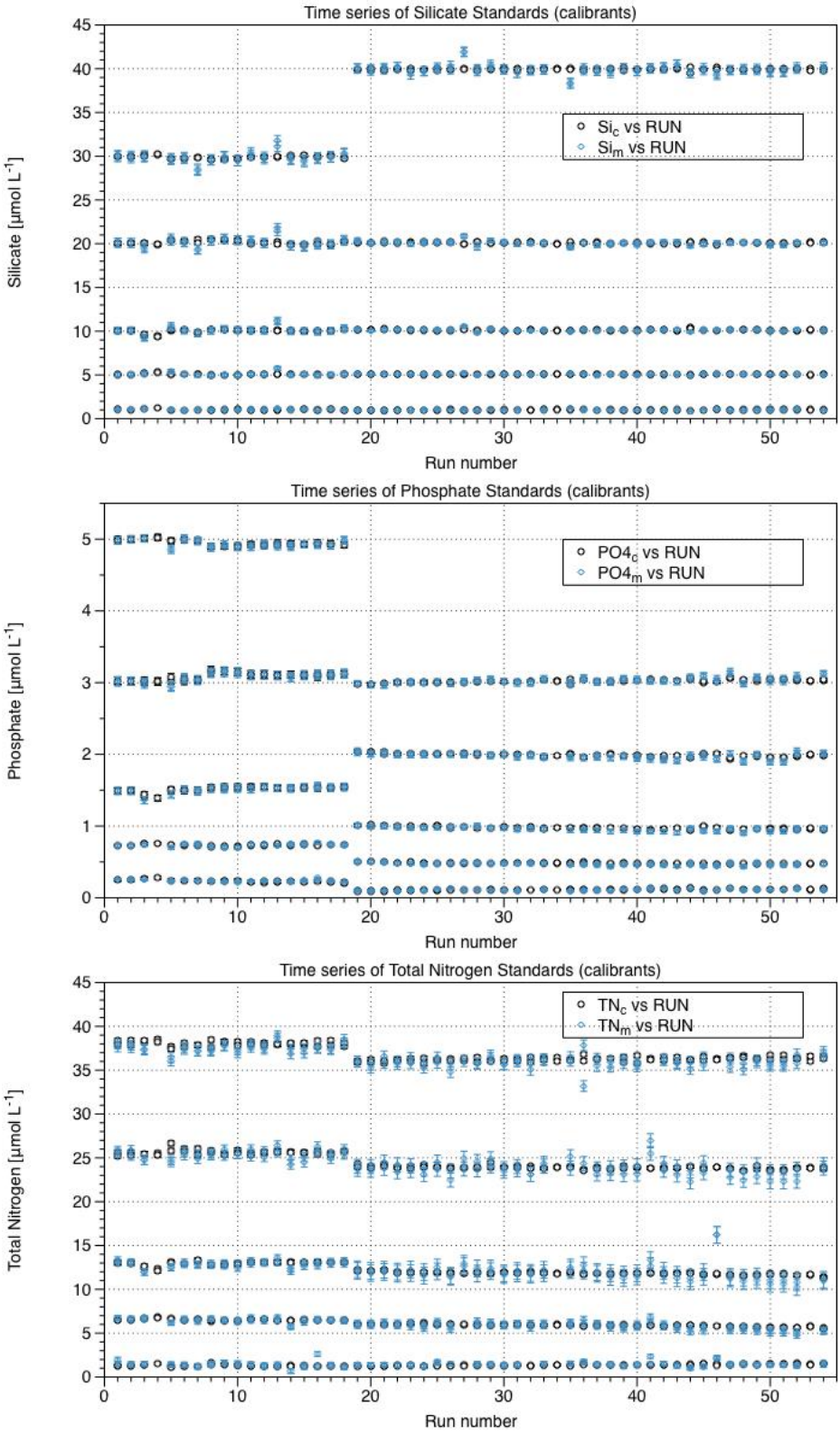


Figure 3.3.2a. Time series of standards set up as calibrants for the analysis (black symbols) and measured as unknowns at the end of each run (blue symbols). Error bars show the standard deviation of the mean of all runs (n=54)

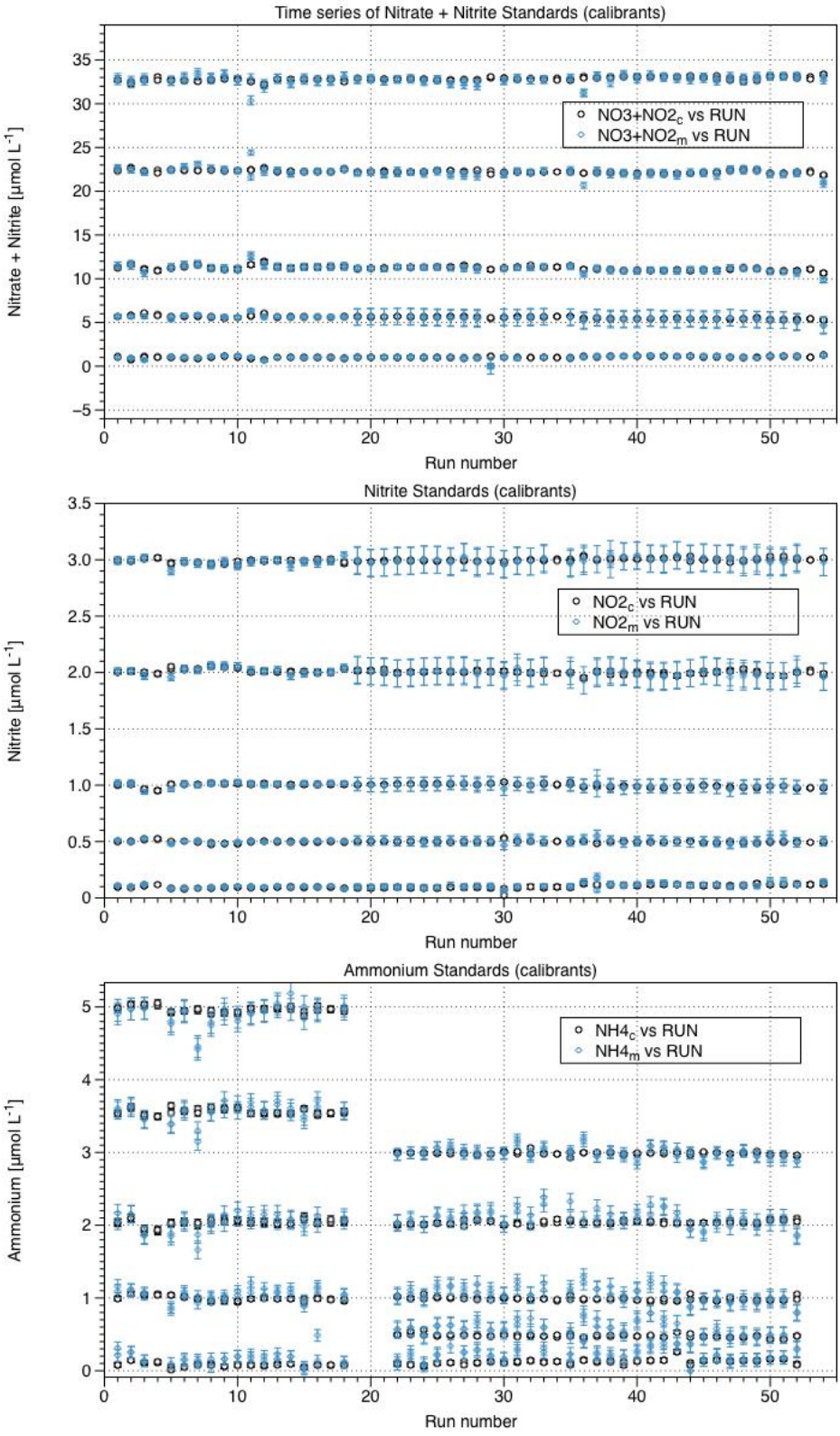


Figure 3.3.2b. Time series of standards set up as calibrants for the analysis (black symbols) and measured as unknowns at the end of each run (blue symbols). Error bars show the standard deviation of the mean of all runs (n=54)

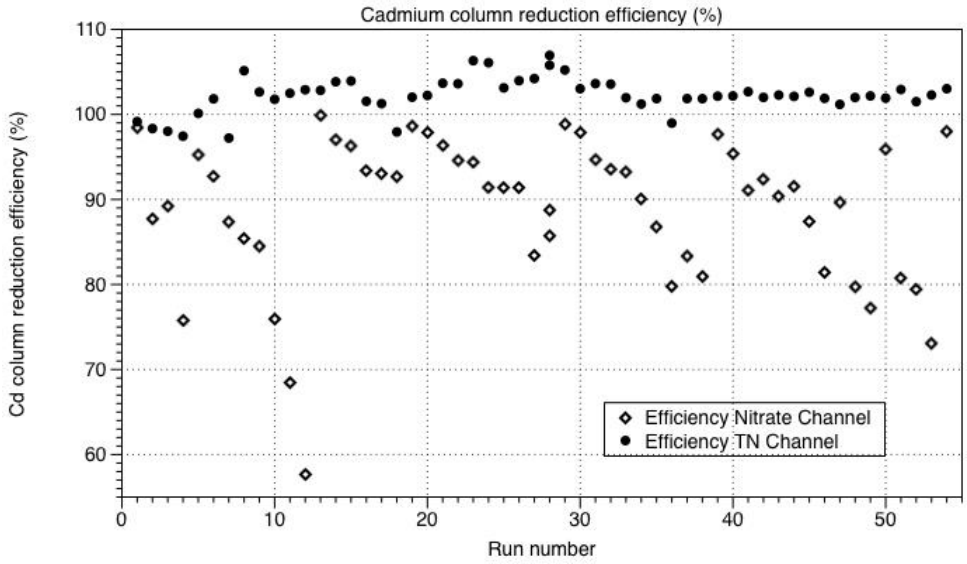


Figure 3.3.3. The efficiency of the cadmium column in reducing nitrate to nitrite is tested by measuring a nitrite and nitrate standard of similar concentration (~30 umol L^{-1}). The ratio of nitrate to nitrite expressed as percentage (%) provides an indication of the reduction efficiency. The concentration of both standards may not be exactly the same, resulting in a ratio slightly higher or lower or than 1 (or lower than 100%). Knowing this, the nitrate to nitrite ratio of a newly installed cadmium column is expected to remain relatively constant. 7 new cadmium columns were installed during JR302. It can be seen that any new column installed (open diamonds close to 100% efficiency) in the nitrate+nitrite channel lost its reduction efficiency immediately. This column, when swapped to the TN channel, performed well (slightly above 100%, black dots).

3.4 Carbonate system measurements

Eithne Tynan, Rebecca Garley, Alex Griffiths and Claudia Fry

3.4.1 DIC/TA

Sampling protocol

Samples for total alkalinity (TA) and dissolved inorganic carbon (DIC) were drawn from the Niskin bottles with a piece of Tygon tubing into borosilicate glass bottles following best practices (Dickson et al 2007). Most bottles were 250ml but for every cast two 500ml bottles were taken at an upper water column and deep water column depth to test instrument precision. Additionally, the surface and deepest depths were sampled as duplicates in two 250 ml bottles, to test for sampling error. All samples were immediately poisoned with 50ul of a saturated mercuric chloride solution (100ul for 500ml bottles) after leaving a headspace of 1% of the volume in each bottle to allow for thermal expansion. Samples were taped and stored in a cool dark place until analysis.

3.4.2 Analysis

Two VINDTA 3C system (Marianda, Kiel) were brought to sea to analyze DIC and TA on board. VINDTA #24 was connected to a CM5014 CO2 coulometer (UIC, Inc.) and VINDTA #38 was connected to a newer CM5015 CO2 coulometer (UIC, Inc.). Both these coulometers have the CM5011 emulation software.

For DIC analysis, samples are warmed in a water bath for at least 30 mins before analysis. A set volume of the sample (~20ml) is acidified by addition of excess 10% phosphoric acid, which converts all inorganic carbon species to CO2. This is carried into the coulometric cell by an inert carrier gas (CO2-free N2 that is first passed through a magnesium perchlorate and soda lime scrubber), and a coulometric

titration determines the amount of CO2, which is equal to DIC.

For TA determination, small increments of 0.1 M hydrochloric acid are added to a set volume of sample (~100ml) while the electromotive force is measured by a glass and reference electrode system. The amount of acid added to reach the carbonic acid equivalence point is equal to the TA.

Once analysis started and on testing with the same batch of seawater, it was noticed that VINDTA #38 had a considerable DIC drift, with values decreasing by 10umol every 10-15 samples. When investigating into the cause of this, and after switching the coulometers on the two systems, the 5015 coulometer was identified as the source of this drift. UIC were contacted and after failed attempts to correct this it was decided to leave CM5015 and send it back to UIC after the cruise. In order to maximize the number of samples analyzed for the rest of the cruise DIC was run on VINDTA #24 connected to the CM5014 coulometer and TA was run on VINDTA #38. DIC titrations are quicker than TA so samples for TA would accumulate during the run. However when changing the coulometric cell for DIC was required, the majority of TA samples were run by the time the new cell was prepared and settled. This set-up allowed a throughput of approximately 50 samples per 24 hours.

On the fourth week of the cruise, the DIC titrations started to be extremely noisy with alternating end-points of 0 and ~100. Once again, electronic issues with the coulometer were identified but on this occasion it was possible to correct them on the ship and mainly consisted of adjusting the voltages on some of the coulometer components. The CM5014 will need a recalibration after the cruise, but this should not affect results as it just produces an offset in the measurements that is corrected for by running CRMs.

Regular measurements of both DIC and TA were made from batch 135 and 136 Certified Reference Material (CRM) from A. G. Dickson (Scripps Institution of Oceanography) and used to calibrate the results as follows:

DICsample, corrected = DICsample, measured x (DICCRM, certified / DICCRM, measure)
TAsample, corrected = TAsample, measured x (TACRM, certified / TACRM, measured)

No difference in correction factors was found between the two batches. To obtain the final results in units of μmol kg-1, a correction for density (ρ) due to salinity (S) variations was then applied using salinity measured from Niskin bottle samples and an equation of the form (Zeebe and Wolf-Gladrow 2001):

ρsea water, 25°C = ρpure water, 25°C + AS + BS1.5 + CS2

For DIC, CRMs were run at the beginning, middle and end of each coulometer cell. Cell solution was replaced every 12 hours with average titration times of 10 minutes (ranged from 8-17 mins). The average value of the three CRMs during the cell session was used to calculate the correction factor for each cell (shown on Figure 3.4.1). Before cell session 40 correction factors were centred around 1.0333, while after it they were centred around 1.0343. This shift was due to the adjustment of the electronics on the CM5014 coulometer due to the noise described previously. While recalibration of the unit will be needed after the cruise, the spread of the correction factors appeared to decrease after electronic adjustment.

For TA measurements, one 20L batch of 0.1M HCl acid was prepared at the beginning of the cruise and stored in a plastic carboy in the fumehood. Bottles for the titrino were subsampled from this throughout the cruise. VINDTA 24 was only used for TA in the first two weeks of the cruise when all TA measurements were switched to VINDTA 38. Figure 3.4.2 shows the correction factors for TA obtained from the CRMs run during each of the acid bottles. The decrease in the correction factor for VINDTA 38 throughout the cruise can be attributed to the evaporation of the bulk batch of acid in fumehood and not to a drift of the instrument itself. Therefore each set of samples run on a particular acid bottle was corrected with the average correction factor obtained from that bottle.

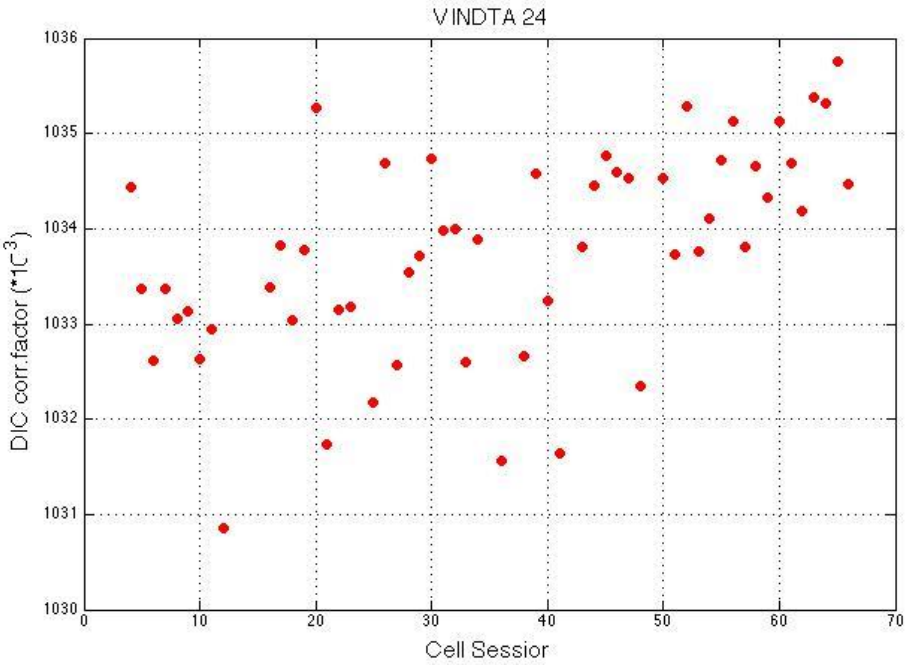


Figure 3.4.1. Correction factors per coulometer cell run on VINDTA 24.

Replicate analysis from a 500ml bottle were used to evaluate precision of the instruments for both TA and DIC. Duplicate analysis (samples drawn on two different 250ml bottles from the same niskin bottle) were used on DIC to check for sampling technique, while on TA it was used to check no change in concentration occurred between the time the bottle had been run for DIC and running on TA. Figure 3.4.3 shows the absolute differences between duplicate and replicate measurements. The standard deviation of the duplicates was taken as the precision of the measurements for this cruise.

In total 2167 samples were collected for DIC/TA on JR302, and 1616 of these were analysed on board. 551 samples were taken back to the lab in Southampton for analysis there.

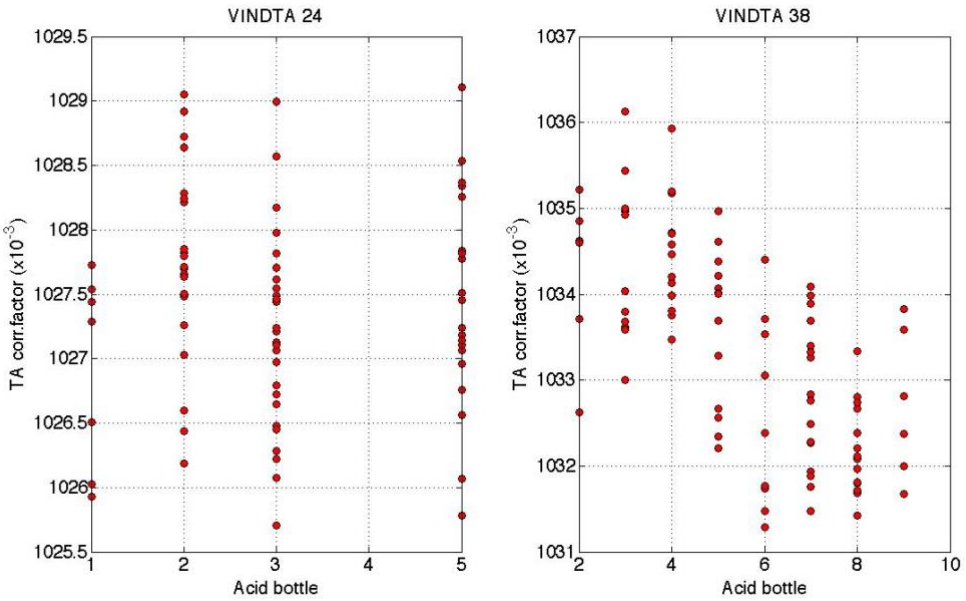


Figure 3.4.2. TA correction factors per acid bottle used for the two VINDTAs where TA was run.

Table 3.4.1. TA and DIC Duplicate and replicate statistics

	Replicates		Duplicates	
	Average	St.Dev.	Average	St.Dev.
TA	1.27	1.07	2.00	1.46
DIC	1.60	1.16	2.22	1.64

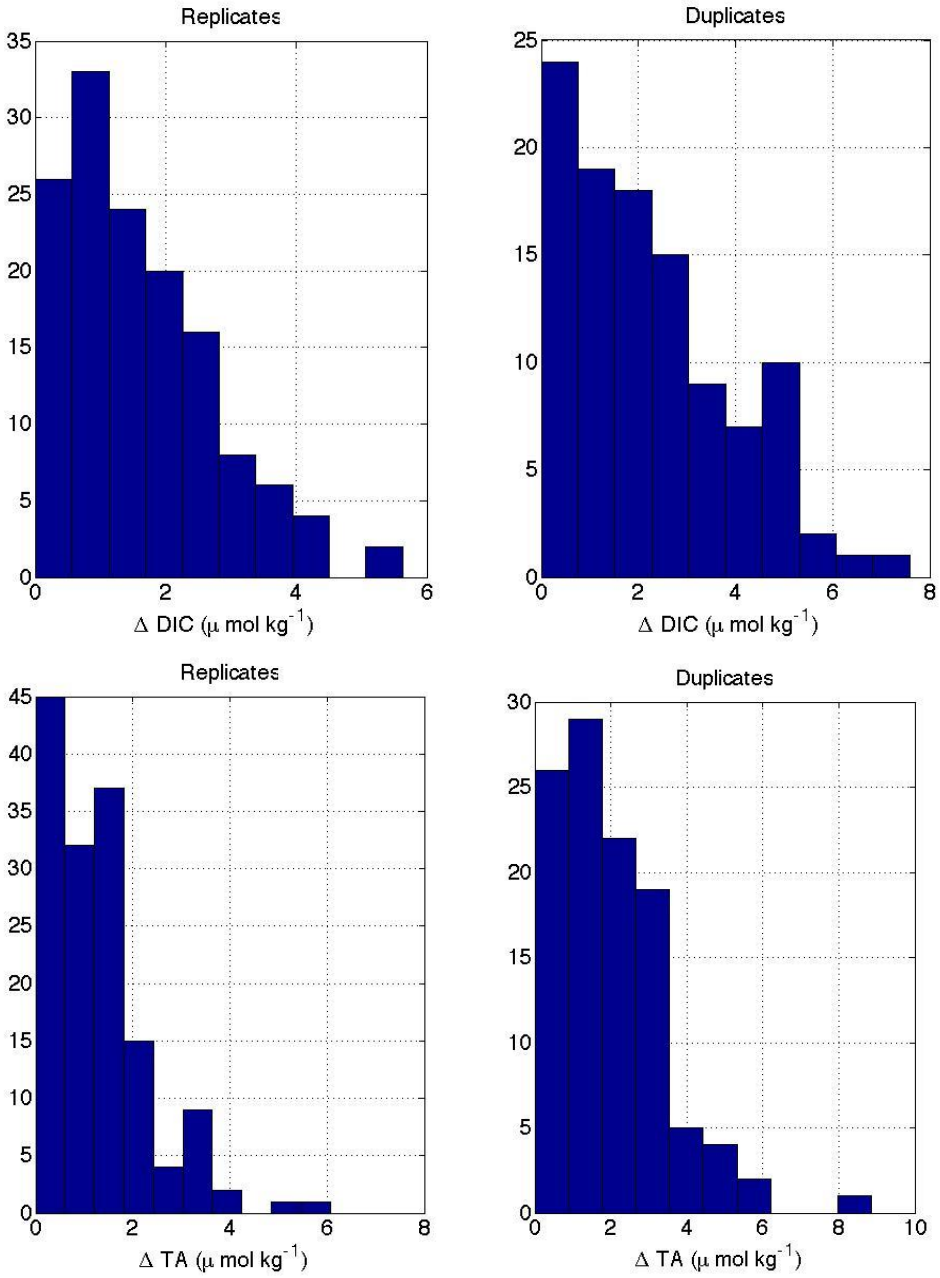


Figure 3.4.3. Distribution of absolute difference between duplicate and replicate measurements.

3.4.2. Isotope Samples

Samples for δ13C of DIC and δ18O of H2O were collected during the cruise and will be analyzed at the NERC Isotope Geosciences Laboratory (NIGL) in East Kilbride.

Samples for δ13C were collected in either 100 ml soda-lime glass bottles or 250 ml borosilicate glass bottles. Preparation for storage was as recommended by Dickson et al. (2007) for DIC samples: soon after collection, a 1% bottle volume headspace was created and 20 µl (for 100ml bottles) or 50 µl (250 ml bottles), of saturated mercuric chloride were added. The stopper was dried and Apiezon L grease was added to make the seal air-tight. Electrical tape was wrapped around the bottle and stopper to hold the lid shut. Samples were then stored at 4° C.

Samples for δ18O were collected in 5 ml glass vials. These vials were filled completely and closed with the screw cap top. Parafilm was put around the top before wrapping with electrical tape. Samples were stored at 4° C to avoid evaporation.

References

Dickson, Andrew G., Christopher L. Sabine, and J. R. Christian. (2007). *Guide to Best Practices for Ocean CO2 Measurements*. PICES Special Publication 3.

Zeebe, Richard E., and D. A. Wolf-Gladrow. (2001). *CO2 in Seawater: Equilibrium, Kinetics, Isotopes*. Elsevier Oceanography Series 65.

3.5 Chlorofluorocarbons (CFCs) and sulphur hexafluoride (SF6) measurements

Marie-José Messias, Tobia Tudino, Pete Mead, Lilo Henke and Gary Murphy

A series of three halocarbons (dichlorodifluoromethane – CFC-12, trichlorofluoromethane - CFC-11, and trichlorotrifluoroethane - CFC-113) and sulphur hexafluoride (SF6) were measured on board by a purge-and-trap gas chromatographic method. The method combines the Lamont Doherty Earth Observatory CFC method [Smethie et al., 2000] and the Plymouth Marine Laboratory SF6 method [Law et al. 1994] tied together with a common valve for the introduction of gas and water samples. This system has the advantage of a simultaneous analysis of SF6 and halocarbons from the same water sample with a running time per sample of ~20 minutes when CCl4 is not measured. The system was set up in the temperature controlled NMF container # 200227 which was installed on the after deck of the JCR.

3.5.1 Sample collection

Water samples were collected from 10 litre bottles as soon as the CTD sampling rosette was on board. As per WOCE protocol, they were the first samples drawn. The Niskin nitrile 'O' rings were first washed in isopropanol and baked in a vacuum oven for 24 hours to remove susceptible contamination before installation in individual Niskin bottles. The trigger system of the bottles was external stainless steel springs. Water samples were collected in 500 ml ground glass stoppered bottles that were filled from the bottom using Tygon tubing and overflowed at least 2 times to expel all water exposed to the air. Immediately after sampling, the glass bottles were immersed in a cool box of clean cold deep seawater and stored in the cold room (~5°C) to prevent degassing until their analysis.

For air sampling, ¼" o.d. Dekabon tubing was run from the system to the monkey island of the ship. Air was pumped through the line to the instrument using a DA1 SE Charles Austen pump, with the line being flushed for approximately 30 minutes before beginning analysis.

3.5.2 Analysis technique

Sample analysis was performed on board as soon as possible after collection using a coupled SF6 and CFCs system with a common valve for the introduction of gas and water samples. Samples were introduced to the system by applying nitrogen (N2) pressure to the top of the sample bottles, forcing the water to flow through and fill a 27 cm3 calibrated volume for CFCs and a 300 cm3 volume for SF6. The measured volumes of seawater were then transferred to separate purge and trap systems, before being

stripped with N2 and trapped at -100°C on a Unibeads 3S trap (for CFCs) and at -80 °C on a Porapak Q trap (for SF6) each immerged in the headspace of liquid nitrogen. Each purge and trap system was interfaced to an Agilent 6890N gas chromatograph with electron capture detector (GC-ECD). The traps were heated to 100° C for CFCs and 65°C for SF6 and injected into the respective gas chromatographs. The SF6 separation was achieved using a molecular sieve packed 2 meters main column and 1meter buffer column. The CFCs separation was achieved using a 1m Porasil B packed pre-column and a 1.5m carbograph AC main column. The carrier gas was pure nitrogen, which was cleaned by a series of purity traps.

Liquid nitrogen was used as the cryogenic cooling material for the sample traps, and was provided by an on-board liquid nitrogen generator located in the deck workshop of the JCR.

3.5.3 Calibrations

The CFCs and SF6 concentrations in air and water were calculated using an external gaseous standard. The standards supplied by NOAA (Brad Hall, December 2008 and 2009) correspond to clean dry air slightly enriched in SF6, CFC-11 and CCl4 in 29L Aculife-treated aluminum cylinders (Table 3.5.1). The calibration curves were made by multiple injections of different volumes (0.1, 0.25, 0.3, 0.5, 1, 2, 3, 5, 8 ml) of standard that span the range of tracers measured in the water. Complete calibration curves were made at the beginning, middle and end of the cruise (Figure 3.5.1). The changes in the sensitivity of the system for each compound were tracked by injections of a fixed volume of standard gas (Figure 3.5.2) and used to adjust the calibration curves respectively.

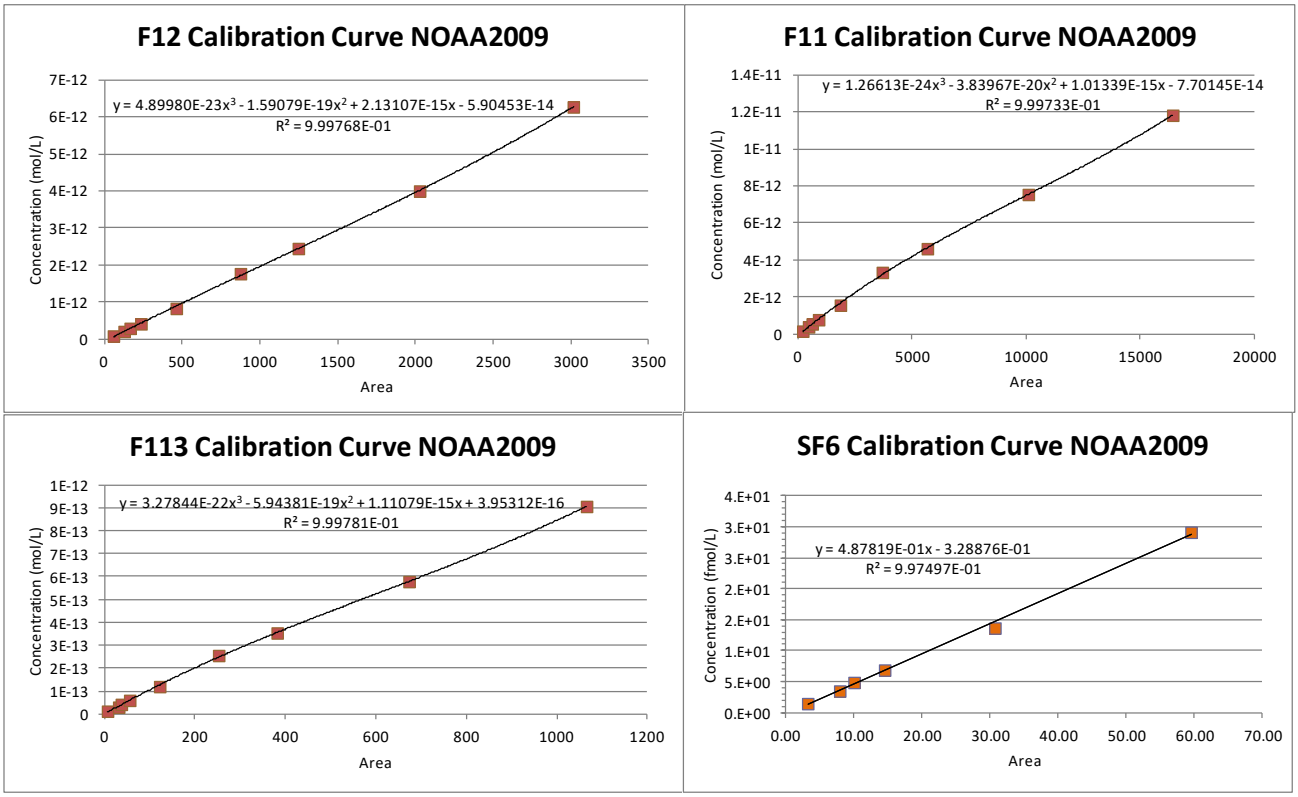


Figure 3.5.1: Calibration curves for CFC-11, CFC-12, CFC-113 and SF6 at the beginning of the cruise (8th of June 2014).

Table 3.5.1: Concentrations of the used NOAA standards

	NOAA2008 AAL-70510		NOAA2009 AAL-072073	
	PPT	STDVE	PPT	STDVE
SF6	7.27	0.02	10.15	0.03
CFC-11	1010	5	1003	6
CFC-12	510.6	0.8	532	1.4
CFC-113	75.2	0.28	76.9	0.2

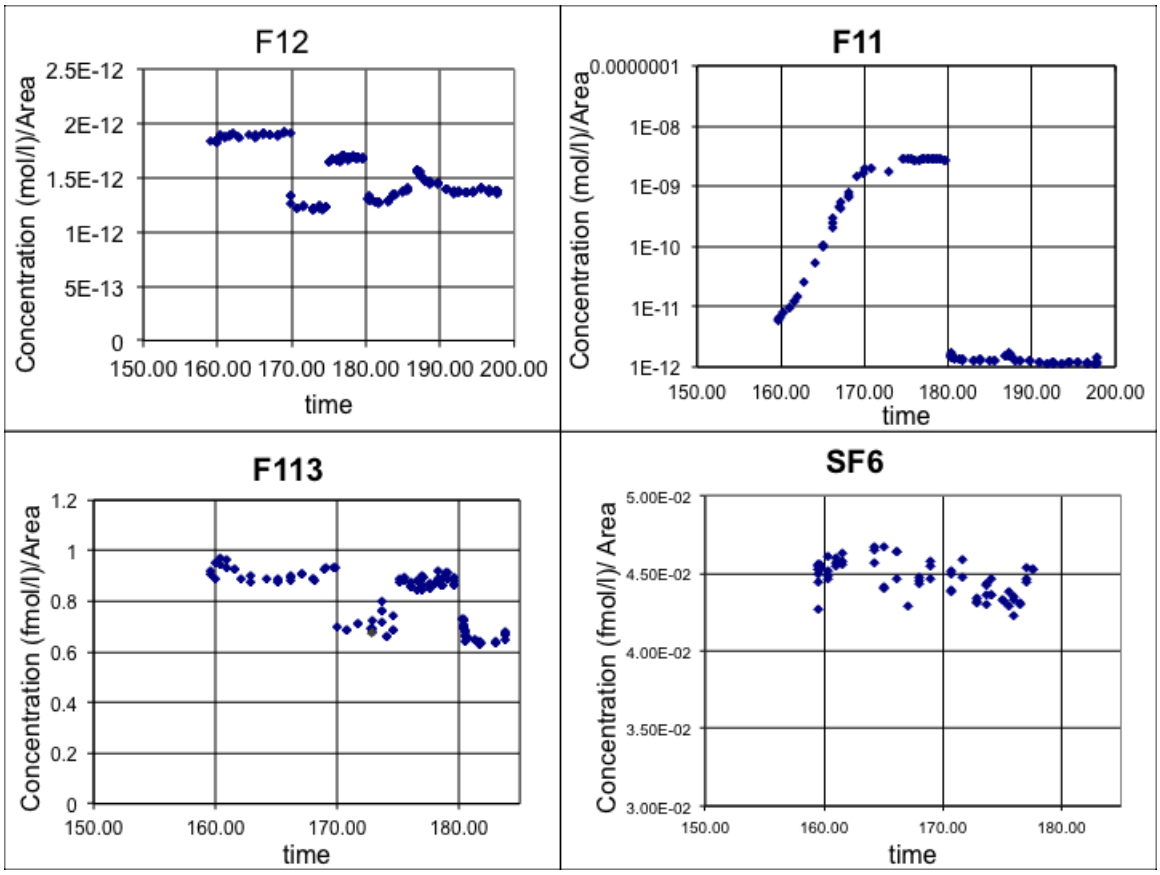


Figure 3.5.2: Instrument response as for the analysis of 1ml standard analyses (NOOA 2009 and 2008) for CFC-12, CFC-11, CFC-113 and SF6. The time is the number of days from 1rst of January 2014. Abrupt changes noticeable for CFC-12 and CFC-113 correspond to instrument interventions. The gradual loss of sensitivity for CFC-11 was due to the deterioration of the Porasil B column changed days 180.

3.5.4 Precision and accuracy

The precision (or reproducibility) for the water samples measurements can be determined from replicate samples drawn on the same Niskin. 5% of the samples were duplicate samples drawn randomly from the rosette along the cruise when possible (time and sampling permitting). This gave measurement precisions for SF6 of 1.05 % for surface values & 0.011 fmol/kg for values < 0.1 fmol/kg, for CFC-12 0.95 % for surface values & 0.003 pmol/kg for values < 0.1 pmol/kg, for CFC-11 1.1 % for surface values & 0.006 pmol/kg for values < 0.1 pmol/kg and for CFC-113 1.5% for surface values & 0.001 pmol/kg for values < 0.1 pmol/kg. The reproducibility for tracer concentration was also estimated at the test station (#34) where all Niskin bottles were fired at the same depth (2700 dbars) and only one sample was drawn per Niskin (Table 3.5.2).

Table 3.5.2: Results from the test station (#34) for 24 samples, mole/kg.

	SF6	CFC-12	CFC-11	CFC-113
MEAN	7.084E-16	1.429E-12	2.96E-14	1.347E-13
STDEV	1.873E-17	5.491E-15	4.919E-15	2.168E-15

The blank correction is to compensate for any trace CFCs/SF6 originating from the sampling bottles, handling and from the measurements procedure. This correction is normally estimated from analysis of either samples collected in water that are free of CFCs or water collected after sparging all the tracers out of a niskin bottle. System blanks were determined through the analysis of water samples that had been purged of all dissolved gases.

Sparge efficiencies were investigated through the continual resparge of a single sample until results did not change (having reached the system blank) at a number of different flow rates. Initial results for general lab conditions are reported in Table 3.5.3.

Table 3.5.3: Sparge efficiency

Tracer	Sparge efficiency
SF_6	97.5 %
CFC-12	98.5 %
CFC-11	99.2 %
CFC-113	100 %

3.5.5 Preliminary data

137 stations were sampled [1: 10, 12, 14, 16, 18:19, 21, 22, 23, 24, 26, 27, 28, 30:34, 36:38, 40, 42:50, 52:55, 57, 59:61, 63, 65:66, 68, 71, 73, 75, 78:79, 82, 84:89, 91:94, 96, 99, 101, 103, 113:115, 117, 119:120, 124, 126, 128:130, 132:138, 140:142, 144:155,157, 171, 175,176,177, 180:186, 188:196,202:206, 210:215] and analysed for CFCs and SF6. However, some stations were sampled only for the Nordics Seas Overflows because analysis time was limited. Initial results for the first transect are presented in Fig. 3.5.3. The distributions of the CFCs and SF6 seen here are largely consistent with previous studies, showing ventilation in the Labrador Sea down to 1800m and the Denmark Strait Overflow Water signal in the bottoms waters.

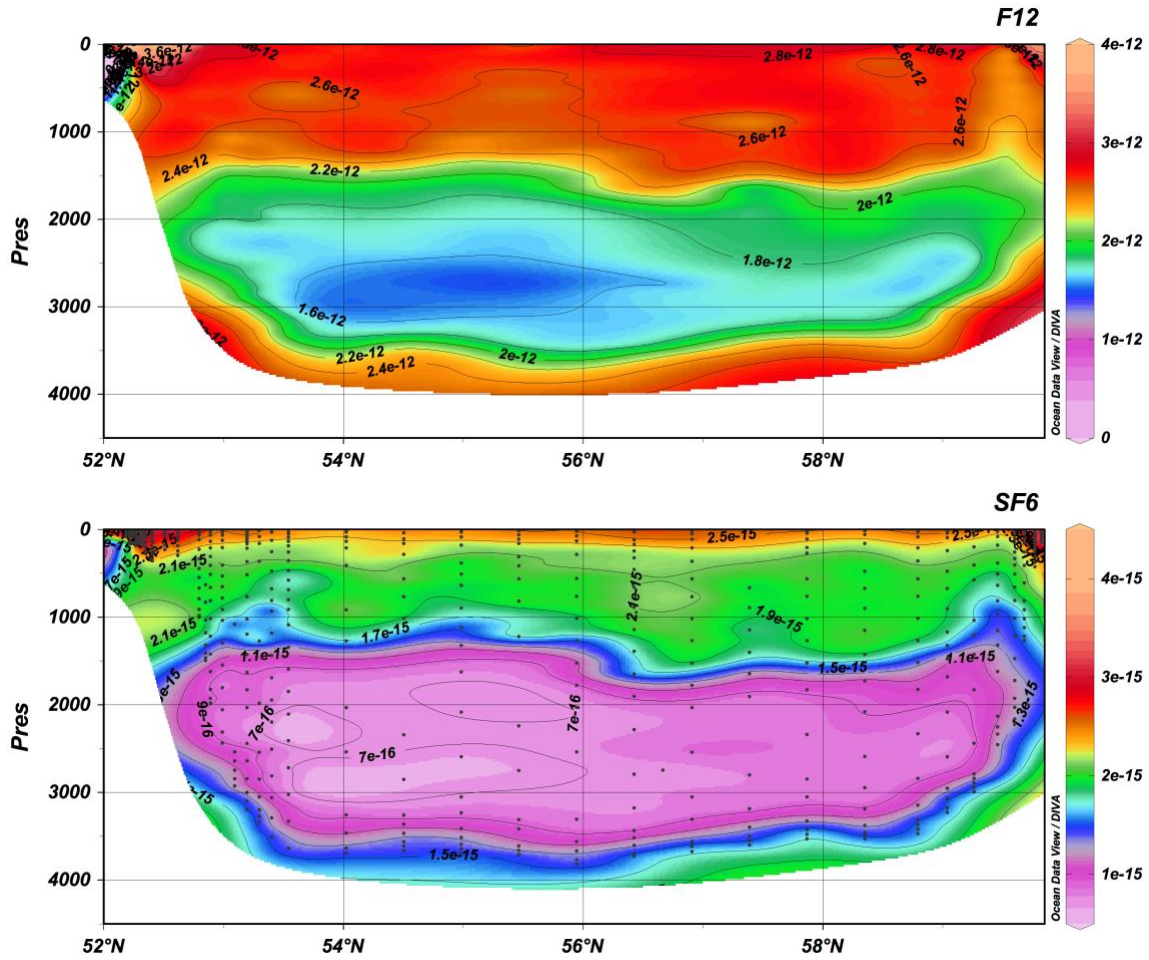


Figure 3.5.3: Preliminary plots of CFC-12 and SF6 extending from southern Labrador to the southwestern tip of Greenland across the mouth of the Labrador Sea (OSNAP West) in the Labrador Sea in Mole/kg.

3.6 Methane and Nitrous Oxide

Ian Brown

Nitrous oxide and methane are biogenically produced trace gases whose atmospheric concentrations are increasing at a rate in the order of 0.7 ppbv y^{-1}. Both gases are radiatively active, contributing approximately 6% and 15% of "greenhouse effect" respectively, whilst N2O contributes to stratospheric ozone depletion and CH4 limits tropospheric oxidation capacity.

The oceans are generally considered to be close to equilibrium relative to the atmosphere for both gases, however oceanic source/sink distributions are largely influenced by oxygen and nutrient status and regulatory processes are complicated and are currently not well understood.

The aim for this cruise is to examine spatial variability in methane production and Nitrous oxide along the cruise track.

Samples were collected from CTD stations. 1 litre samples were equilibrated with compressed air and headspace analysis performed onboard using FID-gas chromatography and ECD-gas chromatography for CH4 and N2O respectively. Atmospheric concentrations were determined by the same methods using a Tedlar bag filled with a hand pump from the bow of the ship.

3.7 Surfactants, CDOM and Pigments

Bita Sabbaghzadeh

The aim of this work was to investigate the vertical and horizontal distribution of natural surfactants and CDOM in North Atlantic Ocean which then will be combined with the next AMT cruise (AMT24) data to explore natural surfactants control of air-sea CO2 exchange in regions of contrasting primary productivity. Surfactants will be measured by AC Voltammetry and in order to provide some preliminary characterisation of the organic matter pool of which surfactants are a component CDOM will be determined using an ULTRAPATH system.

Methods

During the cruise I targeted specific stations for my analysis. For surface samples, I chose the stations which allowed me to assess the impact of variability in wind speed and its direction and also primary productivity impact on surfactant concentration and their distribution. For vertical profile water samples I selected the stations which enabled me to compare surfactant distribution between different water masses and to investigate the impact of ocean circulation.

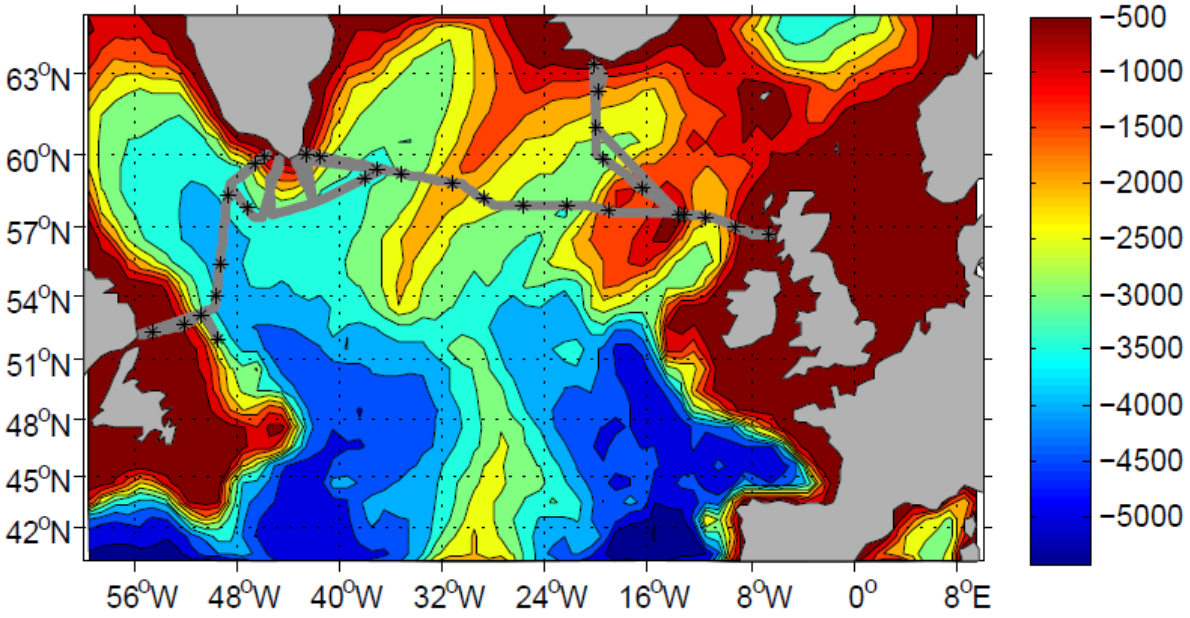


Figure 3.7.1. Location surfactant/CDOM and pigment sampling stations

Surface Micro Layer (SML) samples (upper 400um) were collected using in-house constructed Garrett Screen (60cmx60cm). The screen pre-rinsed 10 times in sea water that it was about to sample and then it was allowed to drain 5s before collection start. The screen was deployed horizontally and lift through the SML and the samples were drained along one of its corners until most of the adhering water was drawn.

The thickness of the SML also may vary depending on both the oceanographic and meteorological conditions at the time the samples are taken. So, the thickness of the SML was measured in two ways in every sample station; firstly, the Garrett Screen was dipped 10 times in one place and the water samples were taken each time. Then the total volume of the samples was recorded. Secondly, the screen was dipped 10 times in 10 different places around the ship and the volume of the sample from each place was recorded and then added the volume taken up. In order to minimise the disturbance to SML from the ship's discharges at the stations, the ship went to full attention (i.e. no discharge to the sea).

The vertical profile water samples were also collected during daily hydrocasts from a 24x10L water-bottle rosette fitted with a CTD probe (Sea-Bird Electronics, SBE09). Finally, the underway water samples (~6 meter depth) were collected.

All the samples were made in two duplicates. Samples for surfactant analysis were collected in 15ml centrifuge tubes. For CDOM samples, 200ml borosilicate volumetric flasks were used.
All the containers were pre-rinsed with 10% HCL and Milli-Q water (Millipore, model ZFSQ240P4) first and then rinsed with some samples three times prior to collection. During the sampling Nitrile Powder-Free disposable gloves were worn.

One batch of CDOM samples was filtered through 0.22µm Surfactant-Free single use syringe filters (MILLEX GP, Millipore). In order to avoid contamination during the filtration process, the syringes and all containers used during filtration rinsed with 10% HCL and M.Q. three times prior to use and between each sample. A small volume of sample (~20ml) was used to rinse filters and the filtrate discarded before collection.

Surfactant activity (SA) measurement

SA measurements were carried out by 797 VA Computerace Voltammetry (Metrohm) with a hanging mercury drop electrode. The calibration was conducted by analysing 10ml of 0.55mol l^{-1} NaCl as the blank/reference solution and followed by adding and analysing the standard (Triton-X-100) to the initial reference solution. The surfactant activity of the sample was measured from the decrease of the capacity current over a range of potentials after 15 and 60s accumulation of surfactants at the starting potential. The potential range was between E=-0.6V at the starting point and E=-0.9998V at ending point.

It has been noticed from the capacity current that the ship vibration is a potential problem. In order to minimize the vibration effect, the instrument was set up in Biology Lab (central line of the ship) and was stood on a gimballed table over some foam. However, the later results showed that the issue still exists when the winch is in operation at the stations and also low current capacity results was due to the Reference Electrode (R.E.) malfunction. Therefore, no further measurements were carried out at the stations. In this occasion, the samples were stored at -80˚C for later analyses.

CDOM determination

CDOM measurements were conducted by high-performance spectrophotometer (UltraPath). Absorbance spectra (250-730nm) of filtered (0.2µm) and unfiltered for SML, underway and CTD samples were measured using a 50cm pathlength, providing greater sensitivity compared to conventional 10cm pathlength spectrophotometer.

The single scan mode with an average of 10 numbers of scans was applied to record the CDOM spectrums. In order to minimize the refractive index effect due to the salinity difference between seawater samples and M.Q. water, NaCl solution standards with the same salinity as the samples were used. The solutions were prepared using analytical grade NaCl dissolved in M.Q. water. To remove any organic contaminants, the salt was baked at 400˚C in advance. The absorbance of the salt solution was measured at the same time as the samples. The integration time was set to maximize the signal measured for the the applied pathlength while avoiding oversaturation of the detector. Between the samples run the UltraPath was flushed with M.Q. water. The data were gathered for both filtered and unfiltered samples and will be available after calibration.

Chlorophyll *a* measurements

3 litre water samples were collected from the depth with maximum Chlorophyll *a* during daily hydrocasts from Niskin bottles. Then the samples were split into pseudo-replicates of 1L and filtered through 0.22 µm pore size 25mm diameter nylon membrane filters using the vacuum pump (Millipore) at low pressure (4.2 Hg).

Then the filters were folded in half twice, wrapped in aluminium foil and stored at -20˚C for later analysis.

Table 3.7.1. Chlorophyll analysis: station number, Niskin bottles and the approximate depths.

Station	Niskin Bottle	Approximate Depth(m)
CTD007	21	24
CTD014	23	5
CTD021	23	20
CTD027	22	45
CTD031	23	29
CTD040	22	37
CTD046	23&24	5
CTD050	16&17	14
CTD059	22	15
CTD077	18	32
CTD084	24	7
CTD096	18	26
CTD110	16	27
CTD124	14	31
CTD133	22	24
CTD145	20	25
CTD152	21	24
CTD161	7&8	24
CTD170	21&22	25
CTD180	20&21	15
CTD186	13&14	13
CTD191	21&22	21
CTD198	21&22	27
CTD200	9&10	38
CTD206	21&22	33
CTD216	11&12	17
CTD230	7&8	13

3.8 Trace Metals

Stefan Gary

Samples for trace metal analysis were collected at 12 stations along the cruise (Table 3.8.1). A total of 90 125 mL polyethylene bottles were specially cleaned and completely filled with deionized water to minimize contamination during transport and storage before the cruise. Each bottle was in a plastic re-sealable bag and only removed from the bag for labeling the bottle and taking the seawater sample. After the sample was collected, the bottle was put back in the bag. Each sample was 100 mL and drawn after all the other samples were taken. For each sample, the bottle and lid were rinsed three times with the seawater from the Niskin bottle and the fourth time bottle was filled with seawater was the final sample. Immediately after sampling was finished, the freshly filled sample bottles were carried to the -18°C freezer for storage for the remainder of the cruise. Gloves were worn whenever the bottles were handled (labeling, sampling, organization in the freezer, and packing).

For each cast, samples were taken on at most 7 depth levels but most frequently at 6 levels. The goal was to sample the subsurface chlorophyll maximum (if present), waters below the seasonal thermocline (~100 m), an intermediate depth (~300 – 500 m), the oxygen minimum zone (~800 m), a deeper

intermediate level (~1500 m), and the bottom. On shallow stations other levels were chosen. Every cast also included at least one duplicate sample (usually two) ideally drawn from a second Niskin bottle that was fired at the same depth as the duplicated sample's Niskin bottle. This was not always possible, so if there was only one Niskin fired at each depth, then the duplicated sample was drawn from the same Niskin.

The trace metal samples will be analyzed for transition metals (Ti to Zn) and the rare earth elements (La to Lu). The concentrations will be measured by the method of combined preconcentration using the SeaFAST Pico (Elemental Scientific Inc., Nebraska, USA) and analysis by ICP-MS (Thermo XSeries2).

Table 3.8.1. Summary of trace metal samples by zone along the section and station number. Adjacent gray blocks indicate duplicate samples.

Zone	Station	Samples →	1	2	3	4	5	6	7	8
OSNAPWest	12	Depth [m]	246	226	131	76	52	37	12	12
		Niskin bottle #	01	04	07	09	11	13	15	16
	24	Depth [m]	3452	3454	2768	1670	469	81	25	25
		Niskin bottle #	01	02	05	09	15	20	23	23
	40	Depth [m]	3467	3467	2051	664	330	92	37	-
		Niskin bottle #	01	02	09	15	17	20	22	-
Green-land	107	Depth [m]	496	253	104	24	24	-	-	-
		Niskin bottle #	01	04	06	08	09	-	-	-
OSNAPEast	89	Depth [m]	2835	1750	427	250	87	87	26	-
		Niskin bottle #	01	07	13	14	17	18	21	-
	138	Depth [m]	2668	2568	1500	469	470	102	30	-
		Niskin bottle #	01	02	08	14	15	19	22	-
EEL	169	Depth [m]	1206	1006	751	751	345	80	28	29
		Niskin bottle #	01	04	05	06	11	17	21	22
	177	Depth [m]	2413	1754	586	586	449	151	26	26
		Niskin bottle #	01	06	11	11	12	15	18	18
	192	Depth [m]	1788	1487	713	713	353	104	24	24
		Niskin bottle #	01	04	08	08	11	14	16	17
	204	Depth [m]	1789	1251	899	898	451	98	42	42
		Niskin bottle #	01	05	06	07	10	17	19	20
	213	Depth [m]	1915	1500	916	916	451	101	23	23

		Niskin bottle #	01	05	08	09	12	17	21	22
	225	Depth [m]	208	208	142	98	99	53	28	29
		Niskin bottle #	01	02	03	05	06	07	09	10

3.9 Phytoplankton community structure and species identification.

Mark Stinchcombe

Samples for particulate organic carbon (POC), particulate organic nitrogen (PON), particulate organic phosphorous (POP), high performance liquid chromatography (HPLC), scanning electron microscopy (SEM), taxonomy (Lugols) and bacterial composition (Glutaraldehyde) were taken from approximately one station per day. In all but one station (CTD006) water was drawn from the shallowest Niskin into a 20L plastic jerrycan.

For POC/PON, water was filtered onto a pre-combusted GF/F filter, rinsed with 1% HCl and then put into a cryovial. For POP, water was filtered onto a GF/F filter that had been pre-combusted, soaked in 10% HCl for 24 hours, soaked in MilliQ water for 12 hours and finally left in a second MilliQ bath until required. The filter was then rinsed with MilliQ and placed into a pre-combusted glass tube. For HPLC, water was filtered onto a normal GF/F filter, rinsed with MilliQ and placed into a cryovial. For SEM water was filtered onto a 0.8µm polycarbonate filter, rinsed with MilliQ water that had been adjusted to a pH of 7.5 with ammonia, and then placed onto a petri-slide. In all cases 500ml was filtered unless otherwise stated in Table 3.9.1. One SEM sample was not taken, from CTD022, as there was not enough water. POC/PON, POP and SEM filters were dried in an oven at 60°C for approximately 24 hours. The HPLC sample was placed straight into the -80°C freezer.

A sample for taxonomy was taken by filling a 100ml amber glass with water and adding 2ml of acidified Lugols solution. These were kept at room temperature. For bacterial composition, 45-50ml was put into a 50ml centrifuge tube and 250ml glutaraldehyde was added. The lid was then put on and sealed with parafilm. The sample was left for 10-15 minutes before being placed in the -80°C freezer.

Table 3.9.1. All the stations sampled for biological parameters, the associated Niskin numbers and the approximate depths the samples were taken from.

Station	Niskin	Approximate depth from wire out (m)	POC/PON	POP	HPLC	SEM	Lugols	Glut.
CTD005	24	5	√	√	√	√	√	√
CTD006	20	29	√	√	√	√	√	√
CTD011	24	5	√	√	√	√	√	√
CTD022	24	5	√	√	√	X	√	√
CTD023	24	5	√	√	√	√	√	√
CTD028	24	0	√	√	√	√	√	√
CTD033	24	11	√	√	√	√	√	√
CTD038	24	10	√	√	√	√	√	√
CTD042	24	10	√	√	√	√	√	√
CTD043	24	5	√	√	√	√	√	√
CTD048	24	2	√	√	√	√	√	√

CTD049	24	1	√	√	√	√	√	√
CTD056	24	5	√	√	√	√	√	√
CTD062	24	5	√	√	√	180ml	√	√
CTD068	24	10	√	√	√	√	√	√
CTD071	24	5	√	√	√	√	√	√
CTD075	24	5	√	√	√	√	√	√
CTD078	24	0	√	√	√	√	√	√
CTD088	24	5	√	√	√	√	√	√
CTD093	24	0	√	√	√	√	√	√
CTD099	24	0	√	√	√	√	√	√
CTD104	24	0	√	√	√	√	√	√
CTD116	24	0	√	√	√	√	√	√
CTD119	24	0	√	√	√	√	√	√
CTD128	16	0	√	√	√	√	√	√
CTD137	19	0	√	√	√	√	√	√
CTD142	21	5	√	√	√	√	√	√
CTD148	19	0	√	√	√	√	√	√
CTD156	19	0	√	√	√	√	√	√
CTD166	12	0	√	√	√	√	√	√
CTD177	20	10	√	√	√	√	√	√
CTD183	19	0	√	√	√	√	√	√
CTD196	19	0	√	√	√	√	√	√
CTD202	14	0	√	√	√	√	√	√
CTD211	19	0	√	√	√	√	√	√
CTD226	10	5	√	√	√	√	√	√

3.10 Iodine Isotope Sampling

Mark Stinchcombe

45 samples for ^{129}Iodine were taken along the cruise track. These consisted of 5 profiles, 8 depths each, and 5 surface samples taken from the shallowest Niskin on the associated cast. Water was drawn from the required depths into 200ml polyethylene bottles and stored at approximately 4°C in the dark.

The required stations can be seen in Figure 3.10.1, the closest station to these locations were chosen and sampled as per our instructions from Dr Maria Villa from the University of Seville. If the required sampling depth was not available, the Niskin closest to this depth was chosen instead. The samples will be returned to the University of Sevilla for analysis. The actual stations and depths sampled can be seen in Table 3.10.1.

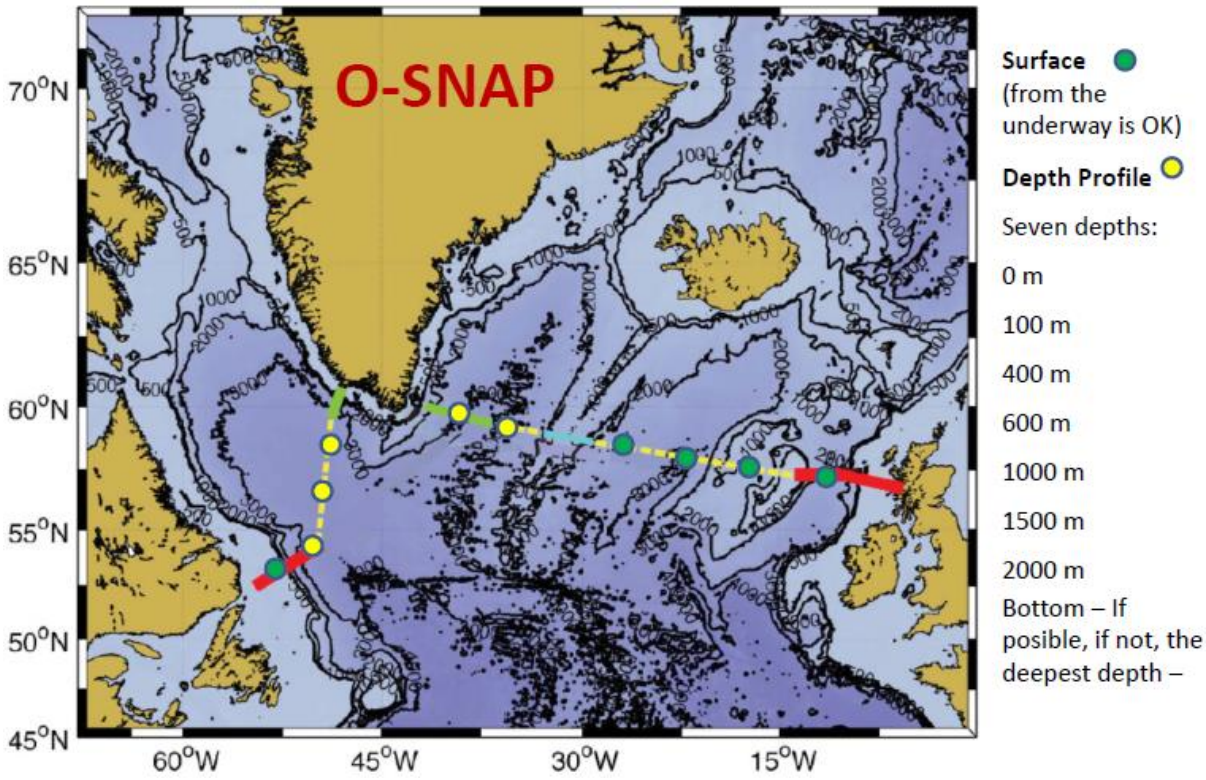


Figure 3.10.1. Location map of the required sampling stations for ^{129}I including the required depths at these stations.

Table 3.10.1. The actual stations that were sampled for ^{129}I and the associated Niskin and approximate depth of those samples.

Station	Niskin	Approximate depth from wire out (m)	^{129}Iodine
CTD005	24	5	√
CTD024	1	3450	√
CTD024	8	1920	√
CTD024	10	1420	√
CTD024	12	920	√
CTD024	14	670	√
CTD024	16	360	√
CTD024	19	120	√
CTD024	24	5	√
CTD032	1	?	√
CTD032	8	?	√
CTD032	10	?	√
CTD032	12	?	√
CTD032	14	?	√
CTD032	15	?	√
CTD032	19	?	√
CTD032	24	?	√
CTD042	1	3172	√
CTD042	7	2055	√
CTD042	10	1455	√
CTD042	14	891	√

CTD042	15	667	√
CTD042	16	472	√
CTD042	20	92	√
CTD042	24	10	√
CTD094	1	3087	√
CTD094	6	2000	√
CTD094	8	1500	√
CTD094	10	1000	√
CTD094	11	750	√
CTD094	12	500	√
CTD094	15	100	√
CTD094	22	0	√
CTD116	1	2650	√
CTD116	4	2100	√
CTD116	6	1500	√
CTD116	8	1000	√
CTD116	9	750	√
CTD116	10	500	√
CTD116	13	100	√
CTD116	19	0	√
CTD136	19	0	√
CTD147	21	0	√
CTD156	19	0	√
CTD211	18	0	√

4. Underway Measurements

Team Physics

4.1 SCS data streams

The SCS data streams (ashtech [nav/ash], ea600 [sim], anemometer [met/surfmet], oceanlogger [ocl], emlog-vhw [chf], gyro [nav/gyro], seatext-gell [nav/seapos], em122 [em122], seatext-hdt [nav/seahead]) were processed on fola during the cruise. Most were processed in 24-hour segments, using m_jr302_daily_processing.m, with cleaning and appending as required. Winch data were processed by CTD station as part of the standard CTD processing.

Daily processing generates a best navigation file, data/nav/seapos/**bst_jr302_01.nc**.

The final surface meteorological data file is data/met/surfmet/**met_jr302_truav.nc**.

Other final, cleaned and appended files from the daily processing are:

chf_jr302_01.nc
ocl_jr302_01_medav_clean_cal_botcompare.nc
em122_jr302_01.nc
ocl_jr302_01_medav_clean_cal.nc
ocl_nav_jr302_01.csv
gyr_jr302_01.nc
sim_jr302_01_nav_cordep.nc

Notes on the processing stages of these underway data are available in the cruise report for JR306 (Firing, 2015).

4.2 VMADCP

4.2.1 Introduction

A 75 kHz RD Instruments Ocean Surveyor (OS75, – model 71A-1029-00, SN 2088) ADCP was used during this cruise. The OS75 is capable of profiling to deeper levels in the water column than the previous 150 kHz ADCP and can also be configured to run in either narrowband or broadband modes.

4.2.2 Instrumentation

The OS75 unit is sited in the transducer well in the hull of the JCR. This is flooded with a mixture of 90% de-ionised water and 10% monopropylene glycol. The OS75 transducer on the JCR is aligned at approximately 60 degrees relative to the centre line. The hull depth was 6.47m. Combined with a value for the distance of the transducer behind the seachest window of 100-200mm and a window thickness of 50mm, this implies a transducer depth of 6.3m.

The OS75 causes interference with most of the other acoustic instruments on JCR, including the EM120 swath bathymetry system. To circumvent this, the ADCP pinging can be synchronised with the other acoustic instruments using the SSU. The heading feed to the OS75 is the heading from the Seapath GPS unit.

4.2.3 Configuration

The OS75 was controlled using Version 1.42 of the RDI VmDas software. The OS75 ran in narrowband with bottom-tracking on and narrowband with bottom-tracking off. The 'set modes' configuration files, as described in JR195 report, were used during the cruise.

Salinity at the transducer was set to zero, and Beam 3 misalignment was set to 60.08 degrees. Data logging was stopped and restarted once a day to keep files to a manageable size for processing.

4.2.4 Outputs

The ADCP writes files to a network drive that is samba-mounted from the Unix system. The raw data (.ENR and .N1R) are also written to the local PC hard drive. For use in the matlab scripts the raw data saved to the PC would have to be run through the VMDas software again to create the .ENX files. When the Unix system is accessed (via samba) from a separate networked PC, this enables post-processing of the data without the need to move files.

Output files are of the form JRNNN_XXX_YYYYYY.ZZZ, where XXX increments each time the logging is stopped and restarted, and YYYYYY increments each time the present filesize exceeds 10 Mb. ZZZ are the filename extensions, and are of the form:-

.N1R (NMEA telegram + ADCP timestamp; ASCII)
.ENR (Beam co-ordinate single-ping data; binary). These two are the raw data, saved to both disks
.VMO (VmDas configuration; ASCII)
.NMS (Navigation and attitude; binary)
.ENS (Beam co-ordinate single-ping data + NMEA data; binary)
.LOG (Log of ADCP communication and VmDas error; ASCII)
.ENX (Earth co-ordinate single-ping data; binary). This is read by matlab processing
.STA (Earth co-ordinate short-term averaged data; binary)
.LTA (Earth co-ordinate long-term averaged data; binary).

.N1R and .ENR files are saved to the secondary file path and can be reprocessed by the software to create the above files.

4.2.5 CODAS/Hawaii processing.

The data were processed using the CODAS software. The processing route can be summarised as copying the raw files, converting them into a working format, merging navigation data, deriving velocities, quality control, and conversion of data to matlab and netcdf files. Calibration information

can be obtained after several water and bottom-track data files have been processed; calibration can be performed at any time during the cruise or left until the end.
While the ship is steaming, the main signal that the ADCP instrument records is the ship speed. 12 knots (6 m/s) is 1-2 orders of magnitude greater than the water velocity. This velocity is removed using GPS derived ship velocities but there is clearly the potential for a significant error associated with this process as the output data is the small difference between two large numbers. To address this, the velocity of the bottom can be measured and compared directly to the GPS velocity of the ship. This should give the amplitude error for the ADCP and the misalignment with the ship heading. This only works in water where the bottom track ping can reach the sea bed – 800m or shallower. In deeper water the processing uses changes in the ship velocity to assess what proportion of the ship velocity is contaminating the calculated water velocity. This calculation necessarily invokes assumptions that the true water velocity is relatively constant in space (if slowing down) or time (if turning round) and is therefore considered less precise than bottom tracking. A large number of water track data were collected, from slowing down and speeding up from stations.

Note that this software sometimes outputs a decimal day, calculated from time in seconds since the start of the year. Decimal day is 0.5 for noon on the 1st January: this contrasts with a jday of 1.5 for noon on the 1st January.

Below is a summary of the processing steps.

1) Created once at start of cruise
~/data/vmadcp/jr302_os75
~/data/vmadcp/jr302_os75/rawdata

2) For dataset NNN (eg NNN = 002),
copy raw data files (ENX, N1R, etc) from /mnt/data/cruise/jcr/current/adcp into

/local/users/pstar/jr302/data/vmadcp/jrCCC_os75/rawdata file names like OS75_JR302NNN_000000.ENX
NNN increments each time the ADCP logging is re-started. Data logging was stopped and started once every day. The 000000 increments each time a new file is started, when the previous one reaches 10 Mb. All raw files are automatically transferred to
/mnt/data/cruise/jcr/current/adcp (i.e. on jrlb)

3) cd ~pstar/jr302/data/vmadcp/jr302_os75

cshell script in /local/users/pstar/cruise/data/exec
vmadcp_movescript
redistributes raw data from rawdata to rawdataNNN; rawdataNNN is created if necessary (may need to edit movescript so that it parses the file names correctly).

4) adcptree.py jrCCCNNNnbenx --datatype enx

Note "nb" for narrowband ping, and that the -- datatype has two dash characters

5) cd jrCCCNNNnbenx
copy in a q_py.cnt file. Generally, you only need to edit the dbname and datadir for each NNN. An example q_py.cnt file is
q_py.cnt is
comments follow hash marks; this is a comment line
--yearbase 2011
--dbname jr302001nnx
--datadir /local/users/pstar/cruise/data/vmadcp/jr302_os75/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 jrCCCNNNPTT 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 jr195NNNn, there are only two left to identify ENX, ENS, LTA, STA

6) still in directory ~data/vmadcp/jr302_os75/jr302001nbenx

quick_adcp.py --cntfile q_py.cnt
("killed matlab engine" is the normal message received). This takes a minute or two per 24 hours of ENX data. Note –cntfile has two dash characters

7) To see the BT (bottom track) or WT (water track) calibration, look at the ascii output of jr302001nbenx/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.

8) To access data in Matlab

matlab &
>> m_setup
>> codaspaths

9) Can manually clean up data by applying flags to suspected bad data cycles (this can be done post-cruise, ie omitted, go straight to step 10). This step can also be a useful first look at the data. Note that the uncalibrated files may show a slight bias in u and/or v which will appear as stripes that coincide with periods of on-station and steaming. This effect will disappear when you correct for the amplitude and phase error (step 12).

>> cd data/vmadcp/jr302_os75/jr302001nbenx/edit
>> gautoedit

Clean up data. Select day and step (typically 0.1 or 0.2 days) 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 doesn’t change the data. To apply the flags and recalculate a calibration,
quick_adcp.py –-cntfile q_pyedit.cnt (note two dashes before cntfile)

where q_pyedit.cnt contains
q_pyedit.cnt is
comments follow hash marks; this is a comment line

--yearbase 2009
--steps2rerun apply_edit:navsteps:calib:matfiles
--instname os75
--auto

end of q_pyrot.cnt

10) To get data into MSTAR:

>> cd /local/users/pstar/cruise/data/vmadcp/jr302_os75/jr302NNNnbenx
>> mcod_01
produces output file os75_jr302NNNnnx.nc
which has a collection of vars of dimensions Nx1 1xM NxM
>> mcod_02
will calculate water speed and ship speed and get all the vars onto an NxM grid. This step makes data available for comparison with LADCP data.

11) Append individual 48-hour files using

>>mcod_mapend
This script will append individual files to create a single cruise file. It does seem to depend on the files having the same bin number and bin depths which was not the case on JR302.

12) cd /local/users/pstar/cruise/data/vmadcp/jr302_os75/jr302NNNnbenx
In directory apply the final cal ONLY ONCE (adjustments are cumulative, so if this step is done twice, the cal is applied twice) when you have done the edits and applied the time-varying heading adjustment. After inspecting the cal out files, and deciding what the amplitude and phase of the calibration should be:
quick_adcp.py –-cntfile q_pyrot.cnt (note two dashes before cntfile), where q_pyrot.cnt contains:

q_pyrot.cnt is
comments follow hash marks; this is a comment line
--yearbase 2011

--rotate_angle -1.0564
--rotate_amp 1.0116
--steps2rerun rotate:navsteps:calib

--auto
end of q_pyrot.cnt

Final calibration values used were those given by the JR302 Bottom Track data.

13) In each directory re-create Matlab files:
>>cd /local/users/pstar/cruise/data/vmadcp/jr302_os75/jr302NNNnbenx

>>mcod_01
>>mcod_02
Then remove and recreate the appended matlab file:
>>cd /local/users/pstar/cruise/data/vmadcp/jr302_os75

>>!/bin/rm os75_jr302nnx_01.nc
>>mcod_mapend

4.3 Pumped seawater: underway carbon

Jennifer Clarke, Alex Griffiths, Becky Garley Eithne Tynan

4.3.1 Introduction

The carbonate system is a key component of the chemical perspective of oceanography as it plays an important role in the oceans' capacity to take up atmospheric CO_2. Dissolved inorganic carbon (DIC) is present in seawater in three forms ($CO_{2(aq)}$, HCO_3^- and CO_3^{-2}) which are in equilibrium on timescale longer than a few minutes. In oceanography, the carbonate system can be determined by four parameters: DIC, dissolved carbon dioxide (pCO_2), alkalinity (TA) and pH.

3 instruments were set-up to measure with high resolution from the non-toxic underway water supply along the entire cruise track. This cruise was an opportunity to test the immobilised fluorophore pCO_2 sensor JC is developing for her PhD, alongside pH and DIC analysers.

4.3.2 Method

pH sensor:
pH is measured by adding a coloured indicator to the seawater sample and measuring the colour of the mix. The indicator is 2 mM Thymol Blue for the underway system. The spectrophotometric sensor was developed by Victoire Rerolle at NOCS sensors group (Rérolle, Floquet et al. 2012).

DIC Sensor:
An Apollo SciTech System has been used. The equipment is divided into two sections. The first part allows the conversion of all the inorganic species of carbon into CO_2 gas by mixing it with 10% vol phosphoric acid in a closed cell. The total CO_2 gas is then carried out with the help of N_2 gas (99.9%) to the Li-COR, where by infrared analysis, the amount of CO_2 gas produced is analysed. The flow rate of the gas was maintained at 300ml/min.

The sample volume used was 0.75 ml and a partial calibration was undertaken twice daily. The calibration consisted of flushing the instrument with air (2 x 1.5ml), followed by deionised water (1 x 1.5 ml) before being flushed with the Certified Reference Material provided by Professor A. Dickson from Scripps Oceanographic Institute (Batch 136). Seven repeats of 3 volumes (0.5, 0.75, and 1 ml) were then run with the Certified Reference Material. Furthermore, every 30 samples, the CRM was analysed 7 times (0.75 ml) to allow corrections due to the natural drift of the LICOR analyser.

The CRM was changed daily, and kept in the glass bottle with a special lid and sample tube that once the CRM was opened remained on the bottle until changed. The sample tube was always sampling from the bottom of the bottle.

Drift in the underway water measurements was corrected using the ratio of the measured CRM DIC (umol kg^{-1}) to the certified value for the particular CRM.

pCO_2 sensor:
The sensor is based on an immobilised indicator entrapped in a polymer membrane alongside a fluorescent reference compound. The indicator fluorescence altered according to the pCO_2 of the seawater. The fluorescence intensity was recorded throughout the cruise and analysed based on time-

domain dual-luminophore referencing (Liebsch, Klimant et al. 2000, Liebsch, Klimant et al. 2001, Stahl, Glud et al. 2006, Schroeder, Neurauter et al. 2007) using a PMT (Hamamatsu). The sensing spot was purchased from PreSens GmbH, previously attached to a PMMA disc using silicon glue provided by PreSens GmbH and soaked in artificial seawater for a month prior to use. The PMMA disc/sensing spot was then attached to the fibre optic cable head with a glue gun.

Drift in the underway water measurements was corrected using the ratio of the measured CRM pCO_2 (ppm) to the certified value for the particular CRM.

Underway Sampling:
Underway sampling for DIC and TA was undertaken every 6 hours when not at a station until the 04/07/14 where it was reduced to one sample per 8 hours. Samples were collected in 250 ml Schott Duran borosilicate glass bottles with glass stoppers that provided an air-tight seal, held shut with electrical tape wrapped around the stopper and the bottle. 2.5 ml headspace was left in each bottle and 50 µl saturated mercuric chloride solution added directly after sampling. Samples were stored in dark, insulated boxes. These will be analysed at a later date at the NOC.

4.3.3 Underway measurements

The automated pCO_2 and DIC systems were running continuously on the non-toxic water supply from the 06/06/2014 to 17/07/2012. Measurements were only interrupted for system performance checking, maintenance and in the ice when the non-toxic water supplied was stopped. The pH system was running from 26/06/2014 to the 17/07/2012.

The data will undergo further corrections for temperature and salinity changes. The pCO_2 sensor will also undergo post cruise calibration and testing and further corrections based the results of this.

The consistency of the data will finally be checked thanks to comparison between the sensors, 100 underway supply DIC/Alkalinity samples and trends and correlation in other parameters such as chlorophyll, temperature, salinity and nutrients.

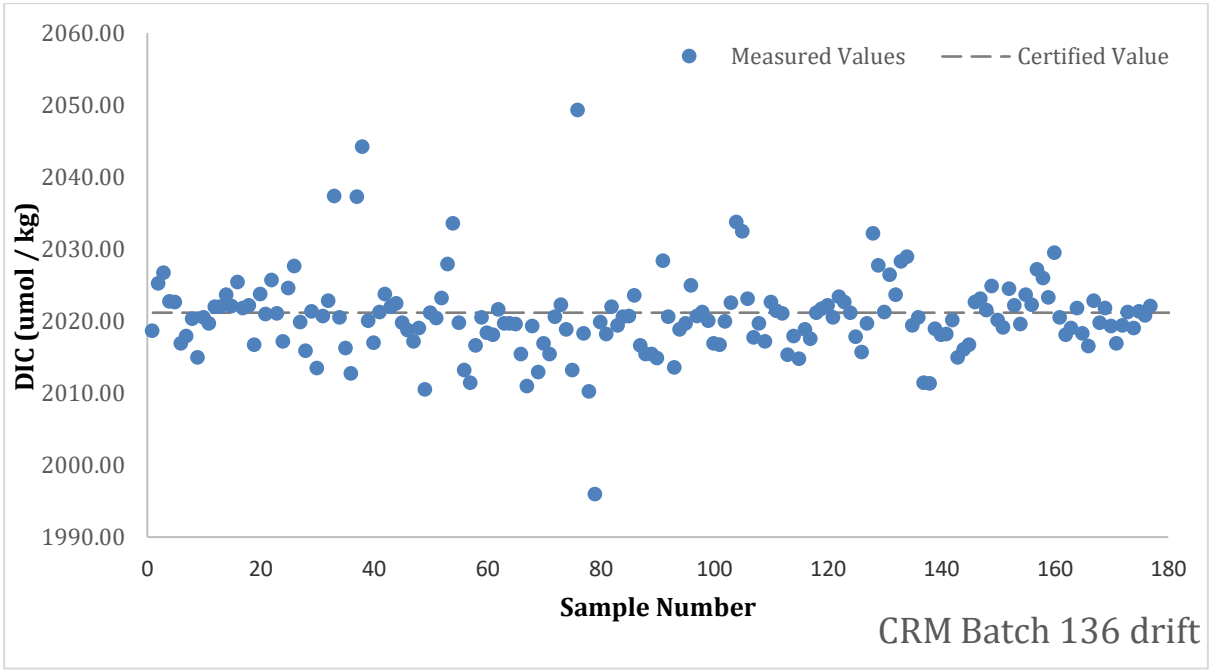


Figure 4.3.1. CRM 136 drift for the DIC analyser

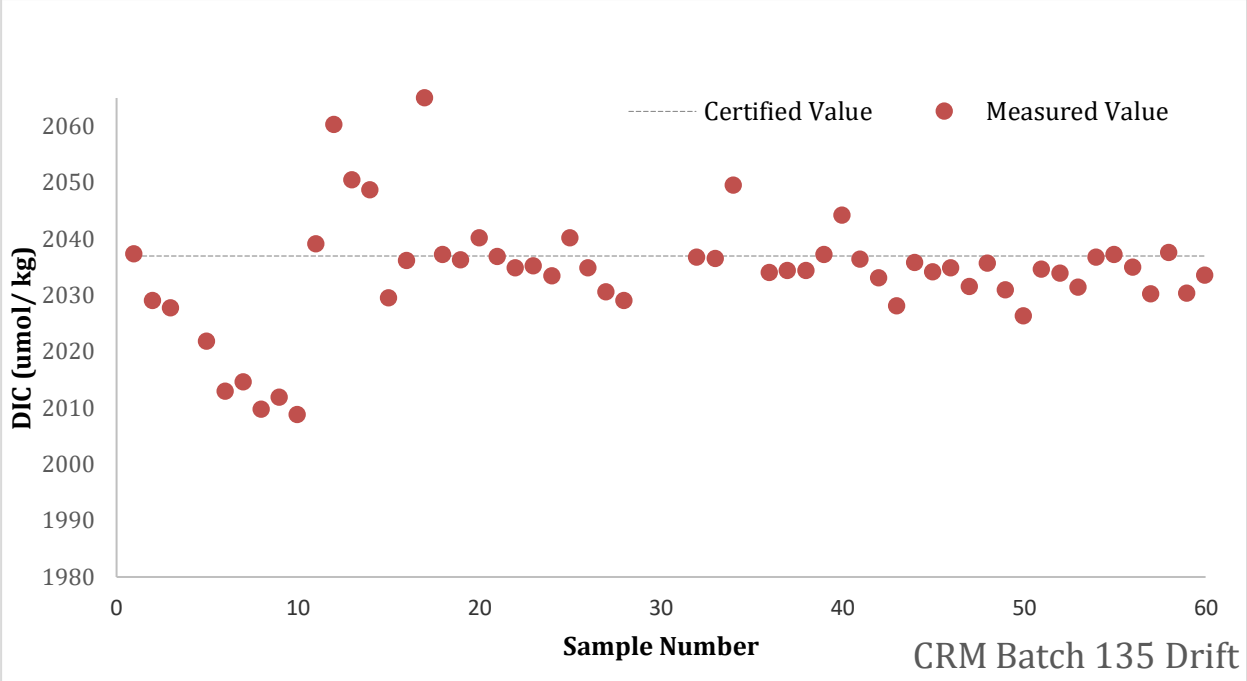


Figure 4.3.2. CRM 135 drift for the DIC analyser:

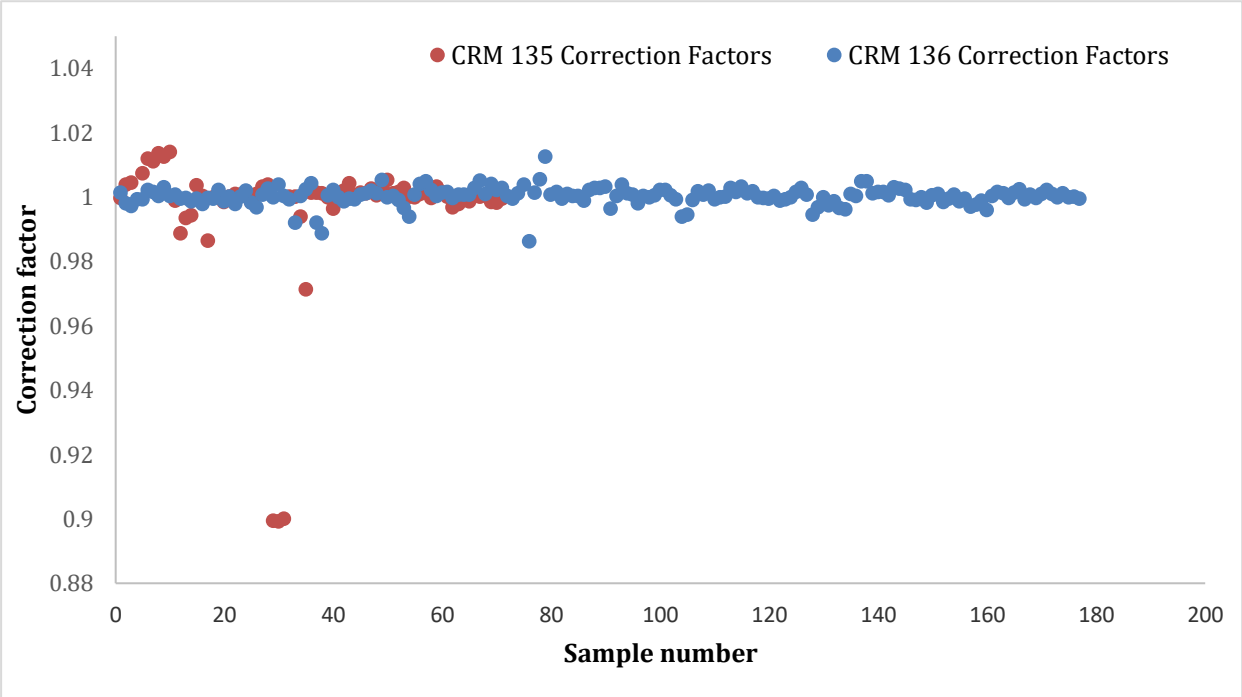


Figure 4.3.3. Correction factor over the whole cruise

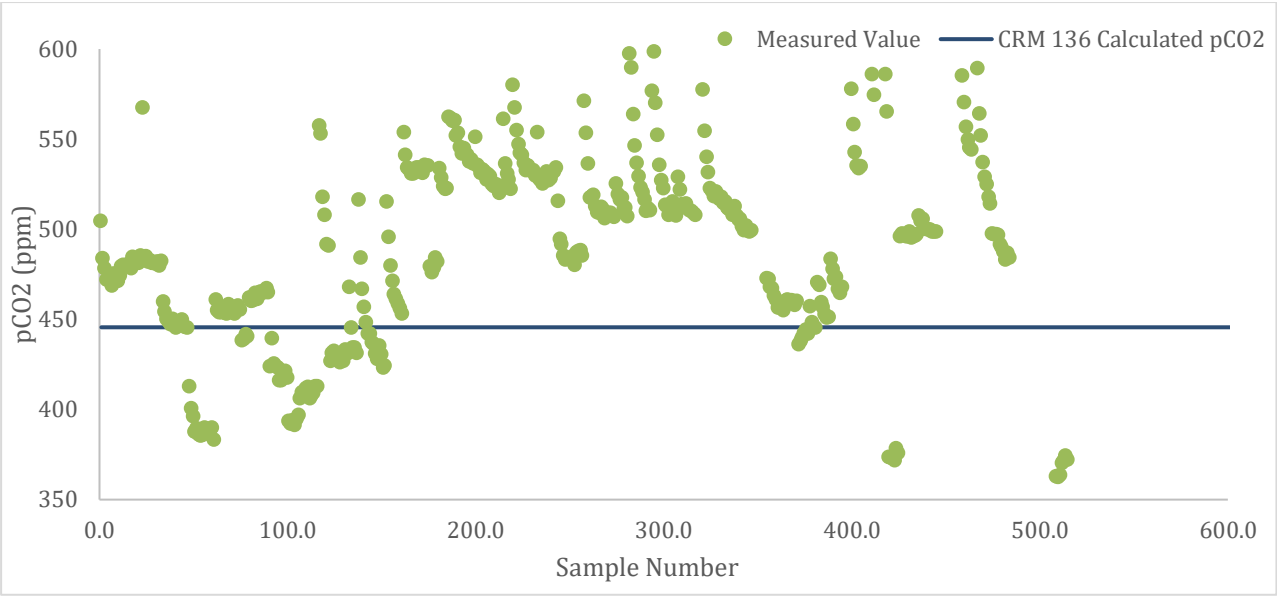


Figure 4.3.4. CRM 136 Drift for the experimental pCO_2 sensor.

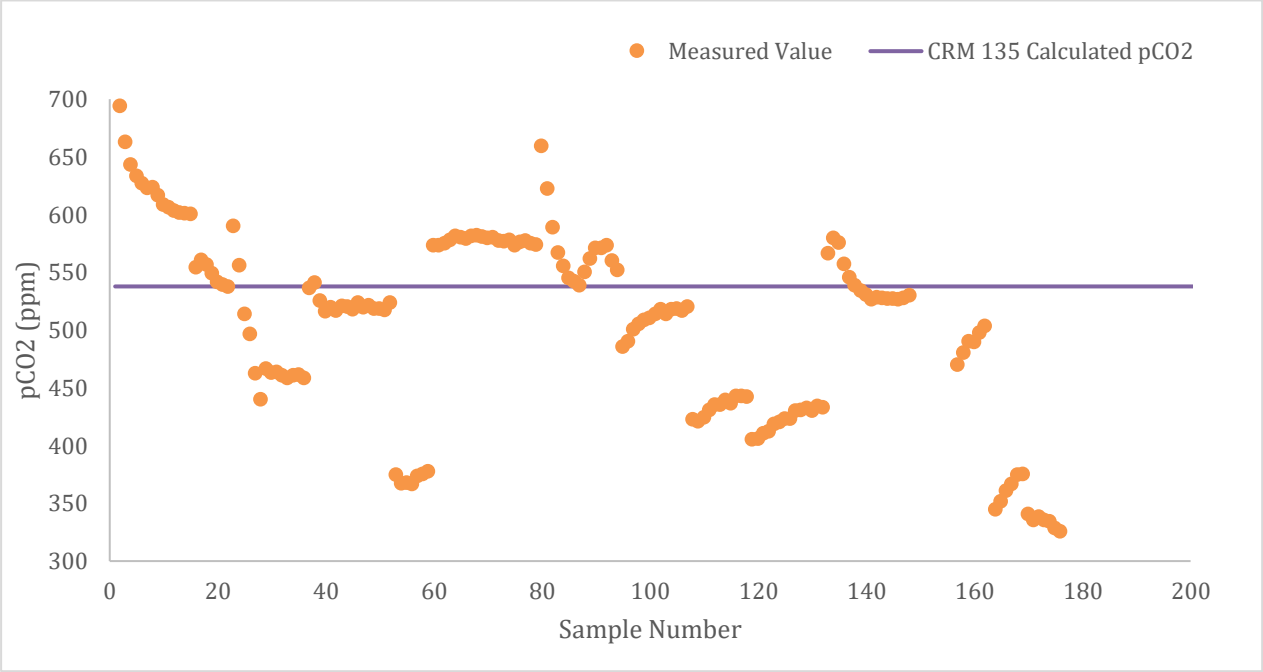


Figure 4.3.5. CRM 135 Drift for the experimental pCO_2 sensor.

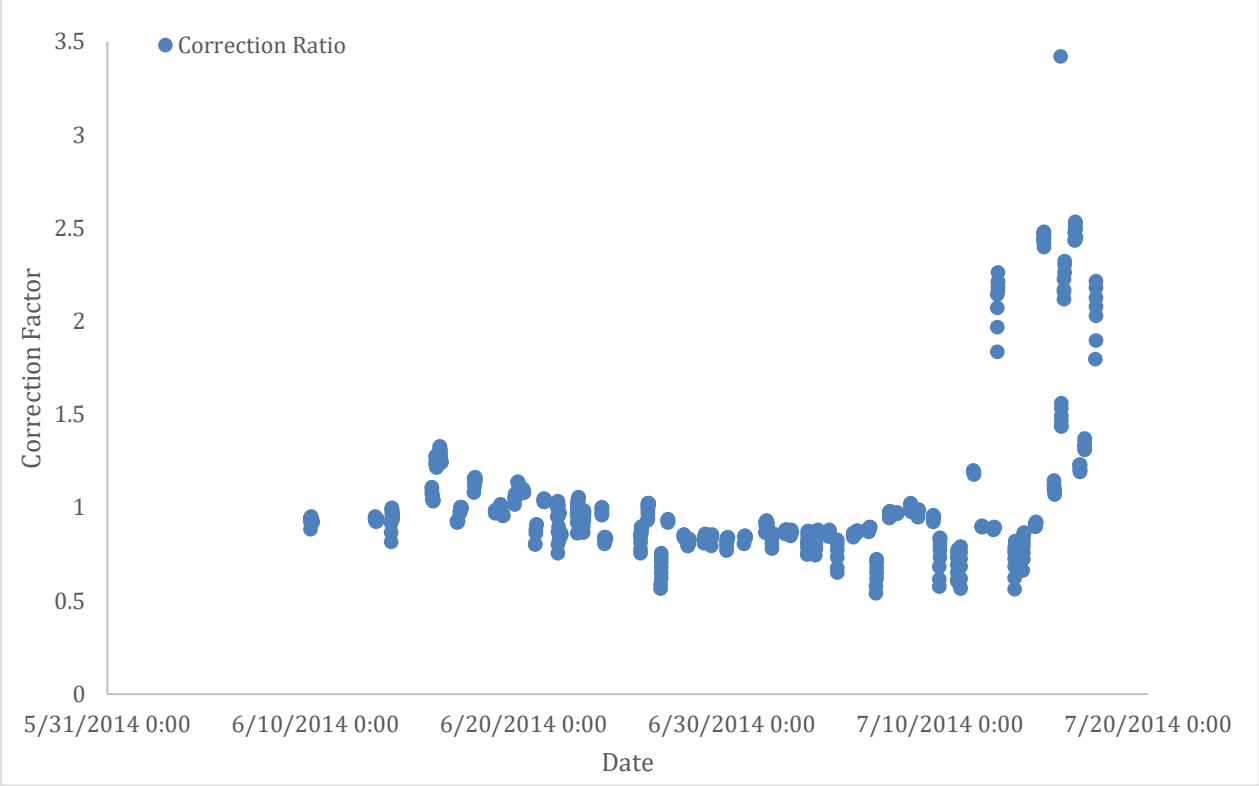


Figure 4.3.6. Correction factor for the experimental pCO_2 sensor.

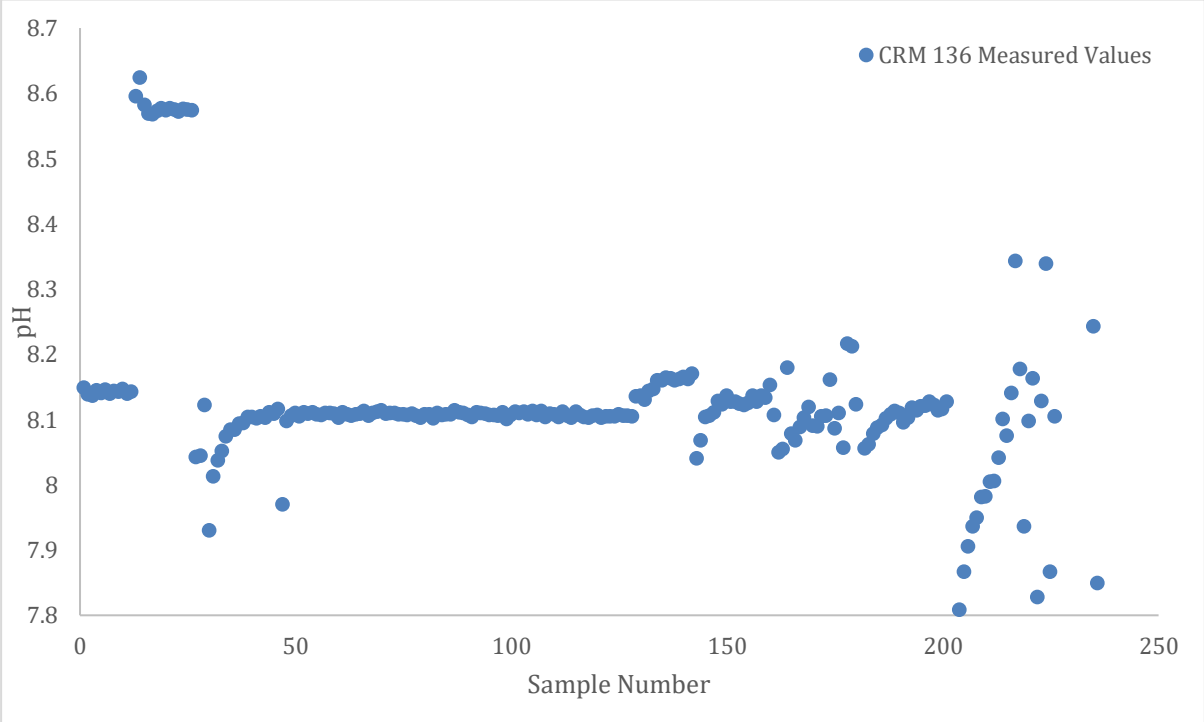


Figure 4.3.7. CRM 136 Drift pH sensor

References

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Stahl, H., A. Glud, C. R. Schroder, I. Klimant, A. Tengberg and R. N. Glud (2006). "Time-resolved pH imaging in marine sediments with a luminescent planar optode." Limnology and Oceanography: Methods **4**: 336-345.

Table 4.3.1. Underway DIC/TA Sampling Log

Sampler	**Sample ID**	**Date**	**GMT**	**Notes**
ET	*UW000*	*16/06/2014*	*15:40*	*A lot of bubbles in underway*
ET	*UW001*	*16/06/2014*	16:12	
ET	*UW002*	*16/06/2014*	22:55	
AG	*UW003*	*17/06/2014*	06:10	
AG	*UW004*	*17/06/2014*	10:20	
JC	*UW005*	*17/06/2014*	22:00	
AG	*UW006*	*17/06/2014*	05:10	At station- delayed sample
BG	*UW007*	*18/06/2014*	10:07	
JC	*UW008*	*18/06/2014*	16:02	Almost at station 53
ET	*UW009*	*18/06/2014*	23:04	
AG	*UW010*	*19/06/2014*	04:10	
BG	*UW011*	*19/06/2014*	12:34	
JC	*UW012*	*19/06/2014*	16:03	
JC	*UW013*	*20/06/2014*	01:07	bubbly
AG	*UW014*	*20/06/2014*	05:56	At station 57- delayed sample
BG	*UW015*	*20/06/2014*	12:53	
ET	*UW016*	*20/06/2014*	21:53	
AG	*UW017*	*21/06/2014*	05:00	
BG	*UW018*	*21/06/2014*	12:19	
JC	*UW019*	*21/06/2014*	16:04	STN BY GREENLAND
JC	*UW020*	*21/06/2014*	23:07	
AG	*UW021*	*22/06/2014*	07:06	STN 69
BG	*UW022*	*22/06/2014*	10:21	
JC	*UW023*	*22/06/2014*	16:09	
JC	*UW024*	*22/06/2014*	21:55	
AG	*UW025*	*23/06/2014*	04:11	
BG	*UW026*	*23/06/2014*	10:19	NO SAMPLING TUBE
JC	*UW027*	*23/06/2014*	16:56	NO SAMPLING TUBE
JC	*UW028*	*23/06/2014*	23:37	
AG	*UW029*	*24/06/2014*	05:16	

BG	*UW030*	*24/06/2014*	10:26	
JC	*UW031*	*24/06/2014*	16:11	
JC	*UW032*	*24/06/2014*	01:02	
AG	*UW033*	*25/06/2014*	04:54	
BG	*UW034*	*25/06/2014*	10:26	
JC	*UW035*	*25/06/2014*	17:52	
AG	*UW036*	*26/06/2014*	05:42	
BG	*UW037*	*26/06/2014*	10:21	
JC	*UW038*	*26/06/2014*	17:22	
JC	*UW039*	*26/06/2014*	22:04	
AG	*UW040*	*27/06/2014*	06:14	
BG	*UW041*	*27/06/2014*	10:23	
JC	*UW042*	*27/06/2014*	16:05	
AG	*UW043*	*28/06/2014*	06:00	
BG	*UW044*	*28/06/2014*	10:14	
JC	*UW045*	*28/06/2014*	23:51	
AG	*UW046*	*29/06/2014*	08:25	
BG	*UW047*	*30/06/2014*	10:17	
JC	*UW049*	*30/06/2014*	17:54	
JC	*UW050*	*30/06/2014*	00:57	
AG	*UW048*	*01/07/2014*	07:27	
BG	*UW051*	*01/07/2014*	11:20	
JC	*UW052*	*01/07/2014*	21:38	
BG	*UW053*	*01/07/2014*	11:01	
JC	*UW054*	*02/07/2014*	16:11	
JC	*UW055*	*02/07/2014*	23:27	
AG	*UW056*	*03/07/2014*	05:19	
BG	*UW057*	*03/07/2014*	10:18	
JC	*UW058*	*03/07/2014*	17:30	
JC	*UW059*	*03/07/2014*	22:04	
AG	*UW060*	*04/07/2014*	06:15	
BG	*UW061*	*04/07/2014*	11:33	
JC	*UW062*	*04/07/2014*	18:05	
AG	*UW063*	*05/07/2014*	04:10	
BG	*UW064*	*05/07/2014*	09:00	
JC	*UW065*	*05/07/2014*	19:13	
AG	*UW066*	*06/07/2014*	03:23	
BG	*UW067*	*06/07/2014*	09:29	
JC	*UW068*	*06/07/2014*	17:51	
AG	*UW069*	*07/07/2014*	03:42	
BG	*UW070*	*07/07/2014*	10:27	
JC	*UW071*	*07/07/2014*	18:49	
AG	*UW072*	*08/07/2014*	01:31	
BG	*UW073*	*08/07/2014*	09:20	
AG	*UW074*	*09/07/2014*	01:30	

BG	*UW075*	*09/07/2014*	09:25	
JC	*UW076*	*09/07/2014*	18:18	
AG	*UW077*	*10/07/2014*	02:03	
BG	*UW078*	*10/07/2014*	11:11	
CF	*UW079*	*10/07/2014*	19:38	
AG	*UW080*	*11/07/2014*	02:22	
BG	*UW081*	*11/07/2014*	09:11	
JC	*UW082*	*11/07/2014*	17:22	
AG	*UW083*	*12/07/2014*	02:28	
BG	*UW084*	*12/07/2014*	10:08	
JC	*UW085*	*12/07/2014*	17:50	
AG	*UW086*	*13/07/2014*	05:36	
BG	*UW087*	*13/07/2014*	10:04	
JC	*UW088*	*13/07/2014*	17:03	
AG	*UW089*	*14/07/2014*	01:21	
BG	*UW090*	*14/07/2014*	08:33	
JC	*UW091*	*14/07/2014*	17:59	
AG	*UW092*	*15/07/2014*	02:02	
BG	*UW093*	*15/07/2014*	09:08	
JC	*UW094*	*15/07/2014*	16:36	
AG	*UW095*	*16/07/2014*	01:14	
BG	*UW096*	*16/07/2014*	08:11	
JC	*UW097*	*16/07/2014*	17:23	
AG	*UW098*	*17/07/2014*	02:35	
BG	*UW099*	*17/07/2014*	08:23	
JC	*UW100*	*17/07/2014*	16:03	

5. Autonomous Platforms

5.1 Floats

Eight Met Office Argo floats were deployed during the cruise. All floats were checked for functionality before being deployed; they were connected to a laptop and a series of pre-deployment checks carried out. After disconnection from the laptop they were reset and activated using a magnet. Deployment was from the stern starboard quarter with a rope, as the ship steamed slowly forwards.

Table 5.1. Float deployments

Float ID	**Reset time**	**Deployment time (year day/UTC)**	**Deployment latitude**	**Deployment longitude**	**Associated CTD station number**
7011	186/0158	186/0350 5 July 2014	57.95295 57 57.18 N	-27.00062 27 0.04 W	jr302/138
7012	187/2242	187/2352 6 July 2014	57.90795 57 54.48 N	-20.68557 20 41.13 W	jr302/148
7013	191/0016	191/0144 10 July 2014	59.40160 59 24.10 N	-18.43511 18 26.11 W	jr302/177

7014	191/0907	191/1108 10 July 2014	59.80868 59 48.52 N	-19.50388 19 30.23 W	jr302/180
6608	191/1728	191/1855 10 July 2014	60.24949 60 14.97 N	-19.99944 19 59.97 W	jr302/182
6611	193/1836	193/2005 12 July 2014	61.49963 61 29.98 N	-20.00134 20 0.08 W	jr302/195
6610	194/0837	194/0955 13 July 2014	61.00055 61 0.03 N	-20.00137 20 0.08 W	jr302/198
6609	196/1720	196/1852 15 July 2014	57.29858 57 17.91 N	-10.38108 10 22.86 W	jr302/211

5.2 Seaglider

Stefan Gary

The iRobot Seaglider Bellatrix (SG532) was recovered on the morning of 13 July. Bellatrix had been waiting at 61N, 20W, which coincided approximately with stations 185 and 198, for several days for an appropriate weather window for recovery. On 13 July, conditions were ideal: good visibility and low swell. As the JCR approached the rendez-vous point, Bellatrix was commanded to execute successively shallower dives and the positions of each dive were monitored in real time via an SSH link to the glider's base station at the Scottish Association for Marine Science (SAMS). At 0700GMT, the pilot commanded Bellatrix to enter recovery mode. She was sighted about 10 minutes later and the ship pulled alongside at 0736GMT.

After several attempts, at 0748GMT, a line was secured to Bellatrix's rudder, the lift point for a Seaglider, using a bowline-in-a-bight taped on the end of an approximately 10 m pole. This process was challenging since Bellatrix's rudder was almost continuously submerged and the line sunk very slowly. After the recovery, it was discovered that the glider was floating low because the pilot ommitted to command Bellatrix to pump to maximum buoyancy. Future Seaglider recoveries should be easier if this command is executed. The ~10 m pole, worked by a minimum of two people, was of sufficient length to lasso the glider despite the height of the freeboard. With the glider lassoed, she was then lifted aboard with the gantry at 0750GMT, placed in her cradle, and the wings, rudder, and antenna where disassembled.

Standard post-recovery internal pressure (~8.5 PSIA) and internal humidity (~14.00RH) checks were carried out and these values matched the safe operating ranges maintained by the glider for the duration of her mission. Bellatrix was then commanded to enter travel mode, turned off, and then rinsed with freshwater before being packed into the shipping crate. The Argos tag on Bellatrix's antenna was also switched into standby mode.

Bellatrix was deployed west of the Isle of Coll on the Scottish Shelf on April 30th and navigated to the rendez-vous point over the course of two months (Figure 5.2.1). The raw data collected during this mission were posted in real time to http://velocity.sams.ac.uk/gliders/sg532. Bellatrix operated with remarkably few errors or other issues for her whole mission. Recovering a glider from a large ship is a challenging task and the crew of the JCR did an outstanding job supporting the recovery; everyone was very keen to sort out logistical details, open to hearing about the special requirements of gliders, and enthusiastic.

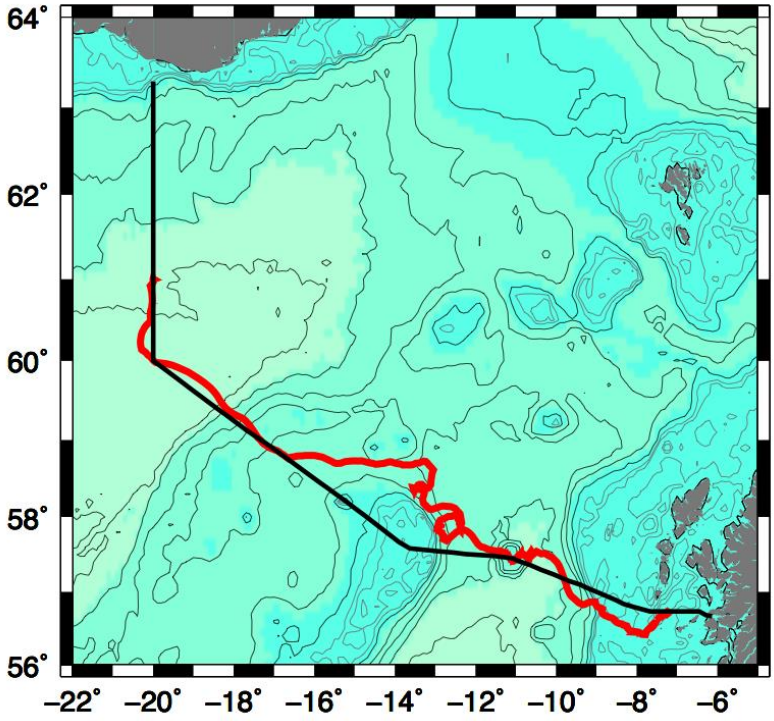

Figure 5.2.1. Seaglider Bellatrix (SG532) track from 30th April, 2014 to 13th July, 2014 (red line) compared to the Extended Ellet Line (black line). Bathymetry is contoured at 500 m intervals (black lines) and 100 m intervals for depths less than 500 m (gray lines).

6. Outreach

N.P. Holliday

A daily cruise blog was written during JR302 (ukosnap.wordpress.com), with the specific ambition of attracting readers who are not marine scientists. The aim was to provide simplified explanations of our science and of life onboard the ship and to illustrate this with nice photographs. Posts were mainly written by Penny Holliday and featured contributions from scientists and ship's staff.

The blog was advertised through Facebook and Twitter (@ukosnap) and word of mouth (family and friends). The readership grew steadily throughout the cruise, peaking at over 1200 views on one day, and reaching a total of over 25,000 views by the end of the cruise.

Video footage was collected throughout the cruise by Penny Holliday, Sinhue Torres Valdes and Stefan Gary. We filmed people working, the scenery, and the CTD underwater, and interviewed the PS. We also made some time lapse movies. Some were put on the UKOSNAP youtube channel during the cruise, and more will be added after the cruise and advertised through our websites, twitter and facebook. The clips will be used for outreach activities by NOC, PML and SAMS for the RAGNARRoC and OSNAP projects.