University of Exeter

Cruise Report No. xx

RRS Discovery Cruise DY138

17 September 2021 – 03 November 2021

Bottom Boundary Layer Turbulence and Abyssal Recipes (BLT)

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ABSTRACT

A long-standing problem in Physical Oceanography has been balancing the sinking of cold, dense waters at high latitudes with deep-ocean upwelling across isopycnals at lower latitudes. The BLT Recipes project seeks to test an emergent new paradigm of ocean mixing, whereby deep-ocean upwelling is primarily driven by bottom boundary layer turbulence instead of by breaking internal waves in the ocean interior. The cruise DY138 follows the cruise DY132 (also known as BLT1, 19 June 2021 to 29 July 2021) during which two long-term observational schemes were launched in a canyon on the eastern slope of the Rockall Trough (RT). The RT is taken as a representative ocean circulation microcosm with northern and southern deep-water sources, moderate tides and a comparatively weak mesoscale flow field. First, tree type of moorings (1 Moored Profiler or MP mooring, 2 Modular Acoustic Velocity Sensor or MAVS with fast thermistor moorings, 1 thermistor chain) were deployed to investigate the processes responsible for sustaining the circulation and mixing near and above the topographic boundary. Those targeted the detailed observation of turbulent phenomena within a few hundreds of metres from the ocean floor, along the canyon's axis. Second, the long-lived inert chemical tracer, SF_5CF_3, was released at the bottom of the canyon to assess the long-term circulation, dispersion and mixing of deep waters. The DY138 research expedition (or BLT2, 25/09/22 – 03/11/22) carried out the CTD, bottle water sampling and tracer measurements to documents the physical characteristics of the waters and the spreading of the tracer in and beyond the canyon 2 months after its release. Also, the MP mooring and the 2 MAVS mooring, were recovered, serviced and redeployed and informed on the turbulent phenomena in the canyon between BLT1 and BLT2. The thermistor-chain mooring remained in place and will be recovered during the cruise BLT3 planned July-August 2022. Three Argo floats were also released on behalf of the UK Met Office to increase the numbers floats in this region of interest. Preliminary analyses of the data obtained in BLT1 and BLT2 confirm evidence of strong diapycnal upwelling and mixing within the canyon, suggesting broad support for the project's overarching hypothesis.

KEYWORDS
Ocean Mixing, turbulence, upwelling, meridional overturning circulation, bottom boundary layer, canyon.

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ABSTRACT

A long-standing problem in Physical Oceanography has been balancing the sinking of cold, dense waters at high latitudes with deep-ocean upwelling across isopycnals at lower latitudes. The BLT Recipes project seeks to test an emergent new paradigm of ocean mixing, whereby deep-ocean upwelling is primarily driven by bottom boundary layer turbulence instead of by breaking internal waves in the ocean interior. The cruise DY138 follows the cruise DY132 (also known as BLT1, 19 June 2021 to 29 July 2021) during which two long-term observational schemes were launched in a canyon on the eastern slope of the Rockall Trough (RT). The RT is taken as a representative ocean circulation microcosm with northern and southern deep-water sources, moderate tides and a comparatively weak mesoscale flow field. First, tree type of moorings (1 Moored Profiler or MP mooring, 2 Modular Acoustic Velocity Sensor or MAVS with fast thermistor moorings, 1 thermistor chain) were deployed to investigate the processes responsible for sustaining the circulation and mixing near and above the topographic boundary. Those targeted the detailed observation of turbulent phenomena within a few hundreds of metres from the ocean floor, along the canyon's axis. Second, the long-lived inert chemical tracer, SF_5CF_3*, was released at the bottom of the canyon to assess the long-term circulation, dispersion and mixing of deep waters. The DY138 research expedition (or BLT2, 25/09/22 – 03/11/22) carried out the CTD, bottle water sampling and tracer measurements to documents the physical characteristics of the waters and the spreading of the tracer in and beyond the canyon 2 months after its release. Also, the MP mooring and the 2 MAVS mooring, were recovered, serviced and redeployed and informed on the turbulent phenomena in the canyon between BLT1 and BLT2. The thermistor-chain mooring remained in place and will be recovered during the cruise BLT3 planned July-August 2022. Three Argo floats were also released on behalf of the UK Met Office to increase the numbers floats in this region of interest. Preliminary analyses of the data obtained in BLT1 and BLT2 confirm evidence of strong diapycnal upwelling and mixing within the canyon, suggesting broad support for the project's overarching hypothesis*.

1 INTRODUCTION

1.1 CRUISE TRACKS

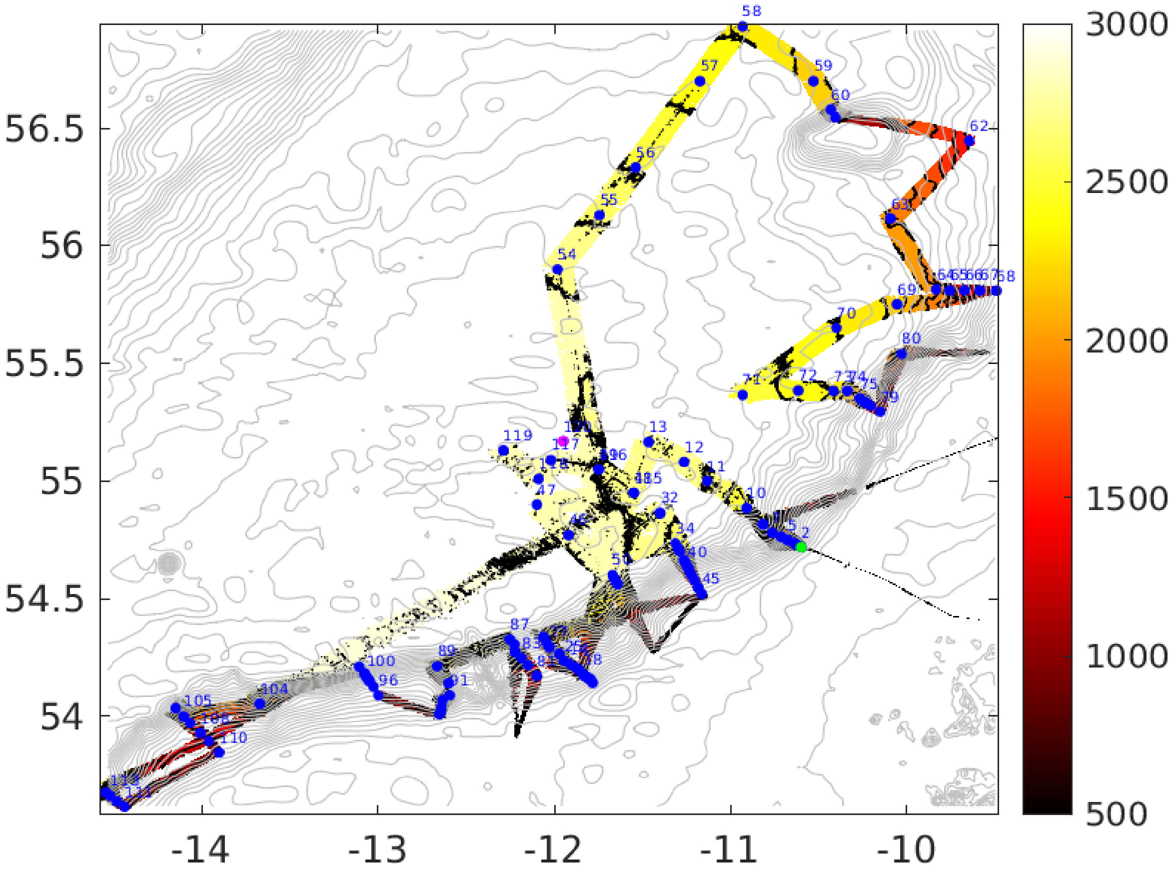

Figure 1: Map depicting CTD locations and station numbers on multibeam bathymetry.

Figure 1 shows the full cruise track. Blue dots indicate station locations. The cruise began at the green dot and ended at the pink dot.

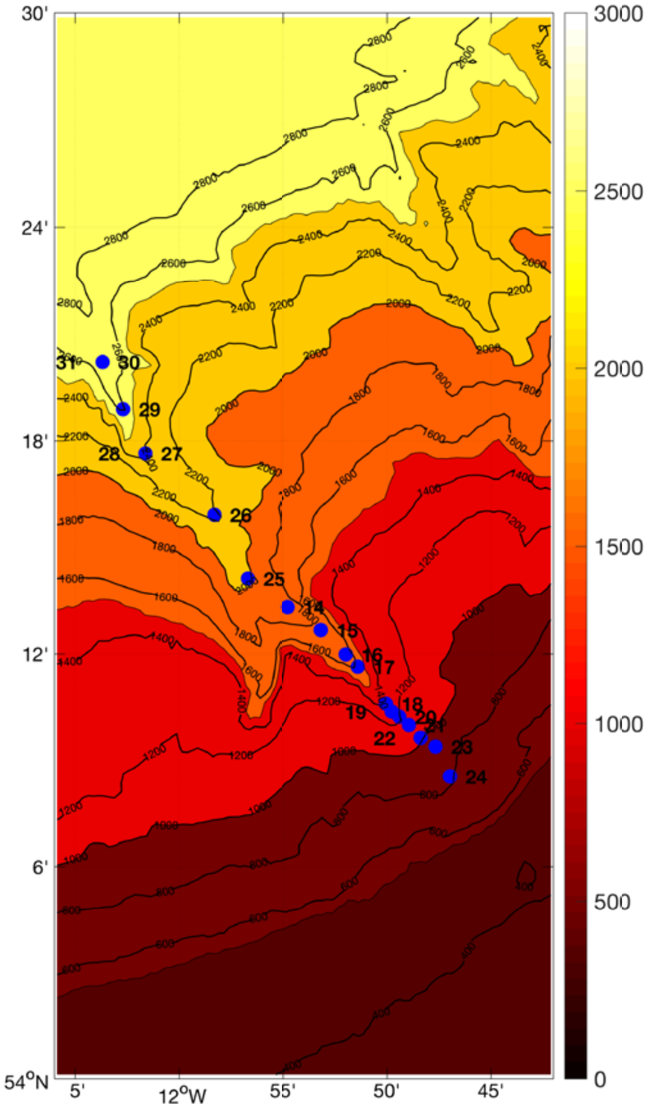

Figure 2: Map depicting CTD locations and station numbers in the BLT canyon on Gebco bathymetry.

1.2 EVENT LOGS

Table 1: Mooring event log.

Date & Time	Event #	Description	Latitude	Longitude	Multibeam depth
04/10/2021 13:17	0	Log started	54.178683	-11.838638	1424.43
04/10/2021 13:30	1	MAVS2 recovery	54.180518	-11.836987	NA
05/10/2021 09:38	2	MAVS1 recovery	54.195113	-11.854971	NA
05/10/2021 13:38	3	MP recovery	54.199427	-11.865065	NA
22/10/2021 10:10	4	MP3 deployment	54.185239	-11.848426	1479.08
22/10/2021 15:56	5	MAVS4 deployment	54.197956	-11.84374	1387.81
22/10/2021 20:16	6	MAVS3 deployment	54.181742	-11.851228	NA

Table 2: CTD Event Log.

Date & Time	Event #	Description	Latitude	Longitude	Multibeam Depth
27/09/2021 11:21	1	CTD test	55.681289	-5.864466	168.78
27/09/2021 11:26	0	Log started	55.681327	-5.864483	172.40
27/09/2021 13:24	2	CTD test2 - surface	55.685242	-5.865463	167.93
27/09/2021 13:29	3	CTD test2 – 100m	55.686251	-5.865454	168.01
27/09/2021 13:34	4	CTD test2 - bottom	55.685238	-5.86548	169.71
27/09/2021 13:59	5	CTD test2 – surface	55.685244	-5.865462	164.97
28/09/2021 15:30	6	CTD1 surface	54.719054	-10.601957	701.67
28/09/2021 15:56	7	CTD1 bottom	54.71902	-10.601942	704.48
28/09/2021 16:18	8	CTD1 surface	54.719024	-10.601936	702.98
28/09/2021 23:13	9	CTD2 surface	54.718309	-10.60038	700.32
28/09/2021 23:40	10	CTD2 bottom	54.718359	-10.600397	696.14
29/09/2021 02:26	11	CTD 3 in water	54.728362	-10.623544	966.49
29/09/2021 04:45	12	CTD 4 in water	54.737578	-10.641945	1191.83 SB
29/09/2021 07:25	13	CTD 5 in water	54.750171	-10.678698	1556.51
29/09/2021 10:27	14	CTD 6 in water	54.763528	-10.713896	1780.29
29/09/2021 13:58	15	CTD 7 in water	54.780702	-10.764776	2015.26
03/10/2021 07:41	16	CTD 8 in water	54.81634	-10.816175	2292.52 SB
03/10/2021 11:05	17	CTD 9 in water	54.816357	-10.816154	2298.10
03/10/2021 15:29	18	CTD 10 in water	54.884767	-10.908342	2490.89
03/10/2021 20:05	19	CTD 11 in water	55.000541	-11.133007	2688.70
04/10/2021 00:08	20	CTD 12 in water	55.081383	-11.263505	2716.27
04/10/2021 04:18	21	CTD 13 in water	55.16523	-11.465232	2733.51
04/10/2021 18:35	22	CTD 14 in water	54.221958	-11.913095	1871.67
04/10/2021 22:02	23	CTD 15 in water	54.211193	-11.886399	1761.44
05/10/2021 01:05	24	CTD 16 in water	54.19972	-11.866502	1634.05
05/10/2021 04:20	25	CTD 17 in water	54.193958	-11.8569	1571.35
05/10/2021 07:02	26	CTD 18 in water	54.176705	-11.834273	1405.99
05/10/2021 16:16	28	CTD 19 in water	54.172883	-11.829648	1346.08
05/10/2021 19:19	29	CTD 20 in water	54.170528	-11.82356	1205.52
05/10/2021 22:06	30	CTD 21 in water	54.166668	-11.815872	1115.24
06/10/2021 00:55	31	CTD 22 in water	54.160745	-11.806555	993.52
06/10/2021 03:37	32	CTD 23 in water	54.156506	-11.794434	900.50

06/10/2021 05:55	33	CTD 24 in water	54.142517	-11.782988	799.24
06/10/2021 08:31	34	CTD 25 in water	54.23558	-11.945232	2008.54
06/10/2021 12:11	35	CTD 26 in water	54.265455	-11.97193	2177.30
06/10/2021 15:53	36	CTD 27 in water	54.294186	-12.02794	2391.40
06/10/2021 19:56	37	CTD 28 in water	54.294191	-12.027271	2415.29
06/10/2021 23:52	38	CTD 29 in water	54.314889	-12.044931	2590.28
07/10/2021 04:46	39	CTD 30 in water (AX15)	54.336914	-12.061464	2701.88
07/10/2021 08:59	40	CTD 31 in water (AX15)	54.336916	-12.061474	2695.52
07/10/2021 18:37	41	CTD 32 in water	54.863737	-11.399701	2740.31
07/10/2021 22:33	42	CTD 33 in water (T3-1)	54.863733	-11.399655	2735.48
08/10/2021 05:06	43	CTD 34 in water (T3-2)	54.734271	-11.313039	2590.47
08/10/2021 09:16	44	CTD 35 in water (T3-3)	54.712091	-11.295083	2492.99
08/10/2021 12:25	45	CTD 36 in water (T3-3)	54.712077	-11.295108	2491.48
08/10/2021 16:25	46	CTD 37 in water (T3-4)	54.701255	-11.287529	2392.15
08/10/2021 20:07	47	CTD 38 in water (T3-5)	54.664066	-11.263596	2192.75
08/10/2021 23:57	48	CTD 39 in water (T3-6)	54.652627	-11.256414	2097.59
09/10/2021 03:38	49	CTD 40 in water (T3-7)	54.635641	-11.244561	1801.62
09/10/2021 06:47	50	CTD 41 in water (T3-8)	54.62189	-11.235745	1594.47
09/10/2021 09:38	51	CTD 42 in water (T3-9)	54.602602	-11.222805	1393.08
09/10/2021 12:12	52	CTD 43 in water (T3-10)	54.577666	-11.204834	1191.12
09/10/2021 15:19	53	CTD 44 in water (T3-11)	54.5464	-11.184897	1001.68
09/10/2021 18:01	54	CTD 45 in water (T3-12)	54.5207	-11.165131	795.11
10/10/2021 01:51	55	CTD 46 in water (T4-1)	54.769834	-11.919426	2862.77
10/10/2021 06:27	56	CTD 47 in water (T4-2)	54.899978	-12.099628	2867.46
10/10/2021 12:17	57	CTD 48 in water (T3-13)	54.949929	-11.550213	2760.95
10/10/2021 16:56	58	CTD 49 in water (T3-14)	55.049755	-11.7488	2789.08
11/10/2021 00:54	59	CTD 50 in water (T4-3)	54.600073	-11.66932	2839.84
11/10/2021 04:41	60	CTD 51 in water (T4-4)	54.587254	-11.659304	2796.01
11/10/2021 08:11	61	CTD 52 in water (T4-5)	54.561129	-11.640182	2596.12
11/10/2021 11:38	62	CTD 53 in water	54.571729	-11.648092	2691.40
12/10/2021 00:53	63	CTD 54 in water (T5-1)	55.900039	-11.98263	2772.76
12/10/2021 06:06	64	CTD 55 in water (T5-2)	56.130635	-11.744378	2672.47
12/10/2021 11:10	65	CTD 56 in water (T5-3)	56.333053	-11.539693	2592.15
12/10/2021 17:23	66	CTD 57 in water (T5-4)	56.699739	-11.174737	2462.00
12/10/2021 22:10	67	CTD 58 in water (T5-5)	56.932491	-10.932224	2379.07

13/10/2021 03:57	68	CTD 59 in water (T6-1)	56.700105	-10.529336	2230.56
13/10/2021 07:23	69	CTD 60 in water (T6-2)	56.579487	-10.432566	2096.73
13/10/2021 10:41	70	CTD 61 in water (T6-3)	56.54728	-10.405753	1800.89
13/10/2021 16:41	71	CTD 62 in water (T6-4)	56.446691	-9.646343	1498.59
13/10/2021 23:04	72	CTD 63 in water (S1-1)	56.11538	-10.093031	1984.87
14/10/2021 05:22	73	CTD 64 in water (S1-2)	55.814994	-9.833911	1997.91
14/10/2021 09:23	74	CTD 65 in water (T8-1)	55.810851	-9.756053	1744.92
14/10/2021 12:08	75	CTD 66 in water (T8-2)	55.811347	-9.673636	1495.07
14/10/2021 15:22	76	CTD 67 in water (T8-3)	55.809917	-9.586512	1244.53
14/10/2021 18:05	77	CTD 68 in water (T8-4)	55.809429	-9.493391	1007.07
14/10/2021 23:07	78	CTD 69 in water (T8-5)	55.751247	-10.056845	2248.68
15/10/2021 04:16	79	CTD 70 in water (T8-7?)	55.651193	-10.399362	2401.31
15/10/2021 10:33	80	CTD 71 in water (T9-1)	55.366354	-10.933013	2535.58
15/10/2021 15:23	81	CTD 72 in water (T9-2)	55.383151	-10.617468	2481.86
15/10/2021 19:15	82	CTD 73 in water (T9-3)	55.383075	-10.41678	2378.61
15/10/2021 22:58	83	CTD 74 in water (T9-4)	55.38285	-10.336851	2191.79
16/10/2021 02:28	84	CTD 75 in water (T9-5)	55.351189	-10.267899	1988.78
16/10/2021 05:52	85	CTD 76 in water (T9-6)	55.338269	-10.244478	1790.64
16/10/2021 08:37	86	CTD 77 in water (T9-7)	55.331268	-10.228255	1593.03
16/10/2021 11:32	87	CTD 78 in water (T9-8)	55.319396	-10.205323	1390.90
16/10/2021 14:38	88	CTD 79 in water (T9-9)	55.295127	-10.150461	1116.15
16/10/2021 19:03	89	CTD 80 in water (T10-1)	55.540266	-10.029767	2137.58
23/10/2021 14:14	90	CTD 81 in water (T11-4)	54.172238	-12.100796	1325.65
23/10/2021 17:39	91	CTD 82 in water (T11-3)	54.217387	-12.149669	1566.07
23/10/2021 20:37	92	CTD 83 in water (T11-2)	54.247757	-12.185366	1839.62
23/10/2021 23:50	93	CTD 84 in water	54.274665	-12.221658	2079.99
24/10/2021 02:50	94	CTD 85 in water (T11-1)	54.274636	-12.22165	2081.96
24/10/2021 05:34	95	CTD 86 in water (T11-5)	54.304671	-12.224992	2375.47
25/10/2021 08:38	96	CTD 87 in water (T11-6)	54.327185	-12.252202	2657.07
25/10/2021 14:10	97	CTD 88 in water	54.327201	-12.253169	2644.66
25/10/2021 19:48	98	CTD 89 in water (T12-1)	54.21233	-12.664844	2911.30
26/10/2021 01:03	99	CTD 90 in water (T12-2)	54.139946	-12.599376	2387.45
27/10/2021 07:36	100	CTD 91 in water (T12-3)	54.089201	-12.592817	1989.64
27/10/2021 11:40	101	CTD 92 in water (T12-4)	54.069721	-12.632684	1926.46
27/10/2021 15:16	102	CTD 93 in water (T12-5)	54.03741	-12.639748	1744.20

27/10/2021 18:35	103	CTD 94 in water (T12-6)	54.016734	-12.64456	1494.72
27/10/2021 22:08	104	CTD 95 in water (T12-7)	54.009601	-12.653505	1371.41
28/10/2021 02:20	105	CTD 96 in water (T13-1)	54.088437	-12.997942	1280.48
28/10/2021 05:47	106	CTD 97 in water (T13-2)	54.125625	-13.025401	1480.05
28/10/2021 16:22	107	CTD 98 in water (T13-3)	54.149333	-13.049165	1790.81
28/10/2021 20:00	108	CTD 99 in water (T13-4)	54.156832	-13.056506	1992.76
28/10/2021 23:32	109	CTD 100 in water (T13-5)	54.168303	-13.067751	2471.30
29/10/2021 03:38	110	CTD 101 in water (T13-6)	54.180574	-13.076876	2594.08
29/10/2021 08:08	111	CTD 102 in water (T13-6)	54.18048	-13.076828	2594.47
29/10/2021 12:12	112	CTD 103 in water (T13-8)	54.211085	-13.107143	2958.77
29/10/2021 19:09	113	CTD 104 in water (T14-1)	54.052538	-13.670389	2392.69
29/10/2021 23:58	114	CTD 105 in water (T15-1)	53.999195	-14.101824	2086.08
30/10/2021 03:18	115	CTD 106 in water (T15-2)	54.034601	-14.147909	2600.38
30/10/2021 07:09	116	CTD 107 in water (T15-3)	53.971221	-14.065332	1788.72
30/10/2021 10:01	117	CTD 108 in water (T15-4)	53.929093	-14.008341	1495.95
30/10/2021 12:46	118	CTD 109 in water (T15-5)	53.894827	-13.959567	1292.26
30/10/2021 15:41	119	CTD 110 in water (T15-6)	53.845143	-13.901387	993.34
30/10/2021 20:05	120	CTD 111 in water (T16-1)	53.614964	-14.438068	1184.17
30/10/2021 23:02	121	CTD 112 in water (T16-2)	53.637647	-14.479316	1461.13
31/10/2021 08:54	122	CTD 113 in water (T16-3)	53.660876	-14.518629	1799.31
31/10/2021 11:59	123	CTD 114 in water (T16-4)	53.675157	-14.546175	1997.48
01/11/2021 07:45	124	CTD 115 in water (T3-13)	54.94968	-11.550036	2773.62 SB
01/11/2021 12:28	125	CTD 116 in water (T3-14)	55.049424	-11.748636	2788.45
01/11/2021 16:46	126	CTD 117 in water (T3-15)	55.089309	-12.018961	2848.84
01/11/2021 19:59	127	CTD 118 in water (T3-16)	55.008925	-12.089705	2865.94
02/11/2021 00:04	128	CTD 119 in water (T3-17)	55.129796	-12.289784	2876.24
02/11/2021 04:06	129	CTD 120 in water (T3-18)	55.169472	-11.949756	2824.66

2 CONDUCTIVITY, TEMPERATURE AND DEPTH (CTD) OPERATIONS

2.1 STAINLESS STEEL CTD OPERATIONS (NMF)

Tom Ballinger, Dave Childs, Jade Garner, Tim Powell, John Wynar

120 CTD casts were undertaken with an NMF 24-way stainless steel CTD frame with 10l Niskin water samplers. All instrument serial numbers were checked and all channels of the 9plus underwater unit checked prior to drafting the Sensor Information Sheets for DY138. A SBE 43 Dissolved Oxygen sensor was used to supplement the primary pair of Temperature and Conductivity sensors, additionally a SBE 35 DOST was fitted to the frame, for taking additional temperature measurements at each bottle stop.

Between casts sensors were flushed with MilliQ three times before installation of caps on the TC-duct inlet and pump exhaust of both sensor ducts. After the rosette had been sampled, the whole CTD package was rinsed with fresh water to prevent salt crystals forming in the sensors, associated tubing and particularly the carousel latch assembly. Due to the frequent use of the CTD packages, and low temperatures, the TC-ducts were only cleaned once during the cruise with dilute bleach and Triton-X solutions. No drift or shift was observed in the differences between the Temperature, Conductivity, Salinity or Dissolved Oxygen sensors.

All CTD's were operated out of the hangar using the overhead gantry to move the CTD frame in and out of position as required. The Stainless Steel CTD was deployed on the 11.43mm conducting CTD wire (CTD1 storage drum) and made use of an MDS Titanium CTD Swivel.

For all CTD operations, the ship's crew drove the winches remotely from the winch cab, with radio contact maintained between the lab and winch cab in order to provide details such as bottom depths and depths to stop the winch for bottle stops.

Usually the normal range of 5m from bottom for maximum wire out was used, the altimeter provided solid returns of the seabed from depths of around 80m to 90m for most casts.

2.1.2 STAINLESS STEEL CTD SENSOR INFORMATION

The following sensors were installed on the stainless steel CTD frame:

Table 3: Sensors installed on CTD frame

Instrument / Sensor	**Manufacturer & Model**	**Serial Number**	**Channel**	**Casts**
Primary CTD deck unit	SBE 11plus	11P-24680-0588	N/A	All casts
CTD Underwater Unit	SBE 9plus	09P-24680-0637	N/A	All casts
Stainless steel 24-way frame	NOCS	CTD 6	N/A	All casts
MDS Titanium CTD Swivel	MDS	1246-1	N/A	All casts
Primary Temperature Sensor	SBE 3P	03P-2674	F0	All casts
Primary Conductivity Sensor	SBE 4C	04C-2450	F1	All casts
Digiquartz Pressure sensor	Paroscientific	79501	F2	All casts
Secondary Temperature Sensor	SBE 3P	03P-4116	F3	All casts
Secondary Conductivity Sensor	SBE 4C	04C-2580	F4	All casts
Primary Pump	SBE 5T	05T-3607	N/A	All casts
Secondary Pump	SBE 5T	05T-3085	N/A	All casts
24-way Carousel	SBE 32	32-31240-0423	N/A	All casts
SBE 35 DOST	SBE35	35-34173-0037	N/A	All casts
Dissolved Oxygen Sensor	SBE 43	43-1624	V0	All casts
FREE	N/A	N/A	V1	All casts
Transmissometer	Wet Labs	CST-1719TR	V2	All casts
Fluorimeter	Chelsea	088244	V3	All casts
FREE	N/A	N/A	V4	All casts
FREE	N/A	N/A	V5	All casts
Altimeter	Valeport VA500	65228	V6	All casts
FREE	N/A	N/A	V7	All casts
10L Water Samplers	OTE	N/A	N/A	All casts
LADCP master	TRDI Workhorse 300kHz	24609	N/A	All casts
LADCP slave	TRDI Workhorse 300kHz	13329	N/A	All casts
LADCP battery pack	NOC	WH007	N/A	All casts

2.1.3 INSTRUMENT CONFIGURATION FILES

The Seasave instrument configuration files used for all casts are shown below:

DY138_SS_0637_nmea_.xmlcon:

```
<?xml version="1.0" encoding="UTF-8"?>
<SBE_InstrumentConfiguration SB_ConfigCTD_FileVersion="7.26.4.0" >
<Instrument Type="8" >
<Name>SBE 911plus/917plus CTD</Name>
<FrequencyChannelsSuppressed>0</FrequencyChannelsSuppressed>
<VoltageWordsSuppressed>0</VoltageWordsSuppressed>
    <ComputerInterface>0</ComputerInterface>
    <!-- 0 == SBE11plus Firmware Version >= 5.0 -->
    <!-- 1 == SBE11plus Firmware Version < 5.0 -->
    <!-- 2 == SBE 17plus SEARAM -->
    <!-- 3 == None -->
    <DeckUnitVersion>0</DeckUnitVersion>
    <ScansToAverage>1</ScansToAverage>
    <SurfaceParVoltageAdded>0</SurfaceParVoltageAdded>
    <ScanTimeAdded>1</ScanTimeAdded>
    <NmeaPositionDataAdded>1</NmeaPositionDataAdded>
    <NmeaDepthDataAdded>0</NmeaDepthDataAdded>
```

```
<NmeaTimeAdded>1</NmeaTimeAdded>
<NmeaDeviceConnectedToPC>1</NmeaDeviceConnectedToPC>
<SensorArray Size="13" >
  <Sensor index="0" SensorID="55" >
    <TemperatureSensor SensorID="55" >
      <SerialNumber>03P-2674</SerialNumber>
      <CalibrationDate>8Sept2020</CalibrationDate>
      <UseG_J>1</UseG_J>
      <A>0.00000000e+000</A>
      <B>0.00000000e+000</B>
      <C>0.00000000e+000</C>
      <D>0.00000000e+000</D>
      <F0_Old>0.000</F0_Old>
      <G>4.35687871e-003</G>
      <H>6.42430783e-004</H>
      <I>2.36135920e-005</I>
      <J>2.33827752e-006</J>
      <F0>1000.000</F0>
      <Slope>1.00000000</Slope>
      <Offset>0.0000</Offset>
    </TemperatureSensor>
  </Sensor>
  <Sensor index="1" SensorID="3" >
    <ConductivitySensor SensorID="3" >
      <SerialNumber>04C-2450</SerialNumber>
      <CalibrationDate>13 Aug 2020</CalibrationDate>
      <UseG_J>1</UseG_J>
      <!-- Cell const and series R are applicable only for wide range sensors. -->
      <SeriesR>0.0000</SeriesR>
      <CellConst>2000.0000</CellConst>
      <ConductivityType>0</ConductivityType>
      <Coefficients equation="0" >
        <A>0.00000000e+000</A>
        <B>0.00000000e+000</B>
        <C>0.00000000e+000</C>
        <D>0.00000000e+000</D>
        <M>0.0</M>
        <CPcor>-9.57000000e-008</CPcor>
      </Coefficients>
      <Coefficients equation="1" >
        <G>-1.04302300e+001</G>
        <H>1.66058054e+000</H>
        <I>-1.15085793e-003</I>
        <J>2.24056164e-004</J>
        <CPcor>-9.57000000e-008</CPcor>
        <CTcor>3.2500e-006</CTcor>
        <!-- WBOTC not applicable unless ConductivityType = 1. -->
        <WBOTC>0.00000000e+000</WBOTC>
      </Coefficients>
      <Slope>1.00000000</Slope>
      <Offset>0.00000</Offset>
    </ConductivitySensor>
  </Sensor>
  <Sensor index="2" SensorID="45" >
    <PressureSensor SensorID="45" >
      <SerialNumber>76501</SerialNumber>
      <CalibrationDate>24-Jan-2020</CalibrationDate>
      <C1>-6.052595e+004</C1>
      <C2>-1.619787e+000</C2>
      <C3>1.743190e-002</C3>
      <D1>2.819600e-002</D1>
      <D2>0.000000e+000</D2>
      <T1>3.011561e+001</T1>
      <T2>-5.788717e-004</T2>
      <T3>3.417040e-006</T3>
      <T4>4.126500e-009</T4>
      <Slope>0.99977900</Slope>
      <Offset>-1.24262</Offset>
      <T5>0.000000e+000</T5>
      <AD590M>1.293660e-002</AD590M>
      <AD590B>-9.522570e+000</AD590B>
    </PressureSensor>
  </Sensor>
  <Sensor index="3" SensorID="55" >
    <TemperatureSensor SensorID="55" >
```

```
      <SerialNumber>03P-4116</SerialNumber>
      <CalibrationDate>07-Oct-20</CalibrationDate>
      <UseG_J>1</UseG_J>
      <A>0.00000000e+000</A>
      <B>0.00000000e+000</B>
      <C>0.00000000e+000</C>
      <D>0.00000000e+000</D>
      <F0_Old>0.000</F0_Old>
      <G>4.41812231e-003</G>
      <H>6.83204268e-004</H>
      <I>2.41763625e-005</I>
      <J>2.03489763e-006</J>
      <F0>1000.000</F0>
      <Slope>1.00000000</Slope>
      <Offset>0.0000</Offset>
     </TemperatureSensor>
    </Sensor>
    <Sensor index="4" SensorID="3" >
     <ConductivitySensor SensorID="3" >
      <SerialNumber>04C-2580</SerialNumber>
      <CalibrationDate>13 Aug 2020</CalibrationDate>
      <UseG_J>1</UseG_J>
      <!-- Cell const and series R are applicable only for wide range sensors. -->
      <SeriesR>0.0000</SeriesR>
      <CellConst>2000.0000</CellConst>
      <ConductivityType>0</ConductivityType>
      <Coefficients equation="0" >
       <A>0.00000000e+000</A>
       <B>0.00000000e+000</B>
       <C>0.00000000e+000</C>
       <D>0.00000000e+000</D>
       <M>0.0</M>
       <CPcor>-9.57000000e-008</CPcor>
      </Coefficients>
      <Coefficients equation="1" >
       <G>-1.04719858e+001</G>
       <H>1.53925782e+000</H>
       <I>4.70218594e-004</I>
       <J>5.56851492e-005</J>
       <CPcor>-9.57000000e-008</CPcor>
       <CTcor>3.2500e-006</CTcor>
       <!-- WBOTC not applicable unless ConductivityType = 1. -->
       <WBOTC>0.00000000e+000</WBOTC>
      </Coefficients>
      <Slope>1.00000000</Slope>
      <Offset>0.00000</Offset>
     </ConductivitySensor>
    </Sensor>
    <Sensor index="5" SensorID="38" >
     <OxygenSensor SensorID="38" >
      <SerialNumber>43-1624</SerialNumber>
      <CalibrationDate>06-Mar-21</CalibrationDate>
      <Use2007Equation>1</Use2007Equation>
      <CalibrationCoefficients equation="0" >
       <!-- Coefficients for Owens-Millard equation. -->
       <Boc>0.0000</Boc>
       <Soc>0.0000e+000</Soc>
       <offset>0.0000</offset>
       <Pcor>0.00e+000</Pcor>
       <Tcor>0.0000</Tcor>
       <Tau>0.0</Tau>
      </CalibrationCoefficients>
      <CalibrationCoefficients equation="1" >
       <!-- Coefficients for Sea-Bird equation - SBE calibration in 2007 and later. -->
       <Soc>3.5090e-001</Soc>
       <offset>-0.7075</offset>
       <A>-4.4695e-003</A>
       <B> 1.7825e-004</B>
       <C>-2.8294e-006</C>
       <D0> 2.5826e+000</D0>
       <D1> 1.92634e-004</D1>
       <D2>-4.64803e-002</D2>
       <E> 3.6000e-002</E>
       <Tau20> 1.3000</Tau20>
       <H1>-3.3000e-002</H1>
```

```
      <H2> 5.0000e+003</H2>
      <H3> 1.4500e+003</H3>
     </CalibrationCoefficients>
    </OxygenSensor>
   </Sensor>
   <Sensor index="6" SensorID="27" >
    <NotInUse SensorID="27" >
     <SerialNumber></SerialNumber>
     <CalibrationDate></CalibrationDate>
     <OutputType>2</OutputType>
     <Free>1</Free>
    </NotInUse>
   </Sensor>
   <Sensor index="7" SensorID="71" >
    <WET_LabsCStar SensorID="71" >
     <SerialNumber>CST-1719TR</SerialNumber>
     <CalibrationDate>2nd April 2021</CalibrationDate>
     <M>21.3758</M>
     <B>-0.0513</B>
     <PathLength>0.250</PathLength>
    </WET_LabsCStar>
   </Sensor>
   <Sensor index="8" SensorID="5" >
    <FluoroChelseaAqua3Sensor SensorID="5" >
     <SerialNumber>088244</SerialNumber>
     <CalibrationDate>07 Aug 2020</CalibrationDate>
     <VB>0.210666</VB>
     <V1>2.032520</V1>
     <Vacetone>0.245650</Vacetone>
     <ScaleFactor>1.000000</ScaleFactor>
     <Slope>1.000000</Slope>
     <Offset>0.000000</Offset>
    </FluoroChelseaAqua3Sensor>
   </Sensor>
   <Sensor index="9" SensorID="27" >
    <NotInUse SensorID="27" >
     <SerialNumber></SerialNumber>
     <CalibrationDate></CalibrationDate>
     <OutputType>2</OutputType>
     <Free>1</Free>
    </NotInUse>
   </Sensor>
   <Sensor index="10" SensorID="27" >
    <NotInUse SensorID="27" >
     <SerialNumber></SerialNumber>
     <CalibrationDate></CalibrationDate>
     <OutputType>2</OutputType>
     <Free>1</Free>
    </NotInUse>
   </Sensor>
   <Sensor index="11" SensorID="0" >
    <AltimeterSensor SensorID="0" >
     <SerialNumber>65228</SerialNumber>
     <CalibrationDate>09 August 2019</CalibrationDate>
     <ScaleFactor>15.000</ScaleFactor>
     <Offset>0.000</Offset>
    </AltimeterSensor>
   </Sensor>
   <Sensor index="12" SensorID="27" >
    <NotInUse SensorID="27" >
     <SerialNumber></SerialNumber>
     <CalibrationDate></CalibrationDate>
     <OutputType>2</OutputType>
     <Free>1</Free>
    </NotInUse>
   </Sensor>
  </SensorArray>
 </Instrument>
</SBE_InstrumentConfiguration>
```

2.1.4 CTD SUITE TECHNICAL ISSUES AND INSTRUMENT CHANGES

There were no major technical issues with the Stainless Steel CTD suite during the cruise and no instruments required changing. 2 full sets of spare instruments were available for use and a spare CTD frame was also available on board, details of which are listed in the DY138 Spare CTD Sensor Info document.

There were some occasional issues with the 10L Niskin water samplers, several taps needed their o-rings replacing throughout the cruise. On occasion, a bottle would fail to seal correctly, to mitigate this extension pieces were fitted to the latch assembly on the carousal, the latch was also routinely washed to help reduce the build-up of salt crystals which can cause sticky latches. At the end of the cruise all bottles were leak tested again and all sealed well.

Spot checks of the termination took place throughout the cruise to make sure the bolts and locking nuts on the clamps were tight and at the correct torque.

On a couple of casts the NMEA Data display window stopped showing data, once closed and re-starting the issue was resolved. A timeout error also occurred on several occasions when trying to connect to the deck unit and 9plus at the start of a cast, again closing down Seasave and re-starting the application resolved the issue.

2.1.5 CAST SUMMARY

Table 4: DY153 CTD cast summary

Cast	**Julian Day**	**Max Wire Out (m)**		**Cast**	**Julian Day**	**Max Wire Out (m)**	
001	271	708		062	286	1492	
002	271	690		063	286	1985	
003	272	923		064	287	1994	
004	272	1183		065	287	1735	
005	272	1465		066	287	1490	
006	272	1770		067	287	1240	
007	272	2000		068	287	1002	
008	276	1500		069	287	2246	
009	276	2292		070	288	2395	
010	276	2487		071	288	2530	
011	276	2685		072	288	2466	
012	277	2717		073	288	2375	
013	277	2730		074	288	2190	

014	277	1858
015	277	1746
016	278	1615
017	278	1579
018	278	1395
019	278	1320
020	278	1185
021	278	1087
022	279	988
023	279	900
024	279	800
025	279	2003
026	279	2185
027	279	2412
028	279	1700
029	279	2568
030	280	2710
031	280	1800
032	280	2737
033	280	2730
034	281	2593
035	281	2485
036	281	2485
037	281	2392
038	281	2197
039	281	2094
040	282	1805
041	282	1593
042	282	1390
043	282	1190
044	282	992
045	282	796
046	283	2858
047	283	2864
048	283	2756
049	283	2785
050	284	2830
051	284	2790
052	284	2595
053	284	2688
054	285	2767
055	285	2668
056	285	2582
057	285	2459
058	285	2375
059	286	2227
060	286	2080

075	289	1985
076	289	1785
077	289	1600
078	289	1396
079	289	1116
080	289	2141
081	296	1328
082	296	1570
083	296	1840
084	296	2093
085	297	1800
086	297	2380
087	297	2650
088	298	2655
089	298	2770
090	299	2382
091	300	1978
092	300	1925
093	300	1743
094	300	1498
095	300	1334
096	301	1280
097	301	1480
098	301	1792
099	301	2004
100	301	2290
101	302	2600
102	302	1900
103	302	2956
104	302	2398
105	302	2080
106	302	2590
107	303	1785
108	303	1495
109	303	1293
110	303	995
111	303	1183
112	303	1459
113	304	1795
114	304	1190
115	305	2756
116	305	2785
117	305	2825
118	305	2850
119	305	2860
120	306	2810

061	286	1800	

2.1.6 DATA PROCESSING

Standard Sea-Bird processing of the raw data was completed using Sea-Bird Data Processing software. The BODC “Recommended steps for basic processing of SBE-911 CTD data.” Version 1.0 October 2010 instructions were followed for all casts, these being:

- Data Conversion
- Bottle Summary
- Align CTD
- Cell Thermal Mass
- Derive
- Bin Average
- Strip

Once completed, all processed and raw data files were backed up onto the network drive and made available to the scientific party.

Data from the SBE 35 DOST was downloaded immediately after each cast and before the deck unit was powered off, this was achieved by using the Upload Data function of Seaterm.

2.1.7 LADCP

2.1.7.1 Instrument configuration

Two self-logging Teledyne RDI Workhorse 300kHz ADCP’s were installed on the Stainless Steel CTD frame and used for all CTD casts.

The down-looking unit (S/N: 24609) was sited in the centre of the frame with its transducers just above the bottom tube of the CTD frame. The upward-looking unit (S/N: 13329) was fitted to the side of the frame using a stand-off bracket directly opposite the vane. Both instruments were powered with NMF Workhorse Battery Pack serial number WH007.

All casts were setup using BBTalk software run via a laptop in the Deck Lab.

In between casts the battery pack was charged using a bench top power supply, once fully charged and not deployed the battery pack was left connected to the power supply with a trickle voltage applied to maintain the pack.

2.1.7.2 Deployment command scripts

Master LADCP

```
$P **************************************************************************
$P ******************* LADCP Primary. Looking down. ************************
$P **************************************************************************
; Send ADCP a BREAK
$B
; Wait for command prompt > (sent after each command)
$W62
;**Start**
; Display real time clock setting
TT?
$W62
; Set to factory defaults
CR1
$W62
; Print firmware etc.
PS0
$D1
; Set Water Mode 15 LADCP
WM15
$W62
; Set minimum correlation magnitude and threshold for good bottom-track data. Default values used here.
LZ030,220
; Set baud rate to 9600
CB411
$W62
; Save settings as User defaults
CK
$W62
; Set transducer depth to zero
ED0000
$W62
; Set salinity to 35ppt
ES35
$W62
; Set beam coordinates
EX00000
$W62
; SET AS PRIMARY ADCP
SM1
$W62
; TRANSMITS SYNCHRONIZING PULSE BEFORE EACH WATER PING
SA001
$W62
; Disable hardware-break detection on Channel B
SB0
$W62
; SYNCHRONIZING PULSE SENT ON EVERY PING
SI0
$W62
;WAIT 7.5 MILLISECONDS
SW75
$W62
; Set one ensemble 1.00/sec
TE00000100
$W62
; Set one second between pings
TP000100
$W62
; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good WD111100000
$W62
; Set one ping per ensemble. Also sets LP command.
WP1
```

```
$W62
; Set to record 20 bins. Also sets LN command.
WN020
$W62
; Set bin size to 8 m. Also sets LS command.
WS0800
$W62
; Set blank to 176 cm (default value for 300kHz ADCP). Also sets LF command.
WF0176
$W62
; Set max radial (along the axis of the beam) water velocity to 275 cm/sec. ; Also sets LV command. Default
value is 170 cm/s, adding 60 cm/s for vertical CTD package motion.
WV275
$W62
; Set ADCP to narrow bandwidth and extend range by 10%.
;Also sets LW command.
WB1
$W62
; Set to use a fixed speed of the sound
EZ0111111
$W62
; Set speed of sound value. 1500 m/sec is default.
EC1500
$W62
; Heading alignment set to 0 degrees
EA00000
$W62
; Heading bias set to 0 degrees
EB00000
$W62
; Record data internally
CF11101
$W62
; Save set up
CK
CS
$P **************************************************************************
$P Set deployment file name with RN and then start pinging with CS.
$P **************************************************************************
```

Slave LADCP

```
$P **************************************************************************
$P ******************* LADCP Secondary. Looking up. ************************
$P **************************************************************************
; Send ADCP a BREAK
$B
; Wait for command prompt > (sent after each command)
$W62
;**Start**
; Display real time clock setting
TT?
$W62
; Set to factory defaults
CR1
$W62
; Print firmware etc.
PS0
$D1
; Set Water Mode 15 LADCP
WM15
$W62
; Set baud rate to 9600
CB411
$W62
; Save settings as User defaults
CK
$W62
; Set transducer depth to zero
ED0000
$W62
; Set salinity to 35ppt
ES35
$W62
```

```
; Set beam coordinates
EX00000
$W62
; SET AS SECONDARY ADCP
SM2
$W62
; Wait for ping
SA001
$W62
; Time out after 300s and start pinging
ST0300
$W62
; Disable hardware-break detection on Channel B
SB0
$W62
; SYNCHRONIZING PULSE SENT ON EVERY PING
SI0
$W62
;WAIT 7.5 MILLISECONDS
SW75
$W62
; Set one ensemble 1.00/sec
TE00000100
$W62
; Set one second between pings
TP000100
$W62
; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good WD111100000
$W62
; Set one ping per ensemble. Also sets LP command.
WP1
$W62
; Set to record 20 bins. Also sets LN command.
WN020
$W62
; Set bin size to 8 m. Also sets LS command.
WS0800
$W62
; Set blank to 176 cm (default value) Also sets LF command.
WF0176
$W62
; Set max radial (along the axis of the beam) water velocity to 275 cm/sec. ; Also sets LV command. Default
value is 170 cm/s, adding 60 cm/s for vertical CTD package motion.
WV275
$W62
; Set ADCP to narrow bandwidth and extend range by 10%.
;Also sets LW command.
WB1
$W62
; Set to use a fixed speed of the sound
EZ0111111
$W62
; Set speed of sound value. 1500 m/sec is default.
EC1500
$W62
; Heading alignment set to 0 degrees
EA00000
$W62
; Heading bias set to 0 degrees
EB00000
$W62
; Record data internally
CF11101
$W62
; Save set up
CK
CS
$P ***************************************************************************
$P Set deployment file name with RN and then start pinging with CS.
$P ***************************************************************************
```

2.1.7.3 Deployment recovery and procedure

Prior to each deployment a standard checklist was followed:

Pre-deployment

- Create a deployment terminal capture log file for each LADCP
- Change baud rate to 9600 baud (CB411) to ensure correct parsing of command file
- Check instrument time (TS?) by comparing to GPS time. Reset time if offset > 5s
- Check free data storage available (RS?), reformatting the card if required
- Record number of deployments on instrument storage card (RA?)
- Run pre-deployment tests (PA, PT200 and PC2)

Note that a lot of these tests are intended to be run with the instrument submerged in water and can be expected to fail in air.

The command script file is then sent to the instrument to deploy it, once started the battery is then taken off charge and the deck-cables disconnected and blanking plugs fitted for deployment.

Post-deployment

- Reconnect deck-cables. Start charging battery pack
- Upon recovery at the end of the cast, the instruments are stopped by sending a break in BBTalk
- The baud rate is changed to 115200 baud (CB811) to reduce the data download time
- Record number of deployments on instrument storage card (RA?)
- Start download of data using BBTalk ‘Recover Recorder’ command, selecting appropriate file(s) and noting their number in the default filename sequence RDI_xxx.000
- Rename the downloaded files
- Backup the files to the network archive
- Check data files in WinADCP;
- Select a region of data with high echo intensity and check for consistent levels for all four beams for echo intensity and beam correlation

- Check that the start and stop times of the data files corresponds with the deployment and recovery times
- Record the number of pings (ensembles) in each data file

2.1.8 SALINOMETRY

Salinity samples were taken from the CTD rosette by the NMF S&M party using crates of sample bottles (24 bottles per crate). Four samples were taken from each cast, randomly selected.

After collection, all samples were stored in the Salinometer lab for a period of at least 24 hours prior to sampling; this is to allow the samples to stabilise at the lab's temperature.

All samples were analysed on Guildline Autosal 8400B S/N 68426. Guildline Autosal 8400B S/N 71185 was initially setup at the start of the cruise and was left running throughout for use as a spare should the primary Salinometer fail, however this was never needed.

The Autosal was standardised using IAPSO Standard Seawater batch P164 (K15=0.99985, 2xK15=1.99970, 34.994 PSU). The machine was standardised at the beginning of the cruise and left throughout the cruise, however due to the ship having to return to port for repairs it as decided that in order to reduce the risk of equipment being damaged we would shut down everything. Once the vessel left port with repairs completed, the salinometers were powered up again and re-standardised. A standard seawater bottle was run as a sample before and after each crate as a control.

A data file from the analysis software was supplied for each crate as an Excel spreadsheet, these data were also copied to the network drive allowing access for the scientific party. All measurements were also logged manually on paper log-sheets to avoid the possibility of data loss.

2.1.9 SOFTWARE USED

- Sea-Bird SeaTerm 1.59
- Sea-Bird Seasave 7.26.7.121
- Sea-Bird SBE Data Processing 7.26.6.28

- TRDI BBTalk
- TRDI WinADCP 1.14

2.2 LADCP UNDERWAY QUALITY REPORT

Henri Drake

This report briefly describes the underway collection, processing, and quality-control of 112 velocity profiles from two Lowered Acoustic Doppler Current Profilers (LADCPs), one up-looking and one down-looking, during the DY138 cruise on the RSS Discovery under Chief Scientist Marie-Jose Messias.

2.2.1 INSTRUMENTS AND DATA

Both the down– and up–lookers were 300 kHz broadband TRDI Workhorse ADCP (WH300) with s/n 24609 and 13329, respectively. They were both used throughout and did not experience any intrinsic problems, aside from strange compass readings on the up-looker for just one cast (see below).

CTD data were separately processed by Catherine Kermabon using standard Seabird software to yield corrected 1Hz-averaged timeseries for each cast and included GPS navigation data required to determine the barotropic velocities of the reference frame.

A free-running Ship-board ADCP (SADCP), a 75 kHz narrowband TRDI Workhorse ADCP, was also used to further constrain horizontal velocities, as described below. The SADCP data was processed by Zoltan (NMF Technical Support) using the UHDAS Python package and whose output is fed to LDEO IX via the standard .mat files.

2.2.2 SOFTWARE

The raw TRDI binary files were processed using the LDEO matlab toolbox, version IX.14, developed and maintained by Andreas Thurnherr (e.g. Thurnherr 2012) and based on the inversion algorithm of Visbeck (2002).

The following parameters were modified relative to the LDEO defaults:

- ps.dz was set to 16 m, twice the set bin size of 8 m.

- p.ctdmaxlag was increased from 100 pings to 200 pings because of poor time lags (apparently due to many dropped CTD scans).

- p.btrk range minimum decreased from 50 m to 20 m above bottom to try and improve bottom velocities.

- p.cut increased to 20 m to avoid surface all surface artifacts

- ps.outlier increased from 1% to 2% for stations 2–32 to reflect poor quality of data due to large ship motions and ambiguity velocity issues.

A separate document describes additional post-processing that estimates turbulent kinetic energy dissipation rates E from LADCP-derived horizontal velocity shear variance (e.g. Kunze et al., 2006) and vertical velocity variance (Thurnherr et al., 2015).

2.2.3 QUALITY CONTROL

2.2.3.1 Ambiguity velocity problems

The ambiguity velocity was set to WV = 1.2 m/s for casts 1–27, much too low for the sea states of 3 m, as evidenced by CTD vertical velocities frequently exceeding 2.5 m/s (from wCTD = d z(p), not shown). The ambiguity velocity was first increased to 1.75 m/s for casts 28–31 and then again to 2.75 m/s for cast 32 and the rest.

2.2.3.2 General quality-control workflow

The data quality was checked by carrying out the following set of steps, as recommended by Andreas Thurnherr:

1. Data are processed without constraints from either the bottom track or the SADCP (in no constraints

output folder), but with barotropic velocity constrains from the CTD’s GPS drift.

2. All standard output figures are visually inspected for explicit warnings or abnormalities (e.g. relative to the figures shown in the software documentation). Significant deviations between

the LADCP+GPS velocity profiles and the SADCP or Bottom Track profiles may indicate data quality issues. Agreement with Bottom Track velocities is generally excellent; disagreements with SADCP seem generally good except for some casts where the SADCP profiles include gaps, spikes, or otherwise drift from the LADCP+GPS profile. Major issues (and possible corrections) are listed in Section 3.3 below; if corrections are possible, they are included in the following processing stages.

3. Data are processed with both bottom track and SADCP constraints (in both constraints output folder).

4. Data are processed with the more reliable bottom track constraint but without the SADCP (in final output folder).

2.2.3.3 Cast-specific corrections

- Cast #82: Up-looker's heading readings appear completely erroneous, causing the no-constraints velocity profile to deviate significantly from the SADCP profile. p.rot2updown = 3 was used to fix up-looker heading based on down-looker's compass, resolving this issue.

- Cast #94: All navigations plots looked completely erroneous on the upcast. It was realized that the problem was just that the binary output had been mysteriously separated into two files. They were concatenated using the UNIX command `cat [file1] [file2] > [newfile]` and the issues were immediately resolved.

- Cast #102: Bottom not detected for some reason, but the final profile still seems to be of good quality.

2.2.4 SUMMARY

After the data cleaning and correction steps above, all final vertical profiles of horizontal velocities appear to be of good quality for most research purposes. As mentioned above, the SADCP contains data gaps, apparent spikes, and deviates significantly from the no constraints profiles for some casts, so it is recommended to use final (with just Bottom Track constraints) as opposed to both constraints.

2.2.5 REFERENCES

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3 CTD DATA CONVERSION, CALIBRATION AND PROCESSING

Catherine Kermabon, Herlé Mercier, Marie-José Messias

3.1 DATA CONVERSION AND PROCESSING

We describe in this section the conversion of the SeaBird Binary files to Ascii and the post-processing of the SBE9+ raw data.

3.1.1 CONVERSION OF BINARY FILES INTO ASCII FILES

This was performed using SbeDataProcessing/DatCnv software that creates two files per station:

1. A .cnv file containing the 24 Hz raw data for the following variable names and parameters :
    - # name 0 = prDM: Pressure, Digiquartz [db]
    - # name 1 = t090C: Temperature [ITS-90, deg C]
    - # name 2 = t190C: Temperature, 2 [ITS-90, deg C]
    - # name 3 = c0mS/cm: Conductivity [mS/cm]
    - # name 4 = c1mS/cm: Conductivity, 2 [mS/cm]
    - # name 5 = sbeox0V: Oxygen raw, SBE 43 [V]
    - # name 6 = latitude: Latitude [deg]
    - # name 7 = longitude: Longitude [deg]
    - # name 8 = timeJ: Julian Days
    - # name 9 = scan: Scan Count
    - # name 10 = ptempC: Pressure Temperature [deg C]
    - # name 11 = modError: Modulo Error Count
    - # name 12 = CStarTr0: Beam Transmission, WET Labs C-Star [%]
    - # name 13 = flC: Fluorescence, Chelsea Aqua 3 Chl Con [ug/l]
    - # name 14 = timeQ: Time, NMEA [seconds]
    - # name 15 = timeY: Time, System [seconds]
    - # name 16 = altM: Altimeter [m]

- # name 17 = pumps: Pump Status

2. A .ros file containing the data of the above parameters when the bottles were closed. Scans taken into account are those 4 seconds before and 4 seconds after the bottles were closed. For each bottle, we therefore have 8 seconds of data, or 192 scans.

Only Pressure, Temperature, Conductivity, Salinity, Oxygen were further processed. The transmissometer and fluorometer data are thus only available from these 24 Hz raw data (.cnv) files.

3.1.2 BAD DATA REMOVAL USING THE CADHYAC/HYDRO_NETT SOFTWARE

The software was developed at LOPS. Bad data for pressure (dbar), temperature (°C), conductivity (mS/cm) and oxygen (volt) are identified on threshold criteria and by applying iteratively a median deviation test:

Table 5: Removal of bad pressure, temperature, conductivity and oxygen data

	Minimum Value (Vmin)	Minimum Value (Vmax)	Width of the window for the test of devation from the median (TF)	Number of standard deviation for the test of deviation from the median (NbStd)	Minimum deviation for the test of deviation from the median (Emin)	Maximum deviation for the test of deviation from the median (Emax)	Number of iterations of the test for deviation from the median (niter)
Pressure (dbar)	0	4000	20	2.8	1.5	10	2
Temperature (°C)	0	30	6	3	0.05	0.4	2
Conductivity (mS/cm)	30	20	10	2.8	0.01	0.4	3
Oxygen (Volt)	0	5	10	2.8	0.01	0.4	3

For each parameter, a value V was suppressed when:

-V was smaller than Vmin or larger than Vmax (threshold criteria)

- abs(M-V) >= NbStd*Std, where M and Std are the median and the standard deviation of a packet of 2*TF values. In case Emin <= NbStd*Std (NbStd*Std <= Emax), NbStd*Std was replaced by Emin (Emax). This procedure was performed niter times.

3.1.3 REGENERATION OF THE .ROS FILES

This step is required in order not to take into account the data previously eliminated.

3.1.4 OXYGEN HYSTERESIS CORRECTION IN VOLT

This step uses CADHYAC/hydro_nett. The hysteresis correction was applied for all profiles deeper than 1000 m according to Seabird application note 64-3. The default settings are used, namely:

H1	**H2**	**H3**	**Offset**
-0.033	5000	1450	-0.7075

3.1.5 DATA CORRECTION FOR DYNAMICAL EFFECTS ON SENSORS

This step was done using Seabird's SbeDataprocessing software:

- Pressure low-pass filtering with time constant of 0.15 second
- Oxygen alignment in volt using a lag of 4 seconds
- Correction of the thermal mass effect on the conductivity cell for the primary and secondary sensors using a thermal anomaly amplitude of alpha = 0.03 and a time constant of tau = 7
- calculation and addition of oxygen in ml/l and primary and secondary salinities in the .cnv files. Note that these variables are uncalibrated data.
- Flagging data when the probe goes up (resp. down) during the down (resp. up) cast using LoopEdit.

3.1.6 CREATION OF .BLT FILES

These files include all CTD data averaged over 8 seconds for each bottle based on the previously regenerated .ros files.

3.2 DATA CALIBRATION WITH CADHYAC/HYDRO_CAL

CADHYAC/hydro_cal software has been developed at LOPS. Independent adjustments are made for the 2 sets of sensors (primary and secondary).

3.2.1 PRESSURE AND TEMPERATURE

As we did not have metrology data after the cruise for pressure neither temperature, no correction is made on these data. We rely on the pre-cruise calibration. On board, temperature was monitored by comparing data from the SBE9+ CTD probe to data from an SBE35 probe. No drift was noted.

3.2.2 CONDUCTIVITY

The calibration of the CTD conductivity data uses the salinity data from the seawater sample analyzed on an Autosalt. 452 samples were analyzed, 4 samples per station for stations 2 to 114. Chemical analyses on the Autosal were performed by groups of 24 bottles (i.e. every 6 stations). The Autosal provides a double conductivity ratio (CR). The Autosal was standardized twice, once at the beginning of the cruise, once after the Autosal was stopped during the port call in Glasgow. These standardizations provided 2 different offsets that we applied to the Autosal CR data:

- offset = -0.000004 to be applied from station 2 to station 78
- offset = 0.000008 to be applied from station 79 to station 114

The chemical salinity is calculated as follows:

Chemical_Salinity = sw_sals((CR + offset)/2, 21) ,

With 21 being the bath temperature in °C of the autosal.

The principle of the CTD conductivity calibration is as follows. First, chemical salinity data are converted to chemical conductivity. Then, the differences between the probe conductivities and the chemical conductivities are calculated : $\Delta C = C_{chemical} - C_{probe}$. Finally, the CTD conductivity data are calibrated by applying first order polynomial corrections that will minimize ΔC in a least-squares sense. Three different polynomials can be used. P1 will be used to minimize ΔC as a function of the station numbers (i.e. time); P2 is function of conductivity; P3 is function of pressure. The polynomials P1, P2 and P3 are estimated sequentially by minimizing ΔC in a least-squares sense. New ΔC deviations are calculated considering the conductivity data thus corrected. Deviations greater than 2.8 times the standard deviation of the deviations are discarded and P1, P2, P3 are recalculated using the remaining data. This process is iterative and ends when no more deviations are rejected.

For the primary sensor set, we considered two groups of stations because the sensor presented an apparent linear drift from station 8 (compare the top to the middle panel in Fig. 2). Thus, the sensor conductivity data are corrected:

- From stations 2 to 7 as a function of conductivity (P2) and pressure (P3)

```
P2(1)= -0.000199244, P2(0)= 0.00486744
P3(1)=6.79864e-08, P3(0)= -6.7971e-05
```

- From stations 8 to 120 as a function of time (P1), conductivity (P2), and pressure (P3)

```
P1(1)= 3.15269e-05, P1(0)= -0.00479895
P2(1)= -0.000178713, P2(0)= 0.00619993
P3(1)= -1.15753e-07, P3(0)= 0.000173304
```

For the secondary sensor set, we did not perform a split. The sensor conductivity data of all stations are corrected as a function of conductivity (P2) and then of a pressure effect (P3).

```
P2(1)= -0.000140229, P1(0)= 0.00462541
P3(1)= -1.64629e-07, P3(0)= 0.000240545
```

The probe salinity data are calculated from the calibrated conductivity data using the following formula:

```
sw_salt(conductivity/sw_c3515,temperature,pressure);
```

The following plots compare the probe salinity data with the chemical salinity data before and after data adjustment. From Fig. 6, it can be seen that the data from the secondary sensor (Sal1) are slightly further away from the chemical data than those from the primary sensor (Sal0). The difference between the CTD and the chemical data are in the range [-0.002 0.002] for the primary sensor while they are in the range [-.004 0.004] for the secondary sensor. The mean and standard deviation of these differences are -0.000003 (resp. -0.000004) and 0.000830 (resp. 0.001048) for the primary (resp. secondary) sensor. Comparisons of Fig. 3 with Fig. 4 and comparison of Fig. 5 with Fig. 6 show that the bias, which depends on pressures and time, has been corrected during the calibration.

In figure 3, the top panel compares the raw salinity data from the primary sensor (Sal0) with those from the secondary sensor (Sal1). The middle (resp. bottom) panel compares the raw salinity data from the primary (resp. secondary) sensor with the chemical salinity data (Salc). In red are represented the stations corresponding to the first station of a new series of chemical analysis using the Autosal.

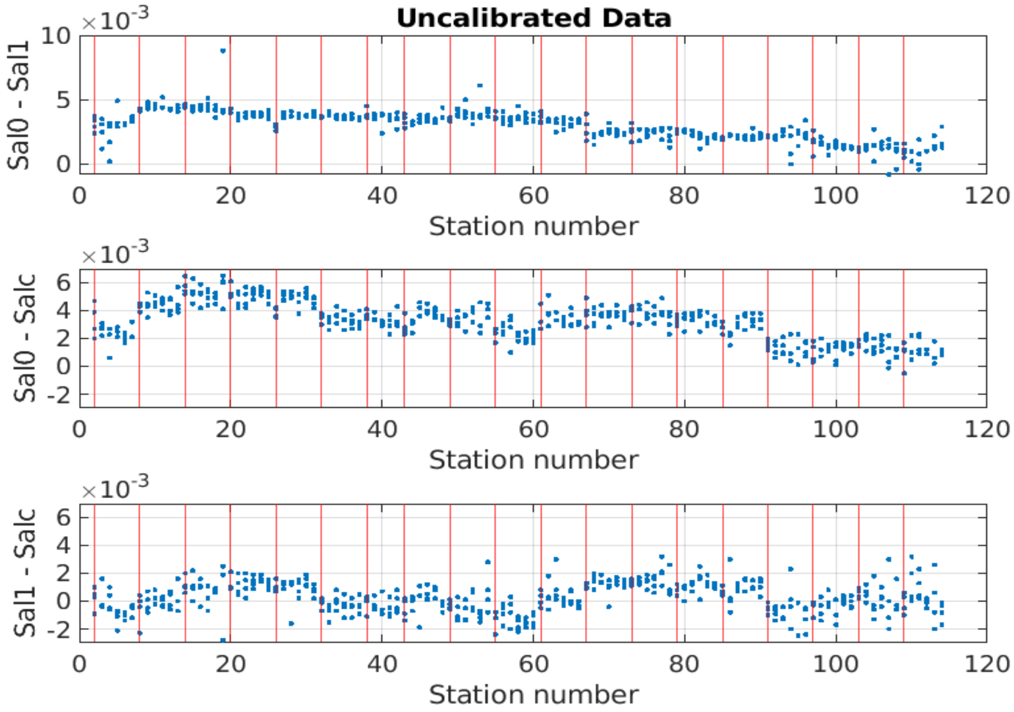


Figure 3: Salinity comparison by station before data calibration.

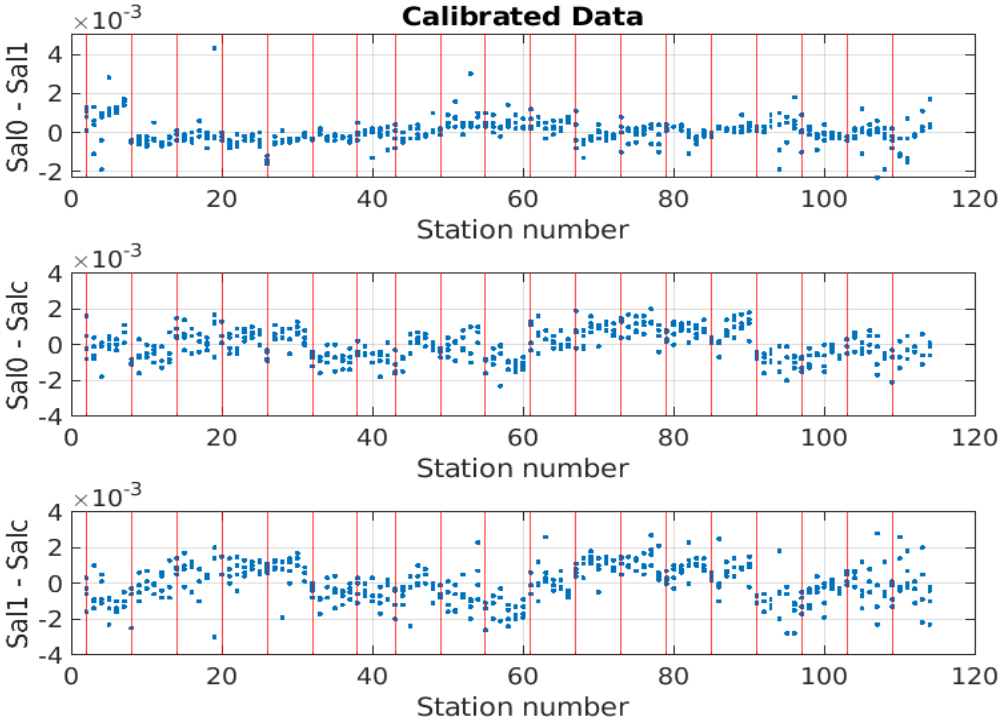


Figure 4: Same as Fig. 3 but for calibrated data.

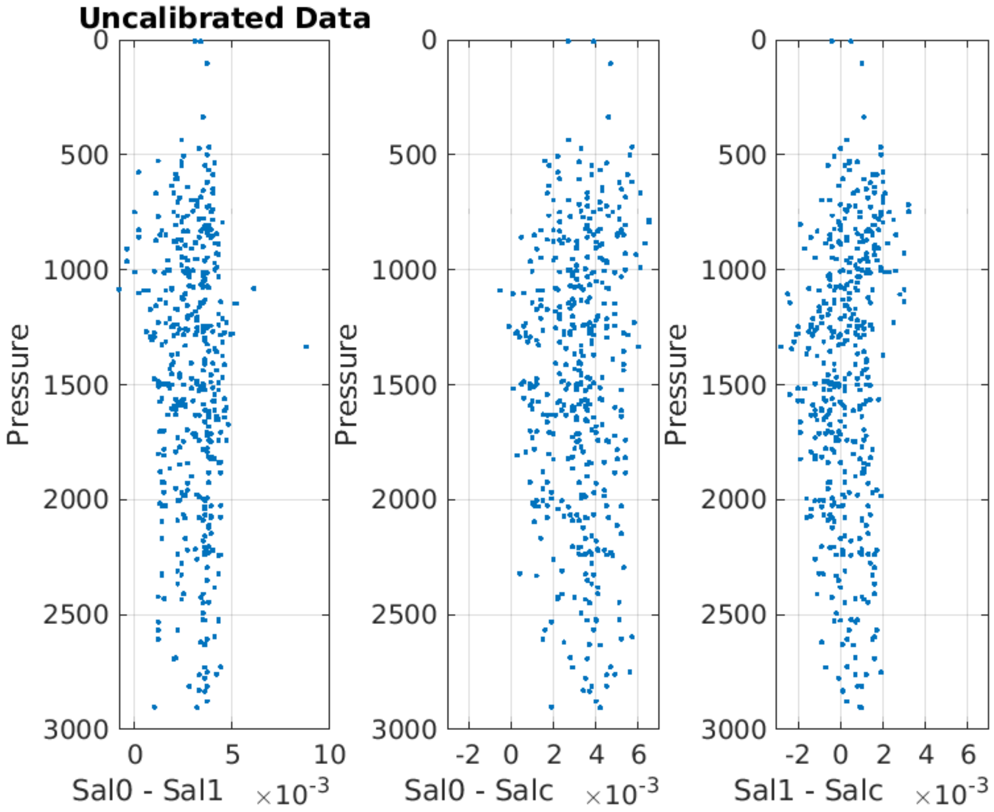


Figure 5: CTD and chemical Salinities comparison versus pressure before data calibration.

In figure 5, The left plot compares the uncalibrated salinity data from the primary sensor (Sal0) with those from the secondary sensor (Sal1). The middle (resp. right) plot compares the uncalibrated salinity data from the primary (resp. secondary) sensor with the chemical (bottle) salinity data.

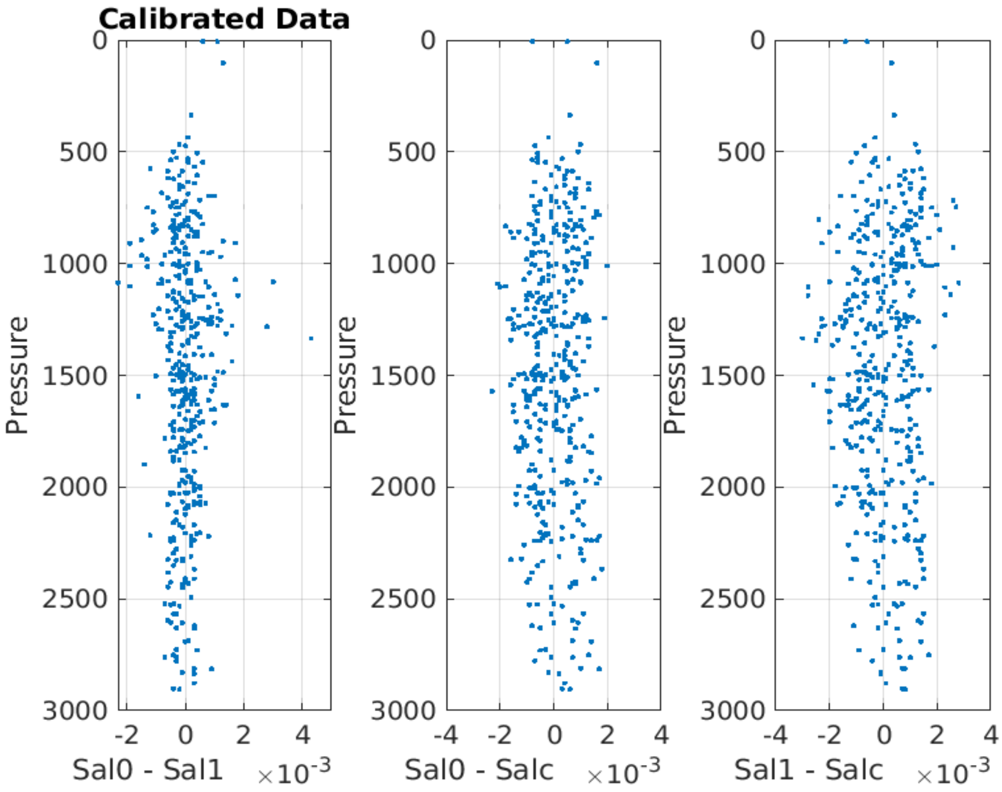


Figure 6: Same as Fig. 5 but for calibrated data.

3.2.3 DISSOLVED OXYGEN

Since we do not have bottle data for oxygen, no calibration was done and the processing was limited to correcting for hysteresis and applying the 4 second lag on oxygen in volt as mentioned earlier. The oxygen in ml/l is then calculated from the oxygen in volt using the formula:

$$\text{Oxygen (ml/L)} = [Soc * (V + Voffset + tau(T,P) * dV/dt)\} * Oxsol(T,S) * (1.0 + A*T + B*T + C*T\ ) * e^{(E*P/K)}$$

Where V is Oxygen in Volt. tau(T,P) is a time constant dependent on temperature and pressure to be used in areas of strong oxygen gradients but that can amplify the noise in the signal. Therefore, it was not used (tau(T,P) = 0). dV/dT is a time derivative (volt/second), not used because tau(T,P) = 0. T is Temperature (°C), S is Salinity, P is Pressure (db) and K is Temperature (°K). Soc, Voffset, A, B, C, E are the parameters associated with the oxygen sensor. Oxsol(T,S) is oxygen saturation.

3.3 DATA REDUCTION EVERY 1 DBAR – CREATION OF NETCDF RESULT FILES

This step averages the adjusted sensor data at 24 Hz in bins of 1 dbar. Only one data per sensor is kept (pressure, temperature, salinity, oxygen in ml/l) by steps of 1 decibar.

The bin average is done in 2 steps:

- **Step 1**: the pressure, temperature and conductivity data are bin averaged simultaneously. To do this, only the scans with increasing pressure when descending (resp. decreasing pressure when ascending) and have valid data for the 3 sensors are considered. If a scan has an invalid value for oxygen, this scan is nevertheless kept.
- **Step 2**: the oxygen data are bin averaged. For this purpose, only scans with increasing pressure when descending (resp. decreasing pressure when ascending) and with valid data of pressure, temperature, conductivity and oxygen are considered.

Below, a brief presentation of the principle of bin averaging. A scan corresponds to a set of measurements (P, T, S, O2) acquired at a given time in the 24 Hz file.

- Reading of all scans at 24Hz
- Elimination of scans with an invalid sensor value (-9.990 e-29)
- Every scan is compared to the previous one. The process starts by creating a starting scan: average of the first 30 scans. A scan is valid if it does not differ from the previous scan by more than: 0.5 db for pressure; 1°C for temperature and conductivity for pressure in the range (en db) : [0 et 1500[; 0.2°C for temperature and 0.2 mS/cm for conductivity for pressure greater than or equal to 1500 db; 0.2 for oxygen (volt). If 24 scans are rejected consecutively, the 24th rejected scan becomes the reference and the next scan will be validated against it. From the surface to the bottom for the descending profile (from the bottom to the surface for the ascending profile), a value per sensor per db is calculated. For an integer pressure P, for each sensor, this is calculated by averaging all the validated values between (P-0.5) and (P+0.5) on the condition that there are at least 6 valid scans. If there are not enough scans to calculate the average, then no data is associated with the level P.

- Creation of a reduced NetCDF file for the descending profile and a reduced NetCDF file for the ascending profile for each station for each sensor sets (primary and secondary). If bottles were closed during the ascending profile, the sensor data and the chemical data, if they exist, are integrated to each of the files.
- Manual invalidation of probe data to eliminate non-physical salinity peaks (setting of the flag 4 associated with these data (mainly conductivity and salinity))
- Creation of a matlab file for each station containing all the reduced data at 1 dbar (descending and ascending profile for the 2 sets of sensors).

We obtain 238 reduced NetCDF files for each sensor set (primary and secondary), with 119 files associated to the descending profile and 119 files associated to the ascending profile. We also obtain 119 matlab file, one per station.

The nomenclature of the file names is as follows: blt2**d**XXX_cli.nc for descending profile files, blt2**a**XXX_cli.nc for ascending profile files, XXX being the station number on 3 digits. The matlab files are named blt2_CTDXXX.mat and contains both up and down cast data. The contents of these files are presented in the appendix.

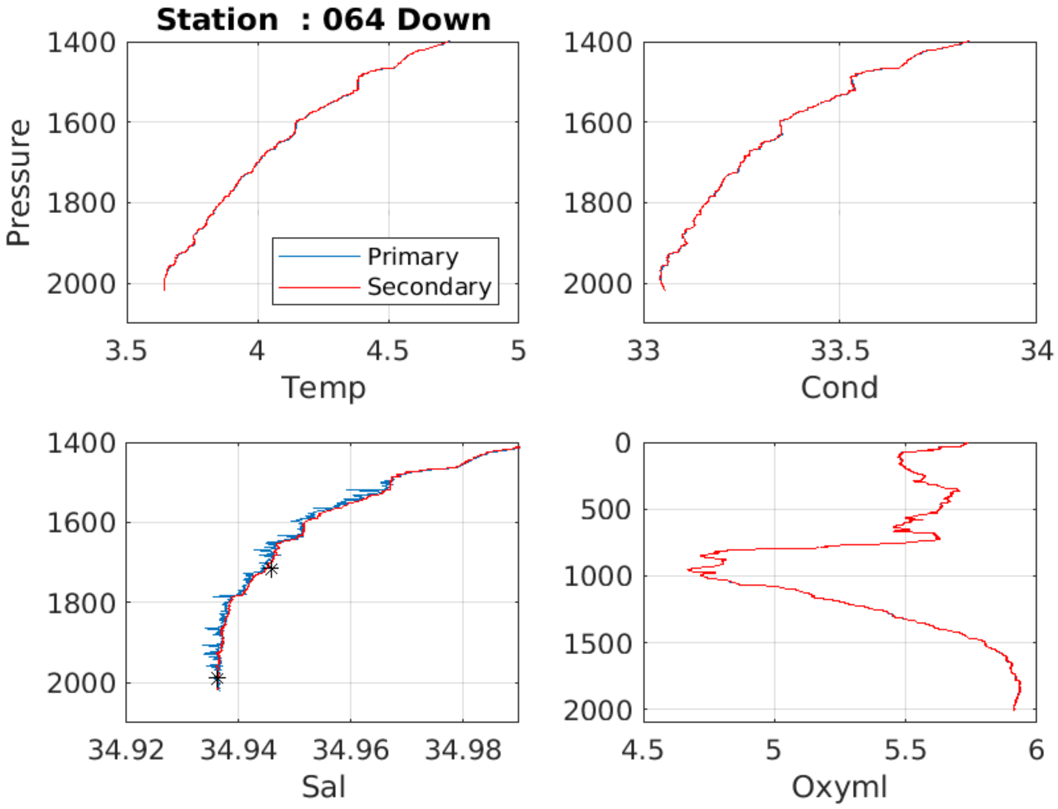


Figure 7: Station 64, 1 dbar bin averaged data for primary and secondary sensors.

Note that for stations 64 to 66, the salinity data reduced to 1 db from the primary sensor are highly noisy (Fig. 7). The noise on salinity appears clearly on the downward profile of station 64 from 1500m. It is persistent on the ascending profile of this station and on stations 65 and 66. We suspect a problem with the pump explaining a possible phase shift between temperature and conductivity. Indeed, we do not see systematic noise on the temperature and conductivity sensor on these stations.

3.4 APPENDIX

3.4.1 STRUCTURE OF NETCDF 1-DBAR FILES

```
netcdf blt2d014_cli {
dimensions:
        STRING4 = 4 ;
        STRING20 = 20 ;
        STRING7 = 7 ;
        STRING28 = 28 ;
        N_PROF = 1 ;
        N_PARAM = 6 ;
        N_LEVELS = 1882 ;
        N_PARAM_CHIM = 9 ;
        DATE_TIME = 14 ;
        N_BOTTLES = 24 ;
```

```
variables:
        double LATITUDE_BEGIN(N_PROF) ;
                LATITUDE_BEGIN:long_name = "Latitude begin of the station, best estimates" ;
                LATITUDE_BEGIN:units = "degree_north" ;
                LATITUDE_BEGIN:convention = "decimal degree" ;
                LATITUDE_BEGIN:valid_min = -90. ;
                LATITUDE_BEGIN:valid_max = 90. ;
                LATITUDE_BEGIN:_FillValue = -9999. ;
        double LATITUDE_END(N_PROF) ;
                LATITUDE_END:long_name = "Latitude end of the station, best estimates" ;
                LATITUDE_END:units = "degree_north" ;
                LATITUDE_END:convention = "decimal degree" ;
                LATITUDE_END:valid_min = -90. ;
                LATITUDE_END:valid_max = 90. ;
                LATITUDE_END:_FillValue = -9999. ;
        double LONGITUDE_BEGIN(N_PROF) ;
                LONGITUDE_BEGIN:long_name = "Longitude begin of the station, best estimates" ;
                LONGITUDE_BEGIN:units = "degree_east" ;
                LONGITUDE_BEGIN:convention = "decimal degree" ;
                LONGITUDE_BEGIN:valid_min = -180. ;
                LONGITUDE_BEGIN:valid_max = 180. ;
                LONGITUDE_BEGIN:_FillValue = -9999. ;
        double LONGITUDE_END(N_PROF) ;
                LONGITUDE_END:long_name = "Longitude end of the station, best estimates" ;
                LONGITUDE_END:units = "degree_east" ;
                LONGITUDE_END:convention = "decimal degree" ;
                LONGITUDE_END:valid_min = -180. ;
                LONGITUDE_END:valid_max = 180. ;
                LONGITUDE_END:_FillValue = -9999. ;
        char STATION_DATE_BEGIN(N_PROF, DATE_TIME) ;
                STATION_DATE_BEGIN:long_name = "Beginning Date_Time of the station" ;
                STATION_DATE_BEGIN:convention = "YYYYMMDDHH24MISS" ;
                STATION_DATE_BEGIN:_FillValue = " " ;
        char STATION_DATE_END(N_PROF, DATE_TIME) ;
                STATION_DATE_END:long_name = "End Date_Time of the station" ;
                STATION_DATE_END:convention = "YYYYMMDDHH24MISS" ;
                STATION_DATE_END:_FillValue = " " ;
        double JULD_BEGIN(N_PROF) ;
                JULD_BEGIN:long_name = "Julian day (UTC) of the beginning of the station relative to
REFERENCE_DATE_TIME" ;
                JULD_BEGIN:units = "days since 1950-01-01 00:00:00 UTC" ;
                JULD_BEGIN:convention = "Relative julian Days with decimal part (as parts of day)" ;
                JULD_BEGIN:_FillValue = -9999. ;
        double JULD_END(N_PROF) ;
                JULD_END:long_name = "Julian day (UTC) of the end of the station relative to REFERENCE_DATE_TIME" ;
                JULD_END:units = "days since 1950-01-01 00:00:00 UTC" ;
                JULD_END:convention = "Relative julian Days with decimal part (as parts of day)" ;
                JULD_END:_FillValue = -9999. ;
        float BATHYMETRY_BEGIN(N_PROF) ;
                BATHYMETRY_BEGIN:long_name = "Bathymetry at the beginning of the station" ;
                BATHYMETRY_BEGIN:units = "meter" ;
                BATHYMETRY_BEGIN:_FillValue = -9999.f ;
        float BATHYMETRY_END(N_PROF) ;
                BATHYMETRY_END:long_name = "Bathymetry at the end of the station" ;
                BATHYMETRY_END:units = "meter" ;
                BATHYMETRY_END:_FillValue = -9999.f ;
        char STATION_PARAMETER(N_PARAM, STRING4) ;
                STATION_PARAMETER:long_name = "Mesured parameter of the station" ;
                STATION_PARAMETER:_FillValue = " " ;
        float PRES(N_PROF, N_LEVELS) ;
                PRES:long_name = "Sea Pressure" ;
                PRES:Sensor_type = "Digiquartz[db]" ;
                PRES:Sensor_serial_number = 76501 ;
                PRES:resp_param = "MJ MESSIAS" ;
                PRES:Organism_resp = "UNIVERSITY EXETER" ;
                PRES:units = "decibar" ;
                PRES:valid_min = 0. ;
                PRES:valid_max = 15000. ;
                PRES:precision = -9999. ;
                PRES:_FillValue = -9999.f ;
        float PRES_QC(N_PROF, N_LEVELS) ;
                PRES_QC:long_name = "Sea Pressure quality flag" ;
                PRES_QC:convention = "1: good, 4: bad, 9: No data" ;
                PRES_QC:_FillValue = -9999.f ;
        float TEMP(N_PROF, N_LEVELS) ;
```

```
		TEMP:long_name = "In situ temperature ITS-90" ;
		TEMP:Sensor_number = 1. ;
		TEMP:Sensor_type = "SBE3" ;
		TEMP:Sensor_serial_number = 3 ;
		TEMP:resp_param = "MJ MESSIAS" ;
		TEMP:Organism_resp = "UNIVERSITY EXETER" ;
		TEMP:units = "degree celsius" ;
		TEMP:valid_min = -2. ;
		TEMP:valid_max = 40. ;
		TEMP:precision = -9999. ;
		TEMP:_FillValue = -9999.f ;
	float TEMP_QC(N_PROF, N_LEVELS) ;
		TEMP_QC:long_name = "In situ temperature quality flag" ;
		TEMP_QC:convention = "1: good, 4: bad, 9: No data" ;
		TEMP_QC:_FillValue = -9999.f ;
	float COND(N_PROF, N_LEVELS) ;
		COND:long_name = "Conductivity" ;
		COND:Sensor_number = 1. ;
		COND:Sensor_type = "SBE4" ;
		COND:Sensor_serial_number = 4 ;
		COND:resp_param = "MJ MESSIAS" ;
		COND:Organism_resp = "UNIVERSITY EXETER" ;
		COND:units = "mS/cm" ;
		COND:valid_min = 0. ;
		COND:valid_max = 60. ;
		COND:precision = -9999. ;
		COND:_FillValue = -9999.f ;
	float COND_QC(N_PROF, N_LEVELS) ;
		COND_QC:long_name = "Conductivity quality flag" ;
		COND_QC:convention = "1: good, 4: bad, 9: No data" ;
		COND_QC:_FillValue = -9999.f ;
	float PSAL(N_PROF, N_LEVELS) ;
		PSAL:long_name = "Practical Salinity PSS78" ;
		PSAL:Sensor_number = 1. ;
		PSAL:Sensor_type = "SBE4" ;
		PSAL:Sensor_serial_number = 4 ;
		PSAL:resp_param = "MJ MESSIAS" ;
		PSAL:Organism_resp = "UNIVERSITY EXETER" ;
		PSAL:units = "psu" ;
		PSAL:valid_min = 0. ;
		PSAL:valid_max = 60. ;
		PSAL:precision = -9999. ;
		PSAL:_FillValue = -9999.f ;
	float PSAL_QC(N_PROF, N_LEVELS) ;
		PSAL_QC:long_name = "Practical Salinity quality flag" ;
		PSAL_QC:convention = "1: good, 4: bad, 9: No data" ;
		PSAL_QC:_FillValue = -9999.f ;
	float OXYL(N_PROF, N_LEVELS) ;
		OXYL:long_name = "Dissolved oxygen concentration" ;
		OXYL:Sensor_number = 1. ;
		OXYL:Sensor_type = "SBE43" ;
		OXYL:Sensor_serial_number = 43 ;
		OXYL:resp_param = "MJ MESSIAS" ;
		OXYL:Organism_resp = "UNIVERSITY EXETER" ;
		OXYL:units = "ml/l" ;
		OXYL:valid_min = 0. ;
		OXYL:valid_max = 40. ;
		OXYL:precision = -9999. ;
		OXYL:_FillValue = -9999.f ;
	float OXYL_QC(N_PROF, N_LEVELS) ;
		OXYL_QC:long_name = "Dissolved oxygen concentration quality flag" ;
		OXYL_QC:convention = "1: good, 4: bad, 9: No data" ;
		OXYL_QC:_FillValue = -9999.f ;
	float OXYK(N_PROF, N_LEVELS) ;
		OXYK:long_name = "Dissolved oxygen concentration" ;
		OXYK:sensor_number = 1. ;
		OXYK:Sensor_type = "SBE43" ;
		OXYK:Sensor_serial_number = 43 ;
		OXYK:resp_param = "MJ MESSIAS" ;
		OXYK:Organism_resp = "UNIVERSITY EXETER" ;
		OXYK:units = "micromol/kg" ;
		OXYK:valid_min = 0. ;
		OXYK:valid_max = 600. ;
		OXYK:precision = -9999. ;
		OXYK:_FillValue = -9999.f ;
```

```
        float OXYK_QC(N_PROF, N_LEVELS) ;
                OXYK_QC:long_name = "Dissolved oxygen concentration quality flag" ;
                OXYK_QC:convention = "1: good, 4: bad, 9: No data" ;
                OXYK_QC:_FillValue = -9999.f ;
        float BOTTLE_NUMBER(N_PROF, N_BOTTLES) ;
                BOTTLE_NUMBER:long_name = "Bottle number" ;
                BOTTLE_NUMBER:_FillValue = -9999.f ;
        char STATION_PARAMETER_CHIM(N_PARAM_CHIM, STRING7) ;
                STATION_PARAMETER_CHIM:long_name = "Mesured chemistry parameter of the station" ;
                STATION_PARAMETER_CHIM:_FillValue = " " ;
        float CHPRESP(N_PROF, N_BOTTLES) ;
                CHPRESP:long_name = "Probe sea pressure" ;
                CHPRESP:resp_param = "NMF" ;
                CHPRESP:Organism_resp = "NMF" ;
                CHPRESP:units = "decibar" ;
                CHPRESP:valid_min = 0. ;
                CHPRESP:valid_max = 15000. ;
                CHPRESP:precision = -9999. ;
                CHPRESP:_FillValue = -9999.f ;
        float CHPRESP_QC(N_PROF, N_BOTTLES) ;
                CHPRESP_QC:long_name = "Probe sea pressure quality flag" ;
                CHPRESP_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
                CHPRESP_QC:_FillValue = -9999.f ;
        float CHTEMPP(N_PROF, N_BOTTLES) ;
                CHTEMPP:long_name = "Probe in situ temperature ITS-90" ;
                CHTEMPP:Sensor_number = 1. ;
                CHTEMPP:Sensor_type = "SBE3" ;
                CHTEMPP:resp_param = "NMF" ;
                CHTEMPP:Organism_resp = "NMF" ;
                CHTEMPP:units = "degree celsius" ;
                CHTEMPP:valid_min = -2. ;
                CHTEMPP:valid_max = 40. ;
                CHTEMPP:precision = -9999. ;
                CHTEMPP:_FillValue = -9999.f ;
        float CHTEMPP_QC(N_PROF, N_BOTTLES) ;
                CHTEMPP_QC:long_name = "Probe in situ temperature ITS-90 quality flag" ;
                CHTEMPP_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
                CHTEMPP_QC:_FillValue = -9999.f ;
        float CHPSALB(N_PROF, N_BOTTLES) ;
                CHPSALB:long_name = "Bottle Practical Salinity PSS78" ;
                CHPSALB:resp_param = "NMF" ;
                CHPSALB:Organism_resp = "NMF" ;
                CHPSALB:units = "psu" ;
                CHPSALB:valid_min = 0. ;
                CHPSALB:valid_max = 60. ;
                CHPSALB:precision = -9999. ;
                CHPSALB:_FillValue = -9999.f ;
        float CHPSALB_QC(N_PROF, N_BOTTLES) ;
                CHPSALB_QC:long_name = "Bottle Practical Salinity PSS78 quality flag" ;
                CHPSALB_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
                CHPSALB_QC:_FillValue = -9999.f ;
        float CHPSALP(N_PROF, N_BOTTLES) ;
                CHPSALP:long_name = "Probe Practical Salinity PSS78" ;
                CHPSALP:Sensor_number = 1. ;
                CHPSALP:Sensor_type = "SBE4" ;
                CHPSALP:resp_param = "MJ MESSIAS" ;
                CHPSALP:Organism_resp = "UNIVERSITY EXETER" ;
                CHPSALP:units = "psu" ;
                CHPSALP:valid_min = 0. ;
                CHPSALP:valid_max = 60. ;
                CHPSALP:precision = -9999. ;
                CHPSALP:_FillValue = -9999.f ;
        float CHPSALP_QC(N_PROF, N_BOTTLES) ;
                CHPSALP_QC:long_name = "Probe Practical Salinity PSS78 quality flag" ;
                CHPSALP_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
                CHPSALP_QC:_FillValue = -9999.f ;
        float CHOXYLB(N_PROF, N_BOTTLES) ;
                CHOXYLB:long_name = "Bottle dissolved oxygen concentration" ;
                CHOXYLB:resp_param = "NMF" ;
                CHOXYLB:Organism_resp = "NMF" ;
                CHOXYLB:units = "ml/l" ;
                CHOXYLB:valid_min = 0. ;
                CHOXYLB:valid_max = 40. ;
                CHOXYLB:precision = -9999. ;
                CHOXYLB:_FillValue = -9999.f ;
```

```
	float CHOXYLB_QC(N_PROF, N_BOTTLES) ;
		CHOXYLB_QC:long_name = "Bottle dissolved oxygen concentration quality flag" ;
		CHOXYLB_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
		CHOXYLB_QC:_FillValue = -9999.f ;
	float CHOXYLP(N_PROF, N_BOTTLES) ;
		CHOXYLP:long_name = "Probe dissolved oxygen concentration" ;
		CHOXYLP:Sensor_number = 1. ;
		CHOXYLP:Sensor_type = "SBE43" ;
		CHOXYLP:resp_param = "MJ MESSIAS" ;
		CHOXYLP:Organism_resp = "UNIVERSITY EXETER" ;
		CHOXYLP:units = "ml/l" ;
		CHOXYLP:valid_min = 0. ;
		CHOXYLP:valid_max = 40. ;
		CHOXYLP:precision = -9999. ;
		CHOXYLP:_FillValue = -9999.f ;
	float CHOXYLP_QC(N_PROF, N_BOTTLES) ;
		CHOXYLP_QC:long_name = "Bottle dissolved oxygen concentration quality flag" ;
		CHOXYLP_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
		CHOXYLP_QC:_FillValue = -9999.f ;
	float CHOXYKB(N_PROF, N_BOTTLES) ;
		CHOXYKB:long_name = "Bottle dissolved oxygen concentration" ;
		CHOXYKB:resp_param = "NMF" ;
		CHOXYKB:Organism_resp = "NMF" ;
		CHOXYKB:units = "micromol/kg" ;
		CHOXYKB:valid_min = 0. ;
		CHOXYKB:valid_max = 600. ;
		CHOXYKB:precision = -9999. ;
		CHOXYKB:_FillValue = -9999.f ;
	float CHOXYKB_QC(N_PROF, N_BOTTLES) ;
		CHOXYKB_QC:long_name = "Bottle dissolved oxygen concentration quality flag" ;
		CHOXYKB_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
		CHOXYKB_QC:_FillValue = -9999.f ;
	float CHOXYKP(N_PROF, N_BOTTLES) ;
		CHOXYKP:long_name = "Probe dissolved oxygen concentration" ;
		CHOXYKP:Sensor_number = 1. ;
		CHOXYKP:Sensor_type = "SBE43" ;
		CHOXYKP:resp_param = "MJ MESSIAS" ;
		CHOXYKP:Organism_resp = "UNIVERSITY EXETER" ;
		CHOXYKP:units = "micromol/kg" ;
		CHOXYKP:valid_min = 0. ;
		CHOXYKP:valid_max = 600. ;
		CHOXYKP:precision = -9999. ;
		CHOXYKP:_FillValue = -9999.f ;
	float CHOXYKP_QC(N_PROF, N_BOTTLES) ;
		CHOXYKP_QC:long_name = "Probe dissolved oxygen concentration quality flag" ;
		CHOXYKP_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
		CHOXYKP_QC:_FillValue = -9999.f ;
	float CHTMPOB(N_PROF, N_BOTTLES) ;
		CHTMPOB:long_name = "Oxygen sample temperature ITS-90" ;
		CHTMPOB:resp_param = "NMF" ;
		CHTMPOB:Organism_resp = "NMF" ;
		CHTMPOB:units = "degree celsius" ;
		CHTMPOB:valid_min = -2. ;
		CHTMPOB:valid_max = 40. ;
		CHTMPOB:precision = -9999. ;
		CHTMPOB:_FillValue = -9999.f ;
	float CHTMPOB_QC(N_PROF, N_BOTTLES) ;
		CHTMPOB_QC:long_name = "Oxygen sample temperature ITS-90 quality flag" ;
		CHTMPOB_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No data" ;
		CHTMPOB_QC:_FillValue = -9999.f ;

// global attributes:
		:ORIGINAL_CLI = "blt2d014_cli.nc" ;
		:SHIP_NAME = "RRS DISCOVERY" ;
		:SHIP_WMO_ID = "" ;
		:PI_NAME = "MJ MESSIAS" ;
		:PI_ORGANISM = "EXETER UNIVERSITY" ;
		:CRUISE_NAME = "BLT2" ;
		:STATION_NUMBER = 14. ;
		:LEG_NUMBER = "1" ;
		:DIRECTION = "d" ;
		:DATA_PROCESSING_ORGANISM = "LPO/IFREMER" ;
		:PROBE_TYPE = "SBE 911" ;
		:PROBE_NUMBER = 76501 ;
		:REFERENCE_DATE_TIME = "19500101000000" ;
```

```
                    :DATE_CREATION = "20220201120644" ;
                    :LAST_UPDATE = "20220201120644" ;
                    :COORD_SYSTEM = "GEOGRAPHICAL-WGS84" ;
                    :BOTTLE_VOL = "12L" ;
                    :ROSETTE_TYPE = "SEABIRD" ;
                    :PINGER = "y" ;
                    :SAMPLING_MODE = "r" ;
                    :DATA_MODE = "calibrated" ;
                    :SPUN_LINE = -9. ;
                    :DIST_PROBE_BOTTOM = 5. ;
                    :PRESCRIBED_CTD_VELOCITY = "1 m/s" ;
                    :SOFTWARE_VERSION = " CADHYAC 3.1" ;
                    :COMMENTS = " " ;
}
```

3.4.2 STRUCTURE OF MATLAB FILES

Each matlab file (1 per station) contains the following data:

Metadata structure:

STATION_NUMBER
LATITUDE_BEGIN
LATITUDE_END
LONGITUDE_BEGIN
LONGITUDE_END
STATION_DATE_BEGIN
STATION_DATE_END
SHIP
PI
PI_organism
cruise
probe
name:
{'pres0, pressure for primary sensors (db)'}
{'pres1, pressure for secondary sensors (db)'}
{'temp0, primary temperature ITS-90 (°C)'}
{'temp1, secondary temperature ITS-90 (°C)'}
{'cond0, primary conductivity (mS/cm)' }
{'cond1, secondary conductivity (mS/cm)'}
{'psal0, primary salinity PSS-78 (psu)'}
{'psal1, secondary salinity PSS-78 (psu)'}
{'oxyl0, dissolved oxygen calculated from primary sensors (ml/l)'}
{'oxyl1, dissolved oxygen calculated from secondary sensors (ml/l)'}
{'oxyk0, dissolved oxygen calculated from primary sensors (micromol/kg)'}
{'oxyk1, dissolved oxygen calculated from secondary sensors (micromol/kg)'}
{'chemical_psal, chemical bottle salinity (psu)'}
{'chemical_oxyl, chemical bottle dissolved oxygen (ml/l)'}
{'chemical_oxyk, chemical bottle dissolved oxygen (micromol/kg)'}
{'chemical_tempoxy, oxygen sample temperature (Â°C)'}
{'qc, quality flag, 1: good, 3: doubtful, 4: bad, 6 : uncalibrated, 9: No data'}

The data are in the following variables:

pres0_down
pres0_qc_down
temp0_down
temp0_qc_down
cond0_down
cond0_qc_down
psal0_down
psal0_qc_down
oxyl0_down
oxyl0_qc_down
oxyk0_down
oxyk0_qc_down
pres0_up
pres0_qc_up
temp0_up
temp0_qc_up
cond0_up

```
cond0_qc_up
psal0_up
psal0_qc_up
oxyl0_up
oxyl0_qc_up
oxyk0_up
oxyk0_qc_up
pres1_down
pres1_qc_down
temp1_down
temp1_qc_down
cond1_down
cond1_qc_down
psal1_down
psal1_qc_down
oxyl1_down
oxyl1_qc_down
oxyk1_down
oxyk1_qc_down
pres1_up
pres1_qc_up
temp1_up
temp1_qc_up
cond1_up
cond1_qc_up
psal1_up
psal1_qc_up
oxyl1_up
oxyl1_qc_up
oxyk1_up
oxyk1_qc_up
pres_bottle
pres_qc_bottle
temp0_bottle
temp0_qc_bottle
psal0_bottle
psal0_qc_bottle
oxyl0_bottle
oxyl0_qc_bottle
oxyk0_bottle
oxyk0_qc_bottle
temp1_bottle
temp1_qc_bottle
psal1_bottle
psal1_qc_bottle
oxyl1_bottle
oxyl1_qc_bottle
oxyk1_bottle
oxyk1_qc_bottle
chemical_psal_bottle
chemical_psal_qc_bottle
chemical_oxyl_bottle
chemical_oxyl_qc_bottle
chemical_oxyk_bottle
chemical_oxyk_qc_bottle
chemical_tempoxy_bottle
chemical_tempoxy_qc_bottle
```

4 TRIFLUOROMETHYL SULPHUR PENTAFLUORIDE (CF_3SF_5) MEASUREMENTS

Marie-Jose Messias, Herle Mercier, Jack Hughes, Thierry Reynaud, Kaylim Reddy, Emanuela Piga.

The released tracer (CF_3SF_5) dispersion is measured from discrete sample collected by the CTD-rosette. The analysis was performed in-situ in the Exeter laboratory container installed on the port side of the aft deck.

4.1 SAMPLE COLLECTION

Seawater samples were collected from the 24, 10 litre niskin bottles mounted on the stainless steel CTD frame provided by NMF. Samples were transferred into 500ml ground-glass stoppered reagent bottles. The transfer was done by using sterile Tygon tubing in order to fill the bottles from the bottom to the top, overflowing twice in order to remove any water that may have been exposed to the atmosphere. After sampling, all samples were immediately stored in the Controlled Temperature (CT) laboratory at a constant 4°C to prevent the sample from heating up and degassing before analysis could be completed

4.2 TRACER ANALYSIS TECHNIQUE

Sample analysis was performed as soon as possible by a purge-and-trap gas chromatographic method. The carrier gas – oxygen-free Nitrogen (N_2) – was cleaned by a series of purifying hydrocarbon, nitrogen and oxygen traps. The water sample was introduced into the system by applying N_2 pressure to the top of the sample bottle, forcing the water to flow through and fill a calibrated volume. The measured volume of seawater was then transferred to a purge-and-trap system, entering a sparge tower under vacuum. The water was sparged with an N_2 flow at 120ml/min for 4 minutes and trapped at -110°C in a Unibeads 3S trap (two inches of 1/8 inch diameter tubing) immersed in the headspace of liquid nitrogen.

The purge and trap system were interfaced to an Agilent 6890N gas chromatograph (GC) with an Electron Capture Detector (microECD). The GC was set up similarly to that described by

[Smethie et al., 2000]. The traps were heated to 110°C and injected into the GC. The CF_3SF_5 separation was achieved using a 1m Porasil B packed pre-column and a 1.5m CarbographAC main column. A 6-inch molecular sieve post column was used to remove N2O. The GC N2 carrier flow rate was 30ml/min, the GC oven temperature was at 110°C and the MicroECD temperature was at 310°C.

4.3 CALIBRATION, DETECTION LIMIT AND PRECISION METHODOLOGY

The CF_3SF_5 concentrations in water are calibrated using external gaseous standards of various concentrations to cover the large range of tracer signals (figure 8). We used working standards supplied by NOAA (Brad Hall, March 2017, CF_3SF_5 at 47.9ppt) and the University of East Anglia (UEA, Andrew Manning, Agust 2011, CF_3SF_5 at 12ppt, 215ppt and 4.6*10^6ppt) respectively. The NOAA standard is clean air enriched in CF_3SF_5 inside a 29L Aculife-treated aluminium cylinder. The UEA standard in Nitrogen enriched in CF_3SF_5 inside 20L steel cylinders. The CF_3SF_5 concentration of the UEA standard was estimated by gravimetry at UEA and intercalibrated with the NOAA standard with our instrument. CF_3SF_5 concentrations in air and seawater samples are determined by fitting their chromatographic peak area to multipoint calibration curves, made by injecting known volumes of gas from the working standard to the analytical system. The calibration curves were made by injections of different volumes (0.1, 0.23, 0.3, 0.5, 1, 2, 3, 5, 8 ml) of the working standards.

The changes in the sensitivity of the system were tracker by injections of a fixed volume of standard gas in between stations and used to adjust the calibration curves respectively. The standard repeatability was 2% for the tracer CF_3SF_5. Blank or ‘contamination’ are estimated from the analysis of tracer free water obtained by sparging a water sample with Nitrogen and subtracted from the measured concentrations. Sparging efficiency is determined by successive resparges of a single sample until no further compound could be detected. The blank for SF_3SF_5 was zero. The results of these protocols will be applied during the post-cruise data processing required to calculate concentrations accurately, assign uncertainties and perform the data quality control.

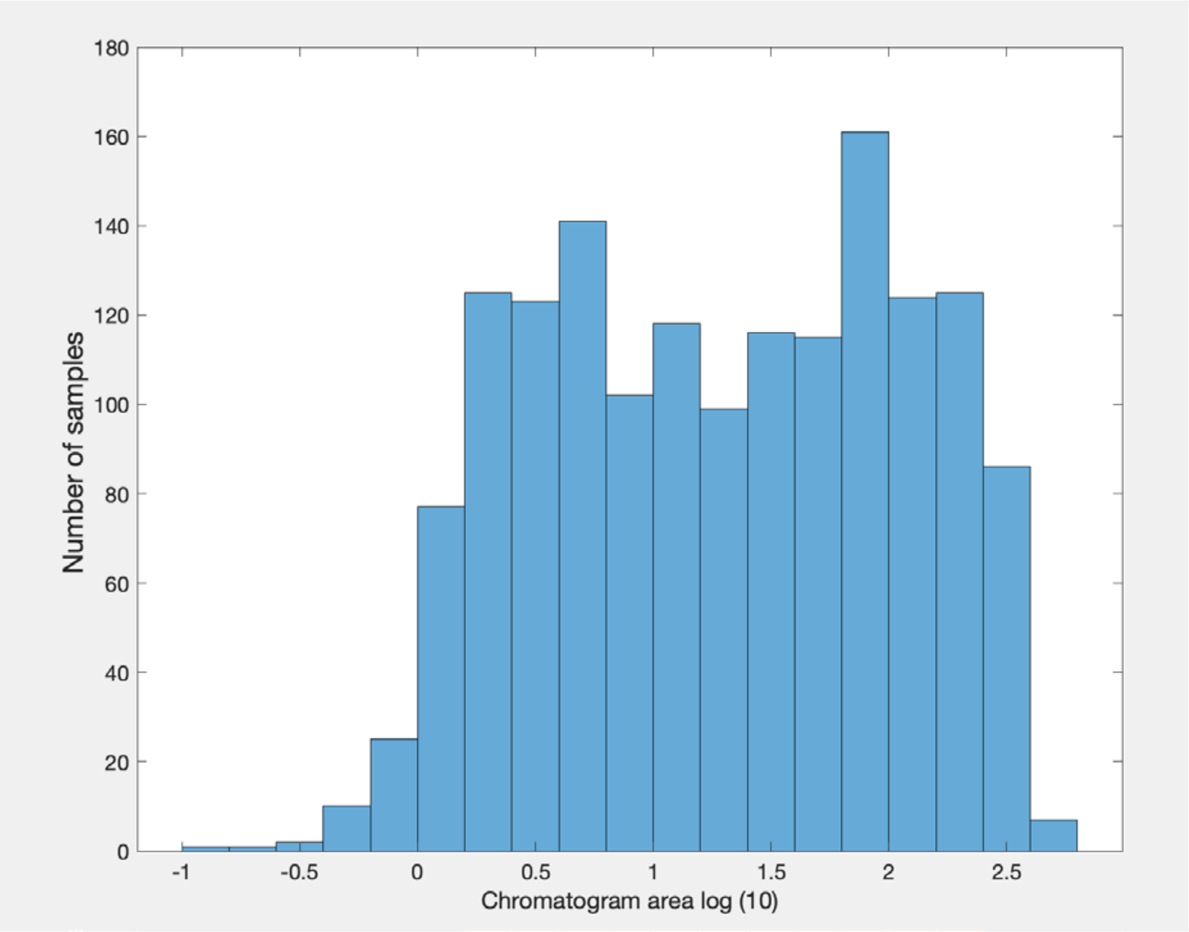


Figure 8: Distribution of chromatographic peak areas of all analysed seawater samples.

5 MOORING OPERATIONS

5.1 MODULAR ACOUSTIC VELOCITY SENSOR (MAVS) MOORING

Kurt Polzin, Andrew Davies, Gunnar Voet

Two short (300 m) MAVS moorings (MAVS-1 and MAVS-2) were deployed during BLT1. Each mooring consisted of 8 custom MAVS travel time sensors, O(80) self contained temperature recorders, a down-looking 75 kHz ADCP mounted on the upper floatation sphere and one or two CTDs. Four MAT-1 loggers were mounted with the MAVS sensors on MAVS 2. MAVS-1 was deployed in the early afternoon of July 6th, MAVS-2 was similarly deployed on July 7th. Post-deployment triangulation located MAVS-1 at 1612m and MAVS-2 at 1466m water depth.

MAVS1 and MAVS2 were recovered on October 5 and 4. All instruments were initially interrogated on 06 October 2021.

The MAVS current meters that were used on the MAVS 1 and MAVS 2 moorings generally performed well on their deployment and had a very good data return. Of the sixteen that were deployed, two had flooded and the majority of the others ran for the duration of the deployment before exhausting their batteries. When the units were first evaluated on deck prior to communications, corrosion was noticed on some of the housings as well as cables and bulkhead fittings. Even though the instruments had run through their full deployment six of them showed signs of water intrusion through bulkhead fittings causing flooding and corrosion. One MAVS (s/n 10290) leaked; the electronics were damaged with heavy salt buildup, and data were downloaded from the deployment. The leak appeared to have been through the RBR bulkhead connector on the end cap which was found to be loose. The pressure case was found to have been approximately one third full of seawater. Another MAVS (s/n 10298) flooded through the communication/power port connection and had about ¼" of salt residue at the sensor end. The compact flash cards for both instruments were readable and showed only 1-2 days of data before failure.

Of the other four that leaked the water intrusion was minor, the only sign being a few droplets on the interior of the pressure case or on the aluminium plate that supports a Teensy microcontroller. All of the bulkhead fittings were found to be tight so one explanation would be the water came in along the pins of the connectors. The water resulted in some failures, though none of them uniform. Two of the RBRs failed likely due to the Teensie getting wet, the other two had no failures. Some of the other instruments showed others failures even without water intrusion. Some of the RBRs failed to report and further testing revealed that the cause was likely the Teensie failing.

At the turnaround, all of the CF2 units were fitted with a larger 4GB compact flash card, which was formatted for each instrument. Prior to redeployment all of the MAVS/RBR units were tested in a 55-gallon drum, which was filled with water and lined with foam. The instruments were then powered by an external source, interrogated, bench tested, and deployed for ten minutes. This test would determine the quality of the path velocities, sensor performance, and would verify instrument reporting. Testing revealed a few units had issues with one or more of their paths.

A new Fast8 RBR was used to double-check any thermistors that were not reporting. All of the RBRs that are returned to WHOI will be sent out for repairs and calibration to verify that they are still working. MAVs returning to WHOI will be sent out to Nobska for further evaluation. The MAVS that were redeployed instead used a standalone Fast8 for temperature readings. The alkaline battery packs used in the external cases were exchanged with lithium for a longer duration deployment. When this work was done, all alkaline pack voltages were checked in the lab.

While all of the recovered MAVS and batteries were serviced and tested, attempts were made to keep the transducers wet. The sensors were sprayed down with fresh water and promptly wrapped up with plastic wrap to contain the moisture around them.

The MAVS1 and MAVS2 moorings deployed during BLT1 were redeployed as MAVS3 and MAVS4 on October 21 during BLT2. Instrumentation for the BLT2 MAVS 3 and 4 moorings consisted of 12 CF2 MAVS current meters and RBR rapid temperature sensor units with external battery packs, 2 TT8 MAVS, complemented with an array of temperature sensors fastened along the mooring wire. Due to some sensor issues from the previous deployment (flooding, component failures, etc.) and the use of the TT8's, five standalone RBR thermistors were used to monitor the temperature in close proximity to the current sensor. The CF2 instrumentation was programmed just prior to deployment with a start date of 21 October 2021 and instructions to sample at 5Hz for 182 days ending at 12:00 23 April 2022. The deployment time frame was the same for the TT8s with sample rate of 2.5 Hz. In order to set the correct UTC time, the laptop was synced with the Discovery's shipboard clock, which is continuously updated via GPS signal. Figure 9 below gives an overview of the instrumentation used on the MAVS 3 and 4 moorings according to the engineered design.

Greater detail about performance issues will be contained in an end-of-project report that encompasses BLT1-BLT2-BLT3.

5.2 MOORED PROFILER (MP) AND THERMISTOR CHAIN (TCHAIN) MOORINGS

Gunnar Voet, Spencer Kawamoto

5.2.1 MOORINGS

The goal of the mooring team was to recover and redeploy moorings initially deployed during BLT1 in summer 2021. Mooring recoveries were carried out in the afternoon of October 4th (MAVS2) and on October 5th (MAVS1 and MP2). It was decided to leave the TCHAIN mooring in the water and to build the new array around it, thereby reducing the number of mooring operations in weather conditions that were beyond what was deemed safe and workable for a large part of the cruise. The moorings were redeployed in a cross-canyon configuration on October 22nd (MP3, MAVS3, MAVS4).

5.2.2 INSTRUMENT PERFORMANCE

The moored profiler on mooring MP2 worked for the full deployment period, returning profiles of velocity and stratification every 80 minutes. The RDI Longranger 75kHz ADCPs mounted in the top floats of MAVS1, MAVS2, and MP2, worked as expected.

All thermistors were recovered and delivered mostly full time series at 0.5, 1, or 2Hz resolution, depending on instrument type. A number of RBR Solo Ti sensors stopped sampling early due to replenished batteries, before mooring recoveries, in late September. These instruments all came from the same batch of newly delivered sensors. The reason for battery replenishment is still under investigation. The units had been delivered directly from RBR with Tadiran lithium

AA batteries pre-installed. We redeployed the thermistors with Saft lithium AA batteries and will know more about their performance next summer.

5.3 MOORING DIAGRAMS

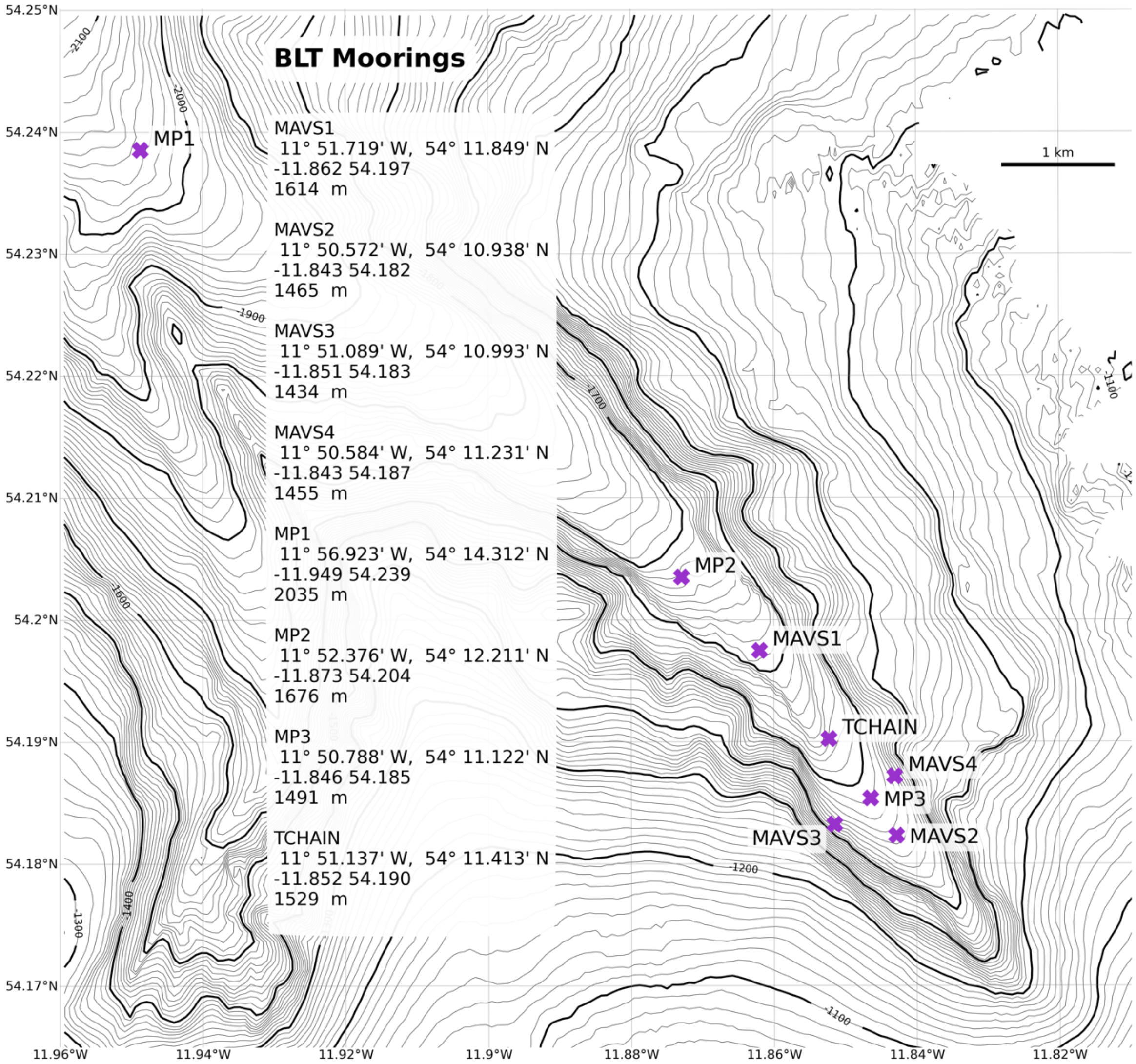
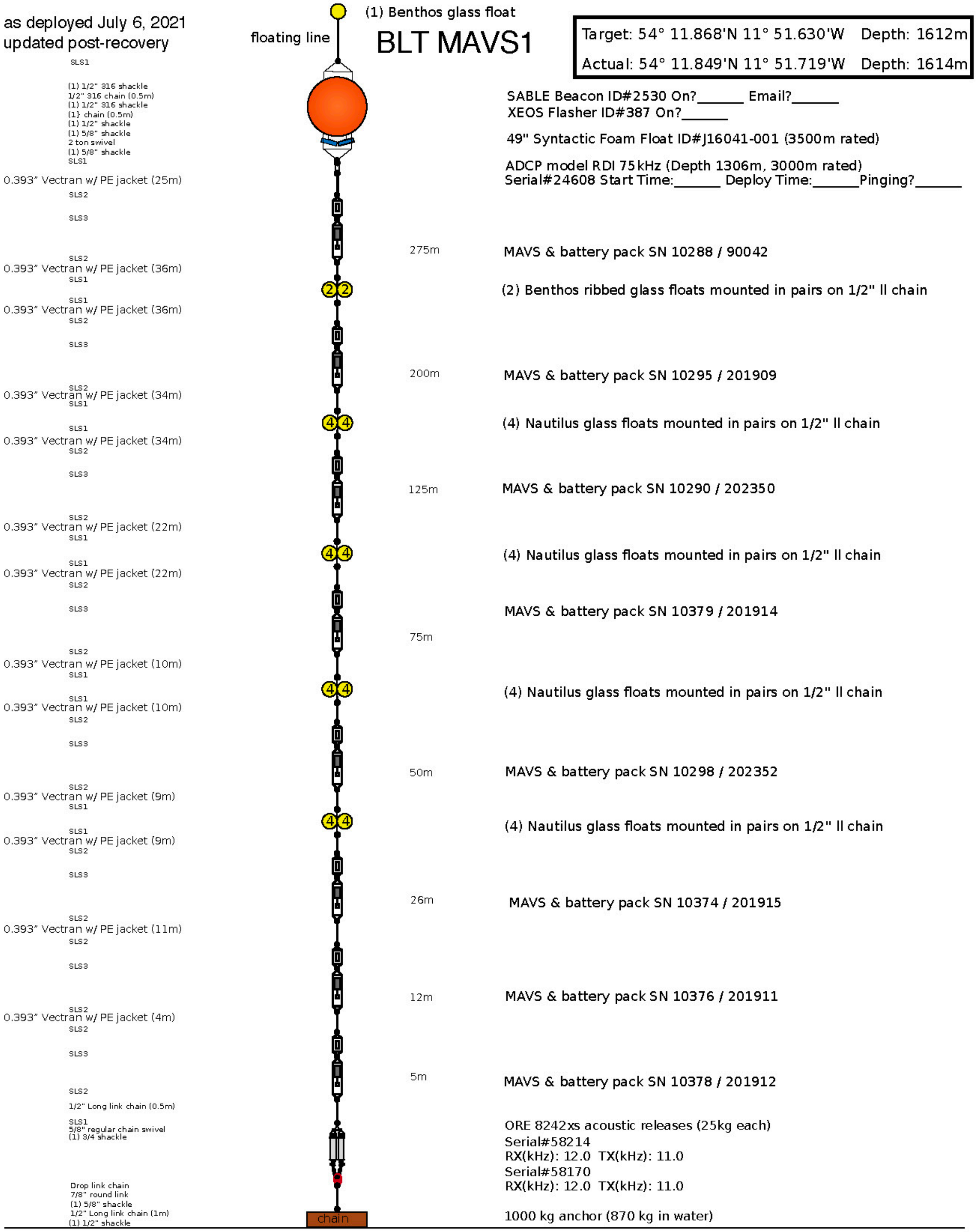


Figure 9: Location of BLT1 and BLT2 mooring sites.

as deployed July 6, 2021
updated post-recovery

BLT MAVS1

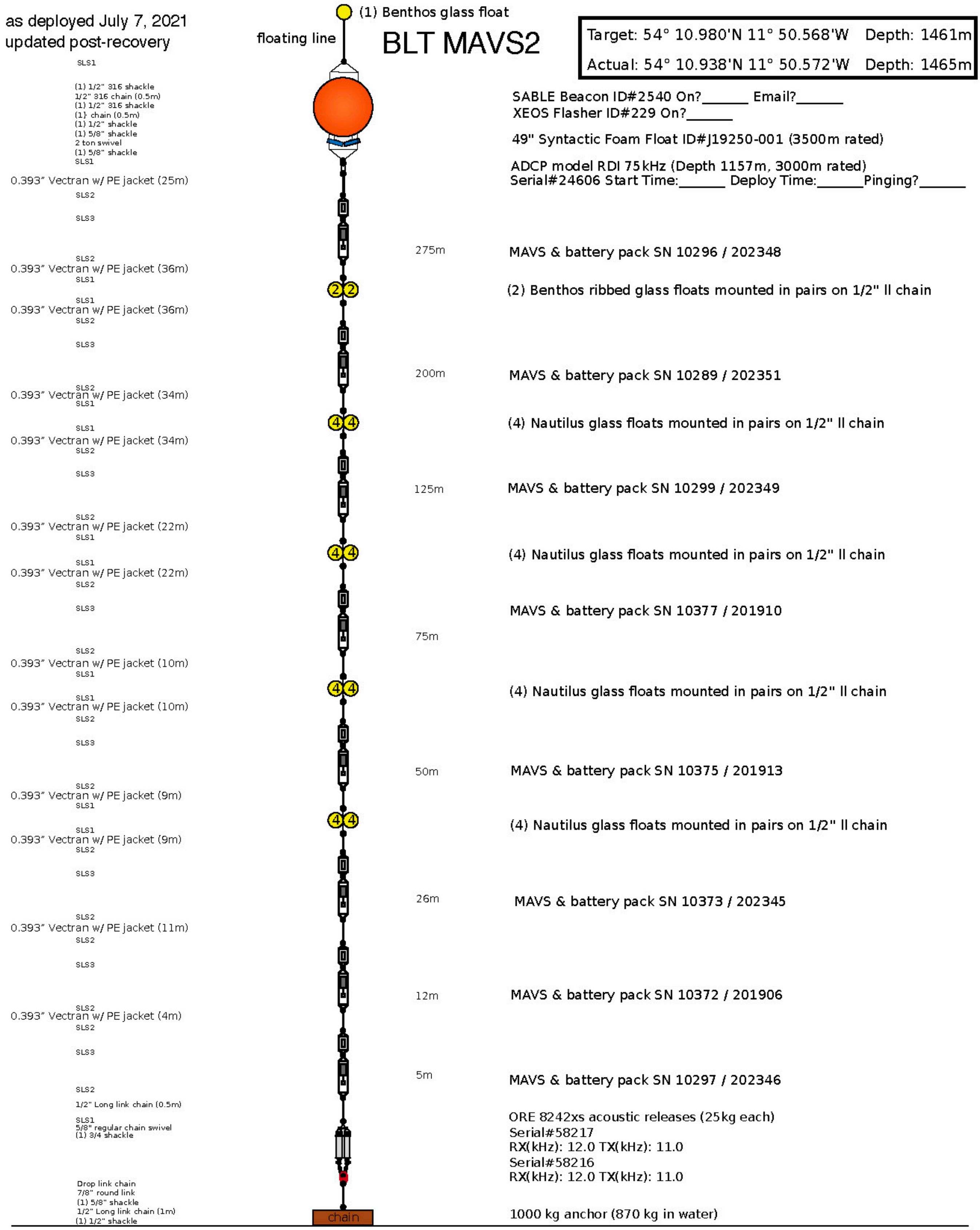
Target: 54° 11.868'N 11° 51.630'W Depth: 1612m
Actual: 54° 11.849'N 11° 51.719'W Depth: 1614m



SLS1: 1/2" shackle - 5/8" sling link - 1/2" shackle
SLS2: 1/2" shackle - 5/8" sling link - 1/2" shackle - 5/8" shackle
SLS3: 5/8" shackle - 5/8" sling link - 5/8" shackle

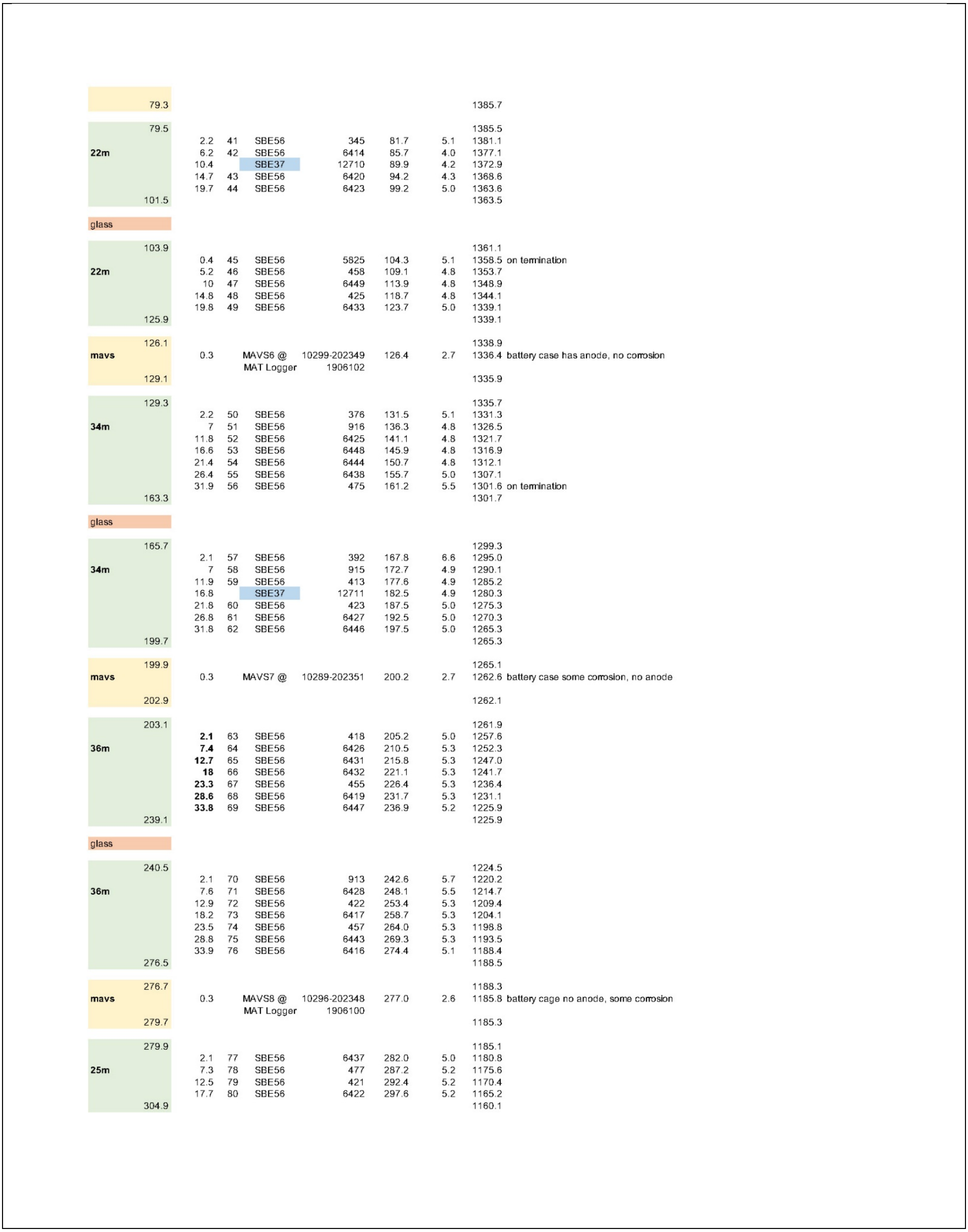
wire [from - to]	distance on line	T #	Type	SN	height	spacing	depth	comments
							1614.0	
releases		1	Solo Ti	72156	2.7	2.7	1611.3	
3.2								
4.4							1609.6	
mavs	0.3		MAVS1 @	10378-201912	4.7	2.0	1609.3	
	2	2	Solo Ti	72185	6.4	1.7	1607.6	on battery cage
7.4							1606.6	
7.7							1606.3	
	0.1	3	Solo Ti	207288	7.8	1.4	1606.2	on termination
4m	0.9	4	Solo Ti	207376	8.6	0.8	1605.4	on termination
	1.7	5	Solo Ti	207375	9.4	0.8	1604.6	on termination
	2.5	6	Solo Ti	207308	10.2	0.8	1603.8	on termination
	3.5	7	Solo Ti	207301	11.2	1.0	1602.8	on termination
11.7							1602.3	
12							1602.0	
mavs	0.3		MAVS2 @	10376-201911	12.3	1.1	1601.7	
	2	8	Solo Ti	72197	14.0	1.7	1600.0	on battery cage
15							1599.0	
15.2							1598.8	
	0.1	9	Solo Ti	207306	15.3	1.3	1598.7	on termination
11m	1.1	10	Solo Ti	72212	16.3	1.0	1597.7	on termination
	2.2	11	Solo Ti	72148	17.4	1.1	1596.6	
	3.3	12	Solo Ti	72171	18.5	1.1	1595.5	
	4.4	13	Solo Ti	72213	19.6	1.1	1594.4	
	5.5	14	Solo Ti	72161	20.7	1.1	1593.3	
	6.6	15	Solo Ti	72144	21.8	1.1	1592.2	
	7.7	16	Solo Ti	72198	22.9	1.1	1591.1	
	8.8	17	Solo Ti	72218	24.0	1.1	1590.0	
	9.9	18	Solo Ti	72154	25.1	1.1	1588.9	
	10.9	19	Solo Ti	72189	26.1	1.0	1587.9	on termination
26.2							1587.8	
26.5							1587.5	
mavs	0.3		MAVS3 @	10374-201915	26.8	0.7	1587.2	
	2	20	Solo Ti	72176	28.5	1.7	1585.5	on battery cage
29.5							1584.5	
29.7							1584.3	
	0.1	21	Solo Ti	72211	29.8	1.3	1584.2	on termination
9m	1.2	22	Solo Ti	72187	30.9	1.1	1583.1	on termination
	2.3	23	Solo Ti	72207	32.0	1.1	1582.0	
	3.4	24	Solo Ti	72186	33.1	1.1	1580.9	
	4.5	25	Solo Ti	72216	34.2	1.1	1579.8	
	5.6	26	Solo Ti	72157	35.3	1.1	1578.7	
	6.7	27	Solo Ti	72162	36.4	1.1	1577.6	
	7.8	28	Solo Ti	72210	37.5	1.1	1576.5	
	8.9	29	Solo Ti	72181	38.6	1.1	1575.4	on termination
38.7							1575.3	
glass								
41.2							1572.8	
	0.1	30	Solo Ti	72188	41.3	2.7	1572.7	on termination
9m	1.7	31	Solo Ti	72183	42.9	1.6	1571.1	on termination
	3.5	32	Solo Ti	72158	44.7	1.8	1569.3	
	5.3	33	Solo Ti	72217	46.5	1.8	1567.5	
	7.3	34	Solo Ti	72163	48.5	2.0	1565.5	on termination
50.2							1563.8	no mark for 35
50.4							1563.6	
mavs	0.3		MAVS4 @	10298-202352	50.7	2.2	1563.3	
53.4							1560.6	
53.6							1560.4	
	0.1	36	Solo Ti	72170	53.7	3.0	1560.3	on termination
10m	2.2	37	Solo Ti	72173	55.8	2.1	1558.2	
	4.3	38	Solo Ti	72208	57.9	2.1	1556.1	
	6.4	39	Solo Ti	72178	60.0	2.1	1554.0	
	9.9	40	Solo Ti	72180	63.5	3.5	1550.5	on termination
63.6							1550.4	
glass								
66.1							1547.9	
	1.6	41	Solo Ti	72164	67.7	4.2	1546.3	on termination
10m	4.6	42	Solo Ti	72196	70.7	3.0	1543.3	

		7.6	43	Solo Ti	72214	73.7	3.0	1540.3	
	76.1							1537.9	
	76.3							1537.7	
mavs		0.3		MAVS5 @	10379-201914	76.6	2.9	1537.4	
	79.3							1534.7	
	79.5							1534.5	
		2.2	44	Solo Ti	72168	81.7	5.1	1532.3	
22m		7.2	45	Solo Ti	72215	86.7	5.0	1527.3	
		12.7	46	Solo Ti	72219	92.2	5.5	1521.8	
		18.2	47	Solo Ti	72209	97.7	5.5	1516.3	
	101.5							1512.5	
glass									
	103.9							1510.1	
		0.1	48	Solo Ti	72159	104.0	6.3	1510.0	on termination
22m		5.8	49	Solo Ti	72167	109.7	5.7	1504.3	
		11.8	50	Solo Ti	72172	115.7	6.0	1498.3	
		17.8	51	Solo Ti	72147	121.7	6.0	1492.3	
	125.9							1488.1	
	126.1							1487.9	
mavs		0.3		MAVS6 @	10290-202350	126.4	4.7	1487.6	corrosion on end cap
	129.1							1484.9	
	129.3							1484.7	
		3.4	52	Solo Ti	72149	132.7	6.3	1481.3	
34m		9.4	53	Solo	201847	138.7	6.0	1475.3	
		15.4	54	Solo	201848	144.7	6.0	1469.3	
		21.4		SBE37	12709	150.7	6.0	1463.3	
		27.4	55	Solo	201852	156.7	6.0	1457.3	
		33.4	56	Solo	201846	162.7	6.0	1451.3	on termination
	163.3							1450.7	
glass									
	165.7							1448.3	
		3.1	57	Solo	201845	168.8	6.1	1445.2	
34m		9.1	58	Solo	201844	174.8	6.0	1439.2	
		15.1	59	SBE56	6429	180.8	6.0	1433.2	
		21.1	60	Solo	201851	186.8	6.0	1427.2	
		27.1	61	SBE56	393	192.8	6.0	1421.2	
	199.7							1414.3	
	199.9							1414.1	
mavs		0.3		MAVS7 @	10295-201909	200.2	7.4	1413.8	some corrosion on pressure case
	202.9							1411.1	
	203.1							1410.9	
		3.7	62	Solo	201843	206.8	6.6	1407.2	
36m		9.7	63	SBE56	395	212.8	6.0	1401.2	
		15.7	64	Solo	201849	218.8	6.0	1395.2	
		21.7	65	SBE56	6418	224.8	6.0	1389.2	
		27.7	66	Solo	201850	230.8	6.0	1383.2	
		33.7	67	SBE56	6413	236.8	6.0	1377.2	
	239.1							1374.9	
glass									
	240.5							1373.5	
		2.3	68	Solo	102970	242.8	6.0	1371.2	
36m		8.3	69	SBE56	6441	248.8	6.0	1365.2	
		14.3	70	Solo	102973	254.8	6.0	1359.2	
		20.3	71	SBE56	466	260.8	6.0	1353.2	
		26.3	72	Solo	102977	266.8	6.0	1347.2	
		32.3	73	SBE56	424	272.8	6.0	1341.2	
	276.5							1337.5	
	276.7							1337.3	
mavs		0.3		MAVS8 @	10288-90042	277.0	4.2	1337.0	
	279.7							1334.3	
	279.9							1334.1	
		4	74	Solo	102982	283.9	6.9	1330.1	
25m		10	75	SBE56	416	289.9	6.0	1324.1	
		16	76	Solo	102969	295.9	6.0	1318.1	
		22	77	SBE56	6415	301.9	6.0	1312.1	
	304.9							1309.1	



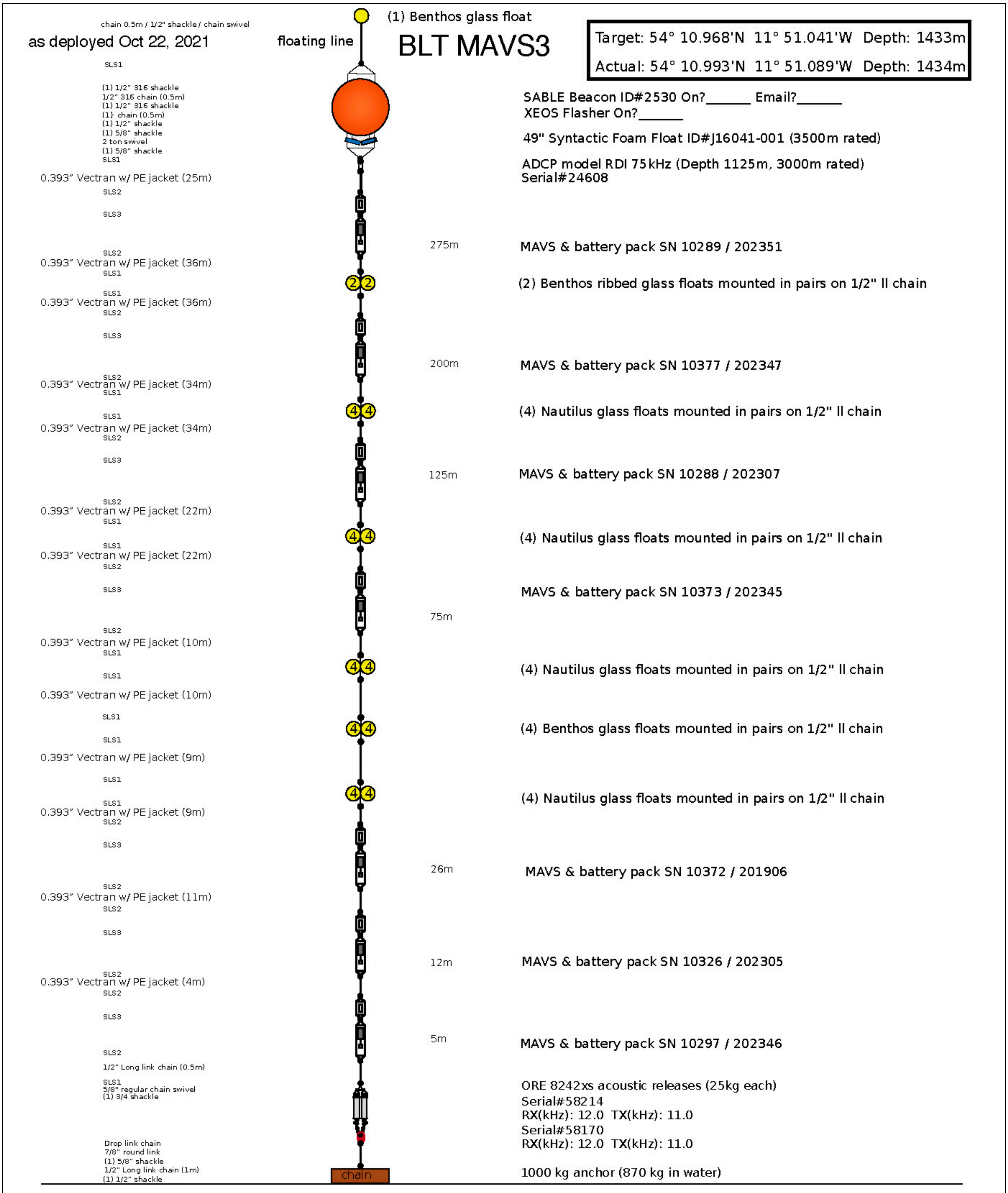
SLS1: 1/2" shackle - 5/8" sling link - 1/2" shackle
SLS2: 1/2" shackle - 5/8" sling link - 1/2" shackle - 5/8" shackle
SLS3: 5/8" shackle - 5/8" sling link - 5/8" shackle

wire [from - to]	distance on line	T #	Type	SN	height	spacing	depth	comments
							1465.0	
releases		1	Solo Ti	207378	2.7		1462.3	
3.2							1461.8	
4.4							1460.6	
mavs	0.3		MAVS1 @	10297-202346	4.7	2.0	1460.3	
	2	2	Solo Ti	207309	6.4	1.7	1458.6	on battery cage
7.4							1457.6	
7.7							1457.3	
	0.3	3	Solo Ti	207304	8.0	1.6	1457.0	on termination
4m	1.3	4	Solo Ti	207303	9.0	1.0	1456.0	on termination
	2.3	5	Solo Ti	207382	10.0	1.0	1455.0	on termination
	3.3	6	Solo Ti	207305	11.0	1.0	1454.0	on termination
11.7							1453.3	
12							1453.0	
mavs	0.3		MAVS2 @	10372-201906	12.3	1.3	1452.7	
	2	7	Solo Ti	207380	14.0	1.7	1451.0	on battery cage
15			MAT Logger	1906103			1450.0	
15.2							1449.8	
	0.3	8	Solo Ti	207379	15.5	1.5	1449.5	on termination
11m	1.5	9	Solo Ti	207381	16.7	1.2	1448.3	on termination
	2.6	10	Solo Ti	207307	17.8	1.1	1447.2	
	3.7	11	Solo Ti	207289	18.9	1.1	1446.1	
	4.8	12	Solo Ti	207300	20.0	1.1	1445.0	
	5.9	13	Solo Ti	207286	21.1	1.1	1443.9	
	7	14	Solo Ti	207302	22.2	1.1	1442.8	
	8.1	15	Solo Ti	207377	23.3	1.1	1441.7	
	9.2	16	Solo Ti	207383	24.4	1.1	1440.6	on termination
	10.4	17	Solo Ti	207287	25.6	1.2	1439.4	on termination
26.2							1438.8	
26.5							1438.5	
mavs	0.3		MAVS3 @	10373-202345	26.8	1.2	1438.2	
	2	18	Solo Ti	72191	28.5	1.7	1436.5	on battery cage
29.5							1435.5	
29.7							1435.3	
	0.3	19	Solo	102983	30.0	1.5	1435.0	on termination
9m	1.4	20	Solo	102984	31.1	1.1	1433.9	on termination
	2.5	21	Solo	102978	32.2	1.1	1432.8	
	3.7	22	Solo	102975	33.4	1.2	1431.6	
	4.9	23	Solo	102986	34.6	1.2	1430.4	
	6.1	24	Solo	102981	35.8	1.2	1429.2	
	7.3	25	Solo	102972	37.0	1.2	1428.0	on termination
	8.5	26	Solo	102974	38.2	1.2	1426.8	on termination
38.7							1426.3	
glass								
41.2							1423.8	
	0.3	27	Solo	102971	41.5	3.3	1423.5	on termination
9m	1.9	28	Solo	102980	43.1	1.6	1421.9	on termination
	3.6	29	Solo	102979	44.8	1.7	1420.2	
	5.4	30	Solo	102987	46.6	1.8	1418.4	
	7.3	31	Solo	102976	48.5	1.9	1416.5	on termination
50.2							1414.8	
50.4							1414.6	
mavs	0.3		MAVS4 @	10375-201913	50.7	2.2	1414.3	
			MAT Logger	1906101				
53.4							1411.6	
53.6							1411.4	
	0.1	32	Solo	102985	53.7	3.0	1411.3	on termination
10m	2.2	33	Solo	102968	55.8	2.1	1409.2	
	4.3	34	SBE56	6439	57.9	2.1	1407.1	
	6.4	35	SBE56	6445	60.0	2.1	1405.0	
	9.9	36	SBE56	6424	63.5	3.5	1401.5	on termination, bent thermistor
63.6							1401.4	
glass								
66.1							1398.9	
	1.6	37	SBE56	6435	67.7	4.2	1397.3	on termination
10m	3.6	38	SBE56	6436	69.7	2.0	1395.3	
	5.8	39	SBE56	5462	71.9	2.2	1393.1	
	8	40	SBE56	6430	74.1	2.2	1390.9	on termination
76.1							1388.9	
76.3							1388.7	
mavs	0.3		MAVS5 @	10377-201910	76.6	4.7	1386.2	

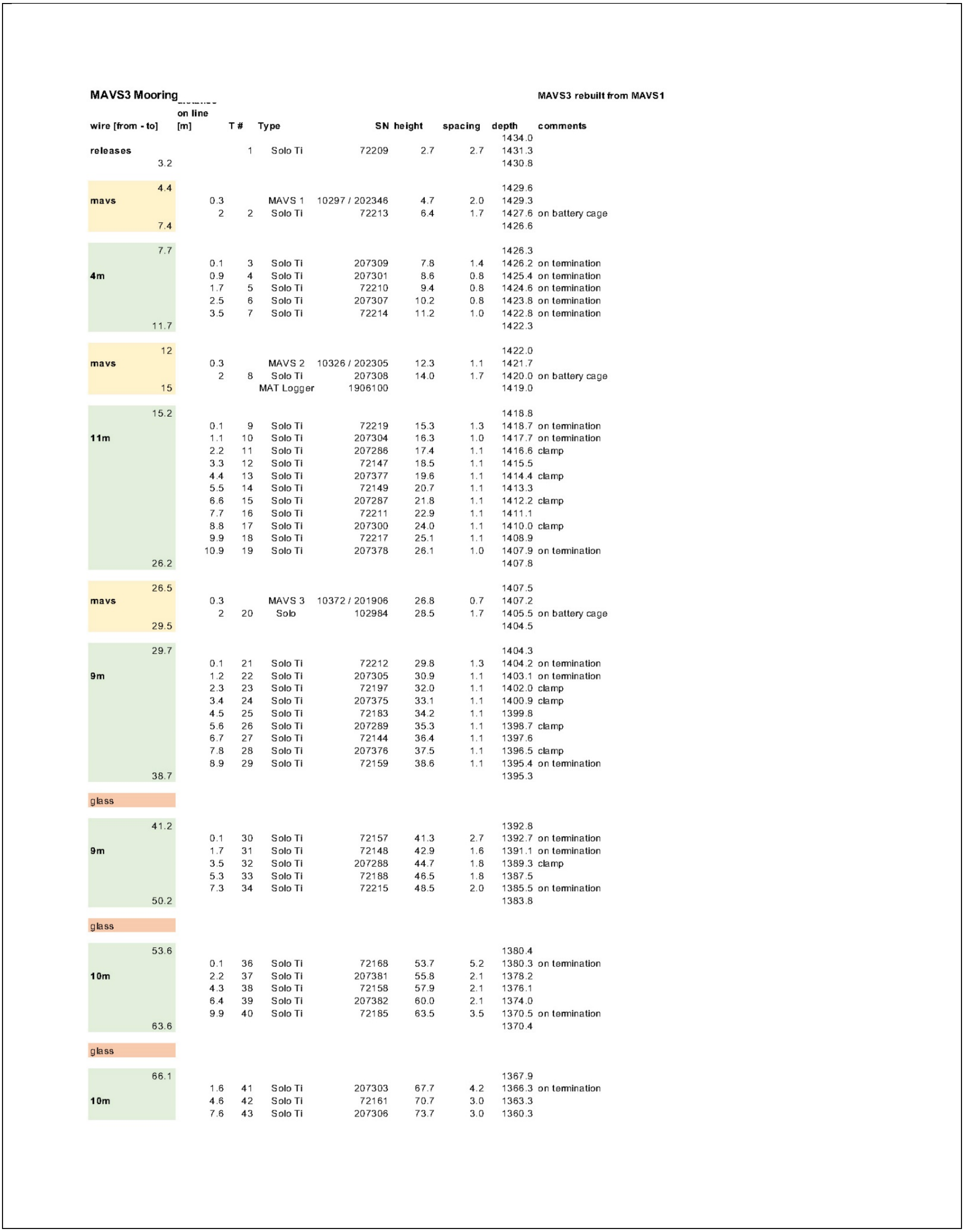


	79.3							1385.7	
	79.5							1385.5	
		2.2	41	SBE56	345	81.7	5.1	1381.1	
22m		6.2	42	SBE56	6414	85.7	4.0	1377.1	
		10.4		SBE37	12710	89.9	4.2	1372.9	
		14.7	43	SBE56	6420	94.2	4.3	1368.6	
		19.7	44	SBE56	6423	99.2	5.0	1363.6	
	101.5							1363.5	
glass									
	103.9							1361.1	
		0.4	45	SBE56	5825	104.3	5.1	1358.5	on termination
22m		5.2	46	SBE56	458	109.1	4.8	1353.7	
		10	47	SBE56	6449	113.9	4.8	1348.9	
		14.8	48	SBE56	425	118.7	4.8	1344.1	
		19.8	49	SBE56	6433	123.7	5.0	1339.1	
	125.9							1339.1	
	126.1							1338.9	
mavs		0.3		MAVS6 @ MAT Logger	10299-202349 1906102	126.4	2.7	1336.4	battery case has anode, no corrosion
	129.1							1335.9	
	129.3							1335.7	
		2.2	50	SBE56	376	131.5	5.1	1331.3	
34m		7	51	SBE56	916	136.3	4.8	1326.5	
		11.8	52	SBE56	6425	141.1	4.8	1321.7	
		16.6	53	SBE56	6448	145.9	4.8	1316.9	
		21.4	54	SBE56	6444	150.7	4.8	1312.1	
		26.4	55	SBE56	6438	155.7	5.0	1307.1	
		31.9	56	SBE56	475	161.2	5.5	1301.6	on termination
	163.3							1301.7	
glass									
	165.7							1299.3	
		2.1	57	SBE56	392	167.8	6.6	1295.0	
34m		7	58	SBE56	915	172.7	4.9	1290.1	
		11.9	59	SBE56	413	177.6	4.9	1285.2	
		16.8		SBE37	12711	182.5	4.9	1280.3	
		21.8	60	SBE56	423	187.5	5.0	1275.3	
		26.8	61	SBE56	6427	192.5	5.0	1270.3	
		31.8	62	SBE56	6446	197.5	5.0	1265.3	
	199.7							1265.3	
	199.9							1265.1	
mavs		0.3		MAVS7 @	10289-202351	200.2	2.7	1262.6	battery case some corrosion, no anode
	202.9							1262.1	
	203.1							1261.9	
		2.1	63	SBE56	418	205.2	5.0	1257.6	
36m		**7.4**	64	SBE56	6426	210.5	5.3	1252.3	
		12.7	65	SBE56	6431	215.8	5.3	1247.0	
		18	66	SBE56	6432	221.1	5.3	1241.7	
		23.3	67	SBE56	455	226.4	5.3	1236.4	
		28.6	68	SBE56	6419	231.7	5.3	1231.1	
		33.8	69	SBE56	6447	236.9	5.2	1225.9	
	239.1							1225.9	
glass									
	240.5							1224.5	
		2.1	70	SBE56	913	242.6	5.7	1220.2	
36m		7.6	71	SBE56	6428	248.1	5.5	1214.7	
		12.9	72	SBE56	422	253.4	5.3	1209.4	
		18.2	73	SBE56	6417	258.7	5.3	1204.1	
		23.5	74	SBE56	457	264.0	5.3	1198.8	
		28.8	75	SBE56	6443	269.3	5.3	1193.5	
		33.9	76	SBE56	6416	274.4	5.1	1188.4	
	276.5							1188.5	
	276.7							1188.3	
mavs		0.3		MAVS8 @ MAT Logger	10296-202348 1906100	277.0	2.6	1185.8	battery cage no anode, some corrosion
	279.7							1185.3	
	279.9							1185.1	
		2.1	77	SBE56	6437	282.0	5.0	1180.8	
25m		7.3	78	SBE56	477	287.2	5.2	1175.6	
		12.5	79	SBE56	421	292.4	5.2	1170.4	
		17.7	80	SBE56	6422	297.6	5.2	1165.2	
	304.9							1160.1	

BLT MAVS3



SLS1: 1/2" shackle - 5/8" sling link - 1/2" shackle
SLS2: 1/2" shackle - 5/8" sling link - 1/2" shackle - 5/8" shackle
SLS3: 5/8" shackle - 5/8" sling link - 5/8" shackle



MAVS3 Mooring

MAVS3 rebuilt from MAVS1

wire [from - to]	on line [m]	T #	Type	SN	height	spacing	depth	comments
							1434.0	
releases		1	Solo Ti	72209	2.7	2.7	1431.3	
3.2							1430.8	
4.4							1429.6	
mavs	0.3		MAVS 1	10297 / 202346	4.7	2.0	1429.3	
	2	2	Solo Ti	72213	6.4	1.7	1427.6	on battery cage
7.4							1426.6	
7.7							1426.3	
	0.1	3	Solo Ti	207309	7.8	1.4	1426.2	on termination
4m	0.9	4	Solo Ti	207301	8.6	0.8	1425.4	on termination
	1.7	5	Solo Ti	72210	9.4	0.8	1424.6	on termination
	2.5	6	Solo Ti	207307	10.2	0.8	1423.8	on termination
	3.5	7	Solo Ti	72214	11.2	1.0	1422.8	on termination
11.7							1422.3	
12							1422.0	
mavs	0.3		MAVS 2	10326 / 202305	12.3	1.1	1421.7	
	2	8	Solo Ti	207308	14.0	1.7	1420.0	on battery cage
15			MAT Logger	1906100			1419.0	
15.2							1418.8	
	0.1	9	Solo Ti	72219	15.3	1.3	1418.7	on termination
11m	1.1	10	Solo Ti	207304	16.3	1.0	1417.7	on termination
	2.2	11	Solo Ti	207286	17.4	1.1	1416.6	clamp
	3.3	12	Solo Ti	72147	18.5	1.1	1415.5	
	4.4	13	Solo Ti	207377	19.6	1.1	1414.4	clamp
	5.5	14	Solo Ti	72149	20.7	1.1	1413.3	
	6.6	15	Solo Ti	207287	21.8	1.1	1412.2	clamp
	7.7	16	Solo Ti	72211	22.9	1.1	1411.1	
	8.8	17	Solo Ti	207300	24.0	1.1	1410.0	clamp
	9.9	18	Solo Ti	72217	25.1	1.1	1408.9	
	10.9	19	Solo Ti	207378	26.1	1.0	1407.9	on termination
26.2							1407.8	
26.5							1407.5	
mavs	0.3		MAVS 3	10372 / 201906	26.8	0.7	1407.2	
	2	20	Solo	102984	28.5	1.7	1405.5	on battery cage
29.5							1404.5	
29.7							1404.3	
	0.1	21	Solo Ti	72212	29.8	1.3	1404.2	on termination
9m	1.2	22	Solo Ti	207305	30.9	1.1	1403.1	on termination
	2.3	23	Solo Ti	72197	32.0	1.1	1402.0	clamp
	3.4	24	Solo Ti	207375	33.1	1.1	1400.9	clamp
	4.5	25	Solo Ti	72183	34.2	1.1	1399.8	
	5.6	26	Solo Ti	207289	35.3	1.1	1398.7	clamp
	6.7	27	Solo Ti	72144	36.4	1.1	1397.6	
	7.8	28	Solo Ti	207376	37.5	1.1	1396.5	clamp
	8.9	29	Solo Ti	72159	38.6	1.1	1395.4	on termination
38.7							1395.3	
glass								
41.2							1392.8	
	0.1	30	Solo Ti	72157	41.3	2.7	1392.7	on termination
9m	1.7	31	Solo Ti	72148	42.9	1.6	1391.1	on termination
	3.5	32	Solo Ti	207288	44.7	1.8	1389.3	clamp
	5.3	33	Solo Ti	72188	46.5	1.8	1387.5	
	7.3	34	Solo Ti	72215	48.5	2.0	1385.5	on termination
50.2							1383.8	
glass								
53.6							1380.4	
	0.1	36	Solo Ti	72168	53.7	5.2	1380.3	on termination
10m	2.2	37	Solo Ti	207381	55.8	2.1	1378.2	
	4.3	38	Solo Ti	72158	57.9	2.1	1376.1	
	6.4	39	Solo Ti	207382	60.0	2.1	1374.0	
	9.9	40	Solo Ti	72185	63.5	3.5	1370.5	on termination
63.6							1370.4	
glass								
66.1							1367.9	
	1.6	41	Solo Ti	207303	67.7	4.2	1366.3	on termination
10m	4.6	42	Solo Ti	72161	70.7	3.0	1363.3	
	7.6	43	Solo Ti	207306	73.7	3.0	1360.3	

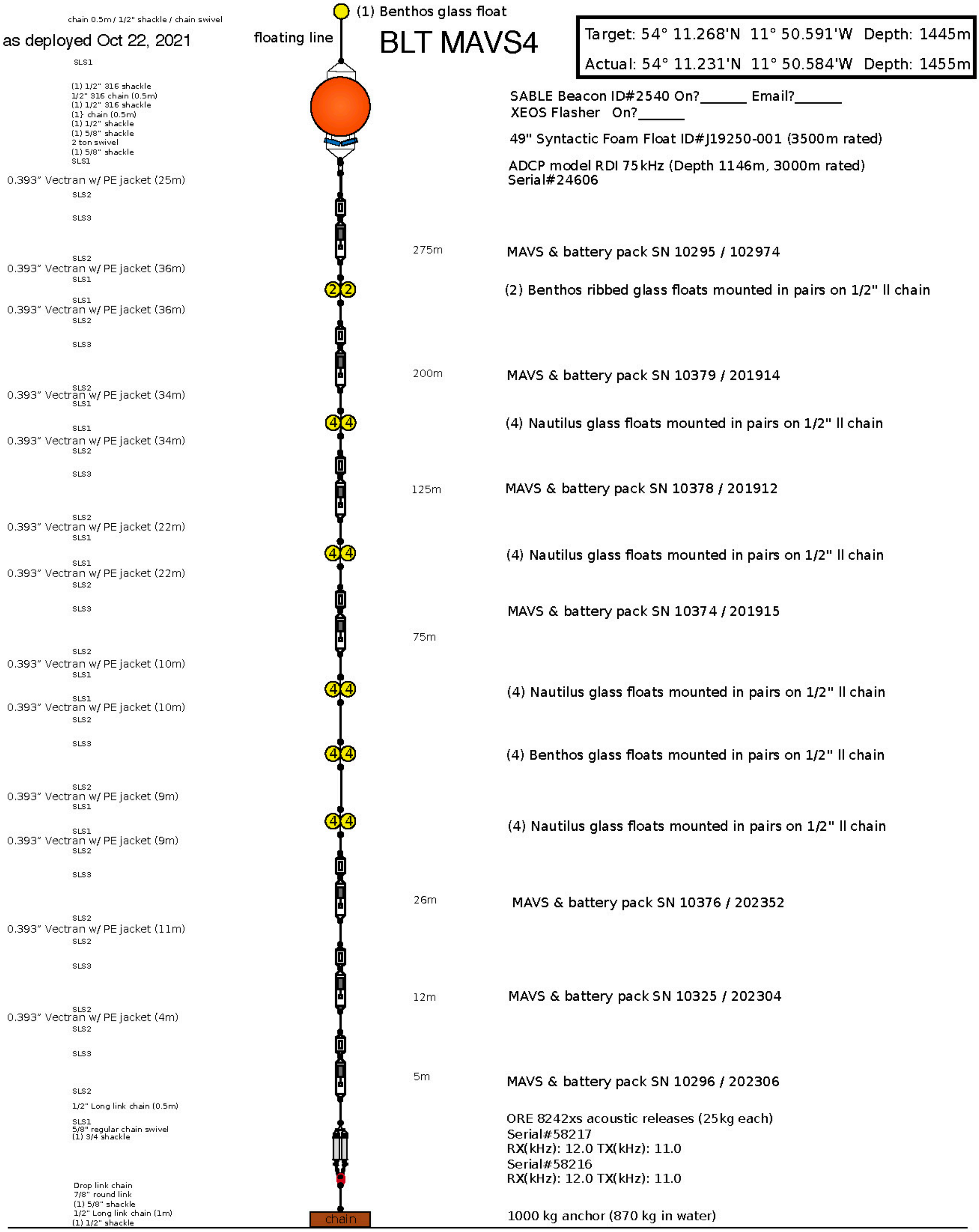
	76.1							1357.9	
	76.3							1357.7	
mavs		0.3		MAVS 4	10373 / 202345	76.6	2.9	1357.4	
				MAT Logger	1906101				
	79.3							1354.7	
	79.5							1354.5	
		2.2	44	Solo Ti	72154	81.7	5.1	1352.3	
22m		7.2	45	Solo Ti	207379	86.7	5.0	1347.3	
		12.7	46	Solo Ti	72163	92.2	5.5	1341.8	
		18.2	47	Solo Ti	207302	97.7	5.5	1336.3	
	101.5							1332.5	
glass									
	103.9							1330.1	
		0.1	48	Solo Ti	72167	104.0	6.3	1330.0	on termination
22m		5.8	49	Solo Ti	207380	109.7	5.7	1324.3	
		11.8	50	Solo Ti	72156	115.7	6.0	1318.3	
		17.8	51	Solo Ti	72164	121.7	6.0	1312.3	
	125.9							1308.1	
	126.1							1307.9	
mavs		0.3		MAVS 5	10288 / 202307	126.4	4.7	1307.6	
	129.1							1304.9	
	129.3							1304.7	
		3.4	52	Solo Ti	72176	132.7	6.3	1301.3	
34m		9.4	53	Solo	201844	138.7	6.0	1295.3	clamp
		15.4	54	Solo	201847	144.7	6.0	1289.3	clamp
		21.4	37	SBE37	12711	150.7	6.0	1283.3	
		27.4	55	Solo	102980	156.7	6.0	1277.3	
		33.4	56	Solo	102985	162.7	6.0	1271.3	on termination
	163.3							1270.7	
glass									
	165.7							1268.3	
		3.1	57	Solo	102975	168.8	6.1	1265.2	
34m		9.1	58	Solo	201845	174.8	6.0	1259.2	clamp
		15.1	59	SBE56	477	180.8	6.0	1253.2	clamp
		21.1	60	Solo	102986	186.8	6.0	1247.2	
		27.1	61	SBE56	6415	192.8	6.0	1241.2	
	199.7							1234.3	
	199.9							1234.1	
mavs		0.3		MAVS 6	10377 / 202347	200.2	7.4	1233.8	
				MAT Logger	1906102				
	202.9							1231.1	
	203.1							1230.9	
		3.7	62	Solo	102969	206.8	6.6	1227.2	
36m		9.7	63	SBE56	6414	212.8	6.0	1221.2	clamp
		15.7	64	Solo	102981	218.8	6.0	1215.2	
		21.7	65	SBE56	416	224.8	6.0	1209.2	
		27.7	66	Solo	201851	230.8	6.0	1203.2	
		33.7	67	SBE56	6436	236.8	6.0	1197.2	
	239.1							1194.9	
glass									
	240.5							1193.5	
		2.3	68	Solo	102978	242.8	6.0	1191.2	
36m		8.3	69	SBE56	6429	248.8	6.0	1185.2	
		14.3	70	Solo	201843	254.8	6.0	1179.2	clamp
		20.3	71	SBE56	6444	260.8	6.0	1173.2	
		26.3	72	Solo	102968	266.8	6.0	1167.2	
		32.3	73	SBE56	6431	272.8	6.0	1161.2	
	276.5							1157.5	
	276.7							1157.3	
mavs		0.3		MAVS 7	10289 / 202351	277.0	4.2	1157.0	
				MAT Logger	1906103				
	279.7							1154.3	
	279.9							1154.1	
		4	74		no sensor	283.9	6.9	1150.1	
25m		10	75	SBE56	6428	289.9	6.0	1144.1	
		16	76		no sensor	295.9	6.0	1138.1	
		22	77	SBE56	6441	301.9	6.0	1132.1	
	304.9							1129.1	

BLT MAVS4

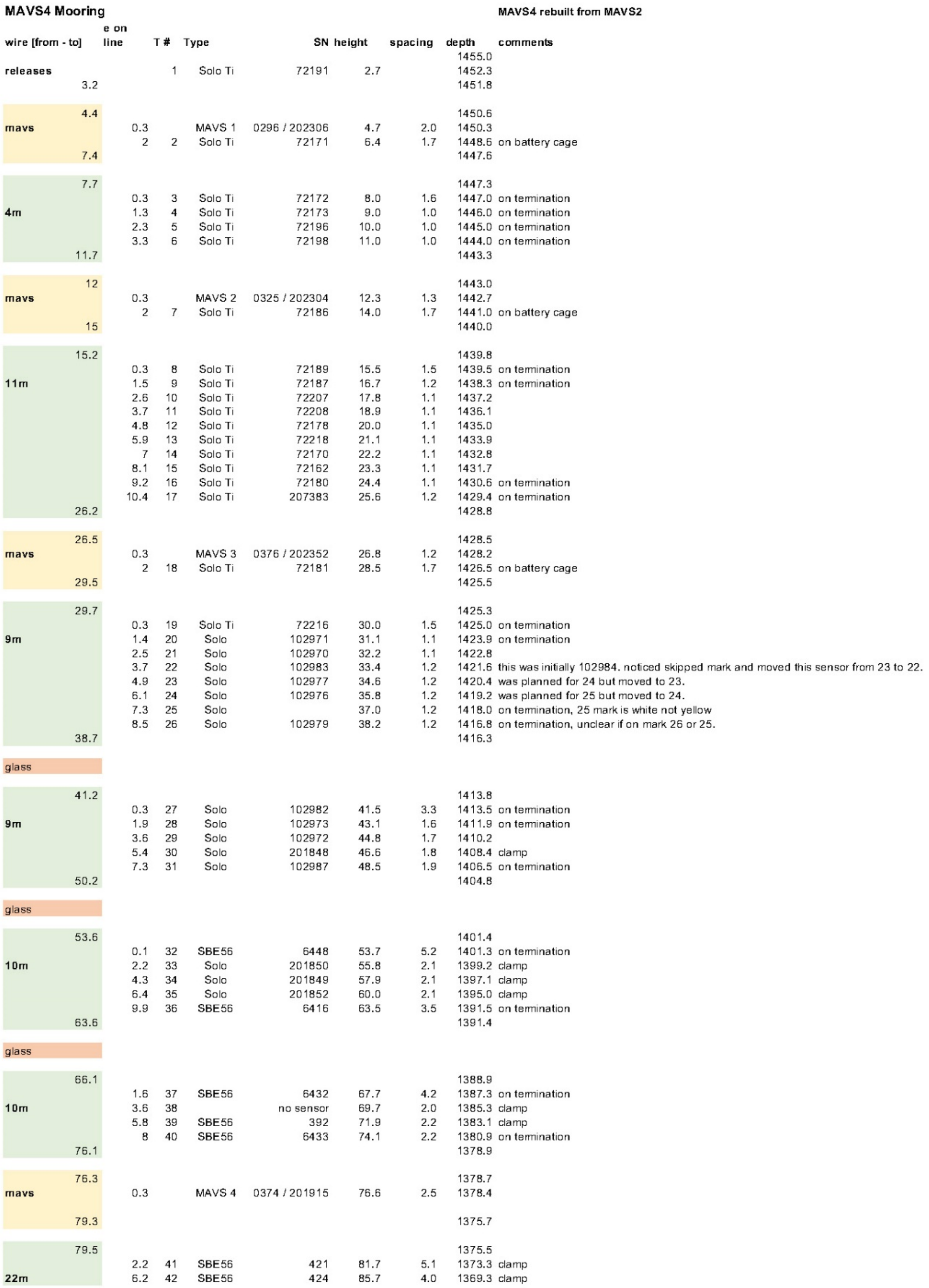
as deployed Oct 22, 2021

Target: 54° 11.268'N 11° 50.591'W Depth: 1445m

Actual: 54° 11.231'N 11° 50.584'W Depth: 1455m



SLS1: 1/2" shackle - 5/8" sling link - 1/2" shackle
SLS2: 1/2" shackle - 5/8" sling link - 1/2" shackle - 5/8" shackle
SLS3: 5/8" shackle - 5/8" sling link - 5/8" shackle



MAVS4 Mooring

MAVS4 rebuilt from MAVS2

wire [from - to]	e on line	T #	Type	SN	height	spacing	depth	comments
							1455.0	
releases		1	Solo Ti	72191	2.7		1452.3	
3.2							1451.8	
4.4							1450.6	
mavs	0.3		MAVS 1	0296 / 202306	4.7	2.0	1450.3	
	2	2	Solo Ti	72171	6.4	1.7	1448.6	on battery cage
7.4							1447.6	
7.7							1447.3	
	0.3	3	Solo Ti	72172	8.0	1.6	1447.0	on termination
4m	1.3	4	Solo Ti	72173	9.0	1.0	1446.0	on termination
	2.3	5	Solo Ti	72196	10.0	1.0	1445.0	on termination
	3.3	6	Solo Ti	72198	11.0	1.0	1444.0	on termination
11.7							1443.3	
12							1443.0	
mavs	0.3		MAVS 2	0325 / 202304	12.3	1.3	1442.7	
	2	7	Solo Ti	72186	14.0	1.7	1441.0	on battery cage
15							1440.0	
15.2							1439.8	
	0.3	8	Solo Ti	72189	15.5	1.5	1439.5	on termination
11m	1.5	9	Solo Ti	72187	16.7	1.2	1438.3	on termination
	2.6	10	Solo Ti	72207	17.8	1.1	1437.2	
	3.7	11	Solo Ti	72208	18.9	1.1	1436.1	
	4.8	12	Solo Ti	72178	20.0	1.1	1435.0	
	5.9	13	Solo Ti	72218	21.1	1.1	1433.9	
	7	14	Solo Ti	72170	22.2	1.1	1432.8	
	8.1	15	Solo Ti	72162	23.3	1.1	1431.7	
	9.2	16	Solo Ti	72180	24.4	1.1	1430.6	on termination
	10.4	17	Solo Ti	207383	25.6	1.2	1429.4	on termination
26.2							1428.8	
26.5							1428.5	
mavs	0.3		MAVS 3	0376 / 202352	26.8	1.2	1428.2	
	2	18	Solo Ti	72181	28.5	1.7	1426.5	on battery cage
29.5							1425.5	
29.7							1425.3	
	0.3	19	Solo Ti	72216	30.0	1.5	1425.0	on termination
9m	1.4	20	Solo	102971	31.1	1.1	1423.9	on termination
	2.5	21	Solo	102970	32.2	1.1	1422.8	
	3.7	22	Solo	102983	33.4	1.2	1421.6	this was initially 102984. noticed skipped mark and moved this sensor from 23 to 22.
	4.9	23	Solo	102977	34.6	1.2	1420.4	was planned for 24 but moved to 23.
	6.1	24	Solo	102976	35.8	1.2	1419.2	was planned for 25 but moved to 24.
	7.3	25	Solo		37.0	1.2	1418.0	on termination, 25 mark is white not yellow
	8.5	26	Solo	102979	38.2	1.2	1416.8	on termination, unclear if on mark 26 or 25.
38.7							1416.3	
glass								
41.2							1413.8	
	0.3	27	Solo	102982	41.5	3.3	1413.5	on termination
9m	1.9	28	Solo	102973	43.1	1.6	1411.9	on termination
	3.6	29	Solo	102972	44.8	1.7	1410.2	
	5.4	30	Solo	201848	46.6	1.8	1408.4	clamp
	7.3	31	Solo	102987	48.5	1.9	1406.5	on termination
50.2							1404.8	
glass								
53.6							1401.4	
	0.1	32	SBE56	6448	53.7	5.2	1401.3	on termination
10m	2.2	33	Solo	201850	55.8	2.1	1399.2	clamp
	4.3	34	Solo	201849	57.9	2.1	1397.1	clamp
	6.4	35	Solo	201852	60.0	2.1	1395.0	clamp
	9.9	36	SBE56	6416	63.5	3.5	1391.5	on termination
63.6							1391.4	
glass								
66.1							1388.9	
	1.6	37	SBE56	6432	67.7	4.2	1387.3	on termination
10m	3.6	38		no sensor	69.7	2.0	1385.3	clamp
	5.8	39	SBE56	392	71.9	2.2	1383.1	clamp
	8	40	SBE56	6433	74.1	2.2	1380.9	on termination
76.1							1378.9	
76.3							1378.7	
mavs	0.3		MAVS 4	0374 / 201915	76.6	2.5	1378.4	
79.3							1375.7	
79.5							1375.5	
	2.2	41	SBE56	421	81.7	5.1	1373.3	clamp
22m	6.2	42	SBE56	424	85.7	4.0	1369.3	clamp

		10.4	37	SBE37	12710	89.9	4.2	1365.1	
		14.7	43	SBE56	422	94.2	4.3	1360.8	clamp
		19.7	44	SBE56	6449	99.2	5.0	1355.8	
	101.5							1353.5	
glass									
	103.9							1351.1	
		0.4	45	SBE56	6422	104.3	5.1	1350.7	on termination
22m		5.2	46	SBE56	393	109.1	4.8	1345.9	clamp
		10	47	SBE56	425	113.9	4.8	1341.1	clamp
		14.8	48	SBE56	395	118.7	4.8	1336.3	clamp
		19.8	49	SBE56	6445	123.7	5.0	1331.3	
	125.9							1329.1	
	126.1							1328.9	
mavs		0.3		MAVS 5	0378 / 201912	126.4	2.7	1328.6	
	129.1							1325.9	
	129.3							1325.7	
		2.2	50	SBE56	6447	131.5	5.1	1323.5	
34m		7	51	SBE56	915	136.3	4.8	1318.7	clamp
		11.8	52	SBE56	466	141.1	4.8	1313.9	clamp
		16.6	53	SBE56	413	145.9	4.8	1309.1	clamp
		21.4	54	SBE56	458	150.7	4.8	1304.3	clamp
		26.4	55	SBE56	6420	155.7	5.0	1299.3	
		31.9	56	SBE56	6417	161.2	5.5	1293.8	on termination
	163.3							1291.7	
glass									
	165.7							1289.3	
		2.1	57	SBE56	423	167.8	6.6	1287.2	clamp
34m		7	58	SBE56	6419	172.7	4.9	1282.3	
		11.9	59	SBE56	6426	177.6	4.9	1277.4	
		16.8	37	SBE37	12709	182.5	4.9	1272.5	
		21.8	60	SBE56	6437	187.5	5.0	1267.5	
		26.8	61	SBE56	6430	192.5	5.0	1262.5	
		31.6	62	SBE56	418	197.3	4.8	1257.7	was at 31.8 but moved to 31.6
	199.7							1255.3	
	199.9							1255.1	
mavs		0.3		MAVS 6	0379 / 201846	200.2	2.9	1254.8	solo 201914 was replaced by standalone sensor
	202.9							1252.1	
	203.1							1251.9	
		2.1	63	SBE56	916	205.2	5.0	1249.8	clamp
36m		**7.4**	64	SBE56	6435	210.5	5.3	1244.5	
		12.7	65	SBE56	6423	215.8	5.3	1239.2	
		18	66	SBE56	6446	221.1	5.3	1233.9	clamp
		23.3	67	SBE56	6424	226.4	5.3	1228.6	
		28.6	68	SBE56	457	231.7	5.3	1223.3	clamp
		33.8	69		no sensor	236.9	5.2	1218.1	
	239.1							1215.9	
glass									
	240.5							1214.5	
		2.1	70	SBE56	6418	242.6	5.7	1212.4	
36m		7.6	71	SBE56	6438	248.1	5.5	1206.9	
		12.9	72	SBE56	6443	253.4	5.3	1201.6	clamp
		18.2	73	SBE56	6413	258.7	5.3	1196.3	
		23.5	74	SBE56	475	264.0	5.3	1191.0	
		28.8	75	SBE56	6425	269.3	5.3	1185.7	
		33.9			no sensor	274.4	5.1	1180.6	
	276.5							1178.5	
	276.7							1178.3	
mavs		0.3		MAVS 7	0295 / 102974	277.0	2.6	1178.0	
	279.7							1175.3	
	279.9							1175.1	
		2.1	77		no sensor	282.0	5.0	1173.0	
25m		7.3	78	SBE56	6439	287.2	5.2	1167.8	
		12.5	79	SBE56	376	292.4	5.2	1162.6	clamp
		17.7	80	SBE56	5825	297.6	5.2	1157.4	clamp
	304.9							1150.1	

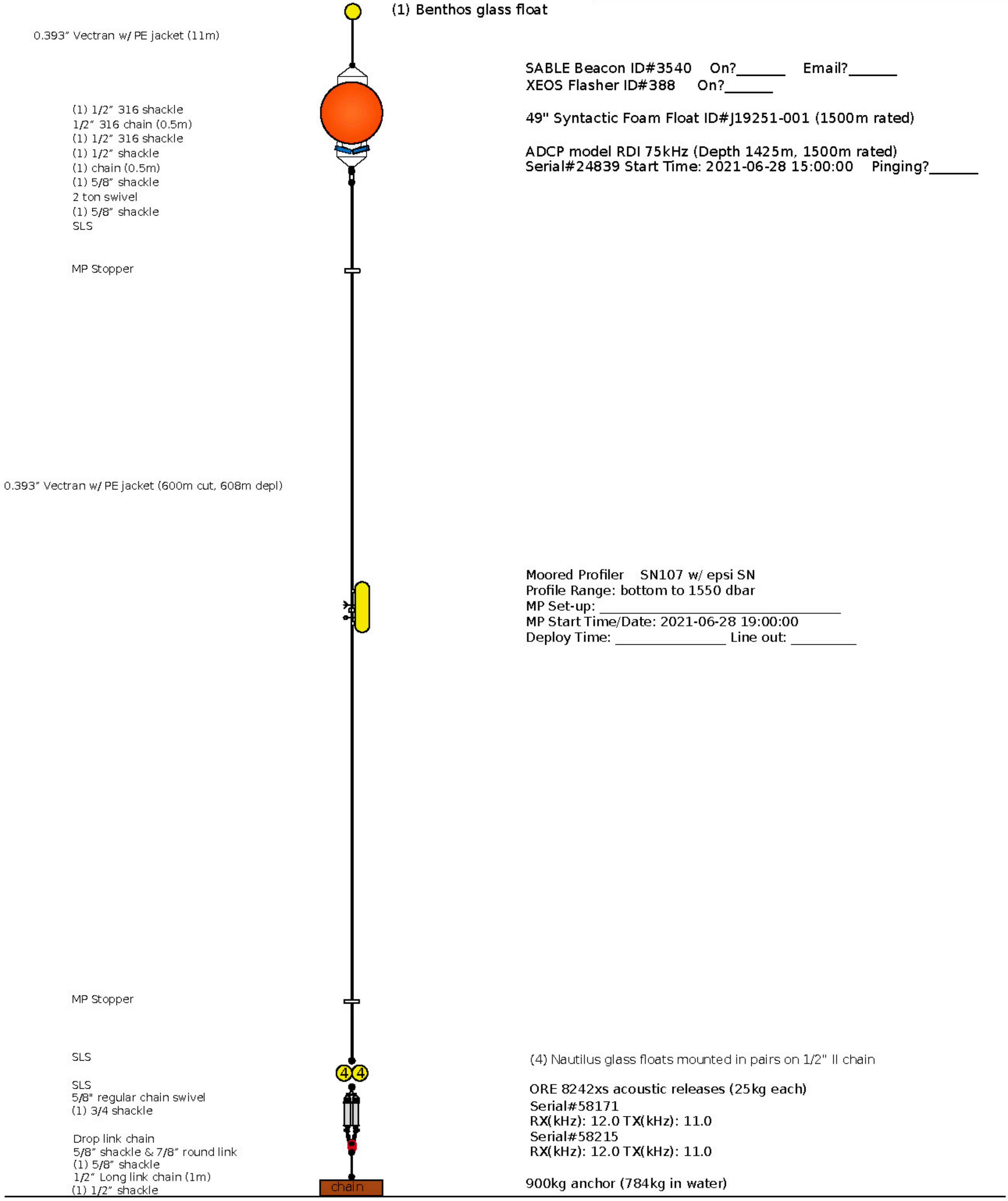
as deployed June 28, 2021

SLS: 1/2" shackle - 5/8" sling link - 1/2" shackle

BLT MP1

Target: 54° 14.334'N 11° 56.958'W Depth: 2034m

Actual: 54° 14.312'N 11° 56.923'W Depth: 2035m



(1) Benthos glass float

0.393" Vectran w/ PE jacket (11m)

SABLE Beacon ID#3540 On?______ Email?______
XEOS Flasher ID#388 On?______

49" Syntactic Foam Float ID#J19251-001 (1500m rated)

ADCP model RDI 75kHz (Depth 1425m, 1500m rated)
Serial#24839 Start Time: 2021-06-28 15:00:00 Pinging?______

(1) 1/2" 316 shackle
1/2" 316 chain (0.5m)
(1) 1/2" 316 shackle
(1) 1/2" shackle
(1) chain (0.5m)
(1) 5/8" shackle
2 ton swivel
(1) 5/8" shackle
SLS

MP Stopper

0.393" Vectran w/ PE jacket (600m cut, 608m depl)

Moored Profiler SN107 w/ epsi SN
Profile Range: bottom to 1550 dbar
MP Set-up: ______________________
MP Start Time/Date: 2021-06-28 19:00:00
Deploy Time: ______________ Line out: ________

MP Stopper

SLS

(4) Nautilus glass floats mounted in pairs on 1/2" ll chain

SLS
5/8" regular chain swivel
(1) 3/4 shackle

ORE 8242xs acoustic releases (25kg each)
Serial#58171
RX(kHz): 12.0 TX(kHz): 11.0
Serial#58215
RX(kHz): 12.0 TX(kHz): 11.0

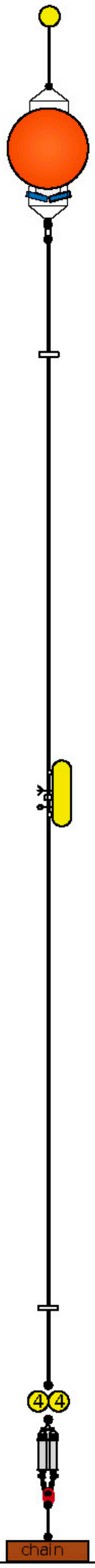
Drop link chain
5/8" shackle & 7/8" round link
(1) 5/8" shackle
1/2" Long link chain (1m)
(1) 1/2" shackle

900kg anchor (784kg in water)

as deployed July 7, 2021
SLS: 1/2" shackle - 5/8" sling link - 1/2" shackle

BLT MP2

Target: 54° 12.210'N 11° 52.350'W   Depth: 1666m
Actual: 54° 12.211'N 11° 52.376'W   Depth: 1676m



(1) Benthos glass float

floating line (15m)

SABLE Beacon ID#3540   On?______   Email?______
XEOS Flasher ID#388   On?______

(1) 1/2" 316 shackle
1/2" 316 chain (0.5m)
(1) 1/2" 316 shackle
(1) 1/2" shackle
(1) chain (0.5m)
(1) 5/8" shackle
2 ton swivel
(1) 5/8" shackle
SLS

49" Syntactic Foam Float ID#J19251-001 (1500m rated)

ADCP model RDI 75kHz (Depth 1066m, 1500m rated)
Serial#24839 Start Time: 2021-07-07 10:00:00   Pinging?______

MP Stopper

0.393" Vectran w/ PE jacket (600m cut, 608m depl)

Moored Profiler   SN107
Profile Range: 1677 to 1177 dbar
MP Set-up: ______________________________
MP Start Time/Date: 2021-07-07 18:00:00
Deploy Time: ______________ Line out: ________

MP Stopper

SLS

(4) Nautilus glass floats mounted in pairs on 1/2" II chain

SLS
5/8" regular chain swivel
(1) 3/4 shackle

ORE 8242xs acoustic releases (25kg each)
Serial#58171
RX(kHz): 12.0 TX(kHz): 11.0
Serial#58215
RX(kHz): 12.0 TX(kHz): 11.0

Drop link chain
7/8" round link
(1) 5/8" shackle
1/2" Long link chain (1m)
(1) 1/2" shackle

1000kg anchor (870kg in water)

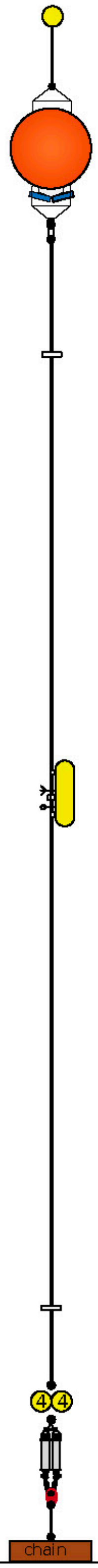
as deployed Oct 22, 2021

SLS: 1/2" shackle - 5/8" sling link - 1/2" shackle

BLT MP3

Target: 54° 11.118'N 11° 50.801'W Depth: 1491m

Actual: 54° 11.122'N 11° 50.788'W Depth: 1491m



(1) Benthos glass float

chain 0.5m / 1/2" shackle / chain swivel
floating line (15m)

SABLE Beacon ID#1780 On?______ Email?______
XEOS Flasher On?______

49" Syntactic Foam Float ID#J19251-001 (1500m rated)

ADCP model RDI 75kHz (Depth 881m, 1500m rated)
Serial#24839

(1) 1/2” 316 shackle
1/2” 316 chain (0.5m)
(1) 1/2” 316 shackle
(1) 1/2” shackle
(1) chain (0.5m)
(1) 5/8” shackle
2 ton swivel
(1) 5/8” shackle
SLS

MP Stopper

0.393” Vectran w/ PE jacket (600m cut, 608m depl)

Moored Profiler SN107
Profile Range: 1000 - 1510 dbar
MP Set-up: ______________________________
MP Start Time/Date: 2021-10-22 14:00:00
Deploy Time: _____________ Line out: ________

MP Stopper

SLS

(4) Nautilus glass floats mounted in pairs on 1/2" ll chain

SLS
5/8" regular chain swivel
(1) 3/4 shackle

ORE 8242xs acoustic releases (25kg each)
Serial#58171
RX(kHz): 12.0 TX(kHz): 11.0
Serial#58215
RX(kHz): 12.0 TX(kHz): 11.0

Drop link chain
7/8” round link
(1) 5/8” shackle
1/2” Long link chain (1m)
(1) 1/2” shackle

1000kg anchor (870kg in water)

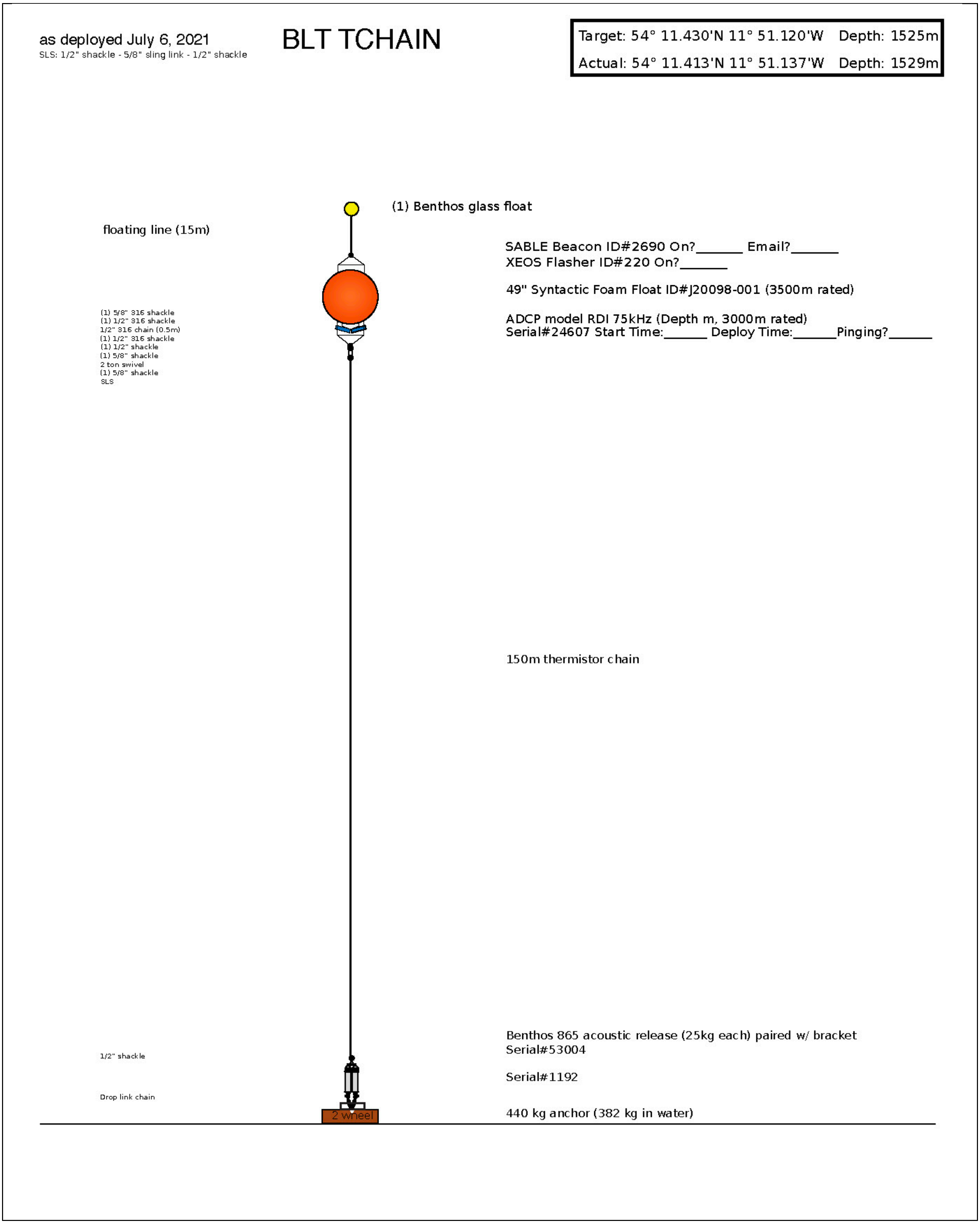


Figure 10: Mooring deployment and technical information

6 ARGO FLOAT DEPLOYMENTS

Three Argo floats were deployed during DY138 on behalf of the UK Met Office.

Table 6: Argo float deployment log

CTD #	Latitude	Longitude	Date	Time	Float ID
49	55°3.704 N	11°44.974 W	10/10/21	20:10	8590
64	55°48.900 N	9°50.035 W	14/10/21	08:10	9196
71	55°21.985 N	10°56.031	15/10/21	13:19	8986

7 NMF SHIP SCIENTIFIC SYSTEMS

Zoltan Nemeth

7.1 CRUISE OVERVIEW

Cruise	*Departure*	*Arrival*	*Technician(s)*
DY138 BLT/2	25/09/2021	03/11/2021	Z. Nemeth (zome@noc.ac.uk)

Ship Scientific Systems (SSS) is responsible for operating and managing the Ship's scientific information technology infrastructure, data acquisition, compilation and delivery, and the suite of ship-fitted instruments and sensors in support of the Marine Facilities Programme (MFP).

All times in this report are in UTC.

7.2 SCIENTIFIC COMPUTER SYSTEMS

7.2.1 UNDERWAY DATA ACQUISITION

Data from the suite of ship-fitted scientific instrumentation was aggregated onto a network drive on the ship's file server. This was available throughout the voyage in read-only mode to permit scientists to work with the data as it was acquired. A Public network folder was also available for scientists to share files.
A copy of these two drives are written to end-of-cruise disks that are provided to the Principal Scientist/Data Centre as required.

List of logged ship-fitted scientific systems:
/Cruise_Reports/DY132_Ship_fitted_information_sheet.docx

The data acquisition systems used on this cruise are detailed in the table 7. The data and data description documents are filed per system in the *Data* and *Documentation* directories respectively within Ship Systems folder on the cruise data disk.

Table 7: Data acquisition systems used on this cruise.

Data acquisition system	*Usage*	*Data products*	*Directory system name*
Ifremer TechSAS	Continuous	NetCDF ASCII pseudo-NMEA	/TechSAS/
NMF RVDAS	Continuous	ASCII Raw NMEA + generated NetCDF	/RVDAS/RAM /RVDAS/NCC
Kongsberg EA640	Continuous	xyz, redirected to Techsas/RVDAS RAM,NCC	/Acoustics/EA-640/
Kongsberg EM122	Continuous	Kongsberg .all raw and RVDAS RAM,NCC	/Acoustics/EM122/
Kongsberg SIS (EM710)	Discrete	Kongsberg .all	/Acoustics/EM-710/
UHDAS (ADCPs)	Continuous	ASCII raw, RBIN, GBIN, CODAS files	/Acoustics/ADCP/
Env_Temp	Continuous	NetCDF + Ascii and RVDAS RAM,NCC	/Env_Temp
Sonardyne Ranger2	Discrete	None, redirected to Techsas/RVDAS RAM,NCC	/Acoustics/USBL/

Data description documents (PDF & .docx) for each systems logged data is located in the below directory:

/ship_systems/documentation/TechSAS/Data-Description/

Data directories per system:

/Ship_Systems/Data/[System]/

7.2.1.1 Significant acquisition events and gaps

TechSAS logger DY138 mission started on 2021-09-20 12:42

RVDAS RAM Acquisition started on 2021-09-24 11:20

Level-C acquisition started on 2021-09-24 05:48:00

Wamos Waveredar started on 2021-09-25 09:10:00

RVDAS – NCC: TRUEWIND calculation valid from 2021-09-29 15:42 to 2021-11-02 23:59

RVDAS RAM Acquisition terminated on 2021-11-03 00:00:02

TechSAS logger DY138 mission terminated on 2021-11-03 06:01

Wamos Wavereadar stopped at 2021-11-03 06:24

Data gaps:

Acoustic sensor routinely switched off/on during trilateration or mooring release or deployment tests, these events recorded with the eventlogger, data available in Documentation/Eventlogs folder.

Sensor	From:	To:	Length:	Issue:	Reason:
WAMOS II	2021-10-07 11:01	2021-10-08 09:09	22h 08m	Data gap in files and timeseries	Unknown.
WAMOS II	2021-10-24 11:55	2021-10-24 15:36	3h 41m	Data gap in files and timeseries	Unknown Possible winwamos recording crashed.
EA640	2021-10-30 08:06:52	2021-10-30 08:40:58	34m	Data gap in files and timeseries	Unknown – Acquisition PC crashed.
Seapath GPS	2021-10-30 17:41:56	2021-10:30 18:29:50	~48m	Data gap only in TechSAS NetCDF.	Unkmown.

7.2.2 INTERNET PROVISION

Satellite communications were provided with both the VSAT and Fleet Broadband systems. While underway, the ship operated with bandwidth controls to prioritise business use.

7.3 INSTRUMENTATION

7.3.1 COORDINATE REFERENCE

Path to survey ship files:

/Ship_Systems/Documentation/Vessel_Survey

7.3.1.1 Origin (*RRS Discovery*)

All coordinates, unless otherwise specified, us the following convention:

> Central reference point (0,0,0) at Frame 44, centreline, main deck with sense (X+ fwd, Y+ stbd, Z+ down). This CRP is at (32.4m, 0m, -7.4m) with respect to the ship's absolute stern, centreline, baseline.

The ship's survey (Parker Maritime, 2013) defines two systems of reference point using two different central reference points (CRPs):

1. (0,0,0) at Frame 0 (aft-most frame, 6m forward from stern), centreline (centre of keel), baseline (ship's bottom-most longitudinal).
2. (0,0,0) at ship's centre of gravity (CG), Frame 44 (26.4m forward from Frame 0 at 0.6m framespacing), centreline (centre of keel), main deck (7.4m up from baseline).

The survey coordinate sense is X is positive forward, Y positive starboard, and Z positive down. The coordinate order in the survey is (Y,X,Z), but unless otherwise noted, all coordinates are given elsewhere as (X,Y,Z).

For all scientific purposes, unless otherwise stated, the coordinate system is referenced using the second system, with the CRP at the CG.

7.3.1.2 Origin (*RRS James Cook*)

The common coordinate reference was defined by the Blom Maritime survey (2006) as:

1. The reference plane is parallel with the main deck abeam (transversely) and with the baseline (keel) fore- and aft-ways (longitudinally).
2. Datum (X = 0, Y = 0, Z = 0) is centre topside of the Applanix motion reference unit (MRU) chassis.

7.3.1.3 Multibeam

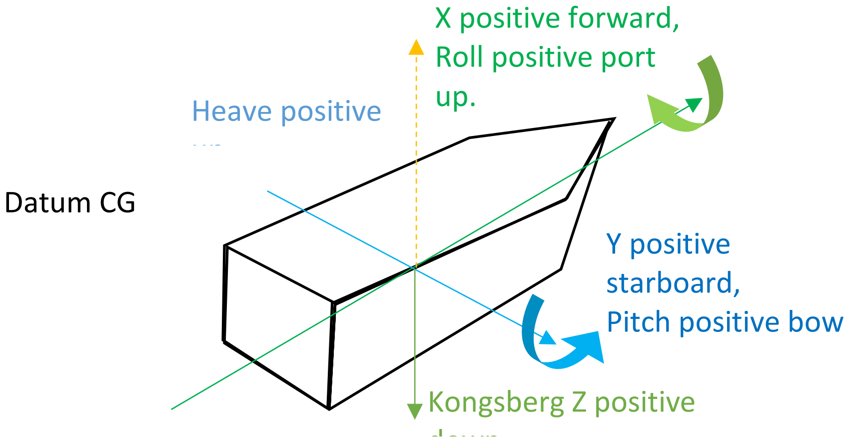


Figure 11: Conventions used for position and attitude.

The Kongsberg axes reference conventions are (see Figure 11) as follows:

1. X positive forward,
2. Y positive starboard,
3. Z positive downward.

The rotational sense for the multibeam systems and Seapath is set to follow the convention of Applanix PosMV (the primary scientific position and attitude system), as per Figure 11.

7.3.1.4 Primary Scientific Position and Attitude System

The translations and rotations provided by this system (Applanix PosMV) have the following convention:

1. Roll positive port up,
2. Pitch positive bow up,
3. Heading true,
4. Heave positive up.

7.3.2 POSITION, ATTITUDE AND TIME

System	**Navigation (Position, attitude, time)**
Statement of Capability	*/Ship_Systems/Documentation/GPS_and_Attitude*
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Pseudo-NMEA: */Ship_Systems/Data/TechSAS/NMEA/* Raw NMEA: */Ship_Systems/Data/RVDAS/RAM/* NCC: */Ship_Systems/Data/RVDAS/NCC*
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*
Other documentation	*/Ship_Systems/Documentation/GPS_and_Attitude*

Component	***Purpose***	***Outputs***	***Headline Specifications***
Applanix PosMV	Primary GPS and attitude.	Serial NMEA to acquisition systems and multibeam	Positional accuracy within 2 m. With L2 correction from

			CNAV3050 within 0.15 m.
Kongsberg Seapath 330	Secondary GPS and attitude.	Serial and UDP NMEA to acquisition systems and multibeam	Positional accuracy within 1 m. With L2 correction from Fugro within 0.15m.
Oceaneering CNav 3050	Correction service for primary and secondary GPS and dynamic positioning.	Correction to primary GPS	Positional accuracy within 0.15 m.
Fugro Seastar / MarineStar	Correction service for primary and secondary GPS and dynamic positioning.	Correction to secondary GPS	Positional accuracy within 0.15 m.
Meinberg NTP Clock	Provide network time	NTP protocol over the local network.	Time accuracy within microseconds

7.3.3 OCEAN AND ATMOSPHERE MONITORING SYSTEMS

7.3.3.1 Surfmet

System	**SURFMET (Surface water and atmospheric monitoring)**	
Statement of Capability	*/Ship_Systems/Documentation/Surfmet*	
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Pseudo-NMEA: */Ship_Systems/Data/TechSAS/NMEA/* Raw NMEA: */Ship_Systems/Data/RVDAS/NMEA/* NCC: */Ship_Systems/Data/RVDAS/NCC*	
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*	
Underway events and other documentation	*/Ship_Systems/Documentation/Surfmet*	
Calibration info	See Ship Fitted Sensor sheet for calibration info for each sensor.	
Component	*Purpose*	*Outputs*
Inlet temperature probe (SBE38)	Measure temperature of water at hull inlet	Serial to Interface Box
Drop keel temperature probe (SBE38)	Measure temperature of water in drop keel space	Sensor out of calibration.
Thermosalinograph (SBE45)	Measure temperature, salinity, conductivity and sound velocity at sampling board	Serial to Interface Box
Interface Box (SBE 90402)	Signals management	Serial to Moxa
Debubbler	Reduces bubbles through instruments.	No recorded output
Transmissometer (CST)	Measure of transmittance	Analogue to NUDAM
Fluorometer (WS3S)	Meausure of fluorescence	Analogue to NUDAM
Flowmeter (Litremeter)	Measure of flow	Analogue to NUDAM
Air temperature and humidity probe (HMPxxx)	Temperature and humidity at met platform	Analogue to NUDAM

Ambient light sensors (PAR, TIR)	Ambient light and energy at met platform	Analogue to NUDAM
Barometer (PTBxxx)	Atmospheric pressure at met platform	Analogue to NUDAM
Anemometer (Windsonic)	Wind speed and direction at met platform	Analogue to NUDAM
NUDAM	A/D converter	Serial NMEA to Moxa
Moxa	Serial to UDP converter	UDP NMEA to Surfmet VM
Surfmet Virtual Machine	Data management	UDP NMEA to TechSAS, RVDAS

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port, and whilst alongside. Please see the separate information sheet for details of the sensors used and whether their recorded data have calibrations applied or not.

Surface Water Sampling Board Maintenance

All underway events are recorded in the undervay.pdf in:

/Ship_Systems/Documentation/Surfmet

The system was cleaned prior to the cruise on 06/06/2021.

TechSAS logger started: 2021-09-20 12:42

RVDAS logger started: 2021-09-24 11:20

TSG Data Acquisition valid from: 2021-09-26 10:15:00 (51^{o} 24.52N, 005^{o} 54.11W)

TSG Data Acquisition terminated: 2021-10-17 09:00:00 (55^{o}34.21N, 007^{o}36.78W) remark: Heading to Fairlie, Scotland ports of call (starboard propulsion service)

TSG Data Acquisition restarted (valid from): 2021-10-21 08:15 (55^{o}34.24N, 007^{o}37.09W)

TSG Data Acquisition terminated: 2021-11-02 12:00:00 (55^{o}18.37N, 009^{o}55.90W)

TechSAS logger terminated: 2021-11-03 06:01

RVDAS logger terminated: 2021-11-03 00:00:02

7.3.3.2 Wave Radar

System	**WAMOS Wave Radar**		
Statement of Capability	*/Ship_Systems/Documentation/Wamos*		
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Raw NMEA: */Ship_Systems/Data/RVDAS/RAM/* NCC: */Ship_Systems/Data/RVDAS/NCC*		
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*		
Other documentation	*/Ship_Systems/Documentation/Wamos*		
Component	***Purpose***	***Outputs***	***Headline Specifications***
Rutter OceanWaves WAMOS	Measure wave height, direction, period and spectra.	Summary statistics in NMEA to TechSAS and RVDAS. Spectra files.	
RS Aqua REX Waveradar	Non-contact wave height measurement	-	
Furuno Radar	Measures radar reflection on sea surface.	Radar data to WAMOS.	

The wave radar magnetron requires annual replacement. Following replacement, WAMOS needs to collect wave data within 5 km of another wave height sensor over the full range of sea-states in order to derive wave height calibration coefficients for the new magnetron. This reference dataset can be derived by examining the ship’s track for wave buoys and downloading their data. The sensor was out calibration during the cruise.

7.4 HYDROACOUSTIC SYSTEMS

System	**Acoustics**
Statement of Capability	*/Ship_Systems/Documentation/Acoustics*
Data product(s)	Raw: */Ship_Systems/Data/Acoustics* NetCDF (EA640, EM122cb): */Ship_Systems/Data/TechSAS, /Ship_Systems/Data/RVDAS* NMEA (EA640, EM122cb): */Ship_Systems/Data/RVDAS*
Data description	*/Ship_Systems/Documentation/Acoustics*
Other documentation	*/Ship_Systems/Documentation/Acoustics*

Component	***Purpose***	***Outputs***	***Operation***
10/12 kHz Single beam (Kongsberg EA-640)	Primary depth sounder	NMEA over serial, raw files	Continuous Triggered by K-Sync
Kongsberg SIS (EM122)	Multibeam Deep Water sounder	Kongsberg .all	Discrete
2.5–6.5 kHz Sub-bottom Profiler (Kongsberg SBP-120)	Multi-frequency echogram to provide along-track sub-bottom imagery.	BMP, raw files, optional water column data.	Discrete
Drop keel sound velocity sensor	Provide sound velocity at transducer depth	Value over serial to Acoustics System.	Continuous
Sound velocity profilers (Valeport Midas, Lockheed XBT)	Direct measurement of sound velocity in water column.	ASCII pressure vs sound velocity files. Manually loaded into Kongsberg SIS or Sonardyne Ranger2.	Discrete (See deployment event log, below)
75 kHz ADCP (Teledyne OS75)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running
150 kHz ADCP (Teledyne OS150)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running

7.4.1 EQUIPMENT SPECIFIC COMMENTS

7.4.1.1 ADCPs

Path of ADCP data on the cruise datastore: /Ship_Systems/Data/Acoustics/ADCP

Attribute	***Value***
Acquisition software	UHDAS
Frequencies used	75 kHz (3 beams), 150 kHz
Running mode	Free-running untriggered by K-Sync
Configuration details	os150: Narrow band 40 bins, length 8m, 4m blanking, os75: narrow band, 60 bins, length 16m, 8m blanking
	Bottom tracking with was run from leaving Southampon from 2021-09-25 09:42 to 2021-09-28 11:18 then, used Narrowband with water tracking mode from 2021-09-29 11:19 to 2021-11-02 13:00. Recording stopped during the Fairlie, Scotland Ports of Call between 2021-10-18 12:00 – 2021-10-20 12:08.
	Survey name: DY138.

7.4.1.2 EM-122 Configuration and Surveys

Path of Multibeam data on the cruise datastore: /Ship_Systems/Data/Acoustics/EM-122

From 2020-September-30 patch test

Item	*X (m, + Forward)*	*Y (m,+Starboard)*	*Z (m, + Down)*
Tx transducer	39.910	0.885	7.426
Rx transducer	35.219	-0.005	7.438
Att 1 (Applanix)	0.00	0.00	0.00
Att 2 (Seapath)	0.00	0.00	0.00
Waterline (distance from Att 1 to Waterline)			1.34

Item	*Roll (deg)*	*Pitch (deg)*	*Yaw (deg)*
Tx transducer	0.07	0.15	0.05
Rx transducer	0.05	0.37	359.98
Att 1 (Applanix)	-0.10	0.00	-0.85

Att 2 (Seapath)	0.00	0.00	0.00

Survey information – note any particular transducer settings (e.g. beam spacing) in comments, Applanix PosMV used for providing position and attitude data.

Table 8: EM-122 survey details

Survey Site Name	***SIS Survey Name***	***Datetime Start***	***Total time of Logging* h:m:s**	***Vessel survey speed (kts)***	***SVP(s) Used (Filename)***	***Comments***
English Ch, Irish Sea	shallow	2021-09-25 07:12:00	80:05:26 167 lines	6-11	Default	Default SVP profile and Sensor
North Atlantic Ocean	deep	2021-09-28 16:54:50	(139:45:59) 1551 lines	0-11	SVP from CTD005; CTD008; CTD032; CTD048; CTD054; CTD088; CTD103;	CTD005 from line 39; CYD008 from line 233; CTD032 from line 469 CTD048 from line 538 CTD054 from line 659 CTD088 from line 1210 CTD103 from line 1365

Data processed daily with CARIS HIPS&SHIPS version 11 and with MB-System version 5.5.

Path of processed data on the cruise datastore:

/Ship_Systems/Data/Acoustics/EM-122/Caris_processed

/Ship_Systems/Data/Acoustics/MB-System_processed_multibeam_data

7.4.1.3 EM-710 Configuration and Surveys

Path of Multibeam data on the cruise datastore:

/Ship_Systems/Data/Acoustics/EM-710

Item	*X (m, + Forward)*	*Y (m, + Starboard)*	*Z (m, + Down)*
Tx transducer	37.570	-1.994	7.425

Rx transducer	36.819	-2.051	7.427
Att 1 (Applanix)	0.00	0.00	0.00
Att 2 (Seapath)	0.00	0.00	0.00
Waterline (distance from Att 1 to W/L)			1.34

Item	*Roll (deg)*	*Pitch (deg)*	*Yaw (deg)*
Tx transducer	-0.07	0.33	0.22
Rx transducer	0.01	0.12	359.7
Att 1 (Applanix)	-0.14	-0.40	-1.00
Att 2 (Seapath)	0.00	0.00	0.00

Survey information – note any particular transducer settings (e.g. beam spacing) in comments, Applanix PosMV used for providing position and attitude data.

7.5 OTHER SYSTEMS

7.5.1 CABLE LOGGING AND MONITORING

Winch activity is monitored and logged using the CLAM system.

7.5.2 VSAT AND FBB SATELLITE INTERNET

VSAT Usage:

Table 9: VSAT usage

DATE	Total Inbound (MB)	Total Outbound (MB)	Max IN	Max OUT
2021-09-18	5818	1540	1.67	0.60
2021-09-19	7799	3486	1.55	0.70
2021-09-20	7750	3810	1.60	0.70
2021-09-21	8349	4081	1.72	0.74
2021-09-22	9219	3902	1.75	0.72
2021-09-23	8977	3891	1.77	0.73
2021-09-24	7356	3408	1.64	1.18
2021-09-25	12723	5719	1.80	1.41
2021-09-26	22456	9678	3.77	1.49
2021-09-27	22840	10375	3.80	1.42
2021-09-28	22501	9451	3.69	1.46
2021-09-29	24207	7968	4.30	1.48
2021-09-30	25280	7007	3.80	1.49
2021-10-01	25194	8985	4.66	2.12
2021-10-02	27086	7554	5.07	1.59
2021-10-03	27151	7397	5.62	1.56
2021-10-04	27697	7785	5.74	1.83
2021-10-05	28257	9246	5.47	2.12
2021-10-06	30492	12824	5.50	1.94
2021-10-07	31142	13047	5.67	1.94
2021-10-08	28524	13764	5.47	2.03
2021-10-09	27903	10037	6.77	1.95
2021-10-10	28596	10345	5.73	1.94
2021-10-11	31826	9670	6.31	1.95
2021-10-12	35986	8643	6.28	1.97
2021-10-13	32531	9229	6.00	1.95
2021-10-14	36774	9600	6.62	1.79
2021-10-15	32853	7641	7.06	1.89
2021-10-16	36357	7572	7.15	1.95
2021-10-17	29267	8106	7.04	1.96

2021-10-18	22976	10939	6.55	2.42
2021-10-19	21729	7949	6.19	1.95
2021-10-20	24606	6448	7.48	1.92
2021-10-21	35910	9250	7.46	1.96
2021-10-22	28484	8585	7.16	1.94
2021-10-23	28207	11578	5.88	1.93
2021-10-24	27653	12623	5.31	1.92
2021-10-25	33303	12498	6.36	1.94
2021-10-26	35855	13700	7.06	1.95
2021-10-27	38653	15707	7.43	2.35
2021-10-28	39847	15625	7.10	1.95
2021-10-29	29529	14967	6.41	1.94
2021-10-30	27438	13542	6.57	1.91
2021-10-31	31808	13750	6.82	1.95
2021-11-01	33820	12765	8.04	2.34
2021-11-02	35615	10681	8.06	1.95