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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 –which the 40-day DY132 (or BLT1) research expedition initiates– 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. To enable such testing, in BLT1 a chemical tracer (SF5CF3) and a fluorescein dye were injected and subsequently measured in a canyon on the eastern slope of the Rockall Trough, a representative ocean circulation microcosm with northern and southern deep-water sources, moderate tides and a comparatively weak mesoscale flow field. The tracer and dye are well suited to respectively assess the long-term (up to O(1 year)) and short-term (up to O(1 day)) circulation, dispersion and mixing of deep waters in and beyond the canyon. The processes responsible for sustaining the circulation and mixing near and above the topographic boundary were investigated in two ways. First, through the deployment of three types of moorings (1 Moored Profiler mooring, 2 Modular Acoustic Velocity Sensor + fast thermistor moorings, 1 thermistor chain), which targeted the detailed observation of turbulent phenomena within a few hundreds of metres from the ocean floor, along the canyon?s axis. And second, through the frequent deployment of multiple fine- and microstructure profilers (the untethered HRP and VMP-6000 and untethered FastCTD, EpsiFish and VMP-2000) along, across and around the rim of the canyon. A Seaglider was also deployed in the region for the duration of the expedition, to provide contextual hydrographic information to interpret the specialised measurements from ship- and mooring-based instruments. Preliminary analyses of the data obtained in BLT1 provide 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 –which the 40-day DY132 (or BLT1) research expedition initiates– 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. To enable such testing, in BLT1 a chemical tracer (SF5CF3) and a fluorescein dye were injected and subsequently measured in a canyon on the eastern slope of the Rockall Trough, a representative ocean circulation microcosm with northern and southern deep-water sources, moderate tides and a comparatively weak mesoscale flow field. The tracer and dye are well suited to respectively assess the long-term (up to O(1 year)) and short-term (up to O(1 day)) circulation, dispersion and mixing of deep waters in and beyond the canyon. The processes responsible for sustaining the circulation and mixing near and above the topographic boundary were investigated in two ways. First, through the deployment of three types of moorings (1 Moored Profiler mooring, 2 Modular Acoustic Velocity Sensor + fast thermistor moorings, 1 thermistor chain), which targeted the detailed observation of turbulent phenomena within a few hundreds of metres from the ocean floor, along the canyon?s axis. And second, through the frequent deployment of multiple fine- and microstructure profilers (the untethered HRP and VMP-6000 and untethered FastCTD, EpsiFish and VMP-2000) along, across and around the rim of the canyon. A Seaglider was also deployed in the region for the duration of the expedition, to provide contextual hydrographic information to interpret the specialised measurements from ship- and mooring-based instruments. Preliminary analyses of the data obtained in BLT1 provide evidence of strong diapycnal upwelling and mixing within the canyon, suggesting broad support for the project?s overarching hypothesis.

1 Introduction

1.1 Maps

The following pages are rotated to lanscape and contain maps showing the locations of the observations made on this cruise.

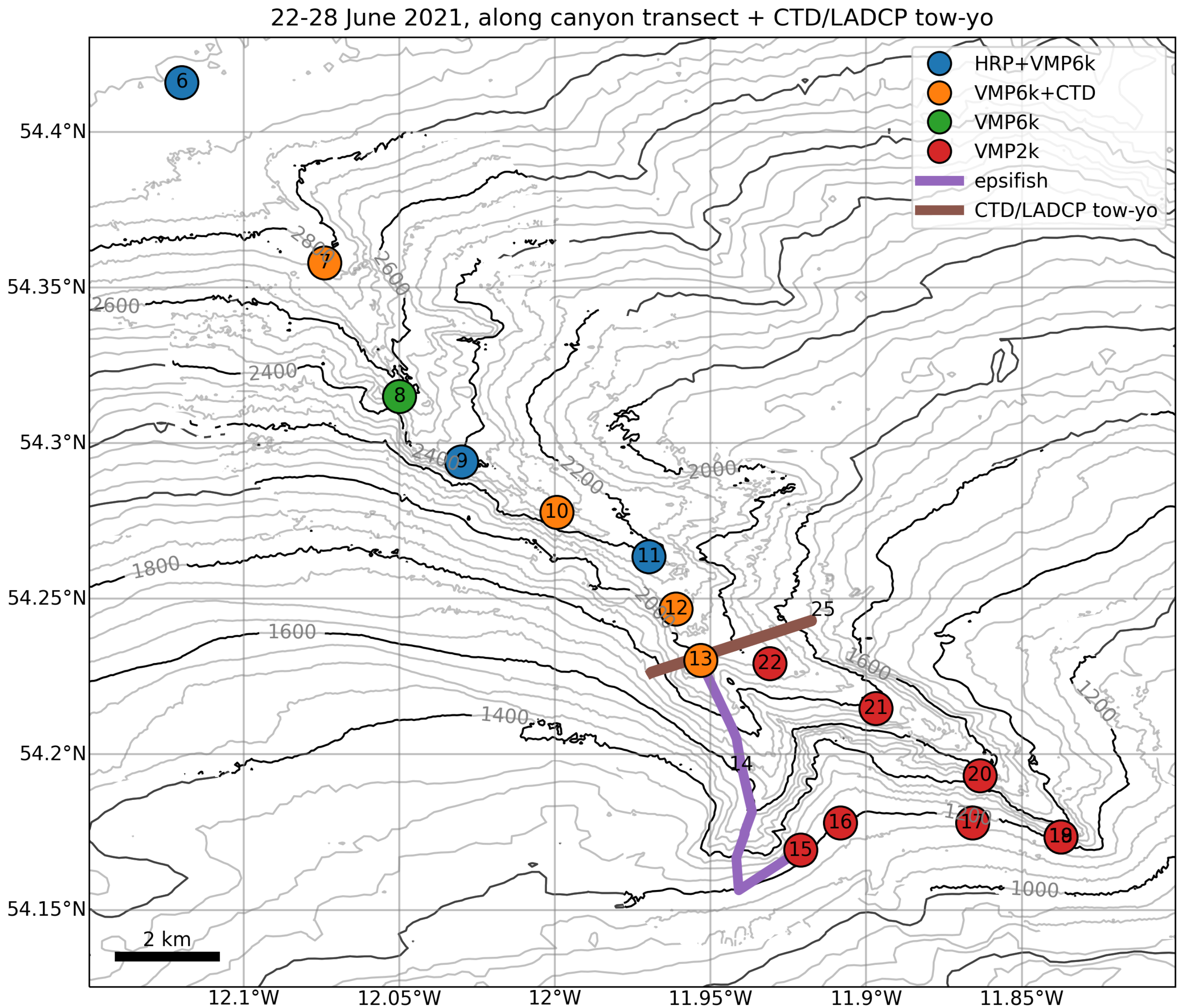


Figure 1: Map for 22nd June to 28th June

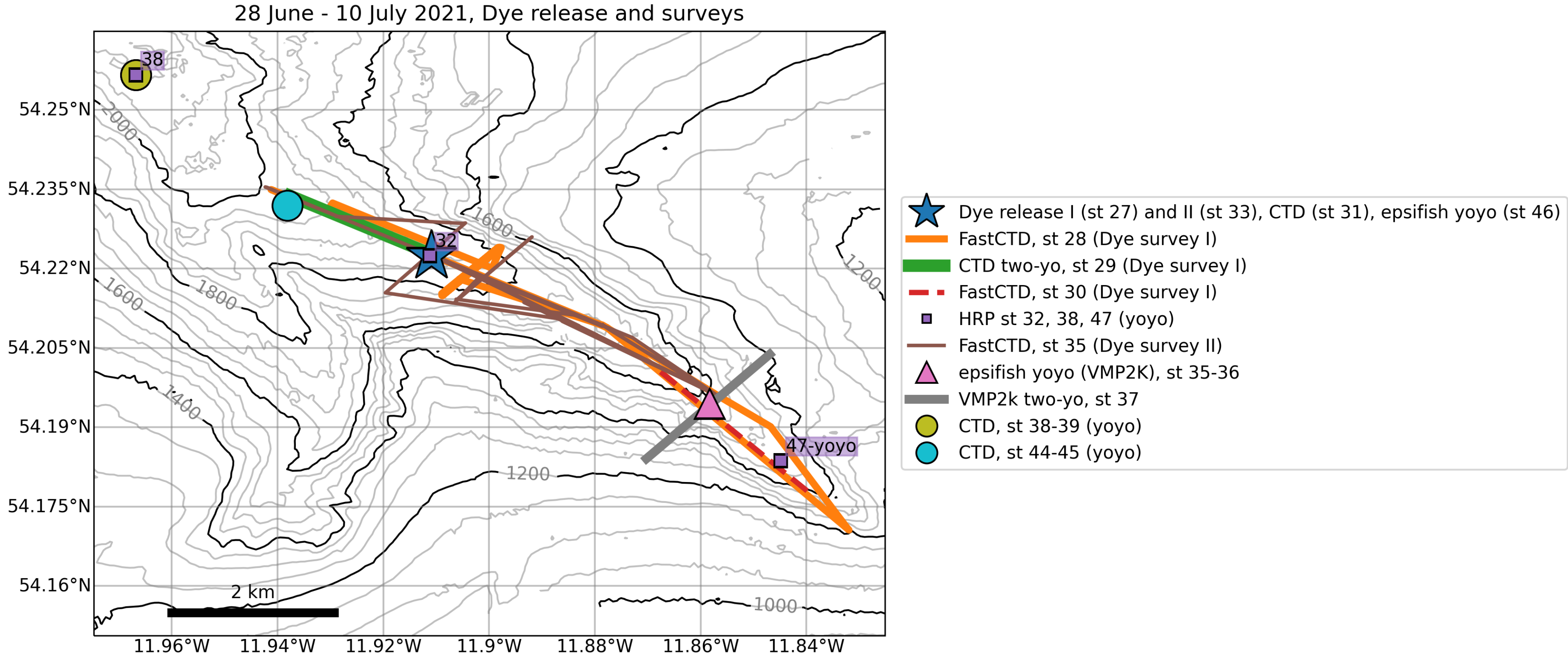


Figure 2: Map for 28th June to 10th July

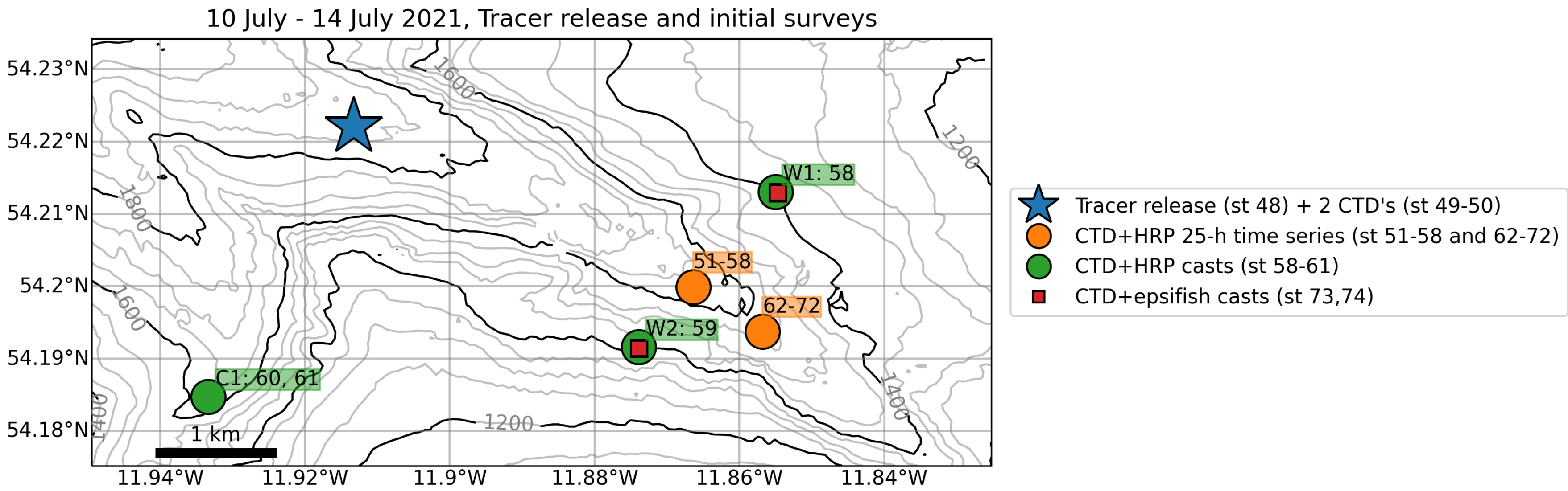


Figure 3: Map for 10th July to 14th July

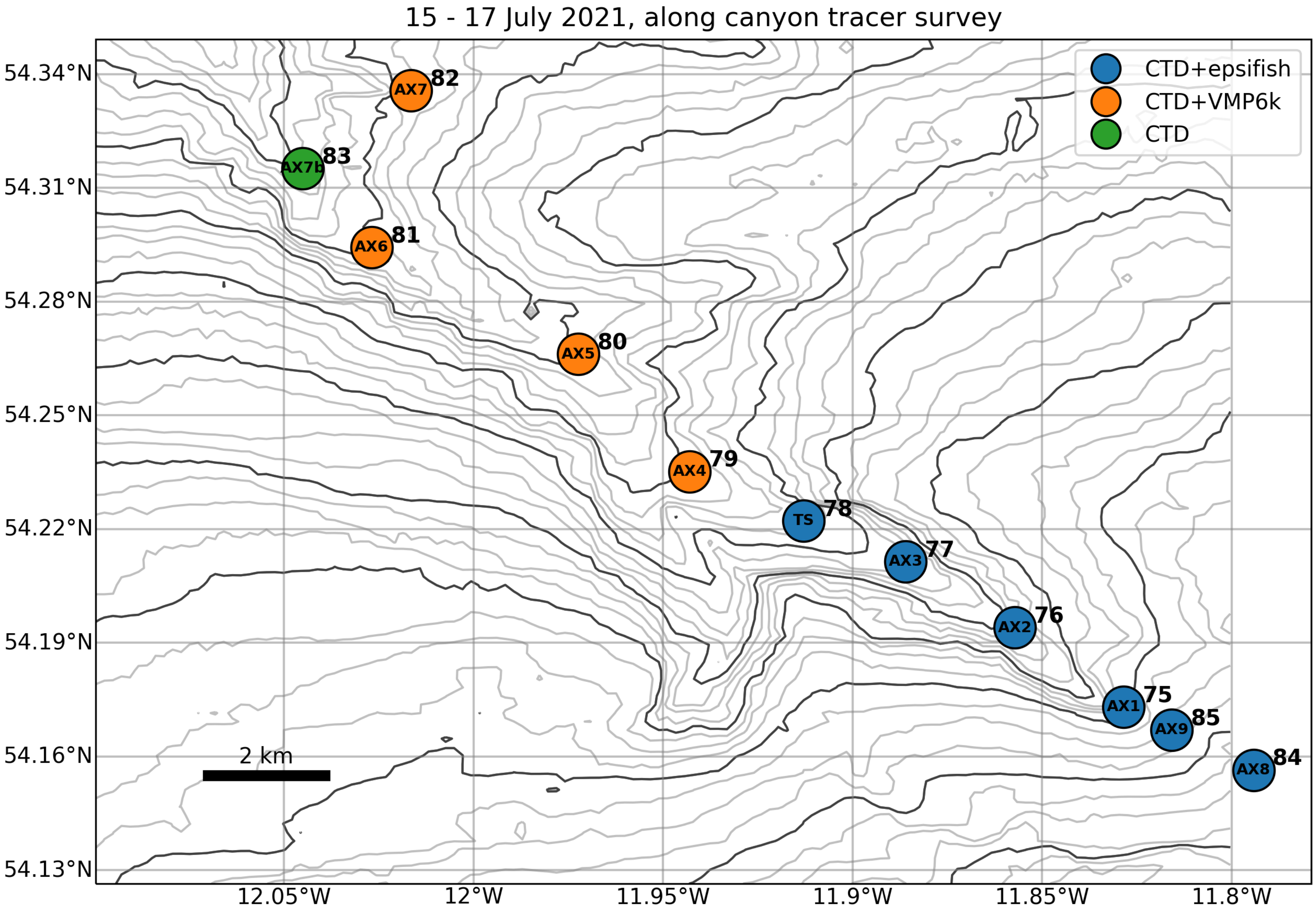


Figure 4: Map for 15th July to 17th July

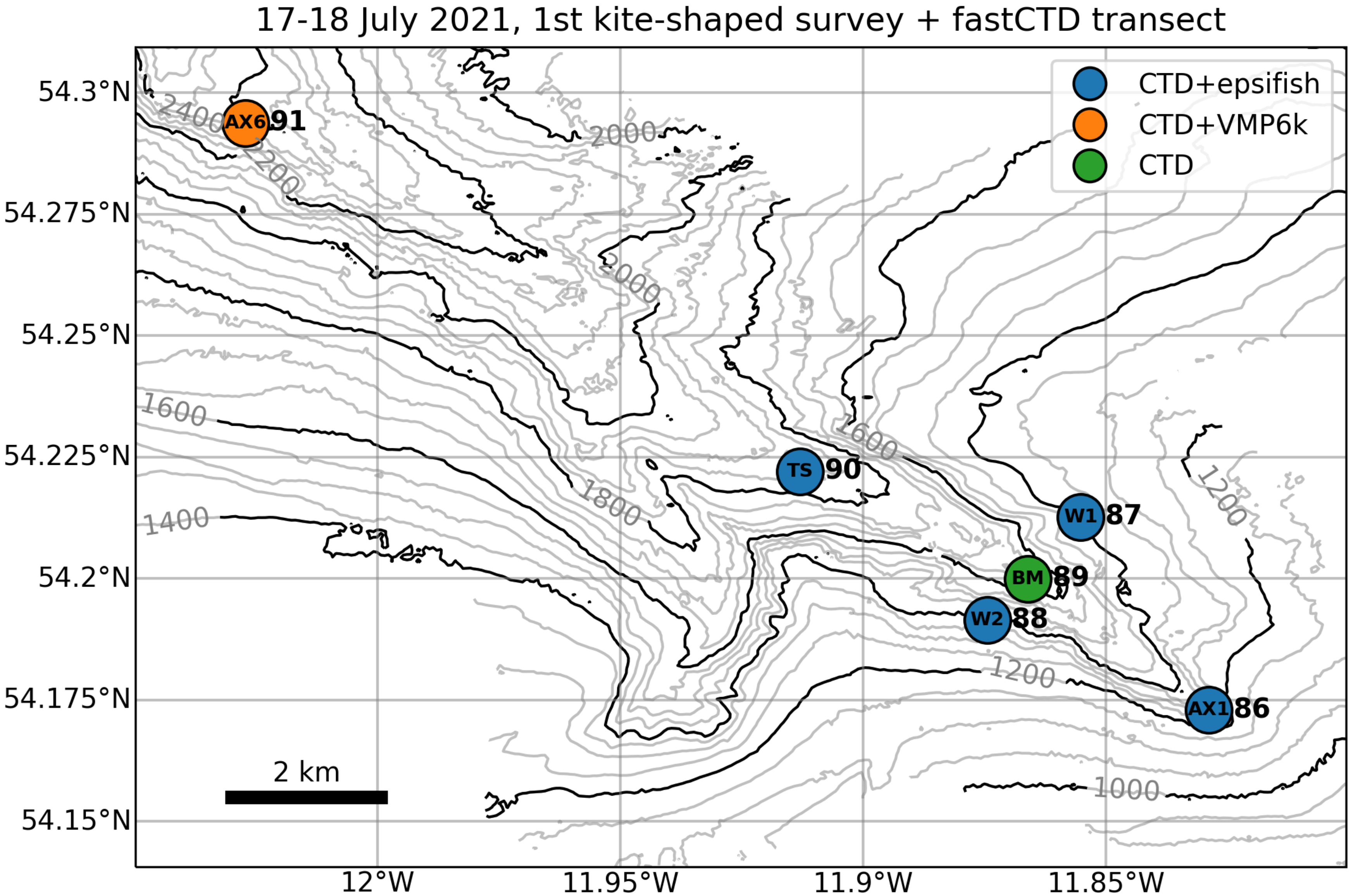


Figure 5: Map for 17th July to 18th July

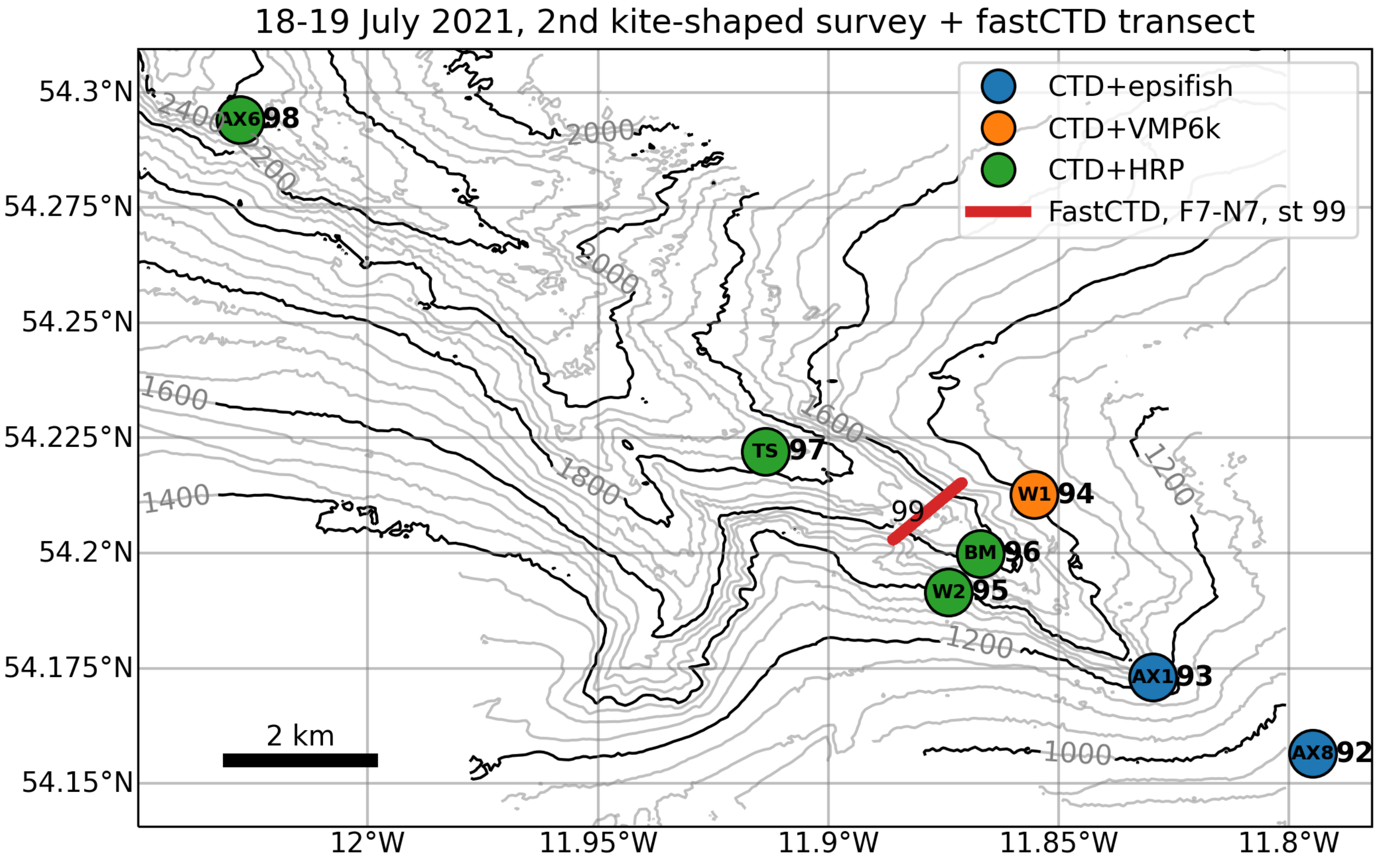


Figure 6: Map for 18th July to 19th July

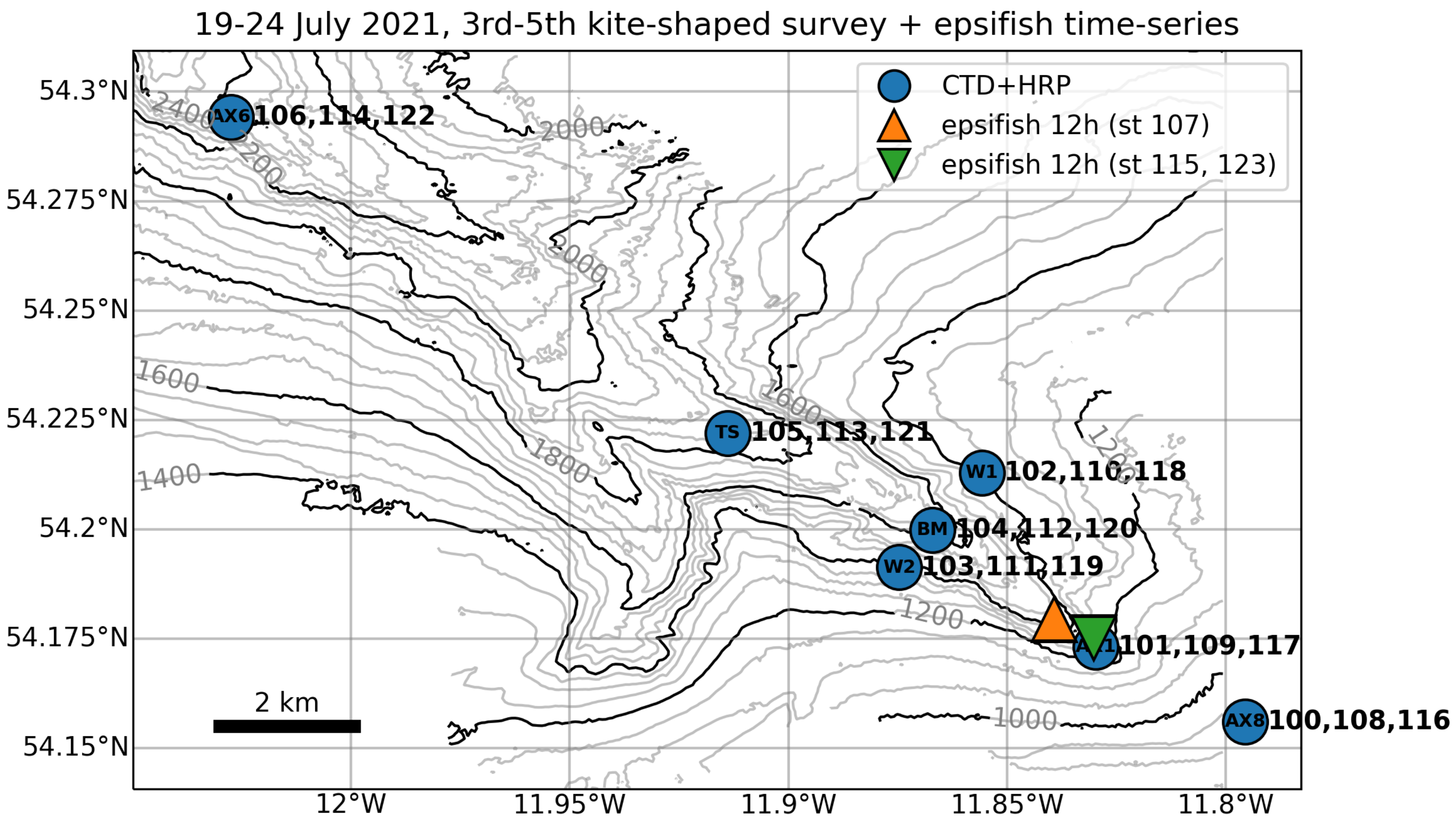


Figure 7: Map for 19th July to 24th July

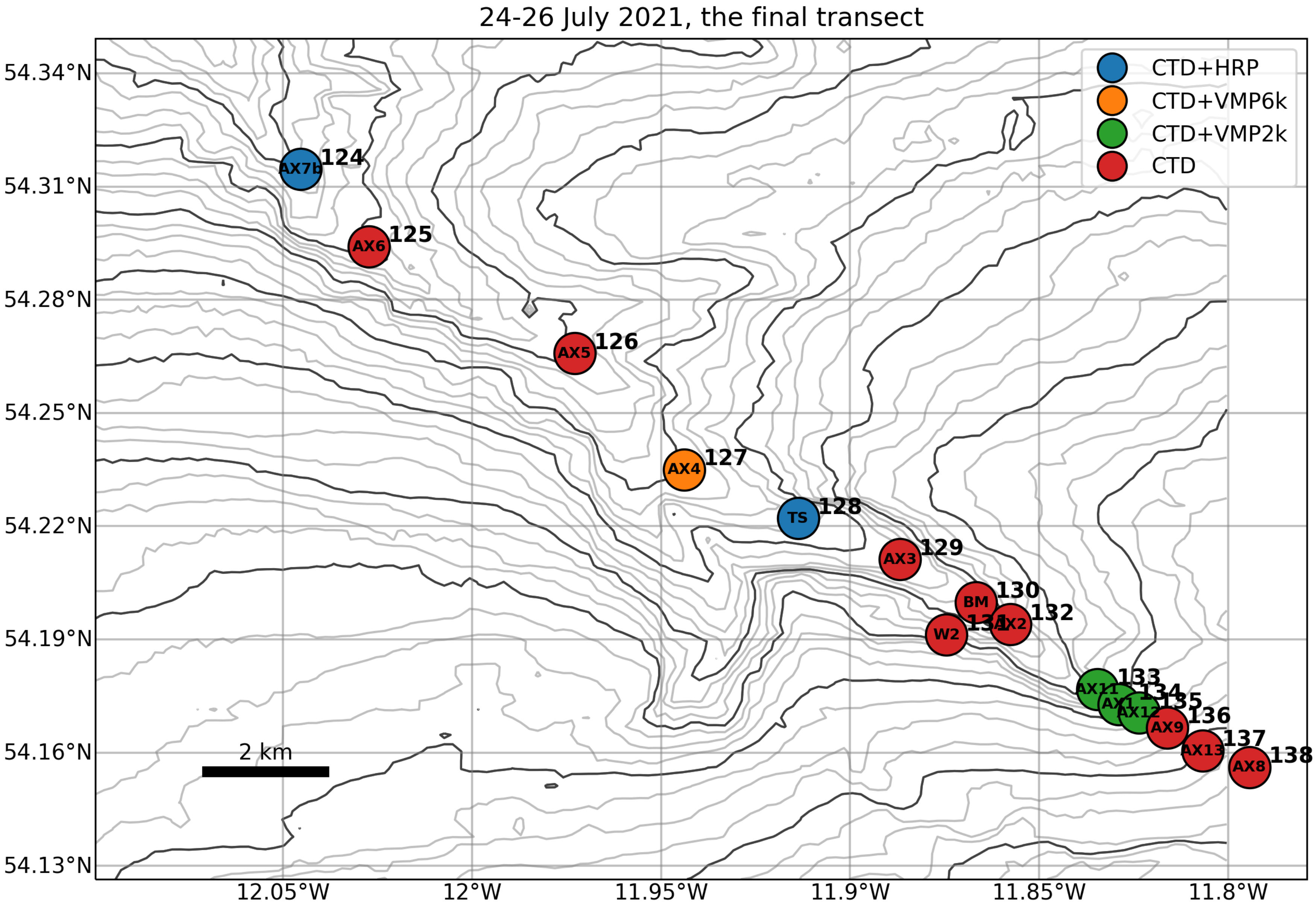


Figure 8: Map for 24th July to 26th July

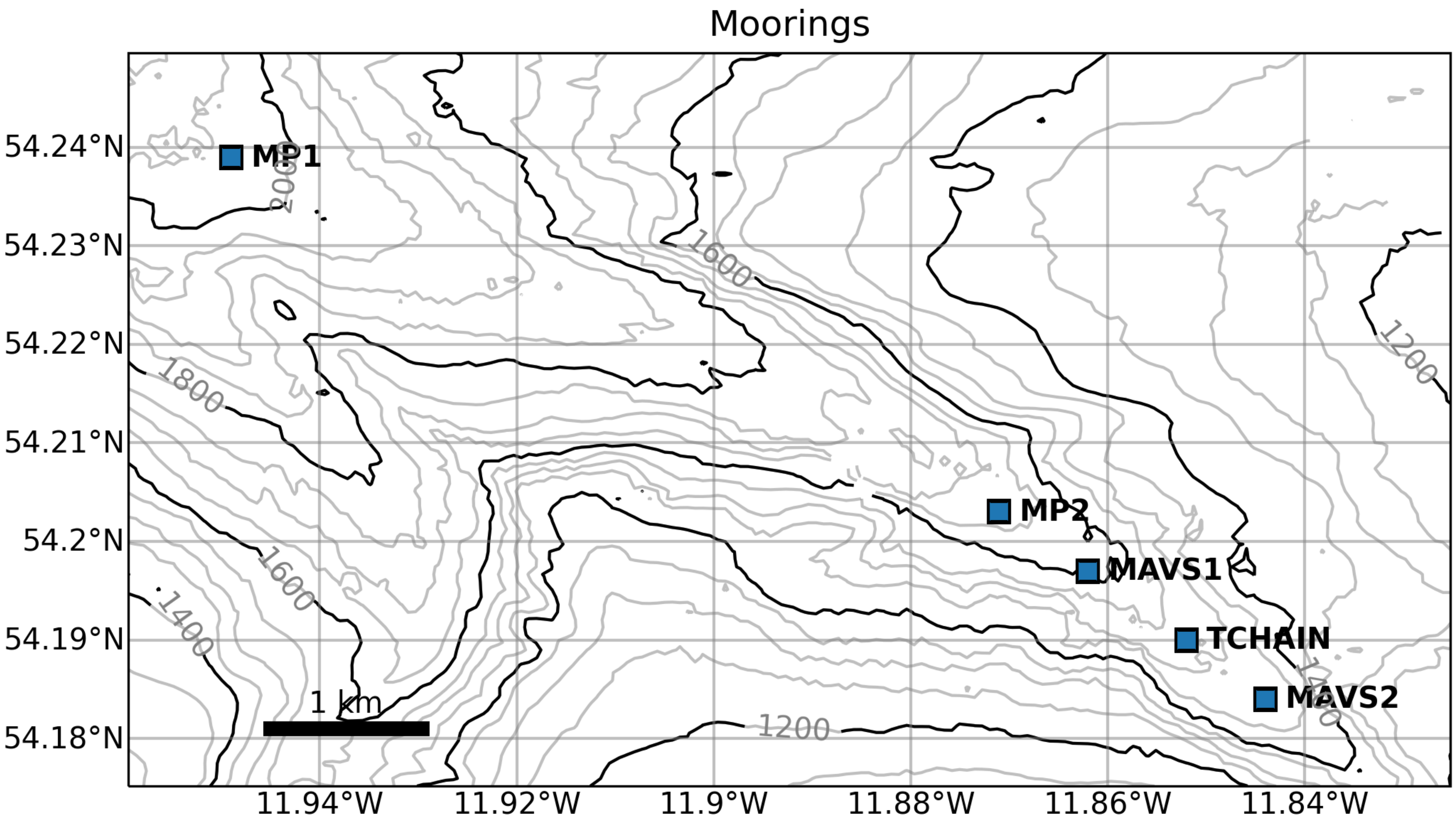


Figure 9: Map of the mooring locations

1.2 Event Logs –

The following pages are rotated to lanscape and contain a table with details of every instrument deployment.

Table 1: Event log

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
	1	2	19/06/2021 17:37	50.040544	-3.514265	FastCTD				FCTD deployed	
	1	3	19/06/2021 17:59	50.040341	-3.5218					FCTD recovered	
	2	6	20/06/2021 09:21	49.971705	-7.244136	CTD				CTD Deployed	
	2	7	20/06/2021 09:30	49.971709	-7.244149					CTD Recovered due to sensor failure	
	3	8	20/06/2021 09:54	49.971697	-7.244151	VMP				VMP Deployed w/out weights	
	3	9	20/06/2021 09:56	49.971616	-7.244163					VMP Recovered	
	4	10	20/06/2021 10:11	49.971995	-7.243931	VMP				VMP Deployed to 80m	
	4	11	20/06/2021 10:15	49.973238	-7.243451					VMP on the surface, beacon rec'd on VHF ch.72	
	4	12	20/06/2021 10:19	49.973905	-7.243191					VMP Recovered	
1	7	20	20/06/2021 12:11	50.068841	-7.404708	CTD	1	1		CTD deployed	
2	11	37	22/06/2021 06:16	54.200	-13.000	Glider	1			Glider deployed	
2	12	38	22/06/2021 07:23	54.200	-13.000	CTD	2	2		CTD deployed	
3	13	41	22/06/2021 09:18	54.196	-13.009	HRP	1			HRP deployment	Recovered 09:54

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
4	14	45	22/06/2021 10:42	54.195	-13.018	Tracer sled	1			Tracer sled dip test	Recovered: 11:22
5	15	49	22/06/2021 16:11	54.416	-12.114	Epsifish	1			epsifish test deployment	Recovered: 19:34
6	16	53	22/06/2021 20:28	54.416	-12.120	HRP	2		2937	Along canyon transect : T1. HRP	
6	17	54	22/06/2021 20:28	54.416	-12.120	VMP6000	1		2937	Along canyon transect: T1. VMP	Recovered: 23:28
7	19	61	23/06/2021 01:26	54.358	-12.074	VMP6000	2		2785	Along canyon transect: T2. VMP	Recovered: 04:50
7	20	62	23/06/2021 01:38	54.358	-12.075	CTD	3	3	2785	Along canyon transect: T2. CTD	
8	21	67	23/06/2021 05:43	54.315	-12.050	VMP6000	3		2547	Along canyon transect: T3. VMP	Recovered: 08:01
9	22	71	23/06/2021 08:59	54.294	-12.030	VMP6000	4		2352	Along canyon transect: T4. VMP	Recovered: 11:20
9	23	72	23/06/2021 09:06	54.293605	-12.029693	HRP	3		2352	Along canyon transect: T4. HRP	Recovered: 11:10

Stn	**Event**	**Bridge Event**	**Date Time**	**Latitude**	**Longitude**	**Instrument**	**Dive**	**CTD cast**	**Depth**	**Description**	**Comments**
10	24	80	23/06/2021 12:23	54.277767	-11.999498	VMP6000	5		2305	Along canyon transect: T5. VMP	Recovered: 14:47
10	25	81	23/06/2021 12:35	54.277768	-11.999492	CTD	4	4	2305	Along canyon transect: T5. CTD	Recovered: 14:28
11	26	88	23/06/2021 15:55	54.263619	-11.969798	VMP6000	6		2181	Along canyon transect: T6. VMP	Recovered: 17:46
11	27	89	23/06/2021 16:04	54.263622	-11.969797	HRP	4		2181	Along canyon transect: T6. HRP	Recovered: 17:51
12	28	94	23/06/2021 19:05	54.24672	-11.961103	VMP6000	7		2098	Along canyon transect: T7. VMP	Recovered: 20:56
12	29	95	23/06/2021 19:14	54.24672	-11.961103	CTD	5	5	2098	Along canyon transect: T7. CTD	Recovered: 20:52
13	30	100	23/06/2021 22:18	54.23032	-11.953213	VMP6000	8		1978	Along canyon transect: T8. VMP	
13	31	101	23/06/2021 22:43	54.23032	-11.953213	CTD	6	6	1978	Along canyon transect: T8. CTD	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
14	32	108	24/06/2021 01:23	54.22841	-11.95267	Epsifish	2		1974	Along canyon trasect: T8 to T16, Epsifish	Recovered 07:34
15	33	120	24/06/2021 09:26	54.169287	-11.921025	VMP2000	1		1219	Along canyon transect. T15. VMP2000	Recovered: 10:20
16	34	123	24/06/2021 10:57	54.178037	-11.908306	VMP2000	2		1194	Along canyon transect. T14? VMP2000	Recovered: 11:39
17	34	126	24/06/2021 12:21	54.178034	-11.865844	VMP2000	3		1171	Along canyon transect. T14 VMP2000	Recovered: 13:15
18	35	128	24/06/2021 13:47	54.173441	-11.837506	VMP2000	4		1190	Along canyon transect. T13. VMP2000	Recovered: 14:46
19	36	129	24/06/2021 14:49	54.173451	-11.837518	VMP2000	5		1233	Along canyon transect. T12. VMP2000	Recovered: 15:49
20	37	133	24/06/2021 16:19	54.193234	-11.863497	VMP2000	6		1466	Along canyon transect. T11. VMP2000	Recovered: 17:39
21	38	136	24/06/2021 18:24	54.21483	-11.896862	VMP2000	7		1800	Along canyon transect. T10. VMP2000	Recovered: 20:15ish

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
22	39	139	24/06/2021 20:31	54.229161	-11.930929	VMP2000	8		1907	Along canyon transect. T9. VMP2000	Recovered: 22:12
23	40	144	25/06/2021 02:12	54.229525	-11.953244	Sled(ge)	9		1954	Sled deep dive test	Recovered 06:54
24	42	148	27/06/2021 12:40	54.243563	-11.918496	FastCTD	1		1734	Fast CTD test	Recovered: 14:15
25	43	152	27/06/2021 14:47	54.2261	-11.9688	CTD	7	7-23	1722	25h cross-canyon two-yo (part 1)	Recovered: 2am on 28th for battery replacement
25	43	159	28/06/2021 03:00	54.242846	-11.917474	CTD	8	24-51	1734	25h cross-canyon two-yo (part 2)	Recovered: 14:54
26	44	168	28/06/2021 16:24	54.229495	-11.94172	MP mooring	1		2027	MP mooring deployment	Dropped: 17:30 at 54.239647N 11.949841W
27	45	173	28/06/2021 20:15	54.222385	-11.910866	Inkbot	1		1872	Dye release	Release: 21:46
28	46	176	28/06/2021 23:16	54.222411	-11.910785	FastCTD	2		1863	Dye survey	
29	47	211	30/06/2021 10:26	54.233764	-11.937651	CTD	9	43-51		Dye survey (CTD tow-yo)	Issues with fastCTD fluorometer. Backup with CTD
30	48	215	30/06/2021 14:25	54.177982	-11.839884	FastCTD	3		1333	Dye survey	
31	49	220	30/06/2021 18:33	54.22242	-11.911197	CTD	10	52	1866	Pre-dye release test	End: 20:12
32	51	228	30/06/2021 21:57	54.222403	-11.911166	HRP	5		1864	Instrument test	Profiling depth 500 m

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
33	52	232	01/07/2021 01:24	54.222997	-11.911168	Inkbot	2		1867	Dye release II	Release at 03:01
34	53	236	01/07/2021 05:04	54.219431	-11.90372	FastCTD	4			Dye survey II	
35	54	299	03/07/2021 12:53	54.194422	-11.858276	Epsifish	3		1592	24 h time-series at G9	Stopped after 12 hr
36	55	301	04/07/2021 04:35	54.194272	-11.858365	VMP2000	9		1585	24 h time-series at G9	Switching to VMP2000 to work on epsifish. End 12:20
37	60	311	04/07/2021 15:43	54.203807	-11.846942	VMP2000	10			Tow-yo transect across canyon (C9-G9)	End: 5 July at 14:10
37	65	324	05/07/2021 07:57	54.237032	-11.940246	MP mooring	1			MP mooring recovery	
38	67	335	05/07/2021 15:31	54.25664	-11.966785	CTD	11	53	2147	Water sampling for tracer	Control (zero for tracer)
38	68	336	05/07/2021 15:50	54.25664	-11.966785	HRP	6		2147	HRP test	
39	70	344	05/07/2021 20:16	54.256585	-11.966319	CTD	12	54-67	2144	Yoyo	12hour sampling to get tidal information for tracer deployment
40	71	347	06/07/2021 10:34	54.198556	-11.861534	MAVS1 mooring	1		1615	MARS1 Mooring deployment	Released: 14:15
41	72	351	06/07/2021 15:59	54.190944	-11.852474	BLT Tchain	1		1530	Tchain deployment	Released: 16:60

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
42	73	359	07/07/2021 13:28	54.183718	-11.843511	MAVS2 mooring	1			MAVS2 deployment	Anchor released: 13:28
43	74	362	07/07/2021 15:05	54.204139	-11.873439	MP mooring	2		1670	MP mooring deployment	Anchor released: 16:11
44	75	369	07/07/2021 18:48	54.231922	-11.938119	CTD	13	68	1979	Water sampling for tracer	Control (zero for tracer)
45	78	372	08/07/2021 12:53	54.232121	-11.937498	CTD	14	69	1978	Water sampling for tracer	Control (zero for tracer)
46	79	381	08/07/2021 12:53	54.222739	-11.91044	Epsifish	4		1865	24+ Yoyo at dye release site J4.4	End 09/07/2021 16:31
47	80	386	09/07/2021 17:34	54.183687	-11.844861	HRP	7		1469	24h time-series	End: 10/07/2021 at 22:30
47	81	387	09/07/2021 20:02	54.183758	-11.844814	HRP	8		1469	24h time-series	
47	82	389	09/07/2021 22:32	54.183753	-11.844882	HRP	9		1469	24h time-series	
47	83	391	10/07/2021 01:03	54.183795	-11.844887	HRP	10		1469	24h time-series	
47	84	393	10/07/2021 03:34	54.183783	-11.844825	HRP	11		1469	24h time-series	
47	85	395	10/07/2021 05:57	54.183849	-11.84431	HRP	12		1469	24h time-series	
47	86	397	10/07/2021 08:25	54.183855	-11.844368	HRP	13		1469	24h time-series	
47	87	399	10/07/2021 11:02	54.183921	-11.84446	HRP	14		1469	24h time-series	
47	88	401	10/07/2021 13:39	54.184074	-11.844445	HRP	15		1469	24h time-series	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
47	89	403	10/07/2021 16:06	54.183922	-11.844648	HRP	16		1469	24h time-series	
47	91	407	10/07/2021 17:27	54.183896	-11.844723	HRP	17		1469	24h time-series	
47	92	409	10/07/2021 21:03	54.1839	-11.844563	HRP	18		1469	24h time-series	
49	95	437	11/07/2021 23:36	54.222	-11.912843	CTD	15	70	1866	Tracer sampling at release site	
48	94	410	11/07/2021 23:59	54.222083	-11.913279	Sledge	1		1860	Tracer release	End: 11/07/2021 at 18:47
50	96	440	12/07/2021 03:25	54.221944	-11.912885	CTD	16	71	1866	Tracer sampling at release site	
51	97	444	12/07/2021 07:15	54.199895	-11.866363	CTD	17	72	1629	25 hours sampling between MMP and MAVS1	
51	98	445	12/07/2021 07:52	54.199897	-11.866358	HRP	19		1629	25 hours sampling between MMP and MAVS1	
52	99	449	12/07/2021 11:31	54.199878	-11.866274	CTD	18	73	1629	25 hours sampling between MMP and MAVS1	
53	100	451	12/07/2021 14:41	54.199911	-11.866255	CTD	19	74	1616	25 hours sampling between MMP and MAVS1	
54	101	454	12/07/2021 18:20	54.199945	-11.866328	CTD	20	75	1616	25 hours sampling between MMP and MAVS1	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
54	102	456	12/07/2021 19:19	54.19994	-11.866314	HRP	20		1616	25 hours sampling between MMP and MAVS1	
55	103	460	12/07/2021 21:21	54.199917	-11.866285	CTD	21	76	1629	25 hours sampling between MMP and MAVS1	
55	104	462	12/07/2021 22:15	54.199916	-11.866279	HRP	21		1629	25 hours sampling between MMP and MAVS1	
56	105	466	13/07/2021 00:36	54.200148	-11.866283	CTD	22	77	1635	25 hours sampling between MMP and MAVS1	
56	106	468	13/07/2021 01:20	54.200151	-11.866269	HRP	22		1635	25 hours sampling between MMP and MAVS1	
57	107	471	13/07/2021 03:50	54.200107	-11.866198	CTD	23	78	1635	25 hours sampling between MMP and MAVS1	
57	108	472	13/07/2021 04:33	54.200107	-11.866208	HRP	23		1635	25 hours sampling between MMP and MAVS1	
58	109	478	13/07/2021 07:26	54.21304	-11.855027	CTD	24	79	1383	Station on canyon wall (W1)	
58	110	479	13/07/2021 08:11	54.213034	-11.855039	HRP	24		1383	Station on canyon wall (W1)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
59	111	484	13/07/2021 11:00	54.191605	-11.873898	CTD	25	80	1406	Station on the opposite canyon wall (W2)	
59	112	486	13/07/2021 11:32	54.191614	-11.87391	HRP	25		1406	Station on the opposite canyon wall (W2)	
60	113	490	13/07/2021 13:44	54.18472	-11.933364	CTD	26	81	1603	Station on the other canyon branch (C1)	
60	114	492	13/07/2021 14:34	54.184716	-11.933362	HRP	26		1603	Station on the other canyon branch (C1)	
61	115	495	13/07/2021 16:55	54.184491	-11.933269	CTD	27	82	1601	Station on the other canyon branch (C1)	
61	116	496	13/07/2021 17:27	54.184491	-11.933276	HRP	27		1601	Station on the other canyon branch (C1)	
62	117	501	13/07/2021 20:00	54.193756	-11.856802	HRP	28		1560	25 hours sampling between MAVS1 and Tchain	
63	118	504	13/07/2021 22:31	54.19382	-11.856678	HRP	29		1560	25 hours sampling between MAVS1 and Tchain	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
64	119	507	14/07/2021 00:10	54.194009	-11.857206	CTD	28	83	1560	25 hours sampling between MAVS1 and Tchain	
64	120	509	14/07/2021 01:00	54.194006	-11.857211	HRP	30		1560	25 hours sampling between MAVS1 and Tchain	
65	121	511	14/07/2021 03:25	54.19383	-11.856722	HRP	31		1560	25 hours sampling between MAVS1 and Tchain	
66	122	514	14/07/2021 05:11	54.193895	-11.856809	CTD	29	84	1560	25 hours sampling between MAVS1 and Tchain	
66	123	515	14/07/2021 06:01	54.193936	-11.856812	HRP	32		1560	25 hours sampling between MAVS1 and Tchain	
67	124	518	14/07/2021 08:28	54.194017	-11.856953	HRP	33		1560	25 hours sampling between MAVS1 and Tchain	
68	125	520	14/07/2021 10:31	54.193957	-11.856762	CTD	30	85	1560	25 hours sampling between MAVS1 and Tchain	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
68	126	522	14/07/2021 11:26	54.193958	-11.856728	HRP	34		1560	25 hours sampling between MAVS1 and Tchain	
69	127	525	14/07/2021 13:53	54.193891	-11.856792	HRP	35		1560	25 hours sampling between MAVS1 and Tchain	
70	128	527	14/07/2021 15:53	54.193773	-11.856618	CTD	31	86	1560	25 hours sampling between MAVS1 and Tchain	
70	129	529	14/07/2021 17:00	54.193756	-11.856638	HRP	36		1560	25 hours sampling between MAVS1 and Tchain	
71	131	534	14/07/2021 19:32	54.193757	-11.856794	HRP	37		1560	25 hours sampling between MAVS1 and Tchain	
72	132	536	14/07/2021 21:18	54.193736	-11.85677	CTD	32	87	1560	25 hours sampling between MAVS1 and Tchain	
72	133	538	14/07/2021 22:16	54.193779	-11.856786	HRP	38		1560	25 hours sampling between MAVS1 and Tchain	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
73	134	542	15/07/2021 00:16	54.212931	-11.854696	CTD	33	88	1422	Station on canyon wall (W1)	
73	135	544	15/07/2021 02:06	54.212936	-11.854684	Epsifish	5		1427	Station on canyon wall (W1)	
74	136	547	15/07/2021 03:56	54.191408	-11.873824	CTD	34	89	1396	Station on the opposite canyon wall (W2)	
74	137	549	15/07/2021 05:50	54.191391	-11.873848	Epsifish	6		1400	Station on the opposite canyon wall (W2)	
75	138	553	15/07/2021 07:43	54.173098	-11.828545	CTD	35	90	1314	Along canyon transect (AX1)	
75	139	556	15/07/2021 09:49	54.173062	-11.82854	Epsifish	7		1319	Along canyon transect (AX1)	
76	140	559	15/07/2021 11:29	54.193983	-11.857217	CTD	36	91	1556	Along canyon transect (AX2)	
76	141	561	15/07/2021 13:36	54.193948	-11.85717	Epsifish	8		1556	Along canyon transect (AX2)	
77	142	564	15/07/2021 15:23	54.211436	-11.886004	CTD	37	92	1758	Along canyon transect (AX3)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
77	143	567	15/07/2021 17:40	54.211405	-11.886013	Epsifish	9		1758	Along canyon transect (AX3)	
78	144	571	15/07/2021 19:15	54.222181	-11.912941	CTD	38	93	1870	Along canyon transect (TS)	
78	145	573	15/07/2021 21:41	54.222182	-11.91295	Epsifish	10		1870	Along canyon transect (TS)	
79	146	576	15/07/2021 23:44	54.235157	-11.942956	CTD	39	94	2053	Along canyon transect (AX4)	
79	147	579	16/07/2021 01:58	54.235195	-11.942959	Epsifish	11		2003	Along canyon transect (AX4)	
80	148	582	16/07/2021 04:13	54.266101	-11.972324	VMP6000	9		2199	Along canyon transect (AX5)	
80	149	583	16/07/2021 04:19	54.266102	-11.972319	CTD	40	95	2199	Along canyon transect (AX5)	
81	150	588	16/07/2021 08:20	54.294291	-12.026872	VMP6000	10		2410	Along canyon transect (AX6)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
81	151	589	16/07/2021 08:26	54.294292	-12.026881	CTD	41	96	2410	Along canyon transect (AX6)	
82	152	594	16/07/2021 12:47	54.335662	-12.016506	VMP6000	10		2409	Along canyon transect (AX7)	
82	153	595	16/07/2021 12:58	54.335666	-12.016513	CTD	42	97	2409	Along canyon transect (AX7)	
82	NA	NA	16/07/2021 16:39	54.335666	-12.016513	HRP	39		2409	Shallow test cast at AX7	
83	154	605	16/07/2021 18:14	54.31508	-12.045017	CTD	43	98	2581	Along canyon transect (AX7B)	
84	155	608	16/07/2021 22:49	54.156446	-11.794251	CTD	44	99	901	Along canyon transect (AX8)	
84	156	611	17/07/2021 00:26	54.156393	-11.794206	Epsifish	12		908	Along canyon transect (AX8)	
85	157	614	17/07/2021 01:51	54.16699	-11.815805	CTD	45	100	1106	Along canyon transect (AX9)	
85	158	617	17/07/2021 03:28	54.166988	-11.815813	Epsifish	13		1106	Along canyon transect (AX9)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
86	159	621	17/07/2021 04:51	54.172944	-11.828797	CTD	46	101	1280	Along canyon transect (AX1)	
86	160	624	17/07/2021 06:36	54.172944	-11.828806	Epsifish	14		1340	Along canyon transect (AX1)	
87	161	627	17/07/2021 08:18	54.21266	-11.855287	CTD	47	102	1434	Tracer kite-shaped survey (W1)	
87	162	629	17/07/2021 10:15	54.212662	-11.855288	Epsifish	15		1436	Tracer kite-shaped survey (W1)	
88	163	632	17/07/2021 11:43	54.191401	-11.874489	CTD	48	103	1401	Tracer kite-shaped survey (W2)	
88	164	635	17/07/2021 13:44	54.191351	-11.874512	Epsifish	16		1407	Tracer kite-shaped survey (W2)	
89	165	638	17/07/2021 15:34	54.199931	-11.866114	CTD	49	104	1637	Tracer kite-shaped survey (BM)	
90	166	643	17/07/2021 18:28	54.222034	-11.913024	CTD	50	105	1870	Tracer kite-shaped survey (TS)	
90	167	646	17/07/2021 20:42	54.221991	-11.913179	Epsifish	17		1870	Tracer kite-shaped survey (TS)	
91	168	649	17/07/2021 23:09	54.293735	-12.027186	CTD	51	106	2429	Tracer kite-shaped survey (AX6)	
91	169	650	18/07/2021 00:42	54.293734	-12.027189	VMP6000	11		2421	Tracer kite-shaped survey (AX6)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
92	170	654	18/07/2021 04:27	54.156467	-11.79483	CTD	52	107	900	Tracer kite-shaped survey 2 (AX8)	
92	171	656	18/07/2021 05:59	54.156429	-11.794896	Epsifish	18		900	Tracer kite-shaped survey 2 (AX8)	
93	172	661	18/07/2021 07:20	54.173003	-11.829503	CTD	53	108	1274	Tracer kite-shaped survey 2 (AX1)	
93	173	663	18/07/2021 09:06	54.172797	-11.829177	Epsifish	19		1274	Tracer kite-shaped survey 2 (AX1)	
94	174	666	18/07/2021 11:25	54.212606	-11.855284	CTD	54	109	1423	Tracer kite-shaped survey 2 (W1)	
94	175	667	18/07/2021 12:13	54.212615	-11.855286	VMP6000	13		1423	Tracer kite-shaped survey 2 (W1)	
94	176	671	18/07/2021 14:20	54.212938	-11.856806	HRP	40		1423	Tracer kite-shaped survey 2 (W1)	Test cast 500m
95	177	674	18/07/2021 15:22	54.191487	-11.873881	CTD	55	110	1396	Tracer kite-shaped survey 2 (W2)	
95	178	676	18/07/2021 16:16	54.191445	-11.873884	HRP	41		1396	Tracer kite-shaped survey 2 (W2)	
96	179	681	18/07/2021 18:22	54.199899	-11.866984	CTD	56	111	1616	Tracer kite-shaped survey 2 (BM)	
96	180	683	18/07/2021 19:42	54.199898	-11.866972	HRP	42		1616	Tracer kite-shaped survey 2 (BM)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
97	181	687	18/07/2021 21:58	54.222032	-11.913651	CTD	57	112	1868	Tracer kite-shaped survey 2 (TS)	
97	182	689	18/07/2021 22:47	54.222034	-11.913651	HRP	43		1868	Tracer kite-shaped survey 2 (TS)	
98	183	693	19/07/2021 01:40	54.294026	-12.027759	CTD	58	113	2399	Tracer kite-shaped survey 2 (AX6)	
98	184	694	19/07/2021 02:41	54.294022	-12.027766	HRP	44		2399	Tracer kite-shaped survey 2 (AX6)	
99	185	699	19/07/2021 06:45	54.203101	-11.885542	FastCTD	5		1499	F7 to N7 repeat transect	
100	186	713	19/07/2021 21:29	54.156078	-11.795526	CTD	59	114	905	Tracer kite-shaped survey 3 (AX8)	
100	187	715	19/07/2021 22:06	54.156071	-11.795543	HRP	45		905	Tracer kite-shaped survey 3 (AX8)	
101	188	719	20/07/2021 00:33	54.173066	-11.829647	CTD	60	115	1325	Tracer kite-shaped survey 3 (AX1)	
101	189	721	20/07/2021 02:36	54.172196	-11.838168	HRP	46		1325	Tracer kite-shaped survey 3 (AX1)	Recovered time - Deployed time not recorded
102	190	723	20/07/2021 03:45	54.212878	-11.855756	CTD	61	116	1423	Tracer kite-shaped survey 3 (W1)	
102	191	724	20/07/2021 04:24	54.212877	-11.855761	HRP	47		1423	Tracer kite-shaped survey 3 (W1)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
103	192	730	20/07/2021 06:44	54.191282	-11.874682	CTD	62	117	1387	Tracer kite-shaped survey 3 (W2)	
103	193	732	20/07/2021 07:24	54.191269	-11.874673	HRP	48		1387	Tracer kite-shaped survey 3 (W2)	
104	194	737	20/07/2021 10:04	54.199853	-11.867031	CTD	63	118	1633	Tracer kite-shaped survey 3 (BM)	
104	195	738	20/07/2021 10:49	54.199853	-11.867032	HRP	49		1633	Tracer kite-shaped survey 3 (BM)	
105	196	742	20/07/2021 13:40	54.221935	-11.913803	CTD	64	119	1867	Tracer kite-shaped survey 3 (TS)	
105	197	743	20/07/2021 14:41	54.221937	-11.913803	HRP	50		1867	Tracer kite-shaped survey 3 (TS)	
106	198	748	20/07/2021 17:18	54.294157	-12.027545	CTD	65	120	2383	Tracer kite-shaped survey 3 (AX6)	
106	199	750	20/07/2021 18:18	54.294151	-12.027548	HRP	51		2383	Tracer kite-shaped survey 3 (AX6)	
107	200	754	21/07/2021 03:35	54.179499	-11.839201	Epsifish	20		1434	12-hr time-series at D11	
108	201	758	21/07/2021 16:50	54.156477	-11.79485	CTD	66	121	912	Tracer kite-shaped survey 4 (AX8)	
108	202	762	21/07/2021 17:31	54.156451	-11.794883	HRP	52		912	Tracer kite-shaped survey 4 (AX8)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
108	203	763	21/07/2021 18:55	54.16127	-11.802285	VMP2000/epsifish	11		977	Comparison between VMP2000 and epsifish	
109	204	765	21/07/2021 20:19	54.172958	-11.829421	CTD	67	122	1325	Tracer kite-shaped survey 4 (AX1)	
109	205	767	21/07/2021 21:09	54.172965	-11.829431	HRP	53		1325	Tracer kite-shaped survey 4 (AX1)	
110	206	768	21/07/2021 23:28	54.212753	-11.855913	CTD	68	123	1384	Tracer kite-shaped survey 4 (W1)	
110	207	772	22/07/2021 00:12	54.212755	-11.855943	HRP	54		1384	Tracer kite-shaped survey 4 (W1)	
111	208	775	22/07/2021 02:22	54.191588	-11.874982	CTD	69	124	1387	Tracer kite-shaped survey 4 (W2)	
111	209	776	22/07/2021 03:08	54.191593	-11.87499	HRP	55		1387	Tracer kite-shaped survey 4 (W2)	
112	210	780	22/07/2021 05:41	54.199863	-11.866939	CTD	70	125	1633	Tracer kite-shaped survey 4 (BM)	
112	211	782	22/07/2021 06:40	54.199858	-11.866931	HRP	56		1633	Tracer kite-shaped survey 4 (BM)	
113	212	786	22/07/2021 08:50	54.222338	-11.913659	CTD	71	126	1867	Tracer kite-shaped survey 4 (TS)	
113	213	788	22/07/2021 09:46	54.222351	-11.91365	HRP	57		1867	Tracer kite-shaped survey 4 (TS)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
114	214	792	22/07/2021 12:23	54.294491	-12.027436	CTD	72	127	2386	Tracer kite-shaped survey 4 (AX6)	
114	215	793	22/07/2021 13:26	54.294492	-12.027451	HRP	58		2386	Tracer kite-shaped survey 4 (AX6)	
115	216	797	22/07/2021 16:54	54.17506	-11.830193	Epsifish	20		1360	epsifish time-series upcanyon	
116	217	800	23/07/2021 05:40	54.156539	-11.795287	CTD	73	128	912	Tracer kite-shaped survey 5 (AX8)	
116	218	802	23/07/2021 06:25	54.156539	-11.795276	HRP	59		912	Tracer kite-shaped survey 5 (AX8)	
117	219	805	23/07/2021 08:14	54.17308	-11.829327	CTD	74	129	1325	Tracer kite-shaped survey 5 (AX1)	
117	220	808	23/07/2021 08:55	54.173097	-11.829291	HRP	60		1325	Tracer kite-shaped survey 5 (AX1)	
118	221	812	23/07/2021 11:35	54.212956	-11.855266	CTD	75	130	1384	Tracer kite-shaped survey 5 (W1)	
118	222	813	23/07/2021 12:16	54.212953	-11.855271	HRP	61		1384	Tracer kite-shaped survey 5 (W1)	
119	223	814	23/07/2021 14:42	54.191314	-11.874584	CTD	76	131	1380	Tracer kite-shaped survey 5 (W2)	
119	224	816	23/07/2021 15:32	54.191312	-11.874591	HRP	62		1380	Tracer kite-shaped survey 5 (W2)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
120	225	821	23/07/2021 17:22	54.199799	-11.867075	CTD	77	132	1626	Tracer kite-shaped survey 5 (BM)	
120	226	823	23/07/2021 18:16	54.199978	-11.86688	HRP	63		1626	Tracer kite-shaped survey 5 (BM)	
121	227	826	23/07/2021 20:36	54.222316	-11.913713	CTD	78	133	1866	Tracer kite-shaped survey 5 (TS)	
121	228	829	23/07/2021 21:15	54.222371	-11.913607	HRP	64		1866	Tracer kite-shaped survey 5 (TS)	
122	229	833	24/07/2021 00:32	54.29393	-12.027551	CTD	79	134	2400	Tracer kite-shaped survey 5 (AX6)	
122	230	834	24/07/2021 01:39	54.293939	-12.027553	HRP	65		2400	Tracer kite-shaped survey 5 (AX6)	
123	231	838	24/07/2021 04:18	54.174562	-11.830279	Epsifish	21		1360	epsifish time-series upcanyon	
124	232	841	24/07/2021 18:38	54.314585	-12.045341	CTD	80	135	2572	The final transect (AX7b)	
124	233	843	24/07/2021 19:50	54.314718	-12.04548	HRP	66		2572	The final transect (AX7b)	Profile aborted, microRider failed
125	234	847	24/07/2021 22:21	54.294067	-12.027294	CTD	81	136	2415	The final transect (AX6)	
126	235	850	25/07/2021 02:22	54.265776	-11.972871	CTD	82	137	2211	The final transect (AX5)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
127	236	854	25/07/2021 05:49	54.235006	-11.943898	CTD	83	138	2000	The final transect (AX4)	
127	237	855	25/07/2021 06:45	54.235034	-11.943942	VMP6000	14		2000	The final transect (AX4)	
128	238	859	25/07/2021 09:59	54.208274	-12.143823	Glider	1			Glider recovered	
128	239	861	25/07/2021 11:21	54.222071	-11.913742	CTD	84	139	1866	The final transect (TS)	
128	240	862	25/07/2021 13:11	54.219491	-11.917745	HRP	67		1866	The final transect (TS)	
129	241	866	25/07/2021 14:54	54.211189	-11.88677	CTD	85	140	1759	The final transect (AX3)	
130	242	870	25/07/2021 17:55	54.199788	-11.866673	CTD	86	141	1617	The final transect (BM)	
131	243	874	25/07/2021 20:37	54.191221	-11.874573	CTD	87	142	1387	The final transect (W2)	
132	244	878	25/07/2021 23:50	54.193964	-11.8576	CTD	88	143	1570	The final transect (AX2)	
133	245	881	26/07/2021 02:46	54.176796	-11.834617	CTD	89	144	1413	The final transect (AX11)	
133	246	883	26/07/2021 04:49	54.176769	-11.83481	VMP2000	12		1399	The final transect (AX11)	
134	247	886	26/07/2021 06:09	54.172842	-11.82894	CTD	90	145	1339	The final transect (AX1)	

Stn	Event	Bridge Event	Date Time	Latitude	Longitude	Instrument	Dive	CTD cast	Depth	Description	Comments
134	248	889	26/07/2021 08:01	54.173015	-11.829532	VMP2000	13		1317	The final transect (AX1)	
135	249	892	26/07/2021 09:26	54.170516	-11.823579	CTD	91	146	1203	The final transect (AX12)	
135	250	895	26/07/2021 11:33	54.170536	-11.823615	VMP2000	14		1203	The final transect (AX12)	
136	251	899	26/07/2021 13:40	54.166574	-11.816106	CTD	92	147	1100	The final transect (AX9)	
137	252	902	26/07/2021 16:38	54.160522	-11.806733	CTD	93	148	1004	The final transect (AX13)	
138	253	905	26/07/2021 18:16	54.156156	-11.794374	CTD	94	149	902	The final transect (AX 8)	

2 Narrative

2.1 PSO's Diary

Saturday 19th June 2021 (Julian day 170) We set off from Southampton at around 7:00 am local time, after spending a week loading the ship, preparing instrumentation and going through covid-19 protocols. We sailed westward along the English Channel in fair weather while continuing to configure instruments. In the evening, we conducted a successful in-water trial of the EpsiFish.

Sunday 20th June 2021 (Julian day 171) We continued to sail westward onto the Celtic Sea on our way to the Rockall Trough, and performed in-water tests of the CTD / LADCP rosette (station 1) and the two VMP-6000s. We also attempted an HRP test, but this was aborted before entering the ocean.

Monday 21st June 2021 (Julian day 172) We sailed along the western coast of Ireland in transit to our target canyon. We conducted an in-water tethered test of HRP.

Tuesday 22nd June 2021 (Julian day 173) We arrived at the glider deployment site at the foot of the continental slope in the early hours, and deployed the glider at around 6:00 am. We subsequently performed a CTD / LADCP cast at the same position (station 2) with mooring thermistors attached for calibration, and an untethered test of HRP to 500 m (station 3). We then conducted a shallow test dive of the tracer sled (station 4), and proceeded to sail to the first station in the along-canyon transect. There, we performed a series of test EpsiFish casts (station 5), which were followed by a joint HRP and VMP-6000 station (station 6) at the end of the day.

Wednesday 23rd June 2021 (Julian day 174) We continued the transect with joint casts of two out of CTD/LADCP, VMP-6000 and HRP (stations 7-13). At station 8, HRP could not be deployed due to a minor technical problem, so only a VMP-6000 cast was performed.

Thursday 24th June 2021 (Julian day 175) We spent the entire day completing the along-canyon transect. Initially we towed EpsiFish along the transect (station 14), until its cable developed a fault and required re-termination. We conducted the rest of the transect with single-profile casts of VMP-2000 (stations 15-22). During the day, it was confirmed that the following morning we were to break off science and steam to Oban, in order to disembark one of our team due to a serious personal matter.

Friday 25th June 2021 (Julian day 176) We conducted a successful dive test of the tracer sled during the night (station 23). Around 7:00 am, we broke off science and started steaming toward Oban.

Saturday 26th June 2021 (Julian day 177) We arrived in Oban around 10:00 am and, after disembarking our team member, we commenced steaming back to our study area.

Sunday 27th June 2021 (Julian day 178) We arrived at the starting position for the CTD/LADCP tow-yo around 12:30 pm, and proceeded to test the FastCTD (station 24). Upon completion of this test, we started the tow-yo (station 25) at around 3:00 pm, and carried it on till the end of the day.

Monday 28th June 2021 (Julian day 179) We concluded the two-yo at around 3:00 pm, following which we deployed the MMP mooring at the axis of the canyon (station 26). Upon triangulating the mooring position, at around 7:00 pm we transited slightly up-canyon to the location of the dye injection. There, we lowered the inkbot to a few metres above the seabed (station 27). Our first attempt at doing this had been aborted by a leak of dye at the ocean surface, which was subsequently remedied. After monitoring the evolution of hydrographic properties at the seabed for some time using the CTD mounted on the inkbot, we injected the dye at around 9:45 pm. As we recovered the inkbot, the FastCTD was deployed at around 11:15 pm (station 28) to initiate the dye survey.

Tuesday 29th June 2021 (Julian day 180) We conducted the dye survey throughout the entire day with the FastCTD. Initially, the survey entailed repeats of a cross-canyon transect near the dye injection position. Subsequently, the survey involved an up-canyon transect along the canyon's axis, where we expected the bulk of the dye to have moved. The first traces of the dye were detected at around 7:00 am, and higher levels were encountered later in the day, though at substantially lower concentrations than we had expected.

Wednesday 30th June 2021 (Julian day 181) After surveying the axis of the canyon with the FastCTD all night, without finding significant dye levels, we detected a problem with the instrument's fluorometer. We decided to continue the along-canyon transects with the ship's CTD/LADCP (station 29) until the FastCTD was repaired. Then, we returned to deploying the FastCTD (station 30). Over the afternoon, we developed the idea that our lack of success in finding the bulk of the dye might stem from its having been too dense at injection, possibly sinking down-canyon as a near-bottom gravity current. We thus decided to repeat the dye experiment with a lighter dye mixture. We repositioned the ship to the same dye injection site as that of the first experiment, and conducted a CTD/LADCP there (station 31) and an HRP test (station 32) there.

Thursday 1st July 2021 (Julian day 182) We performed the second dye injection at around 2:00 am (station 33) and, following a stage of localized sampling with the inkbot to verify that the injection had been successful, we recovered the inkbot and deployed the FastCTD (station 34). We conducted along-canyon transects all night and day, successfully tracking the dye patch in its up-canyon progression modulated by back-and-forth tidal sloshing.

Friday 2nd July 2021 (Julian day 183) We continued our successful tracking of the dye patch with FastCTD transects along and across the canyon, throughout the day (still in station 34), in eerily calm weather.

Saturday 3rd July 2021 (Julian day 184) After an entire night of continuing to track the dye patch with FastCTD transects, the dye became too dilute to be detectable in the morning. Around noon, we commenced a 24-hour time series with EpsiFish at a mid-canyon site (station 35).

Sunday 4th July 2021 (Julian day 185) Soon after midnight, EpsiFish developed a fault, so we continued the time series with VMP-2000 (station 36). Upon completion of the time series around noon, we commenced a 24-hour tow-yo across the canyon with VMP-2000 (station 37). Weather conditions continued to be favourable, as they had been for the entire cruise thus far.

Monday 5th July 2021 (Julian day 186) We continued performing the VMP-2000 cross-canyon tow-yo through the night. After recovering the MMP mooring in the morning, we returned to the tow-yo (still station 37). Around 2:00 pm, we ended the tow-yo and moved to the tracer release position, where we conducted a CTD/LADCP station (station 38) and sampled rosette bottles for tracer background concentrations. When sampling was concluded, around 7:00 pm, we commenced a CTD/LADCP yo-yo station (station 39) at the same site.

Tuesday 6th July 2021 (Julian day 187) We continued the CTD/LADCP yo-yo until around 8:00 am, and subsequently commenced operations to deploy mooring MAVS1. After completing deployment at around 2:30 pm, we proceeded to deploy the T-chain mooring by 4:30 pm, and triangulated the positions of both moorings. We did not conduct any over-the-side work the following night, as the Scripps team's profiler systems were down and NMF personnel needed to rest following mooring work.

Wednesday 7th July 2021 (Julian day 188) We restarted mooring activities, in freshening weather, with the deployment of mooring MAVS2 in the morning, followed by the MMP mooring in the afternoon. We then steamed to our new choice of tracer release site, and conducted a CTD/LADCP cast (station 44) there, sampling rosette bottles for tracer background concentrations. We concluded the day with the Exeter team filling the sled's accumulators with tracer, in preparation for the release. As windy conditions had died down into the evening, we were forced to steam at a fair speed, facing the wind, during the accumulators' filling.

Thursday 8th July 2021 (Julian day 189) Upon concluding work on the accumulators, we steamed back to the tracer release site, where we performed a further CTD/LADCP cast (station 45), with rosette bottle sampling for tracer background levels. We subsequently (at around 1:00 pm) took on a ¿24 h-long time series with EpsiFish (station 46) at the site of the dye injection.

Friday 9th July 2021 (Julian day 190) The EpsiFish time series continued uneventfully until 4:00 pm today, when we steamed to near the location of the MAVS2 mooring to conduct a ¿24 h-long HRP time series (station 47) by the mooring. We had intended to perform the tracer release at the end of today, but issues with the batteries on the tracer sled meant that the release had to be delayed by a day.

Saturday 10th July 2021 (Julian day 191) The HRP time series was continued until around 11:00 pm, after which we relocated further down the canyon and commenced the tracer release (station 48), at about midnight.

Sunday 11th July 2021 (Julian day 192) The tracer release was performed during the entire night and most of the day, concluding at around 8:00 pm. The release entailed the chasing of a tidally-displaced target temperature class up and down the canyon while towing the tracer sled, sporadically interrupting tracer injection when the target temperature class was lost. Upon finishing the tracer release, we steamed to the initial release site and performed a CTD/LADCP cast (station 49) there, in order to provide initial sampling of the tracer profile hours after injection.

Monday 12th July 2021 (Julian day 193) A second CTD/LADCP cast (station 50) was performed at the same position, to sample the tracer at a different phase of the tide. Subsequently, we conducted a 24 h-long CTD/LADCP and HRP time series (stations 51-57) at a site between the MMP and MAVS1 moorings, where we predicted that the tracer's centre of mass would arrive toward the end of that sampling period.

Tuesday 13th July 2021 (Julian day 194) Upon concluding the time series above, we proceeded to conduct a CTD/LADCP and HRP station on either side of the canyon (stations 58 and 59) in 1400 water depth, in order to gauge the extent to which tracer might have been spilling over the canyon walls. Then we carried out two CTD/LADCP and HRP casts (stations 60 and 61) at a location in the western branch of the canyon, which we had barely sampled till then. We concluded the day by commencing a 24 h-long CTD/LADCP and HRP time series (stations 62-72) at a site between the MAVS1 and T-chain moorings, again following the anticipated up-canyon spread of the tracer.

Wednesday 14th July 2021 (Julian day 195) Following completion of the 24 h-long CTD/LADCP and HRP time series at the end of the day, we steamed to the canyon walls in order to re-occupy the sites of stations 58 and 59.

Thursday 15th July 2021 (Julian day 196) We performed CTD/LADCP and EpsiFish (which replaced HRP, as this has developed technical issues) stations at the canyon walls (stations 73-74) and at the tip of the canyon (station 75), to gauge the extent to which the tracer was overflowing the canyon-bounding topography. This was followed by a transect of CTD/LADCP and EpsiFish stations along the canyon axis (stations 76-83), which continued into the day after.

Friday 16th July 2021 (Julian day 197) The entire day was taken up with occupation of stations in the transect with CTD/LADCP, plus EpsiFish or VMP-6000, depending on the water depth. In one of the stations (station 83), we decided to not deploy the VMP-6000 due to the foggy conditions. After conclusion of the transect, we returned to the tip of the canyon to explore the local leakage of tracer with further CTD/LADCP and EpsiFish stations.

Saturday 17th July 2021 (Julian day 198) Re-occupation of the transect from the canyon's tip to its mouth with CTD/LADCP and EpsiFish (stations 84-91) went on all day and into the following day, in eerily calm conditions. In one of the stations (station 89), we omitted to deploy EpsiFish due to a technical fault.

Sunday 18th July 2021 (Julian day 199) After concluding the last station (station 91) in the tip-to-mouth canyon transect in the early hours, we initiated another re-occupation of the same transect (stations 92-98) with CTD/LADCP and a combination of EpsiFish, VMP-6000 and HRP, which was repaired during the day.

Monday 19th July 2021 (Julian day 200) The last two stations in the transect were completed in the early hours. Subsequently, we steamed to near the location of the MMP mooring, and commenced a 12-h FastCTD tow-yo across the canyon (station 99) to assess the tidal variability in the structure of the up-canyon flow. On finishing the tow-yo, around 8:30 pm, we re-occupied the tip-to-mouth canyon transect with CTD/LADCP and HRP (stations 100-106) through the rest of the day and most of the day after.

Tuesday 20th July 2021 (Julian day 201) The bulk of the day was taken up repeating the transect, in the same exceptionally calm and foggy conditions that we had generally had throughout the cruise. In the last transect station, the thick fog hampered HRP recovery operations, and the instrument was lost for 5 hours, into the early hours of the following day.

Wednesday 21st July 2021 (Julian day 202) After completing HRP recovery at 2 am, we steamed to a site directly upcanyon of mooring MAVS2, where we performed a 12-h EpsiFish time series (station 107). Then, we commenced re-occupation of the tip-to-mouth canyon transect with CTD/LADCP and HRP (stations 108-114), in glorious weather.

Thursday 22nd July 2021 (Julian day 203) Re-occupation of the transect was concluded at 3 pm. Subsequently, we steamed to a site upcanyon of the moorings, at 1250 m water depth, where we performed a 12-h EpsiFish time series (station 115).

Friday 23rd July 2021 (Julian day 204) The EpsiFish time series was concluded until 5 am, and was followed by a final re-occupation of the tip-to-mouth canyon transect with CTD/LADCP and HRP (stations 116-122) in stunning weather.

Saturday 24th July 2021 (Julian day 205) The transect iteration was completed around 4 am, and a new 12h EpsiFish time series started (station 123) shortly after at the same location as the previous day's. Upon finishing this time series at 5 pm, we embarked on a final occupation of the tip-to-mouth canyon transect with CTD/LADCP and HRP/VMP-6000 (stations 124-138), including more comprehensive tracer mapping with additional stations (some of which had been occupied once already, immediately following the tracer release).

Sunday 25th July 2021 (Julian day 206) Performance of the transect continued all day in fair weather. As the HRP developed a technical fault, and time to complete the transect was tight, we decided to drop microstructure measurements in a number of the stations. The glider was recovered safely and swiftly in the morning, in close proximity to the transect.

Monday 26th July 2021 (Julian day 207) The last station on the transect was concluded at 7 pm, after which we commenced the steam back to Southampton. Five of the last six transect stations entailed the deployment of VMP-2000 while sampling of bottles was being performed after each CTD/LADCP cast.

Tuesday 27th July 2021 (Julian day 208) The steam back proceeded uneventfully. Cruise participants held an evening barbeque on the starboard deck to celebrate the end of a successful cruise.

Wednesday 28th and Thursday 29th July 2021 (Julian day 209-210) The steam back continued uneventfully. We arrived in Southampton in the early morning of 29th July.

3 Conductivity, Temperature, Depth (CTD) Operations

3.1 CTD Operations – *John Wynar*

3.1.1 CTD System Configuration

See separate Sensor Information document.

3.1.2 CTD Operations

There were 149 CTD casts made all using the stainless steel (s/s) system. Log sheets were scanned and included with the data from this cruise. Twenty-four 10L water samplers were used throughout except during tow-yo casts when they were removed. There was the occasional failure where an end cap did not close properly (see log sheets for more information) but this was the exception rather than the rule.

Casts 7 to 42, 43 to 51 and 54 to 67 were tow-yo casts where the CTD was continuously cycled from a few metres above the sea floor to 1000m above bottom. A new cast file was begun after each cycle. During the first tow-yo after cast 23 the CTD was brought on deck in order for the LADCP battery pack (s/n: WH007) to be exchanged for a charged one (s/n: WH008T).

Primary SBE3P and SBE4C sensors were located inside the frame attached to the 9plus, and secondary sensors on the vane. An SBE35 DOST temperature sensor was fitted as an additional check to the two SBE3P's. It was attached to a vertical stanchion on the CTD frame, the tip being 110cm higher and 120cm vertically away from the primary SBE 3P. It was set up to average 20 samples at each bottle firing.

CTD1 was used for all casts. Currently it gives an insulation figure of ¿ 999MΩ o/c and a s/c value of 70Ω after the last cast.

MDS swivel s/n: 1246-2 was used for all casts.

Total number of casts: 149 Casts deeper than 2000m: 42 Deepest cast: 2798m

3.1.3 Sensor Changes

After cast 106 the user supplied fluorimeter was removed leaving channel V4 free.

No communication with the slave LADCP s/n: 24609 was able to be established after cast 79 so it was replaced with s/n: 13329. The dissolved oxygen sensor SBE43-0862 began to give sporadically erroneous data during cast 116 and was thought to be fouled. However during cast 117 no data from the sensor was usable and it was replaced with SBE43-1624.

3.1.4 Data Processing

Basic post-processing of the CTD cast data was done to guidelines established with BODC (ref. Moncoiffe 7th July 2010). Additionally, CTD2MET processing was carried out for each cast as well as processing to obtain sound velocity profiles for the multi-beam system.

3.1.5 Salinity Measurement

A Guildline Autosal 8400B salinometer, s/n: 71185, was used for salinity measurements. The salinometer was sited in the Salinometer lab. Initially, the bath temperature was set at 21°C, the ambient temperature being approximately 20°C. The salinometer was standardised at the beginning of the first set of samples, and checked with an additional standard analysed prior to setting the RS. Once standardized the Autosal was not adjusted for the duration of sampling. A standard was analysed after each crate of samples to monitor and record drift (second standard analysed after sample 24, third standard analysed after sample 48, etc). Standards were recorded in the spreadsheet as '0' and had a standard salinity value of 34.994. Standard deviation was set to 0.0001.

A bespoke program written in Labview called "Autosal" was used as the data recording program for salinity values.

Salinity samples were taken and analysed from most casts and the results tabulated in a spreadsheet `SALFORM_SS.xlsx`.

3.1.6 Configuration Files

Initial configuration file used from casts 1 to 117

```
Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY132\Setup Files\DY1

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

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

1) Frequency 0, Temperature

   Serial number : 03P-4381
   Calibrated on : 15 Sep 2020
   G             : 4.42360271e-003
   H             : 6.44988546e-004
   I             : 2.27189858e-005
   J             : 1.98859956e-006
   F0            : 1000.000
```

```
   Slope          : 1.00000000
   Offset         : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-3698
   Calibrated on : 12-May-20
   G             : -1.01489414e+001
   H             : 1.43675257e+000
   I             : -2.63550454e-003
   J             : 2.85076061e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 76501
   Calibrated on : 24-Jan-2020
   C1            : -6.052595e+004
   C2            : -1.619787e+000
   C3            : 1.743190e-002
   D1            : 2.819600e-002
   D2            : 0.000000e+000
   T1            : 3.011561e+001
   T2            : -5.788717e-004
   T3            : 3.417040e-006
   T4            : 4.126500e-009
   T5            : 0.000000e+000
   Slope         : 0.99977900
   Offset        : -1.24262
   AD590M        : 1.293660e-002
   AD590B        : -9.522570e+000

4) Frequency 3, Temperature, 2

   Serial number : 03P-4383
   Calibrated on : 07-Aug-20
   G             : 4.39869412e-003
   H             : 6.55435937e-004
   I             : 2.42259434e-005
   J             : 2.00806467e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000
```

```
5) Frequency 4, Conductivity, 2

   Serial number : 04C-3873
   Calibrated on : 12-May-20
   G             : -1.01920432e+001
   H             : 1.35647113e+000
   I             : -7.44503969e-004
   J             : 1.25242864e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

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

   Serial number : 43-0862
   Calibrated on : 06-Feb-21
   Equation      : Sea-Bird
   Soc           : 5.01000e-001
   Offset        : -5.04100e-001
   A             : -4.49660e-003
   B             : 1.51430e-004
   C             : -2.70690e-006
   E             : 3.60000e-002
   Tau20         : 1.13000e+000
   D1            : 1.92634e-004
   D2            : -4.64803e-002
   H1            : -3.30000e-002
   H2            : 5.00000e+003
   H3            : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Altimeter

   Serial number : 62679
   Calibrated on :
   Scale factor  : 15.000
   Offset        : 0.000

9) A/D voltage 3, Free

10) A/D voltage 4, Free

11) A/D voltage 5, Free
```

```
12) A/D voltage 6, Free

13) A/D voltage 7, Transmissometer, WET Labs C-Star

    Serial number : CST-1720TR
    Calibrated on : 6.26.18
    M             : 21.1810
    B             : -0.1800
    Path length   : 0.250

Scan length                   : 41
---------------------------------------------
Pump Control
   This setting is only applicable to a custom build of the SBE 9plus.
   Enable pump on / pump off commands: NO
---------------------------------------------
Data Acquisition:
   Archive data:                    YES
   Delay archiving:                 NO
   Data archive:                    C:\Users\sandm\Documents\Cruises\DY132\Data\CTD R
   Timeout (seconds) at startup:    60
   Timeout (seconds) between scans: 20
---------------------------------------------
Instrument port configuration:
   Port      = COM4
   Baud rate = 19200
   Parity    = N
   Data bits = 8
   Stop bits = 1
---------------------------------------------
Water Sampler Data:
   Water Sampler Type:   SBE Carousel
   Number of bottles:    36
   Port:                 COM5
   Enable remote firing: NO
   Firing sequence:      User input
   Tone for bottle fire confirmation uses PC sound card.
---------------------------------------------
Header information:
   Header Choice = Prompt for Header Information
      prompt 0 = Ship: RRS Discovery
      prompt 1 = Cruise: DY132
      prompt 2 = Cast:
      prompt 3 = Station:
      prompt 4 = Julian Day:
```

```
      prompt 5 = Date:
      prompt 6 = Time (GMT):
      prompt 7 = Latitude:
      prompt 8 = Longitude:
      prompt 9 = Depth (uncorrected m):
      prompt 10 = Principal Scientist: Prof A Garabato
      prompt 11 = Operator:
---------------------------------------------
TCP/IP - port numbers:
   Data acquisition:
      Data port:           49163
      Status port:         49165
      Command port:        49164
   Remote bottle firing:
      Command port:        49167
      Status port:         49168
   Remote data publishing:
      Converted data port: 49161
      Raw data port:       49160
---------------------------------------------
Miscellaneous data for calculations
   Depth, Average Sound Velocity, and TEOS-10
      Latitude when NMEA is not available:  48.000
      Longitude when NMEA is not available: 0.000
   Average Sound Velocity
      Minimum pressure [db]:                20.000
      Minimum salinity [psu]:               20.000
      Pressure window size [db]:            20.000
      Time window size [s]:                 60.000
   Descent and Acceleration
      Window size [s]:                      2.000
   Plume Anomaly
      Theta-B:                              0.000
      Salinity-B                            0.000
      Theta-Z / Salinity-Z                  0.000
      Reference pressure [db]               0.000
   Oxygen
      Window size [s]:                      2.000
      Apply hysteresis correction:          0
      Apply Tau correction:                 1
   Potential Temperature Anomaly
      A0:                                   0.000
      A1:                                   0.000
      A1 Multiplier:                        Salinity
---------------------------------------------
Serial Data Output:
```

```
   Output data to serial port: NO
---------------------------------------------
Mark Variables:
   No variables are selected.
---------------------------------------------
Shared File Output:
   Output data to shared file: NO
---------------------------------------------
TCP/IP Output:
   Raw data:
      Output raw data to socket:            NO
      XML wrapper and settings:             NO
      Seconds between raw data updates:     0.000
   Converted data:
      Output converted data to socket:      NO
      XML format:                           NO
---------------------------------------------
SBE 11plus Deck Unit Alarms
   Enable minimum pressure alarm:    NO
   Enable maximum pressure alarm:    NO
   Enable altimeter alarm:           NO
---------------------------------------------
SBE 14 Remote Display
   Enable SBE 14 Remote Display:     NO
---------------------------------------------
PC Alarms
   Enable minimum pressure alarm:    NO
   Enable maximum pressure alarm:    NO
   Enable altimeter alarm:           NO
   Enable bottom contact alarm:      NO
   Alarm uses PC sound card.
---------------------------------------------
Options:
   Prompt to save program setup changes: YES
   Automatically save program setup changes on exit: NO
   Confirm instrument configuration change: YES
   Confirm display setup changes: YES
   Confirm output file overwrite: YES
   Check scan length: YES
   Compare serial numbers: YES
   Maximized plot may cover Seasave: NO
```

From cast 118 to 149 the SBE43 on A/D voltage 0 was:

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

```
Serial number : 43-1624
Calibrated on : 06-Mar-21
Equation      : Sea-Bird
Soc           : 3.50900e-001
Offset        : -7.07500e-001
A             : -4.46950e-003
B             : 1.78250e-004
C             : -2.82940e-006
E             : 3.60000e-002
Tau20         : 1.30000e+000
D1            : 1.92634e-004
D2            : -4.64803e-002
H1            : -3.30000e-002
H2            : 5.00000e+003
H3            : 1.45000e+003
```

3.2 CTD Processing and Calibration – *Carl Spingys*

A total of 149 CTD profiles were collected on DY132 from a 90 single profile stations and 3 yoyo/towyo stations. The CTD processing was performed using a combination of the SBE Data Processing, Version 7.26.7 and Matlab routines. For details of the instrumentation see the previous section.

3.2.1 Processing Workflow

The initial steps of the processing were performed using the SBE Data Processing tools in the following order:

Table 2: SBE Data Processing Steps

Step	Details
SBE Convert	Apply Tau and Hysteresis corrections with 2 sec window.
SBE Wildedit	Applied to all variables other than beam attenuation, beam tranmission, and fluorescence. First pass uses 2 standard deviations and the second pass uses 20 standard deviations.
SBE Align CTD	Oxygen is advanced by 6 seconds.
SBE Cell Thermal Mass	Thermal anomaly amplitude of 0.03 and time constant of 7 applied to both sensors.
SBE Loop Edit	Use a fixed minimum velocity of 0.25 m/s
SBE Derive	Derived variables: Descent Rate, Potential Temperature, Practical Salinity

These steps were then followed with a series of matlab routines to do additional manual spike removal, addition of derived variables, and bin average the up and down cast seperatly.

3.2.2 Salinity Calibration

A total of 194 bottle samples were processed for salinity (for details see the previous section). These were used to seperatly calibrate the salinity measurement from each pair of T-S sensors. This was performed using the routines below.

The primary salinity was offset by 0.00321. The secondary salinity was offset by 0.00248 for casts 1 to 114 and 0.00252 for the stations from 115 to the end of the cruise. After calibration the calibrations samples lie within 0.001, giving a bound on the accuracy of calibrated salinity. See the plots below for details of the calibration.

Table 3: Matlab Processing Steps

Step	Details
Convert_cnv_to_mat	Loads the SBE .cnv file and saves as a .mat file.
Manual_Spike_Check	Provides a plots of temperature, conductivity and oxygen. Then allows the manual selection of spikes etc to be removed
Take_Bottle_Average	Averages all the variables between the start and end scans for each bottle firing (as given by the .bl file)
Derive_TEOS10	Calculates the Absolute Salinity and Conservative Temperature as defined by TEOS10
Do_Bin_Averaging	Averages the down and up casts in 2 dbar bins

Table 4: Calibration Steps

Step	Details
Read_All_Salinometer	Loads all the salinometer data and saves to a mat file
Add_Salinometer_LookUp	Loads a lookup table to match the salinity bottle to CTD niskin bottles and adds to mat file
Add_Sensor2Salinometer	Adds the bottle averaged sensor data to the salinity mat file
Make_Sal_Calib_Plots	Generates a bunch of plots allowing the comparison of the sensor combinations and the salinometer samples
Apply_Sal_Calib	Loads in the CTD mat file and applies a calibration.
Derive_TEOS10	Repeat of above
Do_Bin_Averaging	Repeat of above

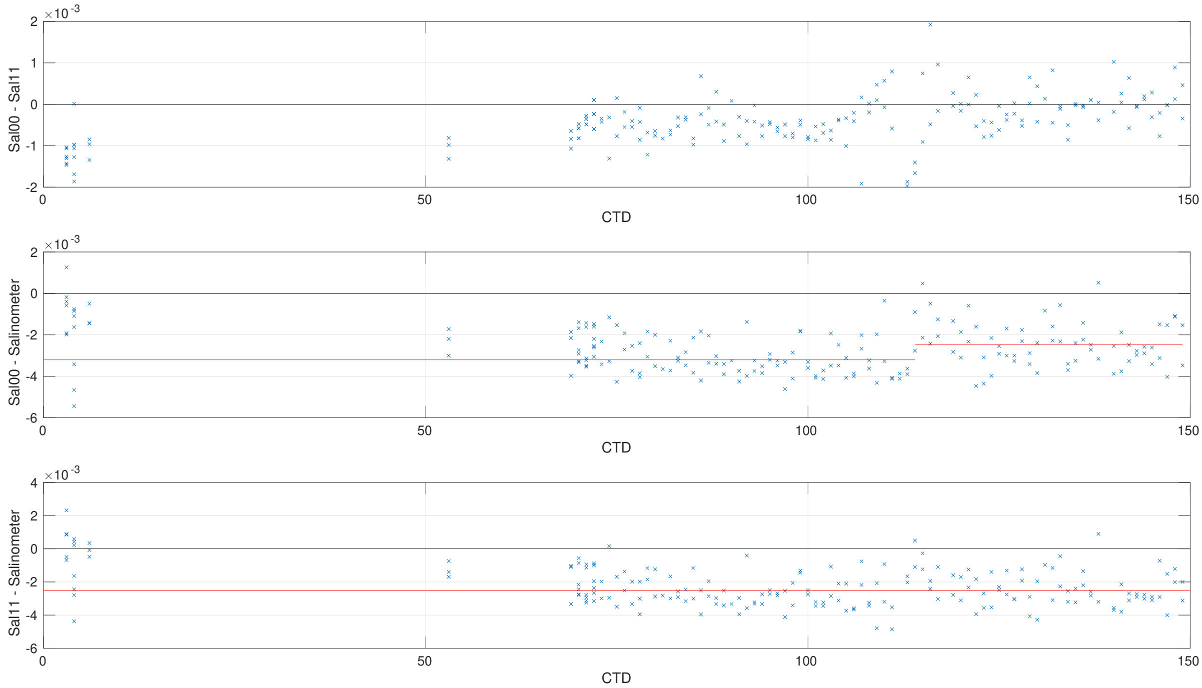


Figure 10: Calibration plots showing the offsets between (a) the two sensor pairs, (b) the primary sensor pair and the calibration samples, and (c) the secondary sensor pair and the calibration samples by CTD number. The black lines show no offset and the red lines the applied calibration.

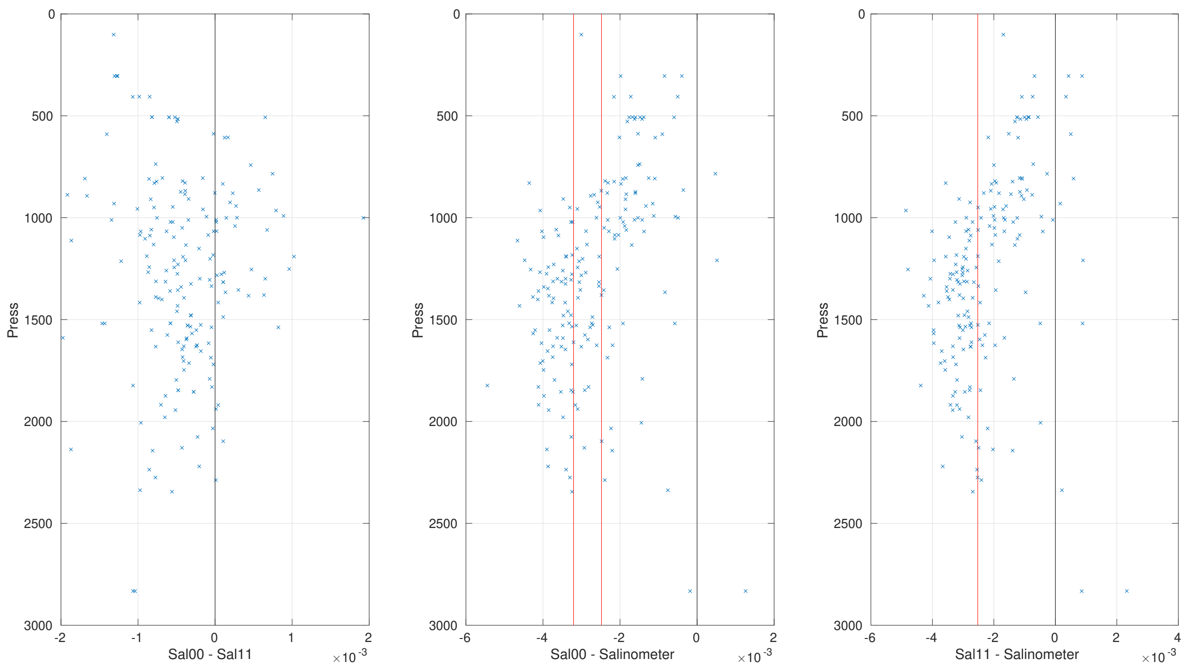


Figure 11: Calibration plots showing the offsets between (a) the two sensor pairs, (b) the primary sensor pair and the calibration samples, and (c) the secondary sensor pair and the calibration samples by pressure. The black lines show no offset and the red lines the applied calibration.

3.3 Lowered Acoustic Doppler Current Profiler (LADCP) – *Gunnar Voet*

Ocean velocities were measured from the CTD rosette with two RDI Acoustic Doppler Current Profilers in up/downlooking configuration. The uplooker was a 300 kHz RDI Workhorse (SN 24609 up to cast 094, SN 13329 from cast 095 onwards) provided by NMF, the downlooker a 150 kHz RDI Quartermaster (SN 24681) provided by Scripps Institution of Oceanography. Prior to the cruise it had been planned to stream data from the downlooker through the SBE 9/11+ system to acquire real time data that was thought to be valuable especially during towyo sections. It turned out that the SBE 9 on the rosette did not have the uplink capability and thus the instruments were self-recording only with data downloaded after each cast. The 300 kHz ADCP recorded data in 8 m bins, the 150 kHz ADCP in 16 m bins. Both instruments measured in narrow band mode to extend the range of the measurements and recorded in beam coordinates. The two instruments were synced using the WM=15 command and the SM=1 option for the downlooker and SM=2 for the uplooker. See LADCP setup files for both instruments attached to the cruise report for further details. Power was provided by an external battery pack, provided by NMF, that was charged during data download between casts. In addition, the downlooker was equipped with internal alkaline battery packs for the case that the external battery pack would be depleted during longer towyo sections.

Individual casts were numbered according to CTD cast numbers. While many casts were stationary, two towyo sections were conducted where the CTD rosette was slowly towed by the ship. The first towyo across the canyon just upcanyon of the later process mooring included cast numbers 7-23 and 24-42, with a short recovery in between casts 23 and 24 to swap out the external battery pack for a freshly charged replacement unit. The second towyo included cast numbers 43-51 and was conducted during the dye survey when the fluorometer on the fastCTD underwent an inspection. One yoyo station (casts 54-67) was carried out near the tracer injection site in between mooring deployments.

Horizontal velocities from stationary casts were processed using the LDEO IX_13 processing toolbox.

3.3.1 Downlooker Setup File

```
$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
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 1.31/sec
TE00000131
$W62
; Set one second between pings
TP000131
$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.
WN021
$W62
; Set bin size to 16 m. Also sets LS command.
WS1600
$W62
; Set blank to 352 cm (default value for 150kHz ADCP). Also sets LF command.
WF0352
$W62
; Set max radial (along the axis of the beam) water velocity to 230 cm/sec. ; Also se
WV230
$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
; Start pinging
CS
; Delay 2 seconds
$D2
$P ******************************************
$P Started deployment of primary / downlooker
$P ******************************************
```

3.3.2 Uplooker Setup File

```
$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 1.31/sec
TE00000131
$W62
; Set one second between pings
TP000131
$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 230 cm/sec. ; Also se
WV230
$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
; Start pinging
CS
; Delay 2 seconds
$D2
$P *****************************************************
$P Started deployment of secondary / uplooker.
$P Will start pinging in 300s if primary does not start.
$P *****************************************************
```

3.4 Fast CTD – *Bethan Wynne-Cattanach*

The fast CTD (FCTD), originally envisioned by Rob Pinkel and built and operated by the Multiscale Ocean Dynamics group (mod.ucsd.edu), was deployed from a 9m-long boom situated on the aft port quarter of the RRS Discovery (Figure 12). The boom

Figure 12: FCTD boom in its stowed position on the port side of the aft deck

swings out to 90 or 45 degrees from the side of the ship to keep the profiler at a safe distance from the ship and its screws, while a powerful, direct-drive electric winch allows us to profile up and down at 2.5 - 3 m/s (Figure 13). Most of the FCTD data collection was done while the ship was steaming at 0.5-1 knot. Data were collected on both the up and down casts using the onboard Seabird SBE 49 CTD and a dual-needle micro conductivity probe similar to a Seabird 7 but built in house by SIO. The CTD measures conductivity, temperature and pressure at a frequency of 16Hz and the micro conductivity probe measures conductivity at 320Hz.

For the purposes of this study the FCTD was also equipped with a Turner C-FLUOR fluorescein fluorometer measuring at 320Hz. A total of three deployments were carried out with the FCTD, two of which were part of the dye release component of the experiment and the third was a high resolution cross-canyon survey. A total of 1763 profiles were made over the course of the cruise, with usable data on both the up and down casts.

Figure 13: FCTD ready for deployment at the end of the boom.

3.4.1 Dye surveys

After the dye injection was complete, the FCTD was deployed for surveying. The rapid profiling speed of the FCTD and the addition of the fluorometer allowed us to track the fluorescein as it spread through the canyon.

To allow for ease of communication with the bridge during the dynamic surveys we mapped out a 9 x 4km grid orientated along the canyon axis with 200m resolution (Figure **??**). Real time displays of the measured fluorescence were used to inform the next steps in the survey pattern.

Dye release 1 The dye was released at 21:47 on June 28th 2021 along the 4.01°C isotherm, during slack tide. The FCTD was deployed once the InkBot was back on deck at 23:11. The tidal flow at this time was expected to be upcanyon, therefore we moved up the canyon of the release site and completed 9 cross canyon transects from grid point M5 to G5, beginning at 02:45 June 28th and 15:30pm on June 29th. Profiles were done 100m above bottom to the seafloor. Dye was seen on 3 of these cross canyon transects between 07:00 and 12:00. To continue following the dye we began an up canyon transect from I5 to J7, then to H9, following the axis of the canyon. We found the dye at kilometer 8.5 and beyond. Micro-conductivity was damaged during a bottom impact at 1634 and we operated without this measurement between then and the end of this deployment. At

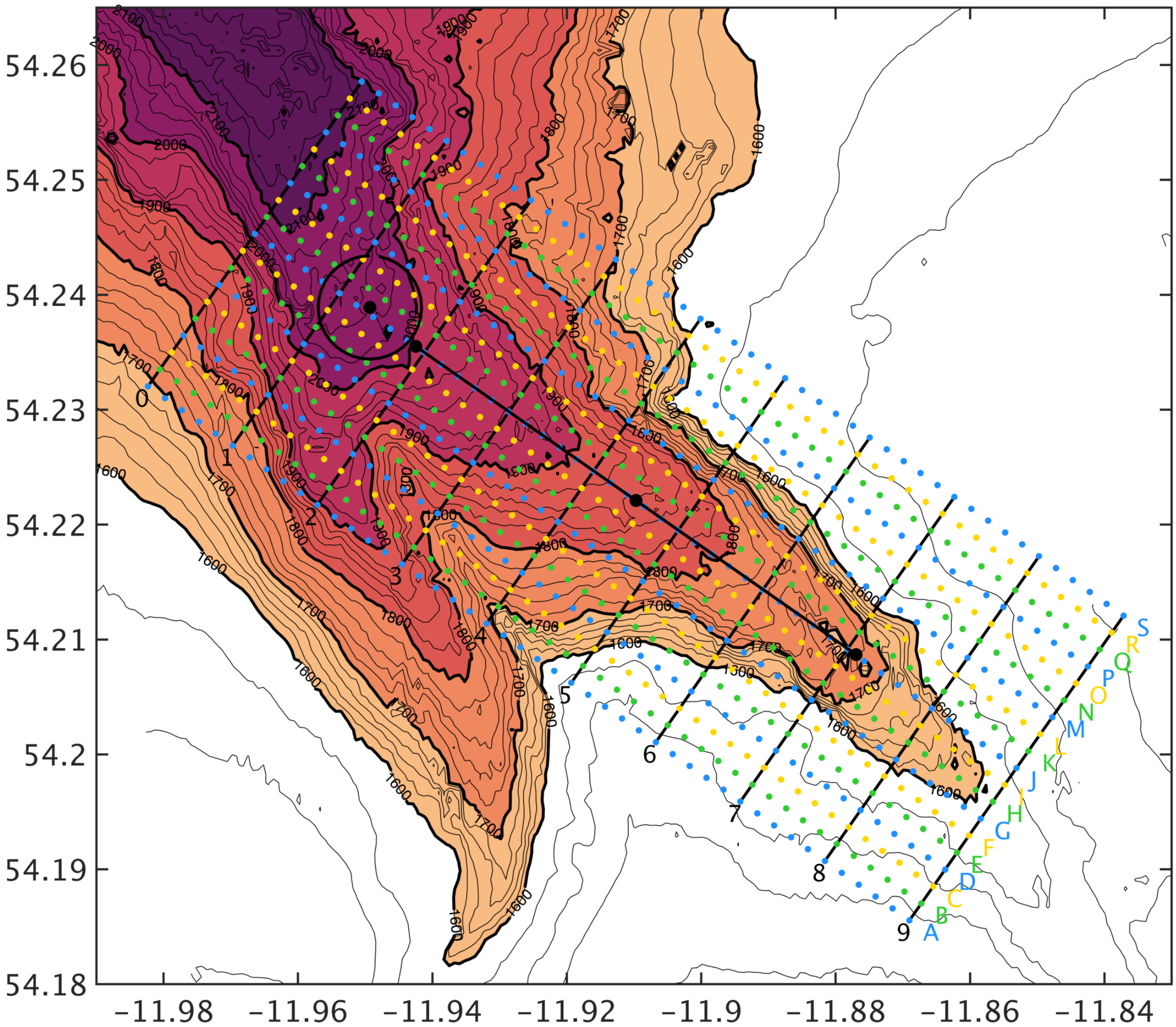


Figure 14: Map of the canyon showing the grid used for the dye survey. Along canyon lines are labelled every 200m from A-S and cross canyon lines are labelled from 0-9km in the upcanyon direction. The location of the MMP moored process mooring is shown with a 500m radius around it and the location of the dye release is marked at J4.5.]

19:34 the fish hit the seafloor. At 20:40 we noticed issues with the CTD data, and upon inspection discovered the pump was clogged. No more dye was seen after redeployment on any of our subsequent up or down canyon transects. We hypothesise that the density of the dye was greater than any water in the canyon, and so the bulk of it moved down canyon out of our survey area.

Dye release 2 The second dye release was done with lighter dye so that it would remain within the branch of the canyon we were surveying. The isotherm of injection was 3.76°C for this injection, and it was done at 03:00 on July 1st. Slack tide was at 0:00, and flow was up canyon at the time of the dye release so we again headed up canyon of the injection site to follow the dye. We steamed from J5 to J7 and found the dye at the end of this transect. We turned around at 7am, at the next slack tide to follow the dye as it went back down canyon. We consistently saw dye, likely moving with it and the tide. We finished the end of this line at 11:20. We repeated this up/down canyon pattern, seeing dye at 18:30 during our down canyon leg. We continued up and down the canyon until 10:10 on July 2nd.

Note that the fish was being towed behind the ship with up to 3km of cable out, putting the fish at least a significant distance away from the ship. This meant that while the ship was where we expected the dye to be due to the tides, the fish was further up canyon and so we were not measuring it.

We then began a cross canyon section from G5.2 to O5.2, dye was found at the deepest parts of the canyon during the first transect, but less was seen on the second. According to the simple tidal model we used, we believed that the dye was probably already up canyon of our location, so restarted the J7-H9 up canyon line. We saw small amounts of dye as we moved up and down canyon during this leg. We then moved down canyon again to J7 where we completed a 12 hr times series at this location to measure the dye as it was swept past us by the currents. We profiled in the bottom 300m for the purposes of the time series. By this time the dye had spread and diluted substantially such that we were measuring just above our noise floor by the end of the time series, and so we concluded our survey here (Figure (15).

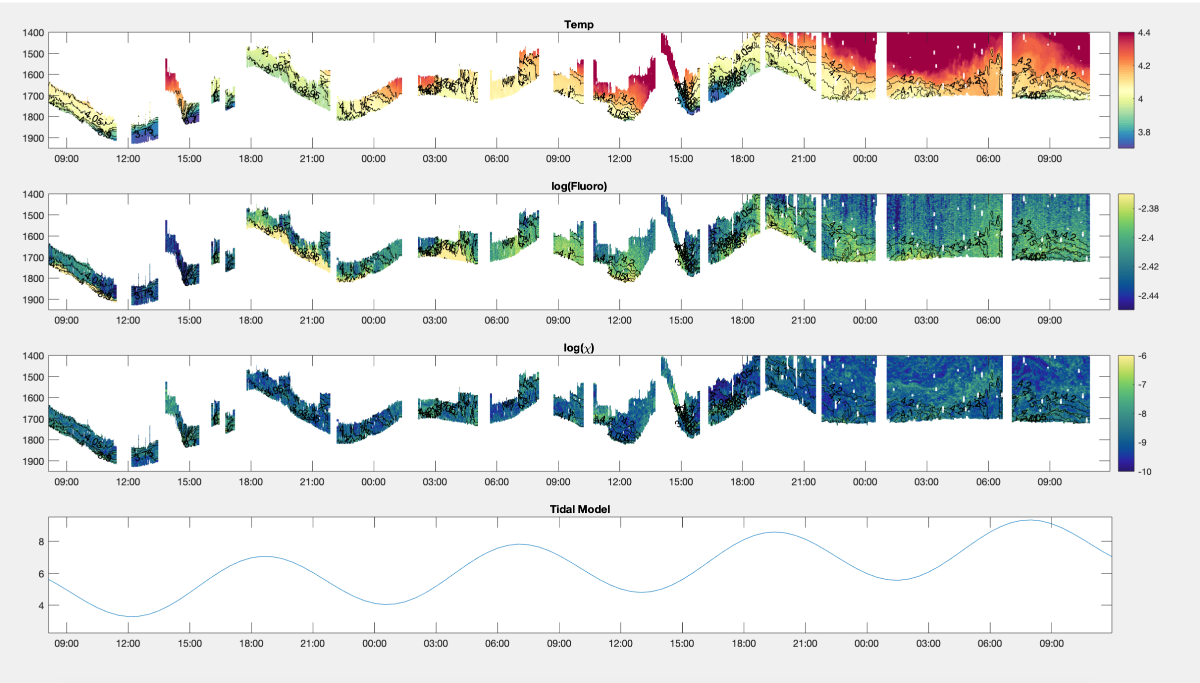


Figure 15: Timeseries of full FCTD record for the second dye release deployment, showing temperature, log of fluorescence (measured voltage), log of χ and the tidal model used for the survey, plotted against upcanyon distance as defined by the grid.]

3.4.2 Cross-canyon transects

The cross canyon survey took place on July 19, and began at 06:32 from F7-N7 (1.4km) between the 1500m isobath for 13.5 hours. This location was chosen due to it being just down canyon of the moored profiler mooring MP2 and the narrowness of the canyon here allowed us to keep the transects tidally resolving and repeat it several times during the 12 hours (Figure 16). To try and ensure the fish followed the ship across the canyon, the ship transited the line then stopped at the far way point, waiting as the fish was pulled across the canyon towards the ship. Once the fish was back underneath the ship we brought it to the surface for the ship to turn and repeat the line. The ship speed and sampling style was altered until we found the best method. We settled on alternating between casts from 200m depth to the bottom and casts from 500m above the bottom and down. This method allowed for the fish to be brought closer to the ship every other cast, overcoming the water sheave that happens due to drag on the cable and thus allowing the fish to make progress across the canyon.

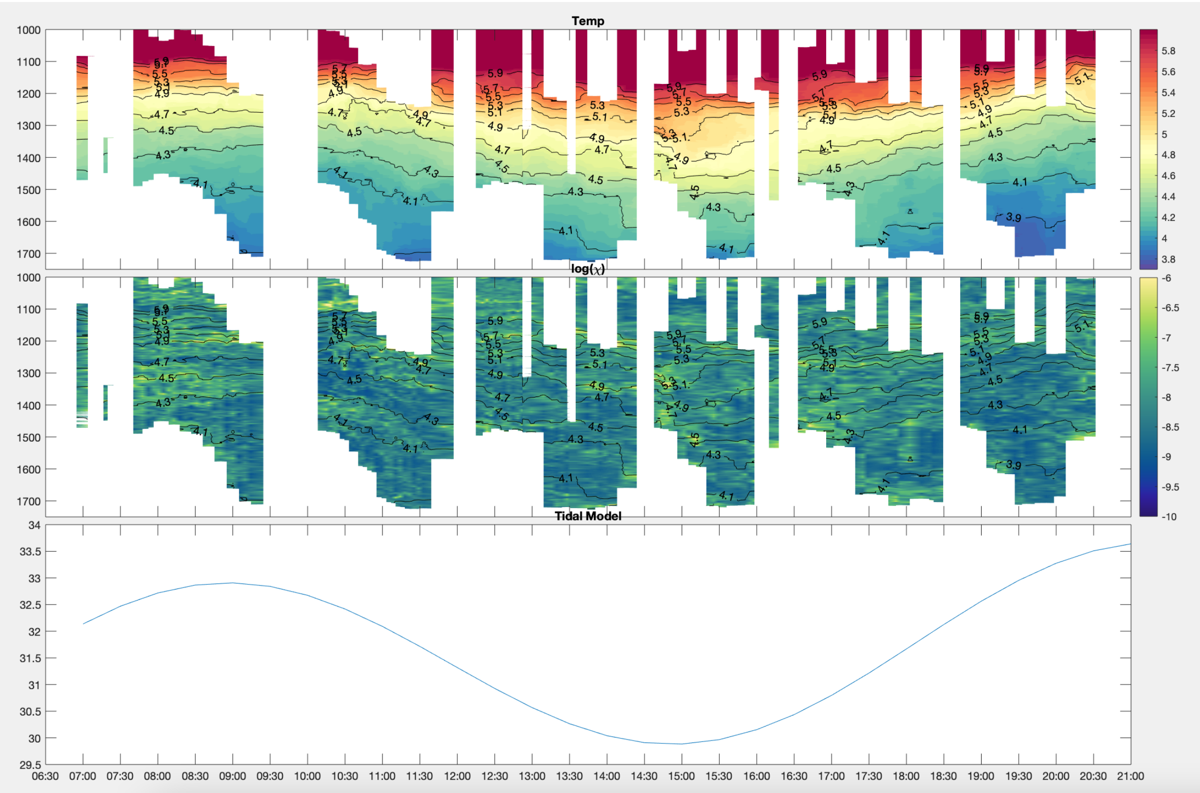


Figure 16: Time series temperature and $log(\chi)$ measured during the cross canyon transects, together with a model of the tidal velocity during the deployment.

3.4.3 Microconductivity and χ calculation

The microconductivity sensors on the FCTD were calibrated to the Seabird CTD. The gain between the two measurements of conductivity was calculated as the appropriate factor such that the power spectral density of the microconductivity and conducitivity matched, particularly at the lowest frequencies. The spectra and gain were calculated over 100 second segments, then averaged together to give a single calibration coefficient for the deployment. During the second dye release survey, at 18:08 on July 2nd, the FCTD hit the seafloor and while this did not break the probes completely it did cause the microconductivity signal to shift higher, therefore the separate coefficients were calculated for before and after this bottom hit.

From the microconductivity we are able to calculate the dissipation of thermal variance (χ_T). Theoretically this is calculated from the intergral of the temperature gradient spectrum within the intertial subrange ($\Phi_{T_x}(f)$) where

$$\chi_T = 6D_T \int_0^{\infty} \Phi_{T_x}(f)df \quad [^{\circ}Cs^{-1}], \tag{1}$$

where D_T is the thermal diffusivity. Here, we are measuring the conductivity, therefore must convert from the spectrum of the time gradient of conductivity to the vertical gradient of temperature. Our estimate of χ is given by

$$\chi = 6D_T \frac{\left(\frac{dT}{dC}\right)^2}{w^2} df \sum_{f_{min}}^{f_{max}} \Phi_{C_t} \quad [^{\circ}Cs^{-1}], \tag{2}$$

where $f_{min} < f < f_{max}$ is the subrange of frequencies resolved by the sensor and w is the fall rate of the instrument. The coefficient $\frac{dT}{dC}$ was estimated in a similar way to the microconductivity calibration, this time between the conductivity gradient spectrum and the temperature gradient spectrum. The estiamtes of χ were computed over 2 second segments.

3.4.4 Fluorometer calibration

To calibrate the Turner C-FLUOR, it was submerged in a bath filled with filtered sea water. The fluorometers output in raw volts, and must be calibrated using known concentrations. A measured amount of dye was incrementally added to the water, which was then mixed by a pump to equilibrate the concentration throughout the bath. The time and amount of dye were noted at each addition. A maximum amount of 10mL could be added at a time, smaller concentrations were doubled at each addition, after which 10mL was added at a time to reach the desired concentration. The times in the table indicate the time of the first addition to reach the noted concentration (Table 5).

Time Dye Added	Total in Bath (mL)	Time Dye Added	Total in Bath (mL)
16:52	0.02	18:23	200.06
16:56	0.04	18:36	280.06
17:01	0.08	18:53	360.06
17:03	0.16	18:54	370.06
17:06	0.32	18:55	380.06
17:08	0.64	19:57	390.06
17:09	1.28	19:02	400.06
17:13	2.56	19:04	410.06
17:16	5.06	19:05	420.06
17:19	10.06	19:06	430.06
17:22	20.06	19:11	440.06
17:24	40.06	19:12	450.06
17:30	80.06	19:14	460.06
17:38	120.06	19:15	470.06
18:15	160.06	19:17	480.06

Table 5: Time and concentration of each dye addition for the calibration experiment conducted on June 25 2021.

4 Microstructure

4.1 High Resolution Profiler (HRP3) – *Kurt Polzin, Bieito Fernandez Castro, Alex Forryan, Carl Spingys, Brian Hogue*

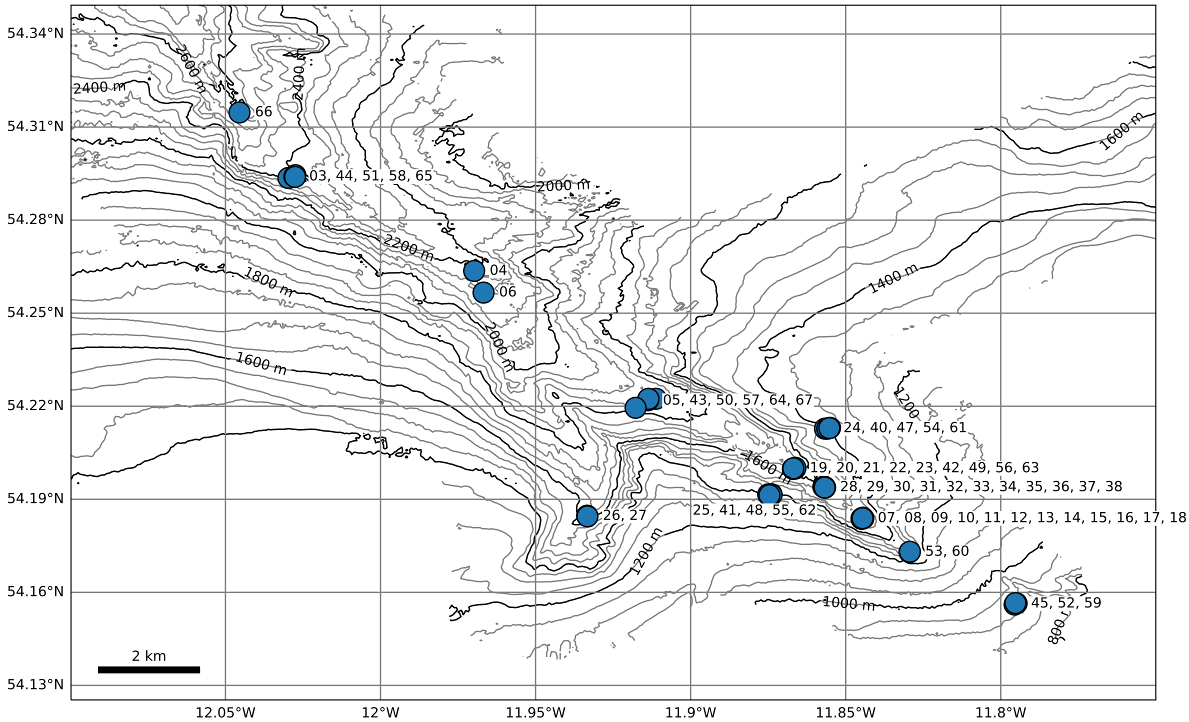


Figure 17: High Resolution Profiler sampling During BLT-1. Station positions are denoted by blue circles, numbers are the HRP dive numbers.

The High Resolution Profiler (HRP) is a free-fall vertical profiler designed to sample the entire vertical range of spatial variability in ocean velocity, temperature, salinity and density. The freefall configuration eliminates vibrations and extraneous tugging associated with a tether on the instrument (even a loose one). However, autonomy requires onboard decision making for dive termination by release of ballast weights. The task of estimating the entire vertical spectrum of variability is accomplished with two sensor suites: microstructure sensors resolve scales of 1 meter to several millimeters while finestructure sensors resolve vertical scales from around 1 meter to as large as the entire water column. Microstructure quantities typically represent gradient variances averaged over slightly more than one second in time and are gridded at half-decibar intervals. Estimates of finestructure variables, ie. temperature, salinity and 3-D velocity, are averaged on this same grid. The instrument electronics are housed within two pressure cases, with altimeter card and 12 kHz transponder residing within an auxiliary pressure case that is optically isolated from the main pressure case. The two pressure cases are powered by separate battery packs in separate 'flashlight' enclosures.

The 2021 Boundary Layer Turbulence - Recipes cruise (BLT-1) represents the fourth deep-ocean use of the High-Resolution Profiler #3. The instrument is out of its development stage. In recognition of this, an effort was made to transition into a more operational status with high level engineers providing support from shore. Two electronics systems were created, referred to as HRP3a and HRP3b below, to provide a plug-and-play option in case repair was required.

The major systemic performance issue concerned intermittent aborts resulting from the mRider not sending pressure data to the Beagle Bone controller in a timely manner. Efforts to improve communications between the altimeter and Beagle Bone controller with new connectors and polypro cables proved successful as only one altimeter abort was encountered in which no data were presented to the Beagle Bone. Two instances of early terminations were encountered in which the altimeter provided ambiguous data that eventually triggered the dive termination criteria. Noise in the pressure signals output by the Rockland subsystem was also reduced.

A total of 67 profiles were obtained, figure 17. Work started with two time series about the MAVS moorings and then was dominated by profiling in conjunction with tracer sampling using the LADCP/CTD Rosette system.

Table 6: HRP dive control particulars. Dive termination via [P, T, A] = [Pressure, Time, Altimeter]

HRP	depth [m]	Pmax [Dbars]	max(P) [Dbars]	Alt. on [Dbars]	nominal range [m]	range [m]	release code	comments
01	2550	500	500.12	490	100.0	n/a	P	
02	2939	2969	2838.46	2800	20.0	20.0	A	
03	2350	2260	2260.36	2075	20.0	30.9	P	on deck release failure
04	2180	2120	2120.19	1950	20.0	88.7	P	
05	1864	500	500.64	490	20.0	n/a	P	
06	2136	2216	2183.03	1991	5.0	5.6	T	T buffer not added
07	1469	1538	1503.29	1313	5.0	4.9	A	
08	1469	1538	1494.33	1313	5.0	5.0	A	
09	1469	1538	1472.25	1313	5.0	5.0	A	
10	1469	1538	1474.62	1313	5.0	4.9	A	
11	1469	1538	1497.96	1313	2.0	2.0	A	
12	1469	1538	1512.41	1313	2.0	1.4	A	
13	1469	1538	1503.62	1313	2.0	2.0	A	
14	1469	1538	1486.76	1313	2.0	2.0	A	
15	1469	1538	1494.16	1313	2.0	1.9	A	
16	1469	1538	1505.43	1313	2.0	2.0	A	
17	1469	1538	1505.51	1313	2.0	1.5	A	
18	1469	1538	1492.17	1313	2.0	1.9	A	
19	1629	1729	1668.55	1504	5.0	4.9	A	
20	1633	1704	1666.40	1479	2.7	2.7	A	
21	1633	1704	1648.65	1479	2.7	2.5	A	
22	1633	1704	1629.56	1479	2.7	2.7	A	
23	1633	1704	1662.09	1479	2.7	2.6	A	
24	1397	1443	1389.86	1218	2.7	2.7	A	
25	1409	1477	1411.82	1251	2.7	2.3	A	

see next page

Dive Control Particulars, continued

HRP	depth [m]	Pmax [Dbars]	max(P) [Dbars]	Alt. on [Dbars]	nominal range [m]	actual range [m]	release code	comments
26	1641	1712	1649.18	1487	2.7	2.7	A	
27	1641	1712	1654.93	1487	2.7	2.6	A	
28	1582	1653	1431.59	1428	2.7	1.0	A	Alt. flaky
29	1582	1653	1598.11	1428	2.7	2.1	A	
30	1581	1653	1558.78	1428	2.7	2.4	A	
31	1581	1653	1561.69	1428	2.7	2.6	A	
32	1581	1653	1597.04	1428	2.7	2.7	A	
33	1581	1653	1625.42	1428	2.7	2.6	A	
34	1581	1653	1600.91	1428	2.7	2.7	A	
35	1581	1653	1580.42	1428	2.7	2.6	A	
36	1581	1653	1566.75	1428	2.7	2.6	A	
37	1582	1653	1577.84	1428	2.7	2.7	A	
38	1582	1653	1571.68	1428	2.7	2.7	A	
39	2409	500	500.88	490	20.0	n/a	P	
40	1416	500	500.89	490	20.0	n/a	P	
41	1407	1474	1250.57	1249	2.7	NaN	abort	no A, # 2
42	1628	1699	1582.62	1474	5.0	5.0	A	
43	1863	1938	1880.47	1713	2.7	2.7	A	
44	2400	2472	2341.65	2246	2.7	1.7	A	Alt. dropouts
45	912	972	905.10	747	2.7	2.7	A	
46	1330	1397	1337.59	1172	2.7	2.5	A	
47	1430	1498	1480.82	1273	2.7	2.7	A	
48	1396	1464	1343.26	1238	2.7	1.9	A	Alt. dropouts
49	1640	1712	1598.02	1486	2.7	2.7	A	
50	1863	1938	1716.90	1713	2.7	2.0	A	Alt. flaky
51	2400	2472	2338.39	2246	4.2	4.0	A	
52	912	972	917.21	747	2.7	2.6	A	
53	1330	1397	1217.52	1172	2.7	1.5	A	Alt. dropouts
54	1430	1498	1462.49	1273	2.7	2.7	A	
55	1413	1396	1383.45	1171	2.7	2.3	A	
56	1627	1698	1598.36	1473	2.7	2.7	A	
57	1868	1971	1860.44	1745	2.7	2.7	A	
58	2400	2472	2407.76	2246	3.7	3.7	A	
59	915	1002	933.52	777	2.7	2.7	A	
60	1332	1399	1281.24	1174	2.7	2.4	A	
61	1410	1478	1441.11	1252	2.7	2.5	A	
62	1388	1456	1384.78	1231	2.7	2.6	A	
63	1632	1704	1629.51	1479	2.7	2.6	A	
64	1868	1944	1827.69	1720	2.7	2.5	A	
65	2419	2497	1125.20	2272	2.7	n/a	abort	no P# 2
66	2576	2665	126.18	2440	3.2	n/a	abort	no P # 2
67	1857	1935	1325.40	1710	3.2	n/a	abort	no P # 2

anomalous events:

- Dive 3a: Release failure on deck; leaking weight release oil bladders, bent cam shafts.
- Dive 3b: ACM appears to have contacted ship's side during recovery. Delrin bumpers were created out of mooring clamps and mounted in the lower body inline with the MAVS stings.
- Dive 04: HRP3b deployed, lots of ACM dropouts, transducer #2 displaced.
- Dive 05: now using HRP3a
- Dive 21: Bolt left in upper tygon tube for CTD. CTD data suboptimal.
- Dive 32: HRP3 appears to have struck something near bottom. Transducer damaged but functional. ACM sting bent
- Dive 39: now using HRP3b due to noise in microstructure of HRP3a. Second transducer of HRP3a delmainating.
- Dive 51: 5 1/2 hour recovery in fog.
- Dives 65-67: Pressure aborts result in cessation of activities.

Table 7: HRP dive log. Start times and positions are well defined. There is a bit of ambiguity between instrument surfacing and recovery.

sta	HRP	event	CTD	deploy day/time	Lon	Lat	recover day/time	Lon	Lat
nan	nan	8	nan	2021-06-20 15:10:02	-07.8075	50.2142	2021-06-20 15:13:33	-07.8075	50.2142
03	1	13	nan	2021-06-22 09:18:15	-13.0095	54.1961	2021-06-22 09:54:19	-13.0177	54.1954
06	2	16	nan	2021-06-22 20:28:58	-12.1196	54.416	2021-06-22 22:30:03	-12.1196	54.4159
09	3	23	nan	2021-06-23 09:06:09	-12.0297	54.2936	2021-06-23 11:09:42	-12.0283	54.2804
11	4	27	nan	2021-06-23 16:05:27	-11.9698	54.2636	2021-06-23 17:46:19	-11.9683	54.2627
32	5	51	nan	2021-06-30 21:57:12	-11.9112	54.2224	2021-06-30 22:24:42	-11.9114	54.2217
38	6	68	53	2021-07-05 15:50:22	-11.9668	54.2566	2021-07-05 17:57:51	-11.9680	54.2511
47	7	80	nan	2021-07-09 17:35:44	-11.8449	54.1837	2021-07-09 18:46:48	-11.8480	54.1848
47	8	81	nan	2021-07-09 20:02:35	-11.8448	54.1838	2021-07-09 21:15:18	-11.8462	54.1831
47	9	82	nan	2021-07-09 22:32:06	-11.8449	54.1838	2021-07-09 23:55:13	-11.8458	54.1796
47	10	83	nan	2021-07-10 01:03:03	-11.8449	54.1838	2021-07-10 02:27:27	-11.8460	54.1802
47	11	84	nan	2021-07-10 03:34:15	-11.8448	54.1838	2021-07-10 04:53:19	-11.8503	54.184
47	12	85	nan	2021-07-10 05:57:25	-11.8443	54.1838	2021-07-10 07:15:55	-11.8515	54.1865
47	13	86	nan	2021-07-10 08:25:27	-11.8444	54.1839	2021-07-10 09:42:31	-11.8484	54.1842
47	14	87	nan	2021-07-10 11:02:09	-11.8445	54.1839	2021-07-10 12:24:25	-11.8433	54.1811
47	15	88	nan	2021-07-10 13:39:48	-11.8444	54.1841	2021-07-10 14:57:57	-11.8444	54.1821
47	16	89	nan	2021-07-10 16:06:39	-11.8446	54.1839	2021-07-10 17:27:05	-11.8483	54.1849
47	17	91	nan	2021-07-10 18:36:19	-11.8447	54.1839	2021-07-10 19:53:21	-11.8479	54.1849
47	18	92	nan	2021-07-10 21:03:08	-11.8446	54.1839	nan		
51	19	98	72	2021-07-12 07:52:36	-11.8664	54.1999	2021-07-12 09:04:51	-11.8664	54.1999

see next page

								Dive Log, continued	
sta	HRP	event	CTD	deploy day/time	Lon	Lat	recover day/time	Lon	Lat
54	20	102	75	2021-07-12 19:19:17	-11.8663	54.1999	2021-07-12 20:41:41	-11.8701	54.201
55	21	104	76	2021-07-12 22:15:42	-11.8663	54.1999	2021-07-12 23:52:47	-11.8722	54.2009
56	22	106	77	2021-07-13 01:20:44	-11.8663	54.2002	2021-07-13 02:51:45	-11.8623	54.1965
57	23	108	78	2021-07-13 04:33:54	-11.8662	54.2001	2021-07-13 06:00:17	-11.8703	54.2012
58	24	110	79	2021-07-13 08:11:21	-11.8550	54.2130	2021-07-13 09:47:04	-11.8593	54.2163
59	25	112	80	2021-07-13 11:32:43	-11.8739	54.1916	2021-07-13 12:55:33	-11.8752	54.1903
60	26	114	81	2021-07-13 14:34:49	-11.9334	54.1847	2021-07-13 16:03:28	-11.9329	54.1837
61	27	116	82	2021-07-13 17:27:56	-11.9333	54.1845	2021-07-13 19:08:44	-11.9322	54.1836
62	28	117	nan	2021-07-13 20:00:31	-11.8568	54.1938	2021-07-13 21:17:49	-11.8615	54.1951
63	29	118	nan	2021-07-13 22:31:13	-11.8567	54.1938	2021-07-13 23:55:19	-11.8606	54.1929
64	30	120	83	2021-07-14 01:00:29	-11.8572	54.194	2021-07-14 02:30:46	-11.8580	54.1901
65	31	121	nan	2021-07-14 03:25:06	-11.8567	54.1938	2021-07-14 04:48:15	-11.8581	54.1909
66	32	123	84	2021-07-14 06:01:18	-11.8568	54.1939	2021-07-14 07:24:40	-11.8620	54.1969
67	33	124	nan	2021-07-14 08:28:40	-11.857	54.194	2021-07-14 09:54:02	-11.8637	54.1992
68	34	126	85	2021-07-14 11:26:31	-11.8567	54.194	2021-07-14 12:50:31	-11.8562	54.1922
69	35	127	nan	2021-07-14 13:53:05	-11.8568	54.1939	2021-07-14 15:37:16	-11.8503	54.1867
70	36	129	86	021-07-14 17:00:40	-11.8566	54.1938	2021-07-14 18:22:59	-11.8616	54.1911
71	37	131	nan	2021-07-14 19:32:48	-11.8568	54.1938	2021-07-14 20:55:23	-11.8643	54.1947
72	38	133	87	2021-07-14 22:16:04	-11.8568	54.1938	2021-07-14 23:40:39	-11.8628	54.1948
82	39	nan	97	2021-07-16 16:39:00	-12.0173	54.3356	2021-07-16 17:27:50	-12.0241	54.3357
94	40	176	109	2021-07-18 14:17:36	-11.8567	54.2128	2021-07-18 14:55:19	-11.8652	54.2138
95	41	178	110	2021-07-18 16:16:14	-11.8739	54.1914	2021-07-18 17:23:46	-11.8777	54.1892
96	42	180	111	2021-07-18 19:42:33	-11.867	54.1999	2021-07-18 21:15:52	-11.8739	54.193
97	43	182	112	2021-07-18 22:47:46	-11.9137	54.222	2021-07-19 00:41:52	-11.9291	54.2172
98	44	184	113	2021-07-19 02:41:50	-12.0278	54.294	2021-07-19 05:28:45	-12.0427	54.2922
100	45	187	114	2021-07-19 22:06:11	-11.7955	54.1561	2021-07-19 23:28:38	-11.8036	54.1487
101	46	189	115	2021-07-20 01:16:00	-11.8296	54.1731	2021-07-20 02:36:28	-11.8382	54.1722
102	47	191	116	2021-07-20 04:24:56	-11.8558	54.2129	2021-07-20 05:47:26	-11.8672	54.2118
103	48	193	117	2021-07-20 07:24:36	-11.8747	54.1913	2021-07-20 08:51:52	-11.8849	54.1836
104	49	195	118	2021-07-20 10:49:31	-11.8670	54.1999	2021-07-20 12:35:06	-11.8827	54.1958
105	50	197	119	2021-07-20 14:39:01	-11.9138	54.2219	2021-07-20 16:23:20	-11.9298	54.2227
106	51	199	120	2021-07-20 18:18:44	-12.0275	54.2942	2021-07-20 20:07:09	-12.0276	54.2942
108	52	202	121	2021-07-21 17:31:25	-11.7949	54.1565	2021-07-21 18:24:52	-11.7956	54.1583
109	53	205	122	2021-07-21 21:09:45	-11.8294	54.173	2021-07-21 22:34:20	-11.8333	54.1642
110	54	207	123	2021-07-22 00:12:37	-11.8559	54.2128	2021-07-22 01:35:29	-11.8639	54.209
111	55	209	124	2021-07-22 03:08:37	-11.8750	54.1916	2021-07-22 04:22:12	-11.8835	54.1903
112	56	211	125	2021-07-22 06:40:29	-11.8669	54.1999	2021-07-22 08:07:48	-11.8717	54.1976
113	57	213	126	2021-07-22 09:46:54	-11.9137	54.2224	2021-07-22 11:24:38	-11.9143	54.216
114	58	215	127	2021-07-22 13:26:16	-12.0275	54.2945	2021-07-22 15:29:20	-12.0307	54.2914
116	59	218	128	2021-07-23 06:25:21	-11.7953	54.1565	2021-07-23 07:14:20	-11.7996	54.1589
117	60	220	129	2021-07-23 08:55:16	-11.8293	54.1731	2021-07-23 10:22:19	-11.828	54.1716
118	61	222	130	2021-07-23 12:16:37	-11.8553	54.2130	nan	nan	nan
119	62	224	131	2021-07-23 15:32:51	-11.8746	54.1913	2021-07-23 16:48:44	-11.8834	54.1877
120	63	226	132	2021-07-23 18:16:40	-11.8669	54.2	2021-07-23 19:41:24	-11.8781	54.1999
121	64	228	133	2021-07-23 21:31:25	-11.9136	54.2224	2021-07-23 23:19:46	-11.9139	54.2183
122	65	230	134	2021-07-24 01:39:26	-12.0276	54.2939	2021-07-24 03:07:11	-12.0322	54.2878
124	66	233	135	2021-07-24 19:50:12	-12.0455	54.3147	2021-07-24 20:17:23	-12.0510	54.3138
129	67	240	139	2021-07-25 13:11:22	-11.9177	54.2195	2021-07-25 14:29:22	-11.9254	54.2103

4.1.1 Sensor subsystem Performance

Dive Control

Altimeter based bottom approaches of 2 meters are entirely possible. Prior experience was that early termination of profiles was associated with an absence of data coming into the Beaglebone controller. System performance improved during BLT-1 as connectors on the altimeter and auxiliary pressure cases were renewed and neoprene cables replaced with those having a polypro jacket. Only one altimeter based abort was experienced, compared to a prior O(10%) occurrence rate. Several profiles were terminated early as when the altimeter reported random altitudes at startup.

Note: Previously, the replacement altimeter (serial number here) represented 'no range received' by the value 0 whereas in the original unit (serial number here) 'no range received' was reported as 100.00. Valid data lie between 99.99 and the blanking distance, 0.7 m. These units were shipped back to the manufacturer, where upon ...

further information here about code logic for dive termination. Precise logic and how to deal with pressure aborts: erasing data from SD card or reformatting?

Finestructure

The finestructure suite consists of a Conductivity-Temperature-Depth (pressure) instrument (CTD), an Acoustic Current Meter (ACM), an Inertial Measurement Unit (IMU: compass, accelerometers and rate gyros in 3- d) and a Global Positioning System (GPS) module.

CTD performance

The HRP3 utilizes a pumped SeaBird (SBE) 3-4 T/C sensor system and Keller pressure transducer. The SBE sensor output is routed through the RSI mRider and combined with data from the pressure sensor. This configuration is the standard setup for the Rockland system. The response of the SBE T and C sensors is a function of the pump rate, the time constant of the thermometer, the physical distance between the T and C sensors, and the length and thermal inertia of the C sensor (Lueck and Picklo, 1990[1]; Morrison et al., 1994[2]; Johnson et al., 2007[3]). The T and C sensors on HRP are mounted under the instrument cowling, further complicating the response.

Following Johnson et al. (2007), a time offset of 10 scans (0.156 seconds at 64 Hz) for fluid parcels to travel from the temperature sensor to the conductivity sensor was deduced, and a thermal mass time constant for the conductivity cell was estimated. The temperature of the sea water in the conductivity cell may be predicted with the following (in Matlab):

$$
\begin{aligned}
[b,a] &= butter(1, \text{thermal\_mass\_time\_constant}) \\
T_{cell} &= filter(b,a,Tsbe)
\end{aligned}
$$

[1]Lueck, R.G., and J.J. Picklo, 1990. Thermal inertia of conductivity cells: Observations with a Sea-Bird cell. J. Atmos. Oceanic Technol., 7, 754-768.

[2]Morrison, J., R. Andersen, N. Larson, E. D'Asaro and T. Boyd, 1994. The correction for thermal-lag effects in Sea-Bird CTD data. J. Atmos. Oceanic Technol., 11, 1151-1164.

[3]Johnson, G. C., J. M. Toole, and N. G. Larson, 2007. Sensor corrections for Sea-Bird SBE-41CP and SBE-41 CTDs. Journal of Atmospheric and Oceanic Technology, 24, 1117-1130.

with a thermal_mass_time_constant of 0.2 seconds. In words, the cell temperature is predicted from a recursive single pole Butterworth filter applied to the measured temperature. Salinity is then derived using the measured conductivity and the filtered temperature data.

A linear correction for the raw pressure data with coefficients (scale factor, bias) was obtained from a laboratory calibration at Woods Hole (p.c. Eric Hayden, April 9, 2021):

$$\begin{aligned} rawP\_coefs &= [0.3102203 \quad 37.9516181] \quad (HRP3a) \\ rawP\_coefs &= [0.2857574 \quad -54.7685053] \quad (HRP3b) \end{aligned} \tag{3}$$

The bias for both units was changed during the cruise to obtain on deck pressure readings near 0 dBars.

Pre-cruise efforts at reducing noise in the pressure data resulted in much higher quality data. See previous cruise reports for discussion.

Table 8: Calibrations for the SBE 3 and 4 T and C modules and pressure transducer used during BLT-1. The SBE are manufacturer's cals supplied when the units were purchased and are part of the hardware. The mRider configuration file implements the manufacture's calibration as per Rockland's literature.

sensor	serial number	calibration date
SBE 03F.320	03-5863	07-Apr-2016
SBE 04C.320	04-4507	12-Apr-2016
SBE 05T.22221	05-8682??	
Keller PA11/80059/600Bar	151760 (HRP3a)	04.05.2017
Keller PA11/80059/600Bar	470483 (HRP3b)	27.02.2018

Modular Acoustic Velocity Sensor (MAVS)

The MAVS provides an estimate of travel time difference between 4 pairs of transducers, which are then combined to provide estimates of three-dimensional relative flow field past the sensor. The arrangement of the acoustic paths between the transducer pairs is different from that of the standard MAVS current meter so consequently, a formula specific to HRP is used to derive the 3-D relative velocity from the 4 path speeds:

For each scan of observations, the 4 raw velocity path estimates (*acmraw*) are corrected for laboratory-derived bias (*acmz*) and scaled to engineering units (m s^{-1})

$$senvel = .003021 * (acmraw(:, 2:5) - ones(j, 1) * acmz);$$

The scaled and bias-corrected velocity path data (*senvel*) are subsequently passed through a matrix transformation to obtain Cartesian velocity estimates in HRP body coordinates (*hrpvel*):

$$\begin{aligned} C = [&-.3660 \quad -.3660 \quad .3660 \quad .3660 \\ &.3660 \quad -.3660 \quad -.3660 \quad .3660 \\ &.9659 \quad .9659 \quad .9659 \quad .9659\ ]; \end{aligned}$$

$$hrpvel = (C * (senvel)')';$$

The MAVS output represents an estimate of relative flow past the instrument. An estimate of the oceanic velocity is obtained by using the relative velocity estimate and a model of the instrument's response to this relative flow (Schmitt et al. 1988). The instrument is nearly in equilibrium with the relative flow at long time scales, making the estimate of large vertical scales in the velocity field problematic: integrating small offsets (biases) in the sensor's estimate of velocity can represent large trends in the vertical: a good calibration is required to eliminate such biases.

Even with the laboratory calibration, there exists the likelihood that the biases, which are sensitive to the cross-sectional area of a very high capacitance wire, change with changes in pressure and temperature. Future analysis should start by examining the profiles in relation to trends with that of the shipboard ADCP, but there is no guarantee that the later effort will account for temperature/pressure dependent changes in the bias.

The so-called point mass model of Evans et al. (1979)[4] and Schmitt et al. (1988)[5] is used to relate measured relative horizontal velocity to estimates of the ocean's horizontal velocity. At large vertical scales (long time scales), the HRP moves with the ocean currents. (This is the assumption behind dropsonde instruments whose lateral displacements while falling are used to deduce the ocean current profile.) This tracking ability is the product of forces that arise on the HRP when there is differential relative flow. In the point mass model, these forces are represented by potential flow theory around the leading end of the instrument; in this theory the force is proportional to the product of the relative horizontal and relative vertical flow (that are both measured by the HRP). An estimate of the time-varying horizontal velocity of the center of mass of the HRP is thus derived by time integrating Newton's first law: $F = ma$. (The time integral of acceleration is velocity.) Subsequently, the ocean velocity is obtained by summing the center of mass velocity profile with the measured relative velocity. An unknown constant of integration results from the time integral. This is estimated by comparing HRP and shipboard ADCP data and/or by estimating the depth-average absolute velocity of the HRP from deployment and recovery positions.

While bias error in the ACM velocity measurements is a concern, its impact is greatly ameliorated by having the HRP spin as it falls. In situ bias errors in the two horizontal relative flow components (in body coordinates) are derived under the assumption that the time-averaged relative horizontal flow measured by the HRP is zero (said another way, there is no correlation between ocean currents and the compass orientation of the HRP during a profile). In practice, the time-averaged horizontal currents are subtracted from the MAVS velocity estimates before rotating the data into geographic (east and north) coordinates and applying the point mass model. Any errors in these bias estimates are manifest in the final data product as signals on the scale (and sense) of the spin rate of the HRP. Bias that varies in time through a dive may be addressed by removing a very-low-pass filtered velocity profile from the raw body-coordinate relative flow estimates prior to rotating to geographic coordinates. No similar process has been discovered for correcting

[4]Evans, D.L., H.T Rossby, M. Mork and T. Gytre, 1979. YVETTE, a free-fall shear profiler. Deep-Sea Res., 26, 703-718.

[5]Schmitt, Raymond W., John M. Toole, Richard L. Koehler, Edward C. Mellinger, and Kenneth W. Doherty, 1988. The development of a fine- and microstructure profiler. Journal of Atmospheric and Oceanic Technology, 5(4), 484?500.

the measured relative vertical velocity for sensor bias. Rather, under the assumption that the time-averaged ocean vertical velocity is very small, errors in vertical velocity may be assessed by comparing measured relative flow to the time rate of change in measured pressure. During the cruise, differences between these signals were observed in the upper 1-200 m of profiles. As of this writing it is not evident if the discrepancy is an error in the MAVS data or the measured pressure (or both).

Table 9: Calibrations for the MAVS acoustic current meter. Recalibration is required when either a new sting or new board is installed, or the lead wires are rearranged.

MAVS ACM	HRP3 casts	zeros	date	comment
HRP3a	5-38	[1707 -732.1 439.7 -1914.5]	May 7, 2021	p.c. F. Thwaites
HRP3b	1-4	[-63.91 -650.5 -56.3 -1090.8]	May 7, 2021	p.c. F. Thwaites
HRP3b	39-67	[688.3 -1754.1 -55.5 -1067.8]	Dec. 15, 2021	p.c. F. Thwaites

<u>IMU</u>

The motion package in the HRP is a Microstrain, Inc. unit that includes a 3-axis fluxgate compass, 3-axis accelerometer system and 3-axis rate gyro. Data from the IMU are streamed to the BeagleBone controller, where they are time stamped and logged. From these observations, the orientation of the instrument relative to Earth's magnetic field and the tilts of the instrument from vertical may be estimated. A complication with the IMU observations was detected during the cruise associated with the (steel) ballast weights. Magnetic fields associated with the weights introduced offsets to the IMU fluxgate compass observations. These errors were addressed during data processing by applying a very low pass time varying adjustment to the x and y compass channels so that the data (x plotted versus y) describe a circle about the origin. BLT-1 featured a new implementation of this sensor, which occasionally does not send a complete data string. The sensor would then puase in the transmission of further data if it were not for the flushing of a buffer. This buffer slushing results in a message of "Flush" being sent to the BeagleBone screen during run time. It is entirely harmless and the dropping of 1 data sca of a sensor running at 25 Hz once every 2-5 minutes is a little consequence.

<u>GPS</u>

As noted above, the point-mass model used to relate HRP measured relative flow to ocean velocity profiles includes a depth-independent constant of integration. Independent information is needed to estimate the ocean's absolute velocity. One approach is to document the deployment and surfacing positions and times of the HRP. From the displacement, an estimate of the depth-average absolute ocean current may be obtained under the assumption that the HRP moves with the ocean flow. Deployment and recovery positions were logged by the bridge officers during the cruise, as were the times of surfacing. The ship's position on recovery of the HRP can differ significantly from HRP's surfacing position, introducing error in the estimated depth-average ocean velocity. The HRP carries its own GPS transceiver but this unit is intended primarily for locating HRP after surfacing. The GPS unit samples and reports position fixes on rather long time interval (again, introducing error in the depth-average ocean velocity). Because the HRP dives were relatively shallow during this cruise, a significant fraction of profiles were within the range of the shipboard ADCP system. Thus depth-averaged ship ADCP data were used to reference the point-mass model HRP velocity profiles.

Microstructure

The HRP-3's Microstructure suite consists of two air foil shear probes (μS), two FP07 fast response thermistors (μT) and a dual needle conductivity (μC) probe in the RSI μRider subsystem. The shear data are typically contaminated by noise of an electronic origin, with μS2 being far more problematic than μS1. This could be associated with the proximity of the μS2 cable to the μC cable on the outer endcap through-hull. The pre-emphasized micro-conductivity data suffers from high noise levels that could be board related. Need to follow manufacturer's recommendations, though, for probe wetting, before coming to a conclusion. The micro-temperature data are generally high quality and calibrated *in situ* against the HRP's CTD.

The data were processed using the program micro_diagnostics_v2.0 with extensive diagnostic tools. The data set was then processed twice. A first pass was used to document the basic character of the noise, which then informed refinements to the algorithm concerning integration limits and avoiding vibrational peaks in the shear data. Analytic representations of the noise spectra (P_n) are:
shear probes: $P_n(f) = A\ 1 \times 10^{-7}$ s^{-2}/cps
temperature: $P_n(f) = B\ 0.22 \times 10^{-10} \times (0.625 * f/FallRate)^{3.25}[sinc(f/512)]^4$ C^{2}m^{-2} / cps
conductivity: $P_n(f) = C\ 1.4 \times 10^{-7} \times f^{1.5}[sinc(f/512)]^4$ mmho^{2}m^{-2} / cps
with f being frequency in cycles per second (cps), $sinc(x) = sin(\pi x)/\pi x$ and 512Hz being the sampling frequency of the microstructure data. Anti-aliasing filters with transfer function $[1.0 + (f/98)^8]^2$ are additionally applied to the data. The constants [A B C] are likely slowly varying with fall rate and may also vary from dive to dive. Here constants of [A B C]=[1 1 1] were used. The rate of dissipation of turbulent kinetic energy ϵ is estimated from formulas assuming isotropic relations between components of the rate of strain tensor as $\epsilon = 15/2\nu S$ with molecular viscosity ν and S representing the variance of the single component of the rate of strain tensor measured by the shear tensor S. Integrating over 10 cps, the quoted noise spectra $15/2 \times 1.5 \times 10^{-6} m^2 s^{-1} Pn(f) \times 10$ cps translate into dissipation rates of 1.25×10^{-11} W/kg. These are not average electronic noise levels. The quoted noise levels represent the those 1/2 Dbar data segments having the lowest 5-10% of the sample variances using data from low signal environments, with the complication that the sample data have contributions from both noise and oceanic signal. These shear noise estimates are very much lower bounds on the average noise. Also note that the quoted values represent what a 'healthy' instrument is capable of. In contrast, the curve fits for temperature and conductivity noise represent the average electronic noise spectra of the system.

After the second round of processing, a mask was developed to discard noisy data. For a normal data set, this mask consists of two steps: visually inspecting for isolated spikes that are more than an order of magnitude larger than their neighbors, then replacing those with a nominal bad data value, such as NaN, and estimating the gradient variance S from two redundant probes Sx and Sy as

if (Sx $<$ 3 Sy & Sy $<$ 3 Sx) then S=(Sx+Sy)/2;
else
if(Sx $>$ 3 Sy) S=Sy;
if(Sy $>$ 3 Sx) S=Sx;
end

Currently this is accomplished using a program called micro_mask_plus.sta.m. That program provides an estimate of ϵ and two estimates of χ, one based upon a maximal signal-to-noise algorithm and a second that estimates the measured temperature gradient variance at frequencies smaller than 15 Hz and then adds in the temperature gradient variance in the Kraichnan passive scalar spectrum for frequencies greater than 15 Hz.

Table 10: Microstructure probe usage and post-cruise assessments.

Cast	Sx	Sy	T1	T2	C1	comment
01-06	M779	M780	T1406	T1958	C238	comment
07-09	M779	M783	T1406	T1958	C238	comment
10	M779	M784	T1406	T1958	C238	comment
11-12	M779	M792	T1406	T1958	C238	comment
13-14	M779	M792	T1959	T1958	C238	comment
15-18	M779	M1599	T1959	T1958	C238	comment
19	M1599	M1599	T1958	T1959	C238	comment
20	M1603	M1599	T1958	T1959	C238	comment
21	M1603	S2	T1958	T1959	C238	comment
22-32	M1603	dummy	T1958	T1959	C238	comment
33	M1606	summy	T1958	T1959	C238	comment
34-35	M1606	M2184	T1958	T1959	C238	comment
36-37	M2197	M1606	T1958	T1959	C238	comment
38	M2197	M2184	T1958	T1959	C238	comment
39	M2197	M2184	T1958	T1959	C238	comment
40-49	M2197	M2184	T1958	T1959	C295	comment
50-58	M2197	M2199	T1958	T1959	C295	comment
59	M2197	M2199	T1958	T1959	C295	comment
59-67	M2202	M2200	T1958	T1960	C295	comment

One *in situ* calibration for the thermistor time constants was attempted. This was based upon HRP 14 in a region of high dissipation ($\epsilon > 1 \times 10^{-7}$ W/kg) and low salinity gradient. This is assumed to apply to all the probes used in this experiment.

Table 11: Shear probe sensitivities and calibration dates.

M779	0.0646	Feb. 25, 2019	NOTE! This calibration is off. RETIRE
M780	0.0514	Feb. 26, 2019	dismounted for diagnostic purposes
M783	0.0580	Feb. 26, 2019	dismounted for diagnostic purposes
M784	0.0556	Feb. 26, 2019	dismounted for diagnostic purposes
M792	0.0805	Feb. 25, 2019	dismounted for diagnostic purposes
M1599	0.0645	Feb. 22, 2019	spikey. RETIRE
M1603	0.0624	Feb. 22, 2019	delaminated at end of cast 37. RETIRE
M1606	0.0433	Feb. 25, 2019	Not loving the change in calibration at recalibration. RETIRE
M2184	0.0655	Dec. 9, 2019	KP touched this probe a little too hard post dive 35. Recal.
M2197	0.0616	Jan. 20, 2020	Appears to have jumped cal, Dives 54-ish on. RETIRE
M2199	0.0673	Jan. 21, 2020	Bieito reports this has delaminated post Dive 58. RETIRE
M2200	0.0722	Jan. 20, 2020	
M2202	0.0617	Jan. 20, 2020	

Table 12: Thermistor time constants.

T1406	0.0089	RETIRE
T1958	0.0089	
T1959	0.0089	RETIRE
T1960	0.0089	

4.2 Epsilometer – *Nicole Couto*

The Epsilometer (or Epsi) is a microstructure profiler built by engineers in the Multiscale Ocean Dynamics group at Scripps Institution of Oceanography. It can be deployed as part of the "Epsifish" from the Fast CTD winch or as a standalone instrument attached to a mooring or other profiler. We deployed Epsilometers in both configurations on this cruise (Table 13). On each deployment, we sampled with two shear probes and two fast-response thermistors allowing us to compute the dissipation rate of turbulent kinetic energy (ϵ) and the dissipation rate of thermal variance (χ).

Date	Description	Instrument
June 24	Along-canyon transect T8-T16	Epsifish
June 28-July 3	Process mooring	Standalone
July 3	13-hr time series at G9	Epsifish
July 8-9	30-hr time series at dye release site J4.4	Epsifish
July 15-18	Profiles at tracer-sampling CTD stations	Epsifish
July 21	12 hr time series near MAVS2 mooring	Epsifish
July 21	Comparison profile with VMP	Standalone
July 22-23	12 hr time series at up canyon location	Epsifish
July 24	12 hr time series at up canyon location	Epsifish

Table 13: Timing of Epsifish and standalone Epsi deployments.

4.2.1 FCTD boom and sheave

The Epsifish was deployed from a winch on the port side of the back deck. A long boom allows the fish to be deployed a safe distance from the ship and its propellors. The sheave at the end of the boom has a precise encoder which lets the cable fall steadily off the winch drum and provides the winch driver with the length of cable out in the water. This is important because the fish needs to free fall through the water column to get good turbulence measurements so the cable should be slack but not too slack. Too much slack out can create knots in the line, which could damage the outer coating, or it can cause the fish to keep falling to the seafloor after the winch starts hauling in the line at the end of a cast. We had great success with the setup on this cruise taking a total of 379 Epsifish profiles!

4.2.2 Popping the chute

The Epsifish is fit with parachute arms that remain latched until scientists in the lab send a command to "pop the chute." This novel feature was important in this experiment because we were interested in targeting the bottom few hundred meters of the water column. We saved a lot of time falling quickly to depth with the chute closed and only opening it when we had reached our target depth.

4.2.3 Along-canyon transect

On June 24th, as part of our initial along-canyon CTD and microstructure survey, we did 5 full-depth casts with Epsifish at stations T8-T16 (See map for 22-28 July 2021)

4.2.4 Process mooring

On June 28th, a process mooring (MP1) was deployed ahead of the dye release at a station along the canyon axis in 2028 m of water (See blt1_mooring_locations.png). A standalone Epsi was mounted to the McLane Moored Profiler. Vibrations from the profiler itself were likely too strong for the shear probes to accurately measure in-situ turbulence, but the fast-response thermistors provided a 5-day time series of temperature variance dissipation (χ). The spatial and temporal pattern of χ are consistent with those of Thorpe scale overturns (see BLT MP1 sections).

4.2.5 13 hr time series at G9

On July 3rd, we conducted our first long time series with Epsifish. Initially, wee planned to spend 24 hours profiling in the lower 400 m at dye grid station G9. However, some problems with data dropouts forced us to recover the fish after only 13 hours. (Fig. 18) These problems were solved before the next time series, which was 30 hours long!

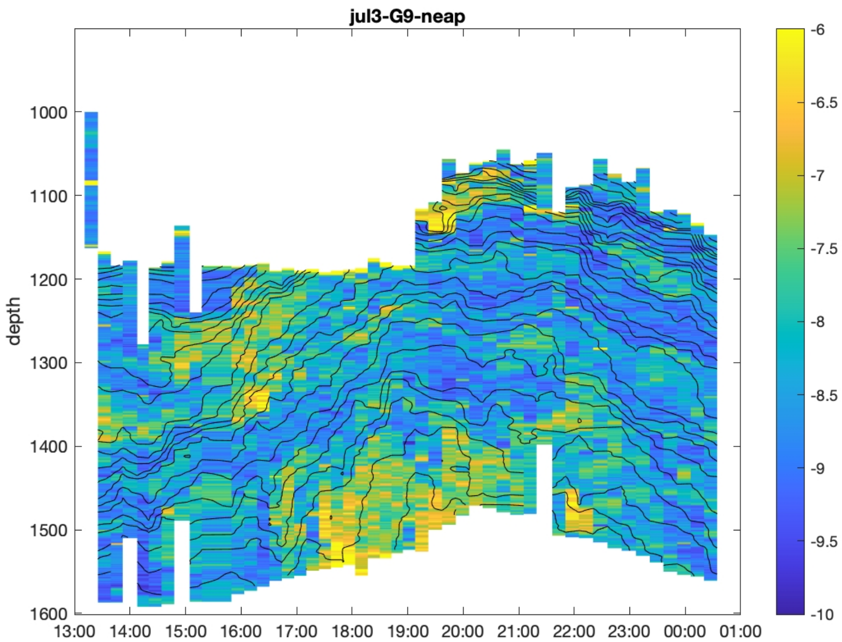


Figure 18: 13 hr time series of $log_{10}(\epsilon)$ at G9 during neap tide

4.2.6 30 hr time series

On July 8th, we conducted a 30 hour time series with Epsifish at the dye release station (J4.4) (Fig. 19) .

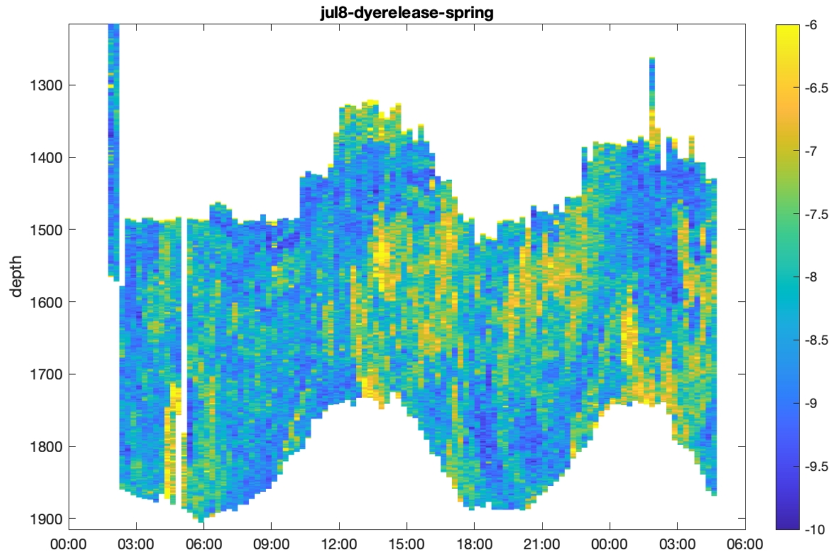


Figure 19: 30 hr time series of $log_{10}(\epsilon)$ at dye release site during spring tide

4.2.7 Profiles at tracer CTD stations

In the days after the tracer release, we occupied several stations with the CTD rosette to sample tracer. At each of these stations, a microstructure profile was also measured with HRP, VMP, or Epsifish. Between July 15th and July 18th, we collected 15 full-depth Epsifish profiles at the tracer sampling stations. When there was time, we snuck in a second profile in the lower 400 m before hauling the fish back up to the surface. (See maps for 15-19 July 2021 for locations).

4.2.8 Time series stations after tracer release

Beginning 10 days after the initial tracer release, we began a pattern of completing one full cycle of the 7 tracer sampling stations (AX8, AX1, W1, W2, BM, TS, AX6) followed by profiling with Epsifish in a single location for 12 hours. In this way, we completed three 12-hour stationary time series. The first was on July 21st 400 m upcanyon of the MAVS2 mooring in 1430 m of water (orange triangle on map for 19-24 July 2021 and Fig. **??**). The second and third were at a location a little farther up the canyon in 1360 m of water. These two stations were occupied between 17:00 and 05:00 on the 22nd/23rd and then between 05:00 and 17:00 the following day (the 24th), approximating a 24-hour occupation

During all of the Epsifish time series, while the ship held position in DP, the fish itself moved up and down canyon with the tide. We profiled in the lower 400 m of the water column, using the altimeter to come within 10 m of the bottom. The motion of the fish is reflected in the lower limit of the epsilon figures (Figs. 18-22). As the tide flows upcanyon, the fish moves into shallower water, and as the tide flows downcanyon the fish moves into deeper water.

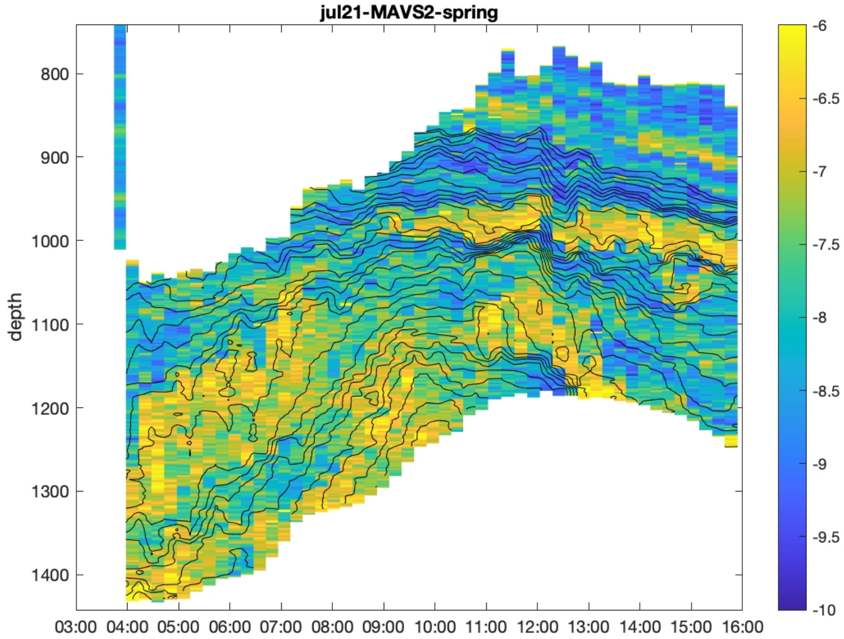


Figure 20: 12 hr time series of $log_{10}(\epsilon)$ 400 m upcanyon of the MAVS2 mooring at spring tide

4.2.9 Comparison with VMP-2000

During this cruise, we measured microstructure profilers with multiple instruments: VMP2000, VMP6000, HRP, and Epsilometer. Very occasionally, deployments of different instruments were done within an hour of each other which may later be useful for cross-calibrations, but as we have learned, the turbulent environment in this canyon changes quickly. In order to be sure that the different instruments give consistent measurements, we deployed the VMP2000 with the standalone Epsi attached with its probes protruding in line with the VMP probes.

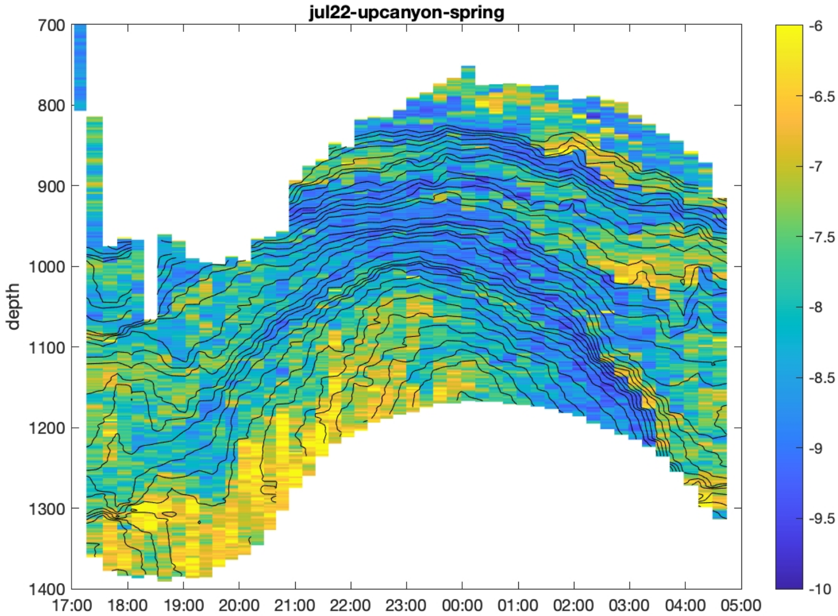


Figure 21: 12 hr time series of $log_{10}(\epsilon)$ at the farthest upcanyon station during spring tide

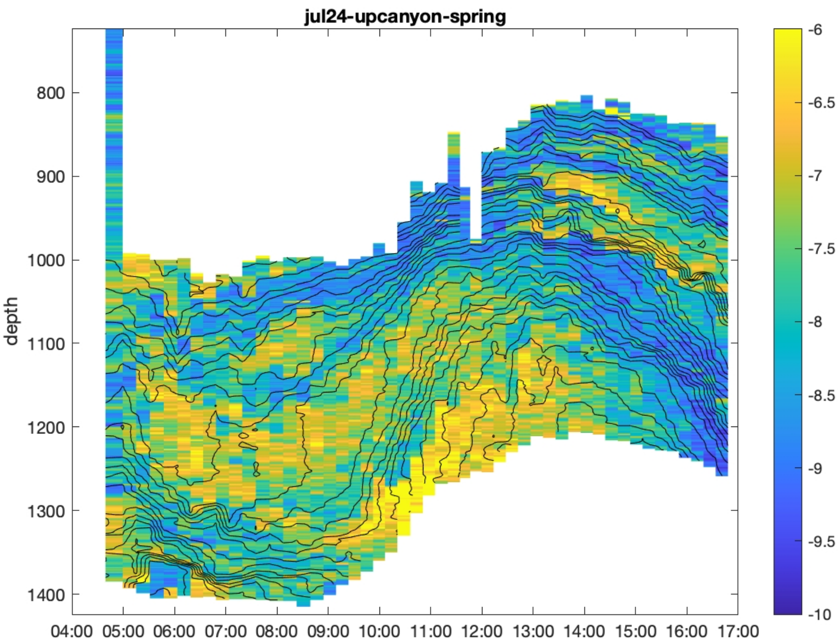


Figure 22: Second 12 hr time series of $log_{10}(\epsilon)$ at the farthest upcanyon station during spring tide

Figure 23: NMF and Scripps scientists getting ready to deploy the VMP2000 with the Epsifish attached

4.3 Vertical Microstructure Profiler (VMP) – *Carl Spingys, Alex Forryan, Bieito Fernandez Castro*

During DY132 a series of microstructure observations were made using two unteathered (VMP 6000s SN016 and SN107) and one teathered (VMP2000 SN???) freefall profiliers manufactured by Rocklands Scientific International. These types of instruments measured profiles of temperature and velocity microstructure (i.e. on the length scales of dissipation of turbulent flows, typically a few millimetres to tens of centimetres), from which the rates of dissipation of turbulent kinetic energy (ϵ) and temperature variance (χ) are estimated using methodology based on Oakey (1982); and finescale temperature, salinity and pressure with a Seabird CTD mounted on each instrument. The aim of the BLT microstructure operations was to document the mixing occurring near the bottom boundary eastern slope of the Rockall Trough, primarily focussed on a canyon on the continental slope. The VMP profiliers were used here in support of other primary microstructure instruments, the epsilometer for shallow teathered profiling and the HRP for deep untheathered profiling.

4.3.1 VMP 6000 Operations

On DY132 a total of 14 VMP 6000 profiles were collected (12 using SN016 and 2 using SN107). There were significant problems with SN107 leading to SN016 being used as the primary instrument on this cruise.

Table 14: VMP 6000 Casts

Stn (Cast)	Lat	Lon	Date	Time	SN	File	Comments
6(1)	54 24.961	-12 7.177	22/06/21	20:52	016	S006_001	Sh2-Slight Noise
7(2)	54 21.508	-12 5.569	23/06/21	01:26	107	S007_001	Sh1-Noise
8(3)	54 18.988	-12 2.997	23/06/21	05:43	016	S006_002	
9(4)	54 12.6	-12 1.8	23/06/21	09:01	107	S009_001	New Sh1, Looks bad, 1Hz spikes
10(5)	54 16.66	-11 59.995	23/06/21	12:23	016	S010_001	
11(6)	54 15.829	-11 58.223	23/06/21	15:55	016	S011_001	New Sh2, New T1
12(7)	54 14.80	-11 57.66	23/06/21	19:05	016	S012_001	New Sh1
13(8)	54 13.819	-11 57.193	23/06/21	22:18	016	S013_001	1Hz noise in upcast
80(9)	54 15.967	-11 58.342	16/07/21	04:13	016	S080_001	Fall rate release
81(10)	54 17.657	-12 1.612	16/07/21	08:20	016	S081_001	
82(11)	54 20.14	-12 0.993	16/07/21	12:47	016	S082_001	Sh2 spikes, T1 higher noise floor than T2
91(12)	54 17.623	-12 1.631	17/07/21	00:42	016	S091_001	
94(13)	54 12.756	-11 51.328	18/07/21	12:15	016	S094_002	Sh2<Sh1, T1 noise
127(14)	54 14.100	-11 56.634	25/07/21	06:45	016	S127_001	New T1, Sh1 bad near bottom, T2 bad

4.3.2 VMP 2000 Operations

On DY132 a total of 61 VMP 2000 profiles across 14 stations were collected. The VMP 2000 performed well on this cruise, with minimal issues other than occasional bottom strikes. Avoiding bottom contact proved difficult when performing tow-yo's over rapidly changing topography.

Table 15: VMP 2000 Casts

Stn (Cast)	Lat	Lon	Date	Time	SN	File	Comments
15(1)	54 10.35	-11 54.98	24/06/21	09:26	023	DY132_S015_001	
16(1)	54 10.68	-11 54.65	24/06/21	11:39	023	DY132_S016_001	New Sh2
17(1)	54 10.69	-11 52.14	24/06/21	12:47	023	DY132_S017_003	
18(1)	54 10.31	-11 50.14	24/06/21	14:14	023	DY132_S018_001	
19(1)	54 10.48	-11 50.39	24/06/21	15:17	023	DY132_S019_001	
20(1)	54 11.68	-11 51.92	24/06/21	16:52	023	DY132_S20_001	New Sh1, New SBET
21(1)	54 13.17	-11 54.60	24/06/21	19:04	023	DY132_S21_003	Short stop at 1572
22(1)	54 13.71	-11 55.88	24/06/21	21:15	023	DY132_S22_004	Slow fall rate at 200-300, Hit bottom, Deepest VMP2000!
36(1)	54 11.64	-11 51.42	04/07/21	05:12	023	DY132_S20_001	File name error, Hit bottom
36(2)	54 11.62	-11 51.30	04/07/21	05:40	023	DY132_S20_002	File name error, No upcast data
36(3)	54 11.59	-11 51.23	04/07/21	06:03	023	DY132_S20_004	File name error, Stall on upcast, Recovered
36(4)	54 11.43	-11 50.8	04/07/21	07:39	023	DY132_S20_007	File name error, First after repositioning
36(5)	54 11.49	-11 50.88	04/07/21	08:00	023	DY132_S20_008	File name error
36(6)	54 11.55	-11 50.95	04/07/21	08:20	023	DY132_S20_010	File name error
36(7)	54 11.58	-11 51.02	04/07/21	08:39	023	DY132_S20_012	File name error
36(8)	54 11.63	-11 51.09	04/07/21	08:58	023	DY132_S20_013	File name error
36(9)	54 11.68	-11 51.16	04/07/21	09:20	023	DY132_S20_014	File name error
36(10)	54 11.75	-11 51.22	04/07/21	09:42	023	DY132_S20_016	File name error
36(11)	54 11.82	-11 51.27	04/07/21	10:03	023	DY132_S20_017	File name error
36(12)	54 11.89	-11 51.32	04/07/21	10:28	023	DY132_S20_018	File name error
36(13)	54 11.96	-11 51.37	04/07/21	10:49	023	DY132_S20_019	File name error

Stn (Cast)	Lat	Lon	Date	Time	SN	File	Comments
36(14)	54 12.04	-11 51.43	04/07/21	11:15	023	DY132_S20_020	File name error
36(15)	54 12.11	-11 51.48	04/07/21	11:38	023	DY132_S20_022	File name error, Recovered
37(1)	54 12.00	-11 51.08	04/07/21	16:19	023	DY132_S0037_001	Sh2 questionable
37(2)	54 11.86	-11 51.25	04/07/21	16:40	023	DY132_S0037_002	Sh2 good
37(3)	54 11.71	-11 51.42	04/07/21	17:01	023	DY132_S0037_004	Short stop at 1393, Possibly hit bottom
37(4)	54 11.52	-11 51.66	04/07/21	17:30	023	DY132_S0037_005	Short stop at 1325, Hit bottom
37(5)	54 11.28	-11 51.94	04/07/21	18:05	023	DY132_S0037_006	Short stop at 1270, Recovered
37(6)	54 11.21	-11 52.01	04/07/21	19:38	023	DY132_S0037_008	Short stop at 1125, Sh2 failing
37(7)	54 11.32	-11 51.89	04/07/21	19:54	023	DY132_S0037_009	Sh2 failing
37(8)	54 11.43	-11 51.76	04/07/21	20:10	023	DY132_S0037_010	Possibly hit bottom
37(9)	54 11.56	-11 51.61	04/07/21	20:28	023	DY132_S0037_011	
37(10)	54 11.61	-11 51.55	04/07/21	20:39	023	DY132_S0037_012	Instrument far behind ship, hauled close to surface
37(11)	54 11.97	-11 51.12	04/07/21	21:08	023	DY132_S0037_013	Short stop at 1357, Sh2 noise
37(12)	54 12.08	-11 51.00	04/07/21	22:34	023	DY132_S0037_015	Sh2 is ok
37(13)	54 12.18	-11 50.88	04/07/21	22:57	023	DY132_S0037_016	
37(14)	54 12.29	-11 50.74	04/07/21	23:26	023	DY132_S0037_017	
37(15)	54 12.41	-11 50.61	04/07/21	23:54	023	DY132_S0037_018	
37(16)	54 12.46	-11 50.54	05/07/21	00:16	023	DY132_S0037_019	Sh2 questionable, Recovered
37(17)	54 12.37	-11 50.65	05/07/21	02:11	023	DY132_S0037_020	Sh2 questionable
37(18)	54 12.23	-11 50.82	05/07/21	02:31	023	DY132_S0037_021	Sh2 questionable
37(19)	54 12.09	-11 50.99	05/07/21	02:52	023	DY132_S0037_022	
37(20)	54 11.95	-11 51.15	05/07/21	03:11	023	DY132_S0037_023	

Stn (Cast)	Lat	Lon	Date	Time	SN	File	Comments
37(21)	54 11.83	-11 51.30	05/07/21	03:30	023	DY132_S0037_024	Sh2 questionable
37(22)	54 11.68	-11 51.48	05/07/21	03:51	023	DY132_S0037_025	Hit bottom, Stuck for a while with tension on line, Recovered
37(23)	54 11.43	-11 51.78	05/07/21	05:47	023	DY132_S0037_026	All probes are new, Sh2 and mC bad, Recovered
37(24)	54 11.01	-11 52.27	05/07/21	10:54	023	DY132_S0037_027	New Sh2 and mC, Hit bottom
37(25)	54 11.08	-11 52.19	05/07/21	11:17	023	DY132_S0037_028	Hit bottom
37(26)	54 11.12	-11 52.14	05/07/21	11:34	023	DY132_S0037_029	
37(27)	54 11.17	-11 52.08	05/07/21	11:52	023	DY132_S0037_030	Hit bottom
37(28)	54 11.23	-11 52.01	05/07/21	12:15	023	DY132_S0037_031	Hit bottom
37(29)	54 11.28	-11 51.95	05/07/21	12:33	023	DY132_S0037_032	
37(30)	54 11.33	-11 51.90	05/07/21	12:49	023	DY132_S0037_033	Hit bottom
37(31)	54 11.38	-11 51.89	05/07/21	13:04	023	DY132_S0037_034	Hit bottom
37(32)	54 11.42	-11 51.78	05/07/21	13:21	023	DY132_S0037_036	Recovered
108(1)	54 9.68	-11 48.16	21/07/21	18:56	023	DY132_S109_001	File name error, Shallow cast, Comparison with Epsilometer
108(2)	54 9.79	-11 48.39	21/07/21	19:22	023	DY132_S109_002	File name error, Shallow cast, Comparison with Epsilometer
108(3)	54 9.89	-11 48.51	21/07/21	19:35	023	DY132_S109_004	File name error, Shallow cast, Comparison with Epsilometer
133(1)	54 10.61	-11 50.09	26/07/21	05:19	023	DY132_S133_002	New foam added to slow fall rate
134(1)	54 10.38	-11 49.77	26/07/21	08:35	023	DY132_S134_001	Even more foam added
135(1)	54 10.21	-11 49.38	26/07/21	12:26	023	DY132_S0135_002	Hit bottom

4.3.3 Processing

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

Table 16: Processing steps for VMP data

Routine	Description
VMP_firstlook4	Reads to .P file and converts the raw data into physical units. Produces a series of diagnostic plots for the raw un-calibrated VMP data (from XXX.P, produces XXX.mat) and calibrates data (XXX_cal.mat)
VMP_process_seabird4	Processes the VMP seabird data and applies various corrections (despike, filter, ...). Output is saved as a separate matlab file, XXX_dCTD.mat
VMP_process_micro6	Processes the VMP microstructure shear, temperature and conductivity are calibrated by regressing against the processed VMP seabird temperature and conductivity. Output saved as a separate matlab file, XXX_micro.mat

5 Artifical Tracers

5.1 Dye Release – *Marie-José Messias, Herlé Mercier, Jack Hughes, Harry Hallbrook, Kaylim Reddy and Nile Ross*

A fluorescent dye, fluorescein ($C_{20}H_{10}O_5Na_2$), was used to examine processes of small spatial scale and short time scale at the bottom of the canyon. The field dye experiment consisted in tagging the bottom boundary layer by releasing dye 10 meters above the seafloor and subsequently map the dye patch over time and space. The fluorescein is ideal for this because its concentrations are easily measured with the high sampling frequency of a fluorometer. However, the length of time the dye can be measured is limited. The limitation comes from the speed of the dilution versus the amount of dye released, the relatively small range of detection of the fluorometer (Fig. 25) and dye degradation. Fluorescein release experiments are therefore typically suited for short experiments of 2-5 days over few kms. Here we used fluoresceine liquid 40% supplied by Town End plc (Leeds, UK).

The dye release system (Inkbot) was designed and built by Andrew Brousseau (Black Earth Compost LLC, Manchester by the Sea, US) in collaboration with Exeter University, WHOI and CNRS. INKBOT comprises: 1 Seabird SBE 911plus CTD, 1 Acoustic release OCEANO 2500S Universal, 1 AQUAtracka III Fluorometer (Chelsea Technologies Group, Surrey, U.K.), 1 altimeter and a 219-liter drum of dye (Fig. 26). We calibrated the fluorometers using different dilution of the fluorescein 40% as reported in Figure 24 and illustrated in Fig. 25 for our Chelsea fluorometer. The Inkbot was lowered to 10 meters above the bottom using the ship winch, CTD sea cable and the altimeter. Its drum was emptied by simultaneous flipping the drum and opening of the drum lid on acoustic command. We used fluorescein mixtures denser than the local water and kept the drum opened upside-down at the same position about 15 minutes (Fig. 3) to make sure that the drum emptied well.

We performed 2 dye releases. The first dye release (Stn 27) was performed on the 28th of June and used 219 liters of pure Fluoresceine liquid at 40% (Specific gravity: 1.12 +/- 0.05 from supplier). The dye patch of the first dye release could not be found. For the second release (Stn 33, bottom depth = 1870 m), we used a lighter mixture made of 149 liters of Fluoresceine liquid 40%, 64 liters of Iso-propyl alcohol and 6 liters of sea-water. The second dye release was performed on the 1st of July 03:01 am, 10 meters above the bottom at a potential temperature of 3.65C (Fig. 27). The position was 54.22N and -11.91W.

(Vertical)										Error					Error	
Position2	Addition / mL	Addition error / mL	Total Added / mL	Total error / mL	Conc. / (ppb)	Conc. Err / (ppb)	Log10(C)	log10(C) positive error	log10(C) negative error	log10(C_{max})	log10(C_{min})	V-Vb / (Volts)	(V / Volts)	error / V	Vmax	Vmin
10-100 µL pip.	0	0.0000	0	0.0000	0	0.000	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	0	0.75	0.125	0.870	0.630
	0.02	0.0005	0.02	0.0005	0.01	0.000	-2	0.011	0.011	-1.99E+00	-2.01E+00	0.127	0.88	0.115	0.970	0.790
	0.02	0.0005	0.04	0.0010	0.02	0.001	-1.69897	0.011	0.011	-1.69E+00	-1.71E+00	0.27	1.02	0.065	1.080	0.960
	0.04	0.0005	0.08	0.0015	0.04	0.001	-1.39794	0.008	0.008	-1.39E+00	-1.41E+00	0.389	1.14	0.055	1.190	1.090
	0.08	0.0005	0.16	0.0020	0.08	0.001	-1.09691	0.005	0.005	-1.09E+00	-1.10E+00	0.559	1.31	0.025	1.330	1.290
100-1000 µL	0.16	0.0025	0.32	0.0045	0.16	0.002	-0.79588	0.006	0.006	-7.90E-01	-8.02E-01	0.859	1.61	0.025	1.630	1.590
	0.32	0.0025	0.64	0.0070	0.32	0.004	-0.49485	0.005	0.005	-4.90E-01	-5.00E-01	1.115	1.87	0.015	1.880	1.860
	0.64	0.0025	1.28	0.0095	0.64	0.005	-0.19382	0.003	0.003	-1.91E-01	-1.97E-01	1.39	2.14	0.015	2.130	2.150
	1.28	0.0050	2.56	0.0145	1.28	0.007	0.10721	0.002	0.002	1.10E-01	1.05E-01	1.68	2.43	0.005	2.430	2.430
2,000-10,000 µL (=2mL-10mL) pip	2.5	0.0500	5.06	0.0645	2.53	0.032	0.403121	0.006	0.006	4.09E-01	3.98E-01	1.97	2.72	0.005	2.720	2.720
	5	0.0500	10.06	0.1145	5.03	0.057	0.701568	0.005	0.005	7.06E-01	6.97E-01	2.26	3.01	0.005	3.010	3.010
	10	0.0500	20.06	0.1645	10.03	0.082	1.001301	0.004	0.004	1.00E+00	9.98E-01	2.54	3.29	0.005	3.290	3.290
	20	0.1000	40.06	0.2645	20.03	0.132	1.301681	0.003	0.003	1.30E+00	1.30E+00	2.825	3.58	0.005	3.580	3.580
	40	0.2000	80.06	0.4645	40.03	0.232	1.602386	0.003	0.003	1.60E+00	1.60E+00	3.09	3.84	0.005	3.840	3.840
	40	0.2000	120.06	0.6645	60.03	0.332	1.778368	0.002	0.002	1.78E+00	1.78E+00	3.24	3.99	0.005	3.990	3.990
	40	0.2000	160.06	0.8645	80	0.432	1.90309	0.002	0.002	1.91E+00	1.90E+00	3.32	4.07	0.005	4.070	4.070
	40	0.2000	200.06	1.0645	100	0.532	2	0.002	0.002	2.00E+00	2.00E+00	3.39	4.14	0.005	4.140	4.140
	40	0.2000	240.06	1.2645	120	0.632	2.079181	0.002	0.002	2.08E+00	2.08E+00	3.44	4.19	0.005	4.190	4.190
	40	0.2000	280.06	1.4645	140	0.732	2.146128	0.002	0.002	2.15E+00	2.14E+00	3.49	4.24	0.005	4.240	4.240
	80	0.4000	360.06	1.8645	180	0.932	2.255273	0.002	0.002	2.26E+00	2.25E+00	3.555	4.31	0.005	4.310	4.310
	80	0.4000	440.06	2.2645	220	1.132	2.342423	0.002	0.002	2.34E+00	2.34E+00	3.6	4.35	0.005	4.350	4.350
	80	0.4000	520.06	2.6645	260	1.332	2.414973	0.002	0.002	2.42E+00	2.41E+00	3.63	4.38	0.005	4.380	4.380
	80	0.4000	600.06	3.0645	300	1.532	2.477121	0.002	0.002	2.48E+00	2.47E+00	3.65	4.40	0.005	4.400	4.400
	80	0.4000	680.06	3.4645	340	1.732	2.531479	0.002	0.002	2.53E+00	2.53E+00	3.67	4.42	0.005	4.420	4.420
	100	1.0000	780.06	4.4645	390	2.232	2.591065	0.002	0.002	2.59E+00	2.59E+00	3.67	4.42	0.005	4.420	4.420
	100	1.0000	880.06	5.4645	440	2.732	2.643453	0.003	0.003	2.65E+00	2.64E+00	3.67	4.42	0.005	4.420	4.420
	105	1.5000	985.06	6.9645	493	3.482	2.692847	0.003	0.003	2.70E+00	2.69E+00	3.67	4.42	0.005	4.420	4.420

Figure 24: Chelsea fluorometer calibration parameters

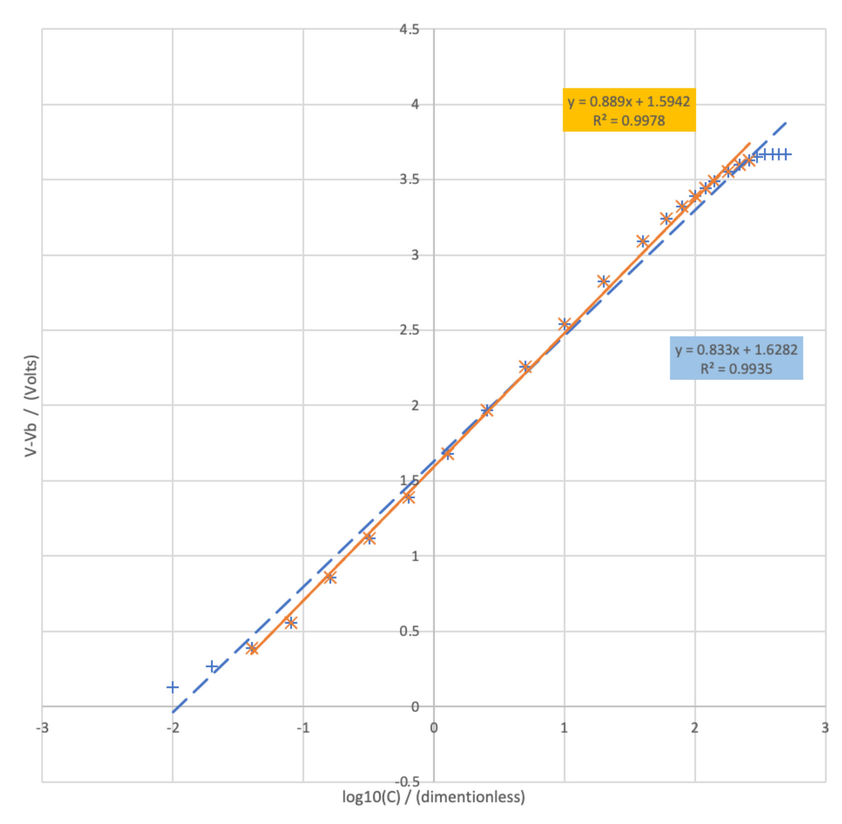


Figure 25: Curve of the Chelsea fluorometer calibration.

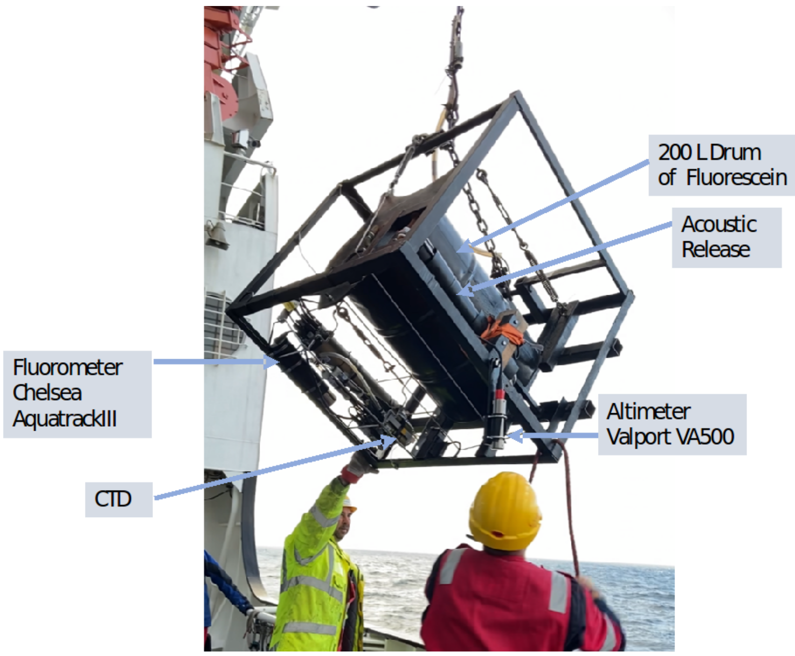


Figure 26: Deployment of the dye release system (INKBOT).

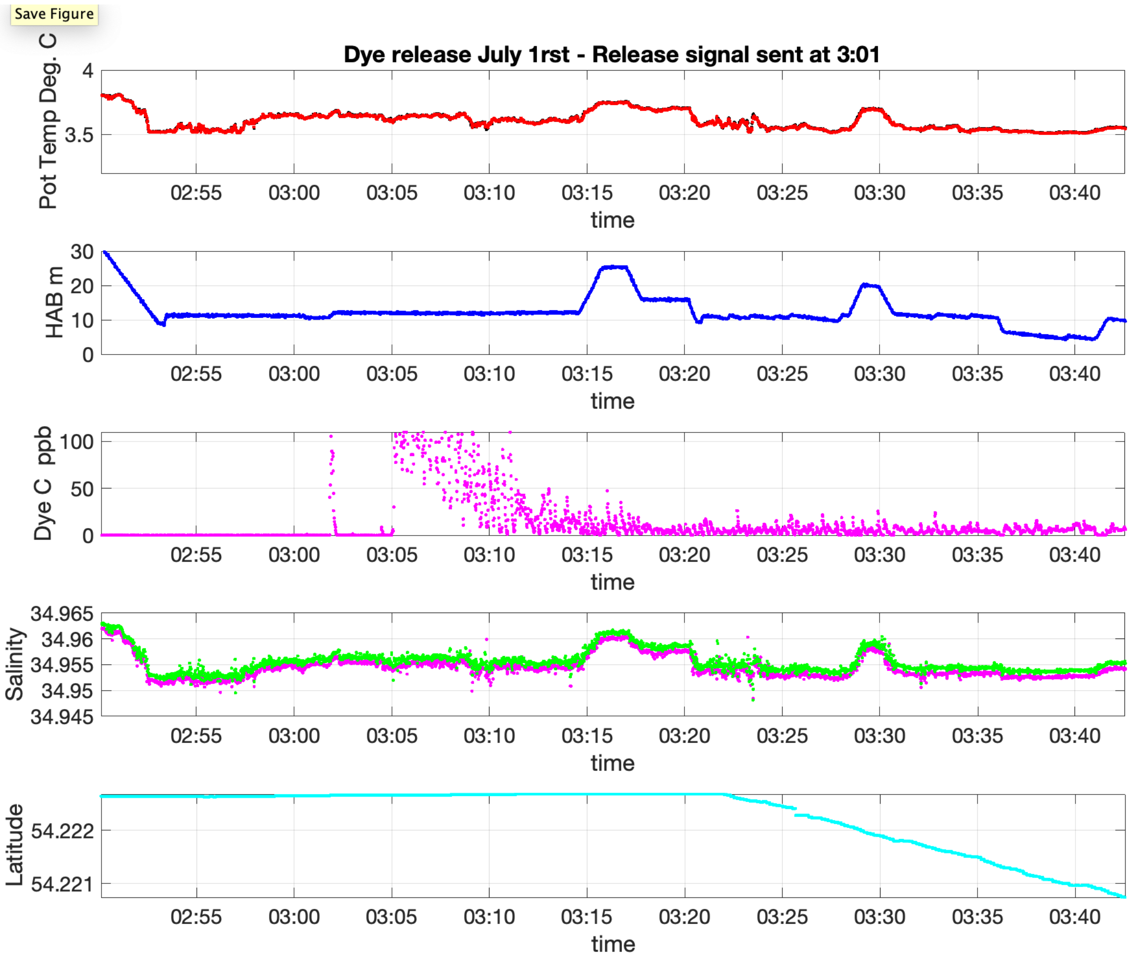


Figure 27: CTD, fluorometer and altimeter parameters, uncalibrated, during the second dye injection.

5.2 Tracer Injection – *Marie-José Messias, Herlé Mercier, Jack Hughes, Harry Hallbrook, Kaylim Reddy and Nile Ross*

To study ocean mixing and dynamics/overturning (including upwelling and downwelling) at the scales ranging from the canyon to the Rockall Trough, we used the long-lived tracer, trifluoromethyl sulfur pentafluoride (CF_3SF_5), an artificial compound from the class of perfluorocarbons supplied by Fluorochemika (Poland). The predominance of fluorine in this compound gives it properties which make it an attractive tracer for oceanographic studies. CF3SF5 has low atmospheric background levels, is inert and does not degrade in the troposphere. Its atmospheric lifetime is relatively long, estimated to 800 years. The tracer is measured using electron capture chromatography and reliably detectable in the ocean down to concentrations of about 5.10^{-18} moles per litre. We used the Ocean Tracer Injection System (OTIS sled, Fig. 28 developed and built at WHOI by Jim Ledwell and his team and adapted here to be towed close to the seabed. It comprises: 1 Seabird SBE 911plus CTD (Sea-Bird Electronics, Inc., Bellevue, Wash.), 2 Milton Roy HPLC duplex "minipump", 2 x lead acid batteries (130 Amp and 12 VDC) and 1 Injection Control Unit (ICU) with their pressure cage, 2 x 17-liter tanks for tracer, 2 x 17-liter tanks for primer fluid (Vertrel), 2 pressure compensating oil reservoirs, 1 Valport VA500 altimeter and 150 kg of weights. The tracer is sprayed into the "target" water through 12 nozzles with 50-micron orifices by the two pump systems at a typical rate of 15 ml/minute of fluid at 89 rpm. Therefore, tracer injection is a long procedure taking several hours. Pressure sensors are mounted on the system to give indication on the flow rate during the injection (See their calibration Fig. 29) but their reliability to determine the quantity of the tracer injected is poor and we used the weighing of the tracer cylinders before and after the deployment to estimate the quantity of tracer injected.

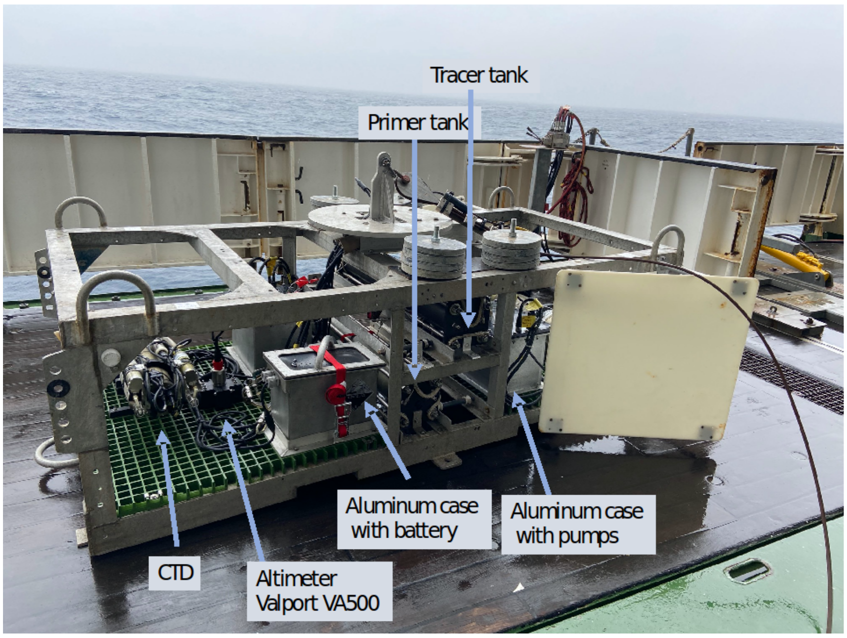


Figure 28: The Ocean Tracer Injection System (OTIS).

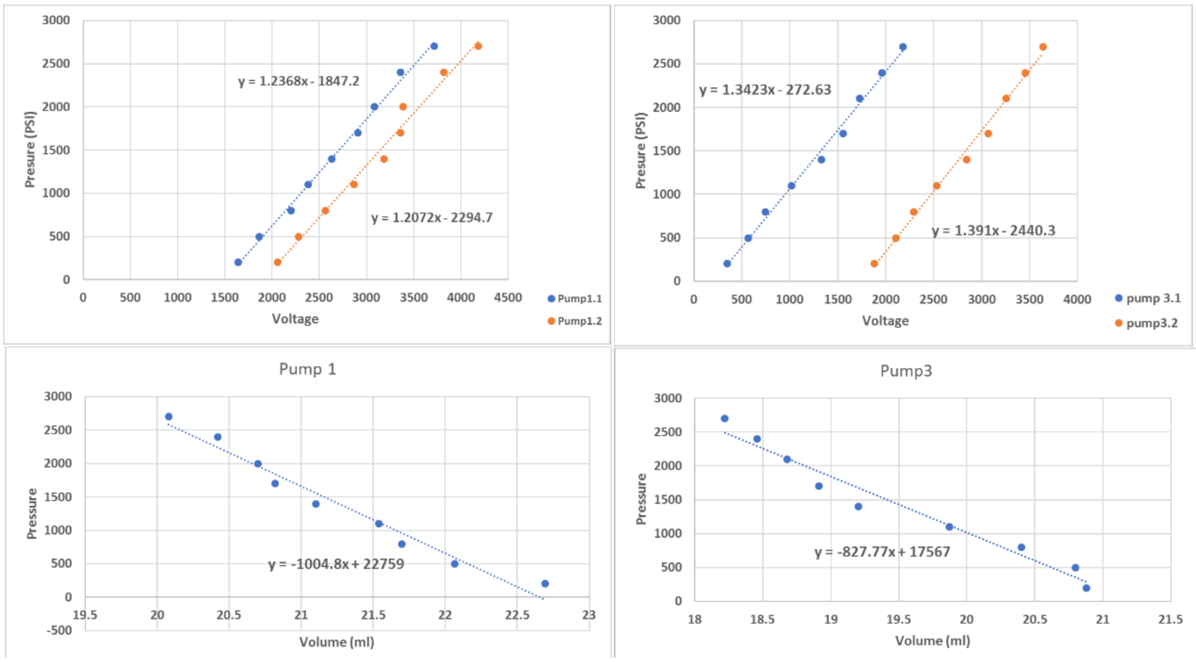


Figure 29: Calibration of the Milton Roy HPLC Duplex "Minipumps" versus the pressure sensors

The tracer release started on the 11 of July at 01:00 am. To maximise the documentation of the canyon upwelling, we released the tracer in the deep part of the canyon. The release was performed along canyon and we aimed at following the tidal flow in order to tag a target "water" defined by a temperature surface. To keep up with the tidal flow, the tracer sled was towed by the ship underway at speed up to 0.6 knots (maximum speed limited by the tracer sled package and tension on the cable) minimising the excursions outside the target temperature surface. We towed the injection sled close to the seabed approximatively 7 meters above the bottom (in the bottom boundary layer) by manual winch control guided by the altimeter. Over the 20 hours of the injection, the tracer streaks totalised 15 km positioned at depths ranging between 1800 and 2050 m. A map of the streaks is shown in Fig. 30a. When the tidal flow could not be followed and/or the sled was out of the 'window' target temperature surface ±0.05C, the pumps stopped injecting tracer switching to the primer fluid, hence the discontinuous tracer streaks. Note that the local flow field was estimated from the 25-hour LADCP station that resolved the semi-diurnal and diurnal tidal cycles and showed an apparent mean upcanyon velocity reaching 0.08 m/s at the bottom.

The amount injected was approximately 16 kg determined with an electronic balance in a calm day, the output of the balance being fed to a computer and averaged over several minutes. The hydrographic parameters measured during the injection are shown in Fig. 30b. The target potential temperature was 3.58±0.05C with a rms depth relative to the target HAB of 3 meters. During the filling of the tracer tanks, both the Exeter laboratory container and the sea water sampling gear (including the rosette bottles) were sealed to prevent their contamination.

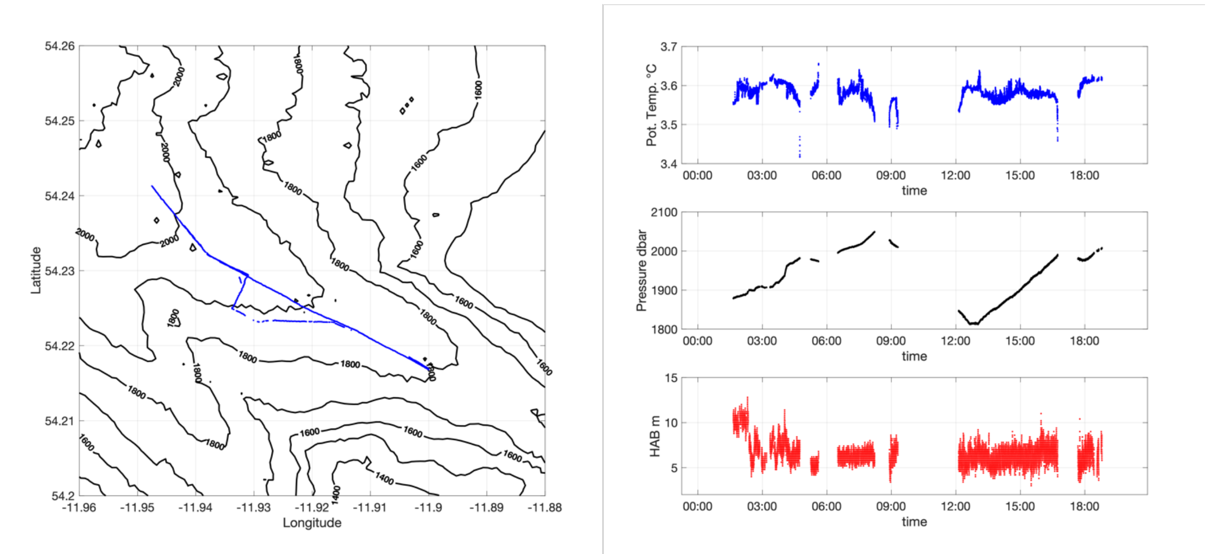


Figure 30: Tracer release: a) map of the bathymetry with the tracer streaks in blue. b) CTD and altimeter parameters, uncalibrated, during the tracer injection tow. The tracer injection interruptions correspondent to periods when the pumps switched to inject primer fluid as OTIS was outside of the target temperature window.

5.3 Measurement of the tracer, trifluoromethyl sulphur pentafluoride (CF_3SF_5) – *Marie-José Messias, Herlé Mercier, Jack Hughes, Harry Hallbrook, Kaylim Reddy and Nile Ross*

The released tracer (CF_3SF_5) dispersion is measured from discrete sample collected by the CTD-rosette. The analysis were performed directly on board in the Exeter laboratory container installed in the Discovery mezzanine. Tracer sampling and analysis started at the release site within 24 hours of the day of release. Then fixed-point repeated stations were carried out during 25-hours at two different sites located between the tracer release site and the head of the canyon to resolve the tracer variability over a tidal cycle in this early stage of the tracer dispersion. Survey of the tracer then consisted of a high-resolution section along the major axis of the canyon, with additional stations sampling the walls. The tracer sampling continued at 6 key stations that were occupied repeatedly before a final along-canyon high resolution section. A total of 80 stations totalizing 1920 seawater samples were measured. The map of the locations of the tracer stations is shown in Fig. 31.

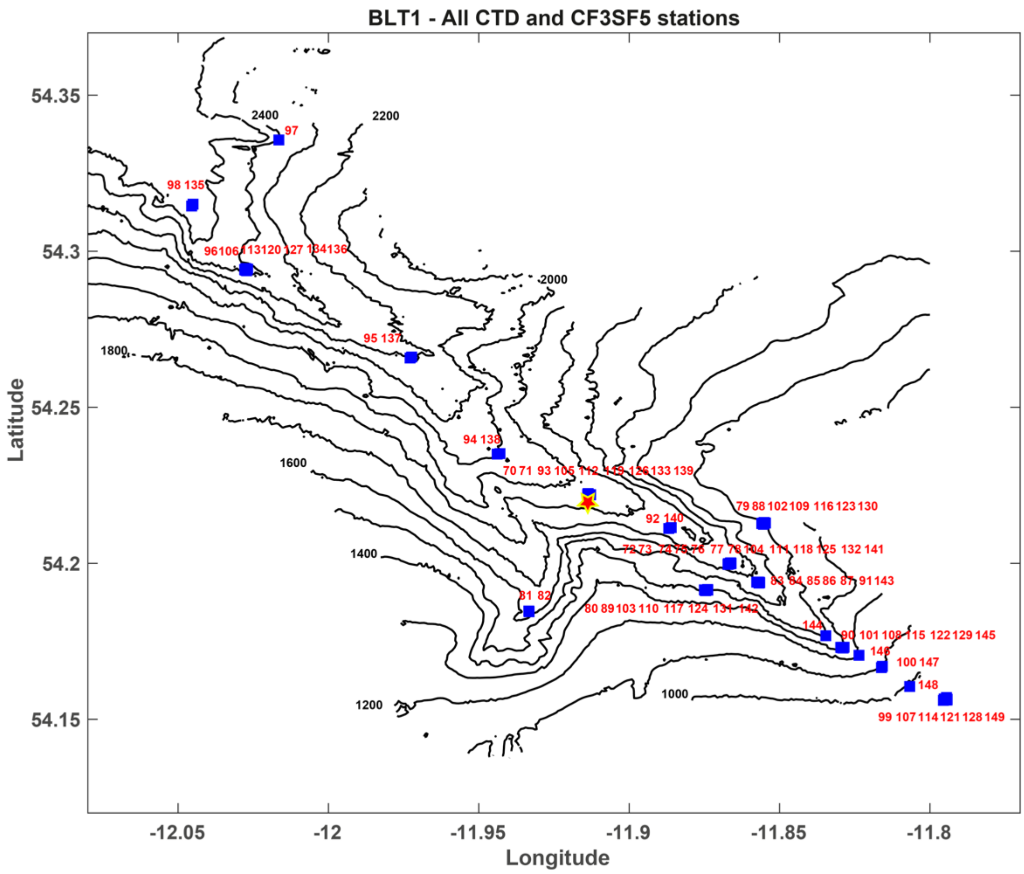


Figure 31: Tracer sampling positions on bathymetry. The station numbers are indicated in red. The star indicates the start of the tracer sampling.

5.3.1 Sample collection

The water sampling for the CF_3SF_5 measurements used the 24 bottles (10l bottle) mounted on the CTD rosette, allowing to sample 24 depths per cast. Water samples were transferred in 0.5 litre ground-glass stoppered bottles that were filled from the bottom using Tygon tubing and overflowed two time to expel all water exposed to the air. Immediately after sampling and until analysis, the water samples were kept cold (4-6C) to prevent sample degassing in the ship's controlled temperature laboratory.

5.3.2 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 traps (VICI nitrogen purifier and oxygen trap). 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 27 cm^3 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 a N_2 flow at 120ml/min for 4 minutes and trapped at -110Â°C on a Unibeads 3S trap (two inches of 1/8inch tubing) immersed in the headspace of liquid nitrogen.

The purge and trap system was interfaced to an Agilent 6890N gas chromatograph (GC) with electron capture detector (MicroECD). The gas chromatograph was set up similarly to that described by [Smethie et al., 2000]. The traps were heated to 110Â°C and injected into the gas chromatograph. The CF_3SF_5 separation was achieved using a 1m Porasil B packed pre-column and a 1.5m carbograph AC main column. A six inches molecular sieve post column was used to remove N_2O. The chromatograms shown in Figure 4 were obtained at the chromatograph oven temperature of 110Â°C. The GC N_2 carrier flow rate was 30 ml/min and the MicroECD temperature was 310Â°C.

The distribution of the chromatographic peak areas of all analysed samples shown in Fig. 32 covers 6 orders of magnitudes.

5.3.3 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 (Fig. 33). We used working standards supplied respectively by NOAA (Brad Hall, March 2017, CF_3SF_5 at 47.9 ppt) and the University of East Anglia (UEA, Andrew Manning, August 2011, CF_3SF_5 at 12 ppt, 215 ppt, 4.6*106 ppt). The NOAA standard is clean air enriched in CF_3SF_5 inside a 29L Aculife-treated aluminium cylinders. The UEA standard is nitrogen enriched in CF_3SF_5 inside a 20L steel cylinder. 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 concentration 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, 0.25, 0.3, 0.5, 1, 2, 3, 5 and 8 ml) of the working standards.

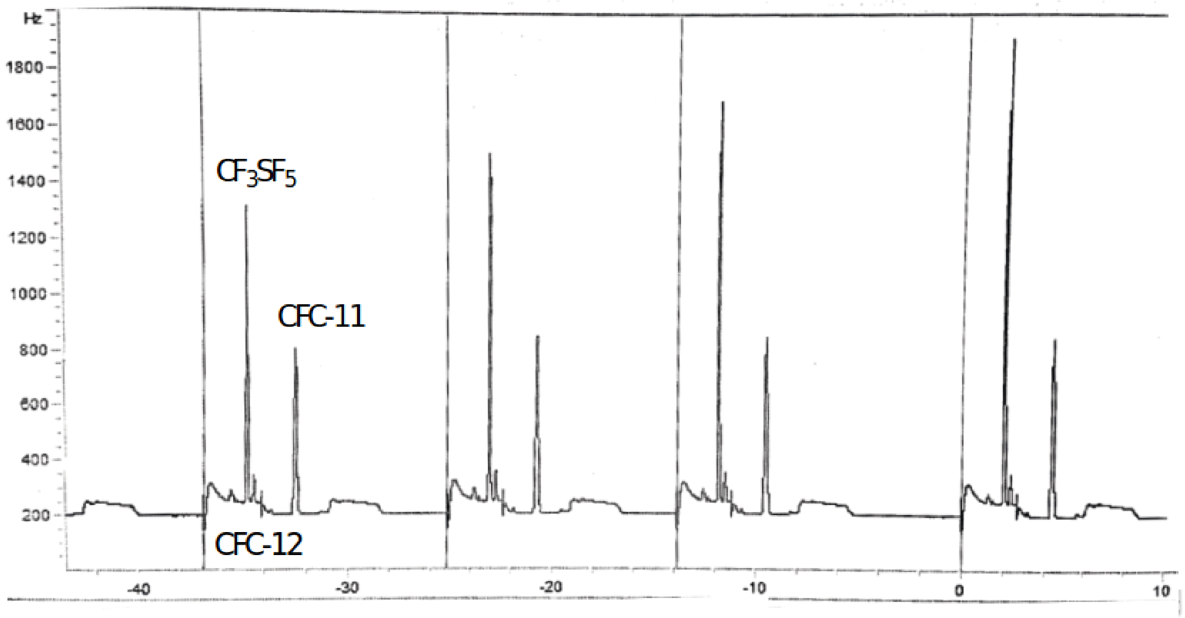


Figure 32: Chromatograms of 4 successive 27ml seawater samples analysed by the analytical system. Chromatograms give the ECD signal (Hz) as a function of time (minutes, x-axis). Peaks at 1.9, 2.2 and 4.1 minutes are CF_3SF_5, CFC-12 and CFC-11 respectively.

The changes in the sensitivity of the system were tracked 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 CF3SF5.

Blank or 'contamination' are estimated from the analysis of tracer free water obtained by sparging a water sample with N_2 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 CF_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.

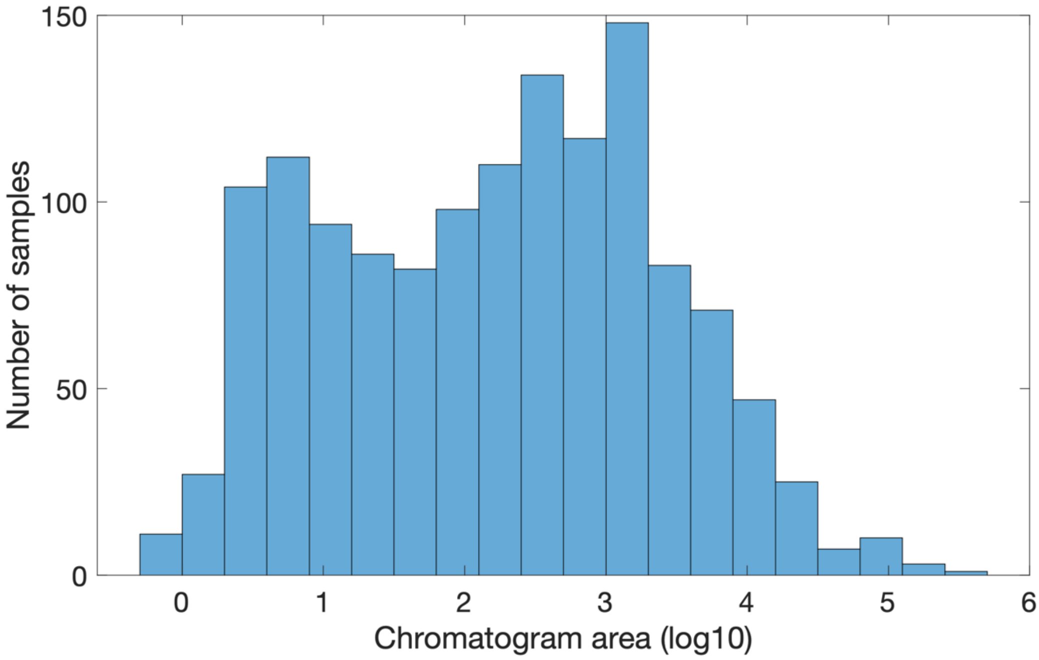


Figure 33: Distribution of chromatographic peak areas of all analysed 27 ml seawater samples.

6 Mooring Operations

6.1 Modular Acoustic Velocity Sensor (MAVS) Mooring – *Kurt Polzin, Brian Hogue, Gunnar Voet, Matthew Alford*

Two short (300 m) MAVS moorings (MAVS-1 and MAVS-2) were deployed as part of the project. 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 CTD. Four MAT-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.

The MAVS current meters were configured to log serial data from a custom RBR temperature sensor whose probe tip was inserted into the sensing volume of the acoustic current meter. The MAVS current meters are typically used as turbulent flux sensors mounted on rigid frames. There use on standard moorings is complicated by package motion in association with strumming of the mooring cable. This strumming is often aliased by possible sampling schemes. Here, the current meters have been set to sample as fast as possible (5 Hz) and to record continuously. The custom setup is completed by enhanced memory and an external battery pack mounted above in its own mooring cage. Strumming is quantified by the MAT-loggers sampling at 64 Hz. The ADCP serves both to quantify ocean velocity between the MAVS current meters and as a single metric of current direction.

Table 17: MAVS1 mooring sensor disposition.

sensor	Nominal H_{ab}	MAVS/RBR s/n
MAVS	276.3	10288/90042
MAVS	199.5	10295/201909
MAVS	125.8	10290/202350
MAVS	76.1	10379/201194
MAVS	50.3	10298/202352
MAVS	26.5	10374/201915
MAVS	12.1	10376/201911
MAVS	4.7	10378/201192

Table 18: MAVS2 mooring sensor disposition

sensor	Nominal H_{ab}	MAVS-RBR s/n	MAT-logger s/n
MAVS	276.3	10296-202348	1906100
MAVS	199.5	10289-202351	
MAVS	125.8	10299-202349	1906102
MAVS	76.1	10377-201910	
MAVS	50.3	10375-201913	1906101
MAVS	26.5	10373-202345	
MAVS	12.1	10372-201906	1906103
MAVS	4.7	10297-202346	

6.2 Moored Profiler (MP) Mooring – *Gunnar Voet*

A process mooring (MP1) was deployed the afternoon of June 28th, 2021, set to sample for the duration of the dye survey. The mooring was deployed on the canyon axis in 2028 m water depth. The mooring was 600 m tall and had an RDI Longranger 75 kHz ADCP mounted in the top float. It was equipped with a McLane Moored Profiler, outfitted with a Seabird SBE52 CTD, an FSI ACM travel time current meter, and an Epsilometer to measure temperature variance dissipation. In addition, a fluorometer was clamped onto the Epsi and its data stream fed into one of the Epsi shear channels. The moored profiler was set to continuous profiling mode and collected about one 500 m profile every thirty minutes.

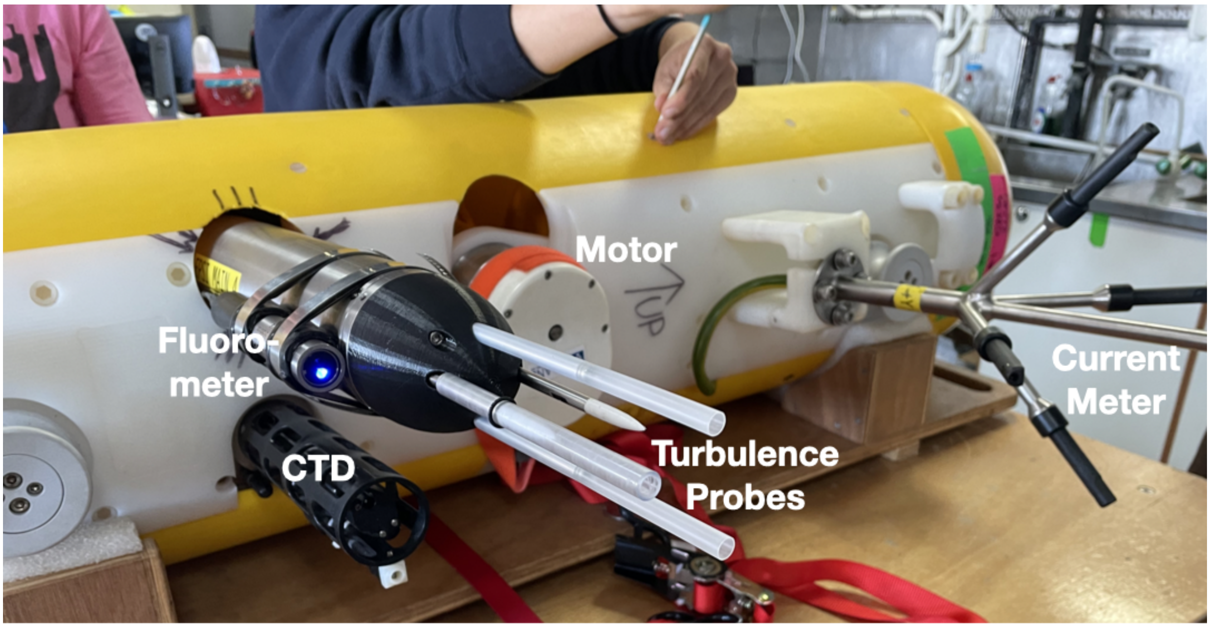


Figure 34: Moored profiler in the lab prior to deployment.

The mooring was recovered on the morning of July 5th, 2021. On recovery, the travel time current meter and one of the thermistors on the Epsilometer were found to be damaged. It was later determined that the damage had happened on recovery as all sensors measured fine until recovery (ACM, CTD) or until their battery ran out (Epsi). The most likely culprit seemed to be the glass floats above the acoustic releases rising into the moored profiler after release.

The dataset from the mooring provides a detailed picture of tidal motion and associated turbulence in the canyon. On first inspection, chi measurements from the Epsilometer seemed to have worked well. The fluorometer detected a signal of the dye about 20 hours after it was released upcanyon on July 1st.

The process mooring was re-deployed the afternoon of July 7th, 2021. The moored profiler had to be re-ballasted to account for a new FSI ACM and the missing Epsi that was not attached on this deployment.

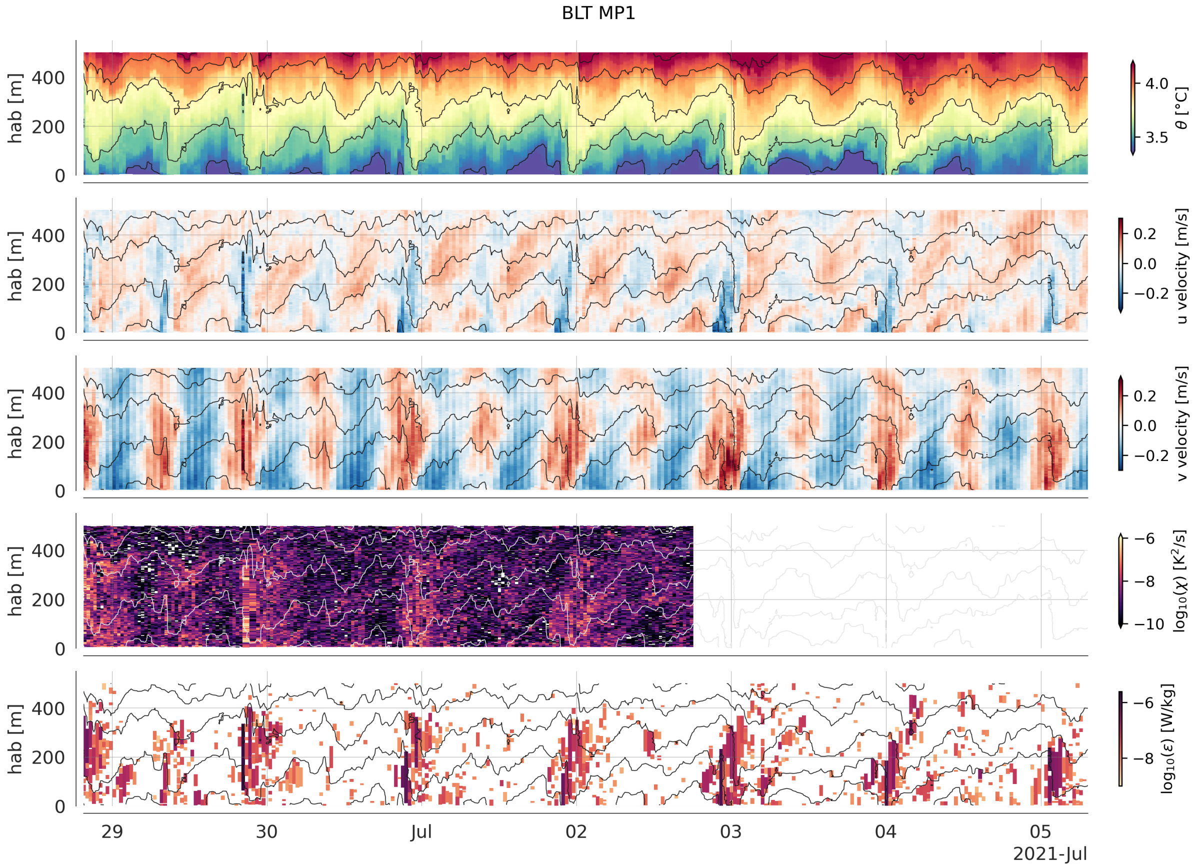


Figure 35: Six day time series from mooring MP1. From top to bottom: Potential temperature, eastward velocity, northward velocity, temperature variance dissipation, dissipation rate of turbulent kinetic energy from Thorpe scales. Contours in all panels show potential temperature.

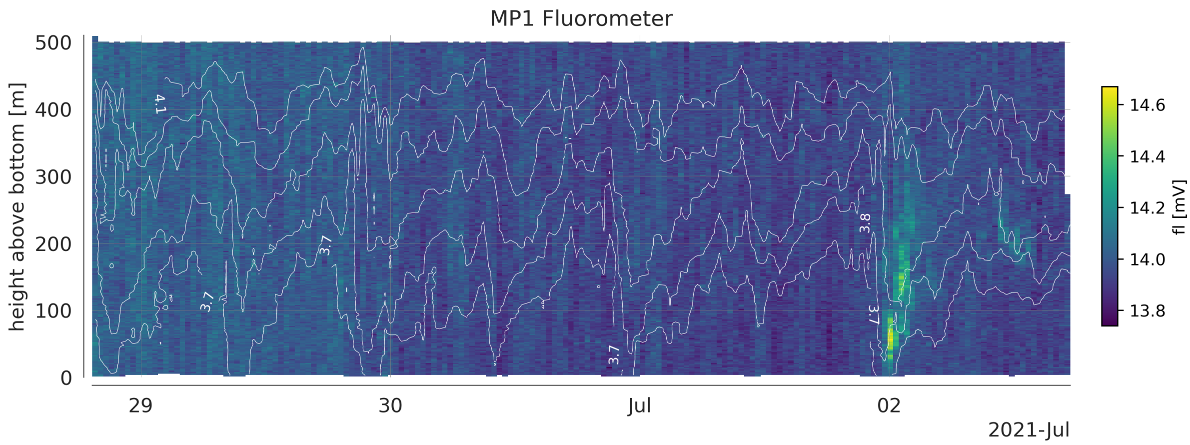


Figure 36: Fluorescence as measured by the fluorometer mounted on the MP-Epsi (in still somewhat arbitrary units). Note the increase in fluorescence around midnight on July 2nd.

6.3 Thermistor chain Mooring – *Gunnar Voet*

A thermistor chain was deployed the afternoon of July 6th, 2021, on the axis of the eastern fork of the canyon in 1525 m water depth. The mooring consisted of a 150 m thermistor chain with 102 pre-attached thermistors, borrowed from NIOZ/Hans van Haren and attached to acoustic releases that were mounted with a custom-made bracket directly on the mooring anchor. This mechanism brought the bottom-most thermistors to within 0.5 m of the ocean floor. The top float of the mooring held a 75 kHz RDI ADCP.

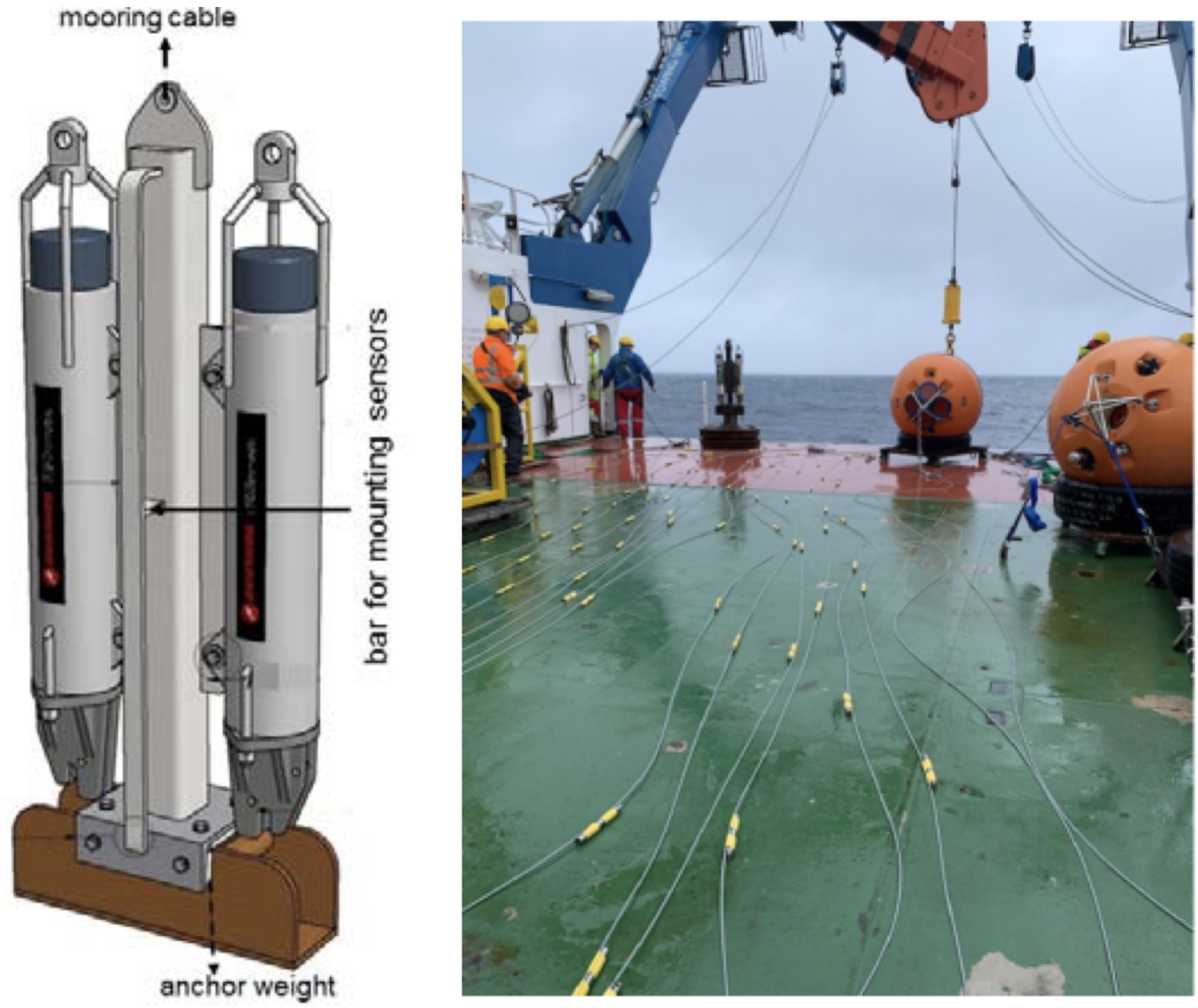


Figure 37: Left: Bracket design for acoustic releases on the TCHAIN mooring. Right: The TCHAIN mooring prior to deployment flaked out on the deck.

6.4 Mooring Diagrams

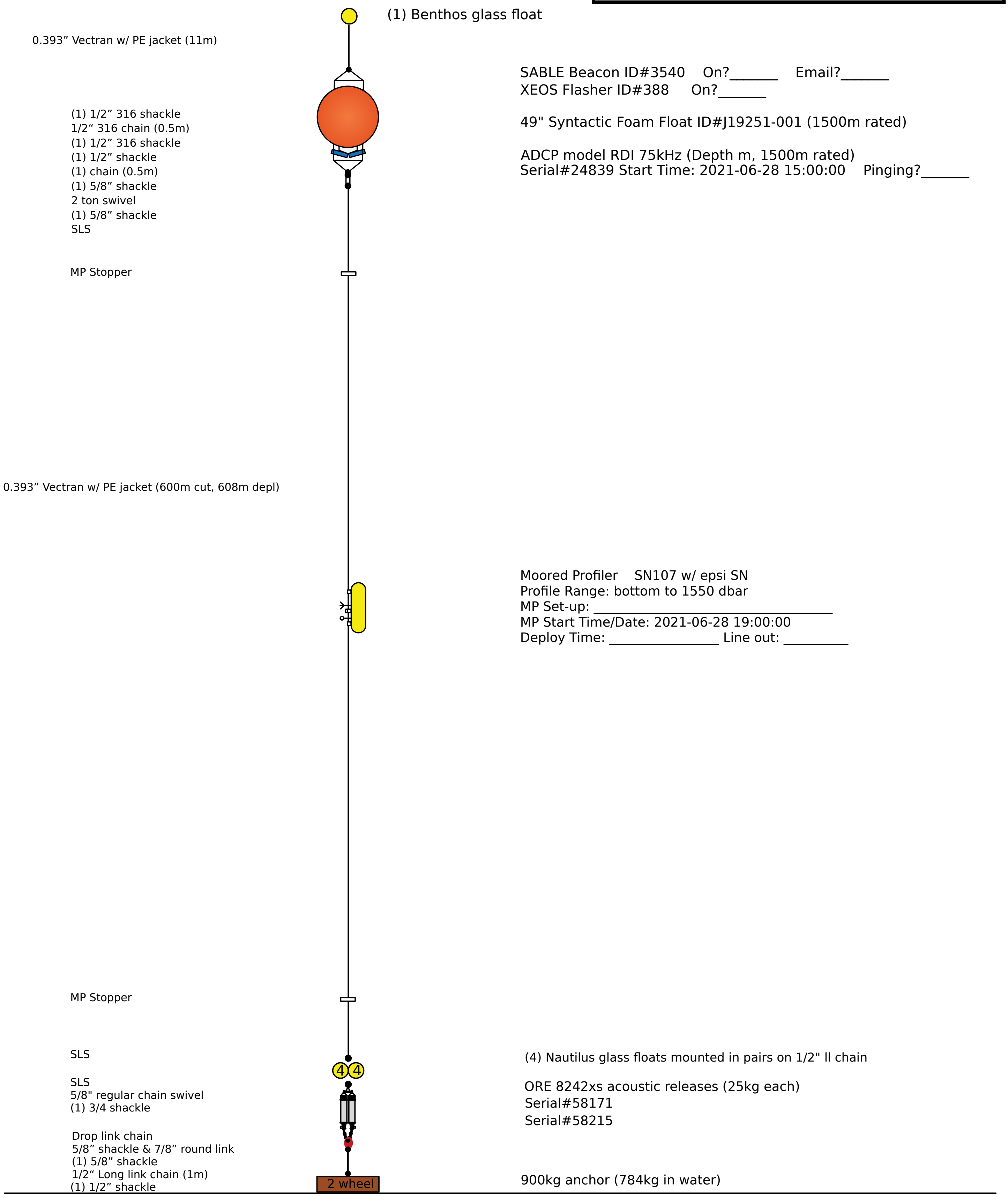
as deployed June 28, 2021

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

BLT MP1

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

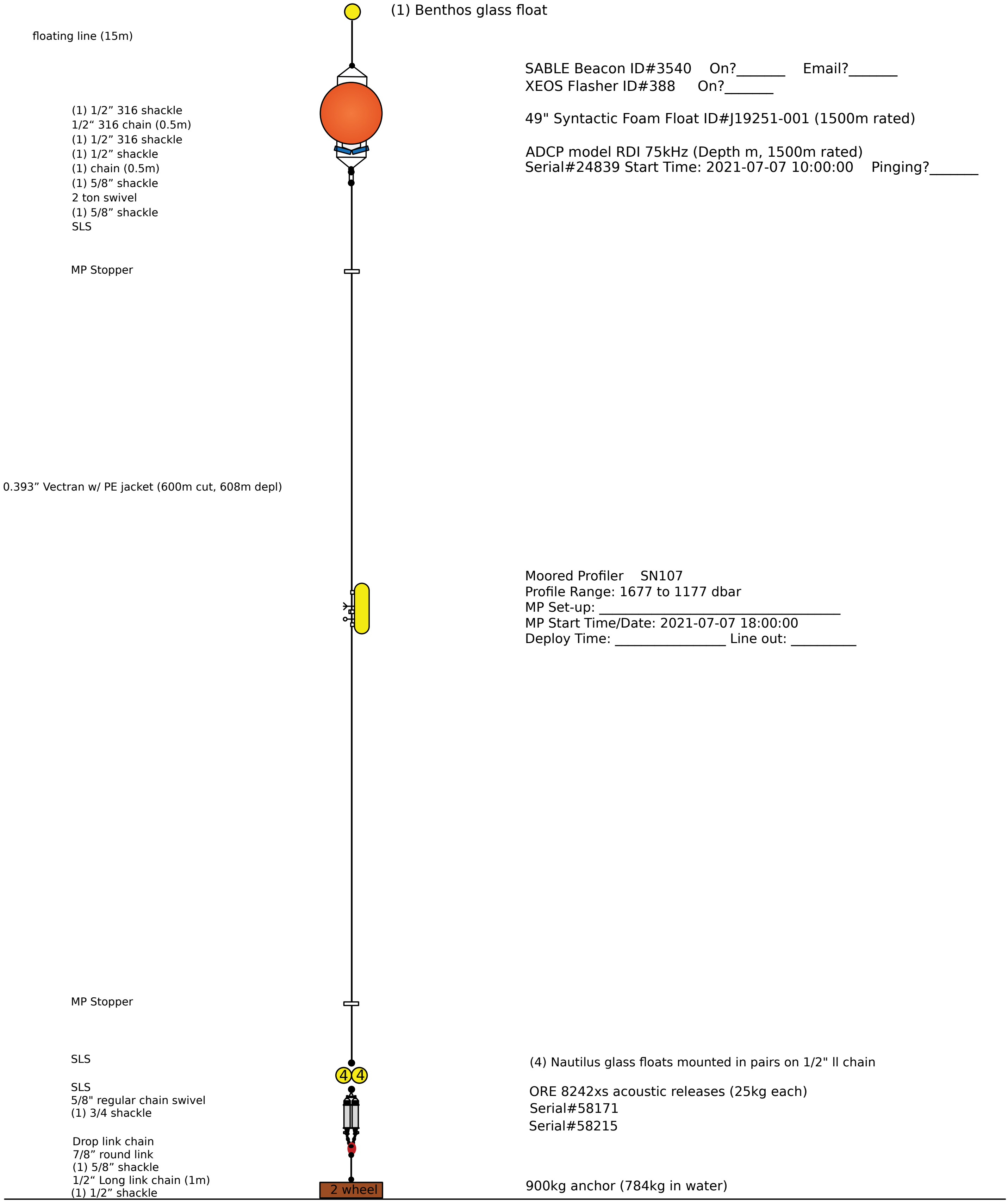
Actual: 54° 14.312'N 11° 56.923'W Depth: 2028m

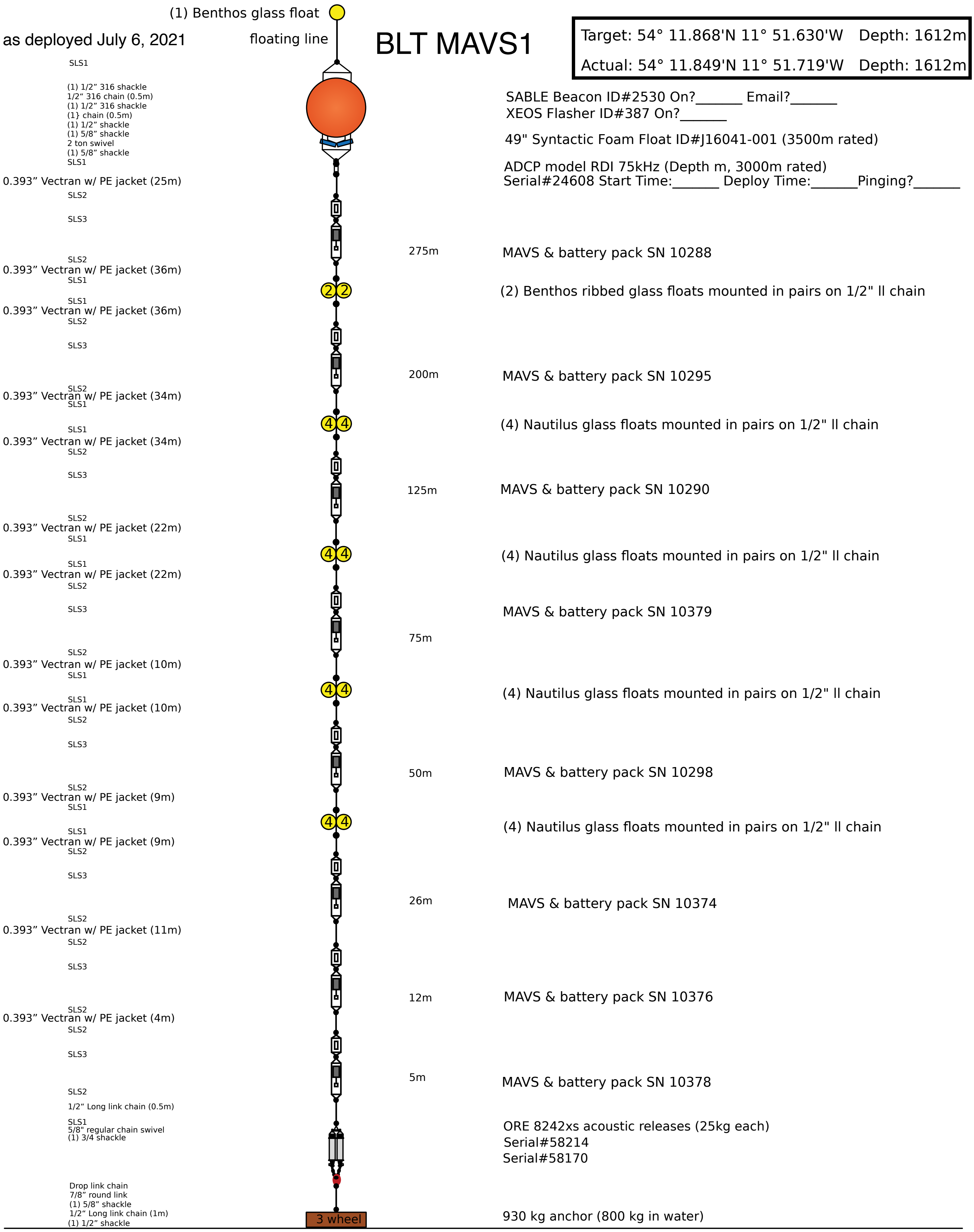


as deployed July 7, 2021
SLS: 1/2” shackle - 5/8” sling link - 1/2” shackle

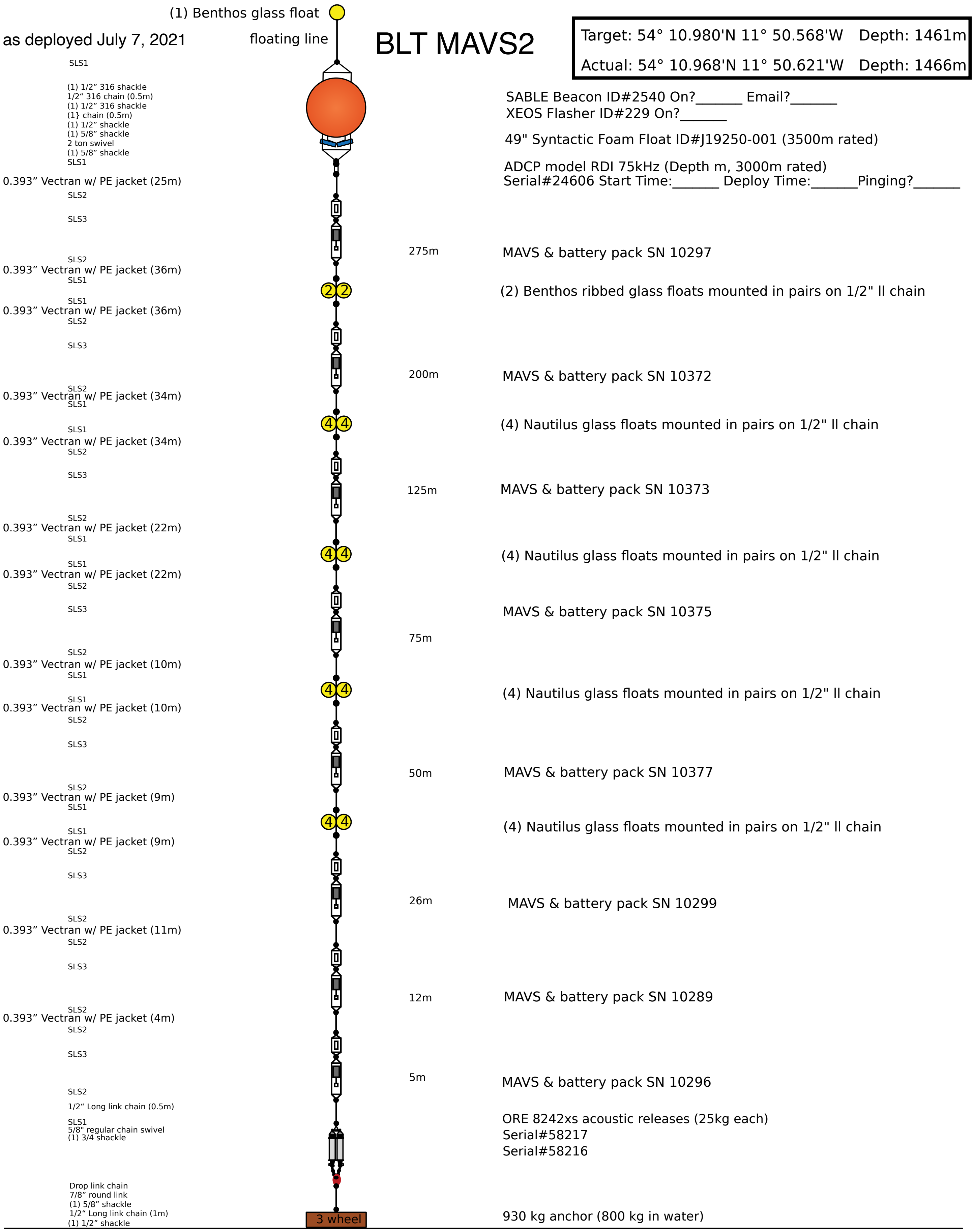
BLT MP2

Target: 54° 12.210'N 11° 52.350'W Depth: 1666m
Actual: 54° 12.167'N 11° 52.268'W Depth: 1653m





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

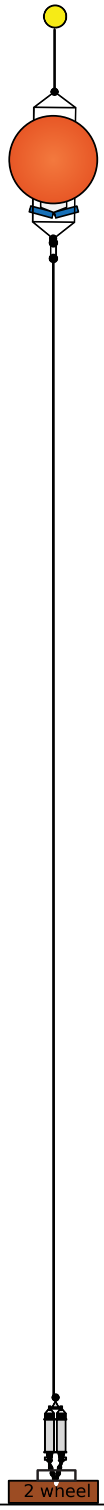


SLS1: 1/2" shackle - 5/8" sling link - 1/2" shackle
SLS2: 1/2" shackle - 5/8" sling link - 5/8" shackle
SLS3: 5/8" shackle - 5/8" sling link - 5/8" shackle

as deployed July 6, 2021
SLS: 1/2” shackle - 5/8” sling link - 1/2” shackle

BLT TCHAIN

Target: 54° 11.430'N 11° 51.120'W Depth: 1525m
Actual: 54° 11.413'N 11° 51.137'W Depth: 1525m



7 Underway Systems

7.1 NMF Ship Scientific Systems – *Zoltan Nemeth*

7.1.1 Cruise overview

Table 19: Table Data acquisition systems used on this cruise.

Cruise	*Departure*	*Arrival*	*Technician(s)*
DY132 BLT	19/06/2021	01/08/2021	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.

7.1.2 Scientific computer systems

7.1.3 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 below. 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.

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/

Data acquisition system	*Usage*	*Data products*	*Directory system name*
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]/

Significant acquisition events and gaps TechSAS logger DY132 mission started on 2021-06-16 06:00

RVDAS RAM Acquisition started on 2021-06-16 06:23

Level-C acquisition started on 2021-06-12 09:00:00

Wamos Waveredar started on 2021-06-19 06:04:00

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:
CNAV3050 GPS	2021-06-21 10:15	2021-06-21 11:21	01hour 07min	Signal Lost	Unknown; resolved with the restart
EM710	2021-06-21 09:38	2021-06-21 13:58	04hour 20min	PC crashed	What caused this are not found in windows eventlog.
Seapath330	2021-06-23 04:16:24	2021-06-24 07:33:12	27hour 17min	Unknown	Missing data only in TechSAS logger, the RVDAS recorded the data.

Sensor	From:	To:	Length:	Issue:	Reason:
Seapath330	2021-07-06 06:43:06	2021-07-07 06:08:08	23hour 24min	Unknown	Missing data only in TechSAS logger, the RVDAS recorded the data.
Seapath330	2021-07-08 15:48:50	2021-07-08 15:50:44	114 seconds	Unknown	Missing data only in TechSAS logger, the RVDAS recorded the data.
Phins	2021-07-09 04:15:38	2021-07-09 06:11:51	1hour 56min	Unknown	Resolved with restart ˜ 5 minutes until fine alignment state
Seapath330	2021-07-11 15:29:13	2021-07-12 05:39:51	14hour 12min	Unknown	Missing data only in TechSAS logger, the RVDAS recorded the data.
Seapath330	2021-07-21 00:04:22	2021-07-21 06:10:13	6hour 6min	Unknown	Missing data only in TechSAS logger, the RVDAS recorded the data.

7.1.4 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.

7.1.5 Instrumentation

7.1.6 Coordinate reference

Path to ship survey files:
/Ship_Systems/Documentation/Vessel_Survey

Origin (RRS Discovery) All coordinates, unless otherwise specified, use 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.

Multibeam Figure Conventions used for position and attitude. On the Discovery, the Datum is the CRP at the CG. On the Cook the Datum is on the centre, topside of the Applanix MRU.

The Kongsberg axes reference conventions are (see Figure 1) 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 1.

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.

7.1.7 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_Syste*		
Data description	*/Ship_Systems/Documentation/TechSAS /Ship_Systems/Documentation/RVDA*		
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. Wi
Kongsberg Seapath 330	Secondary GPS and attitude.	Serial and UDP NMEA to acquisition systems and multibeam	Positional accuracy within 1 m. Wi
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

7.1.8 Ocean and atmosphere monitoring systems

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_Syste*	
Data description	*/Ship_Systems/Documentation/TechSAS /Ship_Systems/Documentation/RVDA*	
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

System	**SURFMET (Surface water and atmospheric monitoring)**	
Drop keel temperature probe (SBE38)	Measure temperature of water in drop keel space	Not installed yet.
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

SURFMET 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.
Transmissometer open air measurement: 4.9760, close measurement: 0.008
TechSAS logger started: 2021-06-16 06:00
RVDAS logger started: 2021-06-16 06:23
TSG Data Acquisition valid from: 2021-06-19 11:00:00
TSG Data Acquisition terminated: ??

TechSAS logger terminated: ??
RVDAS logger terminated: ??

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 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.	
Furuno Radar	Measures radar reflection on sea surface.	Radar data to WAMOS.	

Wave radar 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.

7.1.9 Hydroacoustic systems

System	**Acoustics**		
Statement of Capability	*/Ship_Systems/Documentation/Acoustics*		
Data product(s)	Raw: */Ship_Systems/Data/Acoustics* NetCDF (EA640, EM122cb): */Ship_Syster*		
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-S
Kongsberg SIS (EM122)	Multibeam Deep Water sounder	Kongsberg .all	Discrete

System	**Acoustics**		
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 eve
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

Equipment-specific comments

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

Attribute	*Value*
Acquisition software	UHDAS
Frequencies used	75 kHz, 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 Broadband was run from leaving Southampon from 2021-06-19 06:00 to 2021-06-21 18:34 then, used Narrowband with water tracking mode from 2021-06-21 18:34 to 2021-06-25 10:51, then used bottom tracking again with BroadBand mode from 2021-06-25 11:00 to 2021-06-27 07:17, then used Narrowband with water tracking from 2021-06-27 07:18 to 2021-07-27 04:27 then from 2021-07-27 04:28 used Narowband with bottom tracking mode until the end of the cruise. Survey name: DY132 until 2021-06-24 16:30 when the DY132 recording terminated and the option files set to work with 3 beams with 150kHz transducer. The Survey name after this time was DY132_part2.

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

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.

Survey Site Name	*SIS Survey Name*	*Datetime Start*	*Total time of Logging*	*Vessel survey speed (kts)*	*SVP(s) Used (Filename)*	*Comments*
English Channel	Soton-to-Trough	2021-06-19 06:00:58	29:32:09 (h:m:s) 60 lines	9-11	Default	Default SVP profile and Sensor
North Atlantic	shallow	2021-06-20 12:01	34:05:56 (h:m:s) 70 lines	0-11	*ctd001*	From ctd001
North Atlantic	Rockall-trough	2021-06-21 22:16		0-12	Various from CTD casts	From ctd002;ctd097;ctd098

Caris Processing Logsheets:

1. CARIS Processing LogSheet DY132 Z.N.

2021-06-20 EN122 - ~~poma~~ - Jolan-to-Trough 06/19 data processing 37 lines shallow water + 06/20 lines
2021-06-21 DY132-EN122-pomu-shallow 06/20 data processing
2021-06-22 DY132-EN122-pomu-rockall-trough 06/21 data processed 5 lines
2021-06-22 09:11 DY132-rockall-trough 06/22 to line 23 +9999 data processing
2021-06-23 06:07 DY132-rockall-trough 06/22 from line 24 - processing
2021-06-23 11:47 DY132-rockall-trough 06/23 lines from 58-63 processing
2021-06-24 06:00 DY132-rockall-trough 06/23 lines from 64 processing
2021-06-24 15:53 DY132-rockall-trough 06/24 lines from 75 to 104 processing
2021-06-24 DY132-rockall-trough 06/24 from line 105 to end of the day
2021-06-25 06:03 DY132-rockall-trough 06/25 from line 122 to 133 processing 06:00
2021-06-25 06:41 DY132-rockall-trough 06/25 from line 135 to 171 processing
2021-06-26 05:57 DY132-rockall-trough 06/25 from line 172 to 203 processing
2021-06-26 16:50 DY132-rockall-trough 06/26 from line 204 to 219 processing
~~2021-06-26 16:50 DY132-rockall-trough 06/26~~
27 08:40
DY132-rockall-trough 06/27 from line 220 to 267 processing
2021-06-28 07:10 DY132-rockall-trough 06/27 from line 268 to 311 processing
2021-06-29 07:19 DY132-rockall-trough 06/28 from line 312 to 359 processing
2021-06-30 07:15 DY132-rockall-trough 06/29 from line 360 to 407 processing
2021-07-01 05:50 DY132-rockall-trough 06/30 from line
2021-07-02 Cleaning...
2021-07-03 Cleaning Contour 0629-0000 line 0312-316-332-346-356- all surfaces recomputed
2021-07-03 ~~1055~~ Cleaning Contour 0630-0000 line 360-365-370-392 ✓

weird display resolution change restarted!

0623-0000
0623 1152
0625 0000 0078
0625 1530 ✓
0625 0000 0130
0625 0601 0151
not in bathymetry
0627-0000 223-
226-227
225 263 to dream
256
0628-0000 ✓
278 295

2. CARIS Processing LogSheet DY132 zome@noc.ac.uk

2021-07-03 14:22 DY132-EN122-pomu-rockall-trough 07/01 data processing lines from 408-455 +418-431
2021-07-04 06:56 DY132-EN122- —〃— 07/01 data cleaning contour from line 431-445-455 / recomputed
2021-07-04 08:34 —〃— 07/02 data processing from line 456-507/559-586/588/496
—〃— 07/02 data cleaned recompute running.
2021-07-04 12:20
2021-07-04 12:50 —〃— 07/03 data processing from line 503-551
2021-07-04 13:56 —〃— 07/03 data cleaning 509/525/576/ 16:54 finished
2021-07-04 16:55 —〃— 07/03 data cleaned recompute surface running
2021-07-05 06:16 —〃— 07/04 data processing from line 552-599
2021-07-05 06:55 —〃— 07/04 data cleaning 552-553/562/573/591
2021-07-05 15:06 —〃— 07/04 data cleaned surface recomputed
2021-07-06 06:20 —〃— 07/05 data processing from line 0600-0645
2021-07-06 07:20 —〃— 07/05 cleaning 610/615/625/ - 17:40 recompute
2021-07-07 06:16 —〃— 07/06 data processing from line 646 to 693
2021-07-07 06:38 DY132-EN122-pomu-rockall-trough 07/06 data cleaning started 669/ 07:17 recomputed
2021-07-08 06:36 DY132- —〃— 07/07 data processing from line 694 to 740
—〃— 07/07 data cleaning started 713/ recomputed 08:20
2021-07-08 07:05
2021-07-08 08:26 DY132-finalised-test started 10-3500 min uncertainty 10.00m
—〃— 07/03 edited again surface recomputed
2021-07-08 09:57
2021-07-09 07:07 DY132-EN122-pomu-rockall-trough 07/08 data processing from line 741 to 788
07/08 data cleaning started, surface recomputed 08:50
2021-07-09 07:55 —〃— 07/07 data cleaning started surface recomputed
2021-07-09 08:58 —〃— 07/06 data cleaning started 667/ surface recomputed 15:40
2021-07-09 09:53 —〃—

1. CARIS Processing LogSheet DY132 Z.N.

2021-06-20 EN122-pomu-Solan-to-Trough 06/19 data processing 37 lines shallow water + 06/20 lines
2021-06-21 DY132-EN122-pomu-shallow 06/20 data processing
2021-06-22 DY132-EN122-pomu-rockall-trough 06/21 data processed 5 lines
2021-06-22 09:11 DY132-rockall-trough 06/22 to line 23 +9999 data processing
2021-06-23 06:07 DY132-rockall-trough 06/22 from line 24 - processing
2021-06-23 11:47 DY132-rockall-trough 06/23 lines from 58-63 processing
2021-06-24 06:00 DY132-rockall-trough 06/23 lines from 64 processing
2021-06-24 15:53 DY132-rockall-trough 06/24 lines from 75 to 104 processing
2021-06-25 06:03 DY132-rockall-trough 06/25 from line 105 to end of the day
2021-06-25 06:41 DY132-rockall-trough 06/25 from line 122 to 133 processing 06:00
2021-06-25 DY132-rockall-trough 06/25 from line 135 to 171 processing
2021-06-26 05:57 DY132-rockall-trough 06/26 from line 172 to 203 processing
2021-06-26 16:50 DY132-rockall-trough 06/26 from line 204 to 219 processing
~~2021-06-26 16:50 DY132-rockall-trough 06/26 from line~~ 27 08:40
2021-06-27 DY132-rockall-trough 06/27 from line 220 to 267 processing
2021-06-28 07:10 DY132-rockall-trough 06/28 from line 268 to 311 processing weird display resolution change restarted!
2021-06-29 07:19 DY132-rockall-trough 06/29 from line 312 to 359 processing
2021-06-30 07:15 DY132-rockall-trough 06/30 from line 360 to 407 processing
2021-07-01 05:50
2021-07-02 Cleaning...
2021-07-03 Cleaning Contour 0629-0000 line 0312-318-332-346-356- all surfaces recomputed
2021-07-03 ~~1055~~ Cleaning Contour 0630-0000 line 360-365-370-392 ✓

0623-0000
0623 1152
0625 0000 0078
0625 1530 ✓
0625 0000 0130
0625 0601 0151
not in bathymetry
0627-0000 223-226-227
225
263 to delete
256
0628-0000 ✓
278 275

3. CARIS Processing Logsheet DY132 zome@noc.ac.uk

2021-07-09 15:58 DY132-EN122-pomu-rockall-trough 07/05 data cleaning started 505 surface recomputed 15:33
2021-07-09 16:56 — " — 07/05-0001 data — " — 550 recomputed 17:17 & 17:30
2021-07-09 17:57 — " — 07/05-0000 — " — 579 recomputed removed layer!
2021-07-09 18:20 — " — 07/03 data cleaning started recomputed 18:32
2021-07-10 06:37 — " — 07/03 data processing started recomputed 07:13
2021-07-10 07:29 — " — 07/02 data cleaning started 456 466 550 444 ok recomputed
2021-07-10 08:19 — " — 07/01 — " — started recomputed
2021-07-10 09:01 — " — 06/30 data cleaning started recomputed 09:08
2021-07-10 09:11 DY132-EN122-pomu-rockall-trough 06/27 data cleaning started 10:21 recomputed 10:25
2021-07-10 10:38 — " — 06/26 data cleaning started line 208-218 raw recomputed 11:26 and 11:56
2021-07-10 15:08 — " — 06/25-0601 — " — 157-171 raw recomputed 15:47
2021-07-10 15:55 — " — 06/25-0000 — " — 132 recomputed 16:00
2021-07-10 16:03 — " — 06/24-1530 — " — 105(end) recomputed 16:27
2021-07-10 16:30 — " — 06/24-0000 — " — 97 recomputed 17:15
2021-07-10 21:53 — " — 06/23-1152 — " — 69 recomputed 21:49
2021-07-10 21:52 — " — 06/23-0000 — " — 68 recomputed 22:05
2021-07-10 22:27 — " — 06/20-0910 — " — recomputed 22:31
2021-07-10 22:42 — " — 06/22-0000 — " — recomputed 23:30
2021-07-11 07:18 — " — 07/10-0000 — " — recomputed 07:36
2021-07-12 06:42 — " — 07/11-0000 processing from line 833 to 880
2021-07-12 07:00 — " — 07/11-0000 cleaning started recomputed 07:45
2021-07-12 09:18 — " — 07/12-0000 07:03 processing from line 881 to 894 recom
2021-07-12 09:55 DY132-EN122-pomu-rockall-trough 07/12-0000 cleaning started, surface recomputed at 10:09

1. CARIS Processing LogSheet DY132 Z.N.

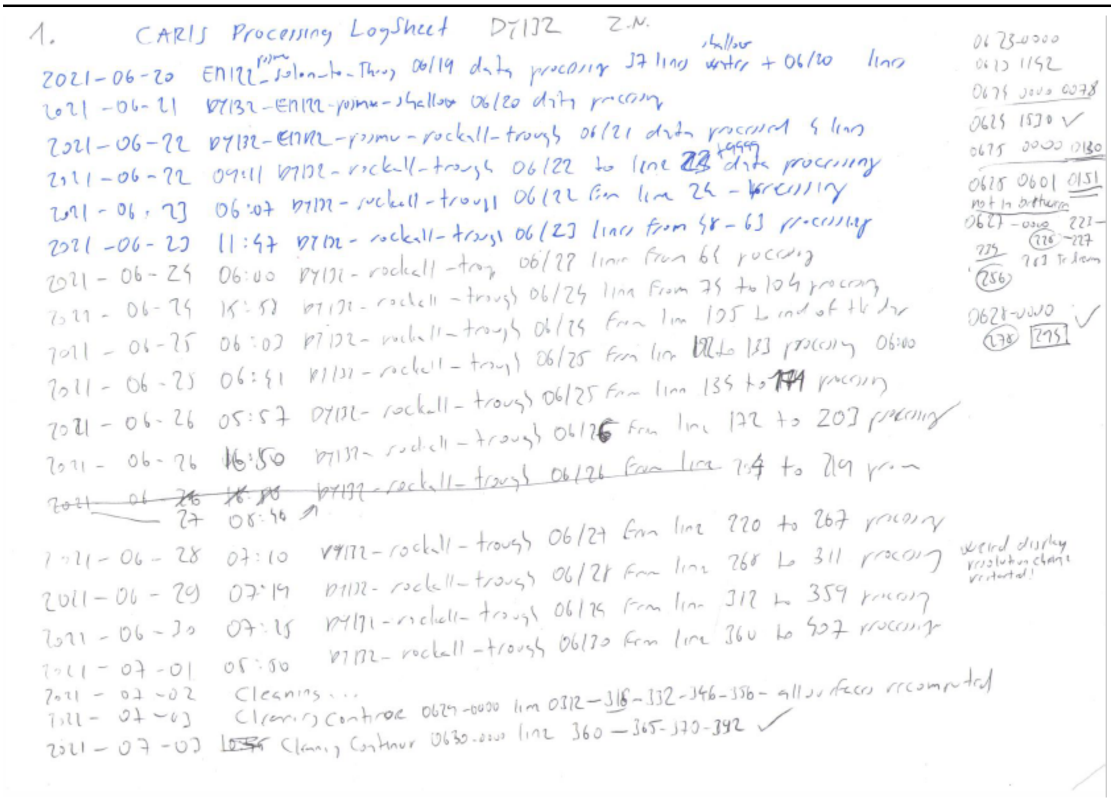
2021-06-20 EM122 pymu solent-to-Thorney 06/19 data processing 37 lines shallow water + 06/20 lines
2021-06-21 DY132-EM122-pymu-shallow 06/20 data processing
2021-06-22 DY132-EM122-pymu-rockall-trough 06/21 data processed 5 lines
2021-06-22 09:11 DY132-rockall-trough 06/22 to line 23 +9999 data processing
2021-06-23 06:07 DY132-rockall-trough 06/22 from line 24 - processing
2021-06-23 11:47 DY132-rockall-trough 06/23 lines from 58-63 processing
2021-06-24 06:00 DY132-rockall-trough 06/22 lines from 64 processing
2021-06-24 15:53 DY132-rockall-trough 06/24 lines from 75 to 104 processing
2021-06-24 06:02 DY132-rockall-trough 06/24 from line 105 to end of the day
2021-06-25 06:02 DY132-rockall-trough 06/25 from line 122 to 133 processing 06:00
2021-06-25 06:41 DY132-rockall-trough 06/25 from line 135 to 171 processing
2021-06-26 05:57 DY132-rockall-trough 06/25 from line 172 to 203 processing
2021-06-26 16:50 DY132-rockall-trough 06/26 from line 204 to 219 processing
~~2021-06-26 16:50 DY132-rockall-trough 06/26 from line~~
27 08:46
DY132-rockall-trough 06/27 from line 220 to 267 processing
2021-06-28 07:10 DY132-rockall-trough 06/27 from line 268 to 311 processing
2021-06-29 07:19 DY132-rockall-trough 06/28 from line 312 to 359 processing
2021-06-30 07:25 DY132-rockall-trough 06/30 from line 360 to 407 processing
2021-07-01 05:50
2021-07-02 Cleaning...
2021-07-03 Cleaning Contour 0629-0000 line 0312-318-332-346-356- all surfaces recomputed
2021-07-03 ~~1056~~ Cleaning Contour 0630-0000 line 360-365-370-392 ✓

0623-0000
0623 1152
0625 0000 0078
0625 1530 ✓
0625 0000 0130
0625 0601 0151
not in between
0627-0000 223-
225 226 -227
256 263 to down
0628-0000 ✓
278 275

weird display resolution change restarted!

4. CARIS Processing Logsheet DY132 zomc@noc.ac.uk

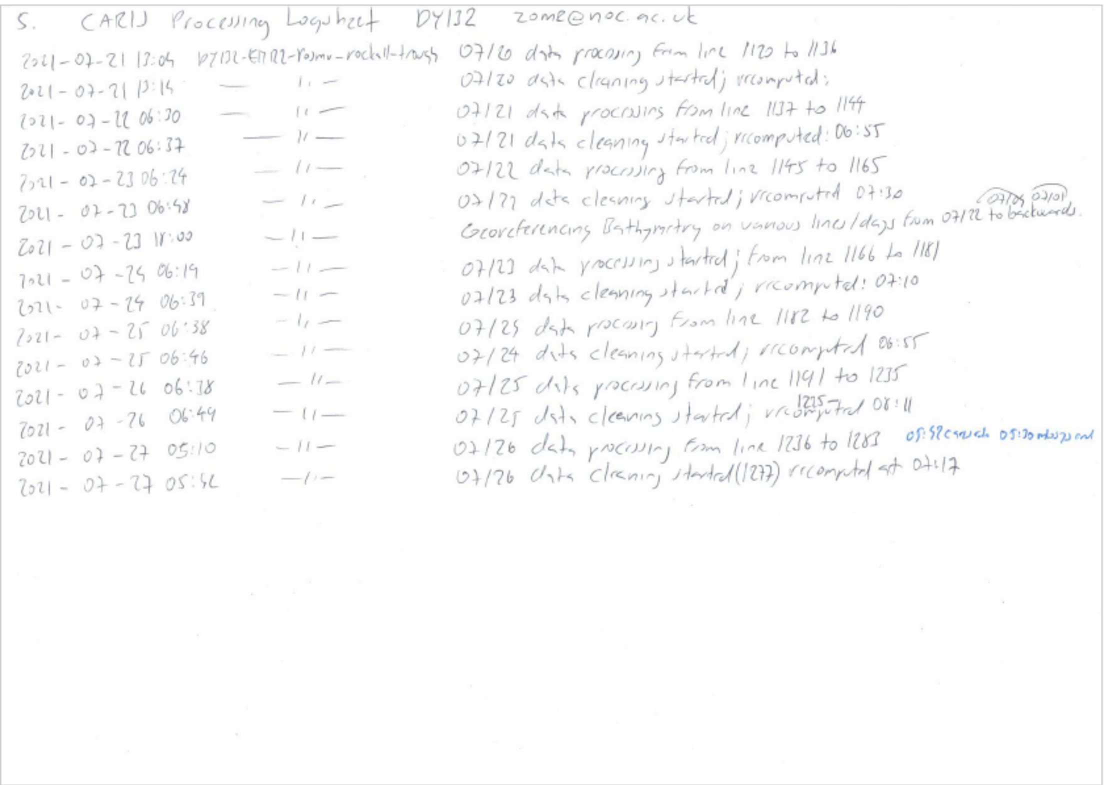
2021-07-13 06:19 DY132-EM122-pymu-rockall-trough 07/12 data processing ~~started~~ done yesterday EM122 not logging due HKR activation
2021-07-14 06:12 — " — 07/13 data processing from line 901 to 915
2021-07-15 06:30 — " — 07/13 data cleaning started recomputed 06:45
2021-07-15 06:34 — " — 07/14 data processing from line 916 to 917
2021-07-15 06:47 — " — 07/14 data cleaning started recomputed: 06:52
2021-07-15 06:52 — " — 07/15-0000 data processing from line 919 to 931 (06:??)
2021-07-15-07:02 — " — 07/15-0000 data cleaning started recomputed: 07:
2021-07-16-07:15 — " — 07/15-0644 data processing from line 932 to 966
2021-07-16 07:39 — " — 07/15-0644 data cleaning started, recomputed 08:31
2021-07-17 06:27 — " — 07/16-0000 data processing started from line 967 to 997
2021-07-17 06:58 DY132-EM122-pymu-rockall-trough 07/16-0000 cleaning started recomputed 07:15
2021-07-18 06:23 — " — 07/17-0000 data processing started
2021-07-18 07:09 — " — 07/17-0000 data cleaning started 1021 recomputed
2021-07-18 08:45 — " — 07/15-0000 edited and recomputed
2021-07-18 08:45 — " — 07/17-0000 edited and recomputed
2021-07-18 08:56 — " — 07/15-0000 layer removed!
2021-07-18 09:03 — " — 07/15-0644 ~~vessel~~ edited, recomputed
2021-07-18 09:32 — " — 07/17-0000 edited, recomputed
2021-07-19 06:21 — " — 07/18-0000 data processing line 1085 (sound error not added!)
2021-07-19 06:42 — " — 07/18-0000 data cleaning started 1055 recomputed
2021-07-19 16:17 — " — 07/19-0000 data processing from line 1085 to 1106
2021-07-20 06:16 — " — 07/19-1602 data processing from line 1107 to 1119
2021-07-20 06:29 — " — 07/19-0000 and -1602 data cleaning started both recomputed 07:10



1. CARIS Processing LogSheet DY132 Z.N.

2021-06-20 EN122-palomar-Solander-Trough 06/19 data processing 37 lines shallow water + 06/20 lines
2021-06-21 DY132-EN122-palomar-shallow 06/20 data processing
2021-06-22 DY132-EN122-palomar-rockall-trough 06/21 data processed 5 lines
2021-06-22 09:11 DY132-rockall-trough 06/22 to line 23 +9999 data processing
2021-06-23 06:07 DY132-rockall-trough 06/22 from line 24 - processing
2021-06-23 11:47 DY132-rockall-trough 06/23 lines from 58-63 processing
2021-06-24 06:00 DY132-rockall-trough 06/22 lines from 64 processing
2021-06-24 15:52 DY132-rockall-trough 06/24 lines from 75 to 104 processing
2021-06-25 06:02 DY132-rockall-trough 06/25 from line 105 to end of the day
2021-06-25 06:02 DY132-rockall-trough 06/25 from line 122 to 133 processing 06:00
2021-06-25 06:41 DY132-rockall-trough 06/25 from lines 135 to 171 processing
2021-06-26 05:57 DY132-rockall-trough 06/25 from line 172 to 203 processing
2021-06-26 16:50 DY132-rockall-trough 06/26 from line 204 to 219 processing
~~2021-06-26 16:50 DY132-rockall-trough 06/26 from line~~
27 08:40
2021-06-27 DY132-rockall-trough 06/27 from line 220 to 267 processing
2021-06-28 07:10 DY132-rockall-trough 06/27 from line 268 to 311 processing weird display resolution change restarted!
2021-06-29 07:19 DY132-rockall-trough 06/28 from line 312 to 359 processing
2021-06-30 07:25 DY132-rockall-trough 06/30 from line 360 to 407 processing
2021-07-01 05:50 DY132-rockall-trough 06/30 from line 360 to 407 processing
2021-07-02 Cleanings...
2021-07-03 Cleaning Contour 0629-0000 line 0312-316-332-346-356- all surfaces recomputed
2021-07-03 ~~1035~~ Cleaning Contour 0630-0000 line 360-365-370-392 ✓

0623-0000
0623 1152
0625 0000 0078
0625 1530 ✓
0625 0000 0130
0625 0601 0151
not in bathymetry
0627-0000 223-226-227
225 263 to from
256
0628-0000 ✓
278 275



5. CARIS Processing Logsheet DY132 zome@noc.ac.uk

2021-07-21 13:04 DY132-EN122-palomar-rockall-trough 07/16 data processing from line 1120 to 1136
2021-07-21 13:14 — 〃 — 07/20 data cleaning started; recomputed;
2021-07-22 06:30 — 〃 — 07/21 data processing from line 1137 to 1144
2021-07-22 06:37 — 〃 — 07/21 data cleaning started; recomputed: 06:55
2021-07-23 06:24 — 〃 — 07/22 data processing from line 1145 to 1165
2021-07-23 06:48 — 〃 — 07/22 data cleaning started; recomputed 07:30 07/05 07/01
2021-07-23 18:00 — 〃 — Georeferencing Bathymetry on various lines/days from 07/22 to backwards.
2021-07-24 06:19 — 〃 — 07/23 data processing started; from line 1166 to 1181
2021-07-24 06:39 — 〃 — 07/23 data cleaning started; recomputed: 07:10
2021-07-25 06:38 — 〃 — 07/25 data processing from line 1182 to 1190
2021-07-25 06:46 — 〃 — 07/24 data cleaning started; recomputed 06:55
2021-07-26 06:38 — 〃 — 07/25 data processing from line 1191 to 1235
2021-07-26 06:49 — 〃 — 07/25 data cleaning started; recomputed 08:11
2021-07-27 05:10 — 〃 — 07/26 data processing from line 1236 to 1283 05:52 crash 05:30 rebooted
2021-07-27 05:52 — 〃 — 07/26 data cleaning started (1277) recomputed at 07:17

Figure Caris Processing Logsheet

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

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

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.

Survey Site Name	*SIS Survey Name*	*Datetime Start*	*Total time of Logging*	*Vessel survey speed (kts)*	*SVP(s) Used (Filename)*	*Comments*
North Atlantic	Fastnet shallow	2021-06-20 19:18	14:51:57 (h:m:s)	0-11	default	Micro-X SVP sensor used
North Atlantic	Shallow2 test	2021-06-21 15:55	09:58:36 (h:m:s)	0-11	*ctd001*	From ctd001
North Atlantic	To_oban	2021-06-25 09:02		0-12	Various from ctd casts	Cellsize 5.09m

USBL Configuration and deployments Path of USBL calibration information on the cruise datastore:
/Ship_Systems/Data/Acoustics/USBL

Attribute	*Value*
Number of deployments	?
Datetime of last CASIUS	15 August 2019 12:41:24
Starboard Head 1DRMS	See in the included Casius report
Port Head 1DRMS	See in the included Casius report

Deployment information:

Deployment name	*Head used*	*Beacon(s) used*	*Date*	*Remarks*
Simulation	Stbd	2707	2021-06-16 08:41-08:52	
Simulation	Stbd	2613, 2704	2021-06-19 12:57 – 13:10	USBL - two new WMT 6G 2613, 2704 added to Ranger WMT 6G 3003 removed.
CTD	Stbd	2613	2021-06-20 09:25 – 10:11	CTD cast aborted
VMP	Stbd	2704	2021-06-20 10:30 – 10:52	
CTD001	Stbd	2613	2021-06-20 12:18 – 12:49	
VMP	Stbd	2613	2021-06-22 20:50 – 23:50	VMP016
VMP	Stbd	2704	2021-06-23 09:00 – 15:56	VMP107
VMP	Stbd	2613	2021-06-23 19:11 – 2021-06-24 00:37	
CTD	Stdb	2704	2021-06-28 03:00 – 15:00	CTD024
CTD	Stbd	2704	2021-06-30 10:30 – 13:29	CTD043
Tracer Sled	Stbd	2707	2021-07-11 00:01 – 20:11	towed
VMP6000	Stbd	2704	2021-07-16 04:15 – 05:57	-
VMP6000	Stbd	2704	2021-07-16 08:24 – 10:10	-
VMP6000	Stbd	2704	2021-07-16 10:15 – 14:40	-

7.1.10 Other systems

Cable Logging and Monitoring Winch activity is monitored and logged using the CLAM system.

Cable Logging and Monitoring VSAT Usage:

DATE	Total Inbound (MB)	Total Outbound (MB)	Max Inbound	Max Outbound
18-06-21	14155.44	5861.074	3.15	0.96
19-06-21	17027.379	7780.747	4	0.98
20-06-21	22663.801	8874.685	4.19	0.99
21-06-21	22480.717	8798.337	4.13	0.83
22-06-21	25488.519	9787.753	4.15	1.4
23-06-21	24531.14	11597.722	4.42	1.5
24-06-21	22658.518	10183.674	4.14	1.48
25-06-21	26704.976	11091.617	4.02	1.47
26-06-21	23517.077	11152.362	4.17	1.88
27-06-21	25384.242	10824.816	4.26	1.9
28-06-21	25299.648	9703.943	4.26	1.45
29-06-21	22663.095	10101.661	4.4	1.47
30-06-21	26245.758	10920.789	4.32	1.45
01-07-21	23316.072	10708.486	4.3	1.68
02-07-21	26791.702	11158.253	4.33	1.48
03-07-21	23075.577	9708.623	4.34	1.39
04-07-21	24572.318	10596.661	3.97	1.45
05-07-21	24701.642	10485.992	4.21	1.86
06-07-21	22620.451	9669.94	4.33	1.46
07-07-21	25197.345	9495.951	4.34	1.57
08-07-21	32438.254	9988.731	5.03	1.47
09-07-21	28291.467	10591.664	4.41	1.48
10-07-21	30805.883	10660.596	4.57	1.47
11-07-21	29178.865	9445.885	4.32	1.54
12-07-21	27268.136	11700.096	4.35	1.57
13-07-21	28287.842	11269.722	4.2	1.46
14-07-21	31243.319	11855.074	5.31	1.46
15-07-21	30749.936	12422.82	5.15	1.46
16-07-21	30721.581	12489.462	5.1	1.64
17-07-21	31992.62	12485.465	5.6	1.48
18-07-21	29188.812	12226.29	5.33	1.46
19-07-21	29887.582	11801.048	5.68	1.54
20-07-21	29588.707	11920.766	5.17	1.45
21-07-21	29168.219	11750.39	4.95	1.45
22-07-21	29964.929	11782.298	5.14	1.46
23-07-21	31716.946	12420.958	5.31	1.47

DATE	Total Inbound (MB)	Total Outbound (MB)	Max Inbound	Max Outbound
24-07-21	31282.893	11350.376	5.29	1.46
25-07-21	30351.886	11579.24	5.07	1.47
26-07-21				
27-07-21				
28-07-21				
29-07-21				
30-07-21				
SUM	1011223.294	406243.967		

8 Glider

8.1 Glider – *Stephen Woodward*

8.1.1 Vehicle & Configuration

- Seaglider SG550 (Eltanin)
- Seabird CT s/n 0345 cal date 29/07/2018
- WetLabs Ecopuck FLBBCD s/n 1340 cal date 26/08/2015
- icListen Hydrophone s/n 1722
- 24/10V Lithium primary batteries

8.1.2 Aims & Rationale

The integration of an ICListen hydrophone into this glider was funded by the EU Marine Robotics programme. BLT offered a suitable test deployment in an area of interest, with glider data to complement the objectives of BLT (although only to a maximum depth of 1000m).

8.1.3 Deployment

The glider was deployed at 06:16 UTC on 22/6/2021, at 54 12.1'N, 13W. A buoyancy test was performed first, with rigid rope securely attached to the glider lifting point (by the rudder) and the starboard pedestal crane via a 3m strop. The glider was allowed to flood and settle into a stable surface position before being recovered to deck. The glider was then deployed via a rigid rope/greasy pin release from the starboard pedestal crane, slewed out to maximise distance from the vessel. An initial calibration CTD was performed (Station 12) whilst the glider performed its first dive.

8.1.4 Mission

The initial glider mission plan was to run transects across the shelf break from SW to NE, but the glider was soon found to have a low H-moment/VCG-VCB separation, leading to twitchy flight and causing adjustments to the pitch motor settings to be very complex.

Combined with the presence of a strong eddy close to the deployment site (Fig. 38), the extended time required to successfully trim the glider's flight meant it was decided to use the eddy to loop around to the NE and approach the study area from offshore (Fig. 39). This long transit reduced the available mission time considerably.

By the time the glider was in the study area (06/07/2021), it was well trimmed and coping well with currents. It was therefore decided to run transects along the BLT study canyon, from waypoints N1 (54 30'N, 12 12'W) to S2 (53 48'N, 11 30'W), but turning around early once in shallow water if tides became problematic. In reality, this meant the glider was able to run transects from the Rockall Trough up to 350m isobath. Glider systems including altimeter performed well, NRT conductivity/temperature data are shown (Fig. **??**).

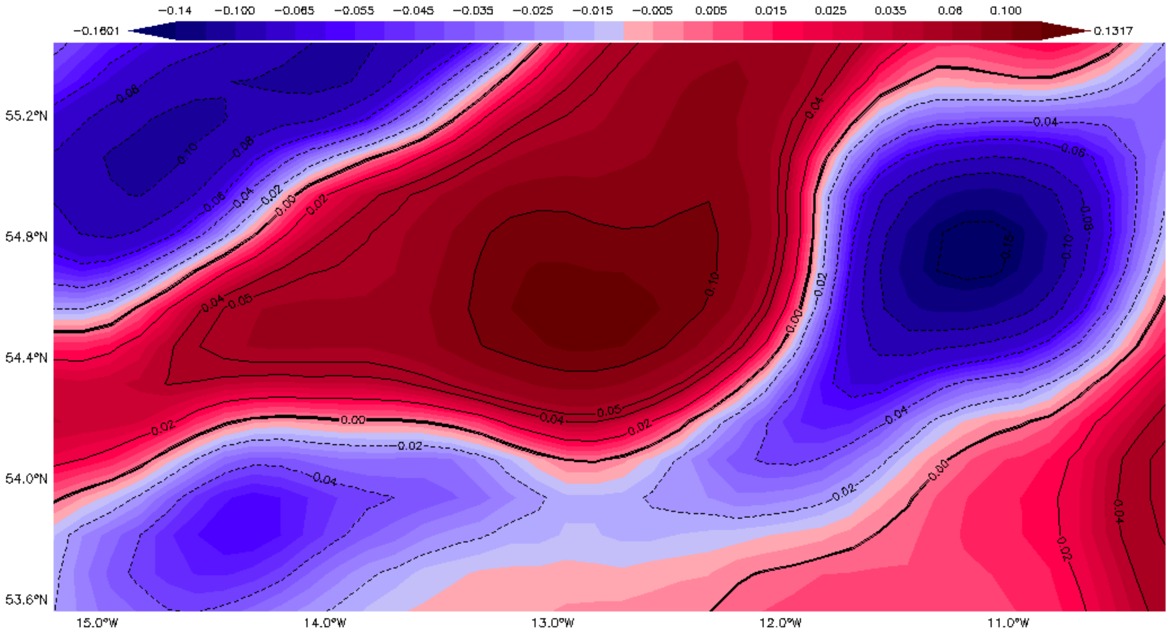


Figure 38: Absolute dynamic topography from 28th June 2021

8.1.5 Recovery

The glider was recovered at 09:59 UTC on 25/7/2021, at 54 12.5'N, 12 8.6'W, by means of a lasso hoop and telescopic pole. Once hooked in, the glider was recovered to the starboard waste using the P-frame, thereby keeping the glider well forward of the props at all times.

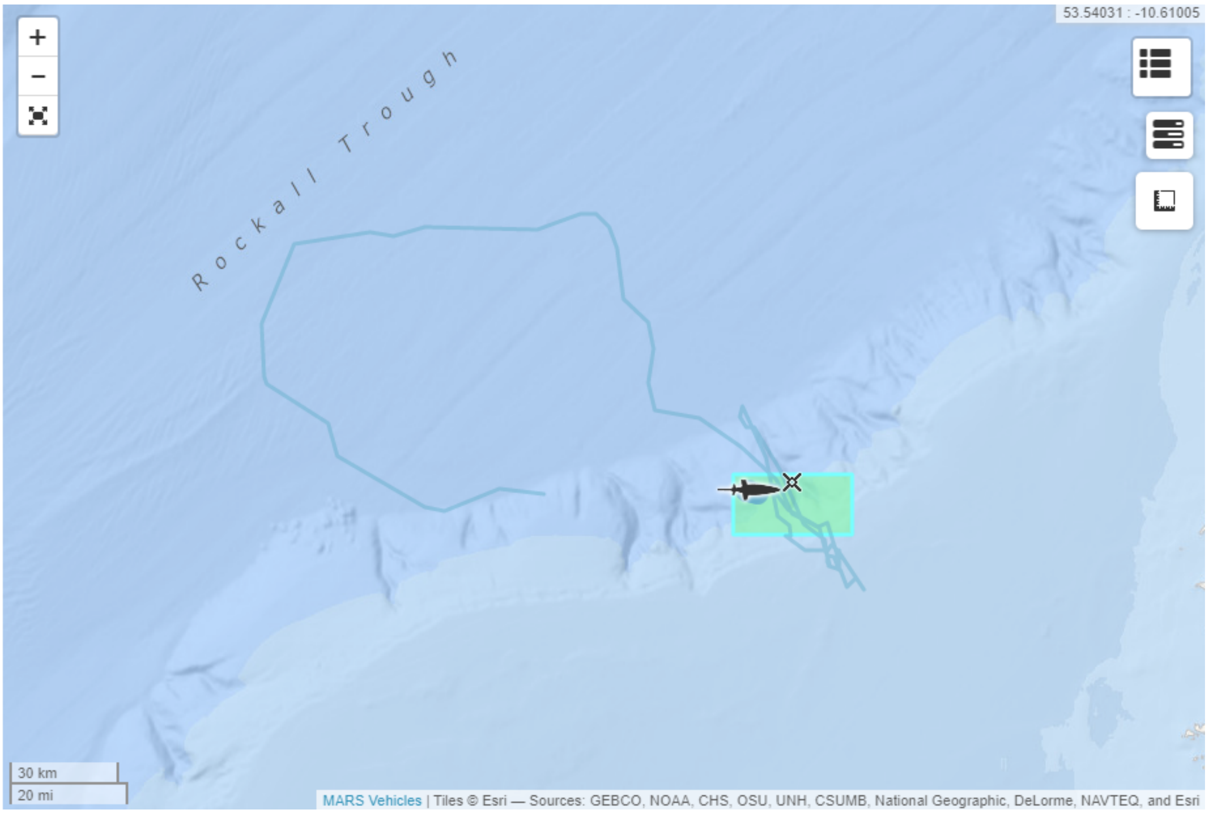


Figure 39: Glider track

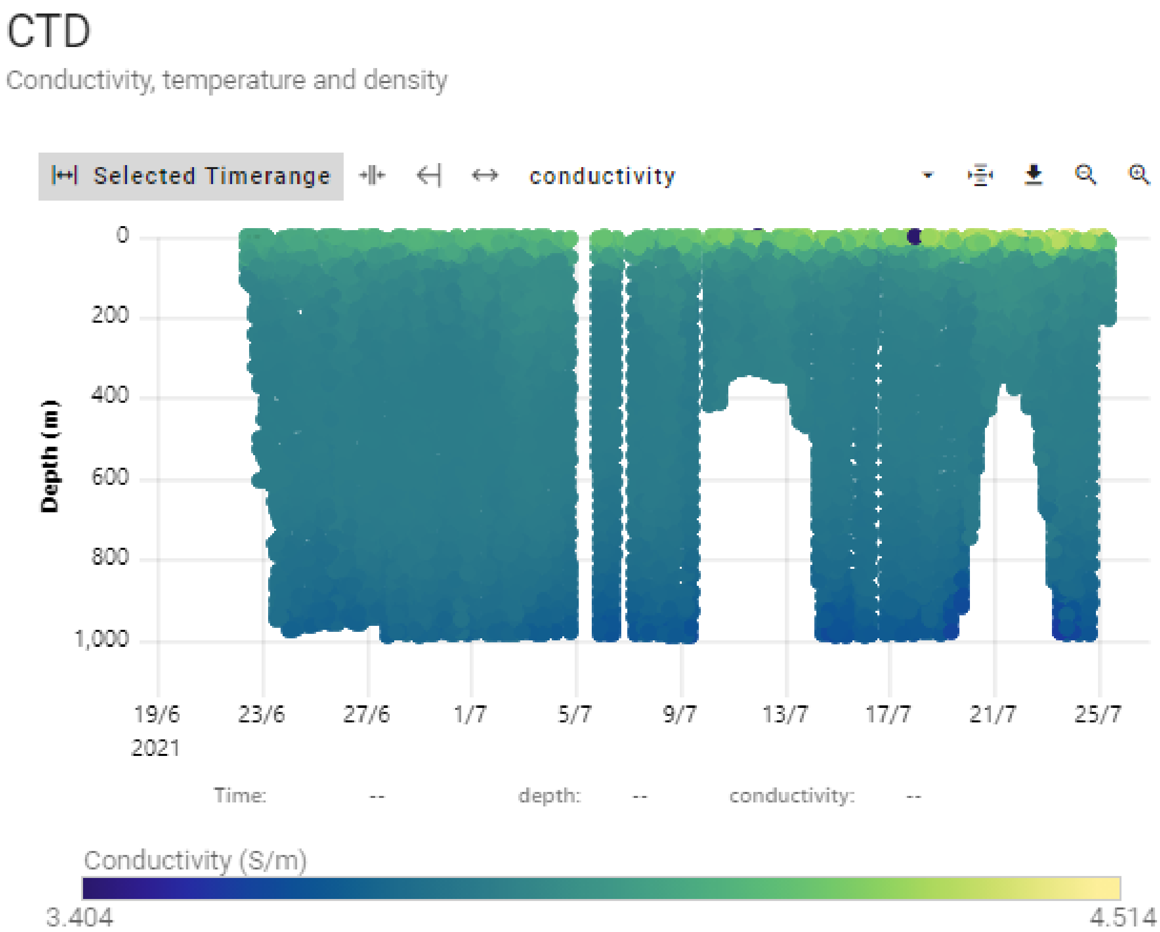


Figure 40: Conductivity, mission duration

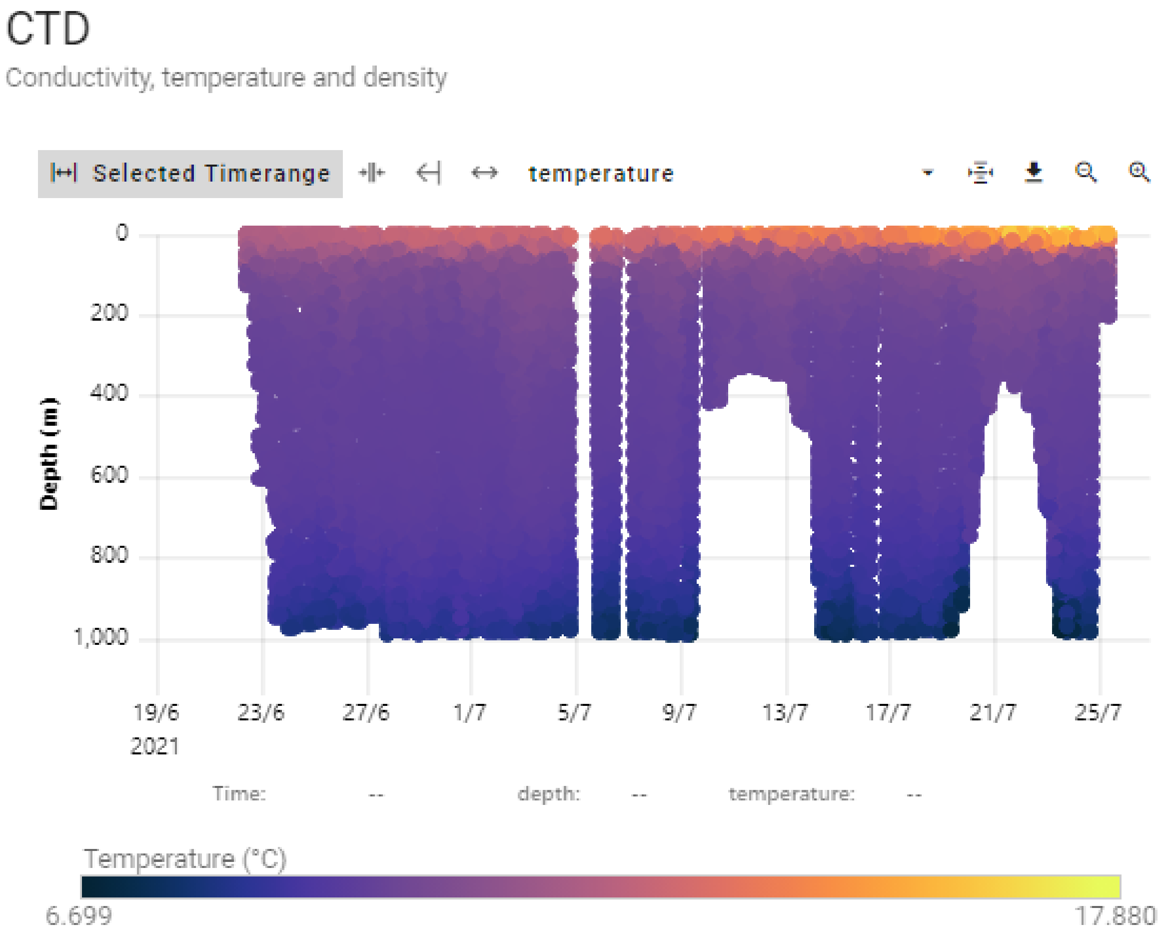


Figure 41: Temperature, mission duration

Acknowledgements

This work was supported by the U.K. Natural Environment Research Council grant ??? and NSF grant(s) ???.