University of Exeter

Cruise Report No. xx

RRS Discovery Cruise DY153

30 July 2022 – 05 September 2022

Bottom Boundary Layer Turbulence and Abyssal Recipes (BLT)

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ABSTRACT

This cruise report details the scientific programme of the third and final cruise of the BLT Recipes project, namely BLT3 and DY153 completed between 30/07/2022 – 5/09/2022. For context, the project was initiated by the research expedition DY132 (or BLT1) in June/July 2021 and followed by the second expedition DY138 (or BLT2) between 25/09/22 – 03/11/22. The BLT Recipes project addresses a long-standing problem in Physical Oceanography about the balance of the cold and dense sinking waters at high latitudes with deep-ocean upwelling across isopycnals at lower latitudes. The BLT Recipes project seeks to test an emergent new paradigm of ocean mixing, whereby deep-ocean upwelling is primarily driven by highly localised turbulence within the bottom boundary layer instead of by breaking internal waves in the ocean interior, the later having been shown as driving downwelling of abyssal waters. To enable such testing, the BLT project undertook a multiple approach including turbulence measurements using microstructure profiler deployments, turbulence-measuring instruments moored at the seafloor and tracer release experiments using the fluorescein dye and the long-lived chemical tracer SF_5CF_3 in a canyon situated on the eastern slope of the Rockall Trough. The Rockall Trough is taken as 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 (3 days)) circulation, dispersion and mixing of deep waters in and beyond the canyon. The turbulence measurements highlight the processes responsible for sustaining the circulation and mixing near and above the topographic boundary and were undertaken in two ways. First, through the deployment of three types of moorings (1 moored profiler (MP) mooring, 2 Modular Acoustic Velocity Sensor (MAVS) + 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-60000 and tethered FastCTD, EpsiFish and VMP-2000) along, across and around the rim of the canyon as well as the whole basin. The first expedition DY132 (or BLT1) undertook the mooring deployments, profilers turbulence measurements as well as the dye and tracer release experiments and their subsequent measurements in the canyons. During the second expedition DY138 (or BLT2) both MAVS moorings and the MP mooring were recovered, serviced and redeployed. Measurements of the long-lived tracer 2 months after the release in and outside the canyon were also undertaken. This cruise report is for DY153 (or BLT3) and was divided into 2 legs completed between 30/07/2022 – 05/09/2022. Leg 1-DY153

(30/07/2022 –15/08/2022) was dedicated to the microstructure measurements in the BLT canyon. Leg 2-DY153 (16/08/2022 – 5/09/2022) was dedicated to measurements of the long live tracer and measurements of turbulence at numerous sites throughout the basin. During leg1-DY153 the MAVS and MP moorings (deployed during BLT2) and TCHAIN mooring (deployed during BLT1) were successfully recovered. Two more moorings – a Sonardyne ADCP lander and G1 mooring – were deployed and recovered during the DY153 cruise. The BLT canyon was surveyed by the EpsiFish instrument, consisting of 6 timeseries lasting between 22 and 41 hours. Camera surveys and sediment cores were also conducted in the locations of the MAVS1 and MAVS2 mooring sites. During leg 2-DY153, measurements of the long-lived tracer were repeated at previous sampled stations and also undertaken throughout the wider Rockall Trough to define the vertical and horizontal tracer spread one year after the release. Alongside the tracer measurements, 22 HRP casts and 21 VMP-6000 casts were completed. Preliminary analyses of the data obtained in BLT1, BLT2 and BLT3 provides 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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UoS – University of Southampton: Hydrography, VMP, LADCP
UoE – University of Exeter: Tracer
CNRS – National Centre for Scientific Research: Tracer, Hydrography
WHOI – Woods Hole Oceanographic Institution: HRP, Moorings
SIO – Scripps Inst. of Oceanography: Fast CTD, Espifish, Moorings
NMF – National Marine Facilities: Ship instruments, CTD, LADCP
VMP, MisoCamera, Deep Core.


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ABSTRACT

This cruise report details the scientific programme of the third and final cruise of the BLT Recipes project, namely BLT3 and DY153. 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 initiated in June/July 2021 – seeks to test an emergent new paradigm of ocean mixing, whereby deep-ocean upwelling is primarily driven by highly localised turbulence within the bottom boundary layer instead of by breaking internal waves in the ocean interior, the later having been shown as driving downwelling of abyssal waters. To enable such testing, the BLT project undertook a multiple approach including turbulence measurements using microstructure profiler deployments, turbulence-measuring instruments moored at the seafloor and tracer release experiments using the fluorescein dye and the long-lived chemical tracer SF_5CF_3 in a canyon situated on the eastern slope of the Rockall Trough. The Rockall Trough is taken as 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 (3 days)) circulation, dispersion and mixing of deep waters in and beyond the canyon. The turbulence measurements highlight the processes responsible for sustaining the circulation and mixing near and above the topographic boundary and were undertaken in two ways. First, through the deployment of three types of moorings (1 moored profiler (MP) mooring, 2 Modular Acoustic Velocity Sensor (MAVS) + 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-60000 and tethered FastCTD, EpsiFish and VMP-2000) along, across and around the rim of the canyon as well as the whole basin. DY132 (or BLT1) undertook the mooring deployments, profilers turbulence measurements as well as the dye and tracer release experiments and their subsequent measurements in the canyons. DY138 (or BLT2) was completed between 25/09/22 – 03/11/22 during which time subsequent measurements of the long-lived tracer were repeated 2 months after the release in and outside the canyon. Both MAVS moorings and the MP mooring were recovered, serviced and redeployed. This cruise report is for DY153 (or BLT3) and was divided into 2 legs completed between 30/07/2022 – 05/09/2022. Leg 1-DY153 (30/07/2022 –15/08/2022) was dedicated to the microstructure

measurements in the BLT canyon. Leg 2-DY153 (16/08/2022 – 5/09/2022) was dedicated to measurements of the long live tracer and measurements of turbulence at numerous sites throughout the basin. During leg1-DY153 the MAVS and MP moorings (deployed BLT2) and TCHAIN mooring (deployed BLT1) were successfully recovered. Two more moorings – a Sonardyne ADCP lander and G1 mooring – were deployed and recovered during the cruise. The BLT canyon was surveyed by the EpsiFish instrument, consisting of 6 timeseries lasting between 22 and 41 hours, plus 1 fastCTD. Camera surveys and sediment cores were also conducted in the locations of the MAVS1 and MAVS2 mooring sites. During leg 2-DY153, measurements of the long-lived tracer were repeated and extended throughout the wider Rockall Trough to define how the tracer had spread 1 year after the release. Alongside the tracer measurements, 22 HRP casts and 21 VMP-6000 casts were completed. Preliminary analyses of the data obtained in BLT1, BLT2 and BLT3 provides evidence of strong diapycnal upwelling and mixing within the canyon, suggesting broad support for the project's overarching hypothesis.

1 INTRODUCTION

1.1 MAPS

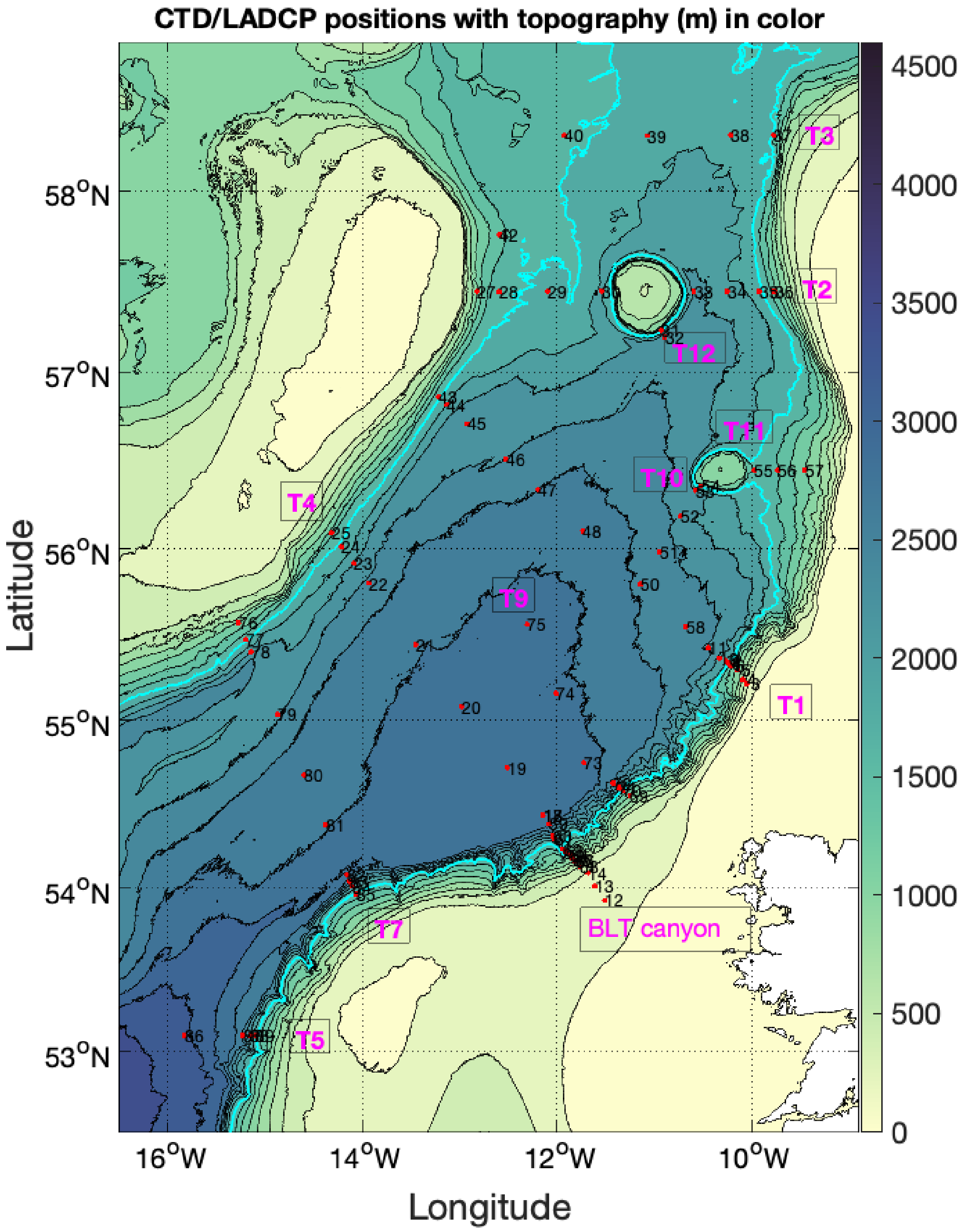


FIGURE 1: CTD/LADCP STATIONS WITH TRANSECT LABELS

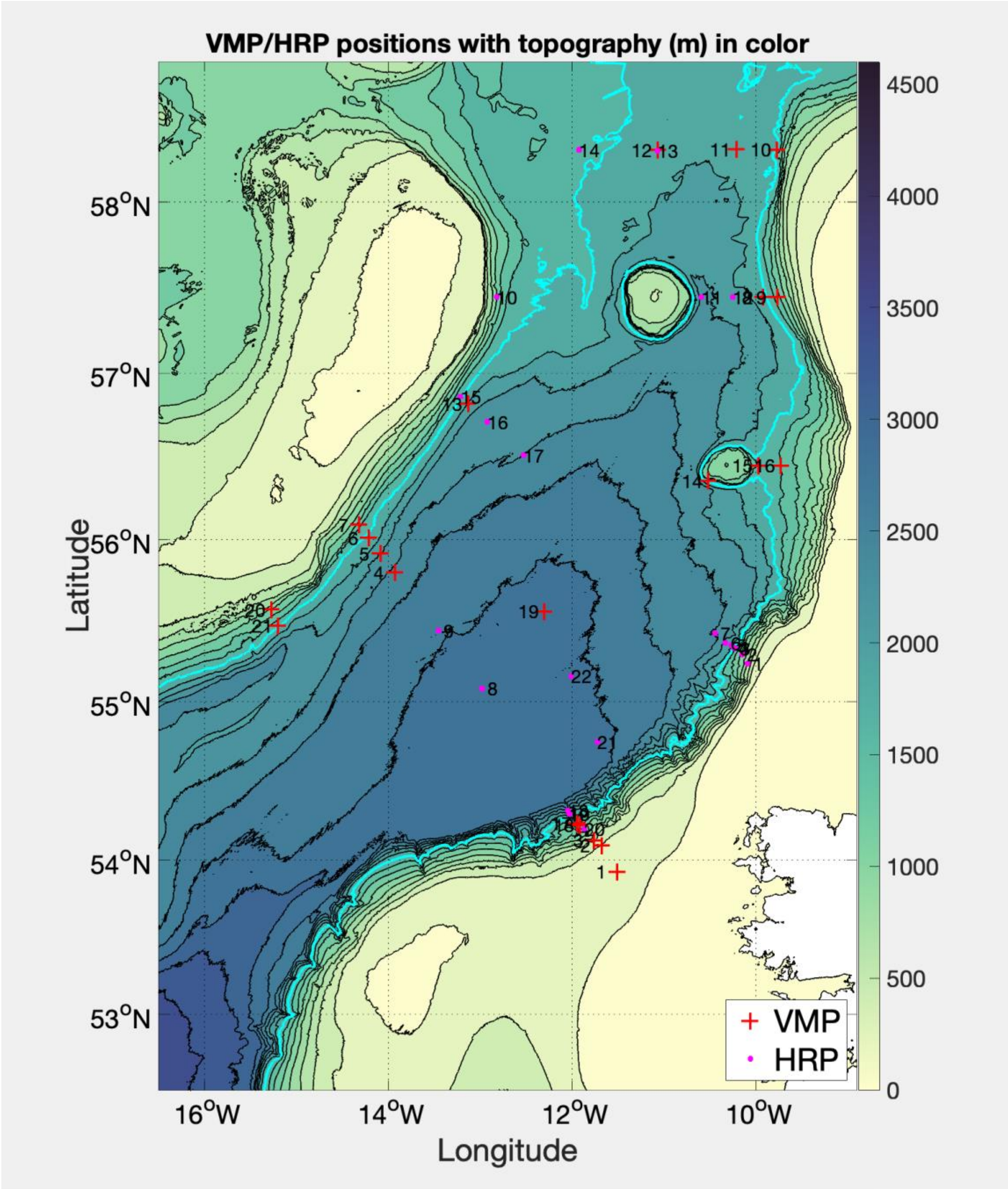


FIGURE 2: VMP/HRP STATIONS

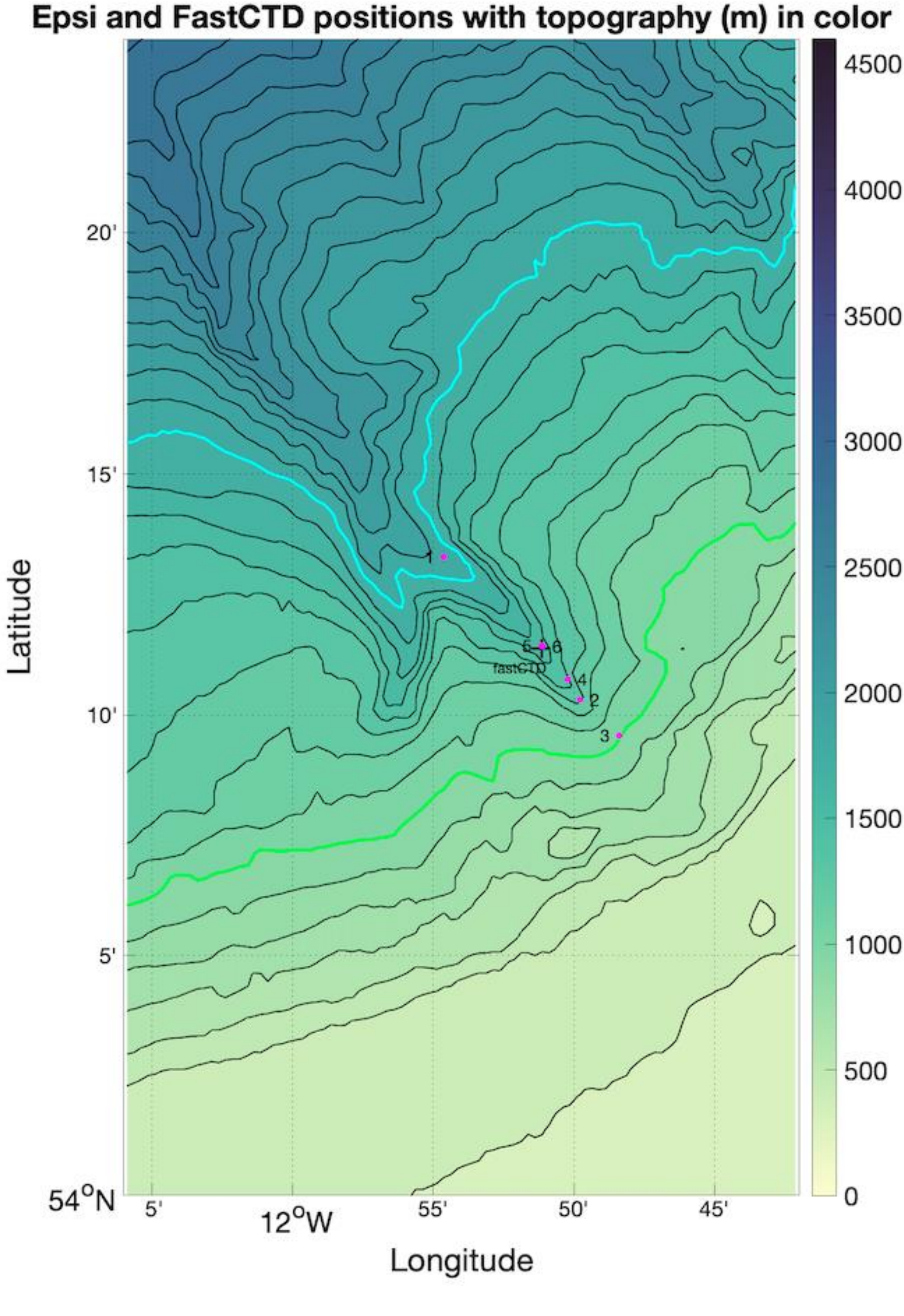


FIGURE 3: EPSIFISH AND FASTCTD STATIONS

In figure 3, the bathymetry contours are at 100 m interval with the cyan contour indicating 1800m and the green contour indicating 1000m. The Epsi cast positions are indicated by dots and numbers, the fast CTD position is indicated by a cross.

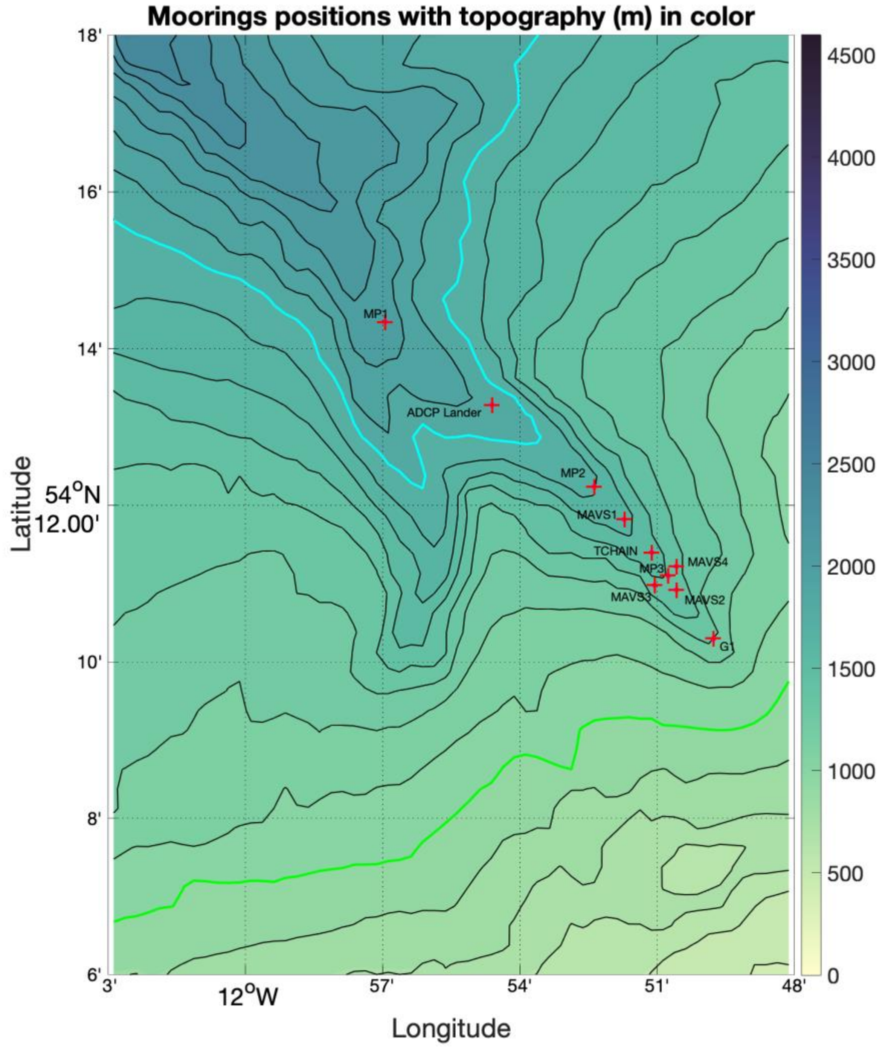


FIGURE 4: MOORING POSITIONS

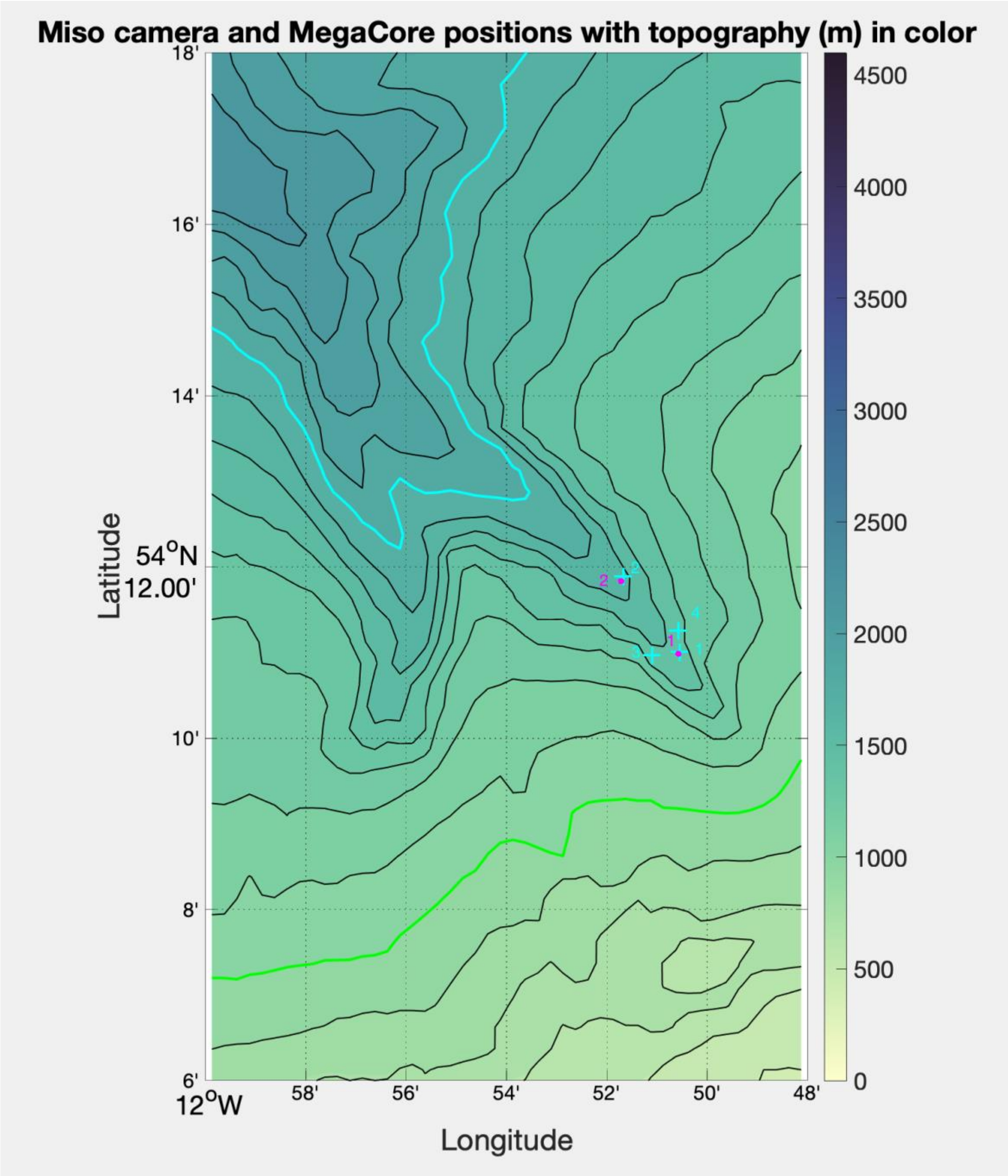


FIGURE 5: MISOCAM AND MEGACORE STATIONS

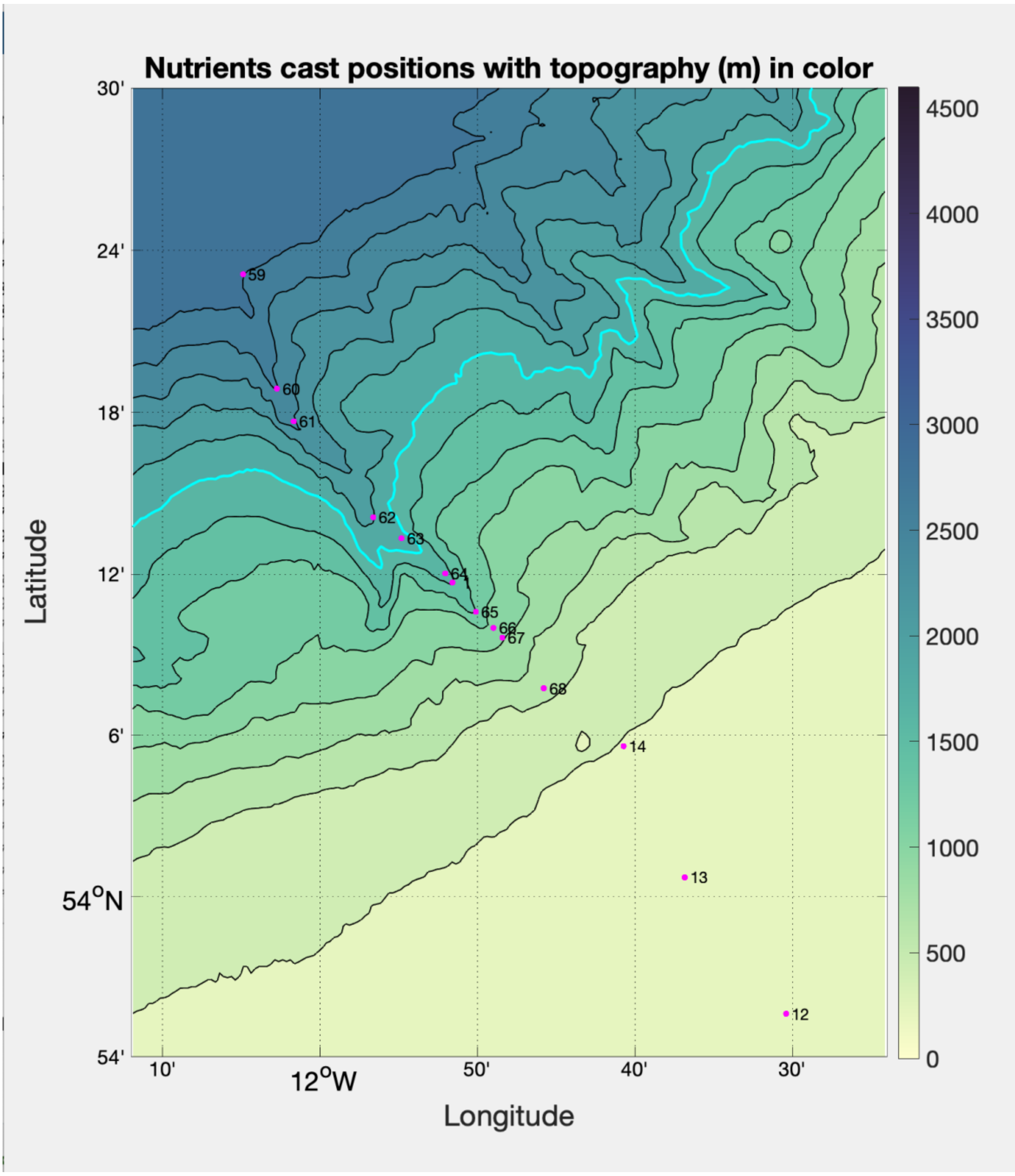


FIGURE 6: NUTRIENT SAMPLING LOCATIONS

In figure 6 the station numbers relate to the CTD cast the samples were taken on.

1.2 EVENT LOGS

TABLE 1: FULL CRUISE EVENT LOG

Bridge event	Date & Time	Latitude	Longitude	Instrument	Dive	CTD/LADCP cast	Multibeam Depth (m)	Description	Comments
10	02/08/2022 07:10	54.171987	-11.858952	MP3 mooring				MP3 recovery	
11	02/08/2022 08:43	54.221379	-11.910193	ADCP Lander				ADCP Lander deployment	
13	02/08/2022 10:29	54.221359	-11.91046	EpsiFish	1				22-hour timeseries
17	03/08/2022 09:45	54.225476	-11.906186	USBL	1			ADCP triangulation	Recovered 10:21
23	04/08/2022 17:29	54.196351	-11.915914	MAVS3 mooring				MAVS3 recovery	
26	04/08/2022 18:25	54.171595	-11.829514	G1 mooring				G1 deployment	
30	04/08/2022 21:06	54.171969	-11.829686	EpsiFish	2				35-hour timeseries

32	06/08/2022 09:34	54.183546	-11.842412	MisoCam	1			MAVS2 camera survey	Recovered 14:19
36	06/08/2022 14:56	54.183145	-11.84289	Mega Core	1			MAVS2 site core	Recovered 16:28
40	06/08/2022 17:10	54.19726	-11.861919	Mega Core	2			MAVS1 site core	Recovered 18:44
44	06/08/2022 19:14	54.198219	-11.861321	MisoCam	2			MAVS1 camera survey	Recovered 00:12 7th
48	07/08/2022 01:20	54.159504	-11.806601	EpsiFish	3				31-hour timeseries
71	08/08/2022 14:28	54.17084	-11.884147	MAVS4 mooring				MAVS4 recovery	
72	08/08/2022 15:19	54.19483	-11.859873	CTD/LADCP	1	CTD001	1560.73	AX2 in water	
75	08/08/2022 18:16	54.1943	-11.860022	CTD	2	CTD002	1532.86	AX2 in water	
78	08/08/2022	54.179084	-11.83695	EpsiFish	4				33-hour timeseries

	20:45								
90	10/08/2022 09:01	54.172874	-11.827435	G1 mooring				G1 recovery	
96	10/08/2022 12:21	54.217008	-11.914139	ADCP Lander				ADCP Lander recovery	
99	10/08/2022 14:31	54.181831	-11.860735	TCHAIN mooring				TCHAIN recovery	
100	10/08/2022 17:12	54.190706	-11.852469	EpsiFish	5				28-hour timeseries
113	12/08/2022 08:21	54.189665	-11.852725	FastCTD	1				Recovered 10:32
117	12/08/2022 11:54	54.182785	-11.851647	MisoCam	3			MAVS3 camera survey	Recovered 16:42
121	12/08/2022 17:18	54.190494	-11.85189	EpsiFish	6				41-hour timeseries
127	14/08/2022 11:32	54.187656	-11843038	MisoCam	4			MAVS4 camera survey	Recovered 17:04

132	16/08/2022 05:09	55.217337	-10.050787	CTD	3	CTD003	490.95	T1-1 in water	
137	16/08/2022 07:23	55.238394	-10.090269	CTD	4	CTD004	785.44	T1-2 in water	
140	16/08/2022 09:21	55.238379	-10.090269	HRP	1		785		Recovered 09:54
144	16/08/2022 10:57	55.295282	-10.149091	CTD	5	CTD005	1115.69	T1-3 in water	
146	16/08/2022 12:33	55.295297	-10.1491	HRP	2		1115		Recovered 13:07
150	16/08/2022 14:23	55.319443	-10.205786	CTD	6	CTD006	1396.78	T1-4 in water	
154	16/08/2022 17:53	55.331811	-10.227513	CTD	7	CTD007	1616.80	T1-5 in water	
156	16/08/2022 19:03	55.3318	-10.227503	HRP	3		1616		Recovered 20:06
160	16/08/2022 21:48	55.33827	-10.243394	CTD	8	CTD008	1778.48	T1-6 in water	

162	16/08/2022 22:52	55.338266	-10.243403	HRP	4		1778		Recovered 00:26 17th
168	17/08/2022 00:58	55.351292	-10.267297	CTD	9	CTD009	1982.62	T1-7 in water	
170	17/08/2022 02:24	55.351285	-10.26732	HRP	5		1982		Recovered 03:59
176	17/08/2022 04:38	55.366279	-10.331112	CTD	10	CTD010	2189.88	T1-8 in water	
178	17/08/2022 05:55	55.366266	-10.331112	HRP	6		2189		Recovered 07:48
183	17/08/2022 08:57	55.425726	-10.443369	CTD	11	CTD011	2382.85	T1-9 in water	
185	17/08/2022 09:53	55.425731	-10.443366	HRP	7		2382		Recovered 12:09
191	18/08/2022 00:00	53.926826	-11.506611	CTD	12	CTD012	293.98	T4-22 in water	
194	18/08/2022 01:23	53.926844	-11.506604	VMP	1		299.0		Recovered 01:41

200	18/08/2022 02:47	54.011756	-11.614042	CTD	13	CTD013	333.88	T4-21 in water	
204	18/08/2022 04:42	54.093303	-11.678756	CTD	14	CTD014	376.40	T4-20 in water	
207	18/08/2022 05:57	54.093294	-11.678763	VMP	2		383		Recovered 06:20
211	18/08/2022 07:21	54.126912	-11.760784	CTD	15	CTD015	666.94	T4-19 in water (aborted)	Comms lost
214	18/08/2022 08:25	54.126931	-11.760774	VMP	3		673		Recovered 09:06
219	18/08/2022 10:37	54.127528	-11.760549	CTD	16	CTD016	679.75	T4-19 in water (aborted)	Comms lost
235	19/08/2022 19:12	54.436205	-12.144476	CTD	17	CTD017	2944.10	T4-08 in water	
238	19/08/2022 23:19	54.436267	-12.144498	CTD	18	CTD018	2943.88	T4-08 in water	
242	20/08/2022	54.721017	-12.513302	CTD	19	CTD019	2886.47	T4-07 in water	

	05:47								
247	20/08/2022 13:15	55.081694	-12.980538	CTD	20	CTD020	2888.79	T4-06 in water	
249	20/08/2022 14:26	55.083003	-12.979207	HRP	8		2888		Recovered 17:13
254	20/08/2022 21:36	55.441929	-13.451535	CTD	21	CTD021	2771.54	T4-05 in water	
255	20/08/2022 21:51	55.441865	-13451865	HRP	9		2771		Recovered 01:07 21st
261	21/08/2022 05:11	55.800937	-13.930507	CTD	22	CTD022	2431.67	T4-04 in water	
262	21/08/2022 05:09	55.800936	-13.930505	VMP	4		2439		Recovered 08:02
268	21/08/2022 09:22	55.915411	-14.083777	CTD	23	CTD023	2196.11	T4-03 in water	
269	21/08/2022 09:46	55.915323	-14.083736	VMP	5		2201		Recovered 12:07

276	21/08/2022 13:20	56.010734	-14.21028	CTD	24	CTD024	1847.96	T4-02 in water	
278	21/08/2022 14:12	56.010722	-14.210288	VMP	6		1853		Recovered 16:00
282	21/08/2022 17:03	56.091274	-14.316111	CTD	25	CTD025	1506.92	T4-01 in water	
283	21/08/2022 17:34	56.091274	-14.316125	VMP	7		1515		Recovered 19:25
288	22/08/2022 05:44	57.448775	-12.819007	CTD	26	CTD026	1192.30	T2-01 in water (aborted)	
291	22/08/2022 07:51	57.448735	-12.819102	CTD	27	CTD027	1197.08	T2-01 in water	
293	22/08/2022 08:42	57.448737	-12.8191	HRP	10		1197		Recovered 09:59
298	22/08/2022 11:09	57.445372	-12.594731	CTD	28	CTD028	1737.44	T2-02 in water	

302	22/08/2022 15:22	57.448434	-12.094676	CTD	29	CTDO29	1838.85	T2-03 in water	
306	22/08/2022 19:34	57.450041	-11.538962	CTD	30	CTD030	2015.35	T2-04 in water	
310	23/08/2022 01:16	57.23512	-10.92593	CTD	31	CTD031	1789.25	T12-4 in water	
315	23/08/2022 04:15	57.194779	-10.892989	CTD	32	CTD032	2314.76	T12-3 in water	
322	23/08/2022 08:56	57.447343	-10.594576	CTD	33	CTD033	2221.01	T2-05 in water	
324	23/08/2022 09:54	57.447347	-10.59456	HRP	11		2221		Recovered 11:55
329	23/08/2022 13:20	57.447852	-10.251371	CTD	34	CTD034	2086.94	T2-06 in water	
330	23/08/2022 13:58	57.44788	-10.251386	HRP	12		2086		Recovered 14:34
335	23/08/2022 16:55	57.448532	-9.921024	CTD	35	CTD035	1846.75	T2-07 in water	

336	23/08/2022 17:23	57.448536	-9.921031	VMP	8		1855		Recovered 19:16
340	23/08/2022 20:14	57.448536	-9.765561	CTD	36	CTD036	1496.36	T2-08 in water	
341	23/08/2022 20:46	57.448997	-9765392	VMP	9		1504		Recovered 22:06
348	24/08/2022 03:54	58.300752	-9.772435	CTD	37	CTD037	1842.38	T3-04 in water	
349	24/08/2022 03:52	58.30075	-9.77244	VMP	10		1849		Recovered 06:26
355	24/08/2022 08:25	58.302465	-10.213032	CTD	38	CTD038	1903.55	T3-03 in water	
356	24/08/2022 09:07	58.302467	-10.213009	VMP	11		1908		Recovered 11:10
362	24/08/2022 15:06	58.298761	-11.06816	CTD	39	CTD039	1897.42	T3-02 in water	
364	24/08/2022 15:49	58.298763	-11.068169	VMP	12		1903		Recovered 17:28

367	24/08/2022 17:37	58.294179	-11.071177	HRP	13		1903		Recovered 18:20
369	24/08/2022 21:58	58.299589	-11.923694	CTD	40	CTD040	1723.89	T3-01 in water	
370	24/08/2022 22:05	59.299588	-11.293711	HRP	14		1723		Recovered 23:38
376	25/08/2022 03:33	58.001526	-12.226226	CTD	41	CTD041	1686.85	T3-06 in water (aborted)	
378	25/08/2022 08:17	57.761385	-12.588671	CTD	42	CTD042	1535.32	T3-07 in water	
383	25/08/2022 16:20	56.860143	-13.214619	CTD	43	CTD043	1750.60	T1-16 in water	
384	25/08/2022 16:24	56.860145	-13.214614	HRP	15		1750		Recovered 17:57
388	25/08/2022 18:42	56.818839	-13.133203	CTD	44	CTD044	2005.95	T1-15 in water	
389	25/08/2022	56.818845	-13.133219	VMP	13		2001		Recovered 20:41

	18:52								
394	25/08/2022 22:04	56.709819	-12.921619	CTD	45	CTD045	2307.83	T1-14 in water	
395	25/08/2022 22:10	56.709819	-12.921611	HRP	16		2307		Recovered 04:25 26th
401	26/08/2022 02:12	56.510027	-12.526759	CTD	46	CTD046	2394.68	S1-11 in water	
402	26/08/2022 02:27	56.510032	-12.526778	HRP	17		2394		Recovered 17:17 (stuck in seabed)
415	26/08/2022 19:06	56.335505	-12.191166	CTD	47	CTD047	2596.55	T1-13 in water	
418	26/08/2022 23:27	56.100539	-11.733419	CTD	48	CTD048	2695.16	T1-12 in water	
421	27/08/2022 04:31	55.79365	-11.143263	CTD	49	CTD049	2553.44	T1-11 in water (aborted)	
424	27/08/2022 05:46	55.793645	-11.143104	CTD	50	CTD050	2553.30	T1-11 in water	

428	27/08/2022 09:11	55.979994	-10.948449	CTD	51	CTD051	2470.33	T10-1 in water	
432	27/08/2022 12:41	56.184767	-10.73455	CTD	52	CTD052	2333.37	T10-2 in water	
435	27/08/2022 15:38	56.332524	-10.5782	CTD	53	CTD053	2183.04	T10-3 in water	
439	27/08/2022 18:18	56.356892	-10.520914	CTD	54	CTD054	1771.10	T10-4 in water	
440	27/08/2022 18:29	56.356898	-10.520915	VMP	14		1778		Recovered 20:01
445	27/08/2022 22:28	56.447826	-9.97314	CTD	55	CTD055	1716.48	T11-2 in water	
446	27/08/2022 22:45	56.447822	-9.973121	VMP	15		1722		Recovered 00:13 28th
453	28/08/2022 01:21	56.447955	-9.731159	CTD	56	CTD056	1586.04	T11-3 in water	
454	28/08/2022 01:43	56.447948	-9.731161	VMP	16		1590		Recovered 03:30

460	28/08/2022 04:47	56.447783	-9.456538	CTD	57	CTD057	1220.46	T11-4 in water	
465	28/08/2022 13:36	55.548064	-10.675978	CTD	58	CTD058	2490.98	T1-10 in water	
469	29/08/2022 00:16	54.385378	-12.081423	CTD	59	CTD059	2776.53	T4-09 in water	
473	29/08/2022 02:46	54.314804	-12.045655	CTD	60	CTD060	2571.75	T4-10 in water	
474	29/08/2022 03:16	54.314813	-12.045654	HRP	18		2571		Recovered 05:36
480	29/08/2022 06:09	54.294596	-12.027878	CTD	61	CTD061	2410.87	T4-11 in water	
481	29/08/2022 06:30	54.294576	-12.027882	HRP	19		2410		Recovered 09:01
487	29/08/2022 09:51	54.254414	-11.969127	CTD	62	CTD062	2111.48	T4-12 in water	
488	29/08/2022 10:07	54.235224	-11.9437	VMP	17		1997		Recovered 11:49

495	29/08/2022 12:20	54.222257	-11.913834	CTD	63	CTD063	1855.50	T4-13 in water	
496	29/08/2022 12:40	54.222261	-11.91382	VMP	18		1861		Recovered 14:22
501	29/08/2022 14:50	54.200474	-11.867445	CTD	64	CTD064	1617.94	T4-14 in water	
502	29/08/2022 15:00	54.200478	-11.867444	HRP	20		1617		Recovered 16:23
508	29/08/2022 16:56	54.176721	-11.834996	CTD	65	CTD065	1397.83	T4-15 in water	
512	29/08/2022 18:47	54.166717	-11.816529	CTD	66	CTD066	1097.20	T4-17 in water	
516	29/08/2022 20:41	54.160686	-11.807013	CTD	67	CTD067	986.51	T4-18 in water	
520	29/08/2022 22:37	54.129306	-11.763265	CTD	68	CTD068	702.44	T4-19 in water	
524	30/08/2022 03:11	54.556147	-11.249799	CTD	69	CTD069	1172.87	T9-07 in water	

528	30/08/2022 05:08	54.586507	-11.32095	CTD	70	CTD070	1729.21	T9-06 in water	
532	30/08/2022 07:18	54.603449	-11.365467	CTD	71	CTD071	2174.41	T9-05 in water	
536	30/08/2022 09:42	54.628275	-11.424947	CTD	72	CTD072	2511.18	T9-04 in water	
539	30/08/2022 12:58	54.749955	-11.720936	CTD	73	CTD073	2830.73	T9-03 in water	
541	30/08/2022 13:08	54.750012	-11721866	HRP	21		2830		Recovered 15:34
547	30/08/2022 18:43	55.159907	-12.00951	HRP	22		2826		Recovered 21:13
548	30/08/2022 18:50	55.159917	-12.009513	CTD	74	CTD074	2826.97	T9-02 in water	
553	31/08/2022 00:51	55.561699	-12.303111	VMP	19		2867		Recovered 03:17 (surfaced early)

554	31/08/2022 00:58	55.561708	-12.303102	CTD	75	CTD075	2860.93	T9-01 in water	
560	31/08/2022 14:27	55.571912	-15.274049	CTD	76	CTD076	1200.32	T7-11 in water	
561	31/08/2022 14:45	55.571911	-15.274051	VMP	20		1208		Recovered 15:49
567	31/08/2022 16:50	55.472749	-15.198558	CTD	77	CTD077	1751.79	T7-10 in water	
568	31/08/2022 17:07	55.472412	-15.198151	VMP	21		1760		Recovered 18:42
573	31/08/2022 19:33	55.401259	-15.143562	CTD	78	CTD078	2195.20	T7-09 in water	
577	31/08/2022 23:44	55.034851	-14.866575	CTD	79	CTD079	2371.55	T7-08 in water	
581	01/09/2022 04:03	54.677851	-14.59785	CTD	80	CTD080	2734.30	T7-07 in water	
585	01/09/2022 08:09	54.379862	-14.377105	CTD	81	CTD081	2736.43	T7-06 in water	

589	01/09/2022 12:43	54.079157	-14.152627	CTD	82	CTD082	2980.18	T7-05 in water	
593	01/09/2022 15:28	54.041628	-14.128546	CTD	83	CTD083	2570.08	T7-04 in water	
597	01/09/2022 17:59	54.010086	-14.101126	CTD	84	CTD084	2173.67	T7-03 in water	
601	01/09/2022 20:12	53.963235	-14.065295	CTD	85	CTD085	1736.02	T7-02 in water	
605	02/09/2022 06:23	53.099877	-15.829259	CTD	86	CTD086	3214.22	T5-01 in water	
609	02/09/2022 11:09	53.102764	-15.230073	CTD	87	CTD087	2581.17	T5-02 in water	
613	02/09/2022 13:29	53.100179	-15.147494	CTD	88	CTD088	2169.72	T5-03 in water	
617	02/09/2022 15:27	53.100145	-15.093193	CTD	89	CTD089	1834.08	T5-04 in water	

2 NARRATIVE

The DY153 cruise had two legs. Leg1 sailed from Southampton on the 30th of July 2023 and ended in Killybegs on the 15th of August 2023. Leg1 was dedicated to the moorings and the microstructure investigations of the BLT canyon. Leg2 sailed from Killybegs on the 15th of August and returned to Southampton on the 5th of September 2023. Leg2 was dedicated to microstructure and tracer was surveyed over the large scale of the full Rockall Trough.

2.1 PSO DIARY – LEG 1 (30TH JULY TO 15TH AUGUST) – ALBERTO NAVEIRA GARABATO

Saturday 30th July 2022 (Julian Day 211) We sailed from Southampton at around 7:30 am in a warm sunny morning. After performing a short safety drill in the Solent, we proceeded to steam along the English Channel. In the evening, we conducted a test of the two EpsiFish systems, and continued toward the Rockall Trough.

Sunday 31st July 2022 (Julian Day 212) Our transit toward the Trough continued in moderate seas, with the sole interruption of a further EpsiFish profiler test.

Monday 1st August 2022 (Julian Day 213) We continued steaming toward the region of the BLT canyon. In the morning, we finally received the diplomatic clearance to work in Irish waters, which we had nervously been awaiting since before leaving Southampton. Another EpsiFish profiler test was conducted in the afternoon, to address issues remaining with one of the systems.

Tuesday 2nd August 2022 (Julian Day 214) We arrived at the MP3 mooring site around 6:00 am, and proceeded to successfully recover the mooring. After a short transit to the location of the BLT1 dye injection, we deployed the Sonardyne ADCP mooring there. We then commenced a 2-day EpsiFish time series at the same location, but worsening conditions and strong surface currents meant that this had to be aborted shortly after starting. Upon consultation with the captain and ship personnel, we re-started the EpsiFish time series, which proceeded into the evening. The EpsiFish was then recovered to replace some probes. With roughening seas and intensifying winds, there were doubts as to whether the station could be continued. Ultimately, the time series was resumed before midnight.

Wednesday 3rd August 2022 (Julian Day 215) We continued the EpsiFish station through the night and the following day, with seas dying down from about 3 am.

Thursday 4th August 2022 (Julian Day 216) We continued the EpsiFish station until around 1 pm, and proceeded to triangulate and recover the MAVS3 mooring. After deploying and triangulating the new short-term ADCP mooring (G1), we commenced another EpsiFish time series near the steepest point in the slope at the head of the canyon.

Friday 5th August 2022 (Julian Day 217) We continued the EpsiFish station through the night and the following day, in calm seas.

Saturday 6th August 2022 (Julian Day 218) The EpsiFish station was concluded around 10 am, and was followed by the successful deployment of a sled-mounted camera at the MAVS2 site, still in fair seas. We then proceeded to obtain a core sample of the seabed at the same location. After coring at the MAVS1 site, we performed camera work at that position, and followed with an EpsiFish station at the far head of the canyon around midnight.

Sunday 7th August 2022 (Julian Day 219) We continued the EpsiFish station through the entire day, in calm seas.

Monday 8th August 2022 (Julian Day 220) We concluded the EpsiFish station at around 10:45 am and, after testing the second EpsiFish instrument, we proceeded to successfully recover the MAVS4 mooring. We then steamed to position AX2 on the canyon axis, and conducted two CTD stations (CTD001 and CTD002) there, as well as performed float and tethered tests for the two VMP-6000s. Our last activity of the day was the start of an EpsiFish time series (station ??) at site B1 near the steep head of the canyon, where we had measured some of the strongest turbulence during the BLT1 expedition.

Tuesday 9th August 2022 (Julian Day 221) We continued the EpsiFish station through the entire day, in calm seas.

Wednesday 10th August 2022 (Julian Day 222) We concluded the EpsiFish station around 9 am, and proceeded to recover the G1 mooring. After triangulating the position of the Sonardyne ADCP mooring, we successfully recovered it, followed by the T-Chain mooring. This concluded mooring operations in the BLT-3 expedition. We then performed a float test of the HRP, but our attempt to do a subsequent tethered dive was aborted following failure of the launch and recovery system (LARS). We concluded the day with the start of an EpsiFish time series at the site of the T-chain mooring.

Thursday 11th August 2022 (Julian Day 223) We continued the EpsiFish station through the entire day, in calm seas. The issue with the HRP's LARS was successfully resolved.

Friday 12th August 2022 (Julian Day 224) The EpsiFish station was interrupted at around 2 am by technical issues, which persisted into the morning. A successful tethered HRP test was performed while the EpsiFish technical issues were being investigated. As these issues persisted for several hours, we conducted a camera survey of the seabed at the MAVS3 site. Upon completion of the camera work, the EpsiFish station was resumed.

Saturday 13th August 2022 (Julian Day 225) The EpsiFish time series continued overnight, and uneventfully through the day, in favourable conditions.

Sunday 14th August 2022 (Julian Day 226) We continued the EpsiFish station until noon. Then, we steamed to the MAVS4 site, where we conducted the last camera survey. At around 6 pm, we commenced the steam to Killybegs.

Monday 15th August 2022 (Julian Day 227) We arrived in Killybegs at around 8 am. Most of the Scripps party and two of the Southampton party (including the PSO of the first leg) disembarked at this time.

2.2 PSO DIARY – LEG 2 (15TH JULY TO 5TH SEPTEMBER) – MARIE-JOSE MESSIAS

Monday 15th August 2022 (Julian Day 227) We departed Killybegs (Ireland) at 5 pm heading back to the Rockall Trough for the 2nd leg dedicated to the largescale surveys of the tracer, CTD/LADCP and microstructure (VMP/HRP).

Tuesday 16th August 2022 (Julian Day 228) We arrived at the start of the first transect (T1) around 2 am south of the Hebridean Continental shelf at the north-east of the Rockhall Trough. We began science at 5 am undertaking the first CTD/LADCP/tracer sampling of the 2nd leg (CTD003, T1-1) at 55.217°N-10.05°W and 785 m depth on the shelf. We proceeded offshore westward undertaking CTD/LADCP/tracer sampling as well as HRP deployments (CTD004, T1-2; CTD005, T1-3; CTD006, T1-4; CTD007, T1-5; CTD008, T1-6).

Wednesday 17th August 2022 (Julian Day 229) We continued the CTD/LADCP/tracer sampling as well as HRP deployments (CTD009, T1-7; CTD010, T1-8; CTD011, T1-9) until science work had to stop ~noon at 55.42°N-0.44°W and 2383 m depth, because of bad weather in the area. We therefore left the transect 1 (T1) and sailed southeast to the transect 4 (T4) that crosses the basin from the BLT canyon to the Rockall Bank.

Thursday 18th August 2022 (Julian Day 230) We arrived at the shallowest station of transect 4 (T4) at 00:00 am and proceeded eastward toward the head of the BLT canyon with CTD/LADCP/tracer and nutrients sampling as well as VMP deployments sampling 3 locations (CTD012, T4-22; CTD013, T4-21; CTD014, T4-20). The next CTD cast was interrupted (CTD0150 aborted) as the communication was lost, at 9 pm and 640 m depth following a fault of the CTD blowing the fuse of its deck unit. Paul Provost started the CTD fault investigation when CTD returned on deck. The VMP deployment continued. The CTD was put back in the water at 10:30 am after changing the swivel, but without success (CTD016 aborted). The second repair involved redoing the termination and load test, which took 8 hours. During this time, we headed for the mouth of the canyon (T4-08 equivalent to AX15 of BLT1) in the hope of resuming work there, but weather deteriorated and prevented the resumption of scientific work.

Friday 19th August 2022 (Julian Day 231) 8 am: Weather was still too rough to put the CTD in the water. The deep tow cable was prepared to be used instead of the CTD cable if needed. Weather improved at 11:00 am and we proceeded with CTD tests in the water changing and probing different parts of the CTD system (CTD units, winding and unwinding the wire in the winch room). At 7:30 pm, the CTD communication hold and we could finally proceed with the double CTD casts of position T4-08 (CTD017 and CTD018) needed to define the vertical spread of the tracer at the mouth of the canyon of 2940 m depth. Then, we transited slowly (5 knots) to position T4-07 because of the strong winds.

Saturday 20th August 2022 (Julian Day 232) We started CTD019 (T4-07) at 6 am and managed to fire 23 bottles before losing communication again. It was then decided to use the deep tow cable for the next CTD casts. The wire change was done during the 5 hours of transit to the next station. We arrived at position T4-06 at 13:00 where the deep tow cable was used successfully for CTD/LADCP/tracer and nutrients sampling (CTD020). The HRP deployment followed. We steamed for position T4-05 at 19:45 pm. CTD021 went well, however HRP had technical issues and the VMP successfully took the relay.

Sunday 21st August 2022 (Julian Day 233) We continued CTD/LADCP/tracer sampling with CTD022 (T4-04) at 5 am, smoothly followed by CTD23 to CTD25 and VMPs, and finished transect T4 (56.09°N -14.32°W) at 21:00 pm starting a 11 hours transit at good speed of 10 knots to the northern trans-basin transect T2 at the latitude of Anton Dohrn. ETA T2-01 was 05:30 am. During the transit the CTD wire was put back into the CTD system.

Monday 22nd August 2022 (Julian 234) CTD026 was deployed back with the CTD wire at 5:45 am but aborted as the communication was again lost at 400 m going down. The CTD was taken back on board and the CTD cable was replaced by the deep tow cable. CTD027 was deployed successfully with the deep tow wire, at the easternmost side of T2 (west of Anton Dohrn) at 57.45°N -12.82°W and 1197 m depth and followed by CTD028(T2-02), CTD029 (T2-03), CTD030(T2-04).

Tuesday 23rd August 2022 (Julian Day 235) On the early hours of the day, we deviated south to the transect 12 (T12) designed to sample the currents between the south of the Anton Dohrn seamount and Hebridean Continental shelf. Because of the time lost to the CTD technical issues and the bad weather, that transect was reduced to 2 stations only with CTD031 and CTD032 (positions T12-4 and T12-3, where steep slopes extend down the side of the seamount to a moat at around 2400 m deep). In the morning, we returned north to proceed with the T2 transect east of Anton Dohrn undertaking CTD033, CTD034, CTD035 and positioned along T2-05 to T2-08. Lovely sunny evening and sunset on this day. VMPs were deployed as HRP had technical issues. At 11 pm, we steamed northward to the transect T3, to sample the shallower region north of Anton Dohrn.

Wednesday 24th August 2022 (Julian Day 236) It was decided that to mitigate for time lost to the bad weather and CTD technical issues, from now on (CTD037), the CTD Niskin bottles would be fired on the fly when spacing between bottles is equal or greater than 40 m. When the spacing would be less than 40 m, the CTD would slow down at the firing depth or stop if salinity sample are taken. The oxygen sensors seemed to give more stable results. The SBR35 was removed. The response of the other sensors looked fine. We started the transect T3 at 3:50 am at the eastern part of the Trough and proceeded westward undertaking CTD/LADCP/tracer sampling and HRP/VMP at T3-04, T3-03, T3-02, T3-01 (CT037, CTD038, CTD039 and CTD040) up to 58.30°N -11.92°W. The northern transect was completed by 10:00pm and the vessel then headed southeast to do the two planned stations on route between the westernmost position of T3 and westernmost position of T1, linking the two transects.

Thursday 25th August 2022 (Julian Day 237) The next CTD/LADCP/tracer sampling was aborted at planned station T3-06 (CTD041) at 3:30 am because of crossed seas. The ship could not hold position so the station was aborted and we moved further towards T1 relocating the station south where weather conditions were good for a CTD. We arrived at T3-07 at 8 am and successfully proceeded with CTD 42. We then continued southward and arrived at T1-16 (CTD43) at 16:00. We proceeded south-eastward along T1 undertaking CTD/LADCP/tracer sampling and HRP/VMP at T1-15, T1-14, S1- 01 (CT044, CTD045, CTD046).

Friday 26th August 2022 (Julian Day 238) The HRP got stuck in the bottom at CTD046 at 03:00 am. It was confirmed that the bottom was mud. We waited 4 hours to see if it would dislocate by itself and then decided to do one attempt to drag for it. The dragging system consisted of a cable of 1000 m long maintained near the sea bed by two 1ton weights that ship drag around the estimated location (56° 30.77718 N and 12° 32.435 W). The position of the cable was monitored by the USBL. The setting preparation lasted 3 hours after which the dragging started at 12:30 am at ship speed of 1 knot. The dragging attempt was successful and we had the HRP back on board at 18:15 pm. To make up for time lost, it was decided to remove several VMP/HRP and CTD stations from the initial plan. It was also decided that the ship would do good speed in between station of ~ 9 knots, sea state and weather permitting. The survey along T1 resumed at 19:00 at position T1-13 followed by T1-12 (CTD047 and CTD048).

Saturday 27th August 2022 (Julian Day 239) At position T1-11, CTD049 was aborted at 4:31 am due to a rupture in the hydraulics of the winch when the CTD was 80 m in water going down. After repair, T1-11 was successfully sampled (CTD050). Afterwards, the ship left temporally the T1 transect and headed northeast to performed the transect 10 (T10), a line linking T1 to the Hebridean seamount at the positions T10-1, T10-2, T1-3 and T10-4 (CTD051 to CTD054), and which was finished at 20:00 pm. The ship then headed eastward to perform the transect 11 (T11) to sample the waters between the seamount (position T11-2, CTD055 performed at 22:30 pm) and the eastern position Hebridean continental shelf at the depth of 1220 m (position T11-4).

Sunday 28th August 2022 (Julian Day 240) We continued the survey along T11 by sailing eastwards and taking samples at positions T11-3 and T11-4 (CTD056 and CTD057). We then returned south to complete transect T10 (T1-10, CTD058) before sailing further south back to the BLT canyon to complete its survey (the eastern extension of transect T4).

Monday 29th August 2022 (Julian Day 241) We arrived at the mouth of the BLT canyon at 01:00 am and then proceed up canyon from position T4-09 to T4-19 (CTD059 to CTD068).

Sea water samples were also taken for nutrients analysis for Prof McGillicuddy (WHOI) and Woodward (PML). HRP/VMP was done for the deep stations as the head of the canyon was sampled for microstructure at Leg1.

Tuesday 30th August 2022 (Julian Day 242) We sailed to the transect 9 (T9) situated roughly parallel between the eastern part of T4 and T1. We started transect T9 around 03:00 am and finished the slope survey (T9-07 to T9-04, CTD69-CTD72) at 10:00 am, and then processed along that transect in the abyssal plain (T9-03 to T9-02, CTD73-CTD74). Station T9-2: the HRP come back up head of time.

Wednesday 31th August (Julian Day 243) We completed the last station of T9 (T9-01, CTD75) in the early morning and then sailed west to begin the trans-basin transect of the Rockall Trough entrance (T7). We arrived at its most westerly point at 14:00 pm and proceed the survey southeast at position T7-11, T7-10, T7-09 and T7-08 (CTD076 to CTD079).

Thursday 1st September 2022 (Julian Day 244) We completed the sampling along T7, at positions T7-07 to T7-02 (CTD080 to CTD085), and then sailed to the last transect 5 (T5) to survey the eastern side of the RT at the cruise southernmost latitude of 53.1°N.

Friday 2nd September 2022 (Julian Day 245) We arrived at the porcupine abyssal plain position of T5 (T5-01, CTD086) at 06:00 am and then proceed eastward sampling positions T5-02 to T5-04 (CTD087 to CTD089) towards the continental slope. The T5 was then abandoned anticipating with the deterioration of the weather, and we began transit to Southampton.

Sunday 4th September 2022 (Julian Day 247) Smooth transit at 10 knots. At 15:00, we enter a rail, crossing many ships along our route.

Monday 5th September (Julian Day 248) We passed the Needles at 10:00 am. The weather is good to enjoy the scenery. Another day of packing and backing up of computers.

Tuesday 6th September (Julian Day 249) Demobilisation from DY153 from 8:00 am to 15:00 pm.

3 CONDUCTIVITY, TEMPERATURE AND DEPTH (CTD) OPERATIONS

3.1 STAINLESS STEEL CTD OPERATIONS (NMF)

Billy Platt, Paul Henderson, Jeremy Evans, Jade Garner, Simon Jones, Paul Provost

3.1.1 CTD CAST SUMMARY

Total number of casts: 89

Deepest cast: 3218m

3.1.2 CTD WIRES

3.1.2.1 CTD Wire 2

CTD Wire 2 was used for cast 001–020 & 026. The mechanical and electrical termination was the same as used in DY150. Resistance and insulation of the cable were checked periodically. The torque setting on the fasteners of the mechanical termination was checked throughout and no slippage was noted. CTD cast 015 was aborted when the sea cable fuse was blown. The cause was eventually traced to the inside of the winch drum, where the cables between the slipring and the junction box were shorting on the inside of the winch drum. The cables were damaged due to chaffing against a chipped/sharp edge. A temporary fix was made by protecting the cables with electrical tape. A permanent fix was made later by inserting a plastic ring into the winch drum to stop the cables coming into contact with any sharp edges. The cables were further protected by shielding them in hose/conduit. See photos at end of cruise report.

CTD cast 019 was aborted due to water ingress at the electrical termination after which the wire was re-terminated. CTD cast 026 was also aborted due to water ingress at the electrical termination after which the wire was re-terminated. During re-terminations approximately 89m of wire was chopped off of CTD2.

CTD Wire 2 at beginning of cruise:

Resistance 76.2 Ohms Insulation >550 MOhms @500 VDC

CTD Wire 2 at end of cruise:

Resistance 72.9 Ohms Insulation >550 MOhms @500 VDC

3.1.2.2 Deep Tow

The Deep Tow was terminated as a back-up to CTD Wire 2 and was used on casts 020-025 and 027-089. There were two incidents where the Deep Tow winch rapidly hauled or veered when approaching an auto-stop when the active heave compensation (AHC) was activated. This is a problem known to Kongsberg which can happen in flat/calm seas when AHC is on. Further information can be found in Kongsberg service note Ref. SN BR098-2022. It is recommended the AHC is not used in flat/calm seas.

Deep Tow after termination:

Resistance 92 Ohms Insulation >550 MOhms @500 VDC

Deep Tow at end of cruise:

Resistance 92 Ohms Insulation >550 MOhms @500 VDC

3.1.2.3 CTD Wire 1

CTD Wire 1 was not available for use having not been streamed since the cable was replaced.

3.1.3 CTD sensor set-up

CTD frame was set-up for DY153 with primary conductivity and temperature sensors on the 9plus and secondary conductivity and temperature sensors on the vane. Analogue sensors on the 9plus were dissolved oxygen, altimeter, fluorometer, transmissometer, backscatter. Up-looking and down-looking 300kHz LADCP's were fitted for all casts. 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 for casts 001-041 and to average 1 sample casts 042-089. Full sensor information can be found on the Sensor Information Sheet – Appendix 1.

The 9plus was replaced between cast 016 and 017 when troubleshooting problems with the CTD. It was later determined that the problems were with CTD Wire 2, not the 9plus.

A new Valeport altimeter was trialled on the cruise and was found to be significantly better than the Benthos and Tritechs. The altimeter trace would reliably start at 99m meters above the seafloor on every cast.

3.1.4 WATER SAMPLERS

OTE 10L Water Samplers (Set B) were used on the frame and performed well throughout the cruise with only two bottles misfiring (bottle 18, cast 002 & bottle 21, cast 079). Two venting bungs and O-rings where replaced after cast 044. For casts 040-089 bottles were fired on the fly (i.e. without stopping) except for where salts samples were taken, or the distance between the bottle stops was <40m.

3.1.5 SBE DATA PROCESSING

Basic post-processing of the CTD cast data was carried out following 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 acoustic systems.

The data was processed using SBE Data Processing, V7.26.7. The following modules were used to process the data:

- Data Conversion
- Bottle Summery
- Align CTD
- CellTM
- Derive
- Bin Average
- Strip

An instrument configuration report can be found in the Appendix of this section.

3.1.6 LADCPS

300kHz up-looking and down-looking Lowered Acoustic Doppler Current Profilers (LADCPs) were deployed on every CTD cast.

The master normally logs twice as many dives as the slave. On several occasions the recorded deployments on the master no longer equalled double that of the slave. Usually this happened after around 15-20 deployments. Using the command re ErAsE, the memory was wiped and normal logging of deployments would continue for several days until it happened again.

Also, the master occasionally downloaded all the files even after selecting just one. Initially this was thought to be just operator error but the third time this happened it had been doubled checked and only one file had been selected. This was with laptop 95YJPJ2 and instrument Sn24609. It is unknown why this happened but was approximately 3 out of 89 deployments.

Other than these small issues these instruments performed well with no other problems reported other than occasional time slipping on the master. A copy of the script/command files can be found in Appendix 3.

3.1.7 AUTOSAL

A Guildline Autosal 8400B salinometer, S/N: 71185, was used for salinity measurements. The salinometer was installed in the Salinometer lab. Bath temperature was set at 21°C, the ambient temperature being approximately 18.5-19.0°C. The salinometer was standardised before the first set of samples, and checked with an additional standard analysed prior to setting the RS. Once standardised the Autosal was not adjusted for the duration of sampling. A standard was analysed before and after each crate of samples to monitor & record drift. Standards were recorded in the spreadsheet as ‘0’ or ‘9999’ or K15 and had a standard salinity value of 34.994 from batch P164. Standard deviation was set to 0.0003. Salinometer S/N 68958 was set-up but not used during the cruise.

A program written in Labview called “Autosal” was used to record data for salinity values. Salinity samples were taken and analysed from most casts and the results tabulated in spreadsheet SALFORM_SS.xlsx.

3.1.8 APPENDIX 1

SENSOR INFORMATION SHEET

SHIP: RRS DISCOVERY	CRUISE: DY153

FORWARDING INSTRUCTIONS / ADDITIONAL INFORMATION:
Main Stainless Steel 24-way CTD frame on DY153 (BLT3)

Checked By: PH, PP, BP	DATE: 04/09/2022

Instrument / Sensor	Manufacturer/ Model	Serial Number	Channel	Casts Used
Primary CTD deck unit	SBE 11plus	11P-24680-0588	N/A	All casts
CTD Underwater Unit	SBE 9plus	09P-24680-0637	N/A	Casts 001-016
CTD Underwater Unit	SBE 9plus	09P-77801-1182	N/A	Casts 017-089
Titanium EM CTD Swivel	Machinery Development Services/V2_2	1246-2	N/A	All casts
Stainless steel 24-way frame	NOCS	SBE CTD6	N/A	All casts
Primary Temperature Sensor	SBE 3P	03P-5835	F0	All casts
Primary Conductivity Sensor	SBE 4C	04C-4139	F1	All casts
Digiquartz Pressure sensor	Paroscientific	79501	F2	Casts 001-016
Digiquartz Pressure sensor	Paroscientific	129735	F2	Casts 017-089
Secondary Temperature Sensor	SBE 3P	03P-5785	F3	All casts
Secondary Conductivity Sensor	SBE 4C	04C-4140	F4	All casts
Primary Pump	SBE 5T	05T-3085	n/a	All casts
Secondary Pump	SBE 5T	05T-3607	n/a	All casts
24-way Carousel	SBE 32	32-60380-0805	n/a	All casts
Primary Dissolved Oxygen Sensor	SBE 43	43-0862	V0	All casts
Free	---	---	V1	---
Fluorometer	CTG Aquatracka MKIII	088-244	V2	All casts
Altimeter	Valeport VA500	81629	V3	All casts
Free	---	---	V4	---
Free	---	---	V5	---
Transmissometer	WETLabs CStar	CST-1719TR	V6	All casts
Light Scattering Sensor	WETLabs BBRTD	BBRTD-758R	V7	All casts
10L Water Samplers	OTE	Set B	N/A	All casts
LADCP Battery Pack	NOCS	WH006T	N/A	All casts
LADCP WH 300kHz – Up Looking	TRDI	15288	N/A	All casts
LADCP WH 300kHz – Down Looking	TRDI	24609	N/A	All casts
DOST	SBE 35	35-66264-0070	N/A	All cast

3.1.9 APPENDIX 2

Instrument configuration file used casts 017-089

PSA file: C:\Users\sandm\Documents\Cruises\DY153\Data\Seasave Setup Files\DY153_SS_1182_nmea.psa

Date: 09/04/2022

Instrument configuration file: C:\Users\sandm\Documents\Cruises\DY153\Data\CTD Raw Data\DY153_CTD_069.xmlcon

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

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

1) Frequency 0, Temperature

   Serial number : 03P-5835
   Calibrated on : 02-Sep-21
   G             : 4.37871437e-003
   H             : 6.73104457e-004
   I             : 2.75570914e-005
   J             : 2.11069534e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-4139
   Calibrated on : 25-Aug-21
   G             : -9.89092738e+000
   H             : 1.45687093e+000
   I             : 4.45002601e-004
   J             : 5.58999576e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
```

Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 129735
Calibrated on : 13-Nov-2020
C1 : -6.064446e+004
C2 : 6.966022e-002
C3 : 1.971200e-002
D1 : 2.882500e-002
D2 : 0.000000e+000
T1 : 3.029594e+001
T2 : -6.713680e-005
T3 : 4.165390e-006
T4 : 0.000000e+000
T5 : 0.000000e+000
Slope : 0.99986000
Offset : -3.33660
AD590M : 1.279180e-002
AD590B : -8.821250e+000

4) Frequency 3, Temperature, 2

Serial number : 03P-5785
Calibrated on : 02-Sep-2021
G : 4.33680024e-003
H : 6.28125678e-004
I : 1.97135700e-005
J : 1.48598016e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 04C-4140
Calibrated on : 19-Aug-21
G : -9.83714820e+000
H : 1.48391211e+000
I : -1.99680672e-003
J : 2.40272948e-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-2021

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, Fluorometer, Chelsea Aqua 3

Serial number : 088244
Calibrated on : 07 August 2020
VB : 0.176199
V1 : 2.032520
Vacetone : 0.245650
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

9) A/D voltage 3, Altimeter

Serial number : Valeport VA500 81629
Calibrated on :
Scale factor : 15.000
Offset : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Transmissometer, WET Labs C-Star

Serial number : CST-1719TR
Calibrated on : 01-August-2022
M : 21.1975
B : -0.0784
Path length : 0.250

13) A/D voltage 7, OBS, WET Labs, ECO-BB

Serial number : 758R
Calibrated on : 30/8/2019

```
   ScaleFactor   : 0.004284
   Dark output   : 0.054400

Scan length                : 45
---------------------------------------------
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\DY153\Data\CTD Raw
Data\DY153_CTD_072.hex
  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: DY153
    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: A. Garrabato
    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:  48.000000
    Longitude when NMEA is not available: 0.000000
  Average Sound Velocity
    Minimum pressure [db]:             20.000000
    Minimum salinity [psu]:            20.000000
    Pressure window size [db]:         20.000000
    Time window size [s]:              60.000000
  Descent and Acceleration
    Window size [s]:                   2.000000
  Plume Anomaly
    Theta-B:                          0.000000
    Salinity-B                        0.000000
    Theta-Z / Salinity-Z               0.000000
    Reference pressure [db]            0.000000
  Oxygen
    Window size [s]:                   2.000000
    Apply hysteresis correction:         0
    Apply Tau correction:              1
  Potential Temperature Anomaly
    A0:                               0.000000
    A1:                               0.000000
    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:      0.000000
  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

Appendix 3

LADCP Set-up Files

Master LADCP – Downlooking

```
$P
*****************************************************************************
$P ****************** LADCP Primary. Looking down. ***********************
$P
*****************************************************************************
; Send ADCP a BREAK
$B
; Wait for command prompt > (sent after each command)
$W62
;**Start**
; Display real time clock setting
TT?
$W62
; Set to factory defaults
CR1
$W62
; Print firmware etc.
PS0
$D1
; Set Water Mode 15 LADCP
WM15
$W62
; Set minimum correlation magnitude and threshold for good bottom-track data. Default values
used here.
LZ030,220
; Set baud rate to 9600
CB411
$W62
; Save settings as User defaults
CK
$W62
; Set transducer depth to zero
ED0000
$W62
; Set salinity to 35ppt
ES35
$W62
; Set beam coordinates
EX00000
$W62
; SET AS PRIMARY ADCP
SM1
$W62
```

; TRANSMITS SYNCHRONIZING PULSE BEFORE EACH WATER PING
SA001
$W62
; Disable hardware-break detection on Channel B
SB0
$W62
; SYNCHRONIZING PULSE SENT ON EVERY PING
SI0
$W62
;WAIT 7.5 MILLISECONDS
SW75
$W62
; Set one ensemble 1.00/sec
TE00000100
$W62
; Set one second between pings
TP000100
$W62
; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good WD111100000
$W62
; Set one ping per ensemble. Also sets LP command.
WP1
$W62
; Set to record 20 bins. Also sets LN command.
WN020
$W62
; Set bin size to 8 m. Also sets LS command.
WS0800
$W62
; Set blank to 176 cm (default value for 300kHz ADCP). Also sets LF command.
WF0176
$W62
; Set max radial (along the axis of the beam) water velocity to 275 cm/sec. ; Also sets LV command. Default value is 170 cm/s, adding 60 cm/s for vertical CTD package motion.
WV275
$W62
; Set ADCP to narrow bandwidth and extend range by 10%.
;Also sets LW command.
WB1
$W62
; Set to use a fixed speed of the sound
EZ0111111
$W62
; Set speed of sound value. 1500 m/sec is default.
EC1500
$W62
; Heading alignment set to 0 degrees
EA00000
$W62
; Heading bias set to 0 degrees

```
EB00000
$W62
; Record data internally
CF11101
$W62
; Save set up
CK
CS
$P
***************************************************************************
$P Set deployment file name with RN and then start pinging with CS.
$P
***************************************************************************
```

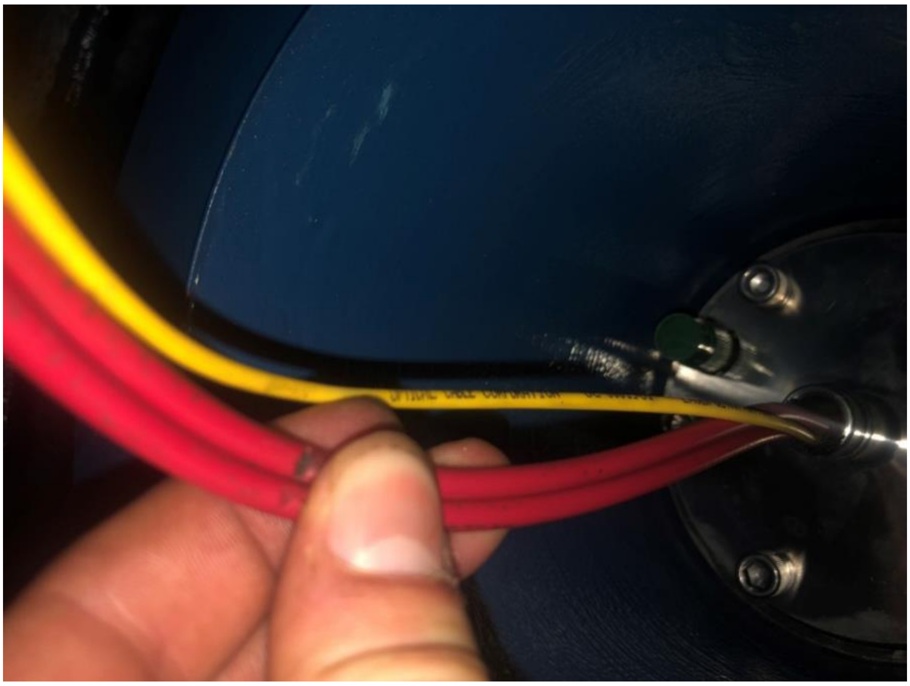
Slave LADCP – Uplooking

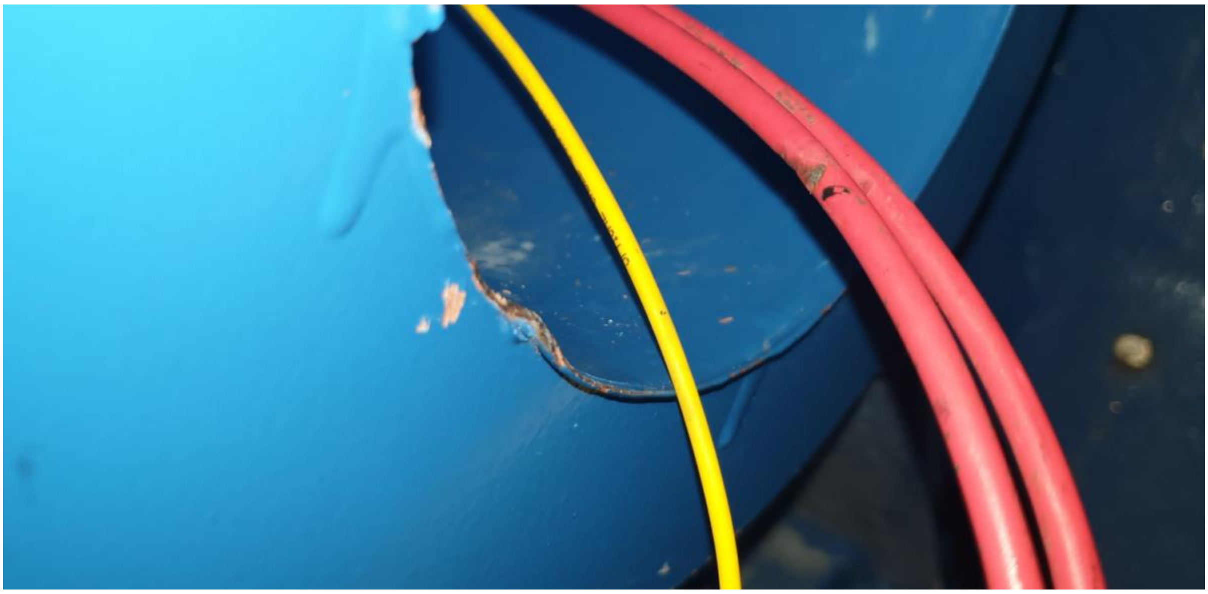
```
$P
***************************************************************************
$P ******************* LADCP Primary. Looking down. ************************
$P
***************************************************************************
; Send ADCP a BREAK
$B
; Wait for command prompt > (sent after each command)
$W62
;**Start**
; Display real time clock setting
TT?
$W62
; Set to factory defaults
CR1
$W62
; Print firmware etc.
PS0
$D1
; Set Water Mode 15 LADCP
WM15
$W62
; Set minimum correlation magnitude and threshold for good bottom-track data. Default values
used here.
LZ030,220
; Set baud rate to 9600
CB411
$W62
; Save settings as User defaults
CK
$W62
; Set transducer depth to zero
ED0000
```

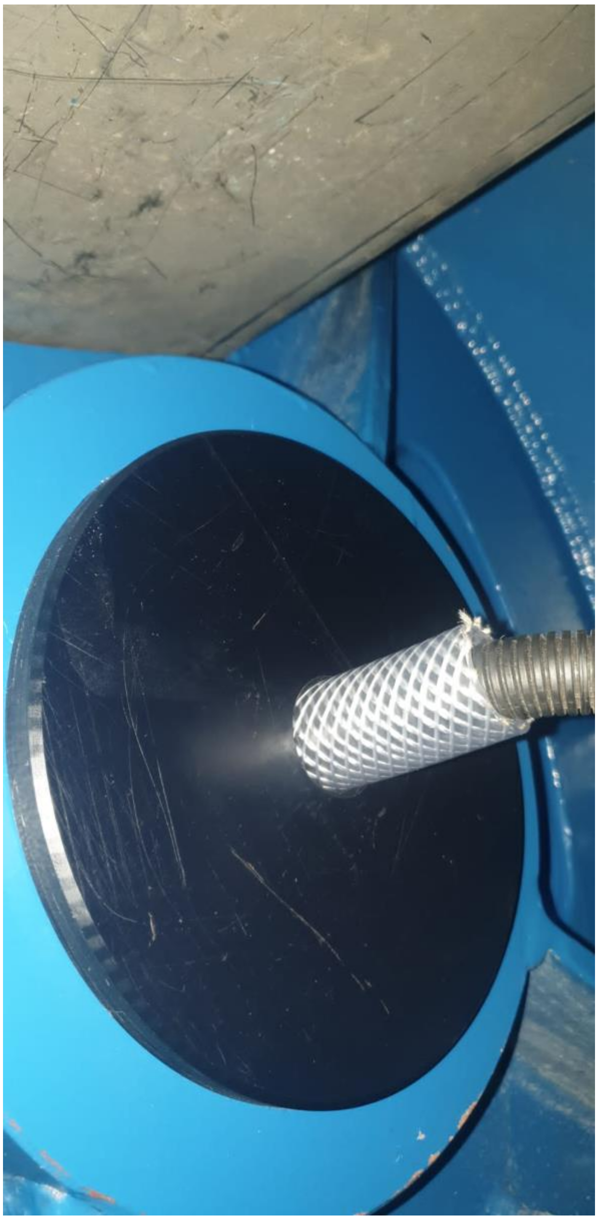
```
$W62
; Set salinity to 35ppt
ES35
$W62
; Set beam coordinates
EX00000
$W62
; SET AS PRIMARY ADCP
SM1
$W62
; TRANSMITS SYNCHRONIZING PULSE BEFORE EACH WATER PING
SA001
$W62
; Disable hardware-break detection on Channel B
SB0
$W62
; SYNCHRONIZING PULSE SENT ON EVERY PING
SI0
$W62
;WAIT 7.5 MILLISECONDS
SW75
$W62
; Set one ensemble 1.00/sec
TE00000100
$W62
; Set one second between pings
TP000100
$W62
; Set LADCP to output Velocity, Correlations, Amplitude, and Percent Good WD111100000
$W62
; Set one ping per ensemble. Also sets LP command.
WP1
$W62
; Set to record 20 bins. Also sets LN command.
WN020
$W62
; Set bin size to 8 m. Also sets LS command.
WS0800
$W62
; Set blank to 176 cm (default value for 300kHz ADCP). Also sets LF command.
WF0176
$W62
; Set max radial (along the axis of the beam) water velocity to 275 cm/sec. ; Also sets LV
command. Default value is 170 cm/s, adding 60 cm/s for vertical CTD package motion.
WV275
$W62
; Set ADCP to narrow bandwidth and extend range by 10%.
;Also sets LW command.
WB1
$W62
```

```
; Set to use a fixed speed of the sound
EZ0111111
$W62
; Set speed of sound value. 1500 m/sec is default.
EC1500
$W62
; Heading alignment set to 0 degrees
EA00000
$W62
; Heading bias set to 0 degrees
EB00000
$W62
; Record data internally
CF11101
$W62
; Save set up
CK
CS
$P
*************************************************************************
$P Set deployment file name with RN and then start pinging with CS.
$P
*************************************************************************
```

Damage to Slip-ring wires and repairs








3.2 LOWERED ACOUSTIC DOPPLER CURRENT PROFILER (LACDP)

3.2.1 INSTRUMENT AND CONFIGURATION

For all CTD casts, two RDI 300kHz Workhorse LADCP units were fitted to the CTD frame one in a downward-looking orientation the other upward-looking. Each LADCP was configured to have 20 x 8 m bins, a 176 cm blank-to-surface, one ping per ensemble in narrowband mode. Data were collected in beam coordinates. See NMF technical report for details.

3.2.2 DATA PROCESSING

RDI format binary files, recorded by the instrument, were downloaded after each cast and stored with the corresponding pre-deployment test log files. All data were processed using the latest version of the Lamont-Doherty Earth Observatory (ldeoIX) software which calculates velocities using an inverse method. This package was also used to monitor the health of the beams on the instrument.

Navigation data, for use in the processing, were extracted for the ship's primary GPS positional system the POSMV GPS. Data from the ship mounted ADCP was averaged in into station mean profiles for all casts. CTD data was extracted from the raw SeaBird .hex files, corrected for cell thermal mass, filtered to remove noise, and averaged into one second bins.

Parameters changed from the ldeoIX default values were set in the *set_cast_params.m* script and are given below:

TABLE 2: LADCP PARAMETERS

Parameter Setting	Description
p.edit_mask_dn_bins = [1]; p.edit_mask_up_bins = [1];	Disregard data from 1st bin
p.nav_error = 30	Allowable error in navigation (30 m)
p.navtime_av = 1/60/24	Average navigation data into 1 minute bins
ps.shear = 1	Calculate a shear solution
ps.std_weight = 1	Use super ensemble to weight

	data
ps.sadcpfac = 0.5	weight for vmadcp profile
ps.shear_stdf = 2	Average shear over two standard deviations
ps.dz = 8	8 m vertical resolution for profiles
ps.outlier = 1	Remove 1% of outlier data after solution

4 CTD Data Conversion, Calibration and Processing

Catherine Kermabon, Herle Mercier and Marie-Jose Messias

4.1 Introduction

The BLT3 DY153 cruise took place on the British oceanographic vessel 'Royal Research Ship Discovery' from 25/07/2022 to 07/09/2022. During the cruise, 89 CTD stations were carried out (Figure 7). CTD data acquisition worked well, with the exception of stations 15, 16 and 26 there were aborted. The CTD pressure sensor was changed after station 15. This report presents the post-cruise CTD data processing and conductivity calibration. Stations 1 and 2 have not be calibrated (tests stations carried out during the first leg).

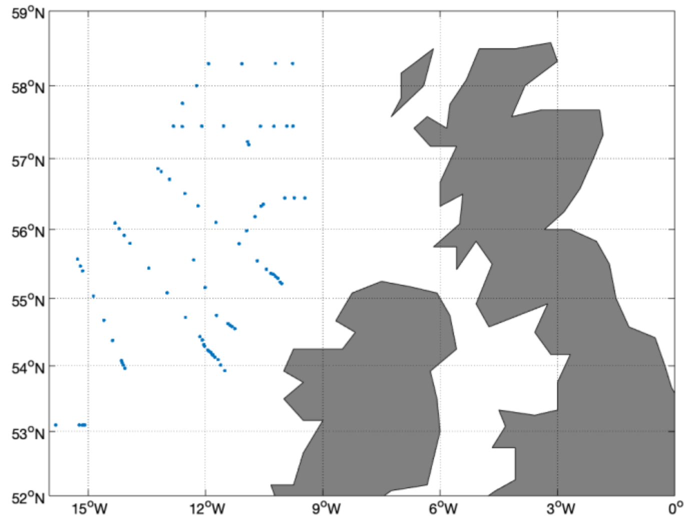


FIGURE 7: LOCATIONS OF HYDROGRAPHIC STATIONS OCCUPIED DURING BLT2

4.2 CTD Set-up and Configuration File

The SBE9+ CTD was equipped with the following sensors (Figure 8) :

- 1 pressure sensor, 1 oxygen sensor SBE43, 1 altimeter, 1 turbidity sensor
- 2 sets of temperature/conductivity sensors
    - 1 primary set (temp0/cond0)
    - 1 secondary set (temp1/cond1)

FIGURE 8: CTD SENSOR LOCATIONS

Below are the SBE9+ CTD configuration file used from stations 1 to 14 and 17 to 89. They inform on the calibration coefficients for the sensors mounted on the CTD.

```
Configuration report for SBE 911plus/917plus CTD : STATIONS 1 to 14
-------------------------------------------------------------------

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

```
Scan time added               : Yes

1) Frequency 0, Temperature

   Serial number : 03P-5835
   Calibrated on : 02-Sep-21
   G             : 4.37871437e-003
   H             : 6.73104457e-004
   I             : 2.75570914e-005
   J             : 2.11069534e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-4139
   Calibrated on : 25-Aug-21
   G             : -9.89092738e+000
   H             : 1.45687093e+000
   I             : 4.45002601e-004
   J             : 5.58999576e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 79501
   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-5785
   Calibrated on : 02-Sep-2021
   G             : 4.33680024e-003
```

```
   H             : 6.28125678e-004
   I             : 1.97135700e-005
   J             : 1.48598016e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000
```

5) Frequency 4, Conductivity, 2

```
   Serial number : 04C-4140
   Calibrated on : 19-Aug-21
   G             : -9.83714820e+000
   H             : 1.48391211e+000
   I             : -1.99680672e-003
   J             : 2.40272948e-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-2021
   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, Fluorometer, Chelsea Aqua 3

```
   Serial number : 088244
   Calibrated on : 07 August 2020
   VB            : 0.176199
   V1            : 2.032520
   Vacetone      : 0.245650
   Scale factor  : 1.000000
   Slope         : 1.000000
   Offset        : 0.000000
```

```
9) A/D voltage 3, Altimeter

   Serial number : Valeport VA500 81629
   Calibrated on :
   Scale factor  : 15.000
   Offset        : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Transmissometer, WET Labs C-Star

    Serial number : CST-1719TR
    Calibrated on : 01-August-2022
    M             : 21.1975
    B             : -0.0784
    Path length   : 0.250

13) A/D voltage 7, OBS, WET Labs, ECO-BB

    Serial number : 758R
    Calibrated on : 30/8/2019
    ScaleFactor   : 0.004284
    Dark output   : 0.054400

Scan length                   : 45


Configuration report for SBE 911plus/917plus CTD : Stations 17 to 89
--------------------------------------------------------------------

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

1) Frequency 0, Temperature

   Serial number : 03P-5835
   Calibrated on : 02-Sep-21
   G             : 4.37871437e-003
   H             : 6.73104457e-004
   I             : 2.75570914e-005
```

```
   J             : 2.11069534e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 04C-4139
   Calibrated on : 25-Aug-21
   G             : -9.89092738e+000
   H             : 1.45687093e+000
   I             : 4.45002601e-004
   J             : 5.58999576e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 09p-77801-1182. (changed to 129735 for sts 24 to 89)
   Calibrated on : 13-Nov-2020
   C1            : -6.064446e+004
   C2            : 6.966022e-002
   C3            : 1.971200e-002
   D1            : 2.882500e-002
   D2            : 0.000000e+000
   T1            : 3.029594e+001
   T2            : -6.713680e-005
   T3            : 4.165390e-006
   T4            : 0.000000e+000
   T5            : 0.000000e+000
   Slope         : 0.99986000
   Offset        : -3.33660
   AD590M        : 1.279180e-002
   AD590B        : -8.821250e+000

4) Frequency 3, Temperature, 2

   Serial number : 03P-5785
   Calibrated on : 02-Sep-2021
   G             : 4.33680024e-003
   H             : 6.28125678e-004
   I             : 1.97135700e-005
   J             : 1.48598016e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2
```

```
   Serial number : 04C-4140
   Calibrated on : 19-Aug-21
   G             : -9.83714820e+000
   H             : 1.48391211e+000
   I             : -1.99680672e-003
   J             : 2.40272948e-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-2021
   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, Fluorometer, Chelsea Aqua 3

   Serial number : 088244
   Calibrated on : 07 August 2020
   VB            : 0.176199
   V1            : 2.032520
   Vacetone      : 0.245650
   Scale factor  : 1.000000
   Slope         : 1.000000
   Offset        : 0.000000

9) A/D voltage 3, Altimeter

   Serial number : Valeport VA500 81629
   Calibrated on :
   Scale factor  : 15.000
   Offset        : 0.000

10) A/D voltage 4, Free
```

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

12) A/D voltage 6, Transmissometer, WET Labs C-Star

    Serial number : CST-1719TR
    Calibrated on : 01-August-2022
    M             : 21.1975
    B             : -0.0784
    Path length   : 0.250

13) A/D voltage 7, OBS, WET Labs, ECO-BB

    Serial number : 758R
    Calibrated on : 30/8/2019
    ScaleFactor   : 0.004284
    Dark output   : 0.054400

Scan length                 : 45
```

4.3 DATA CONVERSION AND PROCESSING

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

4.3.1 CONVERSION OF BINARY FILES INTO ASCII FILES

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

1. A .cnv file containing the 24 Hz raw data for the following variable names and parameters :

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

name 16 = altM: Altimeter [m]
name 17 = pumps: Pump Status
name 18 = turbWETbb0: Turbidity, WET Labs ECO BB [m^-1/sr]

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

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

4.3.2 Bad Data Removal Using the CADHYAC/hydro_nett software

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

TABLE 3: IDENTIFICATION OF BAD DATA VIA A MEDIAN DEVIATION TEST

	Minimum value (Vmin)	Maximum value (Vmax)	Width of the window for the test of deviation from the median (TF)	Number of standard deviation for the test of deviation from the median (NbStd)	Minimum deviation for the test of deviation from the median (Emin)	Maximum deviation for the test of deviation from the median (Emax)	number of iterations of the test for deviation from the median (niter)
Pression dbar	0	7000	20	2.8	1.5	10	2
Temperature °C	-5	30	6	3	0.05	0.4	2
Conductivity mS/cm	0	70	10	2.8	0.01	0.4	3
Oxygen Volt	0	5	10	2.8	0.01	0.4	3

For each parameter, a value V was suppressed when

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

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

4.3.3 Regeneration of the .ros files

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

4.3.4 Oxygen hysteresis correction in Volt

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

TABLE 4: OXYGEN HYSTERESIS CORRECTION

H1	H2	H3	Offset
-0.033	5000	1450	-0.7075

4.3.5 Data correction for dynamical effects on sensors

This step was done using Seabird's SbeDataprocessing software :

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

4.3.6 Creation of .blt files

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

4.4 Data calibration with CADHYAC/hydro_cal

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

4.4.1 PRESSURE AND TEMPERATURE

As we had no metrology data after the cruise for pressure and temperature, no correction is made on these data. We rely on the pre-cruise calibration.

4.4.2 CONDUCTIVITY

The calibration of the CTD conductivity data uses the salinity data from the seawater sample analyzed on an Autosalt. A total of 228 samples were analyzed. Chemical analyses on the Autosal were performed by groups of 24 bottles. The Autosal provides a double conductivity ratio (CR). The Autosal was standardized at the beginning of the cruise, which provided an offset that we applied to the Autosal CR data :

- offset = -0.000029 to be applied from station 3 to station 89

The chemical salinity is calculated as follows :

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

with 21 being the bath temperature in °C of the Autosal.

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

We considered two groups of stations before and after the pressure sensor change (station 17). Thus, the sensor conductivity data are corrected :

- From stations 3 to 14 as a function of time (P1), conductivity (P2) and pressure (P3)

Sensor 0

```
P1(1): 7.35587e-05  P1(0): -0.00596024
P2(1): -0.000563859 P2(0): 0.0201098
P3(1): -3.44674e-08 P3(0): 3.66224e-05
```

Sensor 1

```
P1(1): -6.00187e-06 P1(0): 0.000656085
P2(1): -0.000299443      P2(0): 0.0106793
P3(1): -3.95979e-08      P3(0): 4.20736e-05
```

❖ From stations 17 to 89 as a function of time (P1), conductivity (P2), and pressure (P3)

Sensor 0

```
P1(1): 1.09363e-05 P1(0): -0.00544262
P2(1): -0.000583701 P2(0): 0.00856049
P3(1): -3.53009e-08 P3(0): 6.80787e-05
```

Sensor 1

```
P1(1): 7.37369e-06 P1(0): 0.000591293
P2(1): -0.000256263     P2(0): 0.0106793
P3(1): 7.93332e-08 P3(0): 0.000152863
```

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

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

The following plots compare the probe salinity data with the chemical salinity data before and after data adjustment. From Figure 9 it can be seen that the data from the primary sensor (Sal0) are slightly further away from the chemical data than those from the primary sensor (Sal1). The difference between the CTD and the chemical data are in the range [0.002 0.007] for the primary sensor (Sal0) while they are in the range [-.003 0.004] for the secondary sensor (Sal1). Comparisons of Figure 9 with Figure 10 and comparison of Figure 11 with Figure 12 show that the bias, which depends on pressures and time, has been corrected during the calibration. After calibration, the mean and standard deviation of the differences are 0.000000 (resp. -0.000018) and 0.000810 (resp. 0.00074) for the primary (resp. secondary) sensor.

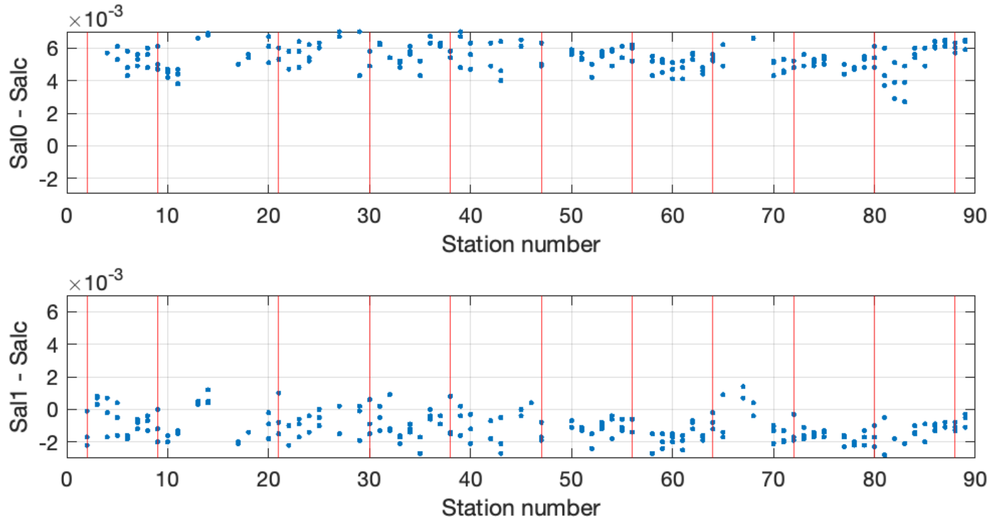


FIGURE 9: SALINITIES COMPARISON BY STATION BEFORE DATA CALIBRATION

For Figure 9 and Figure 10, the upper (resp. lower) panel compares the raw salinity data from the primary (resp. secondary) sensor with the chemical salinity data (Salc). In red are represented the stations corresponding to the first station of a new series of chemical analysis using the Autosal.

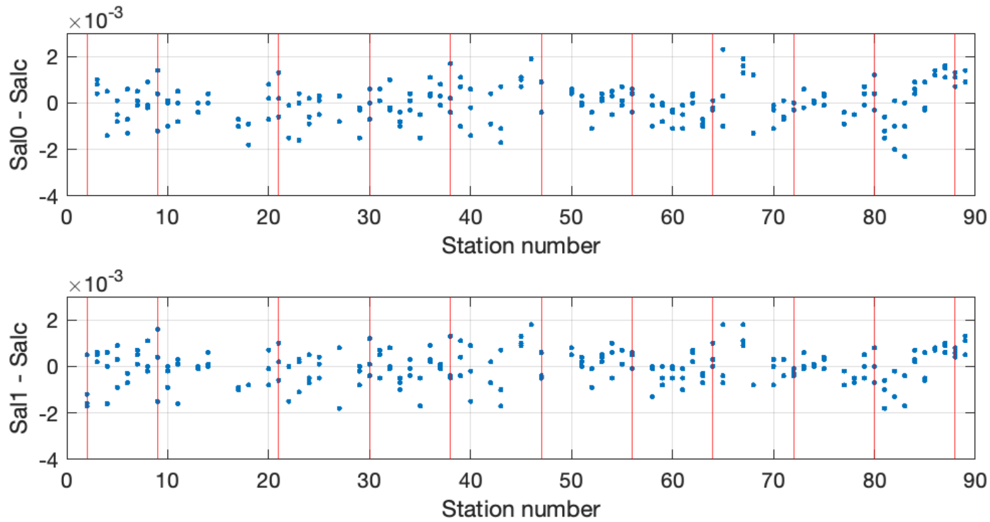


FIGURE 10: SALINITIES COMPARISON BY STATION AFTER DATA CALIBRATION

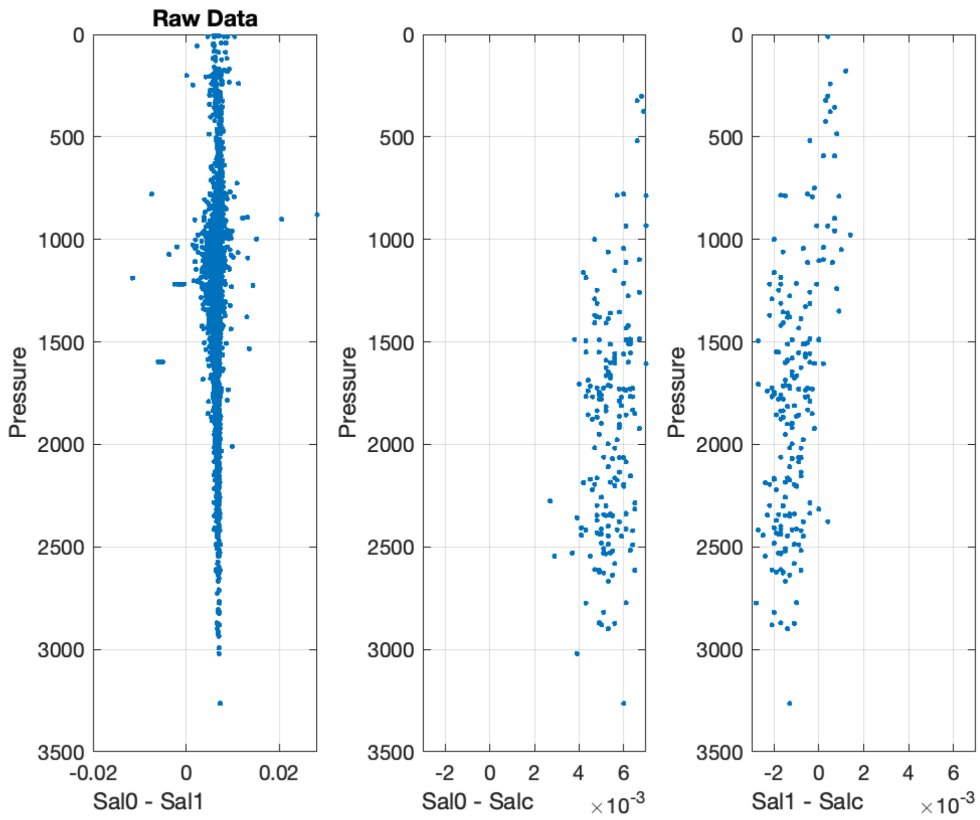


FIGURE 11: CTD AND CHEMICAL SALINITIES COMPARISON VERSUS PRESSURE BEFORE DATA CALIBRATION

In Figure 11, the left plot compares the uncalibrated salinity data from the primary sensor (Sal0) with those from the secondary sensor (Sal1). This is for all bottles that were closed during the cruise (only 10% of them have been measured for salinity). The larger differences observed above 2000 dbar are because the bottles were closed in the fly. The middle (resp. right) plot compares the uncalibrated salinity data from the primary (resp. secondary) sensor with the chemical (bottle) salinity data. The bottles analyzed for salinity were not closed in the fly.

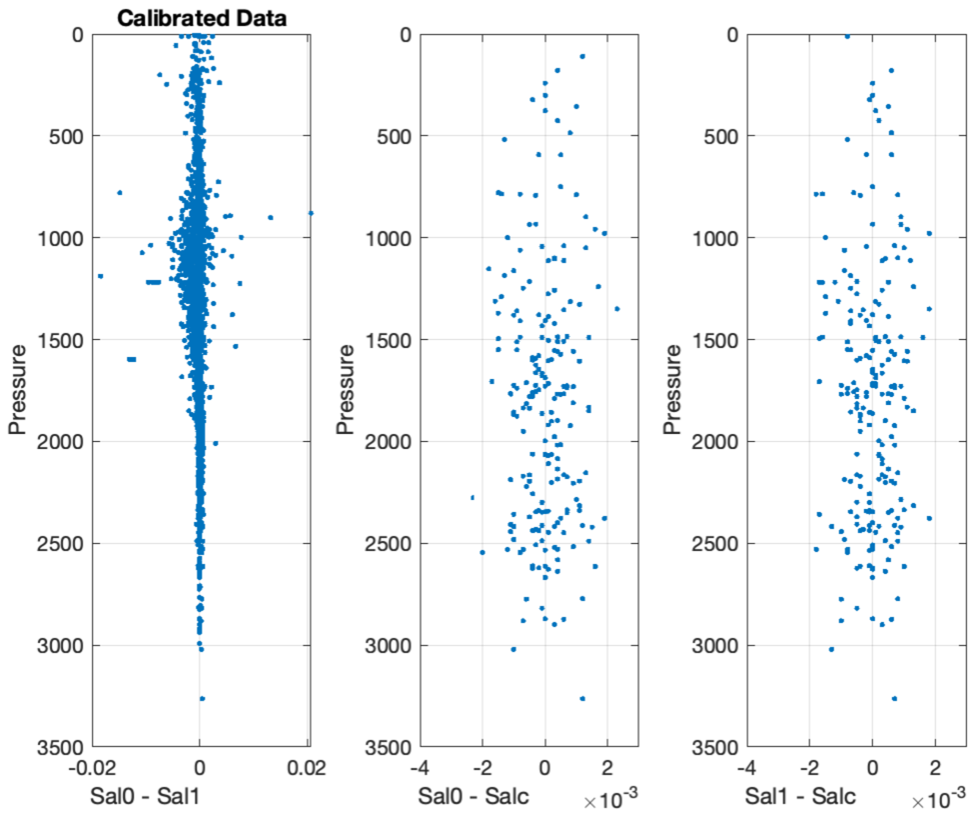


FIGURE 12: CTD AND CHEMICAL SALINITIES COMPARISON VERSUS PRESSURE AFTER DATA CALIBRATION

4.4.3 Dissolved Oxygen

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

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

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

Temperature (°K). Soc, Voffset, A, B, C, E are the parameters associated with the oxygen sensor. Oxsol(T,S) is oxygen saturation.

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

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

The bin average is done in 2 steps :

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

• **step 2** : the oxygen data are bin averaged. For this purpose, only scans with increasing pressure when descending (resp. decreasing pressure when ascending) and with valid data of pressure, temperature, conductivity and oxygen are considered.

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

• Reading of all scans at 24Hz

• Elimination of scans with an invalid sensor value (-9.990 e-29)

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

• Creation of a reduced NetCDF file for the descending profile and a reduced NetCDF file for the ascending profile for each station for each sensors sets (primary and secondary). If bottles were closed during the ascending profile, the sensor data and the chemical data, if they exist, are integrated to each of the files.

- Manual invalidation of probe data to eliminate non-physical salinity peaks (setting of the flag 4 associated with these data (mainly conductivity and salinity))
- Creation of a matlab file for each station containing all the reduced data at 1 dbar (descending and ascending profile for the 2 sets of sensors).

The nomenclature of the file names is as follows : blt3**d**XXX_cli.nc for descending profile files, blt3**a**XXX_cli.nc for ascending profile files, XXX being the station number on 3 digits. The matlab files are named blt3_CTDXXX.mat and contains both up and down cast data. The contents of these files are presented in the appendix.

4.6 APPENDIX

4.6.1 STRUCTURE OF NETCDF REDUCED FILES

```
netcdf blt2d014_cli {
dimensions:
      STRING4 = 4 ;
      STRING20 = 20 ;
      STRING7 = 7 ;
      STRING28 = 28 ;
      N_PROF = 1 ;
      N_PARAM = 6 ;
      N_LEVELS = 1882 ;
      N_PARAM_CHIM = 9 ;
      DATE_TIME = 14 ;
      N_BOTTLES = 24 ;
variables:
      double LATITUDE_BEGIN(N_PROF) ;
            LATITUDE_BEGIN:long_name = "Latitude begin of the station,
best estimates" ;
            LATITUDE_BEGIN:units = "degree_north" ;
            LATITUDE_BEGIN:convention = "decimal degree" ;
            LATITUDE_BEGIN:valid_min = -90. ;
            LATITUDE_BEGIN:valid_max = 90. ;
            LATITUDE_BEGIN:_FillValue = -9999. ;
      double LATITUDE_END(N_PROF) ;
            LATITUDE_END:long_name = "Latitude end of the station, best
estimates" ;
            LATITUDE_END:units = "degree_north" ;
            LATITUDE_END:convention = "decimal degree" ;
            LATITUDE_END:valid_min = -90. ;
            LATITUDE_END:valid_max = 90. ;
            LATITUDE_END:_FillValue = -9999. ;
      double LONGITUDE_BEGIN(N_PROF) ;
            LONGITUDE_BEGIN:long_name = "Longitude begin of the station,
best estimates" ;
```

```
            LONGITUDE_BEGIN:units = "degree_east" ;
            LONGITUDE_BEGIN:convention = "decimal degree" ;
            LONGITUDE_BEGIN:valid_min = -180. ;
            LONGITUDE_BEGIN:valid_max = 180. ;
            LONGITUDE_BEGIN:_FillValue = -9999. ;
      double LONGITUDE_END(N_PROF) ;
            LONGITUDE_END:long_name = "Longitude end of the station,
best estimates" ;
            LONGITUDE_END:units = "degree_east" ;
            LONGITUDE_END:convention = "decimal degree" ;
            LONGITUDE_END:valid_min = -180. ;
            LONGITUDE_END:valid_max = 180. ;
            LONGITUDE_END:_FillValue = -9999. ;
      char STATION_DATE_BEGIN(N_PROF, DATE_TIME) ;
            STATION_DATE_BEGIN:long_name = "Beginning Date_Time of the
station" ;
            STATION_DATE_BEGIN:convention = "YYYYMMDDHH24MISS" ;
            STATION_DATE_BEGIN:_FillValue = " " ;
      char STATION_DATE_END(N_PROF, DATE_TIME) ;
            STATION_DATE_END:long_name = "End Date_Time of the station"
;
            STATION_DATE_END:convention = "YYYYMMDDHH24MISS" ;
            STATION_DATE_END:_FillValue = " " ;
      double JULD_BEGIN(N_PROF) ;
            JULD_BEGIN:long_name = "Julian day (UTC) of the beginning of
the station relative to REFERENCE_DATE_TIME" ;
            JULD_BEGIN:units = "days since 1950-01-01 00:00:00 UTC" ;
            JULD_BEGIN:convention = "Relative julian Days with decimal
part (as parts of day)" ;
            JULD_BEGIN:_FillValue = -9999. ;
      double JULD_END(N_PROF) ;
            JULD_END:long_name = "Julian day (UTC) of the end of the
station relative to REFERENCE_DATE_TIME" ;
            JULD_END:units = "days since 1950-01-01 00:00:00 UTC" ;
            JULD_END:convention = "Relative julian Days with decimal
part (as parts of day)" ;
            JULD_END:_FillValue = -9999. ;
      float BATHYMETRY_BEGIN(N_PROF) ;
            BATHYMETRY_BEGIN:long_name = "Bathymetry at the beginning of
the station" ;
            BATHYMETRY_BEGIN:units = "meter" ;
            BATHYMETRY_BEGIN:_FillValue = -9999.f ;
      float BATHYMETRY_END(N_PROF) ;
            BATHYMETRY_END:long_name = "Bathymetry at the end of the
station" ;
            BATHYMETRY_END:units = "meter" ;
            BATHYMETRY_END:_FillValue = -9999.f ;
      char STATION_PARAMETER(N_PARAM, STRING4) ;
            STATION_PARAMETER:long_name = "Mesured parameter of the
station" ;
            STATION_PARAMETER:_FillValue = " " ;
      float PRES(N_PROF, N_LEVELS) ;
            PRES:long_name = "Sea Pressure" ;
            PRES:Sensor_type = "Digiquartz[db]" ;
            PRES:Sensor_serial_number = 76501 ;
            PRES:resp_param = "MJ MESSIAS" ;
            PRES:Organism_resp = "UNIVERSITY EXETER" ;
            PRES:units = "decibar" ;
```

```
        PRES:valid_min = 0. ;
        PRES:valid_max = 15000. ;
        PRES:precision = -9999. ;
        PRES:_FillValue = -9999.f ;
  float PRES_QC(N_PROF, N_LEVELS) ;
        PRES_QC:long_name = "Sea Pressure quality flag" ;
        PRES_QC:convention = "1: good, 4: bad, 9: No data" ;
        PRES_QC:_FillValue = -9999.f ;
  float TEMP(N_PROF, N_LEVELS) ;
        TEMP:long_name = "In situ temperature ITS-90" ;
        TEMP:Sensor_number = 1. ;
        TEMP:Sensor_type = "SBE3" ;
        TEMP:Sensor_serial_number = 3 ;
        TEMP:resp_param = "MJ MESSIAS" ;
        TEMP:Organism_resp = "UNIVERSITY EXETER" ;
        TEMP:units = "degree celsius" ;
        TEMP:valid_min = -2. ;
        TEMP:valid_max = 40. ;
        TEMP:precision = -9999. ;
        TEMP:_FillValue = -9999.f ;
  float TEMP_QC(N_PROF, N_LEVELS) ;
        TEMP_QC:long_name = "In situ temperature quality flag" ;
        TEMP_QC:convention = "1: good, 4: bad, 9: No data" ;
        TEMP_QC:_FillValue = -9999.f ;
  float COND(N_PROF, N_LEVELS) ;
        COND:long_name = "Conductivity" ;
        COND:Sensor_number = 1. ;
        COND:Sensor_type = "SBE4" ;
        COND:Sensor_serial_number = 4 ;
        COND:resp_param = "MJ MESSIAS" ;
        COND:Organism_resp = "UNIVERSITY EXETER" ;
        COND:units = "mS/cm" ;
        COND:valid_min = 0. ;
        COND:valid_max = 60. ;
        COND:precision = -9999. ;
        COND:_FillValue = -9999.f ;
  float COND_QC(N_PROF, N_LEVELS) ;
        COND_QC:long_name = "Conductivity quality flag" ;
        COND_QC:convention = "1: good, 4: bad, 9: No data" ;
        COND_QC:_FillValue = -9999.f ;
  float PSAL(N_PROF, N_LEVELS) ;
        PSAL:long_name = "Practical Salinity PSS78" ;
        PSAL:Sensor_number = 1. ;
        PSAL:Sensor_type = "SBE4" ;
        PSAL:Sensor_serial_number = 4 ;
        PSAL:resp_param = "MJ MESSIAS" ;
        PSAL:Organism_resp = "UNIVERSITY EXETER" ;
        PSAL:units = "psu" ;
        PSAL:valid_min = 0. ;
        PSAL:valid_max = 60. ;
        PSAL:precision = -9999. ;
        PSAL:_FillValue = -9999.f ;
  float PSAL_QC(N_PROF, N_LEVELS) ;
        PSAL_QC:long_name = "Practical Salinity quality flag" ;
        PSAL_QC:convention = "1: good, 4: bad, 9: No data" ;
        PSAL_QC:_FillValue = -9999.f ;
  float OXYL(N_PROF, N_LEVELS) ;
        OXYL:long_name = "Dissolved oxygen concentration" ;
```

```
            OXYL:Sensor_number = 1. ;
            OXYL:Sensor_type = "SBE43" ;
            OXYL:Sensor_serial_number = 43 ;
            OXYL:resp_param = "MJ MESSIAS" ;
            OXYL:Organism_resp = "UNIVERSITY EXETER" ;
            OXYL:units = "ml/l" ;
            OXYL:valid_min = 0. ;
            OXYL:valid_max = 40. ;
            OXYL:precision = -9999. ;
            OXYL:_FillValue = -9999.f ;
      float OXYL_QC(N_PROF, N_LEVELS) ;
            OXYL_QC:long_name = "Dissolved oxygen concentration quality
flag" ;
            OXYL_QC:convention = "1: good, 4: bad, 9: No data" ;
            OXYL_QC:_FillValue = -9999.f ;
      float OXYK(N_PROF, N_LEVELS) ;
            OXYK:long_name = "Dissolved oxygen concentration" ;
            OXYK:sensor_number = 1. ;
            OXYK:Sensor_type = "SBE43" ;
            OXYK:Sensor_serial_number = 43 ;
            OXYK:resp_param = "MJ MESSIAS" ;
            OXYK:Organism_resp = "UNIVERSITY EXETER" ;
            OXYK:units = "micromol/kg" ;
            OXYK:valid_min = 0. ;
            OXYK:valid_max = 600. ;
            OXYK:precision = -9999. ;
            OXYK:_FillValue = -9999.f ;
      float OXYK_QC(N_PROF, N_LEVELS) ;
            OXYK_QC:long_name = "Dissolved oxygen concentration quality
flag" ;
            OXYK_QC:convention = "1: good, 4: bad, 9: No data" ;
            OXYK_QC:_FillValue = -9999.f ;
      float BOTTLE_NUMBER(N_PROF, N_BOTTLES) ;
            BOTTLE_NUMBER:long_name = "Bottle number" ;
            BOTTLE_NUMBER:_FillValue = -9999.f ;
      char STATION_PARAMETER_CHIM(N_PARAM_CHIM, STRING7) ;
            STATION_PARAMETER_CHIM:long_name = "Mesured chemistry
parameter of the station" ;
            STATION_PARAMETER_CHIM:_FillValue = " " ;
      float CHPRESP(N_PROF, N_BOTTLES) ;
            CHPRESP:long_name = "Probe sea pressure" ;
            CHPRESP:resp_param = "NMF" ;
            CHPRESP:Organism_resp = "NMF" ;
            CHPRESP:units = "decibar" ;
            CHPRESP:valid_min = 0. ;
            CHPRESP:valid_max = 15000. ;
            CHPRESP:precision = -9999. ;
            CHPRESP:_FillValue = -9999.f ;
      float CHPRESP_QC(N_PROF, N_BOTTLES) ;
            CHPRESP_QC:long_name = "Probe sea pressure quality flag" ;
            CHPRESP_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No
data" ;
            CHPRESP_QC:_FillValue = -9999.f ;
      float CHTEMPP(N_PROF, N_BOTTLES) ;
            CHTEMPP:long_name = "Probe in situ temperature ITS-90" ;
            CHTEMPP:Sensor_number = 1. ;
            CHTEMPP:Sensor_type = "SBE3" ;
            CHTEMPP:resp_param = "NMF" ;
```

```
            CHTEMPP:Organism_resp = "NMF" ;
            CHTEMPP:units = "degree celsius" ;
            CHTEMPP:valid_min = -2. ;
            CHTEMPP:valid_max = 40. ;
            CHTEMPP:precision = -9999. ;
            CHTEMPP:_FillValue = -9999.f ;
      float CHTEMPP_QC(N_PROF, N_BOTTLES) ;
            CHTEMPP_QC:long_name = "Probe in situ temperature ITS-90
quality flag" ;
            CHTEMPP_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No
data" ;
            CHTEMPP_QC:_FillValue = -9999.f ;
      float CHPSALB(N_PROF, N_BOTTLES) ;
            CHPSALB:long_name = "Bottle Practical Salinity PSS78" ;
            CHPSALB:resp_param = "NMF" ;
            CHPSALB:Organism_resp = "NMF" ;
            CHPSALB:units = "psu" ;
            CHPSALB:valid_min = 0. ;
            CHPSALB:valid_max = 60. ;
            CHPSALB:precision = -9999. ;
            CHPSALB:_FillValue = -9999.f ;
      float CHPSALB_QC(N_PROF, N_BOTTLES) ;
            CHPSALB_QC:long_name = "Bottle Practical Salinity PSS78
quality flag" ;
            CHPSALB_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No
data" ;
            CHPSALB_QC:_FillValue = -9999.f ;
      float CHPSALP(N_PROF, N_BOTTLES) ;
            CHPSALP:long_name = "Probe Practical Salinity PSS78" ;
            CHPSALP:Sensor_number = 1. ;
            CHPSALP:Sensor_type = "SBE4" ;
            CHPSALP:resp_param = "MJ MESSIAS" ;
            CHPSALP:Organism_resp = "UNIVERSITY EXETER" ;
            CHPSALP:units = "psu" ;
            CHPSALP:valid_min = 0. ;
            CHPSALP:valid_max = 60. ;
            CHPSALP:precision = -9999. ;
            CHPSALP:_FillValue = -9999.f ;
      float CHPSALP_QC(N_PROF, N_BOTTLES) ;
            CHPSALP_QC:long_name = "Probe Practical Salinity PSS78
quality flag" ;
            CHPSALP_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No
data" ;
            CHPSALP_QC:_FillValue = -9999.f ;
      float CHOXYLB(N_PROF, N_BOTTLES) ;
            CHOXYLB:long_name = "Bottle dissolved oxygen concentration"
;
            CHOXYLB:resp_param = "NMF" ;
            CHOXYLB:Organism_resp = "NMF" ;
            CHOXYLB:units = "ml/l" ;
            CHOXYLB:valid_min = 0. ;
            CHOXYLB:valid_max = 40. ;
            CHOXYLB:precision = -9999. ;
            CHOXYLB:_FillValue = -9999.f ;
      float CHOXYLB_QC(N_PROF, N_BOTTLES) ;
            CHOXYLB_QC:long_name = "Bottle dissolved oxygen
concentration quality flag" ;
```

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

```
            CHTMPOB:valid_min = -2. ;
            CHTMPOB:valid_max = 40. ;
            CHTMPOB:precision = -9999. ;
            CHTMPOB:_FillValue = -9999.f ;
      float CHTMPOB_QC(N_PROF, N_BOTTLES) ;
            CHTMPOB_QC:long_name = "Oxygen sample temperature ITS-90
quality flag" ;
            CHTMPOB_QC:convention = "1: good, 3: doubtful, 4: bad, 9: No
data" ;
            CHTMPOB_QC:_FillValue = -9999.f ;

// global attributes:
            :ORIGINAL_CLI = "blt2d014_cli.nc" ;
            :SHIP_NAME = "RRS DISCOVERY" ;
            :SHIP_WMO_ID = "" ;
            :PI_NAME = "MJ MESSIAS" ;
            :PI_ORGANISM = "EXETER UNIVERSITY" ;
            :CRUISE_NAME = "BLT2" ;
            :STATION_NUMBER = 14. ;
            :LEG_NUMBER = "1" ;
            :DIRECTION = "d" ;
            :DATA_PROCESSING_ORGANISM = "LPO/IFREMER" ;
            :PROBE_TYPE = "SBE 911" ;
            :PROBE_NUMBER = 76501 ;
            :REFERENCE_DATE_TIME = "19500101000000" ;
            :DATE_CREATION = "20220201120644" ;
            :LAST_UPDATE = "20220201120644" ;
            :COORD_SYSTEM = "GEOGRAPHICAL-WGS84" ;
            :BOTTLE_VOL = "12L" ;
            :ROSETTE_TYPE = "SEABIRD" ;
            :PINGER = "y" ;
            :SAMPLING_MODE = "r" ;
            :DATA_MODE = "calibrated" ;
            :SPUN_LINE = -9. ;
            :DIST_PROBE_BOTTOM = 5. ;
            :PRESCRIBED_CTD_VELOCITY = "1 m/s" ;
            :SOFTWARE_VERSION = " CADHYAC 3.1" ;
            :COMMENTS = " " ;
}
```

4.6.2 STRUCTURE OF A MATLAB FILE

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

Metadata structure :

STATION_NUMBER

LATITUDE_BEGIN

LATITUDE_END

LONGITUDE_BEGIN

LONGITUDE_END

STATION_DATE_BEGIN

STATION_DATE_END

SHIP

PI

PI_organism

cruise

probe

name :

{'pres0, pressure for primary sensors (db)'}

{'pres1, pressure for secondary sensors (db)'}

{'temp0, primary temperature ITS-90 (°C)'}

{'temp1, secondary temperature ITS-90 (°C)'}

{'cond0, primary conductivity (mS/cm)' }

{'cond1, secondary conductivity (mS/cm)'}

{'psal0, primary salinity PSS-78 (psu)'}

{'psal1, secondary salinity PSS-78 (psu)'}

{'oxyl0, dissolved oxygen calculated from primary sensors (ml/l)'}

{'oxyl1, dissolved oxygen calculated from secondary sensors (ml/l)'}

{'oxyk0, dissolved oxygen calculated from primary sensors (micromol/kg)'}

{'oxyk1, dissolved oxygen calculated from secondary sensors (micromol/kg)'}

{'chemical_psal, chemical bottle salinity (psu)'}

{'chemical_oxyl, chemical bottle dissolved oxygen (ml/l)'}

{'chemical_oxyk, chemical bottle dissolved oxygen (micromol/kg)'}

{'chemical_tempoxy, oxygen sample temperature (Â°C)'}

{'qc, quality flag, 1: good, 3: doubtful, 4: bad, 6 : uncalibrated, 9: No data'}

The data are in the following variables :

pres0_down

pres0_qc_down

temp0_down

temp0_qc_down

cond0_down

cond0_qc_down

psal0_down

psal0_qc_down

oxyl0_down

oxyl0_qc_down

oxyk0_down

oxyk0_qc_down

pres0_up

pres0_qc_up

temp0_up

temp0_qc_up

cond0_up

cond0_qc_up

psal0_up

psal0_qc_up

oxyl0_up

oxyl0_qc_up

oxyk0_up

oxyk0_qc_up

pres1_down

pres1_qc_down

temp1_down

temp1_qc_down

cond1_down

cond1_qc_down

psal1_down

psal1_qc_down

oxyl1_down

oxyl1_qc_down

oxyk1_down

oxyk1_qc_down

pres1_up

pres1_qc_up

temp1_up

temp1_qc_up

cond1_up

cond1_qc_up

psal1_up

psal1_qc_up

oxyl1_up

oxyl1_qc_up

oxyk1_up

oxyk1_qc_up

pres_bottle

pres_qc_bottle

temp0_bottle

temp0_qc_bottle

psal0_bottle

psal0_qc_bottle

oxyl0_bottle

oxyl0_qc_bottle

oxyk0_bottle

oxyk0_qc_bottle

temp1_bottle

```
temp1_qc_bottle
psal1_bottle
psal1_qc_bottle
oxyl1_bottle
oxyl1_qc_bottle
oxyk1_bottle
oxyk1_qc_bottle
chemical_psal_bottle
chemical_psal_qc_bottle
chemical_oxyl_bottle
chemical_oxyl_qc_bottle
chemical_oxyk_bottle
chemical_oxyk_qc_bottle
chemical_tempoxy_bottle
chemical_tempoxy_qc_bottle
```

5 MICROSTRUCTURE

5.1 EPSILOMETER

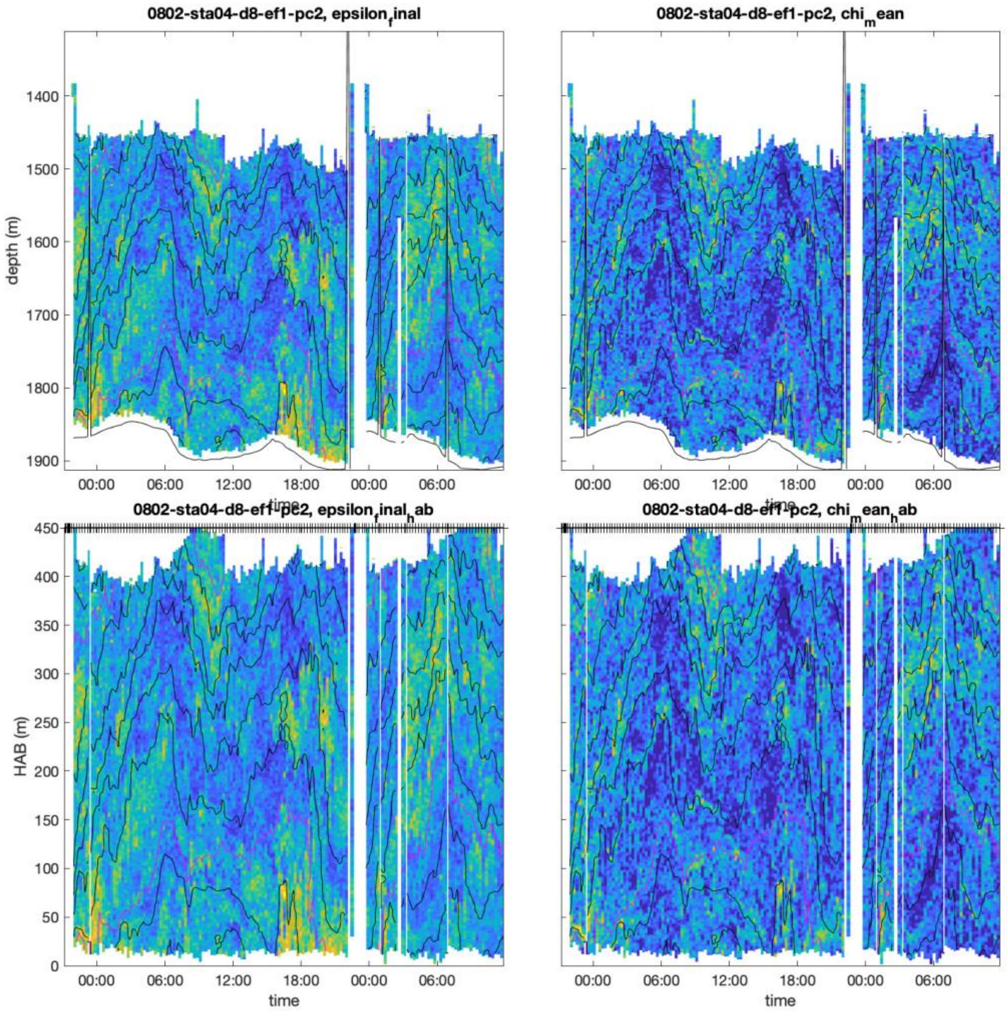
Matthew Alford, Nicole Couto, Sara Goheen, Arnaud Le Boyer, Helen Dufel, Bethan Wynne-Cattanach, Andrea Rodriquez-Marin freudmann, Isabella Franco, Charlotte Bellerjeau

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 profiling mode from the ship on this cruise. On each deployment, we sampled with two shear probes and two fast-response thermistors allowing us to use the shear and temperature gradient wavenumber spectra to compute the dissipation rate of turbulent kinetic energy (ε) and the dissipation rate of thermal variance (χ) using standard methods.

This year, in order to resolve the tidal phases, we aimed to complete timeseries of 36 hours. We were able to complete six timeseries between 22 hours and 41 hours in duration (Figure 3). During all of the Epsifish deployment, 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 depth limit of the epsilon data in Figures 13-15. As the tide flows up-canyon, the fish moves into shallower water, and as the tide flows down-canyon the fish moves into deeper water.

TABLE 5: EPSIFISH EVENT LOG

Date	Duration	Location
August 2	22 hours	54.22 N, 11.91 W, over ADCP lander location
August 4	35 hours	54.17 N, 11.83 W, over G1 mooring location
August 7	31 hours	54.16 N, 11.81 W, at camera/megacore location
August 8	33 hours	54.18 N, 11.84 W, over MAVS4 mooring location
August 10	28 hours	54.18 N, 11.85 W, 1200 m isobath, near MAVS4 mooring
August 12	41 hours	54.19 N, 11.85 W, 1200 m isobath, near MAVS4 mooring


0802-sta04-d8-ef1-pc2, epsilon_final
0802-sta04-d8-ef1-pc2, chi_mean
depth (m)
1400
1500
1600
1700
1800
1900
00:00
06:00
12:00
18:00
00:00
06:00
time
0802-sta04-d8-ef1-pc2, epsilon_final_hab
0802-sta04-d8-ef1-pc2, chi_mean_hab
HAB (m)
450
400
350
300
250
200
150
100
50
0
time

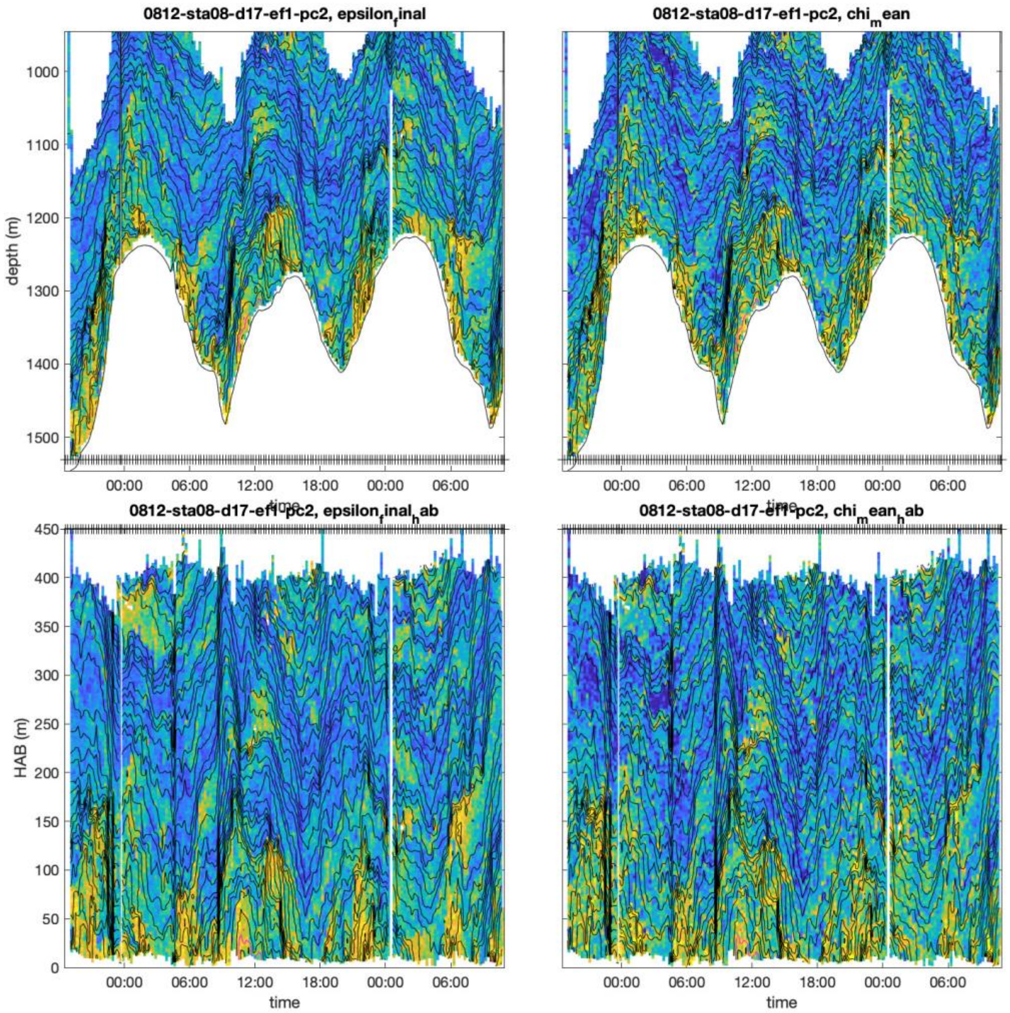


FIGURE 13: EPSILON AND CHI VERSUS PRESSURE AND HEIGHT ABOVE BOTTOM

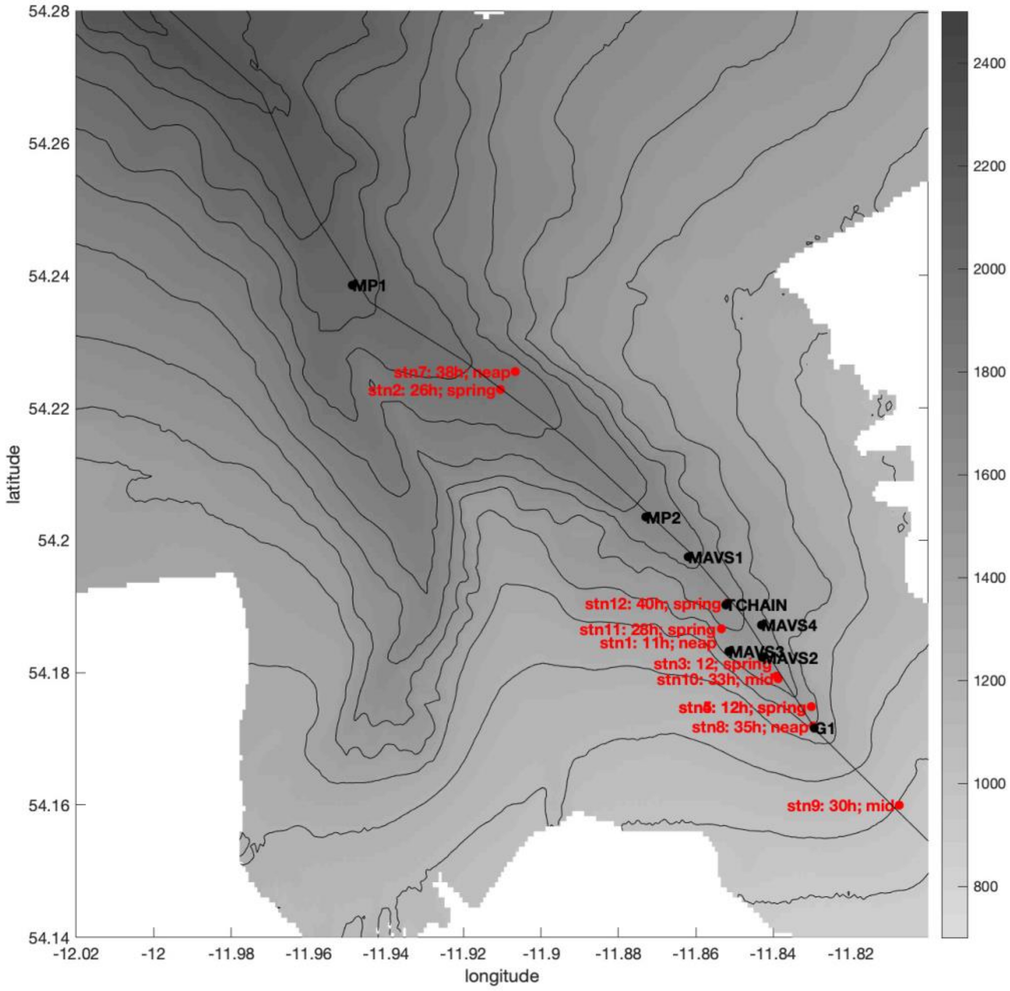


FIGURE 14: EPSIFISH STATION MAP IN RELATION TO MOORING SITES

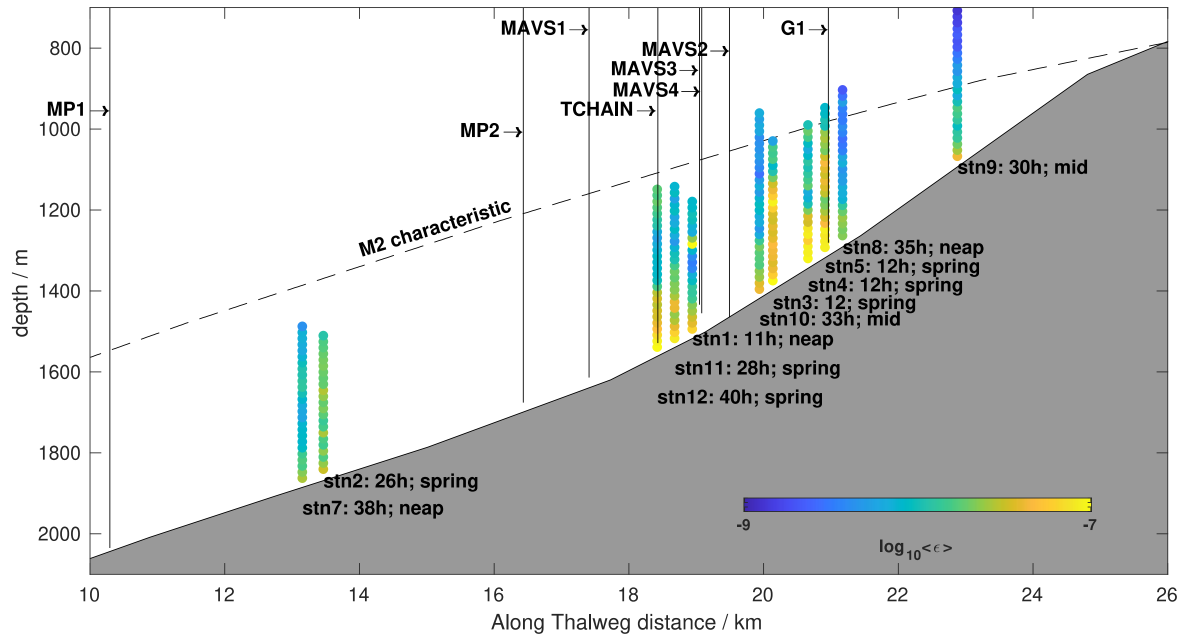


FIGURE 15: CROSS SECTION SHOWING TIME-MEAN EPSILON AT EACH EPSIFISH STATION

5.2 HIGH RESOLUTION PROFILER (HRP3) USE IN BLT3/DY153

Kurt Polzin, Brian Hogue, Alex Forryan, Andrea Rodriguez-Marin Freudmann, Kate Oglethorpe.

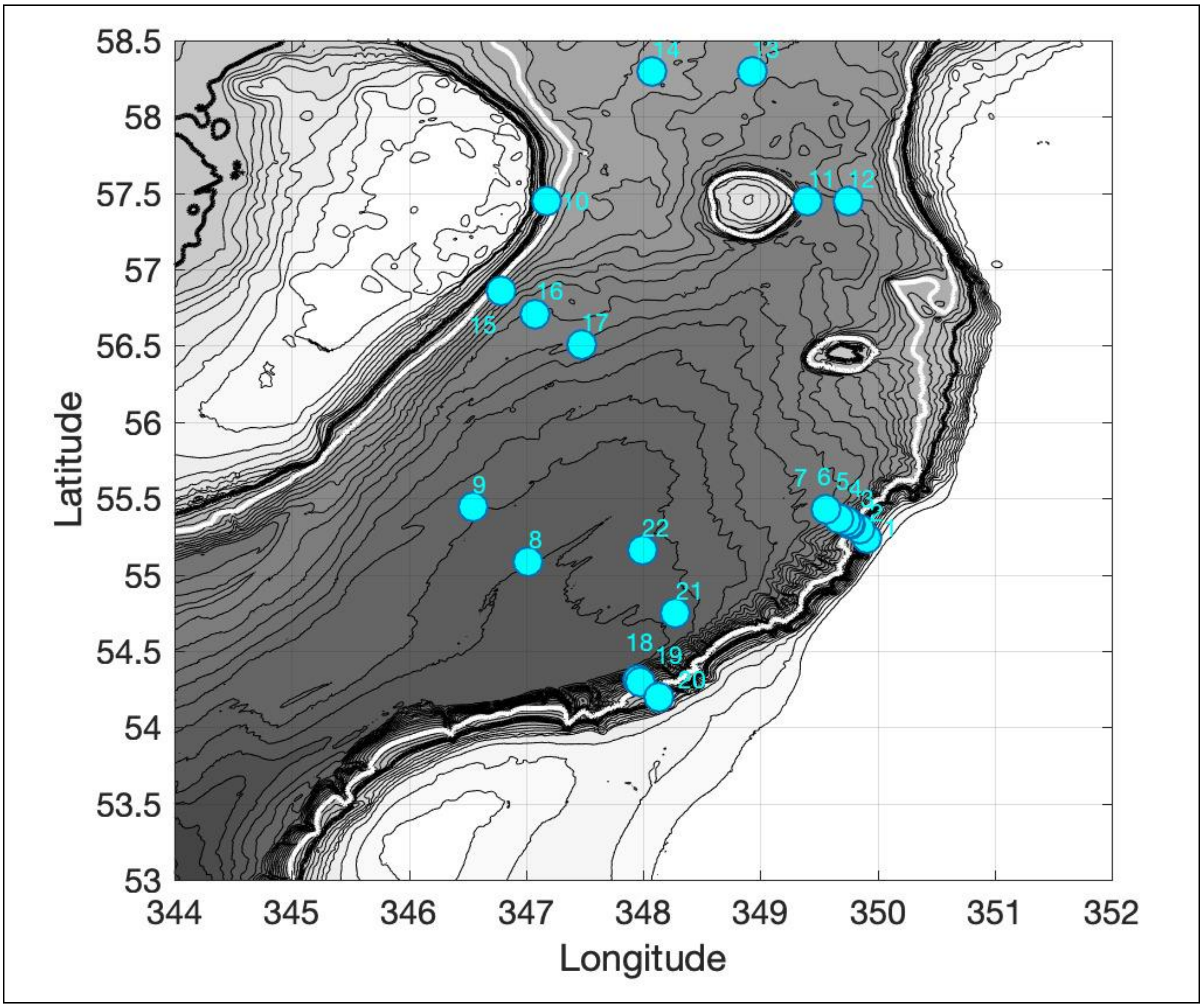


FIGURE 16: HRP SAMPLING DURING BLT-3

The High Resolution Profiler (HRP) is a free-fall vertical profiler designed to sample te entire vertical range of spatial variability in ocean velocity, temperature, salinity and density. The freefall configuration eliminates vibrations and extraneous tug ging 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 transponders 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.

The two data suites are provided by multiple instrument subsystems that are integrated by a Beaglebone UNIX controller. The instrument subsystems include a Rockland Scientific International micro-Rider providing microstructure and CTD data at 64 and 512 Hz sampling rates. The micro-Rider also provides a calibrated 1 Hz pressure signal that the UNIX controller uses for dive control operations. Finescale velocity is provided by a Modular Acoustic Velocity Sensor (MAVS) and complemented by Microstrain IMU. The electronics also include a Trident 200 kHz altimeter for estimating height of the instrument from the bottom

Historically, the major systemic performance issues concern intermittent aborts resulting from the micro-Rider improperly sending pressure data to the Beaglebone controller in a timely manner and communication failures with the altimeter. Efforts to improve communications between the altimeter and Beaglebone controller with new connectors and polypro cables proved successful as no altimeter aborts were encountered. Two instances of early terminations (Dives 4 and 5) were encountered in which the altimeter provided ambiguous data that eventually triggered the dive termination criteria. These are normal behaviour when the altimeter is turned when more than 150m from bottom and the release height is in excess of 50m height above bottom. Aborted profiles associated with the 1 Hz pressure channel (Dives 1, 2, 9, 12 and 22) continue to be problematic.

The 2022 Boundary Layer Turbulence – Recipes cruise (BLT3) represents the fifth 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 and plug-and-play option in case repair was required. A total of 22 profiles were obtained, Figure 16. HRP efforts were backstopped by Vertical Microstructure Profie (VMP) capabilities provided by the National Marine Facilities (NMF) personnel. Work was conducted in support of tracer sampling and occurred in conjunction with deployment of a LADCP/CTD rosette system.

TABLE 6: HRP DIVE CONTROL PARTICULARS

HRP	Depth (m)	Pmax [Dbars]	Max(P) [Dbars]	Alt. on [Dbars]	Nominal range [m]	Range [m]	Release code	Comments
01	792	500	382.21	400	50.0	n/a	P abort 2	Out of bounds
02	1122	1050	797.74	975	50.0	n/a	P abort 2	Out of bounds
03	1612	1575	578.78	1475	50.0	n/a	W abort	Unit box hangs
04	1789	1750	1626.27	1625	50.0	44.6	A	Early
05	1984	1962	1838.98	1837	50.0	49.1	A	Early
06	2196	2360*	2145.70	2235	50.0	n/a	T	
07	2388	2441	2401.70	2290	20.0	19.8	A	
08	2895	2940	2929.44	2800	10.0	9.9	A	
09	2780	2830	319.20	2700	10.0	n/a	P abort 1	No pressure
10	1199	1280	1198.75	1081	10.0	9.8	A	
11	2226	2313	2246.42	2113	10.0	9.9	A	
12	2103	2140	45.37	1975	5.0	n/a	P abort 2	Out of bounds
13	1906	500	500.26	475	10.0	n/a	P	Switch to HRP3a
14	1728	1760	1735.77	1620	20.0	19.9	A	
15	1760	1790	1763.32	1650	10.0	9.9	A	
16	2313	2335	2335.01	2200	10.0	14.1	P	Back to HRP3b
17	2400	2725	2441.70	2525	10.0	n/a	T	Stuck in the mud
18	2577	2689	2610.64	2400	10.0	10.0	A	
19	2416	2476	2405.47	2276	10.0	10.0	A	
20	1635	1675	1624.78	1475	10.0	9.9	A	
21	2834	2900	2879.79	2700	10.0	9.9	A	
22	2836	2900	547.26	2725	10.0	n/a	P abort 2	Out of bounds

TABLE 7: HRP DIVE LOG

Sta	Event	HRP	CTD	Deploy	Lat	Lon	Recover	Lat	Lon
T1-2	140/141	01	04	08-16 09:21:55	55.238379	-10.090269	08-16 09:54:52	55.236192	-10.086032
T1-3	146/148	02	05	08-16 12:33:56	55.295297	-10.1491	08-16 13:07:18	55.294651	-10.147986
T1-5	156/158	03	07	08-16 19:03:03	55.3318	-10.227503	08-16 20:06:54	55.339587	-10.206154
T1-6	162/165	04	08	08-16 22:52:48	55.338266	-10.243403	08-17 00:26:37	55.341729	-10.231187
T1-7	170/173	05	09	08-17 00:26:37	55.351285	-10.26732	08-17 03:59:36	55.354099	-10.262462
T1-8	178/181	06	10	08-17 05:55:15	55.366266	-10.331112	08-17 07:48:43	55.373948	-10.318558
T1-9	185/189	07	11	08-17 09:53:13	55.425731	-10.443369	08-17 12:09:17	55.434504	-10.434369

T4-6	249/251	08	20	08-20 14:26:45	55.083003	-12.979207	08-20 17:13:10	55.088299	-12.948567
T4-5	255/259	09	21	08-20 21:51:22	55.441865	-13.451612	08-21 01:07:25	55.469004	-13.444995
T2-1	293/296	10	26	08-22 08:42:49	57.448737	-12.8191	08-22 09:59:33	57.442694	-12.818076
T2-5	324/327	11	33	08-23 09:54:26	57.447347	-10.59456	08-23 11:55:33	57.452212	-10.596706
T2-6	330/332	12	34	08-23 13:58:21	57.44788	-10.251386	08-23 14:34:07	57.44865	-10.25445
T3-2	367/368	13	39	08-24 17:37:34	58.294179	-11.071177	08-24 18:20:31	58.2928.25	-11.0712
T3-1	370/374	14	40	08-24 22:05:26	58.299588	-11.923711	08-24 23:38:43	58.304357	-11.912688
T1-16	384/386	15	43	08-25 16:24:23	56.860145	-13.214614	08-25 17-57-49	56.858386	-13.224263
T1-14	395/399	16	45	08-25 22:10:09	56.709819	-12.921611	08-26 00:04:25	56.709819	-12914367
SO-1	402/413	17	46	08-26 02:27:33	56.510032	-12.526778	08-26 17:17:27	56.512499	-12.504544
T4-10	474/478	18	60	08-29 03:16:43	54.314813	-12.045654	08-29 05:36:45	54.31662	-12.036204
T4-11	481/485	19	61	08-29 06:30:00	54.294576	-12.027882	08-29 06:30:00	54.300463	-12.026859
T4-14	502/506	20	64	08-29 15:00:39	54.200478	-11.867444	16:23:33	54.19784	-11.869583
T9-3	541/545	21	73	08-30 13:08:00	54.750012	-11.721866	08-30 15:34:36	54.743659	-11.745897
T9-2	547/551	22	74	08-30 18:43:07	55.159907	-12.00951	08-30 21:13:01	55.151329	-12.002768

5.2.1 Sensor Subsystem Performance

5.2.1.1 Dive Control

Altimeter based bottom approaches of 2 metres 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 when the altimeter failed to report data at start up. This trend continued during BLT-3 in which no altimeter aborts were experienced. Two instances of early terminations (dives 4 and 5) were encountered in which the altimeter provided ambiguous data that eventually triggered the dive termination criteria. These are normal behaviour when the altimeter is turned when more than 150m from bottom of the release height is in excess of 50m height above bottom.

Aborted profiles associated with the 1Hz pressure channel (dives 1, 2, 9, 12 and 22) continue to be problematic. Dive control logic on the Beaglebone aborts a dive if five failures in a row are encountered, in which a ‘failure’ is either no data transferred in a two second window (abort code 1) or the pressure data are out of bounds (abort code 2, either less than -5 Dbar or greater than 6000 Dbar). Abort code two signals an issue with the serial data transfer. Coincident with these dive aborts are 0-byte length .P data files in the micro-Rider. After the second pressure abort, the pressure case of HRP3b was opened and the clock battery (new as of January 2022) was replaced. It was noted that the mu-metal cover on the micro-Rider was missing all but one of its plastic retaining bolts, resulting in that cover ‘flapping in the wind’. After the third abort, the compact flash card was erased. After the fourth, HRP3a was used. Electronic noise with HRP3a was problematic and operations resumed with HRP3b at dive 16. At this juncture it wasn’t clear whether the zero byte length .P data files were a systemic issue of the micro-Rider’s disk operating system having difficulty utilising the compact flash as a disk, or whether this was merely a symptom of a different problem. This a ‘-X’ was appended to the micro-Rider’s AUTOEXEC.BAT file to eliminate recording of .P files on the micro-Rider’s compact flash. The hope here was that a corrupt serial data transfer of the 1Hz pressure could be eliminated by reducing the work load of the Micro-Rider’s Persistor controller. After the fifth pressure abort the electronics were unshipped from the pressure case and full-scale diagnostic efforts ensued:

- The CF2 boards from HRP3a were placed into HRP3b, electronics rack placed into the pressure case. The unit had a very difficult time running 10-15 minute bench tests.
- The electronics rack was unshipped and 3x15 minute bench tests were completed with *both* the HRP3a and HRP3b end caps. The unit was placed back into the pressure case and failed to complete a bench test.

- The electronics rack was unshipped and it was noted that the blind mate screws on the HRP3b end cap were loose, possinly resulting in a warping of the electronic rack, leading to grounding of the rack with the pressure case. The screws were tightened and the unit placed back into the pressure case. It had a very difficult time completing 10-15 minute bench tests.
- The electronics rack was unshipped and 10x15 minute bench tests were successfully performed.
- The mu-metal covering the micro-Rider electronics was removed, the electronics rack replaced in the pressure case and 10x15 minute profiles were successfully performed. The mu-metal cover was then entirely covered with electrician's tape.
- The electronics rack was unshipped, the fully taped mu-metal cover mounted and 10x15 bench tests were successfully performed.

At the end of this diagnostic effort, electronic noise levels on the unit were consistent with Rockland's specifications. We are led to believe that the pressure aborts result from grounding of the electronics rack with the pressure case. There is some collective memory that this vintage of DOS operating system results in the loss of a data file if power is pulled, explaining 0 byte length .P data files. There was also a watchdog abort (dive 3) indicating that the UNIX controller hung.

5.2.1.2 Finestructure

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

<u>CTD performance</u>

The HRP3 utilise a pumped SeaBird (SBE) 3-4 T/C sensor system and a 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 on 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; Morrison et al, 1994; Johnson et al, 2007). 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 64Hz) 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 seawater in the conductivity cell may be predicted with the following (in Matlab):

$$[b, a] = butter(1, \text{thermal mass time constant})$$

$$T_{\text{cell}} = filter(b, a, Tsbe)$$

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 quadrating calibration for the raw pressure data with coefficients (scale factors, bias) was obtained from laboratory measurements at Woods Hole (Kurt Polzin and Jason Smith, operators, June 23, 2022):

rawP_coefs = [-67.40170 0.4036580 -1.3412*e*-07] (HRP3a)

rawP_coefs = [-118.1120 0.3935728 -1.2740*e*-07] (HRP3b)

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

TABLE 8: HRP SENSOR CALIBRATIONS

Sensor	Serial number	Calibration date
SBE 03F.320	03-5863	22-Apr-2022
SBE 04C.320	04-4507	13-Apr-2022
SBE 05T.22221	05-8682??	
Keller PA11/80059/600Bar	1053037 (HRP3a)	13.05.2022
Keller PA11/80059/600Bar	1053038 (HRP3b)	13.05.2022

CTD performance was improved by addressing the exhaust ducting of the pump, which had previously been ported out the top end of the HRP. This is likely not a bad idea, but a practical issue developed in keeping the exhaust duct tubing from collapsing while making small radius turns at the profiler top. The exhaust duct was modified to be consistent with SeaBird specifications and ported out through the HRP nose, at a depth equivalent to the intake. Greatly reduced salinity spiking was noted in comparison to BLT-1 data.

<u>Modular Acoustic Velocity Sensor (MAVS)</u>

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 path 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*):

C =	[-.3660	-.3660	.3660	.3660
	.3660	-.3660	-.3660	.3660
	.9659	.9659	.9659	.9659];

$$hrpvel = (C * (senvel)^1)^1;$$

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 in 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) and Schmidt et al (1988) 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 centre of mass of the HRP is thus derived by time integrating Newton's first law: $F = ma$. (The time integral of accelerating is velocity.) Subsequently, the ocean velocity is obtained by summing the centre 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 practise, 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 point mass 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. Ni similar process has been discovered for correcting 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 1-200m 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).

Better agreement between MAVS *w* and *dP/dt* on this cruise than in either GOMIX1-3 or BLT-1. There are two possible reasons. The first is the repair of the transducers. The second is a change in the personnel doing the calibrations and a change in the volume of the container used for calibrations as FiXIT personnel used a different *larger?* tub (23" dia x 16" deep compared with 18"x18"x12" deep) with reduced potential for reflections.

TABLE 9: HRP CALIBRATIONS FOR THE MAVS ACOUSTIC CURRENT METER

MAVS ACM	HRP3 Casts	Zeros	Date	Comment
HRP3a	13-15	[1557.7 -1877.9 142.2 -1720.0]	June 27, 2022	Hogue/Davies
HRP3b	1-12&16-22	[710.6 -1688.6 -49.05 -928.8]	June 27, 2022	Hogue/Davies

- The HRP3a string is visually out of alignment.
- Connectors coming out of both stings need to be cleaned up.
- The ACM for HRP3a is currently wired backwards. This needs to be corrected for in post-processing of dives 13-15, a step which, as of writing, has not been taken.

IMU

The motion package in the HRP is a Microstrain, Inc. unit that includes a 3-axis fluxgate compass, 3-axis accelerometer system and a 3-axis rate gryo. Fata 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 pause in the transmission of further data if it were not for the flushing of a buffer. This buffer flushing 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 scan of a sensor running at 25Hz once every 2-5 minutes is a little consequence.

GPS

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. Once 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 HRPs surfacing position, instroducing error in the estimated depth-average ocean veloxity. The HRP carries its own GPS transceiver but this unit is intended primarily for location HRP after surfacing. The GPS unit samples and reports position fixes on rather long time intervals (again, instroducing 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.

5.2.1.3 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. Electronic noise was problematic for BLT-3, as it was on BLT-1. The noise levels of HRP3a were unacceptably high, resulting in HRP3b being used for the bulk of the cruise despite issues with the dive termination. The shear data are contaminated by noise of an electronic origin with one channel better than the other and shifting characteristics as attempts were made to address the issue. The micro-temperature data are less problematic than the shear. An exception is the appearance of a 27Hz noise spike in (μT_1) that required a 'notch' filter in processing. The pre-emphasised micro-conductivity data of HRP3b suffered from high noise levels that were board related on BLT-1. Replacement of the board returned far better data in BLT-3.

The data were processed using the program micro diagnositcs 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 intergration 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^2m^{-2} / cps

Conductivity $P_n(f) = C\ 1.4 \times 10^{-7} \times f^{1.5}[sinc(f/512)]^4$ $mmho^{-2}$ / cps

With *f* being frequency in cycles per second (cps), $sinc(x) = sin(\pi x)/\pi x$ and 512 Hz being the sampling frequency of the microstructure 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 *E* is estimated from formulas assuming isotropic relations between components of the rate of strain tensor a $E = 15/2vS$ with molecular viscosity *v* 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 those ½ 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. The 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 neighbours, 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) the 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. The program provides an estimate of ε and two estimates of χ, one based upon a maximum signal-to-noise ratio 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 Kracihnan passive scalar spectrum for frequencies greater than 15 Hz.

TABLE 10: HRP MICROSTRUCTURE PROBE USAGE AND ASSESSMENTS

Cast	Sx	Sy	T1	T2	C1	Comment
01-10	M1604	M1605	T2026	T2027	C238	Comment
11-13	M2200	M2203	T2026	T2027	C297	Comment
14	M2200	M2203	T1958	T2027	C297	Comment
15-22	M2200	M2203	T1958	T2027	C297	Comment

One *in situ* calibration for the thermistor time constants was attempted in BLT-1. This was based upon HRP 14 in a region of high dissipation ($\varepsilon > 10^{-7}$ W/kg) and low salinity gradient. This is assumed to apply to all the probes used in this (BLT-3) experiment. This really need to be re-evaluated as there are significant questions about probe response that could be related to the nibs not projecting far enough from the sensor mount.

TABLE 11: HRP SHEAR PROBE SENSITIVITIES AND CALIBRATION DATES

M1604	0.0624	Feb. 22, 2019	Delaminated during BLT-1. RETIRE
M1605	0.0433	Feb. 25, 2019	Not loving this during BLT-1. RETIRE
M2200	0.0722	Jan. 20, 2020	
M2202	0.0617	Jan. 20, 2020	
M2203	0.0911	Jan. 21, 2020	Sceptical about this number. See scatter plots

TABLE 12: HRP THERMISTOR TIME CONTRAINTS

T1958	0.0089	nominal
T2026	0.0089	nominal
T2027	0.0089	nominal

5.3 VERTICAL MICROSTRUCTURE PROFILER

Alex Forryan, Andrea Rodriguez-Marin Freudmann, Kate Oglethorpe

During DY153/BLT3 a series of microstructure observations were made using two untethered (VMP 6000s SN016 and SN107) freefall profilers 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 and temperature variance 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.

5.3.1 VMP 6000 OPERATIONS

On DY153 a total of 21 VMP 6000 profiles were collected.

TABLE 13: VMP-6000 DEPLOYMENTS

CTD	Date	Time (GMT)	Lat.(ºN)	Lon.(ºE)	Depth (m)	Comments
12	18/8/22	00:00	53.926844	-11.506604	299	shear 2 to be swapped out
14	18/8/22	04:46	54.093294	-11.678763	383	
15	18/8/22	07:35	54.126931	-11.760774	673	
22	21/8/22	05:03	55.800936	-13.930505	2439	
23	21/8/22	11:01	55.915323	-14.083736	2201	
24	21/8/22	13:32	56.010722	-14.210288	1853	
25	21/8/22	17:06	56.091274	-14.316125	1515	
35	23/8/22	17:20	57.448536	-9.921031	1855	
36	23/8/22	20:44	57.448997	-9.765392	1504	
37	24/8/22	03:45	58.30075	-9.77244	1849	shear 1 & 2 rotated to be same orientation
38	24/8/22	08:26	58.302467	-10.213009	1908	power restarts - data files corrupt
39	24/8/22	15:45	58.298763	-11.068169	1903	power restarts again.
44	25/8/22	18:47	56.818845	-13.133219	2009	shear 1 noisy
54	27/8/22	18:29	56.356898	-10.520915	1778	shear 1 to be swapped out
55	27/8/22	22:44	56.447822	-9.973121	1722	power restarts - data file corrupt
56	28/8/22	01:20	56.447948	-9.731161	1590	shear 1 noisy
62	29/8/22	09:50	54.235224	-11.9437	1997	
63	29/8/22	12:24	54.222261	-11.91382	1861	
75	30/8/22	12:30	55.561699	-12.303111	2867	shear2 broken
76	31/8/22	13:53	55.571911	-15.274051	1208	
77	31/8/22	16:40	55.472412	-15.198151	1760	

5.3.2 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:

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

6 WATER SAMPLING AND ANALYSES

6.1 TRIFLUOROMETHYL SULFUR PENTAFLUORIDE (CF_3SF_5) MEASUREMENTS

Marie-José Messias[1], Herlé Mercier[2], Jack Hughes[1], Jonathan Crocker and Hannah Green,
Both MAVS moorings and the MP mooring were recovered, serviced and redeployed
[1]University of Exeter University, UK and [2]CNRS Ifremer Plouzane, France

The University of Exeter objectives were to 1) document the horizontal and vertical spreading of the tracer in the Rockall Trough along CTD/LADCP measurements and 2) to recover the largest amount of tracer for an inventory by unbiased sampling. BLT3- Leg2 undertook the last survey of the long-lived tracer (CF_3SF_5) released in the BLT canyon at 54.22°N &-11.91°E on the 11th of July 2021. The released tracer (CF_3SF_5) dispersion is measured from discrete samples collected from the CTD-rosette. The analysis was performed on board in the Exeter laboratory container installed on the port side of the aft deck.

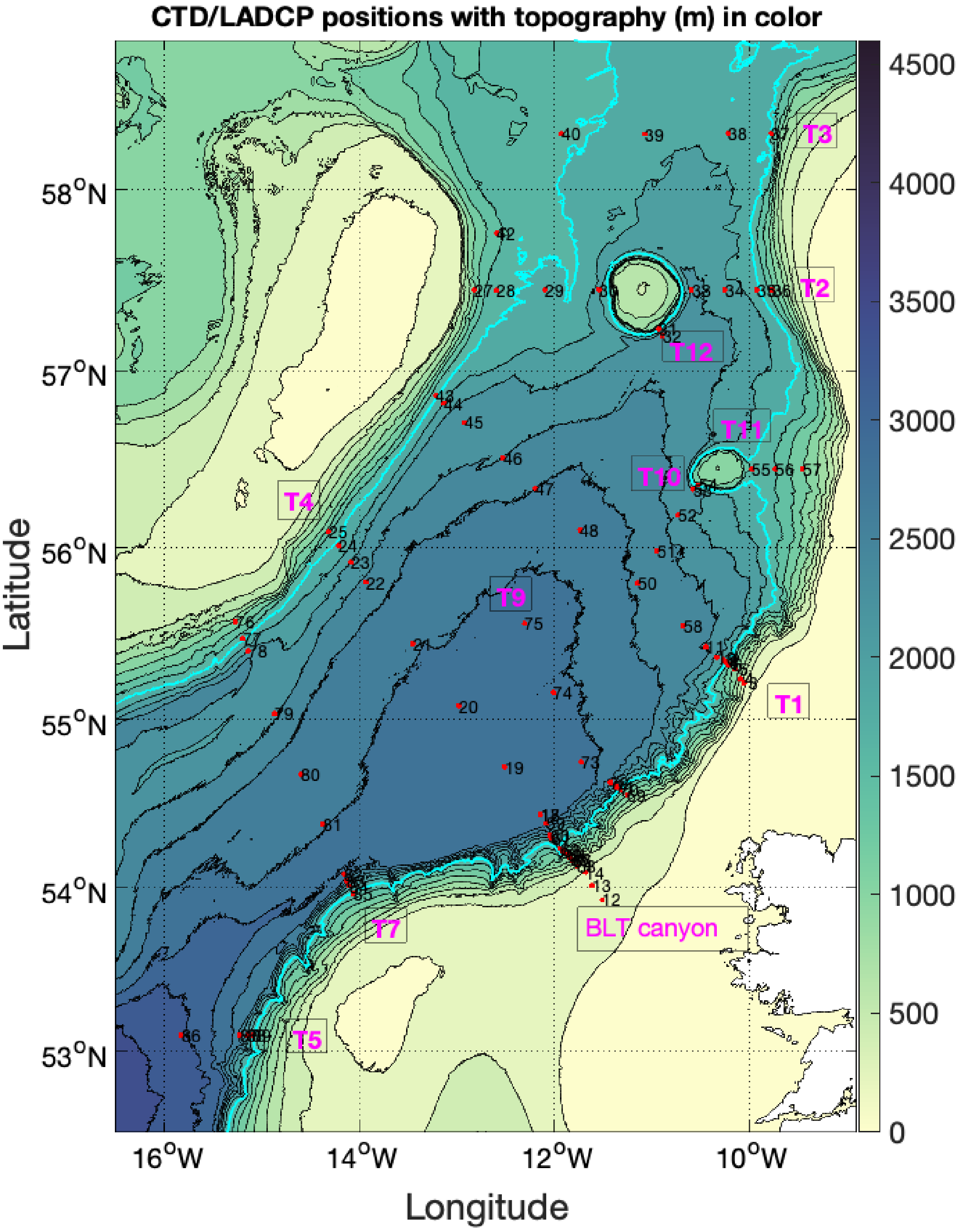
6.1.2 TRACER SURVEY

By the time of the BLT3-Leg2 study, 13 months after release, the tracer had spread throughout the Rockall Trough. The spread of the tracer was documented by transects running from one side of the basin to the other when possible. In total, 79 casts out of the 89 CTD (figure 17) sampled water for the tracer study along the transects, the numbering and order of which had to follow the vagaries of bad weather or technical problems at the CTD.

6.1.3 SAMPLE COLLECTION

Seawater samples were collected from the 24 niskin bottles (10 litre) mounted on the stainless steel CTD frame provided by NMF. Samples were transferred into 2 litre ground-glass stoppered reagent bottles (figure 17). The transfer was done by using sterile Tygon tubing in order to fill the bottles from the bottom to the top, overflowing 2 litres in order to remove any water that may have been exposed to the atmosphere. After sampling, all samples were immediately stored in the Controlled Temperature (CT) laboratory at a constant 4°C to prevent the sample from heating up and degassing before analysis could be completed.

FIGURE 17: TRACER SAMPLING: SEA WATER SAMPLING IN ACTION (ABOVE) AND LOCATIONS OF CTD AND TRANSECTS (BELOW) WITH BATHYMETRY IN COLOR.



6.1.4 Tracer Analysis Technique

Sample analysis was performed as soon as possible by a purge-and-trap gas chromatographic method. The carrier gas – oxygen-free Nitrogen (N_2) – was cleaned by a series of purifying hydrocarbon, nitrogen and oxygen traps. The water sample was introduced into the system by applying N_2 pressure to the top of the sample bottle, forcing the water to flow through and fill a 1165 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 an N_2 flow at 120ml/min for 4 minutes and trapped at -110°C in a Unibeads 3S trap (two inches of 1/8 inch diameter tubing) immersed in the headspace of liquid nitrogen.

The purge and trap system was interfaced to an Agilent 6890N gas chromatograph (GC) with an Electron Capture Detector (microECD). The GC was set up similarly to that described by [Smethie et al., 2000]. The traps were heated to 110°C and injected into the GC. The CF_3SF_5 separation was achieved using a 1m Porasil B packed pre-column and a 1.5m CarbographAC main column. A 6-inch molecular sieve post column was used to remove N_2O. The GC N2 carrier flow rate was 30ml/min and the MicroECD temperature was 310°C. The chromatograms shown in Figure 18 were obtained at the GC oven temperature of 110°C. The distribution of the chromatographic peak areas of all analysed samples shown in Figure 19 covers 2 orders of magnitudes.

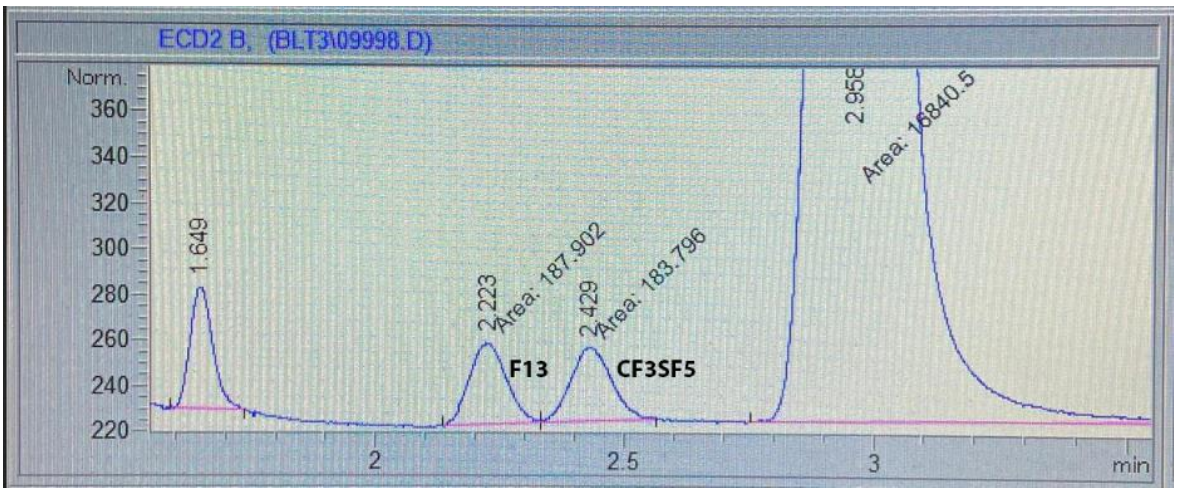


FIGURE 18: CHROMATOGRAM OF A SEAWATER SAMPLES ANALYSED BY THE ANALYTICAL SYSTEM. THE CHROMATOGRAMS GIVES A THE ECD SIGNAL (HZ) AS A FUNCTION OF TIME (MINUTES, X-AXIS). PEAKS AT 2.22, 2.43 AND 2.96 MINUTES ARE F-13 AND CF3SF5 AND CFC-12 RESPECTIVELY

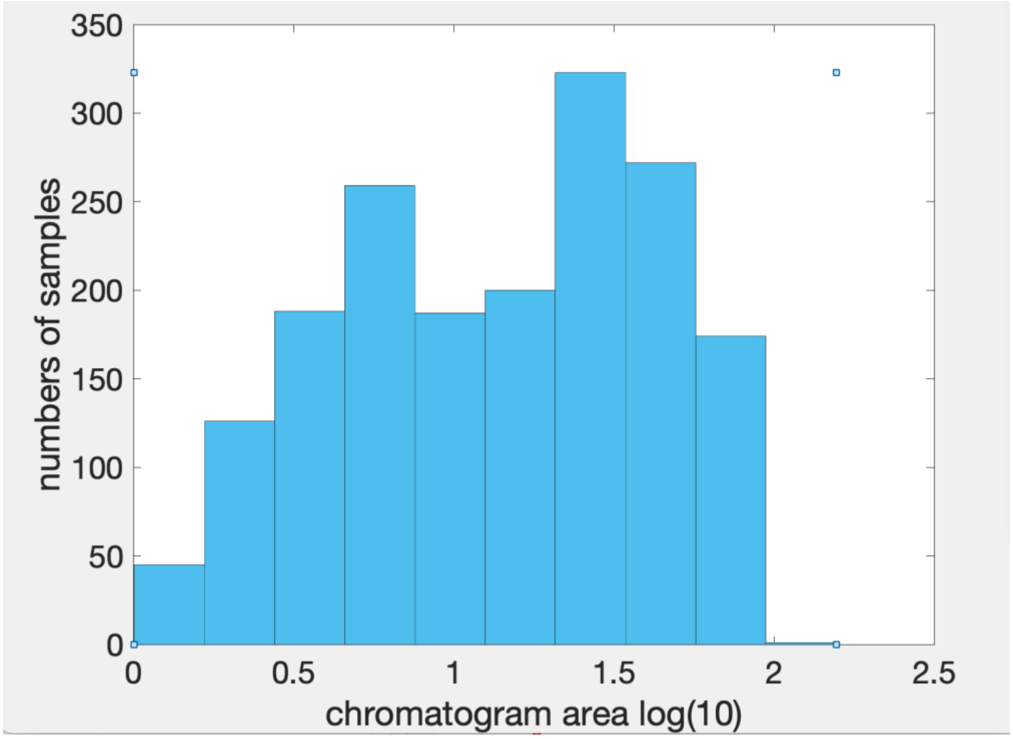


FIGURE 19: DISTRIBUTION OF CHROMATOGRAPHIC PEAK AREAS OF ALL ANALYSED SEAWATER SAMPLES.

6.1.5 Calibration, Detection Limit and Precision Methodology

The CF_3SF_5 concentrations in water are calibrated using external gaseous standards of various concentrations to cover the large range of tracer signals (Figure 19). We used working standards supplied by NOAA (Brad Hall, March 2017, CF_3SF_5 at 47.9ppt) and the University of East Anglia (UEA, Andrew Manning, August 2011, CF_3SF_5 at 12ppt, 215ppt and 4.6*10^6ppt) respectively. The NOAA standard is clean air enriched in CF_3SF_5 inside a 29L Aculife-treated aluminium cylinder. The UEA standard in Nitrogen enriched in CF_3SF_5 inside 20L steel cylinders. The CF_3SF_5 concentration of the UEA standard was estimated by gravimetry at UEA and intercalibrated with the NOAA standard with our instrument. CF_3SF_5 concentrations in air and seawater samples are determined by fitting their chromatographic peak area to multipoint calibration curves, made by injecting known volumes of gas from the working standard to the analytical system. The calibration curves were made by injections of different volumes (0.1, 0.23, 0.3, 0.5, 1, 2, 3, 5, 8 ml) of the working standards.

The changes in the sensitivity of the system were 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 CF_3SF_5. Blank or 'contamination' are estimated from the analysis of tracer free water obtained by sparging a water sample with Nitrogen and subtracted from the measured concentrations. Sparging efficiency is determined by successive resparges of a single sample until no further compound could be detected. The blank for SF_3SF_5 was zero. The results of these protocols will be applied during the post-cruise data processing required to calculate concentrations accurately, assign uncertainties and perform the data quality control.

6.2 NUTRIENT SAMPLING

Marie-José Messias, Herlé Mercier, Jack Hughes, Jonathan Crocker and Hannah Green, University of Exeter University, UK.

Nutrient samples were taken at a number of stations on DY153 for Malcolm Woodward (Plymouth Marine Laboratory) and Dennis J. McGillicuddy (Woods Hole Oceanography Institute). Table 14: Nutrient sampling and locations describes where and when each sample was collected during the cruise.

Each bottle was labelled with CTD cast number and niskin number prior to sampling the CTD rosette. A bell filter was connected to acid rinsed tubing and connected to each niskin, with the filter being rinsed 3 times. Once the filter was rinsed, the sampling bottle and lid was rinsed 3 times using water directly from the filter. Once the sample had been taken, it was stored in a -80°C freezer for the duration of the cruise, and the filter was emptied and stored in a clean Ziploc bag until required again. It was noted that the water flow through the filter was very slow and that in the future a suitable pump should be used to increase the water flow to speed up the time taken to sample. Once the cruise was completed, the samples were transported in their frozen state to be analysed at Plymouth Marine Laboratory, UK.

TABLE 14: NUTRIENT SAMPLING AND LOCATIONS

Date & Time	Event #	Number of samples	Position	Latitude	Longitude
09/08/2022 15:17	CTD001	3	Leg-1	54.194817	-11.85985
18/08/2022 00:00	CTD012	11	T4-22	53.926826	-11.506611
18/08/2022 02:47	CTD013	11	T4-21	54.011756	-11.614042
18/08/2022 04:42	CTD014	12	T4-20	54.093303	-11.678756

29/08/2022 00:16	CTD059	12	T4-09	54.385378	-12.081423
29/08/2022 02:46	CTD060	23	T4-10	54.314804	-12.045655
29/08/2022 06:09	CTD061	15	T4-11	54.294596	-12.027878
29/08/2022 09:51	CTD062	12	T4-12	54.235219	-11.943698
29/08/2022 12:20	CTD063	12	T4-13	54.222257	-11.913834
29/08/2022 14:50	CTD064	12	T4-14	54.200474	-11.867445
29/08/2022 16:56	CTD065	12	T4-15	54.176721	-11.834996
29/08/2022 18:47	CTD066	17	T4-17	54.166717	-11.816529
29/08/2022 20:41	CTD067	17	T4-18	54.160686	-11.807013
29/08/2022 22:37	CTD068	17	T4-19	54.129306	-11.763265

7 MOORING OPERATIONS

Gunnar Voet, Kurt Polzin, Arnaud Le Boyer, Brain Hogue, Hans van Haren (NIOZ), Helen Dufel

Our initial goal for the mooring operations was to recover all four moorings in the water since summer or fall 2021 and to deploy a short-term profiling mooring. In addition, we planned on deploying a Sonardyne prototype lander ADCP.

We switched up the deck operations slightly compared to the summer and fall cruises 2021. The stopper system we used then with just one hook running of a chain attached to an eye bolt on the center line had proved to be a bit worrisome for the synthetic mooring line as it was chafing over the deck during mooring recoveries. This time we brought two cleats, placed them left and right of the center line, and ran two stopper lines (one with a hook, the other one with a slip line) to be able to place connections on the deck edge and thereby protect the mooring line against chafing. This system, while slightly slower to work than just one hook on a chain, worked much better and we saw less damage on the mooring line and its jacket.

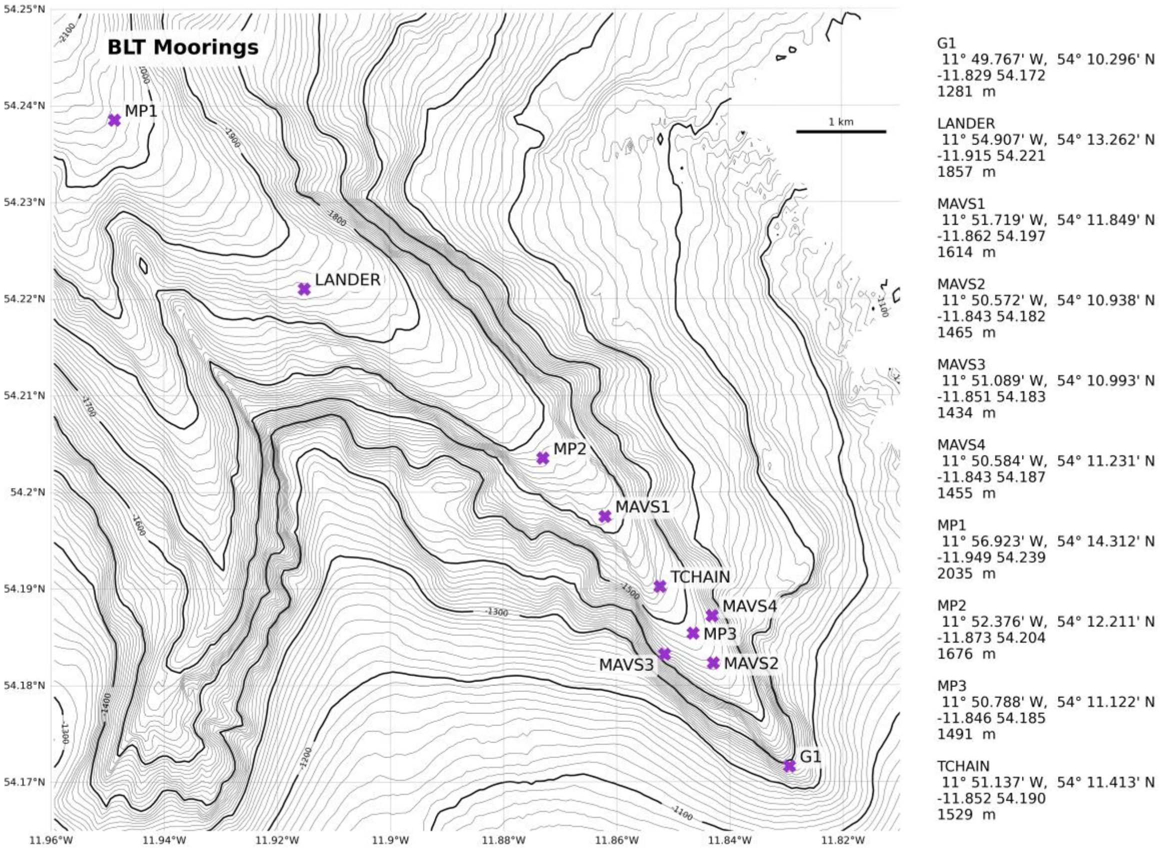


FIGURE 20: BLT MOORING LOCATIONS WITH LAT/LON

Generally, the data return was excellent with all Longranger ADCPs still pinging on recovery and almost all thermistors and all SBE37s functioning throughout the deployment. The only major issue was the moored profiler having motor issues, see next section.

7.1 MOORED PROFILER (MP3/G1) MOORINGS

The recovery of the moored profiler mooring was relatively uneventful and the mooring was safely brought back on board on Aug 2nd. Unfortunately, it turned out that the moored profiler on MP3 only profiled for about 200 profiles. Most likely the drive pin in the motor sheared off after that and the profiler did not crawl any further. We still need to investigate the issue further once the gear arrives back to La Jolla.

Independently of this failure mode and motivated by wanting the ability to run an EpsiFish time series on top of the mooring, we decided not to deploy the moored profiler again and turned the MP mooring into a short velocity mooring (G1) that consisted only of a syntactic foam float with an upward looking Longranger ADCP attached to the releases. We added weights (~65kg) at the bottom of the float to make it stand upright in the water on recovery which proved to work quite well. G1 was deployed Aug 4th in one pick with a bit of excitement when one of the tag lines got tangled up on the releases. The issue could be resolved by poking the line with a long stick. Mooring G1 was recovered on Aug 10th.

7.2 Modular Acoustic Velocity Sensor (MAVS3/MAVS4) Moorings

The recovery of MAVS3 on Aug 4th was complicated by a bit of a wuzzle where part of the mooring was looped around itself. Weather conditions were not the easiest with the wind picking up right after release and it took a long time to grapple on the mooring. This may have led to the wuzzle, but it could also have happened on the way to the surface or right when arriving at the surface. Despite the wuzzle we did not see much instrument damage and only a couple thermistors slipped from their initial locations. Our newly designed thermistor clamps worked well.

The recovery of MAVS4 on Aug 8th went very well without any line tangling.

Thermistors on both MAVS moorings performed exceptionally well with only two thermistors terminating early.

For MAVS instrument performance see the dedicated report by Kurt Polzin, WHOI.

7.3 Thermistor Chain (TCHAIN) Mooring

The TCHAIN recovery on Aug 10th went smoothly. One thermistor slipped (we marked it with black tape). The clock synchronizer was dangling a bit but was still attached. We took it off (and unfortunately popped the pressure case open) on recovery. We took the bottom two thermistors off the release frame and marked their locations with tape on the instruments. The thermistor chain system was sent back to NIOZ for data readout after the ship returned back to Southampton.

7.4 Sonardyne ADCP Lander Origin 65 Mooring

The Sonardyne ADCP was deployed on Aug 2nd. We added a 13" Nautilus float with about 15m line for easier recovery. The float was the only visible recovery help which proved to be enough to spot the instrument in the water but only barely so. Initial trilateration attempts of the mooring failed due to firmware issues with the acoustic deckset provided by Sonardyne. After some communication via email we were able to trilaterate prior to recovery. It turned out that the instrument had drifted with the relatively strong westward current at deployment time

(~0.6kts) about 380m to the west from the drop location. The ADCP was recovered on Aug 10th.

The instrument sampled all the way through and collected about 9GB of data. Sonardyne is currently investigating cross-transducer issues that led to noisy data in the bins covering the first few hundred meters away from the instrument.

8 Ship Scientific Systems

Zoltan Nemeth

8.1 Cruise Overview

Cruise	***Departure***	***Arrival***	***Technician(s)***
DY153	30/07/2022 NOCS UK		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.

8.2 Scientific Computer Systems

8.2.1 Underway Data Acquisition

Data from the suite of ship-fitted scientific instrumentation was aggregated onto a network drive on the ship's file server. This was available throughout the voyage in read-only mode to permit scientists to work with the data as it was acquired. A Public network folder was also available for scientists to share files.

A copy of these two drives are written to end-of-cruise disks that are provided to the Principal Scientist/Data Centre as required.

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

The data acquisition systems used on this cruise are detailed in the table 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.

TABLE 15: UNDERWAY DATA ACQUISITION SYSTEMS

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	Discrete	Kongsberg .all raw and RVDAS RAM,NCC	/Acoustics/EM122/
Kongsberg SIS (EM710)	Discrete	Kongsberg .all	/Acoustics/EM-710/
Kongsberg SBP27	Discrete	Raw + SegY	/Acoustics/SBP27
Kongsberg EK80	Discrete	Raw + XYZ + NetCDF	/Acoustics/EK-80
UHDAS (ADCPs)	Continuous	ASCII raw, RBIN, GBIN, CODAS files	/Acoustics/ADCP/
Env_Temp	Continuous	NetCDF + Ascii and RVDAS RAM	/Env_Temp
Sonardyne Ranger2	Discrete	PSONALL to RVDAS RAM, NCC, redirected to Techsas/RVDAS RAM	/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]/

8.2.1.1 Significant Acquisition Events and Gaps

Primary TechSAS logger DY153 mission started on 2022-07-29

Secondary TechSAS logger DY153 mission started on 2022-07-29

RVDAS primary RAM Acquisition started on 2022-07-29

RVDAS secondary RAM Acquisition started on 2022-07-29

Level-C acquisition started on 2022-07-29

RVDAS – NCC: TRUEWIND calculation valid from 2022-07-29 07:15 to 2022-09-05 05:46

RVDAS RAM DY153 Acquisition terminated on 2022-09-05 05:54

TechSAS logger DY153 mission terminated on 2022-09-05

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.

TABLE 16: UNDERWAY DATA ACQUISITION ISSUES

Sensor	**From:**	**To:**	**Length:**	**Issue:**	**Reason:**
RVDAS	2022-08-04 12:11:30	2022-08-04 12:19:49	08min 18sec	Software crashed	
TECHSAS	2022-08-05 00:31:53	2022-08-05 16:31:31	16hrs 11min	DY_Ships-Gyro GAP	GAP only in TechSAS
POSMV GPS	2022-08-08 18:05:27	2022-08-08 18:09:17	3min 50sec	DY_POSMV*	GPS reset
WAMOS Waveradar	2022-08-12 20:48:26	2022-08-13 06:17:40	9hours 29min 14sec	Software crashed	Unknown yet.
WAMOS Waveradar	2022-08-17 04:24:03	2022-08-17 05:03:10	39min 7sec	Software crashed	Unknown yet.
WAMOS Waveradar	2022-08-18 02:08:01	2022-08-18 04:59:34	2hours 51min 33sec	Software crashed	Unknown yet.

RVDAS	2022-08-27 15:57:48	2022-08-27 15:58:40	2min 4sec	Planned Restart	Planned Restart

8.2.2 Internet Provision

Satellite communications were provided with both the VSAT and Fleet Broadband systems occasionally topped up with 4G if we had a signal.

While underway, the ship operated with bandwidth controls to prioritise business use.

8.3 Instrumentation

8.3.1 Coordinate Reference

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

8.3.1.1 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.

8.3.1.2 Multibeam

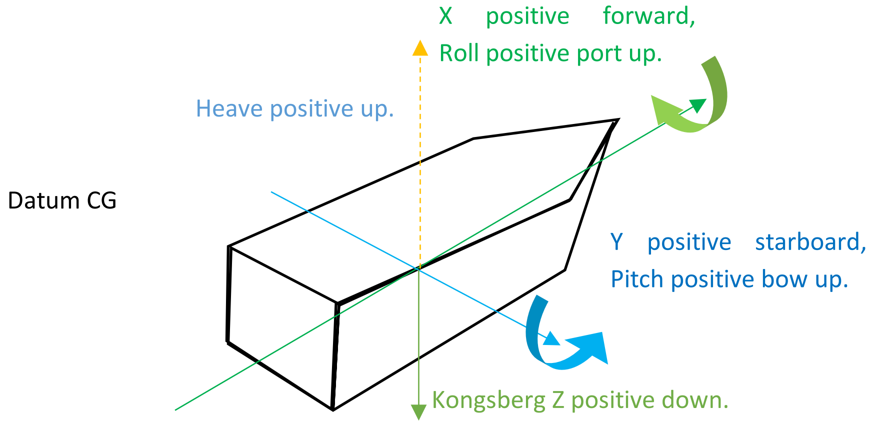


FIGURE 21: CONVENTIONS USED FOR POSITION AND ALTITUDE. ON THE DISCOVERY, THE DATUM IS TH CRP AT THE CG

The Kongsberg axes reference conventions are (see Figure 21) 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 21.

8.3.1.3 Primary Scientific Position and Altitude 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.

8.3.2 Position, Altitude and Time

TABLE 17: GPS AND ALTITUDE

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

Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*		
Other documentation	*/Ship_Systems/Documentation/GPS_and_Attitude*		
Component	***Purpose***	***Outputs***	***Headline Specifications***
Applanix PosMV	Primary GPS and attitude.	Serial NMEA to acquisition systems and multibeam	Positional accuracy within 2 m. With L2 correction from CNAV3050 within 0.15 m.
Kongsberg Seapath 330	Secondary GPS and attitude.	Serial and UDP NMEA to acquisition systems and multibeam	Positional accuracy within 1 m. With L2 correction from Fugro within 0.15m.
Oceaneering CNav 3050	Correction service for primary and secondary GPS and dynamic positioning.	Correction to primary GPS	Positional accuracy within 0.15 m.
Fugro Seastar / MarineStar	Correction service for primary and secondary GPS and dynamic positioning.	Correction to secondary GPS	Positional accuracy within 0.15 m.
Meinberg NTP Clock	Provide network time	NTP protocol over the local network.	Time accuracy within microseconds

8.3.3 Ocean and Atmosphere Monitoring Systems

8.3.3.1 SURFMET

TABLE 18: SURFMET

System	**SURFMET (Surface water and atmospheric monitoring)**
Statement of Capability	*/Ship_Systems/Documentation/Surfmet*
Data product(s)	NetCDF: */Ship_Systems/Data/TechSAS/NetCDF/* Pseudo-NMEA: */Ship_Systems/Data/TechSAS/NMEA/* Raw NMEA: */Ship_Systems/Data/RVDAS/NMEA/* NCC: */Ship_Systems/Data/RVDAS/NCC*
Data description	*/Ship_Systems/Documentation/TechSAS* */Ship_Systems/Documentation/RVDAS*
Underway events and other documentation	*/Ship_Systems/Documentation/Surfmet*

Calibration info	See Ship Fitted Sensor sheet for calibration info for each sensor.	
Component	***Purpose***	***Outputs***
Inlet temperature probe (SBE38)	Measure temperature of water at hull inlet	Serial to Interface Box
Drop keel temperature probe (SBE38)	Measure temperature of water in drop keel space	Analogue to NUDAM
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 (PTB210)	Atmospheric pressure at met platform	Analogue to NUDAM
Anemometer (Windsonic)	Wind speed and direction at met platform	Analogue to NUDAM
NUDAM	A/D converter	Serial NMEA to Moxa
Moxa	Serial to UDP converter	UDP NMEA to Surfmet VM
Surfmet Virtual Machine	Data management	UDP NMEA to TechSAS, RVDAS

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

Surface Water Sampling Board Maintenance

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

/Ship_Systems/Documentation/Surfmet

The system was cleaned prior to the cruise on 2022-07-26.

TSG Data Acquisition valid from: 2022-08-01 10:25 (49º 44.78N, 006º 37.08W)

TSG Data Acquisition paused (Killybeg) 2022-08-14 19:25 (54º 12.70N, 011º 18.45W)

TSG Data Acquisition restarted 2022-08-16 08:45 (55º 14.30N, 010º 05.42W)

TSG Data Acquisition terminated: 2022-09-03 11:55 (51º00.22N, 011º10.61W)

72227 litre seawater pumped through the TSG!

8.3.3.2 Wave Radar

TABLE 19: WAMOS WAVE RADAR

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

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

8.3.4 HYDROACOUSTIC SYSTEMS

TABLE 20: HYDROACOUSTIC SYSTEMS

System	**Acoustics**

Statement of Capability	*/Ship_Systems/Documentation/Acoustics*		
Data product(s)	Raw: */Ship_Systems/Data/Acoustics* NetCDF (EA640, EM122cb): */Ship_Systems/Data/TechSAS, /Ship_Systems/Data/RVDAS* NMEA (EA640, EM122cb): */Ship_Systems/Data/RVDAS*		
Data description	*/Ship_Systems/Documentation/Acoustics*		
Other documentation	*/Ship_Systems/Documentation/Acoustics*		
Component	***Purpose***	***Outputs***	***Operation***
10/12 kHz Single beam (Kongsberg EA-640)	Primary depth sounder	NMEA over serial, raw files	Continuous Triggered by K-Sync
Kongsberg EK-80 Fishradar	Split beam scientific echo sounder	Raw, XYZ, NetCDF	Discrete
Kongsberg SIS (EM122)	Multibeam Deep Water sounder	Kongsberg .all	Discrete
2.5–6.5 kHz Sub-bottom Profiler (Kongsberg SBP-27)	Multi-frequency echogram to provide along-track sub-bottom imagery.	BMP, raw, SEGY files, optional water column data.	Discrete
Drop keel sound velocity sensor	Provide sound velocity at transducer depth	Value over serial to Acoustics System.	Continuous
Sound velocity profilers (Valeport Midas, Lockheed XBT)	Direct measurement of sound velocity in water column.	ASCII pressure vs sound velocity files. Manually loaded into Kongsberg SIS or Sonardyne Ranger2.	Discrete (See deployment event log, below)
75 kHz ADCP (Teledyne OS75)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running
150 kHz ADCP (Teledyne OS150)	Along-track ocean current profiler	(via UHDAS)	Continuous Free running

8.3.4.1 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 (3 beams), 150 kHz

Running mode	Free-running untriggered by K-Sync
Configuration details	os150: Narrow band 40 bins, length 8m, 4m blanking, os75: narrow band, 60 bins, length 16m, 8m blanking Bottom tracking with was run from leaving Southampon from 2022-07-30 07:15 to 2022-07-31 18:21 approaching Irish waters, then used Narrowband with water tracking mode from 2022-08-02 04:16:00 to 2022-08-14 17:50 steaming to Killybeg Ports of Call. 2022-08-14 17:52 switched to Bottom Tracking mode until 2022-08-15 06:37 to Killybegs. After Killybegs ports of call ADCP's are running with Bottom tracking from 2022-08-15 16:41 to 2022-08-16 20:06 then switched to Water Tracking mode 2022-08-16 20:07 to 2022-09-03 15:08 and after the system ran on Bottom Tracking Mode until end of recording: 2022-09-04 15:36 Survey name: DY153.

EM-122 Configuration and Surveys

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

Item	***X (m, + Forward)***	***Y (m, + Starboard)***	***Z (m, + Down)***
Tx transducer	39.910	0.885	7.426
Rx transducer	35.219	-0.005	7.438
Att 1 (Applanix)	0.00	0.00	0.00
Att 2 (Seapath)	0.00	0.00	0.00
Waterline (distance from Att 1 to Waterline)			1.64

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	em122-dy153-test	2022-07-29 13:56	35:50:26 hh:mm:ss	0-12	Default 20220419_072900_salinity_03500.asvp	72 lines
North Atlantic	Em122-dy153a	2022-08-01 12:01:01	16:14:52 hh:mm:ss	0-12	Default 20220419_072900_salinity_03500.asvp	34 lines
Rockall Trough	Em122-dy153b	2022-08-02 04:17:59	104:58:57 hhh:mm:ss	0-12	Default 20220419_072900_salinity_03500.asvp after line 197 SVP from CTD001	236 lines
Rockall Trough	Em122-dy153c	2022-08-10 12:35:06	445:48:44 hhh:mm:ss	1-11	SVP from CTD001, CTD010, CTD032, CTD046, CTD048 CTD075 CTD086	992 lines
Rockall Trough to English Channel	Em122-dy153d	2022-09-02 17:05:28	hh:mm:ss	6-12	CTD086	Xx lines

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)			1.63

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

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

Survey Site Name	*SIS Survey Name*	*Datetime Start*	*Total time of Logging*	*Vessel survey speed (kts)*	*SVP(s) Used (Filename)*	*Comments*
English Channel	dy153-test	2022-07-29 13:54:48	22:31:36 hh:mm:ss	0-12	Default 20220419_072900_salinity_03500.asvp	45 lines

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-710/Caris_processed

/Ship_Systems/Data/Acoustics/MB-System_processed_multibeam_data

USBL Configuration and Deployments

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

Attribute	***Value***
Number of deployments	See the Eventlogger Acoustic Events section.
Datetime of last CASIUS	2019-08-15 12:41:24
Starboard Head 1DRMS	See in the included Casius report
Port Head 1DRMS	See in the included Casius report

SBP27 Configuration and Surveys

Path of SBP27 calibration information on the cruise datastore: /Ship_Systems/Data/Acoustics/SBP27

Item	***X (m, + Forward)***	***Y (m, + Starboard)***	***Z (m, + Down)***
Tx transducer	39.919	-1.014	7.425
Rx transducer (EM122 RX)	35.219	-0.005	7.438
Att 1 (Applanix)	0.00	0.00	0.00
Att 2 (Seapath)	0.00	0.00	0.00
Waterline (distance from Att 1 to Waterline)			1.64

Item	***Roll (deg)***	***Pitch (deg)***	***Yaw (deg) (heading)***
Tx transducer	0.06	-0.11	0.04
Rx transducer	0.05	0.37	359.98
Att 1 (Applanix)	0.00	0.00	0.00
Att 2 (Seapath)	0.00	0.00	0.00

Data in RAW and SEGY format recorded mainly during the second part of the cruise for details please see the Acoustic Eventlog.

> *Path of processed data on the cruise datastore*
>
> `/Ship_Systems/Data/Acoustics/SBP27`

8.3.5 Other Systems

8.3.5.1 Cable Logging and Monitoring

Winch activity is monitored and logged using the CLAM system.

8.3.5.2 VSAT and FBB Satellite Internet

TABLE 21: VSAT USAGE

DATE	Total Inbound (MB)	Total Outbound (MB)	Max IN	Max OUT
2022-07-29	12021	3639	2.81	1.44
2022-07-30	13877	8320	3.43	1.89
2022-07-31	24038	11838	4.43	1.75
2022-08-01	26686	10328	4.62	2.05
2022-08-02	22277	8628	4.82	1.84
2022-08-03	29389	9805	5.10	1.78
2022-08-04	37081	11240	5.23	1.82
2022-08-05	45794	11204	6.22	1.87
2022-08-06	46547	13507	7.25	1.90
2022-08-07	32291	12329	6.41	1.92
2022-08-08	36498	12004	7.42	1.87
2022-08-09	31957	9973	7.00	1.82
2022-08-10	30477	9077	7.07	1.75
2022-08-11	30866	9210	6.48	1.87
2022-08-12	39799	10356	7.25	1.74
2022-08-13	35775	9460	6.83	1.64
2022-08-14	34747	9108	7.11	1.65
2022-08-15	21437	7064	6.91	1.57
2022-08-16	27933	7512	6.95	1.48
2022-08-17	30567	7488	7.51	1.70
2022-08-18	24664	7588	6.37	1.68
2022-08-19	21995	7095	6.87	1.70
2022-08-20	24284	7430	5.50	1.77
2022-08-21	23120	8786	6.27	1.83
2022-08-22	23026	8779	6.85	1.80
2022-08-23	23336	10089	6.06	1.74
2022-08-24	24249	9367	5.63	1.88

2022-08-25	28557	10424	6.15	1.75
2022-08-26	28529	8940	5.91	1.71
2022-08-27	25176	7319	6.68	1.61
2022-08-28	20392	7414	6.13	1.49
2022-08-29	17109	8869	2.84	1.54
2022-08-30	24276	8675	4.67	1.73
2022-08-31	25120	9529	5.63	1.74
2022-09-01	27075	10297	5.67	1.80
2022-09-02	26007	10635	6.10	1.81
2022-09-03	24394	9046	6.39	1.81
2022-09-04	26848	9325	6.37	1.77