PACSAFE Leg 3 & Endeavour Ridge OBS Recovery and Redeployment Cruise – Metadata and Data Assessment

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This report summarizes the data and metadata for ocean-bottom seismometer (OBS) operations performed by the National Facility for Seismological Investigations (NFSI) and researchers participating in the NFSI-015-2025-04 cruise in August 2025 offshore British Columbia aboard the *CCGS John P Tully*, as a supplement to the official cruise report. The cruise combined the third leg of the multi-year Pacific Coast Seismic Assessment for Faults and Earthquakes (PACSAFE) project with the first deployment of the "Extension on the Endeavour Segment" (ExtEnd) project. An array of 5 OBS deployed in 2024 to supplement existing monitoring at the Endeavour Ridge by the NEPTUNE observatory (operated by Ocean Networks Canada) was also recovered during this operation. These three broader projects have distinct scientific objectives, but share overlapping teams, are nearby geographically, and rely on the same OBS instrument pool. The projects are referred to as the "PACSAFE", "ExtEnd" and "ONC Endeavour" projects throughout this document. ExtEnd and ONC Endeavour share scientific objectives and study area but have distinct funding and technical arrangements.

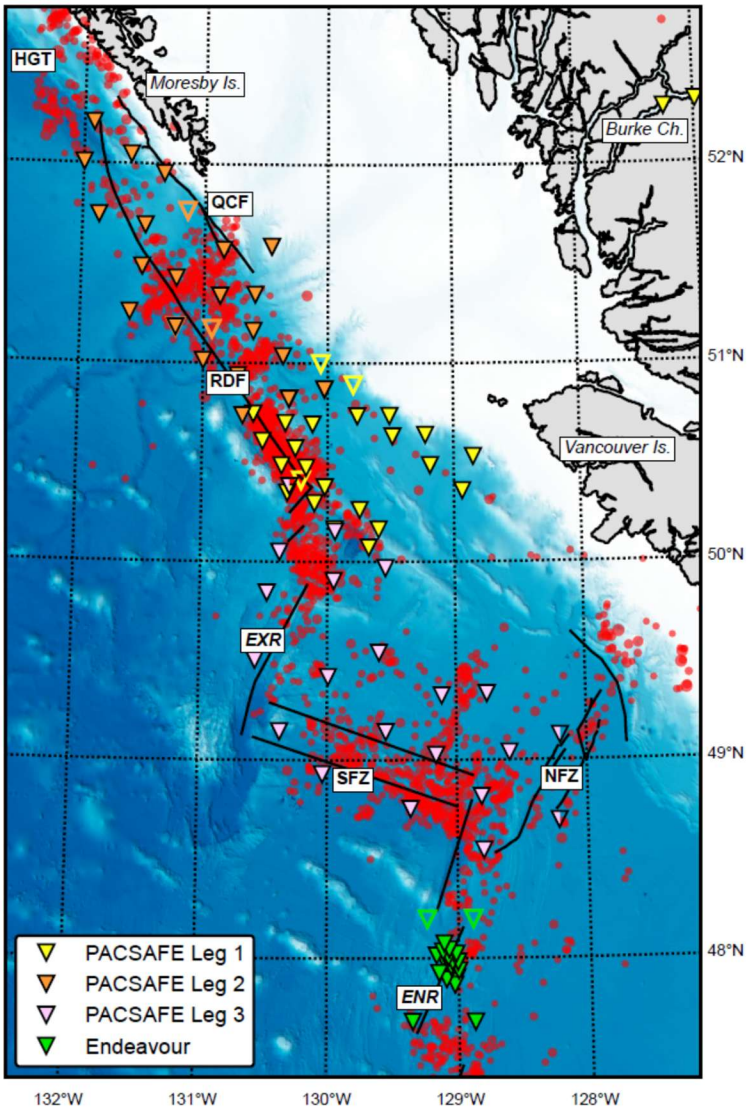


Figure 0-1: Overview map of PACSAFE and Endeavour (ExtEnd) OBS stations. Filled triangles indicate normal stations; coloured outlines represent stations which surfaced prematurely. Partially filled triangles for PACSAFE Leg 3 stations indicate challenges with seafloor acoustic communication.

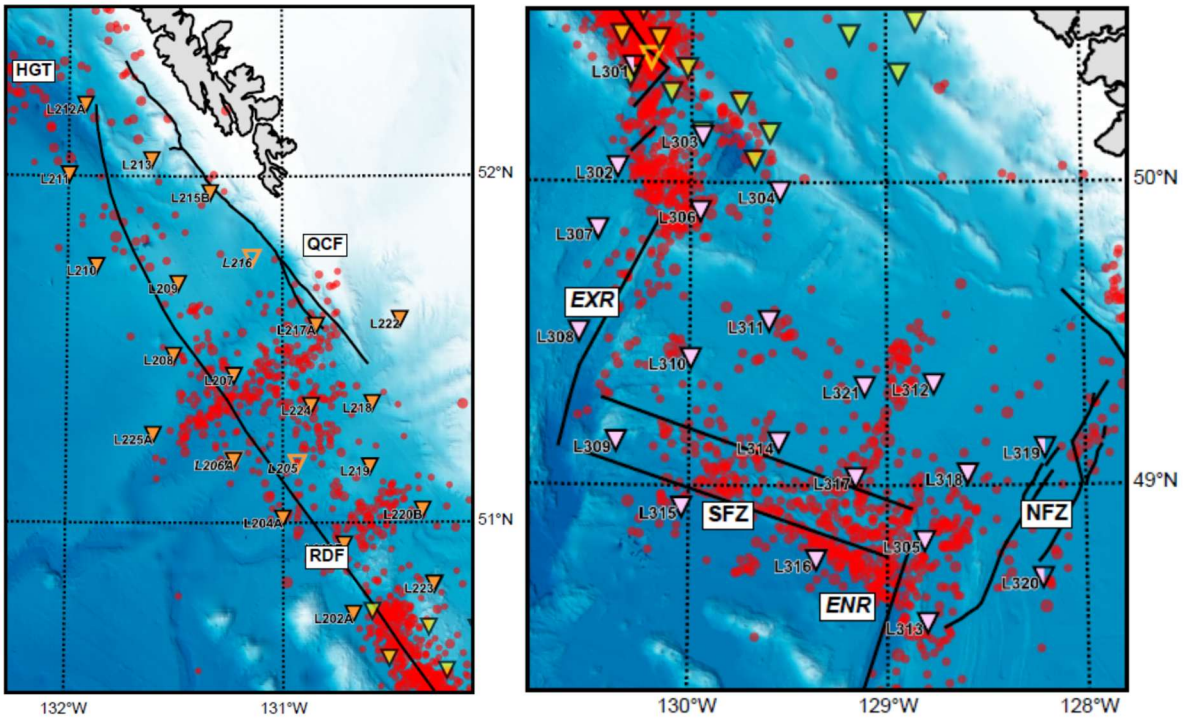


Figure 0-2: Maps of the PACSAFE Leg 2 (left) and Leg 3 (right) OBS arrays. Station colours and symbols are as in Figure 0-1.

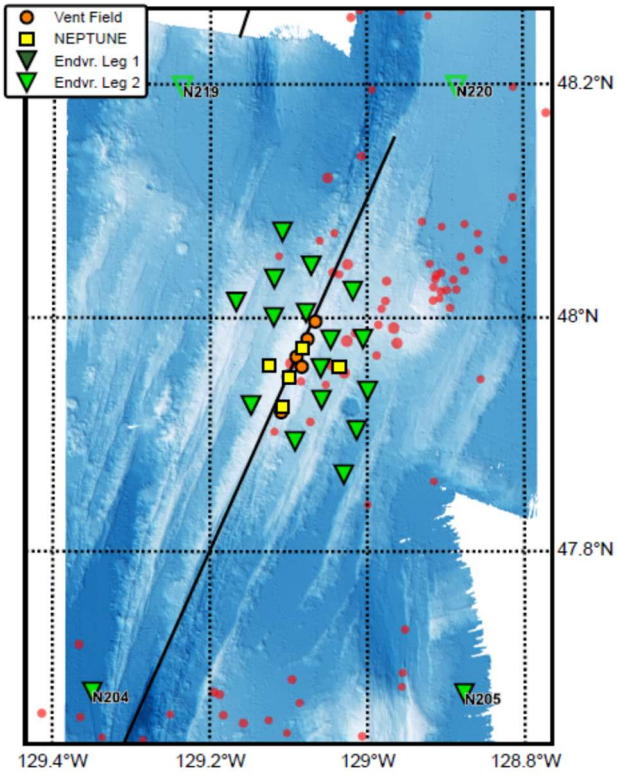


Figure 0-3: Map of ExtEnd OBS stations as deployed in August 2025. Colours and symbols are as described in Figure 0-1. ONC stations (dark green) are not visible due to overlapping symbols; all are reoccupied by ExtEnd stations.

Several identifiers exist to designate this cruise. This addendum will primarily use the NFSI identifier (NFSI-015-2025-04). The official cruise report was prepared and published by co-Chief Scientist Alex Plourde of the Geological Survey of Canada (with input from other team members) with the identifier 2025006PGC (https://doi.org/10.5281/zenodo.21824288).

1.0 Station Metadata

All OBS deployed or recovered during this cruise are the Aquarius model (manufactured by Güralp Systems Ltd), owned and operated by the National Facility for Seismological Investigations (NFSI) based at Dalhousie University. Equipment specifications are included in Appendix A. Sub-sections below are arranged roughly in the time order of operations during the cruise.

Final clock offsets from nearly all recovered stations are skewed to negative values, suggesting a possible systematic calibration problem with temperature correction tables for the clocks. The same behaviour has been observed across several deployments of Aquarius OBS since 2023. Negative offset indicates the on-board OBS clock has fallen behind true GPS time. Clock drift rates are calculated assuming linear clock drift throughout the recording time.

Tilt estimates are calculated from readings of the on-board triaxial MEMS accelerometer (tiltmeter) in the Aquarius, obtained via acoustic communication shortly after deployment and immediately before release from the seafloor. Where both estimates are available for a station, these values are compared to provide information about how the instrument may have moved while deployed. Determining the orientations of the OBS in the Earth reference frame is outside the scope of this report, so the direction of maximum tilt is given as degrees clockwise from instrument north. Apparent rotation of the instruments during the deployment period is calculated as the angle between the tilt vectors at deployment and recovery in three-dimensional space (instrument reference frame). Tilt information obtained in this fashion should be treated as an estimate only, as it is based on single-point readings; it is recommended that researchers confirm these values using other methods prior to applying corrections to the data. The FDSN standard channel naming convention specifies a threshold of 5 degrees from true vertical to allow use of the vertical channel orientation code (Z); this threshold is used as a reference when discussing tilt angle in the following.

When deployed, each instrument is fitted with an Apollo Mono Iridium GPS beacon and an XMB-11k VHF radio beacon, both manufactured by Xeos Technologies Inc. GPS position messages can be viewed through the XeosOnline portal or using the Xeos Hermes handheld receiver, and are forwarded to an email alert list of key personnel. All VHF beacons were set to a frequency of 159.480 MHz for ExtEnd and PACSAFE sites. Each OBS includes an integrated Sonardyne LMF-band acoustic transponder for communication with surface vessels while deployed, which uses the WBV2+ addressing range. A backup release time has been programmed for each OBS in the unlikely event we are unable to establish acoustic contact with an otherwise still-functional instrument during recovery operations. These times are chosen to maximize the possibility of recovery, taking into account the expected battery life of the Aquarius prior to release at its low-voltage threshold (18+ months).

1.1 ExtEnd Deployments

In total, 20 Aquarius OBS were deployed at ExtEnd sites during this cruise. Of these, stations N219 and N220, which are located at the northern extremes of the planned array, surfaced shortly after deployment. Additional instruments were not available to replace these sites. Stations N201-N205

approximately reoccupy sites ENS01-ENS05 from ONC's 2024-25 deployment (see section 1.2), with adjustments to the target locations of sites 1 and 3.

Table 1-1: Planned locations and actual OBS drop locations for all ExtEnd stations.

Station	Launch Time	Planned Location		Actual Drop Location			Distance from Planned (km)
		Latitude	Longitude	Latitude	Longitude	Water Depth (m)	
N201	2025-08-08 21:51:17	47.92989	-129.06152	47.929133	-129.058550	2354	0.237
N202	2025-08-09 00:33:43	47.99978	-129.11817	48.000817	-129.120783	2350	0.226
N203	2025-08-08 17:40:56	47.90271	-129.01207	47.902950	-129.012667	2568	0.052
N204	2025-08-09 19:25:12	47.68038	-129.34952	47.679967	-129.349517	2802	0.046
N205	2025-08-09 15:30:40	47.67887	-128.87826	47.679333	-128.878350	2657	0.052
N206	2025-08-08 20:01:09	47.8658	-129.02996	47.865833	-129.029450	2616	0.038
N207	2025-08-08 20:52:07	47.8933	-129.0896	47.893505	-129.088867	2430	0.059
N208	2025-08-09 22:55:19	47.92406	-129.14827	47.924950	-129.148100	2431	0.100
N209	2025-08-08 17:07:22	47.93617	-128.99787	47.936845	-128.998078	2590	0.077
N210	2025-08-08 23:04:09	47.95679	-129.05903	47.956717	-129.058550	2358	0.037
N211	2025-08-09 01:33:44	47.981	-129.04616	47.980967	-129.045367	2330	0.059
N212	2025-08-08 15:12:16	47.98128	-129.00562	47.981273	-129.005452	2276	0.013
N213	2025-08-10 01:18:12	48.00479	-129.07803	48.004800	-129.077517	2170	0.038
N214	2025-08-10 01:54:48	48.0235	-129.01791	48.023450	-129.017767	2336	0.012
N215	2025-08-09 23:48:35	48.0157	-129.1663	48.014950	-129.166483	2260	0.084
N216	2025-08-10 00:37:07	48.03555	-129.11869	48.035217	-129.118683	2373	0.037
N217	2025-08-10 14:33:28	48.0451	-129.0722	48.045467	-129.072117	2369	0.041
N218	2025-08-10 15:43:22	48.0734	-129.1083	48.073317	-129.108767	2510	0.036
N219	2025-08-10 17:10:15	48.1982	-129.2354	48.198350	-129.235783	2564	0.033

N220	2025-08-10 19:25:19	48.1987	-128.8857	48.198717	-128.885567	2520	0.010

Seafloor locations were surveyed for all 18 stations which remained at the seafloor during this cruise, mostly during overnight operations following each day shift's deployments. A few stations were surveyed at the end of the cruise following completion of PACSAFE operations due to uncertainty about available time and weather conditions early in the voyage. Stations N219 and N220 were not surveyed prior to surfacing. All surveys were performed using a USBL system (using the CASIUS tool within *Ranger 2* software). Coordinates obtained for all stations are listed in Table 1-2. Bearings of drift measurements are given in degrees clockwise from North.

Table 1-2: OBS drop locations and surveyed seafloor locations for ExtEnd stations remaining at the seafloor.

Station	Drop Location		Surveyed Seafloor Location			Horizontal Drift	
	Latitude	Longitude	Latitude	Longitude	Depth (m)	Distance (m)	Bearing (°)
N201	47.929133	-129.058550	47.930007	-129.058132	2320.3	102.0	17.8
N202	48.000817	-129.120783	48.000729	-129.118962	2326.7	136.2	94.1
N203	47.902950	-129.012667	47.903739	-129.013434	2541.8	104.8	326.8
N204	47.679967	-129.349517	47.679957	-129.349034	2751.5	36.3	91.7
N205	47.679333	-128.878350	47.678468	-128.877129	2638.0	132.9	136.4
N206	47.865833	-129.029450	47.865868	-129.029751	2595.3	22.8	279.6
N207	47.893505	-129.088867	47.894462	-129.091924	2411.7	252.2	295.0
N208	47.924950	-129.148100	47.925212	-129.147912	2406.0	32.4	25.7
N209	47.936845	-128.998078	47.937394	-128.999405	2469.1	116.4	301.6
N210	47.956717	-129.058550	47.957121	-129.059163	2336.4	64.2	314.5
N211	47.980967	-129.045367	47.981410	-129.046541	2309.9	100.6	299.4
N212	47.981273	-129.005452	47.982094	-129.005155	2272.1	93.9	13.6
N213	48.004800	-129.077517	48.004428	-129.077781	2135.7	45.8	205.5
N214	48.023450	-129.017767	48.023074	-129.018217	2307.5	53.6	218.8
N215	48.014950	-129.166483	48.013735	-129.166855	2234.0	137.9	191.6
N216	48.035217	-129.118683	48.033611	-129.118226	2375.8	181.8	169.2
N217	48.045467	-129.072117	48.044833	-129.071147	2351.0	101.0	134.3
N218	48.073317	-129.108767	48.073843	-129.107862	2491.8	89.3	49.0

The maximum horizontal drift distance during freefall is approximately 250 metres or 10.4% of water depth for any station. Average drift distance is approximately 100 metres or 4.2% of water depth; almost all stations drift less than 150 metres or 6% of water depth. There does not appear to be a consistent pattern in drift direction for this array.

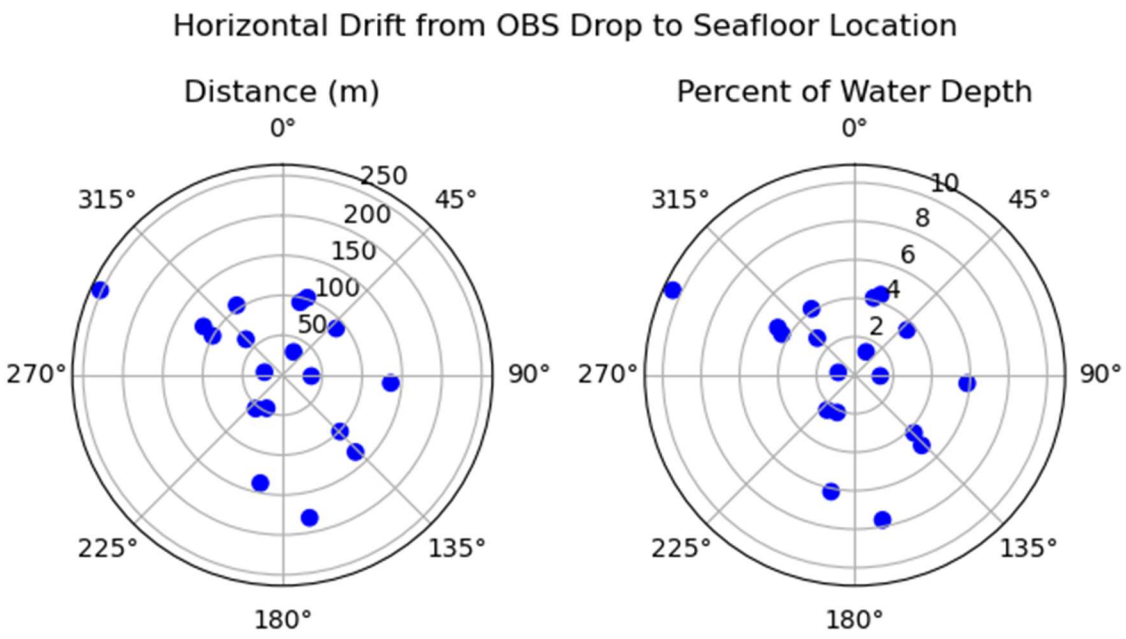


Figure 1-1: Horizontal drift measurements for ExtEnd stations with surveyed seafloor locations (excluding N219 and N220).

Tilt estimates were obtained during the seafloor location survey for all stations which remained at the seafloor. Of these, 7 show tilt angles greater than 5 degrees from vertical, with 5 showing tilt angles of greater than 10 degrees from vertical and 2 at 30 degrees or more. The maximum tilt angle measured is approximately 35 degrees at station N217. These values will be compared with estimates obtained at recovery in 2026. The seismometer used in the Aquarius OBS is designed to be operational when tilted up to 90 degrees from vertical, so the high tilt angles observed for some stations are not expected to impact the integrity of the recorded data, although may require careful correction in data processing workflows.

Table 1-3: Estimated tilt from vertical for each ExtEnd station shortly after deployment. Tilt direction is measured in each instrument's internal reference frame.

Station	Estimated Tilt from Vertical (°)	Tilt Direction (°)
N201	30.1	226.7
N202	2.7	230.7
N203	1.0	85.2
N204	4.2	197.3
N205	1.1	295.9
N206	2.3	189.2
N207	24.8	147.3
N208	15.9	197.3
N209	5.9	168.3
N210	2.3	328.6
N211	8.0	256.5
N212	4.6	103.8
N213	19.8	121.4
N214	1.5	110.3

N215	2.4	7.7
N216	4.6	189.7
N217	35.1	190.3
N218	4.1	172.6

Table 1-4 lists the instrument serial numbers, acoustic modem information, Apollo Mono GPS beacon serial numbers and backup release time for the deployed stations which remained at the seafloor at the completion of the cruise.

Table 1-4: List of key information for each ExtEnd station remaining at the seafloor.

Station	Serial Number	Modem Address	Modem UID	Apollo Mono S/N	Backup Release Time (UTC)
N201	AQU-2464	5901	U0079CC	555	2026-11-15 22:00:00
N202	AQU-9768	5603	U0079D7	513	2026-11-16 00:45:00
N203	AQU-5D66	5611	U0079C8	534	2026-11-15 17:46:00
N204	AQU-1568	5507	U0079D0	446	2025-11-16 20:30:00
N205	AQU-5966	5911	U007615	576	2026-11-16 15:35:00
N206	AQU-9F68	5710	U007A6D	510	2026-11-15 20:06:00
N207	AQU-9968	5803	U007B38	564	2026-11-15 21:00:00
N208	AQU-2366	5804	U0079D3	709	2026-11-16 23:00:00
N209	AQU-1D66	5514	U0079D4	696	2026-11-15 17:10:00
N210	AQU-1C64	5501	U0079CD	633	2026-11-15 23:08:00
N211	AQU-9868	5801	U006AFC	549	2026-11-16 01:40:00
N212	AQU-1F60	5814	U006669	627	2026-11-15 15:20:00
N213	AQU-1664	5503	U0079D8	673	2026-11-17 01:30:00
N214	AQU-2066	5504	U0079D1	1271	2026-11-17 02:00:00
N215	AQU-7C68	5714	U0079D5	1273	2026-11-16 23:55:00
N216	AQU-1A64	5903	U006ADF	1272	2026-11-17 00:40:00
N217	AQU-4E5A	5909	U0076B1	509	2026-11-17 14:30:00
N218	AQU-F45F	5914	U007307	563	2026-11-17 16:00:00

1.2 ONC Endeavour Recoveries

All 5 OBS deployed by ONC in June 2024 were recovered during the NFSI-015-2025-04 cruise. Seafloor locations for all stations were determined during deployment operations using a USBL system permanently installed aboard *EV Nautilus*.

Table 1-5: Seafloor locations for all ONC Endeavour stations, as determined during deployment operations.

Station	Surveyed Seafloor Location		
	Latitude	Longitude	Depth (m)
ENS01	47.929889	-129.061522	2321
ENS02	47.999803	-129.118172	2309
ENS03	47.900393	-128.998660	2559
ENS04	47.680379	-129.349516	2762
ENS05	47.678868	-128.878264	2650

Burnwire corrosion took an average of 7.5 minutes (range 5-14 minutes) for all stations, in line with NFSI's previous operations. After dropping their ballasts, instruments rose to the surface under their own buoyancy at an average of 110 m/min.

Final clock offsets were obtained for all stations recovered during this cruise. The maximum clock drift rate observed for any of the ONC Endeavour sites was measured for station ENS03 at -1.4ms/day.

Table 1-6: Clock drift information for all ONC Endeavour stations. Recording time covers from when the instrument is disconnected from the deck unit before deployment until the clock is stopped after recovery, so is slightly longer than total time on the seafloor. Clock drift rate assumes linear drift throughout the recording time.

Station	Length of Recording (days)	Final Clock Offset from GPS (ms)	Clock Drift Rate (ms/day)
ENS01	427.27	-380	-0.889
ENS02	427.49	9	0.021
ENS03	425.94	-594	-1.395
ENS04	426.67	-550	-1.289
ENS05	426.73	-496	-1.162

Tilt estimates for the ONC stations could not be obtained at deployment, as the USBL system aboard *EV Nautilus* was not equipped to receive and decode status messages from the Aquarius. At recovery, 4 of 5 stations have tilt estimates of less than 5 degrees from vertical. Station ENS01 has a relatively high tilt angle, just over 17 degrees from vertical. The reoccupation of this site by station N201 of ExtEnd also shows a high tilt angle (30°); the seafloor locations for these stations are approximately 140 meters apart.

Table 1-7: Estimates of instrument tilt for ONC Endeavour stations immediately before release. Direction of maximum tilt is measured in each instrument's internal reference frame.

Station	Tilt from Vertical (°)	Maximum Tilt Direction (°)
ENS01	17.4	328.4
ENS02	4.0	15.3
ENS03	2.5	305.1
ENS04	1.3	163.1
ENS05	2.4	345.8

1.3 PACSAFE Leg 2 Recoveries

A total of 21 Aquarius OBS deployed during the NFSI-009-2024-03 cruise in July 2024 remained on the seafloor to be recovered during the NFSI-015-2025-04 cruise. Deployment operations are described in the NFSI-009-2024-03 cruise report (PACSAFE Leg 2). Seafloor locations for all stations were determined during deployment operations using a combination of USBL and dunker triangulation surveys. Stations L205 and L216 surfaced prematurely within weeks after deployment due to water ingress and were recovered by vessels of opportunity in September 2024.

Table 1-8: Seafloor locations for all PACSAFE Leg 2 stations, as surveyed during deployment operations. Stations L205 and L216, which surfaced prematurely, are included here for completeness.

Station	Surveyed Seafloor Location		
	Latitude	Longitude	Depth (m)
L201	50.869488	-130.026382	2134.8
L202A	50.736994	-130.679697	2433.5
L203B	50.937413	-130.719627	2379.0
L204A	51.012764	-131.000604	2467.9
L205	51.171029	-130.933255	2313.4
L206B	51.179370	-131.226756	2494.9
L207	51.424570	-131.225422	2419.6
L208	51.482628	-131.504938	2368.8
L209	51.689815	-131.485327	1959.8
L210	51.740625	-131.865451	2330.8
L211	52.003673	-131.996451	2452.0
L212A	52.205240	-131.923064	2382.1
L213	52.046686	-131.611015	1622.8
L215B	51.951781	-131.336733	1556.4
L216	51.763961	-131.140948	2134.7
L217A	51.569322	-130.844035	2010.7
L218	51.345024	-130.586341	1943.0
L219	51.162137	-130.599484	2027.5
L220	51.035824	-130.359177	2165.0
L222	51.586633	-130.455425	507.9
L223	50.821932	-130.311561	1896.0
L224	51.337502	-130.869669	2239.1
L225A	51.253673	-131.598918	2390.6

Burnwire corrosion took an average of 6.6 minutes (range 4-9 minutes) for most stations. Stations L202A and L210 each required a second activation, although total active burn times visible in the power consumption data for both stations appear to fall within the normal range, suggesting the burnwire circuit spontaneously deactivated itself earlier than it should have. Station L222 required multiple burnwire activations over the course of approximately 55 minutes, at least 35 minutes of which is active burn time based on the recorded power consumption data; this is the shallowest station at about 500m water depth. Long burn times have been observed in other shallow deployments of the NFSI's Aquarius units and may be due to sedimentation or biological activity fouling the burnwire; this behaviour is still under investigation. After dropping their ballasts, all instruments rose to the surface under their own buoyancy at an average of 105 m/min.

Due to damage to the electronics and the time elapsed between surfacing and recovery, reliable final clock offset measurements could not be obtained for stations L205 and L216 which had surfaced unexpectedly prior to the planned recovery operation. Final clock offsets were obtained for all stations recovered during this cruise. High drift rate (greater than ±4 ms/day, or 1 sample per day at 250 Hz) was measured for stations L212A and L213, at -4.14 and -5.43 ms/day respectively. All measured clock drifts are negative, with median clock drift rate of -1.57 ms/day.

Table 1-9: Clock drift information for all PACSAFE Leg 2 stations recovered during this cruise. Recording time covers from when the instrument is disconnected from the deck unit before deployment until the clock is stopped after recovery, so is slightly longer than total time on the seafloor. Clock drift rate assumes linear drift throughout the recording time.

Station	Length of Recording (days)	Final Clock Offset from GPS (ms)	Clock Drift Rate (ms/day)
L201	389.38	-49	-0.126
L202A	393.15	-1056	-2.686
L203B	392.98	-1305	-3.321
L204A	392.80	-552	-1.405
L206B	390.07	-498	-1.277
L207	387.89	-1139	-2.936
L208	389.13	-311	-0.799
L209	387.89	-683	-1.761
L210	387.21	-416	-1.074
L211	386.94	-643	-1.662
L212A	386.79	-1603	-4.144
L213	386.55	-2100	-5.433
L215B	387.46	-334	-0.862
L217A	386.41	-844	-2.184
L218	386.00	-414	-1.073
L219	387.71	-461	-1.189
L220	388.09	-105	-0.271
L222	386.08	-233	-0.604
L223	389.21	-610	-1.567
L224	386.85	-800	-2.068
L225A	390.01	-834	-2.138

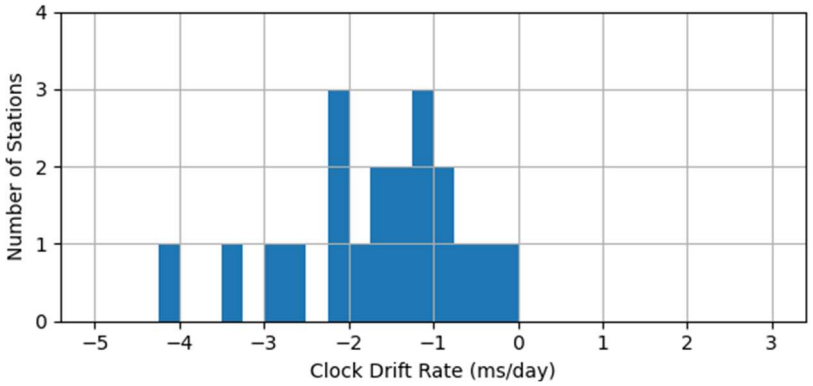


Figure 1-2: Histogram of clock drift rate for all PACSAFE Leg 2 stations with valid final clock offset measurements.

Of the 21 stations recovered, 4 have tilt angles greater than 5 degrees at both recovery and deployment. One additional station has a tilt angle greater than 5 degrees at deployment, but slightly less at recovery. Station L222 has a tilt estimate greater than 10 degrees from vertical at recovery. Apparent rotation during the deployment period is generally small. Seven of 21 stations for which this measure is available show rotations of greater than 1 degree. These rotations can typically be explained by instrument settling on the seabed, although larger rotations may have other causes.

Table 1-10: Estimates of instrument tilt shortly after deployment and immediately before release. Direction of maximum tilt is measured in each instrument's internal reference frame. Apparent rotation is calculated as the angle between the measured tilt vectors at deployment and recovery.

Station	Deployment		Recovery		Apparent Rotation (°)
	Tilt from Vertical (°)	Maximum Tilt Direction (°)	Tilt from Vertical (°)	Maximum Tilt Direction (°)	
L201	4.0	25.0	4.1	24.7	0.1
L202A	2.7	357.5	2.8	357.8	0.1
L203B	3.3	320.0	3.4	317.4	0.2
L204A	3.7	350.5	3.8	355.1	0.3
L205	0.9	332.1	n/a	n/a	n/a
L206B	0.3	228.7	0.1	209.1	0.2
L207	7.9	14.1	7.3	8.6	1.0
L208	3.1	20.7	3.0	11.8	0.5
L209	0.7	1.2	1.1	18.5	0.4
L210	2.6	40.0	2.8	38.8	0.2
L211	3.0	19.0	2.8	17.5	0.2
L212A	3.0	287.7	2.3	235.1	2.4
L213	3.1	351.7	3.2	351.2	0.0
L215B	8.7	293.4	8.1	283.9	1.5
L216	4.6	356.9	n/a	n/a	n/a
L217A	5.1	352.8	4.6	353.0	0.5
L218	1.3	255.0	0.9	349.9	1.6
L219	5.6	10.4	5.4	9.4	0.3
L220	4.0	14.8	4.0	0.2	1.0
L222	9.9	323.2	11.2	324.6	1.3
L223	2.0	322.7	2.2	321.3	0.3
L224	1.1	153.9	1.6	271.5	2.4
L225A	4.1	196.6	4.1	198.0	0.1

1.4 PACSAFE Leg 3 Deployments

In total, 21 Aquarius OBS were successfully deployed at PACSAFE Leg 3 sites during this cruise.

Table 1-11: Planned locations and actual OBS drop locations for all PACSAFE Leg 3 stations.

Station	Launch Time	Planned Location		Actual Drop Location			Distance from Planned (km)
		Latitude	Longitude	Latitude	Longitude	Water Depth (m)	
L301	2025-08-17 23:21:24	50.38160	-130.30380	50.382072	-130.302703	2532	0.094
L302	2025-08-18 18:11:00	50.05075	-130.37632	50.049843	-130.375907	2501	0.105
L303	2025-08-18 01:41:17	50.15036	-129.93664	50.151437	-129.939207	2322	0.219

L304	2025-08-18 22:59:10	49.96549	-129.54442	49.966730	-129.544370	2108	0.138
L305	2025-08-21 14:16:20	48.81805	-128.81183	48.817790	-128.812083	2591	0.034
L306	2025-08-18 20:54:32	49.90274	-129.95630	49.903762	-129.951347	2585	0.372
L307	2025-08-18 16:42:20	49.84518	-130.47485	49.845120	-130.473913	2467	0.067
L308	2025-08-18 14:16:45	49.50497	-130.56623	49.504768	-130.565973	2709	0.029
L309	2025-08-19 14:29:28	49.14361	-130.36873	49.143783	-130.368400	2625	0.031
L310	2025-08-19 22:15:54	49.42091	-129.99707	49.420250	-129.996620	2445	0.080
L311	2025-08-20 00:36:59	49.54156	-129.60066	49.541920	-129.600280	2447	0.048
L312	2025-08-20 19:53:44	49.33553	-128.76410	49.335080	-128.765130	2407	0.090
L313	2025-08-21 16:05:33	48.54619	-128.79831	48.545370	-128.797787	2515	0.099
L314	2025-08-19 19:35:36	49.14183	-129.54723	49.141650	-129.546970	2475	0.028
L315	2025-08-19 17:08:10	48.92828	-130.03537	48.928032	-130.034757	2800	0.053
L316	2025-08-20 14:08:30	48.75408	-129.35670	48.753770	-129.356287	2833	0.046
L317	2025-08-20 16:09:26	49.02572	-129.15777	49.024858	-129.158715	2427	0.118
L318	2025-08-20 21:58:40	49.03971	-128.59383	49.039700	-128.594350	2522	0.038
L319	2025-08-22 01:24:09	49.12348	-128.20211	49.123050	-128.203120	2473	0.088
L320	2025-08-21 19:14:06	48.69418	-128.22017	48.693530	-128.218970	2553	0.114
L321	2025-08-20 18:15:45	49.32574	-129.11411	49.326023	-129.114663	2436	0.051

Seafloor locations were surveyed for 19 of 21 Leg 3 stations during this cruise, mostly during overnight operations following each day shift's deployments. Seafloor communication could not be established at stations L301 and L319. All surveys were performed using a USBL system (using the CASIUS tool within *Ranger 2* software). Coordinates obtained for all stations are listed in Table 1-12. Bearings of drift measurements are given in degrees clockwise from North.

Table 1-12: OBS drop locations and surveyed seafloor locations for all Leg 3 stations.

Station	Drop Location		Surveyed Seafloor Location			Horizontal Drift	
	Latitude	Longitude	Latitude	Longitude	Depth (m)	Distance (m)	Bearing (°)
L301	50.382072	-130.302703	n/a	n/a	n/a	n/a	n/a
L302	50.049843	-130.375907	50.049544	-130.376863	2458.1	76.1	244.1
L303	50.151437	-129.939207	50.152771	-129.940597	2284.0	178.6	326.2
L304	49.966730	-129.544370	49.968679	-129.543741	2083.7	221.4	11.8
L305	48.817790	-128.812083	48.816369	-128.811914	2582.8	158.5	175.5
L306	49.903762	-129.951347	49.904565	-129.950351	2565.8	114.5	38.7
L307	49.845120	-130.473913	49.844317	-130.473708	2422.0	90.5	170.6
L308	49.504768	-130.565973	49.504792	-130.563619	2691.4	170.5	89.1
L309	49.143783	-130.368400	49.144768	-130.368681	2608.3	111.4	349.4
L310	49.420250	-129.996620	49.419735	-129.993643	2426.1	223.5	104.8
L311	49.541920	-129.600280	49.542250	-129.596950	2426.4	243.8	81.3
L312	49.335080	-128.765130	49.334353	-128.763229	2392.0	160.1	120.3
L313	48.545370	-128.797787	48.545793	-128.798970	2502.0	99.2	298.3
L314	49.141650	-129.546970	49.142379	-129.546308	2458.1	94.4	30.8
L315	48.928032	-130.034757	48.928414	-130.035646	2780.7	77.8	303.1
L316	48.753770	-129.356287	48.754181	-129.357436	2816.8	96.1	298.4
L317	49.024858	-129.158715	49.025109	-129.158492	2414.3	32.3	30.3
L318	49.039700	-128.594350	49.038238	-128.594323	2506.3	162.6	179.3
L319	49.123050	-128.203120	n/a	n/a	n/a	n/a	n/a
L320	48.693530	-128.218970	48.693416	-128.219107	2541.5	16.2	218.5
L321	49.326023	-129.114663	49.325689	-129.112220	2423.6	181.4	101.8

The maximum horizontal drift distance during freefall is approximately 240 metres or 10.6% of water depth for any station (excluding those not surveyed). Average drift distance is approximately 130 metres or 5.4% of water depth. There does not appear to be a consistent pattern in drift direction for this array.

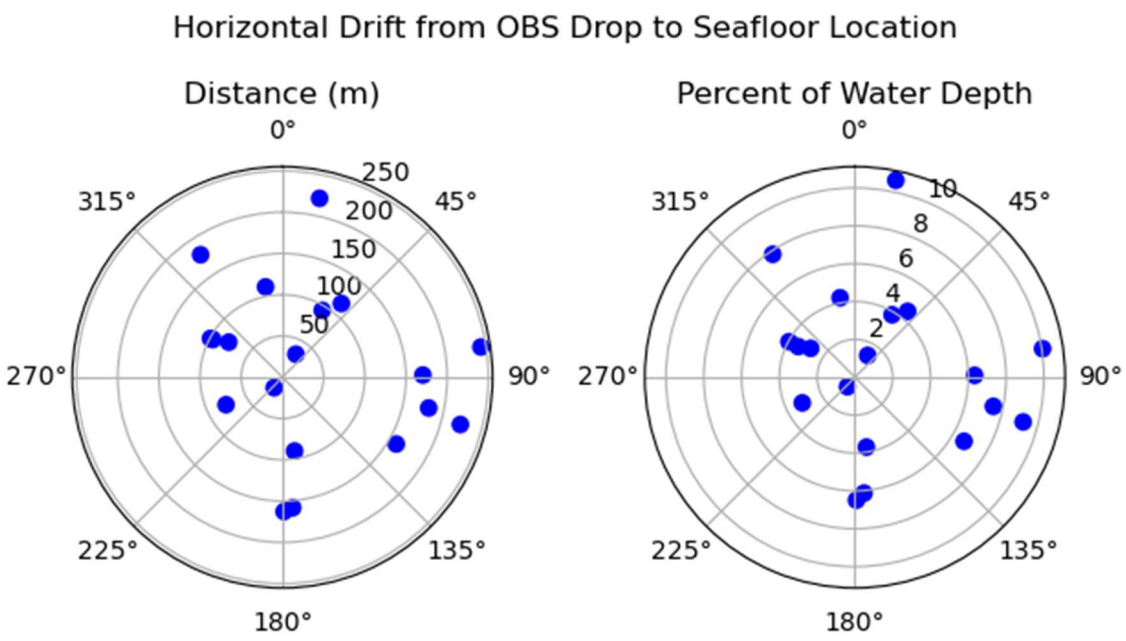


Figure 1-3: Horizontal drift measurements for PACSAFE Leg 3 stations with surveyed seafloor locations (excluding L301 and L319).

Tilt estimates were obtained during the seafloor location survey for stations with reliable acoustic communication. Stations L301 and L319 could not be contacted once at the seafloor. Limited communication was possible for L320, but signal quality was not sufficient to retrieve a status message. Of the 18 stations for which estimates are available, 3 have tilt angles greater than 5 degrees from vertical, with a maximum tilt angle of 9 degrees at station L302. These values will be compared with estimates obtained at recovery in 2026.

Table 1-13: Estimated tilt from vertical for each PACSAFE Leg 3 station shortly after deployment. Tilt direction is measured in each instrument's internal reference frame.

Station	Estimated Tilt from Vertical (°)	Tilt Direction (°)
L301	n/a	n/a
L302	9.0	161.4
L303	0.4	41.1
L304	3.9	114.8
L305	2.7	140.2
L306	4.2	185.1
L307	5.6	180.5
L308	1.6	76.7
L309	3.1	141.9
L310	2.4	142.2
L311	3.1	158.4
L312	2.0	192.2
L313	2.2	204.7
L314	5.3	184.3
L315	2.6	152.2

L316	1.5	127.7
L317	2.3	55.8
L318	4.2	130.2
L319	n/a	n/a
L320	n/a	n/a
L321	4.8	180.9

Table 1-14 lists the instrument serial numbers, acoustic modem information, Apollo Mono GPS beacon serial numbers and backup release time for the deployed stations. During troubleshooting of acoustic communication at station L319, attempts were made to change the address of the OBS acoustic modem. No response was received, so it is unknown if the new setting was accepted by the instrument. The address for this OBS listed below is as set during pre-deployment programming. If settings were changed, the current address may be any of 5505, 5802 or 5711.

Table 1-14: List of key information for each PACSAFE Leg 3 station.

Station	Serial Number	Modem Address	Modem UID	Apollo Mono S/N	Backup Release Time (UTC)
L301	AQU-0E62	5602	U006AE7	514	2026-11-21 23:30
L302	AQU-1561	5805	U007308	669	2026-11-20 18:00
L303	AQU-C05E	5707	U007301	574	2026-11-21 02:00
L304	AQU-3F5F	5607	U0075FF	561	2026-11-20 12:00
L305	AQU-C060	5708	U006660	689	2026-11-19 09:00
L306	AQU-DA61	5712	U007459	512	2026-11-20 15:00
L307	AQU-D361	5610	U007312	577	2026-11-20 21:00
L308	AQU-2B62	5605	U007313	575	2026-11-21 00:00
L309	AQU-2C62	5705	U00745A	629	2026-11-20 12:00
L310	AQU-CB5A	5809	U007306	697	2026-11-20 03:00
L311	AQU-BC60	5702	U006ADD	612	2026-11-20 00:00
L312	AQU-465F	5609	U00746B	695	2026-11-19 15:00
L313	AQU-755C	5913	U00745C	578	2026-11-19 06:00
L314	AQU-BA5C	5905	U00745F	631	2026-11-20 06:00
L315	AQU-E661	5512	U0079C9	630	2026-11-20 09:00
L316	AQU-CB60	5810	U006AC7	670	2026-11-20 00:00
L317	AQU-1B61	5703	U007304	703	2026-11-19 21:00
L318	AQU-CD60	5812	U006646	558	2026-11-19 12:00
L319	AQU-2A61	5505*	U00746C	551	2026-11-19 00:00
L320	AQU-D261	5510	U007314	613	2026-11-19 03:00
L321	AQU-3661	5706	U007303	700	2026-11-19 18:00

2.0 Data Access

Access to the PACSAFE OBS dataset is managed under NFSI's data sharing policy. Principal investigators and collaborators on the NSERC Alliance grant have exclusive access to the data for research performed by them or their mentees during an embargo period of 3 years from the date of data distribution to the

research team (expected within 1-4 months following the cruise end date). Following the embargo period, other researchers may request access to the data by submitting a formal application, which will be reviewed by the project PIs and the NFSI committee.

The full PACSAFE dataset is covered by FDSN network code 2S (2023-2029) and may be cited using its DOI (10.7914/nr48-3x83).

Data collected from the ONC Endeavour stations is managed by Ocean Networks Canada. Stations serviced during this cruise are included in the existing NEPTUNE network (DOI 10.7914/SN/NV) accessible through the EarthScope (IRIS) Data Management Center.

3.0 Preliminary Data Assessment

Data were downloaded from the recovered instruments and preliminary data quality assessment performed within 24 hours of each recovery using NFSI's in-house script to verify data quality and instrument functionality before redeployment. The auto-generated data reports are included in the full metadata package for each dataset.

3.1 PACSAFE Leg 2

Most instruments contained full recordings for the deployment period. Two OBS (stations L212A and L220) showed small gaps in the recorded data, but no more than one gap per channel per instrument, with a maximum gap length on any seismometer channel of 270.748 seconds (gaps are longer for low-sample-rate auxiliary channels). Numbers of gaps are indicated on a per channel basis in Table 3-1, and a full list of data gaps for the seismometer channels is shown in Table 3-2.

Table 3-1: Summary of data collected from all PACSAFE Leg 2 OBS stations for key sensors of interest.

	Good data (no issues observed)
#	One or more data gaps (# = gap count), no other issues
	High clock drift measured (>4ms/day)
	Final clock offset measurement unavailable
	Data missing or corrupt
	Instrument not recovered

Station	Recording Time on Seafloor (UTC)		Seismometer Channels			Environmental Sensors	
	Start	End	Z	N	E	P	T
L201	2024-07-18 16:47:01	2025-08-11 22:07:50					
L202A	2024-07-20 18:44:02	2025-08-17 19:53:59					
L203B	2024-07-20 20:40:04	2025-08-17 17:06:44					
L204A	2024-07-20 22:12:15	2025-08-17 14:48:20					
L205+	2024-07-20 23:44:07	2024-07-31 02:11:04					
L206B	2024-07-21 20:38:12	2025-08-15 17:11:17					
L207	2024-07-21 22:31:46	2025-08-13 17:02:42					
L208	2024-07-21 23:50:38	2025-08-14 23:44:59					
L209	2024-07-22 01:34:35	2025-08-13 20:05:14					

L210	2024-07-23 17:56:30	2025-08-14 20:33:03					
L211	2024-07-23 21:24:43	2025-08-14 17:09:15					
L212A	2024-07-23 23:03:56	2025-08-14 14:42:26	1				
L213	2024-07-23 15:10:04	2025-08-14 01:19:07					
L215B	2024-07-22 14:53:55	2025-08-13 22:59:22					
L216[+]	2024-07-22 16:43:32	2024-08-18 00:48:09					
L217A	2024-07-22 18:42:55	2025-08-13 01:28:06					
L218	2024-07-22 21:56:28	2025-08-12 19:37:12					
L219	2024-07-21 02:17:55	2025-08-12 17:25:37					
L220	2024-07-20 16:04:33	2025-08-12 14:51:06	1	1	1	1	1
L222	2024-07-22 23:16:55	2025-08-12 23:07:11					
L223	2024-07-18 23:12:52	2025-08-12 01:14:23					
L224	2024-07-22 20:34:43	2025-08-13 14:34:01					
L225A	2024-07-21 17:18:52	2025-08-15 14:22:45					

[+] End times for L205 and L216 are end of normal recording before release (some data loss around time of release due to damage from water ingress).

Table 3-2: List of recording gaps for all seismometer channels of PACSAFE Leg 2 stations.

Channel	Start	End	Length (s)	No. Samples
2S.L212A..CH3	2025-08-14 14:23:18.943	2025-08-14 14:23:54.947	36.000	9000
2S.L220..CH1	2025-02-24 22:34:43.299	2025-02-24 22:39:14.051	270.748	67687
2S.L220..CH2	2025-02-24 22:38:16.263	2025-02-24 22:39:14.051	57.784	14446
2S.L220..CH3	2025-02-24 22:38:12.995	2025-02-24 22:39:14.051	61.052	15263

From preliminary assessment, the recorded data appear to be of good quality. Noise levels vary between stations. Figure 3-1 shows examples of acceleration PSD spectrograms for seismometer Z components of selected stations, calculated using an average periodogram method (similar to McNamara and Buland, 2003) for 1-hour time windows with 50% overlap. For all stations, the global microseism is the dominant energy source, covering a band approximately 0.1-2 Hz, with peak power around 0.2 Hz. Seafloor compliance signal is visible for most stations below about 0.025 Hz (40 seconds period), with maximum frequency varying according to water depth. Many local and regional earthquakes are visible in the spectrograms as vertical lines of higher power.

All stations show elevated energy in the 15-30Hz band throughout the fall and winter months. Many stations also show consistent energy at 40-45Hz over a similar time period. These frequencies correspond to known calls made by fin whales and other cetacean species.

Station L222 shows notably high low-frequency noise with an approximately twice-daily periodicity throughout the deployment time. This is the shallowest station, at water depth of approximately 500 metres, and is located between two submarine canyons at the continental slope. The observed noise signals may be related to tidal flows in these benthic troughs.

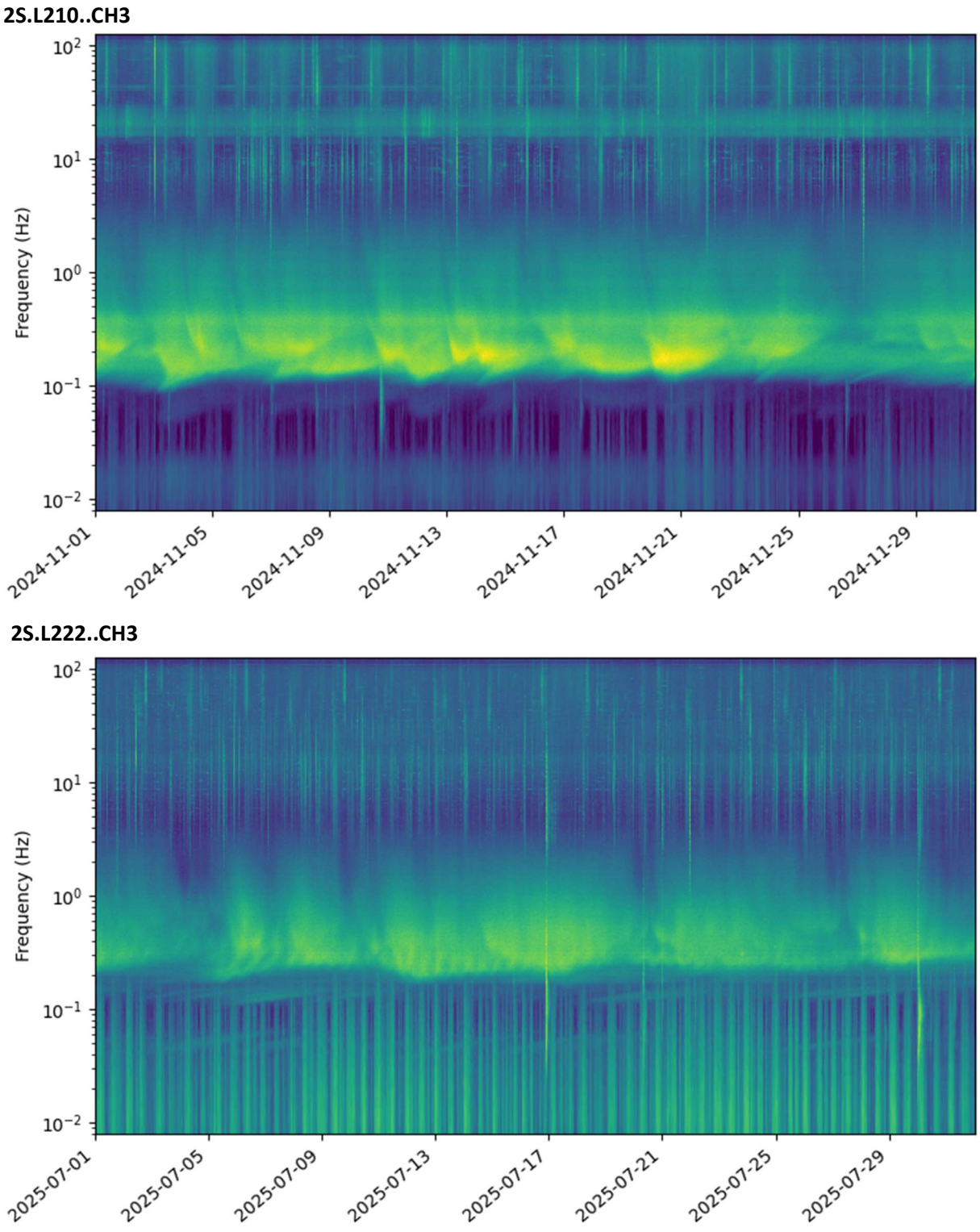


Figure 3-1: Acceleration PSD spectrograms of seismometer Z component at stations L210 in November 2024 (top) and L222 in July 2025 (bottom). Vertical lines of higher amplitude (green/yellow) are characteristic of earthquake signals. Compliance signal can be seen as slightly elevated consistent noise below 0.025Hz at L210 (water depth 2330m) and approximately 0.06Hz at L222 due to shallower water depth (508m).

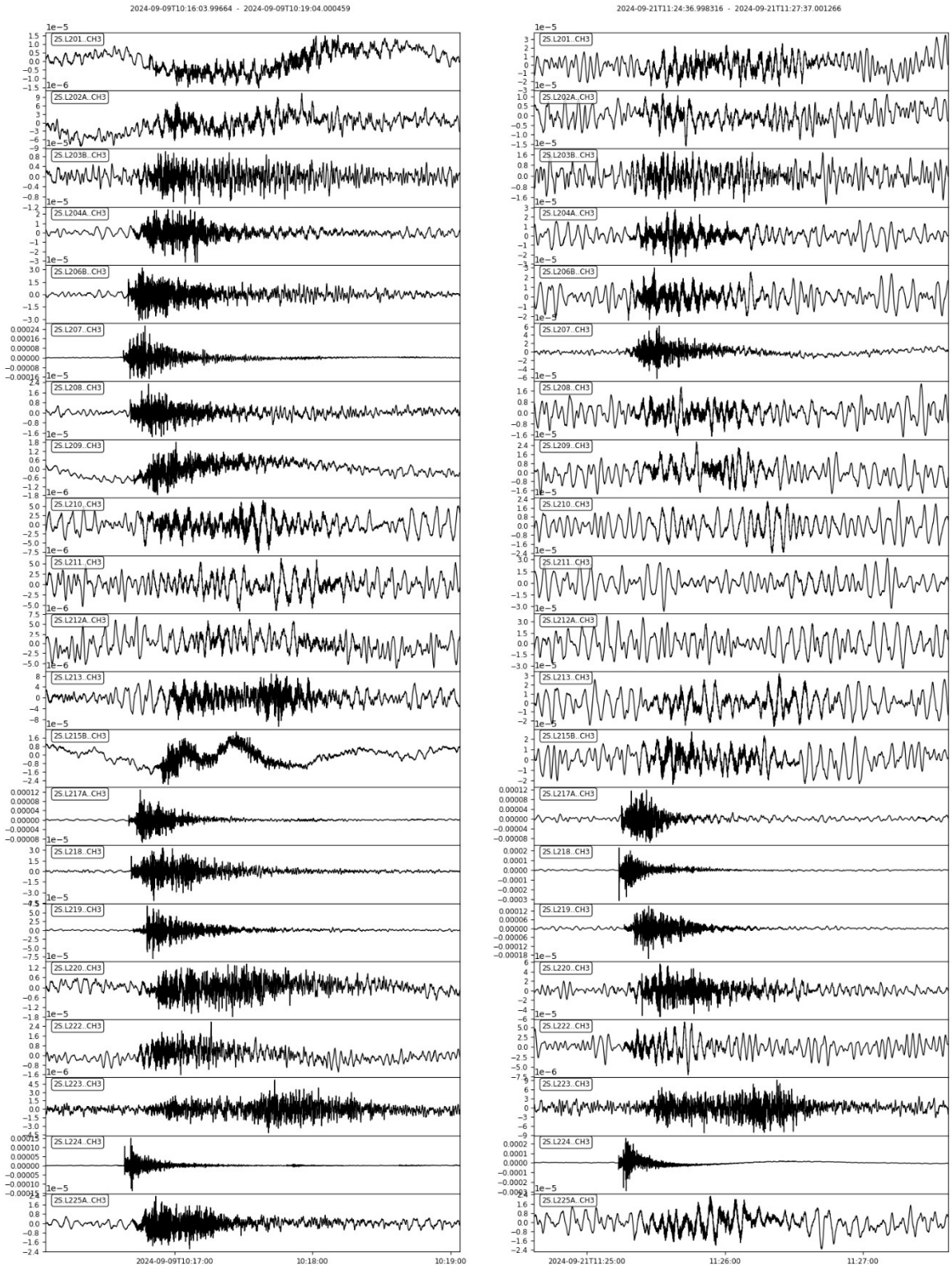


Figure 3-2: Example waveforms recorded by the PACSAFE Leg 2 stations before and after M_w6.4 event on 2024/09/15. For each signal, the window shown is 3 minutes long, starting 30 seconds prior to the event origin time in the NEDB catalog (as of September 2025). Only Z components are shown, ordered by station number. No filtering has been applied. Left: M_L2.3 event at 10:16:34 on 2024/09/09, epicentre 51.448N, 130.975W (closest station L224). Right: M_w3.3 event at 11:25:07 on 2024/09/21, epicentre 51.307N, 130.943W (closest station L224).

Origin times from the Canadian National Earthquake Database (NEDB) maintained by NRCan/GSC were used to search the OBS data for easily identifiable seismic signals. The CNSN land network identified 1007 events within 200km of the array centre during the deployment time, including an extensive sequence related to a M_w6.4 event with estimated origin time on September 15, 2024 at 22:22:43 UTC and epicentre location approximately 7.6km west of station L224 (51.342°N, 130.975°W) near the centre of the OBS array. Processing of the PACSAFE dataset is expected to significantly expand the existing earthquake catalog.

The M_w6.4 event on September 15, 2024, appears to have a significant impact on background noise levels for much of the array in the days immediately following this event and continued impact on the closest stations in the centre of the array for weeks or months. Figure 3-2 shows example waveforms for smaller earthquakes approximately 6 days before and after the mainshock which are located nearby. Although the aftershock shown has significantly larger magnitude (M_w3.3 vs. M_L2.3 for the foreshock), observed signal-to-noise ratios in the OBS data are similar for both events and in fact slightly better for the smaller magnitude foreshock at most stations.

3.2 ONC Endeavour Stations

All 5 instruments contained full recordings for the deployment period. Table 3-3Table 3-1 summarizes the key data collected from all stations. In accordance with ONC's existing data agreements, these data will be reviewed by the United States Navy prior to release.

Table 3-3: Summary of data collected from all ONC Endeavour OBS stations for key sensors of interest.

	Good data (no issues observed)
#	One or more data gaps (# = gap count), no other issues
	High clock drift measured (>4ms/day)
	Final clock offset measurement unavailable
	Data missing or corrupt
	Instrument not recovered

Station	Recording Time on Seafloor (UTC)		Seismometer Channels			Environmental Sensors	
	Start	End	Z	N	E	P	T
ENS01	2024-06-08 03:58:11	2025-08-08 21:45:10					
ENS02	2024-06-07 18:58:53	2025-08-09 00:14:09					
ENS03	2024-06-09 00:06:38	2025-08-08 18:03:05					
ENS04	2024-06-09 07:22:21	2025-08-09 19:44:03					
ENS05	2024-06-09 03:17:12	2025-08-09 15:51:15					

3.3 Signals of Concern

3.3.1 Initial Seismic Data

For several stations, there is a brief period immediately after deployment during which the recorded data is flatlined at either the maximum or minimum reading. This period lasts a variable amount of time for each affected channel, up to a maximum of roughly 8 hours. This appears to be a result of the centring mechanism being locked. The centring mechanism of the Aquarius's seismometer is designed to adjust automatically with movement of the instrument. When under heavy movement, such as on the deck of a ship, the mechanism will fail to centre and enter a locked state to avoid continual centring attempts and save power, with a timeout period before attempting to recentre. The timeout period becomes longer with each consecutive failed attempt.

The NFSI's standard deployment procedure includes manual triggering of the centring mechanism after the instrument reaches the seafloor. As most of the Leg 2 array was deployed in "kick and run" mode, where we did not remain on station for the freefall period and returned later to perform the location survey, this step may not have been performed until well after touchdown leading to the observed initial lockdowns.

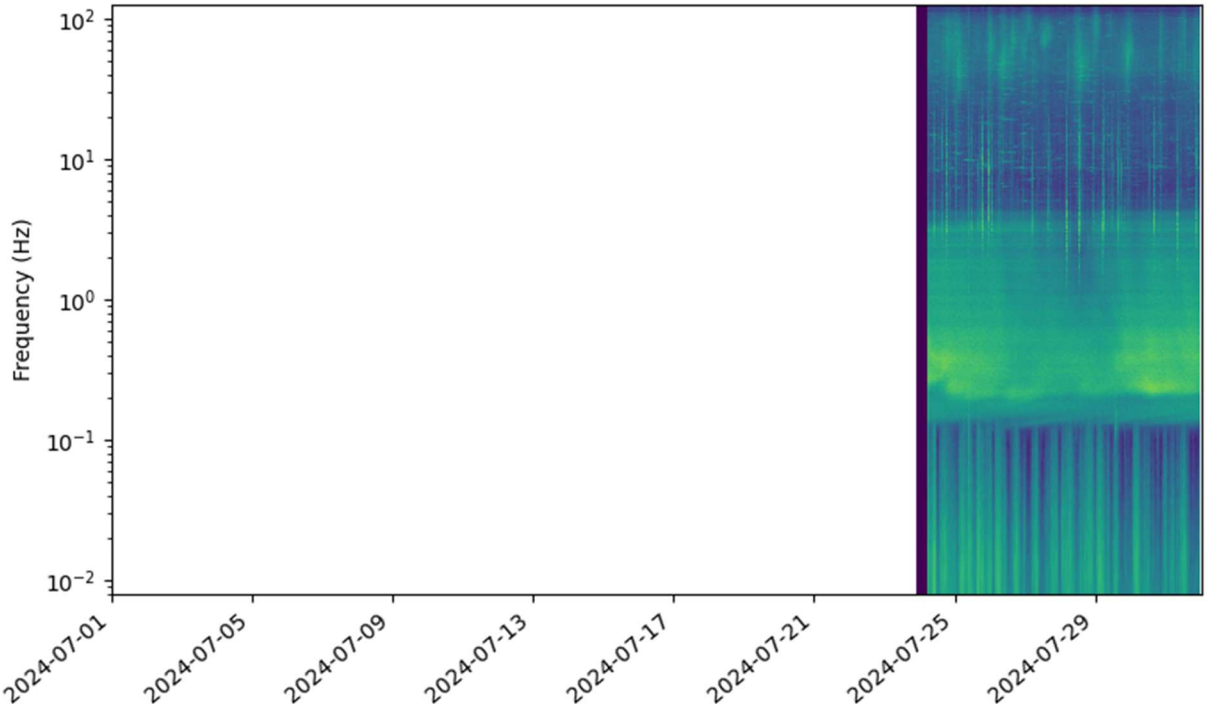


Figure 3-3: PSD acceleration spectrogram for seismometer channel CH1 of station L211 in July 2024. The first ~7.5 hours after deployment show flatlined data.

3.3.2 Evidence of Water Ingress

Clear evidence of water ingress was observed in the internal humidity data of AQU-1F61 (deployed at station L218); this instrument was held back from redeployment. Later forensic investigation revealed an apparent small leak through the 2-pin electrical connector used for the burnwire, which was replaced. No other internal damage was noted.

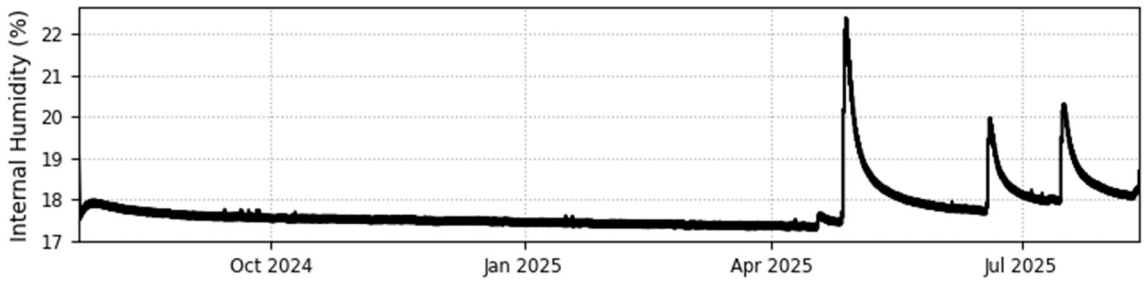


Figure 3-4: Internal humidity data for AQU-1F61 (L218). Successive peaks beginning in April 2025 indicate water ingress events.

Three additional stations (L204A, L206B, L215B) showed potential minor water ingress, but the available evidence was not significant or conclusive enough to preclude redeployment with readings generally returning to baseline quickly. All were successfully redeployed at Leg 3 sites.

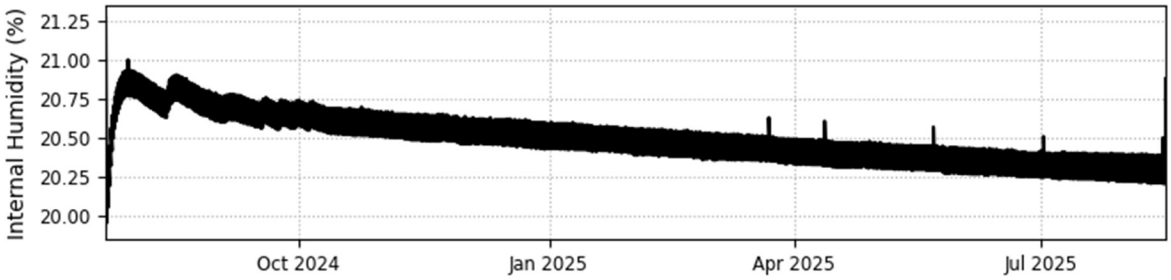


Figure 3-5: Internal humidity data for AQU-C060 (L206B), inconclusive for minor water ingress in the first 3 months deployed.

AQU-CB60 (deployed at L212A) showed abnormally high internal humidity readings throughout the deployment period, including a brief period where measured values were too high to be properly recorded by the instrument. Readings were also unusually high for this instrument in the Leg 1 deployment (station L124). It is unclear if this is a true signal or the sensor may be malfunctioning.

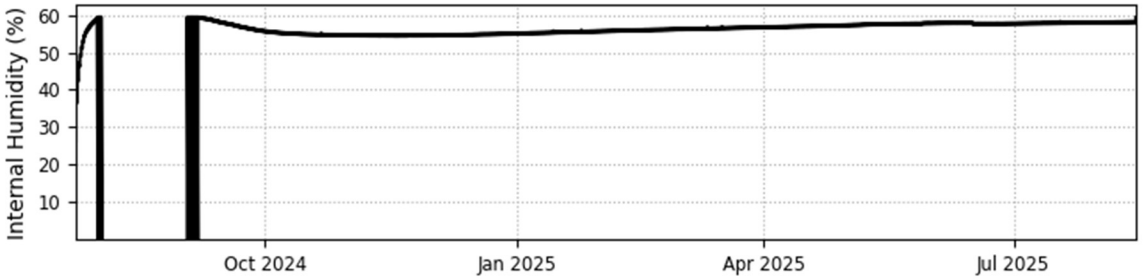
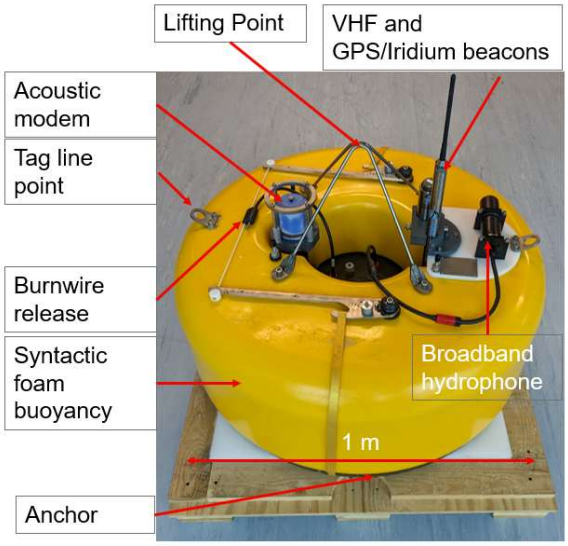


Figure 3-6: Internal humidity data for AQU-CB60 (L212A). Maximum recordable value is ~60%Rh; dropped-out section in Aug-Sept 2024 is artificially wrapped to low values.

Appendix A: Equipment Specifications

Aquarius Broadband Ocean Bottom Seismometers

The NFSI Aquarius Ocean Bottom Seismometers (OBS) are broadband devices made by Güralp Systems Ltd. The instruments are typically deployed in free fall mode, released from a surface vessel to sink to the seafloor under the weight of their detachable ballast, and return to the surface for recovery under their own buoyancy when the ballast is released via acoustic command.



Instrument weight 240kg + 90kg anchor
Sink rate ~0.6 m/s; Rise rate ~1.5 m/s

Specification	Number	Research Impact
Number of units	120+1	High resolution and coverage
Max deployment (months)	18	Allows long-term deployments needed for earthquake monitoring
Clock drift (us/day)	<30	Precise time-keeping over long deployments
Seismometer bandwidth	120s – 100Hz	Joint use for earthquake process and structure imaging studies
Dynamic range	24-bit	Able to record broad range of signal amplitudes
Hydrophone bandwidth	100s – 8kHz	Acoustic monitoring of microseismics and seafloor compliance
Communication	Acoustic Modem	Allows real time data to surface from SF instruments
Buyancy	Syntactic foam	Unsinkable once anchor is released

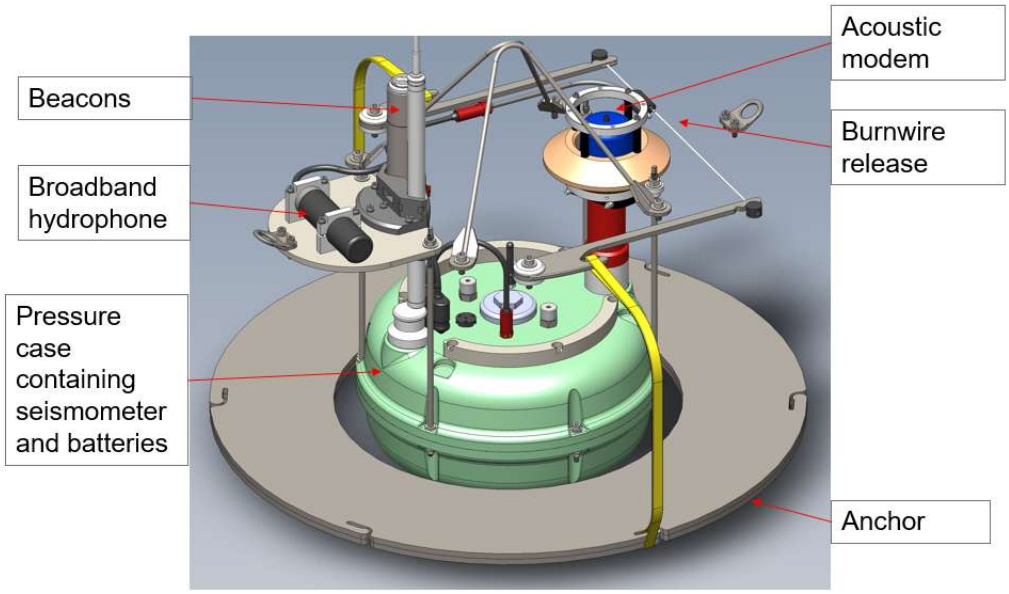


Table A-1: Güralp Aquarius OBS specifications, reflecting NFSI customizations.

Feature	Specification
Seismic sensor	• Broadband triaxial force-feedback sensor • Flat response from 120 s to 100 Hz • Nominal velocity response 2000 V/ms^{-1} • Tilt tolerance +/- 90 deg.
Absolute Pressure Gage	• Keller PA-10L. Accuracy 0.25%
Hydrophone	• High Tech HTI-04-PCA/ULF • Passband 100 s to 8 kHz; Sensitivity -194 dB re: 1V/µPa. • NOT AVAILABLE FOR 2024 OR 2025 DEPLOYMENTS
Additional Channels & State of Health	• 3-comp digital compass composed of MEMS accelerometer and magnetometer • Temperature, humidity & supply voltage sensors
Data Logger	• Güralp Ultra-Low Power Digitizer board with Certimus computer.
Data Storage & Recording formats	• 128 GB dual redundant flash cards • Data stored in miniSEED format • Metadata stored in dataless SEED, RESP and StationXML format
ADC & Sample Rates	• 24-bit low-power 4 channel delta-sigma • Sample rate typically 250 Hz for seismic channels and 5 Hz for auxiliary sensors
Clock	• Double compensated microprocessor controlled TCXO • Locked to GPS time before each deployment • Uncorrected drift typically < 1 ms/day • Linear drift correction applied post-deployment
Power	• Lithium-Ion battery packs made up of 468 LG INR 18650 MJ1 cells • Total energy of 5954 Wh provides nominal autonomy of 15-18 months on seafloor, depending on application • Charge time approx. 1 hr/month of deployment
Acoustic Communication	• Sonardyne 6G LMF omnidirectional transceiver used for communication and positioning instruments on the seafloor • Used with surface transponder or USBL systems • Communication rates up to 9000 bps
Release Mechanism	• Burnwire triggered by acoustic command, timed release or critical battery level trigger
Recovery Tracking Beacons	• Xeos Apollo Mono Iridium GPS LED Flasher beacon • Xeos XMB-11K VHF beacon
Instrumentation Pressure Case	• 7000 series rolled aluminium, anodized • Pressure rated to 6000 m • Weight: 89 kg in air; 44.6 kg in seawater
Syntactic Foam Flotation	• Weight: 150 kg in air; 86 kg uplift in seawater
Ballast	• 10 mm + 15 mm steel plates • Weight: 89 kg in air, 77.4 kg in seawater
Full Instrument Weight/Buoyancy	• Air weight 239 kg instrument + 89 kg ballast = 328 kg • In-water weight: 44.6 + 77.4 – 86 = 36 kg • Buoyancy without ballast: 86 – 44.6 = 41.4 kg

Full Dimensions with Flotation and Ballast	• 1000 mm diameter cylinder • Height to top of buoyancy 459 mm • Height to top of lifting bar 725 mm
Sink/Rise Rate	• Sink rate 0.6 m/s, Ascent rate 1.5 m/s

Recovery Devices

The NFSI Aquarius OBS are equipped with recovery beacons made by Xeos Technologies Inc. These beacons are surface activated and autonomous, providing a margin of safety should the OBS batteries become depleted or the software malfunction. Two types of recovery beacons are used: an XMB-11K VHF beacon and an Apollo Mono Iridium GPS/LED Flasher beacon.

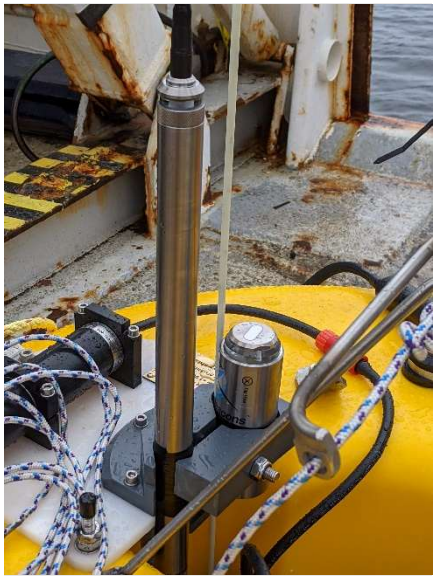


Figure A-1: Recovery devices mounted on OBS. XMB-11k VHF beacon on left, Apollo Mono GPS/LED/Iridium beacon on right.

The XMB-11K emits a VHF radio signal that can be located using a receiver equipped with a directional Yagi antenna to ranges of up to 12 km for a duration of typically 5 days (dependent on pulse length and repetition frequency) after surfacing. For the 2024 and 2025 OBS deployments performed by NFSI, all XMB-11K's were configured to transmit at 159.480 MHz.

The Apollo Mono transmits its GPS position via Iridium satellite and has an LED flasher for visually locating the instrument at night. For the first hour after surfacing, the Apollo will send positional updates every 10 minutes and activate its flasher, then switch to hourly updates. Instrument positions can be tracked via an online map or with a handheld Xeos Hermes receiver. Positional update frequency and LED activation can be reconfigured remotely through the Iridium link to extend battery life. The Apollo is powered by primary lithium batteries. Communication longevity will depend on update frequency and sea conditions, but with daily updates for a drifting instrument will be more than 1 year.

Positioning Systems

NFSI brought two independent acoustic systems on the NFSI-015-2025-04 cruise to communicate with OBS instruments and determine their position on the seafloor: a Sonardyne LMF Ranger 2 Type 8084 Gyro Ultra-Short Baseline (GyroUSBL) 7000 Positioning System, and a Sonardyne Modem 6 Mini-Dunker LMF LBL and Telemetry Transceiver System Type 8244-3156. The USBL system was primarily used, with the dunker as a backup.

The Ranger 2 GyroUSBL system combines a 6th generation directional High-Performance Transceiver (HPT) and a Lodestar Attitude and Heading Reference System (AHRS)/Inertial Navigation System (INS) in the same housing. With the mechanical alignment of the AHRS fixed relative to the HPT's acoustic array, the requirement for a total system calibration to determine the alignment of the ship's motion sensors to the transceiver is, in many situations, eliminated. The LMF 7000 model is optimized for deep water. The system comes with a Navigation Computer which runs the *Ranger 2* software application. For the NFSI-015-2025-04 cruise, the GyroUSBL was mounted on a pivoting pole over the port side of the ship. The pole was raised during transits and put down during operations in order to communicate with the instruments.



Figure A-2: LMF GyroUSBL transceiver mounted on side-along pole of CCGS John P Tully in 2023 (stowed/transit position).

Table A-2: Sonardyne LMF Ranger 2 Type 8084 GyroUSBL 7000 Positioning System Specifications

Feature	Specification
Transceiver depth rating	1,000 m
Operating Frequencies	LMF (14-19.5 kHz)
Transmit Source Level (dB re 1 µPa @ 1 m)	200 dB
Tone Equivalent Energy (TEE)	206 dB
Heading Accuracy	0.2 deg
Pitch & Roll Accuracy	0.01 deg
Heave	+/- 99m Range. 5 cm or 5% (whichever is greater) real time accuracy

Operating Range	Up to 7,000 m. Up to +/- 90 deg
Positioning Accuracy	Better than 15 mm Range Accuracy Up to 0.04% of Slant Range
Data Rates	Up to 9 kbps
Position Update Rate	1 Hz, independent of water depth
Mounting	Through hull, or over the side on pivoting pole

The Dunker is operated by lowering it over the side on the end of a cable. It is nominally able to communicate with instruments to depths of 6000m. It works as an acoustic modem to communicate with instruments on the seafloor or in the water column and can provide range measurements but not direction. Ranging can be used to position instruments with acoustic triangulation by moving the ship to measurement points that provide geometric constraint around the seafloor location.

Table A-3: Sonardyne Modem 6 Mini-Dunker Type 8244-3156 Telemetry Transceiver System Specifications

Feature[1]	
Transceiver depth rating	3,000 m
Operating Frequencies	LMF (14-19 kHz)
Transducer Beam Shape	Directional
Transmit Source Level (dB re 1 μPa @ 1 m)	190-196 dB
Tone Equivalent Energy (TEE)	196-202 dB
Range Accuracy	Better than 15 mm

As listed on Sonardyne datasheet