

Expedition Summary for Pacific Offshore Seamounts Survey PAC2017-036

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PAC2017-036

By

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Abstract

Gale, K.S.P., Norgard, T., Du Preez, C., Chu, J.W.F., Stanley, C., Nephin, J., Halpin, L., Thiess, M., Wallace, K., Zand, J.D.M., Pegg, J., Romaine, S., Gauthier, S., and Ianson, D. 2026. Expedition Summary for Pacific Offshore Seamounts Survey PAC2017-036. Can. Tech. Rep. Fish. Aquat. Sci. 3720: ix + 46 p. <https://doi.org/10.60825/kn2b-ty36>

Fisheries and Oceans Canada (DFO) conducted a deep-sea survey (PAC 2017-036) aboard the Canadian Coast Guard Ship (CCGS) *John P. Tully* from July 18 to August 1, 2017. The primary goals of this expedition were to characterize, map, and explore offshore seamount ecosystems within the recently-announced (May 2017) Pacific Offshore Area of Interest (AOI). A tow-camera system completed twelve dives at one test site, eight seamounts, and one ridge. A total of 62 hours were spent on the seafloor, covering approximately 50 linear km and spanning approximately 2 km of vertical distance. Oceanographic sampling was completed at four seamounts and included water column physical properties, chemistry, and zooplankton composition. Complementary seabird and marine mammal surveys documented 22 species of seabirds, 11 species of marine mammals including the first observation of Common Bottlenose Dolphin (*Tursiops truncatus*) in the Canadian Pacific, and four species of large sharks and fishes. Social media was used to promote the findings during the expedition and attract viewers to the livestream of the daily dives. This survey was the first of a number of expeditions to seamounts in the AOI, which provided empirical observations used to describe and characterize habitats at seamounts in the AOI and supported the development of the Tang.gwan – Һačxwiqak – Tsigis Marine Protected Area (ThT MPA), which was designated under the Oceans Act in 2024.

Résumé

Gale, K.S.P., Norgard, T., Du Preez, C., Chu, J.W.F., Stanley, C., Nephin, J., Halpin, L., Thiess, M., Wallace, K., Zand, J.D.M., Pegg, J., Romaine, S., Gauthier, S., and Ianson, D. 2026. Expedition Summary for Pacific Offshore Seamounts Survey PAC2017-036. Can. Tech. Rep. Fish. Aquat. Sci. 3720: ix + 46 p. <https://doi.org/10.60825/kn2b-ty36>

Pêches et Océans Canada (MPO) a réalisé une enquête en haute mer (PAC 2017-036) à bord du navire de la Garde côtière canadienne (NGCC John P. Tully) du 18 juillet au 1er août 2017. Les objectifs principaux de cette expédition consistaient à caractériser, cartographier et explorer les écosystèmes des monts sous-marins situés au large, dans la zone d'intérêt du Pacifique récemment annoncée (mai 2017). Un système de caméra tractée a effectué douze plongées sur un site d'essai, huit monts sous-marins et une arrête. Au total, 62 heures ont été consacrées à l'exploration du fond marin, couvrant environ 50 kilomètres linéaires et 2 kilomètres de distance verticale. L'échantillonnage océanographique, réalisé sur quatre monts sous-marins, a inclus la collecte de données sur les propriétés physiques de la colonne d'eau, les paramètres chimiques, et la composition du zooplancton. Des inventaires complémentaires des oiseaux et mammifères marins ont permis d'identifier 22 espèces d'oiseaux marins, 11 espèces de mammifères marins incluant la première observation du Grand Dauphin (*Tursiops truncatus*) dans le Pacifique canadien, ainsi que quatre espèces de grands requins et poissons. Les médias sociaux ont été utilisés pour diffuser les résultats de l'enquête et promouvoir la diffusion en direct des plongées quotidiennes. Cette enquête constitue la première d'une série d'expéditions visant les monts sous-marins dans la zone d'intérêt, fournissant des observations empiriques pour la description et la caractérisation des habitats des monts sous-marins et contribuant à l'élaboration de la Zone de Protection Marine Tang.gwan – Һačxwiqak – Tsigis (ZPM ThT), désignée sous la Loi sur les océans en 2024.

1 Introduction

Fisheries and Oceans Canada (DFO) conducted a deep-sea expedition (PAC 2017-036) aboard the Canadian Coast Guard Ship (CCGS) *John P. Tully* from July 18 to August 1, 2017. The primary goals of this expedition were to characterize, map, and explore offshore seamount ecosystems within the recently-announced (May 2017) Pacific Offshore Area of Interest (AOI) (DFO2019; DFO2021). The main research priorities were to:

1. Characterize the locations and distributions of vulnerable marine ecosystem (VME) taxa such as cold-water corals and sponges (CWCS) on seamounts and ridges within the AOI;
2. Characterize the influence of the seamounts on the oceanography within the AOI;
3. Gather improved bathymetry data for known seamounts;
4. Determine if several unnamed pinnacles meet the seamount definition (≥ 1 km increase in elevation within a 20 km radius (Yesson et al. 2011; Du Preez and Norgard 2022)).

Secondary research objectives were to:

1. Document marine mammal and bird observations within the AOI;
2. Ground-truth species distribution models developed to predict the occurrence of VME coral and sponge taxa at these seamounts.

Seamounts are considered VME indicators based on their role in supporting CWCS (FAO (Food and Agriculture Organization of the United Nations) 2009; Watling and Auster 2017) and most seamounts in the offshore AOI are predicted to be highly suitable CWCS habitat (Chu et al. 2019). Two seamounts in the north-east Pacific, SGáan Kínghlas-Bowie (SK-B) and Cobb Seamounts, are relatively well-surveyed and are known to support diverse CWCS assemblages (e.g., Du Preez et al. 2015; Gauthier et al. 2018). However; those seamounts have substantially shallower pinnacles (< 30 m from the surface) than others in the region, which limits the inferences that can be made about the megafaunal assemblages on the deeper seamounts. As of 2017, no visual assessments of seamounts within the AOI had been carried out.

This expedition was the first in a number of expeditions to seamounts in the AOI and was followed by PAC2018-103/NA097 (Norgard et al. 2019; Gartner et al. 2022), PAC2019-014, PAC2021-036, and PAC2022-035. Data from this expedition provided empirical observations used to describe and characterize habitats at seamounts in the AOI (DFO 2019; Du Preez and Norgard 2022) and supported the development of the Tang.çwan – Һačxwiqak – Tsigis Marine Protected Area (TҺT MPA), which was designated under the Oceans Act in 2024.

Figure 1 shows an overview of the expedition, including the ship track and sample types taken. Sampling was completed at five locations: Union, Dellwood, Unnamed (UN) 16/Curtis, and UN18 Seamounts, and on Paul Revere Ridge (PRR). Note that UN16/Curtis and UN18, the unnamed seamounts are now officially listed as NEPDEP ## Seamounts until a time at which they are given Indigenous Names.

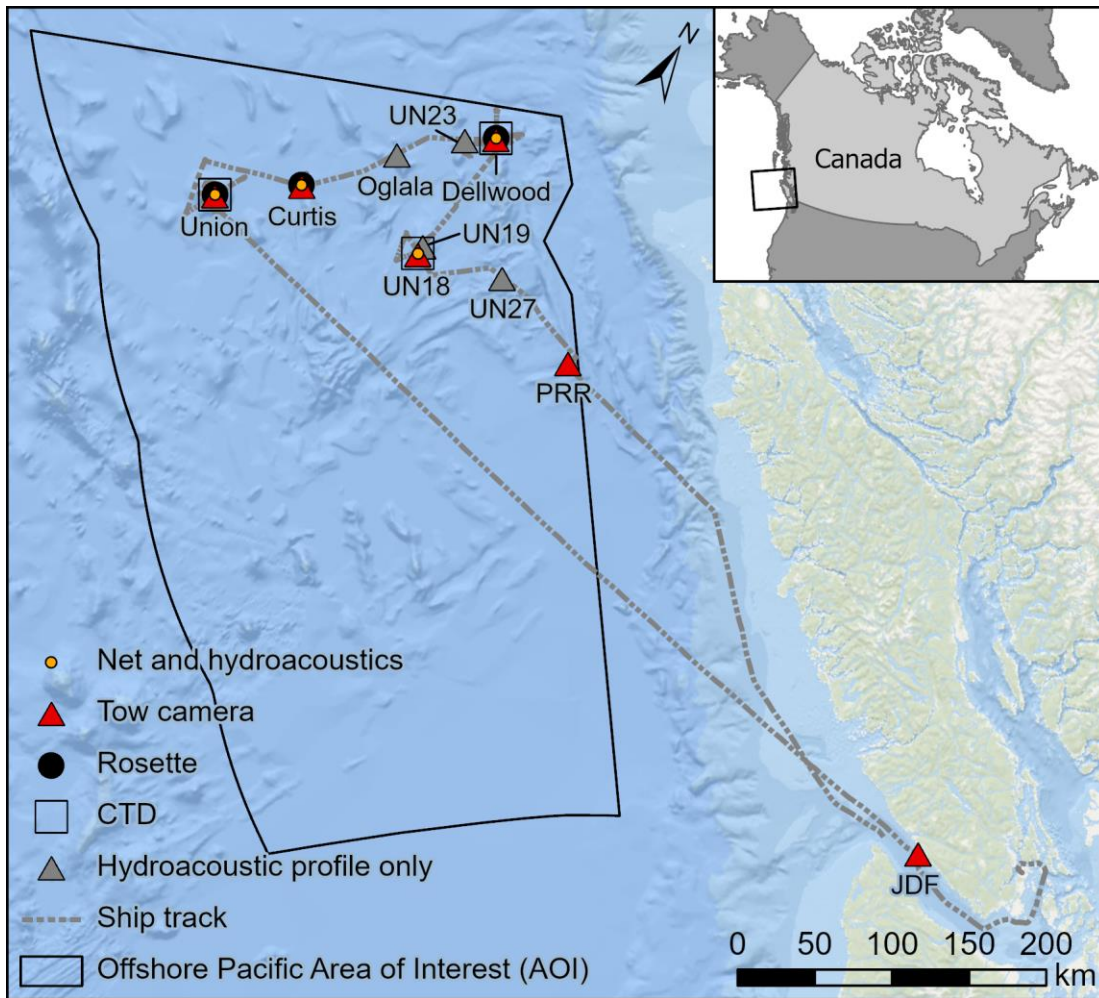


Figure 1. Location of the sites sampled during PAC2017-036, including eight seamounts and one ridge site (Paul Revere Ridge; PRR) in the Offshore Pacific Area of Interest (AOI) and an additional test dive site in the Strait of Juan de Fuca (JDF). See oceanographic sampling section for details on nets (zooplankton sampling with bongo or MOCNESS) and water properties sampled by rosette and CTD (conductivity, temperature, and depth sensor). Bathymetry is World Ocean Base (CHS, Esri, GEBCO, Garmin, NaturalVue).

2 Methods and preliminary results

2.1 Site selection and hydroacoustic mapping

2.1.1 Survey planning

At the time of survey planning, only 12 seamounts were known and named within the AOI, with many more being considered probable seamounts based on available bathymetry (Ban et al. 2016). Bathymetry in offshore areas is generally at a coarse resolution (100s of m) and interpolated based on sparse measurements, limiting its use for accurately estimating the size, shape, and summit locations of seamounts. To prepare for the expedition, available bathymetry from global models was combined with reported depths from historical fishing records to make a general sampling plan, which was then refined in the field using bathymetry measurements taken with a shipboard echosounder (see next section). In addition, acoustic data collected in the months preceding the expedition from two separate research cruises to Union and Dellwood Seamounts were used to plot coarse bathymetry prior to arrival.

The two shallowest seamounts in the AOI, Union and Dellwood, were chosen as the priority targets due to the depth limitations of the tow-camera system used (see *Tow-camera system* section). Species distribution models also predicted VME taxa to have a high probability of occurring within the low oxygen depth range at these two seamounts (Chu et al. 2019).

Prior to the expedition, the approximate depth and location of the summits of Union and Dellwood seamounts were estimated using the best available (at the time) bathymetry ([GEBCO 2014 Bathymetric Grid](#): 30 arc second or ~600 x 950 m resolution) combined with depth measurements from historical commercial fishing records (DFO PacHarvSable groundfish database, Pacific Biological Station). Using these data, the general summit area of Union seamount was delineated and estimated to be between 300 m (from 610 fishing records 1988-2005) and 500-600 m (from GEBCO data). At Dellwood Seamount, only 69 fishing records in 1995-1996 were available, which did not cover the summit identified at around 300 m in the GEBCO data. Estimated summit locations for other seamounts were taken from existing seamount databases (summarized in DFO 2019).

2.1.2 At-sea mapping

To obtain more precise and accurate depth measurements for each seamount prior to deploying the tow-camera, acoustic data were collected using the Simrad EK60 multi-frequency scientific echosounder mounted on the CCGS *John P. Tully* (see Table 1 for calibration parameters and transceiver settings). The system was equipped with five hull-mounted transducers operating at frequencies of 18, 38, 70, 120 and 200 kHz. Calibration of all five frequencies was performed on February 22, 2017 in Coles Bay, Saanich Inlet. The calibration was carried out following International Council for the Exploration of the Sea (ICES) recommended procedures (Demer et al. 2015) using a 38.1 mm diameter tungsten carbide sphere with a 6% cobalt binder. For this calibration, the vessel was anchored in 40 m of water and the sphere was suspended at a depth of approximately 25 m, or 20 m below the face of the transducers on the hull. The sphere was positioned on-axis and moved systematically throughout the beam of each transducer. A temperature and salinity profile was recorded using a conductivity, temperature, and depth sensor (CTD) at the calibration location. These parameters were used to calculate the speed of sound through water and the sound absorption coefficients at each acoustic frequency. The calibration

utility of the ER60 software (version 2.6.4) was used to calculate the transducers' peak gain and sound absorption correction values, the 3 dB beam widths and their offsets, and to generate lists of the calibration parameters as well as other relevant system settings used both during calibration and throughout the expedition.

Water column backscatter data were collected continuously at a rate of one ping every 1-4 seconds dependent on bottom depth for the duration of the expedition. When surveying the seamount, the data were collected down to 2000 m to record the bathymetry but was recorded to only 750 m during transit to, from, and between seamounts. The ping rate was changed as bottom depth increased to avoid false bottom echoes from multiple returns (acoustic reverberation). The echosounder continued to collect data when the camera was in the water. Bathymetric data collected prior to and/or during the expedition were displayed and processed using the Echoview 8.0 to produce accurate representations of the seamount for planning and monitoring camera deployments.

Eight seamounts were surveyed with one of three intensities: extensively (seamount area and summit crossed multiple times in a star-shaped pattern), moderately (two passes over predicted summit), or single passes only over the predicted summit (Table 2). Three-dimensional bathymetric maps (digital elevation models, DEMs) were developed for the four seamounts with extensive or moderate acoustic sampling (Union, Unnamed Seamount UN 16 also called Curtis, Dellwood, and UN18) (Figure 2) and two-dimensional profiles were created for the remaining seamounts (Figure 3). Acoustic bathymetry estimates were derived from the sounder-detected bottom line of the 18kHz frequency sounder. Echoview 8.0 was used to smooth the sounder-detected bottom using an eleven-ping median smoother function. The bottom line underwent manual validation and was corrected when the automated sounder-detected bottom failed. The resulting georeferenced bathymetry data were exported as a text file.

To develop coarse bathymetry models, shapefiles of the bathymetric point data (acoustic and fishing events), were created and projected into BC Albers coordinate reference system (EPSG:3005). DEMs with 100 m horizontal resolution were created from the bathymetry point data using the Topo2Raster interpolation tool (ArcGIS 10.4, Spatial Analyst). The Topo2Raster method, which is similar to a thin plate spline interpolation, was designed to produce hydrologically correct DEMs. From the DEM, bathymetric contours at 100 m intervals were created using the Contour tool and a hillshade layer was built using the Hillshade tool (ArcGIS 10.4, Spatial Analyst).

Four of the profiles transected the predicted summits and confirmed the features as "seamounts" according to the accepted definition (i.e., Oglala, UN23, UN18, and UN27 were each confirmed as a circular or oval-shaped submarine mountain with >1000 m elevation over ≤ 20 horizon km). The UN19 profile did not transect the predicted summit.

High-resolution multibeam bathymetry has since been collected for the entirety of Dellwood Seamount (Gartner et al. 2022), and for the summits of Union, Oglala, UN16/Curtis, UN18, UN19, UN23, and UN27 (Du Preez and Norgard 2022).

Table 1. EK60 calibration parameters and transceiver settings used during the expedition.

Parameter					
Frequency (kHz)	18	38	70	120	200
SIMRAD transducer model	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C
Transducer serial number	2064	30599	123	308	287
Transmit power (W)	2000	2000	750	250	105
Pulse duration (ms)	1.024	1.024	1.024	1.024	1.024
Transducer peak gain (dB)	22.29	19.76	27.02	27.83	26.55
Sa correction (dB)	-0.73	-0.37	-0.32	-0.34	-0.31
Bandwidth (Hz)	1570	2430	2860	3030	3090
Equivalent (two-way) beam angle (dB)	-17	-20.6	-21	-21	-20.7
Angle sensitivity (dB) alongship/athwartship	13.9	21.9	23	23	23
3 dB beamwidth (°) alongship	11.08	7.11	6.56	6.32	6.29
3 dB beamwidth (°) athwartship	11.35	6.94	6.51	6.46	6.35
Angle offset (°) alongship	-0.05	0.21	-0.05	-0.03	-0.01
Angle offset (°) athwartship	0.08	-0.10	-0.04	0.01	0.11

Table 2. Hydroacoustic bathymetry survey summaries of eight seamounts from PAC2017-036. Summits represent the location of the shallowest depth detected by hydroacoustics for that seamount; updated summit locations and depths are available for some seamounts in Du Preez and Norgard (2022).

Survey date (UTC)	Seamount	Survey effort	Product	Summit lat.	Summit long.	Summit depth (m)
24-Jul-17	Union	Extensive	3D map	49.546291	-132.701354	283
25-Jul-17	UN16/Curtis	Moderate	3D map	49.883581	-132.113316	1100
26-Jul-17	Oglala (East)	Summit transect	2D profile	50.34853	-131.566415	1601
26-Jul-17	UN23	Summit transect	2D profile	50.640641	-131.128545	1559
27-Jul-17	Dellwood	Extensive	3D map	50.747826	-130.896933	533
29-Jul-17	UN19	Summit transect	2D profile	49.991815	-130.905404	2202
29-Jul-17	UN18	Moderate	3D map	49.938107	-130.901893	1563
30-Jul-17	UN27	Summit transect	2D profile	50.094333	-130.148846	1689

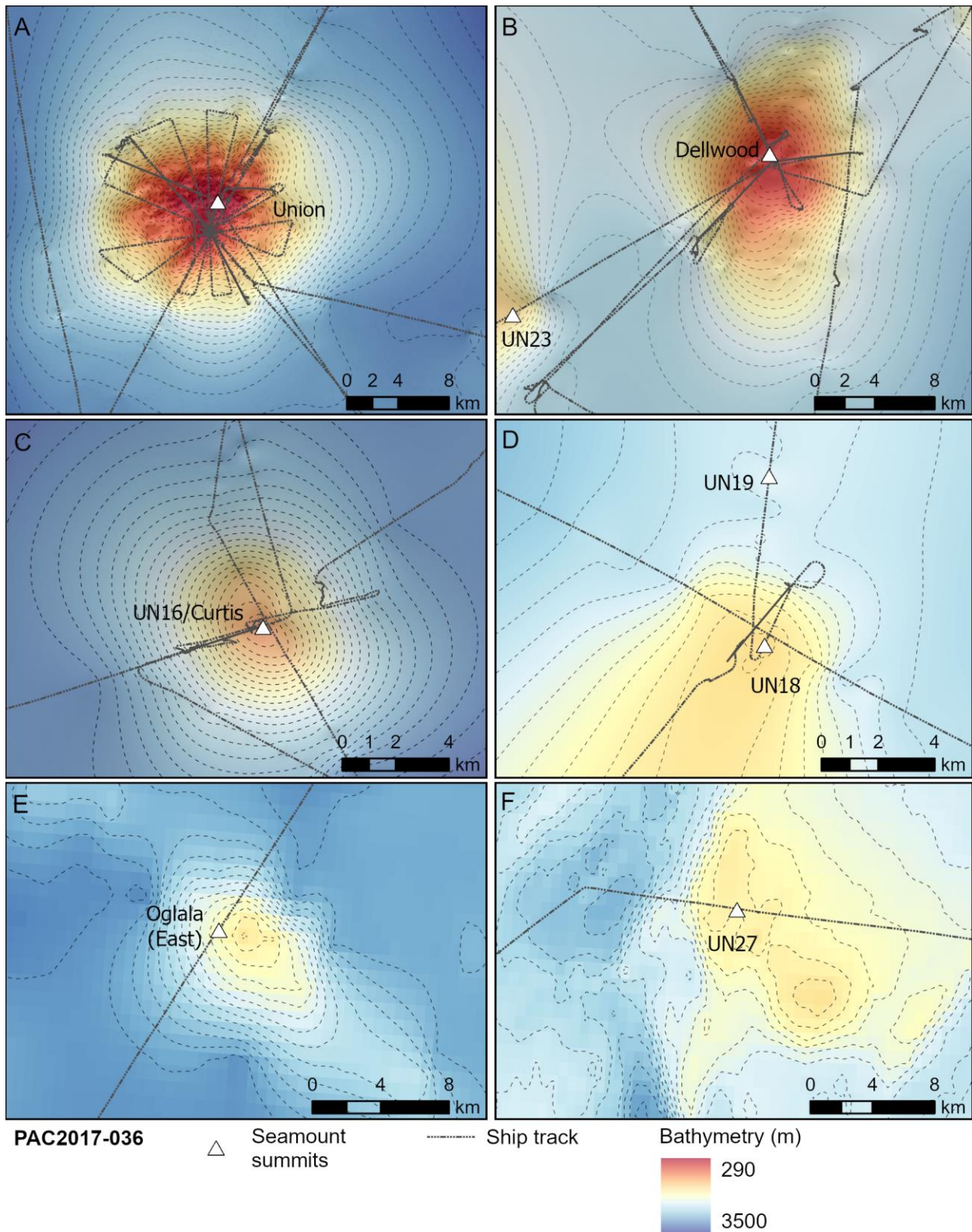


Figure 2. Hydroacoustic track lines over the interpolated 3D bathymetry (A-D) and over GEBCO_2014 bathymetry (E-F). A) Union Seamount, B) Dellwood Seamount, C) UN16/Curtis Seamount, D) Unnamed (UN) Seamounts 18 and 19, E) Oglala (East), and F) UN27. Summits represent shallowest depth detected.

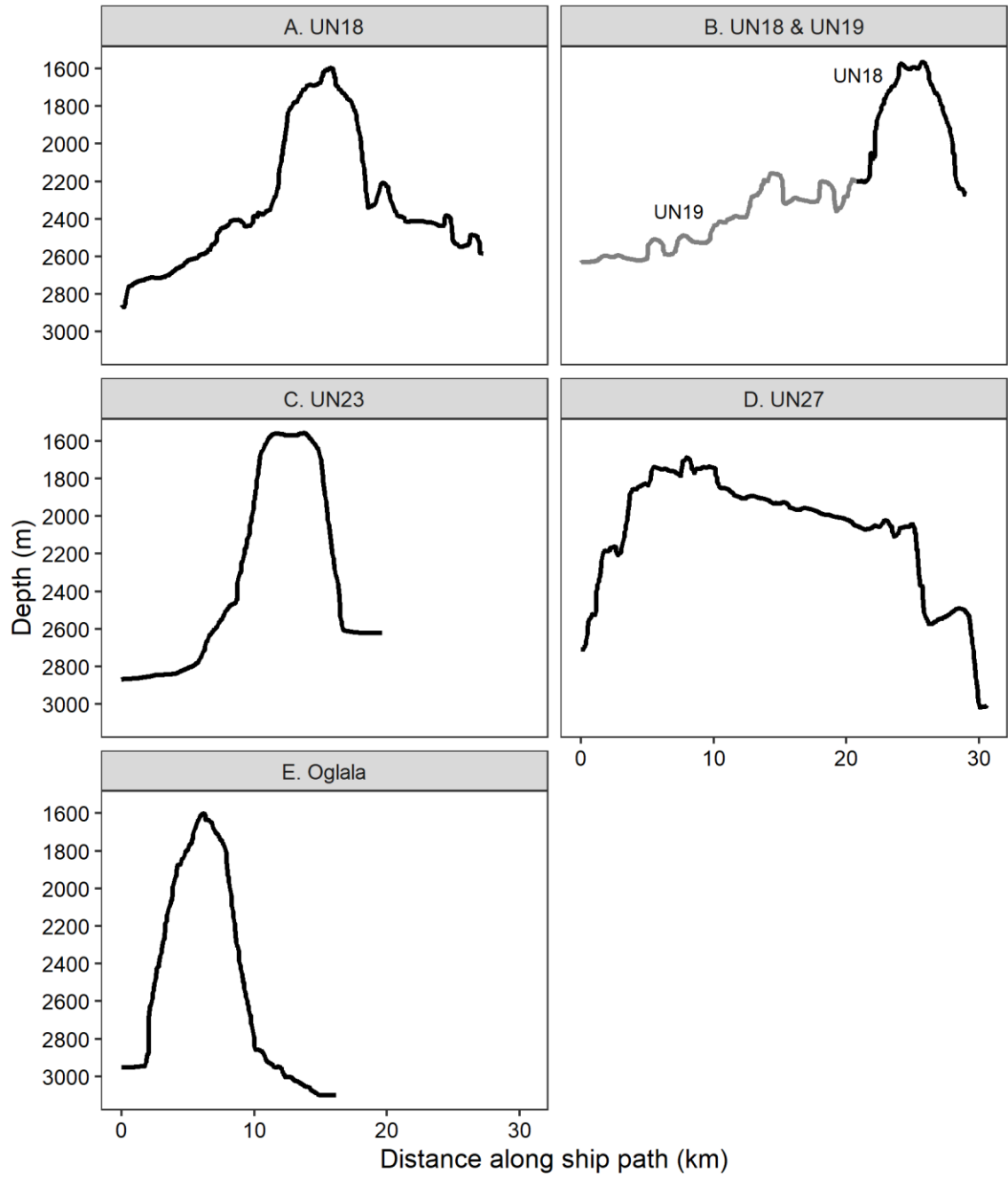


Figure 3. Hydroacoustic bathymetric profiles of seamounts collected during transects. Acoustic transects targeted predicted summit locations (e.g., listed in DFO 2019) at A) unnamed (UN) 18, transect running northwest to southeast, B) UN18 (black) and UN19 (grey), transect running north to south, C) UN 23, D) UN27, and E) Oglala (East).

2.2 Image-based benthic surveys

2.2.1 Tow-camera system

The Bathyal Ocean Observation and Televideo System (BOOTS) is a tow-camera system (Gale et al. 2017), which has a depth rating of 2500 m, that was used to visually survey sites within the AOI. BOOTS has a metal frame to which cameras and instruments are attached, and is tethered to the operating vessel (i.e., the CCGS *John P. Tully*) via a fibre optic cable that allows two-way communication between the instruments and operators aboard the ship. Horizontal movement of BOOTS is controlled by moving the ship, and vertical movement (altitude) is controlled by a winch operator adjusting the amount of cable deployed. Deck configuration generally followed that described in Gale et al. (2017). For this expedition, only passive heave compensation from the ship's A-frame was in place to reduce the effect of ocean swell on the vertical movement of BOOTS (an improved active heave compensation system was installed post-2017).

The software Hypack was used to coordinate data streams from the instruments on BOOTS, which included a video camera (high-definition MiniZeus) with scaling lasers mounted on a pan and tilt unit, a still camera (1camAlpha), several supplementary cameras, a SeaBird SBE25 CTD (which included standard conductivity, temperature, and depth sensors, along with additional sensors for dissolved oxygen and fluorescence), sonar, altimeter, lights, and a transponder for georeferencing. A set of parallel lasers was positioned 10 cm apart in the field of view of the video camera to allow field-of-view measurements during annotation. Appendix A shows instrument details and configuration.

2.2.2 Deployment and transect protocol

The DEMs described in the *At-sea mapping* section were used to plan tow-camera transects, with the goal of covering as wide a depth range (within camera limits) as possible at each seamount. On Dellwood and Union Seamounts, transects were placed on each quadrant of the seamount (North, South, East, West) with the transect start location randomly selected. On the other seamounts, start locations were randomly selected in the deepest location the camera could go. All transects were run from the deepest to shallowest depth.

Pre-dive checklists were completed by the BOOTS technicians and by lab personnel to ensure the camera and data recording systems were prepared. Once the checklists were complete and the ship was correctly positioned, the camera was deployed. One person, assigned the role of pilot, used information from the video feed and data streams (e.g., altitude, depth) to direct the winch operator via VHF radio to adjust camera ascent and descent. Once the seafloor was visible on screen, the winch operator was directed to slow the camera descent speed. Forward motion began once the bottom was in sight at the direction of the Chief Scientist and required constant 3-way communication between Chief Scientist, bridge crew, and the winch operator. During bottom travel, the Chief Scientist would ask the ship to move forward at speeds ranging from 0.2 to 0.7 knots.

Dives were comprised of one or more transects, which generally marked a change in heading (e.g., see dives B025 and B029 in Figure 4). Dive B023 was split into two discrete transects; at the end of the first transect, BOOTS was raised high into the water column while the ship transited to a new location, and then BOOTS was set back down. Transects always ran upslope, starting at the deepest known depth. As the camera moved upslope, the winch operator was

asked to bring the camera up 1 m at a time. This method kept the camera oriented correctly while also keeping it close to the bottom for the best image quality (which would facilitate later taxonomic identification and annotation). Transects generally ended when the top of the seamount was reached, at which time BOOTS was recovered and post-dive checklists completed.

2.2.3 Dive log and real-time video annotation

Dive logs were completed for each dive and stored in an Excel spreadsheet (see example in Appendix B). Details logged included the time (UTC) and ship’s coordinates for important events (launch and recovery, on and off bottom, start and end of transects), as well as notes, names of pilots and loggers, notable observations, [weather](#), and speed of ship.

Along with the Excel dive log, information for each dive was also compiled in an Access Database in real-time using the DFO in-house software, Video Miner, and a protocol similar to that described by Curtis et al. (2015). The database received temporal and spatial information from the ship’s GPS. An annotator recorded the events noted above as well as observations of fishing impacts (e.g., discarded gear), the presence of VME indicator species (as defined by the North Pacific Fisheries Commission (NPF) or South Pacific Regional Fisheries Management Organisation (SPRFMO); Baco et al. 2023), physical habitat, and the presence of species of interest (such as rockfish).

2.2.4 Collection of imagery data

A summary of collected imagery is presented in Table 3.

Table 3. Summary of imagery collected during PAC2017-036. Video duration includes ascent and descent. All cameras were forward/downward facing except the GoPros, which were faced downward, upward, forward, and/or rearward depending on dive. *Note: recording from part of dive 27 was missing.

Camera	Format	Dives	Interval (image) or file size (video)	Number of files	Video duration
Still cameras (photos)					
IcamAlpha	.jpg	B021-B032	1 photo/ 5-10 seconds	>43,000	-
GoPro	.jpg	B022- B024, B026- B032	1 photo/ minute	~3000	-
Rayfin (prototype)	.jpg	B022- B025	1 photo/ ~10 seconds	~600	-
Video cameras					
MiniZeus (StreamZ)	.mpg	B022- B032	~6 clips (~2 GB)	852	~80.5 hr
MiniZeus (Hyperdeck)	.mov	B022- B032*	~2 hour clips (~150 GB)	52	~79 hr
IcamAlpha (Hyperdeck)	.mov	B021- B032	~2 hour clips (~44 GB)	50	~81 hr

2.2.5 Preliminary results

In total, 19 transects were completed over twelve dives conducted across one test site, eight seamounts, and one ridge. See Table 4 for a summary of BOOTS tow-camera dive and see Figure 4 for maps of the tow-camera dive tracks and oceanography sample stations on Union, Dellwood, UN16/Curtis, and UN18 Seamounts, and on PRR. A total of 62 hours were spent on the seafloor, covering approximately 50 linear km and spanning approximately 2 km of vertical distance (Figure 5).

Many VME indicator taxa and human impacts were observed along the dives. Example photos of VME indicator taxa are shown in Figure 6 and a list of observed VME indicator taxa and human impacts by dive is shown in Table 5.

Depth profiles for each dive are shown in Figure 7 and Figure 8. On-bottom oxygen concentration collected with a sensor on the tow camera for each dive is shown in Figure 9 and Figure 10.

Table 4. Summary of BOOTS tow-camera dives on PAC2017-036. Dates (XX-July-2017) are in UTC. Positions represent the ship's position. Dives may be comprised of one or more transects; when all on-bottom time was from a single transect, transect and dive are shown on the same line in the table. Horizontal distances are approximate and represent the straight line distance between start and end of transect or dive, taking into account major turns; total represents dive total (bolded). Depths are the deepest (max) and shallowest (min) depths recorded by the CTD when on seafloor. Hard substrate indicates if rock or boulder was observed. Bottom time and distance do not include time in water column. Note that these differ slightly from the launch-to-recovery durations and preliminary depths reported in Du Preez and Norgard (2022) Table A3.

Site Name	Launch Date	Dive	Transect	Position: On-bottom or Transect Start	Position: Off-bottom or Transect End	Bottom duration (hh:mm)	Transect Duration (hh:mm)	Horizontal distance (m)	Max depth	Min depth	Vertical Distance (m)	Hard Substrate	Note/comments
Juan de Fuca (JDF)	19	B021	n/a	48.46778 -124.33983	48.46784 -124.33964	0:26	-	276	114	112	3	-	Test dive; no transects defined
Union	21	B022	-	49.52549 -132.70904	49.52439 -132.71437	1:23	-	480	482	375	107	x	Includes long stretch of non-transect bottom time.
			B022_1	49.52552 -132.70904	49.52403 -132.71146	-	0:41	240	425	375	49	x	-
		B023	-	49.52463 -132.69456	49.5262 -132.70506	3:11	-	2021	720	408	312	x	BOOTS flown in water column for 54 minutes between transects.
			B023_1	49.52464 -132.69454	49.52165 -132.70984	-	1:55	1157	720	464	256	x	-
			B023_2	49.52111 -132.71411	49.52619 -132.70508	-	1:14	864	496	408	88	x	-
	22	B024	B024_1	49.48229 -132.66521	49.52917 -132.71198	8:01	8:01	6215	2090	388	1702	x	-
	23	B025	-	49.55755 -132.64381	49.54619 -132.70112	8:17	-	5682	1701	292	1408	x	-
			B025_1	49.55746 -132.64485	49.55741 -132.66544	-	2:46	1482	1688	1005	683	x	-
			B025_2	49.55741 -132.66545	49.5546 -132.69482	-	2:34	2175	1161	582	579	x	-
			B025_3	49.55459 -132.69482	49.54324 -132.70174		1:29	1357	581	302	279	x	-
		B025_4	49.54279 -132.70098	49.54618 -132.70108		0:58	668	388	292	95	x	-	

Site Name	Launch Date	Dive	Transect	Position: On-bottom or Transect Start	Position: Off-bottom or Transect End	Bottom duration (hh:mm)	Transect Duration (hh:mm)	Horizontal distance (m)	Max depth	Min depth	Vertical Distance (m)	Hard Substrate	Note/comments
Union	24	B026	B026_1	49.57032 -132.82284	49.55031 -132.72264	9:01	8:57	7560	2117	502	1615	x	-
UN16/ Curtis	25	B027	B027_1	49.87401 -132.14827	49.88365 -132.11274	3:19	3:14	2980	2063	1095	968	x	-
Dellwood	26	B028	B028_1	50.75113 -130.82362	50.74412 -130.88346	5:14	5:09	4260	1848	597	1251	x	-
	27	B029	-	50.78691 -130.93266	50.75546 -130.88969	8:49	-	7350	2073	549	1523	x	Includes non-transect time between transects
			B029_1	50.78689 -130.93265	50.75242 -130.89898	-	6:02	4551	2073	549	1523	x	-
			B029_2	50.7533 -130.89645	50.75872 -130.88102	-	1:03	1252	736	550	187	x	-
			B029_3	50.75886 -130.8806	50.76142 -130.88365	-	0:39	518	832	749	83	x	-
	B029_4	50.76142 -130.88365	50.75549 -130.88967	-	0:52	785	827	606	221	x	-		
28	B030	B030_1	50.69349 -130.95854	50.74312 -130.89355	7:27	7:27	7180	2117	557	1559	x	-	
UN18	29	B031	B031_1	49.95664 -130.89173	49.93482 -130.91629	3:43	3:41	2999	2154	1617	536	x	-
Paul Revere Ridge (PRR)	30	B032	B032_1	49.88788 -129.23126	49.91722 -129.21095	3:21	3:20	3575	2003	1664	340	-	-
Total	-	12	19	-	-	62:12	60:02	50578	-	-	2042	-	-

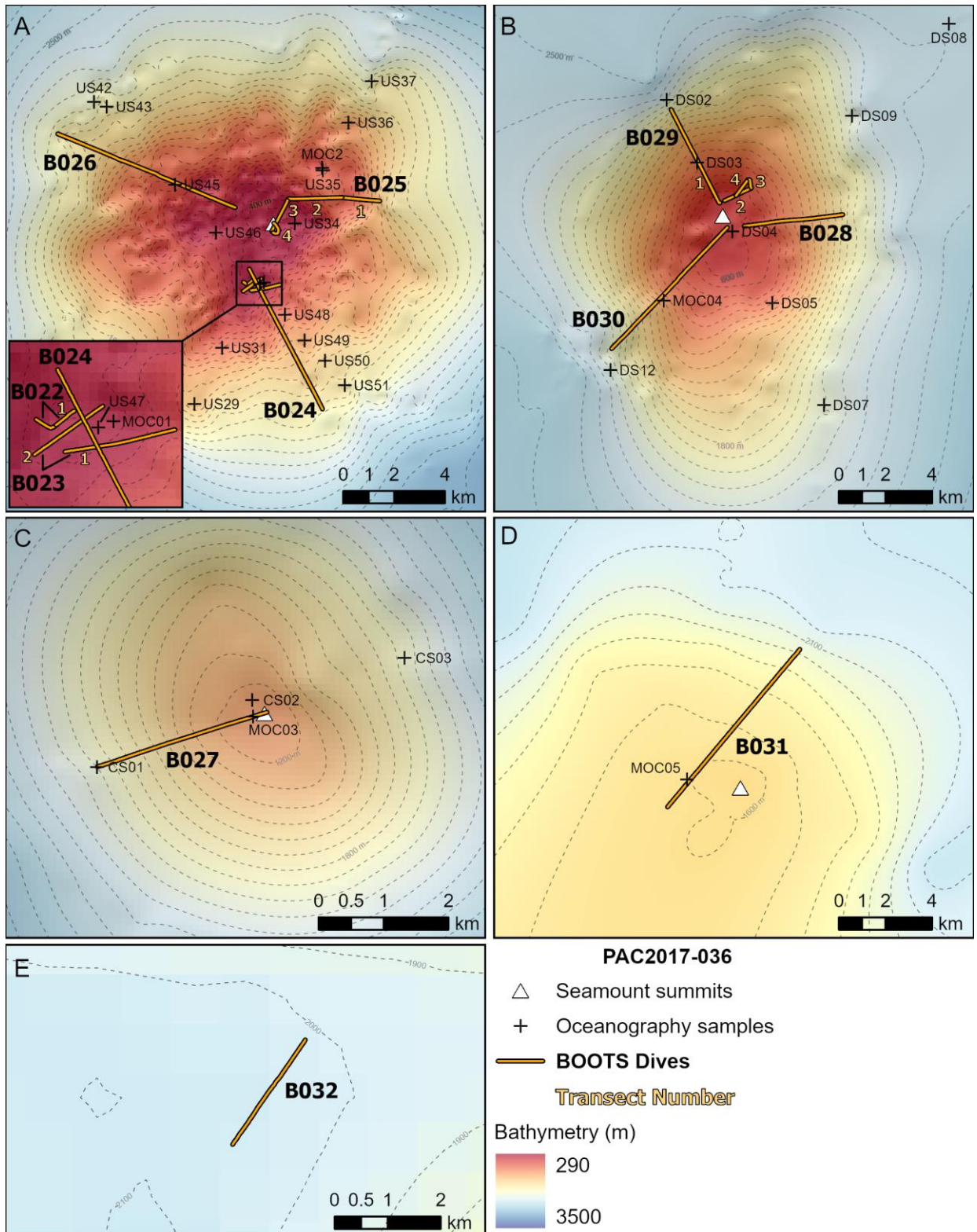


Figure 4. BOOTS tow-camera dive tracks and oceanography sample stations (see Table 6) on A) Union, B) Dellwood, C) UN 16/Curtis, and D) UN18 Seamounts, and on E) Paul Revere Ridge (PRR). Seamount locations shown in Figure 1. Small orange numbers show transect number within dives; if no number is shown, the line represents Transect 1. Bathymetry for A-D was interpolated from hydroacoustic measurements on the CCGS Tully (see

At-sea mapping); E uses the GEBCO_2014 grid.

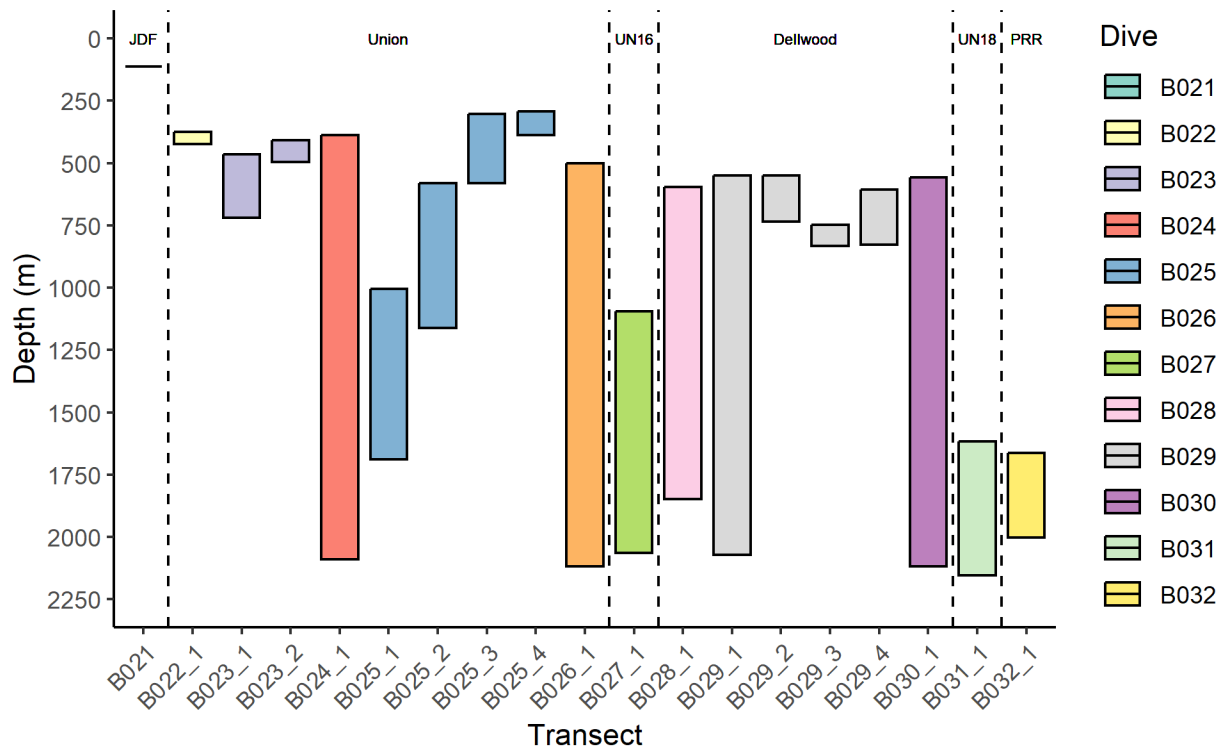


Figure 5. Depth ranges of transects surveyed by BOOTS during PAC2017-036.

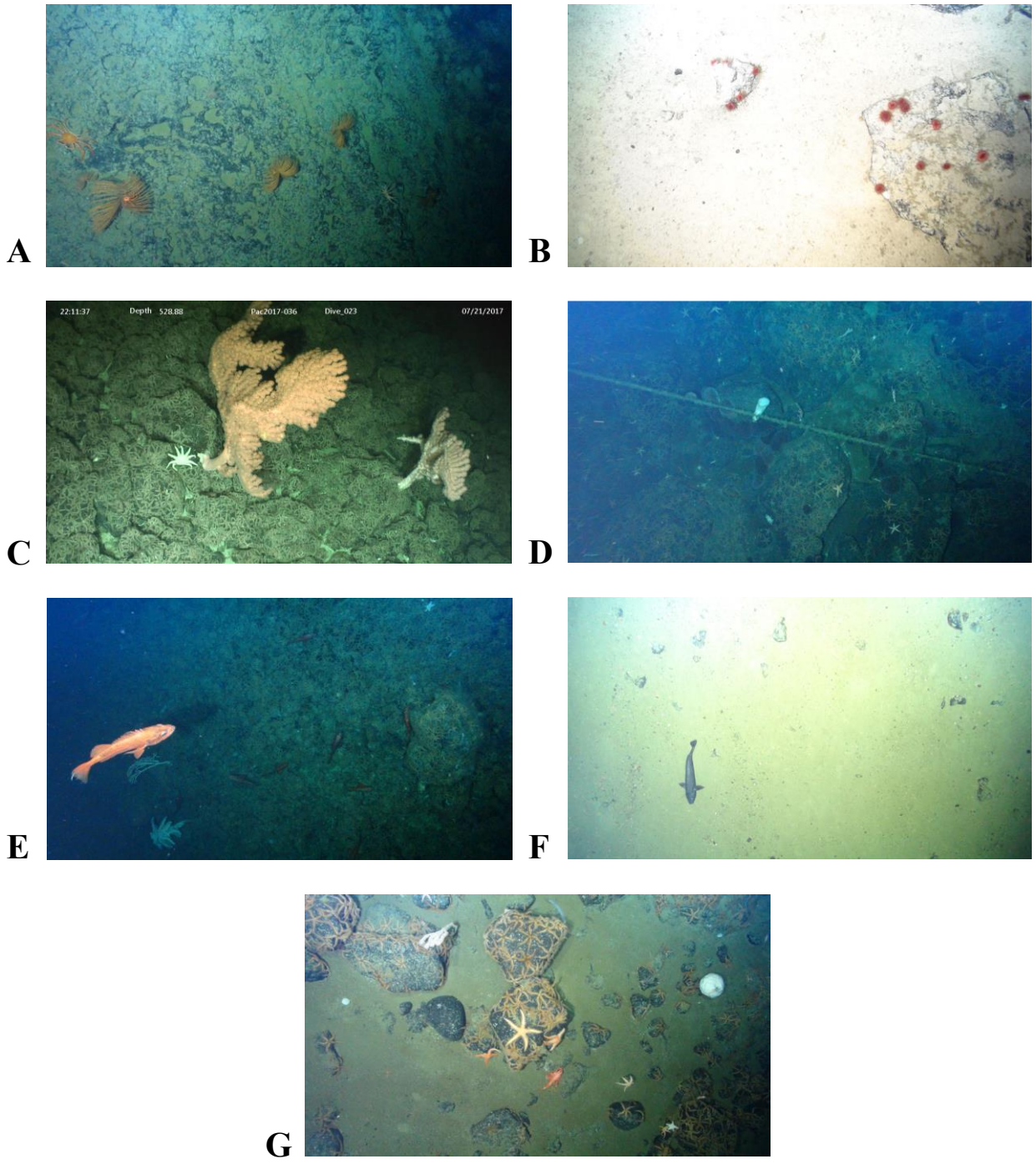


Figure 6. Sample images from BOOTS dives. A) Black coral, B) Stony coral, C) Soft coral, D) lost fishing gear, E) rockfish, F) Sablefish, and G) Thornyhead (*Sebastolobus* sp.).

Table 5. Observations of Vulnerable Marine Ecosystem (VME) indicator species, human impacts, and commercial fish species, as recorded at sea. Detailed annotations will be published at a later date. * NPFC VME indicator species; ^ SPRFMO VME indicator Species. Dive B021 was a test dive; video from this dive was not annotated.

	JDF	Union					UN16/Curtis	Dellwood			UN18	PRR
	B021	B022	B023	B024	B025	B026	B027	B028	B029	B030	B031	B032
VME indicator species												
Anemone*^	na	X	X	X	X	X	X	X	X	X	–	X
Black corals*^	na	X	X	X	X	X	X	X	X	X	X	X
Brisngida^	na	–	–	–	–	–	–	X	–	–	–	–
Crinoid*^	na	–	–	X	X	X	X	X	X	X	X	–
Demosponge^	na	–	–	X	X	–	–	–	X	X	–	–
Glass sponges*^	na	X	X	X	X	X	X	X	X	X	X	X
Hydrocorals*^	na	–	–	X	X	X	–	X	X	X	X	–
Sea pens*^	na	–	–	–	X	X	–	X	X	X	–	–
Soft corals*^	na	X	X	X	X	X	X	X	X	X	X	X
Stony corals*^	na	–	–	X	–	X	X	X	X	X	X	–
Human impacts												
Fishing gear	na	–	–	–	X	–	–	X	X	–	–	X
Fishing mark (impact)	na	–	–	–	–	–	–	–	–	–	–	–
Inanimate object(s)	na	–	–	–	X	X	–	X	X	–	X	X
Commercial fish species												
Rockfish (<i>Sebastes</i> sp.).	na	X	X	X	X	X	–	–	–	–	–	–
Sablefish (<i>Anoplopoma fimbria</i>)	na	X	–	X	–	–	–	–	X	X	–	–
Thornyhead (<i>Sebastolobus</i> sp.).	na	–	X	X	X	X	X	X	X	X	–	–

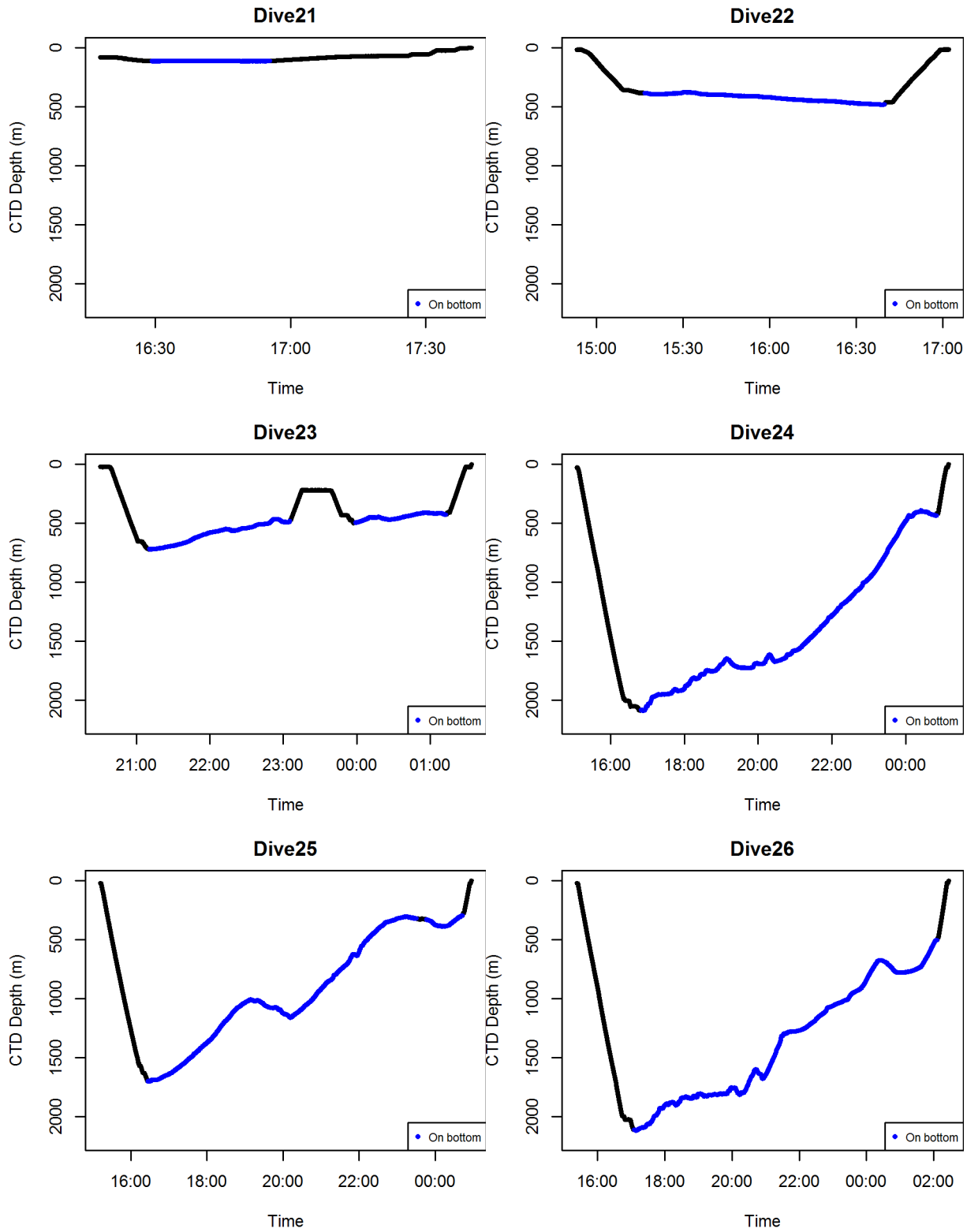


Figure 7 Depth of the tow camera by time for dives 21 to 26, with the time on bottom highlighted in blue. Because speed varied, time is an approximation of distance along each dive.

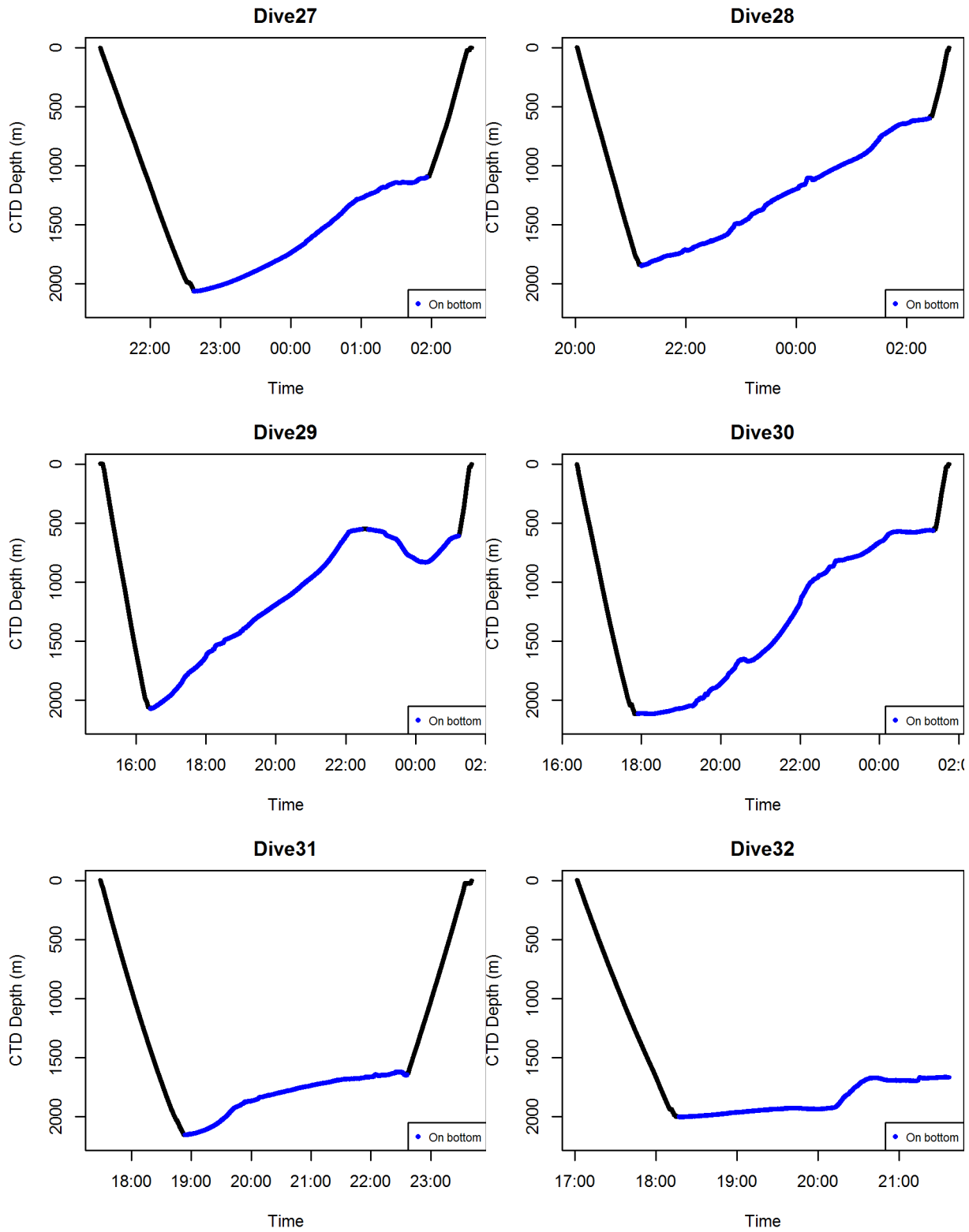


Figure 8. Depth of the tow camera by time for dives 27 to 32, with the time on bottom highlighted in blue. Because speed varied, time is an approximation of distance along each dive.

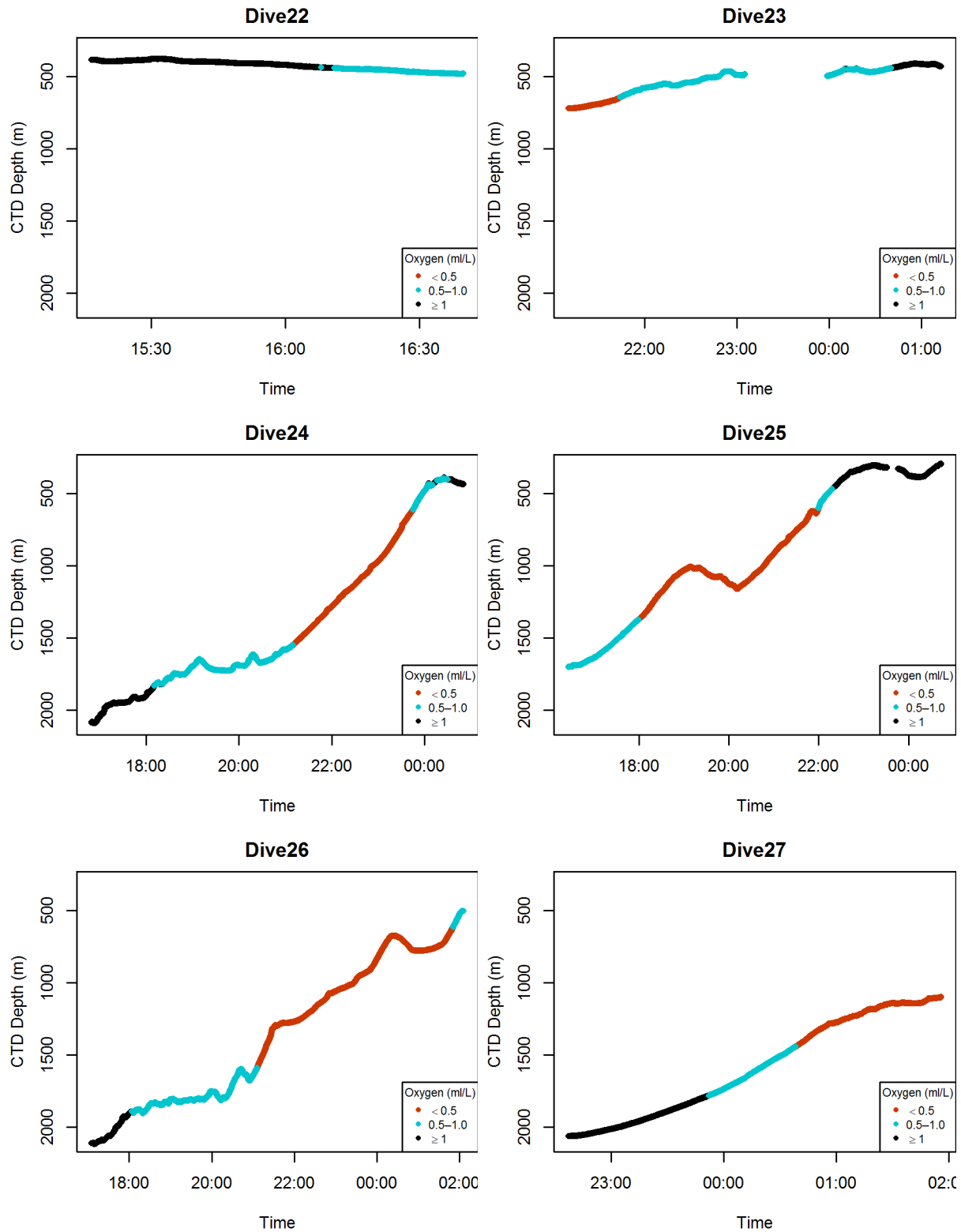


Figure 9. Depth of the tow camera by time for dives 22 to 27, showing “on bottom” time only (i.e., the blue segment of Figures C.1), with highlighted areas showing severe hypoxia (orange; < 0.5 ml/L), hypoxia (cyan; 0.5–1.0 ml/L), and normoxia (black; ≥ 1 ml/L).

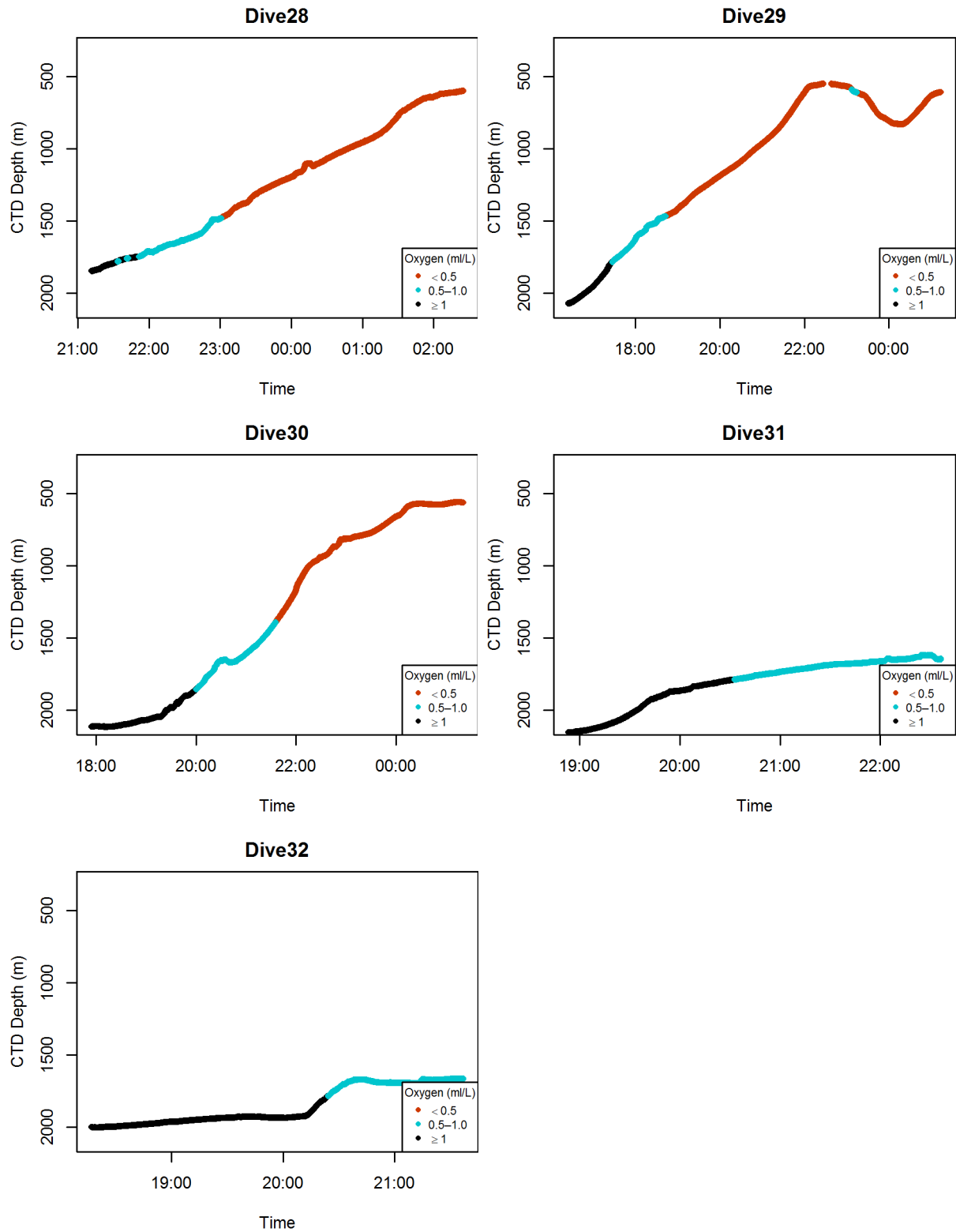


Figure 10. Depth of the tow camera by time for dives 28 to 32, showing “on bottom” time only (i.e., the blue segment of Figures C.1), with highlighted areas showing severe hypoxia (orange; < 0.5 ml/L), hypoxia (cyan; $0.5-1.0$ ml/L), and normoxia (black; ≥ 1 ml/L).

2.3 Oceanographic sampling

A survey grid was designed to integrate the collection of acoustic data (see

At-sea mapping section) with sampling stations for physical properties, chemistry, and zooplankton composition in the water column at each of the four seamounts with camera observations (Union, Curtis, Dellwood, and UN18; Figure 2, Figure 4). The grid consisted of a series of intersecting lines that centered on the estimated peak of each seamount. To compare water chemistry, zooplankton density, and species composition on and off the seamount, the grid lines were extended into deep water away from the seamount peak to a distance equal to the circumference of the seamount at the 2000 m contour.

2.3.1 MOCNESS sampling

A Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS; Figure 11) was deployed on five occasions to a depth of 500 m (Table 6). The net was towed obliquely at a speed of 2-4 kt. The MOCNESS had an effective mouth opening of 2 m² and was equipped with six 333 µm nets that could be triggered to close remotely from a deck unit on the ship. By closing the nets at specific depths, the MOCNESS allowed for stratified zooplankton sampling of the water column. These samples aided in identification of organisms that were responsible for producing the backscattering layers observed on the echosounder. The acoustic signal (echogram) at each of the MOCNESS stations was used to determine the depth strata sampled by each of the nets. Samples were preserved in 10% buffered formalin for later taxonomic analysis.



Figure 11. Recovering the MOCNESS plankton sampling net off the CCGS Tully. Photo credit: Jackson Chu

2.3.2 Bongo net sampling

Zooplankton samples were collected at 18 of the 33 sampling stations (Table 6) using a bongo net (253 μm black mesh) to carry out a vertical haul from a maximum depth of 250 m. The bongo tow resulted in two replicate samples, one of which was preserved in 10% buffered formalin for taxonomic analysis and one of which was frozen at -80°C for size-fractionated biomass calculations. At UN18, the bongo net sampled to 2000 m to capture the deep water plankton community. Bongo net casts that occurred close to a rosette station that sampled dissolved inorganic carbon (see Rossette and CTS cast section below) were also scanned for *Limacina helicina*, a bioindicator for the impacts of ocean acidification on marine ecosystems (Miller et al. 2025). When present, *Limacina helicina* were stored in ethanol so that their calcium carbonate shells would be preserved.

2.3.3 Rosette and CTD casts

The water column at a total of 33 stations were sampled for specific water properties (Table 6). At each of the sampling stations, a rosette equipped with 24-10 L Niskin bottles and a 9/11 Seabird CTD was deployed to examine vertical gradients in water properties with a focus on the bottom boundary layer. The CTD was equipped with sensors for temperature, conductivity, pressure (depth), dissolved oxygen concentration, transmissivity, and fluorescence. At some of the stations, water from the rosette was collected for additional analyses including dissolved oxygen concentration, macronutrients (nitrate, silicic acid and phosphate), salinity, chlorophyll concentration, phytoplankton taxonomy, High-Performance Liquid Chromatography (HPLC) analysis for phytoplankton pigments, environmental DNA (eDNA), Dissolved Inorganic Carbon (DIC) concentration and Total Alkalinity (TA) (Table 6). Most of the samples were preserved at sea to be analyzed at a later date. DIC and TA were treated with mercuric chloride and kept in cool storage (as per Dickson et al. 2007). Nutrients were frozen. Dissolved oxygen was analyzed at sea using an automated Winkler titration system (Metrohm Dosimat model 876), a UV light source and detector with a 365 nm filter controlled by LVO2_876 software designed and constructed by Scripps Institution of Oceanography) with modifications based on Carpenter (1965) and adhering to WOCE protocols (Culberson 1991).

2.3.4 eDNA sampling

Water sampling for eDNA was conducted to detect the presence of coral and sponges. The eDNA sampling protocol was based on sampling methodology provided by Meredith Everett from the National Oceanic and Atmospheric Administration (NOAA). Water for eDNA analysis was collected at seamount rosette stations (depths >2000 m). A single two litre sample of water was collected from the Niskin bottle triggered at 5 m from the bottom, no replicates were taken. Water samples were stored in 2L dark plastic bottles prior to filtering. The samples were filtered through a sterile 0.45 μm filter using a vacuum manifold with pump. The water was allowed to fully filter until the filter was dry before turning off the pump. Surfaces, gloves, and forceps were periodically wiped clean with DNA Away (Thermo Scientific) during filtering and between samples to limit cross-contamination. Filters were transferred from the filtering cups to sample vials that were filled with 5 ml of 95% ethanol using filter forceps, ensuring filters were completely submerged in the ethanol. Vials with submerged filters were placed on a rack in a dark box for storage. The sample bottles were rinsed with a solution of fresh water and 10% chlorine bleach and allowed to dry before re-using.

Table 6. Summary of oceanographic sampling stations on PAC2017-036. Station name denotes Curtis Seamount (CS), Dellwood Seamount (DS), Unnamed Seamount (UN), and Union Seamount (US). ROS/CTD indicates whether water was sampled by rosette (ROS) or not sampled (CTD). Bongo denotes occurrence of bongo (zooplankton) tow and depth of tow. MOC refers to MOCNESS plankton samples and sampling depth. Other columns are types of samples taken: dissolved oxygen (DO), dissolved inorganic carbon and total alkalinity (DIC), nutrients (Nuts), salinity (Salts), environmental DNA (eDNA), chlorophyll (Chl), high pressure lipid chromatography (HPLC), domoic acid (DA), and phytoplankton taxonomy (Phyto).

Station	Depth (m)	ROS or CTD	Bongo or MOC and depth in m	DO	DIC	Nuts	Salts	eDNA	Chl	HPLC	DA	Phyto
CS01	2108	ROS	Bongo 250	x	-	x	x	x	x	x	x	x
CS02	1156	ROS	Bongo 250	x	x	x	x	x	x	x	-	-
CS03	2118	ROS	Bongo 250	x	x	-	x	x	x	x	-	-
DS01	2594	ROS	Bongo 250	x	x	x	x	-	x	x	-	-
DS02	2392	CTD	Bongo 250	-	-	-	-	-	-	-	-	-
DS03	2000	ROS	Bongo 250	x	x	-	x	x	x	x	-	-
DS04	1700	ROS	Bongo 250	x	-	x	x	x	x	x	-	-
DS05	1019	ROS	Bongo 250	x	-	-	x	x	x	x	-	-
DS07	2127	ROS	-	x	-	-	x	x	x	x	-	-
DS08	2438	ROS	Bongo 250	x	-	-	x	-	x	x	-	-
DS09	2172	CTD	-	-	-	-	-	-	-	-	-	-
DS12	2194	CTD	Bongo 250	-	-	-	-	-	-	-	-	-
DS13	2604	ROS	Bongo 250	x	-	-	x	-	x	x	-	-
UN18	2795	CTD	Bongo 2000	-	-	-	-	-	-	-	-	-
US27	3278	ROS	-	x	-	-	x	-	x	x	-	-
US29	1573	ROS	-	x	-	-	x	X	x	x	-	-
US31	1170	ROS	-	x	-	-	x	x	x	x	x	x
US34	371	CTD	Bongo 250	-	-	-	-	-	-	-	-	-
US35	972	ROS	-	x	-	x	x	x	x	x	-	-
US36	1519	CTD	Bongo 250	-	-	-	-	-	-	-	-	-
US37	2186	ROS	-	x	-	-	x	x	x	x	-	-
US39	3256	ROS	-	x	-	x	x	-	x	x	-	-
US40	2000	ROS	-	x	-	x	x	-	-	x	-	-
US42	2216	ROS	-	x	-	x	x	x	x	x	x	x
US43	1997	CTD	Bongo 250	-	-	-	-	-	-	-	-	-
US45	964	ROS	-	x	x	x	x	x	x	x	x	x
US46	610	CTD	Bongo 250	-	-	-	-	-	-	-	-	-
US47	448	ROS	-	x	-	x	x	x	x	x	x	x
US48	1170	CTD	Bongo 250	-	-	-	-	-	-	-	-	-
US49	1380	ROS	-	x	-	x	x	x	x	x	x	x
US50	1760	CTD	Bongo 250	-	-	-	-	-	-	-	-	-
US51	1986	ROS	-	x	-	x	x	x	x	x	-	-
US53	3157	ROS	-	x	x	x	x	x	x	x	x	x
MOC01	460	-	MOC 300 m	-	-	-	-	-	-	-	-	-
MOC02	870	-	MOC 500 m	-	-	-	-	-	-	-	-	-
MOC03	1125	-	MOC 500 m	-	-	-	-	-	-	-	-	-
MOC04	1195	-	MOC 500 m	-	-	-	-	-	-	-	-	-
MOC05	1621	-	MOC 500 m	-	-	-	-	-	-	-	-	-

2.3.5 Slocum Glider

The DFO Slocum Glider SN651 was deployed near Union Seamount on July 24, 2017. This was the first mission for the glider and was planned with the dual goals of 1) testing the glider in deep water, and 2) surveying the oceanography around Union seamount in support of monitoring the Offshore Pacific AOI. The glider operated successfully for 4.5 days, making 19 full depth dives to 1000 m below the sea surface. After successfully transmitting engineering and scientific data indicating no problems on July 28 6:30 am UTC (around midnight PST local time), all communication with the glider stopped. The glider was not recovered and presumed lost – later problems with its sister glider (SN652) suggest that it likely leaked through its CTD.

2.4 Seabird and mammal surveys

2.4.1 At-Sea Survey Protocol

All seabird and mammal surveys were conducted during daylight hours while the vessel was in transit (minimum speed 4 kt) and followed a standardized protocol similar to Tasker et al. (1984). Depending on weather conditions, observations were made from either the outside deck above the ship's bridge (Monkey's Island) or from inside the bridge. Observations were made by scanning ahead to a 90° angle from either the port or the starboard side of the vessel, depending on the glare and/or the direction of the wind (to a maximum distance of 250 m). All birds detected were identified to the lowest possible taxonomic level, enumerated, and recorded on paper data-sheets as either in flight or on the water. All birds were assigned to one of five distance bins (0–50, 51–100, 101–150, 151–200, 201–250 m) that paralleled the direction the ship was heading. Each survey (hereafter referred to as a transect) was ~5 min in duration. Consecutive transects were conducted throughout daylight hours, regardless of whether birds were present.

At the beginning and end of each transect, the ship's position (latitude and longitude) and the time were recorded. In addition, the time and position were recorded whenever the vessel altered speed or changed course. At intervals of 30–60 min, a number of environmental variables were recorded; including presence/absence of precipitation, maximum visibility, glare intensity and direction, cloud cover, Beaufort sea state, swell height, wind speed, and wind direction. Surveys were terminated during periods of reduced visibility (e.g., fog and/or heavy rain) and at the end of daylight.

In addition to birds, other taxa, including marine mammals, large fishes, and sea turtles, which could be identified to species, were included in the survey observations. With the non-bird taxa, all individuals encountered, regardless of the side of the vessel they occurred on, and regardless of the distance from the ship, were noted on the data-sheet in the corresponding 5-min long transect. In addition to recording the species' identity and the number of individuals observed (minimum, maximum and best estimate), the time, estimated distance between the ship and the animal(s) when closest, and the approximate angle from the ship's bow to the animal(s) when closest were also noted. These data could be used at a later date to provide a more accurate estimation of the location where the animal(s) occurred. To derive average density estimates of birds (only) over and away from the seamounts, transects were categorized into two groups: i) transects that fell within 30-km buffers of one of four seamount groups; and ii) transects that fell outside of the buffers. Counts (numbers of individuals) and average densities (numbers/km²)

were calculated for each species of bird within each of the four seamount groups and for the transects outside the buffers.

2.4.2 Results

Survey effort is described in Table 7. Observations are described in Table 8 (seabirds) and Table 9 (marine mammals and fishes). In total, 22 species of seabirds, 11 species of marine mammals including the first record of Common Bottlenose Dolphin (*Tursiops truncatus*) in the Canadian Pacific; Halpin et al. 2018, and four species of large sharks and fishes were observed.

Table 7. Survey effort (number of 5-minute transects, total length and total surface area of transects) for each seamount group (i.e., within the 30km buffer for each seamount and outside of buffer areas), July 19-31, 2017.

	Union, Curtis	Ogala, Delwood	UN18, UN19	UN27, PRR	Non-Buffer Areas
Number of transects	111	110	34	36	314
Total length (km)	151.9	150.7	51.4	62.7	473.4
Total surface area (km ²)	37.9	37.7	12.9	15.7	118.4

Table 8. Counts and density (average, no./km²) of birds observed inside the 30 km seamount buffers for each seamount group, and outside of buffer areas. Birds are listed from most to least numerous.

Common Name	Scientific Name	Union, Curtis		Ogala, Delwood		UN18, UN19		UN27, PRR		Non-Buffer Areas	
		Count	Density	Count	Density	Count	Density	Count	Density	Count	Density
Cassin's Auklet	<i>Ptychoramphus aleuticus</i>	0	-	3	0.08	0	-	0	-	649	5.45
Common Murre	<i>Uria aalge</i>	0	-	0	-	0	-	0	-	565	3.59
Leach's Storm-Petrel	<i>Oceanodroma leucorhoa</i>	76	2.08	84	2.45	13	1.10	122	7.89	223	1.87
Pink-footed Shearwater	<i>Ardenna creatopus</i>	0	-	0	-	0	-	0	-	336	2.01
Sooty Shearwater	<i>Ardenna grisea</i>	12	0.32	2	0.05	0	-	1	0.06	221	1.59
Glaucous-winged Gull	<i>Larus glaucescens</i>	0	-	0	-	0	-	0	-	163	1.22
Fork-tailed Storm-Petrel	<i>Oceanodroma furcata</i>	0	-	7	0.20	4	0.36	12	0.78	105	0.68
California Gull	<i>Larus californicus</i>	0	-	0	-	0	-	0	-	125	0.96
Northern Fulmar	<i>Fulmarus glacialis</i>	4	0.10	4	0.11	0	-	2	0.12	107	0.89
Red-necked Phalarope	<i>Phalaropus lobatus</i>	0	-	0	-	0	-	0	-	52	0.46
Rhinoceros Auklet	<i>Cerorhinca monocerata</i>	0	-	0	-	0	-	0	-	33	0.24
Black-footed Albatross	<i>Phoebastria nigripes</i>	3	0.09	1	0.02	0	-	0	-	10	0.08
Short-tailed Shearwater	<i>Ardenna tenuirostris</i>	8	0.21	0	-	0	-	0	-	6	0.05
Western Sandpiper	<i>Calidris mauri</i>	0	-	1	0.02	0	-	0	-	11	0.10
Herring Gull	<i>Larus argentatus</i>	0	-	0	-	0	-	0	-	8	0.07
Murphy's Petrel	<i>Pterodroma ultima</i>	4	0.08	0	-	0	-	0	-	0	-
Long-tailed Jaeger	<i>Stercorarius longicaudus</i>	1	0.03	0	-	0	-	0	-	1	0.01
Red Phalarope	<i>Phalaropus fulicarius</i>	1	0.03	0	-	0	-	0	-	1	0.01
Heermann's Gull	<i>Larus heermanni</i>	0	-	0	-	0	-	0	-	1	0.01
Marbled Murrelet	<i>Brachyramphus marmoratus</i>	0	-	0	-	0	-	0	-	1	0.01
Pomarine Jaeger	<i>Stercorarius pomarinus</i>	0	-	0	-	0	-	0	-	1	0.01
South Polar Skua	<i>Stercorarius macormicki</i>	0	-	0	-	0	-	0	-	1	0.01
Total	-	109	2.94	102	2.93	17	1.46	137	8.85	2611	19.29

Table 9. Counts of marine mammals and fishes observed inside the 30 km seamount buffers for each seamount group, and outside of buffer areas. Species are listed from most to least numerous. # Described in Halpin et al. (2018). * Estimated totals. ^ Observed when stationary (not following transect protocol).

Common Name	Scientific Name	Union, Curtis	Ogala, Delwood	UN18, UN19	UN27, PRR	Non-Buffer Areas
Marine Mammals						
Pacific White-sided Dolphin	<i>Lagenorhynchus obliquidens</i>	0	525*#	0	0	0
Northern Right-Whale Dolphin	<i>Lissodelphis borealis</i>	0	350*	5	0	0
Common Bottlenose Dolphin	<i>Tursiops truncatus</i>	0	0	200*#	0	0
False Killer Whale	<i>Pseudorca crassidens</i>	0	0	70*	0	0
Dall's Porpoise	<i>Phocoenoides dalli</i>	24	24	0	0	8
Humpback Whale	<i>Megaptera novaeangliae</i>	0	0	0	0	31
Fin Whale	<i>Balaenoptera physalus</i>	0	0	0	0	2
Steller Sea Lion	<i>Eumetopias jubatus</i>	0	0	0	0	2
Northern Fur-Seal	<i>Callorhinus ursinus</i>	0	1	0	0	0
Sperm Whale	<i>Physeter macrocephalus</i>	1	0	0	0	0
Humpback Whale	<i>Megaptera novaeangliae</i>	3^	0	0	0	0
Total	-	25	900	275	0	43
Fishes						
Blue Shark	<i>Prionace glauca</i>	1	0	0	1	22
Ocean Sunfish	<i>Mola mola</i>	0	0	0	0	3
Salmon Shark	<i>Lamna ditropis</i>	0	0	0	0	3
Basking Shark	<i>Cetorhinus maximus</i>	0	0	0	1	0
Total	-	1	0	0	2	28

3 Outreach and communication

3.1 Media and social media summary

DFO's Twitter and Facebook accounts were used to promote the findings during the cruise and attract viewers to the livestream of the daily dives. In addition, a significant amount of attention was received from tweets on the personal Twitter accounts of several DFO employees.

The terms “reach” or “impressions” describe the occasions when a Tweet or post has shown up in a user's timeline or search results. “Engagements” describes the total number of times a user interacted with a Tweet or post, including retweets, replies, follows, likes, links, cards, hashtags, embedded media, username, profile photo or Tweet expansion.

3.2 Twitter and Facebook

Tweets included engaging photos from the expedition and encouraged viewers to click on the link to the livestream. Tweets were published July 18-28 through DFO's @DFO_Science¹ Twitter account and were retweeted by @DFO_Pacific¹ and @CoastGuardCAN. In total, 14 tweets (7 English and 7 in French) were posted for a total reach of 16.9k impressions and 527 engagements (Tables 11 and 12). Reach for tweets was above average for the English accounts (+37%) and slightly lower for French (-6%) compared to other tweets posted on various subjects during the same timeframe.

On average, tweets related to the 2017 Seamount Expedition mission had nearly double the engagement on the English account compared to other tweets posted during the same timeframe (+93%). The French tweets had a slightly lower engagement (-16%). Tweets from the @DFO_Science account were most notably retweeted by Oceana Canada (@OceanaCAN), the David Suzuki Foundation (@DavidSuzukiFDN), and the Royal Ontario Museum (@ROMBiodiversity¹). Tweets that were posted later in the afternoon/evening performed better. This result is likely due to the primary audience being on the West Coast of Canada (three hour time differential from Ontario).

Dr. Jackson Chu, a Postdoctoral Researcher and member of the Science team, was extremely active on Twitter, generating a significant amount of attention for the live feed, the website and the mission in general. His use of interesting facts, exciting themes and beautiful photography combined with a generous volume of timely content to an appropriate audience made for a very successful Twitter campaign. His hashtag #LOMPA2017 (Large Offshore Marine Protected Area) reached 38,981 accounts and created 114,125 impressions. The hashtag was used in 59 tweets by 27 contributors over 10 days. Most notably, the hashtag was retweeted by @Ocean_Networks which created over 40k impressions.

Facebook posts were shared via [DFO's Facebook page](#). Four posts were published (2 English and 2 French) getting a total reach of 13.9k and generating 700 engagements (Table 13).




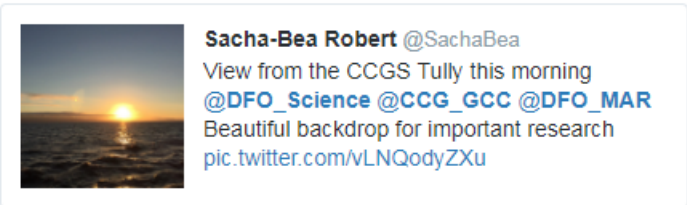
¹ Account no longer active

Table 10. Twitter and Facebook summary statistics.

Metric	Twitter account					DFO Facebook account	
	@DFO_Science	@MPO_Science	@DFO_Pacific	@Jwfchu	@SachaBea	English	French
Posts sent	7	7	1	148	12	2	2
Impressions/Reach	15,920	977	6,298	73k	6k	12,042	1,874
Engagements	503	24	17	61,815	216	625	75
Retweets/Shares	43	5	5	138	9	22	2
Replies/Comments	3	0	1	50	6	7	0
Likes/Reactions	80	3	11	541	73	126	16
Link clicks	142	6	Not available.	153	22	30	4

Table 11. The most popular tweets from these accounts shared during the expedition

Account	Number of unique tweets	Most popular tweet	Impressions
@DFO_Science	7		5.2K

Account	Number of unique tweets	Most popular tweet	Impressions
@MPO_Science	7		281
@DFO_Pacific	1		6,298
@jwfchu (DFO employee on expedition)	148		3,209
@SachaBea (DFO employee on expedition)	12		1,294

3.3 Web

An expedition webpage (no longer active) was developed and posted on the Science At-Sea section of the DFO website. From this page, viewers could access a summary of information about the cruise, link to scientist's profiles, and view photos from the expedition. The website also hosted a link to the live feed hosted on the Ustream website. The expedition webpage received 2,373 page views (1,735 unique), with the average user spending 6.5 minutes on the page. Thirty-four percent of viewers came from Facebook while 7% came from Twitter. The remaining 49% found their way to the website from various sources including search engines, emails, and other websites.

3.4 Ustream

The mission's dives, which generally occurred between 7:30 am and 6:30 pm Pacific time, were livestreamed from the hosted page on Ustream. The livestream ran for a total of 2,075 hours and provided viewers with the same live footage the scientists were viewing on the ship. There were 1,884 unique views of the livestream in total and 3,679 total views of the host page.

Viewers tuned in from 69 different countries across the globe; most viewers were in Canada (2,213 viewings) and the USA (808 viewings). The most popular access point for the livestream was DFO's website, from which 1,486 viewers were directed. Another 1,315 were directed to the livestream of the dives from Ustream's website itself.

3.5 Traditional media

Media pitching began after the first week of the science mission was completed. The most successful pitch was with CTV News Victoria, which provided coverage of the science mission at its completion and was able to share important footage taken during the cruise (Figure 12). The news outlet also shared the video on their Twitter account generating 18 likes and 12 retweets.



Figure 12. The CTV News (@CTVNewsVI) tweet about the mission.

3.6 Media outlets that covered the science mission

TV: CTV Vancouver Island, evening news – Showed the debarkation and shared imagery gathered during the mission. Interviews were conducted with Chief Scientist, Tammy Norgard, along with Dr. Cherisse du Preez and James Pegg. The spot, *Exploring huge undersea mountains off B.C. coast*, aired on August 2, 2017, and the link to the video (no longer active) was viewed on Facebook 232 times.

Radio: Radio-Canada Victoria (French) – Interview took place on July 26, 2017 with Stephane Gauthier from the Institute of Ocean Sciences, Victoria as there were no French speaking scientists on board the CCGS Tully. The interview covered much of the same content as the CBC Radio interview with Dr. Cherisse Du Preez.

CBC Radio 1 Victoria, On the Island program – Interview and discussion with Dr. Cherisse Du Preez, aired on July 27, 2017. The interview took place on the ship via Google phone. The host, Gregor Craigie, asked Dr. Du Preez about the location of the work, what the scientists were examining and why it was important to Canadians.

Web: Radio-Canada International, story [Canadian scientists explore seamounts off British Columbia's coast](#) by Leon Sevunts was published on August 10, 2017. The story provided a brief overview of the objectives of the mission, directing readers to two pages on the DFO website: [coldwater corals and sponges](#) and [Marine Protected Areas](#).

Marine Technology News' story [Scientists Explore Canada's Deep Ocean Seamounts](#) was published on July 25, 2017. The story was “liked” on MTN’s Facebook page 109 times. The article content was mostly taken from information provided on the mission’s web page.

4 Conclusions

This expedition provided the first comprehensive visual, oceanographic, and ecological characterization of the offshore seamounts within the Pacific Offshore AOI, establishing an essential scientific baseline for one of Canada's most remote and understudied deep-sea regions. Through integrated hydroacoustic mapping, benthic imaging, biological sampling, and seabird and marine mammal surveys, the mission documented diverse habitats, VME indicator taxa, and unique oceanographic conditions across multiple seamounts, while generating over 62 hours of seafloor imagery and extensive supporting datasets. Subsequently, these observations have directly informed research expeditions and contributed critical evidence toward the development and eventual designation of the Tang.ḡwan – ḡačxwiḡak – Tsigis Marine Protected Area in 2024, underscoring the long-term importance of this expedition in advancing deep-sea conservation and management in the Offshore Pacific Bioregion.

5 Acronyms

Acronym or symbol	Definition
AOI	Area Of Interest
BC	British Columbia
CCGS	Canadian Coast Guard Ship
DFO	Fisheries and Oceans Canada
CWCS	Cold-Water Corals and Sponges
VME	Vulnerable Marine Ecosystem
SK-B	SGáan Kínghlas-Bowie Seamount
TłT MPA	Tang.gwan – Һačxwiqak – Tsigis Marine Protected Area
PRR	Paul Revere Ridge
UN	Unnamed Seamount
NEPDEP	Northeast Pacific Deep-sea Expedition Project
LOMPA	Large Offshore Marine Protected Area
JDF	Strait of Juan de Fuca
ICES	International Council for the Exploration of the Sea
CTD	Conductivity, Temperature, and Depth (sensor or cast)
CHS	Canadian Hydrographic Service
DEM	Digital Elevation Model
EPSG	European Petroleum Survey Group (Coordinate/Projection code)
NPFC	North Pacific Fisheries Commission
SPRFMO	South Pacific Regional Fisheries Management Organisation
BOOTS	Bathyal Ocean Observation and Televideo System
VHF	Very High Frequency (radio)
GPS	Global Positioning System
Bongo	Type of zooplankton sampling net (Bongo net)
MOCNESS	Multiple Opening/Closing Net and Environmental Sensing System (Type of zooplankton and larval fish sampling net)
SBE25	SeaBird Electronics model 25 (CTD instrument)
.mpg	MPEG video file format
.mov	QuickTime video file format
HPLC	High-Performance Liquid Chromatography
eDNA	Environmental DNA
DIC	Dissolved Inorganic Carbon
TA	Total Alkalinity
ROS	Rosette
DO	Dissolved Oxygen
Chl	Chlorophyll
DA	Domoic Acid
Phyto	Phytoplankton taxonomy/sample
WOCE	World Ocean Circulation Experiment

UV	Ultraviolet (light, sensor)
LVO2_876	Software for Metrohm Dosimat titration system (model 876)
NOAA	National Oceanic and Atmospheric Administration
SN651	Slocum Glider serial number 651
kt	Knot (nautical speed)
CBC	Canadian Broadcasting Corporation
CTV	Canadian Television Network
MTN	Marine Technology News
ROM	Royal Ontario Museum
FDN	Foundation
GB	Gigabyte
hr	Hour
m	Metre
ml/L	millilitres per litre
kt	Knot (nautical speed)
UTC	Coordinated Universal Time
PST	Pacific Standard Time
3D	Three-dimensional
2D	Two-dimensional
Ms	Millisecond
W	Watt
dB	Decibel
Hz	Hertz
°	degrees
µm	micrometre

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Appendix A. Camera & lighting setup on BOOTS tow-camera platform

Cameras

- A) Two main cameras prioritized for optimal lighting and for capturing imagery data.
 - A.) HD Minizeus video camera (HDcam) with scaling lasers mounted on Pan & Tilt unit.
 - B.) 1CamAlpha Still camera (stillcam) with scaling lasers (note: these lasers were not mounted onto stillcam)
- B) One supplementary pilot camera (pilotcam) – for piloting. Lighting was prioritized for dive B32.
- C) Several miscellaneous cameras
 - a. Rayfin still camera with single strobe (prototype stillcam from SubC Imaging)
 - b. Attached GoPros
 - i. Umbilical - lighting was low priority
 - ii. Forward-facing - lighting was low priority

Lights

- Two **Sphere lights** – prioritized for HDcam
 - forward placement
 - forward-down facing
 - fill light for top-half of HDcam field of view
- Two **HID (high-intensity discharge) lights** – prioritized for HDcam
 - middle-sled placement
 - down-forward facing
 - circular hotspots for lower-half of HDcam field of view
- Two still camera **strobes** - prioritized for stillcam
 - Middle-sled placement – either side, in line with stillcam
 - Downward facing
 - *Note: Strobe flashes are visible in HDcam field of view*
- Two **ROS (Remote Ocean Systems) lights** – prioritized for stillcam
 - Rear-sled placement, below CTD cage
 - downward facing away from centerline of sled

Light and camera configurations – relative positioning and priority changes during cruise

B021 – Original sphere light positions were mounted front-side of HDcam

B022 – Sphere lights were moved to position behind HDcam and tilted forward. Both SDcam strobes were repositioned beside and in line with stillcam on either side. This was the most optimal lighting configuration used throughout cruise (Figure A. 1 to Figure A. 8).

B022-25 – **Rayfin + strobe** were mounted rear of stillcam with dedicated strobe on rear bracket pointing forward-down (Figure A. 5).

B032 – Starboard Sphere light removed. Deepsea Sealite LED mounted onto front-top to illuminate pilotcam (Figure A. 10).

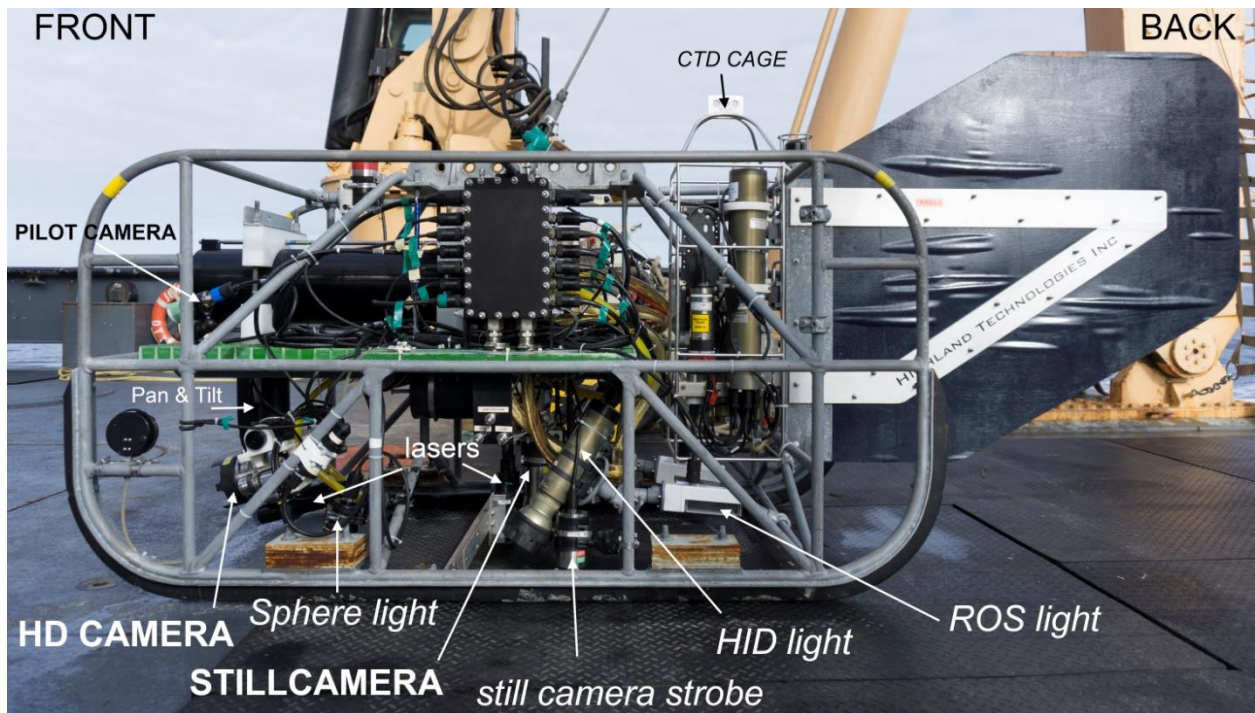


Figure A. 1. BOOTS camera and lighting configuration used during offshore seamount cruise PAC2017-036. Photo credit: Jackson Chu.

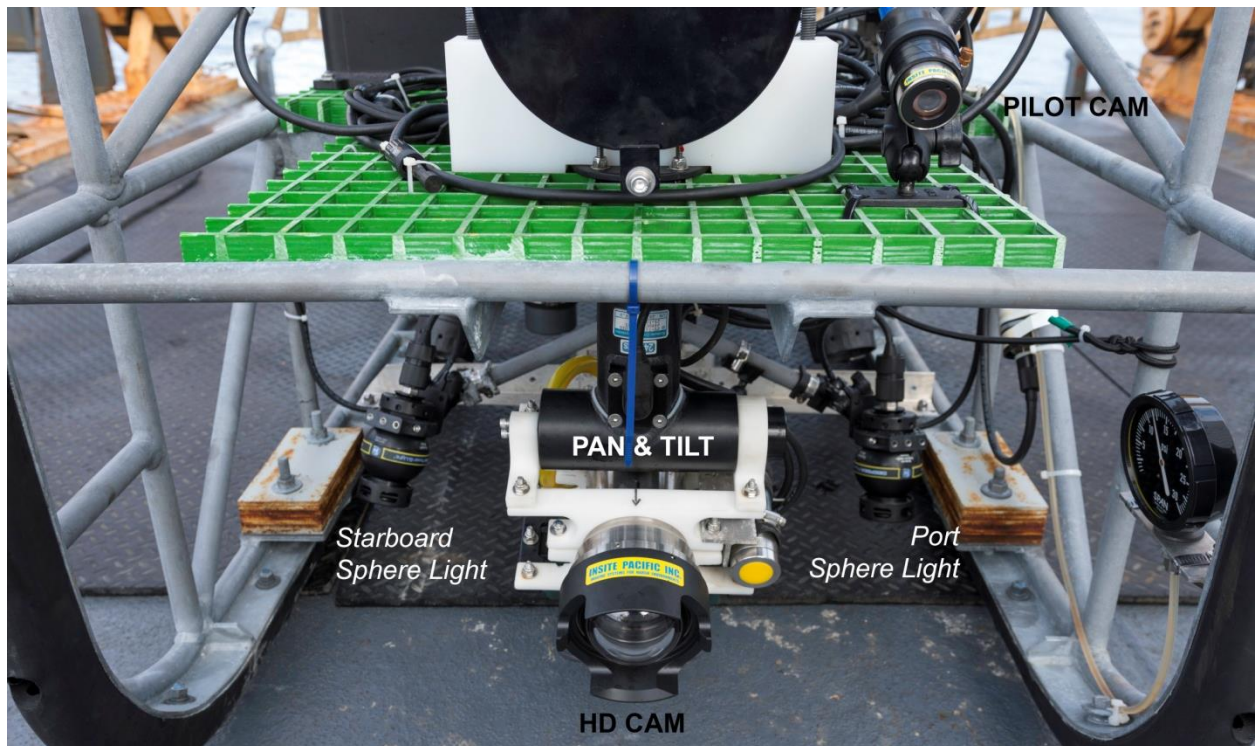


Figure A. 2. BOOTS forward cameras and light positions. Photo credit: Jackson Chu.



Figure A. 3. Sphere light positions. Photo credit: Jackson Chu.

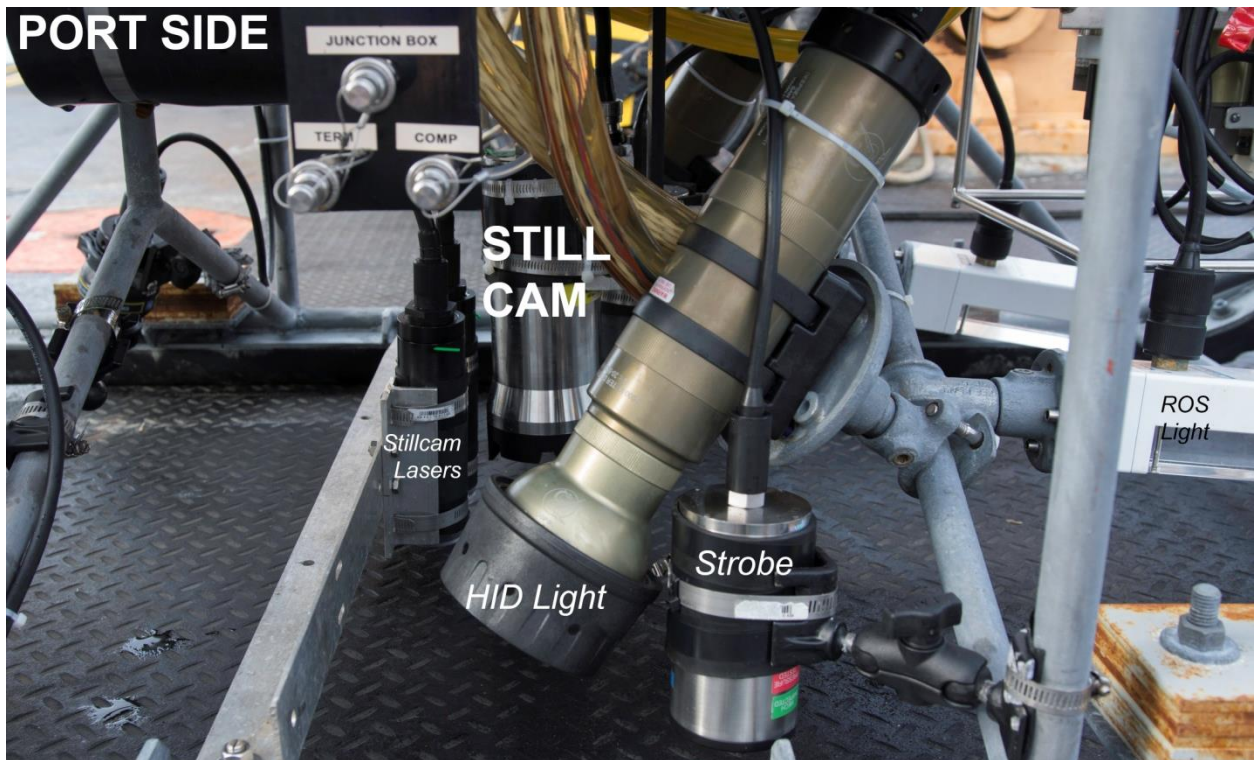


Figure A. 4. BOOTS middle section camera and lighting positions. Photo credit: Jackson Chu.



Figure A. 5. Stillcam laser mounting location at mid-section of sled. Facing rear of sled. Relative positions of scaling lasers for Stillcam for all dives B022-B032. Photo credit: Jackson Chu.



Figure A. 6. ROS light positions. Top-down view from above the CTD cage facing front of sled. Photo credit: Jackson Chu.

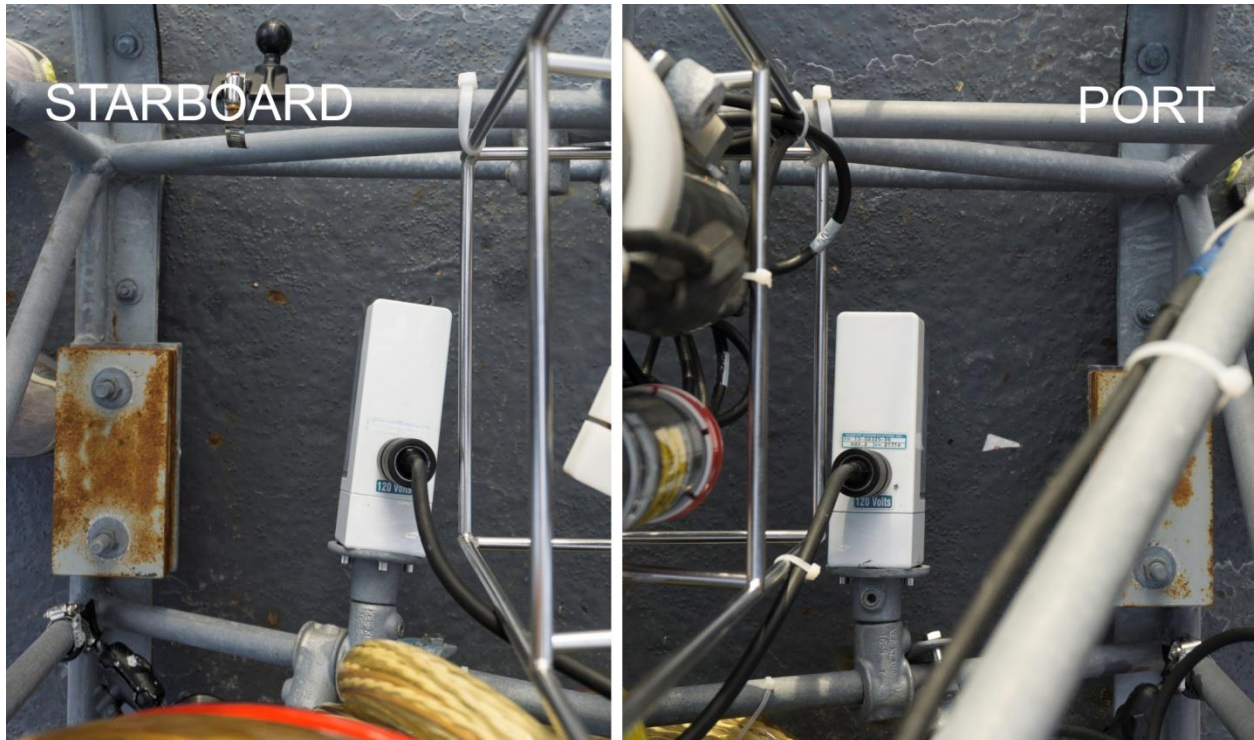


Figure A. 7. ROS light positions. Top-down view facing rear of sled. Photo credit: Jackson Chu.

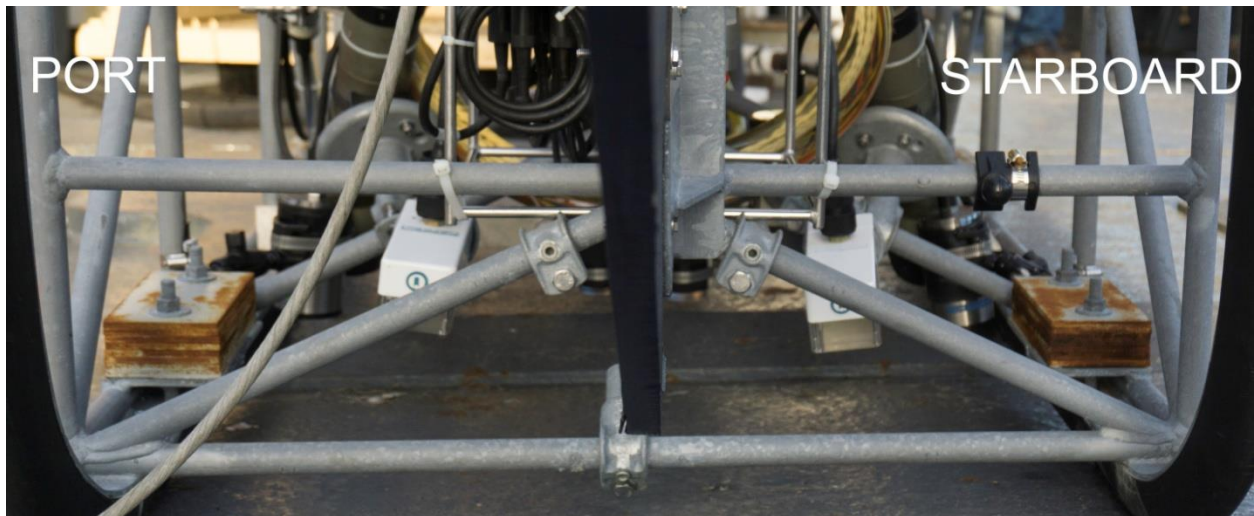


Figure A. 8. ROS light positions. Rear-view facing front of sled. Photo credit: Jackson Chu.

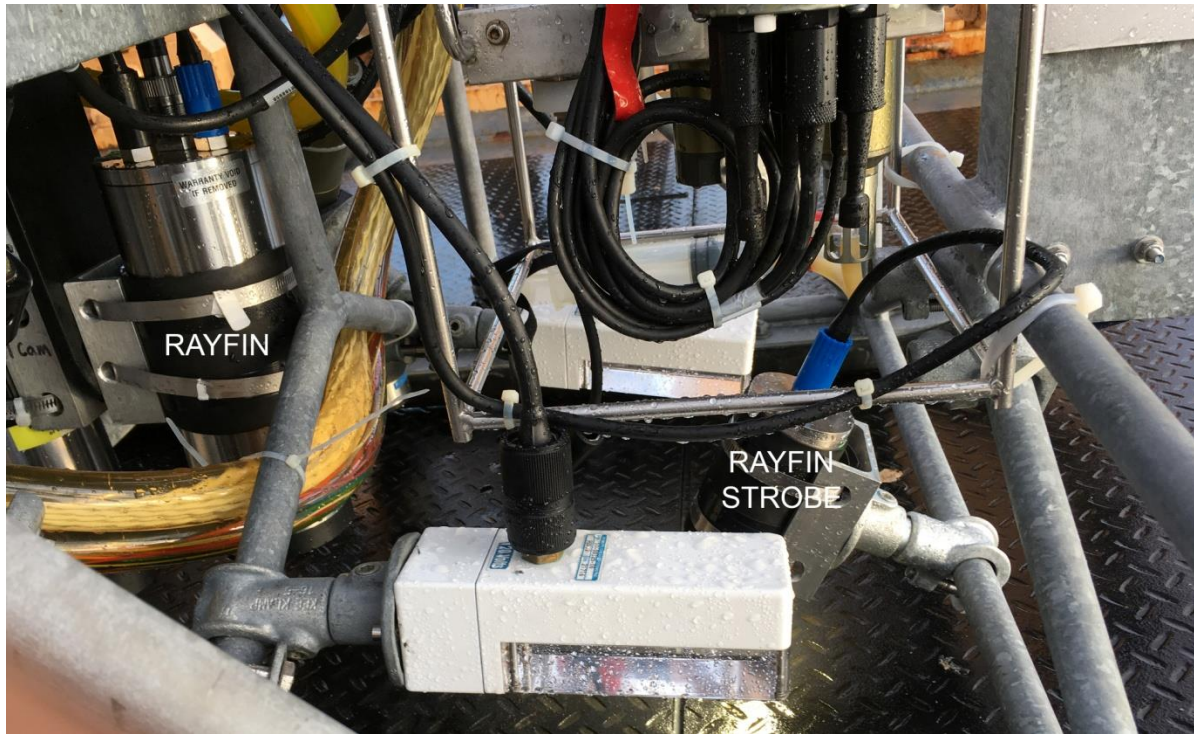


Figure A. 9. Position of Rayfin prototype stillcam and strobe. Rayfin was mounted behind the IcamAlpha stillcam. Rayfin strobe was mounted on back cross beam, underneath BOOTS tailfin between ROS lights and angled forward-down. Photo credit: Jackson Chu.

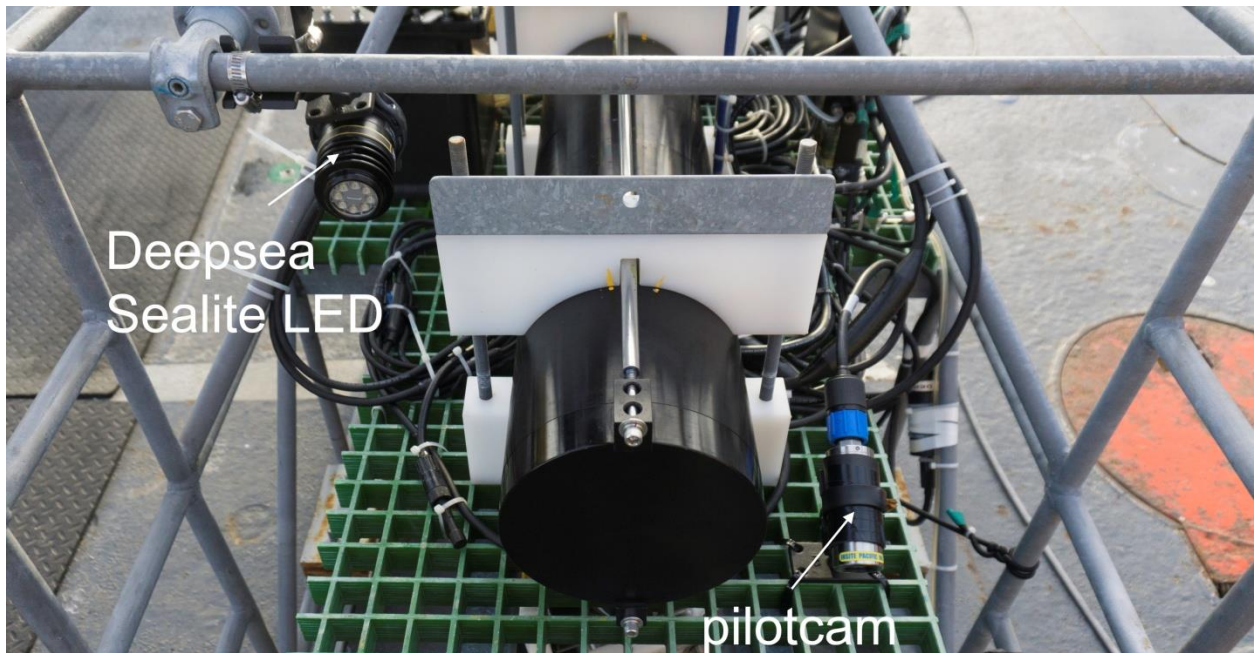


Figure A. 10. Position of Deepsea Sealite LED for pilotcam during dive B032. Photo credit: Jackson Chu.

Appendix B. Example dive log

Table B. 1. Example at-sea dive log. *Calculated as straight-line distance between start and end point, and recalculated post-cruise for Table 4.

Dive name/number	B024
Site/Seamount:	Union
General spatial location	Deep southeast slope (2000 m)
Number of transects completed:	1
Transect descriptions (e.g., long, short):	Long
Launch date (UTC):	22-Jul-17
Recovery date (UTC):	23-Jul-17
Launch time (UTC):	15:02:45
Recovery/on deck time (UTC):	1:13:52
On bottom time (UTC):	16:49:15
Off bottom time (UTC):	0:50:16
Dive duration:	10:11:06
Est. horizontal length (m)*	6723
Launch LAT/LONG:	49.47982, -132.66175
Recovery LAT/LONG:	49.5298, -132.7141
At bottom depth (CTD):	2080
Leaving bottom depth (CTD):	430 (399 was shallowest)
Pilot(s):	Jackson Chu, Tammy Norgard
Logger(s):	Cherisse Du Preez
Notable VME indicator species observations?	Black corals, crinoids, glass sponges, soft corals, anemones
Notable (other) species observations?	Transected through deep zone of abundant grenadiers, <i>Stylaster</i> , thornyheads, squat lobsters, spiny-legged brittle star, bubble-gum coral, <i>Solaster</i> , rockfish; lots of tanner and king crabs.
Notable dissolved oxygen observations?	Squat lobster zone may have been an indicator of low oxygen.
Notable substrate observations?	Steep basalt lava with patches of mud.
Notable seamount features	Steep cliffs and small peaks along the flank.
Notable fishing impact observations?	None.
Notable changes to BOOTS configuration?	Zoomed camera in and panned sideward to face cliffs.
Issues (technical, equipment, environmental, human)?	Oxygen sensor real-time data was not working.
Highlights (for outreach)?	Deepest BOOTS dive ever. Landed on basalt lava.
Watch stander's additional report/comments:	Successfully completed the transect past 700 m (for the research goal of surveying the entire depth range of Union).
Speed of ship	0.2-0.3 kn
Wind speed	14 kn
Swell	1.9 m

Other weather notes	Overcast
Transect #	B024_01
Start time	16:49:24
End time	0:50:16
Duration	8:00:51
Start depth (CTD, m)	2080
End depth (CTD, m)	430
Shallowest (CTD, m)	399
Ship start LAT/LONG	49.48226, -132.6655
Ship end LAT/LONG	49.52928, -132.71222
Est. length (m)*	6224
Est. horizontal speed	0.778