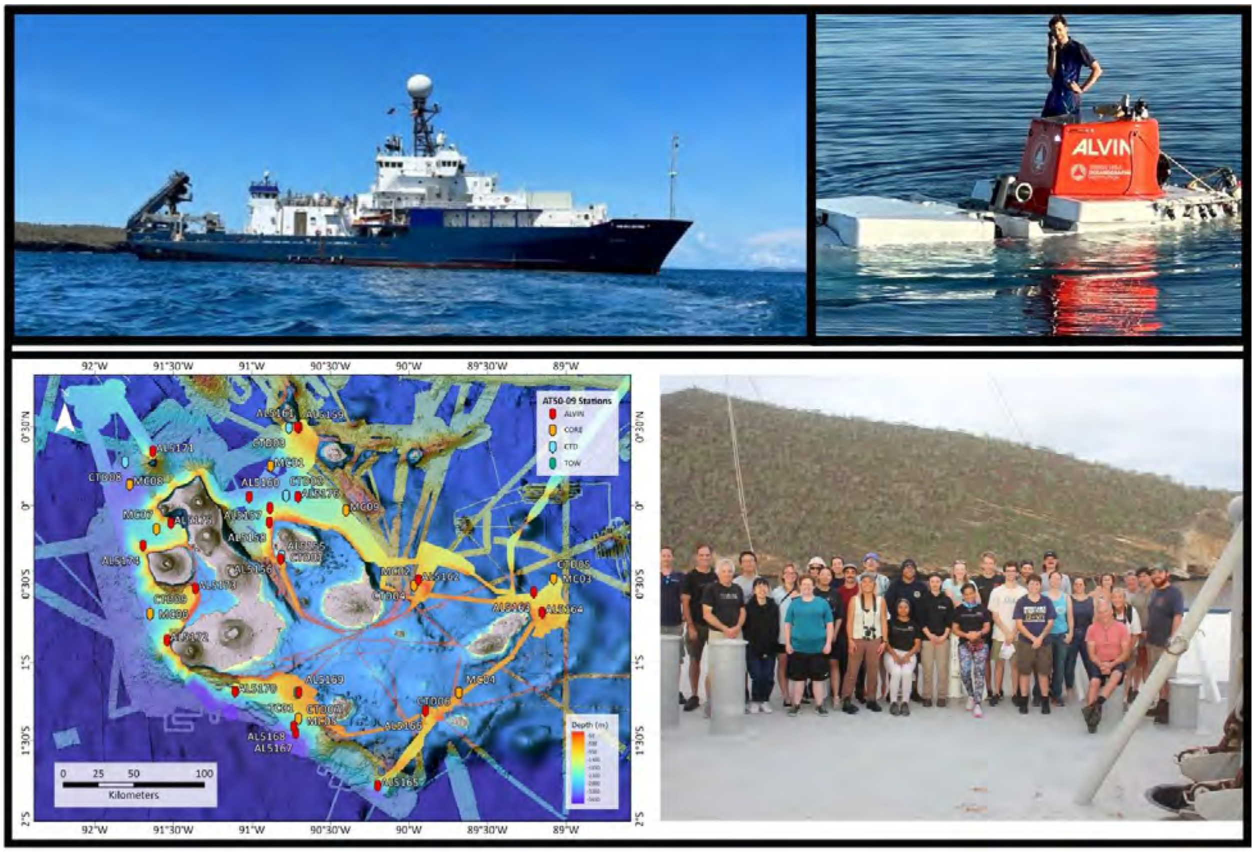
AT50-09 Preliminary Cruise Report

March 20 to April 22, 2023

Puntarenas and Golfito - Costa Rica to Pt. Ayora, Santa Cruz Island, Galápagos, Ecuador



Principal Investigators:

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Dr. Michelle Taylor - University of Essex - UK

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1. Executive Summary and Project Logistics

The AT50-09 expedition is a collaborative project between UK and USA scientists at U. Bristol, U. Essex, Boise State U. and Woods Hole Oceanographic Institution (WHOI). The objective of this multidisciplinary research is to investigate the shallow and deeper portions of the Galápagos Platform to better understand the geological evolution of this important volcanic archipelago and the biological and climate records contained in the fauna. The project is funded through research grants from the Natural Environment Research Council in the UK, and the National Science Foundation - Ocean Sciences Division, in the USA. The grants supporting this research were awarded over 4 years ago, and originally the expedition was meant to utilize the UK research ship *James Cook* and the ROV *Isis*. However, due to scheduling impacts imposed by the COVID-19 pandemic over the past few years that affected oceanographic research programs worldwide, the expedition has been postponed numerous times.

We are extremely grateful to the vessel and deep-submergence facility schedulers at NERC, NSF and WHOI who facilitated the collaborative program elements required to co-fund and provide the seagoing facilities needed to carry out this research. Their work was crucial to using the RV *Atlantis* and human occupied vehicle (HOV) *Alvin* for the 22 submersible dives accomplished, and the numerous seafloor mapping, remote water and sediment sampling and imaging activities carried out over the course of the field program. A total of ~113 hours of on-bottom time was accomplished by *Alvin* during the field program.

We equally acknowledge the superb collaboration of the Galápagos National Park, Charles Darwin Research Foundation, and the Ecuadorian Navy's Oceanographic and Antarctic Institute (INOCAR), all of which facilitated the necessary permits to operate in Ecuadorian waters and the Galápagos Marine Reserve (GMR) to observe, document and sample the unique seafloor features and biology that comprise this iconic ocean island setting.

The mobilization for the cruise commenced on March 20 with the science party embarking RV *Atlantis* on March 20 in Puntarenas, Costa Rica (CR). Because of the necessity to fully clean the ship's hull before entering the Galápagos Marine Reserve (GMR), the ship transited to Golfito, CR and remained dockside while the hull was cleaned by professional divers retained by WHOI so that the ship would pass inspection and be allowed to operate in the GMR. During the Golfito port stop, the science team mobilized and set up the ship's labs for the upcoming field work.

The ship departed Golfito at ~1400L on March 25 and transited to Pt. Ayora directly to clear into Galápagos, arriving on the morning of March 28 at ~0700L. On arrival we successfully met all the operational biohazard requirements for conducting the field work using *Atlantis* and *Alvin*, loaded observers and several *Alvin* team members, and departed at ~1530L for our first dive area between Santiago and northern Isabela Islands. *Alvin* dove successfully until the last dive day on April 18, and which point *Atlantis* transited back to Pt. Ayora, arriving at ~0700L on April 19 to provide several days for demoblization and inspection of our field samples by the authorities of the GNP so that the numerous samples collected could be exported onboard *Atlantis* for eventual landing in San Diego, CA in early June. Table 1 provides a capsulated summary of the *Alvin* dive schedule during AT50-09. The science team (Section 2) departed the ship mid-day on April 21 as planned, and *Atlantis* departed Pt. Ayora for Golfito, CR on the morning of April 22 as scheduled.

2. Personnel Onboard

AT50-09 Science and Observer Team

Shipboard Participants

1. Janine Andrys (U. Rhode Island, Boise State U.)
2. Stuart Banks (Charles Darwin Research Foundation) - Observer
3. Salome Buglass (UBC/CDF)
4. Divar Castro (INOCAR) - Observer
5. Lydia Crampton (Bangor, UK)
6. Maria Luiza De Carvalho Ferreira (U. Chicago)
7. Daniel Fornari (WHOI) - Chief Scientist
8. Dennis Geist (Colgate U.)
9. Jessica Gordon (U. Essex)
10. Shannon Hoy (NOAA-OE)
11. James Kershaw (U. Bristol)
12. Qian Liu (U. Bristol)
13. Samuel Mitchell (U. Bristol)
14. Ana Samperiz (Cardiff U.)
15. Darin Schwartz (Boise State U.)
16. Yingchu Shen (U. Bristol)
17. Jenifer Suarez (Galápagos National Park) - Observer
18. Yun-Ju Sun (U. Bristol)
19. Michelle Taylor (U. Essex) - Co-Chief Scientist
20. Maoyu Wang (U. Bristol)
21. Amy Sing Wong (U. Essex)

Shore-Based Co-PIs

Laura Robinson (U. Bristol)
V. Dorsey Wanless (Boise State U.)

AT50-09 Alvin Team

1. Kaitlyn Beardshear, Alvin Tech
2. John Dymek, Alvin Tech
3. Benen Elshakhs, Alvin Tech
4. Joe Garcia, Alvin Data Lead
5. Randy Holt, Alvin Expedition Leader
6. Rick Sanger, Pilot, Elec. Section Lead
7. Matt Skorina, Alvin Tech
8. Bruce Strickrott, Pilot
9. Nick Osadcia, Pilot, Mech. Section Lead

AT50-09 Ship's Crew

1. Joey Diagle - Master
2. Eric Piper - Chief Mate
3. Kendall Beaver - 2nd Mate
4. Patrick Newmann - 3rd. Mate
5. Alex Deveaux - Chief Engineer
6. Edward Popowitz - Bosun
7. Rosel Garcia - Able Seaman
8. Michael Sessa - Able Seaman
9. Lance Wills - Able Seaman
10. Alexander Jacqueliine - Ordinary Seaman
11. Kolton Hensley - Ordinary Seaman
12. Christopher Billings - 1st. Assistant Engineer
13. Brian Kwedor - 2nd. Assistant Engineer
14. Lucy Fuglestad - 3rd. Assistant Engineer
15. Aminkeng Fhu - Oiler
16. Ryan Gregory - Oiler
17. David Kotschi - Oiler
18. Timothy Burgett - Wiper
19. Brian Keenan - Steward
20. Mark Nossiter - Cook
21. Vongdeuan Vongphrac Hanh - Messman
22. Joshua Sisson - Comm/ET
23. Allison Heater - SSSG
24. Sonia Brugger - SSSG

3. Expedition Background and Goals

The expedition objectives are to advance and integrate knowledge on the formation of the volcanically active Galápagos Platform (GP) and its associated habitats and biodiversity, as well as the historical changes in the deep-water environment in the context of past and ongoing climatic change. The expedition will address these objectives through mapping and imaging the seafloor, collection of important biological and geological samples using the HOV *Alvin* and other oceanographic tools, and subsequent laboratory analyses to be carried out in the UK and USA.

Objective 1 - Context: Characterize the habitat of marine benthic environments and ecosystems, including geology of the substrate, physical and chemical properties of seawater, depth and slope characteristics, using seafloor mapping techniques and imaging, as well as water column profiling, sediment coring and collection of bedrock samples from the GP.

Objective 2 –Biodiversity and habitat: Collect and identify key benthic organisms in each environment to advance knowledge of the biodiversity in the Galápagos Marine Protected Area. Video surveys of benthic ecosystems will be analyzed to investigate drivers of community structure across the GP (images and identifications will be ground-truthed with collected specimens). Specimens will be investigated taxonomically – possibly leading to novel species descriptions. Subsequent genetic analyses (phylo-genomics) will establish the evolutionary history of deep-sea corals of the Galápagos. If suitable samples are collected, they will be included in global/ regional coral connectivity (population genomics) analyses, placing Galápagos into wider connectivity seascapes.

Objective 3: Controls on deep sea corals: Many deep-sea corals make their skeletons from calcium carbonate. As the oceans warm and become more acidified these important habitat forming organisms are becoming more vulnerable. With limited data this vulnerability is not well quantified. During the expedition we will collect representative carbonate forming corals at different depths on the margin of the GP and at diverse locations throughout the GP with the aim of establishing growth rates and bio-mineralization pathways. The data will also be used to reconstruct the environmental history of the deep waters over the last century providing context for interpreting the resilience of deep-water reefs.

Objective 4: Ocean-climate links modern and past: The Eastern Equatorial Pacific (EEP) is a center of large-scale ocean and atmospheric variability. It is also a region where geological and biological systems influence the ocean's carbon cycle and, in doing so, imparts forcing on the global climate. Geochemical analyses of the skeletons of well-dated deep-sea scleractinian corals can provide robust new data to establish how the physics and biogeochemistry of the EEP influenced global climate during important climate transitions. Geochemical analyses on sub-fossil coral skeletal remains will be used to establish the timings of paleoclimate records from ~ 3000m to ~300m depth. Live collected coral samples will be analyzed for growth rates, and ancillary measurements will be used to provide high resolution information on the recent changes in the deep waters of the EEP over the last century. The data, together with carbon cycle modelling, will allow hypotheses that have been put forward for explaining the importance of changing current patterns in the deep Equatorial Pacific and global climate across timescales from decades to tens of thousands of years.

Objective 5: Formation mechanisms of the Galápagos Platform: Geomorphological data and collections of *in situ* lava, associated with the sampled fossil corals, will place important constraints on submarine lava emplacement ages and help establish better subsidence rates for the Galápagos Platform. Geochemical analyses of the submarine lavas will provide important constraints on the magmatic evolution of the Galápagos Islands and relationships between platform building lava flows and those found on adjacent subaerial islands throughout the GP. Given published hypotheses that link release of geologic carbon from volcanic edifices to paleoclimate, these dual efforts have the potential to bring together our two major science themes through this novel interdisciplinary collaboration.

4. Expedition Overview

Mobilization for the expedition was carried out in Charleston, South Carolina, USA in Nov. 2022 to load the 20-foot shipping container and other necessary equipment on RV *Atlantis* in a US port to avoid logistics complications. The expedition commenced on April 20 in Puntarenas Costa Rica. Hull cleaning and re-supply was undertaken in Golfito. We departed Golfito on March 25 and arrived in Pt. Ayora, Santa Cruz Island, Galápagos on March 28, covering the transit route shown in Figure 1. During the transit we acquired multibeam mapping data at the request of the Costa Rican and Ecuadorian authorities along the transit route because of the importance of fully mapping the marine preserve corridor between Costa Rica and the Galápagos Islands. Authorization was provided by a letter dated March 24, 2023 from Dr. R. A. G. Rojas, the Executive Director of the Costa Rican National Conservation Area System (Appendix 1 contains the authorization letter).

Figure 2 shows the multibeam bathymetric mapping data available before the expedition. The area that we were cleared to undertake research in is indicated in the red circle on Figure 3. *Alvin* dive operations commenced on March 19.

Planning for *Alvin* dives (both prior to and during the expedition) took advantage of a wealth of remote sensing mapping data (multibeam and sidescan sonar) and dredge-recovered coral samples (2001-DRIFT-4 expedition and 2010 MV1007 expedition), as well as fossil coral samples collected during limited previous ROV and submersible operations (OET ROV H1443 and MV *Alucia* AL1508 expeditions).

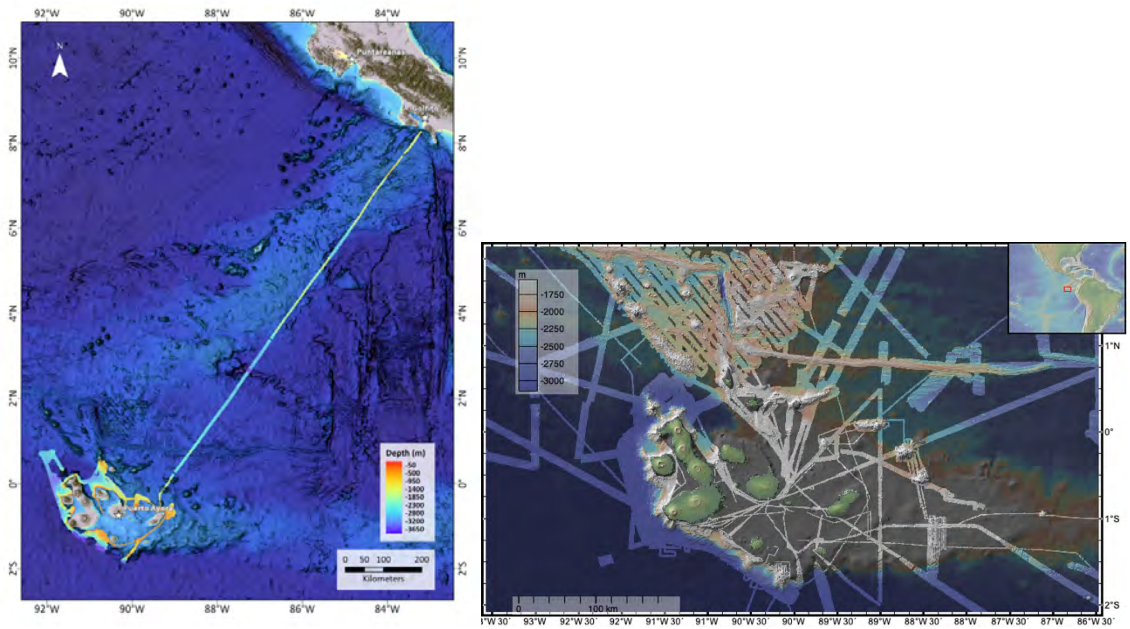


Figure 1. (left) AT50-09 transit track from Costa Rica to the Galápagos Islands. (right) Map of the available multibeam bathymetric data (highlighted colors) in the study area prior to the expedition.

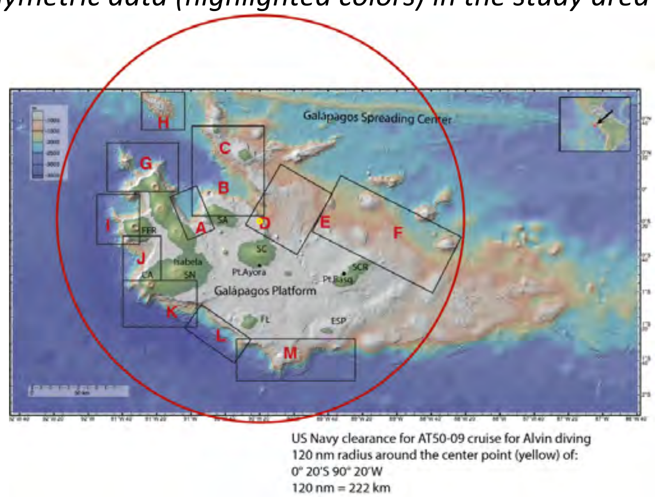


Figure 2. AT50-09 dive areas and US Navy clearance zone (red circle).

5. Operations Overview

Data acquisition on the cruise focused on *Alvin* (Figures 1-3. Table 1) diving during the day (full list of dives presented in Table 2) and a variety of survey and sampling/imaging operations during night hours when *Alvin's* batteries were charging (overview *Alvin* and station map shown in Figure 4). While a good number of the deeper water dive areas had ~2000's vintage 70-100 m gridded multibeam data coverage, many of the shallow water sites (~300-800 m depths) around the platform margin had not previously been mapped. Consequently, we opted to map many areas that were primary targets for the biology and fossil coral objectives during night operations to produce maps to select *Alvin* dive sites. Additionally, we conducted CTD and MC-400 multicoring operations in areas that coincided with sites where live and fossil corals were collected using *Alvin*. 10 CTDs and 9 MC-400 lowerings were accomplished (Figure 4). Finally, we used the WHOI-MISO *TowCam* for one lowering to survey an area on the shallow platform south of Isabela, in the area between Floreana and Sierra Negra. All lowered instruments used an ultra-short baseline (USBL) beacon, hence navigation and positions for water and sediment samples, and images are accurate to within

~10 m in geodetic coordinates. All technical specifications of equipment used during AT50-09 are provided in Appendix 2.

Table 1. Summary of Alvin dive operations during AT50-09 cruise. See Figure 4 for location of dives and night-time operations and Table 3 for station summaries.

	Dive#	Dive Teams	DATE	
1.	5155	Taylor/Schwartz	March 29	OET H1443 site W of Santiago
2.	5156	Taylor/Schwartz	March 29	OET H1443 site W of Santiago
3.	5157	Geist/Liu	March 30	NW corner of Santiago platform
4.	5158	Taylor/Andrys	March 31	Shallow platform on W. Santiago
5.	5159	Schwartz/Kershaw	April 1	D3 MV1007 dredge site S of Pinta
6.	5160	Hoy/PIT	April 2	Deep NW Santiago platform
7.	5161	Mitchell/Ferreira	April 3	D3 MV1007 dredge site S of Pinta
8.	5162	Taylor/Banks	April 4	Croissant smt. E of Santa Cruz -new reef
9.	5163	Schwartz/Samperiz	April 5	Deep terraces NE of San Cristobal
10.	5164	Andrys/Buglass	April 6	Small smt. E of San Cristobal
11.	5165	Geist/PIT	April 7	deep Wittmer Seamount
12.	5166	Hoy/Gordon	April 8	Radiocarbon Stott site N of Espanola
13.	5167	Schwartz/Shen	April 9	Floreana deep terrace ~3300 m
14.	5168	Andrys/Wang	April 10	Floreana middle-terraces ~2700 m
15.	5169	Kershaw/Crampton	April 11	Shallow Floreana terraces
16.	5170	Geist/PIT	April 12	Isabela deep terraces
17.	5171	Samperiz/Suarez	April 13	Roca Redonda shallow
18.	5172	Taylor/Wong	April 14	Punto Cristobal, Isabela - small seamount
19.	5173	Ferreira/Sun	April 15	Shallow terrace between Isabela & Fernandina
20.	5174	Mitchell/Castro	April 16	Fernandina NW submarine rift
21.	5175	Fornari/PIT	April 17	Deep cones between Fernandina & Isabela
22.	5176	Andrys/Gordon	April 18	Deep terrace/flows N of Santiago

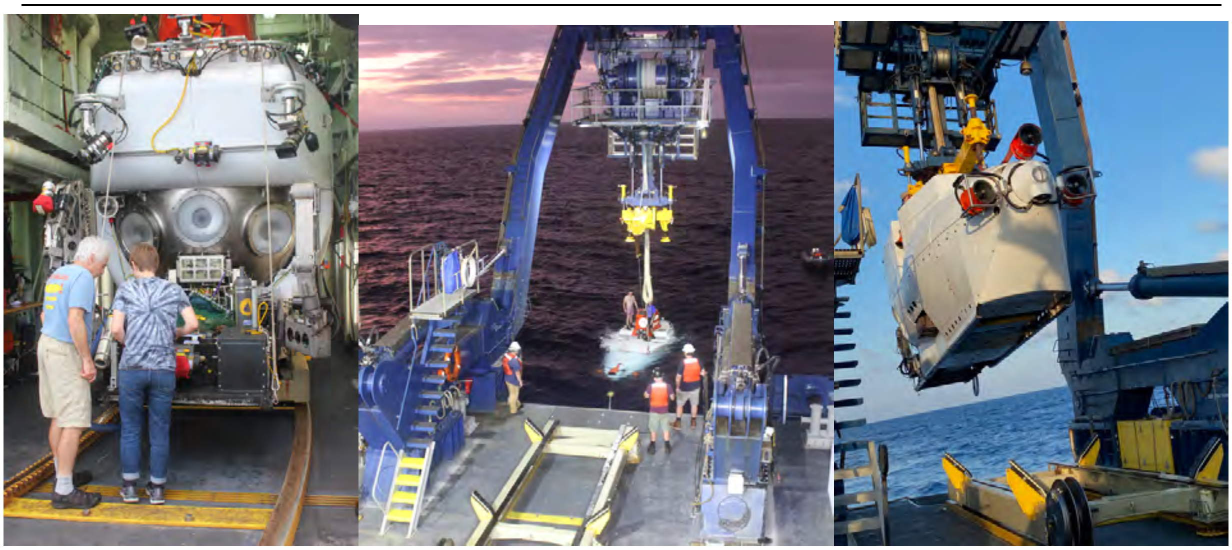


Figure 3. Images of the Alvin research submarine operated from RV Atlantis.

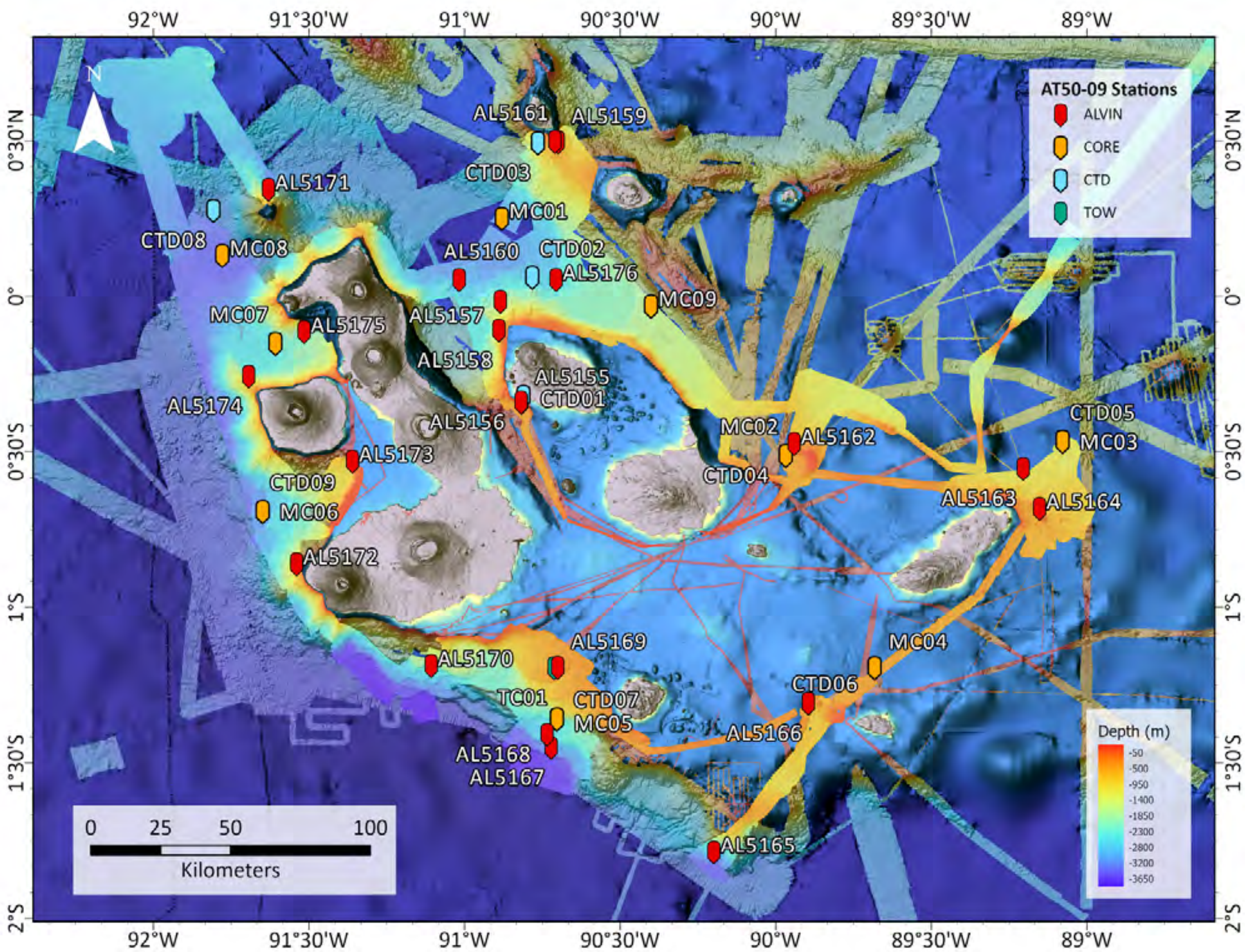


Figure 4. Alvin dives and locations of CTD, MC-400 multicoring and TowCam lowerings during AT50-09.

Bathymetric mapping was a major component of the activities of the expedition as accurate maps were essential in dive planning and dive site selection (please see site maps with each dive summary). The multibeam data collection, quality control, data processing, and ping editing were undertaken by many members of the science team as part of regular watch-standing shifts and led by Shannon Hoy from NOAA-Ocean Exploration, who led the production of final map products and the compiled dive maps shown below in Section 6. Both QPS Qimera and Fledermaus were used for multibeam processing, editing, and visualization. ArcGIS and Fledermaus were used for compiling map data and planning dive traverses. Areas mapped included the following totals:

Costa Rica EEZ (during transit) = 5019 km^2;

Ecuadorian EEZ = 19,055 km^2;

Area mapped inside the Galapagos National Park = 16,796 km^2.

Total seafloor mapped = 24,074 km^2 (approximately the size of Rwanda or New Hampshire).

Video surveys using the array of cameras on *Alvin* were an important component of expedition aims. The imagery data (both video and photos) will aide in benthic community analysis, vulnerable marine ecosystem (VME) identification, and species discovery. In total, ~60 TB of imagery data were collected during *Alvin* dives and station work that included the WHOI-MISO imaging systems (www.whoi.edu/miso) (i.e., MC-400 multicoring and TowCam traverse). Other imagery outputs included pictures of all biological samples (some in aquaria to aide *in situ* visualisation) and photographs of lava and other rock, sediment and fossil coral samples.

In most cases *Alvin* dives were planned to satisfy sampling and observational goals of the combined paleoceanography, geology and biological objectives at numerous locations around the Platform. However, because of the broad range of depths (~500-3500 m) associated with the geology objectives, and the more limited depth range of the paleoceanographic/fossil coral goals (~300-1500 m), some of the dives prioritized discipline specific sampling, but also carried out opportunistic sampling where possible. Table 2 provides a summary of the station information and dive summaries, keyed to locations provided in Figure 4 and more detailed maps and sample summaries for each dive that follow in Section 6.

Table 2. AT50-09 station log.

Station Number & Date (UTC)	Station Type	Station ID	Start Lat. Dec. Deg.	Start Long. Dec. Deg.	End Lat. Dec. Deg.	End Long. Dec. Deg.	Seafloor Depth (m)	Start Depth (m)	End Depth (m)	Bottom Time	Observer Port	Observer Stbd.	Region	Dive Summary
1 3/29/23	ALVIN	AL5155	-0.379993	-90.817084	-0.380148	-90.816985	N/A	530	394	19m	Schwartz	Taylor	Central Platform	Small seamount (H1443) constructed of steep stacks of pillow basalts, with sparse animal life including live solitary coral and rare Antipatharia. Some orange roughy were observed. Short dive due to technical issues. Samples included four rocks, some with biology attached, a live whip coral, and a Niskin water sample.
2 3/29/23	CTD	CTD01	-0.360498	-90.810840	-0.360498	-90.810840	652	638	2	N/A	N/A	N/A	Central Platform	N/A
3 3/29/23	ALVIN	AL5156	-0.378230	-90.818359	-0.378107	-90.817578	N/A	495	464	2h30m	Schwartz	Taylor	Central Platform	The same small seamount as AL5155. Slope of heavily pillowed basalt in fragments and coral debris, coming up to dissected mound of pillows at the crater rim. Top of rim has abundant biology of soft and hard corals, crustaceans and fish.
4 3/30/23	ALVIN	AL5157	-0.054659	-90.884841	-0.063017	-90.881445	N/A	1421	1113	5h7m	Geist	Liu	Central Platform	Elongate seamount - a satellite vent of the Santiago volcano. Sandy sediment on east-facing slope. Pillows out to the south, with soft corals and tiny Stylastridae corals growing on rocks. North-facing slope base of a terrace consiting of pillow-on-pillow outcrop.
5 3/30/23	CTD	CTD02	0.022521	-90.782370	0.022521	-90.782370	2010	2002	5	N/A	N/A	N/A	Central Platform	N/A
6 3/31/23	ALVIN	AL5158	-0.147826	-90.889604	-0.146093	-90.885078	N/A	892	505	6h5m	Taylor	Andrys	Central Platform	Breccia outcrops forming ridges. Amphitheater structure, at the base of the wall was a shear cliff leading to a fossil coral graveyard, also abundance of fish including orange roughies and large jellynose fish.
7 4/1/23	ALVIN	AL5159	0.458179	-90.699037	0.459997	-90.709007	N/A	762	618	5h35m	Schwartz	Kershaw	Pinta Rift	Traversed over two ridges in deeper water leading up to the start of the D03-MV1007 dredge track. The deeper eastern ridge appeared to be a pillow construction. The larger western ridge was composed of steep stacks of pillows, sheet flow lava surfaces and potentially breccia. Fields of fossil colonial coral debris. Lots of Madrepora corals were observed, rare Chrysogorgiidae too. Strong currents on the eastfacing slopes
8 4/1/23	CTD	CTD03	0.455126	-90.764328	0.455126	-90.764328	1258	1237	4	N/A	N/A	N/A	Pinta Rift	N/A
9 4/2/23	ALVIN	AL5160	0.014655	-91.017227	0.001339	-91.017622	N/A	2664	2354	5h34m	Beardshear (PIT)	Hoy	Central Platform	PIT dive. Exploration of deep lava flows at the base of Santiago. Sandy sedimented fields leading up to large basalt ourcrops that are lightly covered in sediment. Biology relatively rare; it includes stlasterid fans, sponges, and tunicates hanging over drop offs. Observed and recovered pillow basalts from multiple terraces.
10 4/3/23	CORE	MC01	0.212140	-90.880208	0.212102	-90.880201	2946	2946	N/A	N/A	N/A	N/A	Pinta Rift	N/A
11 4/3/23	ALVIN	AL5161	0.459837	-90.709448	0.461786	-90.712173	N/A	594	509	4h51m	Mitchell	Ferreira	Pinta Rift	Dredge track (D03-MV1007), high live (Madrepora thickets and Desmophyllum) and fossil coral cover (dive lands on field of colonial and Desmophyllum fossils). Hills of fossils in some areas. Lava flows appear old, with blocky and angular features
12 4/4/23	ALVIN	AL5162	-0.512133	-89.940707	-0.505244	-89.938612	N/A	599	461	6h1m	Taylor	Banks	Eastern Platform	Dive commences in sedimented area. There are large areas of colonial fossil debris, some rare patches of fossil Desmophyllum. Above a basalt pillow wall was a thick reef structure - 50-60% live Madrepora coral cover. Many animals. Sandy area towards end of the dive and one large basalt outcrop that was sampled.
13 4/4/23	CORE	MC02	-0.550196	-89.967894	-0.550196	-89.967894	718	715	N/A	N/A	N/A	N/A	Eastern Platform	N/A
14 4/5/23	CTD	CTD04	-0.550015	-89.967931	-0.550015	-89.967931	718	706	3	N/A	N/A	N/A	Eastern Platform	N/A
15 4/5/23	ALVIN	AL5163	-0.592309	-89.204849	-0.607410	-89.202514	N/A	1159	1064	5h28m	Schwartz	Vizcaino	Eastern Platform	Stack of pillow terraces off of the northern flank of San Cristobal. The interior of what is interpreted to be a collapsed sheet flow top was observed tilting into the center of the pillow mound at the summit of the targeted stack of terraces. Observed bamboo coral, and abundant giant sponges.
16 4/5/23	CTD	CTD05	-0.505092	-89.078466	-0.505091	-89.078457	1233	1219	3	N/A	N/A	N/A	Eastern Platform	N/A
17 4/6/23	ALVIN	AL5164	-0.720911	-89.152145	-0.713956	-89.144409	N/A	557	213	5h18m	Andrys	Buglass	Eastern Platform	Seamount off the eastern flank of San Cristobal. Observed and recovered pillow basalts at the start of the dive near the base of the seamount. Coral was abundant at the start of dive, with some new species seen - Goniocorella for example - but disappeared to just stylasterids in the oxygen minimum zone. Brittlestars and seastars dominated this shallow area of the seamount.
18 4/6/23	CORE	MC03	-0.505439	-89.078135	-0.505439	-89.078135	1228	1228	N/A	N/A	N/A	N/A	Eastern Platform	N/A
19 4/7/23	ALVIN	AL5165	-1.825237	-90.198802	-1.807664	-90.207201	N/A	3186	2852	5h19m	Holt (PIT)	Geist	Southern Platform	Base of Whittmer Seamount, between Floreana and Espanola. Observed vertical exposures of horizontally bedded sediments offset by near vertical faults. Biology is relatively rare. Some seapens in the sediments, sail-bearing sea cucumbers (purple), some urchins.
20 4/7/23	CORE	MC04	-1.232654	-89.682150	-1.232654	-89.682150	604	604	N/A	N/A	N/A	N/A	Southern Platform	N/A
21 4/8/23	CTD	CTD06	-1.232747	-89.682490	-0.123275	-89.682491	602	596	2	N/A	N/A	N/A	Southern Platform	N/A
22 4/8/23	ALVIN	AL5166	-1.346964	-89.895231	-1.330745	-89.896942	N/A	655	433	5h57m	Gordon	Hoy	Southern Platform	Terrace-like plateau - biodiverse - fishes, corals, crustaceans. Victorgorgia present. Lots of fossil corals, lots of megafauna (sharks). Evidence of human impact, dinner plates and wine bottle on seafloor. Lots of rock faults.

Table 2. AT50-09 station log (continued)

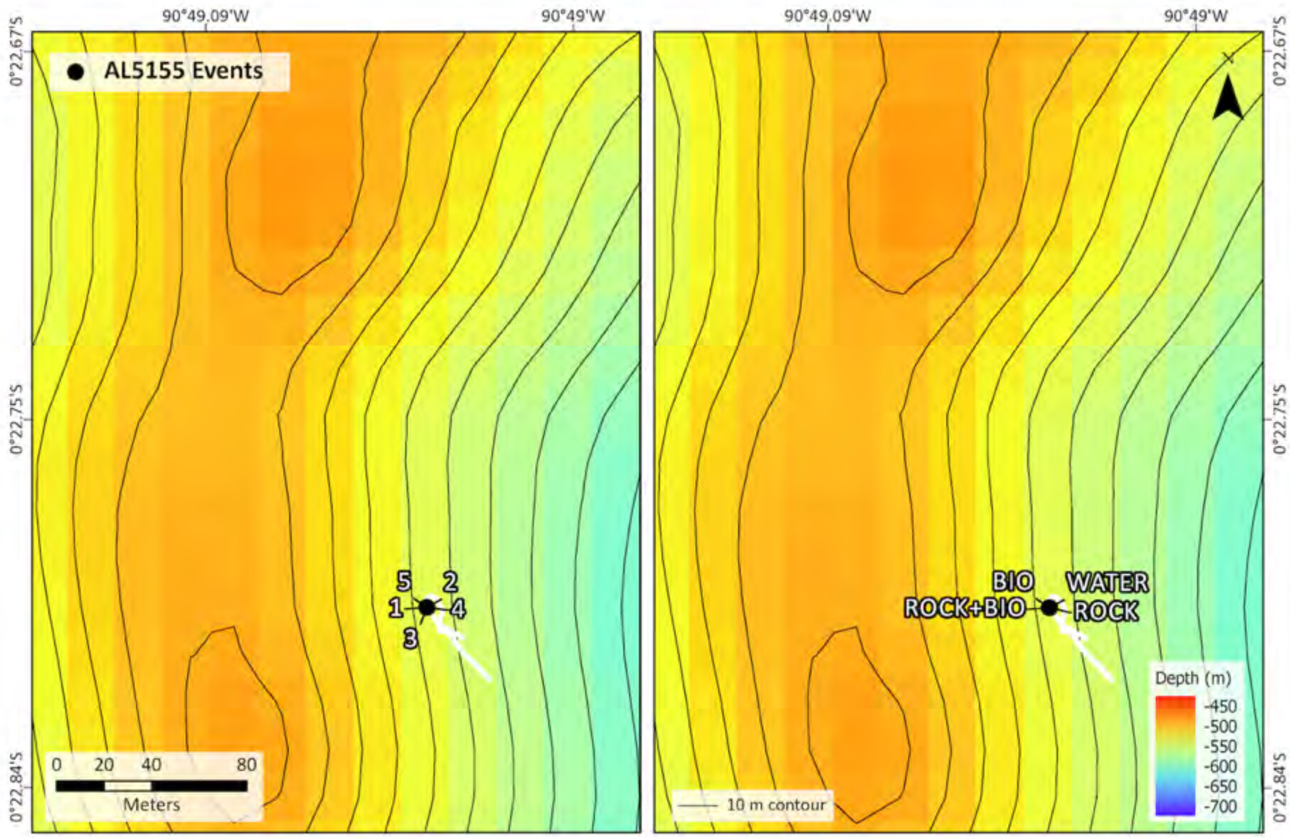
Station Number & Date (UTC)	Station Type	Station ID	Start_LatDec. Deg.	Start_Long Dec. Deg.	End_Lat Dec. Deg.	End_Long Dec. Deg.	Seafloor Depth (m)	Start Depth (m)	End Depth (m)	Bottom Time	Observer Port	Observer Stbd.	Region	Dive_summary
23 4/9/23	ALVIN	AL5167	-1.489385	-90.721812	-1.472973	-90.721297	N/A	3435	3000	5h25m	Schwartz	Shen	Southern Platform	Deep terrace at the base of Floreana. Deep sediment observed on the top and bottom of the terrace with steep exposures of intact and disected pillows within terrace escarpment. Recovered lavas with two distinct lithologies. Observed abundant purple sea cucumbers, sampled one. Sampled only observed bamboo coral.
24 4/9/23	CTD	CTD07	-1.397660	-90.703880	-1.397760	-90.703970		N/A	N/A	N/A	N/A	N/A	Southern Platform	N/A
25 4/10/23	ALVIN	AL5168	-1.447029	-90.734670	-1.434883	-90.735035	N/A	2981	2705	6h04m	Andrys	Wang	Southern Platform	This dive targed mid-depth terraces to the southwest of Floreana. Three terrace escarpments were constituted of pillow lavas, which were samples. Pillows are draped down the slopes. Terraces themselves arecoveredwith thick sediment. Bamboo corals were also encountered and sampled.
26 4/10/23	CORE	MC05	-1.397305	-90.702984	-1.397305	-90.702984	2402	2402	N/A	N/A				N/A
27 4/11/23	ALVIN	AL5169	-1.231383	-90.700507	-1.223757	-90.703591	N/A	730	545	5h48m	Kershaw	Crampton	Southern Platform	This dive was designed to explore a shallow escarpment that appears to have formed from lava flows associated with Volcan Sierra Negra. The lower escarpment is unexpectedly covered with sediment, but pillow lavas crop out in the upper part and were sampled. Live cup corals and stylasterids were encountered and sampled, as well as fossil corals in several localities.
28 4/11/23	TOWCAM	TC01	-1.232611	-90.712353	-1.234407	-90.722393	550	545						N/A
29 4/12/23	ALVIN	AL5170	-1.225614	-91.107190	-1.213376	-91.106021	N/A	2684	2282	5h52m	Geist	Beardshear (PIT)	Southern Platform	The contact relations among three mid-level terraces to the south of Sierra Negra were the main target of this dive. The lower part of it was covered with thick sediment. Pillows were encountered half way up the escarment, and the dive followed lava that formed a dip slope. Two specimens of live coral were sampeled.
30 4/13/23	ALVIN	AL5171	0.305632	-91.630146	0.305530	-91.629794	N/A	700	698	1h13m	Vizcaino	Suarez	NW Roca Redonda	Slope NW of Roca Redonda following 160deg direction (SE). We observed abundant living scleractinian and stylasterids corals, soft corals (Antipatharian and octocorals), sea stars, anemones, sponges, sea urchins, and fishes. Terrain was covered with black rubble and small rocks, with occasional large boulders (old pillow lavas?). We collected several living Desmophyllum, Madrepora and Stylasterid, one living octocoral and several dead Desmophyllum (sub-fossil). Also collected 2 rocks, and several pebble-sized rocks (Scooped with net).
31 4/13/23	CTD	CTD08	0.237594	-91.807160	0.237612	-91.805496	3145	3145	313	N/A				
32 4/14/23	ALVIN	AL5172	-0.898564	-91.539834	-0.891371	-91.534261	N/A	945	649	5h24m	Taylor	Wong	Western Platform	This dive traversed up the diffuse rift to the SW of Cerro Azul volcano, off of Punto Cristobal. The terrain forms a sharp ridge constructed of pillow lavas, which were sampled periodically throughout the dive. Both live coral and fossil Desmophyllum were obtained.
33 4/14/23	CTD	CTD09	-0.730370	-91.648860	-0.732698	-91.647662	2934	N/A	N/A	N/A				N/A
34 4/15/23	ALVIN	AL5173	-0.568308	-91.360395	-0.573100	-91.353565	N/A	784	378	6h6m	Ferreira	Sun	Western Platform	Dive traversed up an escarpment that bounds a sequence of terraces in the embayment between Volcans Fernandina and Cerro Azul. Sharks, rays, octopus, large community of polychaeta, corals, sponges, and crabs were abundant. Live coral was sampled, and fossil scleractinia encountered and sampled.
35 4/15/23	CORE	MC06					2929	2929	N/A	N/A				N/A
36 4/16/23	CORE	MC07	-0.190104	-91.607962	-0.190104	-91.607962	2341	2341	N/A	N/A				N/A
37 4/16/23	ALVIN	AL5174	-0.295082	-91.693604	-0.301465	-91.683626	N/A	783	594	5h19m	Mitchell	Castro	Western Platform	The dive traverse was designed to observe and sample some of the youngest volcanic terrain in the Galápagos: the NW rift of Fernandina. As expected, the terrain is steep, with many mounds of pillows, and poorly sedimented. The area is not particularly rich in coral, but live and fossil (in growth positiion) Desmophyllum were sampled.
38 4/17/23	CORE	MC08	0.093288	-91.778648	0.093211	-91.778598	3226	3226	N/A	N/A				N/A
39 4/17/23	ALVIN	AL5175	-0.152195	-91.515521	-0.143567	-91.518344	N/A	1995	1780	5h19m	Fornari	Holt (PIT)	Western Platform	The dive took place in an extensive volcanic terrain between Volcans Ecuador and Fernandina. The contact relations between a pancake volcano, a conical vent, and a large deep-water lava were explored, and each feature sampled. Large bamboo corals were encountered on the flank of the pancake volcano.
40 4/18/23	CORE	MC09	-0.069758	-90.400777	-0.069758	-90.400777	1710	1710	N/A	N/A				N/A
41 4/18/23	ALVIN	AL5176	0.015073	-90.706170	-0.001055	-90.701123	N/A	2300	2082	5h17m	Andrys	Gordon	Central Platform	Mid-level terraces to the NW of Santiago volcano were observed and sampled. The terrace escarpments are covered by elongate pillows that form a dip-slope surface. The terraces themselves are thickly sedimented, although sheet flows crop out locally. Stylastrids and bamboo corals were observed and sampled.

6. Alvin Dive Summaries

Brief tabular summaries of samples collected on each *Alvin* dive are presented below along with maps of the re-navigated dive track plotted over the multibeam bathymetry Figures 5-26). Figure 4 shows the location of each dive with respect to the adjacent islands and its position on the Galápagos Platform.

AL5155-1556 Summary

Pilot: Nick O'Sadcia, Port Observer: Darin Schwartz, Starboard Observer: Michelle Taylor

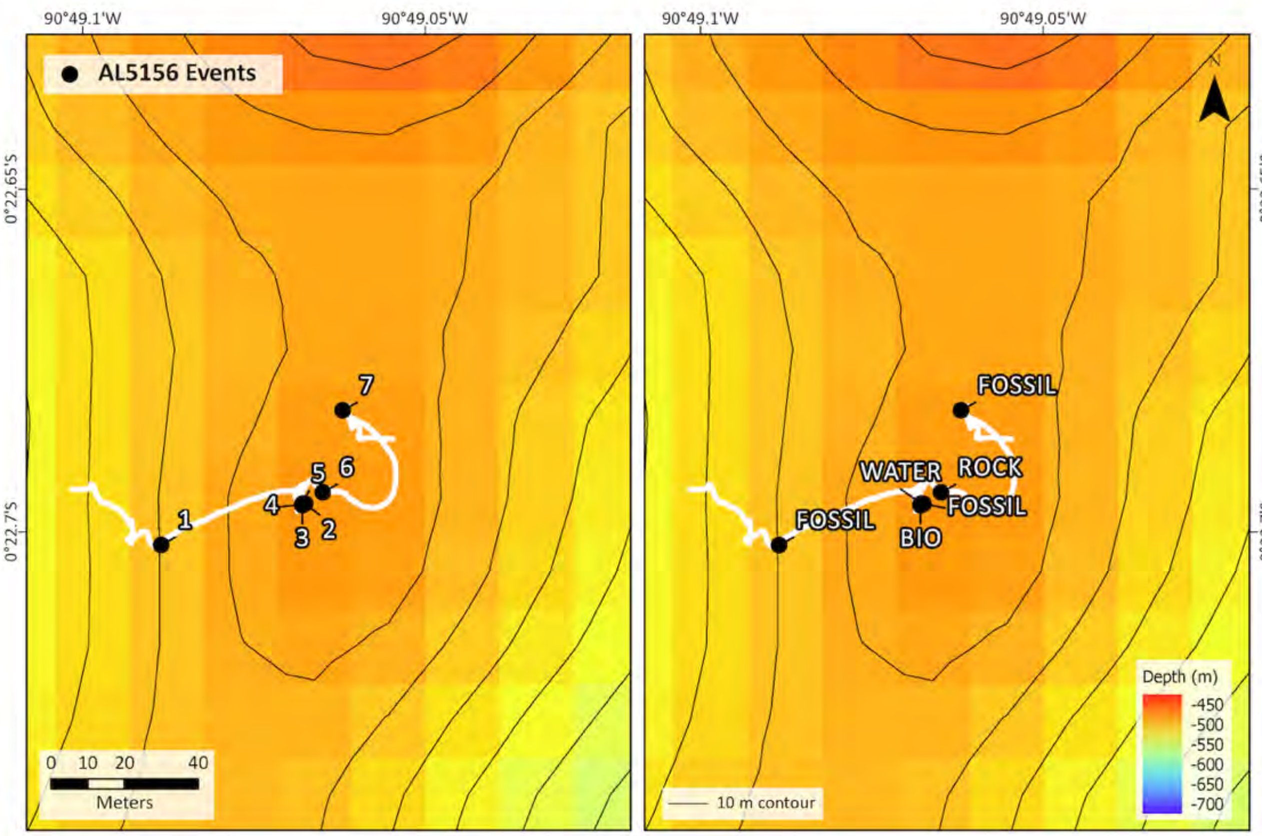


Cruise:	AT50-09	**Dive:**	AL5155
Date:	March 29, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 22.79' S, 90° 49.03' W	**End Location:**	0° 22.81' S, 90° 49.02' W
Start Depth:	531 m	**Start Depth:**	526 m
Observers:	Michelle Taylor Darin Schwartz	**Region:**	Central Platform

AL5155_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5155	29/03/2023	1	GBR	15:58	536	rock w/ 2m, white stylastrid	1		big red	N	MT	Y	Y
AL5155	29/03/2023	2	GBR	16:01	537	rock w/ stylastrid, white sponge ?	2		red	N	MT	Y	Y
AL5155	29/03/2023	3	NSK	16:02	538	by sparse coral		some water turbulence		Y	MT	N	N
AL5155	29/03/2023	4	SLP	16:14	539	2x sm brown/black rock		unsure of ID	fwd bio	N	MT	N	Y
AL5155	29/03/2023	5	GRB	16:17	540	whip orange black coral		Note: one fossil sample (shells) labled event 4 or 5	fwd bio	Y	MT	N	Y

Figure 5. AL5155 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.



Cruise:	AT50-09	**Dive:**	AL5156
Date:	March 29, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 22.63' S, 90° 49.10' W	**End Location:**	0° 22.69' S, 90° 49.05' W
Start Depth:	495 m	**Start Depth:**	463 m
Observers:	Michelle Taylor Darin Schwartz	**Region:**	Central Platform

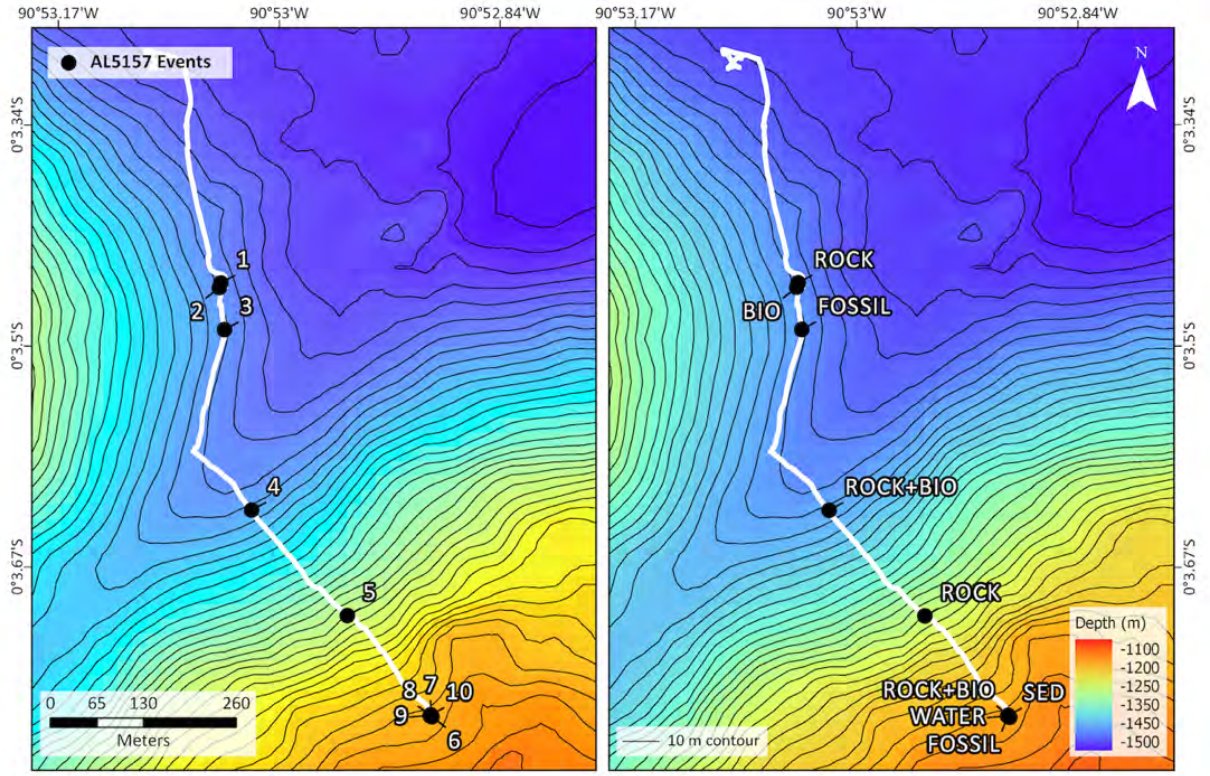
AL5156_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5156	29/03/2023	1	NET 1	22:07	494	Net 1 - branching fossil, possible live ??? in there		live primoic	quiver bio box	Y	MT	Y	Y
AL5156	29/03/2023	2	GRB	22:35	469	Fossil branching & madrepora			black split	Y	MT	Y	Y
AL5156	29/03/2023	3	GRB	22:58	469	Madrepora & solitary corals w/ fossil branching base w/ primnoid white fan			fwd bio	Y	MT	Y	Y
AL5156	29/03/2023	4	NET 3	23:00	469	Fossil solitary coral, yellow fan octo on old branching base			red bio	Y	MT	Y	Y
AL5156	29/03/2023	5	NSK	23:11	469					N	MT	N	N
AL5156	29/03/2023	6	GRB	23:24	466	Rock 3 - top of lobate basalt	3		red bio	Y	MT	N	Y
AL5156	29/03/2023	7	NET2	23:40	477	Net 2 - fossil desmo (in ope?), fossil colonial			blue bio	Y	MT	Y	Y

Figure 6. AL5156 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.

AL5157 Summary

Pilot: Rick Sanger, Port Observer: Dennis Geist, Starboard Observer: Qian Liu



Cruise:	AT50-09	**Dive:**	AL5157
Date:	March 30, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 3.28' S, 90° 53.09' W	**End Location:**	0° 3.78' S, 90° 52.89' W
Start Depth:	1420 m	**End Depth:**	1113 m
Observers:	Dennis Geist Qian Liu	**Region:**	Central Platform

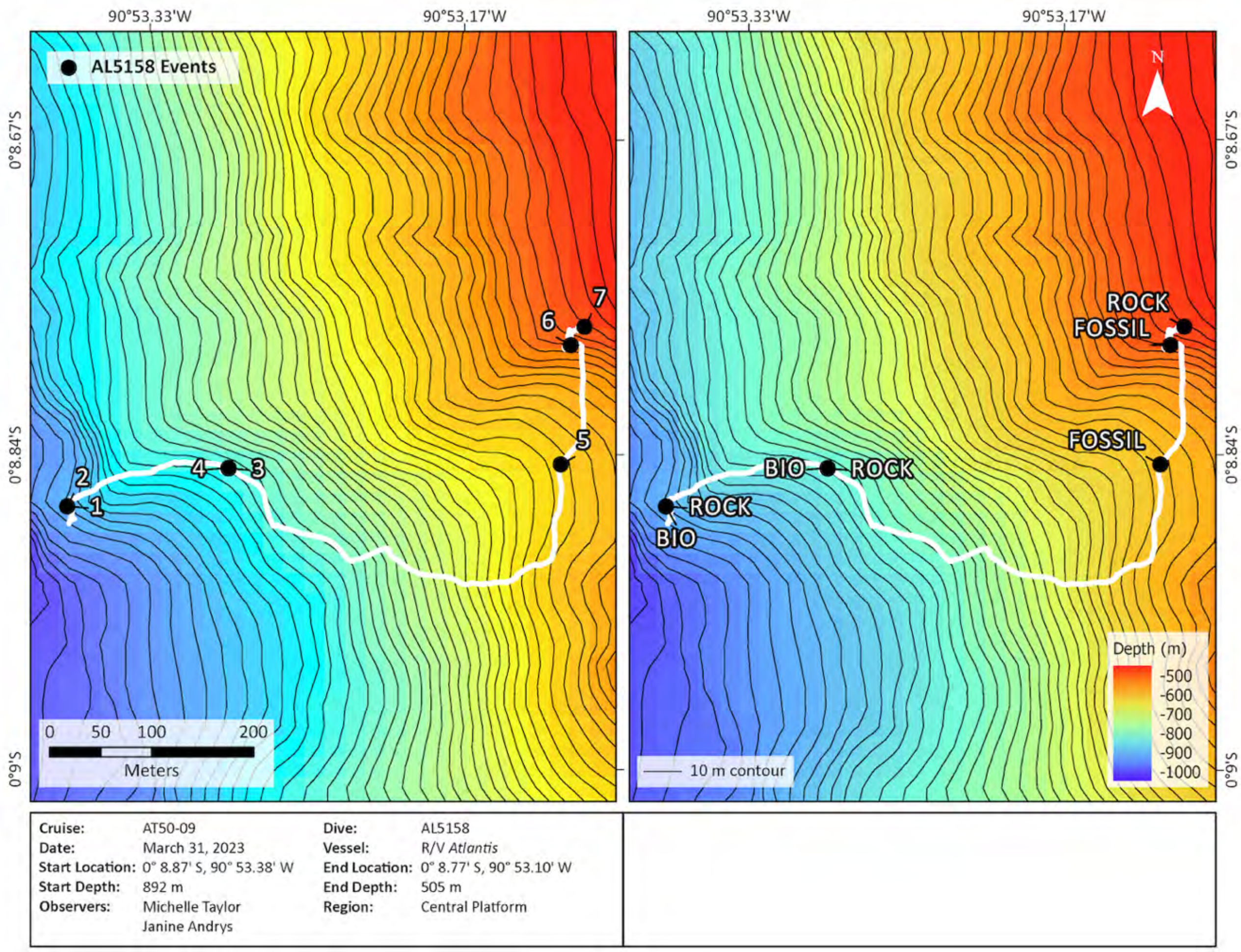
AL5157_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5157	30/03/2023	1	GRB	16:27	1427	rock	9		aft bio box	N	QL		Y
AL5157	30/03/2023	2	SLP	16:56	1427	sty, tiny, white (potontallin slp chamber)		fail to come out of slurp		N	QL		N
AL5157	30/03/2023	3	SLP	17:24	1422	dead coral		same as last one		N	QL	Y	N
AL5157	30/03/2023	4	GRB	18:15	1413	rock with 2 stys	10	small sty corals	fwd bio box	N	QL		Y
AL5157	30/03/2023	5	GRB	18:50	1271	rock	11		red blue box	N	QL		Y
AL5157	30/03/2023	6	GRB	19:33	1170	rock with red coral	12		yellow box	Y	QL		Y
AL5157	30/03/2023	7	GRB	19:44	1170	small rock with coral	13		red blue box	N	QL		Y
AL5157	30/03/2023	8	NET	19:44	1170	net with some corals			purple handle net	N	QL		N
AL5157	30/03/2023	9	NSK	19:51	1170	NSK water			green		QL		N
AL5157	30/03/2023	10	PSH	19:55	1170	1 psh core red handle					QL		N
AL5157	30/03/2023	10	PSH	19:59	1170	2 psh core green handle					QL		N
AL5157	30/03/2023	10	PSH	20:01	1170	3 psh core blue handle					QL		N

Figure 7. *AL5157 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5158 Dive Summary

Pilot: Bruce Strickrott, Port Observer: Michelle Taylor, Starboard Observer: Janine Andrys



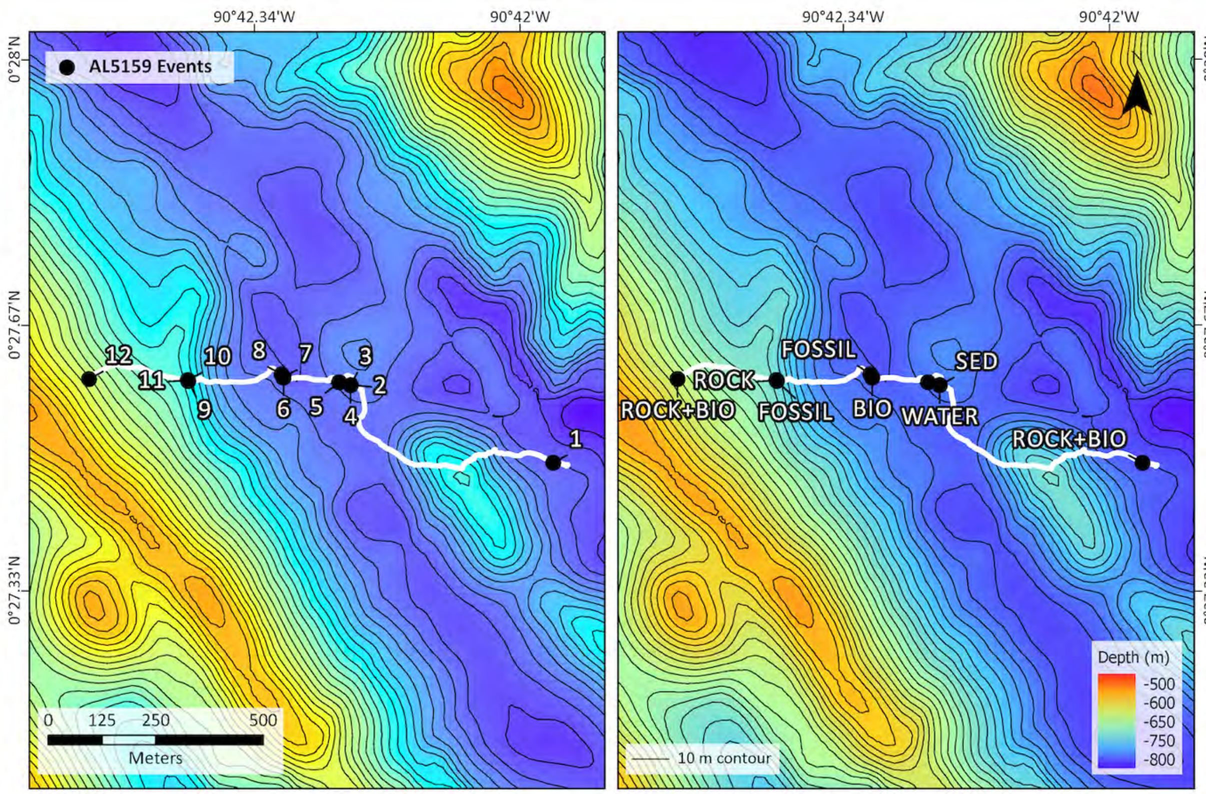
AL5158_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5158	31/03/2023	1	grab	16:20	883	R14-3 small fragments of one rock	14		yellow culver		Andrys		N
AL5158	31/03/2023	2	slurp	16:34	883	stylasterid white and large			yellow culver		Andrys		Y
AL5158	31/03/2023	3	grab	17:14	809	R15-basalt from lobeate structure	15		red handle milk crate		Andrys		N
AL5158	31/03/2023	4	slurp	17:21	809	madrepore, stylasterid, solitary coral, sponge, crinoid			red culver		Andrys		Y
AL5158	31/03/2023	5	net	18:47	622	Net. Lots of fossils and shells.			blue handle net into red handle milk crate.		Andrys	Y	N
AL5158	31/03/2023	6	net	19:48	555	Net. Lots of fossils of desmophyllum.		At base of cliff with catfish.	purple handle net into red handle milk crate		Andrys	Y	Y
AL5158	31/03/2023	7	grab	20:31	512	R16. Basalt from cliff top.	16	At cliff top WP3.	push core box.		Andrys		Y

Figure 8. *AL5158 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5159 Dive Summary

Pilot: Nick O'Sadcia, Port Observer: Darin Schwartz, Starboard Observer: James Kershaw



Cruise:	AT50-09	**Dive:**	AL5159
Date:	April 1, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 27.49' N, 90° 41.94' W	**End Location:**	0° 27.60' N, 90° 42.54' W
Start Depth:	762 m	**End Depth:**	618 m
Observers:	Darin Schwartz James Kershaw	**Region:**	Pinta Rift

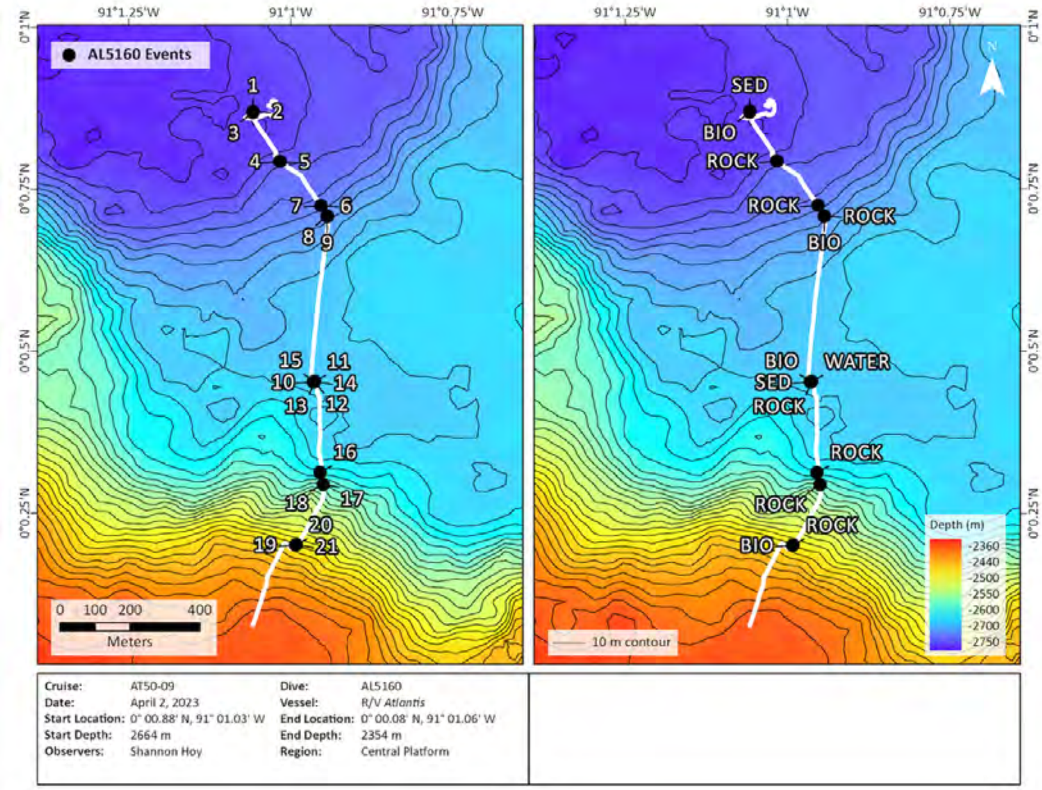
AL5159_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5159	01/04/2023	1	GRB	15:37	766	Rock with live stylestrid and cup corals.	19		Forward bio	N	JK/DS	N	Y
AL5159	01/04/2023	2	PSH	17:11	754	Deep sediment, coarse, with ripples. Lost hat			Blue push core	N	JK/DS	N	N
AL5159	01/04/2023	3	PSH	17:16	754	Second push core. Good recovery.			Red push core	N	JK/DS	N	N
AL5159	01/04/2023	4	NSK	17:17	754	Niskin fired. Observed it closing.			Niskin	N	JK/DS	N	N
AL5159	01/04/2023	5	GRB	17:36	753	Pillow mound in-situ. Rock, 4x live desmo, stylastric.	20	Rock with beautiful desmo	Aft Bio	N	JK/DS	N	Y
AL5159	01/04/2023	6	SLP	17:56	767	Multiple live desmo			Yellow quiver	N	JK/DS	N	Y
AL5159	01/04/2023	7	SLP	17:59	767	Live desmos plus stylastric			Yellow quiver	N	JK/DS	N	Y
AL5159	01/04/2023	8	NET	18:10	767	Fossils. Net of sed near live cup coral spot			Purple net handle	N	JK/DS	Y	N
AL5159	01/04/2023	9	NET	19:13	683	Fossils. Lots of bivalves but also dendrophyllia. Net of coral on slope in between pillow mounds.		Too many bivalves.	Blue net handle	N	JK/DS	Y	N
AL5159	01/04/2023	10	GRB	19:20	680	Rock. Small piece	21		Red quiver	N	JK/DS	N	N
AL5159	01/04/2023	11	GRB	19:21	680	Rock. Large piece.	22		White forward basket	N	JK/DS	N	N
AL5159	01/04/2023	12	GRB	20:20	624	Rock with live desmophyllum	23	Two pieces of rock	Blue and red basket	N	JK/DS	N	Y

Figure 9. *AL5159 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5160 Dive Summary

Pilot: Rick Sanger, Pilot-in-Training: Kaitlyn Beardshear, Starboard Observer: Shannon Hoy



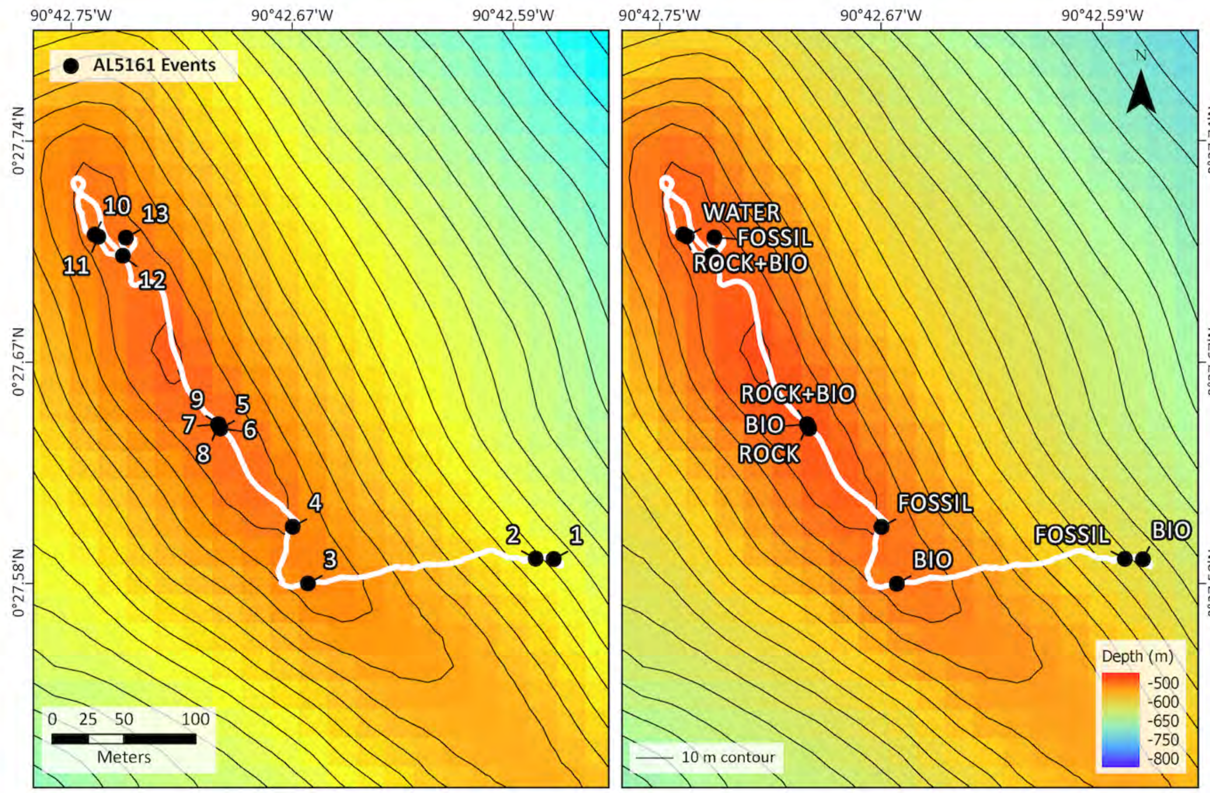
AL5160_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5160	02/04/23	1	PSH	16:49	2702	silty sediment			silver push	Y	SH	N	N
AL5160	02/04/23	2	PSH	16:52	2702	silty sediment			green push	Y	SH	N	N
AL5160	02/04/23	3	GRB	17:01	2702	sea urchin			aft bio	N	SH	N	Y
AL5160	02/04/23	4	GRB	17:35	2685	Rock-small	24		fwd bio	N	SH	N	N
AL5160	02/04/23	5	GRB	17:38	2685	Rock with small coral	25	from same place as R24	fwd bio	N	SH	N	Y
AL5160	02/04/23	6	GRB	18:10	2660	Rock (medium)	26		yellow basket	Y	SH	N	N
AL5160	02/04/23	7	GRB	18:11	2660	Rock (medium)	27	from same place as R26	port yellow	Y	SH	N	N
AL5160	02/04/23	8	GRB	18:23		Rock (large)	28		red basket	Y	SH	N	N
AL5160	02/04/23	9	SLP	18:29	2649	Sea cucumber		in hose	SLP	Y	SH	N	Y
AL5160	02/04/23	10	PSH	19:03	2628	about 12 inches of sediment			orange push	Y	SH	N	N
AL5160	02/04/23	11	PSH	19:07	2628	about 9 inches of sediment			Blue push		SH	N	N
AL5160	02/04/23	12	NSK	19:09	2628	Water sample.			Niskin		SH	N	N
AL5160	02/04/23	13	GRB	19:17	2628	White coral about 3 inches			fwd bio		SH	N	Y
AL5160	02/04/23	14	GRB	19:18	2628	Rock crumble	34		aft bio		SH	N	N
AL5160	02/04/23	15	GRB	19:20	2628	Rock (small)	29		stbd yellow		SH	N	N
AL5160	02/04/23	16	GRB	19:53	2599	Rock (talus?) large	30		purple basket		SH	N	N
AL5160	02/04/23	17	GRB	20:07	2573	Rock (small)	31		white basket		SH	N	N
AL5160	02/04/23	18	GRB	20:07	2573	Rock (medium)	32	same place as R31	white basket		SH	N	N
AL5160	02/04/23	19	GRB	20:47	2438	stalked sponge?			yellow quiver		SH	N	Y
AL5160	02/04/23	20	GRB	20:54	2439	Rock (medium)	33		red basket		SH	N	N
AL5160	02/04/23	21	GRB	20:56	2439	white sponge			aft bio		SH	N	Y

Figure 10. *AL5160 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5161 Dive Summary

Pilot: Bruce Strickott, Port Observer: Samuel Mitchell, Stb. Observer: Malu de Carvalho Ferreira



Cruise:	AT50-09	**Dive:**	AL5161
Date:	April 3, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 27.59' N, 90° 42.57' W	**End Location:**	0° 27.71' N, 90° 42.73' W
Start Depth:	598 m	**End Depth:**	508 m
Observers:	Samuel Mitchell Malu de Carvalho Ferreira	**Region:**	Pinta Rift

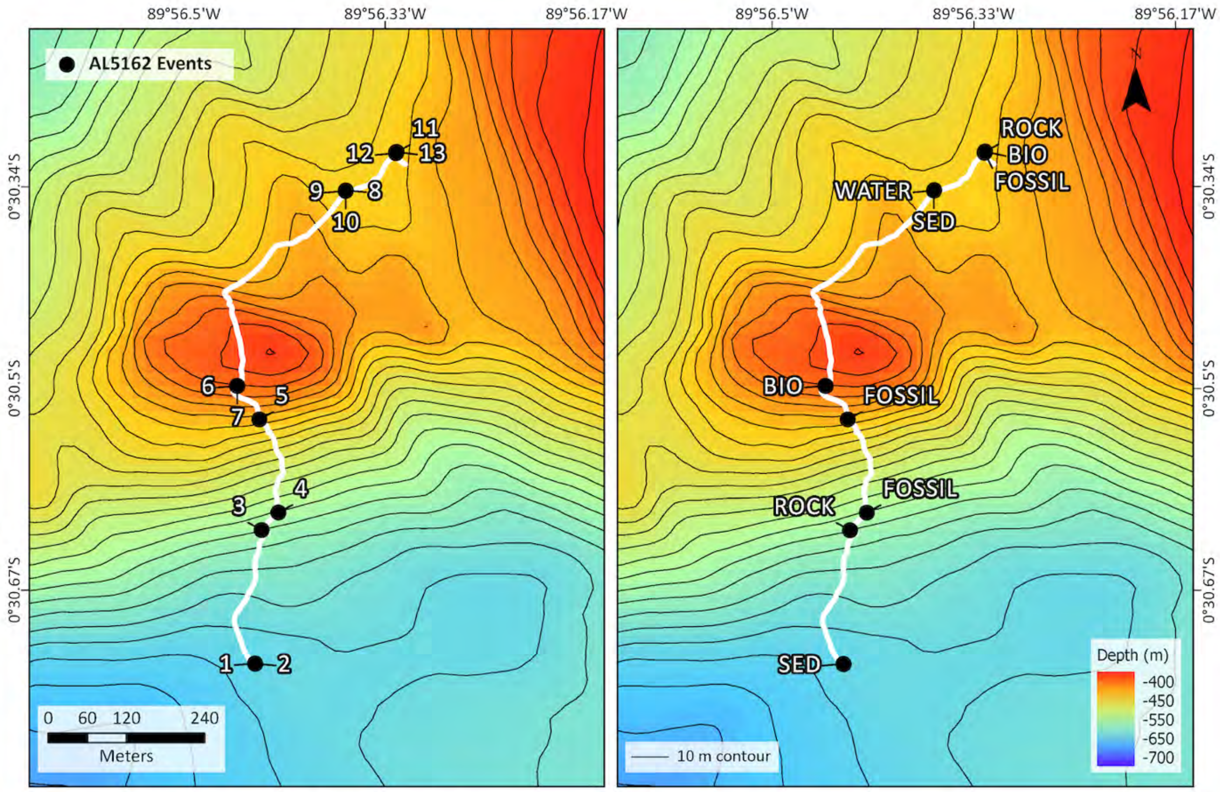
AL5161_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5161	03/04/2023	1	GRB	15:24	596	Live madrepora + many live desmophyllum + live large soft coral on a black coral(?) and attached desmophyllum	-		FWD BIO	Y	SM/MCF	N	Y
AL5161	03/04/2023	2	NET	15:52	592	Scoop of fossils, mostly madreporsa, some desmophyllum, and a rock	-	NET 3	RED BOX		SM/MCF	Y	Y
AL5161	03/04/2023	3	GRB	16:59	526	Live madrepora + many live desmophyllum + fossil desmophyllum - all attached, some material fell out of the quiver into same crate - fossil corals	-	FALLOUT IN WHITE BOX	YELL QUIV		SM/MCF	Y	Y
AL5161	03/04/2023	4	NET	17:14	521	Scoop of fossils, mostly madreporsa, some desmophyllum	-	NET 6	YELL BOX	Y	SM/MCF	Y	Y
AL5161	03/04/2023	5	SLP	17:50	510	Sampling of stylasterids and madrepors including a pink stylasterid - multiple, used the space to preserve	-	USED SPACER	RED QUIV	Y	SM/MCF	N	Y
AL5161	03/04/2023	6	GRB	17:54	511	Black angular rock, not broken in situ (but from top of ridge, so "in place")	R035		PURP BOX		SM/MCF	N	Y
AL5161	03/04/2023	7	SLP	18:14	511	Sampling of larger stylasterid and live madrepora using slurp	-		WHITE QUIV	Y	SM/MCF	N	Y
AL5161	03/04/2023	8	GRB	18:20	510	Small black angular rock, or discernable surface feature + large madrepora attached	R036		PURP BOX		SM/MCF	N	Y
AL5161	03/04/2023	9	GRB	18:21	510	Larger black angular rock with bivalves attached	R037		PURP BOX		SM/MCF	N	Y
AL5161	03/04/2023	10	GRB	19:03	517	Two adjacent rocks - very similar with attached biology and fossil desmophyllum corals	R038		AFT BIO		SM/MCF	Y	Y
AL5161	03/04/2023	11	NSK	19:13	516	Firing of the niskin bottle - successful	-		NISKIN		SM/MCF	N	N
AL5161	03/04/2023	12	NET	19:17	516	Large net of fossil corals, mostly madreporda + some large desmophyllum + large living pink stylasterid with desmophyllum	-	NET 5	WHITE BOX	Y	SM/MCF	Y	Y
AL5161	03/04/2023	13	NET	19:29	517	Smaller fossil coral net for demoshyllum - ran out of power	-	NET 4	BLUE BOX	Y	SM/MCF	Y	N

Figure 11. *AL5161 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5162 Dive Summary

Pilot: Nick O'Sadcia, Port Observer: Michelle Taylor, Starboard Observer: Stuart Banks



Cruise:	AT50-09	**Dive:**	AL5162
Date:	April 4, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 30.73' S, 89° 56.44' W	**End Location:**	0° 30.31' S, 89° 56.31' W
Start Depth:	599 m	**End Depth:**	461 m
Observers:	Michelle Taylor Stuart Banks	**Region:**	Eastern Platform

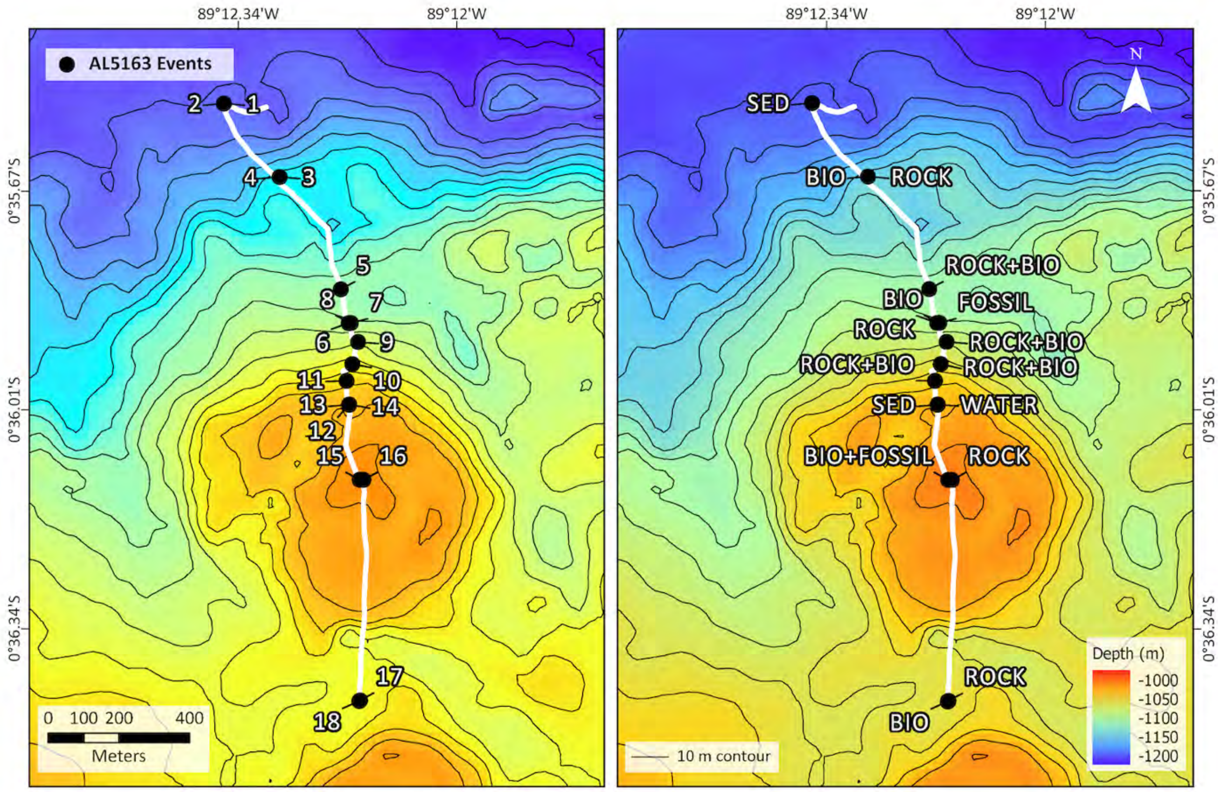
AL5162_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5162	04/04/2023	1	PSH	15:19	600.4	Red handle - 1/2 full soft sediment			red	N	MT	N	N
AL5162	04/04/2023	2	PSH	15:25	600.4	Green handle				N	MT	N	N
AL5162	04/04/2023	3	GRB	16:19	553	small rock	40	toddler's fist size	white crate	Y	MT		
AL5162	04/04/2023	4	NET	16:40	545	Blue handle - fossil colonials			red crate	Y	MT	Y	
AL5162	04/04/2023	5	SLP	17:17	456	fossil desmo		fragments	yellow quiver	Y	MT		
AL5162	04/04/2023	6	SLP	17:51	425	Madrepora and urchin			fwd bio box	Y	MT		Y
AL5162	04/04/2023	7	GRB	18:04	426	Fan primnoid, w gorganocemelas, w/ seastar and live + dead desmo		25 mins col	aft bio box	Y	MT	Y	Y
AL5162	04/04/2023	8	PSH	19:22	474	silver handle, sandy, soft sediment, carbonate rubble			silver handle	Y	MT	N	N
AL5162	04/04/2023	9	PSH	19:27	474	Blue handle -sandy, replicate			blue handle	Y	MT	N	N
AL5162	04/04/2023	10	NSK	19:27	474				niskin	N	MT	N	N
AL5162	04/04/2023	11	GRB	19:53	470	rock 41	41		purple crate	Y	MT		
AL5162	04/04/2023	12	SLP	20:01	470	Desmo fossil = 9, Javania = red x11=2, dendrophyllia, antipath w/o-stars			red quiver	Y	MT	Y	Y
AL5162	04/04/2023	13	GRB	20:29	470	Anemones x 2 on black coral			aft bio box	Y	MT		Y

Figure 12. *AL5162 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5163 Dive Summary

Pilot: Rick Sanger, Port Observer: Darin Schwartz, Starboard Observer: Ana Samperiz



Cruise:	AT50-09	**Dive:**	AL5163
Date:	April 5, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 35.54' S, 89° 12.29' W	**End Location:**	0° 36.44' S, 89° 12.15' W
Start Depth:	1159 m	**End Depth:**	1064 m
Observers:	Darin Schwartz Ana Samperiz Vizcaino	**Region:**	Eastern Platform

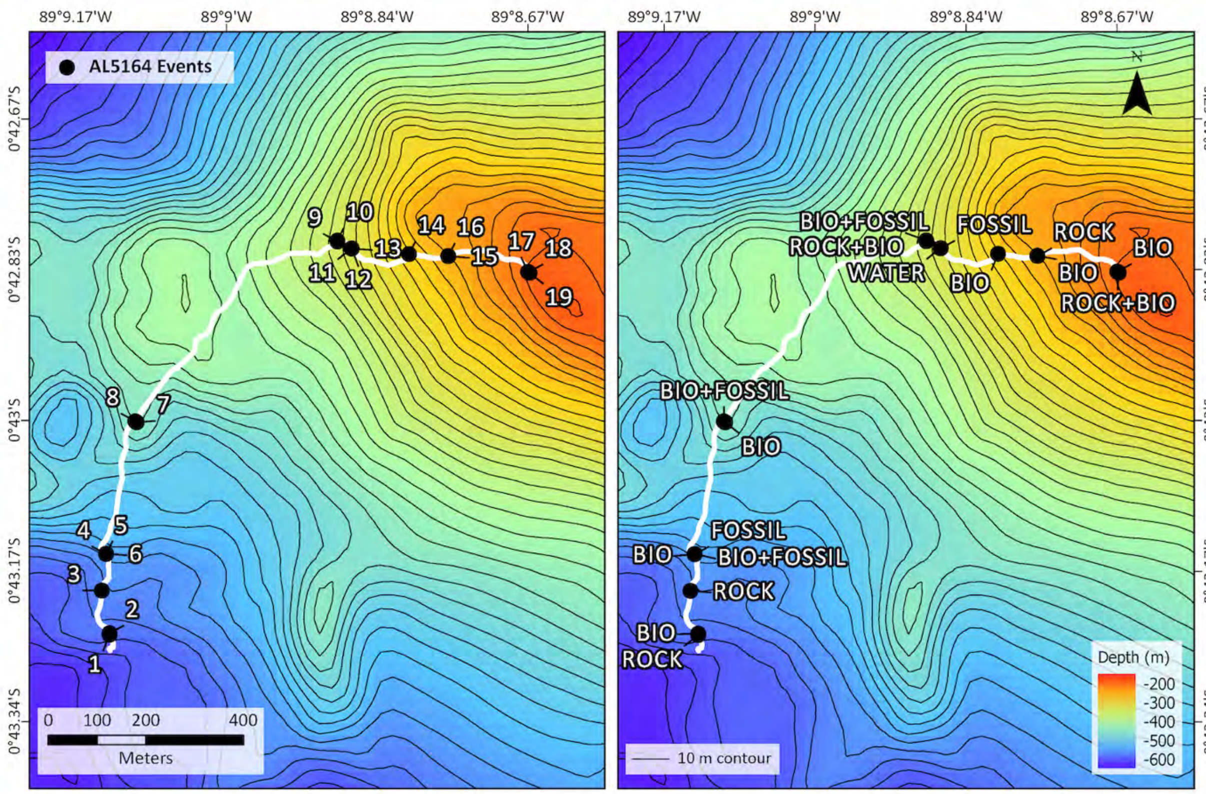
AL5163_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5163	5/4/23	1	PSH	15:16	1169	sediment core			silver	Y	AS		N
AL5163	5/4/23	2	PSH	15:17	1169	sediment core			green	Y	AS		N
AL5163	5/4/23	3	GRB	15:54	1128	2 rocks	42		fwd bio		AS		
AL5163	5/4/23	4	GRB	15:55	1128	soft coral			fwd bio		AS		Y
AL5163	5/4/23	5	GRB	16:42	1095	rock and stylasterid	43		aft bio		AS		Y
AL5163	5/4/23	6	GRB	17:03	1091	2 pieces of rock	44		yellow crate		AS		
AL5163	5/4/23	7	GRB	17:16	1095	cordium fossil?			yellow crate	Y	AS		
AL5163	5/4/23	8	GRB	17:20	1093	soft corals?			yellow quiver	Y	AS		Y
AL5163	5/4/23	9	GRB	17:41	1069	rock and stylastend	45		red crate	N	AS		Y
AL5163	5/4/23	10	GRB	17:59	1050	rock and stylasterid	46		white crate	N	AS		Y
AL5163	5/4/23	11	GRB	18:30	1036	rock and bamboo/primnoid	47		pushcore crate		AS		Y
AL5163	5/4/23	12	PSH	18:40	1029	pushcore			red		AS		N
AL5163	5/4/23	13	PSH	18:44	1029	pushcore			blue		AS		N
AL5163	5/4/23	14	NSK	18:46	1029	niskin					AS		N
AL5163	5/4/23	15	SLP	19:13	1017	javania live and dead			red quiver		AS		Y
AL5163	5/4/23	16	GRB	19:24	1016	rock	48		red crate		AS		
AL5163	5/4/23	17	GRB	20:04	1066	rock	49		net crate		AS		
AL5163	5/4/23	18	GRB	20:17	1066	cucumber			white quiver		AS		Y

Figure 13. *AL5163 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5164 Dive Summary

Pilot: Bruce Strickrott, Port Observer: Janine Andrys, Starboard Observer: Salome Buglass



Cruise:	AT50-09	**Dive:**	AL5164
Date:	April 6, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 43.25' S, 89° 09.13' W	**End Location:**	0° 42.84' S, 89° 08.66' W
Start Depth:	557 m	**End Depth:**	213 m
Observers:	Janine Andrys Salome Buglass	**Region:**	Eastern Platform

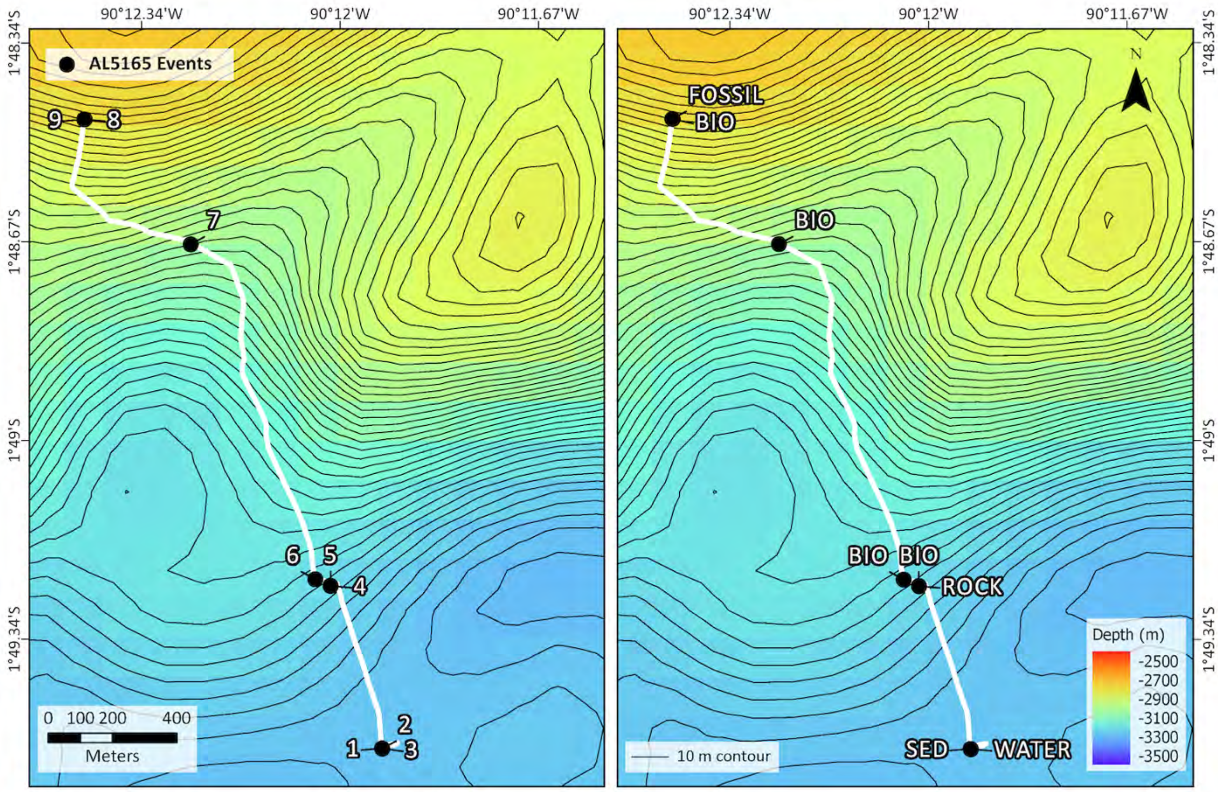
AL5164_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5164	06/04/23	1	GRB	15:00	548	pillow from pillow wall	R51		fwd bio	Y	JA	N	Y
AL5164	06/04/23	2	SLP	15:10	544	white stylastrid x3			red quiver	Y	JA	N	Y
AL5164	06/04/23	3	GRB	15:28	529	pillow from pillow wall	R52		aft bio	N	JA	N	Y
AL5164	06/04/23	4	SLP	16:00	506	fossil coral piece x2 and some solitary			white handle box		JA	Y	N
AL5164	06/04/23	5	SLP	16:00	506	live coral desmophylum			red quiver		JA	N	Y
AL5164	06/04/23	6	SLP	16:05	506	live madropora, fossil desmo			yellow quiver		JA	Y	Y
AL5164	06/04/23	7	GRB	16:33	429	dendrophylia alive			fwd bio	Y	JA	N	Y
AL5164	06/04/23	8	NET	16:43	425	fossil madropora with some live madropora			blue handle net		JA	Y	Y
AL5164	06/04/23	9	GRB	17:24	350	Rock talus with stylastrid and brittlestar	R53		purple handle crate		JA	N	Y
AL5164	06/04/23	10	GRB	17:34	350	Rock talus with stylastrid and brittlestar	R54		white handle box		JA	N	Y
AL5164	06/04/23	11	GRB	17:45	340	madropora alive and dead			aft bio		JA	Y	Y
AL5164	06/04/23	12	GRB	17:48	340	Fossil coral			red box on top of net		JA	Y	N
AL5164	06/04/23	13	NSK	17:50	340	Niskin			niskin	N	JA	N	N
AL5164	06/04/23	14	GRB	18:13	298	different species of dendrophylia alive			yellow handle crate		JA	N	Y
AL5164	06/04/23	15	GRB	18:23	277	Crust from rock. Can't tell what, but maybe evacuated pillow.	R55		black hande crate		JA	N	Y
AL5164	06/04/23	16	SLP	18:25	277	pink stylastrics			yellow quiver		JA	N	Y
AL5164	06/04/23	17	SLP	18:59	213	duo corals			white quiver and white handle basket		JA	N	Y
AL5164	06/04/23	18	GRB	19:14	213	Large rock from cliff top with coral on it	R56		black hande crate		JA	N	Y
AL5164	06/04/23	19	SLP	19:23	213	white goniocorella			white quiver		JA	N	Y

Figure 14. *AL5164 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5165 Dive Summary

Pilot: Nick O'Sadcia, Pilot-in-Training: Randy Holt, Starboard Observer: Dennis Geist



Cruise:	AT50-09	**Dive:**	AL5165
Date:	April 7, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	1° 49.51' S, 90° 11.93' W	**End Location:**	1° 48.46' S, 90° 12.43' W
Start Depth:	3186 m	**End Depth:**	2852 m
Observers:	Dennis Geist	**Region:**	Eastern Platform

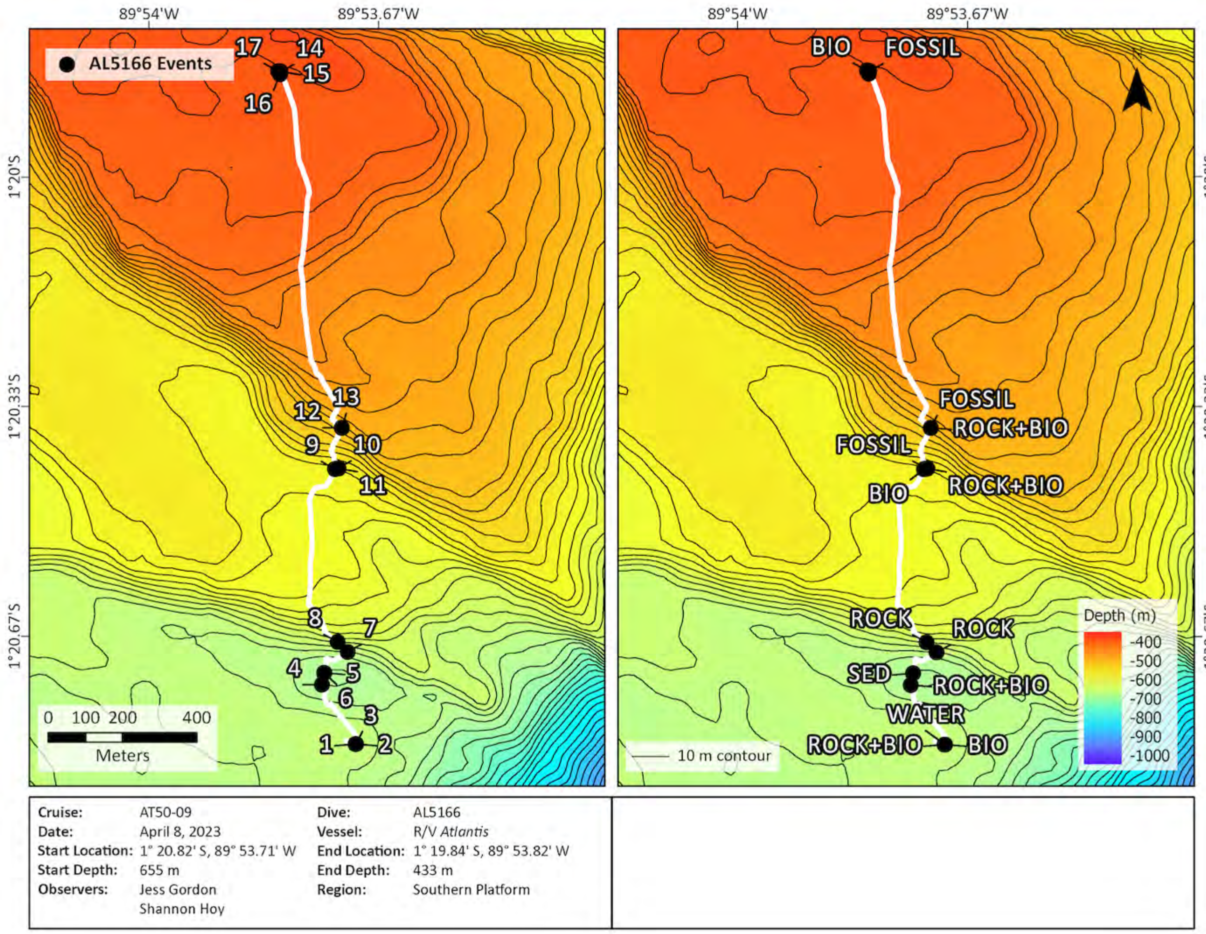
AL5165_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5165	07/04/2023	1	PSH	16:35	3218	Sed			Silver	N	DG	N	N
AL5165	07/04/2023	2	PSH	16:44	3218	Sed			Green	N	DG	N	N
AL5165	07/04/2023	3	NSK	16:46	3218	Water				N	DG	N	N
AL5165	07/04/2023	4	GRB	17:50	3189	R57 - claystone	57		Quiver crate white	Y	DG		
AL5165	07/04/2023	5	SLP	18:01	3189	Bio- crinoid or brittle star			Yellow tube	Y	DG		Y
AL5165	07/04/2023	6	GRB	18:36	3170	Bio - coral?		growing on old cement	front bio	Y	DG		Y
AL5165	07/04/2023	7	GRB	20:06	3024	Bio - whipcoral & crinoid			red	Y	DG		Y
AL5165	07/04/2023	8	GRB	20:54	2867	Bio - cucumber		Green	fore bio	Y	DG		Y
AL5165	07/04/2023	9	NET	21:05	1866	Bio - fossil coral?		Blue Net	red	Y	DG		Y

Figure 15. *AL5165 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5166 Dive Summary

Pilot: Rick Sanger, Port Observer: Shannon Hoy, Starboard Observer: Jessica Gordon



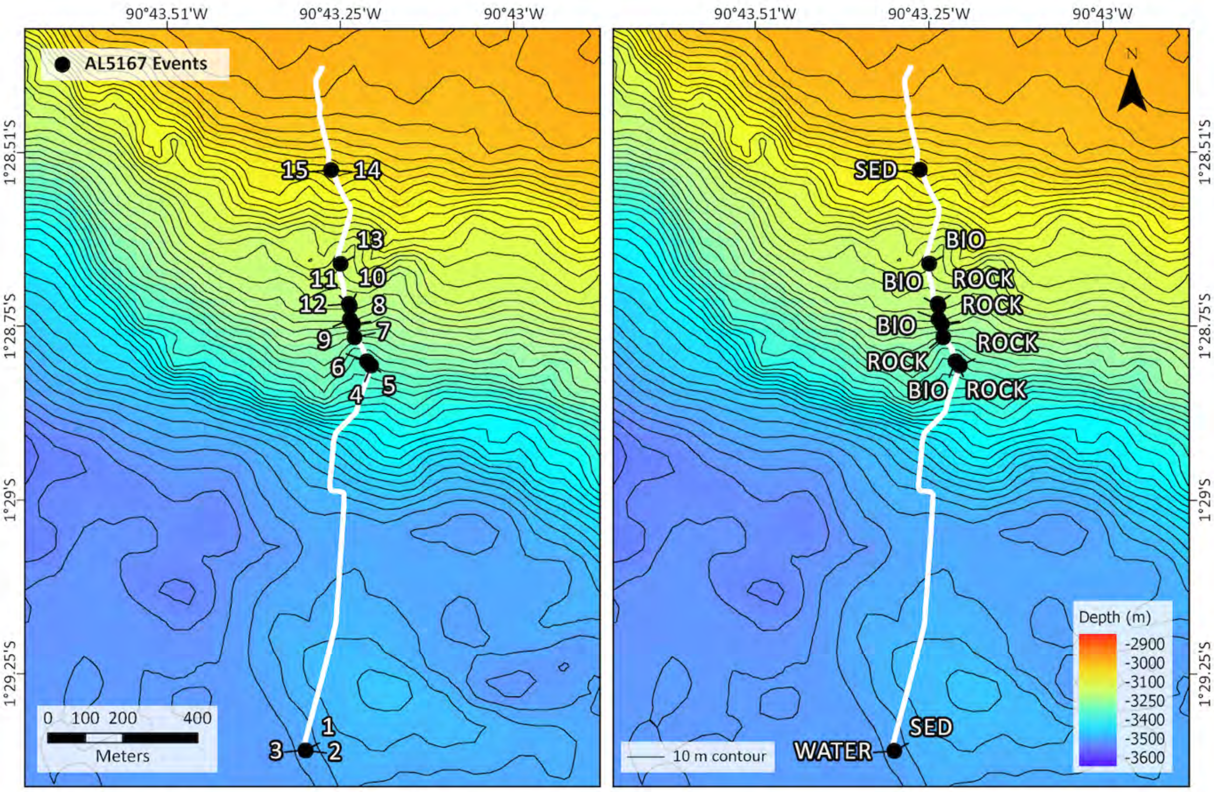
AL5166_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5166	8/4/2023	1	GRB	14:48	665	Rock with Madrepora broken off	58		AFT BIO	Y	JG		Y
AL5166	8/4/2023	2	SLP	14:57	665	2 live desmo (one in FWD bio, one in AFT bio)			FWD and AFT BIO	Y	JG		Y
AL5166	8/4/2023	3	NSK	15:00	665	Niskin		near Madrepora		Y	JG		
AL5166	8/4/2023	4	GRB	15:33	697	2 rocks + stylasterid	59 and 60	two stylasterids	FWD BIO	Y	JG		Y
AL5166	8/4/2023	5	PSH	15:43	696	1/3 full push core		difficult	Silver Push Core	Y	JG		
AL5166	8/4/2023	6	PSH	15:45	696	1/3 full push core		difficult	Green Push Core	Y	JG		
AL5166	8/4/2023	7	GRB	16:00	685	small rock	61		STBD Yellow	Y	JG		
AL5166	8/4/2023	8	GRB	16:15	662	two small rocks	62 and 63		Port Yellow	Y	JG		
AL5166	8/4/2023	9	GRB	17:13	587	Purple octocoral			FWD Bio	Y	JG		Y
AL5166	8/4/2023	10	NET	17:38	584	Fossil coral rubble (blue handle)		should have desmo	White Crate	Y	JG	Y	
AL5166	8/4/2023	11	GRB	17:42	584	Rock with stylastend and cup coral	64		Red Crate	Y	JG		Y
AL5166	8/4/2023	12	NET	18:20	532	Fossil coral rubble (green/yellow handle)			Red Crate	Y	JG	Y	
AL5166	8/4/2023	13	GRB	18:21	532	Rock with stylasterid and 2 solitary	65		Purple Crate	Y	JG		Y
AL5166	8/4/2023	14	NET	19:46	437	Fossil coral rubble (purple handle)			Blue Crate	Y	JG	Y	
AL5166	8/4/2023	15	SLP	19:52	437	Fossil coral desmos		multiple	Yellow Quiver	Y	JG	Y	
AL5166	8/4/2023	16	SLP	20:03	437	Live and fossil desmo			Yellow Quiver	Y	JG	Y	Y
AL5166	8/4/2023	17	GRB	20:21	437	Dendrophyllia		broken	Red Crate	Y	JG		Y

Figure 16. *AL5166 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5167 Dive Summary

Pilot: Bruce Strickrott, Port Observer: Darin Schwartz, Starboard Observer: Yingchu Shen



Cruise:	AT50-09	**Dive:**	AL5167
Date:	April 9, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	1° 29.36' S, 90° 43.31' W	**End Location:**	1° 28.38' S, 90° 43.28' W
Start Depth:	3435 m	**End Depth:**	3000 m
Observers:	Darin Schwartz Yingchu Shen	**Region:**	Southern Platform

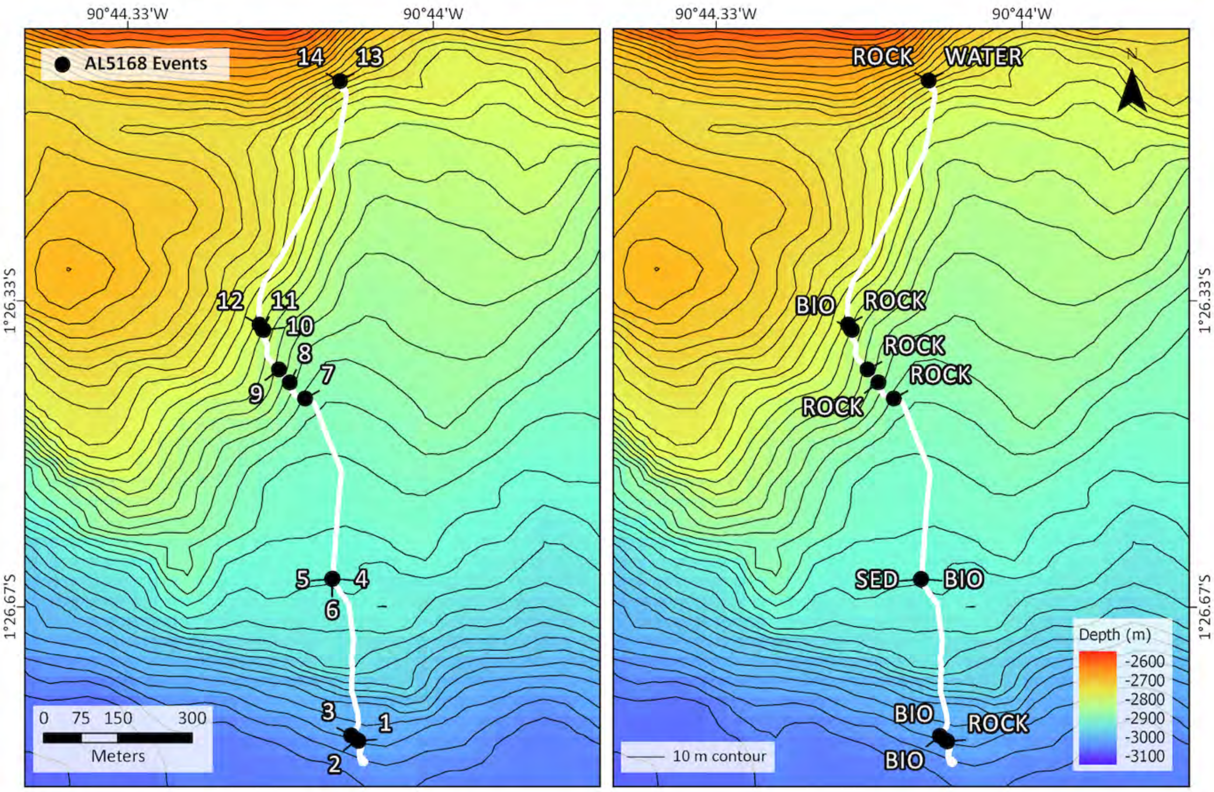
AL5167_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5167	09/04/2023	1	PSH	16:16	3440	Sed		collect replicate PSHs - notice white clayish patches exposured on seafloor. PSH sediments stratified with clear boundary between upper and lower - upper dark browish and lower grey greenish	Silver		YC/DS	N	N
AL5167	09/04/2023	2	PSH	16:15	3440	Sed		collect replicate PSHs - notice white clayish patches exposured on seafloor. PSH sediments stratified with clear boundary between upper and lower - upper dark browish and lower grey greenish	Green		YC/DS	N	N
AL5167	09/04/2023	3	NSK	16:17	3440	Water			NSK bottle		YC/DS	N	N
AL5167	09/04/2023	4	GRB	17:36	3318	R67 - pillow rock	67	small size	white		YC/DS	N	N
AL5167	09/04/2023	5	GRB	18:14	3309	R68 - rock	68		red		YC/DS	N	N
AL5167	09/04/2023	6	GRB	18:15	3307	Bio - soft coral		unidentified species, white and soft, branching, relative common over 3000m depths during the whole dive	AFT BIO		YC/DS	N	Y
AL5167	09/04/2023	7	GRB	18:29	3293	R69 - pillow crust	69		right black box		YC/DS	N	N
AL5167	09/04/2023	8	GRB	18:55	3254	R70 - pillow rock	70	large size	with another rock in red		YC/DS	N	N
AL5167	09/04/2023	9	GRB	19:15	3218	Bio - anemonia			AFT BIO		YC/DS	N	Y
AL5167	09/04/2023	10	GRB	19:47	3184	R71 - pillow rock	71	large size	with event 4 in white box		YC/DS	N	N
AL5167	09/04/2023	11	GRB	19:57	3168	Bio - bamboo coral		~1m size	FWD BIO		YC/DS	N	Y
AL5167	09/04/2023	12	GRB	20:11	3169	R72 - rock	72	small size	purple box		YC/DS	N	N
AL5167	09/04/2023	13	GRB	20:31	3108	Bio - cucumber		big in size, purple-ish, Psychropotes? Common species for cucumbers over 3000m during the whole dive (blue/purple)	FWD BIO		YC/DS	N	Y
AL5167	09/04/2023	14	PSH	20:56	3050	Sed		collect replicate PSHs; stratified, clear layer between upper and lower sediments	red		YC/DS	N	N
AL5167	09/04/2023	15	PSH	20:57	3050	Sed		collect replicate PSHs; stratified, clear layer between upper and lower sediments	blue		YC/DS	N	N

Figure 17. *AL5167 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5168 Dive Summary

Pilot: Nick Osadcia, Port Observer: Janine Andrys, Starboard Observer: Maoyu Wang



Cruise:	AT50-09	**Dive:**	AL5168
Date:	April 10, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	1° 26.82' S, 90° 44.08' W	**End Location:**	1° 26.09' S, 90° 44.10' W
Start Depth:	2981 m	**End Depth:**	2705 m
Observers:	Janine Andrys Maoyu Wang	**Region:**	Southern Platform

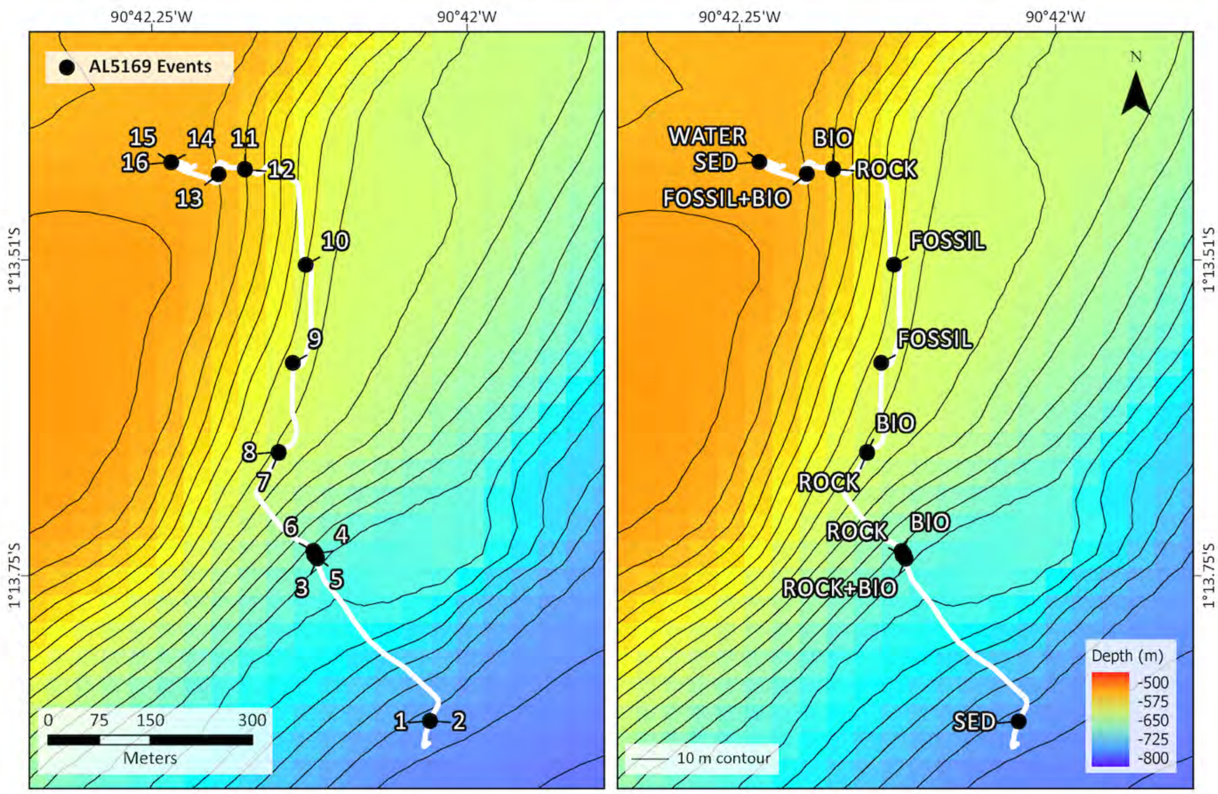
AL5168_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5168	10/4/2023	1	GRB	16:17	2990	Pillow from pillow wall	R073		Fwd Bio		JA	N	N
AL5168	10/4/2023	2	GRB	16:26	2990	Bamboo stick coral			Fwd Bio		JA	N	Y
AL5168	10/4/2023	3	GRB	16:39	2980	Bushy bamboo coral			Fwd Bio		JA	N	Y
AL5168	10/4/2023	4	GRB	17:41	2892	Sea urchin with long spikes and small body			Fwd Bio		JA	N	Y
AL5168	10/4/2023	5	PSH	17:47	2892	Green handle push core			Green handle		JA	N	N
AL5168	10/4/2023	6	PSH	17:47	2892	Silver handle push core			Silver handle		JA	N	N
AL5168	10/4/2023	7	GRB	18:20	2872	Pillow basalt	R074		white handle crate		JA	N	N
AL5168	10/4/2023	8	GRB	19:00	2843	Tiny fragment of pillow	R075		red quiver		JA	N	N
AL5168	10/4/2023	9	GRB	19:16	2827	fragment of pillow	R076		yellow quiver		JA	N	N
AL5168	10/4/2023	10	GRB	19:33	2805	Crinoid			Aft Bio		JA	N	Y
AL5168	10/4/2023	11	GRB	19:44	2805	White translucent sea cucumber			Fwd Bio		JA	N	Y
AL5168	10/4/2023	12	GRB	19:57	2797	fragment of pillow	R077		white quiver		JA	N	N
AL5168	10/4/2023	13	GRB	21:15	2740	Pillow basalt	R078		red crate		JA	N	N
AL5168	10/4/2023	14	NSK	21:15	2740	Niskin fired. Water sample collected.			Niskin		JA	N	N

Figure 18. *AL5168 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5169 Dive Summary

Pilot: Rick Sanger, Port Observer: James Kershaw, Starboard Observer: Lydia Crampton



Cruise:	AT50-09	**Dive:**	AL5169
Date:	April 11, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	1° 13.88' S, 90° 42.03' W	**End Location:**	1° 13.43' S, 90° 42.22' W
Start Depth:	729 m	**End Depth:**	544 m
Observers:	James Kershaw Lydia Crampton	**Region:**	Southern Platform

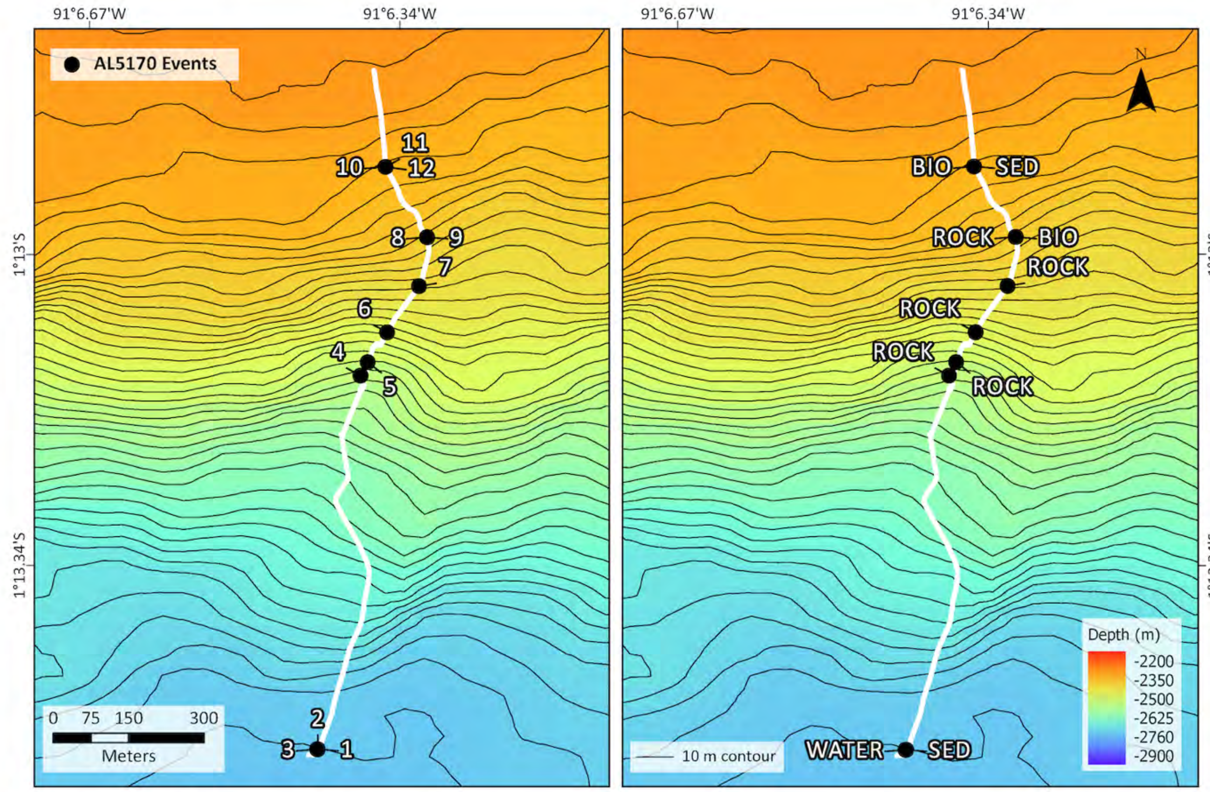
AL5169_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5169	11/04/2023	1	PSH	15:25	740			Good recovery	Green handle push core	N	JK	N	N
AL5169	11/04/2023	2	PSH	15:26	740			Good recovery	Silver handle push core	N	JK	N	N
AL5169	11/04/2023	3	GRB	16:11	679	Sheets of rock. Stylastend attached	79		Fwd bio	N	JK	N	Y
AL5169	11/04/2023	4	GRB	16:21	675	Stylasterid			Fwd bio	N	JK	N	Y
AL5169	11/04/2023	5	GRB	16:24	676	Rock, broken off outcrop	80		Purple crate	N	JK	N	N
AL5169	11/04/2023	6	GRB	16:33	673	Live and dead Madrepora			Aft bio	N	JK	Y	Y
AL5169	11/04/2023	7	GRB	17:15	617	Rock, rounded, loose but hard to remove. Pillow-like shape	81		Red crate	N	JK	N	N
AL5169	11/04/2023	8	GRB	17:20	619	Live Madrepora in several pieces			Red crate	N	JK	N	Y
AL5169	11/04/2023	9	NET	17:56	612	Fossil coral net (few)			Red handle net	N	JK	Y	N
AL5169	11/04/2023	10	NET	18:25:00	609	Fossil coral net (some desmo)		Some cup corals observed	Yellow handle net	N	JK	Y	N
AL5169	11/04/2023	11	SLP	18:56:17	563	Live desmo and stylasterid, multiple			Yellow quiver	N	JK	N	Y
AL5169	11/04/2023	12	GRB	19:00:17	563	Rock, insitu, underneath crust	82		Yellow crate	N	JK	N	N
AL5169	11/04/2023	13	NET	19:38	553	Fossil corals, madrepora and cup corals		LOVELY	Yellow and green handle net	N	JK	Y	N
AL5169	11/04/2023	14	NSK	20:19	550	Push cores @ top of slope accompanied by niskin		Definitely tripped	Niskin	N	JK	N	N
AL5169	11/04/2023	15	PSH	20:21	550	Sandy, good recovery		Good recovery	Red push core	N	JK	N	N
AL5169	11/04/2023	16	PSH	20:22	550	Sandy, good recovery		Good recovery	Blue push core	N	JK	N	N

Figure 19. *AL5169 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5170 Dive Summary

Pilot: Bruce Strickrott, Port Observer: Dennis Geist; Pilot-in-Training: Kaitlin Beardshear



Cruise:	AT50-09	**Dive:**	AL5170
Date:	April 12, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	1° 13.88' S, 90° 42.03' W	**End Location:**	1° 12.80' S, 91° 06.36' W
Start Depth:	2684 m	**End Depth:**	2282 m
Observers:	Dennis Geist	**Region:**	Southern Platform

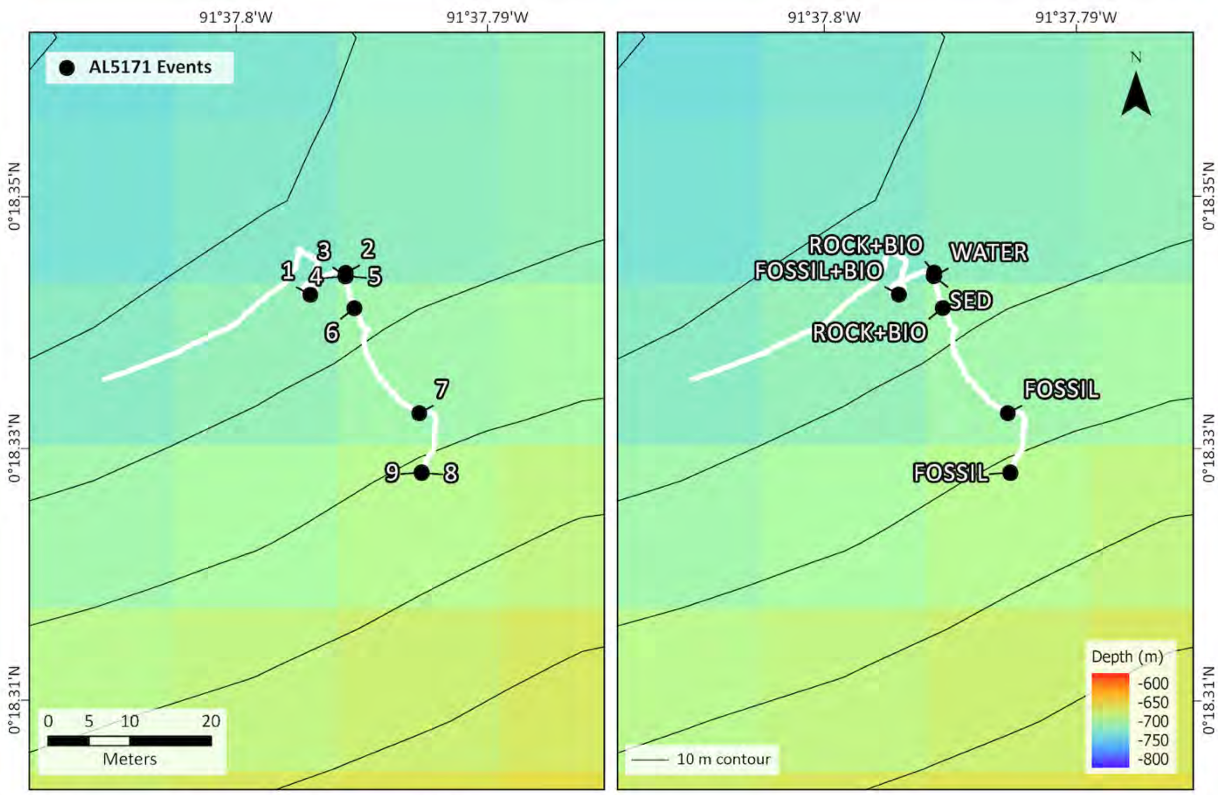
AL5170_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5170	12/04/2023	1	PSH	15:56	2704	push core in muddy sed			green	Y	DG		
AL5170	12/04/2023	2	PSH	15:56	2704	push core in muddy sed			red	Y	DG		
AL5170	12/04/2023	3	NSK	16:02	2704	niskin fired			niskin	Y	DG		
AL5170	12/04/2023	4	GRB	18:03	2536	Rock 83		pillow	white	Y	DG		
AL5170	12/04/2023	5	GRB	18:20	2510	Rock 84		pillow	red		DG		
AL5170	12/04/2023	6	GRB	19:21	2474	Rock 85		pillow	yellow port		DG		
AL5170	12/04/2023	7	GRB	19:55	2422	Rock 86		pillow	purple		DG		
AL5170	12/04/2023	8	GRB	20:27	2377	Rock 87		pillow	blue		DG		
AL5170	12/04/2023	9	GRB	20:32	2377	Bio 1		pepines	bio forward		DG		
AL5170	12/04/2023	10	GRB	21:03	2330	Bio 2		bamboo coral (black coral)	bio aft		DG		
AL5170	12/04/2023	11	GRB	21:05	2330	Bio 3		Black coral (swiftia)	bio aft		DG		
AL5170	12/04/2023	12	PSH	21:10	2330	PC 3			pc silver		DG		

Figure 20. *AL5170 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5171 Dive Summary

Pilot: Nick Osadcia, Observer-Port: Ana Samperiz, Observer-Starboard: Jenifer Suarez



Cruise:	AT50-09	**Dive:**	AL5171
Date:	April 13, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 18.34' N, 91° 37.81' W	**End Location:**	1° 12.80' S, 91° 06.36' W
Start Depth:	700 m	**End Depth:**	698 m
Observers:	Ana Samperiz Vizcaino Jenifer Suarez	**Region:**	NW Roca Redonda

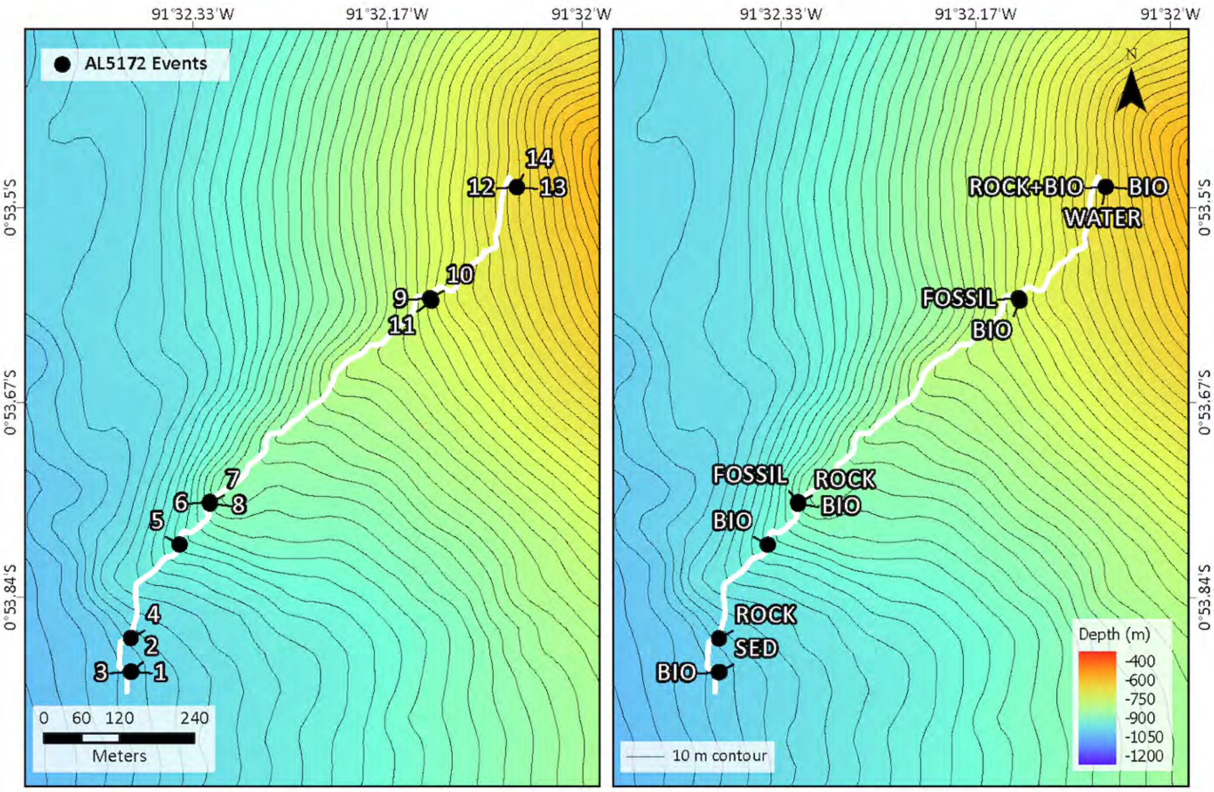
AL5171_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5171	13/04/2023	1	SLP	22:35	716	Dead desmo ~7, live desmo ~4, squat lobster, madrepora			Yellow quiver		AS	Y	Y
AL5171	13/04/2023	2	GRB	22:52	717	rock, live desmom sty, prim	88		Fwd bio		AS		Y
AL5171	13/04/2023	3	PSH	22:55	716	psh			Silver		AS		
AL5171	13/04/2023	4	PSH	23:01	717	psh			Green		AS		
AL5171	13/04/2023	5	NSK	23:02	717	nsk bot			Niskin		AS	N	N
AL5171	13/04/2023	6	GRB	23:05	715	rock and bio corals	89		Aft Bio		AS		Y
AL5171	13/04/2023	7	NET	23:16	705	net fossil coral purple			Red Crate		AS	Y	
AL5171	13/04/2023	8	NET	23:28	701	net red fossil			White Crate		AS	Y	
AL5171	13/04/2023	9	GRB	23:32	701	dead madrepora			Blue Crate		AS	Y	

Figure 21. *AL5171 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5172 Dive Summary

Pilot: Rick Sanger, Port Observer: Michelle Taylor, Starboard Observer: Amy Wong



Cruise:	AT50-09	**Dive:**	AL5172
Date:	April 14, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 53.91' S, 91° 32.39' W	**End Location:**	1° 12.80' S, 91° 06.36' W
Start Depth:	945 m	**End Depth:**	649 m
Observers:	Michelle Taylor Amy Sing Wong	**Region:**	Western Platform

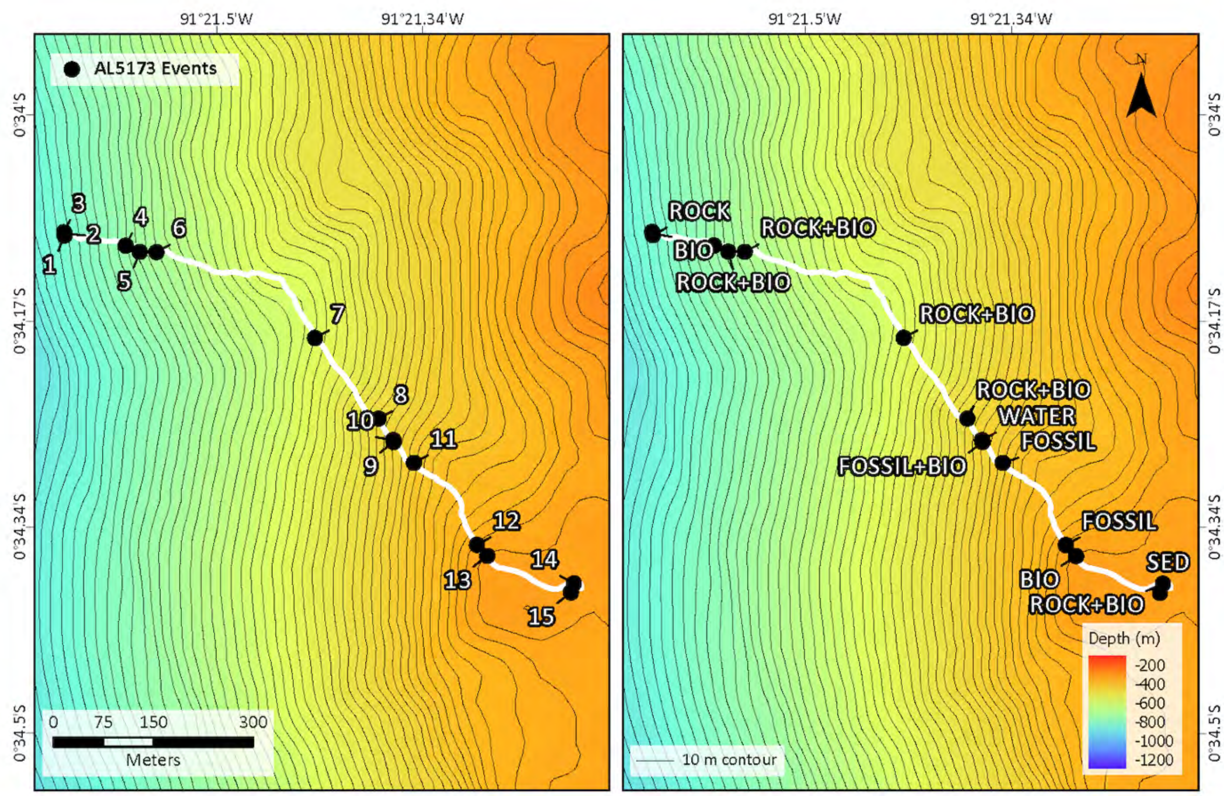
AL5172_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5172	14/04/2023	1	PSH	14:56	961	Soft sediment - very silty		some fell out into tube	Silver		ASW	N	N
AL5172	14/04/2023	2	PSH	14:58	961.7	Looks very silty			Green		ASW	N	N
AL5172	14/04/2023	3	SLP	15:13	962	Stylastridae from rock outcrop, w/ crinoid and solitary coral			Yellow quiver	Y	ASW		Y
AL5172	14/04/2023	4	GRB	15:58	945	Rock 92 - from steep slope	92		Purple crate	Y	ASW		
AL5172	14/04/2023	5	GRB/SLP	16:39	876	Large stylastridae with desmo		broken during sampling - rocks in the way	Red quiver	Y	ASW		Y
AL5172	14/04/2023	6	NLT	17:13	832	Fossil corals including desmo		lots of bio around	Yellow/green Net		ASW	Y	
AL5172	14/04/2023	7	GRB	17:37	830	Rock 93	93	Collected near fossil corals	Black crate	Y	ASW		
AL5172	14/04/2023	8	GRB	17:42	830	Paragorgia, pinky balloon like anemone		taken from rock	Fwd Bio	Y	ASW		Y
AL5172	14/04/2023	9	NLT	18:50	730	Fossil corals, soft sediments - silty, colonial and desmo		Loads of desmo fossils	Yellow Net	Y	ASW	Y	
AL5172	14/04/2023	10	SLP	19:05	730	Desmo fossils			Yellow Net		ASW	Y	
AL5172	14/04/2023	11	SLP	19:22	730	Live corals - stylos, solitary corals			White quiver		ASW		Y
AL5172	14/04/2023	12	GRB	20:01	655	Rock 94 & desmo	94		red crate		ASW		Y
AL5172	14/04/2023	13	SLP	20:04	655	Desmo and stylasteridae			Slurp [illegible]		ASW		Y
AL5172	14/04/2023	14	NSK	20:07	655	Water			Niskin		ASW	N	N

Figure 22. *AL5172 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5173 Dive Summary

Pilot: Bruce Strickott, Port Observer: Malu Ferreira, Starboard Observer: Yun-Su Jun



Cruise:	AT50-09	**Dive:**	AL5173
Date:	April 15, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 34.10' S, 91° 21.62' W	**End Location:**	1° 12.80' S, 91° 06.36' W
Start Depth:	784 m	**End Depth:**	378 m
Observers:	Malu de Carvalho Ferreira Yun-Ju Sun	**Region:**	Western Platform

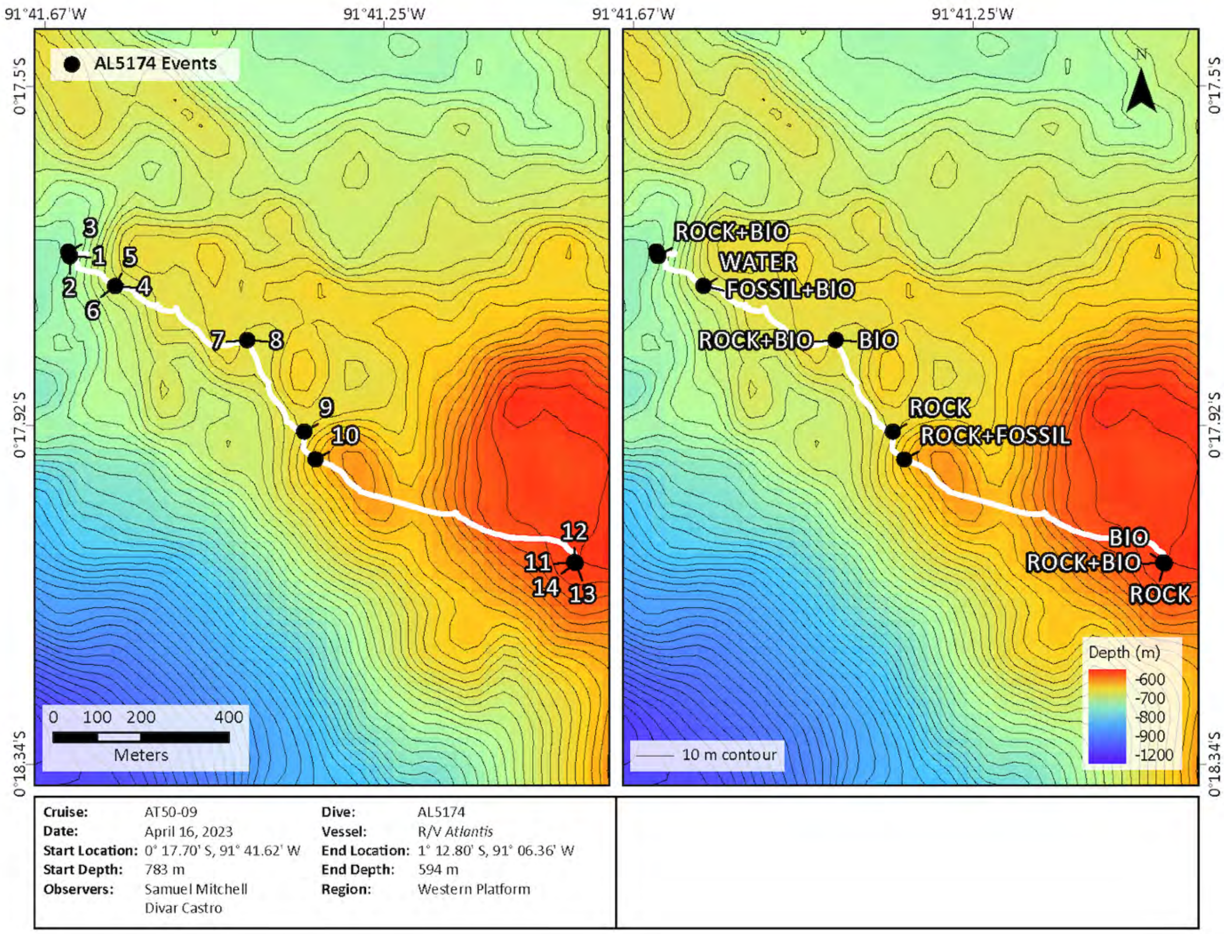
AL5173_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5173	15/04/2023	1	GRB	14:47	787	Rock 95	95	in situ sample from the lava flow base.	red crate		ML/YS	N	N
AL5173	15/04/2023	2	SLP	14:51	789	small Stylastridae, sponge, 2 cup corals			yellow quiver (bottom)		ML/YS	N	Y
AL5173	15/04/2023	3	GRB	15:05	790	Rock 96, same location with Ev 1	96		red crate		ML/YS	N	N
AL5173	15/04/2023	4	PSH	15:37	727	collet 2 pinky Polychaete worms with 2 push core		Biremis sp	silver push core and green push core		ML/YS	N	Y
AL5173	15/04/2023	5	GRB	16:03	712	a large bamboo coral (?) with Rock 97 and small Javania with Rock 98 (collect in situ)	98		Fwd Bio		ML/YS	N	Y
AL5173	15/04/2023	6	GRB/SLP	16:16	694	large pillow basalt (Rock 99), small cup corals and Stylastridae	99		Rock in red crate and corals in yellow quiver (top)		ML/YS	N	N
AL5173	15/04/2023	7	GRB	17:21	607	large Stylastridae, Rock 100, Rock101	101		coral in Aft bio with one piece in Fwd bio. And Rocks in purple crate		ML/YS	N	Y
AL5173	15/04/2023	8	GRB	17:59	519	Rock 102 and 5 cup corals	102		Rock in white crate and corals in red quiver (bottom)		ML/YS	N	N
AL5173	15/04/2023	9	SLP	18:24	504	small fossil corals and live corals, on the steep ridge			red quiver (top)		ML/YS	Y	Y
AL5173	15/04/2023	10	NSK	18:46	503	seawater, same location with ev9			Niskin		ML/YS	N	N
AL5173	15/04/2023	11	NET	18:59	473	fossil colonial coral			yellow-green net, white crate		ML/YS	Y	N
AL5173	15/04/2023	12	NET	19:32	403	fossil colonial coral			yellow net		ML/YS	Y	N
AL5173	15/04/2023	13	GRB	19:56	382	live Dendrophillia			Aft bio		ML/YS	N	Y
AL5173	15/04/2023	14	GRB	20:35	384	Rock 103 (in situ rock with corals) and Rock 104 (in situ rock with corals)	104		blue crate		ML/YS	N	Y
AL5173	15/04/2023	15	PSH	20:39	383	2 push core on platform			red push core and blue push core		ML/YS	N	N

Figure 23. *AL5173 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5174 Dive Summary

Pilot: Nick Osadcia, Port Observer: Samuel Mitchell, Starboard Observer: Divar Castro



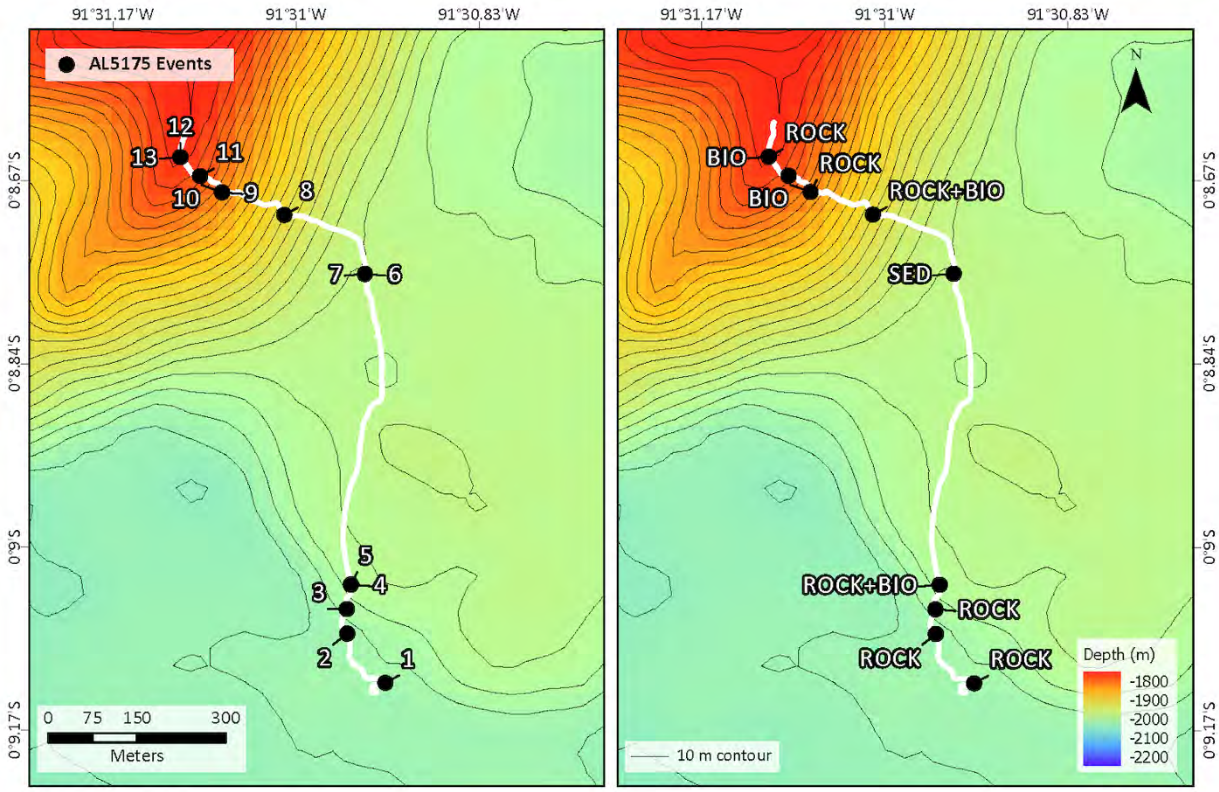
AL5174_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5174	16/04/2023	1	GRB	15:20	816	Crust of pillow lava with biology - desmophyllum and soft coral	105	Broke off easy	BIO FWD	Y	SM	N	Y
AL5174	16/04/2023	2	GRB	15:25	816	Crust of same pillow as Ev.1 with biology - demosphyllum and stylasterid	106	Broke off easy	BIO FWD	Y	SM	N	Y
AL5174	16/04/2023	3	SLP	15:38	819	Slurp of mulitple stylastends, live and dead desmophyllum attached to a pillow crust	-	Mulitple samples in quiver from same rock	YELLOW QUIVER	Y	SM	Y	Y
AL5174	16/04/2023	4	SLP	16:34	745	Slurp of many live and dead demosphyllum from different pockets on one large pillow mound, same rock	-	Mixture of live and dead coral	RED QUIVER	Y	SM	Y	Y
AL5174	16/04/2023	5	GRB	16:40	745	Large rock covered in desmophyllum, styalastend and a soft coral, next to Ev.4	107	Crust of pillow	WHITE BOX	Y	SM	N	Y
AL5174	16/04/2023	6	NSK	16:42	746	Niskin bottle fired successfully	-		NISKIN	n/a	SM	n/a	n/a
AL5174	16/04/2023	7	GRB	17:33	716	Large crust of pillow mound and large attached soft coral	108	Large soft coral still attached	AFT BIO	Y	SM	N	Y
AL5174	16/04/2023	8	SLP	17:37	716	Slurp of desmophyllum, stylasterid and madrepore from the same rock as R108	-	All from the same rock as R108	AFT BIO	Y	SM	N	Y
AL5174	16/04/2023	9	GRB	18:19	717	Two small fragments from edge of same rock, broken off hackly flow - not pillow	109	Jumbled flow, not pillow	PURPLE BOX	Y	SM	N	N
AL5174	16/04/2023	10	NET	18:39	687	Net 1 - mostly rocks, a few dendrophyllia, a few desmophyllum	-	Green/yello handle of Net	RED BOX	Y	SM	Y	Y
AL5174	16/04/2023	11	GRB	19:47	600	Rock with large purple coral + live desmiphyllum and a sea urchin	110	Sea urchin live	BLACK BOX	Y	SM	N	Y
AL5174	16/04/2023	12	SLP	19:49	600	Slurp of live desmophyllum, stylasterid and madrepore	-	Rock attached	WHITE QUIVER	Y	SM	N	Y
AL5174	16/04/2023	13	GRB	19:57	600	Broken crust of a collpased lobe floe roff - no bio attached	111	Fresh crust of collapsed roof	BLUE BOX	Y	SM	N	N
AL5174	16/04/2023	14	GRB	20:01	600	Same as above + stylasterid attached	112	Fresh crust of collapsed roof	YELLOW BOX	Y	SM	N	Y

Figure 24. *AL5174 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5175 Dive Summary

Pilot: Rick Sanger, Port Observer: Dan Fornari, Pilot-in-Training: Randy Holt



Cruise:	AT50-09	**Dive:**	AL5175
Date:	April 17, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 09.13' S, 91° 30.93' W	**End Location:**	1° 12.80' S, 91° 06.36' W
Start Depth:	1995 m	**End Depth:**	1780 m
Observers:	Dan Fornari	**Region:**	Western Platform

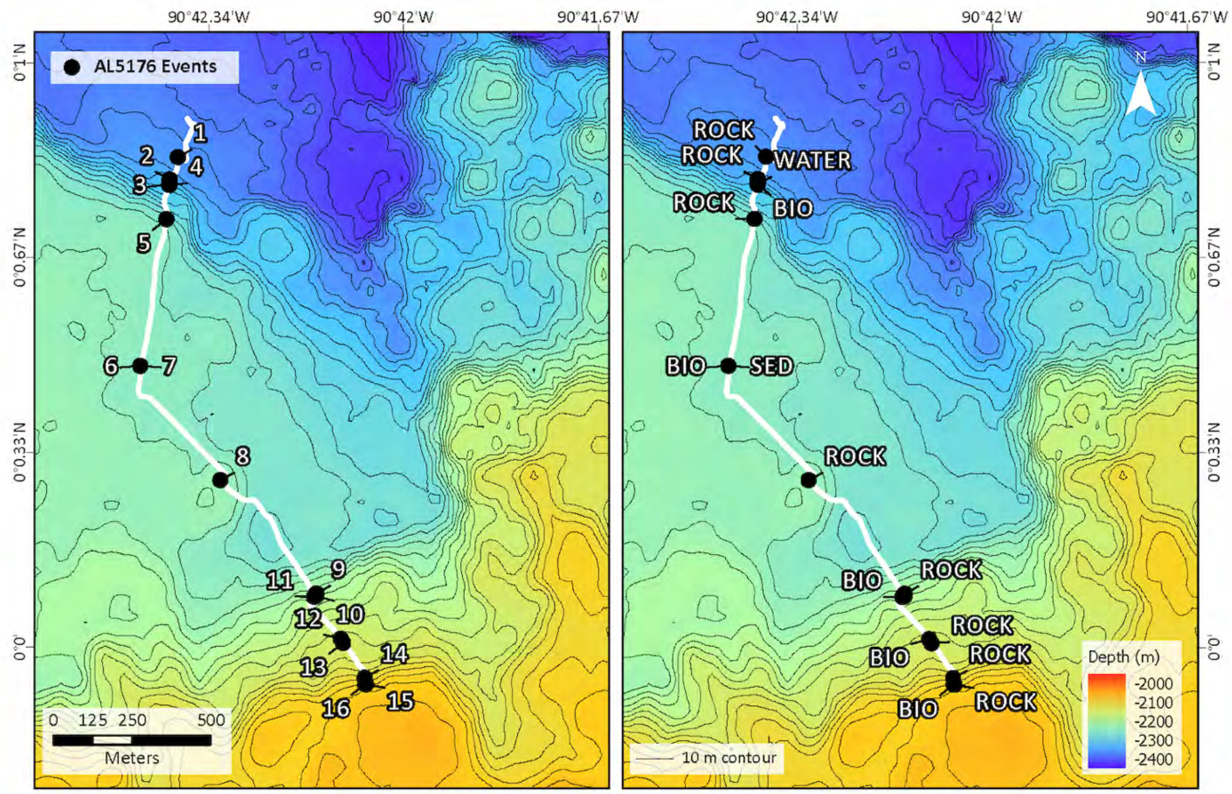
AL5175_event_log

Alvin dive	Date	Event	Equipment code	Time	Depth m	Organism rock description	next rock num	comments	tool tray location	close up picture	Scribe	Fossils	Biology
AL5175	17/04/2023	1	GRB	15:57	2008	Rock 114 crust lava level	114		white crate		DF		
AL5175	17/04/2023	2	GRB	16:23	2012	Rock 115 lug shaped fold	115	lug shaped	white crate		DF		
AL5175	17/04/2023	3	GRB	16:47	1990	Rock 116	116	shaped top of scarp	purple crate		DF		
AL5175	17/04/2023	4	GRB	17:04	1985	Bamboo coral, rock 117	117		Fwd bio		DF		Y
AL5175	17/04/2023	5	GRB	17:05	1985	Small rock 118 w/ 2 lupets	118		Fwd bio		DF		
AL5175	17/04/2023	6	PSH	17:53	1978	Push core w/pennatulid			Silver		DF		
AL5175	17/04/2023	7	PSH	17:56	1978	Push core w/ hydroids			Green		DF		Y
AL5175	17/04/2023	8	GRB	18:28	1925	3 rocks ALL 119, w/ stylasterid, w/ yellow leafy stuff, 2 aust	119		Aft bio		DF		Y
AL5175	17/04/2023	9	GRB	19:06	1849	Rock 120, large red basket	120		Red crate		DF		Y
AL5175	17/04/2023	10	GRB	19:09	1849	small bamboo coral			Aft bio		DF		Y
AL5175	17/04/2023	11	GRB	19:44	1815	Large bamboo coral			Aft bio		DF		Y
AL5175	17/04/2023	12	GRB	20:17	1787	Rock 121 top of core	121		Yellow crate		DF		
AL5175	17/04/2023	13	GRB	20:23	1787	purple coral? w/anemone, brittlestar, on glass crust			Fwd bio		DF		Y

Figure 25. *AL5175 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

AL5176 Dive Summary

Pilot: Bruce Strickrott, Port Observer: Janine Andrys, Starboard Observer: Jess Gordon



Cruise:	AT50-09	**Dive:**	AL5176
Date:	April 18, 2023	**Vessel:**	R/V *Atlantis*
Start Location:	0° 00.90' N, 90° 42.37' W	**End Location:**	0° 00.06' S, 90° 42.07' W
Start Depth:	2300 m	**End Depth:**	2082 m
Observers:	Janine Andrys Jess Gordon	**Region:**	Central Platform

AL5176_event_log

Alvin_dive	Date	Event	Equipment_code	Time	Depth_m	Organism_rock_description	next_rock_num	comments	tool_tray_location	close_up_picture	Scribe	Fossils	Biology
AL5176	18/04/2023	1	GRB	15:59	2320	Squareish rock.	R123		Fwd Bio		JA	N	N
AL5176	18/04/2023	2	GRB	16:11	2310	pillow fragment	R124		White crate		JA	N	N
AL5176	18/04/2023	3	GRB	16:22	2298	small bamboo (maybe 2)			Fwd Bio		JA	N	Y
AL5176	18/04/2023	4	NSK	16:25	2298	Water sample next to collected bamboo coral			Nisken		JA	N	N
AL5176	18/04/2023	5	GRB	16:47	2236	Pillow crust	R125		Aft Bio		JA	N	N
AL5176	18/04/2023	6	GRB	17:26	2228	Octocoral living in sediment			Fwd Bio		JA	N	Y
AL5176	18/04/2023	7	PSH	17:30	2228	Pair of push cores. Both full.			Silver handle and green handle		JA	N	N
AL5176	18/04/2023	8	GRB	18:09	2215	Several pieces of pillow crust	R126		Red crate		JA	N	N
AL5176	18/04/2023	9	GRB	18:48	2201	Flat rock.	R127		Black crate		JA	N	N
AL5176	18/04/2023	10	GRB	19:02	2204	Bamboo coral.			Aft Bio		JA	N	Y
AL5176	18/04/2023	11	GRB	19:14	2206	Primnoid			Red crate		JA	N	Y
AL5176	18/04/2023	12	GRB	19:41	2147	Bamboo coral. Branched.			Yellow quiver		JA	N	Y
AL5176	18/04/2023	13	GRB	19:51	2147	Piece of lobate	R128		Purple box		JA	N	N
AL5176	18/04/2023	14	GRB	20:16	2114	Pillow bud from wall.	R129		Blue box		JA	N	N
AL5176	18/04/2023	15	GRB	20:31	2091	Fragement of pillow	R130		yellow/black box		JA	N	N
AL5176	18/04/2023	16	SLP	20:36	2091	Stylastrids, white.			Red quiver		JA	N	Y

Figure 26. *AL5176 dive traverse, sample locations and event log. See Figure 4 for regional distribution of dives around the Galápagos Platform and with respect to the islands.*

7. Paleo-climate Sampling

7.1 Fossil coral sampling

Fossil coral samples were collected at numerous locations across the Galápagos Platform during 12 of the 22 dives carried out during AT50-09 (Table 3). The coral samples will be dated using different techniques (e.g., laser ablation and isotope dilution U-series dating) and used for paleoclimate studies and characterization of past marine environments and events.

Table 3. Coordinates of coral sampling locations from cruise AT50-09 around Galápagos Islands. Latitude and longitude are in decimal degrees, depths in meters below sea surface.

Dive ID	Event number	Latitude Dec. Deg. (N)	Longitude Dec. Deg. (W)	Depth (m)
AL5155	Ev001	-0.3798756	-90.8172209	506.84
	Ev002	-0.3798756	-90.8172205	503.70
AL5156	Ev001	-0.3783651	-90.8181424	493.43
	Ev002	-0.3782652	-90.8177913	468.82
	Ev003	-0.3782685	-90.8177983	469.08
	Ev004	-0.3782673	-90.8177984	469.14
	Ev007	-0.3780379	-90.8177002	476.73
AL5158	Ev005	-0.1473054	-90.8852655	621.93
	Ev006	-0.1462532	-90.8851758	555.21
	Ev007	-0.1460906	-90.8850542	512.16
AL5159	Ev001	0.4582342	-90.6993055	765.05
	Ev005	0.4599179	-90.7037853	752.13
	Ev006	0.4600143	-90.7049496	766.55
	Ev008	0.4600849	-90.7049886	766.41
	Ev009	0.4599444	-90.7069422	681.99
AL5161	Ev002	0.459878	-90.7095827	591.35
	Ev003	0.4597218	-90.7110127	525.60
	Ev004	0.4600781	-90.7111086	521.16
	Ev007	0.4607214	-90.7115775	509.78
	Ev008	0.4607205	-90.7115739	509.85
	Ev012	0.4617797	-90.7121749	516.94
	Ev013	0.4618935	-90.7121565	516.08
AL5162	Ev004	-0.5100408	-89.9403638	544.44
	Ev005	-0.5087585	-89.9406257	456.15
	Ev012	-0.505092	-89.9387401	469.87
	Ev013	-0.5050734	-89.9387335	469.46
AL5164	Ev005	-0.7191309	-89.1522183	506.04
	Ev006	-0.7191246	-89.152218	506.08
	Ev008	-0.7166818	-89.1516811	425.28
	Ev010	-0.7133521	-89.147957	349.97
	Ev012	-0.7134991	-89.1476925	339.97
AL5166	Ev010	-1.3403855	-89.8954406	583.40
	Ev012	-1.3394023	-89.8953327	531.73
	Ev014	-1.3307904	-89.8968254	436.46
	Ev016	-1.3308455	-89.8968274	437.26
AL5169	Ev009	-1.2263575	-90.7023011	610.54
	Ev010	-1.2250629	-90.7021312	608.12

Dive ID	Event number	Latitude Dec. Deg. (N)	Longitude Dec. Deg. (W)	Depth (m)
	Ev013	-1.2238661	-90.7032816	552.13
AL5171	Ev001	0.3057252	-91.6299179	715.74
	Ev007	0.3055946	-91.6297977	704.97
	Ev008	0.3055287	-91.6297949	700.23
	Ev009	0.3055293	-91.6297951	700.42
AL5172	Ev004	-0.8978024	-91.5397769	944.28
	Ev009	-0.8929533	-91.5355027	729.70
	Ev010	-0.8929556	-91.5355005	729.56
	Ev012	-0.8913669	-91.5342598	654.90
AL5173	Ev006	-0.5685122	-91.3591444	693.69
	Ev009	-0.5710735	-91.3559446	504.26
	Ev011	-0.5713548	-91.3556718	472.73
	Ev012	-0.5724595	-91.354823	404.28
	Ev014	-0.5729799	-91.3535155	383.54
AL5174	Ev001	-0.2951419	-91.6939386	815.01
	Ev003	-0.2950574	-91.6939786	817.52
	Ev004	-0.2957637	-91.6930171	745.04
	Ev005	-0.2957617	-91.6930179	745.05
	Ev008	-0.2968658	-91.6903104	715.48
	Ev010	-0.2993134	-91.6889073	686.20
MC02_4		-0.5501956	-89.9678939	715

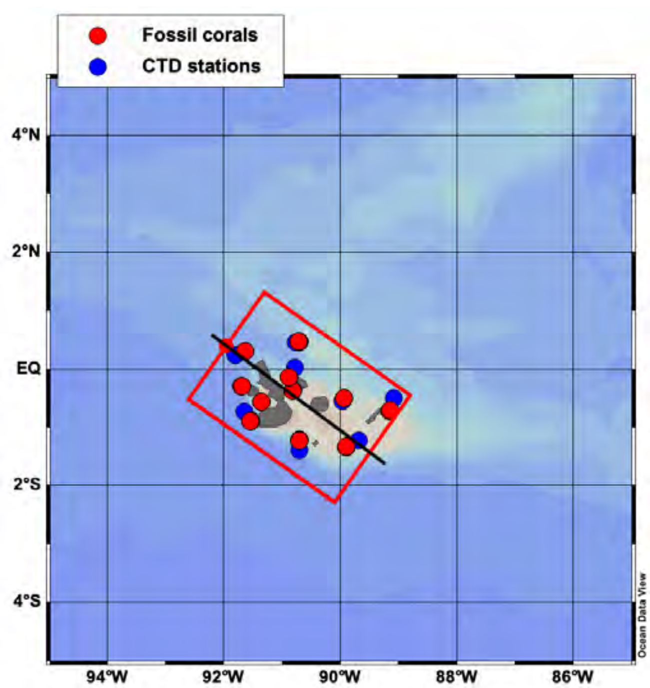


Figure 27. Locations of fossil and sub-fossil coral samples collected during the AT50-09 expedition using Alvin. Oceanographic data collected during conductivity, temperature, depth (CTD) stations (density, oxygen, salinity and temperature) carried out on AT50-09 are shown in Figure 28, roughly projected to the NW-SE black line.

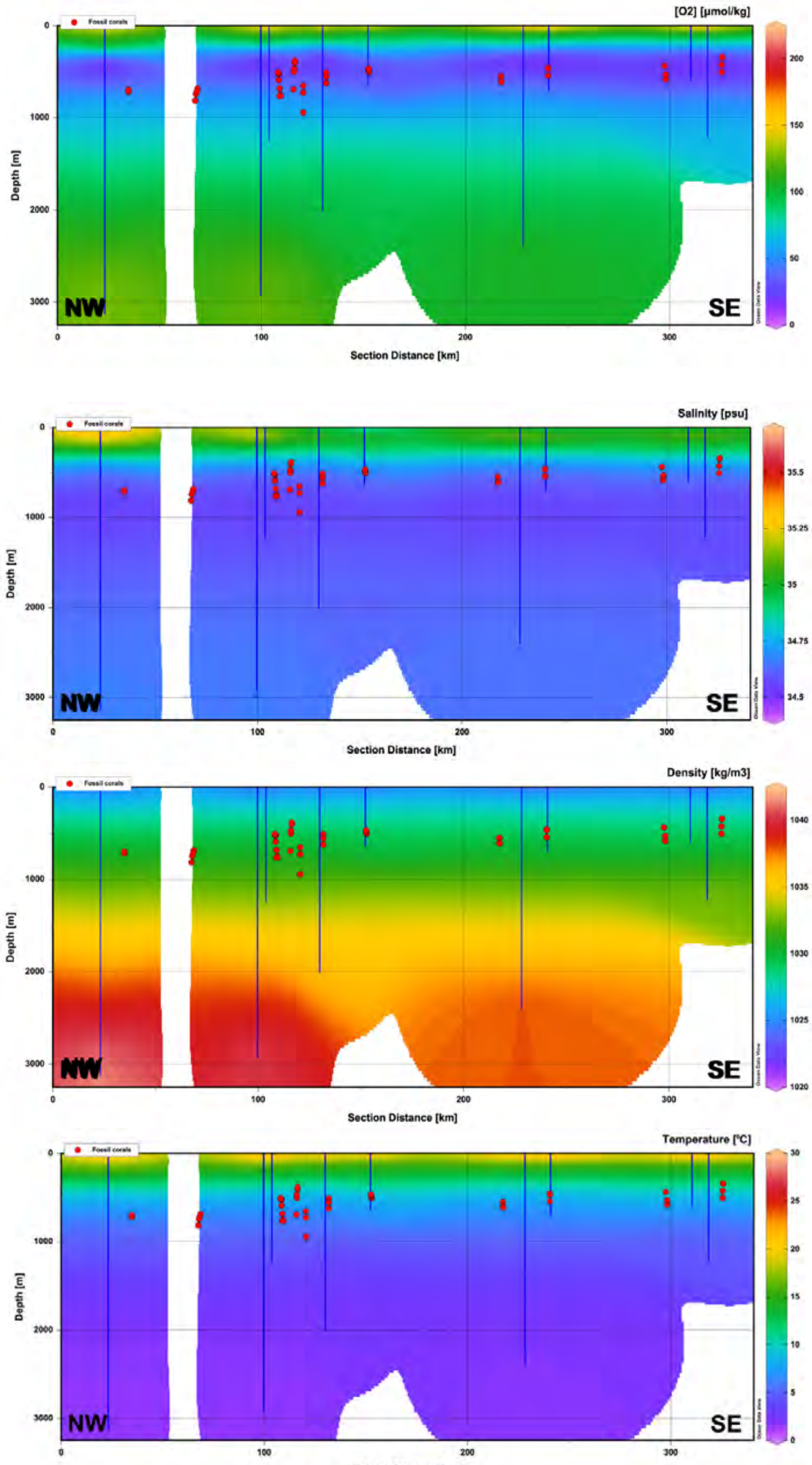


Figure 28. Summary of preliminary CTD data collected during lowerings shown in Figure 27. Red dots show depths of coral samples collected during this expedition.

7.1.1. Sampling protocol

Fossil samples were collected with *Alvin* using various devices, but primarily via the manipulator arms that the pilot directed by scooping the seafloor where aggregations of fossil corals were present as well as with a gated suction hose that was placed over targeted corals on cliff faces and outcrops. Once on deck, samples were examined to extract any living specimens that were then processed through the biology team's protocols inside the cold (~4-6°C) laboratory on board, where they were assigned a unique ID number for each sampling event. The dead coral specimens (fossil and sub-fossil) were rinsed with seawater several times to remove any remains of encrusting organisms and sediments, and then rinsed in freshwater and finally air dried. Once dried, these samples were photographed, cataloged and packed in labeled sample bags.

7.1.2. Sample IDs

Sample IDs contain: the cruise number (AT5009), biology unique numbers that were given to every single event (every sample collection obtained from the seafloor is considered a different event), *Alvin* dive number, event number, and sub-sample locator (e.g., AT5009_F1253_Dive5172_Ev010_A005). For sub-sample locators, an alphanumeric system was used, where letter indicates coral order (i.e., A = Scleractinia, B = Stylasteridae) and number indicates subsample within each event (e.g., A001 to A005 indicates 5 different Scleractinian corals collected within a given event such as a net).

7.1.3. Sampling locations

Fossil and sub-fossil samples were recovered during Alvin dives: AL5155, AL5156, AL5158, AL5159, AL5161, AL5162, AL5164, AL5166, AL5169, AL5171, AL5172, AL5174 at a range of depths between 339 and 944 m (Table 4; Figure 27). In addition, one single specimen (*Flabellum*) was recovered via multicore (Table 4). Scleractinian corals were the most commonly recovered type, both solitary (i.e., *Desmophyllum, Caryophyllia, Javania, Flabellum*) and colonial (i.e., *Madrepora, Dendrophyllia*), followed by Stylasterid corals (possibly *Cryptohelia, Stylaster* and *Errina*) (Figure 29a).

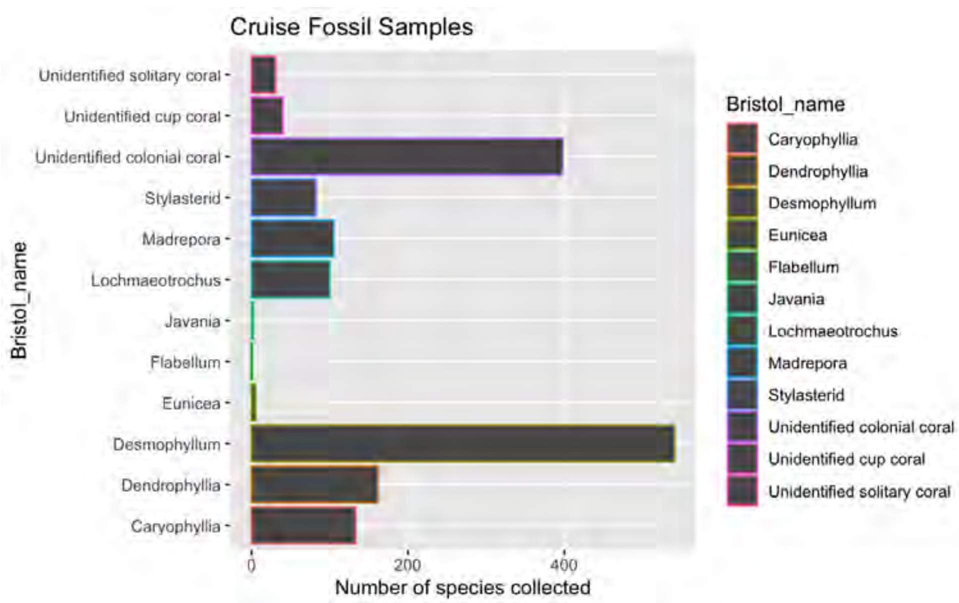


Figure 29a. General taxonomic classification of the fossil and sub-fossil samples recovered during AT50-09 expedition.

Sample preservation varied among sites, with some locations showing predominantly chalky skeletal carbonate material (either entirely altered or just an external chalky layer), while other were typically coated in ferromanganese crust (Figure 29b). Boring was common in both solitary and colonial specimens.

Figure 29b. Examples of fossil preservation state with ferromanganese coating (A) and chalky /corroded character (B).

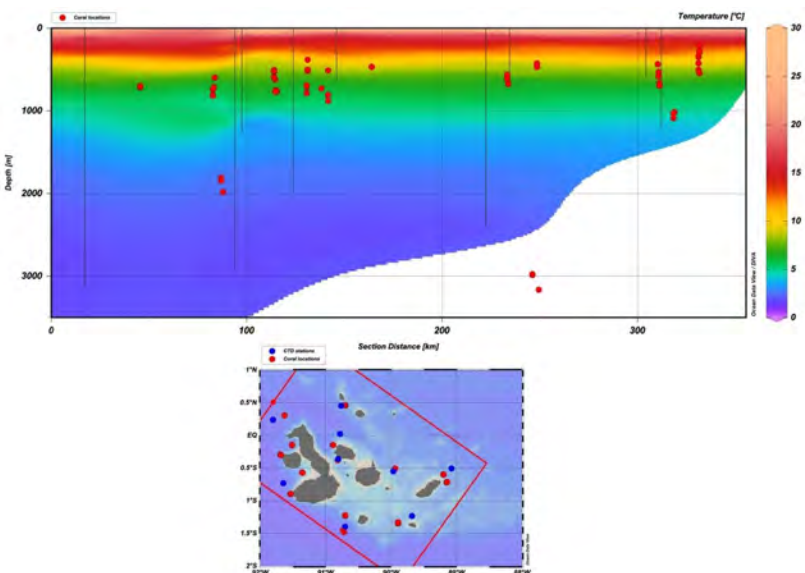


Figure 30. The distribution of live corals collected during the cruise within the context of ambient temperature at collection depth. The red dots in the map and section plot show locations of live corals that were collected. Blue dots in the map represent locations of CTD stations (see Water Sampling Section - 8).

7.2. Live coral sampling

Deep-sea corals were collected live for a variety of scientific purposes, including biogeography for deep-sea coral distribution, deep-sea coral geochemistry, and proxy calibration for paleoclimate, and genetics studies. We collected 430 specimens of live-collected deep-sea coral samples on AT50-09 (named as live coral in the following section) that will be used for coral geochemical work. The tiny corals collected for biological and DNA research were not included in this section (See previous section). Those samples were from a range of depths from 210 m to 3200 m (Figure 30).

7.2.1. Sampling Protocol

After biology sampling was done, the live specimens would need to be cleaned and dried for storage. Except for bamboo coral which the organic nodes need to be reserved for further use, all other Scleractinia and Stylasterid corals are required to remove attached organic tissue. Those samples were bleached in a 30% bleach:freshwater solution for 12 hours. Then all the samples were followed by water rinsing (seawater and then freshwater), and then air dried. Samples were then cataloged, photographed, and packed. Each sample was labeled by a full sample ID, including cruise number, biology-sample group, unique collection event number, Alvin dive number, Alvin dive event number, and sample ID number. For example, AT5009_B1368_Dive5171_Ev001_001 are sample from cruise AT5009, biology sample B, unique collection event number 1368, Alvin dive 5171, Alvin dive event 1, sample number 1.

7.2.2. Sampling collection

Live coral samples were recovered from 16 Alvin Dives (AL5156, AL5158, AL5159, AL5161, AL5162, AL5163, AL5164, AL5166, AL5167, AL5168, AL5169, AL5171, AL5172, AL5173, AL5174, AL5175). The depth range was spanning 210 m to 3200 m water depth, 2 ℃ to 14 ℃ water temperature and 10 µmol/kg to 125 µmol/kg water dissolved oxygen concentration (Figure 31). Most corals were collected from 400 m to 700 m water depth, and only bamboo corals were collected below 1000 m water depth. Key features of the physical ocean sampled via the CTD include the North Pacific Tropical Water (NPTW), Antarctic Intermediate Water (AAIW) and North Pacific Deep Water (NPDW).

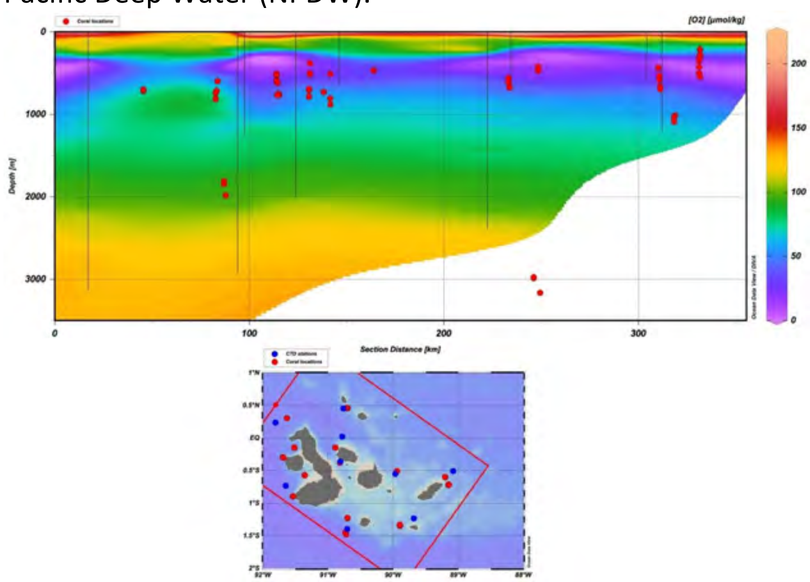


Figure 31. The distribution of live corals collected during the cruise within the context of ambient temperature at collection depth. The red dots in the map and section plot show locations of live corals that were collected. Blue dots in the map represent locations of CTD stations (see Water Sampling Section - 8).

In total, during Alvin diving on AT50-09 we collected 365 Scleractinia corals (*Desmophyllum, Caryophyllia, Javania, Madrepora, Dendrophyllia*; Figure 32), 58 stylasterid corals (Figure 33), and 7 bamboo corals (Figure 34). The detail of coral species and the number are listed in Table 4 (NB- this coral sample number count relates to relatively completed pieces).

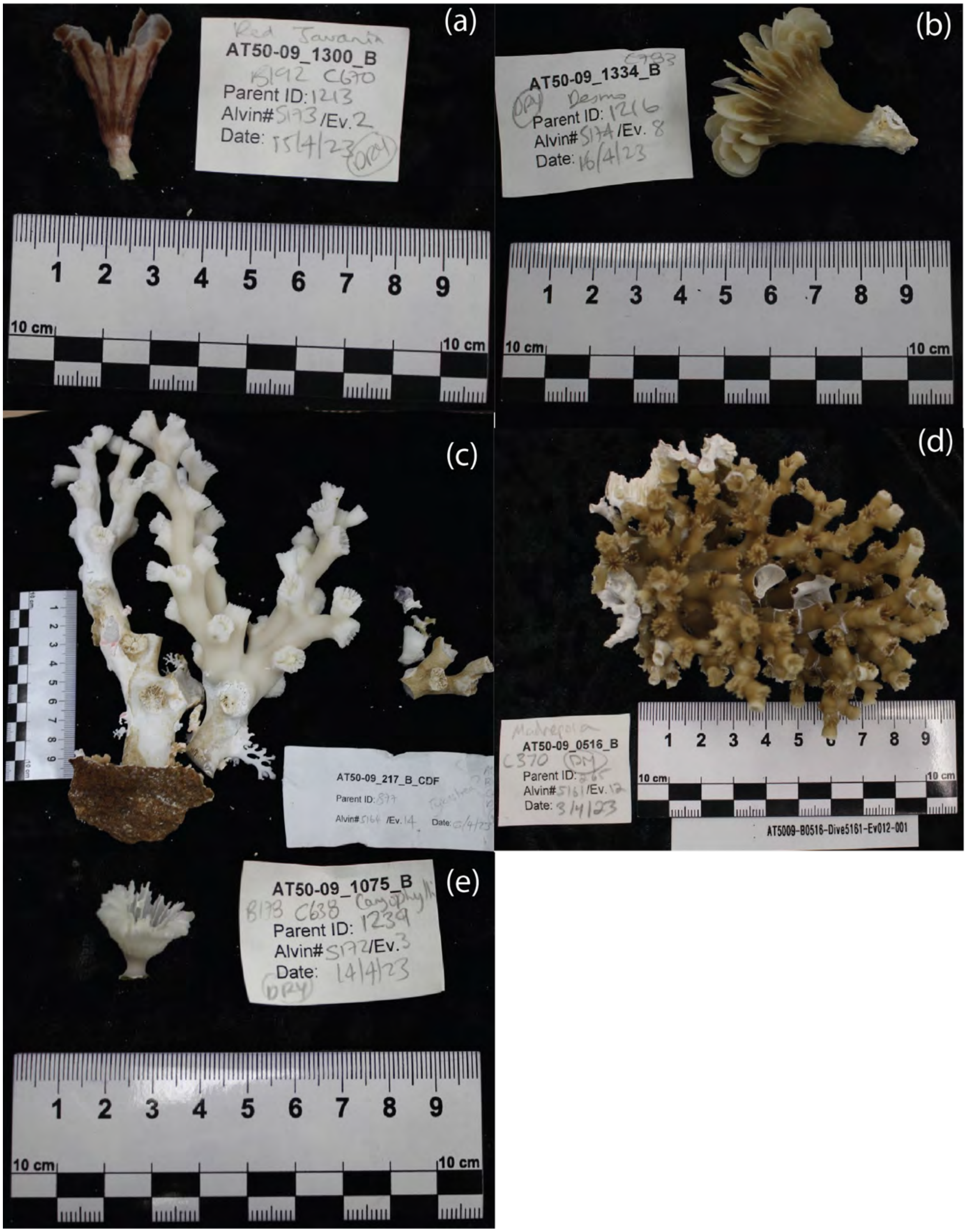


Figure 32. Different species of scleractinian corals collected during the cruise. (a) Javania; (b) Desmophyllum; (c) Dendrophyllia; (d) Madrepora; (e) Caryophyllia.

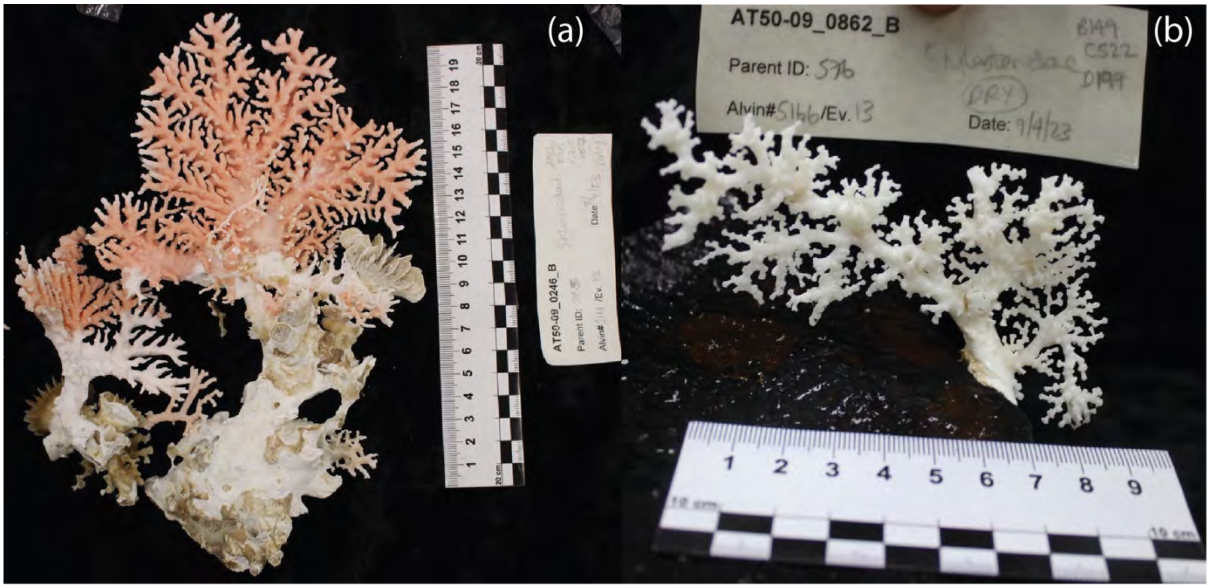


Figure 33. Different species of stylasterid corals collected during the cruise. (a) pink stylasterid type 1; (b) white stylasterid.

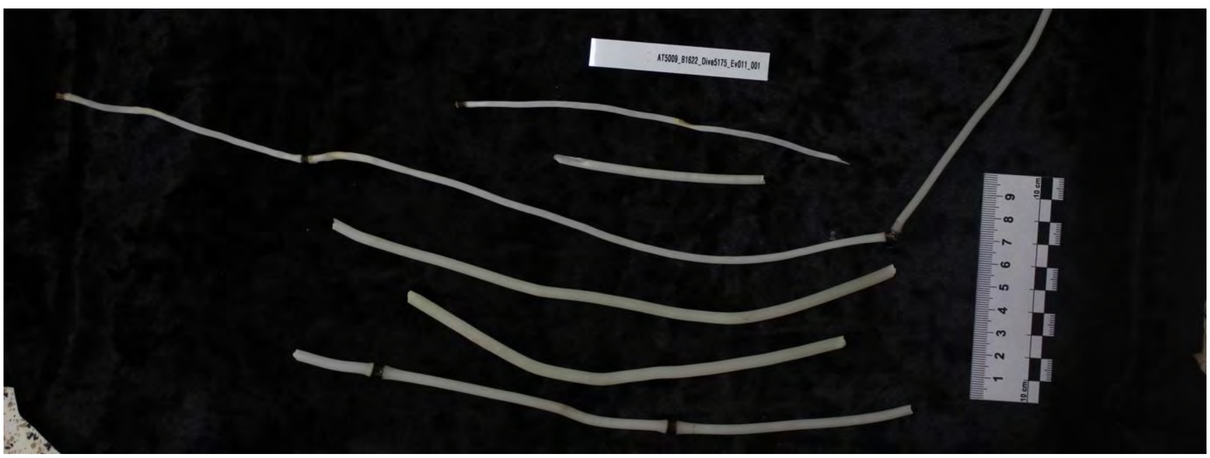


Figure 34. Bamboo coral (Isididae) collected during the cruise.

Table 4. Live coral samples taxa and the collected number for each species

Order	**Family**	**Genus**	**Number**
Scleractinia	Caryophylliidae	*Desmophyllum,*	296
Scleractinia	Caryophylliidae	*Caryophyllia*	5
Scleractinia	Flabellidae	*Javania*	24
Scleractinia	Oculinidae	*Madrepora*	35
Scleractinia	Dendrophylliidae	*Dendrophyllia*	5
Anthoathecata	Stylasteridae	*Cryptohelia, Stylaster, Errina*	58
Malacalcyonacea	Isididae (Bamboo coral)	*Lepidisis*	7

8. *Water Sampling*

One of the primary aims of this cruise was to characterize the water column properties around the Galápagos Platform, to both constrain the local oceanography and current direction, and provide valuable context for coral and sediment geochemistry studies. Water was collected in Niskin bottles during the deployments of three types of equipment: the CTD rosette, MC400 multicorer (configured with the MISO 24MP still imaging system, a SBE19plusV2 CTD with a SBE43 dissolved O2 sensor, and a 5-liter Niskin bottle that tripped when bottom contact was made), and *Alvin*. In total, we collected approximately 180 L of water in more than 1200 bottles, representing 9 CTD sites, 9 multicore sites and 19 *Alvin* dives (Tables 5 and 6). No seawater analyses were carried out on the ship. Water samples will subsequently be analyzed for their carbonate chemistry, radiocarbon content, $\delta^{13}C$ and $\delta^{18}O$, nutrient content, Si isotopic content and for environmental DNA.

8.1. CTD: Overview

The CTD rosette system on *R/V Atlantis* contains 23 10-L Niskin bottles and all were fired during each deployment. During the downcast, live readings of temperature, conductivity and oxygen were used to determine major water masses and water column features. Target depths for firing (i.e., bottle closing) Niskin bottles were then selected. The rosette can hold 24 Niskin bottles, however, one bottle location was used to mount a USBL beacon to provide accurate navigation of the CTD at depth.

All 23 Niskin bottles were fired in each CTD lowering as some bottles were used as replicates. Niskin bottles were fired during the upcast part of CTD deployment. After ascending to the required depth, the CTD was left to rest for 1 minute before firing the Niskin bottle. In many cases, multiple bottles were fired at the same depth in case one of the bottles malfunctioned. Water was then sampled from the Niskin bottles according to the procedures outlined in forthcoming sections. Briefly, environmental DNA (eDNA) samples were collected from the 2 deepest Niskin bottles, and the other Niskin bottles were used to collect water samples for carbonate, radiocarbon, $\delta^{13}C$, $\delta^{18}O$, nutrients, Si isotopes and surface seawater (Table 5).

Figure 35. Preparing the CTD rosette for deployment during AT50-09.

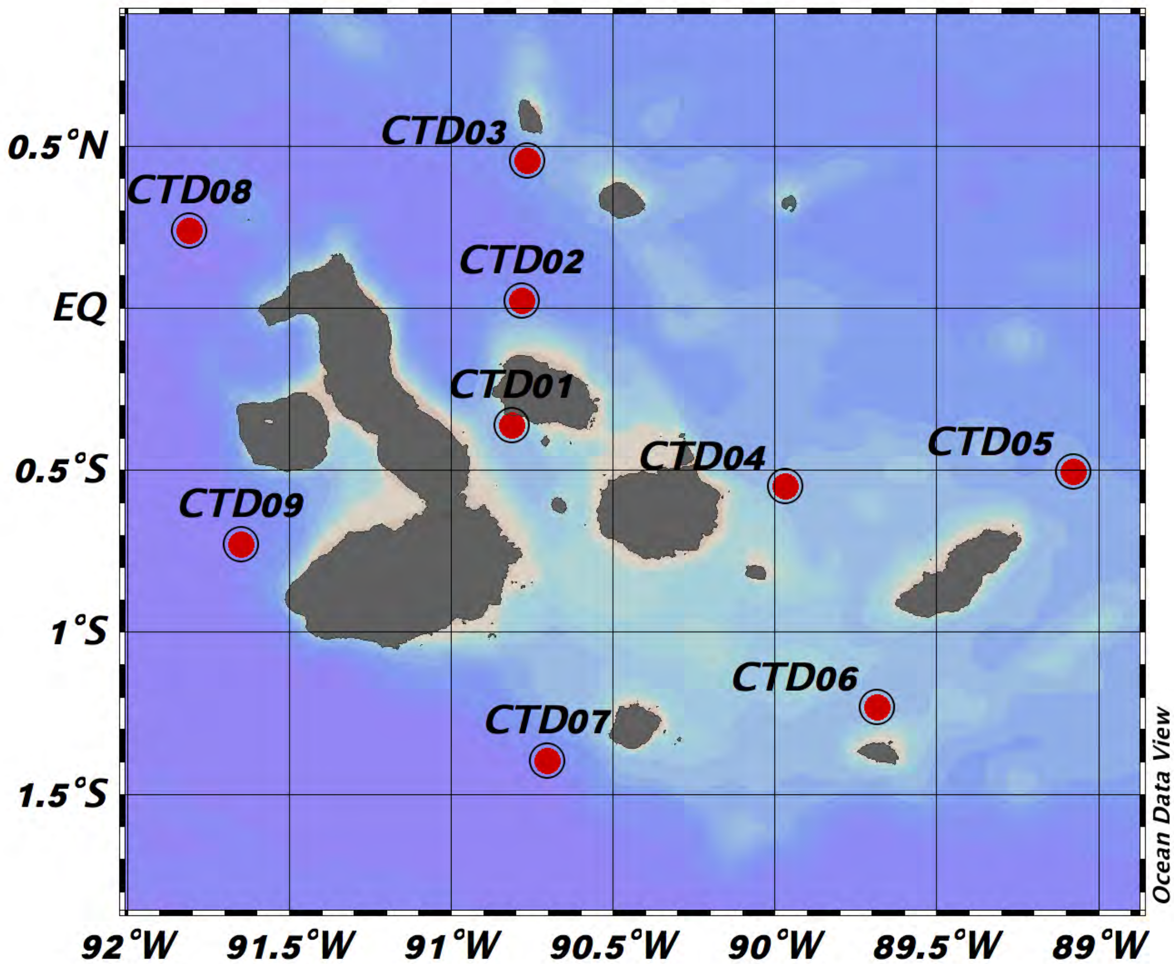


Figure 36. Locations of CTD lowerings accomplished during AT50-09.

In total, we carried out 9 CTDs to characterize the Galápagos Platform, and the locations are shown in Figure 36 and listed in Table 6. The depth range covered by CTD lowerings on AT50-09 was between 640 m and 2971 m. The temperature, salinity and oxygen profiles of each CTD were quite similar, likely owing to their geographic proximity. The salinity vs. potential temperature plots suggests the shallow water mass in this location may be mainly controlled by NPTW (North Pacific Tropical Water), while deeper waters are mainly controlled by AAIW (Antarctic Intermediate Water) and NPDW (North Pacific Deep Water) (Figure 37). The western-most CTD stations (CTD07, CTD08 and CTD09) show higher salinity (Figure 38), likely due to these stations being more proximal to the open Pacific Ocean (Figure 36). CTD01 has the lowest salinity and highest oxygen content, which may suggest the influence of fresh water from Santiago Island (Figure 36).

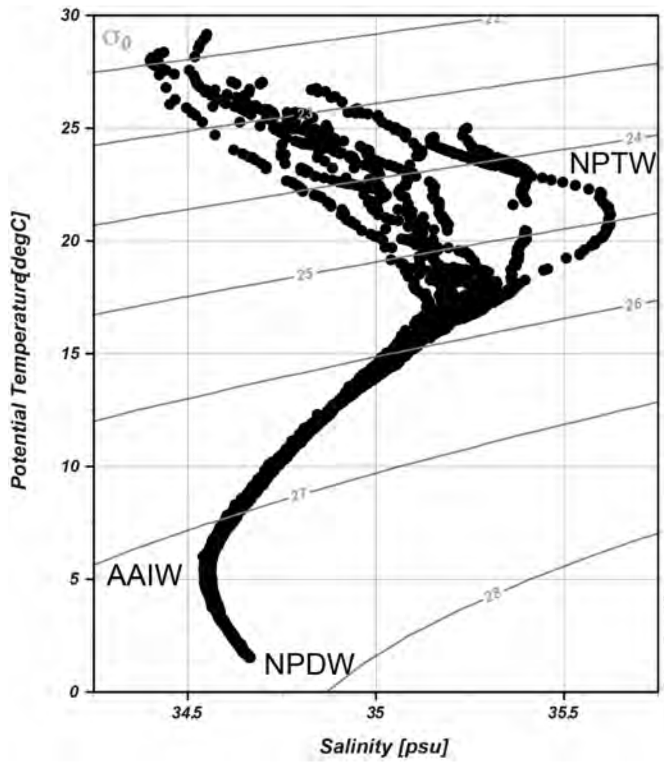


Figure 37. Salinity vs. potential temperature plots of all CTD stations.

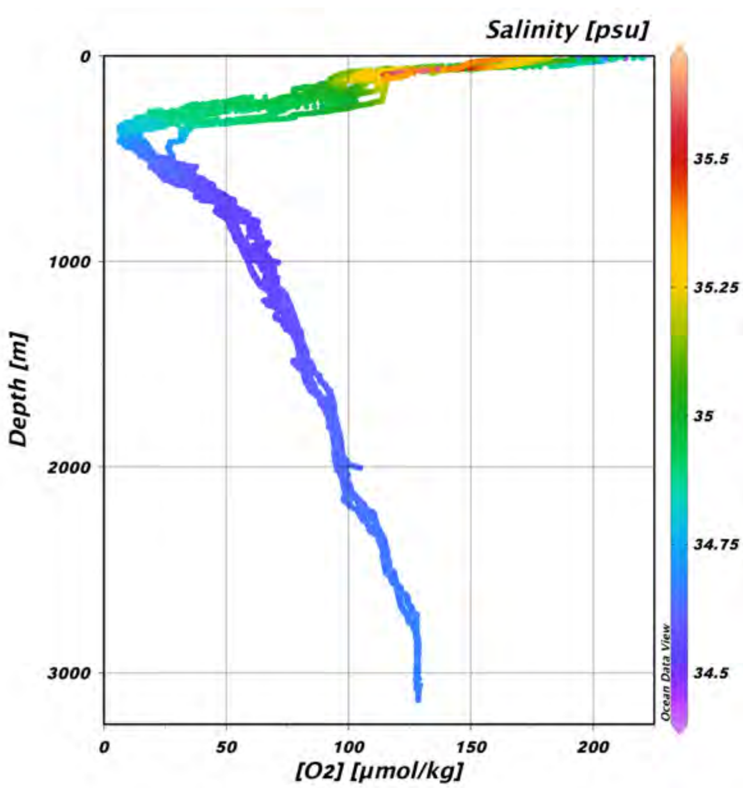


Figure 38. O_2, salinity and depth plots for all CTD stations.

8.2. Alvin: Overview

HOV *Alvin* was fitted with a vertically-oriented 5-L Niskin bottle that could be triggered by pulling on a small cord using the port-side manipulator. On most *Alvin* dives, the Niskin bottle was triggered at sites of interest (e.g., live and fossil coral aggregations) (Table 6). Sampling positions were targeted to important features, for instance where coral sampling was carried out, or next to push core sites. A primary advantage of this sampling strategy is that the *Alvin* Niskin is able to collect seawater from as close to the sampling sites as possible, therefore allowing the best characterize the local environment. Once *Alvin* was recovered, the Niskin bottle was fixed and sampled as soon as possible (normally within 30 minutes) to avoid any change in or modification of the water geochemical properties. The water sampling protocol was the same as that for the CTD Niskin bottles as outlined below.

8.3. Multicore Niskin bottle: Overview

During operation of the multicorer, a 5-L Niskin bottle was mounted to one of the horizontal struts of the corer, ~0.5 m above the base of the core tubes. The Niskin trigger lanyard was attached to the MC400 spyder so that on impact with the seafloor and release of the core shoe arms, the Niskin was also triggered to close. For some cores, we also collected core-top waters. Core-top waters were collected using a peripump and an acid-cleaned piece of tubing to remove water from directly above the sediment-water interface. This was carried out as soon as possible to minimize alteration of the core-top water composition. Locations of the multicore water samples can be found in the Sediments section of this report (Section 9) and outlined in Table 7.

8.4 Water sampling methods

The sampling methods used for each type of seawater sample are outlined in detail in Appendices 3 and 4. Briefly, 250 mL of seawater was collected for carbonate chemistry (alkalinity and DIC), radiocarbon and silicon isotopic analysis each. 60 mL of seawater were collected for measurements of nutrient (phosphate and dissolved silica) concentrations, and 30 mL samples for δ13C of DIC and δ18O of seawater analysis respectively. Carbonate chemistry, radiocarbon and δ13C samples were poisoned with mercuric chloride immediately after collection, to prevent continuing respiration and/or photosynthesis which could alter the measured chemical parameters. Seawater collected for dissolved silicon isotope analysis was filtered and transferred to a new collection bottle, to mitigate for the influence of post-collection dissolution of particulate silica phases. All samples were transferred to cool (i.e., room temperature), dark storage boxes as soon as possible, with the exception of nutrient samples, which were immediately frozen at -20 °C. Finally, environmental DNA (eDNA) samples were collected by gravity filtering seawater from the two deepest samples in each Niskin rosette (normally 5-10 m above the seafloor). Filters were immediately frozen after collection at - 80 °C.

Table 5. CTD log file showing depth that each Niskin bottle was fired at during each cast, and the number of each type of water sample taken.

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD01_NSK_01	-0.3605	-90.81087	640								1
AT50-09_CTD01_NSK_02	-0.3605	-90.81088	640								1
AT50-09_CTD01_NSK_03	-0.3605	-90.81088	640	1	1	2	2	2	1		
AT50-09_CTD01_NSK_04	-0.3605	-90.81088	600	1	1	2	2	2	1		
AT50-09_CTD01_NSK_05	-0.3605	-90.81088	600								
AT50-09_CTD01_NSK_06	-0.3605	-90.81088	500	1	1	2	2	2	1		
AT50-09_CTD01_NSK_07	-0.3605	-90.81088	500								
AT50-09_CTD01_NSK_08	-0.3605	-90.81088	450	1	1	2	2	2	1		
AT50-09_CTD01_NSK_09	-0.3605	-90.81088	450								
AT50-09_CTD01_NSK_10	-0.3605	-90.81086	350	1	1	2	2	2	1		
AT50-09_CTD01_NSK_11	-0.3605	-90.81086	350								
AT50-09_CTD01_NSK_12	-0.3605	-90.81088	300	1	1	2	2	2	1		
AT50-09_CTD01_NSK_13	-0.3605	-90.81088	300								
AT50-09_CTD01_NSK_14	-0.3605	-90.81088	200	1	1	2	2	2	1		
AT50-09_CTD01_NSK_15	-0.3605	-90.81088	200								
AT50-09_CTD01_NSK_16	-0.3605	-90.81088	100	1	1	2	2	2	1		
AT50-09_CTD01_NSK_17	-0.3605	-90.81088	100								
AT50-09_CTD01_NSK_18	-0.3605	-90.81088	50	1	1	2	2	2	1		
AT50-09_CTD01_NSK_19	-0.3605	-90.81088	50								
AT50-09_CTD01_NSK_20	-0.3605	-90.81088	30	1	1	2	2	2	1		
AT50-09_CTD01_NSK_21	-0.3605	-90.81088	30								

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD01_NSK_22	-0.3605	-90.810869	0	1	1	2	2	2	1		
AT50-09_CTD01_NSK_23	-0.3605	-90.81088	0							7	
AT50-09_CTD02_NSK_01	0.02254	-90.782349	2002								1
AT50-09_CTD02_NSK_02	0.02254	-90.78234	2002								1
AT50-09_CTD02_NSK_03	0.02254	-90.78234	2002	1	1	2	2	2	1		
AT50-09_CTD02_NSK_04	0.02254	-90.78236	1900	1		2	2	2	1		
AT50-09_CTD02_NSK_05	0.02254	-90.782344	1700	1		2	2	2	1		
AT50-09_CTD02_NSK_06	0.02254	-90.782347	1500	1	1	2	2	2	1		
AT50-09_CTD02_NSK_07	0.02254	-90.78234	1300	1		2	2	2	1		
AT50-09_CTD02_NSK_08	0.02254	-90.78235	1200	1	1	2	2	2	1		
AT50-09_CTD02_NSK_09	0.02254	-90.78234	1100	1		2	2	2	1		
AT50-09_CTD02_NSK_10	0.02254	-90.78236	1000	1		2	2	2	1		
AT50-09_CTD02_NSK_11	0.02254	-90.78234	900	1	1	2	2	2	1		
AT50-09_CTD02_NSK_12	0.02254	-90.782357	800	1	1	2	2	2	1		
AT50-09_CTD02_NSK_13	0.02254	-90.78234	700	1		2	2	2	1		
AT50-09_CTD02_NSK_14	0.02254	-90.78236	550	1	1	2	2	2	1		
AT50-09_CTD02_NSK_15	0.02254	-90.78234	450	1	1	2	2	2	1		
AT50-09_CTD02_NSK_16	0.02254	-90.78236	350	1	1	2	2	2	1		
AT50-09_CTD02_NSK_17	0.02254	-90.78236	300	1		2	2	2	1		
AT50-09_CTD02_NSK_18	0.02254	-90.78234	250	1	1	2	2	2	1		
AT50-09_CTD02_NSK_19	0.02254	-90.782348	200	1		2	2	2	1		
AT50-09_CTD02_NSK_20	0.02254	-90.78236	100	1	1	2	2	2	1		

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD02_NSK_21	0.02254	-90.78234	60	1	1	2	2	2	1		
AT50-09_CTD02_NSK_22	0.02254	-90.78234	30	1		2	2	2	1		
AT50-09_CTD02_NSK_23	0.02254	-90.78236	0	1	1	2	2	2	1	7	
AT50-09_CTD03_NSK_01	0.45516	-90.76434	1237								1
AT50-09_CTD03_NSK_02	0.45516	-90.76434	1237								1
AT50-09_CTD03_NSK_03	0.4551551	-90.76434	1237	1	1	2	2	2	1		
AT50-09_CTD03_NSK_04	0.45514	-90.76434	1199	1		2	2	2	1		
AT50-09_CTD03_NSK_05	0.45516	-90.76434	1101	1	1	2	2	2	1		
AT50-09_CTD03_NSK_06	0.45516	-90.76434	1000	1	1	2	2	2	1		
AT50-09_CTD03_NSK_07	0.45516	-90.76434	905	1	1	2	2	2	1		
AT50-09_CTD03_NSK_08	0.45516	-90.76434	805	1	1	2	2	2	1		
AT50-09_CTD03_NSK_09	0.45516	-90.76434	805								
AT50-09_CTD03_NSK_10	0.45516	-90.76434	704	1		2	2	2	1		
AT50-09_CTD03_NSK_11	0.45516	-90.76434	704								
AT50-09_CTD03_NSK_12	0.45514	-90.76434	634	1	1	2	2	2	1		
AT50-09_CTD03_NSK_13	0.45515878	-90.76434	634								
AT50-09_CTD03_NSK_14	0.45516	-90.76434	503	1	1	2	2	2	1		
AT50-09_CTD03_NSK_15	0.45516	-90.76434	402	1	1	2	2	2	1		
AT50-09_CTD03_NSK_16	0.45516	-90.76434	352	1		2	2	2	1		
AT50-09_CTD03_NSK_17	0.45516	-90.76434	352								
AT50-09_CTD03_NSK_18	0.45516	-90.76434	272	1	1	2	2	2	1		
AT50-09_CTD03_NSK_19	0.45516	-90.76434	212	1		2	2	2	1		

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD03_NSK_20	0.45516	-90.76434	103	1	1	2	2	2	1		
AT50-09_CTD03_NSK_21	0.45514612	-90.76434	52	1	1	2	2	2	1		
AT50-09_CTD03_NSK_22	0.45516	-90.76434	32	1		2	2	2	1		
AT50-09_CTD03_NSK_23	0.45516	-90.76434	4	1	1	2	2	2	1	7	
AT50-09_CTD04_NSK_01	-0.55	-89.967895	705								1
AT50-09_CTD04_NSK_02	-0.55	-89.9679	705								1
AT50-09_CTD04_NSK_03	-0.55	-89.9679	705	1	1	2	2	2	1		
AT50-09_CTD04_NSK_04	-0.55	-89.9679	649	1		2	2	2	1		
AT50-09_CTD04_NSK_05	-0.55	-89.9679	649								
AT50-09_CTD04_NSK_06	-0.55	-89.9679	600	1	1	2	2	2	1		
AT50-09_CTD04_NSK_07	-0.55	-89.967896	600								
AT50-09_CTD04_NSK_08	-0.55	-89.9679	560	1	1	2	2	2	1		
AT50-09_CTD04_NSK_09	-0.55	-89.9679	560								
AT50-09_CTD04_NSK_10	-0.55	-89.9679	451	1	1	2	2	2	1		
AT50-09_CTD04_NSK_11	-0.55	-89.96788	451								
AT50-09_CTD04_NSK_12	-0.55	-89.9679	401	1	1	2	2	2	1		
AT50-09_CTD04_NSK_13	-0.55	-89.9679	401								
AT50-09_CTD04_NSK_14	-0.55	-89.967884	350	1	1	2	2	2	1		
AT50-09_CTD04_NSK_15	-0.55	-89.9679	350								
AT50-09_CTD04_NSK_16	-0.55	-89.96788	261	1		2	2	2	1		
AT50-09_CTD04_NSK_17	-0.55002	-89.96788	261								
AT50-09_CTD04_NSK_18	-0.54998	-89.96788	200	1	1	2	2	2	1		

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD04_NSK_19	-0.54998	-89.96788	200								
AT50-09_CTD04_NSK_20	-0.5499878	-89.96788	102	1	1	2	2	2	1		
AT50-09_CTD04_NSK_21	-0.55	-89.96788	52	1	1	2	2	2	1		
AT50-09_CTD04_NSK_22	-0.55	-89.96788	32	1		2	2	2	1		
AT50-09_CTD04_NSK_23	-0.5500404	-89.96787	3	1	1	2	2	2	1	7	
AT50-09_CTD05_NSK_01	-0.50508	-89.07846	1219								1
AT50-09_CTD05_NSK_02	-0.50508	-89.07846	1219								1
AT50-09_CTD05_NSK_03	-0.50508	-89.07846	1219	1	1	1	1	1	1		
AT50-09_CTD05_NSK_04	-0.50508	-89.07846	1101	1				1	1		
AT50-09_CTD05_NSK_05	-0.50508	-89.07846	1050	1				1	1		
AT50-09_CTD05_NSK_06	-0.5051	-89.07846	1000	1	1	1	1	1	1		
AT50-09_CTD05_NSK_07	-0.5051	-89.07846	1000	1							
AT50-09_CTD05_NSK_08	-0.50508	-89.07846	901	1				1	1		
AT50-09_CTD05_NSK_09	-0.50508	-89.07846	800	1	1	1	1	1	1		
AT50-09_CTD05_NSK_10	-0.50508	-89.07846	800								
AT50-09_CTD05_NSK_11	-0.50508	-89.07846	701	1				1	1		
AT50-09_CTD05_NSK_12	-0.50508	-89.07846	701								
AT50-09_CTD05_NSK_13	-0.5051	-89.07846	501	1	1	1	1	1	1		
AT50-09_CTD05_NSK_14	-0.5050976	-89.07846	420	1				1	1		
AT50-09_CTD05_NSK_15	-0.50508	-89.07846	361	1	1	1	1	1	1		
AT50-09_CTD05_NSK_16	-0.50508	-89.07846	361								
AT50-09_CTD05_NSK_17	-0.50508	-89.07846	300	1				1	1		

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD05_NSK_18	-0.50508	-89.07846	202	1	1	1	1	1	1		
AT50-09_CTD05_NSK_19	-0.50508	-89.07846	140	1				1	1		
AT50-09_CTD05_NSK_20	-0.50508	-89.07846	102	1	1	1	1	1	1		
AT50-09_CTD05_NSK_21	-0.50508	-89.07846	102								
AT50-09_CTD05_NSK_22	-0.50508	-89.07846	33	1				1	1		
AT50-09_CTD05_NSK_23	-0.5050857	-89.07846	3	1	1	1	1	1	1	7	
AT50-09_CTD06_NSK_01	-1.23278	-89.6825	596								1
AT50-09_CTD06_NSK_02	-1.23278	-89.6825	596								
AT50-09_CTD06_NSK_03	-1.23278	-89.6825	596	1	1	1	1	1	1		
AT50-09_CTD06_NSK_04	-1.23278	-89.6825	452	1		1	1	1	1		
AT50-09_CTD06_NSK_05	-1.23278	-89.6825	452								
AT50-09_CTD06_NSK_06	-1.23278	-89.6825	452								
AT50-09_CTD06_NSK_07	-1.23278	-89.6825	360	1	1	1	1	1	1		
AT50-09_CTD06_NSK_08	-1.23278	-89.6825	360								
AT50-09_CTD06_NSK_09	-1.23278	-89.6825	360								
AT50-09_CTD06_NSK_10	-1.23278	-89.6825	250	1	1	1	1	1	1		
AT50-09_CTD06_NSK_11	-1.23278	-89.6825	250								
AT50-09_CTD06_NSK_12	-1.23278	-89.6825	250								
AT50-09_CTD06_NSK_13	-1.23278	-89.6825	201	1		1	1	1	1		
AT50-09_CTD06_NSK_14	-1.23278	-89.6825	201								
AT50-09_CTD06_NSK_15	-1.23278	-89.6825	201								
AT50-09_CTD06_NSK_16	-1.23278	-89.6825	100	1	1	1	1	1	1		

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD06_NSK_17	-1.23278	-89.6825	100								
AT50-09_CTD06_NSK_18	-1.23278	-89.6825	100								
AT50-09_CTD06_NSK_19	-1.23278	-89.6825	52	1		1	1	1	1		
AT50-09_CTD06_NSK_20	-1.23278	-89.6825	52								
AT50-09_CTD06_NSK_21	-1.23278	-89.6825	2		1	1	1	1	1		
AT50-09_CTD06_NSK_22	-1.23278	-89.6825	2	1							
AT50-09_CTD06_NSK_23	-1.23278	-89.6825	2							7	
AT50-09_CTD07_NSK_01	-1.39766	-90.70388	2392								1
AT50-09_CTD07_NSK_02	-1.39766	-90.70388	2392								1
AT50-09_CTD07_NSK_03	-1.3976478	-90.70388	2392	1	1	1	1	1	1		
AT50-09_CTD07_NSK_04	-1.3976461	-90.70388	2392								
AT50-09_CTD07_NSK_05	-1.39768	-90.70388	2204	1		1	1	1	1		
AT50-09_CTD07_NSK_06	-1.39766	-90.70388	2000	1		1	1	1	1		
AT50-09_CTD07_NSK_07	-1.39766	-90.70388	1800	1		1	1	1	1		
AT50-09_CTD07_NSK_08	-1.39766	-90.70388	1603	1	1	1	1	1	1		
AT50-09_CTD07_NSK_09	-1.39766	-90.70388	1403	1		1	1	1	1		
AT50-09_CTD07_NSK_10	-1.3976739	-90.70388	1203	1		1	1	1	1		
AT50-09_CTD07_NSK_11	-1.39766	-90.70388	1001	1	1	1	1	1	1		
AT50-09_CTD07_NSK_12	-1.39766	-90.70388	801	1		1	1	1	1		
AT50-09_CTD07_NSK_13	-1.39766	-90.70388	603	1		1	1	1	1		
AT50-09_CTD07_NSK_14	-1.39766	-90.70388	501	1	1	1	1	1	1		
AT50-09_CTD07_NSK_15	-1.39766	-90.70386	402	1		1	1	1	1		

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD07_NSK_16	-1.39766	-90.70386	351	1	1	1	1	1	1		
AT50-09_CTD07_NSK_17	-1.39766	-90.70386	351								
AT50-09_CTD07_NSK_18	-1.39766	-90.70386	300	1		1	1	1	1		
AT50-09_CTD07_NSK_19	-1.39766	-90.70386	200	1	1	1	1	1	1		
AT50-09_CTD07_NSK_20	-1.39766	-90.70386	101	1		1	1	1	1		
AT50-09_CTD07_NSK_21	-1.3976731	-90.703864	53	1	1	1	1	1	1		
AT50-09_CTD07_NSK_22	-1.39776	-90.703993	3	1	1	1	1	1	1		
AT50-09_CTD07_NSK_23	-1.39778	-90.704	3							7	
AT50-09_CTD08_NSK_01	0.23756	-91.80715	2392								1
AT50-09_CTD08_NSK_02	0.23756	-91.807144	2392								1
AT50-09_CTD08_NSK_03	0.23756	-91.80714	2392	1	1	1	1	1	1		
AT50-09_CTD08_NSK_04	0.23758	-91.807152	2392	1		1	1	1	1		
AT50-09_CTD08_NSK_05	0.23756	-91.80714	2204	1		1	1	1	1		
AT50-09_CTD08_NSK_06	0.23756	-91.80714	2000	1	1	1	1	1	1		
AT50-09_CTD08_NSK_07	0.23758	-91.807148	1800	1		1	1	1	1		
AT50-09_CTD08_NSK_08	0.23756	-91.80714	1603	1		1	1	1	1		
AT50-09_CTD08_NSK_09	0.23757	-91.807147	1403	1	1	1	1	1	1		
AT50-09_CTD08_NSK_10	0.23756	-91.80714	1203	1		1	1	1	1		
AT50-09_CTD08_NSK_11	0.23756	-91.80714	1001	1		1	1	1	1		
AT50-09_CTD08_NSK_12	0.23756	-91.80716	801	1	1	1	1	1	1		
AT50-09_CTD08_NSK_13	0.23756	-91.80714	603	1		1	1	1	1		
AT50-09_CTD08_NSK_14	0.23756	-91.80716	501	1		1	1	1	1		

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD08_NSK_15	0.23756	-91.807145	402	1	1	1	1	1	1		
AT50-09_CTD08_NSK_16	0.23756	-91.80716	351	1		1	1	1	1		
AT50-09_CTD08_NSK_17	0.23758	-91.80714	351	1	1	1	1	1	1		
AT50-09_CTD08_NSK_18	0.23756	-91.80714	300	1		1	1	1	1		
AT50-09_CTD08_NSK_19	0.23756	-91.80714	200	1	1	1	1	1	1		
AT50-09_CTD08_NSK_20	0.23756	-91.80714	101	1	1	1	1	1	1		
AT50-09_CTD08_NSK_21	0.23757	-91.80716	53	1		1	1	1	1		
AT50-09_CTD08_NSK_22	0.23758	-91.80614	3	1		1	1	1	1		
AT50-09_CTD08_NSK_23	0.23758	-91.80554	3	1	1	1	1	1	1	7	
AT50-09_CTD09_NSK_01	-0.73038	-91.64888	2917								1
AT50-09_CTD09_NSK_02	-0.73038	-91.64888	2917								1
AT50-09_CTD09_NSK_03	-0.73038	-91.64888	2917	1	1	1	1	1	1		
AT50-09_CTD09_NSK_04	-0.73038	-91.64888	2703	1	1	1	1	1	1		
AT50-09_CTD09_NSK_05	-0.73038	-91.648873	2402	1		1	1	1	1		
AT50-09_CTD09_NSK_06	-0.73038	-91.64888	2102	1	1	1	1	1	1		
AT50-09_CTD09_NSK_07	-0.73038	-91.64888	1802	1		1	1	1	1		
AT50-09_CTD09_NSK_08	-0.73038	-91.64888	1501	1	1	1	1	1	1		
AT50-09_CTD09_NSK_09	-0.73038	-91.648876	1302	1		1	1	1	1		
AT50-09_CTD09_NSK_10	-0.73038	-91.64888	1101	1	1	1	1	1	1		
AT50-09_CTD09_NSK_11	-0.73038	-91.64888	1002	1		1	1	1	1		
AT50-09_CTD09_NSK_12	-0.73038	-91.64888	901	1	1	1	1	1	1		
AT50-09_CTD09_NSK_13	-0.73038	-91.648865	801	1		1	1	1	1		

Niskin ID	Event latitude (dec. deg.)	Event longitude (dec. deg.)	Event depth (m)	Carbonate	$\Delta^{14}C$	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$	Surface sample	eDNA
AT50-09_CTD09_NSK_14	-0.73038	-91.64888	701	1	1	1	1	1	1		
AT50-09_CTD09_NSK_15	-0.73038	-91.64888	601	1		1	1	1	1		
AT50-09_CTD09_NSK_16	-0.73038	-91.64888	500	1	1	1	1	1	1		
AT50-09_CTD09_NSK_17	-0.73038	-91.64888	400	1	1	1	1	1	1		
AT50-09_CTD09_NSK_18	-0.73038	-91.64888	300	1	1	1	1	1	1		
AT50-09_CTD09_NSK_19	-0.73038	-91.64888	200	1		1	1	1	1		
AT50-09_CTD09_NSK_20	-0.73038	-91.648862	97	1	1	1	1	1	1		
AT50-09_CTD09_NSK_21	-0.73068	-91.6486	71	1		1	1	1	1		
AT50-09_CTD09_NSK_22	-0.73157	-91.64824	52	1	1	1	1	1	1		
AT50-09_CTD09_NSK_23	-0.73258	-91.647781	3	1	1	1	1	1	1	9	

Table 6. Water sampling from the 5-L Niskin on Alvin's basket. On dive 5158, the Niskin bottle malfunctioned and was empty when brought to the surface. This was an isolated incident which didn't occur again. On two other dives, Niskin water was not collected.

Alvin dive	Time (UTC)	Depth (m)	Equipment code	Latitude (dec. deg.)	Longitude (dec. deg.)	Temp (^oC)
AL5155	3/29/23 16:01	503	NSK	-0.3798762	-90.8172197	8.21
AL5156	3/29/23 23:10	469	NSK	-0.3782647	-90.8177974	8.47
AL5157	3/30/23 19:50	1169	NSK	-0.062977	-90.8814393	3.74
AL5159	4/1/23 17:16	753	NSK	0.4598552	-90.7035426	6.27
AL5160	4/2/23 19:08	2625	NSK	0.0075486	-91.0160687	1.88
AL5161	4/3/23 19:12	516	NSK	0.4618999	-90.7123299	7.66
AL5162	4/4/23 19:26	474	NSK	-0.5056116	-89.9394362	8.29
AL5163	4/5/23 18:45	1028	NSK	-0.5998626	-89.2027351	4.5
AL5164	4/6/23 17:49	340	NSK	-0.7134966	-89.1476926	11.65
AL5165	4/7/23 16:45	3214	NSK	-1.8252803	-90.1988168	1.79
AL5166	4/8/23 14:59	665	NSK	-1.3470534	-89.8949897	6.86
AL5167	4/9/23 16:16	3436	NSK	-1.4893384	-90.7216708	1.81
AL5168	4/10/23 21:14	2737	NSK	-1.4348985	-90.7350301	1.79
AL5169	4/11/23 20:18	549	NSK	-1.2237086	-90.7039086	7.88
AL5170	4/12/23 16:01	2701	NSK	-1.2255085	-91.1070347	1.83
AL5171	4/13/23 23:01	716	NSK	0.3057456	-91.6298789	6.38
AL5172	4/14/23 20:06	655	NSK	-0.8913707	-91.5342594	6.61
AL5173	4/15/23 18:45	503	NSK	-0.5710454	-91.35595	8.07
AL5174	4/16/23 16:41	745	NSK	-0.2957605	-91.6930179	6.11

Table 7. Locations of MC400 multicore 5-L Niskin and ALVIN push core core-top water samples.

Multicore	Type	Sample	Latitude (dec. deg.)	Longitude (dec. deg.)	Depth (m)	Time (UTC)	Coretop sampled?
MC01	NSK	AT50-09_MC01_NSK_01	0.211964	-90.8802	2946	03/04/2023 03:24	
MC02	NSK	AT50-09_MC02_NSK_01	-0.5502	-89.9679	715	04/04/2023 23:15	
MC03	NSK	AT50-09_MC03_NSK_01	-0.50535	-89.078	1228	06/04/2023 00:43	
MC04	NSK	AT50-09_MC04_NSK_01	-1.23265	-89.6822	600.93	08/04/2023 07:54	Yes
MC05	NSK	AT50-09_MC05_NSK01	-1.3973	-90.703	2402	11/04/2023 02:32	
MC06	NSK	AT50-09_MC06_NSK01	-0.73023	-91.6487	2929	16/04/2023 01:51	
MC07	NSK	AT50-09_MC07_NSK01	-0.1901	-91.608	2337	16/04/2023 08:30	
MC08	NSK	AT50-09_MC08_NSK01	0.0933	-91.7788	3226	17/04/2023 08:17	Yes
MC09	NSK	AT50-09_MC09_NSK01	-0.06976	-90.4008	1710	18/04/2023 08:35	Yes
Alvin5160 PC2	Core top	AT50-09_ALVIN5160_ev2	0.014505	-91.0176	2699	02/04/2023 16:51	Yes
Alvin5160 PC3	Core top	AT50-09_ALVIN5160_ev10	0.007548	-91.0161	2624.89	02/04/2023 19:02	Yes

9. Sediment Sampling

9.1. Overview of sediment operations

To characterize the marine sediments of the deep Galápagos Platform seafloor, two coring operations occurred through the expedition: 1) push cores (up to 35 cm) collected during *Alvin* dives, and 2) multicores (up to 65 cm) collected using a MC400 multicorer deployed using the ship's CTD conducting cable during evening/night operations in targeted locations between *Alvin* dives. Push cores have 50 mm diameters, and individual multicores have 100 mm diameters.

During the expedition, nine successful multicore operations collected 34 individual cores, and 40 successful push cores were obtained over the 21 *Alvin* dives (Figure 44). Push cores spanned a depth range of 170 m – 3440 m, and multicores 601 m – 3226 m, with sediment depth ranges of 5 cm – 28 cm and 9 cm – 38 cm respectively. Both push cores and multicores were either sealed and preserved to maintain stratigraphy or sliced appropriately for subsequent grain componentry and geochemical analysis.

All sediment cores will be studied at the University of Bristol with the following aims: i) characterizing grain size and componentry to obtain Galápagos sedimentation history; ii) radiocarbon- or U/Th-dating of foraminifera within sediment, and collection of oxygen and carbon isotope ratios to assess changes in seafloor/benthic environments and how they correlate to current seawater coral paleoclimate records; and iii) to look for evidence of historic volcanic eruptions/activity within potential volcanic ash layers.

9.2. Push core operations and sampling procedure

Every *Alvin* dive had the potential to collect four separate push cores from seafloor sediment – four push cores were attached to the *Alvin* front basket alongside the other crates and boxes used for larger sample collection (Figure 39). Every push core had the potential to collect up to 35 cm of sediment and trap the core top water, in addition to the firing of the 5L Niskin bottle attached to *Alvin* for each dive. It was recommended that push cores be collected in pairs at the same site, to allow one to be preserved and one to be sliced, and for contingency in case one failed. This potentially gave *Alvin* observers two opportunities to collect representative sediments per dive. Target sites for push cores were prioritized through a combination of: characterizing the depth range of the dive, high quality sediment for coring (flat, thick and continuous), and – if found next to an abundance of live and fossil corals – to capture the local sedimentary environment surrounding coral growth cycles.

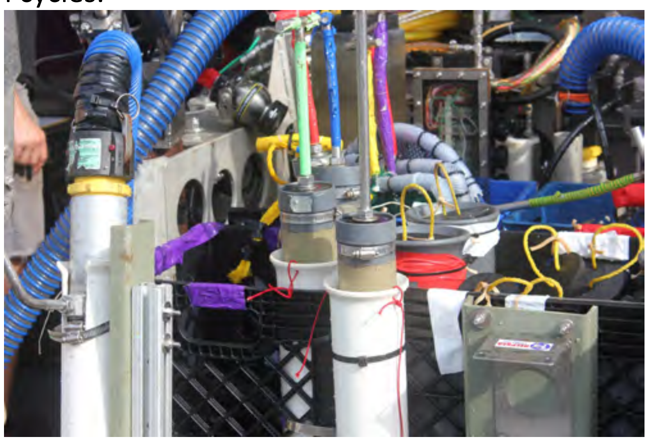


Figure 39. Push cores full of sediment on the Alvin *basket after a successful dive.*

Push cores were collected using *Alvin's* manipulator by grasping the T-handles attached to the top of the push core, then placing and pushing firmly and vertically into sediment that appeared relatively thick and continuous in the local area (Figure 40). After allowing any turbid waters to settle, or be moved away by currents, push cores were slowly removed from the sediment and placed back into their holders on the *Alvin* basket where a fixed rubber stopper fully sealed the base of the collected cores. Once back on deck, the push cores were carefully removed from *Alvin's* basket and processed in the "wet lab" (Figure 41).

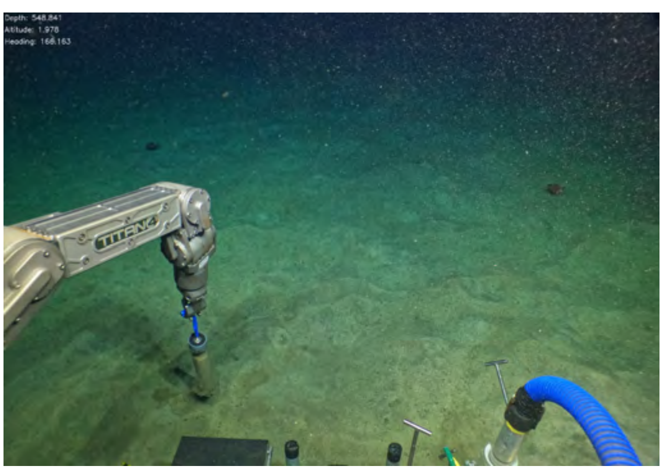


Figure 40. Push core sampling using the Alvin manipulator yielded a successful core with 25cm+ of sediment on dive AL5169 at 548 m depth (see Figures 4 and 44 for dive location).

Push cores from each dive were labeled using the metadata format: ALXXXX_PCY, (e.g., AL5155_PC1), with XXXX corresponding to *Alvin* dive number, and Y corresponding to push core number order on each dive. Each core was also assigned an individual continuous push core number starting at PC001. In most cases, 2 push cores were taken at each location. For each pair, one was preserved and the other sliced at 1cm intervals using a “core extruder” (Figure 40). Top water was removed from all cores using a siphon, and then syringe. For cores where there was interest in core-top water sampling for geochemical analysis (radiocarbon, carbon and silicon isotopes, carbonate, and nutrients – see Water Sampling section 8) , this water was sampled using a pump. Preserved cores were sealed at both ends, photographed, depth measured, described in detail in core log sheets, and then refrigerated for the remainder of the expedition. Sliced cores were bagged and refrigerated, but also photographed and described prior to slicing. The core chosen to be preserved from each pair had the best combination of deepest sediment and best quality, horizontal stratigraphy.

Figure 41. Extruding and slicing of push cores occurred in the Wet Lab on R/V Atlantis.

9.3. MC400 multicore operations and sampling procedure

Multicores were collected during evening and nighttime operations in select locations through the expedition – nine sites were chosen to characterize the Galápagos Platform and the influencing currents on all sides. All nine operations successfully collected sediment cores. The MC400 multicore system was deployed using the 0.322" CTD conducting cable with the assistance and guidance of the Atlantis' onboard technical team (shipboard scientific support group -SSSG) and crew. The multicorer had an attached 5-L water sampling Niskin bottle, which simultaneously fired when the core tubes made contact with the seafloor, hence it represents very near-bottom water. The MC400 also was outfitted with a SBE19plusV2 CTD profiler that provided water properties data transmitted up the CTD cable, a USBL system for navigational positioning, and down-looking 24MP MISO digital still camera and 300 watt/s strobe to collect still images every ~7 seconds continuously during the descent, hovering above the seafloor prior to impact, and ascent – for visual observation and confirmation of existence of suitable seafloor sediment (i.e., no rock/lava outcrops) (Figure 42).

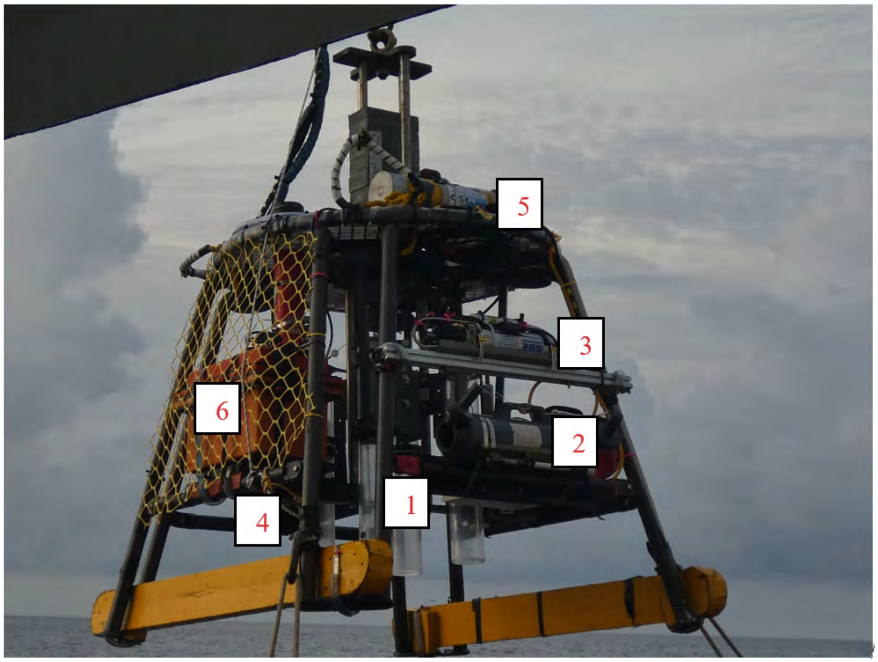


Figure 42 – MC400 Multicore as configured on AT50-09. 1: core tube, 2: 5-L Niskin bottle, 3: CTD, 4: MISO 24MP downlooking-camera, 5: strobe electronics, 6: 24VDC deep-sea battery.

General multicore site locations were best chosen to cover the edges of the entire platform and different depth intervals related to the corresponding *Alvin* dives and CTD stations. Six multicore operations were paired with a full CTD rosette and water sampling deployment. The exact location coordinates for each multicore were chosen through assessing: water depth, newly collected multibeam bathymetry, sidescan sonar, and sub-bottom acoustic echosounder data. Multicore locations were selected based on the following criteria: i. scientifically-targeted depth for that location, ii. flat (as resolved by bathymetry), iii. smooth (as resolved by sidescan), and iv. soft (acoustic profiler). Final confirmation of the presence of sediment was achieved using the real-time low-resolution image from the down-looking MISO camera, which successfully confirmed sediment at all locations. Four individual cores were fixed onto the MC400; only two operations collected less than four successful multicores.

The multicorer was tethered and launched from the starboard deck using the winch, and gently lowered into the water while the ship held position (Figure 43). The multicorer was lowered at a rate of ~30m/min and raised at a rate of ~40m/min once sediments were collected, hence operations took anywhere between 1 – 4 hours depending on seafloor depth. Upon approaching the seafloor, descent rate was lowered to approach the seafloor steadily allowing for MISO imagery (every 7 seconds) to confirm presence of sediment. The multicore was then raised slightly (up to ~10-20 m) and then lowered into the sediment at ~15m/min speed, allowing for the weight of the coring rig to slowly push the open four multicores into the sediment. After 4-5 minutes on bottom, the MC400 was raised triggering the sealing arms and spring-loaded top to swing down and close the top and bottom of each multicore tube. The MC400 was then hauled back to the surface and recovered onto the starboard deck. Each core was removed from and taken into the wet lab to be processed using similar protocols for *Alvin* push core operations.

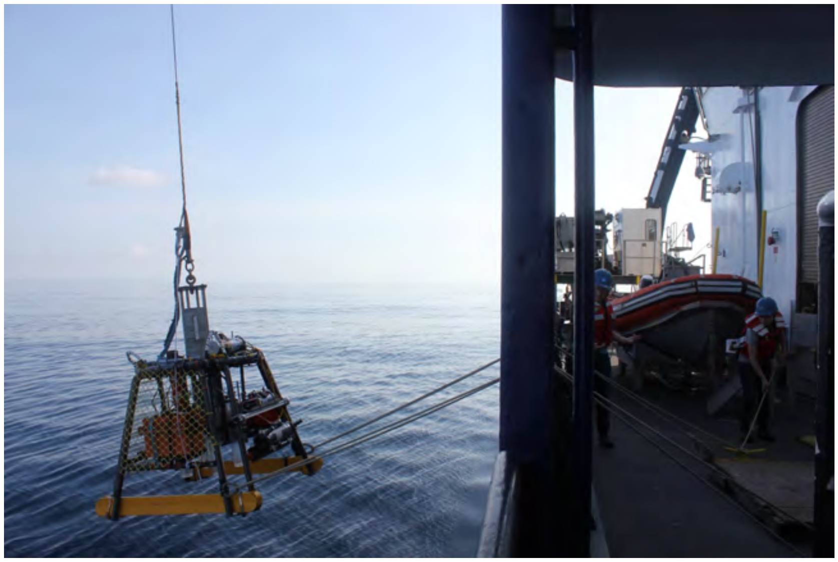


Figure 43. Deployment of MC400 multicorer off R/V Atlantis' starboard deck using the CTD winch.

Multicores from each lowering were labeled using a metadata format: MCXX_Y, (e.g. MC02_1), with XX corresponding to station number, and Y corresponding to core tube number (1-4). Each core was also assigned an individual sequential multicore number starting at MC001. For each multicore, one was preserved, one sliced at 1 cm intervals using a “core extruder”, and the remaining two cores sliced at 1cm intervals for the first 5 cm, then broader intervals for the rest of the core. Top water was removed from all cores using a siphon, and then syringe. For cores where there was interest in core-top water sampling for geochemical analysis (e.g., radiocarbon, carbon and silicon isotopes, carbonate, and nutrients – see Water Sampling Section), this water was sampled using a pump. Preserved cores were sealed at both ends, photographed, depth measured, described in detail in core log sheets, and then refrigerated for the remainder of the expedition. Sliced cores were bagged and refrigerated, but also photographed and described prior to slicing. The core chosen to be preserved from each multicore had the best combination of deepest sediment and best quality, horizontal stratigraphy; the core chosen for entirely 1 cm slicing, was the second-best quality core as per the prior described attributes.

9.4. Core descriptions

Push cores and multicores were described using the same format of core description log sheets, for consistency in depth-scaled observations. Each core was categorized by depth, layers, lithology and componentry (drawn), grain size (mud, silt, fine/medium/coarse sand, granules), color, and noting of any other sedimentary structures or interesting features (life, bioturbation, normal/reverse grading, presence of tephra horizons). Each core sheet was also assigned a core number, water depth, latitude and longitude.

Core descriptions were divided into layers as characterized by distinct changes in color, grain size and/or grain componentry (the rock type). These changes were reflected in the sketch of the cores themselves. An overall description was completed for each core (Figure 44), and then each layer characterized by color, grain size, grain componentry and proportions, and additional sedimentary structures/features. All core description hard copies are scanned and will be taken to the University of Bristol. All push cores have been refrigerated, and all multicores frozen for storage until delivery to the University of Bristol, where they will be stored in a large cold room.

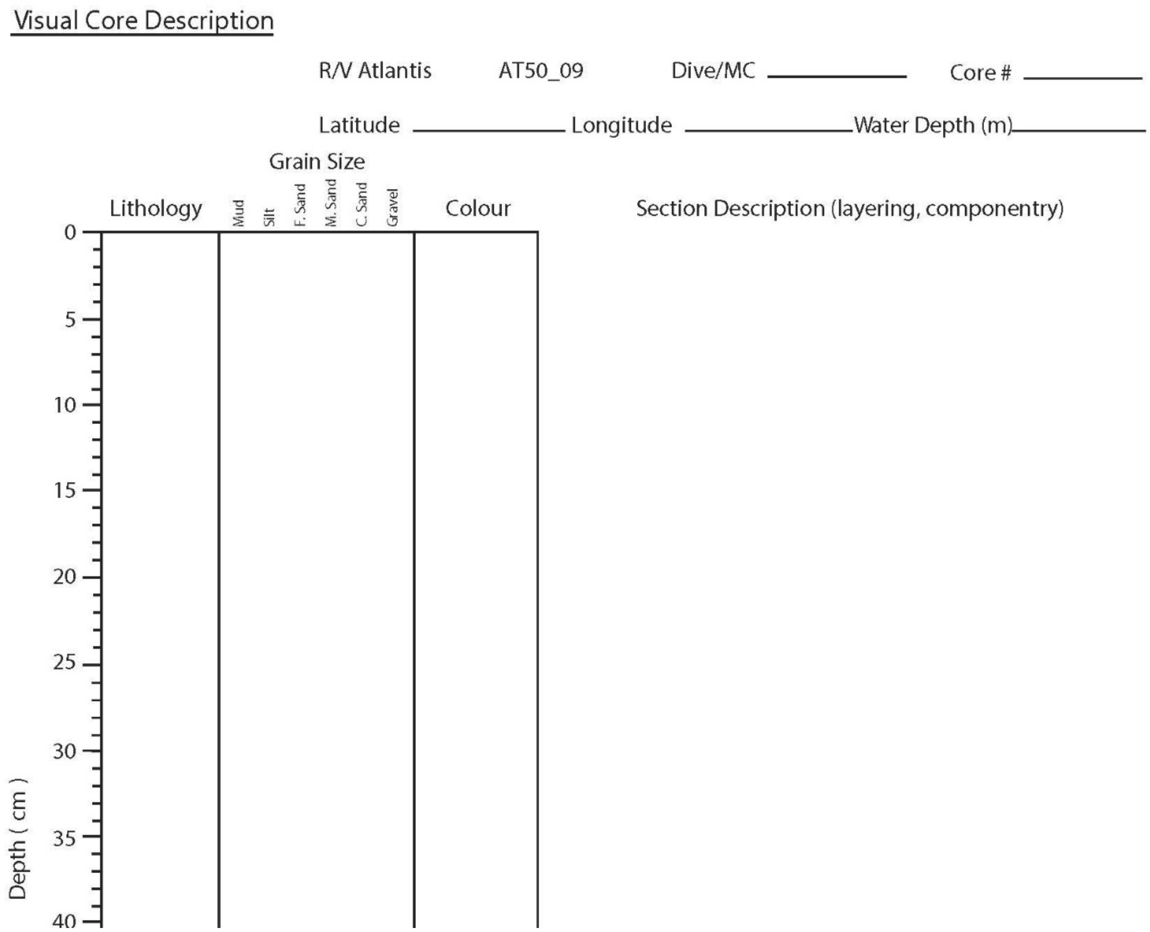


Figure 44. Coring description log sheet used during AT50-09.

9.5. Coring locations

Push cores were successfully collected from all *Alvin* dives except for AL5155,-56,-58,-61,-64,-71, and -74; some dive sites are not always suitable for push core sampling – thin (or complete lack of) sediment cover, coarse unconsolidated sediment cover that does not hold in the core, uneven ground, and/or hard rock substrate (Figure 45). 34 push cores were successfully recovered in 15 dives over a depth range of 170 – 3440 m, averaging 1610 m, and a preserved sediment thickness range of 5 – 28 cm, averaging 18 cm. Push core coverage across the platform reflects the coverage of the *Alvin* dives (Figure 45).

Multicores were successfully collected through nine operations in nine locations from all sides of the platform over a depth range of 601 – 3226 m, averaging 2012 m, and a preserved sediment thickness range of 9 – 38 cm, averaging 23 cm. Only two cores (MC02_4 and MC03_4) did not collect any sediment or water due to a loose capping arm. Multicore coverage was found across the platform – three in the west, two in the south, one in the east and three in the north. The three northern multicores cover a NW-SE-trending depth transect north of Isla Santiago and Santa Cruz at depths of 2946, 1710 and 715 m. Each multicore operation (except for MC01, MC07, MC09) has paired CTD-water sampling operations from other nights of the expedition. However, all multicores acquired successful descent and ascent CTD profiles from the CTD attached to the multicore rig.

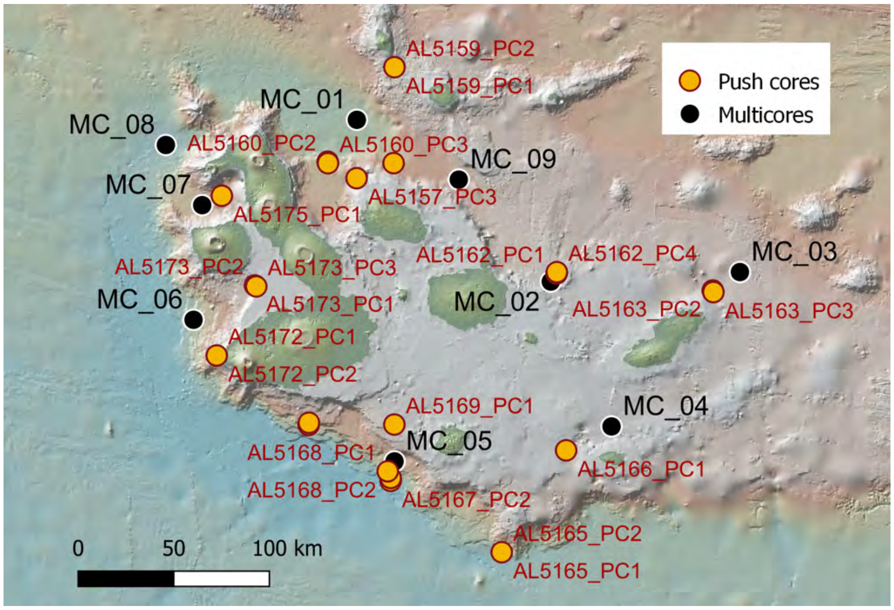


Figure 45. Map of Galápagos platform with multicore (MC0X) and push core locations as indicated by Alvin *dive numbers (AL51XX_PCY).*

9.6. Preliminary shipboard results, & observations

Sediment core analysis will primarily be conducted within the University of Bristol's - *Ocean Past and Present Research Group*. However, some preliminary initial findings and observations were made when describing the cores onboard.

The cores sampled a large range of sediment types and grain sizes, from very muddy, well-bound, fine-grained cores to coarse unconsolidated cores of sand and fossil coral rubble. Many of the deeper cores had a distinct or observable transition in color from brown to grey/green, marking the oxic horizon of the sediment. This layer was usually thicker in the deeper cores (maximum 8 cm down-core depth). These oxic-anoxic transition and their depth can be matched to the CTD profiles from these locations to see how they match with the ocean oxygen concentration profile and location of the oxygen minimum profile. Cores from deeper depths were generally found to be more muddy than sandy. Very few cores had sharp distinct changes in sedimentary layers; most were relatively homogeneous in grain type size and componentry proportion.

There were some notable additional findings in a few select cores (see Figure 46-48) including the following:

1. **Bioturbation –** in the form of sinuous tubes through the sediment, best observed where an upper brown oxic layer was turbated into the underlying older grey anoxic sediment. These features indicate the presence of burrowing benthic organisms into the sediments at this depth and location. The organisms may be indirectly identifiable based on the morphology of the bioturbation itself.
2. **Tephra horizons** – dives AL5160, AL5175, and multicore operation MC07 contained possible layers of tephra that might mark the record of singular volcanic eruptions from nearby islands of either Santiago, Isabella, or Fernandina. These tephra horizons are possibly identifiable by the presence of almost entirely black, unconsolidated angular grains with no other interstitial componentry, and a distinct break in the general stratigraphy. These layers have the potential to be dated and geochemically analyzed to determine the source volcano and age of eruption.

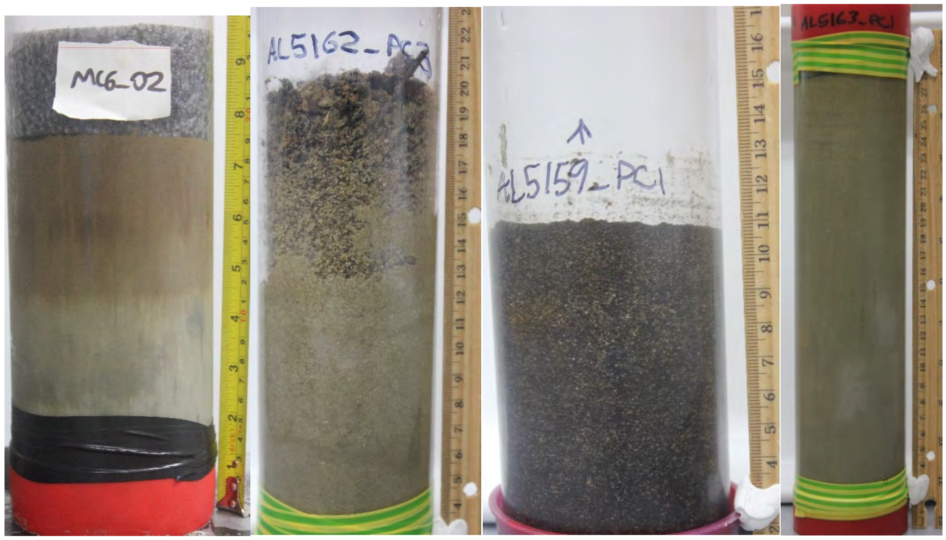


Figure 46. Range of sediments observed in cores collected during AT50-09. FL: multicore of brown to grey oxic-anoxic horizon; ML: push core of fossil coral rubble on top of finer sediment below; MR: push core of coarse unconsolidated volcanic and terrigenous sand; FR: push core of fully homogeneous marine silt, no observable layers or change in size or componentry.

3. **Presence of life** – Some push cores were carefully collected over small benthic organisms on top of the sediments – this was found to be the best way to preserve delicate small biological samples rather than using the *Alvin* manipulator or slurp. Biology sampled included: a xenophyophore in AL5170_PC3, type polychaetes on top and slightly burrowed into cores AL5173_PC1&2, a carnivorous sponge in AL5175_PC1 that was bound to the top 2 cm of substrate, a sea pen on top of AL5175_PC2, and a single *Flabellum* cup coral in the failed multicore of MC02_4 that contained no water or sediment, but a single fossil coral. All biological samples were carefully removed and processed in the cold room by the biology team.

Figure 47. TL: xenophyophore from top view, 35 mm in diameter; TR: polycheate, 40 mm in length; BL: carnivorous sponge with attached polycheates, 100 mm in height; BR: crinoid, 110 mm in height. All collected from the top of push cores.

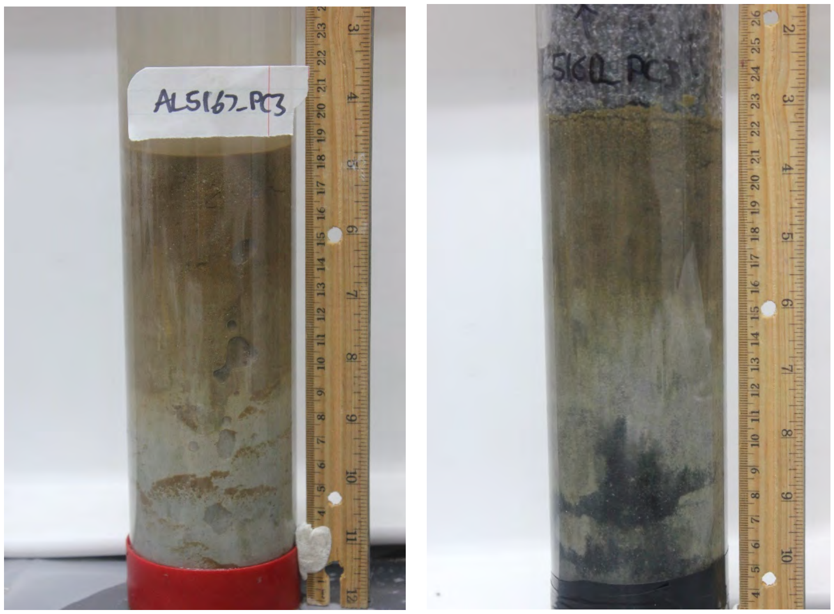


Figure 48. L: Bioturbation of brown oxic horizon; R: possible distinct volcanic black tephra horizon(s) with marine sediment above and below.

9.7. Coring metadata

Table 9. Multicore metadata information.

Timestamp Alvin_UTC	*Core name*	*Core log*	*Water depth (m)*	*Latitude*	*Longitude*	*Success?*	*Thickness (cm)*	*Sliced or preserved*
03/04/2023 03:19	MC01_1	MC001	2946.35	0.211964	-90.880244	Y	28	Preserved
03/04/2023 03:19	MC01_2	MC002	2946.35	0.211964	-90.880244	Y	29	Sliced
03/04/2023 03:19	MC01_3	MC003	2946.35	0.211964	-90.880244	Y	34	Sliced
03/04/2023 03:19	MC01_4	MC004	2946.35	0.211964	-90.880244	Y	32	Sliced
04/04/2023 23:15	MC02_1	MC005	715	-0.550196	-89.967894	Y	22	Sliced
04/04/2023 23:15	MC02_2	MC006	715	-0.550196	-89.967894	Y	23	Preserved
04/04/2023 23:15	MC02_3	MC007	715	-0.550196	-89.967894	Y	23	Sliced
04/04/2023 23:15	MC02_4	n/a	715	-0.550196	-89.967894	No collection	0	n/a
06/04/2023 00:44	MC03_1	MC008	1228	-0.505347	-89.078028	Y	17	Preserved
06/04/2023 00:44	MC03_2	MC009	1228	-0.505347	-89.078028	Y	15	Sliced
06/04/2023 00:44	MC03_3	MC010	1228	-0.505347	-89.078028	Y	14	Sliced
06/04/2023 00:44	MC03_4	n/a	1228	-0.505347	-89.078028	No collection	0	n/a
08/04/2023 07:54	MC04_1	MC011	601	-1.232654	-89.682150	Y	32	Sliced
08/04/2023 07:54	MC04_2	MC012	601	-1.232654	-89.682150	Y	32	Preserved
08/04/2023 07:54	MC04_3	MC013	601	-1.232654	-89.682150	Y	23	Sliced

Timestamp Alvin_UTC	Core name	Core log	Water depth (m)	Latitude	Longitude	Success?	Thickness (cm)	Sliced or preserved
08/04/2023 07:54	MC04_4	MC014	601	-1.232654	-89.682150	Y	34	Sliced
11/04/2023 02:32	MC05_1	MC015	2402	-1.397305	-90.702984	Y	30	Preserved
11/04/2023 02:32	MC05_2	MC016	2402	-1.397305	-90.702984	Y	30	Sliced
11/04/2023 02:32	MC05_3	MC017	2402	-1.397305	-90.702984	Y	29	Sliced
11/04/2023 02:32	MC05_4	MC018	2402	-1.397305	-90.702984	Y	29	Sliced
16/04/2023 01:59	MC06_1	MC019	2939	-0.730231	-91.648701	Y	14	Sliced
16/04/2023 01:59	MC06_2	MC020	2939	-0.730231	-91.648701	Y	19	Preserved
16/04/2023 01:59	MC06_3	MC021	2939	-0.730231	-91.648701	Y	9	Sliced
16/04/2023 01:59	MC06_4	MC022	2939	-0.730231	-91.648701	Y	13	Sliced
16/04/2023 08:30	MC07_1	MC023	2337	-0.190104	-91.607962	Y	23	Sliced
16/04/2023 08:30	MC07_2	MC024	2337	-0.190104	-91.607962	Y	35	Sliced
16/04/2023 08:30	MC07_3	MC025	2337	-0.190104	-91.607962	Y	38	Preserved
16/04/2023 08:30	MC07_4	MC026	2337	-0.190104	-91.607962	Y	26	Sliced
17/04/2023 08:17	MC08_1	MC027	3226	0.093300	-91.778817	Y	16	Sliced
17/04/2023 08:17	MC08_2	MC028	3226	0.093300	-91.778817	Y	18	Preserved
17/04/2023 08:17	MC08_3	MC029	3226	0.093300	-91.778817	Y	11	Sliced
17/04/2023 08:17	MC08_4	MC030	3226	0.093300	-91.778817	bottom lost (Y)	15	Sliced
18/04/2023 08:35	MC09_1	MC031	1710	-0.069785	-90.400777	Y	17	Sliced
18/04/2023 08:35	MC09_2	MC032	1710	-0.069785	-90.400777	Y	26	Preserved
18/04/2023 08:35	MC09_3	MC033	1710	-0.069785	-90.400777	Y	15	Sliced
18/04/2023 08:35	MC09_4	MC034	1710	-0.069785	-90.400777	Y	23	Sliced

Table 10. Alvin Push core data.

Timestamp Alvin_UTC	*Core name*	*Core log*	*Water depth (m)*	*Latitude*	*Longitude*	*Success?*	*Thickness (cm)*	*Sliced or preserved*
30/03/2023 19:54	AL5157_PC1	PC001	1170	-0.0629793	-90.8814345	Y	26	Preserved
30/03/2023 19:58	AL5157_PC2	PC002	1170	-0.0629743	-90.8814377	Y	24	Sliced
30/03/2023 20:00	AL5157_PC3	PC003	1170	-0.0629757	-90.8814336	Y	25	Sliced
01/04/2023 17:10	AL5159_PC1	PC004	183.53	0.4598586	-90.7035396	Y	11	Preserved
01/04/2023 17:15	AL5159_PC2	PC005	170.21	0.4598576	-90.7035399	Bottom lost (Y)	7	Sliced
02/04/2023 16:48	AL5160_PC1	PC006	2702	0.0145049	-91.0176381	Y	17	Preserved
02/04/2023 16:51	AL5160_PC2	PC007	2702	0.0145045	-91.0176376	Y	13	Sliced
02/04/2023 19:02	AL5160_PC3	PC008	2628	0.0075481	-91.0160854	Y	23	Preserved
02/04/2023 19:06	AL5160_PC4	PC009	2628	0.0075474	-91.0160749	Y	19	Sliced
04/04/2023 15:18	AL5162_PC1	n/a	599.61	-0.5121205	-89.9406852	N - lost	7	Lost
04/04/2023 15:24	AL5162_PC2	PC010	599.76	-0.5121251	-89.9406831	Y	19	Preserved
04/04/2023 19:21	AL5162_PC3	PC011	473.82	-0.5056054	-89.9394336	Y	21	Preserved
04/04/2023 19:26	AL5162_PC4	PC012	473.71	-0.5056116	-89.9394362	Y	20	Sliced
05/04/2023 15:15	AL5163_PC1	PC013	1167.41	-0.5922193	-89.2059238	Y	28	Preserved
05/04/2023 15:16	AL5163_PC2	PC014	1167.46	-0.5922186	-89.2059265	Y	27	Sliced
05/04/2023 18:39	AL5163_PC3	PC015	1027.79	-0.5998667	-89.2027365	Y	24	Preserved
05/04/2023 18:43	AL5163_PC4	PC016	1027.85	-0.5998688	-89.2027377	Y	25	Sliced
07/04/2023 16:34	AL5165_PC1	PC017	3214.16	-1.8252714	-90.1988245	Y	20	Sliced
07/04/2023 16:43	AL5165_PC2	PC018	3214.15	-1.825278	-90.1988178	Y	18	Preserved
08/04/2023 15:42	AL5166_PC1	PC019	695.94	-1.3453296	-89.8957589	Bottom lost (Y)	7	Sliced
08/04/2023 15:44	AL5166_PC2	PC020	695.88	-1.3453308	-89.8957603	Y	5	Preserved
09/04/2023 16:15	AL5167_PC1	PC021	3440	-1.4893396	-90.7216687	Y	18	Sliced
09/04/2023 16:14	AL5167_PC2	PC022	3440	-1.4893406	-90.7216663	Y	16	Preserved
09/04/2023 20:55	AL5167_PC3	PC023	3050	-1.4754184	-90.721055	Y	19	Sliced
09/04/2023 20:56	AL5167_PC4	PC024	3050	-1.4754187	-90.7210563	Y	24	Preserved
10/04/2023 17:46	AL5168_PC1	PC025	2892	-1.4439368	-90.7351731	Y	26	Preserved
10/04/2023 17:46	AL5168_PC2	PC026	2892	-1.4439368	-90.7351731	Y	18	Sliced
11/04/2023 20:20	AL5169_PC1	PC027	739	-1.2237085	-90.7039092	Y	19	Sliced

Timestamp Alvin_UTC	*Core name*	*Core log*	*Water depth (m)*	*Latitude*	*Longitude*	*Success?*	*Thickness (cm)*	*Sliced or preserved*
11/04/2023 20:21	AL5169_PC2	PC028	739	-1.2237081	-90.7039093	Y	23	Preserved
12/04/2023 15:55	AL5169_PC3	n/a	549	-1.2255084	-91.1070261	N - lost	n/a	Lost
12/04/2023 15:55	AL5169_PC4	PC029	549	-1.2255084	-91.1070261	Y	22	Preserved
12/04/2023 15:55	AL5170_PC1	PC030	2704	-1.2255084	-91.1070261	Y	16	Preserved
12/04/2023 15:55	AL5170_PC2	PC031	2704	-1.2255084	-91.1070261	Bottom lost (Y)	9	Sliced
12/04/2023 21:09	AL5170_PC3	PC032	2330	-1.215097	-91.1058112	Y	18	Preserved
n/a	AL5171_PC1	n/a	716			N - lost	0.1	A bit recovered
14/04/2023 14:55	AL5172_PC1	PC033	961	-0.898282	-91.5397688	Y	13	Preserved
14/04/2023 14:57	AL5172_PC2	n/a	961	-0.8982818	-91.5397697	N - lost	n/a	Lost
15/04/2023 15:36	AL5173_PC1	PC034	727	-0.5684261	-91.359559	Y	25	Preserved
15/04/2023 15:36	AL5173_PC2	PC035	727	-0.5684261	-91.359559	Y	18	Sliced
15/04/2023 20:38	AL5173_PC3	PC036	383	-0.573103	-91.3535562	Y	9	Preserved
17/04/2023 17:52	AL5175_PC1	PC037	1975	-0.1458577	-91.5156199	Y - Top 2cm lost	11	Sliced
17/04/2023 17:55	AL5175_PC2	PC038	1976	-0.1458573	-91.5156216	Y	13	Preserved
18/04/2023 17:29	Al5176_PC1	PC039	2225	0.0080245	-90.7075145	Possible contam-ination	23	Preserved
18/04/2023 17:29	Al5176_PC2	PC040	2225	0.0080245	-90.7075145	Possible contam-ination	22	Preserved

10. Rock sampling

10.1. Alvin Rock Sampling Summary

Basaltic lava was collected at 21 out of 22 Alvin dives, yielding a total of 134 samples (Table 11). Four samples of sedimentary rock were taken, including mudstone, chemically precipitated Mn-oxides, conglomerate, and breccia. All rocks were collected with the manipulators on *Alvin*, most directly from outcrops and a few from fragments surrounding outcrops. A few samples are clasts that were scooped with a net while sampling fossil coral. Most basalt samples are from pillow lavas; sheet and lobate lavas were rarely encountered in the dives conducted on AT50-09. Sample R056 is likely from a dike from an eroded seamount, based on bathymetric data. Rock samples were subsampled and described following the procedure outlined in Appendix 6 .

Through the entire archipelago, the most common petrographic type collected is plagioclase-phyric basalt: the average mode of plagioclase phenocrysts is 7% and the average size 3 mm. Olivine constitutes only 2% of the rocks on average and occurs in only 62% of the collected rocks. Olivine also tends to be smaller than plagioclase, with an average maximum diameter of < 2 mm. The only dive site with abundant olivine is AL5167, which took place on a deep terrace on the southern margin of the Galápagos Platform, near Floreana Island (whose lavas also tend to be rich in olivine; Figure 49). There does not appear to be any relation between the mode of plagioclase or olivine and collection depth (Figure 49-50), suggesting that all platform building lavas are fed from similar magmatic systems. Clinopyroxene was rarely observed in the collected rocks (n=5) and occurred either as a trace phase or in xenoliths. So far as we know, none of the collected samples are andesites, dacites, or rhyolites (all of which have erupted from volcanoes near the sampling sites).

Almost all rocks have glassy to very fine-grained groundmass, indicating rapid cooling, but the collected samples have small amounts of exterior glass in comparison to typical submarine basalts. Although most samples have glassy rinds sufficiently thick to sample, most glassy rinds are < 2 mm thick. No collected rocks have coarser diabasic texture, which would be indicative of slow cooling and is typical of many subaerial Galápagos basalts. Several samples contain small (< 1 cm) xenoliths of olivine gabbro, and xenoliths up to 10 cm in diameter are found in sample R101. Many of the inspected xenoliths contain glass in the pore spaces, indicating that they were in a partly molten state when incorporated into the magma.

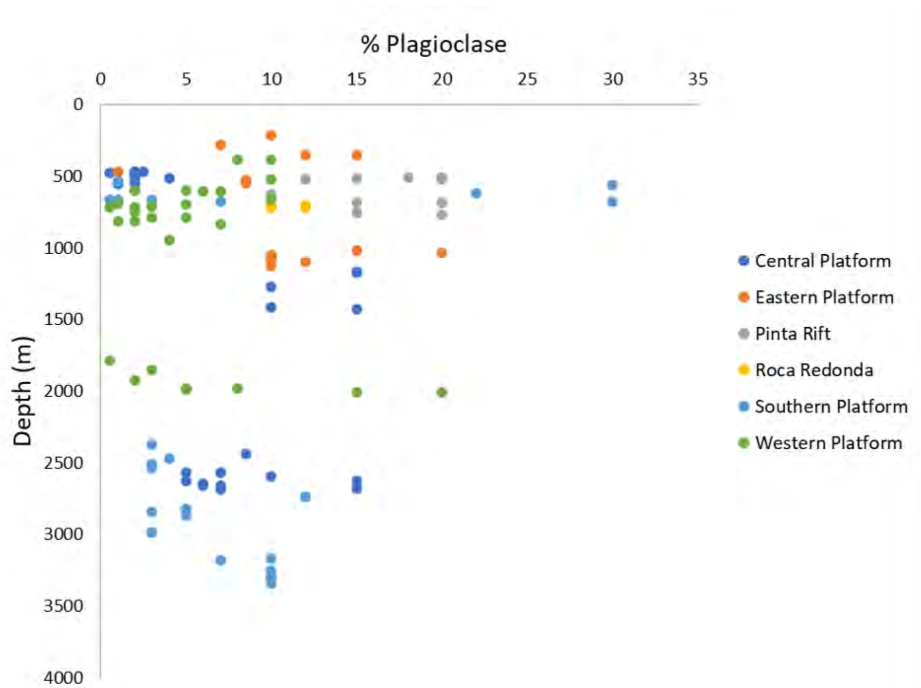


Figure 49. Percent plagioclase phenocrysts as a function of sample collection depth. The abundance of plagioclase does not appear to relate to the collection depth of lavas.

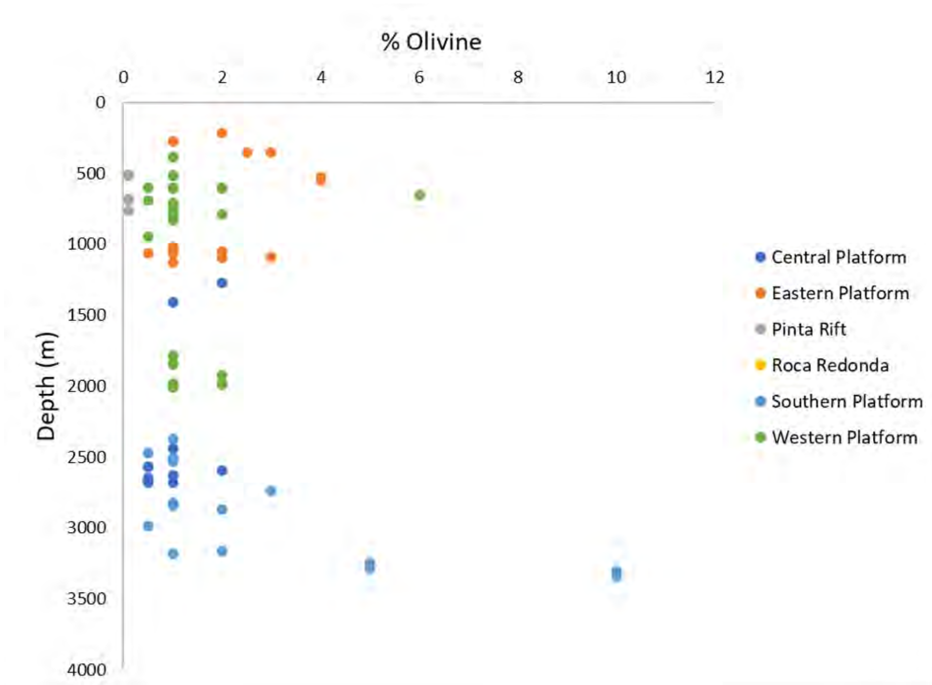


Figure 50. Percent olivine phenocrysts as a function of sample collection depth. The abundance of olivine does not appear to relate to the collection depth. The most olivine-rich rocks come from a deep terrace near Isla Floreana.

Rocks from several dives (notably AL5162, AL5164, AL5166, AL5169) are rounded, contain calcite in vesicles (possibly caliche), and have a distinctive patina that resembles desert varnish. These observations, suggest exposure of these samples subaerially or to wave action near the sea surface. The deepest observed rounded cobbles were collected on a terrace at 679 m water depth.

The vesicularity of the collected samples varies widely, but overall, the samples are highly vesicular in comparison to typical submarine rocks (Figure 51). Rocks from depths > 2000 m tend to have fine (< 1 mm) vesicles that constitute no more than 1% of the rock and are concentrated near the pillow rims. Rocks from <2000 meters have up to 30% coarse vesicles, and many of these are scoreacous. The glassy rims of the scoreacous lavas also contain fine bubbles, indicating that the lavas were actively degassing when they came in contact with seawater (degassing due to pressure release, not cooling and crystallization).

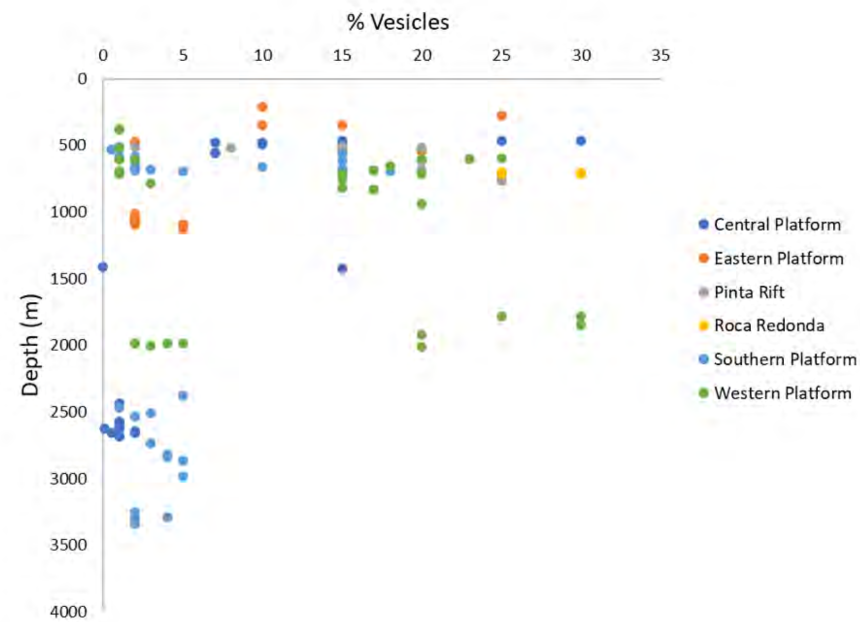


Figure 51. Percent vesicularity as a function of sample collection depth. Most vesicular rocks come from shallower than 1000m. Samples collected from ~2000 m depth between Volcans Ecuador and Fernandina are unusually vesicular for their depth, potentially indicating rapid emplacement or a volatile rich composition.

Most of the lavas from throughout the region were sampled from two principal landforms: seamounts and terrace structures at the base of volcanic islands. Preliminary assessment of the textures, phenocryst mode, and vesicularity indicates that there is no systematic difference among them.

10.2. Regional summaries

Western Platform

In the western Platform, 32 rock samples were collected across four dives. All collected samples were volcanic. Two samples were aphyric and all others contained both plagioclase and olivine phenocrysts. One sample contained clinopyroxene as a trace phase. The average modal percentage of plagioclase was 5% and the average modal percentage of olivine was 1%. The average modal percentage of vesicles was 12%, although samples were collected across a wide range of depths (Figure 51). Notably, rocks from AL5175 were all collected at water depths of 2000 m but span the entire range of vesicularities observed throughout the cruise.

Central Platform

In the central Platform, 37 rock samples were collected across six dives. One sedimentary rock was collected. Of the volcanic rocks, one was aphyric. All samples contained plagioclase phenocrysts and approximately 35% also contained olivine. One sample contained clinopyroxene as a trace phase. The modal percentage of plagioclase was similar in both the plagioclase only and plagioclase+olivine ±clinopyroxene groups; ~7%. In the samples that contained olivine, the modal percentage of olivine was 1%. The average modal percentage of vesicles was 8%, although samples were collected across a wide range of depths (Figure 51).

Southern Platform

In the southern Platform, 31 rock samples were collected across six dives. Two of the collected samples were sedimentary. Of the volcanic rocks, four samples were aphyric and about 50% of them had both olivine and plagioclase as phenocrysts. The other 50% contained only plagioclase and all these samples occur shallower than 700 m water depth. In the samples that contained only plagioclase, the average modal percentage of plagioclase was 12%. In the samples that contained both plagioclase and olivine, the average modal percentage of plagioclase was 7% and the average modal percentage of olivine was 3%. The average modal percentage of vesicles was 8% in plagioclase-only rocks and 3% in plagioclase+olivine rocks (Figure 51).

Eastern Platform

In the eastern Platform, 17 rock samples were collected across three dives. One sedimentary rock was collected. Of the volcanic rocks, one was aphyric. Except for one rock that contained only plagioclase, all other samples contained both plagioclase and olivine as phenocryst phases. The average modal percentage of plagioclase was 11% and the average modal percentage of olivine was 2%. The average modal percentage of vesicles was 8% (Figure 51).

Pinta Rift

At Pinta Rift, 10 rock samples were collected across two dives. All collected samples were volcanic and 60% of samples contained plagioclase and trace olivine phenocrysts. The other 40% contained only plagioclase. The samples were highly phyric, with the average modal percentage of plagioclase being 17%. They were also highly vesicular, with the average modal percentage of vesicles being 17% (Figure 51).

Roca Redonda

At Roca Redonda, 6 rock samples were collected in a single dive. All collected samples were volcanic and contained only plagioclase as a phenocryst phase. The average modal percentage of plagioclase was 11% and the average crystal size was 3 mm. The samples were highly vesicular, with the average modal percentage of vesicles being 28% (Figure 51).

Table 11. List of rock samples collected during AT50-09.

#	Bucket#	Sample Name	Material	Class.	Lat.	Long.	Depth (m)	Launch ID	Collect date	Collect time
1	2	R001	Rock	basalt	-0.3799	-90.8172	507	AL5155	3/29/23	15:57
2	1	R002	Rock	basalt	-0.3799	-90.8172	504	AL5155	3/29/23	16:00
3	2	R003	Rock	basalt	-0.3782	-90.8177	466	AL5156	3/29/23	23:23
4	3	R004	Rock	basalt	-0.3784	-90.8181	493	AL5156	3/29/23	22:06
5	3	R005	Rock	basalt	-0.3780	-90.8177	477	AL5156	3/29/23	23:39
6	3	R006	Rock	basalt	-0.3783	-90.8178	469	AL5156	3/29/23	22:59
7	3	R007	Rock	basalt	-0.3783	-90.8178	469	AL5156	3/29/23	22:59
8	3	R008	Rock	basalt	-0.3780	-90.8177	477	AL5156	3/29/23	23:39
9	4	R009	Rock	basalt	-0.0575	-90.8841	1425	AL5157	3/30/23	16:26
10	4	R010	Rock	basalt	-0.0604	-90.8837	1412	AL5157	3/30/23	18:14
11	4	R011	Rock	basalt	-0.0617	-90.8825	1269	AL5157	3/30/23	18:49
12	4	R012	Rock	basalt	-0.0630	-90.8814	1169	AL5157	3/30/23	19:32
13	4	R013	Rock	basalt	-0.0630	-90.8814	1169	AL5157	3/30/23	19:43
14	5	R014	Rock	conglom.	-0.1477	-90.8896	883	AL5158	3/31/23	16:19
15	5	R015	Rock	basalt	-0.1473	-90.8882	808	AL5158	3/31/23	17:13
16	5	R016	Rock	basalt	-0.1461	-90.8851	512	AL5158	3/31/23	20:30
17	5	R017	Rock	basalt	-0.1463	-90.8852	555	AL5158	3/31/23	19:47
18	5	R018	Rock	basalt	-0.1463	-90.8852	555	AL5158	3/31/23	19:47
19	6	R019	Rock	basalt	0.4582	-90.6993	765	AL5159	4/1/23	15:36
20	6	R020	Rock	basalt	0.4599	-90.7038	752	AL5159	4/1/23	17:35
21	6	R021	Rock	basalt	0.4600	-90.7069	682	AL5159	4/1/23	19:19
22	7	R022	Rock	basalt	0.4600	-90.7070	682	AL5159	4/1/23	19:20
23	7	R023	Rock	basalt	0.4600	-90.7090	623	AL5159	4/1/23	20:19
24	8	R024	Rock	basalt	0.0132	-91.0169	2682	AL5160	4/2/23	17:34
25	8	R025	Rock	basalt	0.0132	-91.0169	2681	AL5160	4/2/23	17:37
26	8	R026	Rock	basalt	0.0121	-91.0159	2658	AL5160	4/2/23	18:09
27	8	R027	Rock	basalt	0.0121	-91.0159	2658	AL5160	4/2/23	18:10
28	8	R028	Rock	basalt	0.0118	-91.0157	2646	AL5160	4/2/23	18:22
29	8	R029	Rock	basalt	0.0076	-91.0161	2625	AL5160	4/2/23	19:19
30	9	R030	Rock	basalt	0.0052	-91.0159	2596	AL5160	4/2/23	19:52
31	9	R031	Rock	basalt	0.0049	-91.0158	2570	AL5160	4/2/23	20:06
32	9	R032	Rock	basalt	0.0049	-91.0158	2570	AL5160	4/2/23	20:06
33	9	R033	Rock	basalt	0.0034	-91.0165	2436	AL5160	4/2/23	20:53
34	9	R034	Rock	basalt	0.0076	-91.0161	2625	AL5160	4/2/23	19:17
35	10	R035	Rock	basalt	0.4607	-90.7116	510	AL5161	4/3/23	17:53
36	10	R036	Rock	basalt	0.4607	-90.7116	510	AL5161	4/3/23	18:19
37	10	R037	Rock	basalt	0.4607	-90.7116	510	AL5161	4/3/23	18:20
38	10	R038	Rock	basalt	0.4619	-90.7124	517	AL5161	4/3/23	19:02
39	10	R039	Rock	basalt	0.4618	-90.7122	517	AL5161	4/3/23	19:16
40	11	R040	Rock	conglom.	-0.5103	-89.9406	553	AL5162	4/4/23	16:18
41	11	R041	Rock	basalt	-0.5051	-89.9387	470	AL5162	4/4/23	19:52
42	12	R042	Rock	basalt	-0.5941	-89.2045	1127	AL5163	4/5/23	15:53
43	12	R043	Rock	basalt	-0.5969	-89.2029	1094	AL5163	4/5/23	16:41
44	12	R044	Rock	basalt	-0.5978	-89.2028	1090	AL5163	4/5/23	17:02
45	12	R045	Rock	basalt	-0.5983	-89.2025	1063	AL5163	4/5/23	17:40
46	13	R046	Rock	basalt	-0.5988	-89.2027	1050	AL5163	4/5/23	17:58
47	13	R047	Rock	basalt	-0.5993	-89.2028	1035	AL5163	4/5/23	18:29
48	13	R048	Rock	basalt	-0.6018	-89.2024	1015	AL5163	4/5/23	19:23
49	13	R049	Rock	basalt	-0.6074	-89.2025	1064	AL5163	4/5/23	20:03
50	11	R050	Rock	basalt	-0.5100	-89.9404	544	AL5162	4/4/23	16:39

#	Bucket #	Sample Name	Material	Class.	Lat.	Long.	Depth (m)	Launch ID	Collect date	Collect time
51	14	R051	Rock	basalt	-0.7206	-89.1522	547	AL5164	4/6/23	14:59
52	14	R052	Rock	basalt	-0.7198	-89.1523	529	AL5164	4/6/23	15:27
53	14	R053	Rock	basalt	-0.7134	-89.1480	350	AL5164	4/6/23	17:23
54	14	R054	Rock	basalt	-0.7134	-89.1480	350	AL5164	4/6/23	17:33
55	14	R055	Rock	basalt	-0.7136	-89.1459	277	AL5164	4/6/23	18:22
56	15	R056	Rock	basalt	-0.7139	-89.1444	213	AL5164	4/6/23	19:13
57	15	R057	Rock	mudstone	-1.8207	-90.2003	3186	AL5165	4/7/23	17:49
58	16	R058	Rock	basalt	-1.3471	-89.8950	664	AL5166	4/8/23	14:47
59	16	R059	Rock	basalt	-1.3456	-89.8958	696	AL5166	4/8/23	15:32
60	16	R060	Rock	basalt	-1.3456	-89.8958	696	AL5166	4/8/23	15:32
61	16	R061	Rock	basalt	-1.3448	-89.8952	685	AL5166	4/8/23	15:59
62	16	R062	Rock	basalt	-1.3446	-89.8954	661	AL5166	4/8/23	16:14
63	16	R063	Rock	basalt	-1.3446	-89.8954	661	AL5166	4/8/23	16:14
64	17	R064	Rock	basalt	-1.3404	-89.8954	583	AL5166	4/8/23	17:41
65	17	R065	Rock	basalt	-1.3394	-89.8953	532	AL5166	4/8/23	18:20
66	17	R066	Rock	basalt	-1.3404	-89.8954	583	AL5166	4/8/23	17:37
67	18	R067	Rock	basalt	-1.4801	-90.7201	3344	AL5167	4/9/23	17:35
68	18	R068	Rock	basalt	-1.4800	-90.7202	3305	AL5167	4/9/23	18:13
69	18	R069	Rock	basalt	-1.4794	-90.7205	3289	AL5167	4/9/23	18:28
70	19	R070	Rock	basalt	-1.4791	-90.7205	3250	AL5167	4/9/23	18:54
71	20	R071	Rock	basalt	-1.4787	-90.7206	3181	AL5167	4/9/23	19:46
72	20	R072	Rock	basalt	-1.4786	-90.7206	3165	AL5167	4/9/23	20:10
73	21	R073	Rock	basalt	-1.4469	-90.7347	2986	AL5168	4/10/23	16:16
74	21	R074	Rock	basalt	-1.4407	-90.7357	2868	AL5168	4/10/23	18:19
75	21	R075	Rock	mn oxide	-1.4404	-90.7359	2840	AL5168	4/10/23	18:59
76	21	R076	Rock	basalt	-1.4401	-90.7361	2823	AL5168	4/10/23	19:15
77	21	R077	Rock	basalt	-1.4393	-90.7365	2794	AL5168	4/10/23	19:56
78	21	R078	Rock	basalt	-1.4349	-90.7350	2737	AL5168	4/10/23	21:14
79	22	R079	Rock	basalt	-1.2289	-90.7020	679	AL5169	4/11/23	16:10
80	22	R080	Rock	basalt	-1.2289	-90.7020	675	AL5169	4/11/23	16:23
81	22	R081	Rock	basalt	-1.2275	-90.7025	618	AL5169	4/11/23	17:14
82	22	R082	Rock	basalt	-1.2238	-90.7029	562	AL5169	4/11/23	19:00
83	23	R083	Rock	basalt	-1.2188	-91.1063	2534	AL5170	4/12/23	18:02
84	23	R084	Rock	basalt	-1.2186	-91.1061	2507	AL5170	4/12/23	18:19
85	23	R085	Rock	basalt	-1.2181	-91.1058	2471	AL5170	4/12/23	19:20
86	23	R086	Rock	basalt	-1.2172	-91.1052	2419	AL5170	4/12/23	19:54
87	23	R087	Rock	basalt	-1.2164	-91.1051	2374	AL5170	4/12/23	20:26
88	24	R088	Rock	basalt	0.3057	-91.6299	716	AL5171	4/13/23	22:51
89	24	R089	Rock	basalt	0.3057	-91.6299	714	AL5171	4/13/23	23:04
90	24	R090	Rock	basalt	0.3055	-91.6298	700	AL5171	4/13/23	23:27
91	24	R091	Rock	basalt	0.3056	-91.6298	705	AL5171	4/13/23	23:15
92	25	Ev8	Rock	basalt	0.3055	-91.6298	700	AL5171	4/18/23	20:30
93	26	Ev7	Rock	basalt	0.3056	-91.6298	705	AL5171	4/18/23	20:30
94	27	R092	Rock	basalt	-0.8978	-91.5398	944	AL5172	4/14/23	15:57
95	27	R093	Rock	basalt	-0.8959	-91.5386	830	AL5172	4/14/23	17:36
96	27	R094	Rock	basalt	-0.8914	-91.5343	655	AL5172	4/14/23	20:00
97	27	Glass	Rock	basalt	-0.4755	-90.7703	1323	AT50-09	4/18/23	20:30
98	28	R095	Rock	basalt	-0.5683	-91.3604	787	AL5173	4/15/23	14:46
99	28	R096	Rock	basalt	-0.5682	-91.3604	789	AL5173	4/15/23	15:04
100	28	R097	Rock	basalt	-0.5685	-91.3594	711	AL5173	4/15/23	16:02

#	Bucket #	Sample Name	Material	Class.	Lat.	Long.	Depth (m)	Launch ID	Collect. date	Collect. time
100	28	R098	Rock	basalt	-0.5685	-91.3594	711	AL5173	4/15/23	16:02
101	30	R100	Rock	basalt	-0.5697	-91.3570	607	AL5173	4/15/23	17:20
102	30	R101	Rock	basalt	-0.5697	-91.3570	607	AL5173	4/15/23	17:20
103	30	R102	Rock	basalt	-0.5708	-91.3561	518	AL5173	4/15/23	17:58
104	30	R103	Rock	basalt	-0.5730	-91.3535	384	AL5173	4/15/23	20:34
105	30	R104	Rock	basalt	-0.5730	-91.3535	384	AL5173	4/15/23	20:34
106	31	R105	Rock	basalt	-0.2951	-91.6939	815	AL5174	4/16/23	15:19
107	31	R106	Rock	basalt	-0.2952	-91.6939	815	AL5174	4/16/23	15:24
108	31	R107	Rock	basalt	-0.2958	-91.6930	745	AL5174	4/16/23	16:39
109	31	R108	Rock	basalt	-0.2969	-91.6903	715	AL5174	4/16/23	17:32
110	32	R109	Rock	basalt	-0.2987	-91.6891	716	AL5174	4/16/23	18:18
111	32	R110	Rock	basalt	-0.3014	-91.6836	600	AL5174	4/16/23	19:46
112	33	R111	Rock	basalt	-0.3014	-91.6836	600	AL5174	4/16/23	19:56
113	33	R112	Rock	basalt	-0.3014	-91.6836	600	AL5174	4/16/23	20:00
114	33	R113	Rock	basalt	-0.2993	-91.6889	686	AL5174	4/16/23	18:38
115	34	Ev10	Rock	basalt	-0.2993	-91.6889	686	AL5174	4/16/23	18:38
116	35	R114	Rock	basalt	-0.1521	-91.5153	2006	AL5175	4/17/23	15:56
117	36	R115	Rock	basalt	-0.1513	-91.5159	2009	AL5175	4/17/23	16:22
118	35	R116	Rock	basalt	-0.1509	-91.5159	1987	AL5175	4/17/23	16:46
119	36	R117	Rock	basalt	-0.1506	-91.5158	1983	AL5175	4/17/23	17:03
120	35	R118	Rock	basalt	-0.1506	-91.5158	1983	AL5175	4/17/23	17:04
121	35	R119	Rock	basalt	-0.1450	-91.5168	1923	AL5175	4/17/23	18:27
122	37	R120	Rock	basalt	-0.1446	-91.5178	1847	AL5175	4/17/23	19:05
123	36	R121	Rock	basalt	-0.1441	-91.5184	1785	AL5175	4/17/23	20:16
124	36	R122	Rock	basalt	-0.1441	-91.5184	1785	AL5175	4/17/23	20:22
125	38	R123	Rock	basalt	0.0140	-90.7064	2318	AL5176	4/18/23	15:58
126	38	R124	Rock	basalt	0.0133	-90.7067	2307	AL5176	4/18/23	16:10
127	38	R125	Rock	basalt	0.0122	-90.7068	2233	AL5176	4/18/23	16:46
128	38	R126	Rock	basalt	0.0048	-90.7052	2212	AL5176	4/18/23	18:08
129	39	R127	Rock	basalt	0.0015	-90.7025	2202	AL5176	4/18/23	18:47
130	39	R128	Rock	basalt	0.0001	-90.7017	2144	AL5176	4/18/23	19:50
131	39	R129	Rock	basalt	-0.0009	-90.7011	2111	AL5176	4/18/23	20:15
132	39	R130	Rock	basalt	-0.0011	-90.7011	2089	AL5176	4/18/23	20:30
133	40	Net	Rock	basalt	-0.4755	-90.7703	1323	AT50-09	4/18/23	20:30
134	40	Bulk	Rock	basalt	-0.4755	-90.7703	1323	AT50-09	4/18/23	20:30

11. Biology sampling

The primary source of biological and geochemical data was from *Alvin* dives, with one exception of colonial tunicates which got caught on the CTD wire and were preserved.

11.1. In Alvin – the event log and basket map

The scientific observers in *Alvin* were responsible for recording the time in UTC of any collections that happened and where the specimens (rocks, fossils, sponges, coral etc) were placed in *Alvin's* basket of assorted containers and tubes etc. Before each dive, the basket and all containers were cleaned and was visually checked.

In the basket map shown in Figure 52, collection locations were written in pencil on waterproof paper with an "event number", and a description of what has been placed into that area if required. The description included a color, shape and basic taxa identification (e.g., pink, bushy coral or flat white sponge or fossil coral with yellow whip octocoral). The event number directly links to the event log (Figure 53).

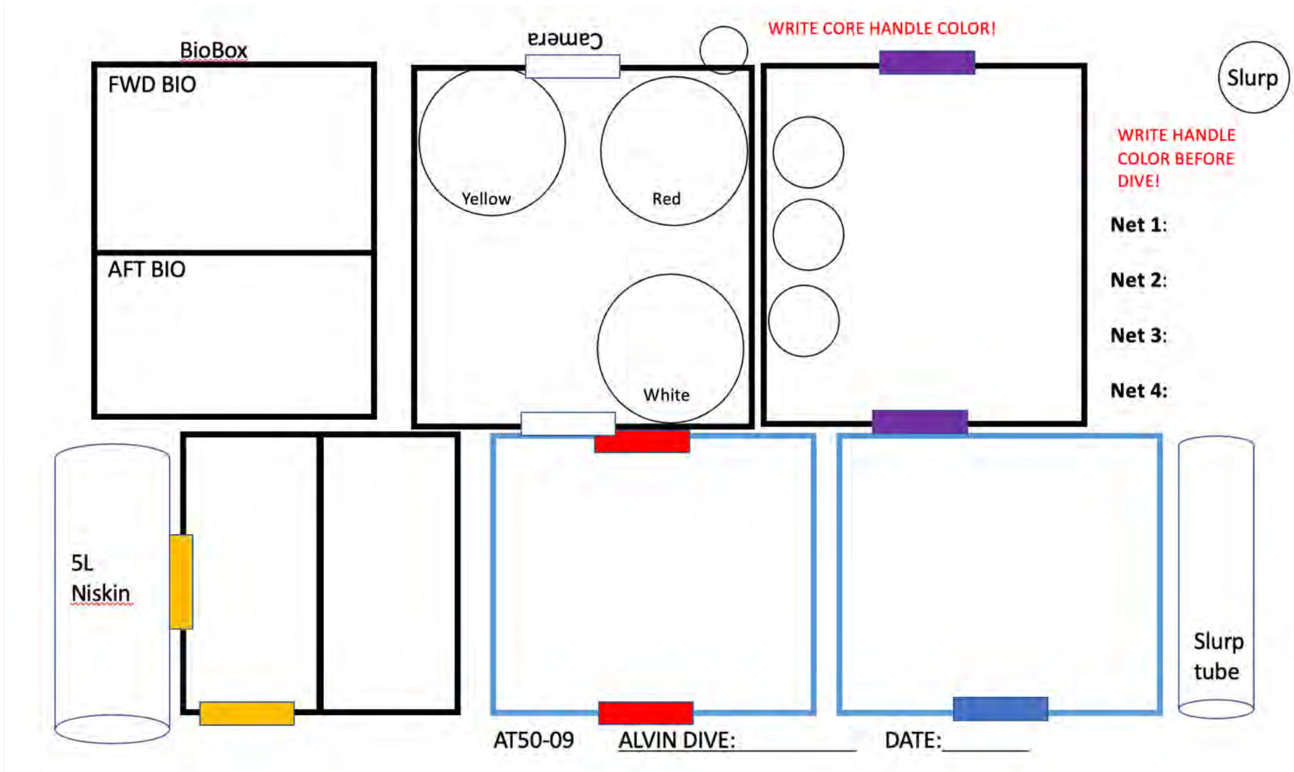


Figure 52. Alvin basket map template used on AT50-09

Date:			AT50-09 Station #:	Site name:	Alvin Dive #:		Sheet #: of	
Event #	Equipment	Time (GMT)	Water Depth (m)	Organism (description)	Comments	Tool Tray Location	Photo ID	Scribe
001	GRB	11.01	950	Orange sponge on ~15cm rock		Bio box 1 - front	IMG0002	MT
002	SLP	11.07	948	~20 cm section of pink flat flexible octocoral colony	Think had yellow crinoid on it	Bio box 1 - front	IMG0010	MT

Figure 53. Alvin event log sheet used on AT50-09.

11.2. Sampling – when Alvin returned

Before *Alvin* returned to the surface, we receive a science report from the scientific observers via underwater telephone. The science report included spaces on the basket that were used so we prepared as many cold-water buckets as were required each day (bucket being kept in the cold room so they remain cold). Each bucket had a random number label assigned to it (identical to the specimen labels i.e., a specimen label).

Format of the specimen identification tags on ethanol-proof paper was as follows:
Unique ID: e.g. AT50-09_0001B
Parent ID:
Event:
Alvin#:
Date:

To maximize the usefulness and breadth of research possible with the samples collected there were a number of subsampling and post-processing procedures that the specimens, especially corals, underwent.

A photo of every individual organism out of water (for larger corals, in an aquarium) with a scale bar and label in shot/image, was taken to ensure “live” color and state were recorded as well as possible (Figure 54).

11.3. Biological photographs protocol

Every photo had a scale included along with the filled out unique ID paper tag. A whole animal image and a close-up (if possible) were taken for each organism we collected– we later label each image with the unique specimen number.

Figure 54. Images of samples recovered using Alvin during AT50-09 for scientific interpretation and aquaria pictures for more natural understanding of animal morphology.

For creatures we want more “natural” images of we set up an aquarium with glass plates to hold organisms upright, and side lights set-up to aid accurate recording of features such as polyps, antenna, branching structure, color, etc. (Figure 54).

11.4. Genetic Sub-Sampling

To ensure future genetic research is possible, several genetics sub-samples of every animal were taken. One of every "morphotype" was flash frozen in liquid nitrogen (with some exceptions, see Table 12) and stored at -80°C. Every animal thereafter was sub-sampled and flash-preserved in 95% ethanol and stored at -20°C.

Small animals (5 cm or smaller) were preserved whole in 2-50ml tubes in 95% ethanol. When there was more than one coral they were split equally between CDF/UK. Larger non-colonial animals were preserved in larger containers in 70% ethanol (after genetic sub-sample(s) were taken in 95% ethanol). Larger colonial animals were split into two – large section for CDF, smaller section for ID for UK (U. Essex). The specific triage and decision tree is shown in Table 12 below.

Table 12. Table of sample triage procedures performed after each dive.

	No. specimens per morphotype / dive	*Preservation*	*Owner*
Small animals (<5 cm), (e.g., polychaete)	1	95% ethanol (as per genetic sub-sample)	CDF
	>1	1st of morphotype > 2ml tube > flash frozen flash frozen for genomics Remainder of individuals: -half in 95% ethanol -half in 95% ethanol	CDF CDF UK
Large animals non-colonial (>5 cm) (e.g., ophiuroid)	1	1st of morphotype for expedition > 2ml tube > sub-sample flash frozen for genomics Every morphotype thereafter gets 95% ethanol sub-sample for genetics then remainder of specimen in 70% ethanol > container	CDF CDF
	>1	1st of morphotype for expedition > 2ml tube > sub-sample flash frozen for genomics Remainder individuals thereafter: - 95% ethanol genetic sub-sample of every individual - Half of samples, post sub-sample, in 70% ethanol > container - Half of samples, post sub-sample, in 70% ethanol > container	CDF UK CDF UK
Large animals colonial (>5 cm) (e.g., Octocorallia)	1	1st of morphotype for expedition > 2ml tube flash frozen + 2ml tube 95% ethanol genetic sub-samples Split each sample, post sub-sample, small + large section > in 70% ethanol = 2 containers	UK UK (sm) CDF (lg)
	>1	1st of morphotype for expedition > 2ml tube flash frozen + 2ml tube 95% ethanol genetic sub-samples Remainder individuals thereafter: - 95% ethanol genetic sub-sample of every individual - Split each sample, post sub-sample, small + large section > in 70% ethanol = 2 containers	UK UK UK (sm) CDF (lg)
Scleractinia corals (target for Bristol aging work = need skeleton)	1	1st of morphotype for expedition > 2ml tube flash frozen + 2ml tube 95% ethanol genetic sub-samples Every morphotype thereafter gets 95% ethanol sub-sample for genetics Remainder > flesh removed & skeleton dried	UK UK UK
	>1-?	1st of morphotype for expedition > 2ml tube flash frozen + 2ml tube 95% ethanol genetic sub-samples Remainder individuals thereafter: - 95% ethanol genetic sub-sample of every individual - Rest of specimen > flesh removed > dried	UK UK UK

11.5. Preservation techniques

We used a "parent-daughter" preservation chain to ensure that information about associates (i.e., all the organisms that live in habitats such as coral and sponges), is not lost (i.e., who lived on what/where). To do this each, specimen has a "parent". Initially the "parent" is simply the location where the specimens was stored on *Alvin*. Thereafter the "parent" will be the colony/ organism an animal is found on (Figure 54). For example, in the *Eunice* worm sample (Figure 55, left) AT50_09_1135_B, the parent is a *Madrepora* coral with the unique ID of AT50_09_906_B indicated by the "Parent ID: 906" where 906 is short for the whole ID of the coral it was removed from. Likewise, the squat lobster (Figure 55, right) AT50_09_0361_B has a parent of a Chrysogorgiidae coral with the unique ID of AT50_09_226_B indicated by the "Parent ID: 226" on the label.

Figure 55. Typical label. Note "Parent ID:"

Colony / animal size generally dictates preservation. Over-sized items were gauged for "display potential" – if an excellent specimen was collected, it was preserved in the few "large" (10 litre) containers of ethanol available in 70% ethanol.

11.5.1. Flash freezing

To preserve genomic DNA indefinitely we flash froze samples in liquid nitrogen. This involved placing the sample into a 2ml cryovial (that can withstand the -196°C temperatures), placing the cryovial into a metal holder, then dipping that holder into liquid nitrogen. This was done wearing large safety gloves, a lab coat, and protective glasses to protect us against the dangerously freezing cold temperatures. Unsurprisingly, given our coral focus, Cnidaria constituted the majority of samples that were collected (Figure 56).

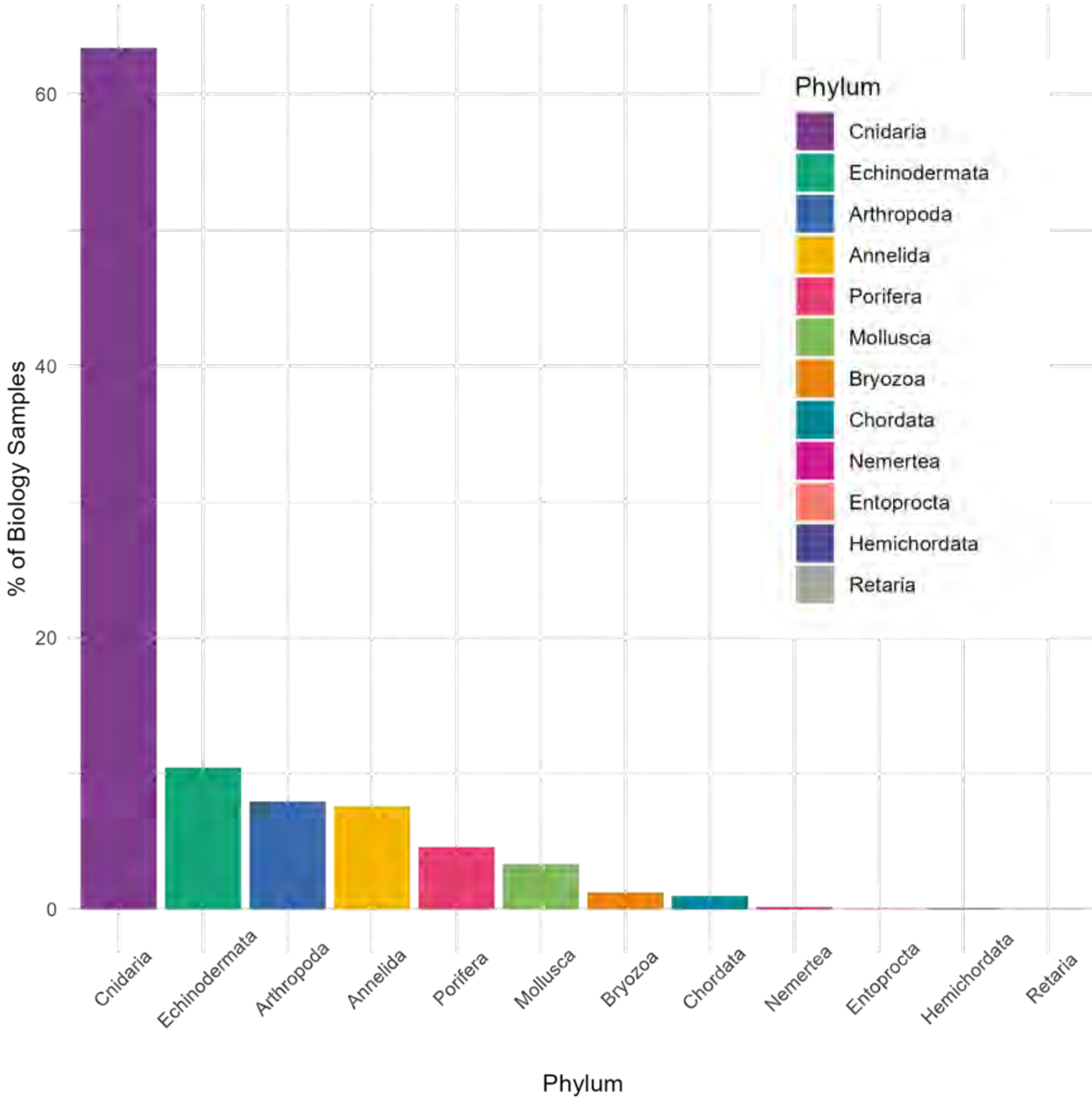


Figure 56. Breakdown by phyla of biological collections on AT50-09.

12. Outreach and Engagement

12.1. Overview of engagement initiative

In addition to the primary scientific objectives of the expedition, an outreach and engagement program was developed between the onboard scientists, offshore media coordinators and marketing strategists from the primary collaborating institutions. The expedition ran (and is still running) a successful website, a common *#GalapagosDeep2023* hashtag across various media platforms, a coordinated social media engagement initiative, local in-person community outreach events in the Galápagos, an external partnership with a marine science education program in the USA at U. Mississippi, press releases from each of the participating institutions, and official Ecuadorian ministerial press release regarding the discovery of the deep-sea coral reef. The press release generated over 110 individual news articles with a potential reach of tens of millions worldwide.
https://www.darwinfoundation.org/en/blog-articles/887-scientists-discover-pristine-deep-sea-coral-reefs-in-the-galapagos-marine-reserve

Through the website, blog posts, social media channels, news releases, school outreach, and scientific education events in the Galápagos, we hoped to:

- generate interest and excitement around the expedition and its scientific objectives
- emphasize what this means for conservation in Galápagos
- inspire the scientific community to do further ocean research in Galápagos
- show how the expedition contributes to understanding of sustainability issues in other ocean regions

Between the numerous institutions and foundations involved, we ensured the impact of this expedition would have a global reach. Our partnership with the Charles Darwin Foundation (FCD), Galápagos National Park Directorate (PNG) and INOCAR ensured that the science and outreach on board was being done carefully and sustainably to prevent any detrimental impact to the ecosystems of the Galápagos Platform. These partnerships were key to our engagement activities with the local community.

12.2. Media platforms used

The two primary platforms used for outreach were the cruise website www.galapagosdeep2023.com (Figure 57) and Twitter through various handles and institution profiles, but all using a common hashtag of #GalapagosDeep2023. Many of the major institutions and observing partners also used Facebook, Instagram and LinkedIn to disseminate key information, messages and findings from the cruise. The onboard media coordinator, Samuel Mitchell, and PI Michelle Taylor, also used their social media platforms to share many of the major findings that was released during the main press release. Around half of the science team also used their own social media pages (primarily Twitter) to share many of main posts being posted.

Figure 57. Front page of the website www.galapagosdeep2023.com

All media content went through a multi-stage approval process starting with the PIs and media coordinator on the ship, then to Charles Darwin Foundation and with final approval from the Galápagos National Park Directorate. The approval chain ensured that all content being shared with the public did not have any detrimental impact on these ecosystems through potential exploitation of seafloor, targeting of sites, but also to check that all information shared was correct, respectful of the partnerships, and engaging.

The main website included a series of pages for general information about the expedition:

- Home page with latest updates, funders, summarized objectives, collaborating institutions, links to key information
- Cruise objectives, and a more outlined summary of each objective: coral and climate history, biology and taxonomy, geology and volcanology, outreach and engagement
- The science team page with short biographies and photographs taken onboard of all scientists and observers involved (including the onshore PIs)
- The *Alvin* team and crew – group photos of the rest of the team onboard the expedition and summarized information about their important roles.
- Information about *R/V Atlantis* and HOV *Alvin* and its history.

- Media gallery – with key photographs, maps, and videos from the expedition covering categories such as: seafloor life, seafloor geology, *R/V Atlantis* and *Alvin*, on board operations, and overview maps of the region and seafloor.
- A maintained blog throughout the expedition. This was regularly updated with science, life on board, highlighting of scientists, and the onboard operation. This will continue to be updated post-expedition.

12.3. Outreach and engagement partners

A large number were involved in the outreach initiative, both onboard and onshore. The expedition PIs (Dan Fornari and Michelle Taylor) and onboard media coordinator (Samuel Mitchell) worked with the media and marketing directors from the primary funded institutions and observing parties.

Media was coordinated between Woods Hole Oceanographic Institution, University of Bristol's School of Earth Sciences, University of Essex's School of Life Sciences, and Boise State Universities Dept of Geosciences. The Charles Darwin Foundation were central to all media to be approved throughout the expedition, led by the media team onshore and also the onshore observers. FCD forwarded all media to the National Park for final approval.

Statement from Woods Hole Media Team:

In addition to a successful traditional media outreach campaign, members of the expedition and shore-based institutional communications staff engaged in a concerted social media effort throughout the duration of the expedition. Beginning with the first use of the expedition hashtag (#GalapagosDeep2023) on 18 March through 19 April, total mentions reached nearly 900 across all major social media platform, peaking with the release of news to the general public 17-18 April. We expect to see an extended tail to this activity as news stories also continue to come out and are shared by participating individuals and institutions. As the news was preparing to break, WHOI ensured that agency representatives at NSF and the Office of Naval Research were made aware of the impending release, as well as the end of embargo period. This resulted in a rapid-turnaround news story *on the NSF news site that included a quote from Gail Christenson, Division of Ocean Sciences program director.*

12.4. Press release of coral reef discovery

On April 16th 2023, an official press release was published on the discovery of the largest deep-sea coral reef ever found in the Galápagos Marine Reserve since its establishment in 1998 (Figure 58). This press release was coordinated with all institutions, partners and the Ecuadorian government.

The release contained imagery and videos from the deep-sea coral reef and of the *Alvin* observers who completed the dive and discovered the reef. The release generated first a lot of interest through social media (primarily Twitter), but also on Instagram, Facebook, LinkedIn and TikTok. The outreach media team worked with several large sources for separate independent releases just after the ministerial release. After that, the story was picked up by more international news sources.

Figure 58. The press release from the Charles Darwin Foundation: https://www.darwinfoundation.org/en/blog-articles/887-scientists-discover-pristine-deep-sea-coral-reefs-in-the-galapagos-marine-reserve

12.5. Potential impact of media efforts

As of April 20th, the discovery of the coral reef had been covered by over 110 separate news items and sources including over 60 Hispanic and Latin-American news sources. These sources included TV news items, mostly online news articles, but also radio interviews and short social media releases. Coverage was also picked up by several worldwide international news platforms including CNN, Sky, The Guardian, BBC and Associated Press, but also the major Ecuadorian networks and news sources for local dissemination of findings. It is very challenging to know at this stage the exact viewership/engagement/impressions of all these items, however, the combined total potential “reach” from all of these news sources was over 120 million. An individual video on Instagram and TikTok also received over 35,000 views with a lot of local Galapagos/Ecuadorian engagement. As of April 20th, the website had also amassed almost 10,000 views and more subscribers for new content.

12.6. Community outreach

As well as the online social media initiative and press relief coordination, the team organized a series of successful community outreach events on Santa Cruz, Galápagos, and also with a marine science education program in Mississippi. For the marine science education program, a group of school children designed and drew on Styrofoam cups to be sent down to the seafloor and shrunk using *Alvin* (Figure 59). All 40 cups were shrunk on dive AL5175 at a depth of ~1900 m and then brought back up to the surface. These were also all photographed before and after the dive. These cups will be returned to the schoolchildren as part of their education program and questions about ocean pressure.

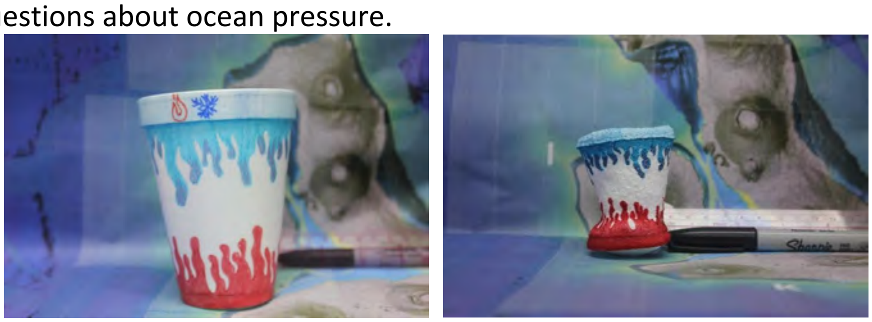


Figure 59. Example of a Styrofoam cup (left) taken to 1900 m depth on the exterior of Alvin and the resulting 'shrinking' (right) that occurred at depth because of the seawater pressure.

Three community events were run for the local Galápagos community in Puerto Ayora: 1) a group of local schoolchildren who visited the Charles Darwin Research Station; 2) scientific findings in presentations to the Charles Darwin Foundation research staff and invited guests and dignitaries; and 3) a public town hall event with Q+A open to the residents of Puerto Ayora and beyond.

A group of 16 local schoolchildren were invited to the Charles Darwin Research Station on April 20th 2023 (Figure 60), the day after the *R/V Atlantis* arrived into Puerto Ayora. A representative contingent of the onboard science party and observers attended the event inside the Research Station laboratory to show students the collected samples (live biology, fossil corals, rocks, sediments), *Alvin* videos, maps of the seafloor, and to explain the purpose and general findings of the cruise. The session opened with a series of short presentations and then moved to an open room exhibit with a biology, fossil, rock, and map station overseen by the scientists. The observers from FCD, PNG and INOCAR were all present. The students engaged well with the samples and scientists, asking a number of questions. Our representative from INOCAR, Divar Castro, translated for the scientists to ensure bilingual communication.

Figure 60. GalapagosDeep2023 scientists and observers with local schoolchildren inside the Charles Darwin Research Station laboratory and its resident scientists.

On April 21st 2023, a series of science presentations were given to the research scientists, staff and volunteers of the Charles Darwin Foundation and Research Station (CDF) (Figure 60). This was also attended by invited guests, naturalists, conservationists, military personnel and friends of the foundation. Over 50 people were in attendance, and a series of 10-minute presentations were delivered by scientists and PIs to highlight: *Alvin* operations, cruise purpose and objectives, water sampling, sediment coring, rock collection, seafloor mapping, and live and fossil biological sampling. This was followed by an open Q+A session. The presentations were delivered in English by scientists with translations within some of slides and in-person if required. This session was also recorded for future use by CDF.

Figure 61. Delivery of findings from the expedition to the Charles Darwin Foundation researchers, staff, volunteers, and invited guests. Lead by Stuart Banks (FCD) and Dan Fornari (Expedition PI, WHOI).

On the same evening, a town hall event was held at Salon de Puerto Ayora for the local residents (Figure 62). This presentation was delivered by Spanish-speakers, including observers from FCD and onboard scientists. This was attended by 80-90 people in total and lasted for 45 minutes before 20 minutes of open Q+A. The presentation included motivation, key findings, benefits to the Galápagos community, and discussions of management and conservation.

Figure 62. Town hall event in Puerto Ayora for the general public, presented by Stuart Banks (FCD), Divar Castro (INOCAR), Ana Samperiz (expedition scientist, Cardiff University).

12.7. Continuation of outreach and engagement

Between in-person community outreach events and the online media initiative, the impact of the GalapagosDeep2023 expedition has already been felt worldwide within just 72 hours of the last scientific data collected on board. However, there is a continued plan of media engagement even though the expedition itself has come to an end. Going forward, the media coordinator will work with the scientists, collaborating partners and institutions to deliver:

- continued blogposts highlighting the procedures and sample processing at sea
- further highlights of the life of scientists, crew and technicians at sea
- regular (potentially biweekly) release of new *Alvin* footage of the seafloor and closer photos of samples back on the ship – with targeted content e.g. a biology week, a rock week, a coral reef week etc.
- continued social media content to further highlight initial findings and to help disseminate continued website material and media releases
- the production of a short (bilingual English-Spanish) documentary including footage from the seafloor, interviews from the lead scientists, observers and collaborating partners, with informative voiceover and other video footage acquired of onboard ship activities and community outreach events.

We wanted to share the lives and experiences of our scientists and observers at sea, share the incredible science being undertaken, and share the incredible technology that was allowing us to reach the greatest depths of the Galápagos Platform. Through this continued effort, we hope to encourage future generations of marine explorers, scientists, conservationists, and educators focused on the Galápagos and elsewhere in our oceans.

APPENDICES

APPENDIX 1 – Permits from Costa Rican and Ecuadorian Authorities

Costa Rican permit for collecting multibeam transit data from Golfito to Galápagos.

SISTEMA NACIONAL DE AREAS DE CONSERVACIÓN
SECRETARÍA EJECUTIVA
DIRECCIÓN EJECUTIVA

March 24, 2023
SINAC-SE-DE-330-2023

Dr. Daniel Fornari
Scientific Expedition / RV Atlantis
Geology & Geophysics Dept.
WHOI, USA

Dear Dr. Fornari:

Upon request from Dr. Stuart Banks, Principal Marine Scientist of the Charles Darwin Foundation, in Galapagos, Ecuador, I am writing to you to communicate the consent of the Government of Costa Rica for the scientific vessel *RV Atlantis* to take bathymetric data during its innocent passage from the port of Golfito, in Costa Rica, to the Galapagos Islands, on March 25 of the current and subsequent days.

From the point of view of Costa Rican regulations, obtaining this type of scientific data during the innocent passage of a vessel through the waters of our Exclusive Economic Zone does not require the prior obtaining of any permit. However, I would like to point out that the Government of Costa Rica and its institutions would be very interested in having access to the data obtained by the RV Atlantis, which would undoubtedly also be of enormous value to universities and other marine research centers in our country.

Sincerely,

RAFAEL ANGEL GUTIERREZ ROJAS (FIRMA)
Firmado digitalmente por RAFAEL ANGEL GUTIERREZ ROJAS (FIRMA)
Fecha: 2023.03.24 18:55:28 -06'00'

M.Sc. Rafael Gutiérrez Rojas
EXECUTIVE DIRECTOR

RGR/gia

C: Archive

Dirección: Santa Rosa de Santo Domingo de Heredia,
Cementerio 300 metros Norte y 300 Oeste, Parque Ecológico.
Central telefónica: (506)2522-6500 / 2522-6666
Apdo.: 11384-1000 San José, Costa Rica
www.sinac.go.cr

Ecuadorian permits for AT50-09 operating in EEZ & Galápagos MPR & collecting samples.

Gobierno del Ecuador
GUILLERMO LASSO
PRESIDENTE

Parque Nacional
GALÁPAGOS
Ecuador

Versión: 01 Fecha: 15/12/12

DIRECCIÓN DEL PARQUE NACIONAL GALAPAGOS
DIRECCIÓN DE ECOSISTEMAS
AUTORIZACIÓN PARA MOVILIZACIÓN DE MUESTRAS

FINES INVESTIGACIÓN	X	**FAUNA SILVESTRE** **FLORA SILVESTRE** **MATERIAL PÉTREO** **AGUA** **SEDIMENTOS**	X	**AUTORIZACIÓN No.** **VÁLIDO** **EMISIÓN** **CADUCA**	**038-2023 DPNG** **1 MES** **10-04-2023** **10-05-2023**

PAIS DE ORIGEN: Ecuador | **DESTINO:** N/A
NOMBRES: Dan Fornari | **INSTITUCION:** N/A

No. CEDULA	No. PASAPORTE	NACIONALIDAD
N/A	505506028	Estadounidense

PAGO DERECHOS FACTURA No. 001-101-000020281

PROYECTO DE INVESTIGACIÓN
"Identificación de la biodiversidad marina béntica sobre montes submarinos de la Reserva Marina de Galápagos" Contrato Marco No. MAAE-DBI-CM-2021-0204.

Considerando: Que mediante Acuerdo Ministerial No. 256 del 20 de agosto de 2014 la Ministra del Ambiente delegó al Director del Parque Nacional Galápagos, para que dentro de su jurisdicción, y a través de la Dirección de Ecosistemas de la Dirección del Parque Nacional Galápagos, ejerza las funciones como Unidad de Patrimonio Natural y cumpla con la siguiente atribución; emisión de permisos de importación y exportación de fauna y flora silvestres, conforme lo establece el Libro IV del TULSMA y la Convención sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres, CITES.

DETALLE	CANTIDAD	NOMBRE CIENTÍFICO	NOMBRE COMÚN	SEXO
Cortes de tejido de 1cm³	120 tubos de eppendorf de 2ml	*Ophiurida*	Ofiura	N/A
Cortes de tejido de 1cm³	55 tubos de eppendorf de 2ml	*Terebellidae*	Anelide	N/A
Cortes de tejido de 1cm³	10 tubos de eppendorf de 2ml	*Antipatharia*	Coral negro	N/A
Cortes de tejido de 1cm³	140 tubos de eppendorf de 2ml	*Alcyonacea*	Coral blando	N/A
Cortes de tejido de 1cm³	380 tubos de eppendorf de 2ml	*Scleractinia*	Coral duro	N/A
Cortes de tejido de 1cm³	220 tubos de eppendorf de 2ml	*Anthoathecata*	Hydrozoa duro	N/A

OBLIGACIONES DEL SOLICITANTE: Las muestras producto de esta exportación, correspondientes al proyecto denominado "Identificación de la biodiversidad marina béntica sobre montes submarinos de la Reserva Marina de Galápagos" Contrato Marco No. MAAE-DBI-CM-2021-0204, son propiedad del Estado Ecuatoriano. En consecuencia, no se autoriza hacer ningún uso comercial, patentar o reconocer derecho de propiedad intelectual alguno; así como otra actividad que no esté establecida en el Contrato Marco No. MAAE-DBI-CM-2021-0204.

La Dirección del Parque Nacional Galápagos entrega en custodia temporal las muestras producto de esta exportación a la PhD. María José Barragán, Directora de Ciencias – FCD, con el fin de que proceda a realizar los análisis requeridos en el marco del proyecto denominado "Identificación de la biodiversidad marina béntica sobre montes submarinos de la Reserva Marina de Galápagos" Contrato Marco No. MAAE-DBI-CM-2021-0204.

La PhD. María José Barragán, Directora de Ciencias – FCD, entregará las muestras, placas preparadas o cualquier material resultante producto de esta exportación a la Dirección del Parque Nacional Galápagos.

Original / 2 copias

Atentamente,	SELLO
HARRY RAUL REYES MACKLIFF .... **DIRECTOR DE ECOSISTEMAS (E)** **DIRECCIÓN DEL PARQUE NACIONAL GALÁPAGOS**	Parque Nacional GALÁPAGOS Ecuador

Ministerio del Ambiente, Agua y Transición Ecológica
Santa Cruz, Pto. Ayora | San Cristóbal, Pto. Baquerizo Moreno | Isabela, Pto. Villamil | Floreana, Pto. Velasco Ibarra | www.galapagos.gob.ec

República del Ecuador

Gobierno del Ecuador
GUILLERMO LASSO
PRESIDENTE

Parque Nacional
GALÁPAGOS
Ecuador

DIRECCIÓN DEL PARQUE NACIONAL GALÁPAGOS
DIRECCIÓN DE GESTIÓN AMBIENTAL
AVISO DE VIAJE DE CAMPO

No. 160

Fecha: 23 de marzo 2023

Proyecto: Expedición R/V Atlantis con sumergible tripulado Alvin
"Montes Submarinos de la Reserva Marina de Galápagos".
N° **PC-26-22** con ampliación de vigencia hasta el 30 de abril de 2023.
(Ref. MAATE-DPNG/DGA-2023-0221-O)

Autorizado 23 de marzo 2023

Responsable del Proyecto: María José Barragán Paladines, PhD/ Stuart Banks.

Institución: Fundación Científica Charles Darwin.

Responsable del viaje: Stuart Banks (FCD).

Duración: Desde: 28 de marzo 2023 **Hasta:** 22 de abril 2023

Participantes:

Personal PNG: Jennifer Suarez (#2000073904)
Personal INOCAR: Divar Castro (Ppt A8191071)

Científicos Visitantes: 23

Nombre **C.I./Pasaporte**

Nombre	Institución	Pasaporte/ Cedula
Stuart Banks (Principal ECCD)	Fundación Charles Darwin	562370989
Salome Buglass	Fundación Charles Darwin	507450113
Michelle Lisa Taylor (Co-principal)	University of Essex	136063548
Daniel John Fornari (Co-principal)	Woods Hole Oceanographic Institution	505506028
Lydia Crampton	Bangor University	548902090
Darin Michael Schwartz	Boise State University	658145715
Virginia Dorsey Wanless	Boise State University	659180617
Ana Samperiz Vizcaino	Cardiff University	XDD410470
Shannon Kelsey Hoy	NOAA	506224947
Samuel J. Mitchell	Universidad de Bristol	528693919
Dennis Geist	Universidad de Idaho	A10837290
James Alex Kershaw	University of Bristol	535060097
Maoyu Wang	University of Bristol	EJ5304820
Maria Luiza de Carvalho Ferreira	University of Bristol	FP498122
Qian Liu	University of Bristol	E45405346
Yingchu Shen	University of Bristol	EJ5938991
Yun-Ju Sun	University of Bristol	306895411
Amy Sut Moy Sing Wong	University of Essex	528471482
Jessica D Gordon	University of Essex	505722559

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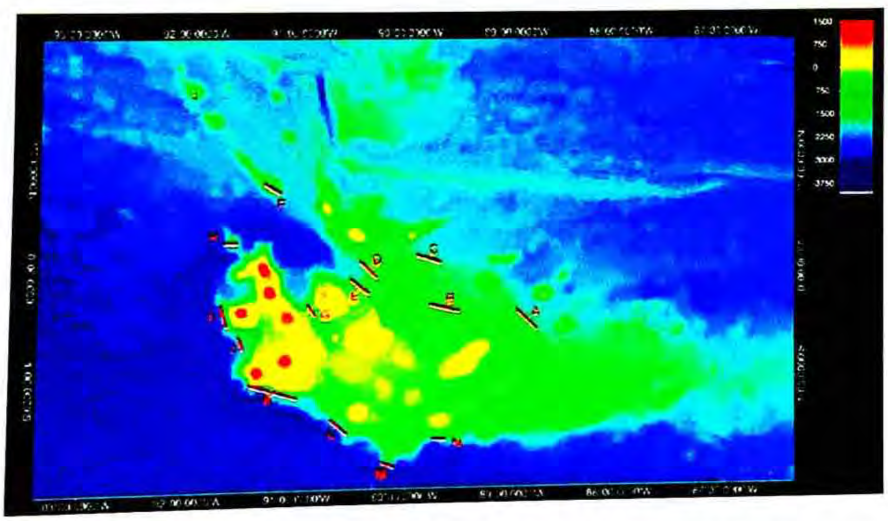
DIRECCIÓN DE GESTIÓN AMBIENTAL
AVISO DE VIAJE DE CAMPO

Nombre	Institución	Pasaporte/ Cedula
Janine Louise Andrys	University of Rhode Island	679703592

Isla (*): Navegación continua con inmersiones submarinas de investigación en aguas abiertos RMG y HMR.

Sitio (s) de estudio:

(1) Localidades propuestas para la caracterización de largo plazo de hábitats profundas de la RMG y HMR por inmersión de vehículos sumergibles remotos, piloteados e instrumentos autónomos, incluyendo sitios priorizados con el RV Atlantis para el crucero programado marzo - abril 2023.



Sitios	Latitud	Longitud	Descripción y localidad con relación a Islas principales
A	-0.4083	-88.8883	Montes submarinos y paredes verticales submarinas al sureste de San Cristóbal
B	-0.375	-89.5967	Montes submarinos y paredes verticales submarinas al sur de San Cristóbal
C	0.11	-89.7433	Montes submarinos y paredes verticales submarinas al noreste de Genovesa
D	0.0417	-90.3467	Montes submarinos y paredes verticales submarinas entre Marchena y Santiago
E	0.0583	-90.6817	Montes submarinos y paredes verticales submarinas entre Marchena y Santiago
F	0.765	-91.275	Montes submarinos y paredes verticales submarinas entre Isabela y Pinta

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G	-0.3567	-90.885	Montes submarinos y paredes verticales submarinas entre Isabela y Santiago
H	0.2467	-91.6083	Montes submarinos y paredes verticales submarinas Roca Redonda al sur de Isabela
I	-0.4117	-91.6817	Paredes verticales submarinas al oeste de Fernandina
J	-0.6417	-91.54	Paredes verticales submarinas al suroeste de Fernandina
K	-1.1217	-91.195	Paredes verticales submarinas al suroeste de Isabela
L	-1.45	-90.6217	Paredes verticales submarinas al suroeste de Floreana
M	-1.7783	-90.1717	Montes submarinos y paredes verticales submarinas entre Floreana y Española
N	-1.5783	-89.685	Paredes verticales submarinas al sur de Española
#	NA	NA	Sitios por definirse dentro del área de la Reserva de la Hermandad.

Lugar de Campamento (coordenadas y nombre): No aplica

Objetivos:

Avanzar e integrar el conocimiento sobre la formación de la plataforma volcánica de Galápagos, sus montes submarinos, hábitats y biodiversidad asociados, e investigar cambios en los ambientes en las aguas profundas en el contexto del cambio climático pasado y el que está en curso.

Detalle de actividades:

Se hará uso del sumergible tripulado S/V Alvin con instrumentación de muestreo oceánico para documentar y clasificar el hábitat comunitario de aguas profundas mediante el uso de transectos de video, colección de muestras por succión y brazo manipuladora y técnicas de estudio visual en localidades priorizados. El muestreo será exploratorio en transectos de 1-4 km a profundidades desde 200m - 3500m en las localidades identificados (arriba) durante el período del crucero, con una inmersión de alrededor de 6-8 horas planificado por día. Las inmersiones del submarino Alvin son tripulados con dos científicos, más un piloto y cuentan con una tripulación científica y operativa a bordo de soporte, para planificación diaria, seguimiento durante inmersiones, procesamiento de muestras físicas y digitales en laboratorio (abordo), y un equipo especialista de seguridad y operaciones para el submarino, sus sensores, instrumentación, y el manejo del barco R/V Atlantis durante las inmersiones.

No se llevarán a cabo operaciones con el submarino en sitios de visitantes y, por lo general, se realizará inmersiones afuera de la costa en cada localidad, según el perfil batimétrico a 200 m - 3500 m. La planificación de las inmersiones por día y sitio preciso depende en gran medida en las condiciones oceánicas en cada localidad y sería confirmado con plena participación entre el equipo científico y con el grupo de observadores a bordo en representación del DPNG, INOCAR y la FCD.

Sitio de desembarque: Puerto Ayora, Santa Cruz, 28 de marzo 2023

Gobierno del Ecuador
GUILLERMO LASSO
PRESIDENTE

Parque Nacional
GALÁPAGOS
Ecuador

DIRECCIÓN DEL PARQUE NACIONAL GALÁPAGOS
DIRECCIÓN DE GESTIÓN AMBIENTAL
AVISO DE VIAJE DE CAMPO

Sitio de embarque (retorno): Puerto Ayora, Santa Cruz, 20 de abril 2023

Medio de transporte: R/V Atlantis

Comunicación: 098 811 7785 (Stuart Banks FCD) / 099 668 7622 (Jennifer Suarez DPNG)

Días: 26 **Hora:** N/a (navegación continua)

Incluir fecha y hora de cuarentena:

Está previsto que los observadores del FCD y DPNG realizaran cuarentena el **viernes 24 de marzo 2023** previo a subir el barco (28 de marzo) por sus equipos personales. Los demás participantes llegan por via marítima en el R/V Atlantis directamente y no bajan del barco.

En coordinación con el agente naviero local (A. Moreano), el buque R/V Atlantis cumple con las medidas de cuarentena en Golfito, Costa Rica previa a su navegación a Galápagos. Está sujeto a inspección con Armada, DPNG y ABG en San Cristóbal al inicio del viaje en cumplimiento de los requisitos legales y fito-sanitarios. Las participantes en el crucero permanecen abordo durante la duración completa de la expedición y no tocan tierra hasta su desembarque al final del viaje en Puerto Ayora el día 20 de abril 2023.

Stuart Banks

Responsable del viaje

*'Se recuerda qué está prohibido realizar actividades de investigación combinadas con turismo: así como realizar campamentos en más de una isla durante mismo viaje

APPENDIX 2 - Equipment technical specifications

Technical Specifications of Research Equipment

A2.1. Multibeam Mapping

RV *Atlantis* is equipped with a Kongsberg EM124 multibeam bathymetry mapping system that was installed in 2021 during the mid-life refit of the ship and funded by the US Navy Office of Naval Research and the National Science Foundation. The EM 124 can acquire high resolution seabed mapping data in shallow to full ocean depth. All beams are maintained and automatically adjusted according to achievable coverage or operator defined limits. Up to 1600 individual beams are available in dual swath mode. Two individual transmitting fans are generated with a small difference in tilt giving a constant sounding separation along track, resulting in a dense sounding pattern on the seafloor. The system is integrated with a SeaPath motion reference unit and the ship's GPS navigation system. Detailed specifications can be found at these websites:

https://www.whoi.edu/what-we-do/explore/ships/ships-atlantis/ships-atlantis-scientific-equipment/mapping-acoustic-systems/

https://www.kongsberg.com/maritime/products/ocean-science/mapping-systems/multibeam-echo-sounders/em-124-multibeam-echosounder-max.-11000-m?OpenDocument=

- Depth range: 20 to 11000 meters, or full ocean depth. The depth range depends on water temperature, noise level and bottom type.
- Nominal frequency: 12 kHz
- Operating frequency: 10.5 - 13.5 kHz
- Swath width: Typically 6 times the depth or more than 40 km
- Number of swath: 2 swaths per ping
- Pulse length: 1 ms CW to 100 ms FM effective pulse length
- Number of transmit sectors: 16 frequency coded transmit sectors per ping / 8 per swath
- Available transmitter models: 0.5 degree, 1 degree, 2 degrees and 4 degrees
- Available receiver models: 1 degree, 2 degrees and 4 degrees
- Number of receiver beams (per ping): 1600 beams, 1 degree RX 1024 beams, 2 degree RX 512 beams, 4 degree RX
- Multi-bounce suppression: Better than 50 dB
- Beam focusing: On transmit and receive
- Deliverables: Bathymetric data, Seabed imagery data, Water column data, Extra depth detections
- Realtime motion stabilization: Roll: ± 15 degrees, Pitch: ± 10 degrees, Yaw: ± 10 degrees
- Sounding pattern: Equidistant and equiangular

A2.2. Human Occupied Vehicle (HOV) Alvin submersible

Alvin is a 3-person research submarine owned by the U.S. Navy and operated by WHOI for use as a deep-sea research platform to take 2 observers and 1 pilot into the ocean and to the seafloor to depths as great as 6500 m to make observations and collect imagery data and samples on dives lasting ~8-10 hrs per day. Specifications for *Alvin* are available online at: https://ndsf.whoi.edu/alvin/using-alvin/specifications/. The submarine was outfitted with additional WHOI-MISO imaging capability using fixed focus WHOI-MISO-OIS designed GoPro systems in DSPL deep-sea housings to augment the 4k and HD cameras standard on Alvin. One MISO GoPro camera (Hero10 module) provided 23MP still images every 5 seconds from a location on the front of the submarine above the pilot's viewport. The other two cameras provided 4k and 5.3k cinematic video (Hero4 and Hero 10 modules, respectively). The 4k MISO video camera was mounted on the starboard manipulator, the 5.3k MISO video camera was mounted near the front of the Alvin basket, inside of the perimeter and centered so the pilot could easily frame subject matter during dives (Fig. A2-2).

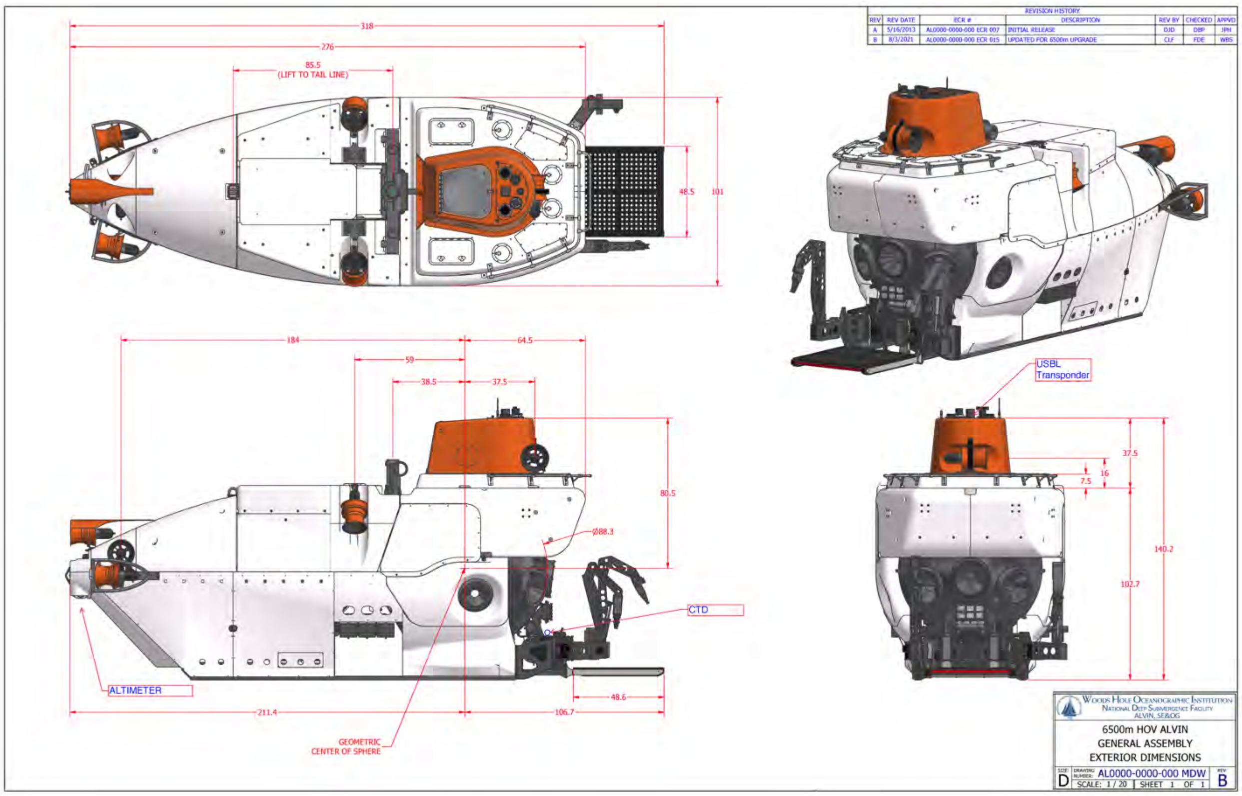

Figure A2-1a. Alvin research submarine showing locations of key science data sensors.

Figure A2-1b. Alvin research submarine being launched from RV Atlantis during AT50-09.

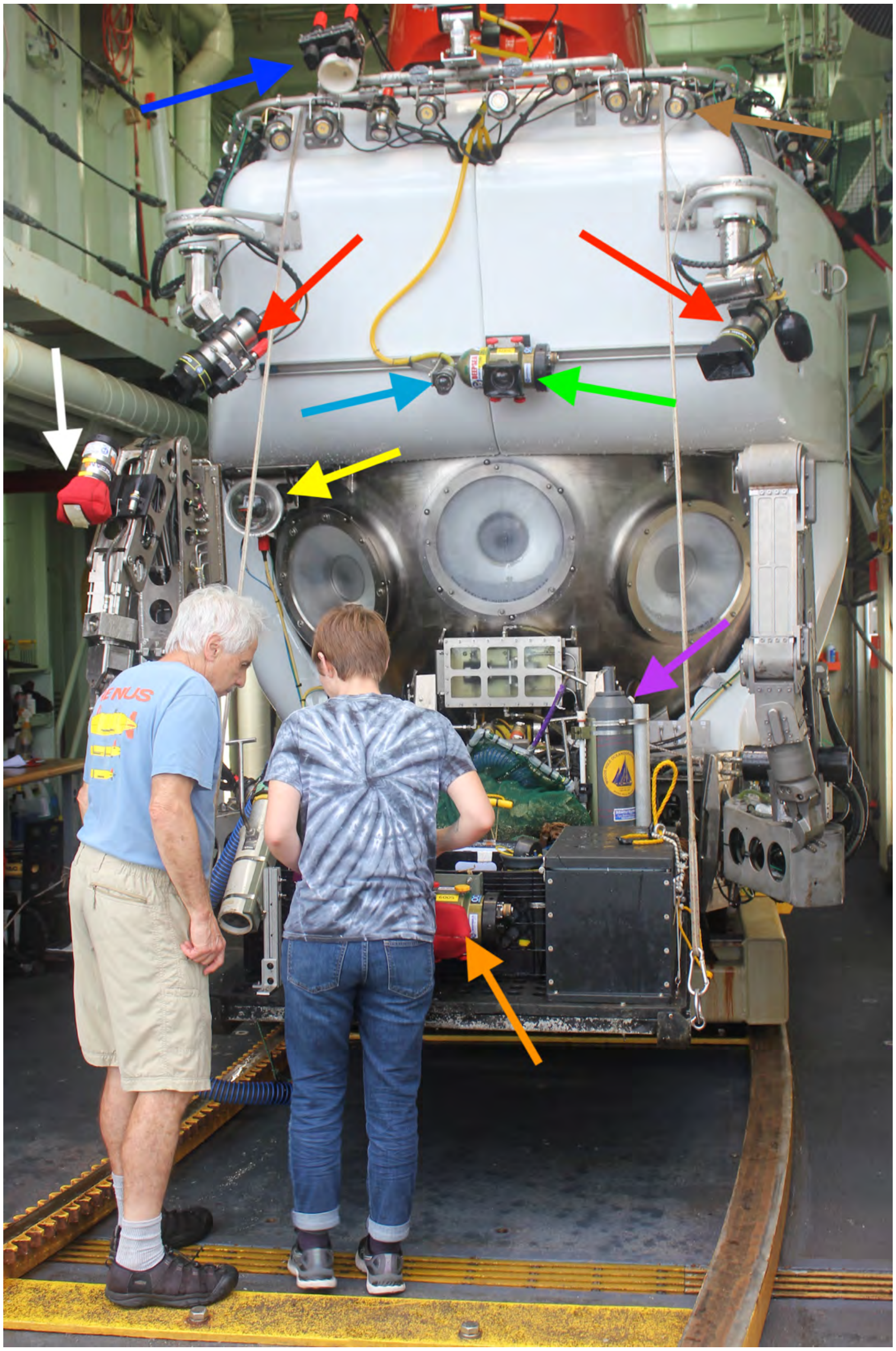

Figure A2-2. Location of lights, cameras, lasers and 5-L Niskin on Alvin for AT50-09 expedition. (Note lasers were 10 cm apart both on the STBD 4K camera and fixed on the brow). Red arrows point to port and stbd 4K DSPL Optim cameras, on pan/tilts and zoom/focusable. Blue arrow points to DSPL IP-SeaCam HD 1080P brow-wide fixed-focus camera. Yellow arrow points to PATZ HD 1080P camera, on pan/tilt and zoom/focusable. Green arrow points to MISO GoPro 23MP still image camera taking photos every 5 sec. throughout the dive. Orange arrow points to MISO GoPro 5.3k cinematic video (30fps) fixed focus camera taking self-recording video throughout the dive. White arrow points to MISO GoPro 4k video (30fps) fixed focus camera mounted on Starboard manipulator taking self-recording video throughout the dive. Blue arrow points to lasers on top sponson rail. Brown arrow points to bank of DSPL LED lights. Purple arrow points to 5-L Niskin bottle mounted on basket.

A2.3. CTD (Conductivity, Temperature, Depth) Instrument- Water Properties & Sampling

The R/V *Atlantis'* CTD System is comprised of a Seabird 9plus CTD unit equipped with auxillary sensors, mounted on a frame containing up to 24 – 10 liter Niskin bottles for water sampling, and a Seabird SBE32 carousel water sampler providing bottle triggering and closure. Real-time communication is established through a computer and SBE11 deck unit that is connected to the SBE9plus with a Rochester 0.322" 3-conductor cable that is deployed and recovered using a DESH-5 Markey winch aboard the vessel. Sampling depths of up to 6000 meters can be reached using the majority of sensors available. Data sampling via the 9plus is at 24 Hz. During cruise AT50-09, only 23-10 liter Niskin bottles were used in order to provide space to incorporate a Sonardyne USBL beacon for acoustic positioning of the package and depth tracking of the CTD rosette. All sensors are listed in Table A1.

Table A1. Names and serial numbers of the sensors used with the CTD package during this cruise, as well as the casts during which they were used.

Sensor	Serial Number	Casts	Comments
9plus – Pressure Sensor	0785	001-009	
SBE3 -Primary Temperature	4406	001-009	
SBE3 -Secondary Temperature	4481	001-009	
SBE4 -Primary Conductivity	2304	001-002	The dual conductivity sensors were reading with a difference of almost 0.2 S/m. Deck experimentation seemed to indicate the primary sensor was in error, so it was replaced prior to cast at5009003
SBE4 – Primary replacement Conductivity	2707	003-009	
SBE4 -Secondary Conductivity	2570	001-009	
FLNTURTD – Fluorometer/Turbidity	7536	001-009	
Altimeter	VA752617	001-009	
C-star Transmissometer	1185DR	001-009	
SBE48 – Oxygen Sensor	1679	001-009	
Biospherical/Licor PAR	70796	001-009	
Biospherical/Licor SPAR	QSR2240-16500	001-009	

A2.4. MC-400 Multicorer with MISO Deep-Sea Imaging, Data and CTD systems

Multicoring is a routine method for acquiring undisturbed, spatially co-located upper sediment and sediment-water interface core samples in a range of water depths for ecological, geological, geochemical, and biogeochemical studies. Having a real-time camera and sensors to monitor water properties and depth/altitude on a multicorer greatly increases the chances of successful coring operations. Advantages of using a real-time camera on a multicorer include locating sampling areas with specific, active biological or chemical processes and performing controlled penetration of the seafloor to achieve optimal sample recovery. The motivation for developing an instrumented multicorer system grew from the extensive experience with deep-sea camera and sampling systems over the past decade's operation of the Multidisciplinary Instrumentation in Support of Oceanography (MISO) Facility at Woods Hole Oceanographic Institution (WHOI), an NSF-funded facility that provides deep- sea imaging and related instrumentation to the US and international oceanographic community (http://www.whoi.edu/main/instruments/miso).

The WHOI MC-400 multicorer (Table A-2, Fig. A2-3) used on AT50-09 was been configured with MISO imaging and environmental sensors to provide real-time capability for direct observation of seafloor terrains during multicoring operations. The system includes the following components (all rated to 6000 m).

- 24 MP Ocean Imaging Systems (OIS) deep---sea digital color camera
- 300 watt/sec strobe electronics and one flash head
- Valeport 500P depth & altitude sensor
- SeaBird Instruments SBE19plusV2 CTD with SBE-43 dissolved O2 sensor
- WHOI---MISO DataLink telemetry system for real---time recording and display of low---resolution images from the camera and 1 Hz data from the Valeport 500P sensor and SBE19plus CTD
- 5 liter Niskin water sampling bottle
- one 24 VDC MISO deep-sea battery rated at 40 amp/hrs) to provide power for all system components.
- MC---400 Ocean Instruments Multi---corer Specifications

Table A2. MC-400 multicorer specifications.

Height	Width	Height (fired)
197 cm	177 cm	197 cm
Weight	Shipping weight	Frame
137 kg	243 kg	Hard anodized 6061---T6 AL
Spyder & holders	Sample tubes	Tube size
Hard anodized 6061---T6 AL	4, polycarbonate	10 cm diameter x 58 cm

Air weight (with full stack of weights and camera, data link, strobe, battery) 790 lbs.
Water weight (with full stack of weights and camera, data link, strobe, battery) 490 lbs.

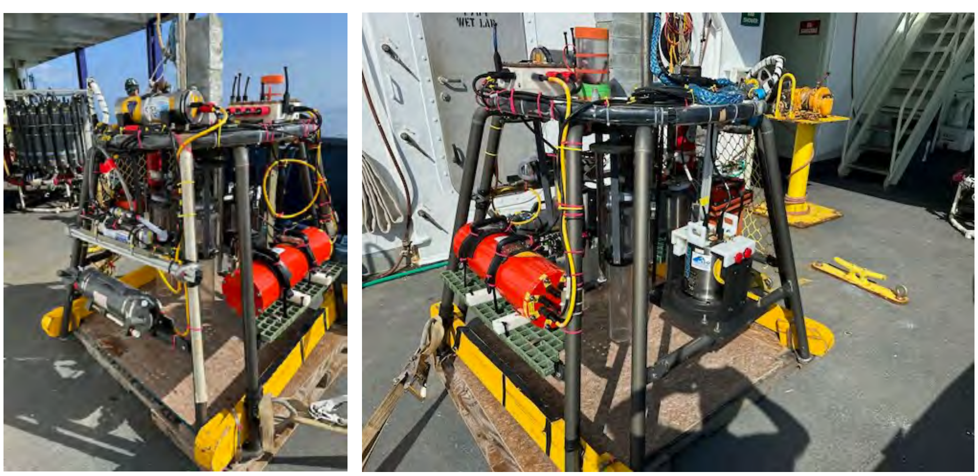

Figure A2-3. MC-400 multicorer configured with MISO imaging and data systems for AT50-09

A2.5. MISO TowCam Deep-Sea Camera System

WHOI's Multidisciplinary Instrumentation in Support of Oceanography (MISO) Facility provides deep- sea digital imaging capabilities for seafloor experiments and surveys, and related equipment primarily to academic oceanographers in the US and internationally. MISO is a NSF-supported facility at the Woods Hole Oceanoraphic Institution (WHOI) operated by Dr. Daniel Fornari (Emeritus Scientist in the Geology & Geophysics Dept.) with the Shipboard Scientific Services Group (SSSG) to facilitate cost-effective and scientifically relevant access to deep-sea imaging and related equipment for oceanographic research in a wide range of seafloor environments The website where descriptions of the various equipment can be found is at: (http://www.whoi.edu/miso).

The WHOI *TowCam* (Fig. A2-4) within the MISO Facility is currently the only routinely available US system for towed high-resolution deep-sea digital imaging. The MISO *TowCam* is an internally recording digital deep-sea camera system (24 megapixel (MP) OIS cameras are now used routinely and the facility has 5 such cameras). The *TowCam* is towed at ~1/4-1/2 knots on a standard UNOLS 0.322" coaxial CTD sea cable while taking photographs every 5-10 sec (on AT50-09 images were acquired every 7 seconds) using a 300 watt/sec strobe with a single flash heads. Real-time acquisition of digital depth and altitude data at 1 Hz can be used to help quantify objects in the digital images and make near-bottom profiles. MISO has developed a high-speed 'Data Link' system that permits real time transmission of the low-resolution video grabs from the camera display up the CTD cable to allow real-time observations of the seafloor during each bottom traverse and to help guide imaging and sampling.

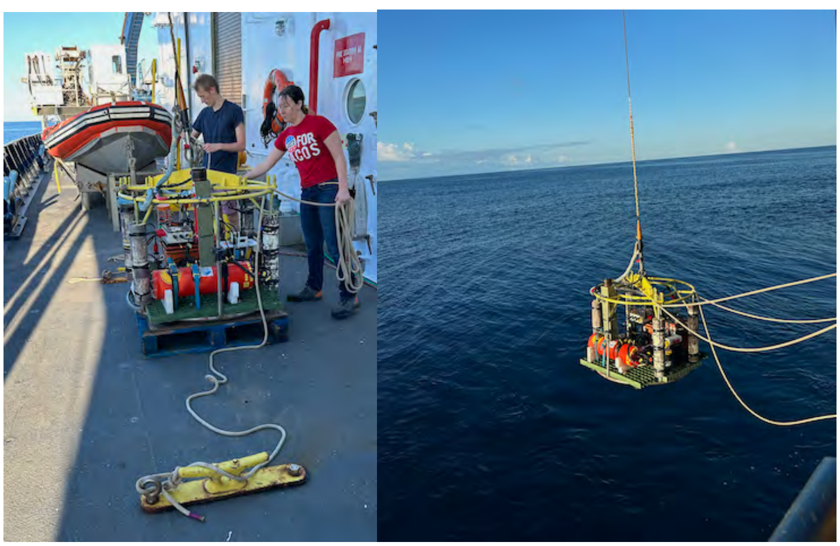

Figure A2-4. WHOI-MISO TowCam deep-sea camera system used on AT50-09 taking 24MP still images every 7 seconds during the entire lowering with 1Hz depth/altitude data to keep the system at an altitude of 3-4 m above the seafloor during the tow at ~0.3 kts. TowCam navigation utilized the USBL beacon and system on RV Atlantis.

A2.6. WHOI-MISO GoPro Deep-Sea Cameras on Alvin

The WHOI-MISO Facility has developed an excellent, autonomous, fixed focus, very high-resolution deep-sea camera (6000 m rated) that can take up to ~30 hrs of 23MP digital still images or ~20 hrs of 5.3k cinematic video. The MISO GoPro camera can be used on a wide range of deep-sea vehicles and sampling systems to 6000 m depth, thereby providing an important capability to better document seafloor and water column observations and sample collection.

The current suite of MISO GoPro deep-sea cameras were developed over the past 7 years using ~20-year-old Deep-Sea Power & Light (DSPL) DigiSeacam camera housings that were originally developed to support the original MISO TowCam system, and through a collaboration with Ocean Imaging Systems (OIS) in Pocassett, MA that developed a modular camera chassis based on a Hero4 module inside a DSPL SuperSeacam 6000m rated Ti housing. The WHOI MISO GoPro systems have been utilized on all *Alvin* dives during the AT50-09 cruise to the Galápagos Platform on *R/V Atlantis* during March-April 2023. HOV *Alvin* was equipped with a MISO forward-looking brow camera capturing still images every 5 seconds and a MISO 4K video camera fixed to the starboard manipulator arm, and a MISO basket mounted camera in the center of the basket near the forward edge (Figs. A2-2 and A2-5).

Figure A2-5. Screen grab of 4k video from MISO GoPro camera mounted on Alvin's starboard manipulator used during all AT50-09 Alvin dives.

APPENDIX 3 – Water sampling procedures for chemical analysis

Detailed sampling procedures are outlined in the TableA3-1, including the equipment required and methods employed. eDNA samples were treated separately, by procedures outlined in Appendix 4.

Table A3-1. Summary of water sample equipment and collection techniques

Sample type	**CO_3**	**^{14}C**	**$\delta^{13}C$**	**$\delta^{18}O$**	**Nutrients**	**$\delta^{30}Si$**
Sampling order	1st	2nd	3rd	4th	5th	6th
Gloves	Nitrile	Nitrile	Nitrile	Nitrile	Vinyl	Nitrile
Bottle size and type	250 ml glass with glass stopper	250 ml glass with blue plastic lid	30 ml plastic	30 ml plastic	60 ml plastic (square bottles)	250 ml plastic
Bottle cleaning	Furnace	Decon-90, HCl, furnace	None required	None required	HCl	HCl
Tubing used	Silicone (Milli-Q rinsed)	Silicone (acid cleaned)	None	None	None	None
Filtering	No	No	No	No	No	Yes
Rinses of bottle before sampling	2 times, plus overflow for 1 bottle volume	3 times, plus overflow for 2 bottle volumes	2 times	2 times	3 times	2 times

Sample type	CO_3	^{14}C	$\delta^{13}C$	$\delta^{18}O$	Nutrients	$\delta^{30}Si$
Filling	To brim, then use pipette to remove 2.5 mL	To brim, then pour away small amount	To brim, then pour away small amount	To brim	Leave headspace	Don't fill to brim
Poison	Yes: 50µl	Yes: 25µl	Yes: 8µl	No	No	No
Sealing the bottles	Grease and electrical tape	Screw on lid	Electrical tape	Parafilm	Screw on lid	Parafilm
Storage	Plastic bags, upright position, foam to protect glass, in cool dark place at room temperature		Plastic bags, upright position ideally (particularly $\delta^{13}C$), at room temperature		Plastic bags, with label-maker labels, frozen at –20 °C	Plastic bags, in cool dark place (room temperature)

APPENDIX 4 – Environmental DNA sampling procedures

All samples were collected using detailed protocols derived from Luke McMartin (Lehigh U.). Briefly, eDNA samples were collected from each CTD cast, by firing 2 Niskin bottles at the deepest point of the cast (in practice 5 to 10 m above the seafloor).

Nitrile gloves were worn at all times, and all equipment which came into contact with seawater used for eDNA analyses was sterilized using bleach before collection. All the water from both Niskin bottles was passed through eDNA filter packs, attached to the Niskin by bleach-sterilized tubing. When all the water from the Niskin bottle had fully filtered, tubing and filter packs were removed from the Niskin. The filter pack was then opened with the outlet portion oriented down, the filter membrane and drain disc removed using bleach-sterilized forceps, and the membrane and disc folded in half so that the filter was folded inward. The folded filter membrane and drain disc stack was placed and sealed in a Whirl-Pak bag, and immediately frozen at -80°C.

APPENDIX 5 –Rock Curation Procedures

Lab setup

- Wet Lab (cutting):
  - Rock saw (fore table)
  - Sample staging area (port table)
- Bio Analytical Lab (curation):
  - Photography Station (port table)
  - Description Station (two tables in the center of the lab)
  - Mount making station (aft table)
  - Polishing station (fore table)
  - Microscopy and picking station (fore table)

Rock Sample Collection and Curation Procedure

Prior to Alvin Launch

- Prepare a clipboard the night leading up to each Alvin dive, containing:
  - An Alvin basket diagram
  - Rock collection worksheet (with first rock sample for associated dive written on top!)
  - Biology and pushcore collection worksheet
  - Freeform dive log

Preparation for Alvin Recovery

- After Alvin is off-bottom following a successful dive, receive a science report from the Alvin Team. The science report should include:
  - A brief description of the dive.
  - The total number of samples collected.
  - The number of rocks collected.
  - The number of these samples, which were collected specifically for biology, should also be noted.

- Assuming all rock samples are mixed with biological samples (yellow bucket):
  - Thoroughly wash/rinse bucket to remove debris (inside and out).
  - Remove all previous bucket labeling using ethanol and towel (inside and out)
  - Fill buckets with water and chill (for biological samples)

- Lay out one aluminum turkey tray per rock sample collected on port table of Wet Lab and line with a sheet of butcher paper
- Prepare a rock description form for each sample and pair with an aluminum turkey tray.

Unloading Alvin Dive Basket

- Take an overhead photo of the dive basket using the Bio Lab camera.
- For rock samples:
  - Alvin Geologist, or one-person at-a-time, at the command of the Alvin Geologist, remove each sample from basket and apply rock sample number to bucket!
  - Bring buckets into the Hydro Lab for biology extraction.
  - Remove biology from each sample while retaining the identity of each rock sample

Wet Sample Preparation

- Transfer sample metadata (lat, long, etc.) to rock sample description forms
- Fill two buckets with freshwater, labeled A and B, to be used for freshwater rinse of samples, and stage in the Wet Lab.
- Transfer geologic remains from Yellow Bio Buckets into submerge into freshwater rinse A and remove.
- Completely submerged sample into freshwater rinse B and remove.
- Transfer geologic remains into turkey trays staged on port table of Wet Lab.
- Remove any loose glass from the sample into the turkey tray.
- Carefully cut each rock sample to expose a cross section of the sample from surface to interior to expose the interior.
- Make another cut parallel to the previous one to create a 1-2cm thick slab (this will be the whole rock [WR] subsample).
- Cut another slab (as thin as possible without breaking the sample) to be cut into a thin section billet. Trim this slab into the shape of a billet using the slide template.
- For samples without glass cut another, thicker slab (2-4 cm), and trim weathered exterior. This cubed sample will be an additional WR split for easy crushing and separation for bulk chemical analysis following the cruise.
- Transfer samples into the Bio Lab for description.
- Arrange rock pieces into turkey trays so all surfaces are exposed to airflow for drying. Allow samples to dry overnight or expedite drying by placing under 90F reptile lamp

Sample Photography

- Bring samples one-at-a-time to photography station on port table.
- Lay out fresh white paper from stock roll.
- Arrange sample with Alvin dive number, sample label, colorscale and grayscale onto paper so slab and remaining whole rock are in view of the mounted camera. If the entire sample is not in view, change the zoom or adjust the camera height.
- Take one good picture.
- If there is something else that is very interesting on the sample, take as many detailed photographs as necessary to document it, using the mounted or unmounted camera (be sure to include the sample name in each photograph with a scale in every additional photograph!)

Rock Descriptions

- Measure and record the thickness of manganese coating and glass (which can be fully disrupted during glass chipping.
- Use the provided guide to complete the physical description of each sample.

Glass Chipping

- Use hammer and chisel to chip ~5 g of glass from the sample remains. Do not chip the slab or thin section billet subsamples unless only sparse glass can be recovered! Be careful to shield the chipped glass from flying through the air into other sample containers.
- Collect the chipped glass into an appropriately sized sample baggie and keep this with the sample tray.

Curation

- Enter the subsamples that are present for each sample on the sample description worksheet.
- Tabulate the subsample data (presence absence of subsamples) for assigning IGSNs and the printing of labels.
- Print out the appropriate sample labels by selectively printing from the master IGSN label document, or selectively print labels if only a few samples from a group of subsamples are to be printed (e.g., there are only two glass samples to print labels for). Four label colors are available, one color for each type of potential subsample.
- Package parent sample and subsample into appropriately sized bags.
- Insert a handwritten TYVEK label of the sample name in each bag and apply an IGSN label to each.
- Sample splits and destination:

Split	Description	Destination
PARENT	Any remains	BSU
G	chipped glass	BSU
WR	whole rock slab	BSU
B	billet for thin section	BSU
X	trimmed cubes for crushing	BSU

Final Data Reporting

- Gather remaining sample metadata from Alvin dive track and report into rock description spreadsheet.
- Scan rock description forms, dive worksheets, rock descriptions and upload onto sci0, insert worksheets into cover slips and put into their respective binders.
- Tabulate rock description forms, dive worksheets, rock descriptions into excel spreadsheets on sci0.
- Compile sample rock description and dive transcript data into master IGSN spreadsheet
- Move subsamples into buckets and record bucket contents in bucket list.
- Download photographs from both mounted and unmounted cameras to sci0 and rename photographs.

-End-