



**U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE**

**Pacific Islands Fisheries Science Center
1845 Wasp Blvd. Bldg. 176 • Honolulu, Hawaii 96818
(808) 725-5300**

PROJECT REPORT

Vessel: NOAA Ship *Rainier*

Project Number: RA-22-01

Project Title: *Rainier* Integrates Charting, Hydrography, and Reef Demographics (RICHARD)

Project Period: 16 February –1 October, 2022

Area of Operation: Guam and the Northern Mariana Islands

Type of Operation: Personnel from the Ecosystem Sciences Division (ESD) and the Science Operations Division (SOD) of the NOAA Pacific Islands Fisheries Science Center, the Cooperative Institute for Marine and Atmospheric Research (CIMAR), and the NOAA Diving Center (NDC), along with partners from NOAA’s Atlantic Oceanographic and Meteorological Laboratory (AOML), National Centers for Environmental Information (NCEI) and University of Guam (UoG) conducted interdisciplinary surveys of oceanographic and benthic parameters related to climate change in coastal waters across Guam and the Northern Mariana Islands as part of the National Coral Reef Monitoring Plan (NCRMP).

All activities described in this report were covered by the following permits and authorizations:

- National Environmental Policy Act, Environmental Assessment PIFSC Coral Reef Ecosystem Division and FONSI signed May 7, 2010 (PIFSC-20100901)
- Endangered Species Act, Section 7 consultation (PIR-2018-10420 and Section 7(d) Determination on the Effects of Research on threatened coral species, Memo dated: March 22, 2022)
- U.S. National Parks Service: War in the Pacific, Scientific Research and Collecting Permit; Permit # WAPA-2022-SCI-003
- U.S. Fish and Wildlife Service: Mariana Islands Refuges & Refuge Complex, Special Use Permit; Permit # 12518-22003
- Guam Division of Aquatic and Wildlife Resources: Special Permit for Marine Protected Area. Permit # SP-22-004

- Commonwealth of the Northern Mariana Islands Department of Lands and Natural Resources, Division of Fish & Wildlife: Scientific Research License. Permit # SRC22-06-RE

Mission

The NOAA Ship *Rainier* was the primary support platform for the Rainier Integrates Charting, Hydrography, and Reef Demographics (RICHARD) research mission from February 25 through September 16, 2022, for a total of 160 Days at Sea (DAS) from arrival at the Inouye Regional Center in Honolulu, HI.

This is a collaborative project between the National Coral Reef Monitoring Program (NCRMP) and the Office of Coast Survey (OCS). The goal of this project is to acquire mapping data to support habitat analysis and navigational chart updates as well as conduct coral reef assessments. These data will be integrated with newly acquired topobathymetric LIDAR data in the region that covered all of the land and nearshore waters (depths < 50 m) for the islands of Guam, Saipan, Tinian, Rota, Aguijan, Pagan, and Farallon de Medinilla. Together, this joint mission will deliver high-quality data, data products, and tools to the region including a seamless map linking hilltops to underwater depths and integrated data on the surrounding coral reef ecosystems. These data can provide information for countless users to make critical management decisions within disciplines such as habitat management, tsunami modeling, monitoring, and marine resource management.

OCS conducted multi-beam hydrographic surveys around Guam and the Northern Mariana Islands in support of maritime safety using two launches in the nearshore waters and the NOAA Ship *Rainier* in deeper waters. In addition to bathymetric data, OCS acquired backscatter data to assist in seabed habitat characterization efforts. Furthermore, water column data and water level data were acquired to provide critical baseline data for future ocean studies. These data will support the international and collaborative Seabed 2030 initiative to map the world's oceans by 2030 as well as provide critical feature and depth information to update National Ocean Service (NOS) nautical charting products and services.

The Ecosystem Sciences Division (ESD) leads the National Coral Reef Monitoring Program—Mariana Archipelago (NCRMP-MA), providing scientific information that supports ecosystem approaches to the management and conservation of coral reefs. Since its inception in 2000, Pacific NCRMP has established baseline ecosystem assessments and conducted long-term monitoring that integrates biological observations with water quality and oceanographic data. Pacific NCRMP is also a key component of NOAA's overall NCRMP, a long-term effort to monitor the status and trends of U.S. coral reef ecosystems.

For this year's RICHARD mission, two small boats were deployed from the NOAA Ship *Rainier* to reach dive survey areas around Guam and the Northern Mariana Islands. Teams of SCUBA divers collected data to monitor nearshore physical and ecological

factors associated with ocean acidification and general water quality, including data on water temperature, salinity, and other physical and biological characteristics of the coral reef environment using an assortment of oceanographic sampling and monitoring instruments. In addition, divers conducted fine-scale, rapid ecological assessment (REA) surveys of reef fishes and corals.

Data collected during this mission are pivotal to the long-term biological and oceanographic monitoring of coral reef ecosystems in Guam and the Commonwealth of the Northern Mariana Islands (CNMI). The 2022 expedition will add to the information collected during monitoring and mapping surveys conducted in 2005, 2007, 2009, 2011, 2014, and 2017. Oceanographic and ecological time series data will allow scientists to evaluate potential changes in environmental conditions and coral reef health in the Mariana Archipelago and enable federal and state resource managers to more effectively conserve coral reef ecosystems of Guam and the CNMI, and manage ecosystem services.

1. **Goals**

The project goals of RA-22-01 were the following:

- To support safe navigation through the acquisition and processing of hydrographic survey data for updating nautical charts and by the identification and dissemination of dangers to navigation as identified during the course of survey operations. The hydrographic survey project instructions are found in (*Appendix # 4*).
- Conduct ecosystem monitoring of the species composition, abundance, percent cover, size distribution, recruitment and general health of the fishes, corals, other invertebrates, and algae of the shallow water (≤ 30 m) coral reef ecosystems of the Mariana Archipelago.
- Quantify Crown-of-Thorns starfish abundance along belt transects during benthic REA surveys.
- Deploy and retrieve long-term oceanographic instrumentation secured to the benthos in shallow waters (≤ 30 m) including Subsurface Temperature Recorders (STRs), Calcification Accretion Units (CAUs) and Bio-erosion Monitoring Units (BMUs) to monitor environmental conditions affecting the coral reef ecosystems of the Mariana Archipelago and biological responses.
- Temporarily deploy and retrieve a suite of oceanographic instrumentation (termed the Diel Suite) which characterizes nearshore physical, biological, and chemical variables associated with ocean acidification and coral reef metabolic processes—at Guam and Maug.
- Conduct general water quality studies, including analysis of seawater for salinity, temperature, total alkalinity, and dissolved inorganic carbon. These parameters will be measured via the collection of water in Niskin bottles and conductivity-temperature-depth (CTD) casts. Shallow-water CTDs are

conducted from small boats to a depth of ≤ 30 m.

- Use Structure-from-Motion (SfM) photogrammetry to collect reef imagery that will be used to extract coral community composition data at benthic survey sites, fish survey sites, and monitoring instrumentation sites. These data will be used to test the comparability of visual vs. imaging methods to assess benthic communities and reef carbonate budget. The data will also be used to track coral growth, mortality, and recruitment at previously imaged instrumentation sites. This will also include testing various data georeference strategies carrying different levels of accuracy and field logistics to geolocate reef sites.
- Conduct carbonate budget assessments at permanent REA sites to estimate rates of reef accretion, reef erosion, and net framework production.
- Collect coral tissue samples at low-pH vent sites and high-pH control sites at Maug to assess transcriptomes of corals in marginal environments and evaluate potential mechanisms of coral resistance to ocean acidification.
- Participate in collaborative Integrated Mapping Product trial between scientists and personnel from the Office of Coast Survey (OCS), the National Centers for Coastal Ocean Science (NCCOS), the Pacific Islands Fisheries Science Center (PIFSC), the NOAA Coral Reef Conservation Program (CRCP), and the NOAA Ship *Rainier*, to generate an integrated, nested, benthic data product covering the benthos from 0-m to < 100 -m depths in select areas across the islands of Saipan, Tinian, Aguijan, and associated shallow banks.
- Deploy and recover High Frequency Acoustic Recording Packages (HARPs) used for long term monitoring of cetaceans in the Pacific Islands Region (For HARP information refer to *Appendix # 5*).
- Use Drop-cams, High Accuracy GPS units and the NOAA Ship *Rainier*'s Global Navigation Satellite System (GNSS) capacity to ground-truth mapping efforts around Saipan Island. Assist in the generation of benthic habitat characterization maps covering the benthos from 0 m to < 100 -m depths in select areas around Saipan Island.

2. Operating Area

The operating area of RA-22-01 was as follows (Figure 1).

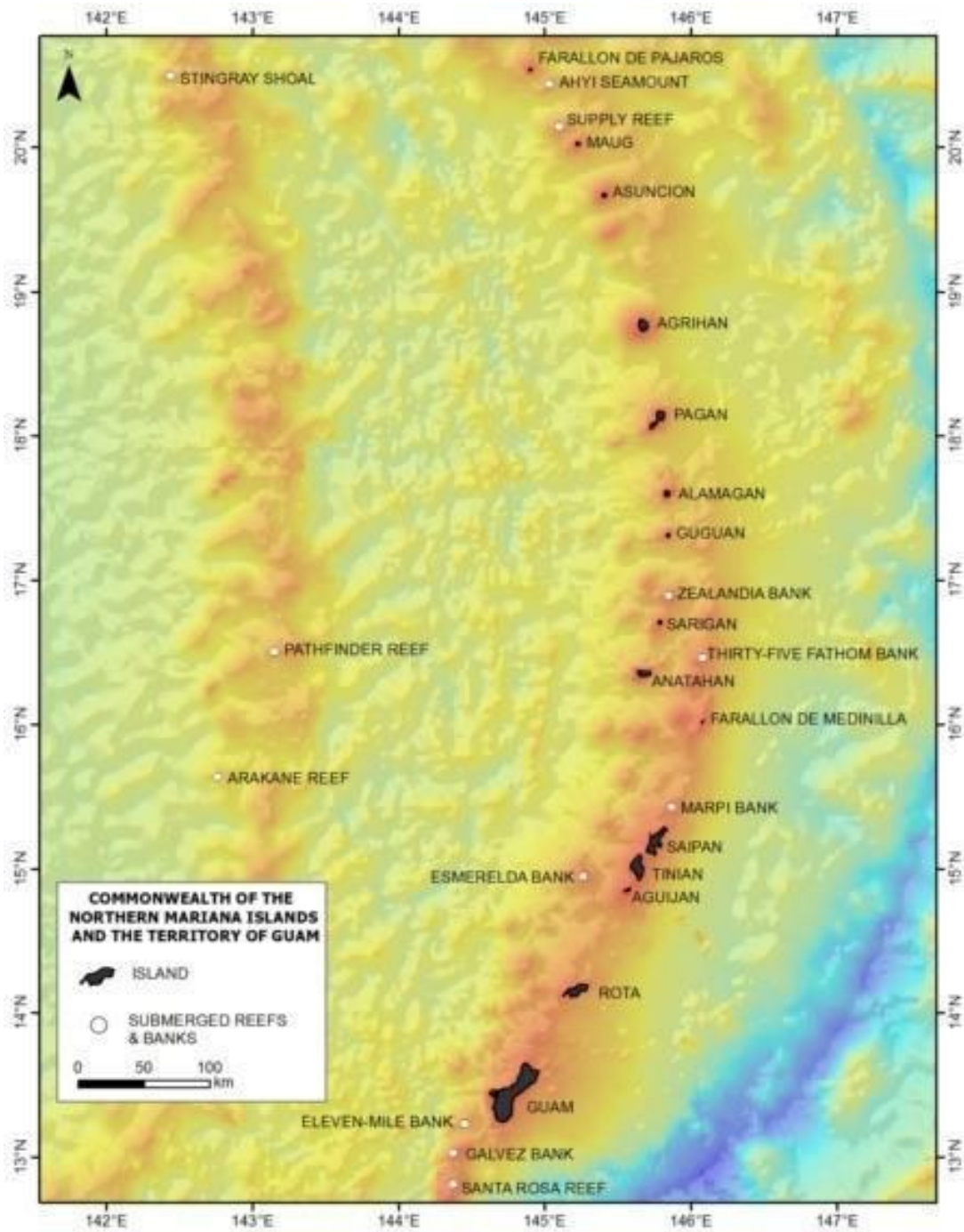


Figure 1. Operating area for the NOAA Ship *Rainier*.

3. *Itinerary*

Leg III

April 11 Departed Apra Harbor, Guam.
April 12 Conducted operations around Guam.
April 13 Safety stand-down due to a positive COVID case on board.
April 14 Conducted operations around Guam.
April 15–16 Conducted operations around Rota.
April 17–18 Conducted operations around Guam.
April 19–20 Conducted operations around Tinian.
April 21–22 Conducted operations around Saipan.
April 23 Rest day.
April 24–26 Conducted operations around Saipan.
April 27 Conducted operations around Tinian.
April 28–29 Conducted operations around Aguijan.
April 30–
May 3 Conducted operations around Guam.
May 4 Rest day.
May 5 Arrived at Apra Harbor, Guam. End of Leg III.

Leg IV

May 10 Departed Apra Harbor, Guam.
May 11 Conducted operations around Guam.
May 12 Conducted operations around Guam.
May 13 Conducted operations around Guam.
May 14 Conducted operations around Guam.
May 15 Conducted operations around Tinian.
May 16 Conducted operations around Saipan.
May 17 Conducted operations around Saipan.
May 18 Rest Day.
May 19 Conducted operations around Pagan.
May 20 Conducted operations around Pagan.
May 21 Conducted operations around Maug.
May 22 Conducted operations around Maug. Ship anchored in caldera.
May 23 Conducted operations around Maug. Ship anchored in caldera during
daytime operations; got underway and transited overnight to Asuncion.
May 24 Conducted operations around Asuncion.
May 25 Conducted operations around Asuncion.
May 26 Conducted operations around Pagan.
May 27 Rest Day.
May 28 Conducted operations around Saipan.
May 29 Conducted operations around Tinian.
May 30 Conducted operations around Rota.
May 31 Conducted operations around Rota.
June 1 Conducted operations around Guam.

June 2 Arrived at Apra Harbor, Guam. End of Leg IV.

Leg V

June 7 Unable to get underway due to positive COVID cases. Ship remained alongside in Apra Harbor, Guam.

June 8 Conducted snorkel operations around Guam; ship remained alongside.

June 9–15 Conducted operations around Guam; ship remained alongside.

June 16 Conducted operations around Guam. Ship got underway and transited overnight to Saipan.

June 17 Conducted operations around Saipan. Ship remained anchored due to limited crew.

June 18 Conducted operations around Saipan. Transited overnight to Pagan.

June 19 Conducted operations around Pagan. Ship remained anchored.

June 20 No diving operations. Retrieved a HARP 15 nm southwest of Pagan on small boats. Transited overnight to Maug.

June 21 Conducted operations around Maug. Ship anchored in caldera.

June 22 Conducted operations around Maug. Ship anchored in caldera during daytime operations; got underway and transited overnight to Farallon de Pajaros.

June 23 Conducted operations around Farallon de Pajaros.

June 24–27 Conducted operations around Maug. Ship remained anchored in caldera.

June 28 Conducted operations around Maug. Transited overnight to Sarigan.

June 29 Conducted operations around Sarigan and Zealandia. Transited overnight to Apra Harbor, Guam.

June 30 Arrived at Apra Harbor, Guam. End of Leg V.

Leg VI

July 5 Unable to get underway due to understaffing. Ship remained alongside in Apra Harbor, Guam. No operations.

July 6 Conducted operations near Apra Harbor; ship remained alongside.

July 7 Conducted operations near Apra Harbor; ship remained alongside.

July 8 Conducted operations near Apra Harbor; ship remained alongside.

July 9 Conducted operations around Guam; ship remained alongside.

July 10 Conducted operations around Guam; ship remained alongside.

July 11 Conducted operations near Apra Harbor; ship remained alongside.

July 12 Conducted operations near Apra Harbor; ship departed and transited overnight to Saipan.

July 14 Conducted operations around Saipan.

July 13 Ship pulled into Saipan Harbor, end of Leg VI.

Leg VII

July 19	Unable to get underway due to potential cases of COVID. Ship remained alongside in Saipan Harbor, Saipan. No operations
July 20	Ship departed Saipan and transited to Pagan
July 21	Conducted operation around Pagan
July 22	Conducted operation around Pagan. Transited overnight to Asuncion
July 23	Conducted operation around Asuncion
July 24	Conducted operation around Asuncion
July 25	Detected four cases of COVID; ship at anchor in Pagan; no operations. Overnight transit to Apra Harbor, Guam
July 26	Ship remained on Anchor at Apra Harbor; no dice operations
July 27	Ship remained on Anchor at Apra Harbor; no dive operations
July 28	Ship came pier side in Apra Harbor; no operations
July 29	Ship remained pier side in Apra Harbor; dive operations around Guam
July 30	Ship remained pier side in Apra Harbor; dive operations around Guam
July 31	Ship remained pier side in Apra Harbor; no dive operations
Aug 1	Ship remained pier side in Apra Harbor; dive operations around Guam
Aug 2	Ship remained pier side in Apra Harbor; dive operations around Guam
Aug 3	Ship remained pier side in Apra Harbor; dive operations around Guam
Aug 4	Early transit to Rota; dive operations around Rota. Overnight transit to Saipan
Aug 5	Conducted operations around Saipan. Overnight transit to Pagan
Aug 6	Conducted operations around Pagan
Aug 7	Conducted operations around Pagan
Aug 8	Conducted operations around Pagan.
Aug 9	Conducted operations around Pagan. Overnight transit to Saipan
Aug 10	Conducted operations around Saipan. Retrieved and deployed a HARP ~14 nm west of Saipan on small boats. Conducted dive operations on a deep bank ~1 nm west of Saipan. Overnight transit to Apra Harbor, Guam
Aug 11	Arrived at Apra Harbor, Guam. End of Leg VII.

4. Results

COVID-19 impacts and loss of NCRMP operational days

COVID-related delays led to an overall loss of 46 NCRMP operational DAS (17 DAS prior to leg I, 29 DAS during operations in the Marianas), reducing the NCRMP allocation from the originally planned 125 DAS to a final total of 79 DAS (37% loss). These delays and loss of operational time significantly impacted NCRMP fish and

climate mission objectives during Legs III and V-VII (Leg III: 1 DAS, Leg V: 9 DAS, Leg VI: 7 DAS, Leg VII: 12 DAS lost).

The fish and climate teams were able to conduct shore-based operations (shore diving and/or small boats launched while alongside) on 19 of the 29 days the NOAA Ship *Rainier* was delayed in port. These shore-based operations largely focused on secondary mission objectives – fish surveys within Guam MPAs and carbonate budget pilot assessments – since most of the primary NCRMP objectives could not be accomplished from shore dives or from small boats launched in Apra Harbor. As a result of the delays, the fish and climate teams were unable to complete planned NCRMP work at Wake, Agrihan, Sarigan, Guguan, Alamagan, and Supply Reef.

Highlights and Accomplishments

Guam (GUA)

- *Fish*
 - Large humphead wrasse (*Cheilinus undulatus*) were seen and even counted within SPC surveys at sites on the Western side of the island.
 - Juvenile humphead wrasse (*Cheilinus undulatus*) were seen in Apra Harbor (Gab Gab beach) and on the western side as well.
 - A pod of spinner dolphins (*Stenella longirostris*) was sighted and remained within the Pati Point area for an entire afternoon.
 - Large school of blackfin barracuda (*Sphyraena qenie*) found off the southeast side of the island on multiple occasions.
 - Completed 43 surveys inside and outside of Guam’s Piti Bomb Holes Marine Preserve as part of an additional CRCP project.
 - Total Fish Team Dives: 244
 - REA: 118 sites surveyed (includes Piti Bomb Holes surveys)
 - Photoquads: 114 sites imaged.
 - SfM: 51 sites imaged.
 - Carbonate chemistry: 31 sites water sampled.

- *Benthic*
 - Total Benthic Team Dives: 130
 - REA: 41 sites surveyed.
 - SfM: 33 sites imaged.
 - CoTS Surveys: 41 sites surveyed.
 - These corals are important members of the benthic communities in Guam, but can be especially susceptible to heat stress during coral bleaching events.

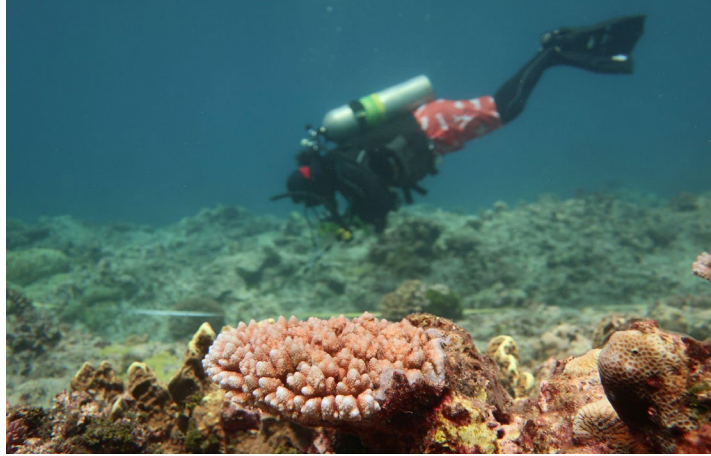


Figure 2. Benthic diver with *Acropora* spp. in foreground.

- *OCC*:
 - Total Dives: 266
 - STRs: STR swap at 14 sites (total of 18 STRs deployed and 17 STRs recovered)
 - CAUs: CAU swap at 4 sites, 1 site pulled (total of 20 CAUs deployed and 25 CAUs recovered).
 - BMUs: BMU swap at 4 sites (total of 20 BMUs deployed and 16 BMUs recovered).
 - Carbonate chemistry: Water samples were collected at 54 sites.
 - SfM Spirals: 11 SfM spirals completed.
 - Photoquads: 15 sites imaged.

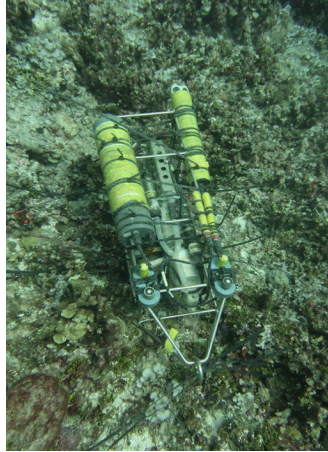


Figure 3. The diel suite instrument package pictured below, includes a moored CTD, SeaFET pH sensor, ADCP, dissolved oxygen sensor, and photosynthetically active radiation sensor), and was installed at the Tumon Bay fixed site for a 19-day deployment during Leg 3.

- Carbonate budget pilot assessments were conducted at Tumon Bay, Gab Gab Beach, Asan, and Piti during Legs V–VII. Work at Gab Gab Beach also included methods calibration for estimating carbonate production rates of *Porites rus* with a laminar columnar morphology.



○

Figure 4. *Porites rus* cover at Gab Gab Beach was ~90%.

Rota (ROT)

- *Fish*
 - Total Fish Team Dives: 34

- REA: 16 sites surveyed.
 - Photoquads: 13 sites imaged.
 - SfM: 7 sites imaged.
 - Carbonate chemistry: 6 sites water sampled.
- *Benthic*
 - Total Benthic Team Dives: 61
 - REA: 16 sites surveyed.
 - SfM: 9 sites imaged.
 - CoTS Surveys: 16 sites surveyed.

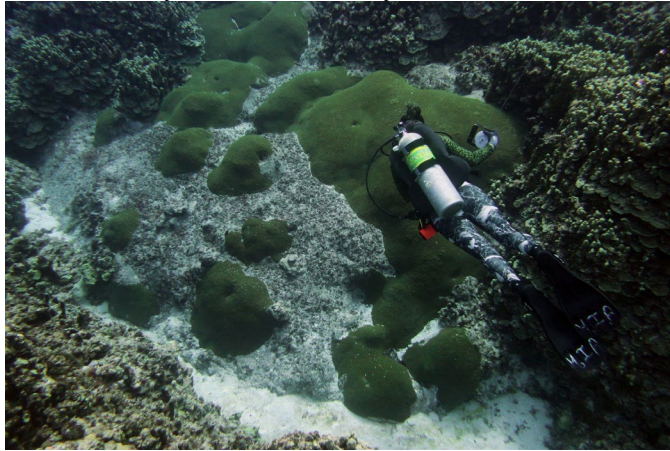


Figure 5. During benthic REA surveys, we often encounter large coral colonies such as this *Diploastrea heliopora* colony pictured below.

- *OCC*
 - Total Dives: 20
 - STRs: STR swap at 3 sites (total of 2 STRs deployed and 3 STRs recovered).
 - CAUs: CAU swap at 2 sites (total of 10 CAUs deployed and CAUs recovered).
 - Carbonate chemistry: Water samples were collected at 7 sites.
 - SfM Spirals: 2 SfM spirals completed.
 - Photoquads: 3 sites were imaged.

Aguijan (AGU)

- *Fish*
 - Sharks were spotted during most dives along the Northeastern side of the island, including blacktip reef sharks (*Carcharhinus melanopterus*) and a school of Galapagos sharks (*Carcharhinus galapagensis*).
 - Total Fish Team Dives: 38
 - REA: 15 sites surveyed.
 - Photoquads: 11 sites imaged.
 - SfM: 6 sites imaged.

- Carbonate chemistry: 11 sites water sampled.
- *Benthic*
 - *Not surveyed.*
- *OCC*
 - Total Dives: 2
 - STRs: STR retrieval at 1 site (1 STR recovered and not redeployed).

Tinian (TIN)

- *Fish*
 - Total Fish Team Dives: 38
 - REA: 19 sites surveyed.
 - Photoquads: 19 sites imaged.
 - SfM: 19 sites imaged.
 - Carbonate chemistry: 11 sites water sampled.
- *Benthic*
 - Total Benthic Team Dives: 64
 - REA: 15 sites surveyed.
 - SfM: 11 Sites imaged.
 - CoTS Surveys: 14 sites surveyed.
- *OCC*
 - Total Dives: 22
 - STRs: STR swap at 5 sites (total of 4 STRs deployed and 2 STRs recovered).
 - CAUs: CAU swap at 4 sites (total of 20 CAUs deployed and 19 CAUs.recovered).



Figure 6. . One CAU pictured below had an Acropora coral roughly 5 years old.

- Carbonate chemistry: Water samples were collected at 4 sites.
- SfM Spirals: 3 SfM spirals completed.
- Photoquads: 4 sites imaged.

Saipan (SAI)

- *Fish*
 - Total Fish Team Dives: 121
 - REA: 55 sites surveyed.
 - Photoquads: 50 sites imaged.
 - SfM: 37 sites imaged.
 - Carbonate chemistry: 21 sites water sampled.



Figure 7. Diver captures our encounter with a large aggregation of bigeye scad (*Selar crumenophthalmus*) just north of Laolao bay.

- *Benthic*
 - Total Benthic Team Dives: 84
 - REA: 24 sites surveyed.
 - SfM: 19 sites imaged.
 - CoTS Surveys: 23 sites surveyed.
- *OCC*
 - Total Dives: 100
 - STRs: STR swap at 16 sites, 1 retrieved and not redeployed (total of 20 STRs deployed and 20 STRs recovered).
 - CAUs: CAU swap at 4 sites (total of 20 CAUs deployed and 15 CAUs recovered).
 - BMUs: BMU swap at 4 sites (total of 20 BMUs deployed and 19 BMUs recovered).

- Carbonate chemistry: Water samples were collected at 26 sites.
- SfM Spirals: 5 SfM spirals completed.
- Photoquads: 15 sites imaged.
- Carbonate budget pilot surveys conducted at the west and south fixed 15-m sites.

Sarigan (SAR)

- *Fish*
 - Total Fish Team Dives: 8
 - REA: 4 sites surveyed.
 - Photoquads: 3 sites imaged.
 - SfM: 1 site imaged.
 - Carbonate chemistry: none
- *Benthic*
 - *Not surveyed.*
- *OCC*
 - Total Dives: 10
 - STRs: STR retrieval at **Zealandia(ZEA)** Bank (1 STR recovered and not redeployed).



Figure 8. Diver at Zealandia (ZEA) Bank where the team encountered large schools of Jacks, Barracudas, Rainbow Runners and even a few Grey Reef sharks.

- Carbonate chemistry: Water sample was collected at 1 site.
- Photoquads: 1 site imaged.

Guguan (GUG)—*Not surveyed.*

Alamagan (ALA) — *Not surveyed.*

Pagan (PAG)

- *Fish*
 - Total Fish Team Dives: 90
 - REA: 39 sites surveyed.
 - Photoquads: 37 sites imaged.
 - SfM: 30 sites imaged.
 - Carbonate chemistry: 17 sites water sampled.

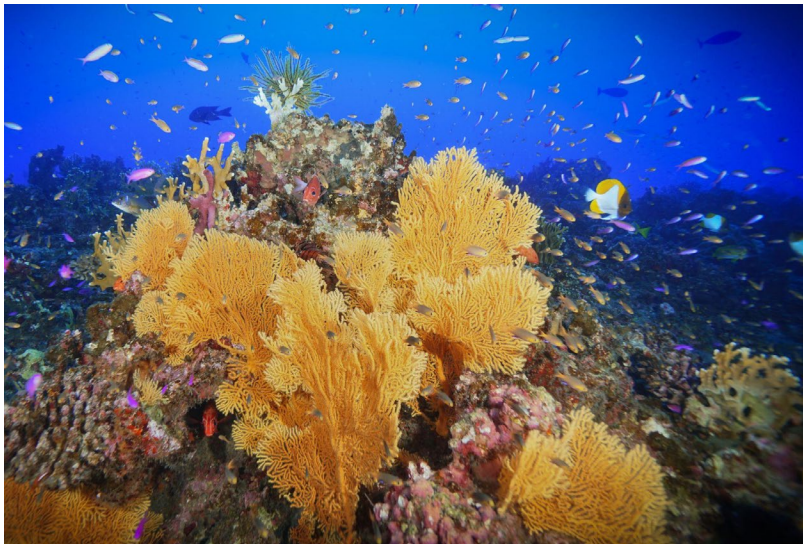


Figure 9. A high current area covered in sea fans on the west side of the Pagan (PAG) anchorage that held high densities of *Macolor* spp. snappers, two-spot red snappers (*Lutjanus bohar*) and a few rarely observed silvertip sharks (*Carcharhinus albimarginatus*).

- *Benthic*
 - Total Benthic Team Dives: 81
 - REA: 24 sites surveyed.
 - SfM: 21 Sites imaged.
 - CoTS Surveys: 24 sites surveyed.

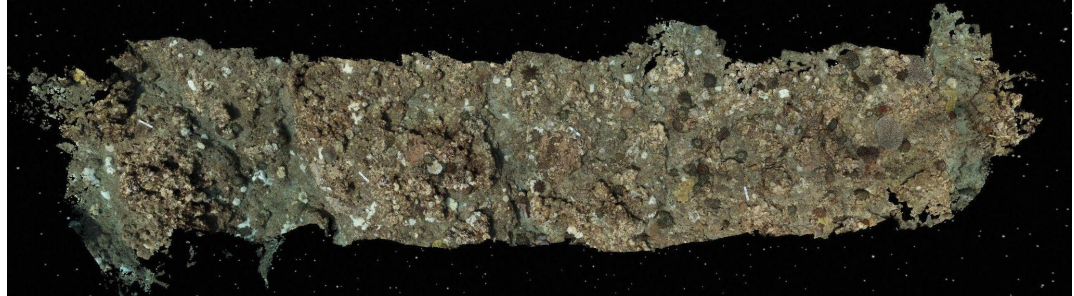


Figure 10. A significant, but spatially restricted Crown of Thorns starfish outbreak discovered in Pagan (PAG). A SfM survey was conducted at this site that provided initial data to CNMI management authorities.

- *OCC*
 - Total Dives: 110
 - STRs: STR swap at 14 sites (total of 15 STRs deployed and 9 STRs recovered).
 - CAUs: CAU swap at 4 sites (total of 20 CAUs deployed and 17 CAUs recovered).
 - BMUs: BMU swap at 4 sites (total of 20 BMUs deployed and 20 BMUs recovered).
 - Carbonate chemistry: Water samples were collected at 16 sites.
 - SfM Spirals: 5 SfM spirals completed.
 - Photoquads: 12 sites imaged.
 - Carbonate budget pilot assessments were conducted at both the East and West 15-m NCRMP sites at Pagan as seen below.



Figure 11. Diver conducting a carbonate budget pilot assessment.

Agrihan (AGR) – *Not surveyed.*

Asuncion (ASC)

- *Fish*
 - Total Fish Team Dives: 30
 - REA: 15 sites surveyed.
 - Photoquads: 15 sites imaged.
 - SfM: 8 sites imaged.
 - Carbonate chemistry: 4 sites water sampled.
- *Benthic*
 - Total Benthic Team Dives: 56
 - REA: 17 sites surveyed.
 - SfM: 15 sites imaged.
 - CoTS Surveys: 17 sites surveyed.
- *OCC*
 - Total Dives: 30
 - STRs: STR swap at 3 sites (total of 3 STRs deployed and 2 STRs recovered).
 - CAUs: CAU swap at 3 sites (total of 15 CAUs deployed and 11 CAUs recovered). Newly deployed CAU pictured below.

- Carbonate chemistry: Water samples were collected at 5 sites.
- SfM Spirals: 4 SfM spirals completed.
- Photoquads: 5 sites imaged.

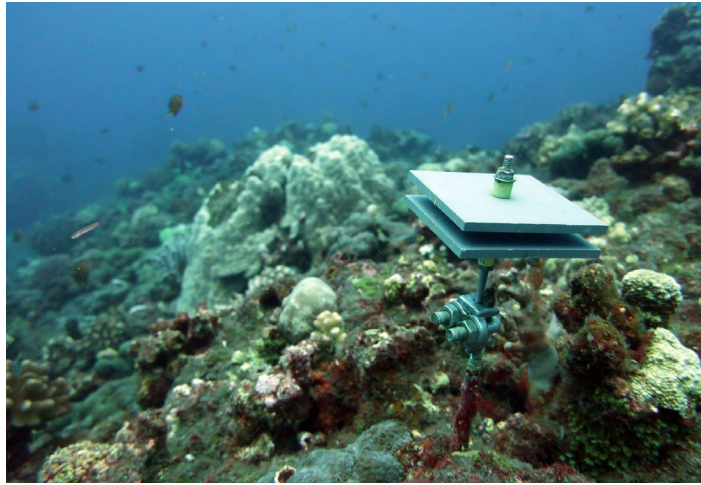


Figure 12. Image of a newly deployed CAU.

Maug (MAU)

- *Fish*
 - Total Fish Team Dives: 73
 - REA: 30 sites surveyed.
 - Photoquads: 28 sites imaged.
 - SfM: 22 sites imaged.
 - Carbonate chemistry: none.
- *Benthic:*
 - Total Benthic Team Dives: 77
 - REA: 24 sites surveyed.
 - SfM: 22 sites imaged.
 - CoTS Surveys: 24 sites surveyed.

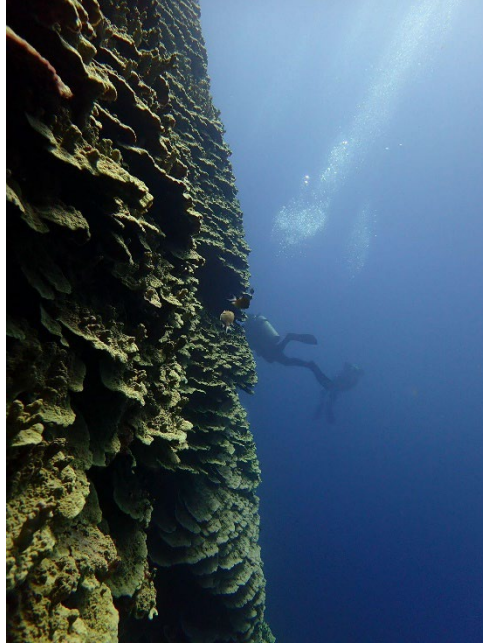


Figure 13. Maug has especially unique geomorphology and is well known for its vast stretches of *Porites rus*-dominated reef.

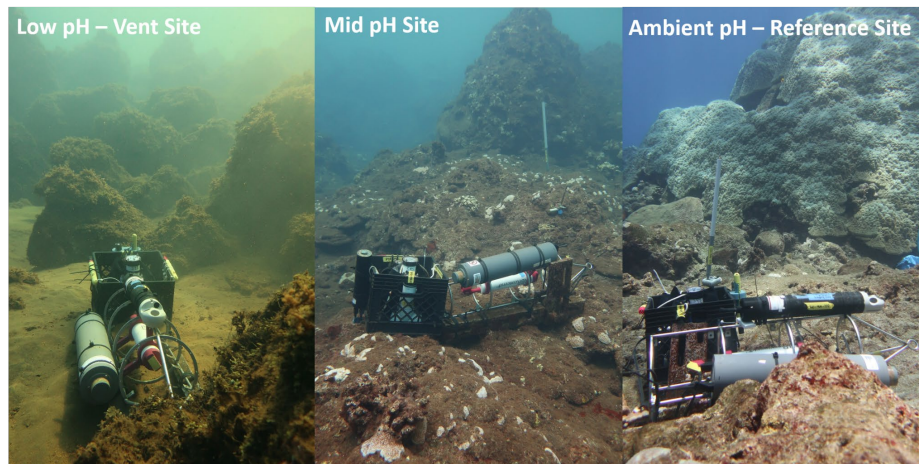


Figure 14. Three diel suite instrument packages, which each included a moored CTD, SeaFET pH sensor, ADCP and/or Tilt Meter, dissolved oxygen sensor, and photosynthetically active radiation sensor), were installed along a pH gradient from a naturally occurring CO₂ vent for three 7-day deployments during Leg V.

- OCC
 - Coral tissue was sampled from approximately 15 *Porites* spp. and 15 *Pocillopora* spp. colonies at each of three sites along a pH gradient for genetic analysis (Total: 43 *Porites* spp. and 39 *Pocillopora* spp.).

- Sediment sample collections occurred at three sites along the pH gradient stemming from the CO₂ vent as well.
- Total Dives: 101
- STRs: STR swap at 9 sites (total of 16 STRs deployed and 9 STRs recovered).
- CAUs: CAU swap at 2 sites (total of 15 CAUs deployed and 10 CAUs recovered).
- BMUs: BMU swap at 5 sites (total of 60 BMUs deployed and 56 BMUs recovered).
- SfM Spirals: 5 SfM spirals completed.
- Photoquads: 4 sites imaged.

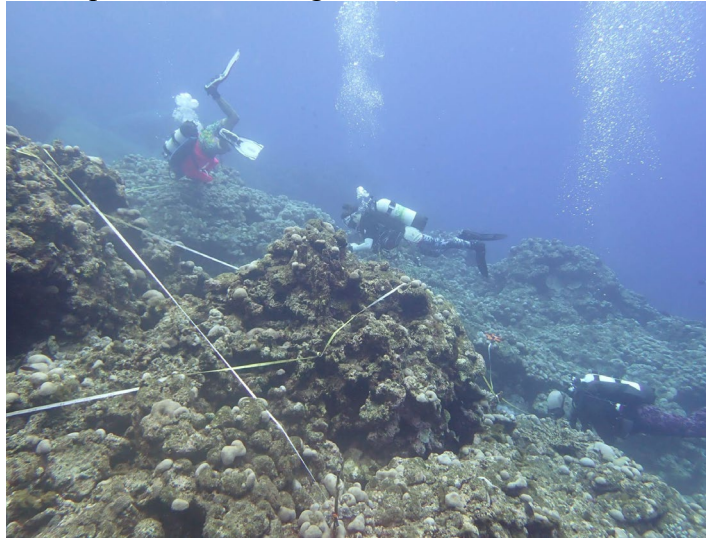


Figure 15. Divers conducting carbonate budget pilot surveys at the north 15-m fixed site and caldera reference site by our OCC dive team.

Farallon de Pajaros (FDP)

- *Fish*
 - Total Fish Team Dives: 18
 - REA: 9 sites surveyed.
 - Photoquads: 8 sites imaged.
 - SfM: none.
 - Carbonate chemistry: none.



Figure 16. Large schools of jacks and sharks observed around Farallon de Pajaros (FDP)

- *Benthic*
 - *Not surveyed.*
- *OCC*
 - Total Dives: 16
 - Two STRs recovered and re-deployed.

Table 1. Summary statistics for RA-22-01. Totals for SCUBA dives include all dives carried out for all activities at each island.

RESEARCH ACTIVITY	GUA	ROT	TIN	SAI	AGU	PAG	MAU	ASC	FDP	SAR	ZEA
SCUBA DIVES	614	111	110	307	40	275	249	112	23	8	10
BENTHIC-REA-SITES	41	16	15	24	0	24	24	17	0	0	0
FISH-REA-SITES	109	16	19	54	15	40	30	15	9	4	0
OCC-SITE-VISITS	70	6	12	45	1	36	30	14	2	0	1
CTD-CASTS	86	13	15	49	11	37	0	9	0	0	0
H2O-SAMPLES	86	13	15	49	11	36	1	9	0	0	0
STR-DEPLOYED	18	2	4	20	0	16	16	3	2	0	0
STR-RECOVERED	17	3	2	19	1	8	12	2	2	0	1
CAUS-RECOVERED	25	10	19	15	0	17	10	11	0	0	0
CAUS-DEPLOYED	20	10	20	20	0	20	15	15	0	0	0
BMUS-DEPLOYED	20	0	0	20	0	20	60	0	0	0	0
BMUS-RECOVERED	18	0	0	18	0	20	56	0	0	0	0

5. *Data Streams*

The following data and samples were collected during this expedition:

Climate Change and Ocean Acidification

Oceanographic Instrumentation and Biological Installations

- Seawater temperature
- CaCO₃ deposition rates by collection of calcifying organisms from retrieved CAUs
- Bioerosion rates from retrieved BMUs

Nearshore Oceanography from Small Boats

- Shallow-water CTD profiles to depth <30 m
- Water samples for dissolved inorganic carbon (DIC) and total alkalinity (TA) collected in concert with shallow-water CTD casts

Diel Suite Instrument Deployments

- High-resolution, instrument time series for the following:
 - Temperature, salinity, and pressure
 - Seawater pH
 - Current speed and direction
 - Dissolved oxygen
 - Photosynthetically Active Radiation (PAR)
 - Dissolved Inorganic Carbon (DIC) and Total Alkalinity (TA)

Biological Monitoring

Benthic REA surveys

- Digital still photographs of overall site character and typical benthos
- Digital still photographs of the benthos along transect lines
- Number, species or genus, size, and condition (% mortality, disease, bleaching) of all coral colonies observed within belt transects of known area
- Digital still photographs of diseased corals and coralline algae
- Number of Crown-of-Thorns Starfish along a 30 × 4 m belt transect.

Fish REA surveys

- Number, species, and estimated sizes of all fishes observed during stationary point count surveys (paired 7.5-m radius cylinders).

Carbonate budget surveys

- Surface distance of all benthic components (coral, algae, abiotic substrate) directly beneath 6 × 10 m transects

- Number, species, and size of bio eroding urchins observed within 6 × 10 m × 1 m belts
- Number, species, and size of all parrotfish observed within 10 × 6 m × 30 m belts

Coral tissue samples

- Tissue samples from *Porites* and *Pocillopora* corals for genomics analysis (~1 cm²) at Maug vent sites

Photomosaics

Benthic Photomosaics (randomized sites)

- Digital photographs of the benthos covering 13 – 20 m belt transects at randomized benthic REA and fish SPC sites.

Benthic Photomosaics (climate stations)

- Digital photographs of the benthos covering a 12-m diameter circle at fixed climate stations

6. Scientific Personnel

Table 2. List of RA-22-01 Leg III cruise participants: CIMAR: Cooperative Institute for Marine and Atmospheric Science; ESD: Ecosystem Sciences Division; NDC: NOAA Diving Center.

Name (Last, First)	Title	Gender	Affiliation	Nationality
Barkley, Hannah	Chief Scientist/OCC Diver	Female	ESD	USA
Kindinger, Tye	Fish Team Lead /Diver	Female	ESD	USA
Weible, Rebecca	OCC Team Lead /Diver	Female	CIMAR	USA
Garriques, Joao	Operations Lead/OCC Diver	Male	CIMAR	USA
Lamirand, Mia	Fish Diver	Female	ESD	USA
Hershberger, Andrea	Fish Diver	Female	CIMAR	USA
Lee, Ro	Fish Diver	Female	CIMAR	USA
Chauvin, Matthew	OCC Diver	Male	CIMAR	USA
Alagata, Candace	OCC Diver	Female	CIMAR	USA

Name (Last, First)	Title	Gender	Affiliation	Nationality
Smith, Joy	OCC Diver	Female	CIMAR	USA
Akridge, Michael	Data Manager	Male	CIMAR	USA
Jeremiah, Nick	Chamber Operator	Male	NDC	USA

Table 3. List of RA-22-01 Leg IV cruise participants. CIMAR: Cooperative Institute for Marine and Atmospheric Science; ESD: Ecosystem Sciences Division; SOD: Science Operations Division; NDC: NOAA Diving Center.

Name (Last, First)	Title	Gender	Affiliation	Nationality
Oliver, Thomas	Chief Scientist/Benthic Diver	Male	ESD	USA
Winston, Morgan	Benthic Team Lead/ Diver	Female	CIMAR	USA
Garriques, Joao	Operations Lead/ Diver	Male	CIMAR	USA
Huntington, Brittany	Chief Scientist/Benthic Diver	Female	CIMAR	USA
Torres-Pulliza, Damaris	Benthic Diver	Female	CIMAR	USA
Amir, Corinne	Benthic Diver	Female	CIMAR	USA
Charendoff, Jonathan	Benthic Diver	Male	CIMAR	USA
Lamirand, Mia	Benthic Diver	Female	CIMAR	USA
Osborn, Nicolas	Benthic Diver	Male	SOD	USA
Ehrenberg, Jon	Benthic Diver	Male	CIMAR	USA
Luers, Lori	Data Manager	Female	CIMAR	USA
Kent, Michael	Chamber Operator	Male	NDC	USA

Table 4. . List of RA-22-01 Leg V cruise participants. CIMAR: Cooperative Institute for Marine and Atmospheric Science; ESD: Ecosystem Sciences Division; NDC: NOAA Diving Center; AOML: NOAA Atlantic Oceanographic and Meteorological Laboratory.

Name (Last, First)	Title	Gender	Affiliation	Nationality
Kindinger, Tye	Chief Scientist/Fish Diver	Female	ESD	USA
Barkley, Hannah	OCC Team Lead/OCC Diver	Female	ESD	USA
McCoy, Kaylyn	Fish Team Lead/Fish Diver	Female	ESD	USA
Garriques, Joao	Operations Lead/OCC Diver	Male	CIMAR	USA
Chauvin, Matthew	Fish Diver	Male	CIMAR	USA
Ingeman, Kurt	Fish Diver	Male	CIMAR	USA
Staman, Jan	Fish Diver	Male	SOD	USA
Besemer, Nicole	OCC Diver	Female	AOML	USA
Halperin, Ariel	OCC Diver	Male	CIMAR	USA
Huntington, Brittany	OCC Diver	Female	CIMAR	USA
Luers, Lori	Data Manager	Female	CIMAR	USA
Kent, Michael	Chamber Operator	Male	NDC	USA

Table 5. List of RA-22-01 Leg VI cruise participants.

Name (Last, First)	Title	Gender	Affiliation	Nationality
McCoy, Kaylyn	Chief Scientist/Fish Diver	Female	ESD	USA
Gray, Andrew	Fish Team Lead/Fish Diver	Female	ESD	USA
Chauvin, Matthew	Operations Lead/Fish Diver	Male	CIMAR	USA


Lee, Ro	Fish Diver	Female	CIMAR	USA
Staman, Jan	Fish Diver	Male	SOD	USA
Alagata, Candace	OCC Diver	Female	CIMAR	USA
Halperin, Ariel	OCC Team Lead/OCC Diver	Male	CIMAR	USA
Scott, Molly	Fish Diver	Female	CIMAR	USA
Charendoff, Jonathan	OCC Diver	Male	CIMAR	USA
Ehrenberg, Jon	OCC Diver	Female	CIMAR	USA
Mason, Zachary	Data Manager	Male	NCEI	USA
Kent, Michael	Chamber Operator	Male	NDC	USA
Digre, Sean	Chamber Operator	Male	NDC	USA

Table 6. . List of RA-22-01 Leg VII cruise participants. CIMAR: Cooperative Institute for Marine and Atmospheric Science; ESD: Ecosystem Sciences Division; NDC: NOAA Diving Center; NCEI: NOAA National Centers for Environmental Information.

Name (Last, First)	Title	Gender	Affiliation	Nationality
Vargas-Angel, Bernardo	Chief Scientist/OCCDiver	Male	CIMAR	USA
Halperin, Ariel	OCC Team Lead/OCC Diver	Male	CIMAR	USA
Gray, Andrew	Fish Team Lead/Fish Diver	Male	CIMAR	USA
Chauvin Matthew	Operations Lead/Fish Diver	Male	CIMAR	USA
Amir, Corinne	OCC Diver	Female	CIMAR	USA
Alagata, Candace	OCC Diver	Female	CIMAR	USA
Smith, Joy	OCC Diver	Female	CIMAR	USA
Boland, Ray	Fish Diver	Male	ESD	USA
Hayes Nathan	Fish Diver	Male	DAR	USA


Milisen, Jeff	Fish Diver	Male	CIMAR	USA
Asirvadam, Lalitha	Data Manager	Female	NCEI	USA
Digre, Sean	Chamber Operator	Male	NDC	USA

Submitted by:



Jennifer Samson, Ph.D.

Approved by:



Michael Seki, Ph.D.
Science Director
Pacific Islands Fisheries Science Center

Appendices

Appendix A. Methods

This appendix describes the methods and procedures used by ESD during the RICHARD mission on the NOAA Ship *Rainier* during the 16 February –1 October, 2022 period.

A.1. Climate and Ocean Acidification Monitoring: Instrumentation, Biological Installations, and Carbonate Chemistry Sampling

Two main activities were conducted to monitor climate and ocean change: (1) near-shore oceanographic and carbonate chemistry surveys; and (2) deployment and an array of subsurface moored instrumentation and installations to provide continuous, high-resolution time-series of physical observations and integrated, ecosystem-wide biological process data.

Climate and ocean acidification monitoring efforts at each survey site fall into four complementary levels of increasing resolution. These are intended to document the island-scale water chemistry, spatial and temporal variability of reef water thermal structure across a depth gradient, and the integrated biological responses of the reef community to the prevailing chemical and physical conditions.

- Class 0 sites: CTD casts and discrete water samples for dissolved inorganic carbon (DIC) and total alkalinity (TA) are collected.
- Class I sites: Subsurface temperature recorders (STRs) are deployed (Sea-Bird SBE 56 and/or RBR solo³).
- Class II sites: Include CTD casts and discrete water for DIC and TA; STR deployments; benthic community surveys from still photograph records; and biological installations, including Calcification Accretion Units (CAUs) and Bioerosion Monitoring Units (BMUs).
- Class III sites: A MAPpCO₂ buoy system is added to the Class II site setup.

Most Class I and Class II sites are distributed along the four cardinal directions around each island surveyed. Thermal structure measurements are obtained from STRs deployed along a perpendicular forereef transect at 1-, 5-, 15-, and 25-m depth; each STR records the near-reef water temperature at the same time, on a 5-min interval, for the duration of the instrument's deployment. Within this context, a permanent water quality, temperature, and biological survey/sampling site, designated as *NCRMP Monitoring Station*, is established at the 15-m depth STR location, at select islands. In addition to the STR, the NCRMP Monitoring Station includes: deployment 5 CAUs and 5 BMUs; collection of carbonate chemistry water samples (with associated CTD casts); and acquisition of still photographic benthic imagery to document benthic cover and composition.

A.1.1. Moored Instruments for Time-series Observations

ESD conducts long-term oceanographic assessment and monitoring through the deployment and R of a variety of installations that record *in-situ* measurements or facilitate biological

recruitment/growth on fabricated structures. The following types of oceanographic instruments and biological installations were retrieved or deployed during this cruise.

Subsurface Temperature Recorder (STR): provides high-resolution temperature data (SBE 56 or RBR solo³). STRs are deployed at depths of 0.5–40 m and record temperature every 5 min. All loggers retrieved were SBE 56s; loggers deployed were a mix of SBE 56 and RBR solo³ sensors. Paired SBE 56 and RBR solo³ loggers were deployed at all 15-m sites.

Calcification Accretion Unit (CAU): are used to detect changes in calcification rates and net accretion of crustose coralline algae and other benthic sessile calcifiers. Each CAU is comprised of two 10 cm × 10 cm PVC plates separated by a 1-cm plastic spacer and mounted on a stainless steel rod driven into the benthos. CAUs are deployed in groups of five, over a 50-m² coral reef area, for 2–3 years. After recovery, the weight of calcium carbonate accreted by the organisms that recruited to the CAU plates (largely crustose coralline algae and corals) is used to provide an estimate of the net rate of calcium carbonate formation (in units of g CaCO₃ cm⁻² yr⁻¹). The majority of CAU deployment locations are at long-term permanent ESD survey sites, and repeated CAU deployments at these permanent sites provide multi-year time series accretion data.

Bioerosion Monitoring Unit (BMU): provides proxy for an integrated signal of net reef bioerosion. Each BMU is comprised of a 1 cm × 2 cm × 5 cm block of recently dead, dense *Porites* spp. skeleton mounted atop a small PVC base. BMUs are mounted on the same stake as the CAUs (i.e., in groups of five and over the same 50-m² coral reef area as the CAUs) and deployed for 2–3 years. Each BMU is accurately measured and scanned before and after deployment by a Micro CT scanner at the NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML). The difference between pre-deployment and post-deployment BMU weight and density is used to estimate net rates of bioerosion, and CT scans of recovered units can be used to identify the bio eroding organisms present. The majority of BMU deployment locations are at long-term permanent ESD survey sites, and repeated BMU deployments at these permanent sites provide multi-year time series bioerosion data.

A.1.2. Hydrographic Surveys

Paired CTD casts and carbonate chemistry water sampling were conducted from the small boats using the following sampling techniques and equipment.

Conductivity, Temperature, and Depth Casts: a CTD profiler (RBR concerto³) deployed from a small boat or ship provides water column data on temperature, conductivity (used to calculate salinity), and pressure (used to calculate depth). The CTD is lowered by hand at descent rates of ~ 0.5–0.75 m/s to depths up to 30 m. Nearshore CTD profiles are collected at all climate sites and, opportunistically, at random sites. Offshore casts are conducted >15 nm from land.

Water Chemistry: Surface seawater samples are collected at 1-m depth using a 5-L Niskin bottle, stored in 500-mL glass bottles, and poisoned with saturated mercuric chloride. Samples are analyzed for dissolved inorganic carbon (DIC) and total alkalinity (TA) at the NOAA Pacific Marine Environmental Laboratory (PMEL). Full carbon system chemistry—including pH and

aragonite saturation state (Ω_{ar})—is calculated from TA and DIC using temperature and salinity values from paired CTD casts.

Diel suite instrument package: To capture high-resolution variability in oceanographic and carbonate chemistry conditions, an instrument package (the “diel suite”) is deployed at priority fixed sites. Each diel suite package includes a SeaFET pH sensor, SBE19 plus v2 or RBR concerto³ Conductivity-Temperature-Depth (CTD) unit, Aquadopp Acoustic Doppler Current Profiler, RBR dissolved oxygen sensor, RBR photosynthetically active radiation sensor, and Sub-surface Automated Samplers (water samples are analyzed for Total Alkalinity and Dissolved Inorganic Carbon). Instruments are programmed to collect data every 1–5 min, and the diel suite package is typically deployed on the benthos for 1–4 weeks at a time.

A.2. Biological monitoring: underwater visual censuses

A.2.1. Benthic composition and coral demographics

A one-stage stratified random sampling design was employed to survey Rapid Ecological Assessment (REA) sites. The survey domain encompassed forereef and hard bottom habitat, and was divided into strata based upon depth. Depth categories of shallow (0–6 m), mid (> 6–18 m) and deep (> 18–25 m) were also incorporated into the stratification scheme. Allocation of sampling effort was proportional to strata area. Sites were randomly selected within each stratum.

Surveys at each site were conducted within one, 30-m belt transect. Adult coral colonies (≥ 5 cm) were surveyed within four segments that were 1.0-m wide by 2.5-m long. Along the transect tape the segments were located at 0–2.5 m, 5.0–7.5 m, 10–12.5 m, and 15–17.5 m. All colonies whose center fell within 0.5 m on either side of each transect line were identified to lowest taxonomic level possible (species or genus), measured for size (maximum diameter to nearest cm), and morphology was noted. In addition, partial mortality and condition of each colony was assessed. Partial mortality was estimated as percent of the colony in terms of ‘old dead’ and ‘recent dead’ and the cause of recent mortality was identified if possible. The condition of each colony, including disease and bleaching, was noted along with the extent (percent of colony affected) and severity (semi- quantitative scale from mild to acute).

Juvenile coral colonies (< 5 cm) were surveyed within three segments along the same two transects. Juvenile segments were 1.0 m wide by 1.0 m long, and were located within the segments used for adults at 0–1.0 m, 5.0–6.0 m, and 10.0–11.0 m (covering 3 m² per transect). Juvenile colonies were distinguished in the field by a distinct tissue and skeletal boundary (not a fragment of larger colony). Each juvenile colony was identified to lowest taxonomic level (genus or species) and measured for size by recording the maximum diameter to the nearest 5 mm.

Still photographs were collected to record the benthic community composition at predetermined points along the same transect line with a high-resolution digital camera mounted on a 1 meter pole. Photographs were taken every 1 m from the 1 m to the 30-m mark. This work generated 30 photographs per reef survey site, which will be analyzed by ESD staff using the computer program CoralNet. This analysis is the basis for estimating benthic cover and composition at

each site (benthic habitat photographs at sites surveyed by the fish team are also analyzed using CoralNet).

Crown-of-thorns starfish were quantified along a 2-m belt on both sides of the 30-m transect line for a total survey area of 120m².

A.2.2. Surveys of Reef Fishes

Divers conducted fish REA surveys using the stationary-point-count (SPC) method at preselected REA sites. All fish REA sites visited were selected using a stratified random sampling design in shallow (0–6 m), mid (6–18 m), or deep (18–30 m) depth strata, in the forereef habitat strata. Surveys were performed using a 30-m transect line set along a single depth contour. The REA sites selected for fish surveys typically differ in location from the REA sites where benthic surveys were conducted. Each fish REA site consists of a team of two divers conducting two adjacent and simultaneous SPC surveys. Once a transect line was deployed, the two divers moved to the 7.5-m and 22.5-m marks on this transect line to start their SPC surveys.

Each of these marks or points, with one diver at each, served as the center of a visually estimated cylindrical survey area with a radius of 7.5 m. During the first 5 min, divers created a list of all fish species found within their cylinder. Afterwards, divers went down their respective species lists, which were created from their work during the initial 5 min of a survey, sizing and counting all individuals within their cylinder, one species at a time. Cryptic species missed during the initial 5 min of a survey could still be counted, sized, and added to the original species list. Fish species observed at a REA site but not recorded during the SPCs were recorded for presence data.

After a survey was completed, divers recorded benthic habitat information within their respective cylindrical survey areas. Divers visually estimated habitat complexity, habitat type, and percentage of cover for hard corals, macroalgae, crustose coralline red algae, turf algae, and sand. Urchin densities were also estimated. Every meter along the transect line still photographs were taken of the benthos to the right side of the line. This work generates 30 photographs per site, which are analyzed later using CoralNet to estimate the benthic cover and composition at each site.

A.2.3. Carbonate Budget Assessments

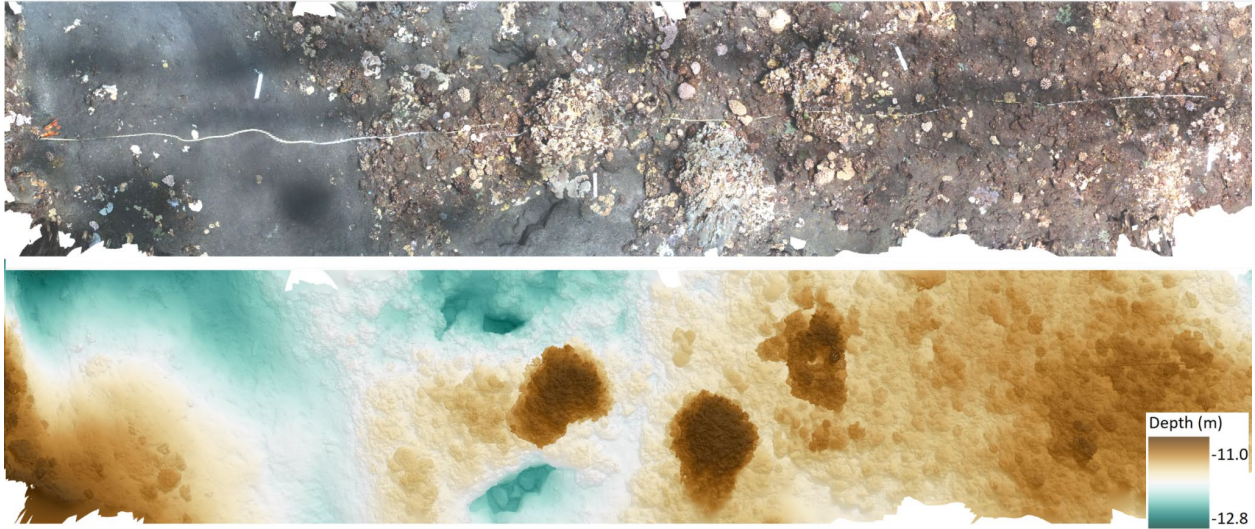
This survey is a census-based approach that measures the cover/abundance of carbonate-producing (corals, CCA, algae) and carbonate-eroding (parrotfish, urchins, macrobioeroders, microbioeroders) taxa and converts these measures to overall production estimates using genera-specific calcification and erosion rates. This survey method involves (6) 8–10m benthic transects, (6) 8—10 m × 1 m urchin belt transects, and (10) 10 m × 5 m fish belt transects at each fixed site. Benthic surveys measure the surface cover (cm) of carbonate producing organisms and substrate available for bioerosion along each transect. Urchin surveys measure the abundance and size of bio eroding urchins on each transect, and fish surveys will estimate the abundance and size of all bio eroding parrotfish present along each transect.

A.3. Photogrammetry

A.3.1. Benthic mosaics (benthic REA/fish SPC sites)

Multiple overlapping photographs are collected at a subset of randomized benthic REA and fish SPC sites as the basis for single time point digital map-making through SfM. The resulting digital maps document the status of benthic communities and reef structural complexity at the time the photographs are taken. To digitally capture continuous areas of the reef, divers operating a single Canon SL2/SL3 take 1,000–2,000 top-down photos in rapid succession within a 20×3 or 13×3 m belt plot (dependent on depth; no-decompression bottom time). Divers complete between 4 and 6 overlapping passes or reciprocal “laps” (dependent on environmental conditions, time available for benthic surveys) zigzagging along a survey transect tape strapped to the bottom and maintaining a distance of 1 m off the benthic substrate. Images are collected in both directions using a “lawn-mower” pattern. The photographic surveys conducted during the benthic REA campaign (leg 4) use the same reference transect line used during the visual coral demographic surveys to facilitate in-situ versus digital methodological comparisons.

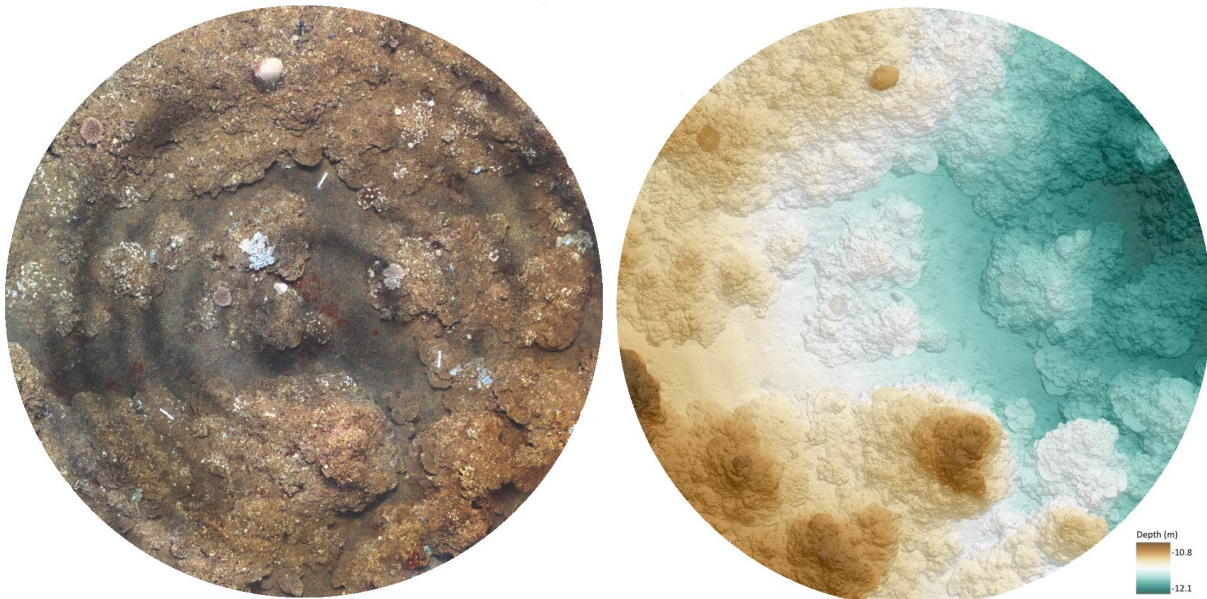
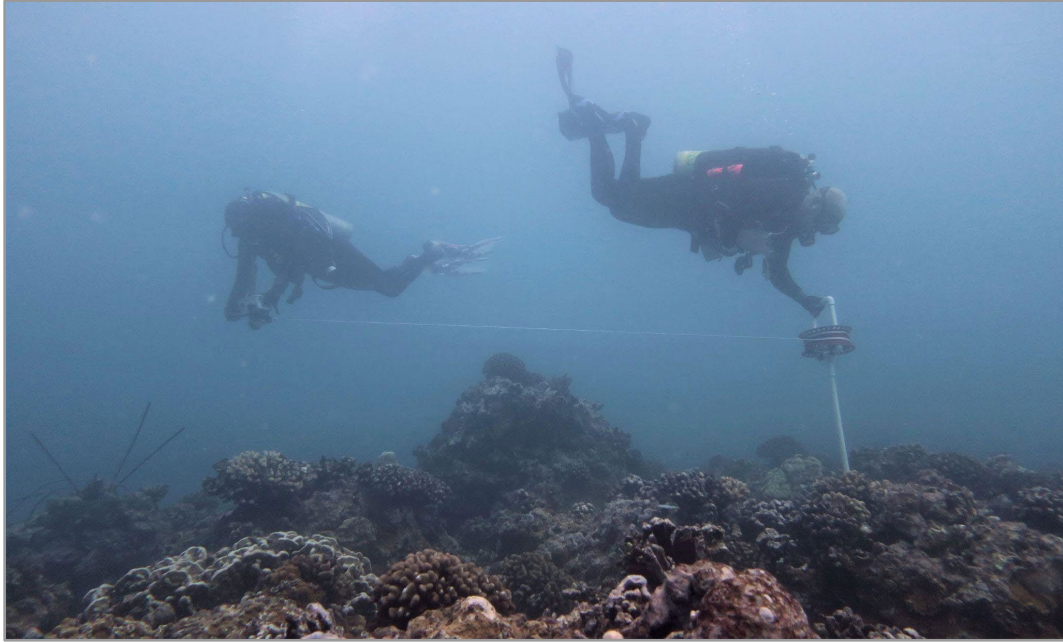




Imagery is collected by divers underwater (top). The imagery is used to generate 3D models and 2D mosaics (middle) of the reef area as well as a digital elevation model (bottom) from which to extract colony- and reef-level structural complexity data.

A.3.2. Benthic mosaics (climate stations)

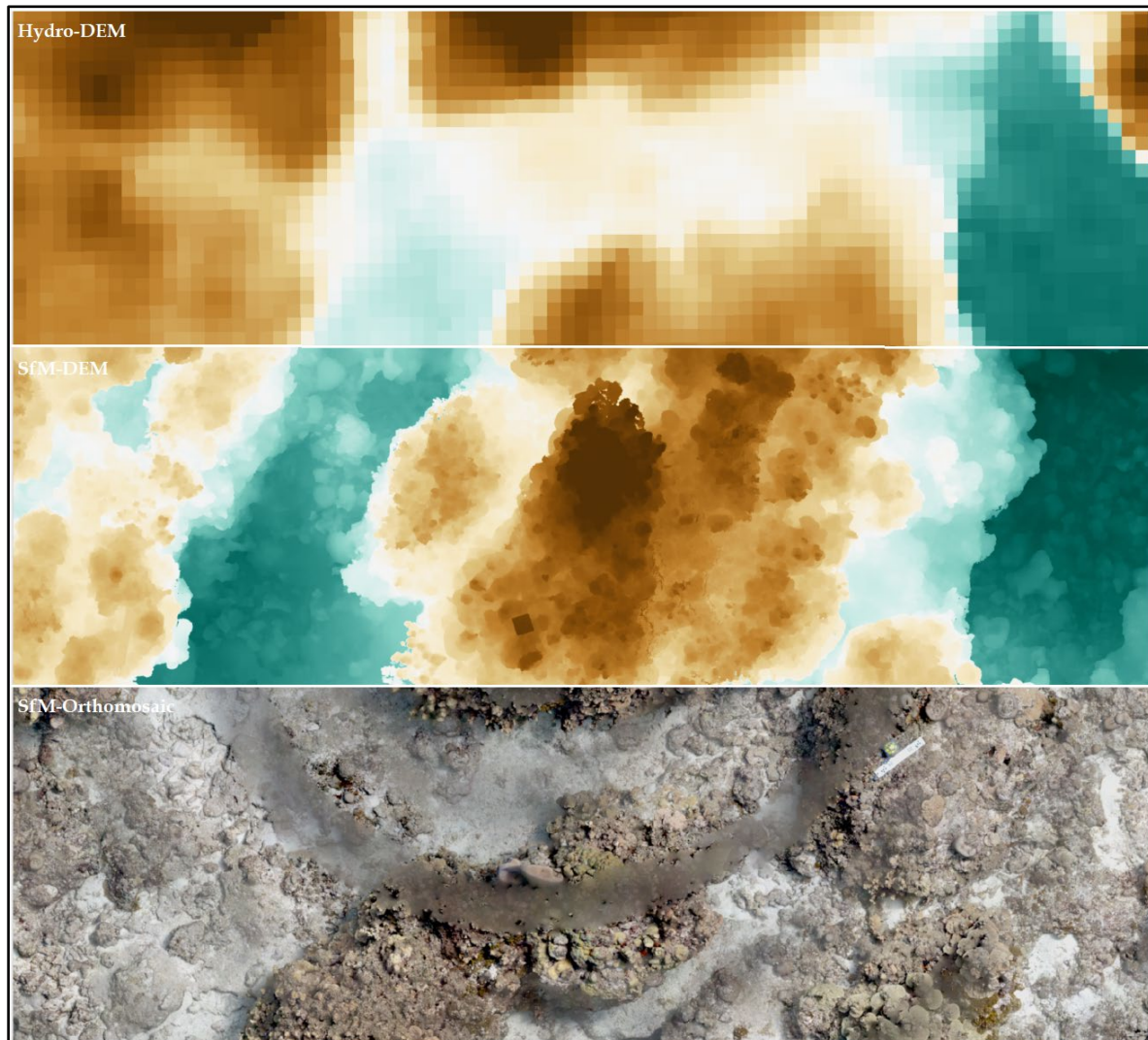
Multiple overlapping photographs are collected at a subset of long-term ESD climate stations as the basis for time-series map-making through SfM. The resulting digital maps capture biological and physical variability of benthic communities and bathymetric complexity through time. To digitally capture the same continuous areas of the reef in time, divers first identified reference markers permanently fastened to the substrate (i.e. pre-installed pins, CAUs or ARMS). Operating a single Canon SL2/SL3 camera, divers took a series of top-down overlapping photographs within a 12-m diameter circular plot maintaining a distance of 1m off the substrate. The divers swam in an expansive spiral pattern around a stationary central drum to which the camera is attached by a measured 6-m cord. Images were collected in both outward and inward directions, covering an approximate continuous coral reef area of 120 m² per site. The fixed-sites SfM models are processed back at the office.



Imagery is collected by divers underwater (top). The imagery is used to generate 3D models and 2D image mosaics (bottom left) of the reef area as well as a digital elevation model (bottom right) from which to extract colony- and reef-level structural complexity data.

SfM photogrammetry can derive image maps with the correct scaling for measurement. However, challenges remain in deriving georeferenced photogrammetry from photos collected underwater where GPS signals lose connectivity. Georeferenced underwater photogrammetry can provide an excellent template for benthic habitat modeling and monitoring, while allowing for data integration with a wide range of spatial data collected from various remote platforms. To that end, we tested the capabilities and field logistics efficiency of methods that captured the position and orientation of reef sites using varying combinations of; commercial grade GPS with or without survey grade GNSS correction profiles, underwater targets marked with surface

buoys, diver-collected underwater bearings among features in the plot, and compasses attached to scale-bars visible in the SfM imagery. Furthermore, and in close collaboration with the NOAA Ship *Rainier* mapping team - multibeam echosounders and multifrequency backscatter sensors aboard small launch vessels acquired high-density data at a subset of NCRMP sites to provide baseline georeferenced data for image-to-image co-registration. The rationale of co-registration is that the SfM imagery generated by the PIFSC-ESD-ARP team become spatially aligned to the georeferenced sonar-generated bathymetry footprint from the small Ship *Rainier* hydrographic boats on the basis of a few position and orientation measurements and by visually identifying and matching common features in both data sets.



A Digital Elevation Model (DEM) with an 8-cm pixel size derived from multibeam bathymetry data collected by a NOAA Ship Rainier hydrographic launch over one of our NCRMP sites at Tinian (top). DEM and orthomosaic imagery (middle and bottom) with a 0.1-cm pixel size processed through Structure from Motion techniques and co-registered to the hydrographic data. The georeferenced imagery complete a mosaic describing different sections of the reef and together provide benthic information at multiple ecologically relevant scales.

A.4. Data Management

Data Management operations were conducted utilizing the shipboard networking systems. Scientist laptops connected to the shipboard network, and accessed various data equipment installed on the ship. The primary data systems included two main components; a Windows data server, and a Synology Network Attached Storage (NAS) machine.

The Windows data server has an Oracle XE database installed and a custom database schema. While the Synology NAS was set up primarily to provide simple file storage, management, and backup services. Field photos, videos, and other physical data streams/files are copied to the NAS on a daily basis. While the Fish, Benthic, & OCC field data/observations are entered nightly into an in-house Mission Application. The application is built with Oracle Application Express (APEX) and interfaces with the Oracle database to both store the data, and perform various data processes like QA/QC, reporting, and so on.

Appendix B. Data Streams

Table 7. Summary of sites where benthic StRS belt transect surveys were conducted.

Site	Depth bin	Reef zone	Depth (ft)	Latitude	Longitude	Photoquads
ASC-585	Shallow	Forereef	14	19.694044	145.38995	Yes
ASC-589	Shallow	Forereef	20	19.704838	145.396377	Yes
ASC-590	Shallow	Forereef	13	19.683009	145.389745	Yes
ASC-594	Shallow	Forereef	16	19.680538	145.393456	Yes
ASC-599	Mid	Forereef	45	19.706689	145.409992	Yes
ASC-601	Mid	Forereef	43	19.677024	145.410765	Yes
ASC-604	Mid	Forereef	38	19.68845	145.419086	Yes
ASC-611	Mid	Forereef	35	19.674966	145.400707	Yes
ASC-612	Shallow	Forereef	45	19.693992	145.389297	Yes
ASC-613	Mid	Forereef	57	19.707896	145.399214	Yes
ASC-614	Mid	Forereef	44	19.704035	145.413804	Yes
ASC-620	Mid	Forereef	43	19.68052	145.391047	Yes
ASC-623	Mid	Forereef	38	19.708138	145.403998	Yes
ASC-626	Deep	Forereef	64	19.683353	145.38745	Yes
ASC-627	Deep	Forereef	75	19.699728	145.390976	Yes
ASC-632	Deep	Forereef	66	19.698668	145.418563	Yes
ASC-637	Deep	Forereef	82	19.680868	145.41562	Yes
GUA-2650	Shallow	Forereef	12	13.569112	144.8213	NO
GUA-2653	Shallow	Forereef	19	13.426338	144.806399	Yes
GUA-2662	Shallow	Forereef	15	13.241626	144.695292	Yes
GUA-2672	Mid	Forereef	17	13.479462	144.706698	Yes
GUA-2677	Shallow	Forereef	19	13.486052	144.873026	Yes
GUA-2681	Mid	Forereef	39	13.652454	144.874849	Yes
GUA-2684	Shallow	Forereef	22	13.633916	144.89092	Yes
GUA-2688	Shallow	Forereef	20	13.467973	144.647385	Yes
GUA-2690	Shallow	Forereef	19	13.369318	144.643595	Yes
GUA-2692	Mid	Forereef	24	13.46439	144.6768	Yes
GUA-2696	Shallow	Forereef	19	13.277189	144.662428	Yes
GUA-2699	Mid	Forereef	51	13.504933	144.894183	Yes
GUA-2701	Shallow	Forereef	15	13.564825	144.818855	NO
GUA-2702	Mid	Forereef	40	13.601985	144.934492	Yes
GUA-2716	Shallow	Forereef	28	13.473304	144.697051	Yes
GUA-2717	Mid	Forereef	38	13.468966	144.684697	Yes
GUA-2720	Mid	Forereef	54	13.527454	144.931278	Yes
GUA-2723	Mid	Forereef	37	13.376485	144.77769	Yes
GUA-2726	Mid	Forereef	27	13.477824	144.865405	Yes
GUA-2727	Mid	Forereef	33	13.249366	144.737206	Yes
GUA-2728	Mid	Forereef	38	13.395917	144.782134	Yes
GUA-2730	Mid	Forereef	53	13.315347	144.646926	Yes
GUA-2734	Mid	Forereef	44	13.600759	144.831362	Yes
GUA-2735	Mid	Forereef	57	13.504738	144.770644	NO
GUA-2737	Mid	Forereef	48	13.255525	144.649654	Yes

Site	Depth bin	Reef zone	Depth (ft)	Latitude	Longitude	Photoquads
GUA-2740	Shallow	Forereef	22	13.654324	144.854606	Yes
GUA-2741	Mid	Forereef	30	13.358686	144.643769	Yes
GUA-2744	Deep	Forereef	65	13.604377	144.921127	Yes
GUA-2745	Deep	Forereef	82	13.614547	144.907654	Yes
GUA-2751	Deep	Forereef	73	13.512508	144.794288	NO
GUA-2758	Deep	Forereef	63	13.469747	144.859791	YES
GUA-2762	Deep	Forereef	65	13.301457	144.775395	YES
GUA-2767	Deep	Forereef	80	13.439638	144.820239	YES
GUA-2768	Deep	Forereef	68	13.28509	144.766998	YES
GUA-2769	Deep	Forereef	71	13.399635	144.784924	YES
GUA-2774	Mid	Forereef	48	13.479698	144.699349	YES
GUA-2777	Deep	Forereef	72	13.33511	144.634585	YES
GUA-2780	Deep	Forereef	70	13.631674	144.838595	YES
GUA-2781	Deep	Forereef	68	13.24215	144.639531	YES
GUA-2783	Mid	Forereef	53	13.610865	144.833072	YES
GUA-2784	Shallow	Forereef	17	13.593838	144.836064	YES
MAU-1200	Shallow	Forereef	17	20.021981	145.210238	YES
MAU-1203	Shallow	Forereef	17	20.026405	145.207878	YES
MAU-1207	Shallow	Forereef	11	20.024278	145.210172	YES
MAU-1213	Shallow	Forereef	15	20.029041	145.232302	YES
MAU-1215	Shallow	Forereef	13	20.015957	145.207474	YES
MAU-1222	Mid	Forereef	54	20.034843	145.215775	YES
MAU-1223	Mid	Forereef	49	20.014172	145.227324	YES
MAU-1225	Mid	Forereef	32	20.03073	145.232888	YES
MAU-1226	Mid	Forereef	57	20.037076	145.219743	YES
MAU-1233	Mid	Forereef	49	20.0108	145.212686	YES
MAU-1239	Mid	Forereef	28	20.029894	145.212493	YES
MAU-1242	Mid	Forereef	26	20.02085	145.207623	YES
MAU-1243	Mid	Forereef	57	20.034007	145.229619	YES
MAU-1245	Mid	Forereef	30	20.014516	145.20871	YES
MAU-1246	Mid	Forereef	59	20.013277	145.234202	YES
MAU-1247	Mid	Forereef	44	20.01815	145.21206	YES
MAU-1248	Mid	Forereef	50	20.011861	145.219944	YES
MAU-1257	Deep	Forereef	73	20.031244	145.234455	YES
MAU-1258	Deep	Forereef	67	20.02366	145.238393	YES
MAU-1262	Deep	Forereef	64	20.036292	145.224529	YES
MAU-1263	Deep	Forereef	67	20.028995	145.207629	YES
MAU-1265	Deep	Forereef	67	20.030462	145.227244	YES
MAU-1268	Deep	Forereef	77	20.009731	145.216603	YES
MAU-1273	Deep	Forereef	65	20.016941	145.238333	YES
PAG-1251	Shallow	Forereef	18	18.085918	145.73531	YES
PAG-1253	Shallow	Forereef	18	18.080695	145.720098	YES
PAG-1254	Shallow	Forereef	15	18.132332	145.759921	YES
PAG-1258	Shallow	Forereef	24	18.054842	145.735584	YES
PAG-1260	Shallow	Forereef	20	18.122613	145.805062	YES
PAG-1266	Shallow	Forereef	18	18.142813	145.75852	YES
PAG-1272	Shallow	Forereef	17	18.102034	145.798057	YES

Site	Depth bin	Reef zone	Depth (ft)	Latitude	Longitude	Photoquads
PAG-1273	Mid	Forereef	27	18.123748	145.756369	YES
PAG-1274	Mid	Forereef	69	18.111985	145.802126	YES
PAG-1278	Mid	Forereef	50	18.099024	145.752808	YES
PAG-1280	Shallow	Forereef	31	18.165819	145.798628	YES
PAG-1286	Mid	Forereef	60	18.060236	145.742535	YES
PAG-1288	Mid	Forereef	33	18.059267	145.710993	YES
PAG-1295	Mid	Forereef	55	18.046889	145.726766	YES
PAG-1297	Mid	Forereef	60	18.103928	145.775635	YES
PAG-1298	Mid	Forereef	51	18.089328	145.758905	YES
PAG-1301	Mid	Forereef	56	18.049332	145.706191	YES
PAG-1305	Deep	Forereef	68	18.065028	145.745486	YES
PAG-1309	Deep	Forereef	75	18.16976	145.790484	YES
PAG-1313	Deep	Forereef	88	18.042136	145.705959	YES
PAG-1316	Deep	Forereef	67	18.104861	145.785961	YES
PAG-1323	Deep	Forereef	69	18.088324	145.738746	YES
PAG-1324	Deep	Forereef	71	18.150932	145.754822	YES
PAG-1326	Deep	Forereef	65	18.147597	145.811663	YES
ROT-830	Shallow	Forereef	21	14.170434	145.174017	NO
ROT-831	Shallow	Forereef	20	14.135827	145.229851	YES
ROT-832	Shallow	Forereef	13	14.188798	145.216889	YES
ROT-840	Shallow	Forereef	18	14.16507	145.156707	YES
ROT-843	Shallow	Forereef	11	14.17578	145.189516	YES
ROT-845	Mid	Forereef	49	14.151463	145.142447	YES
ROT-848	Mid	Forereef	41	14.168004	145.286077	YES
ROT-856	Deep	Forereef	71	14.128407	145.12275	YES
ROT-866	Shallow	Forereef	19	14.134106	145.155615	YES
ROT-867	Shallow	Forereef	19	14.114066	145.203089	YES
ROT-868	Shallow	Forereef	15	14.129371	145.135527	YES
ROT-869	Shallow	Forereef	20	14.127967	145.227178	YES
ROT-872	Mid	Forereef	39	14.123432	145.166732	YES
ROT-874	Deep	Forereef	67	14.113576	145.183134	YES
ROT-879	Mid	Forereef	50	14.200078	145.234837	YES
ROT-889	Deep	Forereef	69	14.201946	145.257866	YES
SAI-1820	Shallow	Forereef	10	15.252987	145.761916	YES
SAI-1822	Shallow	Forereef	7	15.18716	145.70314	YES
SAI-1828	Shallow	Forereef	16	15.255131	145.743974	YES
SAI-1832	Shallow	Forereef	18	15.25273	145.716911	YES
SAI-1838	Shallow	Forereef	9	15.152743	145.748857	YES
SAI-1843	Mid	Forereef	44	15.261448	145.774449	YES
SAI-1848	Mid	Forereef	40	15.257755	145.814669	YES
SAI-1852	Mid	Forereef	38	15.163473	145.693446	YES
SAI-1854	Shallow	Forereef	51	15.241284	145.699827	YES
SAI-1857	Mid	Forereef	59	15.203029	145.697777	YES
SAI-1858	Deep	Forereef	81	15.214494	145.685309	YES
SAI-1859	Deep	Forereef	64	15.142486	145.675647	YES
SAI-1864	Deep	Forereef	74	15.118393	145.690635	YES
SAI-1882	Mid	Forereef	58	15.2811	145.80037	YES

Site	Depth bin	Reef zone	Depth (ft)	Latitude	Longitude	Photoquads
SAI-1883	Deep	Forereef	76	15.200966	145.782855	YES
SAI-1884	Mid	Forereef	42	15.272446	145.788958	YES
SAI-1888	Deep	Forereef	65	15.173064	145.791975	YES
SAI-1906	Deep	Forereef	75	15.268697	145.831897	YES
SAI-1909	Shallow	Forereef	14	15.104457	145.734591	YES
SAI-1915	Mid	Forereef	28	15.15	145.787485	YES
SAI-1916	Mid	Forereef	40	15.159922	145.766053	YES
SAI-1918	Mid	Forereef	32	15.124252	145.753057	YES
SAI-1920	Mid	Forereef	45	15.094726	145.752328	YES
SAI-1921	Deep	Forereef	85	15.145576	145.747041	YES
TIN-830	Shallow	Forereef	19	14.94205	145.628084	YES
TIN-838	Mid	Forereef	23	14.941167	145.652918	YES
TIN-843	Shallow	Forereef	19	15.048611	145.597739	YES
TIN-846	Mid	Forereef	50	14.955508	145.664356	YES
TIN-848	Mid	Forereef	40	15.08859	145.631118	YES
TIN-849	Mid	Forereef	57	15.048234	145.651459	YES
TIN-855	Mid	Forereef	36	15.030392	145.65221	YES
TIN-862	Mid	Forereef	29	14.95869	145.623589	YES
TIN-868	Mid	Forereef	56	15.07149	145.611553	YES
TIN-883	Deep	Forereef	74	15.072696	145.657613	YES
TIN-884	Deep	Forereef	81	14.970555	145.60753	YES
TIN-885	Deep	Forereef	84	15.008705	145.584467	YES
TIN-891	Deep	Forereef	68	14.976049	145.665167	YES
TIN-896	Shallow	Forereef	20	15.019766	145.658985	NO
TIN-903	Deep	Forereef	82	15.004863	145.675257	YES

Table 8. Summary of sites where fish SPC surveys were conducted.

Site	Reef Zone	Depth bin	Depth (m)	Latitude	Longitude
AGU-523	Forereef	Shallow	3.3528	14.85047	145.5388
AGU-532	Forereef	Deep	22.098	14.86086	145.557
AGU-541	Forereef	Deep	21.7932	14.85731	145.5501
AGU-543	Forereef	Mid	16.764	14.85827	145.5533
AGU-545	Forereef	Shallow	9.4488	14.84978	145.5378
AGU-546	Forereef	Mid	12.4968	14.8536	145.5398
AGU-548	Forereef	Mid	11.5824	14.84555	145.5363
AGU-549	Forereef	Shallow	4.2672	14.84678	145.5372
AGU-554	Forereef	Mid	17.0688	14.8441	145.5358
AGU-555	Forereef	Deep	28.8036	14.85189	145.5373
AGU-556	Forereef	Shallow	5.7912	14.85376	145.5418
AGU-558	Forereef	Shallow	5.7912	14.85418	145.543
AGU-570	Forereef	Deep	25.908	14.84681	145.5337
AGU-579	Forereef	Deep	25.2984	14.84365	145.5321
AGU-580	Forereef	Mid	19.3548	14.84173	145.5303
ASC-496	Forereef	Shallow	2.8956	19.70704	145.4012
ASC-499	Forereef	Shallow	5.334	19.69025	145.4187
ASC-501	Forereef	Shallow	4.1148	19.70648	145.4085
ASC-509	Forereef	Mid	13.1064	19.70486	145.4127
ASC-511	Forereef	Mid	13.2588	19.70092	145.4171
ASC-512	Forereef	Mid	13.4112	19.70131	145.3927
ASC-514	Forereef	Mid	16.6116	19.70675	145.3972
ASC-516	Forereef	Mid	15.0876	19.70792	145.401
ASC-518	Forereef	Mid	11.2776	19.70784	145.4027

Site	Reef Zone	Depth bin	Depth (m)	Latitude	Longitude
ASC-519	Forereef	Mid	15.5448	19.70682	145.41
ASC-524	Forereef	Mid	11.43	19.69215	145.4188
ASC-526	Forereef	Mid	14.9352	19.69956	145.4181
ASC-527	Forereef	Deep	24.2316	19.7017	145.3924
ASC-532	Forereef	Deep	24.0792	19.70556	145.4132
ASC-537	Forereef	Deep	28.194	19.67542	145.4084
FDP-375	Forereef	Mid	19.5072	20.54219	144.904
FDP-379	Forereef	Mid	19.812	20.53793	144.8856
FDP-381	Forereef	Mid	19.812	20.54509	144.9049
FDP-388	Forereef	Mid	13.2588	20.55312	144.89
FDP-391	Forereef	Mid	14.3256	20.54969	144.9026
FDP-394	Forereef	Mid	17.2212	20.54402	144.8859
FDP-397	Forereef	Mid	10.3632	20.53748	144.8984
FDP-401	Forereef	Shallow	5.6388	20.53617	144.8905
FDP-404	Forereef	Shallow	5.334	20.54898	144.8865
GUA-026	Forereef	Mid	11.5824	13.47684	144.6978
GUA-2355	Forereef	Shallow	3.3528	13.39056	144.6544
GUA-2362	Forereef	Shallow	3.5052	13.37475	144.6442
GUA-2363	Forereef	Shallow	4.8768	13.3595	144.6382
GUA-2369	Forereef	Shallow	3.6576	13.38213	144.6468
GUA-2371	Forereef	Shallow	4.7244	13.23392	144.6509
GUA-2372	Forereef	Shallow	3.5052	13.23841	144.6699
GUA-2377	Forereef	Mid	10.3632	13.64769	144.8801
GUA-2378	Forereef	Mid	19.3548	13.55102	144.8077
GUA-2379	Forereef	Mid	10.2108	13.40055	144.6582
GUA-2383	Forereef	Shallow	7.62	13.23268	144.6491
GUA-2384	Forereef	Mid	16.4592	13.33469	144.6377
GUA-2387	Forereef	Mid	17.2212	13.59188	144.8325
GUA-2389	Forereef	Mid	11.2776	13.65737	144.8585
GUA-2390	Forereef	Shallow	8.6868	13.60601	144.8342
GUA-2402	Forereef	Deep	23.622	13.64853	144.8831
GUA-2404	Forereef	Deep	21.0312	13.65376	144.8773
GUA-2406	Forereef	Deep	23.0124	13.61142	144.8328
GUA-2408	Forereef	Deep	27.5844	13.58588	144.8314
GUA-2411	Forereef	Deep	23.0124	13.58222	144.8299
GUA-2412	Forereef	Deep	25.6032	13.53407	144.7997
GUA-2414	Forereef	Deep	23.7744	13.57614	144.8262
GUA-2419	Forereef	Shallow	4.572	13.41271	144.7885
GUA-2421	Forereef	Shallow	3.9624	13.2547	144.7391
GUA-2427	Forereef	Shallow	4.572	13.38863	144.7794
GUA-2428	Forereef	Shallow	4.4196	13.35595	144.7751
GUA-2432	Forereef	Mid	13.1064	13.31362	144.7741
GUA-2434	Forereef	Mid	16.1544	13.30154	144.7745
GUA-2438	Forereef	Shallow	8.9916	13.25057	144.738
GUA-2441	Forereef	Shallow	8.0772	13.27397	144.755
GUA-2447	Forereef	Shallow	7.62	13.26279	144.7441
GUA-2448	Forereef	Mid	13.2588	13.28239	144.7645
GUA-2451	Forereef	Mid	15.3924	13.36044	144.7769
GUA-2454	Forereef	Mid	10.2108	13.29117	144.7668
GUA-2460	Forereef	Deep	24.2316	13.38171	144.7809
GUA-2463	Forereef	Mid	12.6492	13.24437	144.7229
GUA-2470	Forereef	Mid	17.3736	13.41709	144.7935
GUA-2471	Forereef	Deep	24.384	13.2432	144.7256
GUA-2473	Forereef	Deep	24.0792	13.32984	144.7772
GUA-2474	Forereef	Deep	26.67	13.28071	144.7648
GUA-2475	Forereef	Mid	17.526	13.2941	144.7706
GUA-2479	Forereef	Mid	19.812	13.25109	144.7399
GUA-2487	Forereef	Deep	26.3652	13.33429	144.7737
GUA-2492	Forereef	Shallow	2.5908	13.24224	144.7083
GUA-2494	Forereef	Shallow	3.5052	13.24171	144.6949
GUA-2497	Forereef	Shallow	7.62	13.24087	144.7

Site	Reef Zone	Depth bin	Depth (m)	Latitude	Longitude
GUA-2499	Forereef	Shallow	9.6012	13.24372	144.7155
GUA-2500	Forereef	Mid	16.3068	13.24095	144.7117
GUA-2502	Forereef	Deep	26.67	13.23856	144.6996
GUA-2503	Forereef	Deep	21.6408	13.24027	144.7096
GUA-2504	Forereef	Deep	21.1836	13.24235	144.716
GUA-2511	Forereef	Shallow	4.2672	13.57448	144.9486
GUA-2512	Forereef	Mid	14.1732	13.60634	144.9126
GUA-2515	Forereef	Mid	11.2776	13.597	144.9574
GUA-2519	Forereef	Deep	20.8788	13.57461	144.9502
GUA-2522	Forereef	Deep	23.1648	13.48253	144.7234
GUA-2523	Forereef	Deep	27.1272	13.48525	144.7347
GUA-2524	Forereef	Deep	23.4696	13.47893	144.7113
GUA-2525	Forereef	Mid	10.3632	13.48201	144.7266
GUA-2526	Forereef	Mid	10.2108	13.48309	144.7302
GUA-2527	Forereef	Mid	16.1544	13.48139	144.7185
GUA-2528	Forereef	Shallow	8.382	13.48157	144.7211
GUA-2529	Forereef	Mid	15.24	13.47814	144.7121
GUA-2530	Forereef	Shallow	9.2964	13.47685	144.7138
GUA-2531	Forereef	Shallow	2.5908	13.48108	144.7247
GUA-2532	Forereef	Shallow	4.572	13.48263	144.7333
GUA-2533	Forereef	Shallow	4.572	13.47793	144.7101
GUA-2534	Forereef	Deep	21.0312	13.48263	144.7201
GUA-2538	Forereef	Mid	10.0584	13.48052	144.7189
GUA-2540	Forereef	Mid	12.954	13.4822	144.7206
GUA-2542	Forereef	Shallow	9.144	13.47874	144.7092
GUA-2543	Forereef	Mid	15.6972	13.48295	144.7284
GUA-2544	Forereef	Shallow	3.3528	13.47988	144.7192
GUA-2546	Forereef	Deep	24.6888	13.47943	144.7101
GUA-2547	Forereef	Deep	21.6408	13.48278	144.7214
GUA-2548	Forereef	Deep	22.5552	13.48415	144.7318
GUA-2550	Forereef	Mid	13.5636	13.48187	144.7252
GUA-2551	Forereef	Shallow	8.2296	13.48138	144.724
GUA-2552	Forereef	Shallow	3.9624	13.48219	144.7285
GUA-2553	Forereef	Shallow	4.4196	13.47798	144.7172
GUA-2554	Forereef	Shallow	3.048	13.4787	144.7181
GUA-2555	Forereef	Shallow	3.2004	13.47745	144.7115
GUA-2556	Forereef	Deep	20.1168	13.48068	144.6999
GUA-2557	Forereef	Deep	22.86	13.48197	144.7053
GUA-2558	Forereef	Deep	26.8224	13.47619	144.6955
GUA-2559	Forereef	Mid	14.478	13.48174	144.7034
GUA-2561	Forereef	Shallow	3.9624	13.47489	144.6969
GUA-2563	Forereef	Shallow	5.9436	13.46911	144.6862
GUA-2565	Forereef	Shallow	8.8392	13.47849	144.6991
GUA-2566	Forereef	Shallow	2.286	13.4738	144.6949
GUA-2568	Forereef	Shallow	3.5052	13.4791	144.7006
GUA-2571	Forereef	Deep	22.86	13.47346	144.6922
GUA-2573	Forereef	Shallow	5.7912	13.60176	144.9267
GUA-2574	Forereef	Mid	12.4968	13.60191	144.9297
GUA-2578	Forereef	Mid	10.3632	13.61347	144.9071
GUA-2579	Forereef	Mid	19.812	13.58944	144.9543
GUA-2581	Forereef	Mid	11.43	13.47654	144.7145
GUA-2582	Forereef	Mid	15.0876	13.47067	144.6901
GUA-2583	Forereef	Mid	18.8976	13.47016	144.6866
GUA-2585	Forereef	Shallow	9.2964	13.47213	144.692
GUA-2586	Forereef	Mid	12.0396	13.46913	144.6849
GUA-2587	Forereef	Mid	10.2108	13.47699	144.6979
GUA-2588	Forereef	Deep	27.5844	13.5312	144.7997
GUA-2589	Forereef	Mid	16.9164	13.52525	144.8011
GUA-2590	Forereef	Shallow	5.1816	13.52093	144.8012
GUA-2591	Forereef	Deep	27.1272	13.51319	144.7946
GUA-2592	Forereef	Mid	12.4968	13.52173	144.7999

Site	Reef Zone	Depth bin	Depth (m)	Latitude	Longitude
GUA-2593	Forereef	Shallow	4.572	13.51908	144.8
GUA-2594	Forereef	Deep	24.0792	13.51207	144.7896
GUA-2595	Forereef	Mid	12.192	13.51877	144.7974
GUA-2597	Forereef	Deep	23.9268	13.5303	144.8001
GUA-2602	Forereef	Shallow	3.8862	13.47198	144.6928
GUA-2603	Forereef	Shallow	3.81	13.48045	144.7046
GUA-2605	Forereef	Shallow	4.4196	13.47963	144.7009
GUA-2608	Forereef	Deep	23.3172	13.48015	144.6992
GUA-2609	Forereef	Shallow	4.572	13.47727	144.6989
GUA-2610	Forereef	Mid	12.192	13.47309	144.693
GUA-8001	Forereef	Mid	11.5824	13.46755	144.6813
MAU-1033	Forereef	Deep	29.8704	20.02646	145.2114
MAU-1034	Forereef	Deep	23.3172	20.02933	145.2239
MAU-1035	Forereef	Deep	26.67	20.03287	145.2108
MAU-1038	Forereef	Deep	21.9456	20.03558	145.2172
MAU-1039	Forereef	Deep	24.5364	20.03657	145.2254
MAU-1041	Forereef	Deep	23.1648	20.03595	145.2266
MAU-1059	Forereef	Deep	25.6032	20.02821	145.2362
MAU-1061	Forereef	Deep	23.3172	20.0316	145.233
MAU-1065	Forereef	Deep	27.7368	20.01312	145.226
MAU-1067	Forereef	Mid	12.0396	20.02004	145.2079
MAU-1074	Forereef	Mid	14.3256	20.03177	145.2105
MAU-1075	Forereef	Mid	15.6972	20.02174	145.2397
MAU-1077	Forereef	Mid	10.668	20.03239	145.213
MAU-1080	Forereef	Mid	13.8684	20.01095	145.2122
MAU-1081	Forereef	Mid	11.7348	20.02642	145.2074
MAU-1089	Forereef	Shallow	8.9916	20.01482	145.2083
MAU-1095	Forereef	Mid	10.0584	20.02405	145.208
MAU-1097	Forereef	Mid	12.4968	20.01685	145.229
MAU-1099	Forereef	Mid	10.3632	20.03009	145.2182
MAU-1100	Forereef	Mid	17.3736	20.01511	145.216
MAU-1103	Forereef	Mid	10.2108	20.01846	145.2302
MAU-1105	Forereef	Shallow	6.7056	20.03353	145.2276
MAU-1108	Forereef	Mid	13.2588	20.015	145.2361
MAU-1112	Forereef	Mid	13.716	20.01507	145.2284
MAU-1116	Forereef	Mid	16.1544	20.0112	145.2313
MAU-1118	Forereef	Shallow	6.4008	20.02365	145.2102
MAU-1119	Forereef	Shallow	1.9812	20.02834	145.2322
MAU-1122	Forereef	Shallow	5.9436	20.03045	145.2233
MAU-1126	Forereef	Shallow	4.2672	20.02155	145.2081
MAU-1129	Forereef	Shallow	3.6576	20.0215	145.2295
PAG-1065	Forereef	Deep	28.956	18.10151	145.8023
PAG-1068	Forereef	Shallow	3.5052	18.08312	145.754
PAG-1070	Forereef	Shallow	4.2672	18.15496	145.8077
PAG-1075	Forereef	Shallow	3.2004	18.05389	145.7108
PAG-1077	Forereef	Shallow	4.1148	18.10564	145.7576
PAG-1081	Forereef	Shallow	3.048	18.05246	145.7331
PAG-1084	Forereef	Shallow	4.8768	18.10391	145.7962
PAG-1085	Forereef	Shallow	3.9624	18.13438	145.7613
PAG-1086	Forereef	Shallow	7.62	18.07113	145.7457
PAG-1088	Forereef	Shallow	5.334	18.15375	145.8076
PAG-1090	Forereef	Shallow	1.8288	18.1224	145.7575
PAG-1091	Forereef	Mid	13.2588	18.11317	145.802
PAG-1095	Forereef	Mid	12.0396	18.04332	145.7107
PAG-1096	Forereef	Mid	10.668	18.14381	145.7553
PAG-1099	Forereef	Mid	12.3444	18.1019	145.7926
PAG-1106	Forereef	Mid	13.8684	18.11661	145.8035
PAG-1110	Forereef	Mid	13.1064	18.05929	145.7412
PAG-1114	Forereef	Mid	10.5156	18.09234	145.762
PAG-1119	Forereef	Mid	13.4112	18.0963	145.7649
PAG-1121	Forereef	Mid	10.668	18.0997	145.7538

Site	Reef Zone	Depth bin	Depth (m)	Latitude	Longitude
PAG-1124	Forereef	Mid	13.5636	18.16787	145.7926
PAG-1125	Forereef	Mid	11.1252	18.0847	145.7255
PAG-1127	Forereef	Deep	24.5364	18.10446	145.7788
PAG-1129	Forereef	Deep	22.7076	18.1005	145.7987
PAG-1131	Forereef	Mid	19.812	18.0767	145.7509
PAG-1132	Forereef	Deep	28.194	18.04592	145.7036
PAG-1134	Forereef	Deep	27.1272	18.12856	145.7531
PAG-1137	Forereef	Deep	24.0792	18.1293	145.8108
PAG-1139	Forereef	Deep	26.67	18.15123	145.8123
PAG-1141	Forereef	Deep	22.098	18.10003	145.7926
PAG-1143	Forereef	Deep	22.5552	18.06691	145.7463
PAG-1144	Forereef	Deep	22.4028	18.04864	145.7343
PAG-1151	Forereef	Deep	25.7556	18.13962	145.8117
PAG-1153	Forereef	Deep	26.2128	18.05674	145.707
PAG-1154	Forereef	Deep	27.2796	18.09696	145.747
PAG-1155	Forereef	Deep	23.9268	18.1143	145.7525
PAG-1158	Forereef	Deep	24.8412	18.09863	145.7936
PAG-1163	Forereef	Deep	25.7556	18.10514	145.7991
PAG-1166	Forereef	Mid	17.3736	18.17046	145.7789
PAG-1166	Forereef	Mid	19.812	18.16145	145.8063
PAG-1166	Forereef	Mid	17.526	18.17046	145.7789
PAG-13	Forereef	Mid	12.954	18.09601	145.7648
PAG-22	Forereef	Mid	14.6304	18.12021	145.7547
ROT-711	Forereef	Deep	22.098	14.17533	145.1844
ROT-712	Forereef	Mid	18.7452	14.13384	145.1395
ROT-717	Forereef	Deep	21.7932	14.19594	145.2238
ROT-735	Forereef	Mid	13.5636	14.17059	145.166
ROT-742	Forereef	Mid	11.2776	14.17751	145.1945
ROT-748	Forereef	Shallow	6.4008	14.13703	145.1494
ROT-755	Forereef	Mid	12.3444	14.12087	145.1681
ROT-757	Forereef	Mid	16.6116	14.18641	145.2102
ROT-766	Forereef	Deep	25.908	14.15038	145.2444
ROT-768	Forereef	Shallow	5.1816	14.11412	145.2021
ROT-771	Forereef	Deep	23.622	14.12641	145.2239
ROT-778	Forereef	Shallow	5.334	14.16287	145.2848
ROT-779	Forereef	Shallow	5.0292	14.1542	145.2591
ROT-780	Forereef	Shallow	5.6388	14.18192	145.2887
ROT-783	Forereef	Mid	14.0208	14.15362	145.2562
ROT-785	Forereef	Shallow	9.7536	14.15188	145.272
SAI-1623	Forereef	Deep	28.4988	15.20841	145.6353
SAI-1624	Forereef	Deep	22.5552	15.13299	145.7457
SAI-1628	Forereef	Deep	22.098	15.15499	145.7502
SAI-1630	Forereef	Deep	29.718	15.19259	145.629
SAI-1633	Forereef	Deep	29.5656	15.20948	145.6561
SAI-1636	Forereef	Deep	26.8224	15.18924	145.6663
SAI-1637	Forereef	Deep	23.622	15.23397	145.8029
SAI-1639	Forereef	Deep	21.4884	15.20197	145.6946
SAI-1640	Forereef	Deep	21.336	15.25641	145.7393
SAI-1644	Forereef	Deep	26.5176	15.17402	145.6171
SAI-1650	Forereef	Deep	20.574	15.14115	145.6843
SAI-1652	Forereef	Deep	26.5176	15.17935	145.7879
SAI-1653	Forereef	Deep	20.8788	15.12247	145.7572
SAI-1654	Forereef	Deep	28.8036	15.20362	145.6362
SAI-1655	Forereef	Deep	25.7556	15.2166	145.6825
SAI-1656	Forereef	Deep	27.8892	15.24214	145.6958
SAI-1662	Forereef	Mid	19.3548	15.16593	145.6925
SAI-1665	Forereef	Deep	27.7368	15.24434	145.6996
SAI-1670	Forereef	Deep	27.432	15.24475	145.8093
SAI-1671	Forereef	Deep	24.2316	15.096	145.7437
SAI-1680	Forereef	Deep	27.7368	15.19243	145.7803
SAI-1687	Forereef	Mid	19.812	15.25632	145.7652

Site	Reef Zone	Depth bin	Depth (m)	Latitude	Longitude
SAI-1692	Forereef	Deep	26.2128	15.10298	145.7284
SAI-1694	Forereef	Deep	24.5364	15.16013	145.7931
SAI-1696	Forereef	Deep	25.2984	15.1914	145.6942
SAI-1701	Forereef	Mid	13.5636	15.09375	145.7512
SAI-1702	Forereef	Mid	16.6116	15.14812	145.6941
SAI-1703	Forereef	Shallow	8.2296	15.23886	145.6986
SAI-1705	Forereef	Mid	10.3632	15.18479	145.7835
SAI-1706	Forereef	Mid	16.1544	15.25619	145.7256
SAI-1709	Forereef	Mid	10.5156	15.19768	145.703
SAI-1710	Forereef	Mid	14.0208	15.10481	145.7096
SAI-1712	Forereef	Mid	11.2776	15.25572	145.7309
SAI-1713	Forereef	Shallow	8.8392	15.25021	145.7115
SAI-1715	Forereef	Shallow	8.382	15.25342	145.7582
SAI-1719	Forereef	Mid	10.9728	15.15214	145.7909
SAI-1720	Forereef	Mid	12.6492	15.2285	145.6939
SAI-1723	Forereef	Mid	11.43	15.22392	145.7013
SAI-1726	Forereef	Mid	16.002	15.21668	145.6964
SAI-1727	Forereef	Mid	17.2212	15.19433	145.6993
SAI-1729	Forereef	Mid	12.4968	15.11817	145.6926
SAI-1732	Forereef	Mid	12.192	15.16901	145.6949
SAI-1735	Forereef	Mid	17.526	15.13293	145.6819
SAI-1741	Forereef	Shallow	3.6576	15.1795	145.6987
SAI-1743	Forereef	Shallow	4.8768	15.1642	145.7943
SAI-1745	Forereef	Shallow	4.7244	15.11002	145.7051
SAI-1748	Forereef	Shallow	3.3528	15.18958	145.7031
SAI-1754	Forereef	Shallow	1.9812	15.0972	145.7449
SAI-1755	Forereef	Shallow	3.2004	15.14499	145.6932
SAI-1758	Forereef	Shallow	4.1148	15.15147	145.7482
SAI-1764	Forereef	Mid	16.764	15.2239	145.7909
SAI-1766	Forereef	Deep	20.574	15.20149	145.7825
SAI-1768	Forereef	Shallow	4.8768	15.16126	145.7635
SAI-1771	Forereef	Deep	23.3172	15.12839	145.7487
SAI-23	Forereef	Mid	11.43	15.15629	145.6897
SAR-381	Forereef	Deep	26.9748	16.7081	145.79
SAR-390	Forereef	Deep	24.0792	16.71666	145.7844
SAR-396	Forereef	Mid	17.8308	16.71099	145.7882
SAR-401	Forereef	Mid	10.9728	16.70084	145.7891
TIN-736	Forereef	Deep	24.5364	15.04967	145.6539
TIN-740	Forereef	Deep	24.8412	14.96223	145.6112
TIN-741	Forereef	Mid	19.9644	14.98438	145.6053
TIN-743	Forereef	Deep	21.0312	15.02896	145.5849
TIN-744	Forereef	Deep	21.6408	14.97108	145.6086
TIN-746	Forereef	Deep	21.0312	14.98915	145.5951
TIN-748	Forereef	Deep	24.384	14.94933	145.6223
TIN-751	Forereef	Mid	19.6596	15.03591	145.6521
TIN-761	Forereef	Mid	12.4968	14.98981	145.6042
TIN-764	Forereef	Shallow	7.1628	15.01192	145.5863
TIN-766	Forereef	Mid	13.2588	15.06777	145.6096
TIN-770	Forereef	Mid	15.3924	15.02851	145.6526
TIN-771	Forereef	Shallow	5.6388	15.0424	145.5964
TIN-775	Forereef	Shallow	6.7056	14.98211	145.6104
TIN-777	Forereef	Shallow	7.62	14.9908	145.6029
TIN-780	Forereef	Mid	16.1544	14.96739	145.6104
TIN-783	Forereef	Shallow	4.7244	15.07963	145.6213
TIN-787	Forereef	Shallow	2.8956	14.97077	145.6117
TIN-792	Forereef	Shallow	3.3528	14.9907	145.6061

Table 9. Summary of sites where structure from motion photogrammetry surveys were conducted.

Site	Survey Size (m)	Latitude	Longitude	Survey Type	Depth (ft)
GUA-2390	3 × 20	13.60601	144.8342	belt	26
GUA-2378	3 × 20	13.55101	144.8077	belt	59
GUA-2412	3 × 13	13.53407	144.7997	belt	82
ROT-717	3 × 13	14.19652	145.224	belt	73
ROT-757	3 × 20	14.18641	145.2102	belt	58
ROT-742	3 × 20	14.17751	145.1945	belt	38
ROT-735	3 × 20	14.17059	145.166	belt	40
OCC-ROT-001	12	14.18318	145.2071	spiral	44
ROT-748	3 × 20	14.13703	145.1494	belt	22
ROT-785	3 × 20	14.15188	145.272	belt	29
ROT-783	3 × 20	14.15362	145.2562	belt	45
OCC-ROT-003	12	14.11394	145.1669	spiral	46
OCC-GUA-002	12	13.60332	144.9236	spiral	43
GUA-2515	3 × 20	13.597	144.9574	belt	39
GUA-2512	3 × 20	13.60634	144.9126	belt	45
GUA-2578	3 × 20	13.61347	144.9071	belt	31
GUA-2573	3 × 20	13.60176	144.9267	belt	20
GUA-2499	3 × 20	13.24372	144.7155	belt	34
GUA-2503	3 × 20	13.24027	144.7096	belt	75
GUA-2494	3 × 20	13.24171	144.6949	belt	12
OCC-GUA-009	12	13.24135	144.7043	spiral	44
OCC-TIN-002	12	15.03465	145.6513	spiral	44
OCC-TIN-001	12	15.0804	145.6214	spiral	35
TIN-770	3 × 20	15.02851	145.6526	belt	32
TIN-736	3 × 20	15.04967	145.6539	belt	80
TIN-751	3 × 20	15.03591	145.6521	belt	66
TIN-783	3 × 20	15.07963	145.6213	belt	17
TIN-766	3 × 20	15.06777	145.6096	belt	48
TIN-771	3 × 20	15.0424	145.5964	belt	22
TIN-748	3 × 20	14.94933	145.6223	belt	83
TIN-787	3 × 20	14.97077	145.6117	belt	9
TIN-741	3 × 20	14.98438	145.6053	belt	64
TIN-792	3 × 20	14.9907	145.6061	belt	11
TIN-777	3 × 20	14.9908	145.6029	belt	26
OCC-TIN-005	12	14.99064	145.6029	spiral	33
OCC-SAI-009	12	15.09785	145.7434	spiral	54
SAI-1692	3 × 20	15.10298	145.7284	belt	81
SAI-1754	3 × 20	15.0972	145.7449	belt	12
SAI-1671	3 × 20	15.096	145.7437	belt	83
SAI-1745	3 × 20	15.11002	145.7051	belt	15
SAI-1729	3 × 20	15.11817	145.6926	belt	41
OCC-SAI-012	12	15.15637	145.6897	spiral	40
SAI-1696	3 × 20	15.1914	145.6942	belt	83
SAI-1662	3 × 20	15.16593	145.6925	belt	64
SAI-1702	3 × 20	15.14812	145.6941	belt	60
SAI-1735	3 × 20	15.13293	145.6819	belt	58
SAI-1741	3 × 20	15.1795	145.6987	belt	13
SAI-1748	3 × 20	15.18958	145.7031	belt	15
SAI-1655	3 × 20	15.2166	145.6825	belt	86
SAI-1709	3 × 20	15.19768	145.703	belt	38
SAI-1726	3 × 20	15.21668	145.6964	belt	50
SAI-1723	3 × 20	15.22392	145.7013	belt	33
SAI-1720	3 × 20	15.2285	145.6939	belt	45
SAI-1665	3 × 20	15.24434	145.6996	belt	88
SAI-1703	3 × 20	15.23886	145.6986	belt	23
SAI-1712	3 × 20	15.25572	145.7309	belt	36
SAI-1715	3 × 20	15.25342	145.7582	belt	24

Site	Survey Size (m)	Latitude	Longitude	Survey Type	Depth (ft)
SAI-1687	3 × 20	15.25632	145.7652	belt	66
OCC-SAI-016	12	15.25652	145.7675	spiral	42
TIN-743	3 × 20	15.02896	145.5849	belt	75
TIN-764	3 × 20	15.01192	145.5863	belt	27
TIN-746	3 × 20	14.98915	145.5951	belt	68
TIN-761	3 × 20	14.98981	145.6042	belt	40
TIN-740	3 × 20	14.96223	145.6112	belt	82
TIN-780	3 × 20	14.96223	145.6112	belt	54
TIN-744	3 × 20	14.97108	145.6086	belt	73
TIN-775	3 × 20	14.98211	145.6104	belt	23
AGU-532	3 × 20	14.86086	145.557	belt	73
AGU-543	3 × 20	14.85827	145.5533	belt	56
AGU-558	3 × 20	14.85418	145.543	belt	19
AGU-523	3 × 20	14.85047	145.5388	belt	10
AGU-548	3 × 20	14.84555	145.5363	belt	40
AGU-546	3 × 20	14.8536	145.5398	belt	43
GUA-2475	3 × 20	13.2941	144.7706	belt	57
GUA-2454	3 × 20	13.29117	144.7668	belt	30
GUA-2448	3 × 20	13.28239	144.7645	belt	46
GUA-2434	3 × 20	13.30154	144.7745	belt	48
GUA-2432	3 × 20	13.31362	144.7741	belt	45
OCC-GUA-007	12	13.29155	144.7677	spiral	38
OCC-GUA-005	12	13.47479	144.8647	spiral	53
GUA-2523	3 × 20	13.48525	144.7347	belt	87
GUA-2532	3 × 20	13.48263	144.7333	belt	21
GUA-2526	3 × 20	13.48309	144.7302	belt	32
GUA-2525	3 × 20	13.48201	144.7266	belt	32
GUA-2531	3 × 20	13.48108	144.7247	belt	8
GUA-2384	3 × 20	13.33469	144.6377	belt	58
GUA-2363	3 × 20	13.3595	144.6382	belt	14
GUA-2362	3 × 20	13.37475	144.6442	belt	13
GUA-2369	3 × 20	13.38213	144.6468	belt	12
GUA-2355	3 × 20	13.39056	144.6544	belt	12
GUA-2379	3 × 20	13.40055	144.6582	belt	34
GUA-2558	3 × 20	13.47619	144.6955	belt	89
GUA-2561	3 × 20	13.47489	144.6969	belt	15
GUA-2563	3 × 20	13.46911	144.6862	belt	22
GUA-2717	3 × 20	13.46897	144.6847	belt	37
GUA-2716	3 × 20	13.4733	144.6971	belt	25
GUA-2672	3 × 20	13.47946	144.7067	belt	16
GUA-2745	3 × 13	13.61455	144.9077	belt	81
GUA-2744	3 × 13	13.60438	144.9211	belt	66
GUA-2702	3 × 20	13.60199	144.9345	belt	37
GUA-2681	3 × 20	13.65245	144.8748	belt	37
GUA-2740	3 × 20	13.65432	144.8546	belt	21
GUA-2684	3 × 20	13.63392	144.8909	belt	19
GUA-2780	3 × 13	13.63167	144.8386	belt	66
GUA-2751	3 × 13	13.51251	144.7943	belt	72
GUA-2783	3 × 20	13.61087	144.8331	belt	51
GUA-2735	3 × 20	13.50474	144.7706	belt	56
GUA-2734	3 × 20	13.60076	144.8314	belt	43
GUA-2701	3 × 20	13.56483	144.8189	belt	16
GUA-2650	3 × 20	13.56911	144.8213	belt	11
GUA-2784	3 × 20	13.59384	144.8361	belt	6
GUA-2758	3 × 13	13.46975	144.8598	belt	62
GUA-2726	3 × 20	13.47782	144.8654	belt	26
GUA-2767	3 × 13	13.43964	144.8202	belt	77
GUA-2699	3 × 20	13.50493	144.8942	belt	48
GUA-2720	3 × 20	13.52745	144.9313	belt	52
GUA-2677	3 × 13	13.48605	144.873	belt	20
GUA-2723	3 × 20	13.37649	144.7777	belt	39

Site	Survey Size (m)	Latitude	Longitude	Survey Type	Depth (ft)
GUA-2728	3 × 20	13.39592	144.7821	belt	35
GUA-2653	3 × 20	13.42634	144.8064	belt	20
GUA-2762	3 × 13	13.30146	144.7754	belt	76
GUA-2768	3 × 13	13.28509	144.767	belt	64
GUA-2727	3 × 20	13.24937	144.7372	belt	36
TIN-903	3 × 13	15.00486	145.6753	belt	83
TIN-891	3 × 13	14.97605	145.6652	belt	66
TIN-846	3 × 20	14.95551	145.6644	belt	47
TIN-838	3 × 20	14.94117	145.6529	belt	25
TIN-883	3 × 13	15.0727	145.6576	belt	74
TIN-849	3 × 20	15.04823	145.6515	belt	59
TIN-855	3 × 20	15.03039	145.6522	belt	35
SAI-1888	3 × 13	15.17306	145.792	belt	63
SAI-1915	3 × 20	15.15	145.7875	belt	28
SAI-1916	3 × 20	15.15992	145.7661	belt	37
SAI-1921	3 × 13	15.14558	145.747	belt	76
SAI-1909	3 × 20	15.10446	145.7346	belt	13
SAI-1918	3 × 20	15.12425	145.7531	belt	32
SAI-1920	3 × 20	15.09473	145.7523	belt	45
SAI-1883	3 × 13	15.20097	145.7829	belt	76
SAI-1848	3 × 20	15.25776	145.8147	belt	37
SAI-1884	3 × 20	15.27245	145.789	belt	42
SAI-1828	3 × 20	15.25513	145.744	belt	13
SAI-1906	3 × 13	15.2687	145.8319	belt	66
SAI-1882	3 × 20	15.2811	145.8004	belt	55
SAI-1843	3 × 20	15.26145	145.7744	belt	42
SAI-1820	3 × 20	15.25299	145.7619	belt	16
PAG-1323	3 × 13	18.08832	145.7387	belt	64
PAG-1278	3 × 20	18.09902	145.7528	belt	41
PAG-1273	3 × 20	18.09902	145.7528	belt	24
PAG-1266	3 × 20	18.14281	145.7585	belt	14
PAG-1313	3 × 13	18.04214	145.706	belt	82
PAG-1301	3 × 20	18.04933	145.7062	belt	53
PAG-1288	3 × 20	18.05927	145.711	belt	35
PAG-1253	3 × 20	18.0807	145.7201	belt	13
PAG-1316	3 × 13	18.10486	145.786	belt	61
PAG-1298	3 × 20	18.08933	145.7589	belt	51
PAG-1258	3 × 20	18.05484	145.7356	belt	22
PAG-1309	3 × 13	18.16976	145.7905	belt	76
PAG-1326	3 × 13	18.1476	145.811663	belt	65
PAG-1274	3 × 20	18.11198	145.8021	belt	62
MAU-1258	3 × 13	20.02366	145.2384	belt	62
MAU-1273	3 × 13	20.01694	145.2383	belt	63
MAU-1223	3 × 20	20.01417	145.2273	belt	44
MAU-1257	3 × 13	20.03124	145.2345	belt	69
MAU-1243	3 × 20	20.03	145.2296	belt	58
MAU-1225	3 × 20	20.03073	145.2329	belt	34
MAU-1213	3 × 20	20.02904	145.2323	belt	13
MAU-1268	3 × 13	20.00973	145.2166	belt	77
MAU-1233	3 × 20	20.0108	145.2127	belt	49
MAU-1245	3 × 20	20.01452	145.2087	belt	28
MAU-1215	3 × 20	20.01596	145.2075	belt	12
MAU-1265	3 × 13	20.03046	145.2272	belt	64
MAU-1226	3 × 20	20.03708	145.2197	belt	55
MAU-1222	3 × 20	20.03484	145.2158	belt	52
MAU-1207	3 × 20	20.02428	145.2102	belt	12
MAU-1263	3 × 13	20.029	145.2076	belt	63
MAU-1242	3 × 20	20.02989	145.2125	belt	25
MAU-1203	3 × 20	20.02641	145.2079	belt	15
MAU-1262	3 × 13	20.03629	145.2245	belt	65
MAU-1248	3 × 20	20.01186	145.2199	belt	43

Site	Survey Size (m)	Latitude	Longitude	Survey Type	Depth (ft)
MAU-1247	3 × 20	20.01815	145.2121	belt	43
ASC-0637	3 × 13	19.68087	145.4156	belt	80
ASC-0614	3 × 20	19.70404	145.4138	belt	43
ASC-0585	3 × 20	19.69404	145.39	belt	14
ASC-0632	3 × 13	19.69867	145.4186	belt	63
ASC-0604	3 × 20	19.68845	145.4191	belt	33
ASC-0601	3 × 20	19.67702	145.4108	belt	32
ASC-0594	3 × 20	19.68054	145.3935	belt	12
ASC-0627	3 × 13	19.69973	145.391	belt	65
ASC-0613	3 × 20	19.7079	145.3992	belt	60
ASC-0623	3 × 20	19.70814	145.404	belt	37
ASC-0612	3 × 20	19.69399	145.3893	belt	41
ASC-0626	3 × 13	19.68335	145.3875	belt	63
ASC-0611	3 × 20	19.67497	145.4007	belt	34
ASC-0620	3 × 20	19.68052	145.391	belt	49
ASC-0590	3 × 20	19.68301	145.3897	belt	11
PAG-1324	3 × 13	18.15093	145.7548	belt	70
PAG-1297	3 × 20	18.10393	145.7756	belt	66
PAG-1260	3 × 20	18.12261	145.8051	belt	17
PAG-1305	3 × 13	18.06503	145.7455	belt	62
PAG-1295	3 × 20	18.04689	145.7268	belt	53
PAG-1251	3 × 20	18.08592	145.7353	belt	18
PAG-COTS	3 × 20	18.08626	145.7353	belt	22
PAG-1254	3 × 20	18.13233	145.7599	belt	14
SAI-1859	3 × 13	15.14249	145.6756	belt	61
SAI-1852	3 × 20	15.16347	145.6934	belt	36
SAI-1857	3 × 20	15.20303	145.6978	belt	57
SAI-1854	3 × 20	15.24128	145.6998	belt	50
TIN-830	3 × 20	14.94205	145.6281	belt	19
TIN-848	3 × 20	15.08859	145.6311	belt	42
TIN-868	3 × 20	15.07149	145.6116	belt	54
TIN-884	3 × 13	14.97056	145.6075	belt	77
ROT-845	3 × 20	14.15146	145.1424	belt	49
ROT-830	3 × 20	14.17043	145.174	belt	18
ROT-889	3 × 13	14.20195	145.2579	belt	64
ROT-879	3 × 20	14.20008	145.2348	belt	51
ROT-874	3 × 13	14.11358	145.1831	belt	66
ROT-872	3 × 20	14.12343	145.1667	belt	38
ROT-866	3 × 20	14.13411	145.1556	belt	18
ROT-848	3 × 20	14.168	145.286077	belt	39
ROT-867	3 × 20	14.11407	145.2031	belt	20
GUA-2777	3 × 13	13.33511	144.6346	belt	72
GUA-2730	3 × 20	13.31535	144.6469	belt	50
GUA-2781	3 × 13	13.24215	144.6395	belt	67
GUA-2737	3 × 20	13.25553	144.6497	belt	48
GUA-2662	3 × 20	13.24163	144.6953	belt	16
OCC-GUA-015	12	13.52893	144.8004	spiral	43
OCC-GUA-024	12	13.44359	144.6433	spiral	20
SAI-1624	3 × 20	15.13299	145.7457	belt	73
SAI-1771	3 × 20	15.12839	145.7487	belt	74
SAI-1701	3 × 20	15.09375	145.7512	belt	40
SAI-1710	3 × 20	15.10481	145.7096	belt	49
OCC-SAI-009	12	15.09791	145.7434	spiral	55
SAI-1653	3 × 20	15.12247	145.7572	belt	68
SAI-1758	3 × 20	15.15147	145.7483	belt	13
SAI-1628	3 × 20	15.15499	145.7502	belt	75
SAI-1768	3 × 20	15.16126	145.7635	belt	14
PAG-1158	3 × 20	18.09863	145.7936	belt	78
PAG-1088	3 × 20	18.15375	145.8076	belt	20
MAU-1103	3 × 20	20.01846	145.2302	belt	37
MAU-1080	3 × 20	20.01095	145.2122	belt	47

Site	Survey Size (m)	Latitude	Longitude	Survey Type	Depth (ft)
MAU-1081	3 × 20	20.02642	145.2074	belt	34
MAU-1118	3 × 20	20.02365	145.2102	belt	20
OCC-MAU-008	12	20.01311	145.208	spiral	51
OCC-MAU-002	12	20.03577	145.2247	spiral	45
MAU-1041	3 × 20	20.63595	145.2266	belt	77
MAU-1105	3 × 20	20.03353	145.2276	belt	26
MAU-1074	3 × 20	20.01685	145.227	belt	42
MAU-1119	3 × 20	20.02834	145.2322	belt	10
MAU-1095	3 × 20	20.02404	145.208	belt	35
MAU-1067	3 × 20	20.02304	145.2079	belt	45
MAU-1089	3 × 20	20.01482	145.2083	belt	30
MAU-1129	3 × 20	20.0215	145.2295	belt	16
OCC-MAU-016	12	20.0299	145.2299	spiral	21
OCC-MAU-019	12	20.01426	145.2273	spiral	29
OCC-MAU-018	12	20.02243	145.2297	spiral	28
MAU-1034	3 × 13	20.02933	145.2239	belt	74
MAU-1074	3 × 20	20.03177	145.2105	belt	45
MAU-1122	3 × 20	20.03045	145.2233	belt	16
MAU-1077	3 × 20	20.03239	145.213	belt	35
MAU-1075	3 × 20	20.02174	145.2361	belt	56
MAU-1108	3 × 20	20.015	145.2313	belt	44
SAR-396	3 × 20	16.71099	145.7882	belt	59
OCC-GUA-025	12	13.46744	144.6812	spiral	39
GUA-2594	3 × 13	13.51207	144.7896	belt	81
GUA-2595	3 × 20	13.51877	144.7974	belt	40
GUA-2590	3 × 20	13.52093	144.8012	belt	18
OCC-GUA-025	12	13.46748	144.6812	spiral	41
GUA-2547	3 × 13	13.48278	144.7214	belt	66
GUA-2551	3 × 20	13.48138	144.724	belt	26
GUA-2554	3 × 20	13.4787	144.7181	belt	11
GUA-2603	3 × 20	13.48045	144.7046	belt	13
GUA-2555	3 × 20	13.47745	144.7115	belt	12
SIO-GUA-2193	12	13.33668	144.6417	spiral	21
SIO-GUA-2166	12	13.36864	144.642	spiral	39
SAI-1727	3 × 20	15.19433	145.6993	belt	58
SAI-1755	3 × 20	15.14499	145.6932	belt	14
SAI-1732	3 × 20	15.16901	145.6999	belt	40
OCC-SAI-012	12	15.15646	145.6898	spiral	38
OCC-PAG-006	12	18.09614	145.7648	spiral	42
OCC-PAG-009	12	18.04561	145.7062	spiral	50
PAG-1119	3 × 20	18.0963	145.7649	belt	46
PAG-1114	3 × 20	18.09234	145.762	belt	35
PAG-1068	3 × 20	18.08312	145.754	belt	9
PAG-1131	3 × 13	18.0767	145.7509	belt	61
PAG-1086	3 × 20	18.07113	145.7757	belt	22
OCC-PAG-002	spiral	18.16788	145.7949	spiral	43
PAG-1124	3 × 20	18.16787	145.7926	belt	50
PAG-1070	3 × 20	18.15496	145.8076	belt	15
ASC-512	3 × 20	19.70131	145.3927	belt	45
ASC-514	3 × 20	19.70675	145.3972	belt	54
ASC-516	3 × 20	19.70792	145.401	belt	56
ASC-496	3 × 20	19.70704	145.4012	belt	9
ASC-518	3 × 20	19.70784	145.4027	belt	38
OCC-ASC-005	12	19.69023	145.3886	spiral	43
OCC-ASC-001	12	19.70834	145.403	spiral	44
ASC-524	3 × 20	19.69215	145.4188	belt	35
ASC-499	3 × 20	19.69025	145.4187	belt	22
ASC-526	3 × 20	19.69956	145.4181	belt	52
OCC-ASC-004	12	19.68068	145.3914	spiral	30
OCC-ASC-003	12	19.67703	145.4108	spiral	38
GUA-2402	3 × 13	13.64853	144.8832	belt	74

Site	Survey Size (m)	Latitude	Longitude	Survey Type	Depth (ft)
GUA-2377	3 × 20	13.64769	144.8801	belt	31
GUA-2404	3 × 20	13.65376	144.8773	belt	70
GUA-2389	3 × 20	13.65737	144.8585	belt	34
GUA-2571	3 × 20	13.57448	144.9486	belt	17
GUA-2574	3 × 20	13.60191	144.9297	belt	43
GUA-2419	3 × 20	13.4127	144.7885	belt	15
GUA-2470	3 × 20	13.41709	144.7935	belt	58
GUA-2427	3 × 20	13.38863	144.7794	belt	14
GUA-2451	3 × 20	13.36044	144.7769	belt	50
GUA-2597	3 × 20	13.5303	144.8001	belt	83
GUA-2589	3 × 20	13.52525	144.8011	belt	54
OCC-GUA-026	12	13.47637	144.9674	spiral	38
GUA-2511	3 × 20	13.57448	144.9486	belt	17
SAI-1719	3 × 20	15.15214	145.7909	belt	34
SAI-1743	3 × 20	15.1642	145.7943	belt	18
SAI-1652	3 × 20	15.17935	145.7879	belt	81
SAI-1705	3 × 20	15.18479	145.7835	belt	33
SAI-1680	3 × 13	15.19243	145.7803	belt	91
OCC-PAG-006	12	18.09619	145.7648	spiral	42
PAG-1143	3 × 20	18.06691	145.7463	belt	69
PAG-1110	3 × 20	18.05727	145.7412	belt	40
PAG-1081	3 × 20	18.05246	145.7331	belt	11
PAG-1144	3 × 20	18.04864	145.7343	belt	75
PAG-1095	3 x 20	18.04332	145.7107	belt	33
PAG-1121	3 x 20	18.0997	145.7538	belt	39
PAG-1077	3 x 20	18.10564	145.7576	belt	8
PAG-1155	3 x 20	18.11429	145.7525	belt	77
PAG-1090	3 x 20	18.1224	145.7575	belt	5
PAG-1134	3 x 20	18.12856	145.7531	belt	92
PAG-1096	3 x 20	18.14381	145.7553	belt	36
OCC-PAG-013	12	18.12007	145.7547	spiral	42
PAG-1125	3 x 20	18.0847	145.7255	belt	32
PAG-1154	3 x 20	18.0969	145.747	belt	91
PAG-1085	3 x 20	18.13437	145.7613	belt	15
PAG-1141	3 x 20	18.10003	145.7926	belt	70
PAG-1099	3 x 20	18.1019	145.7963	belt	37
PAG-1084	3 x 20	19.10391	145.8023	belt	16

Table 10. Summary of sites where CTD casts and water samples were conducted.

LOCATION	CTDFILEID	DATE	LATITUDE	LONGITUDE	WATER SAMPLE
GUA	RA2201_LEG3_SN1280_2022-04-12_001	4/12/2022	13.529077	144.800171	Yes
GUA	RA2201_LEG3_SN1280_2022-04-12_002	4/12/2022	13.529098	144.800042	Yes
GUA	RA2201_LEG3_SN1280_2022-04-14_001	4/14/2022	13.529188	144.8002	Yes
GUA	RA2201_LEG3_SN1280_2022-04-14_002	4/14/2022	13.528871	144.800047	Yes
ROT	RA2201_LEG3_SN1279_2022-04-15_001	4/15/2022	14.196521	145.223978	Yes
ROT	RA2201_LEG3_SN1279_2022-04-15_002	4/15/2022	14.186407	145.210192	Yes
ROT	RA2201_LEG3_SN1279_2022-04-15_003	4/15/2022	14.177573	145.194496	Yes
ROT	RA2201_LEG3_SN1280_2022-04-15_001	4/15/2022	14.183699	145.207182	Yes
ROT	RA2201_LEG3_SN1281_2022-04-16_001	4/16/2022	14.133835	145.139469	Yes
ROT	RA2201_LEG3_SN1280_2022-04-16_001	4/16/2022	14.114118	145.166731	Yes
ROT	RA2201_LEG3_SN1281_2022-04-16_002	4/16/2022	14.137025	145.149443	Yes
ROT	RA2201_LEG3_SN1281_2022-04-16_003	4/16/2022	14.120872	145.168067	Yes
ROT	RA2201_LEG3_SN1280_2022-04-16_002	4/16/2022	14.175041	145.286318	Yes
GUA	RA2201_LEG3_SN1281_2022-04-17_001	4/17/2022	13.58944	144.95432	Yes
GUA	RA2201_LEG3_SN1280_2022-04-17_001	4/17/2022	13.603896	144.92374	Yes
GUA	RA2201_LEG3_SN1281_2022-04-17_002	4/17/2022	13.606343	144.912645	Yes
GUA	RA2201_LEG3_SN1280_2022-04-17_002	4/17/2022	13.603185	144.923928	Yes
GUA	RA2201_LEG3_SN1281_2022-04-17_003	4/17/2022	13.613472	144.907106	Yes

LOCATION	CTDFILEID	DATE	LATITUDE	LONGITUDE	WATER_SAMPLE
GUA	RA2201_LEG3_SN1280_2022-04-17_003	4/17/2022	13.602816	144.923039	Yes
GUA	RA2201_LEG3_SN1280_2022-04-18_001	4/18/2022	13.241042	144.70435	Yes
GUA	RA2201_LEG3_SN1280_2022-04-18_002	4/18/2022	13.241353	144.704269	Yes
GUA	RA2201_LEG3_SN1280_2022-04-18_003	4/18/2022	13.242071	144.703908	Yes
TIN	RA2201_LEG3_SN1280_2022-04-19_001	4/19/2022	15.034782	145.651131	Yes
TIN	RA2201_LEG3_SN1281_2022-04-19_001	4/19/2022	15.079627	145.621341	Yes
TIN	RA2201_LEG3_SN1281_2022-04-19_002	4/19/2022	15.067772	145.609559	Yes
TIN	RA2201_LEG3_SN1281_2022-04-19_003	4/19/2022	15.042398	145.596373	Yes
TIN	RA2201_LEG3_SN1280_2022-04-19_002	4/19/2022	15.080602	145.621312	Yes
TIN	RA2201_LEG3_SN1281_2022-04-20_001	4/20/2022	14.970769	145.611689	Yes
TIN	RA2201_LEG3_SN1280_2022-04-20_001	4/20/2022	14.940561	145.627908	Yes
TIN	RA2201_LEG3_SN1281_2022-04-20_002	4/20/2022	14.984384	145.605315	Yes
TIN	RA2201_LEG3_SN1281_2022-04-20_003	4/20/2022	14.990702	145.606088	Yes
TIN	RA2201_LEG3_SN1280_2022-04-20_002	4/20/2022	14.990434	145.602872	Yes
SAI	RA2201_LEG3_SN1281_2022-04-21_001	4/21/2022	15.102978	145.728435	Yes
SAI	RA2201_LEG3_SN1280_2022-04-21_001	4/21/2022	15.098434	145.744187	Yes
SAI	RA2201_LEG3_SN1281_2022-04-21_002	4/21/2022	15.097198	145.744893	Yes
SAI	RA2201_LEG3_SN1280_2022-04-21_002	4/21/2022	15.097653	145.742881	Yes
SAI	RA2201_LEG3_SN1281_2022-04-21_003	4/21/2022	15.095998	145.743657	Yes
SAI	RA2201_LEG3_SN1280_2022-04-21_003	4/21/2022	15.098178	145.743269	Yes
SAI	RA2201_LEG3_SN1281_2022-04-22_001	4/22/2022	15.191399	145.694212	Yes
SAI	RA2201_LEG3_SN1281_2022-04-22_002	4/22/2022	15.165933	145.69254	Yes
SAI	RA2201_LEG3_SN1281_2022-04-22_003	4/22/2022	15.148115	145.694093	Yes
SAI	RA2201_LEG3_SN1280_2022-04-22_001	4/22/2022	15.154648	145.69241	Yes
SAI	RA2201_LEG3_SN1280_2022-04-22_002	4/22/2022	15.156507	145.689447	Yes
SAI	RA2201_LEG3_SN1280_2022-04-22_003	4/22/2022	15.15774	145.6855	Yes
SAI	RA2201_LEG3_SN1280_2022-04-24_001	4/24/2022	15.258509	145.815569	Yes
SAI	RA2201_LEG3_SN1280_2022-04-24_002	4/24/2022	15.257511	145.816564	Yes
SAI	RA2201_LEG3_SN1280_2022-04-24_003	4/24/2022	15.256167	145.767504	Yes
SAI	RA2201_LEG3_SN1281_2022-04-25_001	4/25/2022	15.216599	145.682506	Yes
SAI	RA2201_LEG3_SN1281_2022-04-25_002	4/25/2022	15.201971	145.694614	Yes
SAI	RA2201_LEG3_SN1281_2022-04-25_003	4/25/2022	15.197677	145.702956	Yes
SAI	RA2201_LEG3_SN1280_2022-04-25_001	4/25/2022	15.290626	145.809632	Yes
SAI	RA2201_LEG3_SN1280_2022-04-25_002	4/25/2022	15.290708	145.809517	Yes
SAI	RA2201_LEG3_SN1280_2022-04-25_003	4/25/2022	15.29108	145.809467	Yes
SAI	RA2201_LEG3_SN1281_2022-04-26_001	4/26/2022	15.244336	145.699648	Yes
SAI	RA2201_LEG3_SN1281_2022-04-26_002	4/26/2022	15.238858	145.698566	Yes
SAI	RA2201_LEG3_SN1280_2022-04-26_001	4/26/2022	15.237351	145.722271	Yes
SAI	RA2201_LEG3_SN1281_2022-04-26_003	4/26/2022	15.255716	145.730897	Yes
SAI	RA2201_LEG3_SN1280_2022-04-26_002	4/26/2022	15.256346	145.766958	Yes
SAI	RA2201_LEG3_SN1280_2022-04-26_003	4/26/2022	15.257158	145.766224	Yes
TIN	RA2201_LEG3_SN1281_2022-04-27_001	4/27/2022	14.962233	145.611212	Yes
TIN	RA2201_LEG3_SN1280_2022-04-27_001	4/27/2022	15.028959	145.584896	Yes
TIN	RA2201_LEG3_SN1281_2022-04-27_002	4/27/2022	14.967393	145.610432	Yes
TIN	RA2201_LEG3_SN1281_2022-04-27_003	4/27/2022	14.971082	145.60862	Yes
TIN	RA2201_LEG3_SN1280_2022-04-27_002	4/27/2022	15.011915	145.586333	Yes
AGU	RA2201_LEG3_SN1280_2022-04-28_001	4/28/2022	14.857417	145.549191	Yes
AGU	RA2201_LEG3_SN1280_2022-04-28_002	4/28/2022	14.853721	145.541404	Yes
AGU	RA2201_LEG3_SN1281_2022-04-28_001	4/28/2022	14.844095	145.535829	Yes
AGU	RA2201_LEG3_SN1281_2022-04-28_002	4/28/2022	14.846808	145.533689	Yes
AGU	RA2201_LEG3_SN1280_2022-04-28_003	4/28/2022	14.84649	145.536515	Yes
AGU	RA2201_LEG3_SN1280_2022-04-29_001	4/29/2022	14.860862	145.557036	Yes
AGU	RA2201_LEG3_SN1281_2022-04-29_001	4/29/2022	14.843653	145.532077	Yes
AGU	RA2201_LEG3_SN1281_2022-04-29_002	4/29/2022	14.845551	145.536337	Yes
AGU	RA2201_LEG3_SN1280_2022-04-29_002	4/29/2022	14.854183	145.543039	Yes
AGU	RA2201_LEG3_SN1281_2022-04-29_003	4/29/2022	14.851889	145.537329	Yes
AGU	RA2201_LEG3_SN1280_2022-04-29_003	4/29/2022	14.850468	145.538754	Yes
GUA	RA2201_LEG3_SN1281_2022-04-30_001	4/30/2022	13.294096	144.770613	Yes
GUA	RA2201_LEG3_SN1280_2022-04-30_001	4/30/2022	13.291183	144.767917	Yes
GUA	RA2201_LEG3_SN1281_2022-04-30_002	4/30/2022	13.291168	144.766769	Yes

LOCATION	CTDFILEID	DATE	LATITUDE	LONGITUDE	WATER_SAMPLE
GUA	RA2201_LEG3_SN1281_2022-04-30_003	4/30/2022	13.282392	144.764464	Yes
GUA	RA2201_LEG3_SN1280_2022-05-01_001	5/1/2022	13.473695	144.865988	Yes
GUA	RA2201_LEG3_SN1280_2022-05-01_002	5/1/2022	13.474787	144.864749	Yes
GUA	RA2201_LEG3_SN1280_2022-05-01_003	5/1/2022	13.474592	144.864968	Yes
GUA	RA2201_LEG3_SN1281_2022-05-02_001	5/2/2022	13.485251	144.734714	Yes
GUA	RA2201_LEG3_SN1281_2022-05-02_002	5/2/2022	13.482628	144.733273	Yes
GUA	RA2201_LEG3_SN1281_2022-05-02_003	5/2/2022	13.483087	144.730218	Yes
GUA	RA2201_LEG3_SN1280_2022-05-02_001	5/2/2022	13.529166	144.80098	Yes
GUA	RA2201_LEG3_SN1280_2022-05-03_001	5/3/2022	13.476185	144.695546	Yes
GUA	RA2201_LEG3_SN1281_2022-05-03_001	5/3/2022	13.334685	144.637741	Yes
GUA	RA2201_LEG3_SN1281_2022-05-03_002	5/3/2022	13.359499	144.638205	Yes
GUA	RA2201_LEG3_SN1280_2022-05-03_002	5/3/2022	13.474887	144.696947	Yes
GUA	RA2201_LEG3_SN1281_2022-05-03_003	5/3/2022	13.374747	144.64416	Yes
GUA	RA2201_LEG3_SN1280_2022-05-03_003	5/3/2022	13.469109	144.68622	Yes
GUA	RA2201_LEG5_SN1280_2022-06-16_001	6/16/2022	13.443566	144.643131	Yes
SAI	RA2201_LEG5_SN1280_2022-06-17_001	6/17/2022	15.097789	145.743221	Yes
SAI	RA2201_LEG5_SN1281_2022-06-17_003	6/17/2022	15.104809	145.709607	Yes
SAI	RA2201_LEG5_SN1281_2022-06-17_001	6/17/2022	15.132299	145.74567	Yes
SAI	RA2201_LEG5_SN1281_2022-06-17_002	6/17/2022	15.128387	145.748739	Yes
SAI	RA2201_LEG5_SN1280_2022-06-18_001	6/18/2022	15.09764	145.742802	Yes
SAI	RA2201_LEG5_SN1281_2022-06-18_001	6/18/2022	15.20948	145.65614	Yes
PAG	RA2201_LEG5_SN1281_2022-06-19_002	6/19/2022	18.098627	145.793621	Yes
PAG	RA2201_LEG5_SN1281_2022-06-19_003	6/19/2022	18.10514	145.799099	Yes
PAG	RA2201_LEG5_SN1281_2022-06-19_001	6/19/2022	18.10446	145.778809	Yes
PAG	RA2201_LEG5_SN1280_2022-06-19_002	6/19/2022	18.09607	145.764689	Yes
PAG	RA2201_LEG5_SN1280_2022-06-19_001	6/19/2022	18.095409	145.765261	Yes
PAG	RA2201_LEG5_SN1280_2022-06-19_003	6/19/2022	18.096428	145.763911	Yes
GUA	RA2201_LEG6_SN1280_2022-07-06_001	7/6/2022	13.449026	144.625394	Yes
GUA	RA2201_LEG6_SN1280_2022-07-06_002	7/6/2022	13.436647	144.6255	Yes
GUA	RA2201_LEG6_SN1279_2022-07-07_001	7/7/2022	13.512066	144.789584	Yes
GUA	RA2201_LEG6_SN1280_2022-07-07_001	7/7/2022	13.467778	144.681056	Yes
GUA	RA2201_LEG6_SN1279_2022-07-07_003	7/7/2022	13.520932	144.801164	Yes
GUA	RA2201_LEG6_SN1279_2022-07-07_002	7/7/2022	13.518771	144.797351	Yes
GUA	RA2201_LEG6_SN1280_2022-07-07_002	7/7/2022	13.513888	144.797781	Yes
GUA	RA2201_LEG6_SN1279_2022-07-08_002	7/8/2022	13.48138	144.723972	Yes
GUA	RA2201_LEG6_SN1280_2022-07-08_001	7/8/2022	13.467802	144.681131	Yes
GUA	RA2201_LEG6_SN1279_2022-07-08_001	7/8/2022	13.482778	144.721371	Yes
GUA	RA2201_LEG6_SN1279_2022-07-09_001	7/9/2022	13.251092	144.739871	Yes
GUA	RA2201_LEG6_SN1280_2022-07-09_001	7/9/2022	13.246886	144.735281	Yes
GUA	RA2201_LEG6_SN1280_2022-07-09_002	7/9/2022	13.261078	144.649228	Yes
GUA	RA2201_LEG6_SN1280_2022-07-09_003	7/9/2022	13.260924	144.652355	Yes
GUA	RA2201_LEG6_SN1279_2022-07-09_002	7/9/2022	13.2432	144.725646	Yes
GUA	RA2201_LEG6_SN1279_2022-07-10_001	7/10/2022	13.280706	144.76482	Yes
GUA	RA2201_LEG6_SN1279_2022-07-10_003	7/10/2022	13.262788	144.744111	Yes
GUA	RA2201_LEG6_SN1280_2022-07-10_001	7/10/2022	13.336547	144.641399	Yes
GUA	RA2201_LEG6_SN1280_2022-07-10_003	7/10/2022	13.378005	144.642693	Yes
GUA	RA2201_LEG6_SN1279_2022-07-10_002	7/10/2022	13.273965	144.755021	Yes
GUA	RA2201_LEG6_SN1280_2022-07-10_002	7/10/2022	13.368678	144.641809	Yes
GUA	RA2201_LEG6_SN1279_2022-07-11_001	7/11/2022	13.484151	144.731761	Yes
GUA	RA2201_LEG6_SN1279_2022-07-11_003	7/11/2022	13.48219	144.728493	Yes
GUA	RA2201_LEG6_SN1279_2022-07-11_002	7/11/2022	13.481866	144.725207	Yes
GUA	RA2201_LEG6_SN1280_2022-07-11_001	7/11/2022	13.467668	144.68093	Yes
GUA	RA2201_LEG6_SN1280_2022-07-11_002	7/11/2022	13.529208	144.80015	Yes
GUA	RA2201_LEG6_SN1280_2022-07-11_002	7/11/2022	13.467668	144.68093	Yes
GUA	RA2201_LEG6_SN1280_2022-07-11_001	7/11/2022	13.529208	144.80015	Yes
GUA	RA2201_LEG6_SN1280_2022-07-12_001	7/12/2022	13.467439	144.681243	Yes
SAI	RA2201_LEG6_SN1280_2022-07-13_001	7/13/2022	15.156512	145.689648	Yes
SAI	RA2201_LEG6_SN1279_2022-07-13_002	7/13/2022	15.144991	145.693165	Yes
SAI	RA2201_LEG6_SN1279_2022-07-13_001	7/13/2022	15.194331	145.699311	Yes
SAI	RA2201_LEG6_SN1279_2022-07-13_003	7/13/2022	15.169006	145.69491	Yes

LOCATION	CTDFILEID	DATE	LATITUDE	LONGITUDE	WATER_SAMPLE
SAI	RA2201_LEG6_SN1279_2022-07-14_003	7/14/2022	15.20149	145.78247	Yes
SAI	RA2201_LEG6_SN1279_2022-07-14_002	7/14/2022	15.223901	145.790878	Yes
SAI	RA2201_LEG6_SN1279_2022-07-14_001	7/14/2022	15.244746	145.809268	Yes
SAI	RA2201_LEG6_SN1280_2022-07-14_001	7/14/2022	15.156641	145.689586	Yes
PAG	RA2201_LEG7_SN1279_2022-07-21_003	7/21/2022	18.083121	145.753955	Yes
PAG	RA2201_LEG7_SN1279_2022-07-21_001	7/21/2022	18.096297	145.764923	Yes
PAG	RA2201_LEG7_SN1279_2022-07-21_002	7/21/2022	18.092339	145.762026	Yes
PAG	RA2201_LEG7_SN1280_2022-07-21_003	7/21/2022	18.044376	145.705022	Yes
PAG	RA2201_LEG7_SN1280_2022-07-21_001	7/21/2022	18.045847	145.706335	Yes
PAG	RA2201_LEG7_SN1280_2022-07-21_002	7/21/2022	18.046039	145.707183	Yes
PAG	RA2201_LEG7_SN1280_2022-07-22_003	7/22/2022	18.169179	145.795459	Yes
PAG	RA2201_LEG7_SN1279_2022-07-22_003	7/22/2022	18.161447	145.806286	Yes
PAG	RA2201_LEG7_SN1280_2022-07-22_001	7/22/2022	18.167589	145.794889	Yes
PAG	RA2201_LEG7_SN1279_2022-07-22_001	7/22/2022	18.139623	145.81169	Yes
PAG	RA2201_LEG7_SN1279_2022-07-22_002	7/22/2022	18.151226	145.812292	Yes
PAG	RA2201_LEG7_SN1280_2022-07-22_002	7/22/2022	18.167967	145.794995	Yes
ASC	RA2201_LEG7_SN1280_2022-07-23_002	7/23/2022	19.708324	145.402469	Yes
ASC	RA2201_LEG7_SN1280_2022-07-23_001	7/23/2022	19.690049	145.388465	Yes
ASC	RA2201_LEG7_SN1280_2022-07-23_003	7/23/2022	19.700917	145.416726	Yes
ASC	RA2201_LEG7_SN1279_2022-07-23_002	7/23/2022	19.701311	145.39273	Yes
ASC	RA2201_LEG7_SN1279_2022-07-23_001	7/23/2022	19.701704	145.392401	Yes
ASC	RA2201_LEG7_SN1279_2022-07-23_003	7/23/2022	19.706751	145.397197	Yes
ASC	RA2201_LEG7_SN1280_2022-07-24_002	7/24/2022	19.680683	145.391387	Yes
ASC	RA2201_LEG7_SN1279_2022-07-24_001	7/24/2022	19.675424	145.408388	Yes
ASC	RA2201_LEG7_SN1280_2022-07-24_001	7/24/2022	19.677471	145.410914	Yes
GUA	RA2201_LEG7_SN1279_2022-07-29_001	7/29/2022	13.574608	144.950154	Yes
GUA	RA2201_LEG7_SN1280_2022-07-29_002	7/29/2022	13.647687	144.880089	Yes
GUA	RA2201_LEG7_SN1279_2022-07-29_002	7/29/2022	13.574479	144.9486	Yes
GUA	RA2201_LEG7_SN1280_2022-07-29_001	7/29/2022	13.648525	144.883149	Yes
GUA	RA2201_LEG7_SN1279_2022-07-29_003	7/29/2022	13.601914	144.929723	Yes
GUA	RA2201_LEG7_SN1280_2022-07-29_003	7/29/2022	13.653763	144.877328	Yes
GUA	RA2201_LEG7_SN1280_2022-07-29_004	7/29/2022	13.657366	144.858492	Yes
GUA	RA2201_LEG7_SN1279_2022-07-30_001	7/30/2022	13.412705	144.788471	Yes
GUA	RA2201_LEG7_SN1280_2022-07-30_003	7/30/2022	13.360443	144.776878	Yes
GUA	RA2201_LEG7_SN1280_2022-07-30_002	7/30/2022	13.388625	144.779433	Yes
GUA	RA2201_LEG7_SN1279_2022-07-30_003	7/30/2022	13.355953	144.775074	Yes
GUA	RA2201_LEG7_SN1279_2022-07-30_002	7/30/2022	13.381706	144.780901	Yes
GUA	RA2201_LEG7_SN1280_2022-07-30_001	7/30/2022	13.417089	144.793458	Yes
GUA	RA2201_LEG7_SN1279_2022-08-01_001	8/1/2022	13.530298	144.800062	Yes
GUA	RA2201_LEG7_SN1280_2022-08-01_001	8/1/2022	13.476366	144.697422	Yes
GUA	RA2201_LEG7_SN1280_2022-08-01_001	8/1/2022	13.476366	144.697422	Yes
GUA	RA2201_LEG7_SN1279_2022-08-01_003	8/1/2022	13.519084	144.799982	Yes
GUA	RA2201_LEG7_SN1279_2022-08-01_002	8/1/2022	13.525254	144.801084	Yes
GUA	RA2201_LEG7_SN1279_2022-08-02_003	8/2/2022	13.477978	144.71715	Yes
GUA	RA2201_LEG7_SN1280_2022-08-02_001	8/2/2022	13.476997	144.697662	Yes
GUA	RA2201_LEG7_SN1279_2022-08-02_002	8/2/2022	13.478741	144.709217	Yes
GUA	RA2201_LEG7_SN1279_2022-08-02_001	8/2/2022	13.479629	144.700927	Yes
GUA	RA2201_LEG7_SN1280_2022-08-03_002	8/3/2022	13.240945	144.711737	Yes
GUA	RA2201_LEG7_SN1280_2022-08-03_003	8/3/2022	13.238558	144.699641	Yes
GUA	RA2201_LEG7_SN1280_2022-08-03_004	8/3/2022	13.24087	144.700048	Yes
GUA	RA2201_LEG7_SN1280_2022-08-03_001	8/3/2022	13.242349	144.715971	Yes
ROT	RA2201_LEG7_SN1279_2022-08-04_003	8/4/2022	14.150382	145.244401	Yes
ROT	RA2201_LEG7_SN1279_2022-08-04_002	8/4/2022	14.126407	145.223922	Yes
ROT	RA2201_LEG7_SN1279_2022-08-04_001	8/4/2022	14.114124	145.202149	Yes
ROT	RA2201_LEG7_SN1279_2022-08-04_004	8/4/2022	14.162868	145.284778	Yes
SAI	RA2201_LEG7_SN1279_2022-08-05_001	8/5/2022	15.179354	145.787891	Yes
SAI	RA2201_LEG7_SN1279_2022-08-05_003	8/5/2022	15.192432	145.780255	Yes
SAI	RA2201_LEG7_SN1279_2022-08-05_002	8/5/2022	15.184788	145.783502	Yes
SAI	RA2201_LEG7_SN1280_2022-08-05_001	8/5/2022	15.152143	145.7909	Yes
PAG	RA2201_LEG7_SN1280_2022-08-06_002	8/6/2022	18.052456	145.733065	Yes

LOCATION	CTDFILEID	DATE	LATITUDE	LONGITUDE	WATER_SAMPLE
PAG	RA2201 LEG7 SN1279 2022-08-06 002	8/6/2022	18.120549	145.753374	Yes
PAG	RA2201 LEG7 SN1280 2022-08-06 003	8/6/2022	18.048642	145.734295	Yes
PAG	RA2201 LEG7 SN1280 2022-08-06 001	8/6/2022	18.066911	145.74625	Yes
PAG	RA2201 LEG7 SN1279 2022-08-06 001	8/6/2022	18.096086	145.764774	Yes
PAG	RA2201 LEG7 SN1279 2022-08-07 001	8/7/2022	18.120344	145.754706	Yes
PAG	RA2201 LEG7 SN1280 2022-08-07 001	8/7/2022	18.099695	145.75377	Yes
PAG	RA2201 LEG7 SN1280 2022-08-07 003	8/7/2022	18.128556	145.753092	Yes
PAG	RA2201 LEG7 SN1279 2022-08-07 002	8/7/2022	18.14562	145.752638	Yes
PAG	RA2201 LEG7 SN1280 2022-08-07 002	8/7/2022	18.114295	145.752509	Yes
PAG	RA2201 LEG7 SN1280 2022-08-08 003	8/8/2022	18.084702	145.725529	Yes
PAG	RA2201 LEG7 SN1279 2022-08-08 001	8/8/2022	18.120072	145.754722	Yes
PAG	RA2201 LEG7 SN1280 2022-08-08 001	8/8/2022	18.04592	145.703629	Yes
PAG	RA2201 LEG7 SN1280 2022-08-08 002	8/8/2022	18.056737	145.70701	Yes
PAG	RA2201 LEG7 SN1280 2022-08-09 002	8/9/2022	18.100031	145.79257	Yes
PAG	RA2201 LEG7 SN1280 2022-08-09 001	8/9/2022	18.129298	145.810759	Yes
PAG	RA2201 LEG7 SN1279 2022-08-09 001	8/9/2022	18.095896	145.76519	Yes
PAG	RA2201 LEG7 SN1280 2022-08-09 003	8/9/2022	18.101903	145.792569	Yes
PAG	RA2201 LEG7 SN1279 2022-08-09 002	8/9/2022	18.100496	145.798707	Yes
SAI	RA2201 LEG7 SN1279 2022-08-10 002	8/10/2022	15.189239	145.666263	Yes
SAI	RA2201 LEG7 SN1279 2022-08-10 001	8/10/2022	15.192591	145.628952	Yes
SAI	RA2201 LEG7 SN1280 2022-08-10 002	8/10/2022	15.208406	145.635309	Yes
SAI	RA2201_LEG7_SN1280_2022-08-10_001	8/10/2022	15.17402	145.617119	Yes

Table 11. Summary of STR sites.

LOCATION	ACTION	OCC SITEID	DATE	TRANSECT	LATITUDE	LONGITUDE	DEPTH M
GUA	DEPLOYMENT	OCC-GUA-015	4/12/2022	GUA-W	13.52886	144.8003	14.3256
GUA	DEPLOYMENT	OCC-GUA-015	4/12/2022	GUA-W	13.52886	144.8003	14.3256
GUA	DEPLOYMENT	OCC-GUA-014	4/12/2022	GUA-W	13.52897	144.8002	24.0792
ROT	DEPLOYMENT	OCC-ROT-001	4/15/2022	ROT-N	14.18318	145.2071	15.8496
ROT	DEPLOYMENT	OCC-ROT-003	4/16/2022	ROT-SW	14.11394	145.1669	15.5448
GUA	DEPLOYMENT	OCC-GUA-003	4/17/2022	GUA-N	13.60229	144.9234	5.4864
GUA	DEPLOYMENT	OCC-GUA-002	4/17/2022	GUA-N	13.60332	144.9236	15.5448
GUA	DEPLOYMENT	OCC-GUA-002	4/17/2022	GUA-N	13.60332	144.9236	15.5448
GUA	DEPLOYMENT	OCC-GUA-001	4/17/2022	GUA-N	13.60388	144.924	24.6888
GUA	DEPLOYMENT	OCC-GUA-009	4/18/2022	GUA-S	13.24122	144.7045	14.0208
GUA	DEPLOYMENT	OCC-GUA-010	4/18/2022	GUA-S	13.24216	144.7039	4.572
GUA	DEPLOYMENT	OCC-GUA-009	4/18/2022	GUA-S	13.24122	144.7045	14.0208
GUA	DEPLOYMENT	OCC-GUA-011	4/18/2022	GUA-S	13.24341	144.7005	0.1524
GUA	DEPLOYMENT	OCC-GUA-008	4/18/2022	GUA-S	13.2409	144.7045	25.2984
TIN	DEPLOYMENT	OCC-TIN-001	4/19/2022		15.0804	145.6214	12.4968
TIN	DEPLOYMENT	OCC-TIN-002	4/19/2022	TIN-E	15.03465	145.6513	14.0208
TIN	DEPLOYMENT	OCC-TIN-005	4/20/2022		14.99064	145.6029	11.5824
TIN	DEPLOYMENT	OCC-TIN-004	4/20/2022		14.9408	145.6279	15.5448
SAI	DEPLOYMENT	OCC-SAI-008	4/21/2022	SAI-S	15.09775	145.7428	24.9936
SAI	DEPLOYMENT	OCC-SAI-009	4/21/2022	SAI-S	15.09785	145.7434	16.4592
SAI	DEPLOYMENT	OCC-SAI-009	4/21/2022	SAI-S	15.09785	145.7434	16.4592
SAI	DEPLOYMENT	OCC-SAI-010	4/21/2022	SAI-S	15.09834	145.7444	5.7912
SAI	DEPLOYMENT	OCC-SAI-011	4/22/2022	SAI-W	15.15763	145.6859	28.6512
SAI	DEPLOYMENT	OCC-SAI-012	4/22/2022	SAI-W	15.15637	145.6897	12.8016
SAI	DEPLOYMENT	OCC-SAI-012	4/22/2022	SAI-W	15.15637	145.6897	12.8016
SAI	DEPLOYMENT	OCC-SAI-013	4/22/2022	SAI-W	15.15469	145.6924	7.3152
SAI	DEPLOYMENT	OCC-SAI-005	4/24/2022	SAI-E	15.25863	145.8157	16.4592
SAI	DEPLOYMENT	OCC-SAI-004	4/24/2022	SAI-E	15.25792	145.8166	24.6888
SAI	DEPLOYMENT	OCC-SAI-017A	4/24/2022	SAI-NW	15.25616	145.7679	5.4864
SAI	DEPLOYMENT	OCC-SAI-005	4/24/2022	SAI-E	15.25863	145.8157	16.4592
SAI	DEPLOYMENT	OCC-SAI-003	4/25/2022	SAI-N	15.29007	145.8095	6.096
SAI	DEPLOYMENT	OCC-SAI-002	4/25/2022	SAI-N	15.29061	145.8094	12.4968
SAI	DEPLOYMENT	OCC-SAI-002	4/25/2022	SAI-N	15.29061	145.8094	12.4968
SAI	DEPLOYMENT	OCC-SAI-001	4/25/2022	SAI-N	15.29076	145.8093	27.7368
SAI	DEPLOYMENT	OCC-SAI-016	4/26/2022	SAI-NW	15.25651	145.7675	12.8016
SAI	DEPLOYMENT	OCC-SAI-014	4/26/2022		15.23751	145.7225	6.4008
SAI	DEPLOYMENT	OCC-SAI-016	4/26/2022	SAI-NW	15.25651	145.7675	12.8016
SAI	DEPLOYMENT	OCC-SAI-015	4/26/2022	SAI-NW	15.25729	145.7665	24.6888
GUA	DEPLOYMENT	OCC-GUA-004	5/1/2022	GUA-E	13.47371	144.866	24.384
GUA	DEPLOYMENT	OCC-GUA-006	5/1/2022	GUA-E	13.47459	144.865	7.0104
GUA	DEPLOYMENT	OCC-GUA-005	5/1/2022	GUA-E	13.47515	144.8649	16.4592
GUA	DEPLOYMENT	OCC-GUA-005	5/1/2022	GUA-E	13.47515	144.8649	16.4592
GUA	DEPLOYMENT	OCC-GUA-017	5/2/2022	GUA-W	13.52883	144.8013	5.1816
PAG	DEPLOYMENT	OCC-PAG-006	6/19/2022	PAG-E	18.09619	145.7649	15.24
PAG	DEPLOYMENT	OCC-PAG-006	6/19/2022	PAG-E	18.09619	145.7649	15.24
PAG	DEPLOYMENT	OCC-PAG-005	6/19/2022	PAG-E	18.09538	145.7654	24.9936
PAG	DEPLOYMENT	OCC-PAG-007	6/19/2022	PAG-E	18.09645	145.764	7.0104
PAG	DEPLOYMENT	OCC-PAG-004	6/19/2022		18.10297	145.7678	0.6096
MAU	DEPLOYMENT	OCC-MAU-016	6/21/2022		20.02316	145.2298	9.144
MAU	DEPLOYMENT	OCC-MAU-019	6/21/2022		20.01399	145.2275	9.144
MAU	DEPLOYMENT	OCC-MAU-009	6/22/2022	MAU-SW	20.01424	145.209	6.096
MAU	DEPLOYMENT	OCC-MAU-010	6/22/2022	MAU-SW	20.0144	145.2096	2.4384
MAU	DEPLOYMENT	OCC-MAU-005	6/22/2022	MAU-E	20.02034	145.2397	14.6304
MAU	DEPLOYMENT	OCC-MAU-003	6/22/2022	MAU-N	20.03481	145.2247	7.0104
MAU	DEPLOYMENT	OCC-MAU-001	6/22/2022	MAU-N	20.03657	145.225	25.6032
MAU	DEPLOYMENT	OCC-MAU-004	6/22/2022	MAU-E	20.02014	145.2403	24.384
MAU	DEPLOYMENT	OCC-MAU-008	6/22/2022	MAU-SW	20.01308	145.208	15.5448
MAU	DEPLOYMENT	OCC-MAU-008	6/22/2022	MAU-SW	20.01308	145.208	15.5448
MAU	DEPLOYMENT	OCC-MAU-005	6/22/2022	MAU-E	20.02034	145.2397	14.6304

LOCATION	ACTION	OCC SITEID	DATE	TRANSECT	LATITUDE	LONGITUDE	DEPTH M
FDP	DEPLOYMENT	OCC-FDP-001	6/23/2022	FDP-SE	20.53755	144.8995	14.3256
FDP	DEPLOYMENT	OCC-FDP-002	6/23/2022		20.54513	144.8858	12.4968
MAU	DEPLOYMENT	OCC-MAU-002	6/24/2022	MAU-N	20.03576	145.2247	14.0208
MAU	DEPLOYMENT	OCC-MAU-002	6/24/2022	MAU-N	20.03576	145.2247	14.0208
MAU	DEPLOYMENT	OCC-MAU-018	6/26/2022		20.02249	145.2297	8.2296
MAU	DEPLOYMENT	OCC-MAU-007	6/26/2022	MAU-SW	20.01235	145.2078	25.6032
MAU	DEPLOYMENT	OCC-MAU-016	6/26/2022		20.02296	145.2299	5.6
PAG	DEPLOYMENT	OCC-PAG-009	7/21/2022	PAG-S	18.04561	145.7062	13.1064
PAG	DEPLOYMENT	OCC-PAG-009	7/21/2022	PAG-S	18.04561	145.7062	13.1064
PAG	DEPLOYMENT	OCC-PAG-008	7/21/2022	PAG-S	18.04462	145.705	25.6032
PAG	DEPLOYMENT	OCC-PAG-010	7/21/2022	PAG-S	18.04589	145.7075	4.572
PAG	DEPLOYMENT	OCC-PAG-002	7/22/2022	PAG-N	18.16788	145.7949	14.6304
PAG	DEPLOYMENT	OCC-PAG-002	7/22/2022	PAG-N	18.16788	145.7949	14.6304
PAG	DEPLOYMENT	OCC-PAG-003	7/22/2022	PAG-N	18.16758	145.7948	8.5344
ASC	DEPLOYMENT	OCC-ASC-001	7/23/2022		19.70836	145.403	14.6304
ASC	DEPLOYMENT	OCC-ASC-005	7/23/2022		19.6903	145.3885	13.4112
ASC	DEPLOYMENT	OCC-ASC-003	7/24/2022		19.67705	145.4107	10.0584
PAG	DEPLOYMENT	OCC-PAG-014	8/6/2022	PAG-W	18.121	145.7568	6.096
PAG	DEPLOYMENT	OCC-PAG-012	8/6/2022	PAG-W	18.12055	145.7534	24.0792
PAG	DEPLOYMENT	OCC-PAG-013	8/8/2022	PAG-W	18.12004	145.7547	14.3256
PAG	DEPLOYMENT	OCC-PAG-013	8/8/2022	PAG-W	18.12004	145.7547	14.3256
GUA	RETRIEVAL	OCC-GUA-015	4/12/2022	GUA-W	13.52886	144.8003	14.3256
GUA	RETRIEVAL	OCC-GUA-014	4/12/2022	GUA-W	13.52897	144.8002	24.0792
ROT	RETRIEVAL	OCC-ROT-001	4/15/2022	ROT-N	14.18318	145.2071	15.8496
ROT	RETRIEVAL	OCC-ROT-003	4/16/2022	ROT-SW	14.11394	145.1669	15.5448
ROT	RETRIEVAL	OCC-ROT-002	4/16/2022		14.17504	145.2863	18.288
GUA	RETRIEVAL	OCC-GUA-001	4/17/2022	GUA-N	13.60388	144.924	24.6888
GUA	RETRIEVAL	OCC-GUA-002	4/17/2022	GUA-N	13.60332	144.9236	15.5448
GUA	RETRIEVAL	OCC-GUA-003	4/17/2022	GUA-N	13.60229	144.9234	5.4864
GUA	RETRIEVAL	OCC-GUA-002	4/17/2022	GUA-N	13.60332	144.9236	15.5448
GUA	RETRIEVAL	OCC-GUA-011	4/18/2022	GUA-S	13.24341	144.7005	0.1524
GUA	RETRIEVAL	OCC-GUA-010	4/18/2022	GUA-S	13.24216	144.7039	4.572
GUA	RETRIEVAL	OCC-GUA-009	4/18/2022	GUA-S	13.24122	144.7045	14.0208
GUA	RETRIEVAL	OCC-GUA-009	4/18/2022	GUA-S	13.24122	144.7045	14.0208
GUA	RETRIEVAL	OCC-GUA-008	4/18/2022	GUA-S	13.2409	144.7045	25.2984
TIN	RETRIEVAL	OCC-TIN-001	4/19/2022		15.0804	145.6214	12.4968
TIN	RETRIEVAL	OCC-TIN-003	4/19/2022	TIN-E	15.03472	145.6511	10.9728
SAI	RETRIEVAL	OCC-SAI-008	4/21/2022	SAI-S	15.09775	145.7428	24.9936
SAI	RETRIEVAL	OCC-SAI-010	4/21/2022	SAI-S	15.09834	145.7444	5.7912
SAI	RETRIEVAL	OCC-SAI-009	4/21/2022	SAI-S	15.09785	145.7434	16.4592
SAI	RETRIEVAL	OCC-SAI-009	4/21/2022	SAI-S	15.09785	145.7434	16.4592
SAI	RETRIEVAL	OCC-SAI-012	4/22/2022	SAI-W	15.15637	145.6897	12.8016
SAI	RETRIEVAL	OCC-SAI-011	4/22/2022	SAI-W	15.15763	145.6859	28.6512
SAI	RETRIEVAL	OCC-SAI-012	4/22/2022	SAI-W	15.15637	145.6897	12.8016
SAI	RETRIEVAL	OCC-SAI-005	4/24/2022	SAI-E	15.25863	145.8157	16.4592
SAI	RETRIEVAL	OCC-SAI-017A	4/24/2022	SAI-NW	15.25616	145.7679	5.4864
SAI	RETRIEVAL	OCC-SAI-017B	4/24/2022	SAI-NW	15.25613	145.7676	6.096
SAI	RETRIEVAL	OCC-SAI-005	4/24/2022	SAI-E	15.25863	145.8157	16.4592
SAI	RETRIEVAL	OCC-SAI-003	4/25/2022	SAI-N	15.29007	145.8095	6.096
SAI	RETRIEVAL	OCC-SAI-002	4/25/2022	SAI-N	15.29061	145.8094	12.4968
SAI	RETRIEVAL	OCC-SAI-001	4/25/2022	SAI-N	15.29076	145.8093	27.7368
SAI	RETRIEVAL	OCC-SAI-016	4/26/2022	SAI-NW	15.25651	145.7675	12.8016
SAI	RETRIEVAL	OCC-SAI-016	4/26/2022	SAI-NW	15.25651	145.7675	12.8016
SAI	RETRIEVAL	OCC-SAI-014	4/26/2022		15.23751	145.7225	6.4008
SAI	RETRIEVAL	OCC-SAI-015	4/26/2022	SAI-NW	15.25729	145.7665	24.6888
AGU	RETRIEVAL	OCC-AGU-001	4/28/2022		14.8478	145.5372	7.62
GUA	RETRIEVAL	OCC-GUA-006	5/1/2022	GUA-E	13.47459	144.865	7.01
GUA	RETRIEVAL	OCC-GUA-005	5/1/2022	GUA-E	13.47515	144.8649	16.46
GUA	RETRIEVAL	OCC-GUA-004	5/1/2022	GUA-E	13.47371	144.866	24.38
GUA	RETRIEVAL	OCC-GUA-005	5/1/2022	GUA-E	13.47515	144.8649	16.46
GUA	RETRIEVAL	OCC-GUA-017	5/2/2022	GUA-W	13.52883	144.8013	5.1816

LOCATION	ACTION	OCC SITEID	DATE	TRANSECT	LATITUDE	LONGITUDE	DEPTH M
GUA	RETRIEVAL	OCC-GUA-013	6/11/2022		13.47556	144.6992	1.2192
SAI	RETRIEVAL	OCC-SAI-006	6/18/2022		15.17491	145.7895	18.8976
PAG	RETRIEVAL	OCC-PAG-005	6/19/2022	PAG-E	18.09538	145.7654	24.9936
PAG	RETRIEVAL	OCC-PAG-006	6/19/2022	PAG-E	18.09619	145.7649	15.24
PAG	RETRIEVAL	OCC-PAG-006	6/19/2022	PAG-E	18.09619	145.7649	15.24
PAG	RETRIEVAL	OCC-PAG-004	6/19/2022		18.10297	145.7678	0.6096
MAU	RETRIEVAL	OCC-MAU-015	6/21/2022		20.02918	145.232	11.2776
MAU	RETRIEVAL	OCC-MAU-016	6/21/2022		20.02313	145.2298	9.144
MAU	RETRIEVAL	OCC-MAU-001	6/22/2022	MAU-N	20.03657	145.225	25.6032
MAU	RETRIEVAL	OCC-MAU-011	6/22/2022	MAU-W	20.01771	145.2073	10.3632
MAU	RETRIEVAL	OCC-MAU-009	6/22/2022	MAU-SW	20.01424	145.209	6.096
MAU	RETRIEVAL	OCC-MAU-008	6/22/2022	MAU-SW	20.01308	145.208	15.5448
MAU	RETRIEVAL	OCC-MAU-004	6/22/2022	MAU-E	20.02014	145.2403	25.2984
MAU	RETRIEVAL	OCC-MAU-003	6/22/2022	MAU-N	20.03481	145.2247	7.0104
MAU	RETRIEVAL	OCC-MAU-012	6/22/2022	MAU-W	20.0177	145.2077	2.4384
FDP	RETRIEVAL	OCC-FDP-002	6/23/2022		20.54513	144.8858	13.4112
FDP	RETRIEVAL	OCC-FDP-001	6/23/2022	FDP-SE	20.53755	144.8995	14.3256
MAU	RETRIEVAL	OCC-MAU-002	6/24/2022	MAU-N	20.03576	145.2247	14.0208
MAU	RETRIEVAL	OCC-MAU-002	6/24/2022	MAU-N	20.03576	145.2247	14.0208
MAU	RETRIEVAL	OCC-MAU-007	6/26/2022	MAU-SW	20.01235	145.2078	25.6032
ZEA	RETRIEVAL	OCC-ZEA-001	6/29/2022		16.89754	145.8535	23.4696
PAG	RETRIEVAL	OCC-PAG-008	7/21/2022	PAG-S	18.04462	145.705	25.6032
PAG	RETRIEVAL	OCC-PAG-001	7/22/2022	PAG-N	18.16915	145.7955	24.9936
PAG	RETRIEVAL	OCC-PAG-003	7/22/2022	PAG-N	18.16756	145.7948	8.5344
ASC	RETRIEVAL	OCC-ASC-002	7/23/2022	ASC-E	19.69982	145.4176	11.2776
ASC	RETRIEVAL	OCC-ASC-006	7/24/2022		19.69332	145.3897	4.2672
PAG	RETRIEVAL	OCC-PAG-012	8/6/2022	PAG-W	18.12055	145.7534	24.0792

Table 12. Geographic coordinates where BMUs were deployed and recovered.

Site	Latitude	Longitude	BMUs deployed	BMUs recovered
GUA-20	13.52886	144.8003	5	3
GUA-21	13.24122	144.7045	5	5
GUA-22	13.47522	144.8648	5	5
GUA-23	13.60332	144.9236	5	5
MAU-02	20.0225	145.2297	15	15
MAU-05	20.03576	145.2247	5	5
MAU-12	20.02034	145.2397	5	3
MAU-20	20.01308	145.208	5	3
MAU-86	20.01399	145.2275	15	15
MAU-88	20.02247	145.2297	15	15
PAG-13	18.09619	145.7649	5	5
PAG-20	18.04561	145.7062	5	5
PAG-21	18.16788	145.7949	5	5
PAG-22	18.12004	145.7547	5	5
SAI-05	15.09785	145.7434	5	4
SAI-20	15.25863	145.8157	5	5
SAI-22	15.25651	145.7675	5	5
SAI-23	15.15637	145.6897	5	4

Table 13. Geographic coordinates where CAUs were deployed and recovered.

Site	Latitude	Longitude	CAUs deployed	CAUs recovered
ASC-04	19.70836	145.403	5	4
ASC-06	19.6903	145.3885	5	4
ASC-20	19.67705	145.4107	5	3
GUA-12	13.4488	144.6259	0	3
GUA-13	13.29162	144.7676	0	5
GUA-20	13.52886	144.8003	5	5
GUA-21	13.24122	144.7045	5	3
GUA-22	13.47522	144.8648	5	5
GUA-23	13.60332	144.9236	5	4
MAU-05	20.03576	145.2247	5	5
MAU-12	20.02034	145.2397	5	2
MAU-20	20.01308	145.208	5	3
PAG-13	18.09619	145.7649	5	3
PAG-20	18.04561	145.7062	5	5
PAG-21	18.16788	145.7949	5	5
PAG-22	18.12004	145.7547	5	4
ROT-03	14.11394	145.1669	5	5
ROT-05	14.18318	145.2071	5	5
SAI-05	15.09785	145.7434	5	4
SAI-20	15.25863	145.8157	5	2
SAI-22	15.25651	145.7675	5	5
SAI-23	15.15637	145.6897	5	4
TIN-01	15.03465	145.6513	5	5
TIN-02	14.9408	145.6279	5	5
TIN-03	14.99064	145.6029	5	5
TIN-06	15.0804	145.6214	5	4