

NOAA Ocean Exploration Program

2016 Deepwater Exploration of the Marianas

EX-16-05 Leg 1 Cruise Report

Guam and the Commonwealth of the Northern Mariana Islands

Guam to Saipan, Northern Mariana Islands

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1. Introduction

NOAA OER Okeanos Explorer Operations

NOAA's Office of Ocean Exploration and Research (OER) is the only federal organization dedicated to exploring our unknown ocean. OER works with partners to identify priority areas for exploration; support innovations in exploration tools and capabilities; and encourage the next generation of ocean explorers, scientists, and engineers. The publicly available data and information gained from our expeditions and the research we fund gives resource managers, the academic community, and the private sector the information they need to identify, understand, and manage ocean resources for this and future generations of Americans.

NOAA Ship *Okeanos Explorer* is the only federal vessel dedicated to exploring our largely unknown ocean for the purpose of discovery and the advancement of knowledge about the deep ocean. America's future depends on understanding the ocean. We explore the ocean to make valuable scientific, economic, and cultural discoveries, and we explore because ocean health and resilience are vital to our economy and to our lives. Exploration supports NOAA mission priorities and national objectives by providing high-quality scientific information about the deep ocean to anyone who needs it.

In close collaboration with government agencies, academic institutions, and other partners, OER conducts deep-ocean exploration expeditions using advanced technologies on the *Okeanos Explorer*. From mapping and characterizing previously unseen seafloor to collecting and disseminating information about ocean depths, this work helps to establish a foundation of information and fill data gaps. Data collected on the ship follow federal open-access data standards and are publicly available shortly after an expedition ends. This ensures the delivery of reliable scientific data needed to identify, understand, and manage key elements of the ocean environment.

2016 Deepwater Exploration of the Marianas Expedition

The 2016 Deepwater Exploration of the Marianas Expedition is the fourth in a series of expeditions that comprises the "Campaign to Address Pacific monument Science, Technology, and Ocean Needs" (CAPSTONE). CAPSTONE is a major multi-year foundational science effort to collect baseline information in unknown and poorly known deepwater areas of U.S. marine protected areas in the central and western Pacific Ocean. Previous expeditions have focused on collecting baseline information in and around the Papahānaumokuākea Marine National Monument, and the Johnston Atoll and Wake Island Units of the Pacific Remote Islands Marine National Monument (PRIMNM). Future expeditions are planned to explore additional Units of PRIMNM, Rose Atoll Marine National Monument, the National Marine Sanctuary of American Samoa, and likely the Phoenix Islands Protected Area.

The Marianas Trench Marine National Monument (referred to here as “The Monument”) was established in January 2009 through a [presidential proclamation](#) under the authority of the Antiquities Act of 1906. The Monument was established for the purpose of protecting objects of interest such as the subduction system in the trench, submerged volcanoes, hydrothermal vents, coral reef ecosystems, and biologically diverse ecosystems where chemosynthetic and photosynthetic organisms exist side by side.

The Monument consists of three units: the Islands Unit, the Volcanic Unit, and the Trench Unit. The Volcanic Unit and the Trench Unit are additionally designated as [National Wildlife Refuges](#), the “Mariana Trench National Wildlife Refuge” (aka “Trench Unit/Refuge”) and “Mariana Arc of Fire National Wildlife Refuge” (aka “Volcanic Unit/Arc of Fire Refuge”).

The Islands Unit encompasses the waters and submerged lands of the three northernmost Mariana Islands (Farallon de Pajaros, Maug, and Asuncion) from the mean low water line to approximately 50 nautical miles offshore. These waters include healthy coral reefs made up of roughly 300 different coral species and a very high density of top predators, including large numbers of sharks.

The Volcanic Unit/Arc of Fire Refuge includes the submerged lands within a one nautical mile radius of the center of each of the 18 active submarine volcanoes and hydrothermal vents in the region. Hydrothermal vents have some of the harshest conditions on the planet, including extremely high temperature water and highly acidic fluids. Even so, there are many species that make vents their homes, including some that are found only at these habitats. Vent communities include animals that have developed symbiotic relationships with chemosynthetic bacteria, such as tubeworms, shrimp, and mussels, as well as other animals like snails, anemones, and squat lobsters.

The Trench Unit/Refuge encompasses the submerged lands within the Mariana Trench, extending from the northern limit of the U.S. Exclusive Economic Zone (EEZ) of the Commonwealth of the Northern Mariana Islands (CNMI) to the southern limit of the EEZ adjacent to the U.S. Territory of Guam.

This part of the Monument is approximately 940 nautical miles long and 38 nautical miles wide along the Mariana Trench seafloor. It includes Sirena Deep at about 10,700 m (35,000 feet), the second deepest point on Earth, remarkable for its steep walls, distinctive geologic features, and deep-ocean life forms. The deepest areas of the Mariana Trench are likened to an inverted chain of islands, where each “peak” points downward, and like islands, each feature can be geologically and biologically unique.

The unique geology, geochemistry, rare biological conditions, and pristine ecosystems of the Monument provide an ideal location for interdisciplinary research. Because the area has a

distinct position in the biogeography of the Pacific as a place where a high number of regional endemic and unusual species assemblages thrive, the Mariana Archipelago and Monument holds outstanding potential for making globally significant scientific contributions.

Despite decades of previous work in the region, much of the Monument and surrounding areas remain unexplored. The three legs of the 2016 Deepwater Exploration of the Marianas expedition worked within the U.S. Exclusive Economic Zone of Guam and the CNMI to help identify and better understand new geological phenomena and habitats – such as extreme life living in the deepest oceanic trench on the planet, enormous mud volcanoes, active hydrothermal vents, chemosynthetic communities, and possibly deep-sea coral and sponge habitats.

Large deep-water areas of the Monument and CNMI in the north remain unmapped with modern sonar. Mapping efforts may reveal new discoveries such as seamounts or other geologic features, providing insight into the plate tectonic processes that create ocean floor features and new discoveries into the continued creation of the continents and connectivity to all life on Earth.

Baseline data from this expedition will help improve our understanding of the deep-ocean habitats of the Mariana archipelago and the connections between communities at different seamounts and hydrothermal vent sites. Data collected will also provide critical information for the development of management plans for Monument areas; support local scientists and managers seeking to understand and manage precious corals and bottom fish resources; and provide a foundation of information to stimulate follow-on exploration, research and management activities.

EX-16-05 Leg 1 is the first of three cruises for the expedition. The leg began on April 20 in Guam and ended on May 11 in Saipan. Operations covered a wide area of the U.S. EEZ focused on the southern half of the CNMI, Guam, and the MTMNM.

2. Objectives

The expedition addressed science themes and priority areas put forward by NOAA scientists and resource managers, local CNMI management agencies, and the broad ocean-science community. The primary objective of the expedition was to survey deep-water areas in and around the CNMI and the MTMNM that had not been previously surveyed, in order to provide baseline information to support management and science needs. Specifically, this expedition sought to:

- (1) Explore the diversity and distribution of benthic habitats – including bottomfish habitats, deep-sea and precious coral communities, hydrothermal vents, mud volcanoes, seamounts, and trench and subduction-zone habitats;
 - a. Collect data on habitat size and extent, and animal diversity and density;
 - b. Focus imaging operations on potential new, rare, and poorly-documented animals as well as dominant members of the communities;

- c. Collect and preserve biological samples of potential new species, new records, dominant community members if not easily recognized, and other animals to aid in site characterization;
- (2) Identify and characterize vulnerable deep-water marine habitats, particularly high-density communities of deep-sea corals. While the Islands Unit of the Monument is renowned for incredible shallow coral reefs and a high density of top predators, there have been no previous focused efforts to discover and document deep-sea coral and sponge communities in the region;
- (3) Survey and characterize priority bottomfish fishery areas and areas likely to host precious corals, and design surveys to investigate whether there is a depth and/or site overlap between the two fisheries. Deep-water bottomfish habitats below ~250m have not been characterized in the region. While the precious coral fishery is listed as a managed fishery in Guam and CNMI, no precious coral beds have been identified to date and only anecdotal accounts have been published of their presence in this region of the Pacific;
- (4) Collect biological and geological data and samples on seamounts within the Prime Crust Zone (PCZ), particularly focusing on ridge tops and summit margins. Seamounts to the east of the Mariana Trench lie along the western boundary of the Prime Crust Zone (PCZ), which harbors the richest and most commercially valuable crusts on Earth;
- (5) Collect geologic data and samples to aid in the understanding of the geologic history of the Pacific and Marianas Plate and the Izu-Bonin-Mariana Arc System, including potential relevance to plate tectonic processes, subduction-zone geology, and volcanic arc and island formation;
- (6) Ground-truth acoustic data using video imagery and characterize associated habitat;
- (7) Provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities in the future.

3. List of Participants

At-Sea Mission Personnel:

Name	Role	Affiliation
Kelley Elliott	Expedition Coordinator	NOAA Office of Ocean Exploration and Research (OER)
Lindsay McKenna	Mapping Team Lead	NOAA OER
Deborah Glickson	Science Team Lead (Geology)	Florida Atlantic University/UCAR
Diva Amon	Science Team Lead (Biology)	University of Hawaii/UCAR
Kevin Jerram	Mapping Watch Lead	University Corporation for Atmospheric Research (UCAR)
Andy O'Brien	Data Management	UCAR/Global Foundation for Ocean Exploration(GFOE)
Jim Newman	Engineering Group Lead 1	UCAR/GFOE
Chris Ritter	Engineering Group 2	UCAR/GFOE

Jeff Laning	Engineering Group 3	UCAR/GFOE
Levi Unema	Engineering Group 4	UCAR/GFOE
Joshua Carlson	Engineering Group 5	UCAR/GFOE
Andy Lister	Engineering Group 6	UCAR/GFOE
Sean Kennison	Engineering Group 7	UCAR/GFOE
Karl McLetchie	Engineering Group 8	UCAR/GFOE
Daniel Rogers	Engineering Group 9	UCAR/GFOE
Tara Smithee	Engineering Group 10	UCAR/GFOE
Brian Kennedy	Engineering Group 11	UCAR/GFOE
Ed McNichol	Engineering Group 12	UCAR/GFOE
Roland Brian	Engineering Group 13	UCAR/GFOE
Caitlin Bailey	Engineering Group 14	UCAR/GFOE

Table 1. Names, roles and affiliation of the mission team onboard NOAA Ship *Okeanos Explorer* for Leg 1 of the expedition.

Shore-based science team:

Shore based science team members participate from remote exploration command centers and from their home locations.

Name	Affiliation	Expertise	Participation Location / Mode
Brian Greene	Association for Marine Exploration	Ichthyology	Kona, HI
Patricia Fryer	University of Hawai'i at Mānoa	Geology/Petrology	Honolulu, HI (UH ECC)
Maria Celia Machel Malay	University of Guam Marine Laboratory	Benthic biology, crustaceans, invertebrates in general, Biogeography	Guam
Rodney Tibbatts	Guam Division of Aquatic & Wildlife Resources	Deep water fish, ichthyology	Guam
Melissa Anderson	University of Ottawa & GEOMAR Helmholtz Centre for Ocean Research Kiel	Economic Geology	Kiel, Germany
Allison Miller	National Park Service	Invertebrate biology and molecular phylogenetics	Guam
David Burdick	University of Guam Marine Laboratory	Mesophotic benthic communities, focus on corals	Guam
Dick Randall	University of Guam	Fish	Guam
Alexander Kerr	University of Guam	Holothuroidea	Guam
Asako Matsumoto	Chiba Institute of Technology	Deep-sea corals	Tokyo, Japan
Mary Wicksten	Texas A&M University	Invertebrate zoology	College Station, TX
Robert Stern	University of Texas at Dallas	IBM arc system geology	Dallas, TX

Gene Rankey	University of Kansas	Carbonate geology	Lawrence, KS
Scott France	University of Louisiana at Lafayette	Deep-sea corals, benthic invertebrates	Lafayette, LA
Shirley Pomponi	Florida Atlantic University	Benthic biology - sponges	Fort Pierce, FL (FAU ECC)
Amy Baco-Taylor	Florida State University	Benthic ecology, deep-sea corals and sponges	Tallahassee, FL
Nicole Morgan	Florida State University	Benthic biology	Tallahassee, FL
Christopher Mah	National Museum of Natural History (Smithsonian)	Starfish, echinoderms, deep-sea biology, etc.	Washington, DC
Mike Ford	NOAA Fisheries	Jellyfish	Silver Spring, MD (SS ECC)
Amanda Netburn	NOAA Ocean Exploration & Research	Water column	Honolulu, HI (IRC ECC) & Silver Spring, MD (SS ECC)
Tara Harmer Luke	Stockton University	Deep sea biology	Galloway, NJ
Santiago Herrera	University of Toronto, WHOI	Benthic biology	Toronto, Canada
Michael Perfit	University of Florida	Geology, Petrology, Geochemistry	Fort Pierce, FL
Amanda Demopoulos	U.S. Geological Survey	Benthic ecology	Gainesville, FL
Taylor Heyl	Woods Hole Oceanographic Institution	Biology	Woods Hole, MA
Timothy Shank	Woods Hole Oceanographic Institution	Benthic biology	Woods Hole, MA
Stace Beaulieu	Woods Hole Oceanographic Institution	Benthic biology	Woods Hole, MA
Julie Huber	Marine Biological Laboratory	Microbiology	Woods Hole, MA
Chris Kelley	University Hawai'i at Mānoa	Deep-Sea Ecology; Fishes, Sponges, Corals	Honolulu, HI (UH ECC)
Allen Andrews	NOAA Fisheries	Fishes and corals	Honolulu, HI (IRC ECC)
Bruce Mundy	NOAA Pacific Islands Fisheries Science Center	Ichthyology (fish identification and biogeography)	IRC ECC
Jeffrey Drazen	University Hawai'i at Mānoa	Deep-sea fishes	UH ECC
Mackenzie Gerringer	University Hawai'i at Mānoa	Deep-sea Fishes, Hadal Trenches	UH ECC
Brian Glazer	University Hawai'i at Mānoa	Hydrothermal	Honolulu, HI (UH ECC)
Les Watling	University Hawai'i at Mānoa	Benthic biology, octocorals	Honolulu, HI (UH ECC), Maine
Sonia Rowley	University. Hawai'i at Mānoa	Biogeography & taxonomy of Octorallia, benthic biology	Honolulu, HI (UH ECC)
Maryjo Brounce	California Institute of Technology	Geological oceanography	Pasadena, CA
Andrea Quattrini	Harvey Mudd College	Benthic bio	Claremont, CA
Bill Chadwick	NOAA Pacific Marine Environmental Laboratory	Geology, volcanology	Newport, OR
Robert Embley	NOAA Pacific Marine Environmental Laboratory	Geology	Newport, OR
Lisa Levin	Scripps Institution of Oceanography	Benthic biology	La Jolla ,CA
Jonathan Kellogg	University of Victoria	Vent circulation	Vancouver, BC
Tina Molodtsova	P.P.Shirshov Institute of Oceanology RAS	Deep-sea corals, benthic biology	Moscow, Russia

Table 2. Name, affiliation, expertise and participation location of the shore-based science team who participated cruise leg 1 of the expedition.

4. Methodology

In order to accomplish its objectives, the expedition made use of the *Okeanos Explorer*'s:

- (1) two-body remotely operated vehicle system (ROVs *Deep Discoverer* and *Seirios*) to conduct daytime seafloor surveys, as well as to collect limited numbers of specimens to help further characterize the deep-water fauna and geology of the region;
- (2) mapping systems (Kongsberg EM302 multibeam sonar, Knudsen 3260 subbottom profiler, Kongsberg EK60 split-beam fisheries sonars, and Teledyne Acoustic Doppler Current Profilers) to conduct nighttime mapping operations and when the ROV was on deck; and
- (3) high-bandwidth satellite connection for real-time ship to shore communications.

4.1 ROV seafloor surveys

ROV dive operations were conducted to support the expedition objectives, including characterizing bottomfish and precious coral habitats, hydrothermal vents, seamounts, mud volcanoes, and habitats within the trench. Dive sites were chosen using high-resolution bathymetry data, when available. With the exception of one site (Esmeralda Crater), all chosen dive locations were previously unexplored by ROV. At Esmeralda Crater, there had been a previous *Jason* dive in 2006, but our dive explored a different area of the crater.

During each dive, the ROV descended onto the seafloor and then moved from waypoint to waypoint, documenting the geology and biology of the area. Onboard and shore-based scientists identified each encountered organism to the lowest possible taxon. For this purpose, scientists used the online pilot version of the OER Benthic Deepwater Animal Identification Guide (http://oceanexplorer.noaa.gov/okeanos/animal_guide/animal_guide.html), as well as the online HURL animal guide (<https://www.soest.hawaii.edu/HURL/animals/id/>). Additionally, onboard and shore-based scientists provided geological interpretations of the observed substrate throughout each ROV seafloor survey.

4.2 Specimen collections

A limited number of geological and biological samples were collected on the seafloor using the manipulator arms and biological and geologic collection boxes on the *Deep Discoverer*. For each collected specimen, the date, time, latitude, longitude, depth, salinity, temperature and dissolved oxygen content were recorded at the time of collection. Geological specimen collections targeted samples for age dating and geochemical composition. Biological specimen collections targeted samples that represented potential new species, range extensions of animals not previously known to occur in the region, or dominant species in the area.

Once specimens were brought back onto the deck of the ship, they were examined for commensal organisms, labeled, photographed and inventoried into a database containing all relevant metadata. Any commensal organisms found were separated from the sample and processed separately. Geological samples were air dried and placed in rock bags. These samples will be shipped to Oregon State University's Marine Geology Repository after the 2016 field season, where they will be analyzed in the laboratory for their chemical composition and geologic age. Biological samples were processed for DNA extractions using a kit provided by the Ocean Genome Legacy (OGL). For this purpose, a small subsample, consisting of ~1 cm² of tissue, was removed from the original sample and processed using the OGL DNA extraction kit. The remainder of the biological sample was preserved in 95% ethanol. Some of these specimens were also frozen. Additionally, several samples had subsamples taken and preserved in 10% buffered formalin for future histological examinations, with some of the subsamples transferred to 70% ethanol after three days. Full details of the preservation of each biological sample can be seen in Table 6 below.

After the 2016 field season, all DNA samples will be sent to OGL for DNA sequencing and storage, whereas the biological specimens preserved in ethanol and formalin will be sent to the National Museum of Natural History, Smithsonian Institution, for taxonomic identification and permanent storage. Some corals and sponges may also be subsampled and provided to Bishop Museum.

4.3 Seafloor mapping

Mapping operations included EM 302 multibeam, EK 60 singlebeam, Knudsen subbottom profile, and ADCP data collection. The schedule of operations included overnight transit mapping and mapping whenever the ROV was on deck. Lines were planned to maximize either edge matching of existing data or data gap filling in areas where existing bathymetry coverage existed. In regions with no existing data, exploration transit lines were planned to optimize potential discoveries. Targeted mapping operations were conducted in the vicinity of: (1) Santa Rosa Reef, (2) Esmerelda Crater, (3) Farallon de Medinilla (4) Saipan and Tinian Islands, and (5) the active "black smoker" hydrothermal vent field. Furthermore, shallow water mapping to search for several lost B29 bombers from WWII was conducted in the vicinity of Saipan and Tinian. These sites are of interest to researchers and managers including the State Historic Preservation Officer, National Park Service, U.S. Navy, the Department of Defense (program that accounts for MIAs) and several academics.

4.4 Education and outreach activities

A primary goal of NOAA's Office of Ocean Exploration and Research is to encourage the next generation of ocean explorers, scientists, and engineers. Working in partnership with NOAA Fisheries, the 2016 Deepwater Exploration of the Marianas expedition had a particular emphasis on engaging the local community in Guam and Saipan – through public presentations, ship tours,

live interactions with museums and schools, and partnerships. Some of these activities were conducted by the team onboard the ship and others were conducted by the team on shore. All of these activities support overall NOAA and expedition objectives of engaging and inspiring the next generation.

A number of outreach and education activities were conducted both before and during the expedition. Activities preceding the expedition included (1) an education webinar hosted by NOAA's Office for Exploration and Research on April 12, (2) briefing the CNMI Senate about the expedition on April 15, (3) a presentation about the expedition at a National Park Service "Science Sunday" Seminar in Guam on April 17, and (4) hosting ship tours for media and teachers in Guam who took part in OER's education professional development workshop on April 18 and 19. Activities conducted during the expedition included (1) live interactions with high school students in Guam and Saipan, and (2) interviews with media. Activities conducted after the expedition included: (1) ship tours for VIPs, media and the general public on May 12 and 13, and (2) a presentation of cruise results to Northern Marianas College and the Asia Pacific Academy of Science, Education and Environmental Management on May 15.

A new Internet-1 based Exploration Command Center (ECC) was brought online at UnderwaterWorld Guam. This ECC allows scientists and managers in the region to participate in 2016 and *Okeanos Explorer* expeditions and beyond, to share the expedition with visiting students and the general public, to conduct live interactions with *Okeanos Explorer*, and to stream live video from other telepresence-enabled vessels. Members of the Expedition team participated in a sneak preview opening event on April 18 at UnderwaterWorld Guam to debut their newly established ECC prior to the start of the first cruise of the Expedition.

The expedition also received "Signature" coverage on NOAA's oceanexplorer.noaa.gov website. Coverage featured a mission plan, background essays, daily updates, photo and video updates, mission logs, live video, media resources, an education section and K-12 lesson plans.

5. Clearances and Permits

A Scientific Research License application to conduct work on the submerged lands extending 3nm surrounding the Northern Marianas Island was approved and received from the CNMI Department of Lands and Natural Resources, Division of Fish and Wildlife on April 15, 2016. This license is effective from April 20 to July 27, 2016. The expedition also received a CNMI Fish and Game License (license number 03345-2016), which covers sample collections effective from April 20 to July 27, 2016. Both licenses are attached in Appendix F.

The expedition was planned and conducted by NOAA as an agency of the U.S. Federal government, in partnership with NOAA NMFS Pacific Islands Regional Office Marine National Monument Program. We do not require a permit to work in the MTMNM.

In order to support or conduct Marine Scientific Research within the U.S. EEZ, work funded, authorized and/or conducted by NOAA must be compliant with the National Environmental Policy Act (NEPA). NOAA Administrative Order (NAO) 216-6 describes NOAA's specific

obligations with regard to NEPA compliance. Among these is the need to review all NOAA-supported projects with respect to their environmental consequences. In compliance with NAO 216-6 and NEPA, a memorandum describing the project’s scientific sensors’ possible effects on the environment was submitted for the project. As expected with ocean research with limited time or presence in the marine environment, the project was determined to not have the potential to result in any lasting changes to the environment. As defined in Sections 5.05 and 6.03.c.3 (a) of NAO 216-6, this is a research project of limited size or magnitude or with only short-term effects on the environment and for which any cumulative effects are negligible, and as such, the project is categorically excluded from the need to prepare a full-scale NEPA environmental assessment. The categorical exclusion met the requirements of NAO 216-6 and NEPA, and authorizes the Marine Scientific Research conducted for the project.

Additionally, informal consultation was initiated under Section 7 of the Endangered Species Act (ESA), requesting NOAA Fisheries’ Protected Resources Division concurrence with our biological evaluation determining that 2016 Marianas Expedition and all other planned *Okeanos Explorer* operations during the 2016-17 field season, may affect, but are not likely to adversely affect, ESA-listed marine species. The informal consultation was completed on February 3, 2016 when NOAA OER received a signed letter from the Regional Administrator of NMFS Pacific Islands Regional Office, stating that NMFS concurred with OER’s determination that the proposed *Okeanos Explorer* cruises were not likely to adversely affect ESA-listed marine species.

6. Expedition Schedule

The expedition was planned for a total of 21 days at sea, from April 20 to May 11, 2016, departing from Guam and ending in Saipan. There were 20 scheduled dives, with 19 dives achieved (Table 3). We lost one dive due to a mechanical problem with the ship’s winch (flag sheave block), with no time lost to weather.

Table 3. *Schedule of the EX1605 Leg 1 Deepwater Exploration of the Marianas.*

Date	Activity	Dive #	Site Name
04/18/2016	- Morning ship tour for Educators - Mission personnel arrive. - Training of mission personnel and preparation for departure. - Evening: Opening event at UnderwaterWorld Guam		
04/19/2016	- Training of mission personnel and preparation for departure. - Afternoon ship tour for media		
04/20/2016	- Depart Guam - CTD Pogo operations at Fina Nagu Caldera A - Overnight mapping at Santa Rosa Reef to define 400m contour and get dive site coverage		

04/21/2016	- Dive Santa Rosa North - Continued overnight mapping at Santa Rosa to try to define the 400m contour	Dive 1	Santa Rosa North
04/22/2016	- Dive Santa Rosa South - Overnight mapping at Santa Rosa and Galvez Banks - Transit to Sirena Canyon	Dive 2	Santa Rosa South
04/23/2016	- Dive Sirena Canyon - Transit mapping over the trench to Enigma Seamount	Dive 3	Sirena Canyon
04/24/2016	- Dive "Enigma Seamount" - Very slow recovery of ROVs due to flag sheave block malfunction	Dive 4	"Enigma Seamount"
04/25/2016	- Early morning recovery of ROVs. - Ship stayed on station for most of the day to keep a steady deck for repairs. Repair of flag sheave block. ADCP data collected all day. - Evening/overnight transit mapping over the trench to Fina Nagu caldera chain		
04/26/2016	- Morning CTD operations at Fina Nagu Caldera C - A few mapping passes at Fina Nagu Caldera D - Dive Fina Nagu Caldera D - Overnight mapping over Toto caldera	Dive 5	Fina Nagu Caldera D
04/27/2016	- Morning mapping/CTD operations at Fina Nagu Caldera A - Dive Fina Nagu Caldera C - Live interaction w/ UWW Guam during dive - Overnight mapping focused on Santa Rosa north	Dive 6	Fina Nagu Caldera C
04/28/2016	- Dive Fina Nagu Caldera A - Overnight transit mapping, including overtop of Pika, Archaean, South Backarc	Dive 7	Fina Nagu Caldera A
04/29/2016	- Dive NW Guam Seamount - Post dive interference testing with the ADCPs - Overnight transit mapping	Dive 8	NW Guam Seamount
04/30/2016	- Dive Mariana back-arc at 15.4°N (young lava flows) - Overnight mapping of previously unmapped area, adding coverage to Falkor EM302 data. Interference testing with ADCP.	Dive 9	Young Lava Flows
05/01/2016	- Dive Mariana back-arc at 15.5°N (hydrothermal vent targets) - Overnight transit mapping including edge matching and building coverage to Falkor EM302 data along a boundary of the back arc area.	Dive 10	New Vent Field at 15.5N
05/02/2016	- Dive Mariana back-arc at 17.0°N (hydrothermal vent targets) - Mapping with all sonars over hydrothermal vent site - Overnight transit mapping	Dive 11	New Vent Field at 17N
05/03/2016	- Dive Zealandia - Live interaction w/ UWW Guam during dive- Overnight transit mapping	Dive 12	Zealandia
05/04/2016	- Dive Kunanaf Hulo' mud volcano - Overnight transit mapping	Dive 13	Kunanaf Hulo' Mud Volcano
05/05/2016	- Morning mapping of Pigafetta to improve map grid for dive. Subbottom mapping over middle of Pigafetta Guyot. - Dive at Pigafetta Guyot. - Overnight transit mapping.	Dive 14	Pigafetta Guyot
05/06/2016	- Morning mapping of Enrique Guyot to improve map grid for dive. Subbottom mapping over middle of Enrique Guyot - Dive Enrique Guyot - Overnight transit mapping.	Dive 15	Enrique Guyot

05/07/2016	- Morning mapping of Del Cano Guyot to improve map grid for dive. Subbottom mapping over middle of Del Cano Guyot - Dive Del Cano Guyot - Overnight transit mapping	Dive 16	Del Cano Guyot
05/08/2016	- Dive Farallon de Medinilla North - Focused mapping north of FDM to map 400m contour - Transit mapping to Esmeralda Bank.	Dive 17	Farallon de Medinilla North
05/09/2016	- Dive Esmeralda Bank. Live interaction with Saipan Southern High School during dive. - Overnight mapping of Esmeralda Crater water column	Dive 18	Esmeralda Bank
05/10/2016	- Dive Esmeralda Crater - Conducted Underwater Cultural Heritage (UCH) mapping survey	Dive 19	Esmeralda Crater
05/11/2016	- Conducted UCH mapping survey - Pull into port in Saipan		
05/12/2016	- Morning cruise wrap-up and preparation for ship tours - Afternoon: Public ship tours - Evening: Most mission personnel depart		
05/13/2016	- Morning: Tours for VIPs - Afternoon: Cruise wrap-up		
05/14/2015	- Remaining mission personnel depart		

7. Expedition Map

Leg 1 of the expedition began in Guam and ended in Saipan. This leg focused on the southern portion of the Marianas. The first dives were located south and west of Guam, dedicated to fisheries, precious corals, geology, and trench habitats. We then transited northward along the Marianas back-arc for some geology and hydrothermal-vent dives, followed by more fisheries dives, before transiting eastward across the Mariana trench to investigate three Cretaceous-age seamounts and a mud volcano. Finally, we transited across the trench to just west of the active volcanic arc for more fisheries and precious-coral dives, as well as one dive on an active volcano. Mapping was conducted during all transits. After completing ROV dive operations on May 10, the *Okeanos Explorer* conducted an Underwater Cultural Heritage mapping survey and then transited to Saipan.

EX1605L1: 2016 Deepwater Exploration of the Marianas Cruise overview map

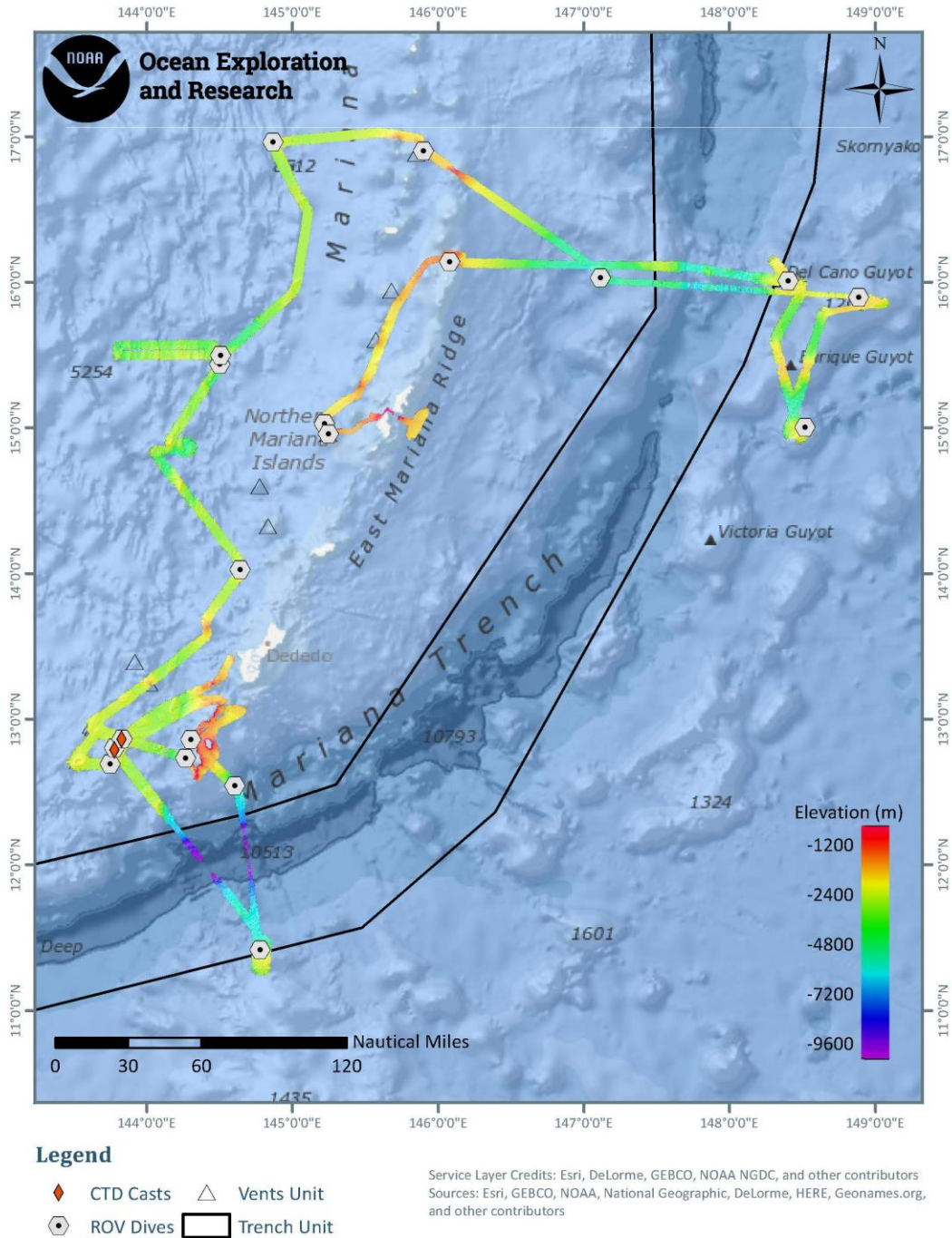


Figure 2. Map showing the locations of the 19 ROV dives, 3 CTD casts, and bathymetry data collected during EX1605 Leg 1.

8. Results

8.1 ROV seafloor surveys

Depth ranges explored during ROV surveys ranged between 240 m and 4,996 m, and bottom times ranged between 2:56 h and 7:33 h. Linear distances covered during ROV surveys ranged between 190 m and 1,470 m. During the 19 dives, the ROV spend a total of 105:18 h on the bottom and covered an estimated total linear distance of 13.075 km, yielding an average of 124 m surveyed per hour of bottom time (Table 4).

Table 4. Summary information for the 19 ROV dives conducted during EX1605 Leg 1.

Dive #	Date	Location	Start Lat. (N)	Start Lon. (E)	End Lat. (N)	End Lon. (E)	Max. Depth (m)	Bottom Time (h:m)	Est. Distance (m)	Geo. Samples *	Bio. Samples *	Comm. Samples *	Main Objective(s)
1	4/21/2016	Santa Rosa North	12.8605	144.3041	12.8548	144.3064	634	6:39	700	2	1	4	Fisheries, precious corals
2	4/22/2016	Santa Rosa South	12.7322	144.2683	12.7319	16.2771	581	6:57	900	2	3	2	Fisheries, precious corals
3	4/23/2016	Sirena Canyon	12.5377	144.6073	12.5377	144.6043	4996	4:01	700	2	3	1	Abyssal communities, geologic history
4	4/24/2016	Enigma Seamount	11.4167	144.7827	11.4125	144.7843	3784	3:44	800	3	2	0	Seamount, geologic history
5	4/26/2016	Fina Nagu Caldera D	12.6934	143.7496	12.7000	143.7475	2974	5:29	750	3	2	1	Geologic history
6	4/27/2016	Fina Nagu Caldera C	12.7968	143.7810	12.7956	143.7888	2755	5:30	670	2	2	1	Geologic history
7	4/28/2016	Fina Nagu Caldera A	12.8614	143.8309	12.8616	143.8283	2379	5:18	760	2	1	0	Geologic history, hydrothermal vents
8	4/29/2016	NW Guam Seamount	14.0244	144.6424	14.0211	144.6367	1343	6:19	480	1	2	0	Seamount; Geologic history, fisheries
9	4/30/2016	Young Lava Flows	15.4373	144.5057	15.4322	144.5047	4068	5:25	700	3	0	0	Geologic history
10	5/1/2016	New Vent Field at 15.5N	15.4982	144.5097	15.4924	144.5047	3930	5:30	640	2	0	0	Hydrothermal vents
11	5/2/2016	New Vent Field at 17N	16.9607	144.8667	16.9610	144.8700	3296	6:25	600	1	1	0	Hydrothermal vents
12	5/3/2016	Zealandia	16.9034	145.8997	16.8964	145.8968	655	7:06	800	0	3	1	Fisheries, precious corals
13	5/4/2016	Kunanaf Hulo' Mud Volcano	16.0275	147.1148	16.0304	147.1118	3703	4:01	650	1	1	1	Mud volcano
14	5/5/2016	Pigafetta Guyot	15.8963	148.8865	15.8910	148.8826	2039	5:32	725	1	2	2	Seamount; Mn-habitats
15	5/6/2016	Enrique Guyot	15.0047	48.5184	15.0034	148.5161	2269.4	2:56	725	1	1	0	Seamount; Mn-habitats
16	5/7/2016	Del Cano Guyot	16.0114	48.3991	16.0043	148.3981	1928	3:39	635	0	0	0	Seamount; Mn-habitats
17	5/8/2016	Farallon de Medinilla North	16.1390	46.0783	16.1317	146.0772	508.7	7:08	700	1	1	1	Fisheries, precious corals
18	5/9/2016	Esmeralda Bank	15.0291	45.2226	15.0357	145.2254	530.2	7:33	640	0	2	5	Fisheries, precious corals
19	5/10/2016	Esmeralda Crater	14.9577	45.2478	14.9626	145.2614	337	6:06	500	0	0	0	Hydrothermal Vents
Total:								105:18:00	13,075	27	27	19	

*Lists the number of morphotypes rather than the number of individuals.

Many different deep-sea habitats were explored in the southern Mariana Island region during EX1605L1 (Figure 3). Six high-density coral communities and two medium-density coral communities, as well as several sponge communities were observed. Many types of corals were documented including primnoids, isidids, chrysogorgiids, paragorgiids, stylasterids, desmophyllids, plexaurids, and more. The corals and sponges provided habitat and shelter for many other animals. There were also six dives (Dives 1, 2, 12, 17, 18, and 19) focused on collecting data on deep-water bottom fishery habitats where species of deep-water snapper, grouper, roughy, tuna, pomfret, and jack were documented. These dives were also designed to survey for precious corals and to investigate whether there was overlap between the ranges of the two resources. Although the precious-coral fishery is listed as a managed fishery in Guam and CNMI, no precious coral beds had been identified prior to this cruise and only anecdotal accounts of their presence in this region of the Pacific existed. The ROV surveys conducted on this expedition confirmed the presence of precious corals – documenting pink, red, gold, and bamboo corals – however, fewer were documented than expected. We also found through our ROV observations that while there was little overlap observed between bottomfish and precious coral habitats, there was overlap between bottomfish and non-precious coral habitat.

Dive 3 collected baseline information on the faunal community in the lesser-known abyssal depths at Sirena Canyon in the Marianas Trench Marine National Monument (Figure 3). A new active high-temperature hydrothermal vent field on Dive 11 in the Mariana back-arc spreading center that was composed of multiple chimneys was also discovered, including a chimney that was over 30 m tall (Figure 3). The field included at least two different chimney sites, plus multiple areas of diffuse flow and a circular crater feature (origin as yet undetermined) with extinct sulfides. Accompanying fauna such as munidopsids, actinarians, gastropods, shrimp, tubeworms etc., showed clear zonation consistent with what we assume is distance from vent fluid. We also saw extinct hydrothermal chimneys on another dive and extinct iron oxide chimneys in Esmeralda Crater on Dive 19 (Figure 3).

Dive 9 surveyed a new lava flow that was no more than two years old. Comparison of bathymetry collected in 2013 and 2015 indicated an eruption had occurred in the intervening years, creating new lava rock over 100 m thick. We visited three 60-m pillow mounds that were composed almost entirely of glassy pillow lavas. Samples of these glassy lavas were collected and will be analyzed to determine the original composition of the erupting lava. Several calderas were visited to investigate how biological communities changed with geologically-younger substrate on Dives 5, 6 and 7.

An unexpected discovery during Dive 12 was the discovery of a rare high-density community of basket stars and crinoids at Zealandia Bank. Dive 13 surveyed the crest of the Kunanaf Hulo' mud volcano. We were unable to find active seepage (typically associated with mud volcanoes), and instead documented a sedimented abyssal-plain habitat that was inhabited by many deposit

feeders and also suspension-feeding sponges with *Relicanthus* (a cnidarian similar to an anemone) living on their stalks (an association rarely seen before) (Figure 3).

Three dives (Dives 14, 15 and 16) surveyed Cretaceous-age guyots with heavy ferromanganese crusts for initial characterization of the biological communities (Figure 3). These guyots are located within the Prime Crust Zone (PCZ) – the area of the Pacific with the highest concentration of commercially-valuable deep-sea minerals. Knowledge of habitat structure and communities on ferromanganese-encrusted seafloor prompt further research and discussion relevant to planning and managing the effects of deep-sea mining.. Each guyot surveyed had distinct geology and species assemblages. Manganese-encrusted rocks were collected at these sites, as well as on almost every other dive during the expedition. There were also two other seamounts visited: on Dive 8 and Dive 4 where the highest densities of trash were recorded for this leg of the expedition.

Hundreds of different types of animals observed during video surveys, and included cnidarians, sponges, echinoderms, arthropods, mollusks, tunicates, bryozoans, ctenophores, fishes, etc. Preliminary estimates suggest that most of the 46 species collected during this leg will be new to science, although confirmation is needed by taxonomists. These include multiple corals, sponges, crustacea and echinoderms. Additionally, there were also many animals seen during the dives that were suspected to be new species but were not collected, including a purple and yellow stalked crinoid, an orange stalked crinoid (a new genus), a blue tilefish, an asteroid, a beautiful jellyfish, a predatory sponge and many more. There were also many new records for the Mariana region representing range and sometimes depth extensions for these species. These included a slit shell snail (cf. *Bayerotrochus teramachii*), a jellynose eel (*Guentherus kati*), a gorgonocephalid basket star, several cusk eels, a large blind lobster (*Acanthocaris tenuimana*) and two nudibranchs, among others.

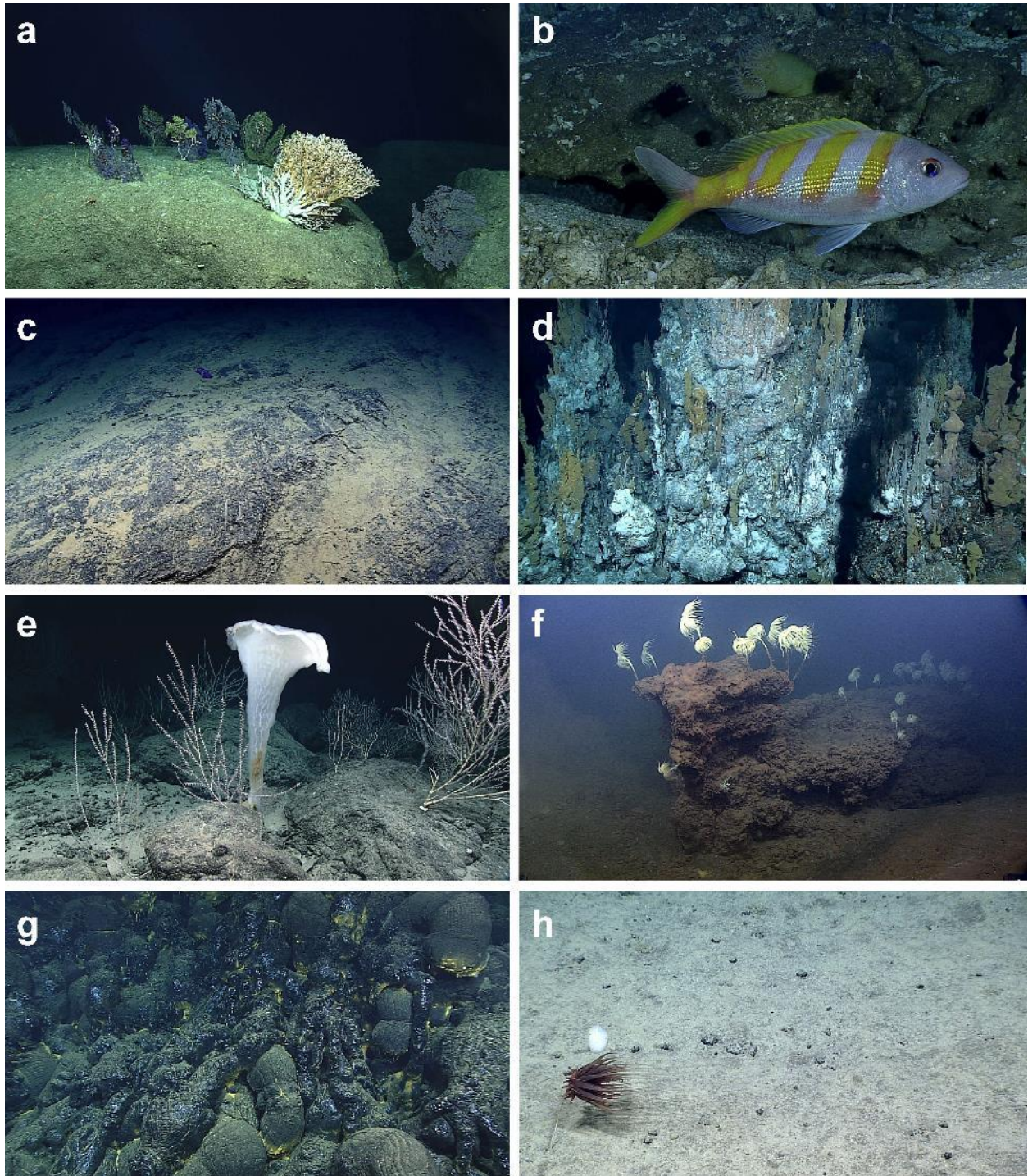


Figure 3. Deep-sea habitats encountered during EX1605L1. (a) High-density coral community at Santa Rosa North; (b) bottomfish habitat at Farallon de Medinilla; (c) the abyssal region of the Mariana Trench at Sirena Canyon; (d) an active hydrothermal-vent field 17N; (e) the Pigafetta Guyot in the Prime Crust Zone; (f) the active volcanic Esmeralda Crater; (g) fresh lava flows at the site 'Young Lava Flows'; (h) a heavily-sedimented area of Kunanaf Hulo' mud volcano.

8.2 Specimen collections

A total of 73 samples were collected during the expedition, including 27 geologic samples, 27 biological samples, and 19 commensal samples. The geological specimens included glassy pillow extrusions, carbonates, sedimentary rocks encrusted with manganese, hydrothermal vent sulfides, and basalts (some of which were also covered in manganese crust) (Table 5 and Figure 4).

Table 5. Inventory of geological samples collected during EX1605L1.

Sample #	Sample ID	Preservation	Site	Date	Time UTC	Latitude	Longitude	Depth m	Salinity	Temp °C	Oxygen mg/l
DIVE01_SPEC01GEO	Basalt	Dry	Santa Rosa North	20160420	23:08:24	12.85992	144.30429	596.0811	34.48534	5.77295	2.43838
DIVE01_SPEC02GEO	Carbonate	Dry	Santa Rosa North	20160421	0:30:32	12.85807	144.30559	544.6907	34.48718	5.76113	2.4201
DIVE02_SPEC02GEO	Carbonate with Mn	Dry	Santa Rosa South	20160421	22:46:20	12.73248	144.26872	543.4915	34.46434	6.67814	2.306
DIVE02_SPEC03GEO	Carbonate with Mn	Dry	Santa Rosa South	20160422	1:29:17	12.73252	144.27318	346.702	34.3863	7.87471	2.58514
DIVE03_SPEC01GEO	Basalt with Mn	Dry	Sirena Canyon	20160423	0:53:19	12.53934	144.60667	4967.8017	34.74141	1.50515	4.87612
DIVE03_SPEC03GEO	Sedimentary	Dry	Sirena Canyon	20160423	2:42:26	12.5386	144.60502	4899.3132	34.69367	1.50629	4.82277
DIVE04_SPEC01GEO	Sedimentary with Mn	Dry	Enigma Seamount	20160423	23:06:24	11.41676	144.78289	3781.0683	34.68387	1.54118	4.37462
DIVE04_SPEC02GEO	Sedimentary with Mn	Dry	Enigma Seamount	20160424	0:06:36	11.41559	144.78348	3754.5252	34.6886	1.54135	4.47323
DIVE04_SPEC04GEO	Basalt	Dry	Enigma Seamount	20160424	1:39:36	11.41313	144.78414	3684.1057	34.68523	1.533	4.41693
DIVE05_SPEC01GEO	Basalt with Mn	Dry	Fina Nagu Caldera D	20160425	23:51:13	12.69344	143.74962	2970.7243	34.66918	1.67745	3.93191
DIVE05_SPEC02GEO	Basalt with Mn	Dry	Fina Nagu Caldera D	20160426	1:24:44	12.6945	143.74903	2938.7875	34.66959	1.67842	3.96013
DIVE05_SPEC05GEO	Basalt	Dry	Fina Nagu Caldera D	20160426	4:51:51	12.69918	143.74789	2675.6261	34.66179	1.70306	3.85569
DIVE06_SPEC01GEO	Basalt with Mn	Dry	Fina Nagu Caldera C	20160427	0:08:04	12.7968	143.78128	2737.8168	34.66297	1.74678	3.87514
DIVE06_SPEC03GEO	Basalt with Mn	Dry	Fina Nagu Caldera C	20160427	4:06:39	12.79558	143.78758	2578.1232	34.66211	1.74587	3.83946
DIVE07_SPEC01GEO	Hydrothermal vent sulphide	Dry	Fina Nagu Caldera A	20160427	23:18:03	12.86181	143.83205	2297.9819	34.64771	1.99174	3.60066
DIVE07_SPEC03GEO	Basalt with Mn	Dry	Fina Nagu Caldera A	20160428	1:33:40	12.86116	143.8286	2294.6914	34.64619	2.0036	3.60313
DIVE08_SPEC02GEO	Basalt	Dry	NW Guam Seamount	20160429	0:10:53	14.02169	144.6406	1209.6871	34.57257	3.75871	2.64257
DIVE09_SPEC01GEO	Pillow extrusion	Dry	Young Lava Flows	20160429	23:17:05	15.43742	144.50557	4056.1005	34.6811	1.66375	4.16593
DIVE09_SPEC02GEO	Pillow basalt	Dry	Young Lava Flows	20160430	2:23:56	15.43482	144.50415	3964.6304	34.68444	1.65325	4.20654
DIVE09_SPEC03GEO	Pillow extrusion	Dry	Young Lava Flows	20160430	3:50:31	15.43274	144.50495	4062.4588	34.68204	1.65194	4.22031
DIVE10_SPEC01GEO	Pillow extrusion	Dry	New Hydrothermal Vent Field 1	20160501	3:34:12	15.4932	144.50809	3820.6279	34.67749	1.62814	4.24515
DIVE10_SPEC02GEO	Pillow extrusion	Dry	New Hydrothermal Vent Field 1	20160501	3:49:57	15.4929	144.50773	3807.9553	34.68317	1.62968	4.13199
DIVE11_SPEC01GEO	Hydrothermal vent sulphide	Dry	New Hydrothermal Vent Field 2	20160502	3:20:43	16.96176	144.86891	3286.8611	34.66831	1.68013	4.03858
DIVE13_SPEC01GEO	Mn-encrusted rock	Dry	Kunanaf Hulo Seamount	20160503	23:14:07	16.02721	147.11463	3677.3178	34.6852	1.50377	4.45974
DIVE14_SPEC01GEO	Mn-encrusted rock	Dry	Pigafetta Guyot	20160504	22:05:29	15.89633	148.88668	2004.6537	34.63172	2.07082	3.3612
DIVE15_SPEC01GEO	Mn-encrusted rock	Dry	Enrique Guyot	20160506	0:37:24	15.00455	148.51825	2266.4091	34.6467	1.90932	3.52711
DIVE17_SPEC02GEO	Carbonate	Dry	Farallon de Medinilla	20160508	3:25:13	16.13222	146.07819	258.3868	34.86913	18.25271	5.81503

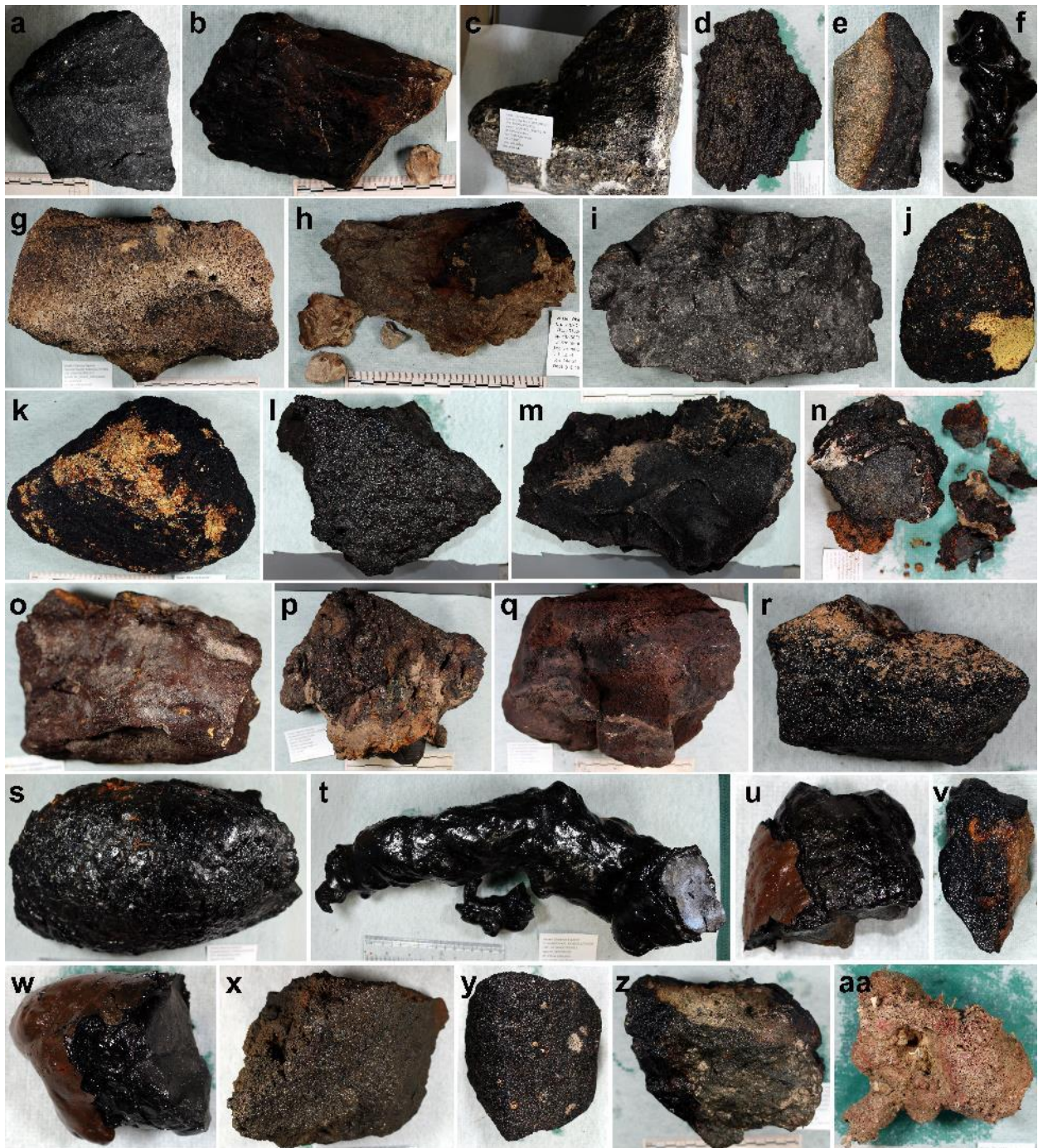


Figure 4. Laboratory photographs of the 27 geological specimens collected during EX1605L1..(a) DIVE01_SPEC01GEO; (b) DIVE02_SPEC02GEO; (c) DIVE01_SPEC02GEO; (d) DIVE07_SPEC03GEO; (e) DIVE03_SPEC01GEO; (f) DIVE09_SPEC01GEO; (g) DIVE02_SPEC03GEO; (h) DIVE03_SPEC03GEO; (i) DIVE04_SPEC04GEO; (j) DIVE04_SPEC02GEO; (k) DIVE04_SPEC01GEO; (l) DIVE06_SPEC01GEO; (m) DIVE06_SPEC03GEO; (n) DIVE07_SPEC01GEO; (o) DIVE05_SPEC05GEO; (p) DIVE05_SPEC02GEO; (q) DIVE05_SPEC01GEO; (r) DIVE08_SPEC02GEO; (s) DIVE09_SPEC02GEO; (t) DIVE09_SPEC03GEO; (u) DIVE10_SPEC02GEO; (v) DIVE13_SPEC01GEO; (w) DIVE10_SPEC01GEO; (x) DIVE11_SPEC01GEO; (y) DIVE14_SPEC01GEO; (z); DIVE15_SPEC01GEO; (aa) DIVE17_SPEC02GEO.

There were 27 biological samples that were purposely collected, as well as 19 samples that were incidentally collected as commensal organisms on other samples. In total, these samples amounted to over 117 individuals. Biological samples (not limited to one individual) collected include 14 corals, nine sponges, four brittle stars, two hydrozoans, one actiniarian, one ctenophore, one zoantharian, four squat lobsters, one shrimp, one hermit crab, two barnacles, one holothurian, one basket star, three crinoids, and one tunicate (Table 6; Figures 5 and 6). Most of these specimens are thought to be new species and/or new records for the Mariana region.

Table 6. Inventory of biological samples collected during EX1605L1.

Sample #	Sample ID	Group	# Ind.	Preservation	OGL Vial #	Site	Date	Time UTC	Latitude	Longitude	Depth m	Salinity	Temp °C	Oxygen mg/l
DIVE01_SPEC02GEOCO1	Ophiuroidea	Brittle star	1	95% ETOH	119	Santa Rosa North	20160421	0:30:32	12.85807	144.30559	544.6907	34.48718	5.76113	2.4201
DIVE01_SPEC02GEOCO2	Ophiuroidea	Brittle star	1	95% ETOH	120	Santa Rosa North	20160421	0:30:32	12.85807	144.30559	544.6907	34.48718	5.76113	2.4201
DIVE01_SPEC02GEOCO3	Ophiuroidea	Brittle star	1	95% ETOH	121	Santa Rosa North	20160421	0:30:32	12.85807	144.30559	544.6907	34.48718	5.76113	2.4201
DIVE01_SPEC03BIO	Chrysogorgiidae	Coral	1	95% ETOH	16	Santa Rosa North	20160421	3:07:35	12.85583	144.30615	354.8415	34.32402	9.03303	3.26928
DIVE01_SPEC03BIOCO1	Munididae	Squat lobster	2	95% ETOH	118	Santa Rosa North	20160421	3:07:35	12.85583	144.30615	354.8415	34.32402	9.03303	3.26928
DIVE02_SPEC01BIO	<i>Madrepora</i> sp.	Coral	1	95% ETOH	18	Santa Rosa South	20160421	21:44:23	12.73216	144.26836	575.2917	34.4735	6.07926	2.38527
DIVE02_SPEC01BIOCO1	<i>Desmophyllum</i> sp.	Coral	1	95% ETOH	19	Santa Rosa South	20160421	21:44:23	12.73216	144.26836	575.2917	34.4735	6.07926	2.38527
DIVE02_SPEC01BIOCO2	Chirostylidae	Squat lobster	1	95% ETOH	123	Santa Rosa South	20160421	21:44:23	12.73216	144.26836	575.2917	34.4735	6.07926	2.38527
DIVE02_SPEC04BIO	Hyocrinidae	Crinoid	1	95% ETOH	122	Santa Rosa South	20160422	2:20:05	12.73242	144.27451	320.1722	34.33843	9.38392	3.4157
DIVE02_SPEC05BIO	<i>Lepidisis</i> sp.	Coral	1	95% ETOH	17	Santa Rosa South	20160422	3:43:04	12.73217	144.27577	298.316	34.37186	11.61839	4.48057
DIVE03_SPEC02BIO	Comatulida	Crinoid	1	95% ETOH and 4% Formalin	124	Sirena Canyon	20160423	1:18:42	12.53925	144.60623	4954.7989	34.69734	1.50829	4.89713
DIVE03_SPEC04BIO	<i>Galatheaturia</i> sp.	Sea cucumber	1	95% ETOH	125	Sirena Canyon	20160423	3:19:48	12.53793	144.60438	4862.9395	34.69691	1.5119	4.85372
DIVE03_SPEC05BIO	Cladorhizidae sp. 1	Sponge	1	95% ETOH and Frozen	126	Sirena Canyon	20160423	3:36:57	12.53774	144.60419	4856.6343	34.69049	1.50394	4.77179
DIVE03_SPEC05BIOCO1	Ophiuroidea	Brittle star	9	95% ETOH	127	Sirena Canyon	20160423	3:36:57	12.53774	144.60419	4856.6343	34.69049	1.50394	4.77179
DIVE04_SPEC03BIO	Primnoidae	Coral	1	95% ETOH	20	Enigma Seamount	20160424	0:36:50	11.41489	144.78372	3736.5856	34.69566	1.53443	4.41438
DIVE04_SPEC05BIO	Primnoidae	Coral	1	95% ETOH	21	Enigma Seamount	20160424	02:16:09	11.41264	144.78422	3642.9573	34.68231	1.55472	4.25617
DIVE05_SPEC03BIO	<i>Hyalonema</i> sp. - orange	Sponge	1	95% ETOH	129	Fina Nagu Caldera D	20160426	2:10:51	12.69524	143.74933	2935.1605	34.66748	1.69353	3.96784
DIVE05_SPEC03BIOCO1	Scalpellidae	Barnacle	1	95% ETOH	-	Fina Nagu Caldera D	20160426	2:10:51	12.69524	143.74933	2935.1605	34.66748	1.69353	3.96784
DIVE05_SPEC04BIO	<i>Hyalonema</i> sp. - white	Sponge	1	95% ETOH	128	Fina Nagu Caldera D	20160426	3:01:13	12.69609	143.74915	2894.6303	34.67932	1.70944	3.98077
DIVE06_SPEC02BIO	Isididae	Coral	1	95% ETOH	22	Fina Nagu Caldera C	20160427	0:51:58	12.79628	143.78181	2711.8696	34.70204	1.74085	3.90475
DIVE06_SPEC04BIO	<i>Pleurogorgia</i> sp.	Coral	1	95% ETOH	23	Fina Nagu Caldera C	20160427	5:12:18	12.79569	143.78889	2509.7045	34.65982	1.79788	3.82085
DIVE06_SPEC04BIOCO1	Actiniaria	Anemone	>20	95% ETOH and 4% Formalin	130	Fina Nagu Caldera C	20160427	5:12:18	12.79569	143.78889	2509.7045	34.65982	1.79788	3.82085
DIVE07_SPEC02BIO	Ascidacea	Tunicate	1	95% ETOH	131	Fina Nagu Caldera A	20160428	0:41:26	12.86129	143.83028	2378.2378	34.64655	2.01302	3.61498
DIVE08_SPEC01BIO	<i>Lepidisis</i> sp.	Coral	1	95% ETOH	24	NW Guam Seamount	20160428	23:56:12	14.02175	144.64052	1209.5705	34.56856	3.60121	2.66495
DIVE08_SPEC03BIO	Cladorhizidae sp. 2	Sponge	1	95% ETOH and frozen; 4% Formalin to 70% ETOH	132	NW Guam Seamount	20160429	3:18:07	14.02064	144.63747	1229.3378	34.5726	3.43611	2.73124
DIVE11_SPEC02BIO	Isididae	Coral	1	95% ETOH	25	New Hydrothermal Vent Field 2	20160502	4:14:01	16.9613	144.86918	3292.6033	34.54563	1.88107	4.09966
DIVE12_SPEC01BIO	<i>Hexapathes</i> sp.	Coral	1	95% ETOH and 4% Formalin	26	Zealandia Bank	20160502	22:32:30	16.90288	145.89918	599.4688	34.34396	6.3034	2.06094
DIVE12_SPEC01BIOCO1	Munididae	Squat lobster	2	95% ETOH	133	Zealandia Bank	20160502	22:32:30	16.90288	145.89918	599.4688	34.34396	6.3034	2.06094
DIVE12_SPEC02BIO	Gorgonocephalidae	Basket star	1	95% ETOH and Frozen	134	Zealandia Bank	20160503	2:11:19	16.89968	145.89747	374.7809	34.36361	12.47086	5.42212
DIVE12_SPEC03BIO	Lithistid	Sponge	1	95% ETOH	135	Zealandia Bank	20160503	3:57:41	16.89718	145.89712	310.2147	34.54562	15.05496	6.26748
DIVE13_SPEC01GEOCO1	Crinoidea	Crinoid	1	95% ETOH	136	Kunanaf Hulo Seamount	20160503	23:14:07	16.02721	147.11463	3677.3178	34.6852	1.50377	4.45974
DIVE13_SPEC02BIO	<i>Caulophacus</i> sp.	Sponge	1	95% ETOH	137	Kunanaf Hulo Seamount	20160504	2:22:36	16.03034	147.11219	3701.0278	34.68806	1.48329	4.49437
DIVE14_SPEC01GEOCO1	Hydrozoa	Hydroid	1	95% ETOH	138	Pigafetta Guyot	20160504	22:05:29	15.89633	148.88668	2004.6537	34.63172	2.07082	3.3612
DIVE14_SPEC02BIO	Bolosominae sp. 3	Sponge	1	95% ETOH	139	Pigafetta Guyot	20160505	0:48:16	15.89389	148.88518	2027.862	34.63118	2.09072	3.4234
DIVE14_SPEC03BIO	Isididae	Coral	1	95% ETOH	28	Pigafetta Guyot	20160505	3:05:15	15.8914	148.88324	1965.6363	34.62791	2.13315	3.26753
DIVE14_SPEC03BIOCO1	Cirripedia	Barnacle	1	95% ETOH	-	Pigafetta Guyot	20160505	3:05:15	15.8914	148.88324	1965.6363	34.62791	2.13315	3.26753
DIVE15_SPEC02BIO	Porifera sp.	Sponge	1	95% ETOH and 4% Formalin	140	Enrique Guyot	20160506	1:41:53	15.00418	148.51727	2190.9216	34.64435	1.95199	3.50755
DIVE17_SPEC01BIO	Plexauridae	Coral	1	95% ETOH	29	Farallon de Medinilla	20160508	0:32:20	16.13436	146.08179	279.9554	34.5863	15.29593	5.70465
DIVE17_SPEC01BIOCO1	Hydrozoa	Hydroid	1	95% ETOH	141	Farallon de Medinilla	20160508	0:32:20	16.13436	146.08179	279.9554	34.5863	15.29593	5.70465

DIVE18_SPEC01BIO	Demospongiae	Sponge	1	95% ETOH and Frozen	142	North Esmeralda Bank	20160509	0:49:03	15.03162	145.22342	364.2557	34.33058	11.41658	4.51962
DIVE18_SPEC01BIOCO1	Paguridae	Hermit crab	5	95% ETOH	143	North Esmeralda Bank	20160509	0:49:03	15.03162	145.22342	364.2557	34.33058	11.41658	4.51962
DIVE18_SPEC02BIO	Chrysogorgiidae	Coral	1	95% ETOH	30	North Esmeralda Bank	20160509	1:39:27	15.03185	145.22355	339.7821	34.2951	10.21001	3.9733
DIVE18_SPEC02BIOCO1	Ctenophora	Comb jelly	>30	95% ETOH	144	North Esmeralda Bank	20160509	1:39:27	15.03185	145.22355	339.7821	34.2951	10.21001	3.9733
DIVE18_SPEC02BIOCO2	Zoantharia	Zoanthid	10	95% ETOH	145	North Esmeralda Bank	20160509	1:39:27	15.03185	145.22355	339.7821	34.2951	10.21001	3.9733
DIVE18_SPEC02BIOCO3	Munididae	Squat lobster	1	95% ETOH	-	North Esmeralda Bank	20160509	1:39:27	15.03185	145.22355	339.7821	34.2951	10.21001	3.9733
DIVE18_SPEC02BIOCO4	<i>Lebbeus</i> sp.	Shrimp	1	95% ETOH	-	North Esmeralda Bank	20160509	1:39:27	15.03185	145.22355	339.7821	34.2951	10.21001	3.9733

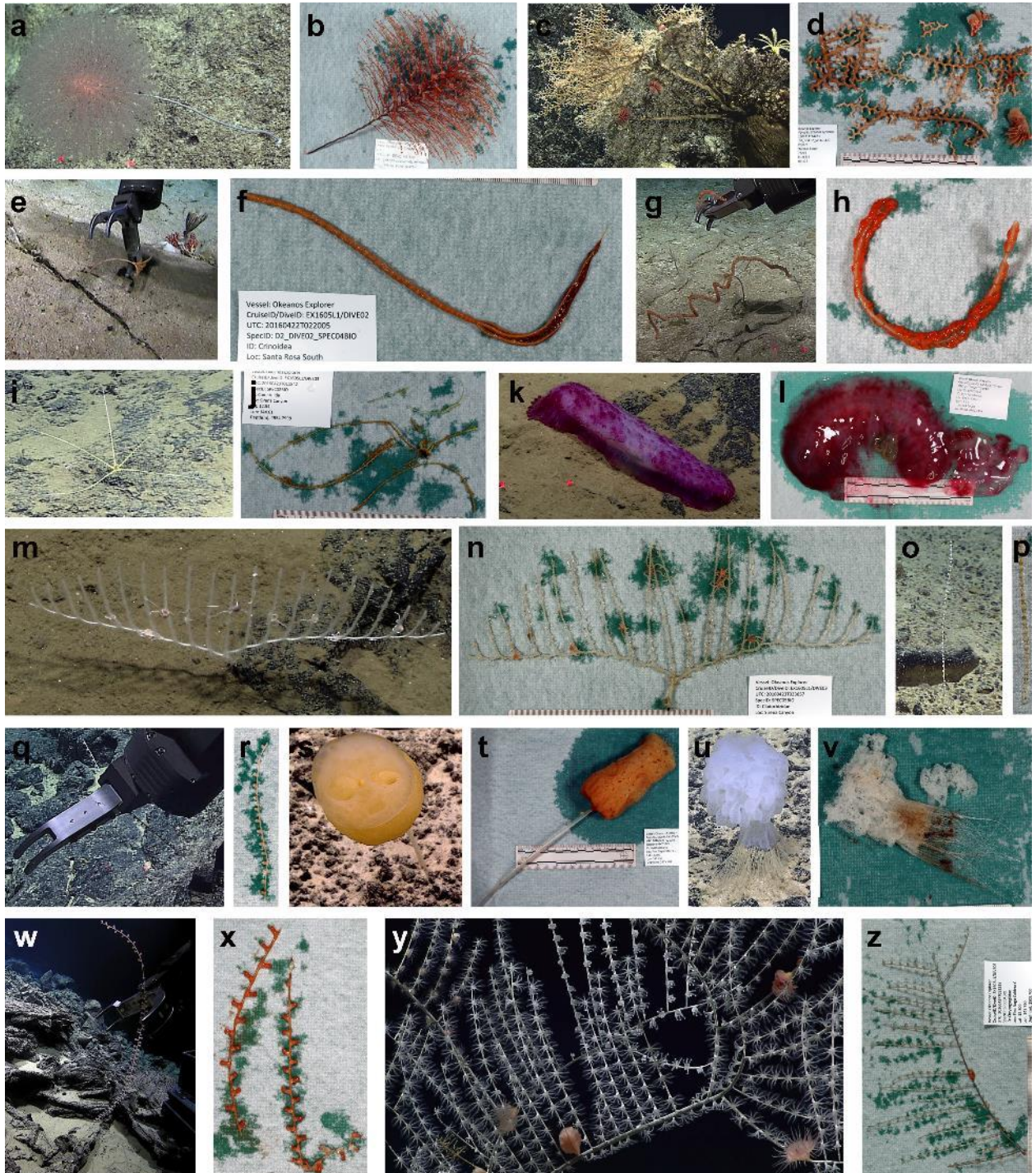


Figure 5. *In situ* (left) and laboratory (right) photographs of the first 13 biological samples collected during EX1605L1. (a) *Chrysogorgia* sp. in situ; (b) *Chrysogorgia* sp. in lab; (c) *Madrepora* sp. with commensal *Desmophyllum* sp. in situ; (d) *Madrepora* sp. in lab; (e) Crinoidea sp. in situ; (f) Crinoidea sp. in lab; (g) *Lepidisis* sp. in situ; (h) *Lepidisis* sp. in lab; (i) Comatulida sp. in situ; (j) Comatulida sp. in lab; (k) *Galatheathuria* sp. in situ; (l) *Galatheathuria* sp. in lab; (m) Cladorhizidae sp. 1 in situ; (n) Cladorhizidae sp. 1 in lab; (o) Primnoidae sp. in situ; (p) Primnoidae sp. in lab; (q) Primnoidae sp. in situ; (r) Primnoidae sp. in lab; (s) *Hyalonema* sp. orange in situ; (t) *Hyalonema* sp. orange in lab; (u) *Hyalonema* sp. white in situ; (v) *Hyalonema* sp. orange in situ; (w) Isididae sp. in situ; (x) Isididae sp. 1 in lab; (y) *Pleurogorgia* sp. with commensal actinarians in situ; (z) *Pleurogorgia* sp. in lab.

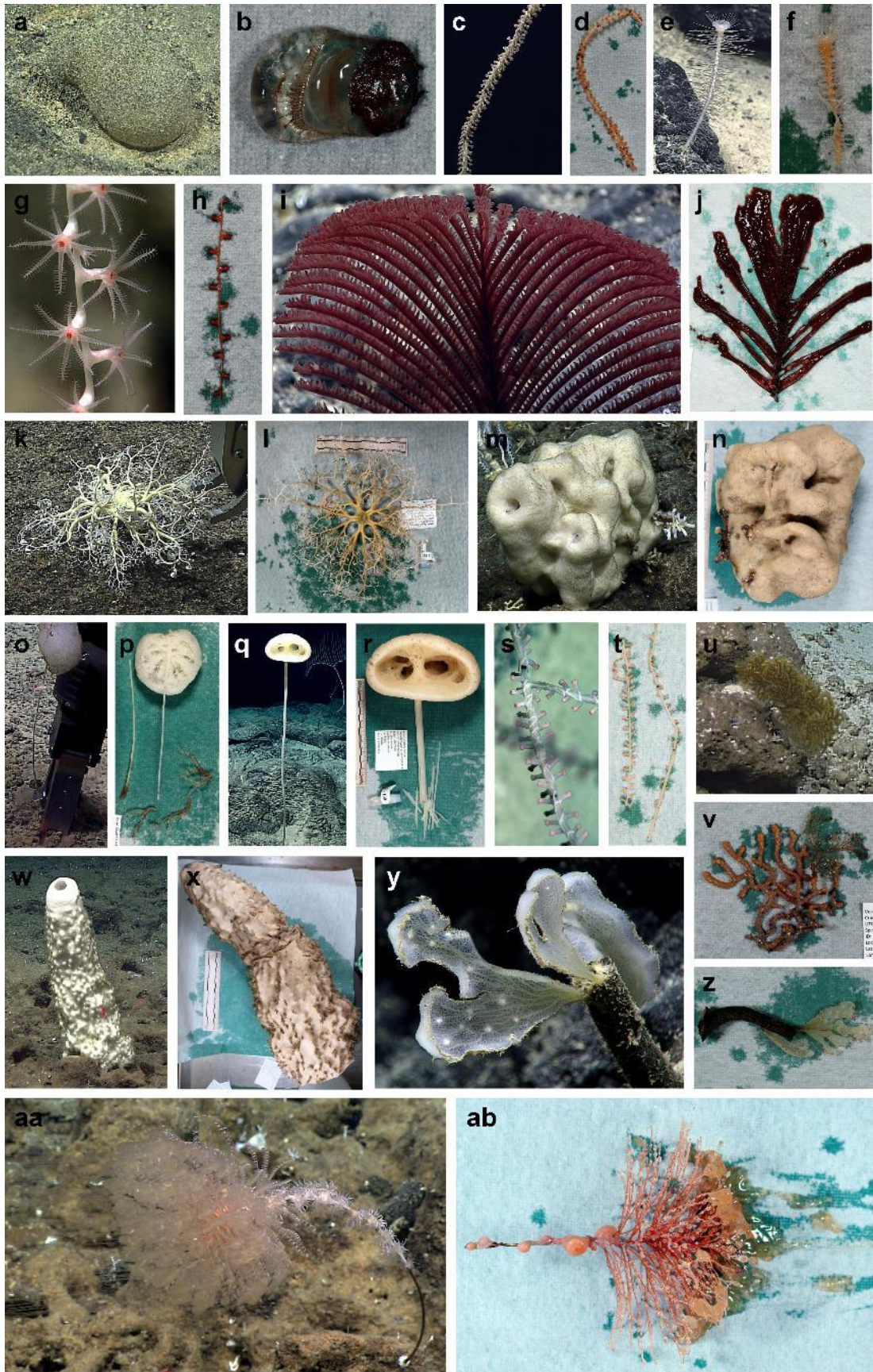


Figure 6. *In situ* (left) and laboratory (right) photographs of the last 14 biological samples collected during EX1605L1. (a) Ascidacea sp. in situ; (b) Ascidacea sp. in lab; (c) *Lepidisis* sp. in situ; (d) *Lepidisis* sp. in lab; (e) Cladorhizidae sp. 2 in situ; (f) Cladorhizidae sp. 2 in lab; (g) Isididae sp. in situ; (h) Isididae sp. in lab; (i) *Hexapathes* sp. in situ; (j) *Hexapathes* sp. in lab; (k) Gorgonocephalidae sp. in situ; (l) Gorgonocephalidae sp. in lab; (m) Lithistid sp. in situ; (n) Lithistid sp. in lab; (o) *Caulophacus* sp. in situ; (p) *Caulophacus* sp. in lab; (q) Bolosominae sp. 3 in situ; (r) Bolosominae sp. in lab; (s) Isididae sp. in situ; (t) Isididae sp. in lab; (u) Plexauridae sp. in situ; (v) Plexauridae sp. orange in situ; (w) Demospongiae sp. in situ; (x) Demospongiae sp. in lab; (y) Porifera sp. in situ; (z) Porifera sp. in lab; (aa) *Chrysogorgia* sp. with commensal benthic ctenophores in situ; (ab) *Chrysogorgia* sp. with commensal benthic ctenophores in lab.

8.3 Seafloor mapping

The total area mapped by the *Okeanos Explorer's* EM302 sonar during the expedition was 19,600 km². This included mapping data acquired both in transit between sites, as well as targeted multibeam surveys. Targeted mapping around Santa Rosa Reef captured a large portion of the 400 m contour, see figure 8. A repeated and detailed survey was conducted over Esmerelda Crater, with focus on collecting high quality EK60 data over this active underwater volcano. Well defined scattering layers were visible in all four EK60 frequencies, figure 9. One water column anomaly, consistent with gas seepage, was detected on one pass, however the anomaly was not detected on subsequent passes over the same area.

Immediately following the ROV dive at the newly discovered black smoker site at 17 N; the *Okeanos Explorer* mapped the water column over the vent field using the 18 kHz EK60 sonar and the multibeam sonar. Six passes were made over the field, transiting at 4-5 knots on various headings. There was a clear and repeatable signal in the split-beam echogram from the venting but less obvious indication in the multibeam data. This data is still being analyzed.

A targeted multibeam survey to search for several lost B-29 bombers from World War II was conducted in the Saipan/Tinian channel and west of Saipan in 50 to 800 m of water. The seafloor west of Saipan was marked with dense coral structures, making it difficult to differentiate between natural and manmade features on the seafloor. The bathymetry and backscatter data was provided to experts for further processing and analysis.

All the raw mapping data from this expedition was deemed unclassified and is available at the NCEI national archives.

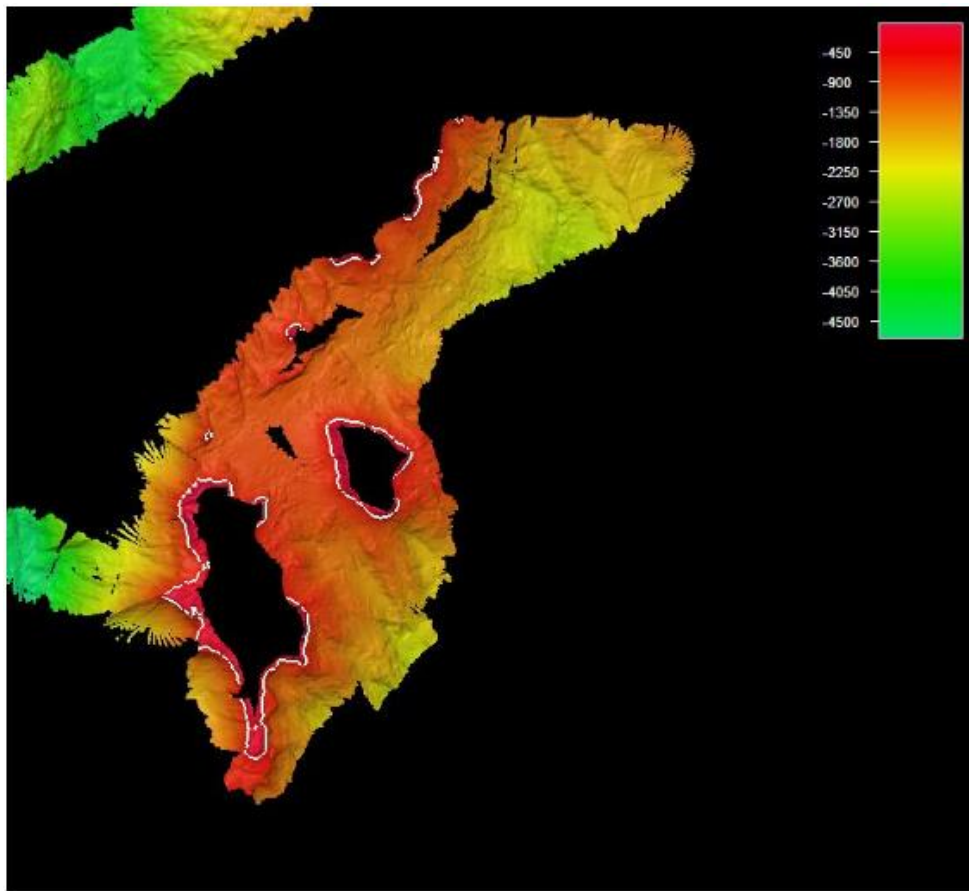


Figure 8. Map showing the bathymetry around Santa Rosa Reef, the white line shows the 400 m depth contour.

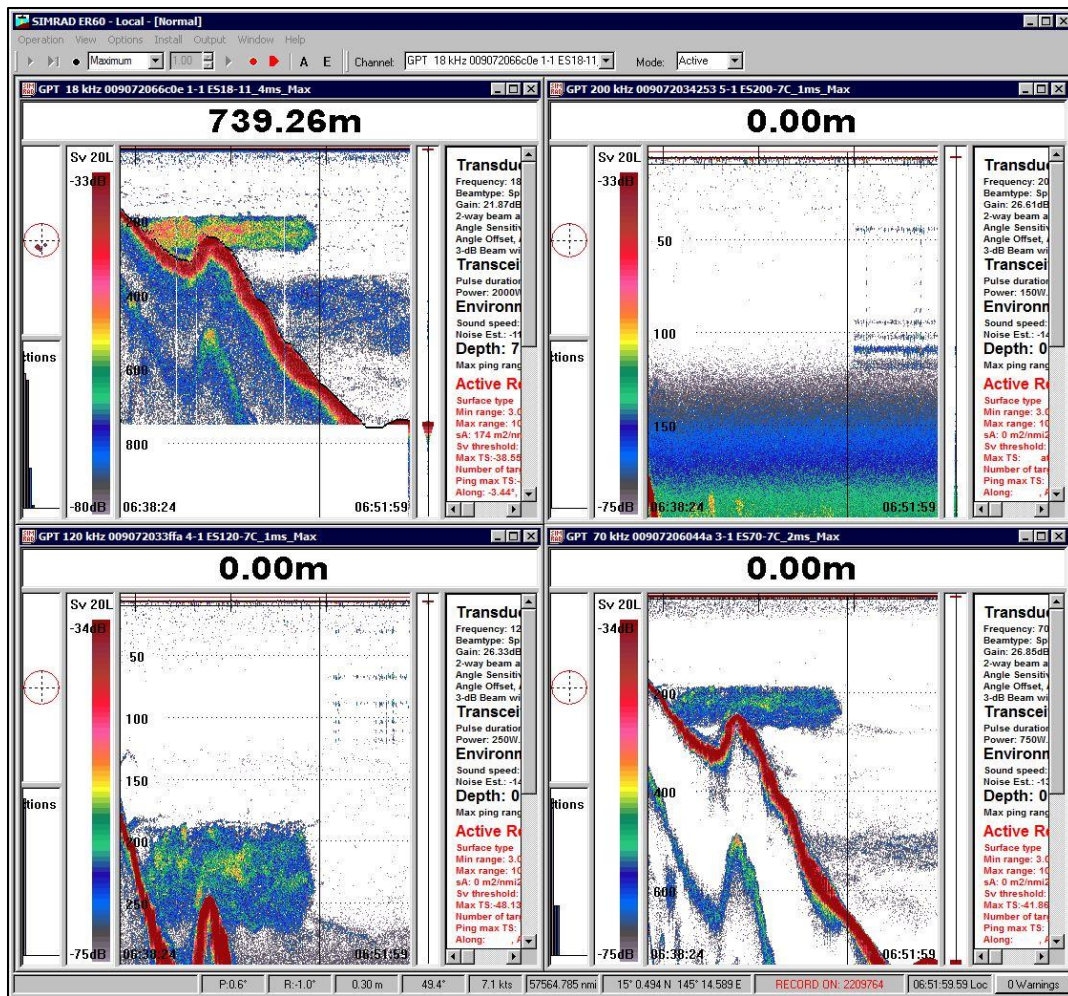


Figure 9. Scattering layer over Esmeralda Crater, the layer is visible over all four frequencies.

8.4 Education and outreach products

The expedition received news and media coverage by more than 70 outlets (including CNN, NPR, LA Times, Washington Post, Scientific American, USA Today, BBC) and conducted 7 interviews with media during the expedition. Live feeds of the expedition were continuously streamed throughout the expedition at UnderwaterWorld Guam and the Waikiki Aquarium. Additionally, the live video feeds of the expedition were streamed over the Internet and garnered more than 2.5 million views, greatly breaking the previous record for live video views of 700,000! The oceanexplorer website received ~440,000 views to web content developed specifically for the expedition by participants.

The Exploration Command Center at UnderwaterWorld Guam served as both a working space for scientists and a public outreach venue. Two live interactions were conducted with UnderwaterWorld Guam during Leg 1 and engaged 90 high school students in local robotics and marine geology clubs. A live interaction was also conducted with Saipan Southern High School and engaged 100 science students.

Ship tours were conducted for members of the public and VIPs in Saipan after the ship pulled into port in Saipan. 216 members of the public (including educators, scientists, CNMI agency experts and students) toured the ship on May 12. VIP tours of the ship were given on May 13 for 30 visitors including the Secretary of CNMI DLNR, representatives from the WPRFM Council and Northern Marianas College, NOAA partners, media, and educators, who participated in OER's education professional development program.

9. Conclusion

EX1605 Leg 1 provided a great depth of baseline information to support management and science needs in CNMI and for the MTMNM. Noteworthy highlights include:

- Conducted 19 ROV dives for a total of over 105.3 hours of bottom time, and an estimated linear survey distance of 13.075 km. ROV surveys were conducted from 240 m to 4,996 m. Dives included:
 - Five within or adjacent to MTMNM boundaries;
 - Six to survey for precious coral or bottomfish fishery habitats;
 - Five at seamounts to look at deep-sea coral communities and manganese-encrusted seafloor habitats;
 - Eight focused on hydrothermal vents, mud volcanoes and associated communities;
 - Six to better understand the geologic history of the region.
- Observed hundreds of different species of animals. There were dozens of potential new species, as well as many records for the region. New species included three cladorhizid sponges, three hexactinellid sponges, a tilefish, a hydromedusae jellyfish, a seastar, two new species of crinoid, although there were likely many more. These should be confirmed at a later date.
- Collected 27 primary biological samples, each possibly an undescribed species, and 27 rock samples for use in age-dating and geochemical composition analysis. When commensals were included, 117 individual animals were sampled representing 46 different species.
- Conducted the first effort to discover and document deep-sea coral and sponge communities in the deep-waters of the Marianas. Documented six high density communities and two medium density communities. Also documented a rare high density community of basket stars and crinoids.
- Confirmed the presence of precious corals in the region, and surveyed deep-water bottomfish fishery habitats. Found that while there was little overlap observed between bottomfish and precious corals, there was overlap between bottomfish and non-precious coral habitat.
- Surveyed three Cretaceous-age guyots with heavy ferromanganese crusts for initial characterization of biological communities in advance of any potential mining activities. Each guyot had distinct geology and species assemblages.

- Collected baseline information on the faunal community at abyssal depths in the Marianas Trench Marine National Monument.
- Documented a new active high-temperature “black smoker” hydrothermal vent field on the Mariana Back Arc spreading center that was composed of multiple chimneys, including one that was over 30 m tall.
- Investigated a number of different geological features, including extinct calderas, active volcanoes, mud volcanoes, fresh lava flows, and carbonate platforms.
- Mapped areas of interest for fisheries resource managers, including the 400 m contour at Santa Rosa Bank and the north side of Farallon De Medinilla.
- Mapped just under 20,000 square kilometers of seafloor - an area nearly the size of New Jersey. This includes data of six sites that are included in the Vents Unit of the MTMNM.
- Conducted a mapping survey to search for several lost B29 bombers from WWII. These sites are of interest to researchers and managers including the State Historic Preservation Officer, National Park Service, U.S. Navy, the Department of Defense (program that accounts for MIAs) and several academics.
- Collected 22.5 TB of data including multibeam, single beam, subbottom, ADCP, CTD, XBT, surface oceanographic and meteorological sensor, video, image, and associated dive and video products.