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Expedition Cruise Report

Cruise EX-17-02
2017 American Samoa Expedition: Suesuega o le Moana o Amerika Samoa (ROV/Mapping)

February 16 to March 2, 2017

Pago Pago, American Samoa to Apia, Samoa

Dr. Matthew Jackson, UC Santa Barbara, University Corporation for Atmospheric Research
Dr. Santiago Herrera, Lehigh University, University Corporation for Atmospheric Research
Elizabeth Lobecker, ERT Inc., NOAA Office of Ocean Exploration & Research
Kelley Elliott, NOAA Office of Ocean Exploration & Research

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NOAA Office of Ocean Exploration and Research
1315 East-West Hwy, SSMC3 RM 10210
Silver Spring, MD 20910

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Final editing and publication of this report was completed by:
Mashkoor Malik, Expeditions and Explorations Division, NOAA Office of Ocean Exploration and Research

For further information direct inquiries to:
NOAA Office of Ocean Exploration and Research
1315 East-West Hwy, SSMC3 RM 10210 Silver Spring, MD 20910
Phone: 301-734-1014
Fax: 301-713-4252
Email: oceanexplorer@noaa.gov

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1. Introduction

The NOAA Office of Ocean Exploration and Research (OER) is the only U.S. federal program dedicated to exploring our deep ocean, closing the prominent gap in our basic understanding of U.S. deep waters and seafloor and delivering the ocean information needed to strengthen the economy, health, and security of our nation. Using the latest tools and technology, OER explores previously unknown areas of our deep ocean, making discoveries of scientific, economic, and cultural value. Through live video streams, online coverage, training opportunities, and real-time events, OER allows scientists, resource managers, students, members of the general public, and others to actively experience ocean exploration—expanding available expertise, cultivating the next generation of ocean explorers, and engaging the public in exploration activities. From this exploration, OER makes the collected data needed to understand our ocean publicly available, so we can maintain the health of our ocean, sustainably manage our marine resources, accelerate our national economy, and build a better appreciation of the value and importance of the ocean in our everyday lives.

NOAA Ship *Okeanos* Ex*plorer* is the only U.S. federal vessel dedicated to exploring our largely unknown ocean for the purpose of discovery and the advancement of knowledge. America's future depends on understanding the ocean. Exploration supports NOAA mission priorities and national objectives by providing a broad diversity of data and information about the deep ocean to anyone who needs it.

In close collaboration with government agencies, academic institutions, and other partners, OER conducts deep-sea exploration expeditions using advanced technologies on NOAA Ship *Okeanos* Ex*plorer*. From mapping and characterizing previously unseen seafloor to collecting and disseminating information about deep waters and seafloor—and the resources they hold—this work establishes a foundation of information and fills data gaps. Data collected on the ship adhere to 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. As the only federal program dedicated to ocean exploration, OER is uniquely situated to lead partners in delivering critical deep-ocean information to managers, decision makers, scientists, and the public, leveraging federal investments to meet national priorities.

2. Project Background

2.1 CAPSTONE: the Campaign to Address Pacific monument Science, Technology, Ocean NEeds

CAPSTONE: the **C**ampaign to **A**ddress **P**acific monument **S**cience, **T**echnology, and **O**cean **Ne**eds, was a 3-year effort designed to provide critical new information on the deep-water resources within the US national marine monuments and sanctuaries located throughout the Pacific. The primary goal of all *EX* expeditions in this campaign was to obtain baseline characterizations of the very poorly known deep-water areas and resources in these extensive marine protected areas.

2.2 Expedition Overview

This cruise was the first of two comprising the 2017 American Samoa Expedition - EX-17-02 and EX-17-04. From February to April 2017, NOAA and partners conducted two telepresence-enabled ocean exploration cruises on NOAA Ship *Okeanos Explorer* to collect critical baseline information of unknown and poorly known deep-water areas in American Samoa, Samoa, and the Cook Islands, with an emphasis on the Rose Atoll Marine National Monument (RAMNM) and the National Marine Sanctuary of American Samoa (NMSAS).

This Expedition was part of a three-year Campaign to Address the Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE), a foundational science initiative to support science and management decisions within and around U.S. marine protected areas in the central and western Pacific. The campaign also served as an opportunity for NOAA and the nation to highlight the uniqueness and importance of these national symbols of ocean conservation.

From a geologic perspective, this expedition provided a unique opportunity to explore the geologic history in American Samoa, where much remains to be learned about hotspot volcanism operating there. Like the Hawaiian chain, the Samoa islands and seamounts form an age-progressive volcanic hotspot: the volcanoes on the eastern portion of the Samoan hotspot are young and the volcanoes in the west are progressively older. A hot, upwelling mantle plume is thought to be responsible for mantle melting and volcanism in the Samoan region. However, it is still not understood how a Samoan volcano evolves over time, or even how long it takes for a Samoan volcano to pass through its lifecycle. In order to better

understand the evolution of a Samoan volcano, a goal of this expedition was to sample various volcanoes at different stages in their development, including the young active volcano, Vailulu'u. But the samples collected may reveal surprises, such as that some of the volcanoes that populate the Samoan region do not trace their heritage to the Samoan hotspot, but may instead relate to older hotspots that contributed volcanism to the Samoan region tens of millions of years ago. New geologic samples obtained from the Samoan hotspot can help address fundamental outstanding issues that relate to the geologic history of the region.

Before this expedition we had a poor knowledge of the deep-sea habitats, including deep-sea coral and sponge communities, in American Samoa. Data and information from the expedition will fill gaps in knowledge about the deep-sea habitats in the region and improve our overall understanding of the deep-sea biogeography of the Central Pacific. American Samoa lies at the boundary of four major biogeographic provinces and thus is a key area to understand the biodiversity transitions that occur in the deep Pacific Ocean. Furthermore, the Samoan Passage north of the American Samoan islands is a major circulation gateway for deep water flowing from the southern Pacific into the Northern Pacific, thus representing a potential longitudinal barrier for larval dispersal, while also potentially serving as a 'funnel' for latitudinal connectivity. The images and biological specimens collected using the Remotely Operated Vehicle (ROV) *Deep Discoverer,* we will enable biogeographical comparisons between American Samoa and characterized areas off New Zealand, Hawaii (CAPSTONE 2015, 2016), and Indonesia (INDEX 2010), in addition to other areas in the central Pacific that will be explored following this expedition.

Baseline data from this expedition will help improve our understanding of the geologic history and deep-sea habitats of American Samoa, the connection between deep-water and shallow-water ecosystems, the connection between communities at different seamounts, and the potential geohazards such as undersea landslides. Data will also provide critical information for the development of management plans for marine protected areas; support local scientists and managers seeking to understand and manage fisheries resources; and provide a foundation of information to stimulate follow-on exploration, research, and management activities.

2.3 Rationale for Exploration

The 2017 American Samoa Expedition addressed science themes and priority areas put forward by scientists and managers from NOAA, management agencies in American Samoa, and the broad ocean science community. These science themes, priority areas, and exploration targets were identified through: 1) An open "call for input" distributed to the

science and management community that requested mapping, CTD rosette and ROV dive site recommendations to inform the 2017 CAPSTONE series of expeditions in the central Pacific, including in American Samoa and Samoa; and 2) Direct conversations and meetings with management agencies, local resource managers and local stakeholders. All unmapped and poorly mapped areas submitted in response to the open "call for input", and appropriate for NOAA Ship *Okeanos Explorer* operations (e.g. water depths greater than 250 m and areas lacking contemporary data), were added to NOAA Ship *Okeanos Explorer* cruise plans for cruises operating in American Samoa (see section 8 "Additional Information" for a list of these cruises). ROV dive sites were selected from those submitted in response to the "call for input" and prioritized based on OER's exploration goals, CAPSTONE science themes, and needs identified by relevant managers. In several cases, a dive was planned on a feature or site of interest to multiple scientists and managers.

Operations were designed to complement previous and planned work in the area. NOAA priorities for the expedition included a combination of science, education, outreach, and open data objectives that will support management decisions at multiple levels:

- Acquire data to support priority Monument and Sanctuary science and management needs
- Identify and map vulnerable marine habitats – particularly high-density deep-sea coral and sponge communities
- Explore the diversity of benthic habitats and features (e.g., seamounts, hydrothermal vents, deep-sea coral habitats, bottomfish habitats)
- Investigate the geologic history of Pacific seamounts, including potential relevance to plate tectonics and subduction zone biology and geology
- Engage a broad spectrum of the scientific community and public in telepresence-based exploration
- Provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities

This expedition was part of a three-year Campaign to Address the Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE), an initiative to collect deep-water baseline information to support science and management decisions in and around U.S. marine protected areas (MPAs) in the central and western Pacific. American Samoa is home to three MPAs: National Marine Sanctuary of American Samoa (NMSAS), Rose Atoll Marine National Monument (RAMNM), and waters of the National Park of American Samoa. NMSAS covers 13,581 square miles of nearshore coral reef and offshore open ocean waters across the Samoan archipelago, including the waters around RAMNM. Six sanctuary units protect extensive coral reefs, deep-water reefs, hydrothermal vent communities, and rare

marine archaeological resources. Rose Atoll is the easternmost Samoan island and remains one of the most pristine atolls in the world. Much remains unknown about the deep-sea habitats and geology in and around these protected places. This expedition contributed new information by exploring areas of the deep ocean in American Samoa for the first time. This expedition also improved our understanding of three topics that are of importance to American Samoans:

- The role of seamounts as hotspots of biodiversity and how they support fish like tuna and red snapper;
- the relationship between shallow-water areas and deep-water areas so we can understand how these ecosystems work; and
- Assessing past (and potential future) geohazards - explosive volcanic eruptions and potentially tsunamigenic submarine landslides.

Data and information from the expedition provide critical information for the development of management plans for marine protected areas; support local scientists and managers seeking to understand and manage fisheries resources; and provide a foundation of information to stimulate follow-on exploration, research, and management activities.

EX-17-02 was the first of two cruises to focus operations in the waters of American Samoa, and one of five 2017 NOAA Ship *Okeanos Explorer* cruises that acquired data in American Samoan waters. See section 8 for more information on the other cruises.

2.4 Objectives

EX-17-02 operations occurred in the U.S. EEZ waters of American Samoa and Samoan waters. This cruise collected baseline data and information to support priority NOAA science and management needs including in two (and in support of a third) marine protected areas of the Pacific Ocean.

Mission objectives for EX-17-02 included a combination of mapping/operational, science, education, outreach, and data management objectives:

i. **Science**
   a. Acquire data to support priority Monument and Sanctuary science and management needs;
   b. Explore the diversity and distribution of benthic habitats – including commercially valuable bottomfish precious coral habitats, a Nautilus habitat, deeper high-density coral and sponge communities, and hydrothermal vents;
      - Collect data on: habitat size and extent, animal diversity and density;

- Focus close-up imaging operations on potential new, rare and poorly documented animals as well as dominant members of the communities;
- 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;

c. Conduct mapping survey operations over Vailulu'u seamount to look for evidence of change since 2005, and to explore vent activity;
d. Conduct mapping survey operations to provide baseline seafloor information in an area where the Samoan Clipper was reported lost, to support future investigation;
e. Collect biological and geological data at sites to aid the understanding of the geologic history of Pacific seamounts;
f. Continue to refine specimen collection protocols and processing procedures;
g. Ground-truth acoustic data using video imagery and characterize associated habitat;
h. Engage a broad spectrum of the scientific community and public in telepresence-based exploration;
i. Successfully conduct operations in conjunction with shore-based ECCs and remote science team participants; and
j. Create and provide input into standard science products to provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities.

ii. Remote Science/ Exploration Command Centers (ECCs)

a. Provide operational support and training to scientists and managers to enable remote participation in at-sea operations;
b. Develop and test best practices for hosting internet-1 based live interactions;
c. Facilitate outreach and engagement activities and events at the ECCs;
d. Conduct an outreach event with the Ocean Center in Tutuila, American Samoa;
e. If developed, test operations with a new Internet1 enabled viewing center at the National University of Samoa;
f. Test and refine ship-to-shore communications procedures that engage multiple ECCs and other remote participants; and
g. Test and refine operating procedures and products.

iii. ROV Engineering

a. Conduct ROV dives on exploration targets;
b. Ongoing training of pilots;

c. Ongoing system familiarization, documentation, and training; and
d. Test and refine new ROV systems and pilot sampling protocol. New systems include sample scoop and 360-degree camera.

iv. Video Engineering

a. Test terrestrial and high-speed satellite links;
b. Support telepresence-enabled ROV operations;
c. Collect/create all standard video products;
d. Continue to refine new highlight video SOPs;
e. Facilitate live outreach events between ship and shore;
f. Continue to refine protocols for using YouTube live to host live video;
g. Test and refine updated video product workflows;
h. Refine and formalize video product generation SOPs and checklists; and
i. Monitor and improve video/data timestamp agreement.

v. Mapping

a. Collect high resolution mapping data from all sonars in priority areas as dictated by operational needs as well as science and management community needs;
b. Support ROV operations with mapping products and expertise;
c. Conduct mapping operations during transit, with possible further development of exploration targets;
d. Collect XBT casts as data quality requires during mapping operations;
e. Create daily standard mapping products;
f. Collect sun photometer measurements as part of survey of opportunity;
g. Continue to test the integration of the new EK60 frequencies and the ADCPs; and
h. Continue to train new Survey Technician on mapping operations and Standard Operating Procedures;
i. Continue to integrate Qimera into standard multibeam bathymetric data processing routines; and
j. As necessary, conduct contingency mapping on days where ROVs dives are not possible due to weather or other delays.

vi. Data Management

a. Provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities;
b. Provide daily products to shore for operational decision making purposes;
c. Test shipboard integration with updated shore data repository server at the Inner Space Center (ISC);

d. Evaluate Aspera software to accelerate ship to shore data transfer;
e. Monitor and improve video/data timestamp agreement;
f. Monitor the newly replaced Storage Area Network (SAN) equipment and related procedures;
g. Refine and formalize updated data management and video product workflow checklists and SOPs;
h. Integrate ONC eventlog into data management processes;
i. Install and configure backup Network Attached Storage (NAS) unit;
j. Cross-train existing ROV dedicated personnel;
k. Implement updated sample management processes; and
l. Ensure marine archaeology data protection protocols are followed during mapping survey of underwater cultural heritage site.

vii. Outreach

a. Engage the general public in ocean exploration through live video and timely content (daily updates, topical essays and web logs, highlight videos, video clips, still imagery and mapping products) posted on the Ocean *Explorer* website;
b. Conduct ship tours for the public, students, teachers, managers and officials while in port in both Pago Pago and Apia;
    1. February 15th in Pago Pago: Student/teacher groups from 8am to noon (groups of 30 each hour ending at noon) and from 1 - 2pm for 30 VIPs;
    2. March 3rd in Apia: Ship tours for educators, students, public;
b. Host live events with teachers, students, media and officials in American Samoa;
    1. February 24th @ 11am: Live interaction with Ocean Center;
    2. February 28th: Possible VIP interaction with Office of Samoan Affairs;
b. Host live events with others; and
    1. February 23rd: Open house at NOAA's IRC ECC.

viii. Ship

a. Continue to refine SOPs for the new VSAT;
b. Provide a high-quality stable internet connection with the new VSAT;
c. Provide stable and reliable VoIP telecommunications;
d. Continue training new deck department personnel in ROV launch and recovery; and
e. Continue to train new Survey Technician and familiarize him/her with *Okeanos* Operations and his/her responsibilities.

2.5 List of Participants

Table 1: At-sea Mission Personnel

Name	Role	Affiliation
Kelley Elliott	Expedition Coordinator	OER
Matt Jackson	Geology Science Lead	UCAR/UCSB
Santiago Herrera	Biology Science Lead	UCAR/Lehigh University
Jonathan Jackson	Sample Data Manager	NCEI
Meme Lobecker	Mapping Lead	OER/ERT
Amanda Bittinger	Mapping Watch Lead	UCAR
Andrew O'Brien	Engineering Team	GFOE
Joshua Carlson	Engineering Team	GFOE
Karl McLetchie	Dive Supervisor	GFOE
Levi Unema	Engineering Team	GFOE
Jeffrey Laning	Engineering Team	GFOE
Bobby Mohr	Engineering Team	GFOE
Sean Kennison	Engineering Team	GFOE
Don Liberatore	Engineering Team	GFOE
Annie White	Engineering Team	GFOE
Dan Rogers	Engineering Team	GFOE
Emily Narrow	Engineering Team	GFOE
Art Howard	Engineering Team	GFOE
Caitlin Bailey	Engineering Team	GFOE
Roland Brian	Engineering Team	GFOE
Bob Knott	Engineering Team	GFOE
Bill Clancey	VIP	IHMC

Shore-based science team members participate from remote ECCs (ECC) and from their home locations. Further information about the participation model/ mode can be found in Section 3.4 of this report.

Table 2: Shore-based Science Participants

Name	Affiliation	expertise	Participation Location
Abby Lapointe	University of Hawaii	Corals	HI (UH ECC)
Alistair Grinham	UQ Australia	Diatoms, technology	HI
Amanda Netburn	NOAA OER	Pelagic Ecology	MD
Amy Baco-Taylor	Florida State University	Benthic ecology, seamounts, deep-sea corals, genetics	FL
Andrea Quattrini	Harvey Mudd College	Benthic ecology, corals, fishes	CA
Andrew Reinhard	UC Santa Barbara	Geochemist	CA
Asako Matsumoto	Planetary Exploration Research Center, Chiba Institute of Technology, Japan	Octocorals, deep-sea coral, taxonomy	Japan
Brennan Phillips	URI	Hydrothermal vents, water column exploration, ocean engineering	HI (UH)
Brian Greene	Association for Marine Exploration	Mesophotic Fishes	HI (UH)
Bruce Mundy	NOAA NMFS Pacific Islands Fisheries Science Center	Ichthyology - fish taxonomy, fish identification, fish biogeography	HI (IRC)
Chris Mah	Dept. of Invertebrate Zoology, NMNH Smithsonian Institution	Asteroidea (sea stars), Echinodermata, taxonomy, general deep-sea invertebrates	DC
Christopher Kelley	University of Hawaii	Benthic biology	HI (UH ECC)
Collin Closek	Stanford U	eDNA Biodiversity, Molecular Metabarcoding	HI (UH)
Cornelia Jaspers	GEOMAR	Ctenophore Ecology and gelatinous Zooplankton	HI (UH)
Craig Young	University of Oregon	Deep-sea ecology, reproduction and development	OR
Deborah Glickson	National Academies of Sciences, Engineering, and Medicine	Geology and geomorphology	DC

Dhugal Lindsay	JAMSTEC	Midwater biology, particularly jellyfishes	Japan
Dick Young	University of Hawaii	Cephalopoda	HI (UH)
Diva Amon	University of Hawaii at Manoa	Benthic biology esp. chemosynthetic habitats, abyssal plains and food falls	Trinidad & Tobago
Elizabeth Andruszkiewicz	Stanford U	eDNA	HI (UH)
Erik Cordes	Temple University	Benthic biology, deep-sea corals, oceanography	PA
Heather Judkins	USF	Cephalopod ecology and taxonomy, invertebrate zoology	HI (UH)
Jasper Konter	University of Hawaii Manoa	Marine geology, geochemistry	HI (UH)
Joseph O'Malley	NOAA/NMFS/PIFSC/FRMD/LHP	Fisheries science, in particular deep-water bottomfish life history	IRC
Kristen Mello	Center for Coastal and Ocean Mapping	Benthic ecology	UNH
Les Watling	University of Hawaii at Manoa	Octocoral taxonomy	HI (UH)
Meagan Putts	University of Hawaii/JIMAR/NOAA	Benthic biology, deep-sea corals, sponges and their associated fauna	HI
Michael Parke	NOAA PIFSC	Coral reef ecology and biogeography	IRC
Michael Vecchione	NMFS	Cephalopods	DC
Natalie Summers	University of Hawaii at Manoa	Benthic biology (corals)	HI (UH)
Nicole Morgan	Florida State University	Benthic Biology - Corals	FL
Nolan Barrett	FAU Harbor Branch Oceanographic Institute	Visual fish and marine invertebrate identification	FL
Peter Auster	Mystic Aquarium & University of Connecticut	benthic biology, fish ecology	CT
Russ Hopcroft	UAF	Zooplankton	HI (UH ECC)
Scott France	University of Louisiana at Lafayette	Deep-sea corals, benthic biology & ecology	LA

Shirley Pomponi	FAU/HBOI	Sponge systematics, biotechnology	HBOI ECC
Sonia Rowley	University of Hawai'i at Manoa	Benthic biology/Octocorals	HI (UH ECC)
Steve Auscavitch	Temple University	Deep-sea corals	PA
Tara Harmer Luke	Stockton University	Deep-sea Hydrothermal Vent invertebrates, deep-sea biology	NJ
Taylor Heyl	Woods Hole Oceanographic Institution	Benthic Biology	MA
Timothy Shank	Woods Hole Oceanographic Institution	Benthic Biology	MA
Tina Molodtsova	P.P. Shirshov Institute of Oceanology RAS	Deep-sea biology, deep-sea corals, seamount and oceanic ridge fauna	Russia
William Chadwick	NOAA/PMEL	Volcanology, geology, hydrothermal vents	OR

3. Methods

3.1 Operations Overview

Operations on NOAA Ship *Okeanos Explorer* were conducted 24 hours-a-day. During EX-17-02, ROV operations were conducted during the daylight hours, with mapping operations conducted during non-ROV hours. Eight to 10-hour dives were conducted during this expedition as staffing, weather, and transits allowed. EX-17-02 operations included EM 302 multibeam, EK 60 single beam, Knudsen sub-bottom profiler, and Teledyne acoustic doppler current profiler (ADCP) data collection. Mapping operations were conducted when transiting between dive sites, conducting focused mapping surveys, and during transit to and from port for repairs.

A test CTD cast was planned off the southern coast of Tutuila immediately following Dive 13. However, as operations began an oil leak occurred in the J-Frame and the test cast was cancelled.

During the ascent from ROV dive 12, a series of midwater transects were conducted over top of Malulu seamount. During this mid-water exploration, the vehicles conducted 10 minute transects at 1500, 1200, 900, 700, 600, 500, and 375 m (the scattering layer

identified by the EK60 sonar). These depths were chosen based on features revealed by the CTD data collected by the *Deep Discoverer* on the way down to the seafloor at the start of the dive. For this dive, we had a unique opportunity to bring together a group of midwater experts to participate in the dive at the University of Hawaii ECC. These scientists were in Hawaii for an Oceanography conference and an upcoming workshop on water column exploration, and their participation was coordinated by Amanda Netburn with NOAA OER. The group contained experts in cephalopods (squids and octopuses), fishes, jellyfish, and other zooplankton.

For dive planning purposes, existing gridded bathymetry data were viewed in collaboration with the onshore science team each day and dive tracks were planned for the next day. On occasion, data was too poor or did not exist for a dive site, so dive goals were discussed the night before and the science leads selected the dive track in the early morning prior to the dive. Planned dive tracks were plotted in 3D and shared with the team. Mapping operations were initiated as soon as the ROV was recovered each day and continued throughout the night until ROV deployment the following day. Kongsberg EM302 multibeam, Simrad EK60 split-beam, and Knudsen 3260 sub-bottom profiler sonar data were collected simultaneously during mapping operations. To ensure high quality multibeam data, sound speed profiles of the water column were obtained using expendable bathythermographs (XBTs) every few hours during mapping operations. 25 XBT casts were completed during the expedition.

A summary of products created during this cruise can be found in Appendix D.

3.2 Equipment

3.2.1 ROV

Okeanos Explorer conducted high-resolution visual surveys to obtain baseline characterization data using NOAA's custom-built, dual-body, 6,000-meter-rated ROVs *Deep Discoverer* (*D2*) and *Seirios*. *D2* has five high-definition (HD) cameras, five standard-definition cameras, and 24 LED lights that bring 144,000 lumens to the seafloor resulting in some of the highest quality deep-sea footage in the industry. *D2* also has four custom-built lighting swing-arms that allow for the position and angle of the light to be adjusted for optimal imaging. *Seirios* has one HD camera, five standard-definition cameras, and 18 LED lights that add 108,000 lumens to *D2*'s lighting. The vehicles work in tandem, with *D2* surveying the seafloor, and *Seirios* providing additional lighting and situational awareness, as well as dampening the movement of the ship.

Every dive the HD video cameras on *D2* are color-corrected and white-balanced to ensure correct color in all HD video recordings.

D2 has two manipulator arms – a Schillings Orion arm and a Kraft Predator arm. The Kraft arm is more dexterous and is used for delicate work. This arm is also equipped with force feedback that allows the operator to "feel" how much force is being exerted by the arm. The Orion arm was used as a backup and this arm was outfitted with the color calibration card. Both vehicles had a Sea Bird 9/11+ CTD with dissolved oxygen (DO) sensors. *D2* also had a temperature probe and a scoop.

3.2.2 Sample Collection and Processing

Biological Specimens: Once a specimen was brought aboard the ship following collection, the specimen appearance and coloration was photographed and documented in the ship's wet lab. Coral and sponge specimens were subsampled for taxonomic analysis (ethanol) and genetic analysis (CHAOS or other buffer). Soft-bodied animals, particularly anemones and hydroids, were preserved in formalin after subsamples were taken for DNA analysis using OGL buffers. All other animals were preserved in either formalin or ethanol, depending on which preservative was more desirable for the particular taxa.

Selected coral and sponge specimens were split, with one aliquot going to Bishop Museum (http://www.bishopmuseum.org/collections-3/invertebrate-zoology/) and the other to the Smithsonian Institution's National Museum of Natural History (https://naturalhistory.si.edu/research/invertebrate-zoology). If it was determined that splitting would be too destructive to a particular specimen, it was provided to the Smithsonian Institution intact in order to provide public access to as many researchers as possible.

An additional small tissue sample for genetic analysis was taken of corals, sponges, and all other specimens when doing so did not effectively destroy the specimen. This tissue sample will be preserved for later genomic DNA and RNA extraction at the Ocean Genome Legacy Center at Northeastern University (https://www.northeastern.edu/ogl/). These results are publicly accessible. Crustaceans and any other commensal organisms found on the corals and sponges were provided to the Smithsonian Institution and if there was enough tissue some tissue were preserved for DNA extraction.

Any other animals were sent to the Smithsonian Institution.

Geologic Specimens: Once a specimen was brought onboard the ship following collection, the specimen appearance and coloration was photographed and documented in the ship's wet lab. For most samples, a portion of the sample was broken off with a hammer and chisel to enable a field identification. Close-up images of every sample were taken using the camera stand (with a 15 cm ruler for scale); photos of every sample were also taken at ~1 m distance to ensure that the complete specimen (in particular the larger specimens) could be included in a photograph (with a 15 cm ruler for scale). Rocks were dried on board the ship. Samples were then packaged in large bags and stored until removal from the ship and preparation for archival. Note that one sample, a carbonate cobble (*D2*_DIVE10_SPEC05GEO), was archived with the associated biology samples.

All rock samples were sent to Oregon State University's Marine Geology Repository (http://osu-mgr.org/) where they were entered into the Repository's sample library. The Repository curated the rocks, described them from a petrology perspective, made polished microscope thin sections and microphotographed the thin sections. The repository also provided online metadata information about the rocks and how to request samples of them.

The OSU Marine Geology Repository is one of a number of facilities in the US and abroad (http://www.ngdc.noaa.gov/mgg/curator/curator.html) that provide the ocean sciences community with access to marine rock and sediment samples. NOAA partnered with Oregon State University through its Cooperative Institute of Marine Resources Studies.

3.2.3 Sonar systems

Okeanos Explorer has three scientific sonar systems that are operated simultaneously during mapping operations: a Kongsberg 30 kHz multibeam system, several frequencies of Kongsberg EK split-beam fisheries sonar (18, 70, 120, and 200 kHz), and a Knudsen 3.5 kHz chirp sub-bottom profiler sonar. ADCP's were not operated during mapping operations due to interference with other sonars, however passive data collection of POSMV data did occur at the request of the University of Hawaii Data Acquisition System (UHDAS) ADCP group. The ADCPs were operated during ROV dives while the ship was stationary, in order to provide situational awareness of currents to the ROV

operators. Mapping operations onboard *Okeanos Explorer* occurred continuously throughout the day and night except when the ROV was deployed.

EM302: *Okeanos Explorer*'s EM302 30 kHz multibeam sonar was used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter. Backscatter represents the strength of the acoustic signal reflected from some target, whether that's the seafloor or bubbles in the water column. The EM302 is a deep-water multibeam system designed to map in depths ranging from approximately 200-7,000 meters.

Single Beam Sonar(s): The *Okeanos Explorer* is equipped with Simrad EK60 split-beam sonar transducers operated at the following frequencies: 18 kHz, 38 kHz, 70 kHz, 120 kHz, and 200 kHz. The Kongsberg EK 60 (18 kHz) single beam was used to collect information about the water column, such as gas plume or seep sites, and to obtain information about biomass. The EK60 split-beam sonar was used as a quantitative scientific echosounder to identify water column acoustic reflectors - typically biological scattering layers, fish, or gas bubbles – providing additional information about water column characteristics and anomalies.

Sub Bottom Profiler: The primary purpose of the Knudsen Chirp 3260 (3.5 kHz) sonar was to provide echogram images of surficial geological sediment layers beneath the seafloor to a maximum depth of about 80 meters below the seafloor. The Sub Bottom Profiler is normally operated to provide information about the sedimentary features and the bottom topography that was simultaneously being mapped by the multibeam sonar. The data generated by this sonar is fundamental in helping geologists interpret the shallow geology of the seafloor.

ADCPs: The *Okeanos Explorer* used two ADCPs: a Teledyne RDI Workhorse Mariner (300 kHz) and an Ocean Surveyor (38 kHz). The hull-mounted ADCP transducers project four beams to record backscatter from the water column and compare the Doppler shift between the four beams to generate profiles of water velocity at various depths. ADCP measurements were therefore critically useful in characterizing the physical oceanography of an area and identifying small to mesoscale ocean current features. In addition to these scientific benefits, the *Okeanos Explorer* used ADCPs to assess currents near remotely operated vehicle (ROV) dive locations to inform dive planning and ensure safe ROV deployment and recovery operations. The 300 kHz Workhorse Mariner ADCP had a typical range of approximately 110 meters and a maximum range of 165 meters, while the 38 kHz Ocean Surveyor ADCP had a range between 900 - 1000 meters depending on operating mode and oceanographic conditions.

XBTs: expendable bathythermographs (XBTs) were deployed to obtain sound velocity profiles to help calibrate the multi-beam system and ensure accurate bathymetric mapping. The XBT type is the Deep Blue probe produced by Lockheed Martin Sippican. expendable bathythermographs were collected every three to six hours at an interval defined by prevailing oceanographic conditions to correct multibeam data for changes in sound speed in the water column, and were applied in real-time using Seafloor Information Software (SIS). Sound speed at the sonar head was determined using a Reson SVP-70 probe, and salinity measurements near the transducers were taken using the ship's flow-through thermosalinograph (TSG).

Sonar Data Acquisition: Throughout the cruise, multibeam data quality was monitored in real-time by acquisition watch standers. Line spacing was planned to ensure 25-30% overlap between adjacent lines of multibeam sonar swaths. Cutoff angles in SIS were generally set between 60° and 70° on both the port and starboard sides. Ship speed was adjusted to maintain data quality as necessary and as transit time to the next dive site allowed.

All multibeam sonar data collected during the expedition was fully processed according to established onboard procedures and was archived with the National Center for Environmental Intelligence (NCEI, formerly NGDC). Additional details about data archival can be found in Section 7 of this report. Raw multibeam bathymetry data files were acquired by SIS, and were imported into CARIS. In CARIS, attitude and navigation data stored in each file were checked, and erroneous soundings were removed using CARIS Swath Editor and Subset Editor. Once per day, cleaned, gridded bathymetric data were exported to ASCII text files (y,x,z) at 50 meter cell size in WGS84 datum. The ASCII files were then used to create Fledermaus SD objects. These SD objects were then exported to geotiff and Google Earth KMZ files, which were copied to the shore-side FTP on a daily basis to support shore-side scientist participation.

For more detailed information about the sonar systems, see the EX-17-02 Mapping Data Acquisition and Processing Summary Report.

3.2.4 Video Data Processing, Chatlog and SeaScribe Annotation Log

The primary data set collected by the ROVs was HD video. The video was recorded and archived in several different formats and resolutions. The dives were recorded in their entirety at 720p 5 megabit per second. In addition to the full dive recording a subset of

the video collected was preserved in ProRes 4.2.2. 1080i 145 megabit per second at the discretion of the science lead and the video engineers on the ship.

The video clips were time coded to UTC time to coordinate with all data products collected on the ship. These clips represented the vast majority of the events of the dives and capture nearly all the geological formations and creatures that were observed. For discoverability each ProRes clip was compressed and at least one frame grab is taken from the clip to allow for easy access and searching without having to deal with the sheer volume of data associated with the ProRes clips.

During ROV dives participating researchers communicated between ship and shore using an instant messaging chatlog. The chatlog is a persistent chat room where all comments, discussions and requests made in the chatlog are logged and provided a timestamp (UTC) and can later be correlated to the operations, location, and data feeds coming off the ship at that time.

During this cruise, SeaScribe was used as the primary annotation log for the first time. SeaScribe is a web-based real-time annotation tool developed by Ocean Networks Canada that complements SeaTube, a video viewer and annotation interface for ROV operations. The SeaScribe served as the digital equivalent to the scientist's logbook. It was used by shipboard and shore-side cruise participants to log real-time observations on a variety of topics – in particular scientific observations and animal identifications. These observations were UTC time-stamped, and included the commenter's name, and the latitude, longitude and depth of the ROV at the time of comment. SeaScribe was accessible to authorized participating researchers to add observations during and after *Okeanos Explorer* ROV expeditions.

With about 15 minutes delay, the video and annotations from SeaScribe became available on SeaTube. SeaTube is a freely accessible online tool to search through and edit your annotations and browse video. While both SeaScribe and SeaTube were operational during the cruise, we focused training and encouraged the use of SeaScribe as this new tool was being tested and transitioned into use during *EX* telepresence-enabled operations for the first time during this cruise.

3.3 Survey of Opportunity

NASA Maritime Aerosol Network

During the cruise, marine aerosol layer observations were collected for the the NASA Maritime Aerosol Network (MAN). Observations were made by mission personnel (as time allowed) with a sun photometer instrument provided by the NASA MAN program. Resulting data were delivered to the NASA MAN primary investigator Alexander Smirnov by the expedition coordinator. All collected data were archived and publicly available at: http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html

Equipment resided on the ship and was stewarded by the expedition coordinator. See Appendix E for full Survey of Opportunity Form.

3.4 Telepresence Operating Model

During the expedition at least 48 scientists, students and managers participated from 12 U.S. states, Japan, Russia, Chile and Trinidad and Tobago. The cruise was conducted primarily via a "distributed" participation model. The primary, core team of scientists who participated daily joined from multiple locations around the world. Some joined from an ECC, some tuned into their institutions Internet2 connection at their home office, and many others joined using the standard internet connection from their home or office. Two primary ECCs were used by scientists during the cruise: University of Hawaii at Manoa and NOAA's Inuoye Regional Center – both located in Honolulu, HI. The ECC in Oregon was used during the Vailulu'u seamount dive. Participation in ROV dives was accomplished by viewing the real-time video feeds, communicating with fellow scientists and the shipboard team via teleconference and/or the instant messaging Chatlog, and annotating the dive in real-time using SeaScribe.

3.5 Permits/Clearances

This project involved Marine Scientific Research in waters under the jurisdiction of the U.S. including the territorial government of American Samoa, and Samoa. Approval was received to conduct Marine Scientific Research in the waters of Independent Samoa from the Samoa Ministry of Foreign Affairs and Trade (Appendix F).

A letter of support to conduct scientific research in the territorial waters of Samoa was received (Appendix G) prior to commencing research, as a Memorandum of Agreement between NOAA and the Samoa Ministry of Natural Resources and the Environment was in progress at the time of cruise departure. The MOA was finalized and is available from NOAA OER upon request.

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 did not require a permit to work in the Rose Atoll Marine National Monument.

A permit was received from American Samoa's Division of Marine and Wildlife (Appendix H).

Permit NMSAS 2017-001 was received to conduct work the National Marine Sanctuary of American Samoa (Appendix I).

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 was a research project of limited size or magnitude or with only short-term effects on the environment and for which any cumulative effects would be negligible, and as such, the project was 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 authorized the Marine Scientific Research conducted for the project (appendix J).

Informal consultation was conducted under Section 7 of the Endangered Species Act (ESA), and requested NOAA Fisheries' Protected Resources Division concurrence with our biological evaluation determining that all planned *Okeanos Explorer* operations during the 2016-17 field season, may affect, but were 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 conducting proposed *Okeanos Explorer* cruises were not likely to adversely affect ESA-listed marine species (appendix K).

OER completed a consultation with NOAA's Habitat Conservation Division on potential impacts of our operations to Essential Fish Habitat (EFH). They concurred that our

operations would not adversely affect EFH provided adherence to our proposed procedures and their guidance stated in the letter (appendix L).

4. Summary of Operations

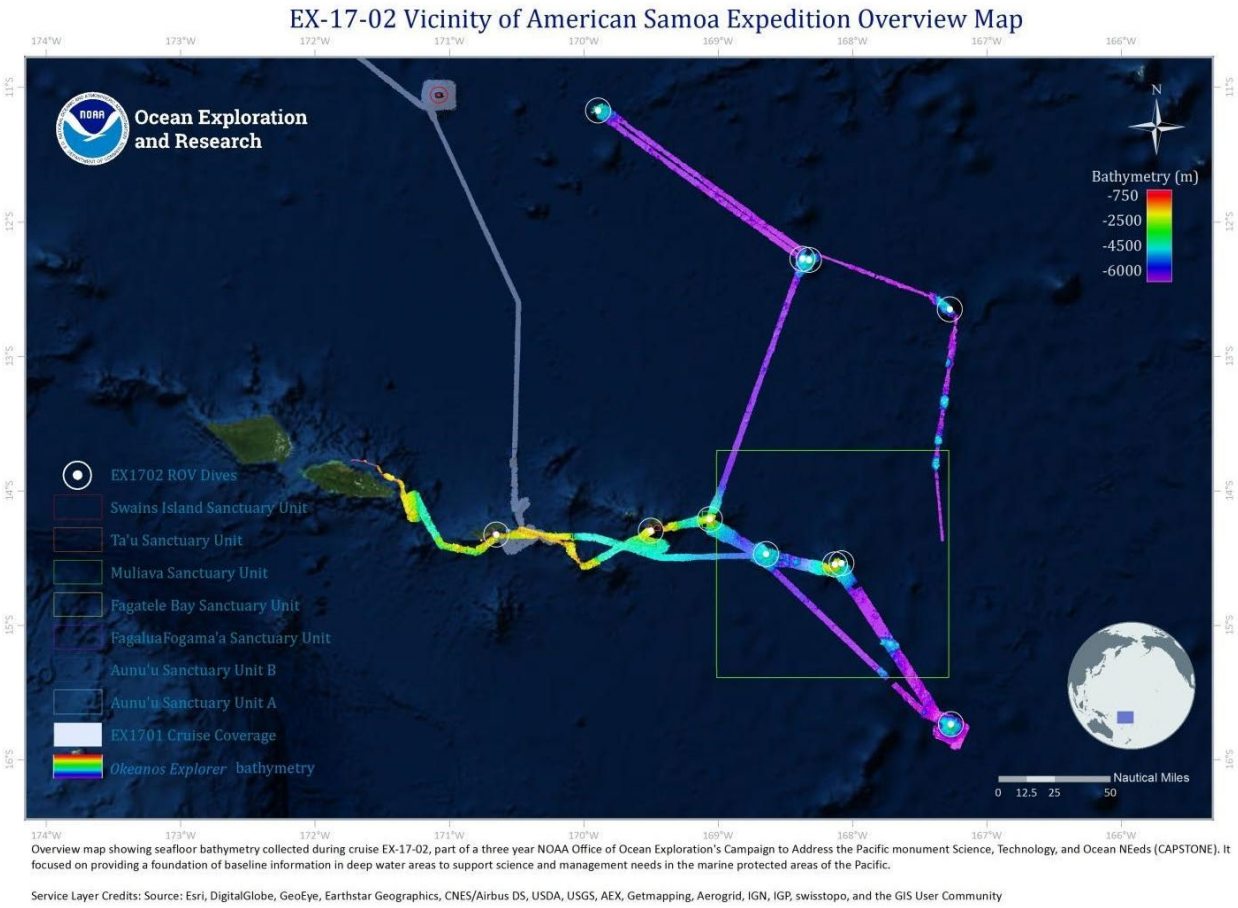


Figure 1. *Cruise map showing bathymetry acquired and ROV dive locations during cruise* EX-17-02. *The Rose Atoll Marine National Monument and Units of the National Marine Sanctuary of American Samoa are also shown.*

During the cruise, 11 ROV dives were successfully conducted from 250 to 3,931 meters depth to survey for a diversity of benthic habitats and features, including high-density deep-sea coral and sponge communities, hydrothermal vents, bottomfish habitats, seamounts, and the water

column (Figure 1). The ROVs spent a collective 90.3 hours in the water and 58 hours on the seafloor.

- Observed hundreds of different species of animals and significant coral and sponge communities. Identified distinct communities on seamounts that appear to be structured by environmental factors that vary with depth.
- Collected 101 biological specimens (31 primary specimens and 80 associates), including corals, anemones, zoanthids, hydroids, sponges, sea stars, feather stars, brittle stars, urchins, squat lobsters, amphipods, shrimp, barnacles, snails, and polychaete worms. As many as 30 of these specimens could represent new species, and most of the specimens from known species will represent new range records.
- Conducted five dives within the National Marine Sanctuary of American Samoa, including three within the Rose Atoll Marine National Monument, to collect a foundation of data and information to inform science and management needs.
- Surveyed for precious coral and bottomfish/fishery habitats during three dives.
- Conducted six dives on seamounts to survey deep-sea coral communities and manganese-encrusted seafloor habitats.
- Conducted one dive focused on midwater surveys to better understand this largely unknown biome and one dive to survey an active hydrothermal vent site.

More than 12,000 square kilometers of seafloor were mapped. Focused mapping surveys were conducted for a variety of reasons, including to support ROV dive site planning, update bathymetry along the pier at the port of Pago Pago, evaluate change in the crater of the Vailulu‘u submarine volcano, and chart unmapped areas offshore of Upolu, Samoa. The survey of Vailulu‘u Seamount revealed that the volcanic cone in the crater of Vailulu‘u – called Nafanua – had grown extensively since it was last mapped in 2012.

A variety of geological features were investigated with sample collection, including seamounts, volcanoes, manganese- encrusted seafloor, and an active hydrothermal vent site.

- Collected 30 rock samples for age dating and geochemical analysis that will help reveal the geologic history of American Samoa seamounts, atolls, and islands.
- Obtained samples from the youngest volcanic structures that formed in the Vailulu‘u volcanic crater since 2012. A subset of the species from older areas on the volcanic cone was observed in the more newly formed areas, indicating a possible succession order after disturbance/creation of new habitat in this ecosystem.

9.5 TB of data were collected, including multibeam sonar, single beam echo sounder, subbottom profiler, Acoustic Doppler Current Profiler (ADCP), expendable Bathy Thermograph

(XBT), CTD, surface oceanographic and meteorological sensors, video, imagery, and associated dive and video products. All the data will be made publicly available through national archives.

4.1 Calendar of Events

Date	Activities
2/13	Mission personnel arrived to ship in Pago Pago, American Samoa
2/14	Orientation, training and mobilization.
2/15	Ship tours. Orientation, training and mobilization.
2/16	Departed Pago Pago for first ROV dive site just outside of harbor. Aborted dive at Nautilus site due to ROV mechanical failure. Commenced transit exploration mapping overtop of East Bank en route to next dive site.
2/17	Dive 2: Dove in the Ta'u Unit of the Sanctuary. Overnight mapping of Vailulu'u crater en route to the next dive site.
2/18	Dive 3: Rose Atoll - Deep & Midwater Communities
2/19	Dive 4: Morning transit mapping. Focused mapping at Seamount 'D'. Aborted dive at seamount "D" due to weather. Transit mapping northward in heavy seas.
2/20	Dive 5: "Leoso Seamount". Contingency site due to tropical storm. Sonars secured for weather. Transit mapping northward in heavy seas.
2/21	Transit mapping in morning. Focused mapping at "Utu seamount". Dive 6: "Utu Seamount". Contingency site due to tropical storm. Transit mapping in evening.
2/22	Transit mapping in morning. Focused mapping at "Moki seamount". Dive 7: "Moki seamount". Contingency site due to tropical storm. Transit mapping in evening.
2/23	Transit mapping in morning. Dive 8: "Utu Seamount". Contingency site due to tropical storm. Open house at NOAA's IRC ECC. Transit mapping in evening.
2/24	Transit mapping in morning. Focused mapping at Vailulu'u Seamount including 3D Scanning. Dive 9: Vailulu'u Seamount. Live interaction with Ocean Center. Transit mapping in evening.
2/25	Transit mapping in morning. Dive 10: South Bank. Transit mapping in evening. Focused mapping at Seamount 'D'.
2/26	Transit mapping in morning. Dive 11: Seamount 'D'. Transit mapping in evening. Focused mapping at Malulu seamount.
2/27	Transit mapping in morning/focused mapping at Malulu Seamount. Dive 12: Malulu Seamount. Water column transects on ascent. Transit mapping in

	evening.
2/28	Transit mapping in morning. Dive 13: Nautilus Site. Live interaction with OSA & VIPs. [Failed] Test CTD cast to 10m in evening. Mapping in Samoan waters.
3/2	Pulled into port in Apia, Samoa.
3/3	Morning ship tours. Cruise demobilization. Evening presentation on Polynesian Celestial Navigation and Ocean Exploration.
3/4	Demobilization. Mission personnel departed.

4.2 Expedition Daily Log

February 13, 2017: Mission personnel arrived to the ship in Pago Pago, American Samoa.

February 14, 2017: Prepared for departure.

February 15, 2017: Ship tours conducted, with over 200 local students touring in the pouring rain.

February 16, 2017: The ship got underway in the morning in Pago Pago, American Samoa. An XBT was conducted immediately and multibeam data was collected to map the under-keel clearance at the dock in the harbor. The data was brought to the attention of the NOAA hydrographic branches for possible incorporation into the chart, which currently has out-of-date soundings. Mapping was conducted as the ship transited to the site of ROV Dive 01, just outside Pago Pago harbor.

The start of the first dive was delayed an hour for Schilling manipulator issues (detailed below). Dive 01 was conducted today at the only known Nautilus community site in U.S. waters, located outside of Pago Pago harbor. 12 scientists joined the dive from shore and a few observations were made in the water column. Shortly before the ROV arrived on the seafloor the pilots noticed one of the *D2* J Box comps was leaking and aborted the dive. Upon ROV early recovery, mapping immediately commenced, adding to coverage south of Tutuila, filling coverage gaps en route to Dive 02 at Ta'u. All sonars are collecting good data as expected.

The new LCI90i traction winch controller in the winch room isn't properly calculating wire out, speed, or tension. The engineering team is talking to the manufacturer and working to resolve the issue before a deep dive (more than 4,000 m) when tension readout is critical. The data management team spent the day sorting out collaboration tool issues.

February 17, 2017: Mapping consisted of focused mapping south of Ta'u in the morning, and immediate analysis for planning that day's ROV dive track. Dive 02 was conducted today at the Ta'u unit of the National Marine Sanctuary of American Samoa. More than 20 scientists joined the dive from shore and a diversity of animals were observed and documented. We had significant frustrations using SeaScribe during the first half of the dive and the shore support and ONC team continued to troubleshoot and make adjustments to SeaScribe in the morning. By the end of the day, use of the chatlog and SeaScribe seemed to go smoothly.

The science team spent much of the evening hand-writing sample labels and preserving the primary samples and their many associates. The engineering team made progress with the traction winch - the depth and speed readouts are now displaying properly. We think that there is a fix for the bug in the tension display that will work for tomorrow's dive and moving forward.

Mapping operations are going smoothly. The XBT autolauncher is being used for XBT casts. In the evening, transit mapping was conducted to Rose Atoll after the ROV was secured on deck. Focused mapping at Vailulu'u Seamount along the way revealed at least one major active gaseous plume, potentially a few minor plumes, and in increase in the height and girth of Nafanua, the recently discovered volcanic cone in the crater.

February 18, 2017: Rose Atoll eastern flank was mapped and data analyzed just prior to ROV launch in the morning. Dive 03 was conducted today at Rose Atoll Deep to investigate deep-sea habitats in the Monument, in particular potential deep-sea coral habitats, and geologic history. 25 scientists participated in the dive from shore and operations went smoothly. Transit mapping was conducted overnight en route to dive site 04 seamount "D" where focused mapping was conducted for dive planning.

February 19, 2017: Partial mapping of seamount "D" in the morning with immediate data analysis just prior to ROV launch to pick dive track. The ROV was deployed for Dive 04 today on unknown seamount B. The weather picked up after deployment and continued building, with wind gusts over 35 knots. We cancelled the dive and recovered the ROV. Due to the poor weather forecast for the next at least 48 hours, we headed north of our operating area to get into calmer waters. Tomorrow if conditions cooperate, we will dive on an unknown seamount north of Rose Atoll Marine National Monument that was not part of the original science plan. The science team spent the afternoon catching up on dive summaries, reviewing science outreach products and continuing to evaluate the weather to determine contingency plans for tomorrow and the next few days.

Transit mapping operations commenced with our transit north, however data quality on all sonars diminished in heavy seas. Data collection was secured for a few hours, then resumed in the afternoon and continued through the night.

February 20, 2017: Today's dive was delayed due to the long transit to get away from the developing storm system in our operating area, to a seamount located north of the Rose Atoll Marine National Monument. The combination of a long transit and the need to map part of the seamount before diving shifted the dive more than two hours past its original start time, and also shifted the recovery time. A seamount on the edge of the American Samoa / Cook Islands maritime border was mapped just prior to ROV Dive 05. Care was taken to not accidentally collect outer beams from the multibeam in New Zealand's waters. Dive 05 was conducted today on the American Samoa side of "Leoso" Seamount. 15 scientists participated in the dive from shore and operations went smoothly. Transit mapping in evening northward to continue to avoid tropical storms blasting American Samoa to our south.

February 21, 2017: Mapping of "Utu" seamount was conducted in preparation for today's dive. Dive 06 was conducted today on the unexplored "Utu" seamount in the north Samoan region to generate baseline information on the geology and geochemistry of this seamount. Operations continue to be conducted in the north Samoa region due to poor weather further south. The ROV team has inspected, fixed, re-installed and tested the manipulator arm last night; all looks good for Dive 07. The ADCP has been problematic for the past few dives. Evening transit mapping to "Moki" Seamount, ship continues to move north to avoid storm and dive on seamounts.

February 22, 2017: Overnight mapping was conducted en route to Dive site 07 with moderate data quality in heavy seas. The dive site was mapped in the early morning. Dive 07 was conducted today on "Moki" seamount in the north Samoan region, near the southern margin of the Manihiki Plateau. The weather is improving in our primary operating area and a second dive was selected on this site as a midway location to allow us to get back to our originally planned dive sites by February 24th.

During the end of today's dive, *D2* cameras were flickering and at one point *D2* lost comms fully for a few seconds with resulting fiber power drops. The engineering team immediately got into recovery position with the tether stretched out and the fiber power returned. We then ascended normally and had no more trouble.

February 23, 2017: Overnight transit mapping was conducted between dive 07 and dive 08. The line was run parallel to lines from 2/21 as dive sites 06 and 08 are on the same

seamount. Dive 08 was conducted today on “Utu” seamount in the north Samoan region, near the southern margin of the Manihiki Plateau. This was the second dive on “Utu”, selected as a mid-way site that would enable the ship to get back to our primary operating area by Feb. 24 if the weather continues to improve in our primary operating area as forecast. A major highlight of the dive was an observation of what looked to be a monoplacophoran mollusk – a living fossil known from soft bottom abyssal plains.

February 24, 2017: Overnight mapping en route to Vailulu'u Seamount occurred, ending with three passes at 8 kts to image the plume. Dive 09 was conducted today on Vailulu’u Seamount – an active undersea volcano that is part of the National Marine Sanctuary of American Samoa. The first hour of the dive was challenging as the turbidity in the water made it impossible to safely navigate the two-body ROV system visually or with sonar. Dive operations were moved above the 700m turbidity layer and explored the tops of all of the newly formed cones in the center of the crater. A live interaction was conducted during the dive with more than 170 students from elementary to college level, media and agency representatives at the Ocean Center in American Samoa. In the evening, several passes were made over the plume with the EM302 and EK60s at 2-3 knots, including a test dataset using the EM302 3D Scanning function to collect dense EM302 data at the plume site while holding station. The Automated XBT launcher is not working again.

February 25, 2017: Overnight mapping was conducted from Vailulu’u to Rose Atoll. Dive 10 was conducted today on Rose Atoll to gather information on habitats in bottomfish and deep and precious coral depth ranges in the Rose Atoll Marine National Monument. The entire dive was located within a mile of shore, and the full transect was not completed as the ending 250 m depth was less than 400 m from shore. The XBT autolauncher is working as expected.

February 26, 2017: In the morning transit mapping between Rose Atoll and Seamount “D” occurred on a parallel, overlapping track to the previous transit to Seamount “D”. Seamount “D” was mapped in its entirety upon arrival in the morning. Launch was delayed a half hour due to the vehicles losing power during the power on pre-dives. Dive 11 was conducted today at the Seamount “D”, and unnamed seamount south of the Rose Atoll Marine National Monument. The goal of this dive was to generate baseline information on the geology of this unexplored seamount and to learn more about its deep-sea habitats and biological communities. In the evening, transit mapping occurred from seamount “D” to the Malulu dive site.

February 27, 2017: The morning survey added coverage over Malulu Seamount. Dive 12 was conducted today on Malulu seamount to generate baseline information on deep-sea

habitats and biological communities, particularly deep-sea coral communities, to better understand their diversity and distribution and support management needs of the Rose Atoll Marine National Monument. The dive plan was split between a steep wall leading up to ridge summit at the top of the seamount. After the ROV came off bottom, water column transects were conducted with scientists in Hawaii for the ASLO aquatic sciences meeting. Evening mapping was conducted en route to a dive site south of Tutuila. The ADCP data/display used during ROV launch and recovery continues to intermittently cut out.

February 28, 2017: Morning transit mapping was conducted to the dive site. Dive 13 was conducted today at a site where Nautilus communities are known to exist. During the dive, a live interaction was held with the Office of Samoan Affairs and other officials at the Ocean Center. During the dive, a new 360-degree video camera (a 500m rated housing with six Go-Pros in it) was tested during the dive. A test CTD cast was planned after today's ROV dive. While using the J-Frame to begin operations, however, an oil leak occurred due to corrosion and the cast was cancelled. In the evening, the science leads were interviewed by Radio New Zealand International and *EX* team leads conducted a thorough cruise evaluation and wrap-up meeting with the ship (CO, XO, Ops). The ship crossed the dateline overnight transiting from American Samoa to Apia, Samoa. Evening mapping was conducted into Samoan waters to reach the sea buoy.

March 2, 2017: The ship pulled into Apia harbor this morning at 0930. A science summary call was conduct in the morning. The expedition coordinator and operations officer met with our US Embassy representatives in the afternoon to discuss Upolu and ship tours. An all hands was held with the mission team in the late afternoon to go over Upolu culture, customs, safety and logistics. Mission spaces were cleaned in preparation for ship tours.

March 3, 2017: Morning ship tours were conducted for local elementary, high school, college, maritime academy and conservation groups from 8am to noon. Media arrived at 10am. In the afternoon, personnel worked on cruise wrap-up. The survey team finalized reporting and cruise maps. In the early evening, Immigration returned to the ship to stamp passports. In the evening, the U.S. Embassy, Samoa Voyaging Society, NOAA and SPREP all co-hosted a presentation by GFOE's Dan Rogers at the Apia Yacht Club.

4.3. Dive Summary Table

Table 3: Summary of EX-17-02 ROV Dives

Dive #	Site Name	Date	Region	On Bottom Position	Off Bottom Position	Max Depth (m)	Length (HH:MM:SS)	Bottom Time (HH:MM:SS)	Science Focus/Theme
1	Nautilus Site	16-Feb	Taema Bank	N/A	N/A	526	0:49:33		Fisheries
2	Ta'u	17-Feb	Ta'u Unit	14°, 17.686' S ; 169°, 29.924' W	14°, 17.452' S ; 169°, 29.914' W	504.9	8:23:44	7:29:38	Sanctuaries, Fisheries
3	Rose Atoll Deep	18-Feb	Rose Atoll Marine National Monument	14°, 32.268' S ; 168°, 04.780' W	14°, 32.235' S ; 168°, 04.934' W	2528.0 m	8:10:6	5:13:07	Monument, Deep Corals
4	Seamount D	19-Feb	Samoa Basin Seamounts	N/A	N/A	439.0 m	0:36:04	N/A	Seamount, Deep Corals, Geologic history
5	Leoso Seamount	20-Feb	Northern American Samoa	12°, 38.994' S ; 167°, 16.287' W	12°, 38.916' S ; 167°, 16.286' W	3771.8 m	6:58:55	2:49:18	Seamount, Deep Corals, Geologic history
6	Utu Seamount	21-Feb	Northern American Samoa	12°, 16.902' S ; 168°, 19.268' W	12°, 16.876' S ; 168°, 19.058' W	3037.0 m	8:03:06	4:38:49	Seamount, Deep Corals, Geologic history
7	Moki Seamount	22-Feb	Northern American Samoa	11°, 10.143' S ; 169°, 53.530' W	11°, 10.007' S ; 169°, 53.533' W	2116.3 m	7:33:33	3:34:37	Seamount, Deep Corals, Geologic history
8	Utu Seamount	23-Feb	Northern American Samoa	12°, 16.452' S; 168°, 22.098' W	12°, 16.432' S ; 168°, 22.036' W	3931.9 m	8:17:14	3:52:24	Seamount, Deep Corals, Geologic history
9	Vailulu'u	24-Feb	Vailulu'u Seamount	14°, 12.642' S ; 169°, 03.515' W	14°, 12.972' S ; 169°, 03.581' W	928.5 m	10:03:49	8:22:26	Hydrothermal Vent, Sanctuary, Seamount
10	Rose Atoll Shallow	25-Feb	Rose Atoll Marine National	14°, 32.747' S ; 168°,	14°, 32.879' S ; 168°,	678.4 m	8:04:22	6:47:35	Monument, Fisheries

			Monument	07.645' W	07.949' W				
11	Seamount D	26-Feb	Samoa Basin Seamounts	15°, 43.981' S ; 167°, 15.878' W	15°, 44.089' S ; 167°, 15.828' W	3005.3 m	7:28:21	4:06:55	Seamount, Deep Corals, Geologic history
12	Malulu Seamount	27-Feb	Rose Atoll Marine National Monument	14°, 28.127' S ; 168°, 38.335' W	14°, 28.172' S ; 168°, 38.191' W	2469.9 m	9:54:26	4:58:11	Seamount, deep corals, Monument
13	Nautilus Site	28-Feb	Taema Bank	14°, 19.492' S ; 170°, 38.818' W	14°, 19.327' S ; 170°, 38.797' W	460.7 m	7:23:50	6:12:15	Fisheries

5. Summary of Findings

5.1 Summary of Completed Science Objectives

a. ***Acquire data to support priority Monument and Sanctuary science and management needs***:

Five dives were conducted within the National Marine Sanctuary of American Samoa: four within the Muliava Sanctuary Unit, including three within Rose Atoll Marine National Monument; and One within the Ta'u Sanctuary Unit. These areas were also mapped in advance of the dives using the multibeam sonar mounted on the *Okeanos Explorer*, filling data gaps in these areas and increasing the resolution of bathymetry maps. The dives within Monument and Sanctuary areas targeted depths between 250 and 2,500 meters, and characterized the habitat distribution, biological diversity, and geological setting in seamounts and hydrothermal vent areas via imagery and specimen collections.

Critical geological samples were obtained from the Monument and Sanctuary to evaluate the geologic history of the region. Basaltic samples were obtained on Monument/Sanctuary target locations: the deep flanks of Rose atoll, Malulu seamount and Vailulu'u seamount. Data collected on these samples will allow the community to obtain ages on the Rose atoll and Malulu seamount to assess their relationship with the Samoan hotspot. Additionally, ^{210}Po ages, to be obtained on the youngest flows from Vailulu'u seamount, will permit a better assessment of their absolute eruption ages. New mapping data obtained during the expedition were instrumental in evaluating the relative ages of new volcanic features in the

crater of Vailulu'u seamount, an active volcano located in the National Marine Sanctuary of American Samoa. New bathymetric data and geological samples were collected from the Sanctuary unit of Ta'u Island to better understand relationships between the geology and geologic history of the island.

***b.* Explore the diversity and distribution of benthic habitats – including commercially valuable bottomfish precious coral habitats, a Nautilus habitat, deeper high-density coral and sponge communities, and hydrothermal vents:**

i. ***Collect data on: habitat size and* Extent, animal diversity and density.**

11 dives were completed during the expedition to explore the distribution of benthic habitats, focusing on areas with highest-probability of deep-sea coral and habitat communities (steep slopes and ridges), within American Samoa. The following was the depth distribution of the dives: three dives at 700-250 m, the depth range for Nautilus, bottomfish and precious coral habitats (no precious corals were observed in any dive); one dive at the 900-700 m depth range (on an active volcano); three dives at the 2500-2000 m depth range; two dives at the 3000-2800 m depth range; and two dives at the 4000-3700 m depth range. More than 55 hours of seafloor footage were collected during these dives.

ii. Focus close-up imaging operations on potential new, rare and poorly documented animals as well as dominant members of the communities.

Collected more than 2,000 high-resolution close-up images of new, rare and poorly documented animals, as well as dominant taxa in the communities observed in American Samoa. These images will aid in the identification of species and community composition patterns.

iii. 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.

Collected 98 biological specimens (31 primary specimens and 77 associates), including corals, anemones, zoanthids, hydroids, sponges, sea stars, feather stars, brittle stars, urchins, squat lobsters, amphipods, shrimp, barnacles, snails, and polychaete worms. As many as 30 of these specimens could represent new species, and most of the specimens from known species will represent new records in American Samoa.

c. Conduct mapping survey operations over Vailulu'u seamount to look for evidence of change since 2005, and to explore vent activity.

The bathymetry collected during EX-17-02 shows that the cone in Vailulu'u crater has grown substantially, and has approximately doubled in volume (mostly laterally, not vertically) since 2012. Additionally, shipboard sonar data showed a plume extending from the northern part of the crater floor (near one of the locations where prior hydrothermal venting was observed during the 2005 *Pisces* dives; Staudigel et al., 2006); the plume is likely to be composed of CO_2 bubbles related to volcanic degassing. Unfortunately, owing to extreme turbidity in the water near the crater floor, the ROV was unable to observe the plume directly or explore the locus of hydrothermal activity that was observed in prior dives of the seamount (see Staudigel et al., 2006). See Section 5.2 and 5.3 (Biology and Geology) below for more details.

d. Conduct mapping survey operations to provide baseline seafloor information in an area where a Samoan Clipper was reported lost, to support future investigation.

The Samoa Clipper mapping survey was deferred to EX-17-04 due to inclement weather, which resulted in cancellation or modification of five of the originally scheduled dives.

e. Collect biological and geological data at sites to aid the understanding of the geologic history of Pacific seamounts.

During 11 successful ROV dives (13 dives were scheduled, but two were cancelled due to weather [dive 4] or equipment malfunction [dive 1]), the EX-17-02 expedition targeted several different types of seamounts and islands within the American Samoa EEZ. In total, nine different volcanoes were targeted and 30 rock samples were collected. Three successful dives were made on the submarine flanks of three different volcanoes related to the Samoan hotspot (Ta'u Island, Tutuila Island, Vailulu'u seamount), and samples obtained on these volcanoes will allow the community to evaluate the geologic evolution (including the early history) of Samoan volcanoes. Additionally, four successful dives were made on the submarine flanks of three different volcanoes located to the east and east-southeast of the Samoan hotspot, and samples from these volcanoes will allow the community to evaluate the geologic history of the volcanoes and their relationship with the Samoan hotspot: Rose atoll (two dives, one shallow and one deep), Malulu seamount, and seamount "D". Finally, four successful dives were made on three different volcanoes offset ~150 km to the north of the Samoan hotspot: "Leoso seamount", "Utu seamount" (two dives, one deep and one shallow), and "Moki seamount". Samples obtained on these northern volcanoes

will allow the community to evaluate the geologic history of these volcanoes and determine the origin of hotspot volcanism in the region immediately to the south of Manihiki plateau.

f. Continue to refine specimen collection protocols and processing procedures.

Sampling procedures were modified to include minor breakage of some of the rock samples (with hammer and chisel), to permit field identification of the samples. Otherwise, sampling and processing procedures remain unmodified from the description in section 3.2.2.

g. Ground-truth acoustic water column data using video imagery and characterize associated habitat.

Multibeam backscatter data in the crater of Vailulu'u seamount showed a plume extending from the northern part of the crater floor (near one of the locations where prior hydrothermal venting was observed during the 2005 *Pisces* dives; Staudigel et al., 2006); the plume is likely to be composed of CO_2 bubbles related to volcanic degassing. The ROV dive was planned to include surveying this plume, however extreme turbidity in the water prevented direct observation of the plume or the locus of hydrothermal activity. See Sections 5.2 and 5.3 below for more details.

***h. Engage a broad spectrum of the scientific community and public in telepresence-based* exploration.**

At least 48 scientists from 27 different institutions participated in dives during EX-17-02. These scientists joined from 12 U.S. states, Japan, Russia, Chile and Trinidad and Tobago. Full coverage of the expedition is available on the ocean *explorer*.noaa.gov website and the website content received ~33,200 views during the cruise, and the live video feeds received more than 6.2 million views via YouTube and Facebook. Additionally, two live interactions were conducted during the cruise with the Tauese P.F. Sunia Ocean Center in American Samoa to engage and share the expedition with ~170 local students, the Office of Samoan affairs, and other agency representatives and officials.

i. Successfully conduct operations in conjunction with shore-based exploration Command Centers and remote science team participants.

Onshore scientists (operating from ECCs and/or remote science team participants) played key roles in dive planning and dive execution. Throughout each dive, scientists on shore provided valuable feedback on sampling and guidance on where to direct the ROV. At least 48 scientists from 27 different institutions participated in dives during EX-17-02.

j. Create and provide input into standard science products to provide a foundation of publicly accessible data and information products to spur further* exploration*, research, and management activities.

Daily products were completed to enable initial site characterization of areas explored during the cruise. This included mapping data and products; ROV dive summary forms; ROV navigation products; *in situ* data from environmental sensors on the ROVs; high definition video and still frame images from ROV dives; science annotations in SeaScribe; still images of onboard samples; and completion of a sample database.

5.2 Biology

A total of 13 ROV dives were completed during the expedition, but only 11 reached the seafloor (one cancelled due to an ROV mechanical failure and another due to bad weather caused by tropical cyclone Bart). These dives focused on exploring benthic habitats and biodiversity within American Samoan waters, with an emphasis on areas with the highest-probability of deep-sea coral and habitat communities (steep slopes and ridges).

During the EX-17-02 American Samoa Expedition 98 biological specimens were collected (31 primary specimens and 77 associates), including corals, anemones, zoanthids, hydroids, sponges, sea stars, feather sea stars, brittle stars, urchins, squat lobsters, amphipods, shrimp, barnacles, snails, and polychaete worms. These samples are listed in Table C-2 (Appendix C). As many as 30 of these specimens could represent new species, and most of the specimens from known species will represent new range records. Most samples were preserved in ethanol, while several anemones and hydroids were preserved in diluted formalin. Large specimens, such as corals, sponges and ophiuroids were sub-sampled for DNA preservation using buffers and protocols provided by Ocean Genome Legacy. These collections will enable confirmation of new species designations, provide type specimens for descriptions and enable genetic analyses to establish evolutionary relationships with other known species.

Distinct communities were identified on seamounts. These communities appeared to be structured by environmental factors that vary with depth (see Figure 2). These communities will be compared to the communities that are known from areas like Hawaii and New Zealand, in addition to those that will be observed in past and subsequent CAPSTONE expeditions in the central pacific, to establish connection patterns and identify factors that define biogeographical provinces.

The following was the depth distribution of the dives:

- Three dives between 700-250 m (Dive 2 Ta'u Unit, Dive 10 Rose Atoll Shallow, and Dive 13 Nautilus Site off Tutuila island). This depth range targeted bottomfish and precious coral habitats, however no precious corals (octocoral family Coralliidae) were observed in any dive during the expedition. Other common deep-sea coral groups, the bubblegum corals (octocoral family Paragorgiidae) and sea pens (octocoral order Pennatulacea), were also conspicuously absent from the American Samoa region explored in this expedition. In general, these dives revealed greater abundance of organisms and apparent higher diversity of megafaunal species than deeper dives, as expected due to the negative relationship between depth and the abundance of organic particles in the deep-sea. Evident structuring of biological communities associated with depth was observed at this depth range, likely caused by the rapid temperature changes in the main thermocline. This depth range also targeted habitat areas for Nautili, which have been previously observed off Tutuila island using baited cameras. These animals are scavengers and are likely attracted by the waste generated from tuna cannery factories in Tutuila. No Nautili were observed in any dive, however significant amounts of trash and discarded fishing gear were observed in Dive 13, near the entrance of Pago Pago harbor.
- One dive (Dive 09 Vailulu'u) at the 900-700 m depth range. This dive aimed at characterizing the biological communities associated with active hydrothermal venting in the crater of Vailulu'u volcano, as well as the biological communities in areas of different age in the central cone of the volcano. The precipitation of particles from hydrothermal venting in the volcano's crater significantly impaired the visibility of the ROV and thus precluded the direct observation of venting sources and biological communities. The visibility on the shallower areas of the central eruptive cone were much better and we observed apparent changes in the community composition between newer and older areas of the cone. Newly erupted areas appeared to have a subset of the species found in older cone areas. Furthermore, the sizes of individuals of anemone and sponge species appeared to be smaller in the newer areas, compared to the older areas. Detailed analyses of the images and specimens collected from this area will be necessary to determine the significance of the observed patterns.
- Five dives between 3000 and 2000 m (Dive 03 Rose Atoll Deep, Dive 06 Utu Seamount, Dive 07 "Moki Seamount", Dive 11 seamount "D" and Dive 12 Malulu Seamount). The relatively high percentage of dives done at this depth rage was caused by the necessity of moving the operations northward during the weather systems that turned into tropical cyclone Bart, and the deep summits of seamounts in the American Samoa region. These dives revealed different communities from those observed at other depth ranges. Golden octocorals (family Chrysogorgiidae), bamboo octocorals (family Isididae),

and glass sponges were the dominant sessile fauna in these dives. Corals in this depth range reached the greatest sizes observed in the expedition (particularly *Iridogorgia* and *'Lepidisi'* specimens). Remarkable observations at these depth ranges included potential new species of goniasterid cookie sea stars as well as rhodalid benthic siphonophores.

- Two dives at 4000-3700 m depth range (Dive 05 Leoso Seamount and Dive 06 Utu Seamount). These dives were the deepest dives performed in the expedition. Similarly, to the 3000-2000 depth range, golden octocorals (family Chrysogorgiidae), bamboo octocorals (family Isididae), and glass sponges were the dominant sessile fauna in these dives, however the species appeared to be different and the sizes of organisms generally smaller. A remarkable observation was made in both dives; dark tracks of rock that had been cleared of sediments were observed. Upon closer inspection, it was determined that the tracks were generated by monoplacophoran mollusks. It is likely that this represented the first observation ever of these animals in their natural environment in the deep-sea, and likely constitute a new species.

More than 55 hours of seafloor footage were collected during these dives. This footage will require further analyses to test the significance of the general patterns observed of depth structuring, the characterization of the deep-sea fauna in the American Samoa region, and its biogeographical connections with surrounding areas in the Pacific.

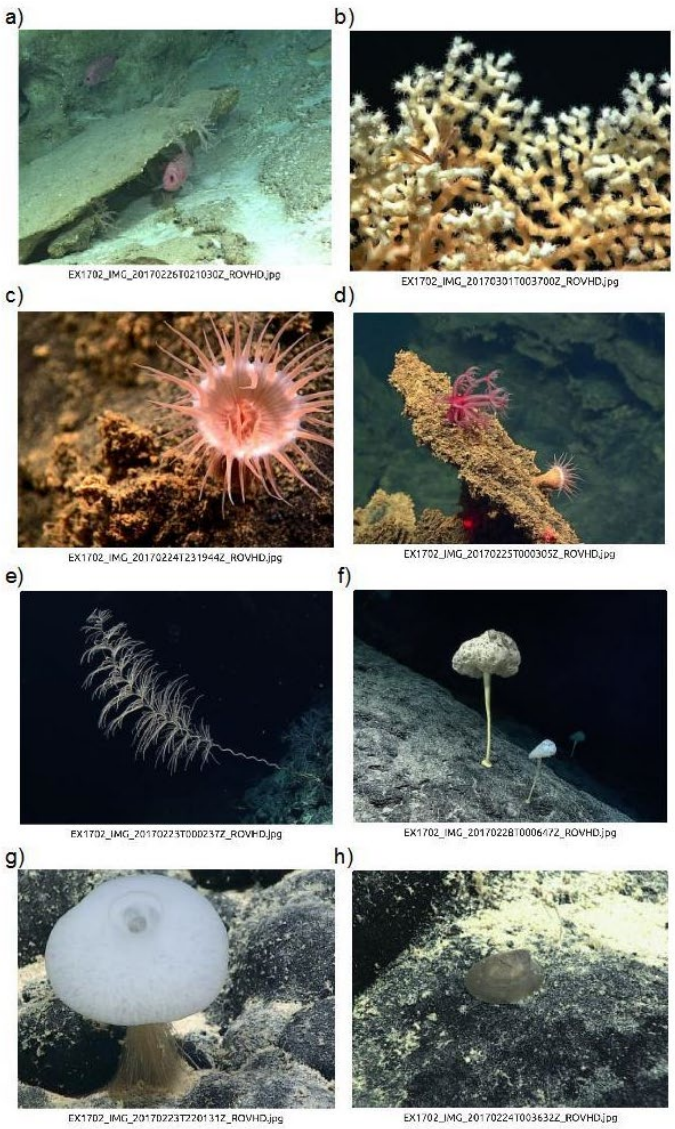


Figure 2. Representative biological observations at different depth ranges during the EX-17-02 American Samoa Expedition. a) Snappers and soft octocorals over carbonate terrain at ~330m, Dive 10 Rose Atoll shallow; b) Stony coral, with associated squat lobster, attached to a carbonate outcrop at ~286 m, Dive 13 Nautilus Site; c) Anemone species observed in both old and new areas of Nafanua cone in Vailulu'u seamount, Dive 09; d) Mushroom coral and large anemone observed in older areas of Nafanua; e) *Iridogorgia* golden chrysogorgiid octocoral at ~2037m, Dive 07 "Moki Seamount"; f) Potential new species of *Bolosoma* glass sponge at ~2420m, Dive 12 Malulu Seamount; g); Potbelly sponges likely genus *Hyalonema* at 3934m, Dive 08 "Utu Seamount". h) Monoplacophoran mollusk, and feeding trail, observed at 3838m, Dive 8 "Utu Seamount".

5.3 Geology

During eleven successful ROV dives (thirteen dives were scheduled, but two were cancelled due to weather [dive 4] or equipment malfunction [dive 1]), the EX-17-02 expedition targeted several different types of seamounts and islands within the American Samoa EEZ. In total, nine different volcanoes were targeted. Three successful dives were made on the submarine flanks of three different volcanoes related to the Samoan hotspot: Ta'u Island, Tutuila Island, Vailulu'u seamount. Additionally, four successful dives were made on the submarine flanks of three different volcanoes located to the east and east-southeast of the

Samoan hotspot: Rose atoll (two dives, one shallow and one deep), Malulu seamount, and seamount "D". Finally, four successful dives were made on three different volcanoes that are offset ~150 km to the north of the Samoan hotspot, in the northern region of the American Samoa EEZ: "Leoso seamount", "Utu seamount" (two dives, one deep and one shallow), and "Moki seamount".

In total, 30 rock samples were collected by the ROV during 10 of the 13 scheduled dives (no rock samples were collected on Dive 13). The rock samples are listed in Table C-1 (Appendix C). Of these 30 samples, seven are basaltic (with or without ferromanganese crusts), four of the samples are carbonates, seven samples are either lithified sediment or ferromanganese-encrusted sediment (but some of these samples may host basalt clasts within), seven of the samples are ferromanganese encrusted hyaloclastites (but the hyaloclastite designation may require modification pending further analysis), and five samples are likely to be highly altered basalts (but, again, this designation will require further analysis with thin sections).

A description of the salient observations made on the 11 successful dives follows:

1. **Samoan volcanoes with developed coral reefs and large submerged carbonate platforms: Rose atoll (shallow dive) and Tutuila island.** Two dives targeted the shallow portions of Rose atoll (Dive 10, maximum depth was 678 m) and Tutuila Island (Dive 13, maximum depth was 460 m), both of which have well developed coral reefs. Carbonate dominated the lithologies encountered on the dives of both volcanoes. Indeed, no basaltic samples were obtained on the shallow dive on Rose atoll, as only carbonate was observed (and no rock samples were collected on the Tutuila dive). Rose atoll and Tutuila island have likely subsided hundreds of meters, as both are inactive volcanoes far from their respective hotspots. The observation of extensive carbonate deposits on the flanks of both volcanoes is consistent with this hypothesis. Indeed, the bathymetry near the dive site on Tutuila shows at least two different submarine platforms that are likely to be submerged coral reef structures. Researchers interested in the geochemistry of reef-related carbonates may be interested in further characterizing the three carbonate samples collected on the flanks of Rose atoll.

2. **The youngest Samoan volcanoes: Ta'u island and Vailulu'u seamount.** Two dives targeted the two youngest volcanoes in Samoa, Ta'u Island and Vailulu'u seamount. Ta'u island is not volcanically active and no evidence for active submarine volcanism was observed in the ROV dive on Ta'u. The Ta'u ROV dive (dive 02, maximum depth was 505 m) targeted a buttressing ridge extending to the southwest of the island. Abundant scoria clasts and highly vesicular and angular blocks littered the landscape, and their

presence is consistent with an explosive volcanic origin. Two basalt samples were collected during the Ta'u dive, and a third sample, likely to be sedimentary in origin, was also collected.

The dive on Vailulu'u (Dive 09, maximum depth was 929 m) yielded some surprises. First, the bathymetry collected during EX-17-02 shows that the cone in Vailulu'u crater has grown substantially and has approximately doubled in volume since 2005 (see Figure 3). Second, a plume was observed that extends from the northern region of the crater floor, near one of the locations where prior hydrothermal venting was observed during the 2005 Pisces dives in Vailulu'u crater (Staudigel et al., 2005); the plume extends up into the water column and is likely to be composed of CO_2 bubbles related to volcanic degassing (Figure 4). Third, when the ROV descended to the crater floor (landing near the location where the plume intersects with the crater floor), the water near the crater floor was much more turbid than during prior dives made in 2005, and the ROV pilots were not able to operate the ROV with such limited visibility. The ROV moved to an older portion of Nafanua away from the crater floor (note that all of Nafanua cone is less than 18 years of age, as Nafanua did not exist when mapped in 1999). A sample was collected on this older portion of Nafanua, which likely formed prior to 2012 (i.e., the last time mapping was completed over Vailulu'u prior to the EX-17-02 expedition). The ROV then moved toward two new volcanic cones that were shown (using differential bathymetry) to have grown since the 2012 mapping expedition. Both cones revealed exceptionally fresh lava surfaces with relatively poorly-developed biological communities, consistent with a young volcanic age. The northern cone was sampled first (*D2*_DIVE09_SPEC05GEO), and the southern cone was sampled second (*D2*_DIVE09_SPEC06GEO). ^{210}Po analyses and basic geochemical characterization (e.g., major and trace element concentrations and Sr-Nd-Pb isotopic compositions) will be needed to determine eruption ages and mantle source origins for these new lava samples.

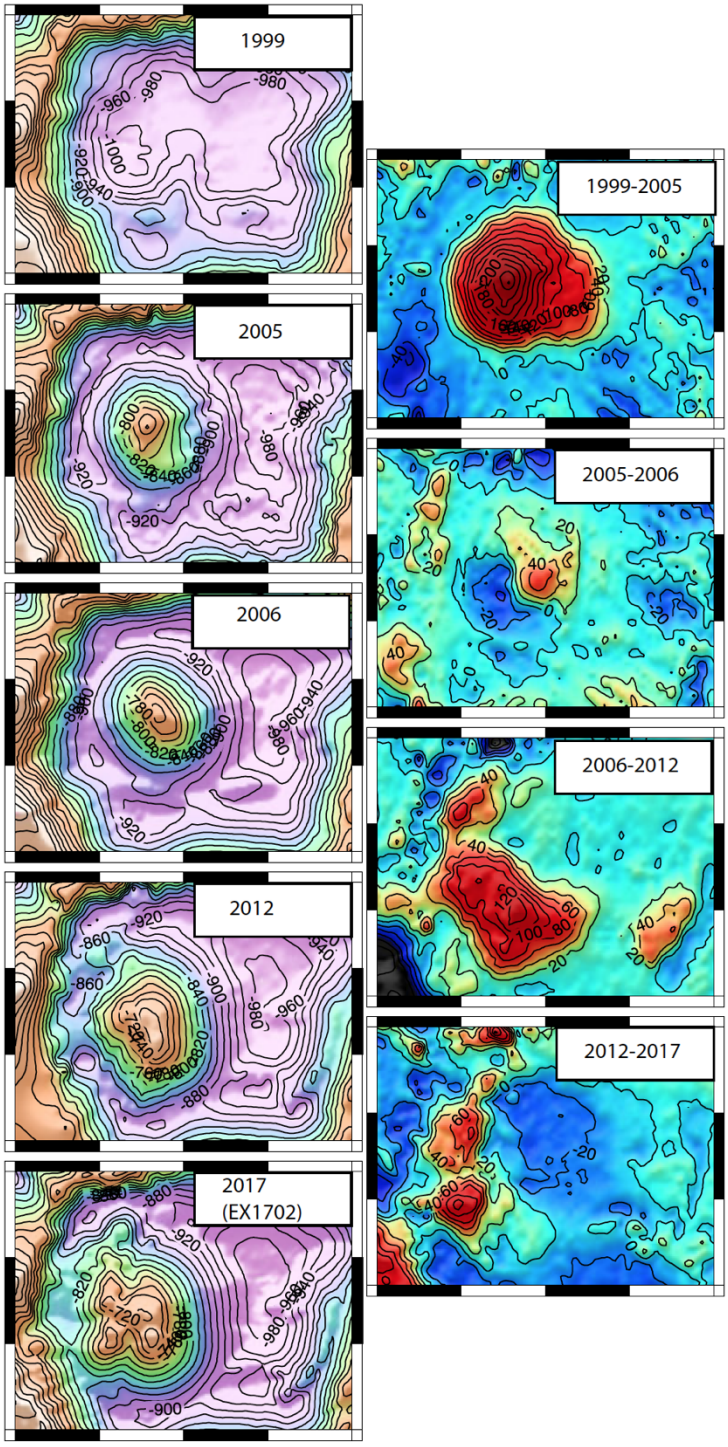


Figure 3. *Left panels: Multibeam bathymetry of Vailulu'u crater, showing growth of the central cone over time, and includes data from five different bathymetric surveys. Right panels: Differential bathymetry, showing magnitude and location of volcanic growth over time. Figure by Jasper Konter.*

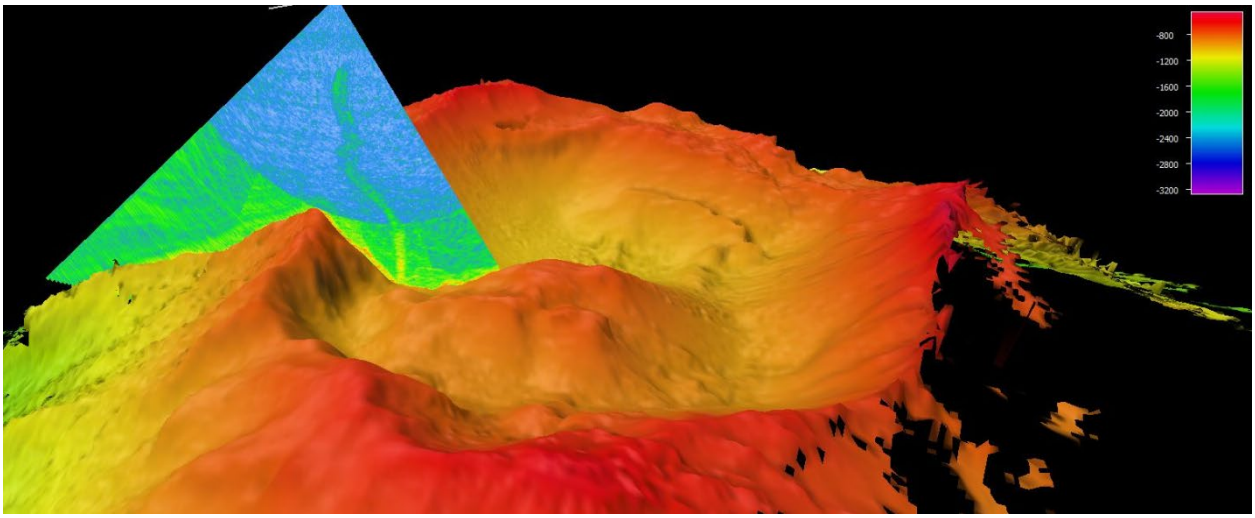


Figure 4. *Bathymetry of Vailulu'u seamount with a view of the summit crater. The central cone in the crater, called Nafanua, has experienced rapid growth from 1999 to 2017. Sonar detected a plume arising from the northern region of Vailulu'u crater, near a site of hydrothermal venting observed in 2005 (Staudigel et al., 2005). The plume is likely composed of gas bubbles (e.g., CO2) emanating from the volcano. The figure is based on data collected during the* EX*-17-02* expedition*. Figure by Meme Lobecker.*

3. **The eastern volcanoes: Rose atoll (deep dive), Malulu seamount and seamount "D".** The ROV dives also targeted the submarine flanks of three different volcanoes located to the east and east-southeast of Vailulu'u, the current location of the Samoan hotspot. Due to their location to the east of the Samoan hotspot, these three volcanoes are unlikely to be genetically related to the Samoan hotspot. Indeed, published geochemical data on dredged lavas from Rose atoll and Malulu seamount do not match the compositions expected for lavas related to the Samoan hotspot (Jackson et al., 2010). Two ferromanganese-encrusted basalt samples were obtained on the deep ROV dive on Rose atoll (Dive 03 on Rose atoll, maximum depth of 2528 m), and hyaloclastite and altered basalt samples (in addition to a carbonate sample) were obtained on dive 12 on Malulu seamount (maximum dive depth was 2469 m). Ages and geochemistry on these samples can be used to better constrain the origin of these two volcanoes, which have been suggested to be linked to hotspots in the Cook-Austral volcanic lineament (Jackson et al., 2010). The third volcano located to the east of the Samoan hotspot that was targeted during the expedition, seamount "D", is even closer to the Cook-Austral

volcanic lineament than Rose atoll and Malulu seamount. To test the hypothesis that seamount "D" is related to the Cook-Austral volcanic lineament, a deep ROV dive (Dive 11, maximum dive depth was 3005 m) targeted a steep face on the north side of the seamount. Four samples, possibly highly altered lavas, were collected. Geochemistry and radiometric ages on the seamount "D" lavas will help constrain the origin of this seamount.

4. **The far northern seamounts: "Leoso seamount", "Utu seamount", and "Moki seamount".** Four successful dives were made on three different un explored (and never before sampled) volcanoes that are located approximately 150 km to the north of the Samoan hotspot: "Leoso seamount", "Utu seamount" (two dives, one deep and one shallow), and "Moki seamount". Description of the four dives on these three seamounts follows:

    a. Dive 05 (maximum depth was 3772 m) targeted "Leoso seamount", which straddles the boundary between the American Samoa EEZ and the Cook Islands EEZ. The seamount is comprised of two distinct structures: The base of the seamount is composed of a larger flat-topped guyot; on top of this guyot is a smaller volcanic structure that is consistent with being a rejuvenated stage of volcanism on this seamount (notably, the rejuvenated structure is also flat-topped). The ROV sampled a steep portion of the southeast margin of the rejuvenated volcanic structure. The ROV transited up this margin with the goal of reaching the flat-topped portion of the rejuvenated volcanic structure. Unfortunately, the three samples obtained by the ROV do not clearly host basaltic material. However, some cuts with a rock saw (not available on the NOAA vessel) will help evaluate whether basaltic clasts exist in the interior of the samples.

    b. Dive 06 (maximum depth was 3037 m) targeted a shallow portion of "Utu seamount", which had never been sampled before. The seamount appears to be comprised of two distinct structures: the base of the seamount is composed of "lumpy" or "blocky" structures, perhaps consistent with pillow or pillow mounds; the basal portion of the volcano is similar in morphology to "pancake" seamounts. Constructed on top of this basal pancake structure is a volcanic structure that has both steeper and smoother sides than the basal pancake portion of the volcano. These two morphologically different structures of the volcano (i.e., the pancake basal portion and the steeper sided upper section) are consistent with two stages of volcanic activity on this seamount. It is notable that the summit of the seamount is nearly flat-topped and is host to a nicely developed volcanic crater: the center of the

crater hosts a volcanic cone, and the crater walls exhibit at least two different "step-like" features, consistent with partial crater collapse like that which is observed in calderas at basaltic shield volcanoes at oceanic hotspots. The ROV landed at the base of the volcanic cone in the crater, transited toward the crater wall, and then climbed up the steep sides of the crater wall; the ROV then crested the rim of the crater wall and summited the seamount. Unfortunately, like Dive 05, the three samples obtained by the ROV do not clearly host basaltic material. However, some cuts with a rock saw (not available on the NOAA vessel) will help evaluate whether basaltic clasts exist within the interior of the samples.

c. Dive 08 (maximum depth was 3932 m) targeted a deeper portion of "Utu seamount". The shallow portion of this seamount was explored by ROV (Dive 06) two days prior to this dive (Dive 08). The two morphologically different structures of the volcano (i.e., the pancake basal portion and the steeper sided upper section) are consistent with two stages of volcanic activity on this seamount. The dive track targeted the flanks of one of the deep "pancake" structures at the base of seamount. During the dive, the ROV transited up the side of a pancake structure, and then crested the rim of the pancake structure. Due to the limited shipboard equipment (a rock saw is not available on the NOAA vessel), it is not possible to determine with confidence whether basaltic clasts exist within the samples. Nonetheless, two of the three samples from this dive appear to be hyaloclastite that hosts altered basalt clasts, and the third sample may host altered basalt.

d. Dive 07 (maximum depth was 2116 m) targeted "Moki seamount". The seamount has a simple conical structure. There are a small number of scattered, smaller cones on the deep flanks of the seamount that may relate to a later stage of volcanism, but no such conical structures are visible on the shallower portions of the seamount (including the dive track of the ROV). The dive track targeted the largest continuous steep region visible in the bathymetry of the volcano. The dive track was designed to start several hundred meters beneath the summit of the seamount and move upslope along a ridge toward to the summit. Three hyaloclastite samples were obtained on "Moki seamount", and at least one sample is host to large (up to 1 cm) clinopyroxene phenocrysts that will be useful for evaluating the geochemistry of the seamount.

6. Summary of Mapping

More details are available in the expedition "Mapping Data Acquisition and Processing Summary Report", accessible from NCEI.

6.1 Mapping Statistics

Date	February 16 – March 2, 2017
Line kilometers of survey	2,622
Square kilometers mapped	12,309
Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files	295 files/ 12.1 GB
Number / Data Volume of EM 302 water column multibeam files	295 files / 42.9 GB
Number / Data Volume of EK 60 water column singlebeam files	74 files / 5.23 GB
Number / Data Volume of subbottom sonar files	36 files / 2.13 GB
Number of XBT casts	25
Number of CTD casts (including test casts)	0

6.2 Summary of Results

12,309 square kilometers of seafloor were mapped with multibeam sonar during the expedition (Figure 1) – an area 60 times the size of American Samoa. This included focused surveys to support ROV dive site planning, updated bathymetry along the pier at the Port of Pago Pago, evaluating change in the crater of Vailulu'u submarine volcano, areas offshore of Upolu, Samoa, and several previously unmapped seamounts.

Water column data was reviewed daily throughout the cruise to examine for the presence of seeps and other water column anomalies. One strong anomaly was detected in numerous survey lines at Vailulu'u Seamount. The 3D Scanning function in SIS was used while holding station over the plume. The ROV was unable to confirm the precise location and content of the source of the plume due to low visibility conditions and the effect of high acoustic noise in the steep, tight terrain on the ROV's forward scanning sonar.

The single plume was detected in several passes of the multibeam, as listed in the Table 4.

Table 4. *Repeat plume detections at Vailulu'u Seamount.*

Longitude (decimal degrees)	Latitude (decimal degrees)	Depth (meters)
-169.0597667	-14.20949444	-890.86
-169.059925	-14.21003056	-919.39
-169.0599583	-14.21011667	-917.83
-169.0598694	-14.209925	-908.39
-169.0595583	-14.20995278	-922.08
-169.059975	-14.20975556	-908.71
-169.0597389	-14.21026667	-913.01

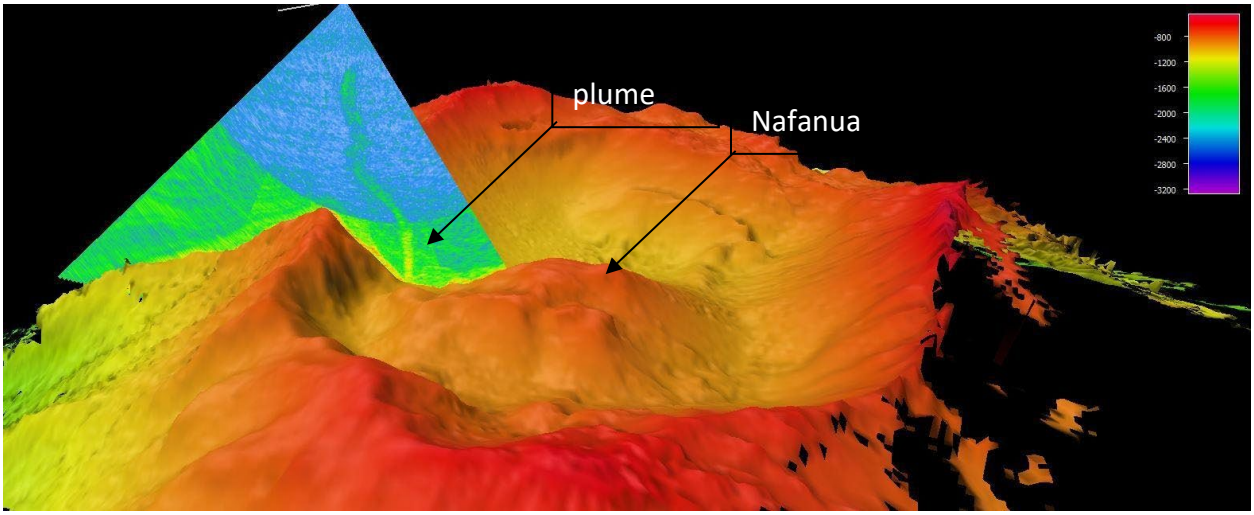


Figure 5. *Screenshot of water column anomaly found at Vailulu'u Seamount. Created in Fledermaus, vertical exaggeration 1. Depths in meters.*

Data collected in 2006 and 2012 at Vailulu'u Seamount was compared to EX-17-02 bathymetry data by personnel at PMEL, and it was determined that the central cone, Nafanua, has grown noticeably in height and width due to volcanic activity (Figure 5, 6). The preliminary results are in section 5.3 and in the graphic below, provided by Susan Merle of NOAA Pacific Marine Environmental Laboratory.

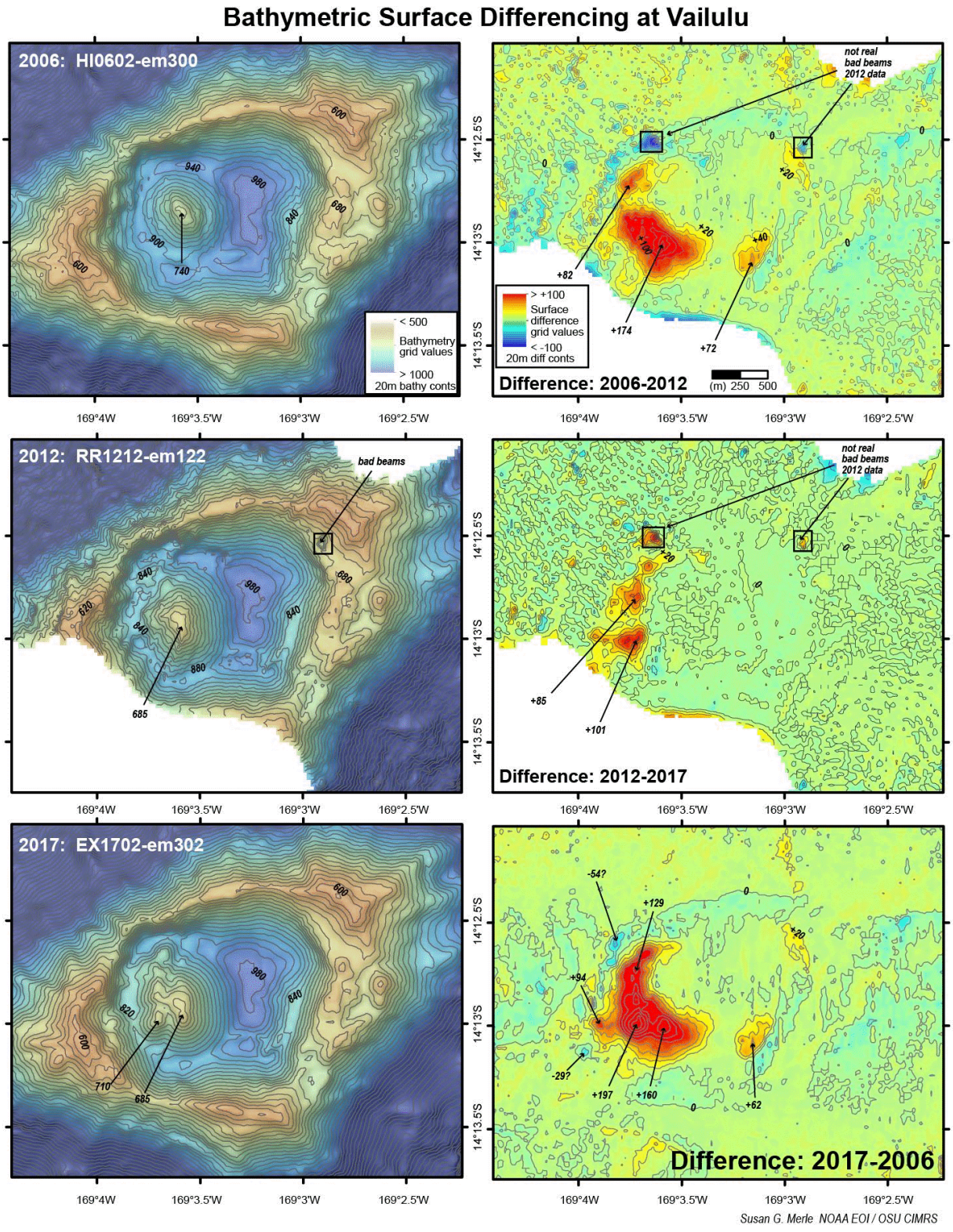


Figure 6. *Maps comparing three bathymetric surveys collected at Vailulu'u in 2006, 2012, and 2017 (left) and depth comparisons between them (right). Red areas show positive depth changes due to eruptions*

at Nafanua cone between the surveys. Image credit: Susan Merle, Oregon State University / NOAA EOI/CIMRS.

7. Data Deposition and Archival

The EX-17-02 Data Management Plan can be found in Appendix A of the EX-17-02 project instructions, available at: https://repository.library.noaa.gov/view/noaa/14336 (last accessed April 2020). The *Okeanos Explorer* Data Types and Product List can be found in Appendix D.

7.1 OER Data Discoverability Tools

All data collected by *Okeanos Explorer* are archived and publicly available within 90 days of the end of each cruise via the National Center for Environmental Intelligence (NCEI, formerly NGDC) online archives. Data can be accessed via the following websites:

- OER Digital Atlas at https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm (last accessed April 2020).
- OER ROV Data Archives at http://service.ncddc.noaa.gov/rdn/oer-rov-cruises (last accessed April 2020).

Details of mapping data collected during the expedition are available through Mapping Data and processing report available at https://doi.org/10.25923/mq6x-8m34 (last accessed April 2020).

Additional data requests are handled through the NOAA Ocean Exploration and Research Program Data Access Request Form which can be found here: https://docs.google.com/a/noaa.gov/forms/d/1pU3jbcV5ffunMKUbYgnA2OK-ZT9qj2Dh6JgZ79TTORM/viewform?formkey=dHAycC1MYndJb0hTdGRaYXAzVTVBdWc6MA&fromEmail=true (last accessed April 2020).

7.2 Sonar Data

Sonar data collected onboard *Okeanos Explorer* undergoes QA/QC after a cruise and is then made publicly available through the OER Data Discoverability Tools, the National Archives, and the following websites:

- All sonar data is permanently discoverable at: https://www.ngdc.noaa.gov/ (last accessed April 2020).

- NGDC Interactive Bathymetry Data Viewer: http://maps.ngdc.noaa.gov/viewers/bathymetry/ (last accessed April 2020).

- NGDC Interactive bathymetry data Viewer: https://maps.ngdc.noaa.gov/viewers/bathymetry/ (last accessed April 2020).

- EM 302 and EK 60 water column data, supporting data, and informational logs are available in the NCEI Water Column Sonar Archives: https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html (last accessed April 2020).

- Sub-bottom data, supporting data, and informational logs will be available in the NCEI Data Archives accessible at https://www.ngdc.noaa.gov/. For any challenges accessing SBP data, send an inquiry to ncei.info@noaa.gov requesting access to EX-17-02 Knudsen 3260 sub-bottom raw and processed data.

- Access ADCP archives for EX-17-02 from: https://www.nodc.noaa.gov/archive/arc0108/0162490/2.2/data/0-data/vessel/Ship_Sensor_Raw_Data/ADCP_Data/ (last accessed April 2020).

7.3 Physical Samples

Biologic samples were made available through the Smithsonian Institution's National Museum of Natural History Research and Collections. Here they were taxonomically identified, curated and made accessible through the Invertebrate Zoology Collection. Online metadata information about the samples, a searchable database, and information on how to request the samples is available online: http://invertebrates.si.edu/collections.htm (last accessed April 2020).

All geological samples were sent to the OSU Marine Geology Repository (http://osu-mgr.org/about-us/ , last accessed April 2020) where they were described and made publicly accessible.

Two samples of fresh basalt from Vailulu'u seamount (*D2*_DIVE09_SPEC05GEO and *D2*_DIVE09_SPEC06GEO) were subsampled for ^{210}Po analysis by Professor Ken Rubin and University of Hawaii, Manoa. When the samples are received by Prof. Rubin, the rock chips will be digested and dissolved in acid and a radioactive tracer (^{209}Po) added to them. Then, aliquots of the rock solution will be analyzed three times over the course of about 1 to 1.5 years. The age will be determined based on how much the ^{210}Po in the rock solution changes over that time. Normally the individual analysis data is not useful, except in the

context of the time-series, so results are not reported until the time series is done (i.e., 1.5 years after collection). Results of the ^{210}Po data as of March 2020 are available in Appendix M.

Selected coral and sponge specimens were split; one aliquot was sent to the Bishop Museum (http://www.bishopmuseum.org/collections-3/invertebrate-zoology/, last accessed April 2020) and another was sent to the Smithsonian. If it was determined that splitting would be too destructive to a particular specimen, it was provided to the Smithsonian Institution intact in order to provide public access to as many researchers as possible.

An additional small tissue sample for genetic analysis was taken of corals, sponges, and all other specimens when doing so would not effectively destroy the specimen. This tissue sample was preserved for later genomic DNA and RNA extraction at the Ocean Genome Legacy Center (https://cos.northeastern.edu/marinescience/, last accessed April 2020) in Northeastern University. These results are publicly accessible.

Crustaceans and any other commensal organisms found on the corals and sponges will be provided to the Smithsonian Institution.

Any other animals will also be sent to the Smithsonian Institution.

Note: An unplanned sediment sample was collected with *D2*_DIVE09_SPEC01BIO at Vailulu'u seamount. This sample was donated to Lehigh University's SEA PHAGE's program. Lehigh is one of over 84 institutions across the United States and Puerto Rico that participate in the HHMI-sponsored SEA PHAGES Program. In this program first and second year undergraduates have the opportunity to engage in discovery and research on novel bacteriophages that infect hosts of the order Actinomycetales. Because this research effort involves many institutions and thousands of undergraduates, all discoveries are shared through the publicly accessible website www.phagesdb.org. Important contributions to the field of phage biology have come from students who have participated in the Alliance since 2008. Several publications are listed in the website as good examples.

At Lehigh the ocean sediments will be used in an attempt to isolate phages that infect Actinomycetales hosts. If successful, the genomic DNA will be isolated for sequencing. Genomes would then be annotated and then compared to known genomes. All of this is done by undergraduates in a yearlong course. Genomic results are submitted to public repositories GenBank and phagesdb and shared with the phage community at an annual symposium. All results are accessible to the public through the phagesdb website and

through publications that may report these findings. Interestingly, the phage community has uncovered nearly identical phages only in a few instances from quite distant locales, raising questions about the evolutionary history of these phages. The potential of isolating phages from ocean sediments presents an interesting set of comparative genomics questions for students to explore.

8. Additional Information

EX-17-02 was the first of two cruises planned to focus operations in the waters of American Samoa, and one of five 2017 NOAA Ship *Okeanos Explorer* cruises that acquired data in American Samoan waters.

Cruise EX-17-04 was conducted from April 4-21, 2017 and conducted 24/7 mapping of high priority areas in American Samoa and Samoa.

Additional mapping and ROV targets were accomplished during other *EX* cruises as part of CAPSTONE, to address priority areas and sites identified by the science and management community. These included:

- EX-17-01: Mapping around Swain's Island (a unit of the NMSAS); on ridge features extending north east and south east from Tutuila; and mapping off the southeast coast of the island of Tutuila en route to port in Pago Pago, American Samoa.
- EX-17-03: An ROV dive on the flank of Swain's Island (a unit of the NMSAS) following departure from Pago Pago, American Samoa, en route to the Howland/Baker Unit of the Pacific Remote Islands Marine National Monument.
- EX-17-05: Conducted one dive in the Aunu'u Unit of the NMSAS.

Cruise records and direct links to archived data can be found on NOAA OER's Digital Atlas (https://www.ncei.noaa.gov/maps/oer-digital-atlas/mapsOE.htm, last accessed April 2020). Daily Situation Reports, internal operational records, are also on file with OER. For questions, please contact OER.

9. References

Staudigel, H., S.R. Hart, A. Pile, B.E. Bailey, E.T. Baker, S. Brooke, D.P. Connelly, L. Haucke, C.R. German, I. Hudson, D. Jones, A.A.P. Koppers, J. Konter, R. Lee, T.W. Pietsch, B.M. Tebo,

A.S. Templeton, R. Zierenberg, and C.M. Young (2006). Vailulu'u Seamount, Samoa: Life and death on an active submarine volcano. *PNAS* **103**, 6448-6453.

Jackson, M.G., S.R. Hart, J.G. Konter, A.A.P. Koppers, H. Staudigel, M.D. Kurz, J. Blusztajn, J.M. Sinton (2010). The Samoan hotspot track on a "hotspot highway": Implications for mantle plumes and a deep Samoan mantle source. *Geochem. Geophys. Geosyst*. (G-cubed) **11**, doi:10.1029/2010GC003232.

10. Appendices

APPENDIX A: Data Management Plan

Data Management Plan
Okeanos Explorer (EX1702): Vicinity of American Samoa (ROV/Mapping)

OER Data Management Objectives
Test, refine, and document the newest requirement updates to the Sampling Operations Database Application (SODA) and the onboard sampling protocol updates. Monitor data pipelines for first FY17 ROV mission, making any needed adjustments as necessary.

06-Feb-17

1. General Description of Data to be Managed

1.1 Name and Purpose of the Data Collection Project

Okeanos Explorer (EX1702): Vicinity of American Samoa (ROV/Mapping)

1.2 Summary description of the data to be collected.

Operations will include the use of the ship's deep water mapping systems (Kongsberg EM302 multibeam sonar, EK60 split-beam fisheries sonars, Knudsen 3260 chirp sub-bottom profiler sonar, and Teledyne Acoustic Doppler Current Profilers), XBT and Underway CTD casts in support of multibeam sonar mapping operations, OER's 6000 m two-body ROV Deep Discoverer and Seirios, and the ship's high-bandwidth satellite connection for continuous real-time ship-to-shore communications.

1.3 Keywords or phrases that could be used to enable users to find the data.

expedition, exploration, explorer, marine education, noaa, ocean, ocean discovery, ocean education, ocean exploration, ocean exploration and research, ocean literacy, ocean research, OER, science, scientific mission, scientific research, sea, stewardship, systematic exploration, technology, transformational research, undersea, underwater, Davisville, mapping survey, multibeam, multibeam backscatter, multibeam sonar, multi-beam sonar, noaa fleet, okeanos, okeanos explorer, R337, Rhode Island, scientific computing system, SCS, single beam sonar, singlebeam sonar, single-beam sonar, sub-bottom profile, water column backscatter, American Samoa, Samoa, Rose Atoll, Malulu Seamount, Vailulu'u Seamount, South Bank, East Bank, Tutuila Island, Upolo Island, Papatua, National Marine Sanctuary of American Samoa, Rose Atoll Marine National Monument, Ta'u Unit, Pago Pago, Apia, Prime Crust Zone, deep sea minerals, habitat surveys, deep sea coral and sponge communities, Central Pacific Seamounts, plate techtonics, subduction zone biology, subduction zone geology, biogeographic patterns, CAPSTONE, Campaign to Address Pacific monument Science, Technology, and Ocean Needs

1.4 If this mission is part of a series of missions, what is the series name?

Okeanos ROV Cruises

1.5 Planned or actual temporal coverage of the data.

Dates: 2/16/2017 to 3/2/2017

1.6 Planned or actual geographic coverage of the data.

Latitude Boundaries:	-16.6	to	-13.4
Longitude Boundaries:	-172.3	to	-165.2

1.7 What data types will you be creating or capturing and submitting for archive?

Okeanos Explorer (EX1702): Vicinity of American Samoa (ROV/Mapping)

Cruise Plan, Cruise Summary, Data Management Plan, Highlight Images, Quick Look Report, ADCP, Bottom Backscatter, CTD (processed), CTD (product), CTD (raw), Dive Summaries, EK60 Singlebeam Data, Expedition Cruise Report, HDCS, Highlight Video, Images, Mapping Summary, Multibeam (image), Multibeam (processed), Multibeam (product), Multibeam (raw), NetCDF, Raw Video (digital), Raw Video (physical), Salinity data, Sample Logs, SCS Output (compressed), SCS Output (native), Selected Raw Video, Sub-Bottom Profile data, Temperature data, Water Column Backscatter, XBT (raw)

1.8 What platforms will be employed during this mission?

NOAA Ship Okeanos Explorer, Deep Discoverer ROV, SEIRIOS Camera Sled

2. Point of Contact for this Data Producing Project

Overall POC:	Kelley Elliott, NOAA Office of Ocean Exploration and Research, kelley.elliott@noaa.gov
Title:	Expedition Coordinator
Affiliation/Dept:	NOAA Office of Ocean Exploration and Research
E-Mail:	kelley.elliott@noaa.gov
Phone:	(301) 734-1024

3. Point of Contact for Managing the Data

Data POC Name:	Andrew O'Brien, Jonathan Jackson, Susan Gottfried
Title:	Onboard Data Manager, Sample Data Manager, Stewardship Data Manager
E-Mail:	andrew.obrien@tgfoe.org, jonathan.jackson@noaa.gov, susan.gottfried@noaa.gov

4. Resources

4.1 Have resources for management of these data been identified? True

4.2 Approximate percentage of the budget devoted to data management. (specify % or "unknown")

unknown

5. Data Lineage and Quality

5.1 What is the processing workflow from collection to public release?

SCS data shall be delivered in its native format as well as an archive-ready, documented, and compressed NetCDF3 format to NCEI-MD; multibeam data and metadata will be compressed and delivered in a bagit format to NCEI-CO

5.2 What quality control procedures will be employed?

Quality control procedures for the data from the Kongsberg EM302 is handled at UNH CCOM/JHC. Raw (level-0) bathymetry files are cleaned/edited into new data files (level-1) and converted to a variety of products (level-2). Data from sensors monitored through the SCS are archived in their native format and are not quality controlled. Data from CTD casts and XBT firings are archived in their native format. CTDs are post-processed by the data management team as a quality control measure and customized CTD profiles are generated for display on the Okeanos Atlas (explore.noaa.gov/okeanosatlas).

6. Data Documentation

6.1 Does the metadata comply with the Data Documentation Directive? True

6.1.1 If metadata are non-existent or non-compliant, please explain:

not applicable

6.2 Where will the metadata be hosted?

Organization: An ISO format collection-level metadata record will be generated during pre-cruise planning and published in an OER catalog and Web Accessible Folder (WAF) hosted at NCEI-MS for public discovery and access. The record will be harvested by data.gov.

URL: https://www.ncddc.noaa.gov/oer-waf/ISO/Resolved/2017

Meta Std: ISO 19115-2 Geographic Information with Extensions for Imagery and Gridded Data will be the metadata standard employed; a NetCDF3 standard for oceanographic data will be employed for the SCS data; the Library of Congress standard, MAchine Readable Catalog (MARC), will be employed for NOAA Central Library records.

6.3 Process for producing and maintaining metadata:

Metadata will be generated via xml editors or metadata generation tools.

7. Data Access

7.1 Do the data comply with the Data Access Directive? True

7.1.1 If the data will not be available to the public, or with limitations, provide a valid reason.

Not Applicable

7.1.2 If there are limitations, describe how data are protected from unauthorized access.

Account access to mission systems are maintained and controlled by the Program. Data access prior to public accessibility is documented through the use of Data Request forms and standard operating procedures.

7.2 Name and URL of organization or facility providing data access.

Org: National Centers for Environmental Information

URL: https://explore.noaa.gov/digitalatlas

7.3 Approximate delay between data collection and dissemination. By what authority?

Hold Time: not applicable

Authority: not applicable

7.4 Prepare a Data Access Statement

No data access constraints, unless data are protected under the National Historic Preservation Act of 1966.

8. Data Preservation and Protection

8.1 Actual or planned long-term data archive location:

Data from this mission will be preserved and stewarded through the NOAA National Centers for Environmental Information. Refer to the Okeanos Explorer FY16 Data Management Plan at NOAA's EDMC DMP Repository (EX_FY16_DMP_Final.pdf) for detailed descriptions of the processes, procedures, and partners involved in this collaborative effort.

8.2 If no archive planned, why?

Okeanos Explorer (EX1702): Vicinity of American Samoa (ROV/Mapping)

8.3 If any delay between data collection and submission to an archive facility, please explain.

8.4 How will data be protected from accidental or malicious modification or deletion?

Data management standard operating procedures minimizing accidental or malicious modification or deletion are in place aboard the Okeanos Explorer and will be enforced.

8.5 Prepare a Data Use Statement

Data use shall be credited to NOAA Office of Ocean Exploration and Research.

APPENDIX B: ROV Dive Summary Forms

Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	South coast of Tutuila Island, Nautilus exploration (250 – 500 m water depth)		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Samoan region, South coast of Tutuila Island		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	01		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ LSS	☒ ORP
	☒ Scanning Sonar	☒ Depth	☒ Altitude
	☒ Pitch	☒ USBL Position	☒ Heading
	☒ Roll	☒ HD Camera 1	☒ HD Camera 2

	☒ Low Res Cam 1	☒ Low Res Cam 2	☒ Low Res Cam 3
	☒ Low Res Cam 4	☒ Low Res Cam 5	☒
Equipment Malfunctions	Hydraulic leaks on the 1) Schilling Orion manipulator and 2) the oil compensation system. These forced cancellation of the dive		
ROV Dive Summary (from processed ROV data)	Dive Summary: EX1702_DIVE01 ^^ In Water: 2017-02-17T00:49:09.265000 14°, 19.620' S ; 170°, 38.731' W Out Water: 2017-02-17T01:38:42.589000 14°, 19.519' S ; 170°, 38.747' W Dive duration: 0:49:33 Bottom Time: N/A Max. depth: 526.0 m		
Special Notes	The dive was cancelled owing to equipment malfunction. The dive never reached bottom.		
Scientists Involved (please provide name, location, affiliation, email)	Chris Kelley (UH), Tara Harmer Luke (Stockton U), Amanda Netburn (NOAA OER), Mike Vecchione (NMFS), Bruce Mundy (NOAA NMFS), Joe O'Malley (PIFSC), Peter Auster (UConn), Diva Amon (Trinidad), Asako Matsumoto, (PERC/CIT), Deb Glickson (NASEM), Ryan Nichols (PIFSC).		
Purpose of the Dive	*The following text was from the original dive plan, but is included here for completeness:* This dive seeks to characterize a population of protected Nautili that has been observed using baited cameras in the Taena Bank area, at depths between 300 and 400 meters, near the harbor of Pago Pago, American Samoa. This is also the depth range for bottomfish and precious corals. From a geologic standpoint, this dive presents an important opportunity to sample the shallow volcanic stratigraphy of Tutuila island. The dive will begin at a depth of approximately 500 meters on a relatively steep wall, with a slope of 40-70 degrees. This wall is likely to have exposed basalt. Sampling 1 or 2 basalt samples from this steep wall would provide a record of the deepest volcanic stratigraphy on this dive. The ROV will climb <100 m to a relatively flat platform that is likely a submerged coral terrace. After traversing this terrace, the ROV will then move up another relatively steep wall—likely to present outcroppings of basalt—that terminates at the modern reef platform at an approximate depth of ~250m; this dive presents an opportunity to obtain 1 or 2 additional samples of the shallower volcanic stratigraphy likely to be present on the second steep wall. At the 250m contour we will move laterally along the second platform edge. A water column transect may be conducted at 250 m for 30-60 minutes to		

	characterize mid-water communities and possible vertical migration of nautiluses. 2-3 biological samples will be collected along this transect.
Description of the Dive	NA. The ROV achieved a depth of ~500 m and had to surface, due to the leak in the oil compensation system. The dive was cancelled and did not reach bottom.

Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
NA. The dive was cancelled.	NA. The dive was cancelled.
NA. The dive was cancelled.	NA. The dive was cancelled.
Representative Photos of the Dive	

 EX1702_IMG_20170217T005308Z_ROVHD.jpg	 EX1702_IMG_20170217T011810Z_CPHD.jpg
[Descriptive caption here]	[Descriptive caption here]

Samples Collected		
Sample		
Sample ID		[*in situ* image of specimen here]
Date (UTC)		
Time (UTC)		
Depth (m)		
Temperature (°C)		
Field ID(s)		
Comments		
Sample		
Sample ID		[*in situ* image of specimen here]
Date (UTC)		
Time (UTC)		
Depth (m)		
Temperature (°C)		
Field ID(s)		
Comments		
Sample		
Sample ID		[*in situ* image of specimen here]
Date (UTC)		
Time (UTC)		
Depth (m)		

Temperature (°C)		
Field ID(s)		
Comments		
Sample		
Sample ID		[*in situ* image of specimen here]
Date (UTC)		
Time (UTC)		
Depth (m)		
Temperature (°C)		
Field ID(s)		
Comments		

Please direct inquiries to:

NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014

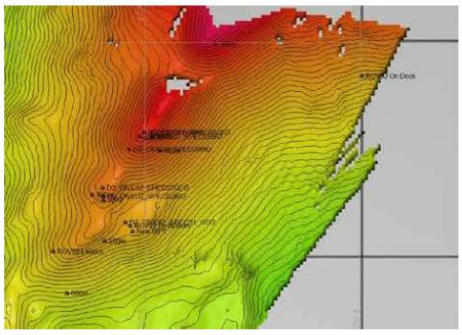
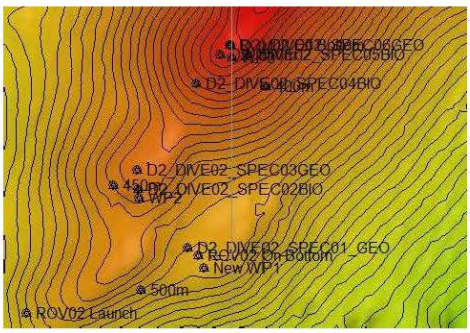
Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	South coast of Ta'u Island, Marine Sanctuary (500 - 350 m water depth)		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Samoan region, South coast of Ta'u (Ta'u Unit)		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	02		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ LSS	☒ ORP
	☒ Scanning Sonar	☒ Depth	☒ Altitude
	☒ Pitch	☒ USBL Position	☒ Heading
	☒ Roll	☒ HD Camera 1	☒ HD Camera 2

	☒ Low Res Cam 1	☒ Low Res Cam 2	☒ Low Res Cam 3
	☒ Low Res Cam 4	☒ Low Res Cam 5	☒
Equipment Malfunctions	Port manipulator not onboard		
ROV Dive Summary (from processed ROV data)	In Water:	2017-02-17T19:15:04.058000 14°, 17.736' S ; 169°, 30.056' W	
	Out Water:	2017-02-18T03:38:48.544000 14°, 17.406' S ; 169°, 29.724' W	
	Off Bottom:	2017-02-18T03:23:21.648000 14°, 17.452' S ; 169°, 29.914' W	
	On Bottom:	2017-02-17T19:53:43.320000 14°, 17.686' S ; 169°, 29.924' W	
	Dive duration:	8:23:44	
	Bottom Time:	7:29:38	
	Max. depth:	504.9 m	
Special Notes			
Scientists Involved (please provide name, location, affiliation, email)	Santiago Herrera, Lehigh University Matthew Jackson, UC Santa Barbara Chris Kelley, UH Manoa Natalie Summers, UH Manoa Bruce Mundy, NOAA PIFSC Joe O'Malley, NOAA PIFSC Erik Cordes, Temple University Peter Auster, UConn) Chris Mah, Smithsonian Tina Moldostova, PP SOI/RAS Diva Amon, UH Manoa		
Purpose of the Dive	The goal of this dive is to generate baseline information on deep sea habitats and biological communities to better understand their diversity and distribution and support management needs of the National Marine Sanctuary of American Samoa, and scientific interests. The dive will begin around 500 m on the southern face of the ridge shown in the bathymetry map. We will climb on the ridge and then continue moving upslope along the crest of the ridge reaching the end of the dive. The dive will begin in precious coral depths and at the lower limit of the bottomfish fishery, then move up into more of the prime depths for bottomfish. A submersible dive was made on the north side of the island in 2005. New species/records of organisms and basalt rock samples from a new dive on the south side of the island may be useful to trace the history of the island.		

Description of the Dive	The dive track is on the large ridge (rift zone) extending away from the southwest side of Ta'u. This particular dive track was designed start on the side of the ridge, then move west up the side of the ridge to the ridge crest. Upon reaching the ridge crest, the ROV would turn and head northeast, following the ridge crest. The depth range of the dive was optimized to arrive just outside of the Ta'u Unit of the National Marine Sanctuary and enter the sanctuary from the southeast over the course of the dive. **Geology perspective** The first view of the ocean floor revealed a relatively flat area. The geology in the field of view consisted entirely of small (1-5 cm clasts) of vesicular basalt, possibly scoria or rubble; all of this substrate was lightly dusted with a light-colored sediment. As the ROV moved forward, several larger cobbles appeared, scattered among the small scoria clasts; one of these cobbles (a ~12 cm loose rock) was the first geologic sample (A shrimp kept circling the cobble as we collected it). At a distance of 70 meters Along Dive Track from "On Bottom" Location (ADTOBL), larger basaltic clasts and boulders (up to 20 or 30 cm) became more abundant, all having the appearance of basalt with relatively little weathering (like due to the fact that all dated rocks from Ta'u are <70,000 years in age). At 110 m ADTOBL, the substrate is no longer clearly a scoria. Instead, the substrate may be pillow tops coated with a thin veneer (<1 cm) of sediment, and Chris Kelley even suggested that this might be a carbonate substrate with occasional basalt clasts on the surface. At 160 m ADTOBL, only 10 meters below the ridge crest, we encountered a abundant clasts and small boulders (<40 cm) of basaltic composition covering the entire field of view. All clasts and boulders were angular and dark in color, except for a single light colored, rounded boulder which appeared to be a basaltic rocks partially covered in carbonate (the rounding may have occurred in a shallow environment and the boulder rolled downhill). On the ridge crest at 175 m ADTOBL, rocks with ropy pillow textures appeared in outcrops, and a large boulder (the largest identified thus far, at 2x4x3 m) appear in the field of view, with another even larger ~5 m further on. A loose basaltic clast near these large boulder outcrops was collected (the second geology sample of this dive), and the clast appeared to have been originally attached to the large boulder outcrop. At 250 m ADTOBL, the substrate was quite similar to the location where the ROV first arrived on bottom, and the area was relatively flat and devoid of larger rocks. At this juncture, Jasper Konter suggested that the geology that we had observed over > 200 m was broadly consistent with being an explosive volcanic deposit, with angular basaltic clasts and boulders (mostly highly vesicular) randomly distributed among a rubble consisting of small (<2 cm) socriaceous rubble. To test this hypothesis, the ROV pilot bumped the ROV into the sustrate (which is similar to the substrate that had been observed over much of the divetrack) away from large clasts and boulders; the substrate was soft and comprised largely of reddish clay and hosted abundant pebbles of scoria, reminiscent of altered volcanic tephra in Iceland. Later in the dive (at 00:07:35 UTC), a new substrate was encountered that was relatively common for the rest of the dive: It is comprised of relatively flat and solid material that does not have the appearance of basalt, but instead looks like volcanic sediment that has been welded together with a chemical precipitate "cement" (possibly carbonate); this substrate breaks into large (up to 1 or 2 meters) flat blocks with linear edges, and the blocks are only 5-10 cm thick; some linear features between the blocks have the appearance of gulleys that are perhaps 10 to 20 cm deep and equally wide.

	This substrate continues until at least 1:35:00 UTC. At 02:17:00, the substrate is similar to that which was exposed when the ROV intentionally bumped into seafloor, and a thin blank of light-colored sediment partially covers the substrate; basaltic clasts and boulders (and possible outcrops) appear in the field of view. Near the end of the dive, a loose boulder near (and likely originally attached to) a basaltic outcrop was sampled, and this was the third geologic sample of the dive. **Biology perspective** ROV landed on a relatively flat area at 500m on the south face of the ridge. Bottom covered by cobbled rocks, observed several stripped squat lobsters, several large-claws pagurid crabs with a zoanthid symbionts, and a few cup corals. Also observed robin fish, a few shrimp with large eyes, and a snake eel. Red/purple urchins were abundant. Also observed a chrysogorgid coral (*Chrysogorgia*), and a toad fish (*Chaunax*) with unusual coloration (green dorsal red ventral). Collected a basalt rock sample. As we moved north to begin climbing on top of the ridge we began observing larger basalt boulders, many sponges, ophiuroids, different fish species, sea stars (including Goniasterids [cookie cutter], and *Cermimaster*). We observed a small *Paragorgia* bubblegum coral, cup corals, a *Bathypates* black coral, and 3 morphospecies of comatulid crinoids: a pale crinoid, stripped crinoid, and a white (curly crinoid). Also a stripped ophiuroid with red oral disk with with dots (reminiscent of the mushroom *Amanita muscaria*). As we reached WP2 on top of the ridge we observed and collected a samples from a Primnoid octocoral with a peculiar folded-fan shape (had snapping shrimp and tiny yellow squat lobster as associates). Also observed a pencil urchin potentially feeding on spider crab. Here we observed a fourth kind of crinoid purple/white. There was a great abundance of crevices in the rocks, with MANY ophiuroids living in them. Great abundance of the Red/purple urchins as a well. ECHINODERM WONDERLAND. Observed larger outcrops on top of ridge. 428m Moved along the top of the ridge. Met stronger currents moving from NW. Collected second basalt. Many demosponges found growing in ribbon patterns. Observed green eyed fishes, a *Chaunax* specimen (same morphospecies as earlier). Observed a yellow stalked crinoid at 420m. The red/violet urchins were abundant in this area. Also observed cardinal fishes living in cracks. Much less abundance of suspension feeders than at shallower depths. At 400-389m we observed very low abundance of megafauna. Substrate appeared subdivided into planar pieces. Found an increase in megafaunal abundance at 388m. Several yellow stalked crinoids. Collected *Anthomastus* mushroom octocoral. During collection we observed shimmering water from thermocline fluctuations (plus or minus 1C). Observed more stalked crinoids and a new (for the dive) morph white cup corals. Encountered several yellow comatulid crinoids (new morphotye) and greater abundance of *Anthomastus*. Very abundant Anthomastus, yellow crinoids at 353m, as well as several half living *Enallopsamia/Dendrophyllia* stony corals. Made first observation of snapper. A

	couple of *Chrysogorgia*, many brown cones sponges? (resembling earlier decay stages of 'spiderwebs' we oserved earlier). Several seabass, and many commercially important fishes. Reached the top of flat terrace on WP3. Observed a new kind of stalked crinoid (sunflower morph, with 'legs'). Observed many 'fried egg' anemones. Also an abundance of *Enallopsamia/Dendrophyllia* half living colonies, with colonization from zoanthids. Collected specimen at DEPTH: 346 m TEMP : 13.15784C, DO : 3.76798 mg/L. Incredible abundance of dead skeletons of '*Chrysogorgia*'? black corals? overgrown by what seemed to be hydrozoans (After on-board examination we did not find inner '*Chrysogorgia*'? skeletons). Also several stalks overgrown with Zoanthids. These two biological species were carpeting seafloor at DEPTH : 343.9526m, TEMP : 13.31684C, DO : 3.80297 mg/L. Sampled a basalt clast at the end of the dive. Also observe an abundance of anemones and mushroom corals *Anthomastus*.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Screen grab of hypack display providing an overview of the actual dive track and targets from dive.	Zoomed in view of hypack screen grab showing dive track, waypoints and targets dropped during the dive.
Representative Photos of the Dive	



EX1702_IMG_20170217T205247Z_ROVHD.jpg

[Descriptive caption here]



EX1702_IMG_20170218T022813Z_ROVHD.jpg

[Descriptive caption here]

Samples Collected

Sample

Sample ID	D2_DIVE02_SPEC01GEO
Date (UTC)	20170217
Time (UTC)	20:20:29
Depth (m)	503.6627
Temperature (°C)	8.40650
Field ID(s)	Basalt clast



EX1702_IMG_20170217T201834Z_ROVHD.jpg

Comments	Two barnacles and a cup coral were found associated with this rock.

Sample

Sample ID	D2_DIVE02_SPEC02BIO
Date (UTC)	20170217
Time (UTC)	22:04:41
Depth (m)	448.1645
Temperature (°C)	10.06324
Field ID(s)	Primnoidae



EX1702_IMG_20170217T220351Z_PTMAN_CORO.jpg

Comments	A squat lobster was found associated with the coral	
Sample		
Sample ID	D2_DIVE02_SPEC03GEO	 EX1702_IMG_20170217T224723Z_ROVHD.jpg
Date (UTC)	20170217	
Time (UTC)	22:47:23	
Depth (m)	433.9793	
Temperature (°C)	10.35211	
Field ID(s)	Basalt sample	
Comments	A shrimp, squat lobster, ophiuroids, a snail, and a sponge were found associated with the rock	
Sample		
Sample ID	D2_DIVE02_SPEC04BIO	 EX1702_IMG_20170218T003418Z_ROVHD.jpg
Date (UTC)	20170218	
Time (UTC)	00:54:52	
Depth (m)	388.9632	
Temperature (°C)	11.48788	
Field ID(s)	*Anthomastus*	
Comments		

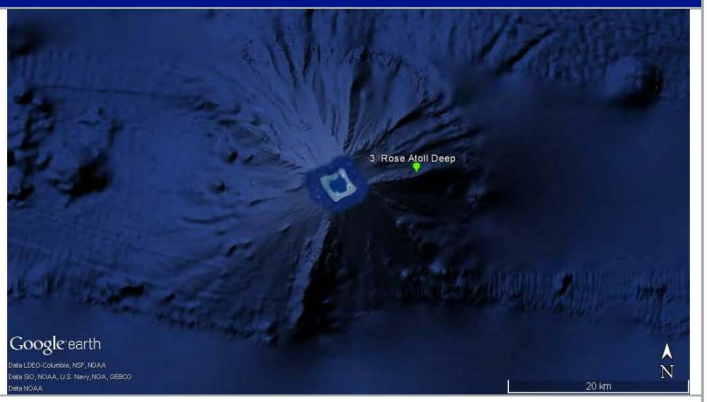
Sample		
Sample ID	D2_DIVE02_SPEC05BIO	 EX1702_IMG_20170218T024816Z_ROVHD.jpg
Date (UTC)	20170218	
Time (UTC)	02:54:31	
Depth (m)	345.3540	
Temperature (°C)	13.22594	
Field ID(s)	*Dendrophyllia*	
Comments	Hydroids, zooantids, a comatulid crinoid, two squat lobsters, barnacles and an ophiuroid were found associated with the coral	

Sample		
Sample ID	D2_DIVE02_SPEC06GEO	 EX1702_IMG_20170218T031347Z_ROVHD.jpg
Date (UTC)	20170218	
Time (UTC)	03:16:08	
Depth (m)	343.9248	
Temperature (°C)	13.15128	
Field ID(s)	Basalt clast	
Comments	Hydroids, zooantids, cup coral, aplacophorans, ophiuroids were found associated with the rock	

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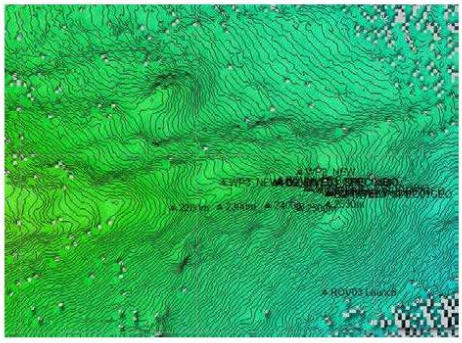
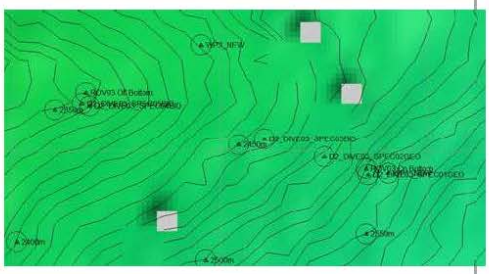
Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	Rose Atoll Marine Sanctuary Deep (ROV on bottom at 2528 m water depth)		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Samoan region, Rose Atoll (East-flanking ridge extending to east of Rose Atoll)		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	03		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2

	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ORP	
Equipment Malfunctions	Port manipulator not onboard		
ROV Dive Summary (from processed ROV data)	In Water:	2017-02-18T19:24:24.316000 14°, 32.489' S ; 168°, 04.824' W	
	Out Water:	2017-02-19T03:34:30.337000 14°, 31.732' S ; 168°, 05.048' W	
	Off Bottom:	2017-02-19T02:10:23.143000 14°, 32.235' S ; 168°, 04.934' W	
	On Bottom:	2017-02-18T20:57:16.077000 14°, 32.268' S ; 168°, 04.780' W	
	Dive duration:	8:10:6	
	Bottom Time:	5:13:7	
	Max. depth:	2528.0 m	
Special Notes			
Scientists Involved (please provide name, location, affiliation, email)	Abby Lapointe, University of Hawaii Amanda Netburn, NOAA OER Amy Baco-Taylor, Florida State University Andrea Quattrini, Harvey Mudd College Asako Matsumoto, PERC, Chiba Institute of Technology, Japan Andrew Reinhard, UC Santa Barbara Brian Greene, Association for Marine Exploration Chris Mah, NMNH Smithsonian Institution Christopher Kelley, University of Hawaii Deborah Glickson, National Academies of Sciences, Engineering, and Medicine Diva Amon, University of Hawaii at manoa Matthew Jackson, UC Santa Barbara Michael Parke, NOAA PIFSC Michael Vecchione, NMFS Natalie Summers, University of Hawaii at Manoa Nicole Morgan, Florida State University Peter Auster, Mystic Aquarium & University of Connecticut Santiago Herrera, Lehigh University Scott France, University of Louisiana at Lafayette Sonia Rowley, University of Hawai'i at Manoa Steve Auscavitch, Temple University Tara Harmer Luke, Stockton University Taylor Heyl, Woods Hole Oceanographic Institution Timothy Shank, Woods Hole Oceanographic Institution		

	Tina Molodtsova, P.P. Shirshov Institute of Oceanology RAS
Purpose of the Dive	The goal of this dive was to generate baseline information on deep sea habitats and biological communities, particularly deep-sea coral communities, to better understand their diversity and distribution and support management needs of the Rose Atoll Marine National Monument. From a geological standpoint, Rose Atoll is thought to be an older seamount linked to the Cook-Austral Islands instead of Samoa. Malulu to the west (to be sampled in a later dive during this cruise) and Rose Atoll are key in defining the Cook-Austral hotspot tracks back in time, and as such an age on a volcanic rock is needed from Rose Atoll. Without an age, it is not possible to truly define plate motion for the time frame represented by this volcano.
Description of the Dive	The dive track is on the large ridge (rift zone) extending away from the east side of Rose Atoll. The dive track was designed to start on the south side of the ridge, then move north up the side of the ridge to the ridge crest. Upon reaching the ridge crest, the ROV would turn and head upslope to the west, following the ridge crest. We did not have enough time to continue upslope along the ridge. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** The first view of the ocean floor revealed abundant individual ferromanganese nodules, covering entire field of view (i.e., no lava flows or lava pillows were visible). Nodules vary from 5 to 50 cm in diameter, and the narrow spaces between nodules were filled with light colored sediment, possibly carbonate from the reef. We moved 5 or 10 m in search of a sufficiently large, loose rock that we could collect; the collected rock was from this boulder field, perhaps 10 m from on bottom site; it is a ferromanganese-encrusted rock, 15 to 20 cm in diameter (sample ID is D2_DIVE03_SPEC01GEO). As we moved along, the geology was unchanging until 21:40:00 (UTC), when the boulder field of nodules ended and the ROV arrived on top of what appeared to be, morphologically, a lava flow that is encrusted in ferromanganese; some boulders were present on top of the flow. However, at 22:08:00, the geology chained again and there were more boulders than flow features; the second (and last) geologic sample was a loose boulder from this area (D2_DIVE03_SPEC02GEO), roughly twice the size of the first boulder. At 22:23:00 the ROV encountered the largest outcrops thus far, consisting of flows (with pillow basalt features) with scattered boulders on the outcrops. At 22:23:35 the ROV went over a large volcanic flow with no boulders and very little sediment; the flows were replete with textbook pillow structures. At 22:53:00, the ROV passed over similar flows with scattered boulders, but a larger amount of sediment existed between the boulders. At 22:55:00 the morphology of the flows became move varied, and included pillow textures

	interspersed with rougher flow textures, but the rough textures may actually be talus deposits (covering pillow flows) that were cemented with ferromanganese deposits. At 22:59:00, the ROV camera illuminated some truly beautiful pillow structures; the ROV camera zoomed in on one specific pillow that had broken open, exposing the interior. At 23:04:00, the ROV was well into an ascent up the side of the east-flanking ridge of Rose atoll; the slow was approximate 30 degrees and composed of outcropping pillows, devoid of sediment cover, that filled the entire field of view. But 23:27:00, the slope increased to 40 degrees, and continued to be entirely composed of pillow basalts. At 23:56:00, the view was completed covered with ropy lava textures, with very little sediment cover. At 00:11:00, the geology in the field of view of the ROV cameras transitioned to pillows with some pillows, and the sediment cover increased; as with all sediment cover observed in the dive, the sediment is light in color and appears to be sandy in texture. At 00:23:00, pillows fill the entire field of view, and no boulders are present; the topography is highly varied, and 5 to 10 meter vertical walls are present. At 00:29:18, a large block (perhaps 20 x 15 x 20 m, estimated) composed of pillow flows came into view and the block does not appear to be attached to the flows below; this large block may be a product of a large landslide? At 00:37:43, the flow edge terminates and the view is dominated by boulders with quantities of sediment between the boulders. Another large block of basalt (perhaps 5 x 5 x 5 m, estimated) appeared in the field of view, and is one of several viewed thus far. From 00:48:00 to 00:56:00, there was large variations in topography with pillow lavas extending to the limit of the field of view. At 01:07:00, it is noted that for the past hour or more, many overhanging ledges have been observed, many of which appear to be large dislodged block of basalt. At 01:23:00, another large possible block (perhaps 10 x 10 x 10, estimated) became the target of two biology samples (the second and third biology samples); several attempts were made to sample rocks on this block, but it was not possible to dislodge the these samples. **The biological perspective is as follows:** At the landing site, no apparent sessile fauna attached. Observed a swimming holothurian sea cucumber at distance. Collected one of the basalt cobbles, no apparent fauna attached on it (D2_DIVE013_SPEC01GEO SF, 20170218 2120, 2538m). Moved slowly uphill making detailed observations. Observed several ophiuroids, two different kinds of comatulid crinoids, a dandelion siphonophore, two different kinds of sea cucumbers of on the seafloor, a new species of Goniasterid seastar, and several carnivorous cladorhizid sponges, and a couple of other glass sponges (also observed several large dead sponge skeletons covered with Mn crust, likely very old). Collected one of the basalt cobbles, no apparent fauna attached on it (D2_DIVE013_SPEC02GEO SF, 20170218 1013, 2513m). Observed first coral at 2497m, a bamboo coral *Lepidisis*? and also a golden coral *Chrysogorgia* with squat lobster associate. At ~2480 (LAT :-14.53773, LON : -168.08028, DEPTH :2474.5984m, TEMP : 1.88585C, SAL : 34.66392 PSU, DO : 4.43871 mg/L) we observed a higher abundance and diversity of corals: Bamboos (*Lepidisis?*), *Chrysogorgia* with squat lobsters, *Pleurogorgia* with tube hydroids and anemones, *Paranthipathes* black corals as well as stalked glass sponges.

	Encountered area of much steeper slope at ~2460m, currents increased in strength (from the NE and downwelling). Collected a *Lepidisis* bamboo coral at 2448m (LAT :-14.53751, LON : -168.08059, DEPTH :2448.8970m, TEMP : 1.87727C, SAL : 34.66145 PSU, DO : 4.45953 mg/L). We continued to climb over steep terrain with significant currents. Benthic community remained relatively constant, composed of Bamboos (*Lepidisis?*), *Chrysogorgia* with associates, *Pleurogorgia* with tube hydroids, *Paranthipathes* black corals. Several dead spoonge stalks. Also observed a large branching bamboo colony (had a predatory seastar on it) and a couple of smaller ones (likely *Jasonisis*) < 2415m. Observed large loose boulders and a reduced abundance of megafauna (at ~2360 m). Many fossil/dead sponges covered with Mn (likely very old). Collected the top of one of this sponges (D2_DIVE03_SPEC04BIO. LAT :-14.53725, LON : -168.08212, DEPTH :2349.7875m, TEMP : 1.92638C, SAL : 34.66007 PSU, DO : 4.46892 mg/L). Also collected a black coral *Parantipathes* sp (D2_DIVE03_SPEC05BIO. LAT :-14.53729, LON : -168.08223, DEPTH :2348.1378m, TEMP : 1.85799C, SAL : 34.66417 PSU, DO : 4.52146 mg/L). Attempted to collect an unknown chrysogorgiid (*Pseudochrysogorgia*? with squat lobster), however strong currents kept pushing Seiros and prevented the collection. Dive ended here.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	



EX1702_IMG_20170218T205806Z_ROVHD.jpg

Abundant individual ferromanganese nodules, covering entire field of view (i.e., no lava flows or lava pillows were visible). Nodules vary from 5 to 50 cm in diameter.



EX1702_IMG_20170219T002443Z_ROVHD.jpg

Anemone and *Chrysogorgia* golden coral on ferromanganese encrusted lava flow

Samples Collected

Sample

Sample ID	D2_DIVE03_SPEC01GEO
Date (UTC)	20170218
Time (UTC)	21:19:45
Depth (m)	2527.8539
Temperature (°C)	1.91257
Field ID(s)	Mn encrusted rock (15-20 cm diameter)



EX1702_IMG_20170218T211747Z_ROVHD.jpg

Comments	No associated fauna on this rock

Sample

Sample ID	D2_DIVE03_SPEC02GEO
Date (UTC)	20170218
Time (UTC)	22:13:43
Depth (m)	2502.4091
Temperature (°C)	1.88699



Field ID(s)	Fe-Mn encrusted rock	
Comments	No associated fauna on this rock	
Sample		
Sample ID	D2_DIVE03_SPEC03BIO	 EX1702_IMG_20170218T232257Z_ROVHD.jpg
Date (UTC)	20170218	
Time (UTC)	23:24:52	
Depth (m)	2448.8971	
Temperature (°C)	1.86345	
Field ID(s)	Lepidisis	
Comments	There is an error in the sample name "D2_DIVE03_SPEC03GEO". It should be "D2_DIVE03_SPEC03BIO". Upon recovery from ROV biobox discovered a polychaete associate.	
Sample		
Sample ID	D2_DIVE03_SPEC04BIO	 EX1702_IMG_20170219T013136Z_ROVHD.jpg
Date (UTC)	20170219	
Time (UTC)	1:33:57	
Depth (m)	2349.8508	
Temperature (°C)	1.90092	
Field ID(s)	Dead sponge	
Comments	Upon recovery from ROV biobox discovered glass sponges, hydroids, polychaetes, barnacles and anemone associates.	

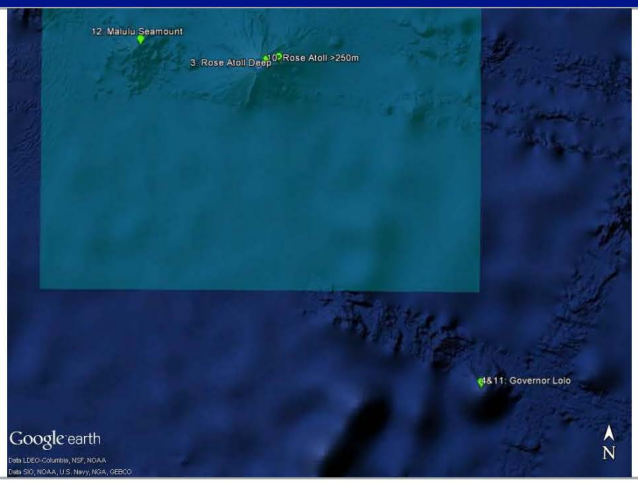
Sample		
Sample ID	D2_DIVE03_SPEC05BIO	 EX1702_IMG_20170219T020602Z_D2_DIVE03...
Date (UTC)	20170219	
Time (UTC)	2:08:40	
Depth (m)	2348.1395	
Temperature (°C)	1.86015	
Field ID(s)	Parantipathes	
Comments	Upon recovery from ROV biobox discovered a shrimp associate.	

Sample	
Sample ID	
Date (UTC)	
Time (UTC)	
Depth (m)	
Temperature (°C)	
Field ID(s)	
Comments	A 3rd geological sample was not obtained.

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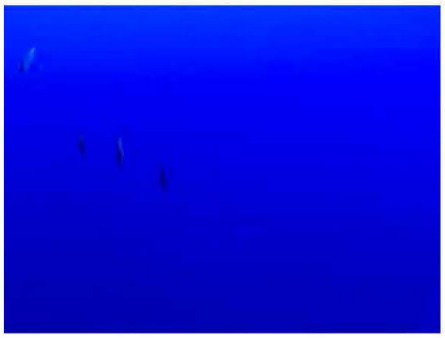
Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	"Governor Lolo" Seamount (formerly "Seamount D")		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Samoan region, eastern portion of Am. Samoa EEZ		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	04		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading

	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2
	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ ORP	
Equipment Malfunctions	Operating without Schilling Orion manipulator.		
ROV Dive Summary (from processed ROV data)	Dive Summary: EX1702_DIVE04 ^^^

	the Cook-Austral Islands, not Samoa. Samples from this seamount are key in defining the Cook-Austral hotspot tracks back in time, and as such an age on a volcanic rock is needed from this seamount. Without an age, it is not possible to truly define plate motion for the time frame represented by this volcano. From the biological perspective this dive has the potential to provide new depth records for several species as well the discovery of new species. Very little work has been done in the Central Pacific at these depths on seamounts. We aim to collect information that will inform the biogeographic identity of the communities at abyssal depths in this region.
Description of the Dive	The ROV never reached bottom. The ROV achieved a depth of ~300 m and the dive was cancelled do to inclement weather.

Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
NA. The dive was cancelled.	NA. The dive was cancelled.
NA. The dive was cancelled.	NA. The dive was cancelled.
Representative Photos of the Dive	

 EX1702_IMG_20170219T193837Z_ROVHD.jpg	 EX1702_IMG_20170219T201036Z_ROVHD.jpg
[Descriptive caption here]	[Descriptive caption here]

Samples Collected		
Sample		
Sample ID		[*in situ* image of specimen here]
Date (UTC)		
Time (UTC)		
Depth (m)		
Temperature (°C)		
Field ID(s)		
Comments		
Sample		
Sample ID		[*in situ* image of specimen here]
Date (UTC)		
Time (UTC)		
Depth (m)		
Temperature (°C)		
Field ID(s)		
Comments		
Sample		
Sample ID		[*in situ* image of specimen here]
Date (UTC)		
Time (UTC)		

Depth (m)		
Temperature (°C)		
Field ID(s)		
Comments		
Sample		
Sample ID		[*in situ* image of specimen here]
Date (UTC)		
Time (UTC)		
Depth (m)		
Temperature (°C)		
Field ID(s)		
Comments		

Please direct inquiries to:

NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014

Okeanos Explorer ROV Dive Summary

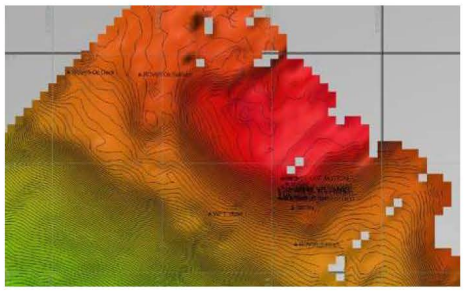
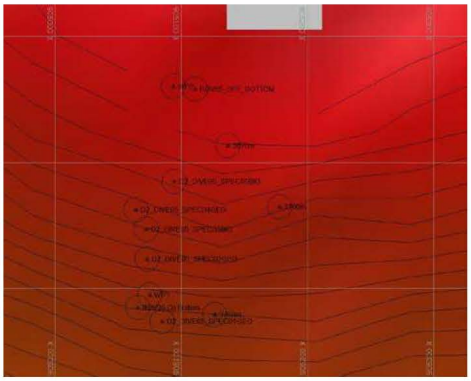
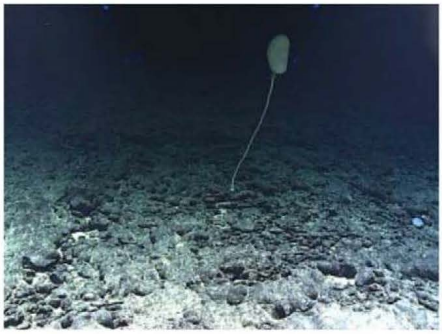
Dive Information			
Dive Map			
Site Name	"Leoso" seamount, ROV on bottom at 3770 m (-12.64986505, -167.27212505)		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	North Samoan region, Near southern margin of Manihiki Plateau		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	05		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2

	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ORP	
Equipment Malfunctions	Port manipulator not onboard		
ROV Dive Summary (from processed ROV data)	Dive Summary: EX1702_DIVE05 ^^^

	hotspot, not Samoa. Samples from this seamount are key in defining the Society hotspot tracks back in time, and as such an age on a volcanic rock is needed from this seamount. Without an age, it is not possible to truly define plate motion for the time frame represented by this volcano. From the biological perspective this dive has the potential to provide new depth records for several species as well the discovery of new species. Very little work has been done in the Central Pacific at these depths on seamounts. We aimed to collect information that will inform the biogeographic identity of the communities at abyssal depths in this region.
Description of the Dive	The new seamount explored in this dive, tentatively called "Leoso" seamount, straddles the boundary between the American Samoa EEZ and the Cook Islands EEZ. The seamount had not been mapped before. Thus, before diving, we mapped a portion of the southeastern half of the volcano. The seamount appears to be comprised of two distinct structures: The base of the seamount is composed of a larger flat-topped guyot; on top of this guyot is a smaller volcanic structure that is consistent with being a rejuvenated stage of volcanism on this seamount (notably, the rejuvenated structure is also flat-topped). The dive track was designed to start midway up a steep portion of the southeast margin of the rejuvenated volcanic structure. The ROV will climb up this margin with the goal of reaching the flat-topped portion of the rejuvenated volcanic structure. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** *01:05:00.* The first view of the ocean floor revealed ferromanganese encrusted surface, possibly a lava flow; scattered sediment represents <2% of cover, and some small pebbles and cobbles (up to approximate 10 cm, estimate), all ferromanganese covered, are scattered on the surface of this flat area. One of these ferromanganese cobbles was targeted as the first geologic sample of the dive (a seastar attached to the cobble, and was placed in the biobox onboard the ROV): D2_DIVE05_SPEC01GEO *01:11:20.* The smoother ferromanganaese substrate visible at the beginning of the dive is now absent, and is replaced with a substrate consisting of ferromanganese-encrusted pebbles and cobbles. *01:19:47.* The substrate in the field of view is now composed of 50% pebble and cobbles and 50% flow structures, all of which are ferromanganese covered; sediment cover is <5%. This sediment, like all sediment observed to this point (and for the rest of the dive), is light colored and may be carbonate in composition. *01:31:54.* The substrate in the field of view consists of 75% flow structures and 25% cobbles and pebbles. We identified a 12 cm cobble with a dead sponge attached, and this became the second geological sample of the collection: D2_DIVE05_SPEC02GEO. A rounded cobble (5 -10 cm) of light colored (off white) pumice was observed 1 to 2 meters uphill of the second geologic sample. The pumice is relatively unaltered (and has little to no ferromanganese cover) compared to the surrounding rocks, and is unlikely to have originated from this seamount; we consider it more likely that this pumice has a recent origin at a distal volcano and the pumice floated to the site of Leoso seamount before becoming waterlogged, thus sinking and coming to rest on the flanks of Leoso

	seamount. *01:39:21.* Large flow structures now fill most of the upper portion of the field of view, with large cobbles (up to 30 cm) positioned in the lower part of the field of view. A second piece of pumice, darker in color than the first, was identified approximately 0.5 m from the location of a large white squat lobster. This pumice is like to have a similar origin as the pumice described above. *01:45:32.* The ROV is now moving up a slope of perhaps 15 degrees. The field of view is dominated by a ferromanganese covered basalt flow that and has relatively few boulders or cobbles. *02:07:25.* The ROV is not moving up a slope of perhaps 15 to 20 degrees. The substrate is composed primarily of smooth, ferromanganese covered flows. Intermittently the smooth basaltic surface breaks up onto pebbles and cobbles. *02:12:23.* The lava flow structures breaks up into boulders (up to 1 m in diameter) and cobbles. Nonetheless, a portion of the lava flow is still visible in the periphery of the field of view. Sediment cover is still minimal. *02:17:30.* The ROV is now moving up a slope of approximately 25 degrees. The slope is covered with ferromanganese deposits. The slope is smooth and mostly devoid of loose rock. *02:28:30.* The ROV is still situation on a relatively steep slope (25 degrees) that consists of a lave flow structure that is smooth and ferromanganese encrusted. *02:34:54.* The lava flow comes to an abrupt end and the western boundary of the lava field is defined by a gully running down the slope; the gulley is filled with cobbles and boulders, all of which likely rolled downslope. At this point, the ROV is only 50 to 100 m from the summit of this seamount structure, so the rocks in the gulley could not have rolled far downhill. A cobble from this gulley was selected as the third geological sample of this dive: D2_DIVE05_SPEC04GEO. *02:45:00.* A lava flow with possible pillow structures dominates the view; only small (<10 cm) ferromanganese nodules are present on the flow, but they arre not abundant; the sediment cover continues to be minimal (<2%). *02:50:07.* The slope is steep (30 degrees, perhaps), and covered with smooth, ferromanganese encrusted pillow basalts; small ferromanganese nodules (<5 cm) are present present (but not abundant), and sediment covers <2% of the surface. *03:12:52.* There is a geological transition to a steeper slope (perhaps 40%). Pillow basalt structures are ubiquitous, and <10 cm ferromanganese nodules are present in abundance in pockets between pillows structures. Sediment coves perhaps 10% of the rock surface. *03:23:34.* The ROV reached the flat top of the rejuvenated volcanic structure. The flat topped nature of this seamount structure–as imaged by the multibeam sonar data—is extremely clear as we summit the seamount and traverse across the flat top: the field of view is dominated by flat, smooth ferromanganese encrusted surface. The sediment cover is much greater (maybe 30%), but the sediment cover is quite thin (estimate at 1 or 2 mm), except in pockets in cracks in the lava flow where the sediment thickness is thicker; ripple patterns are present in the sediment, possibly generated by north-south (or south-north) currents. Only rare ferromanganese encrusted pebbles are present, but not cobbles or boulders. **The biological perspective is as follows:** Landed at LAT :-12.64991, LON : -167.27145, DEPTH :3768.0019m, TEMP : 1.48650C, SAL : 34.69233 PSU, DO : 4.86619 mg/L. Observed gentle sloping terrain 30-40 degrees, all bare rock encrusted by ferromanganese crust, some loose cobbles. Collected a cobble D2_DIVE05_SPEC01GEO 00:57 with a brisingid seastar

	on it. Observed black animal tracks (clean form sediment) on rocks, possibly made by a holothurian or snail (none observed). Saw many small ophiuroids sitting on bare rock. Observed several individuals of stalked glass sponge (*Bolosoma*) with sessile ctenophore attached to it. Also observed other non-stalked glass sponges (*Corbitellinae*?) with folds/lobes on wall and a central barrel. Imaged a beautiful specimen of *Branchiocerianthus* stalked hydroid. Observed asymmetric yellow urchin (*Pilematechinus*?). Several other glass sponges, including *Hyalonema*? (potbelly sponge, brown attachment) were also observed. Collected a rock at 01:33 (D2_DIVE05_SPEC02GEO rock starboard rock box LAT :-12.64930, LON : -167.27184, DEPTH :3748.1127m, TEMP : 1.45541C, SAL : 34.69386 PSU, DO : 4.96605 mg/L). Observed several live and dead stalked glass sponges (*Bolosoma*) in this area. Dead stalks were commonly observed. Many of them colonized by hydroids, barnacles, other sponges and anemones. Attempted collection of a new species of cookie star. But failed ☹. Stalked glass sponge (Bolosoma) was to be the dominant suspension feeder on this wall (3740m). Observed a couple of *Nematocarcinus* shrimp and potbelly sponges. Collected of a holasteroid urchin possibly *Pilematechinus* at 02:25 (D2_DIVE05_SPEC03BIO, LAT :-12.64945, LON : -167.27185, DEPTH :3727.6779m, TEMP : 1.47076C, SAL : 34.68682 PSU, DO : 4.90378 mg/L). Further along in the dive track along the southern slope of the seamount we encountered a chute with many cobbles and broken down pieces of rock. Collected rock D2_DIVE05_SPEC04GEO at 02:38 (LAT :-12.64917, LON : -167.27171, DEPTH :3720.8418m, TEMP : 1.46509C, SAL : 34.69407 PSU, DO : 4.93543 mg/L). Smooth lava flows continue to be dominant substrate, with more dead and alive stalked sponges. First and only observation of a coral in this dive, the black coral *Bathypathes* cf. *patula* at 02:49. Collected at 03:03 D2_DIVE05_SPEC05BIO. Had to move from collection site before putting in biobox because ship had completed a move. (LAT :-12.64919, LON : -167.27166, DEPTH :3696.1976m, TEMP : 1.45622C, SAL : 34.69564 PSU, DO : 4.91035 mg/L) Substrate changed near the edge of the seamount top. Abundant ferromanganese nodules cemented. Not as smooth lava flows. At the top of the seamount we see smooth surface of ferromanganese crust, very little to no fauna, some stalked sponges. Increasing sediment cover. Rippled thin layer of sediments on the top of seamount/guyot, indicate a S-N direction of predominant currents. 03:43:13 End of dive after reaching area of WP2.

Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	
 EX1702_IMG_20170221T020746Z_ROVHD.jpg	 EX1702_IMG_20170221T033203Z_ROVHD.jpg
Stalked glass sponge (*Bolosoma*) attached to ferromanganese crust covering cobbles and old lava flows.	Thin layer of sediment on top of guyot seamount showing ripple patterns likely created by northward moving currents. Several stalked glass sponges visible.

Samples Collected

Sample	
Sample ID	D2_DIVE05_SPEC01GEO
Date (UTC)	20170221
Time (UTC)	0:57:31
Depth (m)	3770.4671



Temperature (°C)	1.45931	
Field ID(s)	Rock (with brisingid)	
Comments		
Sample		
Sample ID	D2_DIVE05_SPEC02GEO	 EX1702_IMG_20170221T013414Z_ROVHD.jpg
Date (UTC)	20170221	
Time (UTC)	1:38:45	
Depth (m)	3747.7579	
Temperature (°C)	1.45278	
Field ID(s)	Rock	
Comments		
Sample		
Sample ID	D2_DIVE05_SPEC03BIO	 EX1702_IMG_20170221T022616Z_D2_DIVE05_SPEC03...
Date (UTC)	20170221	
Time (UTC)	2:27:03	
Depth (m)	3726.8877	
Temperature (°C)	1.47465	
Field ID(s)	*Pilematechinus* ?	
Comments	Urchin	
Sample		
Sample ID	D2_DIVE05_SPEC04GEO	
Date (UTC)	20170221	
Time (UTC)	2:38:27	

Depth (m)	3718.4301	
Temperature (°C)	1.45708	
Field ID(s)	Rock	
Comments		
Sample		
Sample ID	D2_DIVE05_SPEC05BIO	
Date (UTC)	20170221	 EX1702_IMG_20170221T025659Z_ROVHD.jpg
Time (UTC)	3:03:35	
Depth (m)	3682.9185	
Temperature (°C)	1.46343	
Field ID(s)	*Bathypathes?*	
Comments	Black coral	
Sample		
Sample ID		
Date (UTC)		
Time (UTC)		
Depth (m)		
Temperature (°C)		
Field ID(s)		
Comments	A third biology sample was not collected on this dive.	

Please direct inquiries to:

NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)

Silver Spring, MD 20910
(301) 734-1014

Okeanos Explorer ROV Dive Summary

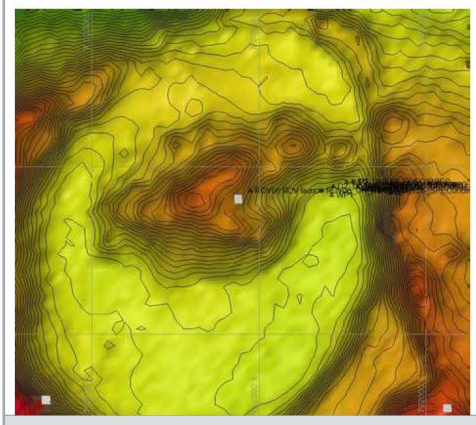
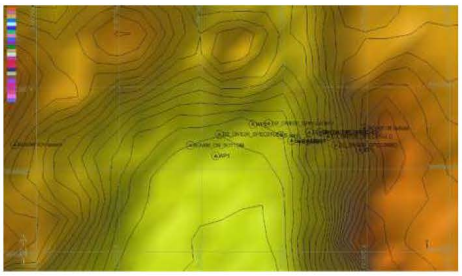
Dive Information			
Dive Map			
Site Name	"Utu" seamount, ROV on bottom at ~3043 m		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	North Samoan region, Near southern margin of Manihiki Plateau		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	06		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1

	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2
	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ORP	
Equipment Malfunctions	Port manipulator not onboard		
ROV Dive Summary (from processed ROV data)	In Water: Out Water: Off Bottom: On Bottom: Dive duration: Bottom Time: Max. depth:	2017-02-21T19:32:29.998000 12°, 16.851' S ; 168°, 19.504' W 2017-02-22T03:35:36.691000 12°, 16.191' S ; 168°, 18.803' W 2017-02-22T01:55:24.911000 12°, 16.876' S ; 168°, 19.058' W 2017-02-21T21:16:35.321000 12°, 16.902' S ; 168°, 19.268' W 8:3:6 4:38:49 3037.0 m	
Special Notes			
Scientists Involved (please provide name, location, affiliation, email)	Asako Matsumoto, PERC, Chiba Institute of Technology, Japan Bruce Mundy, NOAA PIFSC Chris Mah, NMNH Smithsonian Institution Christopher Kelley, University of Hawaii Deborah Glickson, National Academies of Sciences, Engineering, and Medicine Diva Amon, University of Hawaii at manoa Les Watling, University of Hawaii at Manoa Matthew Jackson, UC Santa Barbara Santiago Herrera, Lehigh University Steve Auscavitch, Temple University Timothy Shank, Woods Hole Oceanographic Institution Tina Molodtsova, P.P. Shirshov Institute of Oceanology RAS		
Purpose of the Dive	The goal of this dive was to generate baseline information on geology and geochemistry of this unexplored (and largely unmapped) seamount. There is also significant interest in understanding the deep sea habitats and biological communities on the seamount to better understand their diversity and distribution. Maps of the seamount were generated the night before. From a geological standpoint, this seamount may be an older seamount linked to the Society hotspot, not Samoa. Samples from this seamount are key in defining the Society hotspot tracks back in time, and as such an age on a volcanic rock is needed from this seamount. Without an age, it is not possible to truly define plate motion for		

	the time frame represented by this volcano. From the biological perspective this dive has the potential to provide new depth records for several species as well the discovery of new species. Very little work has been done in the Central Pacific at these depths on seamounts. We aimed to collect information that will inform the biogeographic identity of the communities at abyssal depths in this region.
Description of the Dive	The new seamount explored in this dive, tentatively called "Utu" seamount, lies in the northern region of the American Samoa EEZ. The seamount had been partially mapped before, but required additional mapping at higher resolution for dive site selection. Thus, the night before diving, we mapped much of the volcano. The seamount appears to be comprised of two distinct structures: The base of the seamount is composed a "lumpy" or "blocky" structures, perhaps consistent with pillow or pillow mounds; the basal portion of the volcano is similar in morphology to "pancake" seamounts. Constructed on top of this basal pancake structure is a volcanic structure that has both steeper and smoother sides than the basal pancake portion of the volcano. These two morphologically different structures of the volcano (i.e., the pancake basal portion and the steeper sided upper section) are consistent with two stages of volcanic activity on this seamount. It is notable that the summit of the seamount is nearly flat-topped, and is host to a nicely developed volcanic crater: the center of the crater hosts a volcanic cone, and the crater walls exhibit at least two different "step-like" features, consistent with partial crater collapse like that which is observed in calderas at basaltic shield volcanoes at oceanic hotspots. The dive track was designed to start at the base of the volcanic cone in the crater, transit toward the crater wall, and then climb up the steep sides of the crater wall and crest the rim of the crater wall. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** *21:15:11.* The first view of the ocean floor revealed sediment covered bottom with ripple features in sediment. <1% of the bottom is covered with dark pebbles. Increased to 5% dark pebbles ~5 meters further along. *21:37:42.* Some small (1 to 2 meters, including the largest boulder observed thus far) "islands" of outcropping rock in the sand. There are loose cobbles associated with both outcrops. One ferromanganese encrusted cobble (~20 cm in diameter) was taken as the first geological sample: 02_DIVE06_SPEC01GEO (placed in starboard rockbox of ROV). This rock is close to the central cone of the crater, so is likely to have been derived from the central cone in the volcanoe's crater. *21:55:14.* More outcrops, perhaps 10 m in length, composed of discontinuous exposures of ferromanganese encrusted rock. Light colored sediment continues to dominate the view (>50%). *21:58:32.* Moving out of the outcrop area, but ferromanganese encrusted rocks and smaller outcrops continue to persist in the field of view, representing 10 to 30% of the surface cover. *22:01:00.* A boulder equal in size the prior boulder, perhaps 2 m in diameter, representing the 2nd large boulder seen thus far. Like the first boulder, this boulder is also covered with larger fauna. These larger boulders seem to serve as "islands" for the seafloor fauna. *22:06:22.* We have moved 80 meters since arriving on bottom. We are seeing significant basaltic flow structures, covering perhaps 30% of the field of view, and

	the flow structures are covered with significant sediment deposits. *22:17:23.* Just over 1 hour on the bottom and the geology has been quite similar throughout the dive: ferromanganese encrusted lavas, as well as loose pebbles, cobbles and boulders, are interspersed with a light colored sediment. *22:27:19.* The field of view is dominated by cobbles and boulders with abundant sediment. Probably the highest concentration of loose rock material observed thus far in the dive, and this might be a product of the fact that we are moving closer to the crater wall. A 20 cm cobble was selected as the second geological sample of this dive. However, we are close to the central cone at this point, so this rock may also have come from the central cone in the crater. The rock was placed in the port rockbox: D2_DIVE06_SPEC02GEO. (This is such a large rock sample that the lid on the PORT box won't close). *22:39:18:* Moving out of the boulder field the ROV encounters a relatively flat, sediment-dominated landscape very similar to the first view from the "on bottom" site; the abundance of ferromanganese encrusted pebbles and cobbles representing a higher percentage (perhaps 10% of the total surface cover) of the field of view. *22:48:34.* Large boulder in field of view, perhaps 10 meters in diameter. This is the largest boulder yet on the dive. It may have broken off the crater wall and rolled down the steep wall of the crater. *23:09:02.* Moving beyond the large block noted in the previous observation, the ROV shows numerous large blocks (>5 meters in diameter) with boulders and cobbles interspersed between the boulders; light-colored sediment is interspersed between the blocks, covering >50% of the surface. These large blocks are not attached to the substrate and likely represent portions of the steep crater wall that broke loose and rolled downhill. *23:43:05.* The landscape continues to be dominated by large blocks and boulders (all ferromanganese encrusted) with light-colored sediment infilling the regions between the blocks and cobbles. The slope is approximately 15 to 20 degrees, and the high density of blocks and cobbles is likely due to basaltic rocks detaching from the steep walls of the crater and rolling down hill. *00:10:55.* Large ferromanganese encrusted blocks (up to 1 meter or more) continue to dominate the field of view. Light colored sediment infills spaces between boulders. *00:39:00.* The ROV moved just beyond the field of large blocks and into a field dominated by smaller ferromanganese encrusted boulders (<0.5 meters wide), and the field of view has 50 to 60% sediment cover. One of the smaller boulders (perhaps 15 cm wide) was selected as the third geology specimen and was placed in the starboard rock box with the first rock specimen: D2_DIVE06_SPEC05GEO. This cobble almost certainly detached from the walls of the crater above and rolled down hill. *00:50:27.* The field of view is now dominated by both large ferromanganese encrusted boulders (1-2 meters) and smaller cobbles, with light colored sediment infilling the spaces between the rocks. *01:21:59.* The ROV is on a 10 to 15-degree slope, moving upslope. The field of view is dominated by ferromanganese encrusted cobbles and medium-sized (<1 m) boulders, with ~40% of the field of view showing sediment cover that is concentrated between the spaces between the rocks. *01:24:16.* The ROV is on a 20-degree slope, and all rocks are smaller (<30 cm), and the same light-colored sediment covers only 20 to 30% of the field of view. *01:41:02.* A number of large boulders (>2 m) are coming into view and are complemented by smaller boulders and cobbles. Again, light-colored sediment

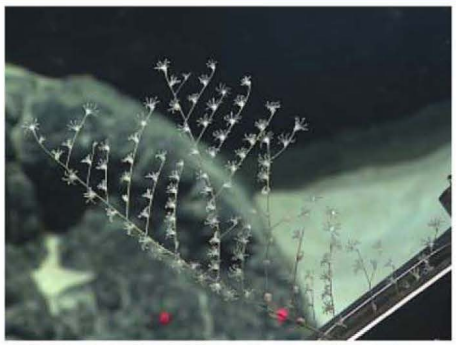
	fills the spaces between the rocks, covering perhaps 10 to 15% of the field of view. Like previous observation made of the geology of the crater wall, the blocks, boulders and cobbles have the appearance of talus resulting from volcanic material that has broken off the craters of the wall and rolled down hill. *02:00:00.* The ROV came quite close to achieving the summit of the crater wall, but the ROV had to surface before we could reach the summit. **The biological perspective is as follows:** Landed at 3043 m at 21:15, flat bottom with rippled sediment, small pebbles of manganese nodules. Not obvious large megafauna, some small sponges/xenophyophores? As we move upslope on the southern face of the feature in the center of the crater we encounter larger cobbles, boulders and outcrops, no apparent ripples on sediment. Collected rock D2_DIVE06_SPEC01GEO at 21:40, 3033m. Observed, stalked glass sponge (*Bolosoma*) with hydroid associate, brinsingid brittle star, a whip primnoid coral with small amphipod associate, carnivorous tunicate. Found another outcrop with barnacle as well as carnivorous tunicate and a glass sponge. Also observed two halosaur fish *Aldrovandia* (one sitting on sediment, one drifting with currents). As we move along upslope we observe an increase of outcrops intermixed with rippled sediment, larger cobbles and pebbles. Observed a beautiful specimen of a holothurian with sail *Psychropotes* (22:20, 3024 m). Moved over similar terrain until reaching the transition zone between central cone feature and the inner eastern wall of the crater. Collected rock D2_DIVE06_SPEC02GEO at 22:32, 3024m. Transition zone covered in sediment and small pebbles likely manganese nodules. Observed another halosaur fish *Aldrovandia*. At 22:55 encountered large outcrop, likely the base of the eastern crater wall. Observed one chrysogorgiid octocoral with sparse branching, several carnivorous tunicates (*Megalodicopia*), whip primnoid and a branching primnoid, another branching chrysogorgiid with more branching (3033m). Two cusk eels of different size (different sex or different species?) at 23:17 3032 m. Larger outcrops and steeper slope. Observed a couple of whip primnoid and *Pleurogorgia*-like chrysogorgiids with anemone associates (likely depth record for anemone associates). Collected the later 23:52 D2_DIVE05_SPEC03BIO, 3012m. Loose boulders with sediment pockets in between. Collected dead sponge stalk with 4 crinoids and 2 hydroids attached to it D2_DIVE06_SPEC04BIO 00:28 2985 m. Continue observing a mix of large boulders, sediment pockets and slides, cobbles of different sizes. Outcropping large boulders had several colonies of *Pleurogorgia*-like chrysogorgiids and 'whip' primnoid octocoral. After several close observations determined that the 'whip' primnoid is likely a juvenile stage of the same species that we later observed branching in long V patterns. Collected rock D2_DIVE06_SPEC05GEO at 00:45 2981 m. Further upslope crossed an area of sediments and cobbles into another area of large boulders. Observed more of the V primnoids, stalked sponges, and an unusual association of a branching chrysogorgiid (different morphology from

	Pleurogorgia) with an ophiuroid (*Ophiacantha*?) associate on bare skeleton. Very unusual as ophiuroids are usually associated with healthy coral tissue. Made collection of this association D2_DIVE06_SPEC05GEO at 01:13, 2967 m. Observed the first bamboo coral of the dive at 01:19, 2953 m, now morph for the cruise (intermodal branching, no needle sclerites in polyps). At 01:34, 2947 m, observed a *Iridogorgia* with a predatory sea star (crinoid on top of predatory sea star). Very large outcrop boulders with many sponges *Bolosoma* 2923 m. At the end of the dive we reached the summit of the wall 2871 m. Observed very large outcrops with very large abundance of *Bolosoma* sponges (>1.5 m tall), as well as very large 'barrel'? glass sponges (>1m tall, >0.5 wide). Also several large octocoral fans (likely bamboos or primnoids), *Iridogorgia,* large bamboo whips (>1.5 meters tall), spectacular end of dive, wish we had more time here.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	
 EX1702_IMG_20170221T213250Z_ROVHD.jpg	 EX1702_IMG_20170222T013254Z_ROVHD.jpg
"Islands" of outcropping rock in the sand with	**Field of view dominated by ferromanganese encrusted**

stalked sponges and other sessile invertebrates	**cobbles and medium-sized (<1 m) boulders, with sediment concentrated between the spaces between the rocks. *Iridogorgia* octocoral with predatory seastar on the right.**

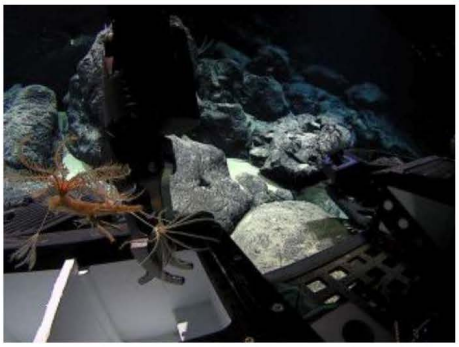
Samples Collected		
Sample		
Sample ID	D2_DIVE06_SPEC01GEO	 EX1702_IMG_20170221T213919Z_ROVHD.jpg
Date (UTC)	20170221	
Time (UTC)	21:15	
Depth (m)	3043	
Temperature (°C)	1.68527	
Field ID(s)	Rock	
Comments		
Sample		
Sample ID	D2_DIVE06_SPEC02GEO	 EX1702_IMG_20170221T223115Z_ROVHD.jpg
Date (UTC)	20170221	
Time (UTC)	22:32	
Depth (m)	3024	
Temperature (°C)	1.68709	
Field ID(s)	Rock	

Comments	
Sample	
Sample ID	D2_DIVE05_SPEC03BIO
Date (UTC)	20170221
Time (UTC)	23:52
Depth (m)	3012
Temperature (°C)	1.70586
Field ID(s)	*Pleurogorgia*-like chrysogorgiids with anemone associates



EX1702_IMG_20170221T235242Z_D2_DIVE06_SPEC03...

Comments	
Sample	
Sample ID	D2_DIVE06_SPEC04BIO
Date (UTC)	20170221
Time (UTC)	00:28
Depth (m)	2985
Temperature (°C)	1.71504
Field ID(s)	Dead sponge stalk with 4 crinoids and 2 hydroids



EX1702_IMG_20170222T002735Z_PTMAN_SAMPLE.jpg

Comments	
Sample	
Sample ID	D2_DIVE06_SPEC05GEO

Date (UTC)	20170222	 EX1702_IMG_20170222T004346Z_D2_DIVE06_SPEC05...
Time (UTC)	00:45	
Depth (m)	2981	
Temperature (°C)	1.79082	
Field ID(s)		
Comments	Black coral	
Sample		
Sample ID	D2_DIVE06_SPEC06BIO	 EX1702_IMG_20170222T010807Z_ROVHD.jpg
Date (UTC)	20170222	
Time (UTC)	01:13	
Depth (m)	2967	
Temperature (°C)	1.70238	
Field ID(s)	Chrysogorgiid (different morphology from *Pleurogorgia*) with an ophiuroid (*Ophiacantha*?)	
Comments		

Please direct inquiries to:

NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014

Ocean Exploration and Research

Okeanos Explorer ROV Dive Summary

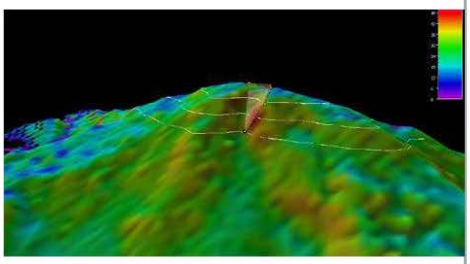
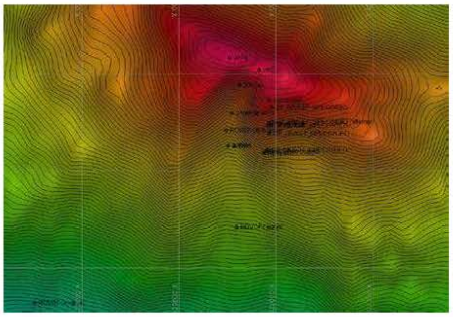
Dive Information			
Dive Map			
Site Name	"Moki" seamount, ROV on bottom at ~2200 m		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	North Samoan region, Near southern margin of Manihiki Plateau		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	07		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2

	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ ORP	
Equipment Malfunctions	Midway through the dive, the video started flickering. The fiber optic power levels began to drop, and this led to concern that the controls might also be influenced. A decision was made to abort the dive and bring the ROV to the surface.		
ROV Dive Summary (from processed ROV data)	In Water:	2017-02-22T20:07:28.025000 11°, 10.235' S ; 169°, 53.627' W	
	Out Water:	2017-02-23T03:41:01.071000 11°, 10.502' S ; 169°, 54.139' W	
	Off Bottom:	2017-02-23T01:21:32.308000 11°, 10.007' S ; 169°, 53.533' W	
	On Bottom:	2017-02-22T21:46:54.550000 11°, 10.143' S ; 169°, 53.530' W	
	Dive duration:	7:33:33	
	Bottom Time:	3:34:37	
	Max. depth:	2116.3 m	
Special Notes			
Scientists Involved (please provide name, location, affiliation, email)	Asako Matsumoto, PERC, Chiba Institute of Technology, Japan Bruce Mundy, NOAA PIFSC Chris Mah, NMNH Smithsonian Institution Christopher Kelley, University of Hawaii at Manoa Deborah Glickson, NASEM Diva Amon, University of Hawaii at manoa Matthew Jackson, UC Santa Barbara Natalie Summers, University of Hawaii at Manoa Santiago Herrera, Lehigh University Tara Harmer Luke, Stockton University Timothy Shank, Woods Hole Oceanographic Institution		
Purpose of the Dive	The goal of this dive was to generate baseline information on geology and geochemistry of this unexplored (and largely unmapped) seamount. There is also significant interest in understanding the deep sea habitats and biological communities on the seamount to better understand their diversity and distribution. Maps of the seamount were generated the night before, complementing existing data. From a geological standpoint, this seamount may be an older seamount linked to the Society hotspot, not Samoa. Samples from this seamount are key in defining the Society hotspot tracks back in time, and as such an age on a volcanic rock is needed from this seamount. Without an age, it is not possible to truly define plate motion for the time frame represented by this volcano. From the biological perspective this dive has the potential to provide new depth		

	records for several species as well the discovery of new species. Very little work has been done in the Central Pacific at these depths on seamounts. We aimed to collect information that will inform the biogeographic identity of the communities at abyssal depths in this region.
Description of the Dive	The seamount explored in this dive, tentatively called "Moki" seamount, lies on the northern region of the American Samoa EEZ. The seamount had been partially mapped before, but required additional mapping at higher resolution for dive site selection. Thus, the night before diving, much of the volcano was mapped. The seamount has a simple conical structure. There are a small number of scattered, smaller cones on the deep flanks of the seamount that may relate to a later stage of volcanism, but no such conical structures are visible on the shallower portions of the seamount (including the dive track of the ROV). The dive track targeted the largest continuous steep region visible in the bathymetry of the volcano. The dive track was designed to start at ~2200 m water depth, which is several hundred meters beneath the summit of the seamount. In the dive plan, the ROV will move upslope along a ridge toward to the summit. The ROV will traverse across the summit and finish at a depth of ~1900 m. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** *21:25:00.* The first view of the ocean floor revealed rough terrain, likely to be a ferromanganese encrusted (FE) rock outcrop. The outcrop appears to be constructed of pillow basalts, and <1% of the surface is covered with a light-colored sediment. Panning out reveals that the outcrop is the edge of a steep wall that drops at least 10 meters below the ROV. *21:35:05.* A small scree/talus flow is observed in a gulley, and the rocks appear to be partially welded together. A small number of cobbles appear to be loose, including the first geologic sample. The first geologic sample was collected from this scree/talus slope; the rock is approximately 15 to 20 cm in diameter (the samples is wide and flat), and was placed in the starboard rock box. The ROV is <300 m from the summit on this dive, so the rock could not have rolled very far: **02_DIVE07_SPEC01GEO** *21:50:22.* A narrow (0.5 to 1 m) razor back ridge came into view as we summated the steep wall. The ridge is constructed of basalt and falls off precipitously (slope >60 degrees) on both sides. Light-colored sediment cover increased to ~30%, and sediment shows evidence of spilling off the steeper rock faces. The ROV traversed along the 10 to 20 meter-long razorback ridge. *21:52:18.* A sheer wall enters the view as the ROV leaves the razorback ridge to the left, and pillow lavas appear to be the primary rock type in the wall. At the top of a wall is a ridge. A camera zoom reveals well-developed FE deposits on the rock surfaces. *22:02:35.* Another steep face is observed in the field of view. Again, the face is constructed of pillow basalts that have well-developed FM deposits on the surface. *22:07:46.* The ROV continues to move upslope, and moves along another razor back ridge that is above the face that we observed. Fe encrusted pillow basalts dominate the field of view, and sediment constitutes <20 to 30% of the surface

	cover. *22:22:00.* The ROV reached the end of the razorback ridge and some small deposits of rock rubble are found on a shallow slope. The razorback ridge intersects with a steep face, and the ROV moved up the face. The face is composed of FE encrusted pillow basalts. *22:30:14.* The ROV summited the face and continued to moved forward along another razorback ridge. Again, the ridge is composed of FE encrusted pillows. Light-colored sediment covers <10% of the rock surface. *22:46:00.* The ROV moved onto a talus slope with scattered FE cobbles (<30 cm in diameter). None of the boulders were suitable for sampling. Sediment cover is ~50%. The ROV moved another 5 or 10 meters upslope and identified a promising rock sample. A FE cobble (angular, perhaps 20 cm in diameter) was taken as the second geological sample, which was laced in the port forward rockbox. The ROV is <300 m from the summit on this dive, so the rock could not have rolled very far: **02_DIVE07_SPEC02GEO** *23:00:35.* The talus deposits transition to a steeper face constructed of FE pillow basalts. Sediment cover is <5% on the steep face. At the top of the steep face is a ridge with a shallower-sloping face on the far side; the sediment cover is up to 60% on this far-facing side. Ripples are present in the sediment. *23:11:40.* The ROV entered a talus field with RE cobbles and boulders. An an angular block (30 cm by 20 cm) was chosen for sampling. The rock was placed in starboard side rock box, and is the larger of the two rocks in the box. The ROV is <300 m from the summit on this dive, so the rock could not have rolled very far: **02_DIVE07_SPEC03GEO** *23:42:41.* The ROV has left the talus field and has moved up on a steeply-sloping face composed of FE-encrusted pillow basalts. Light-colored sediment covers <5% of the surface. 00:05:25. The ROV crested the steep face and arrived on a flatter, more level surface. The surface is composed of basalt flows and is lightly (<10%) sediment covered. 00:09:27. The surface brakes up into basalt rubble including cobble and boulder-sized basalt (~30% of the surface), with ~50% of the surface composed of solid flows and 10 to 20% composed of light-colored sediment. 00:11:55. The field of view is comprised completely of boulders and cobbles (70%) and light-colored sediment (30%). 00:12:35. The ROV approached a relatively steep (perhaps 40 degrees, rough estimate) slope composed of FE pillow basalts. 00:33:28. The steeper surface has very nice pillow structures with perhaps 2% sediment cover, confined to crevasses in the pillows. 00:38:18. Reaching the surface of the steep face the ROV arrived on a FE basaltic ridge. The ridge is 2 or 3 meters wide, and slopes steeply (perhaps 45 degree slope) to the left and to the right. Sediment cover approached 25% on the left-hand ridge, and <5% on the right hand ridge. This might suggest stronger currents on the left hand side of the ridge. 01:04:02. Moving upslope along the ridge, FE basalt flows fill the field of view, and ~10% of the surface is covered with sediment. 01:12:16. The ROV moved into a talus field composed of FE cobbles. 30 to 40% of the field of view shows sediment cover. Some FE outcrops, composed of pillow basalts, are also clear. 01:21:57. The ROV emerged from the talus field and moved up a steeply sloping face composed of FE pillow basalts. Sediment cover is <2%. However, at some locations along the face, there are less steeply sloping areas where larger

	quantities of sediment have accumulated and sediment cover increases to perhaps 30%; on these less steeply sloping areas it appears that cobbles have accumulated and are welded (via FE) to the face of the slope. 01:47:36. The ROV is continuing along above the surface of the same steep wall from the prior observation. 01:48:23. The slope of the wall has diminished a bit, permitting additional sediment accumulation (perhaps 40% sediment cover); additionally, loose cobbles are present in abundance in this region of diminished slope. 01:51:31. The ROV sumits the face and has arrived on a 2 to 3 meter wide ridge that has a rather shallow slope. To the left and right of the ridge the slope is relatively steep (30 to 40 degrees). **The biological perspective is as follows:** Landed on very steep terrain, exposed boulder MANY chrysogorgiid octocorals *Pleurogorgia*, very similar to the ones observed yesterday in Utu seamount. Also observed 3 occurrences of ophiacanthid brittle star ophiuroid possibly genus *Ophioplinthaca* 2215 m Moki Seamount. As yesterday's dive on Utu, this kind of ophiuroid was associated with bare skeleton of the octocoral (possibly feeding on it), novel observation. Also two morphospecies of zoanthids growing on the *Pleurogorgia* corals, as wells as small anemones and hydroids. Intermixed with the live *Pleurogorgia* colonies also saw many dead colonies exposed skeletons colonized by zoanthids and worms. Also observed a feather black coral (*Bathypathes?)*, a whip black coral, as well as a very large (taller than 2m) bamboo whip with no needle sclerites in polyps. A small mostly dead bamboo whip with only 3 polyps near the base; no colonization of the bare skeleton indicating a recent loss of tissue (predation?). Continued climbing along steep terrain of exposed rock. 2107 m 22:21. Imaged a sea star *Chiraster?* Observed a couple of whip black corals. Observed a *Iridogorgia* coral with a squat lobster and anemone associate at 22:34 ~2091 m. Also observed a *Chrysogorgia* with two squat lobsters associated. Also observed a living whip slender bamboo whip (similar to the dead one observed earlier; this one had needle sclerites in/and sticking out of polyps. Observed a drifting sea cucumber at 2085m 22:51. Abundant exposed rock but not too many corals or sponges attached to 2060m 23:12. Observed small juveniles of chrysogorgiid octocorals and black corals. Encountered a large vertical wall at 2037 m with large 22:45 bamboo whips, *Iriogorgia* golden corals (including one larger, a large *Chrysogorgia* with 2 squat lobsters, many *Pleurogorgia.* Encountered another flat-wall step at 2021 m 00:14. Observing many swimming tomopterid? polychaetes throughout the dive. Seen a water layer with a lot of suspended particles here. Attempted to collect cookie star but failed ☹ 00:24. Found large abundances of dead coral holdfasts (branching corals) indicative of old coral communities living on this seamount in the past (sometimes thousands to hundreds of thousands of years given that some are covered with iron manganese crust). Most of them belonged to branching corals which are not currently present here. Troubleshooting vehicle issues 00:42 at 2005 m. 00:48 continuing with the dive

	(slight power problems with some video and data systems of the ROV). Observed first (and only) fish of the dive at 2000m (halosaur). Collected *Chrysogorgia* with a squat lobster and hydroid associates (D2_DIVE07_SPEC04BIO 01:11, 1993 m) Observed corallimorpharian at 01:15 ~1985 m. As we ascend near the top the terrain has a gentler slope with broken talus and pockets of sediment. Encountered another steep vertical wall at 1960 m 01:25. Observed very large abundance of octocorals, primarily *Pleurogorgia* corals with yellow small comatulid associates, anemones, brisingid sea stars, as well as *Ophioplinthaca* ophiuroids. The later were also observed moving on the seafloor. Also observed several large branched isidid colonies, likely from the genus *Jasonisis* with a sponge and hydroids attached on bare skeleton parts. Also on this wall observed one hexactinellid glass sponge (first and only of the dive) as well as large *Iridogorgia* colonies and whip bamboo corals. Problems with vehicles at ~1920 meters 01:50. Came off bottom near the top of the wall (almost at the top of the seamount) and after assessment of situation the dive was ended. Could not reach highest point of seamount.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	



EX1702_IMG_20170222T233907Z_PTMAN_COR_CLIFF....

Steep terrain with light sedimentation. Chrysogorgiid and bamboo whip corals attached to surface.



EX1702_IMG_20170223T000237Z_ROVHD.jpg

Large *Iridogorgia* coral colony and *Pleurogorgia* on a near-vertical wall.

Samples Collected

Sample

Sample ID	02_DIVE07_SPEC01GEO
Date (UTC)	20170222
Time (UTC)	21:38:29
Depth (m)	2115.9718
Temperature (°C)	2.0344
Field ID(s)	Rock
Comments	



EX1702_IMG_20170222T213800Z_D2_DIVE07_SPEC01...

Sample

Sample ID	02_DIVE07_SPEC02GEO
Date (UTC)	20170222
Time (UTC)	22:58:24
Depth (m)	2075.9465
Temperature (°C)	2.1006
Field ID(s)	rock



EX1702_IMG_20170222T225740Z_D2_DIVE07_SPEC02...

Comments	

Sample

Sample ID	02_DIVE07_SPEC03GEO
Date (UTC)	20170222
Time (UTC)	23:20:42
Depth (m)	2054.8783
Temperature (°C)	2.1014
Field ID(s)	Rock

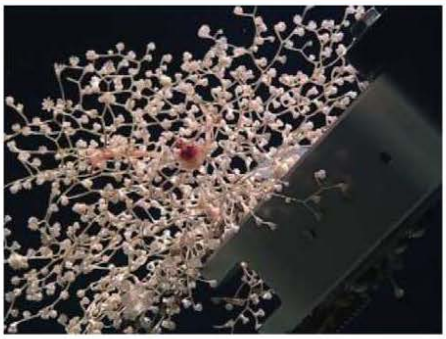


EX1702_IMG_20170222T231832Z_ROVHD.jpg

Comments	

Sample

Sample ID	D2_DIVE07_SPEC04BIO
Date (UTC)	20170223
Time (UTC)	01:10:44
Depth (m)	1993 m
Temperature (°C)	Sensors not transmitting data
Field ID(s)	Chrysogorgia with squat lobster



EX1702_IMG_20170223T010916Z_D2_DIVE07_SPEC04...

Comments	Likely associate hydroid as well
Sample	
Sample ID	
Date (UTC)	
Time (UTC)	
Depth (m)	
Temperature (°C)	
Field ID(s)	
Comments	
Sample	
Sample ID	
Date (UTC)	
Time (UTC)	
Depth (m)	
Temperature (°C)	
Field ID(s)	
Comments	

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(301) 734-1014

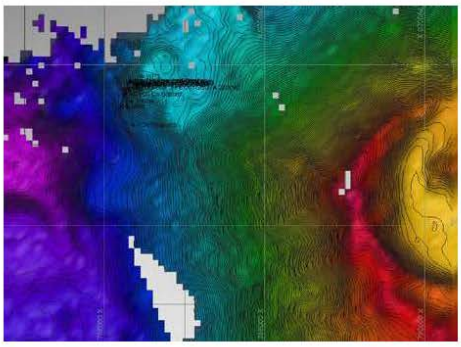
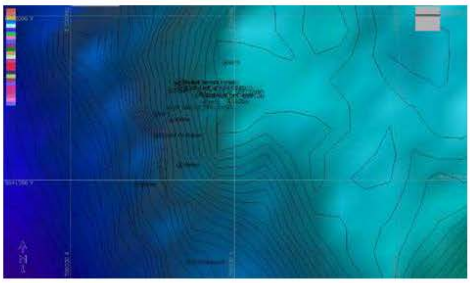
Okeanos Explorer ROV Dive Summary

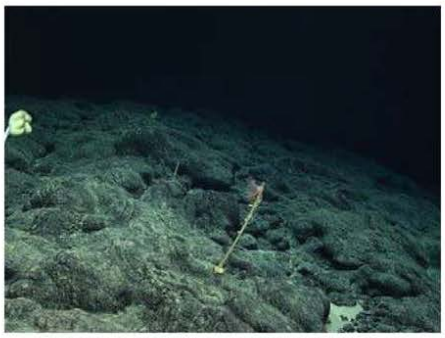
Dive Information			
Dive Map			
Site Name	Deeper dive on "Utu" seamount		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	North Samoan region, Near southern margin of Manihiki Plateau		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	08		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1

	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2
	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ORP	
Equipment Malfunctions			
ROV Dive Summary (from processed ROV data)	In Water: Out Water: Off Bottom: On Bottom: Dive duration: Bottom Time: Max. depth:	2017-02-23T19:15:50.952000 12°, 16.612' S ; 168°, 22.159' W 2017-02-24T03:33:05.515000 12°, 15.840' S ; 168°, 21.991' W 2017-02-24T01:35:08.205000 12°, 16.432' S ; 168°, 22.036' W 2017-02-23T21:42:43.399000 12°, 16.452' S ; 168°, 22.098' W 8:17:14 3:52:24 3931.9 m	
Special Notes			
Scientists Involved (please provide name, location, affiliation, email)	Asako Matsumoto, PERC, Chiba Institute of Technology, Japan Bruce Mundy, NOAA PIFSC Les Watling, University of Hawaii at Manoa Scott France, University of Louisiana at Lafayette Tara Harmer Luke, Stockton University Matthew Jackson, UC Santa Barabara Santiago Herrera, Lehigh University		
Purpose of the Dive	The goal of this dive was to generate baseline information on geology and geochemistry of this unexplored (and largely unmapped) seamount. There is also significant interest in understanding the deep sea habitats and biological communities on the seamount to better understand their diversity and distribution. Maps of the seamount were generated two days before this dive for preparation for the first dive on this seamount; the first dive (Dive 6) was in the crater on the summit of the seamount. This dive (Dive 8) targets the deeper flanks of the volcano, and focuses on the the volcanic platform upon which the volcano is constructed. From a geological standpoint, this seamount may be an older seamount linked to the Society hotspot, not Samoa. Samples from this seamount are key in defining the Society hotspot tracks back in time, and as such an age on a volcanic rock is needed from this seamount. Without an age, it is not possible to truly define plate motion for the time frame represented by this volcano.		

	From the biological perspective this dive has the potential to provide new depth records for several species as well the discovery of new species. Very little work has been done in the Central Pacific at these depths on seamounts. We aimed to collect information that will inform the biogeographic identity of the communities at abyssal depths in this region.
Description of the Dive	The seamount explored in this dive, tentatively called "Utu" seamount, lies in the northern region of the American Samoa EEZ. The shallow portion of this seamount was explored by ROV (Dive 6) two days prior to this dive (Dive 8). Thus, high-resolution maps of the dive site were already available from our prior efforts. The seamount appears to be comprised of two distinct structures: The base of the seamount is composed a "lumpy" or "blocky" structures, perhaps consistent with pillow or pillow mounds; the basal portion of the volcano is similar in morphology to "pancake" seamounts. Constructed on top of this basal pancake structure is a volcanic structure that has both steeper and smoother sides than the basal pancake portion of the volcano. These two morphologically different structures of the volcano (i.e., the pancake basal portion and the steeper sided upper section) are consistent with two stages of volcanic activity on this seamount. It is notable that the summit of the seamount is nearly flat-topped, and is host to a nicely developed volcanic crater: the center of the crater hosts a volcanic cone, and the crater walls exhibit at least two different "step-like" features, consistent with partial crater collapse like that which is observed in calderas at basaltic shield volcanoes at oceanic hotspots. The dive track was designed to target the flanks of one of the deep "pancake" structures at the base of seamount, transiting up the side of the pancake structure, and then crest the rim of the pancake structure and transit along the rim. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** *21:30:10.* The first view of the ocean floor revealed a relatively flat, FE (ferromanganese encrusted/encrustation) surface with ~10% sediment cover (like all prior dives at depths >1000 m, the sediment is light in color). There appear to be FE cobbles and pebbles in the field of view. There is a possible flow structure in the middle of the field of view. *21:47:49.* After moving perhaps 5 or 10 meters from the 'on bottom' location, the ROV shows a boulder field that appears to have been completely covered with FE and the boulders appear to be welded together with FE. It is possible that these boulders are actually pillows, but they may be to be too small to be pillow structures. Moving another 10 or 20 meters, the same surface geology is observed that was observed at 21:47:49; in this field of FE cobbles, a 20 cm cobble was sampled (it has a sponge attached). It was placed in the starboard rock box, the first rock sample of the dive. **D2_DIVE08_SPEC01GEO** *22:17:28.* The same surface geology continues, unchanged. *22:24:07.* The surface geology has transitioned to a greater abundance of smoother surfaces (likely flows), which now represent ~50% of the field of view. The remaining 50% represents FE cobbles and pebbles. *22:26:09.* Some outcrops in the field of view have the appearance of pillow basalt structures. *22:27:30.* A deposit that looks like a talus debris deposit is in the field of view.

	The pebbles and cobbles appear to have been welded together with FE depositions. *22:38:50*. The geology has transitioned to possible FE pillow basalt structures that are partially covered with FE talus composed of cobbles and boulders. Sediment cover is perhaps 20%. *22:55:49*. The surface is composed of 80% FE pillow structures, 15% FE cobbles and pebbles, and ~5% light-colored sediment. *23:12:58*. The surface is composed of perhaps 60% FE pillow structures, 30% FE cobbles and pebbles, and ~10% light-colored sediment. One of the cobbles was loose and was selected as the second geological sample of the expedition (~20 cm long axis diameter). It was placed in the portside rock box: **D2_DIVE08_SPEC02GEO** *23:45:24*. The terrain is not as steep as we approach the summit of this volcanic feature. The field of view is dominated by smooth surfaces, likely FE flows. FE cobbles and boulders are found in abundance between the flows, and sediment cover is <5%. *23:59:10*. The terrain is dominated by FE pillow flows with scattered FE cobbles and pebbles. The sediment cover is ~20%. A cobble with a triangular top was sampled at this location, and is the third geologic sample of the dive. The sample was placed in the starboard rock box (it is likely the smaller of the two rocks in the box): **D2_DIVE08_SPEC04GEO** *00:21:54*. The surface is again becoming rougher. FE pillow flows define most of the field of view, and FE cobbles that are "welded" to the flows provide additional topography on the surfaces of the flows. Sediment comprises ~5 to 10% of the surface cover. *00:24:40*. The slope has increased to perhaps 25 degrees, the steepest yet observed in the dive. FE pillow basalts dominate the field of view. Just within the field of view, perhaps 5 or 10 meters from the ROV, the topography is distinctly rougher and looks to be either FE talus composed of cobble-sized rocks or FE nodules. *01:22:16*. There was a long delay as the ROV attempted to sample an exceptionally small (2 or 3 cm) animal that appears to be the source of the sediment scoured "trails" on rock surfaces on this seamount (and at other seamounts on this expedition). The slope is perhaps 15 to 20 degrees and the field of view is dominated by FE pillows with relatively smooth surfaces. **The biological perspective is as follows:** Landed on a ~40-degree sloping terrain, composed of ferromanganese encrusted cobbles, some loose, some cemented. 21:45 3934m. Observed a dead *Caulophacus sp* -like glass sponge laying on ground. Small *Pleurogorgia* coral. Observing several potbelly sponges *Hyalonema. Freyastera*? Brisingid seastar on rocks. Observed different species of *Freyastera* close by. Collected rock D2_DIVE08_SPEC01GEO at 3917 m 22:15. As we move upslope the terrain is mainly composed of cobbles cemented by ferromanganese crust and pockets of sediment. Observing several potbelly and stalked sponges *Caulophacus* sp (these sponges are different from *Bolosoma,* mainly have a slenderer long stalk and a smaller 'head' proportional to the stalk; they are in fact in different families). Highlight observation of a red/translucent sea cucumber (Family Synallactidae) with its anterior half raised into the water column (may be a reproductive behavior to release gametes).

	Observed several more potbelly sponges and small ophiuroids attached to rocks 22:54 3890 m. Same pattern of potbelly and ophiuroids being the most dominant animals here, not a large abundance. 23:12 3975m. Collected rock D2_DIVE08_SPEC02GEO at 23:16 3863 m. Collected dead sponge stalk with crinoid, hydroids and anemone. D2_DIVE08_SPEC03BIO 23:37 3861 m. Observed several of these dead sponge stalks with several crinoids as the one collected. Observe several large *Caulophacus* sponges, intermixed with several dead sponge stalks with yellow crinoids 3851m 23:56. Observed a different sponge in the family Corbitellinae 23:59 3851 m. Collected rock D2_DIVE08_SPEC04GEO 00:14 3849m. Observed what looked to be like a **monoplacophoran** mollusk. 00:50 3838 m. An extremely rare observation. Known from soft bottom abyssal plains. Fist time seen alive by any of the experts participating. Truly exciting!!!!!!! Attempted collection with scoop, but failed. Observed the first and only fish of the dive at 01:23 a Cusk Eel (*Leucicorus*), 3827 m. Collected D2_DIVE08_SPEC05BIO dead sponge stalk with anemone, barnacle and crinoids (01:26, 3,826 m). Ended dive at the top of feature, observed several stalked sponges on the horizon.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	



EX1702_IMG_20170224T012711Z_ROVHD.jpg

Gently sloping terrain of mostly exposed rock encrusted with iron-manganese. Several alive and dead stalked glass sponges attached to hard substrate



EX1702_IMG_20170224T011235Z_ROVHD.jpg

Close up of monoplacophoran associated with trails of 'clean' rock observed throughout the dive.

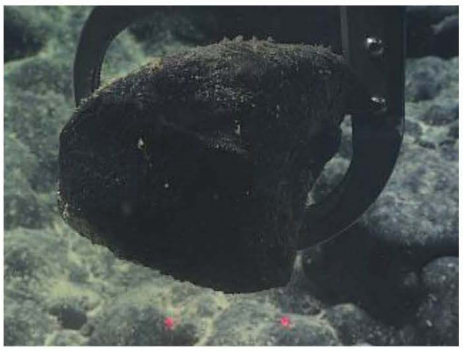
Samples Collected

Sample

Sample ID	D2_DIVE08_SPEC01BIO
Date (UTC)	20170223
Time (UTC)	22:14:28
Depth (m)	3919.9894
Temperature (°C)	1.41114
Field ID(s)	rock
Comments	



EX1702_IMG_20170223T221105Z_ROVHD.jpg

Sample		
Sample ID	D2_DIVE08_SPEC02GEO	 EX1702_IMG_20170223T231431Z_ROVHD.jpg
Date (UTC)	20170223	
Time (UTC)	23:16:07	
Depth (m)	3873.2125	
Temperature (°C)	1.44872	
Field ID(s)	Rock	
Comments		

Sample		
Sample ID	D2_DIVE08_SPEC03BIO	 EX1702_IMG_20170223T233327Z_ROVHD.jpg
Date (UTC)	20170223	
Time (UTC)	23:37:39	
Depth (m)	3861.7208	
Temperature (°C)	1.47184	
Field ID(s)	Commatulid Crinoid on sponge stalk	
Comments		

Sample		
Sample ID	D2_DIVE08_SPEC04GEO	 EX1702_IMG_20170224T001315Z_ROVHD.jpg
Date (UTC)	20170224	
Time (UTC)	00:15:13	
Depth (m)	3847.5135	
Temperature (°C)	1.50309	
Field ID(s)	rock	
Comments		

Sample		
Sample ID	D2_DIVE08_SPEC05BIO	
Date (UTC)	20170224	 EX1702_IMG_20170224T013049Z_ROVHD.jpg
Time (UTC)	01:40:45	
Depth (m)	3710.8195	
Temperature (°C)	1.45730	
Field ID(s)	Anemone on stalked sponge, crinoids	
Comments		

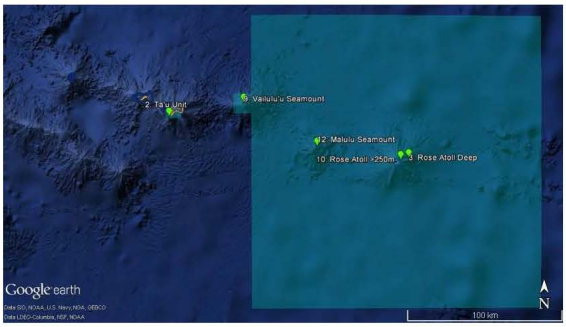
Sample	
Sample ID	
Date (UTC)	
Time (UTC)	
Depth (m)	
Temperature (°C)	
Field ID(s)	
Comments	A third biology sample was not collected

Please direct inquiries to:

NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014

Ocean Exploration and Research

Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	"Vailulu'u" seamount crater		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Eastern Samoan region		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	09		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2
	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5

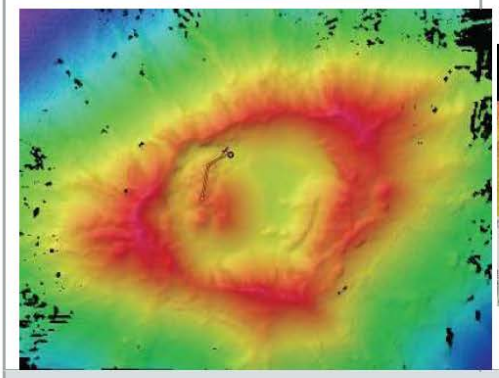
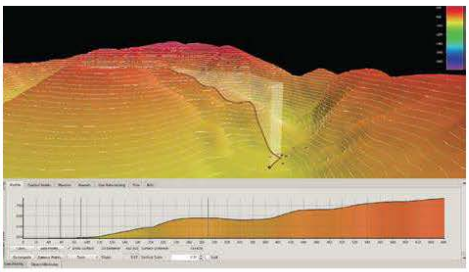
	☒ LSS	☒ ORP	
Equipment Malfunctions			
ROV Dive Summary (from processed ROV data)	In Water:	2017-02-24T19:28:56.796000 14°, 12.494' S ; 169°, 03.397' W	
	Out Water:	2017-02-25T05:32:46.012000 14°, 13.102' S ; 169°, 03.739' W	
	Off Bottom:	2017-02-25T05:07:13.743000 14°, 12.972' S ; 169°, 03.581' W	
	On Bottom:	2017-02-24T20:44:47.678000 14°, 12.642' S ; 169°, 03.515' W	
	Dive duration:	10:3:49	
	Bottom Time:	8:22:26	
	Max. depth:	928.5 m	
Special Notes			
Scientists Involved (please provide name, location, affiliation, email)	Asako Matsumoto, PERC, Chiba Institute of Technology, Japan Bruce Mundy, NOAA PIFSC Christopher Kelley, University of Hawaii Craig Young, University of Oregon Deborah Glickson, NASEM Diva Amon, University of Hawaii at Manoa Jasper Konter, University of Hawaii Manoa Kristen Mello, Center for Coastal and Ocean Mapping Les Watling, University of Hawaii at Manoa Matthew Jackson, UC Santa Barbara Natalie Summers, University of Hawaii at Manoa Santiago Herrera, Lehigh University Scott France, University of Louisiana at Lafayette Tara Harmer Luke, Stockton University William Chadwick, NOAA/PMEL		
Purpose of the Dive	The goal of this dive was to explore the volcanically active crater of Vailulu'u seamount. The dive planned to target a location previously know to be the locus of hydrothermal venting, which is located near a plume in the water column (extending above the crater) that was detected to emanate for a region of the crater that is near the site of previously-observed hydrothermal venting. There is also significant interest in understanding the deep sea habitats and biological communities associated with the hydrothermal activity and the hard-substrate areas on the volcano to better understand their diversity and distribution.		

	From a geological standpoint, this seamount is volcanically active and is likely the youngest volcano in the Samoan region. Therefore, further data on this seamount provides a critical window into the geochemistry and volcanology of the early stages of the evolution of a Samoan volcano. From the biological perspective this dive provides information about the successional changes in the biological communities associated with changes in the environmental setting product of active volcanism. We aim to collect information that will inform the biogeographic identity of the hydrothermal and hard-substrate communities at bathyal depths in this region.
Description of the Dive	The seamount explored in this dive, Vailulu'u seamount, lies in the eastern region of the Samoan hotspot. The seamount has been mapped in high resolution by multibeam in prior years (1999, 2005, 2006, 2012). Since the 2012 mapping expedition to Vailulu'u, new bathymetric data show that the volcanic cone in the crater, called Nafanua, has grown substantially. Additionally, a mapping effort in mid-February 2017 aboard the *Okeanos Explorer* identified plumes (likely composed of CO_2 gas) rising from the location of previously identified hydrothermal vents. The dive track was designed to start at ~908 m water depth at a location of ~50 m east of previously noted locations of hydrothermal activity. After exploring the hydrothermal field, the ROV was to traverse to a feature on the north side of Nafanua that was generated in the 5 years since the 2012 mapping effort. The ROV dive was designed to move progressively upslope, along a series of new volcanic features, and finish at a depth of ~715 m. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** 20:22:00 to 20:44:12 UTC. The ROV arrived in the moat near hydrothermal field. During the dive, turbidity increased substantially with depth; the turbidity meter showed that at ~720 m water depth, the turbidity increases rapidly. One scientist notes that the crater is more turbid than in the 2005 dive in the crater; in 2005, the ROV was able to navigate through the water at the base of the crater as the turbidity was not too severe, but on this dive the turbidity is so severe in the same location that *Seirios* cannot get a visual of D2. The ROV team made a decision to try to move out of the turbidity plume in a direction to the southeast, which is moving against the current (the current is weak, and moves from southeast to northwest). 20:45:08. The seafloor in the crater is visible for the first time. Spectacular pillow basalts are the first objects in the field of view; the pillows are approximately 30 to 50% covered with sediment. The turbidity limits the field of view. ROV depth is ~928 m. 20:50:25. We have moved several meters away from the "on bottom" site and ~80% of field of view is covered by sediment, possibly flocculent material. The remaining 20% consists of basalt boulders. 21:13:25. After a long delay, the ROV is finally moving slowly along bottom, without a visual *Seirios* (owing to high turbidity). Occasional cobbles and boulders are visible, and all are partially covered with sediment. Between the boulders, sediment covers 70 to 80% of the surface. A number of worms feasting on a dead fish constituted the first biological sample of the dive (the fish was not sampled, as it fell out of the scoop). 21:35:00. Due to the very high turbidity severely limiting visibility, the ROV moved

	up the nearest cone feature that is unlikely to be generated by the youngest (<5 years old) volcanic activity. 21:13:25 to 23:17:20. Santiago Herrera and I participated in an online telepresence interaction with 170 students in American Samoa. Thus, our ability to make observations during this period was limited. However, as the ROV moved toward Nafanua, spectacular pillow lavas were observed and noted. One pillow was sampled by the ROV, the first geological sample of the expedition, while Santiago and I were engage in outreach activities (the samples was placed in the portside rockbox): D2_DIVE09_SPEC02GEO 23:42:24. The ROV is transiting toward WP5 so that the youngest volcanic features (i.e., generated since the last mapping cruise in 2012) on Nafanua can be sampled; WP5 is located near the summit of the first and northernmost of the two largest volcanic cones that have formed on Vailulu'u since 2012. 23:43.24. Pillow basalts are observed consistently as the ROV moves along bottom. The surfaces of many pillows show a high degree of vesiculation, and owing to the young nature of the flows (all flows on Nafanua have formed since 1999), it is not surprising that ferromanganese crusts are absent. Light colored and dark (black) colored sediment covers the seafloor between the rock outcrops. 00:09:42. ***The third biology sample of the expedition was taken (a mushroom coral) and a bit of rock was attached.*** The rock was a "crumbly" basalt block, but should be considered for future research purposes: D2_DIVE09_SPEC04BIO 00:15:13 to 00:40:07: The ROV has been moving downslope for the past ~5 minutes, so the ROV is facing water with occasional peripheral views of views of volcanic pillows. 00:40:07. The ROV passed a vertical wall composed of textbook pillow basalt structures. 00:40:15: ROV showing some spectacular pillows. The excessive sediment cover visible on the pillows from the older portions of Nafanua are not present at this site; note that this site is located near the summit of the first and northernmost of the two largest volcanic cones that have formed on Vailulu'u since 2012. Absolutely beautiful pillows that look like "toothpaste". A really nice pillow feature, likely the leading edge of a pillow, broke off the main pillow structure and constitutes the 2nd geological sample of this dive (placed in the starboard rockbox): **D2_DIVE09_SPEC05GEO** 01:02:05. We continue to see an abundance of young pillows with very little sediment cover. Additionally, there are few animals on the pillows (and the animals that are seen are smaller) compared to the older pillows observed on Nafanua observed earlier in the dive. Some of the flow surfaces are dark brown, suggesting some degree of oxidation (Fe oxide). 01:10:49. The pillows are among the largest observed by the ROV. The pillows are darker in color than pillows observed earlier in this dive, and they also have less sediment cover. However, the sediment cover in crevasses between the pillows is reasonably thick, possibly several centimeters. 01:32:37. The ROV shows more of the same geological features, consisting of textbook pillows with minimal sediment cover, that were observed earlier in the dive. Again, all the pillows are <5 years in age. 01:45:54 to 2:00:14. The same pillow structures (from the two prior observations) continue to dominate the field of view. At this point the turbidity is increasing significantly. 02:13:21. The turbidity continues to be elevated. The lavas flow morphology and sediment cover has remained little changed for the past hour as we continue along the ridge (the ridge that joins the two largest volcanic cones that have

	formed on Vailulu'u since 2012). The lack of significant sediment likely owes to the youthfulness of the structure (<5 Ma) on Nafanua. 02:39:21. There is a much greater abundance of sediment between the pillow structures, which may relate to the higher turbidity on this region of Nafanua. The ROV has been heading slightly downhill for the past 10 or 15 minutes. However, it is also possible that the ROV is now passing over an older portion of Nafanua, and this may help explain the enhanced sediment cover. 03:02:09. The ROV team leader has indicated that the ROV will be heading upslope until the ROV reaches the "south point", which is one of the two volcanic features (we explored the first one over an hour ago, from which the second geologic sample was taken) that has experienced significant volcanic growth in the past 5 years. 03:16:41. The ROV is showing a significant change in the morphology of the flows. Instead of the classical pillow basalt structures, the flows have chaotic "broken" structures that have more of the appearance of "submarine a'a". It is not clear what is responsible for this change in lavas morphology. 03:20:59. The ROV is moving over fresh pillow basalt structures again. 03:34:34. The ROV is now transiting over some of the rough basaltic terrain similar to that observed at 03:16:41. The turbidity is now quite low as the ROV continues to climb higher onto the southern peak (the second peak that has experienced the most significant volcanic growth in the past 5 years). 03:37:38. The ROV has reached the summit of the second large volcanic structure that was generated in the past 5 years. The first of the two large volcanic structures was sampled about 2 hours ago (i.e., the second geologic sample of the dive). The lava is angular, with no clear pillow structures. There appears to be significant orange-colored biological material covering the surfaces of the rocks. A loose portion from this summit basalt outcrop was selected as the third geological sample of the dive. The rock is 20 cm long on the long axis, but the sample broke before it was placed in the starboard box, but two portions of the same rock sample were recovered and place in the rockbox (both in the starboard rock box): D2_DIVE09_SPEC06GEO 04:19:37. The ROV has been heading downslope for the past ~15 minutes, and as a result, the view has been of blue water. The ROV is heading for the highest point on Nafanua, a peak that may represent the original summit of Nafanua observed for the first time in 2005. 04:21:58. The seafloor is back in view again. The ROV field of view again shows some spectacular pillow structures. There is some sediment cover. The turbidity remains relatively high. 04:30:50. The ROV moved back downslope again, and the view has been of blue water for the past ~5 minutes as the ROV transits toward the 700+ meter tall summit of Nafanua. 04:38:13. The seafloor has come into view again. The ROV view shows talus composed of large (up to 2 meter wide, estimate) pillow fragments. 04:46:34. Intact pillow flows are coming into view, likely the source rock for the talus blocks below. A darker colored sediment covers the talus and pillows in the field of view. 04:54:16. The surfaces of the rocks have an orange-brown color, suggesting significant hydrothermal alteration. Fresher (grey) surfaces are juxtaposed with the orange-brown surfaces, suggesting a recent disturbance, possibly a landslide. The large degree of sediment cover, in addition to the greater degree of biological diversity and the larger size of the fauna, similar to the location where the first geological samples was recovered; both locations are outside of the regions

	suggested to have experienced growth between 2012 and 2017. Thus, the enhanced sediment cover and change in biological communities is consistent with a lack of recent growth on the summit of Nafanua. 04:59:54. The ROV has just summated the highest point on Nafanua. The ROV reached 677 meters water depth at the summit. **The biological perspective is as follows:** Began detecting plume signals in turbidity, oxygen and ORP sensors at ~720m also visible in the main ROV cameras. Slowly tried to descend to the seafloor, however, turbidity was extremely high, and the vehicles could see each other. Turbidity also interfered with the sonar of the ROV. Turbidity values hovering around 11-13 FTU. Tried to move the ROV up current (very slight current moving from SW to NE) to try to improve visibility by getting out of a possible focused plum. Moved ~100m SE and dropped to seafloor (20:45, 927 m) into the axis of the Moat of Death. Observed lava pillows with a very thick flocculent material cover. Attempted to collect polychaete worm crawling on flocculent seafloor with the scoop, but failed. Proceeded to explore the seafloor for other polychaete worms that may be feeding on fish carcasses in the moat of death. Encountered dead fish with polychaete worms scavenging (21:15, 924 m) and sampled the flocculent material under the dead fish and some of the polychaete worms (20170224 21:25:47, D2_DIVE08_SPEC01BIO. 21:30 Brought the ROV off the seafloor to ~700 m to attempt reach the NE peak of the central cone feature in the center of the crater in order to raise above the turbidity plume and improve visibility. The mid-water transit took ~40 min. Regained view of the seafloor after moving to the top area of the cone at ~700m. Observed several collapsing lava flows. Carnivorous sponges, anemones, and ophiuroids on some of the pillows. Observed an eel at 23:17. Observed abundant small anemones (less than 3 centimeters in diameter on collapsing lava pillows). Also observed *Anthomastus* octocoral and stalked hydroids at 23:39 700 m. Collected stalked hydroid (20170224 23:41:40, D2_DIVE05_SPEC03BIO, 699 m). Observed larvaceans with house, as well as a large colonial salp pyrosome 22:46 at 705 m. Two eels at 23:48 (C. Young "look like the eels in eel city *Dysommina rugosa*"). Continued to observe more eels, ophiuroids, anemones, *Anthomastus,* and stalked hydroids. Collected *Anthomastus* at (20170225 00:11:10, D2_DIVE09_SPEC04BIO, 702 m). Went down hill to reach the western high-grounds of the central cone to explore the newer areas 00:19 708. Observed more larvacean houses. Turbidity increased as we moved ~30 meters deeper and towards the east. 00:40 Regained seafloor view as we reached the NE slope of the NW peak of the central cone in the crater of Vailulu'u. Lava flows had much lighter sediment cover. Collected rock (D2_DIVE09_SPEC05GEO, 20170225 00:50:12, 730). Seafloor on this slope looked younger, with less sediment cover and less orange flock. Observed several sessile organisms, including cladorhizid carnivorous sponges, anemones and solitary hydroids, but all very small in size. Went down a

	slope heading southward after reaching the top most part of the NW peak. Apart from small anemones and cladorhizid sponges there was not much else here. Observed one eel at 02:20 720m. Another eel, lantern fish and thresher shark 02:52 727 m as we moved along southward. Reached the SW peak at 03:38 700 m. Went out of the turbidity layer. Collected a rock, which was likely to be the youngest from this dive. (20170225 03:56:01, D2_DIVE09_SPEC06GEO, 702m). Did a mid-water move after rock collection while we moved to the SE peak of the cone. Observed several larvaceans, a jellyfish, red ctenophore, shrimp, and siphonophores. Re-entered turbidity plume at 04:20 712m. Re-gained visual of the seafloor at 04:22 718 m. Lifted into the water column again and continued mid-water move, observed more jellyfishes and larvaceans. Reached the SE cone at 04:40 733m, observed broken down pillow basalts. Steep slope here. Started observing intact pillow flows intermixed with broken off pillows 04:48 718, continue to observe more broken off pillows intermixed. Observed several *Anthomastus* corals, larger carnivorous sponges and anemones, as well as hydroids. More abundant communities <700 m larger Anemones, solitary hydroids, sponges. Reached the highest point at 677m 05:07 at which point the dive ended.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	



EX1702_IMG_20170224T205810Z_ROVHD.jpg

Turbid water and flocculent material covering seafloor in the Moat of Death



EX1702_IMG_20170225T010340Z_ROVHD.jpg

Lava flows in the newest portions of the volcanic cone, little biological colonization or sedimentation on the newly-formed rocks.

Samples Collected

Sample

Sample ID	D2_DIVE08_SPEC01BIO
Date (UTC)	20170224
Time (UTC)	21:25:47
Depth (m)	925.4315
Temperature (°C)	5.63332
Field ID(s)	Floculent material with polychaete worms



EX1702_IMG_20170224T211943Z_ROVHD.jpg

Comments	Sample is named "D2_DIVE08_SPEC01BIO" in error. Should be "D2_DIVE09_SPEC01BIO"

Sample		
Sample ID	DIVE09_SPEC02GEO	 EX1702_IMG_20170224T225046Z_ROVHD.jpg
Date (UTC)	20170224	
Time (UTC)	22:54:27	
Depth (m)	709.6877	
Temperature (°C)	5.73246	
Field ID(s)	rock	
Comments		

Sample		
Sample ID	D2_DIVE05_SPEC03BIO	 EX1702_IMG_20170224T233630Z_ROVHD.jpg
Date (UTC)	20170224	
Time (UTC)	23:41:40	
Depth (m)	699.7877	
Temperature (°C)	5.76509	
Field ID(s)	Hydroid (stalked)	
Comments	Sample ID "D2_DIVE05_SPEC03BIO" is in error, and should be "D2_DIVE09_SPEC03BIO"	

Sample

Sample ID	D2_DIVE09_SPEC04BIO
Date (UTC)	20170225
Time (UTC)	00:11:10
Depth (m)	701.9167
Temperature (°C)	5.70339
Field ID(s)	Anthomastus



EX1702_IMG_20170225T000741Z_ROVHD.jpg

Comments	

Sample

Sample ID	D2_DIVE09_SPEC05GEO
Date (UTC)	20170225
Time (UTC)	00:50:12
Depth (m)	730.3365
Temperature (°C)	5.53999
Field ID(s)	rock



EX1702_IMG_20170225T004805Z_ROVHD.jpg

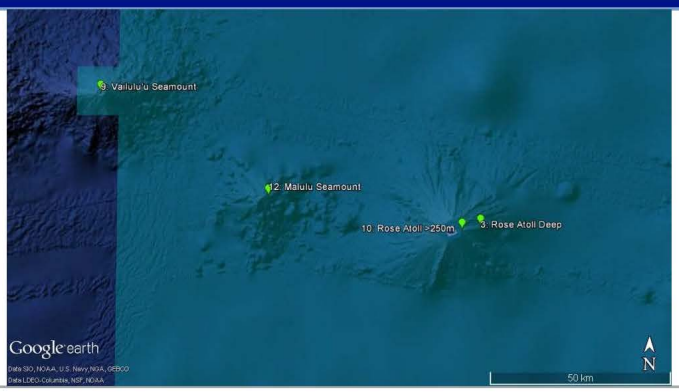
Comments	A spectacular pillow lava

Sample		
Sample ID	D2_DIVE09_SPEC06GEO	
Date (UTC)	20170225	
Time (UTC)	03:56:01	
Depth (m)	702.1822	
Temperature (°C)	5.69937	
Field ID(s)	rock	EX1702_IMG_20170225T035506Z_D2_DIVE09_SPEC06GEO_04.j...
Comments		

Please direct inquiries to:
NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014

Ocean Exploration and Research

Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	Rose Atoll (shallow dive on east flank)		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s) / Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Eastern Samoan region (easternmost island in American Samoa)		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	10		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2

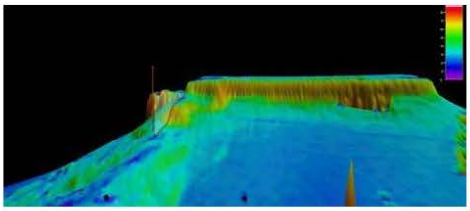
	☒ Low Res Cam 3 ☒ Low Res Cam 4 ☒ Low Res Cam 5	
	☒ LSS ☒ ORP	
Equipment Malfunctions	None	
ROV Dive Summary (from processed ROV data)	In Water:	2017-02-25T19:26:23.774000 14°, 32.505' S ; 168°, 07.700' W
	Out Water:	2017-02-26T03:30:46.671000 14°, 32.898' S ; 168°, 07.924' W
	Off Bottom:	2017-02-26T03:13:39.239000 14°, 32.879' S ; 168°, 07.949' W
	On Bottom:	2017-02-25T20:26:03.561000 14°, 32.747' S ; 168°, 07.645' W
	Dive duration:	8:4:22
	Bottom Time:	6:47:35
	Max. depth:	678.4 m
Special Notes		
Scientists Involved (please provide name, location, affiliation, email)	Asako Matsumoto, PERC/Chiba Institute of Technology, Japan Bruce Mundy, NOAA NMFS Pacific Islands Fisheries Science Center Christopher Kelley, University of Hawaii Deborah Glickson, National Academies of Sciences, Engineering, and Medicine Joseph O'Malley, NOAA/NMFS/PIFSC/FRMD/LHP Les Watling, University of Hawaii at Manoa Matthew Jackson, UC Santa Barbara Santiago Herrera, Lehigh University Scott France, University of Louisiana at Lafayette Sonia Rowley, University of Hawai'i at Manoa Tara Harmer Luke, Stockton University	
Purpose of the Dive	The goal of this dive was to generate baseline information on deep biological communities, including bottom fish and precious corals habitats, to better understand their diversity and structure with the goal of supporting management needs of the Rose Atoll Marine National Monument. The dive began around 700 m deep on a prominent ridge extending from the eastern region of the Rose Atoll, as shown in the bathymetry map. We started on the ridge crest, and then continued moving upslope to a depth of ~250 m. From a geological standpoint, Rose Atoll is thought to be an older seamount linked to the Cook-Austral Islands instead of Samoa. Malulu to the west (to be sampled in a later dive during this cruise) and Rose Atoll are key in defining the Cook-Austral hotspot tracks back in time, and as such an age on a volcanic rock is needed from Rose Atoll. Without an age, it is not possible to truly define plate motion for the time frame represented by this volcano.	

Description of the Dive	Rose Atoll lies in the eastern region of the Samoan islands. However, its atoll morphology defies expectation: the eastern Samoan islands are predicted by the hotspot model to be the youngest volcanic islands, but Rose atoll has the morphological appearance of being quite old, and this calls into question Rose atoll's relationship with the Samoan hotspot. Indeed, existing work shows that the geochemistry of dredged lavas from the deep flanks of Rose atoll are not consistent with an origin at the Samoan hotspot. One hypothesis is that Rose atoll is an ancient volcano that formed over one of the hotspots in the Cook-Austral volcanic lineament. This hypothesis can be tested by obtaining basaltic samples to obtain age-dates and geochemical data. The dive track was designed to target the shallow (<750 m) buttressing ridge on the eastern side of the hotspot; the deeper portions of this ridge were explored on a prior dive (Dive 03). The ROV track was designed to move progressively upslope, along a series of new volcanic features, and finish at a depth of ~250 m. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** 20:24:00 UTC. The ROV arrived on bottom. Ferromanganese encrusted (FE) sediments (or basalt) were visible (~50% of bottom cover) and light colored sediment, similar in color to the light colored sediment visible on previous dives of this expedition, is also visible and cover perhaps 50% of the field of view. Notably there are possible basalt clasts that are welded to the bottom, but it is not possible to sample them as they are "welded" to the seafloor. 20:31:26. Scleractinian stony coral visible (at ~677 meters; ROV location is 14 degrees, 32.7415 S, 168 degrees, -07.6133 W), morphologically similar to the deep sea corals that have been the focus of Jess Adkins' research at Caltech. 20:35:27. The FE material has the morphology of basalt flows, possibly even pillow structures; however, it is not possible to rule out the possibility that the substrate is simply FE carbonate from a submerged reef. The FE materials exhibit some very different morphologies, including 10 to 20 cm tall "pinnacles", which may represent erosive features or chemical weathering features (consistent with a carbonate origin). As the ROV is at only 677 m water depth, it is possible that this portion of the volcano was sub-aerial prior to volcanic subsidence; thus, the hypothesis of a carbonate (submerged reef) deposit is supported. 20:48:47. A pile of FE cobbles and pebbles, located in a relatively narrow (meters) region between what appear to be flows, have a partial cover of light sediment. Unfortunately, the ROV claw did not find any loose rock material for sampling. 21:04:59. A loose 30 cm FE cobble was tapped by the ROV. However, it looks like a ferromanganese crust with sediment, not a pillow basalt fragment, and the rock was left on the seafloor. 21:08:37. More smooth pillow structures are visible along a relatively steep slope (from perhaps 15 degrees ranging up to [on relatively small ledges] approximately 50 degrees). 21:22:40. A FE outcrop, several meters in diameter, rises above the surrounding seafloor. The outcrop appears to be (at least partially) composed of volcanic breccia that has been welded together by ferromanganese. However, due to the FE cover on all surfaces, it is not possible to conclusively rule out coral protoliths (in lieu of basalt) in the breccia. 21:24:54. Two scleractinian coral are visible (< 1 meter apart), a living one and a

	fossil. Both are at ~660 m water depth. 21:40:50. The ROV is moving upslope and smoother FE surfaces come into view, possibly submarine flows. Perhaps 5 to 10 meters upslope the slope steepens to ~30 or 40 degrees and the flow structures look like young flows on Pu'u O'o that have spilled over a steep ledge. Alternatively, these structures could represent coral that has been incised by weathering and subsequently encrusted with ferromanganese. 22:12:25. The FE surface has a reef structure; sub-aerially exposed corals in the nearby Cook Island weather to produce morphologies like that which are observed here. Smoother surfaces sloping at ~20 to 30 degrees dominate the field of view. Of course, a definite assessment of the substrate composition cannot be made without exposing the material that is "hidden" beneath the FE material. If this was once a shallow reef, it would suggest that the volcano has subsided 500 to 600 meters. 22:43:47. The ROV shows more FE smooth surfaces with occasional 5 to 10 cm wide "fissures" that host a dusting of light-colored sediment. 23:28:37. Smoother surfaces continue to dominate the field of view. However, some cobbles, possibly basaltic in origin, are present in the field of view, but the ROV passed over them too rapidly and a sampling opportunity was lost. 23:30:25. A 40 to 50 degree slope is visible in the field of view. Rougher surfaces are present, and these surfaces are incised by gullies, consistent with being weathered coral. 23:34:52. A rounded and elongate FE cobble, perhaps 30 cm (long axis length), is tapped by the ROV and the cobble is loose. No other cobbles are present nearby (there is an angular block, but it is "welded" to the substrate). A small red/pink crab was observed on the rock. This cobble is only the second loose rock encountered thus far, and is the first geological sample of the expedition (it was placed in starboard rock box): **D2_DIVE10_SPEC03GEO**. 23:46:00. Steeper, rougher terrain is observed in the field of view, and the outcrops are nearly vertical walls of outcrops. Gullies are visible at the ~1 m and the ~10 cm length scales. 23:52:11. Spectacular (chemical weathering?) morphologies are observed on the rock surfaces. The morphology of the substrate looks very much like a carbonate that has undergone partial dissolution, then covered in ferromanganese. 23:56:27. More carbonate-like deposits enter the field of view, and they have large scale and small scale morphology that is very similar to that which is seen during sub-aerial carbonate weathering and partial dissolution. The surface morphology is variably rough (and steep), but these substrates are juxtaposed with smoother (and less steep) sections. 00:08:27. The terrain is exceptionally steep over a relatively long distance. The slope is perhaps 50 to 70 degrees and continues for tens of meters. The same carbonate morphology is observed in the substrate. A deep (3 meters perhaps) and narrow (approximately 1 meter) fissure has come into view; it runs for perhaps 10's of meters upslope. 00:25:09. The ROV has moved away from the long fissure for a view to the south, where the carbonate nature of the rock has become more evident. A light-colored sediment covers <2% of the surface. At this point it seems that the ferromanganese covering is minimal in many (most) surfaces, and the light tan color of the carbonate is apparent. However, this may also be a function of the lighting. 00:30:36. The ROV has moved back to the fissure, and the relatively narrow fissure has opened up to form a wide fissure (perhaps 5 or 10 meters). The water has

	become more turbid, which may relate to debris raining down from the reef of the atoll, and this debris is channeled down through the fissure. 00:50:40. The ROV's field of view shows relatively smooth surfaces that are gently sloped (perhaps 10 degrees). The surface appears to be minimally coated with ferromanganese, with most surfaces showing exposed carbonate. It appears that, over the past 30 minutes to 1 hour, the conditions have changed such that either the formation or the preservation of ferromanganese encrustations are no longer favored. 00:52:53. FE scleractinian coral (dead) are observed. 00:57:57. Another dead scleractinian at 388 m water depth. 01:05:20. Another scleractinian at 385 m water depth. 01:05:43. The ferromanganese coat is rarely visible now and the carbonate on the substrate is not clearly visible at the surface. Occasionally, FE carbonate is visible, and this material tends to be elevated and form mini- "buttes" on the carbonate substrate; this may owe to the ferromanganese preserving the underlying carbonate from dissolution. 01:35:58. Smooth carbonate surfaces dominate the substrate. Dissolution of carbonate has resulted in complex and elaborate "sculptures", including nearly "hollowed out" boulders, pinnacles, and overhanging ledges that jut out horizontally into the water. Sediment cover is minimal. 01:47:31. Carbonate lithologies define the substrate. Some evidence for ferromanganese coatings exist in some areas, again primarily in the elevated areas on the otherwise relatively smooth and flat surface. 01:59:29. The surface is defined by coral dissolution features that have generated numerous gullies that are a few cm to 10 cm wide. The gullies are shallow (5 to 10 cm) and filled with sediment; the sediment thus covers 30 to 50% of the surface in the field of view. 02:17:21. Carbonate cobbles are present on the carbonate substrate. One such coral became the second geological sample of the dive, and host to a coral: **D2_DIVE10_SPEC05GEO.** 02:56:18. Carbonate cobbles continue to be present on the carbonate substrate. One such carbonate cobble became the third geological sample of the dive, and is also host to a lovely coral: **D2_DIVE10_SPEC06GEO**. 03:09:26: Four living scleractinians are observed, clustered together under a starfish, at 313 m water depth. These coral are a striking yellow color. 03:10:00. The remainder of the dive continues to be dominated by shallow, submerged reef carbonate. Surprisingly little sediment is observed on the substrate. **The biological perspective is as follows:** Landed at 20:27 678 m on top of the ridge. Sloping ferromanganese encrusted terrain with light sediment cover. Observed a greeneye fish (*Chlorophthalmus*), cup corals, few dead sponges, a small Moridae codling, a mushroom coral *Anthomastus* (same morphospecies as in Vailulu'u?). Observed a dandelion siphonophore, a pycnogonid sea spider, a rattail, several comatulid crinoids (purple Telocrinidae, central part moving quite a bit). Observed conger eel at 21:16 653m (*Bathyconger*). Several cup corals and scorpion fish at 21:25 660m. Two additional species of crinoid and a cideroid (lacking skin on spines) urchin (possible predator of crinoid feather stars). Encountered solitary hydroid at 21:47 648 m (same morphospecies as in Vailulu'u?). Spotted couple of deep-water cardinal fish.

	Encountered steeper terrain 21:56 644 m (vertical wall), rapidly transitioned into less steep slope. Observed a *Hyalonema* potbelly sponge, a couple more cideroid urchins. At 636 m 22:07 observed the first living colonial scleractinian coral likely *Enallopsammia* sp. After this, there was a lower abundance of organisms on the smooth surface of a gentler slope (626m 22:18). At 622m 22:30 collected unusual Hexactinellid Corbitellinae sponge (likely new species). During collection observed a hermit crab and a polychaete worm on the sponge as associates; also, two eels living in the sponge! They swam away (20170225 22:38:11; D2_DIVE10_SPEC01BIO; 623 m). Observed several colonies of black coral *Parantipathes?* at 619m 22:44. Also saw several large anemones, and an *Anthomastus*. Further ahead observed an abundance of small black coral colonies *Parantipathes* sp?, collected specimen at 610m 22:55 (D2_DIVE10_SPEC02BIO; 611 m). Encountered a meter-tall bamboo coral with no spines in tentacles 602 m 23:15. Observed several more colonies of *Parantipathes* sp? black coral at 594 m 23:19, also a different species of scorpion fish. Collected a rock (20170225 23:42:16; D2_DIVE10_SPEC03GEO; 568 m). Imaged a large *Coronaster* sunstar at 23:52 540 m. Observed a *Ortomisis*? bamboo coral fan at23:56 525m. Further upslope encountered an *Enallopsamia* coral 23:57 524m. Substrate was composed of large outcrops of carbonates encrusted with ferromanganese crust (00:01 520 m). Imaged another *Ortomisis*? bamboo coral at 00:11 481m and several whip bamboo corals with small polyps in a large deep fissure in the carbonate substrate at 472m 00:18. Encountered yellow crinoids at 450m 00:22. Observed shimmering water (thermocline) between 450-400 meters. Saw different species of *Anthomastus* (same morphospecies as the one observed in Ta'U). Current was coming from an approximate direction of 225 degrees (392m 00:49). At this point observed a cup coral similar to the one observed on Ta'u. Encountered an octopus 388m 00:59, and two morphospecies of cup corals (all of these animals look like the ones in Ta'U). Imaged a cookie star (different from the white morphospecies seem in previous dives). Observed shimmering water at this depth. At 01:12 370 m imaged a *Dendrophyllia* scleractinian coral with ophiuroid associate and squat lobster (same morphospecies as in Ta'U). Encountered many more *Anthomastus* here. Community here is similar to the communities on Ta'U, yellow crinoids, white and purple cup corals, yellow crinoids, and *Anthomastus*. Observed a yellow demosponge growing flat on top of rocks. At 361 m 01:38 observed may rows of barnacles on rocks, as well as several basket stars *Gorgonocephalus*? Observed shimmering water here as well. Collected basket star (20170226 01:43:52; D2_DIVE10_SPEC04BIO; 362). Encountered a school of large *Etelis* snapper fish at 350m 01:54. At 347m 01:59 observed really abundant soft octocorals and *Acanthogorgid* octocorals. Saw scorpion fish, hundreds of soft octocorals and chrysogorgiid-like octocorals. Collected rock with soft coral on it (20170226 02:20:54; D2_DIVE10_SPEC05GEO; 325).

	At 02:30 we were advised by the bridge that we could not reach WP3 because it would put us too close to the shore. Minimum possible depth for the ROV was 310 meters. Started to make detailed observations of fish. Continued to see hundreds of colonies of the same soft octocoral species. At 02:40 315m stopped seeing the great abundance of soft corals, transitioned into a community of many small yellow scleractinians and small white sponges in an area of shimmering water and small cobbles. Collected a rock with scleractinian and sponge (20170226 03:02:05; D2_DIVE10_SPEC06GEO; 315 m). Observed several fish species, including: Grouper *Hypothordus octofasciatus Grammatonotus* (Callanthiidae), *Polylepion* (Labridae), *Antigonia* (Caproidae), *Ostichthys* (Holocentridae), and *Pontinus* (Scorpaenidae). Observed very abundant small yellow scleractinian corals over a smooth terrain, gentle slope. Last observation we did was of a scleractinian been predated by a *Astroceramus* seastar, followed by a yellow snapper. Ended the dive at 03:16.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	



EX1702_IMG_20170226T000959Z_PTMAN_CREVICE.jpg

Carbonate outcrops split by longitudinal fissures.



EX1702_IMG_20170226T021030Z_ROVHD.jpg

Snappers and soft octocorals over carbonate terrain.

Samples Collected

Sample

Sample ID	D2_DIVE10_SPEC01BIO
Date (UTC)	20170225
Time (UTC)	22:38:11
Depth (m)	623.388
Temperature (°C)	6.25730
Field ID(s)	Hexactinellida sponge
Comments	



EX1702_IMG_20170225T222953Z_ROVHD.jpg

Sample		
Sample ID	D2_DIVE10_SPEC02BIO	 EX1702_IMG_20170225T225825Z_ROVHD.jpg
Date (UTC)	20170225	
Time (UTC)	23:05:47	
Depth (m)	610.9940	
Temperature (°C)	6.33438	
Field ID(s)	Antipatharia	
Comments		

Sample		
Sample ID	D2_DIVE10_SPEC03GEO	 EX1702_IMG_20170225T233930Z_ROVHD.jpg
Date (UTC)	20170225	
Time (UTC)	23:42:16	
Depth (m)	568.0900	
Temperature (°C)	6.93560	
Field ID(s)	rock	
Comments		

Sample		
Sample ID	D2_DIVE10_SPEC04BIO	 EX1702_IMG_20170226T014240Z_ROVHD.jpg
Date (UTC)	20170226	
Time (UTC)	01:43:52	
Depth (m)	361.5599	
Temperature (°C)	14.67788	
Field ID(s)	Gorgonocephalus?	
Comments		

Sample		
Sample ID	D2_DIVE10_SPEC05GEO	
Date (UTC)	20170226	 EX1702_IMG_20170226T021728Z_ROVHD.jpg
Time (UTC)	02:20:54	
Depth (m)	325.4760	
Temperature (°C)	16.68620	
Field ID(s)	Rock with associate soft octocoral	
Comments		

Sample		
Sample ID	D2_DIVE10_SPEC06GEO	 EX1702_IMG_20170226T030048Z_ROVHD.jpg
Date (UTC)	20170226	
Time (UTC)	03:02:05	
Depth (m)	315.2899	
Temperature (°C)	16.97638	
Field ID(s)	Rock with scleractinian and sponge	
Comments	Rock had pink spots (likely calcareous algae)	

Please direct inquiries to:

NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014

Okeanos Explorer ROV Dive Summary

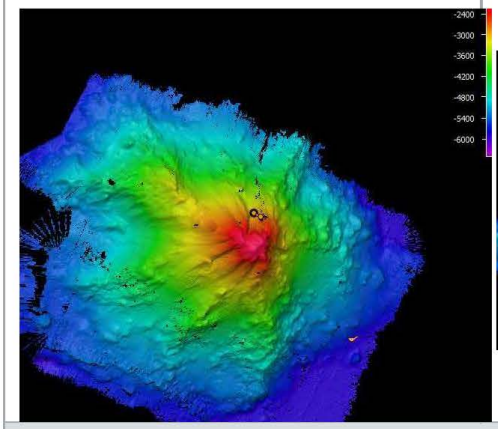
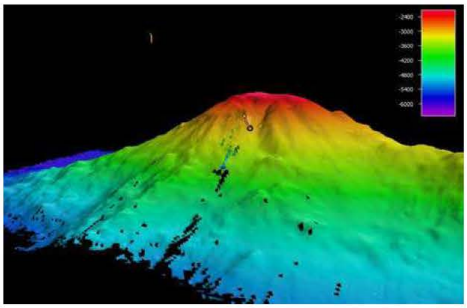
Dive Information			
Dive Map			
Site Name	"Governor Lolo" Seamount (formerly referenced as "Seamount D")		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s) / Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Eastern American Samoa EEZ		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	11		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude

	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2
	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ ORP	
Equipment Malfunctions			
ROV Dive Summary (from processed ROV data)	In Water:	2017-02-26T20:12:21.083000 15°, 44.198' S ; 167°, 15.971' W	
	Out Water:	2017-02-27T03:40:42.741000 15°, 44.101' S ; 167°, 15.414' W	
	Off Bottom:	2017-02-27T01:58:15.047000 15°, 44.089' S ; 167°, 15.828' W	
	On Bottom:	2017-02-26T21:51:19.408000 15°, 43.981' S ; 167°, 15.878' W	
	Dive duration:	7:28:21	
	Bottom Time:	4:6:55	
	Max. depth:	3005.3 m	
Special Notes			
Scientists Involved (please provide name, location, affiliation, email)	Asako Matsumoto, PERC, Chiba Institute of Technology, Japan Christopher Kelley, University of Hawaii Matthew Jackson, UC Santa Barbara Santiago Herrera, Lehigh University Tara Harmer Luke, Stockton University Timothy Shank, Woods Hole Oceanographic Institution Tina Molodtsova, P.P. Shirshov Institute of Oceanology RAS Kevin Kocot, The University of Alabama Les Watling, University of Hawaii Matthias Falk, Lehigh University Scott France, University of Louisiana Steve Auscavitch, Temple University		

Purpose of the Dive	The goal of this dive was to generate baseline information on geology and geochemistry of this unexplored (and largely unmapped) seamount. There was also significant interest in understanding the deep sea habitats and biological communities on the seamount to better understand their diversity and distribution. American Samoa's Division of Marine and Wildlife Resources have expressed an interest in the seamounts in this region as long-line fishing activities are conducted in the area. From a geological standpoint, this seamount may be an older seamount linked to the Cook-Austral Islands, not Samoa. Samples from this seamount are key in defining the Cook-Austral hotspot tracks back in time, and as such an age on a volcanic rock is needed from this seamount. Without an age, it is not possible to truly define plate motion for the time frame represented by this volcano. From the biological perspective this dive had the potential to provide new depth records for several species as well the discovery of new species. Very little work has been done in the Central Pacific at these depths on seamounts. We aim to collect information that will inform the biogeographic identity of the communities at abyssal depths in this region.
Description of the Dive	*NOTE: This dive site was originally termed "Seamount D" and has since been informally named "Governor Lolo" seamount.* "Governor Lolo" seamount lies in the eastern region of the Samoan EEZ. Seamounts located this far east in the Samoan EEZ have never been sampled prior to this expedition. The first high-resolution bathymetry for this seamount was generated during this expedition. The bathymetry reveals that the seamount has a conical shape with a prominent ridge extending to the northeast. The base of the volcano is composed of "pancake" structures like those observed on "Utu" seamount to the north; however, the pancake structures may relate to a rejuvenated stage of volcanism, and these structures were avoided when creating the dive plan. One hypothesis is that "Governor Lolo" seamount is an ancient volcano that formed by a different, non-Samoan hotspot. This hypothesis can be tested by obtaining basaltic samples to obtain age-dates and geochemical data. The dive track was designed to target the northern side of the volcanic structure. A long, steep feature was chosen to maximize rock exposure to enhance the probability of encountering rocks along the dive track. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** 21:50:00 UTC. The ROV arrived on bottom. A FE (ferromanganese encrusted) flow is visible in the upper right of the field of view; FE boulders and cobbles populate the rest of the field of view, with light-colored sediment filling in the region between the FE rocks. One of these rocks constituted the first geological sample of the expedition (an ~30 cm rock, placed in starboard rockbox): **D2_DIVE11_SPEC01GEO** 22:00:04. FE outcrop coming into view with sponges; the outcrops fill the entire field of view. It may be a large (several meters in diameter) block, not attached to the seafloor, but it is difficult to tell with the perspective provided by the ROV. Sediment cover is <5% on the surface of the outcrop.

	22:26:07. There is a steep rock face in front of the ROV. FE cobbles and boulders make up the lithologies at the base of the face; the Seirios view shows an overhanging ledge above the ROV. 22:38:48. The ROV is moving up on top of the overhanging outcrop, and with the 'zoomed out' perspective the outcrop appears to be constructed of pillow basalts. The block with the overhang does not seem to be attached to the substrate, and may have rolled down from above. 22:48:26. Large FE boulders (2 to 5 meters) dot the landscape. Sediment covers 60 to 70% of the field of view, and has ripples. A number of cobbles are in the view screen, and one (10 to 15 cm, long axis) has the appearance of being a pillow fragment. This became the second geological specimen of the dive. It fell out of the claw and rolled perhaps 4 or 5 meters, forcing the ROV to retreat and collect the sample again. It was placed in the port rock box: **D2_DIVE11_SPEC03GEO.** 23:02:21. The sediment cover on the slope (a slope of perhaps 30 degrees) is extensive, and is visible off to the left for 10's of meters as the ROV pans to the left; this is some of the most extensive sediment cover observed on the dive, with >80% sediment (the sediment is predominantly light colored, and appears to host numerous forams, but the sediment also hosts dark-colored fragments that may be fragments of basalt or FE material that has broken off and rolled downhill from above). The ROV continues to head upslope and encounters talus that includes FE boulders and cobbles. 23:13:44. The sediment cover continues to be extensive (perhaps 80% of surface cover) and is light colored. Large blocks visible as the ROV pans right and left, many of which are not attached to the substrate. 23:15:14. A large outcrop, perhaps 10's of meters long, with a FE overhang that is several meters high; FE cobbles lie scattered in sediment at the base of the overhang, and they likely fell off the overhang. The cobbles are likely to be basaltic in origin (and less likely to be sediment), as the cobbles cluster at the base of the ledge and there are no cobbles far from the ledge. One cobble was sampled, and is the third geological specimen of the dive. The rock is perhaps 15 to 20 cm long and is highly elongate (the rock was placed in the starboard rock box): **D2_DIVE11_SPEC04GEO** 23:32:51. A large outcrop several meters high, composed of FE pillows, comes into view. The ferromanganese cover appears to be very think and developed, a testament to the old age of this seamount. 23:49:17. The ROV is moving up on top of a large FE outcrop. It is difficult to evaluate the composition of the outcrop. The ROV then transited back over the sediment, but the sediment cover is somewhat reduced (60% of field of view) and boulders and cobbles cover the rest of the field of view. One of the cobbles had a coral attached, and was sampled. The cobble is likely a pillow fragment. This rock became the fourth rock sample of the dive (and was placed in the port outboard biobox). **D2_DIVE11_SPEC05GEO** 00:13:57. Another FE block (5 or more meters wide) is observed that is not attached to the substrate; it is composed of what appear to be pillows, and cobble debris lies at the base of the boulder. A number of these block are observed as the dive progresses, and is consistent with the dive track going over a debris field that may have resulted from a land slide, or from continuous falling of blocks and boulders from points higher on the seamount. 00:17:48. The sediment cover continues to be extensive on the seafloor, covering >60% of the observed surfaces. The slope appears to be ~30 degrees along this portion of the dive track (and along much of the dive track thus far). FE boulders and cobbles dot the landscape, and likely detached from outcrops above and

	rolled down hill and came to rest at their current locations. 00:42:44. A very large (10 meters or more, perhaps) outcrop of FE pillow basalts comes into view. There appears to be a basaltic dike crosscutting the outcrop. 00:52:33. As the ROV continues upslope, the sediment cover is reduced to <10%. A large (10's of meters) outcrop composed of pillow basalts comes into view, and grades into a rough textured surface, perhaps consisting of a volcanic breccia. 00:56:39. The volcanic breccia continues to be prevalent in the outcrops, and the sediment cover has increased to perhaps 50% of the field of view. 01:13:33. FE boulder and cobbles scattered throughout the sediment. The ROV is moving toward a larger outcrop with less sediment cover, but the composition of the outcrop appears to change from FE pillow basalts at the base to FE volcanic breccia near the top. 01:36:34. The ROV has been moving through scattered boulders and cobbles with sediment (covering perhaps 50 to 60% of the field of view) as the ROV heads upslope. 01:38:48. A large block (perhaps 5 to 10 meters long) has the appearance of having rolled downhill, and is composed of pillow basalts. As the ROV continues uphill, large FE blocks, boulders and cobble-sized rocks come into view, again with light-colored sediment between the rocks. **The biological perspective is as follows:** Observed many small fish at 350 m during descent. Arrived on seafloor at 21:49 2988m. Substrate was a mix of loose cobbles and sediment. Collected rock (20170226 21:58:11, D2_DIVE11_SPEC01GEO, 3003 m) Observed several stalked demosponges as well as non-stalked glass sponges on large outcrops. Encountered slender isidid bamboo coral about 1 foot tall. Observed *Pleurogorgia* (black skeleton) with mysid shrimp and clear ophiuroid. Collected V shaped primnoid with venus flytrap associate (20170226 22:21:53; D2_DIVE11_SPEC02BIO; 2994 m). All these corals look similar to the ones at Utu shallow. At 22:29 2994m observed stalked glass sponge (Bolosominae). Also observed whip primnoid (V branching at the base), small 'chrysogorgiid' (Phil Aldersdale thinks this may be a *Riisea* [Family Ellisellidae]) octocoral with sparse branching (perhaps a juvenile, not *Pleurogorgia*). Also an *Iridogorgia* with attached benthic ctenophore. Observed abundant small sponges on the edges of large detached boulders here. Also several small *Pleurogorgia*. Collected rock at 22:57 2991m (20170226 22:58:04; D2_DIVE10_SPEC03GEO; 298 m). Collected another rock (20170226 23:28:44; D2_DIVE11_SPEC04GEO; 2971 m). Observed couple of whip isidids and a sail holothurian feeding at 2984m 23:05. Another sparse-branching chrysogorgiid or *Riisea*, as well as a *Calophacus* glass sponge and an *Halosaur* fish (23:00 2975m). Imaged an *Iridogorgia,* different bushy chrysogorgiid octocorals and stalked sponges at 2956m 23:50. Observed another whip bamboo at 00:01 2954m on a loose cobble. Collected whip bamboo with cobble attachment at 00:05 2954m (20170227 00:09:23; D2_DIVE11_SPEC05GEO; 2951 m).

	Encountered a diversity of terrain, sedimented slopes, large detached boulders, broken pillow basalts, angular cobbles. *Calophacus* glass sponge at 2944m 00:15. Found sediment area with ripples at 00:18 2944m, followed by larger boulder. Observed and collected 'chrysogorgiid' octocoral with sparse branching. Phil Aldersdale thought *Riisea* (F. Ellisellidae Family), was very brittle when sampled, very unexpected. At this point it is unclear what this coral is (20170227 00:38:17; D2_DIVE11_SPEC06BIO; 2924 m). Observed a juvenile *Iridogorgia*, a *Callophacus* sponge, and a larger mystery octocoral at 00:53 2914m. Observed more small *Callophacus*, bamboo whips followed by sediment and breccia areas. Encountered large outcrops with stalked anemones, some alive, some dead. Found dead sponge skeletons with crinoids (including stalked developing stages), hydroids, barnacles, zoanthids, sabellid worms, hydroids (~01:20, 2880m). Observed a small isidid whip 2868m 01:35. Again at 01:39 2863 m, and also *Callophacus*. Not much fauna at 2857m 01:45. Collected demosponge (20170227 01:56:22; D2_DIVE11_SPEC07BIO; 2853m), ended dive immediately afterwards.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	



EX1702_IMG_20170227T001224Z_ROVHD.jpg

Manganese nodules and broken off basalt cobbles among pockets of sediment



EX1702_IMG_20170226T234322Z_ROVHD.jpg

Boulder outcrop colonized by small golden octocorals and glass sponges

Samples Collected

Sample

Sample ID	D2_DIVE11_SPEC01GEO
Date (UTC)	20170226
Time (UTC)	21:58:11
Depth (m)	3002.9135
Temperature (°C)	1.73237
Field ID(s)	rock
Comments	



EX1702_IMG_20170226T215644Z_ROVHD.jpg

Sample

Sample ID	D2_DIVE11_SPEC02BIO
Date (UTC)	20170226
Time (UTC)	22:21:53
Depth (m)	2994.3977
Temperature (°C)	1.78234



Field ID(s)	Primnoidae with venus flytrap anemone	
Comments		
Sample		
Sample ID	D2_DIVE10_SPEC03GEO	 EX1702_IMG_20170226T225659Z_ROVHD.jpg
Date (UTC)	20170226	
Time (UTC)	22:58:04	
Depth (m)	2989.0247	
Temperature (°C)	1.73864	
Field ID(s)	rock	
Comments		
Sample		
Sample ID	D2_DIVE11_SPEC04GEO	 EX1702_IMG_20170226T232723Z_ROVHD.jpg
Date (UTC)	20170226	
Time (UTC)	23:28:44	
Depth (m)	2971.0581	
Temperature (°C)	1.73955	
Field ID(s)	Rock	

Comments	

Sample		
Sample ID	D2_DIVE11_SPEC05GEO	
Date (UTC)	20170227	
Time (UTC)	00:09:23	
Depth (m)	2951.4718	
Temperature (°C)	1.73801	
Field ID(s)	Rock with associate bamboo	EX1702_IMG_20170227T000056Z_D2_DIVE11_SPEC05GEO_04.j...
Comments		

Sample		
Sample ID	D2_DIVE11_SPEC06BIO	
Date (UTC)	20170227	
Time (UTC)	00:38:17	
Depth (m)	2924.8879	
Temperature (°C)	1.74656	
Field ID(s)	Unknown octocoral	EX1702_IMG_20170227T002648Z_ROVHD.jpg

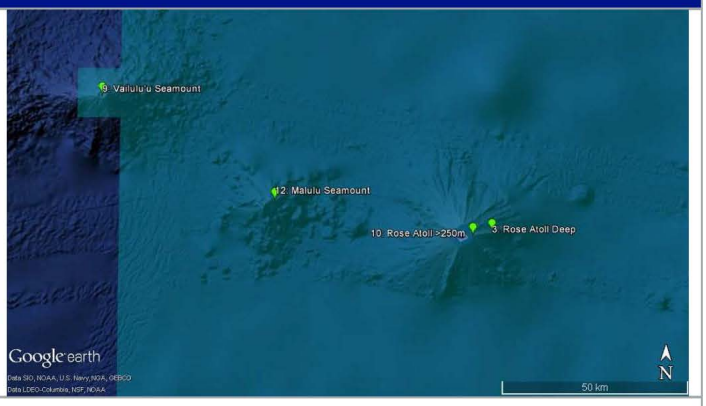
Comments	

Sample		
Sample ID	D2_DIVE11_SPEC07BIO	
Date (UTC)	20170227	
Time (UTC)	01:56:22	
Depth (m)	2852.6506	
Temperature (°C)	1.72205	
Field ID(s)	Demosponge	EX1702_IMG_20170227T015323Z_ROVHD.jpg
Comments		

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(301) 734-1014

Ocean Exploration and Research

Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	Malulu seamount		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s) / Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Eastern American Samoa (between Vailulu'u seamount and Rose atoll)		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	12		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2

	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ORP	
Equipment Malfunctions			
ROV Dive Summary (from processed ROV data)	In Water:	2017-02-27T19:34:34.456000 14°, 27.892' S ; 168°, 38.472' W	
	Out Water:	2017-02-28T05:29:00.542000 14°, 28.324' S ; 168°, 37.935' W	
	Off Bottom:	2017-02-28T02:16:29.021000 14°, 28.172' S ; 168°, 38.191' W	
	On Bottom:	2017-02-27T21:18:17.529000 14°, 28.127' S ; 168°, 38.335' W	
	Dive duration:	9:54:26	
	Bottom Time:	4:58:11	
	Max. depth:	2469.9 m	
Special Notes			

Scientists Involved (please provide name, location, affiliation, email)	Asako Matsumoto, PERC, Chiba Institute of Technology, Japan Chris Mah, NMNH Smithsonian Institution Deborah Glickson, National Academies of Sciences, Engineering, and Medicine Matthew Jackson, UC Santa Barbara Santiago Herrera, Lehigh University Tara Harmer Luke, Stockton University Timothy Shank, Woods Hole Oceanographic Institution Tina Molodtsova, P.P. Shirshov Institute of Oceanology RAS Bruce Mundy, NOAA PIFSC Christopher Kelley, University of Hawaii John Smith, University of Hawaii/SOEST Joseph O'Malley, NOAA PIFSC Scott France, University of Louisiana at Lafayette Steve Auscavitch, Temple University <u>For Midwater Transects:</u> Santiago Herrera, Lehigh University Dhugal Lindsay, Japan Agency for Marine-Earth Science and Technology Collin Closek, Stanford University Elizabeth Andruszkiewicz, Stanford University Russ Hopcroft University of Alaska Fairbanks Cornelia Jaspers, Technical University of Denmark Heather Judkins, University of South Florida St. Petersburg Alistair Grinham, University of Queensland Brennan Phillips, Harvard University Dick Young, University of Hawaii Amanda Netburn, CIOERT at FAU/NOAA OER Mike Ford, NOAA NMFS Marsh Youngbluth, Harbor Branch Oceanographic Institute
Purpose of the Dive	The goal of this dive is to generate baseline information on deep sea habitats and biological communities, particularly deep-sea coral communities, to better understand their diversity and distribution and support management needs of the Rose Atoll Marine National Monument. Water column transects are also planned during this dive to obtain information on animals living in the largest unexplored biome on the planet. The dive will begin around 2500 m, near the summit of Malulu seamount, as shown in the bathymetry map. The ROV will climb to the summit and then continue moving along the flat top of the summit. After the ROV comes off bottom at approximately 2430m, the ROV will ascend to 2000 m to start the water column exploration portion of the dive. A 10-minute transect will be conducted at each of the following depths, while moving the ROV at 0.1 knots: 2000m, 1500m, 1200m, 900m, 700m, 500m and the depth of the scattering layer identified in EK60 data. The EK60 sonar will be on for the duration of these transects, and the 38 kHz ADCP will also be run if it does not cause interference. From a geological standpoint, Malulu seamount is thought to be an older

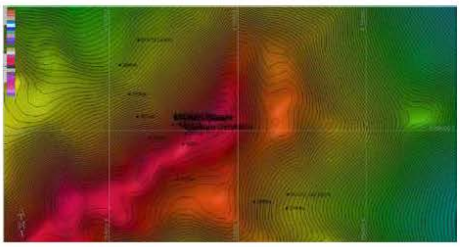
	seamount linked to another, non-Samoa hotspot. Rose Atoll to the east (sampled in an earlier dive during this cruise) and Malulu seamount are key in defining the Cook-Austral hotspot tracks back in time, and as such an age on a volcanic rock is needed from Malulu seamount. Without an age, it is not possible to truly define plate motion for the time frame represented by this volcano.
Description of the Dive	**Malulu seamount** lies in the eastern region of the Samoan islands. The bathymetry reveals that the seamount has a roughly conical shape; additionally, the seamount is host to 5 or 6 smaller conical cones, which may represent a rejuvenate stage of volcanism. These smaller cones were avoided during the dive planning efforts. One hypothesis is that Malulu seamount is an ancient volcano that formed by a different, non-Samoan hotspot. This hypothesis can be tested by obtaining basaltic samples to obtain age-dates and geochemical data. The dive track was designed to target the northwest face of the volcanic structure, near the summit of the volcano. The ROV will move upslope and summit a gently sloping ridge that exhibits a gentle slope to the seamount summit. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** 21:00:00 UTC. The ROV arrived on bottom. The field of view reveals a FE (ferromanganese encrusted) surface. Perhaps 1 to 2% of the bottom is covered with sediment. The slope of the surface is estimated ~30 degrees. Panning to the left, the ROV shows evidence for FE cobbles and pebbles, but all appear to be welded into the substrate. 21:22:04. The sediment cover increases to a light dusting on the FE surface that covers perhaps 30% of the surface. A 0.5 m wide, 0.1 to 0.2 m deep, gulley has a higher concentration of cobbles and pebbles, all welded to the substrate. 21:54:10. The ROV has moved perhaps 20 or 30 meters since arrival on bottom and the field of view is similar to the observation made as 21:22:04. 22:14:31. A loose rock (lying on top of a sponge stem) lies on top of the FE substrate that has dominated the field of view since the ROV landed on bottom. The rock turned out to be unsuitable for collection. 22:32:19. Two light-colored pieces of pumice came into view. Their light color suggests a young age, as ferromanganese has not yet covered their surface. The pumice is likely to have come from a nearby subduction zone system, because Malulu is an extinct volcano and active Samoan volcanoes are not known to generate pumice. 22:36:07. Dozens of sponge stocks litter the surface. Sediment cover is 50% of the field of view. A FE cobble lies in the field of view and was sampled, and was the first geological sample of the expedition (placed in port rock box). **D2_DIVE12_SPEC03GEO** 22:49:45. The view from Seirios shows that the D2 ROV is climbing a steep surface (more than 30 degrees) that has grooves that run up and down the slope. These are either the product of erosive processes (gulleys) or are FE magmatic features including dikes or elongate pillows. 22:53:00. An outcrop perhaps 1 or 2 meters high has significant positive topography relative to the surfaces that the ROV has revealed up until this point. It appears to be a FE volcanic feature.

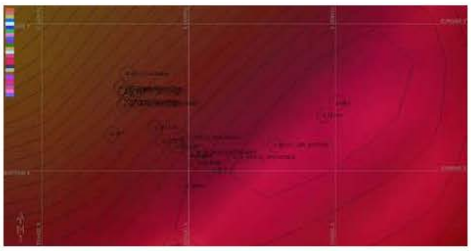
	23:08:11. The ROV continues to move upslope on a steep slope and layered deposits come into view. This could represent FE volcaniclastic debris. 23:18:55. At the base of a relatively steep face that is several meters high, several cobbles lie in the sediment. All are welded to the substrate. The steep face has the appearance of being volcanic breccia. 23:38:25. A steep slope (over 30 degrees) dominates the field of view and is covered with a dusting of light colored sediment. The topography is quite similar to that observed earlier in the dive, but panning right is the steeper face that was observed in the 23:18:55 observation. Clear pillow structures are not evident, and have not been evident during this dive. 23:45:07. A smooth, inclined (> 30 degrees) surface with structures that appear to have the structure of FE pillows. Gulleys continue to be clear in the FE substrate. A light dusting of light colored sediment is pervasive. FE cobbles continue to be welded to the seamount, making it difficult to obtain an additional rock sample. 00:00:29. The substrate is relatively smooth as the ROV continues up a steep (30 to 40 degrees) slope. Cobbles (up to 30 cm in diameter) are present on the slope, but are well cemented to the substrate. This could have been a talus deposit, but the talus has been completely welded to the surface. 00:11:56. The steepest slope yet is coming into view, perhaps 45 degrees. The sediment on the slope is light colored and fills much of the field of view, in spite of the steep slope. The slope appears to be composed of volcaniclastics (much like most of the sloped surfaces observed on this dive). 00:27:21. FE cobbles are welded into the volcaniclastic debris that is prevalent on the steep slope. One FE cobble is found to be loose. It was sampled and became the second geologic sample of the expedition (starboard rock box). **D2_DIVE12_SPEC05GEO** 00:15:14. The surface is relatively smooth and devoid of cobbles, but the low-lying areas that are perhaps 10 to 15 cm deeper than the surrounding surfaces. All surfaces are ferromanganese encrusted. 00:54:13. The substrate appears to host welded cobbles, consistent with being either a volcaniclastic deposit or a talus deposit that has been covered with ferromanganese. 02:34:49. The topography is a bit rougher than before, and the ROV has summited a gently sloping ridge that trends to the summit of the seamount. The slope is more gentle than we have observed for the entire ROV dive; for the past hour or so, all rocks that have been prodded by the ROV have been welded to the bottom thus far. 01:41:23. The surface is relatively flat and no sediment is present. The ROV appears to have reached the ridge that trends to the summit. All surfaces are covered with thick ferromanganese crusts. The surfaces are rough and composed of numerous cobbles that are welded (with ferromanganese) to the surface. 01:52:21. The ROV pilot managed to push a cobble loose with the claw. This sample is from the ridge that that heads to the summit; the sample constitutes the third geologic sample of the expedition (rock placed in starboard box). **D2_DIVE12_SPEC07GEO** 02:01:58. Panning to the left of the summiting ridge, there is more abundant sediment with ripples. The ridge top exhibits very little sediment, and the right side of the ridge has very little sediment. Thus, the bottom current is likely to flow from right to left relative to the ROV track. **The biological perspective is as follows:**

	Landed on ~35 degree slope, observed a couple of large brisingids (one with swelling of arms indicating parasite infection, possibly snails or barnacles). Imaged a *Bolosoma* with yellow stalk, large oscula (likely new species) with shrimp. There were also several dead sponge stalks with ophiacanthid ophiuroids wrapped around them (not observed on living sponge stalks). Collected potential new species of sponge *Bolosoma* (20170227 21:48:39; D2_DIVE12_SPEC01BIO, 2461m). Observed and collected a goniasterid cookie star (same one observed at this depth on Rose Atoll), very likely new species, very few of these sea stars occur below 1000m (20170227 22:08:51; D2_DIVE12_SPEC02BIO; 2457m). Encountered several more brisingid seastars with possible parasitism. Also observed a significant abundance of large *Bolosoma*, in addition to dead stalks with ophiuroids wrapped around them. Also observed a couple of yellow crinoids (maybe the same observed at Rose Atoll). Found large dead sponge skeletons encrusted with iron manganese (just like we observed at the same depth range on Rose Atoll), intermixed with non-encrusted *Bolosoma*-like sponge stalks. Collected rock (20170227 22:43:51; D2_DIVE12_SPEC03GEO; 2449). Observed a *Callophacus* (stalk inserts on the side of the sponge) different from the *Bolosoma* with yellow stalk (stalk insert on the underside of the sponge). Living *Callophacus* had 3 ophiuroids, likely the same as the ones observed on dead stalks. Stalked *Bolosoma* sponges seem to be oriented 'facing' upslope, similarly all ophiuroids observed on sponge stalks were facing upslope (upslope here facing S-SW). Current coming from up upslope, all this indicates that dominant currents are moving to the N-NE. Observed a dead *Chrysogorgia* skeleton with little colonization, only some small snails (indicating that the coral tissue likely died recently). Observed the same '*Lepidisis*' bamboo coral whip collected at 2448m in Dive 03 Rose Atoll Deep. Found a live *Chrysogorgia* with 1 associate squat lobster. Collected a specimen of the golden *Pleurogorgia* morphospecies with hydroid associates on it (20170227 22:43:51; D2_DIVE12_SPEC03GEO; 2449m). Observed several more *Bolosoma* sponges with yellow stalks (most abundant animals on this slope so far) 23:45 2440 m. Observed another *Pleurogorgia* and *Chrysogorgia* with squat lobster associate at 22:58 2429 m. Continued to see an abundance of sponges *Bolosoma* as well as some *Pleurogorgia* and *Chrysogorgia* colonies. Sediment cover increased as well as slope (45 degrees) at 0:21 2402m. Found more brisingids of similar morphology. Imaged a couple of sea cucumbers. Collected rock (20170227 22:43:51; D2_DIVE12_SPEC03GEO; 2449m). Observed a *Pleurogorgia* sea fan perpendicular to the SE moving current 00:40 2392m. Coral had couple of crinoids. Observed many more *Bolosoma*, brisingid sea stars, ophiuroids wrapped around dead coral skeletons that are still attached to hard rock. Found another *Pleurogorgia* sea fan perpendicular to the SE moving current 00:52 2379m, this one had an ophiacanthid ophiuroid on it (clinging to bare skeleton), also had several hydroid and crinoid associates. Encountered and sampled a

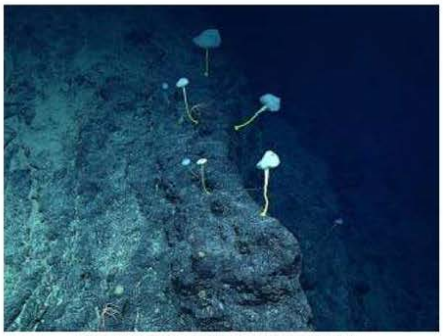
	Pseudochrysogorgia octocoral (same morph as the one from Rose Atoll) with a gravid squat lobster associate at 01:11 2371m (20170228 01:20:53; D2_DIVE12_SPEC06BIO; 2361m). Observed several brisingid seastars on top rocks, bamboo whip, *Bathypathes* black coral, cookie star 01:26 2361m. More *Bolosoma* sponges, *Pleurogorgia* (2 hydroids associated), *Pseudochrysogorgia*, ophiuroids on many dead sponge stalks (2350m 01:41). Saw a *Chrysogorgia* with squat lobster associate as well as 4 benthic ctenophores 01:47 2350m. Reached what appeared to be the top ridge of the seamount 01:50 2351m. Found many more *Bolosoma*, brisingids, ophiuroids on dead sponge stalks, and a few *Pseudochrysogorgia*. Encountered a very large (taller than 3m) bamboo whip with no needle sclerites in polyps 02:01 2349m). Saw rippled sediment 02:03 indicating a current moving from the S-SE. *Bolosoma* were the dominant benthic species during this dive. 2334m 02:19 end of seafloor component of the dive. Transitioned into the mid-water portion of this dive 02:23. **Mid-water transects** (10 min transects at 0.1 knots) **1500 m** Red mysiid shrimp, several trachymedusas. **1200 m** Started at 03:26. Larvacean, polychaete worm, carnivorous tunicate (convergent morphology to a medusa), and Erina? siphonophore. Ended at 03:41. **900 m** Started at 03:54. Fish (most abundant vertebrate on the planet), siphonophore, arrow worm chaetognat, and hydromedusae. Ended at 04:04. **700m** Started at 04:13. Larvacean, siphonophore, shrimp, ctenophore. End of transect 04:24. **600m** Started at 04:29. Rhizarians, euphausid krill, siphonophore, ctenophore, medusa. Ended at 04:39. **500m** Started at 04:47. Ctenophore, several medusae, narcomedusae (jellyfish predator), Rhizarian. Ended at 04:57. **375m** Started at 05:02 Rhizarian, euphausid krill, siphonophore. Encountering surface currents to the south west (matching the ADCP data from the ship). Larvacean. Ended at 05:13.

	Mid-water transects summary (from Amanda Netburn) The water column, though 95-99% of the total inhabitable volume of the planet, remains one of the most poorly explored environments. Especially in remote areas of the globe like the Pacific Islands, there have been very few opportunities to explore the deep water column, and this expedition provided a rare opportunity to do so in this unique region of the ocean. After we completed the benthic portion of the Malulu dive, we conducted several hours of exploration in the midwater. We conducted 10 minute transects at a series of depths- 1500, 1200, 900, 700, 600, 500, and 375 m. These depths were chosen based on features revealed by the CTD data collected by the Deep Discoverer on the way down to the seafloor at the start of the dive. For this dive, we had a unique opportunity to bring together a group of midwater experts to participate in the dive at the University of Hawaii Exploration Command Center. These scientists were in Hawaii for an Oceanography conference and an upcoming workshop on water column exploration. The group contained experts in cephalopods (squids and octopuses), fishes, jellyfish, and other zooplankton. We made many fascinating observations throughout this dive, including multiple individuals of an undescribed lobate ctenophore (comb jelly), large numbers of Halicreatid medusa, particularly in the deeper transects, and high numbers of the Prayid siphonophore (colonial jellyfish) in the shallowest transect at 375 m. We encountered a high diversity of single-celled Rhizaria, each with a different characteristic shape. There were many sightings that were likely first records in the southern hemisphere. These included a species of sea tadpole (larvacean oikopleurid), a carnivorous planktonic sea squirt, a medusoid comb jellyfish (Thalassocalycida), another comb jelly in the family Lampoctenidae, and the physonect siphonophore Erenna. In just a couple of hours, we made all of these and newer observations, demonstrating the utility of ROV-based exploration to understanding the diversity and distributions of these notoriously challenging animals to study.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site





Representative Photos of the Dive



EX1702_IMG_20170227T233853Z_ROVHD.jpg

Ferromanganese encrusted slope with several living *Bolosoma* glass sponges



EX1702_IMG_20170228T014255Z_ROVHD.jpg

Seamount summit with a *Chrysogorgia* coral and several dead sponge stalks with ophiuroids.

Samples Collected

Sample

Sample ID	D2_DIVE12_SPEC01BIO
Date (UTC)	20170227
Time (UTC)	21:48:39
Depth (m)	2460.0819
Temperature (°C)	1.93030
Field ID(s)	Sponge (potential new species)

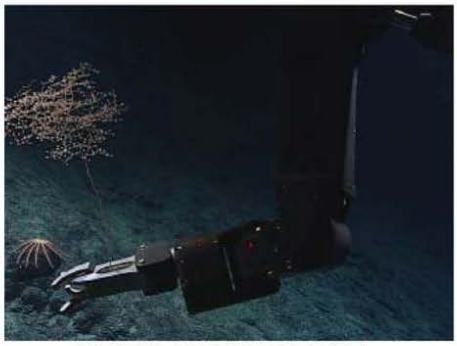
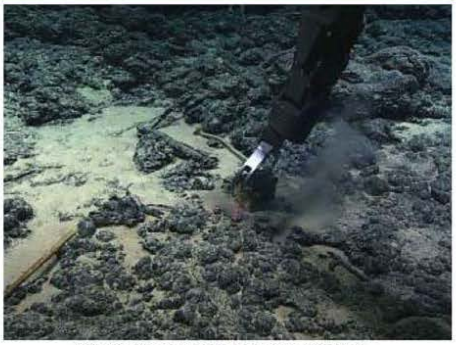


EX1702_IMG_20170227T214556Z_ROVHD.jpg

Comments		
Sample		
Sample ID	D2_DIVE12_SPEC02BIO	 EX1702_IMG_20170227T220608Z_ROVHD.jpg
Date (UTC)	20170227	
Time (UTC)	22:08:51	
Depth (m)	2457.5245	
Temperature (°C)	1.91712	
Field ID(s)	Goniasterid cookie star (potential new species)	
Comments		
Sample		
Sample ID	D2_DIVE12_SPEC03GEO	 EX1702_IMG_20170227T224209Z_ROVHD.jpg
Date (UTC)	20170227	
Time (UTC)	22:43:51	
Depth (m)	2448.9156	
Temperature (°C)	1.88915	
Field ID(s)	Rock	
Comments		

Sample		
Sample ID	D2_DIVE12_SPEC04BIO	 EX1702_IMG_20170227T232801Z_ROVHD.jpg
Date (UTC)	20170227	
Time (UTC)	23:34:05	
Depth (m)	2437.6107	
Temperature (°C)	1.88102	
Field ID(s)	Pleurogorgia (golden) with hydroids	
Comments		

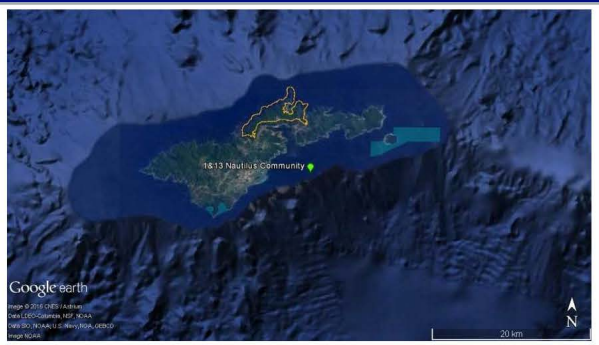
Sample		
Sample ID	D2_DIVE12_SPEC05GEO	
Date (UTC)	20170228	 EX1702_IMG_20170228T002917Z_ROVHD.jpg
Time (UTC)	00:35:32	
Depth (m)	2382.5742	
Temperature (°C)	1.86111	
Field ID(s)	Rock with ophiuroid wrapped around sponge stalk	
Comments		

Sample		
Sample ID	D2_DIVE12_SPEC06BIO	 EX1702_IMG_20170228T011458Z_ROVHD.jpg
Date (UTC)	20170228	
Time (UTC)	01:20:53	
Depth (m)	2361.7238	
Temperature (°C)	1.88915	
Field ID(s)	*cf. Pseudochrysogorgia* w/ chirostylid squat lobster	
Comments		
Sample		
Sample ID	D2_DIVE12_SPEC07GEO	 EX1702_IMG_20170228T015048Z_ROVHD.jpg
Date (UTC)	20170228	
Time (UTC)	01:52:03	
Depth (m)	2340.7705	
Temperature (°C)	1.85781	
Field ID(s)	rock	
Comments		

Please direct inquiries to:
NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014

Ocean Exploration and Research

Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	Tutuila (Nautilus dive)		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s) / Mapping Lead	Kelley Elliott / Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	American Samoa (south side of Tutuila, near Pago Pago harbor)		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	13		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2
	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5
	☒ LSS	☒ ORP	

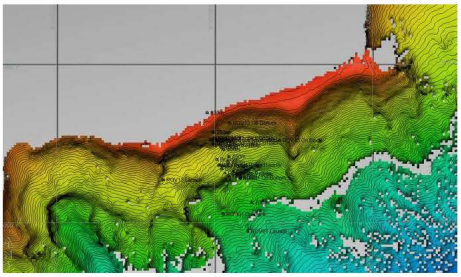
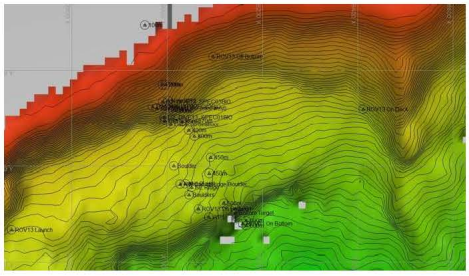
Equipment Malfunctions	
ROV Dive Summary (from processed ROV data)	Dive Summary: EX1702_DIVE13 ^^^

Purpose of the Dive	This dive sought to characterize a population of protected Nautili that has been observed using baited cameras in the Taena Bank area, at depths between 300 and 400 meters, near the harbor of Pago Pago, American Samoa. This is also the depth range for bottomfish and precious corals. From a geologic standpoint, this dive presented an important opportunity to sample the shallow volcanic stratigraphy of Tutuila island.
Description of the Dive	The dive track was designed to target two steep faces, one shallow and one deeper, on the shallow portion of the south side of Tutuila: the upper portion of the deeper wall is separated from the lower portion of a shallower wall by a gently sloping bench. The bench is likely to be a submerged sea terrace. The ROV dive was planned to land midway up on the deeper wall, then move up the deeper wall and transit across the less steep terrain to the base of the shallower face. However due to a potential discrepancy with the bathymetry, the ROV landed on the less steep terrain. Decision was made to continue upslope from here. The ROV moved up the shallower face to a depth of 250 m, and then moved laterally to the east to observe potential nautilus habitats at 250 m water depth. **The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive:** 20:58:00 UTC. The ROV arrived on bottom. It is clear that the steep wall of the first, deeper face was missed completely, and the ROV instead landed on the flat bench that is located just north of the deeper wall. Large (1 or 2 m in diameter) boulders are the first objects in the field view; some are lighter in color (and are likely carbonate in composition) while other boulders are darker in color (and may be basaltic in composition, but may also be carbonates covered with a bit of ferromanganese). Light colored sediment covers the field of view (60%, or so, of the field of view) and dominates the space between boulders. It is notable that very little, if any, ferromanganese is observed to cover the surfaces in the field of view, and this likely relates to the young age (and perhaps the shallow depth) of the outcropping rocks; the lack of ferromanganese coating facilitates observation of the carbonate substrate. 21:10:51. Large blocks continue to be visible on an otherwise flat surface that is covered with light-colored sediment; ripples are visible in the sediment. As in the first observation, sediment cover is extensive on the flat surfaces between boulders. 21:22:00. A large (several meters in diameter) boulder lies on the light colored sediment; this is notable, as the block does not seem to be attached to the substrate, and was thus transported (rolled) a significant distance (100's of meters) across the flat bench. The boulder may have detached from the nearby (shallower) wall. 21:28:55. Carbonate rubble (pebbles and cobbles) is observed around the base of a large (several meters in diameter) block, and may relate to recent breakage. The block (and subsequent blocks observed) is clearly carbonate in origin and it appears to be composed of debris from a former reef. The boulder that the rubble broke from appears to host significant reef-related fossils. 21:50:00. Large carbonate blocks continue to dominate the landscape, with light-colored sediments between the carbonate blocks. 21:50:00 until 23:18:00. Both science leads participated in an onshore outreach activity, taking questions from Samoan officials regarding the science goals of the

	expedition. During this time, the ROV transited across the gently sloping bench—likely a submerged reef--between the deeper and shallower faces. 23:19:00. The onshore scientists found an unidentified coral species and spent ~10 minutes collecting it before moving on. 23:32:00. A vertical wall has come into view, and this appears to be the shallower of the two faces that were targeted for this dive. The wall is composed of carbonate. The ROV began moving up the steep wall. 00:12:13. The ROV is still moving up the steep wall. Carbonate is the dominant (if the only) lithology in the field of view. 00:17:34. Fragments of carbonate, cobbles and carbonate sand, have accumulated in a gulley in the face of the steep wall. 00:24:10. A rubble pile is clear at the base of a face. The largest boulder lies on top of a beer can (the paint on the can looks extremely fresh), indicating that a small landslide (which generated the rubble pile) occurred recently (<50 years). 00:46:51. As the ROV moves upslope, a pile of rubble, including pebbles and clasts, lies at the base of a steep face. All lithologies are carbonate, and likely to be the remains of a submarine reef. 00:50:48. The ROV continues moving up the steep face, and is likely composed of carbonate. 01:02:26. A scleractinia "cup coral" is observed to be attached to the steep wall. A few meters above, a shallow ledge comes into view that is host to carbonate rubble, which likely fell from the steep face above. The ledge provides a natural habitat for fish and coral. As the dive continues, these narrow ledges are found along the steep face and host sediment, pebbles, cobbles and boulders that have fallen from above. 01:28:39: A spectacular overhanging ledge composed of reef debris has come into view. 01:35:52: A small cave feature was observed in the vertical carbonate wall. This is likely a dissolution feature, and is an ideal location for sessile organisms (as evidenced by the abundance of corals in the small cave). Moving laterally, a number of these concave features are observed along the steep wall. 01:41:38. The ROV has been at the target depth of 250 meters for the past 10 or 15 meters, and the decision was made to move east along the 250 meter contour. This is because the slope on the face is less steep toward the east than to the west. 02:03:26. The ROV is still moving eastward along the 250 m contour. The ROV just finished collecting a strange and completely unknown soft-bodied organism (the classification of which generated significant debate). 02:06:16. A scleractinia coral is observed to be hanging on the edge of the near-vertical carbonate wall. Zooming out, the entire field of view is a sheer face composed of carbonate. 02:20:58. The ROV continues to move laterally (to the east) along a steep rock face. A small rubble pile serves as the habitat for a community. On the cliff face there is frequent sediment on narrow (cm lengthscale) ledges. 02:42:04. The ROV continues the lateral traverse of the steep wall, 02:44:18. The steep carbonate face shows some larger overhangs that are host to large (1 to 2 m) carbonate boulders. 03:09:40. A live scleractinia coral (perhaps a second one is visible as well) comes into view. 03:10:00 to end of dive. The ROV moved laterally along the 250 meter contour until the ascent. The ROV then began to ascend up the steep wall to the surface: the wall became more distant, and then disappeared from the field of view, as the

	ROV ascended. The steep wall continues to near the surface. **The biological perspective is as follows:** Reached seafloor at 21:01 454 m depth. Large outcropping boulders, heavy sedimentation, few sessile organisms on rocks, heaving particle load in water. Observed a couple of fishes near the landed site. Encountered significant current coming from N-NE. Observed an *Enallopsamia* scleractinian (~10cm wide) on outcrop, also an anemone, squat lobster, urchins on sediment. Saw fishes in the family Acropomatidae, a flat fish, squat lobsters (likely making burrows), and a sea robin. Encountered some outcrops with *Acanthogorgia* octocorals, cup corals, and parapagurid hermit crabs 21:23 441m. Moved over sediment, observed an urchin, encountered a large outcrop with vertical wall at 21:25 435m. Encountered a couple of different species of small scleractinian corals *Madrepora?* (white), *Enallopsamia?* (yellow), 21:29 430m. Saw a large, and several small, cup corals with yellow base. Observed squat lobsters in holes, a couple of colonies of *Dendrophyllia*? with squat lobster associates on large carbonate outcrop, a group cardinal fishes, and a handful of cup corals (same morph as Rose and Ta'u) 21:33 426m. Observed a stalked crinoid at 21:41 417 m, as well as cup corals and a goniasterid seastar, and a yellow small urchin (same morph as Ta'U). Continued over a gentle slope terrain that was heavily sedimented, where we observed some urchins as well as beer cans. Found a large outcrop with cup corals, squat lobsters small *Enallopsamia?* and *Madrepora?* colonies 21:53 412m. Commencing live event. Live event over, collected *Helicoprimnoa* at 23:20 End EX1702_DIVE13_SPEC01BIO. Encountered vertical wall at 330m 23:27, cup coral. Collected *Helicoprimnoa* at 23:20. Observing a Nautilus egg?, several black single octocoral/crinoid polyps. Several *Stichopathes* whip red colonies 00:16 305m. Amberjack following the ROV 00:25 295m. *Bolocera* bottom fish at 00:31 292 m. Several small fan colonies and smaller yellow colonies of scleractinians at 00:42 286m. Observed a Goniasterid seastar. At 00:48 281m ROV encountered a fishing line. Further upslope, encountered yellow comatulid crinoid with curling arms. Saw a white whip black coral with curling distal end attached to the vertical wall at 01:02 264m. Observed a few more white whip black corals further upslope. Collected shallow water brisingid on whip coral from the family elliselidae (20170301 01:22:56; D2_DIVE13_SPEC02BIO; 257 m). Observed several white plexaurid seafans with associate squat lobsters, as well as more whip elliseids. Started moving laterally to the east, encountered and collected unusual *Alicia* anemone (20170301 02:01:17; D2_DIVE13_SPEC03BIO; 258 m). Found more white plexaurid seafans as well as an Ellisellidae (the same morph collected with the brisingid) at 02:06 255m. Imaged an sponge crab 02:24 256m. Saw a hammerhead shark on Serios cam at 02:28 253m. Found more long line and

	several pieces of cloth perhaps palu (bait bags), in addition to beer cans (260m 02:51). Encountered barren carbonate walls of higher rugosity. Observed another white whip black coral and whip elliselid octocoral with ophiuroid associate 03:15 250m. Commenced recovery ascent facing the wall at 03:19.

Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	
 EX1702_IMG_20170228T214624Z_ROVHD.jpg	 EX1702_IMG_20170301T020521Z_CPHD.jpg
Urchin on gently sloping bench with heavy sediment cover.	D2 facing the near vertical carbonate wall at the 260-250 m depth contour.

Samples Collected		
Sample		
Sample ID	D2_DIVE13_SPEC01BIO	 EX1702_IMG_20170228T232219Z_ROVHD.jpg
Date (UTC)	20170228	
Time (UTC)	23:24:10	
Depth (m)	345.0267	
Temperature (°C)	13.67640	
Field ID(s)	Primnoid Coral	
Comments		
Sample		
Sample ID	D2_DIVE13_SPEC02BIO	 EX1702_IMG_20170301T012030Z_ROVHD.jpg
Date (UTC)	20170301	
Time (UTC)	01:22:56	
Depth (m)	256.8743	
Temperature (°C)	18.38179	
Field ID(s)	Brisingid on octocoral	
Comments		

Sample		
Sample ID	D2_DIVE13_SPEC03BIO	 EX1702_IMG_20170301T020016Z_ROVHD.jpg
Date (UTC)	20170301	
Time (UTC)	02:01:17	
Depth (m)	257.9701	
Temperature (°C)	18.67550	
Field ID(s)	*Alicia*	
Comments		

Please direct inquiries to:

NOAA Office of Ocean Exploration & Research
1315 East-West Highway (SSMC3 10th Floor)
Silver Spring, MD 20910
(301) 734-1014

APPENDIX C: Sample Tables

Table C-1. Inventory of geological samples collected during EX-17-02. Sample descriptions are limited by the fact that samples were not to be cut shipboard (refer to sample descriptions made available at http://osu-mgr.org/noaa-EX-17-02/).

PrimSpecData_ID	Field ID	Preservation	Weight (kg)	Date (UTC)	Time (UTC)	Lat	Long	Depth (m)	Salinity	Temp (°C)	Oxygen (mg/l)	Location of sample collected
D2_DIVE01	No specimens were collected											Tutuila (lost/ mechanical)
D2_DIVE02_SPEC01 GEO	Basalt clast	Dry	1.1	20170217	20:20:29	-14.29462	-169.49890	503.66	34.55	8.41	4.23	Ta'u
D2_DIVE02_SPEC03 GEO	Basalt clast	Dry	4.3	20170217	22:47:23	-14.29320	-169.49990	433.98	34.69	10.35	3.85	Ta'u
D2_DIVE02_SPEC06 GEO	Lithified sediment	Dry	3.1	20170218	3:16:08	-14.29085	-169.49813	343.92	34.92	13.15	3.79	Ta'u
D2_DIVE03_SPEC01 GEO	Mn-encrusted pillow fragment	Dry	4.8	20170218	21:19:45	-14.53780	-168.07972	2527.85	34.63	1.91	4.52	Rose atoll (deep)
D2_DIVE03_SPEC02 GEO	Mn-encrusted pillow fragment	Dry	8.7	20170218	22:13:43	-14.53770	-168.07994	2502.41	34.67	1.89	4.47	Rose atoll (deep)
D2_DIVE04	No specimens were collected											Seamount D (lost/weather)
D2_DIVE05_SPEC01 GEO	Mn-sed. (but poss. alt. basalt within)	Dry	4.1	20170221	0:57:31	-12.65005	-167.27217	3770.47	34.69	1.46	4.98	Leoso
D2_DIVE05_SPEC02 GEO	Mn-sed. (but poss. alt. basalt within)	Dry	2.9	20170221	1:38:45	-12.64940	-167.27163	3747.76	34.69	1.45	5.00	Leoso
D2_DIVE05_SPEC04 GEO	Mn-sed. (but poss. alt. basalt within)	Dry	3.7	20170221	2:38:27	-12.64907	-167.27200	3718.43	34.69	1.46	4.89	Leoso
D2_DIVE06_SPEC01 GEO	Mn-sed. (but poss. alt. basalt	Dry	16.7	20170221	21:41:01	-12.281	-168.320	3033.64	34.68	1.69	4.55	Utu (shallow)

	within)					40	82					
D2_DIVE06_SPEC02 GEO	Mn-sed. (but poss. alt. basalt within)	Dry	10.2	201702 21	22:31: 56	- 12.280 93	- 168.320 20	3024. 43	34.68	1.69	4.46	**Utu (shallow)**
D2_DIVE06_SPEC05 GEO	Mn-sed. (but poss. alt. basalt within)	Dry	4.6	201702 22	0:46:3 2	- 12.281 34	- 168.318 45	2970. 18	34.62	1.79	4.47	**Utu (shallow)**
D2_DIVE07_SPEC01 GEO	Mn rind w/ sediment or hyaloclast ite	Dry	4.0	201702 22	21:38: 29	- 11.169 03	- 169.892 33	2115. 97	NA	2.03	NA	**Moki**
D2_DIVE07_SPEC02 GEO	Hyaloclast ite with large cpx	Dry	10.8	201702 22	22:58: 24	- 11.168 23	- 169.892 16	2075. 95	NA	2.10	NA	**Moki**
D2_DIVE07_SPEC03 GEO	Hyaloclast ite with basalt clasts	Dry	8.8	201702 22	23:20: 42	- 11.167 94	- 169.892 10	2054. 88	NA	2.10	NA	**Moki**
D2_DIVE08_SPEC01 GEO	Mn rind w/ poss. hyaloclast ite	Dry	10.9	201702 23	22:14: 28	- 12.274 04	- 168.368 19	3919. 99	34.70	1.41	5.05	**Utu (deep)**
D2_DIVE08_SPEC02 GEO	Mn rind w/ poss. alt basalt or sed	Dry	5.3	201702 23	23:16: 07	- 12.273 71	- 168.367 88	3873. 21	34.73	1.45	5.08	**Utu (deep)**
D2_DIVE08_SPEC04 GEO	Mn rind w/ poss. hyaloclast ite	Dry	4.0	201702 24	0:15:1 3	- 12.273 65	- 168.367 69	3847. 51	34.69	1.50	4.80	**Utu (deep)**
D2_DIVE09_SPEC02 GEO	Basalt, older part of Nafanua (>5 yrs)	Dry	4.5	201702 24	22:54: 27	- 14.214 53	- 169.060 20	709.6 9	34.45	5.73	4.85	**Vailulu'u**
D2_DIVE09_SPEC05 GEO	Basalt, N. "new" Nafanua cone (<5 yrs)	Dry	17	201702 25	0:50:1 2	- 14.214 56	- 169.061 41	730.3 4	34.45	5.54	4.83	**Vailulu'u**
D2_DIVE09_SPEC06 GEO	Basalt, S. "new" Nafanua cone (<5	Dry	5.8	201702 25	3:56:0 1	- 14.216 18	- 169.061 91	702.1 8	34.43	5.70	4.93	**Vailulu'u**

	yrs)											
D2_DIVE10_SPEC03 GEO	Carbonate cobbles	Dry	16.5	20170225	23:42:16	-14.54681	-168.12861	568.09	34.46	6.94	4.92	**Rose atoll (shallow)**
D2_DIVE10_SPEC05 GEO	Carbonate cobbles	Dry	*a*	20170226	2:20:54	-14.54746	-168.13223	325.48	35.28	16.69	4.57	**Rose atoll (shallow)**
D2_DIVE10_SPEC06 GEO	Carbonate cobbles	Dry	0.3	20170226	3:02:05	-14.54771	-168.13252	315.29	35.32	16.98	4.64	**Rose atoll (shallow)**
D2_DIVE11_SPEC01 GEO	Highly alt. basalt, possible fresh cpx	Dry	10.1	20170226	21:58:11	-15.73307	-167.26461	3002.91	34.67	1.73	4.67	**seamount D**
D2_DIVE11_SPEC03 GEO	Highly alt. basalt, possible fresh cpx	Dry	2.1	20170226	22:58:04	-15.73320	-167.26443	2989.02	34.67	1.74	4.63	**seamount D**
D2_DIVE11_SPEC04 GEO	Highly alt. basalt, possible fresh cpx	Dry	1.9	20170226	23:28:44	-15.73351	-167.26445	2971.06	34.67	1.74	4.67	**seamount D**
D2_DIVE11_SPEC05 GEO	Highly alt. basalt, possible fresh cpx	Dry	5.3	20170227	0:09:23	-15.73382	-167.26439	2951.47	34.68	1.74	4.62	**seamount D**
D2_DIVE12_SPEC03 GEO	Hyaloclastite with basalt fragments	Dry	7.3	20170227	22:43:51	-14.46885	-168.63887	2448.92	34.67	1.89	4.51	**Malulu**
D2_DIVE12_SPEC05 GEO	Carbonate	Dry	12.7	20170228	0:35:32	-14.46945	-168.63815	2382.57	34.66	1.86	4.34	**Malulu**
D2_DIVE12_SPEC07 GEO	Highly alt. basalt with fresh cpx	Dry	3.7	20170228	1:52:03	-14.46963	-168.63744	2340.77	34.66	1.86	4.36	**Malulu**
D2_DIVE13	no specimens were collected											**Tutuila (second attempt)**

sed = sediment; poss = possible; alt = altered; N=North; S=South

a. Attached to coral and stored/archived with the coral.

Table C-2. Inventory of biological specimens collected during EX-17-02.

Date Collected	Time Collected	Sample ID#	Dive Site	Field Identification	Identification Remarks	Vial #	Lat	Long	Depth (m)
20170217	202029	DIVE02_SPEC01GEO_A01	Ta'u Unit of NMSAS	Cirripedia			-14.29	-169.50	504
20170217	202029	DIVE02_SPEC01GEO_A02	Ta'u Unit of NMSAS	Scleractinia			-14.29	-169.50	504
20170217	220421	DIVE02_SPEC02BIO	Ta'u Unit of NMSAS	Primnoidae		OGL 743	-14.29	-169.50	448
20170217	220421	DIVE02_SPEC02BIO_A01	Ta'u Unit of NMSAS	Galatheidae			-14.29	-169.50	448
20170217	220421	DIVE02_SPEC02BIO_A02	Ta'u Unit of NMSAS	Ophiuroidea			-14.29	-169.50	448
20170217	224723	DIVE02_SPEC03GEO_A01	Ta'u Unit of NMSAS	Ophiurida A			-14.29	-169.50	434
20170217	224723	DIVE02_SPEC03GEO_A02	Ta'u Unit of NMSAS	Galatheidae			-14.29	-169.50	434
20170217	224723	DIVE02_SPEC03GEO_A03	Ta'u Unit of NMSAS	Hexactinellida			-14.29	-169.50	434
20170217	224723	DIVE02_SPEC03GEO_A04	Ta'u Unit of NMSAS	Decapoda			-14.29	-169.50	434
20170217	224723	DIVE02_SPEC03GEO_A05	Ta'u Unit of NMSAS	Scleractinia			-14.29	-169.50	434
20170217	224723	DIVE02_SPEC03GEO_A06	Ta'u Unit of NMSAS	Ophiuroidea B			-14.29	-169.50	434
20170217	224723	DIVE02_SPEC03GEO_A07	Ta'u Unit of NMSAS	Gastropoda			-14.29	-169.50	434
20170218	5452	DIVE02_SPEC04BIO	Ta'u Unit of NMSAS	Anthomastus			-14.29	-169.50	389
20170218	25431	DIVE02_SPEC05BIO	Ta'u Unit of NMSAS	Dendrophyllia		OGL 746	-14.29	-169.50	345
20170218	25431	DIVE02_SPEC05BIO	Ta'u Unit of NMSAS	Dendrophyllia			-14.29	-169.50	345
20170218	25431	DIVE02_SPEC05BIO_A01	Ta'u Unit of NMSAS	Zoantharia			-14.29	-169.50	345
20170218	25431	DIVE02_SPEC05BIO_A02	Ta'u Unit of NMSAS	Cirripedia			-14.29	-169.50	345

20170218	25431	DIVE02_SPEC05BIO_A03	Ta'u Unit of NMSAS	Crinoidea			-14.29	-169.50	345
20170218	25431	DIVE02_SPEC05BIO_A04	Ta'u Unit of NMSAS	Ophiuroidea			-14.29	-169.50	345
20170218	25431	DIVE02_SPEC05BIO_A05	Ta'u Unit of NMSAS	Galatheidae A			-14.29	-169.50	345
20170218	25431	DIVE02_SPEC05BIO_A06	Ta'u Unit of NMSAS	Galatheidae B			-14.29	-169.50	345
20170218	31608	DIVE02_SPEC06GEO_A01	Ta'u Unit of NMSAS	Galatheidae			-14.29	-169.50	344
20170218	31608	DIVE02_SPEC06GEO_A02	Ta'u Unit of NMSAS	Ophiuroidea			-14.29	-169.50	344
20170218	31608	DIVE02_SPEC06GEO_A03	Ta'u Unit of NMSAS	Hydrozoa		OGL 744	-14.29	-169.50	344
20170218	31608	DIVE02_SPEC06GEO_A04	Ta'u Unit of NMSAS	Aplacophora			-14.29	-169.50	344
20170218	31608	DIVE02_SPEC06GEO_A05	Ta'u Unit of NMSAS	Zoantharia			-14.29	-169.50	344
20170218	31608	DIVE02_SPEC06GEO_A06	Ta'u Unit of NMSAS	Scleractinia			-14.29	-169.50	344
20170218	232452	DIVE03_SPEC03BIO	Rose Atoll	Lepidisis		OGL 748	-14.54	-168.08	2449
20170218	232452	DIVE03_SPEC03BIO_A01	Rose Atoll	Polychaeta			-14.54	-168.08	2449
20170219	13357	DIVE03_SPEC04BIO	Rose Atoll	Dead sponge			-14.54	-168.08	2350
20170219	13357	DIVE03_SPEC04BIO_A01	Rose Atoll	Hexactinellida A			-14.54	-168.08	2350
20170219	13357	DIVE03_SPEC04BIO_A02	Rose Atoll	Hexactinellida B			-14.54	-168.08	2350
20170219	13357	DIVE03_SPEC04BIO_A03	Rose Atoll	Cirripedia			-14.54	-168.08	2350
20170219	13357	DIVE03_SPEC04BIO_A04	Rose Atoll	Hydrozoa			-14.54	-168.08	2350
20170219	13357	DIVE03_SPEC04BIO_A05	Rose Atoll	Polychaeta			-14.54	-168.08	2350
20170219	13357	DIVE03_SPEC04BIO_A06	Rose Atoll	Actinaria			-14.54	-168.08	2350
20170219	20840	DIVE03_SPEC05BIO	Rose Atoll	Parantipathes		OGL 749	-14.54	-168.08	2348

20170219	20840	DIVE03_SPEC05BIO_A01	Rose Atoll	Decapoda			-14.54	-168.08	2348
20170221	5731	DIVE05_SPEC01GEO_A01	Leoso Seamount	Brisingidae		OGL 751	-12.65	-167.27	3770
20170221	22703	DIVE05_SPEC03BIO	Leoso Seamount	Pilematechinus ?			-12.65	-167.27	3727
20170221	30335	DIVE05_SPEC05BIO	Leoso Seamount	Bathypathes		OGL 750	-12.65	-167.27	3683
20170221	235532	DIVE06_SPEC03BIO		Pleurogorgia	with associate anemones	OGL 754	-12.28	-168.32	2999
20170221	235532	DIVE06_SPEC03BIO_A01		Actinaria		OGL 581	-12.28	-168.32	2999
20170222	2920	DIVE06_SPEC04BIO		Sponge stalk	with 4 crinoids and 2 hydroids		-12.28	-168.32	2974
20170222	2920	DIVE06_SPEC04BIO_A01		Crinoidea A			-12.28	-168.32	2974
20170222	2920	DIVE06_SPEC04BIO_A02		Crinoidea B			-12.28	-168.32	2974
20170222	2920	DIVE06_SPEC04BIO_A03		Crinoidea C		OGL 582	-12.28	-168.32	2974
20170222	2920	DIVE06_SPEC04BIO_A04		Crinoidea D			-12.28	-168.32	2974
20170222	2920	DIVE06_SPEC04BIO_A05		Hydroid A		OGL 583	-12.28	-168.32	2974
20170222	2920	DIVE06_SPEC04BIO_A07		Sabellida			-12.28	-168.32	2974
20170222	2920	DIVE06_SPEC04BIO_A08		Crinoidea E			-12.28	-168.32	2974
20170222	11339	DIVE06_SPEC06BIO		Chrysogorgiid	with ophiuroid Ophiacantha?	OGL 752	-12.28	-168.32	2960
20170222	11339	DIVE06_SPEC06BIO_A01		Ophiacanthia		OGL 753	-12.28	-168.32	2960

20170223	11044	DIVE07_SPEC04BIO	Moki Seamount	Chrysogorgia	with squat lobster	OGL 755	-11.17	-169.89	
20170223	11044	DIVE07_SPEC04BIO_A01	Moki Seamount	Galatheidae			-11.17	-169.89	
20170223	233739	DIVE08_SPEC03BIO	Utu Seamount	Commatulid Crinoid	on sponge stalk		-12.27	-168.37	3862
20170223	233739	DIVE08_SPEC03BIO_A01	Utu Seamount	Crinoidea		OGL 586	-12.27	-168.37	3862
20170223	233739	DIVE08_SPEC03BIO_A02	Utu Seamount	Hydroid			-12.27	-168.37	3862
20170223	233739	DIVE08_SPEC03BIO_A03	Utu Seamount	Amphipoda			-12.27	-168.37	3862
20170224	14045	DIVE08_SPEC05BIO	Utu Seamount	Anemone	on stalked sponge, crinoids		-12.27	-168.37	3711
20170224	14045	DIVE08_SPEC05BIO_A01	Utu Seamount	Actinaria		OGL 584	-12.27	-168.37	3711
20170224	14045	DIVE08_SPEC05BIO_A02	Utu Seamount	Crinoidea A			-12.27	-168.37	3711
20170224	14045	DIVE08_SPEC05BIO_A03	Utu Seamount	Crinoidea B		OGL 585	-12.27	-168.37	3711
20170224	14045	DIVE08_SPEC05BIO_A04	Utu Seamount	Cirripedia A			-12.27	-168.37	3711
20170224	14045	DIVE08_SPEC05BIO_A05	Utu Seamount	Cirripedia B			-12.27	-168.37	3711
20170224	212547	DIVE09_SPEC01BIO	Vailulu'u Volcano	Floculent material	with polychaete worms		-14.21	-169.06	925
20170224	212547	DIVE09_SPEC01BIO_A01	Vailulu'u Volcano	sediment			-14.21	-169.06	925
20170224	234140	DIVE09_SPEC03BIO	Vailulu'u Volcano	Hydroid (stalked)		OGL 587	-14.21	-169.06	700
20170224	234140	DIVE09_SPEC03BIO_A01	Vailulu'u Volcano	Ophiuroid			-14.21	-169.06	700

20170225	1110	DIVE09_SPEC04BIO	Vailulu'u Volcano	Anthomastus		OGL 588	-14.21	-169.06	702
20170225	223811	DIVE10_SPEC01BIO	Rose Atoll	Hexactinellida sponge		OGL 756	-14.55	-168.13	623
20170225	230547	DIVE10_SPEC02BIO	Rose Atoll	Antipatharia		OGL 757	-14.55	-168.13	611
20170225	230547	DIVE10_SPEC02BIO_A01	Rose Atoll	Zoantharia			-14.55	-168.13	611
20170225	230547	DIVE10_SPEC02BIO_A02	Rose Atoll	Amphipoda			-14.55	-168.13	611
20170225	230547	DIVE10_SPEC02BIO_A03	Rose Atoll	Cirripedia			-14.55	-168.13	611
20170226	14352	DIVE10_SPEC04BIO	Rose Atoll	Gorgonocephalus?		OGL 589	-14.55	-168.13	362
20170226	22054	DIVE10_SPEC05GEO_A01	Rose Atoll	octocorallia			-14.55	-168.13	325
20170226	30205	DIVE10_SPEC06GEO_A01	Rose Atoll	Scleractinia		OGL 758	-14.55	-168.13	315
20170226	30205	DIVE10_SPEC06GEO_A02	Rose Atoll	Galatheidae			-14.55	-168.13	315
20170226	30205	DIVE10_SPEC06GEO_A03	Rose Atoll	Demospongiae		OGL 759	-14.55	-168.13	315
20170226	222153	DIVE11_SPEC02BIO		Primnoidae	with venus flytrap anemone	OGL 764	-15.73	-167.26	2994
20170226	222153	DIVE11_SPEC02BIO_A01		Actinaria		OGL 765	-15.73	-167.26	2994
20170227	923	DIVE11_SPEC05GEO_A01		Isididae		OGL 762	-15.73	-167.26	2951
20170227	3817	DIVE11_SPEC06BIO		Unknown octocoral		OGL 763	-15.73	-167.26	2925
20170227	15622	DIVE11_SPEC07BIO		Demosponge		OGL 761	-15.73	-167.26	2853
20170227	214839	DIVE12_SPEC01BIO	Malulu Seamount	Sponge	(new species)	OGL 768	-14.47	-168.64	2460
20170227	214839	DIVE12_SPEC01BIO_A01	Malulu Seamount	Amphipoda			-14.47	-168.64	2460
20170227	220851	DIVE12_SPEC02BIO	Malulu Seamount	Goniasterid cookie star	(new species)		-14.47	-168.64	2458

20170227	233405	DIVE12_SPEC04BIO	Malulu Seamount	Pleurogorgia	(golden) with hydroids	OGL 767	-14.47	-168.64	2438
20170227	233405	DIVE12_SPEC04BIO_A01	Malulu Seamount	Hydroid		OGL 590	-14.47	-168.64	2438
20170228	12053	DIVE12_SPEC06BIO	Malulu Seamount	Pseudochrysogorgia	w/ Chyrostylid squat lobster	OGL 766	-14.47	-168.64	2362
20170228	12053	DIVE12_SPEC06BIO_A01	Malulu Seamount	Chyrostylidae			-14.47	-168.64	2362
20170228	232359	DIVE13_SPEC01BIO	Taena Bank	Unidentified Coral		OGL 770	-14.32	-170.65	345
20170301	12256	DIVE13_SPEC02BIO	Taena Bank	Brisingid		OGL 591	-14.32	-170.65	257
20170301	12256	DIVE13_SPEC02BIO_A01	Taena Bank	Octocoral		OGL 769	-14.32	-170.65	257
20170301	12256	DIVE13_SPEC02BIO_A02	Taena Bank	Decapoda			-14.32	-170.65	257
20170301	20117	DIVE13_SPEC03BIO	Taena Bank	Anemone?		OGL 592	-14.32	-170.65	258
20170301	20117	DIVE13_SPEC03BIO_A01	Taena Bank	Octocoral		OGL 771	-14.32	-170.65	258

APPENDIX D: Data and Products Summary

PRODUCTS AVAILABLE DURING A CRUISE:

A variety of data and products will be collected and/or developed aboard Okeanos Explorer (EX) and at shore-side Exploration Command Centers (ECCs) during the EX 2017 Field Season. Operational products and datasets will be made available to participants during and after the cruise, and can be accessed from several internet-based tools. Below is a summary of products anticipated to be developed for operational uses, product descriptions and information on where to go to access these products during a cruise.

Product	Description	Format	Developer	Developer Location	Access Location	Access Level
OPERATIONS						
Daily Science Team Emails	Brief summary of today's operations and plans and participation info for next two days.	Emails	Science Leads	Ship	Email	Participants/Listserv
Plan of the Day	Plan of the day detailing ship operations	DOCX	Operations Officer	Ship	FTP site / Cruise Data File Server	Participants
SITREPs	Internal Document; Daily status report detailing EX operations	DOCX, PDF	Expedition Coordinator	Ship	FTP Site; Email	OER staff
Mapping						
Raw EM302 Data	Selected full resolution bathymetry and bottom backscatter data. Water column backscatter where appropriate and on a limited basis.	.all, .wcd	Mapping team	Ship/Shore	FTP site / Cruise Data File Server	Participants
EK60 Single Beam Data	Raw water column data. Where appropriate, a processed level 2 image.	.raw, Fledermaus .sd, Image (.jpeg, .TIFF)	Mapping team	Ship/Shore	FTP site / Cruise Data File Server	Participants
Sub-Bottom Profiler Data	Raw data. Where appropriate, a processed geo-referenced vertical curtain.	.seg-y, .keb, .kea, GeoTIFF, .sd.	Mapping team	Ship/Shore	FTP site / Cruise Data File Server	Participants
Daily mapping progress bathymetry	Site-specific or cumulative daily bathymetry	GeoTIFF; Fledermaus .sd; Google Earth .kmz, ASCII text file, Arc Grid .asc	Mapping team	Ship	FTP site / Cruise Data File Server	Participants
Multibeam backscatter data	Where appropriate, site specific backscatter data (seafloor / water column backscatter as needed)	GeoTIFF, .sd, Tiff	Mapping team	Ship	FTP site / Cruise Data File Server	Participants
Science Operations Products						
ROV Dive Planning Form	Planning form detailing desired ROV Ops including waypoints	DOCX, PDF	Science & ROV Team	Ship	Email; FTP site / Cruise Data File Server	Participants
ROV Dive Summary Form	Summary detailing completed ROV dive, summarizing observations, sample collections and including summary maps	DOCX, PDF	Science & ROV Team	Ship	FTP site / Cruise Data File Server	Participants
ROV Tracklines	File containing XYZ + T (1 min avg.) data of the ROV during a dive.	.csv table, KML	ROV Team; Script	Ship	FTP site / Cruise Data File Server	Participants
Hypack Targets	File containing the targets dropped during a dive	KML	ROV Team; Script	Ship	FTP site / Cruise Data File Server	Participants
SeaScribe Annotation Log	Scientific observation log noting fauna, geology and other observations from an ROV dive	CSV	Expedition science participants contribute; SeaScribe server auto-generates	Geographically Distributed	FTP site / Cruise Data File Server	Participants

Chat Log	Literally a group chat room with UTC time-coded and stamped observations that are saved and output as .txt files, and as excel files with associated lat, long, and depth for each entry.	TXT, XLSX	Expedition Science Participants contribute; Automated server generates	Geographically Distributed	FTP site / Cruise Data File Server	Participants
Datasets	Raw oceanographic data, SCS, CTD, DO, LSS, ORP, etc.	various	Automated process; STs	Ship	FTP site / Cruise Data File Server	Participants
CTD Rosette Summary Form	Summary detailing completed ROV dive, summarizing observations, sample collections and including summary maps	DOCX	Science Team	Ship	FTP site / Cruise Data File Server	Participants
Imagery						
Raw Video Clips – Low Res	Video clips from ROV dives, onboard cameras.	.mov (H.264 at 1.5 MB at 640x320)	Video team	Ship	FTP site / Cruise Data File Server	Participants, Web Coordinator and Science Participants
Cruise Highlight Video	OPTIONAL: video highlighting OER mission	.mov HR & LR	Video Team	Ship	FTP site / Cruise Data File Server (Low Res Only)	Public
Daily Highlight Videos	Edited & Scored video of best clips from a specific dive (one per dive)	.mov HR & LR	Video team	Ship	FTP site / Cruise Data File Server (Low Res Only)	Public
Custom Video Products	OPTIONAL: One-off products for the OER website and outreach (Timelapses, "Sea Poke" video, etc)	.mov HR & LR	OER Program Personnel	Shore	FTP site / Cruise Data File Server (Low Res Only); OceanExplorer website	Participants
Highlight Imagery	HD Screengrabs; best 10-15 per dive; Edited for sharing online	Color corrected .jpg	Video team	Ship	FTP site / Cruise Data File Server (Low Res Only)	Participants
Still Images	frame grabs from underwater video which map to the video clips	JPG; TIFF	Video team	Ship	FTP site / Cruise Data File Server (Low Res Only)	Participants
News Articles	Provides more context or info on expedition events	Online	Various	Various	OceanExplorer Website	Participants/ Public
Sampling						
Daily Sample Report	Daily output from SODA that includes information about every sample, lab preparation, and identifies associated images and video	.pdf	Sample Data Manager	Ship	FTP site / Cruise Data File Server	Participants
Daily List of Sampling Associated Images and Video	List of all samples and associated video. This list is used to build the folders of in situ video and stills. Output from the database?	.txt	Sample Data Manager	Ship	FTP site / Cruise Data File Server	Participants
In situ images (via symlinks)	Symbolic links that create a folder of all images associated with a particular sample	JPG via Symlinks	Images - Video team; Identification of Images - Sample Data Manager; Symlinks- Data Manager	Ship	FTP site / Cruise Data File Server	Participants

Video of collection (via symlinks)	Symbolic links that create a folder of all videos associated with a particular sample	.mov via Symlinks	Identification of videos - Sample Data Manager; Symlinks- Data Manager	Ship	FTP site / Cruise Data File Server	Participants
Lab images	Images of samples taken with a color pallet and sample label	RAW, JPG, CR2	Sample Data Manager	Ship	FTP site / Cruise Data File Server	Participants
Microscope images	Images taken using a Caltex LX-100 Series Digital Microscope (when applicable)	JPG	Sample Data Manager	Ship	FTP site / Cruise Data File Server	Participants
Microscope video	Video taken using a Caltex LX-100 Series Digital Microscope (when applicable)	MP4	Sample Data Manager	Ship	FTP site / Cruise Data File Server	Participants
Records in ROV Dive Summary Form	Tables located in the dive summary report that includes summary collection information, field ID, preparation, and any relevant notes about the specimen	.docx	Sample Data Manager	Ship	FTP site / Cruise Data File Server (Once Final)	Participants
Final copy of cruise SODA (database)	Microsoft Access database used during sampling operations to document the metadata of each biological or geological sample collected during a dive	Microsoft Access 2013 database (.accdb)	Sample Data Manager	Ship	FTP site / Cruise Data File Server (at conclusion of the cruise)	Participants
Final Sampling Table	Table of all samples collected, associated data, preparations, planned archival locations, and names of associated imagery	.xls	Sample Data Manager	Ship	FTP site / Cruise Data File Server (at conclusion of the cruise)	Participants

PRODUCTS AVAILABLE AFTER A CRUISE

The following is a list and descriptions of quality assured products and data to be developed and made available after the cruise. Availability timing depends on level of processing required. All data and products listed below are available for direct access from the OER Digital Atlas / Data Access tab. Documents, data and information are added to the Digital Atlas as they are processed and become available. If you cannot find the data you are looking for, please submit a data request form for assistance from the OER data management team.

Product	Description	Format	Developer	veloper Locati	ccess Location	Access Level
OPERATIONS						
Cruise Report	Cruise report summarizing the operations and results of the cruise	DOCX, PDF	Expedition Coordinator (with input from team leads)	Shore	OER Digital Atlas; NCEI	Participants
Initial Expedition Summary	Initial, first look at the results of the cruise	DOCX	Science, Expedition Coordinator	Ship	Email	Partners
Expedition Summary	Summary of major initial expedition findings	PDF	Engagement Team	Shore	OceanExplorer Website	Public
Expedition Infographic	Summary of expedition statistics	PDF	Engagement Team	Shore	OceanExplorer Website	Public
Science Operations Products						
ROV Dive Summary Forms	Summary of dive with operational info, site description and overview of observations	DOCX, PDF	ROV Team, Science Lead	Ship	OER Digital Atlas; NCEI	Participants
CTD Summary Forms	Summary of CTD cast results; detail sample collection	DOCX, PDF	Science Team	Ship and Shore	OER Digital Atlas; NCEI	Participants
Water Column Profile Data	Water Column profiles of sound velocity, XBT, and CTD data collected for mapping.	.asvp, .txt, .cnv	UNH (Mapping Team)	UNH, Ship	OER Digital Atlas; NCEI	Public
Sampling						
Final Sample Database	Microsoft Access database used during sampling operations to document the metadata of each biological or geological sample collected during a dive	Microsoft Access 2013 database (.accdb)	Sample Data Manager	Ship	OER Digital Atlas; NCEI	Public

Final Sample Sumary Table	Table of all samples collected, associated data, preparations, planned archival locations, and names of associated imagery	.xls	Sample Data Manager	Ship	OER Digital Atlas; NCEI	Public
Sample Layer in Okeanos Explorer Atlas	Geospatial layer in the Okeanos Explorer Digital Atlas that associates the locations of samples with digital data collected	Okeanos Explorer Atlas layer	OER Data Manager	NCEI	Okeanos Explorer Atlas; NCEI	Public
Biologic Samples	Biologic samples collected durign the cruise are made available through the Smithsonian	Specimen	CAPSTONE Science Adviser; Smithsonian	University of Hawaii	Invertebrate Zoology Collection	Public
Ocean Genome Legacy Samples	Biologic samples preserved for genetic analysis for the Ocean Genome Legacy Project collected durign the cruise are made available through the Northeastern's OGL Project.	Specimen	CAPSTONE Science Adviser; OGL at Northeastern	University of Hawaii	Ocean Genome Legacy Center	Public
Geologic Samples	Geologic samples collected durign the cruise are made available through the Smithsonian	Specimen	CAPSTONE Science Adviser, Oregon State University	University of Hawaii	OSU Marine Geology Repository	Public
Mapping						
Expedition Summary Map	Standard map showing bathymetry data, ROV dive sites, CTD casts and possibly XBTs	PDF	Mapping Team	Ship	OceanExplorer Website; OER Digital Atlas	

Mapping Data Processing Log	Excel sheet of metadata describing mapping data files information, notes, processing checklist, and QC.	Excel Spreadsheet (.xlsx)	UNH (Mapping team)	UNH, Ship, Shore	OER Digital Atlas; NCEI	Public
Level 0 EM302 Data	Raw uncleaned multibeam sonar files.	Raw EM302 multibeam files (.all, .wcd)	UNH (Mapping team), SST	UNH, Ship	OER Digital Atlas; NCEI	Public
Level 0 EK60 Data	Raw EK60 split-beam sonar files.	.bot, .idx, .raw	UNH (Mapping Team)	UNH, Ship	OER Digital Atlas; NCEI	Public
Level 0 Sub-Bottom Profiler Data	Knudsen 3260 Sub-Bottom Profiler sonar data.	.sgy, .keb, .kea	UNH (Mapping Team)	UNH, Ship	OER Digital Atlas; NCEI	Public
Level 1 EM302 Multibeam Data	Edited & cleaned full resolution multibeam bathymetry data by line	.gsf	UNH (Mapping Team)	UNH, Ship	.gsf to NCEI, HDCS to NOAA OCS	Public
Level 2 EM 302 Multibeam Bathymetry and Bottom Backscatter Data	Cleaned and gridded bathymetry files at summary 25-100 meter resolution, backscatter mosaics (as available)	gridded data (ASCII .xyz), geotiff (.tif/.tfw or .tif), Fledermaus objects (.sd), Google Earth (.kmz), ArcGIS Grid (.asc), backscatter mosaic images (.tif)	UNH (Mapping team)	UNH, Ship	OER Digital Atlas; NCEI	Public
Level 2 EM302 Multibeam Data Coverage Polygons	Survey coverage shapefile used to calculate square km mapped and to show EX activities on the IOCM SeaSketch site.	ArcGIS shapefile (.shp)	UNH (Mapping team)	UNH	OER Digital Atlas; NCEI	Internal to NOAA
Mapping Data Report	Summary of Mapping operations and accomplishments. Given a DOI # and archived with data.	Doc and PDF	Expedition Mapping Lead	UNH, Shore	OER Digital Atlas; NCEI	Public
Imagery						
Raw Video Clips – Full Res	Video clips from ROV dives, onboard cameras.	.mov (ProRes 422 LT at 145 Mb @ 1920 x 1080)	Video team	Ship	By Request (use data request form)	TBD

Highlight Images	**"Best of" compilation of imagery from expedition (Ship and Shore)**	**JPG (with Excel document containing captions, credit & additional info)**	**Web Coordinator**	**Shore**	**NCEI; OE Website**	**Participants/ Public**
All Expedition Video	**All video streamed from the ship to shore will be captured aboard ship and stewarded by NOAA.**	**digital**	**Ship**	**Shore (ISC)**	**By request (form) Archives**	**Public**
Low resoultion video at SeaTube	Deck to deck video, searchable with annotations, with associated environmental data	Digital	ONC / OER	ONC	Web based portal	Public: Viewing, searching Log in protected: Creating / editing annotations

APPENDIX E: Survey of Opportunity

NASA Maritime Aerosols Network Survey of Opportunity

Survey or Project Name

Maritime Aerosol Network

Lead POC or Principle Investigator (PI & Affiliation)

POC: Dr. Alexander Smirnov

Supporting Team Members Ashore

Supporting Team Members Aboard (if required)

Activities Description(s) (Include goals, objectives and tasks)

The Maritime Aerosol Network (MAN) component of AERONET provides ship-borne aerosol optical depth measurements from the Microtops II sun photometers. These data provide an alternative to observations from islands as well as establish validation points for satellite and aerosol transport models. Since 2004, these instruments have been deployed periodically on ships of opportunity and research vessels to monitor aerosol properties over the World Oceans.

During the cruise the marine aerosol layer observations will be collected for the NASA Maritime Aerosol Network (MAN). Observations will be made by mission personnel (as time allows) with a sun photometer instrument provided by the NASA MAN program. Resulting data will be delivered to the NASA MAN primary investigator Alexander Smirnov by the expedition coordinator. All collected data will be archived and publicly available at: http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.htmlhttp://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html

Equipment resides on the ship and is stewarded by the expedition coordinator.

APPENDIX F: Samoa MFAT Marine Scientific Research Approval

GOVERNMENT OF THE INDEPENDENT STATE OF SAMOA

Ministry of Foreign Affairs and Trade

Note No: 17/23

The Ministry of Foreign Affairs and Trade presents its compliments to the Embassy of the United States of America in Apia and has the honour to refer to the latter's Note Verbale 44/16 requesting port courtesies and authorization for Jeremy Potter to conduct marine scientific research in areas requiring the consent of Samoa , during the period of February 5-April 21 2017 from the NOAA research from the research vessel, *Okeanos Explorer*, under the project name CAPSTONE 2017 Mapping Kingman, Palmyra Jarvis.

The Ministry of Foreign Affairs and Trade has further the honor to advise the latter that diplomatic clearance has been granted to *Okeanos Explorer* to conduct marine scientific research for the dates requested (March 1-7 2017 and March 29-April 4 2017)

The Ministry of Foreign Affairs and Trade advises further that diplomatic clearance is granted provided the following conditions are met:

1. A summary of all the data resulting from the research is to be made available to the Ministry of Foreign Affairs and Trade within 6 months of the completion date of the research.
2. Any specimens, whether dead or alive that will be taken out from Samoa's Exclusive Economic Zone during the research are the properties of Samoa and governed under the Intellectual Property Rights Law, therefore appropriate approval must be sought from the Ministry of Natural Resources and Environment and the Ministry of Agriculture and Fisheries through the Ministry of Foreign Affairs and Trade.

PO Box L1859, Apia, Samoa. • Tel (685) 2117 • Fax (685) 21504 • political@mfat.gov.ws

3. At the completion of the research and before departing from Samoa, the team leader must discuss with or communicate to the Ministry of Foreign Affairs and Trade appropriate aspects of the research and explain preliminary findings.

The Ministry of Foreign Affairs and Trade avails itself of this opportunity to renew to the Embassy of the United States of America in Apia the assurances of its highest consideration.

23rd of January 2017

Embassy of the United States of America
APIA

MINISTRY OF FOREIGN AFFAIRS AND TRADE
SAMOA

APPENDIX G: Samoa MNRE Support Letter to Conduct Marine Scientific Research

Government of Samoa

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

Matāgaluega o Puna'oa Faalenatura ma le Siosiomaga

Level 3, Tui Atua Tupua Tamasese Efi Building (TATTE), Sogi, P.O Private Bag, Apia, SAMOA.
Website: http://www.mnre.gov.ws/

Telephone: (+685) 67200
Fax: (+685) 23176
Email: info@mnre.gov.ws

Please address all correspondence to the Chief Executive Officer, Private Bag, Apia, Samoa.

Faamolemole faatuatusi uma mai fesootaiga ma i le Ofisa Sili.

10 January 2017

Craig Russell
Program Manager
Okeanos Explorer Explorations
NOAA Office of Ocean Exploration and Research

Dear Mr. Craig Russell,

APPROVAL TO CONDUCT RESEARCH ONBOARD THE NOAA SHIP *OKEANOS EXPLORER* IN THE WATERS OF SAMOA

I acknowledge receipt of your letter dated on 16th December 2016, regarding the above subject matter. I am also in receipt of your Bioprospecting Application for research permit dated on the same date.

The Ministry of Natural Resources and Environment (MNRE) is fully supportive of this research of seafloor mapping operations to ensure it will provide reliable and useful information primarily in areas where high resolution seafloor bathymetry data currently does not exist and in addition, priority areas of interest to Samoa. This will provide baseline data and invaluable scientific data for Samoa oceanographers, marine researchers and managers in order to make informed decisions with regards to the sustainable use and management of our marine resources.

A Memorandum of Agreement (MOA) must be signed between MNRE and NOAA and any other relevant party to the research, to ensure effective collaboration and working relationship in relation to conducting the research and outline conditions and agreeable responsibilities; in any requirements specified in the MOA. There will be fee(s) applied as part of the requirements of our process.

That said, the Ministry is fully supportive of this scientific exploration in the waters of Samoa.

Please do not hesitate to contact Mrs. Tauti Fuatino Leota (Assistant Chief Executive Officer of the Division of Environment and Conservation) on e-mail: fuatino.leota@mnre.gov.ws or Ms. Maria Satoa on email: maria.satoa@mnre.gov.ws or telephone (685) 67200 for further information.

Sincerely,

Suluimalo Amataga Penaia
CHIEF EXECUTIVE OFFICER

Cc: Chief Executive Officer
Ministry of Foreign Affairs and Trade

Dr. Alan P. Leonardi
Director, Office of Ocean Exploration and Research
NOAA
United States Department of Commerce

Ministry of Natural Resources and Environment
Division of Environment & Conservation

For Official Use Only:

Date Application was received:
date 21 month 12 year 16
Full Payments made: Yes No

Receipt No. _____

MNRE official stamp:

CONSENT APPLICATION FOR COLLECTION OF SAMOA'S BIOLOGICAL AND NON-BIOLOGICAL RESOURCES

Samoa as a party to the Convention on Biological Diversity (CBD) has a complete sovereign right over its biological and non biological resources

1. APPLICANT: (Please type in all required information)

Name: Craig Russell	**Institution:** US NOAA, Office of Ocean Exploration and Research
Nationality: United States of America	**Country of domicile:** United States
Passport number:	**Current Address:** 7600 Sand Point Way NE Seattle, WA 98115, US
	Samoan address: Port of Apia, Samoa
Phone Number: 206-526-4803	**Permanent Address:** 7600 Sand Point Way NE Seattle, WA 98115 United States of America
Fax Number: none	**E-Mail Address:** craig.russell@noaa.gov

2. PURPOSE OF COLLECTION

2.1 What is the purpose of the collection? (Please provide supporting evidence)

Oceanographic data (depth, backscatter, ocean currents) data will be collected using acoustic devices including multibeam sonar, single beam sonar, sub-bottom profiler and Acoustic Doppler Current Profiler (ADCP)

2.2 How will the information be collected (e.g. by reference books, note taking,

All the acoustic data will be digitally collected.

2.3 What tests/laboratory analysis will be carried out on the material to be collected and what is the purpose of each test?

No tests or laboratory analysis will be carried out onboard. These data sets will be freely made available through a national archive and will aid in developing better bathymetric maps of the world oceans.

3. DETAILS OF WHAT IS TO BE COLLECTED

3.1 List and name the materials to be collected

No physical materials will be collected

3.2 List any other material to be collected (soil symbionts, etc.):

Not applicable

4. COLLECTION: Not applicable

4.1 Persons to be involved in the collection

Name	Address	Qualifications
CAPT Mark Wetzler, NOAA	NOAA Ship *Okeanos Explorer* 1897 Ranger Loop, Ford Island Bldg. 184 Honolulu, HI 96818	Commanding Officer NOAA Ship *Okeanos Explorer*
Brian Kennedy	1315 East West Highway, Silver Spring, MD 20905	Expedition coordinator
Kelley Elliott	1315 East West Highway, Silver Spring, MD 20905	Expedition coordinator
Elizabeth Lobecker	1315 East West Highway, Silver Spring, MD 20905	Expedition coordinator
Derek Sowers	1315 East West Highway, Silver Spring, MD 20905	Expedition coordinator
Michael White	1315 East West Highway, Silver Spring, MD 20905	Expedition coordinator
TBD Science Team	TBD	TBD
TBD Remotely Operated Vehicle Engineering Team	TBD	TBD
TBD Data Management Team	TBD	TBD
TBD Video Team	TBD	TBD
TBD Mapping Team	TBD	TBD
Ship's Officers and Crew	TBD	TBD

*TBD: To be decided

4.2 Proposed area(s) and dates of collection (if known)

The acoustic data will be collected while transiting through Samoan waters. Expedition dates extend from January 18 through April 21, 2017. Expedition dates and approximate locations of the track lines are summarized in the following tables.

Expedition Dates (subject to changes customary of research expeditions):

Expedition	Date	Activities
EX1701	**18 Jan 2017**	Depart Honolulu, Hawaii, USA
	10 Feb 2017	Arrive Pago Pago, American Samoa
EX1702	**16 Feb 2017**	Depart Pago Pago, American Samoa
	02 March 2017	Arrive Apia, Samoa
EX1703	**17 March 2017**	Depart Apia, Samoa
	29 March 2017	Arrive Apia, Samoa
EX1704	**04 April 2017**	Depart Apia
	21 April 2017	Arrive Pago Pago, American Samoa

Transits:

Transit through Samoan waters		
	Approximate Latitude (+N,-S)	Approximate Longitude (+E,-W)
EX1701 - Enter Samoan waters	-12.551	-170.892
EX1701 - Depart Samoan waters	-13.453	-170.819
EX1702 - Enter Samoan waters	-14.076	-171.056
EX1703 - Depart Samoan waters	-12.418	-171.391
EX1703 - Enter Samoan waters	-12.132	-171.971
EX1704 - Depart Samoan waters	-13.941	-170.985

Focused Mapping Areas:

Upolu (North Mapping area bounding box)	
Latitude	Longitude
-13.612	-171.489
-13.645	-171.451
-13.630	-171.252

-13.730	-171.208
-13.956	-171.313
-13.903	-171.376
-13.883	-171.508
-13.770	-171.560

Upolu (South Mapping area bounding box)	
Latitude	Longitude
-13.977	-171.957
-14.090	-171.380
-13.968	-171.296
-14.057	-171.217
-14.232	-171.148
-14.236	-171.306
-14.146	-171.965

4.3 Specify expected number or quantity of material to be collected (if known)

No physical material will be collected.

4.4 Describe how collection will be physically performed

No physical collection will be performed.

4.5 List the in-country entities likely to benefit from the activity and in what way.

It is in the best interest of all stakeholders to fully understand the extent of living marine resources that exist in the largely unexplored deep sea. The information and data generated by this project will enable baseline characterization of deepwater areas within Samoa, and the data collected will inform resource managers including the Ministry of Natural Resources and the Environment and the Ministry of Agriculture and Fisheries. The acquisition of high-resolution seafloor mapping data is an essential precursor to making significant biological, geological, archaeological and oceanographic discoveries. These data are both expensive and difficult to acquire - all collection costs are funded by the US Government and its domestic partners.

In addition, the vessel port calls at the port of Apia provide education and outreach opportunities. Ship tours are planned to introduce local students, teachers and officials to deep-sea exploration technologies, and share the findings of cruise activities. These are all opportunities to bring attention to the deep-water habitats and resources in Samoa.

4.6 To what degree will reliance be made on traditional knowledge?

No traditional knowledge will be used or relied on for planned activities.

4.7 Please specify whether specimens collected are listed in Appendix I, II or III of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES).

Not applicable (No specimen will be collected)

5. POTENTIAL IMPACTS

5.1 Describe the potential impacts of the activity. Include:

This is a research project of limited size or magnitude with only short-term effects on the environment and for which any cumulative effects are negligible. As expected with ocean research with limited time or presence in the marine environment, project operations do not have the potential to result in any lasting changes to the environment.

5.2 Describe the nature of any expected research and development plans

The goal of NOAA Ship *Okeanos Explorer* operations to is provide a foundation of publicly accessible data and information products to enable follow-on exploration, research and management activities. The data and information we collect is made publicly accessible as soon as possible after the cruise to enable interested students, scientists and managers to access and use the data. Anyone can use the data once available through the National Centers for Environmental Information.

A standard suite of data and information products are generated for each cruise. Standard data and products include: a cruise plan, multibeam and XBT raw and processed data (including seafloor bathymetry and backscatter, and water column backscatter data), EK60 raw data, ADCP raw data, Knudsen 3260 sub-bottom profiler raw data, mapping data report, and the cruise report.

These data and products are made publicly accessible to ANYONE through the National Centers for Environmental Information and NOAA OER's Digital Atlas within 30-90 days of cruise completion. Once these data are publicly available, we will notify key management groups and scientists interested in the data, including MNRE. Furthermore, our team develops and presents expedition summaries and key findings in various venues including by not limited to: our oceanexplorer.noaa.gov website, an annual Oceanography Supplement publication and major ocean science conferences.

6. FUNDING

6.1 How is the collection supported and by whom?

NOAA Ship *Okeanos Explorer* is a public vessel of the United States of America. Funding for *Okeanos Explorer* originates from the federal budget of the United States of America, specifically the Department of Commerce and the National Oceanic and Atmospheric Administration. NOAA has agreed to provide the ship, multibeam and other sonar systems, and their own technicians required for this cruise.

Signature of Applicant:

Date: 12/16/2016

Application Approved by:

Chief Executive Officer
MNRE

APPENDIX H: Permit from American Samoa DMWR

SCIENTIFIC PERMITS SERIES NO: 2017/001

January 19, 2017

This Constitutes the Department's official action on:
SCIENTIFIC COLLECTION PERMITS APPLICATION SERIES NO: 001
NAME OF APPLICANT: KELLY P. ELLIOTT
ADDRESS OF APPLICANT: 1315 East-West Hwy
SSMC3 RM 10262, Silver Spring MD 20910

TITLE OF PROPOSED STUDY: 2017 CAPSTONE American Samoa Expedition

ACTION: X **APPROVED**

____ **DISAPPROVED**

IF APPROVED, EFFECTIVE DURATION OF PERMIT: February 1 to April 30, 2017

IF APPROVED, SPECIFY CONDITIONS: Regular update of activities and copies of relevant request to the Department of Marine & Wildlife Resources.

REASONS FOR DISAPPROVAL: N/A

NAME OF SIGNATURE OF PERMITTING OFFICIAL: _____

Selaina Tuimavave Vaitautolu
Acting Director
Dept. Marine & Wildlife Resources

DEPARTMENT OF MARINE AND WILDLIFE RESOURCES
AMERICAN SAMOA GOVERNMENT
P.O. BOX 3730
Pago Pago, AS 96799 U.S.A.

SCIENTIFIC STUDY & COLLECTION PERMIT APPLICATION

This application must be completed prior to all scientific studies requiring the observation, collection, handling, &/or manipulation of live or dead entities of both marine and wildlife species whether in part or in whole.

NAME OF APPLICANT: Kelley P. Elliott
ADDRESS: 1315 East-West Hwy, SSMC3 RM 10262, Silver Spring, MD 20910, USA
EMAIL ADDRESS: Kelley.Elliott@noaa.gov
INSTITUTIONAL AFFILIATION: U.S. Department of Commerce, National Oceanic and Atmospheric Instution, Office of Ocean Exploration and Research
INSTITUTIONAL ADDRESS: 1315 East-West HWY, SSMC3 10th Floor, Silver Spring MD 20910

TITLE OF STUDY: 2017 CAPSTONE American Samoa Expedition

OBJECTIVES OF STUDY:
NOAA Ship *Okeanos Explorer* is the nation's first and only federal vessel with a mandate to systematically explore our mostly unknown ocean for the purpose of discovery and the advancement of knowledge. The 2017 CAPSTONE American Samoa Expedition is a part of a major multi-year foundational science effort focused on deepwater areas of U.S. marine protected areas (MPAs) in the central and western Pacific. The overarching goal of the multi-year CAPSTONE project is to extend and improve the understanding of the distribution and diversity of deepwater habitats within MPAs, and collect data and information to support priority monument and sanctuary science and management needs.

The fundamental driver of the multi-leg American Samoa Expedition is to better understand unknown and poorly known areas of our ocean which include diverse living marine resources, and unique geologic phenomena. Data and information from the cruises will build on previous work, and provide a foundation of baseline data to improve management and spur further exploration and research. NOAA priorities for the work include a combination of science, education, outreach, and open data objectives that will support management decisions at multiple levels.

- Acquire data to support priority Monument and Sanctuary science and management needs;
- Explore the diversity of benthic habitats and features (e.g. seamounts, hydrothermal vents, deep-sea coral habitats, bottom fish habitats);
- Identify and map vulnerable marine habitats – particularly high-density deep-sea coral and sponge communities;

- Investigate the geologic history of Pacific seamounts, including potential relevance to plate tectonics and subduction zone biology and geology; and
- Engage a broad spectrum of the scientific community and public in telepresence-based exploration; and
- Provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities.

Operations will use the ship's deep water mapping systems, NOAA's 6000m remotely operated vehicles (ROV), Conductivity Temperature Depth (CTD) rosette, underway CTD, and a high-bandwidth satellite connection for real-time ship to shore communications. Like previous expeditions in the Gulf of Mexico, western Atlantic, Hawai'i and Indonesia, NOAA will work with the scientific community and public to characterize unknown and poorly-known areas through telepresence-based exploration. Data and information from the Expedition will be made publicly available to provide a foundation of publicly-accessible baseline information to improve management and spur further exploration and research.

We propose to conduct activities within the American Samoa Exclusive Economic Zone, including within the Rose Atoll Marine National Monument, the National Marine Sanctuary of American Samoa and within territorial waters to explore and improve understanding of the distribution and diversity of deep water habitats. The activity would occur during five cruises from February 1 to April 30, 2017. Operations will be focused in 250 meters and deeper. No activities would occur on land.

DESCRIPTION OF SPECIMEN(S) TO BE COLLECTED, IF ANY:
During ROV operations, only very selective specimens that have the potential to contribute significant scientific discoveries will be collected. On average only 4-6 total biological and geological specimens will be collected per dive. Biologic samples will focus on potential new species or new records for the region, and the dominant morphotype animal (such as a coral or sponge) in a habitat. When possible, only a sub-sample will be taken of biologic specimens (e.g., only a piece or branch of corals and sponges will be collected, not the entire organism). Selective rock specimens, that have the potential to contribute significant scientific discoveries, as outlined in the expedition goals, will also be targeted. These are expected to include rocks from seamounts and manganese-coated rocks. When possible, rock samples will be selected in a way to minimize disturbance to the surrounding environment and to minimize the take of attached organisms. All samples will be preserved onboard and made freely and publicly accessible to the science community through National Repositories.

Water samples may also be collected using our CTD rosette instrument. The CTD instrument package is used to obtain conductivity, temperature, depth and other oceanographic data (dissolved oxygen, light scattering, oxygen reduction potential). At least one, and potentially several, CTD casts are planned for this cruise. CTD casts would be conducted at selected sites including locations where ROV dives are conducted to allow for an improved understanding of the environmental conditions by measuring the physical or chemical properties of the water column overlying or hosting a particular habitat. No water samples have been requested at this time, however if they are requested and collected they would likely be frozen for later analysis. The results from any analysis would be made publicly available.

DESCRIBE COLLECTION METHODS TO BE USED:

ROV Operations, biological and geological specimens

The purpose of conducting ROV operations is to conduct interdisciplinary site characterization at priority targets in American Samoa. Interdisciplinary site characterization would be achieved by visually surveying priority targets while simultaneously acquiring environmental data with in situ sensors mounted on the ROVs (conductivity, temperature and depth; dissolved oxygen; light scattering; and oxygen reduction potential). ROV targets include seamounts, hydrothermal vents, deep-sea coral and sponge communities and bottom fish habitats. The combined dives will enable scientists and managers to have a better understanding of the diversity and distribution of deep water habitats in American Samoa including the Rose Atoll Marine National Monument and National Marine Sanctuary of American Samoa, and should contribute to enhanced protection of these resources.

The *Okeanos Explorer* is equipped with a dedicated, fully integrated, two-body ROV system. ROV operations are conducted primarily during daylight hours while the vessel is stopped and holding station using dynamic positioning. ROV operations will typically take place within several meters of the seafloor, and are conducted in a way to minimize seafloor disturbances. On occasion, the ROV is set down on the seafloor in order to acquire very close imagery of habitats or features of interest or to collect samples. The ROV also has a temperature probe that may be shallowly inserted into the seafloor sediment to measure the depth or temperature of features of interest.

During these dives, limited sampling operations are planned with the ROV to collect very selective specimens that have the potential to contribute significant scientific discoveries. These specimens would be collected using the ROV's manipulator arms or scoop. Biological specimen collections will focus on potential new species or new records for the region, and the dominant morphotype animal (such as a coral or sponge) in a habitat. When possible, only a sub-sample will be taken of biological specimens (e.g., only a piece or branch of corals and sponges will be collected, not the entire organism). Selective rock specimens, that have the potential to contribute significant scientific discoveries, as outlined in the expedition goals, will also be targeted. These are expected to include rocks from seamounts and manganese-coated rocks. When possible, rock samples will be selected in a way to minimize disturbance to the surrounding environment and to minimize the take of attached organisms. On average only 4-6 total biological and geological specimens will be collected per dive.

CTD Rosette: water samples and sensor data

Water samples may also be collected using our CTD rosette instrument. The CTD instrument package is used to obtain conductivity, temperature, depth and other oceanographic data (dissolved oxygen, light scattering, oxygen reduction potential). The instrument is attached to an open cylindrical steel frame approximately 1.15 m in diameter and 1.4 m high with a 24-position rosette carousel containing 24 2.5 L Niskin bottles for collecting water samples. The system would be lowered to a maximum depth of 6800 m by an embedded scientific winch and wire while the vessel would be stopped and hold station using dynamic positioning. The average time to conduct a CTD casts varies from one to several hours depending on water depth (the CTD is

lowered through the water column at 60m/min). CTD casts would be conducted at selected sites including locations where ROV dives are conducted to allow for an improved understanding of the environmental conditions by measuring the physical or chemical properties of the water column overlying or hosting a particular habitat. No water samples have been requested at this time, however if they are collected they would likely be frozen for later analysis. The results from any analysis would be made publicly available.

Mapping Operations: **acoustic data**
The ship will conduct sonar mapping operations at all times during non-ROV or non-CTD rosette operations throughout the cruise. NOAA Ship *Okeanos Explorer* has a suite of scientific sonars, each with a unique exploration application. All of these systems are routinely used by the ocean science community and have provided invaluable scientific data for oceanographers, marine researchers and managers. Each sonar's acoustic signal is designed to be narrowly focused to provide precise information about a specific, narrowly defined area of the seafloor or water column beneath the ship. The sonars include a Kongsberg EM302 30 kHz multibeam system; 18 kHz, 38 kHz, 70 kHz, 120 kHz, 200 kHz and 333 kHz Kongsberg EK60 split-beam fisheries sonars (the 333 kHz and 38 kHz will not be operational since we don't currently have the hardware general purpose transceiver to run it, but is included just in case); a Knudsen 3.5 kHz chirp sub-bottom profiler sonar; and 300 kHz and 38 kHz Teledyne Acoustic Doppler Current Profilers (ADCPs). The multibeam maps broad swaths for seafloor bathymetry/backscatter and water column feature detection (e.g. gaseous seeps), the split-beam sonars gather calibrated target strength measurements of biologic and gaseous targets in the water column, the sub-bottom profiler provides data useful for interpreting sub-seafloor geology, and the ADCPs provide information about current velocity and direction at various depths through a water column profile. Additionally, expendable bathythermographs (XBTs) and the ship's UnderwayCTD (UCTD) will be deployed at regular intervals in association with multibeam data collection. All of these systems are routinely used by this exploration vessel.

DURATION OF STUDY OR COLLECTION PERIOD:
The activity would occur during five cruises from February 1 to April 30, 2017. The requested dates cover a conservative estimate of the timing that NOAA Ship *Okeanos Explorer* will arrive in American Samoa and can commence work in the region, through a few days after the last cruise departs and is likely to conduct work in American Samoa. During the cruises, 15 deployments of the ROV are planned in American Samoan waters, resulting in 120 hours total dive time (~8 hours for each dive). The Expedition cruise legs, dates and focus areas are below:

EX-17-01 (January 18 – February 10, 2017): 24-day mapping cruise from Honolulu, HI to Pago Pago, American Samoa with focused mapping work in: Kingman/Palmyra and Jarvis units of the Pacific Remote Islands Marine National Monument (PRIMNM); the Phoenix Islands Protected Area (PIPA) part of Kiribati; Tokelau and Swains Island Unit of the National Marine Sanctuary of American Samoa (NMSAS).

EX-17-02 (February 16 – March 2, 2017. Pago Pago, American Samoa - Apia, Samoa): 14-day cruise with daytime remotely operated vehicle (ROV) dives and overnight CTD rosette and mapping operations focused on American Samoan waters.

EX-17-03 (March 7 - 29, 2017. Apia, Samoa - Apia, Samoa): A 23-day cruise with daytime remotely operated vehicle dives and overnight CTD rosette and mapping operations focused on PIPA and the Howland/Baker Unit of the PRIMNM. One dive is planned in the Swains Island unit of the National Marine Sanctuary of American Samoa at either the start or end of the cruise.

EX-17-04 (April 4 – April 21, 2017. Apia, Samoa - Pago Pago, American Samoa): An 18-day mapping cruise focused on American Samoa including unmapped or poorly mapped areas of the Rose Atoll Marine National Monument and National Marine Sanctuary of American Samoa deeper than ~250m.

EX-17-05 (April 27 – May 19, 2017. Pago Pago, AS to Honolulu, HI): A 23-day cruise with daytime remotely operated vehicle (ROV) dives and overnight CTD rosette and mapping operations focused on the Cook Islands and the Jarvis and Kingman/Palmyra Units of the PRIMNM. One dive is planned in or just outside of the Aunu'u Unit of the National Marine Sanctuary of American Samoa at the start of the cruise.

SPECIFIC LOCATION(S) OF STUDY &/or COLLECTING/SAMPLING AREA(S): Mapping, ROV and CTD rosette operations will focus in depths generally between 250 and 6,500 meters, with some mapping planned. CTD rosette operations have been requested in waters south of Tutuila and at Vailulu'u seamount. No activities would occur on land.



Figure 1: Overview map showing the general locations of ROV dives in American Samoa. The red dots are the draft locations of ROV dive sites, and where samples would be collected. The yellow boxes are priority areas for focused mapping surveys. Focused overnight mapping operations will be planned during the cruise based on available time. The light blue polygons are the boundaries of the Rose Atoll Marine National Monument and National Marine Sanctuary of

American Samoa. The green labelled dots are the port locations of Pago Pago, American Samoa and Apia, Samoa. The white line is the publicly available Exclusive Economic Zone of American Samoa and Samoa.

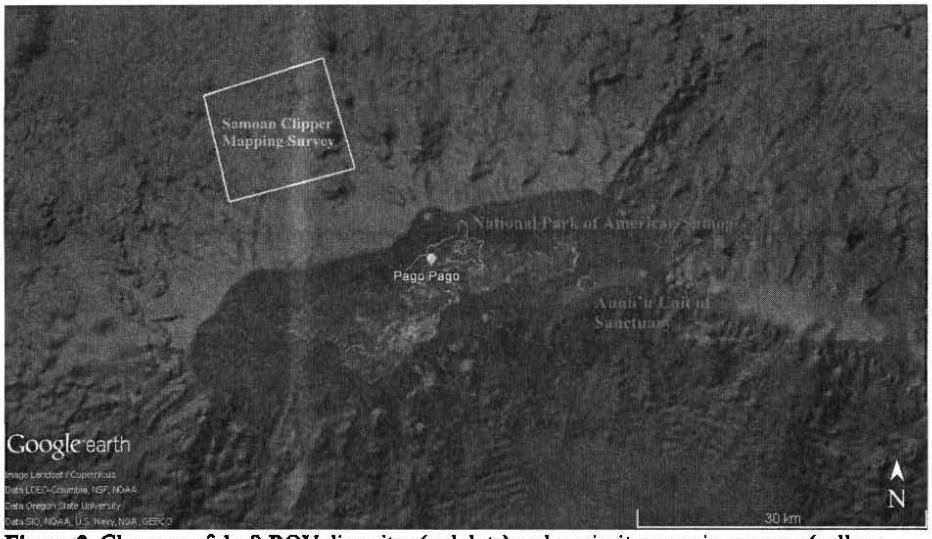


Figure 2. Close-up of draft ROV dive sites (red dots) and a priority mapping survey (yellow polygon) near Tutuila Island. The green polygon is the boundaries of the National Park of American Samoa (which extends to 100m offshore), and the light blue polygon is the Aunu'u unit of the National Marine Sanctuary of American Samoa. The requested sonar mapping survey is to support efforts to find a lost plane and maritime archaeology procedures will be employed during the survey to protect location information.

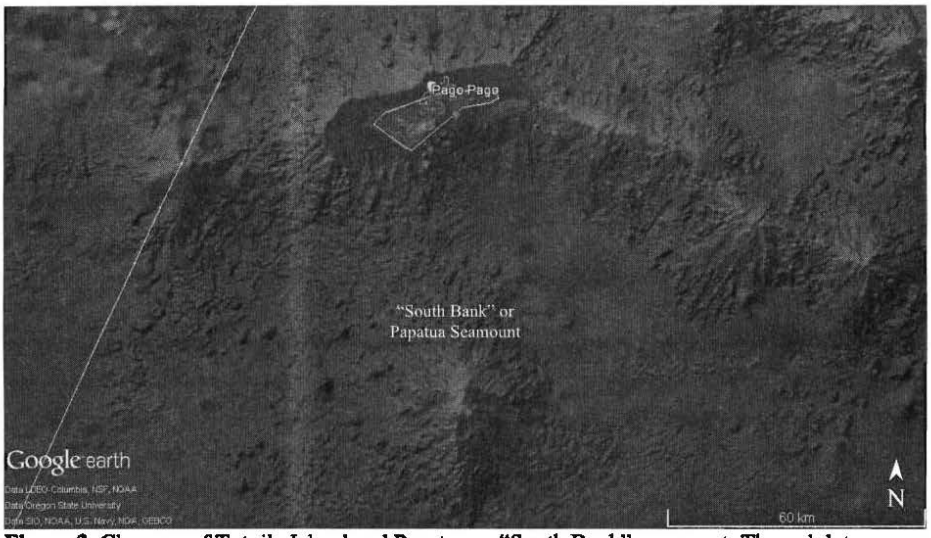


Figure 3. Close up of Tutuila Island and Papatua or "South Bank" seamount. The red dots are the locations of draft ROV dive sites.

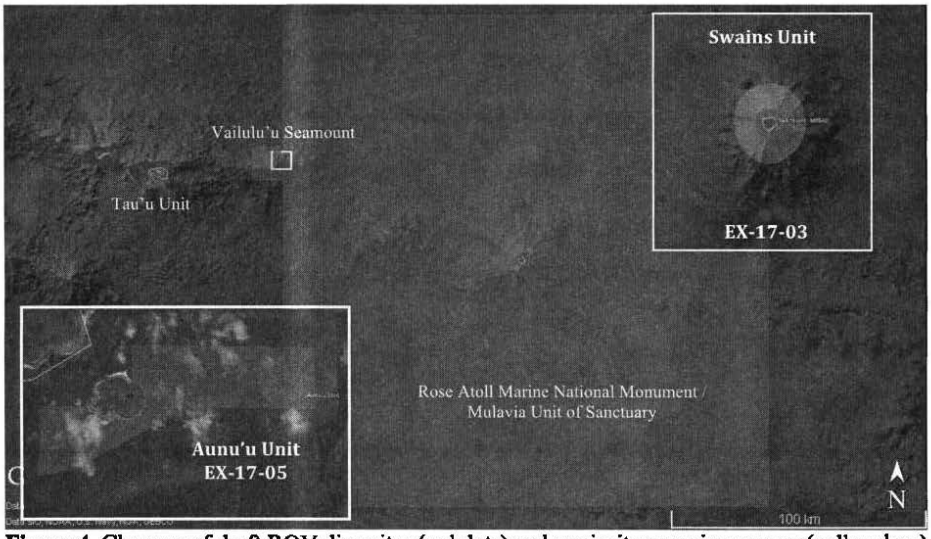


Figure 4. Close up of draft ROV dive sites (red dots) and a priority mapping survey (yellow box) within the National Marine Sanctuary of American Samoa and Rose Atoll Marine National Monument (the light blue boxes).

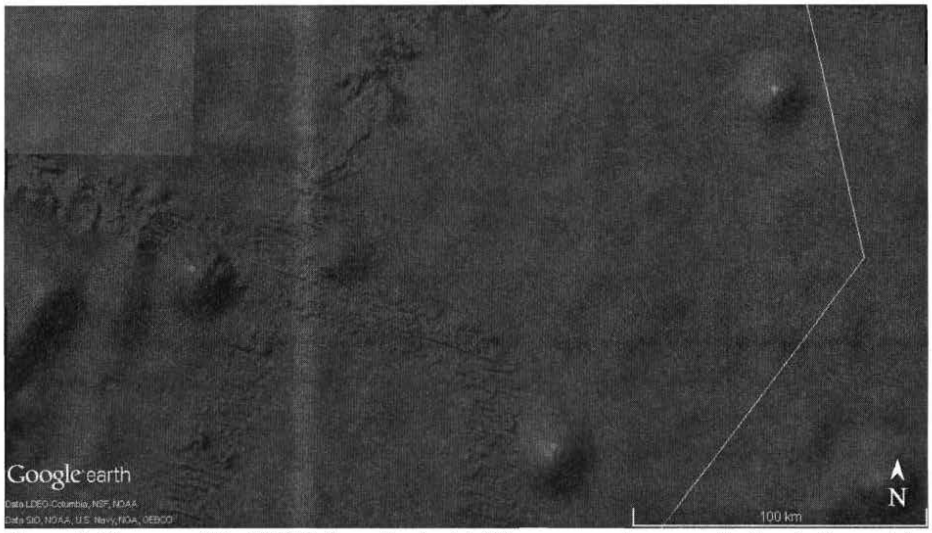


Figure 5. Close up of draft ROV dive sites (red dots) on unnamed seamounts close to the eastern edge of the American Samoa EEZ (white line). The light blue polygon is the southeast corner of Rose Atoll Marine National Monument. Mapping operations will need to be conducted overtop of the seamounts the night/morning prior to the dive to finalize the dive track.

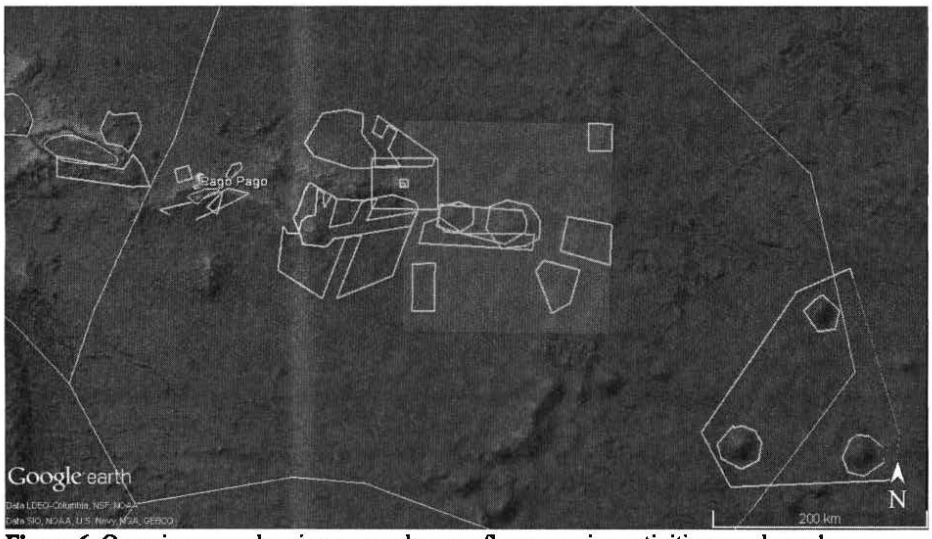


Figure 6. Overview map showing areas where seafloor mapping activities are planned – especially during EX-17-02 and EX-17-04 cruises. The orange polygons are mapping survey

areas requested by the science and management community. Mapping operations will focus on areas 250 meters and deeper.

IF HANDLING &/OR MANIPULATION OF LIVE ANIMALS, DESCRIBE PROTOCOL(S):

ROV Operations:
Once a sample is brought onboard, it will be photographed, documented, and information entered into a sample database. Rocks will be dried and photographed. Aliquots of coral and sponge specimens will be preserved for taxonomic analysis (ethanol), genetic analysis (CHAOS or other buffer), and in some cases, histological examination (10% buffered formalin). All other animals will be preserved in either formalin or ethanol, depending on which preservative is more desirable for the particular taxa.

An additional small tissue sample will be taken of all biological specimens when doing so will not be overly destructive to the specimen. This tissue sample will be preserved onboard for later genomic DNA and RNA extraction at the Ocean Genome Legacy Center (OGL) in Northeastern University.

All samples will remain on the ship until it returns to Honolulu, HI in summer 2017. The samples will then be taken to OER Science Advisor, Dr. Chris Kelley's lab at the University of Hawaii at Manoa for temporary storage. There they will be prepared and transferred to a repository (with preliminary identification provided along with photographs and a deed of gift).

IF SAMPLES COLLECTED WILL BE SUBJECTED TO FURTHER PROCESSING (e.g., genetic analysis or other biochemical analysis, museum prep), DESCRIBE HOW AND WHERE:

All biological and geological samples will be provided to a public repository to be described and made publicly accessible to the scientific research community. Scientists can then request access to the samples to conduct additional analysis, however this is outside the scope of our project.

FINAL DISPOSITION OF SAMPLES OR ANIMALS:
Selected coral and sponge specimens will be split, with one piece going to Bishop Museum in Hawaii, and the other to the Smithsonian to ensure access to as many researchers as possible. If it is determined that splitting will be too destructive to a particular specimen, it will be provided to the Smithsonian Institution intact in order to provide public access to as many researchers as possible. Crustaceans and any other organisms found on the corals and sponges will be provided to the Smithsonian. All other animals will be provided to the Smithsonian.

Tissue samples will be provided to the Ocean Genome Legacy Center (OGL) at Northeastern University. The results of genomic analysis are made publicly available through OGLs website.

All geological samples will be sent to the Oregon State University's Marine Geology Repository to be made publicly accessible. OSU will receive the samples, curate them, describe them from a

petrology point of view (e.g. mineral content, texture, alteration, rock name), microphotograph them and prepare them for future redistribution.

No water samples have been requested at this time, however if they are collected they would likely be frozen for later analysis. The results from any analysis would be made publicly available through the NOAA's National Centers for Environmental Information.

JUSTIFICATION FOR REQUEST TO COLLECT, SAMPLE, HANDLE, &/OR MANIPULATE ANIMALS OF PARTS THEREOF:
The acquisition of high-resolution seafloor mapping data is an essential precursor to making significant biological, geological, archaeological and oceanographic discoveries. The *Okeanos Explorer* cruises will collect seafloor mapping data in areas previously unmapped with sonar or modern sonar, and to supplement previous work. These maps form the basis for selecting ROV dive targets.

ROV dives take the next major step in baseline habitat characterization by using the ROV system to visually investigate unknown and little known deep water habitats within American Samoa identified as priority scientists and managers. CTD casts may be conducted to collect additional information about the physical and chemical properties of the water column, including at sites of interest identified from mapping and ROV investigation.

These dives will be the next step in a baseline habitat characterization, and directly contribute to a better understanding of the deep water habitats, ecosystems and geology of American Samoa. The dives will enable scientists and managers to have a better understanding of the diversity and distribution of deepwater habitats. It is this understanding that enables effective management decisions, and provides continuous support for the monuments, sanctuaries and their protection of these resources. The collective understanding established from the multi-year CAPSTONE expeditions will increase understanding of deep-sea biogeographic patterns across the Central and Western Pacific.

PROJECTED STARTING DATE OF STUDY:
The starting date of the first cruise is January 18th, however the ship will not arrive in American Samoan waters until early February. I have listed project dates of February 1 (the start date) to April 30, 2017. The requested dates cover a conservative estimate of the timing that NOAA Ship *Okeanos Explorer* will arrive in American Samoa and can commence work in the region, through a few days after the last cruise departs and is likely to conduct work in American Samoa. The Expedition cruise legs, dates and focus areas are detailed in the "Duration of Study or Collection Period" section above.

NAME OF LOCAL COLLABORATOR(S) &/OR LOCAL INSTITUTIONAL AFFILIATION,
Local managers have identified many of the priority sites for acoustic mapping and remotely operated vehicle dives in American Samoan waters. The names and affiliations of key partners are included below:

Genevieve (Gene) Brighouse*

National Marine Sanctuary of American Samoa, Superintendent
We have met with the entire Sanctuary team and will be collaborating with them closely, especially on outreach activities.

Fatima Sauafea-Le'au
NOAA Fisheries - PIRO
Habitat Conservation Division
American Samoa Field Office

Brian Peck
Rose Atoll Marine National Monument, Superintendent
Rose Atoll National Wildlife Refuge, Manager
US Fish and Wildlife Service

Dr. Tim Clark
Marine Ecologist
National Park of American Samoa

We also met with representatives from other American Samoa agencies in November 2016 to share our draft project plans and request additional input and feedback. This included Dr. Ruth Matagi-Tofiga, Director of the Department of Marine and Wildlife Resources. Other agencies and officials included the Office of Samoan Affairs, the American Samoa Governor's Coral Reef Advisory Group, American Samoa Environmental Protection Agency, and the American Samoa Power Authority.

OTHER COLLABORATING SCIENTISTS:
Dr. Chris Kelley, CAPSTONE Science Advisory, University of Hawaii at Manoa
Dr. Santiago Herrera, Biology Science Team Lead, Lehigh University
Dr. Matthew Jackson, Geology Science Team Lead, University of California Santa Barbara
Elizabeth Lobecker, Physical Scientist/Mapping Lead, NOAA Office of Ocean Exploration and Research

SIGNATURE OF APPLICANT: [signature]

DATE: Jan. 3, 2017

MAIL or RETURN THIS FORM TO THE ADDRESS ON THE TOP OF THE FRONT PAGE.

FOR OFFICE USE ONLY

APPLICATION SERIES No. _____

DATE APPLICATION RECEIVED: _____

RECEIVED BY: _____

APPLICATION FEE Receipt No. & Amount: _____

REVIEWER'S COMMENTS:

This is an important research initiative to explore and understand the deep-water habitats of American Samoa. These are habitats that are generally out of reach but the technologies borned by this expedition will map and sample environments and living things in the deep.

RECOMMENDED ACTION: Approve



NAME AND SIGNATURE OF REVIEWER: Dr. Domingo Ochavillo

DATE: 9 January 2017

APPENDIX I: NMSAS Permit

Permit NMSAS 2017-001 to conduct work the National Marine Sanctuary of American Samoa.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

National Marine Sanctuary of American Samoa
P.O. Box 4318
Pago Pago, AS 96799

January 19, 2017

MEMORANDUM FOR: THE RECORD

FROM: Gene Brighouse
National Marine Sanctuary of American Samoa

SUBJECT: Decision Memo for Permit # NMSAS-2017-001

The National Oceanic and Atmospheric Administration's National Marine Sanctuary Program (NMSP) has decided to issue permit number NMSAS-2017-001 to Kelley Elliott for the project entitled: 2017 American Samoa Expedition. This memorandum documents the rationale for this decision and compliance with all required consultations generated by this action.

BACKGROUND

Project Summary:
NOAA Ship Okeanos Explorer is the nation's first and only federal vessel with a mandate to systematically explore our mostly unknown ocean for the purpose of discovery and the advancement of knowledge. Operating under a partnership with NOAA's Office of Ocean Exploration and Research and the Office of Marine and Aviation Operations, the 2017 CAPSTONE American Samoa Expedition is a part of a major multi-year foundational science effort focused on deepwater areas of U.S. marine protected areas (MPAs) in the central and western Pacific. The overarching goal of the CAPSTONE project is to extend and improve the understanding of the distribution and diversity of deepwater habitats within MPAs, and collect data and information to support priority monument and sanctuary science and management needs.

Data and information from the Expeditions will provide a foundation of publicly-accessible baseline information to improve management and spur further exploration and research. Like previous expeditions in the Gulf of Mexico, western Atlantic, Hawai'i and Indonesia, NOAA will work with the scientific community and public to characterize unknown and poorly-known areas through telepresence-based exploration. Operations will use the ship's deep water mapping systems, NOAA's 6000m remotely operated vehicles (ROV), underway CTD, CTD rosette, and a high-bandwidth satellite connection for real-time ship to shore communications.

We propose to conduct activities in and around the National Marine Sanctuary of American Samoa to explore and improve understanding of the distribution and diversity of deep water habitats. The activity would occur during five cruises from February 1 to April 30, 2017. Operations will be focused in 250 m and deeper. No activities would occur on land.

Direct impacts:
A standard suite of operations are conducted on Okeanos Explorer and have been 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. Full details of the potential short-term impacts are described in the attached Categorical Exclusion.

Indirect impacts:
No indirect impacts on sanctuary resources will result from this activity.

Cumulative impacts:
A standard suite of operations are conducted on Okeanos Explorer and have been 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. Full details of the potential short-term impacts are described in the attached Categorical Exclusion.

Site-specific impacts and review criteria:
Activity shall be conducted with adequate safeguards for the environment. Environment shall be returned to, or will regenerate to, the condition which existed before the activity occurred.

NATIONAL ENVIRONMENTAL POLICY ACT

Categorical Exclusion:
After reviewing NOAA Administrative Order (NAO) 216-6, including the criteria used to determine significance, the NMSP has concluded that the issuance of this permit would not have a significant effect, individually or cumulatively, on the human environment. Further, we have determined that the proposed action is categorically excluded from the requirement to prepare an environmental assessment or environmental impact statement in accordance with Section 6.03c.3(a) Research Program of NAO 216-6, specifically:

The proposed research activity is of limited size and magnitude and, based on analysis of past projects in the permitted activity area, has been found to have negligible cumulative effects. I certify that this action is not likely to result in significant impacts as defined at 40 CFR 1508.27 and is not an exception to this CE category as defined by section 5.05c of NAO 216-6.

Based on this, the NMSP has concluded that an environmental assessment is not warranted for the issuance of this permit.

MAGNUSON-STEVENS ACT / ESSENTIAL FISH HABITAT

Section 305(b) (2) of the Magnuson-Stevens Fishery Conservation and Management Act requires any federal action agency to complete an Essential Fish Habitat consultation for any action authorized by the agency that may adversely affect EFH. The issuance of this permit will

adversely impact designated EFH within National Marine Sanctuary of American Samoa. Therefore, consultation with NMFS Pacific Islands Regional Office was conducted on November 30, 2016. Recommendations to minimize or mitigate for impacts to EFH have been taken into consideration and incorporated into the final action.

MARINE MAMMAL PROTECTION ACT

The issuance of this permit is not likely to result in the take of any marine mammal protected under the Marine Mammal Protection Act. Therefore, a separate permit to take a marine mammal is not required.

COASTAL ZONE MANAGEMENT ACT

The NMSP has determined that the proposed activity is not reasonably likely to affect any land or water use or natural resource of the coastal zone of American Samoa. In addition, national marine sanctuary permits and authorizations are not listed under the American Samoa Coastal Zone Management Program (CZMP) as activities that generally require a consistency determination. Furthermore, American Samoa CMP has not contacted the NOAA Office of Ocean and Coastal Resource Management with a request to review this permit. Therefore, a federal consistency determination is not required for this action.

ENDANGERED SPECIES ACT

The NMSP has determined that the proposed activity is not likely to adversely affect ESA-listed marine species. Consultation with the National Marine Fisheries Service Pacific Islands Regional Office as required by Section 7 of the Endangered Species Act was conducted on January 14, 2016. Recommendations generated through consultation have been taken into consideration and incorporated into the final action.

NATIONAL HISTORIC PRESERVATION ACT

Section 106 of the National Historic Preservation Act requires federal agencies to consider the impact of their actions on historic properties. The NMSP has determined that the proposed activity is not likely to affect any historic properties. No consultations with the Advisory Council on Historic Preservation, State Historic Preservation Officer, or Tribal Historic Preservation Officer were conducted.

OTHER CONSULTATIONS

No other consultations were required or considered for this action.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

National Marine Sanctuary of American Samoa
P.O. Box 4318
Pago Pago, AS 96799

January 19, 2017

Ms. Kelley Elliott
NOAA Office of Ocean Exploration and Research (OER
1315 East-West Hwy
SSMC3 Room 10262
Silver Spring, MD 20910

Dear Ms. Elliott:

The National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries (ONMS) has approved the issuance of permit number NMSAS-2017-001 to conduct activities within National Marine Sanctuary of American Samoa (sanctuary) for research purposes. Activities are to be conducted in accordance with the permit application and all supporting materials submitted to the sanctuary, and the terms and conditions of permit number NMSAS-2017-001 (enclosed).

This permit is not valid until signed and returned to the ONMS. Retain one signed copy and carry it with you while conducting the permitted activities. Additional copies must be signed and returned, by either mail or email, to the following individuals within 30 days of issuance and before commencing any activity authorized by this permit:

Gene Brighouse
Superintendent
National Marine Sanctuary of American Samoa
P.O. Box 4318
Pago Pago, AS 96799
Gene.Brighouse@noaa.gov

National Permit Coordinator
NOAA Office of National Marine Sanctuaries
1305 East-West Highway (N/ORM6)
SSMC4, 11th Floor
Silver Spring, MD 20910
nmspermits@noaa.gov

Your permit contains specific terms, conditions and reporting requirements. Review them closely and fully comply with them while undertaking permitted activities.

If you have any questions, please contact Gene Brighouse at 011-684-633-6500. Thank you for your continued cooperation with the ONMS.

Sincerely,

Gene Brighouse
Superintendent

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

National Marine Sanctuary of American Samoa
P.O. Box 4318
Pago Pago, AS 96799

NATIONAL MARINE SANCTUARY of AMERICAN SAMOA
RESEARCH PERMIT

Permittee:
Ms. Kelley Elliott
NOAA Office of Ocean Exploration and Research (OER
1315 East-West Hwy
SSMC3 Room 10262
Silver Spring, MD 20910

Permit Number: NMSAS-2017-001
Effective Date: February 1, 2017
Expiration Date: April 30, 2017

Project Title: 2017 American Samoa Expedition

This permit is issued for activities in accordance with the National Marine Sanctuaries Act (NMSA), 16 USC §1431 *et seq.*, and regulations thereunder (15 CFR Part 922). All activities must be conducted in accordance with those regulations and law. No activity prohibited in 15 CFR Part 922 is allowed except as specified in the activity description below.

Subject to the terms and conditions of this permit, the National Oceanic and Atmospheric Administration (NOAA), Office of National Marine Sanctuaries (ONMS) hereby authorizes the permittee listed above to conduct research activities within National Marine Sanctuary of American Samoa (NMSAS or sanctuary). All activities are to be conducted in accordance with this permit and the permit application received January 03, 2017. The permit application is incorporated into this permit and made a part hereof; provided, however, that if there are any conflicts between the permit application and the terms and conditions of this permit, the terms and conditions of this permit shall be controlling.

Permitted Activity Description:
The following activities are authorized by this permit:

Permitted research activities utilizing methods as described in the research application include: Damaging, destroying or possessing any invertebrate, coral, bottom formation or marine plant; Alteration of seabed; collection of bottom-dwelling species throughout the sanctuary.

Specimens to be collected are very unlikely to already reside in a repository as the dives and collections are discovery-based. Only very selective specimens that have the potential to contribute significant scientific discoveries will be collected during ROV operations. Biologic samples will focus on potential new species or new records for the region, and the dominant morphotype animal (such as a coral or sponge) in a habitat. Selective rock specimens, that have the potential to contribute significant scientific discoveries, as outlined in the expedition goals, will also be targeted. These are expected to include rocks from seamounts and manganese-coated rocks.

When possible, only a sub-sample will be taken of biologic specimens (e.g., only a piece or branch of corals and sponges will be collected, not the entire organism). When possible, rock samples will be selected in a way to minimize disturbance to the surrounding environment and to minimize the take of attached organisms. All samples will be preserved onboard and made freely and publicly accessible to the science community through National Repositories.

No further violation of sanctuary regulations is allowed.

Permitted Activity Location:
The permitted activity is allowed only in the following location(s):

Throughout the sanctuary.

Special Terms and Conditions:

The permittee may not anchor within the Sanctuary boundaries.

The permittee may not permanently mark any of the reefs.

The permittee shall submit an annual report of all activities conducted under this permit to the NMSAS Permit Coordinator no later than one year from completion of field activities. The report should include a synopsis of research results to date, as well as information regarding daily activities such as location (latitude and longitude) and depth of surveys, discovery or disturbance of historical artifacts, or equipment lost. Appropriate photographs that may be used by NOAA are appreciated, and will be credited to the photographer.

Any scientific publications and/or reports resulting from activities conducted under the authority of this permit must include the notation that the activity was conducted under permit number NMSAS-2017-001. Additionally, the permittee and his/her respective institution(s) are required to acknowledge during any media coverage (press releases, video/photo, or other means) that the research activities occurred within the NMSAS and under permit.

NOAA reserves the right to place an observer aboard the ship engaged in operations conducted under this permit. The NOAA observer(s) may document the permittee's activities for the purpose of determining whether the permitted activities are conducted in accordance with the terms and conditions of this permit and the applicable statute and regulations. The NOAA observer(s) may also provide limited advice and technical assistance, if requested by the permittee. The NOAA observer(s) will not be present for the purpose of safety of permittees, nor for the purpose of approval of activities not specifically authorized by this permit.

General Terms and Conditions:

1. Within 30 (thirty) days of the date of issuance, the permittee must sign and date this permit for it to be considered valid. Once signed, the permittee must send copies, via mail or email, to the following individuals:

Gene Brighouse Superintendent National Marine Sanctuary of American Samoa P.O. Box 4318 Pago Pago, AS 96799 Gene.Brighouse@noaa.gov	National Permit Coordinator NOAA Office of National Marine Sanctuaries 1305 East-West Highway (N/ORM6) SSMC4, 11th Floor Silver Spring, MD 20910 nmspermits@noaa.gov

2. It is a violation of this permit to conduct any activity authorized by this permit prior to the ONMS having received a copy signed by the permittee.

3. This permit may only be amended by the ONMS. The permittee may not change or amend any part of this permit at any time. The terms of the permit must be accepted in full, without revision; otherwise, the permittee must return the permit to the sanctuary office unsigned with a written explanation for its rejection. Amendments to this permit must be requested in the same manner the original request was made.

4. All persons participating in the permitted activity must be under the supervision of the permittee, and the permittee is responsible for any violation of this permit, the NMSA, and sanctuary regulations for activities conducted under, or in junction with, this permit. The permittee must assure that all persons performing activities under this permit are fully aware of the conditions herein.

5. This permit is non-transferable and must be carried by the permittee at all times while engaging in any activity authorized by this permit.

6. This permit may be suspended, revoked, or modified for violation of the terms and conditions of this permit, the regulations at 15 CFR Part 922, the NMSA, or for other good cause. Such action will be communicated in writing to the applicant or permittee, and will set forth the reason(s) for the action taken.

7. This permit may be suspended, revoked or modified if requirements from previous ONMS permits or authorizations issued to the permittee are not fulfilled by their due date.

8. Permit applications for any future activities in the sanctuary or any other sanctuary in the system by the permittee might not be considered until all requirements from this permit are fulfilled.

9. This permit does not authorize the conduct of any activity prohibited by 15 CFR § 922, other than those specifically described in the "Permitted Activity Description" section of this permit. If the permittee or any person acting under the permittee's supervision

conducts, or causes to be conducted, any activity in the sanctuary not in accordance with the terms and conditions set forth in this permit, or who otherwise violates such terms and conditions, the permittee may be subject to civil penalties, forfeiture, costs, and all other remedies under the NMSA and its implementing regulations at 15 CFR Part 922.

10. Any publications and/or reports resulting from activities conducted under the authority of this permit must include the notation that the activity was conducted under National Marine Sanctuary Permit NMSAS-2017-001 and be sent to the ONMS officials listed in general condition number 1.

11. This permit does not relieve the permittee of responsibility to comply with all other federal, state and local laws and regulations, and this permit is not valid until all other necessary permits, authorizations, and approvals are obtained. Particularly, this permit does not allow disturbance of marine mammals or seabirds protected under provisions of the Endangered Species Act, Marine Mammal Protection Act, or Migratory Bird Treaty Act. Authorization for incidental or direct harassment of species protected by these acts must be secured from the U.S. Fish and Wildlife Service and/or NOAA Fisheries, depending upon the species affected.

12. The permittee shall indemnify and hold harmless the Office of National Marine Sanctuaries, NOAA, the Department of Commerce and the United States for and against any claims arising from the conduct of any permitted activities.

13. Any question of interpretation of any term or condition of this permit will be resolved by NOAA.

Your signature below, as permittee, indicates that you accept and agree to comply with all terms and conditions of this permit. This permit becomes valid when you, the permittee, countersign and date below. Please note that the expiration date on this permit is already set and will not be extended by a delay in your signing.

Kelley R. Elliott 1-26-17

Ms. Kelley Elliott Date
NOAA Office of Ocean Exploration and Research (OER

1-19-17

Gene Brighouse Date
Superintendent
National Marine Sanctuary of American Samoa

0 document(s) attached.

APPENDIX J: NEPA Categorical Exclusion Letter

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
OCEANIC AND ATMOSPHERIC RESEARCH
Office of Ocean Exploration and Research
Silver Spring, MD 20910

January 3, 2017

MEMORANDUM FOR: The Record

FROM: Craig Russell, Program Manager, *Okeanos Explorer* Expeditions
Office of Ocean Exploration & Research (OER)

SUBJECT: NEPA Categorical Exclusion for NOAA Ship *Okeanos Explorer*
Cruise EX-17-02, Vicinity of American Samoa (ROV & Mapping)

This memorandum documents the applicability of a Categorical Exclusion under the National Environmental Policy Act to the NOAA Ship *Okeanos Explorer* Cruise EX-17-02 activities that NOAA's Office of Ocean Exploration & Research (OER) is undertaking for 14 days in American Samoa and Samoa. NAO 216-6, Environmental Review Procedures, requires all proposed projects to be reviewed with respect to environmental consequences on the human environment. The proposed action is to collect data using the sonar mapping systems, two-body remotely operated vehicle (ROV) and CTD rosette system on the NOAA vessel *Okeanos Explorer*.

Description of the Project

This Categorical Exclusion addresses NOAA Ship *Okeanos Explorer* cruise EX-17-02 "Vicinity of American Samoa (ROV & Mapping)" led by Kelley Elliott, Expedition Manager for NOAA OER. This expedition serves as an opportunity for NOAA and the Nation to highlight the uniqueness and importance of the Pacific Monuments and Sanctuaries, which are national symbols of ocean conservation. Operations conducted during this expedition and the broader 3-year CAPSTONE campaign support NOAA missions to understand and predict changes in climate, weather, oceans and coasts, and share the knowledge and information with others. Much of this year's work will contribute to and complement NOAA's Deep Sea Coral Research and Technology Program's three-year Pacific Islands Regional Initiative.

This project is part of the NOAA Office of Ocean Exploration and Research's "FY17 Science Program" and entails ocean acoustic mapping activities ranging from 50 - 6500m water depths, water column profiling measurements using CTD, XBT, and UnderwayCTD casts, and a two-body remotely operated vehicle (ROV) designed to increase knowledge of the marine environment. The latitude and longitude bounding coordinates for the operating area of the cruise are -13.9° to -14.9° S and -165.2° to -171.4° W.

EX-17-02 is a telepresence-enabled ROV cruise that will be conducted from February 16 to March 2, 2017 in the waters of Samoa and American Samoa, including the Rose Atoll Marine National Monument (RAMNM) and National Marine Sanctuary of American Samoa (NMSAS). Operations

will be focused primarily on deep water areas 250m and deeper. The cruise will start in Pago Pago, AS and end in Apia, Samoa. A tandem 6,000 meter ROV system will be deployed and CTD rosette casts may be conducted during the expedition. ROV dive targets include seamounts, hydrothermal vents and bottom fish habitats.

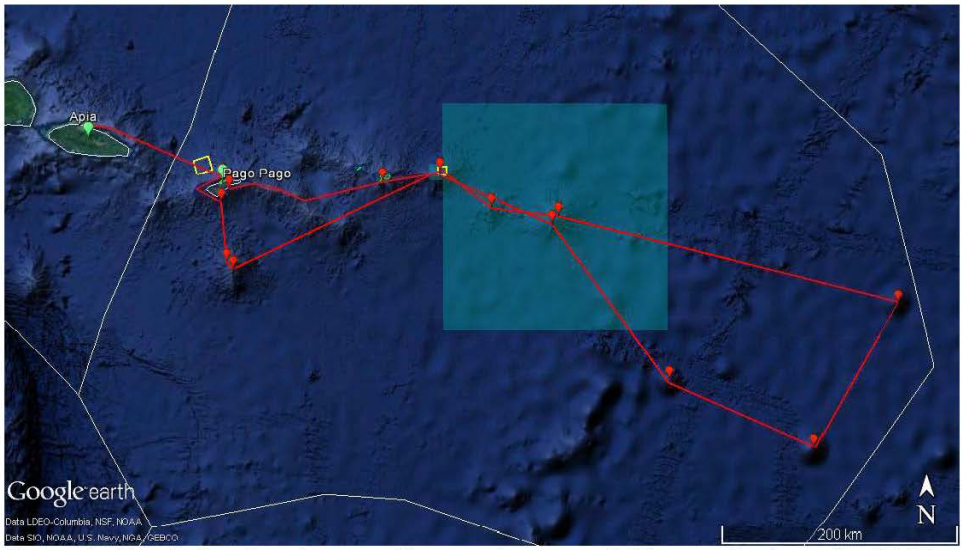


Figure 1: *Map indicating the overall operating area of Okeanos Explorer for EX-17-02. The red line is the generalized cruise track. Focused overnight mapping operations will be planned during the cruise based on available time. The light blue polygons are the boundaries of the Rose Atoll Marine National Monument and National Marine Sanctuary of American Samoa. The red drops are the draft locations of ROV dive sites. The green labelled dots are the port locations of Pago Pago, American Samoa and Apia, Samoa. The yellow boxes are priority areas for focused mapping surveys. The white line is the publicly available Exclusive Economic Zone of American Samoa and Samoa.*

The overarching goal of the project is to extend our breadth of knowledge about the distribution and diversity of deep water habitats within the operating area. The information and data generated by this project will lead to a better understanding of the deep water habitats and ecosystems of the RAMNM, the NMSAS and the marine environment around the Islands and Atolls of American Samoa and Samoa, providing basic information about the rich and unique biological resources and habitats of this region. Ideally, the findings from this cruise will spur further exploration and research and ultimately contribute to effective resource management decisions.

ROV Operations

The purpose of conducting ROV operations is to conduct interdisciplinary site characterization at priority targets in American Samoa. Interdisciplinary site characterization would be achieved by

visually surveying priority targets while simultaneously acquiring environmental data with in situ sensors mounted on the ROVs (conductivity, temperature and depth; dissolved oxygen; light scattering; and oxygen reduction potential). ROV targets include seamounts, hydrothermal vents and bottom fish habitats. The combined dives will enable scientists and managers to have a better understanding of the diversity and distribution of deep water habitats in American Samoa including the RAMNM and NMSAS, and should contribute to enhanced protection of these resources. ROV operations are not planned in Samoan waters.

The *Okeanos Explorer* is equipped with OER's dedicated, fully integrated, two-body ROV system. ROV operations are conducted primarily during daylight hours while the vessel is stopped and holding station using dynamic positioning. ROV operations will typically take place within several meters of the seafloor, and are conducted in a way to minimize seafloor disturbances. On occasion, the ROV is set down on the seafloor in order to acquire very close imagery of habitats or features of interest. Common procedure includes visually scanning the seafloor to ensure the the ROV landing surface does not include corals or other animals, however some animals may reside beneath the sediment or may be too small to see. The ROV also has a temperature probe that may be shallowly inserted into the seafloor sediment to measure the depth or temperature of features of interest. Finally, though every effort is made to prevent any unnecessary seafloor disturbance, it is likely that at some point the ROV will inadvertently touch some benthic fauna (e.g., sea whip) or that water moving through the ROV thrusters will stir up small amounts of seafloor sediment. Any disturbance would likely be similar to that seen during normal near bottom SCUBA dives. During EX-17-02, up to 13 deployments of the ROV would occur during the expedition, resulting in 104 hours total dive time (~8 hours for each dive). After each ROV dive, the vehicles are brought back onboard and thoroughly sprayed with freshwater and allowed to air dry before the next dive. Though marine organisms should not survive this process, the ROV is thoroughly inspected prior to every dive and checked for the presence of biological organisms to prevent the spread of invasive or non-endemic species from one location to another.

During these dives, limited sampling operations are planned with the ROV to collect very selective specimens that have the potential to contribute significant scientific discoveries. Biological specimen collections will focus on potential new species or new records for the region, and the dominant morphotype animal (such as a coral or sponge) in a habitat. When possible, only a sub-sample will be taken of biological specimens (e.g., only a piece or branch of corals and sponges will be collected, not the entire organism). Selective rock specimens, that have the potential to contribute significant scientific discoveries, as outlined in the expedition goals, will also be targeted. These are expected to include rocks from seamounts and manganese-coated rocks. When possible, rock samples will be selected in a way to minimize disturbance to the surrounding environment and to minimize the take of attached organisms. On average only 4-6 total biological and geological specimens will be collected per dive.

Ultra Short Base Line Acoustic Navigation (USBL):
The Tracklink TL10000MA system is used to track and record the position of the ROVs during the course of a dive. It functions by the transmission of an acoustic pulse from the surface ship, which travels through the water column and triggers a responding acoustic pulse from the ROV.

The measurement of the travel time and direction of arrival of the responding acoustic pulse from the ROV enables calculation of the position of the submerged ROV with respect to the surface ship. Integration of this relative position information with the surface ship position as determined by GPS allows the calculation of the position of the ROV on the seafloor. In this way, observations made by the ROV can be geo-referenced to standard latitude, longitude and depth coordinates. The USBL is used during ROV operations, which are conducted daily and primarily during daylight hours while the ship holds station using dynamic positioning. Although such frequencies are within the hearing range of marine mammals, the USBL navigation system is commonly used by researchers and has no known adverse impact on marine life.

The Tracklink operates at frequencies from 7.5 kHz to 12.5 kHz. Acoustic emissions by the USBL system occur at the surface from the hull of the ship, and at both of the ROVs as they travel through the water column and at the seafloor. The repetition rate of emissions is typically no faster than once every 2 seconds, increasing by 1.33 seconds for every 1000 meters of depth of the ROVs. The character of these emissions is detailed below:

Surface transceiver, *Okeanos Explorer*:
Tracklink model TL10000MA
Frequency of operation: 7.5 kHz - 12.5 kHz Spread Spectrum
Beam width: 120º directed at nadir
Peak electrical power: 100 W
Peak acoustic power: 187db relative to 1 micro Pascal at 1 meter.

ROV transponder, Seirios:
Tracklink model TL10010C
Frequency of operation: 7.5 kHz - 12.5 kHz Spread Spectrum
Beam width: 210º directed at zenith
Peak electrical power: 200 W
Peak acoustic power: 190db relative to 1 micro Pascal at 1 meter.

ROV transponder, Deep Discoverer:
Tracklink model TL10015C
Frequency of operation: 7.5 kHz - 12.5 kHz Spread Spectrum
Beam width: 30º directed at zenith
Peak electrical power: 500 W
Peak acoustic power: 200db relative to 1 micro Pascal at 1 meter.

Mapping
The acquisition of high-resolution seafloor mapping data is an essential precursor to making significant biological, geological, archaeological and oceanographic discoveries. The *Okeanos Explorer* cruises will collect seafloor mapping data in areas previously unmapped with sonar or modern sonar, and to supplement previous work. These maps form the basis for selecting ROV dive targets. ROV cruises would take the next major step in baseline habitat characterization by using the ROV system to visually investigate unknown and little known deep water habitats

within American Samoa identified as priority scientists and managers. CTD casts may be conducted to collect additional information about the physical and chemical properties of the water column, including at sites of interest identified from mapping and ROV investigation.

As is standard procedure on exploration cruises with this vessel, the ship will conduct sonar mapping operations at all times during non-ROV or non-CTD rosette operations throughout the cruise. Acoustic instruments that will be operational during the project are a 30 kHz multibeam echosounder (Kongsberg EM 302), Kongsberg EK60 singlebeam echosounders (18, 38, 70, 120, and 200,kHz), Teledyne Acoustic Doppler Current Profilers (38 and 300 kHz), and a 3.5 kHz sub-bottom profiler (Knudsen Chirp 3260). Additionally, expendable bathythermographs (XBTs) and the ship's UnderwayCTD (UCTD) will be deployed at regular intervals in association with multibeam data collection. All of these systems are routinely used by this exploration vessel.

Bridge Officers and Watch Standers will be on watch during all hours and will look for marine mammals and other observable species potentially sensitive to the sound of the sonars. If cetaceans are sighted, knowledgeable personnel will follow established best management practices to minimize disturbance. If cetacean species are present within 400 m of the ship, the vessel will stop until the animals depart the area.

Multibeam:

Multibeam sonar data will produce high-resolution bathymetry and acoustic backscatter maps. These maps will provide critical baseline information to scientists and resource managers interested in identifying and expanding our understanding of the important biological habitats and ecological connections in Samoa and American Samoa, and to improve understanding of the geological history of the region. Additionally, the data collected will help scientists better understand the size and character of seafloor habitats in the area, allowing for improved targeting of future exploration and research, including the selection of sites for further investigation with a ROV. Multibeam data will be collected at planned ROV dive sites, during transits between ROV dives and to/from ports, and at unmapped or poorly mapped areas in the vicinity of ROV dive sites.

Expendable bathythermographs (XBT):

XBTs are deployed to obtain sound velocity profiles. The profiles are required to calibrate the multibeam system and ensure accurate bathymetric mapping. During mapping operations water column sound velocity profiles will be conducted every 4-6 hours. If the UnderwayCTD is not yet ready for collecting these profiles, the data will be gathered using XBTs.

UnderwayCTD

The UnderwayCTD (UCTD) is a piece of equipment used to gather conductivity/temperature/depth (CTD) measurements or sound velocity measurements while the ship is moving. Accurate measurements of sound speed as a function of depth down to approximately 760 meters are needed every 3-6 hours during multibeam sonar mapping operations. The ship currently obtains sound velocity profiles using expendable probes (XBTs). These sound speed measurements are essential for ray-tracing calculations used by the EM302 multibeam sonar system in order to accurately collect bathymetry and backscatter data. To get

these essential data, the *Okeanos Explorer* can either use an XBT or the UCTD equipped with a sound velocity probe. OER has installed the UCTD in order to minimize the use of XBTs while still gathering essential sound velocity profile data needed in order to accurately collect high quality multibeam sonar data. The UCTD has a re-usable probe that is dropped through the water column to log data then retrieved by rewinding the line onto a motorized spool. The UCTD was installed on the ship in December 2015 on the starboard aft railing. When working correctly, UCTD casts will be used instead of XBTs to obtain water column profile data in order to avoid leaving behind expendable XBT waste in the ocean.

Split Beam Sonars:

Kongsberg EK 60 split-beam sonars are used to collect information about the water column, such as at gas plume or seep sites, and to obtain information about biomass. The EK60 split-beam sonar is used as a quantitative scientific echosounder to identify water column acoustic reflectors - typically biological scattering layers, fish, or gas bubbles – providing additional information about water column characteristics and anomalies. Fishery scientists have developed methods to analyze EK60 data to support fish stock assessment (e.g. Atlantic herring, pollock, capelin) and to predict hot spots of large fish in coral reefs. Split-beam sonars are also being used to help develop "acoustic signatures" of different marine species, which will greatly enhance existing efforts to assess abundance, distribution, and behavior using remote sensing methods. Additionally, split beam sonars are being used to estimate gaseous seep flux rates and improve assessments of their contribution to ocean and atmospheric chemistry. The *Okeanos Explorer* has five operational EK60 transducers at the following frequencies: 18 kHz, 38 kHz, 70 kHz, 120 kHz, and 200 kHz. One or more of these sonars will be operated during the majority of the cruise.

Sub Bottom Profiler:

The primary purpose of the Knudsen 3260 (3.5 kHz chirp) sonar is to provide echogram images of surficial geological sediment layers underneath the seafloor to a maximum depth of about 80 meters below the seafloor. The Sub Bottom Profiler is normally operated to provide information about the sedimentary features and the bottom topography that is simultaneously being mapped by the multibeam sonar. The data generated by this sonar is fundamental in helping geologists interpret the shallow geology of the seafloor. The profiler will be run intermittently to gather test data sets and to evaluate syncing options with other sonars.

CTD Operations

The CTD instrument package is used to obtain conductivity, temperature, depth and other oceanographic data (dissolved oxygen, light scattering, oxygen reduction potential). At least one, and potentially several, CTD casts are planned for this cruise. The instrument is attached to an open cylindrical steel frame approximately 1.15 m in diameter and 1.4 m high with a 24-position rosette carousel containing 24 2.5 L Niskin bottles for collecting water samples. The system would be lowered to a maximum depth of 6800 m by an embedded scientific winch and wire while the vessel would be stopped and hold station using dynamic positioning. The average time to conduct a CTD casts varies from one to several hours depending on water depth (the CTD is lowered through the water column at 60m/min). CTD casts would be conducted at selected sites

including locations where ROV dives are conducted to allow for an improved understanding of the environmental conditions by measuring the physical or chemical properties of the water column overlying or hosting a particular habitat. The CTD will not touch the seafloor and will have limited time and presence in the marine environment.

Effects of the Project

OER has conducted a Biological Evaluation for all operations to be conducted as part of the program's 2015-2017 expeditions in the Pacific Ocean. On February 7, 2016 OER received concurrence from the NOAA National Marine Fisheries Service Protected Resources Division that under Section 7 of the Endangered Species Act (ESA), the activities slated to occur during the 2016-17 expeditions are not likely to adversely impact ESA-listed marine species, and would have insignificant effects on designated or proposed critical habitat. The ESA Section 7 concurrence letter is provided as Appendix A.

OER has also consulted with NOAA's Habitat Conservation Division on the potential impacts of our operations to Essential Fish Habit (EFH) as defined in the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855 et seq. §305(b)). They concurred that our operations would not adversely affect EFH provided adherence to OER proposed procedures and their provided guidance. This concurrence letter is provided as Appendix B.

Exposure to noise from the use of the scientific sonars on the *Okeanos Explorer* may result in avoidance behavior or other finite disturbance to this environment and its marine mammals and fish. The methods used to map the ocean during this cruise are used routinely by NOAA and UNOLS research vessels, are non-destructive in nature, and not known to cause harm. Nonetheless, exposure to noise from use of the abovementioned geophysical equipment may result in avoidance behavior or other finite disturbance to this environment and its marine mammals, sea turtles and fish.

Standard practice during all *Okeanos Explorer* cruises and operations include Officers or Watch Standers on the Bridge around-the-clock, monitoring the surrounding ocean for the presence of other ships, unanticipated hazards, and marine animals – especially cetaceans. If a cetacean is observed, the Mapping Watch Stander or Science Lead is notified and if appropriate the team then proceeds with protocols to continue monitoring the animal or shut down mapping or other ship operations until the animal has departed the area for an appropriate period of time. If cetacean species are observed within 400 m of the ship, the vessel would stop until the animals depart the area but the mapping sonars would continue transmitting to avoid startle responses. If an observed animal is unable or unwilling to depart the immediate area, sonars will be secured and the ship will slowly move away from the area if feasible.

When marine mammals are able to be identified by Bridge Officers or Watch Standers, these observations are noted in the NOAA fleet marine mammal observation log as part of standard practice. During the 2016-2017 field season, these procedures will include monitoring for the presence of sea turtles and, when appropriate, taking protection measures. It is understood that visual monitoring for the presence of marine mammals at night is not typically effective due to

limited visibility – however no practicable alternative is currently available. Modest ship transit speeds (<9-10 knots) and avoidance behavior of mammals to noise that may bother them should make it highly unlikely that a marine mammal would get close enough to the ship's sonar transducers to cause temporary or permanent hearing impacts.

Multibeam Echosounder (MBES)

The Kongsberg EM 302 MBES is hull-mounted on the *Okeanos Explorer* and operates at 30 kHz. The transmitting beamwidth is 0.5° fore–aft and 150° athwartship. In the deepest operating mode the maximum source level of the EM302 is 243 dB re 1 microPa. When operating in shallow modes the source level is 238 dB re 1 microPa. The EM302 is a focused sonar array that uses selective angular directivity and transmits short pulses at limited ping rates (Lurton & DeRuiter 2011). These two characteristics of this type of sonar decrease the potential sound exposure level as well as decrease the probability of the animals being subjected to temporary threshold shift intensity levels affecting hearing.

Dr. Xavier Lurton (IFREMER) has recently created a simplified model of the specific behavior of the *Okeanos Explorer's* EM302 system in terms of direct radiated level inside the water. Model output graphics showing radiated sound transmission patterns in the horizontal and vertical planes of the water column are provided below. This analysis represents our best estimates of radiated sound levels given the current configuration of the sonar. The assumptions behind the model are:

1) The Deep Mode of the EM302 was used (i.e., longest pulse length and highest power -- or worst case scenario).
2) The model uses the current best understanding of the directivity pattern of the sonar that includes both the individual transducer directivity and the transmit sector beam forming.
3) The model does not include any masking effects by the hull or gondola. The draft of the transducer "gondola" on the Okeanos Explorer is 5.65 m below the water line. This configuration causes a baffle effect from the gondola structure and the hull above, and further reduces the likelihood of direct ensonification of an animal on or near the surface, especially a short distance away from the ship.
4) A value of 6 dB/km @ 30 kHz was used as a first-order approximation of the absorption coefficient representative of oceanographic conditions in the vicinity of the Main Hawaiian Islands.

Figure 1 (below) shows horizontal plane (top-down) views of sound pressure levels at three different receiving depths within the water column directly below the transducer: 10m, 50m, and 200m. These figures demonstrate the remarkably narrow zone of ensonification in the along-track direction. Note the difference in the 160 dB/µPa isopleth in the beam plane and elsewhere around the ship. For all but this plane, the isopleth occurs at 400 m or less from the ship. For animals directly within the beam plane, sound pressure levels drop below 160 dB/µPa within 1500 m of the ship near the surface, and within 1800 m at a depth of 200 m. Submerged animals more than 400 m from the ship that are caught in the ensonification volume as the ship

passes will be only briefly subjected to the elevated sound levels occurring inside the transmitter beam pattern. Furthermore, the narrow fan-shaped beam patterns of the *Okeanos Explorer* system provide ample possibilities for the animals to quickly escape the sound. The only possible scenario for more extended exposure would be if the animal were to suddenly start moving in the exact direction and speed as the ship while within the narrow ensonification beam, which is unlikely. This very selective spatial pattern of the sound radiation makes this configuration very different from seismic airgun sources (omnidirectional) or military mid-frequency active sonars that are often directed horizontally through the water column.

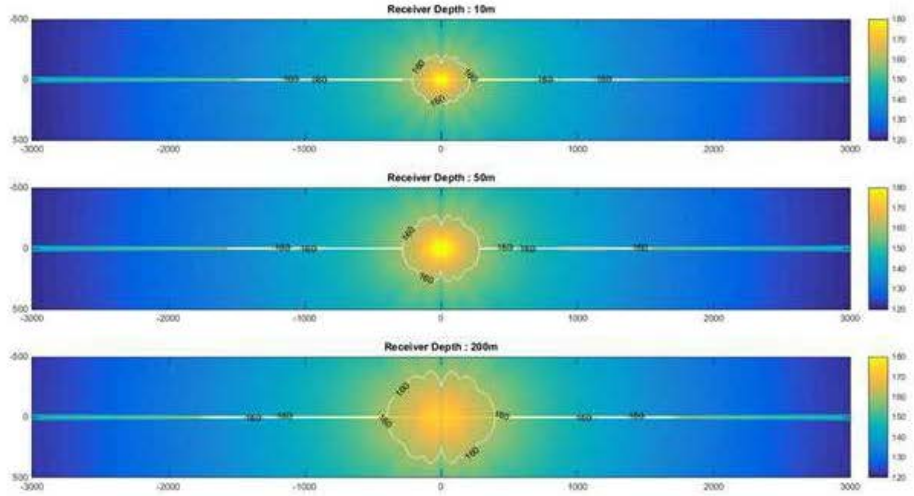


Figure 2: Top down view image of the EM302 radiated beam pattern at several depths (10m, 50m and 200m created by Dr. Xavier Lurton (IFREMER). The ship track is straight up, the Y axis is distance in meters while the X axis in distance in meters. The color scale is signal strength in decibels (dB).

Figure 3 (below) shows the across track radiation pattern for the full water column below the EM302 transducer, with a close up of the near surface region. The 160 and 180 dB/µPa isopleths are plotted to show ranges from the sonar relevant to potential PTS and TTS impacts on cetaceans.

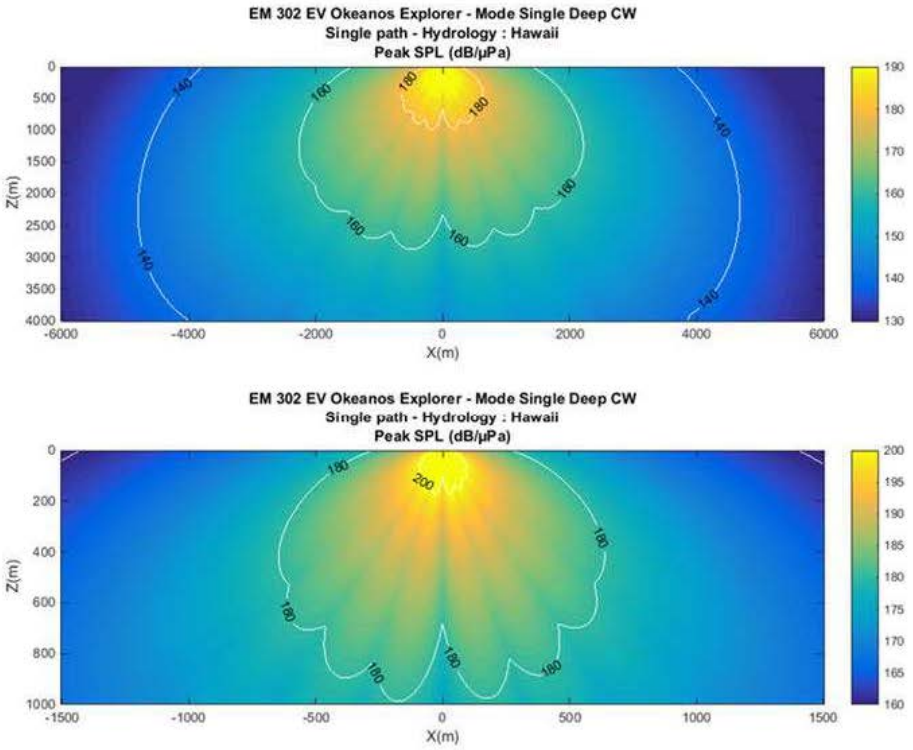


Figure 3: Model created by Xavier Lurton (IFREMER) of the EM302 radiated transmission patterns with the 140, 160 and 180 dB/µPa isopleths plotted for the full water column (top) and of the near surface region (bottom) of a single ping, looking forward through the water column in the along track direction. The y axis is depth below sea surface in meters, and the x axis is distance in meters. The color scale is signal strength in decibels (dB).

Transmit pulse forms and rates are yet two other differences that distinguish multibeam sonar from other types of sonar and acoustic sources and further reduce their potential threat to ESA-listed species. Sound is not transmitted continuously from these systems but rather in extremely short pulses (i.e., pings). Ping durations obtained from the EM302 manual (page 36) are very brief – 0.7 to 5.0 milliseconds. The ping rate or in other words, how frequently pings are emitted, is depth dependent and is provided for different depths in tables 2 and 3 of the manual and show that at a depth of 400 m, the ping rate is 30 pings/min, decreasing to 3.6/min at 4000 m. Another way of putting it is that when the ship is mapping in 400 m of water, any submerged animal within the ensonification volume will be subjected to only a 0.7 millisecond ping every 2 seconds. When the ship is mapping in 4,000 m of water, a submerged animal could potentially experience a 5-40 millisecond ping every 17 seconds. The fore-aft width of the

ensonification volume at 200 m distance from the ship is approximately 4 meters. Based on a mapping speed of 8 knots and using this width as an example, this distance will be traversed by the ship in 1 second. Therefore, a submerged stationary animal 200m from the ship while it is surveying depths of 400 m should be subjected to at most a single ping of 0.7 milliseconds of duration. If the encounter occurs where the water depth is 4,000 m, the chances are low that it will even be subjected to a single ping.

The low operating frequencies, low duty cycles (because of the narrow fore-aft width of the beam), and short pulse lengths portend limited exposure to the MBES pulse for fish, marine mammals and turtles. Based on observed responses to other types of pulsed sounds, and the likely brevity of exposure to the bathymetric sonar sounds, pinniped and sea turtle reactions to the sonar sounds are expected to be limited to a startle or an otherwise brief response of no lasting consequence. In general, marine animals are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics.

As a precautionary measure, to circumvent disturbance and/or possible startling of nearby animals, initial pinging of the multibeam sonar will always be started in the "soft start" mode. The soft start mode is a delay function, starting the sonar transmissions at a low output level and then gradually increasing to the level required for optimal bathymetry data collection. The multibeam power on soft start is set to -20 decibels (20 decibels lower than the full source power setting) with a 10 minute ramp up time to the normal power setting. The soft start feature keeps source levels dampened in case there are cetaceans in the immediate vicinity of the ship, and provides them with time to move away from the ship before the system operates at full power.

Because the EK60, SBP, and ADCP sonars are of lower intensity than the multibeam, and are typically run simultaneously with the multibeam, these protective measures will help avoid inadvertent exposure of marine mammals, sea turtles, and hammerhead sharks to all three sonars. If the multibeam sonar is not being used, but other sonar systems are being turned on, they will be started in lower power settings and will gradually (over a 15 minute time period) be adjusted to higher power settings as appropriate for the water depths. This approach essentially mimics the approach of the "soft-start" mode of the multibeam.

Expendable bathythermographs (XBT):
The very fine wire connecting the XBT probe to the ship is extremely easy to break by hand once the probe reaches maximum depth. The low tensile strength of the wire should represent a minimal entanglement risk for marine animals. The expended materials are unlikely to result either in any significant environmental impacts to the sea floor or in a significant degradation of marine water quality. Over a period of years, these materials would degrade, corrode, and become incorporated into the sediments.

UnderwayCTD
The *Okeanos Explorer* proposes to use the UCTD during the 2017 field seasons as much as possible as a more environmentally-friendly alternative to XBTs, since it does not leave anything

in the ocean after gathering the measurements. Given the limited duration of casts (<1 hour) entanglement risk is considered low.

The UCTD should always be nearly directly behind the ship, either freefalling, or being reeled back in. When UCTD profiling casts are conducted in deep water, the probe has its own tail spool that has hundreds of meters of line wound on to it. This tail spool allows the probe to freefall through the water column with very little drag, since it does not have to pull all the line between the probe and the ship as it falls. Once the probe is dropped off the back of the ship, all of the line on the tail spool must be paid out before it is even possible to begin rewinding the line to reel back in the probe. If a marine mammal is spotted while the probe is falling, we will still have to wait until all the line on the tail spool is paid out prior to starting recovery. Therefore once a deep water UCTD cast is started, there is really not a practicable way to make it much shorter or abort it.

If a marine mammal is spotted by the bridge while the UCTD is in the water, the ship will slow down to 3-5 knots (as possible given what the Engineering Department needs to do with the engines to make this happen), and maintain heading. The Survey Department will finish the UCTD cast as quickly as possible by rewinding the line as soon as they measure the time by which all of the tail spool line should have completed paying off the spool. Slowing the ship down and maintaining heading are the only measures practicable to minimize the risk of entanglement. We will also monitor for entanglement during probe recovery.

Split Beam Sonars:
EK60 and ADCP sonar calibration work planned near Hawaii is specifically planned for an area outside any marine managed areas, Sanctuaries, known sensitive habitats, and state waters. There are no known impacts of EK60 split-beam sonars on marine animals, and there are used routinely by NOAA to assess water column biomass.

Sub Bottom Profiler:
Marine mammal responses to the sub-bottom profiler are likely to be similar to those for other pulsed sources. The pulsed signals from the sub-bottom profiler are much weaker than those from the multibeam echosounder described above. Since they are usually operated simultaneously with other higher-power acoustic sources, behavioral responses are not expected, unless marine mammals are very close to the source. In fact, most animals will move away in response to the approaching higher-power sources or the vessel itself before being close enough for there to be the possibility of effects from the less intense sounds of the sub-bottom profiler.

ADCPs:
Both ADCP instruments on the *Okeanos Explorer* are manufactured by Teledyne RD Instruments. Teledyne has provided OER with a proprietary technical memorandum dated April 28, 2015 that provides sound pressure levels associated with their ADCP instruments. Source levels for the ADCPs are far less than the EM302 multibeam. The acoustic beams from the ADCPs are also very focused, with sound energy levels that decrease rapidly away from the main lobe of the

transducer. Given the more limited ranges, narrow beams, and sound pressure values reported for the ADCPs, they are expected to have minimal impacts on species of concern. Teledyne states that it has never received a report any marine mammals being affected by its ADCPs.

CTD and ROV Operations

The planned cruise would include the deployment of a CTD, which would be deployed over the side of the vessel with a cable, and an ROV, which would be deployed off the aft deck with a cable; creating the potential for entanglement should any animals encounter the cable or tether. However, ship officers maintain watch for and avoid protected marine species in the area during CTD and ROV operations and no deployment would occur if sea turtles, marine mammals or scalloped hammerhead sharks are within 50 yards of the vessel, and all individuals participating in the activity would closely monitor the instrument cables at all times while they are deployed. Based on these measures, and given that protected marine species would likely be widely scattered throughout the proposed areas of operation, we consider it extremely unlikely that any of those animals would come into contact with any of the cables, and have determined that the risk of entanglement would be discountable.

In Summary

In general, these scientific techniques are routinely used by NOAA. As expected for ocean research with limited duration or presence in the marine environment, this project will not have the potential for significant impacts. Knowledgeable experts, who are aware of the sensitivities of the marine environment, will conduct the at-sea portions of this project. Providing the United States, the Territory of American Samoa, and Samoa with scientifically robust and quality-controlled oceanographic data is a key benefit that will result from the cruise.

The survey activities will be localized and of short duration in any particular area at any given time. The survey also will not bring about any permanent influence on marine mammals, their habitats, or the food sources they utilize. This project will not result in any notable or lasting changes to the human environment. In sum, the survey activities are not expected to have any significant impacts of a direct or cumulative nature.

Categorical Exclusion

The geographic scope of this action is small and the temporal duration is short. It is a research project of limited size or magnitude and with only short-term effects on the environment, and for which any adverse or cumulative impacts are negligible, consistent with the class of CE in Section 6.03.c.3(a) of NOAA Administrative Order (NAO) 216-6. It does not trigger any exceptions in section 5.05c of the NAO that would require an environmental assessment or environmental impact statement.

APPENDIX K: Endangered Species Act Section 7 Letter of Concurrence

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Pacific Islands Regional Office
1845 Wasp Blvd., Bldg 176
Honolulu, Hawaii 96818
(808) 725-5000 · Fax: (808) 725-5215

Mr. John McDonough
Deputy Director
NOAA Office of Ocean Exploration and Research

Dear Mr. McDonough:

This letter responds to your January 14, 2016 Request for Consultation by the Office of Exploration and Research (OER) regarding efforts aboard the NOAA vessel *Okeanos Explorer* with the proposed action consisting of activities to explore and improve understanding of the distribution and diversity of deep water habitats in the Pacific, and in particular in the Marine National Monuments. You have requested our concurrence under Section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. §1531 et seq.), with your determination that the proposed action may affect but is not likely to adversely affect green, hawksbill, leatherback, olive ridley, and north Pacific loggerhead sea turtles; Main Hawaiian Islands false killer whale distinct population segment, humpback whales, blue whales, fin whales, sei whales, sperm whales, north Pacific right whales, the Indo-West Pacific and Central Pacific distinct population segment of the scalloped hammerhead shark, Hawaiian monk seals; and the coral species *Acropora globiceps,* A. *jacquelineae, A. retusa, A. speciosa, Euphyllia paradivisa, Isopora crateriformis,* and *Seriatopora aculeata.*

Proposed Action/Action Area: The proposed activity is more fully described in your request for consultation and the associated biological evaluation (CAPSTONE 2016). The proposed action (Okeanos Explorer cruises) includes the use of various ship and submersible-deployed electronic systems to collect data on the distribution and diversity of deep water habitats in the Marine National Monuments. The activity would occur during two years with up to 20 research cruises scheduled between February 2016 and December 2017. The expedition teams (26 crew and up to 20 rotating scientists and/or technicians on each cruise leg) would be authorized to conduct mapping and Remotely Operated Vehicle (ROV) surveys using the Okeanos Explorer's multibeam, split beam, subbottom profiler and acoustic Doppler current profiler (ADCP) sonar systems, utilizing the ship's conductivity-temperature-depth (CTD) sampling rosette for various water measurements and deploying an ROV. No activities are scheduled to occur on land.

The suite of sonars aboard the vessel includes a Kongsberg EM302 30 kHz multibeam system, which collect bathymetry and backscatter data; several Simrad EK 60 split-beam sonars that

range from 18 to 333 kHz which are designed to gather measurements of biological and gaseous targets in the water column; and a Knudsen 3.5 kHz chirp sub-bottom profiler. The 300 kHz and 38 kHz ADCPs provide information about current velocity and direction at various depths. Sonar mapping activities will be conducted throughout the proposed action area and during transits to and from sites where operations will be conducted in an effort to fill in gaps in data knowledge and to build on data already collected. The maps generated from these activities will improve understanding of the geology and important biological habitats in the project area.

Conductivity, temperature and depth data will be collected by both an Underway CTD and a CTD rosette instrument. The CTD rosette, which is deployed while the ship is stopped and holding dynamic position, is lowered by a winch and wire to a maximum depth of 6800 m to collect water samples through 24 2.5 L niskin bottles. The CTD rosette will be deployed at select sites where ROV operations are conducted to allow for an improved understanding of the environmental conditions at that particular site. The deployment and retrieval of the CTD rosette takes up to several hours (depending on depth), while the Underway CTD can be deployed while the ship is moving, saving hours of time and fuel. The instrument is mounted on the stern railing and outfitted with a re-useable probe that is deployed and retrieved through the use of motorized spool. The Underway CTD will be used to collect water column profiles to a maximum depth of 700 m.

ROV operations will be designed to provide interdisciplinary site characterization at priority targets in and around monuments, sanctuaries and protected areas, through visual observation of priority targets while acquiring environmental data with onboard sensors. Sampling will be focused on corals and sponges, but will target specimens believed to be new species or new records for an area. No ESA-listed corals would be sampled. As many as 200 deployments of the ROV may occur during the 2016 – 17 field season resulting in 1600 hours of total dive time. The dives will better enable scientists and managers to understand the diversity and distribution of deep water habitats.

The action area covered by the accompanying biological evaluation encompasses the marine environments of Papahānaumokuākea Marine National Monument (PMNM); Oahu and the big island of Hawai'i; the area south and west of Molokai, Lana'i, and Kaho'olawe, the Geologists Seamounts located about 100 nm south of Honolulu; the Musicians Seamounts located about 150 nm NNE of Nihoa Island; all of the Pacific Remote Island Areas composing the Pacific Remote Islands Marine National Monument (PRIMNM); the Commonwealth of the Northern Marianas Islands (CNMI) and the Marianas Trench Marine National Monument (MTMNM); the vicinity of American Samoa and the National Marine Sanctuary of American Samoa (NMSAS); the Rose Atoll Marine National Monument (RAMNM); and the vessel transit areas between Honolulu, Hawai'i, Guam, Saipan, Kwajalein, Pago Pago where ESA-listed marine species or their habitats may be impacted by the proposed activities.

Species That May Be Affected: OER determined that the proposed action may affect but is not likely to adversely affect green sea turtles (*Chelonia mydas*), hawksbill sea turtles (*Eretmochelys imbricata*), North Pacific distinct population segment of loggerhead sea turtles (*Caretta caretta*),

olive ridley sea turtles (*Lepidochelys olivacea*), leatherback sea turtles (*Dermochelys coriacea*), Main Hawaiian Islands false killer whale distinct population segment (*Pseudorca crassidens*), humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), fin whales (*Balaenoptera physalus*), blue whales (*Balaenoptera musculus*), sei whales (*Balaenoptera borealis*), north pacific right whales (*Eubalaena japonica)*, the Indo-West Pacific and Central Pacific distinct population segments of the scalloped hammerhead shark (*Sphryna lewini*), Hawaiian monk seals (*Neomonachus schauinslandi*), Hawaiian monk seal critical habitat and the coral species *Acropora globiceps, A. jacquelineae, A. retusa, A. speciosa, Euphyllia paradivisa, Isopora crateriformis,* and *Seriatopora aculeata.* Detailed information about the biology, habitat, and conservation status of sea turtles can be found in their recovery plans and other sources at http://www.nmfs.noaa.gov/pr/species/turtles/. The same can be found for Hawaiian monk seals and cetaceans at http://www.nmfs.noaa.gov/pr/species/mammals/; and more information on listed corals can be found at http://www.fpir.noaa.gov/PRD/prd_coral.html.

Critical Habitat: The proposed action would take place within designated monk seal critical habitat. Critical habitat was designated under the ESA for the Hawaiian monk seal on April 30, 1986 and revised on May 26, 1988 (53 FR 18988) and again on August 21, 2015 (80 FR 50926). Designated critical habitat includes all beach areas, lagoon waters, and ocean waters out to a depth of 200 m around Kure Atoll; Midway Islands (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, Gardner Pinnacles, French Frigate Shoals, Necker Island, Maro Reef, and Nihoa Island, and includes the seafloor and all subsurface waters and habitat within 10 meters of the seafloor. Around the Main Hawaiian Islands, critical habitat extends in designated areas from the beach out to the 200 meter depth contour, and includes the seafloor and subsurface waters within 10 meters of the seafloor.

Analysis of Effects: In order to determine that a proposed action is not likely to adversely affect listed species, NMFS must find that the effects of the proposed action are expected to be insignificant, discountable, or beneficial as defined in the joint USFWS-NMFS Endangered Species Consultation Handbook: (1) insignificant effects relate to the size of the impact and should never reach the scale where take occurs; (2) discountable effects are those that are extremely unlikely to occur; and (3) beneficial effects are positive effects without any adverse effects (USFWS & NMFS 1998). This standard, as well as consideration of the probable duration, frequency, and severity of potential interactions, was applied during the analysis of effects of the proposed action on ESA-listed marine species, as is described in detail in the OER consultation request. The OER determined that the risk of collisions with vessels and the risk of entanglement would be discountable; and that the risk from exposure to elevated noise level, disturbance from human activity, as well as exposure to wastes and discharges would result in insignificant effects on ESA-listed sea turtles, marine mammals, sharks and corals; and that the potential effects of the proposed action to designated or proposed critical habitat would also be insignificant.

Considering the information and assessments presented in the OER consultation request, and in the best scientific information available about the biology and expected behaviors of the ESA-listed marine species considered in this consultation; NMFS agrees that: 1) the list of ESA-listed species and critical habitats potentially exposed to the effects of the action is correct, 2) the suite

of identified stressors is comprehensive, and 3) the assessment of exposure risk and significance of exposure to those stressors is accurate. Therefore, NMFS agrees that:

- the risk of collisions with vessels for marine mammals, turtles, sharks and the listed coral species in the action area is discountable;
- the risk of entanglement with marine mammals, sea turtles and sharks is discountable; and,
- ESA-listed species in the action area are unlikely to respond to anticipated elevated noise levels, disturbance from human activity, and exposure to wastes and discharges. Further, if any response were to occur, it would be temporary in nature and never reach the scale where it would affect the individual's health, and as such, have insignificant effects.

Conclusion: NMFS concurs with your determination that conducting the proposed Okeanos Explorer cruises are not likely to adversely affect ESA-listed marine species. This concludes your consultation responsibilities under the ESA for species under NMFS's jurisdiction. However, this consultation focused solely on compliance with the ESA. Additional compliance review that may be required of NMFS for this action (such as assessing impacts on Essential Fish Habitat) would be completed by NMFS Habitat Conservation Division in separate communication, if applicable.

ESA Consultation must be reinitiated if: 1) a take occurs; 2) new information reveals effects of the action that may affect listed species or designated critical habitat in a manner or to an extent not previously considered; 3) the identified action is subsequently modified in a manner causing effects to listed species or designated critical habitat not previously considered; or 4) a new species is listed or critical habitat designated that may be affected by the identified action.

If you have further questions please contact Richard Hall on my staff at (808) 725-5018. Thank you for working with NMFS to protect our nation's living marine resources.

Sincerely,

Michael D. Tosatto
Regional Administrator

cc: Justin Rivera, Papahanaumokuakea Marine National Monument
Aaron Nadig, ESA Section 7 Program, USFWS, Honolulu

NMFS File No.: PIR-2016-9774
PIRO Reference No.: I-PI-16-1347-AG

Literature Cited

Campaign to Address Pacific Monument Sciecne, Technology and ocean Needs (CAPSTONE) 2016. Request for Informal Consultation. Letter from John McDonough to Ann Garrett dated January 14, 2016 and attachments.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Consultation Handbook. Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act.
http://www.nmfs.noaa.gov/pr/pdfs/laws/esa_section7_handbook.pdf

APPENDIX L: Essential Fish Habitat Consultation Letter of Concurrence

EFH Consultation Response for CAPSTONE cruises

Richard Hall - NOAA Federal <richard.hall@noaa.gov> Wed, Nov 30, 2016 at 4:21 PM
To: Kelley Elliott - NOAA Affiliate <kelley.elliott@noaa.gov>
Cc: Ian Lundgren - NOAA Affiliate <ian.lundgren@noaa.gov>, Samantha Brooke <samantha.brooke@noaa.gov>, Kasey Cantwell - NOAA Affiliate <kasey.cantwell@noaa.gov>

Kelley,

On November 14, 2016, the Office of Exploration and Research (OER), through personal communication, initiated a request for an Essential Fish Habitat consultation for a series of cruises by the NOAA Ship *Okeanos Explorer*. The cruises would run from early-December 2016 through late-September 2017, and include the waters around the Main Hawaiian Islands, the Musician Seamounts (north of Hawaii), the American Samoa Archipelago; Johnston, Howland, Baker, Jarvis, Kingman and Palmyra Atolls of the Pacific Remote Islands, and portions of the Cook Islands. The operational minimum depth during the cruises would be 250 m, with the majority of the cruise activities would be in water depths over 500 m.

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855 et seq.) requires review of federally permitted projects for potential impacts to EFH (§305(b)). Pursuant to this authority, I have reviewed and provided comments as necessary for the Habitat Conservation Division of NOAA's Pacific Islands Regional Office.

The proposed cruises are the final legs of the larger 2-year Campaign to Address Pacific Monuments Science, Technology and Ocean Needs (CAPSTONE Project), which is designed to improve the understanding of the distribution and diversity of deepwater habitats within the Pacific monuments and protected areas.

The primary activities to be conducted during this series of cruises would be: remotely operated vehicle (ROV) dives to conduct engineering trials and sonar calibration and testing during two shakedown cruises scheduled for the waters of the Main Hawaiian Islands (no biological or geological samples would be collected); and mapping and ROV dives in the waters of American Samoa, West Samoa, the Pacific Remote Islands, the Musician Seamounts, and portions of the Cook Islands. Five cruises would be dedicated mapping cruise, resulting in 92 days of constant mapping, while six cruises would be combined ROV and mapping cruises which would result in approximately 96 ROV dives and 110 days of overnight mapping. Other activities to be performed during the cruises would include: deployment and recovery of a conductivity-temperature-depth (CTD) sampling rosette and underway CTDs, and possible deployment of Argo floats to acquire ocean chemistry data. During ROV dives various biological and geological samples would be collected.

In order to avoid/minimize impacts to EFH, the OER and the *Okeanos Explorer* have proposed to institute the following procedures:

- The vessel would employ the use of dynamic positioning during ROV dives (no anchoring);
- ROVs would be operated in a manner to avoid seafloor disturbance, and setting the ROV on the seafloor will be held to a minimum. For those situations when the ROV does make contact with the seafloor, visual observations will confirm that the area is sand, mud, or hard-bottom;
- Sample collections would be limited (typically 4 - 6 total rocks and primary biological specimens per dive) that represent new species, new records, or the dominant morphotype animal in a community. Clonal biological specimens (corals, sponges) would be subsampled; and
- Instruments deployed to collect water samples and current data (except for expendable instruments) would not be allowed to contact the seafloor;

In addition to the management practices proposed by OER and the *Okeanos Explorer*, NMFS provides the following guidance to further avoid/minimize impacts to EFH from the proposed cruise activities and vessel operations:
1. Except in an emergency, the vessel should not anchor while at sea;
2. The vessel should adhere to MARPOL discharge regulations at all times during the proposed cruises;
3. The ROV should be thoroughly rinsed between dives, allowed to dry, and checked for the presence of biological

organisms to prevent the spread of invasive or non-endemic species from one location to another.
4. The use detergents and other pollutants which may be washed into the marine environment should be avoided or held to a minimum;

Based on my review of the documents provided, and through our personal communications, NOAA Fisheries has determined that the proposed cruises of the NOAA Ship *Okeanos Explorer* would not adversely affect EFH provided adherence to OER proposed procedures and the NMFS guidance made above. Thank you for the opportunity to review the plans for the upcoming field season of the *Okeanos Explorer*, and to provide our comments. This completes your obligation to consult with our office with regards to EFH for this series of actions. If you have any questions or comments feel free to contact me at your convenience.

--
Richard Hall
Fishery Policy Analyst
Pacific Islands Regional Office
NOAA Inouye Regional Center
1845 Wasp Blvd., Building 176
Honolulu, HI 96818
808-725-5018

APPENDIX M: Preliminary 210Po-210Pb Radiometric dating results for NOAA OER EX-17-02 Dive 09 at Vailulu'u Seamount

Preliminary 210Po-210Pb Radiometric dating results, NOAA OER EX1702, Dive 09, Vailulu'u Seamount
Ken Rubin, University of Hawaii Manoa
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Abstract:
^{210}Po-^{210}Pb radiometric dating analysis of two volcanic rock specimens collected on this dive have a roughly 50% chance of being young (~2 years old on the data of collection) and a 50% chance of being older than 3 years (wherein ^{210}Po and ^{210}Pb are in secular equilibrium, with unresolvable ages). Samples were conclusively not very young (defined as < 1 year old on the date of sample collection). *These interpretations should be considered preliminary and unpublishable in the peer-review literature until the data set is finalized and the statistical analysis of results is complete.*

Samples:
Dive 9 visited Vailulu'u seamount, an active submarine volcano east of the Samoan Islands. 4 rock specimens were collected on the central volcanic cone on February 24, 2017. Aliquots of two of those specimens, D2_DIVE09_SPEC05GEO and D2_DIVE09_SPEC06GEO were provided to the University of Hawaii immediately following the expedition for short-fuse, 210Po-210Pb analysis. Those samples have been assigned ISGN OSU-EX1702-D9-05-EX001 and OSU-EX1702-D9-06-EX001 (with EX001 being the 201Po subsample code). Based on images taken during the ROV dive, D2_DIVE09_SPEC05GEO appears to be part of a large pillow lava toe. The sample has fresh glass on exterior surfaces and mild staining by iron-oxides/iron-rich clays. D2_DIVE09_SPEC06GEO appears to be a piece of fragmented or brecciated lava with less but still visible glassy surfaces and substantially greater amounts of Fe-rich exterior coatings.

Methods and Analysis
A full description of the ^{210}Po-^{210}Pb dating method is beyond the scope of this report. The method was first described in Rubin et al. 1994 (Nature, 368, 841-844). The analysis is based on the degassing of short-lived ^{210}Po (half life 138.4 days) and subsequent radioactive decay. This chronometer can be used to determine the ages of young volcanic rocks erupted within the prior 2.5 to 3 years of the date of sample collection. It results in the highest age resolution for lavas erupted soon before sample collection (1-2 week resolution), diminishing with greater elapsed time between eruption and sample collection. At 2.5 to 3 years after eruption, the initial radioactive signature has decayed away to the point of not being measureable relative to baseline, which is defined by the ^{210}Pb activity in the specimen.

Aliquots of samples were prepared and analyzed for ^{210}Po-^{210}Pb radioactive disequilibrium at the SOEST Isotope Laboratory of the University using standard protocols (described most recently in Embley et al., 2014, Geochemistry, Geophysics, Geosystems. 15, 4093-4115, supplement S3). Briefly, samples were picked under a microscope from 0.25 to 0.5 mm crushed separates that had been washed multiply in purified water, leached in a dilute mixture of HF and HNO_3, washed again in purified water, dissolved and spiked with a ^{209}Po tracer, and each analyzed twice for ^{210}Po activity by alpha particle spectroscopy using sources plated onto silver planchets. Analyses were conducted as aliquots of the same solution over a period of 1+ years. Resulting spectra were corrected for instrumental background. ^{210}Po activities were determined by isotope dilution against the ^{209}Po tracer. Resulting ages are determined by regression of activity ratios to the ingrowth curve for ^{210}Po-^{210}Pb radioactive disequilibrium, assuming an initial eruption event wherein ^{210}Po is degassed from the lava and ^{210}Pb is not.

Preliminary ages in this report are based on a two-point, instead of the more typical three-point time series, because of the slow rate of change in Po between aliquot 1 and 2 on each sample, which led us to

decide to delay the third analysis to allow for more Po ingrowth. Then, beginning in Spring 2018, the alpha spectrometer suffered significant instrumental downtime due to faulty internal components. Once fixed (Autumn 2018) it has been dedicated to another project (high impact eruption of Kilauea volcano in 2018). A final analysis of these two Vailulu'u rocks (which is not time sensitive) is slated for these samples in mid-2020, at which point the preliminary results presented in Table 1 will be updated. There is less confidence in the result of these 2-point regressions then there would be with a 3 point regression.

Preliminary Results

Both D2_DIVE09_SPEC05GEO and D2_DIVE09_SPEC06GEO exhibited small but detectable changes in $^{210}Po/^{210}Pb$ activity ratio over the time period between first and last analysis. The rate of change of ^{210}Po activity, expressed as difference in $^{210}Po/^{210}Pb$ activity ratio between the first and last analysis of the sample, was ~1.6 to 2.4% in both cases, with an analytical uncertainty (1 sigma counting statistics) on each analysis of 1.5 to 2%. Because of the analytical uncertainty, the rate of change is barely detectable, and perhaps not significant. A third analysis in mid-2020 may provide clarity on this issue.

Table 1.	210Po/210Pb	Prelim age on date of collection
rock 05		2.18 yrs, eruption Jan 2015
13-Mar-17	0.982	
19-Feb-18	0.997	
rock 06		1.95 yrs, eruption Apr 2015
13-Mar-17	0.972	
19-Feb-18	0.995	

Final evaluation of ages awaits a third ^{210}Po analysis and a rigorous statistical evaluation to better envelop the extent of uncertainty in the age analysis. Currently the estimate of uncertainty in these ages is + 6, – 2 months. Because of their advanced age, it is not possible to detect age differences between the two specimens outside of analytical uncertainty.

However, two immediate conclusions can be drawn: (a) upon date of collection neither specimen was very young (i.e., < 3 half-lives of ^{210}Po, which is 415 days or 1.13 years); (b) either or both specimens *may have been* as little as 2 or 2.25 years old on the date of sample collection; or, they may be infinite-aged (which in this system means >3 years old). Monte Carlo simulations of similar data collected on other projects with these same characteristics (including analytical uncertainty) indicate a roughly 50% chance that both samples are finite aged and 50% chance they are older than 3 years.