doi: 10.25923/52d7-h744

Ocean Exploration and Research

Expedition Cruise Report: EX-16-06

2016 Deepwater Wonders of Wake (ROV/Mapping)

Remotely Operated Vehicle (ROV) and Mapping Exploration of the Wake Atoll Unit of the Pacific Remote Islands Marine National Monument

July 27 to August 19, 2016

Guam to Kwajalein Atoll, Republic of the Marshall Islands

Christopher Kelley, Ph.D., Jasper Konter, Ph.D., Science Leads, University of Hawai'i at Mānoa
Brian Kennedy, Lindsay McKenna, Expedition Coordinator and Mapping Lead, NOAA Office of Ocean Exploration and Research

March 26, 2020

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

Abstract

In August of 2016, NOAA Ship *Okeanos Explorer* conducted the first-ever deepwater exploration of the Wake Atoll Unit of the Pacific Remote Islands Marine National Monument. (PRIMNM). In total, the ship conducted 14 ROV dives ranging from 350 to 3,136 meters depth. All explored seamounts are flat-topped guyots with mainly pillow lavas coated in ferromanganese crust exposed on their lower flanks. Their tops have increased amounts of carbonate sediment, and some have post-erosional cones. High-density biological communities were documented at four of the 13 surveyed dive sites. Hundreds of different animal species were observed. Of those, a total of 61 specimens were collected, including 20 geological samples and 41 biological samples—19 of which were commensal—that represent either new species or new records for the region. The expedition located and identified the wreck of the *Amakasu Maru No. 1*, a Japanese World War II-era water tanker. In addition to the science and exploration successes, the ship's personnel also participated in numerous education and outreach events.

This report can be cited as follows:
Kelley, C., Konter, J., McKenna, L., Kennedy B., (2016). Cruise EX-16-06—Expedition Report—2016 Deepwater Wonders of Wake (ROV/Mapping). Office of Ocean Exploration and Research, Office of Oceanic & Atmospheric Research, NOAA, Silver Spring, MD 20910. OER Expedition Cruise Report 16-06, doi: 10.25923/52d7-h744

Acknowledgements:
Final editing and publication of this report was completed by:
Amy Bowman, Consultant on contract with NOAA National Marine Sanctuary Foundation
Matt Dornback, Expeditions, NOAA Office of Ocean Exploration and Research

Validity of URLs listed in the report:
All URLs included in the report were last accessed March 2020.

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

Table of Contents

1. Introduction

By leading national efforts to explore the ocean and make ocean exploration more accessible, the NOAA Office of Ocean Exploration and Research (OER) is filling gaps in basic understanding of deep waters and the seafloor, providing deep-ocean data, information, and awareness. Exploration within the U.S. Exclusive Economic Zone (EEZ) and international waters as part of Seabed 2030 efforts to produce a bathymetric map of the world ocean floor by 2030 supports key NOAA, national, and international goals to better understand and manage the ocean and its resources.

Using the latest tools and technology, OER explores unknown areas of the deep ocean. NOAA Ship *Okeanos Explorer* is one such tool. Working in close collaboration with government agencies, academic institutions, and other partners, OER conducts deep-sea exploration expeditions using advanced technologies on the *Okeanos Explorer*, mapping and characterizing areas of the ocean that have not yet been explored. Collected data about deep waters and the seafloor—and the resources they hold—establishes a foundation of information and fills gaps in the unknown.

All data collected during *Okeanos Explorer* expeditions 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.

Exploring, mapping, and characterizing the U.S. EEZ are necessary for a systematic and efficient approach to advancing the development of ocean resources, promoting the protection of the marine environment, and accelerating the economy, health, and security of our nation. 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

The Campaign to Address Pacific Monument Science, Technology, and Ocean Needs (CAPSTONE) was a three-year effort designed to provide critical new information on the deepwater resources within the U.S. National Marine Monuments and Sanctuaries located throughout the Pacific. The primary goal of all *EX* expeditions in this campaign was to obtain baseline data and information of the poorly known deepwater areas and resources in these extensive marine protected areas (MPAs).

2.1 Expedition Overview

From July to August 2016, NOAA and partners conducted a telepresence-enabled ocean exploration expedition on NOAA Ship *Okeanos Explorer* (EX-16-06) to collect critical baseline data and information about unknown and poorly known deepwater areas in the Wake Atoll Unit (WAU) of the Pacific Remote Islands Marine National Monument (PRIMNM). The 24-day expedition was the second CAPSTONE expedition to the WAU; the first, EX-16-04, was a dedicated mapping expedition conducted in March 2016.

Baseline data from this expedition will help to improve our understanding of the geologic history and deep-sea habitats of the WAU. 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.

2.2 Rationale for Exploration

The WAU of the PRIMNM is located roughly halfway between Hawai‘i and the Mariana Islands. Due to its remote location, prior exploration has been limited to less than a handful of cruises carried out over the course of several decades.

These cruises (EX-16-04 and EX-16-06) were limited to either mapping the shallow waters around Wake Atoll, or dredging two of the seamounts in the northernmost reaches of the WAU. However, deepwater surveys with submersibles or remotely operated vehicles (ROVs) had never been carried out in this area, making this expedition one of true exploration. As a result of the very limited previous exploration of the WAU, understanding of its geology is based on very few observations from a much broader area (the entire western Pacific), while the true diversity of its marine life was truly uncharted.

On a broad scale, the geology of the WAU, as we understand it today, can be described by two major components: the (presumed) Cretaceous seamounts and island, and the underlying seafloor. The seafloor is some of the oldest seafloor in the Pacific Ocean (and indeed the world), reaching an age of approximately 170 million years (Ma), as derived from magnetic seafloor anomalies (**Figure 1**). The submarine volcanoes that it supports are thought to be between about 90-100 Ma, based on the trend in ages of similar seamounts around the monument.

These seamounts together make up what is referred to as a "hotspot" chain in geology. In a so-called hotspot, a chain of volcanoes forms as the Earth's tectonic plates move over areas in the Earth's mantle that are thought to be anomalously hot. In the hotspot model, material from deep inside the Earth moves to the bottom of the plate and melts due to its high temperature and decompression; similarly to a flame burning a continuous hole through a passing piece of paper, the hotspot burns a chain of volcanoes into the tectonic plate. Therefore, once analyzed, these volcanoes will become an important part of deriving Pacific tectonic plate motion from this long-lived hotspot, while individually they represent a long history on the Pacific plate.

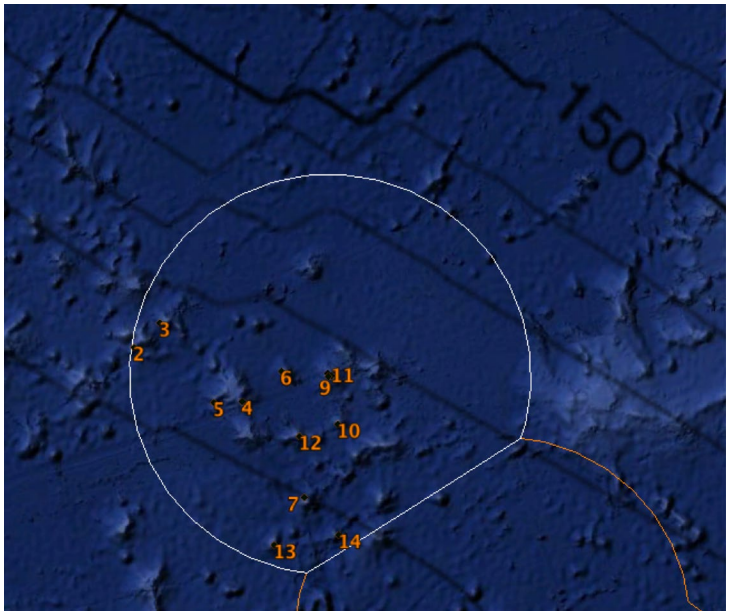

Figure 1. *Wake Atoll Unit seafloor. The white line outlines the Monument, the black contours are seafloor age contours (from seafloor magnetic anomalies), and the orange numbers are the dive sites visited during the expedition. Google Earth screen grab.*

The overall evolution of hotspot volcanoes starts out as volcanic eruptions of basaltic rocks on the seafloor, building piles of what are known as pillow lavas (referring to their physical appearance), while lava flows are rarer. As the submarine volcano (seamount) grows near sea level, some eruptions may become explosive (from the mixing of magma with shallow water), depositing layers of volcaniclastic sediments. Once an island has formed, lava flows become more important in the volcano's structure. After the volcano ceases to erupt, erosion breaks the island down in a matter of millions of years. At the same time, two types of covers develop: coral reefs near the surface and manganese (Mn) crust at depth. Coral reefs usually develop on the flanks of these volcanoes in tropical areas; as the volcano is eroded, the reef becomes increasingly significant. As the last remnants of volcanic material are eroded by ocean waves, the reef remains near sea level, often forming ring-shaped islands known as atolls. Simultaneously, the plate underneath the chain of volcanoes is cooling down and slowly "sinking" into the mantle, which assists in the disappearance of the volcanic island, and eventually the drowning of the reef. Thus, the last stage in the volcanic chains is a drowned volcano covered with a reef structure that is flat-topped from the competition of reef building and wave action near sea level. Such volcanoes are known as guyots, and they are a common occurrence in the western Pacific, and the type of seamount commonly found in the WAU.

Since the deepwater geology and biology of the WAU had never been truly explored before, and given its remote location isolating this Monument unit from most human activities, this area presented a unique exploration target. Furthermore, exploration of the area could inform the ongoing planning and development of deep-sea mining, by providing the first insights into the ecosystems that might be impacted.

Deep-sea mining in this part of the Pacific Ocean is currently focusing on methods to economically extract metals from the ferromanganese (FeMn) crusts that coat most rocks in the 1,000-2,500 m depth range, only existent on seamounts in this part of the Pacific Ocean. Directly to the west of the WAU, the Japanese government has leased a significant number of lease blocks from the International Seabed Authority (ISA) and the continuing chain of seamounts to the west falls in their exclusive economic zone (EEZ) around Marcus Island (and an extended continental shelf claim west of that). Further to the southwest, both China and Russia have leased a significant number of lease blocks from the ISA. As previous work—particularly in the CAPSTONE program—has already established the existence of significant communities of corals and sponges in this depth range in other areas, there is a great need to establish at least a basic level of understanding of the communities that may be impacted in this remote area of the Pacific.

While the dense coral and sponge communities located inside the Monument are protected against potential future anthropogenic impacts such as deep-sea mining, we need to acquire a greater understanding of these biological communities. Obtaining such information will allow managers to develop management strategies for the deepwater resources around the WAU and the PRIMNM in general, as well as the areas directly surrounding the Monument. On the biology front, a better understanding is needed about the location and depth range of any high-density communities, how these communities formed, and which species are part of these communities. Hand-in-hand with a better understanding of these communities is the need for a better understanding of the geology that hosts these communities. This consists of a number of basic questions (are they indeed hotspot volcanoes, what is their stability, their eventual fate, and how does this effect the communities over the short- and long-term?). The purpose of the *2016 Deepwater Wonders of Wake* (EX-16-06) expedition aboard NOAA Ship *Okeanos Explorer* was for an initial exploration of the deep water around Wake Atoll in order to gain a better understanding of the deepwater biology and geology in the region.

2.3 Objectives

NOAA Ship *Okeanos Explorer* cruises in general have a large number of objectives that can be categorized as being either programmatic or scientific in nature. Typically, programmatic

objectives (i.e., operations, telepresence, data management, education, and outreach) are common to all expeditions, whereas scientific objectives are specific to a particular cruise or set of cruises. The detailed objectives for this cruise are provided in EX-16-06 Project Instructions, which are archived in the NOAA Central Library. Below are brief descriptions of the programmatic and science objectives for EX-16-06.

2.3.1 Programmatic Objectives

a) Mapping and ROV Operations

Mapping objectives were to collect high-resolution acoustic data from all four types of sonars that were installed on NOAA Ship *Okeanos Explorer* at the time: EM 302 multibeam, EK60 echo sounder, a 3.5 kHz subbottom profiler, and an Acoustic Doppler Current Profiler (ADCP). Mapping data were acquired during transits, as well as on specific targets identified by the science team. Data from these systems were processed onboard as quickly as possible in order to generate daily mapping products that supported ROV operations. Data quality was expected to be high, as a result of proper instrument maintenance, careful planning of the surveys, and appropriate calibration of the instruments. For example, standard operating procedures (SOPs) for the multibeam sonar were to obtain sound velocity profiles at regular intervals no longer than 3-4 hours using expendable bathythermographs (XBTs).

ROV objectives were to obtain high-quality video and sensor data on exploration targets to achieve the science objectives. This included conducting the first-ever deep submergence dives in the WAU of the Monument. This most often involved surveying benthic habitats and features in priority areas (e.g., deep corals and related benthic ecosystems, canyons, and seamounts). Benthic surveys were not only used to characterize the habitats in each target area, but also to ground-truth the acoustic data with visual data (i.e., video). In 2015, the ROV was fitted with hydraulically-activated sample boxes that permitted ROV pilots to collect limited geological and biological specimens.

b) Telepresence

Telepresence objectives were to provide real-time, high-quality video and audio during ROV dives to as wide a shoreside audience as possible. This audience included the general public, students, and researchers—the latter of whom were either passively watching or actively participating in the dives via teleconference or instant messaging. Telepresence was used to help achieve the science objectives by extending the science team well beyond those actually onboard the ship.

c) Data Management

Data management objectives were to collect, process, distribute, and archive cruise data as quickly and efficiently as possible. Effective data management provided a foundation of publicly accessible information products to spur further exploration, research, and management activities; it also stimulated interest in the deep-sea environment and the excitement of exploration. Each year, new methods and new equipment, such as video encoders, are tried and tested in an effort to improve data management activities.

d) Education and Outreach

Education and outreach objectives included the engagement of the general public in ocean exploration through live video and a variety of other web-based products, both during and after each cruise. Web content included topical essays, daily updates, web logs, highlight videos, still imagery, and mapping products—all of which were posted on the expedition website (https://oceanexplorer.noaa.gov/okeanos/explorations/ex1606/welcome.html). Other educational objectives included school tours to ECCs during live broadcasts, as well as live interactions with expedition science team members at the Exploratorium and the Waikiki Aquarium.

2.3.2 Science Objectives

The objectives of the expedition were to survey deepwater areas in and around the previously unexplored deep water around WAU, in order to provide baseline information to support management and science needs of the Monument. Specifically, this expedition sought to:

(1) Survey Mn-crusted habitats within the Prime Crust Zone (PCZ).
(2) Identify and characterize vulnerable deepwater marine habitats, particularly high-density communities of deep-sea corals and sponges living on Mn crusts.
(3) Collect information about the geologic history of western Pacific Seamounts, focusing on the morphology and (after lab analysis) age of the volcanoes.
(4) Locate and survey the historically important WWII Japanese destroyer, *Hayate*, sunk during the Battle of Wake Island in 1941.
(5) Provide a foundation of publicly accessible data and information products to spur further exploration, research, and management activities in the future.

3. Methods

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

(1) dual-body ROV system to conduct daytime seafloor surveys, as well as to collect limited numbers of specimens to help further characterize the deepwater fauna and geology of the region;
(2) mapping systems (including Kongsberg EM 302 multibeam sonar) to conduct nighttime mapping operations and when the ROV was on deck, combined with backscatter intensities of the mapped areas to target hard (presumably Mn-coated) substrate for the dives; and
(3) high-bandwidth satellite connection for real-time ship-to-shore communications.

3.1 ROV Operations

NOAA Ship *Okeanos Explorer* is equipped with NOAA's custom-built, dual-body, 6,000-meter-rated ROV that is comprised of two interconnected vehicles: *Deep Discoverer* (*D2*) and *Seirios*. *Seirios* is directly cabled to the ship and is, therefore, subjected to the vertical movements of the ship from surface swell. *D2* is laterally tethered to *Seirios* and is, therefore, largely isolated from surface conditions.

D2 has five high-definition (HD) cameras, five standard-definition cameras, and 24 light-emitting diode (LED) lights that bring 144,000 lumens to the seafloor—resulting in some of the highest-quality deep-sea footage in the industry. Four custom-built lighting swing arms allow for the position and angle of the light to be adjusted for optimal imaging. *D2* also has two manipulator arms, a Schillings Orion arm and a Kraft Predator arm. The Kraft arm is more dexterous and is outfitted with custom-built jaws that allow for delicate work like sample collection, detaching small sample fragments, and equipment deployment or recovery. The Orion arm is used as a backup; this arm is also outfitted with a color calibration card. At the beginning of each dive, the HD video cameras on *D2* are color-corrected and white-balanced with the use of this card.

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. Both vehicles have a Sea Bird 9/11+ CTD with dissolved oxygen (DO) sensors.

The protocol for each of the dives was essential the same. The ROV descended to the deepest point of the dive then slowly surveyed upslope, video-documenting the geology and biology, thereby providing an initial site characterization. Onboard science leads were assisted by the participating shore-based scientists with animal identifications, specimen collections, and dive

time management. Additional information about the general process of site selection, collaborative dive planning, scientific equipment on the ROVs, and the approach to benthic exploration can be found in Kennedy et al. (2019).

3.2 Sampling Operations

The *D2* sampling protocol restricted the number of samples collected per dive to two geological and two biological specimens. This rule did not apply to commensal organisms found on the rocks and targeted animals after they were brought to the surface. Samples were collected from the seafloor using the Kraft manipulator and placed into one of the six biological and geological collection boxes on the ROV. At the time of each collection event, the date, time, latitude, longitude, depth, salinity, temperature, and DO were recorded. Relatively large, angular rocks were selected to increase the likelihood of collecting a volcanic rock (within a thick Mn crust). These rocks were targeted to provide information about the geological age and chemical composition of the feature they were collected from. Biological specimen collections targeted samples that represented potential new species, or were new records for the region (though technically all deepwater species were a new record).

Once the samples were brought back on deck, they were examined for commensal organisms, labeled, photographed, and inventoried into a database containing all relevant metadata. Any commensal organisms found were separated from their host sample and processed separately. Geological samples were air dried and placed in rock bags or small containers depending on the size of the sample. At the conclusion of the *Okeanos Explorer* 2016 expeditions, they will be shipped to the Marine and Geology Repository at Oregon State University (OSU) where they will be photographed and entered into the university's online database. Thin and polished sections are made for each hard-rock sample. Descriptions and photos are included in the database. An aliquot consisting of ~1 cm^2 of tissue was removed from most of the biological samples and processed for genetic analysis using a kit provided by the Ocean Genome Legacy (OGL). The remainder of the biological sample was preserved in 95% ethanol. After the 2016 expeditions, all genetic samples will be sent to OGL for DNA sequencing and storage, whereas the biological specimens preserved in ethanol will be sent to the National Museum of Natural History, Smithsonian Institution (USNM), for taxonomic identification, archival, and permanent storage in their invertebrate collections.

3.3 Seafloor Mapping

Seafloor mapping was conducted during all transits from/to port and between ROV dive sites. The corresponding mapping data report for EX-16-06 can be found in the NOAA central library.

In lieu of two dives canceled due to weather conditions, two days were dedicated to mapping more of the seamount features in the WAU. Prior to this expedition season, only very shallow bathymetry around Wake Atoll directly had been collected, as well as a handful of transit lines. Earlier in the season, mapping had been carried out in the WAU on EX-16-04; therefore, most seamounts targeted for dives had only been partially mapped. Consequently, mapping consisted mainly of characterizing the remaining parts of the seamounts that were dive targets. In addition, bad weather time was spent on mapping McDonnell Seamount, a large seamount west of Wake Atoll, and the broad area around the island. Mapping operations consisted of collecting bathymetry and backscatter data with the ship's EM 302 sonar system. All mapping data collected during the expedition were submitted to the National Centers for Environmental Information (NCEI), formerly the National Geophysical Data Center (NGDC) at the end of the 2016 expeditions for archival.

3.3.1 Multibeam Sonar (Kongsberg EM 302)

Multibeam seafloor mapping data were collected using the Kongsberg EM 302 sonar, which operates at a frequency of 30 kHz. Multibeam mapping operations were conducted during all overnight transits between ROV dive sites, which were designed to maximize coverage over seafloor areas with no previous high-resolution mapping data whenever feasible. Overnight surveys were also completed in some areas that were previously mapped with a lower resolution multibeam sonar system. Additionally, multibeam mapping operations were conducted directly over planned ROV dive locations in order to collect seafloor mapping data to help refine dive plans. Multibeam mapping operations collected data on seafloor depth (i.e., bathymetry), seafloor acoustic reflectivity (i.e., seafloor backscatter), and water column reflectivity (i.e., water column backscatter).

3.3.2 Subbottom Profiler (Knudsen Chirp 3260)

The primary purpose of the Knudsen Chirp 3260 (3.5 kHz) sonar is to image sediment layers underneath the seafloor to a maximum depth of about 80 meters below the seafloor. The subbottom profiler was operated simultaneously with the multibeam sonar during mapping operations in order to provide supplemental information about the sedimentary features underlying the seafloor.

3.3.3 Split-beam Sonars (Kongsberg EK60)

The *EX* is equipped with five Kongsberg EK60 split-beam sonar transducers operated at frequencies of 18, 38, 70, 120 and 200 kHz. These sonars were used continuously (aside from the 38 kHz, which interferes with the multibeam during mapping operations) throughout the cruise during both overnight mapping operations and daytime ROV operations. The sonars provided calibrated target strength measurements on water column features such as dense

biological layers or schools of fish. These sonars can also help detect the presence of gaseous seeps emanating from the seafloor.

3.3.4 ADCPs (Teledyne ADCPs)

The *EX* is equipped with two ADCPs: a Teledyne Workhorse Mariner (300 kHz) and a Teledyne Ocean Surveyor (38 kHz). This ADCP had a reliable range of approximately 60 meters throughout the expedition and provided information on the speed and direction of currents underneath the ship. It was used throughout ROV dives to support safe deployment and recovery of the vehicles.

3.3.5 XBTs

XBTs were deployed to obtain sound velocity profiles to help calibrate the multibeam system and ensure accurate bathymetric mapping. The XBT type is the Deep Blue probe produced by Lockheed Martin Sippican. XBTs 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 sound velocity probe, and salinity measurements near the transducers were taken using the ship's flow-through thermosalinograph (TSG).

3.4 Operations

During all CAPSTONE expeditions, NOAA Ship *Okeanos Explorer* operations were conducted continuously around-the-clock and involved either 24-hour-per-day sonar mapping (i.e., mapping-only cruises) or both sonar mapping and ROV dives. For dive planning purposes, existing gridded bathymetry data were viewed in collaboration with the onshore science team as the ROV was being recovered each day. Dive tracks for the next day were then planned, plotted in 3D, and shared with the onboard and shoreside teams prior to the next dive. Tables of the at-sea mission personnel and the shore-based science team are located in **Appendix A** of this report.

3.4.1 Onboard Operations

On this ROV and mapping cruise, mapping operations were initiated as soon as the ship left port and continued each day as soon as the ROVs were secure on deck around 1700. Mapping continued throughout the night until the ship arrived on the next dive site, generally around 0600. Transit surveys were conducted to fill as many data gaps as possible while still ensuring the ship arrived at the dive site on time. Site surveys were conducted at a number of locations when permitted by a shorter transit between dive sites. The mapping and science leads worked

together to develop the ROV trackline plans for these sites, since these surveys in particular were carried out in support of science objectives.

During combined mapping and ROV expeditions, HD video data are recorded and archived in several different formats and resolutions. The dives were recorded in their entirety at 720p. In addition to the full dive recording, a subset of the video collected was preserved in ProRes 4.2.2. 1080i, 145 Mbps. These ProRes highlight clips were selected by the onboard videographers to capture the seafloor habitats and features imaged any time the ROV slowed, stopped, or zoomed in to take a closer look at a feature of interest; features and habitats of interest to the participating science team; and other "best of" imagery. The video clips were time coded to Universal Time Coordinated (UTC) time to coordinate with all data products collected on the ship. In addition to the video itself, at least one frame grab was taken from each ProRes clip that was representative of that video segment for the purpose of discoverability. ProRes clips were then compressed for archiving.

All four sonars were operated simultaneously during mapping operations, with the acquisition of multibeam data generally being the priority for ROV trackline planning. Sound velocity profiles were obtained with XBTs every few hours as standard protocol to ensure the quality of the multibeam data.

ROV operations were conducted during daylight hours, generally starting with the ship arriving on site at 0600, the ROV entering the water around 0830, and the ROV exiting the water around 1630. Operations were conducted at UTC+12 to facilitate collaboration with the U.S. mainland. This schedule generally yielded approximately eight hours of video per dive. CTD data were collected during each dive via the CTD sensors onboard both the *Seirios* sled and *D2*. Both geological and biological samples were collected during the seafloor portion of each dive using *D2*'s manipulator arms. These samples were placed into the sample boxes and retrieved by the onboard science team after the ROV had been secured on deck. Samples were processed immediately in the ship's lab, the protocol for which was described in **Section 3.2**.

3.4.2 Shoreside Operations

The current operating model for NOAA Ship *Okeanos Explorer* cruises is based on telepresence-enabled participation whereby the small onboard science team is augmented by a much larger shoreside science team located around the world. When this model was first implemented from 2010 to 2012, all of the shore-based scientists were co-located at only a few ECCs around the U.S., where they actively helped in the planning and execution of dives. This first effort was called the core participation model because it only accommodated a limited core group of shoreside participants. Subsequently, this model was replaced by a distributed participation

model when the ship's video and audio communication became accessible from any location with an Internet connection (Elliott et al., 2014). This enabled many geographically dispersed scientists to actively participate in the dives from their home institutions or even their own homes. In this paradigm, digital communications such as email and instant messaging replaced the person-to-person discussions and idea exchanges that naturally occur when a group is stationed together. The benefit of this distributed model was that the size of the science team was much larger.

For this expedition, a hybrid of the core and distributed models occurred. Shoreside participation involved small core teams stationed across the country in ECCs in addition to a larger geographically distributed team. This hybrid participation model still benefited from the information exchange and collaboration networks that developed during the use of the distributed model. However, it also benefited from the advantages of having ECCs that included higher Internet2 speeds, the means to simultaneously display all of the video feeds being sent off the ship, and direct interaction between the scientists participating at ECCs. This model is particularly effective for NOAA Ship *Okeanos Explorer*'s exploration.

3.5 Education and Outreach Activities

OER is constantly reaching out in new ways to stakeholders to improve the literacy of learners of all ages with respect to ocean issues. The team engaged the general public in ocean exploration through live video and a variety of other web-based products, both during and after the cruise. Web content included topical essays, daily updates, web logs, highlight videos, still imagery, and mapping products—all of which were posted on the expedition website (https://oceanexplorer.noaa.gov/okeanos/explorations/ex1606/welcome.html). A number of education and outreach activities were conducted during the expedition and included several live interactions, some with school tours to ECCs and others with team members hosting events at the Exploratorium and the Waikiki Aquarium.

4. Expedition Schedule

The expedition was conducted over a total of 23 days at sea, from July 27 to August 18, 2016, starting from Guam and ending in Kwajalein, RMI. Due to mechanical and weather problems, the original cruise plan was adjusted to keep the number of lost dives at a minimum. In total, 16 dives were planned, and 14 were actually executed. In order to accomplish this many dives, the expedition skipped two Japanese lease block sites to map while transiting instead. As a result,

only two dives were completely lost due to bad weather. Of the 14 dives, one dive (Dive 4) was aborted before it reached the seafloor. The schedule is provided in **Table 1**.

The EX-16-06 expedition started in Guam, 17 days after completion of the three-cruise *2016 Deepwater Exploration of the Marianas* expedition, also known as EX-16-05. As a result, several days of transit were necessary to reach the WAU of the PRIMNM. The original cruise plan included three dives on ISA lease blocks to establish a baseline of communities that could experience impacts from mining activities. Due to mechanical issues, two of these dives were canceled. As a consequence, most of the first five days consisted of mapping the entire transit to the WAU. After arrival in the Monument, mapping was conducted every night, as well as during two complete bad weather days and during the transit to Kwajalein, RMI. The map in **Figure 2** shows a complete mosaic of the entirety of the mapping data collected on the cruise overlain on previously existing data.

Table 1. *EX-16-06 Expedition Schedule.*

Date (UTC)	Location	Operation
7/27/16	Guam (Apra Harbor)	Departure
7/28/16	Transit	Mapping
7/29/16	Alba Guyot (“Vlinder Seamount”)	Dive 1
7/30/16	Transit	Mapping
7/31/16	Transit	Mapping
8/1/16	Sampson Guyot	Dive 2
8/2/16	“Delilah Seamount”	Dive 3
8/3/16	McDonnell Guyot (only water column)	Dive 4
8/4/16	McDonnell Guyot	Dive 5
8/5/16	Small seamount west of Wake Atoll (“Moon Waffle Seamount”)	Dive 6
8/6/16	Transit (bad weather)	Mapping
8/7/16	Transit (bad weather)	Mapping
8/8/16	Seamount 130 nm south of Wake Atoll (“Lafayette Seamount”)	Dive 7
8/9/16	North Wake Atoll	Dive 8
8/10/16	West Wake Atoll	Dive 9
8/11/16	Small seamount south of Wake Atoll	Dive 10
8/12/16	East Wake Atoll	Dive 11
8/13/16	Seamount 70nm southwest of Wake Atoll (“Revolver Seamount”)	Dive 12
8/14/16	Southernmost seamount (“Batfish Seamount”)	Dive 13
8/15/16	Seamount near RMI EEZ (“Last Dive Seamount”)	Dive 14
8/16/16	Transit	Mapping
8/17/16	Transit	Mapping
8/18/16	Kwajalein, RMI	Arrival

5. Results

The expedition started in Guam and ended in Kwajalein, RMI (**Figure 2**). After departing from Guam, NOAA Ship *Okeanos Explorer* transited southeast towards the WAU of the PRIMNM. ROV and mapping operations were conducted in route to, inside of, and around the WAU of the PRIMNM, and extended to the areas south of the WAU of the PRIMNM in route to Kwajalein, RMI. After completing ROV dive operations on August 15, NOAA Ship *Okeanos Explorer* transited to Kwajalein, RMI, and conducted mapping operations throughout the transit.

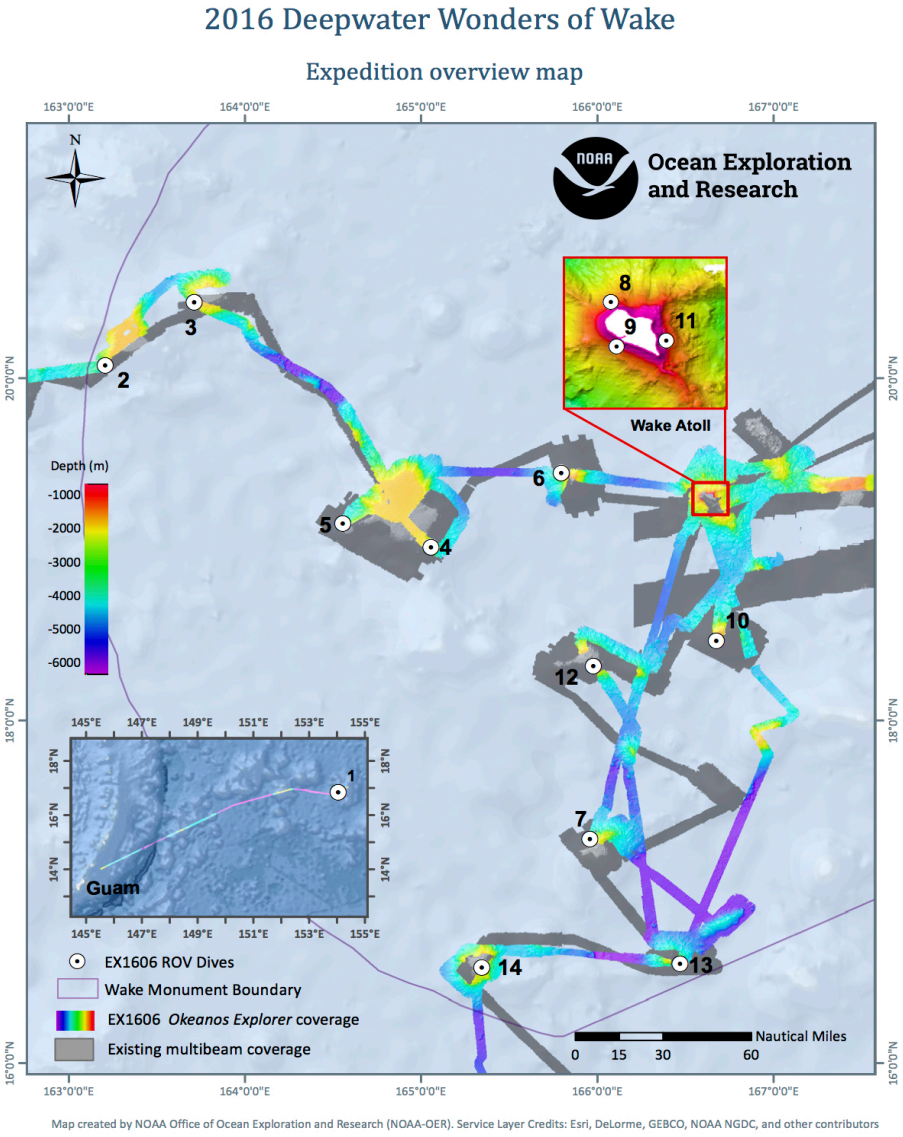

Figure 2. *Map showing the locations of the 14 ROV dives (numbered circles) conducted during EX-16-06 on bathymetry from EX-16-06 (colored) and EX-16-04 (most of the grey tones). Inset shows mapping track from Guam to the first dive site. Map courtesy of the expedition mapping team.*

5.1 ROV seafloor surveys

Of the 14 ROV dives performed, 13 reached the bottom and surveyed the seafloor for varying amounts of time (see **Figure 3**). The deepest dive started at 3,135 m, while the shallowest dive started at 639 m (and broke 500 m). The amount of time on the bottom (1:28 to 8:49) mostly depended on the depth; thus, the total dive time was limited to eight or 10 hours, although the last two dives were cut short for bad weather. The dives routinely aimed to cover approximately 800 m of dive track; however, on Dive 9, the ROV covered over 4 km between the original archeology site (where a ship was found) and two backup sites. A summary of the dives is listed in **Table 2**.

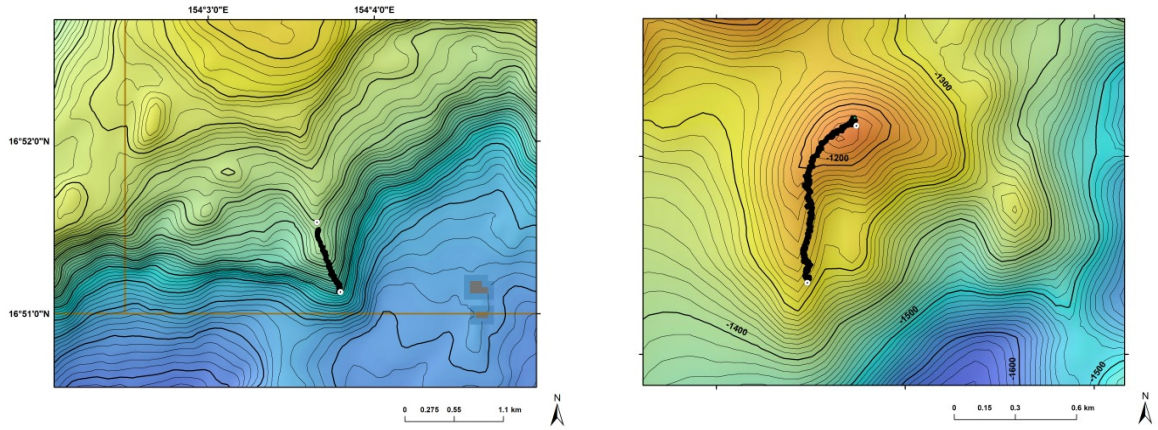

Figure 3. *Examples of dive tracks on (left) a ridge crest (Dive 01), and (right) a cone feature (Dive 12).*

The first ROV dive was outside of the WAU, on a Russian ISA lease block, in order to compare communities within lease blocks to those inside the Monument boundary. Two dives were originally planned on Japanese ISA lease sites directly outside of the WAU; but, due to technical problems, these dives were traded for transit days in order to maintain the same total number of dives. This dive on Alba Guyot (also reported as "Vlinder Seamount") focused on its southwestern rift zone (**Figure 2**). Similar to many dives in other legs of the CAPSTONE program, as well as the rest of the EX-16-06 expedition, this dive followed a ridge crest up the rift zone, as dense communities have previously been documented—particularly along ridge crests.

The remaining ROV dives were all carried out in the WAU of the Monument, and they served a number of different purposes. In order to explore variations in the communities, based on their submarine setting, multiple ridge crest dives (Dives 2, 3, 5, 6, 7, 10, and 13), and several cone feature dives (Dives 12 and 14; **Figure 2**) were performed in deep water (>1,000 m). In order to test for the impact of different depth ranges, the crest dives varied from dives starting around 3,000 m to 1,200 m. Since Wake Atoll presents an opportunity to explore shallow dives, two dives were carried out at <1,000 m to explore fish and precious corals around Wake Atoll (Dives

8 and 11). One dive was also dedicated to the discovery and survey of what was believed to be the World War II-era *Hayate* shipwreck site. A potential target for the wreck site was identified from bathymetry and backscatter data collected during EX-16-04.

Table 2. *Summary information for the ROV dives conducted during EX-16-06.*

Date	Dive	Latitude	Longitude	Depth (meters)	Time in water	Time on Bottom	Number of Scientists	Notes
7/29/16	1	16°, 51.128' N	154°, 03.788' E	2,319.1	8:00:34	5:33:17	14	
8/1/16	2	20°, 04.476' N	163°, 12.578' E	2,250.7	10:01:17	2:49:59	16	
8/2/16	3	20°, 26.627' N	163°, 42.862' E	1,984.4	8:10:27	5:59:28	13	
8/3/16	4	19°, 00.893' N	165°, 03.482' E	766	1:40:09	0	4	aborted
8/4/16	5	19°, 09.091' N	164°, 33.481' E	2,582.4	10:37:09	7:04:53	13	
8/5/16	6	19°, 26.849' N	165°, 47.806' E	2,230.1	7:45:47	5:10:13	7	
8/8/16	7	17°, 18.584' N	165°, 57.611' E	2,089.9	8:19:48	5:30:57	12	
8/9/16	8	19°, 20.033' N	166°, 36.097' E	1,034.3	7:04:40	5:09:12	16	
8/10/16	9	Redacted	Redacted	Redacted	10:18:36	8:49:07	16	archaeology
8/11/16	10	18°, 28.040' N	166°, 40.725' E	1,514.5	8:10:42	6:23:32	12	
8/12/16	11	19°, 17.144' N	166°, 40.150' E	639.4	8:08:48	6:49:52	14	
8/13/16	12	18°, 19.184' N	165°, 58.742' E	1,266.6	8:03:26	6:32:33	9	
8/14/16	13	16°, 34.861' N	166°, 28.317'	3,135.5	7:00:19	1:27:11	9	bad weather
8/15/16	14	16°, 33.638' N	165°, 20.754' E	1,283.9	6:46:58	3:30:05	14	bad weather

5.1.1 Geological Observations and Setting

The deepwater geology of the WAU could be summarized as a series of Cretaceous seamounts. All sampling sites were located on some part of flat-topped seamounts, also known as guyots. Their structure was similar, consisting of a star-shaped pattern of deeper rift zones, with a central shallow, flat top. The exceptions were the seamounts explored during Dives 5 and 12, which showed a smaller neighbor volcano (also guyots) connected by a rift zone on the west side, making for paired volcanoes (previously observed in the Marshall Islands). Except for Dive 13 and the dives on Wake Atoll, the guyots all show a flat top around 1,400 m. Dive 13 explored a guyot that has its flat top at 2,200 m, while Dives 8, 9, and 11 were all in the shallow waters around Wake Atoll. The 2,200 m deep guyot clearly underwent a different geologic history than the other seamounts in the WAU of the Monument. Since guyots typically are thought to become deeper with age, one interpretation might be that this particular seamount is significantly older than the surrounding seamounts. However, even within hotspot chains where ages are known, it has been shown that there is no perfect relationship between depth and age. Only radiogenic age dating will be able to answer this question conclusively.

A more detailed look at the dive sites shows that the majority of the dives were conducted on ridge crests along the deeper rift zones, while two dives visited guyot tops, and three dives

were conducted in shallow water. The ridge crest dives generally were characterized by thick FeMn crusts covering what commonly appeared to be pillow lavas (and tube lavas). On many of the ridge crests, the pillow lavas occurred as concentrated pillow mounds, separated by more sedimented areas. The steeper sides of the pillow mounds provided insight into the potential FeMn crusts, resulting in estimates of up to several inches.

The two guyot-top dives were also conducted, one strictly on a cone on top of the guyot plateau (Dive 12), while the other dive covered a section of plateau and then the slope of a cone (Dive 14). These dives contrasted in their makeup. The cone explored in Dive 12 showed significant layer structures, and—based on the samples—perhaps consists of volcaniclastic sediment layers (implying near-surface eruption). Dive 14 showed pillow lavas and pillow mounds, as well as a substantially more dome-like overall morphology for the cone (implying deeper eruption). The placement of these cones on top of the otherwise flat guyot top implies eruption after a phase of erosion and—potentially—reef formation, generating the flat plateau. This type of volcanism has previously been observed on other guyots (i.e., Alba Guyot, mapped in the 1980s), and is likely equivalent to post-erosional stage volcanism in hotspot volcanoes such as those in Hawai‘i. The difference between the seamounts and their shallow versus deeper eruption at this stage may relate to differences in original volcano size or relative sea level. Extensive sampling of both the base and multiple cones would be needed, combined with age dating, to solve this question.

The last setting explored was the shallow waters around Wake Atoll (Dives 8, 9, and 11). In this setting, significant amounts of carbonate debris were observed. The debris consisted of sand, cobbles, boulders, and exposures of carbonate layers of mainly shell and coral debris from the adjacent, shallow reef. The carbonate layer exposures formed quite steep rock formations with steeply inclined bedding (away from the present-day island). Although the contact with the sand was very sharp, the overall carbonate exposures seemed rather rounded with holes in the layers that resembled dissolution features. When island was submerged again, a new reef partly covered the weathered (potentially Cretaceous) reef deposits. Interestingly, the carbonate-layered deposits in water depths shallower than 1,000 m showed a thin coating of FeMn crust. This would require either a substantially higher sea level (by several hundred meters), or the shallow limit for crust deposition to be shallower than 1,000 m. Examples of the different types of geology observed during this expedition can be seen in **Figure 4**.

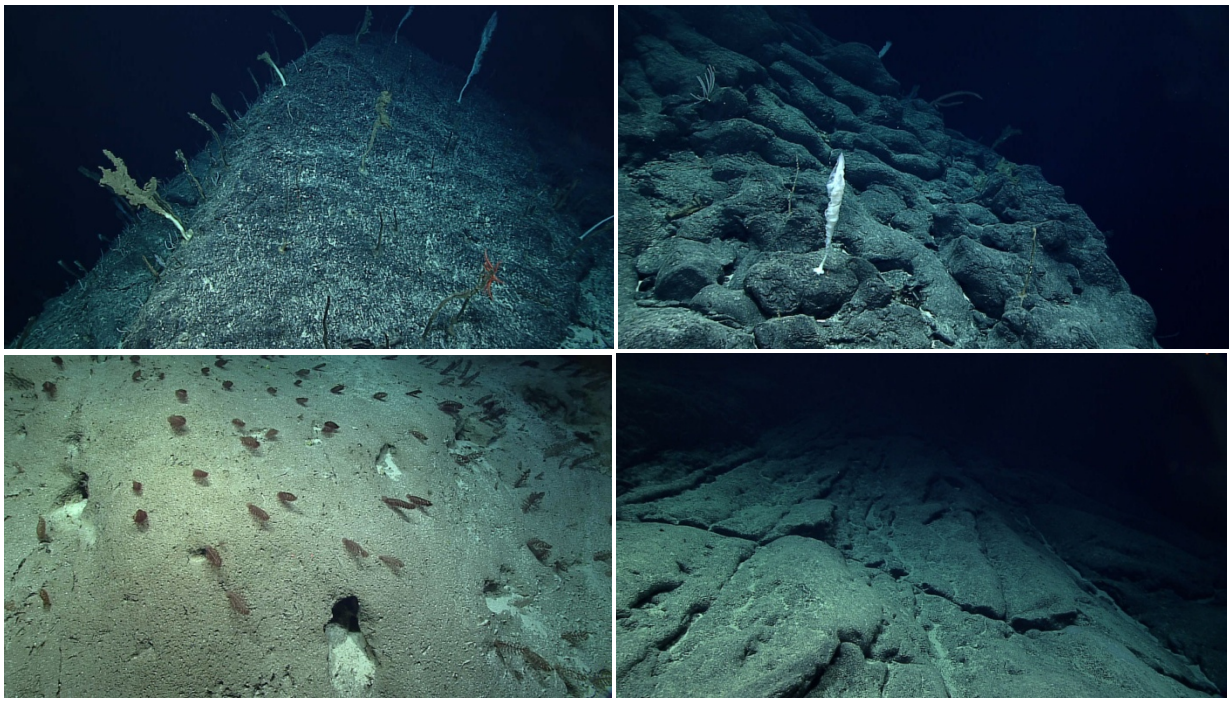

Figure 4. *Examples of different types of geology observed during the dives. Upper right: steep rift zone ridge, Upper left: Mn-encrusted pillow lava flows, Lower left: drowned carbonate reef debris on the slopes of Wake Atoll, Lower right: Mn-encrusted volcaniclastic material on the rim of a volcanic cone found on the summit of an unnamed guyot.*

5.1.2 Description of the Deepwater Biology

High-density communities of deepwater corals and sponges were discovered during four of the dives (Dives 2, 3, 10, and 11), the last being a shallow dive conducted on the east slope of Wake Atoll. The community composition and the types of dominant species were different on each site. Although Dives 2 and 3 were conducted on adjacent seamounts (Sampson Guyot and "Delilah Seamount"), Dive 2 found a strange community of unusual two branched primnoids in the genus *Narella* mixed with antipatharians (*Heteropathes* or *Trissopathes* sp.) and an unusual demosponge dubbed the "Kebab" sponge, whereas Dive 3 found a community of various corals (isidids, coralliids, and primnoids) mixed with large pheronematid glass sponges. The densest groups were observed on the topographic highs. Dive 10 found the most amazing community dominated by huge, apparently very old, coralliids (*Hemicorallium* sp.), primnoids (*Calyptrophora* sp.), and isidids mixed in with various other species of corals and sponges. This was perhaps the most spectacular community found during the cruise. Dive 11 found a dense, shallow community of precious gold and bamboo corals (*Kulamanamana haumeaae* and *Acanella* sp.) growing on the edge of a terrace or fault block. Thousands upon thousands of sea pens (*Calibelemnon* sp.) were observed both below and above the edge. Each of these communities had many other species that were observed in lower numbers. **Figure 5** shows example images of several of these communities. The other dive sites were found to have

moderate- to low-density communities, again each differing in composition and dominant species.

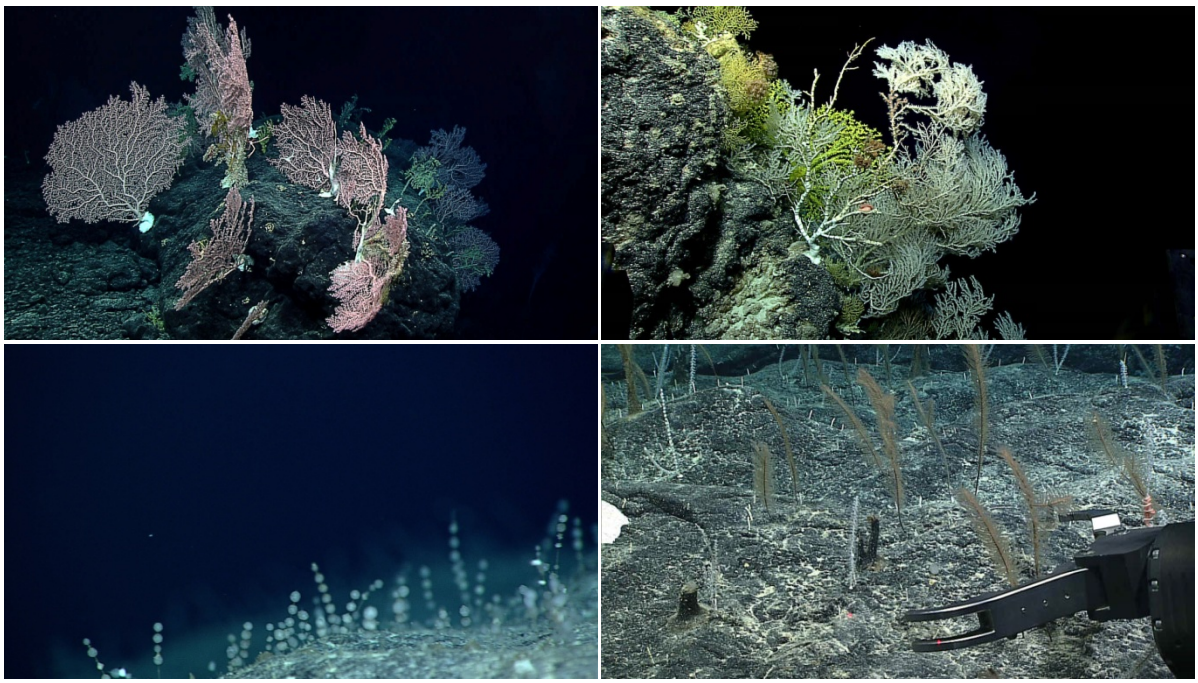

Figure 5. *Different types of high-density communities of deep-sea corals and sponges were encountered at a number of the dive sites, including one dominated by large* Hemicorallium *sp. (upper left); a community dominated by* Acanella *sp. being overgrown by the gold coral* Kulamanamana haumeaae *(upper right); a dense, moderately-sized community of "kebab" demosponges (lower left); and two-branch* Narella *sp. and* Parantipathes *sp. (lower right).*

The dives also revealed some surprises in the fish communities in the WAU. **Figure 6** provides some examples of the more unusual sightings. Perhaps the most common fish group encountered during the deeper dives (>2,000 m) was the cutthroat eels in the family Synaphobranchidae, followed by cusk-eels (Ophidiidae), and rattails (Macrouridae). Halosaurs were the most numerous fishes at intermediate depths (800-1,500 m) whereas alfonsinos (*Beryx decadactylus*) and tinsel fish (*Grammicolepis brachiusculus*) dominated during the one dive conducted above 600 m.

Dive summaries, which give detailed descriptions of observations form each dive, can be found in **Appendix B** of this report. Many other species of both invertebrates and fishes were recorded during the dives; a full list is provided in **Appendix C**. The number of new species is difficult to estimate and considered provisional until confirmed by taxonomic authorities. A few of the corals and sponges were examined under a microscope during the cruise and there clearly are some unusual species, likely new to science. Due to the fact that this cruise was the

first deepwater biological investigation around Wake Atoll, all of the animals collected—as well as imaged by the ROV cameras—are new records for this area.

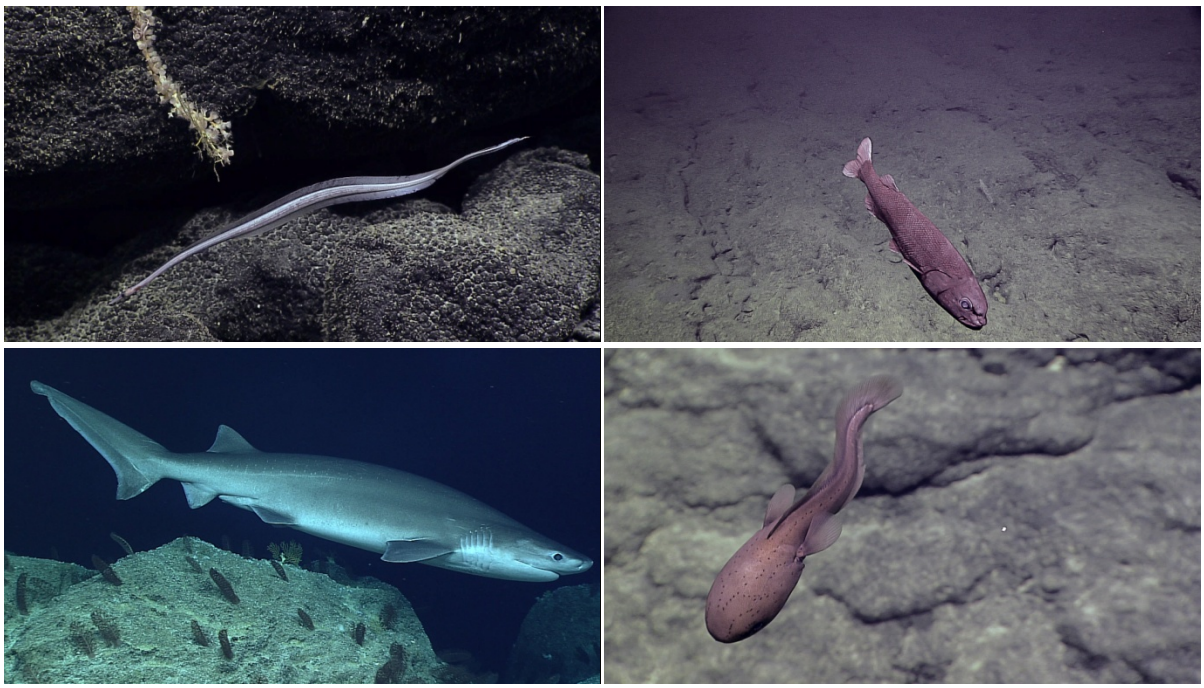

Figure 6. *Examples of some of the unusual fishes observed during the dives. Upper left: rare sorceress eel (*Venefica *sp.;. Upper right: a slime head (Aulepocephalidae;,Lower left: a six gill shark (*Hexanchus griseus*); and Lower right: a suspected rare and unusual species of rattail (Macrouridae).*

5.1.3 Archaeology

Dive 9 was the effort to locate the final resting place of the Japanese destroyer, *Hayate*. The following text was excerpted and paraphrased from the dive summary report text written by NOAA marine archaeologists Hans van Tilburg (Historian, Office of National Marine Sanctuaries) and Frank Cantelas (Chief of Science and Technology Division, OER). The primary target appeared to have the correct dimensions in multibeam data for that vessel (just short of 100 m) as well as height from the surrounding seafloor (roughly 10 m). The vehicles landed approximately 100 m from the target where the seafloor consisted of mainly sand with occasional cobbles and boulders—all carbonate derivatives from the reef. Along the way to the target, the team observed steep terrain with sand and cobbles (to boulders) with a few pieces of debris, suspected to be wooden planks (presumably from the ship's deck). The vehicles arrived at the target location and acquired an image on sonar less than 30 minutes later. The team expected to first encounter the stern of the wreck but instead encountered the bow; thus, the team conducted a low-level visual survey down the starboard side, ascending over the transom and recording an overhead view on return from stern to bow. The prevailing current prevented the *D2* survey of the port side. As soon as the survey started, features varied from the expected destroyer—revealing that the vessel was not the Kamikaze-class *Hayate*, but the

Japanese peace-time converted water carrier, *Amakasu Maru No. 1*. The *Amakasu Maru No. 1* (**Figure 7**), launched in August 1939, was a 1,913-ton, 271-foot long, 40-foot beam, Type D merchant vessel—the first of her class of 40 similar vessels built prior to the war. On December 24, 1942, soon after departing from the Japanese garrison on Wake Island, the USS *Triton* (SS-201) torpedoed the *Amakasu Maru No. 1*, sending the water tanker down with 12 of her crew. Diagnostic features, which confirmed the identity of the merchant ship, included:

- Engine aft design with bridge well forward
- Single-screw, single rudder design
- Masts at forecastle and poop deck
- Kingposts near bridge
- Welded-bead ship name on bow and transom (Japanese and English)

The vessel sat upright on top of sand and some large rocks with a slight (~10 degree) list to starboard. A fore-and-aft split along the starboard bow was mirrored on port by a large hull depression. Two large holes on the lower port hull may be either torpedo damage or rock/bottom impact damage (one source recorded that the USS *Triton's* (SS-201) torpedo hit on port side). A large boulder immediately aft or the propeller appears to have displaced the rudder, which was horizontal atop the boulder. The topside superstructure showed damage, which may be associated with hull impact, sinking, and/or deterioration. The masts had fallen, the stack had fallen and flattened, the cabin spaces were deformed, and the wooden deck was eroded and/or missing. The cargo hold contained large, steel, rectangular containers (possibly water tanks?). Two deck guns had been fitted fore and aft. There was a significant amount of sediment on the deck and in the holds. Rusticles showed abundant growth at numerous locations.

Figure 7. *Bow (left) and stern (right) of the* Amakasu Maru No. 1.

5.2 Specimen Collections

A total of 61 specimens were collected during the expedition, including 20 geological samples and 41 biological specimens. Nineteen of the rocks were Mn-encrusted basalt or sediment, and

one was carbonate. The total weight of all geological samples was nearly 150 kg, with individual rocks ranging between 0.4 and 21.8 kg (**Table 3**). The 41 biological samples collected included 19 corals, eight sponges, three brittle stars, two sea stars, two squat lobsters, two polychaete worms, one stalked crinoid, one shrimp, one barnacle, one bivalve and one unknown blue organism. **Table 4** provides the data for these collections. Images of selected geological and biological samples are in **Figures 8** and **9**.

Table 3. *Inventory of geological samples collected during EX-16-06.*

Specimen ID	Description	Preservation	Weight (kg)	Date (UTC)	Time (UTC)	Latitude	Longitude	Depth (m)	Salinity	Temp. (°C)	Oxygen (mg/l)
D2_DIVE01_SPEC 01GEO	Mn-encrusted volcanic rock	Dry	5.7	20160729	22:56:40	16.85219	154.06314	2315.7025	34.64622	1.9512	3.34226
D2_DIVE01_SPEC 04GEO	Mn crust, likely little substrate	Dry	8	20160730	4:02:00	16.85784	154.06097	1993.2129	34.62967	2.114	3.19293
D2_DIVE02_SPEC 01GEO	Mn-encrusted sediment	Dry	13	20160802	3:33:01	20.07492	163.21028	2229.0453	34.64495	1.86651	3.36068
D2_DIVE03_SPEC 01GEO	Mn-encrusted rock	Dry	2.9	20160802	22:28:41	20.44384	163.71486	1976.855	34.61915	2.11927	3.05987
D2_DIVE03_SPEC 03GEO	Mn crusted rock	Dry	6.8	20160803	1:25:36	20.44506	163.71816	1857.2514	34.61548	2.14459	3.09811
D2_DIVE05_SPEC 01GEO	Mn-encrusted rock	Dry	2.8	20160804	22:32:57	19.15147	164.55808	2580.5131	34.66646	1.59061	3.9374
D2_DIVE05_SPEC 03GEO	Mn-encrusted tube lava	Dry	21.8	20160805	1:22:26	19.14764	164.56051	2545.3429	34.66455	1.62185	3.79453
D2_DIVE06_SPEC 01GEO	Mn-encrusted, possible small pillow	Dry	5.8	20160806	1:40:44	19.44623	165.79723	2160.4303	34.63834	1.92359	3.32429
D2_DIVE06_SPEC 04GEO	Lava tube slice with Mn	Dry	13.6	20160806	4:18:53	19.44387	165.79941	2069.3363	34.62676	2.03175	3.19154
D2_DIVE07_SPEC 01GEO	Mn-coated pillow fragment	Dry	1.8	20160808	22:46:33	17.30961	165.96029	2074.2509	34.62473	2.20481	3.05127
D2_DIVE07_SPEC 03GEO	Mn-encrusted rock	Dry	7.9	20160809	2:19:46	17.30803	165.96167	1949.4269	34.63722	2.21001	2.9912
D2_DIVE10_SPEC 01GEO	Mn-crusted rock	Dry	9.5	20160811	21:46:43	18.46722	166.67883	1507.3082	34.57288	2.84161	2.57539
D2_DIVE10_SPEC 04GEO	Mn-crusted rock	Dry	6.3	20160812	2:31:28	18.47119	166.68157	1414.7739	34.57722	2.87375	2.52096
D2_DIVE10_SPEC 05GEO	Pebble from collected coral	Dry	0.4	20160812	2:19:41	18.4712	166.6815	1414.8265	34.57706	2.83988	2.57109
D2_DIVE11_SPEC 03GEO	Carbonate rock	Dry	5.2	20160813	3:17:58	19.28924	166.66534	461.1346	34.16181	8.83498	4.26991
D2_DIVE12_SPEC 01GEO	Mn-crusted rock	Dry	10.5	20160813	21:23:23	18.31982	165.97902	1266.4993	34.5555	3.2902	2.53598
D2_DIVE12_SPEC 03GEO	Mn-crusted rock, likely volcaniclastic	Dry	8.5	20160814	2:11:49	18.3258	165.97993	1169.3849	34.54303	3.55305	2.48568
D2_DIVE13_SPEC 01GEO	Mn rock	Dry	3.5	20160815	1:43:20	16.58115	166.47195	3096.8367	34.65527	1.59987	3.98942
D2_DIVE13_SPEC 04GEO	Mn-coated rock	Dry	4.2	20160815	2:38:50	16.58185	166.47184	3059.6537	34.68079	1.5973	3.89194
D2_DIVE14_SPEC 01GEO	Mn-crusted rock	Dry	12.2	20160815	22:49:20	16.55981	165.34538	1278.8139	34.55801	3.75843	2.23224

Table 4. *Inventory of biological samples collected during EX-16-06.*

Specimen ID	Description	Group	Preser-vation	DNA vial number	Date (UTC)	Time (UTC)	Latitude	Longitude	Depth (m)	Salinity	Temp. (°C)	Oxygen (mg/l)
D2_DIVE01_ SPEC02BIO	*Crateromorpha* sp.	Sponge	95% Ethanol	252	20160730	1:00:54	16.85363	154.06268	2168.9353	34.64161	1.98232	3.33526
D2_DIVE01_ SPEC03BIO	Hyocrinidae new genus	Crinoid	95% Ethanol	253	20160730	1:58:06	16.85455	154.06219	2113.4995	34.63424	2.17046	3.1842
D2_DIVE02_ SPEC01GEO_ C01	Stylasteridae	Coral	95% Ethanol	84	20160802	3:33:01	20.07492	163.21028	2229.0453	34.64495	1.86651	3.36068
D2_DIVE02_ SPEC02BIO	*Trissopathes* sp. or *Heteropathes* sp.	Coral	95% Ethanol	46	20160802	5:16:35	20.0762	163.21214	2176.5726	34.63808	1.89693	3.3739
D2_DIVE03_ SPEC02BIO	"Kebab" demosponge	Sponge	95% Ethanol	254	20160803	0:05:13	20.44461	163.71659	1890.5744	34.62001	2.08363	3.08341
D2_DIVE03_ SPEC03GEO_ C02	Hexactinellida	Sponge	95% Ethanol	256	20160803	1:25:36	20.44506	163.71816	1857.2514	34.61548	2.14459	3.09811
D2_DIVE03_ SPEC04BIO	*Hemicorallium* sp.	Coral	95% Ethanol	47	20160803	3:01:51	20.44546	163.71951	1846.7753	34.60765	2.24615	2.92634
D2_DIVE03_ SPEC04BIO_ C01	Ophiuroidea	Brittlestar	95% Ethanol	255	20160803	3:01:51	20.44546	163.71951	1846.7753	34.60765	2.24615	2.92634
D2_DIVE05_ SPEC02BIO	Bifurcating ?*Narella* sp.	Coral	95% Ethanol	49	20160804	23:24:19	19.15048	164.55876	2575.3933	34.66975	1.55947	3.95314

Specimen ID	Description	Group	Preser-vation	DNA vial number	Date (UTC)	Time (UTC)	Latitude	Longitude	Depth (m)	Salinity	Temp. (°C)	Oxygen (mg/l)
D2_DIVE05_ SPEC04BIO	*Pleurogorgia* sp.	Coral	95% Ethanol	50	20160805	5:06:21	19.14289	164.56289	2467.9898	34.66273	1.63898	3.8011
D2_DIVE06_ SPEC02BIO	*Regadrella* sp. new	Sponge	95% Ethanol	257	20160806	2:20:28	19.44588	165.79737	2149.1119	34.63746	1.95336	3.26074
D2_DIVE06_ SPEC02BIO_ C01	Shrimp	Shrimp	95% Ethanol	None	20160806	2:20:28	19.44588	165.79737	2149.1119	34.63746	1.95336	3.26074
D2_DIVE06_ SPEC02BIO_ C02	Polynoidae	Polychaete	95% Ethanol	None	20160806	2:20:28	19.44588	165.79737	2149.1119	34.63746	1.95336	3.26074
D2_DIVE06_ SPEC03BIO	*Calyptrophora* sp. unbranched	Coral	95% Ethanol	51	20160806	3:51:41	19.44447	165.79899	2073.2172	34.63257	1.99129	3.23661
D2_DIVE07_ SPEC02BIO	*Chrysogorgia* sp.	Coral	95% Ethanol	52	20160809	1:59:49	17.30822	165.96163	1950.9727	34.62238	2.17029	3.09491
D2_DIVE07_ SPEC02BIO_ C01	*Uroptychus* sp.	Squat Lobster	95% Ethanol	258	20160809	1:59:49	17.30822	165.96163	1950.9727	34.62238	2.17029	3.09491
D2_DIVE07_ SPEC04BIO	?*Jasonisis* sp.	Coral	95% Ethanol	53	20160809	3:06:22	17.30759	165.962	1928.4187	34.61281	2.21584	3.00342
D2_DIVE07_ SPEC04BIO_ C01	Ophiuroidea	Brittlestar	95% Ethanol	259	20160809	3:06:22	17.30759	165.962	1928.4187	34.61281	2.21584	3.00342
D2_DIVE07_ SPEC04BIO_ C02	Barnacle	Barnacle	95% Ethanol	260	20160809	3:06:22	17.30759	165.962	1928.4187	34.61281	2.21584	3.00342
D2_DIVE08_ SPEC01BIO	*Narella* sp.	Coral	95% Ethanol	54	20160810	3:35:27	19.33042	166.60384	745.1986	34.34642	5.26365	1.69854
D2_DIVE08_ SPEC01BIO_ C01	Ophiuroidea	Brittlestar	95% Ethanol	None	20160810	3:35:39	19.33042	166.60383	745.1436	34.33391	5.28338	1.72122
D2_DIVE09_ SPEC01BIO	*Paracalyptropho ra* sp.	Coral	95% Ethanol	55	20160811	5:47:00	19.25427	166.635	1105	na	na	na
D2_DIVE10_ SPEC02BIO	*Calyptrophora* sp.	Coral	95% Ethanol	56	20160812	1:18:33	18.47047	166.68059	1408.9928	34.5806	2.72654	2.61558
D2_DIVE10_ SPEC02BIO_ C01	*Evoplosoma* sp.	Sea Star	95% Ethanol	261	20160812	1:18:33	18.47047	166.68059	1408.9928	34.5806	2.72654	2.61558
D2_DIVE10_ SPEC03BIO	*Stauropathes* sp.	Coral	95% Ethanol	57	20160812	2:19:41	18.4712	166.6815	1414.8265	34.57706	2.83988	2.57109
D2_DIVE10_ SPEC03BIO_ C01	Squat Lobster	Squat Lobster	95% Ethanol	262	20160812	2:19:41	18.4712	166.6815	1414.8265	34.57706	2.83988	2.57109
D2_DIVE11_ SPEC01BIO	Blue bio material with pebble	Unknown	95% Ethanol	263	20160813	1:21:32	19.28813	166.66618	483.944	34.15391	8.53818	4.02839
D2_DIVE11_ SPEC02BIO	?*Acanella* sp.	Coral	95% Ethanol	59	20160813	2:10:40	19.2883	166.66588	458.5413	34.18743	9.85629	4.93411
D2_DIVE11_ SPEC02BIO_ C01	Kulamanamana haumeaae	Coral	95% Ethanol	58	20160813	2:10:40	19.2883	166.66588	458.5413	34.18743	9.85629	4.93411
D2_DIVE11_ SPEC03GEO_ C01	Cup coral	Coral	95% Ethanol	None	20160813	3:17:58	19.28924	166.66534	461.1346	34.16181	8.83498	4.26991
D2_DIVE11_ SPEC03GEO_ C02	Bivalve	bivalve	95% Ethanol	None	20160813	3:17:58	19.28924	166.66534	461.1346	34.16181	8.83498	4.26991
D2_DIVE12_ SPEC02BIO	*Rossellidae*	Sponge	95% Ethanol	265	20160814	0:14:52	18.32295	165.97904	1215.3696	34.54683	3.50741	2.48857
D2_DIVE12_ SPEC02BIO_ C01	*Calliaster sp.*	Sea star	95% Ethanol	None	20160814	0:14:52	18.32295	165.97904	1215.3696	34.54683	3.50741	2.48857
D2_DIVE12_ SPEC02BIO_ C02	Polynoidae	Polychaete	95% Ethanol	266	20160814	0:14:52	18.32295	165.97904	1215.3696	34.54683	3.50741	2.48857
D2_DIVE12_ SPEC04BIO	Brisingidae	Sea star	95% Ethanol	264	20160814	3:43:26	18.32656	165.98106	1142.5695	34.54369	3.59086	2.51505
D2_DIVE13_ SPEC02BIO	?*Stelodoryx* sp.	Sponge	95% Ethanol	267	20160815	2:15:58	16.58154	166.47178	3067.6163	34.67678	1.56416	3.92444
D2_DIVE13_ SPEC03BIO	Unbranched octocoral	Coral	95% Ethanol	60	20160815	2:28:33	16.58159	166.47185	3065.5112	34.68758	1.58107	4.00454
D2_DIVE14_ SPEC02BIO	*Farrea* nr. *occa erecta*	Sponge	95% Ethanol	269	20160816	0:32:15	16.55926	165.34413	1215.4572	34.55193	3.8988	2.23345
D2_DIVE14_ SPEC02BIO_ C01	Antipatharia	Coral	95% Ethanol	62	20160816	0:32:15	16.55926	165.34413	1215.4572	34.55193	3.8988	2.23345
D2_DIVE14_ SPEC03BIO	*Victorgorgia* sp.	Coral	95% Ethanol	61	20160816	0:46:23	16.55915	165.34416	1215.4846	34.55796	3.88041	2.19316
D2_DIVE14_ SPEC03BIO_ C01	Astroschematida e	Sea Star	95% Ethanol	268	20160816	0:46:23	16.55915	165.34416	1215.4846	34.55796	3.88041	2.19316

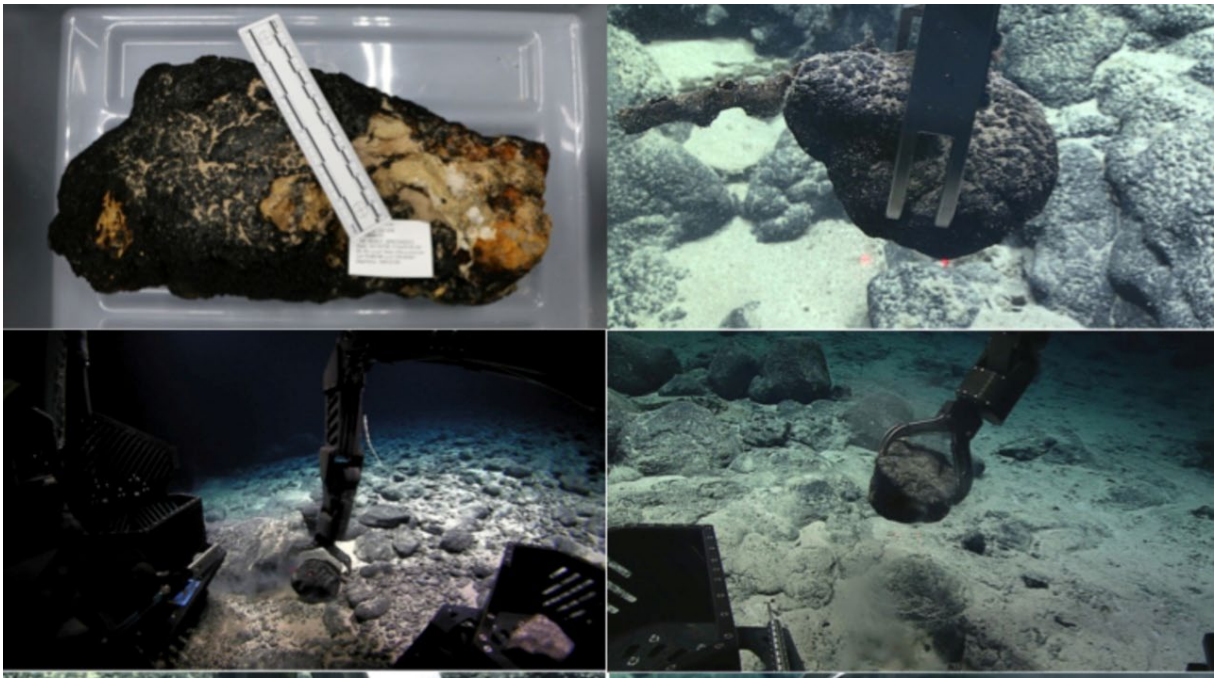

Figure 8. *Examples of rock specimens collected during the ROV dives. All volcanic rocks were covered in FeMn crust, as were many of the sedimentary rocks. Upper left: sedimentary rock partially covered in Mn crust. Upper right: fragment of pillow lava (most common volcanic rocks). Lower left: segment of lava tube being collected, note additional sample in starboard rock box. Lower right: lava tube segment.*

Figure 9. *Examples of biological specimens collected during EX-16-06. Upper left:* Hemicorallium *sp., Upper right:* Parantipathes *sp., Lower left: Unknown species of hexactinellida in the genus* Regadrella*. Lower right:* Farrea *nr.* occa erecta *with commensal antipatharian.*

5.3 Seafloor Mapping

NOAA Ship *Okeanos Explorer* mapped continuously for eight days, and when ROV operations had concluded on the remaining days of the expedition, covering ~33,000 km^2. Night mapping focused on completing the partial coverage on a number of seamounts collected on the EX-16-04 cruise (augmented by a handful of existing transit lines), this report can be found archived in the NOAA Central Library (Sowers et al., 2016). **Figure 10** highlights the newly detected and fully mapped seamounts. EX-16-06 completed the mapping work begun during EX-16-04. The eight different 3D views are annotated with dive numbers, since only three have officially been named seamounts, while the other seamounts remain unnamed. Except for Wake Atoll, none of these seamounts had previously been mapped to their full extent. The 3D views demonstrate the flat tops and rift zones on the different seamounts. The seamount featured on Dives 4 and 5 (McDonnell Seamount) also indicated sizeable debris slopes with large channels. These channels presumably result from significant sediment transport in high-density currents.

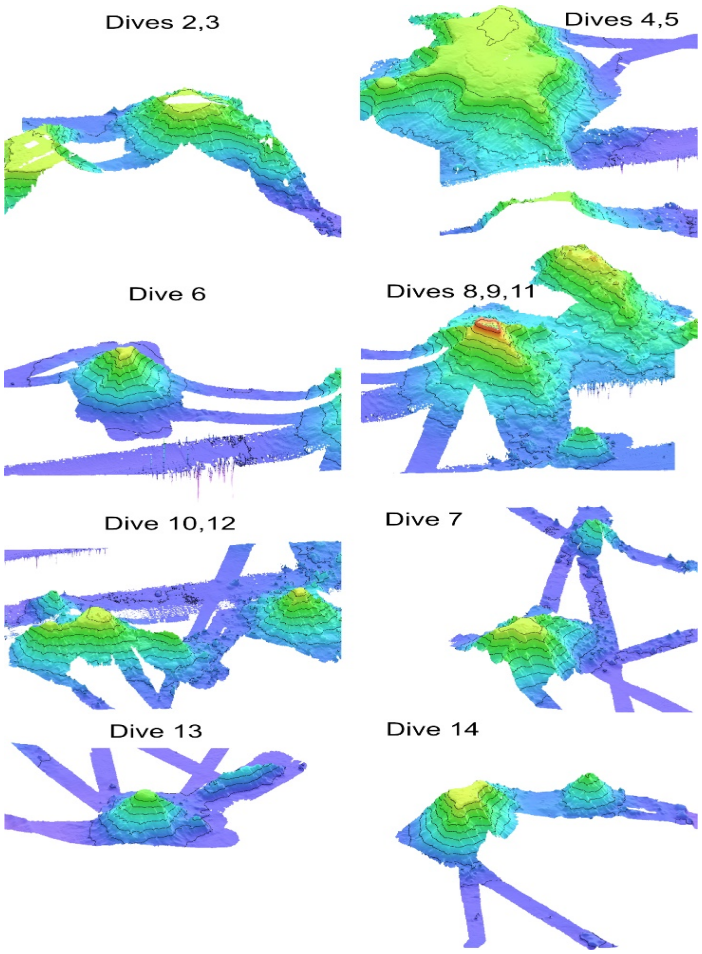

Figure 10. *Three-dimensional views of the now completely mapped seamounts during EX-16-06 (prior mapping was conducted during EX-16-04). Seamounts are labeled by dive number as many are unnamed. All panels show approximately 1x1 degree boxes.*

5.4 Education and Outreach

During the expedition, the live video of dives streamed to the public over the Internet, garnering more than 479,000 views. Additionally, the live video was continuously streamed throughout the expedition at the Maui Ocean Center and the Waikiki Aquarium. Working in partnership with the National Park Service, OER established a live viewing station at the USS *Arizona* Memorial in Hawai'i, to allow guests to watch live as scientists searched for the Japanese destroyer, *Hayate*.

In addition to serving as a working space for scientists, the exploration command centers (ECCs) at both the NOAA Inouye Regional Center (IRC) and the University of Hawai'i at Mānoa (UH) received regular visits from school groups and the general public. Live interactions were conducted with the Exploratorium, the Inner Space Center (ISC), and the University of Connecticut (UConn), directly reaching more than 100 students, educators, and members of the general public.

6. Data Deposition and Archival

All links to the data repositories were checked to ensure functionality at the publishing of this report (3/26/2020), if you are having trouble connecting to any document or service, email ex.expeditioncoordinator@noaa.gov.

The EX-16-06 Data Management Plan can be found in **Appendix D** of this report as well as Appendix B of the EX-16-06 Project Instructions, available at: https://repository.library.noaa.gov/view/noaa/13127

6.1 OER Data Discoverability Tools

All data collected by NOAA Ship *Okeanos Explorer* are archived and publicly available within 90 days of the end of each cruise via the NCEI 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
- OER ROV Data Archives at https://service.ncddc.noaa.gov/rdn/oer-rov-cruises/ex1606

Products created during the cruise, including the ship track, shaded bathymetry, dive locations and tracks, specimen collection data and images, ships meteorological and oceanographic sensor data, and status reports can be viewed on the interactive OER Digital Atlas.

Additional data requests, including Daily Situation Reports, internal operation records, and data from previous archived expeditions can be obtained by contacting OER at ex.expeditioncoordinator@noaa.gov.

6.2 Sonar Data

Sonar data collected onboard NOAA Ship *Okeanos Explorer* undergoes quality assurance/quality control (QA/QC) after every cruise and is then made publicly available through NCEI and the following websites:

- EM 302 bathymetry data, supporting informational logs, and ancillary files are available with the NCEI (formerly NGDC) Interactive Bathymetry Data Viewer at: http://maps.ngdc.noaa.gov/viewers/bathymetry/
- EM 302 water column data are available with the NCEI (formerly NGDC) Interactive Water Column Sonar Data Viewer at: http://maps.ngdc.noaa.gov/viewers/water_column_sonar/
- NCEI map tool with tracklines showing all publicly available geophysical surveys: https://maps.ngdc.noaa.gov/viewers/geophysics/
- Subbottom data, supporting data, and informational logs are available in the NCEI Data Archives accessible at https://www.ngdc.noaa.gov/

6.3 Physical Samples

Biological samples collected during NOAA Ship *Okeanos Explorer* expeditions are archived in the collections of the USNM. Here, they are catalogued, curated, and made publicly available.

- Biological samples of invertebrate organisms are archived in the Invertebrate Zoology Collections found here: https://naturalhistory.si.edu/research/invertebrate-zoology
- Information on how to request access to these samples can be found here: https://naturalhistory.si.edu/research/invertebrate-zoology/collections-access/specimen-loans
- Biological samples of fishes are archived in the Division of Fishes of the Vertebrate Zoology Collections found here: https://naturalhistory.si.edu/research/vertebrate-zoology/fishes
- Information on how to request access to these samples can be found here: https://naturalhistory.si.edu/research/vertebrate-zoology/fishes/collections-access/specimen-loans

Selected coral and sponge specimens were split; one aliquot was sent to the Bernice Pauahi Bishop Museum (BM) (https://www.bishopmuseum.org/collections-3/invertebrate-zoology/) and another sent to the USNM. If it had been determined that splitting would be too destructive to a particular specimen, it was provided to the USNM 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 extraction at the OGL Center at Northeastern University (https://www.northeastern.edu/ogl/). Information on how to request access to these results and any remaining DNA samples can be found at: https://www.northeastern.edu/ogl/request-2/.

All geological samples collected during NOAA Ship *Okeanos Explorer* expeditions were sent to the Marine Geology Repository (MGR) at OSU (http://osu-mgr.org/noaa-ex/) where they were described from a petrology perspective (e.g. mineral content, texture, alteration, rock type), photographed, and made publicly accessible. The repository provides photographs (including microphotographs) and online metadata information about each geological specimen. Information on how to request access to these geological samples can be found here: http://osu-mgr.org/request-samples/.

6.4 Video Data

NOAA Ship *Okeanos Explorer* video data are publicly available shortly after each expedition. Highlight videos and still images can be found on the OER website at https://oceanexplorer.noaa.gov/okeanos/explorations/ex1606/welcome.html. Additionally, expedition video data can be found using the OER Video Portal at https://www.nodc.noaa.gov/oer/video/.

6.5 Environmental and Tracking Data

The *D2* environmental data collected during each dive were provided to the OER archive as raw Seabird HEX files. The *D2* tracking data were exported from Tracklink as text files. In order to make these data types more accessible to interested researchers, the science team processed all CTD and tracking data and merged them together in comma-separated values (CSV) files. These files were provided to both OER and NOAA's Deep Sea Coral Research and Technology Program (DSCRTP) for distribution.

6.6 Eventlog

During ROV dives, participating researchers communicated between ship and shore using the Eventlog. The Eventlog is a persistent chat room where all comments, discussions, and requests are logged and provided a UTC timestamp that can later be correlated to the operations, location, and data feeds collected by the ship. The chat server facilitated the first-order annotation of cruise activities, serving as a digital version of scientists' daily logs and enabling input from multiple users. Eventlog users were encouraged to use codes, which were three to five letter shorthand codes that were used to standardize and speed up the recording of observations in the Eventlog.

6.7 Survey of Opportunity Data

During the EX-16-06 expedition, data were collected for the National Aeronautics and Space Administration (NASA) led, long-term Maritime Aerosol Network (MAN) research effort. Mission personnel made observations (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 made publically available at:
http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html

The full survey of opportunity description is available in **Appendix E** of this report.

7. Conclusion

EX-16-06 to the WAU of the PRIMNM provided the first-ever glimpse of the deepwater geology and biology around Wake Atoll. The findings and collections will generate a better scientific understanding of this area, and they will inform both Monument management as well as potential mining plans directly outside of the Monument. Noteworthy highlights included:

- A total of 14 ROV dives were conducted, 13 of which explored the seafloor in this area for the very first time. In addition, this cruise completed mapping of seamounts targeted for ROV dives (totaling 13 newly revealed seamounts between two cruises, EX-16-06 and EX-16-04).
- All explored seamounts were flat-topped guyots with pillow lavas coated in FeMn crust exposed on their lower flanks. Their tops had increased amounts of carbonate sediment, and some had post-erosional cones. These cones could either consist of volcaniclastic

sediments or pillow lavas, reflecting explosive interaction with seawater or non-explosive submarine eruption.

- High-density biological communities were documented at four of the 13 surveyed dive sites.
- A total of 61 specimens were collected, including 20 geological samples, 41 biological samples. The biological specimens were all collected because they represented either new species or new records for the region.
- The video surveys resulted in the seven-page table of likely species identified in **Appendix C**.
- High-resolution bathymetry data revealed for the first time the morphology of 13 seamounts.
- A total of 32 scientists and students participated with the expedition a regular basis, including participants from the U.S., Japan, Canada, Russia, and the Netherlands.
- The live video feeds broadcast over the Internet garnered over 479,000 views. Additionally, live feeds were continuously streamed throughout the expedition at the Maui Ocean Center, the Waikiki Aquarium, and the Mokupapapa Discovery Center.
- The science leads were interviewed live for Hawai'i Public Radio's talk shows *The Conversation* and *ByteMarks Café*.
- Education webinars conducted prior to the expedition were attended by over 70 educators, and included participants from the U.S., American Samoa, Guam, Germany, Portugal, and Brazil.
- The expedition team participated in a Reddit Ask Me Anything (AMA) session and answered close to 100 questions. The AMA session was visited by over 4,200 individual viewers.

8. Clearances and Permits

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) 216-6A Companion Manual (https://www.nepa.noaa.gov/docs/NOAA-NAO-216-6A-Companion-Manual-03012018.pdf) describes NOAA's specific procedures for 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 has been submitted for the project. As expected with ocean research with limited time or presence in the marine environment, the project has 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; as such, the project is categorically excluded from the need to prepare a full-scale NEPA environmental assessment. The categorical exclusion met the requirements of NOA 216-6 and NEPA, and authorizes the Marine Scientific Research conducted for the project. Permits for this expedition can be found in **Appendix F** of this report and the NEPA Categorical Exclusion Letter can be found in **Appendix G** of this report.

Prior to the 2016 cruises, OER completed an informal consultation with NOAA's National Marine Fisheries Service (NMFS) under Section 7 of the Endangered Species Act (ESA) of 1973 that addressed the potential impacts of NOAA Ship *Okeanos Explorer*'s activities to ESA-listed species and critical habitat within the Monuments and transits between Monuments. The NMFS Protected Resources Division concurred with OER's biological evaluation determining that the *2016 Deepwater Wonders of Wake* expedition may affect, but was not likely to adversely affect, ESA-listed marine species. The informal consultation was completed on February 3, 2016 when OER received a signed letter from the Regional Administrator of NMFS Pacific Islands Regional Office (PIRO), stating that NMFS concurs with OER's determination that conducting proposed NOAA Ship *Okeanos Explorer* cruises are not likely to adversely affect ESA-listed marine species. The ESA Section 7 Letter of Concurrence (LOC) can be found in **Appendix H** of this report.

9. References

Elliott, K., Potter, J., Martinez, C., Pinner, W., Russell, C., Verplanck, N. (2014). NOAA Ship *Okeanos Explorer*: Evolving Models Enabling Remote Science Participation via Telepresence. AGU, Fall 2014. Poster ID ED11C-3425.

Kennedy BRC, Cantwell K, Malik M, Kelley C, Potter J, Elliott K, Lobecker E, Gray LM, Sowers D, White MP, France SC, Auscavitch S, Mah C, Moriwake V, Bingo SRD, Putts M and Rotjan RD (2019) The Unknown and the Unexplored: Insights Into the Pacific Deep-Sea Following NOAA CAPSTONE Expeditions. Front. Mar. Sci. 6:480. doi: 10.3389/fmars.2019.00480

Sowers, D., Kelley, C., Kennedy B.R.C, Elliott, K., Price, M., Grenier, B., Martinez-Rivera, S., 2016. EX-16-04 Expedition Report- CAPSTONE Wake Island PRIMNM (Preliminary Mapping). Office of Ocean Exploration and Research, Office of Oceanic & Atmospheric Research, NOAA, Silver Spring, MD 20910. OER Expedition Rep. Cruise EX-16-04, 30p. https://repository.library.noaa.gov/view/noaa/21417

10. Appendices

Appendix A: EX-16-06 Participants

Participation on EX-16-06 involved 20 at-sea mission personnel and 70 shoreside scientists engaging either by audio commentary or instant messaging vie the expedition chat room on a regular basis. At-sea personnel included the expedition coordinator, mapping specialists, ROV engineers, video engineers, data specialists, and on-board scientists. Shore-based science team members participated from remote ECCs and from their home locations. Lists of these participants are provided in the tables below. In addition to these participants, all NOAA Ship *Okeanos Explorer* expeditions are made possible with the work of the ship's dedicated crew, and the work of the shoreside operations team.

Table 5. *EX-16-06 At-sea Mission Personnel*

Name	Role	Affiliation
Brian Kennedy	Expedition Coordinator	NOAA OER, University Corporation for Atmospheric Research (UCAR)
LTJG Nick Pawlenko	Assistant Expedition Coordinator/ROV Engineer	NOAA OER
Lindsay McKenna	Mapping Team Lead	NOAA OER
Chris Kelley	Biological Sciences Lead	Joint Institute for Marine and Atmospheric Research (JIMAR)/UH
Jasper Konter	Geological Sciences Lead	UCAR/UH
Dan Frietas	Mapping Watch Lead	UCAR
Joshua Carlson	Data Management	Global Foundation for Ocean Exploration (GFOE)
Dan Rogers	Engineering Group Lead	GFOE
Jeff Lanning	ROV Engineer	GFOE
Fernando Aragon	ROV Engineer	GFOE
Levi Unema	ROV Engineer	GFOE
Chris Ritter	ROV Engineer	GFOE

Andy Lister	ROV Engineer	GFOE
Roland Brian	Video Engineer	GFOE
Annie White	Video Engineer	GFOE
Emily Narrow	Video Engineer	GFOE
Sean Kennison	Video Engineer	GFOE
Tara Smithee	Video Engineer	GFOE
Dave Casagrande	Video Engineer	GFOE
Art Howard	Video Engineer	GFOE

Table 6. *EX-16-06 Shore-based Science Team*

Name	Affiliation	Email
Diva Amon	UH	divaamon@hawaii.edu
Steve Auscavitch	Temple University	steven.auscavitch@temple.edu
Amy Baco-Taylor	Harbor Branch Oceanographic Institute (HBOI), Florida State University (FSU)	abacotaylor@fsu.edu
Nolan Barrett	HBOI, Florida Atlantic University (FAU)	
Katy Bell	Ocean Exploration Trust (OET)	
Samantha Brooke	NOAA	
Robert Carney	Louisiana State University (LSU)	
Alex Catsambis	Naval History and Heritage Command	
William Clancey	Institute for Human & Machine Cognition (IHMC)	
Aaron Colohan	NOAA	
Melanie Damour	Bureau of Ocean Energy Management (BOEM)	
Name	**Affiliation**	**Email**

Bryan Dieter	NOAA Pacific Islands Fisheries Science Center (PIFSC)	
Douglas Ellison	NASA Jet Propulsion Laboratory (JPL)	
Annie Evankow	OGL	
Gary Fabien	NOAA Office of National Marine Sanctuaries (ONMS)	
Kimberly Faulk	Geoscience Earth and Marine Services (GEMS)	
Mike Ford	NOAA NMFS	
Benjamin Frable	Scripps Institution of Oceanography (SIO)	
Scott France	University of Louisiana at Lafayette (ULL)	france@louisiana.edu
John Fraser	Self	
Joan Gardner	Naval Research Lab, UH, Hawai'i Institute of Geophysics & Planetology (HIGP)	
Michael Gawel	Department of the Interior (DOI), National Parks Service (NPS)	
Deborah Glickson	Florida Atlantic University (FAU) Harbor Branch Oceanographic Institute (HBOI)	
Brian Greene	Association for Marine Exploration	
Valerie Grussing	NOAA	
Daniel Haddock	Forum Energy Technologies	
Steven Haddock	Monterey Bay Aquarium Research Institute (MBARI)	
Santiago Herrera	Lehigh University	sherrera@alum.mit.edu
Heidi Hirsh	NOAA NMFS Monuments Program	
Name	**Affiliation**	**Email**

Thomas Hourigan	NOAA DSCRTP	
David Jourdan	Nauticos, LLC	
Hoku Johnson	NOAA NMFS PIFSC	
Eric King	Schmidt Ocean Institute (SOI)	
Spencer King	Oceanix	
Anthony Koppers	College of Earth, Ocean, and Atmospheric Sciences, OSU	
Astrid Leitner	UH	aleitner@hawaii.edu
Susan Loricchio	Air Force Association	
Christopher Mah	USNM	brisinga@gmail.com
Asako Matsumoto	Planetary Exploration Research Center/Chiba Institute of Technology (PERC/CIT)	amatsu@gorgonian.jp
Russ Matthews	Edward E and Marie L Matthews Foundation	
Robert McGuinn	NOAA	
Jennifer McKinnon	East Carolina University	
Allison Miller	University of Guam	
Joyce Miller	UH	
Mary Miller	Exploratorium	
Tina Molodtsova	P.P. Shirov Institute of Oceanology, Russian Academy of Science	tina@ocean.ru
Rich Mooi	California Academy of Sciences	
Nicole Morgan	FSU, HBOI	nbmorgan11@gmail.com
Name	**Affiliation**	**Email**

Bruce Mundy	NOAA NMFS PIFSC	bruce.mundy@noaa.gov
Jerry Ostermiller	NOAA Affiliate	
Michael Parke	NOAA PIFSC	Michael.Parke@noaa.gov
Andrea Quattrini	Harvey Mudd College	
Gene Rankey	University of Kansas	
Kristen Rex	U.S. Air Force 611 Civil Engineer Squadron	
Sonia Rowley	UH	
Daniel Scheirer	U.S. Geological Survey (USGS)	
Charlotte Seid	OGL, Northeastern University	
Alexander Shor	UH	
John R Smith	UH/Hawai'i Undersea Research Laboratory (HURL)	jrsmith@hawaii.edu
Bradley Stevens	University of Maryland Eastern Shore	
Ken Sulak	USGS	
Hans Van Tilburg	NOAA	
Michael Vecchione	USNM/NMFS	VECCHIOM@si.edu
Charles Wahle	NOAA MPA Center	
Dorsey Wanless	Boise State University	
Les Watling	UH	watling@hawaii.edu
Mary Wicksten	Texas A&M University (TAMU)	wicksten@bio.tamu.edu
Gary Williams	California Academy of Sciences	
Name	**Affiliation**	**Email**

Amanda Ziegler	UH	aziegler802@gmail.com
Victor Zykov	SOI	

Appendix B: ROV Dive Summaries

In this Appendix, the Description of the Dive is included from each of the 14 Dive Summaries. To download the full Dive Summaries for each dive, visit: https://service.ncddc.noaa.gov/rdn/oer-rov-cruises/ex1606

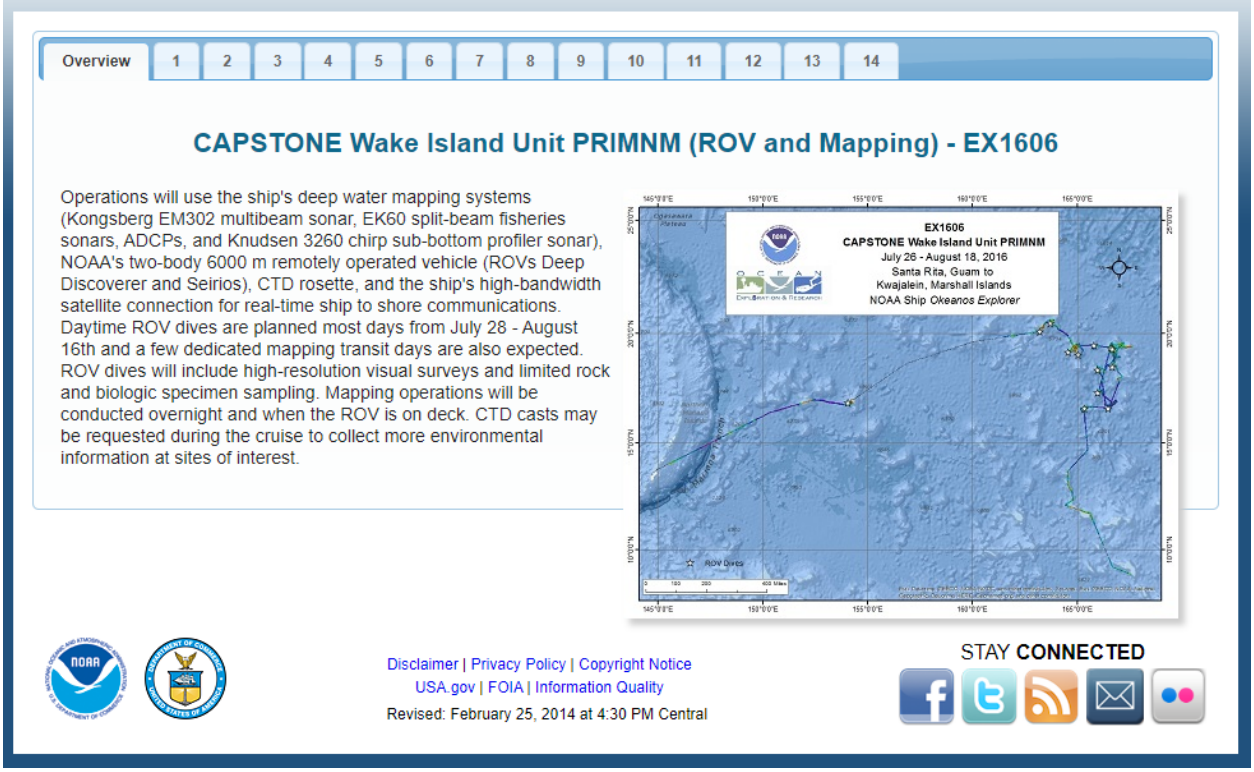

Figure 11: *Screen shot of the dive summary landing page.*

Appendix C: Animals Observed

Animals observed during the 13 ROV seafloor surveys of the expedition. Note that all field identifications from video surveys should be considered provisional until they are confirmed by a taxonomic authority.

Table 7: *A list of all animals observed by Phylum, Group, Lowest Identification, and Dive number.*

Phylum	Group	Lowest Identification	Dive No.
Anellida	Anellida	Polychaeta	3,5,14
Anellida	Polychaetes	Polynoidae	1,2,8,12
Anellida	Polychaetes	Sabellida	7,14
Arthropod	Crabs	Homolidae (red, carrying anemone)	8,12
Arthropod	Crabs	Homolidae	8,11
Arthropod	Crabs	Paguridae	11
Arthropod	Crabs	?*Progeryon mus*	4
Arthropod	Crabs	Unidentified crab	9
Arthropods	Amphipods	Amphipoda	10,12
Arthropods	Barnacles	Balanoidae	5
Arthropods	Barnacles	*Chirona* sp.	10
Arthropods	Barnacles	*Heterolepas* sp.	11
Arthropods	Barnacles	Scalpellidae	6,7,10
Arthropods	Barnacles	Barnacles	2,7
Arthropods	Isopods	Munnopsidae or munnidae	5,6,12
Arthropods	Isopods	Isopod	6,
Arthropods	Lobsters	Polychelidae	3,10,12
Arthropods	Pycnogonids	Pycnogonida	7
Arthropods	Shrimps	?*Acanthophora* sp.	12
Arthropods	Shrimps	Alpheidae	7
Arthropods	Shrimps	Amphipoda	5
Arthropods	Shrimps	Aristeidae	1,2,5,6,9,10
Arthropods	Shrimps	Aristeidae (blue, molting)	3,14
Arthropods	Shrimps	*Glyphocrangon* sp.	8
Arthropods	Shrimps	*Heterocarpus laevigatus*	8,12
Arthropods	Shrimps	*Lebbeus* sp.	5
Arthropods	Shrimps	Mysidae	8
Arthropods	Shrimps	*Nematocarcinus* sp.	1,3,5,6,7,8,9,10,12
Arthropods	Shrimps	Pandalidae	14
Arthropods	Shrimps	*Plesionika* sp.	11
Arthropods	Shrimps	?*Plesionika edwardsii*	11
Arthropods	Shrimps	Unidentified shrimp	5,8,9,10,12,13,14
Arthropods	Squat lobsters	Chirostylidae	7,12
Arthropods	Squat lobsters	Galatheoidea (long-armed, spiny)	10,12
Arthropods	Squat lobsters	*Gastroptychus* sp.	10,14
Arthropods	Squat lobsters	*Munida* sp.	11
Arthropods	Squat lobsters	*Munidopsis* sp.	2,6,7,10

Phylum	Group	Lowest Identification	Dive No.
Arthropods	Squat lobsters	*Pseudomunida* sp.	8
Arthropods	Squat lobsters	*Eumunida* sp.	8,9
Arthropods	Squat lobsters	*Uroptychus* sp.	1,2,3,5,6,7,12,14
Arthropods	Squat lobsters	Squat lobster	2,9,11,13
Bryozoans	Bryozoan	Bryozoan	3
Cnidarians	Actiniarians	*Actinoscyphia* sp.	1,10,11
Cnidarians	Actiniarians	Actinostolidae	1
Cnidarians	Actiniarians	*Actinernus nobilis*	9,14
Cnidarians	Actiniarians	*Exocoelactis* sp.	1,2,3,6,7,8,10,11,12
Cnidarians	Actiniarians	*Liponema* sp.	8,11,12
Cnidarians	Actiniarians	*Phelliactis* sp.	9,11,12
Cnidarians	Actiniarians	Unidentifed anemone	1,2,3,6,8,9,11,14
Cnidarians	Alcyonaceans	*Anthomastus* sp.	1,11,12,14
Cnidarians	Alcyonaceans	*Anthomastus tahinodus*	12
Cnidarians	Alcyonaceans	*Pseudoanthomastus* sp.	3,10,11
Cnidarians	Alcyonaceans	Alcyonacea, clear	11
Cnidarians	Antipatharians	*Bathypathes* sp.	1,2,6,10,11
Cnidarians	Antipatharians	*Heteropathes* sp.	5,7,13
Cnidarians	Antipatharians	*Heteropathes* cf. *americana*	5
Cnidarians	Antipatharians	*Leiopathes* sp.	11
Cnidarians	Antipatharians	*Leiopathes* sp./*Antipathes* sp. (on *Tretopleura* sp.)	7
Cnidarians	Antipatharians	*Lillipathes* sp.	3
Cnidarians	Antipatharians	*Parantipathes* sp.	6,7
Cnidarians	Antipatharians	*Stauropathes* sp.	2,5,6,10,11,13
Cnidarians	Antipatharians	*Trissopathes* sp.	2,3,6,7,10,12
Cnidarians	Antipatharians	*Trissopathes* sp. or *Hexapathes* sp.	2
Cnidarians	Ceriantharian	Ceriantharia	6,7,10,12
Cnidarians	Corallimorpharian	Corallimopharia	3,11
Cnidarians	Gorgonians	?*Acanella weberi*	3
Cnidarians	Gorgonians	?*Acanella* sp.	11
Cnidarians	Gorgonians	*Acanthogorgia* sp.	3,8,9,10,12
Cnidarians	Gorgonians	?Anthothelidae	11
Cnidarians	Gorgonians	*Bathygorgia* sp.	13
Cnidarians	Gorgonians	?*Calyptrophora angularis*	1,3,6,7,9,14
Cnidarians	Gorgonians	*Calyptrophora wyvellei*	9
Cnidarians	Gorgonians	?*Calyptrophora* sp.	6,10,12
Cnidarians	Gorgonians	*Candidella gigantea*	1,2,6
Cnidarians	Gorgonians	?*Candidella helminthophora*	7
Cnidarians	Gorgonians	*Candidella* sp.	3,6,13
Cnidarians	Gorgonians	*Chrysogorgia chryseis*	1,3
Cnidarians	Gorgonians	*Chrysogorgia* sp.	1,2,3,6,7,14
Cnidarians	Gorgonians	*Chrysogorgia stellata*	5,6,7
Cnidarians	Gorgonians	*Chrysogorgia* sp. (stalked)	2,3,5
Cnidarians	Gorgonians	*Eknomisis* sp.	1,10
Cnidarians	Gorgonians	*Hemicorallium* sp.	3,10,12,14
Cnidarians	Gorgonians	*Iridogorgia bella*	5

Phylum	Group	Lowest Identification	Dive No.
Cnidarians	Gorgonians	*Iridogorgia magnispiralis*	3,7,10,12,14
Cnidarians	Gorgonians	*Iridogorgia* sp. (branched)	3
Cnidarians	Gorgonians	*Iridogorgia* sp.	3,6,9
Cnidarians	Gorgonians	*Jasonisis* sp.	2,3,7
Cnidarians	Gorgonians	*Jasonisis* sp./*Orstomisis* sp.	7
Cnidarians	Gorgonians	Keratoisidinae (intermodal)	2
Cnidarians	Gorgonians	Keratoisidinae (D-clade)	3
Cnidarians	Gorgonians	Keratoisidinae (sparsely branched)	3,5,6,10
Cnidarians	Gorgonians	*Keratoisis* sp. (B clade)	1,2,6,8,10,11,12
Cnidarians	Gorgonians	Keratoisidinae (I-4-clade)	3,7,14
Cnidarians	Gorgonians	Keratoisidinae	5
Cnidarians	Gorgonians	*Lepidisis* sp.	1,3,5,6,14
Cnidarians	Gorgonians	?*Narella alvinae* (two branches)	2,5,14
Cnidarians	Gorgonians	?*Narella bowersi* (long branch)	3
Cnidarians	Gorgonians	*Narella dichotoma*	3,5,9,14
Cnidarians	Gorgonians	?*Narella hawaiiensis*	1,5
Cnidarians	Gorgonians	?*Narella macrocalyx*	1,5,12
Cnidarians	Gorgonians	*Narella muzikae*	3
Cnidarians	Gorgonians	*Narella* sp.	2,6,7,8,12,13
Cnidarians	Gorgonians	Unidentified octocoral	11
Cnidarians	Gorgonians	*Paracalyptrophora* sp.	3,6,7
Cnidarians	Gorgonians	*Paragorgia* sp.	3,6,10,12
Cnidarians	Gorgonians	*Paramuricea* sp.	3,12,14
Cnidarians	Gorgonians	*Pleurogorgia kishinoyei*	10
Cnidarians	Gorgonians	*Pleurogorgia militaris*	5
Cnidarians	Gorgonians	Plexauridae	8,9,10,11,12
Cnidarians	Gorgonians	Primnoidae	1,9,12
Cnidarians	Gorgonians	*Rhodaniridogorgia* sp.	11
Cnidarians	Gorgonians	Isididae (unbranched)	5,9,10,12
Cnidarians	Gorgonians	Primnoidae (unbranched)	3,6,13
Cnidarians	Gorgonians	*Victorgorgia* sp.	12,14
Cnidarians	Gorgonians	Isididae (two branches)	1
Cnidarians	Hydrozoans	*Atolla* sp.	12
Cnidarians	Hydrozoans	*Aegina* sp.	10,14
Cnidarians	Hydrozoans	Corymorphidae	3,14
Cnidarians	Hydrozoans	Hydroidolina	6,7,8,10,11,13
Cnidarians	Hydrozoans	Hydromedusae	1,8,10
Cnidarians	Hydrozoans	Siphonophorae	10
Cnidarians	Hydrozoans	*Solanderia* sp.	12
Cnidarians	Hydrozoans	Stylasteridae	2
Cnidarians	Hydrozoans	Tubulariidae	6,14
Cnidarians	Pennatulaceans	*Anthoptilum* sp.	11,12
Cnidarians	Pennatulaceans	*Calibelemnon* sp.	11
Cnidarians	Pennatulaceans	*Halipteris* sp. (but no spines)	5
Cnidarians	Pennatulaceans	?*Kophobelemnon stelliferum*	11
Cnidarians	Pennatulaceans	*Pennatula inflata*	11

Phylum	Group	Lowest Identification	Dive No.
Cnidarians	Pennatulaceans	?*Protoptilum* sp.	8
Cnidarians	Pennatulaceans	*Umbellula* sp.	12,14
Cnidarians	Pennatulaceans	Unidentified sea pen	8
Cnidarians	Scleractinians	?*Eguchispammia fistula*	11
Cnidarians	Scleractinians	*Eguchipsammia* sp.	11
Cnidarians	Scleractinians	*Enallopsammia rostrata*	8,11
Cnidarians	Scleractinians	Polymyces wellsi	11
Cnidarians	Scleractinians	Unidentified cup coral	5,7,10,12,14
Cnidarians	Stoloniferans	Stolonifera	11
Cnidarians	Zoantharian	Zoantharia	1,12
Cnidarians	Zoanthids	Parazoanthidae	6,10
Cnidarians	Zoanthids	*Kulamanamana haumeaae*	11
Ctenophores	Ctenophores	?Cydippida	8,11
Echinoderms	Asteroids	*Asthenactis* sp.	10
Echinoderms	Asteroids	Brisingidae	2,5,10,12,13
Echinoderms	Asteroids	*Calliaster* sp.	3,5,7
Echinoderms	Asteroids	*Ceramaster* cf. *bowersi*	11
Echinoderms	Asteroids	*Evoplosoma* sp.	3,7,10
Echinoderms	Asteroids	Goniasteridae	12
Echinoderms	Asteroids	?Pedicellasteridae	5
Echinoderms	Asteroids	*Henricia* sp.	1,7,10,12
Echinoderms	Asteroids	*Hymenaster* sp.	5,14
Echinoderms	Asteroids	*Hippasteria* sp.	3,7,11
Echinoderms	Asteroids	*Mediaster* sp./*Ceramaster* sp.	6
Echinoderms	Asteroids	Myxasteridae	6
Echinoderms	Asteroids	*Peltaster cycloplax*	10
Echinoderms	Asteroids	*Pythonaster* sp.	2
Echinoderms	Asteroids	?*Sphaeriodiscus ammophilus*	11
Echinoderms	Asteroids	Sibogaster sp (maybe mispelled)	6
Echinoderms	Asteroids	*Tremaster mirabilis*	11
Echinoderms	Asteroids	Asteroidea (unknown)	1,10,11
Echinoderms	Crinoids	Antedonidae	1,2,5
Echinoderms	Crinoids	*Atelecrinus* sp.	1,8
Echinoderms	Crinoids	?Charitometridae	11
Echinoderms	Crinoids	Comatulidae	1,2,3,5,6,11,13,14
Echinoderms	Crinoids	*Glyptometra lateralis*	3,14
Echinoderms	Crinoids	Hyocrinidae	5,7
Echinoderms	Crinoids	*Hyocrinus* sp. (new genus, circular discs)	1
Echinoderms	Crinoids	*Pentametrocrinus* sp.	5
Echinoderms	Crinoids	*Proisocrinus ruberrimus*	12,14
Echinoderms	Crinoids	*Sarametra triserialis*	1,2,3,7,10
Echinoderms	Crinoids	Stalked crinoid	1
Echinoderms	Crinoids	Thalassometridae	10,12
Echinoderms	Crinoids	*Thaumatocrinus* sp.	14
Echinoderms	Holothurians	Deimatidae	5
Echinoderms	Holothurians	*Hansenothuria* sp.	3,6,7,12

Phylum	Group	Lowest Identification	Dive No.
Echinoderms	Holothurians	Laetmogonidae	5
Echinoderms	Holothurians	*Orphnurgus* sp.	8
Echinoderms	Holothurians	Synallactida	1,6,7
Echinoderms	Holothurians	Unidentified holothuriidae	1,10,14
Echinoderms	Ophiuroids	Asteroschematidae	3,6,10,12,14
Echinoderms	Ophiuroids	Ophiocanthidae	1,7
Echinoderms	Ophiuroids	Ophiuroidae	1,2,3,5,7,10,13,14
Echinoderms	Urchin	*Aspidodiadema* sp.	1,7,14
Echinoderms	Urchin	*Caenopedina* sp.	3,12
Echinoderms	Urchin	*Caenopedina pulchella*	11
Echinoderms	Urchin	?*Sperosoma* sp.	6,10
Echinoderms	Urchin	*Tromikosoma hispidus*	6
Echinoderms	Urchin	Unidentified urchin (round, irregular)	6
Echinoderms	Urchin	Unidentified urchin	12
Echiurans	Echiuran	?*Bonellia* sp.	11
Fishes	Eels	*Bathyconger* sp.	8
Fishes	Eels	*Bathyuroconger* sp.	8,14
Fishes	Eels	?*Ilyophis* sp.	2,3,6
Fishes	Eels	*Nettastoma parviceps*	11
Fishes	Eels	?*Synaphobranchus affinis*	14
Fishes	Eels	*Synaphobranchus brevidorsalis/oregoni*	1,2,3,6,7,10
Fishes	Eels	*Synaphobranchus* sp.	7,14
Fishes	Eels	Synaphobranchidae	2,7,9,12,13,14
Fishes	Eels	*Venefica* sp.	12
Fishes	Eels	Unidentified eel	9
Fishes	Halosauridae	*Aldrovandia phalacra*	14
Fishes	Halosauridae	*Aldrovandia* sp.	8,10
Fishes	Halosauridae	Halosauridae	12
Fishes	Macrourids	*Coryphaenoides* sp.	12
Fishes	Macrourids	*Kumba* sp.	2,5,6,10,12
Fishes	Macrourids	*Luciobrotula* sp.	8
Fishes	Macrourids	?*Malacocephalus boretzi*	8,9
Fishes	Macrourids	*Malacocephalus* sp., *Nezumia* sp., or *Ventrifossa* sp.	8
Fishes	Macrourids	*Nezumia* sp.	8
Fishes	Macrourids	*Ventrifossa* sp.	8
Fishes	Macrourids	Unidentified macrouridae	9
Fishes	Morids	*Gadella* sp.	11
Fishes	Morids	?*Laemonema robustum*	8
Fishes	Myctophids	Myctophidae	3
Fishes	Ophidiidae	*Bassogigas* sp.	5,6,12
Fishes	Ophidiidae	*Bassozetus* sp.	3,5,6,7,14
Fishes	Ophidiidae	*Lamprogrammus* sp.	12
Fishes	Ophidiidae	Ophidiidae	8,9,12
Fishes	Ophidiidae	*Porogadus* sp.	1
Fishes	Other fishes	Alepocephalidae	12
Fishes	Other fishes	*Apristurus* sp.	9

Phylum	Group	Lowest Identification	Dive No.
Fishes	Other fishes	*Argyripnus* sp.	11
Fishes	Other fishes	*Astronesthes* sp.	11
Fishes	Other fishes	*Barbourisia* sp.	12
Fishes	Other fishes	*Bathypterois tricolor*	12
Fishes	Other fishes	*Bathytyphlops* sp.	9
Fishes	Other fishes	*Beryx decadactylus*	11
Fishes	Other fishes	*Pyramodon* sp.	8,9
Fishes	Other fishes	Chaunacops coloratus	6
Fishes	Other fishes	Chlorophthalmus sp	11
Fishes	Other fishes	Chrionema chryseres	11
Fishes	Other fishes	*Diplacanthopoma* sp.	8
Fishes	Other fishes	*Epigonus* sp.	11
Fishes	Other fishes	Glossanodon sp?	11
Fishes	*Other fishes*	*Grammicolepis brachiusculus*	11
Fishes	Other fishes	*Hexanchus griseus*	11
Fishes	Other fishes	*Hollardia* sp.	11
Fishes	Other fishes	*Lophiodes miacanthus*	11
Fishes	Other fishes	*Neoscopelus* sp.	8,9
Fishes	Other fishes	*Odontaspis ferox*	8
Fishes	Other fishes	*Plectranthias* sp.	11
Fishes	Other fishes	*Plesiobatis daviesi*	8
Fishes	Other fishes	*Polymixia berndti*	11
Fishes	Other fishes	?*Pontinus* sp.	11
Fishes	Other fishes	*Randallichthys filamentosus*	11
Fishes	Other fishes	*Rexea* sp.	9
Fishes	Other fishes	*Ruvettus pretiosus*	8
Fishes	Other fishes	*Scopelarchus* sp.	8
Fishes	Other fishes	*Setarches* sp.	11
Fishes	Other fishes	*Sladenia* sp.	8,9
Fishes	Other fishes	*Stethopristis eos*	11
Mollusks	Aplocophoran	Aplocophoran	10,11,12
Mollusks	Gastropods	Gastropoda	9,10,12
Mollusks	Gastropods	*Gaza* sp.	1
Sponges	Demosponges	Cladorhizidae	13
Sponges	Demosponges	Demospongiae (“Kebab” sponge)	3,5,6,13
Sponges	Demosponge	*Poecillastra* sp.	11
Sponges	Demosponge	?*Pyloderma* sp.	7
Sponges	Demosponge	?*Stelodoryx* sp.	5,7,13
Sponges	Demosponge	Demospongiae (tiny, unknown)	3
Sponges	Hexactinellids	*Aspidoscupulia* sp.	1,2,3,6,10
Sponges	Hexactinellids	*Atlantisella* sp.	12
Sponges	Hexactinellids	?*Auloplacidae*	6
Sponges	Hexactinellids	*Bolosoma* sp.	1,3,5,6,13,14
Sponges	Hexactinellids	*Bolosoma* sp. A	13
Sponges	Hexactinellids	*Bolosoma* sp. B	5,10,12
Sponges	Hexactinellids	Bolosominae sp. 1	2

Phylum	Group	Lowest Identification	Dive No.
Sponges	Hexactinellids	Bolosominae sp.	1
Sponges	Hexactinellids	*Caulophacus* (*Caulodiscus*) sp.	3,5,7
Sponges	Hexactinellids	*Caulophacus* (New subgenus) sp.	6
Sponges	Hexactinellids	*Caulophacus* (*Oxydiscus*) sp.	13
Sponges	Hexactinellids	*Caulophacus* sp.	1,2,5,10,13,14
Sponges	Hexactinellids	*Chonelasma* sp.	1
Sponges	Hexactinellids	Chonelasmatinae (stalked)	1
Sponges	Hexactinellids	*Crateromorpha* sp.	1,7,13
Sponges	Hexactinellids	Corbitellinae (new genus)	1,13
Sponges	Hexactinellids	*Dictyaulus* sp.	1,2,6,9,11,14
Sponges	Hexactinellids	*Euretidae* sp.	1,2
Sponges	Hexactinellids	*Farrea* sp.	1,3,6,10,12
Sponges	Hexactinellids	*Farrea* nr. *occa*	10
Sponges	Hexactinellids	*Farrea* nr. *occa erecta*	1,2,3,7,14
Sponges	Hexactinellids	*Heterorete* sp.	1
Sponges	Hexactinellids	*Hyalonema* sp.	1,2,9
Sponges	Hexactinellids	?*Hyalostylus* sp.	1
Sponges	Hexactinellids	*Lefroyella* sp.	1,3,7,10
Sponges	Hexactinellids	*Lefroyella* sp. (plate)	3
Sponges	Hexactinellids	*Lophocalyx* sp.	1
Sponges	Hexactinellids	Pheronematidae	2
Sponges	Hexactinellids	*Poliopogon* sp.	1,2,3,5,6,7,8,10,12,14
Sponges	Hexactinellids	*Poliopogon* sp. 2	10
Sponges	Hexactinellids	*Regadrella* sp. (large)	6
Sponges	Hexactinellids	*Saccocalyx* sp.	1,10,12
Sponges	Hexactinellids	*Semperella* sp.	5,10
Sponges	Hexactinellids	*Tretopleura* sp.	1,2,3,5,6,7,10,12,14
Sponges	Hexactinellids	*Walteria* cf. *leukarti*	3,7,14
Sponges	Hexactinellids	*Walteria* sp.	6,12
Sponges	Hexactinellids	Hexactinellida (stalked)	1,8
Sponges	Hexactinellids	Hexactinellida (stalked vase)	1
Sponges	Hexactinellids	Unknown hexactinellida	5,7,14
Tunicate	Ascidacea	Octanematidae (*Megalocopia* sp.)	3,7
Tunicate	Ascidiacea	Ascidiacea (benthic)	6,7
Tunicate	Ascidiacea	Ascidiacea	5
Unknown	Unknown	Unknown blue encrusting organism	11

Appendix D: Data Management Plan

Data Management Plan
Okeanos Explorer (EX1606): CAPSTONE Wake Island Unit PRIMNM

OER Data Management Objectives

Standard Operating Procedures onboard the ship and throughout the ship's established data pipelines will be followed to ensure the data from this mission is organized, documented and archived within 30-90 days of cruise end.

1. General Description of Data to be Managed

1.1 Name and Purpose of the Data Collection Project

Okeanos Explorer (EX1606): CAPSTONE Wake Island Unit PRIMNM

1.2 Summary description of the data to be collected.

Operations will use the ship's deep water mapping systems (Kongsberg EM302 multibeam sonar, EK60 split-beam fisheries sonars, ADCPs, and Knudsen 3260 chirp sub-bottom profiler sonar), NOAA's two-body 6000 m remotely operated vehicle (ROVs Deep Discoverer and Seirios), CTD rosette, and the ship's high-bandwidth satellite connection for real-time ship to shore communications. Daytime ROV dives are planned most days from July 28 –August 16th a few dedicated mapping transit days are also expected. ROV dives will include high-resolution visual surveys and limited rock and biologic specimen sampling. Mapping operations will be conducted overnight and when the ROV is on deck. CTD casts may be requested during the cruise to collect more environmental information at sites of interest.

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, oceans, CAPSTONE, Wake Island, Prime Crust Zone, Pacific Seamounts, deep sea coral, bottom fish habitats, PRIMNM, Pacific Remote Islands Marine National Monument, Guam, Kwajalein, vulnerable marine habitats, seamounts, monument management, WWII submerged cultural heritage, World War II, benthic habitats, archaeological, archaeology, conservation, conserve, crm, cultural resource management, historic, marine archaeology, maritime, maritime archaeology, nautical, nautical archaeology, preserve, protect, protection, submerged cultural heritage, submerged cultural resource, uch, underwater cultural heritage

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: 7/27/2016 to 8/19/2016

1.6 Planned or actual geographic coverage of the data.

Latitude Boundaries:	7.5	to	23
Longitude Boundaries:	142	to	171

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

Cruise Plan, Cruise Summary, Data Management Plan, Highlight Images, Quick Look Report, CTD (raw), CTD (processed), Dive Summaries, EK60 Singlebeam Data, Expedition Cruise Report, Highlight Video, Images, Mapping Summary, Multibeam (image), Multibeam (processed), Multibeam (product), Multibeam (raw), NetCDF, Raw Video (digital), Salinity data, Sample Analysis Reports, SCS Output (compressed), SCS Output (native), Selected Raw Video, 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:	Brian Kennedy
Title:	Expedition Coordinator
Affiliation/Dept:	Global Foundation for Ocean Exploration
E-Mail:	brian.kennedy@noaa.gov
Phone:	706-540-2664

3. Point of Contact for Managing the Data

Data POC Name:	Andy O'Brien, Joshua Carlson, Christopher Kelley, Susan Gottfried
Title:	Onboard Operational Data Management, Shoreside Data Management, Sampling Operations Data Management, Data Stewardship and Archive
E-Mail:	andrew.parson.obrien@gmail.com, joshocar@gmail.com, ckelley@hawaii.edu, 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; video data shall be documented and archived in the NOAA CLASS system and the oceanographic archive; specimens shall be processed onboard the Okeanos Explorer in the WetLab and then delivered with documentation to repositories based upon their specimen type (Biological - Smithsonian, Geological - Oregon State University Marine Geological Laboratory, Genetic - Ocean Genomic Legacy)

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:	http://www.ncddc.noaa.gov/oer-waf/ISO/Resolved/2016/
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:	http://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?

not applicable

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

30-90 days

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 E: NASA 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 the Aerosol Robotic Network (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 ocean.

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

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

Appendix F: Permits

REPUBLIC OF THE MARSHALL ISLANDS
MINISTRY OF FOREIGN AFFAIRS
P.O. BOX 1349
MAJURO, MARSHALL ISLANDS 96960

US/98-15

The Ministry of Foreign Affairs of the Republic of the Marshall Islands presents its compliments to the Embassy of the United States of America and has the honor to make reference to U.S. ***Diplomatic Note No.15-105*** regarding request for an authorization for NOAA Chief of Scientist Jeremy Potter to conduct marine scientific research in area requiring the consent from the RMI Government. It is in this regard that the Ministry has the further honor to inform the Embassy that in compliance with the requirements of the MIMRA Act 1997, NOAA Research Vessel, "Okeanos Explorer", has been granted permission, on the condition that a copy of report of all data and other information from the research vessel in RMI WATERS be forwarded to the Ministry of Foreign Affairs and the Marshall Islands Resource Authority.

The Ministry has the further honor to advise that authorization is granted pursuant with the understanding that the said vessel, captain and crew will comply with all RMI laws and regulations, and in particular the Marine Water Quality (1992) regulations, Solid Waste (1989) regulations, and Toilet Facilities and Sewage Disposal (1990) regulations, copies of which are available for download at the RMI-EPA website http://rmiepa.org.

Furthermore, the Ministry wishes to forward herein, RMI's nominees from Marshall Islands Marine Resources Authority to participate in afore-named research.

Ms. Candice M. Guavis
Deputy Chief, Coastal Fisheries Monitoring and Compliance Unite
MIMIRA
cmguavis@gmail.com

Mr. Benedict Yamamura
Coastal Fisheries Information Officer
MIMRA
Byamamura86@gmail.com

Ms. Lyla Lemari
Coastal Fisheries Research Officer
MIMRA
lylalemari@gmail.com

Phone: (692) 625-2699/2763/3012/3181 Fax: (692) 625-4979 RMI Website: http://www.rmiembassyus.org/

The Ministry of Foreign Affairs of the Republic of the Marshall Islands avails itself of this opportunity to renew to the Embassy of the United States of America the assurance of its highest consideration.

18 December, 2015

Embassy of the United States of America
Majuro, REPUBLIC OF THE MARSHALL ISLANDS

Appendix G: 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

July 13, 2016

MEMORANDUM FOR: The Record

FROM: John McDonough
Deputy Director, NOAA Office of Ocean Exploration and Research (OER)

SUBJECT: Categorical Exclusion for NOAA Ship *Okeanos Explorer* Cruise EX-16-06

NAO 216-6, Environmental Review Procedures, requires all proposed projects to be reviewed with respect to environmental consequences on the human environment. This memorandum addresses NOAA Ship Okeanos Explorer's scientific sensors possible effect on the human environment.

This project is part of the NOAA Office of Ocean Exploration and Research's (OER) "Science Program" and entails ocean mapping activities, Remotely Operated Vehicle (ROV) Operations, and water column profiling using CTD casts designed to increase knowledge of the marine environment. This Categorical Exclusion addresses NOAA Ship Okeanos Explorer cruise EX-16-06 "CAPSTONE : *Deepwater Wonders of Wake: Exploring the Pacific Remote Islands Marine National Monument"* (ROV & Mapping)" led by Brian Kennedy, Expedition Coordinator 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.

EX-16-06 is a telepresence-enabled ROV cruise that will be conducted from July 27- August 19 2016 in Guam, on the High Seas, in the Wake Island unit of the Pacific Remote Islands Marine National Monument (PRIMNM), and the Marshall Islands. Operations will be focused primarily on deep water areas 500m and deeper (though may include high priority work up to 250m). The cruise will start in Guam and end in Kwajalein, Marshall Islands. 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, rift zone ridges, and bottom fish habitats

The Kongsberg EM 302 multibeam (30 kHz), Kongsberg EK 60 split beam sonars (18, 38, 70, 120, 200 kHz), a Knudsen 3260 Sub-Bottom Profiler (3.5 kHz), and two Teledyne Acoustic Doppler Current Profilers (ADCP) operating at 38 kHz and 300 kHz will be operated during the project. Additionally, expendable bathythermographs (XBTs), UnderwayCTD casts, and CTD rosette casts will be conducted in conjunction with multibeam data collection. Mapping operations will be conducted primarily in the evening/overnight, and during transits in water deeper than 50 m. As the ship moves over the surface of the water during mapping operations, negative acoustic impacts from sonar operations on a single target are negligible.

ROV Operations

The purpose of conducting ROV operations is to conduct interdisciplinary site characterization at priority targets in the PRIMNM, on the high seas and in the Marshall Islands. Interdisciplinary site characterization would be achieved by visually surveying priority targets while simultaneously acquiring environmental data with in situ sensors mounted on the ROVs (CTD and DO). ROV targets include seamounts, rift zone ridges, 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 these areas, and should contribute to enhanced protection of these resources.

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 holds 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 area the ROV is set on 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 EX1606, up to 17 deployments of the ROV would occur during the expedition, resulting in 170 hours total dive time (-8-12 hours for each dive). The ROV moves across the seafloor throughout the dive, so impact to any one area are short in duration and therefore minimal.

During these dives, limited sampling operations are planned to collect very selective specimens with the ROV 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; manganese-coated rocks;

and rock samples in support of the United States Extended Continental Shelf Project. 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.

Mapping Operations on *Okeanos Explorer*

The acquisition of high-resolution seafloor mapping data is an essential precursor to making significant biological, geological, archaeological and oceanographic discoveries. The *Okeanos Explorer* cruise will collect seafloor mapping data 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 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 during non-ROV operations throughout the cruise. As the ship moves over the surface of the water during mapping operations, negative acoustic impacts from sonar operations on a single target are negligible. Acoustic instruments that will be operational during the project are a 30 kHz multibeam echosounder (Kongsberg EM 302), Kongsberg EK60 single beam echosounders (18, 38, 70, 120, 200, and 333 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 UCTD will be deployed at regular intervals in association with multibeam data collection. All of these systems are routinely used by this exploration vessel and have provided invaluable scientific data for marine researchers and managers, including numerous National Marine Sanctuaries and Monuments, the Bureau of Ocean Energy Management and the U.S. Geological Survey.

Bridge Officers and Watch Standers will be on watch during all hours and will to look for marine mammals and other observable species potentially sensitive to the sound of the sonars. If cetaceans are sighted, knowledgeable personnel would follow established best management practices to minimize disturbance. If a cetacean is observed, the Mapping Watch Lead and Expedition Coordinator are notified, and if appropriate, the ship will slow down or stop until the animal has departed the area. If cetacean species are present within 400 m of the ship, the vessel will stop until the animals depart the area. 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.

Multibeam Sonar

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 the Monuments, and the geology of the area. 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.

Sound velocity -Underway CTD or XBT

Accurate measurements of sound speed as a function of depth down to approximately 700 meters are needed every 3-6 hours during multibeam sonar mapping operations. These sound speed measurements are essential for ray-tracing calculations used by the EM302 multibeam sonar system in order to collect accurate bathymetry and backscatter data. To obtain these essential data, the Okeanos Explorer can either use an XBT or the new underway CTD (UCTD) equipped with a sound velocity probe. The Okeanos Explorer plans to use the UCTD during the 2016-17 field seasons as much as possible as rather than conducting XBTs, since UCTD does not leave anything in the ocean after gathering the measurements.

The UnderwayCTD (UCTD): The UCTD manufactured by Teledyne Ocean science is a piece of equipment used to gather conductivity/temperature/depth (CID) measurements or sound velocity measurements while the ship is moving. This instrument is mounted on the stem railing and has a re-usable probe that is dropped through the water column then retrieved by rewinding the line onto a motorized spool. The unit would not touch the seafloor. The unit can be equipped with a CTD probe or a sound velocity probe. When equipped with the sound velocity probe, the UCTD can obtain water column profiles down to over 700 meters while the ship is moving at 8 knots, Okeanos Explorer's standard survey speed, so the UCTD can sample the water column while continuously mapping.

Expendable bathythermographs (XBT): XBTs are deployed to obtain sound velocity profiles. The profiles are required to calibrate the multi-beam system and ensure accurate bathymetric mapping. During the EX-16-06 ROV cruise, mapping operations would be conducted mainly at night in transit to the next dive location. XBTs will likely be deployed once every 4-6 hours to ensure accurate bathymetric data collection (resulting in a maximum of 2-3 total XBT deployments in a 24-hour period). It is anticipated that UCTD casts will be the preferred and more commonly used method to obtain sound velocity profile data, however XBTs will likely be used when time to obtain the cast data is very limited (e.g. weather windows, vessel traffic, or ship-time constraints) or there is a mechanical or data quality problem with the UCTD. 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 minimal 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.

Single Beam and Split Beam Sonars

Kongsberg EK60 sonars are specifically designed to provide calibrated quantitative acoustic data useful for interpreting marine life in the water column of the ocean. Additionally, they are now also used to generate gaseous seep flux rates and their contribution to ocean and atmospheric chemistry. In many cases the ability to observe and measure the acoustic backscatter response of different types of marine life (fish, squid, plankton, etc.) is dependent upon the frequency of the sonar. Therefore, the more frequencies that are used for these acoustic surveys, the more complete the picture that can be gained about the marine environment. OER has received specific feedback from marine scientists in the Pacific region that our EK60 data would be much more useful when collected using multiple frequencies than at just the 18 kHz frequency. Given these benefits, OER intends to gather EK60 data at multiple frequencies as much as possible.

Acoustic Doppler Current Profilers (ADCPs)
Ship-mounted ADCPs have been used on oceanographic research vessels for over 25 years, and are useful for characterizing current speeds and direction at various depths in the ocean. ADCP measurements are therefore critically useful in characterizing the physical oceanography of an area, identifying small to mesoscale ocean current features, and even contributing to our understanding of the climatology of a region with repeated measurements over time. In addition to these scientific benefits, the Okeanos Explorer is interested in using the new ADCPs to assess currents near ROV dive locations to inform dive planning and ensure safe ROV deployment and recovery operations. Given these benefits, OER would like to use the new ADCPs within the PRIMNM, within the Marshall Islands and on the High Seas as a useful data stream contributing to characterizing the area, providing new information on ocean currents to scientists and managers, and helping to plan effective and safe ROV exploration dives.

Sub Bottom Profiler
The primary purpose of this Knudsen Chirp 3260 (3.5 kHz) 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. Collecting this data in the Leg II operating area will provide greatly improved insights into the geology of the region, and supplement existing magnetometer and gravity measurements obtained by other vessels.

CTD Rosette Operations
The CTD rosette instrument is used to obtain conductivity, temperature, depth and other oceanographic data (dissolved oxygen, light scattering, and oxygen reduction potential). 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 would not touch the seafloor and would have limited time and presence in the marine environment.

Permits
OER has completed an informal consultation with NOAA's National Marine Fisheries Service (NMFS) under section 7 of the Endangered Species Act of 1973 that addresses the potential impacts of project activities to ESA-listed species and critical habitat for all operations to be conducted as part of the 2016-2017 CAPSTONE expeditions. A Letter of Concurrence was received from NMFS on February 7, 2016, concurring with OER's determination that CAPSTONE Expedition activities are not likely to adversely affect ESA-listed marine species, and would have insignificant effects on designated or proposed critical habitat.

Effects of the Project
As expected for ocean research with 1imited duration or presence in the marine environment,

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

Knowledgeable experts who are aware of the sensitivities of the marine environment will conduct the at-sea portions of this project, and will adhere to standard operating procedures as defined above and make every effort to minimize negative impacts to the environment. The potential gains or beneficial effects of the project seem to outweigh any potential adverse effects. This expedition will provide baseline characterization of poorly understood deep water habitats, including within marine protected areas, contained within the U.S. Exclusive Economic Zone (EEZ) and on the high seas. This work will provide essential information for further research, exploration, and conservation of marine habitats within the planned operating area.

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 and will not result in individually or cumulatively significant impacts on the quality of the human environment. Specifically, this research cruise would have only short-term effects with the principle goals of natural resource inventories and environmental monitoring over a wide geographic area. Furthermore, this action would not be subject to any of the exceptions for categorical exclusion provided at NAO 216-6 section 5.05c. As such, this project is categorically excluded from the need to prepare a NEPA environmental assessment.

Appendix H: ESA 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

January 14, 2016

Ann Garrett
Assistant Regional Administrator
Protected Resources Division
NMFS Pacific Islands Regional Office
1845 Wasp Blvd., Building 176
Honolulu, HI 96818

Re: Request to Initiate Consultation under Section 7 of the Endangered Species Act for the Campaign to Address Pacific Monument Science, Technology and Ocean Needs (CAPSTONE Project)

Dear Ms. Garrett:

Operating under a partnership with NOAA's Office of Ocean Exploration and Research and the Office of Marine and Aviation Operations, the *Okeanos Explorer* team is preparing to continue the CAPSTONE campaign into the Central and Western Pacific during the 2016 and 2017 field seasons. The action area for the 2016 – 2017 season will include the marine environments in and around: the 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.

The activity would occur during two years and could include up to twenty different research cruises aboard the NOAA Ship *Okeanos Explorer* scheduled between February 2016 and December 2017. All cruises will focus on collecting critical baseline information in monuments and sanctuaries to meet NOAA science and management needs. The overarching goal of the project is to extend and improve the understanding of the distribution and diversity of deep-water habitats within the marine protected areas in the Pacific. Data and information from the cruises will build on previous work where appropriate, and 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, Indonesia, and Hawaii, 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), CTD rosette, and a high-bandwidth satellite connection for real-time ship to shore communications. These expeditions will help establish a baseline of information in the region to catalyze further exploration, research and management activities.

We propose to conduct activities to explore and improve understanding of the distribution and diversity of deep water habitats. No activities would occur on land. The expedition teams (26 crew and up to 20 rotating scientists/technicians on each cruise leg) would be authorized to conduct mapping and 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.

Enclosed is a Biological Evaluation (BE) to initiate consultation under Section 7(a)(2) of the Endangered Species Act (ESA). As described in the BE, we have determined that the proposed 2016 CAPSTONE cruises may affect, but are not likely to adversely affect, the following ESA-listed marine species: 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.*

We request your concurrence with our 'not likely to adversely affect' determination for the species listed above and for Hawaiian monk seal critical habitat.

Please contact Kelley Elliott (**Kelley.Elliott@noaa.gov**, 301-734-1024) with questions regarding this consultation request.

Respectfully,

by Path
For John McDaugh

Appendix I: Acronyms

3D—Three-dimensional
ADCP—Acoustic Doppler Current Profiler
AERONET—Aerosol Robotic Network
BM—Bernice Pauahi Bishop Museum
CAPSTONE—NOAA Campaign to Address Pacific monument Science, Technology, and Ocean NEeds
CIT—Chiba Institute of Technology
CSV—Comma-separated values
CTD—Conductivity, temperature, and depth
D2—ROV Deep Discoverer
DNA—Deoxyribonucleic acid
DO—Dissolved oxygen
DOI—Department of the Interior
DSCRPT—NOAA Deep Sea Coral Research and Technology Program
ECC—Exploration Command Center
EEZ—Exclusive Economic Zone
ESA—Endangered Species Act
EX—NOAA Ship Okeanos Explorer
FAU—Florida Atlantic University
FeMn—Ferromanganese
FSU—Florida State University
GEMS—Geoscience Earth and Marine Services
GFOE—Global Foundation for Ocean Exploration
HBOI—Harbor Branch Oceanographic Institute
HD—High-definition
HIGP—Hawai‘i Institute of Geophysics & Planetology
HURL—Hawai‘i Undersea Research Laboratory
IHMC—Institute for Human & Machine Cognition
IRC—NOAA Inouye Regional Center
ISA—International Seabed Authority
ISC—Inner Space Center
JIMAR—Joint Institute for Marine and Atmospheric Research
JPL—NASA Jet Propulsion Laboratory
LED—Light-emitting diode
LLC—Limited liability company
LOC—Letter of Concurrence
LSU—Louisiana State University
MAN—NASA’s Maritime Aerosol Network
MBARI—Monterey Bay Aquarium Research Institute
Mbps—Megabit-per-second
MGR—Marine Geology Repository

Mn—Manganese
MPA—Marine protected area
NAO—NOAA Administrative Order
NASA—National Aeronautics and Space Administration
NCEI—National Centers for Environmental Information
NEPA—National Environmental Policy Act
NGDC—NOAA National Geophysical Data Center
NMFS—NOAA National Marine Fisheries Service
NOAA—National Oceanic and Atmospheric Administration
NPS—National Parks Service
OER—NOAA Office of Ocean Exploration and Research
OET—Ocean Exploration Trust
ONMS—NOAA Office of National Marine Sanctuaries
OSU—Oregon State University
PCZ—Prime Crust Zone
PERC—Planetary Exploration Research Center
PI—Principal Investigator
PIFSC—NOAA Pacific Islands Fisheries Science Center
PIRO—NOAA Pacific Islands Regional Office
POC—Point of contact
PRIMNM—Pacific Remote Islands Marine National Monument
QA/QC—Quality assurance/quality control
RMI—Republic of the Marshall Islands
ROV—Remotely Operated Vehicle
SIO—Scripps Institution of Oceanography
SIS—Seafloor Information Software
SOI—Schmidt Ocean Institute
SOP—Standard operating procedure
TAMU—Texas A&M University
TSG—Thermosalinograph
UCAR—University Corporation for Atmospheric Research
UConn—University of Connecticut
UH—University of Hawai‘i at Mānoa
ULL—University of Louisiana at Lafayette
USGS—U.S. Geological Survey
USNM—National Museum of Natural History, Smithsonian Institution
UTC—Universal Time Coordinated
WAU—Wake Atoll Unit of the PRIMNM
XBT—Expendable bathythermograph