Sponsored Projects

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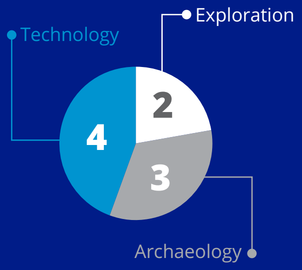
Sponsored Projects:
NOAA's Office of Ocean Exploration and Research

FY2017 BY THE NUMBERS

NUMBER OF PROPOSALS AND AWARDS

86 Pre-Proposal Requests
27 Full Proposal Requests
9 Awarded

NUMBER OF AWARDS BY THEME



FUNDING SUMMARY

$37,250,000 Pre-Proposal Requests
$12,240,000 Full Proposal Requests
$3,600,000 Awarded

Introduction

By Nathalie Valette-Silver, Frank Cantelas, Chris Beaverson, Amanda Netburn, Yvette Jefferson, Joyce Woodford, and Stephen Hammond

To help accomplish its mission to explore and characterize the deep ocean, NOAA's Office of Ocean Exploration and Research sponsors projects through grants and cooperative agreements, as well as intra- and interagency agreements. These projects complement systematic ocean exploration conducted by NOAA Ship *Okeanos Explorer*.

On an annual basis, OER publishes a Federal Funding Opportunity (FFO) that invites the submission of proposals focused on ocean exploration (including maritime exploration for, and of, culturally important submarine sites) and on technological innovations with the potential for increasing the pace and scope of ocean exploration.

For the past several years, dependent on OER's year-to-year budget, the funding allocation for the FFO has ranged from $3 million to $4 million. Projects are selected based on a community-standard process of peer review, coupled with published programmatic selection factors.

Funded projects benefit from proactive OER support, including assistance with cruise planning, federal administrative reporting requirements, and communication of project discoveries and results by means of OER's website.

This section highlights a few of OER's 2017 sponsored projects in archaeology, technology, and exploration that demonstrate the breadth of work supported by OER. In addition to those presented here, two other archaeology projects were supported by OER and conducted using the Ocean Exploration Trust's E/V *Nautilus* (see pages 36–38).

Under the supervision of its pilots, an unmanned aircraft system takes off over Lake Huron in Thunder Bay National Marine Sanctuary. See details on page 90. *Image credit: TBNMS, NOAA*

A new sensor for detecting nitrogen gas was tested on *Okeanos Explorer* in October 2017. See details on page 96. *Image credit: Charles Wilkins, Okeanos Explorer*

Calcified green algae are important to the biogeochemical cycles of coral reefs. In this garden of algae, the science team observed three species of *Halimeda*, as well as *Udotea* and *Rhipocephalus*. See details on page 89. *Image credit: Cuba's Twilight Zone Reefs and Their Regional Connectivity*

Cooperative Institute for Ocean Exploration, Research, and Technology

By Shirley Pomponi, John Reed, Joshua Voss, Dennis Hanisak, M. Cristina Diaz, Andrew David, Felicia Drummond, Patricia González-Díaz, Linnet Busutil López, Beatriz Martínez-Daranas, Dorka Cobián Rojas, and Nathalie Valette-Silver

NOAA's Cooperative Institute for Ocean Exploration, Research, and Technology (CIOERT) is a partnership of Florida Atlantic University-Harbor Branch Oceanographic Institute, University of North Carolina Wilmington, University of Miami (UM), SRI International, and NOAA's Office of Ocean Exploration and Research. Activities focus on three themes: exploration of continental shelf edge frontiers, research on vulnerable coral and sponge ecosystems, and development of advanced underwater technologies.

From May 15 to June 13, 2017, CIOERT conducted an expedition to discover and characterize the extent of mesophotic reefs around Cuba and to compare the health and connectivity of mesophotic and shallow coral reef ecosystems in Cuba and the United States. This collaborative effort involved six Cuban institutions and agencies (Centro de Investigaciónes Marinas at University of Havana, Centro Nacional de Áreas Protegidas, Instituto de Ciencias del Mar, Geocuba Estudios Marinos, Guanahacabibes National Park-Sistema Nacional de Areas Protegidas, and Acuario Nacional de Cuba), and NOAA's Office of National Marine Sanctuaries, National Marine Fisheries Service, and OER. The team explored never-before-studied mesophotic coral reefs from 30 m to 150 m depth around the entire island. Details, mission blogs, and photos are available at http://oceanexplorer.noaa.gov.

Through daily ROV dives from the UM R/V *F.G. Walton Smith*, scientists focused on characterization of deep coral reefs, documenting the geomorphology, biological zonation, and diversity of marine biota (Figures 1 and 2). Many dives were conducted in or adjacent to Cuba's extensive network of marine protected areas to explore locations for possible creation of new MPAs or expansion of existing boundaries. Data analyses are in progress to document density and cover of corals, sponges, algae, and fishes, as well as to determine genetic connectivity among corals from Cuba, Central America, the Gulf of Mexico, and the Florida Keys.

CIOERT also supports NOAA's Deep Sea Coral Research and Technology Program priorities to identify and understand deepwater sponge ecosystems, with active participation in a partner project funded by the European Union Horizon 2020 Program (SponGES). In 2017, several expeditions to the North Atlantic were conducted in support of this project aboard US, Norwegian, Spanish, Swedish, and Canadian research vessels.

CIOERT scientists participated in NOAA Ship *Okeanos Explorer* missions, both as ship-based science leads during two legs of the Marianas Trench Marine National Monument expedition in 2016 and as shore-based science teams supporting the CAPSTONE effort in 2016 and 2017.

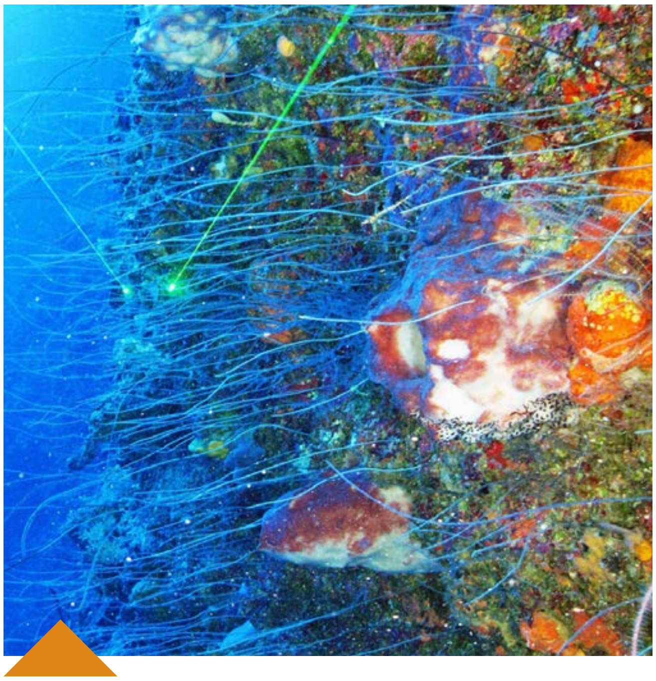


Figure 1. Vertical, rugged rock walls were common at most study sites in Cuban waters from 50 m to 125 m depth. Black whip corals (*Stichopathes* sp.) and whip gorgonians (*Elisella* sp.) are ubiquitous here, feeding on plankton carried along by deep currents. *Image credit: Cuba's Twilight Zone Reefs and Their Regional Connectivity*

Figure 2. Cuba's mesophotic reefs support an incredible diversity of beautiful organisms. *Image credit: Cuba's Twilight Zone Reefs and Their Regional Connectivity*

Pushing the Boundaries: Technology-Driven Exploration of Thunder Bay National Marine Sanctuary

By John Bright, Russell Green, Frank Cantelas, and Nathalie Valette-Silver

Since the expansion of Thunder Bay National Marine Sanctuary in 2014, the priority of sanctuary researchers has been to search new sanctuary waters to discover shipwrecks.

In 2017, Thunder Bay National Marine Sanctuary assembled a collaborative, interdisciplinary team to bring together several different remote-sensing technologies to survey both in shallow water and in some of the deepest offshore areas of Lake Huron.

Although 94 historical shipwrecks are already known throughout this area, archival research indicates that as many as 100 more are yet to be found within the expanded sanctuary. Funded by a grant from NOAA's Office of Ocean Exploration and Research to locate new wrecks, researchers conducted a four-part expedition to test new applications of tools for archaeologically focused remote sensing during the spring and summer of 2017. In particular, innovative approaches to bottom mapping were of great value to maritime archaeologists.

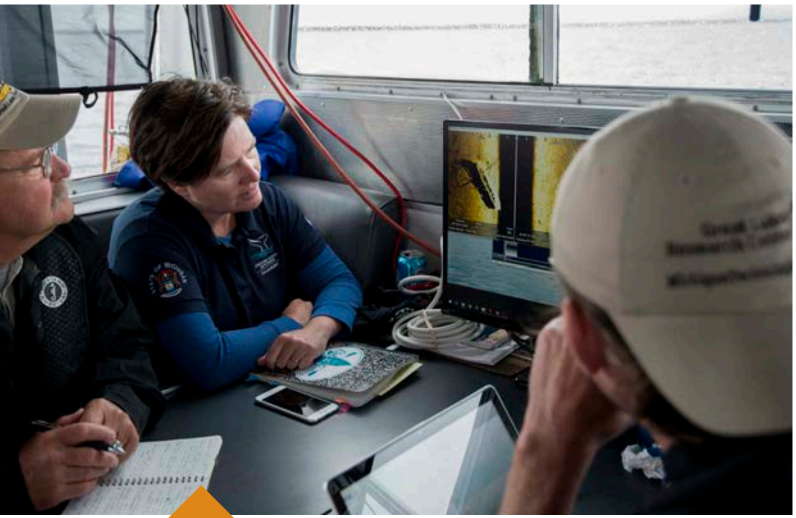


Figure 1. NOAA archaeologist Stephanie Gandulla reviews sonar data with Michigan Tech PI Guy Meadows. *Photo credit: TBNMS, NOAA*

The team took advantage of the exceptional early spring clarity of Lake Huron's water to test new approaches for using unmanned aircraft systems (UASs) as marine archaeological survey tools. Camera-equipped UASs operating over the water in April to image the shallow lake floor produced imagery so detailed that individual timbers from shipwreck sites were easily visible. Partners from NOAA's National Geodetic Survey's Remote Sensing Division, Oceans Unmanned, and Trumbull Unmanned supplied the UAS platforms and pilots.

In May, the team transitioned to deepwater surveying within the sanctuary's new northern boundary. Partnering with the University of Delaware, they used an Edgetech 6205 sonar integrated onto NOAA research vessel R8001. Operating 24 hours a day, the team conducted a wide-area acoustic survey, mapping 243.5 km^2 of lake bottom and revealing two new targets that appeared to be historic shipwrecks.

Target investigations took place throughout June and August, starting with an assessment conducted with an AUV provided and operated by Michigan Technological University. Equipped with an EdgeTech 2205 sonar, the AUV imaged important details such as the size, shape, design, and integrity of each target (Figure 1). Comparing the sonar images to historical records provided the first tentative identities of each vessel. Follow-on investigations using a small ROV provided by Northwestern Michigan College confirmed the sites to be the wooden bulk carrier *Ohio* (lost in 1894) and the steel bulk carrier *Choctaw* (lost in 1915; Figure 2).

Executing the research phases sequentially reduced the amount of time between discovering a historical shipwreck and completing a detailed baseline archaeological understanding of its remains. Likewise, the shallow-water survey completed with UAS technologies provided new insights into their broader application as valuable marine survey tools, especially within the clear waters of the Great Lakes.

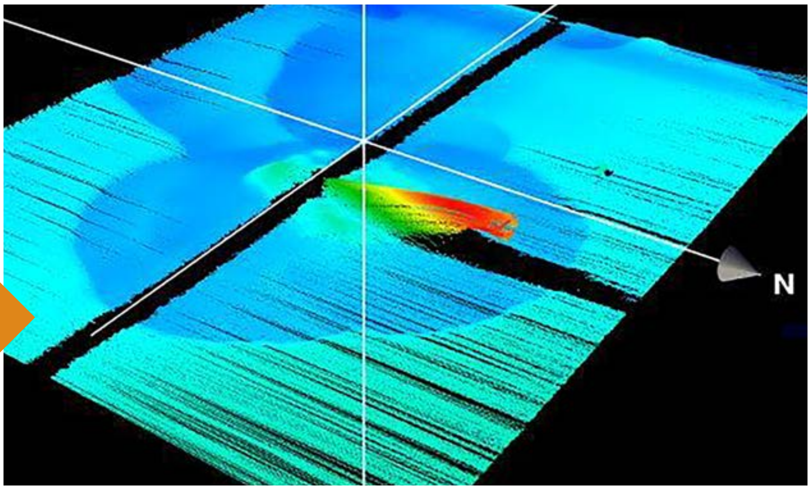


Figure 2. Rendered three-dimensional bathymetric data product from the archaeological site identified as the remains of steel bulk carrier *Choctaw*. *Image credit: Michigan Technological University*

Exploring the Sunken Heritage of Midway Atoll at the 75th Anniversary of the Battle of Midway

By Kelly Keogh, Bert Ho, Nathalie Valette-Silver, and Frank Cantelas

The legacy of World War II is perhaps nowhere more evident than at Midway Atoll, a World Heritage Site located within the Papahānaumokuākea Marine National Monument (Figure 1). One of the most decisive US victories of World War II, the Battle of Midway is considered the turning point of the war in the Pacific, and material remains on the seafloor at Midway are considered war graves. Archival research reveals that at least 31 planes (22 American and 9 Japanese) crashed within 5 km of Midway Atoll (Linville, 2010), and dozens more are probably resting further away from it. June 2017 marked the 75th anniversary of this battle, and our project aimed to raise awareness and honor the legacy of the brave men who perished during the battle.

In May 2017, using small boats provided by the US Fish and Wildlife Service, a team of archaeologists and biologists conducted an exploratory search for sunken aircraft associated with the Battle of Midway and assessed their potential as habitat for invasive species in the Northwestern Hawaiian Islands.

Figure 1. Aerial view of Midway Atoll. *Image credit: Papahānaumokuākea Marine National Monument/NOAA*

To document and analyze known sunken aircraft remains as well as new discoveries, the team of scientists used a technique called photogrammetry, which makes measurements from photographs. This tool is extremely useful in that the imagery can be collected in a short amount of time, providing scientists with a great deal of information. Photogrammetry was used at Midway to produce detailed three-dimensional images of sunken aircraft.

One of the best tools for locating cultural or man-made material underwater is a marine magnetometer, which detects variations in Earth's magnetic field caused by ferrous material. Employing a magnetometer, the team identified 137 magnetic anomalies or "targets" for further visual investigations by divers. Using scuba equipment and freediving to explore some of the shallower anomalies, the team investigated 102 anomalies, 86 of which had positive findings for cultural material (Figure 2). Findings included nineteenth century anchors, Navy anchors, building debris, and possibly part of a radial aircraft engine.

We believe some remarkable discoveries will emerge from this survey (Figure 3), but at this point, the specific identities of the artifacts are inconclusive. Archaeologists are continuing to analyze data and consult records in order to produce more conclusive identification to be shared with the public.

Figure 2. A diver documents a structure discovered by magnetometer survey for any invasive species. *Image credit: Brett Seymour, Exploring the Sunken Heritage of Midway Atoll expedition*

Figure 3. Jason Leonard photographs the remains of the radial engine from the Brewster Buffalo fighter plane. *Image credit: Brett Seymour, Exploring the Sunken Heritage of Midway Atoll expedition*

Cold Seeps of the Cascadia Margin

By Robert Embley, Susan Merle, Nicole A. Raineault, Lindsay Gee, Nathalie Valette-Silver, and Stephen Hammond

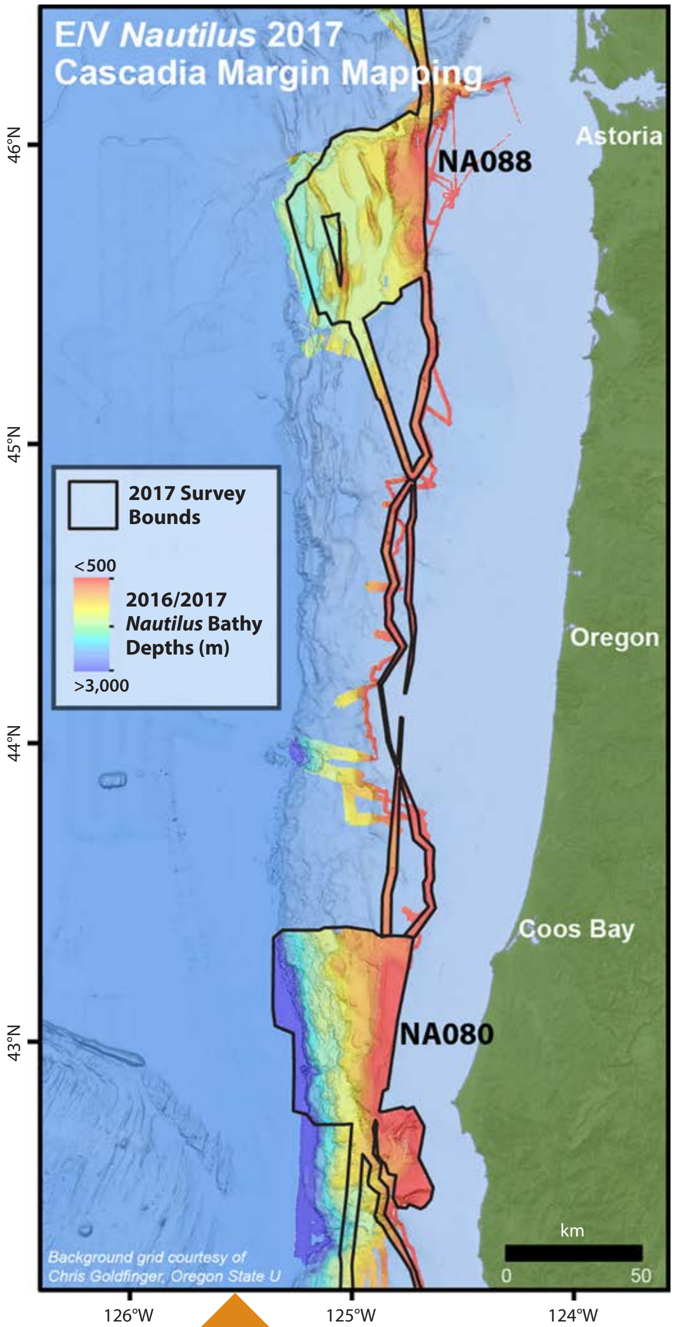


Figure 1. Black polygons enclose the main areas surveyed on the Cascadia margin in 2017 by E/V *Nautilus*. *Image credit: Susan Merle, NOAA PMEL*

In June and September 2016, Ocean Exploration Trust cruises explored cold seeps along the continental margins of Washington, Oregon, and northern California. Work aboard E/V *Nautilus* included bathymetric and water column mapping surveys that identified hundreds of new methane bubble stream sites, which were subsequently explored with ROV *Hercules* (Embley et al., 2017).

In 2017, *Nautilus* cruises NA080 and NA088 conducted seafloor and water column surveys using the EM 302 multibeam echosounder, adding substantially to the database of methane bubble stream sites off the Cascadia continental margin (Figure 1). Subsequent initial processing of the 2017 data aided in the identification of many additional sites in water depths ranging from 83 m to 1,972 m. The NA080 survey added data to an area extending 68 km north of the 2016 surveys, inclusive of the western edge of Coquille Bank and extending west to the base of the continental slope. Cruise NA088, on the northern Oregon continental slope, added considerably to the 2016 survey of this area. During the 2017 field season, *Nautilus* also collected multibeam data on transits along the Cascadia margin in addition to the two planned surveys.

Data from the 2016 and 2017 *Nautilus* surveys are being collated, along with new data from other sources, into an expanded database of methane bubble sites along the entire Cascadia margin. Applying a spatial filter with a 300 m radius, the 2016 and 2017 *Nautilus* surveys located 380 new methane bubble stream sites, about three and a half times the number of sites known prior to 2016. These new data, in addition to new sites identified on 2016 and 2017 multibeam surveys from the Olympic Coast National Marine Sanctuary conducted by NOAA Ship *Rainier*, as well as survey lines made by academic research vessels, provide a significantly expanded baseline for research on potential effects of climate change and tectonics on the ocean carbon cycle. These data sets will also be important for assessing the distribution and extent of methane vent-associated chemosynthetic communities and hard-ground habitat on the Cascadia continental margin.

Exploring US Mid-Atlantic Margin Methane Seeps: IMMeRSS, May 2017

By Carolyn Ruppel, Amanda W.J. Demopoulos, and Nancy Prouty

The May 2017 Interagency Mission for Methane Research at Seafloor Seeps (IMMeRSS) expedition studied the geology, ecology, chemistry, and physics of methane seeps between Baltimore and Norfolk Canyons on the US Mid-Atlantic margin (Figure 1). IMMeRSS was led by US Geological Survey (USGS) scientists in collaboration with the British Geological Survey (BGS) and with support from NOAA's Office of Ocean Exploration and Research and the US Department of Energy.

The IMMeRSS team used Deep Sea Systems ROV *Global Explorer,* managed by Oceaneering International Inc., to complete five dives from May 3 to May 11, 2017, at water depths of 425 m to 1,450 m (Figure 1). The cruise marked the first time that the University of Delaware's R/V *Hugh R. Sharp* was used for ROV operations in water depths greater than 500 m.

Since 2012, over 600 methane seeps have been discovered between Cape Hatteras and Georges Bank on the US Atlantic margin. The seeps occur from the outer continental shelf (~100 m depth) to the middle of the continental slope (~1,500 m depth), with many located on the uppermost slope (150–450 m depth), just shallower than the landward limit of gas hydrate stability. Only a handful of these cold seep sites have been visited by ROVs or the submersible *Alvin*. During the 2017 IMMeRSS cruise, researchers carried out detailed surveys at seeps where chemosynthetic communities had previously been identified, and conducted discovery dives at recently detected seeps (Figure 2).

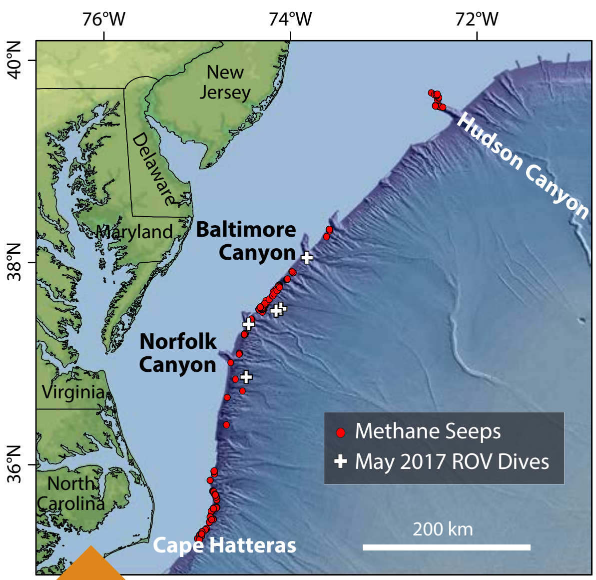


Figure 1. Map showing location of methane seeps (red circles) and dives led by the USGS using ROV *Global Explorer* from R/V *Hugh R. Sharp* in May 2017.

A key focus of IMMeRSS was acquiring samples of methane-derived authigenic carbonates, unique seafloor rocks that form in their present locations as a result of microbial processes. BGS scientists are analyzing the carbonates using uranium-thorium radioisotopic methods to constrain the age of methane emissions responsible for the formation of these rocks. To characterize benthic community ecology, researchers sampled chemosynthetic organisms such as mussels and surveyed the distribution of benthic biota along video transects that crossed seep fields. Biogeochemical data acquired from the organisms, surrounding sediment, and deep ocean waters are being analyzed to determine how environmental factors affect seep ecology. Researchers also collected samples that can be used to infer whether microbial processes or processes like those responsible for petroleum formation produce the methane that is leaking at the seeps.

Outreach activities included real-time video streaming of the ROV dives to onshore web portals managed by OER and Oceaneering International Inc. The video stream received more than 22,000 individual views, with the highest number accessing the portal when an intact baleen whale skeleton was found on the seafloor. The image-only video stream was supplemented with real-time social media updates coordinated by the USGS. The Facebook posts increased likes, reach, and engagement for the USGS Coastal and Marine Geology page by more than 2,000% according to detailed analytics compiled during the IMMeRSS cruise.

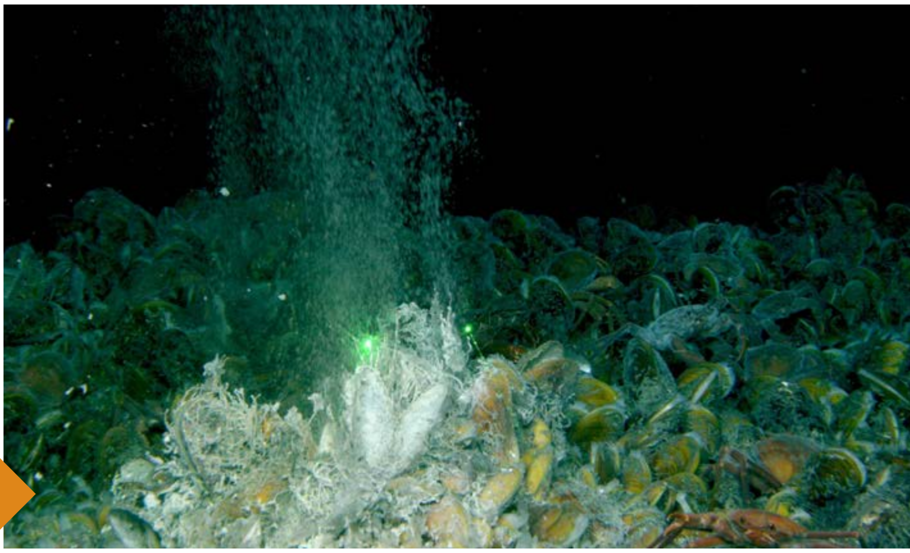


Figure 2. A newly discovered methane seep at approximately 1,000 m water depth offshore Virginia. The bubbles are emanating from a densely populated field of *Bathymodiolus* mussels. Lasers (green dots) are separated by 10 cm. *Image credit: USGS*

Innovative Observing Approaches to Better Understand the Big Picture

By Gabrielle Canonico and Margot Bohan

NOAA's Office of Ocean Exploration and Research provides funds for and advocates on behalf of two independent, complementary ventures that are tapping into new methods for observing the marine environment. The NOAA California Cooperative Oceanic Fisheries Investigations (CalCOFI) Genomics Project (NCOG) and the US Marine Biodiversity Observation Network (MBON) place high value on biological observing to increase our understanding of the Great Lakes, coasts, and ocean, and to augment existing ecosystem assessment and monitoring efforts.

Since 2014, as a component of CalCOFI, NCOG scientists have sequenced marine rDNA and mRNA and conducted associated bioinformatics to identify and quantify microbial organisms and their functions within the context of physical and chemical conditions in the southern California Current ecosystem. Understanding the sensitivity of marine microbial populations to natural and anthropogenic stressors will expand our current insights into ecosystem resiliency, enabling us to better predict environmental tipping points.

MBON scientists working on three demonstration projects (Arctic, Santa Barbara Channel, and National Marine Sanctuaries MBON) are also collaborating to define and develop common biological observing methods and standards to be used as model practices for a national biodiversity observing network. They are making progress on molecular eDNA techniques to evaluate habitat and multi-trophic-level diversity. This novel approach will aid in the detection of significant change in biodiversity (Figure 1) over time, and help identify invasive species. MBON teams are also focused on multivariate remote-sensing techniques to evaluate dynamic seascapes from regional to global scales, enhancing the spatial footprint of in situ observations.

To maximize sustainable use of ocean resources for economic growth and to improve livelihoods and jobs, we need refined tools such as those stemming from NCOG and MBON to provide a fuller, more integrated picture of how our ecosystems function.

Figure 1. Marine biodiversity is key to ocean health and human well-being. *Image credit: Gustav Paulay and Steve Haddock*

Northern Neighbors: Transboundary Exploration of Deepwater Communities

By Martha Nizinski and Caitlin Adams

In June 2017, a team of scientists aboard NOAA Ship *Henry B. Bigelow* spent 14 days at sea exploring canyon and slope habitats off the coast of the northeast United States and Atlantic Canada. Using the Canadian Scientific Submersible Facility's (CSSF) ROV ROPOS, the team targeted minor canyons between Nygren and Heezen Canyons (United States; Figure 1), Georges and Corsair Canyons and Fiddler's Cove (Canada), and sites in western and central Jordan Basin in the northern Gulf of Maine (United States, Canada; Figure 2).

The research team completed 11 ROV dives between 152 m and 1,200 m depth for a total of 180 hours of bottom time. Over 125 physical samples were collected for studies on taxonomy, population connectivity, coral reproduction, age, and growth.

This expedition was the second transboundary US–Canada collaboration; the first was completed in 2014. Through this partnership and sharing of resources, an international team of scientists has gained a better understanding of deep-sea communities on both sides of the border. The data collected both support science and provide resource managers with information to better inform management and conservation actions. In fact, the majority of sampling locations were selected based on the data needs of the New England Fishery Management Council and the Department of Fisheries and Oceans Canada. This collaboration also supports NOAA interests in the Galway Statement on Atlantic Ocean Cooperation and the newly formed ASPIRE campaign (pages 97–101).

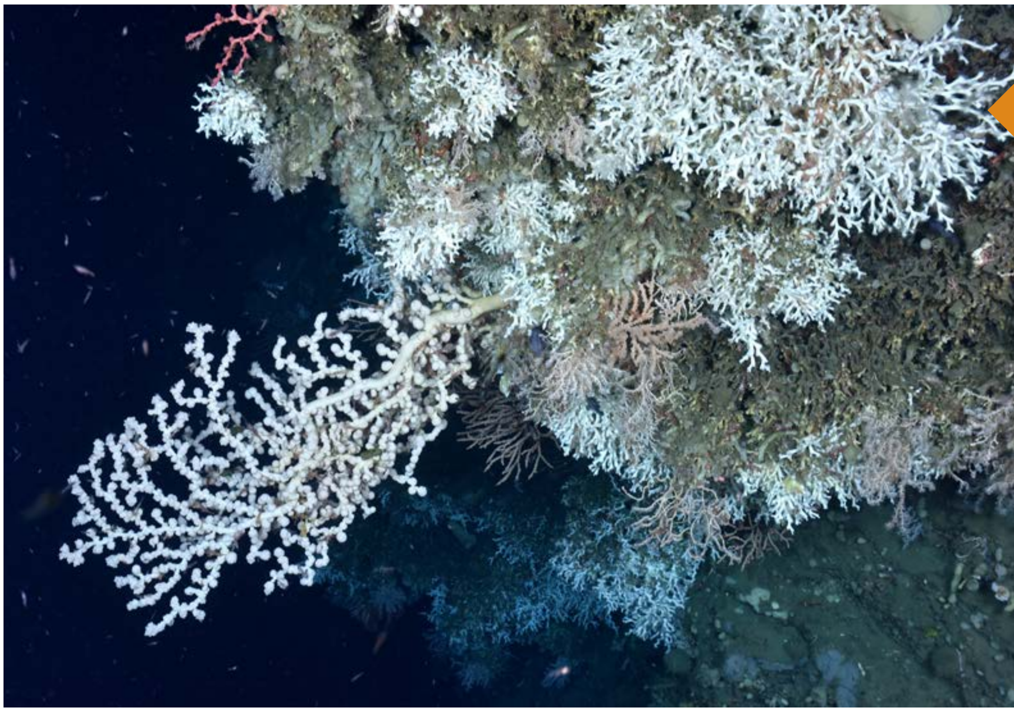


Figure 1. A diverse assemblage of deep-sea corals found on a ledge in an unnamed canyon between Heezen and Nygren Canyons (United States). *Image credit: Northern Neighbors: Transboundary Exploration of Deepwater Communities*

Figure 2. A coral garden found on a large outcrop in western Jordan Basin, northern Gulf of Maine (United States). *Image credit: Northern Neighbors: Transboundary Exploration of Deepwater Communities*

Innovative Nitrogen Sensor Maps the North Pacific Oxygen Minimum Zone

By Craig McNeil, Eric D'Asaro, Andrew Reed, Mark A. Altabet, Annie Bourbonnais, and Chris Beaverson

Oxygen minimum zones (OMZs) play important roles in regulating the ocean's global carbon and nitrogen cycles. In these functionally anoxic waters, denitrifying and anammox (short for anaerobic ammonium oxidation) microbes remove nitrogenous nutrients from the biosphere by transformation to biologically unavailable nitrogen gas (N_2). A newly developed sensor can detect this "excess" N_2 in OMZ regions in order to quantify these nitrogen-loss processes. The near-term goal is to explore OMZs and collect high-quality excess N_2 data to document their baseline inventories. The long-term objective is to determine if excess N_2 inventories in OMZs are increasing as a result of ocean deoxygenation (Stramma et al., 2008; Schmidtko et al., 2017).

N_2 Sensor. Although this new gas tension device (GTD; McNeil et al., 2006) was designed as a low cost, fast response profiling sensor for NOAA Ship *Okeanos Explorer*'s CTD, it could easily be deployed on AUVs, wire crawlers, and gliders. Concentration of N_2 in anoxic waters is derived from gas tension using Henry's Law and expressed as excess N_2, or ΔN_2, relative to atmospheric equilibrium. A standard dissolved oxygen probe compensates the GTD signal for O_2 in hypoxic waters. Biogenic production of N_2 is evidenced by $\Delta N_2 > 0$.

Sensor tests were performed on *Okeanos Explorer* in October 2017 while the ship transited the eastern tropical North Pacific OMZ during a multibeam bathymetry survey (Figure 1). This is the first instance of an OER Federal Funding Opportunity project that leverages *Okeanos Explorer's* capabilities.

Preliminary Results. With the ship on station and the new sensor mounted, the CTD was lowered to a depth of 600 m to soak for 10 minutes to equilibrate heat and gases with the surrounding seawater. After Niskin bottles were triggered, the CTD was raised to the next sampling depth. Repeating this procedure approximately 10 times during the same cast created accurate vertical profiles of dissolved O_2 and N_2. Ten casts during the cruise provided approximately 100 samples.

The measurements (Figure 2) show strong vertical and longitudinal variability. Several layers of waters with different properties are indicated, including: (1) a warmer, fresher, aerated and well-mixed near surface layer; (2) a subsurface layer at 80–200 m depth with minimum salinity; and (3) a weakly stratified deeper layer at 300–600 m depth with low O_2. High ΔN_2 was found in the upper layer of the low O_2 waters, consistent with organic matter export from the sea surface fueling microbial denitrification there. Strong longitudinal variability in O_2 was observed with generally lower O_2 and shallower oxycline toward the east, and minimum O_2 in the OMZ core region. Peak ΔN_2 was found in the OMZ core region at 60–300 dbar. Further analysis will consider mixing effects and the source water supply of ΔN_2 to the region.

The new sensor appears to have worked well and allowed real-time measurement of ΔN_2 on the ship. During post-cruise analysis, these ΔN_2 measurements will be compared to independent estimates derived from N_2/Ar ratios by mass spectrometry and biogenic N_2 using nutrient data.

Figure 1. Map showing 10 CTD stations (red markers) along the cruise track of NOAA Ship *Okeanos Explorer* between Hawai'i and Panama that crosses the eastern tropical North Pacific oxygen minimum zone where loss of nitrogen-based nutrients to N_2 gas occurs (approximate location of high N_2 regions indicated by the shaded gray region. *Image credit: Google Earth overlay with high N_2 regions taken from Figure 1 in Deutsch et al. (2014)*

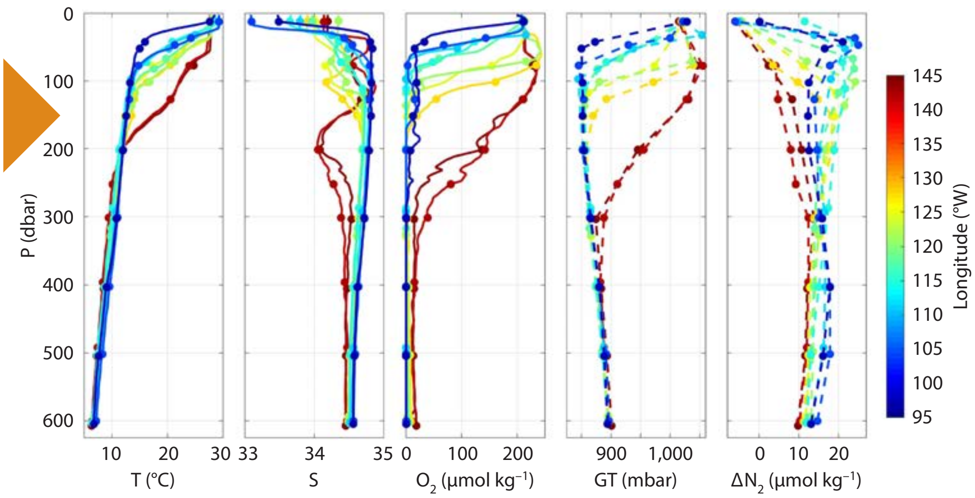


Figure 2. Preliminary data collected at 10 CTD stations (refer to map in Figure 1) showing vertical profiles (plotted to hydrostatic pressure P) of seawater temperature (T), salinity (S), and dissolved oxygen concentration (O_2) collected by an SBE 43 electrochemical sensor; gas tension (GT) measured by the new sensor described here; and derived excess nitrogen concentration (ΔN_2). Data are color coded by longitude (see color bar). Solid lines indicate depth binned (5 m) CTD data and dashed lines linear interpolation between equilibrated data points (colored dots). Intercalibrations and data quality control will be performed during post-cruise analysis.