

**NOAA Office of Ocean
Exploration and Research**
Fiscal Year 2014 in Review

Advancing NOAA and the nation



Through telepresence technology, scientists at the National Centers for Coastal Ocean Science in Charleston, SC, watch the live broadcast of an Okeanos Explorer mission in the Gulf of Mexico and review video images to understand the distribution and abundance of deep-sea corals. Data are formatted by NOAA's Deep-Sea Coral Research and Technology Program and served online to regional Fishery Management Councils to support research and conservation of vulnerable deep-sea habitats. For more on ocean exploration data see page 14. Credit: NOAA.

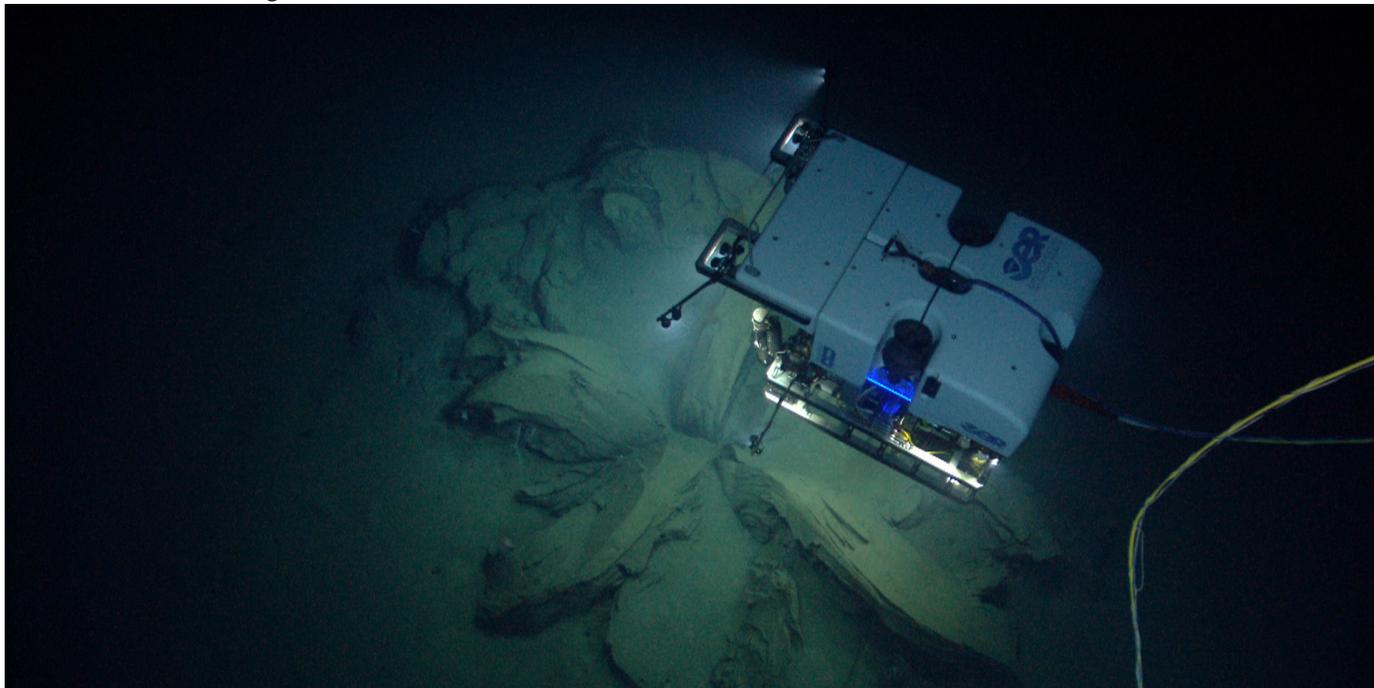


Identified as the biology highlight of the cruise by many participating scientists and viewers alike, this dumbo octopus displayed a body posture that has never before been observed in cirrate octopods. Credit: NOAA OER Gulf of Mexico 2014 Expedition.

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About the Cover Image



Discovery of this asphalt volcano scientists named "tar lily" illustrates the ocean is filled with surprises and that telepresence technology allows scientists ashore to adjust to discoveries at sea. For more on how telepresence adds flexibility and increases the value of ocean exploration to NOAA and the nation, see sidebar story on page 2. Credit: NOAA OER.

Ocean exploration benefits NOAA and the nation

Fiscal year 2014 continued a tradition of excitement and productivity for NOAA's Office of Ocean Exploration and Research (OER). It was a year of accomplishments that advanced our understanding of the ocean. In my view, there are several ocean exploration matters of particular importance.

First, we have a national need to explore the ocean. NOAA is often described as the nation's "environmental intelligence agency," and exploration is the vital first step in gathering ocean intelligence. OER is the only federal organization systematically exploring our largely unknown ocean for the purpose of discovery and the advancement of knowledge. Despite the fact that it covers 71 percent of our planet's surface and supports countless forms of life in and out of the water, much of Earth's ocean remains unexplored.

Second, we acknowledge that OER's exploration record is studded with accomplishments. Those accomplishments are recorded in this and past annual reports, on our website and in scientific journal articles based in whole or in part on OER expeditions and projects. They reflect the leadership, expertise and hard work of the OER team, but also the shared knowledge, planning, funding, equipment, technology and staffing of our many valued partnerships, including other NOAA offices, federal, regional and state agencies, educational and oceanic institutions, industry and not-for-profits. Exploring deep ocean frontiers is too expensive and challenging for any single organization, and partnerships move us all forward with a sense of collaboration and community.

Third, we must always consider the value of ocean exploration and our accountability to a critical stakeholder: the taxpayer. With our partners, NOAA's ocean exploration team acquires and shares crucial data that benefits science and the economy by enabling policymakers and resource managers to make informed decisions about how to best use and protect the

ocean and all it contains.

With each technology advanced and expedition undertaken, OER fills in knowledge gaps about deep-ocean areas, stimulates research and new lines of scientific inquiry and provides high-value environmental ocean intelligence not available elsewhere but needed to address both current and emerging needs. These are the returns on investments OER provides to taxpayers.

I begin my tenure as OER's new director firmly believing in the vital importance of our work. This report chronicles work that OER and our partners have accomplished together, for the great benefit of NOAA and the nation. We also recognize that much work and discovery still lie ahead. Our future will be filled with new and continued partnerships, and advancements in obtaining and sharing information. This includes the possibility of using telepresence in new ways to allow scientists ashore to participate virtually in research at sea.

OER is well known as a reliable partner and source of knowledge, yet it also thrives on incremental and transformational change, improvement and innovation. This balance allows us to sail toward a future bright with potential, and I look forward to bringing you news of our progress in 2015.



Alan P. Leonardi, Ph.D.

Director, NOAA Office of
Ocean Exploration and Research

The area ROV Deep Discoverer surveyed on Retriever Seamount had a high diversity of sponges, including this one with several crinoids using the sponge to elevate their position in the water column. Credit: Okeanos Explorer Expedition, Exploring Atlantic Canyons and Seamounts 2014.

Shipwrecks fill in blank history pages

In the Gulf of Mexico, ROV *Deep Discoverer* investigated the wrecks of three wooden sailing ships from the early 1800s, setting the stage for a possible future cruise to recover diagnostic artifacts and make biological and environmental observations. Scientists believe the ships were likely sailing together when lost, possibly during a storm. Because of their age, excellent condition and intact artifacts, they are nationally significant historic resources. What was suspected to be a fourth shipwreck was revealed by cameras on the ROV to be an asphalt volcano supporting marine life - a geologic feature shaped like a flower that scientists dubbed a "tar lily." Marine archaeologists ashore were ready to investigate and comment on the target, but when it was revealed to be a geologic formation rather than a shipwreck, the focus ashore shifted away from archaeologists to marine geologists and biologists, demonstrating the flexibility of telepresence when expertise ashore needs to be tailored to the unexpected.



This partially buried object is the face of what is believed to be a chronometer discovered on the 200 year-old Monterrey C shipwreck in the Gulf of Mexico. This ancient timepiece is a rare and significant find on an early 19th-century vessel. It was highly unusual for a merchant ship in the Gulf to carry one at this early date. The Roman numerals are still visible and the hand appears to be pointing to 6:30. Credit: NOAA OER.

Exploration and research: advancing NOAA and national goals

NOAA's Office of Ocean Exploration and Research works closely with other parts of NOAA and national and international partners to plan and undertake ocean expeditions and projects that highly leverage resources to maximize return on investment of public funds, while advancing the goals of NOAA, partners and the nation. In advance of regional operations, OER consults members of the scientific community for recommendations on where and how to best explore for maximum value. In the past, NOAA's Ocean Exploration Advisory Working Group has provided highly valuable guidance and in the future, the new Ocean Exploration Advisory Board will do the same.

NOAA Ship *Okeanos Explorer* expeditions

Gulf of Mexico

NOAA Ship *Okeanos Explorer* conducted three expeditions in the Gulf of Mexico to acquire data in priority exploration areas identified by NOAA Research, Fisheries, and the National Ocean Service; other federal organizations including the Bureau of Ocean Energy Management, Bureau of Safety and Environmental Enforcement and U.S. Geological Survey; and the Gulf of Mexico Fishery Management Council. Data from these expeditions are helping to inform discussions and actions related to fisheries management, the potential expansion of

marine protected areas, possible oil and gas development and future scientific exploration.

The data, including high-resolution bathymetric maps, are disseminated quickly after each expedition, helping scientists better understand the size and character of seafloor biological habitats as well as ecological connections. The maps also improve the targeting of future exploration and research. ROV dives were conducted at many deepwater sites including submarine canyons, coral habitats, active gas seeps, historic shipwrecks and undersea volcanoes. Live video from the seafloor enabled 70 scientists and students from 14 states to participate from ashore via telepresence technology, and attracted more than 680,000 visits by the public to OER live-streaming webpages.

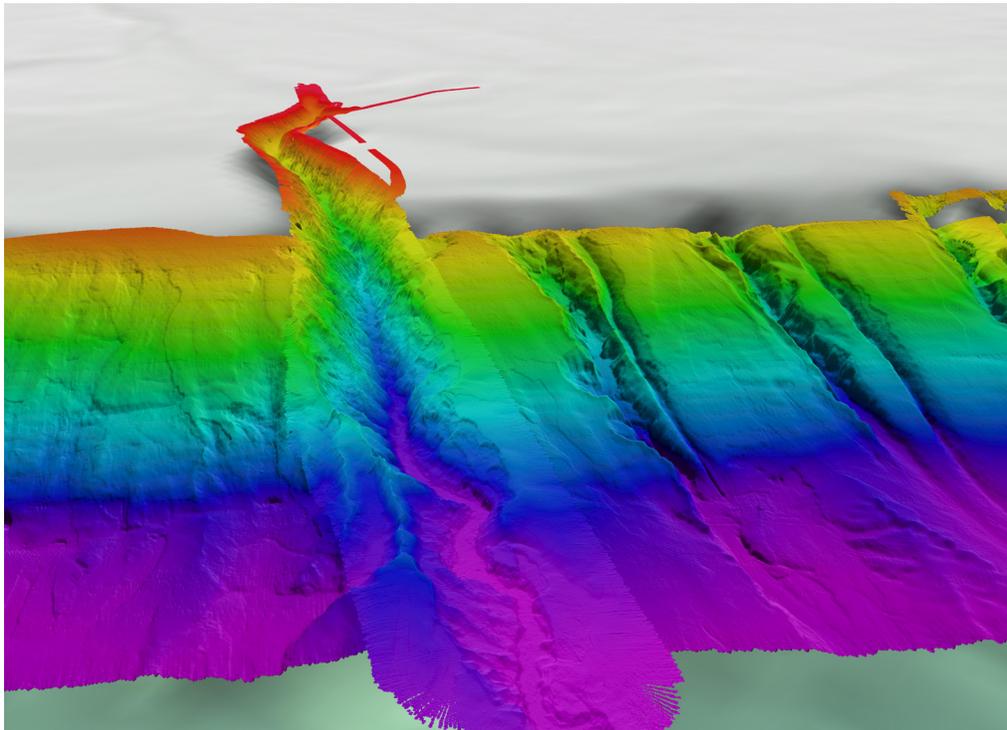
Investigating Atlantic canyons

2014 expeditions by the *Okeanos Explorer* team included investigations of canyons off the U.S. mid-Atlantic margin, and later, expeditions to the canyons and seamounts off the U.S. northeast coast. Many areas were previously unexplored.

The mid-Atlantic expedition investigated fragile coral ecosystems in a marine protected area designated by the South Atlantic Fishery Management Council. Mapping data from this cruise are informing fisheries management and habitat stewardship decisions.



A large black coral along the edge of a nearly vertical cliff heavily encrusted with coral and sponges was seen during the Atlantic Canyons and Seamounts Expedition. Credit: NOAA OER.



A multibeam sonar image of canyons off the U.S. northeast coast in the Atlantic Ocean. The main canyon, Hudson Canyon, is one of many explored by Okeanos Explorer, and demonstrates the vast diversity in under-sea terrain. (See the sidebar on this page.) Credit: NOAA OER.

The expedition also gathered samples that could identify a previously undocumented spawning area for bluefin tuna to help fisheries scientists with programs to rebuild bluefin populations.

OER's mapping team also assisted the Monitor National Marine Sanctuary by locating promising sonar targets later identified as the wreck of the World War II German submarine *U-576* near the wreck of the merchant ship it sunk.

Some 56 scientists in 20 states participated in an expedition when the *Okeanos Explorer* team investigated canyons and seamounts off the U.S. northeast coast, supporting priorities identified by NOAA, other federal and state agencies, regional fishery management councils, regional ocean councils and academic scientists. The mission provided critical deepwater environmental intelligence to NOAA's Habitat Blueprint, state and federal discussions about potential offshore energy development, agencies interested in past and potential submarine landslides and deepwater coral conservation efforts. Coral and sponge ecosystems were documented, providing data important to resource management.

This expedition investigated the last unexplored Atlantic seamount within the U.S. Exclusive Economic Zone and completed a cross-NOAA multi-partner project to map every major U.S. deepwater canyon from Cape Hatteras to the U.S.–Canadian border.

For more information on the canyon and seamount expeditions OER has conducted since the program's inception and on bathymetry previously collected by *Okeanos Explorer*, visit the program website at: <http://oceanexplorer.noaa.gov> and OER's Digital Atlas at: http://www.ncddc.noaa.gov/website/google_maps/OE/mapsOE.htm.

OER ensures public access to the diverse collection of scientific data collected during OER-supported ocean expeditions. Data collections typically include oceanographic and geophysical parameters, video, images, documents, and other information, provided in a range of data formats.

Value of ocean data

In 2014, the mapping team on *Okeanos Explorer* once again responded to regional and national needs to map portions of the undersea Hudson Canyon off the U.S. east coast. The team had initially mapped the canyon in 2012, but when a strong tsunami-like surge in June 2013 produced significant sea surface water-level fluctuations accompanied by strong currents along the northeast U.S. coast, the ship's cruise plan was quickly changed to conduct additional mapping of the canyon. Additional bathymetric surveys were conducted in 2014 to further refine the previous years' maps.

The surge event was detected by a DART® (Deep-ocean Assessment and Reporting of Tsunamis) buoy, and recorded at nearby and distant coastal tide-measuring stations. Although it was quickly determined that the observed tsunami-like surge was not caused by an earthquake, reverse wave-arrival modeling by scientists at NOAA/PMEL's Center for Tsunami Research indicated that the surge did originate in the upper reaches of the Hudson Canyon.

Okeanos Explorer's 2012, 2013, and 2014 before-and-after bathymetric mapping in the suspected source region will be critical for helping to determine if, as currently suspected, this surge (and others similar to it) was generated by a combination of geological and atmospheric processes. A sudden downslope displacement of unstable, semi-consolidated sediments may have been triggered by an abrupt strong barometric pressure change associated with an intense line storm (a derecho).

These surges pose unevaluated potential hazards to safety and life, and NOAA's National Weather Service wants to understand them so that they can be mitigated through education and warnings.

Pioneering expeditions

OER supports expeditions and research to better understand areas and aspects of the ocean. Funded in whole or part by OER, these include systematic exploration of unknown and poorly known areas with *Okeanos Explorer* and the Ocean Exploration Trust's Exploration Vessel *Nautilus* (OET E/V *Nautilus*), and targeted exploration through collaborative partnership opportunities and an annual Federal Funding Opportunity. Many of these expeditions and projects leverage partner resources to maximize return on investment, and address a number of national and NOAA priorities. OER considers proposal reviews along with available funding and assets before recommending grant-funded awards. Other expeditions and projects are funded directly by OER, or by OER and partners.

Extended Continental Shelf

The U.S. Extended Continental Shelf (ECS) Project maps, analyzes and defines the seaward extent of the U.S. continental shelf beyond 200 nautical miles. NOAA is a co-vice chair of the project task force, a multi-agency body established to direct and coordinate the project. OER coordinates NOAA's annual ECS funding and project management.



OER sponsored the Lighthouse Archaeological Maritime Program to search for the Lost French Fleet of 1565 off Canaveral National Seashore, Florida. These are the earliest French ships lost in North America, when they sank during a sudden storm. More about the search and about the mid-16th C. rivalry that pitted France against Spain for control of what is now the southeastern U.S. is at: <http://oceanexplorer.noaa.gov/explorations/14lostfleet/welcome.html>. The coins imaged were previously found in the survivors camp that is believed to be not far from the shipwreck location. The search will help us understand more about the history of our nation much of which is still hidden on the seafloor. Partners in this expedition included the St. Augustine Lighthouse & Museum, National Park Service, Institute of Maritime History and State of Florida. Image courtesy of John de Bry.



A major finding of the 2014 Coral Ecosystem Connectivity expedition was the discovery of large patches (up to 60 meters across) of nearly continuous plate coral (Agaricia spp.) near Pulley Ridge, off the southwest coast of Florida. Credit: Coral Ecosystem Connectivity 2014 Expedition.

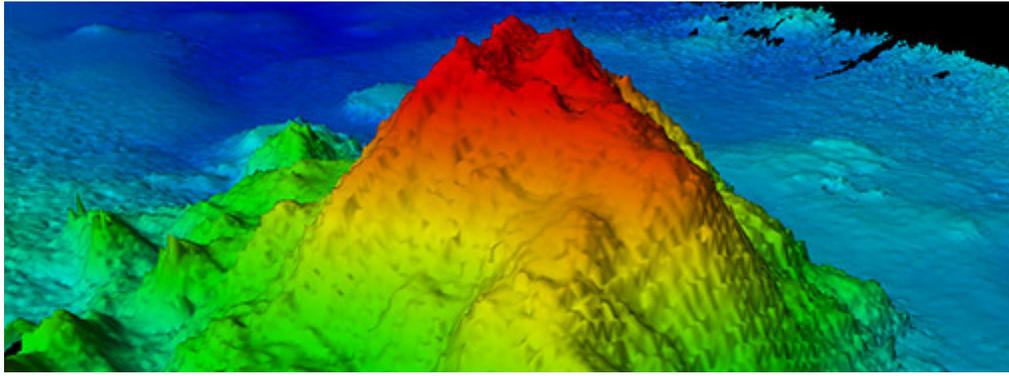
As part of OER's contribution to this year's ECS effort, a multi-week expedition explored the Mendocino Ridge, off California. This survey started where the 2009 Mendocino survey on *Okeanos Explorer* left off. On the cruise, more than 3,000 square nautical miles of high-resolution bathymetric data were collected in a seafloor environment rich with features such as knolls, seamounts and calderas.

A seamount was discovered during another ECS survey in the central Pacific Ocean. Estimated to rise 1,100 meters above a feature-filled seafloor, it has since been incorporated into the newly expanded boundaries of the Pacific Remote Islands Marine National Monument.

The ECS Project enables collection, analyses and archiving of extensive, often unique datasets that may be used to determine a future U.S. ECS. These datasets also expand our understanding of the morphology and geology of the U.S. continental margins, facilitate future ocean exploration and support management of seafloor resources associated with an ECS.

Mesophotic reef connectivity

OER partnered with NOAA's National Centers for Coastal and Ocean Science to fund an expedition to Pulley Ridge, off the southwest coast of Florida, to study how relatively



This yet-to-be-named seamount near Johnston Atoll was discovered during an ECS survey in one of the least explored areas of the Earth's ocean. Discoveries such as this are common during ECS mapping because most project areas have never before been mapped. Credit: UNH/CCOM/JHC.

healthy mesophotic reefs of Pulley Ridge may replenish key reef species such as grouper and snapper in downstream reefs of the Florida Keys National Marine Sanctuary and Tortugas Ecological Reserve.

Because of the well-documented decline of Florida's reefs, it's important to identify, protect and manage sources of larval reef species that can help sustain Florida's reef ecosystems and the tourism economy that depends on them. The expedition discovered a new coral area near the main ridge at Pulley Ridge with the densest cover of plate corals known in the Gulf of Mexico. Results of this multi-year study will help managers determine if the area would benefit from further protection.

The study was led by the University of Miami through NOAA's Cooperative Institute for Marine and Atmospheric Studies in coordination with the Cooperative Institute for Ocean Exploration, Research and Technology (CIOERT) at Florida Atlantic University, and represents a collaboration of more than 35 scientists at 11 universities, and other state and federal partners.

Maug: a natural coral reef ocean acidification lab

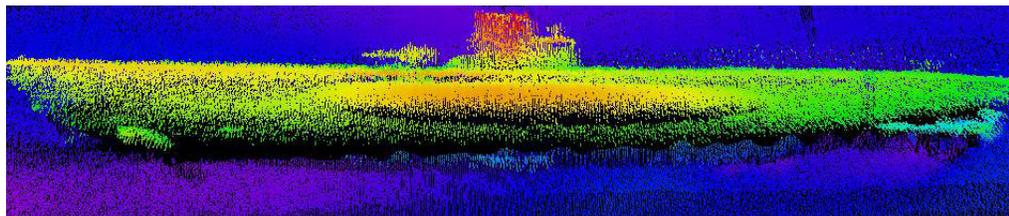
Maug is a volcano in the Mariana Trench Marine National Monument. The volcano's summit, a shallow drowned caldera, hosts a coral reef ecosystem that in places is being

acidified by warm vent fluids containing high concentrations of volcanic carbon dioxide. The site offers the potential as a natural laboratory to help understand acidification in the global ocean.

OER-sponsored exploration of Maug's chemical and biological ocean environments is being led by NOAA's Pacific Marine Environmental Laboratory in partnership with scientists from NOAA's Pacific Islands Fisheries Science Center and Atlantic Oceanographic and Meteorological Laboratory, the National Institute of Standards and Technology, Guam and the Commonwealth of the Northern Mariana Islands.

Seamounts of Anegada Passage

OER supported the U.S. Geological Survey as they investigated seamounts of the Caribbean's Anegada Passage, using sensors and systems on Ocean Exploration Trust's E/V *Nautilus*. Data collected are providing insight into the ecology and biodiversity of Caribbean seamount environments and expanding knowledge about the geologic origin of the region and potentially hazardous geological features, as well as providing information about hazard mitigation. With limited information about location and characteristics of active faults in the region, there is little known about earthquake and earthquake-driven tsunami hazards.



OER worked closely with the Monitor National Marine Sanctuary to find the German submarine U-576, sunk while attacking a ship convoy off North Carolina during WWII. Okeanos Explorer identified a target near the submarine's last victim, the merchant vessel Bluefields, that was later imaged by high-resolution multibeam sonar from an autonomous underwater vehicle (AUV) operated by Scripps Research Institute, a partner in NOAA's CIOERT. Credit: NOAA.

Ocean Exploration Trust's E/V *Nautilus*

To expand the scope, reach and pace of ocean exploration, OER supports the Ocean Exploration Trust's E/V *Nautilus* Program that operates with similar tools, technology and operating profiles as that of the NOAA Ship *Okeanos Explorer*. Through their global reach, robust internship and fellowship programs and extensive outreach and education efforts, the *Nautilus* Program is an excellent complementary investment in the future of understanding our largely unknown ocean, and in the development of emerging ocean leaders, scientists, policy-makers and educators.

In 2014, *Nautilus* expeditions focused on U.S. territories in the Caribbean and Gulf of Mexico, contributing to the understanding of several geologically active regions and to the continued documentation of impacts of the 2010 Deepwater Horizon oil spill, among other efforts. All expeditions were conducted with multidisciplinary teams of scientists, students, and interns collaborating between ship and shore through telepresence, and many expedition locations were selected based on high-priority targets identified from their 2012 Workshop on the Caribbean. In 2015, *Nautilus* will transit to the Pacific to conduct expeditions based largely on results from their upcoming Workshop on the Eastern Pacific Ocean (<http://www.nautiluslive.org/>).

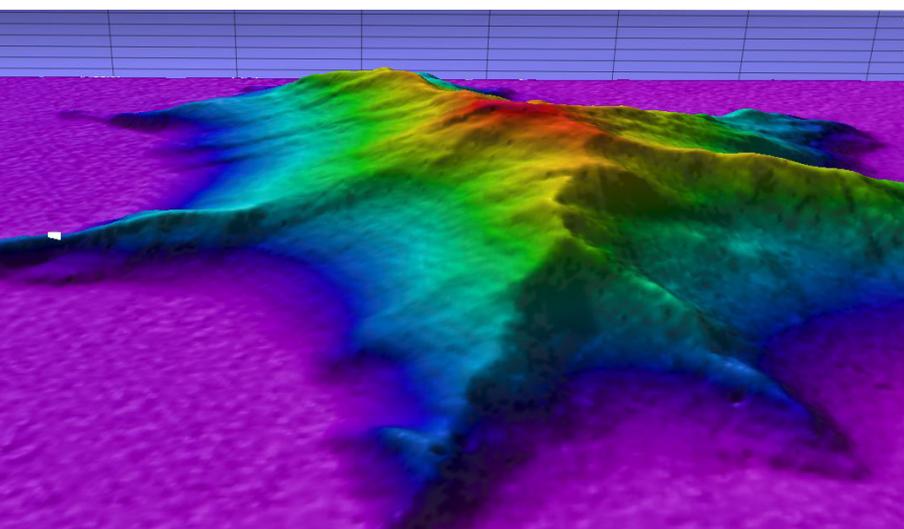


Ocean Exploration Trust's E/V Nautilus. (<http://www.oceanexplorationtrust.org/>) Credit: Ocean Exploration Trust.

America's ship for ocean exploration

Okeanos Explorer

NOAA Ship *Okeanos Explorer* is the only federal vessel that systematically explores the ocean to collect deep-ocean baseline environmental intelligence. With a suite of OER-managed exploration systems and sensors and an exploration team at sea and ashore, the ship supports NOAA and national goals by increasing the pace and efficiency of discovery and the characterization of unknown or poorly known ocean areas. The ship also provides scientists and other audiences ashore with high-quality and publically available deep-ocean environmental data, including live video from the seafloor.

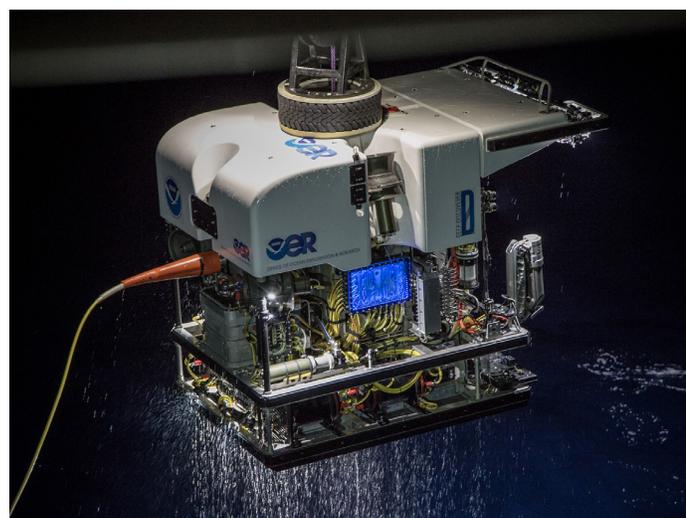


This image shows a side view, two-times vertical exaggeration, of an unnamed seamount explored for the first time during the Exploring Atlantic Canyons and Seamounts mission. The white dot represents the point where ROV Deep Discoverer (D2) was deployed. D2 encountered sea stars, crinoids, squat lobsters, carnivorous sponges and a variety of lava formations. Credit: NOAA OER.

A season of accomplishments and value

Okeanos Explorer's 2014 field season continued NOAA's efforts with partners to collect highly valuable and otherwise unavailable ocean information and deliver it in a timely way and in useful formats. This included characterizations of ecosystems in the water column and on the seafloor, discovery and exploration of geological features and investigation of shipwreck sites that added to our understanding of the nation's history.

OER worked closely with other NOAA entities, national and international partners and ocean managers and scientists to identify pri-



ROV D2 is recovered after an extended dive. Although D2's recovery means the end of the day for telepresence viewers, the onboard team's work carries on into the evening. Credit: NOAA OER.

orities, plan and execute exploration missions and ensure the information acquired met current and future needs of ocean stakeholders.

The information collected in 2014 benefited ocean resource management and protection, nautical charting, tsunami hazards protection and warning efforts, and contributed to sanctuary and protected area expansion.

Data collected by OER also aided fishery management and conservation plans, fisheries and coral habitat modeling and coastal and marine spatial planning, as well as maritime heritage protection and offshore energy environmental impact assessments. *Okeanos Explorer's* 2014 expeditions in deepwater canyons and seamounts off of the U.S. east coast and in the Gulf of Mexico were model examples of how multiple parts of NOAA and outside organizations representing science, management and operational programs, aligned goals and collected baseline deepwater environmental intelligence where little or none existed.

In the Gulf of Mexico, OER completed a multi-year effort to map the West Florida Escarpment, providing insight into submarine landslides and detachment zones; discovered two asphalt volcanoes, geologic features shaped like flowers that scientists named "tar lilies"; observed range extensions of deep-sea corals; discovered two potential new species



On every telepresence-enabled ROV cruise on Okeanos Explorer, two research scientists have an opportunity to join the floating community of mariners, engineers, and data and video specialists that call the ship home. Shown here are Science Lead Scott France and Assistant Scientist Susan Schnur hard at work in the control room at the end of a dive. Credit: NOAA OER.

of crinoids; identified at least 300 potential cold water gas seeps; and conducted ROV explorations of three historically significant shipwrecks from the early 1800s.

In the Atlantic deepwater canyons and seamounts, field season highlights included completion of a multi-year submarine canyons mapping effort of the continental shelf break from North Carolina to the U.S.–Canada maritime border, new information on recently discovered and geographically extensive cold water gas seeps, continued exploration of the New England seamount chain and mapping of two historically significant World War II shipwreck sites.

In both regions, high-resolution mapping led to a better understanding of the geological context in which deep-sea corals develop, while ROV dives provided valuable observations of chemosynthetic and deep-sea coral habitats.

Exploration systems

Okeanos Explorer's multibeam sonar is capable of mapping the water column and seafloor as deep as 7,000 meters. The ship recently deployed a two-vehicle ROV system, capable of diving to 6,000 meters. The science-class main ROV, called *Deep Discoverer*, or *D2*, operates just above the seafloor while tethered to *Seirios*, which operates above *D2* and provides additional lights and cameras. Both ROV vehicles worked flawlessly throughout the field season. Telepresence technology—delivering information from the ship to audiences ashore, including live video from the seafloor via satellite and Internet pathways, added the intellectual capital of

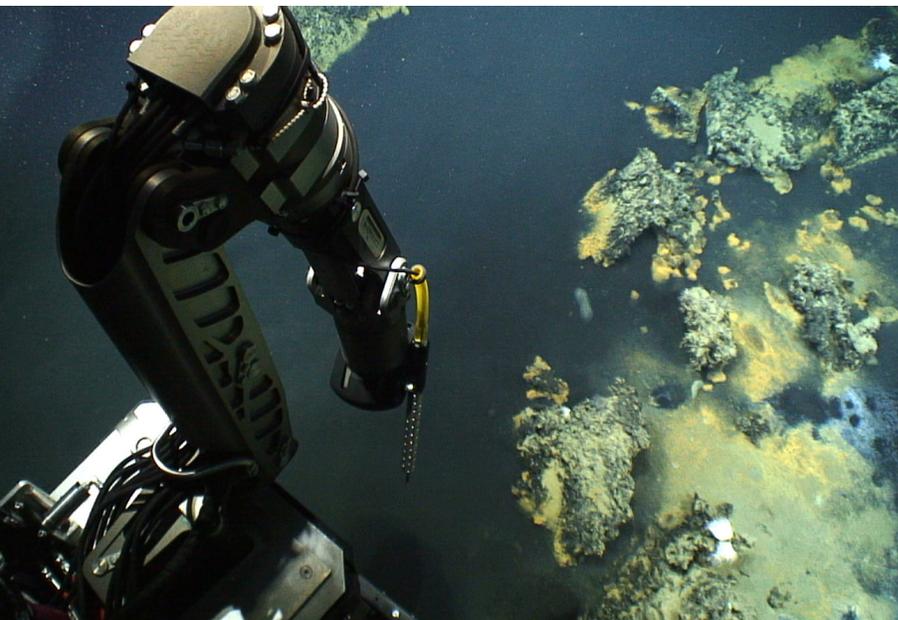
scientists ashore to expeditions at sea, while hundreds of thousands of citizens became virtual explorers by seeing live seafloor video and hearing the comments of scientists who described what they were seeing.



Okeanos Explorer dressed in international maritime signal flags in Baltimore Harbor for the Star-Spangled Spectacular. See page 21 for more on this celebration. Credit: NOAA OER.

Advancing technology

Technology to support deep-ocean exploration, research and information collection has steadily improved but greater improvements are needed to significantly increase the pace, effectiveness and scope of understanding our ocean world. Advancements will enable us to explore longer, deeper and across greater spans while collecting and sharing new and more data. As always, these tools must withstand the rigors of depth, salinity and pressure.



ROV Deep Discoverer uses its new temperature probe to learn more about the deep-sea environment around this brine pool discovered during the Gulf of Mexico 2014 Expedition. Credit: NOAA OER.

NOAA Ship *Okeanos Explorer* as a technology testbed

Okeanos Explorer deploys a recently built two-vehicle ROV system that has worked flawlessly—a record that is a testament to OER's skilled ROV design, construction and operations team of senior and early-career engineers and technicians who collaborate with academia, industry and government partners.

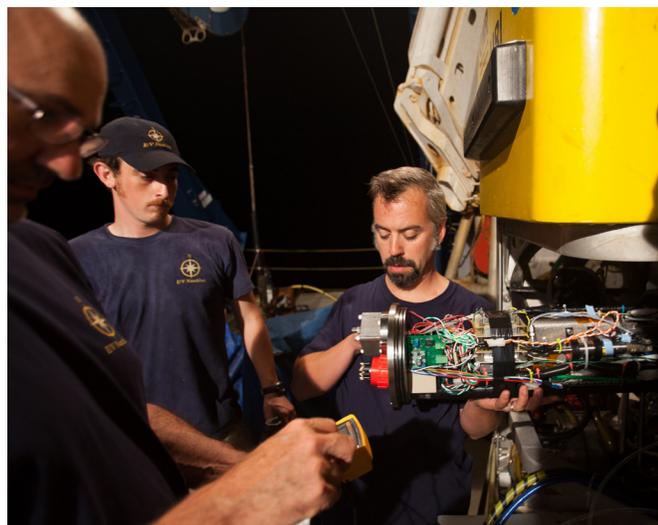
OER continuously reviews opportunities to improve the operational capabilities and to advance technology. For example, *D2* has 400 pounds of reserve buoyancy that could accommodate extra tools, sensors or sample collection areas. Thought has been given to collecting samples during future expeditions, but that would take time away from pure exploration. For the *Okeanos Explorer* team—the only federal group that systematically explores the ocean—exploration time is

limited and valuable. With that in mind, OER is very interested in working with scientists, engineers and technicians to design, develop, test and evaluate protocols and procedures for collecting voucher specimens that would add to baseline characterization products from exploratory expeditions. Further, OER has initiated and will continue discussions to develop new sensors and systems to conduct non-invasive sampling, in essence generating information typically derived from analyzing specimens in a laboratory without having to collect physical samples.

The ocean exploration community should consider *Okeanos Explorer* as a platform for testing new technology. Technology advancement is an important part of OER's role, and the office is always interested in learning about such opportunities in proposals for grant funding or by other means.

Pilot test of a large AUV for exploring fish habitat

OER led the development of NOAA's agreement with Boeing to investigate new data collection methodologies to meet NOAA requirements. OER and the National Marine Fisheries Service Southwest Fisheries Science Center worked with Boeing to test Boeing's large AUV *Echo Ranger* for a rockfish survey. *Echo Ranger* allows increased payload for sensors and batteries and longer mission endurance than most AUVs. The mission objective was to evaluate an AUV's ability to conduct surveys independently or to augment a ship-based rockfish survey.



With the assistance of the ROV pilots, Scott Wankel carefully installs the in situ laser spectrometer into its pressure housing mounted on Hercules for deployment to the Kick'em Jenny crater. Credit: K. Wood, Ocean Exploration Trust.



Echo Ranger is a large displacement AUV, 18.5 feet long, with a 150-nautical-mile range and maximum speed of six knots. The vehicle can be deployed from shore and allows increased payload for sensors and longer mission endurance. Credit: Boeing.

The test took place off Catalina Island in southern California and generated sonar maps of rockfish habitats and information about individual rockfish and aggregations of fish. The AUV simultaneously used a stereo camera to collect 3D optical imagery to identify the number and species of fish detected by sonar. Data are being analyzed for a potential follow-on mission in 2015.

Chemical and isotopic exploration of deep-sea environments

OER funded scientists from Woods Hole Oceanographic Institution to conduct the first-ever in-situ, real-time chemical and stable isotopic exploration of two unique seafloor sites in the Caribbean using a newly designed sensor package for measuring gases expelled from the seafloor. OER partnered with the Ocean Exploration Trust and leveraged an expedition by the Trust's E/V *Nautilus*.

Nereid Under-Ice AUV

OER contributed financial support to a mission that successfully tested *Nereid*, a robotic underwater vehicle for the ocean exploration community that provides a capability for real-time remote control as the vehicle conducts inspections and mapping surveys under the ice. The vehicle was developed by the Deep Submergence Laboratory at the Woods Hole Oceanographic Institution along with colleagues at Johns Hopkins University and the University of New Hampshire, supported primarily by a grant from the National Science Foundation. *Nereid* Under-Ice suc-

cessfully completed its first field expedition from aboard the Alfred Wegener Institute's ice-breaker *Polarstern*. In addition to conducting engineering trials, the vehicle used biological sensors to study near-ice primary productivity.



Nereid two-body system being deployed from the Polarstern during August 2014 sea trials. The mated-depressor and tow-body are lifted above the vehicle to facilitate a single point lift. Credit: C. German, WHOI.

2014 Field Season Activities

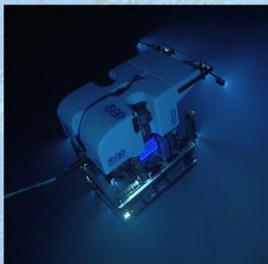


Telepresence-Enabled Exploration

OER systematically explores the world's ocean and advances the telepresence science paradigm using NOAA Ship *Okeanos Explorer* and the Ocean Exploration Trust's *E/V Nautilus*.

1 In 2014, America's Ship for Exploration *Okeanos Explorer* explored the deep-sea environments of the Gulf of Mexico and along the U.S. east coast.

2 This year the *E/V Nautilus* focused operations in the Gulf of Mexico and in the Caribbean.

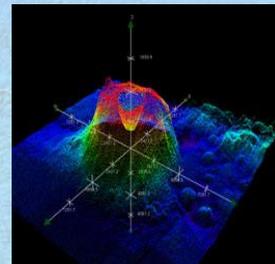


NOAA *Okeanos Explorer*, Gulf of Mexico 2014 Expedition



Extended Continental Shelf Mapping

OER is a critical partner in the interagency U.S. Extended Continental Shelf Project. Since 2007, NOAA and the 12 other U.S. agencies that make up the ECS Project Task Force, have gathered and analyzed survey, seafloor, subseafloor and legal data to establish the full extent of the continental shelf of the U.S. consistent with international law. This year, OER supported two bathymetric mapping expeditions targeting Mendocino Ridge and Johnston Atoll.



UNH/IHC/CCOM



1

2

3

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4

5

Fram Strait

Greenland

5

Developing Technology & Demonstrations

OER pushes the boundaries of existing technology and supports many efforts to advance technology. In 2014, OER supported development of the first-ever in situ, real-time chemical and stable isotopic ROV sensor. Also, in conjunction with NOAA's Southwest Fisheries Science Center and Boeing, OER supported testing the use of an AUV to monitor rockfish populations in untrawlable habitats.



Keith Wood/Ocean Exploration Trust 2014

Partnering & Collaboration

Because it is expensive and challenging to explore the deep ocean, the success of ocean exploration relies on partnerships and collaborations that leverage planning, objectives, funding, expertise, sensors, systems and information delivery. OER partners with NOAA offices; regional, state, federal and international agencies; academic and oceanographic institutions; industry and non-profits to maximize return on investment for the U.S. taxpayer. Locations of OER's 2014 partnership missions are shown on the map.



Ocean Exploration Trust

By the Numbers

Okeanos Explorer

108,300 square kilometers mapped with multibeam sonar (greater than the combined size of Maryland, Massachusetts, New Jersey, Connecticut, Delaware and Rhode Island).

300+ potential cold water seeps mapped in Gulf of Mexico.

15 seamounts completely or partially mapped.

2 World War II wrecks mapped.

32 ROV dives at sites including **9** submarine canyons, **5** seamounts, **3** 19th-century wrecks and **2** cold seeps.

4,989 meters—deepest *Deep Discoverer* ROV dive in FY14.

8 expeditions.

6 conductivity, temperature and depth/CTD casts.

679 expendable bathythermographs/XBTs deployed.

5 NOAA line/staff offices involved in expeditions.

60+ institutions participated in expeditions.

126 scientists and students participated in expeditions.

15 mapping explorers-in-training positions granted.

2,100 visitors received, including **18** private tours, during the September Baltimore port-call.

Data Management

68.7 terabytes of OER data distributed to the public from NOAA data centers.

45-day average for post-mission data from *Okeanos Explorer* to NOAA data centers, with a record of **33** days.

1,168 publications produced with OER support since 2001; **46** in 2014.

Ocean Sampling Day — June 21, 2014

13 U.S. sites sampled as part of the **185** global sites sampled.

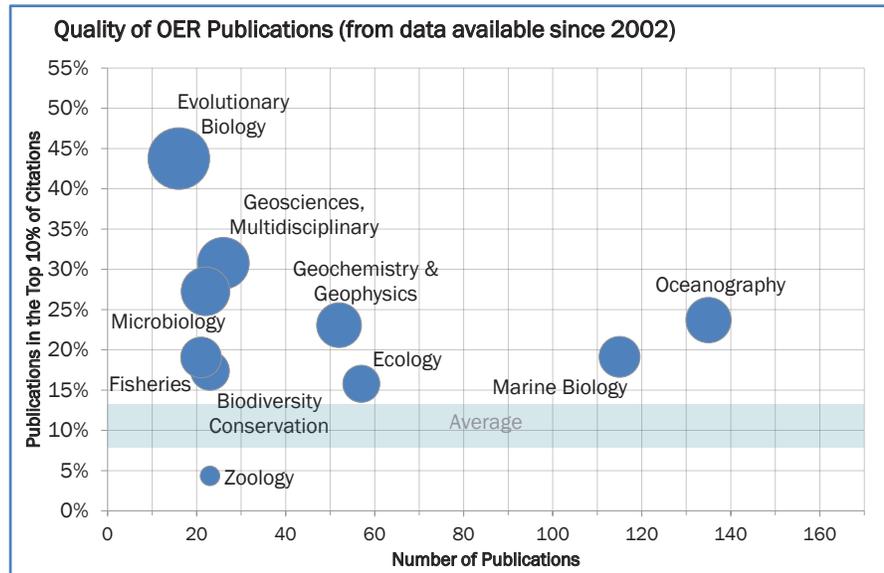
2 educational webpage offerings developed for two NOAA line offices.

Outreach

A record **10.7** million visits to the NOAA Ocean Explorer website (oceanexplorer.noaa.gov).

More than **680,000** visits to live video web pages.

More than **600** new html pages, **500** new images and **60** new videos added to the website.



This bubble chart shows the percentage of OER-supported publications in 10 subject categories that had citation counts ranking in the top 10 percent of all publications in Web of Science. Bubble size indicates the percentage of OER-supported publications in each subject area that had citation counts in the top 10 percent of all publications in that subject area and year of publication. Detailed report: <http://oceanexplorer.noaa.gov/about/what-we-do/publications/welcome.html>

More than **47,600** Twitter followers.

More than **15,500** Facebook likes.

More than **6,100** YouTube subscribers, with posted videos watched more than **475,000** times during the year (lifetime views + **4.7** million).

Education

Nearly **2** million downloads of curriculum and educational materials, more than doubling from FY13.

31 Ocean Exploration Curriculum Professional Development Programs offered at **14** Education Alliance Partners around the country.

647 teachers reached (**4,269** contact hours).

72,257 students reached.

29 countries, **40** U.S. states, **640** participants reached in five-week online course titled "Deep-sea Discoveries in the Atlantic Onboard the NOAA Ship *Okeanos Explorer*: An Online Workshop to Advance Transatlantic Ocean Science Literacy."

Administration

\$26 million FY14 OER budget.

19 proposals totaling **\$11.2** million processed and awarded via OER's federal grants program.

\$4 million in service contracts processed, renewed or extended.

65 procurement actions totaling close to **\$2** million awarded related to *Okeanos Explorer* scientific equipment.

Ocean Exploration Trust's E/V *Nautilus*

33,119 square kilometers of seafloor mapped (equivalent to 10.5 Rhode Islands)

822+ hours of ROV time.

602 biological and geological samples taken.

111 Scientists Ashore Program participants.

22 Science Communication Fellows, **15** Science & Engineering Interns, **1** NOAA Educational Partnership Program (EPP) ocean science intern and **8** Honors Research Program students participated in the 2014 *Nautilus* Exploration Program, representing **21** states and **7** countries.

352 live, interactive broadcasts from E/V *Nautilus* and the Inner Space Center to **60** global education venues.

2.4 million page views and **830,000** unique visitors to E/V *Nautilus* website (<http://nautiluslive.org/>).

More than **4,800** Twitter followers.

More than **25,000** Facebook followers.

More than **12,300** YouTube subscribers and **5.1** million video views.

Information delivery: data for NOAA and the nation

A hallmark of OER is fast and accurate information delivery. OER's open data practices enable adaptive operational management and catalyze innovation and research by others. Effective and efficient data management systems interconnect OER's data acquisition and delivery systems, optimize data stewardship procedures and embrace the administration's Open Data Initiatives for easy access to useable data. NOAA leadership and others cite OER's information management methods as an example for oceanographic data

mediately investigate and identify significant additional resources in an area of OER's initial site characterization, including densely populated deep coral habitats and a previously unknown brine river and pool.

Scientists ashore also worked directly with OER's live video data streams to perform real-time data assessments. At Florida Atlantic University's Harbor Branch Campus, scientists have developed systems to annotate data in real time, and have developed structured curricula that use streaming data to provide students with real-world data analysis experience. Students at the Cordes Laboratory at Temple University used OER data to develop high-resolution maps of the seafloor and coral locations to inform coral habitat models and to select locations for future experimental work on the seafloor. Scientists at NOAA's Center for Coastal Environmental Health and Biomolecular Research observed the open video data stream to understand the distribution and abundance of deep coral species and to assess the health and condition of deep coral colonies. The data are shared online through NOAA's growing National Database of Deep-Sea Corals and Sponges (<http://portal.ncddc.noaa.gov/>) and are used by regional Fishery Management Councils to support research and conservation of these vulnerable deep-sea habitats. See image on inside front cover.



Scientists at Florida Atlantic University's Harbor Branch Campus have developed a programmable "hot keypad" system and database that was tested during the OER 2014 Exploration of the Gulf of Mexico. The system allows scientists to rapidly and accurately annotate observations with complete taxonomic information while observing the live video stream. Faculty there also developed structured curricula that use real-time datasets to provide students with real-world data analysis and annotation experience. Credit: B. Cousin, FAU Harbor Branch.

management. OER data are found at data.gov and are accessible from the OER Digital Atlas at: http://www.ncddc.noaa.gov/website/google_maps/OE/mapsOE.htm.

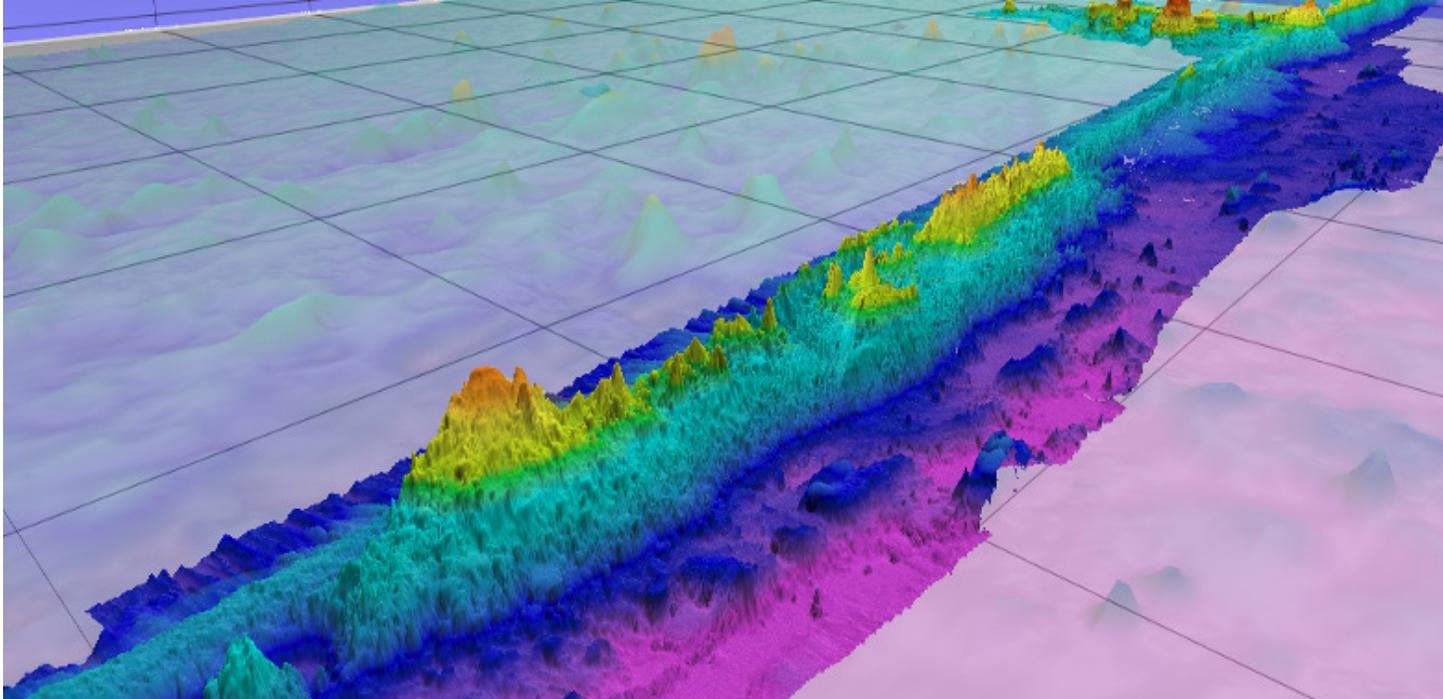
Okeanos Explorer's open data sharing creates actionable information

Exceptional data acquisition systems combine with a state-of-the-art information delivery system to provide instant access to previously unknown information about the world's ocean. Timely access provides scientists, managers and industry with the ability to make better informed decisions and to rapidly respond to changing conditions or discoveries. In 2014, open data sharing enabled scientists conducting concurrent regional research operations at sea to im-

Actionable information travels two ways. When weather conditions forced the cancellation of planned ROV operations, the U.S. Geological Survey science team ashore quickly provided alternate sonar collection targets to the shipboard team. Assets were redirected from ROV operations to seafloor



In this example of the diversity of mid-Atlantic canyons habitat, a deep-sea red crab hangs out on a bubblegum coral. Careful examination reveals a skate egg case on the same branch as the crab and a colony of the white morph of bubblegum coral in the background. Credit: NOAA OER.



In 2008 OER assumed NOAA's annual funding and project coordination responsibilities for the U.S. Extended Continental Shelf Project. NOAA data centers have primary responsibility for stewarding the ECS project data for long-term preservation and public access. In the ECS project, multibeam echo sounder data accurately define the foot of the slope and the 2,500 meter isobath. This 3D view is the seafloor surrounding Mendocino Ridge mapped at 100m grid resolution and 5x vertical exaggeration. Credit: A. Armstrong, UNH/CCOM/JHC.

mapping activities, facilitating substitution of one important mission requirement for another and ensuring that valuable ship time remained productive without interruption.

Actionable information supports resource management

OER's early and open data sharing, as well as the use of community standard formats and protocols, supports a strong requirement from the scientific community for rapid access to final, quality-assured, fully documented datasets. In 2014, the average delivery time for post-mission data from NOAA Ship *Okeanos Explorer* to NOAA data centers was 45 days, with a record time of 33 days for one mission. This exceptional timeline lets ocean researchers inform their research proposals with real data, and provides ocean policy-makers, resource managers, industry members and environmental organizations with the information needed to make informed decisions when managing, using or protecting ocean resources.

In 2014, several mid-Atlantic management actions were based on synthesis of existing data collected by OER-sponsored expeditions between 2011 and 2014. The five-state Mid-Atlantic Regional Council on the Ocean developed recommendations to strengthen federal protection of submarine canyon habitats. The Mid-Atlantic Fishery Management Council obtained information on the distribution, abundance and diversity of deep-sea coral and sponges, which contributed to the

definition of coral conservation zone boundaries. OER data collections also supported a draft amendment to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan.

Map once, use many times

OER is a partner in the collection and management of ocean mapping data for the U.S. Extended Continental Shelf (ECS) Project. Data are in the public domain and made available for other uses as rapidly as possible. Open access to and reuse of these data will help spur new science and exploration, improve understanding and management of ocean resources and likely bring value for years to come. OER's FY15 Federal Funding Opportunity calls for proposals to leverage ECS Arctic data for new exploration and research.

Delivering exploration and research results

NOAA data centers steward OER data for long-term preservation and access. In 2014, 68.7 terabytes of OER data were delivered to the public from these centers. The NOAA Central Library assesses the use of OER exploration data in scientific articles in professional journals. See page 12. Since 2001, 1,168 articles have been published based on OER expeditions. Forty-six of these were published during FY14.

Advancing knowledge

NOAA's ocean exploration mission was founded in 2000 with the report of a presidential panel calling for a national program of ocean exploration. According to the report, the new focus on ocean exploration would be "for the purpose of discovery and the advancement of knowledge." For more than a decade, the mission of NOAA's Office of Ocean Exploration and Research, formerly the Office of Ocean Exploration, has been to explore, discover and advance knowledge by obtaining and sharing ocean information of high value with a variety of audiences. This is critically important knowledge that becomes available in no way other than through ocean exploration.



To study microbes as part of Ocean Sampling Day on June 21, OER coordinated cross-NOAA efforts to obtain ocean, coastal and Great Lakes water samples at 13 U.S. sites, simultaneously with and part of more than 185 international collections. The samples will support international and NOAA objectives to understand the diversity, functions and even the potential economic benefits of microbes. Shown here is Tiani Naholowaa collecting water at the Ala Wai site on Oahu. Credit: NOAA.

In 2014, OER and partner organizations advanced ocean knowledge in numerous ways to a wide variety of stakeholder audiences. Examples include a focus on partnerships to leverage the delivery of ocean information; the expanded use of new communications delivery systems such as social media; presentations posters and panel discussion participation during agency and inter-agency working groups and at regional, national and international seminars and conventions; ever-improving data accessibility; news releases; media interviews; and publications and articles in professional journals. These

and other communication avenues were part of OER's science, outreach and education efforts that contributed to OER's 2014 record of advancing ocean knowledge.

Federal Funding Opportunities

A number of OER science-related projects helped communicate ocean knowledge during the year. OER resumed and expanded its Federal Funding Opportunity grants program. After mail and peer-reviews, the office funded in FY14, 11 new proposals for about \$4.2 million, deferring funding of two proposals for \$0.4 million to FY15. A new FY15 grants program will focus on the use of existing Extended Continental Shelf data to advance knowledge of the Arctic. This support of extramural exploration projects highlights collaborations with NOAA offices and supports OER partnership efforts with other government agencies and the academic community.

Submarine canyon symposium

OER sponsored, co-organized and participated in the second International Network for Submarine Canyon Investigation and Scientific Exchange symposium in Edinburgh, United Kingdom, where NOAA presented papers and posters. The symposium featured a live telepresence interaction with *Okeanos Explorer*. Symposium participants were very interested in the OER exploration model and had numerous questions about the dive location, equipment and data availability.

Outreach and education

Ocean knowledge was advanced using traditional and new media. A news release invited the public in advance to view website pages that offered live streaming video from the seafloor during ROV operations in the deep waters of the Gulf of Mexico, especially during the investigation of three wood-hulled shipwrecks believed to be from the early 1800s. A second news release was issued when, in the course of investigating one of those shipwrecks, a NOAA marine archaeologist observed in the debris field what appeared to be a ship's chronometer. This was an important discovery because ship chronometers were new and very expensive and thus not common at the time, but were critical to determining the position of ships at sea. Because of those considerations, some



More than 2000 members of the public and an additional 18 VIP tour groups visited NOAA Ship Okeanos Explorer and the embarked OER ocean exploration team during the ship's port call in Baltimore for the Star-Spangled Spectacular celebration. Credit: Art Howard, ARTWORK.

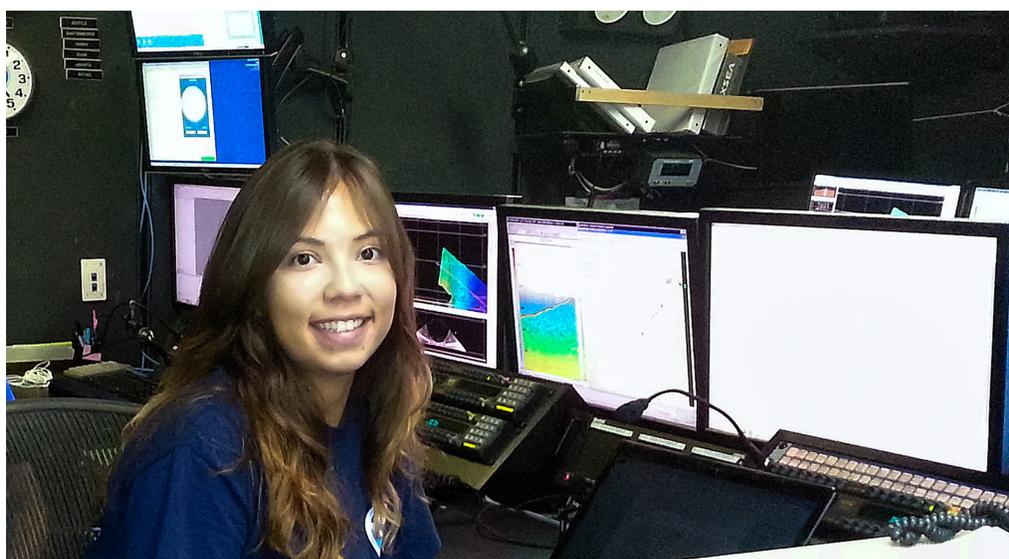
marine archaeologists surmised the ship went down quickly with no survivors—because the chronometer would certainly have been taken from the ship by survivors. Major media worldwide covered these and follow-on stories during the 2014 field season.

About 30 members of the D.C. Science Writers Association and other media toured *Okeanos Explorer* during the ship's port visit in Baltimore. Based on a successful program undertaken by *E/V Nautilus*, OER created Exploration Alerts—sent to media representatives, social media managers and public affairs contacts at partner organizations. More than 100 participants have signed up for alert messages, which

are issued several times over the course of *Okeanos Explorer* ROV expeditions, typically just prior to ROV dives that are anticipated to be of special interest, and immediately after notable discoveries.

In 2014, OER website and social media coverage expanded significantly. That story is mostly told on the “By the Numbers” page in this report, but what is not included there are the uncounted numbers of those exposed to OER stories in the website and social media extensions provided by our many partners, friends and followers.

During FY14, traffic to the NOAA Ocean Explorer website was the highest ever, with 10.7 million visits. This was a 7.6 percent increase



University of Texas Brownsville student and NOAA Educational Partnership Program (EPP) intern Rebekah Rodriguez works on a computer terminal on board the Okeanos Explorer as part of her three-week summer internship. Rodriguez was part of the team that mapped and explored portions of the New England Seamounts, a chain of extinct submarine volcanoes that extend from east to west across the north Atlantic Ocean. Credit: UT Brownsville.

Mapping explorers-in-training

OER offers developmental training opportunities to students on a path to be the next generation of ocean explorers. Students work with OER, notably in mapping the seafloor and water column. In 2014, OER supported 15 mapping explorers-in-training positions on NOAA Ship *Okeanos Explorer*. Most participants come through the University Corporation for Atmospheric Research, which in 2014 provided 12 mapping trainee positions for operations in the Gulf of Mexico and in exploring undersea canyons and seamounts off the U.S. Atlantic coast.

Mapping trainees came from NOAA's Educational Partnership Program, which, in partnership with Minority Serving Institutions, seeks to increase the number of students from underrepresented communities who are educated in fields that directly support NOAA's mission.

Other explorers-in-training come through NOAA's Sea Grant programs in Maryland and Virginia and the NOAA Hollings Scholarship Program.

Opportunities are open to enrolled undergraduate and graduate students and recent graduates from higher education programs. At-sea opportunities provide experience using *Okeanos Explorer's* advanced multibeam sonar mapping system and the chance to contribute in a significant way to NOAA's ocean exploration mission.

A typical experience includes one to three weeks at sea during the spring or summer. Trainees stand daily eight-hour mapping watches that include acquisition and processing of multibeam data and associated sound velocity profile data, as well as precise record keeping. Trainees complete an onboard project they choose, with support from the mapping team. Previous trainees now work for NOAA, USGS, private survey companies, the National Aquarium and other organizations.

over FY13 and a nearly 50 percent increase over FY12 visits. Live video pages were visited about 680,000 times, and percentages of those receiving OER information via social media delivery systems were up significantly.

OER has always focused on advancing ocean education by reaching out to learners of all ages in both formal and informal educational programs, and 2014 was no exception. Educational materials were downloaded approximately two million times, more than doubling from 2013. It was also the year that OER passed the 6,000 mark of teachers who have participated in day-long ocean exploration workshops where lesson plan content aligns with expeditions by *Okeanos Explorer*. OER also worked with a team of educators to tie OER's *Okeanos Explorer* Education Materials Collection Series to the recently released Next Generation Science Standards that have been endorsed by the National Science Teachers Association and the National Research Council.

In 2014, OER offered a five-week long online workshop titled "Deep-sea Discoveries in the Atlantic Onboard the NOAA Ship *Okeanos Explorer*: An Online Workshop to Advance Transatlantic Ocean Science Literacy," as *Okeanos Explorer* investigated that area. A total of 640 national and international participants registered. The workshop extended conversations on transatlantic ocean literacy and



Thanks to telepresence technology, anyone with Internet access can follow one of OER's telepresence-enabled explorations. Here, Oliver and Edwin Tartt watch the mission over breakfast while their family is on vacation in South Carolina. Credit: NOAA OER.

supported a pre-conference workshop prior to the National Marine Educators Association conference. Course materials are archived at: www.coexploration.org/OE2014/.

OER also co-led the Ocean Literacy theme and the Marine Microbial Ecology theme on the E.U.–U.S. Joint Consultative Group/Marine Working Group to increase scientific cooperation and advance transatlantic ocean literacy. Ocean Sampling Day was part of this international effort.



Completed - Online Workshop 2014:

Deep-sea Discoveries in the Atlantic onboard the NOAA Ship *Okeanos Explorer*

- An Online Workshop to Advance Transatlantic Ocean Science Literacy

March 3 – April 4, 2014

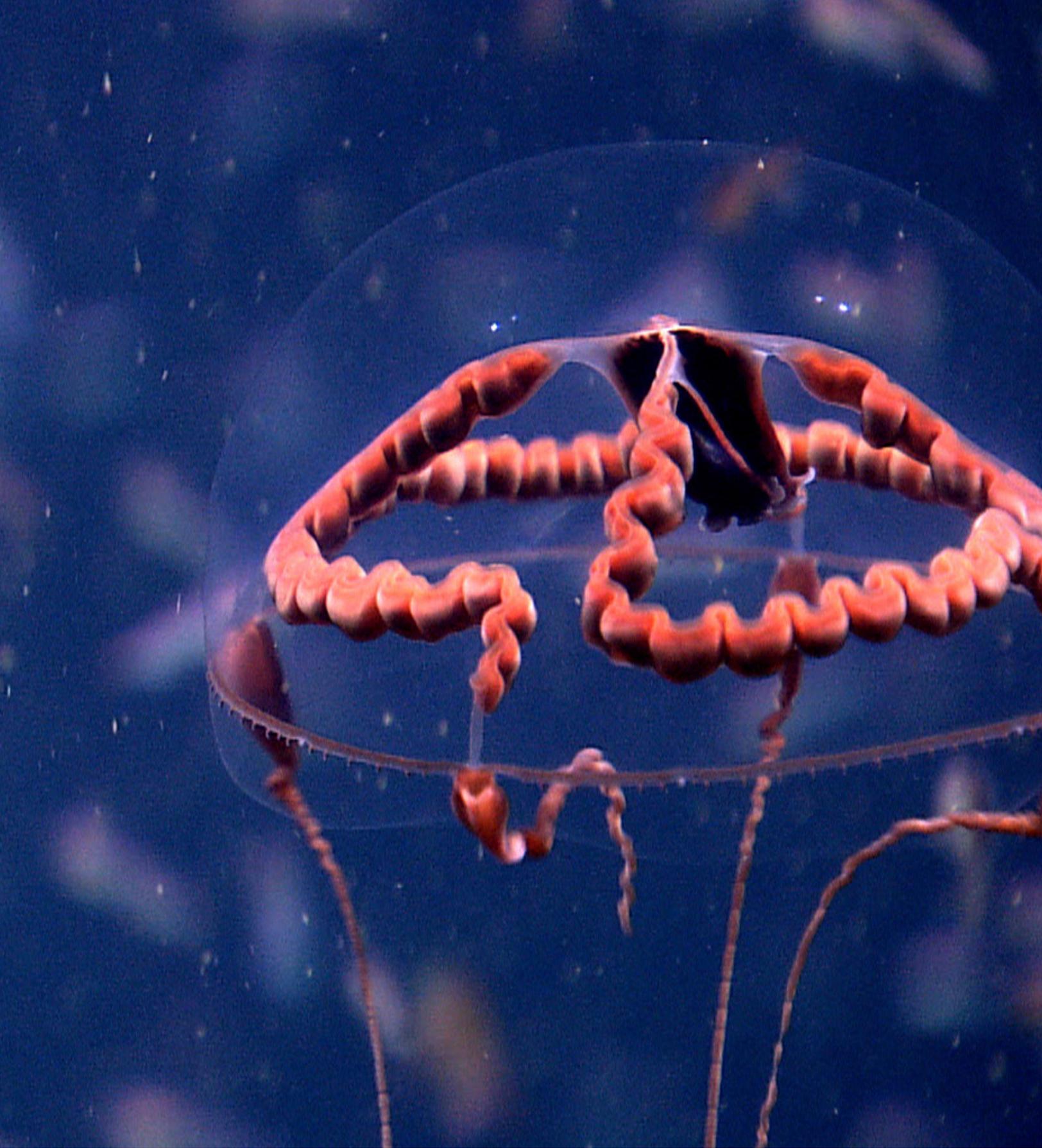
[Click to see the PDF workshop flyer advertisement](#)

Tweets 

Online Professional Development Center

[Login to NOAA OER online workshop](#)

*The five-week online OER workshop focused on discoveries of the NOAA Ship *Okeanos Explorer* and connections to ocean science literacy. Credit: NOAA.*



The ROV D2 imaged a beautiful hydromedusa in Washington Canyon during the investigation of canyons and seamounts off the U.S. northeast coast. Hydromedusa have red-tinted stomachs to camouflage bioluminescence from their prey. This expedition provided critical deepwater environmental intelligence to NOAA programs as well as other federal and state organizations. Credit: NOAA OER.

The course ahead

Okeanos Explorer

From February through September 2015, NOAA Ship *Okeanos Explorer* will investigate ocean areas in the Caribbean and Pacific Ocean. Scientists, technicians and engineers at sea and ashore will map and explore geological, biological, archaeological and chemical features, and telepresence technology will allow scientists and members of the public ashore to follow discoveries via live streaming video from the seafloor.

In the Caribbean, *Okeanos Explorer* will focus on deepwater habitats on Caribbean seamounts and in trenches, including the Puerto Rico Trench where the ROV *D2* will be tested to its rated depth of 6,000 meters. These expeditions will complement previous work by *E/V Nautilus*.

In July, *Okeanos Explorer* will join with other NOAA and external partners to initiate the Campaign to Address Pacific Monument Science, Technology, and Ocean NEeds, or CAPSTONE, to collect baseline information supporting science and management requirements associated with U.S. marine national monuments and other protected places in the Pacific Ocean. These expeditions will also highlight the uniqueness and importance of these symbols of ocean conservation. *Okeanos Explorer* will work in and around Papahānaumokuākea Marine National Monument and the Hawaiian Islands Humpback Whale National Marine Sanctuary and will complement Schmidt Ocean Institute's previous field work.

Arctic projects

OER is partnering with the U.S. Integrated Ocean Observing System (IOOS), NASA and BOEM to initiate the first U.S. network to monitor marine biodiversity at scales ranging from microbes to whales. Such a network is anticipated to serve as a management tool to conserve existing biodiversity and address threats such as invasive species and infectious agents. Three demonstration networks, one of which will occur in the Arctic's Chukchi Sea, will be prototypes for potential development of a national marine biodiversity observation network.

A multi-year Marine Ecosystem Study, or MARES, is designed to monitor and understand ecosystem dynamics of the Beaufort Sea. The study responds to national and international attention to climate change,



NOAA and OER welcome members of the new Ocean Exploration Advisory Board that will provide guidance on the nation's ocean exploration program to the NOAA administrator. VADM Paul Gaffney USN (ret.) will chair the board. Biographies of members and more about the board can be found at <http://oeab.noaa.gov>. Credit: NOAA.

energy development and related issues in the region, and OER is considering ways to engage with BOEM and others in this study.

The FY15 OER Federal Funding Opportunity is Arctic-focused. For details on plans to leverage the rich Arctic data set collected in support of the U.S. ECS Project see: <http://oceanexplorer.noaa.gov/about/what-we-do/funding-opps/fffy-fy15-full.pdf>.

Genomics

OER is teaming with NOAA Fisheries, AOML, and IOOS, as well as the J. Craig Venter Institute and Scripps Institution of Oceanography to enhance ecosystem observation programs by integrating genome-enabled techniques and technologies into the California Cooperative Oceanic Fisheries Investigations (CalCOFI), a multi-partner long-term ecosystem and fisheries study off the coast of California. Integration is expected to help scientists better understand the diversity and functional activity of microbes—enabling more accurate prediction of ecosystem tipping points, ecosystem resiliency and predicting ocean response to large-scale pressures, including climate change. The project is a pilot for applications in other regions.

NOAA and Maryland's Star-Spangled Spectacular

From September 10 to 16, Baltimore became the centerpiece for the Star-Spangled Spectacular, a celebration of Maryland's maritime history and commemoration of its contributions to the defense and heritage of the nation, including the birth of our national anthem. *Okeanos Explorer* took a timely break from exploring Atlantic submarine canyons to be available for the events and to provide a backdrop to highlight NOAA's leadership across ocean issues.

During the week-long celebration, NOAA and the National Aquarium in Baltimore co-hosted a range of events. One such event was a meeting to discuss the value and relevance of ocean exploration to NOAA and the nation. Event participants initiated planning for a 2015 National Ocean Exploration Forum to be held at the National Aquarium.

The Mid-Atlantic Regional Council on the Ocean (MARCO) and Maryland Sea Grant convened a workshop focused on the current and future state of science in the mid-Atlantic undersea canyons. Participants from federal, state and academic groups discussed results of field work by NOAA and partners in the region with some of the shared data collected just three days prior to the meeting. Following the workshop, MARCO adopted a Course of Action to consider and develop recommendations to strengthen federal protection of submarine canyon habitats.

Other highlights included:

- *Okeanos Explorer* tours for more than 2,000 members of the public and an additional 18 group tours for key friends in the region, including partners such as the National Aquarium, Bureau for Ocean Energy Management, U.S. Naval Academy, Mid-Atlantic Regional Council on the Ocean, and Sea Grant;
- Presence of NOAA Research Vessel *Bay Hydro II*, NOAA's primary platform to survey the Chesapeake Bay;
- A Google+ Hangout hosted by the National Aquarium featuring both NOAA Ship *Okeanos Explorer* and our colleagues on the Ocean Exploration Trust's E/V *Nautilus*; and,
- A pier-side tent with National Aquarium exhibits and activities for children including special appearances by Captain Barnacles and Kwazi Kitten of The Octonauts.

Okeanos Explorer and National Aquarium personnel had a great view of the Star-Spangled Spectacular fireworks in Baltimore's Inner Harbor. Credit: A. Howard, ARTWORK.





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