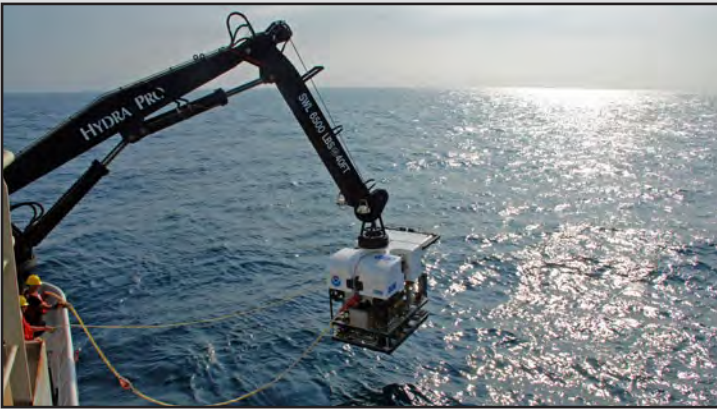


**NOAA Office of Ocean
Exploration and Research**
Fiscal Year 2013 in Review

Expanding Ocean Exploration



Dr. Brendan Roark of Texas A&M University prepares the CTD rosette on board NOAA Ship Okeanos Explorer. Credit: NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

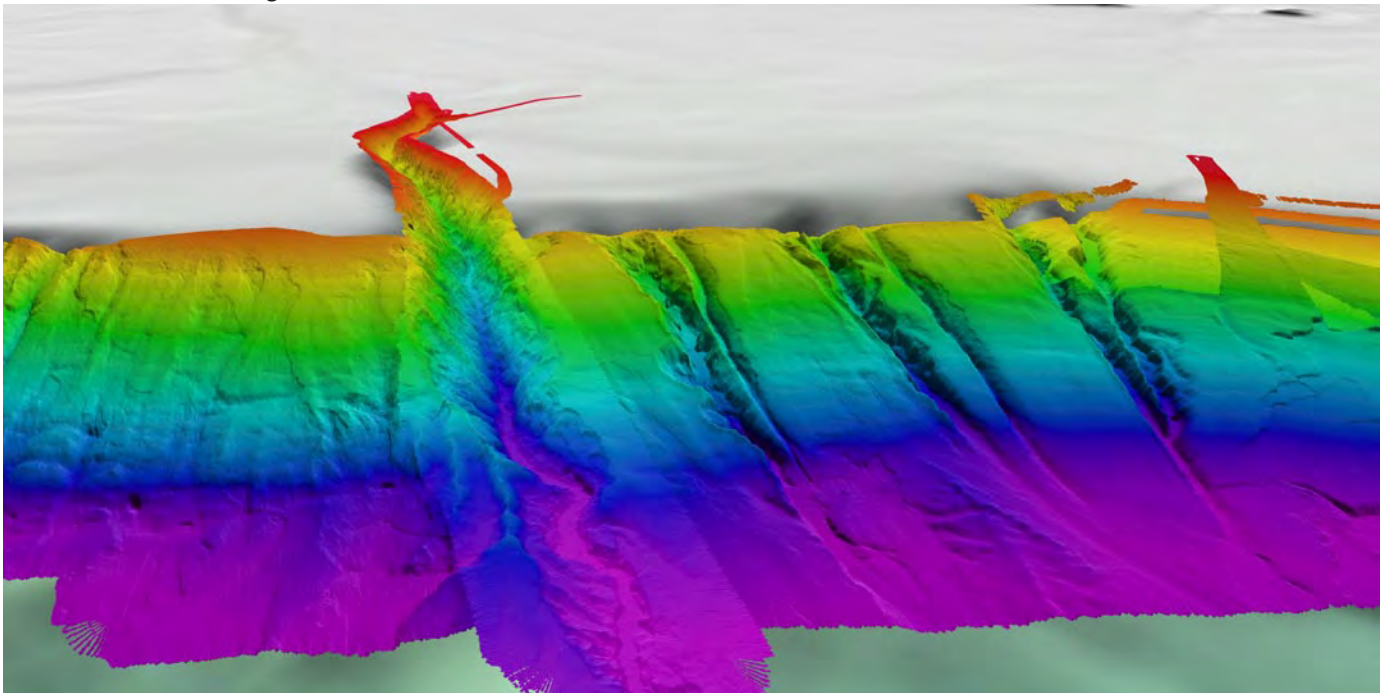


NOAA's new deepwater remotely operated vehicle, Deep Discoverer, is deployed off the fantail of the ship for the first dive of the 2013 Northeast U.S. Canyons Expedition. Credit: NOAA Okeanos Explorer Program.

Contents

OCEAN DISCOVERY	01
EXPANDING EXPLORATION	02
OKEANOS EXPLORER PROGRAM	04
PIONEERING EXPEDITIONS	05
ADVANCING TECHNOLOGY	08
2013 FIELD SEASON ACTIVITIES	10
ADVANCING KNOWLEDGE	12
VALUE OF PARTNERSHIPS	17
DATA MANAGEMENT	18
NUMBERS AND GRAPHS	20

About the Cover Image



A multibeam sonar image of canyons off the U.S. northeast coast in the Atlantic Ocean. The main canyon is Hudson Canyon, one of many explored in 2013 by NOAA Ship Okeanos Explorer, and it demonstrates the vast diversity of the undersea terrain. Credit: NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

Ocean Discovery

NOAA and the nation have a long history of exploring the world's oceans, from Thomas Jefferson's order to establish the Survey of the Coast in 1807 to the most recent discoveries of new habitats, species and deep-sea hydrothermal vents. However, there is much that is unknown about the seafloor features, mineral and natural resources, and chemical and physical processes of our marine environment--and so much work that remains to be done.

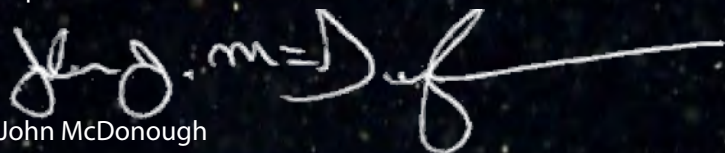
The NOAA Office of Ocean Exploration and Research was formed with these challenges in mind. It was created to investigate unknown regions of the oceans while establishing baselines to stimulate research and new lines of scientific inquiry and to support marine resource management. Through dedicated voyages of exploration, the Office and its partners investigate new ocean areas and phenomena, delivering information to meet national and international priorities. Together, we communicate the results of our expeditions to the ocean exploration and research communities to further the national ocean exploration enterprise and to the public to raise awareness of the oceans and the incredible diversity of habitats, species, and features.

The Office sets exploration priorities to meet NOAA mission needs and to investigate areas of importance identified in consultation with our partners from other federal agencies, academic institutions, industry, and non-governmental organizations.

With our partners and national ocean exploration stakeholders, we have developed a strong foundation for exploration focused on four goals:

- Conduct baseline characterizations of unknown and poorly-known ocean basin boundaries, processes, and resources;
- Transition ocean exploration discoveries to new research areas and research results to new applications to benefit society;
- Communicate exploration results to partners, stakeholders, and the public; and,
- Increase the pace, scope, and efficiency of exploration and research by advancing new and emerging underwater technologies.

The pages ahead tell the story of an exciting year of discoveries and progress in ocean exploration for NOAA—and the nation.



John McDonough

Acting Director, Office of Ocean Exploration and Research

*A unique relationship between a specific species of octocoral (cf. *Metallogorgia melanotrichos*) and brittle star (cf. *Ophiocreas oedipus*). To our knowledge, these species were not previously known to occur in the northeast U.S. canyons region. Credit: NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition*

Expanding Exploration

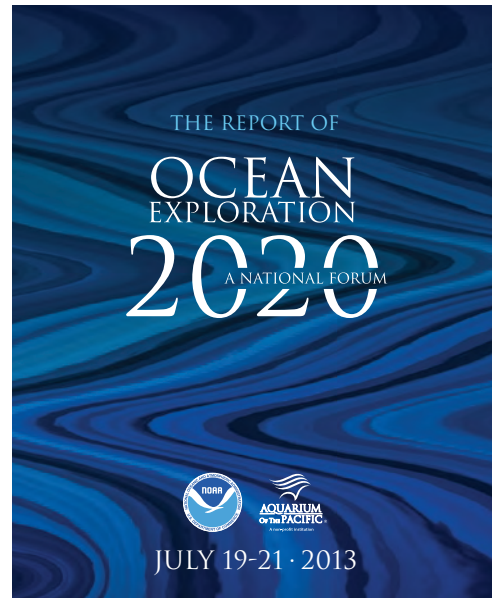
National Forum

Congress recognized the need for a national program of ocean exploration—a network of ocean explorers that includes federal agencies, non-governmental organizations, academic institutions, and the private sector—in the Ocean Exploration Act of 2009. The Act calls for NOAA to establish such a national program in consultation with ocean exploration stakeholders, and to host a “national forum on ocean exploration” to allow stakeholders to share information, results, and opportunities.

In July 2013, the Aquarium of the Pacific in Long Beach and NOAA hosted the first national forum to engage the community in framing the national program. Ocean Exploration 2020: A National Forum brought together more than 100 ocean explorers, scientists, government officials, academics, and industry leaders to identify key elements of a national program of ocean exploration, including the emerging issues, trends and potential priorities that should drive a national program.

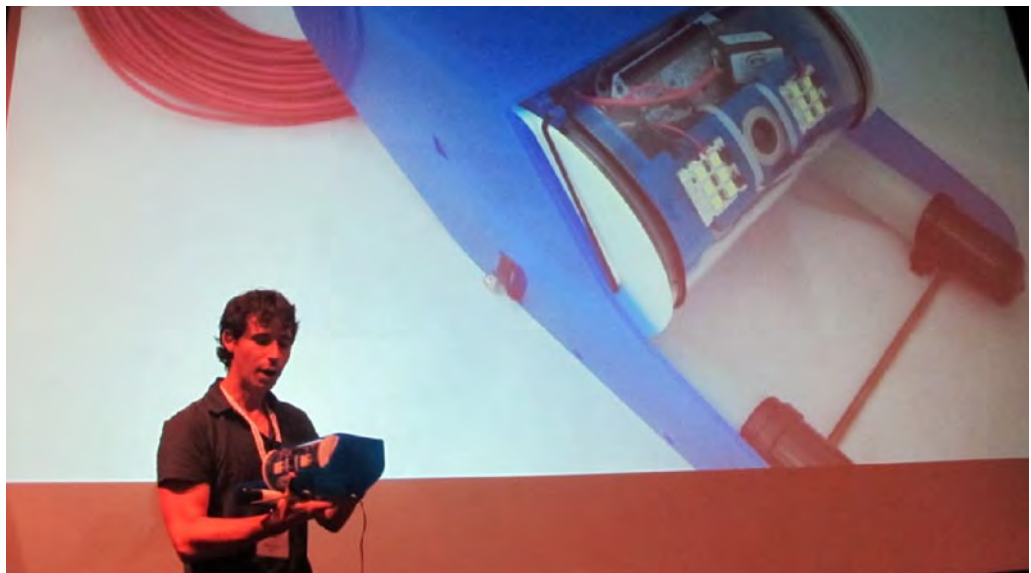
The Ocean Exploration 2020 report describes a national program of ocean exploration that by the year 2020 includes elements focused on:

- National priorities for ocean exploration, including the Arctic and Antarctic, exploration of the water column to characterize the ocean from seafloor to



surface, and exploration of processes, in particular ocean acidification;

- Forming and strengthening ocean exploration partnerships, recognizing that partnerships are key to almost any significant ocean exploration expedition;
- Ensuring platforms—ships and vehicles—are available for ocean exploration and are capable of operating in the context of all data about the ocean that is available, such as satellite data and data from cabled observatories;



At the Ocean Exploration 2020 Forum, OpenROV co-creator Eric Stackpole describes the vehicle to an interested audience. This low-cost, capable ROV could put more ‘citizen scientists’ to work gathering information for ocean exploration data sets. Credit: Jenifer Austin Foulkes, Google, Inc.



Forum attendees from government, academia, non-profits, industry and others met to shape the future of U.S. ocean exploration. Credit: Aquarium of the Pacific at Long Beach.

- Technology development, in particular testing and validating new platforms and instruments;
- Citizen science as an emerging and increasingly important capability to advance the national program;
- Data management to ensure expedition results are available in real- or near-real time to meet different needs and that there are mechanisms for all potential data collectors, including citizen explorers, to contribute; and
- Engaging the public in the conduct of ocean exploration and sharing expedition results with diverse audiences.

Forum partners included NOAA, Aquarium of the Pacific, the Global Foundation for Ocean Exploration, the Schmidt Ocean Institute, Google, Inc., the Bureau of Ocean Energy Management, Esri, NASA, the National Geographic Society, the National Science Foundation, the Ocean Exploration Trust, the Roddenberry Foundation, the U.S. Geological Survey and the U.S. Department of State.

The complete report is at: <http://oceanexplorer.noaa.gov/oceanexploration2020/nationalframework.html>.

The next national forum is planned for September 2014 at the National Aquarium in Baltimore.

External Guidance

The NOAA Science Advisory Board's Ocean Exploration Advisory Working Group (OEAWG), a committee of experts from academia and non-governmental organizations, has provided NOAA with advice on priorities, partnerships, and other facets of NOAA's Ocean Exploration program since its inception.

The OEAWG helped establish and frame the 2012 independent review of the Ocean Exploration Program. The Review Panel submitted their report to the Science Advisory Board in December 2013 (see <http://go.usa.gov/Bth5>).

The Ocean Exploration Program has aggressively implemented review recommendations, including hosting a National Forum, conducting a rigorous cost analysis of operations, pursuing new and creative public engagement strategies and developing innovative management approaches to leverage partnerships and increase effectiveness.

Under the Ocean Exploration Act of 2009, the OEAWG will be replaced with the new Ocean Exploration Advisory Board (OEAB), a federal advisory committee reporting directly to the NOAA Administrator. In 2013, NOAA solicited and processed nominations for the new OEAB, which is expected to be operational in the summer of 2014.

Okeanos Explorer Program

NOAA Ship *Okeanos Explorer*, America's ship for ocean exploration, is the only federal vessel that systematically explores and identifies the unknowns of our ocean. The program supports NOAA and national goals by increasing the pace and efficiency of discovery and by providing high-quality, publicly accessible deep water ocean data, including live video from the seafloor, to scientists, managers, industry, and the public ashore.

Informing Management Decisions with Deep Water Canyon Data

In 2013, OER and the NOAA/National Marine Fisheries Service Deep Sea Coral Research and Technology Program engaged an interdisciplinary team of scientists from dozens of institutions and multiple sectors to investigate the U.S. northeastern deep-water canyons' habitats. The expedition discovered a wide variety of seafloor features and biological communities in and between largely unexplored canyons, providing new information about how these canyons change over time and revealing hot spots for biodiversity. Today, this data supports NOAA's Habitat Blueprint, regional state ocean councils, offshore energy, coastal resilience and fisheries management.

Northernmost U.S. Atlantic Seeps Discovered

During the expedition, explorers detected and mapped water-column plumes about 90 nautical miles southeast of Nantucket, Mass. The plumes were traced to seafloor seeps where explorers observed chemo-synthetic communities of life. These, and an unexpected seep community discovered in Nygren Canyon, are the northernmost seeps detected to date on the U.S. Atlantic margin. As of June 2012, only two seep communities were known to exist. Since then, the *Okeanos* program and partners have discovered nine additional seep communities, and scientists believe there may be as many as 200 seeps in the Atlantic margin. Knowledge of these seeps and associated biological communities will help NOAA and other scientists, managers, and policy makers better understand, use, and protect the ocean and its resources.



NOAA Ship Okeanos Explorer uses satellite and Internet2 technologies to transmit data and video in real-time from the ship and ROVs at depth, to audiences ashore, including scientists at exploration command Centers. The University of Rhode Island's Inner Space Center compresses the video for distribution via standard Internet. Video and internet-based collaboration tools allow scientists on shore to join the expedition in real-time. Credit: B. Ambrose, GDIT/NODC, R. Canfield, NOAA & NOAA OER.

Telepresence technology brings a world of expertise to an expedition at sea.

When NOAA Ship *Okeanos Explorer* investigated deep-sea canyons off the U.S. northeast coast, a relatively small number of scientists were on the ship, and the great majority of scientists were ashore in the states and nations depicted here. Those scientists were fully engaged, adding significant intellectual capital to the expedition in real time. Telepresence technology made it possible—delivering data, including live HD video, from the seafloor to scientists ashore via satellite and high-speed Internet pathways. In addition, there were a record number of visits by “citizen scientists”—members of the public—to view live video streaming from the seafloor, and those visitors heard scientists at sea and ashore comment on what they were viewing in those largely unknown canyons.



(continued *Okeanos Explorer Program*)

Detecting Marine Hazards for Coastal Resiliency

In April and June 2013, a Deep-ocean Assessment and Reporting of Tsunamis (DART) buoy off the coast of New England and several coastal tide gauges detected two tsunami-like waves. Partnering with NOAA's Center for Tsunami Research and the U.S. Geological Survey (USGS) Natural Hazards

program, *Okeanos Explorer* rapidly responded and conducted a repeat bathymetric survey of the head of Hudson Canyon (see cover image) where models suggested both waves may have originated, possibly from a submarine landslide. The timely investigation of these events made a significant contribution toward understanding and resolving a potential threat to lives and property along the eastern U.S. coastline. Rapid response is an integral part of *Okeanos'* mission.



Corals, including cup corals and bubblegum corals, reside on hard substrate near the edge of a chemosynthetic mussel bed. The site was investigated during the *Okeanos Explorer* 2013 Northeast U.S. Canyons Expedition. Credit: NOAA *Okeanos Explorer Program*.

Pioneering Expeditions

OER sponsors targeted expeditions to better understand unknown and little known areas of the ocean. The ocean is our planet's life support system. It provides more than half the oxygen we breathe, regulates weather and temperature, provides food and supports fisheries and coastal communities, yet we have explored less than 5 percent of it. If we don't understand the ocean and what resides within it, we cannot detect and understand changes and processes that affect and impact the planet, and all the people and species living on it. Partnerships in ocean sciences not only lead to innovative and comprehensive studies but also leverage resources and expertise to meet national priorities. Over the past 12 years, OER has funded critical exploration efforts that have transformed our knowledge about the ocean environment.

2013 Deepwater Canyons Expedition

In 2013, OER and its partners completed the final field effort in a four-year project to characterize deep-sea communities and historical shipwrecks in and around Norfolk and Baltimore Canyons. Using robotic underwater vehicles and long-term deployments of benthic landers and instrumented moorings, results

have included the discovery of abundant deep-water coral habitats, methane seep communities and the identification and documentation of the "Billy Mitchell Fleet" of WWI-era shipwrecks. The results from this study will be directly utilized by managers to develop protection and conservation measures for these sensitive habitats and cultural resources.

Coral Ecosystem Connectivity Expedition

The 2013 Pulley Ridge Expedition was the second of a five-year study to investigate the role that healthy mesophotic reefs play in replenishing key fish species and other organisms in the downstream reefs of the Florida Keys and Dry Tortugas. Because of the well-documented decline of Florida's reefs, it is 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 goal of this study is to not only provide a better understanding of the underlying processes that regulate Pulley Ridge and whether Pulley Ridge helps sustain the coral reef communities in the Florida Keys and Dry Tortugas, but also to help determine if the area would benefit from further protection.



Often multiple species of invertebrates are found co-occurring on rock ledges and canyon walls. Here an octopus, sea star, bivalves, and dozens of cup coral all share the same overhang. Credit: Deepwater Canyons 2013 - Pathways to the Abyss, NOAA-OER/BOEM/USGS.

Marine Archaeology Investigations

The *Okeanos Explorer's* initial 2012 reconnaissance of the Monterey Shipwreck in the Gulf of Mexico catalyzed further work in 2013 on the Ocean Exploration Trust's *E/V Nautilus*. Using ROV *Hercules* in over 4,300 feet of water, archaeologists recovered diagnostic artifacts and completed an accurate photo mosaic map revealing an armed early 19th century vessel, likely a privateer. The wrecks of two contemporary merchant vessels nearby were visited for the first time during the expedition. These important discoveries open a new window on a significant and volatile period of nation building all around the Gulf that also shaped the formation of our country.

OER partnered with BOEM and others to map and assess the condition of the "Billy Mitchell Fleet," comprised of sunken WWI One German warships. The captured ships were targets in the first aerial bombing

experiments that led directly to the development of American naval air power. Baseline characterization of these artifacts is the essential first step in understanding this pivotal period in American military history and for the long-term management of these significant heritage resources.

With funding from OER and in partnership with NOAA's Office of National Marine Sanctuaries, the Hawaii Undersea Research Laboratory discovered the I-400 off Oahu, Hawaii, one of the most advanced submarines built by Japan during WWII. The submarine, which could sail around the world one and a half times without refueling, carried two attack aircraft stored in a sealed hanger. This discovery expands our knowledge of the rich cultural heritage in Hawaiian waters and will benefit from cultural heritage management.

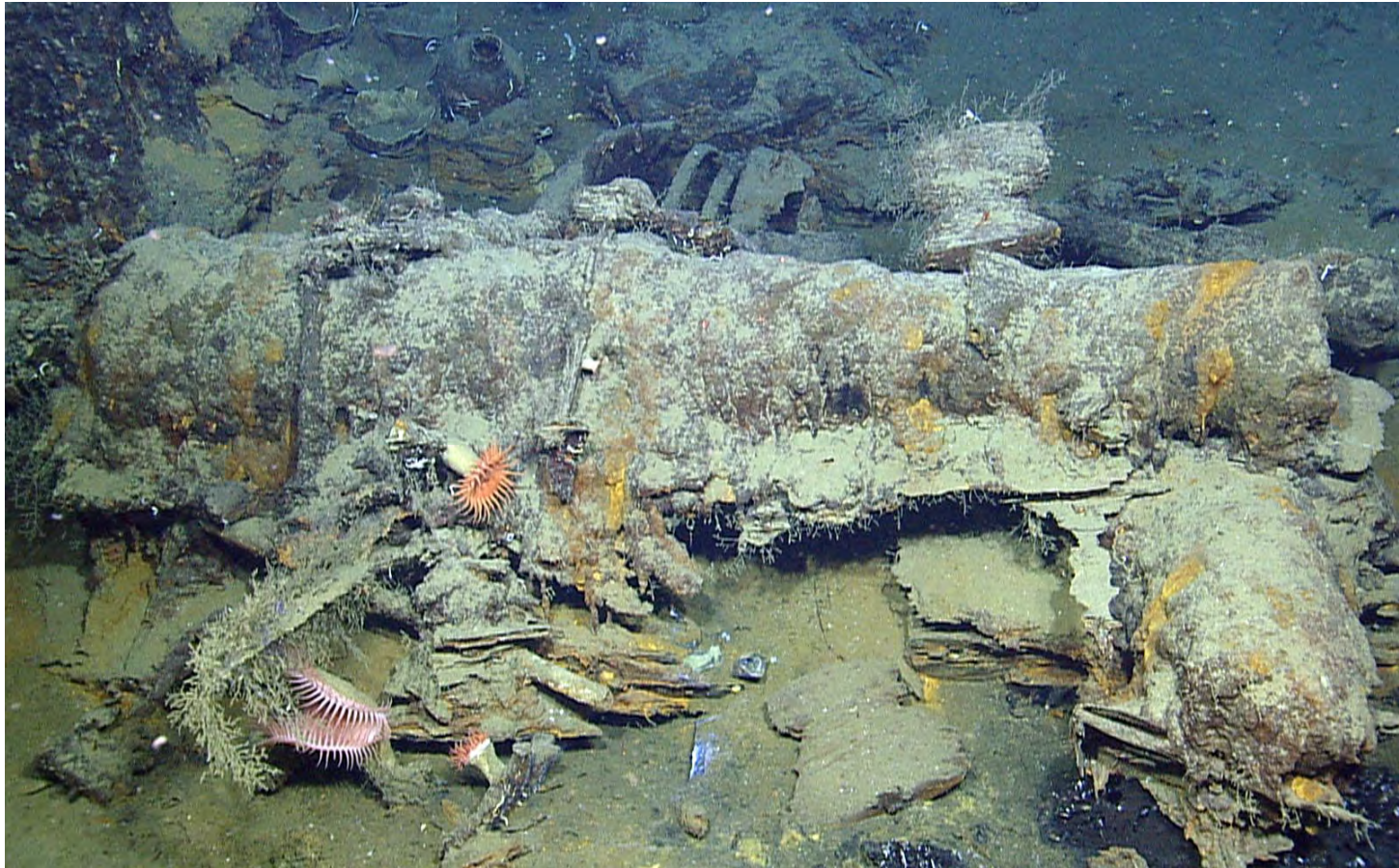
Monterrey Shipwreck

July 2013

Preliminary Results

© 2013 All Rights Reserved
Roman Lab, University of Rhode Island,
Ocean Exploration Trust,
Meadows Center for Water and the Environment, Texas State University

Photomosaic of an early 19th century shipwreck documented and partially excavated in the Gulf of Mexico in more than 4,300 feet of water. In 2013, the Ocean Exploration Trust's E/V Nautilus returned to the wreck that was first investigated by NOAA's Okeanos Explorer Program in 2012. Partners in the 2013 return mission included The Ocean Exploration Trust at the University of Rhode Island, E/V Nautilus, the Meadows Center for Water and the Environment at Texas State University, the Bureau of Ocean Energy Management, the Bureau of Safety and Environmental Enforcement, NOAA and the Texas Historical Commission. NOAA marine archaeologists from OER and NOAA's Office of National Marine Sanctuaries participated in the 2013 expedition. Credit: Ocean Exploration Trust/Meadows Center for Water and the Environment, Texas State University.



A close-up of the cannon on the shipwreck above. This cannon, once rigged on a center-pivoting gun carriage, rests atop another cannon in a jumble of artifacts in the center of this early 19th century shipwreck. At more than 4,300 feet deep, the shipwreck is the deepest site yet documented and partially excavated in U.S. waters. Credit: Ocean Exploration Trust/Meadows Center for Water and the Environment, Texas State University.

Advancing Technology

Exploration and data collection in the deep ocean requires robust undersea technology capabilities that can withstand the rigors of depth, salinity and shipboard operations. OER and our partners create and use this technology, and advance new platforms, sensors and systems, to expand the scope, pace, efficiency and cost effectiveness of ocean exploration.

New 6000-meter Remotely Operated Vehicle

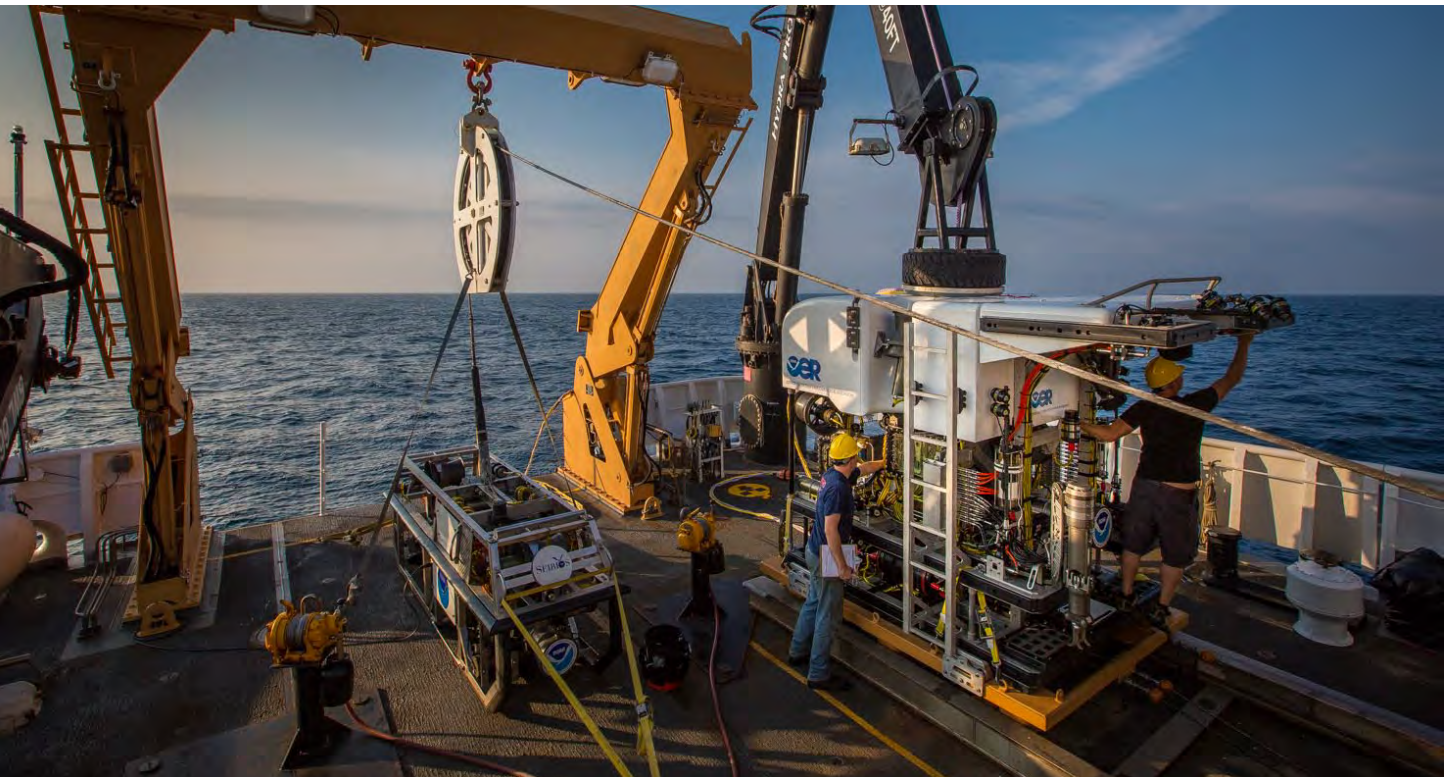
In 2013, OER deployed on board the NOAA Ship *Okeanos Explorer* a new 6,000-meter ROV, the *Deep Discoverer*, with more sophisticated capabilities than the ROV OER had been using for the previous three years. The increased capabilities will enable innovation through research and development of new sensors and systems. The new ROV currently includes hydraulic manipulator arms for deploying oceanographic sensors, an inertial navigation system, a Doppler velocity navigation system, and a system for dynamic lighting control. The vehicle weighs in at 9,200 pounds, has an overall length of 10.5 feet, and stands an impressive 8.5 feet tall. It carries a minimum of six underwater video cam-

eras, two of which are high-definition; a large array of the newest LED lighting technology; and an available sensor payload of over 400 pounds. Two seven-function hydraulic manipulators, a hydraulically actuated sensor platform, full color sector scan sonar, and a fully integrated inertial navigation system are all standard capabilities of the new system.

In 2013, engineers from multiple disciplines performed a “shake down” of the ROV system to ensure that all systems were integrated and functioning properly. The ROV was a critical tool for the successful Atlantic Canyons cruises exploring diverse seafloor habitats and bottom types ranging from very flat areas at the base of the canyons on the continental rise to valleys that provide very complex terrain with steep slopes.

OER Partners Share Technology Risks and Rewards

In 2013, OER supported advancing undersea technology through the Cooperative Institute for the North Atlantic Region, resulting in operational missions with the new hybrid remotely or autonomously operated vehicle AUV *Nereus*, with plans to extend operations



Senior and junior engineers run a pre-dive test on the *Deep Discoverer* ROV and *Seirious* camera sled from the *Okeanos Explorer* control room. A hallmark of the *Okeanos Explorer* Program is a focus on training the next generation of explorers. OER conducts a thriving mentorship program matching early career scientists, engineers, and technicians with experts in their fields. They work side-by-side learning, innovating, and conducting explorations together with the *Okeanos Explorer* team. Credit: NOAA *Okeanos Explorer* Program.

to the Arctic in 2014. Woods Hole Oceanographic Institution operates *Nereus*.

The vehicle may operate in Arctic areas not otherwise accessible, producing high-resolution seafloor maps and images that provide ecosystem assessments and characterizations of the seafloor and water column. This information could be vital to understanding the Arctic where the U.S. may extend its continental shelf and secure rights to use or protect seabed resources.

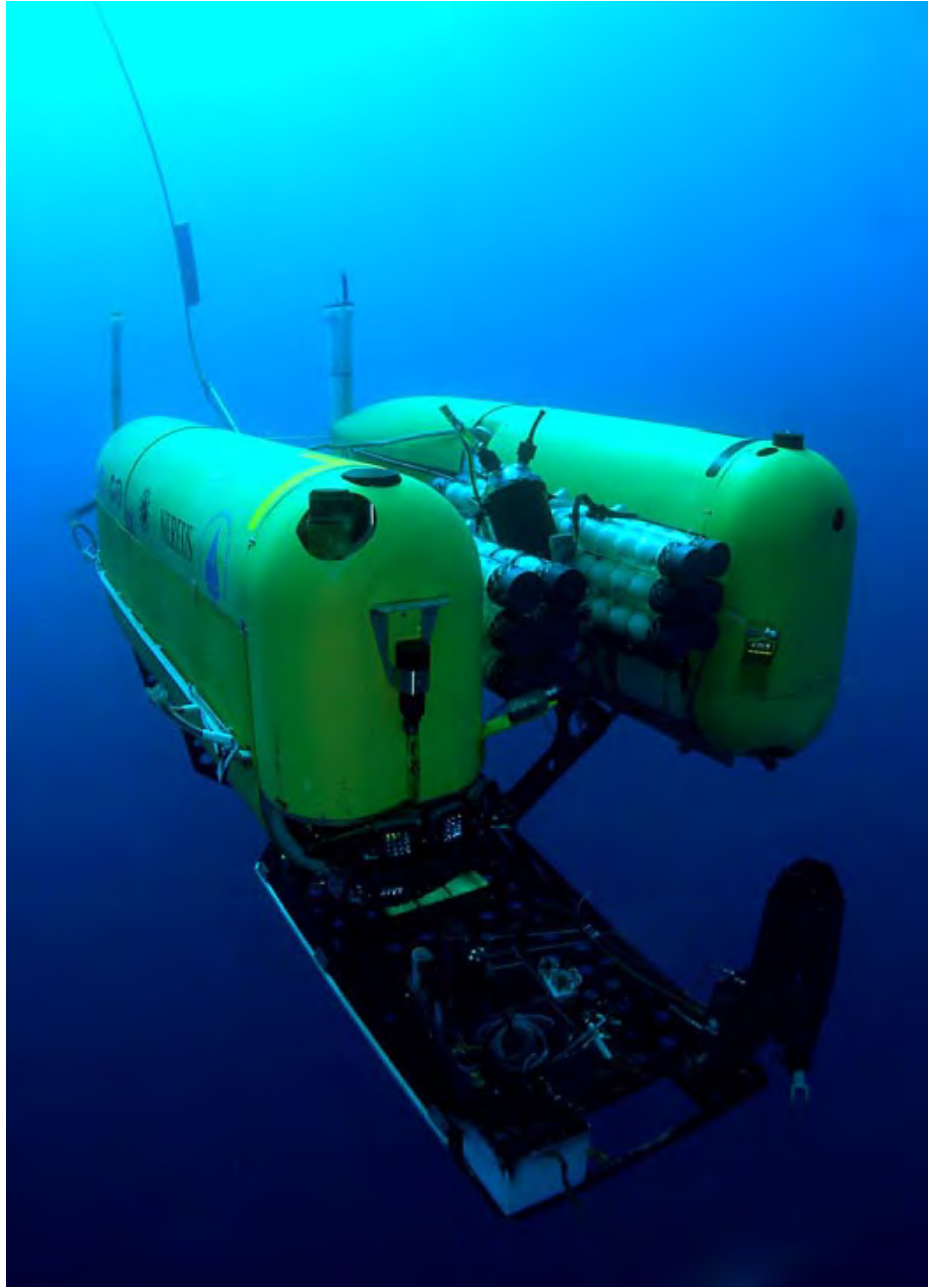
Advanced Technology Engagement

Through the Small Business Innovation Research Program's phase I (proof of concept), OER has successfully supported the development of a new in situ method to measure small changes in the ocean's calcium concentrations. The project was selected for phase II funding, to develop a prototype within the next two years. OER also manages another phase II project to develop a multi-person foldable hypobaric chamber prototype.

OER leads several ocean technology initiatives both within NOAA and between agencies that spur engagement and cooperation on ocean exploration technology development and testing. With industry partners, NOAA's ocean observation innovations forum group developed a series of Cooperative Research and Development Agreements to advance the use of autonomous vehicles to support ocean exploration and other NOAA mission priorities.

OER is also a leader in developing NOAA's Unmanned Systems Roadmap encompassing Unmanned Aerial Vehicles, Unmanned Surface Vehicles and AUVs.

OER also created a federal interagency group, the Task Force on Ocean Exploration and Research Technology, which supports advancement of new technologies and capabilities for ocean exploration. Comprised of NOAA, the National Science Foundation, the Bureau of Ocean Energy Management, the Office of Naval Research, the USGS and NASA, the group identified technical capabilities for Arctic ocean exploration that were common among members. Benefits of this interagency collaboration include cost savings when leveraging investments to develop new or better technology tools that meet common objectives.



The hybrid remotely operated vehicle (HROV) Nereus being launched from the research vessel Cape Hatteras during the first research cruise to search for deep-sea hydrothermal vents along the Mid-Cayman Rise. Nereus was built and is operated by Woods Hole Oceanographic Institution (WHOI). It is an 11,000 meter-rated unmanned remotely operated vehicle that operates in two modes. It can swim freely as an autonomous underwater vehicle (AUV) to survey large areas at depths and it also can be transformed into a ROV tethered to the ship by a microthin, fiber-optic cable. Nereus can transmit real-time video images and receive commands to collect samples and carry out experiments with a manipulator arm. Credit: Advanced Imaging and Visualization Laboratory, WHOI.

2013 Field Season Activities

- 1 NOAA *Okeanos Explorer* Program
- 2 NOAA OER Multi-Agency Partnership project with BOEM and USGS
- 3 Ocean Exploration Trust (OET) Exploration Vessel *Nautilus*
- 4 Cooperative Institute for Ocean Exploration, Research & Technology (CIOERT)
- 5 National Institute for Undersea Science and Technology (NIUST)
- 6 Hawaii Undersea Research Laboratory (HURL)

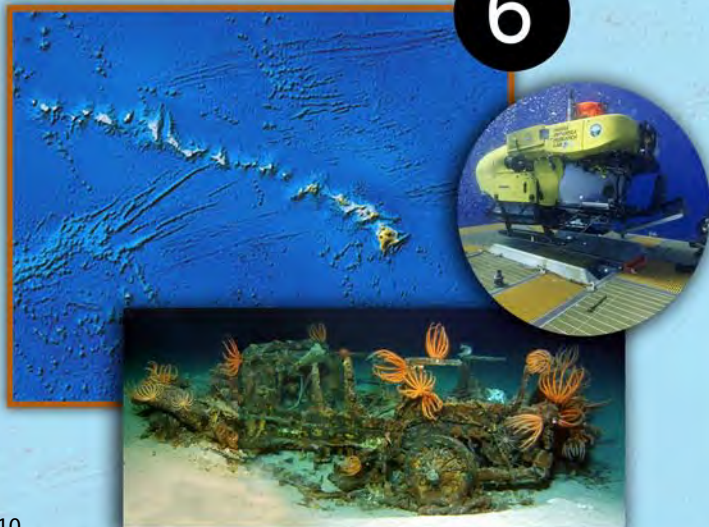
NIUST

Provides cutting-edge AUV and mapping technologies to NOAA and their constituencies to stimulate discoveries in marine biotechnology and methane hydrates. NIUST funded 40 days at sea in the Gulf of Mexico using the AUVs *Mola Mola* and *Eagle Ray*, and innovative landers.



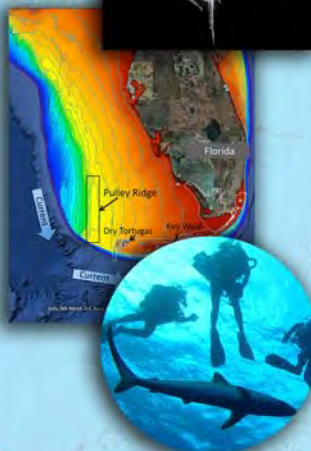
HURL

Supports NOAA's undersea research mission with two manned *Pisces* submersibles and a newly acquired 6,000-meter ROV. In 2013, OER transferred *Pisces V* to HURL and supported the recertification of the Launch, Recovery & Transport platform, plus 61 days at sea studying Pacific Island ecosystems.



CIOERT

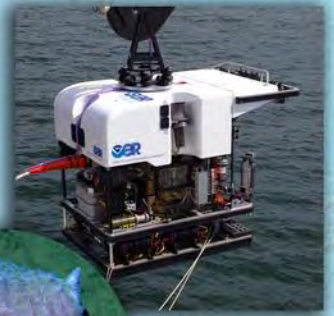
Uses innovative technology to explore the eastern U.S. continental shelf frontier to improve our understanding of vulnerable coral and sponge ecosystems. OER contributed toward 27 days at sea supporting the study of the South Florida coral reef ecosystem [Pulley Ridge, page 5] and fisheries research in the South Atlantic shelf-edge marine protected areas.



Okeanos Explorer

see page 4

America's only ship for systematically exploring the world's ocean uses telepresence to engage experts all around the world in real time to guide expeditions. The *Okeanos Explorer* shares the excitement of ocean exploration through live Internet video to engage and educate the public. In 2013, NOAA's ROV *Deep Discoverer* was launched and explored the deep sea habitats and marine life along the northeast U.S. Canyons located within the U.S. Exclusive Economic Zone.



1

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OET E/V *Nautilus*

see page 17

Exploring the Gulf of Mexico and the Caribbean Sea in 2013, OET focused on areas identified in the 2012 Caribbean workshop. An OET highlight was the return to the *Monterrey* shipwreck, page 7. In 2013 OET launched *Exploration Now!* – an Internet portal that allows the public to view ongoing expeditions in real time.



Multi-Agency Partnerships

see page 17



A three-year partnership between NOAA, the Bureau of Ocean Energy Management, the U.S. Geological Survey, and others culminated in 2013. Partners explored deep-sea coral habitats, cold-seep communities, and shipwrecks in and around Baltimore and Norfolk Canyons.

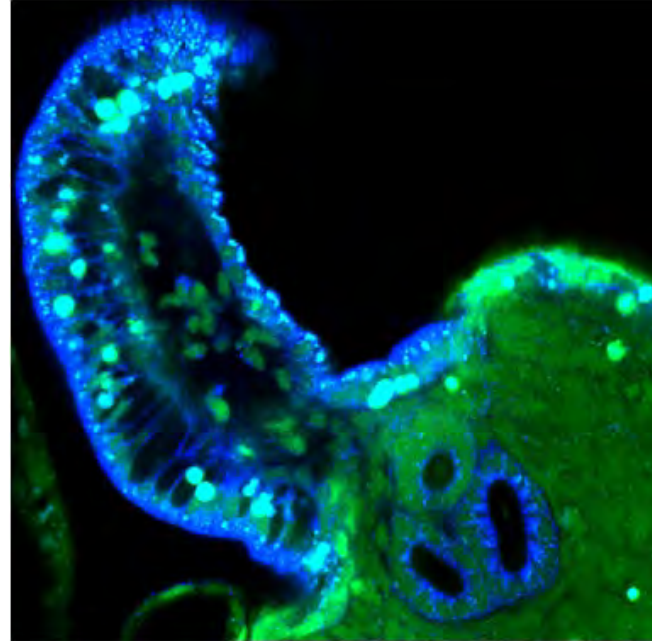


Advancing Knowledge

The results of ocean exploration are discoveries highlighting areas, features, resources or processes that are new to science and in need of further study. OER pursues a scientific continuum where discoveries result in new knowledge and capabilities that benefit NOAA, national and international science and technology, policymakers and ocean management communities. These discoveries and the resulting new knowledge are shared with a wide variety of stakeholders through formal working groups, seminars, town halls, workshops and symposia. Outreach and education are also an important part of this process.

Marine Microbe Biodiversity - Exploring a Largely Hidden World

OER's main product is the baseline characterization of unknown areas. Baseline characterizations include the assessment of the biological, geological, physical and chemical characteristics of the area and the processes at play. Recent development of advanced genetic techniques spurred by the Human Genome Project have revealed new insights into the identity



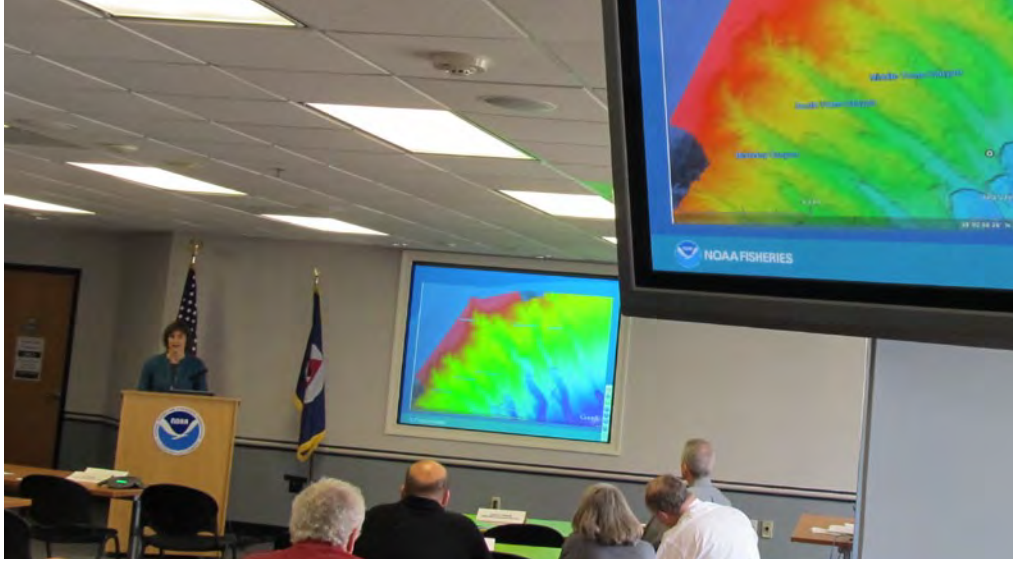
*The symbiotic association between the squid *Euprymna scolopes* and the luminous bacterium *Vibrio fischeri* provides a unique opportunity to study both immune and developmental signals associated with the establishment and maintenance of beneficial animal-bacterial interactions. Credit: Margaret McFall-Ngai, University of Wisconsin-Madison.*



Deep sea Ascomycete fungus.

Marine microbes are a source of natural products that can be detrimental or beneficial to the marine environment. For example, marine fungus can produce diseases in fish and other marine living resources but they can also lead to the discovery of new marine natural products that are substances that could be helpful in treating human diseases. Credit: deepsea news.com.

and metabolic functions of microbes, and heightened awareness of their vital importance to ocean ecosystem health. Microbes comprise 98 percent of the biomass of the world ocean, underpin the function of the biosphere, and are integral to all life on Earth, yet they constitute the least understood and most unexplored group of living organisms that flourishes in the sea. To address NOAA's knowledge gap in this regard, representatives from OER and NMFS Northwest Fisheries Science Center are co-chairing a NOAA-wide working group to advance our understanding of the role of marine microbes. The working group, created as a follow-on to an earlier NOAA science workshop and OER's synthesis report (<http://explore.noaa.gov/sites/OER/Documents/Marine-Microbes-Workshop-Report.pdf>), is striving to develop a NOAA-wide vision on marine microbe science priorities and strategies, and to expand collaboration with external national and international experts.



Dr. Martha Nizinski presents on multibeam mapping and visual survey efforts conducted in the northeast canyons as part of NOAA's Atlantic Canyons Undersea Mapping Expedition (ACUMEN) using the Okeanos Explorer. The work supports NOAA's Regional Habitat Blueprint Initiative. Credit: NOAA OER.

Scientific Engagement at National and International Levels

In addition to interactions with various communities, in 2013 OER initiated and led an annual Ocean Exploration Symposium focused on sharing program discoveries with NOAA and academic partners in OER program discoveries. Principal Investigators presented their scientific findings from OER-supported missions to NOAA leadership, program managers and OER's partners at other federal agencies.

At the international level, proactive engagement between OER and the Institut Français pour l'Exploitation de la Mer (Ifremer) resulted in creation of a telepresence hub in Brest, France, that enabled French scientists to participate remotely in an *Okeanos Explorer* expedition. In addition, personnel exchanges increased the mapping capabilities and compatibilities between the two organizations.

Outreach

Reaching out to stakeholders in new ways with respect to ocean issues has been a focus of the Ocean Exploration program since its inception. OER does that and more with public outreach and education that produce measurable and positive results.

In 2013, there were a record 9.8 million visits to OER's oceanexplorer.noaa.gov website. A news release, one of nine issued during the year, reported on the first leg of an expedition, and invited the public to be "virtual explorers" by watching live streaming video from the seafloor during the expedition's second leg. In the wake of that release, the Associated Press (AP) interviewed expedition scientists and filed worldwide print, radio and television stories and conducted an AP Tweet Chat with scientists. FOX Network television and The Weather Channel also conducted live interviews of mission scientists at sea.



Inge van den Beld, a Ph.D. student at the French Research Institute for Exploitation of the Sea (IFREMER), participated in the OER-led telepresence-enabled 2013 Northeast U.S. Canyons Expedition. Credit: ©Ifremer Stephane Lesbats.



During a port visit in New York City, OER and NOAA Ship Okeanos Explorer hosted media, VIPs and 22 Sea Cadets, members of the youth group of the Navy League of the United States. Following ship tours, Sea Cadets and their leader lined the ship's brow while parents assembled on the pier. Reaching out to young people helps to raise ocean literacy and to excite the next generation of ocean explorers. Credit: NOAA.

This penetrating news coverage along with extensive social media coverage including Facebook, Twitter, YouTube, Flickr and the White House blog, reached a large and diverse audience of stakeholders. This coverage, combined with a site redesign and increased content being delivered on the site, helped to raise ocean literacy and to direct a record-breaking number of visits to OER's website.

OER also went in new directions and to new age groups, including teaming with

Silvergate Media's *Octonauts* children's TV series. *Octonauts* features characters who are ocean explorers, pursuing knowledge and adventure with a mission to "explore new underwater worlds, rescue amazing sea creatures, and protect the ocean." This mission can be read as NOAA's own mission distilled for *Octonauts* three-to-five year old target demographic. Reaching three-to-five year olds who watch *Octonauts* may represent a long-term investment for NOAA—but their parents are immediate beneficiaries of NOAA's messages.



Captain Barnacles and his team of animated ocean explorers are on a mission to "Explore! Rescue! Protect!" the ocean environment. Credit: OCTONAUTS™ Meomi Design Inc. OCTONAUTS© 2014 Vampire Squid Productions Ltd.

Education

OER launched the second volume in the NOAA Ship *Okeanos Explorer* Education Materials Collection titled *How Do We Explore?*. This is a collection of lessons for educators of middle and high school students that build on the unique exploration capabilities and assets of the nation's only federal ship that systematically explores the ocean. During professional development at aquariums, science centers and museums, educators throughout the nation learn about strategies to explore the ocean. They also learn about advanced technologies that allow NOAA to collect new data and imagery, and to communicate discoveries in real time with explorers around the globe.

OER partnered with the U. S. Naval Academy (USNA) and the Office of Naval Research/ Association for Unmanned Vehicles International SeaPerch ROV Program to creatively leverage elements of existing programs in designing a NOAA/SeaPerch ROV Ocean Exploration Workshop for Educators. Educators received hands-on instruction from the USNA to build SeaPerch ROVs, and lessons from OER to convey how ROVs are used in ocean exploration. Educators not only take their new mini-ROVs, but also their new knowledge about real-world applications for these technologies, back to classrooms to stimulate students' interests in the ocean workforce and other science, technology, engineering, and mathematics (STEM)-based careers.



A teacher displays her team's model of seafloor topography, graphs and color-coded sonar swaths as she describes how the NOAA Ship Okeanos Explorer conducts multibeam mapping. Credit: Ryan Sheorn at The Georgia Aquarium.

OER also took ocean exploration literacy to the international level through participation in two U.S.-European Union (E.U.) workshops - one on transatlantic cooperation in science and technology and a second on advancing ocean literacy - OER took ocean exploration literacy to the international level. One key outcome was that ocean literacy is explicitly stated in a research alliance signed by government representatives of the E.U., Canada and the United States, in Galway, Ireland in May, 2013.



Dr. Angela Moran (center), Professor of Mechanical Engineering, USNA, assists educators as they test their mini ROVs outside the South Carolina Aquarium. Credit: Dr. Mark Murray, USNA.



A bobtail squid is imaged by the Deep Discoverer remotely operated vehicle (ROV) in Atlantis Canyon. Nicknamed "Percy," this squid became a favorite of the exploration team. The squid is less than one foot in length. Credit: NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

The Value of Partnerships

Without partnerships, OER cannot fully realize its potential to expand the exploration of our ocean world. OER has teamed with other offices in NOAA, other federal and state agencies, other nations, oceanographic institutes and universities, non-governmental organizations and industry to explore the ocean for the shared purpose of discovery and the advancement of knowledge. Partnerships leverage taxpayer dollars, providing the nation with a greater return on investment

than could otherwise be achieved. This includes increased data provided early and to wide audiences. This is often critical data that is otherwise unavailable to help ocean resource managers make informed decisions about the management, use and protection of the ocean and its resources. Partnerships also expand the roles and effectiveness of outreach and education, helping to raise ocean literacy and to inspire the next generation of ocean stakeholders and explorers.

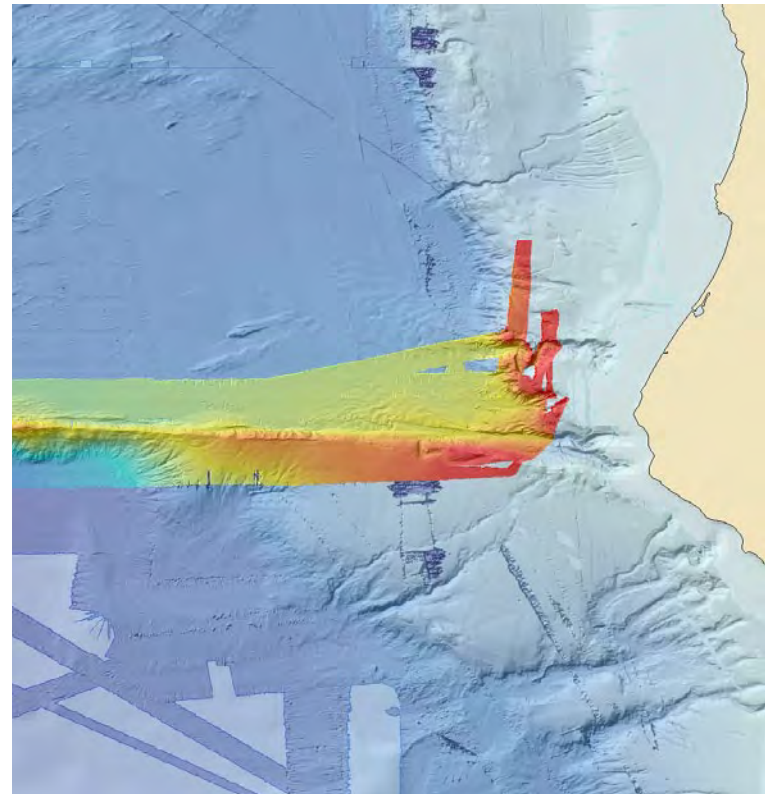
Examples of partnerships in ocean exploration



U.S. Geological Survey scientists (L to R) Jennifer McClain-Counts, Jill Bourque, and Amanda Demopoulos prepare to extract a sediment sample from one of the push cores deployed by the Jason II ROV. Credit: Deep-water Canyons 2013 - Pathways to the Abyss, NOAA-OER/BOEM/USGS.



OER often partners with Exploration Vessel Nautilus, which is equipped with some of the latest technological systems, helping to advance the frontiers of ocean exploration. It carries with it two ROVs named Hercules and Argus that explore the seafloor in real-time online via telepresence technology. Credit: 2013 Ocean Exploration Trust.



The mission of the U.S. Extended Continental Shelf (ECS) Project is to establish the full extent of the U.S. continental shelf, consistent with international law. The 2013 analyses of mapping data collected off California on Mendocino Ridge (shown in this seafloor map) will contribute to the U.S. determination of its shelf entitlements. The U.S. ECS Project is chaired by the Department of State with co-vice chairs from the Department of the Interior and NOAA and 10 additional agencies make up the task force. OER coordinates NOAA's participation and partners with the University of New Hampshire's Center for Coastal and Ocean Mapping/Joint Hydrographic Center to obtain multibeam mapping and other data to support the project. Credit: NOAA National Geophysical Data Center.

Other Key Partners included:

CSA Ocean Sciences, Inc., Cooperative Institute for Marine and Atmospheric Studies of the University of Miami, Cooperative Institute for Ocean Exploration, Research and Technology at Florida Atlantic University, Department of the Interior (Bureau of Ocean Energy Management, Bureau of Safety and Environmental Enforcement, U.S. Geological Survey), Gulf of Mexico Regional Collaboration Team, Meadows Center for Water and the Environment at Texas State University, NASA, NOAA Office of Oceanic and Atmospheric Research (Pacific Marine Environmental Laboratory NOAA Center for Tsunami Research), NOAA National Environmental Satellite, Data, and Information Service (National Geophysical Data Center, National Oceanographic Data Center, and NOAA Central Library), NOAA National Marine Fisheries Service (Office of Habitat Conservation, Deep Sea Coral Research and Technology Program, Northeast Fisheries Science Center, Southeast Regional Office), NOAA National Ocean Service (National Centers for Coastal Ocean Science, Office of National Marine Sanctuaries), NOAA Office of Marine and Aviation Operations, National Science Foundation, Ocean Exploration Trust, Office of Naval Research, Texas Historical Commission, University of Miami, University of Rhode Island, and Woods Hole Oceanographic Institution.

Data Management in the Fast Lane

Data are the tangible and enduring assets that illustrate the return on investment in ocean exploration. Drawing on expertise from across NOAA line offices and extramural partners, OER's data management practices focus on rapid and unfettered data sharing, which inspires exploration and research by others. In 2013, data throughput from dockside to quality-assured public access averaged 49 days for OER collections aboard the NOAA Ship *Okeanos Explorer*. Data are directly accessible from the OER Digital Atlas: <http://explore.noaa.gov/digitalatlas>.

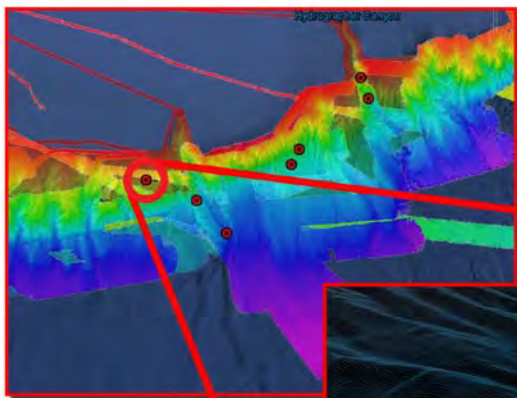
New ROV System Expands Video Data Management Capabilities

In 2013, NOAA launched its new world-class deep submergence ROV. The ROV delivers compelling video of deep-sea marine life and geological features—images that are distributed to the public and to shore-side mission participants in real time via telepresence. Fascinating to watch

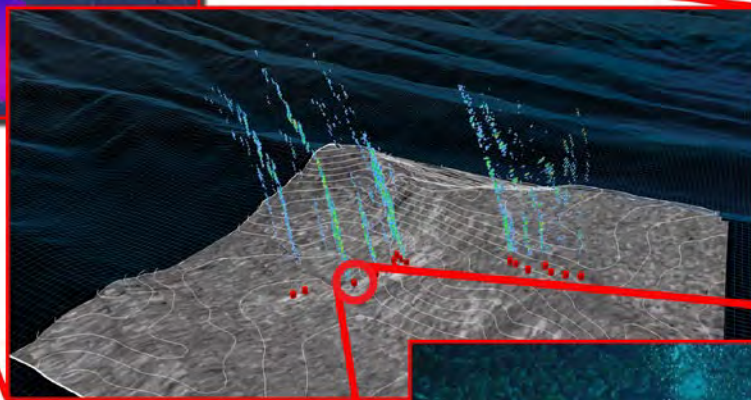
and of high scientific value, video data collection offers a non-destructive method to observe and document fragile deep-sea environments. The OER team continues in the forefront of the video data management field in developing reusable data management tools, archival standards, and methods to ensure ready access and preservation of video data collections. During 2013, OER responded to frequent data requests for high-definition video for reuse in habitat and species studies, feature length films, documentaries and educational materials.

Expanding Exploration and Catalyzing Research with Sonar Data Analysis

In 2012, approximately 50 potential distinct seafloor gas seeps were identified in *Okeanos Explorer* water column mapping data collected along the Eastern U.S. continental margin. During 2013, additional data collection and data reanalysis yielded



Top left: Map showing bathymetric data collected along the U.S. Atlantic coast.



Center: The locations of seafloor gaseous seep discoveries are indicated with a red circle. Seeps are seen in sonar water column data using Fledermaus software. Credit for Top and Center images: NOAA Okeanos Explorer Program.

Right: Methane gas bubbles rise from the seafloor – this type of activity, originally noticed by NOAA Ship Okeanos Explorer in 2012 on a multibeam sonar survey, is what led scientists to return to the area in 2013. Credit: Deepwater Canyons 2013 - Pathways to the Abyss, NOAA-OER/BOEM/USGS.





Telepresence continuously conveys information to the public, sharing the excitement of ocean exploration with a broad audience. Underlying telepresence operations is a robust data management system, which routinely moves operational data products from ship to shore to support shore side mission scientists and educators. NOAA Data Center personnel travel aboard the NOAA Ship Okeanos Explorer to ensure smooth data operations. NODC Scientist Brendan Reser was the operational data manager for the 2013 Northeast Canyons Expedition. Credit: NOAA Okeanos Explorer Program.

newly discovered gas seeps. Rapid data sharing immediately catalyzed research by scientists participating in an expedition aboard the NOAA Ship *Ronald H. Brown* in April 2013. A seep site, newly detected with *Okeanos Explorer's* multibeam sonar, was investigated by scientists aboard the *Brown*, and the *Okeanos's* detection was confirmed. Several new chemosynthetic communities, thought to depend upon methane gases to make energy, were also discovered. Samples will be used for aging analysis, genetic and reproductive studies, and for research into the food chain.

Academic Collaboration Expands Data Management Toolkit

OER serves as a conduit for technology transfer between the National Science Foundation Academic Fleet Rolling Deck to Repository Program (R2R) and the NOAA Fleet. In 2013, OER applied to *Okeanos Explorer's* navigation data R2R quality assurance and data thinning algorithms developed at the University of California, San Diego. This resulted in

an intelligently smoothed and thinned ship track that is easy to display without sacrificing detail when enlarging. If applied fleet-wide, this technique will ensure consistent data quality assurance and a unified display capability.

Measuring the Impact of Exploration and Research Results

The NOAA Central Library identifies, manages, and analyzes the publications resulting from OER-sponsored expeditions. Publications are identified through targeted online searching and author self-reporting. The Library uses the science of bibliometrics to provide a complex picture of the impact exploration has on research, and the impact OER has on the science community through investments in exploration. A total of 1,069 publications have been produced with OER support since 2001. Fifty-four of these were published during 2013.

See page 20-21 for graphics which show the expanding landscape of publications supported by OER.

Okeanos Explorer: By the Numbers



The close alignment of scientific objectives, shipboard operations and data management processes speeds data throughput time for multidisciplinary data collected aboard the NOAA Ship *Okeanos Explorer*. During 2013 throughput time was improved to an average of 49 days, and for one cruise was achieved in a record 28 days!

Data throughput refers to the end-to-end processes that occur from the point at which the ship docks post cruise, to when data is publicly accessible from the NOAA National Archives. Processes include data documentation, data quality assurance, and publishing the archive-ready data package. These methods demonstrate a proof-of-concept for oceanographic data management that result in rapid and unfettered public access to multidisciplinary scientific data.

This successful endeavor is a result of the partnership between OER, the NOAA Data Centers, the University of New Hampshire Center for Coastal and Ocean Mapping / Joint Hydrographic Center, and NOAA's Office of Marine and Aviation Operations.

2013 Field Season Statistics

61,300 Area Mapped (sq km)

16,900 Distance Mapped (km)

46 ROV Dive Sites

29 CTD Casts

355 XBT casts

5 cruises

Numbers and Graphs

Resource Management

Ocean exploration takes place on a backdrop of key financial and administrative functions. OER's efforts include working with partners to realize cost savings and efficiencies; supporting America's ship for ocean exploration; funding travel to move explorers, technicians and equipment from shore to sea and back; and, producing requisitions, contract awards, reports, grants and administrative forms.

OER's Resource Management Team provides budget planning, formulation and execution; procurement; and, administrative, financial, human resource and information technology liaison services critical to performing OER missions. A number of these support the missions of other NOAA offices and outside organizations.

FY 2013 posed a challenging budgetary environment and the team worked to achieve administrative savings by minimizing office expenditures, travel, and training expenses.

In addition, 46 major procurement actions were executed, allowing OER to conduct vital mapping and ROV cruises, technology refresh, and education and outreach activities.

Outreach Numbers:

A record **9.8 million** website visits to oceanexplorer.noaa.gov.

More than **900,000** of those website visits were to live video pages of expeditions.

Facebook – more than **5,800** likes.

Twitter – more than **34,000** followers.

YouTube – more than **5,200** subscribers.

Associated Press print, radio, TV and Twitter audiences estimated in the tens of millions.

FoxNews Network live and multiple replay of interviews on **192** stations.

The Weather Channel live and replay interviews to **140,000** households eight times.

CableOne coverage to **720,000** households in **19** states.

Coverage by NBC, ABC, USA Today, The Wall Street Journal, Christian Science Monitor and multiple other newspapers, magazines and websites worldwide.

Education Statistics:

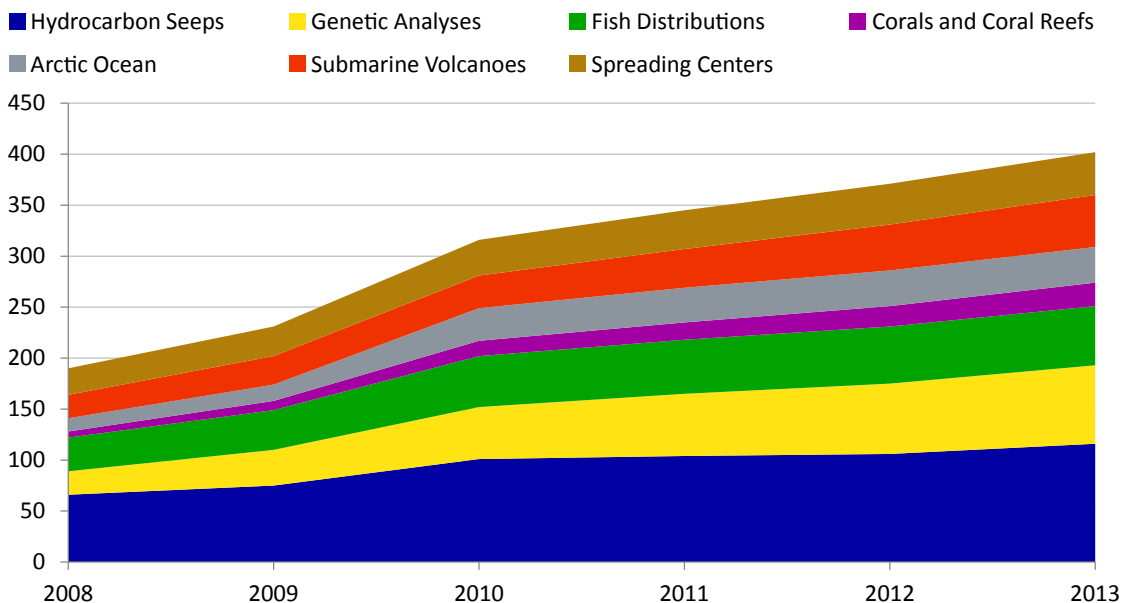
More than **990,000** downloads of curriculum and educational modules from oceanexplorer.noaa.gov.

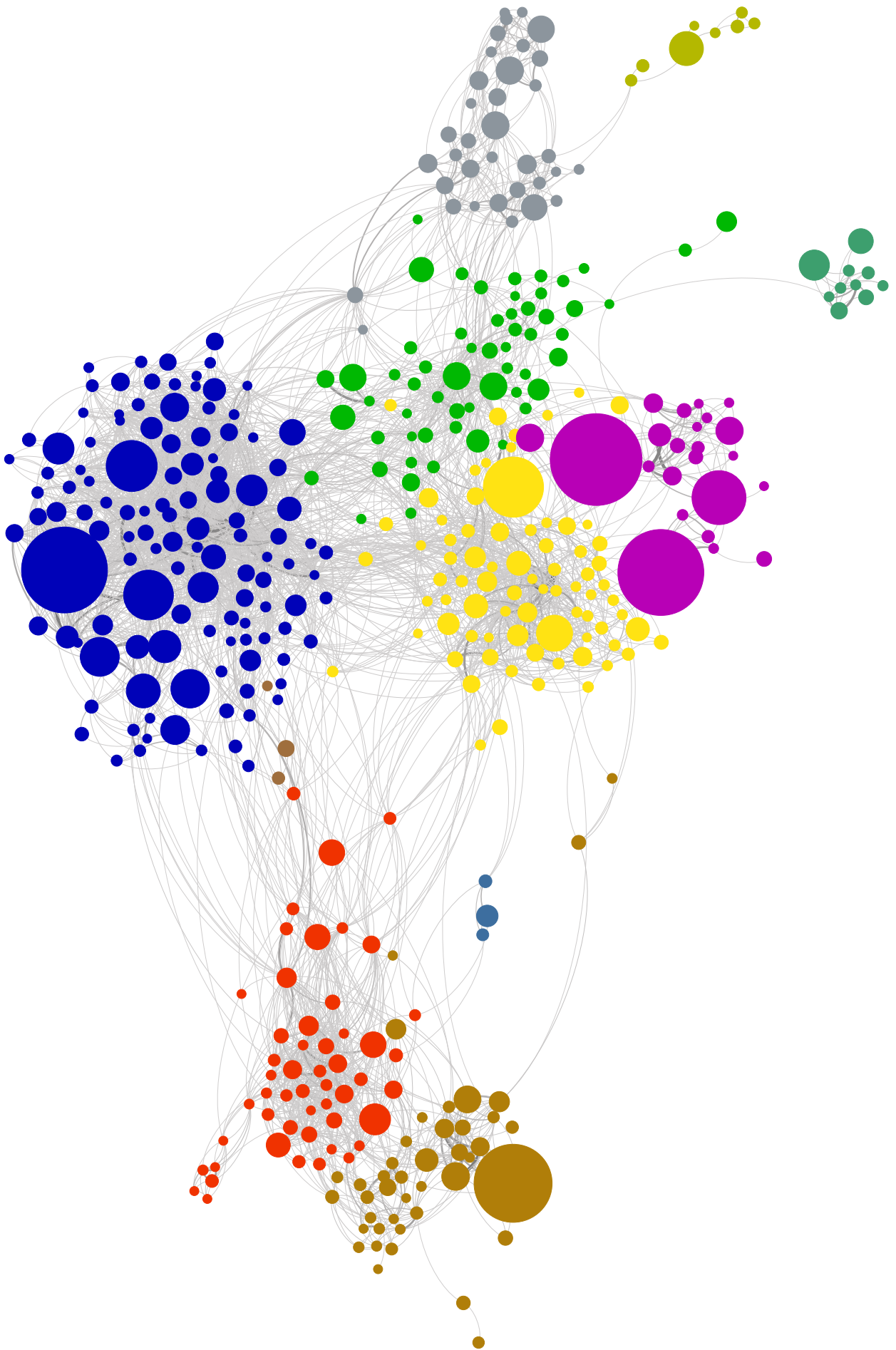
OER passed the **5,000** milestone for educators who have attended a full-day OER professional development offering at one of 15 alliance partners which are aquariums, museums and science centers throughout the country.

Measuring the Impact of Exploration and Research Results

The graphics below and on the following page show the expanding landscape of scientific publications supported by OER. The graph below shows the cumulative number of OER publications produced per year per topic. In the graphic on the following page, circles represent published articles and lines represent topical relationships between publications. The color of circles indicates the article's topic and circle size represents its value to science as measured by the number of times it has been cited by other publications. Larger and darker lines indicate stronger topical relationships between articles. The topics depicted are given in the legend below. Data for these graphics were derived from Web of Science and are accurate through 2013.

Credit: Chris Belter, LAC Group, NOAA Central Library.





2001-2013: 428 Publications



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