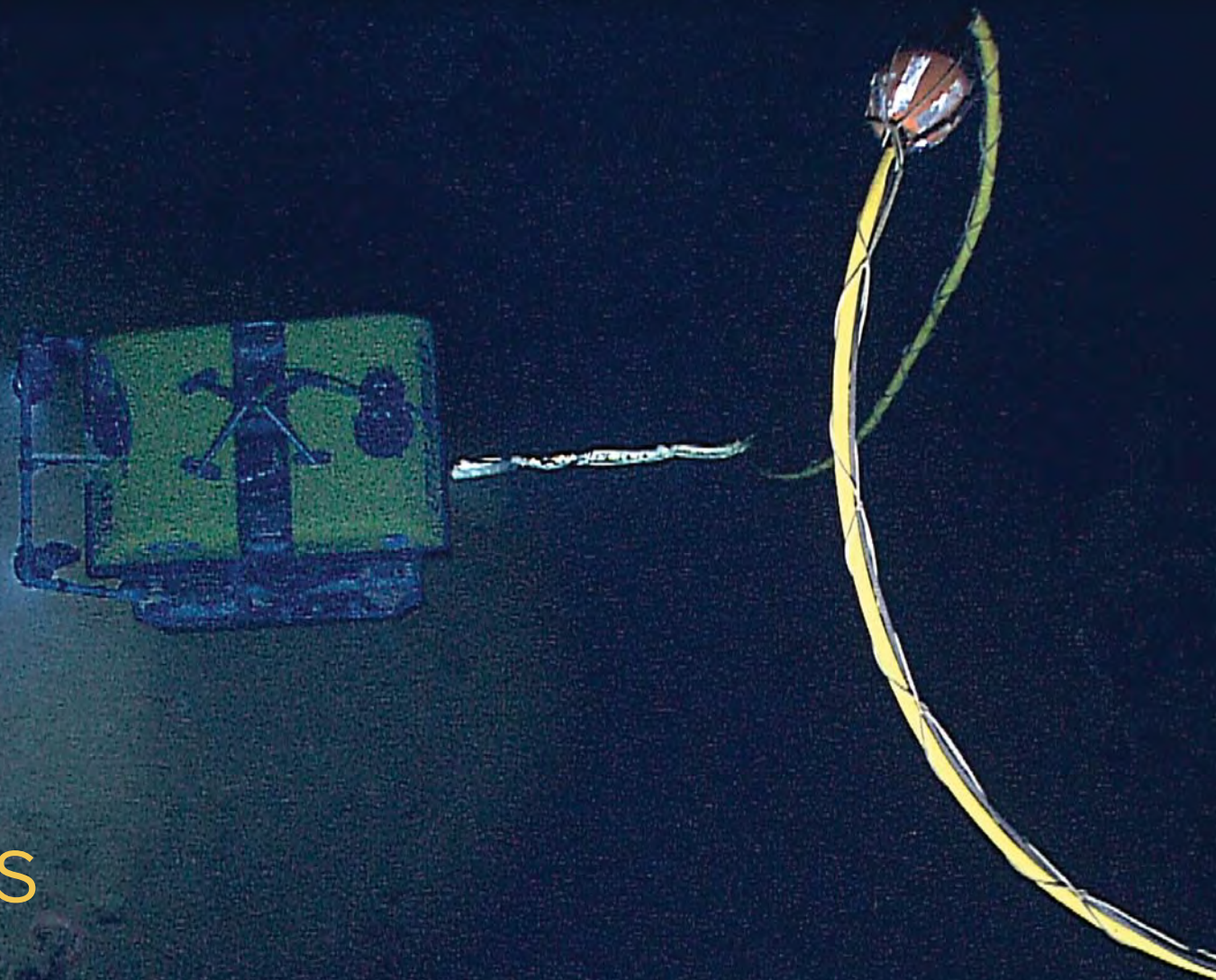


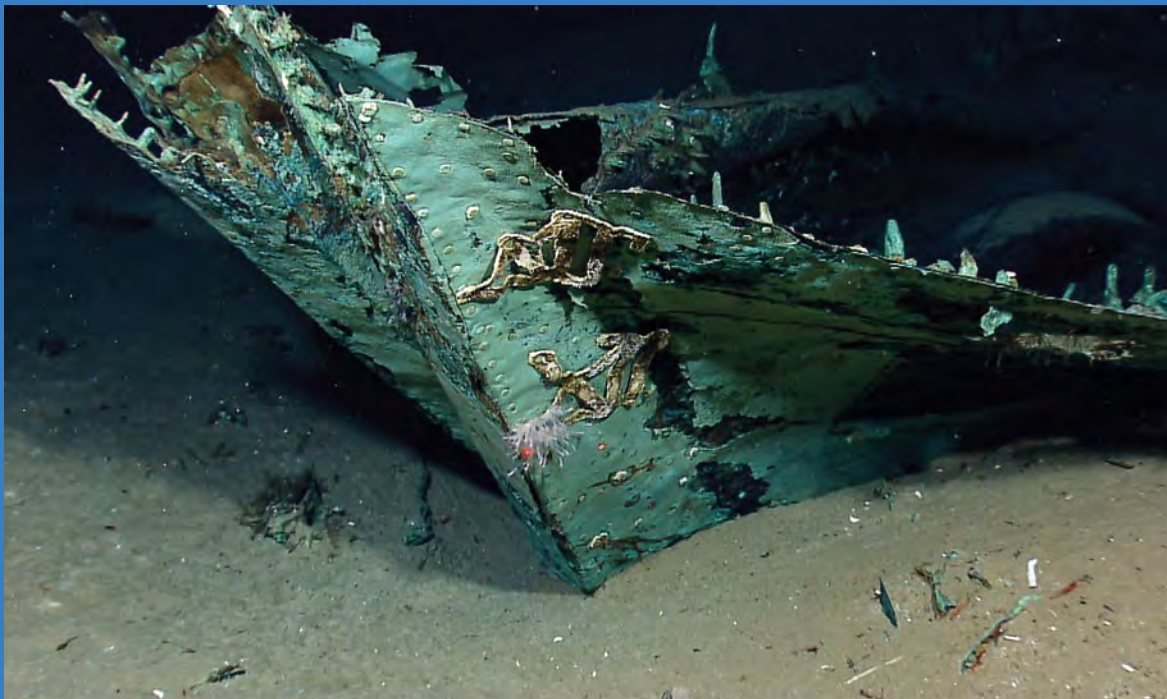
# 2012 Annual Report

NOAA Office of Ocean Exploration and Research



Partnerships  
Run Deep





ABOVE: While most of the wood has long since disintegrated from what is believed to be an early to mid-19th century wooden-hulled shipwreck on the deep Gulf of Mexico seafloor, copper sheets that covered the hull beneath the waterline as a protection against marine-boring organisms remain, leaving a copper shell retaining the form of the ship. NOAA OKEANOS EXPLORER PROGRAM

### ABOUT THE COVER IMAGE

NOAA's Seirios Camera Platform, operating above the Institute for Exploration's (IFE) Little Hercules ROV, images the anchor and remnants of a copper-sheathed shipwreck in the Gulf of Mexico. OER and BOEM worked with 10 federal, academic and private sector archaeologists in five states to explore the shipwreck in real time using telepresence technology. NOAA OKEANOS EXPLORER PROGRAM



**SCAN** this QR code with your mobile phone QR reader to learn more about OER.

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<http://oceanexplorer.noaa.gov>



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# Introduction to OER

**N**OAA's Office of Exploration and Research (OER) supports national and NOAA requirements by exploring the Earth's largely unknown ocean in all its dimensions for the purpose of discovery and the advancement of knowledge, using state-of-the-art technologies in evolutionary and revolutionary ways.

We do this by systematically exploring and mapping, obtaining baseline characterizations and assessments of the water-column, seafloor and habitats, and identifying new areas of energy, mineral and biological natural resources. OER also emphasizes advancing deep ocean technologies, including testing and stressing emerging ocean exploration technologies so they may be assessed for additional development or transition to the science community.

## Program Foundations

OER carries out work called for by the 2000 President's Panel Report on Ocean Exploration which laid out a U.S. Strategy for Ocean Exploration. Recognizing the ocean covers more than 70 percent of the planet and the intricate role it plays in global ecology and economics, the panel recommended a national ocean exploration program focused on:

- mapping and characterizing the 95 percent of the ocean that is currently unexplored
- investigating poorly known ocean processes at multiple scales
- developing new sensors and systems
- engaging and informing stakeholders in new and innovative ways

While the President's Panel in 2000 set the course for OER, Public Law 111-111 firmed it up in 2009. The law established the national ocean exploration program and the national undersea research program within the National Oceanic and Atmospheric Administration (NOAA), and called for:

- a coordinated national program that promotes collaboration with others
- coordination of data and information management systems and outreach and education programs to improve public understanding
- development and transfer of technologies
- interdisciplinary voyages or other scientific activities in conjunction with other federal agencies or academic or educational institutions, to



explore and survey little-known areas of the marine environment

- inventory, observation and assessment of living and nonliving marine resources
- priority attention to deep ocean regions
- scientific voyages to locate, define, and document historic shipwrecks, submerged sites, and other ocean exploration activities that combine archaeology and oceanographic sciences
- developing a transparent, competitive process in consultation with the National Science Foundation

for merit-based peer-review and approval of proposals taking into consideration advice of an established board

- enhancing the technical capability of the United States marine science community by promoting development of improved oceanographic research, communication, navigation and data collection systems, as well as underwater platforms, sensors and autonomous vehicles
- establishing an ocean exploration forum to encourage partnerships and promote communication among experts and others

# The Importance of Ocean Exploration and Research

We are proud to present the 2012 Annual Report of NOAA's Office of Ocean Exploration and Research. Accomplishments here are examples of returns on investment that benefit NOAA and the nation.

OER, a part of NOAA Research, is the only federal program that systematically explores Earth's largely unknown ocean, and it does so with a budget averaging \$20 million annually.

The program nurtures partnerships with other NOAA programs, federal agencies, academic institutions, non-governmental organizations, industries and others. Partnerships leverage funding, equipment, expertise and obtained data.

In many important respects, 2012 was a year that launched expectations and plans for the future. We began creation of an Ocean Exploration Advisory Board to help steer NOAA's course of ocean exploration. A 10-year Program Review of ocean exploration provided recommendations to help set our exploration course. Also, we will deploy and test emerging technologies through our newly organized In-



teragency Task Force on Ocean Exploration and Research Technology and Infrastructure (TFORT).

Telepresence-enabled expeditions will have exponentially larger audiences ashore participating in expeditions at sea in real time. And OER's development and deployment of a Mobile Telepresence Unit means that more ocean expeditions will bring science and the excitement and educational aspects of ocean discoveries live to

scientists ashore and into newsrooms, classrooms and living rooms.

Marine microbes carpet the ocean and play many varied roles. Yet, we have a rudimentary understanding of how our planetary biogeochemical balance (or imbalance) is being achieved, how emerging diseases are responding to global change and how microbial processes should be integrated into our ecological forecasts. An OER-coordinated workshop engaged experts

to identify tools, insights and roles specific to microbe science that NOAA should embrace and OER is now playing a role in the establishment of a NOAA-wide working group that will endeavor to integrate, leverage, and prioritize future marine microbe science pursuits.

Leading ocean explorers will review OER's 2012 program at a symposium in February of 2013 and in July of 2013, OER will conduct an Ocean Exploration National Forum. Both events are designed to shape exploration partnerships.

The view ahead also includes developing new science, communications, data collection and distribution technologies, as well as expanding partnerships to increase the pace, scope and effectiveness of ocean exploration in challenging funding environments.

All this and more awaits your discovery in the pages ahead. Explore with us!

**Joseph T. (Tim) Arcano, Jr., Ph.D.**  
Director, Office of Ocean Exploration and Research





*Kraken2 ROV on board the NOAA Ship Nancy Foster during the Deepwater Canyons  
2012 Expedition © 2012 ART HOWARD PHOTOGRAPHY*





## CORNERSTONE 1

# Targeted Exploration

OER has conducted a peer-reviewed process, similar to that of the National Science Foundation, to award grants to ocean exploration projects that ‘target’ specific geographic areas, phenomena, or issues. Awards support a diversity of investigations including expeditions to explore and characterize undersea features such as seamounts and canyons, and to investigate historically important shipwrecks or paleo-landscapes that may have once been occupied by humans. The results increase our knowledge and understanding of the ocean, and support NOAA and national priorities for making informed decisions about conserving undersea habitats and resources.

In 2012, OER leveraged partnerships in supporting several key targeted exploration missions:

### The Chilean Margin

In April 2012, an international team of scientists explored the Chile Triple Junction where the South Chile rise (a ridge crest) is forced under the methane-rich South American continent. The region is tectonically active and supports unique

*After careful handling and operations—especially on an increasingly lively ship as the weather picks up—Sentry is safely lowered back into its cradle. Almost immediately, downloading of the data from the just-completed mission and servicing of the vehicle to prepare it for the next dive will begin.*

CHRIS GERMAN, INSPIRE: CHILE MARGIN 2012 EXPEDITION, NOAA-OER.

geologic features and biologically diverse habitats associated with hydrothermal vents and methane seeps.

The team used the Woods Hole Oceanographic Institution’s autonomous underwater vehicle (AUV) *Sentry* outfitted with cameras and chemical sensors to locate and characterize heretofore unknown and little known ecosystems, a towed camera system to cover broader areas, and traditional devices such as trawl nets and a multi-core to sample sediments. The expedition was extremely successful and scientists continue to analyze the data including more than 14,000 high-resolution photographs, hundreds of samples, and the data collected by the sensors in preparing reports that will increase our understanding of this very unique area.

### The Lau Basin

The 2012 cruise to the Lau Basin was the latest in a series to explore submarine volcanoes of the western Pacific along the “Submarine Ring of Fire.” An interdisciplinary team of 35 scientists and technicians from the United States, New Zealand, Australia, and the MARUM Center for Marine Environmental Sciences from the University of Bremen (Federal Republic of Germany), used the MARUM remotely operated vehicle (ROV) *Quest 4000* from the Research Vessel (R/V) *Roger Revelle* operated by the Scripps Institution of Oceanography to explore

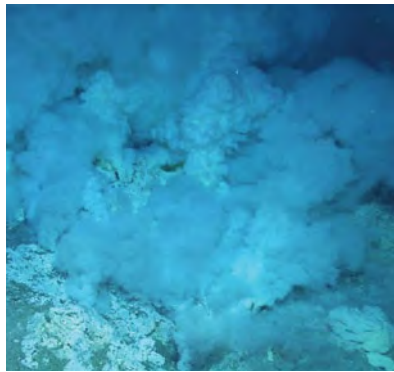
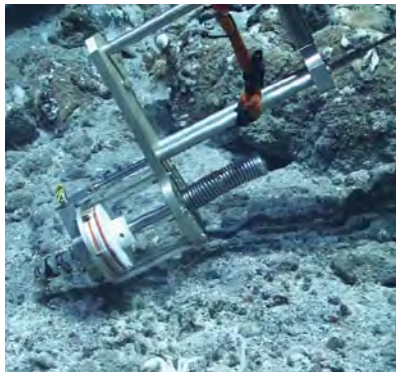
## CORNERSTONES

OER pursues its mission by investing in the following cornerstone activities:

(1) targeted exploration, which funds extramural scientists through peer-reviewed grants; (2) baseline characterization of unknown areas through highly leveraged interagency partnership expeditions; (3) support for the nation’s Extended Continental Shelf (ECS) Project; and (4) systematic exploration of remote ocean areas using telepresence-enabled ships and an extensive shore-based network.

and collect samples at volcanic vents and hot springs. The primary objective was to explore and characterize unique ecosystems in the northeast Lau Basin by investigating the area’s geology, chemistry and biology.

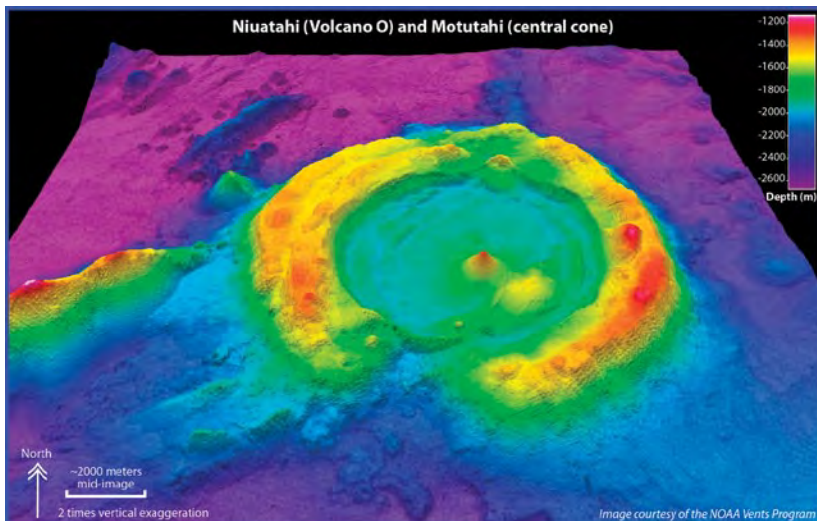
Key findings included determining how the eruptive history in the region is influencing changes in localized habitats and species, the discovery of unique hydrothermal vents exuding highly acidic fluids into the ocean and characterizing unanticipated highly complex and biodiverse chemosynthetic ecosystems.



**LEFT:** QUEST 4000 taking “syringe” sample of microbial-rich sediment near hydrothermal vent at 2,390 m for natural products research program at Oregon State University, College of Pharmacy. The sample will be screened for compounds that could lead to new drug development.

MARUM & NOAA PMEL

**RIGHT:** Highly acidic jets of fluid rich in sulfur and carbon dioxide shooting from holes in the sediment-covered seafloor at 750 m depth MARUM & NOAA PMEL



Niuatahi, a huge submarine volcano with a ~10 km caldera in the NE Lau basin. Image looks toward the north, 2 times vertically exaggerated. QUEST 4000 dive 324 discovered a large pit venting clouds of sulfur-rich fluids from the summit of Motutahi, the small cone near the center of the caldera.



In 2012, scientists returned to the Lau Basin where, in 2009, they had captured on video evidence of the world’s deepest active submarine volcanic eruption. Scan this QR code to watch dramatic video from the 2009 and 2012 expeditions.

## EXPLORING THE SUBMERGED NEW WORLD

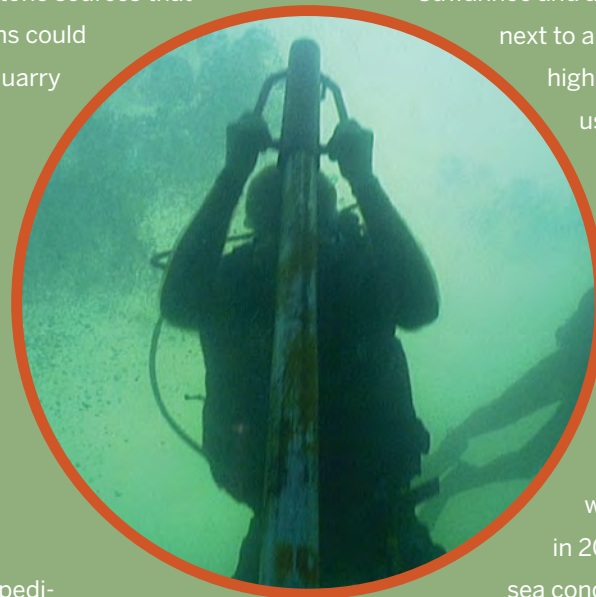
The study of early humans occupying the now submerged continental shelf of North America is an expanding field in prehistoric archaeology. This innovative multi-year investigation is combining geophysical tools and traditional marine archaeological techniques to search for evidence of ancient humans on a landscape submerged over 10,000 years ago.

On previously OER-funded expeditions, the team confirmed the submerged location of the Paleo-Suwannee River channel and the presence of river terraces and stone sources that ancient humans could have used to quarry rock to make tools. These features are similar to the oldest Native American sites located on the adjacent Florida mainland.

The 2012 expedition further explored and sampled two sites off Florida’s Gulf Coast. The study shifted from remote sensing to excavating through marine

sediment to find preserved soils near the stone outcrops that may contain human-made artifacts. The location called the Brownstone site is in 40 feet of water 95 miles northwest of Tampa. The site called Thor’s Elbow, is in 130 feet of water 125 miles west/northwest of Tampa. Brownstone has bedrock exposed on the seafloor forming one side of the buried, but intact, river channel. The bedrock includes chert or dolostone that could have been used for prehistoric tool making. The deeper site is the intersection of the ancient

Suwannee and another river next to an outcrop of high quality rock useable for stone tool making. Sediments document the marine environment and rising sea levels. Excavation was hampered in 2012 by rough sea conditions but will resume in the future.



Hammering the datum post in place at the Brownstone site. EXPLORING THE SUBMERGED NEW WORLD 2012 EXPEDITION. NOAA-OER



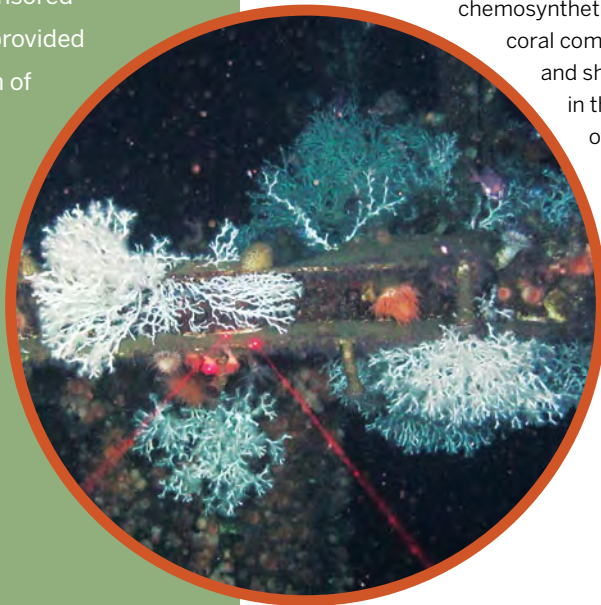
## PULLEY RIDGE

In August 2012, Pulley Ridge was the first mission in a five-year project to study how mid-depth, middle-light (mesophotic) coral reefs may replenish key fish species and other organisms in downstream reefs of the nearby Florida Keys National Marine Sanctuary and Tortugas Ecological Reserve.

With the decline of Florida's reefs, places like Pulley Ridge may be larvae sources to sustain the Florida Keys' reef ecosystem and tourism that depends on it.

Pulley Ridge is a marine protected area in the Gulf off southwestern Florida and is the deepest known coral reef ecosystem off the southeast United States.

This was a NOAA Cooperative Institute for Ocean Exploration, Research and Technology expedition, with ship and ROV time co-funded by OER. A NOAA Center for Sponsored Coastal Ocean Research grant provided primary funding. A collaboration of more than 30 scientists at 10 universities, the mission combined technical scuba diving with operations using the University of North Carolina Wilmington's Super Phantom S2 ROV on the R/V *F.G. Walton Smith*.



## CORNERSTONE 2

# Baseline Characterizations through Interagency Partnerships

The President's Panel Report recommended mapping and characterizing new ocean areas. As OER explores, baseline data are collected to characterize the seafloor and water column and the features, systems and communities of life observed. Baseline characterization provides the first level of understanding about an ocean area, resulting in hypotheses for others to test. OER and partners conducted three major baseline characterizations in 2012.

### Lophelia II

With the Bureau of Ocean Energy Management (BOEM) and others, OER completed the final expedition in a series to investigate deepwater chemosynthetic and coral communities and shipwrecks in the Gulf of Mexico.

Lophelia II, the 2012 mission, explored biological communities associated with currently operating oil and gas platforms.

Scientists discovered Lophelia coral growing at 2,620 feet, deeper than previously seen in the Gulf, and obtained data about Lophelia's growth rate and conditions that will inform decision-making for the protection of deep-water coral habitats. Undersea structures supporting energy production platforms provide some of the scarce hard surfaces in the Gulf where *Lophelia pertusa* can grow.

Partners operated under the National Oceanographic Partnership Program (NOPP) for use of pooled federal resources such as funding, ships, equipment, and personnel to best meet agency and national priorities. Partnerships in this series produced multi-agency benefits and a return on investment that could not have been achieved had agencies operated separately. Indeed, NOPP announced in 2012 that a team in this expedition series won NOPP's "Excellence in Partnering Award."

### Mid-Atlantic Deepwater Canyons Project

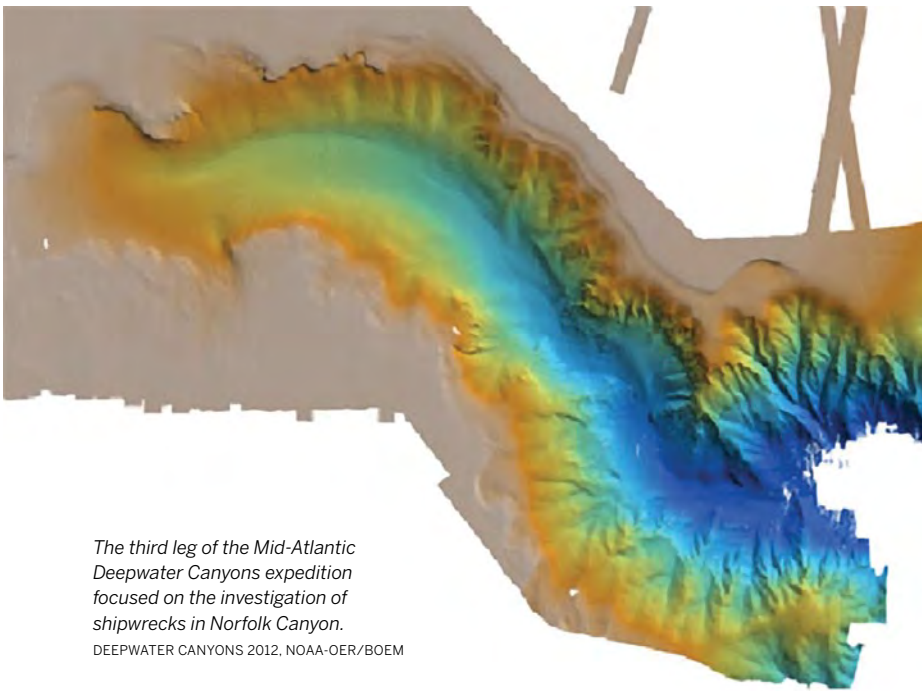
OER supported the 2012 Mid-Atlantic Deepwater Canyons Project, a partnership to explore and characterize communities of life, particularly deep-water corals, and to investigate shipwreck sites and associated habitats in canyons off Virginia and Maryland. Co-funded by BOEM and OER, with partners from several academic institutions, the expedition continued a three-year effort to investigate canyons intersecting the continental shelf along the Mid-Atlantic Bight.

Sensors and systems placed in canyons will remain for a year collecting data on temperature, salinity, oxygen, chlorophyll, currents, monthly sediment deposition, and recruitment and colonization rates of benthic fauna. Experiments measured growth and survival of deep-water corals.

The 2012 expedition operated from NOAA Ship *Nancy Foster* and included exploration of the "Billy Mitchell Fleet," sunk in the Norfolk Canyon. Following World War I, General Mitchell demonstrated that biplanes could sink

*Colonies of Lophelia pertusa coral growing on a test piling at a subsea well installation in the Gulf of Mexico's Mississippi Canyon. Flytrap anemones and Eumunida picta squat lobsters are also present. The two laser beams create dots that are 10 centimeters apart, helping scientists measure undersea features and organisms.* LOPHELIA II 2012, NOAA-OER/BOEM





*The third leg of the Mid-Atlantic Deepwater Canyons expedition focused on the investigation of shipwrecks in Norfolk Canyon.*

DEEPWATER CANYONS 2012, NOAA-OER/BOEM

heavily armored ships, ushering in a new era of military aviation leading to creation of the U.S. Air Force.

### **Russian-American Long-term Census of the Arctic (RUSALCA)**

OER supported Russian and U.S. scientists on an expedition to better understand environmental change in the fragile Arctic. Scientists collected biological, chemical, and physical samples and data, and deployed instruments to record data over time in both U.S. and Russian waters.

The Bering and Chukchi Seas and associated marine life are thought to be particularly sensitive to global climate change because steep temperature, salinity and nutrient gradients in the ocean meet equally steep temperature

gradients in the atmosphere. The Bering Strait acts as the only Pacific “gateway” into and out of the Arctic Ocean and is critical for the flow of heat between the Arctic and the rest of the world. Baseline information about the flow of fresh and salt water is critical to better understanding reduced ice cover in the northern Bering and Chukchi Seas.

RUSALCA is managed by NOAA’s Arctic Research Program with support from OER and Group Alliance in Russia.

*Katrin Iken and Lauren Bell preparing to sort trawl samples* KATE STAFFORD, 2012 RUSALCA EXPEDITION, THE RUSSIAN ACADEMY OF SCIENCES-NOAA







## CORNERSTONE 3

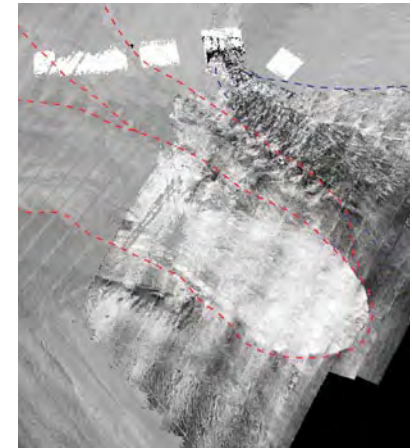
# Extended Continental Shelf Mapping

The mission of the U.S. Extended Continental Shelf (ECS) Project is to establish the fullest extent of the U.S. continental shelf, consistent with the United Nations Convention on the Law of the Sea (UNCLOS) Article 76.

Since 2003, NOAA and other U.S. agencies have been gathering and analyzing survey data (i.e., bathymetry, seismic profiles, magnetic, gravity), legal data and seafloor samples to determine the outer limits of the U.S. ECS. Since 2008, when the ECS Project was added to the President's budget, NOAA's Office of Ocean Exploration and Research has assumed the agency's annual funding responsibilities related to this project.

Although the United States is not a signatory to UNCLOS, this and the previous Administration, as well as Congress, have recognized the value of mapping these areas to enhance our overall understanding of the seafloor, ocean processes and living/non-living marine resources that exist there.

The continental shelf is an important maritime zone, one that holds many resources and vital habitats for marine life. Shelf extension determinations will ultimately provide a rich baseline for setting future exploration, research and resource management priorities, and



*This multibeam sonar backscatter image from a 2012 Atlantic ECS cruise shows submarine landslides on the outer edge of the continental margin, offshore Cape Fear, NC. Backscatter sonar imagery sheds light on ocean floor characteristics (e.g., hard bottoms, gas emissions, slides, downslope erosion and debris flows). It can be key to locating the "base of the slope" zone of the continental margin, an often important factor in determining the outer edge of a nation's ECS.*

UNH-CCOM-JHC

for understanding the diversity of this maritime zone. Defining our rights in concrete geographical terms provides the specificity and certainty required to begin protecting, managing, and/or using those areas and resources.

Scientists on board the U.S. Coast Guard Cutter Healy assess rocks from the ocean floor. NOAA



## ECS in 2012

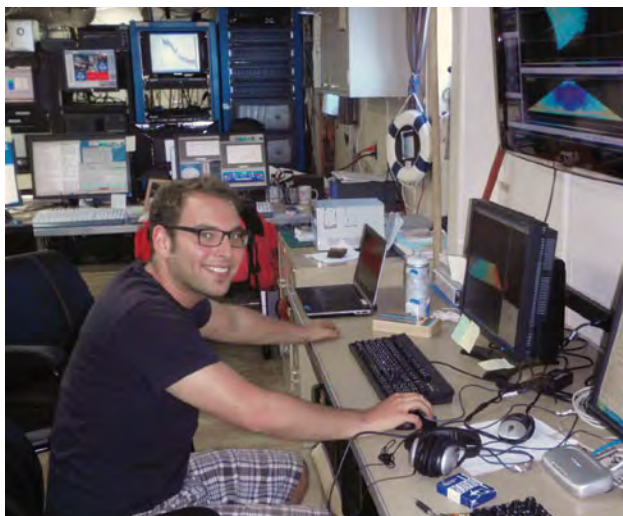
The ECS Project conducted two bathymetric cruises in 2012. From July 2 to July 17, scientists on the NOAA Ship *Ronald H. Brown* collected nearly 65,000 square kilometers of bathymetric data in the southeast Atlantic to characterize the "foot of the slope" and downslope movement, both key parameters in delimiting our ECS. From August 25 to September 28, scientists aboard the U.S. Coast Guard Cutter (USCGC) *Healy* in the Arctic Ocean collected 69,000 square kilometers of bathymetric data (equivalent to an area the size of the states of Maryland, Massachusetts, Delaware, and Rhode Island combined). The focus of the cruise, which was primarily supported by the NOAA Office of Coast Survey, was to determine the exact location of the foot of the slope in the region of transition

between Nautilus Basin and the Alpha/Mendelev Ridge.

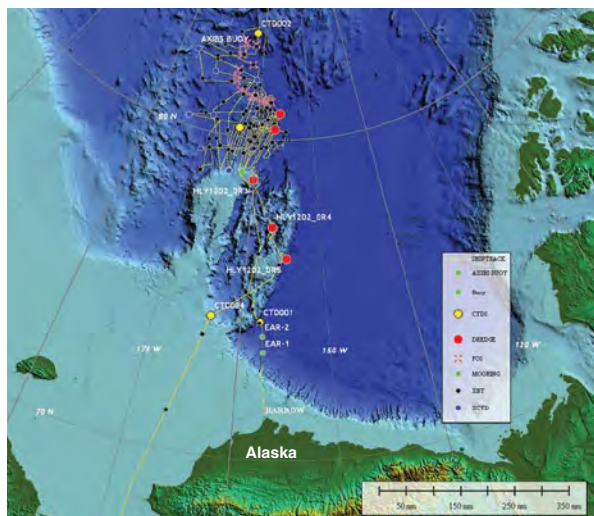
These and past ECS surveys enabled new partnerships and fascinating scientific discoveries, such as previously unknown occurrences of critical minerals and never before seen seamounts and submarine canyons. Ancillary scientific activities aboard the Arctic survey, such as weather and ice observations, deployment of ice buoys and ice studies, and geochemical measurements to evaluate ocean acidification, are yielding baseline data to help us understand climate change in the Arctic.



*The U.S. Coast Guard Cutter Healy has been instrumental to the U.S. Extended Continental Shelf Project's Arctic field data collection efforts. U.S. COAST GUARD*



*Brian Meyer, NOAA National Geophysical Data Center, in the data processing lab aboard NOAA Ship Ronald H. Brown. NOAA*



*Tracklines for 2012 Arctic ECS cruise aboard USCGC Healy focused on the region north of Barrow, AK, between the Nautilus Basin and the Alpha/Mendelev Ridge UNH/NOAA*

## ECS: VALUE TO THE NATION

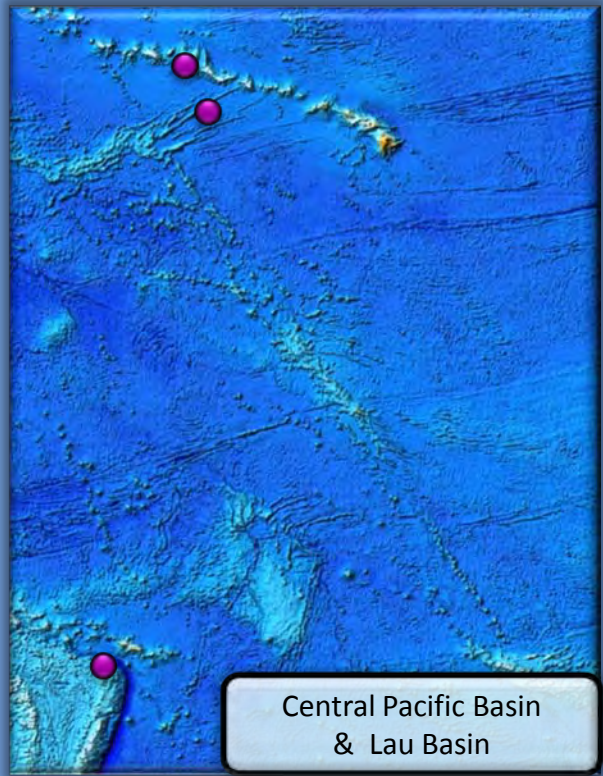
Since 2007, 13 U.S. partner agencies have engaged as a Task Force in gathering and analyzing survey data to determine our nation's ECS. See [www.continentalshef.gov](http://www.continentalshef.gov). This project represents the largest and potentially most significant marine survey ever undertaken by the U.S. The effort is likely to yield more than two million square kilometers of bathymetrically mapped ocean shelf, equivalent to an area twice the size of California, with seabed energy, mineral and living marine resources worth many billions, if not trillions, of dollars. It has the potential to rival the addition of the U.S. Exclusive Economic Zone (EEZ) in terms of its importance to governance and sovereign land rights.

The ECS Project is also a valuable venture for the field of science. ECS findings have provided and will continue to provide a framework for targeting future deep-sea exploration and research and will be a foundation on which ecosystems will be discovered, defined and understood. Already, ECS data from the Bering Sea are being used to understand gas hydrates. Bathymetric data from the Atlantic margin are yielding new insights into submarine landslides and tsunami risks for the U.S. East Coast. Gulf of Alaska data are being used to determine site surveys for future energy exploration. Marianas ECS data are being repurposed for Marianas Trench Marine National Monument management. Data tools developed for the ECS Project are now used across federal agencies to better manage scientific data.





Atlantic Ocean,  
Gulf of Mexico & Caribbean Sea

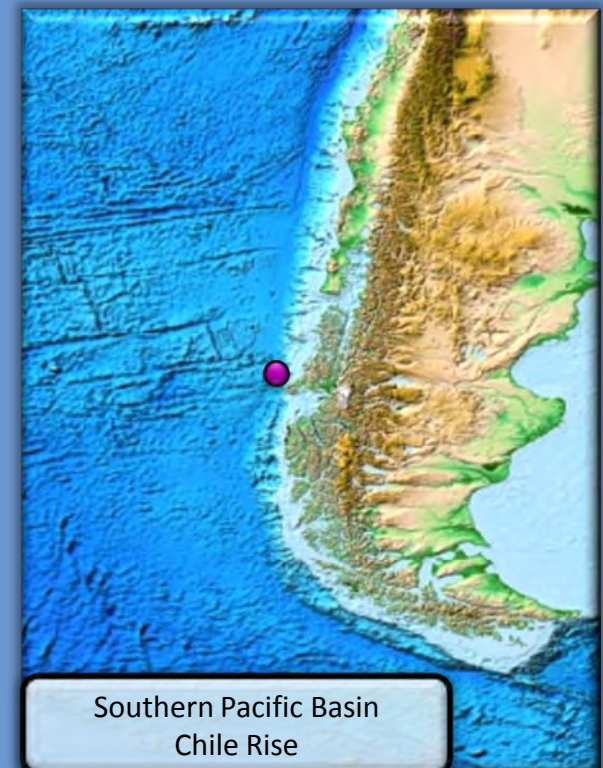


**LEGEND: MISSIONS by CORNERSTONE**

- Targeted Exploration | Page 4
- Baseline Characterization through Interagency Partnerships | Page 6
- Extended Continental Shelf Project | Page 8
- Systematic Telepresence-Enabled Exploration | Page 12



# 2012 OER MISSION OVERVIEW





## PARTNERSHIP EXAMPLES

OER's partnerships leverage complementary capabilities and produce innovations in exploration tools and capabilities. Since 2004, OER and the Institute for Exploration (IFE) collaborated to develop the telepresence-enabled exploration paradigm through technology development and test cruises. Working with the University of Rhode Island Inner Space Center, telepresence-enabled ship-based expeditions are shared globally via a high-bandwidth satellite connection to Internet2 and public web sites, broadcast quality voice communications between ship and shore and coordination of a distributed network of exploration command centers strategically located ashore.

Recent advances in water column exploration resulted from collaborations with the University of New Hampshire's Center for Coastal and Ocean Mapping (CCOM). Additional CCOM collaborations include developing new undersea tools, including ROVs and AUVs.

Training the Next Generation of Explorers is the hallmark of OER's collaborations with the University Corporation for Atmospheric Research (UCAR) Joint Office for Scientific Support. OER and UCAR conduct a thriving mentorship and training 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 OER *Okeanos Explorer* team.

## CORNERSTONE 4

# Systematic Telepresence-Enabled Exploration

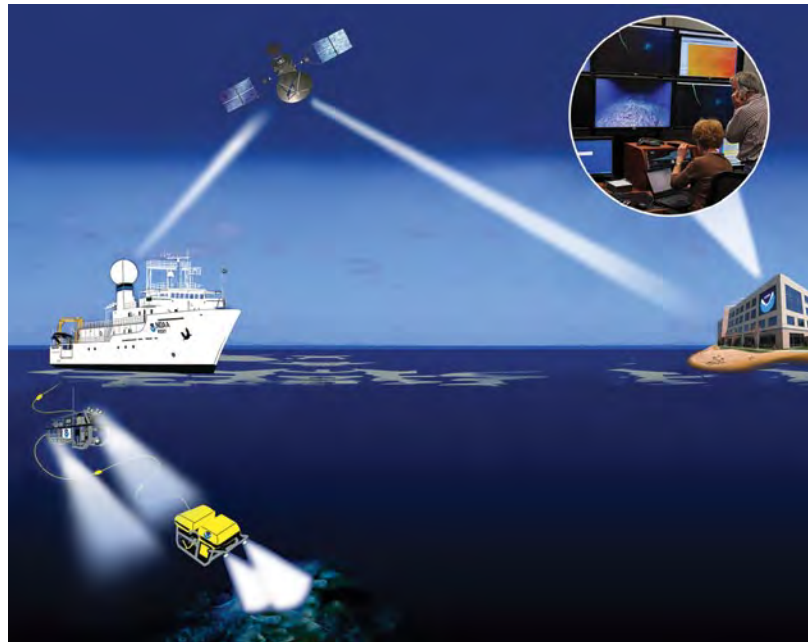
### Telepresence

Telepresence provides an individual or group with information needed to participate in real time in a remote event. This is typically through use of satellites and high bandwidth Internet2 pathways. Applied to oceanographic expeditions, telepresence technology transmits data and video in real time from cameras on the ship or from vehicles at depth, and/or

from data acquisition computers, to a variety of receiving locations on shore. Telepresence enables an unlimited number of participants communicating between ship and shore, increasing the access and efficiency of each operation. Shore-based teams of scientists remain in constant communication with the vessel facilitating ship-to-shore collaboration, enabling participants across the globe to help plan daily expedition op-

erations and to participate in discoveries as they occur.

**Systematic Telepresence-Enabled Exploration increases the pace and efficiency of discovery in high priority areas by: (1) collecting and openly sharing baseline data, (2) conducting interdisciplinary and science community-driven expeditions, (3) catalyzing follow-on research and management activities, (4) advancing technology and being a test bed for new tools and methods, (5) fostering innovative partnerships with other institutions and countries, (6) training the next generation of explorers, and (7) engaging learners of all ages to increase ocean literacy.**



*While a telepresence-enabled exploration ship is at sea, live video and data—including from computer data screens or ROVs working underwater—are transmitted via satellites to a shore-based hub at the University of Rhode Island's Inner Space Center. The live feeds are then made available in high definition on the high-bandwidth Internet2 network, and in lower resolution on standard internet. B. AMBROSE, GDIT/NODC, R. CANFIELD, NOAA & NOAA OER*

### **Okeanos Explorer Program**

Twelve years after the 2000 Presidential Panel Report called for a flagship for ocean exploration, OER conducts worldwide systematic telepresence-enabled exploration with America's ship for ocean exploration—NOAA Ship *Okeanos Explorer*. Using telepresence technology, we share data, video and information with audiences on shore, providing unparalleled virtual access to the deep ocean's mysteries in real-time. Combined with other internet-based collaboration and communication tools,



the technology allows scientists, teachers, students and public audiences to be part of at-sea exploration as it occurs.

OER works with the ocean research and management communities to identify priority exploration areas that support a broad range of objectives. Unlike traditional research cruises, *Okeanos Explorer* cruises have a “Science Team Lead” instead of a Chief Scientist or Principal Investigator. The Science Team Lead is typically onboard the ship during an expedition, and collaborates with teams of scientists ashore for cruise planning and operations on behalf of the broader science community. A dedicated team of scientists, technicians and engineers on board and ashore compile a standardized suite of data and products for all expeditions—including maps, images, high definition video, reports, graphics, and binary data sets for diverse ocean research, management and education uses.

Expert data managers manage a cutting-edge data pipeline to ensure data and products are publicly available on websites in two months or less following a cruise. These baseline data and characterizations support NOAA’s Healthy Oceans, Resilient Communities, and Climate strategic goals, by providing critical data for activities such as: natural resource baseline assessments; marine and geophysical hazards forecasting; fisheries, protected area, natural, and cultural resource management; long-term climate models and studies; charting; and many others.

**The average turn-around time to make quality assured data from the NOAA Ship *Okeanos Explorer* publicly accessible post-cruise is less than 60 days.**

This model enables partnerships between geographically dispersed groups, and provides for unlimited access to personnel on shore, transcending schedules, expertise, skills, and abilities of traditional shipboard teams. It also catalyzes research and management activities by providing baseline data and

makes subsequent expeditions more effective and efficient, increasing the pace and scope of exploring our largely unknown ocean.

### 2012 Field Season Overview

During the 2012 field season NOAA Ship *Okeanos Explorer* conducted exploration missions along the northeastern U.S. continental shelf, mapping canyons from Virginia to Massachusetts, and exploring the Blake Ridge, Florida Escarpment and northern Gulf of Mexico. Two ROV cruises were conducted in the Gulf of Mexico, and *Okeanos*’ first AUV cruise was conducted at the Blake Plateau.

From March through April 2012, a team of scientists and technicians both at sea and on shore explored the great diversity and distribution of deep-sea habitats and marine life in the northern

*Two dedicated ships of exploration—NOAA Ship *Okeanos Explorer* (above) and E/V *Nautilus* (right)—are operating worldwide as they systematically explore the world ocean in a new and evolving way. Using telepresence technology, both ships share data and information with scientists, students and the public on shore, providing access to the deep sea in real-time.*

TOP: NOAA OKEANOS EXPLORER PROGRAM  
BOTTOM: OCEAN EXPLORER TRUST

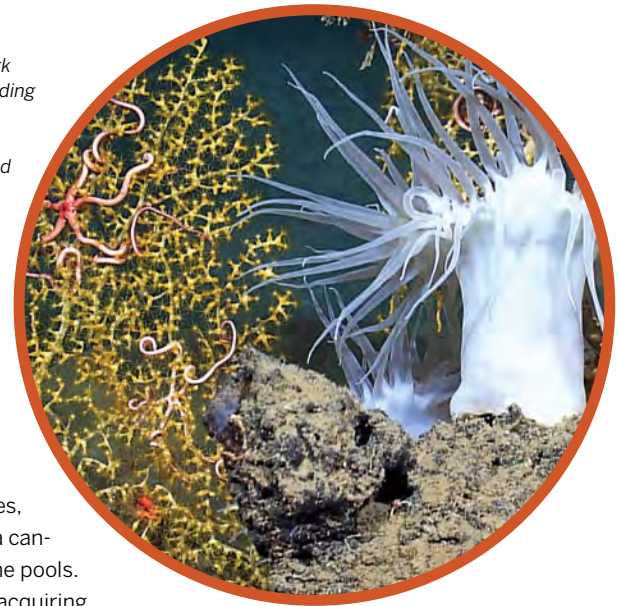






*Deep-sea corals flourish in the dark depths of the Gulf of Mexico, providing foundations that attract lush communities of other animals. A variety of new deep-sea coral and cold seep habitats were identified during the 2012 Gulf of Mexico Expedition. Data and information provide a baseline against which to measure change.*

NOAA OKEANOS EXPLORER PROGRAM



Gulf of Mexico, including cold seeps, deep coral communities, historic shipwrecks, undersea canyons, mud volcanoes and brine pools. Primary operations included acquiring baseline mapping data and high definition video on the west Florida shelf and in Green Canyon, Mississippi Canyon, DeSoto Canyon, the vicinity of the Deepwater Horizon site and deep water areas south of the Flower Garden Banks. ROV dives during one cruise provided the opportunity to develop and test new tools to measure seafloor gas flow in an effort to ground-truth multibeam mapping capabilities. This was done in collaboration with partners at the University of New Hampshire's CCOM and the Department of Interior's BOEM. Live seafloor video of the expedition was shared publicly online and received more than 80,000 visits, including those on NOAA partner site Google Live.

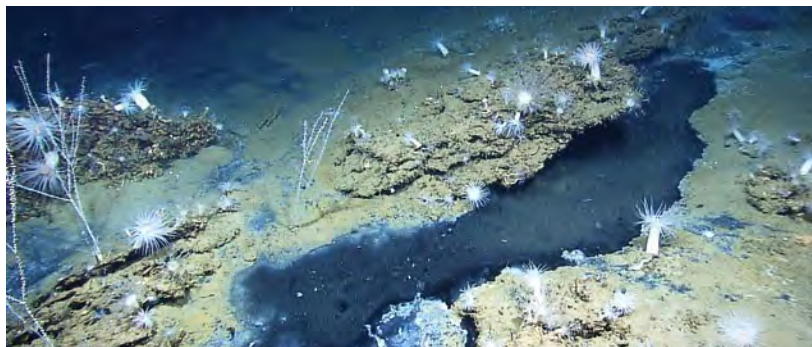
*Penn State graduate student Pen-Yuan Hsing works alongside senior science and ROV team personnel in the Okeanos ROV Control Room to maximize the scientific benefits of ROV dives.* NOAA OKEANOS EXPLORER PROGRAM

The Atlantic Canyons Undersea Mapping Expeditions (ACUMEN) were a collaboration between four NOAA line offices, five U.S. states and academic institutions during which three NOAA ships spent 50 days mapping and ground-truthing northeastern canyons from Virginia to Massachusetts. These included all or part of 36 canyons, and provided critical baseline information to meet a key principle of the NOAA Habitat Blueprint—to integrate and improve delivery of habitat science across disciplines to facilitate conservation actions. The need to understand these areas is also a priority for States in the Mid-Atlantic Regional Council on the Ocean (MARCO). The cross-NOAA campaign showcased OER's ability to bring diverse partners together, leverage the complementary capabilities of NOAA ships and advance our understanding of habitats in the region.

The Blake Ridge Exploration Expedition involved operations with the

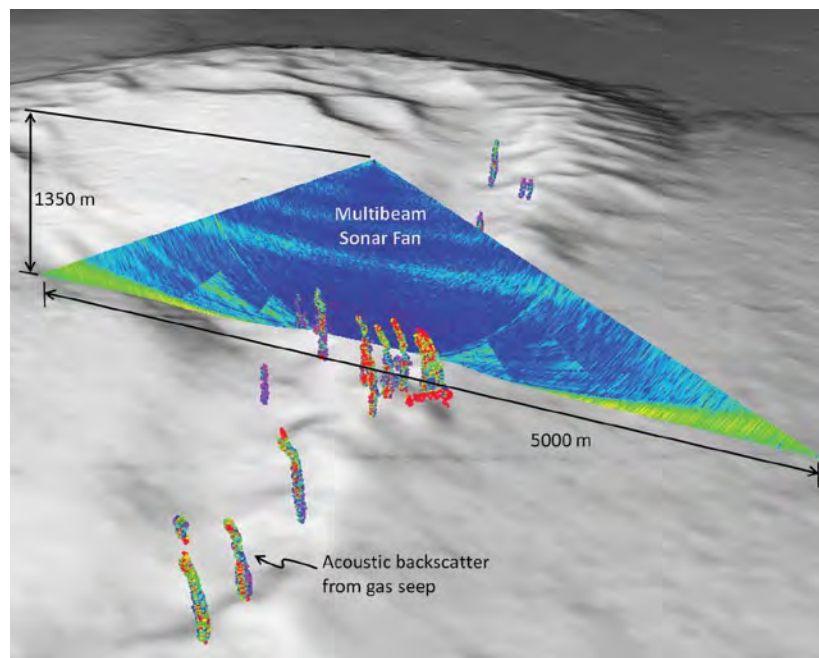


National Deep Submergence Facility's AUV *Sentry* aboard NOAA Ship *Okeanos Explorer* in July for a cruise in the Blake Ridge region of the northern Atlantic. The cruise was conducted in partnership with the National Science Foundation (NSF), Duke University, the University of Rhode Island, the U.S. Geological Survey and Woods Hole Oceanographic Institution (WHOI), completing a variety of complementary objectives. This was *Okeanos'* first AUV cruise focused on assessing how to integrate an AUV into telepresence-enabled operations. NSF objectives included collecting survey data at the Blake Ridge and Cape Fear diapirs to improve efficiency of a follow-on cruise



Interesting geologic features were discovered during the Gulf of Mexico Expedition including undersea brine pools and rivers, asphalt seeps and salt volcanoes centimeters high actively emitting gas. NOAA OKEANOS EXPLORER PROGRAM

in 2013. WHOI conducted engineering trials and experiments of the AUV *Sentry's* capabilities.



A view of multibeam sonar water-column backscatter data used to detect gas seeps on the deep seafloor. Seeps derived from the sonar are shown in the foreground.

UNH/CCOM/JHC USING IVS FLEDERMAUS SOFTWARE

### E/V Nautilus

Supported in large part by OER's partnership with the Institute for Exploration, the Ocean Exploration Trust's Exploration Vessel *Nautilus* undertook a two-month field season in 2012, working in the Black and Aegean Seas conducting archaeological exploration and continuation of geologic and biologic studies in Turkish and Cypriot waters. Nine previously unknown shipwrecks were discovered and exploration targets included mud volcanoes, chemosynthetic communities, and mysterious seafloor scours. An extensive outreach and education program through [nautiluslive.org](http://nautiluslive.org) reached an estimated six to seven million people through partnerships with several organizations, including National Geographic and Sea Research Foundation.

Technicians on board *Okeanos Explorer* prepare for AUV *Sentry's* dive off the ship during Blake Ridge telepresence-enabled AUV cruise in July 2012. NOAA OKEANOS EXPLORER PROGRAM

## OKEANOS EXPLORER 2012 BY THE NUMBERS

- 9 Expeditions
- 8 CTD casts
- 29 ROV dives
- 765 XBT casts
- 40,151 linear kilometers mapped
- 112,399 square kilometers mapped



# Advancing Technology

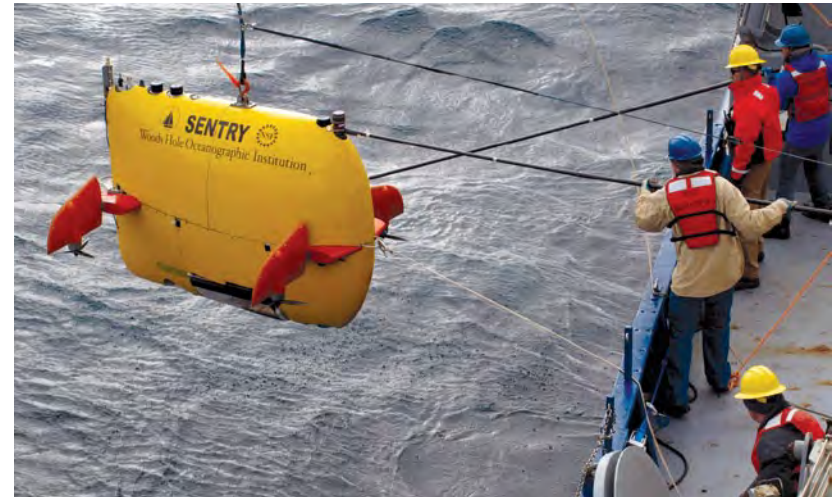
OER's Advancing Technology Team identifies new technologies, innovates use of existing technologies and works to increase the number of new technologies advanced and deployed by OER to improve the pace, scope and efficiency of ocean exploration and research. Priority areas are platforms, sensors, in-situ analytical instruments and communications.

OER technology advancements include:

- a low-cost high capability fly-away telepresence system for use on University-National Oceanographic Laboratory System and NOAA ships. The system was first deployed on

the R/V *Roger Revelle* on the 2012 "Submarine Ring of Fire" expedition to the western Pacific.

- an innovative "glove" designed for the manipulator arm on OER's new ROV for initial use in 2013 that rapidly deploys different environmental sensors, including a probe to quickly measure deep ocean temperature
- improvements in processing *Okeanos Explorer's* multibeam sonar data to provide a state-of-the-art ability to discover gas seeps in the water column
- gas seep detection capability led to closer exploration of seep habitats using the WHOI AUV *Sentry* deployed from *Okeanos Explorer* off the southeast Atlantic Coast. This was the first time in NOAA that engineers and scientists ashore used telepresence to direct an AUV operation at sea.

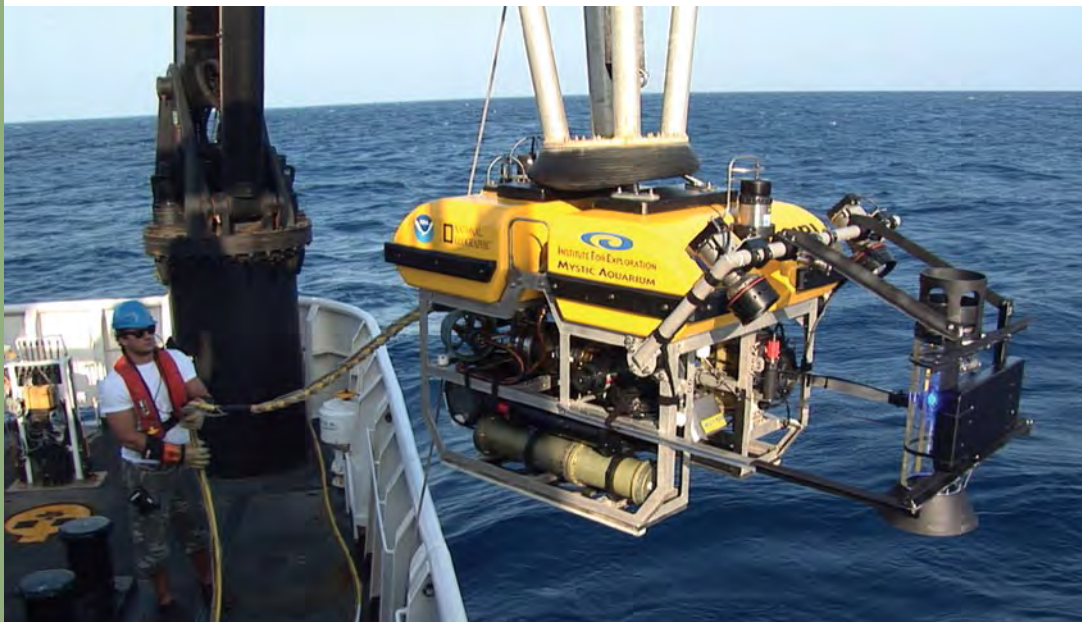


Members of the AUV *Sentry* team and R/V *Melville* crew recover the AUV from a dive during the 2012 Chilean Triple Junction cruise. C. GERMAN, INSPIRE: CHILE MARGIN 2012 EXPEDITION, NOAA-OER

- in 2012, in partnership with NASA, ONR, NSF, BOEM, and other agencies, OER established the Task Force on Ocean Exploration and Research Technology and Infrastructure (TFORT) under the National Oceanographic Partnership Program's Interagency Working Group on Ocean Partnerships. The purpose of TFORT is to apply transition to technology for ocean exploration and related research. A first TFORT technology-stressing discussion group meeting, using an Arctic exploration scenario, identified capability gaps where ocean science would benefit from investment in new technology.

## Catalyzing Research

Exploration often results in discoveries that highlight areas, resources or processes new to ocean science that need further study. OER's Catalyzing Research Team builds on the value of discoveries by facilitating the transfer of ocean exploration observations, data and discoveries to the research and management communities for further studies. The outcomes of these studies benefit NOAA and the nation.



A gas capture device was added to the front of IFE's *Little Hercules* ROV for several dives in the Gulf of Mexico. It was developed with UNH-CCOM and BOEM, and fabricated by OER. Estimating volume of gas combined with other datasets helps assess whether acoustic devices can provide accurate gas flow data, and thus whether sonar can assess the natural input of carbon into the ocean and earth system. NOAA OKEANOS EXPLORER PROGRAM



Examples include:

In FY 2012, OER organized a Marine Microbes Workshop for NOAA and non-NOAA world-renowned scientists to better understand the role of marine microbes in ocean and human health and in marine biogeochemical cycling. Workshop participants recommended NOAA increase its role in marine microbial research dealing with these topics. Participants also recommended that NOAA provide hard-to-obtain marine samples from poorly known areas (e.g., the Arctic). As a follow up, NOAA has created a Marine Microbes Working Group to coordinate and leverage NOAA and partners' activities.

A NOAA Small Business Innovation Research (Phase I award) was supported by OER to develop a new technique to analyze minuscule changes in high calcium ion concentrations in seawater—a difficult challenge. This appeals to businesses and the chemical and biological ocean science communities because it will allow scientists to better assess the impact of changing ocean chemistry (i.e. acidification) on the health of coral reefs and other calcifying marine organisms.

OER supported the Cooperative Institute for Ocean Exploration, Research and Technology in developing and successfully testing, a hand-held coral in-situ metabolism instrument that provides an efficient and non-invasive way to measure physiological parameters as indicators of coral health.

Finally, OER supported development and testing of animal-borne sensors to improve ocean observations, and the modification of AUVs to operate safely and efficiently in very stratified waters of the Arctic where most available instruments have buoyancy problems.

## Education

The OER Education Program reaches out to stakeholders in new ways to improve the literacy of learners of all ages with respect to ocean issues. The program engages educators and students in learning about ocean exploration and experiencing through hands-on activities how science, technology, engineering, and mathematics become integrated when exploring the ocean.

Highlights from 2012 include:

OER offered ocean exploration professional development to educators nationwide at aquariums and science centers. A total of 715 teachers were intensively educated at 15 aquarium sites (5,005 contact hours) enabling them to reach a minimum of 114,400 middle and high school students this year alone. 2012 also recorded the



*Educators explore the science of hydrothermal vent systems during a Learning Ocean Science through Ocean Exploration professional development workshop at New England Aquarium in Boston NOAA-OER*



*During Ocean Exploration professional development workshops, educators become familiar with the Ocean Literacy Essential Principles and Fundamental Concepts and creative methods for incorporating ocean science into their classroom curricula.*

CHARLENE DINDO, DAUPHIN ISLAND SEA LAB

5,000th teacher to receive ocean exploration professional development.

How Do We Explore?, Volume 2 in the *Okeanos Explorer* Education Materials Collection, was produced and professional development in using it in the classroom was implemented nationwide.

OER developed a Special Issue of *Current*, titled "A Closer Look at Ocean Careers through the NOAA Ship *Okeanos Explorer*: A Case Study." In this issue, the *Okeanos Explorer* "comes alive," with the enthusiastic stories of officers, crew and explorers as they live and work onboard the nation's only dedicated ship for systematic ocean exploration.

The "Submarine Ring of Fire" NE Lau Basin 2012 Expedition provided opportunities for live interactions with the public from sea. The Exploratorium in San Francisco, the Long Beach Aquarium of the Pacific in Long Beach, CA, and the Sant Ocean Hall in the Smithsonian Institution's National Museum of Natural History hosted live interactions complete with live video from the seafloor and discussions with mission scientists at sea, a half a world away. Professional development for educators on Saipan was also provided following this mission.

# Data and Information Management

Following the recommendation of the 2000 President's Panel Report, a broad-based task force was formed to manage NOAA's exploration data collections. Since its inception, this extramural team has strategically invested in the development and evolution of advanced tools and techniques to steward and disseminate information, and in the development of unique data visualization tools that provide a holistic view of the exploration program.

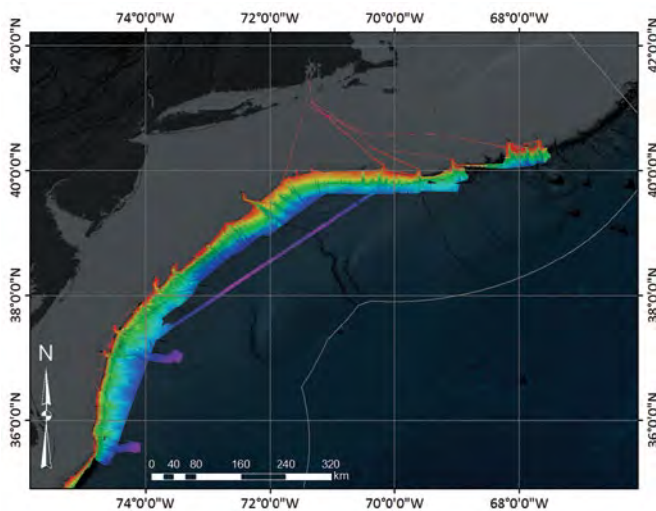
The benefits of this End-to-End (E2E) data management approach are fully realized in the critical metric of data turnaround time from the NOAA Ship *Okeanos Explorer*, which now averages less than 60 days from the end of the

cruise to broad public availability. Rapid turnaround maximizes the impact and benefit of ocean discoveries for research, commercial use, regulatory insight, and education.

The E2E serves as a data management model, and the techniques are applicable to broader needs. For example, as part of ACUMEN 2012 (see pg. 14), OER coordinated data management efforts across seven expeditions on three ships. ACUMEN data were readily combined with data from adjacent areas, providing critical foundation information for the NOAA Habitat Blueprint [below], and demonstrating how rapid turnaround and open information sharing increase overall effectiveness and efficiency.

OER data management team members champion standards and data interoperability. The E2E model is strongly aligned with national geospatial initiatives to ensure that OER-developed capabilities are useful to the broader community.

Data Access: <http://explore.noaa.gov/digitalatlas>



Map of U.S. Atlantic coast between Cape Hatteras, NC and Cape Cod, MA. The brightly colored areas along the continental slope indicate bathymetric coverage of the seafloor collected during multiple NOAA cruises. The data collection effort was primarily part of the OER-led Atlantic Canyons Undersea Mapping Expeditions (ACUMEN) and the OER-BOEM Mid-Atlantic Deepwater Canyons projects, and included 21 scientific and resource management areas prioritized by OER partners. NOAA-OER



## Public Affairs

OER Public Affairs communicates with key audiences, about the accomplishments and value of the office as a leader in ocean exploration and research, and it delivers the message that through partnerships and other means, OER creates and delivers a significant return on investment to NOAA and the nation.

OER news releases reported on the 2012 OER Gulf of Mexico expedition and invited the public to view live video from the seafloor. This resulted in 80,000 visits from those ashore joining the expedition as "virtual explorers." A news release describing another expedition generated 10,000 shoreside visits to live video from a mobile telepresence unit OER placed on a non-NOAA ship. Reaching these large audiences

*Students and teachers from Houston's Stephen F. Austin High School toured NOAA Ship Okeanos Explorer in Galveston, TX. "It was like going to an IMAX theater," said student Fernando Mendez referring to the high-definition camera images taken by ROVs Seirios and IFE's Little Hercules. "I couldn't believe they could go that deep and capture video that has never been seen."* NOAA

was a significant expansion of live telepresence-enabled ship-to-shore connections. Public Affairs also created significant media coverage of ocean expeditions, including numerous national wire service, CNN and NBC Today Show coverage.

We coordinated NOAA Ship *Okeanos Explorer's* Port Day events in 2012 during calls at Charleston, South Carolina and Galveston, Texas. Events included ship tours for media, students, teachers, elected officials, staffers and leaders from area NOAA organizations.



Media coverage included newspapers, radio, television, and a national wire service.

On behalf of 13 U.S. agencies, OER Public Affairs continued to coordinate media and outreach for the nation's ECS Project, and kept current the ECS website, [continentalshef.gov](http://continentalshef.gov). ECS coordination included embarking a video team on the icebreaker USCG Cutter *Healy* for coverage that will result in a TV series on The Weather Channel.

Public Affairs also highlighted the milestone of 10-years of NOAA ocean exploration. Posters and [oceanexplorer.noaa.gov](http://oceanexplorer.noaa.gov) featured exploration highlights and the occasion was cited in NOAA news releases.

### Ocean Explorer Website and Social Media

OER's website [oceanexplorer.noaa.gov](http://oceanexplorer.noaa.gov), continued to chronicle expeditions and projects. For major or "signature" expeditions, coverage included background essays, logs from scientists and technicians at sea, and images and video, including live streaming video. In 2012, the site received more than 6.8 million visits and more than 980,000 lesson plans and education modules were downloaded. Traffic to the website was enhanced as OER expanded social media coverage of web content, using Twitter, Facebook, YouTube and other tools. Live seafloor video from one OER mission was featured in the White House Blog.

[EXPLORE.noaa.gov](http://EXPLORE.noaa.gov) is OER's office website where a variety of offerings explain OER and our operations.

## Ocean Exploration 10-Year Program Review

The Ocean Exploration Advisory Working Group (OEAWG), part of the NOAA Science Advisory Board (SAB), advises the NOAA Ocean Exploration Program. Among its responsibilities is the conduct of periodic reviews of the program's activities to assess the relevance of the program to NOAA and NOAA Strategic Plan goals, the quality of the program's work, and its performance.

This year, the OEAWG conducted its first-ever independent review of the exploration program. OEAWG co-chairs, Dr. Larry Mayer and Dr. Robert Ballard, and the SAB liaison to the OEAWG, Dr. Jerry Schubel, identified potential reviewers and developed the review approach. The panel operated under the auspices of, and reported to, the NOAA Science Advisory Board.

The review panel drew from core documents—primarily the 2000 President's Panel Report on Ocean Exploration, Public Law 111-11 which authorized a national Ocean Exploration Program within NOAA, and program documents as a foundation for evaluation. The formal charge to reviewers asked them to evaluate the program in each of its major areas and to apply indicators of "relevance, performance, and quality." A fourth category, "guidance for the future," prompted reviewers to advise on specific actions that would position the Ocean

Exploration Program to meet the challenges and opportunities in the years ahead.

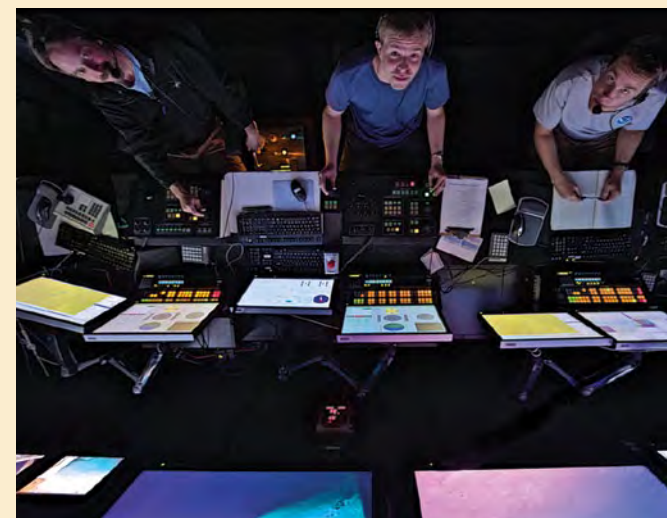
The review panel met May 5 through 7, 2012, and presented initial findings at the end of the meeting. The panel reported review results to the SAB at its November 2012 meeting. After a finding of "undiminished motivation for ocean exploration" and noting the program's significant accomplishments, the panel provided recommendations in the following areas:

- Strategic goals and priorities
- NOAA leadership support for ocean exploration required
- A National Forum on Ocean Exploration
- Radical New Management Models
- Targeted Expeditions
- *Okeanos Explorer*
- Technology
- Extended Continental Shelf
- Branding
- Ocean Exploration Advisory Board

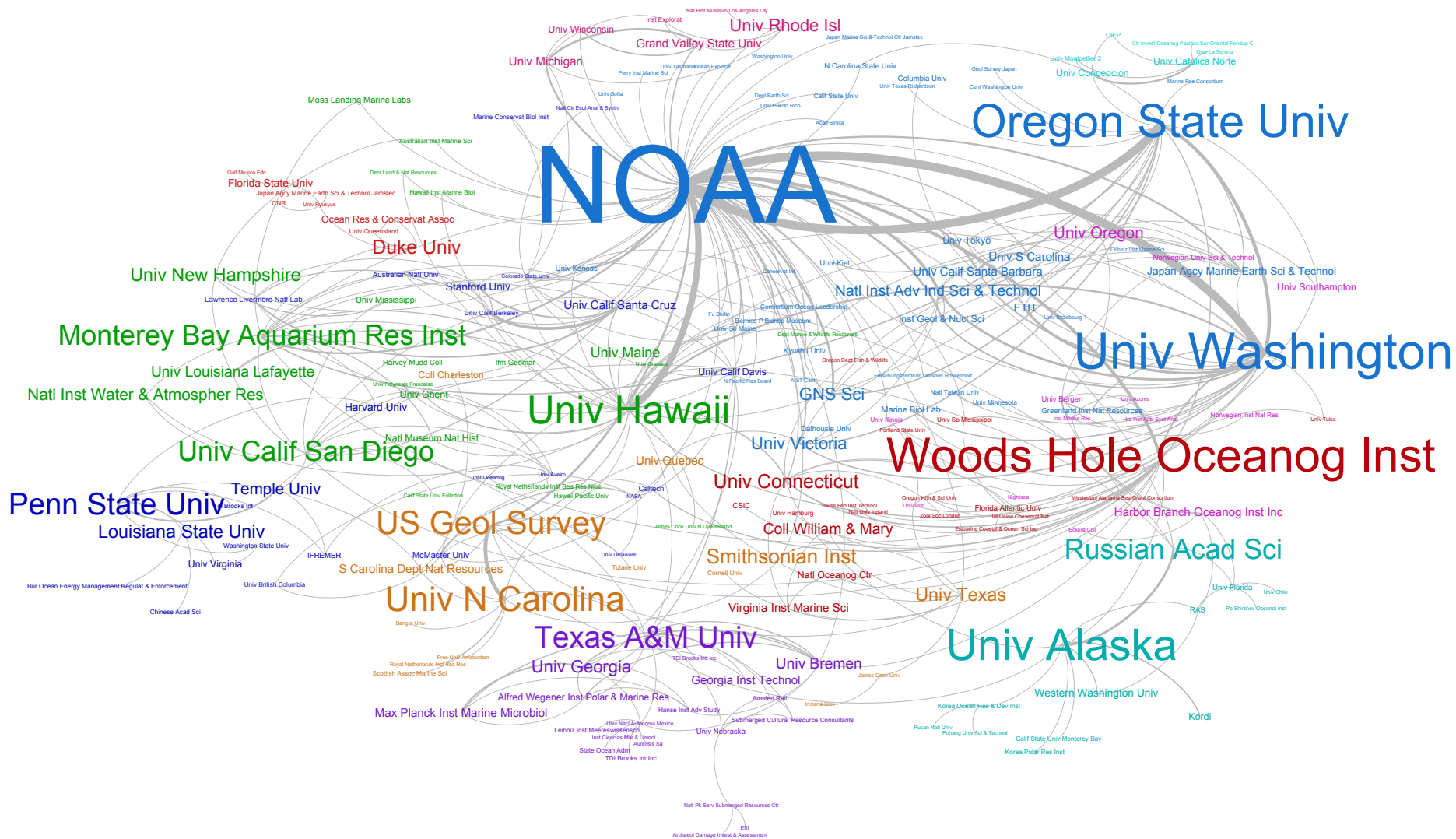
The panel's report may be found at: <http://tinyurl.com/OE-10-year-report>.

Review panel documents, including a list of reviewers and their affiliations, may be found at <http://explore.noaa.gov/about-oer/> Click on Program Review.

The review panel's findings provided OER rich insight and advice that is of great value.



ROV Engineers in the control room of the NOAA Ship Okeanos Explorer  
NOAA OKEANOS EXPLORER PROGRAM



## Partnerships Run Deep

This graphic provides a visual appreciation for the vast network of institutional partnerships forged by expeditions and projects supported by OER from 2002 to the present, as represented by the publication of resulting research articles. Institutions are connected if researchers co-authored one or more peer-reviewed articles with OER support. The size reflects the number of articles produced and colors denote institutions that tend to publish articles in collaboration with others in the group. Lines represent co-authored articles between researchers from the connected institutions and the width of the lines indicates the number of articles on which the institutions collaborated. This graphic was created using data from Web of Science® and is accurate as of January 2013.

CHRIS BELTER, LAC GROUP, NOAA CENTRAL LIBRARY



““ This was one of the best ‘at sea’ experiences I have ever had. It was a rich, rewarding and productive field program because of the dedication, talent, creativity and generosity of your lead [Ocean Exploration] people . . . a chance for a team of very clever people to work together to solve problems and to prove the concept of AUV telepresence. Wow! ””

**DR. CINDY LEE VAN DOVER**  
*Director, Marine Laboratory,  
Duke School of the Environment*

““ Archaeologists, and scientists in general are just beginning to grasp the limitless opportunities for exploration and outreach those programs such as the *Okeanos Explorer* cruises can provide. No longer is the question how to do it, but rather where will we go next and what discoveries await us? ””

**DANIEL WARREN, MA**  
*C&C Technologies, Inc. and Kimberly L. Faulk, MA, GEMS, A Forum Energy Technologies Company —Society for Historical Archaeology Blog*

““ It is plain that having the high-resolution bathymetry data that *Okeanos Explorer* collected during its Gulf of Mexico surveys has lifted our ability to work smart in the DeSoto Canyon by an order of magnitude or more . . . the Ocean Exploration efforts truly blazed a path where others can follow. ””

**DR. IAN MACDONALD**  
*Professor, Earth, Ocean and Atmospheric Science, The Florida State University*

““ The critical metric of data turnaround time from the NOAA Ship *Okeanos Explorer* continues to improve, now averaging less than 60 days from the end of the cruise to broad public availability. Rapid turnaround maximizes the impact and benefit of ocean discoveries for research, commercial use, regulatory insight, and education. ””

**RUSSELL H. BEARD**  
*Director, National Coastal Data Development Center (a Division of the National Oceanographic Data Center) and NOAA Gulf of Mexico Regional Team Lead*

““ I just want to add how pleased I was to... see first hand the results of collaboration within NOAA and with regional partners to advance strategic goals in the region . . . this work involves a [OER-led] collaborative effort to map and further study the ocean canyons of the Atlantic coast. It supports ocean priorities of the Governors in the region, particularly MARCO, it is informing work under our Northeast Habitat Blueprint project, and fishery management priorities of the Mid Atlantic Fishery Management Council. It was clear that this effort is highly valued by state and academic institution partners. ””

**ERIC SCHWAAB**  
*NOAA Fisheries, Acting Assistant Secretary for Conservation and Management*

““ Spurred in part by the OE program, a renaissance of ocean exploration has occurred during the past decade, both nationally and globally . . . OE has itself, and more often in partnership, generated impressive successes in science.” ””

**INDEPENDENT REVIEW OF THE USG OCEAN EXPLORATION PROGRAM**  
*Invited by NOAA Science Advisory Board*

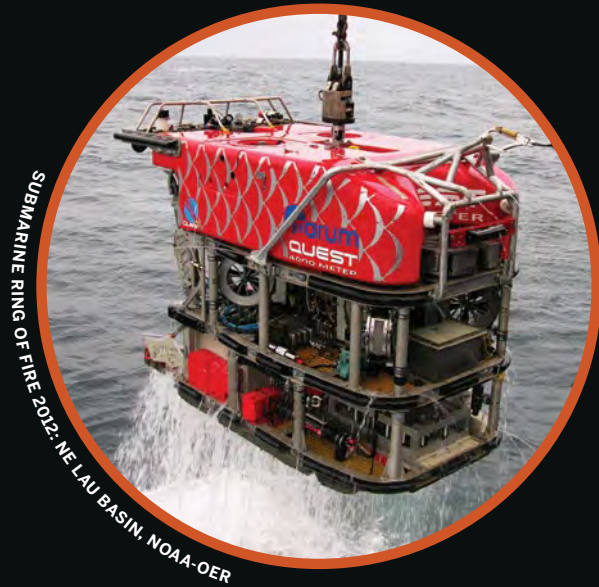
““ The project clearly demonstrated why OER and NOAA Ship *Okeanos Explorer* are critical to addressing both NOAA and National scientific and management needs . . . results from the five expeditions are already providing critical foundational information to meet a key principle of the NOAA Habitat Blueprint—to integrate and improve delivery of habitat science across disciplines to facilitate conservation actions. ””

**DR. WILLIAM KARP**  
*NOAA Northeast Fisheries Science Center*  
**BRIAN PAWLAK**  
*NOAA Fisheries Service  
Office of Habitat Conservation*

““ NOAA [OER] tested the ship’s multibeam sonar last year in the Gulf of Mexico and confirmed its advanced signal processing made it a highly capable new tool to detect gaseous seeps at great depths and over wide areas. This technology and the information it delivers is extremely valuable to researchers and ocean resource managers in NOAA, in other agencies, and across the nation. ””

**DR. ROBERT DETRICK**  
*Assistant Administrator of NOAA Research*

NOAA's Office of Ocean Exploration and Research collaborated with 239 partners in 2012 for the purpose of discovery and advancement of knowledge.



SUBMARINE RING OF FIRE 2012: NE LAU BASIN, NOAA-OER



ROBERT HANSEN, NOAA



NOAA OKEANOS EXPLORER PROGRAM



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