BOEM OCEAN SCIENCE

THE SCIENCE & TECHNOLOGY JOURNAL OF THE BUREAU OF OCEAN ENERGY MANAGEMENT

VOLUME 11 ISSUE 2 • JULY/AUGUST/SEPTEMBER 2014

BOEM OCEAN SCIENCE

THE SCIENCE & TECHNOLOGY JOURNAL OF THE BUREAU OF OCEAN ENERGY MANAGEMENT

VOLUME 11 ISSUE 2
JULY/AUGUST/SEPTEMBER 2014

BOEM OCEAN SCIENCE is published quarterly by the Bureau of Ocean Energy Management to communicate recent ocean science, technological information, and issues of interest related to offshore energy recovery, marine minerals, and ocean stewardship.

Please address all questions, comments, suggestions, and changes of address to:

Melanie Damour, Senior Editor
BOEM OCEAN SCIENCE
Bureau of Ocean Energy Management
1201 Elmwood Park Boulevard
New Orleans, LA 70123
Melanie.Damour@boem.gov
(504) 736–2783

ON THE COVER
Lophelia coral (white) grows on the stem post of the Ewing Bank Wreck. *Image courtesy of Sheli Smith, Lophelia II 2009: Deepwater Coral Expedition: Reefs, Rigs and Wrecks.*

All photos courtesy of the Bureau of Ocean Energy Management unless otherwise noted.

Publication services provided by Schatz Publishing Group.

Frequently Used Abbreviations

AMAPPS	Atlantic Marine Assessment Program for Protected Species
BOEM	Bureau of Ocean Energy Management
ESP	Environmental Studies Program
GOM	Gulf of Mexico
LSU	Louisiana State University
NEPA	National Environmental Policy Act
NMNH	National Museum of Natural History
NOAA	National Oceanic and Atmospheric Administration
PAHs	polycyclic aromatic hydrocarbons
ROV	remotely operated vehicle

Subscribe

To receive *BOEM OCEAN SCIENCE*, visit **www.boem.gov**, click on the *BOEM Ocean Science* magazine cover, then select "Sign up for Ocean Science" at the bottom of the page, or email **Melanie.Damour@boem.gov**.

For More Information

Check out the Bureau of Ocean Energy Management website at **www.boem.gov**.

The Acting Director's Message

I am proud to introduce this issue of *Ocean Science*, which focuses on the concepts of exploration and discovery and how they relate to applied science, use-inspired science and basic research.

Many times throughout history, scientists have set out to solve a problem and made a serendipitous discovery – one that veered off of the original research path but ultimately contributed to a fascinating new body of knowledge. An example of this type of exploration and discovery occurred when our scientists conducted a study of deepwater benthic ecology in the Gulf of Mexico and, on the same mission, discovered new communities and new species that were of substantial scientific significance.

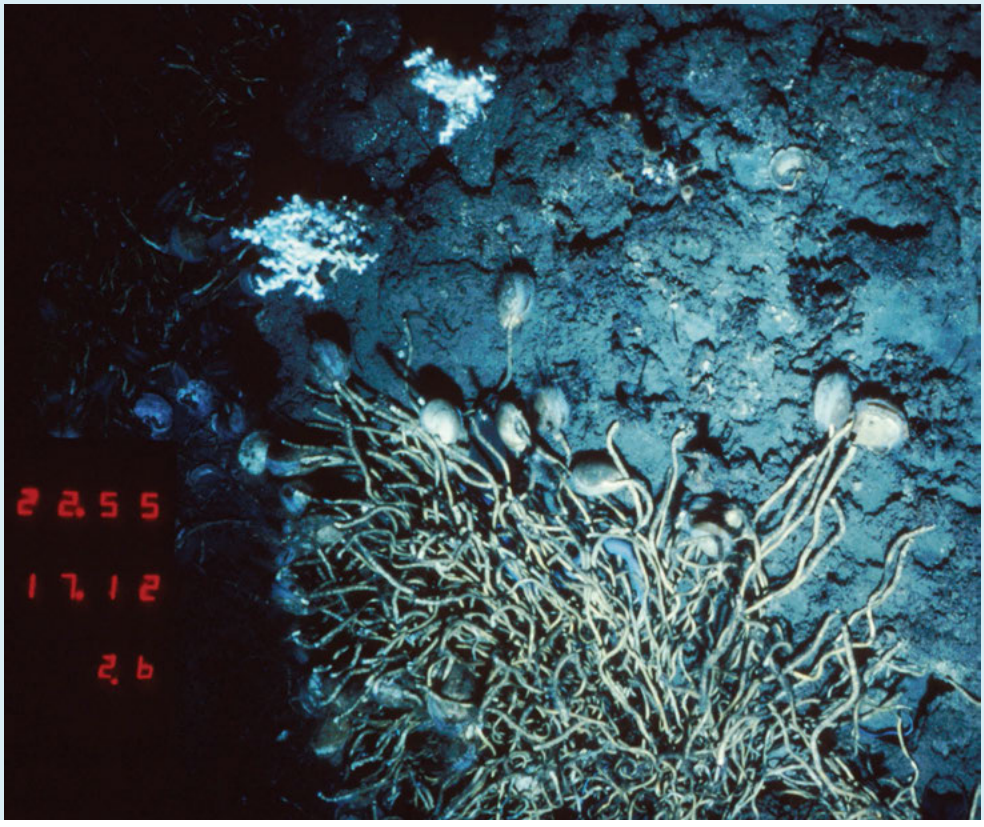
In 1984, during one of many extended cruises to explore and describe the deep Gulf of Mexico, the first documented chemosynthetic community associated with a hydrocarbon seep in the region was recorded. Although the discovery was accidental, it led to additional studies of these unique biological communities that can live independently of photosynthesis and the sun-dependent food chain that supports most life on earth. After the initial discovery, research funded by our bureau helped develop mitigation measures to protect these ecosystems through avoidance of sensitive areas.

A similar significant discovery was made recently as part of a large cooperative study of mid-Atlantic canyons. Recently mapped gas seeps were visited for the first time in 2013, resulting in the discovery of vast areas of chemosynthetic mussels near Norfolk Canyon offshore Virginia. This discovery and the continued study of other similar sites will lead to protective measures for these sites in the Atlantic.

Science-based decisions culminating from exploration and discovery must continue as the underpinning of the work we do as we move the Nation toward the combined goals of energy independence and a sustainable ocean environment.

Please enjoy this issue of *Ocean Science*.

Walter D. Cruickshank,
Acting Director



First image of a high-diversity hydrocarbon seep community in the Gulf of Mexico at a depth of 621 m (2,083 ft.), taken as part of the Minerals Management Service study of the Gulf's continental slope in 1984. The image includes *Lophelia* coral (upper left), clusters of tube worms, and uniquely associated bivalves attached to the ends of the tube worms (published in *Nature* (Boland 1986). *Photo by Gregory S. Boland/LGL Ecological Research Associates for Minerals Management Service.*

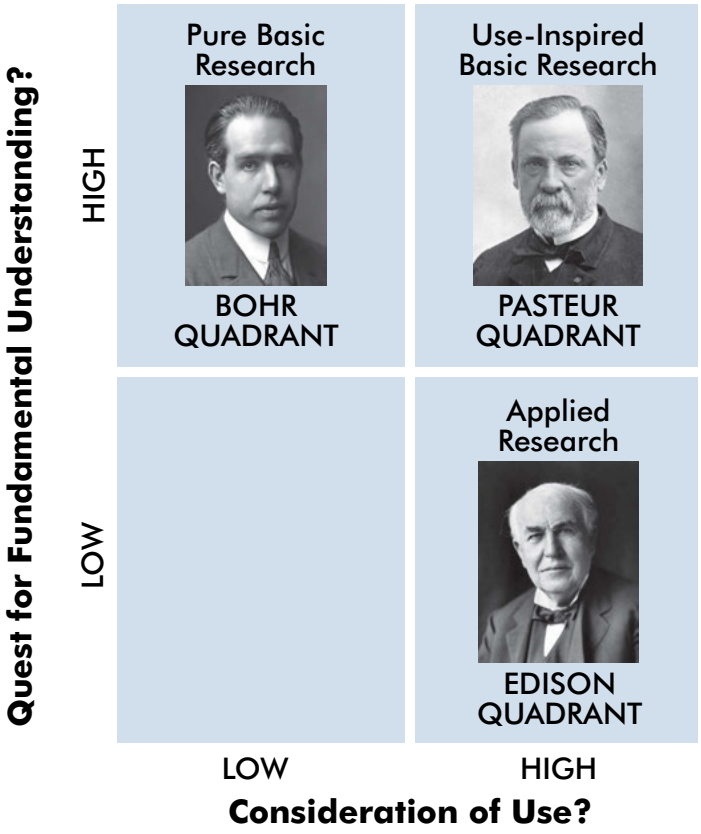
Use-Inspired Basic Research Guides Environmental Studies Program

A Message from the Chief of the Environmental Studies Program, Dr. Rodney Cluck

The Bureau of Ocean Energy Management's (BOEM) Environmental Studies Program (ESP) takes a science-informed strategic planning approach to provide valuable input to the decision-making process. The term "use-inspired basic research" is a two-dimensional plane that integrates the idea of the quest for fundamental knowledge with the desire to inform decisions on practical problems.

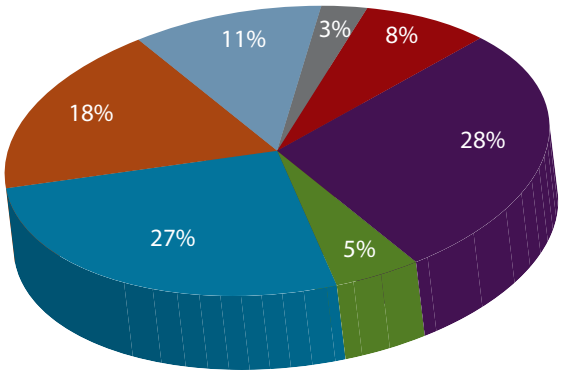
The notion draws from Donald Stokes' 1997 book *Pasteur's Quadrant: Basic Science and Technological Innovation*. Stokes' model comprises three quadrants, each exemplified by a historical figure in science and technology. The pure basic research quadrant exemplified by Niels Bohr represents the traditional view of research inspired by the need for a fundamental understanding. The pure applied research quadrant is represented by Thomas Edison, who was driven by a more practical resolve to solve problems. Louis Pasteur's quadrant is a mix of the two. Pasteur's quadrant influences both applied research and also brings forth a fundamental understanding of the phenomena being examined.

Use-inspired basic research lies at the nexus of "pure" science and "applied" science. Since Manhattan Project scientist Vannevar Bush wrote his famous paper in 1945 emphasizing the importance of government funding of so-called "pure" science (which seeks knowledge for knowledge's sake), there has been an artificial and arbitrary distinction between "pure" science and "applied" science (which seeks knowledge for its application to a given problem). The distinction between "pure" and "applied" science is misleading. In reality the two cannot be separated but rather, in many cases, research that is use–inspired may lead to a broader fundamental understanding. As Louis Pasteur himself suggests, *"There is not pure science and applied science but only science and the application of science"* (Louis Pasteur 1863).



ESP efforts seek not to dichotomize science with these distinctions but rather to explore the continuum of learning through discovery and application. Many of the scientific studies that have been conducted over the years through ESP have lent themselves to remarkable discoveries while providing invaluable information to support decisions. Through our rigorous examination of questioning the direct application of our science, an amazing amount of fundamental understanding has emerged. The purpose of this edition is to show how ESP "use-inspired" research has informed "basic science."

Environmental Studies Program Funds by Discipline FY 2008-2014 Cumulative



Includes expenditures for all studies supporting environmental information needs for all energy types and marine minerals.

Marine Invertebrate Collection Continues to Grow at Smithsonian Institution

Discoveries made during research funded by BOEM help numerous other researchers and scientists around the world, thanks to a unique collection of samples amassed over the past several decades and robust online search capabilities of the collection.

Since 1979, BOEM (formerly Bureau of Land Management then Minerals Management Service) has contracted with the National Museum of Natural History's (NMNH), Department of Invertebrate Zoology, to provide professional management services for the long-term curation of its marine invertebrate specimen collection. The specimens were retrieved from oil and gas lease sites on the East, West, and Gulf Coasts of the United States during environmental studies designed to understand the environment and limit potential impacts of future oil/gas explorations. More than 400 new species have been discovered from BOEM's study collections.

In addition to specimens collected over the years, new ones continue to be added, such as the huge collection recently transferred from a Louisiana State University professor representing decades of BOEM-funded research. Beginning this year, specimens will also be coming from studies in the Beaufort Sea on the north coast of Alaska.

The specimen collections housed at the Smithsonian are vital to protecting our natural resources because they establish a snapshot of U.S. coastal habitats and biological communities at a specific time and place, which can serve as a reference in the event of environmental change. Subsequent sampling of the same habitats over time can provide useful data for tracking climate change, habitat degradation, and species population range shifts. Additionally, extensive sampling areas and sampling in unique deepwater habitats increase the chances of discovering previously undescribed species. One such example is the discovery of a new species to science that most call the "ice worm" made during a BOEM-funded study of chemosynthetic communities in 1997. These polychaete worms live on the surface of frozen methane hydrate in deep ocean areas, first discovered in the Gulf of Mexico.

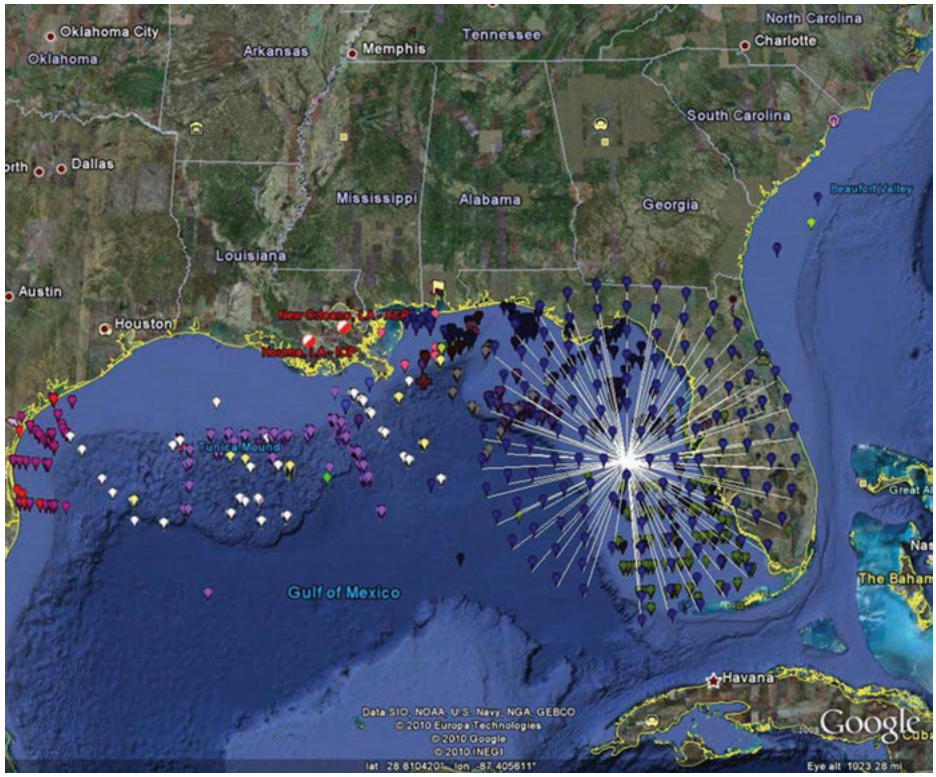
Information contained in the database is available online, which allows researchers to investigate predator/prey or host/parasite relationships and to identify and track disease-causing organisms, introduced species, and coastal pollution effects. The information also helps governments make informed decisions that may affect the animal life in their coastal waters.

– Rita Hess, Schatz Publishing Group

Polychaete "iceworm" first discovered in 1997 during a BOEM-funded study. *Photo by Gregory S. Boland.*

For More Information

Collections and partnership between BOEM and the Smithsonian's NMNH
http://invertebrates.si.edu/boem/boem.htm



The map image is a tool the Smithsonian uses for site users to locate individual specimens taken at all the stations represented by our historical sampling. Each exploded point from this single collection station can be clicked on, leading to detailed information and images of each specimen in the archive.

In the summers of 2012 and 2013, the team conducted research from aboard the U.S. Coast Guard Cutter *Healy* (in the background). Designed for icebreaking and polar research, the vessel can accommodate up to 50 scientists and can break 4.5 feet of ice continuously at 3 knots in temperatures down to -50 degrees F. Here, the team collects ice samples using a small boat.

Chukchi Reach. Painting by Robert Selby, Champlain College

Hanna Shoal Ecosystem Study

Hanna Shoal is a shallow, 30-mile long shelf that sits in the Chukchi Sea northwest of Barrow, Alaska. It is one of the region's most biologically productive spots and an important feeding area for walrus and bowhead whales. The high levels of productivity are associated with large amounts of organic matter received from the highly productive shelf regions of the North Pacific and from local sources. However, the area is downcurrent of oil and gas lease sites in the Chukchi Sea, so anything entering the water at the drill sites can end up in this very productive region.

The **Hanna Shoal Ecosystem Study** is a five-year investigation of the biological, chemical, and physical properties that define this unique ecosystem. Resulting data will help inform decision makers about future policies and activities that could potentially affect the region.

The *Chukchi Sea Offshore Monitoring in the Drilling Area: Chemistry and Benthos (COMIDA-CAB)* study (www.comidacab.org) previously characterized the chemical and biological environment of the seabed. The Hanna Shoal Ecosystem Study, which runs until 2016, expands on this work to help identify and measure important processes that contribute to the high concentration of marine life in the area, advancing the understanding of environmental considerations such as food web dynamics and potential contaminant bioaccumulations.

A team of researchers from multiple institutions and federal agencies, led by the University of Texas at Austin, are looking at all aspects of the area's ecosystem—from polychaetes (worms) in seafloor sediments to krill in the water column to ocean currents—to learn how it works and how toxins (e.g., heavy metals or hydrocarbons) might be transferred through the food web to the highest trophic levels (the whales, walrus,

Organic Contaminants in Surface Sediments and Biota

A persistent organic contaminant and important contributor to toxicity in marine organisms are polycyclic aromatic hydrocarbons (PAHs). Emitted from natural (i.e., fires, petroleum seeps, degradation) and anthropogenic (i.e., fossil fuel combustion) sources, PAHs can accumulate in the environment. As part of the Study, surface sediments and Northern Neptune whelks (*Neptunea heros*) were investigated for organic contaminants, including PAHs, to establish a baseline and understand the potential for bioaccumulation in upper trophic level animals living nearby. Levels of contaminants are some of the lowest in the Northern Hemisphere, reflecting the pristine environment of the Chukchi region.

and seals). One complicating factor is sea ice retreat, which is changing Hanna Shoal's ecosystem. As researchers establish baselines, they must consider whether their findings are a result of human activities or sea ice retreat—or neither or both.

Notable findings of the Hanna Shoal Ecosystem Study to date include the following:

- First-year mooring data seems to indicate that circulation in the Hanna Shoal area is more complicated than previously thought. Results suggest that exchange across the shelfbreak near Hanna Shoal may be higher than anticipated.
- Chemical analyses are providing insights into how bioaccumulation of mercury (Hg) varies in different organisms there. For example, concentration of total Hg correlated closely with size in whelk, but not in snow crab.
- As expected, benthic biomass was quite high on the flanks of Hanna Shoal but relatively low on top of the Shoal.
- The shallow but complex bathymetry of Hanna Shoal influences the productivity of the water column and organic sedimentation processes. Benthic biomass, sediment oxygen demand, and chlorophyll deposited to the surface sediments tend to be higher to the south, including in waters south and east of Hanna Shoal, where large populations of walruses were observed foraging on the benthos in the summer from remnant sea ice.

– Merlin Hayes,
Schatz Publishing Group

For More Information

Hanna Shoal Ecosystem Study

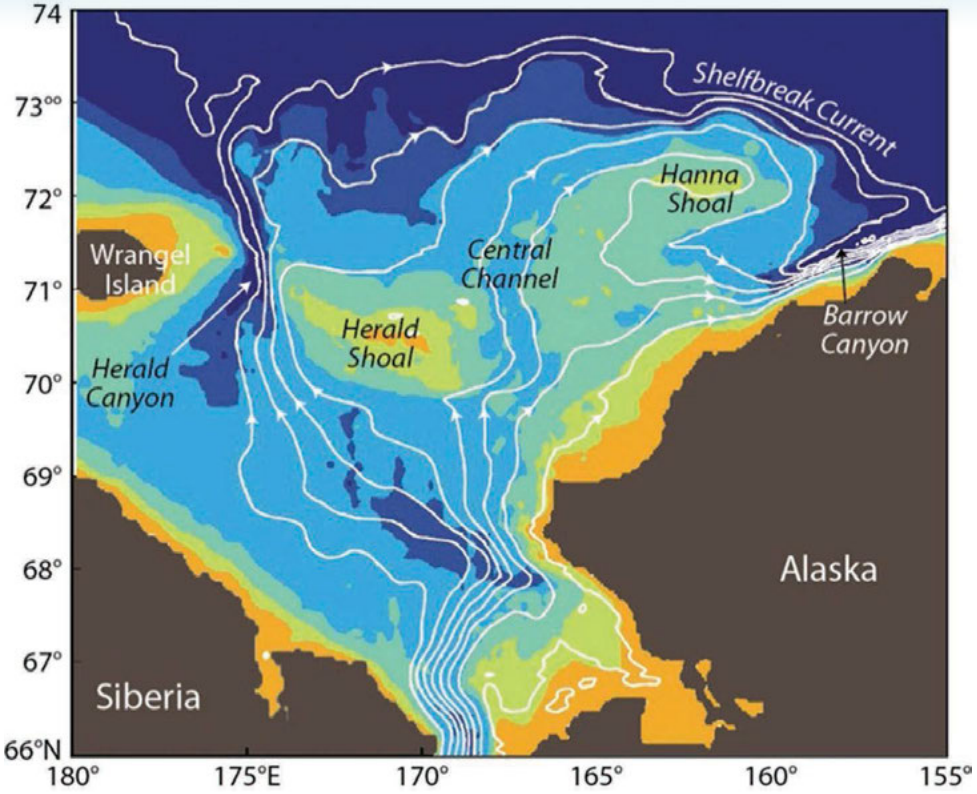
http://www.comidacab.org/hannashoal/index.html

2012 Cruise Report

http://www.comidacab.org/hannashoal/documents/HLY1201HannaShoal_cruise_report_Final.pdf

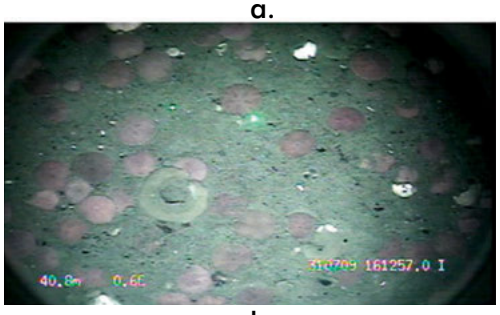
2013 Cruise Report

http://www.comidacab.org/hannashoal/documents/HLY13-01_cruise_report.pdf

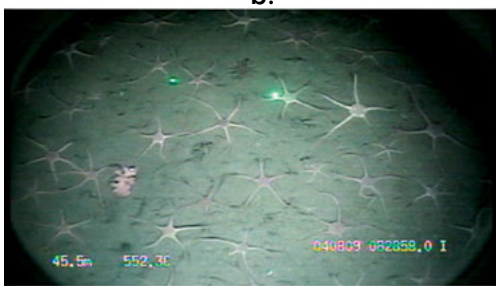


Hanna Shoal Ecosystem Study, physical oceanography. Streamlines of the model-predicted clockwise circulation around Hanna Shoal (from Spall, 2007). One goal of the Hanna Shoal Ecosystem Study is to examine the strength, persistence, and variability of this circulation. *Thomas Weingartner, University of Alaska Fairbanks*

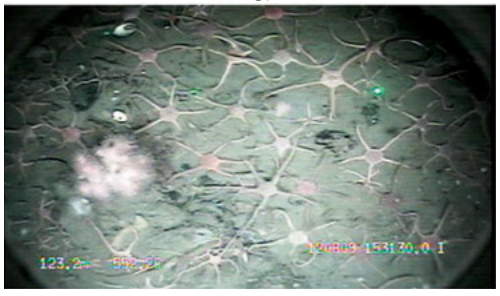
a.



b.



c.



Bottom camera images in the Chukchi Sea.

Faunal Type:

a. Sand dollars (*Echinarachnius parma*) near shore in Alaska Coastal water.

b. Brittle stars (*Ophiura sarsi* and *Ophiura* sp.) in offshore waters.

c. Brittle stars (*Ophiura sarsi*) and soft corals (*Gersemia rubiformis*) in Barrow Canyon.

Cooper and Grebmeier, UMCES

Tube worms inside *Anona's* aft skylight. Green laser scales are 10 cm apart. *Photo by DSSI Global Explorer ROV, March 2014.*

Chemosynthetic Communities and Shipwrecks: New and Unexpected Discoveries in Deep Water

Chemosynthetic communities are known to form around hydrothermal vents and hydrocarbon seeps in the deep ocean. In the GOM, chemosynthetic animals such as tube worms, mussels, and clams can colonize the seafloor where oil and gas escape from the subsurface geological strata. Chemosynthesis involves the use of chemical energy to create food from methane or sulfide found in the seeping hydrocarbons. Unlike most other life forms that rely on photosynthesis—the use of sunlight as the energy source—chemosynthetic organisms can flourish in extreme depths without any available light source or food derived from photosynthesis.

Previous studies funded by BOEM have examined chemosynthetic communities to learn more about these unique collections of animals. Studies that have taught us about shallow-water (< 700 m/2,300 ft.) and deepwater (>1,000 m/3,280 ft.) chemosynthetic communities include:

- *Stability and Change in Gulf of Mexico Chemosynthetic Communities* (OCS Study MMS 2002-035 and 2002-036),
- *Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico* (GM-05-03), and
- *Exploration and Research of Northern Gulf of Mexico Deepwater Natural and Artificial Hard-Bottom Habitats with Emphasis on Coral Communities: Reefs, Rigs, and Wrecks*—Lophelia II.

Bacteria are abundant at seeps and oxidize the emitted hydrogen sulfide into sulfur. During the oxidation process, chemical energy is released. As a result of this chemosynthesis, hydrogen, oxygen, and carbon are combined to form sugar molecules, a valuable food source. Bacteria also exist in a symbiotic relationship with tube worms. Millions of bacteria can reside within a single worm's hardened tube and are protected from predation. The tube worms benefit from the absorption of nutrients produced by bacterial chemosynthesis.

Tube worms, classified in the phylum *Annelida*, include species found at hydrothermal vents that are among the fastest-growing marine invertebrates. They can colonize a new site and grow to more than a meter in length in only a few years. Other species, typically those observed near cold seeps, have a much slower growth rate and may take a century or longer to grow more than a meter in length. In the GOM, many colonies of tube worms have been observed near seeps over the past few decades. Recently, however, tube worms are appearing in new places that they've never been seen before in the deepwater environment of the Gulf—shipwrecks.

To date, tube worms have been observed by scientists on three shipwrecks in the GOM: two of the three 19th century "Monterrey shipwrecks" and *Anona*, a steam yacht lost in 1944.

The first Monterrey Wreck was identified during the NOAA *Okeanos Explorer* expedition to the Gulf in 2012. The team of ship- and shore-based scientists examined a number of biological and geological features in the Gulf along with side scan sonar targets that appeared to be shipwrecks. One of these sonar targets, in 4,300 ft. (1,310 m) of water, turned out to be a 19th-century wooden-hulled sailing ship that was lost in the Keathley Canyon leasing area. As the team of scientists

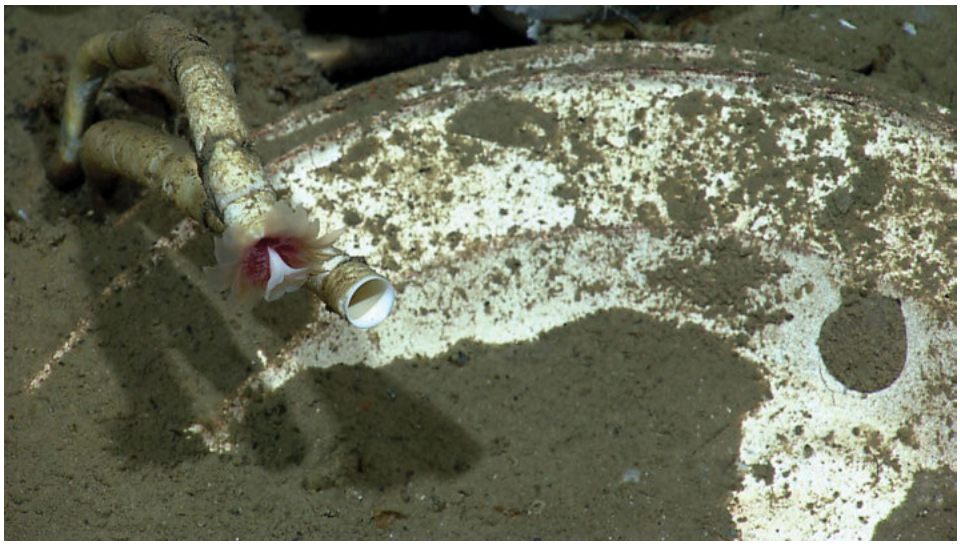
explored the shipwreck, a few tube worms were observed residing within the hull and among its artifacts. A 2013 expedition on board the Ocean Exploration Trust's vessel *Nautilus* returned to the Monterrey Wreck to conduct detailed site recording, sampling, artifact collection, and biological observations. Upon completion of their work, the team decided to explore two additional side scan sonar targets within a few miles of the wreck. Both sonar targets were identified as shipwrecks (Monterrey Wrecks B and C), possibly contemporaneous with the first wreck (dubbed Wreck A). Again, tube worms were observed living on and within the remains of one of the two newly discovered shipwrecks.

Anona is a steel-hulled, propeller-driven, former luxury yacht that sank in 1944 while serving as a freight carrier transporting a cargo of potatoes. Her hull plates suddenly buckled, and she sank in the Viosca Knoll leasing area in more than 4,000 ft. (1,220 m) of water. First recorded as an unidentified side scan sonar target in 1995, *Anona* was not confirmed as a shipwreck until years later through remotely operated vehicle (ROV) investigations. Archaeologists returned to the site in March 2014 during a BOEM-funded study. Unexpectedly, *Anona* is home to several colonies of tube worms growing on her deck and within the hull. A few small colonies were observed near the bow, while a large colony was observed down inside the hull in the aft section.

The presence of tube worms on shipwrecks raises new and intriguing questions about marine invertebrate behavior and chemosynthetic communities in the deepwater environment. Though no samples of tube worms from shipwrecks have been collected to date, initial hypotheses propose that the tube worms and their symbiotic bacterial cohabitants are chemosynthesizing the hydrogen sulfides emitted from the degradation of the ships' organic cargoes. As BOEM continues to fund and conduct studies to better understand the deepwater environment for decision making purposes, we hope to make new and exciting discoveries along the way that raise new research questions within the scientific community.

– Melanie Damour, BOEM

A chemosynthetic tube worm grows in the wooden remains of the hull of Monterrey Wreck B. *Image courtesy of NOAA Okeanos Explorer Program, 2014 Gulf of Mexico Expedition.*



Chemosynthetic tube worms grow on Monterrey Wreck A next to ceramic artifacts. *Image courtesy of NOAA Okeanos Explorer Program, 2012 Gulf of Mexico Expedition.*

For More Information

Stability and Change in GOM Chemosynthetic Communities **(OCS Study MMS 2002-035 and 2002-036)**

http://www.data.boem.gov/PI/PDFImages/ESPIS/2/3071.pdf and
http://www.data.boem.gov/PI/PDFImages/ESPIS/3/3072.pdf

Investigations of Chemosynthetic Communities on the Lower Continental Slope of the GOM **(GM-05-03)**

http://www.boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_Studies/GM-05-03.pdf

Monterrey Shipwrecks

http://www.boem.gov/Gulf-of-Mexico-Expedition-Discovers-Amazing-Historic-Shipwreck/

GOM Shipwreck Corrosion, Hydrocarbon Exposure, Microbiology, and Archaeology (GOM-SCHEMA) project webpage

http://mbac.gmu.edu/mbac_wp/gulf_wrecks/

At the Forefront of Deepwater Coral Research: BOEM Studies in the Gulf of Mexico and Atlantic

For more than a decade, BOEM has had a strong role in deepwater coral research in the Gulf of Mexico (GOM) and now in the Atlantic region. This research has led to numerous remarkable discoveries and a greatly increased understanding of these important habitats in both areas. Deepwater (or cold-water) corals are typically very long-lived, slow-growing colonial organisms that live attached to hard bottoms in the GOM and all other oceans of the world. They can also inhabit artificial substrates, including shipwrecks and deepwater oil and gas platforms. Some types of deepwater corals are known to live several thousand years. There are more species of deepwater corals (over 5,300) than the more familiar shallow corals and they occur in water depths as great as 6,000 m (19,685 ft.). Only 15 percent of coral species are the familiar shallow reef-building kinds. Deepwater corals provide structural habitat for diverse communities of organisms, including important fish species. The surrounding habitat has also been shown to be greatly enriched, including tiny animals living in sediments as well as larger organisms on the seabed. These habitat enhancements also impact the general ecology of more distant deep benthic (seafloor) communities as well as the overlying pelagic (open-ocean) habitat.

Figure 1. A down-looking mosaic of a coral community at 1,400 m (4,600 ft.) depth, including a variety of hard and soft corals from *Lophelia* II study. *Photo courtesy of BOEM/NOAA OER.*

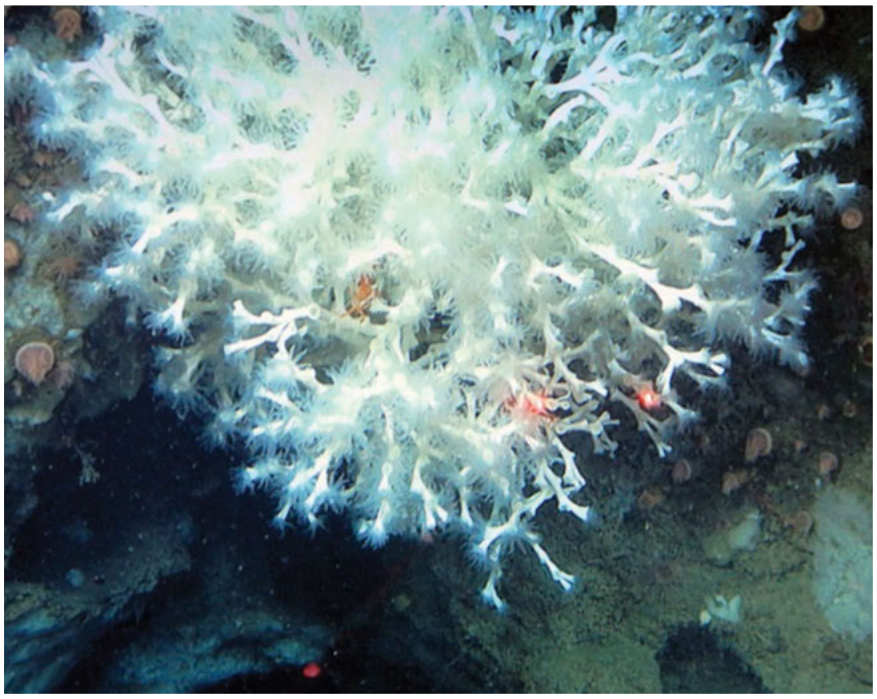
Coincidently, the first discovery of a significant area of the important habitat-forming coral *Lophelia pertusa* in the GOM (since a reported trawl catch in 1955) was made during a mandatory 1990 site survey prior to activities near what was thought to be a chemosynthetic community. This discovery occurred during a period of advancement in capabilities and technology that allowed the development of offshore energy reserves in deeper waters, particularly in the GOM where there was some early knowledge of deepwater coral habitats. Our bureau recognized that the numerous deepwater hard bottom locations in the GOM discovered through modern industry seismic records warranted the expedited design and performance of new studies focused on deepwater coral habitats. The initial *Lophelia* study (MMS 2007-044) began in 2003, followed by others in the GOM and Atlantic regions. All of these studies involved partnering with other federal agencies—the U.S. Geological Survey and the National Oceanic and Atmospheric Administration's Office of Ocean Exploration and Research (*Lophelia* II; BOEM 2012-106 and Atlantic Canyons; AT-10-03, final report in preparation).

The follow up *Lophelia* II study (BOEM 2012-106) included observations of extensive rainbow-colored thickets of hard corals at depths of 1,400 m (4,600 ft.), extensive laboratory aquarium experiments, and documentation of coral communities on several deepwater shipwrecks. Another significant component of the *Lophelia* II project included the documentation of substantial communities of *Lophelia* coral colonizing deepwater platforms in the GOM in water depths ranging from 320 to 995 m (1,050–3,265 ft.). Not only was *Lophelia* seen on every one of the 10 platforms surveyed with a remotely operated vehicle (ROV), but new record observations were made regarding the depth distribution and growth rates of this coral species living on energy platforms. The range of *Lophelia* distribution in the GOM was considerably expanded with observations from platforms in this study ranging from the shallowest observation at 201 m (660 ft.) to the deepest at 801 m (2,600 ft.). Using the platforms' known installation date, measurement of *Lophelia* colony minimum growth (exact settlement time not known) matched record rates of 3.4 cm/yr (1.3 in./yr) reported in the much shallower waters of the North Sea.

The Atlantic Canyons study focused on Norfolk and Baltimore Canyons off the coast of Virginia and Maryland. Numerous substantial discoveries were made during this study, including the documentation of many historical shipwrecks and a vast community of chemosynthetic mussels never before seen near Norfolk Canyon. But on the subject of deepwater corals, many new discoveries and

Figure 2 (left). Well-developed *Lophelia* colonies and associated fish on portion of a subsea completion structure at depth of 450 m (1,475 ft.). *Photo courtesy of BOEM/ NOAA OER.*

Figure 3 (below). First *Lophelia* coral colony observed in Norfolk Canyon at depth of 434 m (1,423 ft.) during a study cruise in 2013. *Photo courtesy of BOEM/ NOAA OER.*



contributions to science were also made. One of these includes the first recorded observations of the coral *Lophelia* in both Baltimore and Norfolk Canyon at depths between 381 and 434 m (1,250–1,420 ft.). Numerous observations of other corals were also mapped as part of this study to understand the unique role that submarine canyons play in the Atlantic deep-sea ecosystem.

We have learned a lot, particularly about how to find deepwater coral habitats. Experiments both on the seabed and in the laboratory have shown the tolerances of coral such as *Lophelia* to extremes in temperature, pH, and burial under sediment. But we are only just beginning to understand the ecological aspects of deepwater corals, including the environmental factors that control food sources, reproduction, genetics, predation, and parasitism which regulate their life histories and distribution. Diverse and often spectacular communities of corals living in very deep water where there is no sunlight are believed to have significant connections to the surrounding oceans. Perhaps the most significant aspect of these remarkable habitats is the unknown and what we may not understand about their contributions, both to their surrounding environment and to us. BOEM is playing a significant role in providing the science to assist in answering these questions.

– Greg Boland, BOEM

For More Information:

Expedition web pages for the Lophelia II and Atlantic Canyons studies.

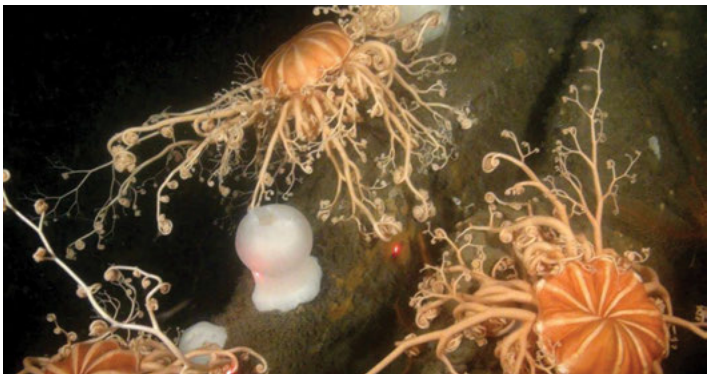
http://oceanexplorer.noaa.gov/explorations/08lophelia/welcome.html
http://oceanexplorer.noaa.gov/explorations/09lophelia/welcome.html
http://oceanexplorer.noaa.gov/explorations/10lophelia/welcome.html
http://oceanexplorer.noaa.gov/explorations/12lophelia/welcome.html
http://oceanexplorer.noaa.gov/explorations/11midatlantic/welcome.html
http://oceanexplorer.noaa.gov/explorations/12midatlantic/welcome.html
http://oceanexplorer.noaa.gov/explorations/13midatlantic/welcome.html

Pacific Northwest Study of Seafloor (Benthic) Habitats

Wave and wind conditions in the Pacific Northwest offer excellent potential for the development of offshore renewable energy, so understanding the potential consequences of siting, testing, and development of renewable energy facilities is important. BOEM has an obligation under the National Environmental Policy Act (NEPA) to identify and describe areas that may be impacted by energy development on the Outer Continental Shelf, and the Outer Continental Shelf Lands Act dictates that BOEM locate and avoid the destruction of unique or sensitive seafloor habitats.

To meet those obligations, the *Survey of Benthic Communities near Potential Renewable Energy Sites Offshore the Pacific Northwest* study was launched off the coasts of Washington, Oregon, and Northern California in 2010. This study, with Oregon State University's (OSU) Hatfield Marine Science Center, is focused on understanding the relationship between invertebrate species living in and on the seafloor with their physical environment (i.e., species-habitat relationships). By better understanding these relationships, BOEM can determine the distribution of unique species groups and predict where benthic invertebrate species of interest and unique communities may occur across this large expanse of seafloor. The study conducted surveys and collected samples in eight areas on the Pacific Northwest continental shelf over a three-year period using multi-beam sonar and backscatter, box core and sediment grab samples, and a remotely operated vehicle (ROV).

Approximately seven percent of the Pacific Northwest continental shelf (over 500 square miles of seafloor) was mapped thanks to collaborations among BOEM, OSU, other Oregon state agencies, U.S. Geological Survey, and NOAA. By integrating these new discrete seafloor areas with habitat maps collected from previous studies, researchers updated and expanded a regional map of seafloor habitat types including sand, mud, gravel, and rocky reefs. Using this regional seafloor habitat map, a suite of other Geographic Information System layers were derived, including a display of the maps' underlying data quality and a computer model that predicts the likelihood of rocky reefs existing in an area.



Basket stars in a marine invertebrate community offshore the Pacific Northwest. *Photo by Sarah Henkel, Oregon State University.*

In the first regional sampling of invertebrates in more than ten years, animals living on and in the seafloor were collected at about 400 sample stations. More unique groups of invertebrates were found throughout the study area than originally predicted; similar to sampling in southern California, water depth and sediment size are key factors for differentiating communities. From these baseline results, researchers merged the results from the seafloor mapping with the biological sampling and developed a modeling tool that predicts invertebrate species beyond the sampled area to understand regional trends, which is a tool that may reduce the need for expensive biological surveys by developers in the future.

Information from this study will be a powerful tool for determining the nature and extent of further seafloor explorations. Findings about the seafloor and the invertebrate species/communities that inhabit that environment will inform NEPA analyses and consultations with other agencies and stakeholders.

– Lisa Gilbane, BOEM

Benthic Study

- The word *benthic* refers to anything associated with or occurring on the bottom of a body of water. The animals and plants that live on or in the bottom are known as the benthos.
- Benthic habitat maps are derived from underwater video and photos, acoustic surveys, and data gathered from sediment samples. The resulting digital map is viewed using geographic information system tools.
- Policy makers, scientists, and researchers use benthic maps to make informed decisions that help protect the Nation's oceans.
- The types and abundances of animals living in a 99 percent sandy sediment environment were significantly different than communities living in a 100 percent sandy sediment environment. This means that more detailed information about the sediment size is necessary to characterize and predict animals living in sandy areas of the seafloor.
- Slow-growing and long-lived sponge and coral species were commonly found on all three rocky reefs in water depths of 160–400 ft. (49–122 m).

For More Information

BOEM *Survey of Benthic Communities* study report will be available Fall 2014 at:

http://www.boem.gov/Pacific-Completed-Studies

http://www.boem.gov/pc-10-07/

Data Viewer:

http://bhc.coas.oregonstate.edu/benthic/

Data Portal:

http://bhc.coas.oregonstate.edu/geoportal/

GulfSERPENT Discoveries Exceed Expectations

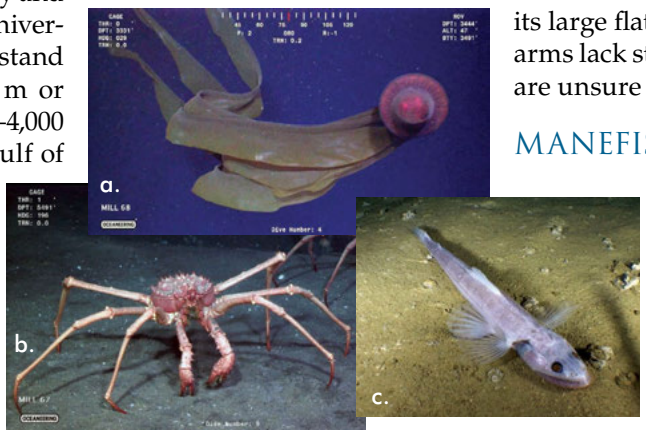
Just as the Hubble Space Telescope has provided scientists with images of uncharted territory in space, the innovative deep sea exploration project called SERPENT has delivered hundreds of exciting new images from our ocean environments. SERPENT (Scientific and Environmental ROV Partnership using Existing Industrial Technology) relies primarily on highly skilled remotely operated vehicle (ROV) teams to become part-time marine biologists of sorts—collecting and sending data, photos, and videos to the National Oceanography Centre, Southampton (UK)—while on standby or during the course of other tasks at offshore oil and gas locations

The GulfSERPENT is part of SERPENT. It is coordinated with the Department of Oceanography and Coastal Sciences at Louisiana State University (LSU), and has helped us understand life in the mesopelagic (200–1,000 m or ~660–3,300 ft.) and bathypelagic (1,000–4,000 m or 3,300–13,000 ft.) zones of the Gulf of Mexico (GOM), one of the largest offshore production areas in the world, with oil and gas exploration and production occurring at increasingly greater depths.

Field reports from GulfSERPENT have fascinated scientists with images of rare marine life.

GulfSERPENT Project Benefits

Data collected from the GulfSERPENT project will help BOEM understand mid-water biology of the deep Gulf and will be valuable for National Environmental Policy Act documents, including lease sale Environmental Impact Statements. Stakeholders of the GOM Region (the States of Texas and Louisiana, and the industry) will benefit through increased knowledge of the deepwater pelagic region. The project will also provide significant information regarding the deepwater artificial reef effect.



Examples of species observed during Gulf SERPENT include: a) *Stygiomedusa gigantea*, b) *Neolithodes agassizii*, and c) *Bathysaurus mollis*.

OARFISH

GulfSERPENT leader Mark Benfield caught extraordinary video of oarfish (*Regalecus glesne*), generally identified as the world's longest bony fish, reaching 6–8 m (19–26 ft.). Their strange appearance may have provided the basis for the sea serpent myths told by early mariners, as their prominent dorsal fin and long body gives them an unusual "serpent" appearance.

"What was interesting about the fish was its swimming behavior," said Professor Benfield. "It moved … its dorsal fin in waves that propelled it backwards at quite a good speed." Professor Benfield said this may be the first time the oarfish has been filmed alive swimming in the mesopelagic layer of the ocean, as they are usually observed dying at the sea surface or washed ashore dead.

GIANT DEEP SEA JELLYFISH

Professor Benfield was also surprised by remarkable footage of a rarely seen giant deep sea jellyfish. The huge *Stygiomedusa gigantea*, thought to be one of the largest invertebrate predators in the deep sea ecosystem, has a disc-shaped bell that can be 1 m (3.3 ft.) wide and has four arms that extend up to 6 m (19.7 ft.) in length.

After the first sighting, subsequent sightings occurred during routine work that energy companies carried out on underwater structures. The reddish-purple jellyfish was seen at depths of 996–1,747 m (3,268-5,732 ft.), and at least one jellyfish was seen attaching itself to subsea equipment using its large flattened arms. These paddle-like arms lack stinging tentacles, and scientists are unsure of their exact function.

MANEFISH

On another ROV survey in the GOM, the deep sea manefish (*Paracaristius* sp.) was observed, giving scientists rare insight into the behavior of the fish in its natural environment. It also showed them how a manefish lives and what it looks like, as manefish collected in trawls are often damaged and don't resemble a fish at all. According to Professor Benfield, seeing this fish in its natural habitat with its fins beautifully splayed out almost as a parachute indicates it's a good swimmer.

Manefish are thought to steal food from or feed on a jellyfish-like animal called a siphonophore, which may explain the need to swim so well—to avoid the stinging tentacles.

BIG FIN SQUID

ROVs in the western GOM have sighted two species (*Magnapinna atlantica* and *M. pacifica*) of big fin squid in the Alaminos Canyon area. The squid had greenish bodies with red-orange markings and appeared to be 15 ft. (4.5 m) long. Magnapinna squid, sometimes called a long-arm squid, has thin elastic tentacles thought to be 15–20 times larger than the squid's body.

Adult big fins have never been captured or sampled by scientists, but rare video footage recorded by a Shell Oil Company ROV reveals their alien-like behavior. Its ten appendages are often held at right angles to the body, which gives them the appearance of having elbows.

– Rita Hess, Schatz Publishing Group

For More Information

http://www.serpentproject.com

FWS aerial team members Troy Wilson, Walt Rhodes, and Tim Jones in front of the FWS Kodiak aircraft. *Photo by U.S. Fish and Wildlife Service*

AMAPPS Findings Close Critical Data Gaps

Since August 2010 exciting new findings have emerged from the AMAPPS (Atlantic Marine Assessment Program for Protected Species) program regarding spatial and temporal distribution and density data of marine mammals, sea turtles, and seabirds in the western North Atlantic Ocean. The data gathered is important to BOEM because of potential impacts in the U.S. Atlantic coastal and offshore waters from seismic surveys, sand and gravel operations, and various proposals for renewable energy.

Historic assessment tools and the seasons during which research was conducted left critical gaps that severely limited the ability to predict seasonal spatial distribution. This was especially true for seabirds, which disperse widely during the "nonbreeding" season. Gaps also occurred for deep-diving marine mammals and sea turtles because it simply wasn't possible for observers to see all the animals at the surface at a given time. AMAPPS changed all that by collecting data from:

- aerial and shipboard surveys that covered nearly 200,000 km of track lines and spanned all four seasons of the year;
- over 100 satellite tags attached to loggerhead turtles, harbor seals, and gray seals; and
- passive acoustic recordings of vocalizations from whales and dolphins obtained from recorders anchored to the seafloor or hydrophone arrays towed behind a ship during marine mammal surveys.

Research data reinforced baseline understandings of the coastal and pelagic distributions of marine mammals, sea turtles, and sea birds in the northwest Atlantic Ocean—and then it revealed more. For example, experts suspected egrets and herons undertook migration flights between North America and Central/South America, but there were few documented cases. In addition to the expected gulls, terns, and shearwaters, crews documented great blue herons, great egrets, and snowy egrets more than 30 miles off the South Carolina/Georgia coast. AMAPPS crews along the southeastern coast documented all three species migrating offshore in both the fall and spring.

There have also been multiple sightings by AMAPPS researchers (and on private charters) of Barolo shearwaters that confirm the species is a member of the northwest Atlantic's rare but regularly occurring late summer to fall avifauna (birds of a particular region or habitat). Previously, there had been up to 100 years between sightings of this small black-and-white seabird. Equally exciting were sightings of an endangered seabird called the Bermuda petrel by AMAPPS researchers. The sightings were confirmed with photos that document the species' encouraging recovery from near extinction.

AMAPPS Overview

AMAPPS is an inter-agency research program funded by BOEM, NOAA Fisheries Service, U.S. Fish and Wildlife Service, and the U.S. Navy. The purpose of the program is to update available data for marine mammals, turtles, and seabirds and to address critical information gaps in their assessments. For more information, go to www.nefsc.noaa.gov/psb/AMAPPS.

Other data excited AMAPPS crews as well. Surveys unexpectedly documented high densities of several species of beaked whales located throughout the shelf break and offshore waters. The highest concentrations were found about 30 nautical miles offshore of Cape Hatteras, North Carolina, offshore of Oceanographer Canyon (about 120 nautical miles southeast of Nantucket), and in the Canadian Northeast Channel (about 100 nautical miles south of Yarmouth, Nova Scotia). One day researchers saw over 110 groups and for the first time were fortunate enough to record the echolocation clicks of Sowerby's beaked whales, whose acoustic characteristics were previously unknown. Beaked whales are one of the least studied whale species because of their extreme dive patterns.

Researchers also documented how grey seals use waters around Cape Cod. Tags put on gray seals near Chatham, Massachusetts in 2013 showed that many individuals spend the entire summer swimming up and down Cape Cod, often within a mile offshore. It was not until autumn that the tagged gray seals began dispersing to Cape Cod Bay, Nantucket Sound, and adjacent waters, including one seal that traveled onto the Scotian Shelf towards Sable Island, then spent a week on Georges Bank before returning to Cape Cod. Some of the tagged seals also spent time at Muskeget Island, which is a major pupping colony. Interestingly, none of the tagged animals travelled to the traditionally known haulout sites along the coast of Maine, suggesting some level of regional site fidelity.

Another surprise was sei whale usage of waters off Georges Bank. Passive acoustic recorders deployed to listen for the songs and calls of baleen whales (e.g., blue, humpback, fin, sei, minke, and right whales) revealed that sei whales, a species of baleen whale about which little is known, were present across most sites from spring through early summer, with more acoustic activity at particular sites. These data help explain the migratory patterns, long-term seasonal distribution, and occurrence of many species, and complement what researchers learn from shipboard and aerial surveys.

AMAPPS-related research efforts also placed over 100 satellite relay data loggers on loggerhead sea turtles between Maryland and Florida. Data from the turtle-borne loggers document patterns in the turtles' surfacing behavior. In comparison to loggerheads in Florida, those in the mid-Atlantic region spend far more time at the surface and are therefore more available to be seen by aerial surveys. Documenting these newly observed patterns in the vertical distribution of loggerheads led the National Marine Fisheries Service to correct regional abundance estimates. You can view tracks of some of the tagged turtles at http://www.nefsc.noaa.gov/psb/turtles/turtleTracks.html.

– Merlin Hayes, Schatz Publishing Group

Sowerby's beaked whale. *Photo Credit: Desray Reeb, BOEM, NMFS MMPA Permit # 17355.*

Tagged grey seal. *Photo credit: D. Johnston, Duke University; NEFSC Sci.Res. Permit# 17670.*

FOR MORE INFORMATION

AMAPPS reports are available for

2010

http://www.nefsc.noaa.gov/psb/AMAPPS/docs/Final_2010AnnualReportAMAPPS_19Apr2011.pdf

2011

http://www.nefsc.noaa.gov/psb/AMAPPS/docs/NMFS_AMAPPS_2011_annual_report_final_BOEM.pdf

2012

http://www.nefsc.noaa.gov/psb/AMAPPS/docs/NMFS_AMAPPS_2012_annual_report_FINAL.pdf

2013

http://www.nefsc.noaa.gov/psb/AMAPPS/docs/NMFS_AMAPPS_2013_annual_report_FINAL3.pdf

BOEM OCEAN SCIENCE
Bureau of Ocean Energy Management
Mail Stop GM 676E
1201 Elmwood Park Boulevard
New Orleans, LA 70123

Prstd Std
US Postage
PAID
Nia. Falls, NY
Permit No. 28

New Waves

Late-Breaking News & Information

BOEM Ocean Science Wins National Communications Award

The National Association of Government Communicators (NAGC) honored ***BOEM Ocean Science Magazine*** this past summer with an "Award of Excellence" in the Magazines category of its 2014 Blue Pencil & Gold Screen Awards.

Ocean Science Editor-in-Chief Melanie Damour, a marine archaeologist with the Gulf of Mexico Regional Office, was the principal contributor listed for the award nomination, along with the *BOEM Ocean Science* Editorial Board (listed on page 2) and Schatz Publishing Group.

The NAGC Blue Pencil & Gold Screens Awards Competitions salutes superior communications efforts of government agencies and recognizes the people who create the products. Blue Pencil Award categories are designed for writing, editing, photography, and published products, such as magazines, books, newsletters and other materials. Gold Screen Award categories recognize audiovisual and multimedia products, including broadcast and internet-based products.

The NAGC is a national not-for-profit professional network of federal, state, and local government employees who disseminate information within and outside government.

NAGC
National Association of Government Communicators