OCEAN LIFE INSTITUTE

2011 Annual Report

Woods Hole Oceanographic Institution

Director's Message

Photo of Simon Thorrold by Tom Kleindinst, WHOI

Human activities are taking an increasing toll on ocean life. Fishing activities around the globe continue at unsustainable levels to the detriment of local stakeholders and the functioning of coastal and oceanic ecosystems. Warming ocean temperatures and ocean acidification will also continue to negatively impact ocean life.

Acknowledging that these pressures will increase significantly in the next decade, the Ocean Life Institute is committed to supporting WHOI researchers who are addressing critical questions in ocean conservation science. As you'll read in the pages of this report, these endeavors are often cross-disciplinary collaborations between scientists and engineers that help to foster technological innovations that in turn facilitate cutting-edge science with direct relevance to societal imperatives.

The Ocean Life Institute is also developing new initiatives that serve as a focus for research efforts at a certain location or on a specific topic. For instance, OLI has been instrumental in the planning of a research expedition to the Phoenix Islands Protected Area (PIPA), part of the island nation of the Republic of Kiribati in the central tropical Pacific Ocean. The June 2012 cruise is made possible by generous philanthropic gifts to WHOI by the Ray Dalio and the Thomas W. Haas Foundation. With the support of the Kiribati government, WHOI researchers and collaborators are helping to ensure that strong basic science will inform conservation and policy in this nation and both the collaboration and its results will serve as a model for other critical conservation needs in the world ocean. We hope to further facilitate such initiatives in the coming year.

Simon Thorrold, OLI Director

Can you hear me now?

Sensory studies may offer insight into squid evolution

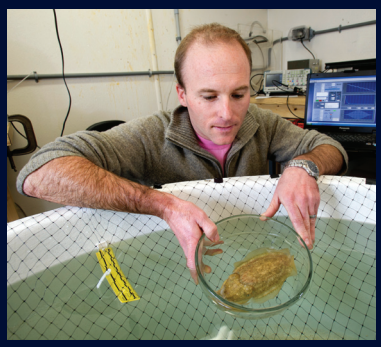
Hearing is a key sense for many marine animals and is fundamental to many critical vertebrate and invertebrate behaviors. Yet, there has been little investigation of hearing or sound responses in most marine invertebrates. It is particularly surprising to Assistant Scientist Aran Mooney that there are few studies of hearing for cephalopods. Octopus, squid, cuttlefish and others in the family display sophisticated behaviors and play a critical role in ocean food webs.

Mooney's recent work demonstrated that sounds stimulate physiological 'auditory' responses in one squid species, *Loligo pealeii*, providing the first strong evidence that squid can hear. With funding from the Ocean Life Institute, today he is trying to understand *why* they hear.

"Despite physiological responses, it is unclear how squid may use sound, if they behaviorally respond, and whether this behavior occurs in other species," Mooney explained. "Addressing these questions is necessary to understand the function and importance of hearing in this crucial marine invertebrate."

In the first part of his study, Mooney

and guest student Julia Samson of the Netherlands are testing behavioral responses to sound in a dozen cuttlefish. In their Woods Hole lab, they place the cuttlefish, one by one, into a test tank. After letting each cuttlefish acclimate to the tank, they play sounds of various frequencies (80-500 Hz) and levels, then observe what the cuttlefish do in response. Some react by swimming away from or toward the sound, some squirt ink, some change color, and others do nothing at all. Mooney and Samson know each animal as if they were family pets; in one experiment Mooney was able to predict the exact color change a certain cuttlefish made in response to sound.



WHOI biologist Aran Mooney places a cuttlefish, a close relative of squid, into a tank to test how it responds to sound.

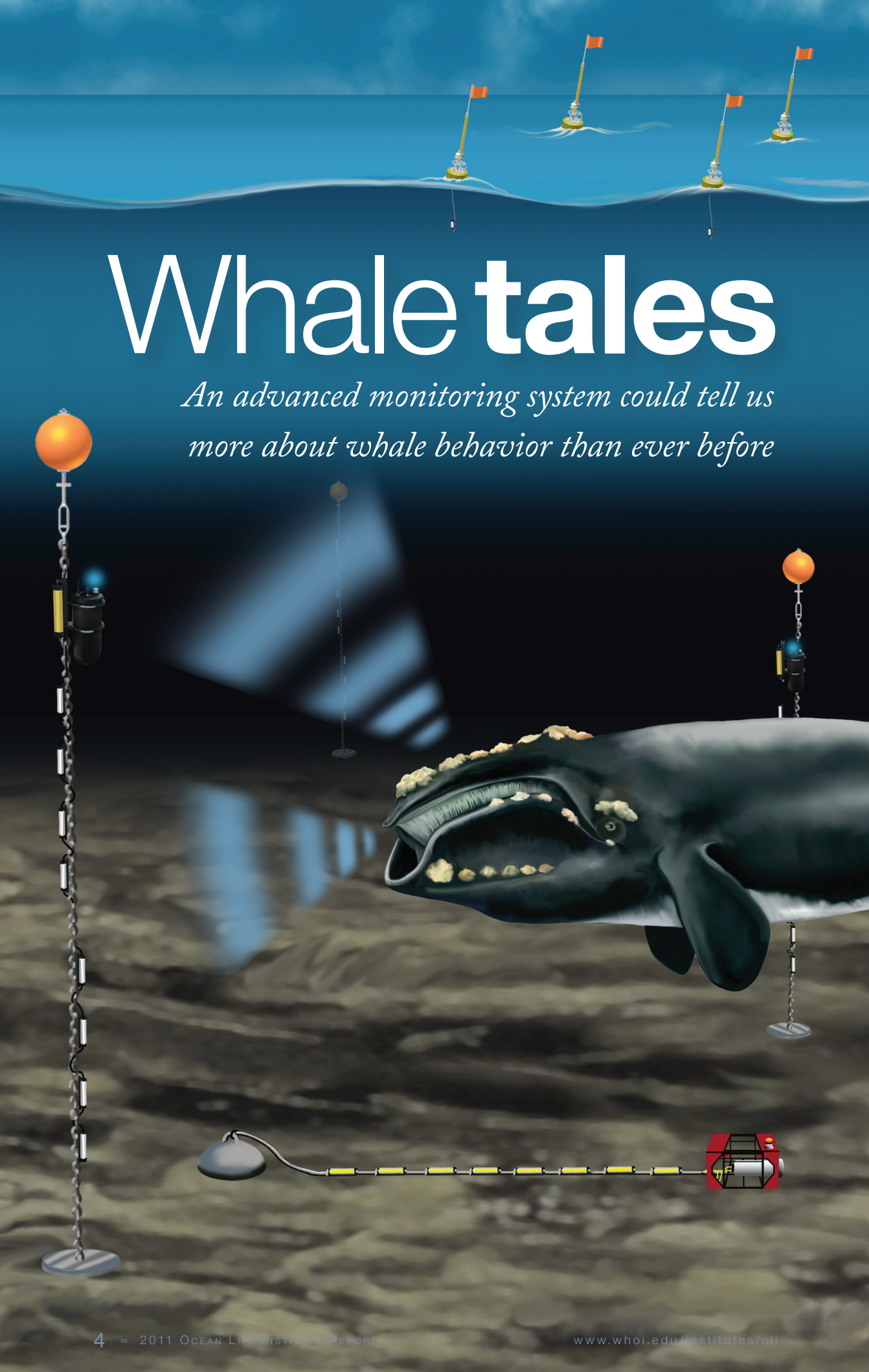
Later this year Mooney will travel to the Azores and to Monterey, California, to work with cephalopods too large for his Woods Hole holding tanks: *L. forbesi* and *Dosidicus gigas*, also known as the jumbo Humboldt squid. The Humboldt squid can grow up to five feet long and can weigh up to 100 pounds, and they represent an important part of the Pacific squid fishery. To test its hearing, Mooney must catch one, locate a quiet harbor, and suspend the sedated animal from a dock.

The studies may reveal whether squid are sensitive to manmade sounds in the ocean, such as shipping or construction noise, as well as build new collaborations and broaden the Institution's research base toward investigating the sensory systems of marine animals.

"The data we are collecting will give us information not only about hearing, but also will offer new insights into how sensory systems evolve," Mooney added.

The Ocean Life Institute awarded Aran Mooney $68,831 for his study, "Can squid really hear? Behavior, directional responses and hearing diversity in cephalopods."

Photos by Tom Kleindinst, WHOI.

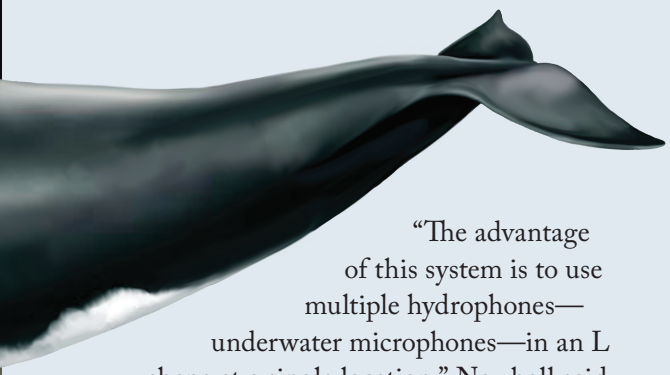


Whale **tales**

An advanced monitoring system could tell us more about whale behavior than ever before

When Ying-Tsong Lin describes a new passive acoustic monitoring system he's testing as an air traffic control system of sorts, he's not far off the mark. Along with fellow Applied Ocean Physics & Engineering Department member Arthur Newhall and biologist Mark Baumgartner, Lin can track the location of a whale miles away using a single moored array.

With funding from the Ocean Life Institute, the trio is bringing together years of research on underwater sound propagation physics, marine mammals, physical oceanography and signal processing to devise an advanced whale monitoring and tracking method using a single integrated horizontal and vertical hydrophone array. Their novel approach has the potential to monitor and track whales over larger spatial scales than previously possible, up to 20 kilometers, and will enable better understanding of animal behavior and marine acoustics.



"The advantage of this system is to use multiple hydrophones—underwater microphones—in an L shape at a single location," Newhall said. "This technology and technique enables us to collect far more data and information about a whale vocalization than we were able to before."

Multiple hydrophones, Lin explained, helped the researchers separate the different travel times from different sound frequencies into their many components. Sounds bend and twist depending on the surfaces they come in contact with between the source and an underwater microphone. A whale vocalization, for example, could sound like a single "gunshot" to the human ear; however, these highly-sensitive hydrophones pick up the many pathways of a single sound, what researchers call independent arrivals. They analyze these arrivals to infer the location of a vocalizing whale.

They tested their array in April 2011 in Cape Cod Bay, an important seasonal habitat of the endangered North Atlantic right whale. Earlier studies had shown that right whale vocalizations made in this area contain significant low-frequency energy which, including a sandy bottom environment, will provide good conditions for underwater sound propagation. They focused on long-distance detection and tracking of right whales over a 22-day period. By testing the new array against previously proven methods of sound collection, the team found that the new system is not only an accurate tool for long-range, long-term whale localization, but would also passively acquire information to determine a whale's depth and the signal it vocalized, data unavailable previously.

"No one has studied the interaction between different species of marine mammals," Baumgartner said. "Right whales and humpbacks, for example, make similar sounds, as seen in our Cape Cod Bay data, and I believe they recognize each others' calls. This passive acoustic monitoring system could help us investigate these interactions."

The group is now working on a paper to document the Cape Cod Bay studies and is looking for ways to leverage the OLI support for larger federal grants.

"OLI support allowed me access to physics and acoustics expertise that just doesn't exist in the biology world," Baumgartner added. "The three of us come from different disciplines, and it's rare to find funding to make something like this happen."

Ying-Tsong Lin, Arthur E. Newhall and Mark F. Baumgartner were awarded $60,070 in 2010 for their study titled "Examination of an Advanced Whale Monitoring Technique Using Passive Acoustics in Cape Cod Bay."

Illustration by E. Paul Oberlander, WHOI

Sea

The barren, rocky cliffs of coastal Terre Adelie, Antarctica, don't appear to be the most hospitable place to raise a family, but the southern fulmar have been doing just that for generations. They brave a number of threats—snow, wind and egg-stealing seabirds, for example—because this location has offered proximity to melting sea ice, providing a source of abundant food. However, as sea ice shrinks, biologists Stephanie Jenouvrier and Julie Kellner are wondering what this new threat means to the southern fulmar.

Jenouvrier and Kellner are among the scientists studying climate change from a different point of view. They are seeking to better understand the link between climate and species—in their case, the southern fulmar—by linking climate models to demographic models using information ascertained from mapping their foraging behaviors. They hope this data will enable them to predict seabird population responses to climate change.

"Seabirds are good bio-indicator species of the ecological consequences of climate and oceanographic changes because they are long-lived, upper trophic-level predators, and therefore, integrate the environmental effect on the food web at large scales," Jenouvrier explained.

Monitoring and describing the ecology and demography of seabirds is the first goal of their project, and Jenouvrier spent much of fall 2011 in Terre Adelie conducting long-term demographic surveys of several seabirds breeding in the southern ocean from Antarctica, as well as deploying monitoring devices to track them at sea.

"The southern fulmar is an impressive bird because it can travel all around Antarctica," she said. "The colony is very small in Terre Adelie; the population size fluctuates around 60 individuals, and last year there were fewer birds."

The data that Jenouvrier collected,

ice and the survival of Antarctic seabirds

Field observations, demographics and mathematical modeling intersect to predict the fate of the southern fulmar

Assistant Scientist Stephanie Jenouvrier checks the nests of breeding southern fulmar in Antarctica.

both through observation and satellite tracking of the seabirds, indicate that shrinking sea ice is jeopardizing their life cycle. Like their more famous neighbors, the emperor penguins, southern fulmar and other Antarctic seabirds depend on sea ice for survival. Sea ice is a critical habitat for polar species that provides a platform for resting, molting, feeding and breeding. It also serves as a grazing ground for krill, tiny crustaceans that thrive on algae growing on the underside of the ice and provide food for seabirds and marine mammals. Climate model simulations developed by the Intergovernmental Panel on Climate Change project that Antarctic sea ice will shrink dramatically by the end of the century. As sea ice retreats, the southern fulmar have to fly farther to obtain food and leave their young for longer periods—deadly options for both adult and fledgling birds.

"As sea ice shrinks, southern fulmars are forced to forage farther and may expend more energy, compromising their own survival and their ability to raise their chicks," Jenouvrier explained. "Species that live long have several opportunities to reproduce and thus adults are less likely to sacrifice their own survival for chicks, so the next generation is jeopardized as foraging trips become longer."

In spring 2012 the team has been developing mathematical models that project the southern fulmar's population growth and decline based on observations of the birds' mating, breeding, and feeding behaviors, as well as birth and mortality rates. By coupling population models with projections of Antarctic climate change and resulting loss of sea ice, they hope to accurately predict what will happen to the southern fulmar's population under various climate scenarios.

"This approach can be applied to other seabirds and marine organisms sensitive to sea ice changes," Jenouvrier added, "and will help guide conservation and management programs."

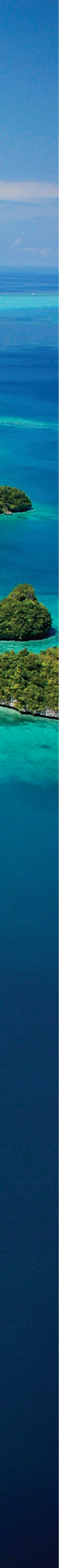
The Ocean Life Institute awarded Stéphanie Jenouvrier and Julie Kellner, both of the Biology Department, $74,993 for their study "Impact of climate changes on an Antarctic seabird: Linking foraging behaviors to demography."

Photos courtesy of Stéphanie Jenouvrier, WHOI

Clues from the Pacific

Post-doctoral fellow hunts for secrets to coral reef resiliency in high carbon dioxide waters

Tom Kleindinst, WHOI; Palau Islands ©Dreamstime.com



For scientists who study the impacts of ocean acidification (OA)—the process by which the ocean becomes more acidic in response to increased levels of dissolved carbon dioxide from the atmosphere—the remote South Pacific island nation of Palau presents quite a challenge. Around the world, researchers have monitored declines in reef communities that may be linked to OA. Portions of Palau's reefs, however, are thriving despite high levels of carbon dioxide.

> **"Earth's carbon cycle connects everything: land, atmosphere, ocean and life.** *—Katie Shamberger*

Katie Shamberger loves this challenge. A Southern California native who grew up a stone's throw from the Pacific and fell in love with reefs during an undergraduate semester in Turks and Caicos, she recently accepted an appointment as an Ocean Life Institute post-doctoral fellow and jumped at the chance to work in Anne Cohen's lab. Her first assignment? An expedition to Palau to study reef ecosystems.

"Earth's carbon cycle connects everything: land, atmosphere, ocean and life," explained Shamberger, who earned her Ph.D. in chemical oceanography from the University of Washington in 2011, "and one change in the cycle can change everything in the cycle. My interest is in examining coral reef ecosystems and how the ecosystem as a whole responds to changing carbon dioxide levels."

Coral reefs, which harbor abundant fauna from microscopic organisms to large sharks, are sensitive to small variations in ocean temperature, light, salinity and other chemical changes. As the ocean becomes more acidic, corals and other calcifying organisms—like shrimp and oysters—begin to lose their ability to build new skeletons. Scientists at WHOI and around the world are looking to coral reefs to help them understand the role of carbon dioxide in ocean health and climate change.

Levels of carbon dioxide can vary not only from reef to reef, but also within a single reef community. What excites Shamberger about the reefs of Palau is that levels of carbon dioxide in waters in the inside the barrier reefs are much higher than ocean water outside the reefs, yet they support a "beautiful" community of ocean life.

"By looking at entire reef ecosystems, we might see some variability in the ecosystem response to increasing carbon dioxide that will help us understand why some reefs can thrive in acidic conditions, like those we found in Palau," she said. "We've locked ourselves into a certain amount of OA and some say we can expect entire reef systems to collapse as early as 2050. I believe that understanding reef communities, like those in Palau, might help us make better decisions about conservation."

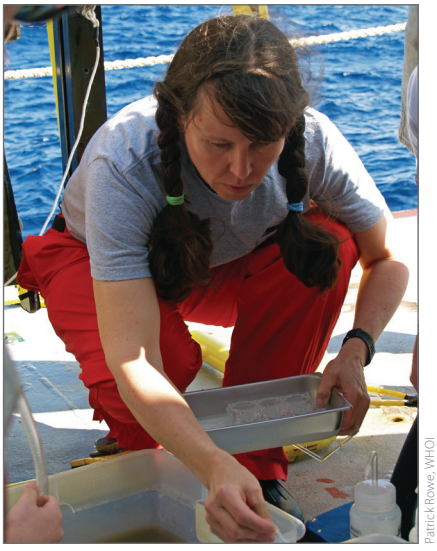
Shamberger had been looking for a way to join Cohen's lab long before her 18-month OLI-funded appointment at WHOI. The fellowship allows her the freedom to explore different research interests without being tied to a single grant or federally-funded project. Eventually, she hopes to teach and conduct research in an academic setting.

"WHOI is a great place to be a post-doc," she added. "If I have a question about any area of ocean science, there's someone here I can discuss the question with."

The Ocean Life Institute awarded Katie Shamberger $85,000 to conduct research as a post-doctoral fellow. She also is working with Dan McCorkle (Geology & Geophysics) and Steve Lentz (Physical Oceanography) on the Palau project.

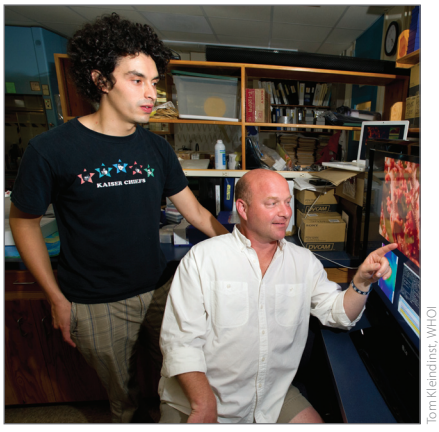
More research from the OLI

In 2011, the Ocean Life Institute awarded approximately $552,749 to new research projects. In addition to the scientists and science featured on the preceding pages, Fellow Lauren Mullineaux has been named and the following studies are underway.



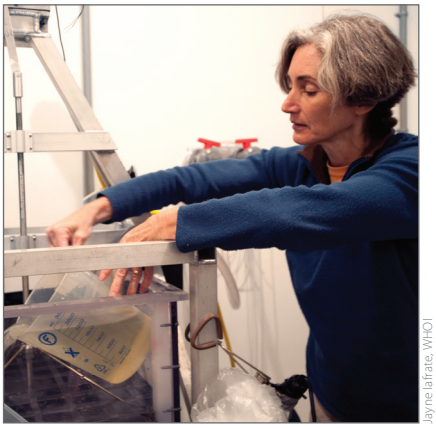
Patrick Rowe, WHOI

Senior Scientist **Joan M. Bernhard** of the Geology and Geophysics Department was awarded $65,000 for her study, "CSI Microscale: Calcification Scene Investigation of calcareous microbenthos—method development and test case." From a scene right out of the "CSI" television franchise, where crime scene investigators use a barrage of high-tech methods to solve their assigned cases, Bernhard is attempting to unravel the mystery of calcium carbonate formation in deep-sea organisms called calcareous microbenthos, things like foraminifera and microscopic bivalves and gastropods. These tiny creatures, which live in or on the seabed, are difficult to study, but researchers believe they can offer great insight into historical changes in climate. Bernhard is seeking to overcome those difficulties by developing a new tool to measure calcium carbonate formation. This project is funded jointly by OLI and the Ocean and Climate Change Institute.



Tom Kleindinst, WHOI

Associate Scientist **Timothy Shank** and Joint Program student **Santiago Herrera**, both of the Biology Department, were awarded $47,784 to study "The Development of Novel Genetic Markers in Coral Communities Impacted by the Deepwater Horizon in the Gulf of Mexico." They are acquiring novel genetic data from deep-water corals and their associate species to determine the potential impact of the loss of coral communities as a result of the Deepwater Horizon spill. Through the development of high-resolution genetic markers, they are assessing population genetic connectivity and parameters associated with potential deep-water coral community recovery in the Gulf of Mexico. Shank was among a team of scientists that reported in the March 26 issue of the journal *Proceedings of the National Academy of Sciences USA* that they found "compelling evidence" that the *Deepwater Horizon* oil spill has impacted deep-sea coral communities in the Gulf of Mexico. This project is funded jointly by OLI and the Deep Ocean Exploration Institute.



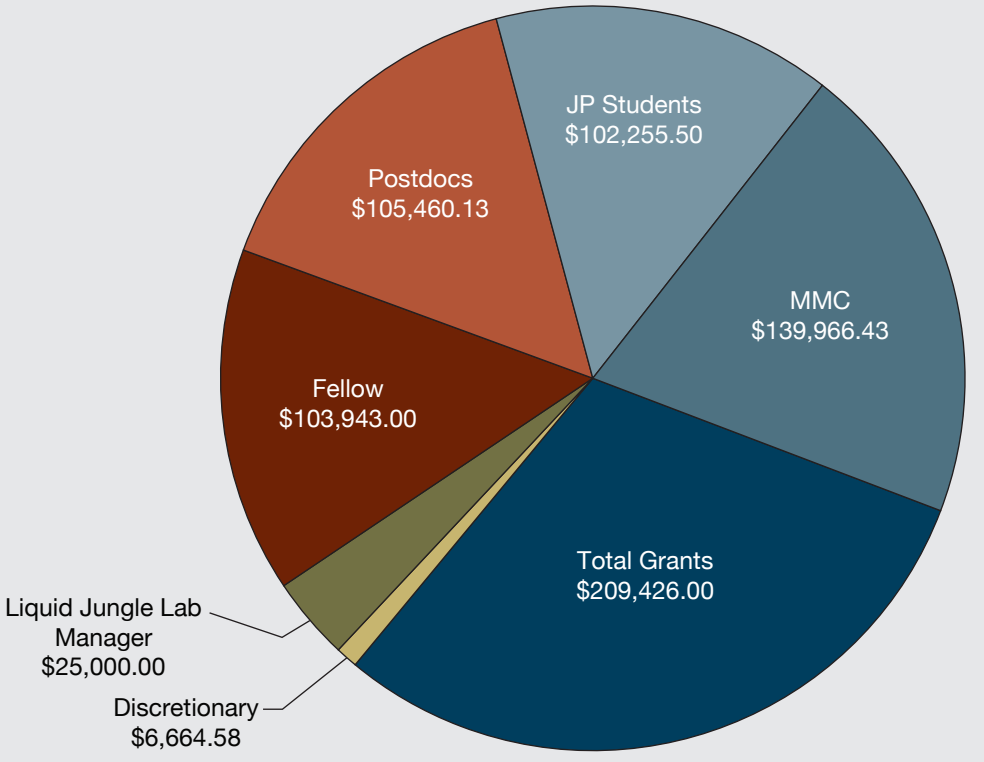
Jayne Laffaite, WHOI

Lauren Mullineaux, 2011-2014 Fellow, studies the ecology of marine benthic habitats. She is particularly interested in how the dispersal of invertebrates in their larval stage influences population dynamics and community structure. As a fellow, she is synthesizing information on larval exchange and community resilience in the deep sea in order to understand the effects of natural and man-made disturbance and help guide international decision-making about deep-sea resources.

Funding highlights

The total spending for OLI in 2011 was $692,715.64. Although the majority of OLI's funds supported research grants for four projects and the Marine Mammal Center, additional support included an OLI fellowship that provides three months of salary support for Lauren Mullineaux, educational activities and communications. Supported researchers include postdoctoral scholars Ying Zhang and Katie Shamberger, and MIT/WHOI Joint Program Ph.D. students Whitney Bernstein and Wu-Jung Lee.

2011 OLI Spending: $692,715.64



About the Ocean Life Institute

The Ocean Life Institute's mission is to launch high-risk, high-reward research that would not otherwise get off the ground—or in the water. The OLI builds bridges between different scientific disciplines to catalyze innovative thinking and collaboration that can open up wholly new scientific vistas. A center of action and source of information about the ocean, the OLI focuses its activity on research themes. It convenes meetings of key scientists and leaders from academia, government and industry to delve into research issues that have significant bearing on society.

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Cover: A scuba diver swims over a tropical coral reef in Palau.
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