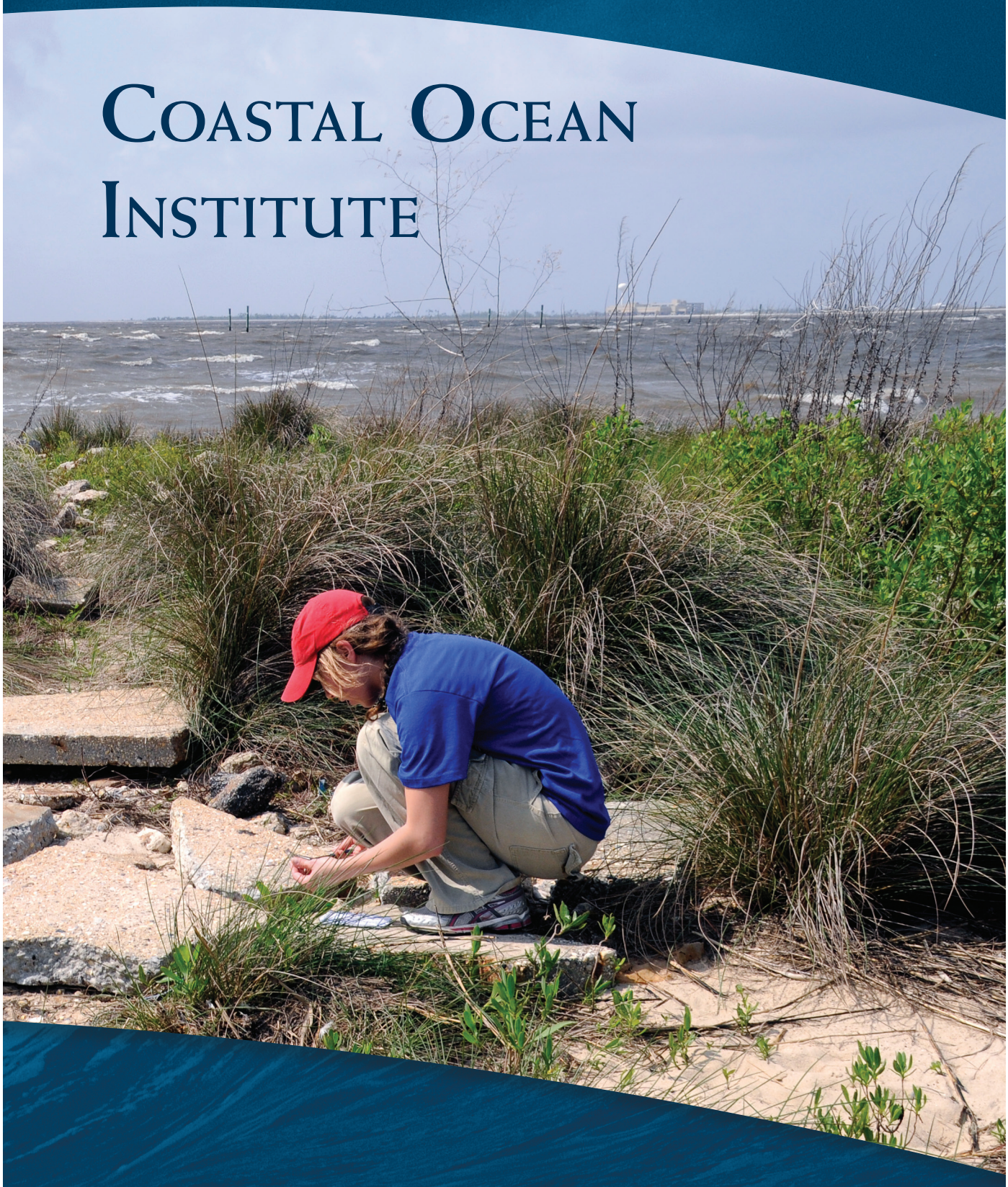
Coastal Ocean Institute



2010 Report

Woods Hole Oceanographic Institution

Director's Message

Photo courtesy of Chris Reddy, WHOI

It has been a busy year for the Coastal Ocean Institute (COI) and me personally, with many of our scientists responding to the Deepwater Horizon disaster. COI supported rapid-response funds during the initial stages of the spill, before federal grants could be obtained. I am proud of the research by our scientists, many of whom have been funded by COI over the years. Their contributions have been novel, fair and timely.

In this year's annual report, we highlight how past research support continues to impact our scientists and their research portfolios. These examples underscore how relatively small starter grants from the COI can blossom into larger projects, and that success in science often is not immediate. It takes time for research projects to mature and for opportunities from federal agencies to advance such work. These COI grants also allow scientists to take a chance and delve into new fields. In the ever-competitive world of federal funding, scientists often are not afforded the luxury to try something new. Institute funding enables just that.

Last, we recognize the vision of Don Anderson, senior scientist in the Biology Department and former COI director, in supporting graduate students. He recognized that these young scientists need to learn how to write proposals to gain their own funds. The process of applying for and obtaining funding provides practice, insights into the career of a research scientist, and a confidence boost. Don has had an outstanding career studying red tides, but one of his greatest legacies will be his vision to help graduate students early in their careers. I'm honored to follow Don's lead.

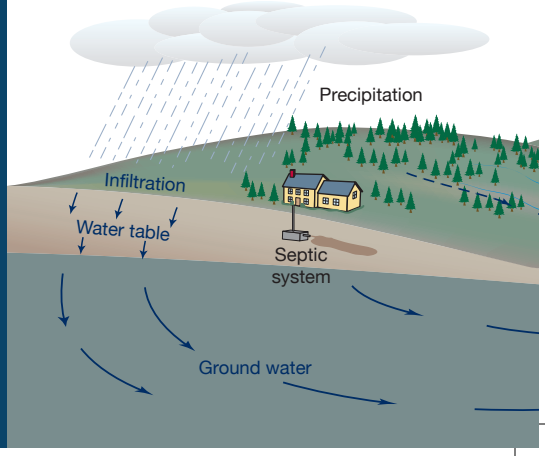
Thank you again for your continued interest in and support for Woods Hole Oceanographic Institution (WHOI) and our work at COI.

—Chris Reddy

Institute funding helps WHOI lead a new field

Matt Charette (dark vest) and Matt Allen work at Pamet Harbor, Truro. The illustration below shows the hydrologic cycle in coastal zones; tides and mixing along the freshwater-saltwater interface result in seawater circulation through the sediments.

In 2010, the Coastal Ocean Institute awarded $49,670 to Ann Mulligan and Matthew Charette to study "Modeling Radium Fate and Transport in a Subterranean Estuary."



Scientists like Matthew Charette of WHOI's Marine Chemistry & Geochemistry Department believe that groundwater discharge is an important factor for determining the chemistry of the coastal ocean. As fresh groundwater flows toward the sea, it rises up over denser, salty water. The fresh and salty water mix along the interface, pick up chemicals from a variety of processes, discharge at the shoreline, and influence an abundance of plants and other living species along our coasts.

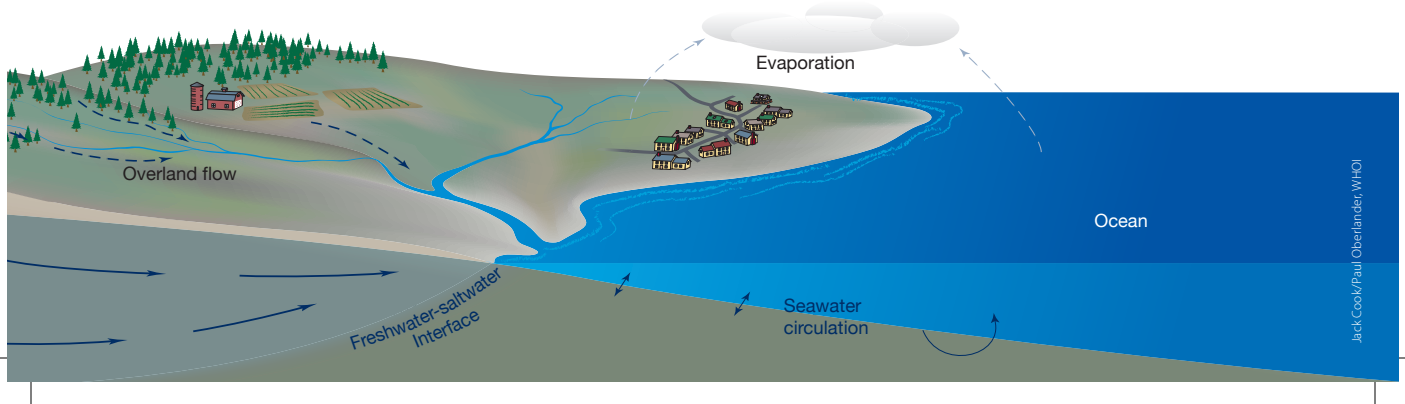
Just a few years ago, this field of study was in its infancy. Thanks to regular funding from the Rinehart Coastal Research Center (an endowment provided by Trustee Gratia Rinehart Montgomery) and the Coastal Ocean Institute (COI), this research topic is thriving and making valuable advances to science that, in turn, impact coastal management and policy. At WHOI alone, this work has resulted in more than 50 published articles over the last decade.

"Rinehart and COI have had a great impact on the field of groundwater discharge," said Charette said, who has received COI funding for seven research projects as well as a COI fellowship. "Early in my career, this area was new and federal funding was very difficult. A disproportionate amount of new work in the field was funded by philanthropy and conducted at WHOI."

When new areas in scientific research emerge, federal funding often lags behind. Institutions like WHOI are often the only source of support for these high-risk endeavors. For example, COI funding in 2010 is allowing Charette and co-principal investigator Ann Mulligan to undertake the first attempt at transient spatial modeling of radium fate and transport in a coastal aquifer, a significant step forward in unraveling the complexities of radium behavior in groundwater discharge. COI's support, Charette explained, leads to acceptance of the field and eventual funding from federal agencies.

Funding from the Ocean Institutes not only advances science; it also advances the development of young scientists. Charette is grateful to COI for regular support of students—"they work on ideas we otherwise don't have funding to pursue"—and for his fellowship in 2001.

"The COI Fellowship was a game-changer for me," he explained. "Fellowships allow us to take on additional Joint Program students or post-doctoral scholars and explore so many other new paths of research. You can't pursue ideas without people, and the fellowship allowed me to fund the people I needed to help me with my work."

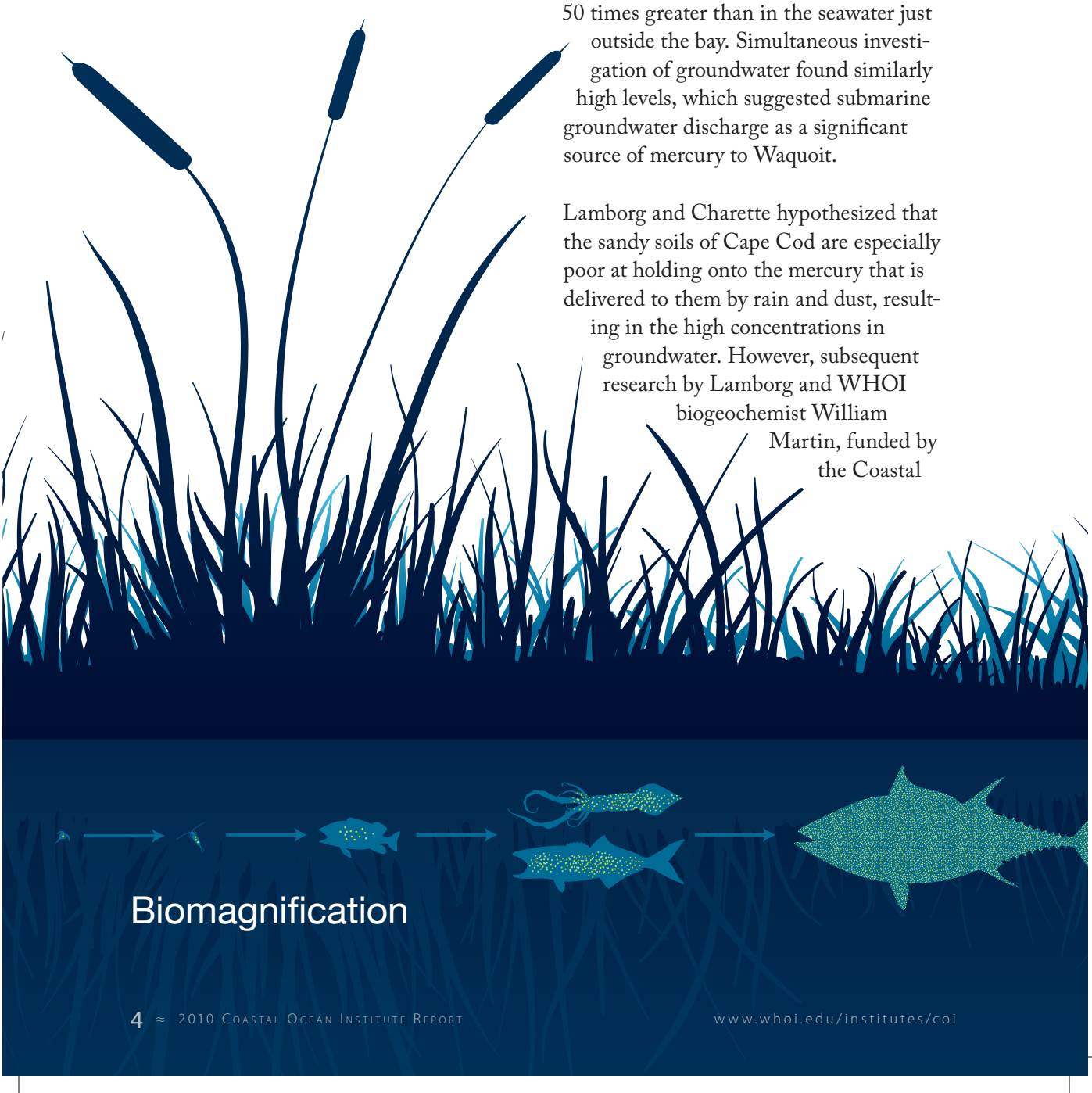


Mercury study

Mercury is a toxic metal released to the environment by natural and human-related processes. While present at very low concentrations in air and water (well below levels that are directly dangerous), the mercury released to the environment perniciously finds its way into seafood, accumulating to concentrations that can be hazardous to humans and wildlife that eat fish. The accumulation of mercury is widespread, and many fresh and saltwater bodies in the U.S. and elsewhere contain fish that authorities warn should not be consumed on a regular basis. Cape Cod is no exception; many of the local fish that have been studied show unusually high concentrations of mercury for the particular species studied when compared to other locations.

During work conducted in Waquoit Bay, Mass., in 2005 in collaboration with Matt Charette and Sharon Bone of the WHOI Marine Chemistry and Geochemistry Department, biogeochemist Carl Lamborg found concentrations of dissolved total mercury in the bay water that were almost 50 times greater than in the seawater just outside the bay. Simultaneous investigation of groundwater found similarly high levels, which suggested submarine groundwater discharge as a significant source of mercury to Waquoit.

Lamborg and Charette hypothesized that the sandy soils of Cape Cod are especially poor at holding onto the mercury that is delivered to them by rain and dust, resulting in the high concentrations in groundwater. However, subsequent research by Lamborg and WHOI biogeochemist William Martin, funded by the Coastal



Biomagnification

opens new lines of inquiry

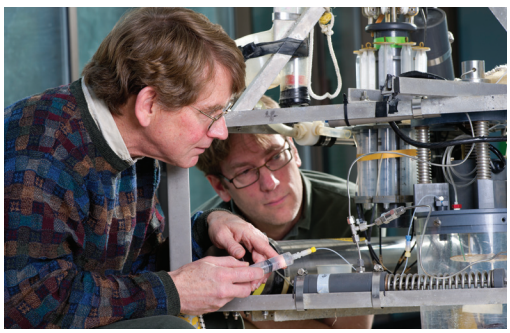
Ocean Institute, indicates that local wastewater management practices are the more likely cause. Specifically, their findings suggest that the widespread use of residential septic leach fields on Cape Cod could be responsible for an elevated delivery of mercury to the coastal zone. The researchers currently have articles in development for at least two publications to scientific journals.

"We think this is a critically important and understudied phenomenon," Martin said. "Biogeochemistry in permeable sediments is an understudied topic in general, and pursuing the study of mercury in Waquoit Bay can help develop this field to a significant degree."

COI funding of this project advanced ocean science in significant ways. First, it gave Lamborg and Martin the freedom to pursue and advance the science on an increasingly important topic on the Cape and in other rural coastal areas. The support also supplied the researchers with an investment that they are now actively working to leverage by pursuing much larger federal grants. Lastly, it has broadened Lamborg's research interests.

"I'm really interested in the whole wastewater/groundwater issue for mercury now," he explained, adding that the project funding also allowed him and Martin to collaborate with WHOI researchers—Senior Research Assistant Joanne Goudreau, Postdoctoral Scholar Paul Drevnick and summer guest student April Abbott—as well as scientists from the U.S. Geological Survey.

COI provided $75,000 in 2007 to Carl Lamborg and William Martin for the proposal "Mercury in Bays and Ponds of Cape Cod."



Tom Kleindinst, WHOI

William Martin (left) and Carl Lamborg deployed a benthic chamber to measure mercury levels in Waquoit Bay.

Fish accumulate monomethylmercury (MMHg) through biomagnification, the natural process that allows a substance to build up to toxic levels as it travels up the food chain. With MMHg, biomagnification starts at the base of the food chain. Phytoplankton contain 10,000 times more MMHg than the seawater around them. The phytoplankton are eaten by zooplankton, which are eaten by small fish, which are eaten by squid and larger fish, which are eaten by still larger fish, dolphins, and whales. None of these animals can readily get rid of MMHg, so it accumulates in their tissues. Each step up the food chain results in an increase in MMHg concentration. Large predator fish such as shark and tuna have about 10 million times more MMHg than seawater—enough to pose health risks to people.

In the mix

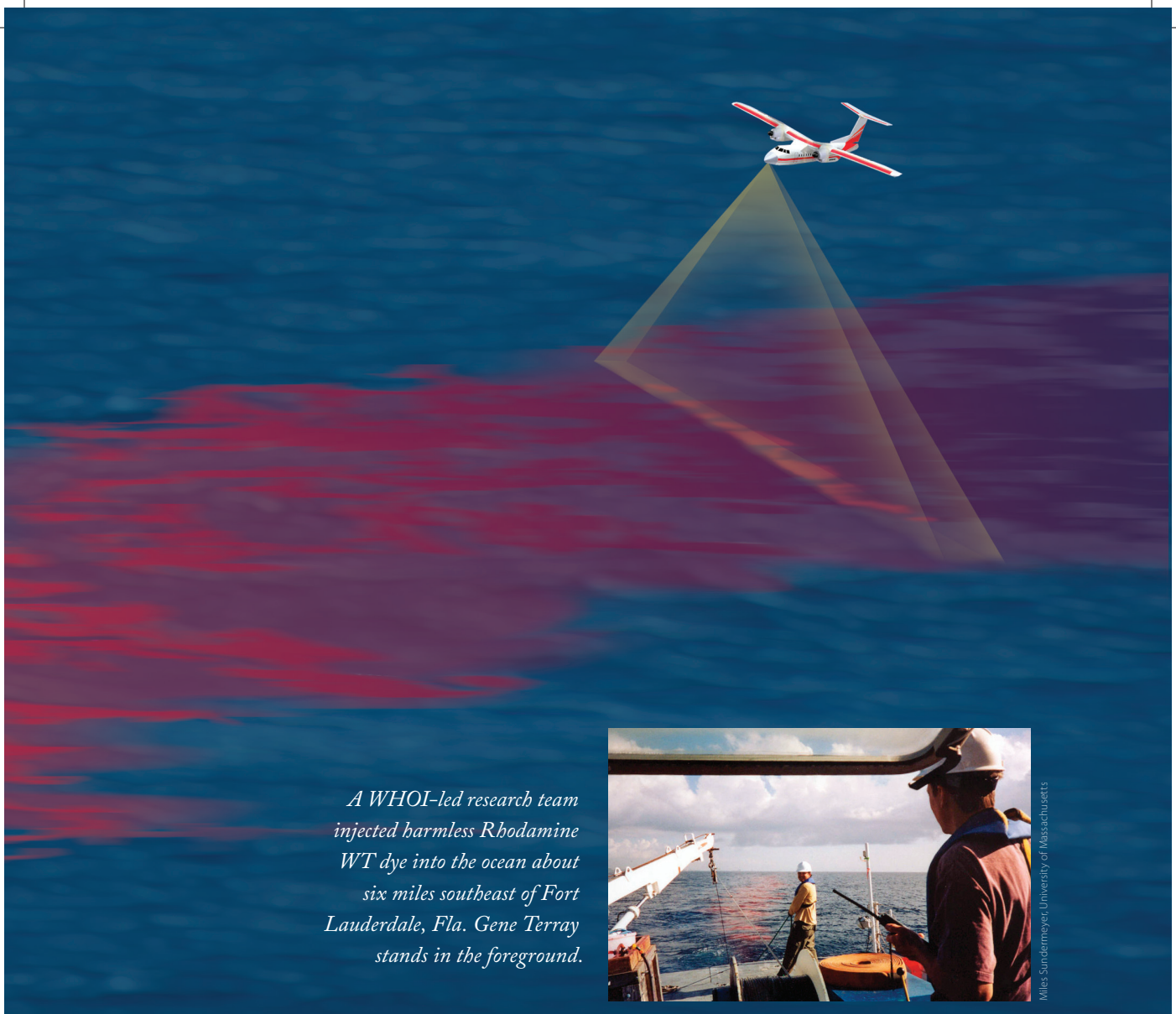
Institute funding seeds new ideas and leverages support

Research Specialist Gene Terray tracks the motion of the ocean. It's a tricky thing to do; water sloshes and streams in all directions—pushed and pulled by winds, tidal forces, Earth's rotation and differences in heat and salt. Better understanding of how water mixes at all levels of the ocean is important because mixing has a profound influence on ocean health, coastal processes and policy, and global climate.

The Coastal Ocean Institute also is in the business of studying mixing, not just in the laboratories, but also in its philosophy. Through funding for high-risk research projects, COI provides the leverage for scientists to pursue even greater federal funding. Terray knows this well.

In 2004 Terray, Senior Scientist Jim Ledwell and Guest Investigator Miles Sundermeyer of the Applied Ocean Physics and Engineering Department submitted the proposal "Airborne Light Detection and Ranging (LIDAR) Mapping of Dispersion and Mixing in the Coastal Ocean" to COI and were awarded $41,643. Those funds allowed them to complete the analysis of a pilot experiment to map the motion of fluorescent dye in the ocean by surveying it from an airplane equipped with a LIDAR instrument. LIDAR uses pulses of laser light and their reflection to excite fluorescent dye so that the scientists can observe the forces that pull it through the ocean.

The work led to three published papers and presentations in 2005-07, an idea for measuring the impact of coastal winds on ocean mixing, and more.



A WHOI-led research team injected harmless Rhodamine WT dye into the ocean about six miles southeast of Fort Lauderdale, Fla. Gene Terray stands in the foreground.

Miles Sundermeyer, University of Massachusetts

"COI support came at a critical time, and allowed us to push the analysis through while the data were fresh and our enthusiasm high," Terray said. "The fact that COI support isn't targeted to specific fields or interest areas is especially important. Our research has traditionally been difficult to fund through federal agencies. The breadth of the COI call for proposals allowed us to move this work forward, and today we're seeing the added benefit of greatly increased federal funding."

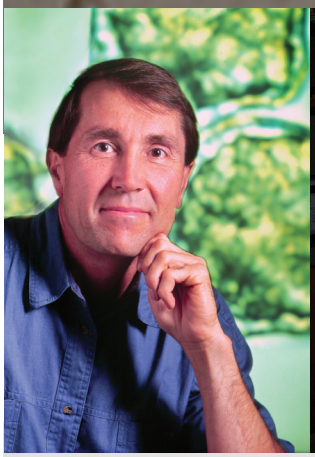
In a subsequent project funded by COI, Terray is investigating the performance of Doppler SODAR (sonic detection and ranging) for profiling winds in the coastal marine atmospheric boundary layer (MABL) from the Martha's Vineyard Coastal Observatory Air-Sea Interaction Tower. The aim is to provide a new tool for studying the complex interaction between the atmosphere and the coastal ocean arising from the differences in the surface heat flux and roughness between the land and water.

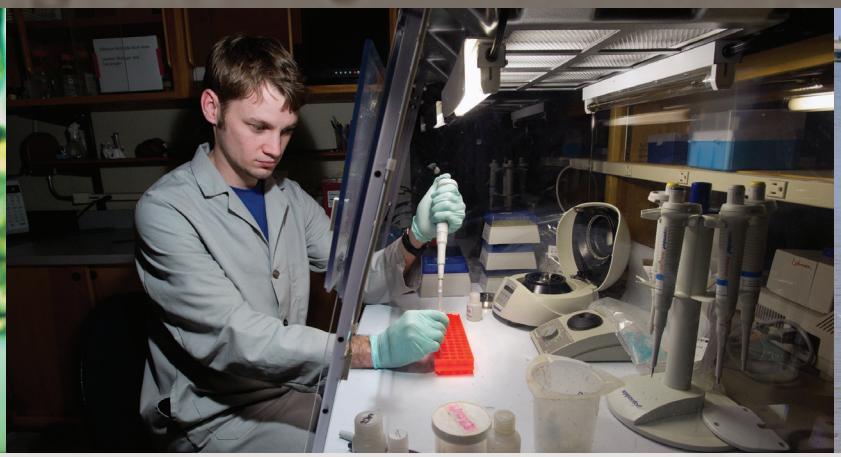
"In addition to its scientific interest, the vertical structure of MABL winds is an important factor affecting the performance and life expectancy of offshore wind turbines, where knowledge of the expected shear across the turbine blades is an essential design consideration," Terray said. "Despite their importance, acquiring long-term wind profiles at sea under a wide range of conditions has been a notoriously difficult problem."

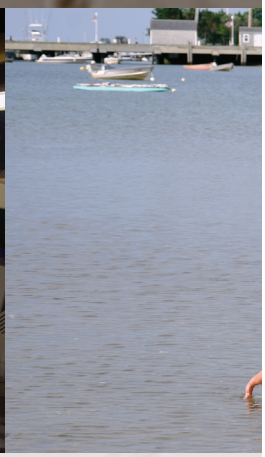
COI helped jumpstart Terray's research with a $41,643 grant in 2004 and a $70,000 grant in 2007.

Paul Oberlander, WHOI

A little funding **goes a**







Louie Wurch studies microscopic phytoplankton—specifically, *Aureococcus anophagefferens*, which causes devastating brown tides up and down the East Coast. When the MIT/WHOI Joint Program student from California had an opportunity to perform *in situ* studies in Long Island Sound, the Coastal Ocean Institute made that happen.

"This was my first chance to sample a natural bloom," Wurch explained. "The COI funding allowed me the freedom to pursue research. I purchased supplies to generate data that I have leveraged into both a thesis project and a larger grant to study harmful algal blooms, which currently supports me. I also have developed collaborations with top researchers in the field."

This is exactly the scenario Senior Scientist Don Anderson, past director of COI and current director of the Cooperative Institute for the North Atlantic Region, envisioned when he launched the Student Research Awards (SRA) at the Institute. Since 2006 more than 30 JP students have received crucial funding for thesis research expenses not otherwise covered by existing support.

"Over the years I worked alongside a number of students in the Joint Program and understood the challenges they faced," Anderson said. "It was clear that a small amount of money given to students could make a huge difference. It gave them positive feedback on their research ideas, and also allowed them to contribute to the labs that support them. Students need unrestricted money to explore new ideas in ways they otherwise could not pursue."

The SRA funding was created with a gift to WHOI, and Anderson said it quickly became apparent that the awards were valuable to WHOI. He received 11 viable proposals in the first year alone and, working in concert with other OI directors, Anderson was able to fund every student.

"The students gave us great feedback about how important the funding was to help them conduct research and write publications," said former COI Administrator Judy Kleindinst. "The awards gave students their first experience writing their own proposals and getting their own funding. There are so many ways in which this small investment has been leveraged."

long way

From left to right: Don Anderson with an image of red tide; Louie Wurch in the lab; Elizabeth Halliday collecting samples in Provincetown; and Mak Saito and Erin Bertrand in the lab.

For Wurch, leverage has meant greater study opportunities in a historically underfunded field and four important publications, including the one chronicling his work with Associate Scientists Sonya Dyhrman and Mak Saito, as well as fellow JP student Erin Bertrand, to complete the first genome sequencing of *Aureococcus anophagefferens*.

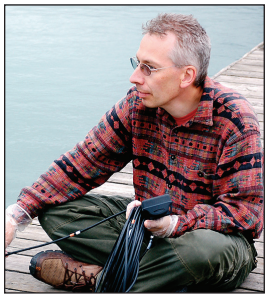
For JP student Elizabeth Halliday, a biological oceanographer from Arizona, COI funding is helping her develop a molecular method of live bacterial detection to improve the way we currently measure the safety of beaches for swimming. In the lab of Rebecca Gast, a microbial ecologist, she has collaborated in three peer-reviewed publications and other articles for the general public, and built collaborations across WHOI's disciplines.

"Personally, I feel lucky to have the freedom and encouragement to pursue my own interests and ideas," she said. "Small grants to students liberate us to test new methods and get good ideas off the ground. COI and its projects serve as an important bridge between physics, chemistry, biology and the policy implications of our research, which is thought-provoking professionally and satisfying to me personally."

Anderson added that by funding students, COI broadened its work. "A large number of important research directives in my lab derive from student initiatives. For example, modeling of harmful algal blooms in the Gulf of Maine—a huge program for us—spun off of early work by Peter Franks, one of my first students and now at Scripps. Students bring in new skills to labs like mine, and these often lead to new research directions moving forward. These COI research awards show that a little money can go a long way. It truly is a win-win opportunity."

Since 2006, COI has provided $102,854 in direct funding to JP students in a variety of labs.

What's coming for COI



COI Fellow **Bernhard Peucker-Ehrenbrink**, a senior scientist in Marine Chemistry and Geochemistry, is working to establish a virtual World River Institute in Woods Hole. In collaboration with colleagues in an expanding global network of river observatories, his research will focus specifically on the interaction of rainwater with the geology of watersheds, because these interactions influence river water chemistry and the delivery of dissolved matter and sediment to the coast.

COI awarded $46,809 to **Andrea Hawkes** of Geology and Geophysics to examine whether marine microfossil communities could serve as indicators of hurricane intensity in the Florida Panhandle. Preliminary data suggests that offshore foraminifera preserved in some storm-induced layers may be a valuable proxy for differentiating more intense hurricane strikes. If this approach proves to be viable it will provide essential data for gaining understanding of the climate factors that modulate hurricane activity.

Human activities release over 35 billion gallons of treated sewage into U.S. rivers and oceans every day. These waste streams contain a variety of natural and synthetic estrogens that can threaten aquatic ecosystems and human health, yet very little is known about them. COI provided $52,775 to **Elizabeth Kujawinski** of the Marine Chemistry and Geochemistry Department and Joint Program student David Griffith to characterize the quantity, speciation, and fate of estrogens in Massachusetts Bay.

Ann Mulligan, an associate scientist in the Marine Policy Center, will join Matthew Charette (see pages 2-3) in the first attempt at transient spatial modeling of radium fate and transport in a coastal aquifer, a significant step forward in unraveling the complexities of radium behavior. Results from this work will help us understand observed radium distributions within coastal aquifers. COI provided $70,046 to support this project.

Stirring and water mass exchange processes that occur across the inner part of the continental shelf maintain the balance between the near-shore ocean circulation and the larger coastal ocean offshore. COI awarded **Irina Rypina** of the Physical Oceanography Department $56,228 to use unconventional techniques— near-surface drifters and a high-resolution HF radar system—to better characterize and quantify inner shelf water mass dynamics.

The shelf break front is one of the most salient features of the Middle Atlantic Bight—the coast region that runs from New England to North Carolina—both in terms of its physics and biology. **Weifeng Zhang** of the Applied Ocean Physics and Engineering Department was awarded $49,670 to use a high-resolution state-of-the-art numerical model to study the impact of cross-frontal exchange on circulation and biological activity on the shelf.

Current student projects (total funding $16,481)

Ann Allen, Biology: "Getting there is half the fun: An investigation of humpback whale navigation and orientation mechanisms"

Whitney Bernstein, Marine Chemistry and Geochemistry: "Environmental controls on coral calcification: Alkalinity budgets of reef communities and coral skeletal records"

Min Ding, Geology and Geophysics: "A field trip to Chile to collect coastal tidal data for earthquake and tsunami research and to gain field experience"

Meagan Gonneea, Marine Chemistry and Geochemistry: "Coral-based proxies of tropical hydrology: method development, validation and application"

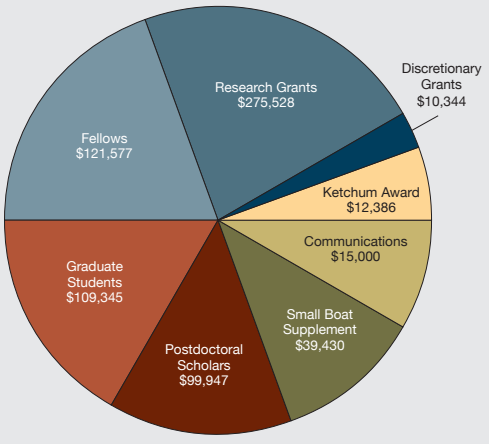
Karin Lemkau, Marine Chemistry and Geochemistry: "The San Francisco oil spill: Exploring stability of asphaltenes in the environment"

Maya Yamato, Biology: "A biochemical perspective on baleen whale sound reception"

Funding highlights

Although COI focused the majority of its funding on research grants, significant support also went to fellows, graduate education and outreach activities. In 2010, COI supported two Institute Fellows (Karen Casciotti and Bernhard Peucker-Ehrenbrink of the Marine Chemistry & Geochemistry Department), postdoctoral scholars Juliette Smith, Weifeng Zhang and Pradeep Nalaka Ranasinghage, and several MIT/WHOI Joint Program students. Funds also provided support for educational activities ranging from research on the biomass enhancement at the shelf break off the U.S. northeast coast to collecting coastal tidal data for earthquake and tsunami research in Chile. COI presented the 15th B.H. Ketchum Award for coastal research and provided support WHOI's small boat fleet for coastal research. Discretionary and Communication funding was used to support conferences, publications, a tsunami Web site translation, and content development and design for a beach water quality website to be launched later this year.

2010 COI Spending: $683,557



The Coastal Ocean Institute promotes scientific inquiry into the phenomena that shape our coastal waters and ecosystems. Through grant programs, scientific gatherings, and state-of-the-art facilities, the Institute encourages innovative, interdisciplinary research and high-risk technology development to improve our understanding of the fundamental processes at work in the coastal ocean. COI strives to translate the results of this basic research for citizens and policymakers, while providing a solid information base for better resource management.

Coastal Ocean Institute

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Front cover: Catherine Carmichael of the Marine Chemistry & Geochemistry Department collects sand and oil samples along the Mississippi coast in April 2011. (Photo courtesy of Chris Reddy, WHOI)

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