Coastal Ocean Institute

Fall 2008 Report

Woods Hole Oceanographic Institution

Message from the COI Director

Tom Kleindinst, WHOI

I am pleased to be the new Coastal Ocean Institute (COI) Director, following Don Anderson's stellar leadership during the past four years and his many accomplishments, including the initiation (and continuation) of the student research awards. Let me first introduce myself. I became the Director in August 2008. I am a chemist and study marine pollution, such as oil spills and other contaminants. My laboratory is busy with students and other researchers. Please let me know if you would like to hear more about my research or wish to visit my laboratory. I also have a strong interest in communicating science, as I have been a recipient of an Aldo Leopold Leadership Program Fellowship, which provides training to scientists to effectively convey science to the lay public, media, and policymakers.

This has been a dynamic and fruitful year for the COI, having sponsored a wide range of coastal projects via support to graduate students, post-doctoral scholars, and scientists. The assistance afforded by the COI has helped our scientists secure funding from federal outlets.

In this report, an update about leveraged funding is described by Rob Evans, as well as three research projects supported by the COI. Fellow Karen Casciotti is studying how nitrogen behaves in groundwater and coastal waters. One of the biggest coastal problems is nitrogen pollution, which stimulates the growth of algae. Too much algae stops sunlight from penetrating into the water, which shades and diminishes eelgrass beds that serve as nurseries for juvenile fish. It also leads to lower oxygen levels in the water, which suffocates fish and shellfish in the bay. Carl Lamborg and Bill Martin, supported by a COI grant, are studying groundwater and coastal sands to determine how much of the toxic metal mercury is stored underground and then potentially released to the coastline where it can be absorbed by fish and other wildlife. MIT/WHOI Joint Program student, Louie Wurch, is also interested in nitrogen, and how algae use it and which ones do so the most efficiently to grow. Disentangling the numerous species in seawater, some that may cause a toxic algal bloom, is difficult to accomplish with traditional methods. However, Louie is using advanced techniques that identify specific toxic algae by the presence or absence of certain genes they possess.

—*Chris Reddy*

Leveraged funding spotlight

COI fellowship support, and a COI new initiative project, has allowed me, working with a number of others in the Institution, to raise funds for two major projects looking at future shoreline change. We began with several research avenues, including looking at the economic impacts of shoreline change locally on the Cape (led by Porter Hoagland, Marine Policy Center), on Long Island, and also at the ways in which federal support is given to basic coastal research. These initial efforts allowed us to write a successful collaborative proposal to the Coupled Natural Human Systems ($1.4 million) program at the National Science Foundation (NSF) looking at the fate of barrier beaches under conditions of sea level rise and how human intervention will impact the evolution of the barrier systems. Another proposal, to SERDP (Strategic Environmental Research and Development Program, Department of Defense), looking at the fate of barriers under future sea level rise and storm impacts, has also been recommended for funding ($1.9 million). This proposal is within the Geology and Geophysics department and includes numerical model development and fieldwork, and nicely complements the NSF work.

—Rob Evans, COI Research Fellow

COI Directors bring expertise to Capitol Hill

Biologist **Don Anderson** was asked to testify at a hearing of the House Science and Technology Committee's Subcommittee on Energy and Environment on July 10 on the growing problem of harmful algal blooms—the periodic rampant growth of toxic marine plants that taint shellfish, kill fish and marine mammals, and cause many other negative impacts. Anderson, who has studied harmful algal blooms for 30 years, reported on research progress to understand the phenomenon and options to prevent and mitigate its economic and health impacts.

Chemist **Chris Reddy** explained to the House Transportation and Infrastructure Committee's Subcommittee on Water Resources and Environment on June 12, the need for research on the often-overlooked impacts of oil discharged to the oceans via insidious pathways: jettisoned fuel from airplanes, activities associated with the extraction of petroleum, air pollution, runoff from land sources such as car motor oil, and routine shipping operations, which alone account for 46 percent of the oil spilled in the ocean.

Nitrogen in our coastal waters

Human activities have dramatically increased the delivery of nitrogen to the coastal ocean. This nitrogen addition to coastal waterways, or eutrophication, leads to an increase in algal growth. Phytoplankton growth fuels the marine food chain, but excess algal growth can ultimately result in depleted oxygen concentrations, loss of biological diversity, changes in food web structure, and increased nuisance or harmful algal blooms. These undesirable effects of nutrient loading have received a great deal of attention in coastal waters near major population centers such as western Long Island Sound and the Gulf of Mexico.

Here on Cape Cod, population growth is closely linked to increases in groundwater nitrogen loading from septic systems. Microbial processes break down the organic nitrogen released from septic systems and eventually transform it to nitrate. This is important because nitrate is mobile, and it moves easily through the aquifer until the groundwater is discharged into coastal bays and estuaries. As the concentrations of nitrate in groundwater increase, the release of nitrate to coastal waters is also likely to increase, unless microbial processes in the aquifer or subterranean estuary (a region of mixing between fresh groundwater and coastal seawater) are capable of removing the nitrate.

With support from COI, the focus of our work in the Waquoit Bay subterranean estuary (Cape Cod, MA) is to understand how microorganisms alter this groundwater nitrate flux. We are applying state-of-the-art microbiological, molecular, and chemical techniques to understand which nitrogen metabolizing microbes are present in the Waquoit Bay subterranean estuary and at what rate they are removing nitrogen from the system. Our work to date has revealed a diverse microbial community within the subterranean estuary. Interestingly, archaea (microorganisms which have been traditionally studied in extreme environments such as hot springs and deep-sea vents) account for a large portion of the microbial population in our system. Further examination of this archaeal population has revealed the genetic ability to transform ammonium to nitrite. In addition, we find microbes that are capable of converting nitrite to nitrogen gas, which is critical for removing nitrogen from the system and preventing it from entering the coastal waters. Through an understanding of how natural microbial populations remove nitrogen, we may be able to exploit their abilities to manage more responsibly nitrogen inputs resulting from human activities. This will hopefully result in a sustainable relationship with our coastal waterways for generations to come.

Karen Casciotti, COI Research Fellow

Mercury in bays and ponds of Cape Cod

Mercury (Hg) is a toxic metal released to the environment by natural and human-made processes. While present at very low concentrations in air and water (well below levels that are directly dangerous), the Hg 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 bioaccumulation of Hg is widespread, and many fresh and salt water 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, with a number of our local ponds appearing on fish Hg consumption advisory lists. Indeed, many of the local fish that have been studied show unusually high concentrations of Hg for the particular species studied when compared to other locations.

During work conducted in Waquoit Bay in 2005, we found concentrations of dissolved total Hg 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 Hg to Waquoit. This was an important new finding, which has garnered scientific attention and local concern and suggests that our highly permeable soils are poor at holding back and storing the Hg loaded onto our watersheds from the atmosphere. It also begs the question as to whether or not all sandy coastal areas are delivering more Hg to the ocean than we previously thought.

With COI funding, we are testing this hypothesis using several approaches. For example, we are examining the Hg content of water, soil, sediment and aquatic animals from a number of Cape Cod water bodies. We are analyzing these samples for total Hg as well as monomethylHg (MMHg). MMHg is more toxic and our regional sampling will provide context for more focused, process-oriented studies in many of these same water bodies.

April Abbott, a summer guest student supported by COI funding, has been providing concentration data from Waquoit Bay, as well as conducting soil sorption experiments. Her results have confirmed our suspicions, that our sandy soils are particularly poor at holding onto Hg. More work remains, and COI is providing the critical support to pursue this mystery.

Assistant Scientist Carl Lamborg with a Niskin bottle, used to collect samples beneath the surface.

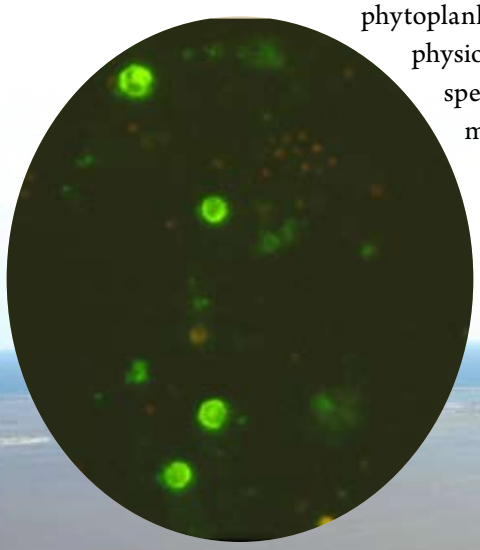
Carl Lamborg and William Martin, MC&G

Photos by Tom Kleindinst, Woods Hole Oceanographic Institution

Nutrients, genes, and harmful algae

Harmful Algal Blooms (HABs) can affect the ecosystem in a variety of ways such as through the release of toxins, the creation of hypoxic or anoxic zones, or by shading benthic sea grass communities. HABs present a global problem because of their widespread effects on public health, the coastal environment, and the economy. Therefore it is critical to understand the factors that promote the growth and proliferation of harmful algal species.

Just like land plants, algae need nutrients such as nitrogen and phosphorus for growth and these nutrients can come in many different forms. Nutrients can thus influence the growth of harmful species. Understanding which nutrients algae are utilizing requires the ability to track the nutritional physiology of the algae in the environment. This is challenging because we are interested in a single species (the harmful species) living within a mixed community. Most traditional metrics of phytoplankton nutrient physiology are not species-specific, making it difficult to link nutrient supply to the physiology of the cells, and to bloom dynamics. However, modern tools from molecular biology may help solve this problem.



Algae express certain genes under specific environmental conditions (such as nitrogen limitation) or when growing on certain nutrients (e.g. urea). The genes can then be used as markers of the organism's physiology in the environment. Furthermore, owing to the fact that different species have different gene sequences, it is possible to analyze a single species from a mixed community.

With funds from a 2007 COI student project award, I am working towards monitoring gene expression in field samples from a "brown-tide" bloom. Brown-tides are caused by the alga *Aureococcus anophagefferens* and are devastating to fisheries around Long Island. Preliminary results from screening these field samples detected the expression of several *A. anophagefferens* genes involved in nutrient utilization. This was an exciting, and critical first step, in my thesis research. In addition, the COI funds have allowed me unique opportunities for professional development. For example, these funds have allowed me to travel to Long Island for field sampling and to build a collaboration with Dr. Christopher Gobler from Stony Brook University, a leading figure on harmful

Long Island, NY. A 2008 "brown-tide" caused by the organism Aureococcus anophagefferens *(inset). Blooms of this species get so dense they turn the water brown and are destructive to the ecosystem. Compare the brown water in the bay with the blue, non-bloom water in the background.*

algal bloom research. In recognition of my work on gene expression, Dr. Gobler included me on the *A. anophagefferens* genome annotation team (www.aureococcus.org). *A. anophagefferens* is the first harmful alga to have its entire genome sequenced, so this is a unique honor to be a part of the team analyzing the genome sequence data. COI funds allowed me to present some of my analysis at the *A. anophagefferens* Genome Consortium meeting, which was held on Long Island in October of 2007. Since that time, I have analyzed many hundreds of genes and will be a coauthor on the upcoming *A. anophagefferens* genome manuscript. In short, the COI funds allowed me to gather valuable data for my Ph.D. thesis, develop professional connections, and work with the *A. anophagefferens* Genome Consortium. Results from my thesis work should provide a better understanding of how nutrient supply impacts harmful algal bloom dynamics, as we work towards better protecting our coastal zone and its users.

Louie Wurch extracting RNA in the lab.

—Louie Wurch, Joint Program Student

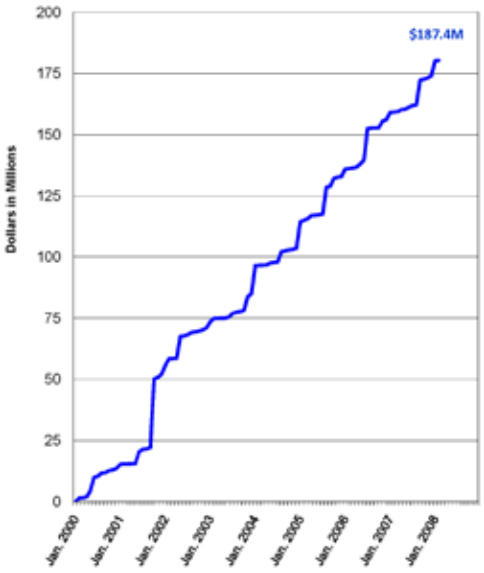
Financial update

WHOI's "Depth of Leadership Campaign" total reached $187,371,960 by September 30th, 2008. We look forward to announcing the conclusion of the $200 million campaign by the end of this year. Sincere thanks to all who have contributed to its success.

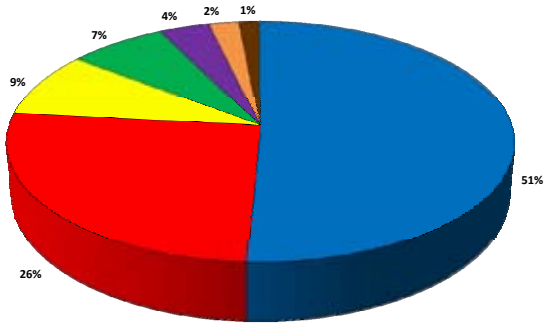
Between 2001 and 2008, the COI distributed $6.1 million in funds. 54 research projects were supported during this time, along with 13 research fellows, 7 postdocs and 7 graduate students. In addition, a variety of workshops, seminars, and outreach activities were supported. COI also provided support to the Martha's Vineyard Coastal Observatory and the small boat fleet for coastal researchers.

Campaign Funds Raised to Date: $187,371,960

As of September 30, 2008



Allocation of COI Funds



- Research Grants $3,081,931
- Research Fellows $1,575,389
- Graduate Students $437,965
- Small boat/Instrumentation $133,289
- Postdocs $533,051
- MVCO Support $224,381
- Symposia/Workshops $91,333

Photo courtesy of Suffolk County Department of Health Services. Inset courtesy of Don Anderson, WHOI.

About the Coastal Ocean Institute

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.

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Front cover: The Waquoit Bay National Estuarine Research Reserve is the site of many projects sponsored by the Coastal Ocean Institute. Photo ©WHOI. Back cover: Brown tides attributed to the organism Aureococcus anophagefferens *have caused severe mortalities of commercially important bivalves such as the bay scallop shown here above. Photo courtesy of V.M. Bricelj, Rutgers University.*