

## 2011 Annual Report: President's Letter

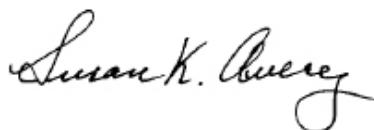
As happens every year, many remarkable social, cultural and political events took place in 2011. For WHOI, however, it is events related to the physical environment of the ocean that capture our attention: 2011 will be remembered for the magnitude 9.0 earthquake and subsequent tsunami that devastated the northeastern coast of Japan. The Tohoku earthquake occurred entirely beneath the ocean, one in a series of extreme events that demonstrate the power of our planet to overwhelm human capacity to predict, prevent, and mitigate natural disasters.

WHOI researchers played a valuable lead role in the aftermath of this quake, as we have in other recent disasters. When the tsunami caused the Fukushima nuclear power plant to experience partial meltdowns, hydrogen explosions, and fires, WHOI senior scientist Ken Buesseler quickly assembled an international team to assess the levels and dispersion of radioactive substances in waters offshore. It was a daunting task in every respect. The government of Japan, from which permission was required to conduct the research, was consumed with responding to the rapidly escalating crisis. It had neither time nor resources to offer.

Ken worked around the clock to recruit colleagues, find a research vessel as close to the area as possible, and—the greatest obstacle—obtain funding. After what he calls the “five busiest weeks of my life,” he set sail from Hawaii—still without all the necessary permits from Japan. He led a science party of 17 people from eight institutions that collected water, air and biological samples from a starting point 400 miles offshore to a point within sight of Fukushima. In the end, of most immediate concern to all, they were able to determine that the release of radioactive material was below the threshold of harm to humans and marine life. Many questions remain, and the analysis of data continues.

As we enter a presidential election year in the U.S., I continue to be concerned about the unpredictability of federal budgets and public policy disputes that threaten to debilitate the agencies that support this kind of research, even when it has such obvious social benefit. The Fukushima research highlights this. Ken was able to get a RAPID grant from the National Science Foundation to help in the earliest stage, but it was the Gordon and Betty Moore Foundation that ultimately stepped forward with the multi-million dollar award necessary to mount the cruise and collect the samples. The Fukushima disaster, especially the release of radionuclides, is still affecting the ocean and ocean ecosystems, and there must be continued attention to and support for ocean research and monitoring.

As federal funding agencies that we have relied on for decades are constrained by enforced austerity, we must look beyond traditional sources to find alternate and supplemental means to sustain our research. Clearly, despite increasing questions about the value of science to society, our efforts contribute significantly to global capacity to better predict, prevent and mitigate natural disasters. As we saw again this year, those disasters affect all of us on Earth. Such events—so often tied to the ocean—are showing signs of increasing in number and severity. It’s worth noting another milestone in 2011: the world’s population passed the seven billion mark. In light of that and the worldwide increase in human population along coasts, the enduring value of ocean research and of WHOI is apparent.



WHOI President and Director Susan Avery

### Related Multimedia



Studying Fukushima's Impacts

» [View Slideshow](#)

### Related Links

» [President and Director's Office](#)

Last updated: July 6, 2012

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)



## 2011 Annual Report: Letter from Laurence P. Madin, Director of Research

If you ask WHOI staff about their work, you might get a range of answers, but most would describe what we do here as basic research in ocean science – investigating how the ocean functions from the perspective of its physics, chemistry, geology and biology, or as we might think of it today, its ‘physicomicrobiogeochemistry’. They are motivated by a desire to understand fundamental mechanisms and use that knowledge for broader understanding of the Earth and its diverse inhabitants. However, we also conduct much more applied research and engineering, whether for an immediate societal problem or a client with particular needs. Recent examples include our deep-sea search and survey work for the Air France crash and the *Titanic* wreck site, our contract to look for biomolecules effective against cystic fibrosis, and our continuing work on the aftermath of the Gulf oil spill.

While answering immediate needs, this kind of research also contributes significantly to our basic knowledge. It may open new opportunities, support additional facilities and people, or help develop new methods or operational experience. Viewing the range of activity at WHOI in recent years it's apparent that our work fits at many places along a spectrum from pure, curiosity-driven science to contractual jobs for clients at the other. The flexibility of our funding structure means that individual scientists, students, engineers and technicians can work at many points on this spectrum according to their interests, the problem at hand, and the funding available. Often the difference between basic and applied research is only the distance in space and time between a discovery and its useful application somewhere.

In its 8 decades WHOI has moved back and forth on this research spectrum, from academic studies of plankton and fish in early years to intensive focus on military needs during WW II, to the postwar advent of federally funded research from NSF. Whatever initiates the work, we are good at asking questions, researching answers, and then building and applying solutions. This versatility puts us in a strong position to broaden and strengthen our funding beyond traditional government sources. At a retreat in early 2011 WHOI leadership explored ways we might foster this, and since then we have made progress in diversifying our portfolio both in the government sector and the newer territory of technology transfer and industrial partnerships.

There is both promise and risk in this new territory. The private sector can offer opportunities and money, but may have different values and motivations, including their view of academic freedom and intellectual property. In fact, we saw both aspects in our relationship with BP during 2011. In September we gave a very well-received course in marine science for 20 BP technical experts from around the world, and in December we were served a subpoena by BP demanding all our data and deliberations for some of the work our staff did during the Deepwater Horizon blowout.

So we need to explore new opportunities and partners carefully, never forgetting our fundamental values of free academic inquiry, but not being afraid to see where else our knowledge and skills can take us. There is much that ocean science and engineering at WHOI can contribute to the well-being of society, sometimes right away, sometimes years from now. The right mixture of government, philanthropic and industry support could let us do that while stabilizing our funding base and strengthening the culture of independent and creative research that have made WHOI a world leader for the last, and the next, 80 years.



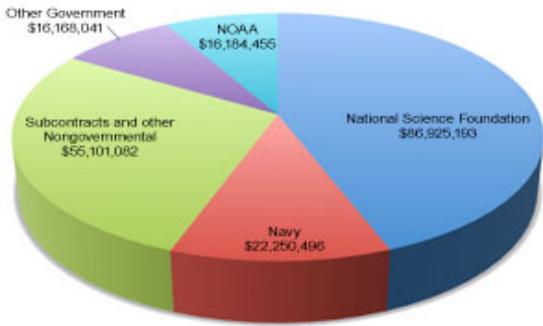
[Enlarge Image](#)

A culture flask containing marine microorganisms could be the source of [new treatments for cystic fibrosis](#), thanks to work recently begun by WHOI microbiologist [Tracy Mincer](#) and the [Flatley Discovery Lab](#) in Charlestown, Mass. To look for chemicals with pharmaceutical potential, a small pouch filled with resin beads is placed in the flask. The pouch works like a teabag in reverse: Instead of sending molecules into the water, the beads soak up compounds made by the microbes. The compounds are then removed from the beads and analyzed. The broth takes on the color of natural pigments made by the microbes, which in this flask were photosynthetic. (Photo by Tom Kleindinst, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

WHOI's Hovey Clifford (center) showed Melissa Simpson and Oniika Davis Peters from BP how to use a [Niskin bottle](#) to take water samples beneath the ocean surface recently. In September, 20 BP employees from around the world involved in environment, safety, and operational risk operations came to WHOI for 12 days for an intensive short course on ocean science. The course was designed to expose members of the oil and gas industry to major themes in oceanographic research with a focus on marine ecosystems and to provide greater appreciation for the environment in which BP's offshore operations are conducted. The course included lectures, seminars, and tours plus a hands-on day of fieldwork on the [R/V Tioga](#) in Buzzards Bay. (Photo by Katherine Spencer Joyce, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

#### 2011 Research Funding

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

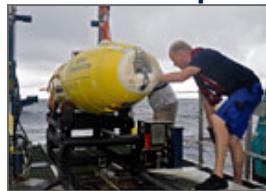
Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

# 2011 Annual Report

## Research Departments



### [Applied Ocean Physics & Engineering](#)

The Applied Ocean Physics and Engineering (AOPE) Department is a unique collection of scientists, engineers, technical support personnel and students conducting research into ocean processes from the turbulent surf zone to the abyssal depths.

### [Biology](#)



The overall goal of research in the Biology Department is to gain a better understanding of the ecology and evolutionary biology of living organisms in the sea.

### [Geology & Geophysics](#)



Research in the Department of Geology and Geophysics (G&G) encompasses earth and ocean processes: from the formation of ocean crust and ocean basins, to the underlying dynamics of plate tectonics and deep earth mantle geochemistry, to climate change and its relation to present and past ocean circulation and coastal environments.

### [Marine Chemistry & Geochemistry](#)



Scientists within the Marine Chemistry and Geochemistry (MC&G) Department seek to understand the processes that drive chemical cycling in the ocean, and to learn how ocean chemistry influences and responds to biological activity and climate on Earth, both today and in the past

### [Physical Oceanography](#)



Researchers in the Physical Oceanography (PO) Department seek to describe and understand the physical structure and variability of the ocean and the processes that determine that structure and variability.

*Last updated: July 6, 2012*

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Applied Ocean Physics & Engineering

During 2011, Applied Ocean Physics & Engineering Department (AOPE) scientists, engineers, and research staff developed new instruments and vehicles, discovered ancient and modern shipwrecks on the sea floor, and investigated ocean processes from the abyss to the surf zone. Ongoing projects examine the fluid dynamics of propulsion of marine organisms, dynamics and sediment transport in the surf zone and estuaries, development and application of autonomous and remotely operated vehicles, ocean acoustics, and mixing in the ocean.

Recently tenured AOPE scientist Houshuo Jiang is working with postdoc Kakani Katija Young on the mechanisms of propulsion of copepods, krill and jellyfish by measuring the flow of water around the organisms at extremely high resolution. These researchers perform their measurements in the lab and in the ocean, to determine how the organisms propel themselves to obtain food and avoid predators. Jiang and Young are also investigating the hypothesis that swimming microorganisms are a major source of ocean mixing!

The REMUS group in AOPE were called upon to search for the Air France jet that crashed in the South Atlantic Ocean in 2009, after commercial efforts to locate the wreckage had failed. Led by Mike Purcell, the group deployed the REMUS 6000 submersible in the vicinity of the last known position of the aircraft, and used the advanced acoustic sensing systems and control mechanisms of the REMUS vehicle to [locate, identify and survey](#) the wreckage at approximately 3,900 meters (2.4 mi) depth.

AOPE's researchers also use autonomous vehicles to [investigate ancient shipwrecks](#). Brendan Foley's group partnered with the Greek Ministry of Culture to carry out a maritime archaeological survey off Crete, Greece. They located 8 shipwrecks dating as far back as ~150 BC, and 3 ancient anchorages dating to as long ago as ~1100 BC.

AOPE scientists are studying how large-scale ocean currents like the Gulf Stream interact with smaller-scale eddies to produce mixing of different ocean water masses. They deployed fluorescent dye off the coast of North Carolina and tracked it with aircraft and oceanographic ships, including WHOI's R/V *Oceanus*, simultaneously measuring the currents and winds in order to determine the mechanisms causing the spreading of the dye and thus the mixing processes at scales from 100 m to 10 km in the ocean.

Martha's Vineyard has been the focus of intensive AOPE research efforts for more than a decade, and that tradition continued in 2011. Steve Elgar's nearshore processes group investigated the recent breach that produced a new inlet between Katama Bay and the Atlantic Ocean, using pressure gauges and current meters to determine the tidal dynamics, and jet-ski surveys to measure rapid changes in the area bathymetry caused by sediment transport. Peter Traykovski and Rocky Geyer investigated the influence of the breach on sediment movements and the morphology of nearby Wasque shoals, where a small island emerged due to changes in the tidal currents and waves resulting from the Katama breach.

Jim Preisig's signal processing and communications group used the Hawaiian archipelago as the field site for a test of new acoustic communication technology. Although sound can travel great distances in the ocean, precise communication is hampered by numerous sources of noise and distortion, particularly in shallow, energetic coastal environments. Preisig's advanced coding and signal processing methods are overcoming these challenges, with particular significance to defense applications.

AOPE scientists also have longstanding interests in acoustics research. The acousticians in Tim Stanton's group are investigating the acoustic backscatter signals (echoes) produced by fish, for the purpose of improved fisheries management. During 2011 they performed field studies in the Gulf



[Enlarge Image](#)

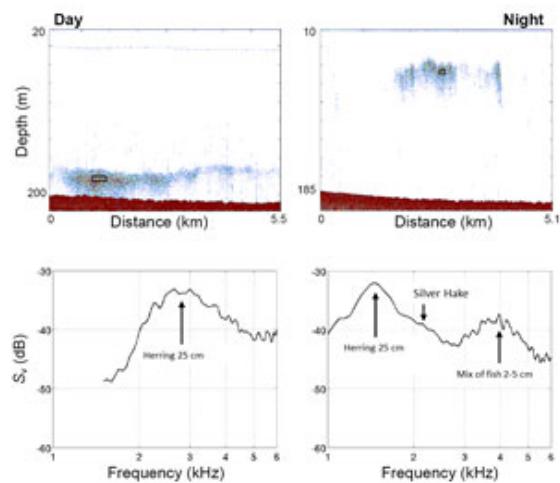
Fred Wendt of [IFM Geomar](#) and WHOI research specialist Mark Dennett (partially hidden) inspect the [REMUS 6000](#) autonomous underwater vehicle owned by the [WAITT Institute](#) as it is positioned on the LARS (Launch and Recovery System) during the April 2011 search for Air France Flight 447. The WHOI-led team used three of the vehicles to [locate the wreckage](#) of the airliner in nearly 2.5 miles of water off the northwest coast of Brazil. (Photo by Mike Purcell, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

[Marine archaeologist](#) Brendan Foley partnered with the Greek Ministry of Culture to conduct a seafloor survey off Crete, Greece. Here, [WHOI Diving Safety Officer](#) Edward O'Brien recovers a 1000-year-old artifact from a shipwreck during the 2011 Crete Ancient Shipwreck Survey. During the project, divers and [REMUS](#) 100 AUVs located and documented eight shipwrecks and three ancient anchorages. (Image by Brendan Foley, Woods Hole Oceanographic Institution)

### Resonance classification of fish



of Maine in collaboration with the National Marine Fisheries Service. This research has the potential to greatly improve our ability to enumerate and manage fish stocks.

In [related research](#), recently tenured scientist Andone Lavery is also studying acoustic backscatter in the Gulf of Maine, but the target of her investigations is the acoustic signal, or type of echoes, produced by pteropods—small plankton with calcium carbonate shells. These animals are particularly vulnerable to ocean acidification, so her research into acoustic methods to determine their abundance is particularly relevant as scientists try to determine the effect of increased atmospheric carbon dioxide on oceanic ecosystems.

—[Rocky Geyer](#), Department Chair

[Enlarge Image](#)

Tim Stanton and colleagues have used broadband sound to identify fish of different sizes. Through a resonance classification technique that uses [broadband sound](#) to resonate fish swimbladder, fish of 2-5 cm length were observed to be collocated with predator species of 15-30 cm length. This observation, which could not otherwise be detected through conventional [acoustics systems](#), led to new understanding of biological processes associated with the cost-benefit tradeoff in predator-prey relationships.

#### Related Multimedia



**Slideshow**

2011 Photo Highlights

» [View Slideshow](#)

#### Related Links

» [Applied Ocean Physics & Engineering Department](#)

Last updated: July 6, 2012

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Biology

Members of the Biology Department at WHOI seek to understand life in the oceans and the interactions of marine life with its environment. WHOI biologists study a variety of organisms including bacteria and archaea, viruses, protists, phytoplankton, zooplankton, fish, seabirds, and whales. Their research covers all levels of biological organization, from molecules and cells to communities and ecosystems, and occurs around the globe and in the laboratory.

In 2011, WHOI biologists engaged in several exciting field expeditions:

Gareth Lawson led a multidisciplinary [cruise](#) on R/V *Oceanus* with colleagues from three WHOI Departments to study pteropods ("sea butterflies", a kind of snail) in the North Atlantic and the potential effects of ocean acidification on this important group of animals.



[Enlarge Image](#)

Craig Taylor and colleagues from MG&G went on a [cruise on R/V \*Atlantis\*](#) to the eastern Mediterranean Sea where—in addition to some [unexpected excitement](#)—they carried out the inaugural deployment of his *Submersible Incubation Device – In Situ Microbial Sampler* (SID-ISMS), a robotic micro-laboratory that was used to study the protozoan community inhabiting deep-sea brine environments.

*Limacina retroversa*, a species of pteropod that proved to be very abundant in the northern part of our study area. These beautiful shells are only about a millimeter long. (Photo by Nancy Copley, Woods Hole Oceanographic Institution)

Tim Shank participated in several cruises to assess the [potential impacts of the Deepwater Horizon oil spill on deep-water coral communities in the Gulf of Mexico](#), while Cabell Davis led a cruise in the Gulf of Mexico to study plankton and marine snow in the Deepwater Horizon region.



[Enlarge Image](#)

During the second of NASA's two ICESCAPE expeditions to the Arctic, Sam Laney, Heidi Sosik and other WHOI researchers observed an [unprecedented phytoplankton bloom](#) under the Arctic sea ice cover in the Chukchi Sea. The bloom, paradoxical because people thought that the ice-covered ocean was too dark for blooms to occur, is possibly the most productive patch of ocean ever sampled. Measurements with a seagoing Imaging FlowCytobot (originally developed by Sosik and Rob Olson) provided information about the phytoplankton species in this unique phenomenon. Laney also teamed with other WHOI scientists and engineers to develop optical sensors for long-term under-ice profilers in the NSF's Arctic Observing Network. The 2011 deployment of these systems provided the first high-resolution measurements of phytoplankton changes with seasons under ice cover in the Arctic Ocean.

In December 2010 the autonomous underwater vehicle *Sentry* surveyed deep water corals and associated animals near the Deepwater Horizon oil spill source in the [Gulf of Mexico](#). In May 2011 (shown here) WHOI biologist [Tim Shank](#) and colleagues returned, surveying more than 1,200 kilometers of seafloor and capturing more than 100,000 images to assess whether the coral communities were affected by the spill. The researchers will sample there again in fall 2012. (Photo by Tim Shank, Woods Hole Oceanographic Institution)

Also in the Arctic, Carin Ashjian led a [6-week cruise](#) on the icebreaker USCGC *Healy* to investigate ocean biology, physics, and chemistry in the Chukchi and Bering Seas during the beginning of the Arctic winter. Despite conditions ranging from sub-zero temperatures and complete sea ice cover in the Chukchi Sea to raging winter storms in the Bering Sea, they collected some of the first early winter data from these seas.



[Enlarge Image](#)

At the other end of the globe at about the same time, new Assistant Scientist Stephanie Jenouvrier conducted [Antarctic field research](#) during the austral summer, studying emperor penguins and the potential impacts of climate change on penguin populations.

Not all expeditions occurred in forbidding environments, though: Jesús Pineda and Ann Tarrant taught Joint Program students during a [field course in Tropical Marine Ecology](#) at the Liquid Jungle Lab on the Pacific Coast of Panama.

Biology Department scientists also carried out a variety of other research activities in 2011, some of which were reported in 124 published papers involving department members. These are some of the important research advances WHOI biologists made this year:

Biologist Carin Ashjian led a [40-day cruise](#) to the Chukchi and Bering Seas to study the [Arctic ocean ecosystem](#) during the onset of winter. Aboard the U.S. icebreaker *Healy*, the science team sampled water properties and

Lauren Mullineaux and collaborators [discovered](#) that surface-generated eddies extend down to the deep seafloor, transporting the larvae of hydrothermal vent species away from the vents and demonstrating a mechanism for long-distance transport of vent larvae.

Sonya Dyrhman helped lead a consortium that sequenced and annotated the [genome of a brown tide alga](#), providing insight into why brown tide blooms occur where they do.

Several scientists reported new research on marine mammals. Peter Tyack and colleagues [showed](#) that beaked whales change their behavior when exposed to naval sonar. Darlene Ketten launched a new [website](#) as a portal to her unique database of computed tomography (CT) images from a wide range of marine species; the web site includes over 3500 images, dozens of animations, and other materials. Tyack, Ketten, Michael Moore, and collaborators published a [paper](#) from a workshop held to explore how deep-diving marine mammals deal with decompression stress. And Mark Baumgartner developed a low-frequency detection and classification system (LFDCS) for calls made by baleen whales, and is working with WHOI engineers and physical oceanographers to deploy it on ocean gliders for long-term monitoring of whale behavior.

Additionally, Aran Mooney [reported](#) for the first time the ability of squid and cuttlefish to respond to sound.

When not at sea or in the lab, many Biology Department scientists are leaders, internally and at national and international levels. Biologists lead WHOI's [Ocean Life Institute](#) (Simon Thorrold), NOAA's [Cooperative Institute for the North Atlantic Region \(CINAR\)](#); Don Anderson) and WHOI [Sea Grant](#) Program (Judy McDowell), WHOI's [Center for Ocean, Seafloor & Marine Observing Systems \(COSMOS\)](#); Heidi Sosik), the NIH/NSF Center for Oceans and Human Health ([COHH](#); John Stegeman), and WHOI's [Marine Mammal Center](#) (Michael Moore). At the national level, Don Anderson took a leadership role in fighting budget cuts for extramural research funding in NOAA and advocated on behalf of harmful algal bloom (HAB) research.

The Biology Department recognized excellence in research by promoting Ann Tarrant to Associate Scientist, Sonya Dyrhman to Associate Scientist with Tenure, and Carin Ashjian to Senior Scientist. Scientist Emeritus John Waterbury received the prestigious [Gilbert Morgan Smith Medal](#) from the National Academy of Sciences "for the discovery and characterization of planktonic marine cyanobacteria, and viruses that infect them, setting in motion a paradigm shift in our understanding of ocean productivity, ecology, and biogeochemical cycles." And Judy McDowell stepped down after a successful five-year term as Biology Department Chair, leaving the department in great shape and with a strong cohort of young scientists who will carry us into the future.

[Mark Hahn](#), Department Chair

## Into the Dark and Ice

Scientists mount the first winter voyage to Chukchi and Bering Seas to study how life has adapted to (and thrives in) the harsh conditions of the frozen north during the shortest days of the year.

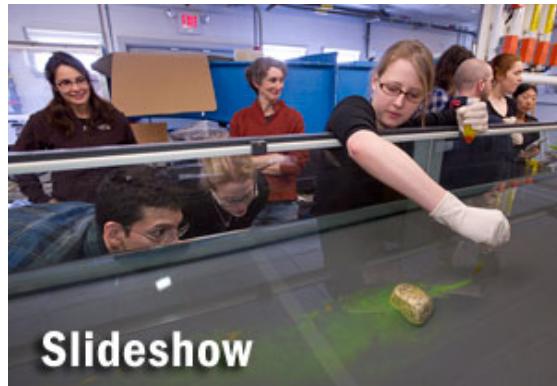
marine organisms to learn what changes as sunlight diminishes and sea ice forms.



[Enlarge Image](#)

Stephanie Jenouvrier uses modeling, fieldwork, and mathematical ecology to investigate how climate change is affecting populations of Southern Ocean seabirds. In 2011 she went to Antarctica to study populations of [emperor penguins](#).

### Related Multimedia



2011 Photo Highlights

[» View Slideshow](#)



The Coral Reef in Kimbe Bay, Papua New Guinea

[» View Slideshow](#)

### Related Links

[» Biology Department](#)

Last updated: July 19, 2012

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

---

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Geology & Geophysics

The Department of Geology and Geophysics (G&G) is a diverse and multidisciplinary group of researchers and technical staff who carry out research from hydrothermal vents and associated seafloor volcanic activity to earthquakes and tsunamis to global climate change in the past and more recent historical times, including the effects on ice-sheets, coastline evolution and sea level change.

In 2011 the G&G Department appointed two new Assistant Scientists as part of a cross-department Climate Initiative: Jessica Tierney is an organic chemist who studies oxygen and hydrogen isotopes in leaf wax, and other proxies, to reconstruct past climates in the Tropics, while Kevin Anchukaitis is a dendrochronologist, using tree rings to also study climate change in tropical regions on a more recent, sub-millennial timescale. Adding their expertise to our existing paleoclimate research staff in the G&G Department broadens and strengthens our ability to address research questions that involve the Tropics and multiple timescales and disciplines. In addition to the new two scientists, Research Associate Brian Monteleone joined the Technical staff in the New England National Ion Microprobe Facility under the direction of Nobu Shimizu. There was one departure in 2011 as Assistant Scientist Yajing Liu left for an academic post at McGill University in Canada. This past year Mark Behn, Anne Cohen and Pablo Canales were promoted to Associate Scientist with Tenure, Bill Thompson and Andrew Ashton were promoted to Associate Scientist and John Collins was promoted to Senior Research Specialist.

Several staff members garnered awards in 2011:

Senior Scientist Henry Dick was [awarded the AGU Harry H. Hess medal](#) in recognition for his "outstanding achievements in research of the constitution and evolution of earth and other planets" and most notably for "his discoveries, creative efforts and deep insights that have led to the modern understanding of the mantle melting and ocean crust formation along the global ocean ridges."

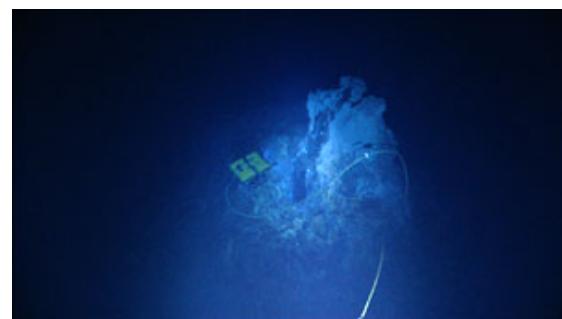
Senior Scientist Lloyd Keigwin was named a fellow of AAAS for his "distinguished contributions to the study of the oceans role in climate change and for national and international leadership."

In early 2012, Ginny Edgcomb was also awarded the "Seymour H. Hutmeyer Award" from the International Society of Protistologists for outstanding contributions to protozoology.

In research news, climate dynamicist Kris Karnauskas in collaboration with Anne Cohen and others published results of a study that shows that a predicted rise in equatorial Pacific surface water temperatures might be mitigated by the equatorial undercurrent for a string of islands that straddle the equator. This could be good news for coral reef ecosystems and fisheries in these remote areas that are under threat from global ocean warming, and shows that regional conditions are important considerations in assessing impacts from climate change.

Also in the climate world—this time looking back in the past—age-dating specialist Bill Thompson published an [improved method of dating fossil coral reef skeletons](#). Bill found that the corals in the Bahamas document rapid sea level changes during the last interglacial period (120,000 years ago), with sea level oscillating up and down by 4 to 6 meters (13-20 feet) over a few thousand years.

Post-doc and microbiologist Bill Orsi, working in Virginia Edgcomb's Lab on deep sea sediment samples found RNA evidence of fungi living deep within the seafloor amidst ancient eukaryotic organisms and implicates fungi as a source of organic substrate turnover in the marine "subsurface".



[Enlarge Image](#)

Geologist Chris German headed an [expedition](#) to the world's deepest known hydrothermal vents, at the Mid-Cayman Rise in the Caribbean. A remotely operated vehicle (ROV), seen here with its tether, landed on the summit of a hydrothermal vent spire nearly 2300 meters deep.



[Enlarge Image](#)

Deep-sea shrimp swarm around one of the hydrothermal vents at the Mid-Cayman Rise. The shrimp feed on microbes that utilize chemicals in hydrothermal vent fluid as an energy source.



[Enlarge Image](#)

Atlantic Ocean hydrothermal vents are known for large shrimp populations, and Pacific Ocean vents for tubeworms, but both depend on chemosynthetic microbes for food, rather than on photosynthetic organisms. On a 2011 expedition to the Mid-Cayman Rise, scientists found the first Atlantic Ocean tubeworms, at the Von Damm vent site at 2300 meters depth.

Chris German was Chief Scientist on board the *Okeanos Explorer* as he made the [first ROV investigation](#) of one of the deepest hydrothermal vents discovered to date; the Piccard site on the Mid-Cayman Rise (ca. 5000 m depth), as well as the [shallower Von Damm vent](#) (2300 m), named after noted vent chemist Karen Von Damm who passed away in 2008. The Von Damm vent site is notable for the discovery of the first tubeworm colony ever seen in the Atlantic. Typically, Atlantic vent sites are dominated by shrimp while Pacific vents have tubeworms, so this new discovery blurs that biogeographical boundary.

Finally, 2011 saw another devastating subduction-zone related earthquake (magnitude 9), this time in Japan, with an unprecedented tsunami that led to a nuclear power plant disaster. Several scientists from Woods Hole including G&G geochemist Chris German and seismologists Jian Lin and Jeff McGuire helped in the [response and documentation of this major event](#). In the hopes of being more prepared for such a catastrophic event off the Washington and Oregon coasts, seismologists Jeff McGuire and John Collins also continued with the community-wide [Cascadia experiment](#): new ARRA-funded ocean bottom seismometers (OBS) along with WHOI's Keck broadband OBS's were installed to capture the complete range of earthquake behavior, from slow slip to rupture, across a wide area of the Pacific seafloor adjacent to the Pacific Northwest.

—[Maurice Tivey](#), Department Chair

## The Scientist Who Loved the Cold

MIT/WHOI graduate student studies ice in a warming world Ali Criscitiello climbs summits and studies climate—particularly how warming ocean temperatures could be melting sea ice around Antarctica. Her success as a young scientist has its roots in the lessons she learned as part of the first all-female team to scale India's 2963 meter (22736 feet) Pinnacle Peak.



[Enlarge Image](#)

This photo was taken in 2011 at the moment scientists first saw tubeworms and vent shrimp living at the same hydrothermal vent, at the Mid-Cayman Rise. Finding these two animals together in Caribbean raises questions about the evolution of vent communities in the Caribbean Sea, lying between the Atlantic and Pacific Oceans.

### Related Multimedia



2011 Photo Highlights

» [View Slideshow](#)

### Related Links

» [Geology & Geophysics Department](#)

Last updated: July 6, 2012

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Marine Chemistry & Geochemistry

Researchers in the Marine Chemistry and Geochemistry Department (MC&G) use field observations, laboratory experimentation, computational modeling, and state-of-the-art analytical techniques to understand processes that regulate ocean chemistry. Much of this work is directed at identifying and determining chemical fluxes, or exchanges, across ocean boundaries at the seafloor, coastal zone, and air-sea interface. This research helps establish the relationship between ocean chemistry and climate and the influence of human activity on the marine environment. The recognition that microorganisms are key players in many of these processes has led to more research programs within MC&G that straddle the borders of marine chemistry, geochemistry, geology and microbiology. The growing number of interdisciplinary researchers has led to exciting and cutting-edge research that contributes greatly to our understanding of ocean chemistry.

A [study published in the journal Science](#) by MC&G Associate Scientist Marco Coolen in 2011 reports the results of a research program positioned at the interface of marine chemistry, paleoceanography, and microbiology. In this study, Coolen used novel techniques to determine fossil genetic signatures from ancient DNA that allowed reconstruction of 7,000 years of population dynamics for marine phytoplankton and their associated viruses in the Black Sea. The study showed that shifts in viral and host populations coincided with environmental changes that affected salinity and nutrient availability.

During the past few years, MC&G has hosted an active and expanding group of scientists interested in exploring the ocean for naturally produced compounds that may have value in medicine and other areas of societal import such as biofuel development.

In 2011, Assistant Scientist Tracy Mincer initiated a [project](#) supported by a \$1.2 million grant from the Flatley Discovery Lab to provide chemical extracts from marine microorganisms to be screened for effectiveness in treating the deadly disease cystic fibrosis. The goal of this research is to identify small molecules that could treat the mutated gene responsible for cystic fibrosis—a new approach that would enable treating the disease at its root cause instead of treating the symptoms. The significance of this work is not limited to medical applications. The chemical extracts prepared by Mincer will also be studied for their function in nature, providing important clues to microbial survival strategies and chemical cycling in marine environments.

The spring of 2011 was marked by the destruction and human loss that resulted from the magnitude 9.0 Tohoku earthquake offshore Japan and subsequent tsunami. Damage to the coastal Fukushima Dai-ichi Nuclear Power Plant resulted in the largest accidental release of radioactivity to the marine environment to date. MC&G Senior Scientist Ken Buesseler, who had been instrumental in documenting the release of radioactivity to the marine environment following the 1986 Chernobyl accident, recognized the need to document the amount of radiation being released to the ocean and how subsequent transport and mixing affected its accumulation. Initial funding from an NSF RAPID grant allowed him to analyze limited water samples sent by colleagues, to determine baseline radiation levels.

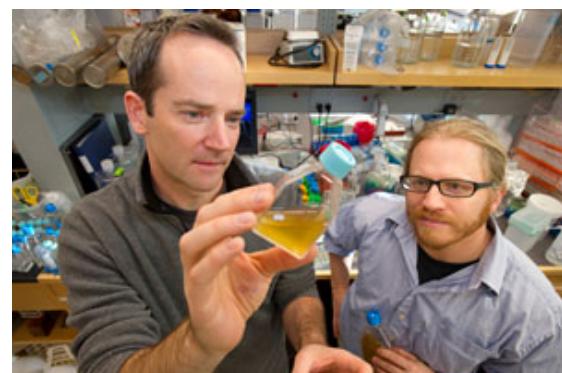
Shortly thereafter, a \$3.7 million [grant](#) from the Gordon and Betty Moore Foundation allowed Buesseler to organize an international field program involving collaborators from more than 10 institutions from 6 different countries in early June 2011. Other WHOI PIs included Matt Charette and Steve Jayne of MC&G and Irina Rypina of the Physical Oceanography Department.

During the two-week research cruise, researchers collected water, small fish, and plankton samples at varying depths and distances from the



[Enlarge Image](#)

Taking sediment cores from the Black Sea, for Marco Coolen's study of ancient DNA molecules. (Photo by Marco Coolen, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

Marine Chemistry and Geochemistry Assistant Scientist Tracy Mincer shows biologist Matt Johnson an extract, made from cultures of marine microbes, which [will be analyzed](#) to look for molecules with useful human health applications. (Photo by Tom Kleindinst, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

Japanese coast. Initial results, published in the Proceedings of the National Academy of Sciences, reveal that radionuclides released from the power plant are rapidly transported away from the coast by the Kuroshio current. Radionuclide levels varied by a factor of 1000 within 20 to 400 miles of Fukushima, with highest levels associated with a near shore eddy and lowest levels farther off shore. Although radiation levels in fish were elevated, they remained below levels considered safe for human consumption.

MC&G Assistant Scientist Rachel Stanley and postdoctoral investigator Brice Loose led an expedition to the Bra D'Or Lakes, Nova Scotia, in order to test a novel method to simultaneously measure biological production and air-sea gas exchange in melting ice zones using newly developed sea-going instruments. Melting ice zones in polar regions are extremely important locations for the exchange of carbon dioxide between the ocean and atmosphere. The researchers took their instruments to an inland sea in Nova Scotia to [test the new method](#) in an easily-accessible locale as a proxy for the Arctic.

They found that "easily accessible" doesn't mean "easy to work in"! After waiting weeks for the ice to melt in order to start their experiments, a storm blew ice into the lake and their boat was pushed by an ice floe onto a sandbar, forcing them to evacuate in a dinghy. When the storm passed two days later, they found that the scientific equipment had survived but the boat was not easily repairable. Undaunted, they plan to return next spring to test their new method in the climatically important—but challenging—melting ice zone.

MC&G researchers were well-represented during the second leg of the [US GEOTRACES North Atlantic cruise](#) as the R/V *Knorr* left Woods Hole in November. This cruise completed the first "zonal transect" (full-ocean-depth sampling along a predetermined track) of the US GEOTRACES program in the North Atlantic, a large-scale research effort to determine the distribution of trace elements and their isotopes in the ocean.

Ken Buesseler, Matt Charette, Bill Jenkins, Phoebe Lam, Carl Lamborg, and Mak Saito are among 44 principal investigators in this highly coordinated effort to simultaneously measure a broad spectrum of trace metals and isotopes. Their results will allow a far richer and deeper interpretation of the data to identify the processes and quantify the fluxes that control distributions of trace elements in the ocean. Even with limited berths available on the ship, MC&G was also represented on the cruise by Joint Program students Jessica Fitzsimmons, Daniel Ohnemus, Stephanie Owens, postdoc Paul Morris, and Research Associate Steve Pike.

Other news from MC&G includes recognition of accomplishment through awards and promotion. Towards the end of 2011, [Scott Doney was elected as a Fellow](#) of the American Association for the Advancement of Science in recognition of "...fundamental contributions to our understanding of the ocean carbon cycle and its interactions with the Earth system and for his scientific leadership." Research Associate Paul Henderson was recognized for his exceptional efforts in the lab and in the field with the 2011 Ryan C. Schrawder Award, given at the 2011 WHOI Employee Recognition celebration. The list of promotions includes Matt Charette to Senior Scientist, Mak Saito to Associate Scientist with Tenure, Phoebe Lamb to Associate Scientist without tenure, Heather Benway and Krista Longnecker to Research Specialist, Crystal Breier to Research Associate II, Kevin Cahill to Senior Research Assistant I, and Donna Mortimer and Janet Moore to Administrative Associate II.

Five new Assistant Scientists joined MC&G Department in 2011, adding substantial youth and breadth to our research portfolio:

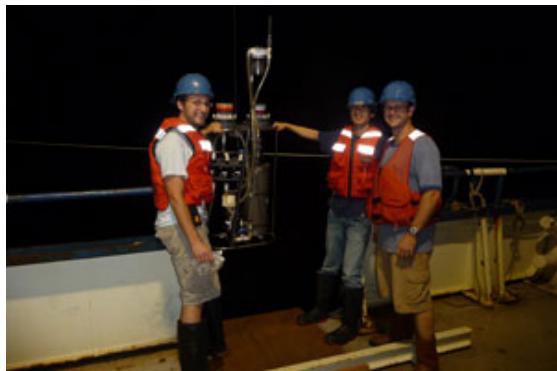
Valier Galy is an organic geochemist who uses a variety of geochemical tools to study the global carbon cycle. He is particularly interested in the

Marine Chemist Ken Buesseler (second from right) led a June 2011 [research cruise](#) off Japan to sample the water and organisms, seeking to understand the fate of radiation released from the Fukushima nuclear plant disaster following the [Japanese earthquake](#). (Photo by Ken Kostel, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

A sudden ice storm on the Bras D'Or lakes in Nova Scotia forced Assistant Scientist Rachel Stanley and postdoc Brice Loose to evacuate their icebound boat during a research trip to study the challenging melting-ice zone. (Photo by Rachel Stanley, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

Night-time sampling during the first Atlantic transect during the [GEOTRACES](#) program, a research effort to study the distribution of trace elements and isotopes in the oceans. (Photo by Paul Morris, Woods Hole Oceanographic Institution)

#### Related Multimedia



2011 Photo Highlights

» [View Slideshow](#)

#### Related Links

» [Marine Chemistry & Geochemistry Department](#)

transport and fate of terrestrial carbon delivered to the ocean and the interplay between carbon cycling and climatic variability.

Amanda Spivak is a cross-disciplinary scientist who examines the relationship between biogeochemical processes and ecosystem functioning in seagrass environments and explores the cycling of carbon and other elements in coastal environments.

David Nicholson is a biogeochemist who studies the distribution of trace gases in the surface ocean to quantify aspects of ocean ventilation, marine productivity, and the carbon cycle. He uses field observations and numerical modeling to understand natural and anthropogenically-driven climate variability.

Frieder Klein is a geochemist/metamorphic petrologist who examines the effects of fluid-rock interaction within the oceanic lithosphere. His research has implications for a diverse set of topical issues that include carbon sequestration, earthquake prediction, and the origin of life.

Amy Apprill is a microbial biogeochemist focused on the interactions of microbial communities and larger host animals. She studies the influence of biogeochemical environments on microbial community composition and function and the development of ecosystem stress indicators.

[Jeffrey Seewald](#), Department Chair

## Research Road Trip

An audio slideshow by a volunteer assistant at the Woods Hole Oceanographic Institution chronicles a three-day, 500-mile quest for tarballs from the Deepwater Horizon oil spill along the northern Gulf coast.

*Last updated: July 6, 2012*

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report:

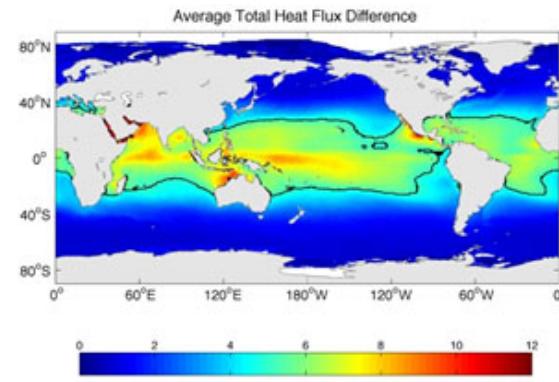
### 2011 Research Highlights

The Physical Oceanography Department, in association with the Geology and Geophysics and Marine Chemistry and Geochemistry Departments, engaged in a scientific staff recruitment effort from 2009 to 2011 that focused on Climate Research. This search was very successful, resulting in the addition of 5 staff members with climate interests to the PO Department (three Assistant Scientists and two Associate Scientists with Tenure). Here we introduce these five investigators and showcase elements of their present research.

I. Much of Carol Anne Clayson's current research focuses on the global water and energy cycles. Using mostly satellite data, Carol Anne works with hydrologists and atmospheric scientists to estimate the uncertainties remaining in these cycles and investigating if, as climate change models suggest, the water cycle is indeed increasing in strength and if there has been a change in the number of weather and climate extremes across the globe. Early indications are that the distributions of weather events are indeed changing. Carol Anne is also investigating diurnal (day and night) sea surface temperature cycles, to accurately account for earth's heat and water budgets and to quantify the impact of diurnal variations on ocean-atmosphere feedbacks. Her analysis of ten years of data showed that if diurnal sea surface temperatures weren't included in the energy calculations for the tropical ocean, the estimated air-sea fluxes (the rates at which heat is exchanged between ocean and atmosphere) could be in error by up to ten Watts per square meter—an important finding that is helping to motivate continuing investigations of the diurnal sea surface temperature cycle and upper ocean mixing processes.

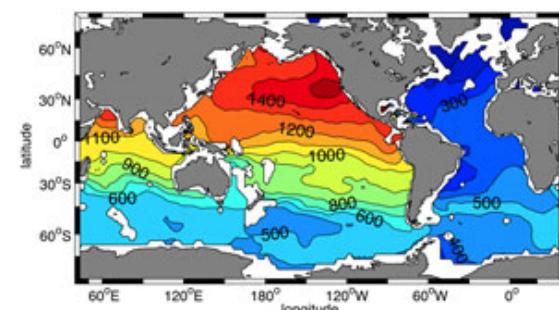
II. A major reason why the ocean is important for Earth's climate is that the deep water can be out of contact with and isolated from the sea surface for very long periods of time. This allows carbon compounds taken up from the atmosphere by surface waters to be sequestered (isolated) at depth, reducing (at least temporarily) the amount of carbon dioxide in the atmosphere. The "age" of ocean waters, defined as the time since water was last at the surface, is a valuable way of characterizing the dominant time scales of the ocean circulation. Carbon-14 is a radioactive isotope long used to calculate the age of fossils, artifacts, and other objects, and also for dating ocean water. One of Geoffrey (Jake) Gebbie's research projects that examines how ocean mixing affects the interpretation of carbon-14 levels uses observations of water property, in conjunction with a circulation model, to individually track over 11,000 water parcels from their surfacing locations to the deep ocean interior (in contrast to previous estimates that typically tracked just a handful of surface source waters). Taking mixing properly into account increases the ocean water age estimates by several hundred years; Jake estimates that deep Pacific Ocean waters are well over 1,000 years old. His research suggests that the ocean played a strong role in the large climatic swings of Earth's past, because ocean waters appear to be renewed on a similar timescale to the waxing and waning of large ice sheets during the Ice Age.

III. Amala Mahadevan studies the impact of upper-ocean physical processes on the distributions and cycling of chemicals between living organisms and the ocean environment. Phytoplankton at the base of oceanic ecosystem food chains are also important components of the 'biological pump'—the process in which single-celled plants take up carbon dioxide and sink to deep waters when they die, removing the carbon from contact with the atmosphere. Phytoplankton grow in sunlit waters supplied with nutrients from the deeper waters. What controls the residence time of phytoplankton in surface waters before being carried to deeper/darker depths by currents? What currents transport nutrient-rich deeper waters to the surface? What controls the surface distribution of dissolved carbon, and carbon dioxide exchange with the atmosphere? How do upper-ocean physical processes facilitate the export of organic carbon to depth? Amala



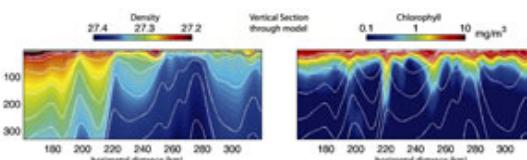
[Enlarge Image](#)

From Carol Anne Clayson's research a map showing, over a ten-year average, the difference between air-to-sea heat exchange values calculated with and without consideration of diurnal sea surface temperature (SST) cycles. The units of the heat exchange are Watts per square meter, "warmer" colors indicate greater difference (greater error) in results when not taking the diurnal SSTs into account; the black contour line marks the 5 Watts per square meter level.



[Enlarge Image](#)

The "age", or time in years since water was last at the sea surface, of ocean waters lying at 2500 meters depth. The estimate shown, from Jake Gebbie's research, was determined by a new analysis of carbon-14 in water samples obtained from ships.



[Enlarge Image](#)

A vertical slice through the ocean at one moment in time: Amala Mahadevan's three-dimensional model simulation shows how upper-ocean fronts and eddies affect the structure of water density (left panel) and chlorophyll concentration, a proxy for phytoplankton abundance (right panel), during spring phytoplankton growth. In the left panel, stacked-up, compressed density contours (white lines) at 220 km indicate an ocean front, like a weather front, separating less-dense water from denser water. In the model, eddies form at such fronts, spreading lower-density water (aqua and warmer colors) over dense water (dark blue). The right panel shows how the distribution of high chlorophyll concentration (green, yellow and red) has evolved in response to the eddy motions. Note in particular how chlorophyll is pulled downward at the front (220 km), and eddy edges, exporting carbon from surface to deep

explores these questions with dynamical models that describe mixed-layers, fronts, eddies and internal waves. Her goal is to improve our understanding of the oceanic carbon cycle and its response and feedback to increasing atmospheric carbon dioxide and changing climate.

IV. While mechanisms inducing climate variability tend to have broad spatial scales, strong interactions among the earth system components often yield regionally-distinct patterns of change. Hyodae Seo seeks to understand how earth system components interact with each other to determine regional-scale climate variability, and, in turn, how these influence the local-scale climate processes relevant to human society. In one current project, Hyodae, working with others, has analyzed 30-year records of summertime water temperatures from coastal weather buoys and remote sensing data on the western U.S. continental shelf. His work reveals a significant cooling trend in sea surface temperature (at an average rate of about  $0.2^{\circ}\text{C}$  per decade) that is more prominent off south-central California than the Oregon-northern California coast. This coastal upwelling is an oceanic process poorly accounted for in climate models and data, but it appears to have intensified in the past 30 years due to more upwelling-favorable winds interacting with the regional coastal landforms. These small-scale climate signals that have significant implications for local weather, rainfall and diurnal cycles likely occur in coastal regions beyond the U.S. West Coast.

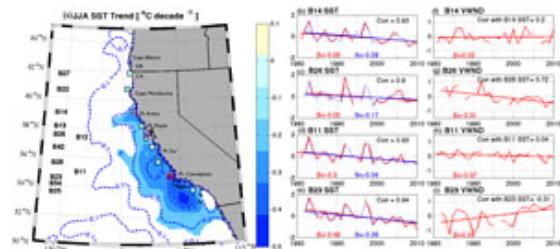
V. Temperature anomalies in the ocean (differences between observed temperatures and expected or average temperatures) persist much longer than the higher-frequency variability in the atmosphere. Better understanding of the links between sea surface temperatures (SST) and regional climate can help improve seasonal and longer term rainfall forecasts: a vital capability for water and agricultural management, as global populations continue to rise and uncertainty related to long-term climate change abounds. Caroline Ummenhofer studies SST variability and its role in modulating [regional rainfall and drought](#). One of her foci is the Indo-Pacific and Australasian region, for which she combines observations, a wide range of model products, and paleoclimate reconstructions to identify patterns and investigate the physical mechanisms producing them. Such studies improve our understanding of the Indian and Pacific Oceans' influence on drought in Indian Ocean-rim countries affected by monsoon systems over a range of timescales. The success or failure of the Asian monsoon can mean the difference between prosperity and severe hardship in the affected regions; clearly a better understanding of Indo-Pacific climate drivers on the monsoon is desirable.

Beyond these additions to the PO scientific staff, Postdocs Marieke Femke de Jong, Jean-Baptiste Gilet, Jeremy Kasper, Paolo Luzzatto-Fegiz, Melissa Omand, Gauher Shaheen, Robert Todd and Jinbo Wang, and Research Associate II Carolina Nobre joined the Department in 2011, while Magdalena Andres transitioned from Postdoc to Assistant Scientist. Senior Scientists Jim Price and Terry Joyce, Senior Research Specialist Dick Limeburner and Senior Information Systems Assistant I Jane Dunworth-Baker retired in 2011; the first 3 were subsequently appointed as Emeritus. Also leaving us in 2011 were Postdocs Liz Douglass and Emily Shroyer.

We applaud Emeritus Scientist Joe Pedlosky for being awarded the [Maurice Ewing Medal](#) from the American Geophysical Union, Associate Scientist with Tenure Lou St. Laurent for receiving the [Nicholas P. Fofonoff Award](#) from the American Meteorological Society, and Senior Scientist Bob Weller for being elected [Fellow of the American Association for the Advancement of Science](#).

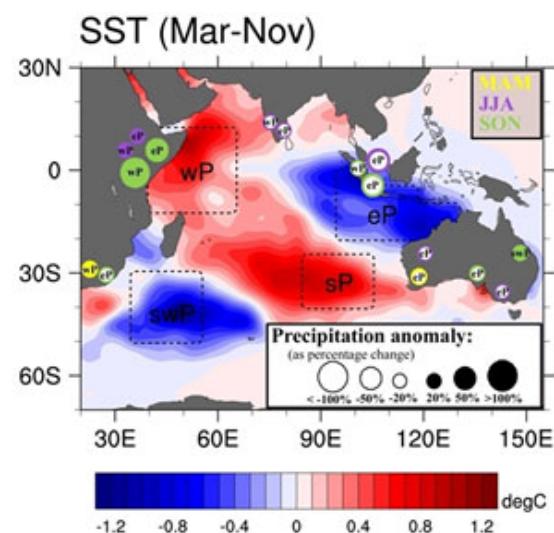
*John M. Toole, Department Chair*

waters.



[Enlarge Image](#)

From Hyode Seo's research: Left, the map shows summer averaged sea surface temperature (SST) trends, measured by NOAA satellites, for the U.S. west coast from 1982-2010: darker blues indicate a larger temperature decline. Middle, declining SSTs measured by four coastal buoys: top-to-bottom plots correspond to north-to-south buoy locations marked by 4 red squares on the map. Right, the trend in wind blowing along coastal topography at the same north to south locations, showing increasing winds in the southern location marked by the largest decline in SSTs.



[Enlarge Image](#)

From Caroline Ummenhofer's work, a map shows Indian Ocean sea surface temperature anomalies (places where the water is cooler or warmer than expected). The inset shows precipitation amounts in Indian Ocean rim countries, inferred from simulations produced by a computer model of atmospheric general circulation for the March-May (MAM), June-Aug (JJA) and Sep-Nov (SON) seasons. The Sea Surface Temperature (SST) anomalies (in degrees Celsius) are shown as the average over the March-Nov months. The model documented the response of the atmosphere to SST anomalies in the four labeled regions indicated by the dashed boxes. The anomalous rainfall associated with these regions of SST anomalies is shown by circles around the Indian Ocean rim countries. Filled (empty) circles denote an increase (decrease) in precipitation, as a percentage change. The size of each circle reflects the magnitude of change and the color of the circle indicating the season.

## Line W: A 10-year Portrait of the Planet

This special video takes a look at the moored instruments and

regular research cruises across the Gulf Stream that have helped form an unprecedented view of ocean circulation in a crucial part of the North Atlantic.

*Last updated: September 28, 2012*



[Enlarge Image](#)

WHOI Senior Scientist Joe Pedlosky (second from left) being awarded the Maurice Ewing Medal from the American Geophysical Union during the fall 2011 meeting. AGU President Mike McPhadden (far left), Tom Drake (ONR) and Rana Fine (AGU Honors Committee) are also shown.

#### Related Multimedia



2011 Photo Highlights

» [View Slideshow](#)

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Ocean Institutes



### Coastal Ocean Institute

The Coastal Ocean Institute (COI) promotes scientific inquiry into phenomena that shape our coastal waters and ecosystems. Through research grants, scientific gatherings, and the development of state-of-the-art facilities, COI encourages interdisciplinary research and innovative technology development.

[» Visit Website](#)

### Deep Ocean Exploration Institute



The Deep Ocean Exploration Institute (DOEI) fosters multi-disciplinary study of physical, chemical, geological, and biological processes in all these areas and in the planet's interior, and development of the technology needed to access environments at and below the seafloor.

[» Visit Website](#)

### Ocean & Climate Change Institute



The Ocean and Climate Change Institute (OCCI) uses its energies and resources to advance the knowledge of "How the Ocean works in the Earth's Changing Climate System" by acting across WHOI departmental structures, blending education, research, access to the sea, and outreach to achieve its goals.

[» Visit Website](#)

### Ocean Life Institute



The Ocean Life Institute (OLI) supports groundbreaking basic research related to conservation science and biodiversity in marine ecosystems. The Institute supports WHOI scientists through OLI fellowships, postdoctoral and graduate student awards, and research grants.

[» Visit Website](#)

*Last updated: July 6, 2012*

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Centers & Programs



### [Marine Policy Center](#)

Research at the Institution's Marine Policy Center (MPC) involves the application of economics and other social sciences to public policy issues connected to the world's oceans and coastal areas.

### [Center for Ocean, Seafloor and Marine Observing Systems \(COSMOS\)](#)



The goal of COSMOS is to establish, off the Northeast US, an ocean observing system capable of achieving WHOI's scientific objectives in the region.

[» Visit Website](#)

### [Cooperative Institute for the North Atlantic Region \(CINAR\)](#)



The overall goal of CINAR is to engage NOAA and academic scientists in cutting-edge research that enables NOAA to make informed decisions about sustainable and beneficial management of the U.S. northeast continental shelf ecosystem.

[» Visit Website](#)

### [Marine Mammal Center](#)



The mission of the WHOI Marine Mammal Center (MMC) is to develop strength in basic research and technology, concentrating on conservation applications through strategic partnerships and interdisciplinary approaches.

[» Visit Website](#)

### [Woods Hole Sea Grant Program](#)



The Woods Hole Sea Grant Program is part of the NOAA's national Sea Grant network of 32 programs. Collectively, Sea Grant promotes cooperation between government, academia, industry, scientists, and the private sector to foster science-based decisions leading to better understanding, conservation, and use of coastal resources.

[» Visit Website](#)

### [Woods Hole Center for Oceans and Human Health \(WHCOHH\)](#)



The mission of the Woods Hole Center for Oceans and Human Health (WHCOHH) is to improve the public health through enhancing our understanding of how oceanic processes affect the distribution and persistence of human pathogens and toxin-producing organisms in marine and coastal environments.

[» Visit Website](#)

Last updated: July 19, 2012

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Marine Policy Center

As the uses of the coastal ocean in the US multiply and intensify, both users and managers are calling for what amount to zoning rules to allocate different areas among competing uses. As on land, ocean zoning entails setting down rules that govern the permissible use of different parts of the ocean. Although the idea of ocean zoning is gaining traction, many questions remain about how to design, implement, and manage a zoned ocean. With support from Woods Hole Sea Grant, researchers at the Marine Policy Center (MPC) are studying alternative approaches to ocean zoning in an effort to understand the overall economic benefits that each would provide to society.

Broadly speaking, there are three main approaches to ocean zoning: government or centralized zoning, community zoning, and decentralized zoning based on property rights. Centralized zoning is a top-down process of government rule-setting for the permissible uses of different parts of the ocean. Community zoning allows communities to decide on their own rules for allocating ocean space. Decentralized zoning involves the establishment of transferable property rights, leading to the emergence of what is essentially a market for ocean space. Of course, these approaches are not mutually exclusive and various hybrids are possible. For example, a centralized approach may be used to identify areas for fishing and a decentralized approach – such as individual tradeable quotas or ITQs – may be used to allocate fishing rights within this area among fishermen.

In 2008, Massachusetts became one of the first states to enact into law the equivalent of a centralized zoning plan for state waters. A key part of the Massachusetts Oceans Act relates to so-called siting decisions that determine what parts of the ocean are open to specific activities. Specifically, in opening part of the ocean to a particular activity, the Act calls for a “demonstration that public benefits clearly outweigh the public detriments.” As part of the Center’s effort in this area, Senior Research Specialist Porter Hoagland worked with Summer Student Fellow Lily Steponaitis from the University of North Carolina to assess the extent to which the process by which siting decisions will be made is based on a consideration of public benefits and costs. They found that this process does not, in fact, ensure such a consideration and instead is subjective, arbitrary, and at least partly reflective of political pressures. In particular, this process reflects a continuing preference for traditional uses like fishing—which is essentially exempt from zoning rules—and navigation over innovative uses like ocean energy and aquaculture, irrespective of the costs and benefits to the public.

The Massachusetts experience underscores a major challenge to centralized ocean zoning. Historically, the management of ocean space has been based on tradition rather than on a true consideration of the benefits to society. Efforts to reverse this will come up against entrenched interests. These interests are well within their rights to use the political process to maintain the *status quo*. Although there will continue to be progress in this area, we should expect it to be slow.

—[Andy Solow](#), Center Director

Last updated: July 27, 2012

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)



[Enlarge Image](#)

Management areas under the Massachusetts Oceans Act.

### Related Links

» [Marine Policy Center](#)

## 2011 Annual Report: Major Research Collaborations



### Ocean Observatories Initiative (OOI) Coastal & Global Scale Nodes

OOI's Coastal Scale Nodes will expand existing coastal observing assets, creating focused, configurable observing arrays. The Global Scale Nodes will address planetary-scale problems via moored open-ocean buoys linked to shore via satellite.

[» Visit Website](#)

### WHOI Partnership with King Abdullah University of Science and Technology



At the end of 2011, researchers at WHOI have completed a fourth year of field work, data and laboratory analysis, and model building as part of the research agreement with King Abdullah University of Research and Technology (KAUST).

[» Visit Website](#)

*Last updated: July 6, 2012*

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Academic Programs

The strength of all the [WHOI education programs](#) is the close linkage with the WHOI research mission and projects and we are very proud of the ways our students and postdocs contribute to WHOI research.

We believe that one of our obligations is to make sure that young scientists understand the responsibilities they have when conducting research. In 2011, we started a regular program for graduate students, postdocs and summer fellows about the responsible conduct of research (RCR). The topics we discuss in both small and large groups range from responsible animal care to plagiarism to cooperative research. Participants interpret and discuss scenarios related to RCR themes, and those discussions are often very lively.

Also in 2011, WHOI, along with the New England Aquarium and other organizations, participated in a project funded by the National Science Foundation (NSF) entitled National Network for Ocean and Climate Change Interpretation (NNOCCI). As the science partner, Joint Program graduate students were responsible for providing accurate information on climate change and its effects on the ocean and ocean animals to interpreters at zoos and aquariums from around the country. As a result of these interactions, Joint Program students learned how to discuss complicated and controversial issues with the public—a skill that should help their careers and our field in the future.

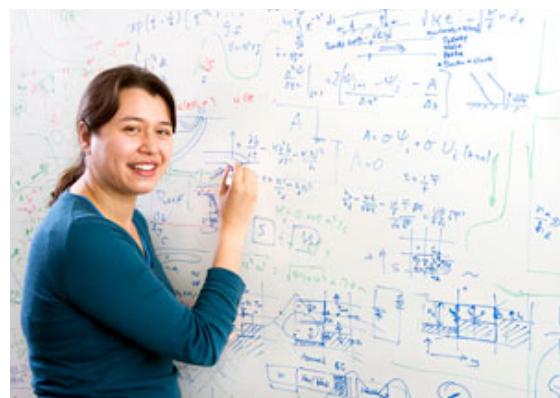
In preparation for an NSF proposal to continue NSF funding for some of our summer fellows, we were able to locate 88% of the 151 WHOI [summer undergraduate fellows](#) in our program from 2007-2011. At the time of our survey, 54 were still undergraduates or graduating in spring 2011, with as yet unannounced plans for the fall. Of former fellows that we located, 65% of those who had graduated from college and settled their plans for fall 2011 were in science graduate programs. The 3 graduate programs having the highest number of our former summer fellows are the MIT-WHOI Joint Program (13 students), Scripps Institution of Oceanography (6 students) and University of Washington (5 students). Eleven former fellows have full-time technical positions in ocean science or related fields and 5 are working in other areas (e.g., the Peace Corps).

In 2011, WHOI Academic Programs developed a 2-week, non-credit, [short course](#) on basic principles in ocean science for 18 BP employees involved in the BP Environmental and Safety Divisions supporting offshore operations around the world, including Gulf of Mexico, North Sea, Arctic, and in waters off Angola and Trinidad. WHOI technical and scientific staff members and WHOI postdocs gave the lectures, tours, and demonstrations that comprised the course. The course was very successful and will be offered again in fall 2012.

During the 2010-2011 academic year, the [Massachusetts Institute of Technology-WHOI Joint Program](#) awarded 20 masters and doctoral degrees in ocean science and engineering. As of Fall 2011, the Joint Program (JP) had awarded 894 degrees. Enrollment is stable at 130 students in residence.

WHOI awarded 15 Postdoctoral Scholar positions in 2011 and for the first time, the number of [WHOI postdoctoral Scholars, Fellows and Investigators](#) in residence topped 100. There was a near 50:50 gender balance among postdocs and about 50% of the postdocs were foreign nationals from 21 different countries.

Students and postdocs bring energy, enthusiasm and new ideas to WHOI's research portfolio and help us move in new directions. We appreciate the support we receive from individual donors and foundations that support these fine education and training programs.



[Enlarge Image](#)

Jessica Benthuysen, a recent graduate of the [MIT/WHOI Joint Program](#), developed a sophisticated mathematical model of upwelling, the vertical motion of water that occurs in certain parts of the ocean. Upwelling often brings nutrient-rich deep waters closer to the surface, providing a [bonanza](#) for phytoplankton, zooplankton, fish, and whales. Benthuysen's model showed that just a few key factors, including bottom slope and along-shore current, can account for upwelling in an area off the U.S. East Coast called the shelf break, where the nearly-flat continental shelf meets the steep continental slope (Photo by Tom Kleindinst, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

To really understand the cycle of life in the deep sea, researchers need [samples](#) to measure chemistry and DNA. And they aren't after just any samples; the ones with the most to offer are likely to come from the extreme, such as a submarine volcanic eruption. Assistant scientist John "Chip" Breier, Summer Student Fellow Kevin Mori and the rest of the team are developing a new sampling tool that will allow scientists to use AUVs like [Sentry](#) to find and sample geochemical and microbial "hotspots" in response to tectonic and volcanic events. Such events can induce major changes in deep sea chemistry and potentially provide a major pulse of energy to a variety of micro-organisms. (Photo by Tom Kleindinst, Woods Hole Oceanographic Institution)

### Related Multimedia

[James Yoder](#), Vice President for Academic Programs & Dean

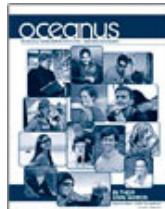
Last updated: July 6, 2012



2011 Photo Highlights

» [View Slideshow](#)

#### Related Links



» [In their own words](#)

Special edition written by MIT WHOI Joint Program students.  
December 2011

» [WHOI Academic Programs](#)

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Marine Operations

2011 was a very busy year for the large research ships operated by Woods Hole Oceanographic Institution (WHOI). The ships traveled the oceans in search of scientific discoveries in an effort to better understand the world's ocean, climate and marine life.

R/V's *Knorr*, *Atlantis* and *Oceanus* spent more than 700 days at sea. *Atlantis* spent most of the year in the Pacific Ocean supporting ROV Jason. Some of the science on these cruises included multi-beam testing, hydrothermal vents and collaborative research. In November, *Atlantis* transited to Piraeus, Greece to begin [research](#) but was called upon by the Greek Coast Guard to respond to a mayday call from a fishing vessel. Following standard safety procedures, Captain A.D. Colburn and the *Atlantis* crew were able to safely [rescue](#) 93 Egyptian fishermen and deliver them to Kalamata, Greece before departing on the research mission.

R/V *Knorr* spent the year in the Atlantic, aiding in research from Halifax, Nova Scotia to Nuuk, Greenland and Reykjavik, Iceland. Research included work on eddies, air/sea gas exchange, and [GEOTRACES](#), a project to identify processes and quantify fluxes that control the distribution of trace elements and isotopes in the ocean and to establish the sensitivity of these distributions to changing environmental conditions.

R/V *Oceanus* travelled from Woods Hole to Barbados and Bermuda to conduct research that included work with a video plankton recorder (VPR), *Trichodesmium*, an important ocean plankton organism, and carbon export studies. R/V *Oceanus* also assisted the [Ocean Observatories Initiative](#) (OOI) with a successful deployment of at-sea testing equipment. The OOI program is a long-term, NSF-funded program to provide 25-30 years of sustained ocean measurements to study climate variability, ocean circulation and ecosystem dynamics, air-sea exchange, seafloor processes, and plate-scale geodynamics.

The National Science Foundation (NSF) decided that R/V *Oceanus* after having been operated for 36 years by WHOI would make its [last voyage from its homeport](#) at WHOI in November 2011. *Oceanus* was determined to be the replacement for R/V *Weomba*, the retiring research vessel at Oregon State University.

WHOI continues to support the construction of AGOR 27 (Auxiliary General Purpose Oceanographic Research), a new Ocean Class [research vessel](#) currently under construction by the U.S. Navy and scheduled to come online in 2015.

The [National Deep Submergence Facility](#) (NDSF) continues to be operated by WHOI for the national oceanographic community. Included in NDSF are HOV *Alvin* (currently out of service being upgraded, and scheduled to return to service in 2013), ROV *Jason/Medea* and AUV *Sentry*. Both *Jason* and *Sentry*, operated from R/V *Atlantis*, conducted engineering dives as well as research dives in the Pacific Ocean which.

The *Alvin* upgrade project is progressing. Certification sea trials are on schedule to be completed by the end of 2012. The new personnel sphere will undergo final assembly and hydrostatic testing in Annapolis, MD, in spring 2012. At WHOI, fabrication and refurbishment of various components continues. We have received and finished testing all of the new 6500m rated syntactic foam, and are making preparations to send it out for bonding and shaping.

[Martha's Vineyard Coastal Observatory](#) (MVCO) is a research observatory located at South Beach and in the ocean a mile off the south shore of Martha's Vineyard. It provides real time and archived coastal oceanographic and meteorological data for researchers, students and the



[Enlarge Image](#)

On April 23, 2011, R/V *Atlantis* came out of dry-dock in Jacksonville, Florida, with a fresh coat of paint and a full [schedule](#) of science cruises. This picture was taken just before the massive A-frame used to deploy and recover *Alvin* was re-installed on the stern that, because it is so heavy, could only be attached once *Atlantis* had been refloated. *Alvin* is currently undergoing a complete overhaul and upgrade, but that won't stop *Atlantis* from continuing its work as a WHOI-operated [UNOLS](#) research vessel, with upcoming cruises to study geologically active regions of the Pacific and to complete a [geochemical survey](#) of the North Atlantic. (Photo by Christopher Morgan, Woods Hole Oceanographic Institution)



[Enlarge Image](#)

Rob Munier, left, WHOI vice president for [marine facilities and operations](#), talks to Admiral Gary Roughead, the Chief of Naval Operations (CNO), during [his visit to WHOI](#) in June. In addition to touring several of the Institution's labs, Admiral Roughead was briefed on its education program and its submersible vehicle programs—many of which have been developed with Navy support. During his address to the WHOI staff, the CNO presented WHOI President and Director Susan Avery with a letter commending the Institution for its 50-year history of [deep submergence](#) and ocean research vehicle development. It was the first such appearance at the Institution by a serving Chief of Naval Operations. (Photo by Tom Kleindinst, Woods Hole Oceanographic Institution)

### Related Multimedia

general public. MVCO, which is managed by Center for Ocean, Seafloor and Marine Observing Systems (COSMOS), required several deployments of coastal research vessel R/V *Tioga* for instrument deployments and dive operations. Divers were deployed from *Tioga* to assist with the Air-Sea Interaction Tower (ASIT) as part of the Optics Acoustics and Stress In-Situ (OASIS) project at MVCO.

WHOI's Access to the Sea endowment funded seven scientific projects in 2011. Scientific research included autonomous underwater glider observations of the Mid-Atlantic Bight shelf, unmanned aerial systems for oceanographic applications, and the enhancement of MVCO ocean observing system web services. Over \$290,000 was awarded for ocean science research.

—[Robert Munier](#), Vice President for Marine Facilities & Operations



2011 Photo Highlights

» [View Slideshow](#)

#### Related Links

» [WHOI's Ships & Technology](#)

## R/V Oceanus: The Little Ship that Could

A video farewell to a stalwart ship and its dedicated crew. (Woods Hole Oceanographic Institution)

Last updated: October 26, 2012

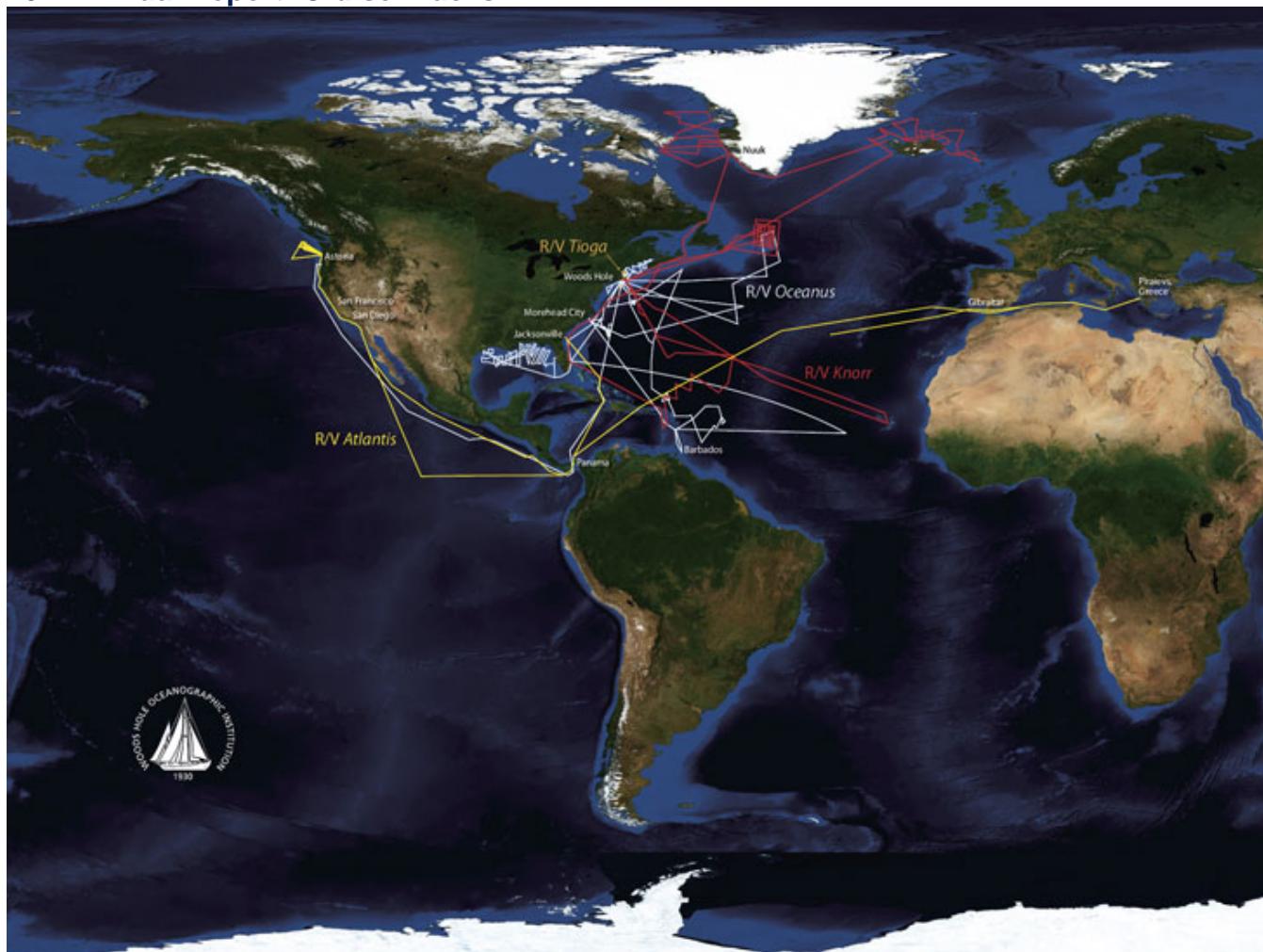
Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Cruise Tracks



### Woods Hole Oceanographic Institution • 2011 Cruise Tracks

#### WHOI's Research Vessels: 2011 Cruise Tracks

Related Files

[#187 Enlarged 2011 Cruise Tracks](#)

*Last updated: July 6, 2012*

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)

## 2011 Annual Report: Letter from Dana Fernandez, Interim Co- Vice President, Finance and Administration

We are pleased to present the CY 2011 unaudited financial statements of the Woods Hole Oceanographic Institution (WHOI). The Institution faced several challenges in 2011 that ranged from managing funding shortfalls in our pension plan to identifying and establishing stronger controls and processes associated with large project management, with year-end results stronger than expected. This was primarily attributable to a strong endowment, healthy increase in revenue, improved operational efficiencies, and the support of organizations and individuals who recognize the long term benefits of basic research.

### S&P Rating AA-with Stable Outlook

The Institution recently received the results of our Standard & Poor's (S&P) annual Bond Rating Review, which was conducted in April, 2012. The Institution was notified in May 2012 that the current rating of AA- with a stable outlook remains unchanged. This continued favorable rating will enable the Institution to negotiate better banking terms, easily establish partnering relationships for federal government grants, and provide potential donors and foundations with evidence of a stable financial outlook to go along with WHOI's scientific reputation.

### Statement of Financial Position

WHOI continues to have a strong balance sheet. At December 31, 2011, WHOI's total assets were \$497 million, total liabilities were \$234 million and total net assets were \$264 million.

Net assets represent the accumulated financial strength of a not for profit organization and are an important gauge of its ability to carry out its mission. Included in the liabilities is the Massachusetts Health and Educational Facilities Authority bond debt of \$60.6 million.

The endowment, \$341 million represents 68% of the total assets at December 31, 2011.

### Statement of Activities

WHOI's total operating revenues increased by \$18.0 million; from \$203 million in CY 2010 to \$221 million in CY 2011; and the Institution's change in net assets from operating activities was (\$5.8) million.

\$16.9 million of endowment income and appreciation was distributed to operations as follows:

- Education      \$6.7 million
- Research       \$6.1 million
- Unrestricted    \$4.1 million

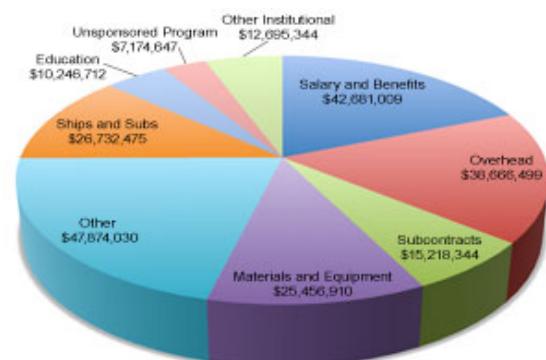
The Institution had overhead costs of \$87.6 million, and approximately 65% of that amount, \$56.7 million, was recovered from the government and non-government research. The remainder was institutional expenses.

WHOI paid \$5.0 million in interest during CY 2011 and \$1.4 million in principal payments on the \$60.6 million outstanding debt in CY 2011. The Federal government allows interest and depreciation for real property and equipment in the Institution's overhead rates for reimbursement.

### Summary

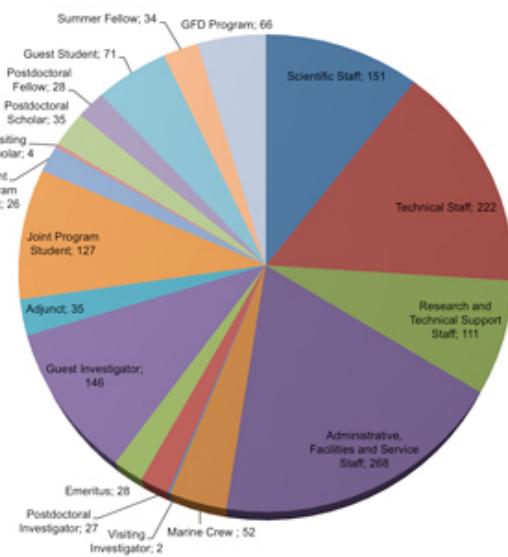
The Institution's commitment to understanding the oceans is unchanged; however, the federal funding environment continues to provide a challenge. WHOI is looking to expand its sources of revenue by leveraging its industry recognized core skills in both the federal and industry marketplaces. We are also continuing the process of evaluating our administrative systems and allocating resources to support our science and an evolving organization.

—Dana Fernandez, Interim Co- Vice President, Finance and Administration



[Enlarge Image](#)

### 2011 Operating Expenses



[Enlarge Image](#)

### 2011 People

WHOI employees totaled 861 in 2011, students, postdocs, and scholars totaled 391, and others affiliated with the Institution totaled 181.

*Last updated: July 20, 2012*

Copyright ©2007 Woods Hole Oceanographic Institution, All Rights Reserved.

Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.

E-Contact: [info@whoi.edu](mailto:info@whoi.edu); press relations: [media@whoi.edu](mailto:media@whoi.edu), tel. (508) 457-2000

Problems or questions about the site, please contact [webdev@whoi.edu](mailto:webdev@whoi.edu)