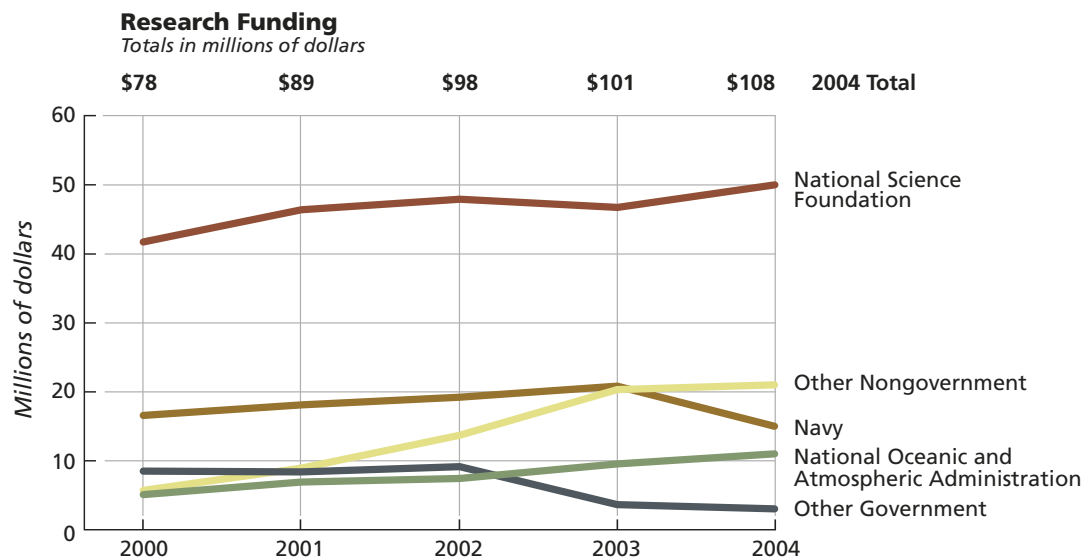


By 2004 we recovered the endowment principle lost in the market downturn since 2001, while distributing more than \$13 million per year since then to support our science. Our endowment ended 2004 at \$291 million, with a 12% annual average rate of return, outperforming our benchmark.

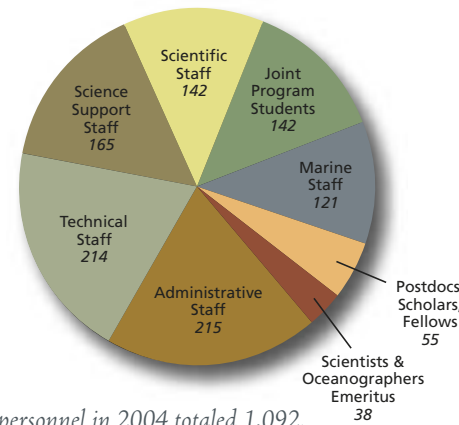
<sup>1</sup>Endowment comprises cash and securities to provide income for maintenance of the organization. Market value is as of December 31.

<sup>2</sup>Total operating revenue is total funding of the Institution's research and education programs, including a component of endowment income appropriated for operations during the financial year ending December 31. See Financial Statements, Note 2, page 49.

<sup>3</sup>Total operating expense is cost incurred in support of research, education, and operations during the financial year ending December 31. See Financial Statements, Note 2, page 49.



The \$7-million increase in research funding (up 7 percent over 2003) was driven mainly by growth in funding from the National Science Foundation and the National Oceanic and Atmospheric Administration. Navy funding is down as the Navy increases its emphasis on applied research.



WHOI personnel in 2004 totaled 1,092.





WOODS HOLE OCEANOGRAPHIC INSTITUTION is a private, nonprofit marine research and engineering, and higher education organization. Its mission is to understand the oceans and their interaction with the Earth as a whole, and to communicate a basic understanding of the ocean's role in the changing global environment. Established in 1930 on a recommendation from the National Academy of Sciences, the Institution is organized into five scientific departments, interdisciplinary research institutes and a marine policy center, and conducts a joint graduate education program with the Massachusetts Institute of Technology.



Jack Whitehead, WHOI



C.A. Linder, WHOI

FRONT COVER: *In June, MIT/WHOI Joint Program students and staff hiked Mount Kilauea on the Big Island of Hawaii to study the island's origin and active volcanism. They are standing near an opening in a lava tube, about eight miles from the eruption source. Leading the field trip was Postdoctoral Scholar Adam Soule (sixth from left, hat backwards). Escorting the students were seismologist Jeff McGuire (far left), geophysicist Hans Schouten (right, with gloves) and physical oceanographer Jack Whitehead (right, with backpack). The trip to Hawaii, part of the geodynamics seminar, was jointly sponsored by the Deep Ocean Exploration Institute and the Academic Programs Office.*

BACK COVER: *Glen Gawarkiewicz, right, and Al Plueddemann deploy a REMUS autonomous underwater vehicle in January off the dive platform of R/V Tioga. The vehicle was used for a hydrographic survey in shallow water off the east coast of Cape Cod.*

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Design and Production: Jim Canavan

Editors: Mike Carlowicz, Vicky Cullen, Shelley Dawicki, Jim Kent, Lonny Lippsett, Kate Madin, Stephanie Murphy, and Amy Nevala

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In 2004 we made significant strides in affirming the leadership position of our Institution and in preparing for difficult times for federally funded basic research.

We took major steps to enhance our science and education, both ashore and at sea.

On the Quissett Campus, we broke ground (photo at right) for much-needed new laboratory space, adding 80,000 square feet to relieve crowding of our scientists and to accommodate newer technologies. The project is on time and on budget, with occupancy scheduled for late 2005. We also provided 10,000 square feet of space in the village for our Deep Submergence Group.

We signed a \$21.6-million cooperative agreement with the National Science Foundation (NSF) to build a replacement for the venerable and industrious submersible, *Alvin*, which was 40 years old in 2004. The replacement sub, which will be the deepest diving and most technically advanced in the world, is scheduled for launch

in 2008. We also began the design phase for a hybrid remotely operated vehicle, an innovative mix of free-swimming and tethered vehicle designs, which will operate to the deepest ocean depths of 36,000 feet—deeper than Mt. Everest is high.

*Tioga*, our new coastal research vessel, completed its first eight months of operations, logging 75 trips in support of WHOI science and our at-sea education for undergraduate summer student fellows, and for media outreach (photos below and on page 7).

A joint grant from NSF and the National Institute of Environmental Health and Sciences funded a new \$6.5-million Woods Hole Center for Oceans and Human Health based at WHOI and operated jointly with Marine Biological Laboratory and MIT. The center will coordinate research at the intersection of oceanographic, biological and environmental health sciences.

An external review committee for our graduate edu-

cation efforts reported that “the MIT/WHOI Joint Program remains a (if not *the*) top educational program covering all the marine sciences and engineering”—a ringing endorsement of the quality of our faculty, staff, and students. In addition, WHOI rated in the top ten U.S. institutions for postdoctoral researchers nationwide in a reader survey conducted by the magazine *The Scientist*.

### A changing attitude toward science

While I’m proud of our accomplishments, we face new challenges that come from a changing attitude toward science in the United States.

In 2004, a modest increase in NSF ocean sciences funding did not keep pace with demand for important research. A rising percentage of highly rated proposals is being turned down, which has a demoralizing effect on our scientists.

As we anticipate declining research support from federal agencies, my focus remains on controlling nonscience expenses while building sources of revenue. Here, there is some good news. With the support and efforts of our Board, our fund raising passed \$115 million toward our campaign goal of \$200 million. The campaign enters its public phase in 2005.

Thanks to the talent of our trustee investment committee and a rebound in Wall Street, by 2004 we recovered the endowment principle lost in the market downturn since 2001, while distributing more than \$13 million per year since then to support our science. Our endowment ended 2004 at \$291 million, with a 12% annual average rate of return, outperforming our benchmark. On the expense side of the balance sheet, our discipline in controlling administrative costs contributed to positive financial results. We are also addressing increasing health care and retirement benefits costs.

A priority for 2005 will be to promote recognition of the importance of our science. Gone are the days of my youth when science, while perhaps not widely understood, was at least widely valued. We can no longer as-



Tom Kleindinst, WHOI Graphic Services

*Tioga* crew, WHOI personnel and members of the Smith family along with others who supported the new coastal research vessel, gathered at its launch in March at Gladding-Hearn Shipbuilding in Somerset, MA.





Tom Kleindinst, WHOI Graphic Services

Bob Gagosian encourages Jim Moltz, Chairman of the Board of Trustees, at the groundbreaking ceremony for the new laboratories being built on the Quissett Campus.

sume the importance of our work is self-evident to the public and those in government. Peer-reviewed journal articles are no longer enough. The public must hear if we are to win its support for science. Congress must hear. The White House must hear. I believe that if the science community does not advocate for science, no one else will.

### Advocating for science

Our Ocean Institutes, with their mission to communicate the importance of our work, are pioneering an approach that will make our research and its benefit to society broadly understood and appreciated. This step is es-

sential to win further federal support for research.

The continuing success of our researchers requires that they write ever more proposals, eroding the time spent on science. Today, the average WHOI researcher writes four to six proposals a year and some write as many as a dozen. Those that are funded, are often at a level below what they need to achieve their scientific objectives.

In this environment, private funding increasingly enables science that likely would not have happened otherwise. Today about 20% of the Oceanographic's science is underwritten by private sources and we are working hard to increase that figure. Private funding is needed to maintain our ability to do high-risk, high-reward science that catalyzes our scientific leadership and pays dividends to society in the long run.

There is some good news in the research arena, despite difficulties with the NSF budget. The crossroads we stand at today, on the threshold of the 75<sup>th</sup> anniversary of our Institution, presents opportunities we have not encountered in decades. The recommendations of the U.S. Commission on Ocean Policy promise to reinvent our country's policy and funding framework for ocean science. Congress has renewed consideration of the U.S. Commission on Ocean Policy recommendations, with hearings likely to stretch until July 2005.

What would implementation of the Commission recommendations mean for WHOI?

We are uniquely prepared to take advantage of a renewed emphasis on oceanography.

First, we have an unmatched scale of sea-going expertise—ships, tethered and autonomous vehicles, buoys and observatories, and we are building a new human-occupied submersible.

Second, we have a unique partnership of science and engineering. We don't just buy new technology off the shelf and adapt it. We invent it, design it, build it, test it, and deploy it.

Third, we have excellent academic programs that cultivate the inventive minds we will need in the future.



Elsa Ruiz

From left, Bob Gagosian, Corporation Chair Tom Wheeler, and Board Chair Jim Moltz were among those attending a formal trustee event in New York on January 6, 2005, the 75<sup>th</sup> anniversary of the Institution's incorporation.

A renewed emphasis on ocean science would mean reinvigorated demands placed on ocean scientists and engineers. Not only are we qualified to meet these demands, the Ocean Institutes have proved their ability to incubate new ideas, and multiply small private investments into major federal support.

For 75 years, researchers at Woods Hole Oceanographic Institution have proved their adaptability. During World War II, we did mainly defense-related work. During the height of the Cold War, our scientific and technical innovation kept our Navy a step ahead of the Soviet navy.

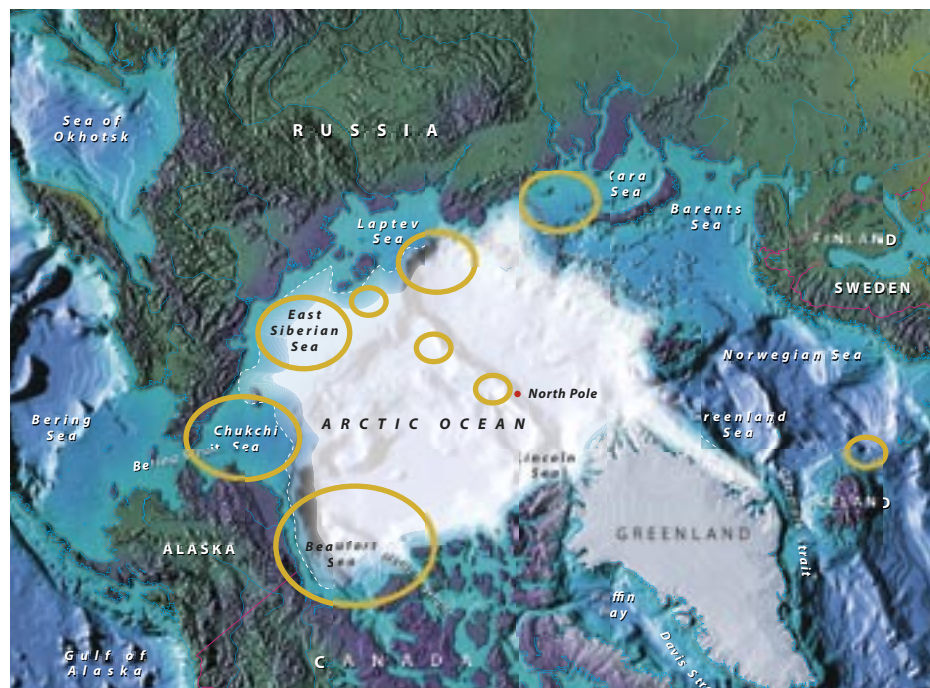
Today, we are in another time of change and I am confident that the world-class creativity and enterprise we nurture in our extraordinary village will lead us productively into new waters.

Shrinking federal investments in basic research will make the coming years challenging for Woods Hole Oceanographic Institution. Despite this outlook, the Institution's research and engineering achievements continue. We are prepared for rough waters in the short term, and are preparing for a new way of funding basic research in the long term.

### Achievements

By the end of 2004, we had approximately \$120 million in hand for funding of 865 research projects. Continuing the trend over the last few years, our Biology Department and Applied Ocean Physics and

Engineering Department show most rapid growth in personnel and in the number and size of sponsored research projects. Our scientists made significant advances in earthquake research, involving the application of mathematical models to the extensive databases for earthquakes on the East Pacific Rise, leading to a better understanding of early release of stress that may ultimately provide some predictive capability. Jeff McGuire, graduate student Margaret Boettcher, and colleagues have led this effort. Jian Lin, with Uri ten Brink of the U.S. Geological Survey, reported their work on assessing the potential for tsunami-generating earthquakes in the Caribbean in December.



Highlighted areas denote locations of selected polar projects by WHOI investigators. Rindy Ostermann is working north of Iceland; Andrey Proshutinsky, Al Plueddemann, and John Toole in the Beaufort Sea; Carin Ashjian and Bob Pickart in the Bering Strait and Chukchi Sea. Peter Winsor and Breck Owens are deploying floats across the Arctic Ocean. Several projects are also pending or underway in Antarctica.

The sensitivity of the polar seas to global changes in climate has led to a large, and growing, research effort to understand the complex relations that control marine life, as well as the processes that control the balance between fresh and salty water—which in turn influences earth's climate. We have more than 40 funded projects scheduled for the Arctic and Antarctic, involving more than 30 investigators from a wide range of disciplines, including biologists Carin Ashjian, Peter Wiebe, Scott Gallagher; physical oceanographers Andrey Proshutinsky, Bob Pickart, Fiamma Straneo, Al Plueddemann, and

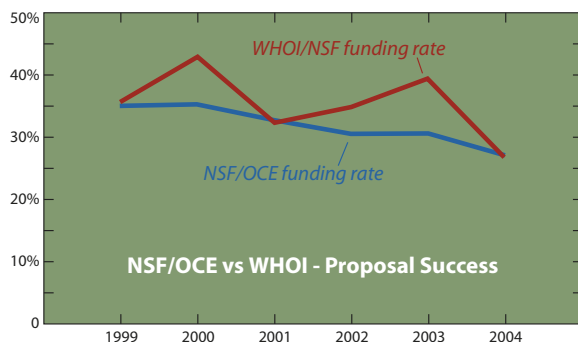
John Toole, geologist Rob Reeves-Sohn, and engineering scientist Hanu Singh. Some of the polar areas of interest to these scientists are highlighted in the map (left). We expect to play a significant role in International Polar Year, a coordinated effort starting in 2007 to focus on leading polar science questions.

The prospect of making observations from autonomous platforms has been a dream for oceanographers for decades. This dream is finally becoming realized. An autonomous transect of the Gulf Stream south of New England was accomplished this year by Breck Owens and Scripps collaborators, using the Spray glider (page 29). In addition, Dave Fratantoni participated with the Naval Oceanographic Office in a field program in the Philippine Sea with five Slocum gliders to test the concept of using a mobile array of gliders as synthetic moorings, using the measurements to initialize and then validate numerical models. Christopher von Alt and colleagues in the Oceanographic Systems Laboratory delivered to the Navy a second autonomous underwater vehicle rated for depths to 6,000 meters. The vehicle successfully conducted more than 5,000 nautical miles of deep ocean surveys for the Naval Oceanographic Office.

Also started in 2004 was the work of Dennis McGillicuddy's group and colleagues in many institutions on biological-physical interactions in the Sargasso Sea to better understand the effect on biological productivity of ocean eddies, which are hundreds of kilometers across. The eddies, sometimes referred to as the "internal weather of the sea," are highly energetic and ubiquitous features of ocean circulation. They perturb the chemical and biological environment that can dramatically impact biogeochemical cycling in the ocean.

Following a recommendation made in 2004 by the "Access to the Sea" task force, an internal fund has been established to foster the development of state-of-the-art sea-going technologies and support high-risk or innovative sea-going research. The first projects are due for selection in 2005.





The National Science Foundation is the largest supporter of WHOI science, with most NSF funds coming from proposals submitted to the Division of Ocean Sciences (OCE). The NSF funding rate—the number of projects funded vs. proposals submitted—is declining as demand for NSF support has outpaced the agency's budget increases.

### Near-term prospects

Much of our existing funding is for ongoing projects, which have been funded in the past few years for three to five years. In addition, there are significant new projects. Some of these include the Clivar Mode Water Dynamics experiment (CLIMODE), a large, multi-institutional observational program to understand the formation and maintenance of large bodies of water adjacent to strong currents (such as the Sargasso Sea, along the south side of the Gulf Stream) and their role in climate. Andrey Proshutinsky is leading a group of investigators working in the Beaufort Gyre, off the Alaska north coast, to understand its role in the balance of fresh and salty water, and its influence on global heat distribution.

As part of an international effort called VERTIGO (VERTical Transport In the Global Ocean), WHOI scientists and technicians Ken Buesseler, Jim Valdes, Tom Trull, Karen Casciotti, Ben Van Mooy, and Steve Manganini are studying processes that control the sinking of particles from the ocean surface to depths of 1,000 meters. This work will enhance modeling of the global carbon budget and understanding of the role of carbon in the global climate.

Biology is thriving because its funding base is highly diverse, and because it has become an international scientific focus driven by extraordinary developments in genomics, proteomics, and in the oceans in particular because of the observational capabilities developed in the past 10 years. The Woods Hole Center for Oceans and Human Health, one of four in the country, exemplifies the application of modern understanding in biology to addressing issues of immediate human interest.

### The longer view

Despite the decrease in National Science Foundation (NSF) funds overall for 2005, the Foundation will still spend more than \$300 million in basic research in ocean science per year. Our scientists and engineers are very competitive (figure at left) and we anticipate that we will continue to participate substantially in the major oceanographic initiatives in the coming decade. We also expect to continue to receive substantial funding for individual investigators and major facilities, such as the accelerator mass spectrometer, ships, and submersibles. We continue to attract highly qualified candidates for new scientific and technical positions.

In addition, advances in instrumentation and technology make possible measurements and understanding that was previously beyond our reach. This advancement is moving faster than the required increase in funding. To fully harness these emerging capabilities, we will require a more diverse funding base. Roughly eighty percent of the federal funding we need will still come from traditional sources, such as NSF, the Office of Naval Research, the National Oceanic and Atmospheric Administration, and the National Institutes of Health. The remainder will need to come from new sources.

Escalating competition for federal research funds is contributing to growing risk aversion in basic science funding. As a result, private funding—which underwrites 20% of WHOI science today—will become increasingly important to demonstrate success and smooth the way



Jim Luyten, left, chats with Corporation Member Ted Dengler.

for subsequent federal support. This is already happening within our Ocean Institutes and other internal programs.

In the larger picture, not only is funding for basic research continuing to decline at most federal agencies, the character of the funding is changing. There is more focus on applied problems. Unlike the funding for basic research, this money comes with more strings attached, more rigid timelines, and firmer expectations of results. To participate in this world, our scientists' way of working will need to change to accommodate the different requirements of the funding agencies. Some of our scientists and engineers have been successful at navigating in this world. We are exploring ways, within the Institution's culture, to create an environment that enables more scientists and engineers to take advantage of these opportunities.

The past year marked a major milestone in deep submergence operations at WHOI. *Alvin*, the nation's only deep-diving, human-occupied research submersible, completed its 4000th dive during its 40th year of operation. As the sub approaches retirement, the National Science Foundation announced in August that it would fund the construction of a new, deeper diving submersible. The replacement vehicle, expected to be complete by 2008, will allow researchers access to more than 99% of the seafloor.

As shown in the maps on pages 8 to 10, *Atlantis* spent 2004 in the eastern Pacific working primarily on the East Pacific Rise and Juan de Fuca Ridge. *Knorr* operated in the North Atlantic conducting a wide variety of research from Panama to Baffin Bay and the Norwegian Sea. *Oceanus* worked in the western North Atlantic and Mediterranean Sea.

In June, after nearly 14 years at the helm of marine operations at WHOI, Rear Admiral Richard F. Pittenger retired. His legacy includes major upgrades to the research vessels *Knorr* and *Oceanus*; the 1996 replacement of *Atlantis II* by the modern vessel *Atlantis*; and the 2004 acquisition of a new 60-foot coastal vessel, *Tioga*.

As the incoming Vice President for Marine Facilities and Operations, I am developing and managing a strategic plan for the integration of the Institution's research fleet with its various undersea vehicles and ocean observatories. In 2005 I look forward to working with others at WHOI to implement recommendations made in 2004 by the Access to the Sea Task Force in areas such as fleet replacement, development of new vehicle platforms and sensors, establishment of seafloor observatories, and improvement of scientific data management at WHOI, both at sea and on shore.

—Robert Detrick

Vice President for Marine Facilities and Operations





## Tioga launch and arrival at WHOI



Jayne Doucette, WHOI Graphic Services

Four years ago, WHOI Vice President for Marine Operations Dick Pittenger and Senior Scientist Rocky Geyer crossed paths while walking through Woods Hole village and talked about bringing a new vessel to WHOI for coastal research. Through their dedication, as well as generous outside donations, on April

16 WHOI welcomed the 60-foot, \$1.6 million coastal research vessel *Tioga*.

During its first nine months of operation 456 people traveled on *Tioga*, including scientists and students who tagged whales, collected water samples, deployed prototype instruments for testing, and gathered data about coastal larvae, sediment, currents, water temperatures, and depth.

*Clockwise from top: WHOI employees, donors, and shipyard workers gathered March 29 for the launch; WHOI President and Director Bob Gagosian, donor Hope Smith, and Dick Pittenger pose at the launch at Gladding-Hearn Shipbuilding in Somerset, Massachusetts; Rocky Geyer (on vessel) talks with well-wishers at the April welcome ceremony; Tioga, capable of cruising 20 knots, speeds into Woods Hole; the WHOI flag is raised on the vessel for the first time. Center photo: Hope Smith cracks a ceremonial champagne bottle across the bow.*



Tom Kleindinst, WHOI Graphic Services



Tom Kleindinst, WHOI Graphic Services



Jayne Doucette, WHOI Graphic Services



Tom Kleindinst, WHOI Graphic Services



Tom Kleindinst, WHOI Graphic Services



Dave Gray, WHOI Graphic Services





Amy Nevela, WHOI

R/V Atlantis and DSV Alvin at the Juan de Fuca Ridge.



274 feet

**Atlantis**  
 Capacity: 59 people at sea for 60 days  
 Launched: 1996  
 Days at sea in 2004: 225  
 Cruises: 12  
 Investigators served: 311  
 Nautical miles: 20,338  
 Alvin dives: 114

**Gulf of Alaska Seamounts** Jul. 30–Aug. 23  
 Surveyed five seamounts. Analyzed and collected deep water corals from various sites. 19 *Alvin* dives

**Nootka Fault, Juan de Fuca Ridge** May 12–May 18: Deployed prototype moored seafloor observatory.

**Endeavour Segment, Juan de Fuca Ridge** May 23–Jun. 7: Recovered and deployed instruments, including several prototypes. Cleared vent field of research instrument debris from previous expeditions. 14 *Alvin* dives

**Endeavour Segment, Juan de Fuca Ridge** Jun. 14–Jul. 13: Sampled fluids at hydrothermal vent fields. Collected animals living at vents.

**Strait of Juan de Fuca and Neah Bay** Sep. 8–Sep. 28: Researched how a harmful algae produces toxins, and studied how algae move to the coast, threatening shellfish. Gathered data on salinity, temperature, and water depth.

**Gorda Ridge and Axial Volcanoes** Aug. 28–Sep. 4: Collected animals living at hydrothermal vents. Surveyed invertebrates colonizing seafloor. 4 *Alvin* dives

**East Pacific Rise** Jan. 28–Feb. 24: Made seafloor maps. Sampled sediment. Measured fluid chemistry. Conducted series of microbiology experiments to determine settlement patterns of deep-sea organisms. 13 *Alvin* dives

**East Pacific Rise** Mar. 15–Apr. 1: Measured heat fluctuations at hydrothermal vents. 11 *Alvin* dives

**East Pacific Rise** Apr. 6–Apr. 30: Made seafloor maps. Gathered data on salinity, temperature, and water depth. 16 *Alvin* dives

**East Pacific Rise** Nov. 5–Nov. 26: Tested chemistry instruments in hydrothermal fluids. Collected sulfide, sediment, and fluid samples. 13 *Alvin* dives

**East Pacific Rise** Nov. 30–Dec. 20: Collected water and sulfide samples as well as vent organisms, including tubeworms, mussels, and clams. 12 *Alvin* dives

**Costa Rica, offshore Nicoya Peninsula** Feb. 27–Mar. 7: Deployed and recovered pressure, fluid, and chemical monitoring instruments. 8 *Alvin* dives



## Cruise tracks: R/V Knorr



Jim Broda, WHOI

R/V Knorr is fitted with a coring device at a Florida dock.

**Grand Banks** Jul. 16–Aug. 15: Conducted coring and seismic surveys. Made seafloor maps.

**North Atlantic, Gulf Stream (including "Station W")** Jun. 17–Jul. 12: Surveyed seafloor. Collected sediment cores. Deployed sediment traps. Gathered plankton samples.



### Knorr

Capacity: 58 people at sea for 60 days  
 Launched: 1970, refit in 1991  
 Days at sea in 2004: 242  
 Cruises: 9  
 Investigators served: 174  
 Nautical miles: 43,529

### Panama Basin

**Panama Basin** Feb. 14–Mar. 5: Collected sediment cores as part of a long-term study into the connection between salinity of the area and global climate.

### Station W

### Davis Strait

**Davis Strait and Baffin Bay** Sep. 22–Oct. 4: Deployed instruments, including subsurface moorings. Conducted bathymetric survey.

### Grand Banks

### Norwegian Basin

**Norwegian Basin** May 8–May 18: Collected sediment cores. Gathered data on salinity, temperature, and water depth.

**Storegga Slide, Norwegian Sea** Aug. 29–Sep. 11: Conducted seismic, sediment, and geochemical research.

### Mid-Atlantic Ridge

**Mid-Atlantic Ridge (7 locations)** Mar. 16–Apr. 10: Deployed and recovered moorings and other ocean instruments monitoring earthquake activity along the Mid-Atlantic Ridge.

**TAG Hydrothermal Vent Field, Mid-Atlantic Ridge** Oct. 25–Nov. 9: Used ROV Jason to monitor "micro-earthquake" activity. Measured vent temperatures. Gauged tidal pressures.

**Kane Fracture Zone, Mid-Atlantic Ridge** Nov. 14–Dec. 17: Used ROV Jason and other vehicles for rock dredging and seafloor mapping.



## Cruise tracks: R/V Oceanus

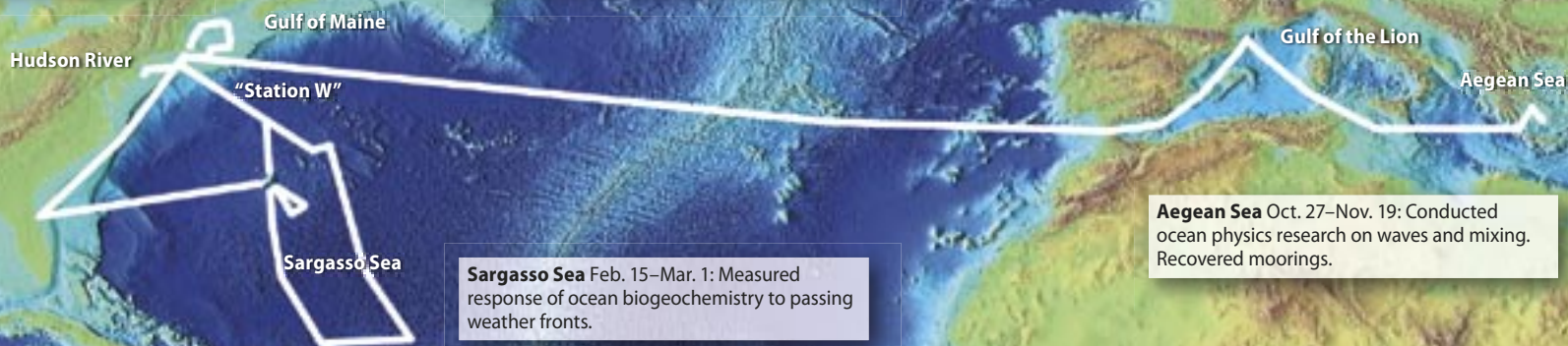
**"Station W" in North Atlantic** Apr. 27–May 6: Deployed and recovered ocean research instruments, including moorings.

**Hudson River (near Staten Island and New Jersey shelf)** Jun. 2–6: Conducted biology, chemistry, and physics experiments to map amounts of dissolved organic matter living in the region.

**Gulf of Maine** Apr. 16–23: Collected water samples and sediments for research on carbon cycling.

**Casco Bay & Penobscot Bay, Gulf of Maine** May 18–28: Mapped spread of harmful algae. Measured offshore coastal current speeds. Gathered data on salinity, temperature, and water depth.

**Gulf of the Lion, Mediterranean Sea** Sep. 25–Oct. 15: Deployed ocean research instruments and collected water and sediment samples.



**Sargasso Sea** Feb. 15–Mar. 1: Measured response of ocean biogeochemistry to passing weather fronts.

**Sargasso Sea** Mar. 19–Apr. 10: Collected surface water samples to measure trace metals, nutrients, and phytoplankton.

**Sargasso Sea** Jun. 11–Jul. 3 & Jul. 25–Aug. 11: Determined impacts of eddies and mixing on plankton communities and biogeochemical cycles.

**Aegean Sea** Oct. 27–Nov. 19: Conducted ocean physics research on waves and mixing. Recovered moorings.



Mike Gregg, University of Washington

R/V Oceanus in the Aegean Sea.



### *Oceanus*

Capacity: 31 people at sea for 30 days  
Launched: 1975, refit in 1994  
Days at sea in 2004: 210  
Cruises: 9  
Investigators served: 190  
Nautical miles: 37,547



## On top of the world

WHOI researchers scouted the perfect spot to deploy instruments in the Beaufort Sea in the western Arctic Ocean. In August 2004, John Kemp (far right) and Rick Krishfield (who took this photo) found their spot: a stable, four-meter-thick piece of ice to install an Ice-Tethered Profiler (ITP). Developed at WHOI by John Toole, the ITP is secured to a drifting ice flow. It dangles an instrumented cable into the ocean to measure water temperature and salinity—through all seasons and over several years—transmitting data back via satellite. (It was also an ideal spot for polar bears—hence Seaman Andrew Kaiser of the Canadian Coast Guard Icebreaker *Louis S. St. Laurent* and his shotgun.)

Using a variety of instruments to measure ocean, ice, and atmosphere in the Beaufort Sea, WHOI researchers seek to elucidate the sea's critical role in global climate. Vast amounts of fresh water collect in the sea: from the Pacific Ocean through the Bering Strait; from precipitation and melting snow and ice; and from great Siberian and Canadian rivers draining into it. This huge freshwater reservoir is trapped by a wind-driven, cyclonic current called the Beaufort Gyre. WHOI physical oceanographer Andrey Proshutinsky has theorized that when the winds occasionally shift, the gyre weakens, allowing large volumes of fresh water to leak into the North Atlantic. This flywheel may have large impacts on ocean circulation and climate, and it may be sensitive to global warming. Nobody knows for sure, because the Beaufort Sea is among the Earth's most hostile and inaccessible regions, and data is scarce. But pioneering, annual expeditions to the Beaufort Sea from 2003 to 2008 will begin to reveal its secrets.

*The Beaufort Gyre Freshwater Experiment is funded by the National Science Foundation and the WHOI Ocean and Climate Change Institute. The Cecil H. and Ida M. Green Technology Innovation Award at WHOI funded initial development of the ITP.*





# In whale blubber, a tiny, telltale chemical clue

Emma Teuten may be a vegetarian, but that didn't deter her from seeking intriguing chemical clues in whale blubber to an important marine pollution issue. Teuten and fellow chemist Chris Reddy discovered that two suspected man-made pollutants found in marine mammals actually came from natural sources.

Methoxylated polybrominated diphenyl ethers (MeO-BDEs), a component of flame retardants, have been found accumulating in animal tissues around the world. Some researchers suspect that these compounds may affect animal and human health, and some compounds have been banned. Bromine compounds have been found in fish and humans near industrialized areas, but they have also shown up in the flesh of sea sponges, dolphins, and other creatures far removed from human activity.

Teuten, a postdoctoral fellow in the Department of Marine Chemistry and Geochemistry (MCG), dulled a dozen knives and burned up two blenders in order to isolate just 1 gram of brominated compound from 20 kilograms (22 pounds) of blubber from a beached whale that had died. "There was no road map for this," said Teuten. "This just hasn't been done before."

Teuten and Reddy examined her sample for carbon-14, a natural radioactive isotope of carbon that is incorporated into all living things, but is not found in industrial petrochemicals. They found that BDEs in the whale tissue contained carbon-14, meaning the chemicals were derived from a natural (though still unidentified) source. Gordon Gribble, an environmental chemist at Dartmouth College, called the technique "very exciting... a great tool for distinguishing natural compounds from man-made ones."

*This research was supported by the National Science Foundation and The Camille and Henry Dreyfus Foundation, Inc.*



# Delicate life in the depths

In near-freezing waters thousands of meters below the ocean surface, communities of brightly colored corals bloom on the seafloor, living quiet, long lives far from sunlight and waves. Like their tropical, shallow-water cousins, these deep-sea corals harbor a rich diversity of underwater life, including abundant commercially valuable fish.

Scientists only recently discovered these ancient ecosystems. So have fishermen, who have begun to target seamounts—extinct submarine volcanoes whose rocky slopes and nutrient-rich currents provide the rare combination of foundation and food that deep-sea corals need to grow.

Like old-growth forests, deep-sea coral communities may persist for hundreds of years and, scientists fear, may be slow to recover from disruption. Once damaged, they may disappear, along with the rich ecosystems they have sustained over long reaches of time.

“Conservation concerns have added urgency to our research,” said Lauren Mullineaux, senior scientist in the Biology Department. “Closures of many shallow-water fisheries have forced people to fish deeper, so there is increasing pressure on these habitats. We’ve seen trawl tracks on them.”

In 2003 Mullineaux (below, left) and WHOI biologist Susan Mills (below, right) dived in the submersible *Alvin* and in 2004 used the remotely operated vehicle *Hercules*. (*Alvin*’s claw extends to sample a coral, at right.) They took part in an expedition to the New England Seamount Chain off the U.S. Eastern Seaboard to study where and how long the corals live, to catalog the richly diverse animal communities that live with them, and to find out how they reproduce. In particular, they seek to learn how coral larvae disperse through the oceans to settle and reseed coral communities, or to create new colonies. The answer is essential for understanding if deep-sea coral habitats can endure and recover from the threats they now face.

*The research was supported by the NOAA Office of Ocean Exploration and the WHOI Ocean Life Institute.*



Deep-sea coral photos courtesy of "Mountains in the Sea" scientific party, NOAA, and the Institute for Exploration

Tom Kleindinst, WHOI Graphic Services



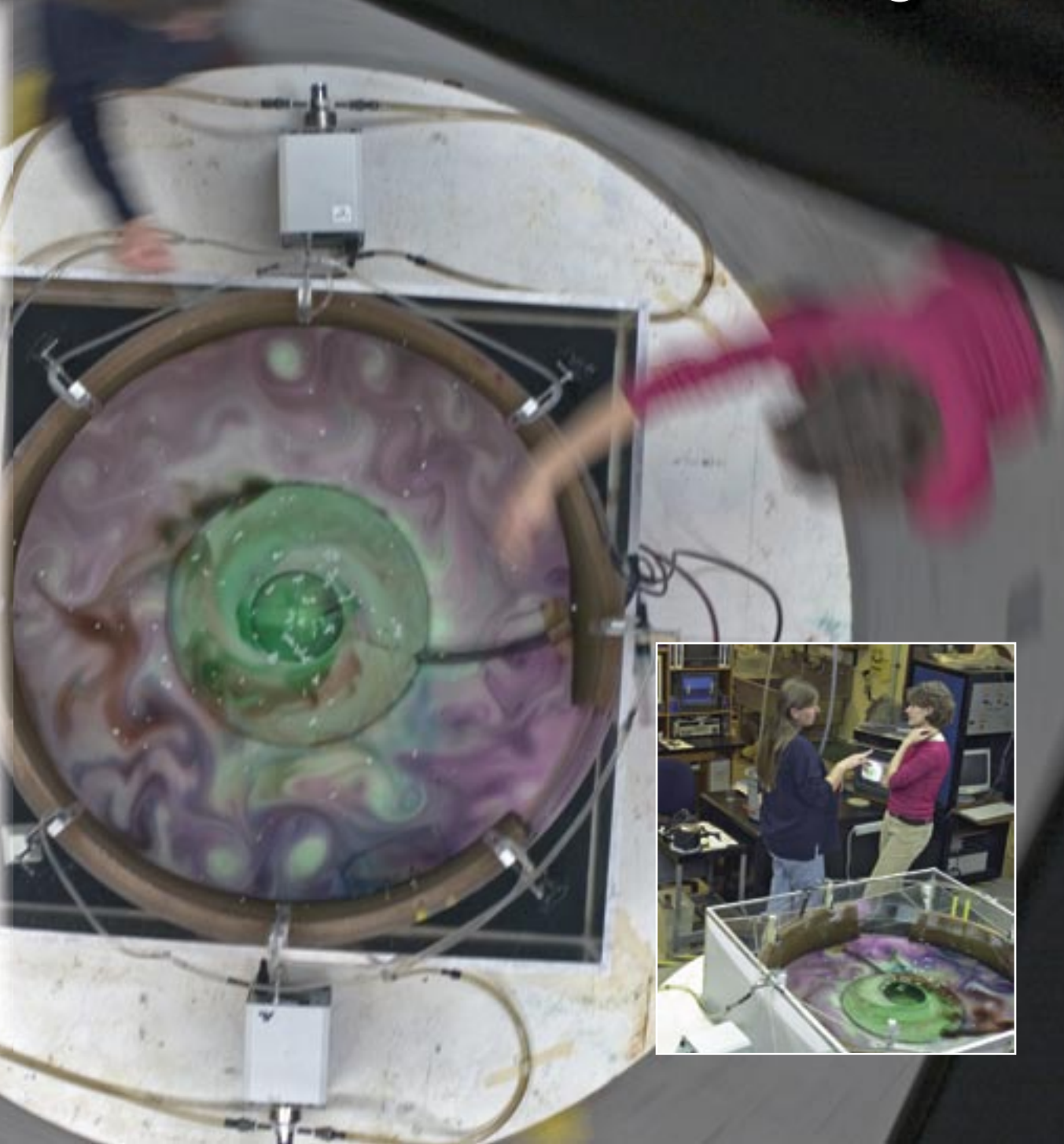
# Round and round it goes

At first glance, it looks like an art project: a spinning Plexiglas box filled with paint. To Claudia Cenedese, the box contains the ocean—but on a miniature scale.

A plastic mound in the center of the box represents a seamount—an extinct submarine volcano—that would span 1,500 kilometers (9,000 miles) in the real ocean. Colored food dyes are injected into the water from different locations on the “seamount” (blue from the bottom, red from the middle, and green from the top). The table rotates as the Earth does. A camera above, rotating in synchrony with the table, photographs the swirling field of small vortices that spin off the seamount. One large, single vortex (green), however, forms above the seamount.

The same basic physical laws that govern geophysical fluid dynamics in the box apply in the real ocean. In this experiment, Cenedese (in blue, above and at right), an associate scientist in the Physical Oceanography Department, and Rachel Bueno de Mesquita, a visiting undergraduate from the University of Rome, explore how seamounts sticking up from the seafloor modify ocean circulation and create organized, rather than random, patterns of vorticity. Such experiments reveal subtle complexities of ocean circulation. They also help explain, for example, how larvae of animals living on seamounts might spin out to colonize new seafloor regions (as indicated by blue or purple dyes), or alternatively, spin endlessly around the seamount and become trapped in one region (as indicated by the green dye).

Theoreticians create mathematical equations with all the interacting variables that go into complex geophysical fluid dynamics. Observationalists go to sea to observe actual ocean dynamics, but can observe only a tiny portion of a wide-scale process. Somewhere in between is Cenedese, an experimentalist, who devises laboratory studies to observe and measure actual fluid dynamics on a small scale.

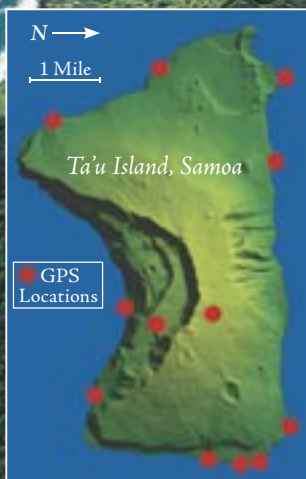




# Rambling and rumbling on an island volcano



Stan Hart, WHOI



The Samoan island of Ta'u is a tropical paradise, but Rhea Workman knows it was created by an undersea volcano that is still active. Ta'u's central volcano was formerly dome-shaped, but one of its sides collapsed in landslides that cast debris all the way onto the seafloor. The landslides left a steep escarpment, which is primed for further catastrophic landslides—and possibly tsunamis—especially if it is disturbed by movements inside the volcano.

Within a volcano's underlying magma chamber, magma or gas continually surges or subsides, inflating, deflating, and deforming the volcano's surface. These deformations are usually tiny, but they can be measured to evaluate what's going on inside the volcano and predict whether it might erupt.

Workman, a graduate student in the WHOI Geology and Geophysics Department, wanted to assess Ta'u's volcano and landslide

hazard potential by measuring the volcano's subtle motions with Global Positioning Satellite receivers, which can measure ground-motion changes within 1 centimeter. She organized an expedition, conscripting GPS equipment and fellow MIT/WHOI Joint Program students. In 2002, they installed GPS benchmarks (left, red dots on the map) throughout the island and took GPS measurements. In 2004, Workman returned to re-measure the benchmarks, also taking time to explain her research at local schools (above).

Since her return, Workman scrambled to complete and defend her Ph.D. dissertation on March 16. Dr. Workman will now analyze and compare her GPS measurements to see if she can detect telltale ground motion on Ta'u.

*This research was supported by a grant from the Robert H. Cole Endowed Ocean Ventures Fund.*



# Thar she feeds



Courtesy of Michael Moore, WHOI

The North Atlantic right whale never rebounded from centuries of whaling, and fewer than 350 remain. With the species edging toward extinction, the WHOI Ocean Life Institute mustered scientists from several institutions and with a diverse range of expertise to launch the collaborative Right Whale Research and Conservation Initiative in 2004. The ambitious research plan aims to quickly advance understanding of the critical factors hindering the species' recovery and to accelerate more effective conservation efforts.

Under one Initiative-sponsored study, for example, WHOI biologist Mark Baumgartner works between Nantucket and Georges Bank to learn essential details about why the whales' main food (microscopic zooplankton called copepods) aggregate where they do, and how the whales dive and forage. Such fundamental knowledge will provide new insights to devise management strategies that protect critical feeding grounds and help reduce acciden-

tal whale deaths caused by ship collisions and fishing gear entanglements.

At left, WHOI biologist Michael Moore steers toward a whale, with Baumgartner poised to use a 9-meter (27-foot) pole to attach a temporary tagging device that records whale movements. Meanwhile, the scientists use instruments to measure salinity, temperature, and other ocean properties and to assess the abundance and location of copepods in the area. The scientists used WHOI's new coastal research vessel *Tioga* (background above), which was delivered in 2004.

"*Tioga* gives us the capability to rapidly respond to right whale sightings," Baumgartner said. "We can leave the dock very early in the morning, zoom out to where the whales are (virtually anywhere in the western Gulf of Maine off the Massachusetts coast), work a full day with the whales, and be back at the dock by evening."

*The vessel and part of the research were funded by donors of WHOI.*



# Teamwork for discovering vents on the seafloor

Like deep-sea treasure hunters, the oceanographers and engineers began their search with a rough map and a few clues. They sought neither silver nor gold, but hydrothermal vents in the Lau Basin, a previously unexplored area in the southwest Pacific Ocean.

"We knew there were vents, but we had to figure out exactly where," said Dana Yoerger, one of six WHOI researchers who worked from the research vessel *Kilo Moana* in September 2004. "Our clues appeared in the form of smoke," he said of the buoyant plumes of warm, chemical-rich fluids that rise from deep-sea vents and spread a few hundred meters above the seafloor.

The vents offer a potential treasure trove of information about how Earth works, and how deep-sea vent organisms have adapted to thrive in these sunless places, under extreme pressure and intense heat. The processes that shape the Lau Basin are undergoing study through a series of cruises that are part of the Ridge 2000 Program.

High-resolution seafloor and plume maps made by a University of Hawaii group were used to guide surveys by WHOI's Autonomous Benthic Explorer (ABE). ABE, a free-swimming robot used to locate the vents, flew 10 to 300 meters (33 to 990 feet) above the seafloor on a series of missions at six sites. The robot searched for telltale changes in water temperature and chemistry that signaled the presence of a vent.

In the image shown, at the ABE vent site, the vent spires were about 10 meters (33 feet) tall and located along fissures that crack the volcanic seafloor, allowing hydrothermal fluids to exit. ABE enabled researchers to make detailed bathymetry maps of the site and also collected digital images to document organisms living at the vents.

*The cruise was funded by the National Science Foundation Ridge 2000 Program; four WHOI scientists were supported by the Deep Ocean Exploration Institute.*



Tom Kleindinst, WHOI Graphic Services

*Like many expeditions involving WHOI scientists and engineers, the cruises to the Lau Basin require a multidisciplinary team. Participants on the September 2004 cruise included engineers Dana Yoerger (1), Rod Catanach (2), Al Bradley (3), and Joint Program engineering student Mike Jakuba (4), as well as geologist Dan Fornari (5) and biologist Tim Shank (6). Geochemists Meg Tivey (7) (who will be the Chief Scientist) and Jeff Seewald (8) will participate on the April 2005 return to Lau Basin, which will involve deep-sea exploration with the remotely operated vehicle Jason.*



# The (more) intelligent robot

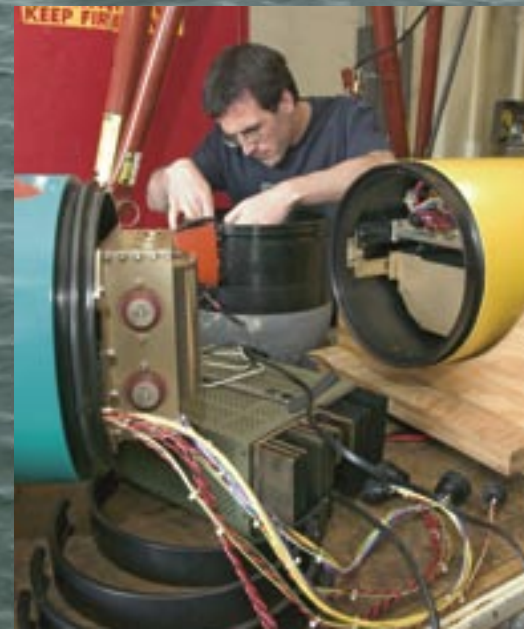
WHOI engineers call them pickup trucks, though these underwater vehicles are a bit sleeker than the typical terrestrial model from Detroit. And these multi-purpose workhorses drive themselves.

Chris von Alt (below right) and colleagues from the WHOI Oceanographic Systems Laboratory have been rolling out new models of Remote Environmental Monitoring Units, or REMUS, since the mid-1990s. New customers for these autonomous underwater vehicles (AUVs) arrive each year with requests for custom-built chassis and features—from Navy personnel who used REMUS to hunt for mines in Iraqi harbors, to urban engineers who use them to examine underground aqueducts for leaks. REMUS can be launched and recovered from small boats (or even torpedo tubes) and equipped with a variety of instruments and sensors to tackle assorted missions.

The newest vehicle is the REMUS 600, designed for dives as deep as 600 meters (1,980 feet) and for long-duration missions, REMUS 600 has enough battery power to range from nearshore areas to the continental shelf break and back. REMUS 600 is equipped with Global Positioning System receivers, and Iridium satellite and WiFi transmitters to allow scientists to track it even on a several-hundred-mile survey.

Senior Engineer Tom Austin (large photo) launched a REMUS 600 from the WHOI dock for a test drive in 2004. This one had a synthetic aperture sonar (white portion of the tube) mounted in its midsection for detailed mapping of the ocean bottom. Engineers such as Fred Jaffre (above right) can swap instruments and preprogrammed flight plans in and out of the AUVs.

*Development of the REMUS 600 vehicle was supported by the Office of Naval Research.*





# How do deltas form and evolve?

They traveled in small “dormitory” boats from Tulcea, Romania, where the roads end, to their base station near the Black Sea coast. They cruised along canals and tributaries to find ancient beach sediments and used sonar to map the seafloor near the mouth of the Danube River. On two expeditions funded by the WHOI Coastal Ocean Institute, WHOI geologists Liviu Giosan and Jeff Donnelly teamed with colleagues from Bucharest University to reconstruct the evolution and dynamics of one of the world’s most environmentally and economically important river deltas.

“The Danube delta is like the Everglades,” said Giosan. More than 300 bird species and 45 freshwater fish species live in its labyrinth of marshes, dunes, and channels. At the mouth of the 2,840-kilometer (1,776-mile) river, the delta forms the largest wetland in Europe and has been dredged and altered to create canals and shipping channels.

Giosan and Donnelly are trying to understand how river flow, sediment load, sea level change, and coastal currents combine to form a delta. A first challenge from the new research comes to the traditional view, which holds that rivers carry all the sediment deposited at their mouths. But the research team’s sediment cores, seafloor maps, and theoretical models suggest that the river actually serves as a natural barrier, partly blocking the natural flow of waves and sand along the coast.

Besides the fundamental implications on river delta geology, the results are expected to be important for the management of shipping lanes and coastal water supplies, and for protection of coastal habitat.

*This research was supported by the WHOI Coastal Ocean Institute and a WHOI Interdisciplinary and Independent Study Award.*







Tom Kleindinst, WHOI Graphic Services

The Applied Ocean Physics and Engineering Department (AOPE) is famous for building instruments, sensors, and vehicles at the forefront of oceanographic research and discovery. The department is also increasingly recognized for scientific advances in ocean physics and interdisciplinary ocean sciences. Our scientific and engineering activities focus on five areas: ocean acoustics, environmental fluid dynamics, submersible vehicles, observing systems and sensors, and engineering services.

Early in 2004, we held a retreat to examine our priorities and directions for the next decade. The retreat reaffirmed the value of the synergy between scientists and engineers within the department and the institution. This synergy will be particularly important in the growing enterprise of oceanographic observatories, which is likely to be a major element of our engineering and research effort in the next decade.

An emerging research area in the Department is computational fluid dynamics, in which ever-faster computers are used to model and predict the complex flows that occur in the ocean at a wide range of scales. Houshuo Jiang

is modeling the flow around minute crustaceans called copepods at scales of micrometers. He recently revealed a subtle interaction between “feeding currents” produced by the organisms to gather prey and their upward propulsion, which optimizes their feeding efficiency.

New Assistant Scientist Tom Hsu is modeling the complex interactions of waves and sediment in the surf zone. His models are revealing how changing wave conditions can shape shorelines on time scales from days to years. New Assistant Scientist Ruoying He is modeling currents in the coastal ocean, at scales of 1 to 100 kilometers (1/2 to 60 miles). His recent work in the Gulf of Maine and the Gulf of Mexico is being applied to the prediction of the transport of toxic “red tide” organisms.

Ruoying’s collaborator in red-tide studies, Dennis McGillicuddy, is modeling biological-physical interactions at a variety of scales, extending to basin-scale circulation models. These large-scale modeling studies focus on the role of eddies—some as wide as 150 kilometers (90 miles)—in the vertical redistribution of nutrients, which he has found to be a key link in the productivity of the open ocean. Dennis is now leading a major field study to

test his numerical predictions, using two ships to measure the influence of eddies in the North Atlantic during the summers of 2004 and 2005.

Jim Ledwell is collaborating with Dennis in the eddy study, using a tracer to quantify the vertical mixing within the eddies with unprecedented precision. Jim is also working with Research Specialist Gene Terray to measure horizontal mixing in the coastal ocean with airborne light detection and ranging (LIDAR).

—W. Rockwell Geyer, Department Chair

▲ From left, Griff Outlaw, Bob Brown, Rocky Geyer, and Barrie Walden, inspect the mock-up of the 7-ft personnel sphere for the Alvin replacement submersible. With funding from the National Science Foundation, WHOI staff began design work this year on a replacement for the 40-year-old Alvin. The new submersible, due in 2008, will dive deeper, be more maneuverable, and provide better visibility for the pilot and two observers.



## Awards & Recognition

**Tom Hurst** received the Excellence Award for highest ranking senior electrical engineering major (transfer student) from the Electrical and Computer Engineering Department, University of Massachusetts, Dartmouth.

Swashzone Process Student Fellows **Catie Lichten** and **Kristie Loncich** both received Sigma Xi gold ribbons for excellence in research they did under the direction of Britt Raubenheimer in 2004.

**Jim Lynch** and **Sandy Williams** have been elected Fellows of the Institute of Electrical and Electronics Engineering. Jim was also named recipient of the Robert W. Morse Chair for Excellence in Oceanography.

**Dennis McGillicuddy** received an American Geophysical Union Editors' Citation for Excellence in Refereeing 2003 (*Journal of Geophysical Research—Oceans*).

**Peter Schultz** received the inaugural Ryan C. Schrawder award, established in memory of the late Ryan Schrawder of the Physical Oceanography Department. The award recognizes "an employee who has, after a short period of time, proven himself/herself to be a valuable asset to scientific projects both at sea and ashore in the lab, exhibited the ability to learn quickly, and applied acquired knowledge towards the success of scientific missions."

*Clockwise from top left: Jim Edson attaches a tube for an ozone sensor on the Air-Sea Interaction Tower off Martha's Vineyard; Dennis McGillicuddy deploys a drifter in the Gulf of Maine to study coastal circulation and its impact on transport of toxic plankton blooms; Andy Billings prepares the autonomous benthic explorer (ABE) for deployment; Dick Nowak prepares a temperature control incubator for experiments by postdoc Beatriz Mouriño to determine the ability of the surface layers of the ocean to work as a sink or source for carbon dioxide; Bob Brown, left, and Tito Collasius are at work on Sentry, the next-generation autonomous underwater vehicle.*



Jielun Sun, NCAR



Judy Kleindinst, WHOI



Tom Kleindinst, WHOI Graphic Services



Tom Kleindinst, WHOI Graphic Services



Tom Kleindinst, WHOI Graphic Services





Tom Kleindinst, WHOI Graphic Services

The Biology Department continued to expand into new research, even while preparations are underway for expansion into two new buildings on the Quissett Campus. Studies continued on whales, microbes, and a variety of organisms between. In pursuit of questions about organisms and their function in the seas, biologists employ a wide range of methods, from traditional sampling to isotope chemistry, molecular genetics to mathematical modeling. This year, we spotlight research into the lives of whole animals, focusing on research of two associate scientists who were awarded tenure in 2004. Both study the persistence and distribution of populations of marine animals, but in very different settings.

Carin Ashjian continued her work on planktonic ecosystems in polar seas, with a cruise to the Beaufort and Chukchi seas in summer, 2004. There she studied population dynamics and distribution of copepods, including rates of reproduction and population exchange between the two seas, as part of the Shelf-Basin Interaction project ([www.whoi.edu/science/B/people/cashjian/index.html](http://www.whoi.edu/science/B/people/cashjian/index.html)). She monitors copepods to help estimate how climate change may influence not only their abundance and dispersal, but

also the structure of the entire Arctic Ocean ecosystem.

Simon Thorrold studies distribution of larval fish, particularly tropical reef fish. He has developed techniques of measuring small amounts of naturally occurring isotopes in fish ear bones that allow him to trace an adult back to its place of origin. Knowing how far fish travel from their spawning place allows him to estimate rates of dispersal, the degree of connection between isolated populations of a species, and the likelihood of success of marine protected areas in re-establishing populations in depleted areas ([www.whoi.edu/science/B/thorroldlab/](http://www.whoi.edu/science/B/thorroldlab/)).

Among the hundreds of projects, other work in the department included: a finding that bone lesions in adult sperm whales are linked to chronic decompression damage; discovery by mathematical modeling that marine protected areas enhance fish catches; and research on the biochemistry and ecology of deep sea organisms including corals on sea mounts and bacteria in deep sediments.

In April, the Woods Hole Center for Oceans and Human Health was established as a partnership between WHOI, the Marine Biological Laboratory, and the Massachusetts Institute of Technology, administered

through WHOI with novel joint funding by the National Institute of Environmental Health Sciences (a component of the National Institutes of Health), and the National Science Foundation. One of four such centers nationwide, the Woods Hole Center encompasses research on harmful marine species (e.g., algae that create “red tide” blooms) and human pathogens in coastal waters as influenced by physical and environmental factors as well as population dynamics and genetics, and also studies of possible pharmacologically useful marine biochemicals. The Center also funds small feasibility grants at the member institutions, which allow scientists to do initial research on a topic and determine whether to pursue it.

—John Stegeman, Department Chair

▲ John Stegeman (standing) in his lab with postdocs, from left, Ann Tarrant (a member of Mark Hahn’s group), Tim Verslycke, and Heather Handley Goldstone. Work in the lab centers on biochemistry and molecular biology of genes and proteins and their role in how organisms respond to foreign chemicals.



## Awards & Recognition

*The Scientist* magazine ranked the WHOI **Biology Department** as the second most cited organization in the U.S. in the field of pharmacology and toxicology.

**Don Anderson** was listed in *ISI Highly Cited.com*, in recognition of the high number of citations of his scientific papers.

**Darlene Ketten** was keynote speaker and featured scientist at the Australian Ministry of the Environment in Sydney, Australia.

**Larry Madin** and **John Stegeman** addressed the United Nations Law of the Sea conference respectively on, seamounts and deep coral beds and developing marine genetic resources.

**Michael Moore** received the Cape Cod Stranding Network Outstanding Service Award.

**Lauren Mullineaux** received the first WHOI Arnold B. Arons Award for Excellence in Teaching, Advising and Mentoring.

**Mike Neubert** was elected Chairman, Theoretical Ecology Section, Ecological Society of America.

**John Stegeman** was appointed Chair of the Institute of Medicine Committee on Health Effects of Agent Orange in Vietnam Veterans. He also gave a keynote address at the European Society for Comparative Physiology and Biochemistry, Alessandria, Italy.

**Simon Thorrold** was keynote speaker at the Third International Symposium on Fish Otolith Research and Application, Townsville, Australia.

**Tim Shank** received the Ocean Explorers Award from NOAA in recognizing of his research and outreach efforts regarding the evolution of deep-sea communities and species on the Galápagos Rift, seamounts, and polar ridge.

*Clockwise from top: Joint Program student Regina Campbell-Malone steadies a right whale jaw bone during a 3-D laser scan (This bone, recovered from a whale hit by a ship off Virginia, will be used to study the material properties of whale bones and develop speed restriction recommendations for ships.); Joint Program student Kristen Whalen studies a sea slug that feeds on a chemically-defended sea fan, which then uses the sea fan's noxious compounds for its own defense; Chad Klinesteker (U.S. Coast Guard), Bob Campbell (University of Rhode Island), and Phil Alatalo deploy a net to capture copepods during Carin Ashjian's cruise to study the Arctic food web.*



Tom Kleindinst, WHOI Graphic Services



Carin Ashjian, WHOI



Ann Tarrant





Tom Kleindinst, WHOI Graphic Services

The Geology and Geophysics Department focuses on understanding how our Earth works by investigating the dynamics of convection in the mantle, the geologic structure and tectonics of the ocean basins, interactions of continental and oceanic geologic processes, the history of ocean circulation patterns and climate change, and the interactions between geological and biological systems.

In 2004, the G&G Department comprised 97 staff and 28 postdoctoral and Joint Program students who were involved in 268 research projects. Bob Detrick stepped down as Chair in 2004 and was succeeded by Susan Humphris. During Bob's term, G&G began building a coastal processes group by hiring three assistant scientists, while simultaneously strengthening and diversifying the geophysics, geochemistry, and paleoceanography groups. In 2004, two new assistant scientists were appointed. Sarah Das is a glaciologist with an interest in the factors that cause surface melting on ice sheets, and in understanding the dynamics of ice sheets. Mark Behn, a 2002 graduate of the Joint Program, is a geophysicist who integrates field observations with numerical modeling to understand a broad

range of magmatic and tectonic processes.

G&G staff and students traveled far and wide in 2004 collecting data and samples. Some conducted fieldwork on land, collecting volcanic gases from Nicaragua and Sicily; studying the volcanology of Ta'u Island, Samoa; conducting geophysical surveys across South Africa; and investigating the geology and tectonics of the western Sichuan basin, east of the Tibetan plateau. Others worked near shore at the interface between land and sea, along the east coast of the U.S. and in the Danube and Indus river deltas. Still others led or participated in research cruises to the East Pacific Rise, the Mid-Atlantic Ridge, the western north Atlantic, the Gulf of Mexico, the Panama Basin, and the Lau back-arc spreading center west of Tonga (see page 17).

This year, the capabilities of the WHOI Seafloor Sampling Laboratory (above) were greatly enhanced when Liviu Giosan, Jeff Donnelly, and Rindy Ostermann received funding for the acquisition of a core scanner. The first of its kind in the U.S., this instrument allows rapid, nondestructive, ultra-high resolution measurements of the chemical composition and density structure of sediment cores and other geologic materials. One of the major uses

of this instrument will be in detecting chemical changes in sediment cores at an annual to millennial resolution that can be linked to environmental and climatic changes.

Science highlights of 2004 included significant advances in earthquake research made by two groups. Jeff McGuire and graduate student Margaret Boettcher, together with a colleague from the University of Southern California, applied a mathematical model to a database of earthquakes on the East Pacific Rise and demonstrated that the largest earthquakes are preceded by abundant foreshocks, thus indicating a significant amount of predictability. This work, published in *Nature*, represents an important breakthrough in earthquake predictability studies. In addition, Jian Lin, Debbie Smith, and graduate student Trish Gregg investigated a several year record of earthquakes along the Siqueiros Transform Fault in the eastern Pacific and showed that an earthquake in one area can transfer stress and trigger an earthquake nearby. Both studies emphasized the need for a better understanding of these oceanic faults, and suggest that at least some earthquakes might be predictable.

—Susan Humphris, Department Chair



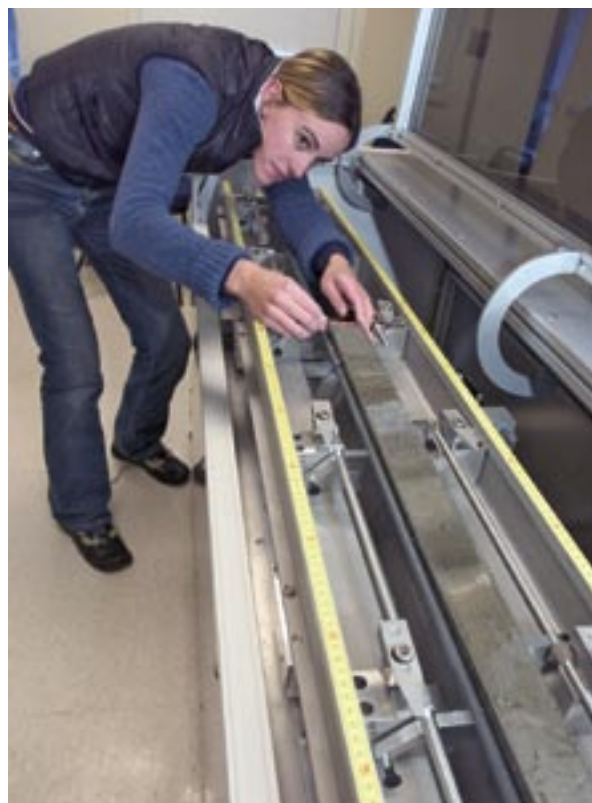
◀ From left, Ellen Roosen, Susan Humphris, and Jim Broda work in the rock and core storage area of the Seafloor Samples Laboratory. This collection holds more than 14,000 marine geological samples recovered from the seafloor. Construction will begin in 2005 to add 10,000 square feet to the facility by 2006.

### Awards & Recognition

**Susumu Honjo** received the 2003 Medal of the Imperial Order of the Rising Sun for his research on the transfer of carbon dioxide from the atmosphere to the ocean's interior and for his efforts to strengthen Japan's role in the international ocean science research community.

**Lloyd Keigwin** was recipient of the 2004 Edna McConnell Clark Chair for Excellence in Oceanography.

**Dan McCorkle** was awarded the position of J. Seward Johnson Chair/Educational Coordinator.



Tom Kleindinst, WHOI Graphic Services



Don Voigt

Clockwise from top left: Research Assistant Jess Tierney runs the new X-ray fluorescence spectrometry core scanner, which allows detailed imaging and elemental analysis of sediment cores; Assistant Scientist Sarah Das works on the Greenland Ice Sheet with an ice core used to determine changes in ice sheet conditions over the past few centuries; a new addition to McLean Laboratory expands the sample preparation lab for radiocarbon-dating at the National Ocean Sciences Accelerator Mass Spectrometry Facility. The addition also houses a newly designed gas-accepting accelerator, the first of its kind.



Tom Kleindinst, WHOI Graphic Services





Tom Kleindinst, WHOI Graphic Services

Scientists in the Marine Chemistry and Geochemistry (MCG) Department were extremely active in 2004 analyzing the chemical composition of the ocean and its constituent sediments, rocks, and biota. While laboratory studies, modeling, and remote sensing of the ocean all are important to many of our staff, what stands out in 2004 was the wide range and number of field programs.

Jeff Seewald, Katrina Edwards, and Wolfgang Bach conducted research cruises to undersea hot spots in the Pacific, where chemical and microbiological transformations at high temperature and pressure take place in and around underwater volcanic systems. Such sites are accessible several miles below the surface only by remote samplers and submersibles that take measurements and collect samples for analyses.

At the ocean surface, MCG scientists studied processes in waters off Bermuda. Ed Sholkovitz measured chemical input to the surface ocean on a novel buoy-mounted aerosol sampler, catching dust as it falls on the waters off Bermuda. Bill Jenkins made monthly measurements of dissolved gases in the ocean, to understand ocean produc-

tivity and the physical processes that mix water to depth.

Bill Jenkins and Ken Buesseler also joined an interdisciplinary team of scientists from three WHOI departments to look at ocean eddies off Bermuda, which alter the local physical conditions and induce plankton blooms that change chemical conditions as they move through the ocean.

Bermuda and the wider Sargasso Sea also attracted the attention of Jim Moffett and his group for studies of very rare metal compounds required for phytoplankton growth. In a related study in the Pacific, Jim and other U.S. scientists made detailed comparisons of the analytical methods they use to measure minute traces of iron in seawater.

Notable in 2004 was the launch of VERTIGO, an international and interdisciplinary study of ocean particles in the “twilight zone,” depths below about 100 meters, where sinking particles are either consumed by bacteria and zooplankton, or settle to the bottom. It is a region of interest to many on our staff (Ken Buesseler, Dave Glover, Karen Casciotti, Benjamin Van Mooy, and Tim Eglinton).

Scientists in MCG also worked close to home. Bill Martin studied marine sediments and their fluids in local waters, Matt Charette studied how ground water flows

from the Cape into Waquoit Bay, and Nelson Frew investigated the chemical exchange of gases across the ocean surface. Bernhard Peucker-Ehrenbrink and Chris Reddy examined riverine systems in the Hudson River and Gulf of Maine, respectively, while a bit further from home, Dan Repeta studied coastal systems of Chesapeake Bay and Jean Whelan worked on Saanich Inlet, Washington.

Our scientists recover samples that require chemical analyses with cutting-edge analytical facilities at WHOI, including mass spectrometers (above), gas chromatographs, spectrophotometers, low-level radiation detectors, and other instruments, to tease out the chemical composition.

What does all this traveling and chemical analysis mean for the advancement of ocean sciences? Without direct measurements of chemical distributions and transformations in the oceans, we’d be studying the oceans with our eyes closed. MCG scientists work diligently in the field and lab, make models of ocean processes, and open our eyes with chemical analyses that help us better see how this ocean planet works.

—Ken Buesseler, Department Chair



◀ From left, Bernhard Peucker-Ehrenbrink, Lary Ball, Ken Buesseler, and Dave Schneider are shown in the Plasma Mass Spectrometry Facility, which provides state-of-the-art sensitivity, precision, and accuracy for elemental and isotopic analysis of aqueous and solid materials.

### Awards & Recognition

**Lary Ball** received the Al Vine Senior Technical Staff award in recognition of his outstanding technical accomplishments and management of the Inductively Coupled Plasma-Mass Spectrometer facility.

**Scott Doney** was selected as a 2004 Aldo Leopold Leadership Fellow, for excellence in modeling of ocean biogeochemistry. This award recognizes interdisciplinary environmental research and encourages scientists to communicate their results to policy makers, the media, and the public.

**Jim Moffett** received the Mary Sears Chair for Excellence in Oceanography, in recognition of his research in understanding chemical transformation of trace metals in natural waters.

**Chris Reddy** was awarded a WHOI Coastal Ocean Institute Fellowship, in recognition of his research on the sources, transport, and fate of organic contaminants in the ocean.

**Meg Tivey** was named the RIDGE 2000 Distinguished Lecturer for 2003–04, an honor that involved traveling the U.S. giving lectures on seafloor hydrothermal systems. Meg also received the J. Seward Johnson Chair as MCG education coordinator.

MIT/WHOI Joint Program students **Desiree Plata, James Saenz, Kristen Smith, and Jacob Waldbauer** received National Science Foundation Graduate Research Fellowships. Waldbauer was also awarded a National Defense Science and Engineering Graduate Fellowship. These fellowships encourage U.S. students to pursue careers in science and engineering.

*Clockwise from top left: Nelson Frew, Leah Houghton, and Nick Witzell (AOPE) launch the Slick Chemical Identification and Measurement System from Tioga for air-sea interface studies; Chris Reddy, left, and Liz Kujawinski sectioning a multicore from the Columbia River margin; from left, Steve Manganini, Devin Ruddick, Jim Valdes, and Ken Buesseler celebrate success upon recovering the seventh and final instrument array for a study of how materials move from the surface to the deep ocean, hitchhiking on sinking particles; Carl Johnson works in the nuclear magnetic resonance facility.*



Mike Novak, UNH



Tom Kleindinst, WHOI Graphic Services



Daniel Montluçon, WHOI



KN0414 VERTIGO cruise member





Tom Kleindinst, WHOI Graphic Services

Research in the Physical Oceanography Department centers on the description and understanding of the evolving state of the ocean and its interaction with the atmosphere and Earth. While we have traditionally identified ourselves with making observations at sea, our scientists also make important contributions to numerical modeling, theory, laboratory experimentation, and instrument development.

The last year, once again, has been a busy one at sea. Bob Pickart completed the field phases of two programs, his study of deep convection in the Irminger Sea off the east coast of Greenland and his investigation of the stability of the inflowing Pacific water current along the south coast of the Beaufort Sea. Nearby, Andrey Proshutinsky expanded his array of moored profilers and current meters in the Beaufort Gyre. Across the Pacific, off Japan, Nelson Hogg and Steve Jayne began their study of the Kuroshio Extension Current by installing an array of moored profilers stretching 500 kilometers (300 miles) across the current. Also in 2004, John Toole and colleagues here and in the U.K. began a multi-year Station W program to investigate interannual variations of the poleward flow-

ing Gulf Stream and equatorward flow beneath. A related effort undertaken by Terry Joyce was a hydrographic section from Cape Cod to Bermuda. In addition, Fiamma Straneo installed a mooring in the Hudson Strait to measure freshwater efflux. Surface moorings that measure air-sea fluxes were replaced in the Atlantic (Al Plueddemann) and the Pacific (Bob Weller), and a third air-sea flux site was established off Hawaii. The intent of this program is to provide accurate fluxes in order to ground truth those obtained indirectly, particularly by satellites.

This year we also put some new technology to its first scientific use. The maiden "flight" of an undersea autonomous glider, Spray, was carried out in November from south of Cape Cod to Bermuda under the direction of Breck Owens and colleagues at Scripps Institution of Oceanography. During its seasaw flight, it collected temperature and salinity data from the surface to a depth of 1,000 meters (3,300 feet), thus duplicating what could be done from a ship but more quickly and at lower cost. A new mooring system, called Ultramoored, was installed at Bob Pickart's Irminger Sea site. It has been developed by Dan Frye, Nelson Hogg, and others and has the goals of

lasting five years and sending data back to shore through the periodic release of data-containing capsules, which send their recorded data back to the lab via satellite. The first capsule was released and the data recovered on schedule Thanksgiving Day.

Continuing our expanding interest in the Arctic, Peter Winsor joined the staff as assistant scientist early in the year. Peter's interests focus on Arctic oceanography and he has talents in seagoing observation, data interpretation, and numerical modeling.

Before his appointment to the scientific staff Peter had been a postdoctoral scholar working with Dave Chapman. It is with great sorrow that I report that Dave lost his fight with cancer during the summer. Funds are being solicited for a memorial and to endow a lecture series on coastal oceanography. In a tragic motorcycle accident, the department also lost a talented young seagoing technician, Ryan Schrawder. A fund has also been established in his name to make an annual award to a similarly skilled employee at the institution's annual employee recognition ceremony.

—Nelson Hogg, Department Chair



◀ From left, Jim Valdes, Nelson Hogg, Bob Tavares, and Rick Rupan in the Float Technical Operations Group lab. These floats will be among the 3,000 deployed in the world-wide ARGO float program, to measure various upper ocean properties in the North and South Atlantic.

### Awards & Recognition

**Ken Brink** was named Chief Scientist for Ocean Research Interactive Observatory Networks (ORION) in Washington DC, splitting his time between Woods Hole and Washington.

**Nan Galbraith** won the Linda Morse-Porteous Award, established to recognize a female technician for her leadership, dedication to and quality of work, abilities as a role model and/or mentor for junior women, and involvement in the WHOI community.

**Karl Helfrich** was reappointed to a second term as the J. Seward Johnson Chair/Educational Coordinator for the Physical Oceanography Department.

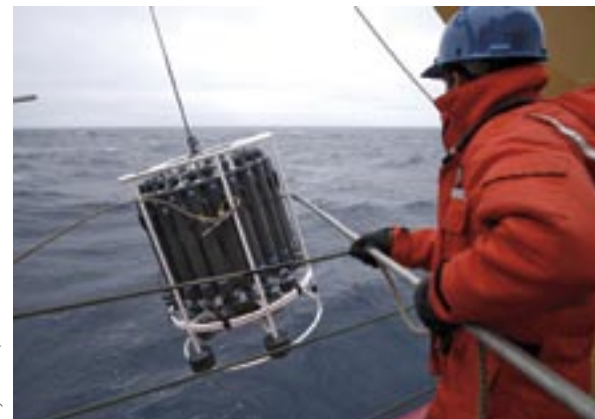
**John M. Toole** was elected an American Geophysical Union Fellow.

**Bruce Warren** received the Ewing Medal from the American Geophysical Union for “contributions to the understanding of the general circulation of the ocean, including water mass formation by sea-air interaction, deep and surface boundary currents and interior flow, planetary waves, and the impact of global integral momentum constraints on ocean circulation.”

*Clockwise from top left: the high-resolution profiler, which measures a variety of physical properties over a wide range of scales, is prepared for sea trials off Long Island, New York; Bob Pickart recovers a sampling device in a remarkably ice-free Beaufort Sea in September; Jim Ryder deploys Fiamma Straneo’s mooring to measure the freshwater flow through Hudson Strait, an important component of climate studies; a mooring is launched during Nelson Hogg’s and Steve Jayne’s study of the Kuroshio Extension Current off Japan; Breck Owens, aboard the Bermuda Biological Station’s R/V Henry Stommel, shuts the Spray glider down after its first successful crossing of the Gulf Stream.*



Ray Schmitt, WHOI



CA Linder, WHOI



Ben Carr, WHOI



Fiamma Straneo, WHOI



Courtesy, Steven Jayne



Close interactivity between research and higher education and the exposure of students and postdocs to theoretical, experimental, and observational ocean sciences and engineering are at the heart of WHOI's Academic Programs. External assessments provide us with one indication of the success of our efforts.

A nationwide survey of postdoctoral programs conducted by *The Scientist* magazine ranked the WHOI postdoctoral program among the top ten nationwide. The contents of the review have provided insights into where our program is on track and the few aspects in need of improvement.

An External Review Committee for the MIT-WHOI Joint Program in Oceanography and Applied Ocean Sciences and Engineering visited both MIT and WHOI in June. As with the previous two external reviews in 1989 and 1998, the comments on the overall quality of the program were laudatory: "The MIT/WHOI Joint Program remains a (if not *the*) top educational program covering all the marine sciences and engineering." The report also suggested several areas for continuing innovation and improve-



Dana Yoerger, WHOI

Graduate student Celeste Fowler was a keen photographer.

ment, such as strengthening opportunities for interdisciplinary research.

Thirty-one new students enrolled in the Joint Program, and the total fall 2004 enrollment was 139. The program awarded 15 Ph.Ds and 4 S.M degrees. The Joint Program Alumni/ae Association continues to be supportive of the Joint Program by offering advice to current students, providing evaluation of the Joint Program graduate education efforts, and contributing financial support for student research and career activities.

We were saddened by the loss of first-year graduate student Celeste Fowler (left), to metastatic melanoma. To honor her memory and love of photography, a Celeste Fowler Memorial Art Show was planned for January of 2005 and will become an annual event showcasing the diverse artistic talents of our graduate students.

The Summer Student Fellow and Minority Fellows Programs for undergraduates enjoyed another successful summer with 32 students from 27 universities and colleges involved in the summer-long research experience. This was the inaugural summer of an at-sea practicum for fellows in the use of coastal ocean sampling and measurement instruments aboard the new coastal research vessel *Tioga* (above).

In collaboration with partners in the Woods Hole scientific organizations, we led an effort to draft an memorandum of understanding signed in July by the presi-



Jayne Doucette, WHOI Graphic Services

Summer student fellows, from left, Tiffany Psemeneke, Elizabeth Cushman, and Christie Wood rig a gravity corer aboard R/V *Tioga* in Buzzards Bay.

dents/directors of these organizations to undertake a collaborative diversity initiative that offers pathways of increased opportunity in sciences and engineering.

Our partnership with New England Aquarium and the University of Massachusetts in the NSF funded New England Center for Ocean Science Education Excellence (COSEE) continued for the second year in K-12 formal and informal education activities along with the twice-yearly teacher workshops that are highly acclaimed by participating teachers.

I will step aside during 2005 after fifteen years as dean. I have been honored to be associated with WHOI's Academic Programs and the superb group of students, postdocs, faculty, and staff involved in these activities.

—John W. Farrington

Vice President for Academic Affairs and Dean



The Coastal Ocean Institute and Rinehart Coastal Research Center promote scientific inquiry into the phenomena that shape our coastal waters and ecosystems, encouraging innovative, interdisciplinary research and high-risk technology development. We also strive to translate the results of this basic research for citizens and policymakers, while providing a solid information base for resource managers.

In July, Don Anderson became the director of COI and RCRC, succeeding Ken Brink. Don is a biologist who conducts research on toxic and harmful blooms of algae, commonly called “red tides.”

In addition to six research projects initiated in 2004 (see map below), we undertook a wide range of activities to promote and communicate coastal research. In April, our Short Course and Workshop on Coastal Change drew 70 individuals, including federal and state agency representatives, students, and researchers. In September,

the Moving Shoreline Forum generated lively debate with trustees and guests, and culminated in a science plan for an initiative on this topic. Bruce Peterson, of the Marine Biological Laboratory, gave a seminar on carbon and nutrient flux in the coastal oceans, and Richard Jahnke, of the Skidaway Institute of Oceanography, gave a seminar on continental margin processes in marine biogeochemical cycles.

We provided support for three postdocs this year. Rubao Ji is studying processes that control phytoplankton blooms on Georges Bank. Kevin Kroeger is studying nitrogen in groundwater at the interface of land and sea to better understand groundwater input to coastal pollu-



Former COI Director Ken Brink, right, with Don Anderson, the Institute's second director.

Tom Kleindinst, WHOI Graphic Services

tion. Tom Hsu is modeling sediment transport in nearshore waters. We initiated support for two new COI Fellows, Jeff Donnelly, a geologist (jointly sponsored with the Ocean and Climate Change Institute), and Chris Reddy, an organic chemist. Jeff specializes in climate change recorded in sediments, and Chris studies the source, transport, and fate of organic compounds in seawater.

We continue to support John

Trowbridge, who is taking a leadership role in guiding work at the Martha's Vineyard Coastal Observatory, and Heidi Sosik (jointly with the Ocean Life Institute), who works on phytoplankton ecology and biooptics.

—Don Anderson, Institute Director

### 2004 COI Research Project Locations

#### Influence of Tidal Pumping on Denitrification in Waquoit Bay Sediments

Waquoit Bay, MA: Joint Program student Emilie Slaby and advisors Dan McCorkle (G&G) and Harry Hemond (MIT) are studying how the mixing of fresh and salty water in nearshore sediments influences the removal of nitrogen from groundwater, a large and often underestimated component of nutrient flux to the coastal ocean.

#### Developing a Coastal Groundwater Observatory

Waquoit Bay, MA: Matt Charette (MCG) and Ann Mulligan (MPC) are establishing an observatory to improve understanding of how tidal and seasonal changes in subsurface flow and chemistry control the flux of land-derived nutrients into estuaries.

#### Reconstructing Hurricane History

Cayman Islands: COI rapid-response funding allowed Jeff Donnelly (G&G) to study inundation of coastal ponds and wetlands with sand overwash when Hurricane Ivan struck the Cayman Islands, part of a larger effort to reconstruct the hurricane history from bands of sand found in cores dating back several millennia.

#### Airborne LIDAR Mapping of Dispersion and Mixing in the Coastal Ocean

East Florida Shelf: Jim Ledwell and Gene Terray (AOPE) are testing airborne light detection and ranging (LIDAR) to more accurately measure dispersion and mixing in the coastal ocean.

#### Heat as a Proxy Tracer for Gases in Air-Sea Exchange

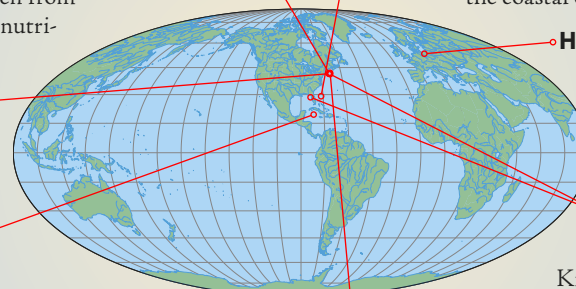
Heidelberg, Germany: Nelson Frew (MCG) is determining whether measurements of heat emitted from the oceans can improve estimates of the exchange of oxygen and carbon dioxide at the air-sea interface.

#### The Economics of U.S. Shoreline Change

Cape Cod & Florida Panhandle: Porter Hoagland, Di Jin, Hauke Kite-Powell (MPC), and Rob Evans (GG) are developing annual estimates of the economic consequences of shoreline change regionally and nationally, a final step in the establishment of programs in shoreline change.

#### Dissolved Organic Carbon (DOC) Cycling in the Coastal Ocean

Plum Island, MA: Dan Repeta and Ben Van Mooy (MCG) are studying the little-known fate of DOC that rivers carry to the sea.





The Deep Ocean Exploration Institute (DOEI) promotes interdisciplinary investigations of planetary processes occurring in the deep ocean and within Earth's interior. These processes help to regulate the chemistry of its ocean, determine the nature of magmatic activity observed on our planet's surface, and impact microbiological, chemical, and geological processes that shape the planet and affect its inhabitants.

The development of technology that provides access to the seafloor is also a key component of the Institute's activities. To support these pursuits, in 2004 we funded six new projects within the Institute's ongoing themes of Seafloor Observatory Science and Instrumentation, Fluid Flow in Geologic Systems, and Earth's Deep Biosphere (see map below).

The Institute currently supports three scientists as research fellows. Wolfgang Bach (MCG) studies the relationship between chemical and microbiological processes occurring within oceanic rocks. Greg Hirth (G&G) uses his understanding of rock mechanics to

study geological and chemical processes that occur deep below the planet's surface. Stan Hart (G&G) studies the evolution of Earth's interior by using chemical clues from magma erupted from oceanic volcanoes as a window into the mantle. As a fellow, he is spearheading a broad, multi-disciplinary study of Vailulu'u, a 4,333-meter (14,300-foot), active submarine volcano in the Pacific Ocean east of Samoa.

In March, the Institute concluded a seminar series for national and international scientists focused on microbes in the deep biosphere. Processes that allow bacteria, protozoa, and other tiny organisms to live in the harsh environment of the seafloor were also the subject of an October workshop, co-sponsored with WHOI's Ocean Life Institute.



Dan Fornari, right, took the helm from first DOEI Director Susan Humphris in 2004.

Tom Kleindinst, WHOI Graphic Services

In the spring, DOEI supported the presentation of the eighth expedition of Dive and Discover™, an online science learning adventure developed at WHOI. The Website received more than 30,000 visitors during the 17-day cruise from people reading posted stories, viewing photos and videos, and interacting with researchers diving in the submersible *Alvin* as they explored hydrothermal vents offshore Oregon and Washington.

After four years as director of DOEI, Susan Humphris stepped down in May to become Chair of WHOI's Geology and Geophysics Department. She guided the Institute during its formative years, nurturing innovative and exciting deep-ocean research. I look forward to continuing her legacy.

—Dan Fornari, Institute Director

## 2004 DOEI Research Project Locations

### Monitoring Rumbles from the Seafloor

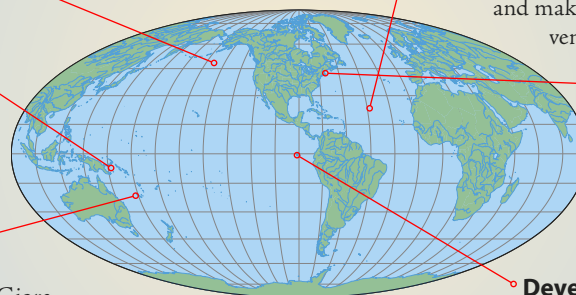
*North Pacific Ocean:* Ralph Stephen (G&G) and John Colosi (AOPE) are using sensors placed on and near the seafloor to record and observe undersea earthquake activity.

### Researching Iron in Hydrothermal Vent Processes

*Manus Basin:* Olivier Rouxel (MCG) and Wolfgang Bach (MCG) are analyzing the role that the heavy metal iron plays in hydrothermal vent chemical and microbiological processes.

### Learning How Life Survives in Harsh Places

*Lau Basin:* Jeffrey Seewald (MCG) and postdoctoral student Giora Proskurowski (MCG) will be collecting and analyzing gases, fluids, and sulfide deposits from hydrothermal vents in the Lau Basin to understand how organisms use chemicals to survive at deep-sea vents.



### Using Lasers to Map Hydrothermal Plumes in the Deep Sea

*Mid-Atlantic Ridge:* Robert Reves-Sohn (G&G) and Albert Bradley (AOPE) are creating a laser mapping system that will improve researchers' ability to find and make images of deep-sea hydrothermal plumes so that new seafloor vents can be discovered.

### Testing a Drill Hole Microbiological Sampler

*Vineyard Sound:* Craig Taylor (Bio) is testing a microbiological sampling device to be used in deep ocean drill holes that will allow researchers to collect uncontaminated bore-hole fluids. This will help in the study of the deep-ocean biosphere in the Earth's crust.

### Developing Better Ways to Collect Living Organisms

*Galápagos Rift:* Joan Bernhard (G&G) and Tim Shank (Bio) are developing samplers that better preserve and protect organisms gathered at hydrothermal vents for microbiological and genetic research.



Pursuing greater understanding of the ocean's role in climate change, the Ocean and Climate Change Institute (OCCI) launched support for several new research projects, two OCCI fellows, and a postdoctoral scholar. The Institute also provided continued support for two fellows, a postdoctoral scholar, and an MIT/WHOI graduate student.

New research projects include the first culture-based calibration of the deep-sea benthic foraminiferal chemistry used to estimate deep-water temperatures; a study focusing on the influence of ocean surface water temperature on the global air-sea flux of CO<sub>2</sub>; the application of control theory to understand how the behavior of the atmosphere can be controlled by sea-surface temperatures; an evaluation of the magnitudes of the buoyancy changes due to changes in heat and freshwater at the surface of the North Atlantic; examination of the sedimentary distribution of protactinium and thorium (uranium radiometric decay products) to measure deep ocean circulation; and the development of DNA extraction techniques to study the his-

torical migration of deep-sea corals from the northwest Atlantic.

OCCI also funded several projects to establish or enhance Atlantic and Arctic Ocean observing systems. They include measurement of the freshwater flux through Hudson Strait; support of equipment and operations to continue data collection at the Beaufort Gyre observing system; development of an observing array off southeast Greenland; modification of an autonomous underwater vehicles for navigation beneath Arctic sea ice; and new measurements to reveal the changes of strength and structure of the Gulf Stream. In addition, OCCI funded the purchase and deployment of a meteorological buoy in the Irminger Sea, and the Institute supported recovery and redeployment of a sediment trap system in the Iceland Sea.

OCCI supported Scott Doney (MCG) in his second year as a fellow and awarded two new fellowships in 2004



Terry Joyce, left, succeeds Bill Curry as OCCI director in 2005.

Tom Kleindinst, WHOI

to Bernadette Sloyan (PO) and Jeff Donnelly (G&G). Bernadette works to improve our understanding of the Southern Ocean and its effects on the global meridional overturning circulation. Jeff examines natural archives of Holocene and Pleistocene environmental change using an interdisciplinary approach, combining the disciplines of sedimentology and

stratigraphy, geomorphology, paleoecology, paleoclimatology, and oceanography. His fellowship is jointly supported with the Coastal Ocean Institute.

A new postdoctoral scholarship was awarded to William Thompson, who studies climate and sea level history. During his time at WHOI he will use radiometric dating of uplifted coral reefs in Barbados to identify rapid changes in sea level that occurred when glaciers melted.

—William Curry, Institute Director

## 2004 OCCI Research Project Locations

### Observing the Inflow of Pacific Water to the Arctic

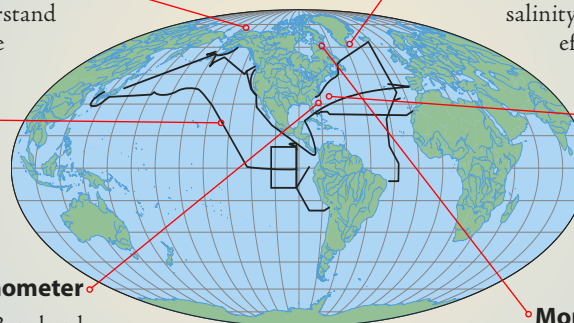
*Off Point Barrow, Alaska:* Al Plueddemann (PO) and Chris von Alt (AOPE) plan to use an autonomous underwater vehicle to better understand how the inflow of Pacific water to the Arctic can influence the thickness and extent of Arctic sea ice.

### Oceanic Thermal Skin as a Modifier of CO<sub>2</sub> Uptake

*Pacific and Atlantic oceans and coastal regions:* Brian Ward and Jim Edson (AOPE) are investigating how the thermal properties at the air-sea interface influence the ocean's uptake of carbon dioxide, a greenhouse gas linked to climate change.

### Calibration of the Benthic Foraminiferal Mg/Ca Thermometer

*Off South Carolina & the Bahamas:* Dan McCorkle and Joan Bernhard (G&G) conducted fieldwork for laboratory culture studies of the shell-chemistry of foraminifera (microscopic organisms), which can be used to estimate past deep-water temperatures.



### Development of a Freshwater Flux Array off Greenland

*Off Southeast Greenland:* Bob Dickson and Stephen Dye (CEFAS\*) are studying salinity distribution and freshwater flow to better model their potential effects on climate change.

### Monitoring the Gulf Stream Flow and Dynamics Northwest of Bermuda

*Gulf Stream:* Mike McCartney (PO) will monitor Gulf Stream strength at a location offshore of WHOI's line W, between Cape Cod and Bermuda.

### Monitoring Freshwater Flow through Hudson Strait

*Hudson Strait:* Fiamma Straneo is quantifying and monitoring the freshwater inflow into the North Atlantic, a crucial variable in climate studies.

\*Centre for Environment, Fisheries and Aquaculture Science, Suffolk, U.K.



The Ocean Life Institute (OLI) seeks to foster novel and interdisciplinary research on organisms and ecosystems in the oceans, providing a scientific basis for marine conservation. The ocean is the origin and major repository of biological diversity, and life processes in its waters affect everything else on Earth. Working under three broad themes—Discover Life, Sustain Ecosystems, and Develop Tools—OLI stimulates and supports research on subjects ranging from microbes to whales, Antarctic birds to tropical fish, and mangroves to deep-sea corals. Often discovery and explanation depend on new techniques and instruments, and OLI supports development of novel hardware for the ocean and new theoretical methods for data analysis and prediction.

In 2004, OLI supported three Institute Fellows. Cabell Davis is working on ways to merge holographic imaging and DNA recognition with autonomous vehicles to create a new breed of automated plankton survey instruments that can cruise independently and record detailed information on species distributions. Heidi Sosik, supported jointly with the Coastal Ocean Institute, is us-

ing remote sensing, in-situ instruments, and physical oceanography to help understand the dynamics of phytoplankton blooms in the coastal ocean (see map below). Mike Neubert develops innovative mathematical models that will help predict the effects of marine reserves on fisheries production. Five new research grants were awarded to WHOI researchers in 2004, adding to those still in progress.

Communication of research results and applications is an important Ocean Institute function. During the year, the Institute hosted the third meeting in the series “Fisheries, Oceanography and Society”, on deep-sea fisheries, co-sponsored with the New England Aquarium. An even deeper subject was the workshop co-sponsored with the Deep Ocean Exploration Institute on the recently discovered communities of microbes living within the Earth’s crust beneath the ocean. An OLI work-



OLI Director Laurence Madin, right, views whale images with biologist Michael Moore.

Tom Kleindinst, WHOI Graphic Services

shop on the demographics of albatross species brought together world experts to analyze the risk of extinction to these increasingly threatened oceanic birds.

OLI has also developed larger research initiatives focused on particular problems in marine ecology or conservation. The Right Whale Research and Conservation Initiative was launched with projects on population genetics and effects of ship collisions. A new initiative on coral reef fishes in the Caribbean will investigate the dispersal and survival of threatened species like grouper. Other research in tropical environments is based at the Liquid Jungle Laboratory in Panama, where OLI has helped develop a modern field station in a pristine tropical environment. It promises to offer many new opportunities for WHOI scientists of all disciplines.

—Laurence Madin, Institute Director

### 2004 OLI Research Project Locations

#### Colonization Dynamics of Deep-Sea Coral

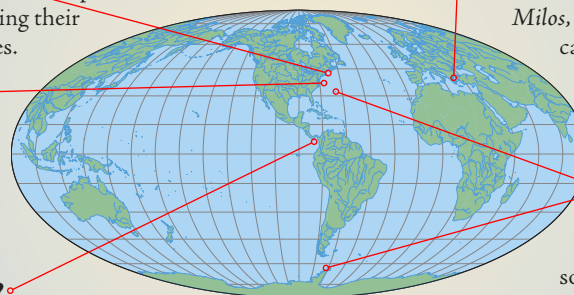
*New England Seamounts:* Lauren Mullineaux (Bio) is studying how deep-sea coral communities form and persist on seamounts, and evaluating their susceptibility to disturbance, especially from seamount fisheries.

#### Monitoring Nano- and Microphytoplankton

*Martha’s Vineyard Coastal Observatory:* Rob Olson, Heidi Sosik, and Scott Gallager (Bio) are developing a submersible instrument that counts and identifies microscopic plankton and samples continuously for months at a time, to investigate the causes of species succession and blooms.

#### Why are There no Invertebrates in These Mangroves?

*Panama, Liquid Jungle Laboratory:* Jesús Pineda (Bio) is testing a hypothesis that tropical rainforest metabolites accumulate in nearby mangroves, killing larvae of organisms that typically attach to mangrove roots.



#### Instrument Development for *In Situ* Preservation of RNA in Deep-Sea Sediment Samples

*Milos, Greece:* Stefan Sievert (Bio) is working to develop a means of capturing and preserving the delicate RNA of organisms living near hydrothermal vents, which provides a more reliable means of understanding genomics of vent microbes.

#### Deuterated Tracers for DMS Dynamics in Seawater

*Bermuda & Antarctica:* John Dacey (Bio) has developed a new isotopic tracer method to understand the production and consumption of dimethylsulfide (DMS) and its precursors and products, which can promote formation of aerosols that influence global climate.



The Marine Policy Center (MPC) conducts social scientific research that integrates economics, policy analysis, and law with the Institution's basic research in ocean sciences. Areas of recent research include nutrient pollution of coastal waters, the economics of ocean observing systems, offshore wind power, biological conservation, and international fisheries management.

Nutrient pollution is one of the chief causes of environmental problems in coastal ecosystems. Reducing inputs from the sources of excess nutrients—fertilizers, sewage disposal, and fossil fuel burning—generally requires costly and difficult technological and behavioral change. In some cases, it may be equally effective and less costly to mitigate the effects of nutrients after they have entered the water. Researchers at MPC are investigating one simple and inexpensive approach: the use of shellfish aquaculture to reduce nutrients and improve water quality in coastal areas.

Several lines of evidence suggest this approach could work. First, shellfish sequester nutrients such as nitrogen in body tissues, so harvesting them can remove a substantial amount from coastal waters. Second, their tendency to eat large amounts of phytoplankton may reduce the likelihood of algal blooms under conditions of increased nutrient enrichment. Third, the presence of shellfish biodeposits (feces and undigested organic matter) in sediments may increase the rate at which nitrogen is converted to a form that diffuses to the atmosphere. This process, known as denitrification, may be an even more potent tool for nitrogen removal than shellfish harvesting.

Using data from previous studies, MPC Research Specialist Hauke Kite-Powell and colleagues are developing a biogeochemical model of nitrogen flows and nitrogen removal via shellfish cultivation. The model will be verified

using data collected at an experimental site in Waquoit Bay, MA. In addition to monitoring sediments for rates of denitrification and monitoring shellfish for rates of survival, growth, and nitrogen uptake, the research team is conducting experiments to assess the effectiveness of on-bottom and off-bottom shellfish cultivation techniques. Their goal is to produce a practical, bio-economic model that can be used to evaluate alternative management scenarios for a range of coastal water bodies.

Kite-Powell also led a project that analyzed the potential economic benefits of improved coastal ocean observing systems around the United States, for which he received the Award for Excellence in Partnering from the National Ocean Partnership Program.

In another recently completed project, MPC and Switzer Foundation Fellow Elena McCarthy addressed the growing controversy over the suspected links between human-generated ocean noise and marine mammal strandings and deaths. Her book, *International Regulation of Underwater Sound*, considers how the problem can be addressed in spite of the lack of a regulatory structure and the considerable scientific uncertainty that surrounds it.

MPC researchers are also addressing the much-publicized problems of deep-sea fisheries, where catches have increased steeply over the last two decades. Deep-sea species are especially vulnerable to rapid depletion from over-fishing because of their long lifespans, slow growth rates, and low fecundity. The ecosystems they inhabit suffer collateral damage as well from the bottom-trawling that destroys complex seafloor communities. Although the status of most



Tom Kleindinst, WHOI Graphic Services

*In Waquoit Bay, Massachusetts, Summer Student Fellow Megan Bela worked with Hauke Kite-Powell on the use of bivalve aquaculture to enhance removal of excess nitrogen and other nutrients from coastal waters*

deep-sea areas remains unknown, many are calling for the conservation of deep-sea biological communities and a moratorium on bottom trawling in international waters.

MPC is contributing legal, regulatory, and economic analysis to the ongoing international debate on deep-sea fisheries. Research Specialist Porter Hoagland and Research Assistant Mary Schumacher prepared a synopsis of the unprotected and largely unregulated status of deep-sea fisheries under relevant international law; it appears in the recently published book *Defying Ocean's End*. Hoagland has also developed an economic analysis that highlights how the biological characteristics of deep-sea species, the "open access" nature of high seas resources, the threat of impending regulation, and the promise of increased scientific exploration, among other factors, combine to favor more fishing in the near term over more fish in the future. In light of the structural obstacles and weak management record of international fisheries organizations, this analysis suggests that consumer awareness and action may be especially important for deep-sea conservation.

—Andy Solow, Director



Tom Kleindinst, WHOI Graphic Services

*Andy Solow, right, with Brendan Foley, who is studying policy aspects of deep water archaeology.*



The Woods Hole Sea Grant Program is part of NOAA's national Sea Grant network of 32 programs; collectively, Sea Grant promotes cooperation among government, academia, industry, scientists, and the private sector.

Woods Hole Sea Grant's annual budget of approximately \$1 million supports research projects in environmental technology, estuarine and coastal processes, and fisheries and aquaculture. In addition, Sea Grant funds smaller, "new initiative" grants to encourage Sea Grant research addressing local and regional needs, and many projects have national or even global implications. Projects in 2004 include:

- Lobster and squid population structures, comparing off-shore and near-shore populations, and potential fisheries management impacts;
- Environmental contaminants and their effects on marine invertebrates, mammals, and fish;
- Application of fiber-optic technology as a way to detect and count harmful algal cells in the marine environment;
- Atmospheric deposition as a source of nitrogen pollution, measuring vehicle emissions around Cape Cod embayments;
- Development of an autonomous, multi-scale digital imaging system to identify and map distributional patterns of aquatic plankton, micronekton, and nekton;
- Effects of long-term bioaccumulation of oil—from the 1969 grounding of a barge carrying No. 2 fuel oil—on salt marsh biota;
- Groundwater as a transport mechanism for nutrients and contaminants flowing into estuarine systems;
- Metal accumulation in sediments as a result of Boston Harbor sewage discharge;
- Larval dispersal in pelagic fish, using fish otoliths (ear bones) as natural tags to reconstruct temperature histories and seawater chemistry;
- Screening sediments, water, algae, and invertebrates to determine the environmental source of QPX (a parasite afflicting hard clams);



Diane Murphy, Barnstable County Cooperative Extension

Woods Hole Sea Grant extension agent Bill Walton (center), talks with Cape Cod Americorps members and staff from Bourne's Natural Resources Department. He is discussing pros and cons of using nets to protect hard shell clam seed planted in Little Bay, Bourne, as part of a town shellfish enhancement project. Providing advice to communities in southeastern Massachusetts is one of the many ways Sea Grant stays connected to its constituents.

- Development of a pattern recognition system to classify benthic habitats and identify flora and fauna.

In addition to research, Woods Hole Sea Grant supports a marine extension program and an outreach/education program. Through those efforts, research is transmitted to a variety of audiences through publications, Web sites, workshops, and lectures. Many Sea Grant outreach programs involve partnerships, such as with the Barnstable County Cooperative Extension Service, to provide technical expertise and demonstration projects on shellfish aquaculture and coastal processes.

A partnership with the Waquoit Bay National Estuarine Research Reserve and the Massachusetts

Coastal Zone Management Program provides research-based training to coastal policymakers ([www.coastaltraining.org](http://www.coastaltraining.org)). In the ocean science education field, Woods Hole Sea Grant has partnered with colleagues at New Hampshire Sea Grant to provide marine career information to students ([www.marinecareers.net](http://www.marinecareers.net)), and with WHOI Academic Programs and the Exhibit Center to provide teacher workshops featuring the latest WHOI research, technology, and instrumentation developments. Woods Hole Sea Grant is also participating in a WHOI effort to promote effective research-outreach partnerships.

—Judith E. McDowell, Director



The Cooperative Institute for Climate and Ocean Research (CICOR) coordinates and fosters interaction between WHOI and the National Oceanic and Atmospheric Administration (NOAA). CICOR administers NOAA-funded research, builds ties between researchers at WHOI and NOAA, and conducts education and outreach activities. The Institute is one of 13 national cooperative institutes.

CICOR's research themes focus on climate, marine ecosystems, and coastal research. The center supported 50 projects in 2004, including 16 new projects totaling more than \$6 million in funding. Since its inception in 2001, CICOR has supported 61 research projects, bringing the four-year budget to more than \$19 million.

One role of the NOAA Cooperative Institutes is to engage the academic and private research communities in working with NOAA to develop plans for research. In 2004, CICOR proposed workshops that would bring NOAA scientists and program managers together with external investigators. The proposal was endorsed, and CICOR has since held the first of a series of workshops on marine ecosystems.

Together with the Northeast Science Center of NOAA's National Marine Fisheries Service, CICOR organized the Workshop on Planning Coordinated Research on Ecosystems, Climate, and Policy in the Northeast in January 2005. The workshop brought together individuals from more than 30 institutions, representing NOAA staff, fisheries and marine resource managers, and researchers. Participants identified management needs for new research on harmful algal blooms, nutrients

and contaminants, biodiversity, and fisheries.

Among CICOR's diverse research programs, the Ocean Reference Sites (ORS)—long-term surface moorings dedicated to measurement of the exchange of heat, moisture, and momentum between the ocean and atmosphere—progressed under the direction of Robert Weller and Albert Plueddemann of the Physical Oceanography Department. The ORS provide essential data for improving our understanding of atmosphere-ocean coupling and for properly calibrating the estimates and assumptions used in climate modeling. ORS sites in the equatorial Atlantic and Pacific are in their fourth and fifth years, respectively, of continuous operation. A third site, 96 kilometers (60 miles) north of Oahu, Hawaii, was established in August 2004.

CICOR welcomed a new postdoctoral scholar in 2004: Nancy Grumet, a June 2004 graduate of Stanford University. She is working with Konrad Hughen in the Marine Chemistry and Geochemistry Department to understand and reconstruct environmental conditions in the subtropical and tropical oceans through the development of coral chemical records. CICOR also continues to support postdoctoral scholar Nicholas Scott, who is working with John Trowbridge of the Applied Ocean Physics and Engineering Department on statistical analyses of steep waves in open ocean waters. Rob Jennings (right), the CICOR-supported graduate student in the MIT/WHOI Joint Program, is working with Lauren Mullineaux of the Biology Department.

—Robert Weller, Director



Tom Kleindinst, WHOI Graphic Services

*Rob Jennings, a graduate student in biological oceanography, studies the population genetics and dispersal of marine annelid worms around Cape Cod, Massachusetts. He is interested in the influence of recruitment and settlement on genetic estimates of dispersal.*



The success of our mission depends on public support, through federally funded research projects and private donations. The Institution therefore employs a variety of channels to enhance the public's awareness and knowledge of the oceans and the critical role of oceanographic research in understanding our planet.

The visiting public's window into ocean research at the Institution is through the Information Office and Exhibit Center, which together serve more than 30,000 visitors each year and respond to more than 7,500 information requests. Program offerings include informational walking tours, interactive educational exhibits, programs for students and educators, and a "Science Made Public" lecture series, bringing scientists and engineers directly to the public for informal talks about their research. Operation of the Information Office and Exhibit Center relies on the assistance of a dedicated and talented pool of about 30 volunteers.

The Institution has a range of methods for introducing its research and engineering to those who cannot visit Woods Hole. In 2004, nearly 140,000 people viewed the Institution's traveling museum exhibition, "Extreme Deep," as it was installed first at ScienceCity in Kansas City, MO, and then at the Maritime Aquarium in Norwalk, CT. At more than 5,000 square feet, the exhibit features a full-size replica of the *Alvin* personnel sphere, models of vehicles used to explore the ocean, and a life-size, 3-D replica of a seafloor hydrothermal vent community.

During a spring rehab of "Extreme Deep," pieces of the exhibit were displayed at the exploration pavilion at *Wired* magazine's NextFest in San Francisco. Twenty five thousand people attended the exposition, during which Executive Vice President and Director of Research Jim Luyten joined *Wired* editor Chris Anderson and NASA Space Architect Gary Martin on a panel entitled "The Future, Above and Below."

Reaching a still larger audience, WHOI scientists are bringing the public closer to the extreme environments



*Left: Jeff Seewald, an associate scientist in the Marine Chemistry and Geochemistry (MCG) department, describes his research and lab equipment to 25 middle and high school science teachers from around New England in November. Jeff spent the day with the group as part of a "Topics in Oceanography" workshop for educators jointly sponsored by Academic Programs, WHOI Information Office, and WHOI Sea Grant. Jeff enlisted help from MCG Senior Scientist Meg Tivey (right), who spoke about the process of collecting and analyzing samples from hydrothermal vents.*



Photos by Tom Kleindinst, WHOI Graphic Services

they work in through the Internet, with five online expeditions in 2004 chronicling life and work at sea ([www.whoi.edu/home/marine/expeditions\\_main.html](http://www.whoi.edu/home/marine/expeditions_main.html)). The largest of these endeavors is Dive and Discover ([www.divediscover.whoi.edu](http://www.divediscover.whoi.edu)), which, with its daily journals, interactive learning modules, and video and slideshows, attracted more than a half-million visitors in 2004. The expansion of *Oceanus* magazine ([oceanusmag.whoi.edu](http://oceanusmag.whoi.edu)) onto the Web has helped to deepen the public understanding of ocean science, with annual visits to the site exceeding 120,000. In addition, the Institution's public Web site saw 3.25 million visits in 2004.

Public outreach at WHOI has also included work directed toward the K-12 audience. While the Institution's educational focus is on the university level and higher, efforts are made to reach out to teachers and their students through partnerships like the Woods Hole Science and Technology Education Partnership (see Academic Programs section, page 30) and individual efforts. WHOI researchers regularly speak to school groups, visit classrooms, give lab tours, and make presentations at muse-

ums and conferences. Our staff has participated as judges, mentors, and advisors in the National Ocean Science Bowl, as well as in local science fairs and WHOI-sponsored workshops for educators.

In addition, WHOI, with the University of Massachusetts and the New England Aquarium, forms the core of the Center for Ocean Sciences Education Excellence—New England (COSEE-NE), a five-year project funded by the National Science Foundation to encourage collaboration among researchers, educators, and the public. COSEE-NE programs ([www.necosee.net](http://www.necosee.net)) in 2004 included workshops to train investigators in giving effective presentations to K-12 students, the creation of a guide for engaging scientists and educators in education and outreach, and a summer education institute fostering researcher-teacher collaboration.

With tightening federal budgets, the importance of cultivating a public educated about the oceans and the value of research and engineering at WHOI has never been greater.

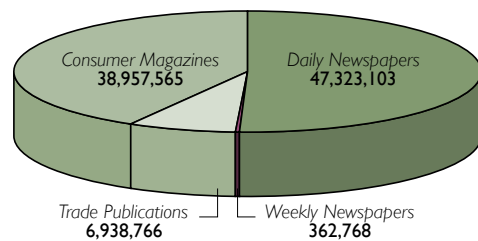
—Stephanie Murphy, Manager of Internal Communications



Research on hydrothermal vents, undersea earthquakes and resulting tsunamis, weather and changing climate, marine mammals, and the development of new undersea exploration technology attracted worldwide media attention in 2004. Conveying Institution research and engineering activities to the public was also accomplished by providing thousands of images, video footage, and information to textbook publishers, for museum and science center exhibits, Websites, publications and organizations as diverse as the American Museum of Natural History in New York, the U.S. Commission on Ocean Policy, John Wiley & Sons, the National Science Foundation, 20th Century Fox, and the Old Farmers' Almanac. The Media Relations Website had an average of more than 400 visits a day, totaling 163,000 visits for the year.

Among the major media events of the year was an August press briefing at the National Science Foundation to announce plans to replace the Deep Submergence Vehicle *Alvin*. Stories appeared in hundreds of newspapers, including *The Washington Post*, *The New York Times*, *The Boston Globe*, *The Miami Herald*, *Los Angeles Times*, and *Chicago Tribune*. Associated Press, Reuters, and Scripps Howard News Service distributed the story, which was also featured on ABC *News.com*, CNN.com and MSNBC.com as well as on *National Public Radio* and in *Science*.

Other stories on a variety of ocean research topics appeared in print and broadcast media in the U.S. and abroad, ranging from *The Science Teacher*, *Mass High Tech*, *Popular Mechanics* in South Africa, *Octopus* magazine in Russia, *NY Teknik* in Sweden and *National Geographic Magazine* to *Discovery Channel*, *The Science Channel*, PBS, *The Learning Channel*, and the BBC.



Print media coverage of WHOI science in 2004 reached more than 93 million readers. Millions more were exposed to WHOI science through wire service, broadcast, and Internet news outlets.



Photo-Op

From left, Margaret Leinen, assistant director of the National Science Foundation (NSF) Directorate for Geosciences, Arden Bement, Jr., director of NSF, and Robert Gagosian, WHOI president and director, watch an animation of the Alvin replacement vehicle during an August media briefing at NSF headquarters in Arlington, VA.

Other highlights for 2004:

- The 20th Century Fox feature film “The Day After Tomorrow,” released in theaters nationwide in May, resulted in dozens of media calls about abrupt climate change before and after the film’s release. Lloyd Keigwin and Ray Schmitt were interviewed for a related one-hour science documentary entitled “Force of Destiny: The Science and Politics of Climate Change,” a special DVD scheduled to be distributed in the U.S. in May 2005.
- The Weather Channel featured Ray Schmitt and the ocean’s role in climate change as part of its “Storm Stories” series in April.
- *Wired Magazine’s* first NextFest, a festival about technology for the future held in San Francisco in May, was featured in a one-hour television special on the Science Channel. Dave Gallo and the au-

- tonomous underwater vehicles (AUVs) REMUS and ABE were featured in the segment on exploration.
- Visiting journalists during the year included the eight 2004 Ocean Science Journalism Fellows, who spent an intense week of study in September as part of the fifth annual program, and ten international Knight Science Journalism Fellows from MIT, who visited in October as part of an annual program begun in 1983.
- Breck Owens and the new glider *Spray*, the first glider to cross the Gulf Stream, were featured in media stories in November ranging from the *Tampa Tribune* and *San Diego Daily Transcript* to *Uvonline.com*.
- Jian Lin, with Uri ten Brink of the U.S. Geological Survey, was featured in numerous media stories about undersea earthquakes and tsunamis related to the devastating Indian Ocean tsunami; their research findings about similar conditions in the Caribbean and Atlantic Ocean were published just two days before the event.

—Shelley Dawicki, Director of Media Relations



Scientists at WHOI contribute to the discussion of public policy and science policy issues at the state, national, and international levels. A selection of their activities in 2004 is given here.

## Public Policy

### Don Anderson

*Testimony on reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act, U.S. House of Representatives Subcommittee on Fisheries Conservation, Wildlife and Oceans*

### Bob Beardsley

*Outfall Monitoring Science Advisory Panel, U.S. Environmental Protection Agency and Massachusetts Department of Environmental Protection*

### Ken Brink

*Member, Science Advisory Panel, U.S. Commission on Ocean Policy*

### Bill Curry

*Testimony on Impacts of Climate Change and State's Actions, U.S. Senate Committee on Commerce, Science and Transportation*

### Ruth Curry

*Briefings on Oceans, Climate Change, and Human Health for members of Congress and Staff, sponsored by U.S. House of Representatives Oceans Caucus and Science and Resources Committees and U.S. Senate Committees on Commerce, Science and Transportation and Health, Education, Labor and Pensions*

*Briefings on Extreme Weather Events, Climate Instability and Abrupt Climate Change and Their Implications for Human Health for Congressional Staff, sponsored by U.S. House of Representatives Science Committee, Senator Olympia Snowe's Office, and the Environmental Energy Study Institute*

### Bob Gagosian

*Member, Science Advisory Panel, U.S. Commission on Ocean Policy*

### Darlene Ketten

*Member, Advisory Board, Stellwagen Bank National Marine Sanctuary*

*Member, Advisory Panels on Acoustic Impacts on Marine Mammals and Sea Turtles for U.S. House of Representatives Committee on Energy and Commerce and U.S. Senate Committee on Commerce, Science and Transportation*

*Briefing on Acoustic Impacts on Marine Mammals for Assistant Secretary of the Navy Donald Schregardus*

*Testimony on Marine Mammal Protection Act for U.S. House of Representatives and U.S. Senate Armed Services Committees*

### Ann Mulligan

*Science Advisory Council, Massachusetts Military Reservation*

### Chris Reddy

*Testimony on Oil Spills, Joint Committee on Natural Resources and Agriculture, Massachusetts Legislature*

### Andy Solow

*Member, Science Advisory Panel, U.S. Commission on Ocean Policy*

*Testimony on the Preliminary Report of the U.S. Commission on Ocean Policy, U.S. House of Representatives Science Committee*

*Member, Science Advisory Panel, Massachusetts Executive Office of the Environment*

*Chair, Outfall Monitoring Science Advisory Panel, U.S. Environmental Protection Agency and Massachusetts Department of Environmental Protection*

### Peter Tyack

*Federal Advisory Committee on Acoustic Impacts on Marine Mammals, U.S. Marine Mammal Commission*

*Briefing on Marine Mammal Protection Act for U.S. House of Representatives Resources Committee Staff*

### Bob Weller

*Testimony on Ocean Observations, U.S. House of Representatives Subcommittee on Fisheries Conservation, Wildlife and Oceans*

## Science Policy

### Don Anderson

*Director, U.S. National Office for Marine Biotoxins and Harmful Algal Blooms*

### Carin Ashjian

*Co-Vice Chair, Arctic Icebreaker Coordinating Committee, University-National Oceanographic Laboratories System (UNOLS)*

### Bob Detrick

*Member, Board of Governors, Joint Oceanographic Institutions (JOI)*

*Chair, Advisory Committee, NSF Geosciences Directorate*

*Member, Board of Governors, International Ocean Drilling Program (IODP) Management International*

### Scott Doney

*Member, Global Carbon Cycle Panel, National Oceanic and Atmospheric Administration*

### Katrina Edwards

*Member, Biogeosciences Working Group, National Science Foundation*

### Glen Gawarkiewicz

*Member, Steering Committee, NSF Coastal Ocean Processes Program*

### Rocky Geyer

*Member, National Academy of Sciences/National Research Council (NAS/NRC) Ocean Studies Board*

### Mark Hahn

*Member, Expert Review Panel, U.S. Environmental Protection Agency, Framework for Application of Dioxin TEF Methodology in Ecological Risk Assessment*

### Stan Hart

*Member, NAS/NRC Ocean Studies Board*

### Lloyd Keigwin

*Chair, Rapid Climate Change Programme Steering Committee, Natural Environment Research Council, U.K.*

### Dennis McGillicuddy

*Member, Steering Committee, U.S. Global Ocean Ecosystems Dynamics Program (GLOBEC)*

### Laurent Montési

*WHOI Representative, Computational Infrastructure in Geosciences, National Partnership for Advanced Computational Infrastructure*

### John Stegeman

*Chair, Institute of Medicine–National Academy of Sciences Committee on Health Effects of Agent Orange in Vietnam Veterans*

### Simon Thorrold

*Connectivity Working Group, Coral Reef Targeted Research and Capacity Building for Management, World Bank-led Alliance*

### Meg Tivey

*Co-Chair, Ocean Research Interactive Observatories Networks (ORION) Workshop Steering Committee*

### Bob Weller

*Co-Chair, U.S. Climate Variability and Predictability (CLIVAR) Science Steering Committee*

*ORION Executive Steering Committee*

*National Research Council Committee on Strategic Guidance to the Atmospheric Sciences Division, National Science Foundation*

### Peter Wiebe

*Chair, UNOLS*

*U.S. Representative, Oceanography Committee, International Council for Exploration of the Sea*

*Member, Steering Committee, U.S. GLOBEC*



### Applied Ocean Physics and Engineering Department

#### Promotions

**John Colosi**  
*Associate Scientist with Tenure*

**Alan Gardner**  
*Engineering Assistant III*

**Laura Goepfert**  
*Information Systems Associate II*

**Sue Grieve**  
*Administrative Associate I*

**Matt Heintz**  
*Research Engineer*

**Thomas Hurst**  
*Engineer II*

**Frederic Jaffre**  
*Engineer II*

**Amy Kukulya**  
*Research Assistant III*

**Gretchen McManamin**  
*Administrative Associate I*

**Marlene Messina**  
*Administrative Associate I*

**Peter Schultz**  
*Research Associate II*

**Alex Shorter**  
*Engineer II*

**Peter Traykovski**  
*Associate Scientist*

**Jonathan Ware**  
*Research Engineer*

#### Appointments

**Linda Cannata**  
*Senior Admin. Assistant II*

**Mary Frederick**  
*Senior Admin. Assistant II*

**George Frisk**  
*Scientist Emeritus*

**Ruoying He**  
*Assistant Scientist*

**Tian-Jian Hsu**  
*Assistant Scientist*

**Casey Machado**  
*Laboratory Assistant II*

**Kris Newhall**  
*Engineering Assistant II*

**Catherine Offinger**  
*Research Associate III*

**Eben Olson**  
*Engineering Assistant I*

**Cliff Pontbriand**  
*Engineering Assistant II*

### Biology Department

#### Promotions

**Molly Allison**  
*Research Assistant III*

**Carin Ashjian**  
*Associate Scientist with Tenure*

**Scott Cramer**  
*Senior Research Assistant I*

**Jen Fitzgerald-Kearney**  
*Research Associate II*

**David Kulis**  
*Senior Research Assistant II*

**Pamela Polloni**  
*Research Assistant III*

**Simon Thorrold**  
*Associate Scientist with Tenure*

**Mary Jane Tucci**  
*Administrative Associate II*

### Geology and Geophysics Department

#### Promotions

**Anne Cohen**  
*Research Specialist*

**Glenn Gaetani**  
*Associate Scientist*

#### Appointments

**Mark Behn**  
*Assistant Scientist*

**Joan Bernhard**  
*Associate Scientist with Tenure*

**Joshua Burton**  
*Research Assistant II*

**Ilya Buynevich**  
*Assistant Scientist*

**Sarah Das**  
*Assistant Scientist*

**Susumu Honjo**  
*Scientist Emeritus*

**Pat Lohmann**  
*Scientist Emeritus*

**Luc Mehl**  
*Research Assistant III*

**Beecher Wooding**  
*Oceanographer Emeritus*

### Marine Chemistry and Geochemistry Department

#### Promotions

**Matt Charette**  
*Associate Scientist*

**Tim Eglinton**  
*Senior Scientist*

**Konrad Hughen**  
*Associate Scientist*

**Bernhard Peucker-Ehrenbrink**  
*Associate Scientist with Tenure*

**Chris Reddy**  
*Associate Scientist*

#### Appointments

**Karen Casciotti**  
*Assistant Scientist*

**Mark Coolen**  
*Assistant Scientist (May 2005)*

**Liz Kujawinski**  
*Assistant Scientist*

**Ben Van Mooy**  
*Assistant Scientist*

### Physical Oceanography Department

#### Promotions

**Claudia Cenedese**  
*Associate Scientist*

**Andrey Proshutinsky**  
*Senior Scientist*

**Kurt Polzin**  
*Associate Scientist with Tenure*

**John Lund**  
*Research Associate II*

**Penny Foster**  
*Administrative Associate I*

**Mary Ann Lucas**  
*Administrative Associate II*

**Hazel Salazar**  
*Administrative Associate I*

**Elizabeth Stokes**  
*Senior Admin. Assistant II*

#### Appointments

**Bob Beardsley**  
*Scientist Emeritus*

**Peter Winsor**  
*Assistant Scientist*



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- F. Thomas Westcott
- John J. Wise
- Alfred M. Zeien

**Deceased 2004**

- Ruth M. Adams**  
*Honorary Trustee and Honorary Member 11/10/04*
- W. H. Krome George**  
*Honorary Trustee and Honorary Member 9/6/04*
- William P.E. Graves**  
*Honorary Member 6/12/04*
- A. Dix Leeson**  
*Honorary Member 5/27/04*
- Frank L. Nickerson**  
*Honorary Member 9/4/04*
- Stephen P. Swope**  
*Member 12/8/04*



The new Marine Research Facility, left, and Biogeochemistry Building rising on the Quissett Campus in December 2004.

Tom Kleindinst, WHOI Graphic Services



# Woods Hole Oceanographic Institution history timeline



In 2005, WHOI celebrates 75 years of ocean research, education, and exploration. While the grand story of Institution accomplishments is told in the scientific literature, some highlights of its growth as an institution are summarized in this timeline and treated more fully in the book *Down to the Sea for Science*, scheduled for publication in late summer 2005.



*Atlantis is moored to the pier and Asterias is at left in the Institution's original small boat basin.*

**1931** By June 1931, the 40-foot (12-meter) coastal vessel *Asterias* had been delivered from New Bedford, MA, in time for the Institution's first research season. On August 31 that year, the 142-foot (43-meter) ketch-rigged *Atlantis*, built in Denmark, arrived in Woods Hole, offering U.S. blue-water research opportunities for the first time in many years.

**1940–1945** WHOI's first federal contract initiated war-related work on July 1, 1940. The mission was to study the organisms that foul ships' hulls and determine how to eliminate them. Soon the Institution became the National Defense Research Committee's premier oceanographic research center.



*Dean Bumpus tutors navy submariners in use of the bathythermograph to avoid detection from the surface during World War II.*



*WHOI staff prepare Nansen bottles for shipping to Bikini Atoll for oceanographic measurements before and after bomb tests there.*

**1946** Navy projects continued after the war, and more than 40 WHOI employees were involved in extensive measurements related to atomic bomb testing at Bikini Atoll in the Pacific Ocean. WHOI biologists renewed prewar studies of ocean productivity and began investigations of marine pollution. In late 1947, *Atlantis* headed to the Mediterranean to map the Aegean seafloor for the U.S. Navy

**1957** Work undertaken for the 1957–58 International Geophysical Year (IGY) tempered continuing funding concerns. WHOI maintained excellence in instrument development—for example, automation of salinity measurements saved time and improved accuracy. Launch of two Russian Sputnik satellites focused U.S. attention on the sciences, including oceanography.



*Al Bradshaw, left, and Karl Schleicher operate their salinometer, one of many WHOI advances in instrumentation.*



*The deep-diving submersible Alvin, funded by the U.S. Navy and assigned to WHOI, was dedicated in June 1964.*

**1962** WHOI was moving ahead on all fronts. The first computer went to sea to process gravity measurements in 1961. The following year, *Atlantis II* was delivered, ground was broken for a new building to house biological and chemical laboratories along with a computing center, and six science departments were formed. *Atlantis II* participated in the search for the sunken submarine *USS Thresher*.

1930

**1930** Based upon the recommendation of a National Academy of Sciences Committee on Oceanography, the Woods Hole Oceanographic Institution was incorporated on January 6, 1930. The chair of the Committee on Oceanography, Frank R. Lillie of the University of Chicago and the Marine Biological Laboratory, was named chairman of the board, and committee secretary Henry Bigelow became director



*By summer 1931, the first WHOI laboratory building was ready for science. It was later named for first director Henry Bigelow.*

1935



*Atlantis accommodated six scientists, several students, three officers, and 13 crewmembers for 30 years of cruises in the Atlantic and eastern Pacific oceans and the Mediterranean Sea.*

**1939** Columbus Iselin—protégé of Henry Bigelow, original captain of *Atlantis*, and second WHOI director—wrote, “By the end of ten years we had made considerable progress in understanding the currents of the western North Atlantic... [and] we felt generally at home in most of the North Atlantic, both physically and chemically, and to a lesser extent geologically and biologically.”

1940

From 1942 to 1945, the staff grew from 92 to more than 300 people working on about 40 war-related projects. These included:

- + development of the bathythermograph, whose temperature/depth measurements helped the U.S. Navy to find enemy submarines and U.S. submarines to avoid detection by the enemy,
- + underwater explosives research and improvements in underwater photography,
- + current and drift predictions for downed aviators on life rafts, and
- + wave and swell predictions for amphibious landings.

Photos are from the WHOI Archives unless otherwise indicated.

1945



*A second WHOI building rose on Water Street in 1954–55 to relieve overcrowded laboratories and house classified work for the U.S. Navy.*

**1950** Wartime inflation rendered ocean science too expensive for private funding. WHOI remained a private corporation, but government funding became essential to progress in ocean science. Coast Guardsman Edward Smith was named director in 1950. He dedicated the Institution's second large building, a Navy-funded laboratory later named for him, and secured the converted 125-foot (38-meter) cutter *Crawford* for WHOI. Iselin again served as director in 1956 and 1957.

1950

1955

**1958** Paul Fye, a wartime member of the explosives research group, returned to WHOI as director. His mission was to lead a rather reluctant staff toward a more formally organized institution. Committees were appointed to consider land acquisition, a building program, research vessel design, and educational policy. Two federal reports promoted new funding for ocean sciences.



*Big-ship oceanography came to WHOI in 1958 with the arrival of *Crawford*, a former U.S. Navy deep-sea salvage tug.*

1960



*Knorr splashes into Michigan waters at its launch in August 1968. At delivery, the ship accommodated 24 scientists and 25 crew.*

1965

**1968** WHOI had grown to about 600 people by this time, and more laboratory space was desperately needed. Acquisition of a large acreage near Woods Hole village brought promise of relief. After years of careful deliberation, an agreement was signed with the Massachusetts Institute of Technology for a joint graduate degree program.



The first MIT/WHOI Joint Program commencement was held in 1970 near the recently completed marine facilities building and with the newly delivered Knorr at the pier.

**1970** The National Science Foundation-sponsored International Decade of Ocean Exploration (IDOE) brought a number of “big science” initiatives. WHOI scientists participated in the Geochemical Ocean Sections Study and others among these programs over the next ten years.

increased the sub’s depth capability from 6,000 feet (1,818 meters) to 10,000 feet (3,030 meters), and *Alvin*, its tender *Lulu*, and *Knorr* participated in the international French-American Mid-Ocean Undersea Study. This “Project FAMOUS” gave scientists their first opportunity to examine in person the plate tectonic processes at work on mid-ocean ridges.



*Oceanus* replaced *Chain* in the WHOI fleet in 1975. The 177-foot (54-meter) vessel accommodated 12 scientists and 12 crew.



In the early 1980s the McLean Laboratory for geosciences, the Coastal Research Laboratory, and the Fye Laboratory for chemistry and geochemistry, pictured above, brought new research facilities to the Institution’s Quissett Campus.

**1980** A 50<sup>th</sup> anniversary celebration included hosting a congress on the history of oceanography, a symposium on the present and future of oceanography, a public open house, and a whimsical “anything but a boat” regatta. Wang word processing had changed the process of writing papers the year before, and recovery of a mooring deployed for 515 days had marked a new record for the buoy group.

**1989** The World Ocean Circulation Experiment’s Hydrographic Programme Office was established at WHOI—one of many administrative or operational offices hosted by the Institution for large oceanographic research programs. *Knorr* was being lengthened and refitted to meet the global operational requirements of these large programs. Craig Dorman succeeded John Steele as director.



In 1989, the first addition to Clark Laboratory was occupied, and this extension to it was being framed.



The Institution’s third *Atlantis* arrives in Woods Hole for the first time on April 11, 1997.

**1997** Following visits to the ports of New York City and Alexandria, Virginia, the Institution’s third *Atlantis*, with *Alvin* transferred from the retiring *Atlantis II*, went to work for ocean science. *Jason* was engaged in a two-month survey of a sunken British bulk ore carrier that would establish the cause of the ship’s demise. A British official said this accomplishment meant “no longer need ships vanish without trace or explanation.”

1970

1975

1980

1985

1990

1995

2000

2005

In 1971, a WHOI marine policy program was established to work toward wise use of the oceans, and the Institution was chosen as the first host for the University National Oceanographic Laboratories System, designed to promote efficient use of ships and other U.S. marine facilities.

**1974** The largest move in the Institution’s history took place in 1974 when some members of each science department relocated, along with the directorate, to the new central laboratory on the Quissett Campus. At its October 1974 dedication, the building was named Clark Laboratory for major WHOI donors Edna McConnell Clark and W. Van Alan Clark. An aquaculture project had moved to the Environmental Systems Laboratory on the new campus the previous year. A new titanium sphere installed in *Alvin*

**1977** After nineteen years as director, Paul Fye stepped down following a period of astonishing growth for WHOI. The number of employees doubled during his tenure, the operating budget increased nearly tenfold from about \$2.5 million in 1958 to \$24 million in 1977, and new buildings, ships, a submersible, a graduate degree-granting program, and a marine policy program expanded the Institution’s capabilities. John Steele followed Fye as director. Scientists diving in *Alvin* on the Pacific’s Galápagos Rift got their first close-up look at hydrothermal vents, which are still a focus of oceanographic research nearly three decades later. In 1978, a quarter-million-dollar VAX 11/780 replaced the Institution’s first mainframe computer.



As its Deep Submergence Laboratory operators gained experience with the remotely operated vehicle *Jason*, it surveyed a Mediterranean wreck site and its cache of amphorae in 1989.

**1985** Discovery of the sunken *Titanic* during a *Knorr* expedition focused an international spotlight on WHOI. The following year, *Alvin*, working from *Atlantis II* dove to the wreck. The sub carried the tiny prototype remotely operated vehicle *Jason Jr.*, which signaled a new era of deep-sea exploration as it revealed the interior of *Titanic*. By 1987, the Deep Submergence Laboratory was operating a full-scale *Jason*.

**1993** The Institution’s most ambitious capital campaign to date, initiated in 1990, went public with a goal of \$50 million. At its completion in 1996, it will have raised \$54 million. Robert Gagosian, who joined the Institution in 1972 as an assistant scientist and had served as associate director for research since 1987, became director.



WHOI autonomous underwater vehicles took to the deep sea in 1995 when ABE (Autonomous Benthic Explorer) mapped magnetic characteristics, lava terrain, and a hydrothermal plume on the Juan de Fuca Ridge in the Pacific Ocean.



The Martha’s Vineyard Coastal Observatory, whose offshore observation tower rises more than 22 meters (70 feet) above sea level, was initiated in 2000 as a WHOI contribution to the growing movement toward long-term ocean observations.

**2000** In order to encourage interdisciplinary research, respond to societal concerns, and enhance communication of scientific results to the public and policymakers, four ocean institutes were established: the Coastal Ocean Institute (joining the Rinehart Coastal Research Center), the Deep Ocean Exploration Institute, the Ocean and Climate Change Institute, and the Ocean Life Institute.



Following completion of a ring road around most Quissett Campus lab buildings at the end of 2002, construction began for a new Biogeochemistry Building, above, and a Marine Research Facility. Two additions to the McLean Laboratory and a variety of infrastructure improvements were also initiated. In Woods Hole village, a 2004 addition to the Blake Building expanded Deep Submergence Laboratory facilities.





WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, MA 02543 • 508-457-2000 • [www.whoi.edu](http://www.whoi.edu)

For the fifth consecutive year, government sponsored revenues surpassed both budget and prior year results and the Institution completed 2004 in strong financial condition. This strength is due in large measure to both the Institution's scientific and engineering achievements and its commitment to administrative efficiency and fiscal discipline.

#### Financial highlights:

- The Institution's total assets grew by more than \$60 million, or 15%, to \$455 million. This increase is attributable to the performance of the Endowment and to construction of new laboratories on both campuses.
- During 2004 the Institution issued \$54,850,000 of Massachusetts Health and Educational Facilities Authority (MHEFA) variable rate bonds to construct new laboratories and to repay previous MHEFA loans. The Institution negotiated an interest rate swap agreement that effectively locks in a fixed rate on the bonds of 3.79% for 30 years.
- The Institution's accrued pension liability increased from \$6.9 million in 2003 to \$24.7 million in 2004. To allow time to evaluate the retirement plan and control the cost, the plan was amended effective December 31, 2004, by freezing compensation. A task force will propose a new plan that will be in place by the end of 2005.
- The Institution ended the year with a slight decrease in total net assets of \$2.5 million due in large part to pension fund accruals.
- The Endowment Fund grew to \$291 million in 2004 from \$269 million in 2003 with a total return of 12%.
- The Institution ended the year with a total increase in net assets from operating activities of \$8.3 million.

Total sponsored research released to operations was \$108.5 million in 2004 compared with \$100.8 million in 2003, an increase of 8 percent. Government sponsored research, excluding ship and submersible operations, was \$67.5 million in 2004 compared with \$63.4 million in 2003, a 6 percent increase. The Institution's labor bases,

against which fringe benefits and overhead are recovered, finished the year slightly over budget, while overhead costs were reduced by almost \$2.7 million, resulting in a substantial over-recovery of overhead expenses. Our total overhead recovery was \$55.2 million compared with \$47.7 million in 2003.

Our primary federal sponsor, the National Science Foundation (NSF), did not receive a large increase in its 2004 appropriation. However, the Institution benefited from a 22% funding increase from NSF, which more than offset a decrease in funding from the United States Navy.

Through the generosity of friends of the Institution, gifts, grants, and pledges reached \$15.3 million in 2004. Outstanding net pledges at the end of 2004 were \$6.9 million.

Investment returns distributed to operations totaled \$13.7 million in 2004. Sponsored research received \$4.7 million, education received \$5.6 million and current operations received \$3.4 million. Distributions from investment returns have become an important source of revenue for the Institution and make up 10 percent of total operating revenues.

The Institution spent \$56.3 million on compensation during 2004. Included in this amount was \$8.9 million for vacation, holidays and sick time. Other fringe benefits cost \$10.8 million for a total compensation package of \$67.1 million, 52 percent of our total 2004 operating expenses of \$128.2 million.

The Institution invested \$19.4 million on the construction and renovation of facilities during 2004. In addition, \$895,000 was invested in maintaining existing facilities compared with \$884,000 in 2003.

During 2004, to relieve overcrowding and create state of the art laboratories, the Institution has made significant progress in developing the Quissett Campus and renovating laboratories in the Village, while maintaining its financial stability. However, we face significant short and long-term economic challenges: reductions in federal funding agency budgets and a shift in focus from basic to applied



Tom Kleindinst, WHOI Graphic Services

Carolyn Bunker with Dave Stephens, controller.

research will probably require that WHOI change as well.

In the short term we are taking steps to control spiraling health plan and retirement plan costs. We are undertaking a comprehensive assessment of the Institution's central administrative functions to improve effectiveness and competitiveness and direct resources to high priorities.

To prepare for long-term challenges, we are exploring additional and new funding sources with an emphasis on intellectual property development and applied research. These changes will be challenging, but with the support of the staff, students, trustees and corporation members, the Institution will continue to prosper and grow in reputation.

A handwritten signature in black ink that reads "Carolyn A. Bunker". The signature is written in a cursive style.



**Statement of Financial Position**

December 31, 2004 (with comparative information as of December 31, 2003)

	2004	2003
<b>Assets</b>		
Cash, unrestricted	\$12,669,547	\$18,097,572
Cash, restricted	382,421	1,507,755
Reimbursable costs and fees:		
Billed (net of allowance for doubtful accounts of \$226,658 for 2004 and \$234,033 for 2003)	3,335,365	1,728,635
Unbilled	6,458,930	4,670,629
Receivable for investments sold (Note 3)	-	22,044,791
Interest and dividends receivable	276,130	497,941
Other receivables (Note 12)	2,970,530	8,034,611
Pledges receivable, net	6,879,190	4,846,696
Inventory	1,233,746	1,084,124
Deferred charges and prepaid expenses	1,402,357	775,518
Deferred fixed rate variance	-	3,197,693
Investments, pooled	287,277,109	242,720,582
Investments, nonpooled	5,237,388	5,326,668
Deposits with trustees for construction	24,278,081	-
Deposits with trustees for debt service	3,154,350	-
Prepaid postretirement benefit cost	639,297	788,826
Supplemental retirement	6,537,921	6,257,039
Intangible pension asset	-	5,644,240
Other assets	17,384,437	11,983,651
Deferred financing costs	<u>1,268,753</u>	<u>-</u>
Subtotal	<u>381,385,552</u>	<u>339,206,971</u>
Property, plant and equipment		
Land, buildings and improvements	68,493,906	65,789,103
Vessels and dock facilities	6,442,869	4,365,175
Laboratory and other equipment	18,132,850	15,880,819
Construction in process	<u>24,195,589</u>	<u>7,523,530</u>
	117,265,214	93,558,627
Accumulated depreciation	<u>(53,404,419)</u>	<u>(49,070,058)</u>
Net property, plant and equipment	<u>63,860,795</u>	<u>44,488,569</u>
Remainder trusts	<u>10,043,233</u>	<u>10,532,306</u>
Total assets	<u>\$455,289,580</u>	<u>\$394,227,846</u>

	2004	2003
<b>Liabilities</b>		
Accounts payable and other liabilities (Note 12)	\$17,845,971	\$17,114,484
Accrued payroll and related liabilities	5,291,214	6,227,950
Payable for investments purchased	47,251	-
Deferred fixed rate variance	129,500	-
Accrued supplemental retirement benefits	6,537,921	6,257,039
Accrued pension liability	24,697,407	6,946,274
Deferred revenue and refundable advances	6,739,232	5,316,136
Bond and loans payable	<u>54,850,000</u>	<u>10,724,206</u>
Total liabilities	<u>116,138,496</u>	<u>52,586,089</u>

**Net Assets**

	Unrestricted	Temporarily restricted	Permanently restricted	2004	2003
Undesignated	\$10,306,900	\$ -	\$ -	10,306,900	10,961,721
Pension	(23,705,136)	-	-	(23,705,136)	(645,885)
Designated	2,148,390	8,243,578	-	10,391,968	10,977,926
Pledges and other	-	4,693,522	13,327,331	18,020,853	16,277,347
Plant and facilities	29,968,854	-	-	29,968,854	31,420,297
Education	-	3,437,863	-	3,437,863	3,361,005
Endowment and similar funds	<u>67,894,397</u>	<u>166,942,058</u>	<u>55,893,327</u>	<u>290,729,782</u>	<u>269,289,346</u>
Total net assets	<u>\$86,613,405</u>	<u>\$183,317,021</u>	<u>\$69,220,658</u>	<u>339,151,084</u>	<u>341,641,757</u>
Total liabilities and net assets				<u>\$455,289,580</u>	<u>\$394,227,846</u>

The accompanying notes are an integral part of these financial statements.

**Statement of Activities**

Year Ended December 31, 2004 (with summarized financial information for the year ended December 31, 2003)

	Unrestricted		Temporarily Restricted	Permanently Restricted	2004	2003
	Operating	Sponsored Research				
Operating Revenues						
Fees	\$576,649				\$576,649	\$483,754
Sponsored research						
Government		\$67,496,538			67,496,538	63,389,385
Nongovernment		16,287,190	\$4,725,103		21,012,293	20,711,972
Ships and subs operations		20,102,588			20,102,588	17,558,382
Sponsored research assets released to operations	108,473,591	(103,886,316)	(4,587,275)		-	-
Education						
Tuition	3,455,307				3,455,307	2,977,535
Endowment income	3,683,100		1,902,554		5,585,654	5,671,555
Gifts			351,013		351,013	170,620
Education funds released from restriction	2,176,709		(2,176,709)		-	-
Investment return designated for current operations	3,381,128				3,381,128	3,453,967
Contributions and gifts, net of releases from restrictions of \$884,486 and \$2,023,298 in 2004 and 2003, respectively	7,912,467		(158,970)	\$5,051,897	12,805,394	18,866,945
Contributions in kind	267,687				267,687	309,153
Rental income	660,191				660,191	718,440
Communication and publications	294,620				294,620	262,004
Other	544,184				544,184	195,644
<b>Total revenues</b>	<b>131,425,633</b>	<b>-</b>	<b>55,716</b>	<b>5,051,897</b>	<b>136,533,246</b>	<b>134,769,356</b>
Expenses						
Sponsored research						
National Science Foundation	41,499,749				41,499,749	34,097,378
United States Navy	14,223,555				14,223,555	18,379,000
Subcontracts	12,127,174				12,127,174	9,324,911
National Oceanic & Atmospheric Administration	8,514,822				8,514,822	7,412,224
Department of Energy	690,864				690,864	878,280
United States Geological Survey	999,024				999,024	822,196
National Aeronautics & Space Administration	741,428				741,428	753,186
Ships Operations	14,809,301				14,809,301	13,001,577
Submersible and ROV operations	5,293,287				5,293,287	4,556,805
Privately funded grants	3,126,607				3,126,607	3,742,846
Other	6,447,780				6,447,780	7,780,861



## Statement of Activities (continued)

	Unrestricted		Temporarily Restricted	Permanently Restricted	2004	2003
	Operating	Sponsored Research				
Education						
Faculty expense	2,930,827				2,930,827	2,968,490
Student expense	3,963,605				3,963,605	3,840,130
Postdoctoral programs	369,900				369,900	472,037
Other	687,280				687,280	647,797
Rental expenses	498,164				498,164	535,178
Communication, publications and development	2,572,930				2,572,930	2,284,343
Fundraising expenses	2,507,237				2,507,237	2,201,452
Un-sponsored programs	5,279,055				5,279,055	3,821,259
Other expenses	920,888				920,888	980,073
Total expenses	128,203,477	-	-	-	128,203,477	118,500,023
Change in net assets from operating activities	3,222,156	-	55,716	5,051,897	8,329,769	16,269,333
Nonoperating income						
Investment return in excess of amounts designated for sponsored research, education and current operations	5,379,780		14,155,380		19,535,160	31,182,420
Net realized/unrealized gains (losses) on interest swap	(4,020,690)				(4,020,690)	-
Change in split interest agreements	(14,038)		(35,851)	(593,686)	(643,575)	1,149,391
Net periodic pension cost	(9,004,045)				(9,004,045)	(5,819,299)
Contributions and gifts			15,502		15,502	2,163,286
Net assets released from restriction	1,151,030		(1,151,030)		-	-
Nonoperating expenses						
Other nonoperating expenses	(99,976)				(99,976)	(99,972)
Redesignation of gifts	(847,746)		(1,249,343)	60,500	(2,036,589)	57,558
Write-off of fixed assets	(511,023)				(511,023)	-
Change in net assets from nonoperating activities	(7,966,708)	-	11,734,658	(533,186)	3,234,764	28,633,384
Change in net assets from operating and nonoperating activities	(4,744,552)	-	11,790,374	4,518,711	11,564,533	44,902,717
Change in additional pension minimum liability (Note 8)	(14,055,206)				(14,055,206)	5,975,263
Total change in net assets	(18,799,758)	-	11,790,374	4,518,711	(2,490,673)	50,877,980
Net assets at beginning of year	105,413,163		171,526,647	64,701,947	341,641,757	290,763,777
Net assets at end of year	\$86,613,405	\$ -	\$183,317,021	\$69,220,658	\$339,151,084	\$341,641,757

The accompanying notes are an integral part of these financial statements

**Statement of Cash Flows**

Year Ended December 31, 2004 (with comparative information for the year ended December 31, 2003)

	2004	2003		2004	2003
<b>Cash flows from operating activities</b>			<b>Cash flows from investing activities</b>		
Total change in net assets	\$(2,490,673)	\$50,877,980	Capital expenditures		
Adjustments to reconcile increase (decrease) in net assets to net cash used in operating activities			Additions to property and equipment	(20,007,169)	(9,972,134)
Depreciation and amortization	5,180,075	4,585,752	Short-term investments		
Change in split interest agreements	643,575	(1,149,391)	Purchase of investments	-	1,000,000
Allowance for uncollectible pledges	93,679	4,708	Endowment		
Discount on pledges	215,801	(56,202)	Receivable for investments sold	22,044,791	(22,044,791)
Net realized and unrealized (gain) loss on investments	(27,688,898)	(41,731,926)	Payable for investments purchased	47,251	(10,193)
Intangible pension asset	5,644,240	5,854,284	Proceeds from the sale of investments	130,132,661	90,451,740
Additional minimum pension liability	14,055,206	(5,975,263)	Purchase of investments	<u>(146,911,010)</u>	<u>(60,187,013)</u>
Contributions to be used for long-term investment	(2,553,132)	(4,926,199)	Net cash used in investing activities	<u>(14,693,476)</u>	<u>(762,391)</u>
Gift of property	(5,034,355)	(7,620,000)	<b>Cash flows from financing activities</b>		
(Increase) decrease in assets			Borrowings under debt agreement	54,850,000	2,679,044
Restricted cash	1,125,334	534,400	Loan payments	(10,724,206)	-
Interest and dividends receivable	221,811	34,285	Deferred financing costs	(1,290,196)	-
Reimbursable costs and fees			Use of bond proceeds deposited with trustee		
Billed	(1,606,730)	2,194,443	Construction fund	(24,278,081)	-
Unbilled	(1,788,301)	140,509	Change in debt service funds	(3,154,350)	-
Other receivables	5,064,081	6,890,372	Contributions to be used for long-term investment	<u>2,553,132</u>	<u>4,926,199</u>
Pledges receivable	(2,341,974)	(332,147)	Net cash provided by financing activities	<u>17,956,299</u>	<u>7,605,243</u>
Inventory	(149,622)	405,897	Net increase (decrease) in cash and cash equivalents	(5,428,025)	4,123,806
Deferred charges and prepaid expenses	(626,839)	223,686	Cash and cash equivalents, beginning of year	<u>18,097,572</u>	<u>13,973,766</u>
Deferred fixed rate variance	3,197,693	(2,770,823)	Cash and cash equivalents, end of year	<u>\$12,669,547</u>	<u>\$18,097,572</u>
Other assets	(366,431)	(186,464)	<b>Supplemental disclosures</b>		
Remainder trusts	(43,044)	-	Cash paid for interest	\$761,500	\$117,284
Prepaid pension cost	149,529	-	Noncash activity - gift of property	5,034,355	7,620,000
Supplemental retirement	(280,882)	(762,713)	Construction in process additions remaining in accounts payable	4,523,689	-
Increase (decrease) in liabilities					
Accrued pension liability	3,695,927	308,900			
Accounts payable and other liabilities	(3,903,660)	(7,555,154)			
Accrued payroll and related liabilities	(936,736)	(467,491)			
Deferred revenue and refundable advances	1,423,096	(2,003,202)			
Accrued supplemental retirement benefits	280,882	762,713			
Deferred fixed rate variance	<u>129,500</u>	<u>-</u>			
Net cash used in operating activities	<u>(8,690,848)</u>	<u>(2,719,046)</u>			

The accompanying notes are an integral part of these financial statements.



## Report of Independent Auditors

To the Board of Trustees of  
Woods Hole Oceanographic Institution

In our opinion, the accompanying statement of financial position and the related statements of activities and cash flows present fairly, in all material respects, the financial position of Woods Hole Oceanographic Institution (the "Institution") at December 31, 2004, and the changes in its net assets and its cash flows for the year then ended in conformity with accounting principles generally accepted in the United States of America. These financial statements are the responsibility of the Institution's management. Our responsibility is to express an opinion on these financial statements based on our audit. The prior year summarized comparative information has been derived from the Institution's 2003 financial statements, and in our report dated March 19, 2004, we expressed an unqualified opinion on those financial statements. We conducted our audit of these statements

in accordance with auditing standards generally accepted in the United States of America. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements, assessing the accounting principles used and significant estimates made by management, and evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

*PricewaterhouseCoopers LLP*

March 17, 2005

### Notes to financial Statements

#### 1. Background

Woods Hole Oceanographic Institution (the "Institution") is a private, independent not-for-profit research and educational institution located in Woods Hole, Massachusetts. Founded in 1930, the Institution is dedicated to working and learning at the frontier of ocean science and attaining maximum return on intellectual and material investments in oceanographic research.

The Institution is a qualified tax-exempt organization under Section 501(c)(3) of the Internal Revenue Code as it is organized and operated for education and scientific purposes.

#### 2. Summary of Significant Accounting Policies

##### Basis of Presentation

The accompanying financial statements have been prepared on the accrual basis and in accordance with the reporting principles of not-for-profit accounting.

The financial statements include certain prior-year summarized comparative information, but do not include sufficient detail to constitute a presentation in conformity with accounting principles generally accepted in the United States of America. Accordingly, such information should be read in conjunction with the Institution's audited financial statements for the year ended December 31, 2003, from which the summarized information was derived.

Net assets, revenues, and realized and unrealized gains and losses are classified based on

the existence or absence of donor-imposed restrictions and legal restrictions imposed under Massachusetts State law. Accordingly, net assets and changes therein are classified as follows:

##### Permanently Restricted Net Assets

Permanently restricted net assets are subject to donor-imposed stipulations that they be maintained permanently by the Institution. Generally the donors of these assets permit the Institution to use all or part of the income earned and capital appreciation, if any, on related investments for general or specific purposes.

##### Temporarily Restricted Net Assets

Temporarily restricted net assets are subject to donor-imposed stipulations that may or will be met by actions of the Institution and/or the passage of time. Unspent gains on permanent endowment are classified as temporarily restricted until the Institution appropriates and spends such sums in accordance with the terms of the underlying endowment funds at which time they will be released to unrestricted revenues.

##### Unrestricted Net Assets

Unrestricted net assets are not subject to donor-imposed stipulations. Revenues are reported as increases in unrestricted net assets unless use of the related assets is limited by donor-imposed restrictions. Expenses are reported as decreases in unrestricted net assets. Gains and losses on investments and other assets or liabilities are reported as increases or de-

creases in unrestricted net assets unless their use is restricted by explicit donor stipulations or law. Expirations of temporary restrictions on net assets, that is, the donor-imposed stipulated purpose has been accomplished and/or the stipulated time period has elapsed, are reported as reclassifications between the applicable classes of net assets. Amounts received for sponsored research (under exchange transactions) are reflected in unrestricted sponsored research and released to operations when spent for the appropriate purpose, or as deferred revenue if expenditures have yet to be incurred.

### Contributions

Contributions, including unconditional promises to give, are recognized as revenues in the period received. Contributions subject to donor-imposed stipulations that are met in the same reporting period are reported as unrestricted support. Promises to give that are scheduled to be received after the balance sheet date are shown as increases in temporarily restricted net assets and are reclassified to unrestricted net assets when the purpose or items' restrictions are met. Promises to give, subject to donor-imposed stipulations that the corpus be maintained permanently, are recognized as increases in permanently restricted net assets. Conditional promises to give are not recognized until they become unconditional, that is, when the conditions on which they depend are substantially met. Contributions other than cash are generally recorded at market value on the date of the gift (or an estimate of fair value), although certain noncash gifts, for which a readily determinable market value cannot be established, are recorded at a nominal value until such time as the value becomes known. Contributions to be received after one year are discounted at the appropriate rate commensurate with risk. Amortization of such discount is recorded as additional contribution revenue in accordance with restrictions imposed by the donor on the original contribution, as applicable. Amounts receivable for contributions are reflected net of an applicable reserve for collectibility.

The Institution reports contributions in the form of land, buildings, or equipment as unrestricted operating support at fair market value when received.

Dividends, interest and net gains on investments of endowment and similar funds are reported as follows:

- as increases in permanently restricted net assets if the terms of the gift require that they be added to the principal of a permanent endowment fund;
- as increases in temporarily restricted net assets if the terms of the gift or relevant state law impose restrictions on the current use of the income or net realized and unrealized gains; and
- as increases in unrestricted net assets in all other cases.

### Operations

The statement of activities report the Institution's operating and nonoperating activities. Operating revenues and expenses consist of those activities attributable to the Institution's current annual research or educational programs, all gifts received except those received for property, plant and equipment purposes and a component of endowment income appropriated for operations (Note 3). Unrestricted endowment investment income and gains over the amount appropriated under the Institution's spending plan are reported as nonoperating revenue as investment return in excess of amounts designated for sponsored research, education and current operations. Nonoperating revenue also includes the change in value of split interest agreements, contributions restricted for property, plant and equipment purposes, gains or losses on disposals of fixed assets, net realized/unrealized gains (losses) on interest swaps and the net periodic pension cost (income) on the noncontributory defined benefit pension plan. Additionally, nonoperating activities includes redesignation of donor gifts and depreciation on certain government-funded facilities.

### Cash and Cash Equivalents

Cash and cash equivalents consist of cash, money market accounts, certificates of deposit and overnight repurchase agreements with initial maturities of three months or less when purchased which are stated at cost, which approximates market value.

Included in restricted cash at December 31, 2004 and 2003 is \$142,991 and \$1,268,574, respectively, representing advances received from the United States Navy and other U.S. Government and state agencies. Such amounts are restricted as to use for research programs. Interest earned on unspent funds is remitted to the federal government.

Also included in restricted cash at December 31, 2004 and 2003 is \$239,430 and \$239,181, respectively, representing cash restricted by the Massachusetts Department of Public Health. Interest earned on unspent funds is reinvested within the restricted cash account.

In addition, cash and cash equivalents include uninvested amounts from each classification of net assets (e.g., endowment).

### Investments

Investment securities are carried at market value determined as follows: securities traded on a national securities exchange are valued at the last reported sales price on the last business day of the year; securities traded in the over-the-counter market and listed securities for which no sales prices were reported on that day are valued at closing bid prices. The value of publicly traded securities is based upon quoted market prices and net asset values. Other securities, for which no such quotations or valuations are readily available, are carried at estimated fair value as provided by external investment managers. The Institution believes that these valuations are a reasonable estimate of fair value as of December 31, 2004 and 2003 but are subject to uncertainty and, therefore, may differ from the value that would have been used had a ready market



for the investments existed and such differences could be material.

Purchases and sales of investment securities are recorded on a trade date basis. Realized gains and losses are computed on a specific identification method. Investment income, net of investment expenses, is distributed on the unit method.

#### **Investment Income Unitization**

The Institution's investments are pooled in an endowment fund and the investments and allocation of income are tracked on a unitized basis. The Institution distributes to operations for each individual fund an amount of investment income earned by each of the fund's proportionate share of investments based on a total return policy.

The Board of Trustees has appropriated all of the income and a specified percentage of the net appreciation (depreciation) to operations as prudent considering the Institution's long and short-term needs, present and anticipated financial requirements, expected total return on its investments, price level trends, and general economic conditions. Under the Institution's current endowment spending policy, which is within the guidelines specified under state law, between 4 percent and 5.5 percent of the average of the market value of qualifying endowment investments at September 30 of each of the previous three years is appropriated. This amounted to \$13,316,806 and \$13,509,442 for the years ending December 31, 2004 and 2003, respectively, and is classified in operating revenues (research, education, and operations).

#### **Deposits with Trustees**

Deposits with trustees consists principally of investments in United States Government obligations and have been deposited with trustees as required under certain loan agreements. At December 31, 2004, the amounts consist of \$3,154,350 for debt service and \$24,278,081 for construction purposes. Interest income on debt service amounted to \$20,766 in 2004 and is reflected in the statement of activities within other income. Interest income on construction funds amounted of \$310,933 in 2004 and is reflected in the statement of activities within other income.

#### **Inventories**

Inventories are stated at the lower of cost or market. Cost is determined using the first-in, first-out method.

#### **Contracts and Grants**

Revenues earned on contracts and grants for research are recognized as related costs are incurred.

The Institution received approximately 92% and 90% of its operating revenues from government agencies including 57% and 50% of its operating revenues from the National Science Foundation and 14% and 21% from the United States Navy in fiscal years 2004 and 2003, respectively. Although applications for research funding to federal agencies historically have been funded, authorizations are subject to annual Congressional appropriations and payment.

#### **Deferred Financing Costs**

Costs incurred in connection with the placement of the Massachusetts Health and Educational Facilities Authority, Variable Rate Revenue Bonds, Woods Hole Oceanographic Institution Issue, Series 2004, have been deferred and are being amortized over the term of the obligation on a straight line basis.

#### **Interest Rate Swap**

The Institution has entered into an interest rate swap agreement on the Massachusetts Health and Educational Facilities Authority, Variable Rate Revenue Bonds, Woods Hole Oceanographic Institution Issue, Series 2004 Bonds in order to convert a portion of the variable rate debt to fixed rate, thereby economically hedging against changes in the cash flow requirements of the Institution's variable rate debt obligations.

Net payments or receipts (difference between variable and fixed rate) under the swap agreement along with the change in fair value of the swap are recorded in nonoperating activities as net realized/unrealized gains (losses) on interest swap.

#### **Property, Plant and Equipment**

Property, plant and equipment are stated at cost. Depreciation is provided on a straight-line basis at annual rates of 12 to 39 years on buildings and improvements, 10 to 15 years on vessels and dock facilities and 5 to 10 years on laboratory and other equipment. Depreciation expense on property, plant, and equipment purchased by the Institution in the amounts of \$5,058,656 and \$4,485,780 in 2004 and 2003, respectively, has been charged to operating activities. Construction commitments totaled \$24,339,591 at December 31, 2004.

Depreciation on certain government-funded facilities (the Laboratory for Marine Science and the dock facility) amounting to \$99,976 in 2004 and \$99,972 in 2003 has been charged to nonoperating expenses as these assets were gifted by the Government.

During fiscal 2004, the Institution capitalized interest of \$65,500.

Included in construction in process is \$18,799,066 and \$4,829,373 at December 31, 2004 and 2003, respectively, relating to campus development.

**Use of Estimates**

The preparation of the financial statements in accordance with accounting principles generally accepted in the United States of America requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and the disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues and expenses during the period. Actual results could differ from those estimates.

**3. Investments**

The cost and market value of pooled investments held at December 31 are as follows:

	2004		2003	
	Cost	Market	Cost	Market
US treasury bonds	\$ 27,200,000	\$ 27,254,862	\$ -	\$ -
Corporate bonds	17,411,829	17,620,896	52,788,223	53,788,201
International bonds	9,613,758	10,219,035	6,993,216	7,124,933
Equity securities and mutual funds	119,723,809	145,732,044	88,645,967	110,400,060
International equities	50,282,579	63,791,628	43,002,089	50,950,411
Hedge fund limited partnerships	442,829	1,179,948	2,741,760	3,116,672
Venture capital and private equity	27,584,494	21,432,003	24,147,061	17,261,882
Other	46,693	46,693	78,423	78,423
Total investments	<u>\$252,305,991</u>	<u>\$287,277,109</u>	<u>\$218,396,739</u>	<u>\$242,720,582</u>

Amounts held in venture capital and investment partnerships and other investments are invested in securities or other assets for which there is not necessarily a publicly traded market value or which are restricted as to disposition. The return on such investments was \$732,688 and (\$128,840) for the years ended December 31, 2004 and 2003, respectively, including dividends, distributions and changes in the estimated value of such investments.

During 2003, the Institution terminated certain investment managers. Several of these managers were terminated on December 31, 2003 resulting in a receivable for investments sold of \$22,044,791.

The following schedule summarizes the investment return on pooled and nonpooled investments and its classification in the statement of activities:

	Unrestricted	Temporarily restricted	2004 Total	2003 Total
Dividend and interest income	\$4,911,394	\$ 1,902,554	\$ 6,813,948	\$ 4,554,734
Investment management costs	(1,275,801)		(1,275,801)	(1,282,538)
Net realized gains	4,043,938	13,098,183	17,142,121	354,669
Change in unrealized appreciation	4,764,477	5,782,300	10,546,777	41,377,257
Total return on investments	<u>12,444,008</u>	<u>20,783,037</u>	<u>33,227,045</u>	<u>45,004,122</u>
Investment return designated for				
Sponsored research		(4,725,103)	(4,725,103)	(4,696,180)
Education	(3,683,100)	(1,902,554)	(5,585,654)	(5,671,555)
Current operations	(3,381,128)		(3,381,128)	(3,453,967)
Total distributions to operations	<u>(7,064,228)</u>	<u>(6,627,657)</u>	<u>(13,691,885)</u>	<u>(13,821,702)</u>
Investment return in excess of amounts designated for sponsored research, education and current operations	<u>\$5,379,780</u>	<u>\$14,155,380</u>	<u>\$19,535,160</u>	<u>\$31,182,420</u>

Investment return distributed to operations includes \$375,079 and \$312,260 earned on non-endowment investments for the years ended December 31, 2004 and 2003, respectively.

As a result of market declines, the fair value of certain donor restricted endowments is less than the historical cost value of such funds by \$434,022 at December 31, 2004 and \$1,014,212 at December 31, 2003. These unrealized losses have been recorded as reductions in unrestricted net assets. Future market gains will be used to restore this deficiency in unrestricted net assets before any net appreciation above the historical cost value of such fund increases temporarily restricted net assets.

Investment securities are exposed to various risks such as interest rate, market and credit risks. Due to the level of risk associated with certain investments, it is at least reasonably possible that changes in the value of investment securities will occur in the near term and that such changes could materially affect the market values and the amounts reported in the statement of financial position.

Endowment income is allocated to each individual fund based on a per unit valuation. The value of an investment unit at December 31 is as follows:

	2004	2003
Unit value, beginning of year	\$ 3.9177	\$ 3.4719
Unit value, end of year	4.1517	3.9177
Net change for the year	.2340	.4458
Investment income per unit for the year	.0361	.0419
Total return per unit	<u>\$ .2701</u>	<u>\$ .4877</u>

**4. Pledges Receivable**

Pledges that are expected to be collected within one year are recorded at their net realizable value. Pledges that are expected to be collected in future years are recorded at the present value



of estimated future cash flows. The present value of estimated future cash flows has been measured utilizing a discount rate equivalent to U.S. Treasury yields of similar maturity (ranging from 2.36– 3.63, depending upon the anticipated pledge fulfillment date).

Pledges receivable consist of the following at December 31:

	2004	2003
Unconditional promises expected to be collected in:		
Less than one year	\$2,372,251	\$1,688,779
One year to five years	5,087,435	3,428,933
Reserve for uncollectible pledges receivable	(298,387)	(204,708)
Unamortized discount	<u>(282,109)</u>	<u>(66,308)</u>
	<u>\$6,879,190</u>	<u>\$4,846,696</u>

### 5. Contribution Receivable from Remainder Trusts

The Institution recorded \$10,043,233 and \$10,532,306 at December 31, 2004 and 2003, respectively, relating to various charitable remainder trusts in its statement of financial position. The receivable and related revenue is measured at the present value of estimated future cash flows to be received and recorded in the appropriate net asset category based on donor stipulation. During the term of these agreements, changes in the value are recognized based on amortization of discounts and changes in actuarial assumptions.

### 6. Deferred Fixed Rate Variance

The Institution receives funding or reimbursement from federal government agencies for sponsored research under government grants and contracts. Revenue is recognized as related costs are incurred. The Institution has negotiated fixed rates with the federal government for the recovery of certain fringe benefits and indirect costs on these grants and contracts. Such recoveries are subject to carryforward provisions that provide for adjustments to be included in the negotiation of future fixed rates. The deferred fixed rate variance accounts represent the cumulative amount owed to or due from the federal government. The Institution's rates are negotiated with the Office of Naval Research (ONR), the Institution's cognizant agency.

The composition of the deferred fixed rate variance is as follows:

Deferred Fixed Rate Variance asset, December 31, 2002	\$ 426,870
2003 indirect costs	50,441,014
2002 adjustment	(7,930)
Amounts recovered	<u>(47,662,261)</u>
2003 change in receivable	<u>2,770,823</u>
Deferred Fixed Rate Variance asset, December 31, 2003	<u>3,197,693</u>
2004 indirect costs	51,834,850
2003 adjustment	1,081
Amounts recovered	<u>(55,163,124)</u>
2004 change in receivable	<u>(3,327,193)</u>
Deferred Fixed Rate Variance liability, December 31, 2004	<u>\$ (129,500)</u>

As of December 31, 2004, the Institution has received a cumulative recovery in excess of expended amounts of \$129,500 which will be reflected as a deduction to future year recoveries. This amount has been reported as liability of the Institution.

### 7. Bond and Loans Payable

In fiscal 2004, proceeds were received from the offering of the \$54,850,000 Massachusetts Health and Educational Facilities Authority (MHEFA) Variable Rate Revenue Bonds, Woods Hole Oceanographic Institution Issue, Series 2004, which were used to repay the MHEFA B Pool loans and are being used for campus construction. The bonds contain certain restrictive covenants including limitations on obtaining additional debt, filings of annual financial statements and limitations on the creation of liens. In addition, the Institution agrees that, subject to any governmental restrictions, its fiduciary obligations and limitations imposed by law, it will maintain unrestricted resources at a market value equal to at least 75% of all outstanding indebtedness. The bonds also require a debt service fund to be established. Included in deposits with trustees on the statement of financial position is the market value of the debt service fund of \$3,154,350 at December 31, 2004. The Series 2004 Bonds are collateralized by the Institution's unrestricted revenues and bond insurance. The interest rate for the Series 2004 Bonds is variable and set weekly, and at December 31, 2004, the rate was 2.28%.

The aggregate maturities due on long-term debt at December 31, 2004 are as follows:

Fiscal Year	Principal Amount
2008	\$ 1,150,000
2009	1,200,000
Thereafter	<u>52,500,000</u>
	<u>\$54,850,000</u>

In June 2004, the Institution entered into an interest rate swap agreement, with a term through June 1, 2034. This swap effectively locks in a fixed rate of 3.79% per annum. The agreement has a notional amount of \$54,850,000. At December 31, 2004, the market value of the swap agreement amounted to a liability of \$3,298,000. The value of the interest rate swap is reflected within accounts payable and other liabilities and nonoperating income/expense in the financial statements. Additionally, the Institution incurred additional interest expense in association with the swap agreement of \$722,690 which is reflected as part of the net realized/unrealized gains (losses) on interest swap. For internal financial reporting purposes, the realized/unrealized loss on the interest rate swap is reflected in operating expenses, and interest income and interest expense related to the debt is reflected in operating income and operating expenses, respectively.

The following loans were outstanding in the prior year. These loans were repaid in 2004.

On May 27, 1999, the Institution entered into a \$3,000,000 loan agreement with the Massachusetts Health and Educational Facilities Authority (the "Authority") to finance various

capital projects. On January 31, 2000, the agreement was amended to increase the maximum loan commitment to \$6,000,000. As of December 31, 2003, \$5,485,951 had been drawn down on the loan and was outstanding at year-end. The Institution was required to pay interest on the drawdowns at a variable rate established by the Authority, which was 1% at December 31, 2003.

On March 1, 2001, the Institution entered into an \$11,000,000 loan agreement with the Authority to finance additional capital projects. As of December 31, 2003, \$5,238,255 had been drawn down on the loan and was outstanding at year-end. Drawdowns were expected to occur during an eighteen-month period. During this period, no principal payments were due on the loan, but the Institution was required to pay interest on the drawdowns at a variable rate established by the Authority, which was 1% at December 31, 2003.

The Institution's variable rate debt approximates fair value. Fair value is based on estimates using current interest rates available for debt with equivalent maturities.

### 8. Retirement Plans

The Institution maintains a noncontributory defined benefit pension plan covering substantially all employees of the Institution, a restoration plan for certain senior employees and a supplemental benefit plan for certain other employees. Pension benefits are earned based on years of service and compensation received. The Institution's policy is to fund at least the minimum required by the Employee Retirement Income Security Act of 1974.

The Institution uses a December 31 measurement date for all of its plans.

	<b>Restoration Plan Pension Benefits</b>	
	<b>2004</b>	<b>2003</b>
Change in benefit obligation		
Benefit obligation at beginning of year	\$ 1,200,690	\$ 790,023
Service cost	25,699	21,155
Interest cost	86,005	77,640
Plan amendments	(190,939)	-
Benefits paid	-	-
Actuarial loss	197,601	311,872
Benefit obligation at end of year	<u>\$ 1,319,056</u>	<u>\$ 1,200,690</u>
Change in plan assets		
Fair value of plan assets at beginning of year	\$ -	\$ -
Employer contributions	-	-
Benefits paid	-	-
Fair value of plan assets at end of year	<u>\$ -</u>	<u>\$ -</u>
Funded status	\$(1,319,056)	\$(1,200,690)
Unrecognized net actuarial loss	355,726	294,893
Unrecognized prior service cost	(28,941)	249,648
Net amount recognized	<u>(992,271)</u>	<u>\$ (656,149)</u>
Amounts recognized in the statement of financial position consist of		
Accrued benefit liability	\$(1,090,718)	\$ (770,184)
Intangible asset	-	114,035
Cumulative reduction in net assets	98,447	-
Net amount recognized	<u>\$ (992,271)</u>	<u>\$ (656,149)</u>
Cumulative reduction in net assets attributable to change in additional minimum liability recognition	\$ 98,447	\$ -
Information for pension plans with accumulated benefit obligations in excess of plan assets		
Projected benefit obligation	\$ 1,319,056	\$ 1,200,690
Accumulated benefit obligation	1,090,718	770,184
Fair value of plan assets	\$ -	-



	Restoration Plan Pension Benefits	
	2004	2003
Components of net periodic benefit cost		
Service cost	\$ 25,699	\$ 21,155
Interest cost	86,005	77,640
Amortization of prior service cost	87,650	87,650
Recognized actuarial loss	136,768	157,440
Net periodic benefit cost	<u>\$336,122</u>	<u>\$343,885</u>
Weighted-average assumptions used to determine benefit obligations at December 31		
Discount rate	5.75%	6.25%
Rate of compensation increase	6.00%	6.00%
Weighted-average assumptions used to determine net periodic benefit cost for years ended December 31		
Discount rate	6.25%	6.75%
Rate of compensation increase	6.00%	6.00%

### Expected Contributions

The Institution does not anticipate contributing to the Restoration Plan in 2005.

### Estimated Future Benefit Payments

The following benefit payments, which reflect expected future service are expected to be paid as follows:

Years	Benefit Payments
2005	\$ -
2006	93,887
2007	1,427,185
2008 and thereafter	-

	Qualified Plan Pension Benefits	
	2004	2003
Change in benefit obligation		
Benefit obligation at beginning of year	\$ 176,914,377	\$ 169,123,168
Service cost	7,006,323	6,118,111
Interest cost	11,250,529	11,068,835
Plan amendments	(27,041,213)	-
Actuarial loss	18,666,776	4,019,659
Benefits paid	<u>(8,869,550)</u>	<u>(13,415,396)</u>
Benefit obligation at end of year	<u>\$ 177,927,242</u>	<u>\$ 176,914,377</u>
Change in plan assets		
Fair value of plan assets at beginning of year	\$ 143,751,387	\$ 133,980,735
Employer contributions	-	-
Actual return on plan assets	15,734,494	23,186,048
Benefits paid	<u>(8,869,550)</u>	<u>(13,415,396)</u>
Fair value of plan assets at end of year	<u>\$ 150,616,331</u>	<u>\$ 143,751,387</u>
Funded status	<u>\$(27,310,911)</u>	<u>\$(33,162,990)</u>
Unrecognized net actuarial loss	36,107,982	22,579,627
Unrecognized prior service cost	<u>(18,447,001)</u>	<u>9,937,478</u>
Net amount recognized	<u>\$ (9,649,930)</u>	<u>\$ (645,885)</u>
Amounts recognized in the statement of financial position consist of		
Accrued benefit liability	\$(23,606,689)	\$ (6,176,090)
Cumulative reduction in net assets	13,956,759	-
Intangible asset	-	5,530,205
Net amount recognized	<u>\$ (9,649,930)</u>	<u>\$ (645,885)</u>
Cumulative (addition) reduction in net assets attributable to change in additional minimum liability recognition	\$ 13,956,759	\$ (5,975,263)
Information for pension plans with accumulated benefit obligations in excess of plan assets		
Projected benefit obligation	177,927,242	176,914,377
Accumulated benefit obligation	174,223,020	149,927,477
Fair value of plan assets	150,616,331	143,751,387
Components of net periodic benefit cost		
Service cost	7,006,323	6,118,111
Interest cost	11,250,529	11,068,835
Expected return on plan assets	(11,708,592)	(12,710,913)
Amortization of prior service cost	1,343,266	1,343,266
Recognized actuarial loss	1,112,519	-
Net periodic benefit cost	<u>\$ 9,004,045</u>	<u>\$ 5,819,299</u>

The Institution has reflected the net periodic benefit cost in nonoperating income. In 2004, the Institution was required to record an additional charge of \$13,956,759 to reflect a minimum balance sheet liability equal to the Plan's unfunded accumulated benefit obligation. In 2003, the additional minimum liability that was established in 2002 was reversed as the minimum balance sheet liability was no longer necessary.

	Qualified Plan Pension Benefits	
	2004	2003
Weighted-average assumptions used to determine benefit obligations at December 31		
Discount rate	5.75%	6.25%
Rate of compensation increase	3.50%	3.50%
Weighted-average assumptions used to determine net periodic benefit cost for years ended December 31		
Discount rate	6.25%	6.75%
Expected long-term rate of return on plan assets	8.50%	8.50%
Rate of compensation increase	3.50%	3.50%

To develop the expected long-term rate of return on assets assumption, the Institution considered the current level of expected returns on risk-free investments (primarily government bonds), the historical level of the risk premium associated with the other asset classes in which the portfolio is invested and the expectations for future returns of each asset class. The expected return for each asset class was then weighted based on the target asset allocation to develop the expected long-term rate of return on assets assumption for the portfolio, net of expenses expected to be paid. This resulted in the selection of the 8.50% assumption.

Effective December 31, 2004, final average compensation for the Plan was frozen and equal to a participant's final average compensation determined as of December 31, 2004. A one-year index of 4.5% will be applied to the frozen December 31, 2004 final average compensation for service performed during 2005. In addition, effective December 31, 2004, the minimum lump-sum benefit was amended to eliminate the 8% pay credit for years after 2005. These changes have been reflected in the liabilities as of December 31, 2004.

**Plan Assets**

The Institution's pension plan weighted-average asset allocations at December 31, 2004 and 2003, by asset category are as follows:

Asset Category	2004	2003
Equity securities	80%	67%
Debt securities	18%	25%
Cash	2%	8%
	<u>100%</u>	<u>100%</u>

The following target asset allocation is used:

Asset Category	Target Allocation
U.S. equity	30%
Global excluding U.S. equity	12%
Emerging markets equity	3%
Hedge fund of funds	15%
Alternative investments	15%
Real assets	5%
Bonds	20%

The primary financial objectives of the assets of the Plan are to (1) provide a stream of relatively predictable, stable and constant earnings in support of the Qualified Plan's annual benefit payment obligations; and (2) preserve and enhance the real (inflation-adjusted) value of assets, over time, with the goal of meeting the anticipated future benefit obligations of the qualified plan.

The long-term investment objectives of the assets of the Plan are to (1) attain the average annual total return assumed in the Plan's most recent actuarial assumptions (net of investment management fees) over rolling five-year periods; and (2) outperform the custom benchmark.

**Contributions**

The Institution anticipates contributing \$1,900,000 to the Qualified Plan in 2005.

**Estimated Future Benefit Payments**

The following benefit payments, which reflect expected future service are expected to be paid as follows:

Years	Benefit Payments
2005	\$12,282,106
2006	14,891,932
2007	14,810,058
2008	14,622,043
2009	15,776,625
Years 2010 - 2014	79,904,781



	<b>Supplemental Plan Pension Benefits</b>	
	<b>2004</b>	<b>2003</b>
Change in benefit obligation		
Benefit obligation at beginning of year	\$3,430,977	\$3,282,549
Service cost	89,087	78,650
Interest cost	227,880	209,638
Actuarial loss	393,799	53,532
Benefits paid	(219,460)	(193,392)
Benefit obligation at end of year	<u>\$ 3,922,283</u>	<u>\$ 3,430,977</u>
Change in plan assets		
Fair value of plan assets at beginning of year	\$ -	\$ -
Employer contributions	219,460	193,392
Benefits paid	(219,460)	(193,392)
Fair value of plan assets at end of year	<u>\$ -</u>	<u>\$ -</u>
Funded status	\$(3,922,283)	\$(3,430,977)
Unrecognized actuarial loss (gain)	331,548	(115,013)
Unrecognized prior service cost	1,316	1,631
Net amount recognized	<u>\$(3,589,419)</u>	<u>\$(3,544,359)</u>
Amounts recognized in the statement of financial position consist of		
Accrued benefit liability	<u>\$(3,589,419)</u>	<u>\$(3,544,359)</u>
Information for pension plans with accumulated benefit obligations in excess of plan assets		
Projected benefit obligation	\$ 3,922,283	\$ 3,430,977
Accumulated benefit obligation	3,402,514	2,854,088
Fair value of plan assets	-	-
Components of net periodic benefit cost		
Service cost	\$ 89,087	\$ 78,650
Interest cost	227,880	209,638
Expected return on earmarked reserves	(213,372)	(215,441)
Amortization of prior year service cost	315	315
Net periodic benefit cost	<u>\$ 103,910</u>	<u>\$ 73,162</u>
Actual return on earmarked reserves	\$ 160,610	\$ 124,929
Weighted-average assumptions used to determine benefit obligations at December 31		
Discount rate	5.75%	6.25%
Rate of compensation increase	3.50%	3.50%
Weighted-average assumptions used to determine net periodic benefit cost for years ended December 31		
Discount rate	6.25%	6.75%
Expected long-term rate of return on plan assets	8.50%	8.50%
Rate of compensation increase	3.50%	3.50%

The accrued supplemental retirement is matched by a "Rabbi" Trust with \$6,537,921 and \$6,257,039, respectively, as of December 31, 2004 and 2003. An additional accrual of \$2,948,502 and \$2,712,680 has been established for the excess of the "Rabbi" Trust assets over the accrued supplemental retirement benefits at December 31, 2004 and 2003, respectively.

### Contributions

The Institution anticipates paying benefit payments to the Supplemental Plan of \$299,004 from earmarked reserves in 2005.

### Estimated Future Benefit Payments

The following benefit payments, which reflect expected future service are expected to be paid as follows:

Years	Benefit Payments
2005	\$299,004
2006	275,996
2007	268,327
2008	256,312
2009	229,250
Years 2010 - 2014	1,097,300

**9. Other Postretirement Benefits**

In addition to providing retirement plan benefits, the Institution provides certain health care benefits for retired employees and their spouses. Substantially all of the Institution's employees may become eligible for the benefits if they reach normal retirement age (as defined) or elect early retirement after having met certain time in service criteria.

	Other Postretirement Benefits	
	2004	2003
Change in benefit obligation		
Benefit obligation at beginning of year	\$ 33,153,875	\$ 30,459,830
Service cost	1,055,495	669,237
Interest cost	2,216,096	1,746,394
Plan amendment	(18,015,085)	-
Benefits paid	(1,278,178)	(1,128,721)
Actuarial loss	9,462,299	1,407,135
Benefit obligation at end of year	<u>\$ 26,594,502</u>	<u>\$ 33,153,875</u>
Change in plan assets		
Fair value of plan assets at beginning of year	\$ 16,213,670	\$ 12,619,281
Actual return on plan assets	1,397,393	2,753,110
Employer contributions	2,823,000	2,063,679
Benefits paid	(1,278,178)	(1,128,721)
Administrative expenses	(113,484)	(93,679)
Fair value of plan assets at end of year	<u>\$ 19,042,401</u>	<u>\$ 16,213,670</u>
Funded status	\$(7,552,101)	\$(16,940,205)
Unrecognized actuarial loss	20,957,816	12,153,392
Unrecognized portion of net obligation (asset) at transition	-	7,681,947
Unrecognized prior service cost (credit)	(12,766,418)	(2,106,308)
Net amount recognized	<u>\$ 639,297</u>	<u>\$ 788,826</u>
Amounts recognized in the statement of financial position consist of		
Prepaid benefit cost	<u>\$ 639,297</u>	<u>\$ 788,826</u>
Weighted-average assumptions used to determine benefit obligations at December 31		
Discount rate	5.75%	6.25%
Weighted-average assumptions used to determine net periodic benefit cost for years ended December 31		
Discount rate	6.25%	6.75%
Expected long-term rate of return on plan assets	8.50%	8.50%

For measurement purposes, annual rates of increase of 11.5% and 9% in the per capita cost of covered healthcare benefits was assumed for 2004 and 2003 for both pre-65 and post-65 benefits.

These were assumed to decrease gradually to 5.0% in 2013 and remain at that level thereafter.

	2004	2003
Components of net periodic benefit cost		
Service cost	\$ 1,055,495	\$ 669,237
Interest cost	2,216,096	1,746,394
Expected return on plan assets	(1,456,524)	(1,112,924)
Amortization of transition obligation	853,549	853,549
Amortization of prior service cost	(526,577)	(526,577)
Recognized actuarial loss	830,490	434,000
Net periodic benefit cost	<u>\$ 2,972,529</u>	<u>\$ 2,063,679</u>

The Institution has reflected the net periodic benefit cost in operating expenses, as the amount is reimbursed through federal awards.

On December 8, 2003, Medicare reform legislation was enacted, providing a Medicare prescription drug benefit beginning in 2006 and federal subsidies to employers who provide drug coverage to retirees. The Institution decided not to reflect the future government subsidy in the fiscal 2004 expense. However, in December 2004, the Institution amended the plan to eliminate prescription drug coverage for all post-65 retirees effective January 1, 2006, and to encourage enrollment in Medicare Part D by reimbursing Medicare Part D premiums beginning in 2006. These changes have been reflected in the obligations as of December 31, 2004.

	2004		2003
	Pre-65	Post-65	Pre-65 & Post-65
Assumed health care cost trend rates at December 31			
Health care cost trend rate assumed for next year	11.0%	11.0%	11.5%
Rate to which the cost trend rate is assumed to decline (the ultimate trend rate)	5.0%	4.3%	5.0%
Year that the rate reaches the ultimate trend rate	2014	2013	2013

Assumed health care cost trend rates have a significant effect on the amounts reported for the health care plan. A one-percentage-point change in assumed health care cost trend rates would have the following effects:

	2004	2003
	One-Percentage-Point Increase in Trend	One-Percentage-Point Increase in Trend
Effect on total of service cost and interest cost components	\$ 803,127	\$ 578,023
Effect on year-end postretirement benefit obligation	3,682,332	5,633,557
	One-Percentage-Point Decrease in Trend	One-Percentage-Point Decrease in Trend
Effect on total of service cost and interest cost components	\$ (410,643)	\$ (446,376)
Effect on year-end postretirement benefit obligation	(3,002,534)	(4,483,697)



## Plan Assets

The Institution's postretirement benefit plan weighted-average asset allocations at December 31, 2004 and 2003, by asset category are as follows:

Asset Category	2004	2003
Equity securities	82%	81%
Debt securities	18%	19%
	<u>100%</u>	<u>100%</u>

The asset allocation follows the broad allocation of 80% equities and 20% fixed income.

To develop the expected long-term rate of return on assets assumption, the Institution considered the current level of expected returns on risk free investments (primarily government bonds), the historical level of the risk premium associated with the other asset classes in which the portfolio is invested and the expectations for future returns of each asset class. The expected return for each class was then weighted based on the target asset allocation to develop the expected long-term rate of return on assets assumption for the portfolio, net of expenses expected to be paid. This resulted in the selection of the 8.50% assumption.

## Contributions

The Institution anticipates contributing \$893,000 to its retiree medical plan in 2005.

## Estimated Future Benefit Payments

The following benefit payments, which reflect expected future service are expected to be paid as follows:

Years	Benefit Payments
2005	\$1,515,281
2006	1,243,486
2007	1,260,392
2008	1,270,574
2009	1,267,858
Years 2010 - 2014	6,058,206

## 10. Commitments and Contingencies

The Defense Contract Audit Agency (DCAA) is responsible for auditing both direct and indirect charges to grants and contracts on behalf of the ONR. The Institution and the ONR have settled the years through 2003. The current indirect cost recovery rates, which are fixed, include the impact of prior year settlements. The DCAA issued an audit report on the completed audit of direct and indirect costs for the year ended December 31, 2003 on September 21, 2004. The audit resulted in no questioned direct or indirect costs.

The Institution through its endowment fund is committed to invest approximately \$24,000,000 in certain venture capital and investment partnerships as of December 31, 2004.

The Institution is a defendant in legal proceedings incidental to the nature of its operations. The Institution believes that the outcome of these proceedings will not materially affect its financial position.

## 11. Related Party Transactions

In fiscal year 2004, the Institution passed through Federal Awards of approximately \$1,247,000 to subgrantee organizations in which an individual at the subgrantee organization is also a member of the Institution's Board of Trustees or Corporation. The Institution also has other transactions such as legal services and other items with organizations where members of the Board of Trustees or Corporation are affiliated with the organizations. Total expenditures for legal and other transactions were approximately \$496,000 for the year ended December 31, 2004.

The Institution has loans due from various employees for education advances and computer purchases. The amounts outstanding are approximately \$643,000 at December 31, 2004.

## 12. Clark Laboratory Fire

In October 2002, the Institution experienced a fire in the Clark Laboratory Building which resulted in contamination and damage to several laboratories, clean rooms and equipment. Since then, the Institution has coordinated with its insurance carrier and other interested parties to identify and quantify the damage caused by the fire. At December 31, 2002, the Institution had recorded a receivable due from the insurance company of approximately \$13,259,000 to reflect the estimated insurance proceeds to cover the cost of renting temporary clean laboratories, repairing the laboratories, and cleaning and repairing or replacing damaged or destroyed equipment. Additionally, the Institution established an accrual of approximately \$14,669,000 to estimate the costs to be paid going forward associated with the fire. Included in the accrual but not covered by insurance was approximately \$1,500,000 relating to displaced employees' salaries, fringe benefits and general and administrative costs as well as \$100,000 associated with renting temporary clean laboratories. The total amount not covered by insurance of \$1,600,000 was reflected in 2002 as a loss on the fire.

In 2003 and 2004, the Institution has continued to coordinate its fire loss recovery efforts with its insurance carrier and other interested parties. At December 31, 2004 and 2003, respectively, a receivable due from the insurance company of \$2,293,000 and \$7,435,000 and an accrual of \$1,889,000 and \$8,877,000 are included in the statement of financial position. During 2003, \$4,000,000 was received in cash from the insurance company and approximately \$4,150,000 was paid to various outside parties for fire-related damages. During 2004, \$1,000,000 was received in cash from the insurance company and approximately \$2,718,000 was paid to various outside parties for fire-related damages. The receivable and related accrual have been adjusted during 2004 and 2003 as more information has become available. The estimated amounts continue to be subject to revision. A gain on the fire of \$129,000 was recognized in 2004. Any additional resulting gain or loss related to accounting for the fire will be recognized when such amounts can be determined with certainty.