Photos by Doug Weisman

The Quissett Campus (top), showing the newly cut ring road, and the Woods Hole Campus and dock.

Woods Hole Oceanographic Institution (WHOI) is a private, nonprofit research and higher education organization dedicated to the study of marine science and to the education of marine scientists. It is the largest independent oceanographic research institution in the US, with staff and students numbering about 1,000.

In a culture that nurtures discovery, WHOI scientists, engineers, and students collaborate to explore the frontiers of knowledge about Earth. They develop theories, test ideas, build seagoing instruments, and collect data in diverse marine environments. The research agenda includes geological activity deep within the earth; plant, animal, and microbial populations and their interactions in the oceans; coastal erosion; ocean circulation; pollution impact; and global climate change.

The WHOI fleet includes three large research vessels (R/V *Atlantis*, R/V *Knorr*, and R/V *Oceanus*), coastal craft, remote and autonomous vehicles, and the deep-diving, human-occupied submersible *Alvin*. The 2002 WHOI operating budget of $108 million was supported by grants from federal agencies, including the National Science Foundation, the Office of Naval Research, and the National Oceanic and Atmospheric Administration, and by private contributions and endowment income.

Stanley Rowin

Bob Gagosian, left, with Jim Moltz, Chairman of the Board of Trustees.

This year we made steady progress down the path of change begun several years ago. Despite tougher competition, our investigators continue to have remarkable success in securing research funding from federal agencies. Private funds, however, account for an increasing percentage of our innovative work, and in some instances have seeded a "proof of concept" to help us secure continuing funding from federal sources. The Ocean Institutes, organized to look beyond traditional scientific boundaries and blend skills of many disciplines, completed their second year. They are already making a difference in the intellectual environment of the Institution's research and education, and informing national and international policy (see pages 30 to 31). Construction of a ring road on the Quissett Campus this year completed the first phase of our campus master plan. We now have a plan in place for building new science facilities at Quissett, and will soon be ready to implement it. We are also reviewing our Woods Hole village facilities.

In this time of rapid evolution, we took stock this year and articulated a vision:

To advance our leadership as the foremost research and higher education institution in oceanography by nurturing inventive minds in a creative environment with unmatched access to the sea, premier shore-based facilities, and unparalleled opportunities to convey the benefits of scientific discovery.

Let me offer my perspective on this vision.

To advance our leadership as the foremost research and higher education institution in oceanography…

Our leadership has many components. One is our unique ability to combine science and engineering. The two complement each other, producing a whole greater than the sum of its parts. Our leadership also comes from a willingness to risk traveling into uncharted territory, both physical and intellectual. And we lead by preparing new leaders through our academic program, encouraging students and postdocs to continue exploring and innovating.

…by nurturing inventive minds in a creative environment…

By bringing together world-class scientists and cultivating intellectual freedom, we enable them to do fulfilling, valuable work and enable the Institution to more easily attract and retain people of similar talent. In 2002, our investigators produced more than 400 scientific publications. In addition, we strive for the right balance of independence and interdependence. We collaborate closely within the oceanographic community, yet remain autonomous in how we work. Each scientist commands his or her own research program, breeding a resourceful, entrepreneurial spirit that lies at the core of our success.

…with unmatched access to the sea…

Three ocean research vessels, the submersible *Alvin*, a new coastal vessel, and a wide range of autonomous and remotely operated vehicles give us unique reach into the oceans, temporally, laterally, and vertically. We can bring scientists in person to depths of 4,500 meters (14,850 feet). Through our programmable instruments, we can sample round the clock, seven days a week, and in environments not previously accessible. This capability not only allows us to address key questions in ocean science, it enables us to frame entirely new sets of questions.

…premier shore-based facilities…

Our dock provides excellent research support capabilities for cruises around the corner or around the globe. Our campus plan will bring state-of-the-art laboratories and meeting spaces to the Oceanographic, and with Internet 2 fully implemented, high-speed network access will enhance efficiency within the organization and with scientific partners worldwide.

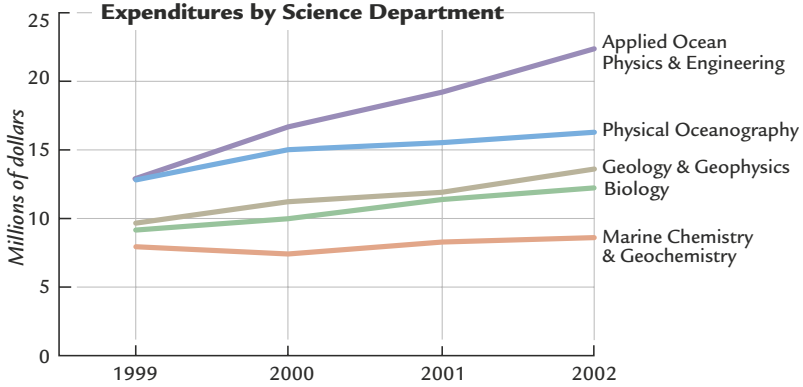
…and unparalleled opportunities to convey the benefits of scientific discovery.

The diversity, depth, and breadth of our work, our unique marriage of science and engineering, and our independence allow us to quickly grasp research opportunities of the greatest promise. Our scientists spend an increasing part of their time communicating their findings to help bring about understanding and sound bases for decision making.

Woods Hole Oceanographic Institution today is in the enviable position of intellectual leadership, financial stability, and increasing strength at a time when many research and higher learning institutions are having to retrench. In this report you will see some of the people and ideas that made WHOI an exciting place in 2002. By continuing to engage in constructive debate and inquiry, I know we can challenge the status quo at all levels in oceanography with fresh ideas.

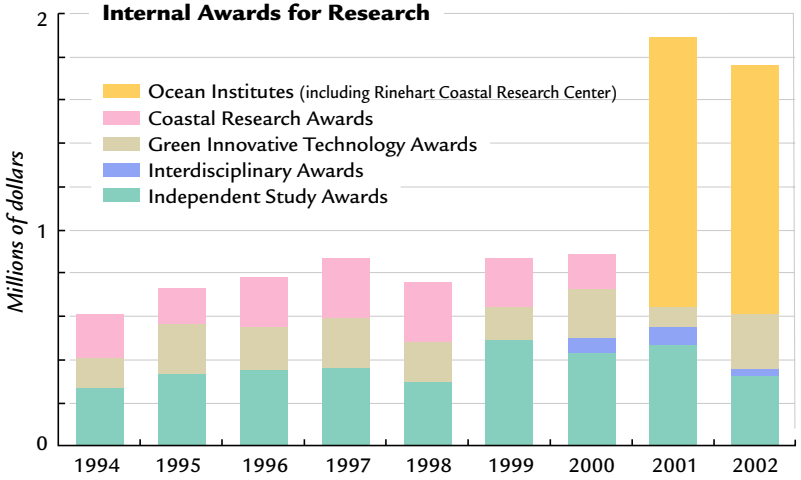
The Woods Hole Oceanographic Institution had an excellent year in 2002, both scientifically and in preparing for physical improvements to our campus.

Federally sponsored research, not including marine operations, increased 30 percent from 1999 to 2002 inclusive, and total sponsored research, which includes subcontracts and nongovernment funds, increased 41 percent, with 9 percent of that growth in 2002. This growth reflects modest increases in federal agency budgets, an increase in proposals submitted as well as funding success rate, and our overall success in fundraising. All our science departments shared in this growth over the past several years.



Success of Institutes

The four Ocean Institutes completed their second full year of activities in 2002. The Ocean Institutes were introduced to provide a focus and stimulus for interdisciplinary research and to communicate the results of our scientific research to the influential public. Each Institute developed specific research areas and themes (see pages 30 to 31). In 2002 the Institutes awarded 19 grants comprising $1.2 million in research support, bringing research support administered through internal competitions to nearly $2 million per year (graph above right). These funds underwrite higher risk science and jump-start programs to better attract federal support. In addition, the Ocean Institutes provided fellowships, postdocs and other activities, bringing their total funding to $1.89 million.



The Institutes have also developed a suite of communications tools, including Web sites, brochures, and Ocean Forums on key scientific issues related to their themes. In 2002, the Ocean and Climate Change Institute hosted the first Ocean Forum, focused on abrupt climate change and supported by the Comer Science and Education Foundation. Four visiting scientists, who are experts in different aspects of abrupt climate change, presented seminars and collaborated with WHOI scientists over the summer. In the fall they participated in two days of discussion with WHOI researchers, trustees, and corporation members to frame next steps for addressing scientific issues related to the ocean's role in abrupt climate change. The Forum resulted in a comprehensive research program and strategies to examine policy implications (www.whoi.edu/institutes/occi/activities/ocf.html). Funding from the Comer Foundation will provide key support for initiating this program.

Campus Planning

For the past two years, we have developed a master plan that articulates a coherent vision for the Quissett Campus. It includes additional and upgraded laboratory space and other improvements that enable our advancement of knowledge. The Biology and Marine Chemistry and Geochemistry depart-

ments, now overcrowded in the Redfield and Fye laboratories, have the most critical needs. The first phase of the master plan was a ring road, which connects all the buildings on the Quissett Campus and forms an interior pedestrian core. The ring road was completed in November 2002.

Phase two of the plan calls for two new laboratories, additional parking, and upgrades to the energy plant and wastewater treatment facilities. Schematics have been completed, and the design development stage is scheduled for completion in summer 2003. Provided regulatory approval and construction proceed as planned, we anticipate occupancy by the end of 2005.

Expansion of our science facilities demands that we further formalize our approach to managing our physical plant. Following a fire in October in the Clark Laboratory, we reviewed our safety procedures and are implementing a more aggressive approach to further minimize the risk of such an event. The Clark fire caused no injuries and minimal fire damage, but there was extensive smoke damage, compounded by the sensitive nature of many instruments and facilities in the laboratory. We immediately resettled the two dozen affected investigators in temporary work spaces, and began the cleanup, which includes replacement or repair of equipment. We expect recovery to be complete by summer 2003.

Challenges

Our greatest challenge in 2002 came from outside the scientific community, and has far-reaching effects on all of ocean science.

The safety of exploring the ocean by emitting sound under water—as fundamental to oceanography as radar is to aviation—has become an increasingly contentious subject. Acoustical studies in the oceans have drawn scrutiny by environmental activists, who exploit ambiguities and inconsistencies in regulations and jurisdictional coverage concerning the effect of emitting sound on marine animals. Today there appears to be no definitive scientific basis for determining the potential impact of using sound in the ocean that can survive challenges in the courts. As a result, scientists at WHOI and other research institutions have had their work delayed. Ironically, investigations that seek to understand the effect of sound on marine mammals have been postponed. The Institution is working with other research centers, environmental organizations, and funding and regulatory agencies to develop a research plan to address fundamental questions that could form a rational basis for the necessary regulation of sound in the ocean.

Another challenge for us is the evolving nature of our funding. The end of the Cold War brought a welcome relaxation of international tension, but also prompted a steady decline of oceanographic research sponsored by the Office of Naval Research. This loss of support has been most acute in two areas:

- Instrument development, which often requires up to 10 years of sustained effort and support to progress from conception to prototype to useful instrument;
- Process studies at sea, which are risky and require a concentrated effort of many investigators over several years of planning, work at sea and analysis.

Fortunately, we have secured alternative sources of support for both instrument development and process studies at sea. The Vetlesen Foundation, for example, has provided support to the Ocean and Climate Change Institute to initiate the Station W program, a long-term observatory stretching 150 kilometers (93 miles) from southeast of Cape Cod to Bermuda. Station W was developed by WHOI for monitoring changes in the thermohaline circulation, known as the Global Conveyer. This circulation is believed to be a critical element in how the ocean affects climate. Vetlesen support provided proof of concept for the Station W work, which helped us leverage further funding from the National Science Foundation. In addition, the Kerr Fund has provided critical support for the WHOI glider program, using an instrument that can provide autonomous ocean sampling over extensive areas.

It is clear that the success of our instrument development and long-term observational studies will depend on our ability to enlist private support and to leverage our work to attract continued funding from both private and government sources.

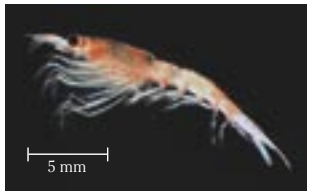
By the end of 2002, we were well positioned for the year ahead. We have strong and growing support at the federal level, solid commitment from foundations and private donors, and renewal of infrastructure that will enable our investigators to work more effectively. In concert with our oceanographic colleagues and other stakeholders, we are pursuing a constructive discussion and science plan to address the issue of ocean noise. If we can satisfactorily resolve this issue, we will help improve both the quality of life for marine animals and the quality of marine science overall.

—**James R. Luyten**, Executive Vice President and Director of Research

South for the Winter

Even in the cold darkness of the austral winter, the Global Ocean Ecosystems Dynamics (GLOBEC) Program continues to shed light on processes that support the ocean's food chain. Because one of the most thriving biological communities in the world is found in the icy waters of Antarctica, the third phase of GLOBEC is examining the Southern Ocean. Woods Hole Oceanographic Institution (WHOI) Senior Scientist Peter Wiebe led researchers from WHOI and other institutions on two Southern Ocean GLOBEC cruises during 2002, including a rare winter research cruise to the Antarctic. They traveled aboard the National Science Foundation research vessel, *Nathaniel B. Palmer* (right).

The Southern Ocean GLOBEC cruises surveyed marine life from microscopic plankton to the largest mammals. Teams biopsied whales, fit seals with satellite tracking devices, and tagged penguins. Other teams catalogued everything caught in nets or captured on high-resolution video aboard the WHOI towed vehicle, BIOMAPER II. But a primary focus of the WHOI research team was the Antarctic krill (*Euphausia superba*, right), central in the food chain that links single-celled phytoplankton to the top predators. Marguerite Bay, off the Antarctic Peninsula can contain enormous swarms of krill, covering tens of square kilometers and forming a vast banquet for whales, seals, and penguins. Although much is known about the life cycle of krill, little is known about how it survives long, frigid, winters in the ice-covered ocean. Preliminary data indicated a level of nutrients in the water column and under the sea ice similar to that found in 2001. But the team found that larval krill were less abundant than in 2001, so questions remain about relative reproductive success, competitors for food, and larval distribution. Because krill typically live under the sea ice in winter, researchers must don dive suits and use small plankton nets to collect specimens for laboratory studies (right).



Kendra Daly

Larval stage of Antarctic krill.


John Higdon

Nathaniel B. Palmer, left, and *Lawrence M. Gould* meet bow to stern in Antarctica's Marguerite Bay.

As part of the effort to understand the environment that harbors such an abundance of life, the Southern Ocean GLOBEC cruises also collected data about the conductivity, temperature, density, and fluorescence of seawater; took meteorological measurements; and sampled sea ice in all its forms. The 2002 cruises encountered far more pack ice and icebergs than in 2001, which prevented the ships from returning to Marguerite Bay in August, forcing them to work farther offshore. The early and rapid freeze-up occurred during the second-coldest May, with temperatures averaging -11.5°C (11.3°F) and the coldest June, averaging -19°C (-2.2°F), since air temperature record keeping began in 1977 at Rothera, the nearby British Antarctic research base.

GLOBEC cruises were funded by the National Science Foundation, and some data analysis was funded by the National Oceanic and Atmospheric Administration, via the WHOI Cooperative Institute for Climate and Ocean Research. ◆

globec.whoi.edu/globec.html


Stian Alesandrini

Melanie Parker and Kerri Scolardi, of the University of South Florida, collect juvenile krill under the ice.

Two manipulators on the new *Jason* can maneuver payloads of up to 150 pounds (330 kilograms).

Dan Fornari

On its first mission, the new *Jason* vehicle operated nearly 300 hours without a failure. The UK's Southampton Oceanography Centre has enlisted WHOI to build a *Jason* copy, called *Isis*.

The New *Jason*: Better, Faster, Deeper

A decade ago, WHOI Research Specialist Andy Bowen and colleagues struggled to persuade scientists that remotely operated vehicles (ROVs)—deep-sea robots tethered to a cable carrying power and data—were valuable tools for observing and sampling the seafloor, not just novelties.

Three-dozen expeditions later, oceanographers don't argue over whether to use *Jason*. They compete for research time using it. "It is rewarding to see the enthusiasm of the scientists working with this vehicle," said Bowen, project manager for the new *Jason*. The second-generation ROV was unveiled in 2002 by the WHOI Deep Submergence Laboratory and the National Deep Submergence Facility.

The new ROV uses high-bandwidth, digital communications systems and state-of-the-art robotics to allow scientists to observe and sample the seafloor without leaving the deck of a ship. The new *Jason* has two manipulator arms (above left), which can reach twice as far and lift five times as much as the single arm on the original vehicle (above, left). A more robust design allows the new *Jason* to dive to 6,500 meters (21,320 feet), compared with 6,000 meters (19,680 feet) for the original, while carrying more equipment, gathering more samples, and supplying more power to the instruments. It can do all of this moving at twice the speed of its predecessor.

In September 2002, the new *Jason* completed its first science mission, diving to the Juan de Fuca Ridge off Oregon. Researchers led by University of Washington oceanographer Paul Johnson used the ROV to deploy and retrieve several experiments to study microbes living within oceanic crust. "ROVs have a reputation of taking one or two years to be fully operational," Johnson said. "The new *Jason* worked well right out of the box. In my view it doesn't get any better than this."

How important has the new *Jason* become to the US oceanographic community? It is already booked into 2004.

Development and construction of the new *Jason* were funded by the National Science Foundation, the W. M. Keck Foundation, and WHOI. ◆

www.whoi.edu/marine/ndsf/vehicles/jason/

Learning What Whales Hear

They come in all shapes, sizes, and species—from seals and whales to squirrels and hippos, the Marine Sensory Systems Laboratory (MSSL) in the Biology Department scans them all. As the only US oceanographic research institution with a computerized tomographic (CT) 2-D/3-D scanner, WHOI is bringing advanced technology to bear on many fundamental questions in the marine environment.

The lab, headed by Senior Scientist Darlene Ketten, compares hearing and other sensory systems in terrestrial and aquatic animals, undertakes forensics studies for the National Marine Fisheries Service to try to determine why marine mammals strand, and conducts basic research in a variety of disciplines.

For Ketten and colleagues, 2002 had many highlights. Not only was she awarded tenure and promoted to Senior Scientist, but the lab installed a new water-cooled CT scanner, similar to those used at Massachusetts General Hospital, to perform studies in 20 minutes that previously took four hours. Specimens arriving at the lab from around the world often undergo both digital and physical dissection, complementary approaches that allow Ketten to first examine hearing-related structures and other organs and then to study them on a microscopic level.

Tom Kleindinst

Darlene Ketten with images of a beaked whale skull.

Tom Kleindinst

CT Technologist Julie Arruda, front, works with Postdoctoral Investigator Soraya Moein Bartol and Research Assistant Scott Cramer imaging a white sided-dolphin that was stranded. 3D reconstructions of the dolphin are visible on the two workstations.

This combination of techniques has been critical to wide-ranging studies of hearing in beaked whales, a major focus of lab activity in 2002. Little is known about this species, but early MSSL studies indicate that the shape and composition of fatty deposits in the beaked whale's jaw may be critical to what this species can hear. The scanner has also been used to better understand the physical shape and function of skulls and other body parts such as the olfactory system in sea otters and the overall shape of porpoises, the latter as part of collaborative studies with Frank Fish at West Chester University to determine how they "fly" underwater. Applying the principles of "biomimetics," engineers can map the 3-D geometry of the dolphin to help develop more efficient autonomous underwater vehicles.

Funding for MSSL in 2002 was provided by ONR, NOAA, and the Northeast Consortium. ◆

www.whoi.edu/science/B/dept/working_groups/marinemammals.htm

Seasons in the Deep Ocean

In 1977, while studying microscopic marine animals called foraminifera, WHOI geochemist Werner Deuser (below) decided to try something new. He would use a newly developed technology—a funnel-shaped sediment trap—moored at 3200 meters (10,560 feet) off Bermuda to collect the tiny animals as they sank. Within a year, Deuser realized the amount and kind of material in his sediment trap told a story no one at that time thought possible: Far from being a highly stable, unchanging environment, the deep ocean experiences seasonal changes directly connected to the seasonal patterns in the upper ocean. The study has changed oceanographers' views of ocean processes and has become the longest running time-series experiment of its kind—the Oceanic Flux Program (OFP). Studied by researchers worldwide, and funded by the National Science Foundation, OFP samples provide critical information on how the ocean's carbon cycle operates and is influenced by climate.

Vicky Cullen

Geochemist Werner Deuser in 1977, now Scientist Emeritus in Marine Chemistry and Geochemistry.

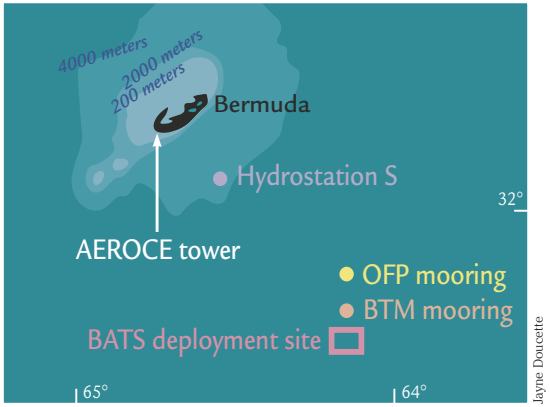
Times-series work takes tremendous dedication. Since 1994, Associate Scientist Maureen Conte, now the principal investigator of the program, has visited Bermuda every four months to recover and reset the OFP mooring (right). Conte examines the connections between upper ocean physical, chemical, and biological processes and the flux and composition of material that reaches the deep sea. She found that short-lived phenomena, such as the passage of storms and eddies, can generate large pulsed fluxes of fresh organic material and may be a major factor controlling the long-term average flux of organic materials and associated elements through the water column.

Today, Conte's analyses exploit the synergy among several ongoing research programs operating near Bermuda (right)—the Bermuda Atlantic Time-series Study (BATS), the Bermuda Testbed Mooring (BTM) Program, and atmospheric programs—to explore interrelationships among upper ocean processes and the export of material and energy to the deep ocean. ◆

www.whoi.edu/OFP/

Sean Chamberlin

Associate Scientist Maureen Conte, left, and crew deploy a sediment trap.



Jayne Doucette

Atmospheric and oceanic sampling stations near Bermuda. Deuser deployed his sediment trap near Hydrostation S, in place since the 1950s, to use its hydrographic information when analyzing samples. Today Conte uses data from several sample areas.

Genomic Studies

Tom Kleindinst

Research Associate Sibel Karchner, foreground, and Associate Scientist Mark Hahn examine bacterial colonies used to clone fish genes that play a role in determining susceptibility to toxic chemicals. Senior Research Assistant Diana Franks, right, prepares samples for DNA sequencing.

An architect's blueprints offer keen insights into how a building is constructed and how it works. Similarly, an organism's genome—the total of all the genes in its DNA—holds clues to how that organism functions in its environment, adapts to change, and evolves over time.

To unveil new layers of understanding about marine life, WHOI biologists are exploiting technological and scientific advances in the field of genomics—the systematic analysis of the structure, variation, evolution, and function of genes and the myriad of life-sustaining proteins they produce.

Associate Scientist Mark Hahn and Senior Scientist John Stegeman are leading investigations of the genetic mechanisms by which marine organisms detect, respond to, and adapt to environmental changes, especially the introduction of toxic chemicals. Such research may shed light on the ability of living things to respond or adapt to the influence of toxins, such as carcinogenic pollutants.

Senior Scientist Don Anderson and Research Associate Deana Erdner are using a recently developed genetic technique to identify the toxin-producing genes in marine microbes that produce harmful algal blooms. This will give scientists the ability to create molecular "tags" to identify contaminated shellfish more easily.

Assistant Scientist Tim Shank employs genomics to help answer questions about organisms living around hydrothermal vents. He is probing the genetic machinery that has allowed organisms to thrive in a hostile environment where there is no light, pressure is 250 times what we experience at the surface, and vent plumes contain high concentrations of metals at 660° to 750°F (350° to 400°C).

Genomics has become a component of much of the work underway in the Biology Department. About half of the department's 27 Scientific Staff members are involved at some level in genomics-based studies of marine life. As a key tool to understanding the structure and function of life, its role is expected to grow in reach and influence. ◆

River Chemistry as Geologic Clock

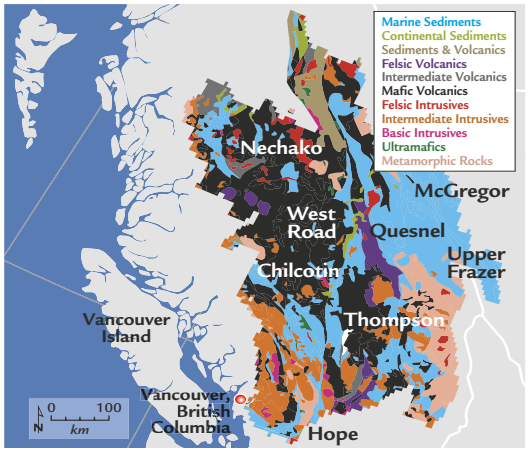
Associate Scientist Bernhard Peucker-Ehrenbrink had what he calls a simple idea: to estimate the chemistry of the world's rivers without ever leaving his lab.

A geochemist, Peucker-Ehrenbrink studies the chemical composition of oceans and rivers, a major source of dissolved elements in seawater. Knowing that river chemistry is strongly influenced by the interaction of rainwater with soils and bedrock, he reasoned that he could use data on river basin bedrock and how different bedrock weathers to estimate river chemistry. Conveniently, the data were readily available as digital bedrock plots, maps of river basins, and well-documented measurements of naturally occurring strontium isotopes in rivers. (Strontium is a kind of natural clock, with strontium-87, a stable decay product, causing $^{87}Sr/^{86}Sr$ to increase with age.)

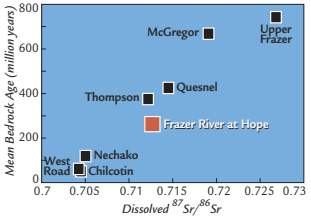
Overlaying bedrock plots with maps of river basins (which, in the case of the Mississippi River, can cover nearly a third of the continental US), Peucker-Ehrenbrink began by computing the abundance and age of bedrock in 14 large river basins. He then compared the mean age of the bedrock in different river basins with the known isotopic composition of strontium in the rivers.

He found a surprisingly clear correlation between the isotopic composition of dissolved strontium and the mean age of bedrock. As bedrock age increased, so too did $^{87}Sr/^{86}Sr$. This linear correlation held true for the Frazer River in British Columbia (right), and, in the US, for the Mississippi, Susquehanna, and the Brazos rivers.

The database is the first of its kind and opens up many possibilities for future research. Not only will it help clarify aspects of today's seawater chemistry, but Peucker-Ehrenbrink believes the analysis can also be applied to reconstructions of global bedrock distribution in the past to explain past changes in seawater chemistry. This work was funded by the National Science Foundation. ◆



Digital bedrock maps show the distribution and age of different types of rock in Canada's Frazer River Basin (above). Peucker-Ehrenbrink's first-of-its-kind analysis reveals a linear relationship between the mean age of the bedrock and the isotopic composition of the Frazer River tributaries (right). The findings illuminate the interrelationship between continental geology and ocean chemistry.

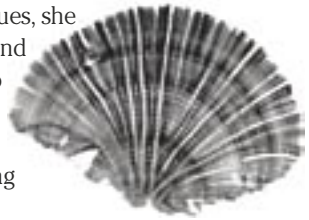


From the Seafloor to Capitol Hill

Imagine you are a historian struggling to reconstruct the history of a medieval village. Searching the basement of a remote monastery, you discover a diary that has meticulously recorded daily events over centuries. Anne Cohen, a Research Associate in the Geology and Geophysics Department, is a historian of past climate, and she found her "diary"15 meters (50 feet) below the sea surface near Bermuda—a venerable 3,300 kilogram (1,500-pound) mushroom-shaped brain coral.

X-ray images of coral slices (right) reveal annual growth bands that indicate age, much like tree rings. Chemical analyses of coral skeletons reveal the temperature and salinity of ocean waters in which the corals grew. By correlating the data, Cohen can chronicle past climate conditions and historic hurricane patterns (which create telltale spikes of rainfall and fresh water) long before ocean-monitoring instruments were invented.

Cohen X-rays coral slices during off-hours at Falmouth Hospital. But with Hanu Singh of the Applied Ocean Physics and Engineering Department, Cohen is developing techniques to get higher resolution and 3-D coral data using the Oceanographic's new CT scanner. With Boston University colleagues, she is developing ultrasound imaging equipment to analyze living coral underwater, sidestepping expensive hoisting and cutting.



X-ray of a coral section.

Cohen testified in June 2002 before a US House of Representatives subcommittee on the oceans. With a perspective on North Atlantic climate changes reaching back before the American Revolution, she reported an unusually rapid rise of more than 1°C (1.8°F) in average wintertime Atlantic Ocean temperatures since 1970. This work was funded by the National Oceanic and Atmospheric Administration and by the WHOI Ocean and Climate Change Institute. ◆

www.whoi.edu/GG/science/people/acohen

WHOI Research Associate Anne Cohen and colleagues hoist a coral from the seafloor near Bermuda to gather evidence of past climate conditions.

A Climate Canary in the Coal Mine

The Arctic has been described as an environmental "canary in a coal mine" likely to send the first warning signals of climate change. Understanding this isolated, delicately balanced ocean at the top of the world is critical to understanding climate all the way down to the tropics.

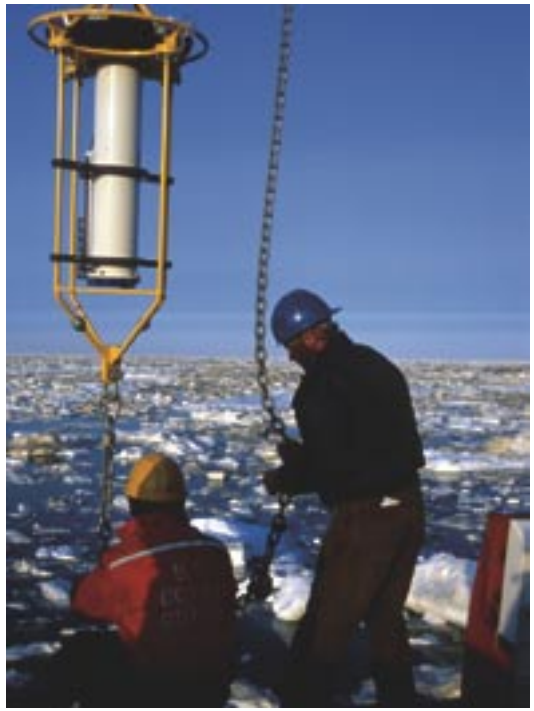
During the summer of 2002, a WHOI science team led by physical oceanographer Bob Pickart launched a three-year effort to observe one of the world's least-studied bodies of water. The team is investigating how Pacific-origin waters that move across the Chukchi and Beaufort shelves penetrate the deep interior of the Western Arctic.

Pickart and colleagues are particularly interested in the behavior of the cold "halocline," the layer of salty water 150 to 200 meters (500 to 650 feet) below the surface. The halocline acts as a barrier between ice at the surface and a reservoir of warmer water at depth. If this shield is weakened, there is enough heat stored in the deep water to melt or reduce the polar ice cover, likely altering global ocean current systems, Earth's albedo (reflecting capability), and the Arctic food web.

To characterize this important gateway, researchers deployed an array of eight moorings, a "picket fence" of profiling instruments extending 40 kilometers (25 miles) across the edge of the Beaufort Sea. A complementary array was set up in the Chukchi Sea by researchers from the universities of Washington and Alaska. The picket fence approach is new in a region where scientists have typically been limited to one or two "fence posts." With this continuous, high-resolution series of data, scientists hope to gain a better view of how the Western Arctic Ocean varies on seasonal and longer time scales, and how such changes reflect or presage climate change.

The WHOI portion of the Western Arctic Shelf-Basin Interactions program was funded by the Office of Naval Research, with additional support from Gratia Rinehart Montgomery. ◆

www.whoi.edu/arcticedge



Christopher Linder

Senior Engineering Assistant John Kemp, standing, guides an acoustic Doppler current profiler through ice in the Arctic Ocean.

Float Data Reveal Complex Circulation

Sophisticated descendants of message-in-a-bottle drifters are changing our picture of North Atlantic circulation and how it may impact global climate. Working with colleagues from the US and several other countries, WHOI researchers launched an armada of drifting instruments and used their data to directly measure deep ocean currents in the northern North Atlantic Ocean.

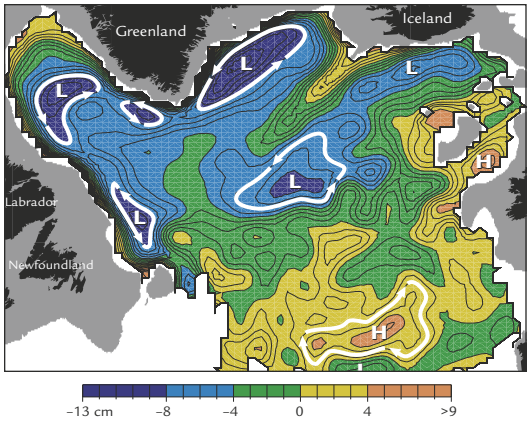
This regional circulation strongly influences global climate. Warm subtropical surface waters flow toward high latitudes where, according to simple circulation models, they cool (becoming denser), sink, and return south in deeper currents. Satellite data offer a broad picture of the surface motion, but subsurface float coverage has only recently been extensive enough to map deeper flow over large areas. The colorful figure on the front cover shows trajectories from 211 floats traveling at three depths in the northern North Atlantic between 1994 and 2002. The accompanying map of the circulation (right) deduced from these data reveals unanticipated and complex deep flow, including boundary current recirculations at 700 meters (2,300 feet), significant flow into the North Atlantic Current, and little evidence of the predicted southward-flowing deep western boundary current. Institution scientists involved in these studies include physical oceanographers Kara Lavender and Brechner Owens.

Amy Bower and Phil Richardson, also of the Physical Oceanography Department, participated in float work in the Northeast Atlantic that details how warm, saline water from the Mediterranean

Sea reaches high latitudes, where it is important in dense water formation. They also found that currents crossing over the Mid-Atlantic Ridge are nearly locked in place over deep, narrow gaps in the ridge, an effect that may have implications for the ocean's response to climate change.

US funding for this research was provided by the National Science Foundation, the Office of Naval Research, and the National Oceanic and Atmospheric Administration. ◆

www.whoi.edu/science/cicor/research/abstract_breck.html



Kara Lavender

A map of large-scale ocean circulation at 700 meters (2,300 feet) from analysis of float trajectories plotted in the cover figure. Flow is shown as pressure contours, analogous to a weather map. In such maps, flow (of water or air) is along the contours, and tightly packed contours indicate higher speeds. Float trajectories did not measure predicted clear southward flow along the western boundary, but instead revealed an unexpected series of recirculations, which appear as counterclockwise flow around low pressure (L) centers.

Exploring the Boundary of Sea and Sky

The complex processes at work where the sea meets the sky is the topic of a major Office of Naval Research-sponsored effort involving eight WHOI investigators. During the 2001 and 2002 field seasons, they collected data using moorings and floats and built the Air-Sea Interaction Tower (ASIT) at the Martha's Vineyard Coastal Observatory. The ASIT will be an important enhancement for the 2003 field season.

The program, called CBLAST for Coupled Boundary Layers and Air-Sea Transfer, is designed to improve understanding of ocean-atmosphere interactions in low to moderate winds and to improve marine weather forecasts and ocean circulation models. To accomplish these goals, researchers are measuring vertical exchange of momentum, heat, and mass at the air-sea boundary; identifying processes that drive this exchange; and creating a 3-D map of the boundary layers over a range of space and time scales.

Six moorings with surface buoys were deployed south of Martha's Vineyard in June 2002. Their objective was to capture data from both atmosphere and ocean for studies of how ocean currents, temperature, and salinity respond to momentum from the wind and energy from the sun. The mooring data will help improve atmospheric and circulation models being developed at WHOI and elsewhere.

Located 3.2 kilometers (2 miles) offshore and connected by cable to the observatory, the ASIT supports instruments that can directly measure momentum and heat exchange on both sides of the air-sea interface. This unique coastal-processes platform will contribute to investigations that include air-sea interactions, ocean mixing, biological content of the water, and sediment transport. ◆

mvcodata.whoi.edu/cgi-bin/mvco/mvco.cgi/

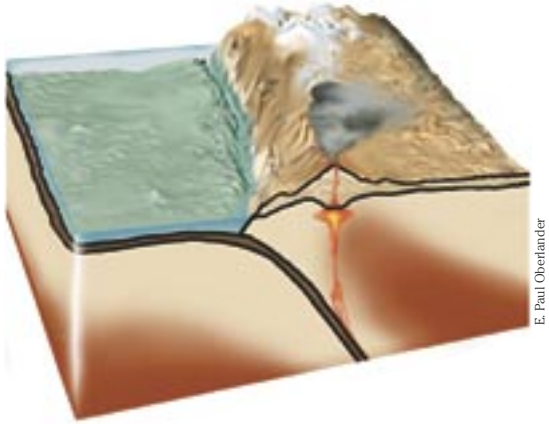
Jim Edson

Jay Sisson, left, and Mike Purcell complete connection of the Martha's Vineyard Coastal Observatory Air-Sea Interaction Tower data node (black cylinder at center) with the observatory laboratory ashore. The connection facilitates transmission of a variety of data from tower sensors both above and below the sea surface. The south shore of Martha's Vineyard is in the background.

Rethinking Subduction Zones

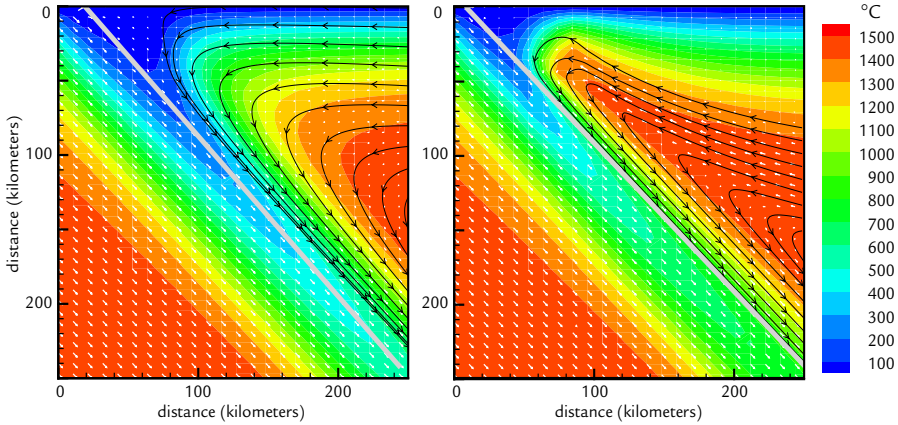
Earth's surface comprises separate, moving plates, some carrying continents and others made primarily of oceanic crust. When an oceanic plate collides with another plate, it slides beneath it in a process called subduction. Beyond this simple picture, what happens beneath the surface has been debated for 40 years.

As the subducting plate plunges into the mantle, magma is generated that can erupt at the surface of the overriding plate. The process can create volcanic "arcs": volcanic mountain chains on land, such as the Cascades, or volcanic island chains, such as the Aleutian Islands. But the thermal models that attempt to explain heat distribution, volcanism and other processes in subduction zones did not seem to fit the observed phenomena.



E. Paul Oberlander

When an ocean plate collides with another oceanic plate or with a plate carrying continents, one plate will bend and slide under the other. As the subducting plate plunges deep into the mantle, the top gets hot enough to melt. Molten rock and hot fluids rise through the rock, creating additional melt. The melt forms new crust and volcanos at the surface of the overiding plate.



Traditional thermal models, left, of subduction zones assumed a rigid plate atop a constant viscosity mantle wedge, leading to cooler temperatures at shallower levels than a model produced by WHOI Senior Scientist Peter Kelemen and colleagues. Their model does not impose a rigid plate and allows wedge viscosity to vary with temperature.

Recent evidence shows that the composition of rocks from arcs indicates that temperatures in the mantle wedge (the area beneath the arc and above the subducting plate) are much hotter at shallower depths than predicted by thermal models—for example, from 20 to 30 miles deep (30 to 45 kilometers), existing models predicted 1,100° to 1,500°F (600° to 800°C), whereas lava composition requires temperatures of 2,400°F (1,300°C) or higher at those depths

Were the geophysicists' models missing important aspects of subduction processes? Or were petrologists and volcanologists misinterpreting chemical data?

Peter Kelemen, Senior Scientist in the Geology and Geophysics Department, working with colleagues from Brown University and the University of California Santa Barbara, recently integrated petrological and geochemical data on wedge temperatures with knowledge of subduction zone dynamics to solve this problem. Traditional thermal models of subduction zones assumed a rigid top above a constant viscosity mantle wedge. In a paper in press, Kelemen and colleagues show that if this upper plate is not so rigid and the wedge's viscosity varies with temperature, the thermal models and volcanic data can easily be reconciled.

This simple modification of subduction zone models has resolved a decades-old paradox and significantly improved our understanding of arc volcanism.

Kelemen's work is funded by the National Science Foundation. ◆

science.whoi.edu/labs/mclean210/kelemen/

J. Frederic Grassle

The "Rose Garden" hydrothermal vent community in 1979: Lush with tubeworms...

Tim Shank

Tim Shank

...but by 2002, paved over with fresh lava. Scientists think a recent volcanic eruption on the seafloor erased Rose Garden, but not far away, they discovered a young vent community, dubbed "Rosebud."

Rosebud Succeeds Rose Garden

Jerusalem. Wall Street. Yankee Stadium. For every field and passion, there is a location where it all began, a profound, ongoing source of inspiration and knowledge.

For marine biologists, that spot was "Rose Garden." Two years after geologists diving in *Alvin* on the Galápagos Rift made the revolutionary discovery of life thriving on the sunless seafloor, biologists returned in 1979 to find a hydrothermal vent site lush with blood-red tubeworms peeking out of slim, 2-meter-tall (6-foot) white tubes—like the petals atop tall stems (above left). They called it Rose Garden. Scientists revisited Rose Garden in 1985, 1988, and 1990, getting intermittent snapshots that chronicled how these new-found animal communities evolved.

In May 2002, an expedition co-led by WHOI Assistant Scientist Tim Shank aboard *Atlantis* set out to explore how Rose Garden had changed over the past 12 years. By night, the WHOI Autonomous Benthic Explorer (ABE) mapped the seafloor and searched for signs of active venting. When ABE surfaced at dawn, WHOI Associate Scientist Dana Yoerger quickly turned the data ABE collected into detailed seafloor maps. Hot off the color printer, these maps were handed to pilots and scientists about to dive in *Alvin*, who used them to guide their way in the seafloor darkness.

But instead of Rose Garden, they found a field of fresh lava (above center). The disappointed scientists concluded that since the last visit in 1990, Rose Garden had been paved over by a seafloor eruption—like Pompeii after Vesuvius erupted.

But nearby, atop this new lava flow, Shank and colleagues discovered an area with tubeworms about 2.5 centimeters (1 inch) tall and very young clams and mussels (above right). They named the new site "Rosebud" and hope to return to watch how this cradle community develops.

The 2002 Galápagos Expedition was funded by the National Oceanic and Atmospheric Administration, the National Science Foundation, Woods Hole Oceanographic Institution, and the WHOI Deep Ocean Exploration Institute. ◆

www.divediscover.whoi.edu (Expedition 6)

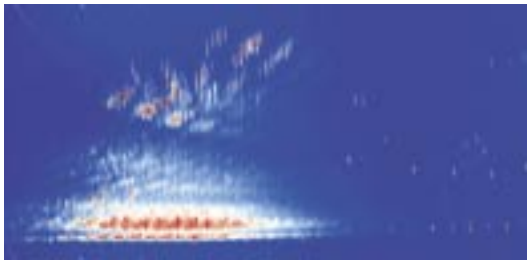
Map compiled by Dan Scheirer

Colored lines show the tracks of five *Alvin* dives searching for Rose Garden and finding Rosebud in May 2002. ABE collected data to make this high-resolution seafloor map.

Oil Spill Effects Can Persist for Decades

In September 1969, when the oil barge *Florida* went aground off West Falmouth, Massachusetts, conventional wisdom said the 650,000 liters (169,000 gallons) of diesel fuel spilled into Wild Harbor would disappear after a day or so. Conventional wisdom could not have been more wrong.

More than 30 years after the spill, WHOI Assistant Scientist Chris Reddy and colleagues have shown that, despite the recovery of the marsh in most areas, oil persists in the most heavily oiled area of Wild Harbor's marshes. Concentrations of some compounds are similar to those observed immediately after the spill and reflect the persistence of No. 2 fuel oil in coastal salt marsh sediments. Animals burrowing into these sediments can be exposed to high levels of some of these compounds, although the long-term biological effects of oil contamination at this site remain unknown. Reddy's work builds on research by WHOI scientists, begun immediately following the spill and continuing for decades, which showed effects of oil spills could not be dismissed with the disappearance of the visible slick.



Thousands of compounds that compose petroleum are evident in this gas chromatogram of sediment from the Wild Harbor salt marsh area most heavily impacted by the 1969 oil spill. Most of the oil-type compounds in this sample are still present after 33 years.

Tom Kleindinst

WHOI Scientist Emeritus George Hampson, right, and Research Associate Bob Nelson revisit the Falmouth, MA Wild Harbor salt marsh most affected by the 1969 oil spill.

Important early work by WHOI geochemist Max Blumer checked on the fate of the oil. WHOI biologists Howard Sanders and George Hampson sampled bottom-dwelling organisms, and biologist John Teal studied the oil's effects on the marsh. Others at WHOI joined the research as months of follow-up extended to years in several locations.

A revisit to Wild Harbor marsh 20 years after the spill, led by WHOI scientists John Teal, John Farrington, and John Stegeman, documented significant quantities of oil buried in marsh sediments at the most heavily oiled location. Nearby animals showed signs of exposure to petroleum chemicals.

Chris Reddy's work, published in 2002, uses a newly developed chemical technique, comprehensive two-dimensional gas chromatography. This method provides new insight into the oil's composition and could unlock secrets about why oil compounds persist for years in some locations and not in others. It is the latest addition to decades of scientific effort, which has had significant influence on oil pollution policy and management worldwide.

Chris Reddy's work was funded by the National Science Foundation. ◆

www.whoi.edu/media/westfalmouthoilspill.html

Science and engineering at WHOI continued to draw worldwide media attention in 2002. WHOI fielded 2,500 information requests from print and broadcast media in 20 countries, and handled more than 500 media interviews with WHOI investigators on topics as diverse as abrupt climate change, marine mammal survival, and the use of our technology to find leaks in the New York City water system.

Applied Ocean Physics and Engineering Department

The Applied Ocean Physics and Engineering Department (AOPE) comprises a diverse group of engineers and scientists who push the frontiers of technological innovation as they observe and model the ocean. Research projects include fundamental investigations of ocean processes, acoustics, signal processing, and vehicle dynamics. Teams of engineers and technicians develop and deploy instruments, moorings, and vehicles in support of research both at WHOI and in the larger oceanographic community.

The Department is renown for its deep-sea research vehicles, notably the 4,500-meter (14,764-foot) human-occupied submersible *Alvin*. The Deep Submergence Laboratory launched the second-generation, 6,500-meter (21,450-foot) remotely operated vehicle *Jason* in 2002 (see page 7). This vehicle's imaging capabilities set the standard for oceanographic studies, and the associated image processing is an important AOPE research area.

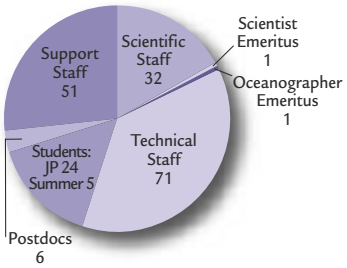
Active Projects: 220
Publications: 101
Total Funding: $21.9 million

Department staff also develop and operate several autonomous underwater vehicles, including small, agile ones for shallow-water, high-energy environments and efficient, high-endurance vehicles for abyssal exploration. Other AOPE engineering activities include development of mooring systems, advanced sampling devices, and sensing systems.

The Department's scientific projects encompass a wide range of disciplines and ocean environments. Acousticians investigate the propagation and scattering of sound in the ocean, from the microscopic to ocean-basin scale. Related research focuses on communication and signal processing. Fluid dynamicists investigate physical processes in the ocean such as turbulent mixing, surf-zone dynamics, internal waves, coastal circulation processes, and interdisciplinary studies. The fluid dynamics subgroup focuses on air-sea interaction, which is of particular relevance to the role of the oceans in climate change.

Two Assistant Scientists hired in 2002 enhance the intellectual breadth and diversity of the Department. Houshuo Jiang studied meteorology and atmospheric dynamics at Nanjing University in China and holds master's and PhD degrees in oceanography from The Johns Hopkins University. He employs numerical models to investigate the small-scale fluid dynamics associated with marine organisms. Andone Lavery studies the acoustic scattering signature of organisms and turbulent microstrucuture with the objective of developing theoretical and experimental bases for distinguishing them (photo opposite). Andone holds an undergraduate degree in mathematics from the University of Cambridge and a PhD degree in physics from Cornell University.

—**W. Rockwell Geyer**, Department Chair
www.whoi.edu/science/AOPE/dept/



Awards & Recognition

Joint Program student **Fernanda Hoefel**, advised by Steven Elgar, received an Outstanding Student Paper Award from the American Geophysical Union.

Jim Irish received the Al Vine Senior Technical Staff Award for moored instrument technology.

Jim Ledwell received the Mary Sears Endowed Visitor funding to bring two Venezuelan colleagues to Woods Hole for collaboration on a tracer experiment conducted in tropical Atlantic waters.

Britt Raubenheimer received a National Science Foundation Early Career Development Award for her work on swash zone processes.

Promotions

Larry Anderson, Research Associate III
Keenan Ball, Engineer II
Marie Basile, Research Associate I
Megan Carroll, Engineer II
Peter Koski, Engineer II
Steve Lerner, Senior Engineer
Don Peters, Senior Engineer
Ken Shorter, Engineer I
Chris Taylor, Research Engineer

Tom Kleindinst

Applied Ocean Physics and Engineering Department Assistant Scientist Andone Lavery, center, works on a tank experiment with Ray Schmitt, left, Senior Scientist in Physical Oceanography, and Joint Program Student David Stuebe. They are developing a technique for measuring acoustic scattering from the microstructure (small-scale physical characteristics) occurring at the boundaries between layers of seawater with different physical properties.

Research in the Biology Department spans the scales from microbes to whales and from molecular to global systems.

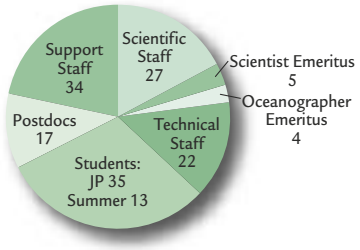
During 2002, continuing studies off the mid-Atlantic coast focused on the distribution, biomass and life cycle of gelatinous planktonic animals called salps and their role in the oceanic food chain. A May–June cruise to the Galápagos Islands celebrated the 25th anniversary of the discovery of hydrothermal vents; a new vent field dubbed Rosebud was found (see page 15), along with a novel species of sponge never before seen at the vents. Several Department members worked in the Arctic on shelf-basin exchange and climate variability as part of the Shelf Break Interaction Experiment. Others ventured to the Antarctic during the austral winter as part of Southern Ocean GLOBEC (Global Ocean Ecosystems Dynamics) to continue studies of zooplankton and their role in Antarctic ecology (see page 6). Research on toxic and harmful algal blooms ranges from large-scale field programs to molecular and cellular studies.

Development of innovative instruments and new mathematical models continues apace. A new automated submersible flow cytometer to continuously count and characterize different kinds of phytoplankton was tested at the Martha's Vineyard Coastal Observatory as part of our research to understand how the phytoplankton community is regulated and to develop methods to retrieve information about phytoplankton from bio-optical measurements. The data are available 24/7 via the Internet in real time, a first for phytoplankton studies traditionally done in the lab with a large instrument and a human operator. The new autonomous microbial sampler was successfully deployed at vent sites at 9°N on the East Pacific Rise this year using the submersible *Alvin*. The instrument collects six uncontaminated and exogenous DNA-free microbial samples for studies of diversity, community structure, and function using combined molecular and cultural methods.

Active Projects: 206
Publications: 120
Total Funding: $11.9 million

Two Assistant Scientists hired in 2002 enhance traditional Department strengths in microbiology and phytoplankton biology. After receiving a BS degree in biology from Johannes-Gutenberg University in Germany, Stefan Sievert earned an MS degree in biological oceanography in 1996 from Bremen University and the Alfred Wegener Institute for Polar and Marine Research, and a PhD degree in microbial ecology in 1999 from Bremen University and the Max Planck Institute for Marine Microbiology. He studies ecology of microbial communities at hydrothermal vents and other marine environments. Sonya Dyhrman earned an undergraduate degree in biology at Dartmouth College in 1994 and completed a PhD degree in marine biology in 1999 at the Scripps Institution of Oceanography, University of California, San Diego, prior to her appointment as a Postdoctoral Scholar at WHOI in 2000. She studies the coupling between phytoplankton and their chemical environment using molecular and biochemical approaches.

—John J. Stegeman, Department Chair
www.whoi.edu/science/B/dept



Awards & Recognition

Darlene Ketten was elected a Fellow of the Acoustical Society of America for "contributions to the understanding of auditory structures and functions of marine mammals."

Simon Thorrold received a National Science Foundation Career Young Investigator Award for his work on natal origins of marine fishes using geochemical signatures in their ear bones.

Promotions

Nicoletta Biassoni, Research Associate II
Deana Erdner, Research Associate II
Darlene Ketten, Senior Scientist
Susan Mills, Research Associate II

Tom Kleindinst

Stefan Sievert, left, at the anaerobic glove box in Redfield Laboratory meets with Sonya Dyhrman and Eric Webb. Along with Tim Shank (who was on a research cruise) they comprise the Biology Department's four assistant scientists.

Geology and Geophysics Department

The scientists and research staff of the Geology and Geophysics Department (G&G) study the role of the oceans in past climate change, as well as the geologic structure and evolution of the ocean basins and their margins. Among the many scientific pursuits in G&G, three areas stand out this year.

Several scientists are using sediment cores from the North Atlantic to examine large-scale changes in ocean circulation and climate over the past 10,000 years. Others have been looking back even further, to warmer "interglacial" periods that may be analogs of today's climate.

Active Projects: 231
Publications: 77
Total Funding: $12.7 million

Another recent research focus has been field, laboratory, and theoretical studies of how molten rock from Earth's interior leads to volcanism at mid-ocean ridges and in island arcs (see page 14). Geochemistry is a particularly powerful tool for these studies, and our department hosts some of the finest analytical facilities for determining the chemistry of igneous rocks.

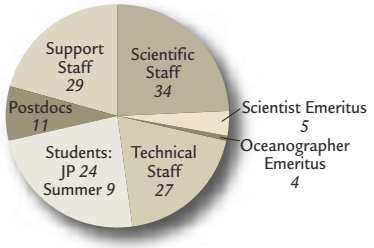
A third major focus is geophysics, including marine seismology, geomagnetism, tectonics, and geodynamical modeling. The study of mid-ocean ridges has been a traditional focus of this group, but there is increasing interest in hot spots, subduction zones, and the large-scale dynamics of the mantle.

Over the past two years, the department has strengthened and expanded its research in coastal geology and geophysics. As part of that effort, Jeff Donnelly was invited to join the scientific staff in 2002 as an Assistant Scientist. Jeff uses the geologic record preserved in coastal sediments to reconstruct the history of sea level change and intense storms. He and Associate Scientist Rob Evans, along with postdoctoral scholars Ilya Buynevich and Liviu Giosan, form a nucleus for this emerging scientific initiative.

The appointment of seismologist Jeff McGuire as an Assistant Scientist also represents a new direction. Jeff studies the physical processes of earthquakes along oceanic transform faults, and is interested in the emerging field of seafloor geodesy. In the fall of 2002, Jeff and associate scientists Greg Hirth and Jian Lin organized a workshop to identify the scientific opportunities and technical challenges of utilizing this powerful geophysical technique on the seafloor.

The marine geosciences are entering an exciting period. A new multiplatform, international Integrated Ocean Drilling Program is slated to begin in October 2003. Progress is being made in establishing a network of seafloor observatories. And recent advances in seismological imaging, geochemical analysis, and geodynamic modeling are providing unprecedented opportunities to understand the structure and circulation of Earth's mantle. The G&G Department is poised to play a leading role in these efforts.

—Robert S. Detrick, Department Chair
www.whoi.edu/science/GG/dept



Awards & Recognition

Stan Hart was elected an Honorary Fellow of the European Union of Geosciences.

John Hayes received the 2002 Goldschmidt Medal from the Geochemical Society for his contributions to geochemistry "that have had great influence on the field."

Emily Van Ark received an Outstanding Student Paper Award from the American Geophysical Union for her work with WHOI Scientist Jian Lin on hotspot flux changes in the Hawaii volcano chain.

Kenneth W. Sims gave a keynote address on mantle melting and magma transport at the 12th Annual V.M. Goldschmidt Conference in Davos, Switzerland.

Promotions

Karen Bice, Associate Scientist
Kathy Elder, Research Associate II
Rob Evans, Associate Scientist–Tenured
Patricia Long, Senior Engineering Assistant I
Jerry McManus, Associate Scientist
Ann McNichol, Senior Research Specialist
Ken Sims, Associate Scientist

Tom Kleindinst

Postdoctoral Scholars Ilya Buynevich (left) and Liviu Giosan deploy the G&G Department's new ground-penetrating radar (GPR) unit on Cedar Lake in Falmouth, MA. This high-resolution geophysical technique helps geologists visualize the layering of sediments to determine their age and structure.

Marine Chemistry and Geochemistry Department

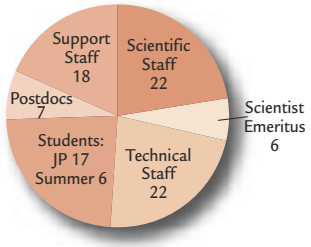
Research in the Marine Chemistry and Geochemistry Department (MCG) involves all aspects of oceanic chemical fluxes. MCG researchers use laboratory, field-based, and computational tools to understand the processes that control the chemistry of the oceans. Research projects often focus on mechanisms and rates of chemical transport at ocean boundaries, from the flux of pollutants in the coastal zone to the effects of ocean biology on atmospheric carbon dioxide, and hydrothermal influences on the deep ocean. Many studies require the use of ships in remote places: MCG cruises in 2002 ranged from the North Pacific to the Antarctic. Ken Buesseler and his research group participated in the Southern Ocean Iron Experiment (SOFeX), which was unique in the simultaneous use of three ships in the Ross Sea, Antarctica (photo opposite). Ken was the chief scientist on board the Coast Guard icebreaker *Polar Star.* Scientists from 17 institutions, including WHOI, collaborated to examine the relationship between biological productivity and dust inputs to the ocean surface. Using samples collected on the cruise, the WHOI group will measure how much carbon was removed from the surface by an iron-induced phytoplankton bloom.

Active Projects: 177
Publications: 66
Total Funding: $8.0 million

Because the ocean can be chemically and biologically variable in both space and time, MCG scientists are heavily involved in making time-series measurements. Two additions to the department in 2002, Senior Scientist Bill Jenkins and Associate Scientist Scott Doney, bring valuable expertise to this pursuit. Bill's newest project uses tritium-helium and noble gas measurements to understand the biological productivity variations and gas exchange processes near Bermuda. Scott and David Glover are coupling satellite observations with ocean measurements from the Bermuda region to formulate and test mathematical models of the biogeochemical processes. Their time-series work uses data from the Oceanic Flux Program (OFP) operated by Associate Scientist Maureen Conte (see page 9). Started 25 years ago by Scientist Emeritus Werner Deuser, the OFP uses moored sediment traps near Bermuda to continuously measure the carbon flux to the deep ocean. It is the longest record of its kind.

The research programs of assistant scientists Katrina Edwards and Chris Reddy are part of a new departmental initiative in microbial biogeochemistry. Katrina is studying the role of microtopography in microbial attachment to mineral surfaces. This research has important implications for life in the deep ocean, how rapidly minerals weather, and biofouling in the marine environment. Chris is conducting research crucial to understand the long- and short-term effects of oil spills in the ocean. He is using comprehensive two-dimensional gas chromatography to study the effects of microbial degradation on sedimentary petroleum hydrocarbons in both laboratory and field samples (see page 16).

—Mark Kurz, Department Chair
www.whoi.edu/science/MCG/dept



Awards & Recognition

Bill Jenkins delivered the Harald Ulrik Sverdrup Lecture at the fall meeting of the American Geophysical Union.

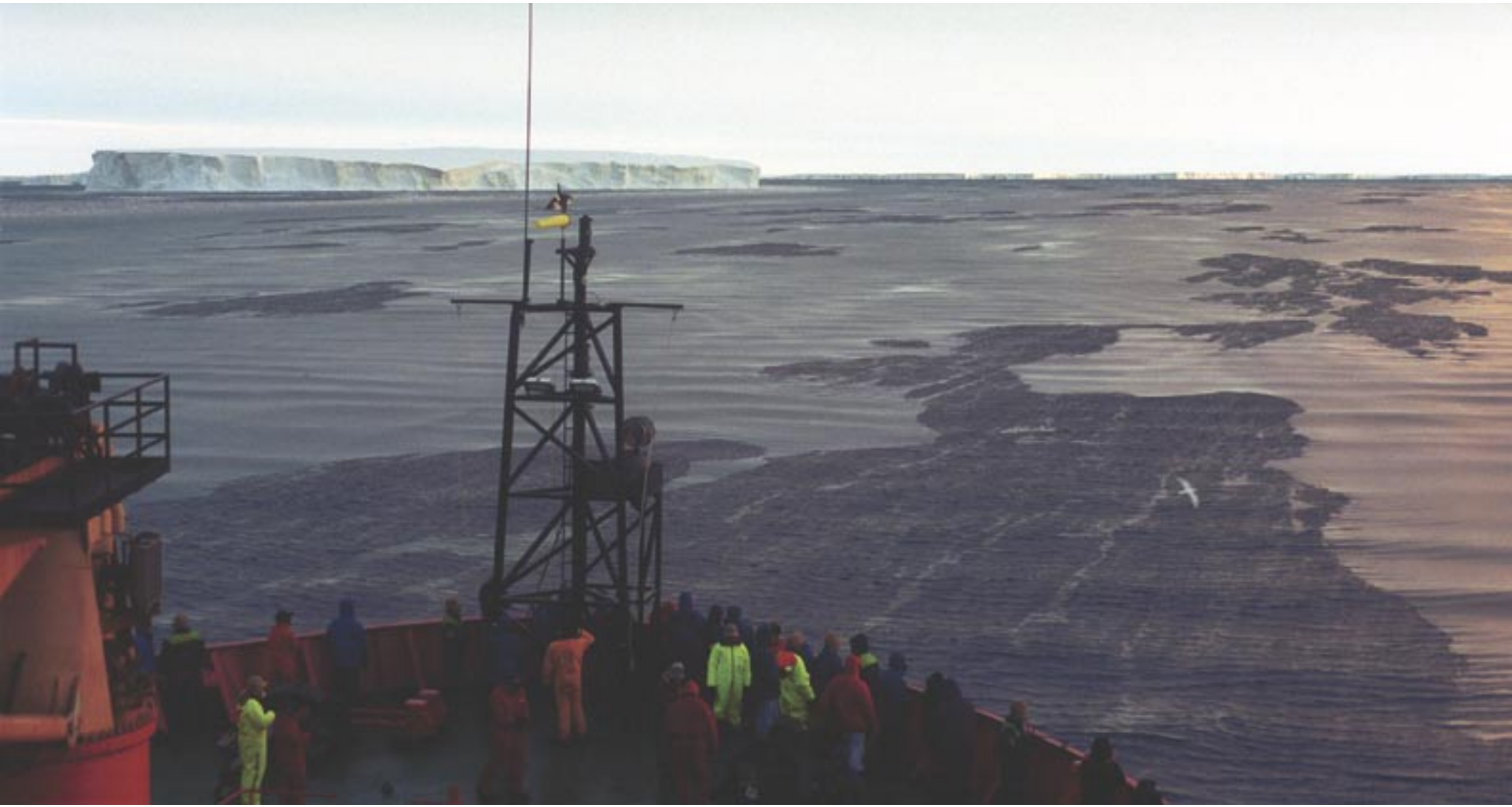
Katrina Edwards received a Young Investigator Award from the Office of Naval Research for work on microbial attachment to mineral surfaces.

John Hunt was awarded the Gold Medal of Honor of Albert Einstein of the Russian Academy of Natural Sciences, US Section, for outstanding contributions in the field of geology. He was also elected to the Russian Academy as a foreign member in the geologic sciences.

Appointments:

Mike Bacon, Scientist Emeritus

Ken Buesseler



The US Coast Guard icebreaker *Polar Star* approaches the Mertz Glacier field in the Southern Ocean. Early in 2002, Senior Scientist Ken Buesseler served as *Polar Star* chief scientist during the Southern Ocean Iron Experiment (SOFeX). The three-ship operation investigated the relationship between biological productivity and iron added to the ocean surface to mimic dust inputs thought to stimulate growth of marine plankton. Buesseler studied the natural iron cycle during the early melt season in the Southern Ocean aboard the Australian RSV *Aurora Australis*.

Physical Oceanography Department

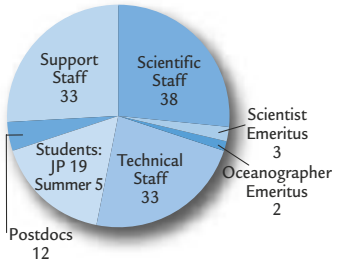
As scientists in the Physical Oceanography Department advance our understanding of ocean physics, their long-term goal is accurate prediction of how the ocean and the atmosphere will evolve on time and space scales that are important to society. The interests of the department range from theoretical and modeling studies to sea-going observational programs, and from the ocean's role in long-term climate change to the smallest time and space scales relevant to ocean mixing. Development of new measuring tools is a continuing department emphasis.

Climate change is a major theme in physical oceanography. It encompasses study of the broad influence of the meridional overturning in the North Atlantic, that is, the northward flow of warm water and its return south in deep-sea currents after cooling and sinking at high latitudes. The influence of this phenomenon is global. The first of six planned moorings to monitor these north-south flows was established in 2001with Vetlesen Foundation funding at Station W, southeast of Woods Hole and just inshore of the Gulf Stream. A notable achievement in 2002 was securing National Science Foundation support to expand this research in collaboration with British colleagues. Conditions that could lead to abrupt climate change—such as an influx of fresh water in the North Atlantic that could change the meridional overturning—will be quickly evident at Station W.

Active Projects: 225
Publications: 55
Total Funding: $15.6 million

In 2002, Terry Joyce completed his four-year term as Department Chair, and Nelson Hogg succeeded him. Pavel Berloff joined the staff as an Assistant Scientist. He received a PhD degree from Florida State University in 1996 and spent the next six years at UCLA's Institute of Geophysics and Planetary Physics. His interests center on theoretical and modeling studies of turbulence and eddy dynamics in ocean circulation. This coming year will bring us at least one new scientist as Jason Goodman joins us in late spring. He brings a strong background in climate-related problems involving the coupling of the atmosphere and the ocean. His interests also include planetary systems and paleoclimate, and we expect that he will build important connections to research in other WHOI departments and the Ocean Institutes. Jason has a PhD degree from MIT and did two years of postdoctoral work at the University of Chicago.

—Nelson Hogg, Department Chair
www.whoi.edu/science/PO/dept



Awards & Recognition

Nick Fofonoff received an Honorary Doctor of Science degree from the University of Victoria, Canada, for his "pioneering contributions to oceanography on Canada's Pacific coast and fundamental contributions to physical oceanography."

Steve Jayne received a Zeldovich Award from the International Science Council and the Russian Academy of Sciences for contributions to space science using satellite observations.

Mike McCartney received the prestigious but tongue-in-cheek American Miscellaneous Society's Albatross Award "for describing the Atlantic circulation with bewildering simplicity." This award includes the dubious honor of transporting a stuffed albatross home from a meeting located as remotely as possible from the winner's laboratory.

Fiamma Straneo received the Ferruccio Mosetti Prize from the University of Trieste for her work on the dynamics of convection in the ocean in the presence of sheared flow and wind.

Jack Whitehead was elected a Fellow of the American Academy of Arts and Sciences.

Promotions:

Dave Fratantoni, Associate Scientist
Mike Spall, Senior Scientist
Jiayan Yang, Associate Scientist–Tenured

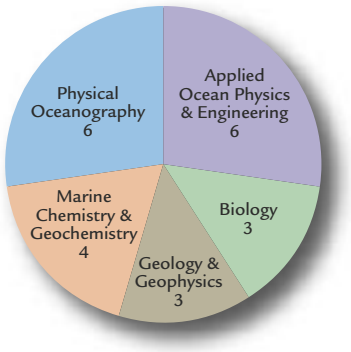
Tom Kleindinst

Assistant Scientist Claudia Cenedese, right, explains laboratory processes to the Joint Program Coastal Physical Oceanography class. Dave Chapman, left, and Steve Lentz, second from left, were also instructors. The students are Carlos Moffat, Melanie Fewings, Jim Thomson, Andrew Mosedale, and Jason Hyatt. The experiment on the rotating table demonstrates coastal upwelling.

Institution educational activities focus on close interaction with research, where learning takes place in small groups and one-on-one. This engages bright, early career scientists in a dynamic ocean research environment. Our alumni/ae are leaders in the academic, government, industry, and nonprofit sectors of ocean science, policy, engineering, and education. Our present postdocs and students are on course for continuing this legacy.

Our postdoctoral program has expanded over the past several years. Fifty to eighty-two postdoctoral appointees are present each year, about half funded by WHOI fellowships or research projects and about half with fellowship support from their home countries. Four new fellowships for interdisciplinary studies were added in 2002 by the WHOI Ocean Institutes.

2002 Graduate Degrees By Department



Mario Sengco was chosen by the graduate students to receive the first Panteleyev Award. This award, honoring the memory of George P. "Gera" Panteleyev, a Joint Program student who lost his life in Siberia while pursuing graduate research, was presented at the WHOI graduation celebration. The annual award is given to the graduating student who exemplifies a commitment to improving the graduate educational experience and student life at WHOI.

For the 2002 Joint Program, 167 students applied, 40 were admitted, and 24 matriculated, bringing enrollment to 121. Fifteen PhD and six SM degrees were granted. Our graduate students are encouraged to learn from each other in addition to formal and informal learning with the faculty and staff. Exemplifying this tradition, graduate students Margaret Boettcher and Jeff Standish assisted their colleague Rhea Workman in her fieldwork in American Samoa—as did her thesis advisor Stan Hart, Senior Scientist in the Geology and Geophysics Department. Rhea's thesis focuses on the Samoan Islands volcanoes and contributes to the overall understanding of ocean basin dynamics. All three students shared their field experiences with WHOI Corporation Members, Trustees and guests in a presentation at the May 2002 Annual WHOI Meeting (opposite, top right).

The 2002 Summer Student Fellowship and Minority Fellowship Program for undergraduates included 26 participants from 15 US and five international colleges and universities. Research by Nicholas Hartmann from Pennsylvania State University, for example, furthers knowledge of the cycling of colored material in the surface oceans, which has far-reaching consequences for understanding remote sensing of the oceans and chemical reactions at the ocean surface. Nick's research, conducted under the guidance of Dan Repeta, Senior Scientist in the Marine Chemistry and Geochemistry Department, was selected for presentation in the Research Experiences for Undergraduates at the American Society of Limnology and Oceanography meeting in February 2003. Nick has been selected for a prestigious, nationally competitive George C. Marshall Fellowship to study during the 2003–2004 academic year at the University of Cambridge, UK.

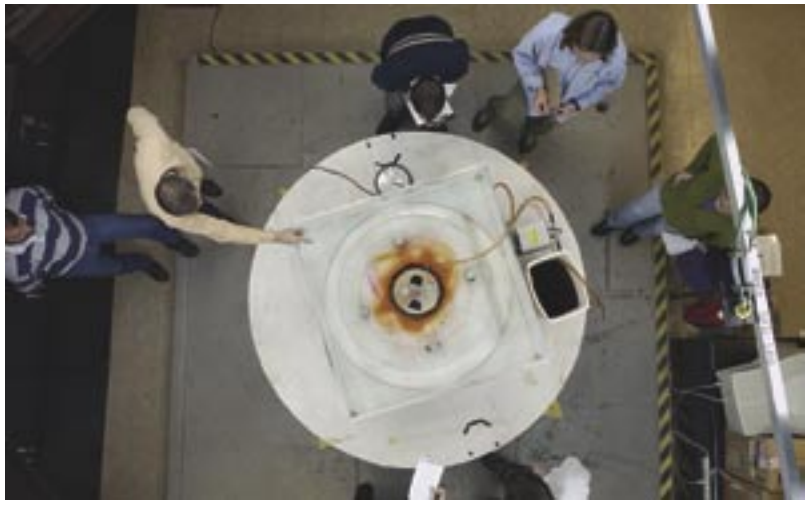
For several decades, Woods Hole Oceanographic Institution has engaged in formal and informal K-12 education activities. This year, WHOI, in association with the New England Aquarium and the University of Massachusetts system, received funding from the National Science Foundation to establish a New England Regional Center for Ocean Science Education Excellence (COSEE). This is part of an NSF-funded national network of such centers responsible for facilitating collaboration and communication between ocean science researchers and educators. The principal investigator at WHOI is Deborah Smith, Senior Scientist in the Geology and Geophysics Department. Working closely with Debbie in NER-COSEE efforts at WHOI are Andrea Thorrold, NER-COSEE WHOI coordinator, Tracey Crago, Kate Madin, and Stephanie Murphy.

—John W. Farrington
Vice President for Academic Programs and Dean
www.whoi.edu/education

At the 2002 MIT/WHOI Joint Program graduate reception in June, degree recipient Ben Reeder is joined by his daughter Emma and wife Lisa, and flanked by WHOI President and Director Bob Gagosian, left, and John Farrington, Vice President for Academic Programs and Dean. Dr. Reeder completed a PhD degree in ocean engineering and serves as a lieutenant commander in the US Navy aboard USS *Tarawa*.

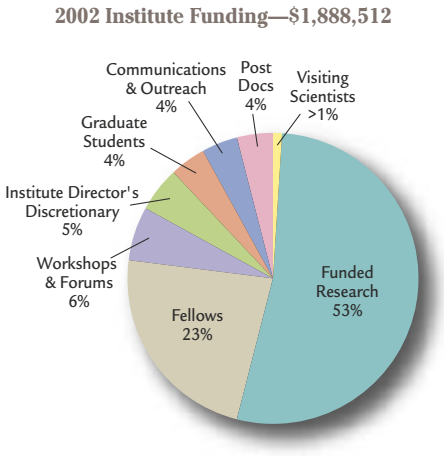
Joint Program students, from left, Rhea Workman, Jeff Standish, and Margaret Boettcher report to Corporators and guests on their field research in Samoa on ocean volcanic islands.

MIT/WHOI Joint Program graduate students Linda Kalnejais, left, and Tracy Quan section a core in the WHOI core lab.



In the Rinehart Coastal Research Center, students study fluid mixing properties at a rotating table used for geophysical fluid dynamics experiments.

Photos by Tom Kleindinst



Coastal Ocean Institute and Rinehart Coastal Research Center

Although the oceans cover 71 percent of Earth, it is the seven percent that comprises the coastal ocean that most influences, and is influenced by, human activity. The importance of this narrow strip of ocean—from the outer edge of the continental shelf to the farthest penetration of salt water up rivers—is increasing as more people live near the shore and draw resources from the water.

The Coastal Ocean Institute and Rinehart Coastal Research Center responds to this societal phenomenon by supporting innovative experiments and field expeditions, and by communicating the results to the public. In 2002, the Institute focused on understanding the sources of nutrients in coastal waters, especially those arriving from the deep ocean and from land via groundwater. All three Institute fellowships and five of six research projects were related to nutrients in coastal waters.

Institute researchers also investigate what happens to organic material after coastal organisms die. These processes are important for understanding biological productivity in the ocean, particularly the health of fisheries and how additions from human activities alter coastal waters.

In 2002, COI hosted the biannual Ketchum Award celebration. The award was presented to Nancy Rabalais of the Louisiana University Marine Consortium, in recognition of her contributions to science and public policy related to nutrient pollution offshore from the Mississippi River.

During 2003, the Institute will continue to promote research related to coastal nutrients and exchanges, and also will branch out to include shoreline change and its economic and biological implications. Plans are being made for an Ocean Institute Forum on this topic in 2004.

—**Kenneth Brink**, Institute Director
www.whoi.edu/institutes/coi/

Deep Ocean Exploration Institute

The Deep Ocean Exploration Institute investigates processes that shape Earth's surface, regulate the chemistry of its oceans, and impact its inhabitants. The objective is a better understanding of how Earth works. While continuing studies under the initial broad theme, "Seafloor Observatory Science and Instrumentation," the Institute initiated a second cross-disciplinary theme, "Fluid Flow in Geologic Systems," in 2002. Fluid flow influences many processes that modify Earth; for example, interactions between fluids, rocks, and biologic systems form oil and gas, spawn exotic ecosystems at hydrothermal vents, and probably nurture a deep biosphere beneath the seafloor. Fluid flow was the principal topic for the 2002 Geodynamics Seminar for students and staff. It is also the theme for new research projects that include a pilot program to determine whether gas hydrates can be mapped to depths of 20 meters (66 feet) below the seafloor with a towed electromagnetic system (Rob Evans), and an experimental study to examine how microbes grow by oxidizing iron in volcanic rocks (Wolfgang Bach and Katrina Edwards).

Notable Institute events in 2002 included a special online "Dive and Discover" expedition that returned to the Galápagos Rift where hydrothermal vents were first discovered 25 years ago. The

Institute also produced and distributed 10,000 copies of an educational CD-ROM documenting this discovery and its scientific legacy. In October, the Institute held a workshop for scientists interested in adapting recently developed space and land-based geodetic techniques to studies of seafloor deformation—an issue with implications for detection of Earth's movements, seafloor stability, and the generation of tsunamis.

In 2003, DOEI Fellows Meg Tivey, Dana Yoerger, and Jean Whelan will continue investigations related to seafloor observatory science and instrumentation. Their efforts will be particularly pertinent to a July workshop (co-sponsored with NSF, ONR, and the Ocean Life Institute) on "The Next Generation of In Situ Biological and Chemical Sensors in the Ocean."

—**Susan Humphris**, Institute Director
whoi.edu/institutes/doei/

Ocean and Climate Change Institute

The OCCI significantly advanced its mission to understand the ocean's pivotal role in climate change with two initiatives in 2002:

• We recovered Station W, our new Gulf Stream observing station near Bermuda—a strategic location for monitoring ocean circulation changes that affect regional and global climate. In its first year, Station W collected 300 profiles of temperature and salinity data at depths of 90 to 2,950 meters (297 to 9,735 feet).

• OCCI convened an Ocean Forum on Abrupt Climate Change, inviting to WHOI four leading scientists with a broad range of expertise as Visiting Summer Scholars. Together, the scholars and WHOI scientists assessed our state of knowledge on this issue and devised plans to launch future research.

OCCI supported four fellows in the second year of their terms: Ray Schmitt investigates changes in the hydrological cycle over the ocean and its impact on future ocean circulation and climate variability; Lloyd Keigwin reconstructs recent geological history of ocean circulation and climate change; Konrad Hughen pursues high-resolution reconstructions of past climate, ocean circulation, and atmospheric chemistry; and John Toole leads the Station W initiative.

The Institute also supported MIT/WHOI graduate student Rose Came and initiated five new research projects: a survey of seafloor locations near Station W for paleoclimate records; investigation of the transport of salt and fresh water between the tropics and high latitudes and its impact on ocean circulation and climate change; examination of ocean mixing in the Southern Ocean; studies of socio-economic impacts of the North Atlantic Oscillation; and development of a new geochemical method to obtain high-resolution climate records.

—**William Curry**, Institute Director
www.whoi.edu/institutes/occi/

Ocean Life Institute

In 2002 the Institute funded proposals from four WHOI researchers. Two apply genomic techniques to studies of bacteria and toxic red-tide algae. Another examines effects of copper pollution from mining on seaweeds along the coast of Chile. The fourth develops a technique to measure oxygen isotopes in coral skeletons and to deduce the ocean temperature when the animals lived.

Progress continues on projects funded in 2001. Scott Gallager and Mark Grosenbaugh are studying the swimming dynamics of cod larvae, and another biologist-engineer team advanced their development of a heart-rate sensor for tagging whales. Heidi Sosik and Rob Olson have made great strides with their new instrument to simultaneously identify phytoplankton cells and gauge their physiological state. Mark Baumgartner was appointed a Postdoctoral Scholar to study foraging behavior of Right Whales, and Joint Program student Jonathan Blythe continues work on protozoan physiology.

Three Institute fellows are now in their second year of funding: Ken Buesseler is investigating the role of biology in transport of carbon to the deep sea, Darlene Ketten continues expanding applications of CT scanning and visualization, and Simon Thorrold is using geochemical tracers in animal skeletons to learn about the habitats and population dynamics of fishes and invertebrates. In addition, Ken Halanych pursued studies of the evolutionary relationships of worms and related forms prior to his departure to another faculty position at the end of the year.

Important progress was made in two initiatives. The Right Whale group prepared a comprehensive proposal to save this endangered whale from extinction. In Panama, OLI became a partner in a new tropical field station that will offer exceptional research opportunities to WHOI scientists.

—**Laurence Madin**, Institute Director
www.whoi.edu/institutes/oli/

Marine Policy Center

The Marine Policy Center (MPC) conducts social scientific research that integrates economics, policy analysis, and law with the Institution's strengths in ocean sciences. Areas of recent research include fisheries and aquaculture, offshore oil and gas, marine transportation, and coastal and marine environmental management.

One recent MPC study addressed managing the introduction of nutrients, such as nitrogen, to coastal waters from agricultural and other human activities. Excess nutrients can lead to problems such as harmful algal blooms or "red tides," mass mortalities of bottom-dwelling species, and loss of seagrass and coral reef habitats. Improved control of nutrient pollution requires better understanding of the source and behavior of nutrients, including the role of the ocean as both a nutrient source and sink (right). MPC researchers developed a model of nutrient management in a coastal community under conditions of uncertainty about nutrient sources. The results show that better oceanographic information can improve management by allowing more efficient regulation of nutrient sources.

MPC also recently launched a three-year project, funded by the Henry Luce Foundation, to strengthen the connection between oceanographic science and public policy through a visiting program for Congressional staff members, a seminar in public policy, and a science and public policy fellowship program. In 2002, MPC hosted a legislative assistant to the Chair of the House Subcommittee on Fisheries Conservation, Wildlife and Oceans. MPC researchers also conducted a weekly seminar that introduced WHOI students and scientists to the basic problems and methods of marine policy.

Tom Kleindinst

Ann Mulligan of the Marine Policy Center and Matt Charette of the Marine Chemistry and Geochemistry Department discuss aerial photographs of Waquoit Bay, Falmouth, MA, showing groundwater discharge patterns, part of a study to understand nutrient loading. Excess nutrients in Waquoit Bay are believed to be responsible for a decline in eelgrass, which serves as habitat for scallops.

In the near future, MPC will examine environmental and policy issues associated with the siting of wind energy facilities in the coastal ocean. Another MPC study will estimate regional and national economic impacts of the introduction and spread of nonindigenous aquatic nuisance species and identify cost-effective policies for their control.

—Andrew Solow, MPC Director
www.whoi.edu/science/MPC/dept

WHOI Sea Grant Program

The WHOI Sea Grant Program supports research, education, and extension projects that encourage environmental stewardship, long-term economic development, and responsible use of the nation's coastal and ocean resources. It is part of the National Sea Grant College Program of the National Oceanic and Atmospheric Administration (NOAA), a network of 30 programs located in each of the coastal and Great Lakes states, to foster cooperation among government, academia, industry, scientists, and the private sector.

Each year, the WHOI Sea Grant Program supports approximately 10 concurrent research projects and several smaller new initiatives, some of which address local and regional needs, while others have national or even global implications. Each of the projects fits into one of three theme areas.

In 2002, the Environmental Technology theme included projects such as the use of scanning electron microscopy to understand causes and implications of lobster shell disease. Work in the Estuarine and Coastal Processes theme ranged from the effect of chemical pollutants on marine invertebrates, marine mammals, and fish, to a study of the role of tidal marshes in the storage and release of nitrogen. Among the Fisheries and Aquaculture theme projects were studies of the effects of land-derived nitrogen on commercially important bivalves such as quahogs, soft-shell clams and bay scallops, and comparisons of offshore and near-shore lobster and squid population structures and their implications for fisheries management.

In addition to research, WHOI Sea Grant supports a marine extension program and a

Jim O'Connell

Sea Grant extension specialists in the coastal processes, fisheries, and aquaculture fields work with coastal communities to ensure the latest science is available to resource managers, regulators, and users.

communications, public outreach, and education program. Major by-products of WHOI Sea Grant projects include publications, workshops, and lectures.

2002 funding (funding year begins March 1):

Research	$441,601
Research support	$170,919
Education	
Graduate students/Fellowships	$69,106
K-12, undergrad, informal	$23,564
Outreach and Extension	$269,810
Total 2002 Budget	**$975,000***

* Sea Grant is a matching program. In addition to $975,000 in federal funds, $567,017 is contributed by private, state, and local funds or in-kind services, for a total 2002 programmatic budget of $1,542,017.

—**Judith E. McDowell**, Sea Grant Coordinator
www.whoi.edu/seagrant

Cooperative Institute for Climate and Ocean Research

The Cooperative Institute for Climate and Ocean Research (CICOR) functions as the coordinating point between Woods Hole Oceanographic Institution and the National Oceanic and Atmospheric Administration (NOAA). The CICOR group coordinates NOAA-funded research, builds ties between researchers at WHOI and NOAA, and develops cooperative NOAA-funded research in the northeast US. CICOR is among 11 such joint institutes.

Research highlights among the 26 funded projects in 2002: Dana Yoerger of the AOPE Department collaborated with NOAA and Canadian scientists on two summer cruises along the Explorer Ridge in the North East Pacific. The WHOI Autonomous Benthic Explorer (ABE) produced highly detailed bathymetric maps that revealed new fracture systems and found hydrothermal plumes. More than 15 active chimneys were subsequently located (see oceanexplorer.noaa.gov/explorations/02fire/welcome.html).

Breck Owens and a team from the Physical Oceanography Department and program colleagues reached a milestone with the deployment of the 500th Argo float in July 2002. The floats collect profiles globally of temperature and salinity at 1,500 to 2,000 meters depth (4,950 to 6,600 feet). They surface every ten days to transmit data. They are being deployed in an international effort as part of the Global Ocean Observing System. Of the 721 active floats deployed to date, 282 are from the US (see www.argo.ucsd.edu).

In October CICOR Director Bob Weller recovered and redeployed a surface mooring off the

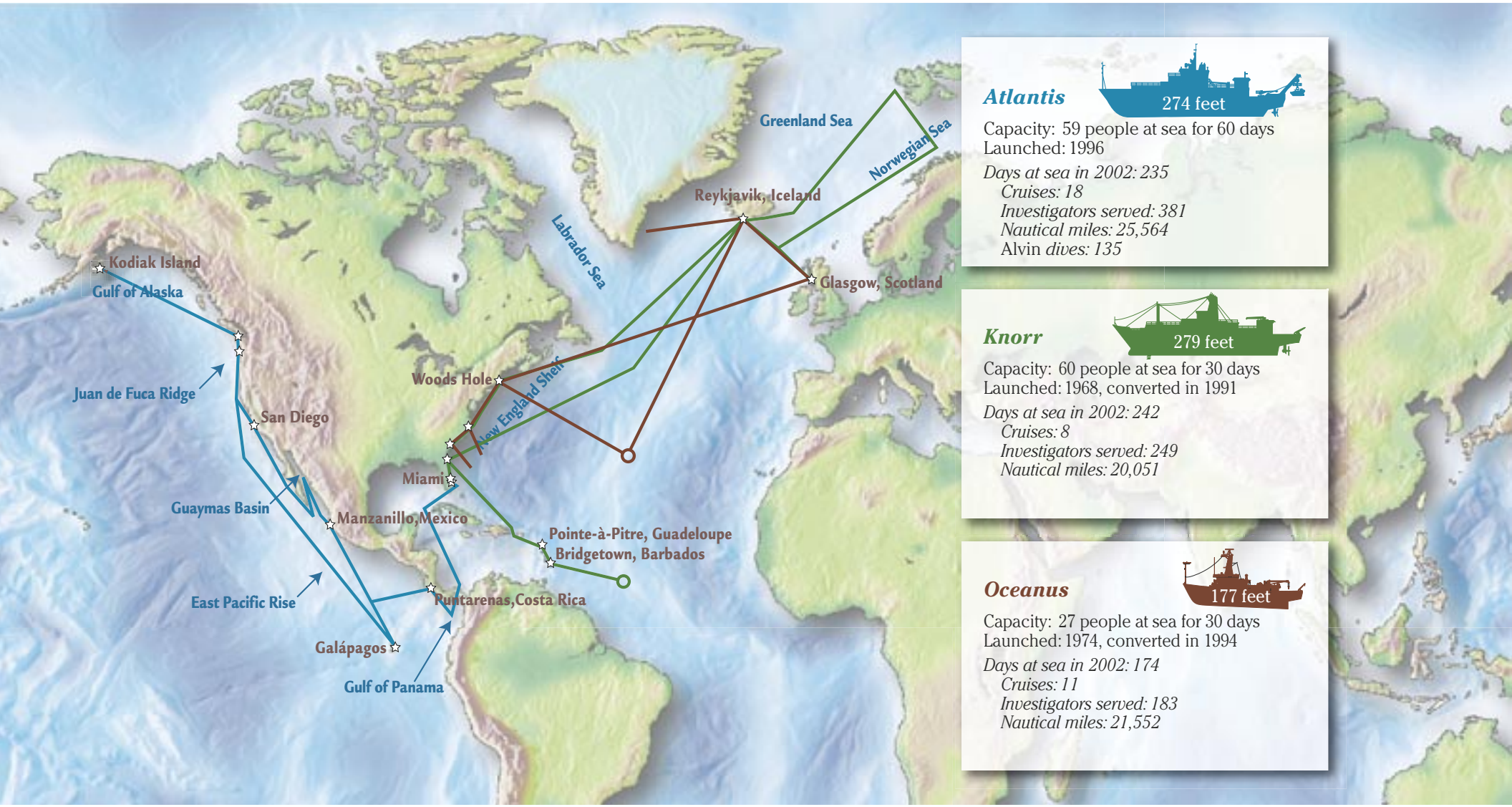
Tom Kleindinst

Brian Guest of the Physical Oceanography Department packs an Argo float for shipment to the Antarctic and deployment in the Drake Passage. The Institution is one of the three US groups building floats for the international program.

northern coast of Chile that measures surface meteorology and upper ocean temperature, salinity, and currents. These data document the coupling of the upper ocean and atmosphere under the persistent stratus clouds found west of Peru and Chile in an area believed to influence seasonal and inter-annual climate variability in the Americas. The mooring provides the first accurate and complete measurements from this region (see uop.whoi.edu/stratus).

—**Robert Weller**, CICOR Director
www.whoi.edu/science/cicor/

Cruise Tracks



Atlantis

Capacity: 59 people at sea for 60 days
Launched: 1996

Days at sea in 2002: 235
Cruises: 18
Investigators served: 381
Nautical miles: 25,564
Alvin *dives: 135*

Knorr

Capacity: 60 people at sea for 30 days
Launched: 1968, converted in 1991

Days at sea in 2002: 242
Cruises: 8
Investigators served: 249
Nautical miles: 20,051

Oceanus

Capacity: 27 people at sea for 30 days
Launched: 1974, converted in 1994

Days at sea in 2002: 174
Cruises: 11
Investigators served: 183
Nautical miles: 21,552

R/V *Atlantis*

Atlantis started the year in Manzanillo, Mexico, supporting scientific work on vent studies on the East Pacific Rise. Scientific research expeditions were conducted on the California continental shelf, the Guaymas Basin, the Juan de Fuca Ridge, the Gulf of Alaska, and the Gulf of Panama. All but two cruises were in direct support of the National Deep Submergence Facility. The ship provided access to the sea, enabling researchers to investigate chemical, biological, physical, and geological oceanography. Hydrothermal vent studies continued the ongoing research of the biological communities found at vent sites. Climate change studies continued off the Oregon coast, and specimens for natural history museums were collected. The ship also provided a test platform for the next-generation of the remotely operated vehicle *Jason*. In our continuing outreach efforts, an IMAX filming cruise of the abyssal plain and vent communities off San Diego completed work started in 2001. *Alvin* made 135 dives during the year. It can dive to depths to 4,500 meters (14,850 feet).

R/V *Knorr*

Beginning the year with a transit from Woods Hole to Fort Lauderdale, two cruises took place in the Bahamas and Florida Keys, including acoustic surveys and studies on fluctuations in the Gulf Stream. The ship transited to Barbados for hydrographic and mooring cruises southeast of the Windward Islands. In early May, *Knorr* moved to Iceland and Scotland where cruises focused on the interactions of Arctic Ocean outflow waters, followed by an acoustic survey cruise, and a cruise to study the paleoceanography of North Atlantic sediment drifts. The ship returned to Woods Hole in late September for a coastal research drilling program in the fall. *Knorr* finished the year with scheduled shipyard maintenance in November and December.

R/V *Oceanus*

Research expeditions carried *Oceanus* from the West Central North Atlantic to the coast of the Southeast United States, and northward to the Greenland, Labrador, and Norwegian seas. Oceanographic studies included the testing of the next generation of video plankton recorder, biological sampling for species diversity, and benthic sampling of marine sediments. *Oceanus* also participated in a multinational acoustic study off the coast of the United Kingdom. In late summer a cruise in the Greenland Sea focused on the physical oceanographic properties of the Denmark Straits. Cruises in the late fall included surveys of plankton communities on the New England Shelf. The ship finished the year with a fish habitat survey, part of a long-term ecological study on the New England continental shelf.

Our ocean-going ships, and the vehicles *Alvin* and ROV *Jason,* are part of the US Academic Fleet, a federation of 27 vessels distributed throughout the coastal states. Providing researchers with unrivaled access to the sea, in a typical year the fleet serves more than 2,500 scientists conducting more than 350 projects. The diversity and distribution of these vessels ensures efficient, affordable and uniformly high quality service to researchers.

The Woods Hole Oceanographic Institution (WHOI) operates three ocean-going ships: *Oceanus*, *Knorr,* and *Atlantis*, each filling a different niche.

www.whoi.edu/marops/

R/V *Atlantis*

Atlantis has the same broad capabilities as *Knorr*, but is equipped for launch and retrieval of the submersible *Alvin* so most of its work involves deep submergence. The ship operates around the clock. *Alvin* typically dives in the morning, spends the day at the bottom of the sea, and is recovered in the late afternoon. At night, while the *Alvin* team prepares the submarine for the next day's dive, the ship performs research operations such as mapping, collection of dredge or water samples, and towing of instruments.

R/V *Knorr*

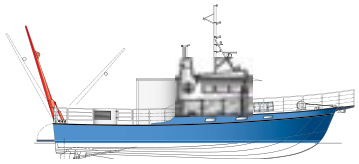
Knorr, our longest ship at 279 feet, can operate globally in any ice-free waters. In the last several years, *Knorr* circumnavigated Africa and worked on the northeast coast of Greenland. Like *Oceanus*, *Knorr* is a general-purpose ship. It is outfitted with thrusters, global positioning system navigation, and a computer-controlled dynamic positioning system, enabling the ship to hold a position to within two meters (seven feet)—an important capability for operations such as drilling core samples and operating tethered vehicles.

R/V *Oceanus*

Scientific operations supported by *Oceanus* include:

- Deployment of deep ocean moorings
- Collection of water samples and data to depths of 5,000 meters (16,500 feet), as well as bottom samples
- Towing oceanographic instruments to measure seawater properties, biological populations, and other physical and chemical variables.

Following a mid-life upgrade in 1994, its service life was extended to 2009.



An *Asterias* has always been part of the Institution. The first *Asterias* was launched in 1931 and replaced in 1979 with a boat of the same design but with a lower maintenance fiberglass hull.

It performed more than 550 hours of service in 2002, with cruises mainly supporting the growing demand for coastal research. Plans are underway to replace *Asterias* in spring 2004 with a more flexible, modern vessel (left). The new 60-foot boat will feature state-of-the-art laboratories, a more flexible and efficient deck design and will support shallow diver operations. It will make 22 knots, more than double that of the old vessel.

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For a complete list of scientific, technical, support, and marine staff as well as degree recipients, students, fellows, and visitors as of December 31, 2002, see: www.whoi.edu/annualreport02/people/

Report from the Vice President for Finance and Administration

Substantial progress was made this year in achieving the vision articulated by President and Director Bob Gagosian (see page 2). We increased research support to the Ocean Institutes, completed the first phase of improving our shore facilities, and began construction of a new coastal research vessel. Despite persistent weakness in the financial markets, the Institution's overall 2002 financial position is healthy. We continue to show positive operating results.

Sponsored research revenue released to operations increased 10 percent to $97.5 million in 2002 compared to an increase of 14 percent to $88.8 million in 2001. Federally sponsored research, excluding ship and submersible operations, was $59.1 million compared to $58 million in 2001. This growth demonstrates the Institution's ability to compete successfully for research grants and contracts. The Institution had a planned, modest under-recovery of overhead expenses.

Gifts, grants, and pledges from private sources totaled $13.8 million in 2002, a remarkable achievement considering global economic problems. Outstanding pledges at the end of 2002 were $4.5 million, compared to $1.8 million in 2001. Friends of the Institution continue to be generous during this difficult financial period.

Although our endowment declined from $268.2 million in 2001 to $234.6 million in 2002, the results were in line with our benchmarks. Our 2002 endowment total return of -11.4 percent outperformed the S & P 500 index of -22.1 percent. Our endowment spending policy seeks to preserve the fund's real purchasing power while providing a predictable stream of income to support annual budgetary needs. During 2002, we distributed $5.4 million of endowment income to education and $4.1 million to research.

The Institution had $8 million in long-term debt on its statement of financial position at year-end, and the use of low-cost, 1 percent at year-end, tax-exempt debt has a substantial financial benefit. We anticipate that tax-exempt borrowings will finance a substantial portion of planned new laboratory space on the Quissett Campus as well as renovations to existing laboratories in the Village Campus. State-of-the-art laboratory space is essential if we are to remain competitive in the conduct of research, graduate education, and recruitment and retention of the best scientists.

In October 2002, a fire occurred in the Clark Laboratory on the Quissett Campus. There were no injuries and minimal fire damage but extensive smoke damage, compounded by the sensitive nature of many instruments and facilities in the laboratory. We immediately resettled the two dozen affected investigators in temporary workspaces, and began the cleanup, which includes replacement or repair of equipment. We expect this work to be completed by summer 2003. The Institution recorded a receivable of $13.3 million to reflect the estimated insurance proceeds that will cover the cost of restoring the building to a pre-fire condition. Following the fire, we have undertaken a comprehensive review of all our facilities and emergency procedures to further minimize the risk of such an event.

The Institution will safeguard the assets created over 72 years to ensure that our research and education continue to thrive. We are indebted to the scientists, staff, students, trustees, and friends whose contributions and talents enable us to pursue our vision of furthering understanding of the oceans.

—**Carolyn A. Bunker,** Vice President for Finance and Administration

Statements of Financial Position

As of December 31, 2002 (with comparative information as of December 31, 2001)

	2002	2001
Assets		
Cash, unrestricted	$13,973,766	$25,279,708
Cash, restricted	2,042,155	2,127,319
Reimbursable costs and fees:		
Billed	3,923,078	2,270,064
Unbilled	4,507,921	3,792,387
Interest and dividends receivable	532,226	747,738
Other receivables (Note 12)	14,924,983	489,022
Pledges receivable, net	4,463,055	1,837,433
Inventory	1,490,021	1,338,200
Deferred charges and prepaid expenses	999,204	632,799
Deferred fixed rate variance	426,870	-
Investments, pooled	231,262,026	255,533,434
Investments, nonpooled	6,318,027	16,914,043
Prepaid pension and postretirement benefit cost	788,826	7,196,027
Supplemental retirement	5,494,326	6,464,586
Intangible pension asset	11,498,524	-
Other assets	4,177,187	4,255,459
	306,822,195	328,878,219
Property, plant and equipment:		
Land, buildings and improvements	62,363,781	58,416,408
Vessels and dock facilities	3,474,118	3,186,277
Laboratory and other equipment	14,485,199	12,687,970
Construction in process	3,788,855	1,714,908
	84,111,953	76,005,563
Accumulated depreciation	(45,009,763)	(41,311,575)
Net property, plant and equipment	39,102,190	34,693,988
Remainder trusts	9,395,272	10,819,303
Total assets	$355,319,657	$374,391,510

Liabilities		
Accounts payable and other liabilities (Note 12)	$25,212,044	$10,099,366
Accrued payroll and related liabilities	6,695,441	5,835,734
Payable for investments purchased	10,193	281,912
Accrued supplemental retirement benefits	5,494,326	6,464,586
Accrued pension liability	12,082,593	-
Deferred revenue and refundable advances	7,016,121	7,483,854
Deferred fixed rate variance	-	2,196,646
Loan payable	8,045,162	5,067,952
Total liabilities	64,555,880	37,430,050

Net Assets

	Unrestricted	Temporarily restricted	Permanently restricted		
Undesignated	$(3,303,895)	$ -	$ -	(3,303,895)	7,595,488
Designated	2,311,223	7,229,346	-	9,540,569	13,517,728
Pledges and other	-	4,691,922	11,201,785	15,893,707	13,840,577
Plant and facilities	30,168,807	300,001	-	30,468,808	30,418,781
Education	-	3,524,553	-	3,524,553	3,389,196
Endowment and similar funds	53,878,577	130,687,993	50,073,465	234,640,035	268,199,690
Total net assets	$83,054,712	$146,433,815	$61,275,250	290,763,777	336,961,460
Total liabilities and net assets				$355,319,657	$374,391,510

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

Statement of Activities

For the Year Ended December 31, 2002 (with summarized financial information for the year ended December 31, 2001)

	Unrestricted					
	Operating	Sponsored research	Temporarily restricted	Permanently restricted	2002	2001
Operating:						
Revenues:						
Fees	$607,986				$607,986	$480,048
Sponsored research:						
Government		$59,124,026			59,124,026	57,999,323
Nongovernment		17,224,926	$4,159,299		21,384,225	15,045,925
Ships and subs operations		17,774,506			17,774,506	16,318,230
Sponsored research assets released to operations	97,467,531	(94,123,458)	(3,344,073)		-	-
Education:						
Tuition	2,963,417				2,963,417	2,422,919
Endowment income	3,683,100		1,671,359		5,354,459	5,087,302
Gifts	-		239,556		239,556	441,327
Education funds released from restriction	1,775,560		(1,775,560)		-	-
Investment return designated for current operations	3,682,563				3,682,563	3,324,643
Contributions and gifts	4,868,541		925,861	$4,824,584	10,618,986	29,555,236
Contributions in kind	237,791				237,791	569,524
Rental income	683,358				683,358	681,800
Communication and publications	283,189				283,189	230,953
Other	210,809				210,809	17,407
Total revenues	116,463,845		1,876,442	4,824,584	123,164,871	132,174,637
Expenses:						
Sponsored research:						
National Science Foundation	32,456,976				32,456,976	32,319,177
United States Navy	16,903,854				16,903,854	16,294,420
Subcontracts	6,921,702				6,921,702	5,602,882
National Oceanic & Atmospheric Administration	5,513,645				5,513,645	5,091,049
Department of Energy	671,558				671,558	760,432
United States Geological Survey	1,150,464				1,150,464	913,216
National Aeronautics & Space Administration	598,067				598,067	752,414
Ships Operations	13,920,251				13,920,251	12,050,433
Submersible and ROV operations	3,854,255				3,854,255	4,267,797
Privately funded grants	3,898,586				3,898,586	2,976,296
Other	11,578,173				11,578,173	7,756,424

Statement of Activities (continued on next page)

Statement of Activities (continued)

	Unrestricted					
	Operating	Sponsored research	Temporarily restricted	Permanently restricted	2002	2001
Education:						
Faculty expense	2,633,267				2,633,267	2,396,656
Student expense	3,591,195				3,591,195	3,134,580
Postdoctoral programs	502,313				502,313	478,479
Other	653,290				653,290	630,559
Rental expenses	527,772				527,772	523,835
Communication, publications and development	1,706,855				1,706,855	1,731,513
Fundraising expenses	1,980,070				1,980,070	1,783,952
Unsponsored programs	4,119,677				4,119,677	3,174,119
Other expenses (Note 12)	2,747,399				2,747,399	2,291,793
Write off of fixed assets	-				-	531,614
Total expenses	115,929,369				115,929,369	105,461,640
Change in net assets from operating activities	534,476		1,876,442	4,824,584	7,235,502	26,712,997
Nonoperating income:						
Investment return (less than) in excess of amounts designated for sponsored research, education and current operations	(13,827,426)		(30,475,544)		(44,302,970)	(31,194,277)
Change in split interest agreements	(23,495)		174,011	(1,403,114)	(1,252,598)	299,554
Change in prepaid pension cost	(1,233,787)				(1,233,787)	2,566,404
Nonoperating expenses:						
Other nonoperating expenses	(302,267)		(366,300)		(668,567)	(204,956)
Net asset transfers - donor redesignation	-		(5,000,000)	5,000,000	-	-
Change in net assets from nonoperating activities	(15,386,975)		(35,667,833)	3,596,886	(47,457,922)	(28,533,275)
Change in net assets from operating and nonoperating activities	(14,852,499)	-	(33,791,391)	8,421,470	(40,222,420)	(1,820,278)
Change in additional pension minimum liability (Note 8)	(5,975,263)	-	-	-	(5,975,263)	-
Total change in net assets	(20,827,762)		(33,791,391)	8,421,470	(46,197,683)	(1,820,278)
Net assets at beginning of year	103,882,474		180,225,206	52,853,780	336,961,460	338,781,738
Net assets at end of year	$83,054,712		$146,433,815	$61,275,250	$290,763,777	$336,961,460

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

Statements of Cash Flows

For the year ended December 31, 2002 (with comparative information for the year ended December 31, 2001)

	2002	2001
Cash flows from operating activities:		
Total change in net assets	$(46,197,683)	$(1,820,278)
Adjustments to reconcile (decrease) increase in net assets to net cash (used in) provided by operating activities:		
Depreciation	3,698,188	3,683,710
Contributions and change in value of remainder trusts	1,252,598	(10,608,626)
Allowance for uncollectible pledges	-	200,000
Discount on pledges	64,446	58,064
Net realized and unrealized (gain)/loss on investments	36,276,953	24,307,603
Accrued pension liability	12,082,593	-
Contributions to be used for long-term investment	(3,094,823)	(1,080,551)
(Increase) decrease in assets:		
Restricted cash	85,164	246,356
Interest and dividends receivable	215,512	88,097
Reimbursable costs and fees:		
Billed	(1,653,014)	(191,914)
Unbilled	(715,534)	(689,393)
Other receivables	(14,435,961)	(73,658)
Pledges receivable	(2,690,068)	779,647
Inventory	(151,821)	(267,897)
Deferred charges and prepaid expenses	(366,405)	(317,893)
Prepaid pension and postretirement benefit cost	(5,091,323)	(2,566,404)
Deferred fixed rate variance	(426,870)	-
Other assets	78,272	478,672
Supplemental retirement	970,260	694,028
Increase (decrease) in liabilities:		
Accounts payable and other liabilities	15,284,111	2,040,160
Accrued payroll and related liabilities	859,707	298,685
Payable for investments purchased	(271,719)	(120,645)
Deferred revenue and refundable advances	(467,733)	(61,427)
Accrued supplemental retirement benefits	(970,260)	(694,028)
Deferred fixed rate variance	(2,196,646)	(1,398,779)
Net cash (used in) provided by operating activities	(7,862,056)	12,983,529

Cash flows from investing activities:		
Capital expenditures:		
Additions to property and equipment	(8,743,124)	(5,045,978)
Disposals of property and equipment	636,734	200,697
Short-term investments:		
Purchase of investments	10,811,667	(5,573,145)
Endowment:		
Proceeds from the sale of investments	252,731,559	197,143,639
Purchase of investments	(264,952,755)	(198,293,388)
Net cash used in investing activities	(9,515,919)	(11,568,175)
Cash flows from financing activities:		
Borrowings under debt agreement	2,977,210	1,146,435
Contributions to be used for long-term investment	3,094,823	1,080,551
Net cash provided by financing activities	6,072,033	2,226,986
Net (decrease) increase in cash and cash equivalents	(11,305,942)	3,642,340
Cash and cash equivalents, beginning of year	25,279,708	21,637,368
Cash and cash equivalents, end of year	$13,973,766	$25,279,708
Supplemental disclosures:		
Interest paid	$109,293	$154,472

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

Report of Independent Accountants

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, 2002 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 2001 financial statements, and in our report dated March 8, 2002, 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, which 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 14, 2003

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, 2001, 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 endowment gains 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 decreases 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.

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 attributable to the Institution's current annual research or educational programs, including a component of endowment income appropriated for operations (see 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 (less than) in excess of amounts designated for sponsored research, education and current operations. Nonoperating revenue also includes the change in value of split interest agreements and the net periodic benefit cost/(income) on the noncontributory defined benefit pension plan.

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. At times the Institution maintains amounts at a single financial institution in excess of federally insured limits.

Included in restricted cash at December 31, 2002 and 2001 is $1,803,162 and $1,890,053, respectively, representing advances received from the United States Navy and other US 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, 2002 and 2001 is $238,993 and $237,266, 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. For investments in venture capital and investment partnerships, the Institution relies on valuations reported to the Institution by the managers of these investments except where the Institution may

reasonably determine that additional factors should be considered.

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.

Options and Futures

An option is a contract in which the writer of the option grants the buyer the right to purchase from (call option) or sell to (put option) the writer a designated instrument at a specified price within a period of time. Premiums received on written options are recorded as negative cost basis until the contract is closed. The liability representing the Institution's obligation under a written option or the Institution's investment in a purchase option is valued at the last sale price or, in the absence of a sale, the mean between the closing bid and asked price or at the most recent asked price (bid for purchase option) if no bid and asked price are available. Over-the-counter written or purchased options are valued using dealer-supplied quotations. Over-the-counter options have the risk of the potential inability of counterparts to meet the terms of their contracts. The Institution's maximum exposure for purchased options is limited to the premium initially paid.

A futures contract is an agreement between a buyer or seller and an established futures exchange or clearinghouse in which the buyer or seller agrees to take (or make) delivery of an amount of an item at a specific price on a specific date (settlement date). Upon entering into a futures contract, the Institution deposits with a financial intermediary an amount ("initial margin") equal to a percentage of the face value of the futures contract. Subsequent payments are made or received by the Institution each day, dependent on the daily fluctuations in the value of the underlying security, and are recorded as unrealized gains or losses. The Institution will realize a gain or loss equal to the difference between the value of the futures contract to sell and the futures contract to buy at settlement date or by closing the contract. Futures contracts are valued at the most recent settlement price.

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 $12,577,096 and $11,106,742 for the years ending December 31, 2002 and 2001, respectively, and is classified in operating revenues (research, education, and operations). The Institution has interpreted relevant state law as generally permitting the spending of gains on endowment funds over a stipulated period of time.

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 72% and 76% of its operating revenues from government agencies including 41% and 44% of its operating revenues from the National Science Foundation and 17% and 17% from the United States Navy in fiscal years 2002 and 2001, respectively. Although applications for research funding to federal agencies historically have been funded, authorizations are subject to annual Congressional appropriations and payment.

Property, Plant and Equipment

Property, plant and equipment are stated at cost. Depreciation is provided on a straight-line basis at annual rates of 8 to 50 years on buildings and improvements, 28 years on vessels and dock facilities, and 3 to 5 years on laboratory and other equipment. Depreciation expense on property, plant, and equipment purchased by the Institution in the amounts of $3,598,212 and $3,583,734 in 2002 and 2001, respectively, has been charged to operating activities. Construction commitments totaled $1,851,000 at December 31, 2002.

Depreciation on certain government-funded facilities (the Laboratory for Marine Science and the dock facility) amounting to $99,976 in 2002 and 2001 has been charged to nonoperating expenses as these assets were gifted by the Government.

Included in construction in process is $1,735,010 and $526,059 at December 31, 2002 and 2001, respectively, relating to campus planning.

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.

Reclassification of Amounts

Certain prior year amounts have been reclassified to conform to the December 31, 2002 presentation.

3. Investments

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

	2002		2001	
	Cost	Market	Cost	Market
U.S. Government and government agencies	$ -	$ -	$10,884,250	$10,706,678
Corporate bonds	52,633,479	53,238,160	39,449,169	39,747,540
International bonds	13,286,797	12,726,162	11,463,914	11,719,036
Equity securities and mutual funds	93,437,150	89,751,465	90,717,251	108,384,925
International equities	43,002,089	36,751,352	42,946,376	38,653,939
Hedge fund limited partnerships	23,920,000	23,523,925	23,920,000	31,516,655
Venture Capital and private equity	21,928,173	15,171,834	15,974,232	14,590,510
Other	99,128	99,128	192,773	192,773
Subtotal investments	248,306,816	231,262,026	235,547,965	255,512,056
Purchased call options	-	-	59,618	21,903
Written call options	-	-	(1,358)	(40)
Written put options	-	-	(20,394)	(485)
Total investments	$248,306,816	$231,262,026	$235,585,831	$255,533,434

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 $5,372,617 and $7,773,970 for the years ended December 31, 2002 and 2001, respectively, including dividends, distributions and changes in the estimated value of such investments.

The following schedule summarizes the investment return and its classification in the statement of activities:

	Unrestricted	Temporarily restricted	2002 Total	2001 Total
Dividend and interest income	$4,684,625	$1,671,359	$6,355,984	$6,106,116
Investment management costs	(1,209,557)		(1,209,557)	(1,233,720)
Net realized gains	61,156	193,252	254,408	1,234,905
Change in unrealized appreciation	(5,862,565)	(30,668,796)	(36,531,361)	(25,542,508)
Total return on investments	(2,326,341)	(28,804,185)	(31,130,526)	(19,435,207)
Investment return designated for:				
Sponsored research	(4,135,422)		(4,135,422)	(3,347,125)
Education	(3,683,100)	(1,671,359)	(5,354,459)	(5,087,302)
Current operations	(3,682,563)		(3,682,563)	(3,324,643)
Total distributions to operations	(11,501,085)	(1,671,359)	(13,172,444)	(11,759,070)
Investment return (less than) in excess of amounts designated for sponsored research, education and current operations	$(13,827,426)	$(30,475,544)	$(44,302,970)	$(31,194,277)

Investment return distributed to operations includes $595,348 and $652,328 earned on non-endowment investments for the years ended December 31, 2002 and 2001, respectively.

Certain losses which would cause individual endowment funds to be reduced below the historical dollar amount contributed by the donor have been allocated to unrestricted net assets. This amounted to $2,537,533 in 2002.

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:

	2002	2001
Unit value, beginning of year	$4.0787	$4.5650
Unit value, end of year	3.4719	4.0787
Net change for the year	(0.6068)	(0.4863)
Investment income per unit for the year	0.0647	0.0655
Total return per unit	$(0.5421)	$(0.4208)

4. Pledges Receivable

Pledges receivable consist of the following at December 31:

	2002	2001
Unconditional promises expected to be collected in:		
Less than one year	$2,101,126	$982,658
One year to five years	2,684,439	1,112,839
Reserve for uncollectible pledges receivable	(200,000)	(200,000)
Unamortized discount	(122,510)	(58,064)
	$4,463,055	$1,837,433

5. Contribution Receivable from Remainder Trusts

The Institution recorded $9,395,272 and $10,819,303 at December 31, 2002 and 2001, 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. 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 (liability), December 31, 2000	$(3,595,425)
2000 indirect costs	39,546,829
2000 adjustment	(63,312)
Amounts recovered	(38,084,738)
2000 change in liability	1,398,779
Deferred Fixed Rate Variance (liability), December 31, 2001	(2,196,646)
2001 indirect costs	44,079,157
2001 adjustment	(8,664)
Amounts recovered	(41,446,977)
2001 change in liability	2,623,516
Deferred Fixed Rate Variance asset, December 31, 2002	$426,870

As of December 31, 2002, the Institution has expended a cumulative amount in excess of recovered amounts of $426,870 which will be reflected as an addition to future year recoveries. This amount has been reported as an asset of the Institution.

7. Loan Payable

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, 2002, $5,485,951 had been drawn down on the loan and was outstanding at year-end. The Institution is required to pay interest on the drawdowns at a variable rate established by the Authority, which was 1.000% at December 31, 2002. The final drawdown has not yet occurred. Once a final drawdown has occurred, a schedule of principal payments will be established by the Authority. The final payment is due on July 1, 2010.

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, 2002, $2,559,211 had been drawn down on the loan and was outstanding at year-end. Drawdowns are expected to occur during an eighteen-month period. During this period, no principal payments are due on the loan, but the Institution is required to pay interest on the drawdowns at a variable rate established by the Authority, which was 1.000% at December 31, 2002. Once the final drawdown has occurred or the eighteen-month period has lapsed, a schedule of principal payments will be established by the Authority until the final payment due on July 1, 2010.

The loan agreements have covenants, the most restrictive of which requires the Institution to maintain unrestricted net assets at a market value equal to at least 1.0x outstanding indebtedness.

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, as well as a supplemental benefit plan which covers certain 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.

	Qualified Plan Pension Benefits	
	2002	2001
Change in benefit obligation:		
Benefit obligation at beginning of year	$142,163,706	$127,889,230
Service cost	5,024,294	3,933,908
Interest cost	10,340,134	9,652,748
Plan amendments	2,628,426	-
Actuarial (gain)/loss	16,311,089	9,003,337
Benefits paid	(7,344,481)	(8,315,517)
Benefit obligation at end of year	$169,123,168	$142,163,706
Change in plan assets:		
Fair value of plan assets at beginning of year	160,254,856	182,595,594
Actual return on plan assets	(18,929,640)	(14,025,221)
Benefits paid	(7,344,481)	(8,315,517)
Fair value of plan assets at end of year	$133,980,735	$160,254,856
Funded status	$(35,142,433)	$18,091,150
Unrecognized actuarial (gain)/loss	29,035,103	(21,492,494)
Unrecognized prior service cost	11,280,744	9,808,545
Net amount recognized	$5,173,414	$6,407,201
Amounts recognized in the statement of financial position consist of:		
Prepaid benefit cost	$ -	$6,407,201
Accrued pension liability	(12,082,593)	-
Accumulated other minimum liability	5,975,263	-
Intangible asset	11,280,744	-
Total amounts recognized	$5,173,414	$6,407,201
Cumulative reduction in net assets attributable to change in additional minimum liability recognition	5,975,263	-
Weighted average assumptions:		
Discount rate as of December 31	6.75%	7.25%
Expected return on plan assets for the year	10.00%	10.00%
Rate of compensation increase as of December 31	3.50%	3.50%
Components of net periodic benefit cost:		
Service cost	$5,024,294	$3,933,908
Interest cost	10,340,134	9,652,748
Expected return on plan assets and reserves	(15,286,868)	(15,167,435)
Amortization of:		
Transition obligation/(asset)	-	(642,223)
Prior service cost	1,156,227	1,175,999
Actuarial loss/(gain)	-	(1,519,401)
Net periodic benefit cost/(income)	$1,233,787	$(2,566,404)

The Institution has reflected the net periodic benefit cost/(income) in non-operating income as the change in prepaid pension cost. In 2002, the Institution recorded the additional minimum pension liability of $5,975,263, which resulted from an unfunded accumulated benefit obligation as of December 31, 2002 due to investment losses on plan assets and the decrease in discount rates.

During the year, the Plan was amended to increase the federal limits on allowable salary as permitted by law. In addition, the determination of the lump sum amounts was updated to reflect the new mortality table. This increased the obligation by approximately $2,600,000.

The Institution also maintains a restoration plan which covers certain employees. Included in the statement of financial position is a payable of $530,044 and an intangible pension asset of $217,780 related to this plan.

	Supplemental Plan Pension Benefits	
	2002	2001
Change in benefit obligation:		
Benefit obligation at beginning of year	$3,243,021	$3,178,410
Service cost	79,154	84,148
Interest cost	216,030	227,879
Plan amendments	2,261	-
Actuarial (gain)/loss	(2,046)	2,918
Benefits paid	(255,871)	(250,334)
Benefit obligation at end of year	$3,282,549	$3,243,021
Change in plan assets:		
Fair value of plan assets at beginning of year	$ -	$ -
Employer contribution	255,871	250,334
Benefits paid	(255,871)	(250,334)
Fair value of plan assets at end of year	$ -	$ -
Funded status	$(3,282,549)	$(3,243,021)
Unrecognized actuarial (gain)/loss	(259,057)	(405,902)
Unrecognized prior service costs	1,946	-
Net amount recognized	(3,539,660)	(3,648,923)
True up to earmarked reserves	(1,954,666)	(2,815,663)
Total earmarked reserves	$(5,494,326)	$(6,464,586)
Amounts recognized in the statement of financial position consist of:		
Supplemental retirement/accrued supplemental retirement benefits	$(5,494,326)	$(6,464,586)

Weighted average assumptions:		
Discount rate as of December 31	6.75%	7.25%
Expected return on plan assets for the year	10.00%	10.00%
Rate of compensation increase as of December 31	3.50%	3.50%
Components of net periodic benefit cost:		
Service cost	$79,154	$84,148
Interest cost	216,030	227,879
Expected return on plan assets	(263,588)	(270,575)
Amortization of:		
Prior year service costs	315	-
Transition obligation	-	127,993
Actuarial loss/(gain)	(26,091)	(39,384)
Net periodic benefit cost	5,820	130,061
Investment return on invested reserves	140,788	184,563
Total periodic cost	$146,608	$314,624

The earmarked reserves are matched by a "Rabbi" Trust with $5,494,326 and $6,464,586, respectively, as of December 31, 2002 and 2001. The true up amount represents the total amount Plan assets are (over)/underfunded compared to the actuarially determined benefit obligation.

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	
	2002	**2001**
Change in benefit obligation:		
Benefit obligation at beginning of year	$24,305,656	$20,694,387
Service cost	529,739	449,011
Interest cost	1,936,615	1,692,874
Actuarial (gain)/loss	4,803,608	2,409,584
Benefits paid	(1,256,870)	(1,046,819)
Plan participants' contributions	141,082	106,619
Benefit obligation at end of year	$30,459,830	$24,305,656
Change in plan assets:		
Fair value of plan assets at beginning of year	$14,532,884	$15,642,206
Actual return on plan assets	(2,419,754)	(1,069,644)
Employer contribution	1,621,939	900,520
Benefits paid	(1,256,870)	(1,046,819)
Plan participants' contributions	141,082	106,619
Fair value of plan assets at end of year	$12,619,281	$14,532,882
Funded status	$(17,840,549)	$(9,772,774)
Unrecognized actuarial (gain)/loss	12,726,764	4,332,017
Unrecognized portion of net obligation/(asset) at transition	8,535,496	9,389,045
Unrecognized prior service cost/(credit)	(2,632,885)	(3,159,462)
Net amount recognized	$788,826	$788,826
Amounts recognized in the statement of financial position consist of:		
Prepaid benefit cost	$788,826	$788,826
Weighted average assumptions:		
Discount rate as of December 31	6.75%	7.25%
Expected return on plan assets for the year	10.00%	10.00%

For measurement purposes, a 10.0% annual rate of increase in the per capita cost of covered healthcare benefits was assumed for 2002 for both pre-65 and post-65 benefits.

These were assumed to decrease gradually to 5.0% in 2010 and remain at that level thereafter.

	2002	**2001**
Components of net periodic benefit cost:		
Service cost	$529,739	$449,011
Interest cost	1,936,615	1,692,874
Expected return on plan assets and reserves	(1,487,375)	(1,568,337)
Recognized actuarial (gain)/loss		-
Amortization of:		
Transition obligation	853,549	853,549
Prior service cost/(credit)	(526,577)	(526,577)
Recognized actuarial (gain) or loss	315,988	-
Net periodic benefit cost/(income)	$1,621,939	$900,520

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

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:

	December 31, 2002	
	1-Percentage Point Increase	1-Percentage Point Decrease
Effect on total of service cost and interest cost:	$ 469,396	$ (367,984)
Effect on the postretirement benefit obligation:	$4,791,050	$(3,856,888)

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 2001. The current indirect cost recovery rates, which are fixed, include the impact of prior year settlements. While the 2002 direct and indirect costs are subject to audit, the Institution does not believe settlement of this year will have a material impact on its change in net assets or its financial position.

The DCAA issued an audit report on the completed audit of direct and indirect costs for the year ended December 31, 2001 on September 3, 2002. The audit resulted in no questioned direct or indirect costs.

The Institution through its endowment fund is committed to invest $55,423,226 in certain venture capital and investment partnerships, of which $25,406,325 has been contributed as of December 31, 2002.

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 2002, the Institution passed through Federal Awards of approximately $708,000 to subgrantee organizations in which an individual at the subgrantee organization is also a member of the Institution's Board of Trustees or Corporation. Additionally, a member of the Board of Trustees is affiliated with a law firm which provides legal services to the Institution. The Institution has purchased insurance services from an insurance company in which an officer of the company is also a member of the Board of Trustees.

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 October, the Institution has been coordinating with its insurance carrier and other interested parties to identify and quantify the damage caused by the fire. At December 31, 2002, the Institution has 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 has established an accrual of approximately $14,859,000 to estimate the costs to be paid in fiscal year 2003 associated with the fire. Included in the accrual but not covered by insurance is 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 has been reflected as a loss on the fire and included in other expenses in the statement of activities. The estimated amounts relating to the fire are subject to revision as more information becomes available.

Editors: Mike Carlowicz, Vicky Cullen, Shelley Dawicki, Danielle Fino, Jim Kent, Lonny Lippsett, Stephanie Murphy, and Tom Nemmers • Design & Production: Jim Canavan