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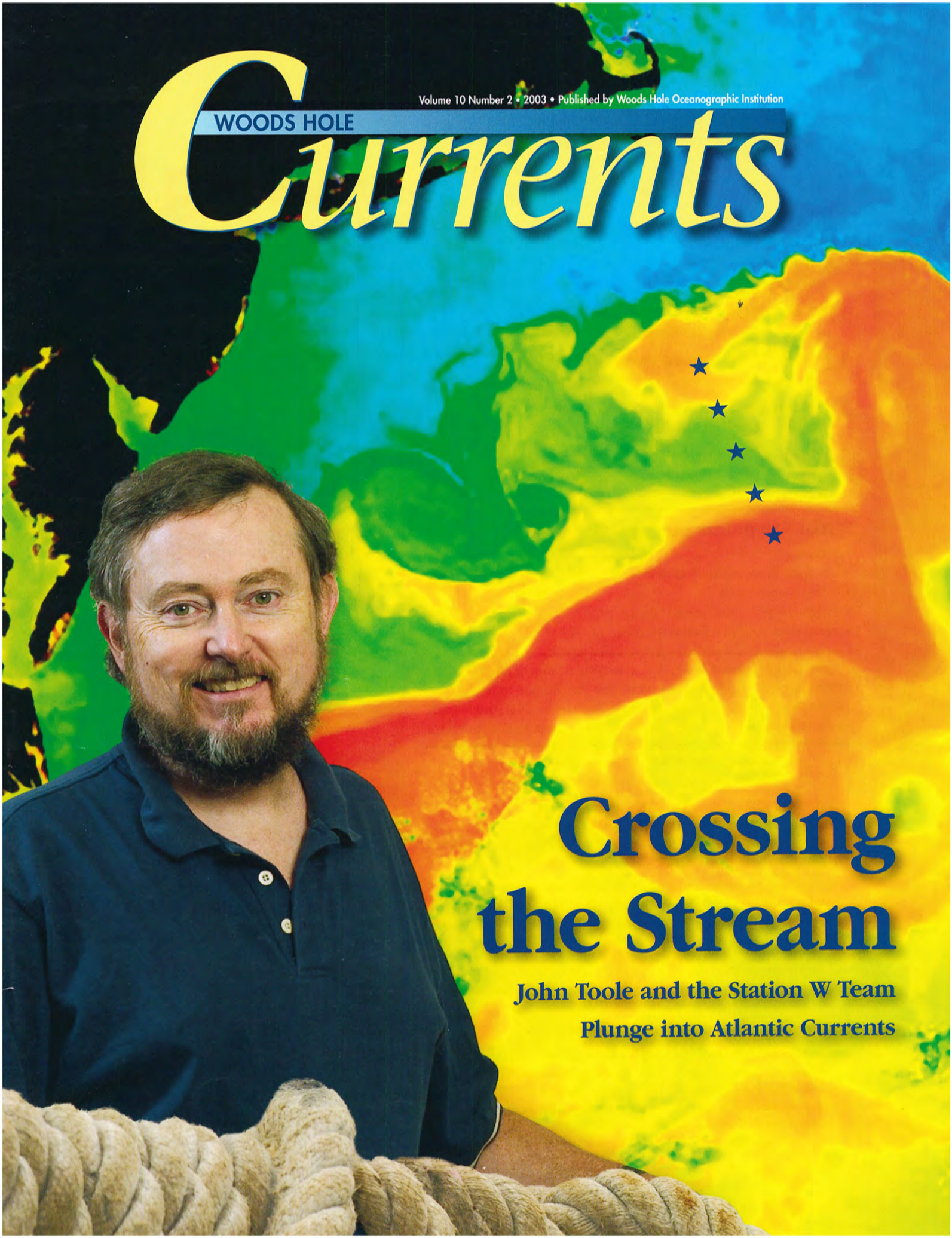
WOODS HOLE Currents



Crossing the Stream

John Toole and the Station W Team Plunge into Atlantic Currents

WOODS HOLE Currents

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COVER: Senior Scientist John Toole is leading a team of physical oceanographers in a program to chronicle the changes in two of the world's most important ocean current systems—the Gulf Stream and the Deep Western Boundary Current. Photos by Tom Kleindinst and NASA.

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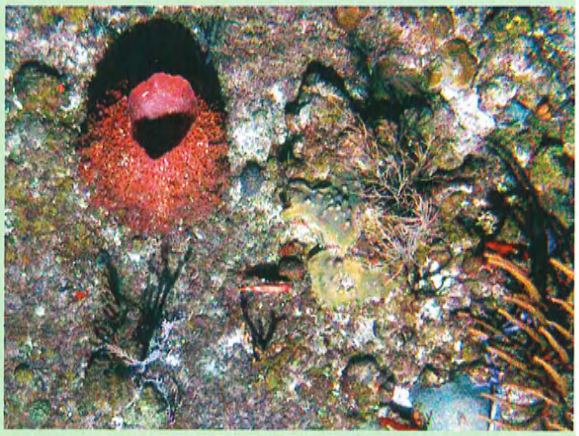
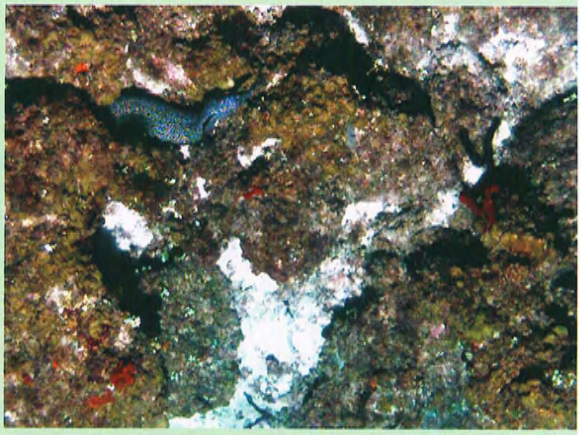
THE WOODS HOLE OCEANOGRAPHIC INSTITUTION is a private, independent, not-for-profit corporation dedicated to research and higher education at the frontiers of ocean science. WHOI's primary mission is to develop and communicate a basic understanding of how the oceans function and how they interact with the earth as a whole. The Institution strives to be a world leader in advancing knowledge about the oceans and explaining their critical role in the global environment.

In Living Co





Corals can grow as deep as light can penetrate the ocean—usually 90 meters (300 feet). But the limits on human divers and the dearth of technologies able to work in mid-water depths has kept a whole realm of corals just out of sight until now.

lor New Vehicle Finds Healthy Coral Reefs

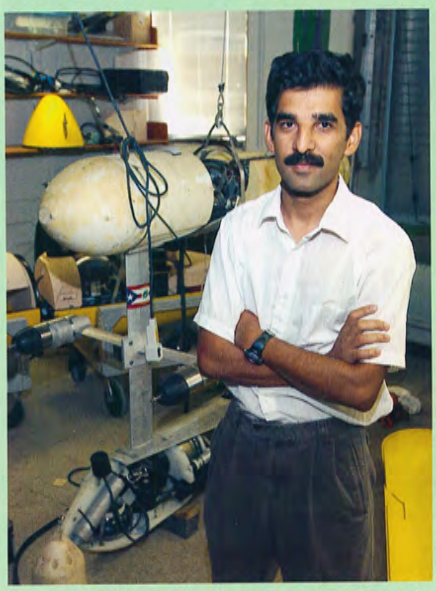
Viewed with human eyes through a diver's mask, coral reefs are atrophying, decaying, and sometimes vanishing. Studies and surveys over the past few decades indicate that corals in the Caribbean Sea and around the world are persistently threatened by disease, pollution, and warming waters, leading to widespread coral mortality in the shallows.

But research conducted earlier this year with electronic eyes revealed a major surprise: coral reefs in the deeper waters of the Caribbean appear to be thriving. More than 7,000 images collected by WHOI Associate Scientist Hanumant Singh and Roy Armstrong of the University of Puerto Rico, Mayaguez, showed corals in intermediate water depths to be in much better health and occupying a significantly larger area than previously thought.

Using Singh's SeaBED autonomous underwater vehicle (AUV), researchers conducted a first-of-its-kind study to determine the health of deepwater coral reefs and the related spawning areas of commercial fishing stocks. They carried out nine missions to the Hind Bank Marine Conservation District and South Drop, two reefs located about 10 miles south of St. Thomas and St. John in the U.S. Virgin Islands. Working at night with underwater strobe lights, the team collected high-resolution color images every three seconds at depths of 30 to 80 meters (90 to 265 feet). Taking the AUV below the safe range for scuba diving, the team found extensive reefs nearly 100 percent covered with living corals.

"Until this survey, we did not know what kind of corals we had, how healthy they were, how deep they extended, how large the reefs were, and what lived there because no one had ever seen them," said Graciela Garcia-Moliner of the Caribbean Fishery Management Council, which assisted in the study. "We had nautical charts of the area, but no maps or images. SeaBED has opened a whole new world to us."

Developed by Singh and colleagues in the WHOI Deep Submergence Laboratory, SeaBED can hover over targets like a helicopter and "fly" slowly in shallow to moderate water depths. The vehicle was designed as a small, low-cost imaging platform and as a test bed for underwater docking and other technologies required for future ocean observatories.



Tom Kleindinst

Hanu Singh and colleagues developed SeaBED to work in underwater regions that are inaccessible or cost-prohibitive for other underwater vehicles.

Tom Kleindinst

Sidescan sonar, cameras, lights, and other instruments are housed in the lower half of SeaBED, with electronics and flotation housed in the upper half.

Armstrong called SeaBED "the perfect tool for this type of project" because it is cost-effective, and it can be deployed and operated by one or two people in a small boat. The AUV can follow the rugged terrain of a coral reef while working as deep as 500 meters (1,600 feet).

Until now, little information was available on the structure and composition of deeper coral reefs. Most corals need light to survive, so they tend to grow within the top 90 meters (300 feet) of the ocean. Since most divers are limited to the top 30 meters (100 feet), and remotely operated vehicles can snag their cables on the rugged terrain, mid-water corals have largely gone unexplored.

Singh and colleagues plan to return to the reefs with SeaBED in October 2004 with new sensors and a wider survey area. The team is planning annual surveys to determine changes in the health of the reef and its inhabitants.

To learn more, visit *www.whoi.edu/DSL/hanu/seabed*

—Shelley Dawicki

A River Runs Through It:

Chronicling the Currents of the North Atlantic

By Mike Carlowicz

In the northwestern Atlantic Ocean, along the edge of the U.S. continental shelf, some of the most important currents in the world are flowing. You can't always see them from the deck of a ship and you don't really notice the flow, except for the occasional mat of *Sargassum* drifting by.

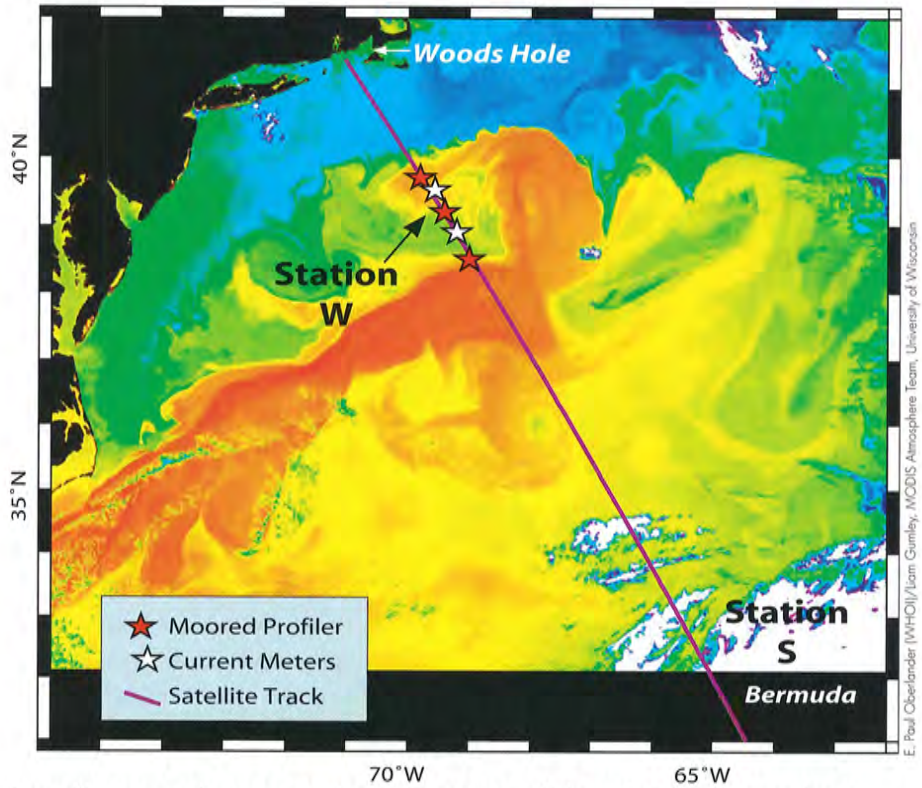
But WHOI Senior Scientist John Toole can see the rivers of water flowing through the ocean. What Toole and his colleagues observe from these vast and deep currents may confirm or change what we know about how the oceans influence global climate.

Their vision is made keen by an instrument Toole has been developing in his mind, his laboratory, and at sea for more than a decade: the moored vertical profiler. The profiler crawls up and down a steel cable anchored to the seafloor and held vertically by floats. It rises to just below the surface and slides back down to the depths (see illustration on page 8). Sensors on the profiler continuously measure the temperature, salt content (salinity), and velocity of water, and then store the data in computer memory.

Ocean scientists have traditionally collected water profiles from research ships, lowering and raising instruments and sampling bottles from the deck. But ocean expeditions to any one spot in the sea are typically rare and short, preventing scientists from gathering anything more than snapshots of what is happening at a few fleeting moments in the ocean. With the advent of the autonomous moored profiler, Toole and other physical oceanographers can repeatedly sample conditions in the same vertical slice of the ocean day after day, for months to years at a time.

Collaborating with European investigators and colleagues in the WHOI Department of Physical Oceanography, Toole has launched a program to use moored profilers and other instruments to gather data on the circulation system of the northwestern Atlantic. They have named the project "Station W" in memory of Valentine Worthington, a pioneering WHOI physical oceanographer and a student of the deepwater currents of the North Atlantic.

The Station W program began in October 2001 with the placement of a mooring in 3000 meters (9800 feet) of water, 320 kilometers (200 miles) southeast of Cape Cod at 69°W longitude. It was the first element of an array of five moorings that will stretch 150 km (93 miles) toward Bermuda.



A satellite image shows sea surface temperatures off the U.S. East Coast; red indicates warm water (the Gulf Stream) and blue shows cooler waters. The full Station W array of moorings will stretch 150 kilometers (93 miles) along a line that follows the ground track of two ocean-observing satellites, which measure changes in the height of sea level (and by proxy, surface current anomalies).

Jim Canavan

Ryan Schrawder (blue hat), Scott Worrilow (white), and Marshall Swartz (orange) ease tag lines and Jeff Stolp (background) motions to the crane operator as the subsurface buoy is lowered over the side. The buoy supports the underlying wire and instruments, holding the mooring vertical in the water column. Inset: Worrilow checks the ARGOS beacon on the subsurface buoy. Signals from the beacon—relayed by satellite—alerted Worrilow to a break in the mooring in November 2002.

The line of moorings will span the continental slope north of the Gulf Stream, the powerful surface current that brings warm, salty waters all the way to Greenland and Northern Europe. It will straddle the other great current system of the western Atlantic, the Deep Western Boundary Current (DWBC), which acts as a pipeline transporting cold Arctic and North Atlantic waters southward (see illustration on page 6). These currents are crucial to the circulation of the Atlantic Ocean, which plays a key role in regulating global climate.

"It is difficult to imagine many sites of greater oceanographic and climatic significance," said Robert Dickson, head of Deep Sea Physical Oceanography at the Centre for Environment, Fisheries, and Aquaculture Science in the United Kingdom.

As Goes the Gulf Stream, So Goes the Climate

In *20,000 Leagues Under the Sea*, Jules Verne wrote: "We then went with the current of the sea's greatest river, which has its own banks, fish, and temperature. I mean the Gulf Stream...we must pray that this steadiness continues because...if its speed and direction were to change, the climates of Europe would undergo disturbances whose consequences are incalculable."

Verne and scientists of the day didn't have much data, but they were aware of just how much the Gulf Stream meant to nations bordering the North Atlantic. What they guessed then, we can prove now. The Gulf Stream brings warm, salty water from the tropics to the high-latitude North Atlantic. As that water moves north, it gives up heat and some moisture to the atmosphere, making climates in Europe much warmer and moister than one would expect for a landmass at such high latitude.

The process leaves behind cool, salty water that is denser than surface waters. In the seas that ring the northern Atlantic—the Labrador, Irminger, and Greenland seas—this dense water sinks to the depths and flows southward. These conduits of cold, deep waters converge into the Deep Western Boundary Current, which flows adjacent to and sometimes beneath the Gulf Stream. This sinking and southward flow draws more warm water north to replace it, and contributes to a worldwide circulation pattern known as the Global Thermohaline Circulation, or the "Great Ocean Conveyor."

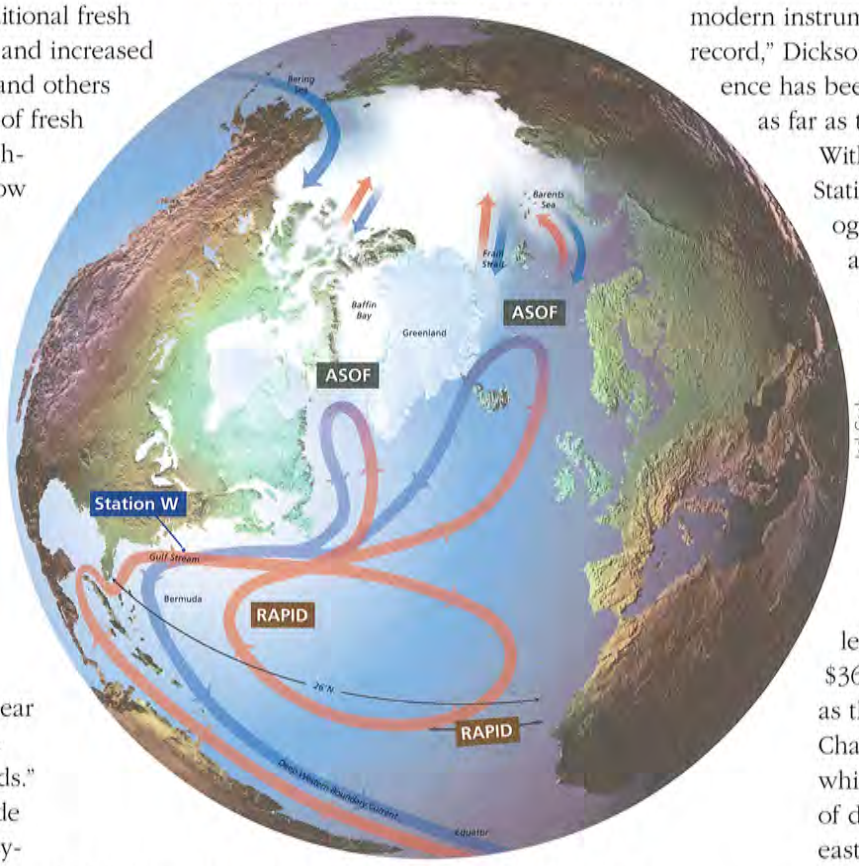
As the world debates global warming and what to do about it, oceanographers are looking for telltale signs that Earth is already changing. Most projections of climate change anticipate a weakening of the circulation in the North Atlantic. Essentially, as greenhouse gases warm the atmosphere, they will cap the Arctic and subarctic seas with additional fresh water from melting ice and increased precipitation. Dickson and others theorize that a blanket of fresh water on top of the high-latitude ocean could slow the sinking of dense, salty waters, thereby slowing the ocean conveyor and altering climate patterns.

"The North Atlantic ocean circulation is a critical component influencing the climate of the Northern Hemisphere," Toole said. "But the ocean's precise role in climate variability remains unclear partially because of the lack of long-term records."

Station W will provide a day-by-day, season-by-season chronicle of the characteristics and intensity of currents flowing through the northwestern Atlantic. Integrating Station W data with that of other ocean observing programs will enable oceanographers to infer changes in the strength of the Gulf Stream and in the intensity and structure of the Boundary Current. It also will advance understanding of how changes in the waters of the Arctic are communicated to lower latitudes. The hope, Toole said, is that these two current systems could provide critical information for analyzing how the ocean ultimately adjusts to climate change.

With signals of global warming emerging from many scientific studies, oceanographers are looking closely to see if the cold, salty waters in the DWBC are growing fresher or warmer. "The supposition is that changes in the Arctic will be transferred south in the ocean circulation," said Dickson, who has been collaborating with Toole and WHOI Research Specialist Ruth Curry. "Station W sits at the first point at which a wide range of upstream influences come together."

"If there is a change in the ocean conveyor," Curry said, "we would see it here."



Jack Cook

Colored arrows approximate two of the major current systems flowing through the North Atlantic, with red representing the warm surface waters of the Gulf Stream, North Atlantic Current, and associated flows, and blue roughly representing the cooler, bottom-flowing Deep Western Boundary Current. Station W will observe limbs of both currents, in conjunction with the British-led RAPID Climate Change Programme and the international Arctic and Subarctic Ocean Flux (ASOF) Study.

Dickson and Curry have seen some intriguing and ominous signs of such a change. In 40 years of data gathering, scientists have observed a decrease in the salinity of the waters in the sub-polar North Atlantic. "The freshening of the whole water column in this great storage basin has been one of the largest changes in the modern instrumented oceanographic record," Dickson said, "and its influence has been tracked south almost as far as the Equator."

With programs such as Station W, physical oceanographers from Europe and North America are starting to build a network of floating and moored observatories that can document variations in the circulation of the Atlantic from the Arctic Circle to the Equator.

British scientists are leading an eight-year, $36-million effort known as the RAPID Climate Change Programme, which will deploy arrays of deep moorings northeast of the Station W line and along another line stretching from Florida to North Africa at 26°N latitude. A joint European and U.S. program called the Arctic and Subarctic Ocean Flux (ASOF) Study will measure currents and water properties in the seas that connect the North Atlantic with the Arctic Ocean. The Research Council of Norway is set to fund a ten-year study of the processes that drive and transform Arctic waters. And the Canadian Department of Fisheries and Oceans will make measurements of flow through the main passageways of the

Canadian Arctic Archipelago.

For their own part, Toole and colleagues were recently awarded $3.7 million from the U.S. National Science Foundation to build and deploy the four additional moorings planned for Station W. From 2004 to 2008, WHOI scientists will make two cruises per year to service the moorings, retrieve data, and make a few traditional hydrographic measurements between Woods Hole and the Sargasso Sea.

The additional moorings will enable scientists to test theories on a wide range of issues relating to ocean circulation and climate. "We have a wealth of theories, every piece approved by models," Dickson said. "The need is to resolve theory, and it is precisely to meet that need that Station W was designed."

Try and Try Again

"Sometimes, bad things happen for a reason," said John Toole a few months after his Station W mooring system broke into pieces in the North Atlantic in the fall of 2002. An ambitious research program had run into a snafu, but it was trouble that Toole would eventually appreciate.

In October 2001, Toole, Senior Engineering Assistant Scott Worrilow, and a WHOI mooring team installed the first piece of the Station W line. It went off without a hitch. When Toole and Worrilow returned in October

What's in a Name?

The tradition of naming ocean stations with letters began in the 1940s when the U.S. Coast Guard and the U.S. Weather Bureau stationed vessels across the Atlantic and Pacific oceans to provide positions and weather reports to transoceanic airplanes. The data collected by these ships have been of great use to ocean science, but weather satellites have diminished the navigational need for "weather ships" (though not the oceanographic need), and just one ship remains.

S Marks the Spot

WHOI Archives

Henry Stommel

Nearly 50 years ago, a group of scientists set out from Bermuda on the 61-foot R/V *Panulirus* and cruised 15 nautical miles to the southeast. They strung Nansen bottles on a cable and collected water samples from the surface to the seafloor. They measured the salinity, temperature, and dissolved oxygen in the water. In the process, they started one of the longest year-round chronicles of the open ocean in the history of science.

Bermuda Biological Station for Research

David Menzel (left) and William Sutcliffe of the Bermuda Biological Station for Research collect samples during a Station S cruise aboard Panulirus *in the late 1950s.*

Approximately every two weeks since June 7, 1954, scientists from the Bermuda Biological Station for Research (BBSR) have returned to the exact spot—32°10'N latitude, 64°30'W longitude—and repeated the process. By November 4, 2003, researchers had made 1,000 samplings at "Station S."

"It wasn't at all clear then what such a series would reveal, or if it would be interesting," said then-WHOI Senior Scientist Henry Stommel, who helped initiate the series along with BBSR Director William Sutcliffe. But Station S has had more impact than the visionary scientists could have imagined.

Data from these profiles of the water column have been widely used for monitoring long-term changes in both North Atlantic circulation and global climate. The importance of the data prompted the establishment of a sister site, the Bermuda Atlantic Time-series Study, in 1988. Together the sites have become a model for other integrated ocean observation programs around the globe, and both projects will figure prominently in the science done by researchers in the Station W project.

"Station S is a perfect tribute to the foresight of the late Henry Stommel, and to his legacy of contributions in advancing the understanding of the oceans," said WHOI President and Director Bob Gagosian during an event commemorating the 1,000th sampling. "Station S continues to be our window into the climate of the North Atlantic. It also underscores the valuable and long-enduring relationship between the BBSR and WHOI."

—Mike Carlowicz and Patrick Hagan

2002 to recover the profiler and its precious data, they found what they hoped for: the instrument had operated for ten months before its batteries ran out. Data from more than 300 transects through the water column were collected at depths between 90 meters and 2950 meters (300 and 9700 feet). The profiler had traveled about 750 kilometers (465 miles) up and down the mooring cable—about the distance from Boston to Washington, DC.

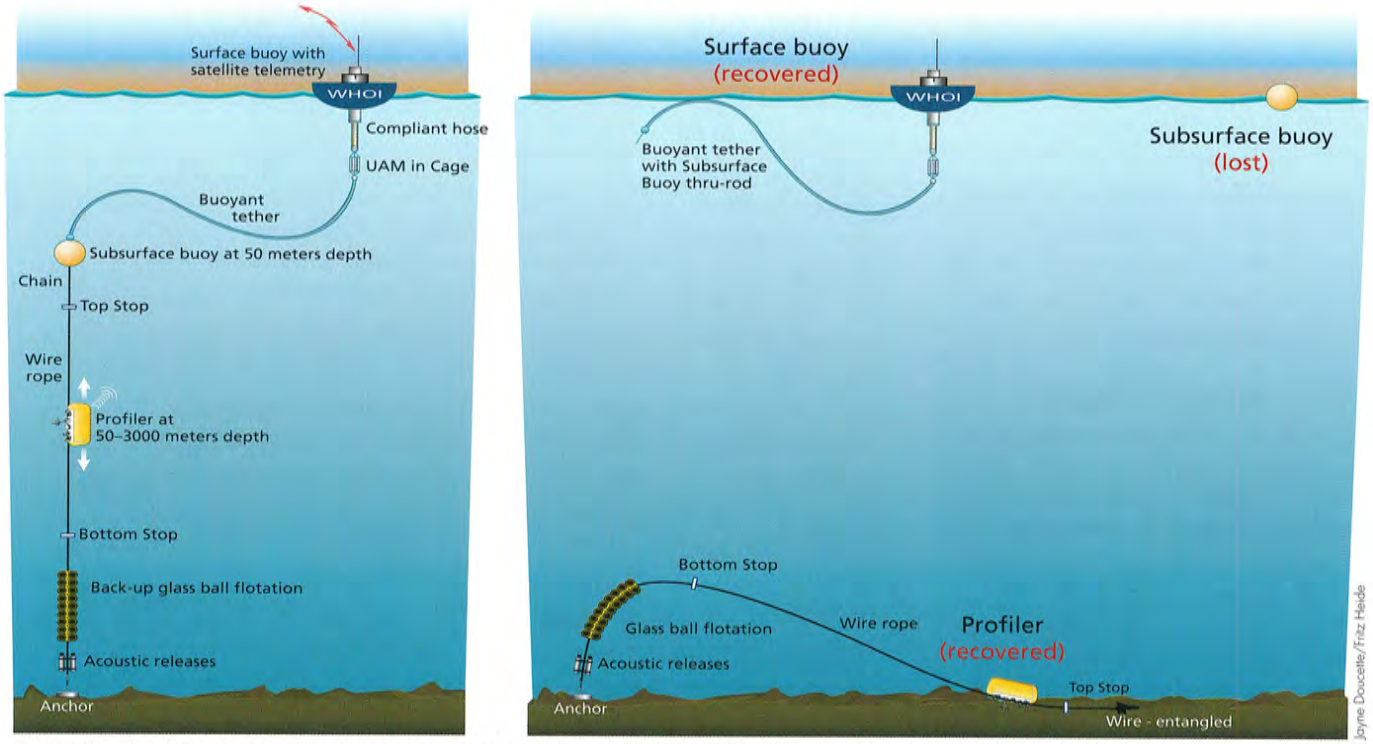
On the same cruise, Toole and Worrilow deployed a replacement mooring, a prototype "telemetering" profiler that could relay data back to shore once a day via satellite. On October 18, 2002, the new mooring was lowered from R/V *Oceanus* into the Atlantic, its surface buoy bobbing and flashing its beacon at the crew.

By Friday, November 9, Worrilow began receiving bizarre readings from the ARGOS satellite system used to track the subsurface buoy. It suggested that the buoy had surfaced. But ARGOS has been known to give erroneous readings from time to time, so Worrilow and colleagues went home for the weekend expecting to find normal readings again on Monday. When Worrilow came in on November 12, the ARGOS signal persisted. Senior Research Specialist Dan Frye examined ARGOS data from the surface buoy and discovered that it, too, was drifting...and not in the same direction. The mooring had broken.

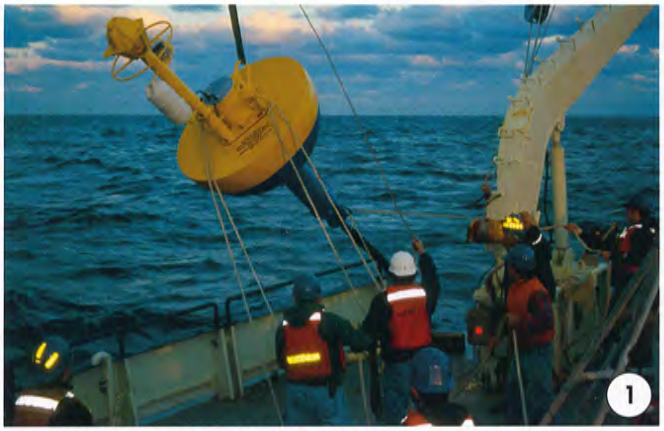
Jim Canavan

John Toole (right) discusses logistics with Captain Larry Bearse on the bridge of R/V Oceanus during the October 2001 expedition to deploy the first mooring.

By November 14, Senior Engineering Assistant John Kemp had chartered a local fishing vessel—the *Morue*, operated by Matt Stommel, son of famed oceanographer Henry Stommel—to find and recover the mooring. In stormy seas, they searched through the night and recovered the surface buoy and tether, but nothing else. The next morning, Kemp located the remaining components (now lying on the seafloor), fired the acoustic releases, and waited for the backup flotation to rise to the surface. Watching on the *Morue*'s echosounder, Kemp saw the glass ball floats rise to 800 feet depth, then stop. The mooring had apparently snagged



Components of the prototype telemetering Station W mooring (left) that was deployed in October 2002. A flaw in a tension rod connecting the surface buoy to the subsurface pieces caused the mooring to break in November 2002 (right). The replacement mooring, re-set in June 2003, includes the same pieces, minus the surface buoy and tether.



Mike Carlowicz

Jim Canavan

The Oceanus crew and Station W science team engage in a well-choreographed series of human and ship motions—conducted over several hours and miles—as they hoist pieces of the mooring into the water. The major pieces include: 1) the surface buoy, 2) the moored profiler, 3) glass-ball floats, and 4) anchor weights. The subsurface buoy is shown on page 5.

on the bottom. Lacking proper equipment and cooperative seas, Kemp and Stommel headed home.

On November 20, Worrilow and Stommel went back to sea with trawling gear and other equipment. They used the echosounder to locate the remains of the mooring, which was still on station. They dragged the fishing gear through the water, and snagged their high-tech catch on the first pass. Nearly all the components were recovered in reusable condition, except for the subsurface mooring sphere and its ARGOS transmitter, which had drifted out of range.

Analyzing the recovered mooring pieces, the team found that a stainless steel tension rod connecting the subsurface components to the surface buoy had broken under the stress of swift Gulf Stream currents. That design flaw, however, turned out to be a savior for Toole. After the recovery, he discovered that the profiler itself was not working. The mooring break prevented what might have been a more heartbreaking outcome: recovering the mooring a year later to find that no data had been collected.

"The mooring break is a reminder of the inherent risks associated with ocean-observing systems," Toole said. "In our efforts to acquire continuous, high-quality observations, we push the limits of technology. The successful recovery of the major components is a testament to WHOI's rapid response capability and to the ingenuity of the engineers and crewmembers."

"Now we've got to do more engineering homework on how to make the subsurface-to-surface data connection work," said Worrilow, who has placed more than 500 moorings and 15 moored profilers in his career.

Until then, the Station W program will continue in its less sophisticated but more reliable configuration. A replacement, subsurface mooring with a new profiler was redeployed at Station W on June 3, 2003, from R/V *Connecticut*. Toole and Worrilow will next head to sea in April 2004 to deploy the full five-element array and to begin collecting the climate signals carried by the great currents of the North Atlantic.

Station W was made possible through the support of The G. Unger Vetlesen Foundation, the WHOI Ocean and Climate Change Institute, and the National Science Foundation. For more information, visit www.whoi.edu/institutes/occi/currenttopics/ct_abruptclimate.htm

Jim Canavan

Jim Canavan

Building the Future

The next milestone is in sight for the reshaping of the WHOI Quissett Campus. In August 2003, the Institution applied to the Cape Cod Commission for permits to construct two new laboratory buildings. The Commission is expected to issue a ruling this winter, and if the decision is favorable, construction will likely begin in spring 2004. Research staff should be working in the new facilities by fall 2005.

The application is the latest phase of a campus redevelopment that began in 2001. In response to the evolving nature of modern oceanographic research, WHOI set up a campus-planning group to evaluate needs and priorities in the village of Woods Hole and on the Quissett Campus. Scientists and engineers increasingly collaborate across disciplines and push the limits of vehicle and instrumentation capabilities. Lab and shop space has become cramped, and travel between campuses has become more frequent as new partnerships have formed between staff in the Village and Quissett.

The planning group concluded that simple renovation of existing facilities would be inadequate to fulfill the Institution's mission over the next quarter century. Space constraints have made it difficult to build new labs in the Village, so the focus turned to the 183-acre Quissett Campus.

In June 2002, WHOI began the first phase of the master plan: construction of a ring road to move vehicle traffic to the periphery of Quissett and to create a pedestrian core in the heart of the campus. The ring road was finished in the spring of 2003. The next phase of campus redevelopment calls for the construction of 68,000 square feet of laboratory space in two new buildings in the center of the Quissett Campus. Additions and upgrades are also being planned for McLean Laboratory (adding 12,170 square feet) and the Central Heating Plant.

—Tom Nemmers

Bird's Eye View

Relocation of scientists and technicians from the Village to the Quissett Campus will ease space pressure on the Village-based departments of Biology and Applied Ocean Physics and Engineering, and on the National Deep Submergence Facility. Preliminary master planning for the Village has begun.

Dave Gray

A new building was completed in December 2002 on the Quissett Campus for the Graphic Services group, formerly located in the Village.

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All information is strictly confidential and used only for helping us improve WHOI publications. Thank you.

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❑ Less than 5 minutes ❑ 5-30 minutes ❑ More than 30 minutes

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❸

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In Living Color			
A River Runs Through It			
Building the Future			
Making Sense of Noise in the Ocean			
Medical Training Gets Put to the Test			
The Sounds of Science			
Remembrance: Cecil Howard Green			

❹

Why did you read certain articles (or not)?	Previous interest in subject	Attracted by artwork/ photos	Good storytelling	Too long	Too technical	Not relevant to me
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WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

Please take five minutes to help us make Currents a better magazine.

Mike Carlowicz,

Remove at perforation and drop into th

The Marine Research Facility will provide 32,000 square feet of work space on two floors. The ground floor will house a computed axial tomography (CAT) scanner, plus labs and service access. The upper floor will consist of labs, offices, and shared spaces.

Two New Buildings

The Biogeochemistry Building will include two floors and 36,000 square feet, with flexible lab and office blocks and shared spaces on each floor. The design concept is to create "neighborhoods" within each building, with staff from nearly all departments—including some currently located in the Village—moving into the new neighborhoods.

Tom Kleindinst

Andrea Thorrold (left) and Deborah Smith are leading WHOI in its regional education project.

WHOI Moves Toward the Head of the Class

Half of the U.S. population—nearly 140 million people—lives in coastal counties, but few students or citizens ever learn much about the ocean or meet the people who study it. At the same time, scientists are increasingly being asked to get involved in educating the public, though many do not have the time, resources, or training to do so.

In 2000, a group of concerned ocean scientists and educators organized a workshop to help bridge this gap. Participants proposed that research institutions, formal educators (K-12 and collegiate), and informal education groups (aquaria, museums, and science centers) should find a way to work together to improve ocean science literacy. These teams would collaborate to bring more current research into education, to increase the involvement and impact of scientists, and to raise public awareness. The result was the establishment of seven Centers for Ocean Science Education Excellence (COSEE), funded by NSF's Division of Ocean Sciences.

Late in 2002, NSF awarded a $2.5-million grant to establish the New England Regional COSEE, a collaborative effort proposed by the New England Aquarium (NEAq), WHOI, and the University of Massachusetts. The program will last five years. An advisory board of researchers and educators will help steer the operations.

"This new partnership combines the strengths and capacities of three well-known institutions," says New England COSEE director Carolyn Levi of the New England Aquarium. "It creates a synergy whereby educators, researchers, and citizens can build awareness of the importance of the ocean in our region and in our lives."

The COSEE@WHOI team is led by Deborah Smith, senior scientist in the

In its first year, COSEE@WHOI:

- Established a Web clearinghouse for information at *cosee.whoi.edu*
- Hosted a talk by James Yoder, director of NSF's Geosciences Division, about the requirement that researchers identify the broader impacts of their research.
- Conducted surveys and interviews with researchers, students, and administrative staff to chart existing education and outreach activities, and to identify what services or information would help researchers better match their time with outreach efforts.
- Developed a listing of different types of outreach for scientists, describing the activities, the amount of preparation and time involved, and the appropriate contacts for more information.
- Planned a lecture series on education and cognitive science.

Ru Morrison

Associate Scientist Scott Gallager of the Biology Department discusses use of a plankton net with teachers attending a workshop in October 2003.

Geology and Geophysics Department, and Andrea Thorrold, program coordinator. They are supported by staff from Academic Programs, Woods Hole Sea Grant, and Communications.

"As we developed the national COSEE plan, I realized that it was a great opportunity for WHOI," said Smith, a participant in the workshops that spawned the COSEE initiative. "We have a chance to be a leader among science institutions in coupling research with education."

Within the New England COSEE, each institution is focusing on a different audience while participating in each other's events (see box, opposite page). In the summer of 2003, the University of Massachusetts team (led by Bob Chen) held an ocean science institute for middle school teachers. In November, the New England Aquarium team (led by Levi and Billy Spitzer) hosted a meeting to establish partnerships between ocean scientists and educators from science centers and museums.

—Kate Madin

Did *You* Know?

- Only 15 percent of Americans feel "well-informed" about science, according to a 2001 survey by the National Science Foundation (NSF). Nearly 35 percent say they are "poorly informed."
- According to that NSF survey, only half of U.S. adults know that humans did not coexist with dinosaurs...that it takes Earth one year to revolve around the Sun...that antibiotics do not kill viruses.
- A similar survey conducted for The Ocean Project found that 79 percent of Americans did not know the oceans produce more oxygen than forests, and 61 percent didn't realize there is more life in the oceans than on land.

Making Sense of Noise in the Ocean

Photo-Op

Peter Tyack on Capitol Hill

WHOI Senior Scientist Peter Tyack of the Biology Department recently testified before the Subcommittee on Fisheries, Conservation, Wildlife, and Oceans of the Resources Committee of the U.S. House of Representatives. Discussing a bill to reauthorize the Marine Mammal Protection Act (MMPA), Tyack made the following comments on July 24, 2003:

"I have been fascinated since I was a child with the social behavior of marine mammals and how they use sound to communicate and explore their environment. As I started my career in basic research, it never occurred to me that chasing my personal interests would ever become central to such an important policy issue...

The dominant source of manmade noise in the ocean is the propulsion sounds from ships, which account for more than 90 percent of the acoustic energy humans put into the sea...Studies have demonstrated that marine mammals respond to ships, dredging, icebreaking, construction, and sound sources such as pingers, air guns, and sonars. Most of these sound sources are currently unregulated simply because the National Marine Fisheries Service (NMFS) chooses not to enforce the prohibition against taking marine mammals by 'harassment'...

Ships regularly collide with marine mammals and often kill them. So many highly endangered right whales are killed by vessel collision that population models predict this additional mortality may drive the species to extinction. Yet there is no regulation of this risk.

Many users of sound in the sea—from the Navy to geophysical contractors to academic oceanographers—find themselves in a no-man's land, where the appropriate regulatory process for incidental harassment takes is obscure...We cannot protect marine life from intense underwater noises until we get better at detecting when a marine mammal or sea turtle is in the danger zone...

It is ironic that NMFS has grown an elaborate process for permitting negligible harassment by researchers, while ignoring widespread and predictable lethal takes caused by activities that do not benefit marine mammals...I am very concerned that the current permitting process will hold scientific research that enhances the survival or recovery of species or stocks to a stricter standard than activities that harm marine mammals."

New England Aquarium

A right whale mother and her calf.

Medical Training Gets Put to the Test

By Mike Carlowicz

It was supposed to be a routine transit cruise from Woods Hole to meet a research expedition originating out of Fortaleza, Brazil. R/V *Oceanus* set out in fair weather, but in just a matter of hours Captain Larry Bearse and crew were caught by a rapidly developing winter storm. With winds whipping up to 30 knots, the ship began to pitch and roll.

The relief mess attendant, Kathleen Uto, was working with steward Chris Moody in the storeroom, carrying sacks of flour, when the ship lurched abruptly. Uto was catapulted through a watertight door opening, crashing headfirst into a steel bulkhead. Moody picked himself up off the storeroom floor, found Uto in a heap in the passageway, and called the bridge for help.

Blood pulsed from Uto's scalp as First Mate Courtenay Barber and Captain Bearse arrived. They tried to stem the flow of blood and assess her vital signs before moving her to a berth closer to the ship's center of gravity, where motion would be less. Ship's Mate Diego Mello, on the bridge of the ship, called for medical assistance on the satellite phone before trading places with Bearse.

Barber and Mello are trained to provide medical care for everything from heart attacks to broken bones when a shipmate is injured at sea, but it's a skill they would rather not have to use. For two days in January 2003, Mello and Barber put those medical skills to work.

For crews on all WHOI-operated vessels, the incident aboard *Oceanus* offered a fresh reminder of the importance of medical training. All crewmembers on WHOI-operated ships must complete courses in basic first aid, said Mike Brennan, Marine Personnel Coordinator. Ten crewmembers also have completed "medical personal in charge" (MEDPIC) courses offered by the Maritime Institute of Technology and Graduate Studies, a continuing education center based in Maryland. Every cruise carries at least one certified MEDPIC.

C.A. Linder

R/V Oceanus and other WHOI-operated ships come equipped with medical supplies, at least one trained medic, and a lifeline to round-the-clock medical advice.

Tom Kleindinst

Ship's Mate Courtenay Barber (left), Captain Larry Bearse (center), and Ship's Mate Diego Mello display the medical supplies they used to treat an injured crewmember.

These shipboard medics do not take the place of licensed medical professionals. They are instructed in basic diagnostic procedures, CPR, medical reporting procedures, and the use of automated external defibrillators and various medications. But their main job is to be the eyes, ears, and hands of a land-based doctor at Medical Advisory Systems (MAS), a 24-hour medical center patched in by satellite phone.

WHOI ships are also equipped with medical supplies recommended by MAS. The supplies are organized and numbered so that a shore-based doctor can call up a computer profile and know exactly what tools and medicines are available to the MEDPIC. (These procedures are mandated by the federal agencies that control the vessels in the U.S. academic research fleet.)

This medical response system was tested when Uto got injured. Barber and Mello applied compresses to her head, but every time they seemed to stop the bleeding, blood would flow

again. Between the rolling ship and Uto's thick, dark hair, it was difficult to assess what was wrong. The MAS support team was concerned about possible unseen trauma, such as a cracked skull, internal hemorrhaging, or a blood clot in the brain. Applying stitches was out of the question. "Envision attempting this on a roller coaster in motion," Bearse said, "and I think you get the idea."

Bearse diverted the ship toward Saint Georges, Bermuda, to set up a medical evacuation. But the nearest land was 30 hours away and the storm was continuing to intensify. In the best weather, *Oceanus* can cruise at 14 knots. Making a steady 12 knots, the ship was knocked about by Force 10 winds (over 55 knots) and seas of 20 to 40 feet. The ship repeatedly rolled 25 to 40 degrees, sometimes 55 degrees.

The ship's crew of twelve was suddenly down to eight. With Uto injured and Barber, Mello, and a rotating shift of helpers tending to their injured shipmate, "sleep and rest became a rare commodity," Bearse said. "Sacrifices had to be made, watches and duties juggled. But it was never necessary to give orders. The entire crew excelled."

Through the pitching and rolling and sleep deprivation, Barber and Mello had to keep Uto sitting up to prevent excessive bleeding. They braced her, and themselves, from sliding off the settee by sandwiching themselves around her for support.

When *Oceanus* finally approached Saint Georges a day later, no weather-worthy helicopters or rescue vehicles were available. (Since the U.S. Navy pulled out of Bermuda, the island has been short of search-and-rescue capability.) A pilot boat ushered the ship into the harbor for a rare night docking.

Doctors met the ship at the dock and rushed Uto to the hospital, where she received many layers of stitches and spent the night. Uto was subsequently flown back to the United States for further treatment and recovery, and *Oceanus* departed for Brazil, short one crewmember. Uto has since recovered from her injuries and is living in Charleston, SC.

"The medical training I received was absolutely critical," Barber said. "I had a degree of confidence, and skill that I would not otherwise have."

But he added a note of caution. "Good medical training is an ongoing process," Barber said. "Unlike EMTs ashore who practice their skills daily, we have long dry spells and, quite frankly, become rusty. Because we practice our craft so infrequently, it is important to attend refresher courses and continue our education."

"Someone once said that going to sea involves long periods of boredom punctuated by moments of terror," Barber said. He now cherishes the boredom a bit more, but he is equipped for the terror.

Sounds of Science

Armed with her dissertation and diploma, MIT/WHOI Joint Program student Carolyn Gramling spent this fall doing what most freshly minted scientists do: working in the field. But her tools weren't the chemical analyzers and radioactive tracers of her days in Woods Hole. Instead, she used microphones and minidisk recorders.

Gramling hit the airwaves in September as a radio journalist, fulfilling a fellowship in science journalism at a National Public Radio station in Columbus, Ohio (WOSU-AM). During the 10-week program, she reported, wrote, and delivered radio broadcasts on a wide range of science topics as a "Mass Media Fellow." Gramling's fellowship was sponsored by the American Geophysical Union.

As a science reporter, she developed stories ranging from the investigation of the space shuttle *Columbia* accident to wetland restoration to groundwater discharge—the topic of the thesis she defended last spring. Prior to the fellowship, Gramling was a contributing writer for the online publications *Geotimes* and *The Wire*, and in August 2002, she won a writing contest for her account of living through Hurricane Andrew.

Tom Kleindinst

Carolyn Gramling

She learned of the media fellowship while researching ways to marry her interests in science and writing. "There's all this jargon that scientists can understand, but it quickly leaves others behind," she said. "I think science communicators can be ambassadors for science."

Gramling is the first MIT/WHOI graduate to receive a Mass Media Fellowship, said Judy Kass, director of the 30-year-old fellowship program administered by the American Association for the Advancement of Science. According to Kass, Gramling was one of just 18 fellows chosen from 170 applicants.

To learn more about Gramling, read her journal, and listen to her radio reports, visit *www.whoi.edu/home/education/student_gramling.html*

—Amy E. Nevala

Ocean Science 101 for Journalists

Journalists from several leading print and electronic media gathered in Woods Hole from September 14 to 19 for a crash course in oceanography. The fourth annual Ocean Science Journalism Fellowship Program included more than forty hours of seminars, field trips, laboratory tours, and meetings between scientists and the media professionals who cover them.

Tom Kleindinst

Research Specialist Jim Broda of the Geology and Geophysics Department describes sediment cores to (foreground, left to right) Beth Daley of The Boston Globe, *Rebecca Perry of* The Los Angeles Times, *and Mary Carmichael of* Newsweek. *Amy Nevala, WHOI science writer, is in the background.*

"The goal is to give the media a well-rounded introduction to oceanography and to open their eyes to the resources and expertise that WHOI can offer," said Shelley Dawicki, WHOI director of public and community relations. The fellowship program began in 2000, with 33 journalists participating to date.

Each day the journalists focused on a different aspect of ocean science based on the five principal research departments of the Institution—Biology, Marine Chemistry and Geochemistry, Applied Ocean Physics and Engineering, Geology and Geophysics, and Physical Oceanography. On a field trip led by Scientist Emeritus George Hampson, Retired Dockmaster Hovey Clifford, and »»

Going Home Again

Photos by Tom Kleindinst

Biological samples borrowed nearly 70 years ago from the Zoological Museum in Copenhagen were discovered in a WHOI warehouse and returned to Denmark this summer. The samples were originally procured for research by the first WHOI Director, Henry Bigelow, and his just-graduated student Mary Sears.

Sears traveled to Copenhagen in 1934 to sort and ship gelatinous zooplankton that had been collected by the scientific crew of the Danish vessel *Dana* during an expedition to the western and southwestern Pacific in the late 1920s. The borrowed samples remained in Sears' Bigelow Laboratory office until she retired in the 1970s, and then were moved to the biology specimen warehouse. Overcrowding in the warehouse prompted WHOI staff to contact the Copenhagen Museum. Oceanographer Emeritus George Hampson (left) and WHOI volunteer George LeRoy sorted and organized the samples, which ranged in size from vials to Mason-jar equivalents. They packed up several thousand wet and dry samples—filling two four-by-four-foot crates—and sent them back across the Atlantic this spring.

Hamson and LeRoy also found other notable samples in Mary Sears' collection. One bottle (above left, in Hampson's hand) from Pacific Grove, California, was hand-labeled in 1929 by Ed Ricketts, the biologist who inspired the character "Doc" in John Steinbeck's novels *Cannery Row* and *Sweet Thursday.*

—Vicky Cullen

Scottish marine biologist John Allen, the group cruised Nantucket Sound on R/V *Asterias* to dredge for marine life, study bivalves, and discuss shipboard operations.

"Most science reporters are generalists," Dawicki noted. "Today they might cover cancer, tomorrow astronomy, and climate change the next day. Our fellowships give them a chance to learn a lot about the oceans in a short period, and to meet great sources for future stories. The program also allows us to educate scientists about how the media works."

The journalists who participated in the 2003 program were: Steven Ashley, an editor for *Scientific American*; Mary Carmichael, an assistant editor at *Newsweek*; Beth Daley, an environmental reporter for *The Boston Globe*; Michael Fincham, a freelance science writer and television producer; Rebecca Perry, an editorial artist for *The Los Angeles Times*; Peter Spotts, a science and technology correspondent for *The Christian Science Monitor*; and Donna Vaughan, a research producer for ScienCentral, Inc. Spotts and Vaughan stayed for a second week of more intense research and reporting with WHOI scientists.

—Amy E. Nevala

Comments on *Currents*?
Send corrections, questions, and ideas to Mike Carlowicz, editor, at mcarlowicz@whoi.edu or 508-289-3771

Institute Fellows Cut Across Disciplines

The four WHOI Ocean Institutes were established in 2001 to build bridges between scientific disciplines, to catalyze innovative thinking, and to shorten the time between acquiring knowledge and making it accessible to decision makers. In that spirit, each Institute has established fellowships to help scientists focus on broader, interdisciplinary issues and to launch high-risk, high-reward research that would not otherwise receive funding from traditional sources. The fellows are awarded two to three months of salary support per year for a three-year term.

Coastal Ocean Institute & Rinehart Coastal Research Center

Heidi Sosik (Biology, BIO) combines satellite observations with *in situ* measurements to develop new models of how the physics of the coastal ocean affects the growth of microscopic plants. Her fellowship is jointly held with the Ocean Life Institute.


Tom Kleindinst

Heidi Sosik

John Trowbridge (Applied Ocean Physics and Engineering, AOPE) focuses on the physical processes—such as turbulence and sediment transport—that drive changes in biological activity.

Matt Charette (Marine Chemistry and Geochemistry, MCG) uses naturally occurring radioisotopes and trace metals to investigate the flow of groundwater into the sea.

Wade McGillis (AOPE) studies the interactions between the ocean and atmosphere, particularly the exchange of carbon dioxide.

Deep Ocean Exploration Institute

Gregory Hirth (Geology and Geophysics, G&G) uses his understanding of the physical properties of rocks to study cracking in the oceanic crust and how it might influence where microbes live.


Tom Kleindinst

Wolfgang Bach

Wolfgang Bach (MCG) investigates mineral-microbe interactions in the crustal and mantle rocks of seafloor hydrothermal systems.

Meg Tivey (MCG) leads a cross-departmental, interdisciplinary group of scientists and engineers with a common interest in building underwater observatories in diverse marine environments.

Jean Whelan (MCG) studies natural gas seeps along the U.S. continental margins, and is building an *in situ* methane sensor to explore for new seep areas and measure the gas being vented.

Dana Yoerger (AOPE) is developing remotely operated and autonomous underwater vehicles that provide access to the deep ocean, including seafloor observatories.

Ocean Life Institute

Cabell Davis (BIO) works with engineers at WHOI, MIT, and Monterey Bay Aquarium Research Institute to combine high-resolution digital holography, *in situ* DNA analysis, and autonomous underwater vehicle technology for identifying and mapping plankton species.

Ken Buesseler (MCG) uses radionuclides to study how fast materials are transferred from the ocean's surface to deep water, and how differing ecosystems control the efficiency of this "biological pump."


Dave Gray

Konrad Hughen

Darlene Ketten (BIO) applies computed tomography (CT) scanning, X-ray imaging, and visualization to the study of marine mammal hearing and behavior.

Simon Thorrold (BIO) conducts geochemical analysis of fish otoliths (ear bones) and carbonate structures (shells, statoliths, etc.) to discover migration pathways and to track larval dispersal of marine fishes and invertebrates.

Ocean & Climate Change Institute

Scott Doney (MCG) constructs models and develops observational strategies to improve our understanding of how the ocean carbon cycle responds to climate change.

Konrad Hughen (MCG) develops high-resolution reconstructions of past climates, ocean circulation, and atmospheric chemistry.

Lloyd Keigwin (G&G) reconstructs and analyzes the recent geologic history of ocean circulation and climate change.

Ray Schmitt (Physical Oceanography, PO) studies the global water cycle and how changes to it may affect ocean circulation and climate variability.

John Toole (PO) leads an effort to establish Station W, a long-term observing system for the Deep Western Boundary Current region of the North Atlantic (see page 4).

—Mike Carlowicz

Remembrance: Cecil Howard Green

Cecil Howard Green, philanthropist and co-founder of Texas Instruments, took special joy in giving away more than $200 million to scientific and educational institutions during his 102-year lifetime. "Our giving has been an investment in pleasure and satisfaction," he said. "If you don't give it away, a bunch of strangers will be giving it away for you. Why not do it yourself while you're still around?"

As a man who built a career on the development of scientific instrumentation, Green appropriately endowed a program to promote advances in leading-edge technologies at WHOI. The Cecil H. and Ida M. Green Technology Innovation Awards were established in the 1990s to provide initial funding of $20,000 to $30,000 for inventive and groundbreaking ideas.

Many of these seemingly small seeds have already borne fruit. For instance, an inter-departmental team including Richard Krishfield, Ken Doherty, John Toole, and Andrey Proshutinsky received $30,000 in 2002 to begin development of expendable moored profiling systems that could be suspended below pack ice for sustained observation of the waters beneath polar caps. This year, that seed blossomed into $650,000 from the National Science Foundation to construct and field-test prototype ice-tethered profilers in the central Arctic.

Terri Corbett

Cecil Howard Green
August 6, 1900 to April 12, 2003

Andy Bowen, Alan Chave, and Joe Coburn used Green Technology funding in 1996 to study the feasibility of using an abandoned telephone cable to support a seafloor science observatory halfway between Hawaii and California. In 1998, the team established the Hawaii-2 Observatory, which still stands as the only U.S.-operated deep-ocean observatory.

Green started his career as a geophysical prospector for petroleum. In 1941, Green and three partners bought Geophysical Service Inc., and built it into a world leader in geophysical exploration. During World War II, the company began the electronics work that gave rise to Texas Instruments, where Green served as a vice president and director.

Green worked as hard at philanthropy as he did at business, once noting "the idea is to get down to my last nickel before I die." From 1950 through early 2003, his Foundation endowed scores of academic chairs, fellowships, and scholarships, and contributed to the construction of several hospitals, schools, college buildings, and research facilities.

Green gave not just money, but insight. In a commencement address to the MIT/WHOI Joint Program class of 1980, Green urged graduates to look beyond their own interests and egos.

"You must develop one all-important ability—being able to enlist the help of other people. You have to reach a state where others want to help you. This includes giving credit... which will come back to you a hundredfold. Your reputation stems from what people say when you're not present."

—Mike Carlowicz

A Gift That Gives Back

How do you secure a competitive rate of return on your assets while supporting innovative research at the same time? Make a contribution to the WHOI Gift Annuity Program.

For instance, instead of rolling over a bank certificate of deposit paying 3.3 percent, you could use of gift of $20,000 to establish an 8.0 percent charitable gift annuity (CGA). WHOI would agree to pay a fixed, guaranteed income of $1,600 each year for life. You not only receive a higher return on your money, but you make a meaningful gift to support ocean research.

Establishing a CGA is easy and straightforward. To learn more, contact Lesley Reilly, Director of Planned Giving, at 508-289-3313 or lreilly@whoi.edu.

Age	Payout	Charitable Deduction	Annual Income	Tax Free Portion
65	6.0%	$6,450	$1,200	$680
70	6.5%	$7,372	$1,300	$794
75	7.1%	$8,452	$1,420	$931
80	8.0%	$9,499	$1,600	$1,116
85	9.5%	$10,277	$1,900	$1,430
90	11.3%	$11,286	$2,260	$1,778

These calculations are based on the October 2003 IRS discount rate (4.4%). This rate varies slightly from month to month. Returns are based on the age and number of beneficiaries.

Shedding Light on the Arctic Ocean

In the fall of 2003, the Arctic Edge science team returned to the Western Arctic Ocean to retrieve and redeploy an array of moorings placed in 2002 to observe one of the world's least-studied bodies of water. Their instruments are designed to measure the complex ocean circulation processes between the Pacific and Arctic oceans, with an eye on how that interaction affects regional and global climate. The more immediate question is: how did the instruments and moorings fare after a year in the ice-filled waters? Find out by visiting www.whoi.edu/arcticedge. Photos by C.A. Linder.

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