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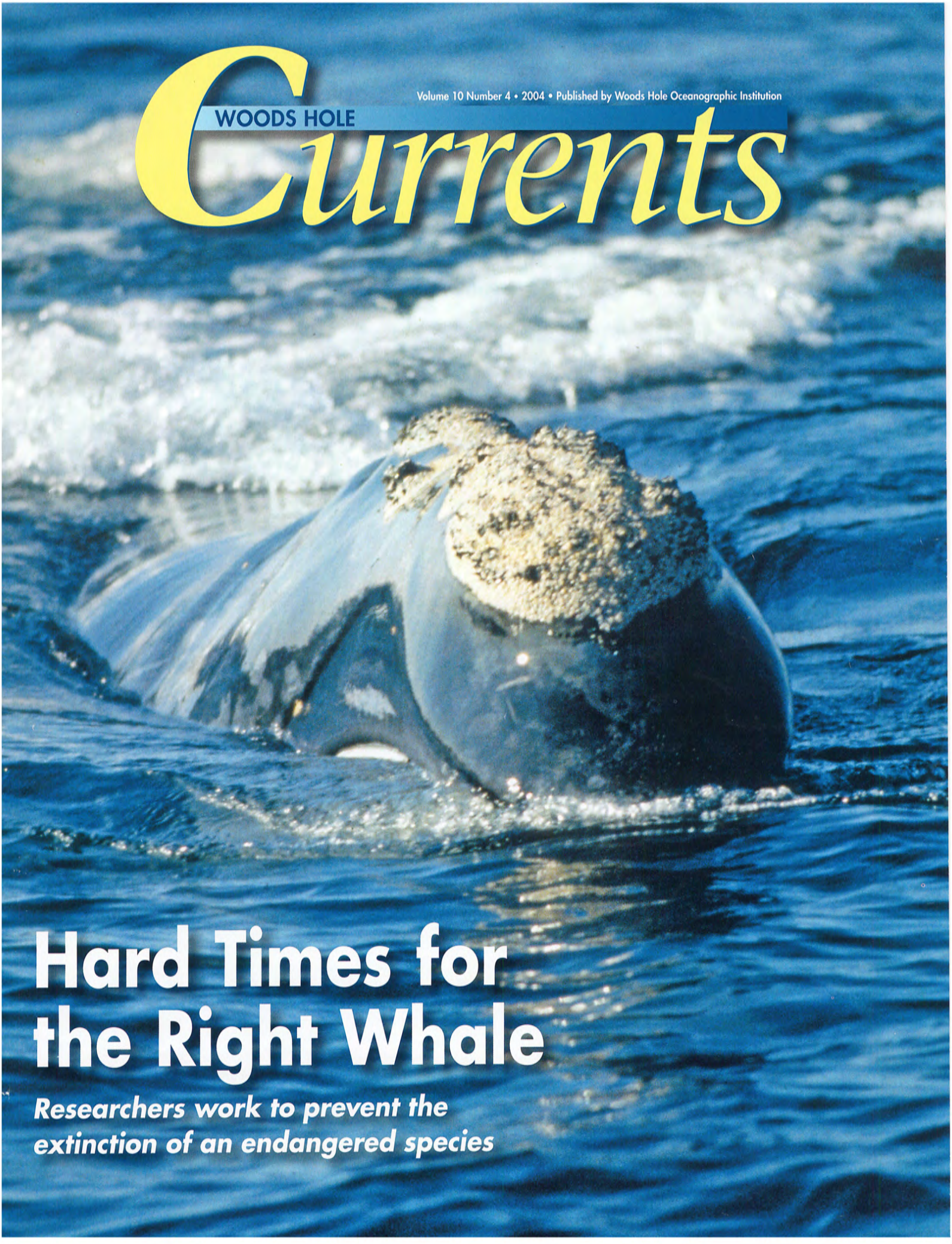

Hard Times for the Right Whale

Researchers work to prevent the extinction of an endangered species

WOODS HOLE Currents

COVER: A right whale approaches with its crusty white calling card—known as callosities—protruding from its skull. North Atlantic right whales are the most endangered of the great whales. Photo © IFAW www.ifaw.org

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Background sunset photo by Michael Moore, WHOI

The Tale of the Whale

By Scott Kraus

Over the past 1,000 years, humans have been conducting a test in population biology with the North Atlantic right whale. For the first 900 years, humans hunted the whales for oil and baleen—first Basque whalers from Spain, then Yankee whalers from New England. They gave the creature its name because it was the "right" whale to hunt: It swam slowly, near the surface, and conveniently floated when killed, making it easy to catch and retrieve.

By 1935, when commercial hunting for right whales was banned worldwide, they had been exterminated in the northeastern Atlantic, and perhaps only a few dozen remained in the northwestern Atlantic. The ban on whaling wasn't much of a reprieve. During World War II, North Americans tried to depth-charge anything vaguely submarine-like that came within 50 miles of the coast—exactly where this species lives. Then, increased human activities in the ocean began to take their toll.

Today, about half of all North Atlantic right whale deaths are caused by accidental entanglements in fishing gear or by collisions between ships and whales. When a whale gets entangled, sometimes it drowns. More often, the ropes get embedded in the whale's skin, killing it with secondary infections. Although fishermen rarely see right whales, more than 70 percent of right whales exhibit scars from fishing gear.

Not many whales survive collisions. Shipping channels to East Coast ports and naval bases cut across the whales' critical calving grounds, migration corridors, and feeding areas. Jacksonville, Fla., Chesapeake Bay, and the port of New York are just a few examples, each with more than 2,000 ship arrivals and departures a year. At least two right whales have been killed by ship collisions in each of the past three years, enough to drive this small population toward extinction.

A 'village' of whales

Another problem for right whales is their wildly variable reproduction. In the 1980s, adult females gave birth to a calf about every three years; by the late 1990s, this interval was well over five years. The trend culminated in 2000 when just one calf was born to the entire population. Then, surprisingly, 31 calves were born in 2001—a record—although this baby boom has not been sustained. This variability is strong evidence of a problem with reproduction, and researchers are studying potential causes, including disease, declining food supplies, bio-toxins, and pollution.

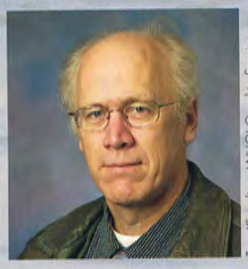
Over the past several decades, researchers and volunteers have made more than 32,000 sightings and photographed and catalogued 460 individual right whales from Florida to Greenland. Of those, we believe about 342 are still alive.

This right whale catalog is an extremely valuable body of information. It allows scientists to track individual whales throughout their lives, providing data on calving, migrations, feeding patterns, associations with other whales, habitat preferences, and deaths. Imagine living in a village of 342 people for 25 years: You would probably know everyone. There are several researchers who have lived in the village of right whales for 25 years and now recognize individual whales on sight.

Pursuing a new, hopeful course

Armed with this extraordinary set of observations, advances in technology, and improved federal funding, we will soon see a tremendous burst of creative scientific energy focused on understanding and correcting what ails the right whale. Solutions will come from blending expertise in a diverse range of scientific fields, and we will capitalize on new findings on whale hearing and behavior; the ecology and oceanography of their habitats; whale genetics, hormones, toxins, and diseases; and population modeling.

A dedicated group of scientists, managers, and conservationists are trying to develop strategies aimed at helping humans and whales coexist. When we figure out how to stop killing right whales, we will be reversing the 1,000-year test. Let the experiment begin!



Tom Kleindinst, WHOI Graphic Services

Scott Kraus

Scott Kraus is Director of Research at the New England Aquarium, where he has pioneered a wide range of studies on right whale biology and conservation since 1980. This essay is adapted from his remarks at an Ocean Forum sponsored by the WHOI Ocean Life Institute. Experts from diverse institutions and fields gathered to devise a collaborative research plan to better understand right whales and to test innovative approaches to protect them. More information is available at http://oceanusmag.whoi.edu/v43n2/madin.html.

The North Atlantic Right Whale

A species on the edge of extinction struggles to recover

NATURAL NET—A right whale skims the surface, showing the mouth full of baleen it uses to filter food from the water.

By Charles Creekmore

The right whale is one of nature's oddest looking creatures; so much so that ancient mariners often mistook it for a sea monster.

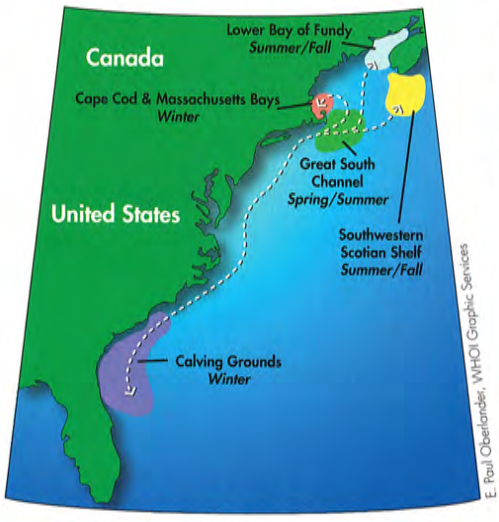
"You've got this big narrow skull sticking in the air with all that baleen hanging down," said Scott Kraus, Director of Research at New England Aquarium. "Then, way in the back, you have this arched tail pushing it along. It almost looks serpentine."

But researchers who study right whales in the field get a more kind and gentle impression of the animal. Studying whales near Nova Scotia, WHOI biologist Mark Baumgartner once used an inflatable boat to approach a female whale. She suddenly and unaccountably stopped dead in the water, causing the boat's momentum to carry it right into her wide body. Realizing that a freaked-out whale could easily flip his boat, Baumgartner yelled, "Hang on!"

But not to worry. "Damned if she didn't just roll over, take a look at us, then submerge with seemingly no motion whatsoever, and disappear," Baumgartner said.

This most endangered of great whales is distinguished by its large size (up to 59 feet long and 80 tons), dark color, "upside-down smile," lack of a dorsal fin, and horny protuberances on the head called callosities.

The callosities, often highlighted by intensely colored whale lice, were called "bonnets" by sailors of old. "These guys had clearly been at sea too long," Kraus joked.



The North Atlantic right whale's north-south migration between calving and feeding grounds hugs the coast.

Callosities also turn out to be the "fingerprints" of right whales. Since 1980, Kraus and colleagues have been studying distinctive callosity patterns on some 250,000 "mug shots" to identify, catalog, and track the approximately 342 remaining North Atlantic right whales. About 150 contributors have donated their photos to this catalog, which includes nearly 32,000 whale sightings.

'Urban whale syndrome'

Kraus also has a colorful phrase to describe the dovetailing histories of humans and right whales: "Our 1,000-year experiment in population biology." Whalers started harpooning right whales a millennium ago in the Bay of Biscayne off Spain, and the assault was nonstop until commercial whaling was banned in 1935.

But starting from similar remnant populations of a few hundred, right

whales in the North Atlantic and in the Southern Hemisphere have journeyed along very different paths in the last 70 years. Southern right whales, a distinct but related species, have recovered to a population of some 10,000 individuals, while their northern counterparts have been following the path of the dodo. Why? Since whaling ceased, southern right whales have lived free of most shipping lanes, pollutants, fishing areas, and other human activities.

By contrast, northern right whales tend to spend their lives within 50 miles of the highly urbanized North American seaboard, from calving areas along the southeastern U.S. coast to feeding grounds between Cape Cod and the Bay of Fundy.

Their proximity to the East Coast is the source of what Rosalind Rolland of the New England Aquarium has called "urban whale syndrome," which threatens the North Atlantic breed. "Urban" whales contend with some of the heaviest shipping traffic in the world, a maze of fishing gear, agricultural and industrial runoff from everywhere east of the Rockies, contaminants from power plants and millions of cars, military testing, waste-dumping, and effluent containing pharmaceuticals and diseases.

"They're swimming in an urban soup," Kraus said. "We seem to be doing everything we possibly can to kill these whales."

Half of known North Atlantic right whale deaths are caused by ship strikes and fishing-gear entanglements. Researchers are also finding diseases and toxins such as giardia, cryptosporidia, PCBs, organic chlorines, and mercury in whale tissues. Not coincidentally, the species' reproduction rate is a third of what it should be.

The resulting body count is sobering indeed. Population projections calculated by WHOI biologist Hal Caswell and colleagues show that, at the current rate of decline, the right whale could become extinct within a century or two.

"How far can we push these animals?" Kraus asked. "In 100 years, a more enlightened society will ask, 'What were these people thinking?' "

A multi-pronged research effort

This bleak outlook is why conservation and research on the right whale's behalf has become more urgent. Regular aerial surveys study the distribution and movement of right whales—making photo IDs, counting newborns, and operating an early warning system to help vessels avoid the creatures. In addition, researchers are examining reproduction, acoustic monitoring, whale-safe fishing gear, toxins, and much more.

Baumgartner studies the right whale's love affair with its favorite food, a rice-sized crustacean known as *Calanus finmachicus*, whose distribution is subject to ocean currents. Right whales must consume 2,625 pounds of *Calanus* every day to survive. They do so through 15-minute dives to the deepwater buffet, where clouds of *Calanus* are catered by swirling currents.

But *Calanus* itself has become a suspect in the survival saga of the right whale. These diminutive creatures at the bottom of the food chain may absorb and pass along contaminants and germs.

Beyond that, global warming and changes in ocean circulation may be affecting the distribution and availability of *Calanus*. If so, reproductively active females might not get enough nutrition to become pregnant, give birth, or lactate properly.

Such subtle and not-so-subtle factors cast long shadows on long-term right whale population projections. In the short term, we must find ways to stop killing them.

"If we managed to prevent just two mothers from dying each year," Caswell said, "we could turn the northern right whale from a declining into a growing population."

©IFAW www.ifaw.org/Trevor Samson

WHALE BONNETS—Callosities, the gray-white patches on the right whale's head, are used like fingerprints to distinguish one whale from another.

The Collision Course of Whales and Humans

Ships and right whales are meeting too often at sea

TROUBLE AT THE TOP—Right whales socialize near the surface, but shipping traffic has been breaking up their parties and lives.

By Charles Creekmore

If the sight of a swimming right whale is one of nature's most majestic images, the sight of a dead one is among the saddest.

In 1999, a 60-ton, female right whale named Staccato was turned quite tragically from a heaving arc of sinew, energy, instinct, and grandeur into one of the world's largest vehicular accident victims. She was found dead in the water off Wellfleet, Mass., the victim of a ship collision.

Staccato had been a prolific breeder, giving birth to six calves since 1977. Hence, her death by blunt trauma also put a huge dent in the growth potential of the dwindling North Atlantic population of right whales.

"We've known Staccato and her calves for a long time," said Scott Kraus of the New England Aquarium (NEAq). "It's like losing a friend and colleague."

A recovery team from various institutions made certain Staccato's death would not be in vain. There was much to be learned from what WHOI researcher Michael Moore called "the freshest right whale recovered in 10 years." After the outsized carcass was towed to a nearby beach, scientists performed a three-day necropsy, which required such less-than-delicate surgical instruments as tractors and excavators.

The examination confirmed that Staccato died of wounds sustained during a collision with a ship: a fractured lower mandible, fractured vertebrae, and complications such as infection, blood clotting, and circulatory failure. Moore and other researchers added Staccato's case study to the mounting body of evidence about what happens when right whales lose close encounters with ships.

Speed kills

Each year since 1991, one to three right whales have died or have been seriously injured by ships, according to the U.S. National Marine Fisheries Service (NMFS). This may represent only a fraction of whales killed by ships, as deaths may go unnoticed if the carcasses drift out to sea.

In February 2004, the carcass of one of the largest right whales in the Atlantic, a 53-foot female named Stumpy (for her damaged tail) was towed ashore in North Carolina. Like Staccato, Stumpy was a prodigious procreator who had given birth to at least five calves in her 40-year life. She was within a week or so of having her sixth when she was killed.

"When we lose Stumpy, we don't lose just that whale," said Charles "Stormy" Mayo of the Center for Coastal Studies. "We lose all of her reproductive future."

On Nov. 24, 2004, yet another carcass of a pregnant right whale came ashore, this time in Ocean Sands, N.C. A preliminary examination indicated that the animal likely died from blood loss from a massive wound to the left tail fluke, probably caused by a ship propeller.

North-south migrating right whales are, quite literally, on a collision course with ships trekking east-west to major commercial and naval ports along the East Coast. Conservation efforts currently focus on two methods for curbing ship strikes: speed limits or rerouting the vessels.

When vessels cut their speed below 13 knots per hour in whale-populated waters, "ship strikes are reduced to almost none," said Bruce Russell, a retired U.S. Coast Guard commander. Russell and Amy Knowlton of NEAq co-chaired an NMFS-sponsored committee to work with the shipping industry on recommendations to enforce mandatory speed limits and to reroute ships in critical habitats.

Moira Brown of NEAq, Knowlton, and collaborators from industry, science, and government in Canada recently persuaded officials to make a modest relocation of a major shipping lane that had gone directly through prime right whale habitat in the Bay of Fundy—a change that lessens the chance of ship strikes by 80 percent.

Investigating whale hearing

Efforts have also begun to educate international mariners to the risk of whale-ship collisions. Since 1998, large commercial ships traveling in U.S. waters have been required to report when they transit right whale habitats. Vessels also receive regular notices about the locations of right whales through an early warning system that dispatches information from aerial surveys.

Knowlton almost lost her life pioneering these surveys. In January 1987, she and four other whale surveyors had to ditch their failing twin-engine Cessna in 50-degree waters off the Georgia coast and wait for Coast Guard rescuers. Last winter, four employees of the Wildlife Trust weren't so lucky. They all died in a crash while surveying right whales.

These efforts, however, are crucial for learning where right whales are. To this end, Christopher Clark of Cornell University is mobilizing a task force of "citizen scientists," who will work like birdwatchers, spotting right whales along the East Coast and reporting to a central Web site.

Meanwhile, researchers want to learn more about the hydrodynamic forces exerted by ships traveling through water. Other scientists are doing pioneering forensic studies on whale bones to determine the threshold at which they break. Such information would provide a rational basis for ship speed limits that balance shipping interests with whale conservation.

From "On the Ordinary Cetacea, or Whales," William Jardine, ©1837

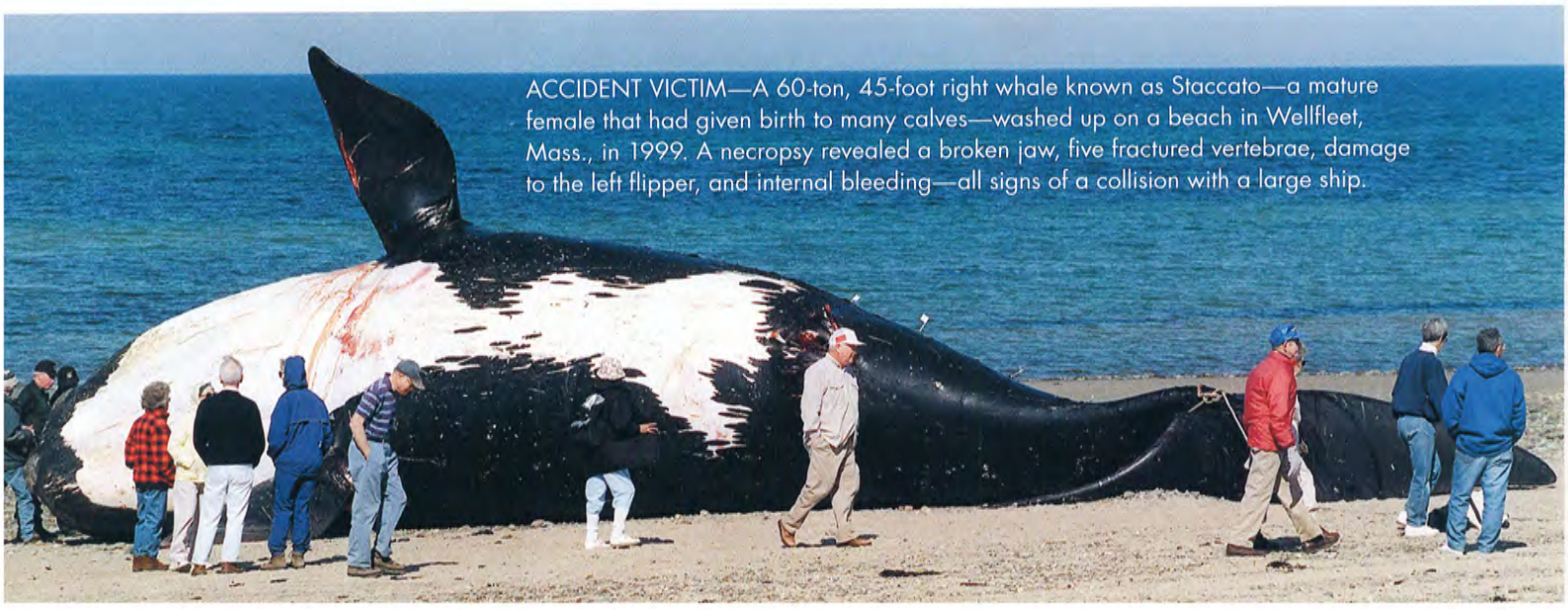
CRASH OF TITANS—In years past, the whale sometimes got the better of a collision with a boat. More often, harpoons fired from close range snuffed out their lives.

Still other scientists are studying the physiology of whale hearing and whale behavior in response to ships—to understand why the whales do not evade collisions, and to test possible alarm systems that could warn whales to get out of the way. WHOI biologist Peter Tyack, for example, has found that right whales can definitely hear approaching ships and are sometimes observed avoiding them. But most disregard vessels, especially near busy shipping lanes.

"We tried looking at this issue from a whale's point of view," Tyack said. "There are a lot of vessels around. Whales are there to feed. If they stopped to avoid every vessel they heard, they would lose a lot of feeding time."

Observations by WHOI biologist Mark Baumgartner indicate that mothers with calves spend a significantly longer time "walking" along the surface than other right whales and are at an even greater risk for ship strikes.

Scientists are the first to admit they need more studies and much more coordination. The urgency of this effort is symbolized by the team of determined researchers who gathered around Staccato's corpse in 1999.



ACCIDENT VICTIM—A 60-ton, 45-foot right whale known as Staccato—a mature female that had given birth to many calves—washed up on a beach in Wellfleet, Mass., in 1999. A necropsy revealed a broken jaw, five fractured vertebrae, damage to the left flipper, and internal bleeding—all signs of a collision with a large ship.

Taking the Right Approach to Whales

A conversation with marine mammal researcher Michael Moore

By Amy E. Nevala

Michael Moore grew up in England, where he trained as a veterinarian. He began his career as a marine mammalogist, working seasonally in Newfoundland and the Caribbean. Moore then followed his wife-to-be, Hannah, back to her New England home. He arrived in Woods Hole in 1985, first at the Marine Biological Laboratory and then at Woods Hole Oceanographic Institution as an MIT/WHOI Joint Program student.

Since becoming a WHOI Research Specialist in 1995, his interests have expanded to encompass a variety of human impacts on marine vertebrates. He is also the veterinarian for the Cape Cod Stranding Network, which responds to individual and mass strandings of marine mammals.

In recent years, much of his work has focused on right whales, or "the urban whale" as Moore's colleague Rosalind Rolland calls them. For hundreds of years, right whales were chased by hunters who used their blubber for oil. Laws now prohibit whaling, but entanglement with fishing gear and collisions with ships continue to threaten the population.

Moore has spearheaded several studies on these whales, from engineering tests to determine how rope interacts with whale baleen, to studying the effect of chemicals and nutrition on whale reproduction. He also recently joined colleagues in launching the Right Whale Research and Conservation Initiative, a collaborative research program to advance understanding of right whales and to test approaches to protect them.

"Most people find whales irresistible," said Mark Johnson, an electronics engineer and frequent collaborator with Moore. "Michael is one of those people who bring folks together to do something about protecting them."

Moore spoke on diverse topics with *Currents* recently: about losing his sense of smell in veterinary school; about sailing 18,000 miles with his wife and four sons to survey whale habitat; and about how scientists and the public can help the right whale population recover.

Q: What prompted you to study right whales?

Moore: I got into right whales by mistake. I had conducted my graduate work [in the lab of John Stegeman of the WHOI Biology Department] on tumors in winter flounder caused by high levels of chemicals in their systems, and I began looking at chemical impacts in marine mammals. For comparison, I needed an animal with low levels of exposure, and I thought right whales would be that species, given their diet. Turns out I was wrong. So in the process of studying toxins in the whales, I was bombarded with questions from other researchers about the species.

Q: What questions did they ask?

Moore: Why are these whales skinny, and does that impact the way they reproduce? Why are they washing up dead on the beach? Are they being killed by ships? So for the past 10 years I've been dragged off at ungodly hours to ungodly places in ungodly weather to answer those questions.

Regina Campbell-Malone, WHOI

WHOI biologist Michael Moore lost his sense of smell in veterinary school, which comes in handy when dissecting whales and other marine mammals.

It has led to a lot of graduate work by students here at WHOI. The more answers we find, the more questions keep coming up.

Q: A colleague mentioned that you have lost your sense of smell and that this helps you spend long hours studying fish and dissecting whales. What happened?

Moore: In vet school in the late 1970s, we would dissect carcasses of dogs, sheep, and cows. The animals would be in these large tubs of formaldehyde, and we would pull them out and work in open air without any ventilation hoods. The closer you got to look at what was going on, the more you got your nose fried. The price you paid for being an assiduous anatomy student was the loss of the sense of smell. It does give me a certain degree of immunity from decaying whale carcasses.

Q. Scientists determined several years ago that North Atlantic right whales had crossed a critical line:

Their population was declining, not growing. How does a species recover under these circumstances?
Moore: Slowly, and with gradual decreases in their death rate. Work by Hal Caswell (a Senior Scientist in the Biology Department) shows that we need to reduce the number of reproductively mature females dying by two a year to reverse the downward trend. If we can develop genuinely whale-friendly fishing gear and can reduce the mortalities from large ship strikes, then there is real hope.

Q: How can we make that happen?
Moore: One step is to encourage fishermen to use sinking rope so that there is less line floating in the water column, which entangles the whales. Requiring whale-safe materials or making gear modifications is already being tried in areas where right whales are very common.

Q: Has any marine mammal species recovered after their numbers slipped so dramatically?
Moore: Yes. The southern right whale is a sister species found feeding in the Antarctic and calving near the Southern Hemisphere continents. Since most whaling stopped in the 1920s, their annual net growth rate has increased seven percent. Today there are an estimated 14,000 southern right whales. That's compared to the whales in the North Atlantic, with a current population of about 340 individuals. Impacts on the southern whale's habitat, including fewer ship strikes, fewer entanglements with fishing gear, and better food availability is allowing for better survival and reproduction among southern right whales.

Q: What can the average person do to assist in the effort?
Moore: Get educated about the issue, and put pressure on politicians to let them know that the public is willing to pay added costs to reduce impacts on whales. That could mean paying more for consumer items brought by ships from abroad—because we would have to change routes—and more for the lobster that is caught with whale-safe fishing gear in right whale habitat.

Q: When whales are killed, you and your colleagues are called to figure out why they died. Do you feel empathy for right whales?
Moore: I find them rather frustrating at this point. I wish they'd figure out how to deal with the dangers in their lives. It's like having children: You get to a point where you want them to figure things out for themselves.

Q: You took a remarkable trip in May 2000 when you, your wife Hannah, and your four sons

Regina Campbell-Malone, WHOI

DIFFICULT BUT NECESSARY WORK—Michael Moore (red jacket) and David Taylor, a retired high school biology teacher and WHOI Guest Investigator, prepare to perform a necropsy on a right whale named Stumpy, who washed ashore in February 2004 near Nags Head, N.C. Researchers try to make the most of unfortunate circumstances, examining wounds for signs of encounters with ships or fishing gear, and examining internal tissues for evidence of man-made or natural toxins.

(then ages 8 to 14), departed on a sailboat for a 13-month voyage to survey North Atlantic right whale habitat. How did you get the idea for the trip?

Moore: We wanted to take a long sailing trip, and we were not that excited by the thought of a leisure cruise. So we made a pilgrimage to right whale habitat and hunting grounds. Different pieces of the ocean have different idiosyncrasies, same as land. The idea was to see, smell, and experience these places, and talk to the people who live near there. Plus, Hannah and I realized that if we were ever to spend a chunk of time in a boat with our children, the time was nigh. Any later and wings would be sprouting.

Q: How did you prepare?

Moore: Preparations took a year. We scoured boat sales on the Internet before finding *Rosita*, a 55-foot sailboat designed for a couple living in the Caribbean. I tore out one head (bathroom) to make room for a workshop, ordered new sails, removed countertops and portholes, fabricated a crow's nest, and overhauled the engine. Hannah took charge of buying nearly 1,000 pounds of rice, canned hams, tinned meats, and cheeses. The boys readied for a year away from school and friends. The two oldest boys dropped back a grade but continued to work with teachers at their school. Their younger brothers completed their seventh- and fifth-grade years through correspondence courses.

Q: Some of the transits between ports lasted two weeks and often included rough seas. Did you struggle with motion sickness or boredom?

Moore: Our children had an amazing ability to throw up, and then go back to whatever they were doing, whether eating or reading. The chief entertainment aboard was more than 500 books stocked by Hannah (she alone read 135 books). The boys relished James Bond movies played repeatedly on a laptop computer. At ports, when they needed to burn pent-up energy, they swam or hiked. During transits, they climbed on our big bunk and beat the hell out of each other.

Q: How many right whales did you see during your voyage?

Moore: Zero. We knew the chances of seeing any were slim, as we were essentially looking for a few remaining right whale needles in the North Atlantic haystack. A sailboat is not the best platform for surveying whale habitat; planes work much better.

Tom Kleindinst, WHOI Graphic Services

GROUNDED—The Moore family stands on dry land after 13 months at sea in search of right whales (clockwise from left): Michael, Oliver, Sam, Chris, Hannah, and Tom.

Tom Kleindinst, WHOI Graphic Services

MIT/WHOI graduate student Regina Campbell-Malone prepares a right whale jawbone for a three-dimensional laser scan. Campbell-Malone is working with Michael Moore to develop a computer model of right whale bone properties and how they respond to massive, blunt trauma, such as ship strikes.

Q: What did you learn?

Moore: I recorded the details of historically important habitat where larger populations of North Atlantic right whales once fed, reproduced, and died. I got firsthand exposure to the currents, hydrology, birds, winds, and weather. I did publish a paper based on the trip, about the impact of cookie cutter sharks that bite cookie-sized chunks of flesh from fin whales off Cape Verde.

Q. You were again at the helm of *Rosita* this summer in Canada. What was the focus of your studies?

Moore: I joined colleagues from New England Aquarium and Trent University of Ontario as we collected

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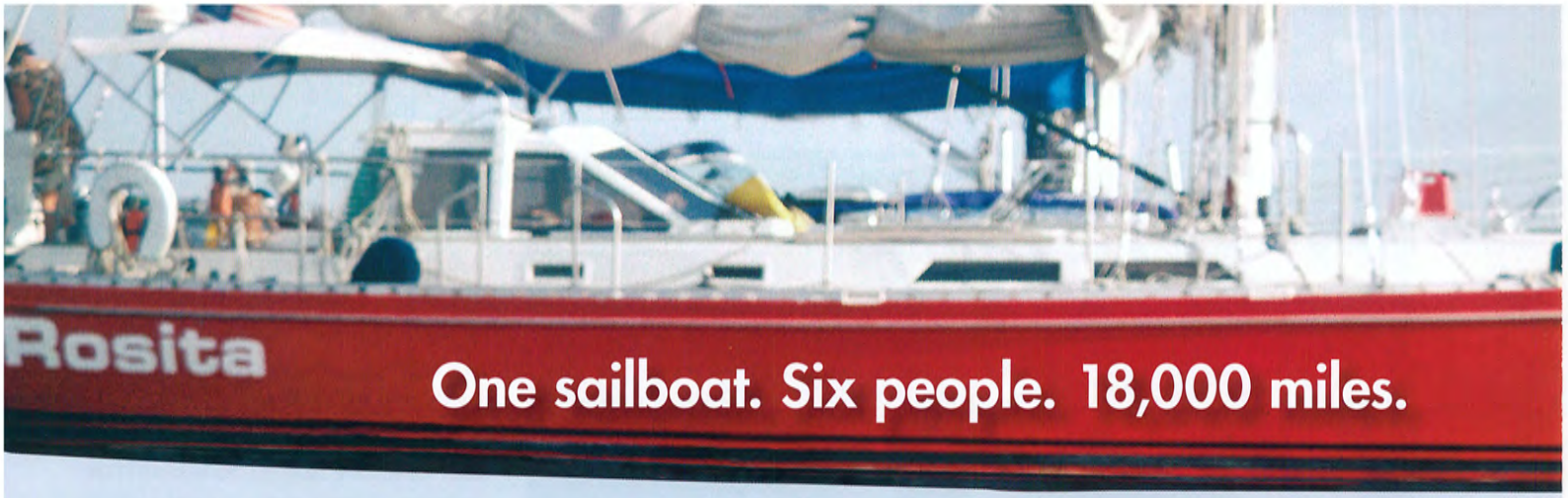


One sailboat. Six people. 18,000 miles.

Members of the Moore family recall night watches, flying fish, and other ups and downs from their North Atlantic voyage in 2000-2001

Michael
Favorite stop: Baixo Ingles, Boavista, Cape Verde Islands. "Watching the sun rise over the sand dunes."
Memorable moment: "Emerging out of Williamsport, an old whaling station on a fjord in Newfoundland, and finding a humpback whale mother and calf in the entrance."
Biggest gripe: "Never escaping email."

Hannah
Favorite stop: Pelican Island, Rio Macareo, Venezuela. "Watching roosting scarlet ibis take off at dawn, making the world's most intense red cloud."
Memorable moment: "Sitting on a dock in Palmiera, Cape Verde, sharing Oreos with my sons and local children."
Biggest gripe: "Living with five males in an aluminum can."

Oliver
Favorite stop: Newfoundland. "The people were so cool."
Memorable moment: Being on watch at night. "I was by myself, with no lights, surrounded by stars and beautiful water. It was amazing."
Biggest gripe: "Not meeting enough girls my own age."

Sam
Favorite stop: A tie between Newfoundland and Scotland.
Memorable moment: "Making a friend in Newfoundland who invited us to watch the Stanley Cup (hockey) finals in his home."
Biggest gripe: "Staying awake through the watches."

Chris
Favorite stop: St. Kilda, Scotland. "Lots of cool wildlife and not many people."
Memorable moment: "We were hiking on St. Kilda and a dive-bombing bird hit my dad."
Biggest gripe: "When we all got really sick in Porto Santo."

Tom
Favorite stop: Newfoundland. "The people welcomed us into their community."
Memorable moment: "Flying fish are very odd. We had one fly through a porthole right onto a frying pan."
Biggest gripe: The lack of privacy and personal space on *Rosita*.

To learn more about the Moore family's 13-month journey, visit http://whale.wheelock.edu/Rosita


Hannah Moore

The Moore boys ranged in age from 8 to 14 at the start of their 13-month journey across the Atlantic.

Joyne Doucette, WHOI Graphic Services

The Moore family's voyage on *Rosita* took them to the edge of four continents, into infamous whaling grounds of years past, and into traditional right whale feeding and calving grounds.

Moira Brown, New England Aquarium

BONE SAMPLES—Researchers Brenna McLeod (left) of Trent University and Yan Guilbault of New England Aquarium drill into whale bones on the shores of Red Bay in Labrador, where Basque whalers once ran an industrial-scale blubber and oil harvesting operation. McLeod and Guilbault extract samples of DNA for genetic studies that could reveal the makeup of the 16th-century whale population.

Continued from page 10

genetic samples from whale bones left by Basque hunters in southern Labrador in the 1500s. This involved some fairly rigorous boat handling, but we were rewarded with over 200 new samples of bones discarded by the hunters. I also spent time in the Bay of Fundy helping to research the impacts of boat noise on right whales.

Q: What's next for you?

Moore: I'm interested in predicting the force it takes for a ship to kill a right whale, so we will be doing some modeling on that. I'm also doing a fair amount of work on seals, whales, and dolphins to understand disease processes. Finally, a sperm whale necropsy three years ago triggered my interest in studying how they manage water pressure during deep dives.

Final entries from the logbook of *Rosita*

August 4, 2001—Cape Cod Canal—The hobbit in me is so happy—home is around the corner. Like Bilbo Baggins, I feel changed by my adventures and am thankful for the wonder of it all, but there is nothing like your own soft chair, bed, and shower! As I look back at the past 14 months, it seems to fill a lifetime...The places were wonderful, but what I hate to see end is the time together. We are just an ordinary family, but we have had the gift of time. I think people usually have to survive something terrible to experience the depth of intense feeling I have just now. The love for my kids has always been huge, but now my respect and understanding is a bigger part of it. We are good friends...Now we are coming home, and who knows what will happen next? —*Hannah Moore*

August 8, 2001—Marion, Mass.—People have asked me what was the most special place we visited. My trite but true reply is the best place I visited was a place only a few fathers ever get to go. That place was a big chunk of time with my family, without the endless competing agendas of work, community, and other things. It is a very self-centered place, but in going there we have learned to respect and love each others' hopes, fears, and differences.

The physical places were second to that overall gift. Of those places, the ones that stand out were largely associated with the ghosts of past sea life abundance and harvest excesses—to hear the silence and see the emptiness was a true monument to man's greed and inability to conserve. The abandoned whaling stations in Scotland, Ireland, Azores, Cape Verde Islands, Trinidad, Bermuda, Newfoundland, and Labrador. But yet the life is there—we heard an astounding amount of sperm whales when off the continental shelves. The humpback whales are coming back. Likewise, if we can do better in the management of right whales, nature has a boundless capacity to regroup—if only we can leave her alone enough to do so.—*Michael Moore*

Michael Moore, WHOI

The Moores left their mark on Horta, in the Azores: "There is a tradition that all visiting yachts leave a painted mural on the marina wall," Hannah Moore wrote. "It's bad luck not to do so."

December 22, 2004

Dear *Currents* reader:

With this issue, we embark on a bittersweet voyage, saying goodbye to an old friend and welcoming a new one.

This is our final issue of *Currents*, which we have published since 1991 to help readers keep in touch with exploration and discoveries—and the people who make them happen—at Woods Hole Oceanographic Institution.

To better meet the evolving needs of our readers, we will be merging our two magazines, *Currents* and *Oceanus*, into one that combines the best of what you have come to expect of each—along with new features and coverage of a wider range of ocean science topics.

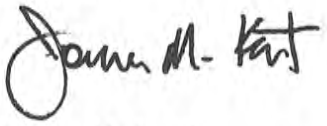
If your *Currents* subscription extends beyond this volume (Vol. 10), you will automatically receive *Oceanus* in its place, starting with the first print issue in April 2005.

If your subscription ends with this issue of *Currents*, you can sign up for *Oceanus* at www.oceanusmag.com for the printed issue ($15/year for three issues). Or you can get the free online edition, updated weekly, at www.oceanusmag.whoi.edu. You can also subscribe to receive free email alerts whenever new *Oceanus* stories are posted to the Web.

We're excited about the new *Oceanus*. It will give you more information about the progress of our researchers, and keep you better informed about their work in understanding the oceans, our climate, and the Earth.

We look forward to serving you with this new magazine, both in print and electronically, and welcome your comments and suggestions.

Regards,



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For information, please contact WHOI Publication Services at 1-800-291-6458, or 508-966-2039 (outside North America).

Oh, What a Tangled Web We Weave

Fishing lines are snaring an unwanted bycatch

Sometimes plying the same waters as fishermen, North Atlantic right whales can find themselves swimming and feeding amid a gauntlet of ropes attached to gillnets and lobster pots. These fishing lines can get caught in the whales' comb-like, filter-feeding baleen, or become snagged around their flippers or tails. As the whales struggle to free themselves, they often wrap the lines more tightly.

The whales swim on for months with fishing gear attached, burdened like Jacob Marley dragging his chains through Dickens' *A Christmas Carol.* The lines impede their breathing, feeding, socializing, and breeding. The whales often free themselves, but others die from drowning or starvation, if not from infections caused when lines slice into their flesh.

"We would not tolerate watching animals on land undergo such pain and gruesome deaths," said WHOI biologist Michael Moore.

About 70 percent of the North Atlantic right whale population exhibits scars from fishing gear, said Scott Kraus, Director of Research at New England Aquarium. Rapid response efforts to disentangle whales have been heroic and spectacular (see "The Death of Churchill," page 15), but finding ways to avoid entanglements is a preferable solution.

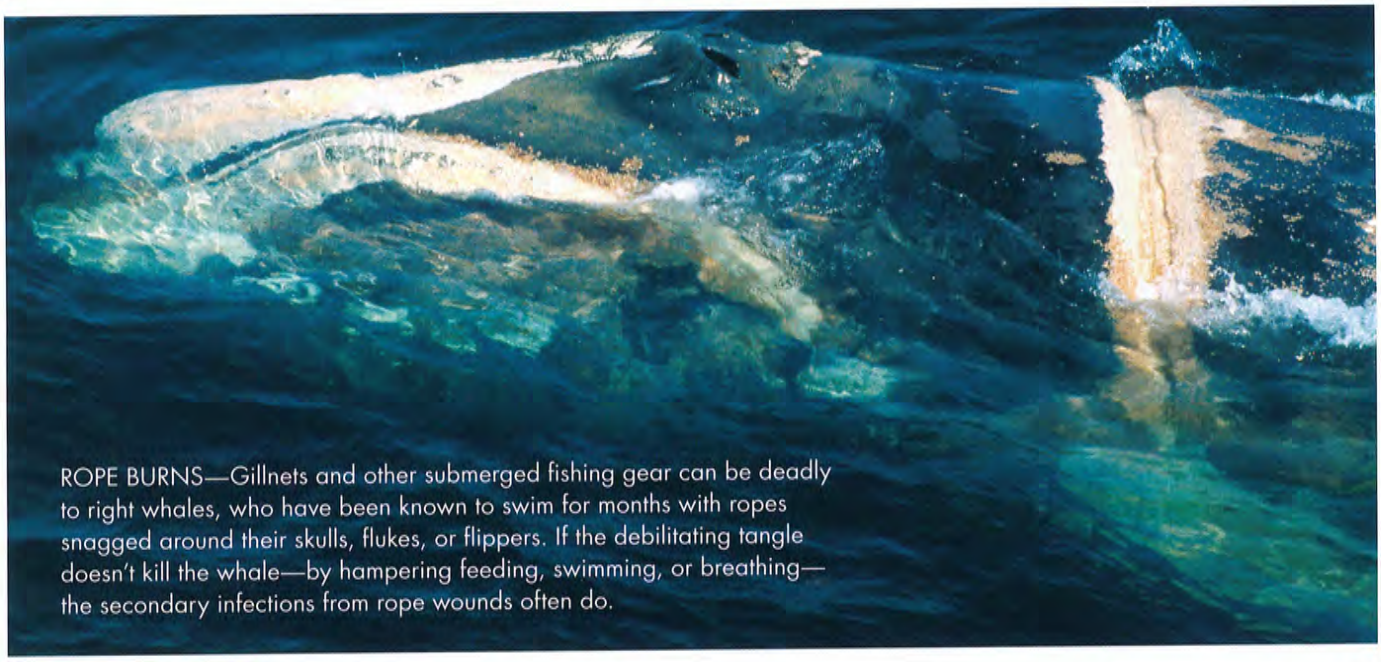
The endeavor is challenging, however, because researchers and fishermen only see the results—not how it happened. "Most fishermen will never see a whale entangled in their fishing gear," said Glenn Salvador, a member of the Whale-Safe Fishing Gear Research Unit at the U.S. National Marine Fisheries Service (NMFS). One fishermen once told Salvador: "Asking me to come up with a solution to this is like asking me how to keep a spaceship from getting entangled in my wife's clothesline."

The NMFS unit educates the fishing community about the problem—at industry meetings, on the Web, and by doing "a lot of dock work, talking with fishermen," Salvador said. The unit also does forensics work, analyzing gear and conducting interviews with fishermen to reconstruct why entanglements occurred.

The NMFS unit, along with private and academic researchers, also conducts research on fishing gear modifications that may decrease or eliminate entanglements. These include developing fishing lines that break rather than obstruct a whale, and changing the buoyancy of lines so that they sink rather than float—minimizing whales' exposure to lines in areas where they dive.

Norm Holy, a chemist at Atlantic Gillnet Supply Inc., is working to develop rope that is strong enough to haul fishing nets, weak enough to be broken by a whale, and thick enough to avoid cutting into animals quickly. His research involves adding dissolvable salt to the polypropylene material and microscopic "holes" to the microfiber texture to weaken the ropes just enough, but not too much.

—Lonny Lippsett



ROPE BURNS—Gillnets and other submerged fishing gear can be deadly to right whales, who have been known to swim for months with ropes snagged around their skulls, flukes, or flippers. If the debilitating tangle doesn't kill the whale—by hampering feeding, swimming, or breathing—the secondary infections from rope wounds often do.

A Slippery Rope

As right whales cruise the ocean with their mouths open to feed, they are vulnerable to catching fishing lines in their baleen, the comb-like material that filters out their staple diet, microscopic zooplankton.

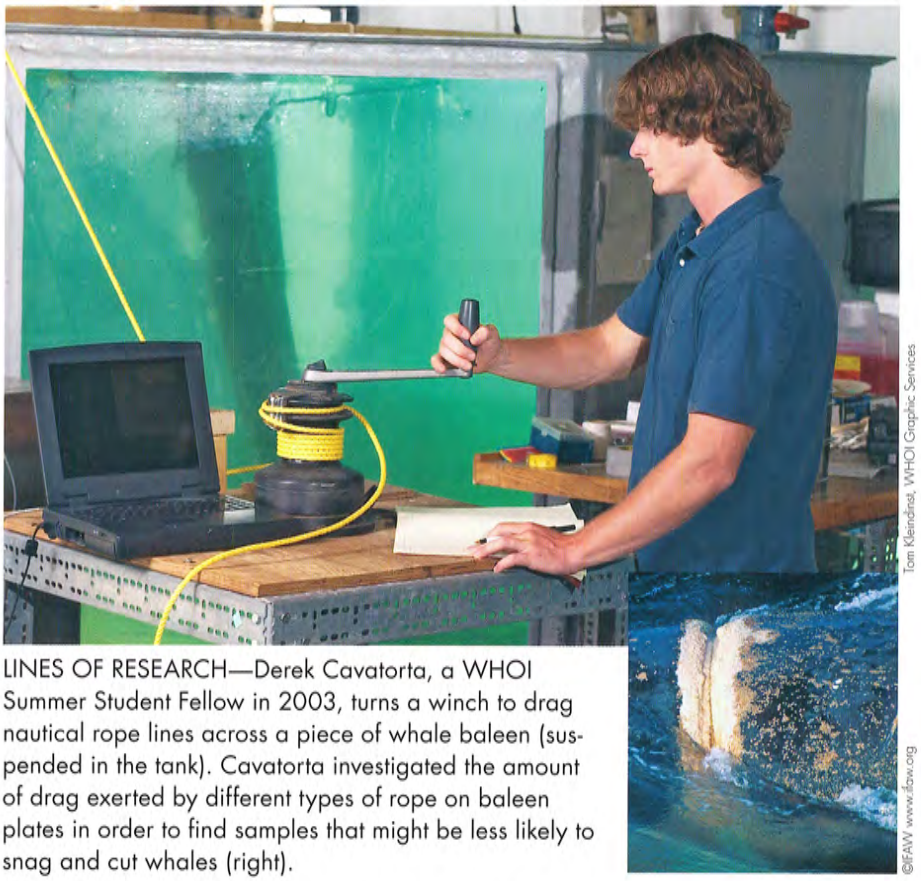
Unlike dental floss in human teeth, fishing ropes are difficult to extricate from baleen. In 2003, WHOI biologist Michael Moore and Derek Cavatorta, a University of Massachusetts undergraduate participating in WHOI's Summer Student Fellowship program, began an experiment to identify ropes with less stick-to-itive properties.

"Derek and I wondered how rope behaves in baleen and whether different kinds of rope might be able to slip out of the baleen more readily," Moore said. "If we can find a way to avoid getting the ropes permanently caught in the baleen, we may alleviate some of the entanglement problem."

Moore and Cavatorta filled a tank in the WHOI Shore Lab with seawater and a preserved sample of baleen from Staccato, a right whale that had died in 1999 off Wellfleet, Mass (see page 6). They pulled various types of ropes through the baleen and used a tension meter to measure the amount of drag.

Their experiment demonstrated that certain types of rope produced less friction in the baleen. The study, slated for publication in the *Journal of Cetacean Research and Management*, could inform new fishing strategies that lessen the chances of deadly whale entanglements.

—Lonny Lippsett



Tom Kleindinst, WHOI Graphic Services

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LINES OF RESEARCH—Derek Cavatorta, a WHOI Summer Student Fellow in 2003, turns a winch to drag nautical rope lines across a piece of whale baleen (suspended in the tank). Cavatorta investigated the amount of drag exerted by different types of rope on baleen plates in order to find samples that might be less likely to snag and cut whales (right).

Hannah Moore

A Fluke of Research

A major issue in whale disentanglement efforts is ensuring the safety of the rescue team. As they approach in inflatable boats, teams try to restrain the whale's tail fluke, both to slow the animal and to decrease the chance of being struck by it. Michael Moore, a biologist at WHOI, and others have been testing newly designed harnesses by practicing on a life-size model of a right whale tail. Moore bought the whale tail from an artist in Canada, who worked from a cast of a whale named Delilah that died in 1992.

The Death of Churchill

In the spring of 2001, about 50 miles east of Cape Cod, a right whale was spotted swimming with ropes streaming out of its mouth and a deep cut over his rostrum. Researchers recognized the distinctive pattern of callosities on the whale's chin and mandible as the markings of a male named Churchill. The Center for Coastal Studies in Provincetown, Mass., quickly assembled a rescue team to try to disentangle the beleaguered whale.

Based on experiences with sedating smaller marine mammals, the team selected two drugs that might help Churchill cooperate during the rescue attempt. One was Midazolam, a sedative hypnotic used in the operating room for anesthesia; the other was Meperidine, a narcotic that physicians often prescribe for pain control. Because Churchill's weight was estimated at more than 40 tons—500 times an average human—he required 1,000 milligrams of Midazolam and 10,000 milligrams of Meperidine. The drug regime was prepared by David Brunson, a veterinary anesthesiologist from the University of Wisconsin Veterinary School. The doses were less than those prescribed for people (by proportion of body weight) but enough, the team hoped, to slow the whale without compromising its ability to swim or breathe.

Because of Churchill's thick layer of blubber, the scientists had to use an extra large syringe with a 12-inch needle. Unsure of the whale's reaction, the team kept their inflatable boat at a safe distance and administered the drugs with a butane-powered automatic injector system—designed by Terrence Hammar of the WHOI Applied Ocean Physics and Engineering Department—which was attached to the end of a long cantilevered pole. Churchill didn't fuss much, and the drugs seemed to calm the crippled whale.

But the disentanglement effort failed. For 100 days, anxious rescue workers used a satellite tag to follow the ailing Churchill as he wandered north to Camp Breton Island, then south again. The team made several more attempts to remove fishing gear. By late summer, observers noted that Churchill was emaciated and still hopelessly tangled.

On Sept. 16, 2001, the team stopped receiving satellite signals. Somewhere off the New Jersey coast, Churchill slipped beneath the waves for the last time.

—Andrew Wilner, M.D.

DELICATE AND DANGEROUS DANCE—A team of researchers and conservationists from the Center for Coastal Studies works in Canada's Bay of Fundy to free a right whale entangled in fishing gear. The team from Provincetown, Mass., attempts to secure a strap over the tail fluke and slow the whale enough to cut it free from the fishing ropes.

Learn More About Right Whale Conservation Efforts

THAR SHE BLOWS—A pair of North Atlantic right whales inhale and exhale vigorously at the water's surface.

Organizations and Programs

National Marine Fisheries Service Office of Protected Resources
This federal agency is responsible for the enforcement of the Marine Mammal Protection Act and the Endangered Species Act, which both demand stringent conservation of the North Atlantic right whale. NMFS supports intra- and extramural research and management programs to that end. http://www.nmfs.noaa.gov/pr

New England Aquarium—Right Whale Research Project
For more than two decades, the New England Aquarium in Boston has been conducting a comprehensive, continuous study of this endangered species. Researchers from NEAq work from Florida to Greenland to identify the distribution of the whales, behavior and migration patterns, genetics, reproductive rates, and causes of mortality. Through aerial and shipboard surveys, they have compiled a unique, extensive catalog of North Atlantic right whales, a critical tool in conservation and research efforts. For more information, write to: The Right Whale Research Team, New England Aquarium, Central Wharf, Boston, MA 02110, or email to rwhale@neaq.org. http://www.neaq.org/scilearn/research/rtwhale.html

IFAW
The International Fund for Animal Welfare works around the world to stop commercial whaling and to protect endangered whales for future generations. The mission of IFAW is to improve the welfare of wild and domestic animals throughout the world by reducing commercial exploitation of animals, protecting wildlife habitats, and assisting animals in distress. IFAW also seeks to motivate the public to prevent cruelty to animals and to promote animal welfare and conservation policies that advance the well-being of both animals and people. To learn more, write to: IFAW, 411 Main Street, Yarmouth Port, MA 02675-1843 or send email to info@ifaw.org. http://www.ifaw.org

The Center for Coastal Studies
From its field station in Provincetown, Mass., members of the Center for Coastal Studies (CCS) work on issues of habitat protection, ecosystem management, and marine mammal and marine wildlife conservation in the Gulf of Maine and the waters around Cape Cod. CCS conducts scientific research with an emphasis on marine mammals, while promoting stewardship of coastal and marine ecosystems. It is the lead agency on the eastern seaboard for responding to large whales entangled in fishing gear. CCS also provides educational

resources for shipping companies, municipal leaders, fishermen, government officials, and everyday citizens. To learn more, write to: Center for Coastal Studies, P.O. Box 1036, Provincetown, MA 02657, or send email to ccs@coastalstudies.org. http://www.coastalstudies.org

WHOI Ocean Life Institute–Right Whale Research Initiative

Over the next several years, scientists from WHOI, New England Aquarium, the Center for Coastal Studies, Trent University in Canada, and other institutions are planning a variety of studies aimed at: reducing accidental whale deaths caused by ship collisions and fishing gear entanglement; understanding critical factors affecting right whale habitats, nutrition, reproduction, and health; and monitoring the North Atlantic right whale population to assess its size, present state, and future viability. http://www.whoi.edu/institutes/oli/currenttopics/ct_rightwhales.htm

Selected Web Sites

North Atlantic Right Whale Consortium

A collaborative effort by researchers from Canada and the United States to work on right whale science and conservation projects.
http://rightwhaleweb.org

WhaleNet

An award-winning, interactive web site focuses on whales and marine research. Sponsored by Wheelock College in Boston.
http://whale.wheelock.edu

Right Whale Sighting Advisory System

Using aerial and shipboard surveys, this site provides right whale sighting information to the commercial shipping industry and other marine traffic.
http://whale.wheelock.edu/whalenet-stuff/reportsRW_NE/

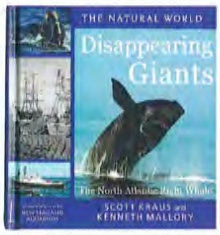
Right Whale Ship Strike Reduction Program

Links to news, science projects, and efforts to avert collisions between whales and ships. Sponsored by the U.S. National Marine Fisheries Service.
http://www.nero.noaa.gov/shipstrike/

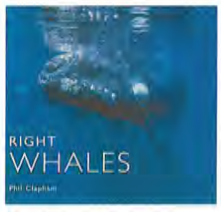
On the Trail of the Right Whale

Archived online expedition to tag, track, and study right whales, sponsored by the U.S. National Marine Fisheries Service.
http://sanctuaries.noaa.gov/special/Rightwhale.pdf

Books, Articles, and Multimedia



Disappearing Giants: The North Atlantic Right Whale
By Scott Kraus & Kenneth Mallory
The North Atlantic right whale is the most endangered large whale in the oceans today. This is a story of science and discovery, of survival and protection, and of research without which we cannot hope to protect the right whale's habitat. Visit http://www.neaq.org/visit/gift.html.



Right Whales
By Phillip Clapham
Despite seven decades of protection, most right whale populations are showing few signs of recovery. This book examines right whale natural history, discusses conservation, and argues that time is running short to help the species.

Journal of Cetacean Research and Management
"Morphometry, gross morphology and available histopathology in North Atlantic right whale (*Eubalaena glacialis*) mortalities (1970 to 2002)," by Michael J. Moore, Amy R. Knowlton, Scott D. Kraus, William A. McLellan, and Robert K. Bonde; (article in press).

Marine Mammals and Porpoise Voices
Originally published as an LP record in 1962 by WHOI researchers William Watkins and William Schevill, this new audio compact disc features the sounds of 18 whale and porpoise species. To this day, many of these early marine mammal recordings are still considered among the best ever captured. The CD is available for $19.95 through the WHOI Exhibit Center and Gift Shop. Call (508) 289-2663 or visit www.whoi.edu/whoistore.

Dick Pittenger Leaves WHOI in Ship Shape

By the time Dick Pittenger stepped down in July 2004 as WHOI Vice President for Marine Operations, he had visited 35 countries, sailed in most of the oceans, and directed the operation of more than a dozen oceanographic research ships.

As Oceanographer of the Navy from 1988 to 1990, he oversaw the U.S. Naval Observatory and the U.S. Naval Oceanography Command, which was responsible for 61 oceanographic facilities around the world, 12 oceanographic survey ships, and three survey aircraft. He spent much of his time getting new ships into the Navy budget, including one that became the WHOI-operated research vessel *Atlantis*. Little did he realize that his brief encounters with the Institution would lead him from Washington to a second career in Woods Hole.

It was former WHOI Director Craig Dorman who invited Pittenger to apply to become WHOI's arctic research coordinator in 1990. "Craig and I worked closely together when I was Director of Antisubmarine Warfare (ASW) in the Navy," Pittenger said. "Our offices were just down the hall from each other in the Pentagon, and we would often meet early in the morning to discuss ways to solve the difficult ASW problem. One day he said he was leaving the Navy, retiring early, and had accepted the job as Director of WHOI. I was surprised, but knowing something about the Institution, I was very impressed and supportive."

"When it came time for me to retire, I spoke with my family about the possibilities," Pittenger added. "They wanted me to go to a world-class organization, so I applied to WHOI, got interviewed by the search committee, and was hired by Bob Gagosian (then Associate Director of Research). It was a great decision for me."

Born in Nebraska during the worst of the Depression-era Dust Bowl days, Pittenger grew up in Tacoma, Wash., where he was active in the Sea Scouts and Sea Cadets. He attended the U.S. Naval Academy on a Naval Reserve appointment and was commissioned as an ensign in 1958. He commanded a minesweeper in Vietnam and held various fleet assignments on destroyers, guided missile destroyers, frigates, and the Navy's most advanced antisubmarine warfare surface ship. In 1984 he was promoted to Rear Admiral and became Chief of Staff of U.S. Naval Forces in Europe, as well as Deputy U.S. Commander for the Eastern Atlantic. He became Director of the Navy's ASW Division in 1986, and the following year he received his second star as Rear Admiral.

Tom Kleindinst, WHOI Graphic Services

At a retirement party in his honor, former Vice President for Marine Operations Dick Pittenger examines the front panel of the original pilot control for the remotely operated vehicle *Jason*, presented as a reminder of his years of steady leadership at the helm of the Institution's seagoing operations. Research Specialist Andy Bowen looks on.

Pittenger's experience in anti-submarine warfare and his postgraduate degree in underwater acoustics from the Naval Postgraduate School made him an excellent candidate for Oceanographer of the Navy, a position he assumed in 1988. He continued the modernization of the Navy's oceanographic fleet and was recognized for his efforts in standardizing the oceanographic models that sailors use in ASW operations; for declassification of the National Oceanic and Atmospheric Administration's Exclusive Economic Zone coastal charts; and for acquisition of the Navy's first supercomputer for oceanographic and meteorological model and data processing.

His challenges at WHOI were of a different sort. After only a few months on the job as arctic research coordinator, Director Dorman asked Pittenger to assume leadership of Marine Operations in 1991. One of the first things he did was make a list of priorities and goals—a list he kept and updated until the day he retired. He accomplished most of his goals.

"We've hired some very good people, changed the organization to be more user-friendly, and made a major shift by integrating the remotely operated vehicle *Jason* and other towed systems into the National Deep Submergence Facility," Pittenger said. "We've improved the quality of operations and worked hard at getting scientists and sailors talking with each other. The marine personnel are good

Dave Gray, WHOI Graphic Services

Dick Pittenger enjoys a day in the sun on the deck of the new coastal research vessel *Tioga*, one of his last major achievements at WHOI.

at what they do, and they care about their reputation. I am extremely proud of them and what we have accomplished together."

As head of WHOI Marine Operations, Pittenger oversaw a major upgrade and lengthening of the Institution's largest research vessel, the now 279-foot *Knorr*, and modernization of the 177-foot *Oceanus*. The 210-foot *Atlantis II* was retired and sold, replaced in 1997 by the new 274-foot *Atlantis*, the support vessel for the *Alvin* submersible. WHOI submitted a successful proposal to replace *Alvin* with a deeper diving submersible, announced in August 2004, and built the 60-foot coastal vessel *Tioga*, which joined the fleet in April.

In his retirement, Dick Pittenger pursues his love of fishing and photography and spends more time with his children and grandchildren. He will continue to provide guidance to the Institution in its fleet replacement efforts and continue to share the experience and expertise of a distinguished 32-year naval career.

—Shelley Dawicki

Charting a New Course

Marine operations at WHOI set a new course July 1 under the leadership of Senior Scientist Robert Detrick, a marine geophysicist who assumed the position of Vice President for Marine Facilities and Operations.

One of Detrick's first tasks was to lead a cross-disciplinary team in developing an "Access to the Sea" plan, which provides a long-range vision for the integration of ships, underwater vehicles, and ocean observing platforms for WHOI and the broader ocean community.

"Technology is changing the way we do ocean science," Detrick said. "Ships will remain an important part of the mix, but other types of vehicles, fixed observatories, and ocean observing systems are enabling us to have a presence in the ocean 24/7, rather than just a snapshot view. It is an exciting time."

Detrick joined the WHOI staff in 1991 as a Senior Scientist after 13 years as a professor and scientist at the University of Rhode Island. He received a bachelor's degree in geology and physics from Lehigh University in 1971, and a master's degree in marine geology from the University of California, San Diego, in 1974. He worked briefly as an exploration geophysicist for the Standard Oil Company of California and then obtained a doctorate in 1978 from the MIT/WHOI Joint Program in Oceanography and Oceanographic Engineering.

Detrick recently chaired the National Academy of Sciences Committee on Implementation of an Ocean Observatory Network for Research. He is a member of the Board of Governors of the Joint Oceanographic Institutions, which organizes U.S. participation in the new International Ocean Drilling Program, and chair of the National Science Foundation's Geosciences Advisory Committee. He has participated in 28 research cruises, 17 as chief scientist.

—Shelley Dawicki

Tom Kleindinst, WHOI Graphic Services

From left: John Collins, Beecher Wooding, and Bob Detrick discuss development of new ocean-bottom seismic monitoring equipment.

X-ray Visions of Climate Change

By Andrea Baird

Late in the evening, after traffic in the radiology lab at Falmouth (Mass.) Hospital has slowed, Mea Cook wheels some unusual patients into an empty X-ray room. Ten PVC pipes full of mud—sediment cores from the bottom of the Bering Sea—lay stacked on her cart. As radiologists in neighboring rooms peer inside human patients for signs of broken bones, Cook scans her cores for different signs. Somewhere in the pale layers of sediment cut by bright slashes of ash, she hopes to find secrets of 70,000 years of climate change.

In climatic terms, the Earth is currently basking in a relatively warm and stable period. But jump back 20,000 years to the last ice age, and the climate data curve gets bumpy. During the ice age and the 40,000-year warm period that preceded it, Earth endured a barrage of major climate shifts, including some sudden and drastic changes in the planet's average temperature.

Paleoclimatologists have deduced from marine sediments and from terrestrial ice that these climate changes were frequent and fast, but just how they occurred remains a mystery. In particular, they are intrigued by the role played by the Pacific Ocean, Earth's largest water mass. The view into the climate history of that vast ocean has been obscured by a scarcity of adequate sediments. Cook's cores might provide an important glimpse.

Getting to the core of the matter

The new cores—extracted from floor of the Bering Sea by WHOI Senior Scientist Lloyd Keigwin and colleagues in June 2002—don't look particularly instructive. In fact, the 20-meter plugs of sediment look like something you might find in a construction ditch after a storm. But these mud-filled PVC and steel pipes are full of information.

Tom Kleindinst, WHOI Graphic Services

Mea Cook examines an X-ray image of a sediment core to find layers of calcium carbonate—signs of life and the state of the climate thousands of years ago.

Like growth rings in a tree trunk, the layers of sediment are built over time, laying down a geologic record of the passing years. Each layer is laced with the chalk-white calcium carbonate shells of tiny animals called foraminifera. By analyzing the chemical composition of these shells, paleogeologists like Cook can determine the temperature and the amounts of salt, oxygen, and nutrients in the waters when the animals lived. This data can be used to model past climate conditions and ocean circulation patterns.

But not all sediment cores are created equal, and Pacific Ocean cores are notoriously unhelpful. Deep Pacific water tends to be corrosive, dissolving the carbonate shells that geologists seek in their cores. As a result, the Pacific's role in climate change is poorly understood.

As the recent disaster film *The Day After Tomorrow* portrayed (with ample Hollywood hyperbole), rapid climate changes are likely triggered, or at least accompanied, by changes in ocean circulation. Modern ocean circulation is dominated by the Atlantic Ocean, but some paleoceanographers theorize

Tom Kleindinst, WHOI Graphic Services

Graduate student Mea Cook examines a sediment core from the Bering Sea with her advisors, WHOI Senior Scientist Lloyd Keigwin (middle) and Assistant Scientist Jeff Donnelly. With funding from the Oak Foundation and the National Science Foundation, the team is attempting to reconstruct the history of sea level in the North Pacific to determine when the Bering Land Bridge was breached.

that the Pacific may have dominated at times in the past. "In the climate record there is evidence that the circulation in the Atlantic has changed, but no one knows much about what happened in the Pacific," Cook said. "This is what I'm trying to find out."

Luckily, Cook's sediments are an exception to the Pacific problem: They are rich with calcium carbonate shells for chemical analysis. "These are great cores," she said. "I can resolve events as short as decades and centuries." Some of the cores include finely layered sections of sediment with which she can resolve three to five year spans.

Three years or even three decades out of 70,000 years may seem like an unnecessary level of detail. But should the climate begin to change rapidly in the future, it would be useful to know whether past temperatures shifts, ocean circulation flips, and sea level changes happened over 10 years or 100.

"It's probably going to be the highest-resolution record from the North Pacific," said Dan McCorkle, an Associate Scientist in the WHOI Department of Geology and Geophysics. The Bering Sea cores won't be the first to yield a record, as sediments collected off Santa Barbara, Calif., have already been used to create a climate history of the Pacific. But a single location does not a global picture make.

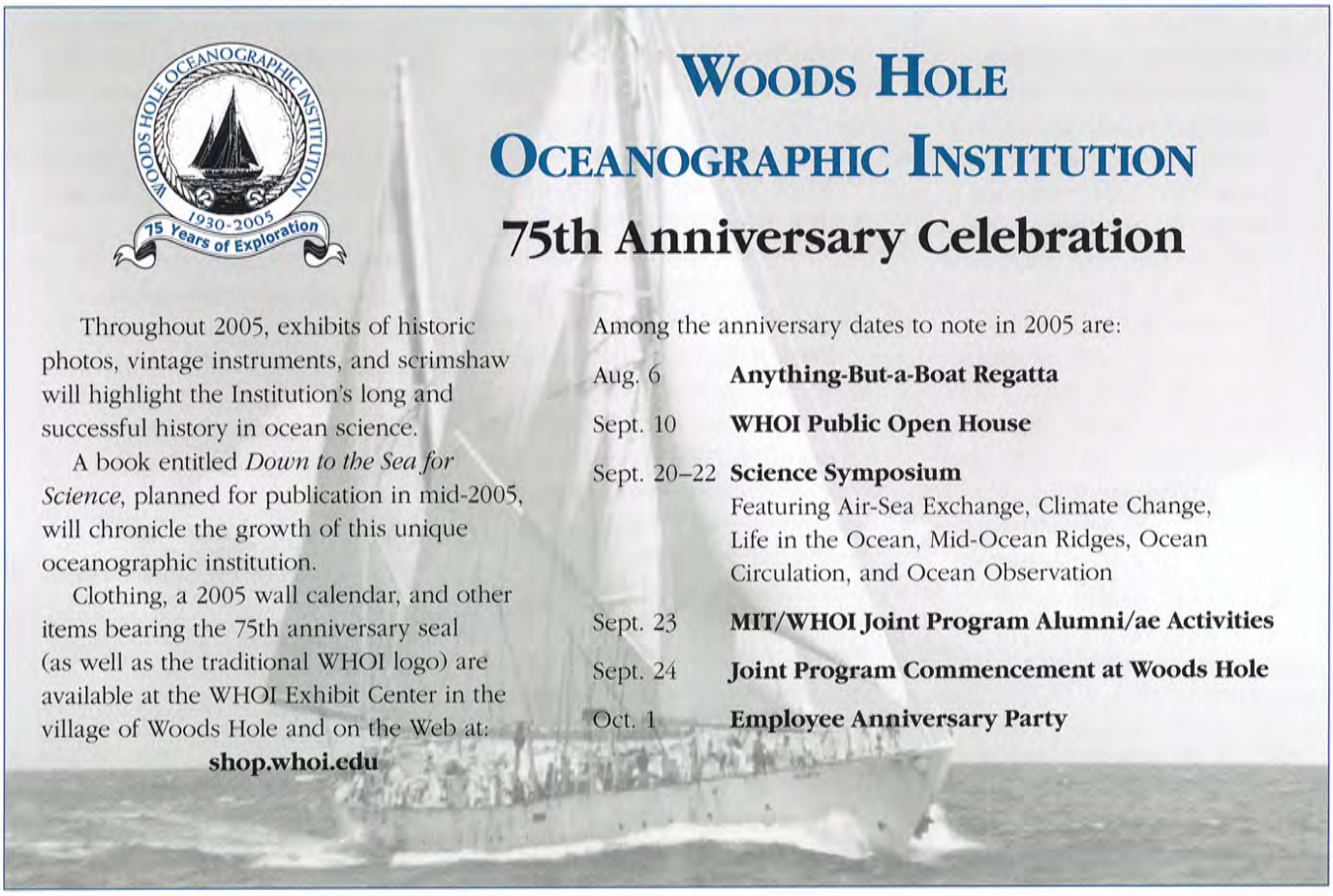
"People have spun a lot of stories about Pacific Ocean paleoceanography from the Santa Barbara record," said McCorkle, "but we really haven't had any way to test that." The Bering Sea cores could finally confirm or refute the Santa Barbara climate story.

Though it is too early to predict her results, Mea hopes she can make a contribution to geologists' understanding of Earth's climatic history. "The Pacific could have an important role in global climate that we don't yet understand. We might be able to use this information to understand what may happen in the future."

Did you know...

▲ Mea has been playing the cello since she was eight years old. While other kids were babysitting as teenagers, she earned money as a freelance musician, giving lessons, and playing for weddings. She still plays each week in an MIT-based chamber music group.

▲ She loves movies and, with friends, hosts a classic-movie night every Wednesday for other WHOI film buffs.



WOODS HOLE OCEANOGRAPHIC INSTITUTION
75th Anniversary Celebration

Throughout 2005, exhibits of historic photos, vintage instruments, and scrimshaw will highlight the Institution's long and successful history in ocean science.

A book entitled *Down to the Sea for Science*, planned for publication in mid-2005, will chronicle the growth of this unique oceanographic institution.

Clothing, a 2005 wall calendar, and other items bearing the 75th anniversary seal (as well as the traditional WHOI logo) are available at the WHOI Exhibit Center in the village of Woods Hole and on the Web at:

shop.whoi.edu

Among the anniversary dates to note in 2005 are:

Aug. 6	**Anything-But-a-Boat Regatta**
Sept. 10	**WHOI Public Open House**
Sept. 20–22	**Science Symposium** Featuring Air-Sea Exchange, Climate Change, Life in the Ocean, Mid-Ocean Ridges, Ocean Circulation, and Ocean Observation
Sept. 23	**MIT/WHOI Joint Program Alumni/ae Activities**
Sept. 24	**Joint Program Commencement at Woods Hole**
Oct. 1	**Employee Anniversary Party**

Recent Awards and Medals for WHOI Researchers

Lauren Mullineaux, a Senior Scientist in the WHOI Biology Department, has been honored for her contributions to graduate education with the Institution's first Arnold B. Arons Award for Excellence in Teaching, Advising, and Mentoring.

Students, alumni, and colleagues chose to honor Mullineaux for a "teaching style that offers clarity without over-generalization, concreteness without simply listing fact after fact, and an open conversational tone that encourages dialogue and exploration of ideas." Others said "her dedication to excellent science, thoughtful and caring interaction with students and colleagues, and her fostering of a positive working environment make her an excellent role model as both a scientist and a lab leader."

Mullineaux, who first came to WHOI in 1987, has participated in more than 30 research cruises, has served on dozens of committees at the Institution and in the international oceanographic community, and has written numerous articles in scientific journals and books. Her research interests include larval dispersal and settlement, benthic community ecology, and deep-sea biology.

The award was established to honor the memory of Dr. Arnold B. Arons, an employee of the Institution during World War II who later served as a WHOI Trustee. He collaborated with WHOI colleague Henry Stommel after the war, making many contributions to physical oceanography, and was instrumental in establishing and developing the MIT/WHOI Joint Program in Oceanography and Engineering in 1968.

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The 11,000-member American Meteorological Society has chosen ***Joseph Pedlosky***, Senior Scientist in the WHOI Physical Oceanography Department, for its prestigious 2005 Sverdrup Gold Medal. The award is granted to researchers who "make outstanding contributions to the scientific knowledge of interactions between the oceans and the atmosphere." In the award notice, Pedlosky was cited "for developing geophysical fluid dynamics, including the theories of baroclinic instability and of ocean circulation driven by wind and buoyancy flux."

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Bob Gagosian presents Lauren Mullineaux with the first Arnold B. Arons teaching award.

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WHOI has awarded endowed chairs to five researchers, recognizing them for "extraordinary scientific research and education." The chairs provide three to five years of funding.

Lloyd Keigwin, Senior Scientist in the Geology and Geophysics Department, was named the first recipient of the Edna McConnell Clark Chair for Excellence in Oceanography. Keigwin's research focuses on the ocean's role in climate change, as viewed through studies of deep-sea sediments. Colleagues noted that Keigwin was among the first to document a change in the properties of Atlantic water masses during the last ice age. He serves as chair of the scientific steering committee for the United Kingdom's Rapid Climate Change Program.

The chair was established in 2004 in honor of longtime Institution supporter Edna McConnell Clark. The Clark Family has generously supported the people, programs, and facilities at WHOI for more than 50 years. Clark Laboratory, the Institution's largest research facility, is named in honor of Mrs. Clark and her late husband, W. Van Alan Clark, Sr. They also helped found the WHOI Associates Program in 1952 and helped endow the joint graduate program with MIT.

James Moffett, Senior Scientist in the Marine Chemistry and Geochemistry Department, was awarded the Mary Sears Chair for Excellence in Oceanography to continue his development of new analytical approaches to controlled laboratory experiments and novel hypotheses concerning the impacts of trace metals like copper, iron, and zinc on plankton in the open ocean. "Creative and innovative science" have been the hallmarks of Moffett's career at WHOI, according to colleagues, who also praised his ability to get marine chemists and biologists to work together. The chair is named for Mary Sears, one of the first staff members of the Institution and a guiding force in its development.

The Robert W. Morse Chair for Excellence in Oceanography was awarded to ***James Lynch***, Senior Scientist in the Applied Ocean

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James Lynch

Physics and Engineering Department. Colleagues noted that he has been "an innovative and invaluable researcher" in the fields of acoustics, geology, and physical oceanography, and has "paved the way to a better understanding of the complicated and many faceted problem of acoustic propagation in shallow water environments." The chair is named for former Associate Director and Dean of Graduate Studies Robert Morse, a physicist with research interests in underwater acoustics.

John Toole, Senior Scientist in the Physical Oceanography Department, is the recipient of the Columbus O'Donnell Iselin Chair for Excellence in Oceanography. Toole studies the physics of ocean mixing, global heat and freshwater budgets, water mass formation and circulation, and oceanographic instrument development. Colleagues noted that Toole "observes widely, measures new things, interprets well, is thoroughly informed about general principles, and even develops new devices to add to the collection of instruments for the world community." The chair is named for the Institution's second director, a major force in American oceanography in the first part of the 20th century.

Lary Ball, a Research Specialist in the Marine Chemistry and Geochemistry Department, was awarded the Allyn Vine Senior Technical Award. A 25-year veteran of WHOI, Ball manages the inductively coupled plasma mass spectrometry and emission spectrometry (ICP) facility and collaborates with chemist Kenneth Buesseler. Colleagues noted that Ball's technical skills and ability as a facility manager have made the ICPMS an internationally recognized facility. The award is named for former WHOI scientist Allyn Vine, a visionary champion of undersea tools and techniques, for whom the submersible *Alvin* was named.

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Lary Ball

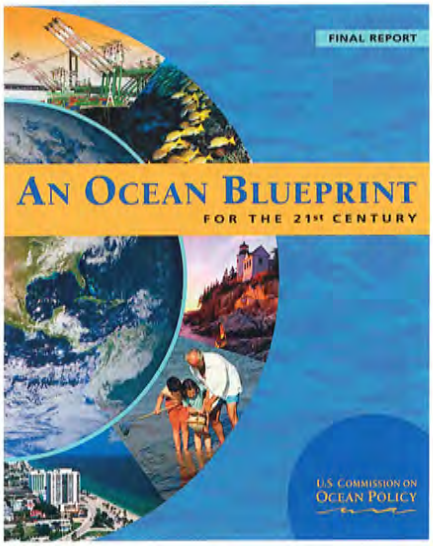
Ocean Commission Recommends a Sea Change

Calling for a new governance framework, more investment in marine science, an ecosystem-based approach to ocean management, and a new stewardship ethic for all Americans, the U.S. Commission on Ocean Policy presented its final report to the White House on Sept. 20, 2004.

The 610-page "Ocean Blueprint for the 21st Century" offers 212 recommendations for a new national ocean policy. The Commission was established through the Oceans Act of 2000, and several WHOI scientists participated in the Commission's Science Advisory Board, including Andy Solow, Director of the Marine Policy Center, Ken Brink, Senior Scientist in the Physical Oceanography Department, and Bob Gagosian, President and Director.

The Commission's recommendations are organized into three major themes:

• To improve decision-making, promote effective coordination, and move toward an ecosystem-based management approach, a new National Ocean Policy Framework was recommended. Commissioners promoted the strengthening of the federal agencies tasked with ocean research, improved coordination of ocean research and management activities, an enhanced regional approach to ocean issues, and coordinated governance of offshore waters.



• The Commission made strong recommendations that sound scientific information should be available for—and applied to—decision-making. The group called for significant new investments in science, exploration, and data collection, as well as promotion of efforts to more reliably turn data into useful management information.

• The Commission strongly emphasized the need to strengthen ocean education at all levels and to improve national science literacy.

By law, President Bush had until Dec. 20 to respond to the report, but Congress started its deliberations in the summer of 2004, holding hearings and introducing more than 20 bills to implement various recommendations. The report is likely to be an important focus when Congress reconvenes in February. Read more at: http://www.oceancommission.gov

—Terry Schaff

Nurturing Hope

Birth of an effort to preserve a species
(page 2)

Chris Slay, New England Aquirium

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