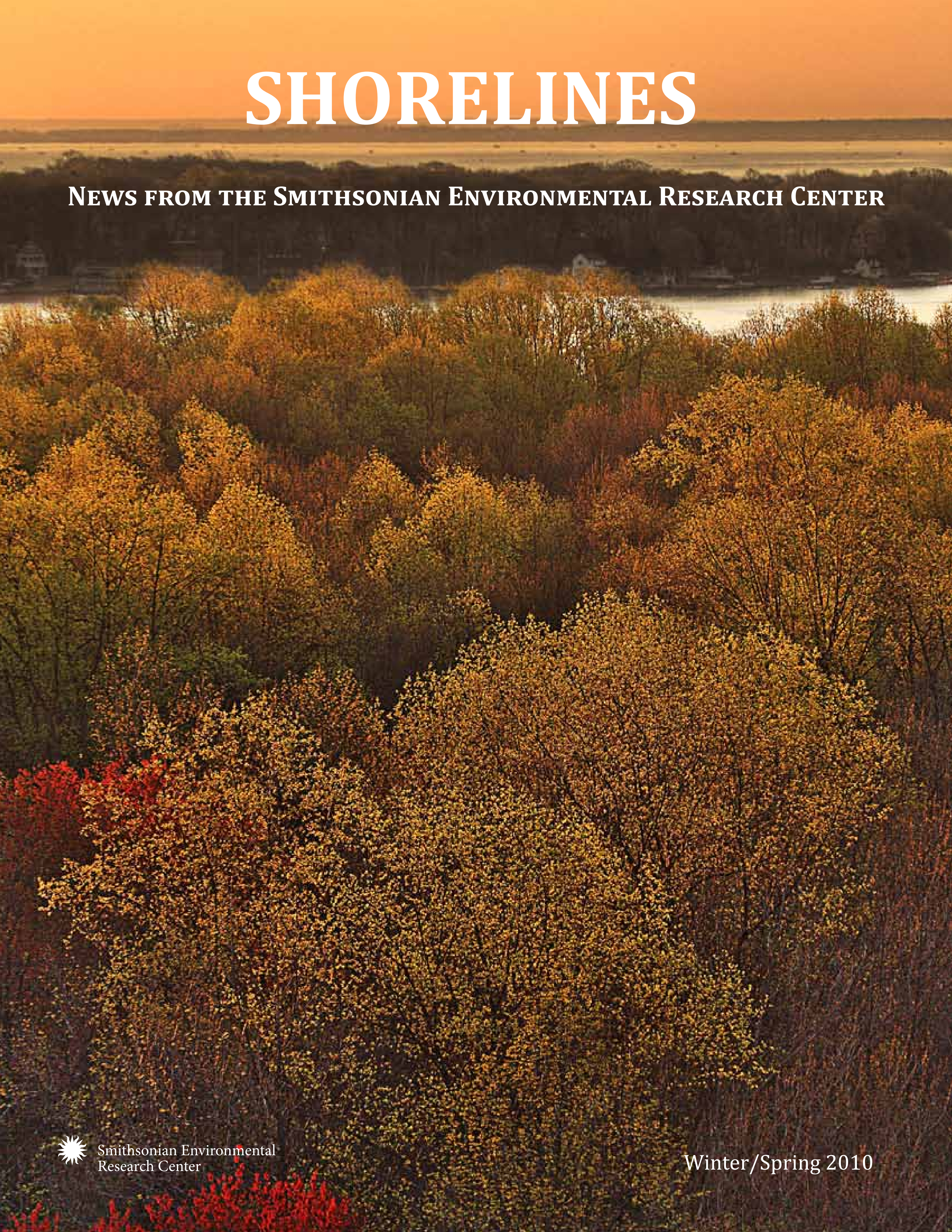
SHORELINES

News from the Smithsonian Environmental Research Center



Smithsonian Environmental Research Center

Winter/Spring 2010

Earth Day turns 40

Image courtesy of the Image Science & Analysis Laboratory, NASA Johnson Space Center.

Taking stock and moving forward

This spring we celebrate the 40th Earth Day – an anniversary marking a journey of commitment for me and others at the Smithsonian Environmental Research Center. For the first Earth Day in 1970, I was a new graduate student at University of California, Berkeley. Then as now, it was a raucous time with the country at war and intense focus on civil rights and the role of government.

The first Earth Day developed as a grassroots movement with teach-ins about the environment. I focused on a career in ecology, but Earth Day inspired my commitment to solutions for human impacts on the biosphere. In the ivory tower of Berkeley, applied research was then portrayed as a lower calling to "pure research." But I was committed to merging fundamental ecology applied to human impacts, now a hallmark of SERC research.

Several issues back then highlighted the environmental crisis and point to both progress and major concerns today. One was a ban on DDT, the insecticide featured in Rachel Carson's *The Silent Spring*, which causes egg shell thinning and drastic declines in bird populations. A success story, today we celebrate many ospreys and a pair of eagles nesting at SERC. However, we are still worried about toxic mercury spewing into the environment and accumulating up the food chain like DDT. Today SERC microbial ecologist Cindy Gilmour sees new hope as mercury is beginning to be scrubbed from coal-fired power plants.

In 1970 the *Whole Earth Catalogue* with its iconic cover image was a major resource for information on sustainability; I still have copies. As Apple's Steve Jobs points out, this was the precursor to Google in a time before the Internet. Today our access to the World Wide Web allows instantaneous global connection to information, as SERC's distance learning programs and Web site show well.

The first Earth Day emphasized the future impacts of human population growth, exemplified then by Paul Ehrlich's book *The Population Bomb*. In 1970 the world's population was 3.7 billion. Today it has nearly doubled to 6.8 billion, with projections of more than 9 billion people in another 40 years. Forty years ago 8 million people lived in the Chesapeake watershed; today there are 17 million, headed toward 25 million by 2050. Our economy assumes that growth can be sustained indefinitely, but ecology shows that resources are finite and limit populations at ecosystem carrying capacity. SERC research indicates overfishing by the ever-growing human population is limiting the Chesapeake blue crab stock, like many other fisheries around the world.

The first Earth Day stressed the integration of Earth's ecosystems. In just 40 years, global change – especially the effects of climate warming – is rapidly overwhelming us. SERC was established just 45 years ago, with the prescient purpose of understanding how coastal ecosystems respond to climate change. I hope that you feel the urgency of SERC's mission to understand and sustain the Earth's ecosystems over the next 40 years and beyond.

- Tuck Hines, Director

A tree grows quickly in the forest

Climate change appears to be driving accelerated growth

Speed is not a word typically associated with trees; they can take centuries to grow. However, a recent study published in the *Proceedings of the National Academy of Sciences* has found evidence that forests in the Eastern United States are growing faster than they have in the past 225 years. The study offers a rare look at how an ecosystem is responding to climate change.

For more than 20 years forest ecologist Geoffrey Parker has tracked the growth of 55 stands of mixed hardwood forest plots in Maryland. The plots range in size, and some are as large as 2 acres. Parker's research is based at the Smithsonian Environmental Research Center, 26 miles east of the nation's capital.

Parker's tree censuses have revealed that the forest is packing on weight at a much faster rate than expected. He and Smithsonian Tropical Research Institute postdoctoral fellow Sean McMahon discovered that, on average, the forest is growing an additional 2 tons per acre annually. That is the equivalent of a tree with a diameter of 2 feet sprouting up over a year.

SERC Forest Ecologist Geoffrey Parker estimates that his lab has taken 250,000 measurments since he began documenting tree growth in 1987. Photo: Kirsten Bauer

Forests and their soils store the majority of the Earth's terrestrial carbon stock. Small changes in their growth rate can have significant ramifications in weather patterns, nutrient cycles, climate change and biodiversity. Exactly how these systems will be affected remains to be studied.

Parker and McMahon's paper focuses on the drivers of the accelerated tree growth. The chief culprit appears to be climate change, more specifically, the rising levels of atmospheric CO_2, higher temperatures and longer growing seasons.

Assessing how a forest is changing is no easy task. Forest ecologists know that the trees they study will most likely outlive them. One way they compensate for this is by creating a "chronosequence"—a series of forests plots of the same type that are at different developmental stages. At SERC, Parker meticulously tracks the growth of trees in stands that range from 5 to 225 years old. This allowed Parker and McMahon to verify that there was accelerated growth in forest stands young and old. More than 90% of the stands grew two to four times faster than predicted from the baseline chronosequence.

By grouping the forest stands by age, McMahon and Parker were also able to determine that the faster growth is a recent phenomenon. If the forest stands had been growing this quickly their entire lives, they would be much larger than they are.

Parker estimates that among himself, his colleague Dawn Miller and a cadre of citizen scientists, they have taken a quarter of a million measurements over the years. Parker began his tree census work Sept. 8, 1987—his first day on the job. He measures all trees that are 2 centimeters or more in diameter. He also identifies the species, marks the tree's coordinates and notes if it is dead or alive.

By knowing the species and diameter, McMahon is able to calculate the biomass of a tree. He specializes in the data-analysis side of forest ecology. "Walking in the woods helps, but so does looking at the numbers," said McMahon. He analyzed Parker's tree censuses but was hungry for more data.

It was not enough to document the faster growth rate; Parker and McMahon wanted to know why it might be happening. "We made a list of reasons these forests could be growing faster and then ruled half of them out," said Parker. The ones that remained included increased temperature, a longer growing season and increased levels of atmospheric CO_2.

During the past 22 years CO_2 levels at SERC have risen 12%, the mean temperature has increased by nearly three-tenths of a degree and the growing season has lengthened by 7.8 days. The trees now have more CO_2 and an extra week to put on weight. Parker and McMahon suggest that a combination of these three factors has caused the forest's accelerated biomass gain.

Ecosystem responses are one of the major uncertainties in predicting the effects of climate change. Parker thinks there is every reason to believe his study sites are representative of the Eastern deciduous forest, the regional ecosystem that surrounds many of the population centers on the East Coast. He and McMahon hope other forest ecologists will examine data from their own tree censuses to help determine how widespread the phenomenon is.

Phragmites australis: Genetic analysis reveals the promiscuous nature of this invasive reed

Phragmites australis took its sweet time taking over East Coast wetlands. A non-native strain of the reed arrived in the U.S. around 1800, likely stowed away in the ballast material of European ships. For nearly two centuries the plant grew in relatively small pockets along the coast. Today it's a poster child for invasive species. In some states along the Atlantic Ocean, *P. australis* blankets as much as a third of the tidal wetland acreage. Among other impacts, it challenges native plants for turf. The European strain has even out-competed North America's native *P. australis*.

The sudden spread of the invasive *P. australis* fascinated SERC's Melissa McCormick, Dennis Whigham and Karin Kettenring. The rapid expansion around the Chesapeake Bay began in the 1980s and highlights a key frustration for scientists and resource managers: it's difficult to predict which non-native species will thrive in a new environment and which ones will fail.

P. australis finagles its way into coastal wetlands when the soil is exposed. This can happen when a muskrat munches away at vegetation or a homeowner builds a seawall or other shoreline-hardening structure. Until now, scientists did not understand how *P. australis* was making these exposed areas home. *P. australis* can reproduce sexually through seeds or clonally, through rhizomes—thick underground stems that sprout new plantlets.

In fall 2007 the three SERC ecologists set out to determine which reproduction method was responsible for *P. australis*' successful spread. They hopped into a small jon boat, and braved shipping traffic and bad weather to collect leaf samples in nine subestuaries within the Chesapeake Bay.

In the end they gathered around 1,500 samples that they ran DNA analysis on. "I've always been interested in what patterns of genetic diversity can tell us about how plants got to their habitats," explains McCormick. If the plants propagated through rhizomes, the *P. australis* patches would be genetically very similar because each offspring is simply a clone of the parent. However, the genetic variation would be greater if *P. australis* was reproducing sexually through seeds.

McCormick found that of the 167 *P. australis* patches they surveyed, 92% were composed of multiple genetic individuals and that no genetic signature was repeated among the patches. This was a clear signal that seeds have driven *P. australis*' explosive expansion in the Chesapeake Bay's brackish wetlands. Furthermore, in a separate study Whigham and Kettenring found that *P. australis* patches with greater genetic diversity produced more viable seeds. "It's a red flag," says Whigham. "The research demonstrates that *P. australis* has the potential to continue to expand at an ever-increasing rate."

Whigham, Kettenring and McCormick are busy sharing their findings with regional resource managers. Their advice: work on a large geographic scale and focus on the genetically-rich patches that crank out seeds. The trio hopes their research will inform a new strategy for dealing with *P. australis* in the Chesapeake Bay, one that will give native marsh plants room to grow.

Climate Change: The Long View

A conversation with plant physiologist Bert Drake

Photo: Tina Tennessen

This past January renowned plant physiologist Bert Drake retired from SERC after nearly four decades with the Smithsonian. For 23 years he has sustained the world's longest-running experiment on the effects of rising CO_2 on natural plant communities. Supporting such long-term research on a series of short-term, competitive grants is a remarkable feat. Drake's experiment is centered at SERC's salt marsh ecosystem on the Chesapeake Bay, but his investigations have taken him around the world, with other experiments in Florida and Norway. His contributions to understanding the role that plants play in global change are reflected in more than 100 publications in leading journals like *Global Change Biology*. During his time at SERC, Drake has trained a diverse array of students, postdoctoral fellows and visiting scientists. He is an animated lecturer, enthusiastically giving of his knowledge. In 2005, he was recognized as the Secretary's Distinguished Lecturer, the Smithsonian's top research award. Thankfully, Drake will continue his research at SERC as an emeritus scientist. Proving that he's not calling-it-quits, he helped secure another decade of funding from the National Science Foundation for SERC's research on global change in salt marshes. - Tuck Hines, Director

How did you earn a living before you became a scientist?
I was a drummer in a jazz band, a ski guide, the host of a jazz radio program and a high school science teacher.

How did you get drawn to the world of plant physiology?
Nature has always fascinated me and science is about discovering how nature works. I grew up in northern Maine. My father was a barber, but loved the outdoors. I was outside year-round: skiing, canoeing, trapping animals, fishing and taking photos. I knew I wanted to do something connected with biology. I became a science teacher, but it wasn't until I attended a summer course in ecology that I wanted to get inside a lab and practice science.

Much of your work has focused on understanding how plants will respond to rising levels of atmospheric CO_2. In 1987, you began a field experiment at a marsh on the Chesapeake Bay that continues to this day. What are you trying to figure out?
The big question has always been whether or not plants and our land ecosystems would remain carbon sinks as atmospheric CO_2 increases and the climate warms. We wanted to know if plants exposed to high CO_2 in the field would keep growing and or if they would simply acclimate to higher CO_2. Earlier studies had focused on greenhouse plants. Most concluded that the photosynthetic capacity of plants would decline after being exposed to elevated CO_2. I thought that critical experiments had not been done. I wanted to get out into the field and study how an entire wetland would respond to higher levels of CO_2.

Immediately after we began the study in 1987, we found the plants were taking up more CO_2. After 5-10 years the extra CO_2 had big effects. We took this to mean that plants and wetland ecosystems could remain a carbon sink, even in a high CO_2 world. After 20 years though, the plants' response to more CO_2 has become erratic. This makes interpretation of the results much more difficult. In science you almost always get an approximation of an answer because an experiment is only an approximation of reality.

What else has your experiment revealed?
Our work has shed light on the relationship between the carbon and water cycles. If we've come up with one painful piece of evidence, it's that water is critical. That may seem obvious, but it's important to understand in the context of climate change models. Some of these models predict more and longer droughts. Drought would reduce the productivity we've seen in plants that are given more CO_2. Without water, these ecosystems can become carbon sources rather than sinks.

What do most outsiders not understand about the art of practicing science?
When I taught high school science, I was required to present my students with a certain body of information. Science at that level was something to be memorized: plant names, their habitat and their range. This approach emphasizes what we know and not how we know it. Very little is taught about science as a process until graduate school. An exception to this is SERC's intern program where we engage undergraduates in research projects.

I think it's also difficult for outsiders to appreciate how much training it takes to become a scientist. Initially I thought all it involved was coming up with a hypothesis, making measurements and EUREKA! That is not how it works. You have to acquire an enormous amount of background knowledge in order to ask a question that makes sense and that can be answered.

What traits make for a good scientist?
Perhaps one of the most important characteristics of a scientist is curiosity. You can go along making measurements and cranking out publishable data sets, but you need to be curious about what the data are saying to you. You also have to be obsessive. Science is extraordinarily hard work. Being obsessive helps you endure it.

Hypoxic waters

Understanding the effects on fisheries

Habitat destruction comes in many forms. The obvious include the clear-cutting of forests and the removal of mountaintops. Then there is the damage that's less visible, like hypoxia.

In coastal waters around the world there are more than 500 hypoxic zones. These are areas where dissolved oxygen concentrations are so low that they threaten fish, invertebrates and aquatic food webs. Some fish manage to escape hypoxic areas, but oysters, clams and other sessile creatures are simply stuck.

Hypoxia makes the evening news when there is a noticeable fish kill. However many of its effects are more subtle. Individuals that fail to escape low oxygen zones can suffer mortality or reduced growth and reproduction. Creatures that flee can become easy targets for fishermen and predators.

Denise Breitburg runs SERC's Marine and Estuarine Ecology Lab; her investigations have revealed new details about hypoxia's many impacts. She's explored the toll it takes on a range of organisms including jellyfish, oysters and finfish. "I'm intrigued by how animals respond to challenges to their environment and how that translates into patterns we see at the population, community and system level."

In the summer months you can find Breitburg's lab dissecting oysters to determine how hypoxia affects disease rates in the Eastern oyster, *Crassostrea virginica*. During the winter, Breitburg does what many ecologists do: she writes papers. In a recent landmark study published in the *Annual Review of Marine Science*, she examined how hypoxia and nitrogen pollution affect fisheries around the world.

Excess nitrogen, from fertilizer runoff and sewage treatment plants, causes a chain reaction that can lead to hypoxia. Algae gorge themselves on extra nitrogen and "bloom." When a bloom dies and decomposes, much of the water's oxygen gets depleted. The result can be hypoxia or—even worse—anoxia: water that is completely devoid of oxygen. Breitburg says that humans have increased nutrient inputs into the environment so much that, "We've turned our coastal waters into overfertilized agricultural systems."

Interns measure dissolved oxygen concentrations in the Chesapeake Bay. Water is typically considered hypoxic if oxygen concentrations are below 2mg/L. Photo: Courtney Richmond

Unlike finfish and crabs, oysters and other sessile creatures cannot escape hypoxic water. Photo: Rebecca Burrell

"An overestimate of hypoxia's effects on fisheries risks drawing attention away from critical stressors like fishing that are the proximate causes of declines in exploited populations."

From a management perspective, an important question is whether reducing nutrient inputs into estuaries like the Chesapeake Bay, in order to reduce hypoxia, will benefit fisheries. Breitburg's study explored this question on a global scale; she looked at data from 30 estuaries and semi-enclosed seas. She found that, although some particular species or locations were negatively affected, the total biomass of fish caught was not lower in systems with hypoxia.

This finding runs counter to what many would assume: that estuaries and seas with high levels of hypoxia would have lower fish catches. It is a puzzle that Breitburg suggests might be answered by exploring the behavior of fish and fishermen. She thinks high fish catches in systems with hypoxic water may reflect the ability of fish to avoid low oxygen areas. And fishermen, wise to the ways of their prey, likely concentrate their activities in the waters where these fish find refuge. Fishing also reduces size of fish populations, so sufficient habitat might be available to support the remaining fish even when some habitat is degraded by hypoxia.

It is common practice for ecologists to identify the factors that limit plant and animal populations. There is no doubt that nitrogen pollution and hypoxia destroy habitat and reduce fish populations in the waters where they occur. But Breitburg's study shows that they may not be the *main* variables that determine the size of fish catches on a system-wide level. She cautions, "An overestimate of hypoxia's effects on fisheries risks drawing attention away from critical stressors like fishing that are the proximate causes of declines in exploited populations."

Breitburg is building upon her global study. This past fall she brought 20 scientists from five countries to SERC. They outlined a plan to share data on nutrients, hypoxia, food webs and fisheries. The group hopes to double the number of seas and estuaries that Breitburg examined and gain a clearer understanding of how human activities alter coastal ecosystems.

Photos: Kirsten Bauer

Homeschoolers turn to SERC for science education

"Ms. Karen's" homeschoolers don't give her apples to show their thanks. They leave her jars of black sand and shards of volcanic rock. It's fitting for a teacher who packs her lessons with as much hands-on science as possible.

There are more than 24,000 students who are homeschooled in Maryland. This spring SERC is offering nine homeschool programs. They include new classes on shark dissection and a laboratory-based class focused on Chesapeake Bay fish.

For many of these parents, teaching science is a daunting proposition. They may not have the background or the lab equipment to help their kids develop the skills and knowledge they need. "We saw that it was an underserved population," says SERC's education director Mark Haddon. Enter Karen McDonald. She launched SERC's homeschool program in earnest four years ago. Since then, she has expanded it from elementary-age kids to include students up to age 16.
Today's class is about birds. A stuffed osprey, a kestrel, a woodpecker, a duck and two owls sit on a table at the center of the room. In one hour, McDonald's 15 homeschool students and a smattering of mothers will learn about bird anatomy, the different types of feathers, and how eggs become pigmented. McDonald doesn't lecture, she engages. During this lesson the students will use crayons, feathers, clay, plastic Easter eggs, markers and tube socks.

Like a normal classroom teacher, McDonald gives her students prep work, vocabulary words and take-home exercises. Homeschool parent Julie Nolan describes a SERC class the way some parents might talk about a video game. "It's a take-away," she says, as in she can threaten to take the classes away from her children if they fail to clean their rooms. "They'll do whatever I ask so they can come to SERC," she laughs.

Nolan has three children ages 5, 7, and 9. This age span among siblings is common in any family, but for teachers like McDonald it poses a unique challenge. McDonald's classes contain a range of ages. It is not as drastic as an old one-room schoolhouse, but 5-year-olds learn with 7-year-olds, 8-year-olds learn with 12-year-olds and so on. The parents say they like this aspect of SERC's homeschool program because it lets older students teach the younger ones. The classroom setting also gives them the chance to socialize with other kids.

The spring classes are at-capacity. "It's easier to get into Harvard," remarks Nolan. Education director Mark Haddon recognizes the growing demand. He says SERC continues to look for ways to offer more opportunities to homeschoolers, but is committed to maintaining the quality of instruction that McDonald's classes offer.

Visit our online calendar to find out about upcoming classes, hikes, canoe trips and educational activities for all ages, http://serc.si.edu.

EVENING LECTURE SERIES BEGINS

April marks the beginning of the Smithsonian Environmental Research Center's 2010 Evening Lecture Series. The free monthly talks highlight current research in today's pressing ecological and environmental issues. The lectures occur on the third Wednesday of the month and run through November. For a complete listing of the talks, please visit the calendar on our Web site, http://serc.si.edu.

SERC's Evening Lecture Series is made possible with the generous support of the Adam J. Weissman Foundation.

Origins and Development of New World Paleo-Indian Cultures
Dennis Stanford, Anthropologist, Smithsonian Museum of Natural History
April 21, 7:00 p.m.

"Weird Deep-Sea Squids and the Nature of Natural History"
Michael Vecchione, Director of the National Systematics Laboratory, NOAA
May 19, 7:00 p.m.

"Evidence for a Recent Increase in Forest Growth: A Response to Climate Change?"
Geoffrey Parker, Forest Ecologist, SERC
June 16, 7:00 p.m.

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Photo: Chuck Gallegos

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