Smithsonian Environmental Research Center

ON THE EDGE

News from the Smithsonian Environmental Research Center

Spring 2019

Rethinking Carbon

Meet the team that's busting myths about blue carbon on the coasts

As habitat for fish and a tourist draw, coral reefs contribute an estimated $172 billion to the world economy. (Photo courtesy of Siva Sankar)

Conservation and the Power of "And" versus "Or"

THE DIRECTOR'S LETTER

There's a false narrative that has infected environmental debates for decades. It boils down to two words: *and* versus *or*.

For too long, policymakers have thought they always had to choose: Care for the environment or boost the economy. Fight climate change or allow business to prosper. Sustain fisheries or help watermen.

Fortunately, that narrative is beginning to change. As we dig deeper into what nature has to give, a series of different stories emerge. By combining our creativity with the services nature offers when we see its real value, we're discovering the power of *and*.

"Marsh organ" experiments like these help measure how wetlands will respond to rising seas. (Credit: SERC)

If you live anywhere on the coast, one story may be unfolding a short drive from your home. Coastal wetlands decorate shorelines all around America. For centuries, landowners regarded wetlands as "unimproved" territories—or, more bluntly, a waste of space that could be better turned into farms. But in the last few decades, we've started to recognize their true worth. They shield us from hurricanes and storm surges, absorbing destructive energy. They filter out nutrients and toxic chemicals, keeping pollution out of the water. They provide critical habitat supporting most of our coastal fisheries. And they bury carbon more efficiently than even forests—so much that businesses and governments are looking to create markets for "blue carbon credits."

Turn to page 4 of this newsletter, and you'll meet some of the scientists who are changing the way we think about wetlands and the carbon they store. Dozens of scientists across the U.S. have joined SERC's new Coastal Carbon Research Coordination Network, because they've realized coastal wetlands are key to a healthier planet and a prosperous future.

SERC director Tuck Hines holds a rockfish (striped bass), one of the most popular commercial fish in the Chesapeake. (Credit: Ben Wechsler)

It's happening in the ocean too. When underwater animals have a place to retreat from intense fishing, such as a marine reserve, it can revive struggling fisheries. Just this spring, marine biologists discovered that predators—many of them popular seafoods—get a boost inside marine reserves. And that abundance can spread to other parts of the ocean, sustaining the livelihoods of thousands who work on the water.

Of course, embracing the power of *and* does not mean we never have to make hard choices. The path to our best possible future will have some uphill climbs. We cannot always afford to take the cheapest, easiest or most convenient path in the short term.

But when we look at the world through the *and* lens, protecting nature becomes an investment that takes advantage of everything the environment has to offer. I've seen it pay off, in the way fisheries have bounced back in the Chesapeake when managed effectively, and the way seagrasses are recovering thanks to a "nutrient diet" that cuts pollution by conserving streamside forests and wetlands. The environment or the economy is a false choice. We can have both, if we have the creativity—and the courage—to change how we value the Earth.

— ANSON "TUCK" HINES, SERC DIRECTOR

Front Cover Photo: Black mangroves like this one are moving up the coast of Florida, outstripping the other two mangroves—red and white—making the same northward migration. (Credit: John Parker/SERC)

RESEARCH DISCOVERIES

MARINE RESERVES CAN REJUVENATE THE FOOD WEB

Creole fish school at the Galápagos Marine Reserve. (Credit: Brian Cheng, UMass Amherst)

Nature doesn't work very well without predators. Ecosystems need carnivores to keep plant-eaters from mowing down all the flora. But many marine predators are also popular seafoods. How do we keep too many from disappearing?

University of Massachusetts biologist Brian Cheng and scientists from SERC and the Smithsonian Tropical Research Institute zeroed in on "marine protected areas"—parts of the ocean that limit or prohibit fishing. Their latest synthesis, published March in *Ecology*, examined data from 30 marine protected areas on five continents. On average, predators increased over four times in protected zones. Prey decreased by half. Marine reserves are increasingly popular for sustaining fisheries, and we've known for some time that they increase production and biodiversity. But now we know they help on a deeper level, by keeping ecosystems ticking.

Link to marine reserve study: http://dx.doi.org/10.1002/ecy.2617

Rhode River, a tributary of Chesapeake Bay. (Credit: Kim Richie/SERC)

THERE'S AN ULTRAVIOLET LINING TO THE RHODE RIVER'S CLOUDINESS

Anyone who's gone swimming in the Chesapeake—or its rivers—has experienced its infamously murky waters. But many things can make a river cloudy. For three decades, scientists led by Pat Neale, Tom Jordan and Chuck Gallegos used the Rhode River at SERC as a case study. Their new paper, highlighted in a special *Limnology and Oceanography* issue, sought to piece apart what's really been happening there over 30 years.

From 1986 through 2005, water clarity remained relatively stable year to year. That changed in the next decade, when scientists suspect increased shoreline erosion and higher sediment loads intensified the murkiness. More stable marshes could ultimately give the river much-needed clarity. But ultraviolet light struggled just as much as visible light to get through the water. Since excess ultraviolet can stop plants from photosynthesizing, perhaps for now a little extra protection isn't a bad side effect.

Link to Rhode River study: https://doi.org/10.1002/lno.11005

FLORIDA'S GREAT MANGROVE MIGRATION IS BOOSTING CARBON STORAGE

We've seen them coming. For decades, Florida mangrove trees have been migrating north, encroaching on salt marshes. Their journey could transform how well coasts fight climate change. Mangroves and marshes are both carbon-storing powerhouses. This begs the question: Will mangrove-invaded marshes store more carbon than pure marshes, or less?

Candy Feller stands next to one of the northernmost black mangroves in a Florida salt marsh. (Credit: Emily Dangremond)

For now, it seems the mangroves have it. In a new *Hydrobiologia* paper, University of Florida postdoc Lorae Simpson and SERC ecologist Candy Feller led an experiment in five sites that—in 2015—were pure salt marsh. By 2018, mangroves had intruded, and carbon storage rose 68 percent. The spike largely came from mangroves' woody stems (which marsh plants conspicuously lack), but root and soil carbon also increased. Most of the mangroves were still young. As they get bigger, carbon storage could spike even more.

Link to mangrove study: https://doi.org/10.1007/s10750-019-3905-z

Rethinking Carbon

A new team is using big data to change how the world calculates its carbon budget on the coasts BY KRISTEN MINOGUE

Carbon Myth-Busting

Here are four of the top assumptions and uncertainties the Coastal Carbon Research Coordination Network has zeroed in on.

ASSUMPTION: **Methane is 25 times more powerful than carbon dioxide.**

REALITY: **That math works if one large burst of methane escapes all at once. But for ongoing leaks, like from natural gas pipes, 45 times higher is closer to the truth.**

ASSUMPTION: **Whenever coastal wetlands lose soil to erosion, all the lost carbon escapes to the atmosphere.**

REALITY: **Anywhere from one-fourth to one-half of the carbon can get buried in ocean sediments.**

UNCERTAINTY: **How much methane do wetlands emit?**

ANSWER: **It depends how salty they are. Salty wetlands generally emit less than fresher ones. One of the largest sources of data in the U.S., the Coastal Change Analysis Program, labels a wetland salty ("estuarine") if its saltiness is above 5 parts per thousand. But a better dividing line is around 18 parts per thousand.**

UNCERTAINTY: **How fast can wetlands bury carbon?**

ANSWER: **It depends on your measuring stick. Scientists have used lead and cesium isotopes, and radiocarbon dating, to calculate when wetlands bury carbon and how quickly. Next step: Making all those different datasets harmonize.**

There's a gaping hole in Earth's carbon budget. Scientists have known about it for years, but the data to balance the books have proven hard to find. The blank line is for coastal wetlands—ecosystems that could protect us not only from climate change, but hurricanes, pollution and a host of other environmental hazards.

"When we think of carbon storage or natural climate solutions, a lot of the time forests and trees come to mind," said David Klinges, a research technician at the Smithsonian Environmental Research Center (SERC). "Because trees have a lot of mass, they store a lot of carbon. But what is not as publicly recognized is that soils—and other forms of plants besides trees—they also store carbon."

Coastal wetlands have an especially good reputation as carbon-storing juggernauts. They can build new soil even as seas rise. And those soils, often loaded with carbon compounds, immediately find themselves buried under oxygen-starved saltwater, where their carbon can't escape.

"It gets refrigerated and pickled all at once," explained SERC research associate James Holmquist.

Knowing exactly how much carbon wetlands store could transform how countries solve climate change. If only we had enough data.

Holmquist and Klinges are spearheading an effort to find that data. Called the Coastal Carbon Research Coordination Network, they're calling on scientists from Conservation International, the U.S. Geological Survey and other organizations across the U.S. to share any numbers on coastal wetland carbon. Along the way, their new team is upending some long-held assumptions about how carbon storage works in the real world.

HIDDEN FIGURES

Ironically, the problem isn't lack of data. Last June Holmquist and other members published a Nature paper that scraped together data from nearly 2,000 soil cores. Most weren't in any official government database. The information is out there, but it's scattered, like pieces of a jigsaw puzzle dropped from an airplane. The challenge is sharing it.

One obstacle is an understandable fear. A scientist's data is her life's work. If published online, an unscrupulous researcher could steal the data without acknowledging her, taking credit for years of labor.

"I used to work in the lab eight, nine, 10 hours a day," Holmquist said. Weigh. Dry. Weigh. Burn. Weigh. Repeat. Measuring dirt can be monotonous. "I remember what it was like doing that hard lab work."

But even for scientists eager to publish data—and many are—there's another barrier. Sharing data is *hard*.

"To make data publicly available, it needs to be clean and tidy. It's a very tedious process," Klinges said.

Sharing data takes more than posting numbers online, explained soil scientist Kathe Todd-Brown, data coordinator for the International Soil Carbon Network. Researchers need to pick a format any software can handle. It needs metadata, or "data about the data"—who collected it, when and where, or image resolutions. And it needs to be legible. Many stretched-thin scientists don't have the time or expertise to tackle it.

Fortunately, Klinges and other network members can help with the more mind-numbing aspects of data processing. Klinges has been pulling all their info together in a Data Clearinghouse, which he calls "our one-stop shop for coastal

"Our willingness to embargo data until researchers are ready is our demonstration of the trust that scientists can place in us."

-David Klinges

carbon data." Earlier in 2019, they created a companion interactive map where users can both visualize and download the data.

They've also built a safety net for scientists nervous about leaving their data out in the open. If a scientist gives data to the Coastal Carbon Research Coordination Network, the network's managers agree not to publish anything until that scientist first publishes it in her own paper.

"Our willingness to embargo data until researchers are ready is our demonstration of the trust that scientists can place in us," Klinges said.

WADING INTO THE UNKNOWN

We can't afford to ignore wetlands in our plans to solve climate change. Yet there's still much we don't know, and several common assumptions are oversimplified or flat-out wrong. Most experts are aware of the shortcomings. But when the highest panel of climate scientists in the world—the Intergovernmental Panel on Climate Change—issues reports, they have to base their estimates on something.

Throwing uncertainties and assumptions into sharp relief, and offering alternatives, is the coastal carbon scientists' second mission.

Methane sits at the top. It's an even more powerful greenhouse gas than carbon dioxide: 25 times more by conventional estimates. But the coastal carbon network suspects it's even higher, possibly 45 times.

Some wetlands emit methane naturally. How much remains a big unknown. So far, scientists know freshwater wetlands emit more methane than salty ones. Coastal wetlands (because they're on, well, the coast) lean saltier. Unless, Holmquist pointed out, they've been altered.

"A lot of these wetlands are artificially freshened," Holmquist said. However, if coastal wetlands are being *made* fresher, we can reverse that process. Reconnecting coastal wetlands to the sea would make them emit less, even zero, methane. "It makes the restoration benefit a lot higher," he said.

Then there's the question the team was most ready to pounce on: How fast can coastal wetlands bury carbon? Are they the same everywhere?

In 2018, the network convened a smaller working group to dig into that. They shared data virtually for months before meeting face-to-face last December. Of course, having loads of data didn't make their job easy.

"Typically when people talk about big data, they're talking about sheer volume of data," said Todd-Brown, a working group member. But there are lots of ways to measure soil carbon. "In soils, your data is wide as opposed to just big. You have a huge diversity of data."

Right now, the group suspects sea-level rise and plant life may shape how fast wetlands bury carbon. Later in 2019, a second group will start drilling into the other big uncertainty: methane.

A QUESTION OF VALUES

Demystifying wetlands is about more than correcting climate change reports. Real people make their homes around coastal wetlands and depend on them for their livelihoods.

"People depend on these ecosystems for many reasons. Fisheries, ecotourism, harvesting, coastal defense from waves and storms," said Jorge Ramos, a carbon scientist with Conservation International, which helped co-found the network. Carbon often isn't the first thing land managers consider when deciding about conserving wetlands. But that data offers a bonus, especially if it can translate into blue carbon credits—credits for carbon in coastal systems like wetlands.

"We want to be able to prove that we're not just another research database," Ramos said. "We actually want to be useful. We want to show examples of how the data is helpful and contributing to protecting these ecosystems."

For Holmquist, the coastal carbon network represents what the future of science needs to be.

"In the past, science has been very tribal. It's been very individual-focused, very lab-focused," he said. Solving planetary problems like this requires more collaborative thinking. "I think that while working together, we're going to move a lot faster and a lot further than we could working as individuals."

Want to go deeper?

Gain access to the Coastal Carbon Research Coordination Network and its data at https://serc.si.edu/coastalcarbon

Top L - R: James Holmquist, network manager and SERC research associate (Credit: Lauren Brown); David Klinges, database manager and SERC technician; Kathe Todd-Brown, data coordinator, International Soil Carbon Network (Credit: Andrea Starr/Pacific Northwest National Laboratory); Jorge Ramos, Center for Oceans manager, Conservation International (Credit: Laura Jaramillo/Conservation International)

Background: Maryland salt marsh where SERC scientists run their global change experiments. (Credit: SERC)

As Sea Level Rises, Wetlands Crank Up Their Carbon Storage

BY KRISTEN MINOGUE

Coastal wetlands, you're our new best friends. In the midst of defending us from some of climate change's worst impacts (e.g., hurricanes), they respond to sea level rise by burying even more carbon.

Coastal wetlands—which include marshes, mangroves and seagrasses—already store carbon more efficiently than any other ecosystem, including forests. A new study, published March in *Nature*, looked at how coastal wetlands worldwide react to rising seas and discovered they perform even better under pressure.

Pat Megonigal (Credit: Tom Mozdzer/SERC)

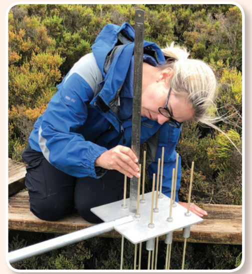
“Scientists know a fair amount about the carbon stored in our local tidal wetlands, but we didn’t have enough data to see global patterns,” said Pat Megonigal, co-author and soil scientist at the Smithsonian Environmental Research Center (SERC).

For a global picture, Australian, Chinese, South African and American scientists pooled data from 345 wetland sites on six continents. SERC scientists James Holmquist, Meng Lu and Lisa Schile-Beers from the Coastal Carbon Research Coordination Network and the Marine Global Earth Observatories joined the effort. The team analyzed those wetlands' carbon storage for up to 6,000 years, comparing whether sea levels rose, fell or remained stable over the millennia.

In wetlands with rising seas, carbon concentrations doubled or nearly quadrupled in just the top 20 centimeters of soil. When scientists looked deeper, 50 to 100 centimeters underground, the difference hit five to nine times higher.

The boost comes because carbon added to wetland soils by plant growth and sediment is buried faster as wetlands become wetter. Trapped underwater with little to no oxygen, organic detritus doesn’t decompose and release carbon dioxide as quickly. And the higher waters rise, the more underwater storage space exists for carbon burial.

The trick, of course, is to ensure wetlands don’t drown and disappear.

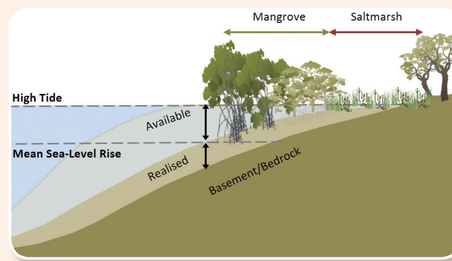


Kerrylee Rogers (Credit: University of Wollongong)

“Just like coral reefs, coastal wetlands can keep pace with low to moderate rates of sea level rise,” said lead author Kerrylee Rogers of Australia's University of Wollongong. However, she added, they’re more vulnerable under high sea-level rise scenarios the Intergovernmental Panel on Climate Change predicts. “Preservation of coastal wetlands is critical if they are to play a role in sequestering carbon and mitigating climate change."

For coastal wetlands to survive, they need space to migrate inland. Whether they have enough space depends largely on how societies prioritize many competing goals. But with climate change accelerating, wetlands can offer protection in more ways than one—if we let them.

Link to full study: https://www.nature.com/articles/s41586-019-0951-7



Bottom Right: When tidal wetlands flood from tides or sea-level rise, carbon-rich sediment accumulates above the bedrock floor. The higher the waters rise, the more space exists for sediment to build up. (Credit: University of Wollongong)

Volunteer Spotlight: Sarah Grady, Assistant Archaeology Director

BY SARA RICHMOND

Sarah Grady and other archaeology volunteers use large wooden sieves called Lavish screens to sift through soil in search of artifacts. (Photo: Sara Richmond)

In 2012, Sarah Grady was waiting tables at the Old Stein Inn and deciding what to do with her new anthropology degree when a customer told her about the Archaeology Lab at the Smithsonian Environmental Research Center (SERC), just a few miles from the restaurant. Six and a half years later, Sarah is the lab’s assistant director. The program has grown from just her and its director, Jim Gibb, to roughly a dozen volunteers who gather every Wednesday to dig and learn about each other’s projects.

The Archaeology Lab is SERC's only all-volunteer lab. It does much of its work at the Sellman House, a brick house that was once part of a plantation dating back to the early 1700s. The lab hosts about 16 projects which volunteers have undertaken on their own.

“We guide them,” Sarah said, “but most of them have taken the research into their own hands.”

The projects have one common thread: They examine past effects of humans on the landscape. One excavation unit revealed three and a half feet of layered sediment, showing how everyday land use by the Sellman House families caused erosion. Another volunteer trio is analyzing pollen, to see what crops may have grown there over the years.

Behind the Sellman house, they're also excavating a 17th-century site called "Shaw’s Folly," where they’ve unearthed Mediterranean ceramics, English pottery and a bone handle with the name “Tho Sparrow.” Thomas Sparrow and his family were neighbors of the Shaws at a site called "Sparrow’s Rest." Finding a Sparrow handle at Shaw’s Folly implies the two families were probably friendly.

Working with the Archaeology Lab took Sarah places she hadn’t even considered while waiting tables. After finishing undergraduate work, she thought she might become an anthropologist living among different cultures. Volunteering, however, led her to become a full-time archaeologist. Today she works as a contract archaeologist and teaches anthropology at Howard Community College. But she still returns regularly to pitch in with the lab.

This bone handle belonged to a man named Thomas Sparrow, who lived at a place called "Sparrow's Rest" during the 1600s.

“We have a family within the lab. We’re really close and have a lot of fun together,” she said. She also enjoys showing volunteers what she does for a living. “Jim showed me what it’s like to be an archaeologist. That’s what I’d like to be able to do for them too.”

Want to join an excavation?

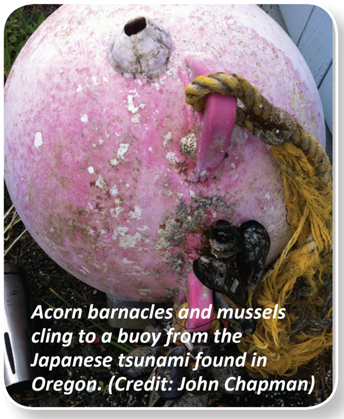
Contact Alison Cawood, Citizen Science Program Coordinator, at cawooda@si.edu.

After Crossing the Pacific on Plastic Tsunami Debris, A New Struggle To Survive

BY KRISTEN MINOGUE

On March 11, 2011, a 125-foot tsunami struck Japan's Tōhoku coast, triggered by a massive earthquake hours earlier. The loss of life and property was devastating. When it receded, it set in motion another chain of events. It's a story of millions of pieces of plastic that journeyed across the ocean, and the plants and animals that rafted with them.

A year after the tsunami, beach walkers in Oregon and Washington began spotting debris with Japanese characters. Many were covered in shellfish, barnacles and other creatures. In 2017, scientists reported nearly 300 living species had rafted to Hawai'i or North America's West Coast on tsunami debris.



Acorn barnacles and mussels cling to a buoy from the Japanese tsunami found in Oregon. (Credit: John Chapman)

But can these species survive in their new homes?

"The tsunami debris basically showed that coastal species can make it for years in the open ocean, which is super weird," said SERC marine biologist Christina Simkanin. But once ashore, would-be colonizers face plenty of hurdles.

Simkanin, with biologists from Williams College and Fisheries and Oceans Canada, led a study attempting to predict which species had the best odds. They looked at 48 of the species that made it to North America. Their findings appeared January in *Global Ecology and Biogeography*.

All told, 70 percent stood a fighting chance. A total of 13 species landed in areas with a potentially hospitable environment—with the right temperature, saltiness and other factors. Another 21 didn't match their exact location, but could have landed somewhere else suitable.

Many are completely new to North America's West Coast. But even species that aren't new could pose a threat. A fresh influx of an already-introduced invader could up genetic diversity, making the entire group more resilient. Of course, environmental matching isn't the only obstacle.

"Things as simple as wave action can take you out," said co-author Jim Carlton of Williams College. Predators and competition pose additional threats. "There are lots of ways between cup and lip, as it were, to not make it."

This leaves environmental managers with a dilemma. Prevention is difficult, as floating debris can land almost anywhere. Early detection is the next best thing, said Simkanin.

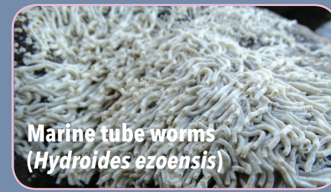
"Eradication is possible when populations are small," she said. "It becomes much harder when nonnative populations become large. So catching an invasion early is really important."

Link to full study: https://onlinelibrary.wiley.com/doi/full/10.1111/geb.12878

Meet the Contenders

Acorn barnacle (*Megabalanus rosa*)

This species of acorn barnacle had never been seen on North America's West Coast until it arrived on tsunami debris. (Credit: Jim Carlton)



Marine tube worms (*Hydroides ezoensis*)

New to North America's West Coast, these marine tube worms are nuisance biofoulers of pipes and ship hulls. (Credit: Surovtseva Natalia Vladimirovna)

Orange striped anemone (*Diadumene lineata*)

Native to Japan, these anemones live on every continent except Antarctica. (Credit: Melissa Frey)

Japanese skeleton shrimp (*Caprella mutica*)

These aren't shrimp, but shrimp-like crustaceans called amphipods! They can survive many temperatures and salinities, making them adept invaders. (Credit: Lina Ceballos/SERC)

Donor Spotlight: Jason Payne, Taking On Oysters Drills & Citizen Science

BY BRIAN MAGNESS

As a successful venture capitalist and former SERC Advisory Board member, Jason Payne understands the importance of reliable funding. When he made a five-year pledge in support of oyster restoration research in San Francisco Bay, he hoped his gift would help this promising program grow and flourish.

Five years later, Payne's hopes have been realized in a big way—the oyster restoration project is now active in dozens of locations around the Bay, tracking the success of new oyster reefs, measuring the effects of a predatory invasive snail called an "oyster drill," and exploring new ways to minimize this threat.

Dr. Chela Zabin, based in the SERC-West branch in San Francisco, is the lead researcher for the oyster portion of the largest living shoreline experiment to date in San Francisco Bay.

"Jason's gift was used to give the oyster drill project a head start, funding citizen scientist work days to remove oyster drills from two sites in Richardson Bay," she said. According to Zabin, so far 153 volunteers have participated in seven events and removed over 14,000 invasive drills.

"Jason's gift also helped fund a graduate fellow to assist with our last round of fieldwork for this project in fall 2018," Zabin added. "This was critical to allowing us to collect one more summer's worth of data on oyster recruitment and survival at seven sites, and an additional three months of temperature and salinity data."

Left: Jason Payne, pictured in a blue vest and baseball cap, joins a 2015 citizen science project to track the movement of oyster drills on the mud flats of Richardson Bay. (Credit: Alison Cawood/SERC) Center: Jason Payne in Richardson Bay, California. (Credit: Alison Cawood/SERC)

647 Contees Wharf Road
Edgewater, MD 21037

Upcoming Events

NEW: SERC SCIENCE SATURDAYS!

This year we're rolling out Science Saturdays, a series of free events where you and your family can do hands-on natural science activities with SERC ecologists. Each Saturday explores a different side of nature, with a different group of scientists. We held our first one on Feb. 23, but if you missed it, there are four more coming up:

May 18 • 10am–1pm: Delve into the secret lives of plants.

June 22 • 10am–1pm: Learn about biodiversity in the ocean with marine biologists.

August 17 • 10am–1pm: Discover how the atmosphere interacts with the land and water.

November 2 • 10am–1pm: Explore the invisible world of microbes and DNA.

Details at https://serc.si.edu/visit-us/serc-science-saturdays

(Credit: Cosette Larash/SERC)

EVENING LECTURES

Sea Level Rise: The Risks & Realities

Tuesday, May 21 • 7–8pm
Speaker: William Sweet, NOAA

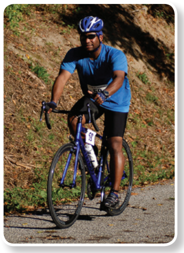
Natural Climate Solutions

Tuesday, June 18 • 7–8pm
Speakers: Ariana Sutton-Grier and Susan Cook-Patton, The Nature Conservancy

Details at https://serc.si.edu/visit/eveninglectures

"TRI FOR THE CHESAPEAKE" SPRINT TRIATHLON

Sunday, September 8 • 7:30am
Register at www.serc.si.edu/event/tri-chesapeake



CHESAPEAKE BAY MUSIC FESTIVAL

Saturday, September 14 • 12–9pm

Above: Susan Cook-Patton (Credit: Kristen Minogue/SERC)
Bottom Right: SERC Triathlon (Credit: Meng Lu)

ON THE EDGE
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