Smithsonian Environmental Research Center

ON THE EDGE

News from the Smithsonian Environmental Research Center

Fall / Winter 2017

The Hidden Lives of Cryptobenthic Fish

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What Does 1 Degree of Warming Mean for Antarctica's Oceans?

Sherman's Lagoon Cartoonist Talks Comics and Conservation

Science to Face the Disasters

The second half of 2017 has not been easy. Many watched in shock as hurricane after hurricane ripped through the U.S. Virgin Islands, Puerto Rico, Florida, and the Gulf Coast. Before hurricane season died out, we also witnessed violent earthquakes in Mexico and devastating wildfires in California.

It's a lot to process. How do we make sense of it all?

As ecologists, we focus on environmental impacts of disasters, the recovery process, and trends in frequency and severity of these events. These often take months or years, long after the media and emergency relief crews depart, but they still have power to reshape our world.

Six years ago, Japan was reeling from the 2011 earthquake and tsunami. This past June, I visited some of the small coastal towns that are rebuilding. At SERC, we can advise communities on recovery methods that last, but we're also discovering unexpected impacts. As Japan has been healing itself, hundreds of marine species spent years rafting across the Pacific on tsunami debris. Many thought coastal species couldn't survive such a journey, until biologists from SERC, Williams College and other organizations found nearly 300 tsunami-borne species washed up alive on beaches of North America's West Coast.

We remember disasters closer to home as well. Early in SERC's history, in 1972, Hurricane and Tropical Storm Agnes dumped so much rain into the Chesapeake that nearly the entire Bay became freshwater. Many oysters, clams and seagrasses were overwhelmed by sediment and have yet to recover. Similarly, downpours in California this winter after years of drought made San Francisco Bay nearly fresh. Our scientists there are measuring ecological responses to that sudden change. In 2003 Hurricane and Tropical Storm Isabel produced record-breaking storm surges–over 8 feet in some places–flooding homes and businesses on both eastern and western shores of the Chesapeake. The SERC dock went underwater, and some SERC employees lost cars. Then this October, while I visited SERC's lab in Tiburon, Calif., on San Francisco Bay, another type of disaster struck: intense fires fueled by growth of grasslands from last winter's rains. The fires burned thousands of homes to the ground, filled the air with smoke and closed the "SERC West" lab.

Yet hopeful signs can come from unexpected places. During three separate years, including this one, SERC scientist Candy Feller has watched hurricanes blow through her Florida mangrove experiments. But from the ruins, she tracks how mangrove trees recover and has made a surprising discovery: "Dwarf mangroves" barely five feet tall proved remarkably resilient—and they may help protect Florida from future hurricanes. Meanwhile, storms helped spread mangrove propagules farther north, all the way to Georgia.

Ecologist Candy Feller studies how Florida mangroves weather hurricanes. (Credit: Anne Chamberlain)

If 2017 has made anything clear, it is that climate change is in our backyards. As sea level rises, cities like Annapolis, Crisfield, Alexandria and Norfolk are flooding many times a year. In the past 50 years carbon dioxide in the atmosphere has risen 20 percent, Arctic ice is now melting at a rate of 13 percent per decade, and since 2000 we have seen the hottest years and decade on record. All this is accelerating the pattern of more frequent, more intense weather—storms in some places and severe droughts in others.

Science has the power to decode disasters, and show us how to fight and recover from them. We cannot stop every extreme event. But ecosystems like mangroves and wetlands can lessen the damage. We can make them less frequent and destructive by taking steps to rein in climate change. What kind of year will 2018 be? I believe it can be the year we rise more resilient, armed with the knowledge to fortify our communities and confront disasters with strength.

— TUCK HINES, DIRECTOR

Top photos, left to right: Ecologist Tom Jordan ventures outside to inspect the SERC weir during Hurricane Floyd in 1999. Aftermath of Hurricane Isabel on SERC's Global Change Research Wetland. (Credit: Gary Peresta / Smithsonian)
Nuns Fire burning in Oakville, Calif. in October 2017. (Credit: Lance Cheung / USDA)

***On the Cover:** Yellowprow goby. Tiny cryptobenthic fish like this are rarely seen, but they make up over half the fish on coral reefs. Learn more about them on page 7. (Credit: Simon Brandl & Jordan Casey / Smithsonian)*

RESEARCH DISCOVERIES

A school of grunts in Carrie Bow Cay, Belize. (Credit: Ross Whippo / Smithsonian)

BIODIVERSITY CAN PACK AS MUCH PUNCH AS CLIMATE CHANGE

"Biodiversity is not just a pretty face," according to Emmett Duffy, SERC biologist and lead author of a September study in *Nature*. For healthy ecosystems, biodiversity can be as influential as climate change.

In controlled experiments, biodiversity has already proven its ability to foster productive ecosystems. However, many questioned whether this would hold in the messier world of nature. For this paper, biologists looked beyond experiments at observational studies in the wild, with data from over 600,000 sites on every continent. In each ecosystem type analyzed—grasslands, forests, and underwater beds—higher biodiversity was tied to flourishing ecosystems. The link held even after controlling for factors like temperature and nutrients. In roughly half the studies, biodiversity topped climate as the biggest shaper of total productivity. In short, biodiversity's power in nature didn't match that in experiments—it surpassed it.

Link to Full Research Study: https://doi.org/10.1038/nature23886

IN ANTARCTIC WATERS, HERE'S WHAT ONE DEGREE OF WARMING CAN REALLY DO

It can be tempting to think 1 degree of warming is nothing to sweat over. But on the floor of Antarctica's Southern Ocean, even that small increase can completely transform marine life.

Gail Ashton (Credit: Terri Souster / British Antarctic Survey)

In a new *Current Biology* study, SERC biologist Gail Ashton and colleagues from the British Antarctic Survey warmed small areas on the seafloor 1 or 2 degrees Celsius (1.8 and 3.6 degrees Fahrenheit) with heated settlement panels. After one year, growth nearly doubled with a 1-degree increase. But not all species profited. A bryozoan called *Fenestrulina rugula* nearly took over the 1-degree panels, and another marine worm species grew 70 percent larger under both temperature increases. "I was quite surprised," Ashton said. "I wasn't expecting a significant, observable difference in communities warmed by just 1 degree C."

Link to Full Research Study: https://doi.org/10.1016/j.cub.2017.07.048

URBANIZATION FORCES STREAM-DWELLERS TO CONFORM

For some stream insects, urbanization may unfold like an Orwellian novel. As paved surfaces like roads encroach, more rainwater and sediment rush into streams, causing resident insects to display some strikingly similar traits, SERC scientists discovered in an *Ecological Applications* paper published online this September.

Non-biting midges and their stream-dwelling larvae (inset) tend to do better as streams become more urbanized.

Thomas Barnum, Don Weller and Meghan Williams analyzed 609 Maryland streams with low to high (above 10 percent) pavement covering their watersheds. As pavement increased, smaller insects like midges that lack gills grew common. Meanwhile, larger predators began vanishing, because added sediment clogs their gills and ultrafast streams don't favor insects with longer life cycles. For midges, urban-enforced conformity is good news. But many lost insects are important food for fish, so their disappearance could spell trouble for fish, their predators and fishermen.

Link to Full Research Study: https://doi.org/10.1002/eap.1619

Tidings from the Sunset Coast

Even though the Smithsonian Environmental Research Center has its headquarters on Chesapeake Bay, SERC ecologists journey to coasts around the world. They're especially active in San Francisco, where they run a branch at San Francisco State University's Romberg Tiburon Center. Here's a glimpse of discoveries from SERC-West.

Tsunami Enabled Hundreds of Species To Raft Across Pacific | BY KRISTEN MINOGUE

On the afternoon of March 11, 2011, a tsunami plowed through Japan, triggered by a 9.0 moment-magnitude earthquake barely an hour earlier. The double disaster left tens of thousands dead and caused billions of dollars of damage. But the tsunami also swept millions of objects out to sea, launching an epic voyage unlike any seen before.

SERC marine ecologist Greg Ruiz samples invertebrates in San Francisco Bay. (Credit: Ross Whippo / Smithsonian)

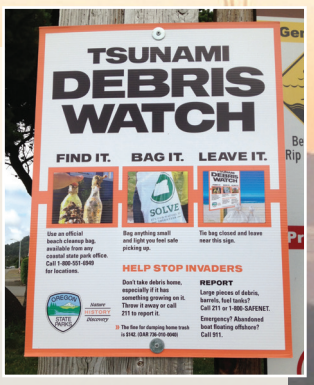
Today, nearly 300 species have reached Hawaii and the U.S. West Coast on debris from the tsunami, biologists from the Smithsonian, Williams College and other institutions reported September in *Science*. Some organisms spent up to six years at sea. It's the first time in recorded history scientists have detected entire coastal communities crossing the ocean on makeshift rafts.

"I didn't think that most of these coastal organisms could survive at sea for long periods of time," said Greg Ruiz, co-author and marine biologist at the Smithsonian Environmental Research Center (SERC). "But in many ways they just haven't had much opportunity in the past."

Scientists began finding buoys, vessels and other Japanese tsunami debris in Hawaii and western North America in 2012. They detected 289 living species on the debris, and they suspect many others slipped in unnoticed. While arrivals have slowed, they haven't stopped: New species were still coming when the study period ended in 2017.

Mollusks, like mussels, appeared most often of the invertebrates. Worms, crustaceans, hydroids like sea anemones, and bryozoans (known for branch-like underwater colonies) weren't far behind. Nearly two-thirds of the species had never been seen on the U.S. West Coast.

What made this possible? The sluggish pace of these "floating islands" may have allowed coastal species to gradually adjust to the harsher open ocean. This may also have made it easier for some species to reproduce, and for their larvae to attach to debris. The increase in marine plastics and other more durable debris also made survival more likely, the scientists said. Much of the tsunami debris was made of fiberglass or other plastic materials that could easily last six-plus years at sea.



Oregon State Parks "Tsunami Debris Watch" poster on Oregon coast, August 2012. (Credit: James Carlton)

"There is huge potential for the amount of marine debris in the oceans to increase significantly," said lead author James Carlton of Williams College. According to a 2015 report in *Science*, over 10 million tons of plastic waste enter the ocean each year. That figure may increase 10 times by 2025. Hurricanes and typhoons, which scientists also expect to occur more often with climate change, also can sweep debris into the ocean.

A Japanese tsunami vessel washed ashore in Oregon, coated in gooseneck barnacles. In a new study, scientists detected 289 species that rafted from Japan to the U.S. on tsunami debris, and they suspect many more were undetected. (Credit: John Chapman)

So far, no new species are known to have colonized the West Coast directly due to the 2011 tsunami. It can take years after a non-native species first arrives to detect a newly established population. This provides a window of time for action, though the full consequences of tsunami-driven rafting are uncertain.

"This has turned out to be one of the biggest, unplanned, natural experiments in marine biology, perhaps in history," said co-author John Chapman of Oregon State University.

Most scientists agree prevention is the most effective way to combat invasive species. Since preventing tsunamis isn't an option, Ruiz suggested focusing on managing plastic. Otherwise, voyages like this may become far more common in years to come.

Link to Full Research Study: https://doi.org/10.1126/science.aao1498

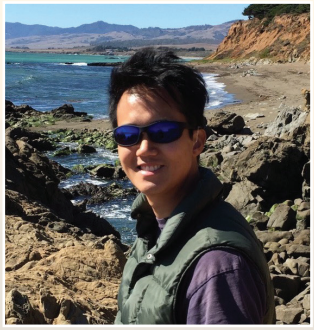
***Left:** Mediterranean mussels, barnacles and sea anemones on a tsunami buoy washed ashore on Long Beach, Wash., in February 2017. Mediterranean mussels are found all over the world, and have invaded both Japan and the U.S. (Credit: Nancy Treneman)*

***Right:** Marine sea slugs from a Japanese vessel from Iwate Prefecture, washed ashore in Oregon in April 2015. (Credit: John Chapman)*

In San Francisco, One Wet Winter Can Switch Up Bay's Invasive Species

BY KRISTEN MINOGUE

For many Californians, last year's wet winter triggered a case of whiplash. After five years of drought, rainfall from October 2016 to February 2017 broke over a century of records. Out in San Francisco Bay, marine ecologists discovered a less-obvious side effect: All that freshwater precipitation can turn the tables on some of the Bay's invasive species.



SERC marine ecologist Andy Chang tracks invasive species in California, and how climate change and extreme weather can alter the playing field. (Credit: Julia Blum)

"As you get wetter and wetter, there are fewer and fewer [marine] species that can tolerate those conditions," said Andrew Chang, lead author of a new *Global Change Biology* study. Chang, a marine ecologist with SERC-West, has been keeping an eye on San Francisco's invaders since 2000. He's especially interested in the fouling community, underwater organisms like tunicates and bryozoans growing on boats, docks, and fishing and aquaculture equipment.

Some species need a salty Bay to survive. When a wet winter sends out massive surges of freshwater, those organisms suffer. In the past, scientists have generally tracked how shifting weather patterns impact a single species. For this study, Chang and SERC's Marine Invasions Lab examined how San Francisco's fouling community as a whole changed over 13 years of wet, dry and moderate weather. Starting in 2001, the team suspended square PVC panels from docks, where they remained underwater for anywhere from one month to five years, collecting all kinds of colorful marine life.

During dry years, when Bay waters remained salty, one invader dominated: *Ciona robusta*, a vase-shaped tunicate from Asia. But when the wetter winters of 2006 and 2011 hit, mat-like colonial tunicates and encrusting bryozoans took over. Many of the new species are also non-native. However, Chang's team noticed a couple native species did better in wetter years too. This suggests with the right strategy, managers could turn the situation to the advantage of native species.

"When you have a wet winter and it kills off a huge number of species…we're really knocking back the non-native population," Chang said. "Perhaps that would be an opportune time to take some aggressive management action." According to Chang, that action could involve addressing boat traffic—one of the key ways invaders arrive in San Francisco Bay—or other tactics to boost native species or ensure invasive ones stay low.

Citizen Science: The Invasion of Seadrift | BY RYAN GREENE AND KRISTEN MINOGUE

European green crabs caught in California's Seadrift Lagoon. (Credit: Ryan Greene / Smithsonian)

Seadrift Lagoon houses the highest density of invasive green crabs documented on the West Coast. Just north of San Francisco, the lagoon contains tens of thousands of them. In nearby sites, green crabs have caused native shellfish to plummet and sometimes edged out native crabs. Since 2009, scientists at SERC-West, Portland State University and the University of California, Davis, have worked with community members and citizen scientists to remove them.

Their first attempts backfired. That's because adult green crabs cannibalize younger ones—and removing adults triggered an explosion of juveniles. In 2014, green crabs in Seadrift reached 325,000, nearly *triple* their number when trapping began in 2009.

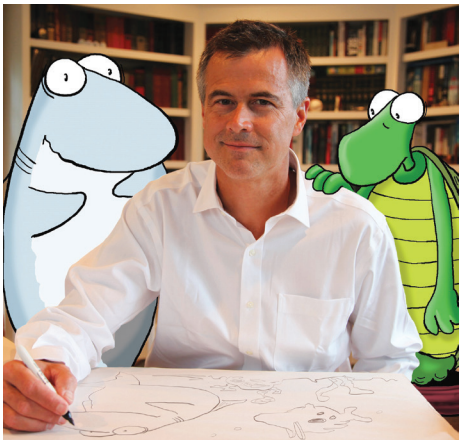
However, instead of calling it quits, the scientists and volunteers shifted focus. Now SERC ecologists Gregory Ruiz and Andrew Chang, with UC-Davis ecologist Ted Grosholz, are leading an effort to better understand the adult-juvenile seesaw in Seadrift. To do this, researchers set out crab traps and work with citizen scientists to gather data on the lagoon's green crabs. They're also still working to reduce their numbers. Today, Seadrift's green crabs have shrunk to between 30,000 and 40,000. Meanwhile, as the team investigates the rare phenomenon in Seadrift, the answers could help other invasive species removals down the road.

"I didn't think that most of these coastal organisms could survive at sea for long periods of time."

Q&A:

Sherman's Lagoon Cartoonist on Ocean Conservation with Comics

BY KRISTEN MINOGUE



Cartoonist Jim Toomey with two of his characters, Sherman the shark and Fillmore the sea turtle. (Image courtesy of Jim Toomey)

Since 1997, a great white shark named Sherman has put a wacky spin on life underwater in the comic strip *Sherman's Lagoon*. Jim Toomey, the comic's creator and conservationist, uses Sherman and his (usually more intelligent) friends to reveal real issues facing the ocean. On Oct. 17, Toomey gave the keynote lecture in SERC's Bay Optimism evening lecture series. In this Q&A he describes adding humor to environmentalism, and what happens when *Sherman's Lagoon* meets Chesapeake Bay. It has been edited for brevity and clarity.

WANT TO DIVE DEEPER? Watch Jim Toomey's TED talk, "Learning from Sherman the Shark" at https://www.ted.com/speakers/jim_toomey. Read the extended Q&A on our blog at https://sercblog.si.edu

Credit: Jim Toomey

Where did the idea for *Sherman's Lagoon* start?

One of the most vivid memories I have in my childhood is going down to the Bahamas…. [One day] we flew over a lagoon, and there was a shark in it sunning itself. I remember that image vividly. So this concept of a discrete little living area like a lagoon, which is great for recurring comedy—if you look at any sitcom, it usually takes place at some hangout or some place, and characters always go back to that place. And I thought, "If I'm going to create an underwater comic strip, I need some kind of discrete living area, and the ocean's too big. So I need this self-contained place where all these crazy things can happen." That's where I came up with the lagoon.

Who is your favorite character?

I can relate to Sherman in a lot of ways. Sherman is a little, not quite well adapted to the real world….The one who's easiest to write for is the crab, Hawthorne. He's always cranky and complaining, and that point of view is a very easy point of view to write for. And I think a lot of people can relate to someone who's crabby and cranky a lot.

I do enjoy [Sherman's wife] Megan a lot. She's probably the strongest character in the whole group. Very no-nonsense, probably the straight character, the Hardy of Laurel and Hardy, the Desi of Desi and Lucy. She's the one who brings everybody back down to earth.

Most of *Sherman's Lagoon* takes place in the open ocean. How are issues different in Chesapeake Bay?

The big three here in Chesapeake Bay would be the agricultural runoff, the loss of coastal habitat and invasive species….I have taken the characters to the Bay a few times. I did address invasive species in one of my latest times there. I had a snakehead pass through the strip.

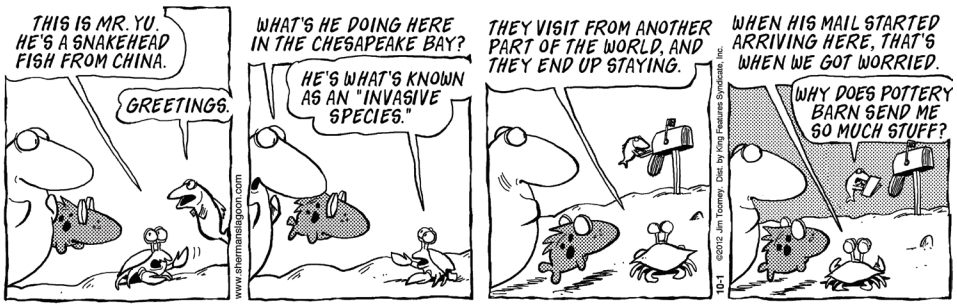
How would the comic be different, if Sherman were a sandbar shark in Chesapeake Bay instead of a great white shark in the open ocean?

He'd certainly have different friends. He wouldn't have a hermit crab and a sea turtle. So maybe it would be a blue crab….I might have a terrapin instead of a sea turtle, or I'd throw a rockfish in there. You'd take some of the charismatic species, and some of the species that are fun to cartoon. The cast would be different, but I think just as much fun to write for. The water wouldn't be as clear—I don't know how I'd deal with that one. It would be green panels every time!

What do you wish more people understood about the ocean?

Things that happen to the ocean and in the ocean have influenced our lives, even if we live very far from the ocean. The fact that the ocean produces half the oxygen we breathe, for example, or the fact that we're upstream communities, no matter how far inland we live. So if we throw things like pharmaceuticals or plastic bottles into our waste stream, it will end up influencing the ocean. So we're all coastal communities in a way….

I also firmly believe that environmental issues are not a partisan message…. Environmentalism is really all about preserving things for future generations. It's about sustainability, it's about the cautionary principle, sustainable business—these are values I think both the left and the right can embrace.



Sherman's Lagoon comic from Oct. 1, 2012. (Credit: Jim Toomey)

Docks Offer Surprising Refuge for Rare Tropical Fish

BY KRISTEN MINOGUE

Endangered Isthmian goby. (Credit: Smithsonian)

Near-threatened black grouper, found beneath a Belize dock. (Credit: Smithsonian)

The Panama Canal houses one of the rarest fish in the world: the Isthmian goby, an endangered, brown-speckled fish less than 3 centimeters long. For years scientists thought it remained only at the canal's Caribbean entrance, until Smithsonian biologists found one nearly 200 miles away.

Isthmian gobies (*Gobiosoma spilotum*) thrive in shallow waters like tidepools. The expansion of the Panama Canal, plus other coastal development, consumed much of their habitat. So scientists were shocked to find the goby circling another manmade structure, a dock off the island of Bocas del Toro, 186 miles from the canal.

Marine biologist Simon Brandl has searched for tiny cryptobenthic fish along the Atlantic, from Maine (here) to Panama. (Credit: Jonathan Rodemann)

"I didn't even know what it was at first," said Simon Brandl, SERC biologist and lead author of the study published in *Ecology and Evolution*. He knew it was a goby, but was unable to pinpoint the species. So Brandl sent the photo to scientists at the Smithsonian's National Museum of Natural History and the American Museum of Natural History. "They were like, holy cow, this is *Gobiosoma spilotum*."

The team also discovered a near-threatened black grouper (*Mycteroperca bonaci*) beneath a Belize dock. Manmade docks—contrary to expectations—turned out to be popular homes for many native fish.

Brandl and the other biologists didn't set out to find an endangered goby. They began the study to understand tiny fish called *cryptobenthics*, which include Isthmian gobies. Cryptobenthic fish live in coral reefs and seagrass beds. But they're rarely seen because of their minuscule size and propensity to hide, so scientists know next to nothing about them. Most fish surveys are done by divers who report only what they can see.

"You're missing more than 50 percent of the fish that are there if you just look for them," Brandl said.

The Smithsonian team took a different approach. Brandl, with Jordan Casey, Nancy Knowlton and Emmett Duffy, used fine mesh nets and clove oil, a fish anesthetic, to sample tinier fishes a visual survey would miss. They surveyed dock pilings in six Atlantic sites, from Maine to Panama.

They expected to find docks teeming with invasive fish. After all, that's the trend for creatures that don't swim, like shellfish and sponges. But instead, they saw flourishing communities of native fish. In total, the scientists found 58 native fish species at the docks and only one invader, the lionfish *Pterois volitans*.

Perhaps, Brandl speculates, docks harbor cryptobenthic fish because they're similar to underwater mangrove roots, where Isthmian gobies may once have thrived. But whatever the reason, Brandl said this shows that the needs of humans and nature sometimes can overlap.

"These docks may in fact be offering some kind of refuge for species that would otherwise struggle," he said. Since humans are already building docks, he added, "we have a really efficient, low-cost way of helping to preserve native fish biodiversity."

Link to Full Research Study:
https://doi.org/10.1002/ece3.3288

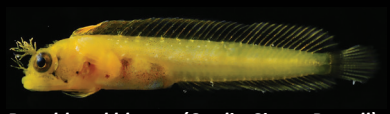
Cryptos: The Tiny Fish Awards

BY JOE DAWSON

Cryptobenthic fish don't get much recognition. They're some of the smallest fish in the sea (most are under two inches long), and they hide from nearly everything. But besides being a vital part of the food web, they have some bizarre qualities and quirks. Here are a few of the coolest cryptos:

MOST STYLISH: TUBE BLENNIES

These tube-dwelling fish sport extravagant "hairdos," which (presumably) are sensory organs, though their exact purpose is unclear. Called "cirri," these can be absolutely ridiculous in species like the roughhead blenny.



Roughhead blenny. (Credit: Simon Brandl)

MOST CREATIVE REPRODUCTION: CARDINALFISH

Male cardinalfish breed their eggs in their mouths until it's time for them to hatch. But do they even get a card on Father's Day? Of course not.

Cardinalfish. (Credit: Simon Brandl)

MOST CONGENIAL: SHRIMP GOBIES

True to their names, shrimp gobies survive by partnering with shrimp. Shrimp dig and maintain a burrow for both to live in, and gobies watch the opening for potential predators. The shrimp may even eat goby feces too, according to Brandl. Best friends!

Yellow prawn goby and tiger snapping shrimp. (Credit: Haplochromis, https://creativecommons.org/licenses/by-sa/3.0/deed.en)

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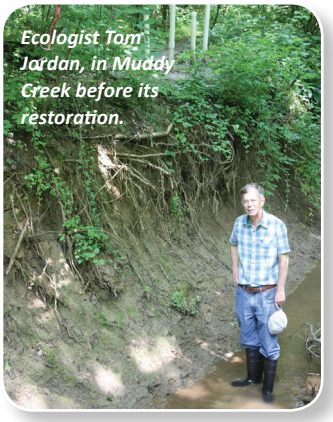
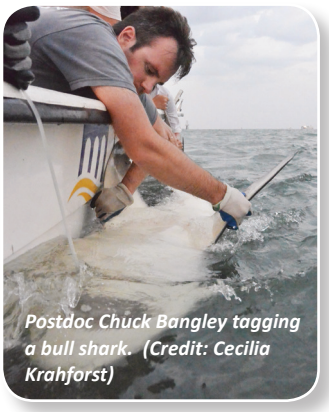
Donor Spotlights



Ecologist Tom Jordan, in Muddy Creek before its restoration.

SUSAN FRYE AND MIKE KIENZLE: STREAM RESTORATION

Susan and Mike's multiple generous donations to the Nutrient Lab have funded research on the Muddy Creek Restoration project, where scientists have restored a once-degraded stream and are tracking its progress in real time. Tom Jordan, head of the Nutrient Lab, says the gifts are especially valuable for their flexibility, enabling him to use the money wherever it's needed most. Susan and Mike's commitment to the environment and SERC's nutrient research stems from the successful transformation of their family farm to organic farming.



Postdoc Chuck Bangley tagging a bull shark. (Credit: Cecilia Krahforst)

SAUDI ARAMCO: SHARK TAGGING

Thanks to Saudi Aramco's support, Matt Ogburn's Fish & Invertebrate Lab is able to tag sharks as part of the Smithsonian-wide Movement of Life initiative. Chuck Bangley, one of the lab's postdocs funded by Saudi Aramco, is tracking the movement of sharks using surgically implanted pingers. The Movement of Life initiative tracks the movements of fish, bird, and terrestrial mammal species using innovative tracking technologies. This long-term research will teach broader audiences about the importance of global migrations.

WINTER LECTURE SERIES: SCIENCE AND HISTORY AROUND THE BAY

Tuesday evenings January through March, Schmidt Conference Center

Discover the past, present and future of the Chesapeake, in a new winter lecture series hosted by local experts. Free and open to all! Visit www.serc.si.edu later in December for more details.

Smooth dogfish shark. (Credit: Chuck Bangley)

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Visiting hours: Mon.-Sat., 8:30am-4:30pm. Closed Sundays & federal holidays

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