Special section: Worship guide recounts "The Easter Story," **inside**

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ARTS & CULTURE, F1

SPECIAL REPORT

EVERY OTHER BREATH

Sure, the rainforests are a big deal, but when it comes to oxygen, something you can barely see is even bigger — plankton. Plankton produce half of the oxygen on Earth and suck out massive amounts of carbon dioxide. But from South Carolina to the open ocean, scientists are seeing dramatic changes in these mysterious creatures. Life on Earth literally began with them, and they could very well determine the climate's fate. Oh, and they're beautiful.

TARA EXPEDITIONS IMAGES/STAFF PHOTO ILLUSTRATION

TONY BARTELME || *tbartelme@postandcourier.com*

It's early in World War II, and America's fate is tied to the sea. In the Atlantic, Nazi U-boats pick off convoy ships, threatening the lifeline to Europe. In the Pacific, Japanese subs prowl the depths, testing a fleet battered at Pearl Harbor. Meanwhile, American war planners know little about this new underwater battlefield. Mastering its terrain could prove decisive. In a secret report, the leader of a hastily assembled group of scientists called Division 6 writes about an urgent need to understand the ocean "for service in a national emergency."

New sonar instruments would be the tool. You could ping the ocean bed, then use the bounce to calculate the seafloor's depth and shape. But sonar operators soon pick up something odd: The seabed seems to move up and down. More pings, and Navy technicians uncover a pattern: This "false bottom" rises at night and descends at dawn. What is it?

Must be alive, the Division 6 scientists think. Squids? Schools of fish? Has to be something pervasive; the sonar picks up false bottoms in all of the world's oceans. Whatever it is, could American submarines hide under it? Could enemy subs?

Division 6 doesn't answer these questions before the war's end, which only stokes more curiosity. Scientists begin calling the false-bottom the "deep scattering layer." They toss nets into the layer; they haul up a few squids and fish but not enough to explain those scattering pings. Then, with fine mesh nets and deep-sea diving gear, scientists in the 1970s finally solve the mystery: The false bottom is a massive daily migration of plankton.

This symphony of tiny and beautiful creatures begins at night when they rise to feed on even smaller surface plankton. Countless fish join this movement — so many that the ocean hums. Then it ends at sunrise as they plunge to escape predators. Though unseen, this daily cycle is the grandest migration of all on Earth. From an ecological standpoint, it's exponentially more significant than the Serengeti's thundering wildebeest or the winged journeys of the world's birds. And it's just a small part of the plankton story. Startling new discoveries about plankton could prove decisive in an emergency that's as urgent as any war: a rapidly changing climate.

The question remains: Will we learn enough in time?

Chapter 1
An Urgent Mystery

Read more about plankton on Pages A6-A9

Barnwell, other towns face new reality after rural hospitals close

BY LAUREN SAUSSER
lsausser@postandcourier.com

BARNWELL — Police Chief Reuben Black found out that Southern Palmetto Hospital was shutting down in January just like most people in this small town did — on Facebook.

"It closed at noon the next day," he said. "It's extremely hard to lose a hospital that's been here since 1950-whatever. The people of this community depended on it."

Three years after Gov. Nikki Haley's administration began bolstering rural hospitals with millions more dollars, three of them, including Southern Palmetto, have closed in 10 months.

Marlboro Park Hospital in Bennettsville shut down in May. Williamsburg County Hospital was forced to close in October due to building damage caused by rain. And, after 60 years in Barnwell County, staff at Southern Palmetto Hospital treated patients for the final time in January.

"It scared me," said Amber Cornett, who works at Common Grounds coffee shop in town. "I have two young children. If something happens to them, what am I supposed to do? ... They could die in transit to another hospital."

Please see **HOSPITALS,** Page A5

Inside

'We're not there yet'

Members of Congress learn different lessons from shooting at Emanuel AME Church

BY EMMA DUMAIN
edumain@postandcourier.com

Like the survivors and family members of victims of the June shooting at Emanuel AME Church, U.S. Rep. John Lewis knows something about the power of forgiveness.

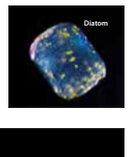
In 1961, as a young civil rights activist in the Deep South, the black Georgia Democrat was severely beaten by members of the Ku Klux Klan. In 2009, one of those Klansmen visited Lewis in his congressional office. He introduced himself as one of Lewis' attackers all those years ago and asked to be forgiven.

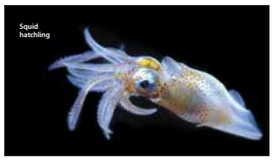
"He hugged me, I hugged him back, and I cried, and he cried," Lewis recalled Saturday, speaking directly to the handful of survivors and the victims' family members seated in the front row of Circular Congregational Church in downtown Charleston. "You are so right. It's better to love."

Though Lewis has told this story many times before, it took on new meaning in the presence of those directly affected by the church shooting

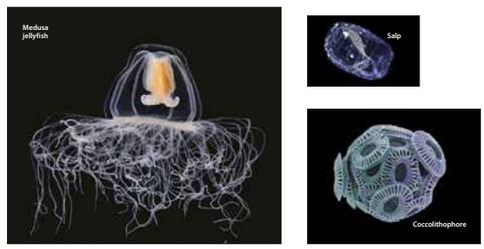
Please see **CHURCH,** Page A5

Partly sunny. High 64. Low 41. Complete 5-day forecast, **B10**


Diatom


Squid hatchling


Ctenophora


Medusa jellyfish

Salp

Coccolithophore


Phronima's fierce appearance is the inspiration for the creature in the movie "Alien."


These crawling worms normally live in sediment on the ocean floor – except when they reproduce. Then, they drift freely in the water, becoming part of the diverse community of plankton. This specimen was found in the lagoon of a French Polynesian island.


Pteropod (sea butterfly) and copepods

PHOTOGRAPHS BY TARA EXPEDITIONS

Counting plankton is like counting stars

Plankton's microscopic world

While the above photos show specimens of zooplankton and phytoplankton, some plankton, such as cyanobacteria shown here, are so tiny that they can only be seen under a high-powered microscope. Despite their small sizes, planktonic bacteria and viruses fill our oceans and lakes. **Just 1 teaspoon** of seawater is likely to contain **1 million** planktonic bacteria and **10 million-100 million** viruses.

Origin of Earth's oxygen

50% Land plants (approximate)

50% Ocean plankton (approximate)

SOURCE: NATURE (2005 AND 2012) STAFF GRAPHIC

1 TSP / 5ML

More on plankton

For a video about some of the plankton described in this story, see **postandcourier.com/plankton.** Also online are photos of scientists collecting plankton in South Carolina and an additional video about the importance of long-term research into the effects of climate change on plankton.

Chapter 2

The Power of Plankton

Plankton may be the most important stuff you've barely heard of — more important to the climate's fate than rainforests. The term plankton is a catchall of sorts for living things that are at the mercy of currents. That broad definition includes jellyfish, krill, marine bacteria, viruses, algae and fish larvae. With no roots to the seabed, planktonic creatures mostly drift, though as those World War II pings revealed, some are masters at swimming up and down. Many forms of plankton are so tiny you need a microscope to see them, but they are the unsung heroes of the planet's air.

You can thank species of sun-loving plankton for the breath you just took. Until about 2 billion years ago, the planet's atmosphere was breathlessly devoid of oxygen. But then a distant cousin of today's blue-green algae began using the sun's rays to split water into hydrogen and oxygen. Earth hasn't been the same since.

Today, half of the atmosphere's oxygen comes from ocean plankton — every other breath. Plankton comes in all shapes and sizes, but scientists divide them into two categories.

Phytoplankton are the microscopic algae and other cells that drift in the sun-infused upper layer of the ocean. Think of them as the plants of the sea, the oxygen producers. Zooplankton are the larger animals that typically feed on the phytoplankton. Think of them as the sea's insects, snails and worms.

Small and large, plant and animal, they do amazing things.

One zooplankton called phronima chomps on smaller plankton and uses their body parts to make protective cellulose barrels. The mother lives in the barrel, zealously guarding her young, while males bolt at the slightest danger. Phronima's fierce appearance is the inspiration for the creature in the movie "Alien."

Some algae and bacteria have red pigments and grow so dense they color vast areas of the ocean; floating pink blankets of bacteria gave the Red Sea its name. One zooplankton species has little blue sails; washing up on the beach, their colonies look like a regatta of tiny blue boats.

Another jellyfish can literally reverse its aging process; its nickname is "the immortal jellyfish."

When phytoplankton die, they emit cloud-forming chemicals that give beaches their intoxicating and briny smell. Some phytoplankton also are killers: Shaped like glistening needles, they secrete neurotoxins that find their way into shellfish and animals that feed on them. After one toxic algal bloom in 1961 in Monterey Bay, Calif., thousands of poisoned seabirds died or bombed houses and cars and piled up dead on streets. The phenomenon inspired Alfred Hitchcock's movie, "The Birds."

Counting plankton is like counting stars, though instead of stars, some species look like Christmas ornaments and the Leaning Tower of Pisa. A single teaspoon of seawater might contain a million phytoplankton cells and 100 million planktonic viruses that feed on them. Viruses alone have an overall biomass in the oceans of 75 million blue whales.

Mostly unseen, these hordes of planktonic algae and viruses are in a constant state of biochemical warfare: The viruses attack the algae while the algae develop special plates of armor.

Much of what we know about plankton has been discovered since World War II, thanks in part to those curious Division 6 scientists, but also because of people like Dennis Allen, who one morning in January, stands in a johnboat in a South Carolina marsh, wondering: Why does the water look so weird?

Chapter 3

Curiosity, and the Long View

Allen is resident director of the University of South Carolina's Belle W. Baruch Marine Field Laboratory, a science center deep in the area of protected pinelands and marsh north of Georgetown. He has a boat captain's white beard and his brown eyes hold a look of delight. He has long been fascinated by the hidden underwater world, and it's easy to imagine that delighted look 60 years before when he watched those Amazing Live Sea Monkeys hatch. (The old comic book ads said: "Own a bowl full of happiness! Because they are so full of tricks, you'll never tire of watching them.") Those brown bits didn't really look like monkeys, though. And he would learn much later that biologists called them brine or fairy shrimp. But they spun and darted and moved about nevertheless, a small world of their own that hinted at a much larger one if you just look closer.

Which he did often with Pop-Pop, his grandfather. An Italian immigrant and successful auto dealer, Pop-Pop took him fishing off the New Jersey coast. His grandfather seemed to be curious about everything in the water, which was infectious to an already curious child.

"Pop-Pop, why do we catch flounder here but not over there?" he asked his grandfather.

"That's a good question!"

"Pop-Pop, what do the fish eat?"

"Let's see."

Gutting the fish, they found dead shrimplike animals in the stomachs — not so different from those Amazing Live Sea Monkeys.

Fast forward to the mid-1970s. Allen was a biology major by now, working on his dissertation, trawling with a fine mesh net off New Jersey, funneling zooplankton into a jar at the end of the net. He pulled up the net and looked at the jar. It was full of mysids, those shrimplike animals he saw when gutting fish with his grandfather. From a distance, the jar looked as if packed with wild rice. But looking closer, you could see it teemed with life. New questions formed in his mind as he watched the mysids flit back and forth: What is their response to light? How do they move with the currents? Years later, he still keeps the jar on a shelf his office at the Baruch Institute. He smiles. "It's a reminder of my roots."

A reminder of the sense of discovery that fueled his most important work.

In January 1981, not long after he landed a job at Baruch, he collected samples in the salt marsh creeks of North Inlet. He recorded the water's temperature, salinity and other chemical characteristics. He collected the zooplankton with a fine mesh net.

Then he kept at it, sampling every two weeks, using the same nets and protocols.

And he kept going, even when the funding was barely there.

As the decades passed, shelves filled with glass jars of the samples, preserved in a pink fluid, data filled columns and charts. Like a savings account, it slowly grew in value.

Today, this data is called a "time series," and Baruch's is the longest continuous time series in an estuary in North and South America, and perhaps the world. Its rarity and scientific value can't be overstated. With so much data collected consistently over such a long period, scientists can begin to understand how estuaries and salt marshes change over time.

And on the johnboat in January, he's shocked by what he sees.

Please see **PLANKTON,** Page A8


PHOTOGRAPHS BY WADE SPEES/STAFF

Dennis Allen (left) of the Belle W. Baruch Institute's marine field laboratory north of Georgetown began collecting zooplankton in 1981 in what became the longest continuous sampling effort in an estuary in North and South America, and perhaps the world. Research technicians Eric Haffey (center) and Paul Kenny have helped take these samples every two weeks.

"So people always ask, 'Why should I care about what's going on in the open ocean?' And I say, 'It's all connected! Our water! Our air!' "

PLANKTON from Page A7

Chapter 4

The Zooplankton Crash

It's the 866th collection in the time series, the first of 2016. The marsh is a winter palate of pale yellows and greens. A bald eagle watches from the top branch of a dead tree. The johnboat moves into the current. The water is brown, the color of ice tea, and this is news.

"This time of year, it's supposed to be grayish-green and really clear," Allen says, as Paul Kenny steers the boat. Kenny, a research specialist, has been collecting samples with Allen for 35 years.

The source of the unusual color is last fall's torrential rains. A record 2 feet fell in one weekend. It's the kind of rain bomb scientists think we'll see more of as the planet warms and the air holds more moisture. More rain fell in November, fueled by one of the largest El Niño's in recent history. This morning, salt marshes have the salinity of freshwater ponds.

Strange weather, but Allen's time series has revealed other surprises that go far beyond any blips in the jet streams.

He grabs a net that looks like a windsock and tosses it overboard. The net funnels zooplankton into a jar. He and Kelly pull in the trawl, and Allen lifts the jar to the sky. A translucent eel larva flickers amid the debris. It probably migrated from the deep ocean, perhaps from the Sargasso Sea.

"The big story is that there are a lot fewer zooplankton in North Inlet than there used to be," Allen says.

When he began in 1981, a trawls-can-sized amount of water held 10,000 to 12,000 zooplankton specimens.

Over time, the numbers declined. In recent years, they've been catching about 6,000 to 8,000.

"That's a 40-percent reduction," he says. "That's huge, and it's remarkable because it happened in just the course of 30 years."

Rising temperatures might be responsible. Human activity releases the equivalent of 36 billion tons of carbon dioxide into the air every year. This CO2 and other greenhouse gases trap heat in the atmosphere. The ocean, however, absorbs much of this warmth. Every day, humans and their machines add heat to the ocean equivalent to 345,000 Hiroshima-size atomic bombs.

This injection of heat has caused the ocean's temperature to rise. Arctic and Antarctic ice are melting. And all these changes affect the mostly hidden world of plankton, the foundation of the food web.

Allen says they once caught hundreds of anchovies in trawls like today's. But in recent years, they've caught one or two per tow, or none at all. Researchers in the Chesapeake Bay, the West Coast, New England and Europe are discovering similar reductions in zooplankton and fish species, he adds. Results of these time-series findings will be published soon in scientific journals, but they only raise more questions.

What else is happening to the plankton? Will this affect the climate?

And the air we breathe?


Baruch research technician Eric Haffey studies a jar containing zooplankton and other species caught during a recent sampling trawl near North Inlet and Georgetown.

Chapter 5

Open Ocean's Secrets

Across the Sargasso Sea near Bermuda, three young scientists on the boat Rumline prepare a gray canister that looks like a small torpedo. The boat slows. White foam breaks over a nearby coral reef. A Brazilian technician lowers the canister into gentle waves of turquoise. He hoists the canister back on board, and the three scientists take turns pipping the contents into beakers. They repeat this four times at other spots off the island, then give a thumbs up to the captain, who turns the boat, painting a white arc of bubbles in the blue.

They head back to the island, with its white roofs like bleached coral, and dock at the Bermuda Institute of Ocean Sciences. In a lab there, they'll take those beakers of seawater and measure salinity, pH and other aspects of the water's chemistry. It's work similar to Dennis Allen's time series in South Carolina. But instead of estuaries, the Bermuda scientists focus on changes in the open ocean. As far as time series go, Bermuda's is the longest-running in an ocean setting, and, therefore, among the most important.

"I'm from Ohio," says Amy Maas, an assistant scientist here whose words tumble out in excited bursts, "so people always ask, 'Why should I care about what's

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Food web

'Some wacky things are going on in our estuaries'

PLANKTON from Page A8

going on in the open ocean?" Her eyes open wide, and her hands dart like fish. "And I say, 'It's all connected! Our water! Our air! And this place is one of the key places in the world where we've learned about the importance of marine bacteria, how migrating plankton change things, how the carbon cycle works."

Growing up in Ohio, Maas thought she would be a librarian. But the more she learned about marine biology in college, the more she found herself captivated by its complexity and beauty. Drifting like plankton from course to course, and then in expeditions to Antarctica and the North Pacific, she found herself steered toward studies about climate change and


Maas

a zooplankton group called sea butterflies, also known as pteropods. Now, she works in Bermuda with her husband, Leo, a Spanish zooplankton researcher, often bringing their new baby, Bastian, who sleeps in a crib next to her desk.

On an afternoon last February, a storm lashes the island, turning the cobalt waters below her office window into froth. Winds whip around the building, generating a sound like Tarzan's jungle yell. Maas' voice rises and falls as she recalls scuba diving with creatures from the deep scattering layer, the humming migration of plankton and fish that baffled the World War II sonar operators.

"During the day, you might see a fish here and there. But at night, when everything rises to the surface, boom, everything is there! The water is packed full of stuff. Wow. It's extremely dark, and you can't see anything beyond your big light. It looks like confetti, but it's all moving around. It's vibrant. You have these flashes of color. Everyone's trying to eat and mate and do everything that needs to happen. It feels as intense as a coral reef or a rainforest. But everything is tiny! There are these little things zooming past. Zoom, zoom, zoom, and then a squid comes flying in! And then when you turn the lights off, there's all this luminescence. And afterward you realize there's so much that you don't know."

Such as the health of this ecosystem. It's not easy to assess the status of the ocean's microscopic creatures, she says. "You can't ask a zooplankton, 'Hey, how are you doing?' That's where the time series is vital. Time series aren't flashy. They're expensive; they're time-consuming, and they're not going to give you this big paper that says, 'I just discovered X!' They're just a slow accrual of data."

But with that growing collection of information, you can understand what happened in the past. Do it long enough, and you can factor out seasonal fluctuations. Then, she says, "you can use this information to make predictions about the future."

Which, when it comes to the open ocean and its plankton, requires a deep breath.

Chapter 6

Oh-oh

It's helpful to know a bit more about phytoplankton, the forests of the sea. Coccolithophores and diatoms are important sun-loving forms of phytoplankton. You can see blooms of coccolithophores from space, milky swirls as large as California.

Under a microscope, you'll see they make fantastic shells. Shaped like flying saucers, they're made of calcium carbonate, the same thing as chalk. The White Cliffs of Dover are old deposits of coccolithophores.

Diatoms, meantime, build glass shells that look like fancy hat boxes. Their shells are even smaller, so small that 30 can fit across a human hair. Medical examiners use diatoms in drowning cases: As victims inhale water, diatoms enter the bloodstream and make their way as far as the kidney and brain. If you find diatoms there, you know the person drowned instead of dying before entering the water. Diatom shells also are used in toothpaste, cat litter, dynamite and nail polish.

Diatoms and coccolithophores don't just make useful and beautiful shells. They also incorporate huge amounts of carbon dioxide into their bodies. Then, larger zooplankton, such as Amy Maas' sea butterflies, gobble them up. Or they die of old age, which in plankton time might be just a few weeks. Then, weighed down by their elegant shells, they fall toward the ocean floor, joining a chorus of other particles, including carbon-infused feces of zooplankton. Scientists call this falling stuff marine snow.

Marine snow piles up unseen on the ocean floor. And over millions of years, geological and other forces compress it and turn it into oil. This ongoing plankton bloom-and-bust represents a massive carbon pump to the ocean floor that scientists have only begun to fully understand. Every year, according to recent studies, phytoplankton incorporate 50 billion tons of carbon into their cells. That's roughly the same as all the forests, bushes and grasses combined.

The Bermuda time series and other research have shown major changes in this biochemical balance. We've unlocked vast amounts of carbon dioxide by burning coal, gas and oil — carbon dioxide that took millions of years to sequester.

This has made the ocean more acidic — about 30 percent more acidic since the Industrial Revolution. This increase is faster than any known change in the sea's chemistry in the past 50 million years.

And that's bad news for some plankton.

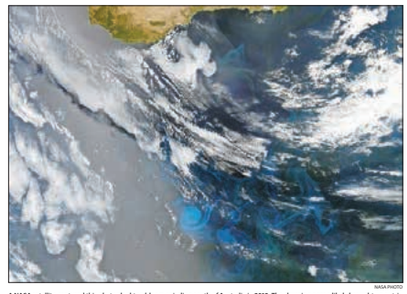
Maas' research on sea butterflies has shown that even slight increases in acidity turn their shells from clear to opaque. Longer exposure, and the shells dissolve. Corals experience similar fates. Some researchers predict that because of ocean acidification, most of the world's coral reefs could be dead within half a century.

To the surprise of scientists, coccolithophores, the chalk-making phytoplankton, are blooming at unprecedented rates in the North Atlantic – a tenfold increase between 1965 and 2010. It's unclear whether this is good news or bad. On the bright side, such blooms are sucking up some of the carbon dioxide we release when we step on the gas pedal. On the other hand, it's a telling sign that we've pumped so much carbon dioxide into the air that our atmosphere and oceans are saturated. "Something strange is happening here, and it's happening much more quickly than we thought it should," one of the study's authors wrote.

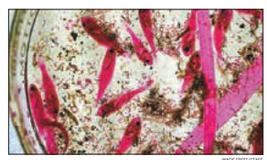
Finally, we have the warming ocean, which could affect plankton in an indirect but deadly way. Many species do just fine in the sea's naturally changing temperatures. But they also depend on hidden underwater currents to stir up nutrients from cooler lower depths. This upwelling of nutrients is the equivalent of marine compost. But hot air hovering above the ocean creates a thick layer of warm water on the surface. And this turns that layer into a cap, preventing the upward movement of nutrients; with no mixing, phytoplankton starve.

You can outrun rising sea levels but with less oxygen, you won't run far. Some scientists predict that because of global warming the ocean's temperature may rise 11 degrees in the next 75 years. Under that scenario, many of the ocean's mixing currents may disappear, researchers at the University of Leicester in England reported last December. With less oxygen from the ocean's phytoplankton, the study's authors said, the planet will experience "mass mortality of animals and humans."

"Are we screwed?" People ask me that a lot," Amy Maas says as the storm outside lets up. But she's an optimist; humanity has a choice about reducing carbon dioxide emissions, reducing the size of that heat-trapping cap. "We're intelligent organisms that can come together and make good decisions." In other words, we're not drifting like the plankton, subject to some external current.


NASA PHOTO

A NASA satellite captured this phytoplankton bloom spiraling south of Australia in 2013. The churning ocean likely brought up nutrients from below, triggering this explosion of photosynthesis in the lighter blue spirals below the clouds.


WADE SPEES/STAFF

Continuous sampling of zooplankton at Baruch Institute has revealed a stunning decline over the past 35 years. Researchers are finding as much as 40 percent fewer zooplankton specimens, a signal that something dramatic is happening to the foundation of the food web. Scientists preserve specimens in a pinkish preservative for future studies.

Chapter 7

The New Abnormal

In South Carolina, Dennis Allen and Paul Kenny continue their trawls. They point their boat toward a place with hidden sandbars and oyster reefs called No Man's Friend. After nearly 40 years working these waters, Allen has answers to many questions he posed to his grandfather so long ago. But as will happen, this knowledge only triggered more questions.

The ocean hides its secrets well: the up- and-down movements of zooplankton that create the deep scattering layer; the movements of fish from the estuaries to the open ocean where they spawn; then the huge unseen migration of planktonic fish larvae back to the estuaries, where they grow into snapper, croaker and shrimp.

"Remarkable creatures," he says. "I've been doing this for 38 years and I still get excited by what the net brings up."

Which happens today. During a trawl, they find a catfish in their net.

A catfish in a salt marsh?

A surprise, but should it be?

Consider last fall's rain bombs, winter's record warm spell when people from Charleston to New York ran shirtless after Christmas, and the stunned scientists who recorded temperatures at the North Pole above freezing. "I just returned from a conference in Portland," Allen says, mentioning a moderator who summed up the meeting's findings. "He says, 'Some wacky things are going on in our estuaries.'"

Ecology is all about relationships and understanding connections, he continues. Pull one string of the food web, and another part might unravel. Pull lots of strings, and sometimes those strings get tangled in a wad, which happens today.

During their first trawl of the previous year, they didn't catch a single fish. Which is normal; many fish are supposed to be in the open ocean now, spawning, laying eggs that will grow into planktonic larvae, the future tide-riders to the Carolina marshes.

But this year, their johnboat slows ever so slightly as the net behind it fills. They pull up the net, Allen straining, four decades of sampling taking its toll on his back.

The net is loaded with fish. Not just one school, either. Many schools of different fish.

"This is an event," Kenny says, his voice suddenly firm. The fish aren't supposed to be here now, and certainly not in these numbers. "This has never happened before at any time of year — winter, spring and fall." Not in 35 years.

Allen nods.

Must be the warmth of the waters, the change in the salinity, many factors probably lumped them into the coast, he says. What will this do to the plankton? The food web? The climate? Tough to say exactly.

Other than it's not supposed to be like this. Wacky.

About this story

In addition to those named in this story, a number of other local and nationally recognized scientists contributed thoughts and information about this complex issue: Jack DiTullio, an assistant professor of biological and chemical oceanography at the College of Charleston, explained the carbon cycle and other notable breakthroughs in phytoplankton research; Ryan Rykaczewski, a biologist at the University of South Carolina's Marine Science Program, described the history of the deep scattering layer and other interesting behaviors of zooplankton; Samuel Laney, a biologist at the Woods Hole Oceanographic Institution in Massachusetts, gave an excellent Plankton 101 lesson.

In Bermuda, Becky Garley, Afonso Goncalves, Sam Stevens and Tim Noyes allowed us to observe their sampling by BIOS for their Bermuda Atlantic Time Series, better known in science circles as (BATS).

Other scientists consulted include: Dianne Greenfield, a phytoplankton expert and associate professor, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; Tammy Richardson, biology professor at USC; Samantha de Putron, an expert in corals at the Bermuda Institute of Ocean Sciences (BIOS); Bill Curry, chief executive officer of BIOS; and Leocadio Blanco-Bercial, a BIOS zooplankton expert. Tara Expeditions, a French non-profit that has done ground-breaking work on plankton, shared their breathtaking photographs and videos. More of those inspiring photos can be found in Plankton: Wonders of the Drifting World, a book by Christian Sardet. Links to studies and discoveries referenced in this story can be found in The Post and Courier's online edition.

Tony Bartelme, a projects reporter for The Post and Courier, is a former Harvard Nieman Fellow and two-time finalist for Pulitzer prizes in feature and explanatory reporting. He can be reached at tbartelme@postandcourier.com and 843-937-5554.

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March 20, 2016 POSTANDCOURIER.COM Charleston, S.C.

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Chapter 1
An Urgent Mystery

It's early in World War II, and America's fate is tied to the sea. In the Atlantic, Nazi U-boats pick off convoy ships, threatening the lifeline to Europe. In the Pacific, Japanese subs prowl the depths, testing a fleet battered at Pearl Harbor. Meanwhile, American war planners know little about this new underwater battlefield. Mastering its terrain could prove decisive. In a secret report, the leader of a hastily assembled group of scientists called Division 6 writes about an urgent need to understand the ocean "for service in a national emergency."

New sonar instruments would be the tool. You could ping the ocean bed, then use the bounce to calculate the seafloor's depth and shape. But sonar operators soon pick up something odd: The seabed seems to move up and down. More pings, and Navy technicians uncover a pattern: This "false bottom" rises at night and descends at dawn. What is it?

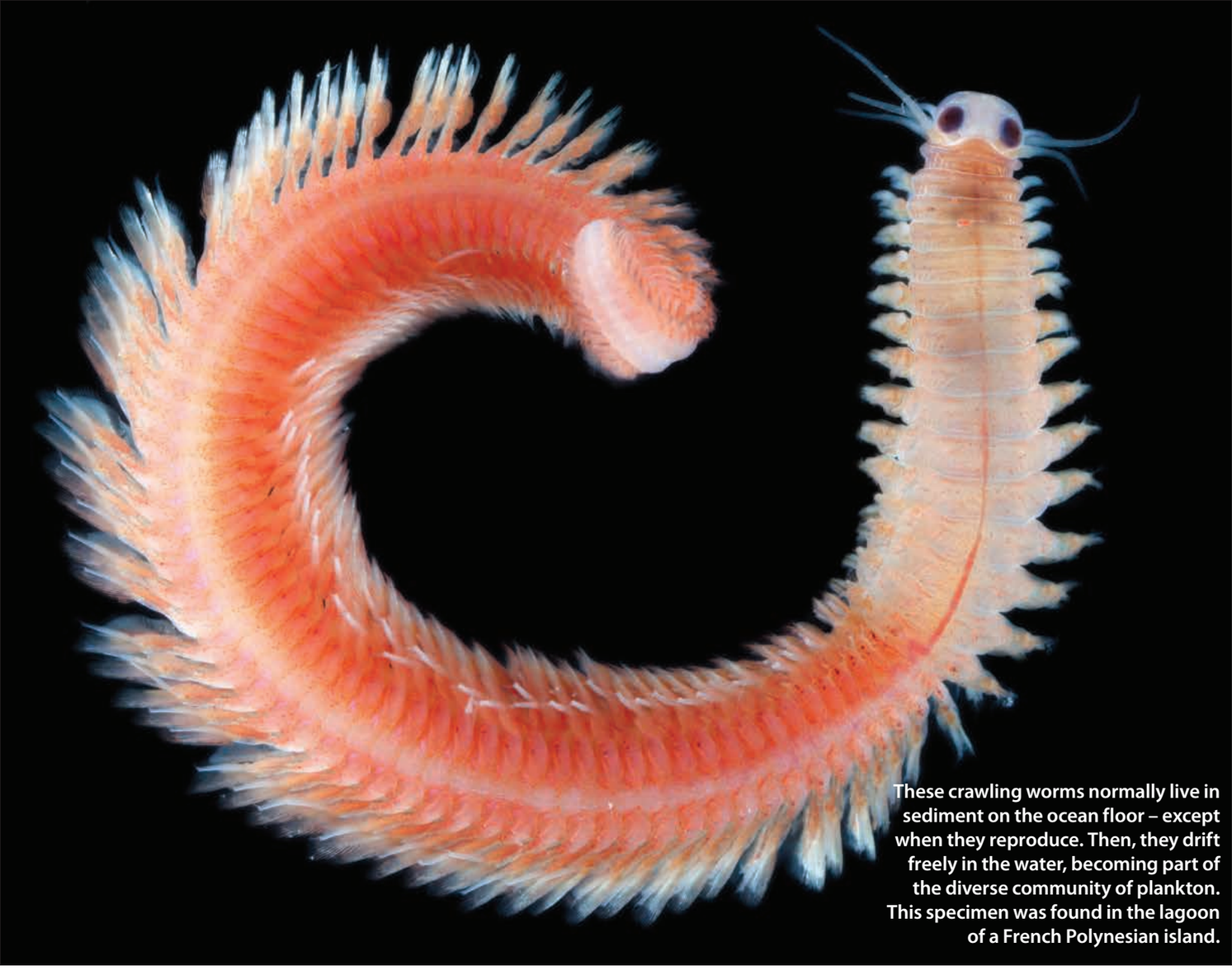
Must be alive, the Division 6 scientists think. Squids? Schools of fish? Has to be something pervasive; the sonar picks up false bottoms in all of the world's oceans. Whatever it is, could American submarines hide under it? Could enemy subs?

Division 6 doesn't answer these questions before

the war's end, which only stokes more curiosity. Scientists begin calling the false-bottom the "deep scattering layer." They toss nets into the layer; they haul up a few squids and fish but not enough to explain those scattering pings. Then, with fine mesh nets and deep-sea diving gear, scientists in the 1970s finally solve the mystery: The false bottom is a massive daily migration of plankton.

This symphony of tiny and beautiful creatures begins at night when they rise to feed on even smaller surface plankton. Countless fish join this movement — so many that the ocean hums. Then it ends at sunrise as they plunge to escape predators. Though unseen, this daily cycle is the grandest migration of all on Earth. From an ecological standpoint, it's exponentially more significant than the Serengeti's thundering wildebeest or the winged journeys of the world's birds. And it's just a small part of the plankton story. Startling new discoveries about plankton could prove decisive in an emergency that's as urgent as any war: a rapidly changing climate.

The question remains: Will we learn enough in time?



These crawling worms normally live in sediment on the ocean floor – except when they reproduce. Then, they drift freely in the water, becoming part of the diverse community of plankton. This specimen was found in the lagoon of a French Polynesian island.

Chapter 2

The Power of Plankton

Plankton may be the most important stuff you've barely heard of — more important to the climate's fate than rainforests. The term plankton is a catchall of sorts for living things that are at the mercy of currents. That broad definition includes jellyfish, krill, marine bacteria, viruses, algae and fish larvae. With no roots to the seabed, planktonic creatures mostly drift, though as those World War II pings revealed, some are masters at swimming up and down. Many forms of plankton are so tiny you need a microscope to see them, but they are the unsung heroes of the planet's air.

You can thank species of sun-loving plankton for the breath you just took. Until about 2 billion years ago, the planet's atmosphere was breathlessly devoid of oxygen. But then a distant cousin of today's blue-green algae began using the sun's rays to split water into hydrogen and oxygen. Earth hasn't been the same since.

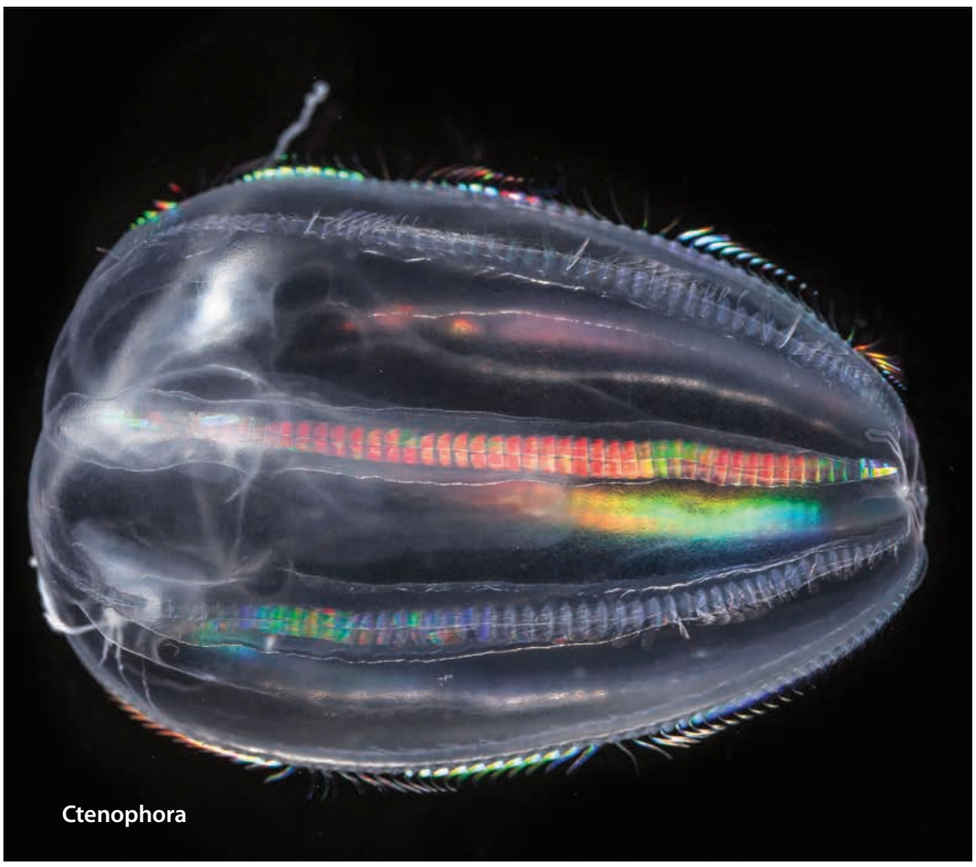
Today, half of the atmosphere's oxygen comes from ocean plankton — every other breath. Plankton comes in all shapes and sizes, but scientists divide them into two categories.

Phytoplankton are the microscopic algae and other cells that drift in the sun-infused upper layer of the ocean. Think of them as the plants of the sea, the oxygen producers. Zooplankton are the larger animals that typically feed on the phytoplankton. Think of them as the sea's insects, snails and worms.

Small and large, plant and animal, they do amazing things.

One zooplankton called phronima chomps on smaller plankton and uses their body parts to make protective cellulose barrels. The mother lives in the barrel, zealously guarding her young, while males bolt at the slightest danger. Phronima's fierce appearance is the inspiration for the creature in the movie "Alien."

Some algae and bacteria have red pigments and grow so dense they color vast areas of the ocean; floating pink blankets of bacteria gave the Red Sea its name. One zooplankton species has little blue sails; washing up on the beach, their colonies look like a regatta of tiny blue boats. Another jellyfish



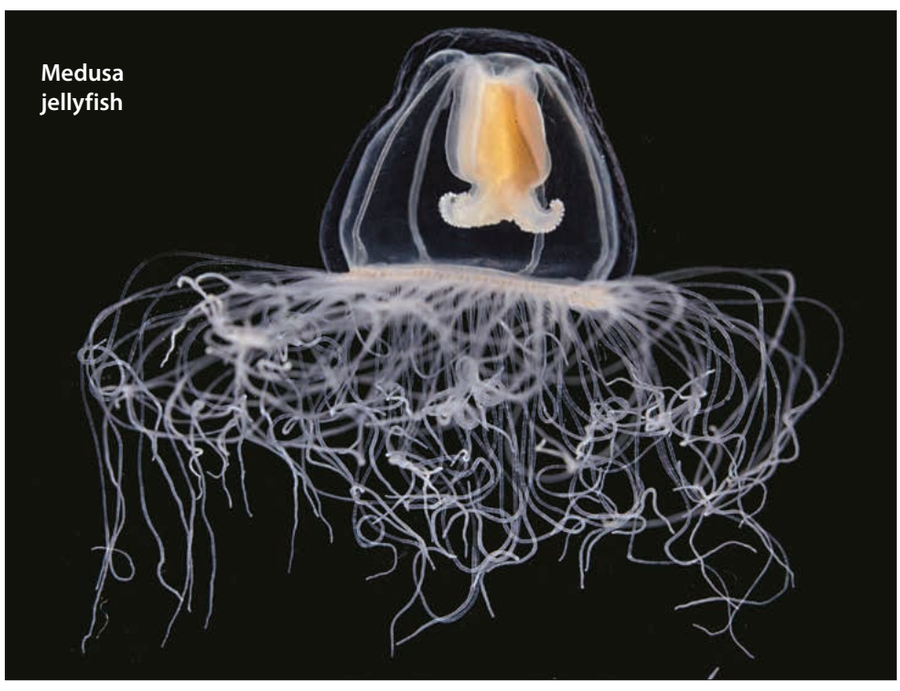
Ctenophora

can literally reverse its aging process; its nickname is "the immortal jellyfish."

When phytoplankton die, they emit cloud-forming chemicals that give beaches their intoxicating and briny smell. Some phytoplankton also are killers: Shaped like glistening needles, they secrete neurotoxins that find their way into shellfish and animals that feed on them. After one toxic algal bloom in 1961 in Monterey Bay, Calif., thousands of poisoned seabirds dive-bombed houses and cars and piled up dead on streets. The phenomenon inspired Alfred Hitchcock's movie, "The Birds."

Counting plankton is like counting stars, though instead of stars, some species look like Christmas ornaments and the Leaning Tower of Pisa. A single teaspoon of seawater might contain a million phytoplankton bacteria and 100 million planktonic viruses that feed on them. Viruses alone have an overall biomass in the oceans of 75 million blue whales. Mostly unseen, these hordes of planktonic algae and viruses are in a constant state of biochemical warfare: The viruses attack the algae while the algae develop special plates of armor.

Much of what we know about plankton has been discovered since World War II, thanks in part to those curious Division 6 scientists, but also because of people like Dennis Allen, who one morning in January, stands in a johnboat in a South Carolina marsh, wondering: Why does the water look so weird?



Medusa jellyfish

Chapter 3

Curiosity, and the Long View

Baruch research technician Eric Haffey studies a jar containing zooplankton and other species caught during a recent sampling trawl near North Inlet and Georgetown.

Allen is resident director of the University of South Carolina's Belle W. Baruch Marine Field Laboratory, a science center deep in an area of protected pinelands and marsh north of Georgetown. He has a boat captain's white beard and his brown eyes hold a look of delight. He has long been fascinated by the hidden underwater world, and it's easy to imagine that delighted look 60 years before when he watched those Amazing Live Sea Monkeys hatch. (The old comic book ads said: "Own a bowl full of happiness! Because they are so full of tricks, you'll never tire of watching them.") Those brown bits didn't really look like monkeys, though. And he would learn much later that biologists called them brine or fairy shrimp. But they spun and darted and moved about nevertheless, a small world of their own that hinted at a much larger one if you just look closer.

Which he did often with Pop-Pop, his grandfather. An Italian immigrant and successful auto dealer, Pop-Pop took him fishing off the New Jersey coast. His grandfather seemed to be curious about everything in the water, which was infectious to an already curious child.

"Pop-Pop, why do we catch flounder here but not over there?" he asked his grandfather.

"That's a good question!"

"Pop-Pop, what do the fish eat?"

"Let's see."

Gutting the fish, they found dead shrimplike animals in the stomachs — not so different from those Amazing Live Sea Monkeys.

Fast forward to the mid-1970s. Allen was a biologist by now, working on his dissertation, trawling with a fine mesh net off New Jersey, funneling zooplankton into a jar at the end of the net. He pulled up the net and looked at the jar. It was full of mysids, those shrimplike animals he saw when gut-

ting fish with his grandfather. From a distance, the jar looked as if packed with wild rice. But looking closer, you could see it teemed with life. New questions formed in his mind as he watched the mysids flit back and forth: What is their response to light? How do they move with the currents? Years later, he still keeps the jar on a shelf his office at the Baruch Institute. He smiles. "It's a reminder of my roots."

A reminder of the sense of discovery that fueled his most important work.

In January 1981, not long after he landed a job at Baruch, he collected samples in the salt marsh creeks of North Inlet. He recorded the water's temperature, salinity and other chemical characteristics. He collected the zooplankton with a fine mesh net.

Then he kept at it, sampling every two weeks, using the same nets and protocols.

And he kept going, even when the funding was barely there.

As the decades passed, shelves filled with glass jars of the samples, preserved in a pink fluid; data filled columns and charts. Like a savings account, it slowly grew in value.

Today, this data is called a "time series," and Baruch's is the longest continuous time series in an estuary in North and South America, and perhaps the world.

Its rarity and scientific value can't be overstated. With so much data collected consistently over such a long period, scientists can begin to understand how estuaries and salt marshes change over time.

And on the johnboat in January, he's shocked by what he sees.

PHOTOGRAPHS BY WADE SPEES/STAFF

Dennis Allen (left) of the Belle W. Baruch Institute's marine field laboratory north of Georgetown began collecting zooplankton in 1981 in what became the longest continuous sampling effort in an estuary in North and South America, and perhaps the world. Research technicians Eric Haffey (center) and Paul Kenny have helped take these samples every two weeks.

Chapter 4

The Zooplankton Crash

It's the 866th collection in the time series, the first of 2016. The marsh is a winter palate of pale yellows and greens. A bald eagle watches from the top branch of a dead tree. The johnboat moves into the current. The water is brown, the color of ice tea, and this is news.

"This time of year, it's supposed to be grayish-green and really clear," Allen says, as Paul Kenny steers the boat. Kenny, a research specialist, has been collecting samples with Allen for 33 years.

The source of the unusual color is last fall's torrential rains. A record 2 feet fell in one weekend. It's the kind of rain bomb scientists think we'll see more of as the planet warms and the air holds more moisture. More rain fell in November, fueled by one of the largest El Niño's in recent history. This morning, salt marshes have the salinity of freshwater ponds.

Strange weather, but Allen's time series has revealed other surprises that go far beyond any blips in the jet streams.

He grabs a net that looks like a windsock and tosses it overboard. The net funnels zooplankton into a jar. He and Kelly pull in the trawl, and Allen lifts the jar to the sky. A translucent eel larva flickers amid the debris. It probably migrated from the deep ocean, perhaps from the Sargasso Sea.

"The big story is that there are a lot fewer zooplankton in North Inlet than there used to be," Allen says.

When he began in 1981, a trash-can-sized amount of water held 10,000 to 12,000 zooplankton specimens.

Over time, the numbers declined. In recent years, they've been catching about 6,000 to 8,000.

"That's a 40-percent reduction," he says. "That's huge, and it's remarkable because it happened in just the course of 30 years."

Rising temperatures might be responsible.

Human activity releases the equivalent of 36 billion tons of carbon dioxide into the air every year. This CO2 and other greenhouse gases trap heat in the atmosphere. The ocean, however, absorbs much of this warmth. Every day, humans and their machines add heat to the ocean equivalent to 345,000 Hiroshima-size atomic bombs.

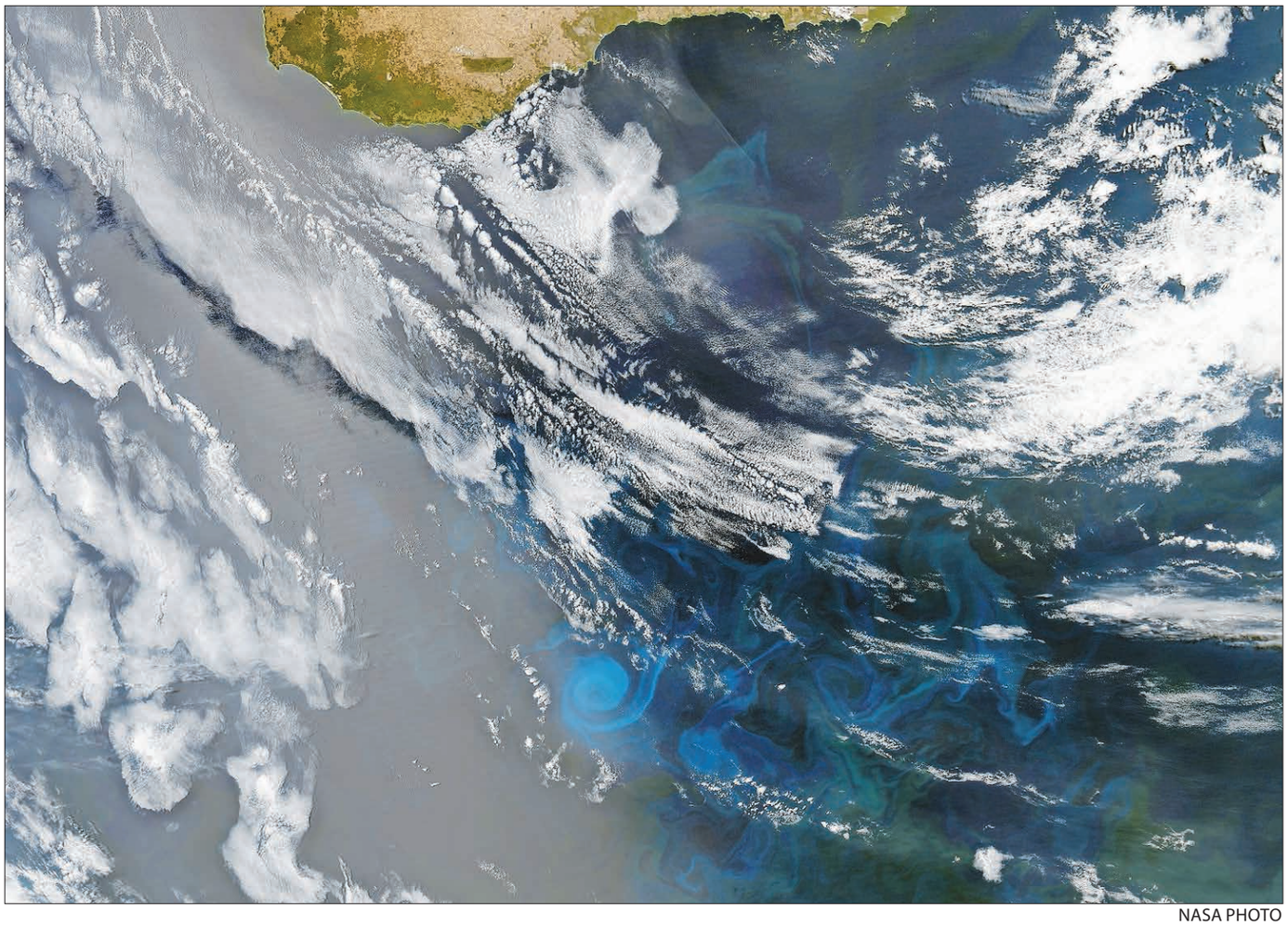
This injection of heat has caused the ocean's temperature to rise. Arctic and Antarctic ice are melting. And all these changes affect the mostly hidden world of plankton, the foundation of the food web.

Allen says they once caught hundreds of anchovies in trawls like today's. But in recent years, they've caught one or two per tow, or none at all. Researchers in the Chesapeake Bay, the West Coast, New England and Europe are discovering similar reductions in zooplankton and fish species, he adds. Results of these time-series findings will be published soon in scientific journals, but they only raise more questions.

What else is happening to the plankton?

Will this affect the climate?

And the air we breathe?



NASA PHOTO

A NASA satellite captured this phytoplankton bloom spiraling south of Australia in 2013. The churning ocean likely brought up nutrients from below, triggering this explosion of photosynthesis in the lighter blue spirals below the clouds.

Chapter 5

Open Ocean's Secrets

Across the Sargasso Sea near Bermuda, three young scientists on the boat Rumline prepare a gray canister that looks like a small torpedo. The boat slows. White foam breaks over a nearby coral reef. A Brazilian technician lowers the canister into gentle waves of turquoise. He hoists the canister back on board, and the three scientists take turns piping the contents into beakers. They repeat this four times at other spots off the island, then give a thumbs up to the captain, who turns the boat, painting a white arc of bubbles in the blue.

They head back to the island, with its white roofs like bleached coral, and dock at the Bermuda Institute of Ocean Sciences. In a lab there, they'll take those beakers of seawater and measure salinity, pH and other aspects of the water's chemistry. It's work similar to Dennis Allen's time series in South Carolina. But instead of estuaries, the Bermuda scientists focus on changes in the open ocean. As far as time series go, Bermuda's is the longest-running in an ocean setting, and, therefore, among the most important.

"I'm from Ohio," says Amy Maas, an assistant scientist here whose words tumble out in excited bursts, "so people always ask, 'Why should I care about what's going on in the open ocean?'" Her eyes open wide, and her hands dart like fish. "And I say, 'It's all connected! Our water! Our air! And this place is one of the key places in the world where we've learned about the importance of marine bacteria, how migrating plankton change things, how the carbon cycle works."

Growing up in Ohio, Maas thought she would be a librarian. But the more she learned about marine biology in college, the more she found herself captivated by its complexity and beauty. Drifting like plankton from course to course, and then in expeditions to Antarctica and the North Pacific, she found herself steered toward studies about climate change and a zooplankton group called sea butterflies, also known as pteropods. Now, she works in Bermuda with her husband, Leo, a Spanish zooplankton researcher, of-

ten bringing their new baby, Bastian, who sleeps in a crib next to her desk.

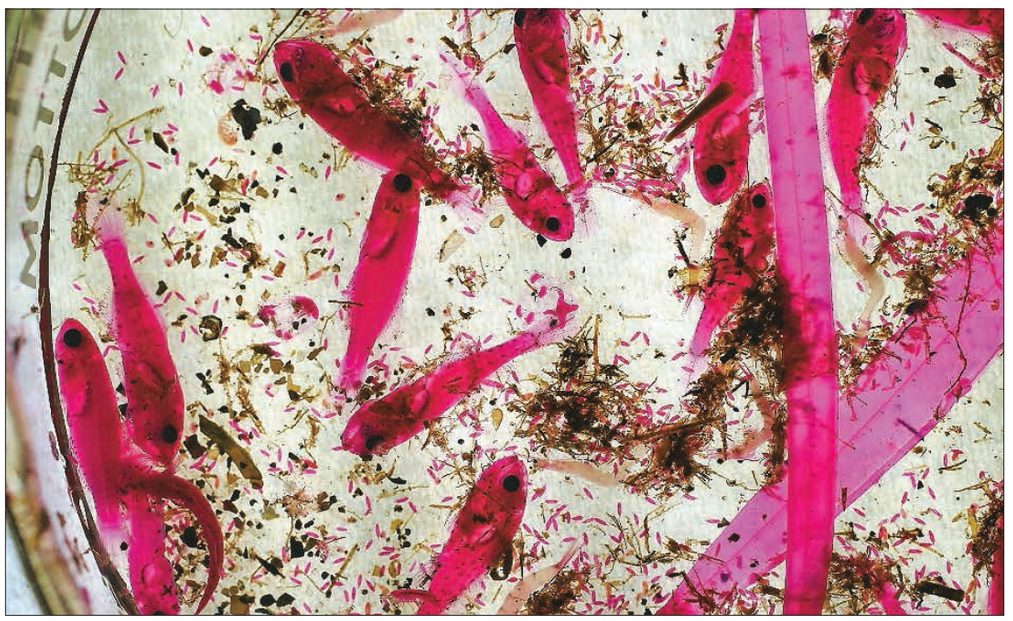
On an afternoon last February, a storm lashes the island, turning the cobalt waters below her office window into froth. Winds whip around the building, generating a sound like Tarzan's jungle yell. Maas' voice rises and falls as she recalls scuba diving with creatures from the deep scattering layer, the humming migration of plankton and fish that baffled the World War II sonar operators.

"During the day, you might see a fish here and there. But at night, when everything rises to the surface, boom, everything is there! The water is packed full of stuff. Wow. It's extremely dark, and you can't see anything beyond your big light. It looks like confetti, but it's all moving around. It's vibrant. You have these flashes of color. Everyone's trying to eat and mate and do everything that needs to happen. It feels as intense as a coral reef or a rainforest. But everything is tiny! There are these little things zooming past. Zoom, zoom, zoom, and then a squid comes flying in! And then when you turn the lights off, there's all this luminescence. And afterward you realize there's so much that you don't know."

Such as the health of this ecosystem. It's not easy to assess the status of the ocean's microscopic creatures, she says. "You can't ask a zooplankton, 'Hey, how are you doing?' That's where the time series is vital. Time series aren't flashy. They're expensive; they're time-consuming, and they're not going to give you this big paper that says, 'I just discovered X!' They're just a slow accrual of data."

But with that growing collection of information, you can understand what happened in the past. Do it long enough, and you can factor out seasonal fluctuations. Then, she says, "you can use this information to make predictions about the future."

Which, when it comes to the open ocean and its plankton, requires a deep breath.



WADE SPEES/STAFF

Continuous sampling of zooplankton at Baruch Institute has revealed a stunning decline over the past 35 years. Researchers are finding as much as 40 percent fewer zooplankton specimens, a signal that something dramatic is happening to the foundation of the food web. Scientists preserve specimens in a pinkish preservative for future studies.

Chapter 6

Oh-oh

It's helpful to know a bit more about phytoplankton, the forests of the sea. Coccolithophores and diatoms are important sun-loving forms of phytoplankton. You can see blooms of coccolithophores from space, milky swirls as large as California.

Under a microscope, you'll see they make fantastic shells. Shaped like flying saucers, they're made of calcium carbonate, the same thing as chalk. The White Cliffs of Dover are old deposits of coccolithophores.

Diatoms, meantime, build glass shells that look like fancy hat boxes. Their shells are even smaller, so small that 30 can fit across a human hair. Medical examiners use diatoms in drowning cases: As victims inhale water, diatoms enter the bloodstream and make their way as far as the kidney and brain. If you find diatoms there, you know the person drowned instead of dying before entering the water. Diatom shells also are used in toothpaste, cat litter, dynamite and nail polish.

Diatoms and coccolithophores don't just make useful and beautiful shells. They also incorporate huge amounts of carbon dioxide into their bodies. Then, larger zooplankton, such as Amy Maas' sea butterflies, gobble them up. Or they die of old age, which in plankton time might be just a few weeks. Then, weighed down by their elegant shells, they fall toward the ocean floor, joining a chorus of other particles, including carbon-infused feces of zooplankton. Scientists call this falling stuff marine snow.

Marine snow piles up unseen on the ocean floor. And over millions of years, geological and other forces compress it and turn it into oil. This ongoing plankton bloom-and-bust represents a massive carbon pump to the ocean floor that scientists have only begun to fully understand. Every year, according to recent studies, phytoplankton incorporate 50 billion tons of carbon into their cells. That's roughly the same as all the forests, bushes and grasses combined.

The Bermuda time series and other research have shown major changes in this biochemical balance. We've unlocked vast amounts of carbon dioxide by burning coal, gas and oil — carbon dioxide that took millions of years to sequester.

This has made the ocean more acidic — about 30 percent more acidic since the Industrial Revolution. This increase is faster than any known change in the sea's chemistry in the past 50 million years.

And that's bad news for some plankton.

Maas' research on sea butterflies has shown that even slight increases in acidity turn their shells from clear to opaque. Longer exposure, and the shells dissolve. Corals experience similar fates. Some researchers predict that because of ocean acidification, most of the world's coral reefs could be dead within half a century.

To the surprise of scientists, coccolithophores, the chalk-making phytoplankton, are blooming at unprecedented rates in the North Atlantic – a tenfold increase between 1965 and 2010. It's unclear whether this is good news or bad. On the bright side, such blooms are sucking up some of the carbon dioxide we release when we step on the gas pedal. On the other hand, it's a telling sign that we've pumped so much carbon dioxide into the air that our atmosphere and oceans are saturated. "Something strange is happening here, and it's happening much more quickly than we thought it should," one of the study's authors wrote.

Finally, we have the warming ocean, which could affect plankton in an indirect but deadly way. Many species do just fine in the sea's naturally changing temperatures. But they also depend on hidden underwater currents to stir up nutrients from cooler lower depths. This upwelling of nutrients is the equivalent of marine compost. But hot air hovering above the ocean creates a thick layer of warm water on the surface. And this turns that layer into a cap, preventing the upward movement of nutrients; with no mixing, phytoplankton starve.

You can outrun rising sea levels but with less oxygen, you won't run far. Some scientists predict that because of global warming the ocean's temperature may rise 11 degrees in the next 75 years. Under that scenario, many of the ocean's mixing currents may disappear, researchers at the University of Leicester in England reported last December. With less oxygen from the ocean's phytoplankton, the study's authors said, the planet will experience "mass mortality of animals and humans."

"Are we screwed?" People ask me that a lot," Amy Maas says as the storm outside lets up. But she's an optimist; humanity has a choice about reducing carbon dioxide emissions, reducing the size of that heat-trapping cap. "We're intelligent organisms that can come together and make good decisions." In other words, we're not drifting like the plankton, subject to some external current.

Chapter 7

The New Abnormal

In South Carolina, Dennis Allen and Paul Kenny continue their trawls. They point their boat toward a place with hidden sandbars and oyster reefs called No Man's Friend. After nearly 40 years working these waters, Allen has answers to many questions he posed to his grandfather so long ago. But as will happen, this knowledge only triggered more questions.

The ocean hides its secrets well: the up-and-down movements of zooplankton that create the deep scattering layer; the movements of fish from the estuaries to the open ocean where they spawn; then the huge unseen migration of planktonic fish larvae back to the estuaries, where they grow into snapper, croaker and shrimp.

"Remarkable creatures," he says. "I've been doing this for 38 years and I still get excited by what the net brings up."

Which happens today. During a trawl, they find a catfish in their net.

A catfish in a salt marsh?

A surprise, but should it be?

Consider last fall's rain bombs, winter's record warm spell when people from Charleston to New York ran shirtless after Christmas, and the stunned scientists who recorded temperatures at the North Pole above freezing. "I just returned from a conference in Portland," Allen says, mentioning a moderator who summed up the meeting's findings: "He says, 'Some wacky things are going on in our estuaries.'"

Ecology is all about relationships and understanding connections, he continues. Pull one string of the food web, and another part might unravel. Pull lots of strings, and sometimes those strings get tangled in a wad, which happens today.

During their first trawl of the previous year, they didn't catch a single fish. Which is normal; many fish are supposed to be in the open ocean now, spawning, laying eggs that will grow into planktonic larvae, the future tide-riders to the Carolina marshes.

But this year, their johnboat slows ever so slightly as the net behind it fills. They pull up the net, Allen straining, four decades of sampling taking its toll on his back.

The net is loaded with fish. Not just one school, either. Many schools of different fish.

"This is an event," Kenny says, his voice suddenly firm. The fish aren't supposed to be here now, and certainly not in these numbers. "This has never happened before at any time of year — winter, spring and fall." Not in 35 years.

Allen nods.

Must be the warmth of the waters, the change in the salinity, many factors probably hemmed them into the coast, he says. What will this do to the plankton? The food web? The climate? Tough to say exactly.

Other than it's not supposed to be like this. Wacky.

About this story

In addition to those named in this story, a number of other local and nationally recognized scientists contributed thoughts and information about this complex issue: Jack DiTullio, an assistant professor of biological and chemical oceanography at the College of Charleston, explained the carbon cycle and other notable breakthroughs in phytoplankton research; Ryan Rykaczewski, a biologist at the University of South Carolina's Marine Science Program, described the history of the deep scattering layer and other interesting behaviors of zooplankton; Samuel Laney, a biologist at the Woods Hole Oceanographic Institution in Massachusetts, gave an excellent Plankton 101 lesson.

In Bermuda, Becky Garley, Afonso Goncalves, Sam Stevens and Tim Noyes allowed us to observe their sampling by BIOS for their Bermuda Atlantic Time Series, better known in science circles as (BATS).

Other scientists consulted include: Dianne Greenfield, a phytoplankton expert and associate professor, Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina; Tammy Richardson, biology professor at USC; Samantha de Putron, an expert in corals at the Bermuda Institute of Ocean Sciences (BIOS); Bill Curry, chief executive officer of BIOS; and Leocadio Blanco-Bercial, a BIOS zooplankton expert. Tara Expeditions, a French non-profit that has done ground-breaking work on plankton, shared their breathtaking photographs and videos. More of these inspiring photos can be found in Plankton: Wonders of the Drifting World, a book by Christian Sardet. Links to studies and discoveries referenced in this story can be found in The Post and Courier's online edition.

Tony Bartelme, a projects reporter for The Post and Courier, is a former Harvard Nieman Fellow and two-time finalist for Pulitzer prizes in feature and explanatory reporting. He can be reached at tbartelme@postandcourier.com and 843-937-5554.

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Every Other Breath
Hidden Stories of Climate Change

LOWCOUNTRY ON THE EDGE

WADE SPEES/STAFF

Norman Levine, a College of Charleston geology professor, dips his hand into a rising king tide this summer in downtown Charleston. Levine's research shows that a surprising amount of land and marsh in Charleston County could end up under water.

Living on the edge has always been risky. Now our blurry edges are beginning to vanish.

BY TONY BARTELME || *tbartelme@postandcourier.com*

The South Carolina Lowcountry is a land of many edges, some obvious, others hidden. The tides blur things.

Because of our low elevation and the moon's pull, vast areas of land and water trade places twice a day. This makes our edges spongy instead of hard; in this soppy zone, green and gold strands of Spartina grass poke from mud so black and gooey it resembles tar; and the land's relationship with water is so intimate, saltwater sometimes pours from the ground like sweat, as it does this warm night when Norman Levine, a geologist at the College of Charleston, steps into it all. "Very impressive."

He says this because the moon is closer than usual to Earth tonight, and its power pushed the Atlantic deeper into our twisting tidal creeks. It's a seasonal king tide, a foot above average, an incoming flood with so much pressure that water bursts through cracks here at the intersection of Fishburne and Hagood streets.

Levine watches it pool and shoot across the street like a rapid. He watches a nurse in blue scrubs tiptoe through the current to reach her car. His voice rises because king tides are a taste of our future, one flavored with salt; he knows that climate change is reshaping the world's low places, and the Lowcountry is accurately named. "Sea rise is no longer a probability, yo."

Voice of Doom

Levine has a round physique and a dark goatee framed by wire-rimmed glasses. Colleagues jokingly call him the "Voice of Doom," but his voice is nothing like Darth Vader's. He speaks quickly and with enthusiasm. His accent has hints of New York and the South, and he has a disarming way of tossing the word "yo" into conversations.

The doom part comes from his title as director of the Lowcountry Hazards Center at the college. The center has seismographs to measure earthquakes, weather gauges to document hurricanes and computers packed with terabytes of mapping data. He and his students have used some of these maps to make

Please see **EDGE,** Page A4

The series

Every Other Breath takes a deep dive into the powerful and largely hidden forces that will shape humanity's future.

TODAY **Lowcountry on the Edge**: Seas are rising, which means big trouble for the Lowcountry and the world's other low places.

WEDNESDAY **Fade to White:** An environmental catastrophe is happening below the waves as coral reefs bleach.

OCT. 9 **Chasing Carbon:** Using a special camera, The Post and Courier exposes the invisible culprit behind climate change.

PAST STORY Plankton produce half of our oxygen, but scientists are seeing major changes in these creatures. Read at **postandcourier.com/plankton**

One year later, lessons still to be learned from epic rains

Little has changed since last October's record floods killed 19 people across South Carolina

BY BO PETERSEN
bopete@postandcourier.com

She shudders when French Quarter Creek rises higher than usual. A year ago, Maryanne Lane crept in the dark down the livingroom stairs with her black retriever, only to have Scalawag stop at the bottom step. She poked with her toe and felt the water.

Her creekside home in Huger had been built on top of pilings that raised it above flood level. It made no difference. The epic rains last fall had flooded the Lanes' home to the rim of the brick hearth fireplace.

Now, "when they say a lot of rain (is forecast), you start worrying what's going to happen," she said.

Nineteen people in South Carolina died last October as rivers, creeks and any other low-lying spot flooded to historic depths after record rains, spawned partly by Hurricane Joaquin offshore, hit hard. The floods left literally billions of dollars of destruction.

Please see **FLOODS,** Page A5

FILE/STAFF

Parts of the residential street along French Quarter Creek in Berkeley County looked more like a river during last October's record floods. South Carolina National Guardsmen used amphibious vehicles to assist residents.

Uptick in deadly violence takes toll

North Charleston on pace for record killings

BY ANDREW KNAPP
aknapp@postandcourier.com

Three gunshots startled Juanita Jones from her bed one morning in August.

Gunfire is no stranger to her North Charleston community, and she knew the city was facing one of its deadliest years ever. But the "pop, pop, pop" she heard this time was close. Too close.

Jones, 54, walked out and saw her grandson lying face down in her yard. She had raised him from an infant into a hardworking dad with a baby of his own and another on the way. He was bleeding in the dirt in front of her.

She wrapped her arms around him and held tight. His eyes were closed.

"Give me a breath, Damarco," she whispered.

For him to say something was too much to ask. She just wanted him to live, to not leave her great-grandson fatherless.

"He gave me a breath, gave me another breath, then he was gone," Jones

Please see **KILLINGS,** Page A6

Some police remain quiet on records

BY GLENN SMITH
gsmith@postandcourier.com

A handful of top police agencies across the country have ignored or refused multiple requests over seven months to answer questions about their use of shadowy databases that track people who crossed paths with officers but were not charged with crimes.

Beginning in February, The Post and Courier surveyed the 50 largest law enforcement agencies in the United States to assess their use of so-called field contact databases to document police encounters with people on the street. The survey led to the recent series, "Watched," which revealed police forces were hoarding the personal information of millions of Americans, many of whom had not been charged.

Please see **RECORDS,** Page A5

Inside

Partly cloudy. High 86. Low 65. Complete 5-day forecast, **B6**

'We're talking about big changes'

EDGE from Page A1

startling predictions about the Lowcountry's edges as the climate warms.

Levine has long been fascinated by mega forces. He grew up in an area of Long Island smoothed by glaciers. He was captivated by how slabs of ice from what's now Upstate New York could transport gneiss, schist and other glittering rocks to yards around his house. In middle school, teachers gave him the key to the school's rock collection. In college, he stared at images of earth snapped by Apollo spacecraft, his mind transfixed by the blues, whites, browns — water, vapor, land.

And so he became a geologist, learning quickly that the field isn't just about rocks. It's also about water and movement and time. He would learn, for instance, that the area around Charleston is sinking. Slowly, but surely, North America's main tectonic plate is tilting like a giant seesaw, with the pivot point roughly on the Canadian border. Loosely speaking, the Canadian side is going up and the South Carolina side, down — down just a few inches a century, not such a big deal. Unless the land already is low and next to a rising sea.

Back to water instead of rocks. Imagine a big pitcher of ice cubes with the water filled to the brim. Water won't flow over the edge as the cubes melt, even if it's a hot day. But add more cubes, and you'll have water pouring onto the table. That's what's happening in Greenland and Antarctica, thanks to another powerful force — rapidly increasing levels of carbon dioxide.

Higher CO2 levels trap more heat in our air and oceans, causing enormous amounts of ice to fall into the ocean. During the past four years alone, Greenland lost 1 trillion tons of ice, a recent study found. All told, Greenland has the equivalent of 23 feet of sea rise in its glaciers and ice. Antarctica holds even more ice — 200 feet of potential sea rise. Meanwhile, the rate of sea rise has already doubled since 1993. Cue the Voice of Doom:

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"Yeah, that's the point," Levine says. We'll have to respond to sea rise in increasingly dramatic ways: with dikes and dirt, and by retreating when the oceans rise too fast. Powerful forces are reshaping the Lowcountry right now. The proof is in the floods pouring out from the storm drains 911 feet from a marsh creek, and in the marshes by North Inlet, and Miami and Norfolk and other low places. Incremental changes, though. Which can blur their seriousness.

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Jim Morris, director of Baruch Institute near Georgetown and a biology professor at the University of South Carolina, and his colleagues have been measuring marsh levels near North Inlet since the 1990s. On a recent afternoon, he and Karen Sunderberg of USC study a marker. Once deep on the marsh, it's now near its edge.

WADE SPEES/STAFF

Jordan Faulk walks in a high spot in a flooded section of Line Street at Hagood Avenue to her car after a day of work as a registered nurse at Medical University of South Carolina. Such flooding is becoming more frequent as the earth warms and the icecaps melt.

Online

Scientists predict the sea could rise as much as 6 feet around Charleston by the end of the century. For a multimedia presentation, see **postandcourier.com / on-the-edge**

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Every Other Breath

Hidden Stories of Climate Change

LOWCOUNTRY ON THE EDGE

WADE SPEES/STAFF

Norman Levine, a College of Charleston geology professor, dips his hand into a rising king tide this summer in downtown Charleston. Levine's research shows that a surprising amount of land and marsh in Charleston County could end up under water.

Living on the edge has always been risky. Now our blurry edges are beginning to vanish.

TONY BARTELME || *tbartelme@postandcourier.com*

The South Carolina Lowcountry is a land of many edges, some obvious, others hidden. The tides blur things. Because of our low elevation and the moon's pull, vast areas of land and water trade places twice a day. This makes our edges spongy instead of hard; in this soppy zone, green and gold strands of Spartina grass poke from mud so black and gooey it resembles tar; and the land's relationship with water is so intimate, saltwater sometimes pours from the ground like sweat, as it does this warm night when Norman Levine, a geologist at the College of Charleston, steps into it all.

"Very impressive."

He says this because the moon is closer than usual to Earth tonight, and its power pushed the Atlantic deeper into our twisting tidal creeks. It's a seasonal king tide, a foot above average, an incoming flood with so much pressure that water bursts through cracks here at the intersection of Fishburne and Hagood streets.

Levine watches it pool and shoot across the street like a rapid. He watches a nurse in blue scrubs tip-toe through the current to reach her car. His voice rises because king tides are a taste of our future, one flavored

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with salt; he knows that climate change is reshaping the world's low places, and the Lowcountry is accurately named. "Sea rise is no longer a probability, yo."

Voice of Doom

Levine has a round physique and a dark goatee framed by wire-rimmed glasses. Colleagues jokingly call him the "Voice of Doom," but his voice is nothing like Darth Vader's. He speaks quickly and with enthusiasm. His accent has hints of New York and the South, and he has a disarming way of tossing the word "yo" into conversations.

The doom part comes from his title as director of the Lowcountry Hazards Center at the college. The center has seismographs to measure earthquakes, weather gauges to document hurricanes and computers packed with terabytes of mapping data. He and his students have used some of these maps to make startling predictions about the Lowcountry's edges as the climate warms.

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LOCAL: Folly bans plastic from beach. **A3**

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Slager's team wants trial moved

Attorney argues video of shooting has created bias in Charleston area

BY GREGORY YEE
gyee@postandcourier.com

Michael Slager's defense team wants his murder trial moved out of the Charleston area.

Andy Savage, the lead attorney for the former North Charleston police officer, filed a motion Tuesday asking to change the venue of Slager's upcoming state trial.

The former officer is accused of fatally shooting Walter Scott, 50, after the man ran from a traffic stop on April 4, 2015, off Remount Road. Slager fired a Taser at him, and a fight ensued.

Video of the shooting taken by a bystander, Feidin Santana, surfaced three days later showing the two men struggling on the ground.

Slager

Slager was jailed on a state murder charge and later was indicted on three federal counts, including a civil rights violation and lying to authorities about the threat Scott posed with the Taser. The federal trial isn't scheduled to begin until 2017.

In his filing, Savage argues that Santana's video has created a pervasive bias against his client in the Charleston area.

An affidavit included with the filing said that a telephone survey of 608 Charleston County adults was conducted Sept. 16-18.

Of the people reached in the survey, 91 percent had knowledge about the Slager case and 85 percent had seen the video, the affidavit said.

"The bystander video has been the main source of the false and incomplete narrative that permeates this community. ... This false narrative was reinforced by the ($6.5 million) civil settlement (in October 2015) which is seen as confirming Slager's guilt," Savage said.

The motion does not say where Savage or Slager would like the trial to be moved.

Account differ about whether Slager or Scott had the upper hand during the struggle.

Slager's attorneys have said he still saw Scott as a threat when he opened fire and that Santana's video showed Scott on top of Slager, beating the officer.

Please see **SLAGER,** Page A9

FADE TO WHITE

From South Carolina to the Florida Keys, coral reefs are the ocean's masterworks. Will they soon be gone?

XL CATLIN SEAVIEW SURVEY

Even amid an environmental catastrophe, bleaching reefs have a beauty to them, as seen in this one in American Samoa. But this beauty will disappear as the reef dies and turns into rubble. Can we save them in time?

BY TONY BARTELME || *tbartelme@postandcourier.com*

The Shipwreck

Mid-September 1914, and the world was as tossed as the sea. The Great War had just begun and Europe's armies were digging in. Off the Carolinas, a storm turned the Atlantic into green froth. Amid the waves, a wooden schooner limped toward Charleston.

The Frederick W. Day was 170 feet long, a four-masted monument to the end of the days of sail. From New York, the ship set off for Wilmington, N.C., its hull crammed with sacks of Portland cement.

But off the Outer Banks, the ship struck an unknown object. Seawater flowed in, winds shoved the schooner away from Wilmington, and the captain made for Charleston, his crew engaged in its own trench warfare against rising water.

Then the pump gave out, the water hit the cement powder, and the ship went down like the stone it would become. The crew made it safely to Charleston Harbor in a lifeboat, and then time passed, and for nearly a century, memories of the shipwreck's location faded.

But the sea's memory was better, and soon tropical corals found the hardened cement. The shipwreck evolved into a northern outpost of the Caribbean, a coral reef with barracudas, spiny urchins and colorful tropical fish you might see in an aquarium or the Florida Keys.

Then, this place fell ill.

The corals turned ghostly white, like a sick person's limbs, and a diver and scientist in Charleston named Phil Dustan knew what was going on. He'd seen the same thing in so many other stunning places.

Please see **CORAL,** Page A6

A special report

Today, in Fade to White, read how an all-but-secret coral reef off Charleston can help us understand a global economic catastrophe hidden under the waves. It's the latest installment in our continuing series, **Every Other Breath: Hidden** stories of climate change.

Mount Pleasant in new fight over height

Battle with Sullivan's Pointe builder focuses on definition of 'story'

BY DAVID SLADE
dslade@postandcourier.com

Poll
Should the town have stopped work on five houses that it previously approved at Sullivan's Pointe? Go to **postandcourier.com/polls** to vote.

MOUNT PLEASANT — A homebuilder has been ordered to stop work on five houses at Sullivan's Pointe that would exceed the town's height rules, although the town approved the plans and issued building permits.

The emerging development off Ben Sawyer Boulevard is the latest disputed development to prompt a lawsuit against the town.

The definition of what a "story" is could be a key issue: Is an elevated house in a flood zone, with parking underneath and three floors of living space above, a three-story building, or a four-story building?

Please see **TALL,** Page A9

Inside

Social Security plans another tiny pay raise

$4 more monthly unlikely to help as medical costs soar

BY STEPHEN OHLEMACHER
Associated Press

WASHINGTON — Millions of Social Security recipients and federal retirees will get a 0.3 percent increase in monthly benefits next year, the fifth year in a row that older Americans will have to settle for historically low raises. The adjustment adds up to a monthly increase of less than $4 a month for an average recipient.

The cost-of-living adjustment, announced by the government Tuesday, will affect more than 70 million people — about 1 in 5 Americans. For recipients, the average monthly Social Security payment now is $1,238.

Unfortunately for some seniors, even the small increase will probably be wiped out by an expected increase in Medicare Part B premiums, which are usually deducted from Social Security payments.

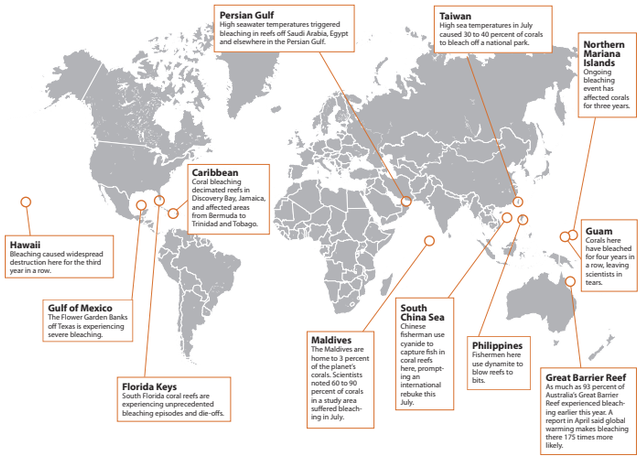
By law, rising premiums for most Medicare recipients cannot exceed their Social Security cost-of-living increase. That's known as the "hold harmless" provision.

Please see **BENEFITS,** Page A9

Mostly sunny. High 85. Low 63. Complete 5-day forecast, **B10**

Fading Coral Reefs: 2016's unfolding global catastrophe

The year 2015 saw one of the world's worst bleaching events. All told, 38 percent of the world's reefs saw some form of bleaching that killed more than 4,633 square miles of reefs, roughly the size of Connecticut. And 2016 was just as bad. Here's a look at the coral carnage:



SOURCE: COMPILED FROM ACADEMIC RESEARCH — BRANDON LOCHETT/STAFF

Ocean's masterpieces in ruins

CORAL from Page A1

The majesty below

Coral reefs are the ocean's masterpieces, the oldest and most complex ecosystems on earth. The corals themselves are tiny cup-shaped animals called polyps. Polyps have a jelly-like consistency with a whitish limestone skeleton that clings to hard surfaces, such as the Frederick W. Day's cement bags.

A polyp has venomous tentacles that pop out at night. With these tentacles, the polyp snares zooplankton and other prey. But zooplankton is just a small portion of its diet. The polyp gets most of its food from microscopic algae that live inside it — several million microorganisms per square inch.


Dustan

The polyp and algae have a deal: the polyp shelters the algae, and the algae make oxygen and sugars for the polyp. Alone, the polyp is translucent. It's the algae that give corals their wild hues.

Married like this, polyps and algae build elaborate structures: the staghorn coral's antlers, the cerebellum-shaped balls of brain corals. Gold, green and brown, most corals grow slowly, an eighth of an inch to 4 inches a year, but over time, this layering adds up. Australia's Great Barrier Reef is the largest living structure on the planet. Coral reefs off Hawaii are more than 80 feet tall.

Corals, however, are picky about real estate, preferring clear water and stable temperatures. If water gets too warm, then algae produce too much oxygen. This triggers a rift in their fragile symbiosis. Sensing a threat, the polyp expels its algae like a betrayed lover.

But without its partner, the polyp fades to its translucent self, and its white reflective limestone skeleton turns bright white. This is what's known as bleaching. And across the world's warming seas, this phenomenon has destroyed one reef after another. When bleached for long periods, they shatter and fall to the sea floor.

Yet, as with cancer, reefs sometimes survive bleaching episodes; when conditions return to normal in time, the symbiosis begins anew. Then the colors come back – the greens and yellows and pinks that have seduced so many scientists and divers, including Phil Dustan, whose quest to understand corals began when he nearly blew his head off.

When light strikes the water

In his office at the College of Charleston, Dustan tells the story: He had two loves as a child: the ocean on Long Island and fixing engines. When not surfing or in school, he worked at a marine engine junk yard. One day, the owner asked him to fill up a truck tire. "I knew a lot about engines but not much about tires." While filling it, the tire's split ring exploded.

The tire and wheel hit his forehead, peeling his scalp back 2 inches. Another section knocked him backward into a truck. For a moment, he felt himself leave his body. He saw a white light around everything. That night, doctors told his mother he probably would die by morning.

But time passed, the double vision in his blue eyes moved back to single, his memory improved, and in some ways, he was a better person for it all. Before, he was a middling college student. After, he earned As. "It was an internal thing, that life is real. I was a little more serious." His senior year in college, he took money from a Workers' Compensation settlement to buy a science course in the Bahamas during spring break.

There, while snorkeling, he had his first look at an offshore coral reef.

"I was stunned. The water was crystal clear" — so different than the green juice off Long Island he'd surfed in. And the blues!

When light hits tropical reefs, it bounces back to the surface, hitting the underside like a rubber ball against a ceiling. This bounce amplifies the light and anything it strikes, so it feels as if you're suspended in blue.

In this light, a healthy reef almost glows. And when you swim under the boat, light beams fall like waterfalls around the shadow.

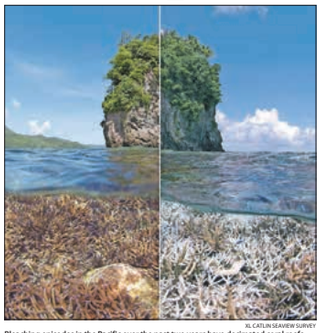
This shimmering light exposes a whole new world: translucent plankton that cast great webs; ctenophores with rainbow-colored filaments. The invisible is suddenly visible.

While exploring the Bahamian reef, a change in the light caught his eye. In the sand below, giant wings appeared.

And then a black-and-white stingray rose and swam in a grand arc, and the suddenness and elegance of all this sealed something inside his mind: love for the reefs and a driving need to understand the mechanics behind their beauty.

As a graduate student, he would go on to study reefs in Jamaica's Discovery Bay in the late 1960s and early 1970s, reefs that left him grinning as he climbed back on board after dives. And from Jamaica, he landed a job with the Smithsonian Institute on Florida's Key Largo. "The reefs off the Keys then were amazing, the biggest and most diverse in the United States, with a few that even looked like the ones I knew in Jamaica."

Back then, he imagined coral reefs to be vast and abundant — ecosystems with the kind of permanence you might expect from something built of limestone. But then one day on a boat off Belize, he had a conversation with the famous explorer Jacques Cousteau, a talk that left him wondering whether he was wrong about reefs, that maybe they could fade like a childhood memory.


XL CATLIN SEAVIEW SURVEY

Bleaching episodes in the Pacific over the past two years have decimated coral reefs, including this one in American Samoa last year.


CHARLESTON SCUBA

This Ling Cod hiding in the Frederick W. Day coral reef off Charleston.

About the series

Every Other Breath takes a deep dive into the powerful and largely hidden forces that will shape humanity's future.

TODAY

Fade to White: An environmental catastrophe is happening below the waves as coral reefs bleach.

SUNDAY

Chasing Carbon: Using a special camera, The Post and Courier exposes the invisible culprit behind climate change.

PREVIOUS STORIES

■ Lowcountry on the Edge: Seas are rising, which means big trouble for the Lowcountry and the world's other low places.

■ Plankton produce half of our oxygen, but scientists are seeing major changes in these creatures. Read at **postandcourier.com/plankton**

Into the blue

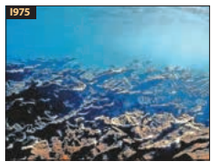
But first, some fresh memories: In the broiling summer of 2016, towering thunderclouds billow on the horizon as the mangroves off Key Largo give way to open water.

The water's reflection flashes like the blue and silver scales of a fish. It's mid-July, and the water is 87 degrees, unusually warm and a tipping point for corals. "I can guarantee you'll see some bleaching," says Jason Vogan, a dive boat captain with Quiescence Diving Services. He steers toward one of the most popular and devastated reefs in the Keys.

Please see **CORAL**, Page A7

The death of a reef

In 1974, Carrysfort Reef in the Florida Keys once was a vibrant place of colors and life. Phil Dustan of the College of Charleston has watched its colors fade and parts of the reef turn into a wasteland.



PHOTOS BY PHIL DUSTAN

"Lots of scientists think that ocean acidification is not going to be a problem until 2050 or 2060. This is happening now."

Chris Langdon, Marine biology professor at the University of Miami

CORAL from Page A6

The Florida reef system traces an arc south of Miami to the Dry Tortugas. It's the third-largest barrier reef in the world, and it's the engine of a $6.6 billion tourism-based economy that supports 70,000 jobs. Reefs like this also are important nurseries for the seafood we eat. Ocean bottoms are mostly sand, but coral reefs are the oases. Reefs cover less than 2 percent of the seabed but one-quarter of the ocean's species depend on reefs for food and shelter. One investigation found 103 species of worms around a single coral.

Four miles off the coast, the blue turns darker in splotches, signaling a shallow reef. Jason slows the boat near a mooring buoy. Five divers jump into the blue world below.

Under the surface, brown-and-blue sea fans wave back and forth like Hawaiian dancers. A shimmering school of minnows pours through a tunnel of coral in a twisting swirl; a 5-foot gray shark suddenly cruises past. Amid it all are corals: brain and elkhorn, and they're easy to pick out because some have turned white from bleaching. And beside them in a sandy area are remnants of what was: staghorn coral antlers lying there like old bones, gathering sediment.

And yet, many colors remain: yellow-and-white zebra fish move to and fro, as well as a school of blue angelfish. Even the bleached corals are beautiful. Some are as white as sugar. Amid the colors, you might wonder what all the fuss is about.

"Yeah," Dustan says later with a nod. The beauty hides a deeper story. "You don't know what it was like before."


PHIL DUSTAN

Phil Dustan uses a plumb bob to make measurements on a reef in Bali in 2013. During a return trip this spring, he found the reef decimated.

Undersea world of Phil Dustan

When Dustan arrived in Key Largo in the mid-1970s, the reefs had a glow that reminded him of the flush energy of a healthy pregnant woman. Water around Carysfort Reef, one of the largest in the Keys, was clear. Visibility was about 80 feet.

He looked different back then as well. His hair was long, and he sometimes wore mismatched socks, but he had a growing reputation for his knowledge about reefs, so much that in 1974 Cousteau had asked him to join an expedition in Belize. During one wine-soaked lunch on Calypso, Cousteau lamented how human activity had killed reefs in the Red Sea. Dustan thought at the time: "Cousteau's out of his mind. Reefs were too robust and stable, right?"

But as Dustan studied the reefs off the Florida Keys, he began to think Cousteau was right. Reefs were like a body fighting off multiple diseases. Developers were carving canals through ancient corals, sending plumes of sediment offshore; septic tanks leaked raw sewage; commercial and recreational fishermen scooped up vast numbers of fish. Sooner or later, the reefs' immunity would suffer. But how could he track its health?

He and colleagues began in 1975 by identifying areas in the reef that seemed representative of the entire ecosystem. "We picked Carysfort on purpose because it was the most well-developed reef and the farthest away from a popular state park."

Next, he and colleagues staked off rectangular areas in the reef with stainless steel rods. He called these staked areas "transects." By analyzing what was inside the transects, he could estimate a reef's "coral cover." It was similar to measuring the density of a forest's tree canopy.

And Carysfort then was a dense undersea forest; in the mid-1970s, about 60 percent of the reef was covered in corals. It seemed like a stable system, except for the kidnappings.

Gone missing

In 1983, a mysterious disease attacked black sea urchins across the Caribbean. In short order, as much as 97 percent of the urchins died. It was a huge blow to coral reefs because urchins munched on algae. Think of an aquarium without a filter; without the urchins, algae soon smothered corals; the antlers of the elkhorn and staghorn corals shattered and fell to the sea floor.

Meanwhile, worldwide carbon dioxide levels continued to rise, trapping heat in the air and sea; the ocean grew warmer by about a degree through the 1980s and 1990s, which may not sound like much, but in the past, a 1- or 2-degree drop was enough to trigger an ice age.

And as the ocean absorbed more carbon dioxide, seawater's pH changed, becoming more acidic. Some reefs began to dissolve.

In 1981, Dustan packed his bags to take a position at the College of Charleston, a new base to continue his studies in the Keys. In 1983, he visited his transect sites.

"It looked like a bomb had gone off."

As time passed, the reef 's condition deteriorated even more. By 2000, the coral reef cover had declined by 92 percent.

This destruction filled Dustan and other longtime divers with sadness and anger. It was an environmental catastrophe as serious as the burning of Amazonian rainforests, but one hidden under the waves. Dustan began talking about it in terms of a crime spree.

"Think of the reefs as a healthy town. Then, suddenly, someone kidnaps a doctor, then a priest, then a police officer, its garbage collectors. After a while, the fabric of the town frays."

He published his dire findings, which he said didn't square with Florida's efforts to market the Keys as a pristine diving destination. With little explanation, he lost a major source of research funding. "That's how it's done. You're marginalized."

But other researchers also uncovered disturbing trends.

Florida scientists found that acidification was eating away at Florida's coral reefs faster than the corals could lay down new layers of limestone.

"Lots of scientists think that ocean acidification is not going to be a problem until 2050 or 2060," says Chris Langdon, a marine biology professor at the University of Miami. "This is happening now."


MAINE MARITIME MUSEUM

The Frederick W. Day sank within sight of the Morris Island Lighthouse in 1914.

Meanwhile, away from the Keys, fishermen in the Philippines and Sri Lanka used dynamite to catch fish, blowing reefs to bits; a bleaching episode this spring affected more than 93 percent of Australia's Great Barrier Reef.

Dustan began his career studying the mechanics behind the reef 's beauty, and mass bleachings such as what happened in Australia were relatively rare until the 1980s; now, like many coral experts, Dustan finds himself a chronicler of death. In 2013, he went back to Jamaica's Discovery Bay. Its once-magnificent reef was a pile of rubble. In 2014, he was back in Key Largo.

"What's left of the reefs looked like a war zone." And yet, there in the Keys, plenty of divers were bowled over by what they saw.

"They were saying, 'Oh, this is beautiful!' And yes, it was. There were little sea fans flapping around, and a few fish, but that's not the baseline. I was really thinking, 'This reef is dead.'"

The 'Freddy Day'

The wreck of the Frederick W. Day was just 11 miles from the mouth of Charleston Harbor. Even so, nautical charts had it in the wrong spot. And so as the decades passed, ocean and time consumed the ship's wood, and Oculina corals took hold, and an undersea forest you might see in Florida appeared with puffer fish, amberjack, grouper, damselfish and manta rays, all just a relatively short boat ride from the Morris Island Lighthouse.

Then, one day in 1982, a shrimper snagged his net on the reef. He called a local diver, Eddie Phillips, who called Tom Robinson, owner of Charleston Scuba. Robinson was blown away by the richness of Frederick W. Day's growth and the world around it.

During later dives, Robinson saw sand sharks, some longer than 10 feet, green moray eels, "tons of urchins," tropical sponges and a 6-foot barracuda. "It looked like a Dr. Seuss picture or the Beatles' Octopus's Garden." He spotted thumping shrimp that strike out with such force they can break glass if put in aquariums; he swam with ctenophores, which floated by like iridescent Christmas balls.

But word was out now about its true location. The kidnappings began: divers with spear guns took out the larger fish, including the sand sharks and grouper. Robinson, who was against spear fishing, also watched as fishermen dangled hooks over the reef. Beer cans landed on the sea floor; fishing lines wrapped around the coral. The Freddy Day, as it's now known, lost some of its equilibrium.

In 2006, one of Dustan's students brought him a video she'd taken while diving on the shipwreck.

There it was, what he'd seen in the Florida Keys, in Jamaica, and now here, bleaching coral.

'Game over'

One recent study found that 70 percent of the world's coral reefs could be gone in 30 years.

"We're doing science wrong," Dustan says recently after returning from a trip to Bali with his students. On that trip, he surfaced with tears in his eyes. In just a year, bleaching and other forces destroyed one of the most beautiful reefs he'd ever seen. "If we don't step up as humans, it's game over. What makes me angry is knowing what's wrong and doing nothing to fix it. That's what I struggle with. But I tell my students that there are things we can do."

Focus on solutions, he tells them: Vote for politicians who treat climate change seriously; vote with their pocketbooks by buying more environmentally friendly products; grow sea urchins, as he and several researchers are trying to do; or grow corals in nurseries and transplant them, as nonprofits are doing in the Florida Keys; create no-take marine sanctuaries, as Tom Robinson would love to do with the Freddy Day.

Do these things — reduce these smaller stresses — and the reefs may handle the larger ones, such as a warming ocean and increase in the sea's acidity. "Like an immune system, the healthier it is, the better it is at warding off diseases," Dustan says. "So there's hope."

As long as it's tied to action. Inaction means more reefs will lose their fragile symbiosis, and in that loss, some of the world's colors will fade for good.

Reach **Tony Bartelme** at 843-937-5554

ACKNOWLEDGMENTS: A number of other scientists not quoted in the story also were consulted, including: Peter Moeller, research chemist with NOAA and MUSC; Cheryl Woodley, College of Charleston and NOAA Hollings Marine Laboratory; Ray Swaggerty, who has done extensive research on the Frederick W. Day; and Samantha de Putron, Bermuda Institute of Ocean Sciences.

How to help

Seven things you can do now to help coral reefs, especially if you're about to go snorkeling:

1. Support creation of no-take marine sanctuaries in appropriate reef areas.

2. If you live on the coast, make sure your septic tank isn't leaking.

3. Use environmentally sensitive mooring buoys over reefs. Example: Environmental Moorings International on Key Largo has placed tens of thousands of buoys over reefs, allowing boats to tie up without throwing an anchor onto a reef.

4. Support groups such as Coral Restoration Foundation that transplant coral reefs.

5. Use reef-safe sunscreen. Scientists from NOAA's Hollings Marine Laboratory and other agencies found that chemicals in common sunscreens are toxic to corals.

6. Don't touch the coral when diving. Touching it can harm corals' fragile membranes, making it susceptible to diseases.

7. Support government and industry efforts to reduce carbon dioxide emissions.

FADE TO WHITE

From South Carolina to the Florida Keys, coral reefs are the ocean's masterworks. Will they soon be gone?

XL CATLIN SEAVIEW SURVEY

Even amid an environmental catastrophe, bleaching reefs have a beauty to them, as seen in this one in American Samoa. But this beauty will disappear as the reef dies and turns into rubble. Can we save them in time?

TONY BARTELME || *tbartelme@postandcourier.com*

The Shipwreck

Mid-September 1914, and the world was as tossed as the sea. The Great War had just begun and Europe's armies were digging in. Off the Carolinas, a storm turned the Atlantic into green froth. Amid the waves, a wooden schooner limped toward Charleston.

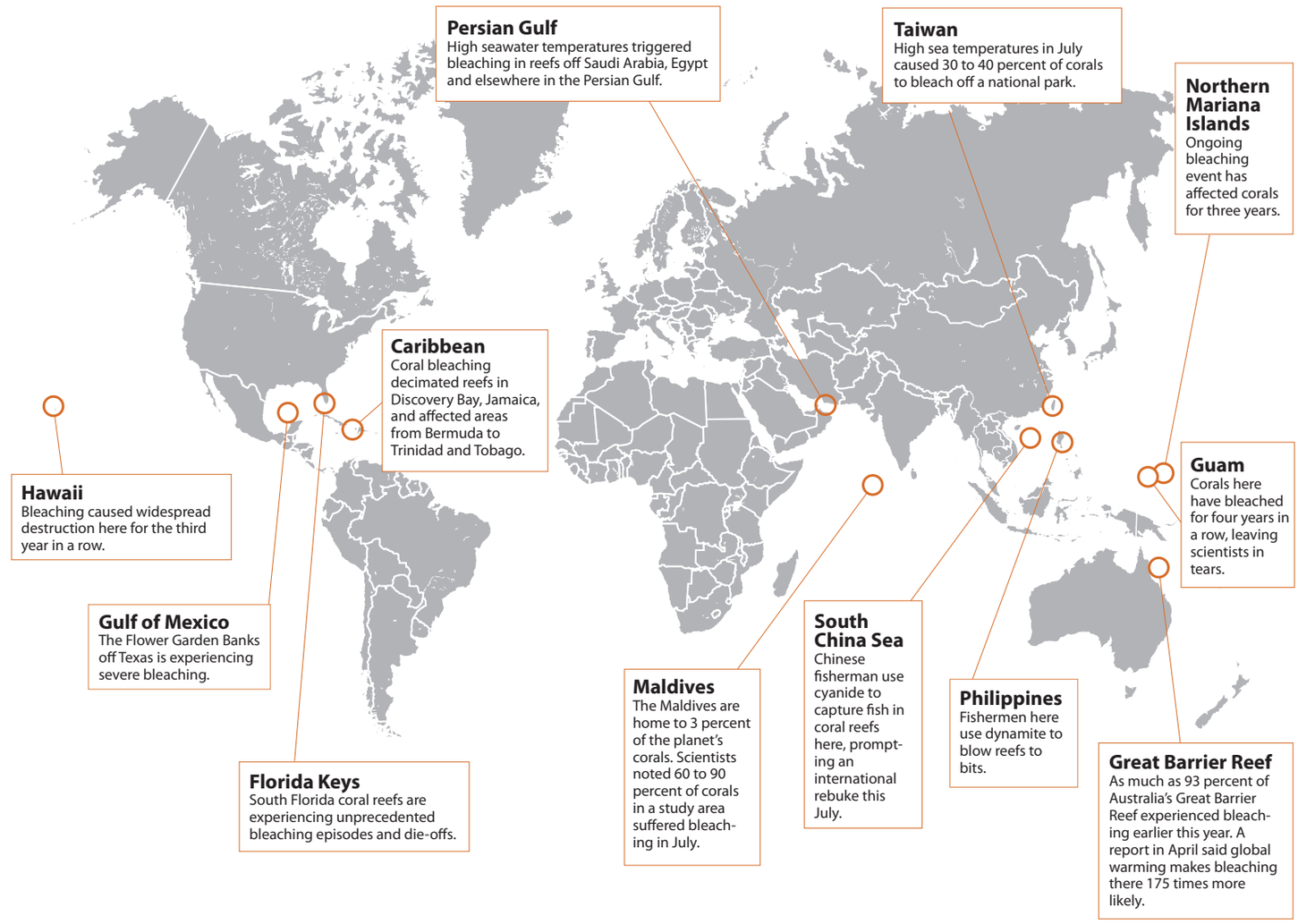
The Frederick W. Day was 170 feet long, a four-masted monument to the end of the days of sail. From New York, the ship set off for Wilmington, N.C., its hull crammed with sacks of Portland cement.

But off the Outer Banks, the ship struck an unknown object. Seawater flowed in, winds shoved the schooner away from Wilmington, and the captain made for Charleston, his crew engaged in its own trench warfare against rising water.

Then the pump gave out, the water hit the cement powder, and the ship went down like the stone it would become. The crew made it safely to Charleston Harbor in a lifeboat, and then time passed, and for nearly a century, memories of the shipwreck's location faded.

Fading Coral Reefs: 2016's unfolding global catastrophe

The year 2015 saw one of the world's worst bleaching events. All told, 38 percent of the world's reefs saw some form of bleaching that killed more than 4,633 square miles of reefs, roughly the size of Connecticut. And 2016 was just as bad. Here's a look at the coral carnage:



SOURCE: COMPILED FROM ACADEMIC RESEARCH

BRANDON LOCKETT/STAFF

But the sea's memory was better, and soon tropical corals found the hardened cement. The shipwreck evolved into a northern outpost of the Caribbean, a coral reef with barracudas, spiny urchins and colorful tropical fish you might see in an aquarium or the Florida Keys.

Then, this place fell ill.

The corals turned ghostly white, like a sick person's limbs, and a diver and scientist in Charleston named Phil Dustan knew what was going on. He'd seen the same thing in so many other stunning places.

The majesty below

Coral reefs are the ocean's masterpieces, the oldest and most complex ecosystems on earth. The corals themselves are tiny cup-shaped animals called polyps. Polyps have a jelly-like consistency with a whitish limestone skeleton that clings to hard surfaces, such as the Frederick W. Day's cement bags.

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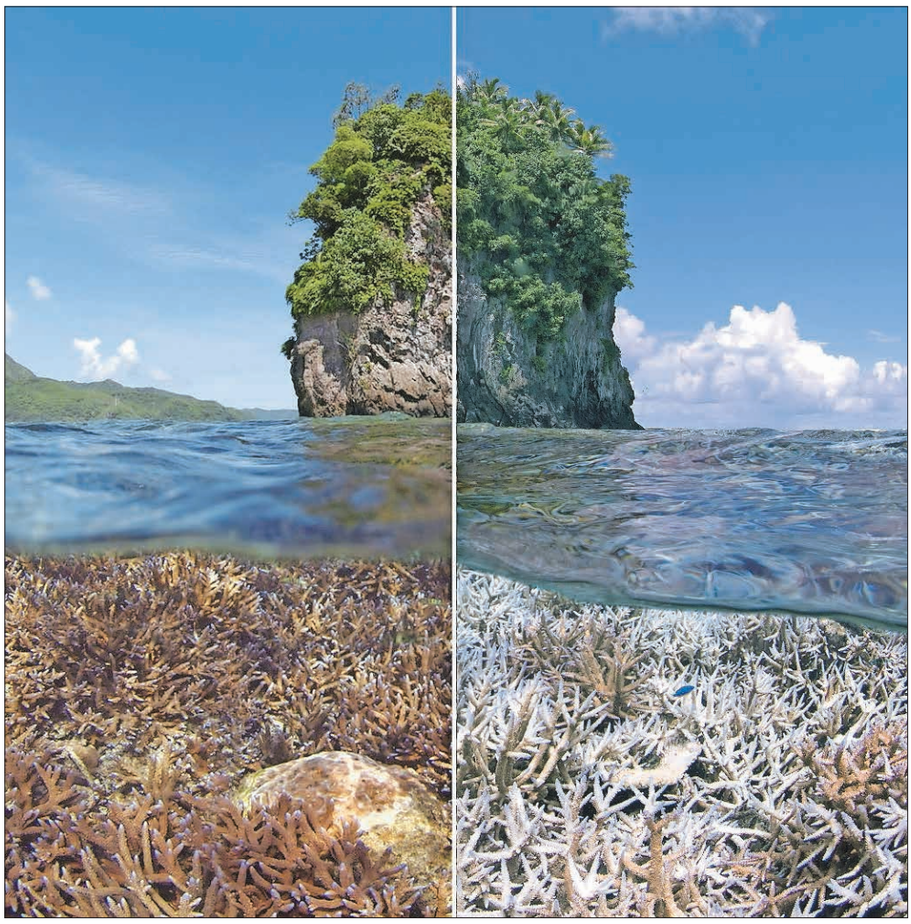

XL CATLIN SEAVIEW SURVEY

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CHARLESTON SCUBA

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PHOTOS BY PHIL DUSTAN

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PHIL DUSTAN

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Under the surface, brown-and-blue sea fans wave back and forth like Hawaiian dancers. A shimmering school of minnows pours through a tunnel of coral in a twisting swirl; a 5-foot gray shark suddenly cruises past. Amid it all are corals: brain and elkhorn, and they're easy to pick out because some have turned white from bleaching. And beside them in a sandy area are remnants of what was: staghorn coral antlers lying there like old bones, gathering sediment.

And yet, many colors remain: yellow-and-white zebra fish move to and fro, as well as a school of blue angelfish. Even the bleached corals are beautiful. Some are as white as sugar. Amid the colors, you might wonder what all the fuss is about.

"Yeah," Dustan says later with a nod. The beauty hides a deeper story. "You don't know what it was like before."

Undersea world of Phil Dustan

When Dustan arrived in Key Largo in the mid-1970s, the reefs had a glow that reminded him of the flush energy of a healthy pregnant woman. Water around Carysfort Reef, one of the largest in the Keys, was clear. Visibility was about 80 feet.

He looked different back then as well. His hair was long, and he sometimes wore mismatched socks, but he had a growing reputation for his knowledge about reefs, so much that in 1974 Cousteau had asked him to join an expedition in Belize. During one wine-soaked lunch on Calypso, Cousteau lamented how human activity had killed reefs in the Red Sea. Dustan thought at the time: "Cousteau's out of his mind. Reefs were too robust and stable, right?"

But as Dustan studied the reefs off the Florida Keys, he began to think Cousteau was right. Reefs were like a body fighting off multiple diseases. Developers were carving canals through ancient corals, sending plumes of sediment offshore; septic tanks leaked raw sewage; commercial and recreational fishermen scooped up vast numbers of fish. Sooner or later, the reefs' immunity would suffer. But how could he track its health?

He and colleagues began in 1975 by identifying areas in the reef that seemed representative of the entire ecosystem. "We picked Carysfort on purpose because it was the most well-developed reef and the farthest away from a popular state park."

Next, he and colleagues staked off rectangular areas in the reef with stainless steel rods. He called these staked areas "transects." By analyzing what was inside the transects, he could estimate a reef's "coral cover." It was similar to measuring the density of a forest's tree canopy.

And Carysfort then was a dense undersea forest; in the mid-1970s, about 60 percent of the reef was covered in corals. It seemed like a stable system, except for the kidnappings.

Gone missing

In 1983, a mysterious disease attacked black sea urchins across the Caribbean. In short order, as much

as 97 percent of the urchins died. It was a huge blow to coral reefs because urchins munched on algae. Think of an aquarium without a filter; without the urchins, algae soon smothered corals; the antlers of the elkhorn and staghorn corals shattered and fell to the sea floor.

Meanwhile, worldwide carbon dioxide levels continued to rise, trapping heat in the air and sea; the ocean grew warmer by about a degree through the 1980s and 1990s, which may not sound like much, but in the past, a 1- or 2-degree drop was enough to trigger an ice age.

And as the ocean absorbed more carbon dioxide, seawater's pH changed, becoming more acidic. Some reefs began to dissolve.

In 1981, Dustan packed his bags to take a position at the College of Charleston, a new base to continue his studies in the Keys. In 1983, he visited his transect sites.

"It looked like a bomb had gone off."

As time passed, the reef's condition deteriorated even more. By 2000, the coral reef cover had declined by 92 percent.

This destruction filled Dustan and other longtime divers with sadness and anger. It was an environmental catastrophe as serious as the burning of Amazonian rainforests, but one hidden under the waves. Dustan began talking about it in terms of a crime spree.

"Think of the reefs as a healthy town. Then, suddenly, someone kidnaps a doctor, then a priest, then a police officer, its garbage collectors. After a while, the fabric of the town frays."

He published his dire findings, which he said didn't square with Florida's efforts to market the Keys as a pristine diving destination. With little explanation, he lost a major source of research funding. "That's how it's done. You're marginalized."

But other researchers also uncovered disturbing trends.

Florida scientists found that acidification was eating away at Florida's coral reefs faster than the corals could lay down new layers of limestone.

"Lots of scientists think that ocean acidification is not going to be a problem until 2050 or 2060," says Chris Langdon, a marine biology professor at the University of Miami. "This is happening now."

Meanwhile, away from the Keys, fishermen in the Philippines and Sri Lanka used dynamite to catch fish, blowing reefs to bits; a bleaching episode this spring affected more than 93 percent of Australia's Great Barrier Reef.

Dustan began his career studying the mechanics behind the reef's beauty, and mass bleachings such as what happened in Australia were relatively rare until the 1980s; now, like many coral experts, Dustan finds himself a chronicler of death. In 2013, he went back to Jamaica's Discovery Bay. Its once-magnificent reef was a pile of rubble. In 2014, he was back in Key Largo.

"What's left of the reefs looked like a war zone." And yet, there in the Keys, plenty of divers were bowled over by what they saw.

"They were saying, 'Oh, this is beautiful!' And yes, it was. There were little sea fans flapping around, and a few fish, but that's not the baseline. I was really thinking, 'This reef is dead.'"

The 'Freddy Day'

The wreck of the Frederick W. Day was just 11 miles from the mouth of Charleston Harbor. Even so, nautical charts had it in the wrong spot. And so as the decades passed, ocean and time consumed the ship's wood, and Oculina corals took hold, and an undersea forest you might see in Florida appeared with puffer fish, amberjack, grouper, damselfish and manta rays, all just a relatively short boat ride from the Morris Island Lighthouse.

MAINE MARITIME MUSEUM

The Frederick W. Day sank within sight of the Morris Island Lighthouse in 1914.

Then, one day in 1982, a shrimper snagged his net on the reef. He called a local diver, Eddie Phillips, who called Tom Robinson, owner of Charleston Scuba. Robinson was blown away by the richness of Frederick W. Day's growth and the world around it.

During later dives, Robinson saw sand sharks, some longer than 10 feet, green moray eels, "tons of urchins," tropical sponges and a 6-foot barracuda. "It looked like a Dr. Seuss picture or the Beatles' Octopus's Garden." He spotted thumping shrimp that strike out with such force they can break glass if put in aquariums; he swam with ctenophores, which floated by like iridescent Christmas balls.

But word was out now about its true location. The kidnappings began: divers with spear guns took out the larger fish, including the sand sharks and grouper. Robinson, who was against spear fishing, also watched as fishermen dangled hooks over the reef. Beer cans landed on the sea floor; fishing lines wrapped around the coral. The Freddy Day, as it's now known, lost some of its equilibrium.

In 2006, one of Dustan's students brought him a video she'd taken while diving on the shipwreck.

There it was, what he'd seen in the Florida Keys, in

Jamaica, and now here, bleaching coral.

'Game over'

One recent study found that 70 percent of the world's coral reefs could be gone in 30 years.

"We're doing science wrong," Dustan says recently after returning from a trip to Bali with his students. On that trip, he surfaced with tears in his eyes. In just a year, bleaching and other forces destroyed one of the most beautiful reefs he'd ever seen. "If we don't step up as humans, it's game over. What makes me angry is knowing what's wrong and doing nothing to fix it. That's what I struggle with. But I tell my students that there are things we can do."

Focus on solutions, he tells them: Vote for politicians who treat climate change seriously; vote with their pocketbooks by buying more environmentally friendly products; grow sea urchins, as he and several researchers are trying to do; or grow corals in nurseries and transplant them, as nonprofits are doing in the Florida Keys; create no-take marine sanctuaries, as Tom Robinson would love to do with the Freddy Day.

Do these things — reduce these smaller stresses — and the reefs may handle the larger ones, such as a warming ocean and increase in the sea's acidity. "Like an immune system, the healthier it is, the better it is at warding off diseases," Dustan says. "So there's hope." As long as it's tied to action. Inaction means more reefs will lose their fragile symbiosis, and in that loss, some of the world's colors will fade for good.

Reach **Tony Bartelme** at 843-937-5554

ACKNOWLEDGMENTS: A number of other scientists not quoted in the story also were consulted, including: Peter Moeller, research chemist with NOAA and MUSC; Cheryl Woodley, College of Charleston and NOAA Hollings Marine Laboratory; Ray Swaggerty, who has done extensive research on the Frederick W. Day; and Samantha de Putron, Bermuda Institute of Ocean Sciences.

How to help

Seven things you can do now to help coral reefs, especially if you're about to go snorkeling:

1. Support creation of no-take marine sanctuaries in appropriate reef areas.

2. If you live on the coast, make sure your septic tank isn't leaking.

3. Use environmentally sensitive mooring buoys over reefs. Example: Environmental Moorings International on Key Largo has placed tens of thousands of buoys over reefs, allowing boats to tie up without throwing an anchor onto a reef.

4. Support groups such as Coral Restoration Foundation that transplant coral reefs.

5. Use reef-safe sunscreen. Scientists from NOAA's Hollings Marine Laboratory and other agencies found that chemicals in common sunscreens are toxic to corals.

6. Don't touch the coral when diving. Touching it can harm corals' fragile membranes, making it susceptible to diseases.

7. Support government and industry efforts to reduce carbon dioxide emissions.

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Challengers tout hope over money

Three Washington jobs, six stories of campaign spending

BY EMMA DUMAIN
edumain@postandcourier.com

WASHINGTON — The saying goes that money isn't everything. That's true for politics as well. But it does count for a heck of a lot.

Three of the candidates running against three leading South Carolina incumbents in Washington want to challenge the convention that money equates to electoral success.

Right now there's more optimism in the bunch than cash.

"If money is the only metric people are relying on, they're going to be surprised this year," said Dimitri Cherny, the Democrat vying to replace Republican U.S. Rep. Mark Sanford in the coastal 1st Congressional District.

"Money defines who a candidate is (and) whether they will be accepted by the party they represent," said Thomas Dixon, the North Charleston pastor challenging Republican U.S. Sen. Tim Scott.

Laura Sterling, the Bluffton Republican running against 24-year Democratic incumbent U.S. Rep. Jim Clyburn in the majority black 6th District, also is unapologetic about her meager fundraising numbers.

"I didn't really start out raising money, other than the filing fee," Sterling said.

Whatever the outcome of these elections, spending always tells a story. Oct. 15 was the deadline for congressional candidates to file their third quarter 2016 financial reports with the Federal Election Commission. Here's a look at the money raised and spent between July and September by these three incumbents and their underdog challengers.

First Congressional District — Sanford vs. Cherny

Sanford raised $41,176 in the third fundraising quarter and now has more than $1 million cash on hand.

Part of the reason he has so much money in his war chest is he doesn't like to spend it. And recently, he hasn't had to. That includes during his June

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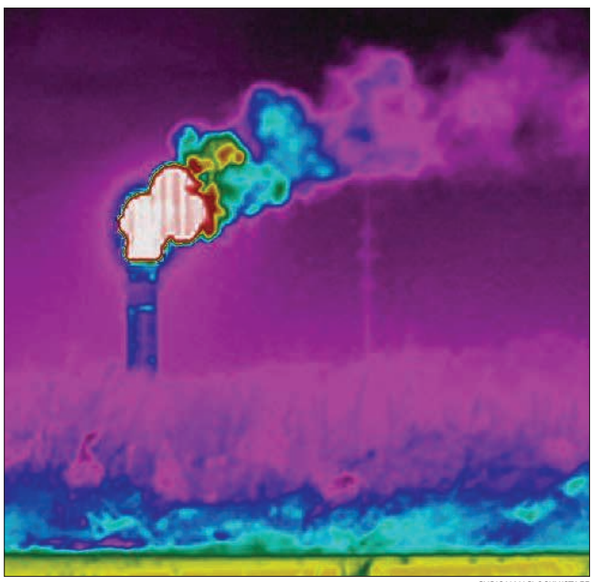
Inside

Every Other Breath

CHASING CARBON



CHRIS HANCLOSKY/STAFF

Through the lens of a rare camera that detects carbon dioxide, SCE&G's Hagood Generating Station in Charleston pumps a plume of CO2 into the sky — a cloud that's invisible to the naked eye.

We can't see carbon dioxide, the main cause of climate change. What if we could?

TONY BARTELME || *tbartelme@postandcourier.com*

In your brain's 3 pounds of wrinkles and folds, roughly 86 billion neurons form electrochemical networks, a good many designed to make sure you jump out of the way of hissing snakes and other immediate threats. Humans are well-designed "get-out-of-the-way machines," Harvard psychologist Daniel Gilbert says.

But your brain's neural pathways light up differently when confronted with thoughts of the future and unseen threats. Key danger detectors, including the amygdala, remain on standby; networks that flush adrenaline into your bloodstream stay dark.

This explains why it's easier to ignore something as serious as climate change, Gilbert and other scientists of the brain say. Our neural wiring is biased in favor of what we see in front of our faces.

What's more, carbon dioxide — the primary driver of climate change — has no color, no odor, no threatening hiss, no roar, nothing that triggers our brains' action centers.

Carbon dioxide is invisible.

What if it wasn't?

Amid the fires

Midsummer on peninsular Charleston, and the noon sun feels like a Bunsen burner. At the intersection of King and Spring streets, we carefully set up a special camera.

At first glance, the camera looks like an old video recorder. But its lens is made of germanium and other rare metals. And its bulky housing hides a liquid-cooled infrared sensor. Once cooled, the sensor captures wavelengths absorbed and emitted by C02. Through this special lens and circuitry, the camera can see carbon dioxide.

The Post and Courier borrowed the camera from FLIR Systems, an Oregon company that makes thermal-imaging cameras.

Please see **CARBON**, Page A7

About the series

Every Other Breath takes a deep dive into the powerful and largely hidden forces that will shape humanity's future

TODAY

Chasing Carbon: Using a special camera, The Post and Courier exposes the invisible culprit behind climate change.

PREVIOUS STORIES

- Fade to White: An environmental catastrophe is happening below the waves as coral reefs bleach.
- Lowcountry on the Edge: Seas are rising, which means big trouble for the Lowcountry and the world's other low places.
- Plankton produce half of our oxygen, but scientists are seeing major changes in these creatures. Read at **postandcourier.com/plankton**

Slager's account revealed in filings

Officer: Scott was talking to mother during encounter

BY ANDREW KNAPP
aknapp@postandcourier.com

Walter Scott dropped something when North Charleston police officer Michael Slager shocked him with a Taser.

It was a cellphone set to speaker mode. Slager could hear someone on the other end, he said.

Slager

It was Scott's mother.

"Stop," the voice said, according to Slager's account. "Do what the officer says."

But Scott did not stop.

Exactly what happened next will be the focus of fierce contention when Slager, 34, is tried next week on a murder charge. But prosecutors' 82-page court filing and accompanying courtroom testimony last week painted the most vivid picture yet of how the former officer said events unfolded on April 4, 2015.

Slager said he shot Scott, 50, after Scott grabbed his Taser and came after him. The authorities, though, counter that his account doesn't align with a video showing Scott running away as he's gunned down.

The footage does not show everything, and other evidence that attorneys present when the trial starts Oct. 31 will largely determine the outcome.

A court hearing Friday about which pieces of that evidence should be allowed centered on Slager's story. He gave a lengthy version to the State Law Enforcement Division, along with shorter accounts at the shooting scene to fellow officers and Police Chief Eddie Driggers.

Defense attorney Andy Savage initially asked for all the statements to be tossed out, though he later withdrew most of the request while the rest of it was rejected by the presiding judge. But he raised the issue in the first place, he said, to show how his client's statements were obtained by the SLED agents who interviewed Slager. Savage contends that they lied when they were asked whether a video existed.

"What I'm really upset about is they lied to a lawyer," Savage said. "The lawyer is depending on integrity to give advice to his client."

Slager sat down for the interview and gave his story that prosecutors now plan to contrast with the video. Federal authorities also used the same statements to charge Slager with lying, along with civil rights and weapons violations.

Please see **SLAGER**, Page A15

Time, money threatens beach renourishment

Demand for limited replacement sand rises as Congress cuts federal funding

BY BO PETERSEN
bopete@postandcourier.com

The beach might be running out of sand, money and time.

Nearly every developed strand on the East Coast has been renourished, many of them repeatedly. And each time a storm such as Hurricane Matthew wracks one, the need increases. Nearshore sand that is fine enough and clean enough for renourishment is found only in shallow pockets that don't replenish quickly. Costs also are

Please see **BEACH**, Page A19

MICHAEL PRONZATO/STAFF

The Washout at Folly Beach after Hurricane Matthew.

Sunny and clear. High 72. Low 47. Complete 5-day forecast, **B6**

Is your leaf blower killing the planet?

Now that it's fall, it's time to pull out the rakes and brooms, right? Perhaps 20 years ago. Now, the air is filled with the sounds of leaf blowers.

All told, people in the United States use more than 121 million gas-powered leaf blowers, trimmers, mowers and other lawn and garden tools. And together, these relatively unregulated machines generate enormous volumes of pollution and greenhouse gases, a study last year found.

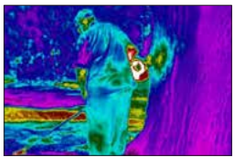
On average, these tools annually crank out more than 6 million tons of CO2, nitrogen oxide and an alphabet soup of other pollutants, including some gases that cause cancer, according to a study by a health researcher and an EPA environmental engineer.

Unlike cars and trucks, emissions from these tools face far fewer regulations. The result: the equipment is a significant contributor of greenhouse gases, and people who use them can be exposed to toxic chemicals, said Jamie Banks, one of the authors and executive director of Quiet Communities, a nonprofit pushing for cleaner outdoor maintenance practices.

Banks said she grew concerned about the health effects of the equipment after observing maintenance workers in her community near Boston. She and an engineer with the EPA discovered that these pieces of equipment generate significant emissions of butadiene and formaldehyde, potent carcinogens. They also generate more than 20 million tons of carbon dioxide and 12 percent of the nation's man-made carbon monixide, another greenhouse gas.

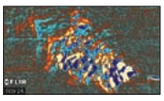
"That's a huge amount for this niche" of machinery, she said. "While there have been a lot of attempts to make vehicles cleaner, regulation of this equipment hasn't kept up."

Her study followed a less formal one by Edmunds, the car information company, did five years ago. Edmunds compared the hydrocarbon emissions of a 2-stroke gas-powered leaf blower and a Ford Raptor truck. They found that the just a half hour of yard work with the leaf blower cranked out as many pollutants as a Ford Raptor truck driving 3,877 miles.

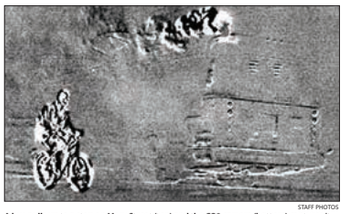


At Cannon Park, The FLIR camera captures the CO2 blowing against the tree.

What if we could see carbon dioxide?



Tailpipe with the naked eye (top) and as seen through the FLIR camera.



STAFF PHOTOS

A bus pulls up to a stop on Mary Street (top) and the CO2 camera (bottom) captures it spewing carbon dioxide.

With the naked eye, it looks like nothing is coming from the rising from SCE&G's Hagood Generating station. The FLIR CO2 camera sees a giant plume.

CARBON, from Page A1

Engineers in the oil and gas industry use infrared cameras to detect leaks, though usually with ones tuned to identify methane and other explosive gases. On occasion, engineers find it helpful to identify CO2 leaks. Some forms of fracking, for instance, involve pumping CO2 and other gases — ones that are flammable — deep into the ground. If they see any CO2 escaping, they know there's a problem with those other gases as well.

Still, CO2-detecting cameras are rarer than a germanium lens. A FLIR representative says they sent us the only CO2 demo camera in the United States, and by the way it costs about $90,000 if you break it.

On King Street, cars and trucks whiz by. You see almost nothing coming from their tailpipes. Not surprising: The auto industry has made tremendous strides to cut soot, hydrocarbons and other visible pollutants. But press the camera's button, and everything changes. Grainy images appear on the viewfinder showing bright plumes of heat and CO2.

The plumes flicker like flames, leaving CO2 swirls that turn in the vehicles' slipstreams.

Black and white, colorized — certain settings tend to show better what's coming out of those tailpipes. The plumes have different shapes and sizes. Ones from newer and smaller cars are relatively small. But some from SUVs have the intensity of torches.

And this difference makes sense, given what scientists know about vehicle emissions. The average passenger car produces about 9,700 pounds of CO2 a year, the EPA says. But an SUV or pickup generates 13,600 pounds — or about 40 percent more.

The hunt is on.

What about other vehicles?

We set up across from a bus stop on Mary Street. Some are packed; others not so much. No matter how full, CO2 pours from their diesel exhaust pipes.

Near the Crosstown, two trucks roar by. In fact, each day on average, the U.S. truck fleet generates 2.2 billion pounds of CO2.

By an overpass, landscaping workers spin their riding mowers, creating their own CO2 clouds.

Amid it all — the idling train at the State Ports Authority terminal and the traffic on the Cooper River bridge — you begin to sense how well we've hidden combustion.

Because, as the camera showed, we are literally surrounded by fires.

Old story, new threat

In 1896, a Swedish scientist named Svante Arrhenius published a paper with what was then a bold hypothesis: burning fossil fuels produces CO2 and other heat-absorbing gasses that act like "glass of a hothouse."

Arrhenius went on to describe that man-made CO2 could heat the entire planet's atmosphere. Perhaps because he was from Sweden, he said this might be a good thing. An increase in CO2 could make the climate "more equable" by stimulating plant growth, which would provide more food to a growing population.

Arrhenius was the first to propose that man-made CO2 could affect the climate's temperature, but most scientists didn't consider this a threat until the 1970s and 1980s. After all, CO2 is the stuff of life.

With every breath, we take in oxygen and breathe out carbon dioxide. Meanwhile, through photosynthesis, plants and ocean phytoplankton do the reverse — turn CO2 into oxygen and carbon. Land-based plants lock up the carbon in their stems and tree trunks, while ocean-based plants, such as phytoplankton, make carbonate shells. Over millions of years, the plants are transformed into coal, and the shells become oil.

Combustion is another spin of this cycle. When we burn those ancient plankton shells and prehistoric plants, we unlock their carbon, turning them back into CO2, heat and a bit of water, which is why you sometimes see water dripping from tailpipes.

Carbon dioxide is measured in parts per million. And for the past 800,000 years, the atmosphere's concentration typically ranged between 200 and 300 parts per million. But humanity's carbon footprint began to grow heavier, first with the advent of widespread agriculture 10,000 years ago, then with the Industrial Revolution.

Scientists say that 350 parts per million is the level where the climate heats up so much that the polar ice caps melt. CO2 levels passed 315 parts per million in 1959 and hit 350 in 1988.

Now, before we set up the camera again, amid the hottest July on record, we check the latest CO2 reading. It tops 404 parts per million.

Electric fires

Internal combustion engines generate about a third of the world's CO2 emissions. What about other sources?

We find a vacant lot in peninsular Charleston's Neck area. Temperatures are in the upper 90s, and air conditioners across the Lowcountry are humming. This means that South Carolina Electric & Gas has cranked up Hagood Power Station "peaker" — a plant switched on during periods of high electrical demand.

The Hagood plant sits on the edge of the Ashley River, a mile north of downtown Charleston's historic areas. Its tall white stack is visible from the raised section of Interstate Highway 26. From a distance, nothing appears to be coming from that stack.

The camera shows something else: A blast of CO2 that looks like a flame in the night.

Power plants that burn fossil fuels contribute another third of the world's man-made CO2. Largely unseen, Hagood pumped out about 48.3 million pounds of CO2 in 2014, according to EPA records. Putting that in perspective, the average person exhales about 900 pounds of CO2 a year.

And yet, because the Hagood Station burns natural gas, it's much cleaner than, say, coal.

Half an hour away is SCE&G's Williams Station, a coal-fired power plant along the Cooper River off Bushy Park Road. The naked eye sees nothing from a smaller stack in its shadow, but the camera displays bright plumes of CO2 and heat.

While the Hagood natural gas plant generated 48 million pounds of CO2 in 2014, the Williams plant produced nearly 7 billion pounds.

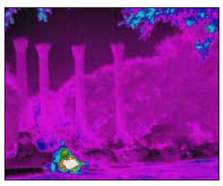
And Williams is a relatively small coal-fired power plant. The largest in South Carolina is farther inland.

Lake Moultrie laps against one side of Santee Cooper's Cross Station, while small mountains of coal sit on the other side. Every day, conveyors and cranes feed this coal into crushers and send the black powder to furnaces that burn at 2,500 degrees. Heat from

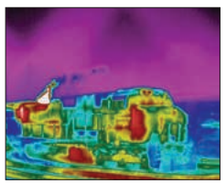
Please see **CARBON**, Page A8

The rise of CO2

Over the past 400,000 years, carbon dioxide levels in the atmosphere bounced up and down, but human impact in recent centuries caused it to bounce sky high. This year, CO2 levels passed 400 parts per million, far beyond the 350 ppm scientists say triggers massive melting of polar ice.



The FLIR camera captures a city of Charleston landscaping crew working at Cannon Park with a riding mower shooting CO2 from the rear.



A train idles at the S.C. Ports Authority's Columbus Street Terminal. The FLIR camera shows CO2 from its engine flaring from its stack.

TONY BARTELME/STAFF

Through the CO2 camera, the stack from a CO2 ship glows as a containership passes under the Cooper River bridge.

CO2 the main cause of climate change

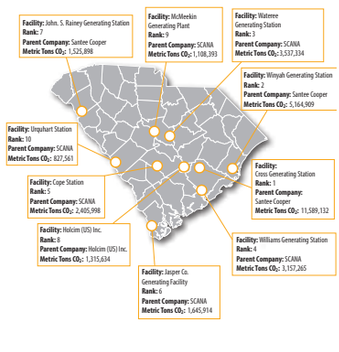
Through the FLIP camera, you see flares of CO2 pour from rear of jets (top) at the Charleston International Airport. You can barely see the exhaust with the naked eye.

CO2 in S.C.: Who emits the most

FILE/STAFF

Santee Cooper's Cross Generating Station is by far South Carolina's largest industrial producer of carbon dioxide, with 11.6 million tons in 2014, or roughly 25 billion pounds, according to the EPA. (The average human produces about 900 pounds a year.) The Cross plant also ranks 23rd nationally. Here are the top CO2 producers in South Carolina and the United States:

Top 10 in S.C.



Top 10 in the U.S.

1. Scherer, Georgia, 20,321,943 metric tons
2. James H Miller Jr., Alabama, 19,746,633 metric tons
3. Navajo Generating Station, Arizona, 12,110,250
4. Gibson, Indiana, 16,164,179 metric tons
5. W A Parish, Texas, 16,006,078 metric tons
6. Rockport, Indiana, 15,679,691 metric tons
7. Bruce Mansfield, Pennsylvania, 15,557,345 metric tons
8. Bowen, Georgia, 15,517,056 metric tons
9. Gen J M Gavin, Ohio, 15,451,055 metric tons
10. Monroe, Michigan, 15,028,118 metric tons

SOURCE: EPA STAFF

CARBON, from Page A7

the furnaces turns water into steam that spins giant turbines generating 2,390 megawatts — enough to power more than 1.1 million homes. Cross is so large that if its turbines suddenly went down on a hot summer day like today, the loss of power could affect the East Coast's grid.

The naked eye sees steam rising from one stack and then merging with clouds in the sky. You don't see the kinds of dark, belching smoke you once saw from coal plants, thanks to expensive scrubbers.

In 2004, as part of a Justice Department investigation, Santee Cooper agreed to spend $400 million by 2012 to reduce sulfur dioxide and nitrogen oxides, ingredients in smog and acid rain. But these scrubbers don't reduce significant amounts of C02.

In fact, Santee Cooper and other utilities, along with South Carolina Gov. Nikki Haley, have long fought federal efforts to classify CO2 as a pollutant. Doing so, she and others said, would raise electric bills.

Through the camera, the Cross Station is transformed. Both stacks shoot massive plumes, and smaller stacks around the plant also have bright flaring CO2 plumes. In 2014, Cross generated 25 billion pounds of carbon dioxide. It was by far the largest source of man-made CO2 in South Carolina. And it ranked 23rd in the nation.

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Some economists have proposed a "cap-and-trade" system. Under this approach, carbon would become a commodity to be bought and sold.

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Others, such as James Hansen, a NASA scientist who has long warned about the dangers of climate change, say a carbon tax makes more sense. Hansen argues that the government could levy fees on fossil fuels and then return 100-percent to the public. This would drive up prices for gasoline, coal and natural gas, but the rebate would soften the blow and steer consumers toward more environmentally friendly products.

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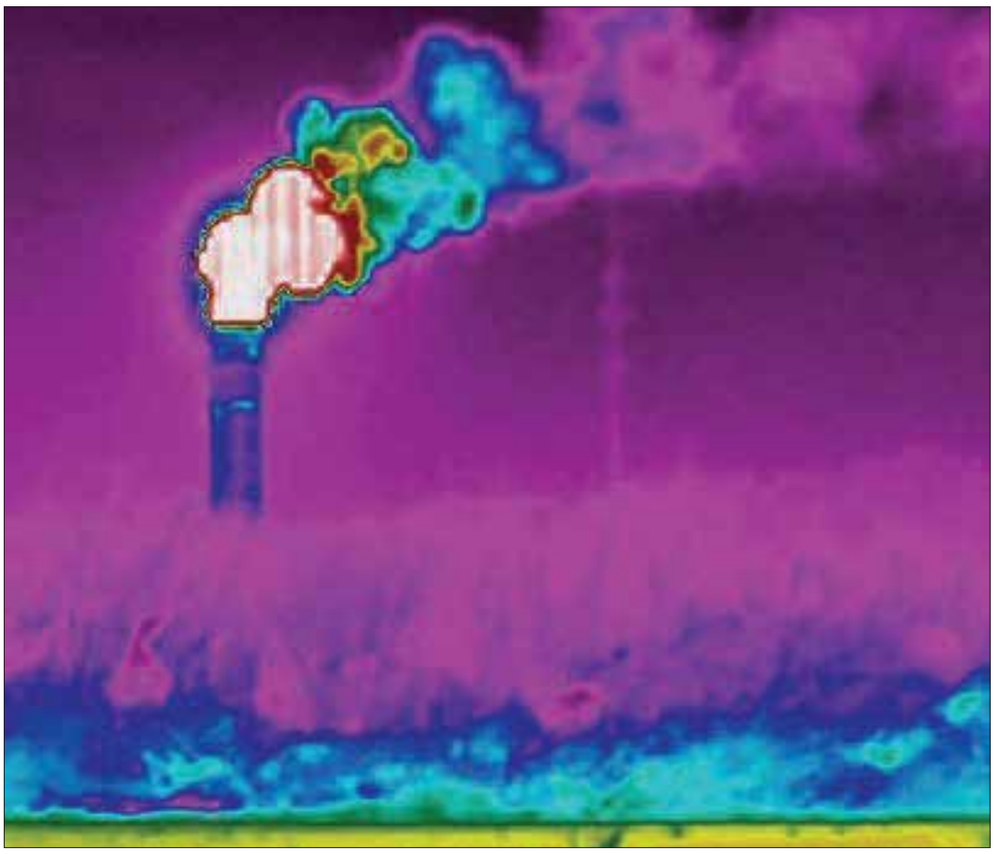
CHASING CARBON



CHRIS HANCLOSKY/STAFF

Through the lens of a rare camera that detects carbon dioxide, SCE&G's Hagood Generating Station in Charleston pumps a plume of CO2 into the sky — a cloud that's invisible to the naked eye.

We can't see carbon dioxide, the main cause of climate change. What if we could?

In your brain's 3 pounds of wrinkles and folds, roughly 86 billion neurons form electrochemical networks, a good many designed to make sure you jump out of the way of hissing snakes and other immediate threats. Humans are well-designed "get-out-of-the-way machines," Harvard psychologist Daniel Gilbert says.

But your brain's neural pathways light up differently when confronted with thoughts of the future and unseen threats. Key danger detectors, including the amygdala, remain on standby; networks that flush adrenaline into your bloodstream stay dark.

This explains why it's easier to ignore something as serious as climate change, Gilbert and other scientists of the brain say. Our neural wiring is biased in favor of what we see in front of our faces.

What's more, carbon dioxide — the primary driver of climate change — has no color, no odor, no threatening hiss, no roar, nothing that triggers our brains' action centers.

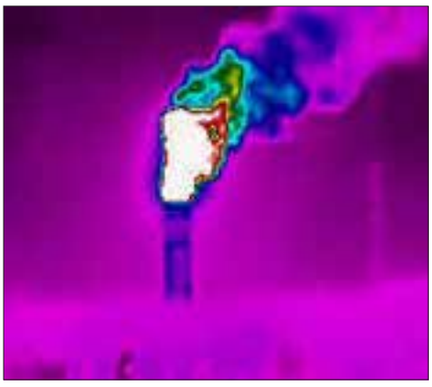
Carbon dioxide is invisible.

What if it wasn't?

Amid the fires

Midsummer on peninsular Charleston, and the noon sun feels like a Bunsen burner. At the intersection of King and Spring streets, we carefully set up a special camera.

At first glance, the camera looks like an old video recorder. But its lens is made of germanium



With the naked eye, it looks like nothing is coming from the rising from SCE&G's Hagood Generating station. The FLIR CO2 camera sees a giant plume.

STAFF PHOTOS

A bus pulls up to a stop on Mary Street (top) and the CO2 camera (bottom) captures it spewing carbon dioxide.

and other rare metals. And its bulky housing hides a liquid-cooled infra-red sensor. Once cooled, the sensor captures wavelengths absorbed and emitted by C02. Through this special lens and circuitry, the camera can see carbon dioxide.

The Post and Courier borrowed the camera from FLIR Systems, an Oregon company that makes thermal-imaging cameras. Engineers in the oil and gas industry use infrared cameras to detect leaks, though usually with ones tuned to identify methane and other explosive gases. On occasion, engineers find it helpful to identify C02 leaks. Some forms of fracking, for instance, involve pumping CO2 and other gases — ones that are flammable — deep into the ground. If they see any CO2 escaping, they know there's a problem with those other gases as well.

Still, CO2-detecting cameras are rarer than a germanium lens. A FLIR representative says they sent us the only CO2 demo camera in the United States, and by the way it costs about $90,000 if you break it.

On King Street, cars and trucks whiz by. You see almost nothing coming from their tailpipes. Not surprising: The auto industry has made tremendous strides to cut soot, hydrocarbons and other visible pollutants. But press the camera's button, and everything changes. Grainy images appear on the viewfinder showing bright plumes of heat and CO2.

The plumes flicker like flames, leaving CO2 swirls that turn in the vehicles' slipstreams.

Black and white, colorized — certain settings tend to show better what's coming out of those tailpipes. The plumes have different shapes and sizes. Ones from newer and smaller cars are relatively small. But some from SUVs have the intensity of torches.

And this difference makes sense, given what scientists know about vehicle emissions. The average passenger car produces about 9,700 pounds of CO2 a year, the EPA says. But an SUV or pickup generates 13,600 pounds — or about 40 percent more.

The hunt is on.

What about other vehicles?

We set up across from a bus stop on Mary Street. Some are packed; others not so much. No matter how full, CO2 pours from their diesel exhaust pipes.

Near the Crosstown, two trucks roar by. In fact,

each day on average, the U.S. truck fleet generates 2.2 billion pounds of C02.

By an overpass, landscaping workers spin their riding mowers, creating their own CO2 clouds.

Amid it all — the idling train at the State Ports Authority terminal and the traffic on the Cooper River bridge — you begin to sense how well we've hidden combustion.

Because, as the camera showed, we are liter-ally surrounded by fires.

Old story, new threat

In 1896, a Swedish scientist named Svante Arrhenius published a paper with what was then a bold hypothesis: burning fossil fuels produces CO2 and other heat-absorbing gasses that act like "glass of a hothouse."

Arrhenius went on to describe that man-made CO2 could heat the entire planet's atmosphere. Perhaps because he was from Sweden, he said this might be a good thing. An increase in C02 could make the climate "more equable" by stimulating plant growth, which would pro-vide more food to a growing population.

Arrhenius was the first to propose that man-made CO2 could affect the climate's temperature, but most scientists didn't consider this a threat until the 1970s and 1980s. After all, CO2 is the stuff of life.

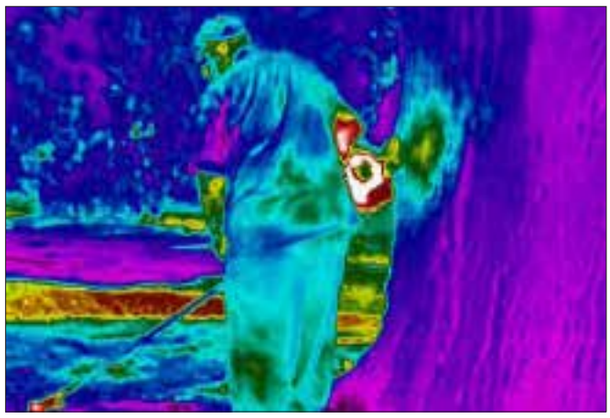
With every breath, we take in oxygen and breathe out carbon dioxide. Meanwhile, through photosynthesis, plants and ocean phytoplankton do the reverse — turn CO2 into oxygen and carbon. Land-based plants lock up the carbon in their stems and tree trunks, while ocean-based plants, such as phytoplankton, make carbonate shells. Over millions of years,. the plants are transformed into coal, and the shells become oil.

Combustion is another spin of this cycle. When we burn those ancient plankton shells and prehistoric plants, we unlock their carbon, turning them back into CO2, heat and a bit of water, which is why you sometimes see water dripping from tailpipes.

Carbon dioxide is measured in parts per million. And for the past 800,000 years, the atmosphere's concentration typically ranged between 200 and 300 parts per million. But humanity's carbon footprint began to grow heavier, first with the advent of widespread agriculture 10,000 years ago, then with the Industrial Revolution.

Scientists say that 350 parts per million is the level where the climate heats up so much that the polar ice caps melt. CO2 levels passed 315 parts per million in 1959 and hit 350 in 1988.

Now, before we set up the camera again, amid the hottest July on record, we check the latest CO2 reading. It tops 404 parts per million.



At Cannon Park, The FLIR camera captures the CO2 blowing against the tree.

Is your leaf blower killing the planet?

Now that it's fall, it's time to pull out the rakes and brooms, right? Perhaps 20 years ago. Now, the air is filled with the sounds of leaf blowers.

All told, people in the United States use more than 121 million gas-powered leaf blowers, trimmers, mowers and other lawn and garden tools. And together, these relatively unregulated machines generate enormous volumes of pollution and greenhouse gases, a study last year found.

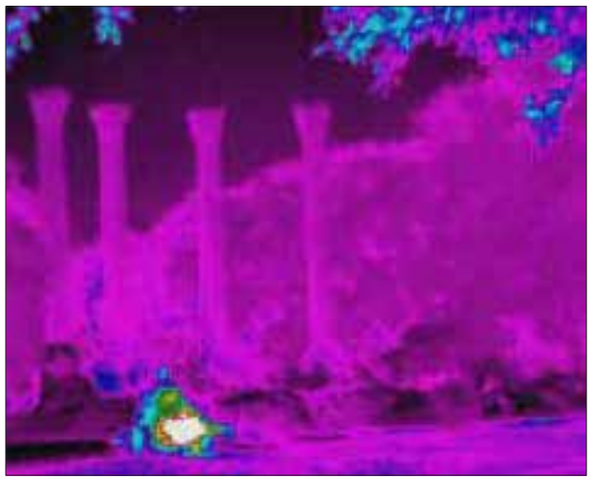
On average, these tools annually crank out more than 6 million tons of C02, nitrogen oxide and an alphabet soup of other pollutants, including some gases that cause cancer, according to a study by a health researcher and an EPA environmental engineer.

Unlike cars and trucks, emissions from these tools face far fewer regulations. The result: the equipment is a significant contributor of greenhouse gases, and people who use them can be exposed to toxic chemicals, said Jamie Banks, one of the authors and executive director of Quiet Communities, a nonprofit pushing for cleaner outdoor maintenance practices.

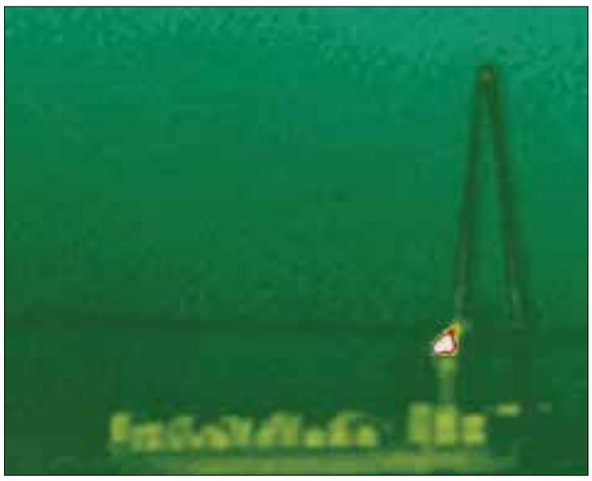
Banks said she grew concerned about the health effects of the equipment after observing maintenance workers in her community near Boston. She and an engineer with the EPA discovered that these pieces of equipment generate significant emissions of butadiene and formaldehyde, potent carcinogens. They also generate more than 20 million tons of carbon dioxide and 12 percent of the nation's man-made carbon monixide, another greenhouse gas.

"That's a huge amount for this niche" of machinery, she said. "While there have been a lot of attempts to make vehicles cleaner, regulation of this equipment hasn't kept up."

Her study followed a less formal one by Edmunds, the car information company, did five years ago. Edmunds compared the hydrocarbon emissions of a 2-stroke gas-powered leaf blower and a Ford Raptor truck. They found that the just a half hour of yard work with the leaf blower cranked out as many pollutants as a Ford Raptor truck driving 3,877 miles.



The FLIR camera captures a city of Charleston landscaping crew working at Cannon Park with a riding mower shooting CO2 from the rear.



TONY BARTELME/STAFF

Through the CO2 camera, the stack from a CO2 ship glows as a containership passes under the Cooper River bridge.

Electric fires

Internal combustion engines generate about a third of the world's CO2 emissions. What about other sources?

We find a vacant lot in peninsular Charleston's Neck area. Temperatures are in the upper 90s, and air conditioners across the Lowcountry are humming. This means that South Carolina Electric & Gas has cranked up Hagood Power Station "peaker" — a plant switched on during periods of high electrical demand.

The Hagood plant sits on the edge of the Ashley River, a mile north of downtown Charles-ton's historic areas. Its tall white stack is visible from the raised section of Interstate Highway 26. From a distance, nothing appears to be coming from that stack.

The camera shows something else: A blast of CO2 that looks like a flame in the night.

Power plants that burn fossil fuels contribute another third of the world's man-made CO2. Largely unseen, Hagood pumped out about 48.3 million pounds of C02 in 2014, according to EPA records. Putting that in perspective, the average person exhales about 900 pounds of C02 a year.

And yet, because the Hagood Station burns natural gas, it's much cleaner than, say, coal.

Half an hour away is SCE&G's Williams Station, a coal-fired power plant along the Cooper River off Bushy Park Road. The naked eye sees nothing from a smaller stack in its shadow, but the camera displays bright plumes of C02 and heat. While the Hagood natural gas plant generated 48 million pounds of C02 in 2014, the Williams plant produced nearly 7 billion pounds.

And Williams is a relatively small coal-fired power plant. The largest in South Carolina is farther inland.

Lake Moultrie laps against one side of Santee Cooper's Cross Station, while small mountains of coal sit on the other side. Every day, conveyors and cranes feed this coal into crushers and send the black powder to furnaces that burn at 2,500 degrees. Heat from the furnaces turns water into steam that spins giant turbines generating 2,390 megawatts — enough to power more than 1.1 million homes. Cross is so large that if its turbines suddenly went down on a hot summer day like today, the loss of power could affect the East Coast's grid.

The naked eye sees steam rising from one stack and then merging with clouds in the sky. You don't see the kinds of dark, belching smoke you once saw from coal plants, thanks to expensive scrubbers.

In 2004, as part of a Justice Department investigation, Santee Cooper agreed to spend $400 million by 2012 to reduce sulfur dioxide and nitrogen oxides, ingredients in smog and acid rain. But these scrubbers don't reduce significant amounts of C02.

In fact, Santee Cooper and other utilities, along with South Carolina Gov. Nikki Haley, have long fought federal efforts to classify CO2 as a pollutant. Doing so, she and others said, would raise electric bills.

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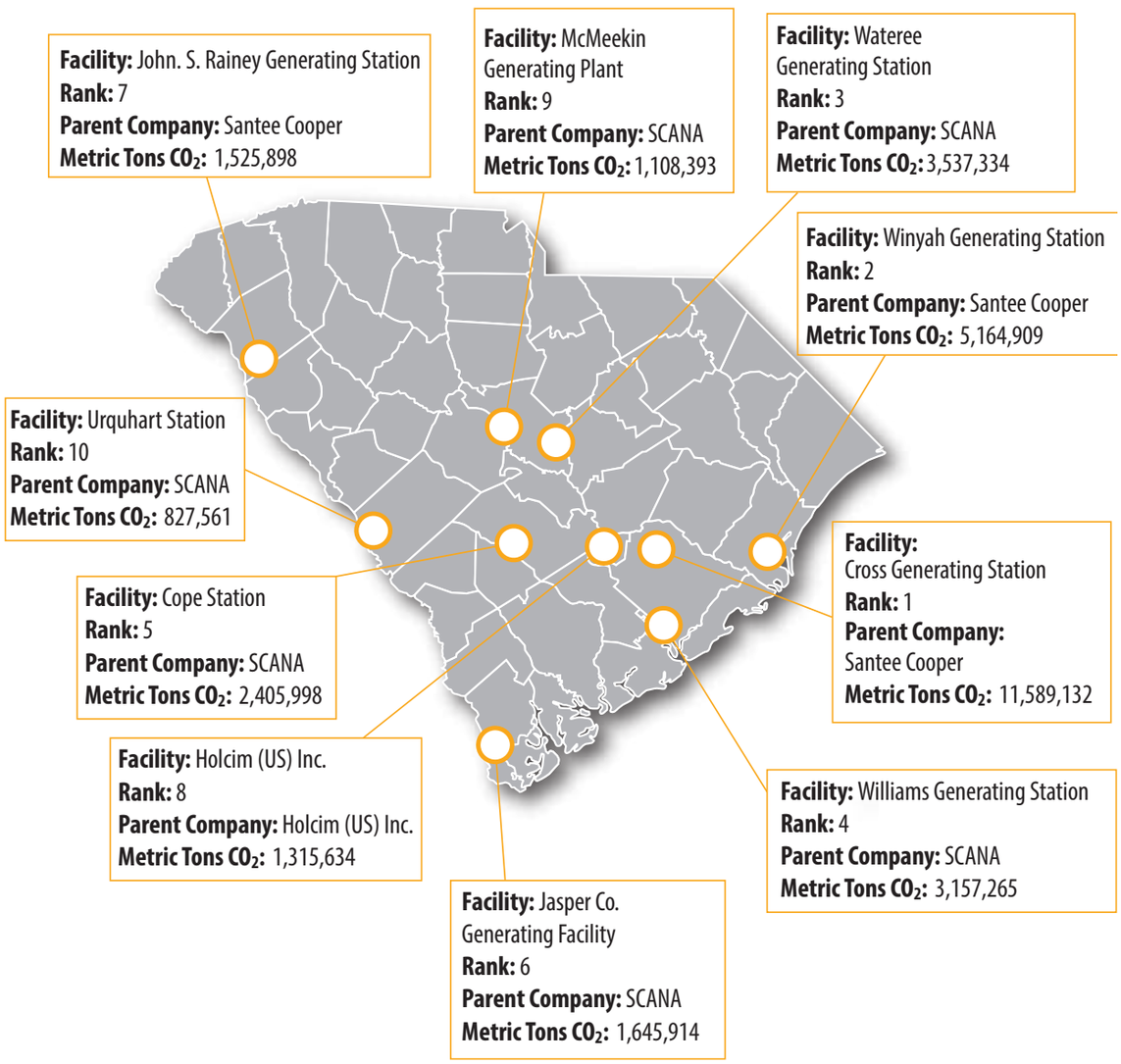
Top 10 in S.C.

FILE/STAFF

Santee Cooper's Cross Generating Station is by far South Carolina's largest industrial producer of carbon dioxide, with 11.6 million tons in 2014, or roughly 25 billion pounds, according to the EPA. (The average human produces about 900 pounds a year.) The Cross plant also ranks 23rd nationally. Here are the top CO2 producers in South Carolina and the United States:



Top 10 in the U.S.

1. Scherer, Georgia, 20,321,943 metric tons
2. James H Miller Jr., Alabama, 19,746,633 metric tons
3. Navajo Generating Station, Arizona, 17,110,250
4. Gibson, Indiana, 16,164,179 metric tons
5. W A Parish, Texas, 16,006,078 metric tons
6. Rockport, Indiana, 15,679,691 metric tons
7. Bruce Mansfield, Pennsylvania, 15,557,345 metric tons
8. Bowen, Georgia, 15,517,056 metric tons
9. Gen J M Gavin, Ohio, 15,451,055 metric tons
10. Monroe, Michigan, 15,028,118 metric tons

SOURCE: EPA

STAFF

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